Endangered Species Act
Federal Columbia River Power System

2013
Comprehensive Evaluation
Section 2

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

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Under Reasonable and Prudent Alternative (RPA) Action 3, the Bonneville Power Administration (BPA), U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation), collectively referred to as the Action Agencies, submit a comprehensive evaluation of 2008-2012 implementation activities. Section 2 describes this implementation progress for each RPA action.

Contents

Hydropower Implementation Reports, RPA Actions 4–33

Table 1. Hydropower Strategy Reporting.

RPA Action No.	Action	Comprehensive Evaluation
Hydropower Strategy 1		
4	Storage Project Operations	Comprehensive Evaluation Report will summarize storage project operations for the fish season. There is no other physical or biological monitoring or reporting.
5	Lower Columbia and Snake River Operations	Comprehensive Evaluation Report will summarize MOP operations at the Lower Snake River projects and John Day elevations for the fish passage season. There is no other physical or biological monitoring or reporting.
6	In-Season Water Management	Comprehensive Evaluation Report will summarize FCRPS operations for the fish passage season. There is no other physical or biological monitoring or reporting.
7	Forecasting and Climate Change/Variability	Comprehensive Evaluation Report will summarize annual forecast reviews and identify any new procedures that become available. The report will also summarize any new, pertinent climate change research and the potential impacts to listed salmon and steelhead.
8	Operational Emergencies	Comprehensive Evaluation Report will summarize any emergency situations and actions taken. There is no other physical or biological monitoring or reporting.
9	Fish Emergencies	Comprehensive Evaluation Report will summarize any emergency situations and actions taken. There is no other physical or biological monitoring or reporting.
10	Columbia River Treaty Storage	Comprehensive Evaluation Report will summarize actions taken to provide 1 Maf of storage in Treaty space. There is no other physical or biological monitoring or reporting.
11	Non-Treaty Storage (NTS)	Comprehensive Evaluation Report will summarize actions taken to refill the remaining non-Treaty storage space by June 30, 2011. There is no other physical or biological monitoring or reporting.
12	Non-Treaty Long-Term Agreement	Comprehensive Evaluation Report will summarize actions taken to refill the remaining non-Treaty storage space by June 30, 2011. There is no other physical or biological monitoring or reporting.
13	Non-Treaty Coordination with Federal Agencies, States, and Tribes	Comprehensive Evaluation Report will summarize actions to coordinate NTS agreements. There is no other physical or biological monitoring or reporting.
14	Dry Water Year Operations	Comprehensive Evaluation Report will summarize 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	Comprehensive Evaluation Report will summarize actions taken to implement actions for ESA commitments. There is no other physical or biological monitoring or reporting.
16	Tributary Projects	No specific Comprehensive Evaluation reporting requirement.
17	Chum Spawning Flows	No specific Comprehensive Evaluation reporting requirement.

RPA Action No.	Action	Comprehensive Evaluation
Hydropower Strategy 2		
18	Configuration and Operational Plan for Bonneville Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
19	Configuration and Operational Plan for The Dalles Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
20	Configuration and Operational Plan for John Day Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
21	Configuration and Operational Plan for McNary Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
22	Configuration and Operational Plan for Ice Harbor Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
23	Configuration and Operational Plan for Lower Monumental Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
24	Configuration and Operational Plan for Little Goose Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
25	Configuration and Operational Plan for Lower Granite Project	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E. The Report will also include an analysis of the biological effectiveness of the actions taken to meet the dam passage survival performance standard.
26	Chief Joseph Dam Flow Deflector	No specific Comprehensive Evaluation reporting requirement.
27	Turbine Unit Operations	No specific Comprehensive Evaluation reporting requirement.
28	Columbia and Snake River Project Adult Passage Improvements	Comprehensive Evaluation Report will summarize actions taken and the results of the associated RM&E.
Hydropower Strategy 3		
29	Spill Operations to Improve Juvenile Passage	This information is the same as will be reported for each mainstem dam in hydro actions 18-25.
30	Juvenile Fish Transportation in the Columbia and Snake Rivers	Please see Hydro Action 31.
31	Configuration and Operational Plan Transportation Strategy	Comprehensive Evaluation Report will summarize the construction and operational action taken and associated RM&E to support the transportation strategy. The Report will also include an analysis of the biological effectiveness of the actions taken to meet a system survival performance target.

RPA Action No.	Action	Comprehensive Evaluation
Hydropower Strategy 4		
32	Fish Passage Plan (FPP)	No specific Comprehensive Evaluation reporting requirement.
Hydropower Strategy 5		
33	Snake River Steelhead Kelt Management Plan	Progress toward achieving the goals of the Snake River Steelhead Kelt Management Plan will be provided in the 2013 and 2016 comprehensive RPA evaluation reports.

Hydropower Strategy 1 (RPA Actions 4–17)

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.*

In 2012, the Action Agencies operated the Federal Columbia River Power System (FCRPS) storage projects to provide flows and water quality to improve juvenile and adult fish survival consistent with Hydropower Strategy 1 of the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) as described in the 2012 Water Management Plan (WMP) at *http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/2012/*. The 2012 WMP was developed in the fall 2011 with full regional coordination. The WMP describes the Action Agencies' annual plan for implementing specific operations identified in the 2008 National Oceanic and Atmospheric Administration (NOAA) Fisheries BiOp, the 2010 NOAA Fisheries Supplemental BiOp, and the 2000 and 2006 U.S. Fish and Wildlife Service (USFWS) BiOps. The 2008 NOAA Fisheries BiOp was issued in May of that year, and Records of Decision (ROD) were signed in September 2008. Prior to that September date, operations were carried out under the 2004 BiOp.

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. Real-time operations follow RPA Action 4 specifications as adjusted in-season with the help of the inter-agency Technical Management Team (TMT), an oversight group consisting of regional biologists and hydrologists.

Dworshak Dam Operations 2008-2012 Overview

Tables 2 and 3 summarize Dworshak Dam inflow forecasts and operations, respectively, for 2008-2011. Dworshak was successfully operated to meet the FCRPS BiOp objectives during the 2008-2012 period. A summary of the 2012 operations follows Table 2.

Table 2. Dworshak Dam Summary of April – July Water Supply Forecast (WSF) Volume Inflow Forecasts. 1 Maf = 1 million acre-feet of water. Percentages are percentage of average forecast for the period 1929 – 1999.

Forecast Release Date	2008	2009	2010	2011	2012
December Early Season	2.425 Maf (90%)	3.437 Maf (128%)	2.373 Maf (88%)	3.452 Maf (129%)	2.724 Maf (102%)
Jan Final	2.717 Maf (101%)	3.075 Maf (115%)	2.174 Maf (81%)	3.340 Maf (124%)	2.473 Maf (92%)
Feb Final	2.738 Maf (102%)	2.681 Maf (100%)	1.742 Maf (65%)	3.142 Maf (117%)	2.504 Maf (93%)
March Final	2.810 Maf (105%)	2.461 Maf (92%)	1.571 Maf (59%)	3.329 Maf (124%)	2.585 Maf (96%)
April Final	3.010 Maf (121%)	2.662 Maf (99%)	1.398 Maf (52%)	3.837 Maf (126%)	2.966 Maf (111%)
May Final	3.003 Maf (97%)	2.631 Maf (98%)	1.562 Maf (57%)	3.727 Maf (141%)	3.226 Maf (120%)
June Final	3.081 Maf (115%)	2.597 Maf (97%)	1.630 Maf (61%)	3.813 Maf (142%)	3.236 Maf (121%)

Forecast Release Date	2008	2009	2010	2011	2012
Actual runoff	3.434 Maf (128%)	2.539 Maf (95%)	1.906 Maf (71%)	4.042 Maf (151%)	3.343 Maf (125%)
Special Notes				Forecast continued to build after the April final forecast and into June.	Runoff started early. Hit initial control flow (ICF) prior to April 30 so stopped flood control draft on April 24.

Table 3. Dworshak Dam Summary of 2008-2012 Operations. In 2008, the FCRPS BiOp was issued in May and the RODs were signed in September. Prior to that date operations were under the 2004 BiOp.

Dworshak Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Operate to standard flood control criteria; shift system flood control to Grand Coulee when possible, unless modified by Hydro Strategy 1, Action 14 (Dry Water Year Operations).	Operated to standard flood control criteria during the winter and spring flood control season with 500 Kaf (thousand acre-feet) of system flood control shifted to Grand Coulee Dam by April 15. The start of refill began on May 15, with Dworshak Dam operating according to Flood Control/Refill Curve procedures.	Operated to standard flood control. During March and through mid-April the project operated to near minimum outflow for shifting system flood control to Grand Coulee Dam. The start of refill began on May 6, when Dworshak Dam began operating according to Flood Control/Refill Curve procedures.	Operated to standard flood control. With dry conditions and low inflows, Dworshak Dam stayed at or below the flood control rule curve, despite near minimum outflow. System flood control was shifted to Grand Coulee Dam. Refill occurred rapidly in June with unusually strong rain events.	Operated to standard flood control. The project operated under April flood control target due to increasing forecasts, delayed runoff, and flow augmentation provided during the latter part of April for Lower Granite Dam flow objectives. Dworshak Dam operated for fill and flood control during May and June. Because this was a high water year, system flood control was not shifted to Grand Coulee Dam.	Operated to meet standard flood-control criteria during the winter and spring flood-control season, with shifted system flood control to Grand Coulee Dam. Declaration to begin refill was on April 24, but the project operated to stay below the May refill curve because of a rising forecast. Dworshak Dam ended May at elevation 1577.8 feet, 1.8 feet below the refill curve target.
When not operating to minimum flows, operate to reaching the upper flood control rule curve on or about April 10 (the exact date to be determined during in-season management) to increase flows for spring flow management.	Operated above system flood control mid-April target. During the latter part of April and into early May, the project released near full powerhouse at the request of the salmon managers to augment flows in the lower Snake River for smolt migration.	Operated above system flood control mid-April target. During portions of May project outflow was increased and adjusted at the request of the salmon managers to maintain flow objectives in the lower Snake River.	Due to extremely dry conditions, mid-April system target could not be met. From May 20-23, the project released near full powerhouse at the request of the Salmon Managers to augment flows in the lower Snake River for smolt migration.	Dworshak Dam operated above the system flood control mid-April target while releasing full powerhouse plus spill to remain under maximum channel capacity.	Dworshak Dam operated above system and local flood control mid-April Target while releasing full powerhouse plus spill to stay under Idaho total dissolved gas standard.

Dworshak Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Provide minimum flows while not exceeding Idaho State Total Dissolved Gas (TDG) water quality standard of 110%.	During all periods when Dworshak Dam was releasing minimum flow, the TDG was maintained below the Idaho state standard of 110 percent.	During all periods when Dworshak Dam was releasing minimum flow, the TDG was maintained below the Idaho state standard of 110 percent.	During all periods when Dworshak Dam was releasing minimum flow, the TDG was maintained below the Idaho state standard of 110 percent.	During all periods when Dworshak Dam was releasing minimum flow, the TDG was maintained below the Idaho state standard of 110 percent.	During all periods when Dworshak Dam was releasing minimum flow, the TDG was maintained below the Idaho state standard of 110 percent.
Refill by about June 30.	Dworshak Dam reached full levels (maximum elevation of 1,599.9 feet) on July 7.	Dworshak Dam reached full levels (maximum elevation of 1,600.0 feet) on July 1.	Dworshak Dam reached full levels (maximum elevation of 1,600.0 feet) on June 25, 2010.	The project filled to 1599.0 by July 6, and briefly reached elevation 1600.0 feet on July 12.	The project was full on July 1 at elevation 1600 feet.
Draft to elevation 1535 feet by the end of August and elevation 1520 feet (80 feet from full) by the end of September unless modified per the Agreement between the U.S. and the Nez Perce Tribe for water use in the Dworshak Reservoir.	By August 31, the reservoir was drafted to elevation 1,535.3 feet. The reservoir reached 1,520 feet on September 28.	By August 31, the reservoir was drafted to elevation 1,535.0 feet. On September 17, the reservoir reached 1,520 feet.	By August 31, the reservoir was drafted to elevation 1,535.7 feet. On September 20, the reservoir reached 1,520 feet.	Elevation 1535 feet was reached on September 4. Drafting to meet end of August elevation was delayed because spill rate was restricted by 110 percent TDG standard. The reservoir reached 1,520 feet on September 17. Alterations of target elevation dates were coordinated in TMT.	By August 31, the reservoir was drafted to elevation 1534.5 feet. On September 19, the reservoir reached 1520 feet.

Dworshak Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Regulate outflow temperatures to attempt to maintain water temperatures at Lower Granite Dam tailwater at or below the water quality standard of 68 degrees Fahrenheit.	Summer temperature augmentation was successful, maintaining Lower Granite Dam tailwater temperatures below 68 degrees Fahrenheit throughout the summer. The maximum Lower Granite Dam tailwater temperature recorded in 2008 was 67.7 degrees Fahrenheit.	The reservoir began drafting on July 5 to provide temperature and flow augmentation for the lower Snake River. Lower Granite Dam tailwater temperatures stayed at or below 68 degrees Fahrenheit for all but portions of two days, July 29 and August 1. The maximum Lower Granite Dam tailwater temperature was 68.4 degrees Fahrenheit.	The reservoir began drafting on July 5 to provide temperature and flow augmentation for the lower Snake River. Lower Granite Dam tailwater temperatures remained below 68 degrees Fahrenheit. Lower Granite Dam maximum tailwater recorded temperature was 67.8 degrees Fahrenheit.	During July and August, Dworshak Dam successfully operated for temperature control on the lower Snake River (as measured at the Lower Granite Project tailwater) and for Endangered Species Act (ESA)-listed species flow augmentation. Lower Granite Dam tailwater temperature stayed at or below 68.0 Fahrenheit for all but 6 hourly readings in early August. Maximum temperature was 68.1 degrees Fahrenheit.	After July 5 and through the end of August, Dworshak Dam successfully operated for temperature control on the lower Snake River (as measured at the Lower Granite Project tailwater) and for ESA-listed species flow augmentation. Lower Granite Dam tailwater temperature stayed at or below 68.0 Fahrenheit for all but 5 hourly readings on July 24. Maximum temperature was 68.1 degrees Fahrenheit.
Maximum project discharge for salmon flow augmentation to be within state of Idaho TDG water quality standards of 110%.	Discharges for salmon flow augmentation did not exceed the Idaho state TDG standard of 110 percent.	Discharges for salmon flow augmentation did not exceed the Idaho state TDG standard of 110 percent.	Discharges for salmon flow augmentation did not exceed the Idaho state TDG standard of 110 percent.	Discharges for salmon flow augmentation did not exceed the Idaho state TDG standard of 110 percent. End of season elevation targets were missed to adhere to TDG standard.	Discharges for salmon flow augmentation did not exceed the Idaho state TDG standard of 110 percent.

Dworshak Dam 2012 Operations

From October to December 2011, Dworshak Dam released near minimum flows between 1,500 and 1,800 cubic feet per second (cfs). Dworshak Dam began January 2012 at elevation 1,521.4 feet, well under flood control elevations. The project stayed at minimum outflow of approximately 1500 cfs for all of January and until February 27, at which time the project ramped up to an outflow of approximately 5.6 thousand cubic feet per second (kcfs). Reservoir levels were below requirements for flood control for January and February, with outflow increases near the end of February planned to allow meeting future required flood control drafts in March and April. As of March 1, the project reservoir elevation was 1529.0 feet (Figure 1). Dworshak Dam was operated to follow its flood control draft requirements during the winter and spring flood control season, with system flood control shifted to Grand Coulee Dam during March and April per its operating rules. This means that Dworshak was drafted a little less and this loss of flood control space was made up for by a deeper draft from Grand Coulee.

Refill operations began on April 24. Dworshak Dam began in May at elevation 1531.5 feet and was operating for refill. With a rising water supply forecast (WSF) in May (9 percent increase from April), Dworshak Dam released the maximum gas cap flow of 14.3 kcfs through the first week in May to maintain flood storage and stayed below the refill curve. For the remainder of May, outflow was held at or below full powerhouse (approximately 10.5 kcfs) to manage for refill and local flood control. Two rain-on-snow events in May increased inflows to 22.4 kcfs and 22.9 kcfs on May 17 and May 23, respectively, but did not surpass the maximum inflow for the year of 38.2 kcfs on April 25. Dworshak Dam ended May at elevation 1577.8 feet, 1.8 feet below the refill curve target.

In June, the project operated to target full pool by the end of the month. One inflow spike of 23.3 kcfs occurred on June 6, the result of rain and snowmelt. Except for the last week in June, releases were held between a near-minimum flow of 2.2 kcfs and full powerhouse. In the last week of June, for final fill operations, outflows were increased above full powerhouse on June 26 and June 27 to 11.4 kcfs and 11.8 kcfs, respectively. The project ended in June at elevation 1599.9 feet and was full on July 1 at 1600 feet.

The project began slowly drafting in July with an elevation of 1599.5 feet by July 5. For the remainder of July and August Dworshak Dam operated for temperature control on the lower Snake River (as measured at the Lower Granite project tailwater) and for Endangered Species Act (ESA)-listed species flow augmentation. Daily average outflows were as high as 13.1 kcfs. The FCRPS BiOp prescribed target is 1535 feet by the end of August unless limited by excessive TDG production above the state of Idaho standard. The project was able to satisfy the temperature control augmentation (highest temperature recorded at Lower Granite Dam tailwater was 68.1 degrees Fahrenheit that occurred for 5 hours on July 24), while limiting TDG to acceptable levels and meeting its end of August target. Actual reservoir elevation on August 31 was 1534.4 feet. 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 1520.0 feet by about September 20. A prescribed and stepped discharge ramp-down to provide the 200 kaf brought the project to 1520 feet by September 19. On September 20 the outflows were brought down to the minimum rate of 1600 cfs and held there through December 2012.

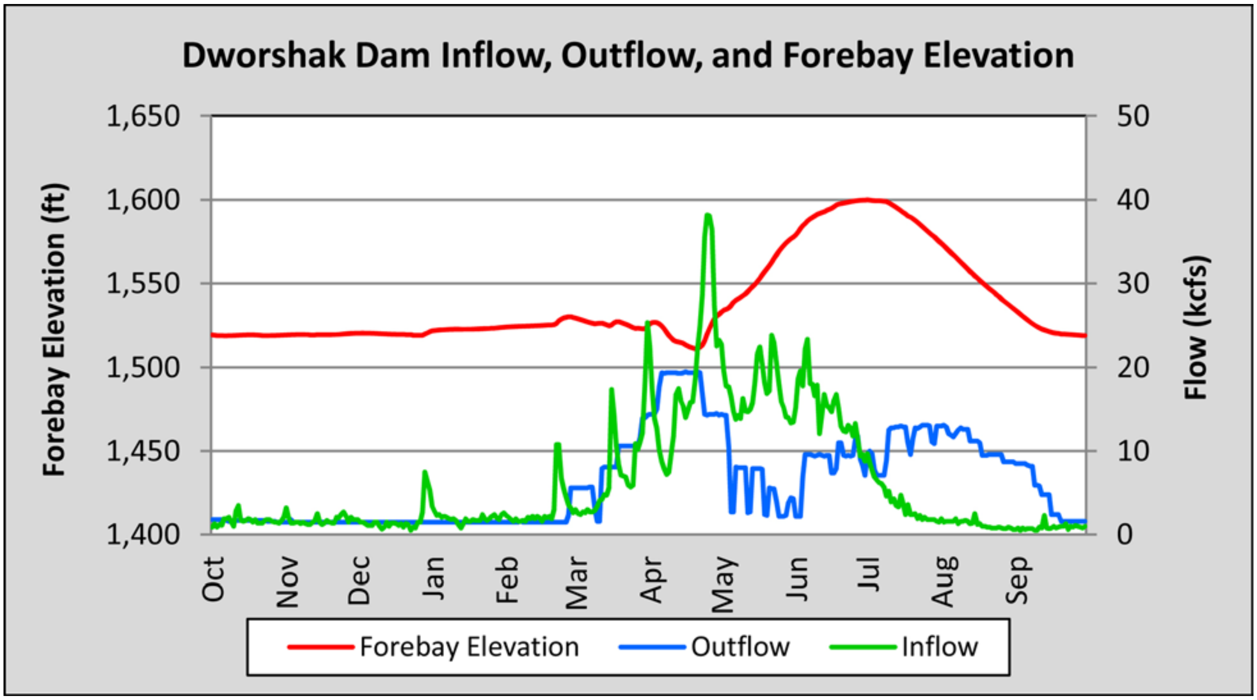


Figure 1. Dworshak Dam Inflow, Outflow, and Forebay Elevation from October 1, 2011, through September 30, 2012.

Libby Dam Operations 2008-2012 Overview

Table 4 and 5 summarize Libby Dam inflow forecasts and operations, respectively for 2008-2011. Libby Dam was successfully operated to meet the FCRPS BiOp objectives during the 2008-2012 period. A summary of the 2012 operations follows Table 4.

Table 4. Summary of April–August WSF Volume Inflow Forecasts at Libby Dam. 1 Maf = 1 million acre-feet of water. Percentages are percentage of average forecast for the period 1929–1999.

Forecast Release Date	2008	2009	2010	2011	2012
December Early Season	6.39 Maf (101%)	5.94 Maf (94%)	6.56 Maf (103%)	6.26 Maf (107%)	5.88 Maf (93%)
January Final	6.28 Maf (99%)	5.53 Maf (87%)	5.71 Maf (90%)	5.61 Maf (89%)	5.43 Maf (86%)
February Final	6.50 Maf (103%)	5.44 Maf (86%)	5.48 Maf (86%)	6.66 Maf (105%)	5.71 Maf (90%)
March Final	6.44 Maf (102%)	5.30 Maf (84%)	5.08 Maf (80%)	7.11 Maf (112%)	5.64 Maf (89%)
April Final	6.39 Maf (101%)	5.67 Maf (90%)	5.10 Maf (81%)	7.20 Maf (113%)	6.87 Maf (108%)
May Final	6.12 Maf (97%)	5.21 Maf (82%)	4.89 Maf (77%)	8.17 Maf (129%)	7.16 Maf (113%)
June Final	6.54 Maf (103%)	5.06 Maf (80%)	4.41 Maf (70%)	8.10 Maf (128%)	7.27 Maf (114%)
Actual runoff	5.54 Maf (87%)	4.44 Maf (70%)	4.52 Maf (71%)	7.73 Maf (122%)	9.19 Maf (145%)

Forecast Release Date	2008	2009	2010	2011	2012
				Forecast continued to build after the April final forecast and into June.	Based on system flood risk management rules, with a relatively early start to spring snowmelt and resultant rising system runoff, the target flow at The Dalles where system refill is initiated was reached on April 24. Therefore, Libby reservoir was allowed to begin refill in April.

Table 5. Summary of 2008 – 2012 Operations at Libby Dam. In 2008, the FCRPS BiOp was issued in May and ROD's were signed in September. Prior to that date operations were under the 2004 BiOp.

Libby Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Follow variable outflow flood control procedures (VARQ).	Operated consistent with the VARQ. The start of refill was declared on May 15, with outflows averaging 13,500 cfs for the remainder of May.	Operated consistent with the VARQ. The start of refill was declared on April 27, with outflows averaging 10,100 cfs for all of May.	In January through April, operated to target each end-of-month elevation using VARQ procedures. Because of a decreasing forecast in May, the modification of VARQ operations was coordinated in TMT and approved by the Corps' internal deviation process. Release of the May VARQ calculated minimum outflow of 14.5 kcfs was delayed until May 21. Delaying VARQ flows resulted in an additional 0.260 Maf of storage for summer sturgeon operations.	Operations followed VARQ flood control procedures. An approved Corps internal deviation allowed for exceeding the mid-March VARQ flood control limit after loss of a generation unit on March 4. Libby Dam continued drafting in May to eliminate trapped storage. On May 12, outflow was set above VARQ minimum (12.1 kcfs) when inflows exceeded powerhouse capacity. System refill began on May 17, thus the VARQ refill calculations were based on May 7 (10 days prior).	Operated to VARQ flood control procedures through April. Refill was declared on April 24. Libby Dam operated for refill through May, ending the month seven feet below the internal Corps target. Record precipitation occurred in June and continued into July, necessitating several actions to reduce flood risk below the project. Per an approved Corps deviation coordinated with Canada, the reservoir was allowed to surcharge two feet above the maximum pool of 2459 feet. Use of the surcharge storage space helped reduce outflows and decrease high river stages at Bonners Ferry and on Kootenay Lake. Libby Dam's peak outflow during June and July was 48 kcfs. Bonners Ferry peaked at 1766.6 feet on July 5, and Kootenay Lake peaked at 1753.8 feet. Outflows were reduced to below powerhouse capacity by late July.

Libby Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Follow variable December 31 flood control draft based on early season water supply forecast (WSF).	Operated to December 2007 flood control elevation target of 2411.0 feet, with actual elevation of 2411.2 feet.	Operated to December 2008 flood control elevation target of 2411.0 feet.	Operated to early season forecast of 6.56 Maf, with a December 2009 target of 2411 feet. Libby Dam ended December at 2410.9 feet.	Operated to end of December 2010 flood control elevation of 2411.0 based on early season forecast of 6.3 Maf. Actual end of December elevation was 2411.9 feet.	December's WSF was 93 percent of normal, allowing slight relaxation of end of December target elevation to 2412 feet. Actual end of December elevation was 2412.44 feet.
Operate consistent with the Columbia River Treaty, the International Joint Commission, and the 1938 Order on Kootenay Lake.	Operated consistent with the Columbia River Treaty, the International Joint Commission, and the 1938 Order on Kootenay Lake.	Operated consistent with the Columbia River Treaty, the International Joint Commission, and the 1938 Order on Kootenay Lake.	Operated consistent with Columbia River Treaty and the 1938 Order on Kootenay Lake.	Operation was consistent with Columbia River Treaty and 1938 Order - consideration given to high Kootenay Lake elevations during summer sturgeon operation. **Based on discussion with the International Joint Commission and the Kootenay Lake Board of Control, the operational requirement that Libby Dam assist Corra Linn Dam in meeting Corra Linn's International Joint Commission Order obligations was ended. Therefore, Libby operates to meet its flood risk management storage space requirement and does not trap water in the reservoir due to Corra Linn International Joint Commission Order limitations.*	Operations followed the Columbia River Treaty, and the International Joint Commission and the 1938 Order on Kootenay Lake to the extent practical, with close coordination occurring between the U.S. and Canada during June/July Flooding.

Libby Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
When not operating to minimum flows, operate to achieve 75% chance of reaching the upper flood control rule curve on or about April 10 (the exact date to be determined during in-season management) to increase flows for spring flow management.	To meet the April 10 target elevation of 2,401.8 feet, Libby Dam operated at the 4,000 cfs minimum, and the forebay elevation for Libby Dam was 2,395.3 feet on April 10.	From January through April 2009, Libby Dam released the minimum flow of 4,000 cfs.	Operated to minimum flows through May 21. Due to a decreasing forecast from January through March, Lake Koocanusa operated below upper rule curve targets.	Operated to be at or below upper rule curve through April 15. Project drafted to an end of April elevation 9.3 feet below the upper rule curve because of increasing snow water equivalent (141 percent of basin average on April 15).	The project operated at full powerhouse capacity from April 5 through 18 to meet flood control elevation objectives.
Operate to provide tiered white sturgeon augmentation volumes to achieve habitat attributes for sturgeon spawning/recruitment consistent with the 2006 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) in May, June and July; shaped in coordination with Regional Forum TMT.	The May forecast for the April through August inflow volume of 6.13 Maf prescribed the sturgeon volume at 1.04 Maf. Bull trout minimum flows through August 31 were 8 kcfs. The sturgeon pulse began June 1 and used the 1.04 Maf volume by June 26. The pulse included 14 days at Libby Dam's full powerhouse and an additional six days above 20 kcfs on the descending limb.	The May forecast for the April through August inflow volume of 5.209 Maf prescribed the sturgeon volume to tier 2 at 0.8 Maf The bull trout minimum flow through August 31 was 7 kcfs. The sturgeon pulse began June 10. The sturgeon volume was exhausted on July 12. The pulse included seven days at Libby Dam's full powerhouse and an additional five days above 20 kcfs on the descending limb.	The May forecast for the April through August inflow volume of 4.89 Maf prescribed the sturgeon volume to a tier 2 at 0.8 Maf. TMT had approved operating below VARQ May minimum flows to store additional water for assuring gated spill during the sturgeon operation. Operations began June 9 with spill and powerhouse outflows of 34 kcfs for seven days. Total volume, including additional storage, was used by July 15.	Operated to provide tier 5 sturgeon volume of 1.2 Maf based on May WSF of 8.165 Maf. Sturgeon operations began June 2. Bonners Ferry stage peaked at 1763.4 feet on June 11. Because of high Kootenay Lake stage, spill was not needed during the sturgeon pulse; Bonners Ferry stage remained above 1763.0 during peak releases of 25.3 kcfs from June 10 through Jun 17. Sturgeon operations ended on July 11 when the tier 2 and additional volume was expended.	The May WSF was calculated to be 7.2 Maf, or 113 percent of average. This forecast resulted in a tier 4 sturgeon flow augmentation volume of 1.18 Maf and bull trout minimum flows of 9 kcfs. The sturgeon operation began on May 28, with spill added beginning June 4. Due to a strong storm system on June 6-8, spill was ended as Bonners Ferry stage approached flood levels. The sturgeon operation transitioned to a flood risk management operation after June 8 due to the high rainfall in the basin.
To provide for summer flow augmentation, refill by early July (exact date to be determined in-season), determined by available water supply and shape and spring flow operations, while also avoiding involuntary spill and meeting flood	Reached a maximum elevation of 2,444.8 feet on July 17 and technically did not refill. This was due to colder than average temperatures in June for a two-week period that dropped inflows to Lake Koocanusa and caused	Reached a maximum elevation of 2,444.3 feet on August 24 and did not refill. The actual April through August water supply volume was 4.40 Maf, much drier than forecast.	Due to the low inflow rate in July and August, and operating to meet the bull trout minimum of 7 kcfs, Libby Dam did not fully refill. Peak pool elevation of 2443 feet occurred on August 17.	Operated for refill after completion of the sturgeon operation. Peak Lake Koocanusa elevation was reached on August 4 at 2453.4 feet.	Libby Dam filled to a record elevation of 2459.96 feet on July 14.

Libby Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
control objectives.	some of the headwater snowpack to sublimate.				
Provide even or gradually declining flows following sturgeon flows during the summer months (minimize double peak) as determined through TMT in-season management.	After completion of the sturgeon pulse, the operation objective was to provide even or gradually declining flows following sturgeon flows during the summer months. This operation was discussed and approved by the TMT.	After the sturgeon pulse, Libby Dam ramped down to a minimum bull trout flow of 7,000 cfs for July and August. In September, Libby Dam operated to the minimum bull trout flow of 6,000 cfs.	From July 1 through July 15, all remaining storage for sturgeon was released and flows decreased to 7,000 cfs on July 15. The project maintained 7,000 cfs, the minimum flow for bull trout for the remainder of July and August.	Flows were reduced gradually to 11 kcfs by July 13 after the sturgeon operations. After TMT coordination, flows were increased in early August from 14 to 16 kcfs to accommodate a System Operational Request (SOR) from the Kootenay Tribe of Idaho for reduced outflows (6 kcfs) in September to perform habitat restoration work.	Due to the flood risk management operations and record high reservoir elevations, flows were stepped down in July and August based on the rate of reservoir inflow to achieve an orderly drawdown of Lake Koocanusa. The stepped down flow reductions were coordinated in TMT.
Experimental draft to 10 feet from full by the end of September (except in lowest 20th percentile water years, as measured at The Dalles (See Table 6.), when draft will increase to 20 feet from full by end of September). If project fails to refill 20 feet from full, release inflows or operate to meet minimum flows through the summer months. Rationale for the experimental draft was adopted by the Northwest Power and Conservation Council (NPCC) and further details of the evaluation can be found in the FCRPS Biological Assessment (Appendix B.2.1). Meet minimum	Regulated to meet the rollover operations based on the 2004 NOAA Fisheries FCRPS BiOp requirement to draft to 2,439 feet by August 31. As part of the Treaty Storage Regulation process, a volume of 60 ksfd was targeted for the Libby-Arrow Swap Agreement. As such, Libby operated to an August 31 elevation of 2441.8', an equivalent of 60 ksfd above normal, and Arrow drafted to an August 31 elevation 60 ksfd below the normal target elevation. This operation was discussed and approved by the TMT.	Low runoff conditions led to an ending September elevation of 2441.4 feet After the sturgeon pulse, Libby Dam ramped down to a minimum bull trout flow of 7,000 cfs for July and August. In September, Libby Dam operated to the minimum bull trout flow of 6,000 cfs.	Through coordination in TMT, the end of September target elevation of 2439 feet was moved to October 9. Unusually high rain events in September resulted in high inflows and an increasing pool elevation. Outflows were increased from 7 kcfs to 9 kcfs on September 20. Maintaining nearly-steady outflows instead of increasing to meet the 2439-foot elevation was preferable for minimizing biological impacts.	To accommodate an approved SOR for habitat restoration work in September which required flows of 6 kcfs, the TMT recommended moving target end of September elevation to the end of August. Lake Koocanusa end of August actual elevation was 2447.7 feet, and the end of September actual elevation was 2446.8 feet.	Lake Koocanusa ended September at elevation 2448.4 feet, achieving a draft to 10 feet from full. The Kootenay Tribe of Idaho coordinated in the TMT to continue habitat restoration work below Libby Dam in September and October. September flows were set at 8 kcfs.

Libby Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
flow requirements for bull trout from May 15 to September 30 as described in the USFWS 2006 Libby BiOp and 4,000 cubic feet per second (cfs) in October through May 14 for resident fish.					
Limit spill to avoid exceeding Montana State TDG standard of 110%, when possible, and in a manner consistent with the Action Agencies' responsibilities for ESA-listed resident fish.	Avoided spill and did not violate the Montana state TDG standard of 110 percent.	Spill in excess of powerhouse capacity to support sturgeon operations was consistent with waiver of the TDG water quality standard provided by the state of Montana. Other than the seven days of spill for sturgeon operations, Libby Dam did not spill and did not exceed the state TDG standard of 110 percent.	Spill in excess of powerhouse capacity to support sturgeon operations was consistent with waiver of the TDG water quality standard provided by the state of Montana. No other spill occurred during the season.	In 2011, no spill occurred in excess of powerhouse capacity during sturgeon operations. The required higher flows were achieved due to local runoff. Spill through a sluice gate from April 30 through May 9 due to unscheduled loss of generator unit resulted in exceeding state standard and was necessary to meet VARQ flood control objectives.	Spill in excess of powerhouse capacity to support sturgeon operations was consistent with waiver of the TDG water quality standard provided by the state of Montana. Percent spill for flood risk management after June 8 and lasting through July exceeded the state of Montana water quality standard, but was unavoidable due to the emergency flood conditions.
Limit outflow fluctuations by operating to ramping rates set in the 2006 USFWS BiOp to avoid stranding bull trout.	Ramping rates were adhered to for all operations.	Ramping rates were adhered to for all operations.	Ramping rates were adhered to for all operations.	Ramping rates were adhered to for all operations.	Ramping rates were adhered to the USFWS BiOp for flows at or below the full powerhouse capacity (25 kcfs).

Libby Dam 2012 Operations

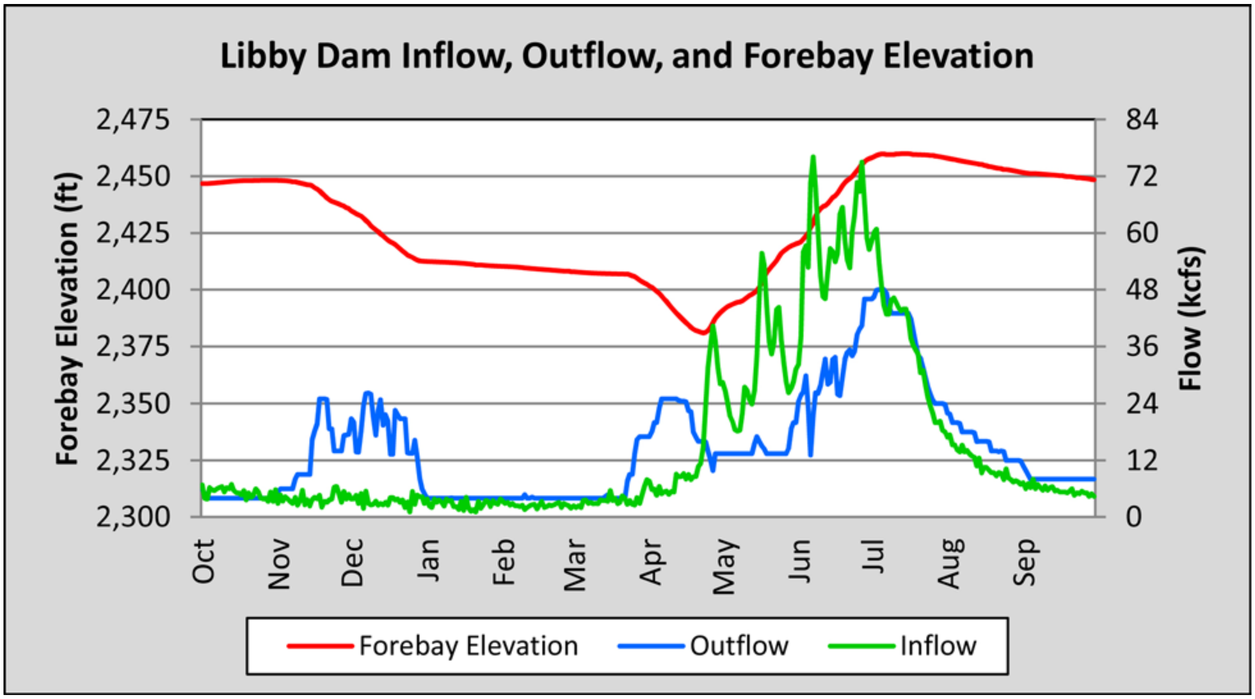


Figure 2. Libby Dam Inflow, Outflow, and Forebay Elevation from October 1, 2011, through September 30, 2012.

Libby Dam began November 2011 at a pool elevation of 2448.3 feet. On November 1, Libby Dam outflows were increased from 4 to 6 kcfs and maintained until November 8 to allow completion of habitat restoration near Bonners Ferry. Outflow was then increased to 9 kcfs and then ramped up further for flood control draft and power benefits. To meet regional power needs with the onset of cold weather, Libby Dam was brought up to full powerhouse (25 kcfs) the weekend of November 19. The project ended November at elevation 2453.3 feet (Figure 2). Outflow averaged 13.5 kcfs over November 2011 with some weekly shaping for power loads. All changes in outflow followed the ramp rate restrictions per the 2006 USFWS BiOp.

The December 2011 WSF was 93 percent of normal, allowing slight relaxation of end-of-December target elevation to 2412 feet. Full draft according to variable outflow flood control procedures (VARQ) and standard flood control is 2411 feet, for December 31. In December the project drafted for flood control, shaping for power. The project's actual elevation on December 31, 2011, was 2412.44 feet and minimum outflow of 4 kcfs was reached on December 31 at midnight. Libby Dam outflow averaged 18 kcfs in December and inflow averaged 3.4 kcfs, or 86 percent of average. Precipitation over the Kootenay River Basin in December was well below normal, at 40 percent of average.

For all of January and February 2012, the Libby Dam project remained at minimum outflow of 4 kcfs except for a brief time for unit testing. By the end of February, the project drafted over four feet while staying at minimum outflow, reaching 2407.8 feet on March 1, 2012. Reservoir levels remained significantly below the VARQ required flood control elevation of 2426.2 feet for the end of January and 2429.2 feet for the end of February. The Corps' official January WSF was 5.4 Maf or 86 percent of average (based on 1929 – 1999 period of record), and the February forecast rose slightly to 5.7 Maf or 90 percent of average. While the WSFs stayed slightly below normal, the dry December 2011 events were replaced by wetter conditions beginning in January 2012. Precipitation for January and February, respectively, averaged 103 percent and 84 percent of normal with temperatures near normal. By the end of February the snow pack was near average over most of the northern Basin, with higher values further north.

The Corp's March WSF stayed about the same as the February forecast at 5.6 Maf, or 89 percent of average. Per VARQ rules, the end of March upper rule curve target was 2435.7 feet for the northern portion of the Columbia River Basin, March started with seasonable temperatures and mostly with high pressure in place. Conditions changed the second week of March with a pattern of recurring storms caused by a persistent northwesterly jet stream. During March, the Kootenay River Basin received 297 percent of average monthly precipitation. Temperature in the basin was average to slightly below average over the month.

Because of the increasing inflow and wet conditions, Libby Dam outflow was increased around mid-March, first to two units at 9 kcfs, and then to three units at 17 kcfs. The project ended March at elevation 2402.5 feet The WSF increased substantially in April, to 6.9 Maf or 108 percent of average. Throughout April, the project operated between three units (about 17 kcfs) and full powerhouse (25 kcfs), operating at or near full powerhouse from April 5 until April 18. System refill was declared on April 24, with the Libby Dam project allowed to retroactively begin refilling 10 days prior. Libby Dam ended April at elevation 2390.2 feet, following VARQ rules and also adjusting releases briefly near the end of the month to remain on the refill curve. April was characterized overall by above average precipitation and near average temperatures in the Kootenay River Basin, with precipitation at 131 percent of average during the month. Late in April, high pressure set in over the region, but this high pressure also caused typical spring thunderstorm activity in the region. Libby Dam inflows averaged 3.7 kcfs in March and 13.5 kcfs in April. Libby Dam outflow averaged 7.2 kcfs in March and 19.7 kcfs in April.

The May WSF was calculated at 7.2 Maf, or 113 percent of average. This forecast resulted in a tier 4 sturgeon flow augmentation volume of 1.18 Maf and bull trout minimum flows of 9 kcfs. In May, the project followed the refill curve and applied VARQ rules staying at or above VARQ flows. Based on the May WSF, the VARQ flow was 13.4 kcfs, but at times during mid-month daily average outflow it was increased above that level in order to control rate of refill. From May 14 through 18, Libby Dam outflow averaged 15.6 kcfs. The project ended May at elevation 2420.4 feet, below the Corps flood risk management guidance target of 2427.2 feet. In contrast to the two previous months, May was a relatively dry month, with precipitation within the Kootenay River Basin averaging 72 percent of average. Temperatures during the month were below average. Snow pack at the end of May was well above average in the northern portion of the Kootenay River Basin and slightly above average in the southern portion.

The ramp up for sturgeon pulse flows began on 28 May, when temperature and fish movement criteria were met. For the 2012 sturgeon operation, the project was to add up to 10 kcfs of spill above the full powerhouse in order to produce the river elevation at Bonners Ferry believed to be optimum for sturgeon reproduction. Spill above the full powerhouse discharge was added by June 4.

The Corps official WSF for June was 7.24 Maf or 114 percent of average. A particularly strong rain event, with wrap-around moisture from the southeast occurred during June 6-8. Inflows to the project peaked on June 7 at 76.1 kcfs. The sturgeon operation was planned to bring Bonners Ferry stage up to 1763.5 feet. With the continuing strong storm activity in the region, the actual sturgeon operation with planned spill was modified at times to an operation below powerhouse flows in order to control Bonner's Ferry below flood stage.

As rainstorms continued, the sturgeon operation transitioned to a pool control and flood risk management operation, initially designed to stay below flood stage at Bonner's Ferry, 1764 feet, and eventually exceeding the Bonner's Ferry flood stage in order to control the pool refill rate. A second inflow peak, slightly lower than the one seen on June 7, was seen on June 27 at 75 kcfs. During the same period, Kootenay Lake was also rising due to the rain response in Canada and high Libby Dam discharge. Following extensive coordination between the U.S. and Canada, an operation was approved by the Corps on June 28 per a Canadian request to allow Libby reservoir to surcharge by one foot above the maximum 2459.0 feet pool elevation up to elevation 2460.0 feet. The ability to fill above the normal full pool allowed the project to maintain a lower release, essentially shifting special curve releases and thus providing stage reduction benefits downstream in the U.S and Canada. Despite the ability to surcharge, outflows were increased up to 46 kcfs on June 28. On July 3 the deviation was modified and superseded with an allowance to surcharge up to elevation 2461.0 feet. One additional increase in discharge was required on July 3, up to 48 kcfs. Coordination between the U.S. and Canada to manage flood events adhered to obligations of the Columbia River Treaty.

Major storm systems moved out of the region by July 3, with some recurrences of localized rain through mid-July. The stage at Bonner's Ferry peaked at 1766.59 feet early on July 4, nearly coinciding with peak stage on Kootenay Lake at Queen's Bay, which peaked at 1753.8 feet. With outflows at 48 kcfs, the Libby reservoir reached a high of 2459.88 feet on July 5. With the surcharge operation approved and a desire to provide downstream relief, project outflows were gradually reduced to 43 kcfs by July 9, with the reservoir drafting slightly. With outflows at 43 kcfs, Libby Dam then filled again slightly to a record high level of 2459.96 feet on July 14 and then again on July 16 due to inflow rises associated with thunderstorms. Montana state water quality standards were exceeded during June and July, outside of the waiver period for sturgeon operations. These water quality exceedences resulting from spillway releases were unavoidable due to the emergency flood situation. Libby Dam inflow averaged 58.2 kcfs in June and 37.6 kcfs in July. Libby Dam outflow averaged 31.4 kcfs in June and 37.6 kcfs in July.

Libby Dam continued to draft in August, with outflows reduced gradually to 12 kcfs by August 24 in preparation for the second season of Kootenai River habitat restoration work. Restoration work requires lower flows in September, October, and the first part of November. The request for the special flow operation, which influenced reservoir levels, was coordinated with and recommended by the TMT. Outflow was gradually stepped down to 8 kcfs by September 3. The reservoir drafted to elevation 2451.7 by August 31, 2012, and to elevation 2448.4 feet by September 30, releasing 8 kcfs through the month. The 8 kcfs September discharge exceeds the minimum flow of 6 kcfs required in September for bull trout in the 2000 USFWS BiOp.

The project reached 4 kcfs minimum outflow by October 3 and was maintaining that outflow into November. Fall and early winter operations targeted elevation of approximately 2435 feet for the end of November, and a default VARQ flood control elevation target of 2411.0 feet for the end of December.

The final April–August inflow volume to the project was 9.2 Maf or 145 percent of normal.

Grand Coulee Dam Operations 2008-2012 Overview

Table 6 summarizes the forecasted runoff for the Columbia River at The Dalles Dam for 2008-2012 which was used to compute flood control space requirements for Lake Roosevelt behind Grand Coulee Dam. Table 7 summarizes operations of Grand Coulee Dam for 2008-2012. Grand Coulee Dam was successfully operated to meet the FCRPS BiOp objective during the 2008-2012 period. A more detailed summary of 2012 operations follows Table 7.

The WSF at The Dalles Dam is used to compute flood space requirements at Lake Roosevelt and to determine summer draft limits at Lake Roosevelt.

Table 6. Summary of April – August WSF Volume Inflow Forecasts at The Dalles Dam. Percentages are percentage of average forecast for the period 1971 – 2000.

Forecast Release Date	2008	2009	2010	2011	2012
January Final	88.2 Maf (94.8%)	82.1 Maf (88.2%)	76.7 Maf (82.4%)	90.6 Maf (97.3%)	77.4 Maf (83.2%)
February Final	91.8 Maf (98.6%)	79.7 Maf (85.6%)	68.5 Maf (73.6%)	92.5 Maf (99.4%)	84.4 Maf (90.7%)
March Final	94.3 Maf (101.3%)	74.8 Maf (80.4%)	62.1 Maf (66.7%)	92.3 Maf (99.2%)	90.6 Maf (97.3%)
April Final	94.7 Maf (101.7%)	82.4 Maf (88.5%)	60.9 Maf (65.4%)	101 Maf (108.5%)	103.7 Maf (114.4%)
May Final	90.9 Maf (97.7%)	81.4 Maf (87.4%)	62.2 Maf (66.8%)	113 Maf (121.4%)	110.8 Maf (119%)
Actual Runoff April – August	93.2 Maf (100%)	80.8 Maf (87%)	77.4 Maf (83%)	127.4 Maf (137%)	119.1 Maf (128%)
Special Notes			High rainfall in late spring resulted in high flows on the Snake River and over-generation for the FCRPS. Despite the low volume forecast Grand Coulee Dam was spilled according to the spill priority list.	Forecast continued to build past the April final and into June.	Runoff started early, hit ICF prior to April 30 so stopped Flood Control draft.

Table 7. RPA Action 4 - Grand Coulee Dam Bullets.

Operation	2008[1]	2009	2010	2011	2012
Use standard flood control criteria including adjustments for flood control shifts from Dworshak and Brownlee dams. (Shifts from Dworshak and Brownlee dams are intended to improve flow conditions for Snake River spring migrants in dry water years.)	A near-average WSF required Lake Roosevelt to draft to elevation 1228.8 feet by May 2 for flood control. Shifted system flood control from Dworshak Dam to Grand Coulee Dam.	Draft to elevation 1257.7 feet by April 30 for flood control. Shifted system flood control from Dworshak Dam to Grand Coulee Dam. Forecast increased between March and April, and the April 30 flood control elevation reduced by 24 feet.	The forecast dropped throughout the year until it was approximately 75 percent of average in June. Flood control draft requirement was to elevation 1283.3 feet but salmon managers requested draft to 1269.5 feet by April 30 to help support chum, Vernita Bar, and Priest Rapids Dam flow objectives. There was a shift from Dworshak Dam to Grand Coulee Dam.	Flood control draft requirement, based on the April forecast, was to elevation 1220.2 feet by April 30 but continued to draft in early May to 1217.7 feet because forecast continued to build through April and beyond April 30. No shift from Dworshak or Brownlee dams due to high water year.	Flood Control draft requirement, based on the March forecast was elevation 1237 feet by April 30. Increasing forecast through March resulted in a flood control draft of 1220.2 feet by April 30 based on the April final forecast. Warm temperatures through April resulted in high inflows. The ICF was achieved on April 25 so refill was initiated at that time. The maximum draft occurred on April 24 at elevation 1227.4 feet.
Operate to achieve 85 percent probability of reaching upper rule curve by about April 10 (intended to maximize flow for spring migrants).	The April 10 elevation objective of 1244.5 feet was met on April 10.	April 10 objective was elevation 1281.9 feet. However, it became apparent Vernita Bar requirements and April 10 elevation could not both be met, so salmon managers elected to allowed Lake Roosevelt to draft slightly. Lake Roosevelt maximum elevation on April 10 was 1280.4 feet.	Drafted to elevation 1275.2 feet, salmon managers recommended draft below April 10 objective to help support chum redd protection and Vernita Bar flow objectives.	April 10 elevation set based on the March final forecast. Significant increase between the March and April forecast required significantly deeper draft to meet April 30 flood control April 10 URC at elevation 1238.5 feet.	April 10 elevation set based on the March final forecast. Significant increase between the March and April forecast required significantly deeper draft to meet April 30 flood control, April 10 URC at elevation 1246 feet.

[1] *Biop was issued in May 2008 and RODs were signed in September 2008. Prior to that date operations were under the 2004 BiOp.*

Operation	2008[1]	2009	2010	2011	2012
Refill by about June 30 each year (exact date to be determined during in-season management) (intent is to maximize water available for flow augmentation to aid summer migrants).	Lake Roosevelt filled to elevation 1290 feet by July 15.	Lake Roosevelt filled to elevation 1290 feet on July 6 – after 4th of July weekend.	Lake Roosevelt refilled to elevation 1290 feet by June 21.	Lake Roosevelt refilled to elevation 1290 feet by July 13. There were delays due to high water. Needed to ensure that the threat of filling and spilling had passed to minimize spill/TDG.	Lake Roosevelt refilled to elevation 1289.8 feet by July 8. Based on FFRAG the recommendation part of the Lake Roosevelt drawdown component was shifted into the spring (see below).
Take advantage of reservoir draft for flood control during high-water years to perform drum gate maintenance. Drum gate maintenance may be deferred in some dry water years; however, drum gate maintenance must occur at a minimum one time in a three-year period, two times in a five-year period, and three times in a seven-year period (intent is to reduce the impact of drum gate maintenance on flow augmentation in dry water years).	Took advantage of the flood control draft to perform drum gate maintenance.	Deferred drum gate maintenance.	Deferred drum gate maintenance.	Took advantage of the flood control draft to perform drum gate maintenance.	Took advantage of the flood control draft to perform drum gate maintenance.
Draft to help meet salmon flow objectives during July-August with variable draft limit of elevation 1278 to 1280 feet by August 31 based on the WSF.	Lake Roosevelt was drafted to elevation 1280.2 feet by August 31 (BiOp objective was1280 feet based on WSF).	Lake Roosevelt was drafted to elevation 1277.5 feet by August 31 (BiOp objective was 1278 feet based on WSF plus Lake Roosevelt drawdown component).	Lake Roosevelt was drafted to elevation 1277.1 feet by August 31 (BiOp objective was 1278 feet based on WSF plus Lake Roosevelt drawdown component).	Lake Roosevelt was drafted to elevation 1279.9 feet by August 31 (BiOp objective was 1280 feet based on WSF, there was no Lake Roosevelt drawdown component).	Lake Roosevelt was drafted to elevation 1279.7 by August 31 (BiOp objective was 1280 feet based on WSF plus Lake Roosevelt drawdown Component).
Reduce pumping into Banks Lake and allow Banks Lake to operate up to five feet from full pool (elevation 1565 feet) during August to help meet salmon flow	Banks Lake reached elevation1565.1 feet on August 31.	Banks Lake reached elevation 1564.7 feet on August 31.	Banks Lake reached elevation 1565.1 feet on August 31.	Pumping to Banks Lake stopped to allow the lake to draft so the project could perform routine maintenance on outlet works. Actual end of August draft elevation of	Banks Lake reached elevation 1565.1 feet on August 31.

Operation	2008[1]	2009	2010	2011	2012
objectives when needed.				1552.4 feet, end of September elevation of 1540.5 feet. Water not pumped to Banks Lake was released downstream from Grand Coulee Dam.	
If the Lake Roosevelt drawdown component of Washington's Columbia River Water Management Program is implemented, it will not reduce flows during the juvenile salmon flow objective period (April to August). The metric for this is that Lake Roosevelt will be drafted by an additional one foot in non-drought years and by about 1.8 feet in drought years (as defined by the state of Washington in WAC-173-563-056) by the end of August. A third of this water will go to in-stream flows.	None.	Temporary contracts limited volume of release to approximately16.5 kaf (about 0.2 feet in Lake Roosevelt). Drafted to elevation 1277.5 feet.	Temporary contracts limited volume of release to 52.5 kaf (about 0.65 feet in Lake Roosevelt). Drafted to elevation 1277.1 feet.	Temporary contracts expired and final contracts not yet in place, therefore there was no release.	Only a limited number of final contracts were in place with a volume of 25.5 kaf (0.3 feet). Drafted to elevation 1279.7 feet.
May be used to help meet tailwater elevations below Bonneville Dam to support chum spawning and incubation.	Grand Coulee Dam was operated to help maintain chum tailwater elevation below Bonneville Dam of 11.5 feet.	Grand Coulee Dam was operated through the fall and winter to help maintain chum tailwater elevation below Bonneville Dam of 11.5 feet.	Grand Coulee Dam was operated during the fall to help maintain chum tailwater elevation below Bonneville Dam at 11.5 feet. Lake Roosevelt was drafted in January and February to support chum tailwater elevation. In March, TMT decided to transition from meeting chum protection to meeting Vernita Bar protection flows.	Grand Coulee Dam was operated to support chum flows.	Grand Coulee Dam was operated from November – February to support the chum tailwater elevation of 12 feet below Bonneville Dam.
Operate to help meet	Grand Coulee Dam was	Lake Roosevelt was	Lake Roosevelt was	Grand Coulee Dam was	Grand Coulee Dam was

Operation	2008[1]	2009	2010	2011	2012
Priest Rapids Dam flow objective to support fall Chinook salmon spawning and incubation.	operated to support Vernita Bar flows of 50 kcfs.	drafted in April to help support Vernita Bar flows of 60 kcfs.	drafted 14 feet below April 30 URC to support Vernita Bar flows. Operated Grand Coulee Dam to help support Vernita Bar flows until June when operations transitioned to refilling Lake Roosevelt.	operated to support Vernita Bar flows.	operated to support the Vernita Bar flows of 65 kcfs below Priest Rapids Dam.
Operate to minimize TDG production. (Operations of Grand Coulee Dam follow detailed standard procedures to minimize spill that could result in elevated levels of TDG below the dam)(System strategy includes putting Grand Coulee low on the spill priority list and using the flow deflectors at Chief Joseph Dam below Coulee to strip gas).	High flows resulted in force spill of up to 50 kcfs spill. TDG was maintained below 120 percent.	Periods of high flows during refill. Forced spill was as high as 29.5 kcfs for a short period. TDG remained below 109 percent. Spill occurred when Lake Roosevelt was near full so spill was over the drum gates, which typically results in little or no increase in TDG.	Heavy precipitation in June resulted in over-generation in the lower river (high flows that resulted in excessive spill). Generation was shifted from Grand Coulee Dam to lower Columbia and Snake river projects, resulting in spill at Grand Coulee Dam. Rapid refill the first part of June helped reduce TDG. Spill reached as high as 75 kcfs, which resulted in TDG less than 116 percent. (Lake Roosevelt water surface elevation was above 1265 feet, allowing spill over the drum gates.)	Up to 102 kcfs of spill occurred when Lake Roosevelt water surface elevation was below elevation 1265 feet. Spill occurred through the outlet works, which generates high gas, so TDG was as high as 145 percent.	Spilled water past Grand Coulee Dam to get to flood control in April. Although the spill was through the outlet tubes TDG did not exceed 120 percent below the dam. Larger amounts of spill were required during the second half of June and through most of July. This spill occurred over the drum gates so TDG only exceeded 120 percent below the dam for five days with the maximum TDG of 122 percent.

Reference the previous FCRPS Annual Progress Reports (APR) for more detail.

Grand Coulee Dam

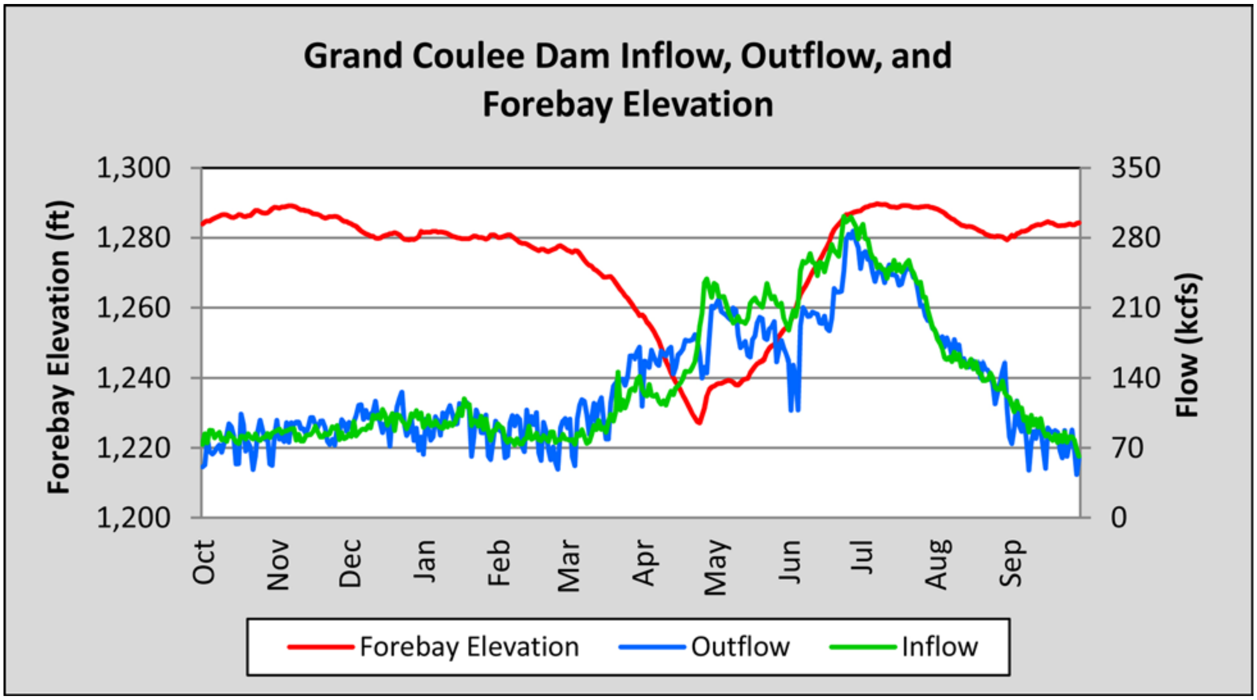


Figure 3. Grand Coulee Dam Inflow, Outflow, and Forebay Elevation from October 1, 2011, through September 30, 2012.

Grand Coulee Dam was operated during November and December 2011 to facilitate chum spawning below Bonneville Dam resulting in a 12.0 feet chum redd protection tailwater elevation at Bonneville Dam for the 2012 season. During January and February of 2012, Grand Coulee Dam was operated to help maintain the chum red protection tailwater of 12.0 feet below Bonneville Dam as well as the Vernita Bar protection flows of 65 kcfs below Priest Rapids Dam. Grand Coulee Dam was operated during the winter and spring of 2012 using standard flood control criteria which uses the Northwest River Forecast Center's (NWRFC) WSF at The Dalles Dam to help determine space requirements and the required flood control draft of Lake Roosevelt. The WSF (April-August) at The Dalles Dam was 83 percent of average starting in January, 91 percent of average in February, and 97 percent of average in March.

The Grand Coulee Dam April 30 flood control elevation based on the March forecast was 1237 feet, and the April 10 elevation objective was 1258.3 feet based on the same March final forecast. The NWRFC's Ensemble Streamflow Prediction (ESP) WSF for The Dalles continued to increase through the month of March. By the middle of March it became apparent that a significant decrease in the Grand Coulee April 30 flood control elevation would occur due to the increasing WSF at The Dalles. The March 16 NWRFC forecast for The Dalles Dam had increased to 103 percent of average (April-August), and as a result, Grand Coulee Dam began to draft significantly by March 19, 2012, in order to achieve the expected lower April 30 flood control elevation. By April 4 the forecast for The Dalles Dam had increased to 111 percent of average, and the final April 30 flood control elevation was set at 1220.2 feet. With Lake Roosevelt at elevation 1257.4 feet on April 1, a 37-foot draft in 30 days was required in order to achieve the April 30 flood control elevation.

Stream flows and inflows into Lake Roosevelt began increasing during the second half of April as a result of warm temperatures. The Initial Control Flow (ICF) was declared on April 25, initiating system refill, and Lake Roosevelt began a controlled refill. The lowest elevation achieved was 1227.4 feet on April 24, 2012. Drum gate maintenance at Grand Coulee Dam was performed in 2012 as a result of the high water year and the lower Lake Roosevelt elevations. Grand Coulee Dam was operated throughout the month of May and June for system flood control operations, and Lake Roosevelt was slowly filled throughout the May/June period. To demonstrate that water was released from Grand Coulee Dam during the spring under the Lake Roosevelt Incremental Storage Release Program, Lake Roosevelt targeted a refill elevation of 1289.8 feet following a recommendation from the Fish Flow Releases Advisory Group (FFRAG). Lake Roosevelt achieved elevation 1289.8 feet on July 8, 2012.

During the spring/summer of 2012, Grand Coulee Dam was operated to minimize TDG production to the extent practicable. In April some spill was required from Grand Coulee Dam in order to draft Lake Roosevelt toward the April 30 flood control elevation. Daily average spill during the month of April averaged 4.0 kcfs, and there were no instances when the daily average TDG (as measured six miles downstream from Grand Coulee Dam) exceeded 120 percent. All spill during the month of April was through the outlet tubes. During the month of May only minor amounts of spill (<10 kcfs) were required during the first week of the month to control the rate of refill. TDG coming across the Canadian border averaged 125 percent during May. TDG in the forebay of Grand Coulee Dam averaged 116 percent, and the average TDG below Grand Coulee Dam was 114 percent. There was one day during May when the daily average TDG below Grand Coulee Dam exceeded 120 percent (121 percent on May 3). Larger amounts of spill were required during the second half of June 2012 to manage the refill of Lake Roosevelt, but the spill during June was over the drum gates, which produces less TDG when compared to outlet tube spill. Daily average spill was 48 kcfs during the last 10 days of June, and daily average TDG below Grand Coulee Dam during this period was 118 percent. TDG at the Canadian border was very high during June and averaged 129 percent during the last 10 days of the month. There were five days during June when TDG below Grand Coulee Dam exceeded 120 percent with the highest day averaging 122 percent. Due to high inflows, Grand Coulee Dam was required to spill throughout most of July. However, all spill was over the drum gates, and TDG below Grand Coulee Dam remained below 120 percent through July even though TDG coming across the Canadian border remained high (averaging 123 percent for July).

Stream flows and inflows into Grand Coulee remained relatively high through July and Lake Roosevelt remained above elevation 1288 feet throughout the month. Lake Roosevelt drafted during August 2012 to support the summer flow augmentation program and was at elevation 1279.5 feet on August 31, 2012. Based on the July final WSF at The Dalles, the summer draft limit for Grand Coulee Dam was 1280 feet. The draft limit was modified an additional 0.3 feet to elevation 1279.7 feet to implement the Lake Roosevelt Incremental Storage Release Program. Pumping was reduced to Banks Lake during August, and Banks Lake reached an elevation of 1565.1 feet on August 31.

Hungry Horse Dam Operations 2008-2012 Overview

Table 8 and 9 summarize Hungry Horse Dam inflow forecasts and operations, respectively for 2008-2012. Hungry Horse Dam was successfully operated to meet the FCRPS BiOp objectives during the 2008-2012 period. A summary of 2012 operations follows Table 9.

Table 8. Summary of May-September WSF Volume Inflow Forecasts at The Hungry Horse Dam. Percentages are percentage of average forecast for the period 1971-2000.

Forecast Release Date	2008[2]	2009	2010	2011	2012
January Final	1840 kaf (100.3%)	1809 kaf (98.6%)	1654 kaf (90.1%)	1944 kaf (105.9%)	1691 kaf (92.2%)
February Final	1858 kaf (101.3%)	1864 kaf (101.6%)	1429 kaf (77.9%)	2139 kaf (116.6%)	1781 kaf (97.1%)
March Final	1877 kaf (102.3%)	1697 kaf (92.5%)	1284 kaf (70.0%)	2222 kaf (121.1%)	1739 kaf (94.8%)
April Final	1912 kaf (104.2%)	1816 kaf (99.0%)	1305 kaf (71.1%)	2357 kaf (128.4%)	1906 kaf (103.9%)
May Final	2131 kaf (116.1%)	1816 kaf (99.0%)	1345 kaf (73.3%)	2798 kaf (152.5%)	1680 kaf (91.6%)
Actual Runoff	2408 kaf (131.2%)	1589 kaf (86.6 %)	1606 kaf (87.5%)	3213 kaf (175.1%)	2095 kaf (114.2%)

Table 9 summarizes Hungry Horse Dam operations for 2008-2011. Hungry Horse Dam was successfully operated to meet the FCRPS BiOp objectives during the 2008-2012 period. A summary of the 2012 operations follows Table 9. Real-time operations follow RPA Action 4 specifications as adjusted in-season with the help of the inter-agency TMT, an oversight group consisting of regional hydrologists and salmon biologists.

[2] *Biop was issued in May 2008 and RODs were signed in September 2008. Prior to that date operations were under the 2004 BiOp.*

Table 9. RPA Action 4 – Hungry Horse Dam Bullets.

Operation	2008[3]	2009	2010	2011	2012
Follow VARQ flood control procedures	Minimum flows governed operations all winter until mid- April when started draft for VARQ flood control requirements were initiated. Followed VARQ flood control procedures during refill.	Minimum flows governed operations all winter until mid-April when started draft for VARQ flood control requirements. Followed VARQ flood control procedures during refill.	Minimum flows governed operations all winter until refill. Followed VARQ flood control procedures during refill.	Minimum flows governed operations in the fall until early January when the reservoir began drafting to meet VARQ flood control. Followed VARQ flood control procedures during refill.	Minimum flows governed operations in the fall until late March when the reservoir began drafting to meet VARQ flood control. Hungry Horse followed VARQ flood control procedures during refill.
Maintain minimum flows all year for bull trout with a sliding scale based on the forecast. Operate to meet minimum flows of 3200-3500 cfs at Columbia Falls on the mainstem Flathead River and 400-900 cfs in the South Fork Flathead River.	Met or exceeded minimum flows.	Met or exceeded minimum flows.	Met or exceeded minimum flows	Met or exceeded minimum flows.	Met or exceeded minimum flows.
When not operating to minimum flows, operate to achieve 75 percent probability of reaching URC elevation by about April 10.	April 10 objective was elevation 3528.3 feet. Operating to minimum flows drafted reservoir Hungry Horse to elevation 3504.7 feet on April 10.	April 10 objective was elevation 3538.4 feet. Operating to minimum flows drafted Hungry Horse reservoir to elevation 3508.8 feet on April 10.	April 10 objective was elevation 3554.4 feet. Operating to minimum flows drafted Hungry Horse reservoir to elevation 3521.4 feet on April 10.	April 10 objective was elevation 3497.7 feet based on the March forecast. Significant increase between the March and April forecast required significantly deeper draft to meet April 30 flood control. Reservoir drafted to elevation 3493 feet on April 10.	April 10 objective was elevation 3536.1 feet based on the March forecast. Significant increase between the March and April forecast required significantly deeper draft to meet April 30 flood control. Reservoir drafted to elevation 3526.4 feet on April 10.
Refill by about June 30 each year (exact date to be determined during in-season management[4]).	Hungry Horse reservoir refilled on July 12 – elevation 3559 feet.	Hungry Horse reservoir refilled on July 19 – elevation	Hungry Horse reservoir refilled on July 1 –elevation	Hungry Horse reservoir refilled on August 3 – elevation	Hungry Horse Reservoir filled to 3560.4 feet on June

[3] *Biop was issued in May 2008 and RODs were signed in September 2008. Prior to that date operations were under the 2004 BiOp.*

Operation	2008[3]	2009	2010	2011	2012
		3559.1 feet.	3559.8 feet.	3559.2 feet.	26. This is a surcharge of 0.4 feet
Experimental draft during July-September to a draft limit of elevation 3550 feet (10 feet from full) by September 30, except in the driest 20 percentile of water conditions limit draft to elevation 3540 feet (20 feet from full) when needed to meet lower Columbia River flow augmentation objectives. If project fails to refill 20 feet from full, release inflows or operate to meet minimum flows through the summer months. Rational for the experimental draft was adopted by the NPPC.	Regulated to meet the rollover operations based on the 2004 NOAA Fisheries BiOp requirement to draft to elevation 3540 feet by August 31. Coordination through TMT based on SOR from Montana to prevent a double peak, if inflows were higher than forecasted, resulted in a drafted to elevation 3541 feet by August 31.	Drafted to elevation 3549.7 feet by Sept 30.	Drafted to elevation 3540.4 feet by September 30.	Drafted to elevation 3550.3 feet by September 30.	Drafted to elevation 3549.2 feet by September 30.
Provide even or gradually-declining flows during summer months (minimize double peak).	Gradually declining flows during summer months.	Gradually declining flows during summer months.	Natural flows declined sharply in early July but able to maintain gradually declining flows during remainder of the summer months.	Natural flows declined sharply in early July but able to maintain gradually declining flows during remainder of the summer months.	
Limit spill to maximum of 15 percent of outflow to avoid exceeding Montana state TDG standards of 110 percent to the extent possible.	No Spill.	No Spill.	No Spill.	Hungry Horse Dam spilled from April 4 - 21 to draft reservoir for flood control. Exceeded the 15 percent spill from April 7 thru 20, maximum spill was 20 percent of total outflow. Exceeded MT state standards April 8-21, maximum TDG 112	Hungry Horse Dam spilled through most of June and part of July. TDG levels exceeded the state of Montana standard of110 percent for 16 days in late June and early July and exceeded 115 percent for four days.

[4] Refill after June 30 is influenced by inflows. If inflows are too high don't want to fill too soon due to risk of spill. If inflows are low don't want to drop outflows to fill only to increase later to summer augmentation flows (double peak).

Operation	2008[3]	2009	2010	2011	2012
				percent.	
Limit outflow fluctuations by operating to ramping rates set in 2000 USFWS BiOp to avoid stranding bull trout.	Followed ramping rates set by the 2000 USFWS BiOp.	Followed ramping rates set by the 2000 USFWS BiOp.	Followed ramping rates set by the 2000 USFWS BiOp.	Followed ramping rates set by the 2000 USFWS BiOp.	Followed ramping rates set by the 2000 USFWS BiOp.

Reference the previous FCRPS Annual Progress Reports (APR) for more detail.

Hungry Horse Dam

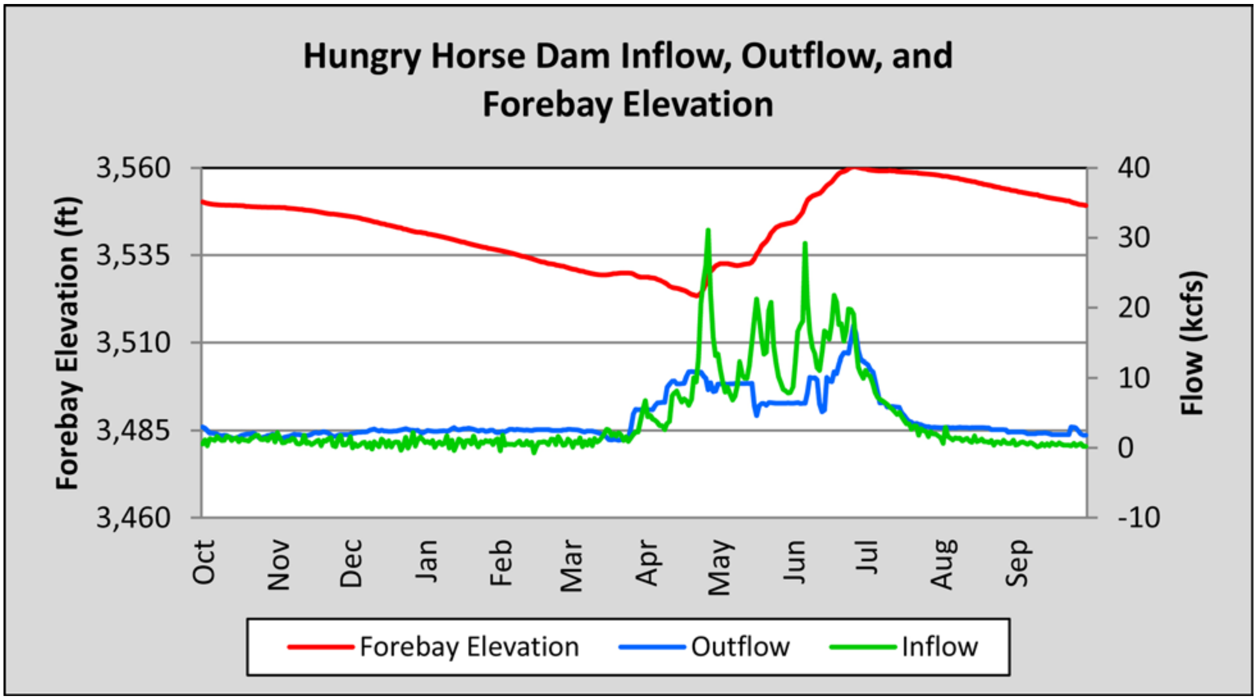


Figure 4. Hungry Horse Dam Inflow, Outflow, and Forebay Elevation from October 1, 2011, through September 30, 2012.

Hungry Horse Dam was operated through the fall 2011 and throughout 2012 to maintain the minimum flow requirements in the Flathead River at Columbia Falls and in the South Fork Flathead River below Hungry Horse Dam. Minimum flows were 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 2011 to December 2012 are listed in Table 10. Minimum flows during the fall 2011 were based on the WSF from March 2011. The minimum flows for 2012 were based on the WSF for January through March, with the March 2012 WSF setting the minimum flows from March 2012 through December 2012.

Table 10. Minimum Flow Requirements from October 2011-December 2012.

Period	Hungry Horse Dam Minimum Flow (cfs)	Columbia Falls Minimum Flow (cfs)
October 2011-December 2011	900	3500
January 2012	900	3500
February 2012	900	3500
March 2012-December 2012	900	3500

Hungry Horse Dam operations in 2012, followed VARQ flood control procedures. In 2012 the WSF for Hungry Horse Dam inflow (May-September period) was at 92 percent of average in January 2012, 97 percent of average in February, 95 percent of average in March, and 104 percent of average in April. The large increase in the WSF from March to April resulted in a significant decrease in the April 30 flood control elevation, from elevation 3533.3 feet based on the March forecast, to 3521.7 feet based on the April forecast. Hungry Horse Dam discharges during the month of April were increased from 6.0 kcfs during the first half of the month to 10.8 kcfs during the second half of April due to rising inflows and to draft toward the April 30 flood control target. The ICF was declared on April 25 which initiated system refill, and Hungry Horse Dam was at the lowest elevation of the season on April 22 at elevation

3523.4 feet. Hungry Horse Dam continued a slow refill during May with discharges of 9.2 kcfs during the first half of May. Discharges were decreased to 6.4 kcfs during the last half of May and early June due to forced unit outages, but discharges were calculated to be within the range required to manage refill given the current inflow forecast. However, record June precipitation in northwest Montana, including the Flathead River Basin, resulted in large inflows to Hungry Horse Dam and high stream flows in the Flathead River Basin. The actual Hungry Horse Dam inflow volume during the spring runoff period (April-July) was higher than forecast at 129 percent of average due to the heavy precipitation in June. Hungry Horse Dam discharges were increased to 17 kcfs (which included 8.0 kcfs of spill) in late June to manage the rapid refill. Hungry Horse Dam reached a maximum pool elevation of 3560.4 feet (0.4 feet over full pool) on June 26, and the maximum discharge was 17.7 kcfs on the same day. Hungry Horse Dam discharges were slowly decreased during late June and early July as inflows began to recede. Unit availability, transmission limitations, and high required discharges resulted in spill during most of June. Spill from Hungry Horse Dam reached a maximum of 8.0 kcfs during late June, with resultant TDG achieving a maximum of 117 percent on June 26. TDG in the South Fork Flathead River exceeded 110 percent for 16 days during late June/early July and exceeded 115 percent for four days.

As the WSF for 2012 was not in the lowest 20th percentile, draft for flow augmentation was limited to 10 feet. Hungry Horse Dam targeted a September 30, 2012, elevation of 3550 feet. Hungry Horse Dam's actual elevation was 3549.2 feet on September 30. Hungry Horse Dam was operated to provide a stable/gradual declining flow during the summer flow augmentation period with an average flow from August through September 2012 of 2.5 kcfs. In 2012, changes in Hungry Horse Dam discharges followed ramping rates as prescribed in the 2000 BiOp (FWS, 2000).

Albeni Falls Dam Operations 2008-2012 Overview

Table 11 summarizes Albeni Falls Dam operations for 2008-2012. Albeni Falls Dam was successfully operated to meet the FCRPS BiOp objectives during the 2008-2012 period. A summary of the 2012 operations follows Table 11. Real-time operations follow RPA Action 4 specifications as adjusted in-season with the help of the inter-agency TMT.

Table 11. RPA Action 4 – Albeni Falls Dam Bullets.

Albeni Falls Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Operate to standard flood control criteria.	The project was operated to standard flood control criteria. Lake elevations were maintained between 2055 and 2056 feet from January through April. Refill of Lake Pend Oreille began May 1, and the lake reached its target summer elevation of 2062.25 feet in early July.	The project was operated to standard flood control criteria. Lake Pend Oreille was operated between elevations 2051 and 2052 feet from January through early April. Refill of Lake Pend Oreille began April 7. The lake reached its target elevation 2062.25 feet by June 27, operating between 2,062 and 2,062.5 feet through September 15.	The project was operated to standard flood control criteria. The winter elevation target of 2,051 feet was reached on November 4, and operated in the winter elevation range of 2,051.0 to 2,052.0 feet until refill began on April 1. The lake reached its normal summer operating range of 2,062.0 to 2,062.5 feet on June 25, maintaining that range through early September.	The project was operated to standard flood control criteria. Due to a high WSF (145 percent of average for April–August), the project operated within the winter elevation range (2055-2056 feet) into May. The project then operated on freeflow from May through July 8. Peak elevation at the Hope gauge was 2064.3 feet, or 1.8 feet above full pool on July 17. Outflows exceeded 100 kcfs from June 7 through July 8, with minor flood damages reported downstream. Normal summer operations at the elevation 2062.0 to 2062.5 feet level began after July 8.	The project was operated to standard flood control criteria. The project operated on freeflow from late April through May because of high inflow. High inflows persisted into June, as a result of abnormally wet weather. The peak project outflow for the year of 95.6 kcfs occurred on June 27. The project reached its normal summer range by the end of June.
Operate to provide Lake Pend Oreille shoreline spawning conditions for kokanee (winter pool levels of 2055 feet or 2051 feet elevation) determined through interagency coordination per USFWS BiOp of 2000.	Lake Pend Oreille drafted to the minimum control elevation (MCE) of 2,051 feet by November. The lake was operated between elevation 2,051 and 2,051.5 feet until the Idaho Department of Fish and Game (IDFG) declared the end of spawning on December 24.	The lake was drafted to the MCE of 2,051 feet by early November. The lake was operated through December between elevation 2,051 and 2,051.5 feet until IDFG declared the end of spawning on December 31.	Lake Pend Oreille was drafted to the MCE of 2055 feet by November 7, 2010. The project operated between elevation 2055.0 and 2055.5 feet until spawning was declared complete by IDFG on December 17.	Lake Pend Oreille was drafted to the MCE of 2051.0 feet by November 6. The project operated between elevation 2051.0 and 2051.5 feet until spawning was declared complete by IDFG on December 16.	Lake Pend Oreille was drafted to the MCE of 2055.0 feet by November 8. The project operated between elevation 2055.0 and 2055.5 feet until spawning was declared complete by IDFG on December 21.

Albeni Falls Dam					
Operation	**2008**	**2009**	**2010**	**2011**	**2012**
Interagency coordination of winter pool levels for kokanee in consideration of spawning and incubation needs for lower Columbia River chum salmon.	Maintaining Bonneville Dam tailwater at elevation needed for lower Columbia River chum salmon spawning and incubation was taken into account in interagency coordination of winter pool levels in Lake Pend Oreille.	Maintaining Bonneville Dam tailwater at elevation needed for lower Columbia River chum salmon spawning and incubation was taken into account in interagency coordination of winter pool levels in Lake Pend Oreille.	Maintaining Bonneville Dam tailwater at elevation needed for lower Columbia River chum salmon spawning and incubation was taken into account in interagency coordination of winter pool levels in Lake Pend Oreille.	Maintaining Bonneville Dam tailwater at elevation needed for lower Columbia River chum salmon spawning and incubation was taken into account in interagency coordination of winter pool levels in Lake Pend Oreille.	Maintaining Bonneville Dam tailwater at elevation needed for lower Columbia River chum salmon spawning and incubation was taken into account in interagency coordination of winter pool levels in Lake Pend Oreille.

Reference the previous FCRPS Annual Progress Reports (APR) for more detail.

Albeni Falls Dam – 2012 Operations

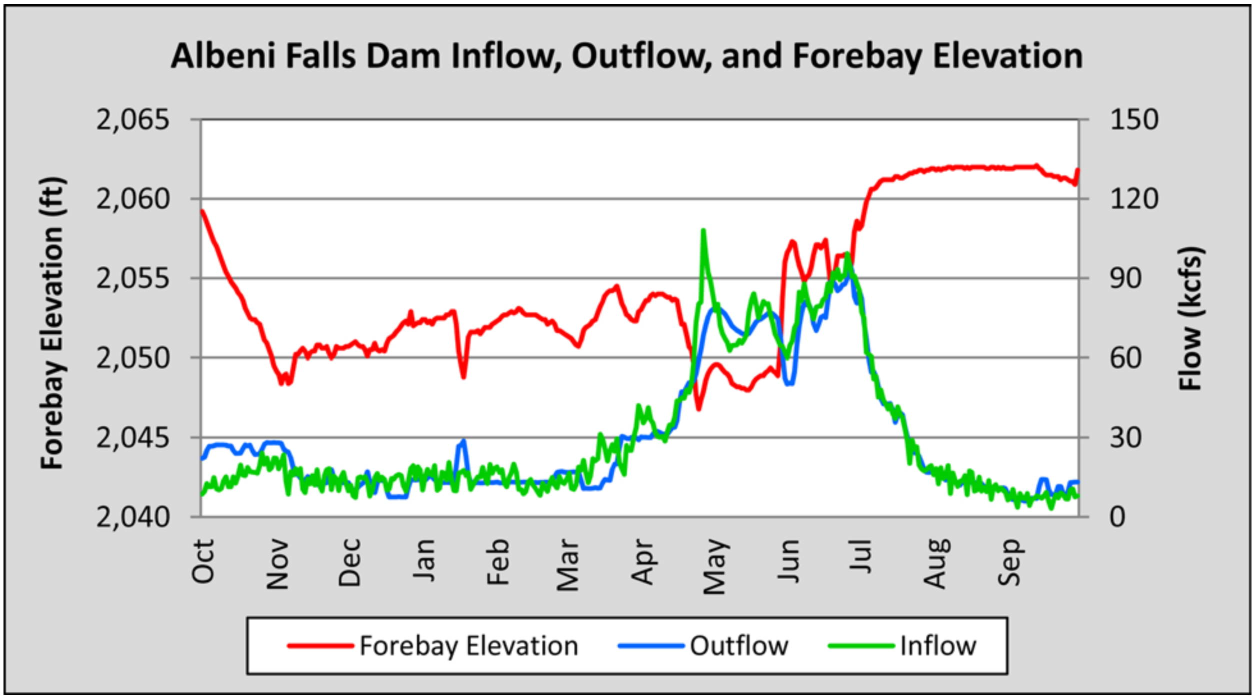


Figure 5. Albeni Falls Dam Inflow, Outflow, and Forebay Elevation from October 1, 2011, through September 30, 2012.

The project began releasing water in mid-September 2011 to draft Lake Pend Oreille from full pool to elevation 2051 feet (all elevations as measured at the Hope gauge). Elevation 2051 feet was established as the winter minimum control elevation (MCE) target through interagency discussions and was recommended by TMT. The winter range was to be reached no later than November 8, if inflow conditions allowed. The Corps initiated an aggressive draft and achieved the MCE target on November 6. The project then operated in a winter lake elevation range of 2051.0 – 2051.5 feet for winter kokanee spawning through December 16, 2011, when Idaho Department of Fish and Game (IDFG) declared kokanee spawning season complete. As shown in Figure 5, from December 17, 2011, through March 2012, the project operated in a five-foot band from elevation 2051.0 to 2056.0 feet (the latter being top of flood control). The pool was operated in consideration of power system flexibility within that range with no more than a 0.5 foot change in pool elevation per day. During the winter and spring, the project operated to standard flood control criteria.

For most of April, Albeni Falls Dam operated between elevation 2055 and 2056 feet. During the last week of April, project outflow became limited by the downstream channel constriction. On April 25, spillway gates were opened and the project transitioned to free flow operation with inflow of 80.1 kcfs, outflow of 59.1 kcfs, and elevation 2056.3 feet. During the remainder of April and most of May, Albeni Falls Dam operated on free flow with project elevations ranging between 2057.4 and 2059.3 feet. Peak inflow for the year occurred on April 27 with a day average of 108 kcfs. On May 29, spillway gates were lowered, taking the project off free flow and restoring partial flow through the powerhouse. The end of May elevation was 2058.7 feet.

The project initially operated to reach the full summer lake elevation of 2062.0 to 2062.5 feet by mid-June. Due to unseasonable early-and mid-June precipitation in the Pend Oreille Basin, outflows were again increased to maintain flood storage space and delay filling until the end of June. Record heavy precipitation continued into late June, with peak daily inflow of 99.3 kcfs occurring on June 26. Peak outflow of 95.6 kcfs for June and for the year occurred on June 27. Albeni Falls Dam filled to elevation

2062.0 feet on June 26. At the end of June the elevation was 2062.4 feet. On July 2, the project transitioned to a pass inflow and operated the pool in the summer operating range of elevation 2062.0 to 2062.5 feet.

The pool was kept within the summer operating range until mid-September, dropping below elevation 2062.0 feet on September 16, with the fall drawdown beginning on September 14. The TMT coordinated and requested MCE for the fall at elevation 2055 feet pursuant to System Operational Request (SOR) *USFWS/IDFG-2012*-1. There were multiple unit outages during September due to necessary, planned switchyard and unit maintenance work. As of October 3, all three units were operational with outflow at 20 kcfs. The Corps initiated an aggressive draft to compensate for the flow limitations due to September outages and to continue to meet the fall target elevation. The lake reached the target elevation of 2055 feet on November 3, 2012.

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 annual WMPs included operations for these run-of-river projects. The projects were operated consistent with the WMP with any in-season adjustments made in coordination with the TMT as provided for in RPA Action 6. Table 12 summarizes RPA Action 5 operations for 2008–2012 including in-season adjustments made. In each year, the WMP called for operating the four lower Snake River projects (Ice Harbor [IHR], Lower Monumental [LMN], Little Goose [LGS], and Lower Granite [LWG] dams) at their Minimum Operating Pool (MOP) and John Day [JDA] at its Minimum Irrigation Pool (MIP) The other lower Columbia River projects, Bonneville [BON], The Dalles [TDA] and McNary [MCN]) were operated as run of river within their normal prescribed operating ranges.

Table 12. RPA Action 5, 2008 – 2011 Overview.

Operation	2008	2009	2010	2011	2012
Operate lower Snake projects at MOP, with a 1-ft operating range unless adjusted to meet authorized project purposes, from April 03 until small numbers of juvenile migrants are present (approximately September 1).	IHR, LMN, LGS, and LWG operated within MOP from April 3 – September 10. Some pools exceed MOP by a few tenths of a foot for a few hours for a variety of operational authorized purposes. LGS had more occurrences slightly above MOP, namely to support safe navigation.	IHR, LMN, LGS, and LWG operated within MOP from April 7 – September 3, in full coordination with regional forums. In a few instances, pool levels went outside of MOP criteria for a short time due to navigation safety issues, primarily for passage of fish barges.	The planned operations at LMN, IHR, LGS, and LWG projects were to operate at MOP from April 3 through August 31. As total river flow decreased in July and August, the IHR pool elevation was increased on Jul 16 to 0.5 foot above MOP to provide minimum clearance over the LMN downstream navigation lock entrance sill for navigation. The same operation was implemented on August 5, when the LGS pool elevation was increased 0.5 foot above MOP to provide minimum clearance over the downstream LWG navigation lock entrance sill. These operations were coordinated with the TMT.	At IHR, LMN, LGS, and LWG the plan was to operate at MOP from April 3 through August 31. On March 23 the Action Agencies received SOR 2011-01 from the Columbia River Towboat Association, requesting a variable MOP + 2 operation on the LWG pool to aid safe navigation due to sediment in the Federal Navigation Channel. After coordination with TMT the Action Agencies implemented a variable MOP +2 operation, which was flow dependent and minimized duration of exceeding MOP. Late in August, due to low flows and navigation concerns, IHR operated slightly above MOP during some hours.	In 2012 a staggered beginning of MOP operation was coordinated through TMT. MOP operations were to begin on April 3 at LGS and LWG, April 04 at LMN and April 05 at IHR. Mop operations would run through August 31. As in 2011, to accommodate safe navigation, a variable MOP +2 operation was conducted at LWG in coordination with TMT. Due to dropping summer flows and not meeting navigation lock sill depths, LGS pool was shifted to a MOP 0.5 feet operation (elevation 633.5 – 634.5 feet) on July 28 for the remainder of the season.

Operation	2008	2009	2010	2011	2012
Except for John Day, operate the lower Columbia River projects in their normal operating range. John Day reservoir will be operated at the lowest elevation (262.5 – 264.0 ft, also called the Minimum Irrigation Pool or MIP) (with a 1.5 ft operating range) from April 10 through September 30 that continues to allow irrigation withdrawals for that period. Slight deviations from these levels may be required on occasion to accomplish other operational requirements.	JDA was operated between elevations 262.5 – 264.0 feet from April 10 – September 30. In 2008, the Columbia River had an average water year. The average spring flow objectives were achieved for MCN and PRD. The average spring flow for LWG and the average summer flows for both LWG and MCN were below the flow objectives.	JDA was operated between elevations 262.5 – 264.0 feet from April 10 – September 30. In 2009, the Columbia River had a below average water year (84 percent of avg. at TDA). The average spring flow objectives were achieved for MCN, LWG, and PRD. The average summer flows for both LWG and MCN were below the flow objectives.	JDA was operated between elevations 262.5 – 264.0 feet from April 10 – September 30. In 2010, the Columbia River had a below average water year (80 percent of avg. at TDA). The average spring flow objective was achieved at PRD. The average spring and summer flows for both LWG and MCN were below the flow objectives.	In 2011, the Columbia River had a well-above average water year (133 percent of average at TDA). Due to high spring flows and need to store into John Day reservoir for authorized flood damage reduction purposes, the top of the MIP range (elevation 264.0 feet) was exceeded during May 16–19, with the highest recorded reading of elevation 265.0 feet. For similar reasons, during June, for a limited number of occasional hours, the JDA pool was operated at the top of the MIP range. In 2011, all the spring and summer flow objectives were met due to the high volume water year.	In 2012, the Columbia River had a well-above average water year (121 percent of average at TDA). All spring flow objectives were met. The MCN summer flow objective was also met. Due to drier Snake River flows, the summer flow for LWG was below the flow objective. Due to the high water year, as in 2011, JDA pool was operated above MIP up to and hourly max of elevation 266.1 feet for a portion of April 24 – 27 for purposes of flood damage reduction.

The 2012 WMP included operations for these run-of-river projects. The projects were operated consistent with the WMP and the March 9, 2012, Fish Operations Plan (FOP) as adopted by court order to guide spill operations for juvenile fish passage and to also minimize water travel time through the lower Columbia and Snake rivers to aid in juvenile fish passage and water temperature management. Although not included in this RPA, surface passage improvements put in place at the dams under RPA strategy 2 combined with spill for fish passage provided pursuant to RPA Action 29 also contribute to improved travel time for fish by reducing passage delay at individual dams.

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 "2012 Year End Review Session" (TMT, 2012). Through a special conference call on March 29, 2012, TMT members were polled and agreed to staggering implementation of MOP operations at the Lower Monumental, Ice Harbor, Little Goose, and Lower Granite projects. BPA proposed a plan to begin operation using a staggered approach to offset surplus flows on the lower Snake River that were causing over-generation conditions. Initiation of MOP ranges were to begin no later than midnight on April 3, 2012, for Lower Granite and Little Goose dams, no later than midnight April 4, 2012, for Lower Monumental Dam, and no later than midnight April 5, 2012, for Ice Harbor Dam. MOP operations would end at midnight August 31, 2012, for all four projects. The Corps also continued the variable MOP-plus-2 operation for the Lower Granite pool in 2012. The Action Agencies implemented the Lower Granite Dam variable MOP operation throughout the 2011 fish passage season from April 3 to August 31. The variable MOP-plus-2 operation is based on SOR 2011-01 from the Columbia River Towboat Association. The goal of variable MOP-plus-2 is to provide safe navigation conditions in the pool, which had been compromised due to sedimentation in the Federal Navigation Channel. The MOP-plus-2 operation minimizes the duration that Lower Granite Dam must be operated outside of the MOP. Due to dropping summer flows and not meeting navigation lock sill depths, the Little Goose pool was shifted to a MOP 0.5 feet operation (633.5 – 634.5 feet) on July 28 for the remainder of the season.

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 6, 7, and 8 show the observed outflow at McNary, Lower Granite, and Priest Rapids dams relative to the flow objectives.

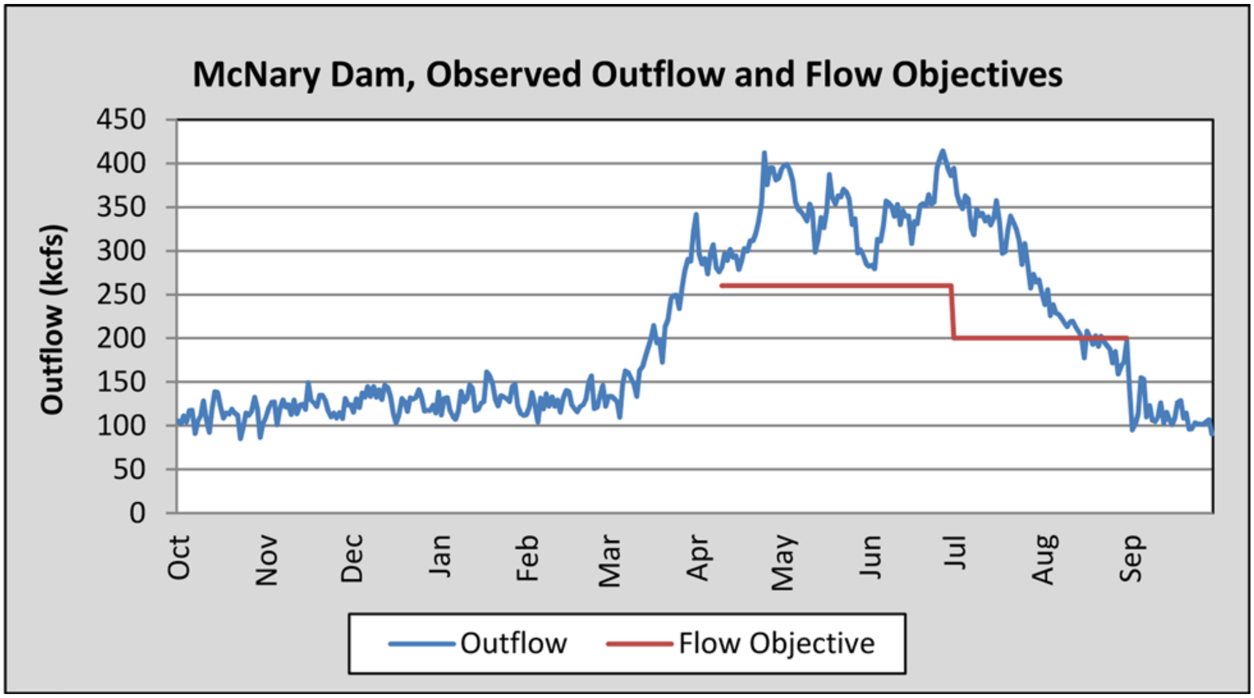


Figure 6. McNary Dam, Observed Outflow and Flow Objectives. April 10, 2012, to June 30, 2012, actual mean flow 342.4 kcfs, flow objective 260.0 kcfs. July 01, 2011, to August 31, 2012, actual mean flow 265.2 kcfs, flow objective 200.0 kcfs. The flow objectives are not achievable in all water conditions; rather they are used for pre-season planning and in-season water management to guide decision making.

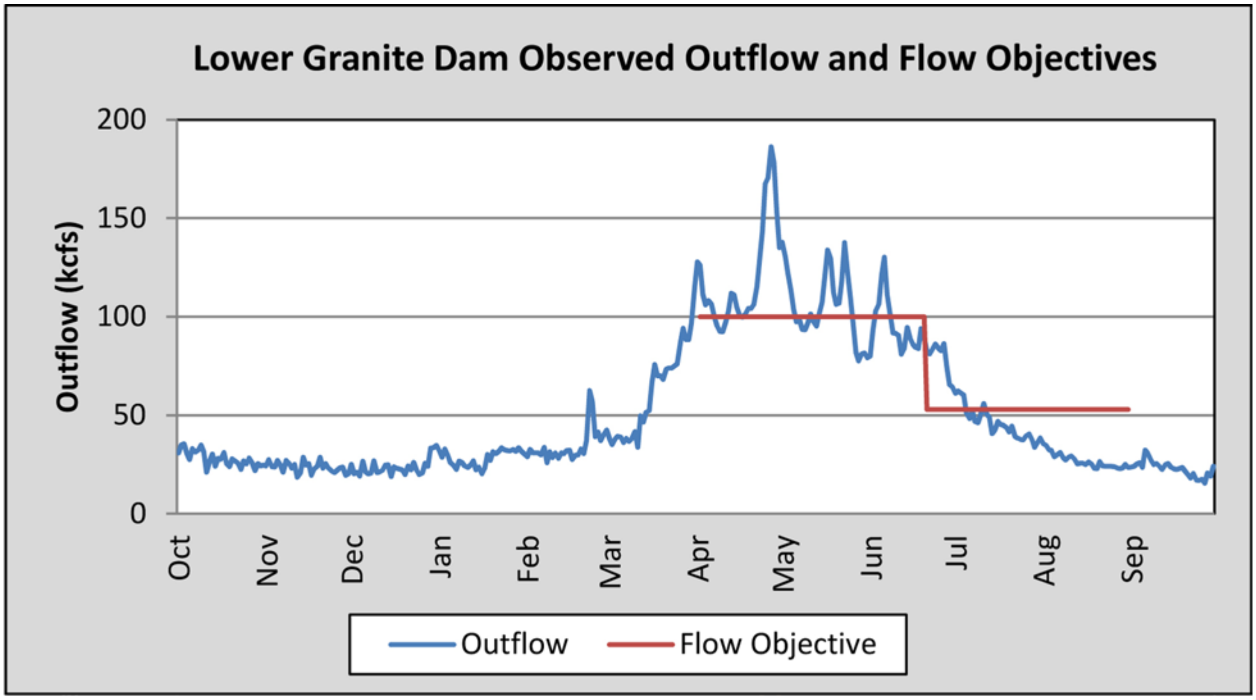


Figure 7. Lower Granite Dam, Observed Outflow and Flow Objectives. April 3, 2012, to June 30, 2012, actual mean flow 107.9 kcfs, flow objective 100.0 kcfs. June 21, 2011, to August 31, 2011 actual mean flow 42.4 kcfs, flow objective 52.9 kcfs. The flow objectives are not achievable in all water conditions; rather, they are used for pre-season planning and in-season water management to guide decision making.

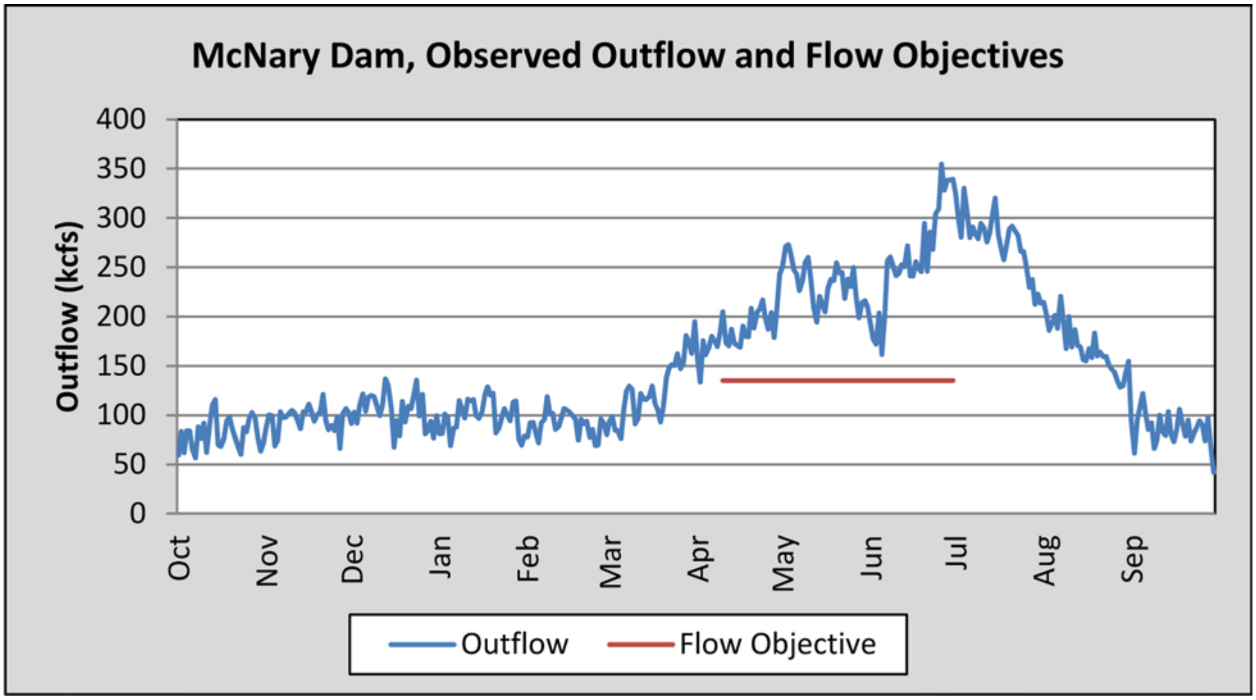


Figure 8. Priest Rapids Dam, Observed Outflow and Flow Objectives. April 10, 2012, to June 30, 2012, actual mean flow 232.5 kcfs, flow objective 135.0 kcfs. The flow objectives are not achievable in all water conditions; rather, they are used for pre-season planning and in-season water management to guide decision making.

In 2012, the Columbia River had an above-average water year according to NWRFC. The January-to-July volume as measured at The Dalles Dam (129.4 Maf) was 121 percent of normal (107.3 Maf for period rankings 1960–2012). The Snake River 2012 volume was slightly above average. Runoff volume from April to July, as measured at Lower Granite Dam (22.7 Maf) was 105 percent of normal (21.6 Maf for period rankings 1960–2012). The WSF had a wide range of variability between December 2011 and July 2012. December 16 to March 25 NWRFC forecasts were characterized as below normal to normal (85–103 percent) water supply conditions. By April, forecasts increased significantly, and this resulted in April-to-July forecasts ranging from 105 to 122 percent of normal. Stream flows at The Dalles Dam throughout the 2012 fish passage season (April through August) were 108–151 percent above average.

Due to the high water year, as in 2011, the John Day pool was operated above elevation 264.0 feet, up to hourly maximum of elevation 266.1 feet for a portion of April 24 – 27 for purposes of flood damage reduction. For the rest of the season, April 10 to September 30, 2012, the pool was operated between elevation 262.5 feet and 264.0 feet.

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 2008-2012 water years (October 1 through September 30) were developed collaboratively with the Regional Forum Technical Management Team (TMT) in accordance NOAA Fisheries' FCRPS 2008 and 2010 Supplemental BiOp as appropriate.

The final WMP for 2012 was finalized and posted on the TMT website on December 31, 2011. Numerous seasonal updates were coordinated with the TMT in 2012 throughout the fall/winter and spring/summer time periods. A draft of the WMP for the 2013 water year was released on October 1, 2012. The final WMP for 2013 was posted on December 31, 2012.

Prior to 2011, the Action Agencies provided two seasonal updates to the WMP per water year in accordance with the RPA: a fall/winter and spring/summer update. In May 2010, the TMT decided that a more effective way to provide updates throughout the water year would be to provide an ongoing "living" WMP Seasonal Update document that would be updated and posted periodically throughout the water year as information on conditions and operations becomes available. The seasonal update includes a table of WMP sections, elements and operations with the date of the most recent update. The WMP seasonal update document will be posted a minimum of two times per water year in accordance with the RPA, with a goal of updating at a greater frequency as operations develop throughout the year. These changes to the updating mechanism to the WMP were coordinated with the TMT and implemented beginning in the 2011 water year.

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.*

In December 2008, the Action Agencies and Fish Accord partners formed the Columbia River Forecast Group (CRFG) to promote and support the advancement of forecasting skill, products, and techniques in the Columbia River Basin with the goal of improving reservoir operations for the benefit of the region. The CRFG provides an avenue for sharing, discussing, evaluating, and potentially implementing new forecasting techniques for the planning and operation of the FCRPS. The group's efforts focus on the four areas listed above with the goal of improving water supply and operational streamflow forecasting, hydrometeorological data quality and availability, and climate change analysis. Major Action Agency accomplishments in the climate change arena from 2008-2012 include the CRFG hosting several performance workshops and meetings to evaluate the performance of current and potential forecasting techniques. These meetings have improved the communication of ideas and challenges faced in forecasting for FCRPS operation in the region. In addition the CRFG has provided valuable input to the Action Agencies for example, CRFG input was considered in the Action Agencies' decision to return to using ESP-based WSFs with 3 days of forecast precipitation for 2013. In 2012, the Action Agencies used 10 days of precipitation data in developing ESP forecasts, but as discussed at the November 2012 CRFG meeting, the ability to forecast precipitation that far into the future is limited and as a result tended to react too quickly at times.

2012 CRFG Forecasting Performance Workshops and Meetings

The CRFG met in February, July, and November 2012. During the February meeting, the group reviewed current Columbia River Basin conditions and compared forecasts. At that point in the season, precipitation was below normal across the basin, even though a La Niña condition was initially expected to bring an elevated chance for above average precipitation. The meeting in July focused heavily on the rapid run-up in volume forecasts as the La Niña condition finally took hold, with near record precipitation in both March and June across the region. The CRFG participants all had similar issues in trying to keep up with the rapidly building snowpack so late in the winter, and managing the runoff once it commenced in combination with record rainfall in Canada. One notable finding from the CRFG meeting was that the use of ESP by the NWRFC tended to forecast the rapidly increasing runoff potential a little earlier than traditional, regression based, statistical forecasts.

At the July meeting, preliminary climate change research conducted by BPA and BC Hydro and Power Authority (BCHydro) was shared with the group and discussed. BPA's research mining the newly published 80-Year Modified Flows dataset was inconclusive in that correlation coefficients are low; there was little temporal or spatial continuity in the signals over the past 80 years. There were also no indications of increased fall runoff over that time, which many climate change modeling studies, including the one conducted by 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, predicts should be underway by the 2020s.

However, the research did suggest a slightly earlier shift in early spring runoff since the 1920s in the northern third of the basin and hints as to somewhat reduced flows in August above Arrow Dam in Canada. BCHydro's recent research, which focused on the available climate change models, were in line with the RMJOC study: the chance will increase for more fall and winter runoff, an earlier spring runoff, and less summer flows as regional temperatures increase over the next 40 years. They are also concerned about the loss of glaciers in the Canadian Rockies over the next 50 years, which are a key contributor to summer flows in the Canadian portion of the Columbia River Basin. BPA, Corps, Reclamation, and BCHydro continue to share and coordinate their ongoing climate change research, scoping activities, and action plans in case climate change impacts increase over the next few years across the region.

Two meetings were held in November, with the first being a field visit to the former site of Condit Dam on the White Salmon River in Washington State. The field visit was let by Bob Heineth, formerly of Columbia River Inter-Tribal Fish Commission (CRITFC), who has tracked the issues surrounding Condit Dam and its removal process for over 20 years. The decommissioning and removal process was conducted by dam owner Pacific-Corp, supported by the economics that it was a cheaper alternative than providing fish passage facilities as would be required under the terms of FERC relicensing.

A second business meeting of the CRFG was also conducted in November and served as the annual forecast review workshop. Various agency representatives presented a review of their runoff forecast performance for 2012, with discussion focused on precipitation and runoff trends that affected the forecasts. Consistency in results was noted amongst the forecasts. A common theme noted was the extreme precipitation that occurred in June over the northern portions of the region, particularly the basins of the upper Yakima, north Idaho, Flathead, and the Kootenai Basin of both Montana and Canada. Operations at Hungry Horse and Libby Dams were particularly challenged by the sudden increase in unprojected inflow, forcing extended flood control operations that were successful in preventing significant flooding downstream. There was a distinct gradient of June precipitation from north to south, and was actually less than 50 percent of average in the upper Snake River Basin. The forecast review concluded with several 2013 Pre-season forecasts. The COE showed a Nov. 1 forecast of Libby for April-Aug of 120 percent, with similar numbers reported by BC Hydro. Both agencies were concerned the forecasts were being artificially inflated due to very high precipitation in October that may not translate to higher spring runoff.

2008-2011 CRFG Forecasting Performance Workshops and Meetings

The CRFG hosted forecasting performance workshops in 2009, 2010, 2011, and 2012. These workshops were attended by numerous entities including the Natural Resources Conservation Service (NRCS), NWRFC, U.S. Geological Survey (USGS), Washington Department of Ecology (WDOE), NOAA Fisheries, CRITFC, BPA, Corps, Reclamation, Northwest Power and Conservation Council (NPCC), the Fish Passage Center (FPC), the NRCS, the NWRFC, and BC Hydro. Session topics ranged from new applications developed to utilize ESP to ongoing work evaluating glacial changes on future water supply. With climate change being part of the group's focus, several talks addressed work on developing climate change streamflow scenarios. Workshops also recapped annual water year forecast performance and procedures. Other presentations included updates on an effort to investigate potential sites for new snow pillow stations in Canada, updates on the potential benefits of performing mid-month forecasts at Hungry Horse and Dworshak reservoirs, updates to the Snotel network, updates on NWRFC forecast methods, and review of anomalous runoff and hydro operations. More information on these workshops is included in prior year Annual Progress Reports (APR).

Climate Change Study

The Action Agencies collaborated to adopt climate change and hydrology datasets for long-term planning activities in the Columbia River Basin. This collaboration was coordinated through the RMJOC. The Action Agencies coordinated with outside agencies including NOAA Fisheries, NPCC, and CRITFC to develop the work plan detailed in "Climate and Hydrology Datasets for Use in the RMJOC Agencies' Longer- Term Planning Studies, Parts I-IV" (Reclamation 2010, 2011a, b and c).

To develop climate change streamflow scenarios for the Columbia River Basin, the Action Agencies leveraged data being developed by the University of Washington's Climate Impacts Group (CIG). The Action Agencies reviewed scenarios produced by the CIG, which were based on a subset of the World Climate Research Programme's (WCRP) Coupled Model Intercomparison Project phase 3 (CMIP3) climate change models and emission scenarios produced as part of the Intergovernmental Panel on Climate Change 4th Assessment Report (AR4). CIG used temperature and precipitation data input from 10 global circulation models and two emissions scenarios to create hydrologic data sets of regulated and unregulated flows at 297 locations in the Columbia River Basin. A combination of 18 climate change projections (plus one historical simulation) were evaluated, including 12 "hybrid-delta" data sets of future runoff of the Columbia River that reflected 30-year periods centered around 2020 (six scenarios) and 2040 conditions (six additional scenarios).

The Action Agencies' four-part climate change reports were completed in 2011. Part I focused on the selection and adoption of future climate and hydrology data from the University of Washington's CIG, the evaluation of those data, and the development of the water-supply forecast to reflect future hydrologic and climate conditions. In Part II, Reclamation reported potential future climate change impacts on project operations in the Yakima, Deschutes and Snake River subbasins using the hydroclimate data generated in Part I as input to reservoir operations models. Part III, which was written by the Corps and BPA, focused on the impacts on flood control and hydropower, due to climate change. The Part IV Summary report provides a brief overview of the three technical reports and provides information on the next steps, which may involve monitoring, evaluation, and additional studies that expand on this work and work of others.

Study results are summarized in the *2011 APR* and available at *http://www.bpa.gov/power/pgf/HydrPNW.shtml*.

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.*

2008 – 2010: There were no operational emergencies in 2008, 2009, or 2010.

2011: In 2011 there were three operational emergencies, all occurring during the month of May. On May 19 at 0714 hours, the Corps switched to a Bonneville Dam Powerhouse 1 (PH1) priority. In accordance with the 2011 Fish Passage Plan (FPP), Powerhouse 2 (PH2) is the priority powerhouse this time of year, but excessive debris associated with high flows blocked 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 reinstalled screens and returned to PH2 operating priority on July 20. This operation was coordinated with the Fish Passage Operations and Maintenance (FPOM) Workgroup.

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 could not pass The Dalles Dam. On May 20, 2011, the Corps coordinated an unscheduled conference call with the TMT 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.

2012: There was one operational emergency during April 2012. On April 24, BPA declared a Transmission System Emergency at 1637 hours as a result of equipment failures. To maintain required transmission grid reliability, generation was re-dispatched to John Day Dam and The Dalles Dam. As a result, The Dalles Dam operated outside the required 1 percent best efficiency range for 37 minutes. BPA reported the emergency declaration and resulting excursion outside the 1 percent range at the TMT meeting on April 25. BPA also reported back to the TMT on May 2 with further details on the nature of the emergency, steps taken to attempt to avoid impacting fish protection measures, and the measures ultimately taken to maintain the transmission grid reliability. There was no spill variance that resulted from this situation since project spill was above the 120 percent TDG level due to high flow conditions. This operation was coordinated during the April 25 and May 2 TMT meetings.

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.*

2008: There was one fish emergency in May 2008. Starting May 16, 2008, high juvenile fish descaling was observed at the Bonneville Dam Powerhouse Two (PH2) smolt monitoring facility. Upon inspection of the juvenile bypass system (JBS), the project staff discovered a heavy accumulation of small sticks, leaves, and other detritus on vertical barrier screens (VBSs) in the system. The screens are designed to guide migrating juvenile fish to the JBS. Coinciding with these events was an increase in total river flows to above 300 kcfs and unusually high river debris levels. Sensors that normally would have alerted project operators to this problem were out of calibration. Additionally, project personnel were not able to keep up with screen cleaning because the turbine intake extension crane — a critical component for cleaning screens — was out of service. While project personnel focused efforts on cleaning the VBSs, excessive debris was accumulating on other system components, such as adult ladder water supply intakes. Regional coordination occurred with the TMT on May 21. Subsequently, the Corps, with support from all TMT members, elected to remove the JBS intake screens (submersible traveling screens, or STSs). With this operational adjustment, fish that would otherwise pass through the JBS passed instead through turbines.

This action avoided a potential VBS failure, eliminated fish exposure to plugged screens, allowed PH2 to operate at full capacity (thereby minimizing spill-generated total dissolved gas[TDG]), and allowed project personnel to maintain other critical fish passage system components (e.g., adult fish ladders). On May 27, Operations Division and the Bonneville Project assessed river flows and debris and determined that the conditions were not suitable to reinstall the STSs. The decision regarding when to reinstall screens was coordinated through the TMT regional forum. On May 28, the Corps updated the TMT on the situation and provided results from a modeling analysis of effects on juvenile salmon survival. The Corps used the COMPASS model to compare the difference in overall dam passage survival of yearling Chinook salmon and steelhead when operating PH2 under the current debris conditions with STSs installed versus STSs removed, and estimated that the difference would be less than 0.1 percent. All screens were re-installed by June 18 and remained in place for the rest of the fish passage season, in accordance with the 2008 Fish Passage Plan (FPP), available online at *http://www.nwdwc.usace.army.mil/tmt/documents/fpp.*

2009: During 2009, there were two fish emergencies, one in May and one in July. On May 22 fish collection for routine transport at Lower Granite Dam was temporarily stopped due to excessive debris entering the collection system and clogging the incline dewatering screen. These conditions caused injury and mortality to fish present in the collection system (screens, raceways, and sampling tanks). In response, the project switched to primary bypass mode and transportation operations were stopped. NOAA Fisheries and TMT representatives were notified of the change in operations on May 22. Corps personnel calculate that a total of over 500,000 juvenile salmonids passed Lower Granite Dam on May 22, with a total of 721 juvenile fish mortalities associated with the debris conditions. These mortalities included 347 clipped yearling Chinook, 104 unclipped yearling Chinook, 60 clipped subyearling Chinook, 54 unclipped subyearling Chinook, 37 clipped steelhead, 9 unclipped steelhead, 23 clipped sockeye, 6 unclipped sockeye, and 81 coho. In addition, project personnel noted that an undetermined number of impacted fish exited the bypass system, increasing the overall total number of mortalities. The 721 known mortalities represent approximately 0.14 percent of the total number of juvenile fish estimated to have passed Lower Granite Dam on May 22. The Corps implemented the

TMT recommendation to increase spill up to the 120 percent total dissolved gas (TDG) cap to pass debris as quickly as possible and resume transportation. Fish collection for transport operations at Lower Granite Dam resumed on May 25 after debris levels subsided, with notification to TMT representatives on May 26.

Water temperatures at the McNary Dam Juvenile Fish Facility (JFF) increased rapidly on July 16-18, resulting in temperatures ranging from 64 degrees Fahrenheit in the gatewells to 71 degrees Fahrenheit in the bypass system. It is believed this relatively large temperature change, which continued until July 24, stressed fish passing through the system and contributed to elevated juvenile mortality. The average daily facility mortality rate between July 16 and July 22 was 8.8 percent, peaking at 17.1 percent on July 18 (11,101 fish mortalities occurred, of which an estimated 405 were listed Chinook). The north powerhouse turbine unit operating priority began on July 17 for temperature abatement as described in the FPP. The JFF switched to primary bypass on July 22 until July 23. In addition, on July 21, several regional fish managers submitted a SOR to the TMT requesting an increase in spill from 50 percent of project outflow to 24-hour spill to the gas cap to pass as many fish as possible via the spillway. As requested in the SOR and supported by TMT members, the Corps began gas cap spill at McNary Dam at 1300 hours on July 22, 2009. At 1300 hours on July 24, the Corps achieved all the criteria outlined in the SOR and resumed 50 percent spill. Fish transport operations changed from alternate-day departures to daily departures on July 24 and continued through August 16. This reduced fish holding times in the raceways. By July 24, fish mortalities returned to the normally observed low levels as a result of reduced temperature gradients and reduced fish holding times.

2010-2012: There were no fish emergencies in 2010, 2011, or 2012.

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.*

Year	1 Maf of Storage Provided	Agreement Start Date	Agreement End Date
2007-08	Yes	December 15, 2007	July 31, 2008
2008-09	Yes	December 15, 2008	July 31, 2009
2009-10	Yes	December 11, 2009	July 31, 2010
2010-11	Yes	December 11, 2010	July 31, 2011
2011-12	Yes	December 11, 2011	July 31, 2012

For each operating year listed above, the Columbia River Treaty Operating Committee executed an Agreement on Operation of Treaty Storage for Non-Power Uses. Under these agreements, BPA and the Corps were able to fill 1 Maf of Treaty storage space in Mica Reservoir by April 15. Treaty storage space was filled between December and February of these years (see 2008-2011 APRs for additional details). The Columbia River Treaty Operating Committee Agreement on Operation of Treaty Storage for Non- Power Uses for December 11, 2011, through July 31, 2012, was executed on November 30, 2011.

BPA and the Corps held meetings with federal agencies, states and tribes at least twice per year to discuss Treaty and non-Treaty storage (NTS) operating plans.

RPA Action 11 – Non-Treaty Storage: *BPA, in concert with BC Hydro, will refill the remaining non-Treaty storage space by June 30, 2011, as required under the 1990 non-Treaty storage agreement. Refill will be accomplished with minimal adverse impact to fisheries operations.*

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

RPA Action 12 – Non-Treaty Long-Term Agreement: *BPA will seek to negotiate a new long-term agreement on use of non-Treaty space in Canada so long as such an agreement provides both power and non-power benefits for BC Hydro, BPA, and Canadian and U.S. interests. As part of these negotiations, BPA will seek opportunities to provide benefits to ESA-listed fish, consistent with the Treaty. If a new long-term, non-Treaty agreement is not in place, or does not address flows for fisheries purposes, BPA will approach BC Hydro about possibly negotiating an annual/seasonal agreement to provide U.S. fisheries benefits, consistent with the Treaty.*

From 2008-2010, BPA entered into short-term agreements on use of non-Treaty space in Canada to provide spring and summer flow shaping to support fish operations.

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

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.*

BPA held meetings with federal agencies, states and tribes at least twice per year to solicit input for negotiations on annual agreements and a new long-term NTSA. BPA considered stakeholder feedback when preparing for discussions with BC Hydro. BPA also reported to stakeholders on progress of the negotiations with BC Hydro.

As explained in RPA Action 12, BPA entered into a new Columbia River NTSA with BC Hydro on April 10, 2012 (2012 NTSA). The 2012 NTSA allows for coordinated use of NTS in Canada to shape flows within the year for fisheries benefits, and provides up to an additional half Maf of water to benefit fish in the lowest water conditions.

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 Northwest River Forecast Center's (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:*

- *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.*
- *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.*
- *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.*
- *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.*
- *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.*
- *In very dry years, the Action Agencies will maximize transport for Snake River migrants in early spring, and will continue transport through May 31.*
- *BPA will implement, as appropriate, its Guide to Tools and Principles for a Dry Year Strategy to reduce the effect energy requirements may pose to fish.*

The FCRPS 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 71.8 Maf. For water years 2008-2012, only the 2010 water year met the FCRPS BiOp definition for a dry year because the May 2010 final forecast was 62 Maf. In dry water years there is insufficient water to meet all water management objectives. Many decisions were made, through in-season management, to prioritize annual operations in light of dry year conditions, including (but not limited to): 1) relaxing chum flows during March to reduce their impact on spring flows; 2) drafting Lake Roosevelt below its April 30 flood control elevation in May to maintain a TMT coordinated flow objective at Priest Rapids Dam of 125 kcfs-135 kcfs; 3) implementing low flow spill operations in accordance with the 2010 FOP and close coordination with TMT; 4) implementing a three-day pulse of flow was provided from Dworshak Dam in late May 2010 to aid the spring migration; and 5) implementing reservoir summer refill and flow augmentation drafts as much as possible as described in RPA Action 4 tables above. Due to abundant precipitation in the late spring, runoff conditions improved significantly in June 2010 and the actual April-August 2010 runoff volume at The Dalles Dam was 77 Maf, exceeding the dry year trigger.

The Action Agencies convened a technical workgroup, which scoped and initiated investigations of alternative dry water year flow strategies, to enhance flows in dry years for the benefit of ESA-listed Evolutionary Significant Units (ESU). From 2008 through 2012, the Dry Year Strategy Work Group met to analyze dry year operations and evaluate biological effects on fish species. Participants varied, but included the Action Agencies, NOAA Fisheries, the NPCC, CRITFC, the Colville Tribe, the Spokane Tribe, the Umatilla Tribe, and the states of Oregon, Montana, and Washington. The group's analysis contributed to the development of a dry water year provision of the new NTSA (see RPA Action 12), and is informing Treaty negotiations. See summary of actions described under RPA Actions 10-13 for more information on Canadian operations, Columbia River Treaty, and NTS operations.

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 Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers (ACOE, 2009a) provides the overall framework for addressing water quality measures needed to meet both the ESA and Clean Water Act (CWA) responsibilities. The 2009 plan was an update from the previous 2006 Water Quality Plan, and the current version is scheduled to be updated in 2013.

In 2008-2012, spill at the projects was managed consistent with the respective annual TDG Management Plans, and real-time monitoring was operated consistent with the Dissolved Gas Monitoring Plans of Action for 2008, for 2009 and for 2010-2014 (ACOE, 2008a, 2008b, 2008c).

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.* Historical values from 2008-2012 are also stored at this site.

Both the John Day Dam tailwater and the Bonneville Dam tailwater fixed monitoring stations suffered damage during the high-runoff flows in 2011. Although the stations were both replaced with new electronics enclosure boxes and moved to higher ground with new concrete foundations and cable conduits, the Bonneville Dam tailwater station was again damaged and replaced during high-runoff in 2012.

A summary of actions implemented to further develop fish passage strategies with less production of TDG in 2008-2011 are shown in Table 13, Fish Passage Strategies with Less Production of TDG.

The System Total Dissolved Gas (SYSTDG) model was used as a real-time decision support tool to manage spill at lower Columbia and Snake river projects. A statistical evaluation of the model is completed annually resulting in model improvements updating the TDG exchange equation to address structural and operational modifications for projects such as Grand Coulee, Chief Joseph, Dworshak, and McNary dams. The results of these analyses are included as Appendix G of the annual Total Dissolved Gas and Water Temperature Monitoring Report (ACOE, 2008d, ACOE 2009b, ACOE 2010, ACOE 2011, ACOE 2012, all available at http://www.nwd-wc.usace.army.mil/tmt/wqnew/).

The CE-QUAL-W2 model was used annually from late June through early September 2008-2012 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 and have been very effective at maintaining Lower Granite Dam tailwater temperatures at, or below, the 68 degree Fahrenheit threshold. In 2009-2010, the Corps made improvements in pre-processing data that resulted in more efficient model execution.

The Corps completed a CE-QUAL-W2 water temperature model for the Chief Joseph reservoir and awarded a contract to develop CE-QUAL-W2 temperature models for the lower Columbia River from Pasco, Washington, to the tailwater of Bonneville Dam, including McNary, John Day and The Dalles reservoirs. The CE-QUAL-W2 temperature models for the lower Columbia River reservoirs were completed in 2012.

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

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

During the fish migration season, all of the lower Snake River projects were operated at MOP as discussed in RPA Action 5 (with a 1-foot operating range) except for brief adjustments needed to meet authorized project purposes (e.g., navigation). All adjustments were coordinated with TMT.

Table 13. RPA Action 15 – Fish Passage Strategies with Less Production of TDG. The FCRPS BiOp was issued in May 2008 and ROD's were signed in September 2008. Prior to that date operations were under the 2004 BiOp.

Dam	2008	2009	2010	2011	2012
Chief Joseph Dam	Completed construction of flow deflectors on all 19 spillbays in October.	Conducted post construction spill test to evaluate TDG with completed flow deflectors.	Conducted post construction spill test to evaluate TDG with completed flow deflectors.	Operated Chief Joseph Dam to maximize flow deflectors capacity to strip TDG and manage systemwide TDG levels.	Draft post-construction spill test report completed.
Little Goose Dam		Installed spillway weir (SW) in spillbay 1 along with flow deflectors in spillbays 1 and 8 prior to start of juvenile fish migration season.			
Lower Monumental Dam	SW was put into service for 2008 fish passage season.				
Ice Harbor Dam	Ice Harbor Dam Study indicated that lower TDG loadings can be realized through optimizing spill volume and pattern with SW flows.				
John Day Dam	John Day Dam Decisional Analysis framework identified cost-effective surface flow routes such as the top-spill weir, tailrace improvement, and behavioral guidance through the spillway.	John Day Dam Spill Bay 20 flow deflector construction.	Completed construction of Spill Bay 20 flow deflector.		
The Dalles Dam	The Dalles Dam Study evaluated two spillwall locations to improve egress condition for fish passage with TDG minimization.	Construction of Spillwall between spillbays 8 & 9. (Construction completed in March).			

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.*

Yakima Consultation

Reclamation met with the NOAA Fisheries and U.S. Fish and Wildlife Services (Services) in early December to resume consultation. Two teams, a technical and a policy, made up of representatives of each of the agencies were assigned. These teams will meet monthly to develop a proposed action for the operation and maintenance of the Yakima Project. The current schedule is to define a Proposed Action (PA) by the end of April, a draft Biological Assessment (BA) by summer of 2013 and a final BA by the end of the 2013. The plan is to produce one combined BA for both Services.

Tualatin Consultation

Reclamation submitted a BA in 2009 which was accepted by NOAA Fisheries for consultation. NOAA Fisheries was granted a time extension in 2010, but Reclamation is waiting for a draft BiOp. Reclamation provided more information to NOAA Fisheries and performed a fish study which indicated that there is very little salmonid use of the Tualatin River near Reclamation projects. As a result of these studies, NOAA Fisheries has agreed that new fish screens (that meet the most current NOAA Fisheries mesh size criteria) are not required at the Spring Hill Pumping Plant.

Okanogan Consultation

Reclamation submitted a BA in 2008 for the future operation and maintenance of the Okanogan Project (Project). Reclamation met with NOAA Fisheries in early 2009 at which point NOAA Fisheries stated that the proposed action wasn't sufficient to avoid jeopardy and asked that the action be reconsidered by making substantial improvements. Reclamation has made small improvements to the Project, continues to lease water (through the FCRPS), and is analyzing the Project in more detail to identify additional water sources, but has not yet changed the proposed action from that which was described in 2008. Reclamation has installed additional stream gauges and SnoTel sites to collect information to quantify basin hydrology and to increase the predictive capabilities for better water management of the project each year. The consultation is "on-hold" while more information is collected.

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.*

Table 14. Summary of Chum Operations at Bonneville Dam for Water Years 2007-2012.

RPA Action 17 Operation - 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.	
2007-2008	Beginning November 9, 2007, at 2200 hours, Bonneville Dam operated to maintain the tailwater elevation within the range of 11.3–11.7 feet. Spawning operations ended the morning of December 24, 2007.
2008-2009	Beginning November 7, 2008, at 0600 hours, Bonneville Dam operated to maintain the tailwater elevation within the range of 11.3–11.7 feet. If high flow management actions were insufficient, the Action Agencies were to target a Bonneville Dam tailwater elevation of 12.0 feet, with an operating range of 11.5-12.5 feet. Chum spawning operations ended on December 31, 2008.
2009-2010	Beginning November 6, 2009, at 0600 hours, Bonneville Dam operated to maintain the tailwater elevation within the range of 11.3–11.7 feet with a target of 11.5 feet during daylight hours, and no lower than 11.3 feet during all hours. Chum spawning operations ended on December 30, 2009.
2010-2011	Beginning October 27, 2010, at 0600 hours, Bonneville Dam operated to maintain the tailwater elevation no lower than 9.5 feet during all hours. Beginning November 1, 2010, the project operated to maintain the tailwater elevation within the range of 11.3–11.7 feet during daylight hours, and no lower than 11.3 feet during all hours. NOAA Fisheries declared the end of chum spawning and initiation of incubation on December 22, 2010.
2011-2012	Beginning November 1, 2011, at 0600 hours, Bonneville Dam operated to maintain the tailwater elevation within the range of 11.3-11.7 feet with a target of 11.5 feet during daylight hours, and no lower than 11.3 feet during all hours. On November 2, the upper limit of the daytime range was increased to 12.0 feet. On November 23, the tailwater operating range was increased to 11.7-12.5 feet during daylight hours, and no lower than 11.7 feet during all hours. Chum spawning operations ended on December 28, 2011.
2012-2013	Beginning November 1, 2012, at 0600 hours, Bonneville Dam operated to maintain the tailwater elevation within the range of 11.3-11.7 feet with a target of 11.5 feet during daylight hours, and no lower than 11.3 feet during all hours. On November 21, the tailwater operating range was increased to 12.2-12.8 feet with a target of 12.5 feet during daylight hours, and no lower than 12.2 feet during all hours. On November 27, the tailwater operating range was increased to 13.5-14.5 feet with a target of 14.0 feet during daylight hours, and no lower than 13.5 feet during all hours. On November 30, the upper limit of the daytime range was increased to 15.5 feet. Chum spawning operations ended on December 21, 2012.
RPA Action 17 Operation - 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.	
2007-2008	Not applicable.
2008-2009	Not applicable.
2009-2010	Not applicable.
2010-2011	Not applicable.
2011-2012	Not applicable.
2012-2013	Not applicable.
RPA Action 17 Operation - Make adjustments to the tailwater elevation through the TMT process consistent with the size of the spawning population and WSFs.	

2007-2008	High inflows from late November through December 2007 necessitated increased nighttime tailwater elevations to move excess water at a time when chum tend not to spawn.
2008-2009	Excess water was generally discharged at night, when chum tend not to spawn. In addition, the TMT developed contingency plans for managing chum operations that established a priority for actions to be taken to manage excess water if it could not be managed at night.
2009-2010	High inflows during November and December 2009 necessitated deviations to move excess water at night (from 1700 to 0600 hours). Tailwater elevation increased to 18.5 feet during these times. On February 23, 2010, the Action Agencies lowered the Bonneville Dam tailwater target operation for chum to 11.3 feet based on WSFs that were significantly below average. On March 11, 2010, the action agencies gradually lowered the Bonneville Dam tailwater minimum following this schedule: 1) March 15, 2010, operate to a minimum tailwater of 11.0 feet; 2) March 17, 2010, operate minimum tailwater of 10.8 feet; and 3) March 19, 2010, operate to a minimum tailwater of 10.5 feet.
2010-2011	During spawning, as needed, excess water was passed with an increased tailwater elevation up to 18.5 feet during evening hours (1700-0600 hours). From December 13–16, 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 discussed the impacts of a 48-hour higher tailwater elevation due to increased precipitation in the system. No redds were discovered at higher elevations in response to this operation.
2011-2012	On November 23, 2011, the tailwater elevation operating range was increased in response to chum spawner surveys and WSFs. On December 21, 2011, the target elevation was increased to 12.0 feet in response to the TMT recommendation to protect redds from exposure at high tides.
2012-2013	On November 21, 28 and 30, 2012, the Action Agencies coordinated with TMT to increase the tailwater elevation operating range in response to observed and forecasted high inflows at Bonneville Dam. The maximum nighttime tailwater elevation was set at 18.5 feet to minimize fluctuations between day/night tailwater elevations. On December 4, the Action Agencies coordinated with TMT to increase the maximum daytime tailwater elevation to 18.5 feet if necessary to pass excess flow that could not be passed at night.
<u>RPA Action 17 Operation</u> - 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.	
2007-2008	On the morning of December 24, 2007, operations shifted from spawning to incubation protection with a 24-hour minimum tailwater elevation of 11.5 feet. From March 6 through March 10, 2008, spill was provided at Bonneville Dam for the Spring Creek Hatchery release. During this period a minimum tailwater was maintained between 12.5–13.0 feet to provide depth compensation and protect chum redds from TDG produced by spill. Chum emergence ended by April 9, 2008. The tailwater was operated to 11.5 feet as a soft constraint to facilitate chum fry egress following emergence. The soft constraint ended on April 11, 2008.
2008-2009	On January 1, 2009, operations shifted from a spawning to an incubation operation, a 24-hour minimum tailwater elevation of 11.5 feet took effect. On April 1, 2009, chum emergence was completed.
2009-2010	Post-spawning and incubation operation began on December 31, 2009. The chum operation ended on March 22, 2010.

2010-2011	The incubation tailwater elevation was set at 12.2 feet during all hours with no nighttime maximum elevation. The chum operation ended April 18, 2011.
2011-2012	The Action Agencies coordinated with TMT to transition to an operation for chum redd incubation on December 28, 2011, based on spawner surveys and flow data that indicated spawning was complete. The minimum tailwater elevation was established at 12.0 feet during all hours. The chum incubation operation was ended on March 28, 2012.
2012-2013	The Action Agencies coordinated with TMT to transition to an operation for chum redd incubation on December 21, 2012, based on spawner surveys and flow data. The minimum tailwater elevation was established at 13.5 foot during all hours. On February 20, 2012, the Action Agencies coordinated with TMT to modify the chum incubation operation in response to a decreasing WSF. The chum tailwater elevation was gradually reduced over 7 days down to 11.8 feet during all hours with an increase to 13.5 feet for one hour in every 24 hour period. The chum incubation operation is ongoing and will likely end sometime during the first week of April 2013, as coordinated with TMT.
<u>RPA Action 17 Operation</u> - If the emergence period extends beyond April 10, 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.	
2007-2008	Not applicable.
2008-2009	Not applicable.
2009-2010	Not applicable.
2010-2011	Not applicable.
2011-2012	Not applicable.
2012-2013	Not applicable.
<u>RPA Action 17 Operation</u> - 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.	
2007-2008	Chum operations were coordinated regularly through the TMT prior to the initiation of chum spawning and through the end of chum emergence.
2008-2009	Chum operations were coordinated regularly through the TMT prior to the initiation of chum spawning and through the end of chum emergence. Chum operations were complicated by forebay constraints in place to facilitate the construction of the spillwall at The Dalles Dam. A plan to manage these complications included: 1) use of a new gauge installed near The Dalles Dam spillbay 23, to assist with real-time surface elevation monitoring throughout the season; 2) modification of operating restrictions for spillwall construction to support more flexibility of the chum operations; and 3) specific guidance from the salmon managers on real-time management (timing, patterns) of excess water that might enter the system.
2009-2010	Chum operations were coordinated regularly through the TMT prior to the initiation of chum spawning and through the end of chum emergence. Chum operations were complicated by forebay constraints in place to facilitate the construction of the spillwall at The Dalles Dam. A plan to manage these complications included: 1) use of a new gauge installed near The Dalles Dam spillbay 23, to help with real-time surface elevation monitoring throughout the season; 2) modification of operating restrictions for spillwall construction to support more flexibility of the chum operations; and 3) specific guidance from the salmon managers on real-time management (timing, patterns) of excess water that might enter the system.
2010-2011	Chum operations were coordinated regularly through the TMT prior to the initiation of chum spawning and through the end of chum emergence.
2011-2012	Chum operations were coordinated regularly through the TMT prior to the initiation of chum spawning and through the end of chum emergence.

2012-2013	Chum operations were coordinated regularly through the TMT prior to the initiation of chum spawning and through the end of chum emergence.

For all years, the official gauge for chum tailwater readings is on the Oregon side of the Columbia River, 0.9 miles downstream from Bonneville Dam's first powerhouse, 50 feet upstream from Tanner Creek, and at River Mile (RM) 144.5.

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, 2011, 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 intended to achieve a higher tailwater for chum spawning and also assist with repair work underway on the Bonneville Dam Bradford Island B-Branch Fish Ladder.

On November 23, 2011, 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 coordinated with the TMT during that day's TMT meeting, and 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.nwdwc.usace.army.mil/tmt/sor/2011/*.

On December 28, 2011, 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.

2012–2013: The 2012-2013 chum operation began on November 1, 2012. The Action Agencies issued the following guidance to Bonneville Dam to protect spawning chum:

1. Effective November 1, 2012, at 0600 hours:
    a. during all hours, maintain the tailwater elevation at a minimum of 11.3 feet;
    b. during daylight hours (0630-1700), maintain the tailwater elevation within a 0.4-foot band of 11.3-11.7 feet, with a target elevation of 11.5 feet;
    c. as needed to pass excess water, increase tailwater elevation during nighttime hours (1700-0630) up to 18.5 feet, then if necessary, during daylight hours up to 12.5 feet.

On November 21, 2012, the Action Agencies coordinated with TMT to increase the minimum tailwater elevation to 12.2 feet during all hours, with a range of 12.2-12.8 feet during daytime hours, due to spawner counts and high inflows. The increase in the daytime tailwater range was intended to provide access to spawning habitat at higher elevations. As needed to pass excess water, the nighttime tailwater elevation (1700-0630) would be increased up to 18.5 feet, then if necessary, during daylight hours up to 13.5 feet.

On November 27, 2012, the Action Agencies coordinated with TMT to increase the minimum tailwater elevation range to 13.5 feet during all hours, with a daytime range of 13.5-14.5 feet and a target of 14.0 feet, due to spawner counts and high inflows. The increase in the daytime tailwater range was intended to provide access to spawning habitat at higher elevations.

On November 30, 2012, the Action Agencies coordinated with TMT to increase the upper limit of the daytime range to 15.5 feet due to increasingly high inflows.

On December 21, 2012, as coordinated with TMT, the Action Agencies ended Chum spawning operations and transitioned to chum redd incubation operations with a minimum tailwater elevation of 13.5 feet during all hours.

On February 20, 2013, the Action Agencies coordinated with TMT to modify the chum incubation operation in response to a decreasing WSF. The chum tailwater elevation was gradually reduced over 7 days down to a minimum of 11.8 feet during all hours with an increase to 13.5 feet for one hour in every 24 hour period. The Action Agencies will maintain this operation through the first week of April 2013, or as coordinated through 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

- *Sluiceway modifications to optimize surface flow outlet to improve fish passage efficiency (FPE) and reduce forebay delay (2009).*
- *Minimum-gap turbine runner installation to improve survival of fish passing through turbines (2009).*
- *Bonneville Powerhouse II*
- *Screened bypass system modification to improve fish guidance efficiency (FGE) and reduce gatewell residence time (2008).*
- *Shallow BGS installation to increase Corner Collector efficiency and reduce forebay delay (prototype 2008).*

Bonneville Dam Spillway

- *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.

The following section focuses on dam configuration actions identified in the COP to achieve the juvenile dam passage survival performance standards at Bonneville Dam. Included are items completed to date, along with a description of research and results of performance standard testing conducted. The FCRPS BiOp current condition estimates of dam survival suggested that yearling Chinook and juvenile steelhead survival rates at Bonneville Dam were already above the 96 percent dam survival standard. Configuration and operation improvements at Bonneville Dam therefore focused on subyearling Chinook salmon. However, configuration actions that benefited subyearling Chinook were expected to benefit yearling Chinook and steelhead as well. An assessment of status in meeting the juvenile dam passage survival performance standards describes the current progress made to date. If further actions are necessary to achieve juvenile performance standards, potential actions to consider will be identified in the Bonneville Dam COP.

Bonneville Dam COP Actions Completed Since 2007

Table 15. Summary of Juvenile Fish Passage Improvements Implemented at Bonneville Dam since 2007.

Improvement	Year	Effect
Powerhouse II Fish Guidance Efficiency Improvements	2008	Increased the amount of juvenile fish guided away from turbines and into the JBS. The JBS has the second highest survival of all routes at the project.
New Spill Operation	2007-2008	Increased juvenile fish survival at the spillway through improved conveyance over the spillway chute and improved egress in the tailrace. This was accomplished by setting the minimum spill gate opening to 2 feet and adjusting the pattern of gate openings to eliminate eddies and maintain shoreline velocities in the spillway tailrace.
Conversion of the Powerhouse I Sluiceway to a Surface Flow Outlet	2010	Provided a safer, more effective non-turbine passage route for adult and juvenile fish at Powerhouse I by increasing the hydraulic capacity, improving channel flows, and automating the entrance weirs.
New Powerhouse I Turbines	2010	Increased juvenile fish survival at Powerhouse I through installation of Minimum Gap Runners (MGR) at all 10 turbines. The MGRs were designed to provide safer conveyance for juvenile fish.

Spillway Operation or Structure Modification to Reduce Injury and Improve Survival - The 2008 amendment to the Bonneville Dam Configuration and Operation Plan identified spillway improvements as the most likely action to increase subyearling Chinook fish survival at Bonneville Dam. Two parallel studies were conducted: one considering alternative spillway operations, the other considering structural changes. An alternatives report that evaluated the cost, feasibility, and potential biological benefits of structural modification to the spillway was completed in 2009. Hydraulic model studies and field studies were conducted in 2007 and 2008. Results from 2007 and 2008 studies indicated that subyearling Chinook spillway survival can be increased substantially by changing summer spill operations from 75 kcfs daytime spill to 85 kcfs daytime spill (Table 16).

Table 16. Spillway Passage Survival for Subyearling Chinook Salmon at Bonneville Dam, 2004-2008. Results from 2004-2005 are based on radio telemetry studies (Counihan et al., 2006a, Counihan et al., 2006b); 2006-2008 results are based on acoustic telemetry studies (Ploskey et al., 2007; Ploskey et al., 2008; Ploskey et al., 2009).

Year	Operation	Subyearling Chinook Spillway Passage Survival Rate
2004	48 Day / TDG Cap Night	88%
2005	75 Day / TDG Cap Night	91%
2006	75 Day / TDG Cap Night	86%
2007	85 Kcfs Daytime Only	93% (daytime survival estimate)
2008	85 Day / TDG Cap Night	97%

Powerhouse II Screened Bypass System Modifications to Improve Fish Guidance Efficiency – Improvements to the JBS were completed in 2008. The intended purpose of those modifications was to increase the fish guidance efficiency (FGE) of the JBS. Since completion of those modifications a fish injury problem has been identified. Research to better understand the nature and source of these injuries was conducted during the 2008 and 2009 juvenile fish passage seasons. An alternatives report to evaluate potential solutions to the gatewell injury problem was completed in 2012. Testing of recommended improvements is planned for 2013.

Powerhouse I Sluiceway Modifications – Planned sluiceway modifications, including increasing the width of the collection channel, shaping the sluiceway floor, removing the decommissioned juvenile bypass outfall and other components, and automating the sluiceway gates were completed during the 2009-10 winter work period.

Powerhouse I Minimum-Gap Turbine Runner Installation – Fish survival improvements were incorporated into the rehabilitation of PH 1 turbines. These improvements included a new runner design that greatly reduced fish-injury causing gaps between the runner, hub, and discharge ring. Testing of the new design showed a 40 percent decrease in juvenile salmonid injury rates compared to the original units (Normandeau, 2000). Installation of minimum-gap runners on all ten PH 1 turbine units was completed in 2010.

Powerhouse II Shallow Behavioral Guidance Screen (BGS) Installation – A prototype shallow draft BGS was installed in 2008 and evaluated in 2008, 2009, and 2010. Pre- and post-BGS results are presented in Table 17. Due to the overall lower than expected guidance to the corner collector (CC) in addition to high operation and maintenance cost, the BGS was removed during the winter 2010-2011 in-water work period.

Table 17. Percent of Yearling Chinook, Yearling Steelhead, and Subyearling Chinook Passing from the Bonneville Dam PH2 Forebay into the CC in 2004 and 2005 without the BGS Compared to 2008-10 with the BGS. Results from 2004-05 are based on radio telemetry studies (Reagan et. al, 2006; Adams and Rondorf, 2007); 2008-10 results are based on acoustic telemetry studies (Faber et al., 2010; Faber et al., 2011; Ploskey et al., 2011).

Age / Species	Percent of PH2 Salmonids that Passed through the Corner Collector			
	2004-05 (No BGS)	2008 (With BGS)	2009 (With BGS)	2010 (With BGS)
Yearling Chinook	40	49	40	44
Yearling steelhead	70	75	59	55
Subyearling Chinook	40	40	52	35

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 18). Dam passage survival estimates for yearling Chinook were below the 96 percent FCRPS BiOp performance standard, at 95.6 percent, while juvenile steelhead dam passage survival met 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. Performance standard testing was conducted in 2012 for subyearling Chinook salmon. Dam passage survival for subyearling Chinook salmon was above the 93 percent performance standard for summer migrants at 97.4 percent however, the actual spill level was above both of the two targeted spill operations evaluated during the summer due to high river flow (Table 18).Other actions are summarized below.

Table 18. Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon and Juvenile Steelhead in 2011 (Ploskey et al., 2013) and Subyearling Chinook Salmon in 2012 (Skalski et al., 2013a) at Bonneville Dam.

Species	Dam Passage Survival (% with standard error)	Forebay/Tailrace Passage Time (hours)	Spill Passage Efficiency (%)
100-kcfs Spill (April 30-May 13, 2011)			
Yearling Chinook	95.8 (0.4)	n/a	n/a
Juvenile Steelhead	97.6 (1.8)	n/a	n/a
181-kcfs Season-wide Spill (April 30-May 31, 2011)			
Yearling Chinook	96.0 (1.8)	0.6/0.4	56.6
Juvenile Steelhead	96.5 (2.1)	0.9/0.4	54.4
149-kcfs Season-wide Spill (June 19-July 22, 2012)			
Subyearling Chinook	97.4 (0.7)	0.5/0.4	53.2

Figure 9 shows Comprehensive Fish Passage Model (COMPASS) estimates used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage, along with the predicted survival for both yearling Chinook salmon and juvenile steelhead that was expected to result as a consequence of the proposed action. Subyearling Chinook were not modeled because of their more complex life history; not all Snake River subyearling Chinook outmigrate in their first year. Estimates of juvenile dam passage survival from performance standard testing in 2011 shown in Figure 9 indicate dam passage survival is exceeding the expected or COMPASS estimate value of what was expected for juvenile steelhead. In addition, survival estimates for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon are generally meeting the performance standards of 96 percent for spring migrants and 93 percent for summer migrants.

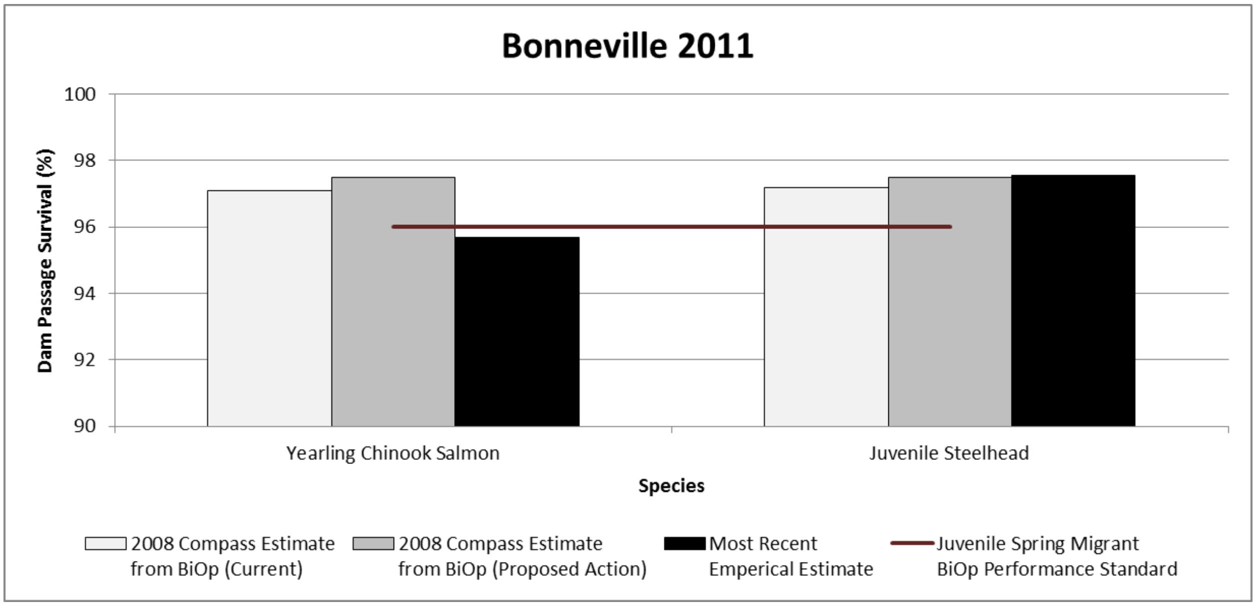


Figure 9. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for Bonneville Dam in 2011 (Ploskey et al., 2013). Survival estimates for 2011 are for the early test period (April 30 – May 13), where the intended spill operation of 100 Kcfs was met. COMPASS modeling estimates are not available for subyearling Chinook.

Figures 10-12 summarize the most recent juvenile fish passage distribution and route-specific survival rates at Bonneville Dam. The 2011 estimates for yearling Chinook and steelhead used the virtual paired release model that is currently employed for performance standard testing. The most recent subyearling Chinook survival estimates are from 2010 and are single release survival model estimates. As such, the subyearling Chinook estimates underestimate dam- and route-specific survival because they include nearly 80 km of river not influenced by dam operations and configuration as well as all potential mortality sources, such as handling effects.

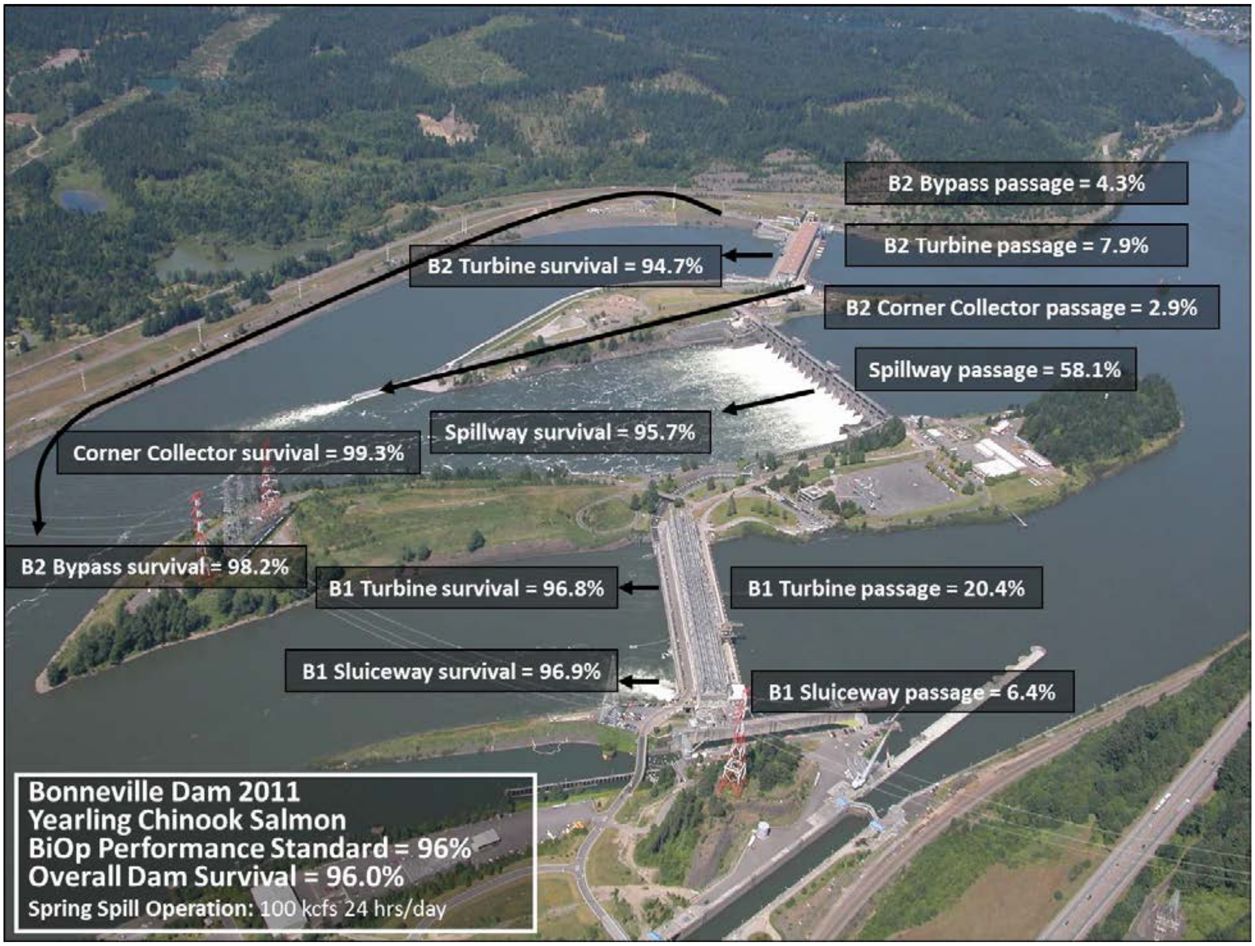


Figure 10. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at Bonneville Dam in 2011. Data are from the entire study period (April 30-May31) **(Ploskey et al., 2012).**

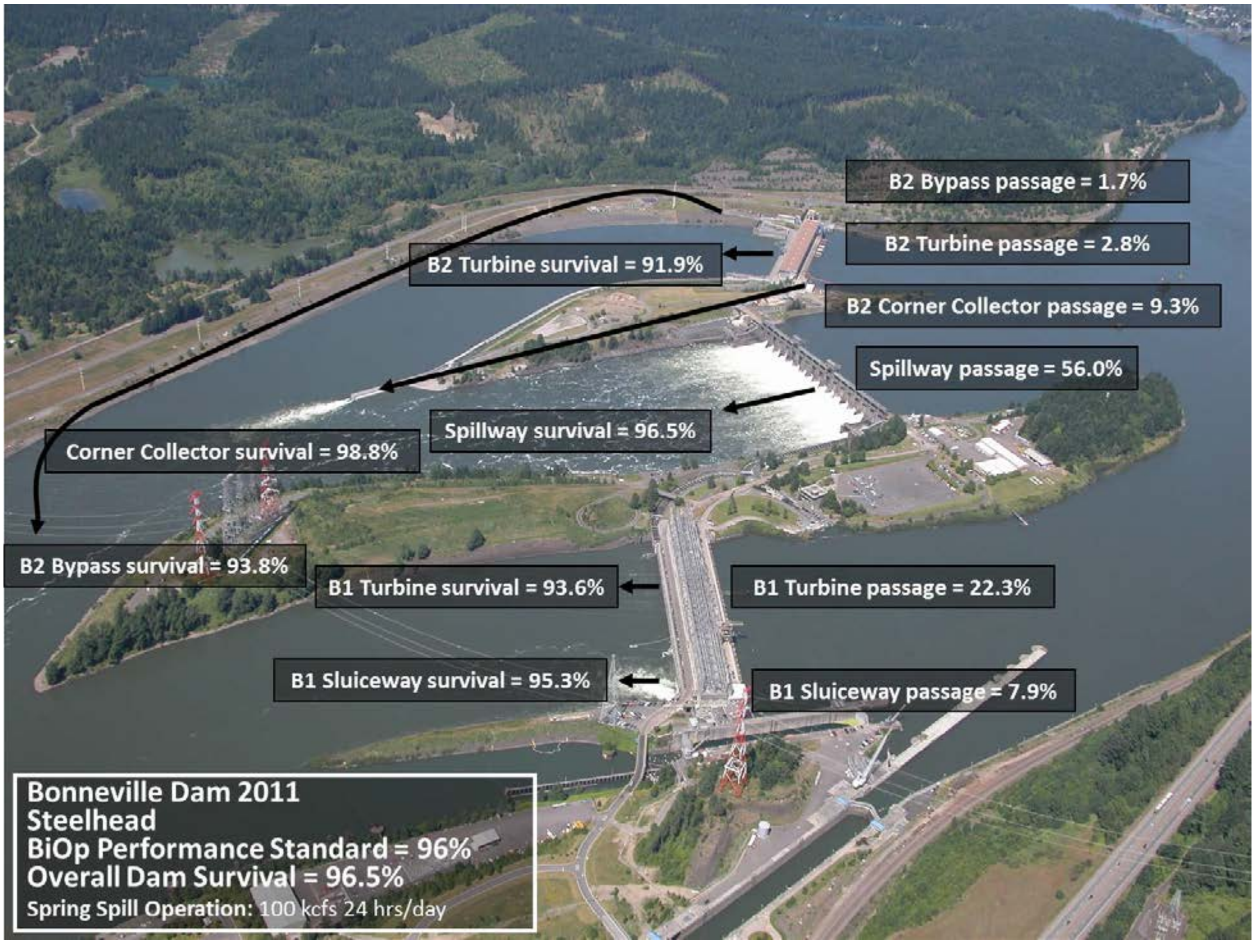


Figure 11. Percent Passage by Route and Route-Specific Survival Rates (Virtual Paired Release) for Yearling Steelhead Trout at Bonneville Dam in 2011. Data are from the entire study period (April 30-May31) **(Ploskey et al., 2012).**

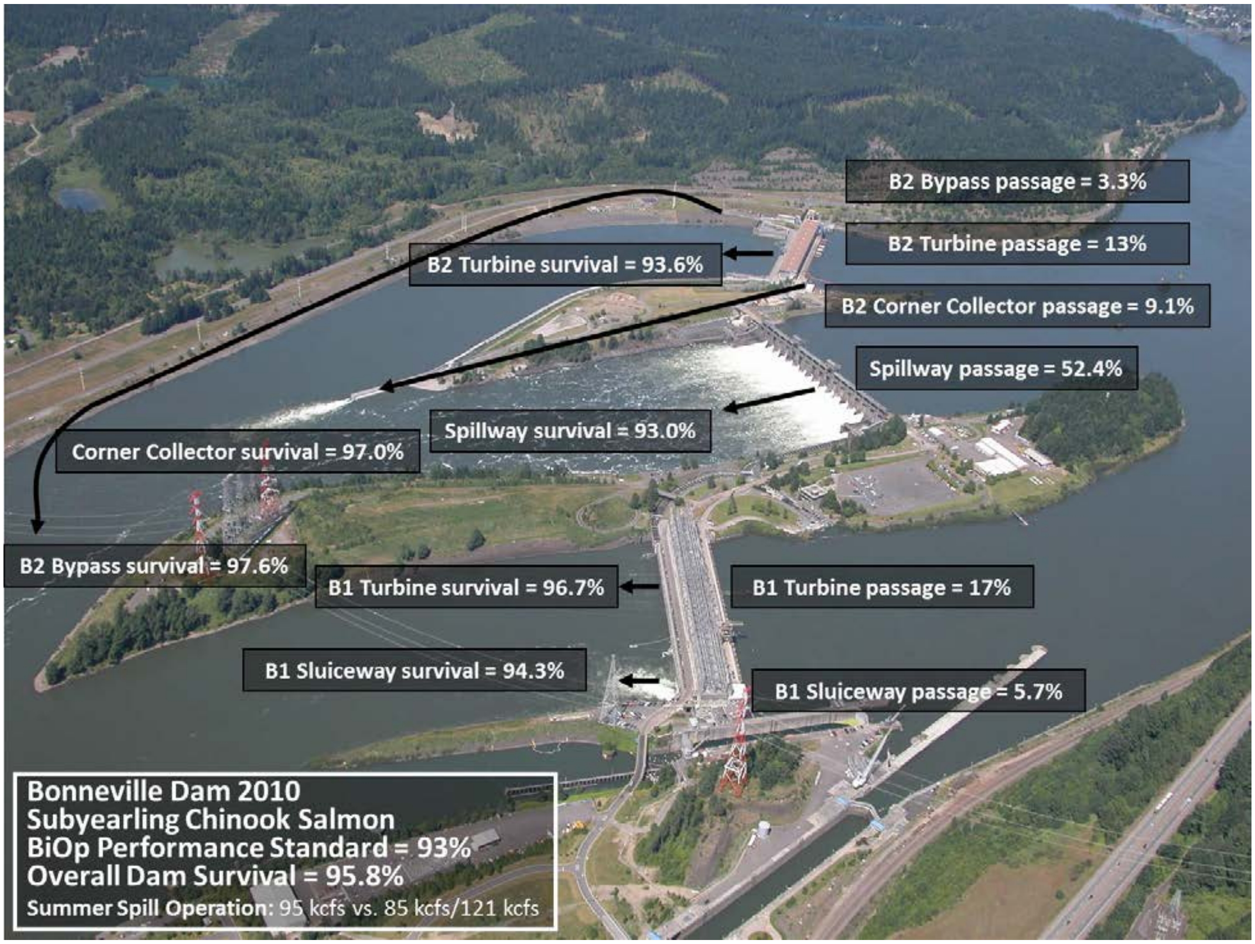


Figure 12. Percent Passage by Route and Route-Specific Survival Rates (Single Release) for Subyearling Chinook Salmon at Bonneville Dam in 2010 (Ploskey et al., 2012).

The route-specific information from Bonneville Dam 2010 and 2011 studies indicate that juvenile salmon and steelhead survival is in the mid to high 90's for all routes at the dam, and that juvenile fish dam passage performance standards are met or very nearly met for spring and summer migrants.

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:*

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

The following summary focuses on dam configuration actions identified in the COP to achieve the juvenile dam passage survival performance standards at The Dalles Dam. Included are items completed to date, along with a description of research and results of performance standard testing conducted. An assessment of status in meeting the juvenile dam passage survival performance standards describes the current progress made to date in achieving performance standards. If further actions are necessary to achieve juvenile performance standards, potentials actions to consider will be identified in The Dalles Dam COP.

Table 19. Summary of Juvenile Fish Passage Improvements Implemented at The Dalles Dam Since 2007.

Improvement	Year	Effect
Extended Length Spill Wall	2010	Increases juvenile fish survival by: 1) Improving stilling basin hydraulic conditions, and 2) Improving tailrace egress for fish that pass through the spillway.
Tailrace Bird Wire Array	2011	Increase juvenile fish survival by protecting spillway-passed fish from avian predators.

Turbine Operation Optimization to Improve Overall Dam Survival – A model turbine runner was procured for use in turbine operation optimization activities. The runner will be used in construction of a physical model so that flow patterns can be observed. That data will be used to develop a best operating point hypothesis. Also see RPAs 27 and 55.6.

Extended Tailrace Spill Wall to Increase Direct and Indirect Survival of Spillway Passed Fish – In 2008, The Dalles Dam COP was revised to include additional project configuration actions to improve juvenile dam passage survival and assist in achieving juvenile dam passage survival performance standards. The primary action recommended in the COP to improve juvenile fish passage survival was the construction of a spillwall to guide spillway-passed juvenile migrants away from shallow water, thereby reducing predation. As recommended in the COP, a two-year construction contract was awarded in 2008 to begin construction of a spillwall at The Dalles Dam spillway to be completed during the 2008-09 and 2009–10 in-water work periods. The $51.3M, 700-foot long spillwall was constructed between spillbays 8 and 9 to help guide juvenile fish that pass the dam via the spillway away from shallow-water predator habitat towards the deeper main river channel to expedite conveyance downstream.

Following the completion of spillwall construction in spring 2010, a full performance standard evaluation for both spring and summer juvenile salmonids was initiated. Results from the first year of full performance standard testing indicated a marked improvement over the pre-spillwall configuration in dam survival of both spring and summer migrants. Dam survival of yearling Chinook salmon have met the spring migrant performance standard of 96.0 percent at 96.4 percent in 2010 (Table 20). Dam survival of juvenile steelhead was slightly below the spring juvenile migrant performance standard of 96.0 percent at 95.3 percent in 2010 (Table 20), however, elevated levels of avian predation occurred downstream of the dam during testing. Additional avian wires were installed following 2010 performance standard testing in anticipation that additional wires would help further reduce avian predation and increase dam survival above the spring migrant performance standard of 96.0 percent. Dam survival of subyearling Chinook salmon met the summer juvenile migrant performance standard of 93.0 percent at 94.0 percent (Table 20).

A second year of full performance standard testing was conducted in spring 2011. Summer performance standard testing for subyearling Chinook salmon was cancelled due to high river flow. Dam passage survival for yearling Chinook salmon and juvenile steelhead have met the performance standard requirement of 96 percent (Table 20).

A second year of performance standard testing for subyearling Chinook salmon was completed in 2012; the estimated dam passage survival of 94.7 percent for subyearling Chinook salmon met the summer juvenile migrant performance stand of 93.0 percent (Table 20).

Table 20. Juvenile Salmonid Dam Passage Survival, Forebay Passage Time, and Spill Passage Efficiency Estimates for Spring and Summer Migrants at The Dalles Dam in 2010, 2011, and 2012 (Johnson et al., 2011a; Skalski et al., 2012a; Skalski et al., 2013b).

Species	Dam Passage Survival (% with standard error)	Forebay Passage Time (hours)	Spill Passage Efficiency[A] (%)
The Dalles Dam (2010) – 40 Percent Spill			
Yearling Chinook	96.4 (1.4)	1.28	94.7
Juvenile Steelhead	95.3 (1.4)	1.28	95.4
Subyearling Chinook	94.0 (0.9)	1.20	83.0
The Dalles Dam (2011) – 40 Percent Spill			
Yearling Chinook	96.0 (1.0)	1.0	83.1
Juvenile Steelhead	99.5 (0.8)	0.8	89.2
The Dalles Dam (2012) – 40 Percent Spill			
Subyearling Chinook	94.7 (0.6)	1.08	70.7

A - spill passage efficiency value includes sluiceway passage.

According to performance standard test results, the addition of the spillwall at The Dalles Dam provided a marked improvement in overall juvenile salmonid dam passage survival from pre-FCRPS BiOp survival levels. Figure 13 shows COMPASS estimates used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage, along with the predicted survival for both yearling Chinook salmon and juvenile steelhead that was expected to result as a consequence of the proposed action. Subyearling Chinook salmon were not modeled because of their more complex life history; not all Snake River subyearling Chinook outmigrate in their first year. The most recent empirical estimates of juvenile dam passage survival from performance standard testing shown in Figure 13 indicate dam passage survival is exceeding the expected or COMPASS estimate value of what was expected for spring migrants with the addition of the spillwall (COMPASS estimates are not available for summer migrants). In addition, survival estimates for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon are generally meeting the performance standards of 96 percent for spring migrants and 93 percent for summer migrants. No further configuration actions to improve juvenile dam passage survival are anticipated at this time.

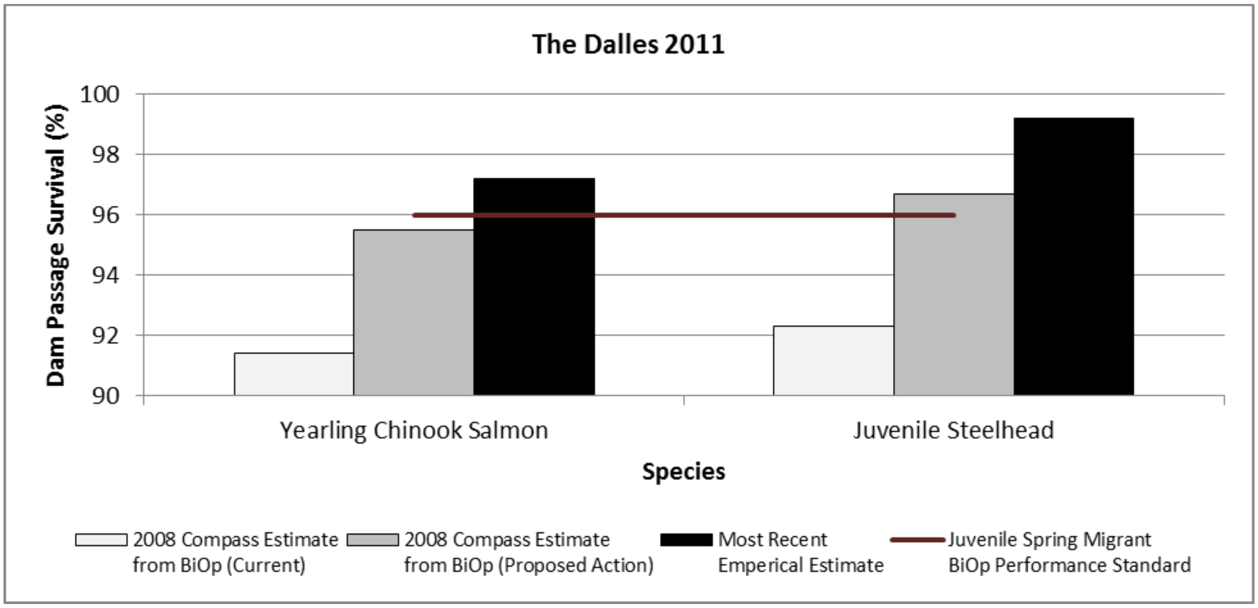


Figure 13. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for The Dalles Dam in 2011 (Skalski et al., 2012a). COMPASS modeling estimates are not available for subyearling Chinook.

COP Update

An update to the COP was completed in 2009. The COPs updated analysis confirmed that extending the spillway training wall and spilling 40 percent of the river during the juvenile fish passage season had the highest likelihood of meeting dam passage performance standards for juvenile Chinook and steelhead.

Figure 14. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at The Dalles Dam in 2010-2011 (Ploskey et al., 2012).

Figure 15. Percent Passage by Route and Route-Specific Survival Rates for Steelhead at The Dalles Dam in 2010-2011 (Ploskey et al., 2012).

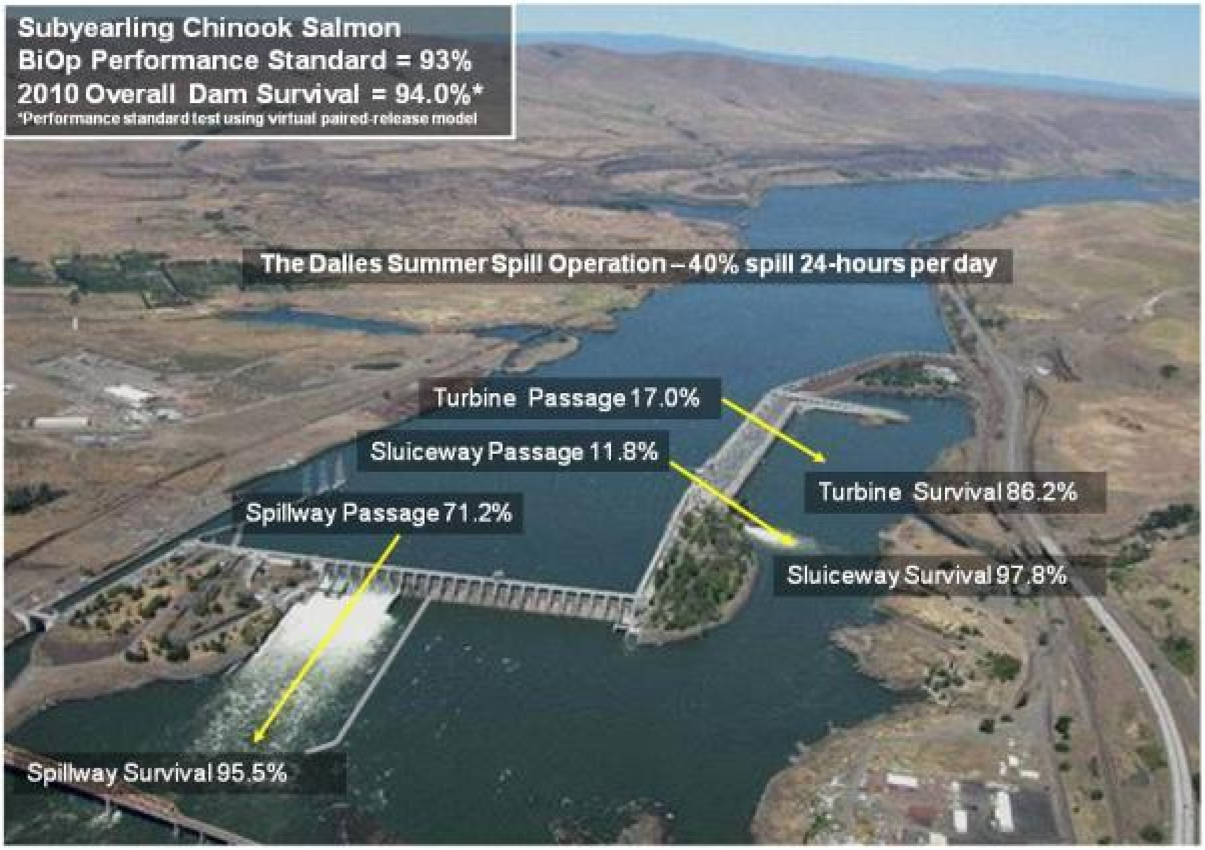


Figure 16. Percent Passage by Route and Route-Specific Survival Rates for Sub-Yearling Chinook Salmon at The Dalles Dam in 2010 (Ploskey et al., 2012).

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:*

- *Full-flow bypass and PIT-tag detection installation to reduce handing stress of bypassed fish (2007).*
- *Turbine operation optimization to improve overall dam survival (2011).*
- *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.

The following summary focuses on dam configuration actions identified in the COP to achieve the juvenile dam passage survival performance standards at John Day Dam. Included are items completed to date, along with a description of research and results of performance standard testing conducted. An assessment of status in meeting the juvenile dam passage survival performance standards describes the current progress made to date. If further actions are necessary to achieve juvenile performance standards, potential actions to consider will be identified in the John Day Dam COP.

Table 21. Significant Juvenile Fish Passage Improvements Implemented at John Day Dam Since 2007.

Improvement	Year	Effect
Full Flow Passive Integrated Transponder (PIT)-tag Detection in the JBS	2007	Increases PIT-tag detection capability and operational flexibility of the JBS.
Surface Flow Outlets at the Spillway	2010	Increases juvenile salmonid survival by reducing turbine entrainment (by~50 percent) of juvenile salmon and steelhead passing the dam.
Extended-Length Flow Deflector – Bay 20	2010	Improves tailrace egress conditions for fish passing through the surface flow outlets. Reduced TDG generation at Bay 20.
Tailrace Bird Wire Array	2010	Protects spillway-passed fish from avian predators.

Full Flow Bypass – Passive Integrated Transponder **(PIT)-tag detection** – This improvement was installed on the John Day Dam JBS pipe in 2007 and has been operational from 2008 to present. Installation of this system enabled continued PIT-tag detection while bypassing fish around the sampling facility. This capability has been particularly important when river temperatures are high and further dewatering and handling causes increased stress to juvenile fish.

Turbine Operation Optimization – Hydraulic and numerical model studies of the turbine environment, laboratory studies on fish, and field studies were conducted to develop and verify a turbine operating point for John Day Dam turbines. Based on this information, the Turbine Survival Program (TSP) team hypothesize that the best operating point for juvenile fish survival at John Day Dam is approximately half way between peak efficiency and the upper one percent of the peak efficiency range. While direct survival tests appear to confirm this hypothesis, an evaluation of total mortality, which also incorporates pressure effects on fish, was determined to be infeasible at this time. However the best operating point information was incorporated into a repair strategy for Baldwin-Lima-Hamilton Kaplan turbines (the family of turbines at John Day, Lower Monumental, Little Goose, and Lower Granite dams). This strategy was utilized for two failed turbines at John Day Dam and resulted in the turbines being fixed at the best operating point for fish.

Surface Flow Outlets - Two spillway weirs (SW) were constructed and installed into spillway bays 18 and 19. The primary objectives of the SWs are to reduce the proportion of juvenile salmon and steelhead that pass through turbines and reduce their forebay residence times. Compared to previous years with 24-hour spill and no SWs, the SWs reduced the proportion of juvenile salmonids that pass through turbines by approximately 50 percent.

Tailrace Improvements - As part of the surface flow outlet system, three tailrace improvements were installed. This included an extended length flow deflector in spillbay 20, new spill patterns and turbine operating priorities, and an expanded avian wire array.

The first year of performance standard testing at John Day Dam was conducted in 2011 for yearling Chinook salmon and juvenile steelhead. For the latter half of the spring, outmigration high total river flows precluded operation of the dam at the target spill levels. However, for both species the dam passage performance standard was met at both operations as well as across the spring outmigration (Table 22). Also, due to high flows, the summer portion of testing in 2011 was cancelled.

In 2012, a second year of performance testing was conducted for yearling Chinook and juvenile steelhead, and the first year test was conducted for subyearling Chinook. High total river flows precluded consistent operation at the targeted spill levels, so results were pooled across the respective seasons for spring and summer migrants. Survival estimates for spring migrants met the 96.0 percent performance standard at 96.7 percent and 97.4 percent for yearling Chinook salmon and juvenile steelhead, respectively. Survival estimates for subyearling Chinook salmon also met the 93.0 percent performance standard at 94.1 percent. Results for both years are summarized in Table 22 below.

Table 22. 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 and 2012 (Skalski et al., 2012b, Skalski et al., 2013c).

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

Based on performance standard test results, the addition of SWs and tailrace improvements provided a marked increase in overall juvenile salmonid dam passage survival from pre-FCRPS BiOp survival levels. Figure 17 shows COMPASS estimates used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage, along with the predicted survival for both yearling Chinook salmon and juvenile steelhead that was expected to result as a consequence of the proposed action. Subyearling Chinook salmon were not modeled because of their more complex life history; not all Snake River subyearling Chinook outmigrate in their first year. The most recent empirical estimates of juvenile dam passage survival from performance standard testing shown in Figure 17 indicate dam passage survival is meeting the expected or COMPASS estimate value of what was expected for spring migrants with the addition SWs and tailrace improvements (COMPASS estimates are not available for summer migrants). In addition, survival estimates for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon are generally meeting the performance standards of 96 percent for spring migrants and 93 percent for summer migrants. The second year of performance testing for subyearling Chinook salmon is planned for 2014. No further configuration actions to improve juvenile dam passage survival are anticipated at this time

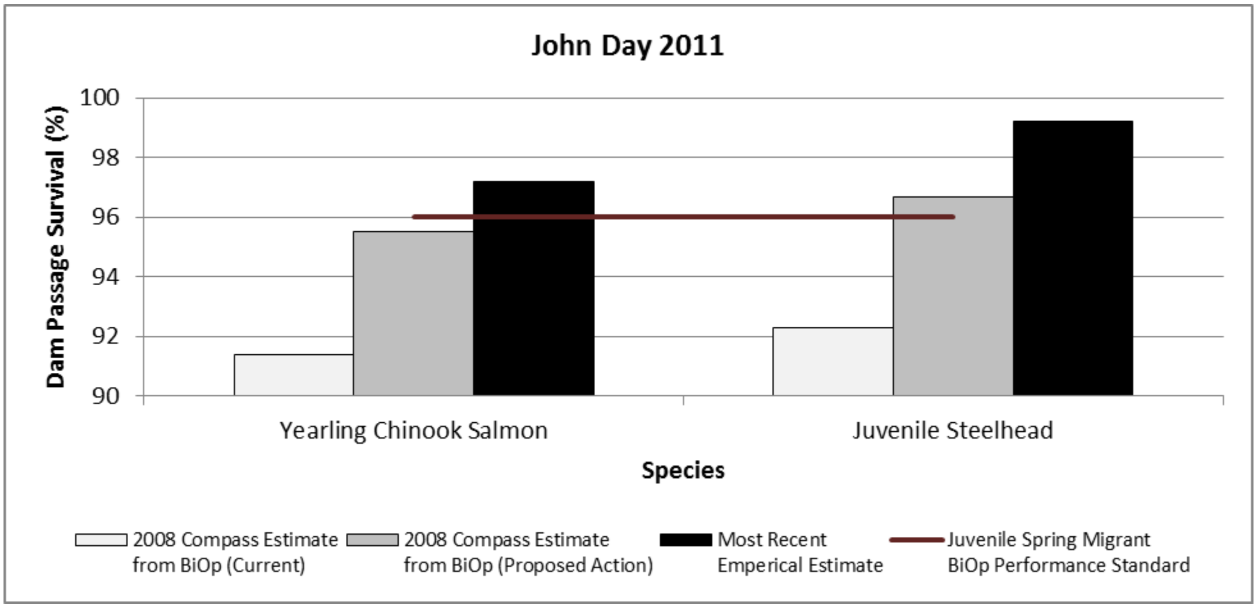


Figure 17. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for John Day Dam in 2011 (Skalski et al., 2012b). COMPASS modeling estimates are not available for subyearling Chinook.

Figure 18. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at John Day Dam in 2011 (Ploskey et al., 2012).

Figure 19. Percent Passage by Route and Route-Specific Survival Rates for Steelhead at John Day Dam in 2011 (Ploskey et al., 2012).

Figure 20. Percent Passage by Route and Route-Specific Survival Rates for Sub-Yearling Chinook Salmon at John Day Dam in 2010 (Ploskey et al., 2012).

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.

The following section focuses on dam configuration actions identified in the COP to achieve the juvenile dam passage survival performance standards for McNary Dam. Included are Phase I actions identified in RPA Action 21 that have been implemented since 2008 (Table 23). The FCRPS BiOp current condition estimates of dam survival computed by the COMPASS model suggested that yearling Chinook and juvenile steelhead survival rates at McNary Dam were below the 96 percent dam survival standard (94.1 percent for yearling Chinook and 95.4 percent for steelhead; Figure 21). The FCRPS BiOp proposed action estimates of dam survival for implementation of the Phase I actions computed by the COMPASS model suggested that yearling Chinook and juvenile steelhead survival rates at McNary Dam were above the 96 percent dam survival standard (96.2 percent for yearling Chinook and 97.3 percent for steelhead; Figure 21). The biological performance tests for developing the best placement of spillway surface weirs performed during 2007, 2008, and 2009 suggested that a configuration and operation would be successful in meeting the FCRPS BiOp COMPASS and juvenile dam survival performance standard of 96 percent for spring migrants. The FCRPS BiOp did not compute current condition or proposed action estimates of dam survival by the COMPASS model for subyearling Chinook, but pre-FCRPS BiOp and SW placement treatment dam survival studies suggested that traditional deeper spill operation of 50 percent without SWs for subyearling Chinook would exceed the 93 percent dam survival standard (Fredricks, 2009).

Configuration and operation improvements designed to meet the FCRPS BiOp juvenile dam performance standards at McNary Dam therefore focused on relocating the bypass outfall pipe. This action was completed in early 2012. After coordination with NOAA Fisheries and regional sovereigns a performance standard evaluation was conducted in 2012. Preliminary data from 2012 studies indicate 96.2 percent survival for yearling Chinook, 99.1 percent survival for steelhead, and 97.5 percent survival for subyearling Chinook. If further actions are necessary to achieve juvenile performance standards, potential actions to consider have been identified in the McNary Dam COP.

McNary Dam COP Actions Completed Since 2008

Actions completed since 2008 to assist in meeting the juvenile dam passage survival performance standards are identified in Table 23 and described below.

Table 23. Summary of Juvenile Fish Passage Improvements implemented at McNary Dam since 2008.

Improvement	Year	Effect
Turbine Operation Optimization	2009-2010	Improve survival of turbine passed fish.
Debris Management	2009-2010	This effort was initiated to minimize adverse impacts on fish condition, such as descaling, from debris on trashracks and in the forebay.
Juvenile Bypass Outfall Relocation	2012	Released juvenile and adult bypassed fish in an area with higher river velocities and consistent downstream flow during all operations. This relocation is expected to decrease predation on the bypassed fish while facilitating more rapid egress from the tailwaters of the dam.
Surface Flow Outlet Installation	2007, biological evaluation 2008-2009	Increased juvenile fish survival at the spillway through improved conveyance over two adjacent spillway surface weirs for spring migrants and improved egress in the forebay and the tailrace while reducing turbine and bypass entrainment of spring-run juvenile salmon and steelhead.

Turbine Operation Optimization to Improve Survival of Turbine Passed Fish – A Biological Index Test (BIT) was planned for 2009 to evaluate operating turbines above the upper end of the 1 percent efficiency range at McNary Dam. The evaluation was limited to operations within 1 percent due to concerns of potential gatewell descaling raised in the Studies Review Work Group forum. A gatewell descaling evaluation under two turbine operating conditions was conducted in 2010 at McNary Dam. Results of this work suggest that no significant difference in juvenile fish descaling could be discerned between turbine operations points of 13,800 and 12,100 cfs.

Debris Management – An evaluation of the existing screen cleaning data and consultation with project staff was conducted in 2009 to initiate the process for improving debris management at McNary Dam. Preliminary analysis of available screen cleaning data showed little correlation between descaling detected at the McNary Dam fish facility and screen cleaning events. Further data collection and analysis was conducted in 2010. The frequency of screen cleaning was increased to a minimum of three times during each fish passage season (in addition to the preseason cleaning). This effort was initiated to minimize adverse impacts on fish condition from debris on trashracks and in the forebay. As a result, the frequency of vertical barrier screen cleaning was modified.

Juvenile Bypass Outfall Relocation - The McNary Dam outfall relocation project entered the design and site selection phase in 2009, including modeling visits to the Corps' Engineer Research and Development Center (ERDC), visual tracking data modeling, estimates of potential survival improvements and a literature review of related predator information. Modeling efforts narrowed the potential site locations to a zone well downstream of the existing outfall. The relocated outfall releases fish in an area with higher river velocities and consistent downstream flow during all operations. This relocation is expected to decrease predation on the bypassed fish. Efforts during 2010 were focused on developing the design of the juvenile bypass outfall relocation. Construction began in September 2011, with completion prior to the beginning of the juvenile migration season in April 2012. Route specific paired release survival estimates for this modified route in 2012 were: 93.6 percent for yearling Chinook, and 100 percent for both steelhead and subyearling Chinook (preliminary data).

Surface Flow Outlet Installation - In 2007, two SWs were installed in spillbays 20 and 22. During 2008, the weir in spillbay 22 was moved to spillbay 19 to investigate whether this configuration would improve biological performance. A Juvenile Fish Surface Passage Feasibility Study evaluating the engineering feasibility, operational concerns, and magnitude of cost associated with various surface passage alternatives was completed in December 2008. Eleven alternatives underwent an evaluation and selection process conducted with regional stakeholders. Four alternatives were forwarded for detailed evaluation of engineering feasibility and cost. In 2009, the weir in spillbay 19 was moved to spillbay 4 for the spring outmigration. Since 2010, SWs have been operated in spillbays 19 and 20 for the spring outmigrants.

Evaluation of Survival and Passage Rates Under Various Spill Operations – In 2008, a second year of biological testing was conducted to assess relative juvenile survival, passage efficiencies, and forebay behavior while operating two prototype SWs. The primary objective was to gather information on approach behavior, passage route use, and survival after passage with a different SW configuration. The long term goal was to facilitate a decision on the most effective location for a permanent surface passage structure(s) at McNary Dam.

During the spring fish passage season, a single treatment test of 40 percent spill was evaluated. Passage over the SWs decreased, particularly for steelhead under the new configuration. Overall, steelhead passage dropped from 65.7 percent in 2007 to 53.1 percent in 2008. Yearling Chinook passage over SWs also was lower during 2008. Flow averaged 40 kcfs higher in 2008 relative to 2007. Surface flow outlets are generally less efficient at higher flows which may explain the drop in passage efficiency in 2008.

In 2008, dam passage relative survival was 99.9 percent for steelhead, meeting the FCRPS BiOp spring performance standard; however, dam passage relative survival was 95.8 percent for yearling Chinook, which is just under the 96.0 percent spring migrant FCRPS BiOp performance standard. During the summer passage season, a two-treatment test (40 percent vs. 60 percent spill) was initiated. At 60 percent spill, subyearling Chinook passage over the SWs was notably lower in 2008 compared to 2007. The average summer flow volume was also higher in 2008, similar to that observed in the spring. The summer migrant FCRPS BiOp performance standard of 93.0 percent was met (95.9 percent) with 60 percent spill, but was just under the performance standard with 40 percent spill (92.9 percent).

In 2009, the third year of biological testing was conducted to assess relative juvenile survival, passage efficiencies, and forebay behavior while operating two prototype SWs. During the spring fish passage season a single treatment test of 40 percent spill was conducted; however, after May 20, involuntary spill forced the overall spill level above 40 percent for 80 percent of the remaining days of the spring spill period. This was not a distinct break in flow volume as in 2008, and the subsequent survival and passage analysis was provided as a single estimate for the entire spring migration period. It was found that a shift occurred in SW passage, for both steelhead and yearling Chinook, when SW1 was shifted from the south end of the spillway (spillbay 19 in 2007 and spillbay 22 in 2008) to the north in 2009 (spillbay 4). Steelhead passage over the SWs dropped from 67.4 percent in 2007 to 41.6 percent in 2008 and 34.9 percent in 2009. Yearling Chinook passage over SWs was also lower during 2009 than 2007-2008. The total discharge was similar for the three years, but the late season involuntary spill was present during 2008- 2009, and surface flow outlets are generally less effective at higher flows. Relative concrete survival estimates met the performance standard for steelhead (99.2 percent) and yearling Chinook (97.2 percent) during 2009.

The summer passage season test was a single treatment of 50 percent spill for subyearling Chinook tagged for a telemetry evaluation. This was the first year for estimating survival at 50 percent, and average flow was lower than 2006-2008 when 40 percent vs. 60 percent spill treatments were tested. Subyearling Chinook passage was higher with 50 percent spill in 2009 compared to 2008, primarily due to increased passage at SW1.The average summer flow volume was lower in 2009 than in 2008, which appears to make smolts more readily utilize a surface passage route. Subyearling Chinook relative concrete survival was 89.2 percent, which was below the 93 percent performance standard and was influenced by mortality attributable to thermal shock in mid-July. Subyearling Chinook relative concrete survival prior to July 18 was calculated at 93.7 percent, meeting the performance standard. It was estimated that passing smolts were being rapidly transitioned through an approximate 6 degree Fahrenheit water temperature differential causing thermal shock and subsequent mortality. An increase in turbine unit loading on the north powerhouse is thought to be a contributing factor to the thermal gradient and suspected of inducing mortality. In 2012, survival was estimated at 97.6 percent over the SWs for both yearling Chinook and steelhead (preliminary data).

Juvenile Dam Passage Survival Performance Standard Testing – In 2012, the first year of performance standard testing was completed at McNary Dam. Juvenile dam passage survival met the performance standard for spring and summer migrants (Table 24). Due to high river flow, actual spill levels during performance standard testing exceeded the target spill levels for both spring and summer periods. During spring testing, actual spill was 51 percent compared to the target spill level of 40 percent. During summer testing, actual spill was 61 percent compared to the target spill level of 50 percent.

Table 24. Juvenile Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook Salmon at McNary Dam in 2012 (Preliminary Data) (Skalski et al., 2013d).

Species	Dam Passage Survival (% with 95% CI)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (%)
40 Percent Spill, SW bays 19 and 20			
Yearling Chinook	96.2 (94.8-97.6)	1.8	72.5
Juvenile Steelhead	99.1 (97.3-100.9)	1.8	83.2
50 Percent Spill, no SWs			
Subyearling Chinook	97.5 (96.4-98.6)	1.8	78.3

Figure 21 shows COMPASS estimates for McNary Dam survivals used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage prior to 2006. Predicted survival for both yearling Chinook salmon and juvenile steelhead expected to result from the proposed action is also included in Figure 21. Dam passage survival estimates for spring migrants from performance standard testing in 2012 (Figure 21) indicate dam passage survival is exceeding the expected value (COMPASS estimate) for yearling Chinook salmon and juvenile steelhead.

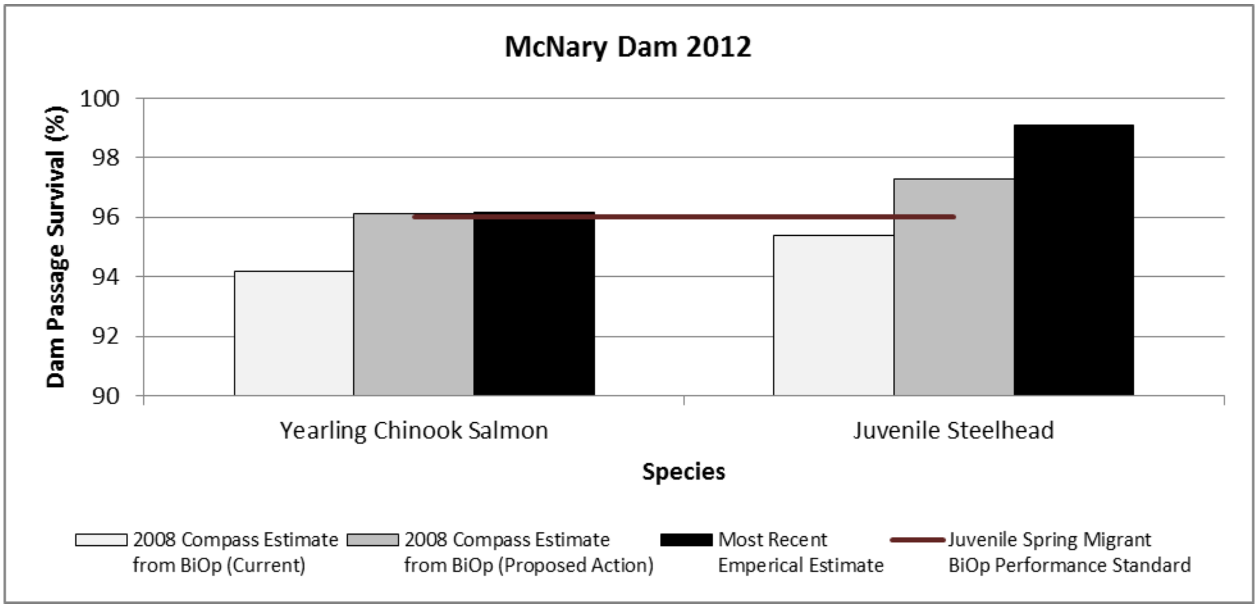


Figure 21. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for McNary Dam in 2012 (Preliminary Data) (Skalski et al., 2013c). COMPASS modeling estimates are not available for subyearling Chinook.

Figures 22-24 summarize recent juvenile fish passage distribution and route-specific survival rates at McNary Dam. The 2012 estimates for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon used the virtual-paired release model.

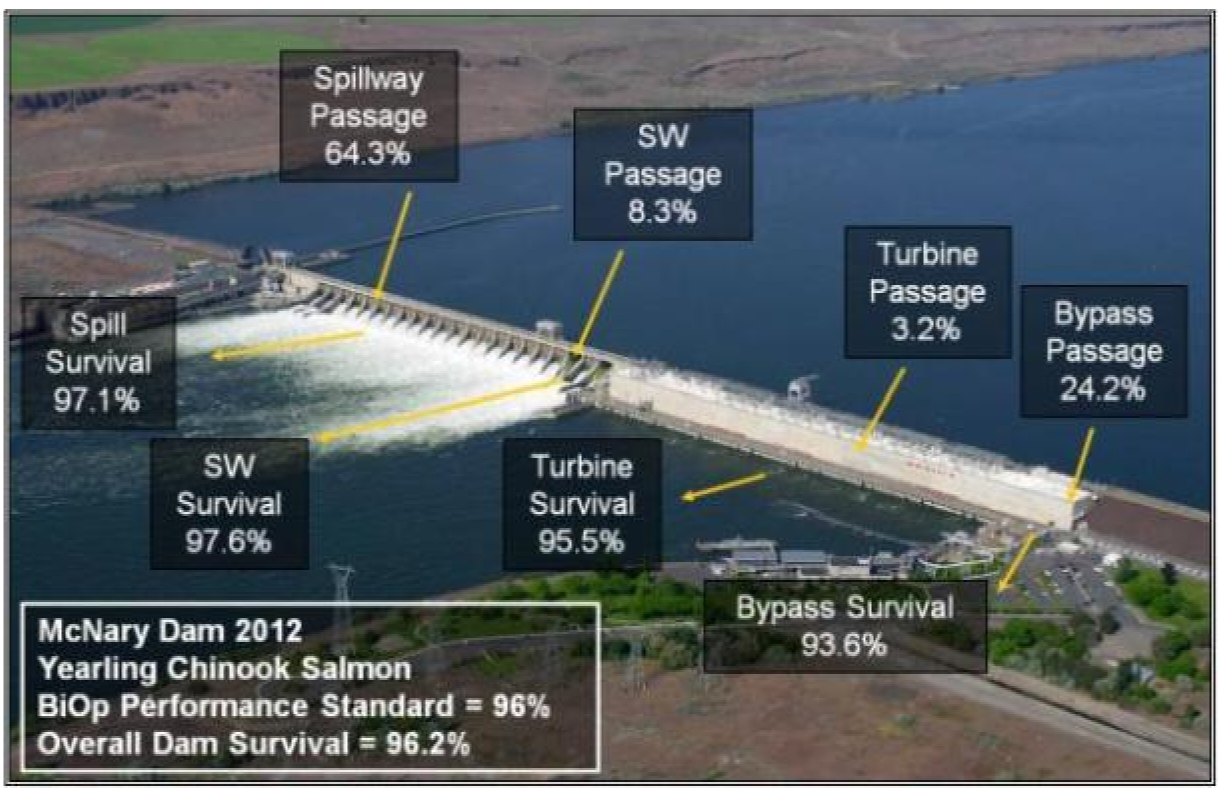


Figure 22. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at McNary Dam in 2012 (Skalski et al., 2013d).

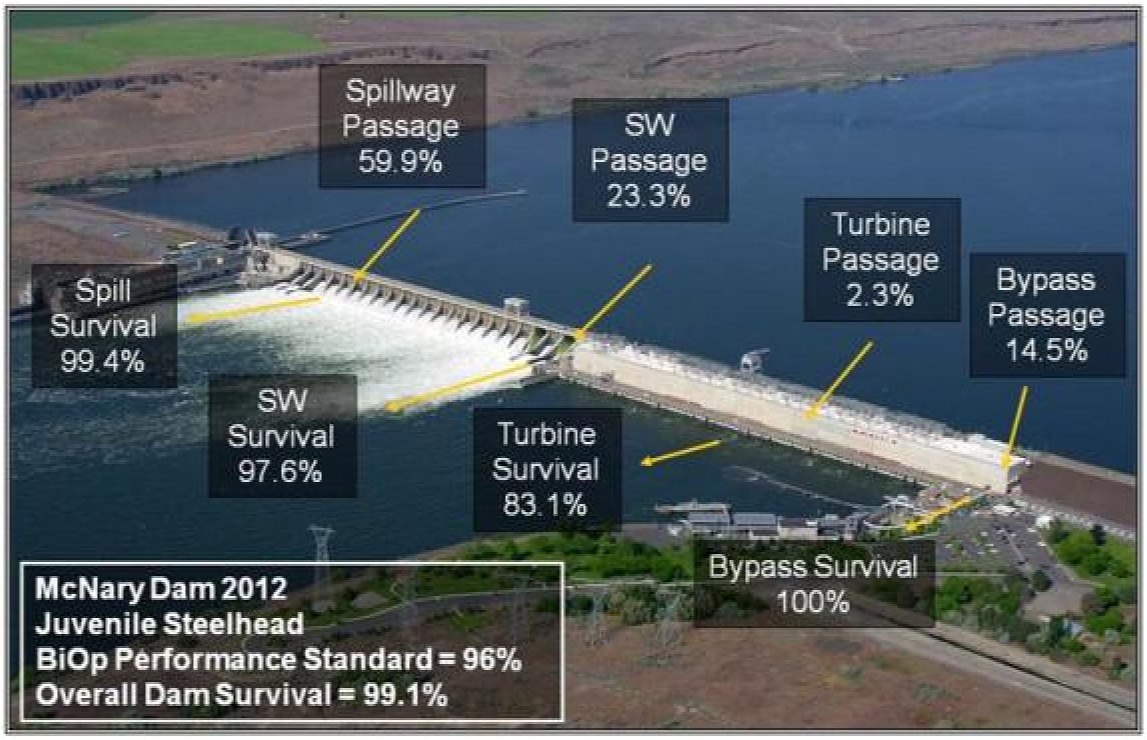


Figure 23. Percent passage by route and route-specific survival rates for juvenile steelhead at McNary Dam in 2012 (Skalski et al., 2013d).

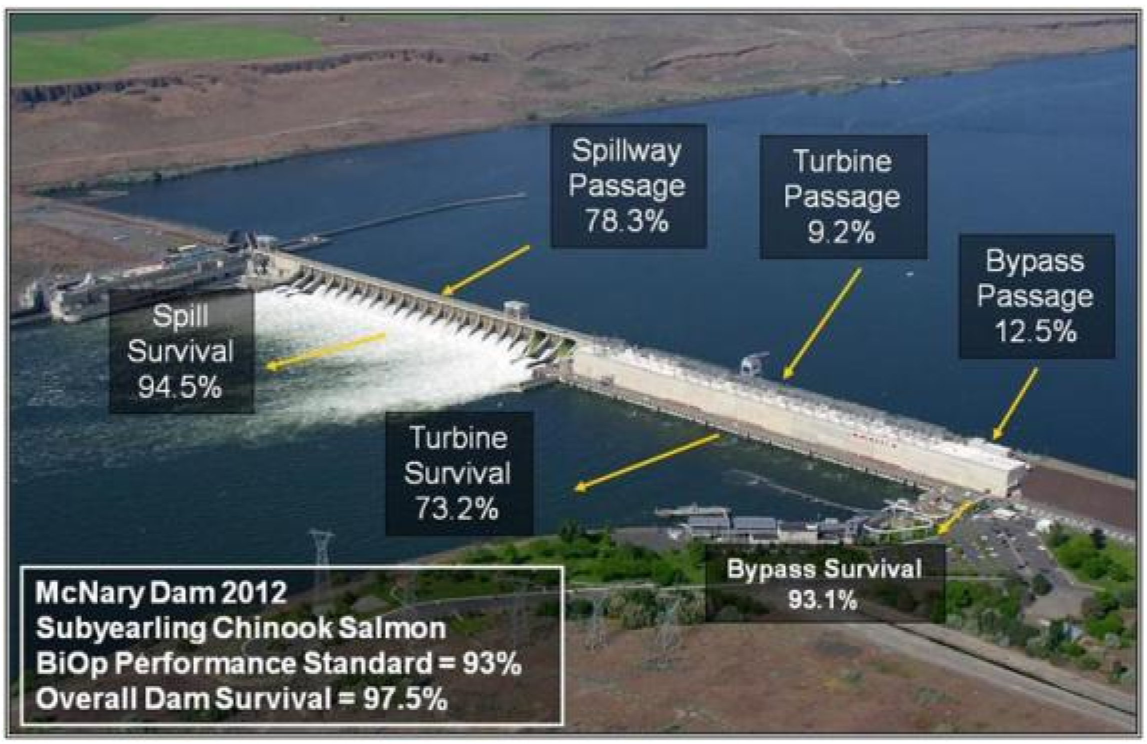


Figure 24. Percent Passage by Route and Route-Specific Survival Rates for Subyearling Chinook Salmon at McNary Dam in 2012 (Skalski et al., 2013d).

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:*

- *Guidance screen modification to improve FGE (2010).*
- *Turbine operation optimization to improve survival of turbine passed fish (2011).*
- *Spillway chute and/or deflector modification to reduce injury and improve survival of spillway passed fish through the RSW (2009).*
- *Turbine unit 2 replacement to improve the survival of fish passing through turbines and reduce oil spill potential (2012).*

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.

Development of the Ice Harbor Dam COP was initiated in 2007 and a draft was issued in December 2008 for Regional Forum review in 2009. Several actions were undertaken to improve the survival of fish passing Ice Harbor Dam in 2010 and 2011 (Table 25) and were completed as part of the Ice Harbor Dam COP process in working toward a final project configuration for full performance standard testing. Actions under development are also part of the Ice Harbor Dam COP process in working toward a final project configuration for meeting juvenile dam passage survival performance standards specified in the FCRPS BiOp. An Ice Harbor Dam COP Update was released in 2011.

Table 25. Summary of Juvenile Fish Passage Improvements implemented at Ice Harbor Dam since 2008.

Improvement	Year	Effect
Turbine operation optimization	On-going.	Improve the survival of turbine-passed fish.
Turbine units 2 and 3 replacement with turbine designed for fish passage	On-going – scheduled installation for Unit 2 in 2016, for Unit 3 in 2017.	Improve the survival of fish passing through turbines and reduce oil spill potential.

Guidance Screen Modification - A regional team evaluated the biological effects of improvements to the existing Standard Length Traveling Screens (i.e., raising the STS or adding flow vanes to reduce the potential of juvenile fish traveling through an 18-inch gap to the turbines) and concluded that no significant survival benefit (SB) was gained from eliminating this gap. Therefore, this action was not recommended in the draft COP, and was indefinitely deferred in 2009 due to a lack of regional support, as there were other potential actions that were both cost-effective and could provide significant SBs.

Turbine Operation Optimization - Turbine units were operated within 1 percent of best efficiency, with a few exceptions for maintenance between 2008 and 2011. In 2008, data collection for a study of turbine pressure regimes on untagged fish survival was completed. A risk assessment model to predict fish mortality rates during turbine passage is being developed that will provide updated operational guidance.

Spillway Chute and/or Deflector Modification - A SW was installed in spillbay 2 during the winter in-water work window of 2004/2005, with post-construction smolt passage and survival studies beginning in 2005 (Axel et al., 2007a; Ogden et al., 2005). Hydraulic modeling of a spillway chute (ogee shape similar to Little Goose Dam spillbays) and deflector modification (radius and extended lengths) was initiated in 2008; however, completion of the SW chute modification was deferred because of a lack of regional support. In 2009, design and hydraulic model tests for a SW chute modification was expanded in scope to include consideration of a spillbay PIT-tag system with implementation planned for the winter of 2011-2012 following detection efficiency testing in 2011. In 2009, passage behavior, passage distribution, and survival of the competing spill operations were re-evaluated to compliment the 2008 evaluations using radio telemetry at Ice Harbor Dam for yearling Chinook, juvenile steelhead, and subyearling Chinook. The design of the potential SW chute modifications, including PIT-tag system integration was completed in 2010, but then deferred to spillway PIT-tag detection at the higher priority Lower Granite Dam SW spillbay.

Turbine Unit 2 Replacement - In 2008, development of water pathway modification alternative testing and selection was completed for the development of draft plans and specifications for design and supply for a new turbine runner. The design and supply plan was completed in 2009. Contractors submitted a draft final report of rapid decompression effects on tagged and untagged fish in 2009 as well. The primary design goals are to optimize the turbine for safe fish passage by increasing nadir pressures and minimizing the potential for direct injury and disorientation. Design for power and efficiency is secondary. Physical scaled model studies at ERDC were exercised to determine alternatives for runner, stay vane, wicket gate, and draft tube designs for the new turbine runners. Through literature review and Sensor Fish data analysis provided from Bonneville PH2, and John Day and Ice Harbor dams (Carlson et al., 2008), minimum nadir pressure criteria of 12 psia was established for the new turbine runners.

The second iteration of the fixed and Kaplan runners was complete in 2012, identifying improvements to be made during the third iteration. The computational fluid dynamics (CFD) modeling of the turbine runner designs indicated that minimum nadir pressures of the prototype runners will be above 13 psia for all operations, and in most cases, greater 14 psia.

These turbine runners will essentially eliminate the risk of barotrauma and reduce rates of mechanical injuries relative to existing turbine passage conditions. The third iteration of the fixed-blade runner is being used to reduce some flow turbulence below the runner and finalize the design. Installation is scheduled for 2016 and 2017.

Passage and Survival Evaluations – The purpose of the 2008 (Axel et al., 2010a) and 2009 (Axel et al., 2010b) passage and survival studies was to compare fish passage and survival under two spill operations; gas cap day/45 kcfs spill night vs. 30 percent spill 24 hours per day. NOAA Fisheries used single-release survival estimates of radio tagged smolts during the Lower Monumental Dam passage and survival studies to examine behavior, passage, and survival of spring (yearling Chinook and steelhead) and summer (subyearling Chinook) juvenile migrants passing Ice Harbor Dam. Tagged fish were released near Central Ferry State Park, 21 km upstream from Ice Harbor Dam, and in the tailrace of Lower Monumental Dam, approximately 0.5 km downstream from the dam. Relative concrete survival estimates are listed below for 2008 (Table 26) and 2009 (Table 27). Operation pooled estimates for 2008 for all three listed Snake River stocks met the FCRPS BiOp juvenile salmon dam survival performance standards of 96 percent for spring migrants and 93 percent for summer migrants (Table 26). Survival estimates for individual spill treatments in 2009 are summarized in Table 27.

Performance standard testing will be completed prior to 2018.

Table 26. Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook Salmon at Ice Harbor Dam in 2008 (Axel et al., 2010a).

Species	Dam Passage Survival (% with 95% CI)	Forebay Median Passage Time (hr)	Spill Passage Efficiency (%)
2008: Pooled Gas Cap day/45 kcfs spill night & 30% 24 hr (April 28-May 24) single release			
Yearling Chinook	96.6 (95.5-97.8)	1.7	71.0
Juvenile Steelhead	97.0 (95.9-98.1)	3.0	83.8
2008: Pooled Gas Cap day/45 kcfs spill night & 30% Spill 24 hr 30% (June 8-July 4) single release			
Subyearling Chinook	93.3 (91.9-94.7)	1.5	68.3

Table 27. Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook Salmon at Ice Harbor Dam in 2009 (Axel et al., 2010b).

Species	Dam Passage Survival (% with SE)	Forebay Median Passage Time (hr)	Spill Passage Efficiency (%)
2009: (April 28-May 25) single release			
Yearling Chinook			
Gas Cap day/45 kcfs spill night	93.1 (0.7)	1.3	93.2
30% spill 24 hr	94.1 (1.8)	3.1	76.6
50% spill 24 hr	91.4 (1.6)	1.0	80.8
Juvenile Steelhead			
Gas Cap day/45 kcfs spill night	95.0 (1.0)	2.7	88.0
30% spill 24 hr	94.3 (1.0)	4.0	69.9
50% spill 24 hr[1]	90.1 (1.7)	1.4	72.2
2009: (June 10-July 4) single release			
Subyearling Chinook			
Gas Cap day/45 kcfs spill night	89.6 (1.5)	1.7	92.8
30% spill 24 hr	91.3 (1.1)	2.3	62.0

1 - Results for the 50% spill treatment are reported, but are not comparable to the other two treatments since this treatment occurred during the latter portion of the study and also took place during much higher flows.

Figure 25 shows COMPASS estimates for Ice Harbor Dam survivals used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage prior to 2006, along with the predicted survival for both yearling Chinook salmon and juvenile steelhead that was expected to result as a consequence of the proposed action.

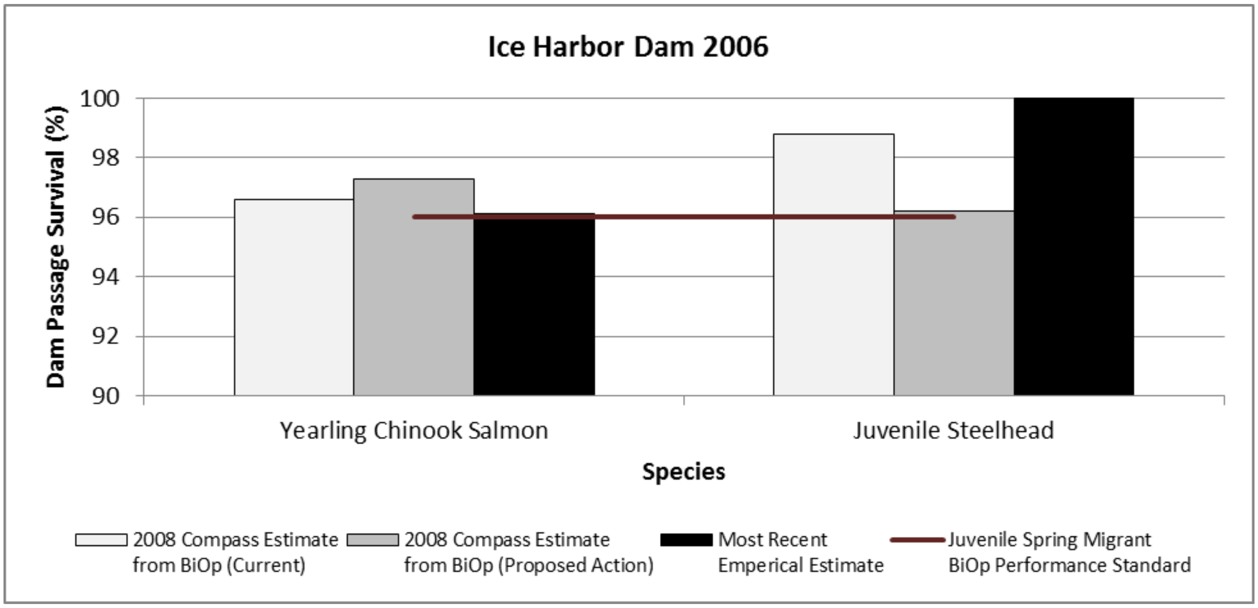


Figure 25. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for Ice Harbor Dam in 2006 (Axel et al., 2007b). COMPASS modeling estimates are not available for subyearling Chinook.

Figures 26-28 summarize the most recent juvenile fish passage distribution and route-specific survival rate estimates at Ice Harbor Dam. The 2009 estimate for subyearling Chinook salmon used the single release model taking opportunity of using sample fish surviving the Lower Monumental Dam study.

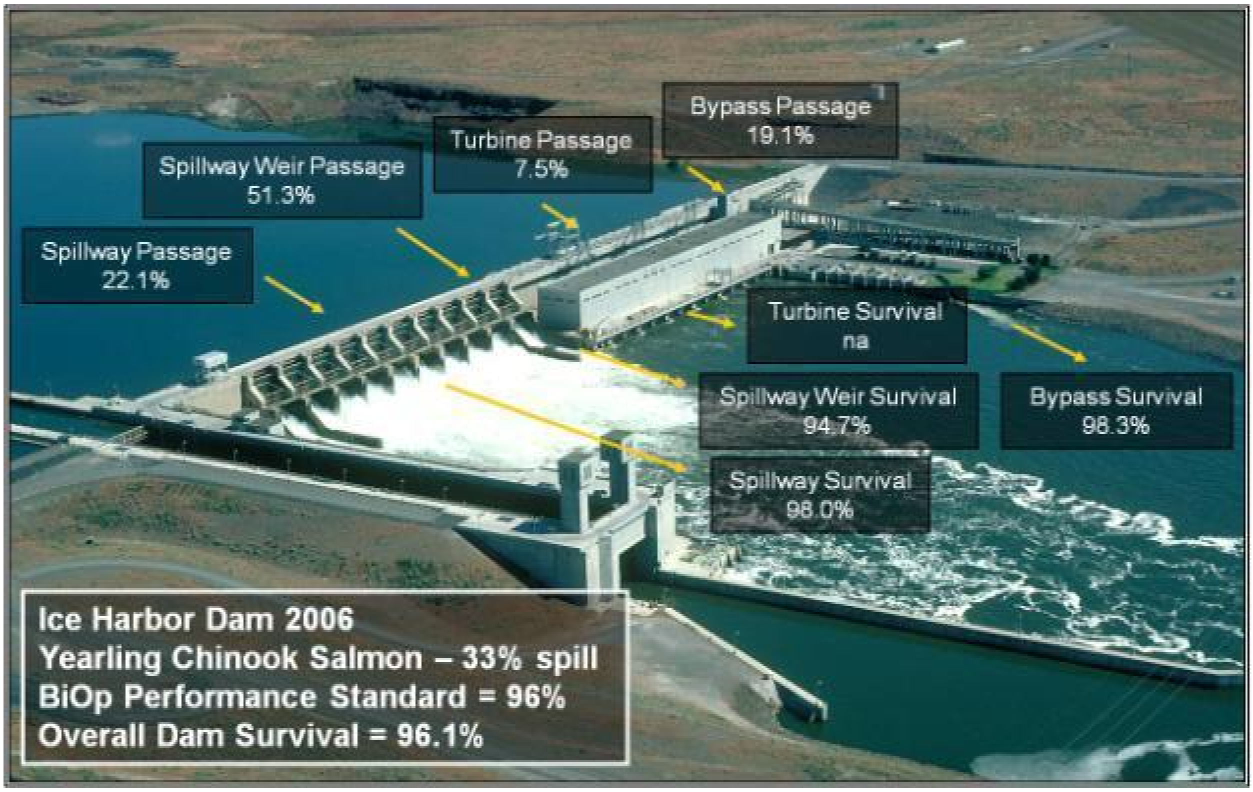


Figure 26. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at Ice Harbor Dam in 2006 (Axel et al., 2007b). Pooled gas cap day/45 kcfs spill night with surface weir and 30 percent spill 24 hr with surface weir (April 28-May 24).

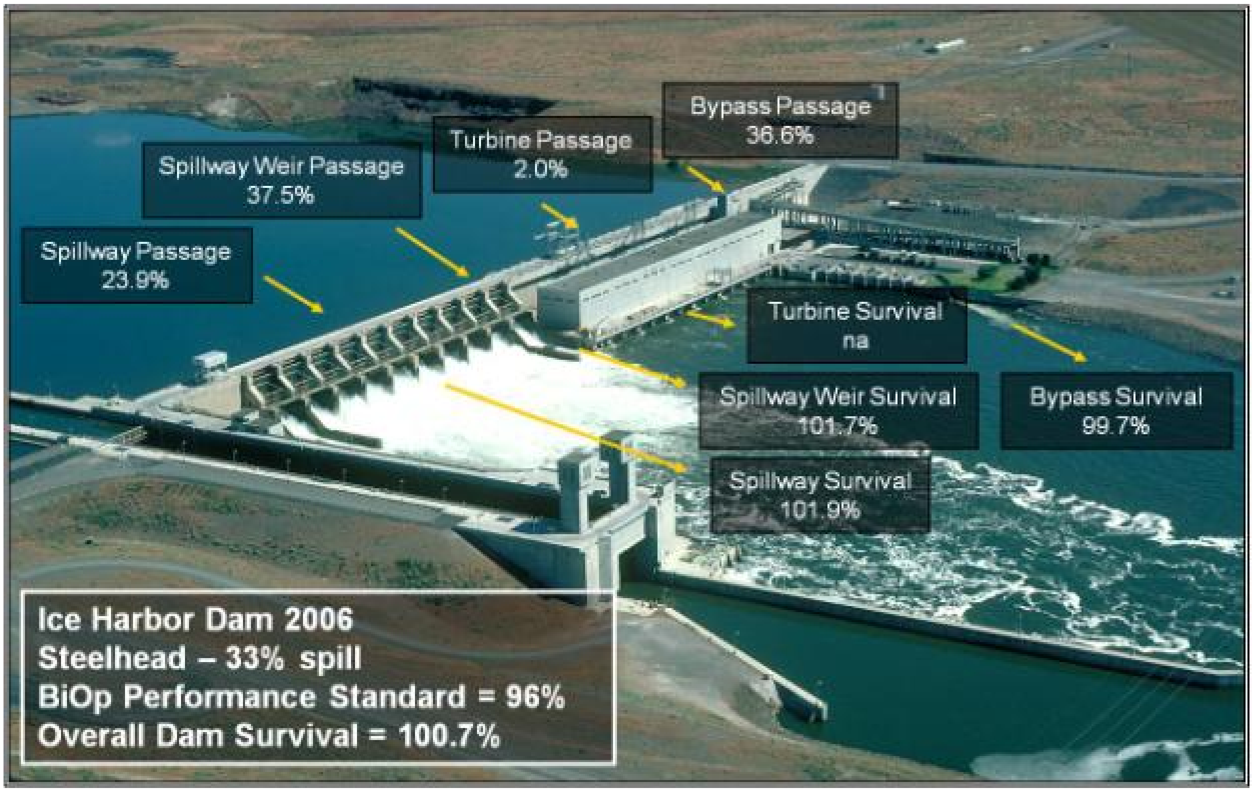


Figure 27. Percent Passage by Route and Route-Specific Survival Rates for Juvenile Steelhead at Ice Harbor Dam in 2006 (Axel et al., 2007b). Pooled gas cap day/45 kcfs spill night with surface weir and 30 percent spill 24 hr with surface weir (April 28-May 24).

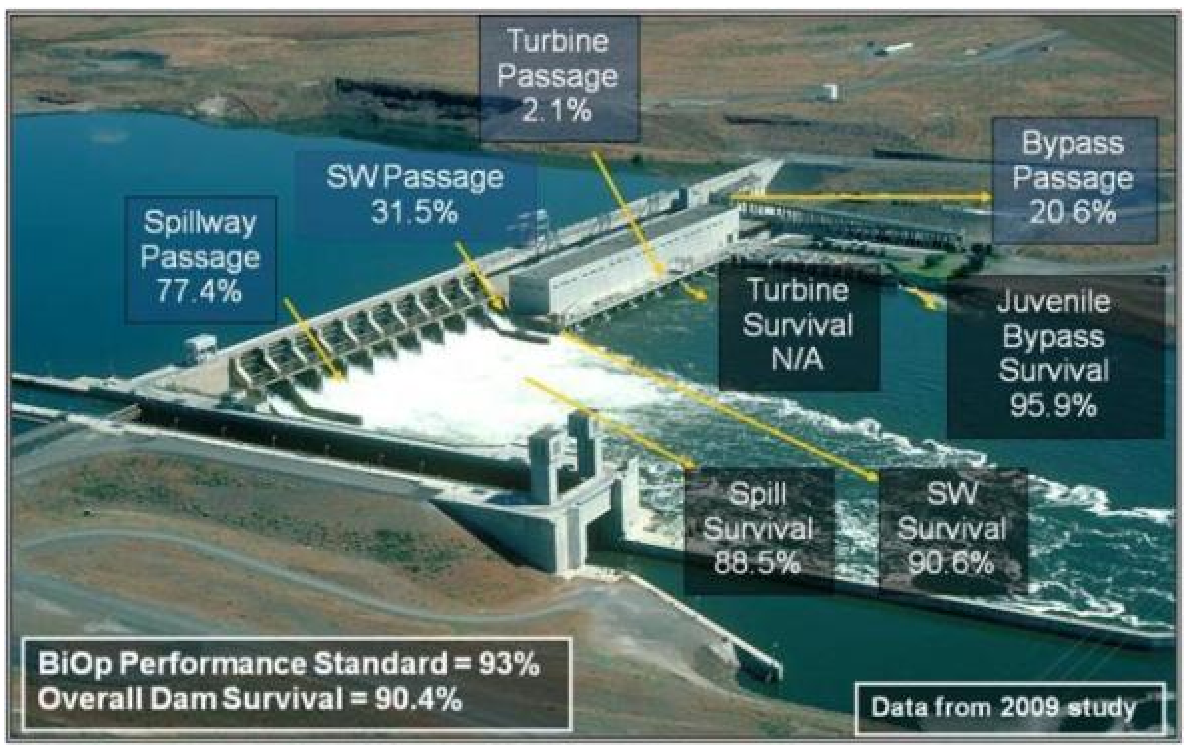


Figure 28. Percent Passage by Route and Route-Specific Survival Rates for Subyearling Chinook Salmon at Ice Harbor Dam in 2009 (Axel et al., 2010b). Pooled gas cap day/45 kcfs spill night with surface weir and 30 percent spill 24 hr with surface weir (June 8-July 4). Single release estimates.

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:*

- *Primary bypass operations with PIT-tag detection installation to reduce handling stress of bypassed fish (2007).*
- *Juvenile bypass system outfall relocation to improve egress, direct and indirect survival on bypassed fish (2011).*
- *Turbine operation optimization to improve the survival of fish passing through turbines (2013).*
- *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.

The following section focuses on dam configuration actions identified in the COP to achieve juvenile dam passage survival performance standards for Lower Monumental Dam. Included are items completed between 2008 and 2011, along with a description of research and results of performance standard testing conducted. The FCRPS BiOp current condition estimates of dam survival computed by the COMPASS model suggested that yearling Chinook and juvenile steelhead survival rates at Lower Monumental Dam were below the 96 percent dam survival standard (Figure 29). The FCRPS BiOp did not compute current condition estimates of dam survival by the COMPASS model for subyearling Chinook, but pre-2008 FCRPS BiOp dam survival studies in 2006 and 2007 showed mixed results for subyearling Chinook survival with survival estimated at 94.1 percent in 2006, and 84.5 percent in 2007 (Absolon et al., 2008a and 2008b). The primary focus of these studies was to collect passage metrics and survival estimates before the installation of a surface passage structure. The post construction passage and survival studies in 2008 and 2009 (Hockersmith et al., 2010a and 2010b) were very near the 93 percent dam survival performance standard with an estimate of 93.2 percent (95 percent C.I. 88.8-97.6) in 2006 and 92.9 percent (95 percent C.I. 90.8-95.1) in 2007.

The SW was completed just prior to the 2008 juvenile fish passage season. The SW increased juvenile fish survival at the spillway through improved conveyance over the SW and improved egress in the forebay and tailrace while reducing turbine and bypass entrainment of juvenile salmon and steelhead.

Further configuration and operation improvements at Lower Monumental Dam therefore focused on relocating the juvenile bypass outfall pipe, which was completed in the winter of 2011-2012. A performance standard evaluation began in 2012 to verify the 2009 spring survival evaluation where Hockersmith et al. (2010b) demonstrated dam survivals of 96 percent for spring/summer Chinook salmon and juvenile steelhead. The first year of performance standard testing to verify the 93 percent survival of subyearling Chinook salmon was also conducted in 2012. Once performance standard testing is complete, if further actions are necessary to achieve or maintain juvenile performance standards, potential actions to consider have been identified in the Lower Monumental Dam COP.

The following research was conducted between 2008-2012 to evaluate post-construction effects for juvenile survival and passage efficiency metrics:

Passage and Survival Evaluations – The purpose of the 2008 and 2009 passage and survival studies was to document fish passage and survival when the dam was operated with the new SW installed in March of 2008. Relative concrete survival estimates were 96.3 percent for yearling Chinook, 100.6 percent for steelhead, and 93.2 percent for sub-yearling Chinook salmon in 2008. In 2009, two spill patterns (bulk and uniform) were tested, and relative concrete survival estimates were 97.3 percent for yearling Chinook, 96.7 percent for steelhead, and 93.2 percent for sub-yearling Chinook salmon during uniform spill and 97.5 percent for yearling Chinook, 97.6 percent for steelhead, and 92.9 percent for sub-yearling Chinook salmon using the bulk pattern.

Performance standard testing at Lower Monumental Dam was conducted in 2012 for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon. The purpose of this passage and survival study was to test for survival of spring and summer migrating salmon and steelhead to in meeting performance standard metrics of 96 percent overall dam survival in the spring and 93 percent overall dam survival in the summer as outline in the FCRPS BiOp. Overall dam passage survival estimates were 98.7 percent for yearling Chinook, 98.3 percent for steelhead and 97.9 percent for subyearling Chinook salmon.

A retrospective review of recent survival study results at FCRPS dams where spill operations were similar to current spill operations is currently underway. The Action Agencies are proposing that results from a passage and survival study conducted in 2009 at Lower Monumental Dam (Hockersmith et al., 2010b) meet the criteria for conducting an acceptable study to estimate juvenile fish survival and therefore, may be considered towards meeting the performance standard of 96 percent dam passage survival for spring migrants (spring/summer Chinook salmon and steelhead). After further regional review of these study results, the Action Agencies in consultation with NOAA will make a determination whether the 2009 study results can be applied towards meeting the spring migrant performance standard.

Direct Injury Evaluation of the SW – Post-construction evaluation included estimating the direct injury of salmonids prior to the juvenile outmigration. The study design included estimating the survival (direct effects) and injury of juvenile Chinook salmon smolts during passage through a newly installed SW in spillbay 8. All four metrics used to assess SW passage effects pointed to the same conclusion; fish passing near the ogee encountered a less benign exit route than those passing higher (within 6.5 feet) in the water column.

Table 28. Dam Passage Survival (with 95 Percent CI), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook Salmon at Lower Monumental Dam in 2008, 2009 and 2012 (Hockersmith et al., 2010a, 2010b; Skalski et al., 2013e).

Year	Spill treatment	Species	Dam Passage Survival (% with 95% CI)	Forebay Median Passage Time (h)	Spill Passage Efficiency (%)
2008	Combined	Yearling Chinook	96.3 (92.9-99.7)	2.2	64.6
2009	Uniform	Yearling Chinook	97.3 (95.1-99.6)	2.8	80.2
2009	Bulk	Yearling Chinook	97.5 (93.1-102.0)	3.6	73.0
2012	Combined	Yearling Chinook	98.7 (96.9-100.5)	2.4	78.9
2008	Combined	Juvenile Steelhead	100.6 (98.7-102.6)	2.2	81.8
2009	Uniform	Juvenile Steelhead	96.7 (93.9-99.6)	3.2	71.3
2009	Bulk	Juvenile Steelhead	97.6 (95.5-99.8)	3.1	68.8
2012	Combined	Juvenile Steelhead	98.3 (97.9-98.7)	2.2	65.9
2008	Combined	Subyearling Chinook	93.2 (88.8-97.9)	2.3	40.4
2009	Bulk	Subyearling Chinook	92.9 (90.8-95.1)	1.3	61.5
2012	Combined	Subyearling Chinook	97.9 (96.3-99.5)	2.6	83.6

Figure 29 shows COMPASS estimates for Lower Monumental Dam survivals used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage prior to 2006, along with the predicted survival for both yearling Chinook salmon and juvenile steelhead that was expected to result as a consequence of the proposed action. Estimates of juvenile dam passage survival from radio telemetry survival estimates in 2008 and 2009 shown in Figure 29 indicate dam passage survival is generally exceeding the expected or COMPASS estimate value of what was expected for yearling Chinook salmon and juvenile steelhead.

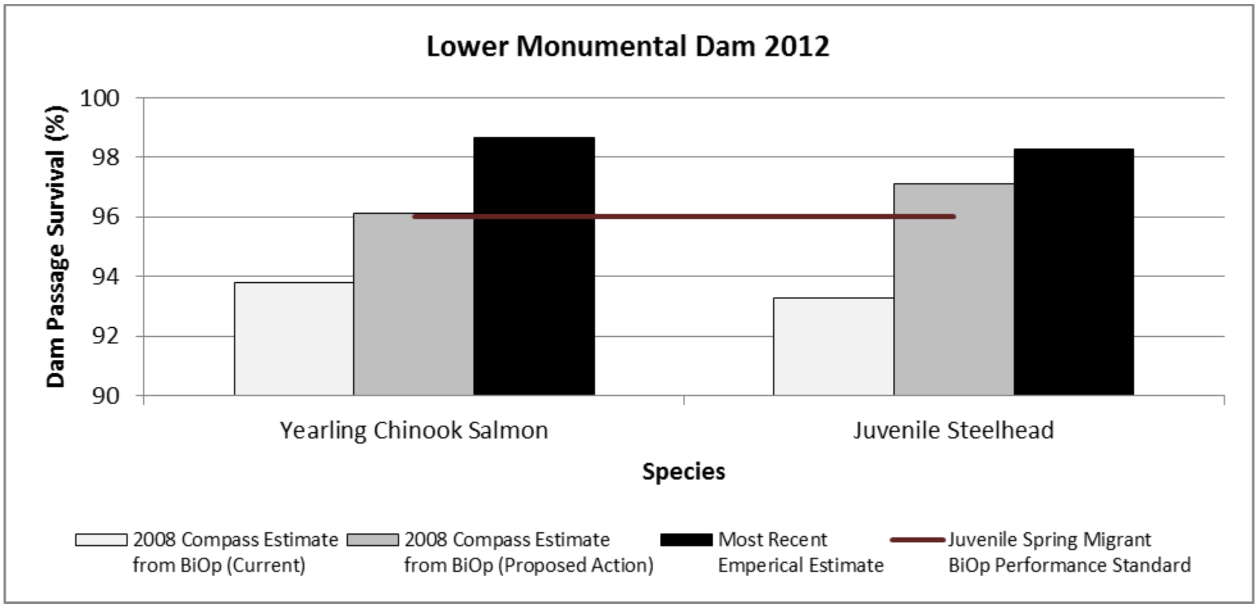


Figure 29. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for Lower Monumental Dam in 2012 (Skalski et al., 2013e). COMPASS modeling estimates are not available for subyearling Chinook.

Figures 30-32 summarize the juvenile fish passage distribution and route-specific survival rates at Lower Monumental Dam during 2012.

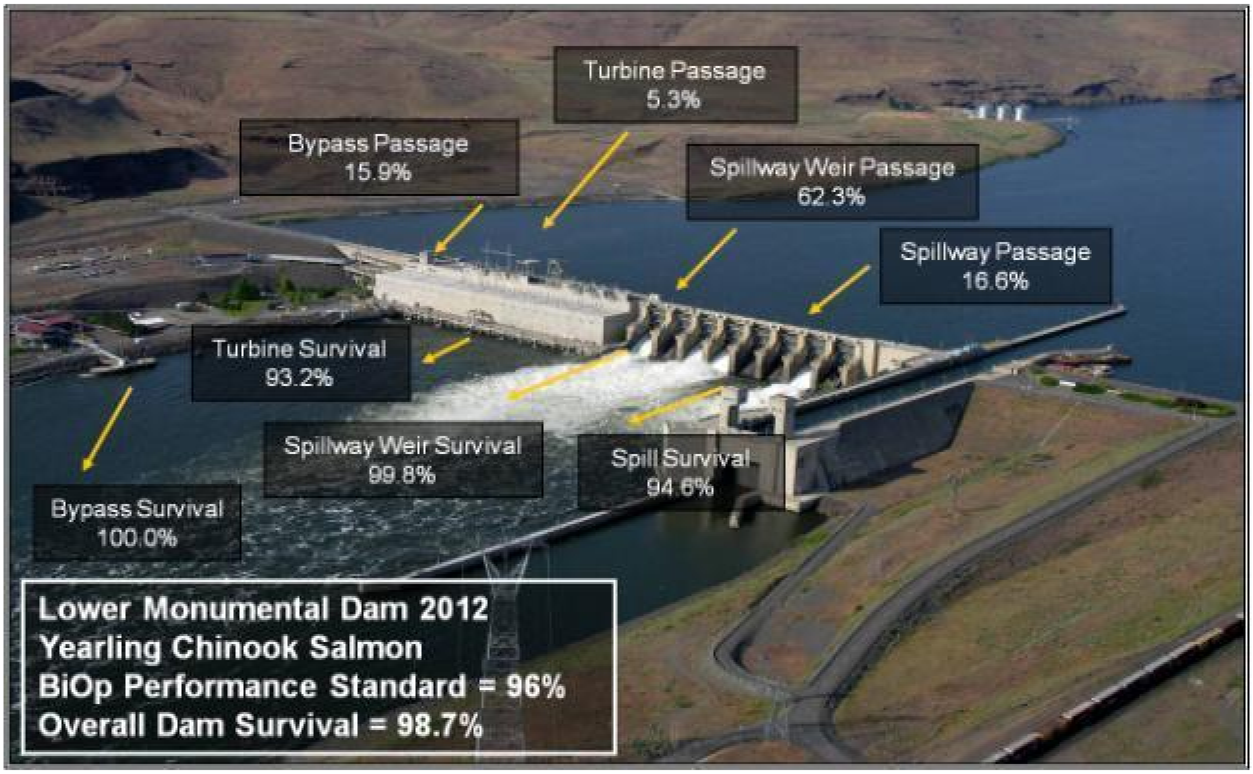


Figure 30. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at Lower Monumental Dam in 2012 (Skalski et al., 2013e).

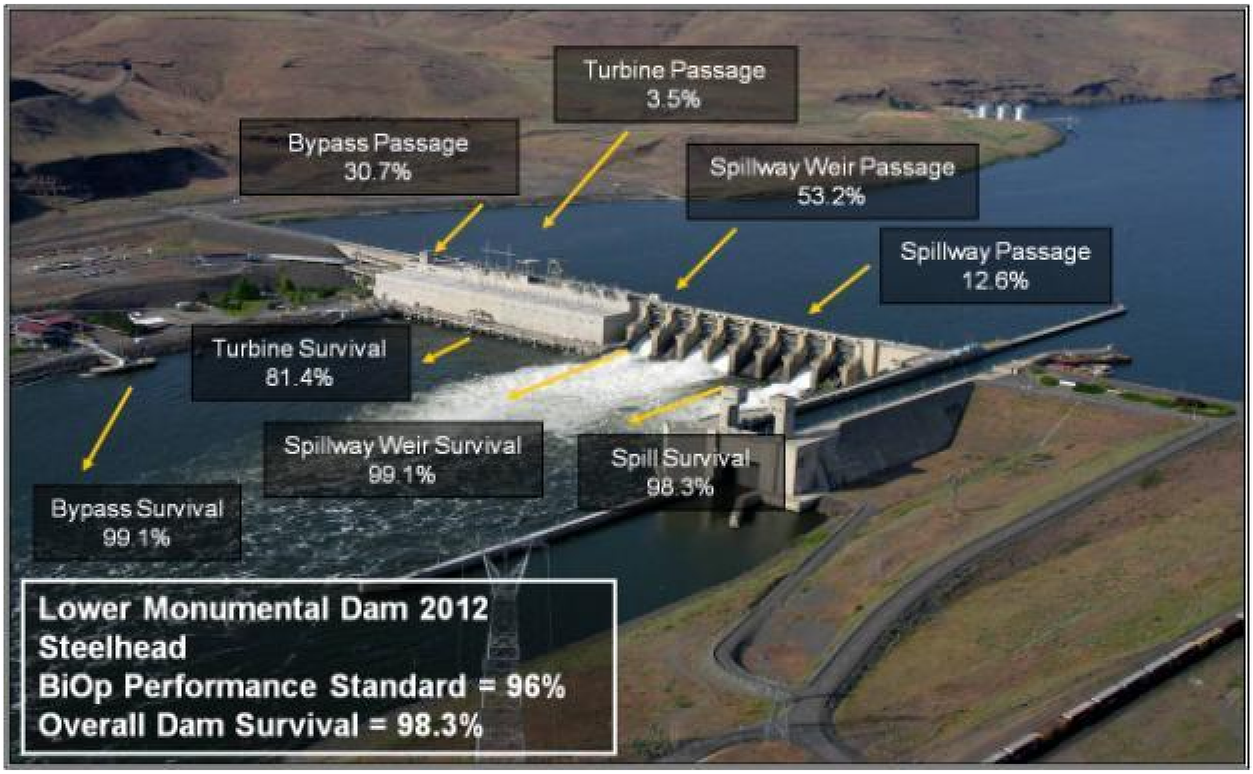


Figure 31. Percent Passage by Route and Route-Specific Survival Rates for Juvenile Steelhead at Lower Monumental Dam in 2012 (Skalski et al., 2013e).

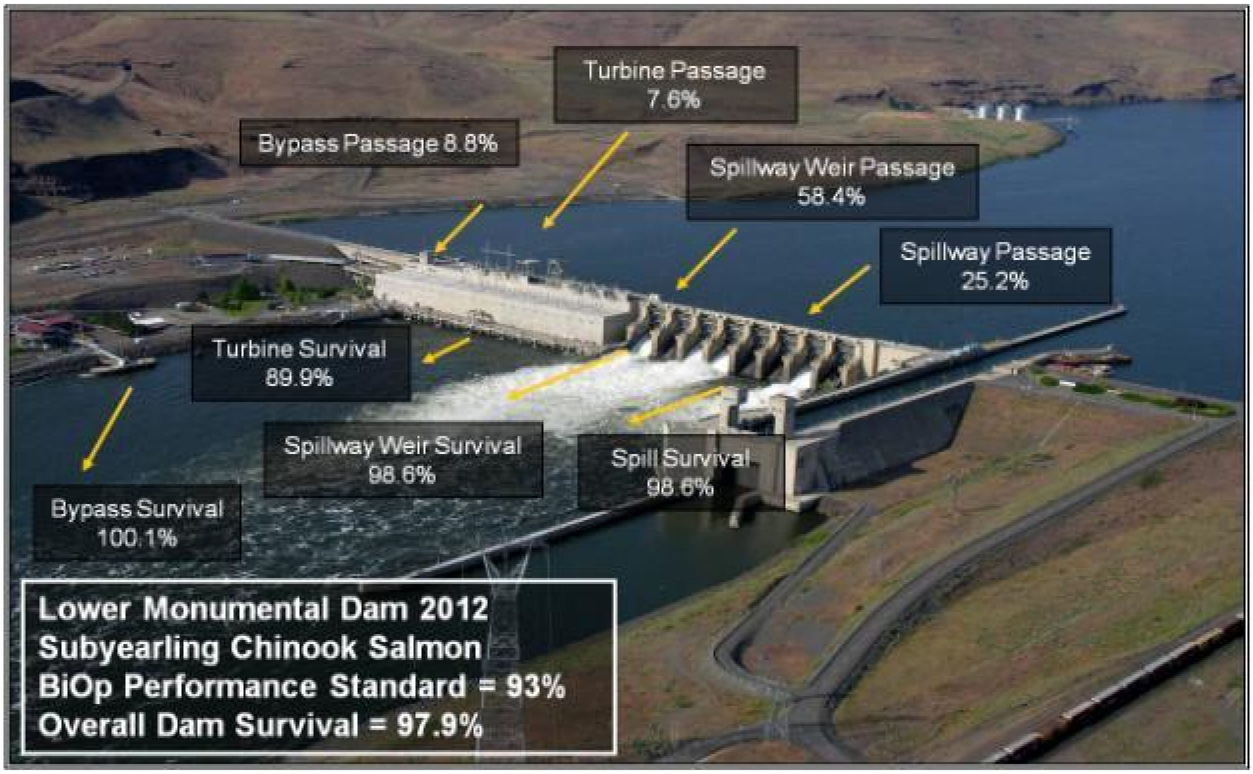


Figure 32. Percent Passage by Route and Route-Specific Survival Rates for Subyearling Chinook Salmon at Lower Monumental Dam in 2012 (Skalski et al., 2013e).

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:*

- *Turbine operation optimization to improve the survival of fish passing through turbines (2014).*
- *Primary bypass operations with PIT-tag detection installation to reduce handling stress of bypassed fish (2008).*
- *Primary bypass outfall relocation to improve egress, direct and indirect survival on bypassed fish (2009).*
- *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.

The following section focuses on dam configuration actions identified in the COP to achieve the juvenile dam passage survival performance standards for Little Goose Dam. Included are items completed between 2008 and 2011, along with a description of research and results of performance standard testing conducted. The FCRPS BiOp current condition estimates of dam survival computed by the COMPASS model suggested that yearling Chinook and juvenile steelhead survival rates at Little Goose Dam were already above the 96 percent dam survival standard (Figure 33). The FCRPS BiOp did not compute current condition estimates of dam survival by the COMPASS model, but pre-FCRPS BiOp dam survival studies suggested that only one pre-SW operation for subyearling Chinook might meet the 93 percent dam survival standard. Only the 2006 30 percent spill with uniform spill pattern and its overall estimate (season-wide average combining uniform and bulk patterns for 24 hours) during the summer of 2006 resulted in a dam (concrete) passage survivals of 95.0 percent (95 percent C.I. 90.7,99.7) (SE 2.3) for uniform and 93.5 percent (95 percent C.I. 90.1,96.7) (SE 1.7) assisted by a single-release control survival over 94 percent (Beeman, 2010). Almost all other dam passage survival studies estimated Subyearling Chinook survival at approximately 3.0-4.2 percent below the 93 percent performance standard (Beeman et al., 2008; Beeman, 2010; Beeman et al., 2010). These paired release studies had low tailrace release control survival estimates less (≤90%). The post- top-spill weir (TSW) passage and survival study in 2009 (Beeman et al., 2010) met the 93 percent dam survival performance standard (95 percent: 95 percent C. I. = 92.6-97.8); however, 88 percent control survival led the Region to question the accuracy of the estimate and not fully accept it as having met the subyearling Chinook performance standard. Configuration and operation improvements at Little Goose Dam therefore focused on the relocated juvenile bypass outfall pipe that was completed in the winter of 2008-2009.

The draft Little Goose Dam COP was reviewed by NOAA Fisheries in 2010. The Draft Final COP was distributed in 2011, and full performance standard testing was conducted in the spring and summer of 2012. If further actions are necessary to achieve or maintain juvenile performance standards, potential actions to consider have been identified in the Little Goose Dam COP.

Table 29. Summary of Juvenile Fish Passage Improvements Implemented at Little Goose Dam since 2008.

Improvement	Year	Effect
Juvenile Bypass Outfall Relocation	2008-2010	Releases juvenile and adult bypassed fish in an area with higher river velocities and consistent downstream flow during all operations. This relocation is expected to decrease predation on the bypassed fish while facilitating more rapid egress from the tailwaters of the dam.
JBS Full Flow PIT-Tag Monitoring	2009	Increases PIT-tag detection capability and operational flexibility of the JBS while avoiding potential stressors in the facility and capable of directly (primary) bypassing fish back to the river.
Spillbays 1 and 8 Flow Deflectors	2009	Improves tailrace egress conditions for fish passing through the surface flow outlets (bay 1) and outside spillbay (bay 8). Increased adult attraction flow recognition for North Shore and South Shore Ladder Entrances. Reduced TDG generation.
Spillbay 1 Spillway Weir	2009	Increased juvenile fish survival at the spillway through improved conveyance over the spillway surface weir and improved egress in the forebay and the tailrace while reducing turbine and bypass entrainment of juvenile salmon and steelhead.
Adult Chinook and Sockeye Salmon Passage Delay during Spring SW Operation	2011	Increased outflow pattern for the northern training spillbays (spillbay 8 priority) to reduce eddy formation that interfered with attraction flow net emitted from the north shore ladder entrance while not compromising the juvenile outmigrant conditions benefit from TSW operation.

Juvenile Bypass Outfall Relocation – The relocation was completed during the 2009–2010 JBS winter maintenance period. The relocated outfall releases fish in an area with higher river velocities and consistent downstream flow during all operations decreasing predation on bypassed fish.

JBS Full Flow PIT-Tag Monitoring – The installation of a juvenile PIT-tag monitoring system in the full-flow section of the primary bypass pipe occurred during the 2008-2009 winter maintenance period. The system provides PIT-tag detections while avoiding potential stressors in the facility and bypassing fish to the river.

Spillbays 1 and 8 Flow Deflectors – In conjunction with the SW, spillbay flow deflectors were constructed in bay 1 (SW bay) and bay 8 prior to the start of the2009 juvenile fish migration season. The new deflectors were designed with a longer radius curve, which reduces potential injury to fish in addition to reducing TDG production. The addition of a deflector in bay 8 also provides greater operational flexibility for adult and juvenile passage efficiencies during voluntary spill conditions.

Spillbay 1 SW –A SW was installed in spillbay 1 in 2009 prior to the juvenile fish migration season. The SW completion resulted in a surface passage route at each of the Corps' eight Columbia and Snake river dams. This is the first SW that incorporates an adjustable flow feature that allows the flow over the weir to be higher for spring runoff conditions and lower for summer runoff conditions.

Adult Chinook and Sockeye Salmon Passage Delay during Spring SW Operation - The spill pattern was modified to prioritize earlier spill season use of spillbay 8 to 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 operation was evaluated using the physical hydraulic model at the ERDC in Mississippi, and the new spill pattern was implemented in the Corps' 2011 FPP.

Passage and Survival Evaluation – The purpose of the 2009 passage and survival study was to document fish passage and survival when the dam was operated with the new SW installed in March 2009. The USGS used radio telemetry to examine behavior, passage, and survival of spring and summer juvenile salmonid migrants passing Little Goose Dam (Beeman et al., 2010). Tagged fish were released near Central Ferry State Park, 21 km upstream from the dam, and in the tailrace, approximately 0.5 km downstream from the dam. Relative concrete survival estimates were 99.4 percent for yearling Chinook, 99.8 percent for steelhead, and 95.2 percent for sub-yearling Chinook salmon.

Performance standard testing at Little Goose Dam was conducted in 2012 for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon. The purpose of this passage and survival study was to test for survival of spring and summer migrating salmon and steelhead to in meeting performance standard metrics of 96 percent overall dam survival in the spring and 93 percent overall dam survival in the summer as outline in the FCRPS BiOp. Overall dam passage survival estimates were 98.2 percent for yearling Chinook, 99.5 percent for steelhead and 95.1 percent for subyearling Chinook salmon in 2012 (Skalski et al., 2013f).

Direct Injury Evaluation of the SW and a Spillbay with a New Spill Deflector – Post-construction evaluation included estimating the direct injury of salmonids prior to the juvenile outmigration. The study design included estimating the survival (direct effects) and injury of yearling Chinook salmon during passage through a newly installed SW in spillbay 1 with a low and high crest. The investigation also evaluated survival and condition of fish passing over new flow deflectors (30-foot turning radius) installed in both spillbay 1 (SW) and spillbay 8 (unmodified spillway gate). The fish passing through the TSW-equipped spillbay had a lower survival than mid- or deep-passed fish at spillbay 8, however, the fish that survived were less likely to be injured. The low crest TSW with its higher discharge inflicted the fewest and least severe maladies. Installation of a new flow deflector with a 30-foot turning radius in a conventional spillbay (spillbay 8) at Little Goose Dam appeared to diminish the incidence and severity of injuries for deep-passed fish compared to that observed previously at a conventional Little Goose Dam spillbay (spillbay 2) that was equipped with a flat flow deflector.

Table 30. Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook Salmon at Little Goose Dam in 2009 (Skalski et al., 2013f).

Species	Dam Passage Survival (% with 95% CI)	Forebay Median Passage Time (hours)	Spill Passage Efficiency (%)
30 Percent Spill (April 18-May 21)			
Yearling Chinook	98.2 (97.5-99.0)	2.58	65.3
Juvenile Steelhead	99.5 (98.7-100.3)	7.80 2.67	56.1
30 Percent Spill (June 6-July 5)			
Subyearling Chinook	95.1 (94.1-96.1)	2.80	72.5

Figure 33 shows COMPASS estimates for Little Goose Dam survivals used in the development of the FCRPS BiOp using the best available empirical information on juvenile dam passage prior to 2006, along with the predicted survival for both yearling Chinook salmon and juvenile steelhead that was expected to result as a consequence of the proposed action. Estimates of juvenile dam passage survival from radio-telemetry survival estimates in 2009 shown in Figure 33 indicate dam passage survival is exceeding the expected or COMPASS estimate value of what was expected for yearling Chinook salmon and juvenile steelhead.

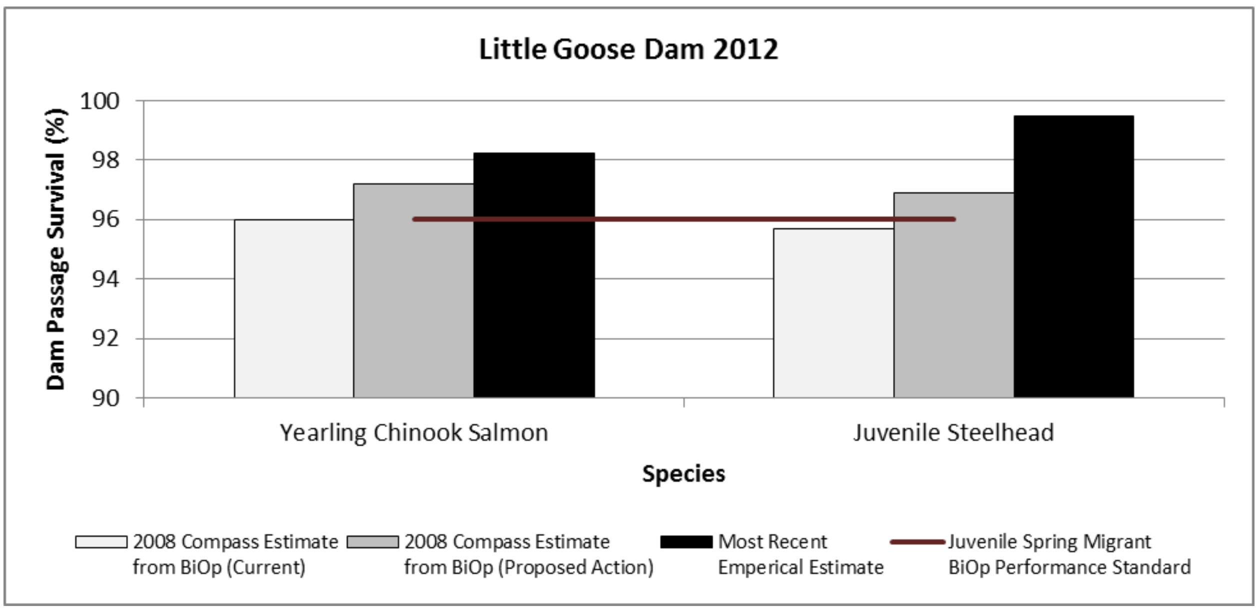


Figure 33. Yearling Chinook Salmon and Juvenile Steelhead Dam Passage Survival Estimates from the FCRPS BiOp COMPASS Modeling vs. Most Recent Empirical Survival Estimates for Little Goose Dam in 2012 (Skalski et al., 2013f). COMPASS modeling estimates are not available for subyearling Chinook.

Figures 34-36 summarize the most recent juvenile fish passage distribution and route-specific survival rates at Little Goose Dam. The 2012 estimates for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon used the virtual paired release survival model.

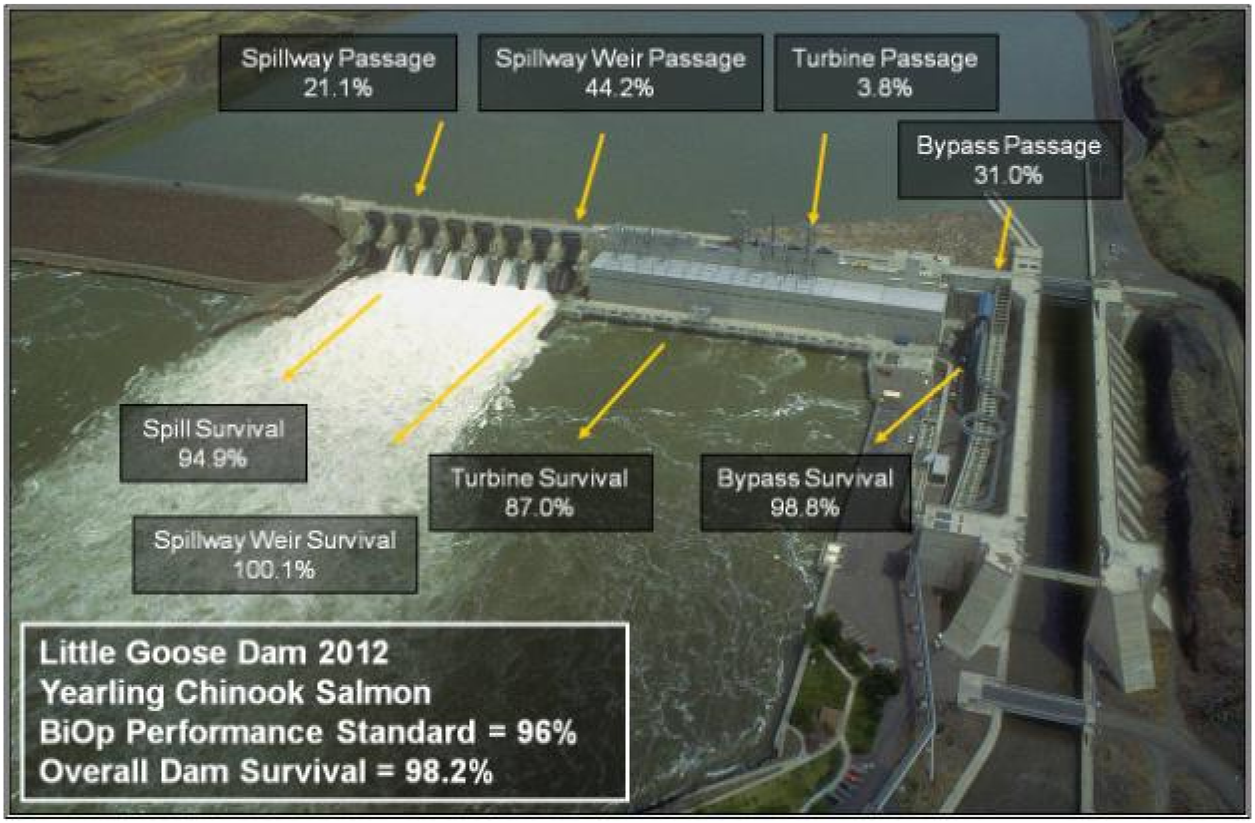


Figure 34. Percent Passage by Route and Route-Specific Survival Rates for Yearling Chinook Salmon at Little Goose Dam in 2012 (Skalski et al., 2013f).

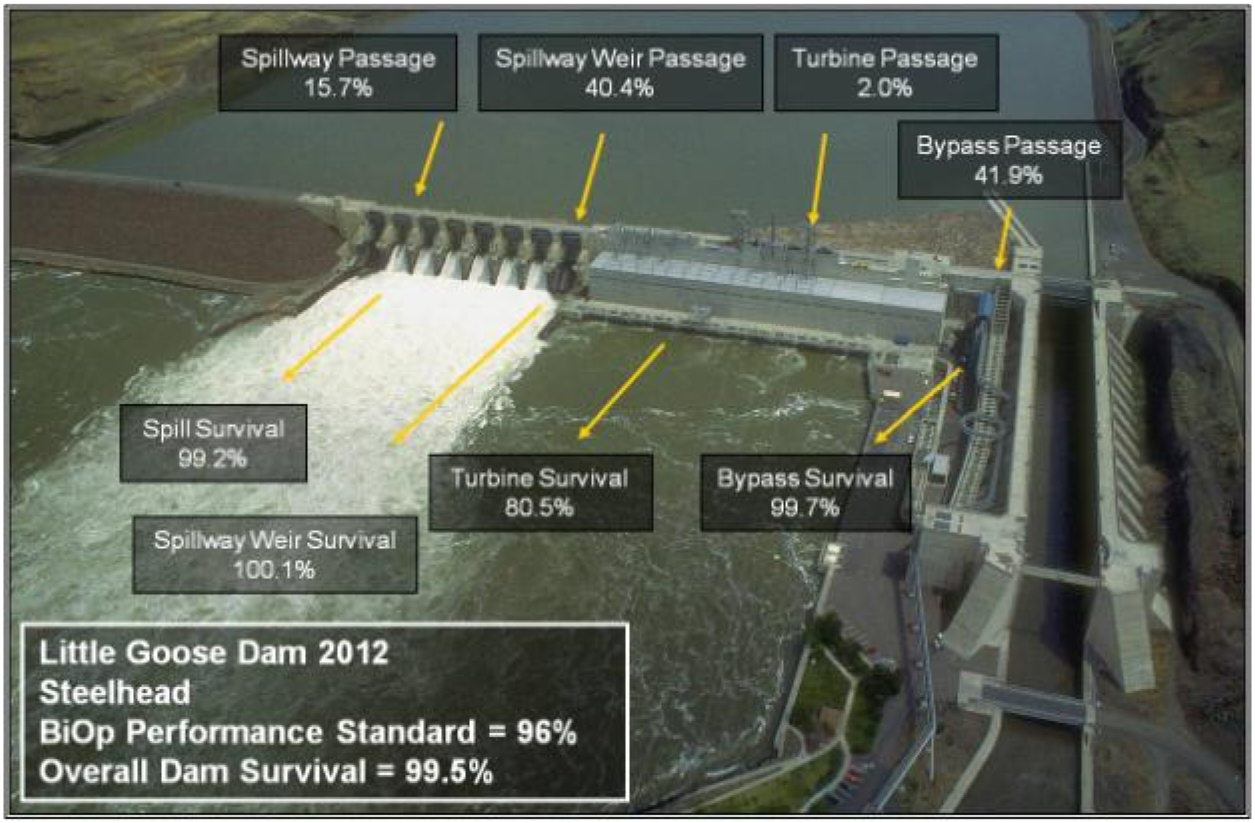


Figure 35. Percent Passage by Route and Route-Specific Survival Rates for Juvenile Steelhead at Little Goose Dam in 2012 (Skalski et al., 2013f).

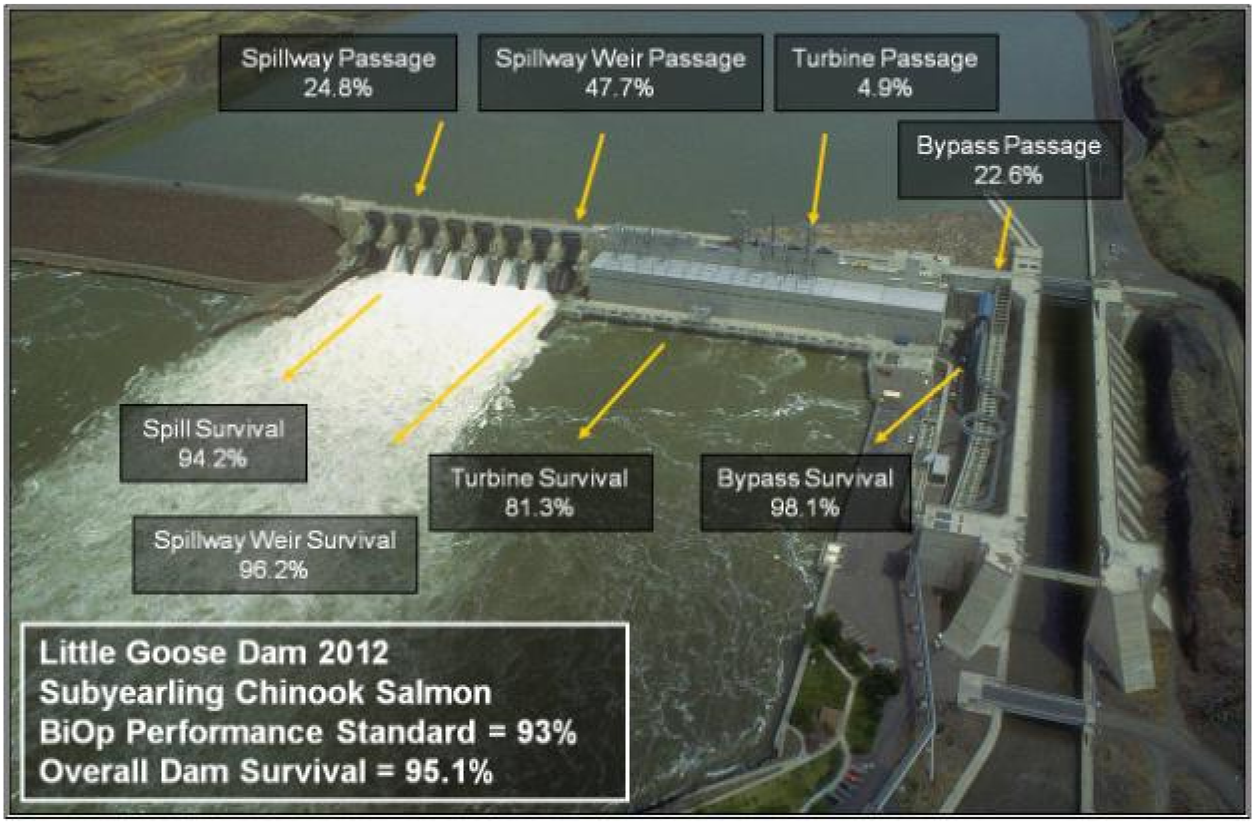


Figure 36. Percent Passage by Route and Route-Specific Survival Rates for Subyearling Chinook Salmon at Little Goose Dam in 2012 (Skalski et al., 2013f).

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:*

- *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).*
- *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.

No operation or configuration changes have taken place at Lower Granite Dam since 2008. Operations have been maintained from year to year and no construction of fish passage configuration alternatives has occurred. Completion of a draft Configuration and Operation Plan (COP) for Lower Granite Dam for internal review is now scheduled for 2013. Previously, regional meetings were held to develop alternatives and to assign biological benefits to these alternatives. Preliminary modeling was conducted on assigned benefits, and alternatives were ranked on their ability to meet the FCRPS BiOp performance standards. While performance standard testing has not been carried out at Lower Granite Dam, estimated juvenile survival from the Snake River trap to the Lower Granite tailrace (i.e. through both the dam and it's reservoir) in 2011 was 94.3 percent for yearling Chinook and 98.6 percent for steelhead (Faulkner et al., 2012). Corresponding preliminary 2012 survival estimates were 92.8 percent for yearling Chinook and 100.0 percent for steelhead (Zabel, 2012). These estimates, made with a single-release methodology, indicate that standard paired-release performance test results would likely be near the 96 percent target for spring migrants.

A final draft Engineering Design Report (EDR) was completed in March 2010 for the Lower Granite JFF Upgrade. This EDR described proposed modifications to the JFF to provide safe and efficient holding, loading, and bypass facilities for juvenile salmon and steelhead. Modifications and additions would also benefit passage of adult salmonids, particularly steelhead kelts. Due to the high cost of the plan recommended in that EDR relative to projected future Columbia River Fish Mitigation (CRFM) budgets, the Corps decided to prepare a supplemental report to evaluate and recommend a plan that would prioritize and sequence implementation into phases to better fit within projected CRFM funding constraints. The supplemental report considered splitting the Lower Granite JFF Upgrade into two phases. The first phase would include larger collection gallery orifices and/or overflow weirs, transportation flume, primary dewaterer, primary bypass and new outfall, and would be connected to the existing juvenile fish separator. Everything downstream of the separator (distributions flumes, sampling system, fish holding and loading facilities, etc.) would be included in the second phase. Developments of plans and specifications for Phase 1 began in 2012, with construction expected to begin in 2014.

To assist in development of JFF Upgrade plans, two prototype overflow weirs and enlarged (14") orifices between the turbine intake gatewells and the juvenile fish collection channel will be tested in 2013 and 2014. Plans and specifications for the test weirs and enlarged orifices in turbine intakes 5A and 6A have been completed and a construction contract was awarded in FY2012 for installation of the prototypes. Installation of the new orifice and weir for 5A was completed before the 2013 migration season. The installation for 6A is scheduled for completion before the 2014 migration season. Biological testing will occur in spring and summer 2013 and 2014 to help assess final configuration of the juvenile collection channel design.

RPA Action 26 – Chief Joseph Dam Flow Deflectors: *The Corps will complete the flow deflector construction at Chief Joseph Dam by 2009.*

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

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 2008 through 2012, turbine units were, with a few exceptions, 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 PH 1 was allowed to operate outside the 1 percent operating range to accommodate high river discharge and to mitigate TDG levels in the spillway. The lower head at Bonneville Dam provides good fish passage survival through the powerhouse, so no adverse effects of this operation were expected or experienced. In 2012, in coordination with the TMT, Bonneville PH 1 was operated outside the 1 percent operating range to implement a SOR that resulted in limiting PH2 to operating at the mid-point. Data on turbine unit operations are provided to NOAA Fisheries annually.

From 2008 through 2012, the Corps also continued work to determine the safest turbine operating point for fish passing through existing FCRPS turbines, along with studies related to a new turbine design for Ice Harbor Dam. Results are discussed in the coverage of RPA subactions 54.4 and 55.6.

RPA Action 28 – Columbia and Snake River Project Adult Passage Improvements: *The Corps will implement the following structural improvements to adult passage at the mainstem Columbia and Snake river projects:*

- *Bonneville Dam*
    - *Improve the Bradford Island ladder system to reduce stress and improve reliability of upstream adult passage (2013).*
- *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).*
- *John Day Dam*
    - *Adult ladder systems modifications to improve upstream adult passage conditions (2011).*
- *Ice Harbor Dam*
    - *Repair or replace north shore fishway auxiliary water supply (AWS) equipment as needed so that any two of the three pumps can meet flow criteria.*
- *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).*
- *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 (need will be determined by results of further research) (prototype 2011).*

Improvement Status at the Six Dams

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

- The second phase of a two-phase project was completed to assess the fishway condition and recommend feature repairs/replacement for the Bradford Island fishway at Bonneville Lock and Dam. The results of the study will be used by the Corps to establish priorities and budget funds for repairs/replacement.
- In addition to the Phase II fishway assessment report, the Corps accomplished the following repairs to the Bradford Island Ladder during 2008-2012:
  - Repaired A-branch diffusers
  - Repaired fish valve FV4-3
  - Refurbished count station crowder, including repair of structural integrity, sealing to reduce leakage and algal growth, and sandblasting and painting
  - Repaired hole in fish ladder floor at FG3-12
  - Removed wooden bulkhead in south collection channel

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).*

East Ladder Back-up Auxiliary Water Supply – Past radio-telemetry studies have shown passage times for adult fish crossing The Dalles Dam to be among the shortest in the FCRPS. As a result of these studies, adult fish passage at The Dalles Dam is generally considered to be good. However, there is concern regarding reliability of the auxiliary water supply system at The Dalles Dam east ladder. The auxiliary water system (AWS) supplies attraction flow to the ladder entrances, and an AWS failure could result in long passage delays for adult fish. Most adult salmon and steelhead at The Dalles Dam pass via the east ladder. To address east ladder AWS reliability, the Corps completed an alternatives study in 2012 and, in coordination with regional salmon managers, selected a back-up water supply alternative to construct. Design of the system will occur in 2013-14, and construction is planned for the 2014-2015 in-water work period.

North Ladder Entrance - In 2004, a 150-foot spillway training wall was constructed between spillbays 6 and 7, and a 6-bay spill pattern was implemented to improve juvenile fish survival. Adult passage through the north ladder was notably reduced following the change in spill operation due to the new training wall and spill patterns, particularly during periods of high spill (e.g., >100 kcfs). In 2010, a longer training wall was constructed between spillbays 8 and 9, and an 8-bay spill pattern was implemented. A 2010 radio-telemetry study suggested that adult spring-summer Chinook passage was not delayed as a result of the new tailrace conditions and structure, but the percentage of tagged salmon using the north ladder was lower during higher spill conditions (100-150 kcfs) (Jepson et al., 2011). The percent of fish using the north shore ladder before construction of the spillwall (2000-03) versus after construction of the extended wall (2010-12) was assessed as well (Figure 37). Based on the fish count data, there has been no substantial reduction in north shore ladder use by Chinook and steelhead. Sockeye use of the north shore ladder, however, was substantially lower post-spillwall vs. pre-spillwall. A radio-telemetry study is planned for 2013 and 2014 to further assess whether the extended-length spillwall has delayed adult salmon as compared to pre-spillwall conditions. Using results from this study as well as ladder counts, the Corps will work with regional stakeholders to determine whether additional improvements are warranted.

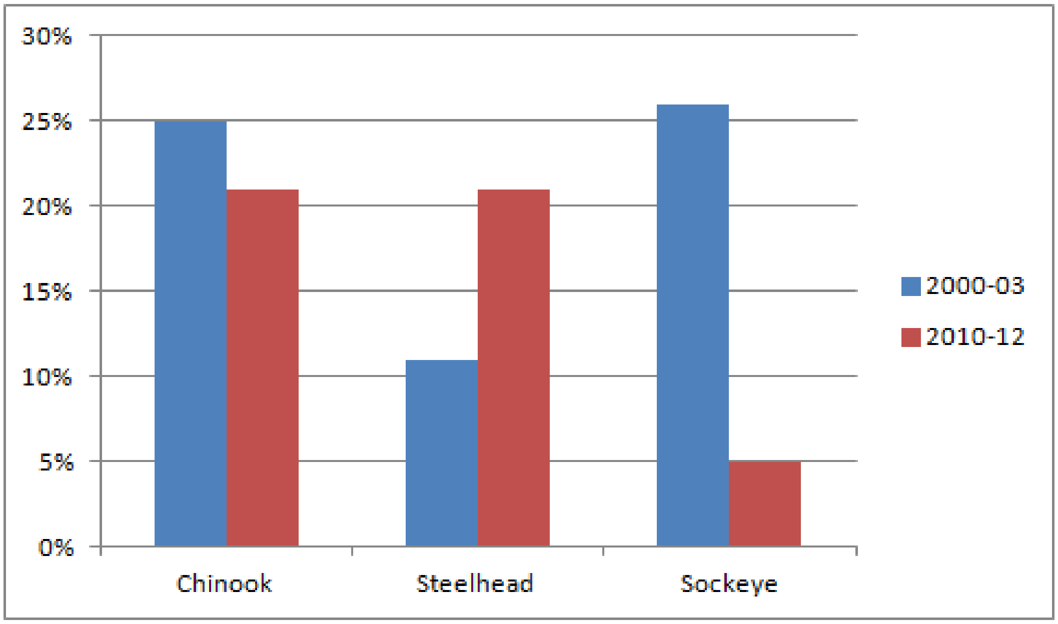


Figure 37. Percentage of Adult Salmon and Steelhead Using the North Shore Ladder at The Dalles Dam During Pre-Spillwall Years (2000-03) and Post-Spillwall Years (2010-12). Figures base on adult fish count data available at http://www.nwp.usace.army.mil/Missions/Environment/Fishdata.aspx.

John Day Dam – *Adult ladder systems modifications to improve upstream adult passage conditions (2011).*

The majority of fish ladders at Columbia and Snake river dams continue to perform well for adult salmon and steelhead. However, John Day Dam ladders were cited in RPA Action 28 as a concern with regard to historic problems with fish passage. These problems include adult fish dropping back into the tailrace after entering the ladders, long passage times, fish jumping out of the ladder in the exit sections, and difficulties with fish counting related to fish delaying just above the count stations. At John Day Dam north ladder, the main cause of these problems has been attributed to hydraulic issues at two separate locations; the count station exit section area and the lowest section of the ladder from the entrance to the transition pool.

Upper Ladder and Count Station - The Corps completed structural improvements to the upper section (including count station) at the John Day Dam north fish ladder in spring 2010. Passage evaluations in 2010 suggest that the upper ladder modifications successfully resolved the chronic delay, jumping, and turn-around problems observed in that section (Jepson et al., 2011; Madson and Jonas, 2011).

Auxiliary Water Supply and Ladder Entrance - Auxiliary water supply pumps were replaced, power supply upgraded, and a new entrance was installed during the 2011-2012 in-water work period.

Construction of Phase II Items – These include modification to the ladder entrance transition pool and auxiliary water supply system, which are planned for the 2012-2013 in-water work period.

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.*

Repairs to gearshafts and gearboxes on the AWS pumps for the north shore fishway started in December 2008 and were completed in February 2009, prior to the start of the adult fish passage season. During that period, at least two of the three pumps were in service at all times.

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).*

Adult migration at Little Goose Dam was slowed significantly during pre-surface SW implementation for high-volume summer spill in 2005 and bulk pattern spill in spring 2007. Prior to SW implementation, a 2008 study to determine the cause of adult passage delay used two bulk patterns (to mimic a surface passage structure) and a uniform pattern that mimicked the anticipated training spill for a surface passage structure (Jepson et al., 2009). Data indicated that adult passage percentage was slightly higher through the north shore spillway entrance than the south shore powerhouse entrance, with about 10 percent of the adults entering the north powerhouse entrance near the dam's center. The uniform pattern produced the shortest median times from first tailrace record to first fishway approach, produced the highest percentage of first fishway approaches resulting in fishway entrance, and produced the shortest median time from first tailrace record to last record at the top of the fish ladder. A two-elevation SW was installed in spillbay 1 in 2009 with adult passage monitored via daily count comparisons at Little Goose Dam and upriver/downriver of the dam during 2009, revealing no substantial passage delays during the more average flow-year operations with 30 percent spill. Slight delays for sets of two-three days during higher in-season spill proportions for spring Chinook salmon and sockeye were detected.

Passage delays of spring Chinook salmon did occur more regularly at Little Goose Dam during the higher spring freshet of 2010, prompting removal of the SW and switching to a uniform spill pattern for several-day increments to allow several hundred delayed Chinook adults to pass. Additional analysis late in 2010 prompted a February 2011 visit to the scaled physical model at the Corps' Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi. There it was found that opening spillbay 8 first, rather than spillbays 2 and 3, broke up the surface weir-powered eddy that may have caused adult passage delay. That change was implemented in the Fish Passage Plan for 2011.

During 2011, only minimal delay in the tailrace was detectable in count data distributions and that occurred only during extreme spill conditions at inflows approaching 200 kcfs. Additional analysis and physical modeling in February 2011 resulted in a new spill pattern to further reduce adult passage delay. That revised pattern was incorporated into the operations for 2012. No delays of adult fish passage were noted during the 2012 fish passage season.

Delays in closing the SW of up to three days led to a decision to design an automated hoist that would allow closure of the SW in a more immediate manner and provide a more rapid response to future adult passage problems.

Lower Granite Dam - *Adult fishway modification to improve upstream adult passage conditions impaired by temperature differentials (need will be determined by results of further research) (prototype 2011).*

An adult passage study targeted at ladder temperature differential effects at Lower Granite Dam was completed for the 2008 spring-summer Chinook salmon and steelhead migration (Clabough et al., 2008). Water temperatures in the fish ladder during 2008 were cooler than in previous study years, with only five percent or less (about two days) of all radio-tagged fish passing the dam when water temperatures differences between upper and lower segments of the fishway exceeded 1 degree centigrade. A significantly higher percentage of spring-summer Chinook salmon exited the fish ladder to the tailrace when temperatures exceeded 18 degrees centigrade than when water ladder temperatures were less than 18 degrees centigrade. No differences were found in the percent of steelhead and fall Chinook salmon that exited the ladder when temperatures were greater than or less than 18 degrees centigrade. Median dam and transition pool passage times were higher for all runs of radio-tagged fish when water ladder temperatures exceeded 18 degrees centigrade. A higher percentage of fish overnighted when water temperatures were greater than 18 degrees centigrade. The general conclusion was that since 2008 was a relatively cool year, future studies may be needed to more effectively evaluate the relationship between fish passage and temperature gradients within the fish ladder at Lower Granite Dam.

An engineering study was conducted to assess and develop alternatives to improve ladder temperature conditions (Juul, 2012). Three alternatives were identified and analyzed. The study determined that a pilot study with a simple prototype structure was not feasible, including the Fish Facility Design Review Workgroup (FFDRWG) proposed inductor concept previously tested at McNary Dam in 2001. The cost/benefit of all three proposed alternative structures warranted some assumption uncertainty and reliability analyses. FFDRWG recommended additional forebay temperature data collection at representative source water locations for 2011 and 2012 to estimate the reliability of availability of colder source water for mixing. Results of the additional data collections could result in the alternative study being revisited for modification. Temperature data collected in 2011 showed no distinct cooler water thermocline developing at any depth to 32 meters. Replicate temperature string profiling was planned in 2012 in anticipation of comparing between a warmer and drier water year.

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

A valve was replaced in November 2010. With this replacement, full auxiliary water supply from the forebay water supply to all the troughs at Lower Granite Dam adult fish trap was accomplished without a change in MOP operations.

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 2008-2012 Spring and Summer FOPs as adopted by respective court orders. The annual 2008-2012 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 annual Total Dissolved Gas and Water Temperature Reports, Appendix E at *http://www.nwd-wc.usace.army.mil/tmt/wqnew/*. This report describes the Corps' Columbia River Basin spill and water quality monitoring program for each year 2008-2012 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 (GBT).
- Progress on implementing measures contained in the lower Columbia and lower Snake rivers TDG total maximum daily load (TMDL) documents.

Spring Fish Passage Spill

Spring fish passage spill at the lower Columbia and lower Snake river projects was implemented consistent with the annual 2008-2012 Spring FOP and the Corps' 2011 Total Dissolved Gas Management Plan at *http://www.nwd-wc.usace.army.mil/tmt*. 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.

Consistent with the FCRPS BiOp, the 2010 Supplemental BiOp and respective court orders, in-season adjustments addressing real-time conditions were implemented in coordination with regional sovereigns.

Table 31. RPA Action 29 – Spring Spill 2008-2012. Spill levels are 24 hours/day unless specified otherwise.

Facility	2008	2009	2010	2011	2012
Lower Granite Dam	20 kcfs				
Little Goose Dam	30% of river flow, plus 14 days of night spill to the spill cap between April 22 and May 15.	30% of river flow[5]			
Lower Monumental Dam	To the spill cap (approximately 27 kcfs)				
Ice Harbor Dam	Alternating between (a) 30% of the river flow and (b) 45 kcfs during the day and up to the spill cap at night				
McNary Dam	40% of river flow				
John Day Dam	April 10 – April 20: no spill during day, 60% of river flow at night April 21 – May 1: 30% of river flow May 2 – June 20: alternating between 30% and 40% of river flow	April 10 – April 27: 30% of river flow April 27 – June 4: alternating between 30% and 40% of river flow June 4 – June 30: 30% of river flow	April 10 – April 27: 30% of river flow April 27 – July 1: alternating between 30% and 40% of river flow	April 10 – April 27: 30% of river flow April 27 – July 20: alternating between 30% and 40% of river flow	
The Dalles Dam	40% of river flow				
Bonneville Dam	To the spill cap up to 100 kcfs	100 kcfs			

[5] On two separate occasions in May, 2010, adult spring Chinook passage was delayed. The problem was remedied by taking the surface weir out of service for approximately 24 hours and implementing a uniform spill pattern.

Summer Fish Passage Spill

Consistent with the Summer FOP, summer spill begins June 21 and continues through August 31 at the lower Snake River projects. Summer spill on the lower Columbia River begins June 20 at McNary Dam, July 1 at John Day and The Dalles dams, and June 16 at Bonneville Dam. Spill continues through August 31.

Consistent with the FCRPS BiOp, the 2010 Supplemental BiOp and the respective Court orders, in-season adjustments addressing real-time conditions were implemented in coordination with NOAA Fisheries and regional sovereigns.

The annual 2008-2012 FOPs called for the following spill operations during the summer:

Table 32. RPA Action 29 – Summer Spill 2008-2012. Spill levels are 24 hours/day unless specified otherwise.

<table>
<tr><th>Facility</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th></tr>
<tr><td>Lower Granite Dam</td><td colspan="5">18 kcfs</td></tr>
<tr><td>Little Goose Dam</td><td colspan="5">30% of river flow</td></tr>
<tr><td>Lower Monumental Dam</td><td colspan="5">17 kcfs</td></tr>
<tr><td>Ice Harbor Dam</td><td>Alternating between (a) 30% of river flow 24 hours/day or (b) 45 kcfs during the day and up to the spill cap at night.</td><td colspan="4">June 21 - July 11: alternating between (a) 30% of river flow 24 hours/day or (b) 45 kcfs during the day and up to the spill cap at night.
July 12- August 31: 45 kcfs during the day and up to the spill cap at night</td></tr>
<tr><td>McNary Dam</td><td>Alternating between 40% and 60% of river flow</td><td colspan="4">50% of river flow</td></tr>
<tr><td>John Day Dam</td><td>June 21 – July 18: alternating between 30% and 40% of river flow
July 19 – August 31: 30% of river flow</td><td>30% of river flow</td><td colspan="3">July 1 – July 21: alternating between 30% and 40% of river flow
July 21 – August 31: 30% of river flow</td></tr>
<tr><td>The Dalles Dam</td><td colspan="5">40% of river flow</td></tr>
<tr><td>Bonneville Dam</td><td colspan="2">June 21 – July 20: 85 kcfs during the day, to the spill cap at night
July 21 – August 31: 75 kcfs day, to the spill cap at night</td><td colspan="3">June 16 – July 20: alternating between (a) 95 kcfs 24 hours/day and (b) 85 kcfs during the day and 121 kcfs at night
July 21 – August 31: 75 kcfs during the day, to the spill cap at night</td></tr>
</table>

River Conditions and TDG Monitoring

During fish passage spill season, system flows vary based on the amount of runoff volume each year. High runoff volumes tend to result in spill rates which can be significantly higher than estimated FOP spill levels. Daily average total river flows on the lower Columbia River are measured at Bonneville Dam and at Ice Harbor Dam for the lower Snake River.

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 and adjusts spill patterns and spill rates to stay within acceptable levels. The Corps also tracks the number of instances when TDG exceeded state standards as modified by waivers or criteria adjustment.

Excessive TDG levels can result in GBT. The FPC monitors fish for GBT and prepares an annual summary with their findings.

A summary of river flows, TDG instance and GBT monitoring results is shown in Table 33. This information with additional detail is provided in the 2008-2011 Annual Dissolved Gas and Water Temperature Monitoring Reports at: *http://www.nwd-wc.usace.army.mil/tmt*.

Table 33. RPA Action 29 – River Conditions and TDG Monitoring 2008-2012. Gas bubble trauma data are from Fish Pass Center at http://www.fpc.org

	2008	2009	2010	2011	2012
Range of Columbia River Daily Average River Flows at Bonneville Dam (April-August)	119-418 kcfs	93-361 kcfs	96-398 kcfs	160-507 kcfs	155-442 kcfs
Columbia River Annual Average River Flows at Bonneville Dam(April-August)	236 kcfs	214 kcfs	194 kcfs	335 kcfs	313 kcfs
Range of Snake River Daily Average River Flows at Ice Harbor Dam (April-August)	26-199 kcfs	25-171 kcfs	22-216 kcfs	33-216 kcfs	24-192 kcfs
Snake River Annual Average River Flows at Ice Harbor Dam (April-August)	80 kcfs	80 kcfs	63 kcfs	114 kcfs	79 kcfs

	2008	2009	2010	2011	2012
Number of Instances TDG exceeded 115 percent/120 percent state standards	**515 Total** 93 - Voluntary spill 422 – Involuntary spill	**308 Total** 116 - Voluntary spill 192 - Involuntary spill	**234 Total** 67 - Voluntary spill 167 - Involuntary spill	**792 Total** 103 - Voluntary spill 389 - Involuntary spill	**785 Total** 45 - Voluntary spill 740 - Involuntary spill
Number of TDG Instances above 125 percent hourly standard	**668 Total** 652 - involuntary spill 16 - debris spill	**52 Total** 51- involuntary spill 1- debris spill	**555 Total** 553 - involuntary spill 2 - debris spill	**3174 Total** Includes 207 at Chief Joseph Dam All during involuntary spill	**345 Total** All during involuntary spill
Gas Bubble Trauma	12,884 fish examined 88 fish with less severe signs 1 fish with severe signs	11,148 fish examined 25 fish with moderate symptoms	13,624 fish examined 49 fish with moderate symptoms	15,302 fish examined 382 fish with non-severe signs 15 fish with severe signs	14,054 fish examined 96 fish with moderate symptoms

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 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 2012 transportation program was conducted in accordance with NOAA Fisheries ESA Permit No. 1237 and the Juvenile Fish Transportation Program criteria in the 2012 FPP.

The start of juvenile fish transport operations by barge was staggered and commenced May 2 at Lower Granite Dam followed by Little Goose Dam on May 4, and Lower Monumental Dam on May 6. This allowed early season fish to migrate in-river. Truck operations began August 18 and continued until October 1 at Lower Monumental Dam and October 31 at Little Goose Dam and Lower Granite dams. At Lower Granite 3,133,040 fish were bypassed back to the river in 2012, and 2,674,880 were transported. At Little Goose, 678,174 fish were bypassed back to the river in 2012, and 2,536,134 fish were transported. At Lower Monumental, 24,271 fish were bypassed, and 1,225,364 were transported.

The final barge departures from the Lower Granite, Little Goose and Lower Monumental facilities took place on August 16. At Snake River facilities, trucks carried juvenile fish from August 17 through the end of the transport season. All trucked fish were released into the Bonneville Juvenile Monitoring Facility outfall flume except for Lower Granite fish during the last two weeks which were released at the alternate site (Dalton Point) due to the abundance of predatory birds.

At McNary Dam in 2012, fish were bypassed from March 29 through August 16. During this period sampling operations occurred every other day beginning April 10, 2012, to support research and BPA-sponsored smolt monitoring activities, as well as to assess bypass system conditions. Collection for transport began on August 17, after which fish were sampled daily. Normal operations at McNary Dam are to bypass fish in the spring until early to mid-July when river conditions are no longer "spring like," after which migrants are collected and transported by barge. In 2012, no fish transport by barge occurred at McNary Dam as regional fish agencies and the Corps reached a consensus to transport only by truck, due to the newly constructed bypass outfall and PIT-tag data demonstrating an increasing trend in survival of inriver migrants. Due to high river water temperatures and the increased potential for fish stress, fish were trucked daily from August 18 through August 30 (except for August 24, when a power outage prevented transport). The first every-other-day truck was to depart the facility on September 1, but biologists opted to truck on September 2 to reduce the amount of debris entering the trucks. From September 3-6, fish were bypassed to the tailrace as large amounts of forebay debris entering the facility made fish transport unfeasible. Routine every-other-day trucking operations resumed September 7 and concluded for the season on October 1. All trucked fish were released into the Bonneville Juvenile Monitoring Facility outfall flume. A total of 214,454 juvenile fish were transported from McNary Dam in 2012, as compared with the 1,473,211 transported in 2011 and the 447,252 transported in 2010.

In 2012, a total of 6,650,832 fish were transported, which represented 48.9 percent of the fish collected. This was a smaller proportion than in 2011, when 9.749,857 fish were transported, 64 percent of the fish collected. All collected fish that were not transported were bypassed to the river. Of the fish transported, 6,412,865 96.4 percent) were transported by barge, and 237,967 (3.6 percent) were trucked.

The 2011 juvenile fish transport season was marked by higher than normal river flows in the Snake and Columbia rivers. Barge operations were suspended from May 23 through 28 due to a navigation lock outage at The Dalles Dam and extreme high river flow conditions.

The start of juvenile fish transport operations by barge was staggered and commenced May 2 at Lower Granite Dam followed by Little Goose Dam on May 6, Lower Monumental Dam on May 9 and McNary Dam on July 21. At Lower Granite in 2011, 2,429,798 fish were bypassed back to the river, and 3,874,873 were transported. At Little Goose, 347,521 fish were bypassed back to the river, and 3,030,558 fish were transported. A total of 207,024 fish were bypassed from Lower Monumental in 2011, and 1,371,215 were transported. Truck operations began August 16 and continued until October 1 at Lower Monumental Dam, October 31 at Little Goose Dam and November 1 at Lower Granite Dam.

At McNary Dam, transport operations began on July 21, as compared to July 16 in 2010. Due to high river water temperatures and the increased potential for fish stress, fish were trucked on alternate non-barge days from August 3 through August 15. Routine truck operations began August 17 and ceased on September 30. Trucking operations were suspended from September 10 – 17 as fish were bypassed to the tailrace since large amounts of forebay debris entering the facility made fish transport unfeasible. A total of 1,473,211 juvenile fish were transported from McNary Dam in 2011, as compared with the 447,252 transported in 2010 and the 448,833 transported in 2009.

A total of 9,749,857 fish were transported in 2011, 64 percent of the fish collected, compared with 64 percent in 2010. Of the fish transported, 9,308,289 were transported by barge (95.5 percent) and 441,568 were trucked (4.5 percent).

The 2010 juvenile fish transport season was marked by much lower than normal river flows in the Snake River and well below average river flows in the Columbia River. The start of juvenile fish transport operations by barge was staggered and commenced April 22. This start date was set 10 days earlier than the 2009 start date due to much lower than usual spring flows. Truck operations began August 18 and continued until October 31 (similar dates in 2009). At Lower Granite 247,129 fish were bypassed back to the river in 2010 and 3,394,601 were transported. At Little Goose, 140,719 fish were bypassed back to the river, and 2,723,402 fish were transported. At Lower Monumental 6,137 fish were bypassed back to the river, and 1,057,640 fish were transported.

At McNary, normal operations are to bypass fish in the spring until early to mid-July when collection and transport of summer migrants begin by barge. In 2010, the McNary transport operation began on July 16. Truck transport operations began August 18 and ceased on October 1. A total of 447,252 juvenile fish were transported from McNary compared with 448,833 transported in 2009 and the 425,743 transported in 2008.

A total of 7,622,895 fish were transported in 2010, 64 percent of those collected, compared to 52 percent in 2008. Of the fish transported, 7,447,369 were transported by barge (97.7 percent) and 175,526 were trucked (2.3 percent).

The 2009 juvenile fish transport season was marked by slightly below normal river flows in the Snake River, and well below average river flows in the Columbia River. The start of juvenile fish transport operations was staggered and commenced on May 1 at Lower Granite, May 6 at Little Goose, and May 8 at Lower Monumental. At Lower Granite in 2009, 2,465,023 fish were bypassed back to the river and 4,119,643 were transported. At Little Goose, a total of a total of 2,228,651 fish were bypassed back to the river in 2009 and 2,944,890 were transported. At Lower Monumental, 13,891 fish were bypassed from Lower Monumental in 2009 and 1,167,425 were transported.

At McNary, in 2009, transport operations began on July 16 as in 2008. In 2007, TSW operations had precluded the transport of fish by barge and no fish were transported until truck operations began on August 18. A total of 448,833 juvenile fish were transported from McNary in 2009, noticeably higher than the 425,743 transported in 2008 and much higher than the 35,993 transported in 2007.

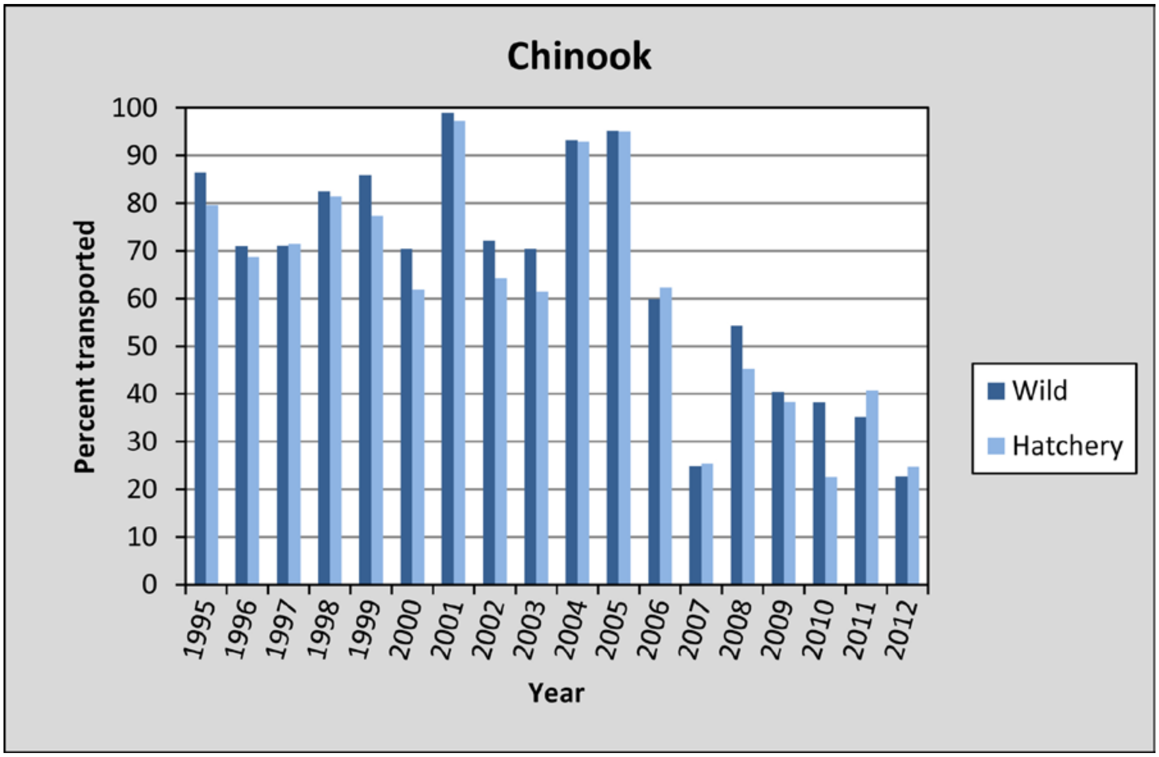
The 8,680,791 fish that were transported accounted for 52 percent of fish collected, compared to 64 percent in 2008. Of the fish transported, 8,637,279 were transported by barge (95.5 percent) and 43,512 were trucked (0.5 percent).

The 2008 juvenile fish transport season was marked by slightly below normal river flows in the Snake River, and below average river flows in the Columbia River. Although start dates were later than in 2007, (Lower Granite-May 1; Little Goose –May 9; Lower Monumental –May 12) collection and transport numbers were higher in 2008 as cool spring weather delayed snow melt and spring runoff. At Lower Granite 815,565 fish were bypassed back to the river in 2008 and 4,252,195 were transported. At Little Goose, 1,114,654 fish were bypassed back to the river and 3,764,974 were transported. At Lower Monumental, 1,330,880 fish were bypassed and 765,489 were transported.

In 2008, collection for transport operations began on July 16 at McNary dam. A total of 425,743 juvenile fish were transported from McNary, notably higher than the 35,993 transported in 2007 and lower than the 1,005,373 transported in 2006.

A total of 9,208,401 fish were transported in 2008, 64 percent of those collected, compared to 51 percent in 2007. Of the fish transported, 9,095,546 were transported by barge (99 percent) and 112,855 were trucked (1 percent).

From 2008-2012, juvenile salmonids were transported as described in RPA Action 30 and in accordance with NOAA Fisheries ESA permit 1237 and the Juvenile Fish Transportation Program criteria in the Corps' FPPs from 2008-2012. The proportion of Snake River yearling Chinook salmon and steelhead transported as juveniles has decreased since 2008 (Figure 38).



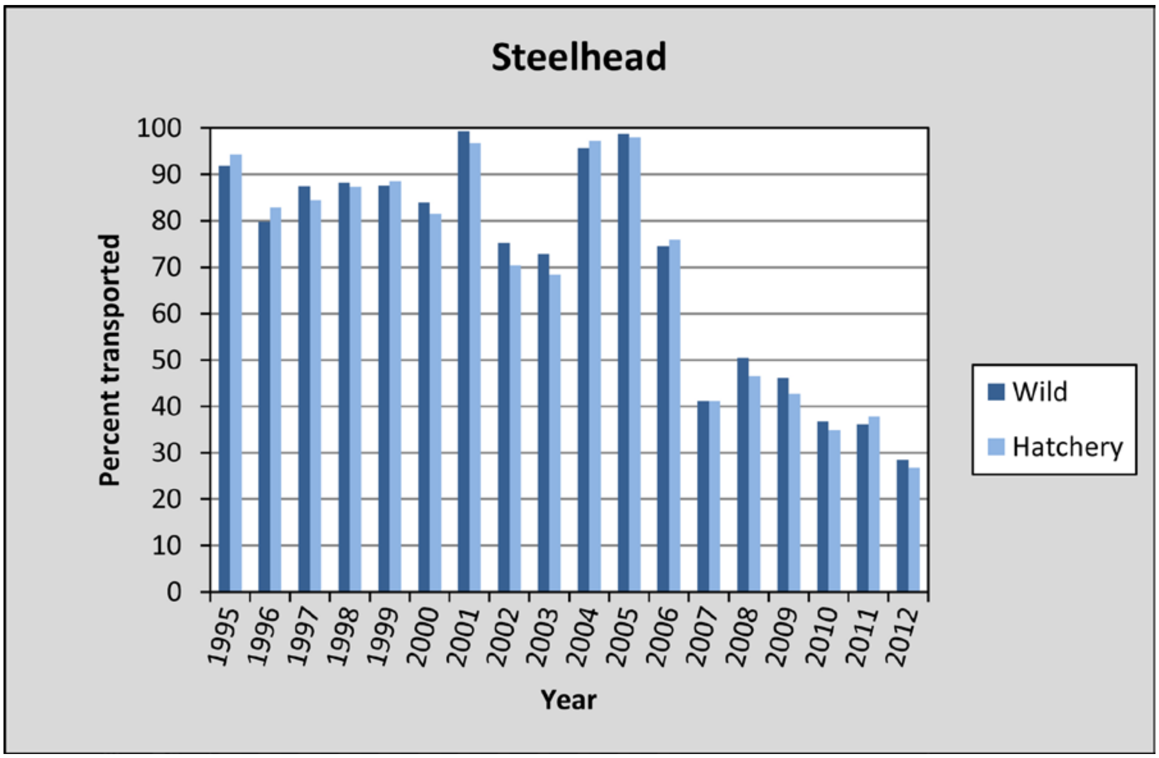


Figure 38. Estimated Percent of Yearling Chinook Salmon and Steelhead, Respectively, Transported to Below Bonneville Dam, by Year, 1995-2012. 2012 Values are Preliminary and Subject to Revision. (1995-2011 data from Faulkner et al., 2012. 2012 data from Zabel, 2012.)

The initiation of transport on an annual basis has been determined through the Regional Forum, beginning at Lower Granite Dam no later than May 1. Corps-funded research evaluating the seasonality of transport benefits has been critical to helping the Action Agencies and regional fish managers identify periods when it is most beneficial to transport specific groups of fish and select dates for initiating transport actions. Understanding the factors that influence changes in transport benefits will be important to managing juvenile transportation. Furthermore, monitoring transport and in-river migrant smolt-to-adult-returns (SARs) in a spatially and temporally explicit scale will be necessary to determine the best transport strategy in a dynamic environment. This will also provide the most pertinent information for adaptive management processes.

Transportation actions at Lower Granite, Little Goose, Lower Monumental, and McNary dams have followed Tables 3 and 4 of the FCRPS BiOp, except as modified by court order or through collaborative regional forums. While transport operations have been consistent with the FCRPS BiOp and mostly supported in regional forums, the transport program has not operated consistent with the best available data. Maximizing collection and transportation during a two-week period in May at all Snake River collector projects and transporting fish collected at McNary Dam in the spring would return substantially more adults than operating under the “spread the risk” strategy.

RPA Action 31 – Configuration and Operational Plan Transportation Strategy: *The Corps, in coordination with the Regional Forum, will initiate a Configuration Operational Plan in 2009. The plan will be completed in 2010 and will present a strategy for prioritizing and carrying out further transportation actions at each dam. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. Construction actions for transportation are primarily in the context of changes to juvenile bypass systems. Changes meant to increase adult salmon returns through the juvenile fish transportation process are being evaluated. Some changes include additional barges, a new juvenile fish facility at Lower Granite Dam and modifications to the juvenile fish facilities at Little Goose, Lower Monumental and McNary dams.*

The transportation COP has been actively coordinated with the regional forum. Scoping meetings on this plan were completed in 2011, a draft data summary of recent transport research has been completed by the Corps, and a final COP is anticipated in 2013. The delay in producing the transportation COP as scheduled in the FCRPS BiOp is primarily the result of the need for additional data from transport evaluations. Critical data on seasonality of transport operations, the effects of transportation on sockeye salmon and fall Chinook salmon, and analysis of bypass effects was not available until after the 2012 adult returns. Unlike project COPs that rely primarily on juvenile survival information, the transportation COP requires adult returns for analysis. Adult salmon and steelhead spend up to five years in the ocean before returning, creating a significant delay between the initiation of a critical study and final analysis of the data. There will be multiple opportunities for regional input into the development of transportation actions designed to increase adult salmon and steelhead returns, while minimizing impacts to other species, and proposing cost efficiencies in the existing program.

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.*

From 2008 through 2012, draft FPPs were released each October; the final plans were released in March of the following year. These documents are found at: *http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/*.

The FPPs were completed in coordination with the region and Corps fish passage facilities and 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 perform emergency repairs on vital equipment.

As a result of adult fish mortalities associated with maintenance at Dworshak Dam in November 2010, the Corps performed significant revisions to the procedures for routine turbine dewatering. These procedures are designed to minimize risks to fish during future maintenance activities. After coordination with regional sovereigns, the new procedures were incorporated into the 2011 FPP. For more information on this incident please see the incident report at:

http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/2011_FPOM_MEET/2011_JAN/DWO%20Draft%20Tube%20Mortality%20Report_2010%20Dec%2022.pdf

The draft 2013 FPP was released for regional review in October 2012.

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 Snake River Kelt Management Plan (KMP) has been in implementation following completion of the 2009 KMP. BPA and the Corps complete KMPs on an annual basis to supplement the 2009 KMP and support active adaptive management. The goal of the kelt management actions laid out in the KMP is to improve survival and productivity of listed Snake River steelhead by allowing an additional 6 percent of the Snake River B-run female kelts to successfully survive and spawn in a subsequent year (Bellerud et al., 2007). This is intended to be accomplished via the following actions: 1) measures to increase in-river survival of migrating kelts; 2) assessment of the viability of transport to support kelt survival; and 3) development of a successful kelt reconditioning program.

Several actions were taken in 2008 by BPA and the Corps to enable development of a KMP in 2009. The Corps and BPA identified Lower Granite Dam as the primary collection point for Snake River B-run kelt research and monitoring. BPA initiated funding to CRITFC to prepare a master plan for kelt (**BPA Project 2007-401-00**, Kelt Reconditioning and Reproductive Success), that would provide the detail on the reconditioning action encompassed in the broader Snake River KMP. The Kelt Master Plan is part of a three-step technical review process required by the NPPC for artificial propagation projects, particularly those that affect natural populations and involve construction of capital facilities. The master plan focuses on the feasibility and utility for kelt collection and reconditioning at alternative or multiple locations designed to hold and propagate kelt to a subsequent spawning condition so they can be released to spawn in a subsequent year. The NPT and University of Idaho were subcontracted to implement the reconditioning program, as well as the experimental monitoring of transport and in-river passage survival and return spawning of B-run kelt. Also initiated in 2008 was development of planned reconditioning efforts at the Dworshak National Fish Hatchery (NFH) beginning in 2009.

The 2009 version of the KMP was a synthesis of previous research on kelt migration studies through the hydrosystem as well as kelt reconditioning efforts. The 2009 KMP also discussed research efforts that would continue in 2010 as well as kelt-specific operations at Bonneville and The Dalles dams. To facilitate increased efforts in the kelt research program, the Corps initiated collection of Snake River post-spawned kelt and construction of kelt holding facilities at Lower Granite Dam. In addition, the Corps worked with BPA, CRITFC, and the University of Idaho to provide space and water for kelt holding tanks associated with reconditioning efforts at the Dworshak NFH. The Corps also developed a design for an enhanced kelt facility in the EDR for the Lower Granite Lock and Dam JFF Upgrade.

The 2010 version of the KMP built upon the framework of the 2009 plan including review and synthesis of previous research on kelt migration studies through the hydrosystem as well as kelt reconditioning efforts. The 2010 KMP discussed research efforts as well as a continued focus on kelt-specific operations at Bonneville and The Dalles dams. Snake River transport survival and Kelt-to-Spawner Return (KSR) survival studies were deferred, and a more robust in-river survival and KSR study was proposed following the pilot study with limited acoustic receivers. As part of the overall package to increase the number of adult B-run Snake River steelhead above Lower Granite Dam, the Action Agencies, along with NOAA Fisheries, developed a benefit analysis based on the 2008-2010 research at The Dalles Dam (Tackley and Clugston, 2011). Results from those studies allowed the Action Agencies to conclude that by extending the operating season of the ice and trash sluiceway (ITS) to include December 1-15, 2010, and March 1-April 9, 2010, a 0.9 percent increase in adult returns would be realized. NOAA Fisheries concurred in benefits to B-run Snake River steelhead, and the operation was implemented. In addition to The Dalles Dam operation, the Bonneville Dam PH2 CC was opened nearly one month early (March 14, 2010) in an effort to provide a safer route of passage for early-migrating (primarily lower Columbia River) steelhead kelts.

The 2011 KMP supplemented previous annual KMPs by providing updates on reconditioning program status and also identified future direction for 2012 through 2018. There was a shift in focus from research planning to reporting progress on RPA Action 33 and adaptive management actions toward achieving the 2008 SCA Appendix J goal for an additional 6 percent of the Snake River B-run female kelts to successfully survive and spawn in a subsequent year (Bellerud et al., 2007). CRITFC and subcontractor research results were reported in CRITFC's annual reports, and the focus of the annual KMP. The 2011 KMP summarizes continuing kelt migration studies performed during 2011, including kelt reconditioning efforts. Rearing at Dworshak NFH kelt facility using Lower Granite Dam separator-collected B-run kelt is feasible, but compromised water quality in 2010 and 2011 affected the survival of collected kelts. Due to extensive coordination efforts amongst the Corps, BPA, USFWS, CRITFC and the NPT water source for the kelt program was improved in 2012 and is being actively managed to ensure that water quality issues no longer pose a risk to the program.

BPA and the Corps completed the 2012 KMP which describes efforts that will continue in 2013, including kelt collection at Lower Granite Dam for reconditioning efforts at Dworshak Dam, future planning for use of a barge as a reconditioning facility at Lower Granite, kelt-specific operations at Bonneville and The Dalles dams, and in-river survival and reconditioning research at Lower Granite Dam. The 2012 KMP also summarized recent research results falling under the major strategies of 1) reconditioning of kelts at specialized hatchery facilities, 2) transportation of kelts to the Columbia River estuary, and 3) operation of the hydropower system to enhance steelhead migration and subsequent kelt passage during outmigration.

Research highlights included two major in-river survival studies conducted with Snake River and lower Columbia River non-reconditioned kelts fitted with acoustic tags during the May outmigration. The Snake River study (Colotelo et al., 2013) showed that direct survival rates exceeded 89.5 percent at each dam, and more kelts used surface passage routes than traditional spill except at McNary and John Day dams. Cumulative mean survival of kelts from Lower Granite to an estuary detection array in at rkm 156 below Bonneville was 40.7%, and somewhat elevated mortality was observed in the Lower Granite tailrace and upper Dalles reservoir. The lower Columbia River kelt survival study (Rayamajhi et al., 2013) showed a cumulative single release survival rate from McNary to rkm 156 of 60.2%. The Corps funded a two year study to estimate winter passage rates and vertical distribution of overwintering steelhead at McNary Dam (Ham et al., 2012). The Corps also conducted passage distribution and survival tests at Bonneville Dam in 2011-2012 (Normandeau Associates, 2011). Survival of adult steelhead released directly into the BON Corner collector and ITS were 99 percent and 100 percent respectively. 51 percent of tagged steelhead kelts released upstream of Bonneville passed via the spillway. At PH1, 49 percent of kelts were successfully diverted to the ITS, and 74 percent of kelts entering PH2 passed via the CC. These results confirm that priority operation of PH2 combined with early operation of the PH2 CC according to the current FPP results in the fewest kelts passing through turbines.

Several multiyear studies have monitored transport survival and KSR among kelts undergoing short and long-term reconditioning treatments. The BPA funded kelt study demonstrated that transported kelts from Lower Granite and Prosser dams have shown little to no increase in return rates compared to fish left in the river; therefore the highest priority research efforts, for the time being, are directed at evaluating strategies other than transport. Kelts reconditioned at some hatchery sites showed higher survival rates to release after long-term reconditioning than others, and the pattern cannot be easily explained by migration distance from the estuary. Although Hood River and Yakima River programs saw the greatest success rates, a program at Omak Creek observed higher reconditioning success than Snake River or Shitike Creek programs despite its inland location (RM 566). Return rates of rematuring spawners among lower river steelhead kelts still exceed those of Snake River origin kelts. In the future research might be directed at whether genetically based differences in iteroparity rates exist between populations, and addressing what role energy stores at arrival play in reconditioning survival.

Adaptive Management Strategy

In 2012, nine natural origin B-run steelhead kelts successfully reconditioned and were released into the Snake River, contributing 0.5 percent toward the 6 percent survival goal. In total, a credit of 1.4 percent of the 6.0 percent improvement goal has been completed in 2012 with the modified operation at The Dalles Dam for kelt and preliminary reconditioning efforts at Dworshak NFH. The number of reconditioned kelts credited towards the 6 percent improvement goal must be recalculated on an annual basis and the proportion of contribution of the reconditioning program towards the 6 percent improvement goal is expected to increase substantially as the program expands.

Reconditioning efforts focused on B-run hatchery kelts have been developed and implemented at Dworshak NFH, and this program is to expand and achieve greater numbers of reconditioned fish. Successes in research directed at improving approaches to reconditioning, recent infrastructural improvements at hatcheries support that the reconditioning program can be successfully expanded to meet the 6.0 percent improvement goal to female Snake River B-run steelhead spawning population in future years. In order to facilitate this process, BPA continues to fund CRITFC and NPT to develop and finalize a master plan for the kelt reconditioning program.

Tributary Habitat Implementation Reports, RPA Actions 34-35

Table 34. Habitat Strategy Reporting, RPA Actions 34–35.

RPA Action No.	Action	Comprehensive Evaluation Reporting	2012 Annual Progress Reporting
Habitat Strategy 1			
34	Tributary Habitat Implementation 2007 to 2009 – Progress Toward 2018 Habitat Quality Improvement Targets.	N/A— RPA Action 34 addresses accomplishments that began in 2007 and ended in 2009. There is no Comprehensive Evaluation reporting requirement in the 2008/2010 FCRPS BiOp for RPA Action 34.	N/A— RPA Action 34 addresses accomplishments that began in 2007 and ended in 2009. There are no 2012 annual progress reporting requirements in the 2008/2010 FCRPS BiOp for RPA Action 34.

Table 34. Habitat Strategy Reporting, RPA Actions 34–35.

RPA Action No.	Action	Comprehensive Evaluation Reporting	2012 Annual Progress Reporting
Habitat Strategy 1			
35	Tributary Habitat Implementation 2010-2018 – Achieving Habitat Quality and Survival Improvement Targets.	Comprehensive report on status of project implementation, by project, (including project milestones) for all actions identified in implementation plans. (See Section 3, Attachment 2). By population, report progress toward overall habitat quality improvement targets and population-specific survival benefit (SB) (See Table 35.). Comprehensive report of physical metrics for implementation achieved (e.g., miles of access, cfs streamflow acquired, #s of screens installed, miles or acres of habitat protected or enhanced, and miles of complexity enhanced by benefited population(s)) and still remaining, by project. (See Section 3, Attachment 2, Table 1). Where population-specific SBs are not achieving progress guidelines above, identify processes or projects to place to ensure achievements by the next comprehensive report. (See Adaptive Management Plans (Appendix A). Report results of all biological effectiveness monitoring/studies, including new scientific information, and identify how results will be applied to future implementation, if appropriate. Where new scientific or other information suggests that habitat quality improvement estimates for projects from the previous cycle were significantly in error, the Action Agencies will describe the analytical approach used to re-evaluate the estimated habitat and SBs for each project affected.	RPA Action 35 Annual Progress Report accomplishments for 2012 are presented in the Annual Progress Report format specified in the 2008/2010 FCRPS BiOp (See Section 3, Attachment 2). 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 streamflow acquired, #s 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 and achieve the estimated SBs, by project.

Habitat Strategy 1 (RPA Actions 34–35)

Protect and Improve Tributary Habitat Based on Biological Needs and Prioritized Actions

Reporting for Habitat Strategy 1 is presented in two major parts in this section. The first part addresses Comprehensive Evaluation (CE) reporting for RPA Actions 34 and 35. The second part addresses 2012 annual progress reporting requirements for RPA 35.

2007 to 2012 Comprehensive Evaluation Reporting for Tributary Habitat

RPA Action 34 – Tributary Habitat Implementation 2007-2009 – 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 2007-2009 as part of a tributary habitat program to achieve the population-specific overall habitat quality improvement. If projects identified for implementation in 2007-2009 prove infeasible, in whole or in part, the Action Agencies will implement comparable replacement projects in 2010-2013to 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.*

RPA 34 concerns tributary habitat implementation and achievements from 2007 to 2009. Accomplishments were reported in previous FCRPS Annual Progress Reports (2006-07, 2008, and 2009). Those Annual Progress Reports included accomplishments from projects identified in the 2007 FCRPS Biological Assessment, which served as the 2007-09 Implementation Plan, any additional projects that were not included in the 2007 BA but were completed by 2009, and projects implemented in place of those that proved infeasible. Projects that were in progress, but not completed by 2009 were carried forward and evaluated by subsequent expert panels.

The habitat metrics achieved from 2007 through 2009 to benefit upper Columbia River, Snake River, and middle Columbia River Chinook and steelhead 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.
- 15 locations with fish screens installed or addressed for fish protection.
- 696 miles of improved access to fish habitat.

See also Table 35 for habitat quality improvement (HQI) progress by 2009.

***RPA Action 35 - Tributary Habitat Implementation 2010-2018**: Achieving Habitat Quality and Survival Improvement Target:*

The Action Agencies and state, tribal, federal and other regional partners have made steady progress in efforts to identify and implement habitat improvement projects that contribute to meeting or in some cases exceeding the HQIs in RPA Action 35 Table 5 by 2018 (Table 35). By 2011, HQIs had been achieved for every population except Yankee Fork. The first project in the Yankee Fork was completed in 2012. Results from multiple expert panels indicated that projects completed by 2011—less than half way through the duration of the BiOp— had delivered at least 50 percent of the 2018 HQIs for 44 of 56 populations (Table 35). This is a noteworthy achievement considering the scale and scope of the program, and demonstrates steady progress toward BiOp goals. Substantial momentum has been built since 2008, especially in priority areas where legacy impacts from human disturbance and development has altered conditions for salmon. A track record of accomplishments between 2007 and 2012 combined with partner momentum and the infrastructure necessary to get projects on the ground, positions the Action Agencies well in their efforts to meet the tributary habitat commitments by 2018.

Menus of projects submitted by regional partners, evaluated by expert panels, and implemented with funding and technical assistance from the Action Agencies are presented in the 2007 Biological Assessment and the 2010-2013 Implementation Plan. Reports on completed projects and associated metrics are presented in Annual Progress Reports dating back to 2006-07 (*http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/ProgressReports.aspx*).

These planning and progress reports present only part of the accomplishments attained since the 2008/2010 FCRPS BiOp was initiated. The Action Agencies and regional partners have built on the substantial accomplishments in tributary habitat improvements that were made even before the 2008/2010 FCRPS BiOp was initiated. Recent advances include the adoption of standardized limiting factors[6] and definitions that characterize habitat conditions limiting growth and survival of salmon and steelhead, development of limiting factor pie maps that depict limiting factor status and aid project planning and evaluation purposes, and the production of tributary and reach assessments that scientifically characterize existing geomorphic, hydraulic, and vegetation conditions and identify opportunities for sustainable habitat improvement projects within river channels and their floodplains. Also, several recent publications on the results of the monitoring and evaluation for some completed projects have demonstrated benefits of tributary habitat improvement projects to salmon and steelhead growth and survival. These reports are more readily available than in the past and contribute valuable information to project planning and development. Preliminary results are demonstrating how projects provide fish benefits and how projects can be adjusted through adaptive management where benefits were not realized. The Action Agencies also have revamped their internal organizational structure to operate and respond more effectively to attain FCRPS BiOp goals and have hired geomorphologic and engineering technical specialists with specific education, training, and direct professional experience in habitat improvement implementation. Relationships among planning, evaluation, implementation, monitoring, and evaluation activities between the Action Agencies and regional partners are depicted in the process diagram (Figure 39). Collectively, these advances have occurred since the 2008/2010 FCRPS BiOp was initiated, effectively focusing the Action Agencies and regional partners on planning, development, prioritization, implementation, monitoring, and evaluation

[6] Standardized limiting factors and definitions characterize habitat conditions that limit growth and survival of salmon and steelhead and bound the discussion of limiting factor “effect” insofar as salmonids are concerned. Standard nomenclature and a point of reference to an agreed upon statement of median or average condition improves comparison of pre- and post-treatment of a limiting factor.

of habitat improvement projects that address the most important limiting factors to the growth and survival of anadromous fish.

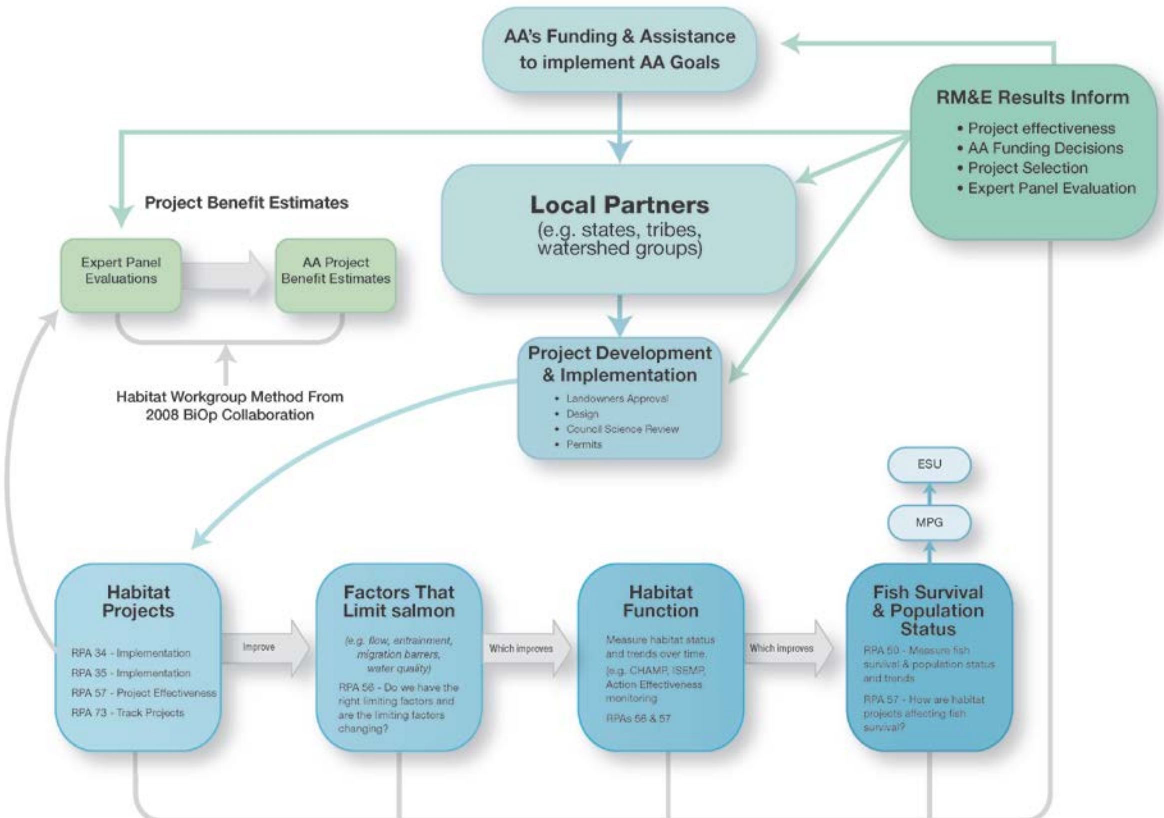


Figure 39. Interrelated Tributary Habitat Planning, Evaluation, Implementation, and Research Activities.

Tributary habitat progress attained through 2012 and estimated through 2018, combined with progress in the other H's, demonstrate a significant improvement in conditions since before the 2008/2010 FCRPS BiOp took effect. Improved conditions benefit the overall growth and survival of salmon and steelhead while they are in the continental environment[7] and result in salmon and steelhead that are better prepared to endure the ocean environment. The Action Agencies and regional partners will continue to implement habitat improvement projects needed to meet or exceed the 2018 RPA Action 35, Table 5 HQIs for the remainder of this BiOp, and will apply preliminary findings from monitoring and evaluation to project design and implementation. An adaptive management approach will facilitate continuous improvement of treatments implemented to obtain benefits for salmon and steelhead growth and survival.

The following items are specific CE reporting requirements.

[7] *Continental refers to freshwaters draining toward the ocean and may include tributaries to the Columbia and Snake mainstems and including the estuary.*

a. Comprehensive report on status of project implementation, by project, (including project milestones) for all actions identified in implementation plans.

BPA has developed the Pisces and Taurus data management systems to facilitate development, administration, and reporting on BPA contracts. This database provides comprehensive details on project status and milestones for tributary habitat actions addressed for the 2008/2010 FCRPS BiOp. The far right column of Section 3, Attachment 2, Table 1 contains hyperlinks to the Taurus database for projects identified in the 2007 Biological Assessment (for 2007 to 2009 RPA Action 34 projects) and the 2010-2013 Implementation Plan (for 2010-2012 RPA Action 35 projects), and the link to the Reclamation record number for actions presented in CE Section 3, Attachment 2, Tables 2 and 3. Detailed information in the Taurus database obtained by following the CE Section 3, Attachment 2, Table 1 hyperlinks includes project summaries, annual progress reports, timelines, implementation metrics, and budget information. Start and end dates of project milestones are displayed in the Work Elements section.

Reclamation stores information for completed actions and associated metrics in a separate database. Information for actions with Reclamation involvement is presented in CE Section 3, Attachment 2, Tables 2 and 3.

b. Comprehensive report of physical metrics for implementation achieved (e.g. miles of access, cfs streamflow acquired #s of screens installed, miles or acres of habitat protected or enhanced, and miles of complexity enhanced by benefited population(s)) and still remaining, by project.

The comprehensive report of physical metrics at the population level for tributary habitat measures completed with funding and technical assistance from BPA and Reclamation from 2007 to 2012 is summarized in CE Section 3, Attachment 2, Table 1. Table 1 includes completed metrics for 2007 to 2009, planned and completed metrics for 2010-12, metrics for 2012, and cumulative metrics for 2007 to 2012. Metrics for BPA projects were obtained from the Taurus database. Reclamation metrics included in Section 3, Attachment 2, Table 1 were summarized from the detailed metrics reported in Section 3 Attachment 2, Tables 2 and 3. BPA and Reclamation data sources were reconciled to eliminate redundancy and avoid over-reporting. Metrics in Section 3, Attachment 2 may be reported twice if they are located in areas used by both Chinook and steelhead. Further detail of work accomplished can be found in BPA's Report Center Habitat Metrics Report, available at http://www.efw.bpa.gov/IntegratedFWP/reportcenter.aspx.

c. By population, report progress toward overall habitat quality improvement targets and population-specific survival benefit."

Habitat quality improvements (HQIs) achieved from 2007 to 2011 and projected from 2012 through 2018 are reported in Table 35. The HQIs under the "From RPA Action 35, Table 5" columns are the requirements specified in the 2008/2010 FCRPS BiOp. The HQIs under the "From Expert Panel Results" columns are derived from expert panel results. HQIs achieved by 2009 represent projects completed by the time the panels were convened in 2009. Projects identified in the 2007 Biological Analysis, but not completed for various reasons by 2009, were completed later or replaced by other projects. In all cases, the projects were evaluated by expert panels when the panels convened. HQIs achieved by 2011 reflect completed projects evaluated by the expert panels convened in 2009 and 2012. HQIs for 2018 were derived from the menu of 2012 to 2018 habitat improvement projects evaluated by the expert panels and for a menu of supplemental actions (2014-18 Implementation Plan (IP), Appendix B Tributary Habitat Supplemental Actions Table) whose projects will be evaluated by the 2015 expert panels. The last two columns denote the progress toward or in addition to the BiOp requirements based on projections of the 2012 expert panels and supplemental actions for applicable populations. Values that exceed 100 percent indicate that the 2018 Table 5 requirement was met or exceeded by projects completed through 2011 (second to last column) or through the menu of all 2012 to 2018 habitat improvement projects (last column). Evaluations and revisions of the menu of 2012 to 2018 projects by the 2015 expert panels will be based on updated information and may cause these results to change up or down in 2015.

Table 35. Habitat Quality Improvements Achieved from 2007 to 2011 and Projected from 2012 through 2018. [**Bold** entries represent priority populations. The "*" represents populations evaluated with the "Appendix E method" (2004 FCRPS BiOp) (Comprehensive Analysis, Appendix C, Attachment C1, 2007); the "**" represents populations evaluated with the Appendix E method from 2007 to 2009, and evaluated by expert panels from 2010 to 2018; unmarked populations were evaluated by expert panels beginning in 2007].

			From RPA Action 35, Table 5		Results from Expert Panel or Appendix E Evaluations			Including Menu of Sup-plemental Projects	Percentage at or above 2018 Table 5 Habitat Quality Improvement	
ESU	MPG	Population	Estimated Percentage Habitat Quality Improvement of 2007-2009 Actions	Total Estimated Percentage Habitat Quality Improvement of 2007-2018 Actions	Habitat Quality Improvement Achieved through 2009[8]	Habitat Quality Improvement Achieved through 2011	Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates	Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates	Percentage of 2018 Habitat Quality Improvement through 2011	Projected Percentage of 2018 Habitat Quality Improvement Based on the Full Menu of Identified Projects Available through 2018[9]
Snake River Spring/Summer Chinook	Grande Ronde/ Imnaha	**Catherine Creek**	**4**	**23**	**3**	**5**	**11**	**15[10,11]**	**22%**	**65%**
		**Lostine/	2	2	2	3	7	7	150%	350%

[8] *HQI achieved through 2009 reflects habitat improvement projects that were completed by 2009 as planned in 2007, planned in 2007 but completed with modifications by 2009, and completed by 2009 but not planned in 2007. Expert panels assigned the planned benefits as evaluated in 2007 for projects completed as planned, adjusted benefits up or down, as appropriate, for projects completed with modifications, and estimated benefits for projects completed by 2009 but not planned in 2007. Projects planned in 2007 but not completed by 2009 were completed in a subsequent implementation cycle, planned for completion in a later implementation cycle, or proved infeasible to complete at this time. Infeasible projects were replaced by feasible projects at the population, MPG, or ESU/DPS level and evaluated by expert panels. The steady increase in projects and project metrics (Section 3, Attachment 2, Table 1), and HQI (Section 2,Table 35) demonstrates the progress that the Action Agencies and regional partners have made since work was initiated for the 2008/2010 FCRPS BiOp.*

[9] *This column represents results of 2012 Expert Panel or Appendix E evaluations for all populations and supplemental projects for seven populations including six priority populations that were obtained after the 2012 Expert Panels were concluded. These supplemental projects have been evaluated by the Action Agencies for associated benefits (Appendix B) which will be reviewed and confirmed by the 2015 Expert Panels.*

[10] *Includes estimated HQI from supplemental projects for this population. HQI for projects evaluated by expert panels, supplemental projects, and Fish Accord projects are shown separately in Section 3, Appendices A and B of the 2014-2018 FCRPS BiOp Implementation Plan.*

[11] *This estimate includes HQIs for Catherine Creek produced from results of 2007 to 2018 habitat improvement projects evaluated by expert panels and supplemental projects that are identified in the 2014-2018 Implementation Plan, Appendix B and estimated by the Action Agencies. An additional adaptive management strategy that the Action Agencies, in coordination with regional partners, are currently employing is the use of the Catherine Creek Atlas Process. This process, similar to that implemented for the Entiat will deliver a product at the same level of detail as the Entiat Project Map Books that will include a menu of additional habitat improvement opportunities to the ones in Appendix B of the 2014-2018 Implementation Plan. Projects that are identified through the Catherine Creek Atlas process will be presented to the Expert Panel in 2015 to evaluate and estimate HQIs. Additional benefits to Catherine Creek Chinook have also occurred as a result of reforms implemented for Lookinglass hatchery that are not captured in this Table. For more details about the 12% relative reproductive improvement, see Appendix C: Estimating the Benefits of Hatchery Reform.*

			From RPA Action 35, Table 5		Results from Expert Panel or Appendix E Evaluations			Including Menu of Sup-plemental Projects	Percentage at or above 2018 Table 5 Habitat Quality Improvement	
ESU	**MPG**	**Population**	**Estimated Percentage Habitat Quality Improvement of 2007-2009 Actions**	**Total Estimated Percentage Habitat Quality Improvement of 2007-2018 Actions**	**Habitat Quality Improvement Achieved through 2009[8]**	**Habitat Quality Improvement Achieved through 2011**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Percentage of 2018 Habitat Quality Improvement through 2011**	**Projected Percentage of 2018 Habitat Quality Improvement Based on the Full Menu of Identified Projects Available through 2018[9]**
		Wallowa River								
		Grande Ronde River upper mainstem	**2**	**23**	**2**	**4**	**5**	**23[10]**	**17%**	**100%**
		**Imnaha River mainstem	1	1	1	1	1	1	100%	100%
	Middle Fork Salmon River	Big Creek	1	1	0	0.4	4	4	40%	400%
	South Fork Salmon River	Secesh River	1	1	1	5	6	6	500%	600%
		South Fork Salmon River Mainstem	<1	<1	0.2	2	5	5	200%	500%
	Lower Snake	**Tucannon River**	**7**	**17**	**1**	**2**	**29**	**29**	**12%**	**171%**
	Upper Salmon River	East Fork Salmon River	1	1	2	2	6	6	200%	600%
		Lemhi River	7	7	12	28	32	32	400%	457%
		Pahsimeroi River	41	41	41	62	70	70	151%	171%
		Salmon River lower mainstem below Redfish Lake	1	1	2	3	3	3	300%	300%
		Salmon River upper mainstem above Redfish Lake	14	14	4	5	13	14[10]	36%	100%

			From RPA Action 35, Table 5		Results from Expert Panel or Appendix E Evaluations			Including Menu of Sup-plemental Projects	Percentage at or above 2018 Table 5 Habitat Quality Improvement	
ESU	**MPG**	**Population**	**Estimated Percentage Habitat Quality Improvement of 2007-2009 Actions**	**Total Estimated Percentage Habitat Quality Improvement of 2007-2018 Actions**	**Habitat Quality Improvement Achieved through 2009[8]**	**Habitat Quality Improvement Achieved through 2011**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Percentage of 2018 Habitat Quality Improvement through 2011**	**Projected Percentage of 2018 Habitat Quality Improvement Based on the Full Menu of Identified Projects Available through 2018[9]**
		Valley Creek	1	1	3	13	19	19	1300%	1900%
		Yankee Fork	**10**	**30**	**0**	**0**	**21**	**43[10]**	**0%**	**143%**
Upper Columbia Spring Chinook	Upper Columbia – Below Chief Joseph	**Entiat River**	**10**	**22**	**1**	**3**	**9**	**24[10]**	**14%**	**109%**
		Methow River	**2**	**6**	**1**	**2**	**8**	**8**	**33%**	**133%**
		Wenatchee River	**1**	**3**	**1**	**1**	**5**	**5**	**33%**	**167%**
Middle Columbia Steelhead	Cascades Eastern Slope Tributaries	*Deschutes River – eastside	1	1	1	1	1	1	100%	100%
		*Deschutes River – Westside	<1	<1	<1	1	1	1	100%	100%
		*Fifteen mile Creek (winter run)	<1	<1	<1	1	1	1	100%	100%
		*Klickitat River	4	4	4	4	4	4	100%	100%
	John Day River	*John Day River lower mainstem tributaries	<1	<1	<1	1	1	1	100%	100%
		*John Day River upper mainstem	<1	<1	<1	1	1	1	100%	100%
		*Middle Fork John Day River	<1	<1	<1	1	1	1	100%	100%
		*North Fork John Day River	<1	<1	<1	1	1	1	100%	100%
		*South Fork John Day River	1	1	1	1	1	1	100%	100%

			From RPA Action 35, Table 5		Results from Expert Panel or Appendix E Evaluations			Including Menu of Sup-plemental Projects	Percentage at or above 2018 Table 5 Habitat Quality Improvement	
ESU	**MPG**	**Population**	**Estimated Percentage Habitat Quality Improvement of 2007-2009 Actions**	**Total Estimated Percentage Habitat Quality Improvement of 2007-2018 Actions**	**Habitat Quality Improvement Achieved through 2009[8]**	**Habitat Quality Improvement Achieved through 2011**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Percentage of 2018 Habitat Quality Improvement through 2011**	**Projected Percentage of 2018 Habitat Quality Improvement Based on the Full Menu of Identified Projects Available through 2018[9]**
	Umatilla and Walla Walla River	*Touchet River	4	4	4	4	4	4	100%	100%
		*Umatilla River	4	4	4	4	4	4	100%	100%
		*Walla Walla River	4	4	4	4	4	4	100%	100%
	Yakima River Group	*Naches River	4	4	4	4	4	4	100%	100%
		*Satus Creek	4	4	4	4	4	4	100%	100%
		*Toppenish	4	4	4	4	4	4	100%	100%
		*Yakima River upper mainstem	4	4	4	4	4	4	100%	100%
Snake River Steelhead	Clearwater River	**Lochsa River**	**6**	**16**	**4**	**6**	**8**	**17[10]**	**38%**	**106%**
		Lolo Creek	**8**	**12**	**2**	**3**	**18**	**18**	**25%**	**150%**
		Selway River	**<1**	**<1**	**0**	**0.01**	**1**	**1**	**100%**	**100%**
		South Fork Clearwater River	**5**	**14**	**2**	**4**	**13**	**17[10]**	**29%**	**121%**
	Grande Ronde River	**Grande Ronde River lower mainstem tributaries	<1	<1	<1	0.01	0.4	0.4	100%	100%
		Grande Ronde River upper mainstem	4	4	2	3	4	4	75%	100%
		**Joseph Creek (OR)	<1	<1	<1	0.4	1	1	100%	100%
		*Joseph Creek	4	4	4	4	4	4	100%	100%

			From RPA Action 35, Table 5		Results from Expert Panel or Appendix E Evaluations			Including Menu of Sup-plemental Projects	Percentage at or above 2018 Table 5 Habitat Quality Improvement	
ESU	**MPG**	**Population**	**Estimated Percentage Habitat Quality Improvement of 2007-2009 Actions**	**Total Estimated Percentage Habitat Quality Improvement of 2007-2018 Actions**	**Habitat Quality Improvement Achieved through 2009[8]**	**Habitat Quality Improvement Achieved through 2011**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates**	**Percentage of 2018 Habitat Quality Improvement through 2011**	**Projected Percentage of 2018 Habitat Quality Improvement Based on the Full Menu of Identified Projects Available through 2018[9]**
		(WA)								
		**Wallowa River	<1	<1	<1	2	3	3	200%	300%
	Hells Canyon	Hells Canyon								
	**Imnaha River	Imnaha River		<1	<1	<1	3	3	100%	300%
	Lower Snake	Asotin Creek	4	4	5	5	5	5	125%	125%
		Tucannon River	5	5	1	3	47	47	60%	940%
	Salmon River	**Lower Middle Fork mainstem and tributaries (Big, Camas, and Loon Creeks)**	**1**	**2**	**0**	**0.4**	**3**	**3**	**21%**	**150%**
		East Fork Salmon River	2	2	1	2	4	4	100%	200%
		Lemhi River	3	3	8	23	27	27	767%	900%
		Pahsimeroi River	9	9	19	27	37	37	300%	411%
		Salmon River upper mainstem	6	6	2	4	8	8	67%	133%
		Secesh River	**1**	**6**	**1**	**5**	**6**	**6**	**83%**	**100%**
		South Fork Salmon River	**<1**	**1**	**0**	**1**	**5**	**5**	**100%**	**500%**
Upper Columbia Steelhead	Upper Columbia River –	**Entiat River**	**6**	**8**	**1**	**3**	**8**	**8**	**38%**	**100%**
		Methow River	**2**	**4**	**2**	**2**	**7**	**7**	**50%**	**175%**

			From RPA Action 35, Table 5		Results from Expert Panel or Appendix E Evaluations			Including Menu of Sup-plemental Projects	Percentage at or above 2018 Table 5 Habitat Quality Improvement	
ESU	MPG	Population	Estimated Percentage Habitat Quality Improvement of 2007-2009 Actions	Total Estimated Percentage Habitat Quality Improvement of 2007-2018 Actions	Habitat Quality Improvement Achieved through 2009[8]	Habitat Quality Improvement Achieved through 2011	Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates	Habitat Quality Improvement Achieved through 2011 + 2012-18 Estimates	Percentage of 2018 Habitat Quality Improvement through 2011	Projected Percentage of 2018 Habitat Quality Improvement Based on the Full Menu of Identified Projects Available through 2018[9]
	below Chief Joseph	**Okanogan River**	12	14	1	7	17	17	50%	121%
		Wenatchee River	1	4	2	2	6	6	50%	150%

d. *Where population-specific survival benefits are not achieving Progress Guidelines above, identify processes or projects in place to ensure achievements by the next comprehensive report."*

The Action Agencies are committed to meet or exceed the RPA Action 35, Table 5 HQIs for all 18 priority populations by 2018. This commitment is grounded in the tables of completed projects presented in CE Section 3, Attachment 2, Tables 1, 2, and 3 and the menu of 2012 to 2018 projects in Appendix A of the 2014-2018 IP. All of the projects in these tables were evaluated by expert panels. Results from the 2012 expert panels indicate that 12 of 18 priority and 37 of 38 of the remaining Table 5 populations have either already met or exceeded or are projected to meet or exceed the Table 5 HQIs for Chinook (Figure 40) and steelhead (Figure 41) by 2018. The Action Agencies have developed a multi-faceted Adaptive Management Plan (CE Appendix A) to meet or exceed Table 5 HQIs for all Table 5 populations in close coordination with regional partners and NOAA, focusing attention on the six Table 35 priority populations where 2012 expert panel results are not currently projected to reach Table 5 HQIs. This approach includes three components:

- *Habitat projects reviewed for benefits by the 2012 Expert Panels.* Results from the 2012 Expert Panels indicate that 12 of 18 priority populations evaluated by the Expert Panels and 37 of 38 remaining populations have either already met or exceeded or are projected to meet or exceed the FCRPS BiOp RPA Action 35 Table 5 HQIs for Chinook (Figure 40) and steelhead (Figure 41) by 2018. The Action Agencies have committed to implement projects from a "menu of projects" as necessary to meet or exceed the RPA Action 35, Table 5 HQIs. The menu of projects is presented in the 2014-2018 IP, Appendix A Tributary Habitat Projects table.
- *Supplemental habitat actions for the six priority populations where 2012 Expert Panel results were not projected to reach Table 5 HQIs.* The Action Agencies, with Fish Accord and other partners have identified and evaluated a menu of additional habitat actions, where they may be necessary, to meet the 2018 Table 5 HQIs for four priority and one other Chinook populations and for two priority steelhead populations (Table 35). These supplemental habitat actions will be implemented as necessary to meet the 2018 HQIs under the Fish Accords or through existing contracts. All of the supplemental actions took limiting factors for each population into consideration and built from geomorphic analysis or tributary and reach assessments completed by Federal and local entities. Supplemental actions are presented in the 2014-2018 IP, Appendix B. The Action Agencies estimated the benefits of these supplemental habitat actions using results from the expert panels as a basis for an interim estimate. These estimates will be reviewed by the expert panels as they perform their evaluations in 2015.
- *Insurance Plan. As an added precaution for meeting BiOp commitments, a "replacement project strategy"* may be implemented in the unlikely event that the program is not projected to meet the 2018 HQIs for any priority population. This would be determined after the 2015 expert panels evaluate progress and projections for implementation. The Action Agencies have coordinated with NOAA to develop a methodology for "replacement projects" as called for in RPA 35. The replacement project strategy is presented in the 2014-2018 IP, Appendix D.

Aspects of the first two bullets above are incorporated in specific adaptive management plans summarized below.

<u>Grande Ronde/Imnaha Rivers</u>

To ensure that 2018 Table 5 HQIs are met for the Grande Ronde River populations, the Action Agencies have worked to enhance the administrative capacity necessary to implement projects in the upper Grande Ronde River and Catherine Creek, prepared tributary and reach assessments for Catherine Creek, are starting to prepare tributary and reach assessments in the upper Grande Ronde

River, are providing organizational support to the local watershed groups, and are spearheading a process with the local watershed groups to identify specific types of projects that would address high-priority limiting factors. The Action Agencies have worked with Fish Accord partners to develop supplemental actions to assure that 2018 Table 5 HQIs are met for the upper Grande Ronde Chinook population and achieve a significant portion of the HQIs for the Catherine Creek Chinook population. In addition, the Action Agencies have adopted a strategy for achieving the complete target HQI for Catherine Creek by 2018. (See CE Appendices A and C).

Upper Salmon River

Table 5 2018 HQIs for most of the upper Salmon River populations do not warrant any special implementation or adaptive management changes, but the highly degraded habitat, complicated opportunities, and potential hazards associated with legacy land use in the Yankee Fork watershed called for careful investigation and analysis before attempting further habitat modifications. The Action Agencies are addressing the Yankee Fork Chinook 2018 Table 5 HQI by building and strengthening working relationships with local partners and using newly developed tributary and reach assessments to plan, prioritize, and implement habitat improvement actions that will provide fish benefits. Reclamation’s Yankee Fork tributary and reach assessments were developed in partnership with Idaho’s Office of Species Conservation, the U.S. Forest Service (USFS), Shoshone-Bannock Tribe, Idaho Department of Fish and Game, multiple private landowners, Trout Unlimited, and others. With the first habitat improvement actions implemented in 2012, the Action Agencies have started to make progress toward the 2018 Table 5 HQI. The Action Agencies have worked with regional partners to develop supplemental actions to assure that 2018 Table 5 HQIs are met or exceeded for Yankee Fork Chinook.

Lower Salmon River

After the Action Agencies expanded funding to support implementation for all of the FCRPS BiOp RPA Action 35 Table 5 populations in the lower Salmon River, they also adaptively manage implementation by working closely with project sponsors to ensure that the actions are consistent with identified priority areas and limiting factors. This is facilitated through the use of tools such as updated limiting factor maps, and updated limiting factor status and potential information. In addition, research, monitoring, and evaluation results are being used to inform project identification, prioritization, and implementation decisions.

Lower Snake River

Since 2007, the Action Agencies more than doubled funding for habitat improvement in the Tucannon River Basin. The increased funding has allowed the local watershed implementers to expand the pace, scale, and quality of habitat improvement projects being implemented. By relying on the well-organized Snake River Salmon Recovery Board to plan, prioritize, and select projects for implementation, the Action Agencies have an adequate strategy and resources in place to achieve the 2018 Table 5 HQIs.

Clearwater River

Since 2008, the Action Agencies have increased the available funding for habitat improvement projects for the four Clearwater populations with 2018 Table 5 HQIs. This funding increase has allowed the Action Agencies’ implementation partners, e.g., the Nez Perce Tribe and the USFS, to ramp up their capacity and increase progress to achieve the 2018 Table 5 HQIs for each Clearwater River population. The Action Agencies are also working closely with the project sponsors to ensure that the actions implemented address the priority limiting factors and assessment units. The Action Agencies will review actions prior to executing contracts to ensure they are focused on meeting the Table 5 HQIs by 2018. The Action Agencies have worked with regional partners to develop supplemental actions to assure that 2018 Table 5 HQIs are met or exceeded for the Lochsa and South Fork Clearwater steelhead.

Upper Columbia River

The Action Agencies have continued to support an expanded effort to implement projects in the Wenatchee, Entiat, Methow and Okanogan river basins that began in 2001. In 2008, funding for habitat improvements was increased through the Fish Accord Agreements with the Yakama Nation and Confederated Tribes of the Colville Reservation (CTCR). BPA also merged the other non-Accord habitat projects into a single programmatic contract with the Upper Columbia Salmon Recovery Board (UCSRB) in 2011. Both BPA and Reclamation have dedicated professional staff that remain involved in project design, preparing tributary and reach assessments, and working with other local processes and entities to develop high-quality habitat projects. By expanding available funding and dedicating staff to support efforts of the UCSRB, and by providing tools to identify, prioritize, and select projects that address high priority limiting factors, the Action Agencies have a strategy and the resources to achieve the upper Columbia River population Table 5 HQIs by 2018. The Action Agencies have worked with Fish Accord partners to develop supplemental actions to assure that Table 5 HQIs are met or exceeded for Entiat Chinook salmon.

A detailed description of the Adaptive Management Plan is presented in CE Section 2, Appendix A.

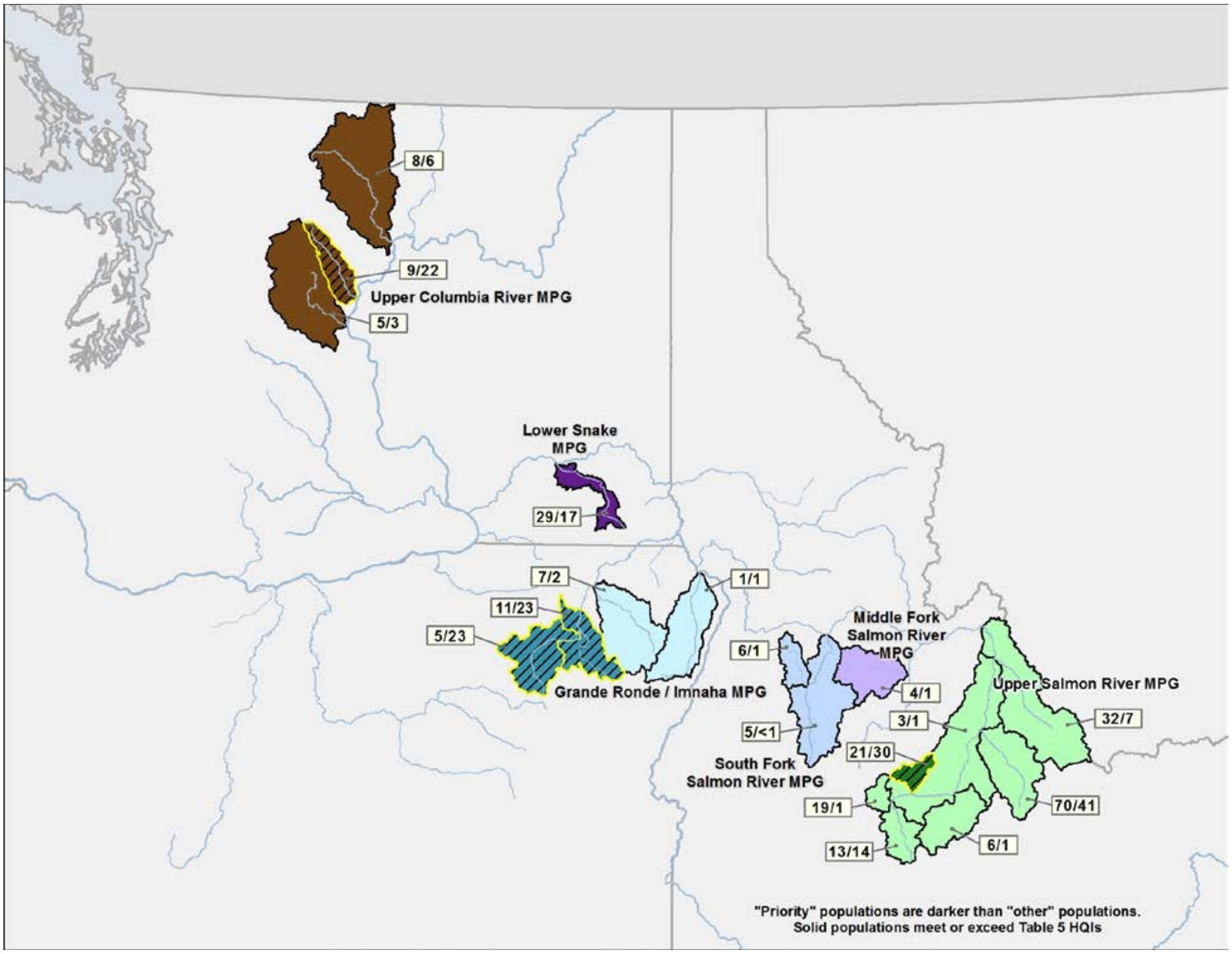


Figure 40. 2012 Projections toward Achieving 100 Percent of 2018 Table 5 Habitat Quality Improvement by 2018 for Chinook Salmon. This map of the Columbia River Basin in Oregon, Washington, and Idaho, depicts (in color) the tributary basins where habitat is being improved by the Action Agencies and partners. Darkest shades depict areas with priority populations. Projected 2018 HQIs based on expert panel results are shown in the white boxes near each basin. The number to the left of the slash represents the percent HQI projected through 2018; the number to the right of the slash represents the percent HQI to be achieved by 2018 for Chinook salmon (RPA 35 Action, Table 5).

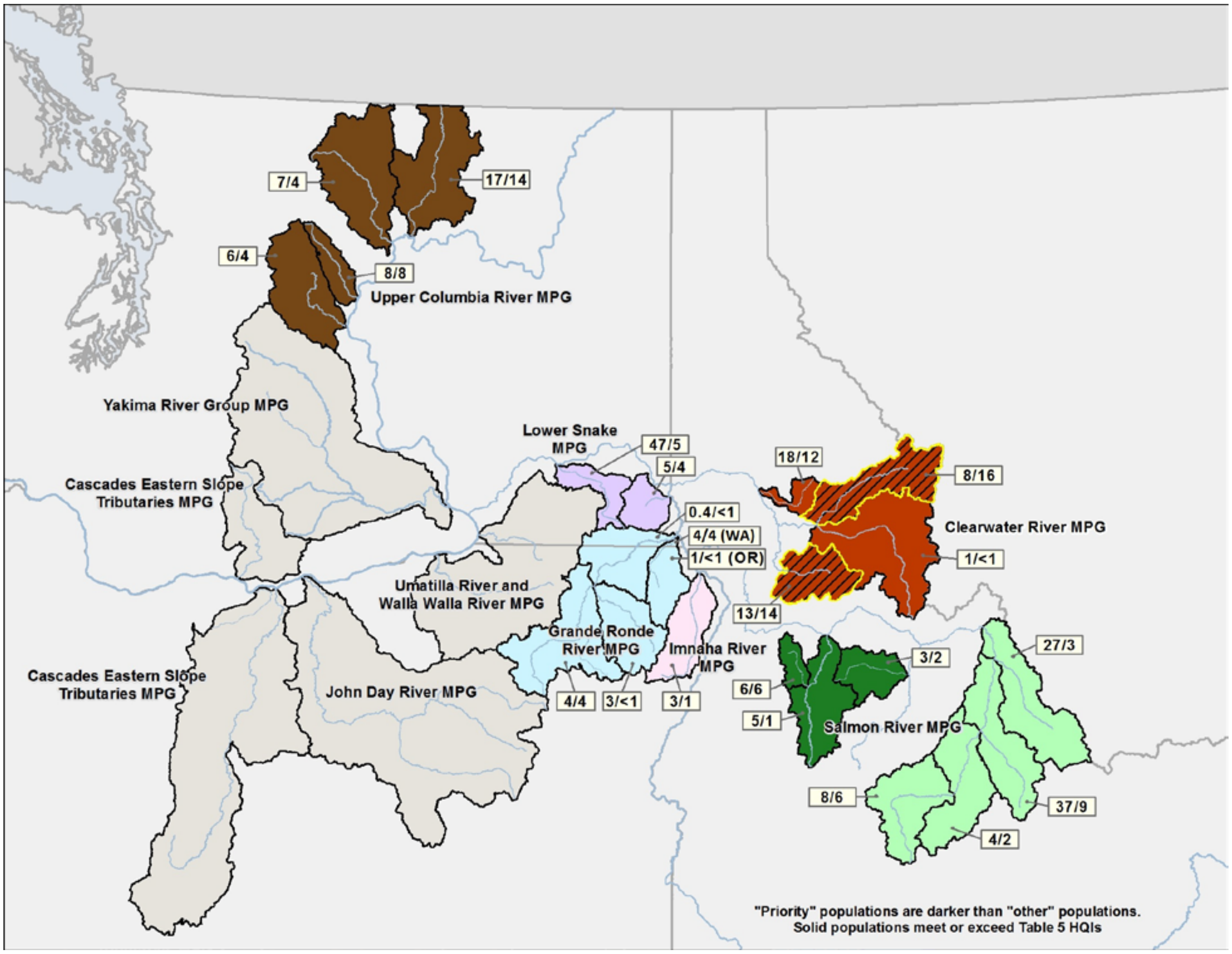


Figure 41. 2012 Expert Panel Projection to Meet or Exceed 100 Percent of 2018 Table 5 Habitat Quality Improvement by 2018 for Steelhead. This map of the Columbia River Basin in Oregon, Washington, and Idaho, depicts (in color) the tributary basins where habitat is being improved by the Action Agencies and partners. Darkest shades depict areas with priority populations. Projected HQI values out to 2018 are shown in the white boxes near each basin. The number to the left of the slash represents the expert panel percent HQI projected through 2018; the number to the right of the slash represents the percent HQI to be achieved by 2018 for steelhead (RPA 35 Action, Table 5).

e. *Report results of all biological effectiveness monitoring studies, including new scientific information, and identify how results will be applied to future implementation, if appropriate.*

Recent Research

The effects of tributary habitat improvement projects are documented in results from status and trend monitoring of habitat and fish conditions. Current research links these different monitoring and evaluation results to develop empirical relationships that are incorporated into numerical models that relate habitat projects with changes in habitat conditions, and changes in habitat conditions with changes in fish survival and growth. Status and trend monitoring and related research fit into the short- and long-term strategies presented in the action agency RME Framework.

Several studies from the literature discuss and/or support the effectiveness of tributary habitat improvement projects for Pacific salmon and steelhead. Roni et al. (2008) summarized current knowledge about the effectiveness of techniques such as road improvement, riparian rehabilitation, floodplain connectivity and rehabilitation, instream habitat improvement, nutrient addition, and other, less-common techniques for improving physical habitat and water quality and increasing fish and biotic production. The authors reviewed 345 studies on effectiveness of stream rehabilitation but noted that conclusions regarding specific techniques were difficult to make because of the limited information provided on physical habitat, water quality, and biota, as well as the short duration and limited scope of most published evaluations. The effectiveness of projects that reconnect isolated habitats, rehabilitate floodplains, or improve instream habitat has been documented where preliminary results are available. Techniques such as riparian rehabilitation, road improvements (sediment reduction), dam removal, and reintroduction of natural flood regimes have shown promise for reintroducing natural processes that create and maintain habitats. Long-term studies documenting the success of these projects have not been published. The authors noted that the low success of many rehabilitation projects in achieving objectives is attributable to inadequate assessment of historic conditions and factors limiting biotic production, poor understanding of watershed-scale processes that influence localized projects, and monitoring at inappropriate spatial and temporal scales. The approach of the Action Agencies to address the RPA tributary habitat improvement actions for the FCRPS BiOp takes into consideration these concerns.

Summary of Biological Effects of Tributary Habitat Actions

The goal of tributary habitat improvement projects is to improve the growth and survival of Pacific salmon and steelhead during the time they reside in tributaries to the Columbia and Snake rivers. This period includes the life history stages of spawning adults, eggs, parr, fingerlings, and smolts. Ongoing tributary habitat research, monitoring, and evaluation (RME) conducted by regional state, tribal, and other federal agencies has been designed to document the benefits that tributary habitat improvement actions contribute to improving survival of Pacific salmon and steelhead during the tributary life history stages (egg to out-migrating smolts). Additional information on tributary habitat RME is presented in RPA Actions 56 and 57, the RME Framework report (BPA, 2013a), and the Tributary Habitat Benefits report (BPA, 2013b).

Implementation and Compliance Monitoring

Implementation and compliance monitoring verifies that habitat actions have been completed and are still in place and functioning as intended. Tables including limiting factors and metrics for actions completed from 2007 to 2011 (CE Section 3, Attachment 2, Tables 1, 2, and 3) are examples of implementation monitoring. Examples of compliance monitoring include completion reports produced by the Action Agencies (CE Section 3, Attachment 3) and databases maintained by the Action Agencies with input from regional partners that are used to produce reports of completed projects and associated metrics (CE Section 3, Attachment 2). Examples of compliance monitoring include expert panel evaluations of how projects function after they are completed and project review reports produced by the Action Agencies that assess the continuing function of completed projects (CE Section 3, Attachment 3).

Project-level Tributary Habitat Improvement Actions and Effectiveness Monitoring

Habitat improvement actions have been implemented in the Columbia Basin to support the RPA Actions in the 2008-2010 FCRPS BiOp and other programs. Habitat improvement actions address factors limiting the growth and survival of Pacific salmon and steelhead, such as streamflow, stream complexity, riparian protection and enhancement, water diversions and fish screens, and access to suitable spawning and rearing habitat. Some habitat actions such as placement of instream structures or barrier removal have been implemented on a small scale to address local or stream-reach habitat issues. Project-level action effectiveness monitoring tracks changes in the response of fish to habitat improvement actions.

Some results and findings of tributary habitat action effectiveness monitoring that demonstrate relationships between habitat improvement actions (e.g., stream flow, complexity, riparian protection and enhancement, screening, and access) and Pacific salmon and steelhead growth and survival are discussed below. Habitat improvement actions in the interior Columbia Basin to improve salmon and steelhead habitat and fish growth and survival have been implemented over a long time frame and at various scales. As a result, for some recently implemented habitat actions, action effectiveness monitoring may not have been conducted for a sufficient amount of time to yield definitive results. For some actions citable results may be years in the future. Given this and the need to be able to discuss what is being accomplished with managers, administrators, and decision makers, the Action Agencies developed the Tributary Habitat Benefits report (BPA, 2013b). This report allows for a preliminary "report out" and discussion of actions that have resulted in observable benefits to either habitat or fish numbers.

Streamflow

Adequate streamflow is required to maintain the condition of the instream habitat, maintain hydrologic and channel building processes, and maintain the production and distribution of macroinvertebrates and fish. Improved streamflow where flows had been diminished over time has been shown to improve macroinvertebrate and fish productivity (Roni et al., 2012). Reduced streamflows are consequent of historic diversions and have adversely affected rearing or migrating juvenile salmon and steelhead. Increasing streamflow is also important for the success of other habitat improvement actions such as riparian plantings and floodplain and side channel reconnection.

A BPA-funded water leasing program that began in 2005 returned water to the Lostine River in northeast Oregon, where irrigation diversions had previously left sections dry when Snake River Chinook salmon returned to spawn. The additional water helped support a rising number of returning natural-origin and hatchery-origin adult Chinook salmon reach more miles of spawning habitat and improved conditions for their eggs through late summer and fall. Redd counts rose following the higher influx of returning adults and implementation of the leasing program (BPA, 2013).

Complexity

Complex habitat provides more opportunities for a range of habitat conditions to be available for rearing and migrating juvenile salmonids. Instream structures such as boulders or large wood, connection to the floodplain or side channels, and the presence of pool and riffle habitat contribute to tributary habitat complexity.

Elbow Coulee –This habitat improvement action breached a levee to allow water to enter a side channel of the Twisp River. Juvenile spring Chinook salmon and steelhead have been observed in the side channel following nine activation events spanning 284 days over a three-year period. In late 2008, 42 fish representing three species were captured and identified. Fish were captured along the entire length of the wetted channel and were most commonly observed in the deeper portions of the channel in pools (Crandall, 2009). In late 2011, an almost three-fold increase in fish abundance from 2008 occurred (137 fish) with five fish species present in the side channel (with *O. mykiss* predominating, followed by Chinook salmon and brook trout). Coho salmon and sucker were also observed to occur in very low numbers (Crandall, 2010 and 2013).

While rearing-sized fish were observed in the side channel prior to re-connection with the river, the presence of young-of-the-year fish, including Endangered Species Act (ESA)-listed salmonids, in the uppermost pool in the side channel is strong evidence that these fish gained access to the side channel through the newly constructed breach. Although it is plausible that 40 mm salmonids could have gained access to and entered the side channel from downstream, the presence of larval sculpin (<20mm) that lack the swimming ability to move upstream through the side channel provides compelling evidence that the observed fish entered the side channel through the newly created breach. Thus, it was concluded that fish gained access to the side channel during the first activation event post-emergence and resided in the channel (Crandall, 2009). Based on observations, the period of fish residency in the side channel is estimated at several weeks to months and possibly longer for fish that chose to remain in the groundwater influenced portion of the channel. Future monitoring will focus on determining whether undesired stranding is occurring and whether the side channel prematurely begins to fill with fine sediment and detritus.

In 2011, beaver constructed two dams just downstream from the flow monitoring site in the side channel. While the ponds that resulted from this activity disrupted the continuous flow monitoring instrumentation by flooding the area, listed fish species were observed using the ponds almost immediately (Molesworth, USBR, pers. comm.). This change in habitat type has increased habitat complexity within the channel through increased pool habitat, wetted width, and large wood and improved conditions for fish.

Bridge Creek – Bridge Creek, a tributary of Oregon's John Day River, is an IMW under the ISEMP program. Bridge Creek had become deeply incised, straightened, and disconnected from its floodplain, resulting in higher water temperatures and loss of spawning and rearing habitat for steelhead. The habitat improvement action involved installing posts in selected areas to help anchor and stabilize beaver dams that previously washed out during high flows. The project provides a good example of the benefits of experimental habitat improvement actions with control areas for comparison. Stable beaver dams were expected to slow the water flow, reintroduce more natural stream dynamics including sinuosity, reconnect the stream to the floodplain, reduce water temperatures and improve groundwater exchange benefiting riparian vegetation. These habitat improvements were expected to benefit steelhead by providing more food and refuge and more favorable habitat conditions. The installed posts successfully stabilized a larger proportion of beaver dams. Changes in stream contours and riparian vegetation considered favorable for fish occurred relatively quickly. Deposition increased in the experimental reach compared to the control reach as the incised streambed began to aggrade. The width of the stream and the depth, frequency, and percentage of pools increased compared to the control reach and the proportion of small silt particles in the water declined, indicating that the creek was slowing down and evolving into more complex and favorable habitat for fish (BPA and Reclamation, 2013).

Both steelhead abundance and survival increased in the treatment reach relatively quickly. Steelhead abundance in the experimental treated reach steadily rose beyond the abundance of steelhead in the control reach in the years following the treatment. Steelhead survival in the treated reach also eventually increased to exceed that of steelhead survival in the control reach. Steelhead survival had been higher in the control area preceding the treatment to stabilize beaver dams. The area and timing of the response of steelhead populations suggests that the improvements in survival and abundance were the result of the habitat improvement action.

Riparian Protection and Enhancement

Habitat conditions in riparian areas along streams are sometimes degraded to the point that they have a negative effect on the condition of the instream habitat. Degraded riparian conditions can result from excessive livestock grazing and other anthropogenic activities along streams. Degraded instream habitat conditions resulting from degraded riparian habitat include warmer water temperatures, less cover, higher levels of sediment, and reduced productivity. Actions such as fencing to limit or exclude livestock, planting of locally adapted vegetation, and removal of invasive or non-native species over time will generally improve the condition of the riparian vegetation, reduce bank erosion and sediment levels, provide shade to reduce water temperatures and improve water quality, and improve fish and macroinvertebrate production. Livestock exclusion substantially reduces pressure on riparian vegetation, which can recover in a matter of five to 10 years (Roni et al., 2008). Once implemented, riparian habitat treatments may take several years to produce benefits to the stream and fish.

Hancock Springs — A habitat improvement action on a small degraded creek fed by Hancock Springs in the upper Methow River Basin included fencing to exclude livestock grazing, riparian planting, some channel excavation and reconfiguration and addition of large wood. After construction, steelhead and Chinook salmon returned to the improved reach of the creek in greater numbers compared to the control reach (BPA and Reclamation, 2013). It is expected that over time the improved riparian area will help maintain the integrity of the stream channel.

Protection of riparian buffer zones can reduce sediments from reaching the stream and maintain or improve bank stability and water quality. Protecting riparian areas will generally provide long-term benefits to stream habitat and fish. Protection of high quality functioning riparian habitat is generally more effective overall than improving degraded riparian habitat, which could take years or decades to improve.

Screens

Water diversions for irrigation can adversely affect rearing and migrating juvenile salmon and steelhead. Juvenile fish can become entrained into unscreened canals and lost to the system. Screening is an effective way to reduce or eliminate entrainment of juvenile fish.

<u>Lemhi River</u> – Threatened Lemhi River Chinook salmon smolts encounter anywhere from 41 to 71 water diversions during their outmigration. Walters et al., (2012) used PIT-tag data to model the entrainment rate and potential mortality of Chinook salmon smolts as a function of the water removed by irrigation diversions. With unscreened diversions under median streamflow conditions, the estimated cumulative effect of diversions was of 71.1 percent loss of outmigrating smolts due to entrainment. This estimated mortality was reduced to 1.9 percent when all diversions were screened. The authors noted that their modeling approach could be used to quantify the entrainment effects of water diversions in other watersheds and to set screening priorities. The authors suggest that an effective approach to improving juvenile salmon survival is to target large water diversions with high fish encounter rates.

<u>Beaver Creek</u> – In Beaver Creek in the Methow Basin, three groups of about 30 PIT-tagged fish were released into a diversion above a fish screen. Seventy-five percent of fish released into the diversion moved upstream and exited the diversion, most within five days; 16 percent of the fish were recaptured in the diversion. Fish were not accounted for may have left the diversion during periods when the PIT detector was not operating (Connolly et al., 2008). The screen successfully reduced entrainment of juvenile fish to the canal.

Screening of irrigation diversions should provide nearly immediate benefits to survival and protection of rearing juvenile fish or outmigrating smolts. The effectiveness of screening depends on the time of year diversions occur and the presence of rearing juvenile or outmigrating smolts.

Access

Access to suitable spawning and rearing habitat may be limited due to barriers to migration, low streamflows, or unfavorable water temperatures. Improving access by removing barriers to migration or improving streamflows or reconnecting tributaries with the mainstem are effective ways to increase the amount of suitable habitat available for spawning and rearing.

<u>Lemhi River</u> —Treatments in the Lemhi River have focused on tributary reconnection and instream flow augmentation. Most of these actions were completed in 2010 and 2011. Based on three years of data, there was an increase in the number of Chinook salmon produced per redd compared to the control stream, but so far there has not been a significant trend in freshwater survival rates over six years of monitoring. Some high water years may have influenced fish survival rates in both the treatment and control streams (Roni et al., 2012). Additional monitoring will be necessary to evaluate the habitat actions.

<u>Beaver Creek</u> —In Beaver Creek, a tributary to the lower Methow River in Washington, adult steelhead were observed shortly after a series of irrigation diversions were replaced with a series of rock vortex weirs (RVWs). The RVWs maintained the ability to divert water for irrigation, while allowing upstream and downstream passage of both adult and juvenile fish. The Beaver Creek action provided access to suitable spawning and rearing habitat for anadromous salmonids. Screening of associated irrigation canals reduced juvenile fish entrainment into canals. Adult anadromous steelhead entered the newly accessible habitat in Beaver Creek in 2005, the first year that upstream passage was provided. In 2005, two juvenile Chinook salmon were collected above the two RVWs. An adult Chinook salmon was

observed near rkm 10 in 2006. Adult anadromous steelhead entering Beaver Creek increased over the next several years (Martens and Connolly, 2010). Mountain whitefish and coho salmon were also observed moving up Beaver Creek. Adult anadromous steelhead migrated into upper Beaver Creek in 2007 and 2008, two and three years after barrier reconstruction. Juvenile steelhead tagged in Beaver Creek returned as adults to the creek after two years.

Population- or Watershed-Level Tributary Habitat Improvement Project Action Effectiveness Monitoring

Population- or watershed-level action effectiveness monitoring determines how actions across a larger geographic area collectively affect fish survival or productivity. This level of habitat monitoring evaluates the implementation of a suite of habitat improvement actions.

The IMWs are examples of watershed-level action effectiveness monitoring that help discern relationships between habitat conditions and fish survival and growth. The basic premise of the IMW is that the complex relationships controlling a fish population response to habitat conditions can only be understood and quantified by concentrating monitoring and research at appropriate spatial and temporal scales. Since several habitat improvement actions may be implemented simultaneously or within a few-year period, it may not be easy or even possible to separate out or determine the effect of a single habitat improvement action on growth and survival of targeted fish species; overall the habitat improvement actions may have synergistic effects on improving habitat and on the subsequent growth and survival of targeted fish species.

Habitat improvement actions include but are not limited to in-channel improvement actions, riparian and instream large wood treatments, and instream engineered log structures that increase habitat complexity and diversity by creating large pools and off-channel areas and reintroduce floodplain and side channel connectivity. Pre-treatment monitoring documents existing baseline conditions for habitat and fish, and may define limiting factors, although the extent of pre-treatment data collected varies among IMWs. IMWs in the Methow River, Asotin Creek, Bridge Creek, Entiat River, and the Lemhi River are designed to monitor habitat and biological conditions before and after habitat action implementation and evaluate relationships among habitat improvement actions, subsequent changes in habitat conditions, and resulting changes in the biological response of fish survival and production.

Conditions in IMWs are evaluated over several years and at multiple spatial scales. Population and habitat models are used to plan and analyze data collected in field research experiments and monitoring. Not all IMWs require the same level of habitat improvement actions, since not all IMWs have the same suite a factors limiting salmon or steelhead survival and growth. Since some IMWs in the Columbia Basin are in the early stages of implementation, findings on the effectiveness of their actions for improving fish growth and survival are either preliminary or not available but are expected to be available over the next several years.

Table 36 lists the IMWs in the interior Columbia Basin that will be discussed in greater detail below. Table 37 summarizes the IMWs in the Columbia Basin, along with project action, stage of implementation and finding to date.

Table 36. IMWs Ongoing in the Interior Columbia Basin, with Program, Lead Agency, and Funding Source.

Watershed	Program	Lead	Funding
Asotin Creek	NOAA	NOAA	NOAA
Bridge Creek	ISEMP	NOAA	BPA
Entiat River	ISEMP	NOAA	BPA
John Day River	NOAA	NOAA	NOAA
Lemhi River	ISEMP	NOAA	BPA
Potlatch River	NOAA	NOAA	NOAA
South Fork Salmon	ISEMP	NOAA	BPA

Watershed	Program	Lead	Funding
Upper Middle Fork John Day River	ISEMP/ODFW	NOAA	BPA/NOAA
Methow River	Reclamation	Collaboration of local state, tribal and federal agencies	Reclamation
Grande Ronde River	CRITFC	CRITFC	BPA
Okanogan River	Okanogan Basin Monitoring and Evaluation Program	Colville Tribes	BPA

Table 37. IMWs in the Columbia Basin, along with Habitat Improvement Action, Stage of Implementation, and Findings to Date.

Watershed	Project Action	Stage of Implementation	Findings to date
Asotin Creek	Riparian fencing, planting, thinning, in-channel placement of wood posts and large wood.	Actions phased in starting in 2012. Continued comparisons between treatment and control are planned from 2012 to 2018.	Pilot study in 2011-2012 showed that placement of large wood provided beneficial improvements to the stream habitat.
Bridge Creek	Beaver dam support structures and riparian planting.	Ongoing. Continued evaluation of riparian plantings and beaver dam support structures. Four treatments in 2009 and six in 2013, plus four controls.	Pool frequency, area and depth increased as result of habitat actions implemented. Fish survival and abundance increased.
Entiat River	Large wood and rip-rap structures to increase habitat complexity and off-channel habitat areas.	One control and four treatments to be implemented in 2012, 2014, 2017, and 2020.	Greater densities of juvenile Chinook salmon and steelhead at pools created by log structures during early summer.
John Day River	Fish and habitat status and trend monitoring. Control reach for upper Middle Fork John Day River.	Ongoing fish and habitat status and trend monitoring.	Developing fish-habitat relationships.
Lemhi River	Improve summer flows and remove migration barriers to tributaries. Reconnect tributaries to mainstem.	Ongoing fish and habitat status and trend monitoring.	Fish numbers increased in reconnected tributaries, additional monitoring needed to detect changes in fish productivity.
Potlatch River	Large wood treatments in East Fork Potlatch River, removal of Dutch Flat Dam on West Fork Little Bear Creek, small tributary culvert removal, riparian fencing, flow augmentation.		Late summer rearing habitat is a limiting factor. No post-project data available yet.
South Fork Salmon	Status and trend monitoring.	Ongoing status and trend monitoring in Secesh River.	Developing status and trend data base.
Upper Middle Fork John Day River	Re-alignment and installation of 50+ wood structures in the mainstem, numerous fish screen and passage improvements.	Continued monitoring.	Steelhead spawner abundance increased in treatment area from 2008 to 2011 compared to control area.
Methow River	Increase channel complexity and floodplain connection to mainstem Methow River, installation of instream structures.	Habitat improvement actions began in the treatment reach in 2012.	Pre-treatment habitat data collected and analyzed, post-treatment data collection and analysis will occur from 2013 to 2016.
Grande Ronde River	Monitor and document fish response to habitat improvements. Use structural equation modeling to assess	Ongoing monitoring.	Presence of large wood influences frequency of pools and positively affects fish density.

Watershed	Project Action	Stage of Implementation	Findings to date
	relationships between habitat conditions and fish density.		
Okanogan River	Describe existing conditions in the Okanogan River Basin and document changes in conditions over time.	Ongoing monitoring.	A database for this project has been in development since late 2005 to support ongoing collection of field data in the Okanogan Basin and conduct limited status and trend analysis.

Detailed descriptions of the biological effects observed at several IMWs ongoing in the Columbia Basin are provided below.

Asotin Creek – The Asotin and Charley Creek IMW habitat improvement project is intended to reintroduce large wood and improve channel heterogeneity and stream complexity to four 1 km reaches of South Fork Asotin Creek, North Fork Asotin Creek, and Charley Creek in southeastern Washington (Wheaton et al., 2012). The goal is to increase productivity of wild Snake River steelhead in Asotin Creek. Chinook salmon, bull trout, and Pacific lamprey are also expected to benefit from the habitat improvement actions. The habitat treatment will be phased in over a three-year period. Assessment and monitoring of habitat and fish populations began in 2008 to obtain pre-treatment data to understand the effects of the planned habitat improvement actions. The pre-treatment assessment identified sedimentation, embeddedness, temperature, decreased riparian function, floodplain connectivity, habitat diversity, and low levels of large wood and pool frequency/quality as limiting factors. The habitat treatment is intended to improve pool abundance and gravel bar deposition, and increase channel length through the placement of large wood. Approximately 200 wood structures will be installed per stream reach to restore them to reference condition. Most of the structures will be post deflectors with large wood; about 15 percent will be whole trees. The post deflectors will serve as anchor points to hold large wood in place. The structures are expected to reduce channel width by 50 to 75 percent and help create a more heterogeneous channel shape, increase gravel bar deposition, diversify widths/depths, reduce incision, and increase channel length. Pilot structures were installed in 2011. The pilot was successfully completed in 2012. The pilot structures performed as intended even in the high spring flood flows in 2012. Habitat treatments will be implemented over a three-year period ending in 2014. Fish populations will be monitored using PIT-tags. Monitoring of habitat conditions and fish populations is planned to run through 2018. Although there are only preliminary results from the pilot study to date, reports on the influence of the habitat improvement actions on steelhead production and the causal mechanisms of fish response to the habitat actions are expected to be completed by 2018. Results will be reported annually as they become available.

Bridge Creek – The Bridge Creek IMW is evaluating whether beaver dams can improve habitat conditions to benefit steelhead production. The instream improvement is addressing stream incision and restoring floodplain connectivity to produce a population level improvement in steelhead abundance, survival, and productivity.

The habitat action of driving vertical wood posts into the stream bottom resulted in beaver use during the first year. The action was concluded to improve habitat conditions for fish via increased pool frequency, percent pool area, and average pool depth (*http://isemp.org/watershed.php?chi=1*) . Significant aggradation and reconnection of the floodplain is expected to take more time. Fish survival and abundance increased. Monitoring of habitat conditions and fish populations is planned to continue through 2018. Analysis of the influence of the habitat improvement actions on steelhead production and response to the habitat actions will continue. Results will be reported as they become available.

Entiat River – Simplified channel conditions in the lower Entiat River subbasin have created limiting factors for spring Chinook salmon and steelhead populations. Instream structures such as boulders and logs that increase habitat complexity and diversity were recommended as immediate, short-term actions to increase habitat diversity. The Entiat IMW will implement a series of habitat improvement actions over the next several years. The Entiat IMW is assessing whether engineered log structures increase habitat complexity and diversity sufficient to produce a population-level increase in Chinook salmon abundance or productivity. The structures are designed to create large pools and off-channel habitat.

The Entiat IMW is designed with one dedicated control and four treatment reaches. Because of the small size of the Entiat watershed and the need to produce the most statistically accurate results, implementation in the treatment reaches are staggered to occur in 2012, 2014, 2017, and 2020. This design allows for data collected prior to treatment to supplement data collected in the dedicated control reach. Although this IMW is designed to provide a thorough scientific analysis of treatment and response for a relatively small area, this approach delays the construction of identified habitat improvement projects that are also needed to meet or exceed RPA Action 35, Table 5 HQIs. The ISEMP[12] that incorporates IMW results has designed an intensive habitat action effectiveness monitoring program to detect changes in the habitat and the fish response to the improved habitat. The monitoring program will collect data on juvenile fish abundance, productivity, and growth and survival using various accepted techniques.

Preliminary findings include greater densities of juvenile Chinook salmon and steelhead in pools created by the log structures during early summer. Higher densities of juvenile Chinook salmon appear to be associated with increased water depth around the structures. Both Chinook salmon and steelhead favored pools near installed structures. Steelhead sampled from areas around installed structures also had higher growth rates. Monitoring of habitat conditions and fish populations is planned to continue for several years. Results will be reported as they become available.

John Day River – Monitoring of habitat conditions and fish populations is planned through 2018. Although there are only preliminary results from the pilot study to date, reports on the influence of the habitat improvement actions on steelhead production and the causal mechanisms of fish response to the habitat actions are expected to be completed by 2018. Results will be reported as they become available.

Lemhi River – The Lemhi IMW is tracking fish density, productivity, and distribution in the Lemhi River Basin and evaluating fish response to reconnection of tributary streams to the mainstem and instream habitat improvements actions. Objectives of the Lemhi River IMW are to monitor the changes in distribution of adult anadromous salmonids in reconnected tributaries and in a control tributary (Hayden Creek); estimate rearing densities of juvenile salmonids according to habitat type; measure changes in salmon and steelhead productivity in the Lemhi River Basin; and monitor species composition and length and age distribution. Results will inform models being developed to predict the benefits of channel reconnection. Phase I focused on habitat surveys, fish population estimates, redd counts, and PIT-tagging juvenile salmonids. Phase II monitoring activities include continuation of some of these activities as well as expanding fish population sampling. ISEMP is using IMW results in a watershed model that relates fish abundance, distribution, and survival to the quantity and quality of habitat available to the population at each life-history stage.

Most of the habitat improvement actions have been completed. Fish are returning to and using the reconnected tributaries. Additional monitoring over the next several years is intended to detect changes in productivity and other metrics and evaluate fish-habitat relationships (BPA and Reclamation, 2013). Results will be reported as they become available.

[12] The ISEMP is a status and trend monitoring program that provide information to determine if habitat improvement actions are affecting habitat condition and whether fish survival and growth is improving or not.

Potlatch River – The Potlatch River IMW is evaluating the response of steelhead populations to habitat improvement actions in the Potlatch River. The primary habitat improvement actions are large wood treatments in East Fork Potlatch River, Dutch Flat Dam removal on West Fork Little Bear Creek, small tributary culvert removal, riparian fencing, and flow augmentation. Pre-treatment monitoring suggest that late summer rearing habitat is a limiting factor and that five years of monitoring will be required after habitat improvement actions are implemented to detect changes (Roni et al., 2012). Monitoring of habitat conditions and fish populations is planned to continue for at least five years to evaluate the influence of the habitat improvement actions on steelhead production. Results will be reported as they become available.

Methow River – The Methow River IMW is designed to assess the habitat processes that affect fish populations across multiple spatial and temporal scales and to determine potential benefits to spawning and rearing ESA-listed spring Chinook salmon, steelhead, bull trout, and the non-listed Pacific lamprey. Tributary habitat improvement actions were first implemented in 2012 (Reclamation, 2013a). The design includes development of “explanatory” models to guide understanding of the relationship between habitat improvement projects, changes in habitat conditions, and the resulting changes in biological response. As these relations are refined to account for variations over time, the models will help focus habitat projects where they provide the most benefit to anadromous fish. The Methow habitat improvement action effectiveness monitoring program includes collecting and analyzing pre- and post-implementation physical and biological data to assess population level effects before treatment (2010-2012) and after treatment (2013-2016).

Habitat improvement projects to improve fish production in the Methow River Basin include a nutrient treatment project in the Twisp River, a channel reconnection and channel complexity treatment in the middle Methow River, a small channel complexity before and after control and treatment design at Hancock Springs, and a large channel complexity project in middle Beaver Creek. These habitat improvement actions were developed with interagency cooperation and were based on extensive data collection and modeling.

A food web study supports results of the IMW monitoring program found that side channels provide important rearing habitat for juvenile salmon and steelhead (Bellmore et al., 2012). These habitats are not available in the mainstem, and additional suitable side channel habitat is needed to attain the potential juvenile carrying capacity for the study reaches.

Thus far, results of the Methow IMW monitoring program indicate that Chinook salmon and steelhead egg-to-emigrant productivity in the Methow River Basin is very low. The food web study of invertebrates and fish in the Middle Methow River indicated that invertebrate food production far exceeds fish consumption. For an as yet undetermined reason, the fish community, including the Chinook and steelhead, is not taking advantage of the available food supply.

Actions and effectiveness monitoring will continue through 2018. Results will be reported as they become available.

Upper Middle Fork John Day River – The upper Middle Fork John Day IMW is monitoring habitat and steelhead response to in-channel habitat improvement actions. There are 290 habitat improvement actions in the study area, implemented from 2000 to 2010 (Abraham and Curry, 2010), many of which were fish screen installations and improvements to fish passage barriers. The primary habitat actions include remeandering and placement of wood revetments (Roni et al., 2012).

Results indicate that summer steelhead spawner abundance increased in the treatment area from 2008 to 2011 while remaining unchanged in the control area, but the causes of the differential increase are not yet clear. Adult steelhead escapement ranged from 769 in 2008 to 3,692 in 2011 within the treatment area. In 2010 and 2011, escapement was substantially greater than that in the control watershed. Estimates of steelhead smolts per spawner are not yet available. Monitoring of habitat conditions and fish populations is planned to continue for several years. A comprehensive summary of results is scheduled for 2017. Results will be reported as they become available.

Grande Ronde River – The Grande Ronde IMW is monitoring and documenting fish response to habitat improvements, using the results to characterize relationships between habitat actions and fish populations (BPA and Reclamation, 2013). Structural equations and modeling are being used to understand the relationships between habitat conditions and fish density. For example, habitat characteristics such as the volume of large wood are being examined to determine the effect on pool frequency and ultimately the effect on fish density.

Relationships were found between parr-to-smolt survival of wild Snake River spring/summer Chinook salmon and mean road density and land use classifications (agricultural use or wilderness). Monitoring of habitat conditions and fish populations is expected to continue for several years. Results will be reported as they become available.

The several different types of habitat improvement actions evaluated by IMWs are expected to improve habitat condition and fish growth and survival. Where individual habitat improvement actions have been implemented and evaluated, available IMW results have shown that there was generally an improvement in the condition of the habitat. Some actions such as placement of large wood in streams produce results more quickly than others such as riparian plantings. Some actions have already shown improvements in fish growth and survival, while other actions will require more time for a biological response to happen. Preliminary results indicate that the habitat actions undertaken positively affect the fish population. The IMWs evaluate the chain of causation, from implementation of a habitat action to improved habitat conditions to improved salmon and steelhead growth and survival. The IMWs provide results in the short and long-term to demonstrate the benefits of tributary habitat improvement projects on the survival and growth of salmon and steelhead.

Status and Trend Monitoring Programs

Status and trend monitoring programs collect data to describe changes in habitat parameters and biological conditions over time. The ISEMP and CHaMP are status and trend monitoring programs that provide information to determine if habitat improvement actions are affecting habitat condition and whether fish survival and growth is improving or not. RME sections for RPA Actions 50, 51, 56, 57, and 73 present more detailed information on tributary habitat monitoring.

f. Where new scientific or other information suggest that habitat quality improvement estimates for projects from the previous cycle were significantly in error, the Action Agencies will describe the analytical approach used to re-evaluate the estimated habitat and SBs for each project affected.

Updated science findings and other information available to the Action Agencies and expert panels do not suggest that previous habitat quality improvement estimates were in error. Consequently, neither re-examination of habitat actions and estimated benefits nor consideration of additional habitat projects has been necessary or justified.

2012 Annual Progress Reporting for Tributary 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 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.*

RPA Action 1 calls for the Action Agencies to submit implementation plans to NOAA Fisheries in 2009, 2013, and 2016. RPA Action 35 calls for the Action Agencies to identify specific projects with location, limiting factor treated, targeted population(s), reporting metrics, and expected biological benefits in each of those implementation plans.

RPA Action 35 includes specifications for three-year implementation cycles between 2010 and 2018[13]. In June 2010, the Action Agencies released the 2010-2013 Implementation Plan which identified a menu of habitat improvement projects to address the 2010 to 2013 segment of remaining RPA Action 35, Table 5 population HQIs. The 2010-2013 Implementation Plan identified project location, treatment of limiting factor, target population or populations, appropriate reporting metrics, and where applicable, the estimates of habitat improvements based on achieving those metrics. The population specific habitat improvements reported in the 2010-2013 Implementation Plan were based on 2009 expert panel evaluations.

The Action Agencies provided updated climate change information to the expert panel participants in advance of the 2012 workshops. The information was made available on the FCRPS BiOp Tributary Habitat Program — 2012 Expert Panel Workshops website (*http://www.usbr.gov/pn/fcrps/habitat/panels/reference/index.html*) and included the most up-to-date reports from NOAA Fisheries and the USGS. The expert panels considered this information when evaluating effects on limiting factors.

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 have funded and implemented a large number of targeted habitat projects per the RPA with implementation through the NPCC program and the Columbia Basin Fish Accords. The Action Agencies have continued to fund and provide technical assistance to implement specific habitat projects to achieve the RPA Action 35, Table 5 HQIs. Population-level accomplishments for 2012 and Action Agency projects associated with implementation of the population-level accomplishments are shown in CE Section 3, Attachment 2, Table 1. Further details on projects with Reclamation involvement are available in CE Section 3, Attachment 2, Tables 2 and 3. In some cases, Reclamation complements BPA projects (both agencies participate in the same project), in which case references to both BPA project number and Reclamation record number are provided. Reclamation has produced a number of additional reports that document tributary habitat accomplishments.

Expert panels were convened in 2012 to estimate changes in habitat limiting factors from the implementation of habitat actions supported by the Action Agencies. The 2012 expert panels finalized 2009 estimates for the improvements from projects completed between 2009 to 2011 and estimated improvements for a menu of 2012 to 2018 projects. Future habitat quality improvement estimates associated with projects are estimated by expert panels prior to project implementation. However, the Action Agencies, not the expert panels, are responsible for final project selection decisions. Much of the information used in the expert panel process, such as identifying, standardizing, and prioritizing key limiting factors and adjusting the intrinsic potential of specific stream areas when needed to reflect field data and observations, has proved helpful to the Action Agencies and local watershed groups for prioritizing and selecting projects. However, the role of the expert panels is focused on applying best professional judgment to estimate changes in the function of habitat limiting factors that

[13] The Action Agencies identified projects for 2007 to 2009 implementation in the 2007 Biological Assessment, which also served as the proposed action for NOAA's consideration when developing the FCRPS BiOp.

are expected to occur through implementation of projects. Project development, prioritization, and funding recommendations occur through other processes.

- *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.*

Beginning early in 2011, the Action Agencies initiated and completed a series of meetings with regional partners to prepare for the 2012 expert panel workshops. The Action Agencies conducted numerous briefings and orientations to educate and/or remind partners about the process, schedule, and tasks to be completed for the upcoming workshops.

Tasks accomplished through these meetings prior to holding the workshops included:

- Transitioning from the limiting factors used prior to 2012 to a standardized list of limiting factors and limiting factor definitions provided by NOAA Fisheries Northwest Fisheries Science Center (NWFSC) in October 2011 (Hamm, 2012);
- Updating the weight and current and potential habitat functions of the new limiting factors, if appropriate;
- Reviewing and, if appropriate, revising the population-specific assessment unit boundaries;
- Considering new information to adjust assessment unit intrinsic potential when warranted;
- Preparing lists that compare the scope and metrics of habitat improvement actions identified for completion at the 2009 expert panel workshop to those completed by the start of the 2012 workshop;
- Preparing menus of habitat improvement actions to meet or exceed 2018 RPA Action 35, Table 5 HQIs from after the end of the 2012 workshops through 2018 (pursuant to the August 2, 2011 order from the Oregon District Court); and
- Identifying pertinent habitat and fish monitoring data that would be useful for expert panel consideration.

To make information readily available to the expert panel groups and participants, the Action Agencies developed a website with background information; instructions for updating limiting factors and preparing lists of completed and a menu of 2012 to 2018 projects for expert panel review and evaluation; map tools for evaluating assessment unit boundaries and associated limiting factors and limiting factor weights; and latest scientific information on climate change, invasive species, and toxic issues. The website ensures that information is uniformly available among the seven expert panels for their consideration in estimating action benefits.

The website also includes orientation meeting and workshop agendas and attendee lists, as well as presentations on the expert panel process provided by the Action Agencies and effects of habitat projects on different salmonid life history stages provided by the Northwest Fisheries Science Center. The website captures the dozens of preparatory meetings held with regional, state, and tribal partners who willingly contributed to preparing for the 2012 expert panel workshops. This website is located at *http://www.usbr.gov/pn/fcrps/habitat/panels/reference/index.html*.

To better manage the expert panel process data sets, the Action Agencies developed and used a web-accessible system to store and manage the material compiled, reviewed, and analyzed through the expert panel process. This system has improved the recording and tracking of the expert panel data sets and provides a level of consistency across the various expert panels.

In 2012, the Action Agencies convened expert panel workshops in La Grande and Joseph, Oregon; Lewiston, McCall, and Salmon, Idaho; and Dayton, Washington, for priority and other populations of Snake River spring/summer Chinook and steelhead, and in Wenatchee, Washington, for priority populations of upper Columbia River spring Chinook and steelhead (Figure 42). The expert panels reviewed completion status of planned, replacement, and additional actions from the end of the last panel workshops in 2009 up to the start of the workshops in 2012, and they evaluated the menu of habitat improvement actions from the remainder of 2012 to the end of 2018. Expert panels only finalized estimates for projects completed before their workshop started. Projects completed in the same calendar year after their workshop ended were included in the estimates for the following implementation cycle.

The expert panels followed the methodology presented in the next section to estimate benefits for actions supported by the Action Agencies to improve habitat conditions for salmon and steelhead. Updates to limiting factors, actions, and benefits determined by expert panels were made by the Action Agencies directly into the database system at the workshops. Comments were added in the database to note corrections identified by the expert panels. These corrections involved ensuring that the actions and limiting factors organized by the watershed partners and included in the database prior to the workshops were associated with the proper species and assessment units. The Action Agencies addressed the expert panel comments after each workshop and returned the corrected tables of limiting factors, actions, and benefits to each expert panel for their review before the database was finalized.

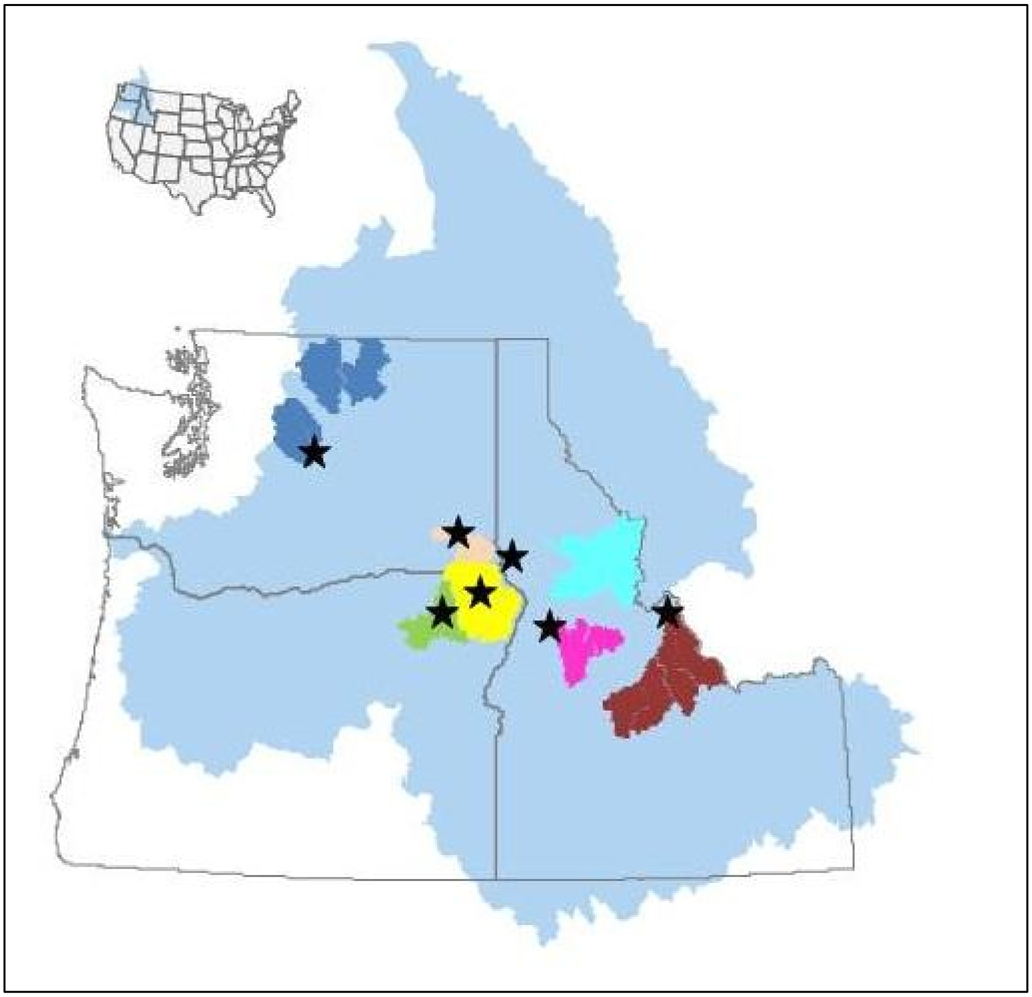


Figure 42. Location of 2012 Expert Panel Workshops.

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

The 2012 expert panels followed the Remand Collaboration Habitat Workgroup process[14] to finalize changes in habitat limiting factors associated with the completed, planned, replacement, and additional 2009-2011 habitat actions and to estimate changes in limiting factors for the menu of 2012 to 2018 habitat actions. A detailed description of the Expert Panel calculation of Tributary Habitat Benefits is described in Comprehensive Evaluation Section 2, Appendix D.

- *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.*

[14] *A method developed and updated by the Remand Collaboration Habitat Workgroup in which the Expert Panel identifies site-specific habitat limiting 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 limiting factors attributable to the project. See also http://www.usbr.gov/pn/fcrps/habitat/panels/reference/1B-CA-AppC.pdf.*

Metrics for habitat improvement actions completed in 2012 are presented in the project tables in Section 3, Attachment 2 tables of this report.

Beginning with the 2012 expert panel workshops, the Action Agencies used Taurus, a web-accessible system to display quantified metrics for actions evaluated by the workshop participants. Metrics (Katz et al., 2006) such as cfs of water protected, stream miles of habitat made accessible, riparian acres improved, and instream miles with improved complexity were identified and arrayed according to the assessment unit location and limiting factor addressed. These quantified metrics were displayed for the workshop participants as they validated the 2009 to 2011 accomplishments and evaluated the 2012 to 2018 habitat actions. This system provides detail to workshop participants about project scope and scale, provides a valuable record for tracking the basis for expert panels' estimates, and will be a key reference at future workshops.

- *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 2012 expert panels finalized estimated changes in limiting factor habitat function that resulted from habitat improvement project actions completed from 2009 to 2011, and estimated limiting factor changes for the menu of 2012 to 2018 project actions for each population in priority population areas. The Action Agencies recorded the final estimates obtained at the 2012 expert panel workshops consistent with guidance developed through the Remand Collaboration Habitat Workgroup in the Taurus data system and calculated the estimated salmonid survival improvements shown in Table 35.

- *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 2010-2013 Implementation Plan. The metrics reported for 2012 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 used to replace infeasible projects. Benefits for all actions completed in the 2010 to 2012 cycle (including any projects carried over from 2007 to 2009) were evaluated at the 2012 expert panel workshops.

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

The Action Agencies continue to cooperate with the NPCC to identify program priorities and obtain Independent Scientific Review Panel (ISRP) review of projects as appropriate. The Action Agencies are coordinating FCRPS BiOp priorities through the NPCC's 2013 geographic categorical review. The Action Agencies included the limiting factor pie maps in the proposed template for the geographic categorical review to encourage proposals for habitat projects that will results in the greatest benefits to fish populations.

- *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.*

Model and data development for habitat effectiveness continues to advance (See RPA Action 57 for 2012 progress on tributary habitat research, monitoring, and evaluation [RME]). While models and the underlying data are being developed, best professional judgment (expert panel input) continues to be acceptable for estimating benefits of future projects at the scale and complexity of this BiOp.

- *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.*

Updated science findings and other information available to the Action Agencies and expert panels does not suggest that previous habitat quality improvement estimates were in error. Consequently, neither re-examination of habitat actions and estimated benefits or consideration of additional habitat projects has been necessary or justified.

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 funded and provided technical assistance for projects that affect the non-bolded populations in RPA Action 35, Table 5. These projects may also improve spawning and rearing habitat, are evaluated by the expert panels, and may be relied on to estimate survival increases at the MPG or ESU level (2014-2018 IP, Appendix D).

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 fund projects 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.

Estuary Habitat Implementation Reports, RPA Actions 36–38

Table 38. Habitat Strategy Reporting, RPA Actions 36–38.

RPA Action No.	Action	Comprehensive Evaluation
Habitat Strategy 2		
36	Estuary Habitat Implementation 2007 to 2009	
37	Estuary Habitat Implementation 2010-2018 – Achieving Habitat Quality and Survival Improvement Targets	Comprehensive report on status of project implementation, by project, (including project milestones) for all actions identified in implementation plans. Comprehensive report of physical metrics for implementation achieved (e.g., number of acres protected/restored/enhanced; riparian miles protected; number of pile dikes removed) and still remaining, by project. Where Evolutionary Significant Unit (ESU)-specific SBs are not achieving Progress Guidelines above, identify processes or projects in place to ensure achievement by the next comprehensive report. Report results of all RME studies, including information from expert regional technical group, and identify how results will be applied to future implementation, if appropriate. Where new scientific or other information suggests that survival improvement estimates for projects from the previous cycle were significantly in error, the Action Agencies will describe the analytical approach used to re-evaluate the estimated SBs for each project affected.
38	Piling and Piling Dike Removal Program	Comprehensive report on status of project implementation (including project milestones) for all actions identified in implementation plans. Comprehensive report of physical metrics for implementation achieved (e.g., number of pilings/pile dikes removed). Report describing the effect of piling and pile dike removal projects implemented on survival of salmonids by ESU/ Distinct Population Segment (DPS).

Habitat Strategy 2 RPA Actions 36-38

Improve Juvenile and Adult Fish Survival in Estuary Habitat

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, 2010).

Some projects scheduled for completion in 2007–09 were carried forward to the 2010–18 period and the associated benefits are included in the estimates for the 2010-18 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 2010–18 to provide SBUs equivalent to those of the projects that proved infeasible. These additional projects will be selected and implemented in accordance with RPA Action 37.

RPA Action 37 – Estuary Habitat Implementation 2010–2018 – Achieving Habitat Quality and Survival Improvement Targets: *The Action Agencies will provide funding to implement additional specific projects as needed to achieve the total estuary survival benefits identified in the FCRPS BA. Projects will identify location, treatment of limiting factor, targeted ESU/DPS or ESUs/DPSs, appropriate reporting metrics, and estimated biological benefits based on the achieving of those metrics. Pertinent new information on climate change and potential effects of that information on limiting factors will be considered.*

- *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.*

The Action Agencies use the ecosystem criteria developed by LCEP's[15] Science Workgroup (LCEP, 2012) to help select restoration and protection projects in the Lower Columbia River and estuary. Additionally, the LCRP was instrumental in coordinating and hosting the outyear restoration project development process undertaken with all regional partners by the Action Agencies.

- *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 Expert Regional Technical Group (ERTG) was convened in 2009 and began evaluating Federal projects for their SB potential. The ERTG has five members, representing: the ODFW; the WDFW, NOAA's Northwest Fisheries Science Center, the Department of Energy's Pacific Northwest National Laboratory (PNNL); and the Skagit River System Cooperative (ERTG, 2012). Through 2012 the ERTG has completed a number of key deliverables:

- They refined the approach to estimating benefits based on emerging scientific findings and best professional judgment, as described below.
- They estimated the benefits of habitat projects completed in 2008 through 2012, as well of those of a number of potential projects.
- They held regional public meetings to disseminate benefit "scores," to educate the Action Agencies' project partners about how the ERTG applies scientific principles to the benefit estimation process, and to solicit feedback from project partners on the project design information required by the ERTG; and
- They created additional guidance documents to assist project partners in filling out the ERTG template and navigating the ERTG scoring process.

- *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 2009, the ERTG and the Action Agencies began development of a template for the data needed for submission of proposed projects to ERTG. That template requires clearly described habitat metrics for each aspect of the project. 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.

[15] *The Lower Columbia River Estuary Partnership changed their name in 2012 to the Lower Columbia Estuary Partnership*

- *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.*

In 2009 and 2010 the ERTG reviewed and modified the benefit estimation approach applied in the FCRPS BA. The improved version was used to estimate changes in estuary habitat and population survival during 2011 and 2012. 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.

- *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 2008-2012 were delayed or proved infeasible. The delayed projects will be constructed in 2013-2014. In 2011, the Action Agencies and project partners kicked off a year-long outyear planning and prioritization initiative to identify future project opportunities that will provide the SBUs to meet the FCRPS BiOp targets. This initiative prioritized project opportunities based on cost, biological benefit (survival benefit units (SBU), and implementation likelihood.

- *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 to be implemented in the future. This process is outlined in the Columbia Estuary Ecosystem Restoration Program (CEERP) documents (CEERP, 2013a and b).

- *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 2008 through 2012, the Action Agencies actively engaged research agencies, consultants, LCRP'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 2008-2012 period were "significantly overstated."

Comprehensive Evaluation Reporting for RPA Action 37

The estuary restoration program (RPA Actions 36, 37) has experienced significant change since the writing of the BA. These changes can be organized into three different periods. The early years (2007-2009) were a developmental period where the program had not yet ramped up, Action Agency investments were relatively modest, and restoration opportunities were fairly limited. A period of transition (2010-2012) was characterized by a strategic approach guided by regional coordination, commitment, increased effort into project development, cost/SBU and social/technical complexity, and informed by refined planning tools and more robust RME results. Currently, the program is entering a period of high output (2013-2018) characterized by a mature program where the strategy, processes, and implementation are aligned to ensure the delivery of high-value projects.

These three periods are reflected in the rate of SBU delivery (Figure 43) with relatively slow and steady progress up to 2012 and then a substantial increase in the expected rate of delivery beginning in 2013.

The estuary restoration program (RPA Actions 36, 37 and 38) has experienced significant enhancements since the writing of the BA. These changes can be organized into three different periods. The early years (2007-2009) were a developmental period where the program had not yet ramped up, Action Agency investments were relatively modest, and restoration opportunities were fairly limited. A period of transition (2010-2012) was characterized by a strategic approach guided by regional coordination, commitment, increased effort into project development, cost per SBU[i] and social/technical complexity, and informed by refined planning tools and more robust RME results. Currently, the program is entering a period of high output (2013-2018) characterized by a mature program where the strategy, processes, and implementation are aligned to ensure the delivery of high-value projects.

These three periods are reflected in the rate of SBU delivery (Figure 43) with relatively slow and steady progress up to 2012 and then a substantial increase in the expected rate of delivery beginning in 2013. The three phases are described in more detail below.

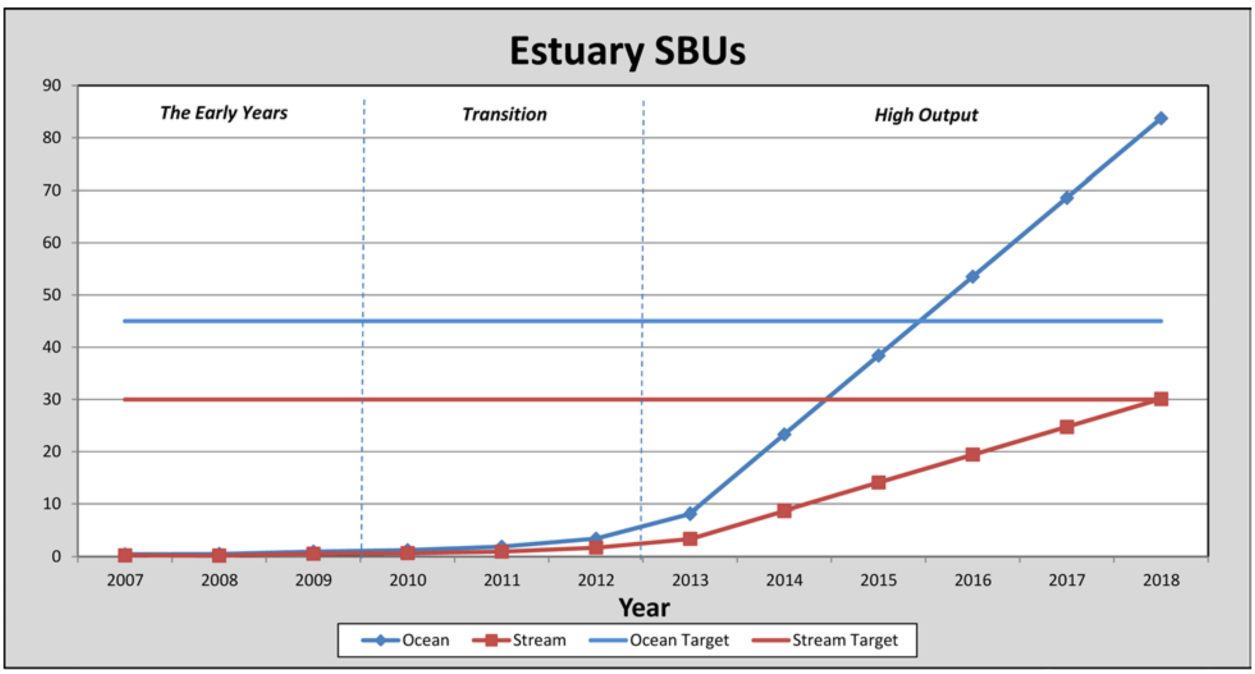


Figure 43. SBU Progress by Year.

The Early Years

Early on, the BPA's restoration funding was channeled almost entirely through the Lower Columbia Estuary Partnership's (LCEP) project review and funding processes. This process involved diverse partners, however, the projects tended to be opportunistic and often emphasized smaller-scale actions such as riparian planting and invasive removal. Implementation under the Corps restoration authorities was limited due to funding restrictions for project development, and the fact that Corps restoration authorities require cost share partners, with 50/50 percent cost share of study phase and 65/35 percent cost share of the restoration (construction) phase.

The Action Agencies evaluated their progress and determined that a change in emphasis and direction was warranted. The ERTG had formed in June of 2009 and had not yet produced a body of work that could be used to guide and prioritize restoration. RME was focused on broad research questions designed to answer critical uncertainties as opposed to action effectiveness that could more directly guide restoration. The Action Agencies recognized the program needed better project identification and selection tools; LCEP and other partners, with Action Agency guidance and funding, began the process of developing a number of prioritization tools. Examples include:

1) Habitat Change Analysis (LCEP, 2012), which compares historical land cover conditions derived from late 1800s topographical survey maps, to current land cover conditions derived from 2010 remotely sensed imagery.
2) Habitat Suitability Index Model for juvenile Chinook salmon (LCEP, 2012), which uses model outputs from an Oregon Health and Science University (OHSU) hydrodynamic model to predict times and locations that meet suitable water temperature, depth, and velocity criteria as identified in Bottom et al. (2005) for juvenile salmon.
3) Landscape Planning Framework (LCEP, 2012), an application of the Columbia River Estuary Ecosystem Classification (CREEC) (USGS, 2011), which allows the user to evaluate different inundation scenarios and the corresponding effect on the landscape. The Framework also supports the prioritization of habitat sites by evaluating the density and distribution of landscape features that support juvenile salmonid rearing.

Transition Period

Implementation Improvements

From 2010-2012 the Action Agencies made a number of changes designed to increase the pace and quality of habitat restoration. To expand capacity, the BPA developed and funded four new projects:

- Project 2010-073-00: Columbia Land Trust Estuarine Restoration (*http://www.cbfish.org/Project.mvc/Display/2010-073-00)*
- Project 2010-004-00: CREST Estuary Habitat Restoration (*http://www.cbfish.org/Project.mvc/Display/2010-004-00)*
- Project 2010-070-00: WA Estuary MOA Project Scoping & Implementation (*http://www.cbfish.org/Project.mvc/Display/2010-070-00)*
- Project 2012-015-00: Cowlitz Indian Tribe Estuary Restoration Program (*http://www.cbfish.org/Project.mvc/Display/2012-015-00)*

Project 2010-070-00 was a joint effort with the Corps and WDFW to expand capacity and provide cost-share under the Corps restoration authorities. These new projects augmented the budget and capacity of the estuary program. The BPA's estuary program budget increased from $3.4 million in 2008 to $16.2 million in 2012. The original estuary project, Project 2003-011-00: Columbia River Estuary Habitat Restoration, served an important role, running a project review selection process and developing restoration prioritization tools, but the four new projects allowed the Action Agencies to get more work on the ground. Additionally, the Action Agencies were able to utilize BPA funding under the Columbia River Estuary Study Taskforce (CREST) and Columbia Land Trust (CLT) habitat programs to provide cost share for the Corps restoration authorities.

Prioritization

The feedback and guidance the Action Agencies received from the ERTG has become a key component of the restoration prioritization strategy. This strategy is guided by a holistic perspective that:

1. A landscape scale perspective is better than narrow site-specific perspective.
2. Natural processes are preferred over engineered processes.
3. A larger area is better than a smaller area; close to the main stem is better than farther away.
4. Restoring remnant channels is better than excavating new ones.

Based on this guidance, the BPA/Corps approach has been modified to focus on floodplain reconnections and wetland channel improvements that have a significant footprint in tidally-influenced areas relatively close to the main stem. Using a combination of best professional judgment and best available restoration science, the ERTG determined that these actions provide the highest juvenile salmonid densities (ERTG 2010a, 2011a). As a result of this new strategy, some of the projects identified in the BA or the 2010-2013 Implementation Plan are no longer being pursued. Instead, the Action Agencies are pursuing projects better aligned with the new emphasis on large projects, located close to the mainstem, that reconnect flood and tidal influences.

Beginning in 2012, the approach to project development involved a "targeted" collaborative approach to identify project opportunities (Figure 44). The result was a new methodology that considers cost-benefit, social and technical complexities, and SBU assessment, and allows for improved coordination among restoration partners and funding agencies developing projects. The Action Agencies and the LCEP, in collaboration with other project partners, have established a process to coordinate work to identify and develop project opportunities. A map with relevant GIS (geographic information system) layers of all possible sites in the lower Columbia River estuary (LCRE) is used to support this process. To focus the project development process, the LCEP applied the following layers to a LCRE GIS map: "tidally impaired" (current floodplain); public vs. private lands (generally large tracts only); and, restoration inventory (existing projects already being tracked). A facilitated discussion around each "opportunity area" is then used to determine which restoration partners may be already having discussions with the corresponding landowners. If none of the restoration partners are holding discussions with the targeted landowners, the group discusses the pros and cons of performing work on that site as well as likely proposed actions. After all project opportunities are identified, BPA and the Corps begin the prioritization and assignment stage with the following objectives: identify cost-effective, high-value (SBU) projects; ensure that all partners have an adequate workload based on their capacity; and assign projects that are a good fit for each restoration partners' interests and skills.

This step includes the following activities: estimate potential SBUs, projected cost, and likelihood of success (see below); prioritize the project opportunities based on cost per SBU, total SBU, and likelihood of completion; request input from sponsors regarding their interest in the unassigned opportunities; develop a draft version of sponsor assignments to project opportunities with the goal of delivering the most SBUs in the shortest period of time where multiple parties are interested in the same projects; consider partnership opportunities; share the draft assignments; and then incorporate feedback from project restoration partners to determine the final assignments.

The resulting prioritized list forms the basis of out-year SBU projections. Only projects with a reasonable cost per SBU and a reasonable likelihood of success are included in projections. Likelihood of success scores account for both social and technical complexity. Factors that affect social complexity include the willingness of landowners and the number of landowners affected. Technical complexity includes factors such as the need for a setback levee or the presence of utilities.

Our prioritization efforts also identified a number of very large and highly complex projects. These projects have unique implementation challenges resulting from their size and complexity and would bias the results if we were to include all of them in the SBU projections. The AAs are only including one of these very large projects, Large Dike Breach – Reach E, in the SBU projections. This project has been evaluated by the ERTG which provided a preliminary SBU score of 31 Ocean SBUs and 11 Stream SBUs. The AAs began evaluating the feasibility of this project in 2012. If this project proves infeasible, the AAs will implement other projects that collectively contribute an equivalent number of SBUs.

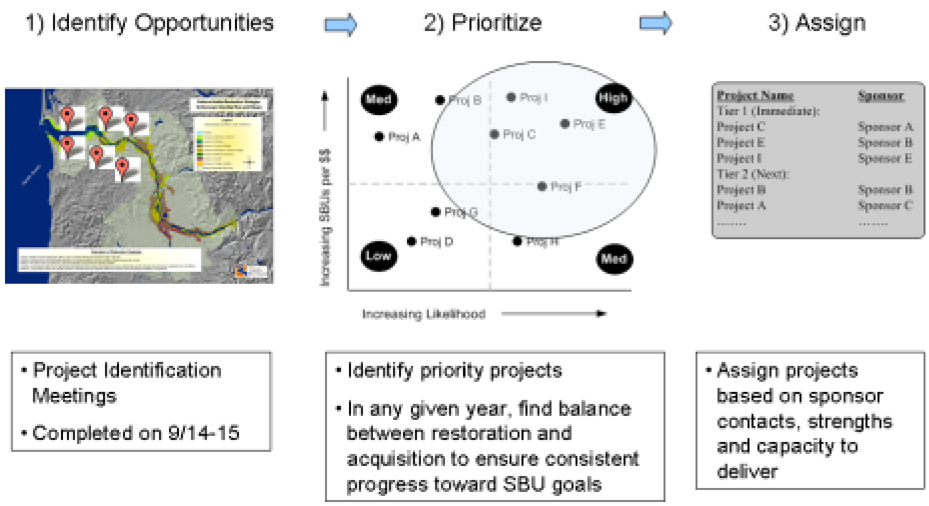


Figure 44. Cost/SBU Approach to Project Development.

Columbia Estuary Ecosystem Restoration Program (CEERP)

A recent key accomplishment was the formal development of the CEERP. The CEERP is founded on a specific goal, principles, objectives, and management questions that are pursued within a specially-designed adaptive management process. The overall goal of the CEERP is to understand, conserve, and restore ecosystems in the LCRE. The CEERP is also addressing a specific requirement from the FCRPS BiOp (NMFS, 2008) for the BPA/Corps to provide SBUs for salmonids. The CEERP seeks to include restoration projects that are consistent with the principles identified in Johnson et al. (2003). Specifically, the program is seeking projects that "are founded on the best available ecological restoration science, implemented in an ecosystem context, and developed with the intent to restore relevant ecological processes…incorporate adaptive management practices with testable hypotheses to track ecological responses to a given restoration effort…are implemented in a coordinated, open process and scientific results from monitoring and evaluation (M&E) are communicated widely and readily accessible." These principles are also consistent with guidance from the ERTG (2010a, 2010b, 2011a).

The CEERP adaptive management process involves five phases (Figure 45)—decisions, actions, monitoring/research, synthesis and evaluation, and strategy (Thom, 2000). The CEERP adaptively proceeds through each of these phases, based on the results from the preceding phase(s). The adaptive management process informs management decisions that are aligned with the long-term CEERP goals and objectives and the latest scientific findings. As management questions are informed by RME results, program objectives and strategies will be revised as necessary and inform future restoration and RME actions.

Activities to support all phases of the CEERP adaptive management process are underway in the LCRE, thereby institutionalizing the process regionally across stakeholders/partners. Adaptive management, however, is only successful when the parties to the program commit to sustained cooperation and responsibilities. Adaptive management can be efficient if existing, required reporting functions are changed to ensure the flow of information from project monitoring staff to project planning staff. The

CEERP uses existing regional coordination efforts, such as the Corps' Anadromous Fish Evaluation Program (AFEP), the NPPC's FWP, and the LCEP's programs. Existing work groups contributing to CEERP purposes include the federal Estuary/Ocean Subgroup for federal RME Estuary and Ocean Subgroup (EOS), the AFEP Science Review Work Group, the LCEP's Science Work Group (SWG), the ERTG, the ISRP, and others. Many federal, state, and local agencies and non-governmental organizations are working to restore and understand estuarine and tidal freshwater habitats for juvenile salmon in the LCRE and are cooperating and collaborating within the CEERP.

Figure 45. CEERP Adaptive Management Process. Brown and Blue Boxes Signify Adaptive Management Phases and Deliverables, Respectively.

High Output Period

The combined effect of these changes is that the program is projecting to exponentially increase delivery of SBUs in the period from 2013-2018 (Figure 46). From 2007-2012, the program averaged 0.65 Ocean and 0.32 Stream SBUs/year. In contrast, the program projects an average of 13.3 Ocean and 4.7 Stream SBUs/year over the remainder of the FCRPS BiOp period. Based on feedback from the ERTG and findings from our RME program (see RPA Actions 58-61), the program is increasingly targeting projects that fully reconnect lost floodplain habitats and tidal influence (Figure 46).

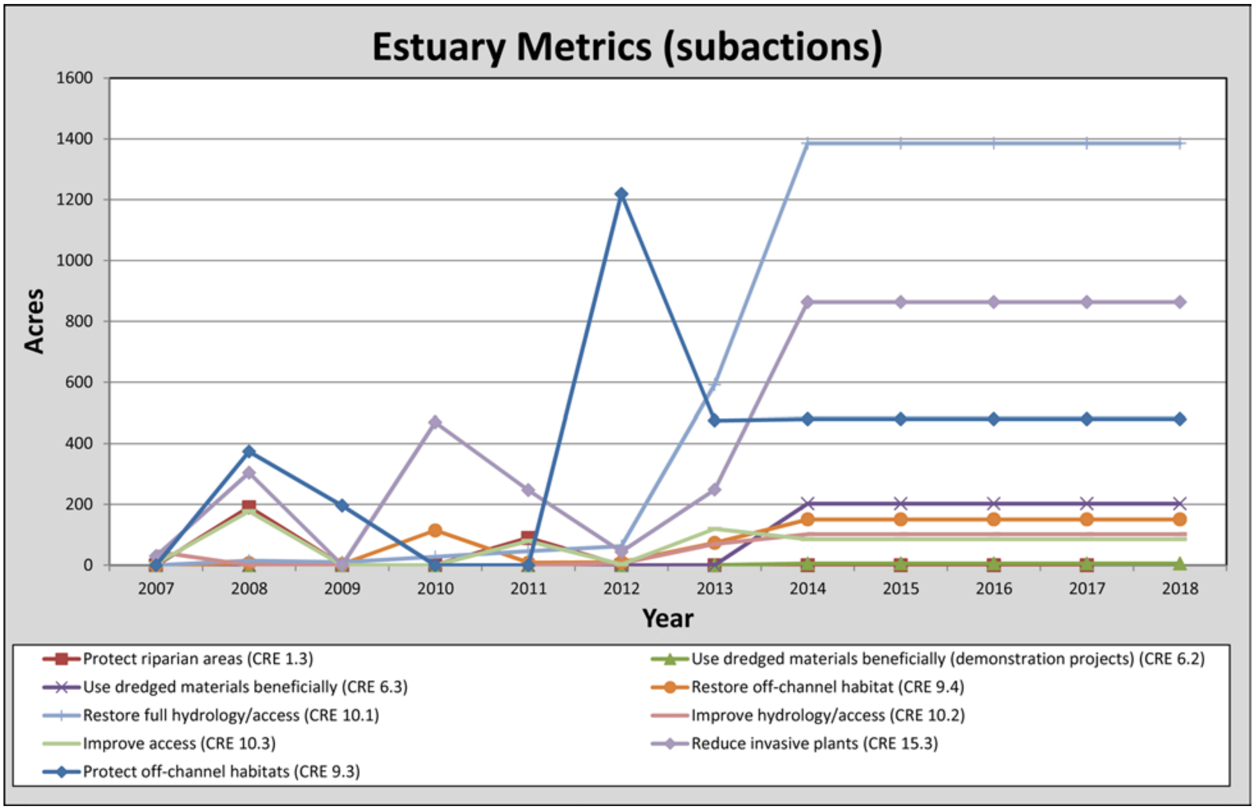


Figure 46. Changes in Estuary Action Type (Columbia River Estuary [CRE] Subactions).

Fully reconnecting floodplain habitat and tidal influence, typically in the form of a dike or levee breach, provides numerous direct benefits to listed FCRPS juvenile salmon including improved habitat availability and use by juvenile salmonids. Reconnected floodplains also help export macrodetritus and associated prey items that improve thermal conditions important to juvenile fish. Research is also underway to detect fish responses to estuary habitat actions at a detailed scale by examining salmonid prey availability, residence time, and other factors.

Tidal and floodplain reconnection also has important indirect benefits for stream type fish passing through the estuary relatively quickly. A large portion of the prey items found in the mainstem Columbia River are transported from tidal wetland habitats as far as seven kilometers away. All salmonids sampled in the mainstem, including stream-type salmonids, had consumed prey items that were produced in LCRE habitats. Research indicates that juvenile salmonids prefer prey items directly linked to tidal and floodplain wetland habitats.

A prime example of the type of project the program is now targeting is Columbia Stock Ranch located adjacent to Deer Island, Oregon (Figure 47). The BPA, in partnership with the CLT, acquired this land in 2012. The Corps is currently working on the restoration design and construction is anticipated in 2014. The primary goal of the project is to breach the perimeter dike in multiple locations to restore tidal influence to 360 acres of floodplain (CRE subaction 10.1). The Preliminary ERTG Scores for this project are 4.4 Ocean and 1.4 Stream.

Figure 47. Aerial View of the Columbia Stock Ranch Project.

Progress Toward Targets

As a result of the improvements described above, the Action Agencies expect to exceed the target of 45 SBUs (i.e., a 9% survival improvement) for ocean-type fish and meet the target of 30 SBUs (i.e., a 6% survival improvement) for stream-type fish called for in RPA Action 36 by the end of the FCRPS BiOp period. Stream SBUs are more challenging to obtain for a number of reasons. The original targets in the FCRPS BiOp (45 Ocean and 30 Stream) assume that habitat projects will deliver roughly 0.66 Stream SBUs for every Ocean SBU (30/45). The actual results from the ERTG Scores to date demonstrate a 0.33 Stream SBUs for every Ocean SBU, roughly half the ratio found in the BiOp targets.

The Role of Land Acquisition in Estuary Habitat Restoration

The majority of land acquisitions planned and completed by the AAs are a prerequisite to restoration. These land acquisitions provide additional benefits by increasing the certainty of success of the related restoration actions and by providing an opportunity for passive restoration to occur. In the rare case where the AAs acquired land without subsequent active restoration, the change in land ownership and land management allowed passive restoration to occur. These “acquisition only” properties receive stewardship funding to manage public access, control invasive species, and monitor site conditions to encourage and maintain passive restoration.

Project by Project Descriptions (by Year)

Projects Completed in 2007:

Fort Clatsop – Phase 1: This CREST restoration project, in partnership with the Lewis and Clark National Historical Park, restored tidal connection to 45 acres of floodplain near Astoria, Oregon. Restoration actions included the removal of a tidegate and installation of a bridge to permit fish access to high quality rearing habitat along the Lewis and Clark River.

Ramsey Lake Restoration: This City of Portland project located at River Mile 2 on Columbia Slough, re-established hydrologic connectivity to the Columbia Slough to reclaim and improve floodplain wetland functions (forested wetland and soft bottom, mud backwater sloughs) and increased the amount and quality of off-channel rearing and refuge habitat for juvenile salmonids. This project will return 5 acres of isolated habitat to benefit upriver salmonid juveniles. Native vegetation was planted along shorelines and within the wetland restoration site.

Scappoose Bottomlands Restoration: The Scappoose Bay Watershed Council enhanced critical habitat connections between Scappoose Bay and salmon refugia habitat in the upper watershed. Actions included controlling invasive plant species, fence installation, and planting of native trees and shrubs. This project was part of a long-term effort to restore wetlands and salmon migration corridors in the Scappoose Bottomlands, one of the few remaining fresh water tidal estuaries on the Lower Columbia.

Projects Completed in 2008:

Walluski River North: The Walluski River Tidal Restoration project restored and enhanced floodplain and side channel habitat along the Walluski River. The site is located approximately 2.5 miles upstream from its confluence with Youngs River and six mile to the confluence of Youngs Bay. Implementation elements included maintenance of a natural dike breach, removal of an additional 100 feet of the dike, addition of large wood to the tidal channels and floodplain, and channel edge native plantings. This CLT project will increase habitat complexity, enhance the hydrologic connection to the Walluski River, and improve juvenile salmonid rearing habitat.

Big Creek: This CREST restoration project improved passage to the lower and upper spawning and rearing reaches of Big Creek. Big Creek is a tributary of Cathlamet Bay at Columbia River RM 26. The project consisted of removal of a culvert preventing access to eight miles of high quality spawning gravels, and increasing hydraulic connection in lower Big Creek.

Wolf Bay – Phase 1: This CLT acquisition placed a 77-acre property into permanent conservation protection, allowing passive restoration actions with the goal of providing critical feeding, acclimatization, and off-channel refugia for juvenile salmon. The property is located adjacent to the Columbia River at RM 22 and is part of the Wolf Bay wetland system. The proximity of the property to the mainstem of the Columbia River ensures that the property provides important low-velocity, off-channel habitat for estuary-rearing juvenile salmonids. Passive restoration includes ceasing recent (last 150 years) land use practices and commencing on-going stewardship activities. These passive actions are expected to improve plant community structure and complexity at this relatively intact site.

Willow Grove – Phase 1: This CLT acquisition protects relatively intact habitats and establishes a land base for passive and active restoration actions. The site is located adjacent to the Columbia River at RM 60 northwest of Longview, Washington. Passive restoration includes additional channel formation as the site adjusts to local hydrologic conditions. Scrub-shrub and forested wetlands are expected to evolve into a mature climax community as historical land use activities are replaced with conservation management objectives. Passive restoration actions may be accelerated through exotic plant control and native plantings.

Scappoose Bay: Several ecosystem restoration projects have been implemented by the Scappoose Bay Watershed Council in Scappoose Bay over the past decade. Scappoose Bay is located near RM 89 on the Columbia River south of the City of St Helens, Oregon. The primary goal of this salmon restoration project was to restore the bottomlands, one of the few remaining fresh water tidal estuaries on the lower Columbia River. This project included riparian restoration on approximately two miles of Scappoose Creek and exotic plant control on approximately 41 acres of bottomlands.

Mirror Lake - Phase I: This restoration project represented the first of several phases of restoration actions at Mirror Lake, which is located approximately 10 miles east of Troutdale in the Columbia River Gorge at RM 129. The project sponsor was Parametrix, working with Oregon State Parks. The primary goal of this restoration project was, to increase salmonid access to potential spawning areas, lower water temperatures, and establish native streamside vegetation. Actions included removing riprap in a newly replaced culvert, installing baffles to improve a fish passage structure through the culvert by removing angular rock, and providing hydrologic refugia in an otherwise uniform channel. Large wood was placed to mimic historical instream habitat conditions and to promote beaver activity. The project also involved planting and protecting native vegetation along Youngs Creek.

Skamokawa Creek: This project re-established tidal-fluvial hydrology to the historical Skamokawa Creek channel through interior culvert retrofits and channel enhancements. The site is located near RM 32 on the Columbia River. When complete, the project will restore 4.0 miles of meandering channel that historically was tide water. The project sponsor is the Cowlitz-Wahkiakum Conservation District. Phase I was completed in 2008 (upstream inlet structure); however, channel function will be restored after implementing Phase II in 2013 (downstream tidegate retrofit).

Sandy River Delta Riparian Forest Restoration: The 1,500-acre Sandy River delta (SDR) is located at the confluence of the Sandy and Columbia rivers at RMs 120-125. The delta was historically a wooded, riparian wetland with ponds, sloughs, bottomland woodland, oak woodland, prairie, and low- and high-elevation floodplain. Both the Corps and BPA have invested in ecosystem restoration activities in support of juvenile salmonid habitat restoration since 2004. The focus of this 2008 phase was to remove exotic plant species and restore native plant species on approximately 255 acres of Sun Dial Island.

Projects Completed in 2009:

Perkins Creek: This CREST and Skipanon Watershed Council project improved channel habitat and connectivity to approximately 1.1 acres of Perkins Creek. Perkins Creek is a tributary of the Skipanon River at approximately RM 10. This was accomplished by replacing an existing barrier with a 17-foot diameter aluminum culvert, performing riparian restoration on 0.3 miles of stream bank, and implementing exotic plant control on 1.1 acres.

Crazy Johnson – Phase 1: This CLT acquisition secured a land base for passive and active juvenile salmon restoration actions. The site is located in the Grays River watershed approximately 13 miles from its confluence with Baker Bay at Columbia River RM 23. Passive restoration at Crazy Johnson will occur as a result of the protection of adjacent upland forests (part of this acquisition). A mature forested riparian canopy will provide increased shade to reduce instream temperatures, critical edge habitat, and create a future source of large wood to improve instream complexity and refugia for juvenile salmonids. Approximately 305 acres were acquired at the project site of which 150.9 are floodplain.

Grays River (Gorley Springs): This CREST-sponsored project restored hydraulic complexity, improved sediment transport and storage, improved width-to-depth ratio and pool/riffle sequences, and increased localized hydraulic connectivity between main and side channels. The project site is located approximately 13 miles upstream of the Grays River confluence. A key objective of this project was to reduce the sediment load moving from upper portions of the Gray's River (where significant logging has taken place) to the lower portion of the Gray's River. The lower portion of the Grays contains wetland habitats that have historically been negatively impacted by sediment. These lower wetlands are accessible to juveniles from Interior Columbia ESUs and provide export of macrodetritus to the mainstem. The project included the installation of five instream structures and multiple engineered log jams to increase opportunities for large woody debris (LWD) recruitment to improve channel roughness and cover for migrating juvenile salmonids.

Columbia Slough: This City of Portland-sponsored project improved in-stream, riparian and floodplain wetland habitat with an emphasis on rearing and refuge habitat for juvenile salmonids. The site is located in the Columbia Slough immediately upstream of its confluence with the Willamette River (less than one mile from the Columbia River at RM 105). The project installed multiple large wood structures along both sides of Columbia Slough and performed native vegetation and erosion control for approximately one mile.

Vancouver Water Resources Wetland: The Corps and City of Vancouver worked together to breach a levee that disconnected a 10-acre floodplain wetland. The site is located along the Columbia River at RM 109 adjacent to a regional environmental learning center. The floodplain wetland includes open water, emergent vegetation, scrub-shrub, and forested wetlands.

Elochoman Slough – Phase 1: The CLT acquired 196 acres of historical spruce swamp intertidal wetland habitat in the floodplain of the Columbia and Elochoman rivers. The property is located adjacent to Highway 4 near the mouth of the Elochoman River and the Elochoman Slough, approximately one mile north of Cathlamet in Wahkiakum County, Washington. Passive restoration at the site includes replacing recent land uses that degraded spruce swamp stands at the site and allowing the site to return to this now rare but valuable juvenile salmonid estuary habitat feature. Active restoration at the site includes the replacement of two undersized tide gates with larger bottomless culverts to restore connectivity to both Elochoman parcels (phase 1 and phase 2). An interior access road would be removed along with channel restoration.

Projects Completed in 2010:

Haven Island: This CLT restoration project enhanced hydrologic connectivity to approximately 28 acres of disconnected tidal floodplain. The historical Sitka Spruce Island is located in the lower Youngs River near RM 4 on the Columbia River. The area affected by the breach included approximately 28 acres; about 68 acres were treated for exotic plant species, and 1.5 miles of riparian edge habitat were restored.

Julia Butler Hanson NWR: The Corps worked with the USFWS to design and replace three tidegates and repaired a failing culvert at the Julia Butler Hanson Wildlife Refuge. The project site is located on the Washington side of the Columbia River at RM 36. The project replaced one derelict top-hinged tide gate with a more hydraulically efficient side-hinged tide gate (providing improved juvenile fish passage and water quality) and installed two new side-hinged tide gates on blind slough, restoring a muted tidal signal and juvenile salmon passage for shallow-water habitat. The project restored 110 acres of slough/wetland habitat and 210 acres of riparian forest habitat.

Mirror Lake – Phase 2: This restoration project represents the second of several phases of restoration actions at Mirror Lake which is located approximately 10 miles east of Troutdale in the Columbia River Gorge at RM 129. The project, sponsored by Parametrix and the LCEP working with Oregon State Parks, improved habitat conditions in Youngs and Lattourell Creeks. In this phase, approximately 1.4 miles of riparian restoration and 3.3 acres of channel restoration occurred. These actions primarily addressed invasive plant control and the installation of large wood in creek channels.

Sandy River Delta Riparian Forest Restoration (BPA & Corps): The 1,500-acre SDR is located at the confluence of the Sandy and Columbia rivers at RMs 120-125. The delta was historically a wooded, riparian wetland with ponds, sloughs, bottomland woodland, oak woodland, prairie, and low- and high-elevation floodplain. In this 2010 phase of the multi-phased project, approximately 192 acres of wetlands and bottomland woodland were restored by removing exotic plant species and re-planting the site with native plants.

Projects Completed in 2011:

Fort Columbia: This CREST-sponsored project was implemented to return tidal hydrology and juvenile salmonid access to an historical 80-acre wetland with additional connection to the Chinook River. The site is located adjacent to Baker Bay on the Columbia River at RM 6 in Pacific County, Washington. The primary restoration action was to replace an undersized and perched culvert with a 12-foot x 12-foot box culvert. Initial monitoring of the site demonstrated utilization of the restoration area by juvenile salmonids immediately after the restoration.

Mill Road (Grays River): This BPA-funded CLT project restored hydrologic connectivity to approximately 46 acres of historical spruce swamp habitat. The site is located approximately three miles upstream of the Grays River confluence with the Columbia River at RM 22. The project included construction of a set-back levee, removal of an existing levee, and channel excavation to reconnect historical channel remnants, and native plantings/invasive control.

Germany Creek – Floodplain: This CLT-sponsored project increased habitat complexity, reduced the need for road armoring, and restored native vegetation in the tidal reaches of Germany Creek. The site is located at the confluence of Germany Creek and the Columbia River at RM 56 in Wahkiakum County, Washington. Restoration actions included the placement of engineered log jams within 2 acres of tidally-influenced river channel, exotic plant control, and planted native species in seven acres of the site.

Sandy River Delta Riparian Forest Restoration: The 1,500-acre SDR is located at the confluence of the Sandy and Columbia rivers at RMs 120-125. The LCRP and Ash Creek Forestry worked to restore ecosystem function to approximately 194 acres of wetland bottom and forested wetland south of Sundial Island. Restoration measures included exotic plant control and native plantings.

Projects Completed in 2012:

Otter Point: This CREST-sponsored restoration project re-established hydraulic and tidal connection between the Lewis and Clark River and a 33-acre historical spruce swamp wetland. The site is on National Park Service property about 3.5 miles upstream of the Lewis and Clark confluence with the Columbia River at RM 12. Restoration activities included dike removal, invasive plant species control, and planting native plants. Other project actions included excavating tidal channels and adding large wood within the project site. Approximately 30 acres of historical habitat was re-connected providing access, rearing, and refugia for juvenile salmonids.

Colewort Creek (Nutel Landing): This CREST-sponsored project enhanced approximately 14 acres of former Sitka spruce swamp in the tidal reaches of the Lewis and Clark River. The Colewort Creek project site is located adjacent to the Lewis and Clark River approximately four miles upstream of its confluence with the Columbia River at RM 12. The project site, owned by the National Park Service, is part of a larger 45-acre wetland complex that was reconnected to the Lewis and Clark River in 2007 by CREST. Restoration elements included channel excavation, removal of fill material in historical wetlands, and improved hydrologic connection to an additional three acres of wetlands.

Gnat Creek - Phase 1: This CREST-sponsored restoration project improved hydrology and physical access to approximately 19 acres of Gnat Creek tidal floodplain. The site is located approximately four miles upstream (via Blind Slough) of the Columbia River near RM 27. This initial phase of the project breached the site in several locations to improve hydrology and increase physical access to the site by juvenile salmonids. Future phases include removal of a dam structure and additional breaches in an adjacent site.

South Tongue Point: This CREST-sponsored restoration project replaced a derelict tide gate with an appropriately sized bottomless culvert. The site is located in Clatsop County adjacent to Cathlamet Bay in the Columbia River near RM 19. Historically, this site was a brackish wetland and was directly connected to Cathlamet Bay. However, the site was disconnected from the bay when Liberty Lane was constructed. The wetland is fed by a 95-acre tributary basin southeast of the project site. Improved hydrology and restored physical access for salmonids is further complemented by strategic scalping of the wetland to expand tidal prism and habitat-forming processes.

Abernathy Creek Tidal Restoration: This WDFW-sponsored project improved habitat complexity and hydrology in the lower tidal reaches of Abernathy Creek. The site is located adjacent to the Columbia River at RM 55 on the Washington side of the river. Restoration actions included the removal of a road prism within the floodplain, installation of large wood along the Abernathy Creek Channel, and riparian edge treatments for exotic plants and native plantings.

Wallacut River – Phase 1: The CLT project acquired 111 acres of disconnected forested wetlands adjacent to Baker Bay in Pacific County, Washington. Approximately 82 acres of the site are Wallacut River floodplain and the remaining 29 acres are adjacent forested uplands. The site is located on the Washington side of the Columbia River at RM 4. Antiquated tidegates, failing culverts, and flood control levees prevent unimpeded juvenile salmonid access to the site and severely limit the tidal connection between the site and Baker Bay. Passive restoration includes replacing the current land use (e.g., agriculture) to historical ecological use. The site's upland topography will be allowed to return to its native successional structure (e.g., scrub-shrub and forested canopy) providing important ecotone habitats, shading, and eventually, large wood recruitment. Potential future restoration actions include removal of levees and other hydrologic constraints, exotic plant species control, riparian plantings, and placement of large wood. Restored hydrology to lower elevations of the site will provide the opportunity for additional passive restoration to occur in the form of a native wetland plants (e.g., Wapato) outcompeting reed canary grass as a result of a more normative tidal inundation pattern.

Grays Bay, Deep River Confluence – Phase 1: This CLT project is the first acquisition of a multi-parcel site located in the lower tidal reaches of Deep River near its confluence with the Columbia River at RM 22. Passive restoration includes a change in land use (primarily agricultural) to ecological uses. This change will allow adjacent uplands to develop into mature edge habitat providing marsh buffer, shade, and eventual large wood recruitment. Future active restoration actions include the removal of an existing levee, channel excavation to jump-start channel-forming processes, and native plantings/exotic plant control to boost passive components of the project. After all parcels are acquired, hydraulic and tidal connectivity will be restored between Grays Bay and Deep River.

Elochoman Slough – Phase 2: The CLT acquired an additional 90 acres of salmonid habitats along the floodplain of the Columbia and Elochoman rivers. The property is located adjacent to Highway 4 near the mouth of the Elochoman River and the Elochoman Slough, just north of the City of Cathlamet in Wahkiakum County, Washington. Passive restoration at the site includes replacing recent land uses that degraded the site's wetland and upland character to an ecological-based land use. Passive restoration on this site complements Phase I activities because this site represents transitional topography from wetland to upland. Scrub shrub and upland forests will be allowed to reach successional maturity providing important buffer, prey resources, shade, and large wood recruitment. Seasonal flooding will provide important macrodetrital inputs to the larger site, the Elochoman River, and the estuary. Active restoration at the site includes the replacement of two undersized tide gates with larger bottomless culverts to restore connectivity to both

Elochoman parcels (phase 1 and phase 2). An interior access road would be removed along with enhancements to existing and relic tidal channels.

Knappton Cove – Phase 1: The CLT acquired the 436-acre Knappton Cove site which has approximately 4000 feet of relatively undisturbed Columbia River shoreline between RMs 30 and 32 in Pacific County, Washington. Knappton Cove is important because much of the lower Columbia River shoreline has been impacted through shoreline armoring, road fill, and the construction of levees. Columbia Land Trust will restore the site primarily with passive actions. Upland forests will be allowed to mature providing a historically abundant but now rare forested edge to the estuary. This will provide a source of large wood that will contribute to establishing a more complex shoreline. Tidal and subtidal zones within and adjacent to the site will be allowed to respond naturally to estuary flows allowing local sedimentation processes to respond accordingly with greater resilience than modified shorelines upstream and downstream.

Columbia Stock Ranch – Phase 1: This CLT acquisition secured 885 acres of Columbia River floodplain and mixed deciduous and coniferous upland forest. Approximately 545 acres are floodplain. The site is located in Oregon adjacent to the Columbia River at RM 75. Passive restoration includes transitioning from contemporary land uses (e.g., agriculture) to ecologically beneficial uses. This will allow natural plant communities, including tidal marsh, scrub-shrub, forested wetlands, and upland forests to return to the site. Water quality will also be improved by eliminating cattle grazing. Beaver colonization is expected to increase with the return of native plants which will create juvenile salmonid rearing and refugia opportunities. Over time, large stands of successional mature forests will provide cooler waters and large wood inputs to the floodplain. Future active restoration actions include levee breaches at several locations along the Columbia River, removal of multiple interior hydrologic constraints, channel restoration and riparian enhancements in the form of exotic plant control and native plantings.

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.*

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

In 2008, the Action Agencies, in collaboration with LCEP, set up a Pile Structure Program subcommittee under LCEP's Science Work Group, and began designing a scientific approach to guide implementation. A draft program plan was presented to NOAA Fisheries in November, 2008, and was reviewed in early 2009.

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

To account for uncertainties and knowledge gaps, LCEP initiated the BPA-funded program by focusing on developing and refining a scientifically defensible framework for the Pile Structure Program (PSP). The program's strategic approach included the following objectives: (1) develop a plan for the removal and/or modification of select pile structures; (2) determine program benefits for juvenile salmonids and the lower Columbia River ecosystem through a series of intensively monitored pilot projects; (3) incorporate the best available science and pilot project monitoring results into an adaptive management framework to guide future management actions. The program team made considerable progress in establishing the PSP and moving it toward full implementation. Specifically, the program team accomplished the following:

- Developed a program plan that established an approach to determine if the benefits of PSP projects could be scientifically evaluated, as well as an adaptive management plan;
- Developed a comprehensive, geo-referenced inventory of all pile structures in the lower river;
- Reached out to the broader science community via formation of a Pile Structure Subcommittee, hosting of site visits, and gathering of research scientists, regulatory officials, and others to solicit input;
- Developed program hypotheses, which formed the basis of pilot project experiments designed to attempt to determine program benefits for ecosystem restoration and salmon recovery;
- Developed a Research, Monitoring, and Evaluation plan that specifies protocols, methods, frequency, and duration for all program monitoring;
- Categorized pile structures into three separate classes and assigned relevant hypotheses to each class;
- Selected a suite of pilot projects for implementation;
- Initiated pilot project due diligence, monitoring, and permitting;
- Initiated a study to develop a rapid assessment method that would provide a means of cost-effectively identifying contaminant issues at project sites;
- Implemented a NOAA Fisheries-funded pilot piling removal project at Coal Creek Slough, a side channel of the lower Columbia River located near Longview, Washington. The Corps funded pre- and post-monitoring of the project;

- Completed an investigation that assessed the feasibility of, and developed concept designs for modifying existing pile structures to enhance habitat conditions, generally through the addition of LWD or modifying structures to more effectively recruit LWD;
- The Corps funded a monitoring study using underwater imagery to determine differences in fish use between different pile structures types, e.g., between spur dikes and pile fields, and determine differences in fish use between spur dikes with high and low levels of structural complexity, i.e., spur dikes that have recruited varying amounts of woody debris;
- The Corps also funded a monitoring study at Coal Creek Slough to evaluate potential water quality issues with pile structure removal using a BACI design;
- Completed a study to start collecting baseline data on three different types of pile structures in the LCR (spur dikes, transverse dikes, and pile fields) to begin informing program hypotheses, to use as a comparison to post-project implementation data, to inform implementation alternatives, and to identify three to five pile structures similar enough to be used as replicates in a future manipulative study.

With program development underway and initial research complete, the program team began focusing on pilot project implementation, monitoring, hypotheses testing, and determining program benefits. The program team made significant progress in areas such as pilot site identification, stakeholder coordination, and permitting; however, several issues limited progress on the program.

- Specific projects to evaluate potential benefits and study designs were not completely identifiable;
- Although regional experts were contacted and taken out on site visits, those experts were not able to provide direct guidance regarding potential benefits for different pile structure modifications;
- Some of the suitable pile fields were found to be historically significant structures;
- Most suitable pile fields are located in the lower portion of the estuary, an area in which the public considers these structures to be evocative of the river's history and therefore likely would not support modification or removal;
- Considerable issues arose regarding the possibility of adding large woody debris to pile structures or modifying pile structures to recruit such debris; and,
- Ownership of many structures proved very difficult to determine.

The emphasis of the program therefore turned to Corps-owned structures, primarily spur dikes. In 2010 and 2011 the Corps funded a structural, hydraulic, and environmental evaluation of Corps-owned pile dikes in the Columbia River (AECOM 2011). The Corps also established a Project Delivery Team (PDT) to speed implementation however, as efforts proceeded, it became apparent that removal of Corps-owned pile dikes would have its own set of challenges.

- While some structures could limit access to shallow water habitat, others could be stabilizing shallow water habitat. A full hydraulic analysis would be necessary before removing any structure.
- Pile dike removal could be followed by erosion of downstream bankline, which may be attributed to removal.
- Additional research would be needed before the actual benefit of pile dike removal could be determined. This would further delay full implementation of the program.
- Because pile structure removal is still experimental, extensive testing and monitoring would be critical to maximizing project benefits and cost effectiveness, and to ensure potential impacts are avoided.

- The overall cost effectiveness of the necessary research, monitoring and evaluations is not known.

As a result of the above points, the Action Agencies are at this time reviewing the future viability of the Pile Structure Program.

Hatchery Implementation Reports, RPA Actions 39–42

RPA Action No.	Action	Comprehensive Evaluation
Habitat Strategy 1		
39	FCRPS Funding of Mitigation Hatcheries – Programmatic	Report level of compliance with NOAA Fisheries approved HGMPs at all FCRPS mitigation hatchery programs.
40	Reform FCRPS Hatchery Operations to Reduce Genetic and Ecological Effects on ESA-Listed Salmon and Steelhead	Comprehensive report on status of project implementation for all actions identified in implementation plans. Report on any reform-specific monitoring and evaluation (M&E).
Hatchery Strategy 2		
41	Implement Safety Net Programs to Preserve Genetic Resources and Reduce Short-term Extinction Risk	Comprehensive report on status of implementation of all actions identified in implementation plans. Report on any associated M&E results that may inform future operations.
42	Implement Conservation Programs to Build Genetic Resources and Assist in Promoting Recovery	Comprehensive report on status of implementation of all actions identified in implementation plans. Report on any associated M&E results that may inform future operations.

Hatchery Strategy 1 (RPA Actions 39-40)

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 was initiated in September 2008 for upper Columbia River hatchery programs, in March 2009 for programs in the Mid-Columbia Steelhead DPS, and in May 2009 for Snake River Basin programs. NOAA Fisheries announced initiation via letter to hatchery operators and interested parties, and requested the Action Agency-funded hatchery operators in these regions to update the Hatchery and Genetic Management Plans (HGMPs) for their respective hatchery programs. In July 2009, the Action Agencies sent a letter to hatchery program operators that 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 River 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.

During the period of 2009 through 2012, 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. Tables 39, 40, and 41 briefly describe the hatchery programs funded by the Action Agencies in terms of their status relative to the ESA consultation process.

Table 39. FCRPS-Funded Hatchery Programs in the Upper Columbia River Region.

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation, December 2012
Wenatchee	Leavenworth National Fish Hatchery (NFH) Spring Chinook	USFWS	Reclamation	Letter transmitted to NOAA Fisheries 08 July 2009	NOAA transmitted working draft of BiOp (Version 3) to USBR and USFWS on 11 July 2012; Issuance of final BiOp pending NOAA Fisheries action.
Entiat	Entiat NFH Summer Chinook Program	USFWS	Reclamation	Letter transmitted to NOAA Fisheries 08 July 2009	NOAA transmitted 2nd draft of BiOp to USBR and USFWS on 29 August 2012. The USBR provided feedback on the draft BO to NOAA Fisheries on 13 September 2012. Issuance of final BiOp and permits pending NOAA Fisheries action.
Methow	Winthrop NFH Methow Composite Spring Chinook	USFWS	Reclamation	Revised HGMP submitted to NOAA Fisheries Nov. 15, 2012.	Hatchery Operators have collaborated with other hatchery program operators and funding entities to address NOAA Fisheries concerns, revised HGMP accordingly and submitted for NOAA Fisheries review.
Methow	Winthrop NFH Steelhead	USFWS	Reclamation	Revised HGMP submitted to NOAA Fisheries Nov. 13, 2012.	Operators have collaborated with other hatchery program operators and funding entities to address NOAA Fisheries concerns, revised HGMP accordingly and submitted for NOAA Fisheries review.
Methow	Methow Coho	Yakama Nation (YN)	BPA	Letter transmitted to NOAA Fisheries 02 August 2010	Letter of Sufficiency for Consultation Issued by NOAA 13 December 2010; initiation of formal consultation process pending NOAA Fisheries action.
Wenatchee	Wenatchee Coho	YN	BPA	Letter transmitted to NOAA Fisheries 22 July 2010	Letter of Sufficiency for Consultation Issued by NOAA 13 December 2010; initiation of formal consultation process pending NOAA Fisheries action.

Table 40. FCRPS-Funded Hatchery Programs in the Mid-Columbia River Region.

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
Yakima	Yakima Spring Chinook	YN	BPA	Letter transmitted to NOAA Fisheries 19 January 2011; and Letter of Sufficiency for Consultation issued by NOAA 20 June 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Yakima	Yakima Summer-Fall Chinook [1]	YN	BPA	Letter transmitted to NOAA Fisheries 19 January 2011; and Letter of Sufficiency for Consultation issued by NOAA 20 June 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Yakima	Yakima Coho	YN	BPA	Letter transmitted to NOAA Fisheries 19 January 2011; and Letter of Sufficiency for Consultation issued by NOAA 20 June 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Walla Walla	Touchet Endemic Steelhead	WDFW	BPA, Lower Snake River Compensation Plan (LSRCP)	Letter transmitted to NOAA Fisheries 03 December 2010; and Letter of Sufficiency for Consultation issued by NOAA 10 March 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Umatilla	Umatilla Spring Chinook	Oregon Department of Fish and Wildlife (ODFW) & Confederated Tribes of the Umatilla Indian Reservation (CTUIR	BPA	Letter transmitted to NOAA 22 July 2011; and Letter of Sufficiency for Consultation issued by NOAA 03 January 2011	Consultation Completed with NOAA Fisheries issuance of BiOp and permits on 20 April 2011.
Umatilla	Umatilla Fall Chinook [2]	ODFW & CTUIR	BPA and Corps	Letter transmitted to NOAA Fisheries 22 July 2011; and Letter of Sufficiency for Consultation issued by NOAA 03 January 2011	Consultation Completed with NOAA Fisheries issuance of BiOp and permits on 20 April 2011.

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
Umatilla	Umatilla Coho [3]	ODFW & CTUIR	BPA	Letter transmitted to NOAA Fisheries 22 July 2011; and Letter of Sufficiency for Consultation issued by NOAA 03 January 2011	Consultation Completed with NOAA Fisheries issuance of BiOp and permits on 20 April 2011.
Umatilla	Umatilla Summer Steelhead	ODFW & CTUIR	BPA	Letter transmitted to NOAA Fisheries 07 January 2011; and Letter of Sufficiency for Consultation issued by NOAA 01 March 2011	Initiation of formal consultation process pending NOAA Fisheries action.

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 41. FCRPS-Funded Hatchery Programs in the Snake River Region.

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
Lower Snake	Lyons Ferry Summer Steelhead	WDFW	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 04 April 2011; and Letter of Sufficiency for Consultation issued by NOAA 02 May 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Lower Snake	Snake River Stock Fall Chinook (Lyons Ferry Hatchery) [1]	WDFW	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 11 May 2011; and Letter of Sufficiency for Consultation issued by NOAA 08 June 2011	Consultation Completed with NOAA Fisheries issuance of BiOp and permits on 09 October 2012.
Tucannon	Tucannon Summer Steelhead Endemic	WDFW	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 08 February 2011; and Letter of Sufficiency for Consultation issued by NOAA 02 May 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Tucannon	Tucannon Spring Chinook	WDFW	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 22 July 2011; and Letter of Sufficiency for Consultation issued by NOAA 26 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Clearwater	NF Clearwater River Summer Steelhead (B-Run-Clearwater River Hatchery)	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 23 January 2011; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Clearwater	Clearwater River Basin Spring/Summer Chinook (Clearwater Hatchery)	IDFG	BPA (LSRCP)	LSRCP letter transmitted to NOAA Fisheries 17 January 2012; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Clearwater	NF Clearwater	USFWS	Corps	Revised HGMP submitted to	Initiation of formal consultation process

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
	Summer Steelhead (B-Run-Dworshak NFH)			NOAA Fisheries for comment in February 2011; as of end of 2012, HGMP finalization and submittal of consultation request were pending NOAA Fisheries action	pending USFWS and NOAA Fisheries actions.
Clearwater	NF Clearwater Spring Chinook (Dworshak NFH)	USFWS	BPA (LSRCP)	LSRCP letter transmitted to NOAA Fisheries 21 December 2010; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Clearwater	Clearwater Spring Chinook (NPTH-Hatchery)	Nez Perce Tribe (NPT)	BPA	Draft HGMP reviewed by Action Agency (10 July 2012) has not been submitted to NOAA Fisheries for review-comment	Initiation of formal consultation process pending submittal of Co-Manager approved HGMP and operator's request for consultation.
Clearwater	Clearwater Fall Chinook (NPTH-Hatchery)	NPT	BPA	Letter Transmitted to NOAA 11 May 2011; and Letter of Sufficiency for Consultation Issued by NOAA 08 June 2011	Consultation Completed with NOAA Fisheries issuance of BiOp and permits on 09 October 2012.
Grande Ronde	Grande Ronde Summer Steelhead-Wallowa Stock (Cottonwood Creek/Lyons Ferry Hatchery)	WDFW	BPA (LSRCP)	LSRCP letter transmitted to NOAA Fisheries 26 January 2011; and Letter of Sufficiency for Consultation issued by NOAA Fisheries 02 May 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Grande Ronde	Grande Ronde Summer Steelhead (Wallowa Stock)	ODFW	BPA (LSRCP)	LSRCP letter transmitted to NOAA Fisheries 26 May 2011; and Letter of Sufficiency for Consultation issued by NOAA Fisheries 31 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
Grande Ronde	Upper Grande Ronde River Spring/Summer Chinook Salmon Stock	ODFW & CTUIR	BPA (LSRCP)	BIA letter transmitted on behalf of CTUIR to NOAA Fisheries 15 July 2011; and Letter of Sufficiency for Consultation issued by NOAA Fisheries 26 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Grande Ronde	Catherine Creek Spring/Summer Chinook	ODFW & CTUIR	BPA (LSRCP)	Letter Transmitted to NOAA 02 May 2011; and Letter of Sufficiency for Consultation Issued by NOAA 04 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Grande Ronde	Wallowa/Lostine Spring Chinook	ODFW, NPT & CTUIR	BPA (LSRCP)	BIA letter transmitted on behalf of NPT to NOAA Fisheries 27 May 2011; and Letter of Sufficiency for Consultation issued by NOAA Fisheries 04 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Grande Ronde	Lookingglass Creek Spring/Summer Chinook	ODFW	BPA (LSRCP)	Letter Transmitted to NOAA 23 January 2012; and Letter of Sufficiency for Consultation Issued by NOAA 16 March 2012	Initiation of formal consultation process pending NOAA Fisheries action.
Imnaha	Little Sheep Creek Summer Steelhead	ODFW	BPA (LSRCP)	Letter Transmitted to NOAA 02 May 2011; and Letter of Sufficiency for Consultation Issued by NOAA 04 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Imnaha	Imnaha Spring/Summer Chinook	ODFW	BPA (LSRCP)	Letter Transmitted to NOAA 02 May 2011; and Letter of Sufficiency for Consultation Issued by NOAA 04 August 2011	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	Upper Salmon River B-Run	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries	Initiation of formal consultation process pending NOAA Fisheries

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
	Steelhead			17 January 2012; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	action.
Salmon	Upper Salmon Spring Chinook (Sawtooth Hatchery)	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 21 December 2011; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	South Fork Salmon Summer Chinook (McCall Fish Hatchery)	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 21 December 2011; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	Johnson Creek Summer Chinook (South Fork Salmon)	IDFG & NPT	BPA (LSRCP)	BIA letter transmitted on behalf of NPT to NOAA Fisheries 17 June 2011; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	Yankee Fork Summer Steelhead Streamside Incubation Supplement ation	IDFG & Shoshone-Bannock Tribes (SBT)	BPA	Draft HGMP (Action Agency reviewed 08 June 2010) submitted to NOAA Fisheries 03 June 2012; draft HGMP pending NOAA review-comment	Initiation of formal consultation process pending submittal of Co-Manager approved HGMP and operator's request for consultation.
Salmon	Yankee Fork Summer Steelhead Supplement ation	IDFG & SBT	BPA	Draft HGMP (Action Agency reviewed 11 June 2010) submitted to NOAA Fisheries 23 April 2010; draft HGMP pending NOAA review-comment	Initiation of formal consultation process pending submittal of Co-Manager approved HGMP and operator's request for consultation.
Salmon	Yankee Fork Chinook Supplement	IDFG & SBT	BPA	Draft HGMP (Action Agency reviewed 11 June 2010)	Initiation of formal consultation process pending submittal of Co-Manager approved HGMP

Basin	Program	Operator	Lead Action Agency	Submittal Date of Formal Consultation Request by Operator	Status of Formal Consultation
	ation			submitted to NOAA Fisheries 23 April 2010; draft HGMP pending NOAA review-comment	and operator's request for consultation.
Salmon	SF Salmon-Dollar Creek Summer Chinook (McCall FH-Egg Box)	IDFG & SBT	BPA	Draft HGMP (Action Agency reviewed 08 June 2010) submitted to NOAA Fisheries 03 June 2012; draft HGMP pending NOAA review-comment	Initiation of formal consultation process pending submittal of Co-Manager approved HGMP and operator's request for consultation.
Salmon	E. Fork Salmon River Natural integrated Steelhead (Sawtooth)	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 21 December 2011; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	Little Salmon River A&B Run Steelhead (Niagara/Magic Valley)	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 13 September 2011; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	Upper Salmon River A-Run Steelhead (Sawtooth/ Magic Valley/Hagerman National)	IDFG	BPA (LSRCP)	Letter transmitted to NOAA Fisheries 17 January 2012; and Letter of Sufficiency for Consultation pending NOAA Fisheries action	Initiation of formal consultation process pending NOAA Fisheries action.
Salmon	Snake River Sockeye	IDFG	BPA (LSRCP)	NOAA Fisheries issued Letter of Sufficiency for Consultation on June 13 2012.	Initiation of formal consultation process pending NOAA Fisheries action.

By the close of 2012, the Action Agencies had reviewed draft HGMPs for all 44 Action Agency-funded hatchery programs. The remaining steps to complete the hatchery program consultations identified in RPA Action 39 will be conducted primarily by NOAA Fisheries, with assistance and review by the Action Agencies.

Upper Columbia River 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 *US v. OR* dispute resolution, regarding apportionment of Winthrop NFH production between Methow and Okanogan (CTCR program) releases. Informal discussions made progress towards resolution of these issues, culminating in resolution of the issues in 2012. The program is now aligned with the *US v. OR* management agreement, USFWS revised the draft HGMP to be sufficient for formal consultation and submitted it to NOAA Fisheries November 15, 2012. On March 19, 2013, NOAA Fisheries a letter of sufficiency. However, the Yakama Nation has raised objections with the HGMPs and further consultation is underway.
- *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-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. These discussions continued in 2012, and issues have been resolved. Co-managers (USFWS, Douglas County PUD, and WDFW) developed a framework to evaluate and manage steelhead programs in the Methow Basin comprehensively. USFWS has revised the HGMP to be sufficient for formal consultation and submitted it to NOAA Fisheries November 13, 2012. A Letter of Sufficiency letter was provided by NOAA Fisheries on March 19, 2013. However, the Yakama Nation has raised objections with the HGMPs and further consultation is underway.
- Methow Coho Program: A letter of sufficiency for Section 7 consultation for this program was forwarded by NOAA Fisheries on December 13, 2010. Per informal telephone conversations between NOAA Fisheries and BPA, NOAA Fisheries has indicated that a consultation for the Methow Coho Program can and will likely proceed separately of other Methow hatchery programs that were delayed. No date for initiating the consultation for this program has been provided by NOAA Fisheries.

Entiat Subbasin

- *Entiat NFH Summer Chinook Program:* The Entiat NFH Summer Chinook HGMP was submitted by USFWS on July 29, 2009, to NOAA Fisheries. In a letter (March 9, 2011), NOAA Fisheries accepted the HGMP for this program as sufficient for formal ESA consultation (Section 7), and began development of a draft BiOp. In 2012, NOAA Fisheries provided a draft BiOp, USFWS and Action Agencies provided comments, and issues were resolved through informal consultation. A Final BiOp was issued April 18, 2013.

Wenatchee Subbasin

- *Leavenworth NFH Spring Chinook Program*: The HGMP was submitted by USFWS in July, 2009. The consultation was delayed by Icicle Creek water issues. In 2011, the water issues were resolved and a Section 7 ESA consultation was completed with USFWS on effects to bull trout and other USFWS jurisdiction species, thereby clarifying the proposed action for this consultation. The HGMP was revised and submitted on March 21, 2011. NOAA Fisheries indicated the consultation package is sufficient for formal consultation on June 2, 2011, and began drafting a BiOp. In 2012 NOAA Fisheries provided a draft BiOp, USFWS and Action Agencies provided comments, and further issues were resolved through informal consultation.

A final BiOp is expected soon. Actions to lessen effects to listed species include removal of Leavenworth NFH Spring Chinook salmon adults at Tumwater Dam.

- *Wenatchee Coho Program*: A letter of sufficiency for Section 7 consultation for this program was forwarded by NOAA Fisheries on December 13, 2010. The consultation process and issuance of a BiOp for this program is on track for completion in early 2013.

Middle Columbia River Programs

Yakima Subbasin

- *Yakima Spring Chinook, Fall/Summer Chinook, and Coho Programs*: A letter response from NOAA Fisheries to BPA was sent on May 2, 2011, requesting BPA to notify NOAA Fisheries that the contents of the letter "accurately characterizes each proposed action and its effects on salmon and steelhead under the ESA." On June 20, 2011, based on WDFW and YN responses to BPA, BPA responded with a letter concurring with NOAA Fisheries' finding that the programs are HGMP sufficient *Continuance of the consultation process for the Yakima progra*ms was pending the submittal of a co-managers approved Klickitat Endemic Summer Steelhead program HGMP; this HGMP has been submitted and is pending action by NOAA Fisheries to initiate consultation ('batching of programs') for the Mid-Columbia Summer Steelhead ESU (Yakima, Walla Walla, Umatilla, Deschutes, and Klickitat populations). The co-managers approved HGMP for the Klickitat Summer Steelhead Programs has been submitted by YN and accepted by NOAA Fisheries in July 2011. Completion of consultation process and issuance of BiOps for the Yakima hatchery programs is expected in early-mid 2013.

  Note: The Yakima Summer Steelhead Reconditioning Program has ESA coverage, and a permit has been issued for this program.

Walla Walla Subbasin

- *Touchet Endemic Steelhead Program*: NOAA Fisheries determined WDFW consultation package (Letter and co-managers Approved HGMP) as sufficient for Section 10 consultation on March 16, 2011. Per the August 2012 Annual Operations Plan, technical representatives agreed to move forward for formal policy level discussion/agreement for a change in the endemic program in 2013 as part of the AOP process. After 12 years of testing, RME data for the endemic program indicates the program as it exists may pose a risk to the long-term health of the native Touchet River population; and a policy decision is needed as to whether to terminate the program or transition the program to an integrated harvest augmentation program. In the future, if the program is changed or modified, a new HGMP document would be drafted, approved by the co-managers, and submitted to NOAA Fisheries for review and determination as sufficient for Section 10 consultation. Completion of the consultation process and issuance of a BiOp are expected in 2013 pending policy decision of co-managers for the current program.

Umatilla Subbasin

- *Umatilla Spring Chinook, Fall Chinook, Coho, and Steelhead*: On April 20, 2011, NOAA Fisheries 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 and issuance of a BiOp for Umatilla Summer Steelhead ESU is expected in 2013.

Snake River Programs

Lower Snake River Subbasin

- *Lyons Ferry Stock Summer Steelhead (Lyons Ferry) Program*: A letter of sufficiency for Section 7 consultation for this program was forwarded by NOAA Fisheries on May 2, 2011; completion of the consultation process and issuance of a BiOp are expected in 2013.
- *Lyons Ferry Snake River Fall Chinook Hatchery-Acclimation Project Program*: NOAA Fisheries completed the BiOp and issued permits to program operators (WDFW and NPT) for the Lyons Ferry Fall Chinook Hatchery-Acclimation Project and Nez Perce Tribal Hatchery Fall Chinook (Clearwater River Subbasin) programs on October 9, 2012.
- *Tucannon Summer Steelhead Endemic Program*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on May 2, 2011; completion of consultation process is expected in 2013.
- *Tucannon Spring Chinook Program*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on August 26, 2011; completion of the consultation process and issuance of a BiOp are expected in 2013.

Clearwater River Subbasin

- *North Fork Clearwater Spring Chinook (Dworshak-Hatchery) Program*: Lower Snake River Compensation Plan (LSRCP) and USFWS submitted a Section 7 consultation package (Cover letter and Co-Managers Approved Final HGMP) on December 21, 2010. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the HGMP's sufficiency for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *North Fork Clearwater Summer Steelhead (Dworshak-Hatchery) Program*: USFWS submitted a draft HGMP to NOAA Fisheries on April 8, 2010. The draft was revised in February 2011 and again submitted to NOAA Fisheries for comment. As of the end of 2012, finalization of the HGMP and submittal for consultation were pending NOAA Fisheries' comments to that draft. Completion of the process and issuance of a BiOp are expected in 2014.
- *Nez Perce Hatchery Fall Chinook Program*: Refer to "*Lyons Ferry Snake River Fall Chinook Hatchery-Acclimation Project Program*" in lower Snake River Subbasin section.
- *Nez Perce Hatchery Spring Chinook Program*: A draft HGMP for this program was reviewed by BPA in July 2012; and he tribe communicated to BPA that a draft final HGMP is in the process for completion and submittal to NOAA Fisheries. Completion of a final co-managers' approved HGMP and submittal of request for consultation is pending tribal action. Completion of the process and issuance of a BiOp are expected in 2014.
- *Clearwater Hatchery Spring/Summer Chinook Program*: The IDFG submitted a consultation package (Cover letter and Co-Managers Approved Final HGMP) requesting Section 10 consultation on January 17, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the HGMP's sufficiency for consultation; completion of the process and issuance of a BiOp are expected in 2014.
- *Clearwater Hatchery Summer Steelhead Program*: IDFG submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) requesting Section 10 consultation on January 23, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the HGMP's sufficiency for consultation; completion of the process and issuance of a BiOp are expected in 2014.

<u>*Grande Ronde-Imnaha Subbasin*</u>

- *Wallowa/Lostine Spring Chinook Program (NE Oregon Hatchery)*: On 27 May 2011, the Bureau of Indian Affairs (BIA), on behalf of the NPT, submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) requesting ESA consultation under Section 10 (a)(1)(A). A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on August 4, 2011; completion of the consultation process and issuance of a BiOp is expected in 2013.
- *Grande Ronde Summer Steelhead-Wallowa Stock (Cottonwood Creek/Lyons Ferry Hatchery) Program*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on May 2, 2011; completion of the consultation process and issuance of a BiOp are expected in 2013.
- *Grande Ronde Summer Steelhead (Wallowa Hatchery)*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on August 31, 2011; completion of the consultation process and issuance of a BiOp are expected in 2013.
- *Catherine Creek Spring/Summer Chinook*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on August 4, 2011; completion of the consultation process and issuance of a BiOp are expected in 2013.
- *Imnaha Spring/Summer Chinook*: ODFW submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on May 2, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of consultation process is expected in 2013.
- *Little Sheep Creek Summer Steelhead (Imnaha)*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on August 4, 2011; completion of the consultation process and issuance of a BiOp is expected in 2013.
- *Upper Grande Ronde Spring Chinook*: On behalf of the CTUIR, BIA submitted a letter (and co-managers approved HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on July 15, 2011. A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on August 26, 2011; completion of the consultation process and issuance of a BiOp are expected in 2013.
- *Lookingglass Creek Spring/Summer Chinook (Grande Ronde)*: A letter of sufficiency for Section 10 consultation for this program was forwarded by NOAA Fisheries on March 16, 2012; completion of the consultation process and issuance of a BiOp are expected in 2013.

<u>*Salmon River Subbasin*</u>

- *Little Salmon River Summer Steelhead (A & B)*: IDFG submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on September 13, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *Johnson Creek Summer Chinook*: The BIA on behalf of the NPT submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on June 6, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.

- *East Fork Salmon River Summer Steelhead*: IDFG submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on December 21, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *Upper Salmon River Summer Steelhead (B-Run)*: The LSRCP submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on January 17, 2012. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *Upper Salmon River Summer Steelhead (A-Run)*: The LSRCP submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on January 17, 2012. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *Upper Salmon River Spring Chinook*: IDFG submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on December 21, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *McCall (South Fork Salmon River) Summer Chinook*: IDFG submitted consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program on December 21, 2011. Initiation of the consultation process is pending acknowledgement from NOAA Fisheries of the sufficiency of the HGMP for consultation; completion of the consultation process and issuance of a BiOp are expected in 2014.
- *Yankee Fork Programs (Summer Steelhead Stream Side Incubation and Supplementation, and Spring Chinook Supplementation)*: Submittal of consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program is pending action by Shoshone Bannock Tribes. Initiation and completion of the consultation process for these programs are expected in 2014.
- *Dollar Creek (South Fork Salmon River) Summer Chinook (Egg-Box)*: Submittal of consultation package (Cover letter and Co-Managers Approved Final HGMP) to NOAA Fisheries requesting application for Section 10 permit for this program is pending action by Shoshone Bannock Tribes. Initiation and completion of the consultation process for this program are expected in 2014.
- *Snake River Sockeye*: NOAA Fisheries forwarded review comments on draft HGMP to IDFG on May 18, 2010; consultation package (Cover letter and Co-Managers Approved Final HGMP) requesting application for Section 10 permit was submitted by IDFG to NOAA Fisheries. NOAA Fisheries issued letter of sufficiency of the HGMP for consultation on June 13, 2012; completion of the consultation process and issuance of a BiOp are expected in 2013.

RPA Action 40 – Reform FCRPS Hatchery Operations to Reduce Genetic and Ecological Effects on ESA-listed Salmon and Steelhead: *The Action Agencies will undertake/fund reforms to ensure that hatchery programs funded by the Action Agencies as mitigation for the FCRPS are not impeding recovery. The Action Agencies will work with FCRPS mitigation hatchery operators to cost effectively address needed reforms of current hatchery programs while continuing to meet mitigation responsibilities. Specific reforms to be implemented under this action (following any necessary regulatory approval) are listed in Table 6 of the RPA action table. Other reforms will be identified and implemented following the conclusion of the Columbia River Hatchery Scientific Review Group process.*

1. *For Lower Columbia Chinook: The COE will review the John Day Hatchery Mitigation Program.*
2. *For Snake River Steelhead: Fund the Tucannon River steelhead supplementation program to transition to local broodstock using BMPs.*
3. *For Middle Columbia Steelhead: Fund the Touchet River steelhead supplementation program to transition to local broodstock using BMPs.*
4. *For Upper Columbia Steelhead: For the Winthrop NFH steelhead program, implement measures to transition to local broodstock and to manage the number of Winthrop NFH-produced steelhead on the spawning grounds. Such broodstock and adult escapement reform measures, including capital construction, would be identified through development of an updated HGMP and ESA consultation. Implementation of reform measures is contingent on a finding, in consultation with NOAA Fisheries, that the measures are biologically and economically feasible and effective. Implementation of reforms will be prioritized and sequenced.*

RPA Subaction 40.1 – *For Lower Columbia Chinook: The COE will review the John Day Hatchery Mitigation Program.*

The review 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 construction and operational modifications to the program that will better provide in-place, in-kind mitigation.

As a first step in this process, in 2008 the Corps finalized a plan for reprogramming production of juveniles and transferring releases between Spring Creek NFH (above Bonneville Dam) and Bonneville Hatchery (below Bonneville Dam). That reprogramming was implemented in 2009 and revised in 2011. The net effect is to shift the acclimation and release of 2.5 million juvenile upriver bright (URB) Chinook salmon (of the original 4.5 million URB juveniles previously reared and released at Bonneville Hatchery), to the Little White Salmon NFH located above Bonneville Dam in Zone 6. In addition, 15 million Tule Chinook juveniles that were originally reared and released at Spring Creek NFH were reprogrammed such that 10.5 million of those Chinook are currently released at Spring Creek NFH, while the remaining 2.8 million and 1.7 million Tule Chinook juveniles are released at Bonneville and Little White Salmon hatcheries, respectively.

The review of the John Day Mitigation Program must take into account the requirements of *U.S. v. Oregon.* In 2009 and 2010, the Corps continued ongoing negotiations with *U.S. v. Oregon* parties to resolve key issues necessary to proceed with the evaluations and planning for the specific actions to achieve this objective and address the ESA issues associated with the current and potential future mitigation program.

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 evaluated mitigation production and assumptions, clarified in-place, in-kind mitigation production objectives, determined delta between objectives and production, analyzed alternatives, and prepared preliminary designs and cost estimates for the most feasible alternatives. The *U.S. v. Oregon* parties have provided comments on the report. As a result, the Corps has agreed to use the Total Adult Production method and current SARs to determine production adjustments. The Corps is revising the Alternative Study and preparing a Design Report in 2012 and 2013 that will recommend specific adjustments to the current production program. Subject to agency review and funding, the Corps could implement program adjustments in the FY 2015/16 time frame.

RPA Subaction 40.2 – *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, WDFW, and the LSRCP hatchery program operator for the Tucannon River steelhead supplementation program. For Tucannon steelhead, WDFW developed a revised HGMP (released September 22, 2011) to eliminate releases of Lyons Ferry Hatchery steelhead in the Tucannon River and to increase production of the endemic Tucannon River summer steelhead program. A summary of the proposed changes was submitted to the *U.S. v. Oregon* Production Advisory Committee for review and approved by the *U.S. v Oregon* Parties in 2011. The current Tucannon River endemic stock summer steelhead smolt production was increased from 50,000 to 75,000 fish annually (beginning with BY2010 production for release in 2011), and may expand up to 100,000 in 2013, which is 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.

RPA Subaction 40.3 – *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 NOAA Fisheries in November 2010 to align with NOAA Fisheries' request to consult on mid-Columbia River stocks. The new HGMP is consistent with the current management plan and the *U.S. v. Oregon* agreement. At this time, the program remains the same (50,000 smolts annually) and continues to be evaluated.

Per the August 2012 Annual Operations Plan meeting with co-managers, technical representatives agreed to move forward for formal policy level discussion/review for a potential change in the endemic program in 2013 as part of the Annual Operations Plan process. After 12 years of testing, RME data for the endemic program indicates the program as it exists may pose a risk to the long-term health of the native Touchet River population; and policy decision needs to be made as to whether to terminate the program, continue to test the program, or transition the program to an integrated harvest augmentation or native stock supplementation program. In the future, if the program is changed or modified, a new HGMP document would have to be generated, approved by the co-managers, and submitted to NOAA Fisheries for review and determination as sufficient for Section 10 consultation.

RPA Subaction 40.4 – *For Upper Columbia Steelhead: For the Winthrop NFH steelhead program, implement measures to transition to local broodstock and to manage the number of Winthrop NFH-produced steelhead on the spawning grounds. Such broodstock and adult escapement reform measures, including capital construction, would be identified through development of an updated HGMP and ESA consultation. Implementation of reform measures is contingent on a finding, in consultation with NOAA*

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

The Winthrop NFH is in the process of transitioning to local broodstock by collecting more brood from the Winthrop Basin via hatchery volunteers, and angling. The program began in 2008 with 25,000 juvenile steelhead from local broodstock, and has transitioned over time to 40,000 in 2009, 50,000 in 2010, 60,000 in 2011, and 100,000 in 2012. The release goal of 100,000 fish annually continued throughout the transition with the remainder coming from traditional broodstock from Wells Dam collection. 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 NOAA Fisheries to evaluate the SBs of the local broodstock and two-year rearing strategy. Preliminary results from BPA funded project (1993-056-00) indicate the success of this strategy, with better survival and migratory performance under the two-year rearing regime. (See RME Strategy 6, RPA Action 64 for further discussion of these results).

The USFWS has implemented increasing efforts to manage returning Winthrop NFH-produced steelhead on the spawning grounds from 2008-2012. All NFH-produced steelhead collected through hatchery volunteers or angling are now removed, and Action Agencies are increasing efforts to remove more hatchery returns with additional effort. 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 for management, but this is a difficult and controversial solution. The Value Planning process included a coordination meeting in February 2011; a larger, facilitated “Group Objectives and Logistics (GOAL)” meeting to develop a problem statement, sideboards, and criteria; and a focused workgroup session or Project Alternatives Solutions Study (PASS) to develop proposals to collect broodstock and effectively manage returning adults. Entities involved in these meetings included Reclamation, BPA, USFWS, WDFW, YN, Douglas County PUD, UCSRB, CTCR, Grant County PUD, and Chelan County PUD. Proposals included: 1) 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; 2) Using temporary structures such as picket panel weirs or pound nets throughout the basin to capture returning adults; 3) modifying Foghorn Dam to enhance capability to manage adults and collect broodstock; and 4) 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 the first two proposals, 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 3 and 4 as longer-term structural solutions to be considered if necessary (Reclamation, 2012a). In 2012, per the recommendation from the team, Reclamation funded a scope of work within the funding agreement with USFWS to enable implementation of Proposals 1 and 2 to increase local broodstock collection, enhance returning hatchery fish management, and monitor these efforts, beginning in 2013.

Hatchery upgrades included a project to remove and replace outdated structures and install new holding and rearing ponds for sorting and spawning adult fish at Winthrop NFH. This project was considered by the technical evaluation team and bids were solicited in 2010, a contract was awarded in 2011, and construction was completed in 2012. There was an additional recommendation for Winthrop NFH to reduce spring Chinook salmon production and thereby increase steelhead production capability. This recommendation has resulted in surplus hatchery spring Chinook salmon being removed from the natural spawning population and donated to the Yakama, Colville, and Spokane tribes and allowed full scale production of steelhead from local broodstock.

Other Significant Reforms:

Other significant FCRPS hatchery reform accomplishments include the Entiat NFH Summer Chinook Program. This hatchery previously raised and released Spring Chinook salmon that were found to be a limiting factor to population viability of listed Spring Chinook salmon. Spring Chinook salmon releases were discontinued in 2008 and the mitigation program was replaced with unlisted Summer Chinook salmon, thereby eliminating effects of Entiat National Fish Hatchery Spring Chinook salmon on the spawning grounds. No Entiat NFH Spring Chinook salmon carcasses were found in 2011 or 2012 spawning surveys (Hamstreet, 2012; Cooper, 2012).

Additional significant FCRPS hatchery reform accomplishments also include cost-effective improvements in Best Management Practices and facility infrastructure at Dworshak NFH that have significantly increased the survival and production of ESA-listed hatchery summer steelhead (egg-fry, fry, juvenile, pre-smolt, and smolt life phases). These improvements, which were implemented through a coordinated effort by the hatchery operator (USFWS) and the funding agencies (Corps and BPA), include:

- New upgraded degassing towers for reducing nitrogen saturation from 107.5 percent to 98.6 percent.
- Innovative management of river and reservoir water sources that significantly decrease IHN virus infections.
- Upgrades in nursery tanks that improve post-emergent fry survival.
- Replacement of incubation chiller with water-to-water heat pump.

Hatchery Strategy 2 (RPA Actions 41–42)

RPA Action 41 – Implement Safety Net Programs to Preserve Genetic Resources and Reduce Short-term Extinction Risk: *The Action Agencies will continue to fund the operation of on-going "safety net" programs that are providing benefits to ESA-listed stocks at high risk of extinction by increasing genetic resources and will identify and plan for additional safety-net programs, as needed.*

1. *For Snake River sockeye: Continue to fund the safety net program to achieve the interim goal of annual releases of 150,000 smolts while also continuing to implement other release strategies in nursery lakes such as fry and parr releases, eyed-egg incubation boxes, and adult releases for volitional spawning (see Action 42 for expansion of the program for building genetic resources and assisting in promoting recovery).*
2. *For Snake River Spring/Summer Chinook: For the Tucannon River spring/summer Chinook safety-net supplementation program fund capital construction, operation and monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock and a sliding scale for managing the composition of natural spawners comprised of hatchery-origin fish.*
3. *For Snake River Spring/Summer Chinook: For the Upper Grande Ronde and Catherine Creek safety net supplementation programs fund capital construction, operation and monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock, and a sliding scale for managing the composition of natural spawners comprised of hatchery origin fish.*
4. *For Snake River Spring/Summer Chinook: Fund the Johnson Creek / South Fork Salmon River safety net supplementation program, as described in the existing Section 10 permit.*
5. *For Snake River/Summer Chinook: Fund the experimental captive rearing program for East Fork and West Fork Yankee Fork Salmon River (until phased out by IDFG).*
6. *For Snake River Steelhead, as a project to benefit primarily B-run steelhead, the Action Agencies will work with NOAA Fisheries to develop a trigger for future artificial propagation safety-net planning or to identify populations for immediate safety-net planning.*

RPA Subaction 41.1 – *For Snake River sockeye: Continue to fund the safety net program to achieve the interim goal of annual releases of 150,000 smolts while also continuing to implement other release strategies in nursery lakes such as fry and parr releases, eyed-egg incubation boxes, and adult releases for volitional spawning (see Action 42 for expansion of the program for building genetic resources and assisting in promoting recovery).*

BPA continued to fund **BPA Project 2007-402-00** (Snake River Sockeye Salmon Captive Broodstock) to preserve this species. The program has produced hundreds of thousands of progeny from remnants of the wild stock. 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, 4,549 adults from the program have returned to Redfish Lake in Idaho.

RPA Subaction 41.2 – *For Snake River Spring/Summer Chinook: For the Tucannon River spring/summer Chinook safety-net supplementation program fund capital construction, operation and* *monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock and a sliding scale for managing the composition of natural spawners comprised of hatchery-origin fish.*

BPA Project 2000-019-00 (Tucannon River Spring Chinook Captive Brood), a one-generation safety-net program, was completed as planned in 2010. The captive brood program was not successful in meeting its adult return goals, so the co-managers decided to use a conventional hatchery supplementation program to help rebuild the Tucannon River spring/summer Chinook salmon population. BPA continues to fund this supplementation program through the LSRCP Direct Funding Agreement.

RPA Subaction 41.3 – *For Snake River Spring/Summer Chinook: For the Upper Grande Ronde and Catherine Creek safety net supplementation programs fund capital construction, operation and monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock, and a sliding scale for managing the composition of natural spawners comprised of hatchery origin fish.*

BPA continued to fund this safety-net program through **BPA Project 2007-404-00** (Spring Chinook Captive Propagation - Oregon). 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.

RPA Subaction 41.4 – *For Snake River Spring/Summer Chinook: Fund the Johnson Creek / South Fork Salmon River safety net supplementation program, as described in the existing Section 10 permit.*

BPA continued to fund this safety-net program through **BPA Project 1996-043-00** (Johnson Creek Artificial Propagation Enhancement project).

RPA Subaction 41.5 – *For Snake River/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 2007-403-00** (Idaho Snake River Spring Chinook Captive Propagation). All captive-rearing ended in 2010 when the last remaining brood year (BY05) was released as mature adults to spawn in their natal waters. M&E of the contribution of released captive-reared Chinook to natural adult returns is on-going for this project, and one critical field evaluation remains; complete evaluation of captive-reared production (adult-to-adult) via genetic parentage analysis. The highest likelihood of observing captive-reared contribution to adult returns is during adult return years 2010-2014, since the greatest number of captive-reared redds were produced during 2006-2009. In 2015, upon completion of these last remaining tasks and analyses, IDFG will then draft a completion report on the efficacy of captive rearing for Chinook salmon.

RPA Subaction 41.6 – *For Snake River Steelhead, as a project to benefit primarily B-run steelhead, the Action Agencies will work with NOAA Fisheries to develop a trigger for future artificial propagation safety-net planning or to identify populations for immediate safety-net planning.*

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 Subaction 50.5, work will begin with NOAA Fisheries to develop the type of "trigger" described above. It is estimated that 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.*
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.*
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.*
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.*
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.*
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.*
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.*
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.*
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.*
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.*

RPA Subaction 42.1 – *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.*

Okanogan Spring Chinook Reintroduction Program **(BPA Project 2003-023-00, Chief Joseph Hatchery):** The primary objective of this CCT program is to re-establish a natural spawning population in suitable habitat. Phase I of the program used out-of-ESU Leavenworth stock as a proof of concept. The program has been dormant for several years awaiting the completion of the Chief Joseph Hatchery and regulatory approvals for the use of broodstock. Phase II includes the approval of a "non-essential experimental population" designation under section 10(j) of the ESA that will allow for the transfer of juveniles or eggs of Methow Composite UCR spring Chinook stock from the adjacent Methow subbasin. The primary objective of Phase II is to reestablish a population of UCR spring Chinook in the Okanogan River Basin and increase the abundance, distribution, and diversity of this ESA-listed ESU to aid in its recovery. Upon successful reintroduction of local broodstock, CCT will transition to an integrated program in Phase III which will propagate spring Chinook that are locally adapted to the Okanogan River Basin while providing some limited harvest opportunity on hatchery fish in excess of recovery needs.

RPA Subaction 42.2 – *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 2012, BPA funded the YN to complete construction of a steelhead kelt reconditioning facility at Winthrop NFH. Eight kelts were being reconditioned at the end of 2012, the first year of facility operation.

RPA Subaction 42.3 – *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 CTCR through **BPA Project 2007-212-00** (Locally Adapted Okanogan Steelhead Broodstock). A contract to complete the Master Plan (Step 1 of the NPPC's three-step process) is in place through May 2013. The CTCR have agreed to defer contracting for Steps 2 and 3 until FY 2015.

RPA Subaction 42.4 – *For Middle Columbia Steelhead: Fund a program to recondition natural origin kelts in the Yakima River Basin including capital construction, implementation and monitoring and evaluation costs.*

BPA continued to fund this action through **BPA Project 2007-401-00** (Kelt Reconditioning/Reproductive Success). The project collects steelhead kelts from Mid-Columbia DPS populations (e.g., Satus Creek, Toppenish Creek, and Naches River) at Prosser Dam on the Yakima River for reconditioning.

RPA Subaction 42.5 – *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. An ESA consultation package, including a co-manager approved HGMP, has been submitted to NOAA Fisheries. Site-specific application of BMPs will be defined during the ESA consultation, which is expected to be completed in 2013.

RPA Subaction 42.6 – *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.*

HGMPs for the Lostine and Imnaha rivers supplementation programs were submitted to NOAA Fisheries for ESA consultation by the NPT and ODFW in May 2011. After review and discussions with NOAA Fisheries, the HGMPs were finalized in July 2011, and NOAA Fisheries sent “sufficiency” letters to NPT and ODFW stating the documents were sufficient to publish in the Federal Register and begin the consultation process. When consultation is completed by NOAA Fisheries, 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 NOAA Fisheries may complete ESA consultation for this program during the RPA Action 39 ESA consultation process for the Snake River Basin in 2013.

RPA Subaction 42.7 – *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 FCRPS BiOp action. Construction of the Springfield Sockeye Hatchery began in the summer of 2012 and is scheduled to be completed in the spring of 2013. Construction, as well as operation and maintenance of the new hatchery are being funded under **BPA Project 2007-402-00** (Snake River Sockeye Captive Broodstock).

RPA Subaction 42.8 – *For Snake River Sockeye: The Action Agencies will work with appropriate parties to investigate feasibility and potentially develop a plan for ground transport of adult sockeye from LGR Dam to Sawtooth Valley lakes or artificial propagation facilities.*

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

RPA Subaction 42.9 – *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, BPA-funded project implementing this action (**BPA Project 2001-053-00**, Reintroduction of Chum Salmon into Duncan Creek), was merged into **BPA Project 2008-710-00** (Development of an Integrated Strategy for Chum Salmon Restoration in the Tributaries Below Bonneville Dam).

RPA Subaction 42.10 – *For Columbia River Chum: Fund assessment of habitat potential, development of reintroduction strategies, and implementation of pilot supplementation projects in selected Lower Columbia River tributaries below Bonneville Dam.*

BPA continued to fund **BPA Project 2008-710-00** (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. During 2012, WDFW continued ongoing restoration efforts at Duncan Creek and other sites while proceeding through the NPCC’s Three-Step Review process for potential new hatchery supplementation projects in lower Columbia tributaries.

Predation Management Implementation Reports, RPA Actions 43–49

RPA Action No.	Action	Comprehensive Evaluation
Predation Management Strategy 1		
43	Northern Pikeminnow Management Program (NPMP)	Comprehensive Evaluation Report will summarize actions taken.
44	Develop strategies to reduce non-indigenous fish	Comprehensive Evaluation Report will summarize actions taken as a result of the workshop.
Predation Management Strategy 2		
45	Caspian Tern	Comprehensive Evaluation Report will summarize the effects of redistribution of Caspian terns on salmonids in the Columbia River estuary.
46	Double-Crested Cormorant	Comprehensive Evaluation Report will summarize actions taken.
47	Inland Avian Predation	Comprehensive Evaluation Report will summarize actions taken.
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.*

Predation by large northern pikeminnow (*ptychocheilus oregonensis)* is a major source of mortality for juvenile salmonids in the lower Columbia and Snake rivers. BPA has funded research into juvenile salmon fish predation since the early 1980s. That research led to the development of a hypothesis by Rieman and Beamesderfer (1990), who posited that a relatively low annual exploitation rate (10-20 percent) applied to northern pikeminnow populations could in principle result in a reduction of up to 50 percent in total consumption of juvenile salmonids by pikeminnow. Other research estimated that approximately 16.4 million emigrating juvenile salmonids are consumed by pikeminnow annually in the Columbia and Snake rivers (Beamesderfer, 1996). The Northern Pikeminnow Management Program (NPMP) has implemented removal fisheries targeting larger northern pikeminnow for over 20 years with the purpose to reduce numbers of larger pikeminnow to improve survival of outmigrating juvenile salmon.

Biological evaluation of the program has been an important component of the NPMP since its inception. Three primary objectives of ongoing biological evaluation are: 1) evaluate response of pikeminnow to sustained fisheries; 2) check for compensatory predation by smallmouth bass and walleye; and 3) evaluate the effect of the removal program on salmonid predation.

To date, the NPMP has removed over 3.65 million northern pikeminnow from the Columbia River Basin since 1990. Evaluation indicates that, as a result of the program, pikeminnow predation on juvenile salmon has declined 37 percent, saving 3 to 5 million juvenile salmon annually that would otherwise have been consumed by this predator. The 2012 exploitation rate on northern pikeminnow 250mm or larger is estimated at 16.1 percent. Researchers have not found evidence of compensation by other fish predators nor have they found indication that northern pikeminnow are growing faster or becoming more fecund as a result of sustained removals to date. Over 30 peer-reviewed journal articles have been published regarding the NPMP and the results of its biological evaluation.

The overall system wide exploitation rates are listed below. The original program set minimum sizes in the sport reward fishery at 11 inches (equal to or greater than 250mm FL). The ISRP recommended changing the minimum size down one more age class and this change was made in 2000 making the minimum size for reward payments 9 inches (equal to or greater than 200 mm FL). Exploitation rates for fish for both of these minimum sizes are computed from 2000 forward to provide comparison back to the start of the program in 1991.

Table 42. Pikeminnow Sport Reward Fishery Exploitation Rates, 2004 -2012.

Year	Exploitation Rate Fish 9 Inches and Larger	Historic Exploitation Rate Fish 11 Inches and Larger
1991		8.50%
1992		9.30%
1993		6.80%
1994		10.90%
1995		13.40%
1996		12.10%
1997		8.90%
1998		11.10%
1999		12.70%
2000	11.00%	11.90%
2001	15.50%	16.20%
2002	10.60%	12.30%
2003	10.50%	13.00%
2004	17.00%	18.00%
2005	16.30%	19.00%
2006	14.60%	17.10%
2007	15.30%	17.80%
2008	14.80%	19.50%
2009	8.80%	12.80%
2010	15.90%	18.80%
2011	13.50%	15.60%
2012	11.00%	15.90%

Note: Program model is based on John Day study prior to implementation that forecast removal of fish in the 10-20% exploitation range annually could result in a predation savings of as much as 50%.

A component of RPA Action 43 calls for BPA to increase tagging efforts to better evaluate the exploitation rate and resultant biological benefit of targeted pikeminnow removals. The biological evaluation component of the NPMP uses tag recoveries in sponsored fisheries to quantitatively measure the benefit of removals within the year and cumulatively. Tagging numbers have varied over the years, however, and have generally trended upwards. In 2012, a total of 1,676 northern pikeminnow greater than or equal to 250 mm were tagged which more than doubled the previous years' tally. Tagging in the lower Snake River reservoirs has seen the most increase from a low of two fish in 2010 to 187 in 2012.

Table 43. Northern Pikeminnow Tagged in the Columbia and Snake Rivers, 2005–2012.

Reservoir / Reach	2005	2006	2007	2008	2009	2010	2011	2012
Below Bonneville Dam	406	467	205	290	1,003	519	207	412
Bonneville Dam	203	501	120	98	115	72	136	293
The Dalles Dam	31	48	31	38	38	12	24	213
John Day Dam	21	41	18	44	28	17	10	17
McNary Dam[A]	148	105	133	241	225	83	150	536
Little Goose Dam	—	125	12	163	226	37	90	20
Lower Granite Dam	92	44	56	131	168	2	65	187
Total	901	1,331	575	1,005	1,803	742	682	1,678

[A] McNary Dam also includes the Hanford Reach

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.*

The Action Agencies have funded two studies to address this RPA and the resultant prioritized non-native fish predation issues resulting from a series of workshops that began in 2009. The first study objective was to evaluate the physiological condition of smallmouth bass, walleye, and channel catfish as they enter 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. The purpose of the forebay and tailrace study was to describe and compare the relative density and diet of smallmouth bass between sites perceived to be "hot spots" and other nearby sites.

The expanding population of American shad *(Alosa sapidissima)* in the middle Columbia River —out-migrating juveniles provide a high energy food available in the summer and fall—may be contributing to the increased growth and enhanced condition of nonnative piscivores. To test this hypothesis, researchers quantified the late summer and autumn diets of smallmouth bass (*Micropterus dolomieu)*, walleyes (*Sander vitreus)*, and channel catfish (*Ictalurus punctatus)* in the three lowermost reservoirs on the Columbia River (Bonneville, The Dalles and John Day). Only smallmouth bass and walleye consumed relevant amounts (up to 27 percent by mass for walleye) of American shad. However the influence of this diet item on their condition was not discernible because these fish showed only slight increases in condition indices that did not always correspond to a dietary shift that included an increase in shad consumption, and could not discount the importance of other prey items. Research to date does not support the management option of reducing the number of exotic shad in the Columbia Basin; however results should be useful for future discussions regarding predation and shad management in the Columbia River.

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, and NOAA Fisheries completed the BiOp for the proposed action on February 16, 2006. In 2008, the Corps began the implementation of the CTMP with the construction of a one-acre island in Fern Ridge Reservoir.

In the FCRPS BiOp, three islands were proposed for construction in San Francisco Bay. Difficulties in obtaining the necessary property interest and environmental and legal clearances rendered those projects infeasible. Through adaptive management, and after consultation with NOAA Fisheries, USFWS, and other parties, the Corps constructed islands at alternative locations, as shown in Table 44. This allowed a continuing reduction in the amount of nesting habitat made available at East Sand Island. Implementation of the management plan continued in 2012 with completion of a 1.0 acre island in Malheur Lake. This additional island allowed a further reduction of the acreage available for nesting on East Sand Island to 1.5 acres.

The Corps continues to pursue construction of an additional island in San Francisco Bay. That island, if construction becomes possible, would allow reduction of available nesting area on East Sand Island to the minimum of 1.0 acre.

Information on tern abundance and fish consumption in the estuary is contained under RPA Action 66.

Table 44. Status of Artificial Caspian Tern Nesting Islands 2006 – 2012. First six entries (i.e., thru Don Edwards NWR) were listed in the 2007 BA and FCRPS BiOp.

Location	Size (acres)	Completion Date Proposed in BA	Project Completed	Acres Available during Nesting Season				
				2008	2009	2010	2011	2012
Fern Ridge (OR)	1.0	2007 / 2008	February 2008	1.0	1.0	1.0	1.0	1.0
East Link Unit, Summer Lake Wildlife Area (OR)	0.5	2008	December 2008	-	0.5	0.5	0.5	0.5
Crump Lake (OR)	1.0	2009	March 2008	1.0	1.0	1.0	1.0	1.0
Brooks Island (SF Bay)	2.0	2008 / 2009	Not Constructed	-	-	-	-	-
Hayward Regional Shoreline (SF Bay)	0.5	2008 / 2009	Not Constructed	-	-	-	-	-
Don Edwards NWR (SF Bay)	0.5 – 1.0	2009	Not Constructed	-	-	-	-	-
Dutchy Lake, Summer Lake Wildlife Area (OR)	0.5	-	February 2009	-	0.5	0.5	0.5	0.5
Sump 1B, Tule Lake NWR (CA)	2.0	-	August 2009	-	-	0	2.0	2.0
Gold Dike Unit - Summer	0.5	-	September	-	-	0	0	0.5

Location	Size (acres)	Completion Date Proposed in BA	Project Completed	Acres Available during Nesting Season				
				2008	2009	2010	2011	2012
Lake Wildlife Area (OR)			2009					
Orems Unit, Lower Klamath NWR (CA)	1.0	-	September 2009	-	-	0	1.0*	1.0
Sheepy Lake, Lower Klamath NWR (CA)	0.8	-	February 2010	-	-	0.8	0.8	0.8
Malheur Lake	1.0	-	March 2012	-	-	-	-	1.0
Hayward (SF Bay)				-	-	-	-	-
Total Acres of Replacement Habitat Available	**-**	**-**	**-**	**2.0**	**3.0**	**3.8**	**6.8**	**8.3**
Total Acres Made Available on East Sand Island	**-**	**-**	**-**	**5.0**	**3.5**	**3.1**	**2.0**	**1.5**

* For some, but not all of the 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 was planned for 2012. This information will be utilized in developing the cormorant management plan.

In 2012, the Corps determined that implementation of an effective cormorant management plan would require preparation of an Environmental Impact Statement (EIS) and began the initial steps in preparing that document. Notice of the EIS was published in the Federal Register, and in November, several public scoping meetings were held. The expected date of release for the draft EIS is August 2013.

The EIS process will lead to a Record of Decision, scheduled for 2014, documenting the actions to be taken to reduce predation on juvenile salmonids from double-crested cormorants in the Columbia River estuary. Implementation of actions is expected to begin in 2015.

Alternatives under consideration in the EIS are:

- No action;
- Non-lethal management program to achieve juvenile salmonid survival improvement targets;
- Integrated management program with non-lethal and lethal methods to achieve juvenile salmonid survival improvement targets;
- Integrated management program with non-lethal and lethal methods to completely eliminate double-crested cormorant predation in the Columbia River estuary.

The Corps will select a preferred alternative that provides the maximum achievable benefit for improving the survival of juvenile salmonids and is compliant with the Migratory Bird Treaty Act, ensuring USFWS's conservation goals for double-crested cormorants in the region are met.

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.*

The Action Agencies begun development of an Inland Avian Predation Management Plan (IAPMP) in 2008 to address avian predation on the Columbia Plateau based ongoing RME efforts since 2004. The Action Agencies expect to complete the IAPMP in 2013 with recommendations where reductions in predation appear most warranted. It is anticipated that implementation of IAPMP recommended predation reduction measures will begin prior to the 2014 nesting season, depending on the final array of actions to be determined to be warranted for implementation. The IAPMP covers the FCRPS portion of the Columbia River Basin upstream of Bonneville Dam (i.e., the Columbia Plateau) and within the foraging range of piscivorous waterbirds (i.e., 80 km of the mainstem Columbia and Snake Rivers) whereas management plans associated with RPA Actions 45 and 46 address management by piscivorous avian predators downstream of Bonneville Dam (i.e., in the Columbia River estuary). Subsequent to discussions with NOAA Fisheries and other regional partners, it was decided in 2011 that the IAPMP would focus on management of Action Agency-owned land away from areas of direct influence by the Corps FCRPS hydropower projects. Management of avian predators around Corps FCRPS hydropower projects will be managed in coordination with FPOM and included in the FPP as called for in RPA Action 48, independently of the IAPMP. See RPA Action 68 for a summary of the RME conducted for development of this plan. Additional references to avian predation research on the Columbia Plateau are made in RPA Actions 48 and 52.

To determine baseline conditions for development of an IAPMP as part of previous BiOp requirements, RME activities were initiated in earnest in 2004 on the Columbia Plateau. Beginning in 2008, meetings, workshops and discussions have been regularly held with the Action Agencies, NOAA Fisheries, USFWS, and other interested regional partners on project approach and scope for plan development. In 2009, a programmatic framework document was completed to provide overall guidance on the completion of the IAPMP. The Action Agencies, with input from an Inland Avian Predation Work Group (IAPWG), have continued to develop the IAPMP through 2012 including further research and analyses necessary for completion of the plan. This includes synthesis of available research (Lyons et al., 2011a) and a 'Benefits Analysis' (Lyons, et al., 2011b) to assist in determining where potential management actions are most warranted based on currently available data. The results of these analyses indicate the greatest potential benefit from reductions in predation by piscivorous waterbirds from a single colony in the Columbia Plateau region was for upper Columbia River steelhead when predation by Caspian terns nesting on Goose Island (Potholes Reservoir near Othello, WA) is reduced. The next greatest potential benefit to Columbia River and Snake River ESU's from reductions in predation by a single colony in the Columbia Plateau region could be achieved by reductions in predation from the Crescent Island (near Pasco, WA) Caspian tern colony. Potential benefits for Snake River ESUs are lower, in part because significant portions of those ESUs are transported around the largest waterbird colonies on the Columbia Plateau and thus inaccessible to avian predators in the Columbia Plateau region. Cumulative potential benefits for eliminating predation by birds nesting at the five largest Columbia Plateau nesting colonies considered in the 'Benefits Analysis' were generally comparable to estimates of benefits from dispersing approximately two-thirds of the large Caspian tern colony in the Columbia River estuary. Cumulative benefits are potentially greater, however, for upper Columbia River steelhead from eliminating predation by birds nesting at the five Columbia Plateau colonies. Reductions in avian predation could result in increases in salmonid population growth rates, particularly for upper Columbia River and Snake River steelhead populations. See RPA Action 68 for further discussion of RME completed in support of the IAPMP.

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.*

The Corps conducts regular hazing activities and maintenance of bird abatement structures at its lower Columbia and Snake river FCRPS hydropower facilities. This program is coordinated through the FPOM and carried out in accordance with the annual FPP (*http://www.nwd-wc.usace.army.mil/tmt/documents/fpp*).

In an attempt to reduce the impact of avian predators on outmigrating juvenile salmonids, a variety of methods have been employed including passive deterrents such as avian line arrays covering tailrace areas of the dams, and active deterrents such as hazing with pyrotechnics, high power water sprinklers, and propane cannons. During 2006–2008, project biologists documented an increase in the number of gulls feeding at John Day and The Dalles dams. Evaluations of the effectiveness of the deterrents (Zorich et al., 2010) led to a complete rebuild of the John Day Dam avian line array in 2010, and additions to The Dalles Dam array in 2011. The Corps' Fish Field Unit conducted two years of post-construction monitoring at John Day Dam and one year of post-construction monitoring at The Dalles Dam to assess whether the new wire array structures are providing adequate protection. (Zorich et al., 2011 and 2012). The 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. In 2009 and 2010, lethal take was permitted for gut analysis purposes. The results showed juvenile salmonids, including listed stocks, dominated the diets of gulls foraging downstream of these dams.

Results of the three years of evaluation indicated that a combination of hazing from boats and improved avian line arrays appeared successful in dissuading avian predators from both projects. At John Day Dam, estimated fish consumption decreased after the completion of a larger avian line array and implementation of boat hazing, from 108,000 to 38,000, to 6,000 (2009, 2010, and 2011, respectively). At The Dalles Dam, estimated fish consumption also decreased from 86,000 to 16,000 (2010 to 2011). These numbers represent total fish consumption rather than salmonid fish consumption, as lethal take for diet analysis was not permitted in 2011. 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.

Since bird hazing method and intensity was greatly increased from 2009 to 2010 at John Day Dam (the addition of boat hazing most daylight hours) and the avian line array completed, the FFU expected a reduction in fish consumption at this site. However, hazing method and intensity were similar between 2010 and 2011, and yet the FFU saw the greatest reduction in fish consumption between these years. As the deterrent effort was similar in 2010 and 2011, the FFU attributed the decreases in fish consumption to natural variation in the number of foraging gulls and not to level of deterrent effort. The reduction in gulls and consumption may have been due to the unusually high runoff and river level. The FFU speculated that prey would be difficult to see due to high turbidity and high water velocity, but the near-dam environment was also changed. For example, at The Dalles Dam in 2010, hundreds of gulls loafed on downstream basalt islands and made forays to the dam or to the nearby Wasco County landfill. In 2011, high river levels kept these loafing islands covered with water for most of the spring outmigration. This may have contributed to the reduction of gulls in the area and thus the reduction of fish consumed. Regardless, the management objective of reducing avian predation was achieved in both 2010 and 2011 at John Day Dam. As well, in 2011 avian predation was reduced at The Dalles Dam, aided by the expansion of the spillway avian lines and continuation of boat hazing.

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 recent years, California sea lions, which are protected under the Marine Mammal Protection Act (MMPA), have been observed swimming more than 140 miles up the Columbia River to Bonneville Dam to prey on adult Chinook salmon, steelhead, and white sturgeon and Pacific Lamprey. California sea lions generally arrive from mid- to late February and leave by the first week in June, these male sea lions eat to gain weight in preparation for the summer mating season. Steller sea lions arrive at Bonneville as early as September and depart by late May.

In 2008-2012, the Corps implemented and evaluated a variety of sea lion deterrents, from physical barriers to non-lethal harassment. Since 2006, the Corps has contracted with the USDA Wildlife Services to harass sea lions away from fishways and other dam structures. Dam-based harassment by USDA agents began each year in early March and was conducted daily through the end of May. Harassment involved a combination of acoustic, visual, and tactile non-lethal deterrents, including above-water pyrotechnics (cracker shells, screamer shells, and rockets), rubber bullets, rubber buckshot, and beanbags. In general, dam-based harassment appears to temporarily alter the behavior of some sea lions, but does not prevent continued predation by habituated pinnipeds.

Since 2006, sea lion exclusion devices (SLEDs) have been installed annually at Bonneville Dam's 12 primary fishway entrances to prevent sea lions from entering the fishways. The SLEDs feature 15.38-inch (39.05-centimeter) gaps that are designed to allow fish passage. The floating orifice gates at PH2 are also equipped with similar barriers. These exclusion devices have proven effective at keeping sea lions out of the fishways.

From 2006 through 2010, the Corps also evaluated the effectiveness of acoustic devices at deterring sea lion predation on salmon near fishways. The acoustic devices, which emit a 205-decibel sound in the 15-kilohertz range, were installed underwater near primary fishway entrances and operated annually. They proved ineffective at deterring sea lions and were removed before the 2011 season.

From 2008 through 2012, the Action Agencies supported boat-based harassment conducted by CRITFC, ODFW, and WDFW. Boat-based harassment occurred annually from March through May. Boats operated from the Bonneville Dam tailrace at RM 146 downstream to navigation marker 85 (RM 139). The Corps granted boats access to the Bonneville Dam boat restricted zone (BRZ) 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 PH2 CC and smolt monitoring facility. Boat crews ceased use of seal bombs inside the BRZ 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.

The abundance of pinnipeds at Bonneville Dam, their consumption of salmonids, and the effectiveness of harassment efforts are discussed in more detail in the coverage of RPA action 69, below.

RME Implementation Reports, RPA Actions 50–73

RPA Action No.	Action	Comprehensive Evaluation
RME Strategy 1		
50	Fish Population Status Monitoring	The evaluation of fish population status information will be included.
51	Collaboration Regarding Fish Population Status Monitoring	Progress on collaboration will be reported.
RME Strategy 2		
52	Monitor and Evaluate Fish Performance within the FCRPS	The evaluation will include information from these actions.
53	Monitor and Evaluate Migration Characteristics and River Condition	The evaluation will include information from these actions.
54	Monitor and Evaluate Effects of Configuration and Operation Actions	The evaluation will include information from these actions.
55	Investigate Hydro Critical Uncertainties and Investigate New Technologies	The evaluation will include information from these actions.
RME Strategy 3		
56	Monitor and Evaluate Tributary Habitat Conditions and Limiting Factors	The evaluation will include information from these actions.
57	Evaluate the Effectiveness of Tributary Habitat Actions	The evaluation will include information from these actions.
RME Strategy 4		
58	Monitor and Evaluate Fish Performance in the Estuary and Plume	The evaluation will include information from these actions.
59	Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions	The evaluation will include information from these actions.
60	Monitor and Evaluate Habitat Actions in the Estuary	The evaluation will include information from these actions.
61	Investigate Estuary/Ocean Critical Uncertainties	The evaluation will include information from these actions.
RME Strategy 5		
62	Fund Selected Harvest Investigations	The evaluation will include information from these actions.
RME Strategy 6		

RPA Action No.	Action	Comprehensive Evaluation
63	Monitor Hatchery Effectiveness	The evaluation will include information from these actions.
64	Investigate Hatchery Critical Uncertainties	The evaluation will include information from these actions.
65	Investigate Hatchery Critical Uncertainties	
RME Strategy 7		
66	Monitor and Evaluate the Caspian Tern Population in the Columbia River Estuary	The evaluation will include information from these actions.
67	Monitor and Evaluate the Double-Crested Cormorant Population in the Columbia River Estuary	The evaluation will include information from these actions.
68	Monitor and Evaluate Inland Avian Predators	The evaluation will include information from these actions.
69	Monitoring Related to Marine Mammal Predation	The evaluation will include information from these actions.
70	Monitoring Related to Piscivorous (Fish) Predation	The evaluation will include information from these actions.
RME Strategy 8		
71	Coordination	The evaluation will include a report on coordination efforts, projects and associated products and how the Action Agencies have incorporated those products into their RME and data management projects.
72	Data Management	The evaluation will include a report on data management projects.
RME Strategy 9		
73	Implementation and Compliance Monitoring	The Action Agencies will use the project level detail contained in the Action Agencies' BiOp databases to track results and assess our progress in meeting programmatic level performance targets. This performance tracking will be reported through APRs 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).*
2. *Monitor adult returns at mainstem hydroelectric dams using both visual counts and the PIT-tag detection system (see Hydrosystem section). (Annually).*
3. *Monitor juvenile fish migrations at mainstem hydroelectric dams using smolt monitoring and the PIT-tag detection system (see Hydrosystem section). (Annually).*
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).*
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).*
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).*
7. *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).*
8. *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).*
9. *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).*
10. *Report available information on population viability metrics in annual and comprehensive evaluation reports. (Initiate in FY 2008).*

RPA Subaction 50.1 – *Implement and maintain the Columbia River Basin passive integrated transponder (PIT)-Tag Information System.*

To implement this RPA subaction, the AA's and NOAA will support further development of the PIT-Tag Information System (PTAGIS) information system to manage PIT-tag data and associated metadata, and to manage and display locations of PIT-tag arrays and hand held readers, as well as other operational information. The PTAGIS system provides supporting data used for abundance and survival status and trend assessments for both adult and juvenile salmonids.

Major Accomplishments and Findings

BPA funded the following two projects to support the implementation and maintenance of the Columbia River Basin passive integrated transponder PTAGIS.

BPA Project 1990-080-00 (Columbia Basin Pit-Tag Information): The PTAGIS is operated and maintained at *http://www.ptagis.org/ptagis*. The existing PTAGIS database was revised and expanded for more user friendly data entry, to document metadata about tagged fish and to include information from interrogation systems that are being installed in tributaries. Today, PIT-tags managed in PTAGIS under the Columbia River Basin PIT-Tag Information project (1990-080-00) are primarily used for hydro system and tributary survival assessments, as well as tributary assessments of population adult return abundance and diversity to help assess viable salmon population (VSP) attributes of spawner abundance, adult productivity, spatial distribution, and diversity. In 2011, it was upgraded to facilitate data entry into and retrieval from the system and further support tributary PIT-tag assessments. Figures 48 and 49 show updates to interrogation network and mark and release sites since 2008.

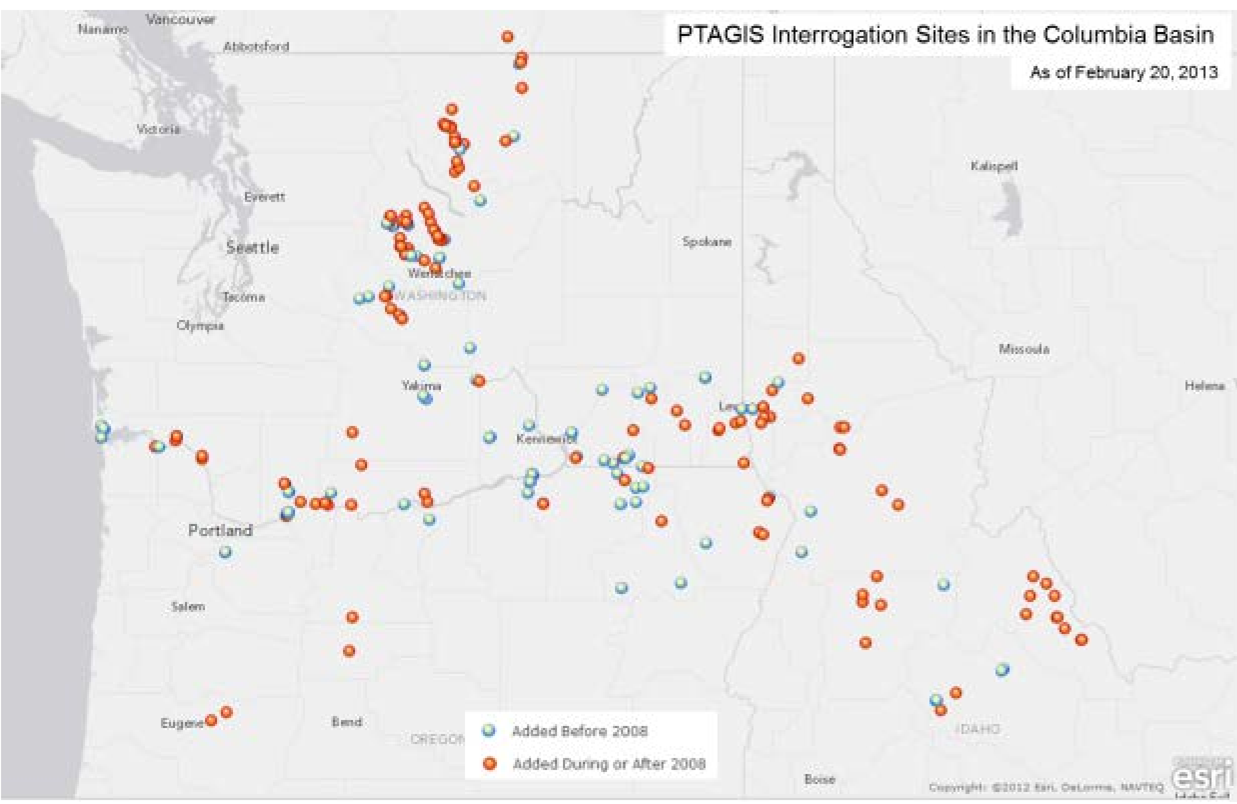


Figure 48. PTAGIS Interrogation Sites in the Columbia River Basin as of February 20, 2013.

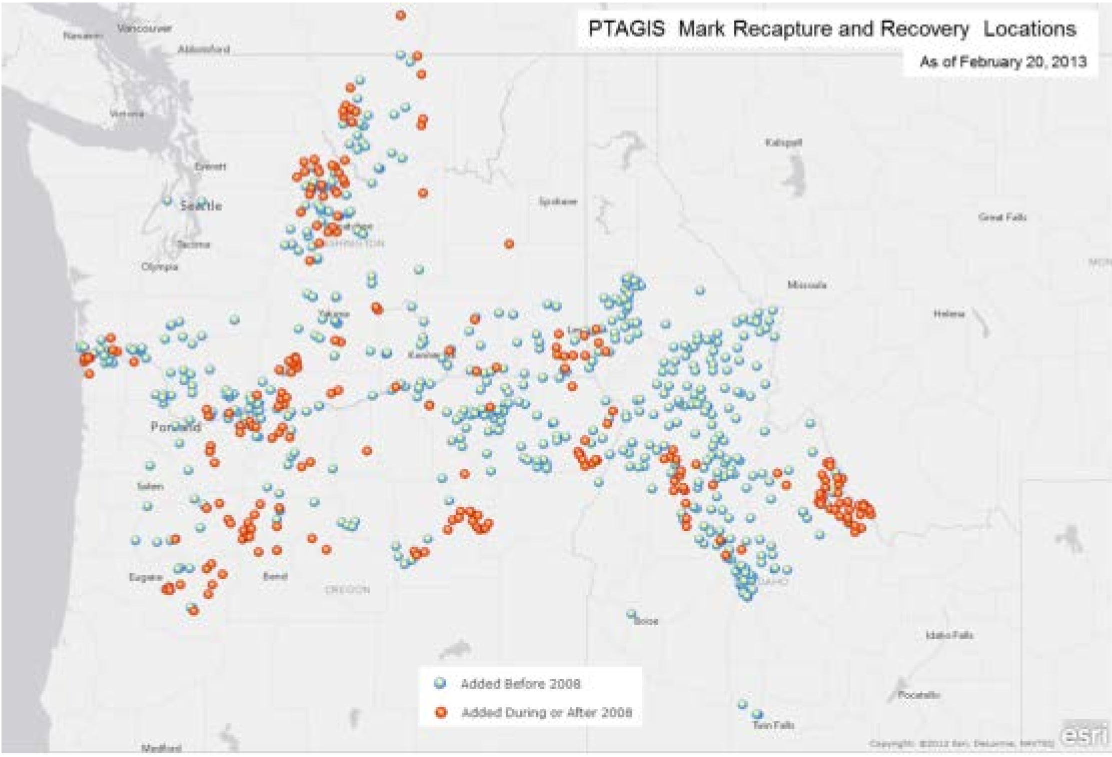


Figure 49. PTAGIS Mark Recapture and Recovery Locations as of February 20, 2013.

Today PTAGIS stores information for the detection of over 2.8 million marked fish and their detections each year. Figure 50. Represents example data from PIT-tagged fish from the Columbia Basin; this includes listed and non-listed fish from the interior as well as Willamette and lower Columbia ESU/DPSs.

BPA Project 2003-017-00 (ISEMP): This collaboration between the ISEMP project and Columbia River Basin PIT-Tag Information project supported rapid reduction of PIT-Tag data to support assessment of adult returns. Figure 50 provides an example of data synthesized for steelhead escapement, which is further discussed under RPA Subaction 50.5.

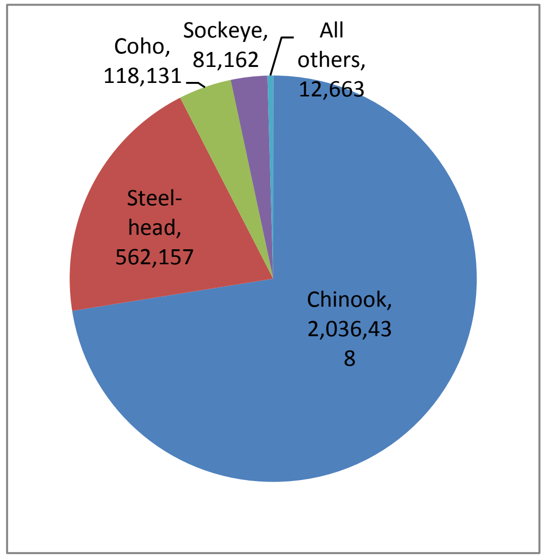


Figure 50. PIT-tags by Species in 2011 and 2012. Source: PTAGIS.

Run-Year	MPG	Population	Subpopulation	PIT Tag Decomposition: Fraction Sampled[1]	PIT Tag Decomposition: Escapement	PIT Tag Decomposition: CV	PIT Tag Decomposition: 95% CI	Independent Estimate: Escapement	Independent Estimate: CV	Independent Estimate: 95% CI
2009-2010	Lower Salmon	Asotin Creek[2]		95%	1,687	8.5%	± 280	1,500	N/A	N/A
2009-2010	Salmon River	South Fork		90%	1,497	9.1%	± 268			
2009-2010		Secesh		100%	298	22.1%	± 129			
2009-2010		Middle Fork	Big Creek	100%	753	21.8%	± 322			
2009-2010		Upper Salmon	Valley Creek	100%	237	17.7%	± 82			
2009-2010		Upper Salmon	Pahsimeroi River[2]	100%	138	22.9%	± 62	115	N/A	N/A
2009-2010		Lemhi River		95%	630	14.2%	± 175			
2009-2010		Little Salmon	Rapid River[2]	95%	136	24.0%	± 64	150	Census	Cen-sus
2009-2010	Clearwater River	Lochsa River	Fish Creek[2]	100%	246	58.1%	± 117	205		164-255
2010-2011	Lower Salmon	Asotin Creek[2]		95%	890	10.0%	± 175	1,128	2.0%	± 44
2010-2011	Grande Ronde	Joseph Creek[3]		100%	1,627	1.4%	± 45	1,698	22.4%	± 744
2010-2011	Imnaha River	Imnaha River		100%	3,298	1.5%	± 97			
2010-2011		Imnaha River	Cow Creek	100%	147	1.4%	± 4			
2010-2011		Imnaha River	Big Sheep Creek	100%	765	2.2%	± 33			
2010-2011	Salmon River	South Fork		90%	2,540	1.9%	± 93			
2010-2011		Secesh		100%	397	3.1%	± 24			
2010-2011		Middle Fork	Big Creek	100%	687	1.6%	± 22			
2010-2011		Upper Salmon	Valley Creek	100%	232	1.5%	± 7			
2010-2011		Lemhi River		95%	428	1.7%	± 14			

[1]Fraction sampled refers to the fraction of spawning believed to occur above PIT tag arrays.
[2]Weirs that capture and enumerate steelhead and use handheld wands to identify PIT tags, but do not have PIT tag arrays.
[3]Locations with weirs that capture and enumerate steelhead and use handheld wands to identify PIT tags and also have neighboring PIT tag arrays.
[4]Independent estimate generated from a video weir paired with a single PIT tag array.

Figure 51. Steelhead Run Year, MPG Population, Subpopulation Fraction of Population Sampled, Escapement Estimate, Coefficient Variation (CV), and Independent Estimate (if Available) Monitored ISEMP PIT-tag Arrays in the Snake River Basin. Shaded rows identify opportunistic independent estimates of escapement, primarily comprising locations where PIT-tag wands are utilized to interrogate PIT-tags.

In the Tributaries, ISEMP was the lead in development of infrastructure and software programs that integrate with the PTAGIS system to support tributary assessments for juvenile and adult abundance. ISEMP relied heavily on juvenile and adult PIT-tagging and interrogation at instream PIT-tag detection sites (IPTDS). The development of IPTDS technology represents a significant advancement with regard to the estimation of juvenile and adult distribution, abundance, and survival. Given the relationship between IPTDS site reliability and data quality, ISEMP developed a real-time monitoring system to alert site stewards to site malfunctions. Conditions at each IPTDS are monitored in real time on an hourly basis using Loggernet Software from Campbell Scientific, Ltd. The software allows a site data steward to visually monitor sites using a web interface. This interface allows the data steward to determine whether a site is functioning and if any alerts are present. Real-time monitoring and the documentation of operational metadata to support PIT-tag assessments of the network is managed on the web and portrayed in Figure 52 and Figure 53. Additional information may be found on ISEMP's role in improving PIT-Tag interrogation system assessments under RPA Action 72.

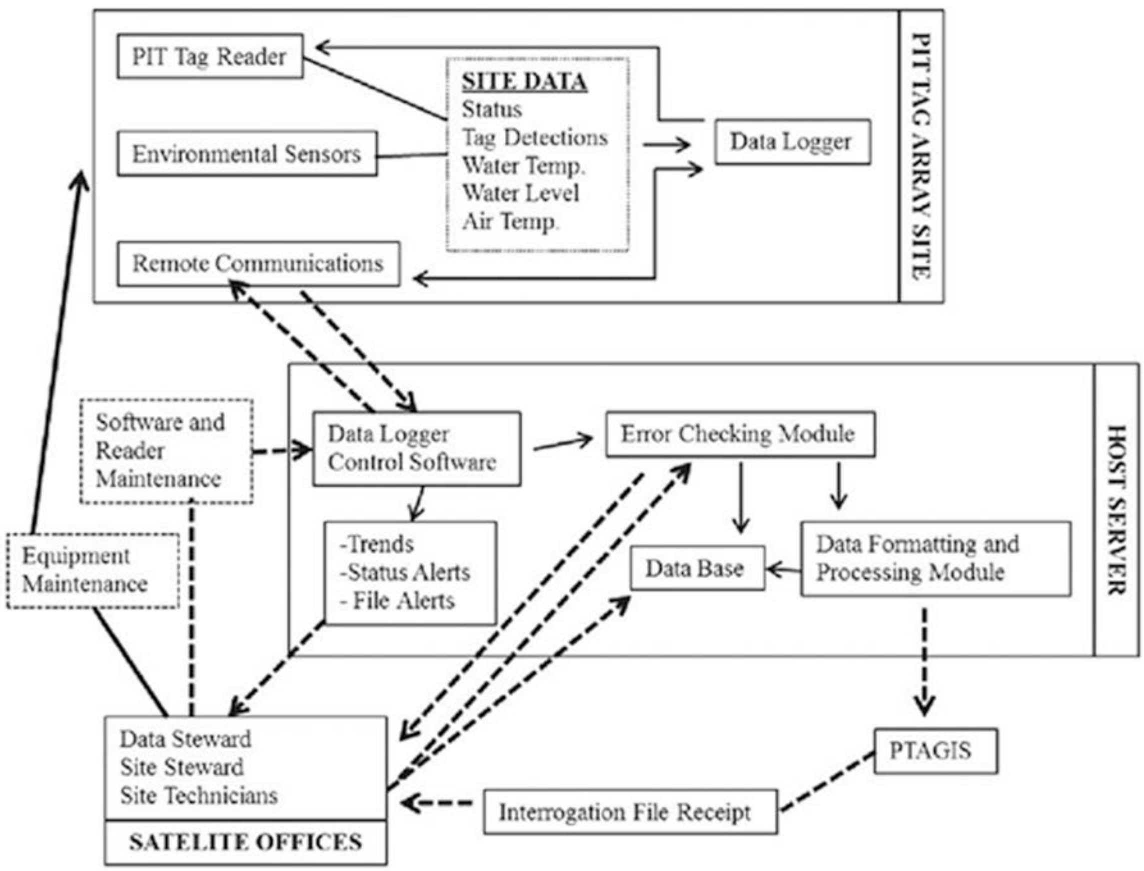


Figure 52. ISEMP Instream PIT-Tag Detection Site Data Management System.

Figure 53. Example of Instream PIT-tag Detection Site Environmental Condition, Functions, and Diagnostic Data from the IPTDS.

- Advances in the PTAGIS system and in stream PIT-tag detection arrays in tributaries may provide opportunity to improve real time Agency management to maximize tributary harvest of hatchery fish.

RPA Subaction 50.2 – *Monitor adult returns at mainstem hydroelectric dams using both visual counts and the PIT-tag detection system.*

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

Major Accomplishments and Findings

BPA Project 2005-002-00 (Lower Granite Dam Adult Trap Operations): This collection and sampling of adult salmonids at Lower Granite Dam is an integral component of many studies. The demands on use of the Lower Granite Dam adult trap have increased in recent years and are expected to continue to increase. Current uses of the adult trap include: fall Chinook broodstock collection; run-reconstruction sampling; sampling of PIT-tagged fish from transportation studies to determine life history type (reservoir- or ocean-type migrant) for fish with known passage histories (i.e., transported, bypassed as a subyearling, bypassed as a yearling, or never detected); radio telemetry studies (both tagging and tag removal at the adult trap); PIT-tagging of wild adult steelhead and wild adult Chinook (in combination with in-stream PIT detection arrays) for population status monitoring; and the application of genetic stock identification (GSI) to estimate the population characteristics of naturally produced steelhead and Chinook salmon.

The Corps implemented its adult fish count program as specified in the annual FPP and as described under RPA Subaction 52.8 below. Information on adult fishway improvements are discussed under RPA Action 28 above.

The Corps selected The Dalles Dam for installation of an adult PIT-Tag detection system. Installation of a temporary system is scheduled for 2013 with a permanent system scheduled for 2015.

Major Lessons Learned

Major lessons learned relative to mitigation action implementation

- An increasing trend in adult abundance has been observed in several years at FCRPS dams (see Sec 1 Fish Status and Environmental Conditions).

Upstream survival has been lower in recent years (2009-2011). An active-tag study is planned to help understand this issue in some areas. Some potential issues include adult impacts associated with high juvenile spill, unaccounted harvest, and/or predation from pinnipeds.

Major Lessons Learned Relative to RME Implementation

The proposed installation of PIT-tag detectors at The Dalles Dam will improve spatial coverage for returning adults, thus enabling more thorough analysis of adult loss in the FCRPS.

RPA Subaction 50.3 – *Monitor juvenile fish migrations at mainstem hydroelectric dams using smolt monitoring and the PIT-tag detection system (see Hydrosystem section). (Annually).*

See also related RPA subactions 52.1 and 52.3.

Major Accomplishments and Findings

BPA Project 1987-127-00 (Smolt Monitoring Program) is a long-term effort involving multiple agencies to gather data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects. Data can be used to support in-season decisions on hydro project operations, and is collected by the FPC in a queryable database (*http://www.fpc.org/smolt/SMP_queries.html*). The Smolt Monitoring Program (SMP) has documented annual flow rates, reservoir water supplies, and operations at FCRPS hydropower and flood control dams, including spill management and Dworshak Dam operations for temperature regulation.

For **BPA Project 1989-107-00** (Statistical Support for Salmon), the Columbia Basin Research has developed statistical software (including SURPH, PitPro, Sample Size, ATLAS, USER, and TribPit) for estimating life history parameters and survival rates from PIT-tag, radio tag, acoustic tag and balloon tag studies. The project has provided guidance and technical assistance in mark-recapture study design and data analysis to multiple tribal, state, and federal agencies.

Several projects conducted additional tagging of hatchery populations to improve the resolution of watershed estimates of juvenile hydrosystem survival. **BPA Project 2007-083-00** (Grande Ronde Supplementation Monitoring and Evaluation (M&E) on Catherine Creek/upper Grande Ronde River), the Umatilla Tribe provided additional spring Chinook tag groups in the upper Grande Ronde River and Catherine Creek. **BPA Project 1990-055-00** (Idaho Steelhead Monitoring and Evaluation Studies (ISMES)), tagged additional wild steelhead populations in the Clearwater River and upper reaches of the Snake River. **BPA Project 2008-311-00** (Natural Production Management and Monitoring) in Idaho tagged additional steelhead and spring Chinook in the Warm Springs River and Shitike Creek. Wild and hatchery origin fall Chinook were tagged under **BPA Project 1991-029-00** (RME of emerging issues and measures to recover the Snake River fall Chinook salmon ESU), with a special focus on investigating passage timing of the ‘reservoir-type’ yearling life history type and the ‘ocean-type’ subyearling migrants observed among fall Chinook above Lower Granite Dam.

Major Lessons Learned

Major Lessons Learned Relative to Mitigation Action Implementation

- One observation was that peak migration timing of yearling Chinook and steelhead was often associated with the start of the spring freshet. Large hatchery releases of fall Chinook above Lower Granite Dam often numerically dominated the smolt index, and their timing has trended earlier in recent years.
- All species have experienced a faster mean rate of travel in the past five years. Wild fall Chinook passage had a later median passage date than observed among hatchery origin subyearlings, and the distribution of wild smolt passage extended over a longer timeframe.
- Survival rates since 2008 of wild and hatchery Chinook originating above Lower Granite Dam remained near the 13 year average. Wild and hatchery steelhead experienced higher mean survival between 2008-2012 outmigrations than during the period from 1999-2008. Sockeye survival rates have the greatest interannual variance in in-river survival among the monitored species.

Major Lessons Learned Relative to RME Implementation

There are numerous projects that PIT-tag juvenile salmonids for a variety of purposes. These include both wild and hatchery populations of ESA-listed species. A number of agencies have noted that the scale of the tagging effort on wild fish is of concern. A key issue involves the tradeoff between the value of the monitoring information and the extent of mortality and risk associated with the capture and tagging of wild depressed stocks. This topic is explored more fully in the PIT-Tag Status Report prescribed under RPA Subaction 52.6. NOAA has yet to establish criteria regarding the acceptable levels of tagging for ESA-listed populations. Depending on their assessment, the scale of the tagging effort could change.

RPA Subaction 50.4 – *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.*

The strategy to address Subaction 50.4 is to continue monitoring fish-in and fish-out within the pilot basins using robust monitoring techniques and designs. This monitoring will be coordinated with The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and the regional Coordinated Assessments process for sharing fish population indicator data.

Major Accomplishments and Findings

The following projects have been implemented to support RPA Subaction 50.4.

BPA Project 1987-127-00 (Smolt Monitoring by Non-Federal Entities): This project supports this RPA through tagging of fish which are used and assessed primarily in the ISEMP project. The SMP provides data on movement of salmonid smolts out of major drainages and past the series of dams on the Snake and Columbia rivers. Indices of migration strength and migration timing are provided for the run-at-large at key monitoring sites. In addition, marked smolts from hatcheries, traps, and dams provide measures of smolt speed and in-river survival through key reaches. Fish quality, descaling, and gas bubble trauma measures are collected at the monitoring sites to provide an indicator of health of the run. These data are used for in-season operational decisions relative to flow and spill management, particularly during periods when spill is being provided to improve smolt passage at dams.

BPA Project 1991-073-00 (Idaho Natural Production Monitoring and Evaluation (INPMEP)): This project monitors and evaluates the status of wild Snake River spring-summer Chinook salmon and summer steelhead populations in the Salmon and Clearwater river subbasins, including the Lemhi and South Fork Salmon rivers. The INPMEP is a long-term study that originated in the 1980s to determine effectiveness of habitat mitigation for steelhead and spring/summer Chinook in Idaho. This project assesses population characteristics, survival, and productivity. Most of the information collected is acquired during Chinook salmon spawning ground surveys, which typically includes both redd and carcass surveys. This information is used to estimate the productivity of each population. Tissue samples obtained from carcasses also contribute to the GSI baseline used to estimate the proportions of returning adults by population for harvest management and abundance monitoring.

Based on age assignments of adults obtained from scale analysis at Lower Granite Dam and estimates of emigrating wild Chinook salmon smolts at Lower Granite Dam, researchers estimate the aggregate smolt-to-adult survival rate for wild Chinook salmon.

Steelhead adult abundance and productivity in Idaho are monitored by the ISMES project; however, INPMEP continues to monitor the spatial structure and density of juvenile steelhead and Chinook salmon during snorkel surveys. The General Parr Monitoring (GPM) program has monitored the abundance and distribution of anadromous and resident salmonids since 1985. A large proportion of Idaho's steelhead and Chinook salmon habitat is located within congressionally designated wilderness areas, and the GPM dataset is the best description of juvenile salmonid spatial structure and density in Idaho. Spring snowmelt runoff precludes the use of redd surveys for steelhead in Idaho. As a result, GPM data are particularly important for monitoring the spatial structure and juvenile-to-juvenile productivity of steelhead populations.

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

Juvenile outmigrant assessments are presented in Figure 54, and Steelhead escapement estimates are presented in Figure 55.

Brood Year	Escapement	95% CI		Out-migrant Estimate	95% CI		Out-migrants / Spawner	95% CI	
2008	769	0	1,675	25,859[a]	20,748	33,012	34[a]	12	-
2009	2,114	1,326	2,901	14,663[b]	9,642	23,194	7[b]	3	17
2010	1,820	1,040	2,598	Currently Incomplete					

[a] Preliminary estimate possible age 4 smolts not included.
[b] Preliminary estimate age-3 and age 4 smolts not included.

Figure 54. Juvenile Outmigrant Assessments in the John Day River Basin.

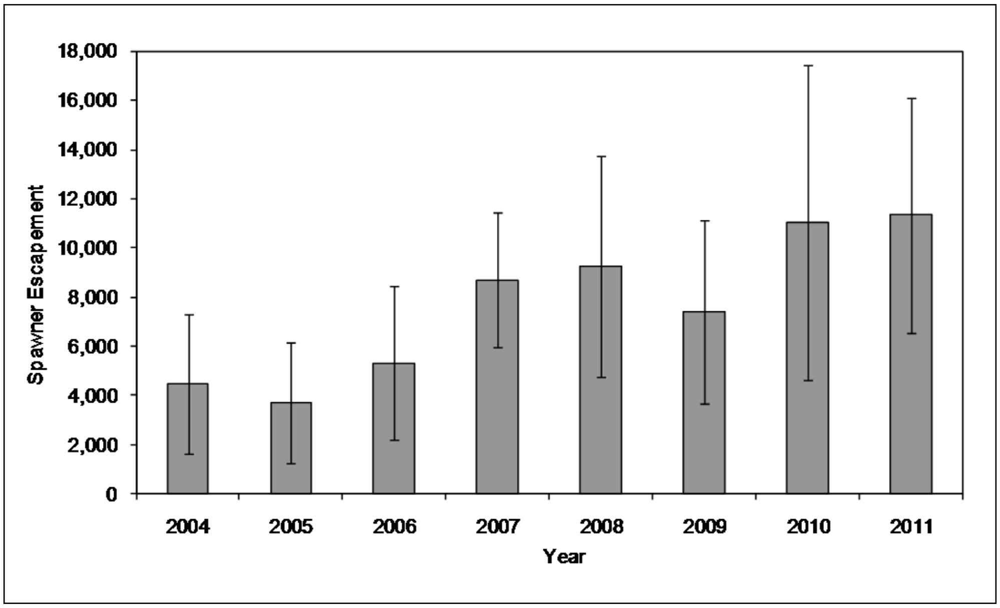


Figure 55. Steelhead Escapement Estimates in the John Day River Basin.

BPA Project 2002-060-00 (Nez Perce Harvest Monitoring on Snake and Clearwater Rivers): This project provides ancillary information, specifically Adult Harvest information, which is used in adult run reconstruction to support Adult-to-Adult productivity which may be used to support Pilot studies in the Salmon MPG. The primary objective of the Nez Perce Harvest Monitoring Project (NPHMP) is to develop and implement a biologically sound anadromous fish harvest monitoring program. To accomplish this, researchers applied a step-wise harvest planning and implementation approach to specific fisheries. Harvest management and monitoring activities for the NPT encompass tribal treaty fishing activities in Zone 6 of the Columbia River and Snake River tributaries located in southeast Washington, northeast Oregon, and a majority of central Idaho. The NPHMP collects, analyzes, and reports catch data for the Snake River spring/summer Chinook salmon ESU, Snake River fall Chinook salmon ESU, and the Snake River steelhead DPS This data is used to correct adult abundance data for assessing the productivity of these ESUs and DPSs.

BPA Project 2003-017-00 (ISEMP): ISEMP was first established in 2003 to develop a set of standardized methods to monitor both fish populations as well as changes in habitat condition which was completed in 2010. ISEMP implements both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs are implemented in the Entiat River, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi river watersheds. In 2010 this worked to the development of CHaMP (2011-006-00, Columbia Habitat and Monitoring Program), fish monitoring methods, IMW methods, and preliminary fish-habitat relationships.

In the Columbia River Basin, redd counts are commonly used as an “index” of abundance, but are accompanied by substantial uncertainty and questions regarding the statistical reliability of many commonly used redd-count protocols. ISEMP initiated a mark-recapture program that PIT-tags a known, representative fraction of natural-origin adult steelhead and spring/summer Chinook salmon as they pass Lower Granite Dam that are subsequently detected in upstream tributaries at instream PIT-tag arrays. This allows researchers to generate estimates of adult escapement for steelhead and spring/summer Chinook salmon with accompanying estimates of uncertainty in the South Fork Salmon and Lemhi river subbasins. Researchers found that the decomposition of the Lower Granite Dam runs-at-large of steelhead and spring/summer Chinook salmon into tributary, population, and MPG- specific escapement estimates is a reliable, precise, and efficient alternative to continuous operation of multiple weirs. In addition, adult capture and PIT-tagging at Lower Granite Dam has not been accompanied by any direct mortality to date, suggesting that handling stress may be minimal at this location relative to upstream weirs. There is the potential to expand PIT-tagging at Lower Granite Dam to include hatchery origin adults, which would enable estimates of hatchery fraction in populations targeted for supplementation and enable estimates of stray rates into non-target populations that are monitored by PIT-tag arrays.

ISEMP is testing multiple survey types to estimate the standing crop and total emigrants of juvenile salmonids. With regard to estimating standing crop, ISEMP is employing a probabilistic based juvenile sampling effort using Generalized Random Tessellation Stratified (GRTS), which allows for site-specific abundance estimates to be aggregated to estimate abundance at any spatial scale. Employing a standardized fish sampling protocol to capture and PIT-tag juvenile anadromous salmonids ensures data can be “rolled up” across multiple spatial scales, for example, across watersheds and subbasins. PIT-tagging, as opposed to direct observation surveys such as snorkeling, means survival and growth estimates can be generated from PIT-tagged juveniles and can be used to represent the population at multiple spatial scales. Using the same GRTS design for both juvenile sampling and CHaMP habitat sampling supports the development of relationships between fish and habitat attributes. These relationships allow the identification of habitat features that are conducive to fish, enabling an assessment of the realized and anticipated effectiveness of habitat actions. In addition, site-based abundance estimates can enable an evaluation of where juveniles reside within a watershed relative to habitat restoration actions. Abundance, survival, and growth estimates enable strong statements about the overall effectiveness of habitat restoration actions to increase fish production as opposed to a simple redistribution of fish to restored habitat.

Different survey types (e.g., snorkeling, electrofishing, e-herding, snerding, seining) are used to estimate fish abundance across the Columbia River Basin, and survey types can change even within a monitoring program as program objectives change. ISEMP implemented side-by-side comparisons of various juvenile fish monitoring survey types to develop linkages between methodologies. This is important because it translates past-time series of relative fish abundance to current fish monitoring protocols used by ISEMP and the FWP, and ensures that long-term datasets are not lost as survey types change or vary across the basin. Comparing the detection efficiency of snorkel surveys and single-pass electrofishing with a mark-recapture effort revealed a strong significant relationship between snorkel estimates and mark-recapture estimates. Snorkel survey efficiency was low, with about 12 percent of the total abundance observed by snorkelers. ISEMP found that snorkel surveys were precise, but not accurate. That is, a consistent bias is observed and reflected in the low detection efficiency of snorkel surveys. However, because this bias is consistent, these abundance estimates can be corrected for through the cross-walk relationships developed by ISEMP. A similar relationship was observed between mark-recapture and one-pass electrofishing.

Rotary screw traps are used throughout the Columbia River Basin to estimate total out-migration (emigration) of juvenile Chinook salmon and steelhead from a tributary. This information is used to estimate total juvenile production from a tributary or population, SAR rates, egg-to-smolt survival, and to study life history characteristics. The temporal and spatial extents of the estimate are usually dependent on logistics associated with access and environmental conditions such as high flows and ice. Traps are usually placed in locations that are accessible for field crews and sometimes do not estimate the total population or subpopulation of interest. Although the goal is to collect all juvenile migrants across the year, the operation of screw traps are often interrupted during the winter when the rivers freeze, during high flows when it is too dangerous to operate, and by budgetary constraints when only a portion of the week is sampled. Because of these logistical constraints, the percentage of a population or tributary juvenile emigration estimated will vary between years.

The emigration estimate is derived by expanding the number of fish captured during a day by the trap efficiency, which is calculated by releasing a known number of fish upstream of the trap and calculating the “efficiency” of subsequent collection of these fish that pass the trap. However, screw trap estimates are often fraught with high levels of estimation error (e.g., trap efficiencies vary daily and seasonally in response to many factors, especially stream flow), this error is often not well reported, and managers may not realize the level of imprecision in these estimates. Additionally, methods to reduce the error in estimation can be costly and ineffective. ISEMP has conducted a series of investigations to highlight the importance of these generally overlooked weaknesses and to suggest improvements that will reduce sampling costs, while improving the value of these critical estimates of fish emigration. Results suggest that estimating downstream migrant abundance using screw traps and mark-recapture methods can provide accurate estimates of abundance, but generic sampling designs for allocating mark-recapture effort (timing and amount) should be used with caution.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring): This project evaluates precision and accuracy of the smolt monitoring methodology for both steelhead and spring Chinook; estimates the proportion of hatchery steelhead in each primary population; estimates the precision of redd counts for both steelhead and spring Chinook; and evaluates the accuracy of the steelhead spawning ground survey design. Steelhead abundance in the upper Columbia River is estimated using fish PIT-tagged at Priest Rapids Dam and recaptured at various locations in each of the Wenatchee, Entiat, Methow, and Okanogan river populations. A total of 2,215 steelhead were PIT-tagged at Priest Rapids Dam in 2010. PIT-tag arrays were installed in selected streams in the Wenatchee, Methow, and Okanogan rivers to recapture PIT-tagged steelhead. In the Wenatchee and Entiat river subbasins, PIT-tag arrays were also installed as part of a different project (ISEMP). Statistical models to estimate steelhead abundance will be developed under the future contracts.

Results from 2011 show that steelhead exhibit a large range in suitable spawning habitats and most spawning ground sampling designs do not account for either the clumped distribution of redds or the range of spawning habitats. Major spawning areas can be adequately sampled using redd surveys, but minor spawning areas are often not surveyed. In the Wenatchee and Methow river Basins, temporary PIT-tag arrays were installed at the uppermost limit of major spawning areas (i.e., minor spawning areas). In the Entiat and Okanogan river basins, temporary PIT-tag arrays were installed at the downstream limit of minor spawning areas. Based on the recapture of fish PIT-tagged at Priest Rapids Dam, 6 percent and 17 percent of the known spawning population spawned in minor areas within the Methow and Wenatchee river subbasins, respectively. In the Entiat and Okanogan river subbasins, redd surveys in minor spawning areas accounted for 55 percent and 41 percent of the PIT-tag based escapement estimate, respectively. The importance of minor spawning areas will continue to be evaluated under future contracts. Online queries were developed to assist in standardizing and querying PIT-tag data generated from the instream arrays.

The detection of redds, which are used to estimate spawning escapements, are likely affected by environmental and habitat conditions and the experience of an individual surveyor. Studies were initiated to determine which factors were most important in explaining variation in observer efficiency for both steelhead and spring Chinook. Intensive steam surveys (every three days) were conducted in selected reaches to map all redds and redd-like features. Naïve surveyors conducted single-pass surveys throughout the spawning period and mapped all observed redds. Observer efficiency, the proportion of redds detected on any given day, differed significantly among streams and observers. The suite of factors most important in predicting the proportion of redds correctly identified included experience on a specific reach, water clarity, density of redds, channel complexity, discharge, stream depth, and stream width. Statistical models to predict observer efficiency will be developed under future contracts. See Figure 56, 57, and 58 for spawner abundance estimates for Spring/Summer Chinook for 2009-2012.

In 2011 the study developed improved methods for estimating juvenile salmonid emigrant abundance (fish out). The method is both unbiased and precise and was determined to be suitable for the environmental conditions that exist in the upper Columbia River Basin to meet the needs of this RPA.

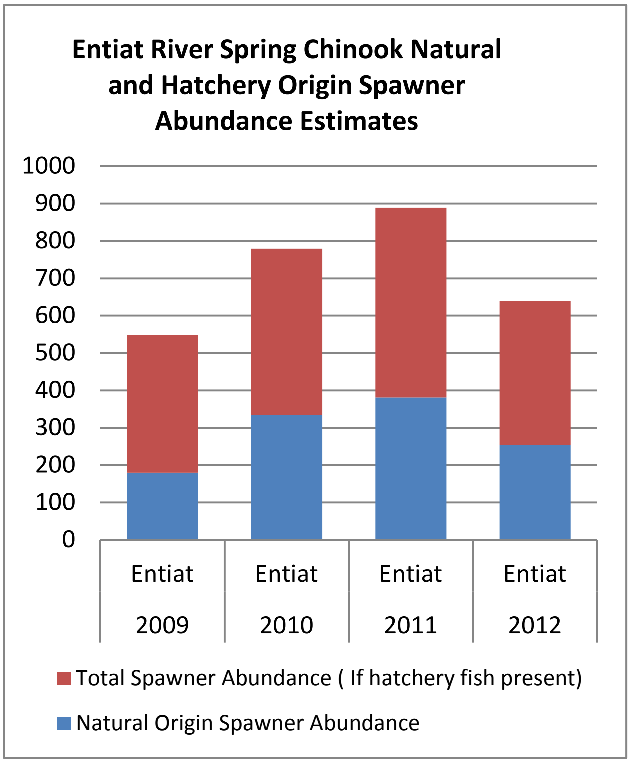


Figure 56. Entiat River Natural and Hatchery Origin Spawner Abundance Estimates for Spring Chinook for 2009-2012.

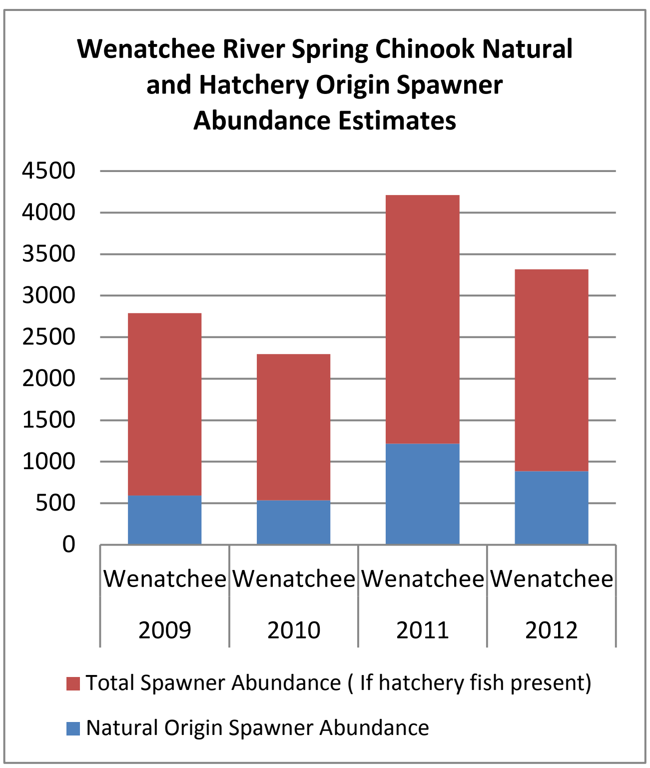


Figure 57. Wenatchee River Natural and Hatchery Origin Spawner Abundance Estimates for Spring Chinook for 2009-2012.

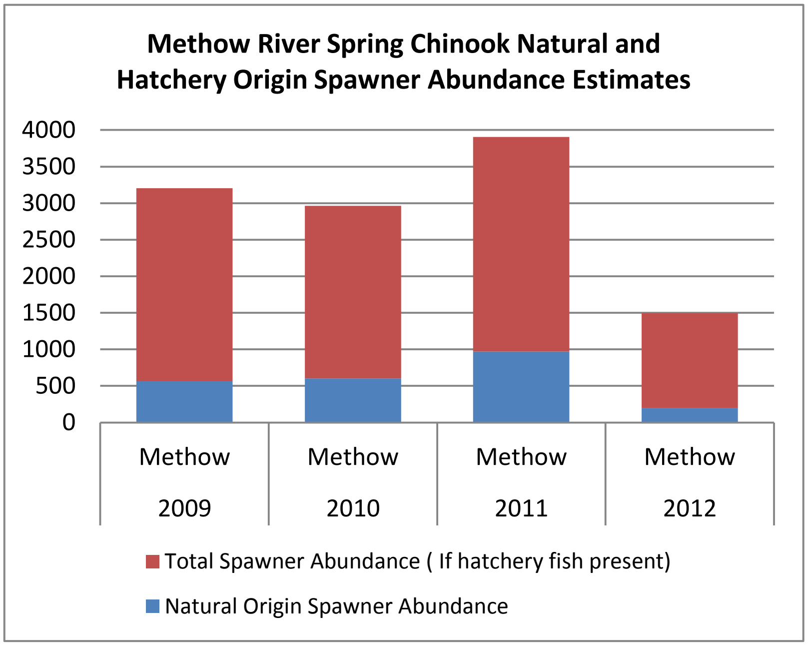


Figure 58. Methow River Natural and Hatchery Origin Spawner Abundance Estimates for Spring Chinook for 2009-2012.

BPA Project 2010-036-00 (Lower Columbia Coded Wire Tag (CWT) Recovery Project): This project provides ancillary information, specifically adult harvest information, which is used in adult run reconstruction to support Adult-to-Adult productivity which may be to support Pilot studies in the upper Columbia and Salmon MPGs. Washington's current tag recovery program in the lower Columbia River is centered on the recovery of coded wire tags (CWT) from fisheries and escapement sampling, and development of escapement estimates primarily for Chinook salmon. Deficiencies have been identified for the program including: 1) low escapement sample rates, 2) non-representative escapement sampling; 3) incomplete escapement sampling; and 4) bias in estimates of total escapement. In addition, the application of PIT-tags has increased from 20,000 in 1988 to over 2,000,000 in 2009. Currently, 2 percent of the returning adult salmon and steelhead passing Bonneville Dam are PIT-tagged.

The goals of this project are to: 1) address high priority deficiencies in the CWT program; 2) expand Washington's lower Columbia River CWT program to include a recovery program for all tags, including PIT-tags, and marks sampled in fisheries and escapement programs; 3) provide point and interval estimates for recovered PIT- and CWT tags by stratum when sample sizes are sufficient; 4) have a single framework for tag recovery and salmon escapement monitoring programs, to report on VSP metrics for Chinook and coho salmon; and 5) make this information available to policy makers, planners, managers, and others. This project builds on the existing framework and infrastructure of the current CWT recovery program along other state, federal, and locally funded fisheries and escapement sampling programs coordinated by the WDFW. At this time, there are no results or reports for this project.

Major Lessons Learned

- Lessons Relative to Mitigation Action Implementation: See Section 1 for 2012 -2018 Fish Status and Environmental conditions for a summary of fish population status and trend information.
- Status and trend monitoring methods have been advanced under this RPA subaction to increase the precision and accuracy of population estimates needed for more effective and robust planning and adaptive management of mitigation actions.

Lessons Relative to RME Implementation

- Under the ISEMP project, Researchers learned that they could generate estimates of adult escapement and accompanying levels of precision for steelhead and spring/summer Chinook by PIT-tagging them as adults at Lower Granite Dam and subsequently detecting them in the Lemhi and South Fork Salmon rivers. They also found that the decomposition of the Lower Granite Dam runs-at-large of steelhead and spring/summer Chinook salmon into tributary, population, and MPG specific escapement estimates is a reliable, precise, and efficient alternative to continuous operation of multiple weirs.
- The ISEMP project found that standing crop estimates of juvenile salmonids based on a GRTS design allowed for site-specific abundance estimates to be aggregated to any spatial scale. Employing a standardized fish sampling protocol to capture and PIT-tag juvenile anadromous salmonids ensures data can be “rolled up” across multiple spatial scales. PIT-tagging also allows for the estimation of survival and growth. ISEMP compared the detection efficiency of snorkel surveys and single-pass electrofishing with a mark-recapture effort and found a strong significant relationship between snorkel estimates and the more robust mark-recapture estimates. Snorkel survey efficiency was low however, with only about 12 percent of the total abundance observed by snorkelers. ISEMP found that snorkel surveys were precise, but not accurate. That is, a consistent bias is observed and reflected in the low detection efficiency of snorkel surveys.
- ISEMP examined screw trap estimates (fish-out) and found that estimating downstream migrant abundance using screw traps and mark-recapture methods can provide accurate estimates of abundance, but generic sampling designs for allocating mark-recapture effort (timing and amount) should be used with caution. Abundance estimates can be significantly biased as a result of violations in mark-recapture assumptions. Allocating more effort to trap efficiency trials, either by conducting more trials or supplementing the numbers of fish used in these trials, may not reduce the bias in abundance estimates. For trapping environments that have significant variability in flows or trap efficiencies over the trapping season, allocating mark-recapture effort disproportionally through the season can address sampling challenges with least cost.
- Studies in the upper Columbia River found that PIT-tagging steelhead at Priest Rapids Dam and subsequent detection in tributaries upstream from Priest Rapids Dam allows estimation of the escapement into the different populations (i.e., Wenatchee, Entiat, Methow, and Okanogan rivers). Researchers are developing the statistical models that will allow the estimation of steelhead escapement into the different populations. The study also found that PIT-tag arrays can be placed to determine the use of minor spawning areas by steelhead. For example, based on the recapture of fish PIT-tagged at Priest Rapids Dam, 6 percent and 17 percent of the known spawning population spawned in minor areas within the Methow and Wenatchee river subbasins, respectively. In the Entiat and Okanogan river subbasins, redd surveys in minor spawning areas accounted for 55 percent and 41 percent of the PIT-tag based escapement estimate, respectively.
- The upper Columbia River study learned that factors most important in predicting the correct proportion of redds in steelhead and spring Chinook spawning grounds included surveyor experience on a specific reach, water clarity, density of redds, channel complexity, discharge, stream depth, and stream width. Statistical models to predict observer efficiency will be more fully developed in the future.

The upper Columbia study developed improved methods for estimating juvenile salmonid emigrant abundance (fish out). The method is both unbiased and precise and was determined to be suitable for the environmental conditions that exist in the upper Columbia River Basin.

Fish population monitoring to inform the pilot studies has established a significant baseline condition which will be used in RPA Actions 56 and 57, to evaluate how restoration actions impact abundance, productivity and survival. Because the restoration actions just were implemented, impacts on adults and juveniles have not yet been assessed for the first generation of salmonids impacted by the action.

RPA Subaction 50.5 – *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)*

The Action Agencies fund additional monitoring for B-run steelhead to assess total escapement of adults and use parental based genetic tagging to determine juvenile out-migrant production and origin. This strategy proportionally PIT-tags adult steelhead at Lower Granite Dam and then uses new technology for large scale PIT-tag arrays in mainstem rivers to detect adult population escapement. In addition genetic samples of adults are taken at Lower Granite to establish a parental base for assessing fish escapement for each population. To complete juvenile out-migrant assessments of B-run steelhead, genetic samples are taken of out-migrating juveniles and compared to parental genetics to assess population production. This approach allows for assessments of population specific escapement and out-migrant production for key populations of steelhead to inform trends in abundance and support comparisons of B-run and A-run composition to assess FCRPS BiOp and recovery strategies.

Major Accomplishments and Findings

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

BPA Project 1989-098-00 (The Salmon Studies in Idaho Rivers- IDFG): This project supported smolt trap infrastructure used to monitor b-run Steelhead in coordination with the ISEMP project.

BPA Project 1990-055-00 (ISMES): ISMES continued to operate temporary weirs to estimate escapement in Fish Creek (Lochsa River), Rapid River (Little Salmon River), and Big Creek (lower Middle Fork Salmon River). Wild fish were sampled further; scales were collected, and a small portion of the anal fin was removed for a genetics tissue sample. Abundance of emigrating juvenile steelhead was estimated from data collected at rotary screw traps located near the mouths of Fish Creek, Rapid River, and Big Creek (Figure 59). Abundance results for these steelhead populations are provided in the project annual reports in BPA Taurus program at *http://www.cbfish.org/Project.mvc/Publications/1990-055-00/2012/Documents*.

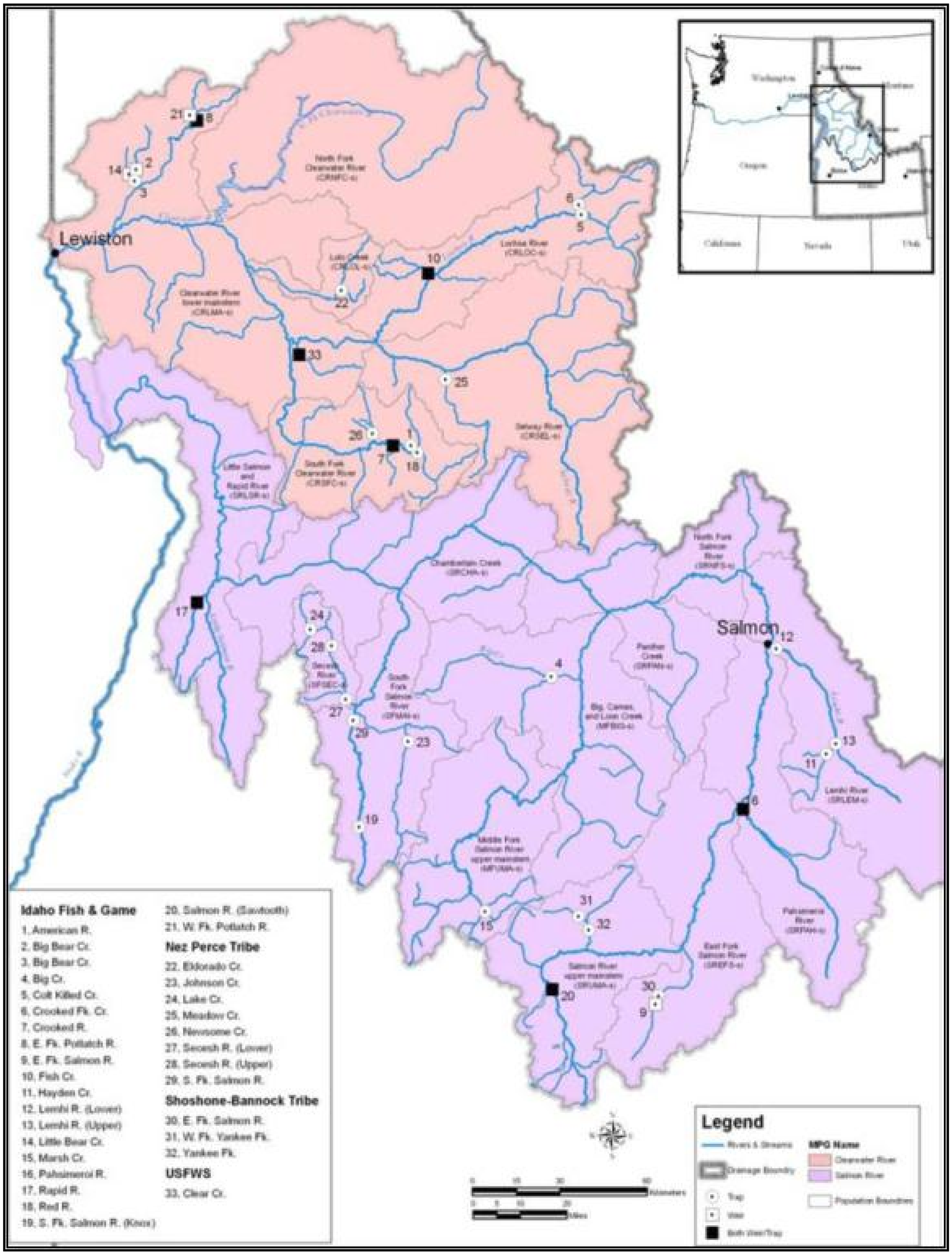


Figure 59. Locations of Weirs and Screw Traps Sampling Steelhead in Idaho.

BPA Project 1991-073-00 (INPMEP): INPMEP uses a rotating panel design to select from previously established snorkeling transects focusing on three objectives: 1) conduct extensive surveys to assess parr distribution and abundance at the population scale; 2) conduct intensive surveys to calibrate parr densities with production of juvenile emigrants estimated from screw traps in target drainages; and 3) conduct surveys at core and non-core trend transects to maintain the long-term juvenile-to-juvenile productivity data series for steelhead.

BPA Project 2002-060-00 (Nez Perce Harvest Monitoring on Snake and Clearwater Rivers): This RPA was removed because the information collected is no longer needed to support this RPA strategy based on PIT-tags and genetic sampling.

BPA Project 2003-017-00 (ISEMP): The proof of concept for Adult PIT-tag evaluations was tested and validated in the ISEMP, **BPA project 2003-017-00**, in 2010. After validation of the concept, the PIT-tag interrogation network was expanded into Lolo Creek, South Fork Clearwater River, in the Salmon River upstream from the confluence of the Middle Fork Salmon River. Due to limitations of detection efficiencies, the lower Grande Ronde River mainstem was not added, but substituted with a plan to install equipment in the Wallowa and upper Grande Ronde river populations in 2012. The current network of monitoring with PIT-tag arrays and weirs is depicted in Figure 60 below with results in Figure 61. The use of a series of PIT-tagging programs coupled with strategically placed detection arrays determined adult migration timing, distribution, and survival of tagged fish.

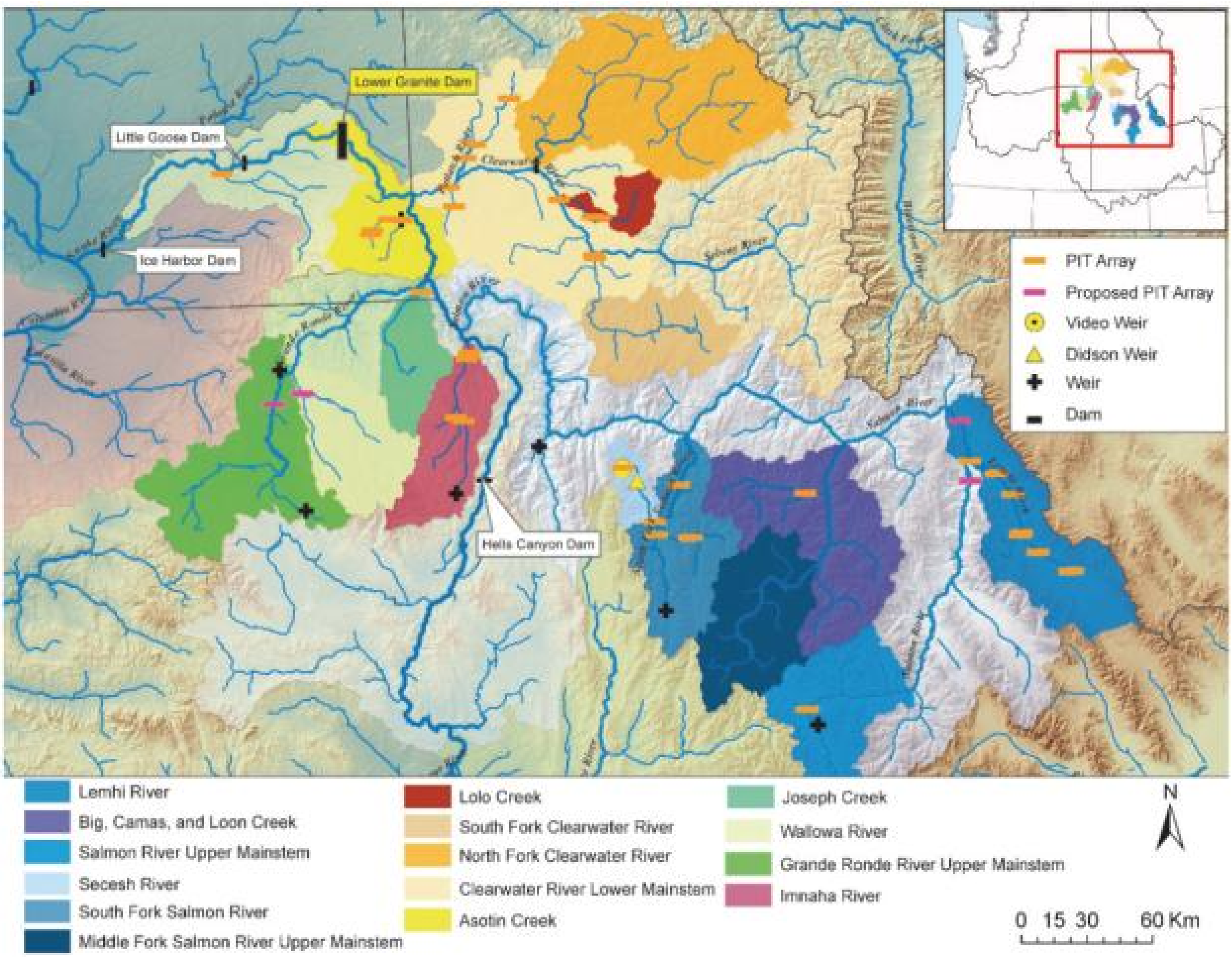


Figure 60. Steelhead PIT-tag, Weir and Didson Monitoring Network.

Run-Year	MPG	Population	Subpopulation	PIT Tag Decomposition: Fraction Sampled[1]	PIT Tag Decomposition: Escapement	PIT Tag Decomposition: CV	PIT Tag Decomposition: 95% CI	Independent Estimate: Escapement	Independent Estimate: CV	Independent Estimate: 95% CI
2009-2010	Lower Salmon	Asotin Creek[2]		95%	1,687	8.5%	± 280	1,500	N/A	N/A
2009-2010	Salmon River	South Fork		90%	1,497	9.1%	± 268			
2009-2010		Secesh		100%	298	22.1%	± 129			
2009-2010		Middle Fork	Big Creek	100%	753	21.8%	± 322			
2009-2010		Upper Salmon	Valley Creek	100%	237	17.7%	± 82			
2009-2010		Upper Salmon	Pahsimeroi River[2]	100%	138	22.9%	± 62	115	N/A	N/A
2009-2010		Lemhi River		95%	630	14.2%	± 175			
2009-2010		Little Salmon	Rapid River[1]	95%	136	24.0%	± 64	150	Census	Census 164-255
2009-2010	Clearwater River	Lochsa River	Fish Creek[2]	100%	246	58.1%	± 117	205		
2010-2011	Lower Salmon	Asotin Creek[2]		95%	890	10.0%	± 175	1,128	2.0%	± 44
2010-2011	Grande Ronde	Joseph Creek[3]		100%	1,627	1.4%	± 45	1,698	22.4%	± 744
2010-2011	Imnaha River	Imnaha River		100%	3,298	1.5%	± 97			
2010-2011		Imnaha River	Cow Creek	100%	147	1.4%	± 4			
2010-2011		Imnaha River	Big Sheep Creek	100%	765	2.2%	± 33			
2010-2011	Salmon River	South Fork		90%	2,540	1.9%	± 93			
2010-2011		Secesh		100%	397	3.1%	± 24			
2010-2011		Middle Fork	Big Creek	100%	687	1.6%	± 22			
2010-2011		Upper Salmon	Valley Creek	100%	232	1.5%	± 7			
2010-2011		Lemhi River		95%	428	1.7%	± 14			

[1]Fraction sampled refers to the fraction of spawning believed to occur above PIT tag arrays.
[2]Weirs that capture and enumerate steelhead and use handheld wands to identify PIT tags, but do not have PIT tag arrays.
[3]Locations with weirs that capture and enumerate steelhead and use handheld wands to identify PIT tags and also have neighboring PIT tag arrays.
[4]Independent estimate generated from a video weir paired with a single PIT tag array.

Figure 61. Steelhead Escapement Data from ISEMP Used by NOAA to Support Spawner Abundance Estimates.

BPA Project 2005-002-00 (Lower Granite Dam Adult Trap Operations): Supported PIT-tagging of adult steelhead returns for adult escapement assessments and parental-based tagging for Genetic Stock Identification (GSI). During 2011, the project operated the adult trap from March 7 to November 20. Samples of the run at large were taken automatically four times an hour, 24 h/d, using a 10 percent sample rate for the entire trapping period for all species. Actual results related to this work are presented under the ISEMP and under the Chinook and Steelhead Genotyping for GSI at Lower Granite Dam project. Even though this project maintained its BPA level of funding, to address state and tribal agency budget reductions in 2013, the adult trap reduced operation to 5 days a week rather than 7 days a week. Ongoing discussions with NOAA, the AA's and the sponsors are underway to ensure increased trapping does not increase ESA Take and that the study design for representational marking is not compromised.

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

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

BPA Project 2010-031-00 (Snake River Chinook and Steelhead Parental Based Tagging): Continued development and evaluation of a new genetic technology called Parentage Based Tagging (PBT). PBT can serve as a versatile tool for the genetic tagging steelhead and Chinook salmon in the Snake River Basin. To support this RPA, Objective 2, creation of genetic parental databases, serves as a major component of the RPA strategy. In close collaboration with the CRITFC project 2010-026-00, they have used the PBT SNPs identified for each species to genotype nearly 100 percent of the steelhead sampled in the Snake River Basin from spawn year (SY) 2010 and 2011. Results, thus far, indicate that annual sampling, inventorying, and genotyping of all steelhead broodstock in the Snake River Basin is feasible and that the SNP sets identified for PBT are sufficient for accurate assignment of offspring to brood year and hatchery stock, thereby allowing an unprecedented ability to mark millions of Snake River smolts and an opportunity to address future objectives of parentage-based management.

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

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

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

Preliminary results support the concept that the A- and B-runs may be an artificial demarcation of the species.

An assessment by BPA using NOAA's Salmon Population Summary data presented in Section 1 of the CE validates sponsors reports of increasing trends in natural-origin adult spawners and a reduction of hatchery-origin spawners (pHOS) for many populations across the basin, improving wild/natural spawning viability attributes for these species since 2008.

Tables 45 and 46 below are summaries of population data presented in the ESU summaries in Section 1.

Table 45. Population-Specific Changes in Average Fractions of Wild-Origin Spawners Between 2003-2007 and 2008-2012. Only populations with at least 3 years data in 2003-2007 and 3 years data within 2008-2012 were considered. Note that several populations had 100 percent wild fish during both periods and these were counted as showing an increase in Table B.

ESU	Population	Wild Fraction (2004-2007)	Wild Fraction (2008-2011)	Percent Change
Middle Columbia River Steelhead DPS	Deschutes River - eastside Steelhead	0.75	0.84	12.35
	Deschutes River - westside Steelhead	0.82	0.89	9.77
	Fifteenmile Creek Winter-run Steelhead	1.00	0.98	-2.49
	John Day River Lower Mainstem Tributaries Steelhead	0.78	0.83	6.30
	John Day River Upper Mainstem Steelhead	0.89	0.95	5.98
	Middle Fork John Day River Steelhead	0.89	0.95	6.66
	Naches River Steelhead	0.99	0.97	-2.20
	North Fork John Day River Steelhead	0.89	0.95	6.69
	Satus Creek Steelhead	0.99	0.97	-2.20

ESU	Population	Wild Fraction (2004-2007)	Wild Fraction (2008-2011)	Percent Change
	South Fork John Day River Steelhead	0.89	0.95	5.92
	Toppenish Creek Steelhead	0.99	0.96	-2.31
	Umatilla River Steelhead	0.72	0.81	11.54
	Walla Walla River Steelhead	0.96	0.98	1.71
	Yakima River upper mainstem Steelhead	0.98	0.97	-1.74
Snake River Basin Steelhead DPS	Grande Ronde River Upper Mainstem Steelhead	1.00	0.99	-0.91
	Imnaha Camp Creek Index Area Steelhead	1.00	1.00	0.00
	Joseph Creek Steelhead	1.00	1.00	0.00
Snake River Spring/Summer-run ESU	Bear Valley Creek Chinook Salmon	1.00	1.00	0.00
	Big Creek Chinook Salmon	1.00	1.00	0.00
	Camas Creek Chinook Salmon	1.00	1.00	0.00
	Catherine Creek Chinook Salmon	0.32	0.40	23.51
	Chamberlain Creek Chinook Salmon	1.00	1.00	0.00
	East Fork Salmon River Chinook Salmon	1.00	1.00	0.00
	Grande Ronde River Upper Mainstem Chinook Salmon	0.19	0.08	-57.58
	Imnaha River Mainstem Chinook Salmon	0.40	0.26	-34.44
	Lemhi River Chinook Salmon	1.00	1.00	0.00
	Loon Creek Chinook Salmon	1.00	1.00	0.00
	Lostine River Chinook Salmon	0.34	0.31	-7.98
	Marsh Creek Chinook Salmon	1.00	1.00	0.00
	Minam River Chinook Salmon	1.00	0.84	-15.51
	Pahsimeroi River Chinook Salmon	0.50	1.00	100.53
	Salmon River Lower Mainstem below Redfish Lake Chinook Salmon	1.00	1.00	0.00
	Salmon River Upper Mainstem above Redfish Lake Chinook Salmon	0.71	0.97	35.65
	Secesh River Chinook Salmon	0.98	0.96	-1.35
	South Fork Salmon River Mainstem Chinook Salmon	0.65	0.69	7.72
	Sulphur Creek Chinook Salmon	1.00	1.00	0.00
	Tucannon River Chinook Salmon	0.63	0.51	-19.90
	Valley Creek Chinook Salmon	1.00	1.00	0.00
	Wenaha River Chinook Salmon	0.98	0.84	-14.53
	Yankee Fork Chinook Salmon	1.00	0.07	-93.27
Upper Columbia River Spring-run ESU	Entiat River Chinook Salmon	0.51	0.59	13.98
	Methow River Chinook Salmon	0.25	0.27	10.20
	Wenatchee River Chinook Salmon	0.36	0.30	-15.85
Upper Columbia River Steelhead DPS	Entiat River Steelhead	0.17	0.29	73.88
	Methow River Steelhead	0.12	0.19	52.70
	Okanogan River Steelhead	0.07	0.11	61.61
	Wenatchee River Steelhead	0.30	0.46	54.53

ESU	Population	Wild Fraction (2004-2007)	Wild Fraction (2008-2011)	Percent Change
Disclaimer: Due to the wide variety of data sources the go into the Salmonid Population Summary (SPS) database, the NOAA Northwest Fisheries Science Center (NWFSC) does not guarantee the accuracy of any of the data in the SPS database. In particular, neither the U.S. Government, nor any agency or employee thereof, makes any warranties, expressed or implied, with respect to the accuracy of the data, including but not limited to the implied warranties or merchantability and fitness for any particular purpose. In no event shall the U.S. Government, nor any agency or employee thereof, be liable for any direct, indirect, or consequential damage flowing from the use of the data in the SPS database.				

Table 46. Population-Specific Percent Change in Average Wild-Origin Spawner Abundances Between 2003-2007 and 2008-2012. Only populations with at least 3 years data in 2003-2007 and 3 years data within 2008-2012 were considered. Column % change represents the average percent change in wild-origin spawner abundance between 2003-2007 and 2008-2012.

ESU	Population	Percent Change
Middle Columbia River Steelhead DPS	Deschutes River - eastside Steelhead	-31.06
	Deschutes River - westside Steelhead	7.78
	Fifteenmile Creek Winter-run Steelhead	-34.43
	John Day River Lower Mainstem Tributaries Steelhead	69.23
	John Day River Upper Mainstem Steelhead	90.64
	Middle Fork John Day River Steelhead	44.91
	Naches River Steelhead	104.82
	North Fork John Day River Steelhead	79.212
	Satus Creek Steelhead	163.512
	South Fork John Day River Steelhead	57.072
	Toppenish Creek Steelhead	31.762
	Umatilla River Steelhead	59.032
	Walla Walla River Steelhead	63.93
	Yakima River upper mainstem Steelhead	96.78
Snake River Basin Steelhead DPS	Grande Ronde River Upper Mainstem Steelhead	38.9
	Imnaha Camp Creek Index Area Steelhead	6.68
	Joseph Creek Steelhead	50.06
Snake River Spring/Summer-run ESU	Bear Valley Creek Chinook Salmon	40.726
	Big Creek Chinook Salmon	74.86
	Camas Creek Chinook Salmon	-55.74
	Catherine Creek Chinook Salmon	303.3
	Chamberlain Creek Chinook Salmon	42.83
	East Fork Salmon River Chinook Salmon	78.71
	Grande Ronde River Upper Mainstem Chinook Salmon	88.84
	Imnaha River Mainstem Chinook Salmon	12.16
	Lemhi River Chinook Salmon	106.96
	Loon Creek Chinook Salmon	-56.37
	Lostine River Chinook Salmon	268.36
	Marsh Creek Chinook Salmon	60.26
	Minam River Chinook Salmon	46.73
	Pahsimeroi River Chinook Salmon	29.41
	Salmon River Lower Mainstem below Redfish Lake Chinook Salmon	8.69
	Salmon River Upper Mainstem above Redfish Lake Chinook Salmon	57.12
	Secesh River Chinook Salmon	75.96

ESU	Population	Percent Change
	South Fork Salmon River Mainstem Chinook Salmon	8.14
	Sulphur Creek Chinook Salmon	29.654
	Tucannon River Chinook Salmon	294.44
	Valley Creek Chinook Salmon	10.4
	Wenaha River Chinook Salmon	5.94
	Yankee Fork Chinook Salmon	-57.074
Upper Columbia River Spring-run ESU	Entiat River Chinook Salmon	64.63
	Methow River Chinook Salmon	80.15
	Wenatchee River Chinook Salmon	44.325065
Upper Columbia River Steelhead DPS	Entiat River Steelhead	98.9
	Methow River Steelhead	84.39
	Okanogan River Steelhead	98.76
	Wenatchee River Steelhead	102.13
Data obtained from the Salmonid Population Summary (SPS) database.		

Lessons Relative to RME Implementation

- Tagging of wild adult steelhead at Lower Granite Dam with subsequent tracking to spawning tributaries with detection arrays was shown to be highly successful with good precision and potential for major cost savings. This technique could replace the need for weirs and spawning ground surveys in the near future. Expansion of this technique to include tagging of hatchery adults should be pursued for a more cost effective method of collecting needed information on the proportion and distribution of hatchery fish.

PBT may potentially be a more economical and efficient technique for tagging fish than CWTs; methods were shown to be successful for the accurate assignment of offspring to brood year, hatchery stock, and even individual parents. This will help support B-run steelhead pedigree analysis, which supports population assessments as well as provides a baseline for potential future assessments with genetics data.

Results, thus far, indicate that annual sampling, inventorying, and genotyping of all steelhead broodstock in the Snake River Basin is feasible and that the SNP sets identified for PBT are sufficient for accurate assignment of offspring to brood year and hatchery stock, thereby allowing an unprecedented ability to mark millions of Snake River smolts and an opportunity to address future objectives of parentage-based management.

RPA Subaction 50.6 – *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.*

To support this RPA the AA's and NOAA will implement a strategy that maintains and/or improves fish population monitoring in key populations used by the TRT to assess species viability and extinction risk. In addition monitoring for adult spawner population abundance estimates and juvenile out-migrant population abundance estimates for a minimum of one population per MPG will be improved to meet recommended confidence and precision targets identified in NOAA's ESA monitoring guidance. This monitoring approach was developed as part of the Anadromous Salmonid Monitoring Strategy (ASMS) developed by the Federal, State and Tribal resource managers in 2010 to support FCRPS BiOp and recovery monitoring for listed species. Actual results for adult monitoring will be maintained at

NOAAs Salmon Population Summary Database at *https://www.webapps.nwfsc.noaa.gov/sps* by 2012 and at StreamNet for Juvenile out-migrant data at *www.streamnet.org* in 2013.

Major Accomplishments and Findings

To Support this RPA, BPA implemented 40 projects.

Due to the large volume of status information contained in these reports, the results of projects are not provided in this section. Annual reports with this information are hyperlinked in Comprehensive Evaluation Section 3. Compliance with this RPA should be validated through the NOAA Fisheries assessment of improvements to population assessment data in the Salmon Population Summary (SPS) data system since 2010.

Table 47 identifies Implementation plan actions identified to fill gaps in existing Chinook and steelhead population status monitoring programs and the assessment of BPA action implementation that fulfilled the RPA requirements.

Table 47. Changes to Existing Steelhead and Chinook Population Status and Trend Monitoring Projects as Identified in the 2010-2013 Implementation Plan Based on RPA Action Recommendations.

MPG	Project No.	Implementation Plan action	Implementation Assessment
Snake River Steelhead DPS			
Lower Snake	200205300, 201004200, 201002600, 201002800	1. PIT-tag juvenile steelhead in the Tucannon to support monitoring the effectiveness of steelhead supplementation in the Tucannon. 2. Fully fund the steelhead monitoring program in Asotin Creek. 3. Use mark-recapture techniques to estimate pre-spawn survival. 4. Conduct redd surveys in all Major Spawning Areas and minor Spawning Areas in Asotin and Tucannon.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. 201004200, supports Action 1. by annual tagging of steelhead. Fully funding the improved design of 200205300, addressed action 2. In combination additional fund for 200205300 and funding 2010-026-00 supports actions 3 and 4. 201002600 was misidentified and was removed from this action but added to the Clearwater and Salmon.
Grande Ronde	199800702, 199202604, 200708300, 200301700, 199703000	1. Extend trapping period at Lostine weir and install second screw trap on Minam River. 2. Fund ODFW 2007-09-00 and proposal 200733700. 3. Expand proposal 199703000 to quantify adult steelhead escapement in Joseph Creek. 4. Add PIT-tag interrogation system in the lower Grande Ronde (as low in the system as possible) and in Joseph Creek.	The Implementation Plan action was fully implemented and maintained by funding revised projects submitted under the NPCC's RME Categorical review in Column 2. 1. 199800702 was expanded in scope to meet the need. 2. 199202604 was expanded to encompass the 2 projects. 3. 199703000 enhancements quantify adult steelhead escapement in Joseph Creek. 4. 200301700 supported this action, however as identified in the 2011 APR this was not feasible and an alternative solution was funded to install arrays in the Lostine and upper Grande Ronde which was completed in 2012. 200708300 supports PIT-tagging of steelhead in the Grande Ronde: No annual report available since 2008.

MPG	Project No.	Implementation Plan action	Implementation Assessment
Imnaha	199701501, 200301700	1. Extend trapping period to enable estimate of juvenile production. 2. Add PIT-tag interrogation system in the lower Imnaha (as low in the system as possible).	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. 1. 199701501 extended trapping period to enable estimate of juvenile production. 2. 200301700 (ISEMP) Added a PIT-tag interrogation system in the lower Imnaha.
Clearwater	19905500, 199107300, 201002600,	Fund full parental genotyping through at least one funding cycle to complete DNA objectives.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. (Idaho Supplementation Study [ISS] 198909800 was identified in error and did not support Steelhead genetics).
Salmon	19905500, 199107300, 201002600,	Fund full parental genotyping through at least one funding cycle to complete DNA objectives.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. ISS 198909800 was identified in error and did not support steelhead genetics).
Mid-Columbia Steelhead DPS			
John Day	199801600, 200301700	1. Expand the work to increase density of sampling sites (using GRTS master sample list) to improve population-scale resolution for VSP in the lower and upper mainstem. 2. Develop proportion hatchery origin spawners (pHOS) and DNA baseline in the MPG, including analysis of the backlog of DNA samples.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. 200301700 supported development of the GRTS design that was implemented by project 199801600 to support basin wide assessment. In 2012 the basin wide design was reduced to only sample two populations. 199801600 also expanded monitoring for (pHOS) and to analyze genetic data to establish a baseline for the MPG.
Yakima	199603501, 199506325	1. Conduct additional DNA evaluations at Prosser Dam and all mainstem Yakima tributaries to accurately parse out adult steelhead spawners and juvenile productivity. 2. For the Toppenish population, conduct complete census surveys for redds in all Major Spawning Areas and Minor Spawning Areas. Use GRTS to sample for redds outside Major Spawning Areas and Minor Spawning Areas in Toppenish Creek.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. 1. 199603501, and 199506325 supported action 1 by acquisition of traps and flow gauges to support juvenile productivity assessments and a new project 2010-030-00 supported the genetic assessments. 2. 2010-030-00 implemented a census in the Toppenish and supported GTRS design for redd monitoring program.
Cascade East Slope	199506335	Combine 199506425 with 19881205 or 19950633. Complete modification of Lyle Falls trap and Castile Falls trap under 198811535.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. The Lyle Falls trap and Castile Falls trap were completed under project 198811535. 200715600 the Rock Creek Fish and Habitat Assessment project was removed from the association because it was determine it did not support the

MPG	Project No.	Implementation Plan action	Implementation Assessment
			proposed action after review of the proposed scope of work under the RME/AP Categorical Review.
Upper Columbia Steelhead DPS			
Upper Columbia	200301700, 200302200	See RPA Subaction 50.4 recommendations.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. (See RPA Subaction 50.4 for full details).
Snake River Chinook ESU			
Lower Snake	201004200	Increase the number of PIT-tag juvenile Chinook in the Tucannon.	The Implementation Plan action was fully implemented and maintained by funding projects in Column 2. 201004200 supports the Action by annual tagging additional Chinook in addition to those tagged under the Lower Snake River Comp Program.

Table 48 identifies one or more populations per MPG that were monitored for fish status and trend (fish in-fish out).

Table 48. Identification of Chinook Salmon, Steelhead, Sockeye Salmon, and Coho Salmon Populations that Should be Monitored for Population (Fish-In/Fish-Out) Status and Trends.

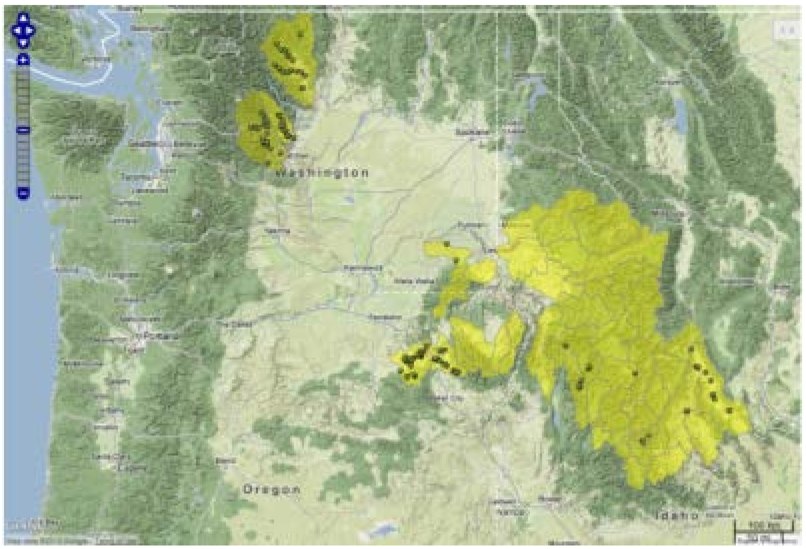
<table>
<tr><th>ESU/DPS</th><th>MPG</th><th>Population</th><th>Projects</th><th>Implementation Assessment</th></tr>
<tr><td colspan="5">Chinook Salmon
The Taurus Portfolio of BPA work elements that support this RPA are included in this link http://www.cbfish.org/Map.mvc/Index/Portfolio/1535.


Figure 62. Map of BPA RME Chinook Monitoring Worksites that Support this RPA with Population Boundaries Highlighted in Yellow. Note: Locations Outside Population Boundaries Relate to Marking/Tagging Efforts Supporting this RPA.</td></tr>
<tr><td rowspan="2">Snake River Spring/ Summer Chinook</td><td>South Fork</td><td>South Fork</td><td>Fish-In: 1989-098-00 Salmon Studies in Idaho Rivers-Idaho Department of Fish and Game (IDFG), and 2003-017-00 ISEMP.

Fish-Out: 1989-098-00 Salmon Studies in IDFG, 2003-017-00 ISEMP and 1991-028-00 Pit-Tagging Wild Chinook, 1991-073-00 Idaho Natural Production M&E</td><td>The South Fork Salmon IMW implemented by ISEMP is supported by the ISS project. Results of data are provided under RPA Subaction 50.4.</td></tr>
<tr><td>Middle Fork</td><td>Big Creek</td><td>Fish-In: 2003-017-00 ISEMP, and 1991-028-00 PIT-tagging Wild Chinook, 1999-020-00 Analyze Persistence and</td><td>ISEMP and Pit-tagging wild Chinook, continued to monitor adult spawner escapement with PIT-tag arrays while Analyze Persistence and Dynamics in Chinook Redds and a joint venture with the LSRCP NPT effort analyzed spawner abundance and juvenile productivity for Chinook Salmon in Big</td></tr>
</table>

<table>
<tr><th>ESU / DPS</th><th>MPG</th><th>Population</th><th>Projects</th><th>Implementation Assessment</th></tr>
<tr><td></td><td></td><td></td><td>Dynamics in Chinook Redds.

Fish-Out: 2003-017-00 ISEMP, and 1991-028-00 PIT-tagging Wild Chinook.</td><td>Creek.</td></tr>
<tr><td></td><td>Upper Salmon</td><td>Lemhi</td><td>Fish-In: 2003-017-00 ISEMP, 1989-098-00Salmon Studies in IDFG.

Fish-Out: 2003-017-00 ISEMP, 1991-073-00 Idaho Natural Production M&E.</td><td>ISEMP and ISS continued to monitor adult spawner abundance and juvenile productivity for Chinook Salmon.</td></tr>
<tr><td></td><td></td><td>Pahsimeroi</td><td>Fish-In: 1991-073-00 Idaho Natural Production M&E.

Fish-Out: 1991-073-00 Idaho Natural Production M&E.</td><td>Idaho Natural Production M&E continues to support adult population spawner abundance and juvenile parr density and production data.</td></tr>
<tr><td></td><td></td><td>Yankee Fork</td><td>Fish-In: 1989-098-00Salmon Studies in Idaho Rivers- IDFG.

Fish-Out: 1989-098-00 Salmon Studies in Idaho Rivers- IDFG.</td><td>Due to monitoring in the Lemhi and Pahsimeroi populations and the desire not to implement CHaMP in the Yankee Fork it was determined by BPA that additional monitoring to meet the recommended action was unnecessary.</td></tr>
<tr><td></td><td>Lower Snake</td><td>Tucannon</td><td>Fish-In: 2010-042-00 Tucannon Expanded PIT-tagging and 2010-050-00 Evaluation of the Tucannon endemic program in combination with existing LSRCP monitoring.

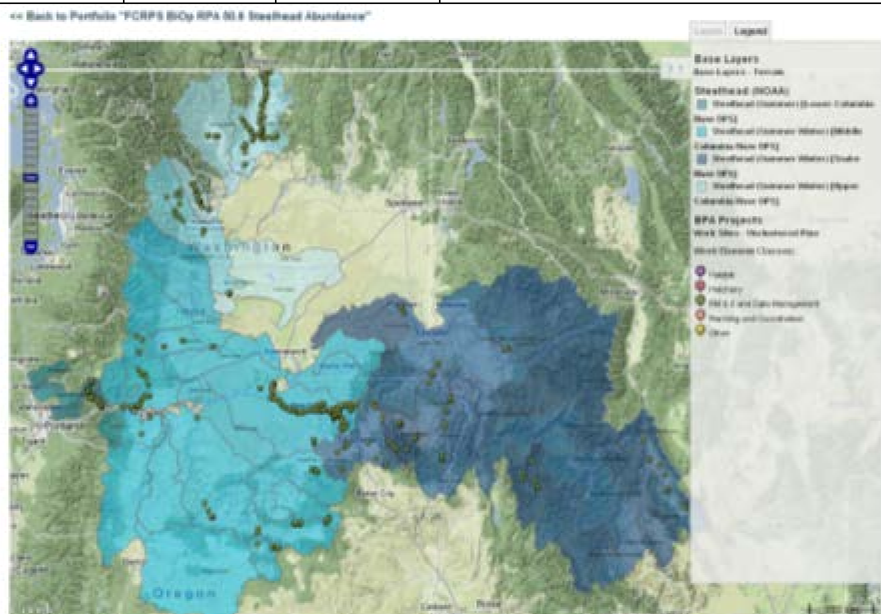
Fish-Out: 2010-042-00 Tucannon Expanded PIT-tagging and LSRCP projects.</td><td>Projects 2010-42-00 and Based on contract Scope of Work 2010-50-00 support PIT-Tag assessments and redd surveys for Tucannon Chinook salmon.
<table>
<tr><th colspan="4">Adults</th></tr>
<tr><th>Species</th><th>Origin</th><th>Release Site</th><th># of Fish</th></tr>
<tr><td rowspan="7">Spring Chinook</td><td>U</td><td>Columbia R. – Estuary</td><td>1</td></tr>
<tr><td>U</td><td>Bonneville Dam</td><td>4</td></tr>
<tr><td>W</td><td>John Day River (Oregon)</td><td>2</td></tr>
<tr><td>H</td><td>Tucannon R. – Curl Lake AP</td><td>33</td></tr>
<tr><td>W</td><td>Tucannon River</td><td>4</td></tr>
<tr><td>W</td><td>Lower Granite Dam</td><td>4</td></tr>
<tr><td>W</td><td>American River (Idaho)</td><td>1</td></tr>
</table>
<table>
<tr><th colspan="2">Juveniles</th></tr>
<tr><th>Release Site</th><th># of Fish</th></tr>
<tr><td>Tucannon R. – Curl Lake AP</td><td>151</td></tr>
</table>
Figure 63. Number of Juveniles Detected in PIT-tag Arrays in 2011.</td></tr>
<tr><td></td><td>Grande</td><td>Upper</td><td>Fish-In: 2003-017-00 ISEMP, 1998-007-</td><td>1998-007-03; 1992-026-04, and 2009-004-00 conducted redd surveys,</td></tr>
</table>

<table>
<tr><th>ESU/DPS</th><th>MPG</th><th>Population</th><th>Projects</th><th>Implementation Assessment</th></tr>
<tr><td rowspan="2"></td><td rowspan="2">Ronde/Imnaha</td><td>Grande Ronde</td><td>03 Grande Ronde Supplementation Operations & Maintenance (O&M) on Catherine Creek/upper Grande Ronde River; 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead; and 2009-004-00: Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators.

Fish-Out: 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead; and 2009-004-00: Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators.</td><td>ISEMP supported the installation of PIT-Tag interrogation systems to support adult escapement assessments. Juvenile production monitoring was implemented by 1992-026-04 and 2009-004-00.
<table>
<tr><th>Stream and MY</th><th>Population estimate</th></tr>
<tr><td>Upper Grande Ronde River</td><td></td></tr>
<tr><td>1994</td><td>24,791</td></tr>
<tr><td>1995</td><td>38,725</td></tr>
<tr><td>1996</td><td>1,118</td></tr>
<tr><td>1997</td><td>82</td></tr>
<tr><td>1998</td><td>6,922</td></tr>
<tr><td>1999</td><td>14,858</td></tr>
<tr><td>2000</td><td>14,780</td></tr>
<tr><td>2001</td><td>51</td></tr>
<tr><td>2002</td><td>9,133</td></tr>
<tr><td>2003</td><td>4,922</td></tr>
<tr><td>2004</td><td>4,854</td></tr>
<tr><td>2005</td><td>6,257</td></tr>
<tr><td>2006</td><td>34,672</td></tr>
<tr><td>2007</td><td>17,109</td></tr>
<tr><td>2008</td><td>11,684</td></tr>
<tr><td>2009</td><td>34</td></tr>
<tr><td>2010</td><td>20,763</td></tr>
<tr><td>2011</td><td>25,133</td></tr>
<tr><td>2011</td><td>12,594</td></tr>
</table>
Figure 64. Upper Grande Ronde juvenile Chinook Salmon Emigrant Abundance Estimates (1992-026-04).</td></tr>
<tr><td>Catherine Creek</td><td>Fish-In: 1998-007-03 Grande Ronde Supplementation O&M on Catherine Creek/upper Grande Ronde River; 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead; and 2009-004-00: Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators.

Fish-Out: 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead; and 2009-004-00: Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators.</td><td>1998-007-03; 1992-026-04, and 2009-004-00 conducted redd surveys. Juvenile production monitoring was implemented by 1992-026-04 and 2009-004-00.</td></tr>
</table>

<table>
<tr><th>ESU/DPS</th><th>MPG</th><th>Population</th><th>Projects</th><th>Implementation Assessment</th></tr>
<tr><td></td><td></td><td></td><td></td><td>
<table>
<tr><th>Stream and MY</th><th>Population estimate</th></tr>
<tr><td>Catherine Creek</td><td></td></tr>
<tr><td>1995</td><td>17,633</td></tr>
<tr><td>1996</td><td>6,857</td></tr>
<tr><td>1997</td><td>4,442</td></tr>
<tr><td>1998</td><td>9,881</td></tr>
<tr><td>1999</td><td>20,311</td></tr>
<tr><td>2000</td><td>23,991</td></tr>
<tr><td>2001</td><td>21,936</td></tr>
<tr><td>2002</td><td>23,362</td></tr>
<tr><td>2003</td><td>34,623</td></tr>
<tr><td>2004</td><td>64,012</td></tr>
<tr><td>2005</td><td>56,097</td></tr>
<tr><td>2006</td><td>27,218</td></tr>
<tr><td>2007</td><td>13,831</td></tr>
<tr><td>2008</td><td>26,151</td></tr>
<tr><td>2009</td><td>21,674</td></tr>
<tr><td>2010</td><td>43,635</td></tr>
<tr><td>2011</td><td>12,594</td></tr>
</table>
Figure 65. Catherine Creek juvenile Chinook Salmon Emigrant Abundance Estimates (1992-026-04).</td></tr>
<tr><td rowspan="3">Upper Columbia Spring Chinook</td><td rowspan="3">Upper Columbia</td><td>Wenatchee</td><td>Fish-In: 2003-017-00 ISEMP.
Fish-Out: 2003-017-00 ISEMP,</td><td>See RPA Subaction 50.4</td></tr>
<tr><td>Entiat</td><td>Fish-In: 2003-017-00 ISEMP,
Fish-Out: 2003-017-00 ISEMP.</td><td>See RPA Subaction 50.4</td></tr>
<tr><td>Methow</td><td>Fish-In: 2003-017-00 ISEMP, and 2010-034-00 Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring.
Fish-Out: 2003-017-00 ISEMP.</td><td>See RPA Subaction 50.4</td></tr>
<tr><td>Snake River Fall Chinook</td><td></td><td></td><td>Fish-In: 2002-032-00 Snake River Fall Chinook Salmon Life History Investigations.
Fish-Out: 2002-032-00 Snake River Fall</td><td>RRS and productivity monitoring required in RPA Actions 64 and 65. New monitoring to be implemented in 2013 to increase Parental Based tagging and assessments of abundance.</td></tr>
</table>

ESU/DPS	MPG	Population	Projects	Implementation Assessment
			Chinook Salmon Life History Investigations.	
Lower Columbia Chinook	Gorge	Hood	Fish-In: 1988-053-03 Hood River Production M&E-Warm Springs, 1988-053-04 Hood River Production M&E-ODFW, and 1988-053-08 Hood River Production O&M and Powerdale. Fish-Out: 1988-053-03 Hood River M&E-Warm Springs, and 1988-053-08 Hood River Production O&M and Powerdale.	These projects were maintained to support existing adult and juvenile monitoring to meet the requirement of this RPA. The removal of the Powerdale dam did lower the precision of the monitoring in the Hood Chinook, but overall the monitoring is sufficient to meet the RPA requirements.
				**Steelhead** The Taurus Portfolio of BPA work elements that support this RPA are included in this link *http://www.cbfish.org/Map.mvc/Index/Portfolio/1370.* **Figure 66. Map of BPA RME Steelhead Monitoring Worksites that Support this RPA with Steelhead Populations Marked in Blue.** Note: Locations outside population boundaries relate to marking/tagging efforts supporting this RPA. Also In the John Day and Grande Ronde Each Point represents 25 Rotating sites (Actual sites are being sent BPA for integration into the tracing tools.
Snake River Steelhead	Clearwater	Lolo Creek	Fish-In: 2003-017-00 ISEMP, 1983-350-03 Nez Perce Tribal Hatchery M&E and 2010-038-00 Lolo Creek Permanent Weir. Fish-Out: 1983-350-03 Nez Perce Tribal Hatchery M&E.	As identified in RPA Subaction 50.5 ISEMP supported installation of the Lolo Creek PIT-Tag arrays while 1983-350-00 conducted adult and juvenile abundance data collection and analysis. Pending NEPA review the Lolo Creek weir should be approved to improve the precision of monitoring of Lolo Creek Steelhead.
	Salmon	Lemhi River	Fish-In: 2003-017-00 ISEMP, and 1991-073-00 Idaho Natural Production M&E. Fish-Out: 2003-017-00 ISEMP, and 1991-073-00 Idaho Natural Production	See RPA Subaction 50.4.

<table>
<tr><th>ESU / DPS</th><th>MPG</th><th>Population</th><th>Projects</th><th>Implementation Assessment</th></tr>
<tr><td></td><td></td><td></td><td>M&E.</td><td></td></tr>
<tr><td></td><td></td><td>South Fork</td><td>Fish-In: 2003-017-00 ISEMP, and 1991-073-00 Idaho Natural Production M&E.

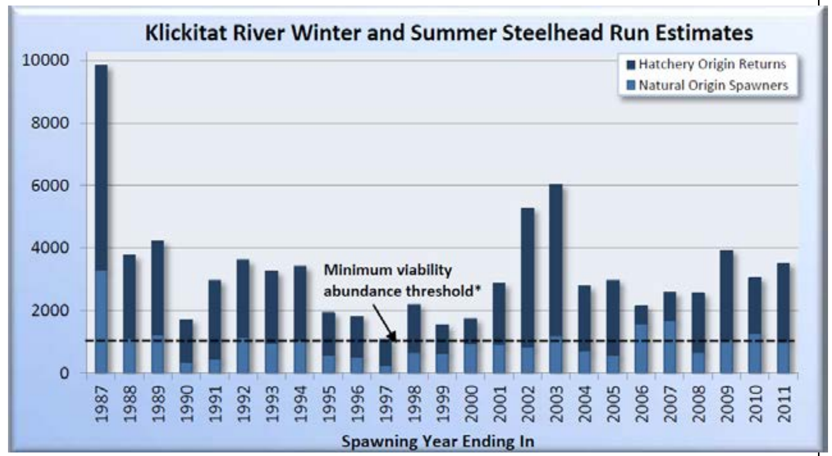
Fish-Out: 2003-017-00 ISEMP, and 1991-073-00 Idaho Natural Production M&E.</td><td>See RPA Subaction 50.4.</td></tr>
<tr><td></td><td>Lower Snake</td><td>Asotin</td><td>Fish-In: 2003-017-00 ISEMP, 2002-053-00 Asotin Creek Salmon Population Assessment, and 2010-028-00.

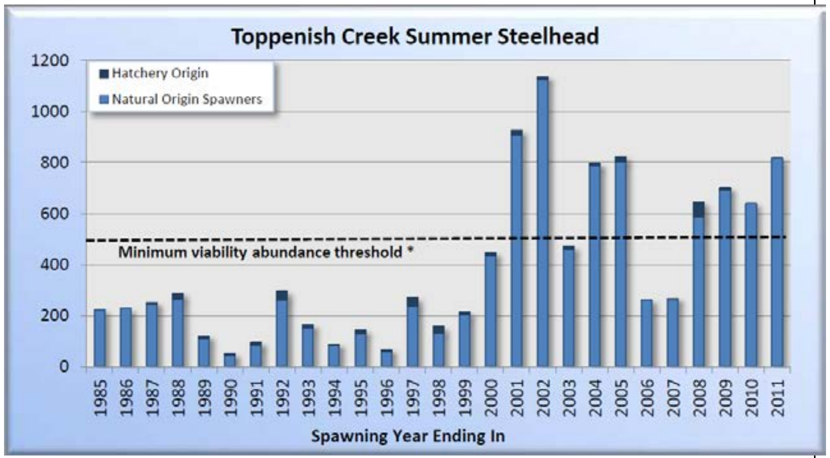
Fish-Out: was supported by existing LSRCP monitoring and 2010-042-00 Tucannon Expanded PIT-Tagging.</td><td>As Identified in RPA Subaction 50.5 using the PIT-Tag Array ISEMP supported 2002-053-00 and 2010-028-00 in conducting adult escapement concluding “A summary of project data collected to date is included: eight years of adult steelhead data (2005–2012) and nine years of juvenile steelhead data (2004–2012). These data continue to describe a persistent, wild steelhead population that is variably affected by adult hatchery strays, but remains substantial for a subbasin of its size when compared to other steelhead populations in the Columbia Basin. The entire Asotin Creek steelhead population could be at or above Viable Salmonid Population abundance (VSP).” while Fish-Out was supported by existing LSRCP monitoring and new tagging in 2010-042-00.
<table>
<tr><th>Year</th><th>N Captured</th><th>N Hatchery Captured</th><th>% Hatchery Captured</th><th>Wild Estimate (95%CI)</th><th>Hatchery Estimate</th><th>% Hatchery Spawners</th><th>% Wild Spawners</th></tr>
<tr><td>2005</td><td>513</td><td>38</td><td>7.41%</td><td>611(568-669)</td><td>41</td><td>6.29%</td><td>93.71%</td></tr>
<tr><td>2006</td><td>474</td><td>41</td><td>8.65%</td><td>509(479-524)</td><td>46</td><td>8.29%</td><td>91.71%</td></tr>
<tr><td>2007</td><td>294</td><td>53</td><td>18.03%</td><td>284(277-294)</td><td>60</td><td>17.49%</td><td>82.51%</td></tr>
<tr><td>2008</td><td>350</td><td>64</td><td>18.29%</td><td>300*</td><td>20</td><td>6.25%</td><td>93.75%</td></tr>
<tr><td>2009</td><td>393</td><td>37</td><td>9.41%</td><td>363*</td><td>12</td><td>3.20%</td><td>96.80%</td></tr>
<tr><td>2010</td><td>1,180</td><td>98</td><td>8.30%</td><td>1,411(1,335-1,463)</td><td>7</td><td>0.49%</td><td>99.51%</td></tr>
<tr><td>2011</td><td>1,010</td><td>51</td><td>5.05%</td><td>1,128(1,095-1,182)</td><td>4</td><td>0.35%</td><td>99.65%</td></tr>
<tr><td>2012</td><td>392</td><td>45</td><td>11.22%</td><td>915(701-1,273)</td><td>15</td><td>1.60%</td><td>98.40%</td></tr>
<tr><td>Average</td><td>576</td><td>53</td><td>10.74%</td><td>690</td><td>26</td><td>5.48%</td><td>94.52%</td></tr>
</table>
Values marked with * are considered minimum estimates.

Figure 67. Estimate Adult Steelhead Abundance in Small Streams Associated with Asotin Populations. (2002-053-00).</td></tr>
<tr><td></td><td>Grande Ronde</td><td>Upper Grande Ronde</td><td>Fish-In: 2003-017-00 ISEMP, and 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead.

Fish-Out: 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead.</td><td>1998-007-03; 1992-026-04, and 2009-004-00 conducted redd surveys, ISEMP supported the installation of PIT-Tag interrogation systems to support adult escapement assessments. Juvenile production monitoring was implemented by 1992-026-04 and 2009-004-00.</td></tr>
</table>

ESU/DPS	MPG	Population	Projects	Implementation Assessment
	Imnaha	Imnaha	Fish-In: 2003-017-00 ISEMP, and 2010-032-00 Imnaha River Steelhead Status Monitoring. Fish-Out: 1997-015-01 The Imnaha River Smolt Monitoring.	ISEMP installed PIT-tag arrays to support adult escapement estimates while projects 2010-032-00 and 1997-015-01 projects implemented adult and juvenile assessments. "We also calculated escapement of the upper Imnaha steelhead aggregate from unique tag detections of the ISEMP tag groups at IR3 and the detection efficiency of the IR3 array. We estimated 133 tagged steelhead crossed over the IR3 site in 2011. We then applied the 2011 Lower Granite Dam time inclusive actual tagging rate ratio of 0.097 queried at the DART PIT-tag Adult Sampling and Tagging at Ladder site (http:/www.cbr.washington.edu/dart/pit_adult_valid.html). Therefore, the escapement estimate for upper Imnaha adult steelhead in 2011 was determined to be 1,371." (2010-032-00 Annual Report).
Upper Columbia Steelhead	Upper Columbia	Wenatchee	Fish-In: 2003-017-00 ISEMP, 2010-034-00 Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring. Fish-Out: 2003-017-00 ISEMP.	ISEMP Installed PIT-tag arrays and in conjunction with existing state and tribal monitoring met monitoring requirements for this RPA. See RPA Subaction 50.4 for more results.
		Entiat	Fish-In: 2003-017-00 ISEMP. Fish-Out: 2003-017-00 ISEMP.	ISEMP Installed PIT-tag arrays and in conjunction with existing state and tribal monitoring met monitoring requirements for this RPA. See RPA Subaction 50.4 for more results.
		Methow	Fish-In: 2003-017-00 ISEMP, 2010-034-00 Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring. Fish-Out: 2003-017-00 ISEMP.	ISEMP Installed PIT-tag arrays and in conjunction with existing state and tribal monitoring met monitoring requirements for this RPA. USGS, through Reclamation funding and management, installed numerous PIT-tag arrays and operated a screw trap to monitor juvenile out-migrating fish. See RPA Subaction 50.4 for more results.
		Okanogan	Fish-In: 2003-022-00 Okanogan Basin Monitoring and Evaluation Program (OBMEP) and 2010-034-00 Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring. Fish-Out: 2003-022-00 (OBMEP) and 2010-034-00 Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring.	In conjunction with other WDFW monitoring, OBMEP and 2010-034-00 supported Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring for this RPA. See RPA Subaction 50.4 for more results.

ESU/DPS	MPG	Population	Projects	Implementation Assessment
Middle Columbia Steelhead	Eastern Cascades	Klickitat River	Fish-In: 1995-063-35 Klickitat River M&E-Yakima/Klickitat Fisheries Project (YKFP). Fish-Out: 1995-063-35 Klickitat River M&E YKFP.	 **Figure 68. Klickitat Steelhead Adult Abundance Estimates from BPA's STAR Project (2009-002-00) Based on Data from 1995-063-35.** Existing monitoring was maintained to support fish installation of the fishways at Lyle and Castile Falls and further improved fish out monitoring to meet the requirements of the RPA.
		Fifteen Mile	Fish-In: 2003-017-00 ISEMP, and 2010-035-00Abundance, Productivity and Life History of Fifteenmile Creek Winter Steelhead. Fish-Out: 2010-035-00 Abundance, Productivity and Life History of Fifteenmile Creek Winter Steelhead.	ISEMP Installed a mainstem PIT-Tag array while 2010-035-00 installed additional arrays and conducted high precision adult and Juvenile monitoring.

ESU/DPS	MPG	Population	Projects	Implementation Assessment
	Yakima	Toppenish	Fish-In: 1996-035-01 Yakama Reservation Watershed Project, 1995-063-25 Yakima River M&E YKFP and 2010-030-00 Project to provided VSP Estimates for Yakima Steelhead MPG. Fish-Out: 1995-063-35 Klickitat River M&E YKFP).	 **Figure 69. Toppenish Creek Steelhead Adult Abundance Estimates from BPA's STAR Project (2009-002-00) Based on Data from 2010-030-00 and 1995-063-25.** *https://pisces.bpa.gov/release/documents/DocumentViewer.aspx?doc=P126573*
	John Day	Lower Mainstem	Fish-In: 2003-017-00 ISEMP, 1998-016-00 Escapement and Productivity of Spring Chinook and Steelhead. Fish-Out: 1998-016-00 Escapement and Productivity of Spring Chinook and Steelhead.	ISEMP supported the development of the GRTS design and juvenile sampling in the middle fork with bridge creek while 1998-016-00 implemented adult abundance assessments and supplemented ISEMPs juvenile monitoring to be representative of the John Day Basin. See RPA Subaction 50.4 for more details.
		North Fork		
		Upper Mainstem		
		Middle Fork		
		South Fork		
	Umatilla/Walla Walla	Umatilla	Fish-In: 1990-005-00 Umatilla Hatchery M&E, and 1990-005-01 Umatilla Basin Natural Production M&E. Fish-Out: 1989-024-01 Evaluate Umatilla Juvenile Salmonid Outmigration, and 1990-005-00 Umatilla Hatchery M&E and 1990-005-00 Umatilla Hatchery M&E.	Improvements were made to the trapping facility to enumerate wild production in project 1989-024-01, while 1990-005-00 and 1990-005-01 were maintained to support existing adult and juvenile monitoring to meet the requirement of this RPA.
Lower Columbia	Gorge	Upper Gorge WA	Increased PIT-tag Arrays and Smolt Traps to assess adult and juvenile	Increased PIT-tag Arrays and Smolt Traps to assess adult and juvenile

ESU/DPS	MPG	Population	Projects	Implementation Assessment
Steelhead		(Wind and Hamilton)	abundance and productivity.	abundance and productivity.
Coho Salmon				
Lower Columbia Coho	Gorge	Upper Gorge WA (Wind and Hamilton)	No project has been funded.	After the ASMS, no action was proposed to BPA to support this by WDFW. Additional work on the Integrated Status and Trends Monitoring (ISTM) project by Pacific Northwest Aquatic Monitoring Partnership (PNAMP) was to occur and may have provided new direction but at this time no action is being taken.
Sockeye Salmon				
Snake River Sockeye	Snake River Sockeye	Red Fish Lake	Fish-In: 2007-402-00 Snake River Sockeye Captive Propagation. Fish-Out: 2007-402-00 Snake River Sockeye Captive Propagation.	Snake River Sockeye Captive Propagation supported fish in and Fish out monitoring for this RPA.

BPA Project 1996-019-00 (Data Access in Real Time): Supported multiple populations of this RPA through creation of software to analyze PIT-Tag Data systems. Without this customized software, sponsors would have a difficult time synthesizing PIT-Tag data for adult escapement. See RPA Subaction 50.5 and RPA Action 72 for additional details on how the tools developed supported implementation of this RPA.

In addition several BPA projects provide ancillary harvest related information used in run reconstruction to assess adult productivity. These include projects:

1982-013-01	Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)
1982-013-02	Coded Wire Tag-Oregon Department of Fish and Wildlife (ODFW)
1982-013-03	Coded Wire Tag-US Fish and Wildlife Service (USFWS)
1982-013-04	Coded Wire Tag-Washington Department of Fish and Wildlife (WDFW)
1987-127-00	Smolt Monitoring by Non-Federal Entities
2002-060-00	Nez Perce Harvest Monitoring on Snake and Clearwater Rivers
2010-036-00	Lower Columbia Coded Wire Tag (CWT) Recovery Project

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

Overall abundance of natural origin Salmonids improved for monitored populations from 2008-2011 as documented in the population assessment section in section 1 of the Comprehensive Evaluation. These increases moved the populations and ESUs further away from AMIP Trigger thresholds since the FCRPS BiOp was published in 2008.

Lessons Relative to RM&E Implementation

Fifteen Mile Creek: Based on preliminary data, the Winter-Run portion of this population (a basis for prioritizing this population over others) may be nonexistent. However the low cost and high precision for monitoring this population still provides a possible justification to continue monitoring this population to support this RPA. Additional review of the alternative Klickitat population will help verify if the Klickitat monitoring program meets the level of precision recommended to support this RPA for the East Cascade Slope MPG.

Lower Snake River Steelhead (Asotin): In addition to habitat restoration and protection actions, data collected by the project shows the need for more adaptive management of hatchery origin fish in the Lower Snake River. Although absolute numbers of hatchery origin fish captured at project weirs have been variable every year, hatchery origin fish have always made up at least 5 percent of the total captured at the Asotin Creek weir.

Yankee Fork and Pahsimeroi River: The confidence levels of monitoring associated with these populations are believed to be sufficient to support the MPG requirements but were not evident in the report. Population monitoring requirements for these populations should be clarified with the ongoing habitat restoration priorities in lieu of monitoring in the Lemhi River, which already meets the intent of the RPA.

Upper George Coho: Further discussion with NOAA Fisheries regarding the Action Agencies responsibility and feasibility to monitor this population is required.

Standardization of data and access to results in data systems delay communication for results. Additional work under RPA Actions 71 and 72 is needed to improve timeliness of tributary abundance data.

PNAMP Integrated Status and Trends Monitoring (ISTM) project developed precision and bias criteria for their review of fish population data in the lower Columbia River. The application of these criteria to all fish population monitoring projects is planned to further support this RPA subaction.

RPA Subaction 50.7 – *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).*

The strategy for the RPA subaction is to continue to work with regional agencies on the importance of high, known mark rates, and to require better reporting of hatchery fish mark rates to better assess where there may be deficiencies or issues that need to be addressed.

Major Accomplishments and Findings

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

Major Lessons Learned

Marking rates should be reported and tracked more closely to insure appropriate marking is taking place as needed.

RPA Subaction 50.8 – *Report available information on population viability metrics in annual and comprehensive evaluation reports. (Initiate in FY 2008).*

Major Accomplishments and Findings

The Action Agencies continued to support the reporting of available population viability metrics to NOAA Fisheries to facilitate population viability assessments. BPA participated and supported the Coordinated Assessments Project working with fishery management co-managers and NOAA Fisheries 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.

Major Lessons Learned

Standardized and timely annual reporting, with synthesis of key results relative to management questions and RPAs, is essential for annual and comprehensive FCRPS BiOp reporting.

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).*
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).*
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).*

RPA Subaction 51.1 – *Support the coordination, data management, and annual synthesis of fish population metrics through Regional Data Repositories and reports. (Annually).*

See RPA Subactions 72.1, 72.2 and 72.3.

RPA Subaction 51.2 – *Facilitate and participate in an ongoing regional RM&E collaboration process to develop a regional strategy for status and trend monitoring for key ESA fish populations.*

See RPA Subaction 50.6.

RPA Subaction 51.3 – *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).*

See RPA Subactions 71.3, 71.4, 72.1, and 72.3.

RME Strategy 2 (RPA Actions 52-55)

RPA Action No.	Action	Comprehensive Evaluation
RME Strategy 2		
52	Monitor and Evaluate Fish Performance within the FCRPS	The evaluation will include information from these actions.
53	Monitor and Evaluate Migration Characteristics and River Condition	The evaluation will include information from these actions.
54	Monitor and Evaluate Effects of Configuration and Operation Actions	The evaluation will include information from these actions.
55	Investigate Hydro Critical Uncertainties and Investigate New Technologies	The evaluation will include information from these actions.

A comprehensive list of all actions implemented by the Action Agencies for RPA Actions 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.*
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.*
3. *Monitor and evaluate adult salmonid system survival upstream through the FCRPS.*
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.*
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.*
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).*
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.*

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.*

RPA Subaction 52.1 – *Monitor and evaluate salmonid dam survival rates for a subset of FCRPS projects. (Evaluate dam survival in terms of the stated standards; 96% for spring migrants and 93% for subyearling Chinook).*

Major Accomplishments and Findings

Multiple dam survival studies were carried out during the 2008–2012 implementation period. In 2009, under the Corps' AFEP program, a new multi-dam experimental design was developed that substantially reduced costs and provided statistically robust survival estimates.

Several tests were carried out in 2010. At John Day Dam, an evaluation of 30 percent and 40 percent spill treatments was conducted. Other changes in configuration included relocating SWs from bays 15 and 16 to bays 18 and 19, construction of an extended-length flow deflector in bay 20, and completion of the avian predation deterrent array over the tailrace. At Bonneville Dam, a dam passage survival evaluation was conducted for spring migrants, and an evaluation of two spill treatments was conducted for summer migrants (24-hour 95 kcfs and 85 kcfs daytime/TDG nighttime spill). The first year of juvenile salmon dam passage performance standard testing was conducted at The Dalles Dam. The experimental design and virtual/paired release survival model developed and reviewed in 2009 was utilized to estimate survival for spring and summer migrants passing The Dalles Dam during 40 percent spill operations.

During 2011, studies to evaluate compliance with the Juvenile Salmon Dam Passage Performance Standards were conducted at John Day, The Dalles, and Bonneville dams. These studies made use of the experimental design and virtual/paired release survival model developed and independently reviewed in 2009. The summer portion of the study was postponed until 2012 due to high flows at all three dams. At John Day Dam, 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 dams. While spill at The Dalles Dam also increased above the 40-percent target spill level after mid-May, the average during the entire spring study period was 42 percent.

In 2012, studies to evaluate compliance with the Juvenile Salmon Dam Passage Performance Standards were conducted at Little Goose, Lower Monumental, McNary, John Day, The Dalles, and Bonneville dams. Similar to previous years these studies utilized the virtual/paired release survival model and standardized methodologies developed for implementation of compliance studies. At Little Goose Dam a first year of compliance testing was conducted at a target spill operation of 30 percent spill for yearling Chinook salmon, juvenile steelhead and subyearling Chinook salmon. At Lower Monumental Dam a first year of testing was conducted at a target operation of TDG spill during the spring for yearling Chinook salmon and juvenile steelhead and at 21 kcfs spill during the summer for subyearling Chinook salmon. At McNary Dam a first year of compliance testing was conducted at a target operation of 40 percent spill for spring migrants and 50 percent spill for summer migrants. At John Day Dam a second year of compliance testing was conducted at target operations of 30 and 40 percent spill for both spring and summer migrants. At The Dalles Dam a second year of compliance testing was conducted at a target operation of 40 percent spill for summer migrants. At Bonneville Dam a first year of compliance testing was conducted at target operations of 24-hour 95kcfs spill and 85kcfs daytime/121 nighttime spill. High river flows led to involuntary spill for part of the season and average daily spill operations were higher than the targets for some projects. However both John Day and The Dalles dams were able to maintain average daily spill operations within the target range of planned spill operations.

Additional information on survival rates from testing at FCRPS projects is provided under RPA Actions 18 through 25 above, and under RPA Action 54.

Major Lessons Learned

Performance standard test results to date indicate that the configuration and operation actions completed to improve juvenile fish survival at FCPRS mainstem dams are generally providing survival benefits either equal to or greater than what was projected in the FCRPS BiOp. (See figures 9, 13, 17, 21, 25, 29 and 33 in the coverage of RPA actions 18-24.) Providing spill, implementing surface passage, improving screened juvenile bypass systems, etc. are collectively showing that the performance standards of 96 percent survival of juvenile spring migrants and 93 percent survival of summer migrants can and will be achieved.

RPA Subaction 52.2 – *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.*

Major Accomplishments and Findings

The RPA is directed at investigations that systematically calculate and report annual survival estimates for the purpose of tracking FCRPS effects over an extended monitoring history. Two projects directly estimated in-river survival rates and relative rates of adult returns, which may, in part, reflect differential delayed mortality associated with transportation (D). Studies directed at evaluating the effects of transporting smolts, particularly as compared to in-river migrants, are discussed under RPA Subaction 55.1.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams): NOAA Fisheries produced annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT-tagged hatchery and wild groups. The project estimated the fraction of transported run-of-river juveniles, and the overall hatchery fraction. The PIT-tag detection trawl vessel below Bonneville Dam, used to improve detection rates below the dam, is coordinated by the Corps and BPA. NOAA Fisheries provides annual updates to the historical record for smolt survival for in-river migrants traversing the FCRPS (Figures 70). These are calculated for the composite wild and hatchery populations of spring-summer Chinook and steelhead. On balance, survival in recent years has been among the highest estimated since 1964, when only Ice Harbor Dam was present on the Snake River. More recently, estimates for sockeye salmon have been calculated and reported (Table 49). Since 2006, the estimated survival for in-river migrating sockeye from Lower Granite Dam to Bonneville Dam has generally been consistent with estimates obtained for Chinook and steelhead. For upper Columbia River ESUs, a more limited data set is available (Table 49). Over the last decade, smolt survival from McNary Dam to Bonneville Dam has averaged 75.2 percent for hatchery Chinook and 71.5 percent for steelhead. NOAA Fisheries does not regularly tabulate annual estimates of delayed differential mortality (D), or report total system survival for in-river and transported smolts. Appropriate estimates of either D, or Transport In-river Ratios (T:I), are required to calculate total system survival with adjustment for delayed transportation effects. However, studies directed specifically at evaluating the effects of transportation do provide more focused estimates of D. Discussion of those projects and findings appear in RPA Subaction 55.1.

Table 49. Estimated Survival for Juvenile Sockeye and Upper Columbia River Chinook Salmon and Steelhead. Standard errors in parentheses. Estimates in some years were of low quality or were not possible due to small sample sizes and low detection probabilities. Steelhead estimates were not possible prior to 2003. Simple arithmetic means. Data from Faulkner et al., (2012).

Year	Snake River Sockeye (Hatchery and Natural Origin) Lower Granite Tailrace to Bonneville Tailrace	Upper Columbia River Sockeye (Hatchery and Natural Origin) McNary Tailrace to Bonneville Tailrace	Upper Columbia River Yearling Chinook (Hatchery) McNary Tailrace to Bonneville Tailrace	Upper Columbia River Steelhead (Hatchery) McNary Tailrace to Bonneville Tailrace
1999	0.548 (0.363)	0.683 (0.177)	0.712 (0.113)	NA
2000	0.161 (0.080)	0.894 (0.867)	NA	NA
2001	0.022 (0.005)	NA	NA	NA
2002	0.342 (0.212)	0.286 (0.110)	0.817 (0.041)	
2003	0.405 (0.098)	NA	0.879 (0.031)	0.871 (0.036)
2004	NA	1.246 (1.218)	0.618 (0.038)	0.823 (0.088)
2005	NA	0.226 (0.209)	NA	0.674 (0.057)
2006	0.820 (0.454)	0.767 (0.243)	0.871 (0.198)	0.733 (0.134)
2007	0.272 (0.073)	0.642 (0.296)	0.730 (0.080)	0.587 (0.059)
2008	0.404 (0.179)	0.679 (0.363)	0.626 (0.133)	NA
2009	0.573 (0.073)	0.958 (0.405)	0.895 (0.116)	0.756 (0.105)
2010	0.544 (0.077)	0.627 (0.152)	0.735 (0.037)	0.626 (0.033)
2011	NA	0.691 (0.676)	0.637 (0.077)	0.651 (0.119)
Mean	**0.388 (0.069)**	**0.780 (0.112)**	**0.752 (0.034)**	**0.715 (0.035)**

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) has evaluated in-river survival and delayed transport effects for smolts on an annual basis. In-river survival estimates are consistent with those reported by NOAA Fisheries. They do not report estimates of total system survival for both in-river and transported migrants, even though they regularly report indices of delayed transport effects in the annual reports. Estimates of season-wide benefit of transport (T:I Lower Granite Dam-to-Lower Granite Dam) remain consistently higher for hatchery yearling Chinook than for cohorts of wild Chinook migrating from the Snake and upper Columbia rivers between 2005-2010. The season-wide T:I ratio fell below 1.0 for wild yearling Chinook migrating in 2006. Wild and hatchery steelhead displayed a greater benefit of transport than yearling Chinook for the 2000-2010 juvenile cohorts, although the season-wide T:I ratio of SARs fell below 1.0 for wild steelhead in 2006. Several hatcheries have average T:I ratios which are consistently higher or lower than the average for the region.

BPA Project 1989-107-00 (Statistical Support for Salmon): The Columbia Basin Research group at the University of Washington evaluated performance standards, and distributed data describing smolt survival, travel time, capture probability, and compliance with TDG and temperature targets at major projects, as well as SAR and smolt system survival by release year. The ROSTER program allows calculation of differential mortality among transported vs. in-river migrant tagged groups from a variety of tributary sites. Their interactive website shows recent results and historical analyses of smolt survival, SARs, T:I ratios, and differential mortality rates based on FCRPS PIT-tag data. *http://www.cbr.washington.edu/trends/roster.php*

BPA Project 2003-114-00 (Coastal Ocean Acoustic Salmon Tracking (COAST)), involved a multiyear experimental evaluation of differential post-Bonneville survival. Detection rates of barged and in-river groups of yearling Chinook originating from Columbia and Snake River hatcheries were compared at acoustic telemetry arrays at the Columbia River mouth and northern coastal sites. No significant difference in survival rates was seen as far away as northern Vancouver Island during the four years of the study for in-river tag groups from the upper Snake vs. Yakima. Barge transported smolts had lower survival rates than in-river smolts in ocean segments in year 2011, but not among 2006, 2008, or 2009 cohorts. There was substantial variation in survival between weekly release groups. It may be worthwhile to explore whether arrival timing in the ocean, or injury rate and other aspects of fish condition may best explain this differential survival rate.

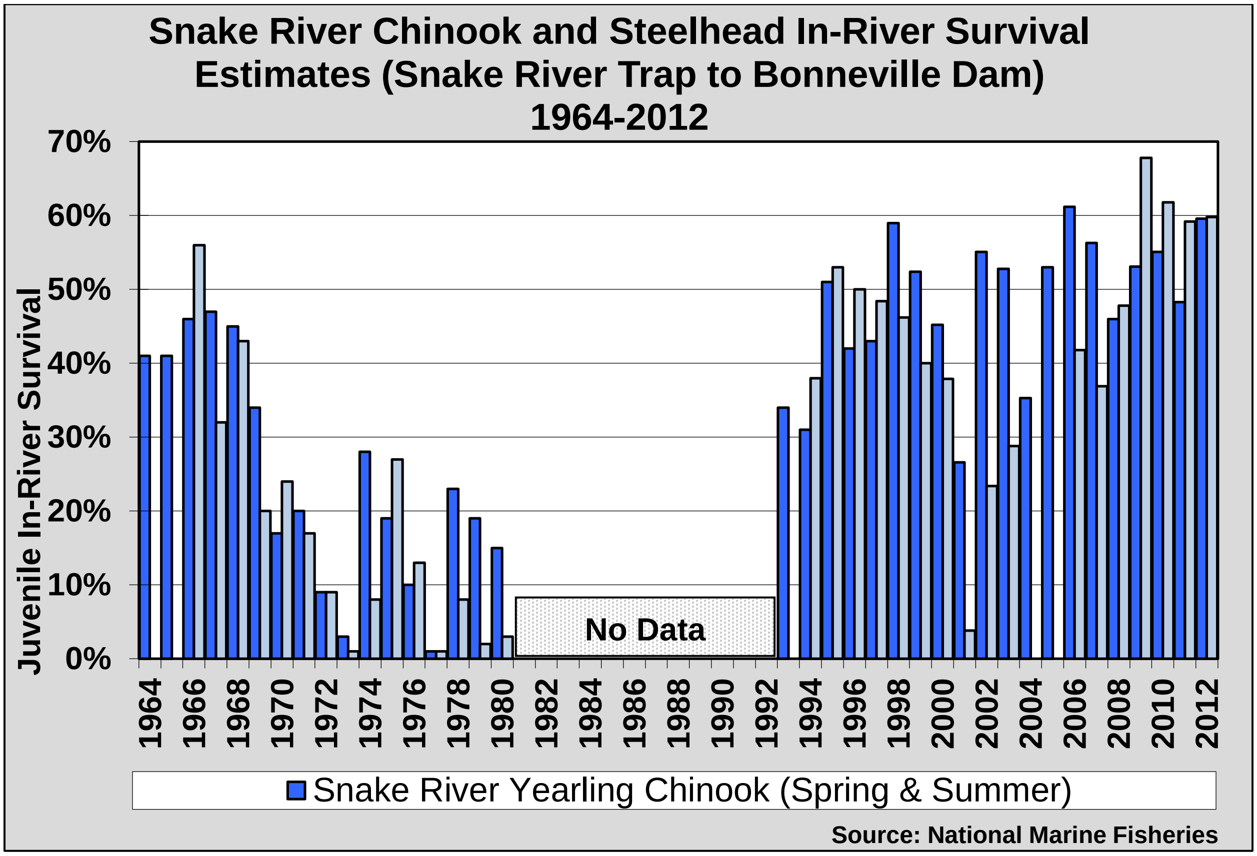


Figure 70. In-River Survival Estimates (Hatchery and Wild Combined) for Snake River Spring-Summer Chinook and Snake River steelhead. Steelhead estimates for 2004 and 2005 are not available due to low PIT-tag detection efficiency at Bonneville dam. Survival estimates are not available for 1981 through 1992. Estimates for 2012 are preliminary numbers and subject to change.

The Corps commissioned a synopsis and literature review of differential delayed mortality (*D*), which also identified critical uncertainties. The Corps then 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* (See RPA Subactions 55.1 and 55.3 for expanded discussion). Better understanding of the interaction of factors affecting *D* through this report and additional research could improve real-time decisions about when, where, and which species of juvenile migrating salmon or steelhead to barge.

In 2008, the Corps commissioned a study (Eder et al., 2009) to assess differential mortality of transported and in-river yearling Chinook salmon in the LCRE using Juvenile Salmon Acoustic Transmitters (JSATS) acoustic tags and concomitant detection arrays. The extent of differential mortality was assessed in terms of the Barge to In-River Survival Ratio (BI ratio) in the LCRE; and the health of barged and in-river out-migrant yearling Chinook salmon was assessed by characterizing the extent and putative causes of mortality of fish held in net pens located at Tongue Point (fresh water site) and Sand Island (salt water site), suggesting that both barged and in-river fish may have higher mortality under extended freshwater residence time. The lowest survival for both barged and in-river fish in the LCRE occurred between rkm 35.6 and 8.3, a location representing both the furthest point of saltwater intrusion into the estuary and the nesting location of avian predators. Mean travel times of in-river fish between rkm 202 and 8.3 were consistent, around 2.3 (SE= 0.01) days for the entire outmigration season, whereas for barged fish the values decreased from 7.9 (SE= 0.19) to 3.1 (SE= 0.03) days over the course of the outmigration season. The longer residence times of barged fish may have increased the risk of avian predation: bird predation estimates below Bonneville Dam were considerably higher in barged study fish (5 percent) than in-river study fish (3 percent). The magnitude of cumulative net pen mortality of all groups of fish held at both net pen locations was strongly impacted by net pen location. All groups of fish held at both net pen locations experienced substantially greater mortality during holding at Tongue Point relative to Sand Island, thus suggesting that both barged and in-river fish arrive at Bonneville Dam in a compromised condition that decreases their probability of survival during extended freshwater residence time. Additionally, fish barged early in the outmigration season had a higher incidence of mortality in the net pens than fish barged later in the season. Overall, mycotic infection and metabolic disease were the main causes of mortality in barged fish held in the freshwater net pen site at Tongue Point, and ceratomyxosis was the main cause of mortality in net pen fish with an in-river outmigration history. Net pen findings in this study were consistent with previous AFEP-funded studies.

Major Lessons Learned

Historical patterns of in-river survival calculated and reported by NOAA Fisheries suggest that the mainstem actions implemented since the FCRPS BiOp have been effective at maintaining high survival through the FCRPS. Smolt survival today exceeds levels estimated during the 1960s when far fewer dams comprised the FCRPS.

Over the last decade, ending with the out-migration year 2008, analyses by NOAA and CSS indicate that transported steelhead and spring-summer Chinook generally exhibit higher SARs than counterparts migrating in-river, although one assessment (Haeseker et al., 2012) reported that SARs of wild spring-summer Chinook salmon were similar for transported and in-river migrants. Within a given year, NOAA analyses indicate that during April, in-river-migrating spring-summer Chinook can survive at rates equivalent to, or slightly higher than transported counterparts, but during May the survival advantage is clearly for transported fish. Transported steelhead consistently survive at substantially higher rates than in-river migrants, regardless of the migration date. Only preliminary results for sockeye are in hand, thus they are not treated under this RPA.

In the Snake River, spring-summer Chinook salmon, sockeye salmon, and steelhead migrate seaward during the same time-frame each spring, thus the populations are comingled and FCRPS operations and configurations implemented under the FCRPS BiOp affect all three ESUs in concert. This is an important element when selecting operations that may affect the ESUs differently. We note that data from the most recent years (through 2012) are not yet in hand. Thus, the effects of the current spill program and the full complement of surface bypass systems are not fully reflected in existing evaluations. More complete data will be available during the next FCRPS BiOp period (through 2018), and the Action Agencies will rely on that information to inform future operations. With available data, it is clear steelhead respond better to transport than spring-summer Chinook. Transported yearling Chinook experience high survival in the barges with an average of 98 percent direct survival rate to release (McMichael et al., 2011a) for spring migrants. Importantly, the transported fraction of smolts was at the lowest level in 2011 and 2012 since 1995 (Figure 38 in coverage of RPA 30), due to the emphasis on spill at Snake River dams, the effectiveness of surface passage structures, and the fact that since 2008 the transport start date at Lower Granite Dam has been delayed until May 1 in four out of five years.

RPA Subaction 52.3 – *Monitor and evaluate adult salmonid system survival upstream through the FCRPS.*

Major Accomplishments and Findings

The 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 five-year rolling average of annual system survival estimates. Snake River Chinook and sockeye are used as surrogates for Snake River sockeye and mid-Columbia River steelhead. In 2011, the five-year rolling averages (2007-11) for Snake River fall Chinook and upper Columbia River steelhead surpassed the performance standard, while the five-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 71).

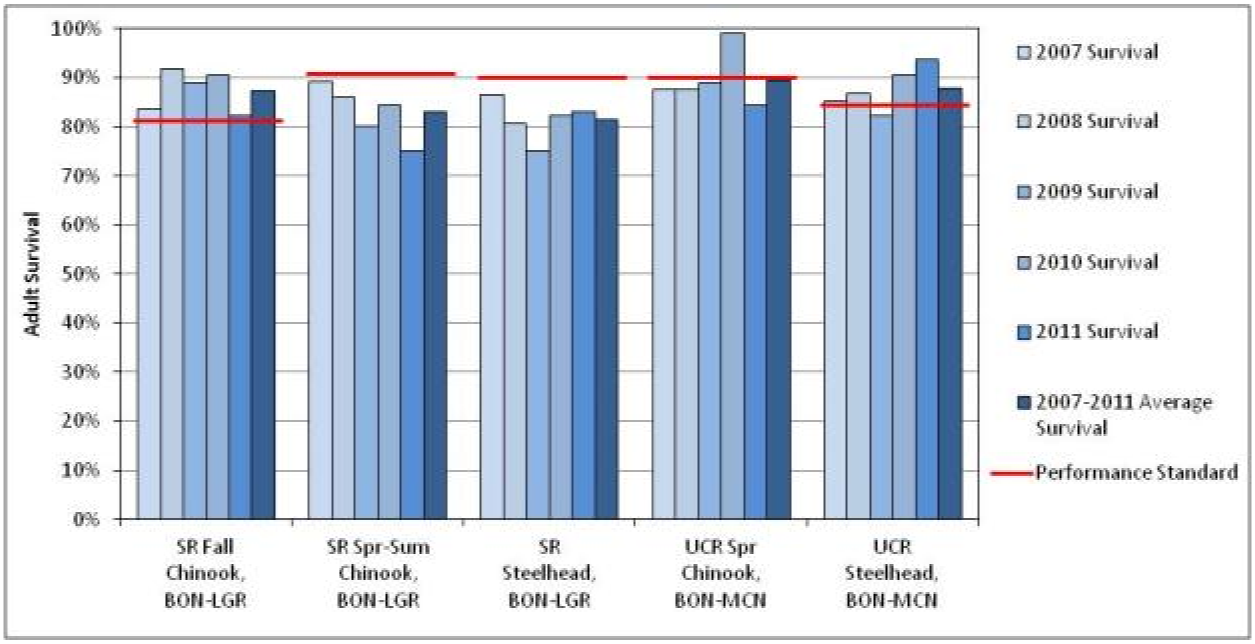


Figure 71. FCRPS BiOp Adult Survival Standard and Five-Year Rolling Average Survival of Adults that Migrated In-River as Juveniles, Based on PIT-Tag Conversion Rates of Snake River (SR) and Upper Columbia River (UCR) ESUs. (BON = Bonneville, MCN = McNary, LGR = Lower Granite).

BPA Project 2008-508-00 (Power Analysis Catch Sampling Rates): This project has four long term objectives: 1) ensure that the sample design and estimation methods for producing tribal catch estimates are statistically valid; 2) make accurate harvest data readily available for decision making; 3) improve the transparency and dissemination of catch estimates, with associated variances; and 4) account for the uncertainty of estimates in management. Short-term objectives are to; 1) observe current sampling methods; 2) document current and historical sampling and estimation methods; 3) improve the sampling scheme, if possible, to maximize precision of estimates under existing funding; and 4) document a formal sampling protocol for future years. Catches in the fall gillnet fishery comprise bright and tule fall Chinook, A and B steelhead, and coho. Fish ticket data do not represent the entire catch due to direct "over-the-bank" sales and subsistence use. Therefore, catch is estimated using creel census techniques, wherein an estimate of catch rate is combined with effort data to estimate total catch of each species and run.

BPA Project 2008-908-00 (FCRPS Water Studies & Passage of Adult Salmon & Steelhead): The objectives of this project are twofold: 1) investigate adult salmon and steelhead passage through the hydroelectric system to validate survival assumptions used in estimating extinction risk and recovery potential, and to determine sources of adult fish mortality; and 2) continue investigations of FCRPS operational rule curves and management options to ascertain the potential benefits to juvenile salmon and steelhead survival of alternative water storage and flow regimes in dry water years.

The NOAA Fisheries Regional Office makes the calculations of adult survival using PIT-tagged adults returning to the Columbia River and reports estimates annually. Estimates reported from 2002 through 2011 are summarized in Table 50.

In recent years (2008-2011), Snake River fall Chinook, and both upper Columbia River ESU's, have exceeded the average survival estimated under the previous FCRPS BiOp era (2002-2007). In contrast, Snake River spring/summer Chinook and Snake River steelhead have been below the 2002-2007 average used in the FCRPS BiOp every year since 2007. As NOAA Fisheries noted in their June 2012 presentation on this topic, the causes for this discrepancy are not known. They may, however, include increased straying or mortality due to increased spill and flow, possible harvest problems, or effects of sea lions below Bonneville Dam.

Table 50. 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. Snake River results are for hatchery and wild fish combined. Upper Columbia River results are for hatchery fish (due to small number of wild fish tagged). Results are adjusted for straying and harvest. Data for Snake River sockeye for 2002-2005 data are not available. 2012 data were not available in time for inclusion in this document.

Year	Snake River Bonneville to Lower Granite				Upper Columbia Bonneville to McNary	
	SR Fall Chinook	SR Spring-Summer Chinook	SR Steelhead	SR Sockeye	UCR Spring Chinook	UCR Steelhead
2002*	79.6%	98.7%	90.5%		90.5%	90.0%
2003	98.6%	92.2%	97.2%		90.9%	91.4%
2004	93.7%	95.7%	95.7%		96.1%	82.0%
2005	71.2%	91.9%	88.3%		89.4%	78.5%
2006	58.8%	82.2%	95.3%	83.2%	86.1%	85.5%
2007	83.5%	89.1%	86.6%	79.1%	87.5%	85.3%
2002-2007 Average	**80.9%**	**91.6%**	**92.3%**	**81.1%**	**90.1%**	**85.5%**
2008	91.9%	86.0%	80.8%	74.9%	87.6%	86.9%
2009	88.8%	80.2%	75.2%	74.9%	88.9%	82.3%
2010	90.6%	84.3%	82.3%	82.8%	99.1%	90.6%
2011	82.4%	75.1%	83.0%	71.4%	84.5%	93.7%
2008-2011 Average	**87.4%**	**81.4%**	**80.3%**	**76.0%**	**90.0%**	**88.4%**

* - incomplete detection at MCN

BPA Project 1991-051-00 (Modeling and Evaluation Statistical Support for Life-Cycle Studies)**:** Columbia Basin Research at the University of Washington support real-time analyses of PIT-tag data to monitor adult passage at Snake and Columbia river dam sites. Daily updates are provided for Chinook salmon, steelhead, coho, and sockeye adult passage since 1994. Predictions and data can be retrieved and independently analyzed using interactive software on the internet (*http://www.cbr.washington.edu*). This project also performs value-added analyses of historical tagging data by testing hypotheses, estimating parameters, and modeling interrelationships without the costs of additional field studies. These life-cycle analyses are being used to characterize the status and trends of steelhead and Chinook salmon in the Columbia River Basin and examine factors influencing return success. Due to restrictions for handling salmonid stocks, the value of retrospective analyses of existing data sets becomes increasingly important. These investigations also provide needed information to perform sample size calculations and to design field investigations more precisely. A series of technical publications on tag analyses have been published to disseminate information learned from these added-value analyses.

BPA Project 2005-002-00 (Lower Granite Dam Adult Trap Operations)**:** see description under RPA Subaction 50.2

Major lessons Learned

The causal agents for the observed decrease in survival in recent years are not known. Therefore, useful mitigation actions cannot be formulated at this time. However, the installation of new PIT-tag detectors in key tributaries, in combination with the planned system at The Dalles Dam, will improve the spatial resolution in the zone where losses are occurring. This will assist in identifying specific locations, and presumably mechanisms, responsible for the low adult passage survival. Candidate factors include harvest, tributary turnoff (straying), and excessive spill volumes.

RPA Subaction 52.4 – *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.*

The Corps PIT-tagged approximately 7,500 juvenile upper Columbia River steelhead annually, from 2009-2012, at Rock Island Dam to improve estimates predation losses by avian predators on this upper Columbia River stock in the Columbia River Basin. Estimates of predation on upper Columbia River stocks and subsequent management actions are further described in RPA Actions 45-47 and 66-68.

Table 51. Number of Juveniles Tagged by Year, Species, and Hatchery/Wild Origin.

Tagging Year vs. Species			
Year	**Chinook**	**Steelhead**	**Total**
2000	72,492	38,700	111,192
2001	117,289	5,039	122,328
2002	512,473	4,824	517,297
2003	599,490	486,941	1,086,431
2004	605,192	488,345	1,093,537
2005	133,590	580,899	714,489
2006	50,058	64,905	114,963
2007	75,620	66,283	141,903
2008	121,541	70,937	192,478
2009	93,305	71,515	164,820
2010	277,252	139,092	416,344
2011	213,944	153,525	367,469
2012	93,155	89,088	182,243
Total	**2,965,401**	**2,260,093**	**5,225,494**
Rearing Type (Hatchery, Wild) vs. Life Stage			
	Parr	**Smolt**	**Total**
H	3,542	4,846,906	4,850,448
W	19,955	355,091	375,046
Total	**23,497**	**5,201,997**	**5,225,494**

The tables above show the number of juveniles tagged by year, species, and hatchery/wild origin. The numbers peaked in 2004, and have averaged about 40,000 fish tagged per year.

BPA Project 2003-017-00 (ISEMP): Additional upper Columbia River salmon were tagged under the ISEMP. See expanded description under RPA Subaction 50.4.

Major Lessons Learned

RME Lessons-The scale of the PIT-tagging effort in the upper Columbia River has been highly variable during the course of the last decade, ranging from tens of thousands to several hundred thousand fish annually depending on the species. On average, wild fish represent about 7 percent of all fish tagged in the last decade.

Management Action Lessons- It is not clear how many tagged fish are required to meet the monitoring needs identified in the FCRPS BiOp because precision criteria have not been specified. The next FCRPS BiOp should explore tradeoffs between the need for information, its quality in terms of precision, and risk to the wild population as associated with negative effects of handling and tagging. Based on that assessment, appropriate tagging levels can be adopted. Alternatively, Snake River ESUs may serve as adequate surrogates for the upper Columbia River as they migrate through the lower Columbia River, the only river segment shared by both ESU complexes. The PIT-Tag Status Report under RPA Subaction 52.6 explores these options in more detail.

RPA Subaction 52.5 – *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.*

Major Accomplishments and Findings

Sockeye outmigrant production increased to allow PIT-tag marking of juvenile sockeye for survival estimation beginning in 2009, which satisfied the test for feasibility. Ability for performing large scale sockeye reach and dam-route passage and survival studies at high precision such as for spring Chinook and steelhead has not been established to date. Monitoring with juvenile and adult sockeye passage behavior has not validated the assumption and working hypothesis in the FCRPS BiOp, that spring Chinook and/or steelhead passage and survival estimate trends could be used as surrogates for sockeye.

Juvenile sockeye salmon were tagged annually from 2009-2012. Approximately 52,000 fish were tagged at Sawtooth Hatchery, and 10,000 fish were tagged at Oxbow Hatchery each year. A portion of the tagged fish were designated for transport so that transport to in-river comparisons could be made. These efforts have provided information on reach survival, travel time, and collection efficiencies; all of which are useful for design of a larger transportation study. Analysis of the first release year's (2009) adult returns suggests that transport was beneficial for Oxbow Hatchery-reared fish and slightly beneficial or neutral for Sawtooth Hatchery-reared fish. These results are important for overall FCRPS management, as many regional salmon managers and Independent Scientific Advisory Board (ISAB) expressed concern and belief that transportation was detrimental to Snake River sockeye salmon, and this provided a significant part of the basis for exercising a "spread the risk" strategy in spill/transport decisions.

Major Lessons Learned

It has proved to be feasible to tag Snake River sockeye in sufficient numbers to yield useful in-river smolt survival estimates from release through the FCRPS.

Management Actions Lessons-NOAA and other fishery agencies are interested in continuing tagging this ESU for long term monitoring. It is anticipated that this will become an ongoing element in the SMP. Furthermore, if sockeye production persists at or exceeds current levels, more comprehensive transportation studies appear feasible. Based on early data from a transport pilot study initiated in 2009, it appears that it may be possible to design and implement informative, long-term transport studies.

RPA Subaction 52.6 – *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. Develop a regional PIT-tagging plan that coordinates efforts across the 4-H's.*

Major Accomplishments and Findings

This goal of the plan was to meet the needs of the FCRPS BiOp, regional Habitat Conservation Plans, and the Fish Accords agreement by improving coordination among user groups and minimizing the effects of tagging on salmon populations. After conferring with regional fishery agencies, NOAA Fisheries and the Action Agencies have revisited and reassessed the need for a regional PIT-tagging plan. The federal family decided that the upcoming Implementation Plan would serve as the vehicle for specifying PIT-tag-related activities that would occur over the next FCRPS BiOp period. With guidance from NOAA Fisheries, the document envisioned under RPA Subactions 52.6 was reformulated as a "status and needs" document addressing options for improving the PTAGIS and specifying the direction and scope of future tagging efforts. The document will be used to inform the Implementation Plan. It is expected to be finished in November 2012. The NPCC Tagging Forum will use that document to complete the PIT-tag component of their effort.

Major Lessons Learned

Continual technological advances in PIT-tag technology and advances in software used to manage the data network create new capabilities for future monitoring of tagged fish through the FCRPS. This ever-changing technological landscape makes it difficult to plot and prescribe a clear course of action for the future PIT-tag system. Accordingly, the PIT-Tag Plan as originally envisioned, has morphed from a prescriptive action plan into a system status and monitoring needs assessment that will inform the next five-year Implementation Plan.

RPA Subaction 52.7 – *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.*

Major Accomplishments and Findings

Project 2008-908-00 – The Colville Confederated Tribes (CCT) initiated an approach to address this sub-action in phases. Phase I was to determine if the current information can determine the mechanisms on why the apparent survival differences between the UCR and SR populations. If the determination was that the current information was sufficient to explain the survival differences, then Phase II would not be necessary. If the current information was not sufficient, then Phase II would develop a study plan to gather the necessary information to determine the mechanisms that affect the survival of the populations differently.

In 2010, a report was completed that satisfied Phase I. This report concluded:

> . . . there does not appear to be a clear understanding of what may be causing differential mortality of UCR fish compared to SR fish. Differences in timing of entry into freshwater and subsequent use of different thermal refuges for steelhead appears to be one potential factor

> (assumes that these fish may be more vulnerable to tributary harvest), but it is unlikely that this would explain the consistent difference in survival observed.
>
> Currently, there are no reliable methods available to segregate the steelhead run at BON into individual DPS's. Additional information pertaining to distinct DPSs would aid in our understanding of the factors that may be affecting survival of steelhead as they pass through the lower Columbia River FCRPS.
>
> Additional information is need in regards to the effects of harvest on total survival of the stocks from the two basins. Because we did find that there is a significant difference between the survival of 1-ocean fish (even though the harvest rate appeared lower) compared to older (larger) members of the same species, the effects of harvest on fish from the two basins is suspected as an important factor in the survival difference, but additional information is needed to verify this.

Peven et al. also recommended:

> Our recommendation is to develop and implement a large-scale telemetry study with known origin fish through the lower Columbia River FCRPS. We also recommend that additional information is collected for harvest to better understand the survival differences between adult fish as they ascend through the lower Columbia River FCRPS, and reiterate the following list to ensure that the appropriate information is collected:
>
> - More DPS/ESU specific rates of harvest by all tribal and non-tribal fishers,
> - Additional information from C&S fisheries in regards to specific ESU/DPS,
> - PIT-tag detection for all fisheries,
> - Increased level of effort (survey) for some fisheries,
> - Increased level of CWT marking for UCR steelhead,
> - CWT tag detections of adipose clipped, non-adipose clipped steelhead and spring Chinook with Treaty and non-Treaty fisheries,
> - Development of similar methods for harvest surveys for Treaty and non-Treaty fisheries, including Catch per Unit Effort (CPUE) and total estimated harvest effort by fishery type (recreational, commercial and ceremonial/subsistence) and harvest method (hook and line, gillnet, hoop net and dip net), and standardized methods of CWT and PIT-tag evaluations of fish harvested (i.e. because not all UCR steelhead and spring Chinook are adipose clipped to indicate CWT, scan all fish encountered in fisheries for presence of CWT and or PIT-tag),
> - Increase the level of creel monitoring effort for Treaty and non-Treaty fisheries in Zone 6.
>
> In addition, we suggest that PIT-tag detectors be installed at John Day and The Dalles dams to ensure that additional information can be gleaned as to where some of the mortality may be occurring.

Based on the conclusion that the current information did not adequately address what mechanisms are affecting survival differently for the populations in the UCR and SR, the CCT began to develop a study plan to gather the information (Phase II).

In early 2012, the CCT met with the Action Agencies and it was recommended that the CCT coordinate with the Studies Review Work Group (SRWG) to investigate whether potential studies being developed through this workgroup could satisfy Phase II. The CCT attended various SRWG meetings to coordinate and see if the scope and objectives for proposed studies could be expanded to determine the mechanisms that affect survival of the UCR and SR fish populations.

Through conversations with the SRWG, it appears that obtaining an adequate sample size of adults at Bonneville Dam adult trap with a known juvenile history currently limits the ability to do a study that will satisfy Phase II.

A known juvenile life history of the adults at Bonneville is one of two key limiting factors to get the study completed. Numerous analyses have shown that the conversion rates of adults that had been transported as juveniles are lower between Bonneville and McNary and Bonneville and Lower Granite dams. Therefore, to make a meaningful comparison with UCR fish, adults that are tagged at Bonneville Dam need to have not been transported as juveniles.

The other factor that limits the ability of doing a study is being able to obtain a robust sample size at Bonneville Dam. The Bonneville WA-side ladder, where the adult trap is located, only samples four hours per day. Whether the sampling time could be extended has not been explored, but regardless, because the number of known-origin fish with juvenile life history information available (PIT-tags) passing Bonneville is so low, even if the sampling period was extended, it does not appear that enough fish could be obtained to implement a robust study.

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

Determining the mechanisms responsible for the apparent survival differences in UCR and SR populations is complicated, and collecting the information could require a large effort. While some of the information that will be collected by the SRWG studies being proposed for 2010 and 2014 will collect some of the information, but many of the variables needed to ensure all of the information is gathered will not be collected.

Lessons Relative to RM&E Implementation

Completely addressing this sub-action will be contingent on increasing the number of fish PIT-tagged in the UCR, and potentially increasing sampling rates at Bonneville Dam. Further coordination among the various stakeholders may still be needed.

RPA Subaction 52.8 – *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.*

Major Accomplishments and Findings

From 2008 through 2012, adult fish counts were conducted, as called for in Table 8 of the RPA, with the following exceptions:

In 2008–2012, at The Dalles, John Day, McNary and Ice Harbor dams, adult fish were counted from April 1 through October 31, rather than the dates shown in Table 8.

In 2009-2012, at Lower Granite Dam, 24-hour counts were conducted from June 15 through September 30, rather than through August 31.

All changes were fully coordinated during development of the FPP and through the FPOM work group process, or both.

Results for 2008–2011 are available in the Annual Fish Passage Reports: Columbia and Snake Rivers, available at the links below. The 2012 report was not available in time for inclusion in this Comprehensive Evaluation.

- *http://cdm16021.contentdm.oclc.org/cdm/singleitem/collection/p16021coll3/id/70/rec/28* (2008).
- *http://cdm16021.contentdm.oclc.org/cdm/singleitem/collection/p16021coll3/id/71/rec/1* (2009).
- *http://cdm16021.contentdm.oclc.org/cdm/singleitem/collection/p16021coll3/id/72/rec/1* (2010).
- *http://cdm16021.contentdm.oclc.org/cdm/singleitem/collection/p16021coll3/id/73/rec/1* (2011).

In addition to counting adult fish at lower Snake and Columbia river dams, several actions were taken to improve the accuracy of fish counts at FCRPS dams. These include reconstructing the count station and exit section at John Day Dam's north fish ladder, counting fish at night at Bonneville, McNary, and Lower Granite dams, investigating count accuracy at Ice Harbor and Lower Monumental dams, and installing count station improvements at Ice Harbor and Lower Monumental dams.

In the 1990s, the Corp's Fish Field Unit investigated fish counts at the John Day Dam north and south fish ladders and found them to be inaccurate. The problem was primarily with steelhead counts, where at both ladders numerous steelhead were delayed in the fish ladder count areas and ladder exit sections. This resulted in many steelhead passing count widows in both (upstream and downstream) directions, which in turn resulted in errors by fish counters. In 2010, the Corps completed structural improvements to the north ladder exit section and count station. The south ladder exit section had been renovated previously, and these improvements resolved the fish delay and counting issues in that ladder. North ladder passage evaluations in 2010 suggest that the upper ladder modifications successfully resolved the chronic delay, jumping, and turn-around problems that were affecting fish count accuracy (Jepson et al., 2011, Madson and Jonas, 2011).

Recently, the Corps has addressed count problems at Ice Harbor and Lower Monumental dams where frequently more fish have been recorded passing Lower Monumental Dam than seen at Ice Harbor Dam. Possible reasons for this count difference could be differential night passage rates, differential navigation lock passage, differential fall back, and re-ascension rates through spill. However, previous radio-telemetry studies in the late 1990s do not indicate these to be likely problems. Therefore, the Corps has focused on fish counter accuracy and improving count station conditions for fish counters. Shading was installed in some of the count stations, which has improved counters' ability to accurately identify fish. Extra lights were turned off or removed to reduce window glare spots. Old cameras and monitors were updated (LCD monitors and security cameras). An evaluation was initiated that will compare video recorded counts with live fish counter counts at all four count windows. Data from this evaluation are currently being analyzed and will compare "what really passed" (video) with what the counters reported, to see if they are indeed unable to accurately count two windows at one time (particularly when shad are passing).

Major Lessons Learned

Not applicable: this is a routine monitoring activity. Evaluation is covered in other locations in this document.

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.*
2. *Monitor and describe the migration timing of smolts at index dams, identify potential problems, and evaluate implemented solutions.*
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.*
4. *Monitor and enumerate adult salmonids passing through fishways in the FCRPS, identify potential problems, and evaluate implemented solutions.*
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.*

RPA Subaction 53.1 – *Monitor and estimate the abundance of smolts passing index dams.*

Major Accomplishments and Findings

BPA Project 1994-033-00 (Fish Passage Center): The FPC maintains an internet database of information gathered by the SMP (1987-127-00). The SMP provides data on movement of salmonid smolts out of the major drainages and past the series of dams on the Snake and Columbia rivers. Indices of migration strength and migration timing are provided for the run-at-large at key monitoring sites. In addition, marked smolts from hatcheries, traps, and dams provide measures of smolt speed and in-river survival through key reaches. Fish quality, descaling, and gas bubble trauma measures are recorded on samples of fish collected at the monitoring sites to provide an indicator of health of the run. These data are used for in-season operational decisions relative to flow and spill management, particularly during periods when spill is being provided to improve smolt passage at dams. An annual report summarizes special operations conducted at dams, and trends in the smolt passage index, migration timing, and reach survivals. Passage indices are not direct estimates of population abundance. The smolt index is corrected within-season for fluctuating passage route efficiencies, which influences the precision of estimates of smolt timing and abundance. Factors such as river flow levels, change of spill operations, or removal of turbine screens to respond to debris or elevated injury/descaling rates can also influence estimation of the collection efficiency at the bypass systems. http://www.fpc.org/smolt_home.html.

BPA Project 1991-051-00 (Statistical Support for Lifecycle studies): Columbia Basin Research at the University of Washington annually provides in-season daily monitoring and forecasting results of outmigrations for PIT-tagged wild stocks originating above Lower Granite Dam, above Rock Island Dam and at McNary Dam. Post-season outmigration success including survival and travel times are compiled for 30 different subgroups of Chinook and steelhead. Bona fide population abundance estimates for smolts at dams are not provided.

http://www.cbr.washington.edu/trends/

BPA Project 1991-029-00 (Issues in early life history of fall-run Chinook) used a modeling approach based on mark-recapture data to estimate the collection probability of subyearling Chinook salmon at dams equipped with bypass systems. The study found that maintaining the same configuration of screens at turbine intakes is the most important factor for maintaining accuracy of the prediction of the fraction of juveniles entering the bypass. The decrease in tag size and tag burden over the past decade has decreased the minimum length at which juveniles may be tagged.

Major Lessons Learned

Not applicable: this is routine monitoring activity. Evaluation is covered in other locations in this document.

RPA Subaction 53.2 – *Monitor and describe the migration timing of smolts at index dams, identify potential problems, and evaluate implemented solutions.*

Major Accomplishments and Findings

The timing and distribution of smolt arrival at dams in inextricably linked to how quickly they migrate through the system (travel time), and influenced by changes in abundance through time. Thus, travel time and timing are not synonymous, but intertwined. Many studies release PIT-tagged fish that can be used to generate such estimates. Only projects that actually track, analyze, and report timing or travel time on a systematic basis are reported in this section.

For **BPA Project 1996-020-00** (CSS), Smolt Monitoring Project data was used to estimate the relationship between water transit time and fish travel time. The study concluded that smolt travel velocities, estimated across a range of river flow levels, have increased in recent few years compared to the 15-year mean. This may be attributed to installation of surface passage routes and programs of spring and summer spill during periods of peak migration. The study also observed that subyearling fall Chinook have displayed a trend of earlier arrival at Lower Granite Dam.

For **BPA Project 1991-051-00** (Statistical Support for Lifecycle studies), Columbia Basin Research developed the program RealTime (accessible online on Columbia River DART at *http://www.cbr.washington.edu/rt/*). Based on historical PIT-tag detections of 51 populations from the Snake and Columbia rivers, this program is updated with juvenile migration data each year to inform the COMPASS model, and allows the TMT to predict run-to-date and days to a specific percent of run passage.

For **BPA Project 1991-028-00** (Migrations of wild Snake River spring Chinook), NOAA Fisheries monitored arrival timing of wild smolts from four drainages at Lower Granite Dam (peak detections occur in mid-May) to calculate parr-to-smolt survival rates over multiple years with different flow conditions. Fish which were larger at tagging tended to arrive earlier at Lower Granite Dam, and juveniles migrating in April were larger when tagged than those migrating in May.

BPA **Project 1991-029-00** (Issues in early life history of fall-run Chinook) tagged thousands of wild and hatchery fall-run juveniles and monitored their emigration from watersheds within the Snake and Clearwater rivers. The general pattern was that juveniles emerged first from the upper reach of the Snake River, followed by fish from the lower reaches of the Snake River, the Grande Ronde River, and then the Clearwater River. During the most recent five year period, a substantial fraction of subyearlings have delayed outmigration at the Lower Granite reservoir during fall and winter, and completed the migration as yearlings during the following spring.

Major Lessons Learned

In the last five years, the mean arrival date at the estuary has trended earlier than generally observed historically. In part this reflects decreased fish travel time through the system as associated with flow augmentation, the placement of surface bypass systems and the enhanced spill regime. The distribution of arrival timing of run-of-river yearling Chinook and steelhead can also be influenced by timing of releases by hatcheries in upstream tributaries. However, travel time from Lower Granite Dam–Bonneville Dam was shorter for both wild and hatchery groups when recent high (2011, 2012) and low (2010) flow years are compared with migration seasons displaying analogous conditions from a decade earlier. Much of the monitoring of timing and abundance of outmigrating smolts in the FCRPS currently depends on detections of PIT-tagged juveniles moving through powerhouse bypass systems. An extensive infrastructure exists for tagging wild and hatchery juvenile salmon, recording and archiving detection histories, and analyzing patterns of migration routes and timing. The SMP, and University of Washington's RealTime software have used bypass detections to estimate daily and cumulative passage graphs for populations migrating from ESUs in the upper Columbia and Snake rivers. The juvenile fish facilities associated with the bypass routes at Lower Granite, Little Goose, and Lower Monumental dams provide for additional tagging opportunities of wild populations.

Management Actions Lessons-The collective information indicates that the combined actions of surface bypass installation, spill and flow management have improved travel time through the system and contributed to improved smolts survival through the FCRPS. Survival is similar to levels observed many decades ago when no or one dams were present in the Snake River. We have achieved, or are nearly at, the upper limits for both travel time and survival through the FCRPS.

RPA Subaction 53.3 – *Monitor and document smolt condition (e.g., descaling and injury) at dams with JBS systems, identify potential problems, and evaluate implemented solutions.*

Major Accomplishments and Findings

BPA Project 1987-127-00 (Smolt Monitoring Program) has monitored mortality, GBT, descaling, and other injuries on a daily and weekly basis at six FCRPS sites: Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville dams. While mortalities and injuries are primarily used to identify management concerns and episodic problems, such as debris buildup at a powerhouse screen, these metrics can also be compared on an annual basis. GBT has remained relatively low when TDG was managed to levels of 115/120 percent. Mortality rates over the past ten years have been variable, with no trend, at the three Snake River SMP sites, McNary, and John Day dams. However, weighted mortality was higher at Bonneville Dam between 2008-2012 than between 2002-2007, particularly for subyearling Chinook and sockeye. Descaling rates have remained the same over 11 years at most SMP sites, but have decreased at Little Goose Dam. Sockeye juveniles at Bonneville Dam had consistently higher levels of descaling. Steelhead had the highest weighted average injury rates, across the SMP sites.

From 2008 to 2012, the Corps contracted for the sampling of fish for the monitoring of fish condition at Ice Harbor Dam and contracts for this work are not included in BPA's smolt monitoring program (SMP). This activity was conducted twice weekly at Ice Harbor Dam from April to early to mid-July. Sampling for descaling and injury was performed in accordance with conditions outlined in the NOAA Fisheries determination of take letters (25.1-08, 26-09-COE44, 21-10-COE44, 24-11-COE44 and 20-12-COE44) for monitoring purposes. Minor changes in take were authorized by NOAA Fisheries as needed to adapt to unexpected changes in river conditions or in the numbers of out-migrating juvenile fish. The collection of fish was conducted by Corps employees with the actual sampling of fish being accomplished by WDFW or Pacific States Marine Fisheries Commission (PSMFC) employees. Sampled fish were anesthetized with MS-222 and examined for species identification, descaling, gas bubble trauma, and injuries. All sample fish were allowed to recover in a recovery tank before being released. Adult fallbacks that passed through the facilities during sampling activities were immediately bypassed back to the river.

Major Lessons Learned

Monitoring fish condition at select smolt sampling systems has proven to be an effective means to detect deleterious site-specific conditions. With respect to TDG, based on years of observation, the current criteria (maximum of 115 percent saturation in the forebay and 120 percent in the tailrace) appear adequate for protecting both juvenile and adult life stages of salmonids.

RPA Subaction 53.4 – *Monitor and enumerate adult salmonids passing through fishways in the FCRPS, identify potential problems, and evaluate implemented solutions.*

Major Accomplishments and Findings

In 2008 through 2012, the Corps implemented its adult fish count program as specified in the FPP, and as detailed in the discussion of RPA Subaction 52.8, above.

Fishways are monitored on a regular basis. Results are discussed in an annual Fishway Inspection Report prepared for each project. Fishways were also inspected by representatives from NOAA Fisheries and other agencies. Results of those inspections are available at *http://www.fpc.org/documents/Fishway_Inspection_Reports.html*.

Also see the discussion of adult passage improvements under RPA Action 28 above.

Major Lessons Learned

Monitoring adults in fishways has proved to be an effective means to identify conditions that may be injurious to adults. Assessments rely both on visually inspecting fish for trauma or lacerations, and enumerating the passage of daily. Visual inspections and quantifying the extent of injuries provides a direct indicator of hazardous agents, such as marine mammal predation or excessive TDG levels. This alerts mangers to take appropriate action, depending on the nature and extent of injuries. Monitoring changes in daily passage patterns is instructive for identifying the location and potential sources of migration delay in the system. For example, at some dams, excessive spill can cause hydraulic conditions that can occlude fishway entrances and preferred spill patterns have been adopted over several decades to minimize such effects. These monitoring activities should continue, at least at some key dams in the FCRPS.

RPA Subaction 53.5 – *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.*

Major Accomplishments and Findings

In 2007 and 2008, the Corps conducted an evaluation of the feasibility of using Bonneville DamPH2 CC to provide safer downstream passage for kelts. This led to the development of triggers for opening the CC early to provide a safer, more effective steelhead kelt passage route. In 2009–2012, the Bonneville Dam CC was opened early (prior to standard April 10 date) for steelhead kelt passage, based on criteria developed by the FPOM committee and incorporated into the FPP.

In 2011, a study to compare the direct injury and survival of adult steelhead passing through Bonneville Dam’s PH1 ITS (PH1 ITS) and the PH2CC was conducted to confirm the assumption that the two sluiceways provide safe downstream passage. Direct survival was 100 percent and 99 percent for adult steelhead released into the sluiceway and the CC, respectively (Normandeau Associates 2011). The injury rate for study fish did not exceed 1 percent for either passage route.

In 2012, a study to assess route-specific distribution of steelhead kelts passing through Bonneville Dam was conducted. At total of 163 steelhead kelts tagged with active transmitters passed Bonneville Dam. Of these, 51 percent (n=83) passed via spill. At PH1, ITS passage efficiency was roughly 49 percent, with 20 kelts passing PH1 ITS, and 21 kelts passing PH1 turbines. Whereas, at PH2, 74 percent of kelts passed via PH2CC, 13 percent via PH2JBS (n=5), and 13 percent via PH2 turbines (n =5) (Rayamajhi et al., 2013). These results confirmed that operation of PH2 as the priority powerhouse in combination with early operation of the PH2 CC per the FPP criteria, results in the fewest kelts passing through turbines at Bonneville Dam.

The Action Agencies have annually updated the Snake River Steelhead Kelt Management Plan called for under RPA Action 33. Management action including hydro operations alternatives at Bonneville and the other mainstem FCRPS dams are detailed in the plan: https://www.salmonrecovery.gov/Files/2011%20APR%20files/2011_Snake_River_Kelt_Management_Plan.pdf

Major Lessons Learned

Operation of PH2 as priority powerhouse in the spring, combined with early operation of the PH2 CC provides a safe and effective method for passing kelts downstream through Bonneville Dam.

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.*
2. *Monitor and evaluate the effectiveness of traditional juvenile bypass systems and modifications to such, on smolt survival and condition.*
3. *Monitor and evaluate the effectiveness of surface bypass structures and modifications on smolt survival and condition.*
4. *Monitor and evaluate the effectiveness of turbine operations and modifications on smolt survival and condition.*
5. *Monitor and evaluate overall dam passage with respect to modifications at projects (including forebay delay and survival).*
6. *Monitor and evaluate the effectiveness of the juvenile fish transportation program and modifications to operations.*
7. *Monitor and evaluate the effects of environmental conditions affecting juvenile fish survival.*
8. *Monitor and evaluate the effectiveness of reducing predation toward improving juvenile fish survival.*
9. *Investigate, evaluate and deploy alternative technologies and methodologies for fish passage and the RME Action.*
10. *Determine if actions directed at benefiting juveniles have an unintended effect on migrating adults (e.g., certain spill operations).*
11. *Install and maintain adult PIT-tag detectors in fish ladders at key dams in the FCRPS and evaluate adult survival (conversion rates).*
12. *Monitor and evaluate the effects of fish ladder operations and configurations on adult passage rates.*
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.*
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).*

Through juvenile fish performance testing and other evaluations of configuration and operation changes to Snake and Columbia River dams, the Action Agencies have conducted numerous studies that address this action. Key metrics from these studies that address RPA Subactions 54.1 – 54.5 are summarized in tables 51-58. Additional information on this action can be found in the sections below and under the hydro configuration and operations RPAs (RPA Actions 18-25).

Table 52. Bonneville Dam (BON) Estimates of Passage Proportions (%), Survival Rates (%), and Standard Error (SE, In Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) Passing through the Spillway, Juvenile Bypass System (JBS), Turbines, CC and Sluiceway (Surface Flow Outlets), and Combined (Dam) for the Years 2007-2012 (Ploskey et al., 2007; Ploskey et al., 2009; Faber et al., 2010; Faber et al., 2011; Ploskey et al., 2012; Skalski et al., 2013a).

Year	BON Operation	Species	Spillway		B1 Turbines		B1 Sluiceway		B2 Turbines		B2 JBS		B2 Corner Collector		BON Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
2007 [b]	Spring - 100 kcfs	CH1		95.7%											
				(1.3%)											
	Summer - 85 kcfs day / TDG cap night	CH0		93.0%											
				(0.7%)											
2008 [c, d]	Spring - 100 kcfs	CH1		96.2%					37.2%	94.6%	14.6%	98.3%	48.1%	98.7%	**96.6%**
				(0.6%)						(3.0%)		(2.2%)		(1.2%)	**(0.4%)**
		STHD		96.2%					15.8%	98.2%	9.4%	98.4%	74.8%	98.4%	**97.2%**
				(0.8%)						(2.4%)		(3.9%)		(2.7%)	**(0.5%)**
	Summer - 85 kcfs day / TDG cap night	CH0		95.2%					42.6%	93.7%	17.6%	97.5%	39.8%	97.8%	**95.3%**
				(0.7%)						(1.8%)		(2.1%)		(1.4%)	**(0.6%)**
2009 [d, e]	Spring - 100 kcfs	CH1							39.8%	97.1%	20.1%	97.4%	40.1%	99.8%	**95.7%**
										(1.4%)		(2.2%)		(0.2%)	**(0.5%)**
		STHD							26.6%	93.9%	14.5%	95.6%	58.9%	99.3%	**96.1%**
										(2.6%)		(1.8%)		(1.0%)	**(0.3%)**

Year	BON Operation	Species	Spillway		B1 Turbines		B1 Sluiceway		B2 Turbines		B2 JBS		B2 Corner Collector		BON Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
		CH0							35.7%	93.9%	12.4%	88.1%	51.8%	94.2%	**90.3%**
										(3.3%)		(3.3%)		(2.8%)	**(1.5%)**
2010 [e, f]	Spring - 100 kcfs	CH1	52.8%	93.5%	3.9%	98.7%	1.9%	98.0%	15.9%	95.7%	6.5%	98.1%	19.0%	99.1%	**95.2%**
			(0.9%)	(0.6%)	(0.3%)	(1.5%)	(0.2%)	(2.4%)	(0.6%)	(0.9%)	(0.4%)	(1.0%)	(0.7%)	(0.5%)	**(0.4%)**
		STHD	40.6%	93.9%	3.4%	90.0%	2.4%	96.3%	17.1%	91.1%	5.9%	97.8%	30.6%	97.5%	**94.5%**
			(0.9%)	(0.7%)	(0.3%)	(2.8%)	(0.3%)	(2.6%)	(0.7%)	(1.3%)	(0.4%)	(1.1%)	(0.8%)	(0.5%)	**(0.3%)**
	All Summer	CH0	52.4%	93.0%	16.7%	96.7%	5.7%	94.3%	12.8%	93.6%	3.3%	97.6%	9.1%	97.0%	**95.8%**
				(0.6%)		(0.8%)		(1.7%)		(1.2%)		(1.5%)		(1.0%)	**(0.6%)**
	Summer - 85 kcfs day / 121 kcfs night														**88.7%**
	Summer - 95 kcfs														**92.3%**
2011 [g, h]	Early Spring - 100 kcfs	CH1													**95.7%**
															(0.4%)
		STHD													**97.6%**
															(1.8%)
	All Spring - includes high spill >> 100 kcfs	CH1	56.6%	95.7%	21.1%	96.8%	6.6%	96.9%	8.2%	94.7%	4.5%	98.2%	3.0%	99.4%	**96.0%**
			(0.7%)	(2.1%)	(0.6%)	(2.1%)	(0.3%)	(2.4%)	(0.4%)	(2.3%)	(0.3%)	(2.4%)	(0.2%)	(2.1%)	**(1.8%)**
		STHD	54.4%	95.7%	23.1%	93.6%	8.2%	95.4%	2.9%	91.9%	1.8%	94.0%	9.6%	99.4%	**96.5%**
			(0.7%)	(2.1%)	(0.6%)	(2.6%)	(0.4%)	(2.8%)	(0.2%)	(3.3%)	(0.2%)	(3.3%)	(0.4%)	(3.3%)	**(2.1%)**
2012 [h, i]	Summer - 95 kcfs and 85 kcfs day/121	CH0													**97.4%**
															(0.7%)

Year	BON Operation	Species	Spillway		B1 Turbines		B1 Sluiceway		B2 Turbines		B2 JBS		B2 Corner Collector		BON Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
	kcfs night														

a. Numbers in parentheses are estimates of precision, calculated as Standard Error (SE) or one-half of the 95% Confidence Interval.

b. 2007 survival estimates for spillway passage based on paired-releases using fish released immediately above and below the Bonneville Dam spillway.

c. 2008 survival estimates based on single-release model of virtual releases detected above Bonneville Dam to downstream arrays.

d. 2008-2009 route-specific passage % calculated for PH2 passage only (% of fish passing PH2).

e. 2009-2010 survival estimates based on single-release model of virtual releases detected above Bonneville Dam downstream to mouth of Willamette River.

f. 2010 survival estimates for each summer spill treatment calculated as a mean of survival by treatment date.

g. 2011 high flows in May forced spill rates in excess of the planned 100 kcfs. Survival estimates split into "Early Spring" (Apr 27-May 13) when spill = 100 kcfs, and "All Spring" (Apr 30-May 31) which includes very high spill rates that occurred in late May. Summer studies were cancelled.

h. 2011 Survival estimates based on virtual paired-release model

i. 2012 high river flows precluded operations at the target levels.

Table 53. The Dalles Dam (TDA) Estimates of Passage Proportions (%), Survival Rates (%), and Standard Error (SE, in Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) Passing through the Spillway, Sluiceway (Surface Flow Outlet), Juvenile Bypass System (JBS), Turbines, and Combined (Dam) for the Years 2007-2012 (Johnson et al., 2011a; Ploskey et al., 2012b; Skalski et al., 2013b).

Year	TDA Operation	Species	Spillway		Sluiceway		Turbines		TDA Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
2007	n/a	----	----	----	----	----	----	----	**----**
2008	n/a	----	----	----	----	----	----	----	**----**
2009	n/a	----	----	----	----	----	----	----	**----**
2010 [b]	40% Spill	CH1	84.1%	96.6%	10.6%	99.3%	5.3%	87.6%	**96.4%**
			(0.8%)	(1.0%)	(0.7%)	(1.5%)	(0.5%)	(3.6%)	**(0.1%)**
		STHD	87.7%	95.8%	7.7%	94.4%	4.6%	88.8%	**95.3%**
			(0.7%)	(1.0%)	(0.6%)	(2.0%)	(0.5%)	(3.4%)	**(0.0%)**
		CH0	71.2%	95.5%	11.8%	97.8%	17.0%	86.2%	**94.0%**
2011 [b]	40% Spill	CH1	65.8%	96.1%	17.3%	99.1%	16.9%	93.0%	**96.0%**
			(0.7%)	(0.8%)	(0.6%)	(0.8%)	(0.6%)	(1.2%)	**(1.2%)**
		STHD	75.4%	100.4%	13.8%	101.0%	10.9%	91.9%	**99.5%**
			(0.7%)	(0.8%)	(0.5%)	(0.9%)	(0.5%)	(1.7%)	**(1.7%)**
		CH0							
2012 [b]	40% Spill	CH0							**94.7%**
									(0.6%)

a. Numbers in parentheses are estimates of precision, calculated as Standard Error (SE) or one-half of the 95% Confidence Interval.

b. 2010-2012 survival estimates based on virtual paired-release model (dam face to tailrace).

Table 54. John Day Dam (JDA) Estimates of Passage Proportions (%), Survival Rates (%), and Standard Error (SE, in Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) Passing through the Spillway Weir (SW, Surface Flow Outlet), Spillway (Non-SW), Juvenile Bypass System (JBS), Turbines, and Combined (Dam) for the Years 2007-2012 (Weiland et al., 2011a; Weiland et al., 2011b; Weiland et al., 2013a; Weiland et al., 2013b; Skalski et al., 2013c).

Year	JDA Operation	Species	Spillway (non-SW)		Spillway Weir (SW)		JBS		Turbines		JDA Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
2007	**n/a**	**----**	----	----	----	----	----	----	----	----	**----**
2008 [b, c]	**30% Spill** [c]	**CH1**	50.9%	95.9%	25.0%	96.0%	17.0%	98.6%	7.2%	82.7%	**94.0%**
			(2.0%)		(2.4%)		(1.8%)				**(0.6%)**
		STHD	22.0%	98.3%	53.8%	100.0%	21.6%	100.1%	2.6%	71.4%	**99.1%**
			(1.9%)		(2.4%)		(1.8%)				**(1.4%)**
		CH0	44.3%	82.0%	21.4%	92.7%	16.3%	97.3%	18.0%	73.2%	**85.2%**
			(1.9%)		(1.8%)		(1.5%)				**(1.2%)**
	40% Spill [c]	**CH1**	55.4%	96.9%	21.3%	95.4%	14.3%	95.8%	9.0%	88.3%	**94.2%**
			(2.5%)		(2.5%)		(2.0%)				**(0.8%)**
		STHD	28.5%	98.1%	43.9%	96.8%	24.7%	99.7%	2.9%	78.9%	**97.2%**
			(2.6%)		(3.4%)		(2.5%)				**(1.9%)**
		CH0	50.3%	85.6%	20.8%	94.0%	13.4%	96.9%	15.6%	71.0%	**86.6%**
			(1.9%)		(1.8%)		(1.4%)				**(1.2%)**
	Combined	**CH1**	52.7%	96.6%	23.6%	96.1%	15.9%	97.6%	7.9%	85.5%	**95.7%**
			(1.2%)	(0.6%)	(1.4%)	(1.0%)	(1.1%)	(2.3%)		(1.7%)	**(0.7%)**
		STHD	24.8%	98.5%	49.6%	99.2%	22.7%	100.2%	2.9%	74.9%	**98.6%**
			(1.3%)	(1.2%)	(1.7%)	(1.2%)	(1.3%)	(1.0%)		(3.2%)	**(1.0%)**
		CH0	48.0%	84.4%	20.6%	92.7%	14.7%	97.3%	16.7%	72.8%	**86.1%**
			(1.2%)	(2.2%)	(1.1%)	(0.8%)	(0.9%)	(2.9%)		(2.9%)	**(0.9%)**

Year	JDA Operation	Species	Spillway (non-SW)		Spillway Weir (SW)		JBS		Turbines		JDA Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
2009 [d]	30% Spill	CH1	44.4%		31.5%		16.8%		7.4%		**94.3%**
											(1.8%)
		STHD	23.0%		48.5%		25.3%		3.2%		**95.5%**
											(1.9%)
		CH0	69.7%		no SW		13.8%		16.9%		**85.1%**
											(4.2%)
	40% Spill	CH1	61.8%		22.6%		8.8%		5.7%		**92.5%**
											(1.0%)
		STHD	29.3%		51.8%		16.8%		2.0%		**94.7%**
											(1.6%)
		CH0	76.0%		no SW		13.8%		14.4%		**85.5%**
											(4.8%)
	Combined	CH1	53.5%	91.3%	27.1%	95.1%	12.8%	97.5%	6.6%	85.1%	**92.7%**
				(1.4%)		(1.4%)		(1.6%)		(4.7%)	**(1.0%)**
		STHD	26.1%	93.6%	50.1%	96.3%	21.1%	96.6%	2.6%	82.4%	**95.3%**
				(1.6%)		(1.0%)		(1.4%)		(8.0%)	**(0.8%)**
		CH0	73.2%	84.7%	no SW	no SW	11.3%	90.8%	15.5%	74.9%	**83.9%**
				(1.6%)				(3.1%)		(3.9%)	**(1.4%)**
2010 [d]	30% Spill	CH1									**94.0%**
		STHD									**94.2%**
		CH0									**91.9%**
	40% Spill	CH1									**94.4%**
		STHD									**97.5%**
		CH0									**91.4%**
	Combined	CH1	33.1%	95.0%	56.8%	95.2%	6.3%	90.1%	3.7%	77.6%	**93.7%**
			(1.0%)	(0.8%)	(1.1%)	(0.6%)	(0.5%)	(2.6%)	(0.4%)	(4.7%)	**(0.0%)**
		STHD	16.9%	94.4%	71.9%	97.2%	9.4%	94.3%	1.8%	69.4%	**95.0%**
			(0.8%)	(1.2%)	(1.0%)	(0.4%)	(0.6%)	(1.7%)	(0.3%)	(7.4%)	**(0.3%)**

Year	JDA Operation	Species	Spillway (non-SW)		Spillway Weir (SW)		JBS		Turbines		JDA Dam
			% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Passage (SE) [a]	% Survival (SE) [a]	% Survival (SE) [a]
		CH0	46.5%	93.7%	31.1%	91.2%	10.7%	94.7%	11.7%	81.8%	**90.8%**
2011 [e]	30% Spill	CH1									**96.7%**
											(1.0%)
		STHD									**98.4%**
											(0.9%)
	40% Spill	CH1									**97.8%**
											(1.1%)
		STHD									**99.0%**
											(0.9%)
	Combined	CH1	39.9%	97.4%	23.8%	95.8%	24.8%	99.3%	11.5%	91.0%	**96.8%**
			(1.0%)	(0.8%)	(0.9%)	(1.1%)	(0.9%)	(0.8%)	(0.7%)	(1.9%)	**(0.7%)**
		STHD	30.5%	99.0%	32.3%	98.9%	33.2%	100.3%	4.0%	79.7%	**98.7%**
			(0.9%)	(0.7%)	(0.9%)	(0.7%)	(1.0%)	(0.6%)	(0.4%)	(4.2%)	**(0.3%)**
2012 [f]	Combined	CH1									**96.7%**
											(0.7%)
		STHD									**97.4%**
											(0.3%)
		CH0									**94.1%**
											(0.3%)

a. Numbers in parentheses are estimates of precision, calculated as Standard Error (SE) or one-half of the 95% Confidence Interval.

b. 2008 survival estimates based on paired-release model using direct releases (via hose).

c. 2008 dam survival estimates by spill condition based on dam passage during 30% spill (including up to 35%) and 40% spill (including 35-45% spill), due to high flows and spill rates in excess of planned treatments.

d. 2009-2010 Survival estimates based on single-release model using passage at JDA to TDA. Route-specific survival was not estimated for individual treatments, only the combined treatment was reported. Variance estimates are reported as the ½ width of the 95% confidence interval.

e. 2011 Survival estimates based on virtual-paired release model (dam face to tailrace).

f. In 2012 high river flows precluded operation of the spillway at the target flow of 30% and 40% spill therefore only a season wide estimate for each species was calculated. To date only dam passage survival has been reported.

Table 55. Estimates of Passage Proportions (%), Survival Rates (%), and Standard Errors or 95% Confidence Intervals (Depending on What Was Reported; in Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) Passing through the Spillway, Juvenile

Bypass System (JBS), Turbines, SWs (Surface Passage), and Combined (Dam) At McNary Dam (MCN) in 2008 and 2009 (Adams and Liedtke, 2009; Adams and Liedtke, 2011; Adams and Evans, 2011; Adams et al., 2011).

Year	MCN Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	
2008	40% Spill maintained until mid-May, uncontrolled after mid-May; TSW 1 in bay 19 and TSW 2 in bay 20	STHD	34%	102.7% (1.5%)	40% (combined for 2 TSWs)	100.2% (1.7%) – 100.4% (1.9%))	17%	103.4% (1.6%)	8%	69.3% (8.9%)	99.1%[2] (1.5%)
2008	19 kcfs Spill target, 40% early season and 60% late season	CH0	50%	100.5% (1.6%)	17% (combined for 2 TSWs)	97.3% (3.7%) – 98.9% (4.2%)	14%	91.2% (3.0%)	20%	82.3% (3.0%)	96.2%[2] (1.5%)
2008	40% Spill maintained until mid-May, uncontrolled after mid-May; TSW 1 in bay 19 and TSW 2 in bay 20	CH1	48%	96.4% (1.1%)	18% (combined for 2 TSWs)	92.2% (2.7%) – 98.1% (2.2%)	21%	96.0% (1.6%)	13%	91.8% (2.5%)	95.4%[2] (0.9%)
2009	40% Spill control lost in late-April and late-May; TSW 1 in bay 4 and TSW 2 in bay 19	STHD	34%	99.7% (1.6%)	35% (combined for 2 TSWs)	101.0% (1.5%) – 102.0% (2.0%)	24%	101.4% (1.7%)	7%	85.1% (5.4%)	99.6%[2] (1.2%)
2009	50% Spill	CH0	51%	94.5% (91.1-97.7%)	13% TSW 2 only, TSW 1 no monitors	91.5% (85.6-96.7%) TSW 2 only	17%	93.1% (87.9-97.8%)	19%	73.2% (67.1-79.1%)	89.2%[2] (86.6-91.8%)
2009	40% Spill control lost in late-April and late-May; TSW 1 in bay 4 and TSW 2 in bay 19	CH1	40%	98.2% (1.1%)	14% (combined for 2 TSWs)	98.8% (1.9%) – 101.1% (1.8%)	32%	98.4% (1.2%)	15%	90.5% (2.5%)	97.3%[2] (0.9%)

Table 56. Estimates of Passage Proportions (%), Survival Rates (%), and Standard Error or 95% Confidence Intervals (Depending on What Was Reported; in Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) Passing through the Spillway, Juvenile Bypass System (JBS), Turbines, RSW (Surface Passage), and Combined (Dam) at Ice Harbor Dam (IHR) in 2008 and 2009 (Axel et al., 2010a and b).

Year	IHR Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	
2008	Mixed; pooled results BiOp (Gas cap/45 kcfs with RSW = 63% spill) + 30% spill with RSW = 35% spill; 56% season ave spill	STHD	84%	97.3% (96.2-98.5%)	45%	97.0% (95.4-98.6%)	15%	97.1% (94.7-99.6%)	1%	Too few fish.	97.0%[3] (95.9-98.1%)
2008	Mixed/ Combined Treatments; 56% season ave spill	CH0	42%	94.2% (92.6-95.8%)	27%	92.0% (89.1-94.8%)	28%	92.9% (90.3-95.6%)	0%	77.8% (68.5-87.0%)	93.3%[3] (91.9-94.7%)
2008	Mixed; pooled results BiOp (Gas cap/45 kcfs with RSW = 63% spill) + 30% spill with RSW = 35% spill; 56% season ave spill	CH1	71%	96.6% (95.3-97.8%)	28%	95.3% (92.7-97.9%)	24%	97.7% (95.4-100.0%)	5%	94.3% (88.9-99.6%)	96.6%[3] (95.5-97.8%)
2009	BiOp Spill (Gas cap/45 kcfs with RSW); 64% season ave spill	STHD	88%	95.8% (0.6%)	27%	92.7% (2.2%)	11%	93.5% (6.9%)	1%	Too few fish.	95.0%[3] (1.0%)
2009	30% Spill; 30% treatment ave spill	STHD	70%	94.0% (1.2%)	47%	92.3% (2.3%)	30%	94.4% (2.1)	0.5%	Too few fish.	94.3%[3] (1.0%)
2009	50% Spill; 49% treatment ave spill	STHD	72%	91.3% (1.8%)	30%	88.5% (3.4%)	27%	87.5% (4.0%)	1%	Too few fish.	90.1%[3] (1.7%)
2009	BiOp Spill with RSW	CH0	93%	88.6% (1.3%)	24%	87.7% (1.6%)	6%	96.1% (2.3%)	0%	Too few fish.	89.6%[3] (1.5%)
2009	30% Spill; 30% treatment ave	CH0	62%	88.5%	39%	91.9%	35%	95.8%	0%	Too few	91.3%[3]

Year	IHR Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	
	spill			(1.5%)		(1.4%)		(1.5%)		fish.	(1.1%)
2009	BiOp Spill (Gas cap/45 kcfs with RSW); 64% treatment ave spill	CH1	93%	92.5% (1.7%)	31%	93.0% (2.5%)	6%	85.4% (5.4%)	1%	Too few fish.	93.1%[3] (0.7%)
2009	30% Spill; 30% treatment ave spill	CH1	77%	93.9% (1.2%)	57%	93.9% (1.6%)	21%	94.1% (3.5%)	2%	Too few fish.	94.1%[3] (1.8%)
2009	50% Spill; 49% treatment ave spill	CH1	81%	92.1% (1.6%)	34%	91.1% (2.7%)	16%	86.1% (4.7%)	3%	Too few fish.	91.4%[3] (1.6%)

Ice Harbor Dam estimation model (1=virtual paired release; 2=paired release; 3=single release).

Table 57. Estimates of Passage Proportions (%), Survival Rates (%), and Standard Error or 95% Confidence Intervals (Depending on What Was Reported; in Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) passing through the Spillway, Juvenile Bypass System (JBS), Turbines, SW (Surface Flow Passage), and Combined (Dam) at Lower Monumental Dam (LMO) in 2008 and 2009 (Absolon et al., 2010; Dumdei et al., 2010; Hockersmith et al., 2010a and b).

Year	LMO Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	
2008	Mixed (bulk and flat), ave inflow 99 kcfs, ave spill 34%	STHD	82%	101.4 (1.1%)	71%	102.6% (1.1%)	17%	97.7% (2.3%)	1%	Too few fish.	100.6[2] (0.9%)
2008	Bulk spill 24 hrs/day (gas cap 25-40 kcfs <20 June, 17 kcfs >21 June), spill % 24 ave 8.8-87.7% range (ave 25.5 kcfs), inflow kcfs 106.4 ave 49.3-171.0 kcfs range,; RSW	CH0	40%	91.9% (2.7%)	24%	97.4% (2.7%)	46%	92.8% (3.1%)	13%	96.0% (5.7%)	93.2%[2] (2.2%)

Year	LMO Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	
	in bay 8										
2008	Mixed (bulk and flat), ave inflow 99 kcfs, ave spill 34%	CH1	65%	97.6% (1.6%)	47%	101.2% (1.6%)	29%	93.6% (2.5%)	6%	Too few fish.	96.3%[2] (1.6%)
2009	Uniform Spill, inflow 98.6 kcfs, spill 36.1 kcfs (38%)	STHD	71%	98.2% (0.9%)	53%	99.3% (0.9%)	28%	89.9% (4.4%)	1%	100.8% (99.9-101.6%)	96.7%[2] (1.1%)
2009	Bulk spill, inflow 101.6 kcfs, spill 26.5 kcfs (27%)	STHD	69%	99.1% (0.9%)	49%	99.8% (0.5%)	30%	93.9% (2.6%)	1%	100.9% (100.0-101.8%)	97.6%[2] (0.9%)
2009	Bulk spill 24 hrs/day (gas cap 25-40 kcfs <20 June, 17 kcfs >21 June), spill % 22 ave (87.3 kcfs ave) 15.9-28.4% range, inflow kcfs 87.0 ave 64.3-119.6 kcfs range, range; RSW in bay 8	CH0	58%	92.7% (1.3%)	46%	95.6% (1.6%)	28%	93.7% (1.3%)	8%	89.1% (84.1-94.1%)	92.9%[2] (1.0%)
2009	Uniform Spill, inflow 98.6 kcfs, spill 36.1 kcfs (38%)	CH1	80%	97.6% (1.3%)	61%	98.8% (1.3%)	17%	94.3% (3.2%)	3%	95.6% (84.6-108.0%)	97.3%[2] (0.9%)
2009	Bulk spill, inflow 101.6 kcfs, spill	CH1	73%	97.2%	57%	98.8%	24%	96.5%	3%	102.1% (100.8-	97.5%[2]

Year	LMO Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	% Pass.	Survival	
	26.5 kcfs (27%)			(1.7%)		(2.1%)		(3.4%)		103.4%)	(1.8%)

Lower Monumental Dam estimation model (1=virtual paired release; 2=paired release; 3=single release).

Table 58. Estimates of passage proportions (%), survival rates (%), and standard error or 95% confidence intervals (depending on what was reported; in parentheses), for yearling Chinook (CH1), steelhead (STHD), and subyearling Chinook (CH0) passing through the spillway, juvenile bypass system (JBS), turbines, SW (surface passage), and combined (dam) in 2009 at Little Goose Dam (LGO) (Beeman et al., 2010).

Year	LGO Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	% Survival	% Pass.	% Survival	% Pass.	% Survival	% Pass.	% Survival	
2009	Modified Bulk; 30% spill 24 hrs achieved; high flow year, TSW HI elevation	STHD	9%	99.7% (0.5%)	49%	99.8% (0.6%)	41%	99.4% (0.7%)	13%	100.5% (100.1-101.2%)	99.8%[2] (0.4%)
2009	Modified Bulk; 30% spill 24 hrs achieved; high flow year, TSW HI elevation	CH0	71%	96.3% (1.5%)	65%	97.5% (1.5%)	24%	90.8% (2.4%)	4%	82.8% (62.3-98.0%)	95.2%[2] (1.3%)
2009	Modified Bulk ; 30% spill 24 hrs achieved; high flow year, TSW HI elevation	CH1	10%	94.8% (1.1%)	63%	100.1% (1.1%)	24%	101.6% (1.2%)	4%	92.8% (77.0-100.5%)	99.4%[2] (1.0%)

Little Goose Dam estimation model (1=virtual paired release; 2=paired release; 3=single release).

Table 59. Estimates of Passage Proportions (%), Survival Rates (%), and Standard Errors or 95% Confidence Intervals (Depending on What Was Reported; in Parentheses), for Yearling Chinook (CH1), Steelhead (STHD), and Subyearling Chinook (CH0) Passing through the Spillway, Juvenile Bypass System (JBS), Turbines, RSW (Surface Passage), and Combined (Dam) in 2006 (Most Recent Information) at Lower Granite Dam (LGR) (Beeman et al., 2008b).

Year	LGR Operation	Species	Spillway		Surface Passage		Juv. Bypass		Turbines		Dam Survival
			% Pass.	%	% Pass.	%	% Pass.	%	% Pass.	%	

				Survival		Survival		Survival		Survival	
2006	RSW (removable spillway weir) in bay 1; BGS OUT treatment; 43% treatment ave spill	STHD	28%	98.5% (94.9-100.3%)	25%	95.2% (89.7-98.5%)	42%	95.5% (91.5-98.1%)	6%	87.9% (67.0-98.1%)	95.8%[2] (93.4-97.7%)
2006	RSW in bay 1; Overall pooled flat and bulk training spill; 36.7% ave spill	CH0	10%	89.4% (80.5-96.1%)	57%	94.5% (91.3-97.5%)	23%	87.5% (81.5-92.7%)	8%	84.6% (72.8-93.6%)	91.4%[2] (88.6-94.2%)
2006	RSW in bay 1; BGS OUT treatment; 43% treatment ave spill	CH1	33%	97.0% (92.3-99.9%)	28%	98.5% (94.1-100.9%)	31%	98.7% (94.7-100.9%)	8%	81.5% (61.9-94.3%)	96.7%[2] (93.9-98.9%)

Lower Granite Dam estimation model (1=virtual paired release; 2=paired release; 3=single release).

RPA Subaction 54.1 – *Monitor and evaluate the effects of existing spillways, modifications, and operations on smolt survival.*

Major Accomplishments and Findings

Spill for juvenile fish occurred at all lower Snake River and lower Columbia River FCRPS dams each year during 2008-12. During that period spillway passage and survival were evaluated at all Lower Snake and Lower Columbia projects except Lower Granite Dam. The most recent spillway passage and survival information for Lower Granite Dam was collected in 2006. Spillway survival estimates by project and species are presented in Tables 52-59 above. Surface flow outlets (SWs) and spillway survival improvements (i.e., The Dalles Dam spillwall and Bonneville Dam improved spill patterns) were included in dam operations tested at each dam in 2008–12. In general, the combination of surface flow outlets at spillways combined with training spill decreased the proportion of smolts that passed through powerhouses and turbines, decreased forebay residence times (see forebay residence time data presented in RPA Actions 18-25), and increased overall dam survival (tables 52-59 and RPA Actions 18-25). In addition, spillway evaluations confirmed the importance of optimizing spill volumes, patterns, and structures to increase juvenile fish survival through spillways and dams. For example, at Bonneville Dam, new spill patterns and volumes were evaluated in an attempt to increase subyearling Chinook survival. Results from those studies indicated that subyearling Chinook spillway survival can be increased substantially with new spill patterns and volumes (Table 60).

Table 60. Spillway passage survival for subyearling Chinook salmon at Bonneville Dam, 2004-2008. Results from 2004-2005 are based on radio telemetry studies (Counihan et al., 2006a, Counihan et al., 2006b); 2006-2008 results are based on acoustic telemetry studies (Ploskey et al., 2007, Ploskey et al., 2008, Ploskey et al., 2009).

Year	Operation	Subyearling Chinook Spillway Passage Survival Rate
2004	48 Day / TDG Cap Night	88%
2005	75 Day / TDG Cap Night	91%
2006	75 Day / TDG Cap Night	86%
2007	85 Kcfs Daytime Only	93% (daytime survival estimate)
2008	85 Day / TDG Cap Night	97%

As another example, a spillwall was constructed at The Dalles Dam spillway to improve tailrace egress and provide safe conveyance for juvenile fish. Results from 2010-12 performance standard testing indicated a marked improvement over the pre-spillwall configuration in dam survival of both spring and summer migrants. Dam survival of yearling Chinook salmon exceeded the spring migrant performance standard of 96.0 percent at 96.4 percent in 2010 (see Table 20 RPA Action 19). The increased dam survival at The Dalles Dam was due to increases in survival of fish passing through the spillway, which, at 40 percent spill, passes approximately 80 percent of all juvenile migrants.

BPA Project 2003-041-00 (Delayed Mortality of yearling Chinook salmon through Snake River dams): In this multiyear study, NOAA Fisheries arranged 10 staggered seasonal releases of the three major treatment groups: juveniles tagged and released at Lower Granite Dam, trucked and then released at Lower Granite Dam, and trucked below Ice Harbor dam. Tagging started in the last two weeks of April and finished in mid-May, spanning the natural migration period for hatchery origin spring/summer Chinook salmon. NOAA Fisheries will not present analysis of the significance of within-season timing on SAR rates until adult returns from seven cohorts are available.

BPA Project 1989-107-00 (Statistical Support for Salmon): see description under RPA Subaction 52.2

Major Lessons Learned

Optimizing spill for fish passage involves balancing minimum gate openings for safe conveyance of juveniles, spill amounts and patterns that minimize juvenile fish exposure to predators, spill amount and patterns that enable upstream migrating adult fish to find ladder entrances quickly, and spill amounts and patterns that meet TDG standards. Through addressing these factors, the Corps further improved fish survival at spillways and dams. In addition, the combination of surface flow outlet(s) at spillways combined with training spill performed as expected: they decreased the proportion of smolts that passed through powerhouses and turbines, decreased forebay residence times, and increased overall dam survival.

RPA Subaction 54.2 – *Monitor and evaluate the effectiveness of traditional juvenile bypass systems and modifications to such, on smolt survival and condition.*

Major Accomplishments and Findings

During 2008-12, JBS fish passage and survival were evaluated at all lower Snake River and lower Columbia River FCRPS projects except Lower Granite Dam. The most recent JBS passage and survival information for Lower Granite Dam was collected in 2006. JBS survival estimates by project and species are presented in Tables 52-59 above. Traditional JBS passage efficiency and survival data were collected incidental to dam performance tests. In addition, specific survival and fish injury evaluations following the completion of JBS modifications at Bonneville Dam, and post-construction evaluations of the new JBS outfalls at Little Goose and Lower Monumental dams were conducted.

In general, the percent of fish that survive passage through traditional bypass systems at FCRPS mainstem dams has been the high 90s as expected. Turbine survival, which is the route bypassed fish would travel if not for turbine intake screens, is substantially lower at many dams when compared to survival of fish that pass through bypass systems (Tables 52-59). For example, at McNary Dam turbine passage survival for steelhead ranged from 69 percent to 85 percent, while survival through the bypass system was 100 percent each year for the same two years.

At Bonneville Dam, injury rates of fish passing through the PH2 JBS have been higher than expected following completion of FGE improvement work. Research to better understand the source and extent of these injuries was conducted during the 2008 and 2009 juvenile fish passage seasons. An alternatives report to evaluate potential solutions to the gatewell injury issue was initiated in 2009 and continued through 2012. In 2010 through 2012, to minimize injury, PH2 turbine units were operated at the lower end of the ±1 percent peak efficiency range during portions of the juvenile fish migration. This operation reduces flow into the gatewells, thereby reducing the injury to fish passing through the JBS. A similar fish injury issue was observed when the Corps evaluated prototype extended length bar screens (ESBS) at John Day Dam and later when the Corps evaluated the effect of operating McNary Dam turbines above the 1 percent efficiency range. At all three dams, there appears to be a gatewell flow upper threshold where injury to fish passing through the bypass systems increases. In the case of John Day Dam, this threshold only occurred with experimental screens that were not used again after testing in the 1990's. At McNary Dam, the threshold occurs above the normal turbine operating range. It should be noted that although though fish condition data at the PH2 smolt monitoring facility has been below normal for some of the juvenile fish migration period, the survival rate for juvenile fish passing the bypass system has been high, and is in many cases the second highest of all routes of passage at the dam.

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.

In recent years several investigators (Tuomikoski et al., 2012; Buchanan et al., 2011) have reported a correlation between the number of juvenile bypass events and reduced adult return rates. However, the causative mechanism(s) of the reduced adult return rates were not identified. The ISAB (2012) reviewed CSS reports and FPC memos on this topic and concluded:

> *"… the available evidence demonstrates that fish bypass systems are associated with some degree of latent mortality, but that its magnitude and 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 hydrosystem operations, FPC and CSS conclusions should be re-examined to consider the possibility of alternative explanations raised in this review. Further research is needed to resolve this issue."*

In recent years, several JBSs have been improved, many dams now have direct bypass to the river, and several dams have had their JBS outlets relocated. Juveniles that would have benefited from these changes have not yet returned as adults. Future research will monitor the effects of these changes. Additional information on this topic is presented under RPA subaction 55.1.

BPA Project 1993-029-00 (Survival through Snake and Columbia River Dams and Reservoirs): see description under RPA Subaction 52.2.

BPA Project 1989-107-00 (Statistical Support for Salmon): see description under RPA Subaction 52.2.

Major Lessons Learned

Traditional JBS continue to provide a safe and effective passage route at FCRPS mainstem dams. Fish survival and injury issues with specific bypass systems have been identified and either been rectified (e.g. bypass outfalls) or have remedies in the design stage (Bonneville PH2 JBS gatewell improvements). Flow that is directed from the turbine intake into JBS gatewells is an important factor to consider in the design of these systems with higher flow resulting in a higher proportion of fish guided, but also higher amount of debris, and potentially higher fish injury rates. This tradeoff needs to be carefully considered when designing or upgrading JBS. The formula developed in the mid-1990's for siting JBS outfalls remains a valid and important method to ensure bypassed fish are directed away from predators. Bypass systems appear to perform well for in-river juvenile salmon and steelhead migrants.

RPA Subaction 54.3 – *Monitor and evaluate the effectiveness of surface bypass structures and modifications on smolt survival and condition.*

Major Accomplishments and Findings

During 2008-12, juvenile salmon and steelhead surface passage and survival were evaluated at all lower Snake River and lower Columbia River FCRPS projects except Lower Granite Dam. The most recent surface passage and survival information for Lower Granite Dam was collected in 2006. Surface passage and survival estimates by project and species are presented in Tables 52-59 above. In general, the combination of surface flow outlet(s) at spillways combined with training spill decreased the proportion of smolts that passed through powerhouses and turbines, decreased forebay residence times (see forebay residence time data presented in RPA Actions 18-25), and increased overall dam survival (tables 16, 20, 22, 24, 26-30 and RPA Actions 18-25).

BPA Project 2001-003-00 (Adult PIT Detector Installation): The PTAGIS project has performed system installations, operation and maintenance of PIT-tag detectors in the FCRPS since 1990. PTAGIS assisted in development of surface bypass PIT detector designs including the system installed in the Bonneville Corner Collector in 2006. See RPA Subactions 52.7 and 54.10 for additional description of PTAGIS.

Major Lessons Learned

The combination of surface flow outlet(s) at spillways combined with training spill performed as expected: they decreased the proportion of smolts that passed through powerhouses and turbines, decreased forebay residence times, and increased overall dam survival.

RPA Subaction 54.4 – *Monitor and evaluate the effectiveness of turbine operations and modifications on smolt survival and condition.*

Major Accomplishments and Findings

In 2010, smolts entering the bypass system at McNary Dam were evaluated for descaling under turbine loads equivalent to the upper 1 percent and a higher discharge beyond the upper 1 percent (approximately 13,000-15,000 kcfs; Axel et al., 2011). Yearling and subyearling Chinook and sockeye salmon and juvenile steelhead were evaluated during this study. Turbines were operated in blocks of 1 percent and Best Operating Point (BOP) treatments between May 3 and June 11, 2010. Results indicated that descaling may be slightly higher for fish entering the JBS when turbines are operated beyond the upper 1 percent, which is intended to improve survival of fish passing through turbines. However, trashrack debris conditions were not diligently observed or quantified during the study and may explain the variability in descaling of yearling and subyearling Chinook throughout the study period.

The Corps completed a meta-analysis of juvenile salmonid turbine passage survival studies at John Day and McNary dams in 2009 to determine if the multi-year data set could reveal a fish survival - turbine operation relationship. 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.

A multi-year analysis was conducted by Adams et al., (2011) at McNary Dam. The survival of subyearling Chinook salmon passing through the turbines was correlated to percent spill. When discharge was less than 175 kcfs, turbine survival was inversely related to percent spill and when discharge was greater than 175 kcfs, turbine survival was positively correlated to percent spill. These relationships were likely influenced by tailrace conditions that favored increased predation of fish passing through the turbines. When discharge was less than 175 kcfs, the relatively high volume of flow through the spillway (60 percent) could have forced the relatively low volume of water leaving the powerhouse to flow along the south shore of the tailrace where predatory birds and fish were prevalent. When less water was spilled (20 percent) and more water passed through the powerhouse (80 percent), water flowing out of the powerhouse would have shifted north, away from the predators along the south shore. When discharge was greater than 175 kcfs, high volumes of spill (60 percent), together with relatively higher bulk flow leaving the powerhouse, could have combined to create favorable tailrace conditions for fish leaving the turbines. Under these conditions, fish leaving the powerhouse tailrace would egress quickly and closer to the center of the river, away from shoreline habitat where predators reside. When discharge was high and most of the water passed through the powerhouse (80 percent), more of the fish exiting the turbines could have been exposed to the predators along the south shore.

Studies conducted by Normandeau Associates et al., (2008) tested direct injury and survival of turbine-passed juvenile Chinook salmon at Ice Harbor Dam under different turbine operations (lower 1 percent, peak efficiency, an intermediate operation between peak and the upper 1 percent, upper 1 percent, and generator limit). Survival was highest at the peak and intermediate operations (94-99 percent) and lowest at the lower 1 percent at 92.9 percent (Table 61; Normandeau Associates et al., 2008).

The TSP initiated a turbine bead strike analysis at ERDC in early 2010 using the model of Bonneville PH 1 to quantify bead strike at four different turbine operational points including what is referred to as "Best Geometry," which is approximately 1.3 kcfs outside the upper 1 percent turbine operating limit.

Table 61. Turbine Survival Estimates for Yearling Chinook Salmon at Five Different Operations at Ice Harbor Dam (Normandeau Associates et al., 2008).

	Lower 1% (8.6kcfs)	Peak (9.8 kcfs)	Intermediate (11.4 kcfs)	Upper 1% 12.6 kcfs	Maximum (14.1 kcfs)
Slot A	0.929 (0.026)	0.960 (0.028)	0.960 (0.020)	0.960 (0.020)	0.940 (0.024)
Slot B	0.960 (0.020)	0.980 (0.020)	0.980 (0.014)	0.970 (0.017)	0.950 (0.022)
Slot C	0.960 (0.020)	0.940 (0.034)	0.990 (0.010)	0.970 (0.017)	0.960 (0.020)

Studies conducted by PNNL in 2009-2011 established that the ratio of pressure change Juvenile salmonid experience during turbine passage is one of the main predictors of barotrauma and mortal injury (Brown et al., 2012). The ratio of pressure change is determined by acclimation depth of migrating fish and the nadir pressure below the turbine runner. This ratio has been expressed as the natural log ratio of pressure change (LRP) and has been defined on a general probability of mortal injury curve (Figure 72).

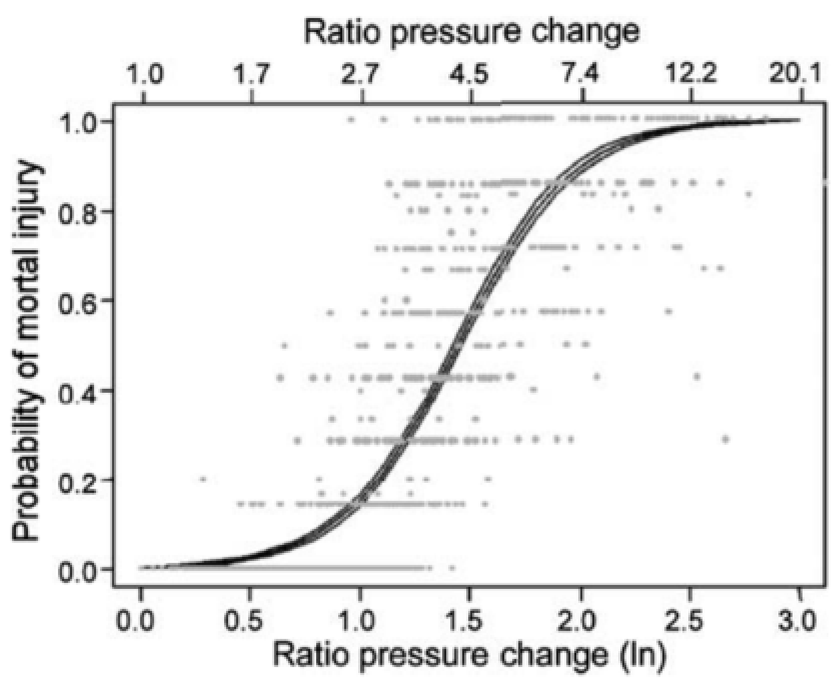


Figure 72. Probability of Mortal Injury from Simulated Turbine Passage along a Range of LRP (Natural Log of The Ratio Of Acclimation To Nadir Pressures) for Juvenile Chinook Salmon (Brown et al., 2012). The 95% confidence interval is shown on either side of the regression line. Each dot on the graph represents the proportion of fish in each test chamber trial (typically comprised of seven fish unless some fish were not neutrally buoyant) that were mortally injured when exposed to simulated turbine passage.

Carlson et al. (2008) determined that the majority of nadir pressures were approximately 9psia or great when Sensor Fish were released at Bonneville Powerhouse II, John Day, and Ice Harbor Dams. Nadir pressures vary depending upon turbine discharge and a distribution of nadir pressures occur below the runner blade depending upon where a fish may pass the blade. Typically, nadir pressure decreases slightly with increasing turbine discharge. Fish acclimation depth and nadir cause LRP to vary as well. Typical LRP at lower Columbia and Snake river dams is ≤ 1.0 (probability of mortal injury approximately 20 percent or less; Figure 72).

In 2010, the Corps completed a final report of rapid decompression effects on fish, and began a new study to determine whether the effects of rapid decompression on tagged fish differ from the effects on untagged fish. Studies conducted at PNNL in 2009-2010 exposed tagged and untagged juvenile Chinook salmon to simulated turbine passage pressures typical of turbines at FCRPS dams (Carlson et al., 2010). These studies elucidated the confounding effects of surgically implanted acoustic tags on juvenile Chinook survival when exposed to simulated turbine passage. Referred to as tag burden, the added mass and potentially organ crowding, caused by the internal tag increased the probability of mortal injury from swim bladder expansion or rupture. Adams et al. (2011) also found survival to be negatively correlated with tag burden (i.e. it appeared that tagged fish had a lower probability of surviving turbine passage than did untagged fish).

BPA Project 1989-107-00 (Statistical Support for Salmon): see description under RPA Subaction 52.2

Major Lessons Learned

Operating turbines at higher discharges may result in higher passage survival. Direct survival of turbine-passed fish is highest between peak efficiency and the upper end of the 1 percent efficiency band of Ice Harbor turbines. This result is consistent with other studies, such as at John Day Dam. Increased turbine load at McNary turbines increases the injury rate for fish passing through the JBS. This result is consistent with observations at Bonneville Dam. Survival of fish passing through turbines can be influenced by percent spill at McNary Dam. This has been observed at John Day dam as well, and highlights the fact that all routes of passage at a dam are interrelated and need to be considered holistically when developing configuration and operation improvements for fish passage.

RPA Subaction 54.5 – *Monitor and evaluate overall dam passage with respect to modifications at projects (including forebay delay and survival).*

Major Accomplishments and Findings

During 2008-2012, juvenile salmon and steelhead overall dam passage survival was evaluated at all lower Snake River and lower Columbia River FCRPS projects except Lower Granite Dam. The most recent passage and survival information for Lower Granite Dam was collected in 2006. Overall dam survival estimates by project and species are presented in tables 52-59. Forebay delay and overall dam passage survival estimates by project and species are presented under RPA Actions 18-25. Additionally, information presented under RPA Actions 18-25 discusses specific configuration and operation changes and study results for each dam.

BPA Project 1987-127-00 (Smolt Monitoring Project): see description under RPA Subaction 53.3

BPA Project 2003-041-00 (Evaluate Delayed Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams): see description under RPA Subaction 54.7

Major Lesson Learned

In general, 2008-2011 changes made to spill, surface flow outlets, and JBS resulted in increased survival, reduced turbine passage, and reduced forebay residence times. Nearly all dams tested for performance standards met or exceeded those standards for all species. In many cases, dam survival increases matched or exceeded those predicted by the FCRPS BiOp.

RPA Subaction 54.6 – *Monitor and evaluate the effectiveness of the juvenile fish transportation program and modifications to operations.*

Major Accomplishments and Findings

Several studies have been initiated and completed since 2008 to monitor and evaluate the effectiveness of the juvenile fish transportation program. Overall, transportation at collector projects results in higher adult returns for most stocks in most years. Juvenile transportation remains an important management tool in the recovery of ESA listed salmon and steelhead.

The Action Agencies continued research to determine the potential of transportation to increase adult returns of anadromous salmon and steelhead. A PIT-tag study to evaluate weekly SARs for spring Chinook salmon and steelhead transported from Lower Granite Dam continues to provide more precise temporal transportation data that should help clarify effects of transportation and relationships to environmental variables (Smith et al., 2013). Initial analyses suggest 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 might not be useful in a real time model for determining when it is best to transport fish. Overall, T:M ratios for 2006-2010 (ratio of SARs of transported to in-river migrating fish not detected at collector projects, except McNary) 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 starting in late April in all years since 2006. Wild steelhead benefit from transportation for all dates we have data (data collection starts approximately mid-April) since 2006. However, hatchery steelhead do not show a benefit from transport until shortly after 1 May. 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.

During 2008-2012 the Corps made numerous changes to project configurations and operations to improve juvenile passage conditions. The Corps will continue to evaluate the benefits of transport operations to determine the degree to which improved passage conditions affect those benefits.

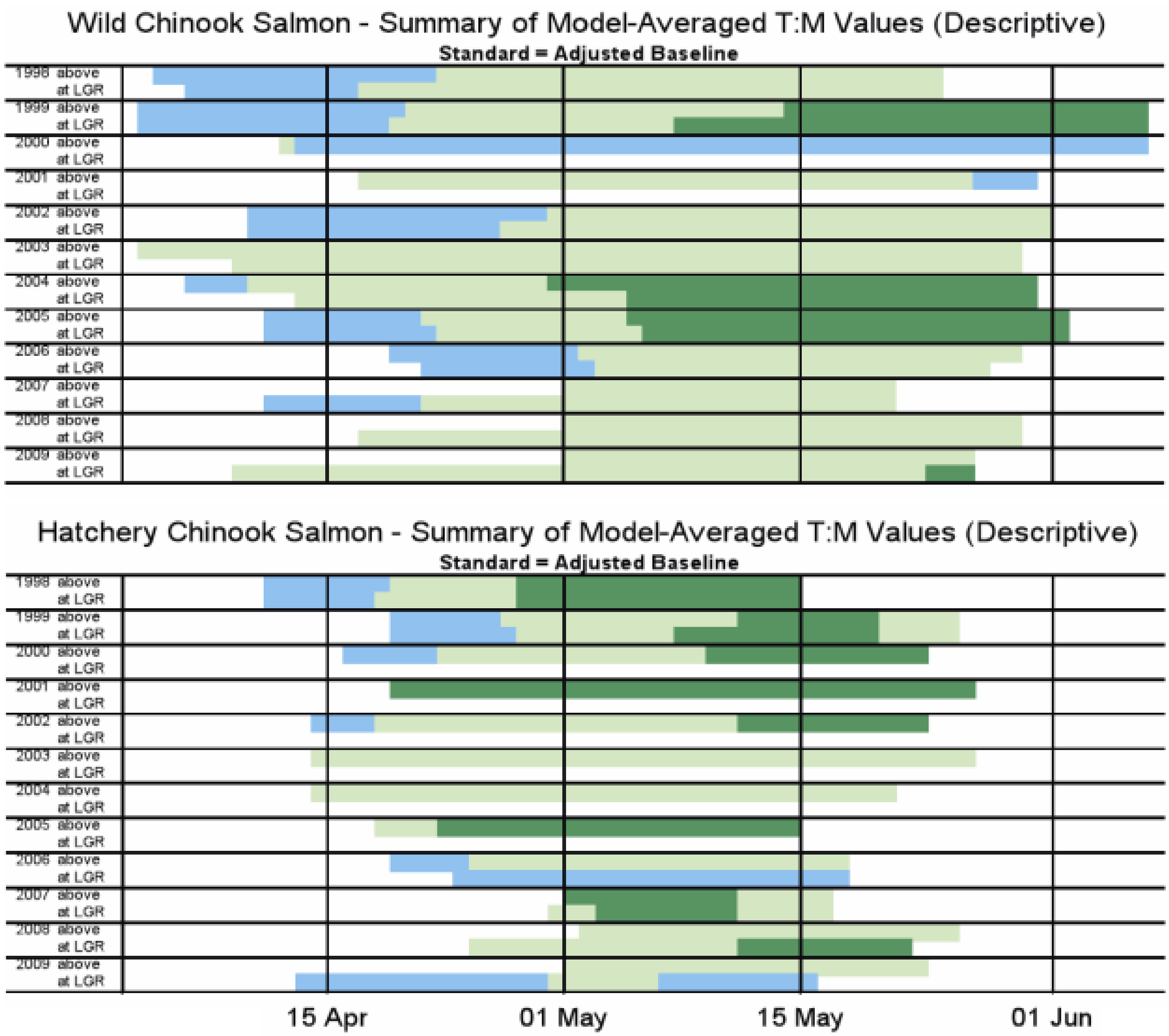


Figure 73. Color Coded Summary of T:M Ratios From Lower Granite Dam for Snake River Hatchery and Wild Chinook Salmon (Smith et al., 2013). Color coding: dark blue cells - T:M significantly < 1; light blue cells – T:M < 1, but not significantly; light green cells - T:M > 1, but not significantly; Dark green cells - T:M significantly > 1. White cells indicate no data. Statistical significance determined from 95 percent confidence envelope around model averaged curve.

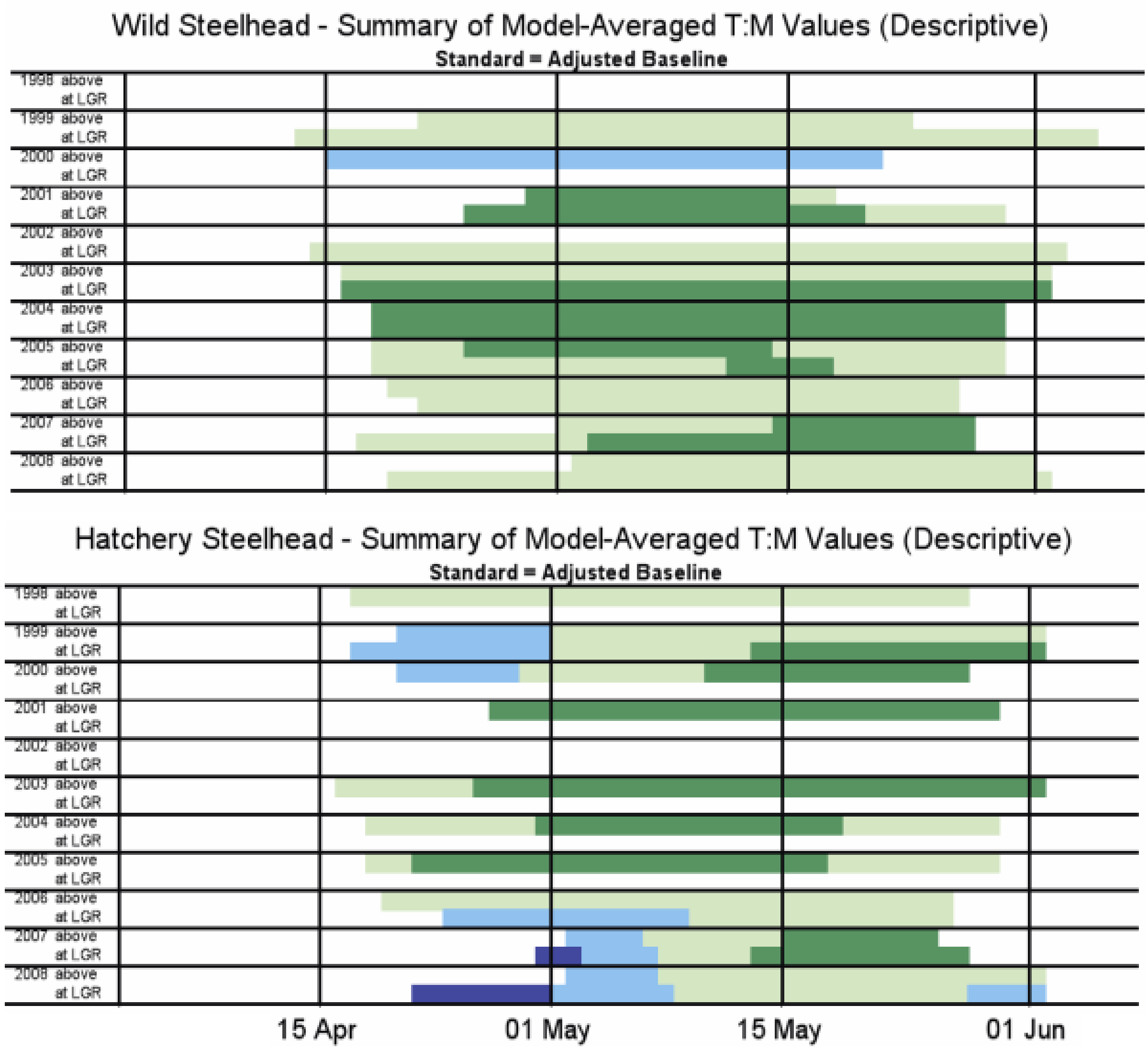


Figure 74. Color Coded Summary of T:M Ratios from Lower Granite Dam for Snake River Hatchery and Wild Steelhead (Smith et al., 2013). Color coding: dark blue cells - T:M significantly < 1; light blue cells – T:M < 1, but not significantly; light green cells - T:M > 1, but not significantly; Dark green cells - T:M significantly > 1. White cells indicate no data. Statistical significance determined from 95 percent confidence envelope around model averaged curve.

Summer Migrants: 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. 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 from returns through 2011 suggest that transport does provide some benefit to surrogate, production, and yearling outmigrants. Researchers continue to refine and evaluate methods for analyzing fall Chinook data and are on track to produce a methods for analysis report for review by ISAB.

Sockeye transport: In an effort to better estimate in-river survivals and SARs, a pilot study was conducted 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 and Oxbow Hatchery in Oregon. 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. After completion of the pilot study managers will have data necessary to either make informed decisions regarding the effects of transportation or critical information for designing a larger and more robust study when a new Sockeye hatchery is completed in Idaho. Initial results from 2009 results suggest transport is neutral for smaller Sawtooth reared sockeye and a strong benefit for larger Oxbow reared sockeye (Anglea and White, 2012).

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). 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.

BPA Projects 1996-020-00/1987-127-00 (CSS and the Smolt Monitoring Project): see description under RPA Subactions 52.2 and 53.1.

BPA Project 2003-041-00 (Evaluate Delayed Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams): see description under RPA Subaction 54.7

BPA Project 1990-055-00 (ISMES): Abundance, productivity, genetic and life history diversity (LHD), juvenile emigration rates, migration timing and SAR rates were gathered annually for wild populations of steelhead in Idaho tributaries.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-Idaho Department of Fish and Game): The objective of the Idaho Supplementation Study (ISS) was to assess the use of hatchery Chinook to augment or restore natural populations in 30 Idaho streams, including analysis of survival and fitness effects. Screw traps were operated on 15 streams to estimate abundance of outmigrating juveniles. Smolts were PIT-tagged and survival rates were monitored during migration through the hydropower system. Returning adults were detected at fish ladders, and redd surveys and carcass surveys were conducted to determine fitness of naturally spawning fish of wild and hatchery origin. 2009 was the last brood year of hatchery juveniles released for the study.

Major Lessons Learned

Results of research conducted from 2008-2012 continue to show that transportation is generally a benefit for Snake River spring Chinook salmon and steelhead; geometric mean transport SARs from Lower Granite Dam were 15-68 percent greater than non-detected in-river migrant SARs and 37-101 percent higher than bypass SARs. The only exception may be wild Chinook that, based on CSS assessments, survive at equivalent rates (SAR) whether transported or left in-river to migrate through the FCRPS. Preliminary results of Snake River sockeye and fall Chinook salmon transport studies suggest that transport is beneficial, and at minimum, transport is not harmful to these species. Evaluations of transport release timing and location concluded that benefits accrued from more distant release locations were negated by increased stray rates of returning adults.

***RPA Subaction 54.7 –** Monitor and evaluate the effects of environmental conditions affecting juvenile fish survival.*

Major Accomplishments and Findings

BPA Project 1996-020-00 (CSS) used a multivariate regression approach to develop survival models using different sets of environmental predictor variables. To integrate both immediate and delayed effects of the migration experience, the CSS study defined river variables covering extended river reaches such as mean spill percent across multiple hydro-projects. The study estimated correlations between river variables and within-river juvenile survival or SAR rates based on the PIT-tag dataset from 1997-present. Model selection was used to identify the most important predictive variables. The best fit models for salmon consistently include fish travel time, spill levels, presence of surface passage routes, temperature, and Julian day. For wild yearling Chinook, survival through Snake River reaches was most strongly correlated with Julian day, water transit time, and surface passage, while hatchery Chinook also responded to water temperatures. Survival among subyearling Chinook in the Snake River was most strongly correlated with water travel time, but was more strongly correlated with water temperature in the lower Columbia River. Steelhead survival was correlated with Julian day, spill, temperature, water travel time, and surface passage. Sockeye survival over the study period was most strongly correlated with presence of surface passage routes in the Snake River.

BPA Project 1989-108-00 (Modeling and Evaluation for lifecycle studies): In 2011, Columbia Basin Research at the University of Washington developed several functional relationships for future use in NOAA Fisheries' COMPASS model. The COMPASS model estimates the separate relationships reservoir survival and fish travel time as a function of river variables using the long-term PIT-tag dataset. Short-term tests using acoustic tag, radio telemetry, and PIT-tags with the most current dam configuration were used to estimate route specific distributions and survival probabilities. Model selection showed that temperature, flow, and spill proportion had the best predictive value for system survival for Snake River steelhead and yearling Chinook. However steelhead survival was more sensitive to river flow than Chinook. Chinook had a nonlinear water temperature relationship with an optimum at 11 degrees centigrade, and was sensitive to mean spill percent across the system in the range of 0-25 percent. CBR evaluated differential post-hydrosystem survival of Snake River hatchery spring Chinook from transported and in-river routes. Dominant factors explaining survival outcomes were cumulative temperature exposure during migration, ocean entrance timing, and upwelling. The functional relationships with temperature and flow were used to explore survival outcomes of scenarios of climate change. Future temperature increases could potentially reduce survival of steelhead more than yearling Chinook. However, changes in outmigration timing could either mitigate or improve the trend.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams and Reservoirs): NOAA Fisheries evaluated reach survival rates of PIT-tagged yearling Chinook and steelhead. Weekly cohorts were used to develop relationships between survival and migration conditions (month, temperature flow) which can be used to update NOAA Fisheries COMPASS model and to monitor interannual trends. Survival from Snake River hatcheries to the Lower Granite tailrace between 1998-2011 was strongly correlated with distance traveled. Installation of surface passage structures has reduced precision of survival estimates by reducing the fraction of smolts traveling through bypass routes. Travel time has decreased after surface passage was installed, and 2011 had the shortest travel time measured during the study. Shorter travel time has reduced cumulative exposure to high water temperatures.

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

BPA Project 2003-041-00 (Evaluate delayed mortality of yearling Chinook through Snake River dams): NOAA Fisheries has completed its seventh study year in 2011. 70,000-300,000 yearling Chinook smolts were tagged annually at Lower Granite Dam, to be split among three experimental treatments. The groups collected at Lower Granite Dam were either released in-river, trucked to McNary reservoir, or trucked and released at Lower Granite Dam. Five full cohorts of returning adults were available in 2012 for analysis of Lower Granite Dam-to-Lower Granite Dam smolt-to-adult survival ratios. The annual cohorts experienced different levels of effect of transport on SAR rates. This suggests that there is a significant year effect on relative survival rates driven by factors other than transportation. In 2005 and 2007, SARs for adults returning to Bonneville Dam were >2X higher for the group transported below Ice Harbor Dam, were somewhat higher for the 2008 cohort, and there was no significant difference in 2006. Additional years of adult returns should help clarify whether annual river conditions, dam operations, or some other factor contributes to this pattern for different species. When full returns are available from all cohorts in 2014, NOAA Fisheries will conduct an analysis of the effects of river conditions on juvenile survival.

Major Lessons Learned

Several studies have explored the relationship between juvenile survival and flow/fish travel time/smolt survival using datasets spanning multiple decades. In recent years the influence of additional predictor variables has been examined. Several of the studies described above rely on SARs as the response variables, which may reflect delayed effects expressed during marine residence. Results from those investigations are more appropriately treated in RPA Subactions 52.2 and 55.1. Not all investigations use the same response variable. This can confuse the conversation with regard to the focus of this RPA, which clearly specifies in-river survival through the FCRPS as the response variable of interest.

In those investigations where in-river smolt survival is the response variable, several predictors regularly emerge as explanatory variables. These include, flow, spill fraction, water temperature, and numbers of surface bypass systems in the FCRPS. A common challenge in estimating the functional relationship with survival is the autocorrelation between many of these variables, which limit the ability to identify the most influential factors. Furthermore, the continual improvement in dam configurations and operations in recent years further confound the ability to disentangle the contribution of individual predictor variables, and limits our ability to assess incremental changes in smolt survival as associated with fluctuations in any single factor.

Finally, while some effects may be directly estimated with at-dam tests, such as the effect of flow levels and spill distributions on route effectiveness and tailrace delay, other variables may exert a delayed effect. For example, both Scheuerell et al., (2009) and Muir et al., (2006) explored the significance of arrival timing in the estuary and early ocean, which may only be detected in adult return rates. Delayed effects are addressed under RPAs 52.2 and 55.1.

RPA Subaction 54.8 – *Monitor and evaluate the effectiveness of reducing predation toward improving juvenile fish survival.*

The Action Agencies continue to implement habitat- and dam-based actions to reduce predation on juvenile and adult salmonids. See RPA Actions 48 and 66 through 70 for detailed information on activities addressing this subaction.

RPA Subaction 54.9 – *Investigate, evaluate and deploy alternative technologies and methodologies for fish passage and the RM&E Action.*

Major Accomplishments and Findings

The Juvenile Salmonid Acoustic Telemetry System (JSATS) development efforts have focused on providing smaller reliable acoustic tags capable of providing accurate survival estimates of juvenile salmonids passing dams. The JSATS tag has been designed to reduce the overall size of the tag while maintaining current detection probabilities (McMichael et al., 2010; Weiland et al., 2011; Deng et al., 2011).

A multi-year evaluation of the effects of surgically implanted acoustic tags (JSATS) on the survival and behavior of juvenile salmon and steelhead was conducted from 2006 to 2008. The purpose was to help determine if active tag studies using smaller tags could provide unbiased reach and system survival estimates as well as dam survival estimates, or if inference from these studies should be restricted to dam survival estimates as earlier studies on larger tags has suggested (Hockersmith et al., 2003). Field studies indicated that although some effects exist, specifically in smaller fish, survival estimates derived using JSATS over longer reaches are comparable, yet more precise, than estimates derived using PIT-tags (Brown et al., 2013)

In addition to these large field studies extensive laboratory studies were conducted from 2008 to 2010 to understand and improve surgical implantation techniques and methodologies (Boyd et al., 2011; Brown et al., 2010a, 2010b and 2011; Carter et al., 2011; Cooke et al., 2011; Deters et al., 2010 and 2012; Harnish et al., 2011; Oldenberg et al., 2011; Panther et al., 2011; Wagner et al., 2011; Walker et al., 2013). Results from these studies were used to ensure that effects from the tagging process were minimized reducing potential for negatively biased survival estimates. In 2009, the Corps' Portland District convened a series of meetings with Federal, State, and Private (PUDs) fisheries scientists to standardize how fish are tagged for survival studies. This process led to formation of a Surgical Tagging Committee and a standardized protocol document on surgical tagging techniques used (Columbia Basin Surgical Protocol Steering Committee, 2010).

In 2009 and in preparation for performance standard testing the Corps funded the development of a new survival model as well as a study design for estimating dam passage survival (Skalski, 2009). Based on the Paired-Release model of Burnham et al. (1987) this new model was designed to reduce the probability of potential bias associated with the Paired-Release Model. The model and robust study design was extensively reviewed by the region (i.e. ISRP, 2009) and along with other regionally reviewed standardized protocols was accepted as the method for estimating performance standards for dam passage survival.

Advanced video image processing development 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 Corps completed a multi-year analysis of juvenile salmonid passage and survival at McNary Dam (Adams et al., 2011). 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). Studies conducted at PNNL in 2009-2010 exposed tagged and untagged juvenile Chinook salmon to simulated turbine passage pressures typical of turbines at FCRPS dams (Carlson et al., 2010). These studies elucidated the confounding effects of surgically implanted acoustic tags on juvenile Chinook survival when exposed to simulated turbine passage. Referred to as tag burden, the added mass and potentially organ crowding, caused by the internal tag increased the probability of mortal injury from swim bladder expansion or rupture.

Understanding the probability of mortal injury related to tag burden and barotrauma is important because turbine survival estimates may be biased low by tag burden. Building upon the works of Carlson et al. (2010), the Corps pursued an external tag laboratory study to develop and 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 (Carlson et al., 2011). Two external tags were developed and examined for their effect on swimming performance and tag retention relative to turbulence and shear. The Type A tag was a backpack style tag that sutured anterior to the dorsal fin, and the Type B tag was a saddle type tag that sutured to either side of the dorsal fin. The external JSATS tags were developed and laboratory tested in 2011 by Battelle at the PNNL in Richland, WA. The external JSATS tags were developed to be neutrally buoyant eliminating tag burden and organ crowding.

Laboratory study results suggested that the Type A tag was superior to the Type B tag and will be discussed further here. Results suggested that there was no significant difference in critical swimming speeds between internally and externally tagged fish ($p = 0.512$); however, critical swimming speeds were significantly different between externally tagged and control cohorts ($p = 0.008$). Predation rates between externally tagged and untagged cohorts were not significant ($p = 0.262$). Externally tagged and untagged controls were exposed to nadir pressures ranging from 1.6-11.6psi. Mortal injury rates were not significantly different for externally tagged and untagged control fish ($p = 0.380$). During shear exposures one Type A tag was lost out of 21 (4.8%).

In 2012, a field study of the Type A tag relative to internally tagged cohorts was conducted in the tailrace at Ice Harbor Dam. A total 1440 fish were released in the Ice harbor tailrace in groups of 240 externally and 240 internally tagged exposed to simulated turbine passage, 240 externally tagged and 240 internally tagged not exposed to simulated turbine passage. A tag retention release group of 480 PIT-tagged fish with dummy external transmitters were released upstream of the Ice Harbor to be collected in the McNary bypass system. Cohorts exposed to simulated turbine passage were released in the unit 1 turbine boil to determine detection efficiency at the Snake and Columbia River confluence and downstream to McNary Dam. Preliminary results indicate that detection efficiencies at Burbank near the Snake and Columbia River confluence between internally and externally tagged fish, both exposed and unexposed to simulated turbine passage were 100%. Detection efficiencies from Burbank to McNary ranged from 95-96 percent for external tags and 93-99 percent for internal tags. Preliminary survival estimates from Ice Harbor to Burbank were not significantly different among internal and external tag groups ($P = 0.128$); however, internally tagged fish survived at a higher rate from Burbank to McNary.

BPA Project 2003-114-00 (COAST): The COAST project successfully deployed transceiver arrays to detect acoustically tagged fish over substantial physical distances in the ocean regions they were deployed along the estuary, Columbia River mouth, Willapa Bay, and Lippy Point, BC. The study included a multiyear experimental evaluation (2006-2011) of hydrosystem survival and post-Bonneville survival of in-river transported groups, and among populations passing four vs. eight hydro-dams. Detection rates were compared at acoustic telemetry arrays at the Columbia River mouth and northern coastal sites. No significant difference in survival rates for in-river tag groups from the upper Snake vs. Yakima river was seen as far away as northern Vancouver Island during the four years of the study. There was substantial within-season variation in survival between weekly release groups.

BPA Project 1983-319-00 (New Marking and Monitoring Technologies) NOAA Fisheries has evaluated designs for spillway or concrete fishway based PIT-tag detection systems. A prototype of the antenna that would be installed at the ogee at Lower Granite Dam was embedded in nonferrous concrete and tested. In 2012, the new transceiver that will be needed for the ogee detector was installed and tested on the CC PIT-tag antenna at Bonneville Dam PH2. Testing of both components were successful. The plans to install the new system at Lower Granite Dam continues. Advances in technology may alter the project. A new type of antenna that can be installed in front of the RSW at Lower Granite Dam is being tested. If successful, this may be used instead of the more costly ogee location. Tag collisions of multiple fish simultaneously passing the detector and low detection rate during periods of high flow are important design challenges.

Major Lessons Learned

It is possible to attain statistically robust, absolute dam survival estimates for juvenile Chinook and steelhead that migrate through the FCRPS. Spillway PIT-tag detection appears feasible at some level, however prototype testing will be needed to determine detection probability and the ability of the system to withstand the harsh spillway hydraulic environment. A potential bias in survival estimates was elucidated by research on fish exposed to rapid decompression. External tags may be a tool for reducing bias in estimates of survival associated with rapid decompression during turbine passage for juvenile salmonids.

The development of the external JSATS tag for turbine survival studies may provide more accurate survival results when specifically evaluating turbine passage by eliminating tag burden associated with surgically implanted tags.

RPA Subaction 54.10 – *Determine if actions directed at benefiting juveniles have an unintended effect on migrating adults (e.g., certain spill operations).*

Major Accomplishments and Findings

In 2008, radio tags were used to determine whether spill patterns at Little Goose Dam were having a negative effect on adult passage (see RPA Action 28 for more detail). Adult migration at Little Goose Dam was slowed substantially during pre-surface SW implementation for high-volume summer spill in 2005 and bulk pattern spill in spring 2007. Prior to a SW implementation, a 2008 study to determine the cause of adult passage delay used two bulk patterns (to mimic a surface passage structure) and a uniform pattern that mimicked the anticipated training spill for a surface passage structure (Jepson et al., 2009). Data indicated that adult passage percentage was slightly higher through the north shore spillway entrance than the south shore powerhouse entrance, with about 10 percent of the adults entering the north powerhouse entrance near the dam's center. The uniform pattern produced the shortest median times from first tailrace record to first fishway approach, produced the highest percentage of first fishway approaches resulting in fishway entrance, and produced the shortest median time from first tailrace record to last record at the top of the fish ladder. A two-elevation Temporary SW was installed in spillbay 1 in 2009 with adult passage monitored via daily counts comparisons at Little Goose Dam and upriver/downriver dam during 2009, revealing no substantial passage delays during the more average flow year operations with 30 percent spill. Slight delays for a couple sets of two-three days during higher in-season spill proportions for spring Chinook salmon and sockeye were detected.

Passage delays of spring Chinook salmon did occur more regularly at Little Goose Dam during the higher spring freshet of 2010, prompting removal of the Temporary SW and switching to a uniform spill pattern for a couple day increments to allow for a few hundred delayed Chinook adults to pass. Additional analysis late in 2010 prompted a February visit to the scaled physical model in Vicksburg, Mississippi, to develop an adjusted spill pattern to break up the Temporary SW jet effects of creating eddies that partially blocked the attraction flow nets at the ladder entrances. 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 SW 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. During the higher flow year 2011, minimal delay in the tailrace of Little Goose Dam was detectable in count data distributions for only the extreme spill conditions at inflows approaching 200 kcfs in the Snake River.

Delays in closing the Temporary SW of up to three days led to a decision to design an automated hoist that would allow closure of the SW in a more immediate manner and provide a more rapid response to future passage problems. No adult telemetry research post- Temporary SW has been prioritized and funded to verify that the revised spill pattern eliminated the masking of attraction flows into the ladder entrances at Little Goose Dam.

In 2010, a 800' long training wall was constructed between spillbays 8 and 9, and an 8-bay spill pattern was implemented at The Dalles Dam. To ensure the new spill pattern did not negatively affect adult fish passage through the North Ladder, the Corps conducted an radio-telemetry study, and assessed fish counts. A 2010 radio-telemetry study suggested that adult spring-summer Chinook passage was not delayed as a result of the new tailrace conditions and structure, but the percentage of tagged salmon using the north ladder was lower during higher spill conditions (100-150 kcfs) (Jepson et al., 2011). The percent of fish using the north shore ladder before construction of the spillwall (2000-03) vs. after construction of the extended wall (2010-12) was assessed as well. Based on the fish count data, there has been no substantial reduction in north shore ladder use by Chinook and steelhead. Sockeye use of the north shore ladder, however, was substantially lower post-spillwall vs. pre-spillwall. A radio-telemetry study is planned for 2013 and 2014 to further assess whether the extended-length spillwall has delayed adult salmon as compared to pre-spillwall conditions. Using results from this study as well as ladder counts, the Corps will work with regional stakeholders to determine whether additional improvements are warranted.

Major Lessons Learned

Observations at Little Goose and The Dalles dams reinforce the notion that that spill amounts and patterns intended to improve juvenile fish passage should be balanced with negative effects on adult passage. When implementing juvenile fish passage improvements at dams, effects on adult passage as well as other factors need to be considered, and in some cases further evaluated, before final decisions on dam configurations can be made.

RPA Subaction 54.11 – *Install and maintain PIT-tag detectors in fish ladders at key dams in the FCRPS and evaluate adult survival (conversion rates).*

Major Accomplishments and Findings

In 2011, the Corps initiated a study at The Dalles and John Day dams to determine a cost-effective adult PIT-tag detection system. In consultation with NOAA Fisheries, the Corps determined that installation of PIT-tag detectors at The Dalles Dam would improve inter-dam adult survival estimates. An alternatives study was completed in October 2012 with preferred alternatives selected for The Dalles Dam ladders. Detailed design of the preferred alternative is planned for 2013-2014. To support telemetry studies planned for 2013-2014, the Corps installed temporary PIT detection systems in The Dalles north and east ladders.

Adult survival results (conversion rates) are presented under RPA Subaction 52.3 above.

BPA Project 2001-003-00 (Adult PIT Detector Installation): PSMFC staff are developing a new thin-wall PIT-tag detector that could offer new capabilities and greatly reduce installation costs. The prototype installation will be tested at The Dalles in 2013.

PIT-tag detectors were installed and maintained in all key FCRPS ladders. Per subaction 52.7, the Corps is designing a long-term solution for permanent detectors at The Dalles Dam (see 52.7 for more details).

The current status of PIT-tag detectors in fish ladders is summarized in the accompanying table.

Table 62. PIT-tag Detector Sites that Provide Data for Hydro-related RM&E. Existing (E), Proposed or Planned (P), and a blank indicates none in place or planned. SFO = Surface Flow Bypass, e.g., RSW, Bonneville Corner Collector.

Site	Smolt Bypass	SFO	Ladder	Other/Comment
Snake River				
Lower Granite	E	P	E	Test the RSW at Lower Granite for 2014
Little Goose	E			
Lower Monumental	E			
Ice Harbor	E		E	
Mid-Low Columbia				
McNary	E		E	
John Day	E			
The Dalles			P	A ladder system is being designed for installation in 2015
Bonneville	E	E	E	
Trawl				The current Trawl Program may be expanded, if necessary.
Upper Columbia				
Wells			E	
Rocky Reach	E		E	
Rock Island	E (Minor)		E	Small sample fraction of downstream migrants
Wanapum				
Priest Rapids			E	
Other				
Harvest Sampling				CRITFC started sampling in fall 2010 to improve conversion rate estimates
Tributary-Stream Bottom				Decisions regarding required coverage are pending

Major Lessons Learned

The distribution of PIT-tag detectors in ladders of the FCRPS (including the temporary installation at TDA) is adequate to meet required monitoring needs. Furthermore, continuing research and development by PSMFC on PIT-tag detection equipment is paying dividends with the promise of new, more compact, and cheaper detectors on the horizon.

RPA Subaction 54.12 – *Monitor and evaluate the effects of fish ladder operations and configurations on adult passage rates.*

Major Accomplishments and Findings

During the 2008-2012 period, the ladder modification that have taken place included a major renovation of the John Day north ladder, and modifications to improve adult lamprey passage through Bonneville and McNary dam ladders. In 2010, lamprey orifices were installed in the stem walls of the telescoping weir walls of the Oregon shore ladder at McNary Dam. Lamprey orifices at three stem walls were monitored using video cameras. This monitoring revealed that, “migrating stocks of adult salmon, steelhead, and shad were not delayed or otherwise harmed by the presence of lamprey orifices. Of all monitored species, sockeye were most likely to attempt lamprey orifice passage, but at a very low frequency (0.016 percent) of the entire run.” (Eder et al., 2011)

In 2011, picketed leads near the count stations at Bonneville Dam were raised approximately 1 to 1.5 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 FFDRWG to determine to what height the leads can be lifted that will assist lamprey passage but not allow sockeye into the AWS.

In 2009 and 2010, radio telemetry studies of spring-summer Chinook salmon were performed at Bonneville Dam to evaluate whether modifications made at the Cascades Island (CI) fishway to facilitate passage of adult Pacific lamprey adversely affected passage of adult salmon. Based on the two years of results, the researchers concluded that the modifications to the CI ladder did not appear to appreciably impede salmon passage and appeared to offer some passage benefits (i.e., increased entrance efficiencies) to lampreys (Jepson et al., 2011).

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.

The Corps completed structural improvements to the upper section (including count station) at the John Day Dam north fish ladder in spring 2010. Passage evaluations in 2010 suggest that the upper ladder modifications successfully resolved the chronic delay, jumping and turn-around problems observed in that section (Jepson et al., 2011; Madson and Jonas, 2011).

For additional details on evaluation of ladder configurations see RPA Action 28.

BPA Project 1996-020-00 (CSS): see description under RPA Subaction 52.2

BPA Project 2003-041-00 (Evaluate Delayed Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams): see description under RPA Subaction 54.7.

Major Lessons Learned

Changes to adult fish ladders that are intended to improve adult lamprey passage can have negative effects on adult salmon, and therefore need to be monitored and evaluated. As improvements for lamprey passage are made at ladders, additional or modified design criteria may be required to ensure salmon are not negatively affected.

RPA Subaction 54.13 – *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.*

Major Accomplishments and Findings

From the winter of 2008 to the spring of 2009, an evaluation was conducted to assess operation of The Dalles Dam sluiceway from March 1–31 and from December 1–15 as a potential means to provide a safer fallback passage route for overwintering steelhead and kelts. A second year of evaluation was initiated in December 2009 and continued through March 2010, including monitoring of turbine passage during the closed-sluiceway operation of mid-December 2009 through the end of February 2010. Results from two years of evaluations of downstream passage through The dam sluiceway by overwintering summer steelhead and outmigrating steelhead kelts suggested that there is a large enough survival increase (0.9 percent of a 6 percent target for Snake River steelhead) to justify keeping this surface route open later, December 1-15 (Tackley and Clugston, 2011). The extended ITS operation has been included in the FPP as part of standard fish passage operations at The Dalles Dam since 2011.

BPA Project 1994-033-00 (Fish Passage Center): see description under RPA Subaction 53.1

Major Lessons Learned

Extending the operation of The Dalles Dam sluiceway through December 15 provides an overall SB for overwintering steelhead. This result, combined with observations at McNary and Bonneville dams suggests that additional in-river improvements for overwintering steelhead and steelhead kelts may be possible by extending the operation period of surface flow outlets at other mainstem dams.

RPA Subaction 54.14 – *Investigate surface-flow outlets during wintertime to provide safer fallback opportunity for over wintering steelhead (need will be determined by results of further research).*

Major Accomplishments and Findings

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 Dam project.

Adult passage was monitored at eight 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 powerhouse 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 be different if all units were operating. What would remain unchanged is the relatively low passage numbers near the center of the powerhouse where sample coverage was complete. (Ham et al., 2012)

A DIDSON camera device was used to monitor the region just upstream of the trash rack at units 5C and 6A to verify the presence of adult steelhead and similar sized individuals of other species. From December 17 through January 20, 2011, the cameras sampled during the first 15 minutes of every hour. From January 20 through April 15 the cameras sampled for 20 minutes at the beginning of every hour. The bulk of steelhead observed were moving and behaving in ways that were not suggestive of turbine passage. It was not possible to determine 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.

Results from continuing this study in the winter of 2011 – 2012 (Ham et al., 2012) show trends in steelhead counts that suggest steelhead were more abundant in mid- December to early January with another small peak in early March. Apparent counts of steelhead in the forebay upstream of turbine unit 6 appeared to decrease somewhat after spill began on March 14. The analysis provides insight on the influence of spill on passage but since spill was not included in the study design it may confound other factors that the researchers wanted to compare. Behavioral observations suggest that steelhead were holding upstream of the powerhouse for some time, and their apparent abundance in the forebay was not highly correlated with the number of fish passing downstream through the hydroacoustic sampling areas within the intake. A total of 193 acoustic targets with track characteristics consistent with adult steelhead were detected. Targets detected increased dramatically from 68 in 2010-11 but there were more sampling locations in 2011-12 (12 turbine intakes monitored vs. 8 in 2010-11) and more sampling days than in 2010-11. Downstream passage of adult steelhead through the monitored intakes at the powerhouse of McNary Dam was estimated to be 1786 individuals. If a similar rate of passage through the two unmonitored turbine intakes is assumed, the estimate of total powerhouse passage would be 1893 individuals (in 2010-11 they estimated 946 steelhead through the monitored intakes and 1,419 including the 6 unmonitored intakes). Distribution of passage among turbine units was similar to 2010–2011 data, in that passage was greatest at turbine units nearer the north or south ends of the powerhouse, and least near the center of the powerhouse. Passage was concentrated near the ceiling of the turbine intake. Very few fish passed at depths well below the intake ceiling. About 67 percent of the steelhead passed at depths of 57 to 60 feet below the water surface. Powerhouse passage was skewed north toward the spillway during forced-spill, which is obviously different from the skew toward the south of the powerhouse during the no-spill period. Although the ad hoc nature of this comparison makes it difficult to infer whether spill or increased turbine flow is responsible for the differences observed, the results indicate that it would be possible to alter adult steelhead passage rates or distributions through management action.

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).*
2. *Investigate the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville. (Initiate in FY 2007–2009).*
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.*
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.*
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.*
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.*
7. *Investigate feasibility of developing PIT-tag detectors for spillways and turbines.*
8. *Evaluate new tagging technologies for use in improving the accuracy and assessing delayed or indirect hydro effects on juvenile or adult fish.*
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.*

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

- RPA Action 55 calls for funding of a comprehensive research program covering a range of uncertainties, with special emphasis on new tagging technologies to improve the information base. Between 2008-2011, each of the RPAs was addressed with multiple research projects. Relevant hydro research conclusions for each RPA is highlighted below.

RPA Subaction 55.1 – *Investigate and quantify delayed differential effects (D-value) associated with the transportation of smolts in the FCRPS as needed.*

Major Accomplishments and Findings

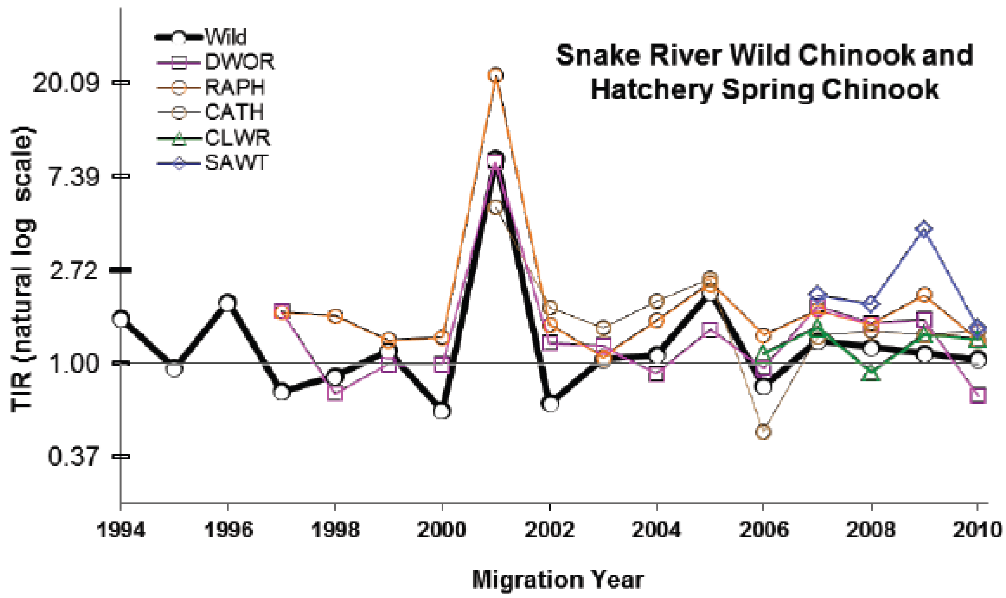
Several multiyear research studies are funded through the FWP. They continue to assess and estimate differential delayed effects associated with the transportation of juvenile salmon and steelhead. The parameter D is the ratio of post Bonneville survival of barged and in-river migrants. Other indices of transportation benefit provide more direct and readily interpretable results, including various transport-to-in-river migrant ratios such as TIR and T:M indices. We report relevant indices as presented by the individual investigative teams.

BPA Project 1996-020-00 (CSS): This project estimated D (ratio of survival from Bonneville Dam to Lower Granite Dam as adults for transported: in-river smolts), and T:I (Ratio of survival from outmigration at Lower Granite Dam to adult return at Lower Granite Dam for transported: in-river smolts) for 15-18 years among hatchery and wild populations of Chinook and steelhead, (and also some sockeye) from tributaries in the Snake and Columbia rivers. This study found that PIT-tagged smolts, which had experienced multiple passages through powerhouse bypass systems, have had lower mean rates of adult return than smolts which were never detected at a bypass (i.e., only passed through the system via spill, surface bypasses, or turbines). The causative mechanism of the correlation between bypass events and lower adult return rates remains a critical unknown (ISAB, 2012). Two primary hypotheses are that bypass systems select for smaller and weaker fish and bypass systems cause stress and injury. For the most recent five juvenile cohorts with full adult returns (2006-2010), the mean T:I for steelhead is well above 1.0 (Figure 75). This indicates that transportation provides a benefit to wild and hatchery steelhead across a wide range of water years. Transported hatchery and wild Chinook survived at mean rates higher than in-river migrants. For both wild Chinook and steelhead displayed a T:I below 1.0 only for the 2006 outmigration. In-river survival in 2006, a moderately high flow year, was the highest in the 14 year time series for hatchery and wild Chinook.

The current time series only spans two years since completion of installation of surface passage outlets, and given the lag in adult returns, several more years may be required to evaluate the success of these major changes in design and configuration.

BPA Project 2003-114-00 (COAST): Kintama compared survival rates from 2006-2009 among smolts tagged at the Cle Elum Hatchery on the Yakima River (passing four dams to reach the estuary), with smolts from Dworshak NFH on the Snake River (passing eight dams to the estuary). The COAST study directly monitored short-term survival rates of juveniles in the coastal ocean after exiting the FCRPS, but could not monitor adult return rates due to short tag life. The Yakima and Dworshak hatchery populations had similar near-term survival rates, despite historically higher mean adult returns at Bonneville Dam for the Yakima population. This could suggest that the difference in SAR appears to develop later in the marine migration. Comparisons were also made between fish tagged at Lower Granite and John Day dams in 2010, and among populations arriving at Bonneville Dam from the mid-Columbia, upper Columbia, and Snake rivers in 2011. Group comparisons indicated upper Columbia and Snake river juveniles had similar mortality rates before reaching detection arrays at the Columbia River mouth, Willapa Bay, and Vancouver Island during experiments conducted in 2006-2011, but had significantly higher mortality rates than mid-Columbia populations. While it was impossible to estimate SARs due to short tag life in the COAST study, barge-transported smolts experienced lower early ocean survival rates only during the year 2011, but not during the 2006, 2008, or 2009 study years. It is still uncertain whether climate or river conditions such as the high flow rates of 2011, contribute to this pattern.

BPA Project 1989-108-00 (Lifecycle Modeling and Evaluation): This project used empirical and statistical approaches to investigate mechanisms which could contribute to D. A retrospective model determined that ocean entrance timing, upwelling, and relative heat exposure best explained the post-hydrosystem survival of barged and in-river migrants. The project also explored the hypothesis of selective culling of fish. Juveniles which arrive at Lower Granite Dam in poor condition (due to disease, injury, or lack of feeding) are expected to suffer higher mortality rates during their in-river outmigration due to predation. Barged juveniles which were at the end of the distribution of physical condition appear to survive at high rates until arrival below Bonneville Dam, but they may experience disproportionate rates of predation during their first weeks in the estuary and coastal ocean.



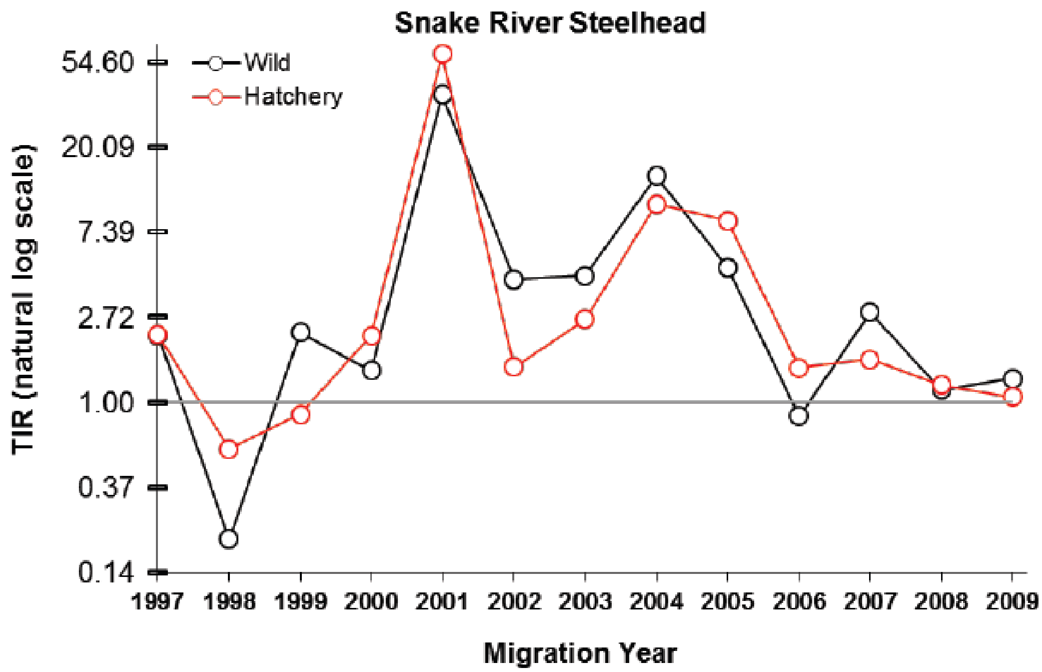


Figure 75a, b. Trend in TIR (Relative Smolt-to-Adult Survival Rate from Lower Granite Dam-to-GRA of Fish which Were Transported Below Bonneville Dam vs. Migrated In-River) on Natural Log Scale For PIT-tagged A. Snake River Wild Chinook and Hatchery Chinook 1994-2010, and B. Snake River Wild and Hatchery Steelhead 1997-2009. The reference line at 1.0 indicates where in-river and transport SARs are equal. (Tuomikoski et al., 2012).

Recently Corps-funded transportation research has been conducted to determine when transport operations provide a benefit to ESA listed fish. For Snake River ESUs, results from the migration years 2006-2009 (only years for which SAR estimates are currently available, post court-ordered spill) vary by species.

With regard to delaying the start of transportation until near the end of April, analyses by NOAA (Smith et al., 2011) indicate that results have been mixed. During early April, wild spring Chinook migrating in-river exhibit higher SAR than those transported. Whereas hatchery spring Chinook and both wild and hatchery steelhead are more variable in their response depending on the year. Unfortunately, ESU-level responses to the operation have not yet been conducted. This is an essential step in ascertaining if this operation results in tradeoffs among species or populations (hatchery or wild), with respect to overall SAR for each ESU.

Importantly, NOAA analyses (Smith et al., 2013) reveal that beyond 1 May both wild and hatchery populations of Snake River spring Chinook and steelhead exhibit higher SARs when transported as compared to any in-river reference group, except hatchery steelhead which have not shown a benefit until after the first week of May since 2006. Although smolt survival through the FCRPS has improved since 2005, transported spring Chinook and steelhead still appear to survive (SAR) at higher rates than in-river-migrating counterparts. This has implications regarding the use of spill at Snake River dams post-1 May. That practice diverts fish away from collection/transport facilities, greatly reducing the proportion of the population transported. This is reflected in recent estimates (2006-2011) of the proportion of smolts transported from the Snake River (Figure 76). The consequences of these operations (delay transport & high spring spill) at the ESU level have not yet been analyzed. This remains a critical step in crafting an effective passage strategy for both these Snake River ESUs.

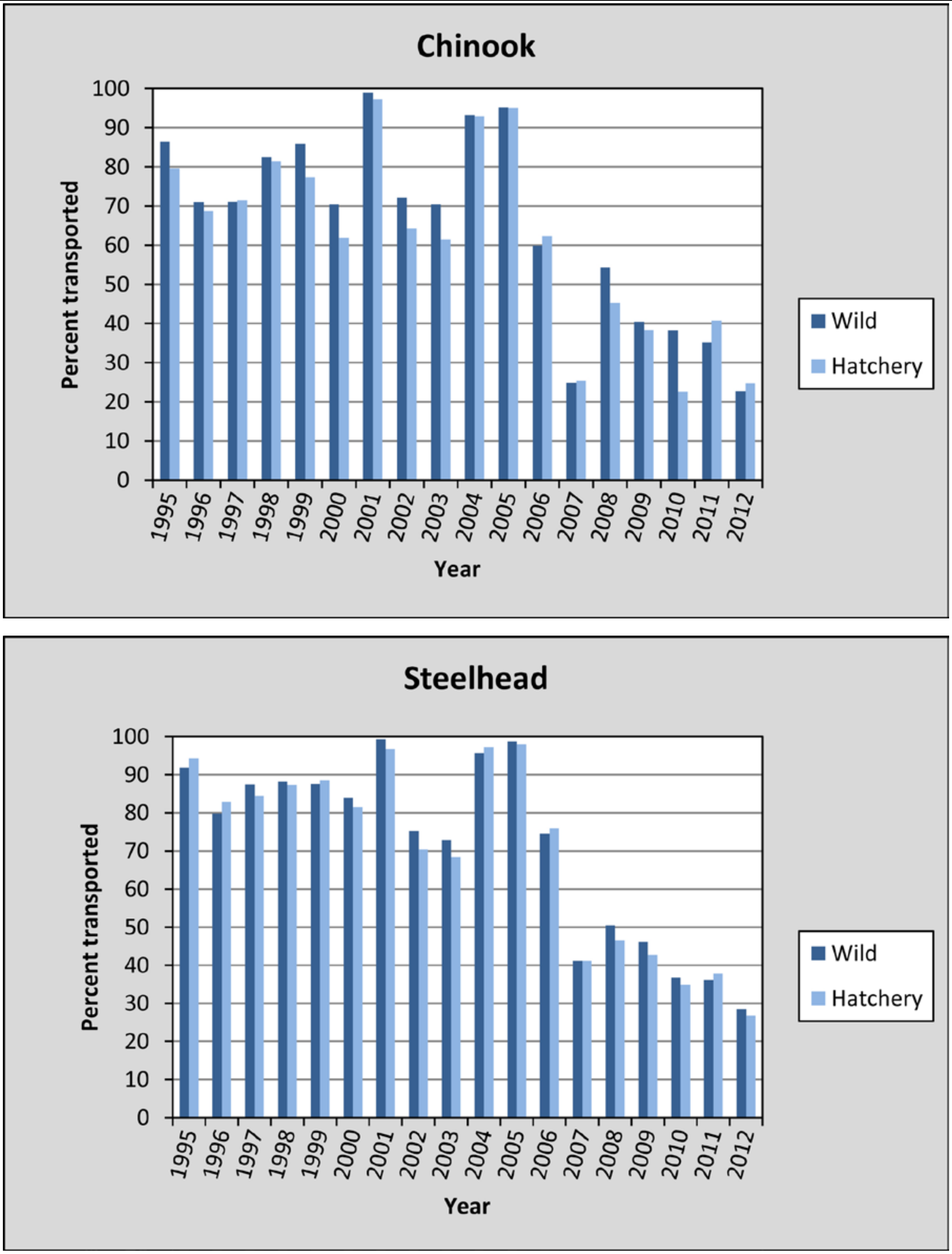


Figure 76. Estimated Percent Yearling Chinook Salmon and Steelhead (Wild and Hatchery) Transported to Below Bonneville Dam (1995-2012). (1995-2011 data are from Faulkner et al., 2012; 2012 data are from Zabel, 2012.)

Although transport may result in higher SARs there can be deleterious effects associated with transportation. Based on observations of increased steelhead straying into some mid-Columbia tributaries, the Corps initiated a program in 2011 to evaluate straying rates and causative mechanisms. The first product in this multi-year effort is a white paper on steelhead stray rates, wherein a model was developed 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). 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 SBs of transportation observed for steelhead.

An evaluation of stray rates and patterns has found consistent evidence that barged fish stray at higher rates than their counterparts that migrate in-river. These same evaluations have also found that populations of the same species have highly variable stray rates (Keefer and Caudill, 2012).

The Snake River smolt population is multi-species complex, which includes sockeye. Passage studies involving sockeye are limited due to their low abundance. Recently, the Corps has been funding a feasibility study that PIT-tagged juvenile sockeye salmon from 2009-2012. Approximately 52,000 fish were tagged at Sawtooth hatchery and 10,000 fish were tagged at Oxbow hatchery each year. A portion of the tagged fish was designated for transport so that transport to in-river comparisons could be made. These efforts have provided information on reach survival, travel time, and collection efficiencies; all of which are useful for design of a larger transportation study. Preliminary analyses of returns suggest that transport may be beneficial depending on fish size or hatchery of origin. Sockeye responses to FCRPS operations will factor into devising a system operation that optimizes survival (SAR) for as many ESUs as practical. Any “spread the risk” strategy will need to consider all spring-migrating ESUs.

Snake River fall Chinook migrate seaward primarily during the summer and fall, but have a complex life history whereby some fraction of the population inhabits portions of the FCRPS nearly year-round. 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 will help determine the appropriate management strategy to optimize adult returns. The collective studies provide information to describe early life history and migration behavior, the performance of hatchery fish used as surrogates for wild fish, the benefits of transportation, and the performance of production fish groups compared to wild and surrogate fish. Hatchery surrogates have consistently performed more similarly to wild fish than to hatchery fish. Preliminary results suggest that transport does provide a small benefit. Researchers continue to refine and evaluate methods for analyzing fall Chinook data and are on track to produce a method for analysis report for review by ISAB.

A Corps sponsored literature review identified 12 primary factors which may influence D (Anderson et al., 2012). D appears to vary with time of arrival into the FCRPS and travel time through it. 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 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 Anderson et al. (2012) report hypothesizes that when adult rates of returns of transported fish are lower than those of in-river migrants 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 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 among 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.

Major Lessons Learned

After surface passage routes were installed at all FCRPS projects, steelhead have exhibited substantially higher in-river juvenile survival rates. Yearling and subyearling Chinook experienced moderately higher in-river survival. However, only three full years of adult returns were available in 2012 to estimate SARs, which is inadequate to examine the impact of surface passage on differential delayed mortality. Muir et al. (2006) suggest that Bonneville-to-Bonneville SARs may have not increased to the extent expected after the adoption of spring and summer hydrosystem spill operations a decade ago caused increased in-river survival rates, particularly among steelhead. They proposed exploring additional factors such as water turbidity and food limitation in the estuary.

The recent time series of adult returns has shown that while in-river conditions have improved the benefits of transport still exist for most stocks in most years. When the mean benefit of transport is small, it is sensible to consider additional factors motivating the decision to transport. Transportation policy is currently inspired by a spread-the-risk strategy, forecasting that returns from transported juveniles will be higher than in-river migrants during years with adverse conditions, but risking lower overall return rates during years with optimum river conditions, or higher potential stray rates to nonnatal tributaries.

Important uncertainties remain which could improve our evaluation of transportation benefits and risks. Adult straying is frequently cited as an adverse risk not accurately represented by the metric of adult returns to Bonneville Dam. The FPC has highlighted straying of adults in the lower Columbia River as a potential extra effect of juvenile transportation which is not captured in the metric of adult returns to Bonneville Dam. Stray rates of transported hatchery origin Chinook and both hatchery and wild steelhead are higher than stray rates of natural origin spring Chinook. The Corps-sponsored synthesis of Columbia River Basin straying research estimated higher apparent straying rates among steelhead and sockeye migrating in summer months between Bonneville and McNary dams than the rate observed among spring-run Chinook (Keefer and Caudill, 2012). They concluded that further studies should distinguish between straying or spawning in nonnatal streams, and 'wandering' or temporary use of thermal refugia in cool water tributaries such as the Deschutes or John Day rivers. Installation of PIT-detection antennas in these lower Columbia River tributaries in 2011-2014 could help address this question in the future.

RPA Subaction 55.2 – *Investigate the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville.*

Major Accomplishments and Findings

Monitoring and research addressed both timing of arrival at upper river dams and traps, arrival at Bonneville Dam, and fish travel time through the FCRPS throughout the season.

The Corps seasonal transportation study continued from 2008 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 Dam survival and that may be useful as triggers to initiate transport. Overall, T:M ratios reported by NOAA Fisheries 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 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.

This seasonal change in mortality rates is addressed in Scheuerell et al. (2009), which found that yearling Chinook and steelhead migrating in early May survived at much greater rates than those migrating in mid-June; year effects and Julian day (which may capture predator effects and fish development stage) had a better predictive value than upwelling intensity or river temperatures.

BPA Project 1991-051-00 (Statistical Support for Lifecycle studies): Columbia Basin Research at the University of Washington addressed several questions relating to post-Bonneville Dam survival using the program ROSTER, which uses juvenile-adult PIT-tag detections across many ESUs from 1997-2012. Timing of ocean entrance, coastal upwelling, and temperature exposure of smolts were the dominant factors predicting differential survival.

BPA Project 1993-029-00 (Survival through Snake and Columbia River dams and reservoirs) estimated travel times and survival rates of wild and hatchery smolts across major reaches of the FCRPS, and the transported fraction of juveniles. The transported fraction of yearling migrants has substantially decreased over the past five years, ranging from 60-95 percent of Snake River smolts in the 1995-2005 period, to 30-50 percent in 2008-2012 (Figure 76).

Two additional studies experimentally addressed the influence of migration timing on fish travel time and post-Bonneville Dam survival rates.

A major finding of **BPA Project 2003-114-00** (Coastal Ocean Acoustic Salmon Tracking) was that survival outcomes varied substantially between weekly tag release groups, which could suggest that a factor related to river conditions, predation, or food availability explained this pattern. Kintama experimentally released one group of tagged yearling Chinook from the mid-Columbia and upper Snake rivers (both transported and in river) in April. The second treatment group was held for five weeks, and then released in-river or transported below Bonneville Dam. Averaged across 2006, 2008, and 2009 experiments, the early release group traveled at 29 percent of the speed of the later treatments, and passed the detection arrays with a wider variance than the later groups. In 2011, treatments were released in four batches between late April and late May. The first release group from the upper Columbia River took 20 days to reach Astoria Bridge, while the mid-May group released at the onset of the spring freshet required only 3.3 days. Survival was higher for the mid-May group, than for the late-May group which may have been exposed to high TDG levels in dam tailraces. The study discovered that yearling Chinook move quickly through the estuary and spend little time feeding (2010 mean = 2.8-3.9 days to Columbia River mouth). Weekly variance in survival rates is still unknown for steelhead, sockeye, or subyearling Chinook, which may allocate different time periods to estuary and early ocean feeding. The study also observed that most weekly release groups quickly head north from the Columbia River, to be detected later at Willapa Bay or Vancouver Island, but occasionally several smolts were detected at an Oregon array, suggesting that circulation patterns in the river plume influences migration direction.

BPA Project 2003-041-00 (Delayed Mortality of yearling Chinook salmon through Snake River dams): See project description under RPA Subaction 54.1.

Major Lessons Learned

Several studies funded by the action agencies on spring migrants confirm that post-Bonneville Dam survival rates are correlated with day of arrival at the estuary. 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. The delayed mortality research synthesis report prepared by Battelle (Anderson et al., 2012) 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 may produce higher survival in barged fish than in the in-river fish during the middle and end of the spring migration season.

From a practical standpoint there are two ways to alter smolt arrival timing at the estuary; alter the timing of transportation or alter in-river conditions for in-river migrants. With respect to transported fish, the timing of implementation of the program within the spring season has been modified. Some but not all analyses suggest that early in the season (April) wild Chinook may not benefit much from transport, since they survive to adulthood at about the same rate as in-river migrating counterparts. This has resulted in delaying transport until May. Timing of arrival in the estuary is implicated as a mechanism. However, transported steelhead and hatchery Chinook have survived (SAR) at higher rates. Importantly, the results in hand reflect ESU performance during years preceding the full surface collector configuration currently in place. The next wave of returning adults should provide information on the most recent system operation.

The timing of arrival at the estuary for in-river migrants cannot be appreciably altered from the current state. The regional strategy has been to minimize travel time. Spring smolt travel time through the FCRPS has been minimized to the practical limits in recent years with the implementation of the spill operations, surface bypass installation and flow augmentation actions.

RPA Subaction 55.3 – *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.*

Major Accomplishments and Findings

See description under RPA Subaction 55.1

The Corps commissioned a synopsis and literature review of differential delayed mortality (*D*), which also identified critical uncertainties. The Corps then 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 March 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.

The review of literature and discussions at the 2011 Differential Delayed Mortality Workshop provided 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. To develop the roadmap of future research, variables 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) influence of 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 JBS 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.

The Corps of Engineers hosted an additional regional workshop on Sept. 23, 2010, in Walla Walla regarding latent mortality with a special focus on effects of juvenile passage through powerhouse bypass systems. 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. One proposed mechanism for the observed correlation between JBS exposure and lower SARs was that JBSs are selective for weaker fish. This may explain why some JBSs 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 multiyear 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.

Major Lessons Learned

As new results from sockeye and fall Chinook studies emerge, it may be possible to update the evaluation of transportation. The workshop format is an efficient means to share information, deliberate findings and identify uncertainties that require inquiry.

RPA Subaction 55.4 – *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.*

Major Accomplishments and Findings

Early life history investigations for this ESU have spanned nearly two decades. The complex life history has been well described. The need for additional information has not been clearly established

A microchemical evaluation of adult fall Chinook otoliths returning to Lower Granite Dam occurred in 2011 and 2012. This study is evaluating the age at ocean entry of Snake River fall Chinook salmon and for those that overwinter in freshwater identify where they overwinter. Initial study goals are to verify regions that have distinct microchemistry signals. Currently, upper Snake, lower Snake, Clearwater/Salmon River, Tucannon/Grande Rhonde and the estuary/ocean are areas that can be differentiated with microchemistry. Preliminary results suggest that the lower Snake region is where most freshwater overwintering occurs for SR fall Chinook salmon.

BPA Project 1991-029-00 (Emerging Issues to recover the Snake River fall Chinook ESU): This project concluded that wild subyearlings display more diverse life histories than hatchery subyearlings, and that hatchery smolts acclimated to river conditions before release survived better than those immediately released from raceways. Growth rates of subyearlings rearing in tributaries was higher than at Lower Granite reservoir, and there is evidence that this may be driven both by the density of juveniles from hatchery supplementation, as well as the nutritional quality of zooplankton found in the reservoir. A variety of new topics are addressed each year for this project.

BPA Project 2002-032-00 (Snake River fall Chinook life history investigations) estimated densities and distribution of overwintering Chinook in Little Goose and Lower Granite dam reservoirs. Most fish were not delayed in the confluence of the Clearwater and Snake rivers, but elevated rates of predation occurred in those locations. Juvenile fall Chinook moved an average of 169 km downstream during winter, and most passed one or more dams. Because turbines were the most likely route of passage, it might be useful to understand winter season rates of turbine survival, when activity of predatory fish is low.

BPA Project 1989-108-00 (Lifecycle modeling and evaluation): Columbia Basin Research found that growth rates and timing of smoltification among fall-run Chinook studied in the upper Snake River were very sensitive to temperature patterns. The implication is that cold water releases from Dworshak Dam are an important operation for providing a thermal refuge (not exceeding 19-20 degrees centigrade) for smaller juveniles which would be unlikely to survive outmigration in late summer when lower river temperatures may approach the lethal threshold.

BPA Project 1987-127-00 (Smolt Monitoring Project): This project monitored the arrival of fall-run Chinook PIT-tagged at upstream traps and hatcheries at Lower Granite Dam and subsequent downstream hydro projects. The distribution of travel times among wild and hatchery groups and the fraction of the run exhibiting reservoir type life history were estimated.

Major Lessons Learned

Fall Chinook display a complex early life history strategy that provides resiliency for this ESU. It enables the population to be productive across a broad range of environmental conditions that characterize the Snake/Clearwater drainage. The ESU exhibits a variety of rearing/migratory forms including subyearling, yearling, and reservoir-type patterns. All are important to the continued recovery of this ESU. Water management actions above Lower Granite Dam, primarily associated with Dworshak Dam, have had a major impact on the mix and proportions of life history types comprising this ESU. Importantly, when Snake River temperatures exceed approximately 20 degrees centigrade juveniles appear to evacuate Lower Granite reservoir, primarily during the late summer. This suggests that reservoir type juveniles that reside in the system through summer and fall could be sensitive to future climate change conditions characterized by low snowpack or high late-summer temperatures. These issues have implications to future management actions, where some mixture of transport and in-river migration may improve overall survival of this ESU.

RPA Subaction 55.5 – *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 which will be coordinated through the Regional Forum.*

Major Accomplishments and Findings

In 1998, the ISAB reviewed the Corps' monitoring, evaluation, and capital improvements work for adult salmon and steelhead passage at FCRPS dams (ISAB, 1999). One recommendation from this report was to assess the effects of hydrosystem passage on adult fish energy expenditure and resulting spawning success: "…questions have been raised about the effects that passage might have on energy reserves required to successfully complete the spawning act once the destination is reached. No information of which we are aware is available on this subject" (ISAB, 1999). In response, the Corps developed and implemented a six-year study to assess this potential issue.

Spawning success as it relates to adult salmon energy condition and migration experience were studied over multiple years (2002-07) for a single population of summer Chinook salmon returning to the South Fork of the Salmon River in central Idaho. In combination, about 400 salmon were radio-tagged at Bonneville Dam across six years to record migration histories and spawning success. Additional fish were PIT-tagged and more were sampled on spawning grounds on the South Fork of the Salmon River. In 2002, muscle lipid, mass-specific somatic energy, and mass-specific total energy were higher for females that died prior to spawning (pre-spawning fish) compared with fish that died after spawning, suggesting that pre-spawn mortality was not directly associated with the exhaustion of energy reserves. Pre-spawn mortality did seem to be correlated with high temperature periods in the South Fork of the Salmon River in early years of the study.

Results of this study were reviewed by the Studies Review Work Group via draft and final reports and annual AFEP research planning. The Studies Review Work Group did not recommend additional research in this area, as it appeared unlikely to result in future management application.

Major Lessons Learned

The critical uncertainty posed by the RPA has been resolved. Based on six years of study, there is no evidence that passage conditions through the FCRPS affect survival of adults through spawning. No further study is proposed.

RPA Subaction 55.6 – *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.*

Major Accomplishments and Findings

Planning for the replacement of Ice Harbor Kaplan turbine units 2 and 3 began in 2002. These two turbine runners have a history of oil leakage and cracked blades beginning in the 1960's with unit 2. The need for replacement of these turbines provided an opportunity to incorporate biological design criteria for safer fish passage and to improve upon the turbine runner design process.

The turbine design process was developed and recommended by the TSP and is summarized in the TSP Phase 1 report (TSP, 2004). This design process incorporates lessons learned and knowledge gained from recent Bonneville and McNary turbine replacement efforts. The primary design goals are to optimize the turbine for safe fish passage by increasing nadir pressures and minimizing the potential for direct injury and disorientation.

Through literature review, Sensor Fish data analysis provided from Bonneville powerhouse II, John Day, and Ice Harbor (Carlson et al., 2008), and laboratory pressure studies conducted by PNNL (Carlson et al., 2010) a minimum nadir pressure criteria of 12 psi (goal of 15 psi) was established for the new turbine runners. Brown et al. (2010c, 2012) estimated the probability of mortal injury in juvenile Chinook salmon relative to simulated turbine passage (STP). Brown et al. (2010c, 2012) exposed fish to varied acclimation pressures and subsequent exposure pressures to mimic turbine pressure time histories (ratio of pressure change).

Results suggested that the main factor associated with mortal injury of juvenile Chinook salmon during STP was the ratio between acclimation and nadir pressures. Other factors such as TDG, rate of pressure change, fish acclimation depth, fish condition factor, fish length, and fish weight may increase the incidence of mortal injury associated with fish passing through hydro turbines. Study results suggest that the minimum nadir pressure criteria of 12 psi for the new Ice Harbor turbine runners will reduce the risk of barotrauma and mortal injury experienced for juvenile (Figure 77).

A contract was awarded in 2010 to design and supply the new turbine runners. The design is an iterative and collaborative process. The contract requires cooperative efforts in design between the Corps and the contractor to ensure that proper design criteria and direction are employed. An iterative design process allows the Corps to evaluate turbine runner designs through review of CFD analysis and physical hydraulic model testing at ERDC.

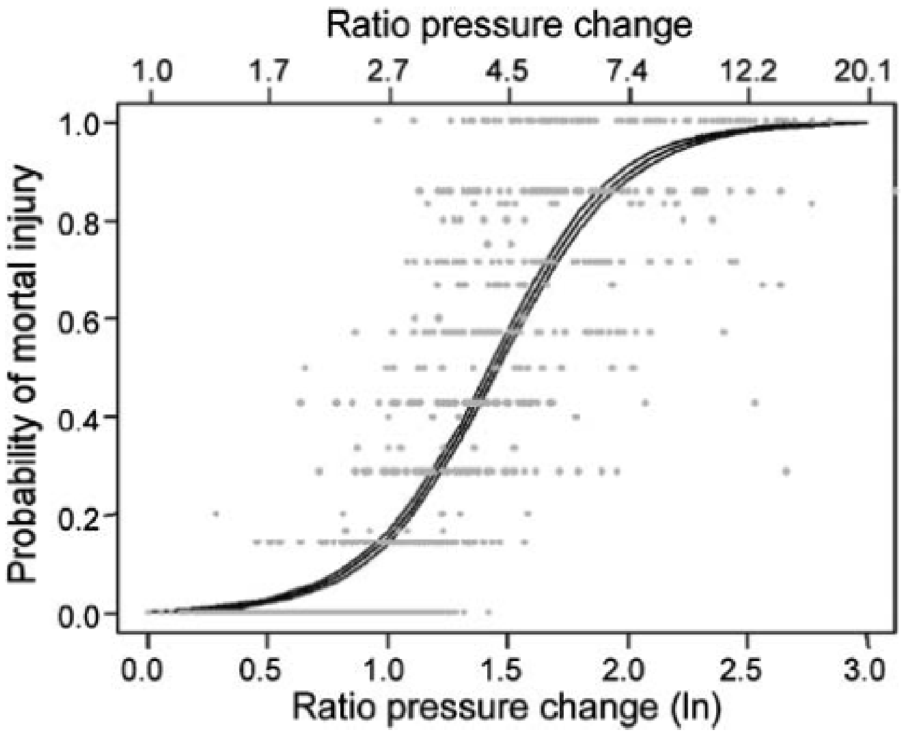


Figure 77. Probability of Mortal Injury from Simulated Turbine Passage along a Range of LRP (Natural Log Of The Ratio Of Acclimation To Nadir Pressures) for Juvenile Chinook Salmon (Brown et al., 2012). The 95 percent confidence interval is shown on either side of the regression line. Each dot on the graph represents the proportion of fish in each test chamber trial (typically comprised of seven fish unless some fish were not neutrally buoyant) that were mortally injured when exposed to simulated turbine passage.

In 2011, the TSP met at ERDC to test the first design for the fixed-blade turbine runner for Ice Harbor Dam. Through 2012 two design and evaluation iterations were completed on the fixed blade runner, and one iteration on the Kaplan runner. The CFD modeling of the turbine runner designs indicate the minimum nadir pressures of the prototype runners will be above 13psia for all operations and in most cases greater 14 psia. These turbine runners will essentially eliminate the risk of barotrauma to passing juvenile salmonids. Mechanical injuries are expected to be reduced relative to existing turbine passage conditions as well. The third iteration for both runners will occur in 2013. The third iteration for the fixed blade runner in 2013 is being used to reduce some flow turbulence below the runner and finalizing the design, while the Kaplan runner will be finalized in 2014.

The Corps also began development of a detailed biological study design for testing of the turbine runners and a draft final study design was submitted to the Region for review in late 2012. The document details project operations and powerhouse operating ranges to determine the safest fish passage configuration and to clarify benefits to fish passage survival resulting from the design features of the new runners. Operations considered in the study design may recommend testing outside the 1 percent operating range.

Major Lessons Learned

In 2004, the Corps completed a Phase 1 report for its Turbine Survival Program (TSP). An important product of Phase I investigations was the development of a process to systematically address physical, economic, and biological aspects of turbine modifications during turbine rehabilitation. Thus far, the Corps has successfully applied this process to Ice Harbor turbine rehabilitation to improve turbines for fish survival. Data from observational hydraulic models, computational fluid dynamic models, and laboratory and field biological studies have been used to address remaining uncertainties in the Phase

1 report and develop biological design criteria for the new Ice Harbor turbine. The fish SBs attributable to following this process cannot be estimated until a prototype is installed and field tested. However multiple lines of evidence suggest that the biological design criteria used for the new Ice Harbor turbines will improve fish passage.

RPA Subaction 55.7 – *Investigate feasibility of developing PIT-tag detectors for spillways and turbines.*

Major Accomplishments and Findings

In 2012, the Corps completed an Engineering Documentation Report that included an evaluation of alternatives considered in developing a prototype Spillway PIT-Tag Monitoring Project. The report documented 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 coordinated with NOAA Fisheries and other regional resource management offices in developing the report. The Action Agencies are developing plans and specifications for a contract for installation of a prototype Spillway PIT-Tag Monitoring System at Lower Granite Dam in the winter of 2013-2014.

Major Lessons Learned

RME activities are still underway and technical issues are being explored. Final results are not yet in hand. As the assessment of the technical feasibility of spillway and turbine PIT-tag detectors advances, it is incumbent on the Action Agencies and NOAA Fisheries to demonstrate the expected range of improvement in survival estimates. Also, the costs of installation and future Operations & Maintenance (O&M) need to be estimated to see if the expected cost-benefit is practical.

RPA Subaction 55.8 – *Evaluate new tagging technologies for use in improving the accuracy and assessing delayed or indirect hydro effects on juvenile or adult fish.*

Major Accomplishments and Findings

The Corps completed a multi-year analysis of juvenile salmonid passage and survival at McNary Dam (Adams et al., 2011). Survival was negatively correlated with tag burden (i.e., it appeared tagged fish had a lower probability of surviving turbine passage than untagged fish). Studies conducted at PNNL in 2009-2010 exposed tagged and untagged juvenile Chinook salmon to simulated turbine passage pressures typical of turbines at FCRPS dams (Carlson et al., 2010). These studies clarified the effects of surgically implanted acoustic tags on juvenile Chinook survival when exposed to simulated turbine passage. Referred to as tag burden, the added mass and potential organ crowding caused by the internal tag increase the probability of mortal injury from swim bladder expansion or rupture.

Understanding the probability of mortal injury related to tag burden and barotrauma is important because turbine survival estimates may be biased low by tag burden. Building upon the works of Carlson et al. (2010), the Corps pursued an external tag laboratory study to develop and 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 (Carlson et al., 2011). In 2011, two neutrally-buoyant external JSATS tags were developed and laboratory tested for their effect upon swimming performance and tag retention in turbulence and shear. The Type A tag was a backpack-style tag that sutured in front of the dorsal fin, and the Type B tag was a saddle-type tag that sutured to either side of the dorsal fin.

Laboratory study results suggested that the Type A tag was superior to the Type B tag and will be discussed further here. Results suggested that there was no significant difference in critical swimming speeds between internally and externally tagged fish ($p = 0.512$); however, critical swimming speeds were significantly different between externally tagged and control cohorts ($p = 0.008$). Predation rates between externally tagged and untagged cohorts were not significant ($p = 0.262$). Externally tagged and untagged controls were exposed to nadir pressures ranging from 1.6-11.6 psi. Mortal injury rates were not significantly different for externally tagged and untagged control fish ($p = 0.380$). During shear exposures, one Type A tag was lost out of 21 (4.8 percent).

In 2012, a field study of the Type A tag relative to internally tagged cohorts was conducted in the tailrace at Ice Harbor Dam. Final results are not yet available; however, a preliminary data report suggests that detection efficiency at the Snake and Columbia river confluence between internally and externally tagged fish is not significantly different ($p > 0.05$).

While external tags are not intended to provide reach or dam survival estimates, they are a potentially valuable tool for estimating unbiased turbine passage survival of juvenile salmonids.

BPA Project 2003-114-00 (Coastal Ocean Acoustic Salmon Tracking): See 54.9 for project description.

BPA Project 1983-319-00 (New Marking and Monitoring Technologies): NOAA Fisheries has actively tested new designs for PIT-tag detection systems which could be installed in spillway ogees and tributary streams. Significant obstacles have included tag 'collisions' or detection of many PIT-tags in fast water within a short time period, and failure to detect over 1 percent of tags in tests. Successful implementation of these next generation antennas would differentiate classes of juveniles passing through the spillway and turbine routes, and could identify adults which stray or wander into nonnatal tributaries above Bonneville Dam.

Major Lessons Learned

Important and critical advances in tagging technology and associated software have been achieved under the directive of this RPA. The miniaturization of active tags has progressed to levels never anticipated. New devices like the JSATS has made performance standard testing practical. The intent of this RPA is to consider and take advantage of such technological advances as they develop. There will be a continued need to do.

RPA Subaction 55.9 – *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.*

Major Accomplishments and Findings

A PIT-tag antenna was installed in the John Day River (RM 20) in 2009. It initially functioned successfully in detecting PIT-tagged adults, both originating from the John Day River, or straying or wandering from other locations. The antenna was damaged in 2011 following a flood and was replaced with a CAN multiplexing transceiver which spans the entire river. This antenna design could be adapted for use with minor modifications at additional sites.

Four PIT-tag readers were installed in the Klickitat River with funds from **BPA Project 1988-115-35** (Klickitat River Design and Construction-Yakima/Klickitat Fisheries Project (YKFP)). A PIT-tag detector was installed at lower White Creek in 2009 to help monitor juvenile steelhead migration patterns and adult returns. A detector with three antennae was placed in the transportation channel of Lyle Falls fishway (RM 2.3) in 2012, and a similar detector was placed in the transportation channel of Castile Falls fishway. USGS Columbia River Research Lab staff assisted with the operation and maintenance of this equipment, under **BPA Project 1995-063-35** (Klickitat River Monitoring and Evaluation-YKFP). Designs and plans have been drafted to install additional PIT-tag readers in two-three out of six tributary streams identified in the lower Klickitat River in 2013 (Dead Canyon Cr., Dillacort Cr., Logging Camp Cr., Snyder Cr., Swale Cr, and Wheeler Cr.).

Five PIT-tag readers have been installed in the Wind River by the USGS under **BPA Project 1998-019-00** (Wind River Watershed). Six-antenna multiplexing PIT-tag detection systems were installed at Trout Creek and the upper Wind River in 2012. 'All-Flex' PIT-tag readers were installed at Trapper Creek, Paradise Creek, and Wind River above Paradise Creek in 2012. Plans have been drafted to install an additional detector in Martha Creek in 2013.

A full-duplex PIT-tag antenna will be installed at the base of the Deschutes River in 2013, and four PIT-antenna arrays will be installed at Lake Creek in the Deschutes under **BPA Project 2008-037-00** (Deschutes River sockeye development).

Following a feasibility study, two PIT-tag antennae were installed in the Hood River Basin in 2012 under **BPA Project 1988-053-03** (Hood River Production Monitoring and Evaluation (M&E)-Warm Springs). These are located at the mouth of the mainstem Hood River, and at Moving Falls fish ladder in the West Fork Hood River

BPA Project 1983-319-00 (NOAA Fisheries New Marking and Monitoring Technologies) is the primary project affiliated with this subaction. A new multiplexing transceiver was developed which will work for in-stream PIT-tag systems, such as tributary or hatchery antennas. Small tags in the 7mm – 9 mm range are available from HDX, Biomark, and RFID solutions in 2012.

Major Lessons Learned

Preliminary installation and testing of stream-based PIT detectors in large tributaries has demonstrated that strategy is feasible in many locations. A substantial number of in-stream arrays have been deployed following successful pilot studies. It is important to coordinate data collection from tributary streams into PTAGIS, as multiple researchers address questions related to straying, wandering (short-term travel into nonnatal streams), harvest, or other potential sources of fish loss through the mainstem.

RME Strategy 3 (RPA Actions 56–57)

A comprehensive list of all actions implemented by the Action Agencies for RPA Actions 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.*
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.*
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.*

RPA Subaction 56.1 – *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.*

The strategy to address Subaction 56.1 is to develop quantitative fish-habitat relationships based on monitoring data generated in each of the pilot study basins. The strategy is based on three approaches to modeling the relationship between fish and habitat data - descriptive, predictive and experimental manipulations. The descriptive approach uses the naturally occurring contrast in habitat quality and quantity across the pilot study basins as the basis for correlations between habitat and fish monitoring data. The predictive approach is based on fitting fish and habitat data to underlying mechanistic models such as population production functions (e.g., Beverton-Holt) or energy balance functions (e.g., Net Rate Energy Intake (NREI), bioenergetics) to predict fish population response in non-pilot study basins. The experimental manipulation approach implements large-scale ecological experiments (IMWs) to directly link fish response to contrasts in habitat quality and quantity resulting from IMW restoration actions.

<u>Major Accomplishments and Findings</u>

The following projects have been implemented to support RPA Subaction 56.1 (Table 1).

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-Idaho Department of Fish and Game): The purpose of the Idaho Supplementation Study (ISS) is to determine the utility of supplementation as a potential recovery tool for stocks of spring and summer Chinook salmon in Idaho. The goals of ISS are to assess the use of hatchery Chinook salmon to restore or augment natural populations, and to evaluate the effects of supplementation on the survival and fitness of existing natural populations. The program has collected data from 30 streams throughout Idaho, including the Lemhi and South

Fork Salmon rivers, which are part of RPA Subaction 56.1. Thus, ISS provides information on fish in (abundance and distribution of Chinook adults into the rivers) and fish out (juvenile survival and production). These biological metrics are collected annually and, when correlated with habitat conditions, could provide fish-habitat relationships that can be used to develop models or parameterize existing models. At this time, these data have not been used to develop or parameterize models. In addition, reporting of results is delayed (current report only covers 2008-2010). For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

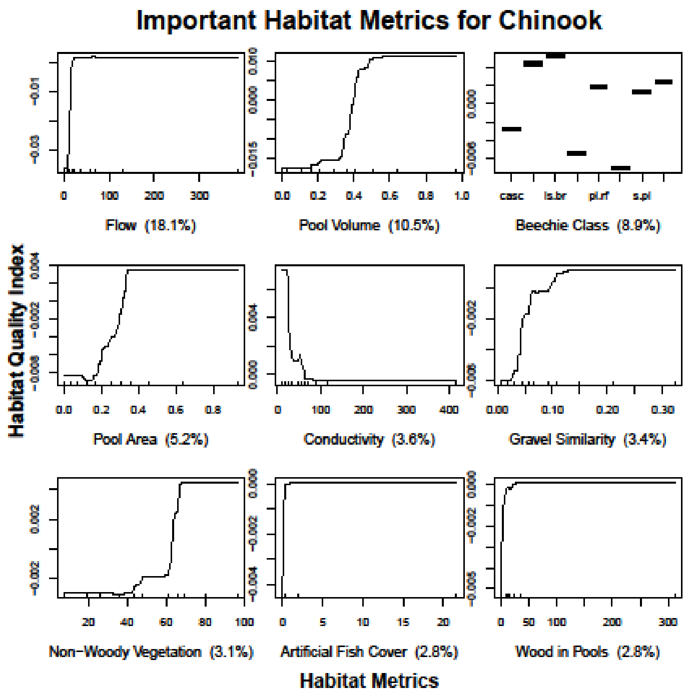
BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation Studies): The goal of ISMES is to monitor and evaluate the status of wild steelhead populations in the Clearwater and Salmon River drainages. Although the focus of the work is in Fish Creek (Lochsa River tributary), Rapid River (Little Salmon River tributary), and Big Creek (Middle Fork Salmon River tributary), the study also provides annual estimates of steelhead abundance for the Lemhi and South Fork Salmon rivers. Thus, as with ISS, these biological data can be correlated with habitat conditions to establish fish-habitat relationships. At this time, these data have not been used to develop or parameterize models. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead): The goal of this project is to provide basin-wide status and trend data for steelhead and spring Chinook in the John Day River Basin. To accomplish this, the study estimated steelhead and spring Chinook out-migrant abundance, physical characteristics of outmigrants, SARs, steelhead life-history patterns, and productivity of steelhead and spring Chinook populations. These data are collected annually and can be used with habitat status and trend data to establish fish-habitat relationships. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): ISEMP was first established in 2003 to develop a set of standardized methods to monitor both fish populations as well as changes in habitat condition. ISEMP implements both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs are implemented in the Entiat, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi River watersheds. This work led to the development of CHaMP (habitat status and trend monitoring protocols; **BPA Project 2011-006-00**), IMW methods, and preliminary fish-habitat relationships.

Fish-habitat relationships were developed from pooled data collected from 152 sampling sites. Sampling sites occurred within the Lemhi River, upper Grande Ronde, John Day, South Fork Salmon, Entiat, and Wenatchee river basins. Researchers used habitat data collected under CHaMP and juvenile fish abundance data from ISEMP to develop preliminary relationships between Chinook salmon abundance and habitat conditions, and steelhead abundance and habitat conditions (Figure 78). Based on this work, Chinook abundance was related to flow, pool volume, Beechie class, pool area, conductivity, gravel similarity, non-woody vegetation, artificial fish cover, and wood in pools. Steelhead abundance was related to subbasin, Beechie class, percent woody cover, stream width, wood in pools, and precipitation. It is important to note that these fish-habitat relationships are based on only one year of data and therefore will likely change as more data are collected. In addition, the metrics themselves may shift in order of importance. A final set of relationships should be available within two years.

A



B

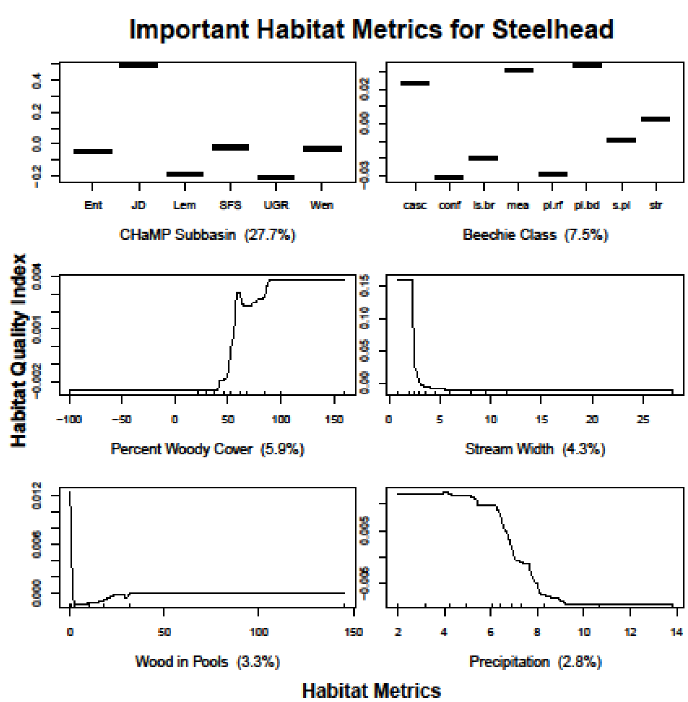


Figure 78. Relationships between Habitat Metrics and Juvenile Chinook Salmon Abundance (A) and Habitat Metrics and Juvenile Steelhead Abundance (B). Figures from Ward et al., (2012).

BPA Project 2008-471-00 (Upper Columbia Nutrient Supplementation): The purpose of this project is to quantify and evaluate nutrient status and availability in the Twisp River, a tributary to the Methow River. The project is conducting multi-trophic level sampling to quantify and evaluate baseline water quality and nutrient availability and primary, secondary, and tertiary productivity rates including algal, periphyton, benthic macroinvertebrates, and fish communities. Using a stratified random sampling design, the program developed a pre- and post-treatment (experimental nutrient addition) BA. To date, the project has characterized baseline nutrient levels in the Twisp River. Initial analyses of lower-tropic metrics indicated that the Twisp River is ultraoligotrophic. This was based on low nutrient concentrations, and generally reduced biological production, abundance, and biomass values within the periphyton and benthic macroinvertebrate communities relative to other Pacific Northwest rivers. The low levels of nitrogen and phosphorus suggest that the Twisp River may be an excellent candidate for experimental nutrient addition to increase natural production of anadromous salmonids and the required supporting biological production and ecological functions at lower trophic levels. This work should be able to establish relationships between fish production and nutrient levels and food. At this time, however, these data have not been used to develop or parameterize models.

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

Steelhead were PIT-tagged at Priest Rapids Dam and the placement of interrogation systems in the Wenatchee, Methow, and Okanogan rivers allowed estimation of steelhead escapements in the different populations. Statistical models to estimate steelhead abundance will be developed under the future contracts. Temporary PIT-interrogation systems were also installed at the downstream limit of minor spawning areas within the populations. Based on the recapture of fish PIT-tagged at Priest Rapids Dam, 6 percent and 17 percent of the known spawning population spawned in minor areas within the Methow and Wenatchee river subbasins, respectively. In the Entiat and Okanogan river subbasins, redd surveys in minor spawning areas accounted for 55 percent and 41 percent of the PIT-tag based escapement estimate, respectively. The importance of minor spawning areas will continue to be evaluated under future contracts. Online queries were developed to assist in standardizing and querying PIT-tag data generated from the instream arrays.

The detection of redds, which are used to estimate spawning escapements, are likely affected by environmental and habitat conditions and the experience of an individual surveyor. Statistical models to predict observer efficiency will be developed under future contracts. Finally, the study developed improved methods for estimating juvenile salmonid emigrant abundance (fish-out). The method is both unbiased and precise and was determined to be suitable for the environmental conditions that exist in the upper Columbia River Basin. Within two years, the development of methods to estimate fish-in and fish-out with precision and accuracy will aid in the development of fish-habitat relationships. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): CHaMP is a habitat quality monitoring program that was designed to detect habitat action responses at the watershed level and provide information regarding fish-habitat relationships. CHaMP provides a standardized data collection and analysis protocol. The 2011 CHaMP pilot year included eight watersheds and collected data on 78 different habitat parameters, which are derived from 24 direct habitat measurements. Over time, the goal is to further streamline the number of measurements.

CHaMP is currently using three different analyses to establish fish-habitat relationships: boosted regression tree modeling, structural equation modeling, and the net energy intake model. Using boosted regression tree models and fish data collected under ISEMP, CHaMP identified nine important metrics for Chinook salmon. Those included flow, pool volume, Beechie class, pool area, conductivity, gravel similarity, non-woody vegetation, artificial fish cover, and wood in pools. Steelhead were correlated with six habitat metrics including subbasin, Beechie class, percent woody cover, stream width, wood in pools, and precipitation. These relationships are shown in Figure 79.

Work in the Grande Ronde using structural equations modeling indicates that juvenile Chinook densities are related significantly to habitat data collected using CHaMP protocols. The model evaluated the interactive effects among stream flow, large wood, pool frequency, and juvenile spring Chinook salmon density. Relationships varied depending on channel type (mountain versus floodplain and constrained). In mountain reaches, juvenile densities were not related to large wood or pool area. In floodplain and constrained reaches, however, Chinook densities were positively related to mean annual flow, LWD, and pool frequency.

CHaMP is also evaluating the use of the NREI model to predict salmonid metrics. In short, the NREI model represents how much a fish has to work to capture food and grow. The model is based on the premise that, by taking the difference between energy gained (food ingested) and energy spent (metabolism and swimming costs), a NREI index can be estimated. The NREI index can then be converted to growth rates, which are believed to be correlated with survival. The model has not yet been calibrated, but initial work appears promising.

Reclamation's Methow IMW Report (Reclamation, 2013a): Reclamation led the development of the Methow IMW Project. Reclamation organized regular annual meetings for the past six years in the Methow River Basin. Reclamation began the development of a Methow IMW Report. The report will describe a methodology to organize monitoring around the development of an aquatic production model and a life-cycle model.

Reclamation-funded Model Development: Six models jointly developed by Reclamation and USGS-Columbia River Research Laboratory (CRRL) will be used to evaluate fish populations and population processes. An aquatic trophic production and full life-cycle visual model is under development in Stella systems dynamic software to facilitate the testing of theoretical concepts. The freshwater model stages are shown in Figure 79.

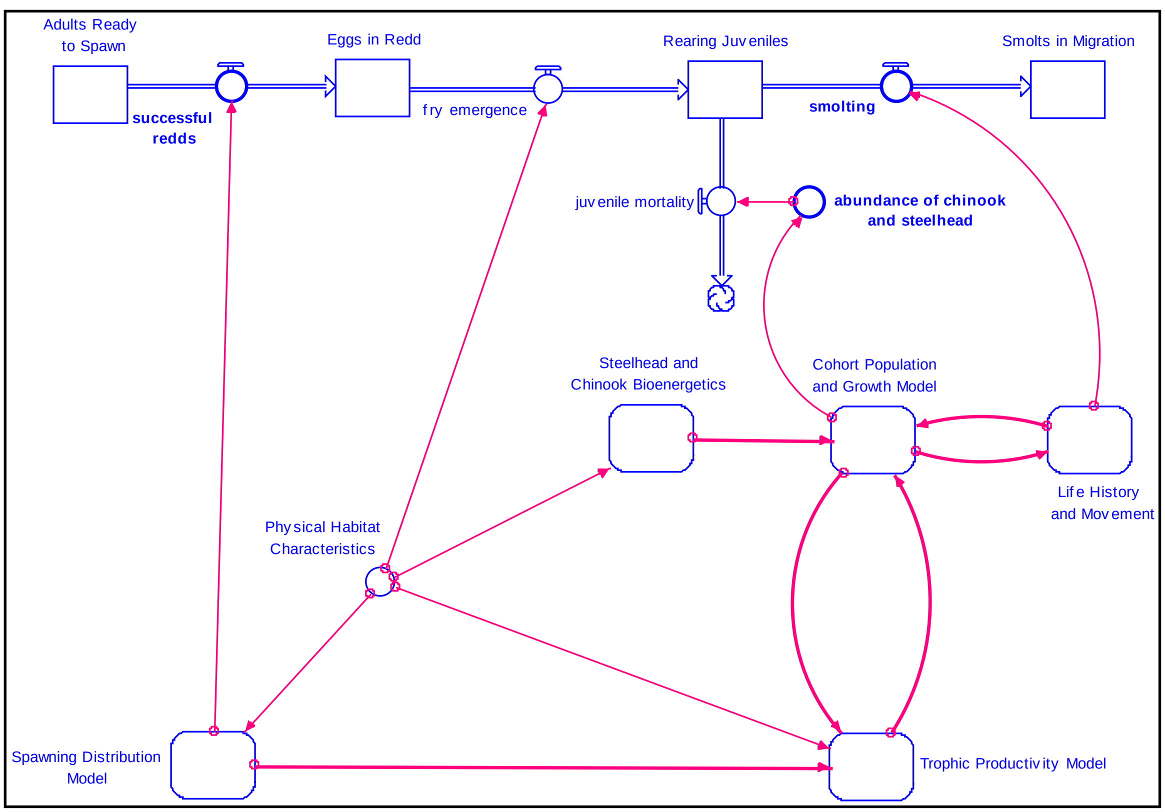


Figure 79. A Conceptual Representation of the Linkages between Different Model Modules and Associated Freshwater Life Stages.

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 two-dimensional 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 spring 2013. There is a significant body of work in the literature that researchers used to parameterize modules in the model. These models will be applied to evaluations of the Methow IMW habitat projects.

Reclamation and USGS-CRRL used a decision state model approach to explore the role fall spawned eggs might have on steelhead trout productivity and smolting. USGS used multiple linked models in the R language to construct a simulation model that predicts life history choices of juvenile steelhead over different diets, growth patterns, and temperature regimes. This was accomplished by linking a water temperature model, bioenergetics model, and a dynamic state-dependent model that predicts life-history trajectories of juvenile steelhead.

Initial steelhead lengths for the model were obtained from available data for Beaver Creek. Average length of young-of-year steelhead in Beaver Creek on August 1 was 55 mm (SD = 0.14). These values were used to create a normal distribution from which lengths were randomly drawn to initialize the bioenergetics model. For each simulation, 5,000 fish or initial start lengths were drawn with replacement. This random draw simulated fish hatching at different times to mimic realistic spawn variability within the population.

Preliminary results suggest that addition of eggs generated faster growth. The addition of coho eggs to diet could alter population structure. One caveat is that fish were not modeled spatially. In some scenarios, the model predicts greater numbers of age-1 smolts. Emergence date is important; later emergents smolt while earlier emergents are predicted to residualize.

Reclamation-funded Methow River Population Studies: Reclamation continued funding of USGS-CRRL's assessments of fish populations for abundance, density, and biomass in 10 side channels and two tributaries (Beaver and Wolf creeks) of the Methow River. Numerous PIT-tag interrogation systems were maintained for remote fish movement detection throughout the year (three in mainstem Methow and Chewuch rivers; seven in tributaries: Wolf, Eightmile, Beaver, Libby, and Gold creeks; and four in side channels). A smolt trap sampled the Chewuch River for most of the year (March 15-May 5 and July 27-November 9). Several fish were captured and handled throughout the year during these activities, and 5,935 of them were PIT-tagged, mostly juvenile steelhead and Chinook.

Reclamation-funded Aquatic Respiration Study: Reclamation assisted the YN in a nutrient enhancement study, Upper Columbia Basin Nutrient Enhancement Project (**BPA Project 2008-471-00**). Reclamation and USGS initiated a stream metabolism study, measured via the change in dissolved oxygen over time. In this study, the question, "Does stream metabolism (i.e., gross primary production and ecosystem respiration) differ among stream reaches with high densities of spawning salmon compared to stream reaches with low densities or no spawning?" was assessed.

The study was intended to provide a feasible means of assessing how ecosystems respond to subsidies such as marine derived nutrients and their impacts on gross primary productivity and ecosystem respiration. Understanding the differences in metabolism across this gradient may improve understanding of the role that marine-derived nutrients and salmon play in improving primary production.

Reclamation's 2D Hydraulic Model Development – Application to the Prediction of 2D Flow and Temperature Variability in the Middle Methow River: Reclamation's Technical Service Center in Denver, Colorado, is using two-dimensional hydraulic modeling to develop 2D flow, temperature, and water resident time scenarios for the middle Methow River treatment project. Progress has been made by

Reclamation and USGS-CRRL to develop a life-cycle model that links bioenergetics, life history, population dynamics, and abiotic factors for understanding salmonid production in the Methow River watershed. The TSC hydraulic model will be used to explore and predict the consequences of climate change and various management actions such as species reintroductions and habitat restoration measures.

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

ISEMP and CHaMP are working together to develop fish-habitat relationships that can be used to improve the development and parameterization of models. At this time, the relationships are based on one year of data and thus should be considered preliminary. Nevertheless, the monitoring programs have identified novel approaches to develop fish-habitat relationships. Because relationships between fish and habitat factors are mostly non-linear, ISEMP and CHaMP researchers used boosted regression tree models to develop analytical relationships. They are also experimenting with structural equation modeling and NERI models.

Preliminary analyses indicate that juvenile Chinook are found at higher densities in areas with higher flow, more pools, and good water quality. Analysis of steelhead densities across CHaMP watersheds identified different habitat metrics as relatively important. For example, the percentage of woody cover was the most important metric in predicting juvenile steelhead density (after accounting for differences between subbasins and Beechie classes). Overall, the ability to detect differences in fish-habitat relationships can be used to guide restoration actions. However, preliminary analyses suggest that different habitat metrics may be more important in some subbasins than in others. Analyses conducted on datasets with multiple years of fish-habitat data confirm that accounting for year-to-year variability in spawners and environmental conditions is important to establishing fish-habitat relationships.

Several projects funded by BPA are collecting fish population status and trend data, which can be used to test or refine fish-habitat relationships. These data, combined with fish-habitat relationships, can also be used to help answer the question: “Are habitat actions effectively helping salmonid populations?”

Studies conducted by or funded by Reclamation in the Methow River Basin have generated needed information on fish assemblage, fish abundance, fish growth, fish movement behavior, habitat availability, habitat quality, side-channel connectivity, and stream productivity. For spring Chinook salmon and steelhead, much information has been gained on their 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 treatment reach.

Results so far indicate that habitat patches (main channel and different side channels) within the floodplain landscape hosted very different local food webs. Juvenile Chinook salmon and steelhead used 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, side channels had a larger portion of energy flowing toward Chinook salmon and steelhead. Carrying capacity estimates for both the main channel and side channels indicate 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.

The development of a fish-habitat model will meet the goals to assess reach-level fish responses to habitat improvement projects where sufficient habitat data have been generated, such as the Reach-based Ecosystem Indicators data produced by Reclamation or the ISEMP studies in IMWs. Predictions at other less well-studied sites will require additional study. It is believed that pairing the aquatic trophic productivity model with CHaMP data will allow researchers to relate habitat improvements to fish productivity at the watershed scale in non-IMW watersheds. Researchers are designing tests first using CHaMP data at the reach scale.

Lessons Relative to RME Implementation

Both CHaMP and ISEMP are critical to this RPA. Continuation of these programs in the time frame with associated contractors is important. In addition, projects that provide quantitative fish population status and trend data are an important component of this RPA. At this time, however, there does not appear to be an effort on the part of the project sponsors to use the fish status and trend data to develop fish-habitat relationships.

Reclamation has been conducting year-round field studies in the Methow River to test the ability of its aquatic trophic production model to estimate the benefits of habitat projects. Year round studies are important as high summer temperatures often cause significant mortalities, and fall (November through April) growth conditions are important to over-winter survival. Monitoring is showing that limited fall temperature and food data prevents an assessment of habitat project benefits to over-winter survival.

More thorough spatial and temporal temperature measurements are needed to test the ability of the 2D model to predict changes in the spatial variation of temperature associated with habitat projects. The spatially diverse set collected by boat has the advantage of data that captures lateral variation. However, the data are difficult to obtain with changing solar conditions throughout the day, when cross-sections are sampled, but are less of an impact for longitudinal profiles. The temporal data using loggers has the advantage of capturing variations due to changing solar and air temperatures, but is only taken at a single point in the channel that may be very different from average conditions in the main channel. A forward-looking-infrared data set will also be used that has spatial variation, but only captures surface temperature and does not generate bottom temperature data.

RPA Subaction 56.2 – *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.*

To support this RPA the AA's and NOAA will implement a tributary habitat status and trend monitoring strategy in the Pilot basins (Wenatchee, Entiat, Lemhi, SF Salmon and John Day) coordinated with Fish-In and Fish-Out monitoring. To conduct representative monitoring across a population the protocol implements a design that uses a GRTS design that includes a three year rotating panel.

Major Accomplishments and Findings

The following projects have been implemented to support RPA Subaction 56.2.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): The purpose of the habitat status and trend component of ISEMP was to identify appropriate sampling designs, sample sizes, indicators, and field sampling methods. To that end, the program determined that the GRTS algorithm implemented within a split rotation panel design best accomplished the objectives of monitoring habitat status and trend. Based on examining the precision of estimates, the program found that sampling 45 sites per year per watershed was an appropriate sample size. Precision was further increased by stratifying sites based on geomorphological classification. Thus, the recommendation was to sample an annual panel of 15 sites and three rotating panels of 10 sites sampled every three years.

ISEMP also tested several different habitat indicators and determined that the most appropriate indicators to measure for habitat status and trend included alkalinity, conductivity, pH, growth potential, percent below summer temperature threshold, percent above winter temperature threshold, velocity heterogeneity, embeddedness of fast-water cobble, pool frequency, channel complexity, channel score, residual pool volume, pool tail fines, total drift biomass, bank angle, LWD volume, fish cover, channel unit volume, channel unit complexity, riffle particle size, riparian structure, and solar input. Not only are these indicators sensitive to habitat change, they also correlate with fish abundance and survival.

Because ISEMP was designed to test and develop appropriate habitat status and trend monitoring designs, techniques, and indicators, it does not report changes in habitat quality within the three habitat status and trend monitoring watersheds (i.e., Wenatchee, John Day, and Lemhi river watersheds). The methods developed under ISEMP were used to develop CHaMP (**BPA Project 2011-006-00**). Thus, habitat quality is described under CHaMP.

BPA Project 2008-471-00 (Upper Columbia Nutrient Supplementation): The purpose of this project is to quantify and evaluate nutrient status and availability in the Twisp River, a tributary to the Methow River (see description under RPA Subaction 56.1). Although this project does not directly address RPA Subaction 56.2, it does monitor and track nutrients and food within a watershed in the Methow River Basin. These data, combined with CHaMP and Reclamation data, should fully satisfy habitat status and trend monitoring within the Methow River Basin.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See RPA Subaction 56.1 for a partial description of CHaMP. With regard to this RPA Subaction 53.2, CHaMP developed a tool for generating and displaying habitat quality indices that can be used to show habitat status and trends. The indices are based on empirically derived functional relationships between the most predictive habitat metrics and juvenile Chinook salmon density from pooled data collected at 152 sites in the Lemhi, upper Grande Ronde, John Day, South Fork Salmon, Entiat and Wenatchee river basins. Regression methods were used to predict juvenile Chinook densities from CHaMP habitat metrics. Resulting scores were transformed into non-parametric habitat quality indices and examined at three spatial scales: subbasin, assessment unit (HUC 5), and site-level. CHaMP has developed preliminary summaries of habitat quality indices for each of the CHaMP watersheds (e.g., see Figure 80). These analyses are considered preliminary because they are based on one year of sampling. At least three years are needed to develop valid indices of habitat quality.

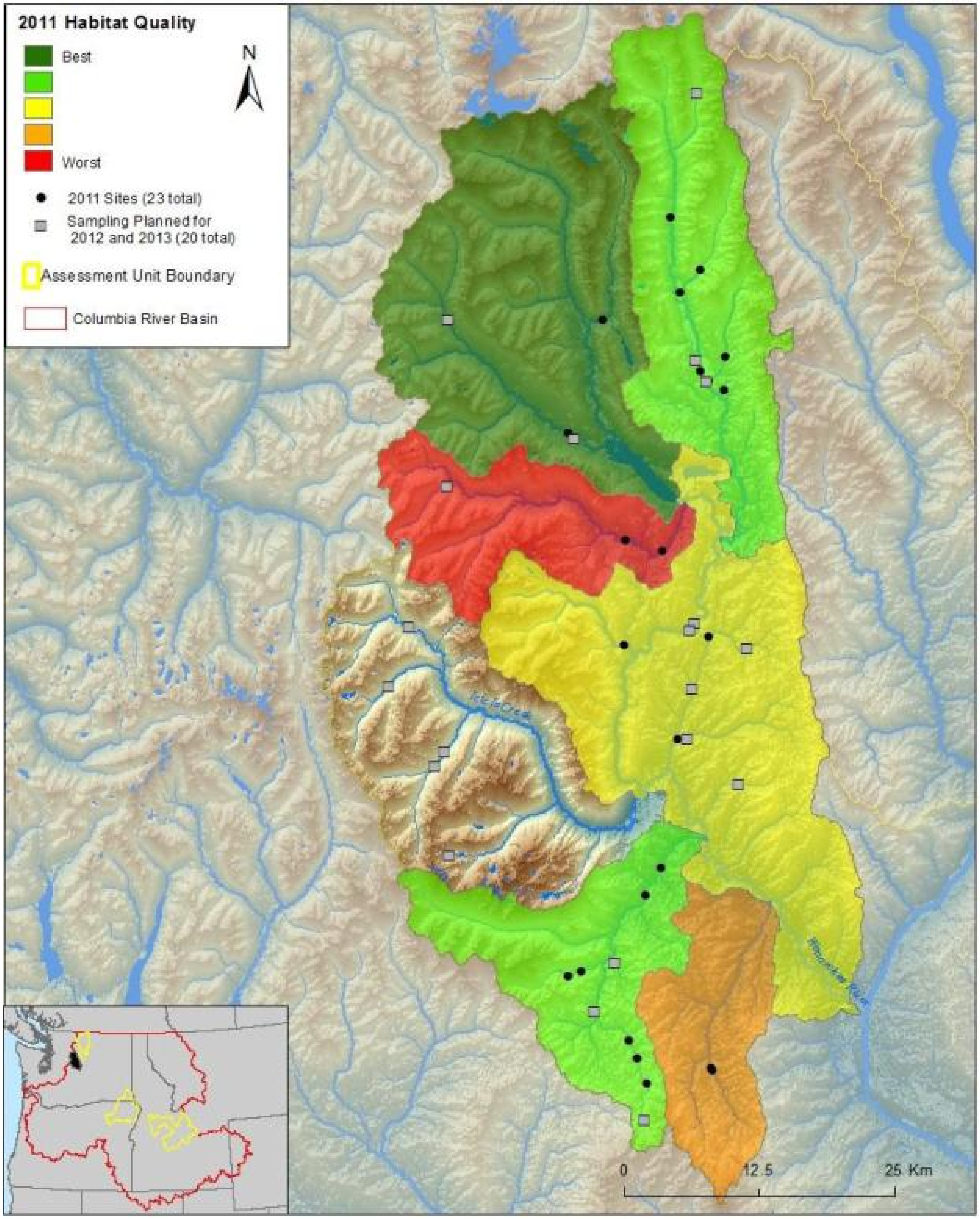


Figure 80. Example of How CHaMP Reports Habitat Quality Conditions (Wenatchee River Basin). Figure from Ward et al., (2012).

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

ISEMP tested several different habitat indicators and determined that the most appropriate indicators to measure for habitat status and trend included alkalinity, conductivity, pH, growth potential, percent below summer temperature threshold, percent above winter temperature threshold, velocity heterogeneity, embeddedness of fast-water cobble, pool frequency, channel complexity, channel score, residual pool volume, pool tail fines, total drift biomass, bank angle, LWD volume, fish cover, channel unit volume, channel unit complexity, riffle particle size, riparian structure, and solar input. Initial analyses, based on one year of data, suggest that about six to nine habitat metrics have the greatest influence in predicting juvenile Chinook and steelhead densities. Additional years of data are needed to determine which habitat metrics most strongly predict fish density, survival, and productivity.

CHaMP is currently monitoring habitat conditions within the six pilot basins specific to this RPA. Importantly, CHaMP and ISEMP have developed tools for generating and displaying habitat quality indices that can be used to show habitat status and trends. The indices are then examined at three spatial scales: subbasin, assessment unit (HUC 5), and site-level. CHaMP has developed preliminary summaries of habitat quality indices for each of the six pilot basins identified in this RPA (e.g., see Figure 80). These analyses are preliminary because they are based on only one year of sampling. At least three years are needed to develop valid indices of habitat quality.

Lessons Relative to RME Implementation

CHaMP is critical to this RPA, and without it, this RPA would not be fully addressed. ISEMP and the Upper Columbia Nutrient Supplementation projects support this RPA by providing additional data and tools for analyzing and reporting habitat status and trend results. Continuation of CHaMP in the pilot basins in the time frame agreed to with the contractor is important. There are two projects that implement restoration actions; one within the John Day River Basin and the other in the upper Columbia River Basin. It is not clear how these projects support this RPA or how the sponsors intend to use their data to describe habitat status and trends. Operation of the adult trap at Lower Granite Dam does not support this RPA.

RPA Subaction 56.3 – *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.*

To support this RPA the AA’s and NOAA will implement a tributary habitat status and trend monitoring strategy in at least one population per MPG coordinated with Fish-In and Fish-Out monitoring for RPA Subaction 50.6. This monitoring uses a protocol (metric, methods and design) that is being tested as a Pilot in 10 key populations for 3 years consistent with its rotating panel design. The pilot populations include the Pilot Study basins of 56.2 plus, the Methow, Tucannon, upper Grande Ronde, and Catherine Creek. During the Pilot a feasibility assessment will be conducted to determine if existing data collected under other programs, like the USFS’s Pacfish/Infish BiOp (PIBO) monitoring program, as well as other monitoring programs, will be able to be integrated into common data analysis methods. Upon completion of the Pilot the AA’s will work with NOAA to determine how to expand monitoring to the additional populations identified under this RPA. Part of this monitoring is also to support salmon life cycle monitoring under the AMIP and RPA Subaction 57.5 using fish population monitoring of various life stages under RPA Subaction 50.6. This monitoring for key populations in Table 5 of RPA Action 35 will help identify and prioritize restoration opportunities and support assessments that habitat survival improvement targets under RPA Action 35 can be achieved.

Major Accomplishments and Findings

The following projects have been implemented to support RPA Subaction 56.3.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): See RPA Subaction 56.1 and 56.2 for a description of ISEMP.

BPA Project 2003-022-00 (Okanogan Basin Monitoring & Evaluation Program (OBMEP)): The purpose of OBMEP is to measure habitat conditions and steelhead natural production in the Okanogan River Basin. Although the focus is on steelhead, the project also consolidates information related to sockeye and Chinook salmon. OBMEP data are used to help identify limiting factors, support adaptive management, prioritize and select restoration actions, manage local fisheries, and develop new restoration actions. With regard to RPA Subaction 56.3, OBMEP collected salmonid habitat data, which were needed to understand existing conditions and changes over time. Additionally, habitat status data fed the EDT model, which was used to understand and articulate the relationships between habitat and fish. The program measured 57 habitat metrics at 125 sites; 50 sites were sampled annually with all sites visited every four years.

In 2012, OBMEP redefined the spatial scales at which they assess habitat conditions. They identified 270 unique reaches contained within 46 diagnostic (biological important) units. These collectively represent the range of habitat conditions across the entire Okanogan River Basin. Between now and 2014, OBMEP will collect habitat data within each of the 270 reaches. A new rapid assessment protocol will be used to fill any data gaps for the 32 most critical EDT habitat attributes for each reach. By 2015, all necessary data should be available to conduct a complete EDT status and trend report.

OBMEP relies on EDT modeling to help determine which ecological concerns are most important within the Okanogan River Basin. Based on EDT model runs for each of the 270 reaches, ecological concerns were identified for each steelhead life stage. Model output showed that low habitat diversity, high water temperatures, elevated sediment load, low channel stability, predation, passage barriers, and low stream flows were the factors that most limit steelhead production within the Okanogan River Basin. The importance of these factors varied among the reaches. For example, factors such as high temperatures, sediment load, and predation were important in the mainstem Okanogan River, while low stream flows, channel stability, and fish passage were important in tributaries. Low habitat diversity and high sediment loads were concerns in most areas.

Because OBMEP uses EDT to evaluate their habitat data, current habitat conditions and trends are reported in terms of fish performance (e.g., abundance, capacity, productivity, and diversity). That is, if the EDT output demonstrates that fish performance is improving over time, then the habitat conditions that drive EDT are also improving. For example, comparing habitat conditions in 2004 with those in 2008, EDT showed that habitat conditions within 63 percent of the 46 diagnostic units improved for steelhead. Across all diagnostic units and habitat metrics, there was a 36 percent improvement in steelhead habitat condition. Habitat capacity for steelhead increased from 126 to 422 adult fish equivalents and equilibrium abundance from 49 to 139 adult fish equivalents. In addition, EDT indicated that Omak Creek was the highest priority area for habitat restoration work, while habitat in Salmon Creek should be protected.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination): In 2004, the Pacific Northwest Aquatic Monitoring Program emerged from an ad hoc effort to become a formal institution charged with providing a forum for coordination of aquatic monitoring efforts in the region. The geographic area of this coordination includes the Pacific Northwest region from Northern California to Canada where participating entities are implementing monitoring efforts. As of 2008, 20 state, tribal, federal, and regional entities signed the Pacific Northwest Aquatic Monitoring Program charter.

The basis of the Pacific Northwest Aquatic Monitoring Program is that monitoring will improve if all programs use consistent monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared. These goals will require considerable effort and commitment to collaboration by many entities and individuals. The Pacific Northwest Aquatic Monitoring Program strives to provide the forum where this collaboration can occur and to facilitate the exchange among technical experts and between technical and policy staff that is necessary to accomplish these goals.

The Pacific Northwest Aquatic Monitoring Program has identified and developed the following concepts important to establishing a regional partnership for aquatic resource monitoring that bridge technical focus areas and individual agencies.

- Protocols: what to measure and how to measure it.
- Survey design: how to decide where and when to monitor.
- Data management: what are our data needs; what must we do before, during, and after data collection to facilitate data sharing?
- Monitoring inventory: better facilitate coordination by describing ”who is doing what monitoring where.”
- High level indicators: seek agreement on a set of indicators (and metrics necessary to determine indicators) to describe landscape-level changes in the region.
- Regional network of monitoring efforts: explore ways to continuously improve our efficiency and effectiveness of monitoring on a regional scale.

Recently, the Pacific Northwest Aquatic Monitoring Program has focused on data management, integration of monitoring, monitoring design, species and watershed monitoring, and technologies to advance monitoring. The Pacific Northwest Aquatic Monitoring Program advanced its coordination goals and objectives for these topics by hosting workshops, work sessions, and meetings. Steering Committee members and subject matter experts participated in these meetings to exchange information about their own programs, coordinate on existing projects, and initiate new tasks. Lastly, the Pacific Northwest Aquatic Monitoring Program continued to emphasize communication as a tool to support collaboration and provided a forum where monitoring practitioners and policy staff could interact and exchange information.

BPA Project 2009-004-00 (Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators): The purpose of the Grande Ronde project is to assess the status and trend of stream habitat conditions in the upper Grande Ronde River and Catherine Creek (two threatened spring Chinook populations of the Grande Ronde MPG). The program will evaluate the potential of freshwater habitat restoration in aggregate, applied in a spatially diffuse manner to these basins, to improve the viability of spring Chinook salmon populations. There are three major components:

i. Assess status and trends in key ecological concerns affecting spring Chinook using a combination of CHaMP monitoring protocol and sampling of subsurface sediment, benthic macroinvertebrates, and fish distribution using a spatially balanced statistical design (GRTS) to select stream reaches to sample on either an annual or a three-year rotating panel series. In addition, water temperature modeling and remote sensing of riparian condition at a stream network level will provide comprehensive status and trend for riparian condition and the water temperature regime.
ii. Evaluate the potential for stream restoration actions to improve key ecological concerns, such as water temperature, spawning substrate condition, streamflow, and riparian condition.
iii. Develop a life-cycle model to link biotic responses of spring Chinook populations to current conditions and projected changes in stream habitat conditions. In collaboration with other partners (NOAA, ODFW, and CTUIR), a quantitative modeling approach will be used to estimate the annual variation in recruitment and survival.

At this time, the Grande Ronde River project has not clearly indicated what factors are limiting Chinook salmon and steelhead production within the upper Grande Ronde River and Catherine Creek watersheds. Measurements of fine sediment levels and temperatures indicate that they are limiting production in some areas of the upper Grande Ronde River and Catherine Creek watersheds. High temperatures appear to be more of an issue in the upper Grande Ronde River than in Catherine Creek. In addition, pools and LWD may also be limiting in certain areas. As additional years of CHaMP and other data are collected, there should be more information on ecological concerns within the Grande Ronde River Basin.

The Grande Ronde River project began using CHaMP and other protocols in 2011. Because CHaMP requires at least three years of data collection to assess current conditions and trends, no trend results are currently available for the upper Grande Ronde River or Catherine Creek watersheds.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See RPA Subactions 56.1 and 56.2 for partial descriptions of CHaMP. For this RPA subaction, CHaMP developed preliminary figures that show the distribution of habitat conditions within the Tucannon, South Fork Salmon, Lemhi, John Day, Grande Ronde, Methow, Entiat, and Wenatchee river watersheds (e.g., see Figure 80 above). It is important to point out that these habitat distribution maps were based on only one year of data and may not accurately reflect true habitat conditions within those watersheds. Indeed, CHaMP notes that the figures were developed to show how habitat conditions can be displayed to improve communication of findings. Thus, at this time, CHaMP results should not be used to conclude habitat conditions within various portions of the watersheds, especially since some of the characterization of habitat quality within a given area was based on data collected within one or two sites.

CHaMP is currently developing tools that will identify which habitat indicators and their interactions result in certain areas being classified as poor habitat quality. These tools will likely be available in 2013. Nevertheless, based on ISEMP, it is known that low summer flows and migration barriers limit salmonid production in the Lemhi River watershed while channel incision, high temperatures, and low summer flows limit steelhead production within Bridge Creek, a tributary to the John Day River, and habitat complexity and floodplain connectivity limit salmonid production within the Entiat River watershed.

CHaMP is designed to assess current habitat conditions and how they change over time at the population scale. Because CHaMP was implemented in 2011 and requires at least three years of data collection, trends in habitat conditions will be available in 2013 or 2014.

Pacfish/Infish Biological Opinion (PIBO): Although PIBO is not a BPA-funded program, it collects habitat status and trend data within the Columbia River Basin. The program is implemented by the USFS and Bureau of Land Management (BLM). PIBO is a large-scale stream/riparian monitoring program intended to ensure listed fish on public lands in the interior Columbia River Basin are protected. PIBO receives funding from three regions of the USFS, two BLM state offices, and the U.S. Environmental Protection Agency (EPA). The main objectives of PIBO are to:

i. Inventory and monitor streams and riparian areas on federal lands of importance to fish in upper Columbia River Basin.
ii. Determine if stream and riparian conditions are being maintained and/or improved.
iii. Determine what effect federal management activities are having on stream habitat trends as related to fish populations.

Geographic coverage is essentially the U.S. portion of the Columbia River Basin upstream from Bonneville Dam. The study area contains about 3,500 subwatersheds, of which approximately 1,300 have been sampled at least once on a GRTS rotating panel design. About 50 metrics are reported for each sampled reach, including data on stream structure, benthic macroinvertebrates, riparian vegetation, and water quality.

Although both PIBO and CHaMP collect habitat status and trend data, the two programs are designed differently. The PIBO program was designed to monitor habitat on public lands in the upper reaches of streams that are typical of national forest lands and that are primarily affected by forestry activities (e.g., road construction, timber extraction and replanting, riparian buffer effectiveness, etc.). These areas may or may not contain anadromous fish. In contrast, CHaMP was designed to monitor stream types and associated habitat conditions within anadromous salmonid habitat in areas that range from upland forests to low-gradient lowland streams on both public and private lands. These two programs collect some of the same measurements (e.g., water temperature, stream depth, etc.), but because they occupy different sections of the watersheds (with some overlap) and are designed to answer different questions, they also measure some habitat components that are unique to each program.

PIBO, unlike CHaMP, does not attempt to describe habitat conditions at the scale of a population. Thus, researchers cannot use PIBO information to identify factors limiting the survival or distribution of Chinook salmon and steelhead at the population scale. In addition, many PIBO sampling sites occur in areas upstream from the distribution of Chinook salmon and steelhead. These areas may have some effect on downstream habitat conditions, but would not represent all the habitat conditions that directly affect Chinook salmon and steelhead abundance and survival. Finally, summary reports produced by PIBO do not describe specific habitat conditions within specific watersheds. Rather, the summary reports describe habitat conditions within managed and unmanaged watersheds pooled across the PIBO sampling universe, which only includes USFS and BLM lands. This is not a criticism of the PIBO monitoring program, because it was not designed to address this RPA. However, it does limit the usefulness of these data to address RPA Subaction 56.3.

PIBO monitoring began in 2001 with the program at half implementation. Full implementation began in 2003. By 2006, PIBO began resampling sites that were originally sampled in 2001. Thus, there are enough years of habitat data to begin assessing trends. Based on these data, preliminary analyses indicate that within both managed (watersheds with grazing, logging, etc.) and reference sites, bank stability and median substrate particle size increased over time, while pool habitat decreased over time. Within managed sites, there was a significant decrease in percent fine sediments in pool tail-outs; fines in pool tail-outs increased in reference sites over time. There was also a significant increase in residual pool depth in managed sites, but not in reference sites. LWD frequency and volume increased in both managed and reference sites, but the increase was larger in reference sites than in managed sites. The percentage of undercut banks did not change in managed or reference sites over time. Overall, these preliminary analyses indicate that habitat conditions for fish are improving over time on USFS and BLM lands.

Because much of PIBO sampling occurred in areas upstream from the distribution of salmon and steelhead, results do not reflect the entire suite of habitat conditions used by these fish. In addition, trends were based on pooling all sites sampled within managed and reference watersheds. Thus, the results provide habitat trends on USFS and BLM lands at the Columbia River Basin scale, but do not identify changes in habitat conditions at the population scale. It may be possible to produce population-scale or subbasin-scale summaries of the PIBO data; however, they would not be defensible statistically because of small samples sizes (few sampling sites within a population) and the fact that only USFS and BLM lands are sampled. PIBO is doing well at what it was designed to do. It was not intended to characterize habitat conditions at finer scales, as were CHaMP, ISEMP, and OBMEP.

Reclamation-hosted Modeling Workshop: Reclamation hosted a modeling workshop in February 2011. Participants learned that a wide variety of habitat-fish models are being used in both retrospective (most) and prospective (seldom) modeling approaches. The two-day workshop proceedings and a retrospective and prospective summary will be captured in an Appendix to the Methow River IMW report.

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

ISEMP was designed to develop a set of standardized methods to monitor both fish populations as well as changes in habitat condition. ISEMP identified appropriate sampling designs, sample sizes, indicators, and field sampling methods. These results were used to develop CHaMP. Importantly, ISEMP tested several different habitat indicators and determined that the most appropriate indicators to measure for habitat status and trend included alkalinity, conductivity, pH, growth potential, percent below summer temperature threshold, percent above winter temperature threshold, velocity heterogeneity, embeddedness of fast-water cobble, pool frequency, channel complexity, channel score, residual pool volume, pool tail fines, total drift biomass, bank angle, LWD volume, fish cover, channel unit volume, channel unit complexity, riffle particle size, riparian structure, and solar input. Not only are these indicators sensitive to habitat change, they also correlate with fish abundance and survival.

Using the protocols developed within ISEMP, CHaMP and the Grande Ronde River project are currently monitoring habitat conditions within eight populations. CHaMP protocols are also being implemented in the Asotin Creek watershed. The Asotin Creek project is funded by NOAA Fisheries. CHaMP and ISEMP have developed tools (and continue to refine the tools) for generating and displaying habitat quality indices that can be used to show habitat status and trends. The indices are then examined at three spatial scales: subbasin, assessment unit (HUC 5), and site-level. CHaMP has developed preliminary summaries of habitat quality indices for each of the six populations. These analyses are preliminary because they are based on only one year of sampling. At least three years are needed to develop valid indices of habitat quality.

OBMEP relies on EDT modeling to help determine which ecological concerns are most important within the Okanogan River Basin. Based on EDT model runs conducted thus far, results indicate that low habitat diversity, high water temperatures, elevated sediment load, low channel stability, predation, passage barriers, and low stream flows are the factors that most limit steelhead production within the Okanogan River Basin. Not surprising, the importance of these factors varied among the reaches. For example, factors such as high temperatures, sediment load, and predation were important in the mainstem Okanogan River, while low stream flows, channel stability, and fish passage were important in tributaries. Low habitat diversity and high sediment loads were concerns in most areas. In addition, EDT indicated that Omak Creek was the highest priority area for habitat restoration work, while habitat in Salmon Creek should be protected.

The Pacific Northwest Aquatic Monitoring Program is working to coordinate habitat status and trend monitoring programs throughout the Pacific Northwest. At this time, different habitat status and trend monitoring programs are being implemented within the Columbia River Basin (e.g., CHaMP, OBMEP, PIBO, and Environmental Monitoring & Assessment Program). The Pacific Northwest Aquatic Monitoring Program is working to coordinate these programs and to develop common methods where appropriate.

Lessons Relative to RME Implementation

Both CHaMP and OBMEP are designed to assess habitat status and trend at the population scale. Because CHaMP is a new monitoring program and began implementation in 2011, it will require at least two additional years before it can provide complete status and trend information at the population scale. OBMEP was implemented earlier than CHaMP and is currently providing habitat status and trend data; however, it recently redefined the spatial scales at which it assesses habitat conditions. This will allow the program to better quantify status and trends at different spatial scales. PIBO has the longest habitat data series, but because it has different objectives and goals, it cannot quantify habitat status and trend at the population scale. Because the Grande Ronde River project has incorporated CHaMP protocols into its design, it should be able to quantify habitat status and trend at the population scale. In sum, CHaMP, OBMEP, and the Grande Ronde River project should be able to identify the primary factors that limit salmonid survival, abundance, and distribution, and they should be able to track habitat changes over time. The Pacific Northwest Aquatic Monitoring Program is working to coordinate these programs.

An outcome from the Modeling Workshop hosted by Reclamation was that some recent “natural experiments,” not executed in a structured study design but nonetheless subjected to intensive monitoring through other programs, have been analyzed using models, and results show promise for assessing management alternatives. Mostly statistical models are used and suitable validation datasets are lacking and mechanistic models are needed.

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.*
2. *Pilot study in the Lemhi River Basin to study treatments to reduce entrainment and provide better fish passage flow conditions.*
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.*
4. *Project and watershed level assessments of habitat, habitat restoration and fish productivity in the Wenatchee, Methow, and John Day basins.*
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.*

RPA Subaction 57.1 – *Action effectiveness pilot studies in the Entiat River Basin to study treatments to improve channel complexity and fish productivity.*

The strategy in the Entiat River Basin is to implement a "traditional" approach to action effectiveness monitoring by tracking changes in physical and biological indicators in treated and reference/control areas. The intent of RPA Subaction 57.1 is to assess habitat restoration effects at the project or reach scale and the population scale.

<u>Major Accomplishments and Findings</u>

The following projects have been implemented to support RPA Subaction 57.1.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): The purpose of the Entiat River IMW is to determine the effectiveness of restoration at improving Chinook and steelhead freshwater productivity. The primary restoration action to be tested is active instream modifications via engineered structures that increase habitat complexity and diversity by creating large pools and off-channel areas. ISEMP is using a hierarchical-staircase statistical design to compare treatment and control sections within the Entiat River. A tributary assessment divided the lower 26 miles of the Entiat River mainstem into geomorphic reaches that will be treated in a spatially and temporally driven manner. Treatment and control sections are present within each geomorphic reach type, and each geomorphic reach is treated in a staggered manner through time. Habitat and fish monitoring sites occur in each section and CHaMP protocols evaluate changes in habitat. Researchers use mark-recapture of juvenile steelhead and Chinook to estimate fish metrics in each reach. A census of redds and operation of a screw trap enumerate adults and out-migrating smolts, respectively. The first round of restoration actions are scheduled to be implemented in 2012. Pre-project implementation has been occurring since 2010.

In addition to the work described above, researchers are also estimating population size and individual growth and movement for Chinook and steelhead at the reach scale to complement the larger-scale effectiveness monitoring. Fish were enumerated at treated (a series of four engineered log jams and five rock barbs that have formed pools within the treated reach) and untreated reaches to determine if: 1) fish growth and movement would slow density dependence, and 2) density dependence would differ between the treated and untreated reaches. Current results indicate that restoration structures provide deeper and slower flowing habitat for fish than untreated stream reaches, and these factors contributed to fish density. Large variation was seen in fish abundance between early- and late-season sampling events, with Chinook salmon density being significantly associated with structure sites only in early-season sampling in all study years. Steelhead were more variable in their habitat selection, being correlated with restoration structures in early-season 2009 and 2011, but present in higher numbers at untreated sites throughout 2010. Steelhead, despite being at lower densities at structures than at untreated sites, had higher growth rates at structures, suggesting that density might not be the only indicator of fish response to restoration.

BPA Project 2009-003-00 (Salmon River Basin Nutrient Enhancement): The purpose of the Upper Columbia Habitat Restoration Project is to restore natural habitat function in the Wenatchee, Entiat, and Methow river basins. The restoration efforts have taken a comprehensive approach to the restoration of habitat for Chinook salmon, steelhead, and bull trout. Based on reach assessments and coordination with ISEMP, restoration actions implemented within the Entiat River included large wood treatments, reconnection of side channels, creation of alcoves, and connection and improvement of back-channel habitat. These actions fit within the context of the Entiat River IMW experimental design.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring): See RPA Subaction 56.1 for a description of this project. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See RPA Subactions 56.1, 56.2, and 56.3 for a complete description of CHaMP. For this RPA subaction, CHaMP developed preliminary summaries of habitat quality indices for the Entiat River Basin (Figure 81). Although CHaMP has only collected one year of habitat data within the Entiat River Basin, over time it will document changes in habitat conditions at the basin, assessment unit, and site scales. This will allow researchers to assess the effects of restoration actions on habitat conditions at three spatial scales.

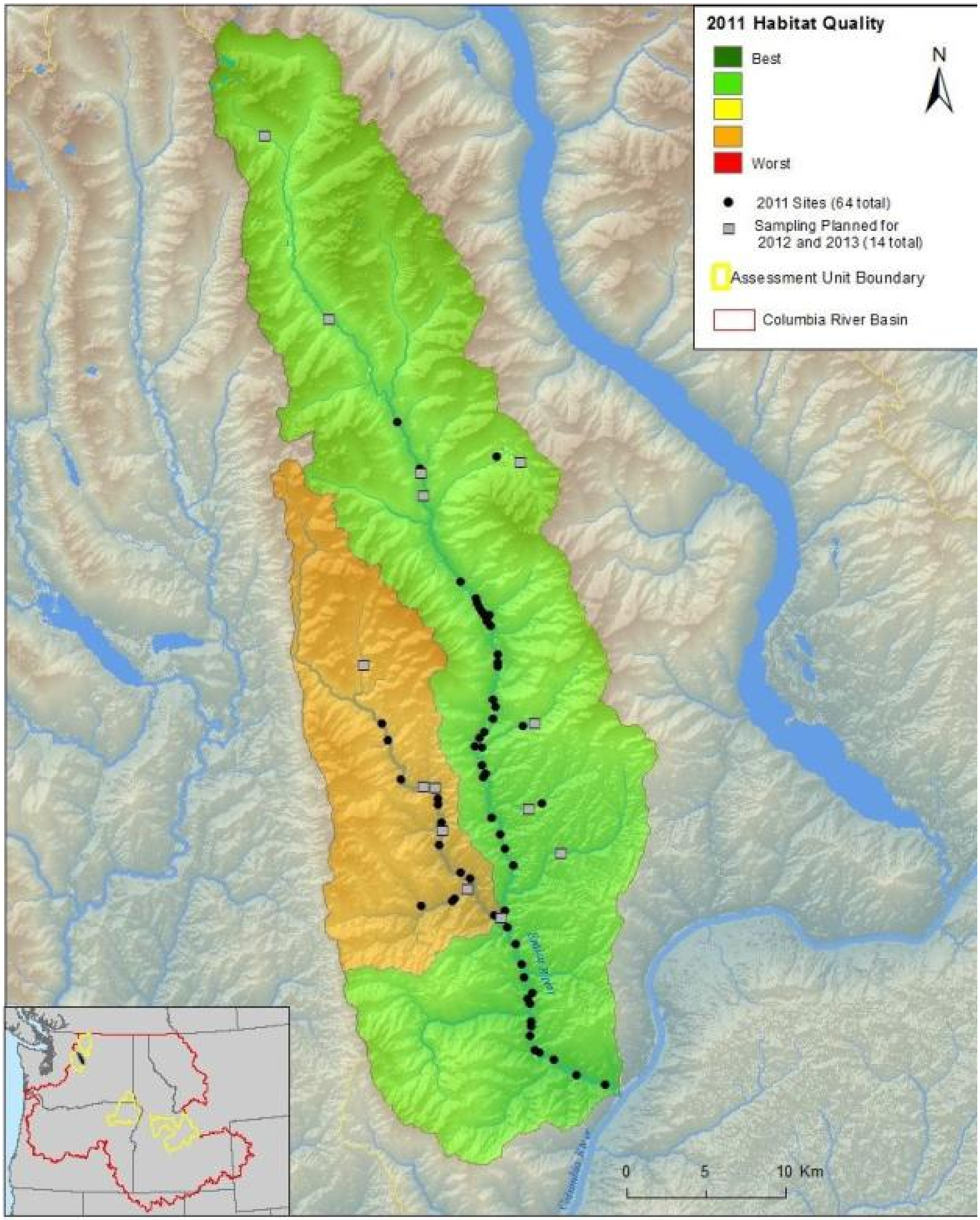


Figure 81. Habitat Quality Conditions within the Entiat River Basin. Figure is from Ward et al., 2012.

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

At the population (watershed) scale, there are no results to report because the bulk of restoration actions are scheduled to be implemented beginning in 2012. Thus, to date, only pre-treatment data have been collected. At the reach scale, however, current results indicate that previously implemented restoration structures (engineered log jams and rock barbs) provide deeper and slower flowing habitat for Chinook and steelhead than untreated stream reaches, and these factors contributed to increased fish density. However, large variation was observed in fish abundance between early- and late-season sampling events, with Chinook salmon density being significantly associated with structure sites only in early-season sampling. Steelhead were more variable in their habitat selection, being correlated with restoration structures in early-season 2009 and 2011, but present in higher numbers at untreated sites throughout 2010. Steelhead, despite being at lower densities at structures than at untreated sites in 2010, had higher growth rates at structures, suggesting that density might not be the only indicator of fish response to restoration. This suggests that fish responses to habitat restoration should not be based solely on density. Post-treatment data, which will be collected over the next several years, will determine if the restoration structures result in a population-scale response.

Lessons Relative to RME Implementation

ISEMP is designed to address both reach-scale and population-scale effects of restoration. CHaMP assesses changes in habitat conditions at the population scale, while the Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring project will improve the accuracy and precision of fish population monitoring (fish-in and fish-out). This will increase the likelihood of detecting a treatment effect at the population scale. Finally, the Upper Columbia Restoration Project, in concert with other restoration projects, is implementing restoration actions within the Entiat according to the design of the Entiat River IMW. The hierarchical-staircase statistical design of the IMW determines when and where actions are to be implemented.

The four projects associated with this RPA are needed to fully address this RPA. At this time, no other projects are needed to address this RPA. Thus, continuation of these projects in the time frame agreed to with the contractors is important.

RPA Subaction 57.2 – *Pilot study in the Lemhi River Basin to study treatments to reduce entrainment and provide better fish passage flow conditions.*

The strategy in the Lemhi River is to implement a "stage-based modeling" approach to assess the effects of entrainment, connectivity, and flow actions on the abundance, productivity, condition, and distribution of anadromous and resident salmonids.

Major Accomplishments and Findings

The following projects have been implemented to support RPA Subaction 57.2.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): The purpose of the Lemhi IMW is to evaluate the effectiveness of reconnecting numerous small tributaries to the mainstem Lemhi River. While tributary reconnections are the major restoration focus, the Lemhi River IMW also evaluates additional habitat actions including channel modifications, riparian fencing, diversion removals and screening, and side-channel development. The lack of access to tributary habitat limits access to potential thermal refugia that could improve survival and condition of migrating adults and rearing juveniles. The physical benefits of this action include: enabling access to historically available spawning and rearing habitat; decreased mainstem Lemhi River water temperatures owing to greater cool-water tributary influence; and greater access to thermal refugia for juveniles and adults.

The Lemhi River IMW is being implemented in a staircase design, where connection of high priority watersheds occurs first, with order of subsequent reconnections depending on results of the prior treatment. The monitoring program is designed to assess status and trends as well as effectiveness of the tributary reconnections. The CHaMP protocol is used to describe habitat at survey sites and bathymetric light detection and ranging (LiDAR) is used to describe habitat throughout the Lemhi River drainage. Mark-recapture of juvenile steelhead and Chinook also occurs at each site. Rotary screw trap and PIT-tag antennas are used to enumerate out-migrating smolts and adults, respectively.

ISEMP is using the Watershed Production Model to provide a landscape and life-cycle context, and to synthesize how restoration is expected to result in tributary and/or reach-scale alterations and changes in Chinook and steelhead survival/productivity, abundance, and condition.

There is currently no information regarding trends in habitat condition, and there were no significant trends in Chinook or steelhead juvenile survival or smolt production during the first several years of the study. Several habitat treatments (primarily instream flow) have been or will be completed by 2012, but there has been no trend in freshwater survival rates over six years of monitoring. To date, the only increase was in number of juvenile Chinook produced per redd in the Lemhi River and Hayden Creek, but there are only three years of data and the trend was the same in both streams. Hence, the increased number of juvenile Chinook/redd may be attributable to wet water years rather than due to restoration actions in the watershed (flow restoration in a key tributary).

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See RPA Subactions 56.1, 56.2, and 56.3 for a complete description of CHaMP. For this RPA subaction, CHaMP developed preliminary summaries of habitat quality indices for the Lemhi River Basin (Figure 82). Although CHaMP has only collected one year of habitat data within the Lemhi River Basin, over time it will be able to document changes in habitat conditions at the basin, assessment unit, and site scales. This will allow researchers to assess the effects of restoration actions on habitat conditions at three spatial scales.

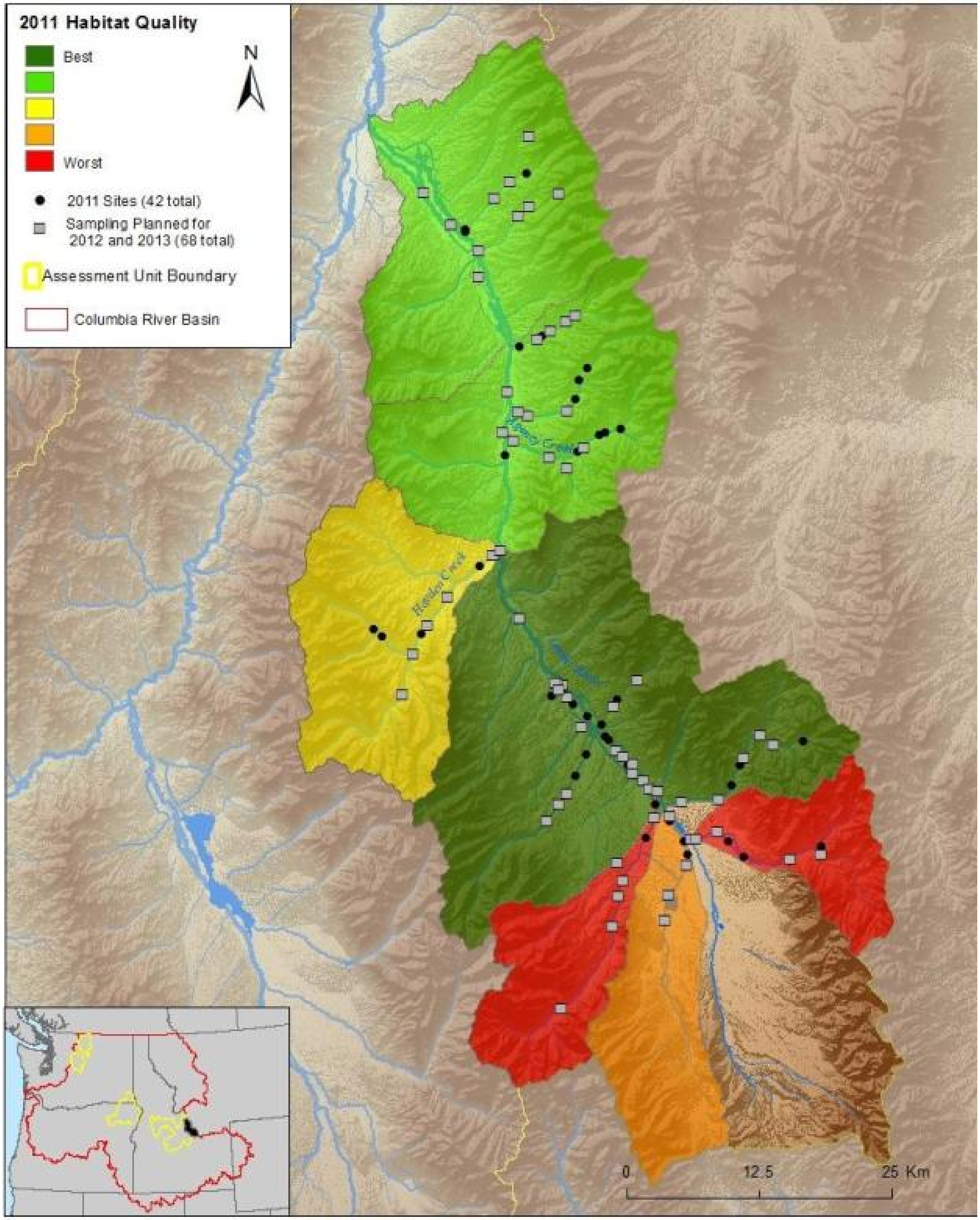


Figure 82. Habitat Quality Conditions within the Lemhi River Basin. Figure is from Ward et al., 2012.

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

ISMEP and CHaMP are working together to address this RPA. There is currently no information on trends in habitat condition, and there were no significant trends in Chinook or steelhead juvenile survival or smolt production during the first several years of the study. Several habitat treatments (primarily instream flow) have been or will be completed by 2012, but there has been no trend in freshwater survival rates over six years of monitoring. To date, the only increase was in number of juvenile Chinook produced per redd in the Lemhi River and Hayden Creek, but there are only three years of data, and the trend was the same in both streams. It is too early to determine if the restoration actions will be successful.

Lessons Relative to RME Implementation

ISEMP is designed to address both reach-scale and population-scale effects of restoration, while CHaMP assesses changes in habitat conditions at the population scale. Both projects are needed to address this RPA. Continuation of these programs in the time frame agreed to with the contractors is important. At this time, no other projects are needed to address this RPA.

RPA Subaction 57.3 – *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.*

The strategy in Bridge Creek is to implement a focused "research" approach to assess the effectiveness of ameliorating incision and sediment recruitment in Bridge Creek.

Major Accomplishments and Findings

The following projects have been implemented to support RPA Subaction 57.3.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead): See RPA Subaction 56.1 for a description of this project. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): The purpose of the Bridge Creek IMW is to examine the effects of restoration actions on aggrading incised stream channels and restoring floodplain connectivity on steelhead growth, survival, abundance, and production. Restoration is aimed at causing aggradation of the incised stream channels by installing a series of instream beaver dam support structures (BDSS, vertical wood post driven into the stream bottom) designed to assist beaver in the construction of stable, longer-lasting dams.

Stream restoration is implemented in a hierarchical-staircase design to create contrasts in time and space at multiple scales. The first step of the staircase design was implemented in 2009 where 84 structures were installed in four treatment reaches, leaving six reaches to serve as controls until they are treated in 2013. The CHaMP protocol, aerial photos, and aerial- and ground-based LiDAR are used to detect changes in habitat and riparian vegetation. Mark-recapture of juvenile steelhead occurs at each site in spring, fall, and winter. PIT-tag antennas are used to enumerate out-migrating smolts and aide in the estimate of juvenile and adult survival. Adults are enumerated using a two-way weir and redd surveys.

The primary change detection metric used by ISEMP to describe aggradation (deposition) is the DEM of difference, or the difference of digital 3D maps of the channel constructed before and after implementation of restoration. The DEM of difference is the change in streambed elevation within the stream channel. The distribution of changes can be summed to describe a net degradation, aggradation, or no change to the reach.

One year after installation of the support structures (2009), 30 percent were colonized by beaver, beaver activity was present in all treatment reaches, and beaver had expanded into a treatment reach previously unoccupied. In general, deposition occurred behind beaver dams and BDSSs, with scour pools forming downstream. Using DEMs, ISEMP was able to describe how the channel changed as a response to the actions, revealing the amount of deposition in treatment reaches was positive (the channel aggraded) (Figure 83).

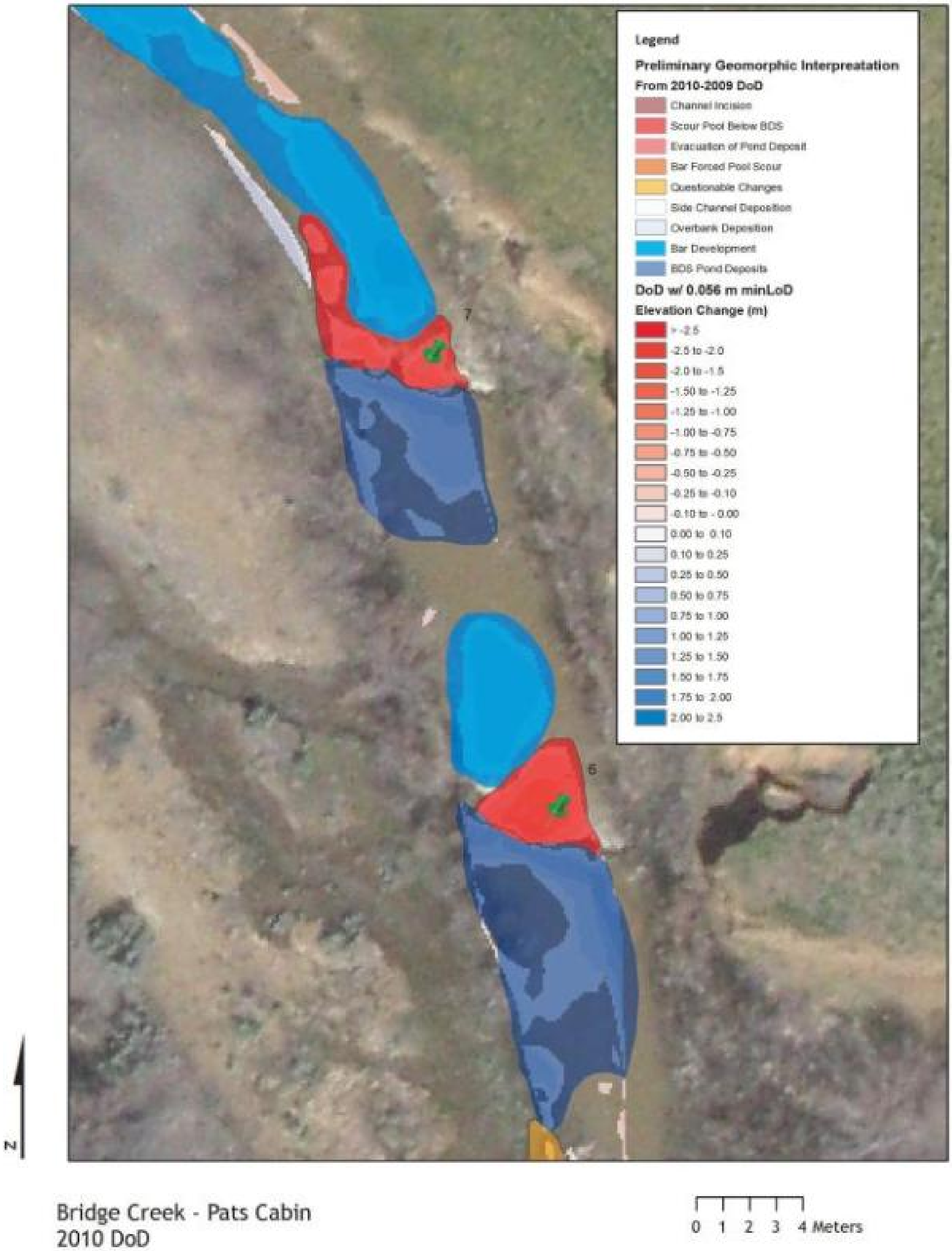


Figure 83. Digital Elevation Model of Difference (Post-Restoration Minus Pre-Restoration) from Topographic Surveys for a Portion of the Treatment Reach in Bridge Creek. Pushpins Indicate Location of Structures. Blue color represents aggradation, while red represents erosion. Figure is from ISEMP (2012).

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See RPA Subactions 56.1, 56.2, and 56.3 for a complete description of CHaMP. For this RPA subaction, CHaMP developed preliminary summaries of habitat quality indices for the John Day River Basin (Figure 84). Although CHaMP has only collected one year of habitat data within the John Day River Basin, over time it will be able to document changes in habitat conditions at the basin, assessment unit, and site scales. This will allow researchers to assess the effects of restoration actions on habitat conditions at different spatial scales.

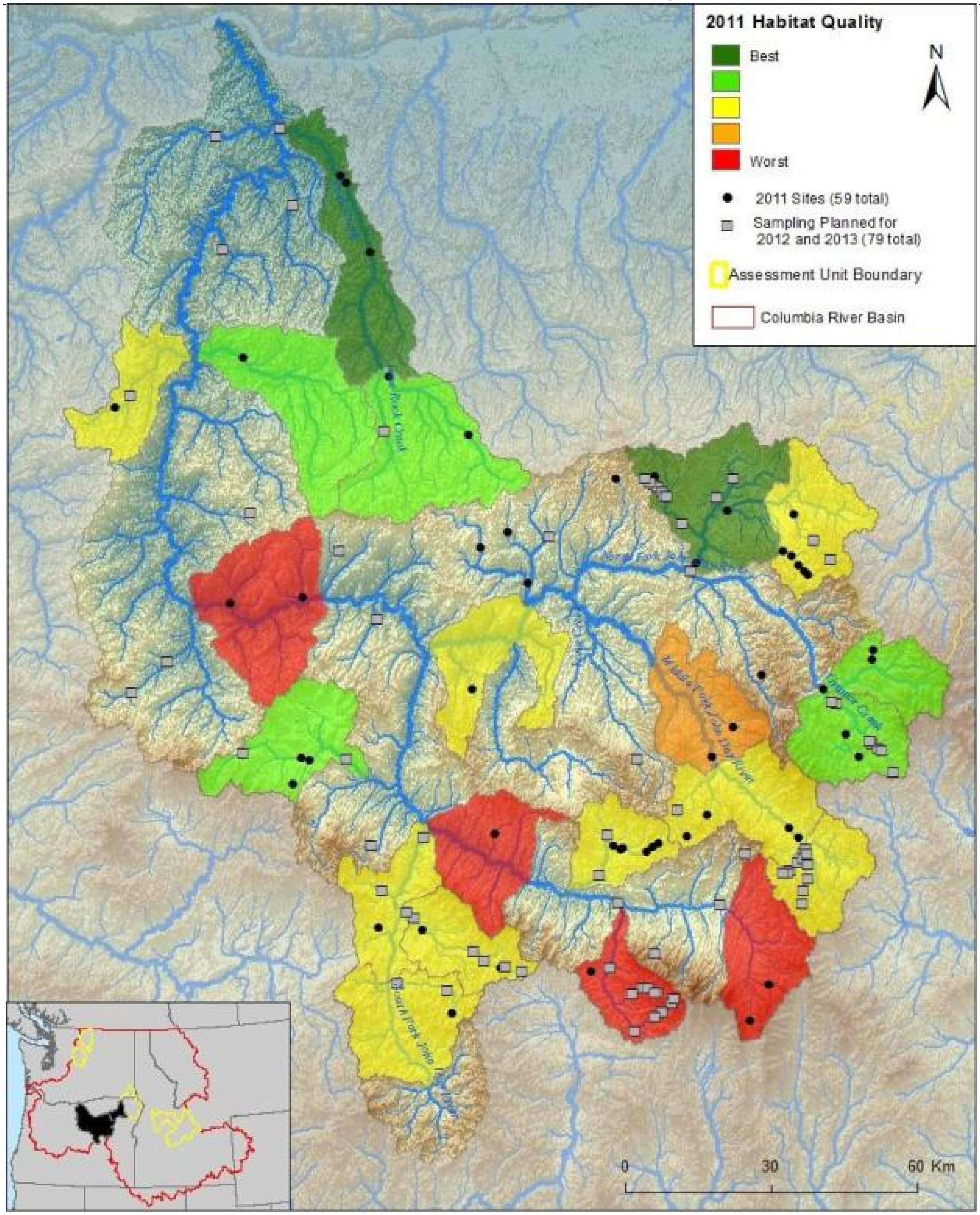


Figure 84. Habitat Quality Conditions within the John Day River Basin. Figure from Ward et al., (2012).

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

BDSSs appear to be a useful technique for aggrading incised channels and reconnecting floodplains. At the assessment unit scale, 30 percent of the BDSSs were occupied by beaver in the first year, and there were significant reach-scale changes in pool frequency, percent pool area, and average pool depth. Initial results indicate that these changes have increased abundance and survival of steelhead in Bridge Creek. To date, the IMW has shown that the BDSSs can create the expected aggradation and reconnect portions of the inset floodplain. However, significant aggradation of the incised channel will take more time, and more time is needed to determine whether the expected fish response has been achieved.

Lessons Relative to RME Implementation

ISEMP is designed to address both reach-scale and watershed-scale effects of restoration. CHaMP assesses changes in habitat conditions at the population scale, while the Escapement and Productivity of Spring Chinook and Steelhead Project assesses population status and trend. Both projects are needed to address this RPA. Continuation of these programs in the time frame agreed to with the contractors is important. At this time, no other projects are needed to address this RPA.

RPA Subaction 57.4 – *Project and watershed level assessments of habitat, habitat restoration, and fish productivity in the Wenatchee, Methow, and John Day river basins.*

The strategy to address RPA Subaction 57.4 is to continue monitoring fish populations (fish-in and fish-out), habitat, and habitat restoration actions within the Wenatchee, Methow, and John River basins using robust monitoring techniques and designs. This RPA is linked closely with RPAs 50.4 and 56.2, and results from this work also support RPA Subaction 56.1.

Major Accomplishments and Findings

The following projects have been implemented to support RPA Subaction 57.4.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead): See RPA Subaction 56.1 for a description of this project. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): See RPA Subactions 56.1, 56.2, 57.1, 57.2, and 57.3 for a complete description of ISEMP.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring): See RPA Subaction 57.1 for a description of this project. For more information on fish population monitoring results see Section 2 RPA Subaction 50.6 and Section 1 Fish Status and Environmental Conditions.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See RPA Subactions 56.1, 56.2, and 56.3 for a complete description of CHaMP.

Reclamation Beaver Creek (Methow River) Passage Study: Reclamation funded a passage study in Beaver Creek, a tributary to the lower Methow River. 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-m 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. PIT-tag interrogation stations were operated and maintained including: the six antenna multiplex unit at Stokes property (rkm 4) and a single antenna station upstream at rkm 12 (near UBR2). Data from these interrogation stations were uploaded into PTAGIS. Databases were searched for tag reads to update tag recaptures. Statistical analysis of genetics and tag movement data for before/after treatment comparisons were conducted and fitness and parentage analysis were conducted for spawners in 2005 and 2006. Fitness attributes and individual reproductive success were related to the proportion of hatchery admixture. Hatchery admixture was also compared in the before/after treatment comparisons. Changes in the population genetic attributes were compared to migration information from PIT-tag interrogation data. Researchers presented results from the Beaver Creek barrier removal studies in a special session on colonization of salmonids at the national American Fisheries Society meeting during September 2011 in Seattle, Washington.

Steelhead entered the re-opened habitat in Beaver Creek in 2005, the first spawning season after barrier removal. Counts of steelhead 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 steelhead migrated into upper Beaver Creek in 2007 and 2008, two-three years after barrier modification.

The migration of steelhead was associated with 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 further 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. Migration data from juvenile steelhead tagged in Beaver Creek returned to Beaver Creek as adults indicating the establishment of the full expression of anadromy in the study area. 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.

Reclamation Elbow Coulee Monitoring: Reclamation funded the design for the Elbow Coulee side-channel reconnection project in the Twisp River, a tributary to the middle Methow River. More than 50 years ago, a levee severed a portion of the floodplain and side channel from the mainstem Twisp River near Elbow Coulee. In September 2008, a project was initiated to reestablish connection to the river by breaching the levee.

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 RM 6.6; 2) increase habitat complexity and LWD 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 post-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, water temperatures are conducive for fish rearing, young-of-the-year spring Chinook and steelhead were observed each year using the side channel, and more fish are using the side channel than before the project.

Major Lessons Learned

Lessons Relative to Mitigation Action Implementation

CHaMP is currently monitoring habitat conditions within the three basins specific to this RPA. Importantly, CHaMP and ISEMP have developed tools for generating and displaying habitat quality indices that can be used to show habitat status and trends. The indices are then examined at three spatial scales: subbasin, assessment unit (HUC 5), and site-level. CHaMP has developed preliminary summaries of habitat quality indices for each of the three basins identified in this RPA. These analyses are preliminary because they are based on only one year of sampling. At least three years are needed to develop valid indices of habitat quality.

The Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring Project is developing methods that will improve the precision and accuracy of smolt monitoring, the precision of redd counts for both steelhead and spring Chinook; and the accuracy of steelhead spawning ground surveys. This work will help improve the probability of detecting population trends and treatment effects.

The Reclamation-funded Beaver Creek study indicated that adult steelhead colonization remained constant during the first five years of the study, suggesting that other factor(s) may be limiting reestablishment of the population. Steelhead express a large amount of life-history diversity including anadromous steelhead and resident fluvial rainbow trout. The study also identified a fall juvenile movement out of Beaver Creek (dubbed the movers) and a following spring juvenile movement (dubbed the stayers). Thus far, the fall movers comprise the majority of the successful adult returns. The relationship between habitat features and life-history expression will be the subject of a model exercise.

Lessons Relative to RME Implementation

ISEMP is designed to address both reach-scale and population-scale effects of restoration. CHaMP assesses changes in habitat conditions at the population scale, while the Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring Project will improve the accuracy and precision of fish population monitoring (fish-in and fish-out). This will increase the likelihood of detecting treatment effects at the population scale.

The three projects associated with this RPA, and the Reclamation-funded monitoring projects in the Methow River, are needed to fully address this RPA. At this time, no other projects are needed to address this RPA. Thus, continuation of these programs in the time frame agreed to with the contractors is important.

RPA Subaction 57.5 – *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.*

Major Accomplishments and Findings in Implementing the RPA Subaction

General, conceptual modeling approaches have been identified within the NOAA/Action Agency RM&E Workgroup and discussed with ISAB/ISRP on multiple occasions between 2008 and 2012. Reclamation funded and co-sponsored a modeling workshop in February 2011 with the U.S. Geological Survey, Northwest Fisheries Science Center and Columbia River Inter-tribal Fish Commission. The workshop identified a wide variety of habitat-fish models being used in mostly retrospective and rarely prospective modeling approaches. Mostly statistical models are used and suitable validation data sets for testing models are lacking. Mechanistic models are needed but rarely attempted. Work in ISEMP has identified three primary approaches to modeling the relationships between fish and habitat data: 1) descriptive, 2) predictive and 3) experimental manipulations. The descriptive approach uses the naturally occurring contrast in habitat quality and quantity across the pilot study basins as the basis for correlations between habitat and fish monitoring data. The predictive approach is based on fitting fish and habitat data to underlying mechanistic models such as population production functions (e.g., Beverton-Holt) or energy balance functions (e.g., NREI, bioenergetics) to predict fish population response in non-pilot study basins. The experimental manipulation approach uses large-scale ecological experiments (IMWs) to directly link fish response to contrasts in habitat quality and quantity resulting from IMW restoration actions. Data needed to support this type of modeling and relationship development is just now starting to reach a stage needed for model investigation and development. Ongoing modeling work under BPA funded Grande Ronde, OBMP, CHaMP, and ISEMP IMW projects are providing initial, investigative modeling to support this RPA action. Reclamation is developing a Methow River life-cycle model, and a fish population and habitat processes mechanistic model in a system-dynamics framework. Additional investigation of regression model approaches at the direction of the AA/NOAA RM&E Workgroup is ongoing under a technical support contract with Paulsen Environmental. The AAs continue to support the NOAA Science Center life cycle modeling which includes the development and testing of several habitat models in collaboration with key state and tribal scientists.

Major Lessons Learned from RPA Subaction 57.5

This RPA subaction was limited by the need for fish and habitat data to support regional collaborative development of models and relationships. Pilot research and monitoring projects were implemented and adaptively managed to identify appropriate fish and habitat metrics and monitoring designs for this needed information. The ongoing implementation and collaboration of ISEMP, CHaMP, and Reclamation monitoring programs, in coordination with federal, state, and tribal collaborative habitat and life cycle modeling lead by the NOAA Science Center, should substantially advance the development and application of habitat and fish relationships during the 2013 to 2016 Implementation Plan.

RME Strategy 4 (RPA Actions 58–61)

RPA Action 58 – Monitor and Evaluate Fish Performance in the Estuary and Plume*: The Action Agencies will monitor biological responses and/or environmental attributes, and report in the following areas:*

2. *Monitor and evaluate smolt survival and/or fitness in select reaches from Bonneville Dam through the estuary.*
3. *Develop an index and monitor and evaluate life history diversity of salmonid populations at representative locations in the estuary.*
4. *Monitor and evaluate juvenile salmonid growth rates and prey resources at representative locations in the estuary and plume.*
5. *Monitory and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.*

RPA Subaction 58.1 – *Monitor and evaluate smolt survival and/or fitness in select reaches from Bonneville Dam through the estuary.*

<u>Major Accomplishments and Findings in Implementing the RPA Subaction</u>

Since 2008 four projects have contributed to this RPA subaction. Information on juvenile salmonid survival and/or fitness in the LCRE is used to identify where habitat and/or prey production may be most limiting for salmonids as indicated by reduced fitness (bottom-up processes) and where predation pressure is most intense (top-down processes). While direct measures of survival (e.g., survival rate) and fitness (e.g., lipid content, tissue synthesis/degradation) are reported under this RPA subaction, indirect measures of bottom-up processes (e.g., prey resources) are further detailed in RPA Subaction 59.3.

Several projects have evaluated smolt survival. A Study of Salmonid Survival and Behavior through the Columbia River Estuary Using Acoustic Tags (AFEP Project EST-P-02-01) used JSATS to evaluate juvenile salmonid survival rates (Chinook salmon yearlings, subyearlings, and steelhead) in the LCRE from 2004 through 2010. JSATS, developed by the Corps, allows tagging of juvenile salmonids as small as 95 mm (fork length). This technology advance was significant, but fish smaller than 95 mm could not be covered in the survival estimates. It is also important to note that the fish used for tagging in these studies were actively migrating fish. Survival results were mostly consistent across study years. Using 2010 results as an example (McMichael et al., 2011b), smolt survival from Bonneville Dam to rkm 50 was generally high (>0.95) for most groups of tagged fish. However, from rkm 50 to rkm 8, survival rates decreased dramatically (approximately 0.60). Harnish et al. (2012) found no differences in survival rates for fish migrating in the main channel as opposed to off-channel routes.

The COAST project (**BPA Project 2003-114-00**, Coastal Ocean Acoustic Salmon Tracking) also assessed survival of Columbia River salmon stocks (>120 mm) in the LCRE. The geographic scope of this project was broad including the hydrosystem, plume, and west coast of North America (see RPA Subaction 61.2). For this RPA subaction, researchers compared survival for the LCRE to other areas. They also evaluated differential survival of size-matched juvenile salmonids that passed through Snake River dams versus those that were transported by barge down to the LCRE.

For smolt fitness, researchers for the Ecosystem Monitoring Project (**BPA Project 2003-007-00**, Lower Columbia River Estuary Ecosystem Monitoring) collected data on juvenile salmonid lipid content at monitoring sites throughout the LCRE. Lipid content can be an indicator of smolt fitness or condition. For hatchery-origin smolts, condition (lipid content) decreased as juveniles moved through the LCRE; however, this trend was not observed for natural-origin smolts (Sagar et al., 2011). Since diet is associated with lipid content, these findings indicate that natural-origin smolts are likely benefiting disproportionately more in terms of diet than hatchery-origin smolts rearing in and migrating through the LCRE (Sagar et al., 2011).

In addition, scientific methods to quantify changes in juvenile salmon survival and fitness as a result of habitat restoration actions in the LCRE are being developed under the Salmon Benefits Project (EST-P-09-01). A conceptual species-habitat model (Diefenderfer et al., 2012) incorporates both onsite benefits of habitat actions (i.e., juvenile salmonids entering and occupying restored habitats) and offsite benefits of habitat actions (i.e., juvenile salmonids that do not enter the site, but benefit from resources exported from the site in the form of detritus and prey) (Figure 85). Onsite and offsite benefits are generally conceptualized for subyearling and yearling salmonids, respectively. An accompanying numerical model also is currently in development.

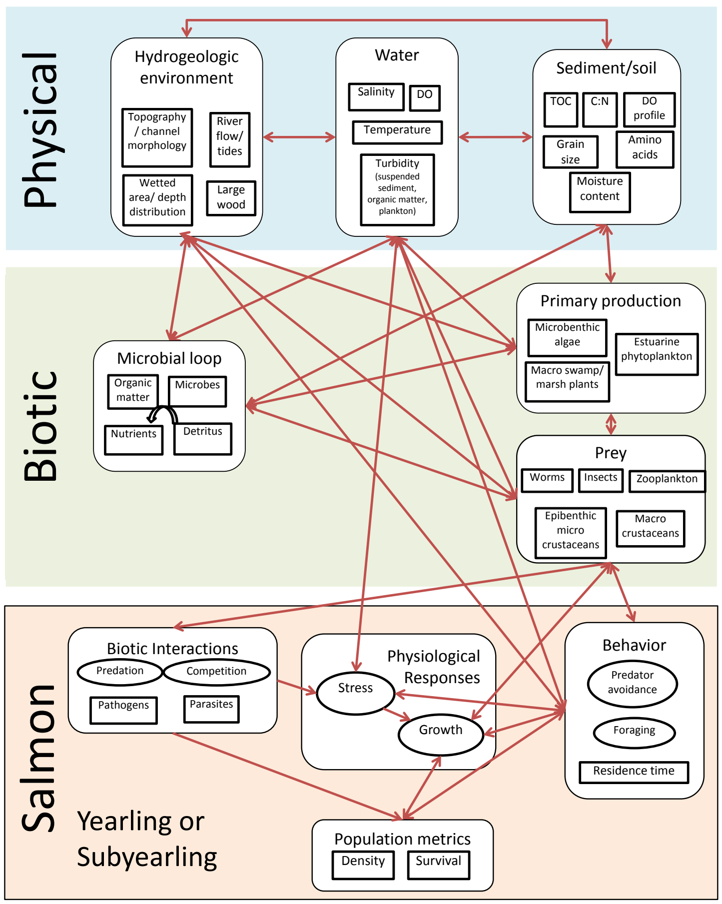


Figure 85. Preliminary Conceptual Species-Habitat Model of Onsite and Offsite Juvenile Salmon Benefits from Habitat Restoration in the LCRE. Reprinted from Diefenderfer et al., 2012.

<u>Major Lessons Learned from RPA Subaction 58.1</u>

<u>Lessons Relative to Action Implementation – Estuary Habitat Restoration</u>

Project sponsors planning habitat restoration actions in the LCRE can use information on survival and fitness/condition as they prepare their ERTG template, thus documenting how different species and stocks may benefit from future habitat actions in the area. The species-habitat-model will be applied by restoration practitioners as they plan action effectiveness monitoring and research studies. The species-habitat model could be used prospectively during habitat restoration planning and design notably, it provides a numerical tool to evaluate project alternatives and include as supporting material to the ERTG as they score a project for technical, certainty of success. In addition, the survival data indicate the lower 50 km is a "hot spot" for losses of juvenile salmonids, most likely due to avian predation. The LCRE reach survival estimates are used to support predation management actions. Actions to control avian predation in the estuary are discussed under RPA Actions 45, 45, 66 and 67. The results from RPA Subaction 58.1 inform pursuit of management actions designed reduce habitats that support predators of juvenile salmon.

Lessons Relative to RME Implementation

Fish physiology is an important element of fitness and survival. Researchers under the "Salmon Benefits" project (EST-P-09-01) are testing assessment of key metrics of fish physiology as a proxy to juvenile salmon fitness. These physiology metrics are similar to those examined during smolt survival studies at mainstem hydropower dams, and some are specifically related to fish growth. This proof-of-concept will be pilot tested via lab experimentation in early spring 2013. Refer to RPA Subaction 58.3 for additional detail on field studies investigating fish growth in the LCRE.

RPA Subaction 58.2 – *Develop an index and monitor and evaluate life history diversity of salmonid populations at representative locations in the estuary.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Early life history diversity (ELHD) may be defined as the variation in behavioral and morphological traits shown within and among populations by individual juvenile salmon during emigration downstream (modified after ISAB 2012). Estuary RME implemented since 2002 has greatly contributed to the scientific understanding of ELHD in shallow-water habitats of Reaches A through H, including peripheral habitats such as Youngs Bay, Baker Bay, and Grays River of the LCRE (Figure 86). The findings have subsequently informed the development of an ELHD index – a method which can be applied to assess changes in ELHD through time (Johnson et al., In Preparation) (AFEP Project EST-P-09-01). Note, use of shallow-water habitats, defined as rearing in a particular habitat for any extended period of time, is reported extensively in RPA Subaction 59.4. Additionally, hatchery releases can affect stock composition, abundance, and habitat-use patterns in the estuary (Bottom et al., 2011), therefore affecting ELHD index results. The ecological relevance of this to the LCRE is reported in RPA Subaction 61.1. Below is a discrete summary of contemporary patterns of species (and stock) timing of use that have been used to inform development of an ELHD index.

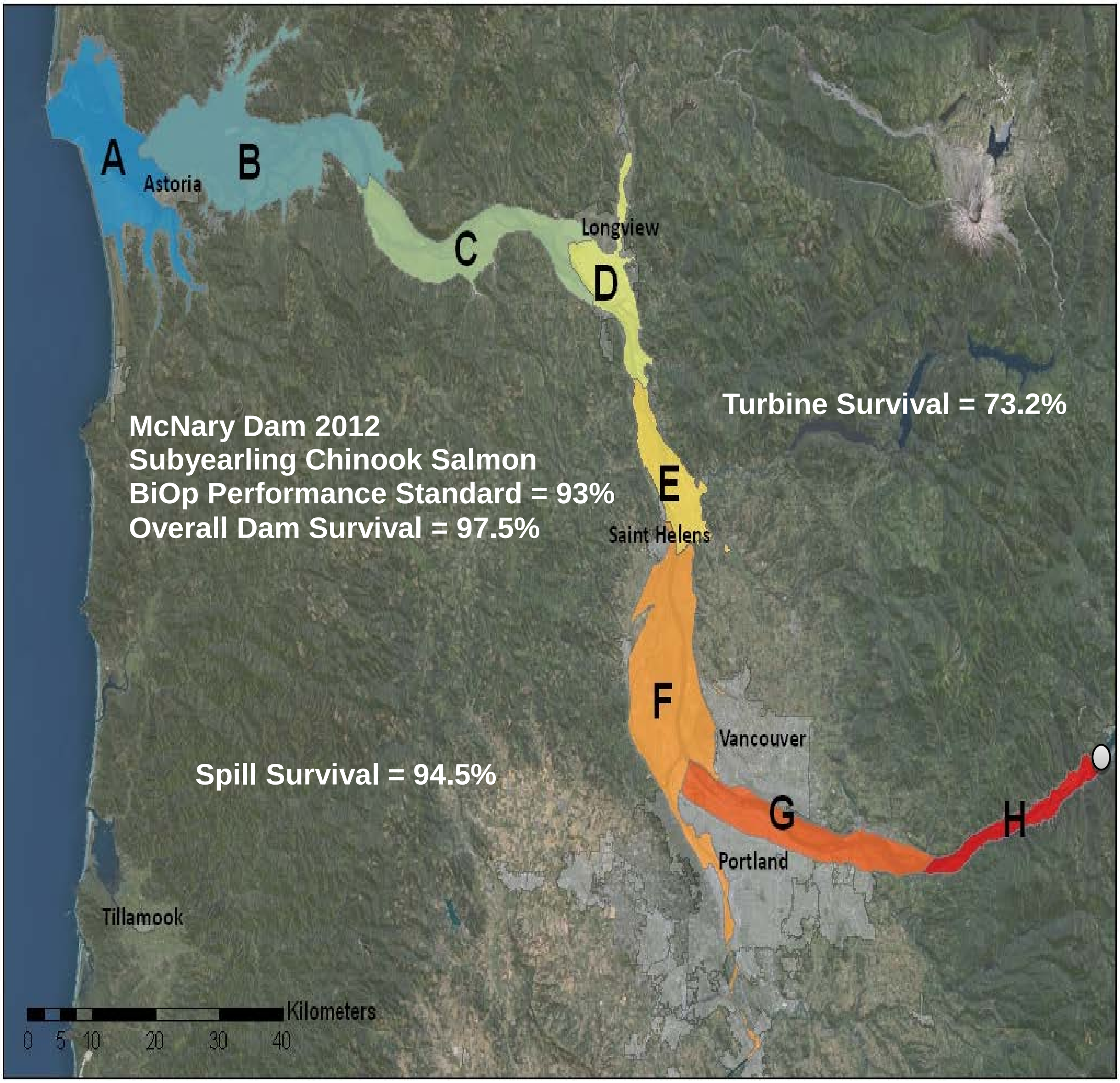


Figure 86. Map Showing Hydrogeomorphic Reaches A-H for the Lower Columbia River and Estuary (LCRE).

<u>*Contemporary Patterns of Species (and Stock) Timing and Use*</u>

Pacific salmon and steelhead display various juvenile life-history patterns, particularly in the timing and size at seaward migration. In the LCRE, six species of salmon and anadromous trout are common: Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), sockeye salmon (*O. nerka*), steelhead (*O. mykiss*), and coastal cutthroat trout (*O. clarkii*). In a comparison of genetic stock diversity in Reaches E and G (Figure 86), stock diversity was greater in Reach E than G (Johnson et al., 2011). Chinook catch included occurrences of Snake River fall Chinook salmon, Snake River spring/summer Chinook salmon and upper Columbia River spring Chinook salmon. Upper Columbia River summer/fall Chinook salmon (may also originate in spawning areas below Bonneville Dam), lower Columbia River fall Chinook salmon, and upper Willamette River Chinook salmon were captured more often. Snake River fall run fish were relatively rare in but occurred in Reaches E-H, comprising an estimated 4 percent of catches in Reach H (Bottom et al., 2011). Both the genetic stock survey and PIT-monitoring results indicate that salmonid species and stocks throughout the basin can enter shallow, tidal wetland channels.

Results show that juvenile salmonids are present in all tidal freshwater habitats sampled (e.g., Bottom et al., 2008; Johnson et al., 2011b; Roegner et al., 2010). The most common species encountered at the Sandy River delta were, in decreasing order: 1) unmarked Chinook (genetic stock varied longitudinally and by season); 2) chum; and 3) coho salmon (Figure 87). Smaller subyearling Chinook and chum salmon make substantial use of shallow subtidal and intertidal habitats, and subyearling coho are abundant in the lower sections of tributary rivers (CREST, 2012; Poirier et al., 2009 and 2010; Roegner et al., 2010; Thom et al., 2013), while yearling Chinook and coho salmon and steelhead primarily use main channel migratory pathways (e.g., Dawley et al., 1986; Magie et al., 2008; Weitkamp et al., 2012). Large (>95 mm) subyearling Chinook salmon also generally migrate rapidly through the LCRE (Dawley et al., 1986; Harnish et al., 2011, although they also use shallow-water habitats at times, especially during late fall, winter, and early spring (e.g., Poirier et al., 2009 and 2010; Bottom et al., 2011; Johnson et al., 2011b; Roegner et al., 2012).

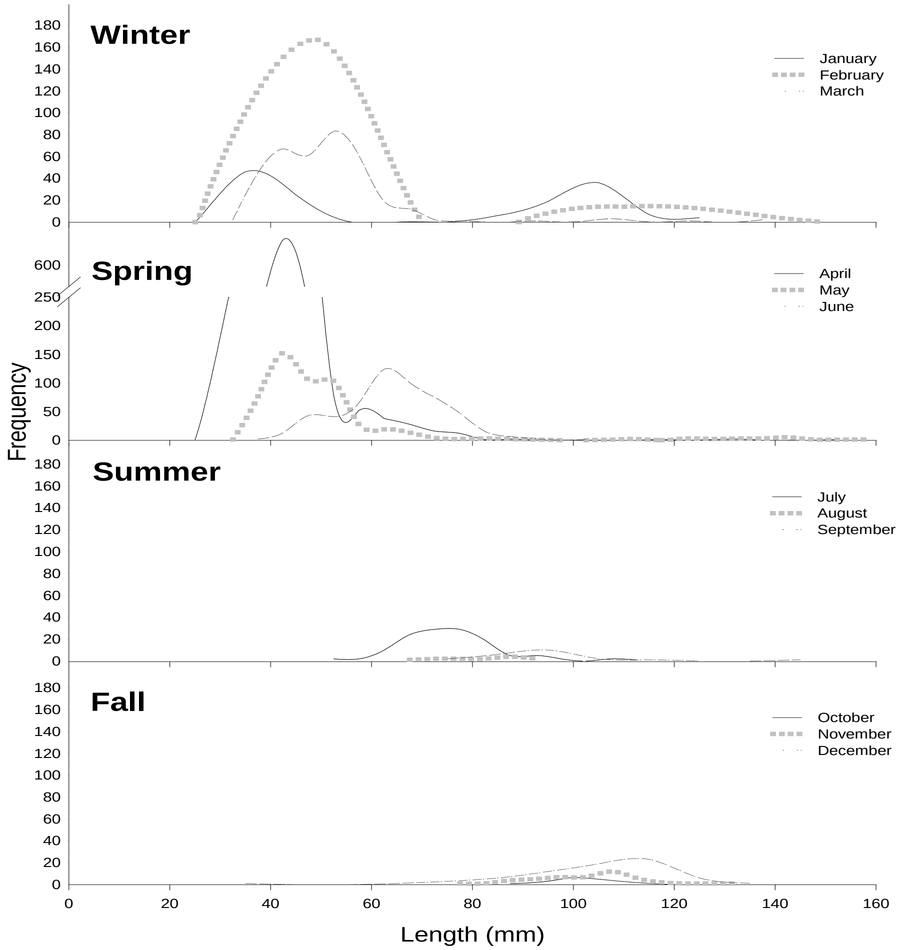


Figure 87. Seasonal Length Frequency Distribution for Unmarked Chinook Salmon Sampled at the Sandy River Delta (SRD) Study Area between June 2007 and April 2010 (Adapted from Johnson et al., 2011b; Figure 2.15)**.**

Small unmarked subyearling Chinook salmon are commonly captured in tidal shallow-water habitats. Their presence has been documented all year, with peak abundance in the spring (March- July) (D. Bottom, personal communication), but with significant numbers also in the winter months. Winter catches include a bi-modal size distribution for unmarked Chinook salmon (Figure 87), suggesting LCRE use by at least two distinct life history groups.

Seasonal patterns of timing are also consistent with mainstem, deep water sampling at the mouth of the Columbia River (Weitkamp et al., 2012). In mid-April, catches are relatively low, but increase through the spring. Peak abundance is observed in mid-May for yearling Chinook salmon; mid-May for coho and steelhead; early May for chum; early June for sockeye; and late June and early July for subyearling Chinook salmon. Only subyearling Chinook salmon are regularly caught after June. Length of time, or the period from which juvenile salmon are captured at the Columbia River mouth varies. Yearling Chinook salmon, coho, and steelhead are generally caught in a 6-8 week period, chum and sockeye in a 2-4 week period, and subyearling Chinook salmon for at least 8 weeks. Sampling typically ceased in late-June or early July. However, subyearling Chinook salmon may be present after that. Juvenile salmon enter the ocean at varying size and age, ranging from fry (<60 mm) to large, late autumn and winter migrants (Bottom et al., 2011; Roegner et al., 2012).

These general observations in species timing are relatively stable from year to year and are generally consistent with species timing observed nearly a century ago (Rich, 1920; Burke, 2004), including observations of peak use by smaller-sized Chinook salmon in March. Most Chinook salmon (except, to a lesser extent, spring run groups from the interior Columbia River Basin) occupy shallow-water habitats in the LCRE during their migration seaward. Back-calculated adult otolith measurements show an estimated period of salt-water (Reach A to D) residency (prior to period of capture at Point Adams Beach) of two months or more for upper Columbia River summer/fall Chinook. These observations suggest that full life history expression is not being realized. For example, researchers know that fewer juvenile migrants now enter or remain in the estuary in the summer and fall compared with the protracted period of estuary use described by Rich (1920) from surveys in 1914-16 (Bottom, personal communication). This loss or reduction in estuary-resident life history expression and use may be, in part, a result of decreased estuary rearing opportunities caused by wetland loss and increased water temperatures. Current spatial and temporal stock distribution do not appear to include the full suite of potential life history strategies that juvenile salmonids could express, perhaps because the fish do not have access to the diverse estuarine habitats that were historically available.

Early Life History Diversity (ELHD) Index

The ELHD index, developed beginning in 2009, provides method to evaluate trends or changes over time in species level attributes of early life history expression. Researchers reviewed literature and developed an index based on the contemporary patterns of juvenile salmon use, as reported above; specifically, density of unmarked, juvenile Chinook salmon, of various size classes for various time periods (e.g., species-size-time) in shallow-water habitats in the LCRE (Diefenderfer et al., 2010, 2011a). Four size categories were chosen for the purposes of the ELHD index: <61 mm, 61-90 mm, 91-120 mm, >120 m (Campbell, 2010; and Johnson et al., 2011b, Figure 87).

Researchers characterized early life history traits and prioritized *timing* and *size* as two appropriate, measurable dimensions for an ELHD index. They reviewed diversity index literature, identified an approach based on effective number of species, and tested several candidates indices for performance and usefulness in case studies using juvenile salmon catch data from the LCRE. The ELHD approach incorporates fish abundance, density, or catch per unit effort data; is applicable to multiple life history patterns; covers both species richness and evenness; and results in interpretable values. The recommended ELHD index is diversity expressed as effective number of species for the Shannon entropy, modified to include an adjustment for missing species and a sample coverage factor (Johnson et al., In Preparation). This index applies to multiple life history strategies of juvenile salmonids, incorporates fish abundance, richness, and evenness, and produces readily interpretable values. The ELHD index can support comparisons across like locales and examinations of trends through time at a given locale.

Major Lessons Learned from RPA Subaction 58.2

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Because the ELHD of salmonid populations in the Columbia River Basin has decreased in the last 100 years (Bottom et al., 2005), estuary habitat restoration under CEERP is managed to reverse this trend. The ELHD index provides one method for CEERP managers to evaluate these trends or changes over time, and thus answer a key management question: What is the level of ELHD in salmonid species in the LCRE and is it increasing? As more stock-specific use of the estuary is understood, researchers can better explain the benefits gained and, importantly, how habitat restoration results in increased opportunities to rear and reside. Also, pragmatically, LHD is considered in assigning SBUs ("ocean" type vs. "stream" type life histories) by the ERTG (see RPA Action 37 for details). SBUs are assigned to each project and they represent additive gains resulting from the implementation of habitat restoration in the estuary.

Furthermore, ELHD index values may reflect changes in stock-specific habitat use over time, and may provide an additional quantitative approach to measure improvements resulting from habitat restoration. For example, if a particular restoration project results in increased use by Snake River fall or spring Chinook salmon, and an increase in densities and times of use compared to that previously measured (hence a higher index value), then the data would indicate that habitat restoration at that given site has provided a benefit to those populations by supporting increased diversity life history strategies.

Finally, the ELHD index will support comparisons across like locales and examinations of trends through time at a given locale. It has application as a high-level indicator to track trends in the status of the recovery of salmon and steelhead populations in the Columbia Basin and elsewhere where salmon recovery efforts are underway.

Lessons Relative to RME Implementation

The development and use of an ELHD index, as it may apply to action effectiveness evaluations, is emerging and will continue to be developed and applied. Future development of the ELHD index might distinguish use for marked and unmarked juvenile salmon, thus quantifying changes in densities and temporal distributions of these fish. While the ELHD index has been developed and applied to the juvenile salmon in the LCRE, it could be used in other systems (e.g., tributary basins) to track changes there in juvenile salmon life history diversity over time.

RPA Subaction 58.3 – *Monitor and evaluate juvenile salmonid growth rates and prey resources at representative locations in the estuary and plume.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Multiple projects have contributed to this RPA subaction since 2008. Collectively, these projects examined: 1) prey availability and prey consumption (salmon gut contents) in the LCRE and plume; 2) differential growth rates (by habitat type and longitudinally in the LCRE and plume); and 3) bioenergetics modeling to integrate the role of temperature, prey, and diet in juvenile salmonid growth. Because size and condition of juvenile salmonids leaving the LCRE and plume have been correlated with improved marine survival (avoiding predation- and starvation-based mortality, Trudel et al., 2012), information related to this RPA subaction can indicate linkages between habitat actions that support juvenile salmonid growth and condition and subsequent survival improvements in later life stages.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring), **BPA Project 2005-001-00** (Tidal Freshwater Monitoring), and **BPA Project 2003-010-00** (Historic Habitat Food Web Linkages) collected data on prey availability, diet (gut contents), juvenile salmonid growth rates, and in some cases, juvenile salmonid condition (lipid content, also used as an indicator of fitness, mentioned in RPA Action 58.1) at monitoring sites in the LCRE. For example, Lott (2004) found that diet composition of juvenile Chinook salmon did not differ significantly among different wetland types, but emergent marsh habitats did support a greater abundance of insects, and juvenile ocean-type Chinook salmon exhibited higher stomach fullness in emergent marsh habitats relative to forested or scrub-shrub wetlands. Bioenergetics model results indicated positive growth for juvenile Chinook salmon in shallow tidal freshwater habitats at the SDR (Storch and Sather, In Review).

In the Columbia River plume, researchers for **BPA Project 1998-014-00** (Ocean Survival of Salmonids) collected information regarding juvenile salmonid growth (IGF-1) rates from (**BPA Project 2003-009-00** (Canada-USA Shelf Salmon Survival Study) cruises dating back to 2007. Otolith growth and somatic growth were also measured by the Salmon Shelf Survival Study (Trudel et al., 2007 and 2012). These analyses allowed NOAA Fisheries and Canada's Department of Fisheries and Oceans (DFO) to match juvenile salmonid growth rates with environmental measurements in the plume, e.g., habitat quality. The information on growth rates was used to test whether size and growth rate were correlated with subsequent ocean survival and whether early marine growth was related to indices of regional productivity, including spring transition timing and copepod community composition. These two BPA projects also compared data with Corps- (formerly BPA-) funded estuary studies on juvenile salmon residence time, habitat use, metrics of growth, condition, diet, and stock identification.

Results Relevant to Growth Rates in the LCRE and Plume:

Estuary Trends in Growth Rate. In the LCRE, information to date indicates that growth rates decreased slightly (but not significantly) as fish moved through the lower Columbia River from reaches H-C; however, this analysis did not include the salinity-influenced estuary (Sagar et al., 2013). On average, growth rates were 0.4-0.6 mm/day for subyearling Chinook salmon (40-100mm fork length) sampled in the tidal freshwater portion of the LCRE.

Regional Variability in Early Marine Growth. There is large regional variability in the growth of Columbia River salmon in the early ocean phase, with early marine growth rates averaging 2.5 mm/day (Tucker et al., 2009; Trudel et al., 2010and 2012). This is higher than the 0.5-0.7 mm/day growth rates reported in earlier freshwater stages. Even though plankton biomass is higher in the northern California Current than in the Alaska Coastal Current (Ware and Thomson 2005), salmon growth and survival is generally higher in the Alaska Coastal Current (Shaul et al., 2007; Trudel et al., 2012). These findings have helped refine factors influencing salmonid survival in the plume and ocean.

Growth Correlations. The Pacific Decadal Oscillation (PDO) affects the abundance of prey types available to juvenile salmonids and other forage fish, which in turn have been correlated with salmon growth and survival in the ocean (Daly et al., 2010; Keister et al., 2011; Litz et al., 2010; Bi et al., 2011). Juvenile fish size early in the marine phase and marine growth rate after approximately 30 days of marine residence were positively related to future adult returns, and size at capture was significantly greater when marine prey quality was high (Tomaro et al., 2012).

Different Chinook Populations and Life History Types Respond Differently to Early Marine Residence. For interior yearling spring Chinook salmon, growth and condition are better when coastal ocean conditions are favorable (cool, productive waters). However, for interior fall subyearling Chinook salmon, overall condition decreased in years with favorable ocean conditions. This could be due to higher overall survival (i.e., even weaker fish survived), or this finding could be due to increased competition for prey resources (Jacobson et al., 2012).

Results Relevant to Prey Resources in the LCRE and Plume:

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) collects data on juvenile salmonid prey resources throughout the LCRE. The Corps' Multi-Scale Action Effectiveness Research in the LCRE (AFEP EST-P-11-01) intensively monitored and evaluated prey resources and juvenile salmonid consumption at SDR (Reach G). Both projects provide useful information to the CEERP; the estuary-wide study provides a broad-scale picture of landscape trends, and the intensive study provides higher resolution information needed to answer questions related to juvenile salmon ecology in tidal freshwater and the effectiveness of the upcoming restoration action to rechannelize the SDR.

For the plume, **BPA Project 1998-014-00** (Ocean Survival Of Salmonids) annually evaluates and reports prey abundance estimates for the Columbia River plume and northern California current based on productivity measurements (see Figure 88). These results are summarized in Section 1 of this report and comprehensive information is available online at *http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm*.

	Juvenile Migration Year				Forecast of Adult Returns	
	2009	2010	2011	2012	Coho 2013	Chinook 2014
Large–Scale Ocean and Atmospheric Indicators						
PDO	🟨	🟨	🟩	🟩	🟢	🟢
ONI (Jan-Jun)	🟨	🟥	🟩	🟩	🟢	🟢
Local and Regional Physical Indicators						
Sea surface temperature anomalies	🟨	🟨	🟨	🟥	🔴	🔴
Coastal upwelling	🟨	🟥	🟥	🟥	🔴	🔴
Physical spring transition	🟩	🟨	🟨	🟥	🔴	🔴
Deep water temperature and salinity	🟨	🟨	🟨	🟨	🟡	🟡
Local Biological Indicators						
Copepod biodiversity	🟨	🟥	🟩	🟩	🟢	🟢
Northern copepod anomalies	🟨	🟩	🟩	🟩	🟢	🟢
Biological spring transition	🟩	🟨	🟩	🟨	🟡	🟡
June spring Chinook	🟩	🟨	🟨	🟩	– –	🟢
September Coho	🟥	🟥	🟨	🟨	🟡	– –

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

Figure 88. Ocean Ecosystem Indicators of the Northern California Current. Colored squares indicate positive (green), neutral (yellow), or negative (red) conditions for salmon entering the ocean each year. In the two columns to the far right, colored dots indicate the forecast of adult returns based on ocean conditions in 2011 (Peterson et al., 2012).

Prey Preference. At SDR, the most important prey taxa for Chinook salmon were dipterans, amphipods, and cladocerans, although the importance of these prey items was variable over time (Johnson et al., 2011b). While these were the most important prey items for juvenile Chinook salmon, they are not consumed in proportion to their abundance in the environment. For example, dipterans are an important prey resource but are more abundant in juvenile salmonid environments than in juvenile salmonid diets, indicating that juvenile salmonids select for other prey items when other prey items are available.

Fish Size and Prey Preference. Chironomids were a major prey item for all juvenile Chinook salmon, but as the size of the fish increased, diet shifted from predominately chironomids to a more diverse prey assemblage that included larger insects and benthic invertebrates (Lott, 2004).

Major Lessons Learned from RPA Subaction 58.3

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Habitat restoration actions provide habitats that produce prey that are consumed by juvenile salmon in the mainstem. This supports continued implementation of habitat restoration actions resulting in onsite and offsite benefits to multiple life history patterns. This lesson is consistent with juvenile salmon growth results in suggesting that implementing habitat restoration benefits juvenile salmon by improving habitat capacity in the LCRE. While uncertainties are not yet resolved, RME activities have improved the understanding of the role of the estuary in improving salmonid survival and reaffirmed the approach to estuary habitat actions to provide growth opportunities for juvenile salmonids rearing in the LCRE, thereby improving their chances of survival during ocean entry.

Lessons Relative to RME Implementation

Prey availability, juvenile salmonid diet, and juvenile salmon growth should be considered as monitored indicators in RME action effectiveness studies because they reflect ecosystems functions supporting juvenile salmonids. Because fish growth is difficult to measure without recapturing fish, RME might focus on physiological measurements of growth, or tissue synthesis. The contribution of prey from restored-wetland to fish growth rates on- and off-site should be quantified. Measurements of fish diet and water temperature at a diverse set of habitat types and longitudinal positions in the LCRE and prey energy density data are needed as inputs to bioenergetics models to improve the robustness and applicability of the models.

RPA Subaction 58.4 – *Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Several major studies have been planned and executed specifically to evaluate predation on juvenile salmon in the estuary under RPA Actions 68-70 (Predation RME). The following is a brief synopsis of findings on species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume derived from projects whose geographic scope is limited to the LCRE. In addition, **BPA Project 1998-014-00** (Ocean Survival of Salmonids) monitored avian predator densities and forage fish abundances in the Columbia River plume.

Key Findings on Avian Predation in the LCRE Include:

Avian Predation Rates. In 2011, Caspian terns (*Hydroprogne caspia*) and double-crested cormorants (*Phalacrocorax auritus*) near the mouth of the Columbia River consumed an estimated 25 million smolts, or approximately 15 percent of all juvenile salmonids moving through the lower estuary (Lyons et al., In prep). It is important to note, however, that not all ESUs/DPSs are affected equally and there are often differences in predation rates between natural-origin and hatchery-origin smolts from the same ESU/DPS.

Effect of Fish Condition. Snake River spring/summer Chinook and steelhead smolts in relatively poor physical condition (as indicated by bacterial infection and incomplete smoltification) were more susceptible to avian predation in the estuary than fish is good condition (Schreck et al., 2006; Hostetter et al., 2011).

High Flows and Avian Diets. During seasonally high flow events many forage fish (e.g., herring, anchovy, surf smelt) that typically move into the estuary from the ocean under lower flows may not be as prominent in estuarine fish assemblages (Anderson et al, 2007; Weitkamp et al., 2012). During these high flow events, juvenile salmonids may comprise a higher percentage of total prey in Caspian tern diets.

Spatial Distribution of Piscine Predators. Predation by piscine predators in the plume and nearshore ocean is associated with larger oceanographic conditions (e.g., warm/cool surface waters) and average densities of predatory fish can vary significantly from year to year (Figure 89) (Jacobson et al., 2012).

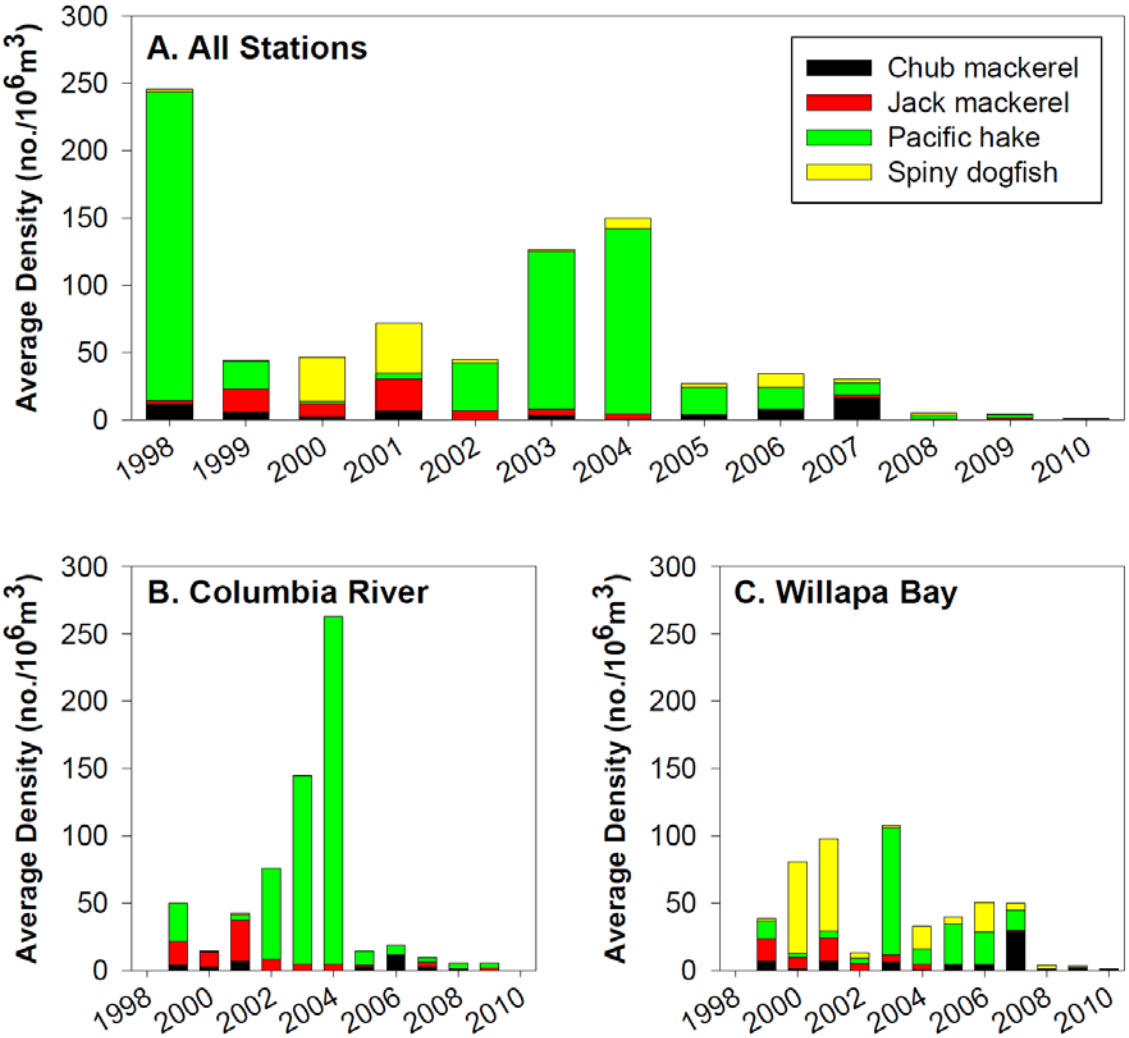


Figure 89. Annual Average Densities of Predatory Fish from (a) both Columbia River and Willapa Bay Transects (1998-2010); (b) Just the Columbia River Transect (1998-2009); and (c) Just the Willapa Bay Transect (1998-2010) (Jacobson et al., 2012).

Major Lessons Learned from RPA Subaction 58.4

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Increases in avian presence since the FCRPS BiOp's baseline period are a significant source of smolt mortality in the estuary. A variety of strategies for decreasing this mortality are being implemented and evaluates (see RPA Actions 45, 46, 66 and 67). It is important to note here that care is taken to not encourage avian predators to move further upriver because salmonids comprise a higher proportion of inland avian predator diets than is seen near the mouth of the Columbia River, where forage fish can sometimes buffer the proportion of juvenile salmonids consumed. Piscine predators apparently have relatively low densities in the LCRE, and their densities are highly variable depending on large-scale oceanographic conditions in the plume and nearshore ocean environments. Also, care must be given to design of restoration actions so as to not build habitat or create conditions (e.g., water temperature) conducive to non-native predator population growth. In fact, floodplain reconnection projects can lower water temperatures at restored sites, affirming the importance CEERP gives to this type of action.

Lessons Relative to RME Implementation

RME directed at estimating juvenile salmonid consumption rates by avian predators in the lower estuary is important, as it allows resource managers to better understand the benefits, or juvenile salmon survival improvements that might be gained by managing bird communities in the LCRE. RME can help inform how different bird communities might respond to different predator habitat reduction and control measures, for example, does reduction in available habitat cause double-crested cormorants to move off-site, out of the Columbia River Basin, or does it simply disperse those birds to other nesting areas (such as Astoria-Megler bridge). In addition to evaluating the effectiveness of different dissuasion measures, RME could help evaluate the effects of habitat restoration on the occupation (roosting, foraging, nesting) of different bird communities in the LCRE, for example, investigate whether or not a restoration action is resulting in increased predation by inadvertently creating predator habitat).

RPA Action 59 – Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions*: The Action Agencies will monitor an evaluate selected ecological attributes of the estuary, which include the following or equivalent:*

1. *Map bathymetry and topography and topography of the estuary as needed for RME.*
2. *Establish a hierarchical habitat classification system based on hydro-geomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.*
3. *Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.*
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.*
5. *Monitory 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 RM&E.*

RPA Subaction 59.1 – *Map bathymetry and topography of the estuary as needed for RME.*

Major Accomplishments and Findings in Implementing the RPA Subaction

BPA Project 2003-007-00 (Lower Columbia River and Estuary Ecosystem Monitoring) has been the primary contributor to developing a seamless elevation dataset for the LCRE. Several other projects also collected local elevation data throughout the LCRE to support this RPA subaction. This dataset represents the most up-to-date, comprehensive, and highest resolution elevation dataset (including high-resolution LiDAR data) that has been generated for mapping bathymetry and topography in the LCRE.

Major Lessons Learned from RPA Subaction 59.1

Lessons Relative to Action Implementation – Estuary Habitat Restoration

These datasets and the resulting seamless elevation model are being used by a wide variety of federal, tribal, state, and local entities for various restoration and other planning purposes. The data will be updated by LCEP and Corps, as needed. For example, the elevation model has been routinely used in the development of habitat restoration design (e.g., hydrologic reconnections) at the site scale and is also a key component of the CREEC (see RPA Subaction 59.2). Additionally, it is a foundational component of the hydrodynamic modeling work currently underway to simulate physical processes in the LCRE and plume under various change scenarios, e.g., flow regimes, sea level rise, degree of salinity intrusion in the estuary.

Lessons Relative to RME Implementation

It is extremely important to assure the quality of bathymetric and topographic data before using it in RME studies. Furthermore, RME researchers must always note the benchmark for the elevation data.

RPA Subaction 59.2 – *Establish a hierarchical habitat classification system based on hydrogeomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Two projects have contributed to this RPA since 2008. However in 2011, all work contributing to this RPA was consolidated into **BPA Project 2003-007-00 (**Lower Columbia River and Estuary Ecosystem Monitoring).

The CREEC (Simenstad et al., 2011) includes all areas of the historic floodplain from the mouth of the Columbia River upstream through both saline and tidal freshwater portions of the system to Bonneville dam (233 rkm). The CREEC was designed to support multiple efforts in the estuary by mapping ecosystem processes to specific locations in the estuary to better organize current efforts (habitat actions and RME), as well as better predict how the LCRE landscape will evolve over time. The CREEC's GIS data layer for Level III hydrogeomorphic reaches (including metadata) is now available on the LCEP website (*www.estuarypartnership.org*). GIS layers for Level IV complexes, Level V catena, and Level VI land cover for the entire LCRE are scheduled for 2013. A final report outlining how the CREEC can be used in research, monitoring, and management in the region is anticipated for release in 2012 or early 2013.

Major Lessons Learned from RPA Subaction 59.2

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Habitat Protection and Restoration Planning. The CREEC provides a system-wide context for identifying, prioritizing, and evaluating potential management actions. Because the CREEC uses a hierarchical framework, these management actions can be evaluated at various spatial scales by associating these actions with geomorphic and hydrologic drivers of ecosystem condition (see Figure 90). Managers will be able to use this information to implement actions that support ecosystem function, such as dike removals or setbacks, to improve connections between mainstem and off-channel habitats at the site scale and in the context of the broader LCRE landscape.

Species Catena. CREEC elements relevant to a species of concern (e.g., water depth, salinity, confluences) can be used to identify locations that could act as refuges or support habitat connectivity for that species. The Landscape Planning Framework (see Figure 91) is one such tool in development that ties the CREEC to juvenile Chinook salmonid habitat use. Because of the framework's basis in the CREEC, project sponsors should be able to quantify and evaluate the effect that habitat actions could have on juvenile salmonid habitat opportunity. These landscape scale analyses can inform site selection and conceptual design development (Figure 91).

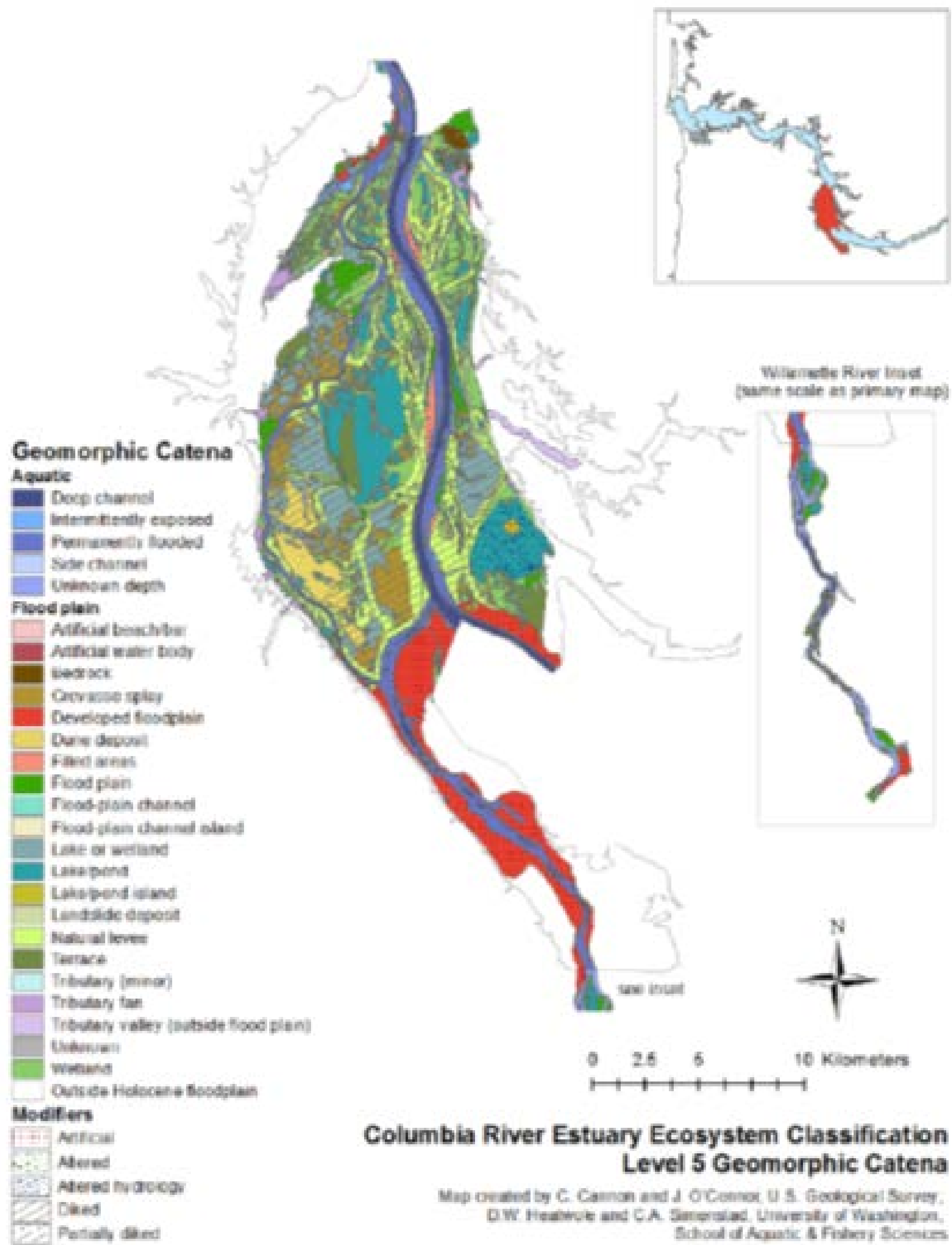


Figure 90. Classification Level 5-Geomorphic Catena in Hydrogeomorphic Reach (Simensted et al., 2011).

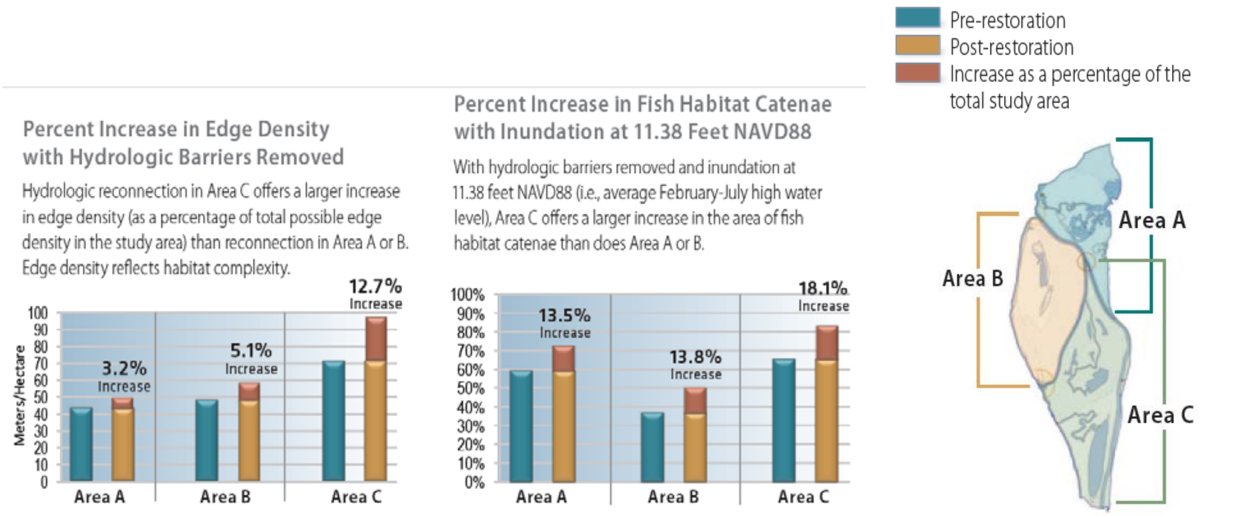


Figure 91. Percent Increase in Fish Habitat Metrics (E.G., Edge Density, Fish Habitat Catenae) under Different Habitat Improvement Scenarios Using the Landscape Planning Framework (Simensted et al., 2011).

Temporal Analyses of Ecosystem Change. The CREEC can be used to delineate and map habitat types to monitor changes over time. For example, researchers compared wetland cover information from the late 1800s to present day and found significant changes in certain wetland cover types (e.g., floodplain forest) relevant to ecosystem processes and juvenile salmonids (Marcoe, 2013). Habitat complexes within the present floodplain form a highly altered mosaic compared to historical condition, and very few “historic” (i.e., late 1800s) wetland habitats remain in the system. In the future, information on the relative loss of habitat types by reach will be a factor when prioritizing restoration work.

Lessons Relative to RME Implementation

Researchers are using the CREEC to stratify the large, dynamic system components into manageable units for research and monitoring designs. For example, the LCEP’s status and trend monitoring design for fish and habitat associations is stratified according to the CREEC’s hydrogeomorphic reaches, with sites chosen by reach and habitat type (see RPA Subaction 59.5). In addition, the CREEC was designed to facilitate the examination of ecosystem diversity and spatial distribution across multiple spatial scales. Practitioners and other interested parties should be able to examine specific locations of interest at the site scale to examine anthropogenic artifacts (e.g., dikes, tide gates) in and around a particular location, as well as look at the specific location in the context of the LCRE landscape.

RPA Subaction 59.3 – *Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Methods to track and quantify changes in habitat connectivity within major reaches of the estuary began in 2009 under AFEP Project EST-P-09-01, *Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the LCRE*. Habitat connectivity was defined as the degree to which habitats in a landscape are physically connected or spatially continuous; and the ability of species or populations to access these habitats. The index assesses structural connectivity and is based on hydrographic and topographic data. Index values provide an indicator of improvement or decline in habitat connectivity. Index development began in 2009, and has progressed since, with work culminating in 2013.

This study began with a comprehensive literature review (Diefenderfer et al., 2010), followed by the development of the habitat connectivity index in 2009. The index tested at a single tributary to the LCRE: the lower Grays River, floodplain, a tidal freshwater area. The index proved successful and was expanded to a larger reach and estuary scale. In 2010, the study focused on measurement, at the estuary scale, of the set of passage barriers in existence since 2000, and measurement of changes as a result of restoration projects funded by the Action Agencies since then. The method involved subtraction of passage barriers that have been reduced or removed, through restoration activities, from the set of previously existing barriers (i.e., from the baseline set in place at the time of the 2000 BiOp). Key metrics included changes in: cross-sectional area of channels, top-width of dikes, and available connected wetted habitat area in the channels and on the floodplain. Expansion of the passage barrier accounting assessment to the reach and estuary scales was more difficult than expected. Obtaining the required data was time-consuming and ultimately not wholly successful because, in some cases, data required for the accounting did not exist or could not be found (data were available for only 29 out of 53 identified passage barrier changes). Although the expansion to the reach and estuary scale has not realized to date, researchers concluded that the method for assessing changes in structural habitat connectivity were valid.

Finally, in related work, an area-time inundation index model (ATIIM) was developed. In 2011 and 2012, work under this study objective also incorporated an ATIIM initially prototyped in the "Cumulative Effects" study (Johnson et al., 2012). The ATIIM integrates advanced terrain processing of LiDAR elevation data; in situ, modeled, or synthesized hourly water surface elevation data; and a wetted area algorithm to determine two- and three-dimensional inundation extent (Coleman et al., 2010). The model integrates these hydrologic processes metrics and other landscape metrics (such as channel density and topographic roughness) to compute maximum inundated area, maximum frequency and duration, inundated area, and water volume fluxes for the purpose of restoration planning (e.g., site selection) and evaluation (e.g., alternatives evaluation). Work in 2012 and 2013 will make the ATIIM available as an ArcGIS extension (planned for 2013). An integrated indicator of habitat connectivity based on the net ecosystem improvement model has been developed and will be completed when the final diking layer is available.

Major Lessons Learned from RPA Subaction 59.3

Lessons Relative to Action Implementation – Estuary Habitat Restoration

The ATIIM can be used expansively through the estuary, allowing 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. These applications allow project planners to assess changes in habitat connectivity by project alternative, at a site scale, providing a rapid, reliable site assessment and characterization of hydrologic changes. Analysis of inundation frequency and duration can show the trade-offs between water-surface elevation and habitat opportunity, compare alternative restoration designs, and predict impacts of altered flow regimes and flux of nutrient and biomass between different, hydrologically connected habitats. These tools are important in understanding project benefits, including SBUs, and thus could be used by restoration planners as they prepare project templates for the ERTG, which calls for a consistent methodology for calculating wetted area.

Note, the model is not intended to substitute for a hydrodynamic model in final project engineering. Rather, it can offer a cost-effective method for preliminary screening of restoration alternatives to assist planners in prioritizing which sites to restore. These types of analysis are also important after project implementation to evaluate changes in habitat connectivity through time, and determine project success. In addition to site scale assessments, researchers expect that this tool will be useful in evaluating the effects of actions at the landscape, reach, and estuary scales (e.g., future cumulative effects evaluations), and, could be used to evaluate habitat and land cover changes resulting from system-wide change, such as FCRPS management and sea level rise. These types of analysis are also important after project implementation to evaluate changes in habitat connectivity through time; and determine project success.

Lessons Relative to RME Implementation

Up to 2011, the study focused on extending the spatial and temporal (trends) scope of the structural/hydrologic metrics, including passage barrier accounting metrics and nearest neighbor distance metrics. In addition, the study continued development of a salmon-specific functional component. Change to site-scale passage barriers, dike breaches, and wetted area were extracted using remote-sensing and modeling techniques. Standard nearest-neighbor distance methods also were adapted using hydrologic routing and directional thresholds specific to juvenile salmon. The Oregon Department of Land Conservation and Development, the NOAA Fisheries, the LCEP and BPA (**BPA Project 2003-007-00**, Lower Columbia River Estuary Ecosystem Monitoring) contributed towards product development, specifically by producing a prototype, rapid extraction, dike map for the LCRE. Data were derived from LiDAR via a computer-assisted, GIS application. The combination of manual and semi-automated techniques (e.g., a human analyst) produced a superior passage barrier GIS layer for the eight reaches of the LCRE (Diefenderfer et al., 2012). These maps will be available to restoration planners and managers. The passage barrier assessment proved to be a straightforward measurement of increases in habitat availability or opportunity for juvenile salmonids resulting from habitat restoration actions. It is quantitative, comparable across sites, can be applied estuary-wide, and relies only on data that are produced from the most basic, least expensive type of restoration site monitoring: implementation and compliance surveys. Because it can be applied estuary-wide, it has the potential to be a high-level indicator of habitat change. However, implementation and compliance surveys are not routinely completed on estuary restoration projects so this indicator has not been calculated yet; retroactive sampling would be required to calculate it. This could be done in an out-year cumulative effects evaluation of habitat implementation.

RPA Subaction 59.4 – *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.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Six projects have contributed to this RPA since 2008. Collectively, these projects have significantly improved the understanding of juvenile salmonid migration and shallow-water habitat use in the LCRE. Researchers consistently find that juvenile salmonids (especially subyearling Chinook salmon) are present in varying densities year-round in shallow-water habitats in the LCRE. RPA Subaction 59.4 research was complementary to that for RPA Subactions 58.2, 61.1, and 61.3.

- Columbia River Estuary Contribution to Salmon Recovery (AFEP EST-P-10-01) conducted genetic surveys throughout the LCRE to look at spatial (mainstem, backwater, and tributary confluence habitats) and temporal patterns in salmonid migration through the LCRE. Genetic sampling involved genetic stock group resolution (microsatellites) for Chinook salmon.
- **BPA Project 2005-001-00** (Tidal Freshwater Monitoring) transferred to the Corps in 2010 under the Washington Memorandum of Agreement [WA MOA]) considered juvenile salmonids and their associated fish communities, habitat characteristics, and prey resources in shallow-water habitat of Reaches D, E, and G (see Figure 90). In 2010, Tidal Freshwater Monitoring transitioned into Multi-Scale Action Effectiveness Research in the LCRE (AFEP EST-P-11-01), which was designed as an in-depth study to gather high-resolution information on juvenile salmonid use of shallow-water habitats at two locations in the LCRE (SDR – Reach G and Lower River Reach (LRR) – Reaches D and E).
- **BPA Project 2003-007-00** (Lower Columbia River Estuary Ecosystem Monitoring) considered the spatial and temporal distribution of juvenile salmonid genetic stocks and life history types,

as well as their associations with shallow-water wetland habitats, fish communities, and prey over time in the LCRE. This information is used to evaluate the relative importance of various shallow-water wetland habitat types to juvenile salmonids.

- **BPA Project 2003-010-00** (Historic Habitat Opportunities and Food-Web Linkages) transferred to the Corps in 2010 under the WA MOA; and AFEP-EST-P-02-02), conducted multi-year simulations and scenario comparisons between the modern and predevelopment conditions for the amount of shallow-water habitat.

Genetic Stock Distributions. Interior Columbia Basin stocks were found primarily in Reaches E-H and overall stock diversity was highest in Reaches E and F (Bottom et al., 2011). Interior Columbia Basin summer/fall juveniles were often a dominant seasonal contributor to stock composition in Reaches E-H. During extreme flooding events in early July 2011, large numbers of Chinook salmon (63 percent upper Columbia River summer/fall Chinook) were found in the forested floodplain of the lower Multnomah Channel (Reach F). Note, interior Columbia Basin stocks can also originate from areas above and below Bonneville Dam. Additionally, individuals from interior Columbia Basin Chinook salmon and steelhead stocks (hatchery-origin and natural-origin) have been detected at one or more PIT-monitoring sites in small secondary channels within wetland habitats of the LCRE (Bottom et al., 2011, Diefenderfer et al., 2012).

Marked and Unmarked. Unmarked juvenile Chinook salmon, coho, and chum salmon were found using shallow-water habitats for feeding and rearing in the LCRE (Sagar et al., 2013), which is consistent with other studies showing that emergent marsh tidal freshwater habitats are productive rearing areas for juvenile salmonids (Dawley et al., 1986; Johnson et al., 2011b; Sather et al., 2009). A PIT-tag array revealed that hatchery Chinook salmon from locations as far away as the Dworshak Hatchery on the Snake River and juvenile sockeye salmon resided in shallow-water habitat for up to 12 days in Campbell Slough (Reach F) (Sagar et al., 2013).

Natural-origin v. Hatchery-origin Habitat Use. Unmarked Chinook salmon far out-numbered catches of marked Chinook salmon, indicating unmarked fish use shallow tidal freshwater to a greater extent than marked fish (Johnson et al., 2011b). Length frequency distributions for unmarked and marked Chinook salmon had medians of 45 mm and 81 mm, respectively. Furthermore, unmarked fish were present year-round, whereas marked fish mostly appeared as a peak in spring. Although some unmarked fish (perhaps approximately 22 percent in these samples) originated in hatcheries, the size distribution and genetics data generally were indicative of naturally produced fish, suggesting that restoration of shallow tidal freshwater habitats aid the recovery of wild fish populations. At SDR (Reach G), unmarked juvenile Chinook salmon were the most abundant salmonid captured (74 percent of the total salmonid catch), followed by chum (10 percent), coho (8 percent) salmon, and steelhead (<1 percent). Chinook and coho salmon were the only salmonid species encountered during every season (Sather et al., 2009) (**BPA Project 2005-001-00**, Tidal Freshwater Monitoring).

Seasonal Salmon Densities and Lengths. Seasonally, the highest Chinook salmon densities and the smallest average lengths were observed in spring (Johnson et al., 2011b). The second highest densities for Chinook salmon were noted in winter, when there was a bimodal size distribution of Chinook salmon, indicating temporal overlap of salmon life stages in tidal freshwater (see Figure 87). At SDR, juvenile salmonids abundance was highest in the spring, and unmarked Chinook salmon was the largest contributor to total abundance. At least two life history types were detected in unmarked juvenile Chinook during winter months; small unmarked Chinook were present from winter to spring (Johnson et al., 2011b).

Winter Residence Times. Average residence time was 33.4 d for acoustic-tagged Chinook salmon (n=41) during early 2010, 24.7 d for Chinook salmon (n=12) and 28.6 d for coho salmon (n=36) during early 2011 (G. Johnson, personal communication). Note, these data represent a residency for larger-sized fish (>95 mm) captured, tagged, and released during January and February 2010, 2011 and 2012 at the SDR.

Food Web Benefits. Various studies show that salmonids feed in the LCRE (Diefenderfer et al., 2012; Diefenderfer et al., 2013a; Sagar et al., 2011) and select disproportionally for food items linked to marsh detritus and benthic diatoms (Bottom et al., 2011; Eaton, 2010; Maier and Simenstad, 2009; Weitkamp et al., 2012). Organic matter and prey transport from shallow estuarine habitats into the mainstem river may benefit all Columbia River salmonids, regardless of hatchery or natural-origin or life history type or migration pathway in the LCRE. Refer to comprehensive summary for RPA Action 58.3 for a more complete description of food web benefits, and the relationship to juvenile salmonid growth rates and prey resources in the estuary and plume.

Life History Diversity and Hatchery Influence. Hatchery production influences stock composition, abundance, and habitat-use patterns in the LCRE (Bottom et al., 2011). In addition, current spatial and temporal stock distribution might not include the full suite of potential life history strategies that juvenile salmonids may be capable of expressing. Many at-risk populations are in low abundance and comprise a small proportion of the fish catch. In addition, much of the historically available habitats remain disconnected from the Columbia River mainstem, hence, these fish simply lack access to the suite of shallow-water habitats existing today. Despite this, hatchery and naturally-produced fish from all interior Chinook and steelhead stocks have been detected at one or more of PIT-tag monitoring sites located in a few small secondary channels of wetland habitats at Campbell Slough (BPA Project 2003-007-00, Lower Columbia River Estuary Ecosystem Monitoring), Russian and Woody Islands, Wallace Island, and Sauvie Island respectively (D. Bottom, personal communication; Diefenderfer et al., 2012). Given the small size of the PIT-tag monitoring channels, the relatively small number of at-risk upper river fish that are PIT-tagged, and the extensive channel networks available in some wetlands, small numbers of detections of at-risk stocks in these few wetland channels could be significant.

Juvenile Salmon Densities. Densities vary widely but can exceed 1.0 individuals per meter square (ind/m2) (Table 3.1). Many intertidal wetland sites are dominated by fry-sized salmon (≤60 mm), which are present at relatively high densities during spring and early summer, while larger individuals are often found contemporaneously in adjacent deeper channels (Bottom et al., 2011; Haskell and Tiffan, 2011), or farther downstream (Roegner et al., 2012). Studies find a greater variety of salmonid species in Grays River wetlands than in the Columbia River mainstem wetlands and seasonal transitions in salmonid species composition.

Major Lessons Learned from RPA Subaction 59.4

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Summary results show that unmarked Chinook salmon out-numbered catches of marked Chinook salmon, indicating unmarked fish use shallow tidal freshwater to a greater extent than marked fish. Length frequency distributions for unmarked and marked Chinook salmon had medians of 45 mm and 81 mm, respectively. Furthermore, unmarked fish were present year-round, whereas marked fish mostly appeared as a peak in spring. Although some unmarked fish (perhaps approximately 22 percent) originated in hatcheries, the size distribution and genetics data generally were indicative of naturally produced fish, suggesting that restoration of shallow tidal freshwater habitats aids the recovery of wild fish populations.

Spatial and temporal variations were evident, as measured by fish density (or catch per unit of effort), size, and genetic stock of origin. These variations reflect the particular uses of habitats by different species, stocks, and life-history stages (or age) as well as the proximity of habitats to stocks of migrating fish. For example, restoration sites that lacked a strong upstream source of migrants, such as Vera Slough in Youngs Bay (Johnson et al., 2012), have lower catch per unit of effort and stock diversities than sites such as Cottonwood Island (Reach C) that are available to a large number of ESUs (Diefenderfer et al., 2011a). The timing and duration of habitat availability to juvenile salmon is largely dependent upon flooding frequencies and the degree of hydrological connectivity of these shallow-water habitats to the mainstem river habitats (Baker, 2008); and rearing opportunities in the upper estuary depend on the migration timing of each stock and the hydrological conditions that control habitat access at those particular times. These factors are considered in the prioritization and design of restoration actions.

Lessons Relative to RME Implementation

Overall, RME studies examining fish are influenced by releases of more than 100 million summer, spring, and fall Chinook salmon produced by 72 artificial propagation programs throughout the Columbia River Basin (HSRG, 2009) are a major factor influencing contemporary patterns of estuary use by juvenile Chinook salmon. Artificial propagation programs and rearing practices, to a large extent, drive temporal and spatial patterns of salmon abundance, stock composition, and size distribution within the estuary (Bottom et al., 2011). By selecting for body size and time of estuary entry, hatcheries further influence salmon habitat use and residence times within the estuary (Campbell, 2010; Bottom et al., 2011). Although RME programs have documented varying levels of overlap in the distributions of hatchery- and naturally-produced salmon (e.g., Bottom et al., 2011; Diefenderfer et al., 2011a), ecological interactions between them have not been investigated. Future RME might consider a close look at these interactions.

Additional lessons learned relative to RME implementation include: monitoring methods are habitat-specific; as such, comparisons across habitat types must be made carefully; landscape-scale assessments were conceptually recommended by the ISAB (2011); RME can be used to estimate juvenile salmon density and ELHD in shallow-water habitats provided rigorous statistical sampling designs are implemented; and, RME in shallow water of the LCRE might consider expanded use of PIT-tag and other marking techniques to examine residence time and migration characteristics for listed fish.

RPA Subaction 59.5 – *Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, primary and secondary productivity, substrate characteristics, dissolved oxygen, temperature, and conductivity, at representative locations in the estuary as established through RM&E.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Five projects have contributed to this RPA since 2008, although Lower Columbia River and Estuary Ecosystem Monitoring (**BPA Project 2003-007-00**, Lower Columbia River Estuary Ecosystem Monitoring) has been the primary contributor to habitat monitoring throughout the LCRE.

Researchers for **BPA Project 2003-007-00** monitor a suite of indicators at sampling locations based on a split rotational panel design using the reaches defined in CREEC as a spatial framework (see RPA Subaction 59.2). The design includes four fixed sites to monitors trends in LCRE habitat conditions. A full suite of fish measurements at the trend sites includes GSI, life history type, growth, and condition. Other measurements are used to develop environmental associations: habitat (vegetation community composition, sediment accretion, hydrology, water quality), fish community composition, and prey resources (macroinvertebrate availability and salmonid prey items). While **BPA Project 2003-007-00** was designed as a monitoring framework with standard measurements across the LCRE, more targeted and specific future studies could be designed to answer mechanistic questions (e.g., the effect of invasive plant species on macrodetritus and prey production relative to juvenile salmonids).

Overall, key findings include: 1) Interannual hydrologic variability and the resulting patterns of marsh inundation vary 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 varies longitudinally and between different habitat types, potentially affecting fish access to the sites. 2) Oxygen concentrations become low in systems with restricted exchange during summer, and near the mouth of the estuary during strong summer upwelling winds. 3) Temperatures increase past the criterion thought to induce stress (19 degrees Celsius) system-wide during June through September every year. Both low dissolved oxygen and high temperature may force salmon from shallow-water systems and induce stress that can affect growth and survival. 4) Preliminary data suggests that a red ciliate (*Magnifera rubra*) is able to bloom during low late summer flows in the lower estuary, which can have a net positive effect on dissolved oxygen levels (Sagar et al., 2013).

In addition, Thom et al. (2013) identified several findings concerning habitat conditions: "Physical changes, including filling of the floodplain, dredging of the navigation channel and harbors, and regulating flow significantly altered the historical geomorphic and ecological state of the LCRE system prior to the CREDDP studies. The rate of physical alteration has apparently slowed compared to the late 19th and early 20th century. Habitat complexes within the present floodplain form a highly altered mosaic compared to historical condition, and very few "historic" (i.e., late 1800s) wetland habitats remain in the system. Based on an analysis of levels of stress associated with diking, overwater structures, land conversion, etc., at both site and watershed scales, the LCRE ecosystem is "moderately stressed" compared to conditions prior to dam construction, forest harvest, diking, etc. The reaches that include Portland, Vancouver, and Longview have been most altered. Data show an expansion of invasive, highly competitive, non-native species such as reed canarygrass. There is a legacy of contamination in sediments. Contamination of water and sediment from persistent chemicals is of significant concern. See RPA Subaction 60.1 for more findings from monitoring LCRE habitat conditions.

BPA Project 1998-014-00 (Ocean Survival of Salmonids) also provides status and trends information relevant to the LCRE in the Climatological Atlas for the Columbia River plume and estuary. This information is synthesized into a variety of indicators that have been combined with data on adult returns over time and are now used to update annual predictions of returning adult salmonids. This information on returns is used for harvest management and as an early warning indicator (see AMIP Section IV.A).

Major Lessons Learned from RPA Subaction 59.5

Lessons Relative to Action Implementation – Estuary Habitat Restoration

A lesson from RPA Subaction 59.5 is that net ecosystem improvement from the CEERP restoration effort is hindered by ongoing human impacts such as road construction and resource extraction in tributary watersheds linked to the lower flood plain habitats and broader LCRE. Even so, restoration projects focused on floodplain habitats have increased and are showing a positive effect on site-scale and ecosystem-scale habitat conditions. Although the full return of floodplain habitats to their historical state will be protracted, these systems will predictably continue to provide services during this development phase as part of the CEERP effort. Climate change is expected to affect the ecological processes of shallow-water habitats and capacity of the habitats to support juvenile salmon through alteration in river flow dynamics and volumes, increases in water temperature, and sea-level rise. CEERP will need to consider these consequences. Understanding overall conditions in the LCRE and ocean provides context for CEERP management decisions.

Lessons Relative to RME Implementation

Results from the Ecosystem Monitoring project can be used in context of action effectiveness evaluations, including monitoring and research efforts (e.g., consistently monitoring at fixed site locations) might provide a control from which to compare action effectiveness monitoring and research (AEMR) results, as new projects are constructed. A reference site is similar to the intended eventual outcome at the affected site after restoration, whereas a control site is similar to the affected site before restoration.

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).*
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.*
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.*

RPA Subaction 60.1 – *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).*

Major Accomplishments and Findings in Implementing the RPA Subaction

Four projects have contributed to this RPA subaction since 2008. The data for reference sites are stored at the LCEP, which is a member of the EPA's National Estuary Program, coordinating and conducting outreach with regional LCRE stakeholders.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) assesses annual trends and reference sites throughout the LCRE. Previously, **BPA Project 2003-011-00** (Lower Columbia River and Estuary Habitat Restoration) developed a suite of reference sites in tidal freshwater wetland habitats that contribute to habitat action effectiveness monitoring in the LCRE. Currently, the LCEP has data on the structure, function, and condition of over 50 reference sites in its database that can be paired with habitat restoration actions for action effectiveness monitoring (see RPA Subaction 60.2). **BPA Project 2005-001-00** (Tidal Freshwater Monitoring), now AFEP Project EST-P-11-01) also collected data for two sites (Chatham Island and McGuire Island) that are now part of the Estuary Partnership's reference site database.

The Columbia River and Estuary Restoration Reference Site Study (**BPA Project 2003-007-00**, Lower Columbia River Estuary Ecosystem Monitoring) synthesized information for factors that structure shallow water vegetated habitats along the entire longitudinal gradient of the LCRE. This project evaluated plant community composition at 52 tidal wetlands (marshes, shrub, and forested) in the LCRE for the purpose of providing specific reference and habitat restoration design elevations. Marshes, shrub wetlands, and forested wetlands were examined respective to their location and landforms (i.e., tributaries, islands, and bays). Three distinct wetland origins were studied: historically present, historically breached, and created. Summary statistics, including environmental tolerance ranges, are characterized in a USGS report to be published later this year 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). These data were analyzed relative to processes that form and maintain habitats as well as the rates at which plant communities and site geometry develop. This analysis will be applied during project design of shallow-water habitats, specifically when sighting target elevations for native plant community establishment, and reduction of non-native plant community establishment. The application of this information is further documented in the project sponsor's ERTG template, and bolsters their "certainly of success" SBU score.

The following results were synthesized from the projects described above and will be reported in Diefenderfer et al. (In Prep).

Non-Native Cover. The proportion of non-native herbaceous plant species cover is highest in deciduous forested wetlands followed by mainstem marshes. The proportion is substantially lower at tributary sites, evergreen forested wetlands, and shrub wetlands. Reed canarygrass is the most prevalent non-native species in the LCRE. Reed canarygrass has a greater probability of occurring at elevations above 1.5 m in all zones except emergent marsh zone 1, Reach A, where it occurs at higher elevations with a lower probability (< 50 percent) of occurrence because of salinity.

Floodplain Inundation. Growing season sum exceedance value (SEV, a hydrologic indicator) increases with increasing river kilometer (rkm) and decreases with increasing average wetland elevation. The highest value of the maximum SEV occurred in low elevation marshes near Bonneville Dam, suggesting that these areas flooded more often during the peak, plant growing season.

Sediment Accretion/Erosion Rate. The minimum of the average sediment accretion rate occurred in mainstem evergreen forested wetlands (0.24 cm/yr), and the maximum occurred in tributary emergent marshes (1.21 cm/yr), suggesting that sediment is more mobile in these hydrologically dynamic systems. Note, there was no significant difference between wetland type. Average sediment accretion rates did not significantly differ from Bonneville Dam to the mouth of the Columbia River, however, the ratio of channel width and depth did.

Water Temperature. Water temperatures differ between tributary and mainstem sites, and in a given location vary between years. Water temperature was analyzed during three periods from 2005 to 2011 with the following results: spring (March 15 to May 2) – only water temperatures in the year 2010 significantly increased with rkm; early summer (May 3 to June 20) – temperatures in both 2008 and 2009 significantly decreased with rkm; late summer (August 22 to October 9) – 2009 water temperatures significantly increased with rkm. Water temperatures in the upper Reaches (G-H) are influenced by colder spring runoff and in the lower Reaches (A-B) by colder seawater in the late summer.

River Position and Elevation. The average emergent marsh site elevation in North American Vertical Datum of 1988 (NAVD88) significantly increases with rkm. The slope of a linear regression of average emergent marsh site elevation on rkm is significantly different from zero ($p < 0.05$) between rkm 111 and Bonneville Dam, and nearly significantly different below rkm 111.

River Position and Plant Species. The interrelated metrics of hydrology and elevation significantly influence plant community distribution in the LCRE. For three of the most abundant plant species—reed canarygrass, common spikerush, and Lyngby sedge—the slope of the simple linear regression of the maximum observed elevation against the distance from the mouth of the Columbia River in kilometers was significant ($p < 0.05$). For two plant species—reed canarygrass and Lyngby sedge—the regression of the minimum observed elevation against the distance from the mouth of the Columbia River in kilometers was significant. The average non-native cover increased significantly ($p < 0.001$) until rkm 60; further landward it remained consistent. The number of sites with reed canarygrass cover >20 percent is significantly fewer in the lower reach and significantly greater in the upper reach.

Elevation and Plant Species. The number of sites with reed canarygrass cover > 20 percent was significantly greater between elevation of 1.5 to 3 than elevations below 1.5 or above 3 m (relative to the Columbia River Datum). Transect slope was not significantly associated with metrics describing plant communities or species.

Wetland Type. Swamps had significantly smaller SEVs than emergent marshes (Kruskal-Wallis: $n = 43$; $p = 0.001$). The width-to-depth ratio of the primary wetland channel at its mouth was significantly different between wetland types. At the study sites, the average transect slope, sediment accretion rates, and proportion of non-native plant species cover were not significantly different between wetland types.

Major Lessons Learned from RPA Subaction 60.1

Lessons Relative to Action Implementation – Estuary Habitat Restoration

The results reported above can be used as a guide to the longitudinal and vertical distribution at which plant species are likely to survive in the LCRE – results by rkm and vertical elevation (Borde et al., In Preparation). Notably, the relationships between location, hydrology, and elevation can be used by restoration planners to design projects. For example, researchers found that the elevation range for most major habitat types (e.g., emergent marshes) was less than 2 meters, indicating that elevation and hydrodynamics should be carefully considered in the design of wetland restoration. Reed canary grass, an invasive plant species, covered the widest elevation range of any species in the LCRE, but native species thrive and appear to outcompete reed canary grass at elevations below 1.5-m. Targeting specific elevation ranges during project design and construction should help control and minimize the spread and proliferation of reed canary grass (e.g., avoid elevations known to support certain invasive species) (Borde et al., 2011). Restoration planners can also use this information to strengthen their ERTG SBU score by improving their proposed action’s “certainty of success” (see RPA Action 37).

Lessons Relative to RME Implementation

Reference and control sites are essential to AEMR studies where the objective is to determine the success or ecological benefits of a particular restoration action. A reference site is similar to the intended eventual outcome at the affected site after restoration, whereas a control site is similar to the affected site before restoration. Using control sites paired with each impact site can add additional statistical power to the analysis when looking to isolate changes in the restoration action compared to changes caused by natural variation or other sources. Selecting a reference site for AMER, however, is sometimes difficult because of variability in the system means the reference concept needs to be revisited. Also, control sites should be used as necessary. Another lesson from RPA Subaction 60.1 is that whenever feasible restoration actions should be matched with appropriate reference and/or control site.

RPA Subaction 60.2 – *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.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Since 2008, restoration action effectiveness studies have showed some positive ecological responses at a site scale (see action effectiveness findings in Thom et al. (2013) and the meta-analysis in Diefenderfer et al., 2012). Responses have been measured according to standardized protocols (Roegner et al., 2009; see RPA Action 60.3), and include water surface elevation, bathymetry and topography, sediment accretion, vegetation community composition, percent cover and percent plant establishment, water quality, and fish (fish community, fish condition, and genetic stock), and prey (prey availability and those selected for by Chinook salmon). Action effectiveness monitoring has occurred in different parts of the LCRE depending on restoration activities, habitats, and geographic reach.

BPA Project 2003-011-00 (Lower Columbia River/Estuary Habitat Restoration): Researchers intensively monitored water surface elevation, bathymetry and topography, substrate, vegetation composition and percent cover, and juvenile salmon density at three sites where tidal reconnections were restored: Mirror Lake, Scappoose Bottomlands, and Fort Clatsop. This and other projects showed that juvenile salmon typically access the newly restored areas once the opportunity is provided. Key results included:

- **Scappoose Bottomlands Site:** Project sponsors initially hypothesized that the lack of understory diversity was primarily caused by cattle grazing (Jina Sagar, personal communication); however, it 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.

- **Sandy River Delta Site (Invasive Removal and Native Plantings)**: At certain locations, distinguishing between individual native plants that are "installed" during site improvement and 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 installed and naturally re-established plants (Johnson et al., 2011b).
- **Fort Clatsop Site**: The 2011 fish sampling modification to address several technical issues proved successful (Jina Sagar, personal communication). Seining the channel increased catch efficiency, provided a measureable area 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 at South Slough and Alder Creek.

BPA Project 2005-001-00 (Tidal Freshwater Monitoring) and Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) contributed to pre-restoration assessment at a site, the SDR and at the landscape-scale, LRR, Reach D and E. Pre-restoration baseline assessment at the Sandy River found juvenile salmon using habitats sampled in the study area (Johnson et al., 2011b). Based on limited data, researchers suspect lateral distance between off-channel habitats and the main channel influences conditions such as structural hydrologic connectivity (with implications for fish access and prey export), temperature, and growth potential. In addition, juvenile salmon may benefit from restoration actions focused on maintaining adequate flow and cooler temperatures in these habitats (Johnson et al., 2011b).

Corps AFEP EST-05-P-07 at Julia Butler Hansen National Wildlife Refuge evaluated pre- and post-habitat restoration condition resulting from the installation of side-hinged, self-restrained tide gates with the purpose of improving 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 thru June 23, 2011. Fish passage, fish presence, and distribution were compared respective to pre-and-post project conditions, and to reference and control sites per a before-after-control-impact (BACI) methodology.

Crims Island site: Restoration actions at Crims Island during 2004/2005 involved grading and channel excavation to provide rearing and refuge habitat for juvenile salmon. Pre- and post-construction RME was conducted, including comparisons between treatment and reference sites. The actions restored natural tidal hydrodynamics and flooding, improved water temperatures on site, allowed increased sediment accretion rates and natural material flux, and increased access and use by juvenile salmon (Haskell and Tiffan, 2011).

Major Lessons Learned from RPA Subaction 60.2

Lessons Relative to Action Implementation – Estuary Habitat Restoration

To date, action effectiveness evaluations indicate that restoration activities improving hydrological connections can result in near-immediate increases in Chinook salmon abundance (Thom et al., 2013b; Roegner et al., 2010; Haskell and Tiffan, 2011; Johnson et al., 2007 and2011b). Another important lesson for the restoration actions is that full breaches may not always be necessary to maximize wetted area during a reconnection project (Diefenderfer et al., 2012). The current results reinforce the need to continue habitat restoration in the LCRE that optimizes reestablishment of natural processes. But the results also reinforce the need to evaluate actions relative to changing site conditions (e.g., increased water temperatures and non-native fish use) and also relative to other reference or control sites in the LCRE. Together, these types of assessments build a reliable foundation from which to assess the value of individual restoration, and allow for comparisons across different sites (spatially) and across time (temporally) in meta-analyses and estuary-wide evaluations of cumulative effects.

Lessons Relative to RME Implementation

As additional types and intensities of restoration actions are planned and implemented, additional AEMR will be considered. The plan for continued action effectiveness research and monitoring is described in the CEERP Strategy Report, and includes recommendations for prioritizing AEMR depending on project type, location, and uncertainties in the knowledge base. After a project is evaluated, it is recommended that an AEMR plan be developed that distinctly identifies restoration project goals and objectives, and aligns these with a site-specific study plan, which may include a statistical plan. Note, in many cases, the level of effort/study is expected to be low, thus effectively characterizing “extensive” indicators of ecosystem response. A few studies will remain that intensively evaluate specific areas of investigation, respective to ecosystem response. These studies can intentionally focus on building the state of the science and relating changes in habitat to juvenile salmon performance (e.g., realized function), including improvement in growth and fitness resulting from habitat restoration. Performance standards for native plant community establishment should include total live installed and naturally re-established plants. Fish capture efficiencies were improved when seining down wetland channels. This approach reduced fish escapement, increased sampling efficiencies and provided a more accurate representation of the fish density, abundance and composition.

The findings from RPA Subaction 60.2 reinforce the need to evaluate actions relative to changing site conditions (e.g., increased water temperatures and non-native fish use), but also relative to other reference or control sites in the LCRE. It is apparent, though, that AEMR builds a strong, reliable foundation from which to assess the value of individual restoration, and allow for comparisons across different sites (spatially) and across time (temporally) in meta-analyses and estuary-wide evaluations of cumulative effects, although as additional types and intensities of restoration actions are implemented, there may be a need for further AEMR. For restoration actions prioritized for AEMR as part of the CEERP process, project-specific AEMR plans should be developed based on restoration project goals and objectives, which may also include a formal statistical design.

RPA Subaction 60.3 – *Develop and implement a methodology to estimate the cumulative effects of the habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem and controlling factors, structures, and processes affecting salmon habitat and performance.*

Major Accomplishments and Findings in Implementing the RPA Subaction

AFEP Project EST-02-P-04, Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the LCRE, was a multi-year project (2004-2012) to address this RPA subaction to develop and apply a methodology to evaluate the cumulative effects of multiple habitat restoration projects in the LCRE.

Levels-of-Evidence Approach

Because it is not possible to measure every feature at every site in the estuary, there was a need to develop a method to adequately detect and measure changes to the ecosystem and represent those critical linkages between the habitats and juvenile salmon response. Methods development commenced in 2004 with a comprehensive literature review of prior quantitative methods to evaluating the cumulative effects of multiple restoration projects across a given estuary. Researchers concluded that no formal methods had been published to date, thus the recommendation was to develop and apply a theoretical and empirical levels-of-evidence approach. This approach is shown in Figure 92 (Diefenderfer et al., 2011b). To facilitate eventual cumulative effects evaluations, the study produced products to either inform data collection efforts and analytical methods in the LCRE; thus, allowing data analysis across studies and time. This approach involved a hierarchical suite of phases: design, data, analysis, synthesis and evaluation, and application.

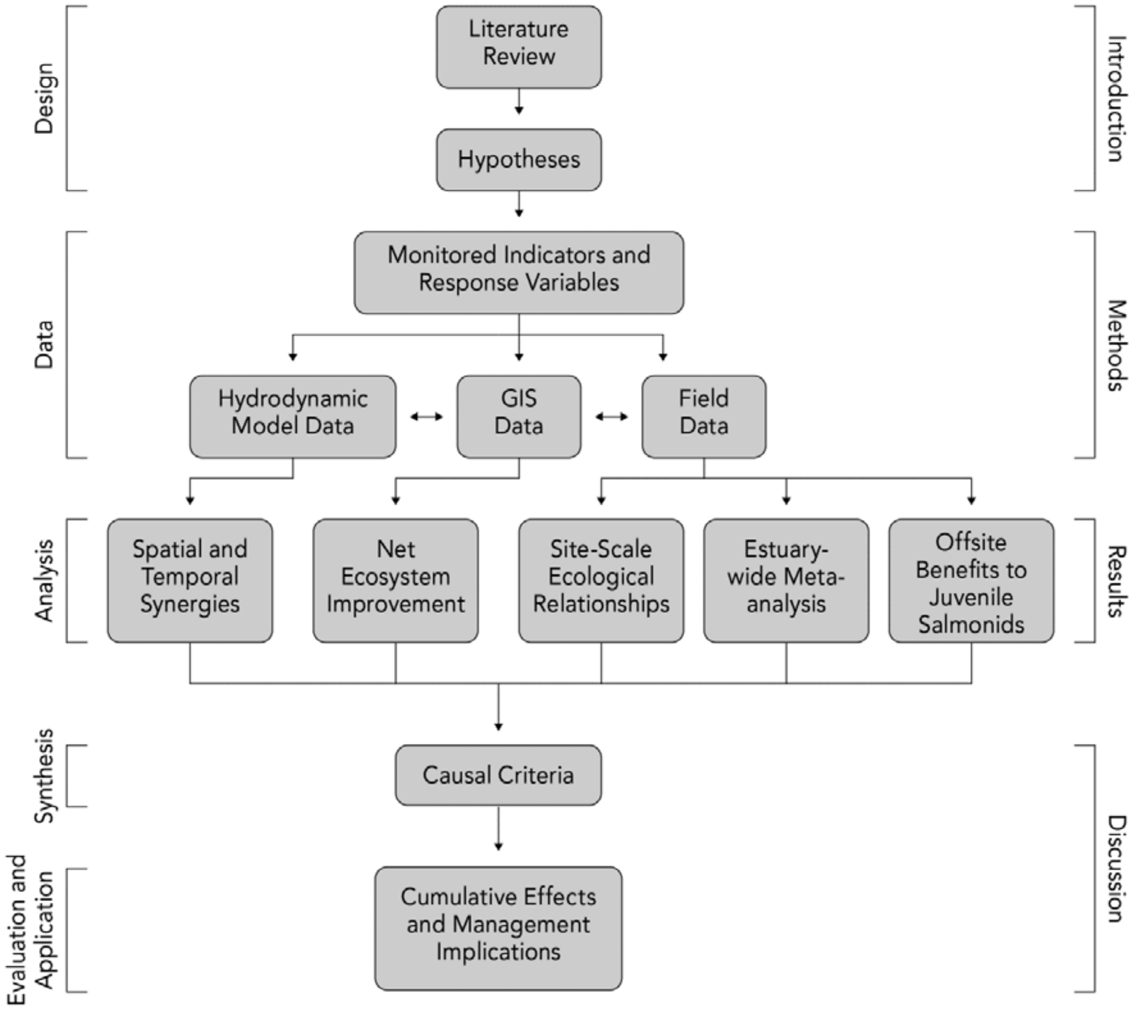


Figure 92. Levels-of-Evidence Approach for Evaluation of the Cumulative Effects of Ecosystem Restoration. (From Diefenderfer et al., 2012).

The cumulative effects methodology is designed, or based upon a hierarchy of hypothesis, including an overarching working hypothesis, a landscape-scale hypothesis, and indicator hypotheses. For the LCRE, the Overarching Working Hypothesis is, “Habitat restoration activities in the LCRE have a cumulative beneficial effect on salmon;” the Landscape-Scale Hypothesis is, “Restoration actions in the LCRE are producing increased habitat connectivity and an increased area of floodplain wetlands trending toward historical levels present prior to land conversion for agriculture and the construction of dams.” Indicator Hypotheses also tests the assumption that a particular site measurement is trending toward reference site, or desired condition. All hypotheses concerning the specific changes to wetland habitats and to the uses of those habitats by fishes are ancillary to the working hypothesis (Figure 93). The working hypothesis for CEERP is that habitat restoration activities in the LCRE have a cumulative beneficial effect on salmon (Diefenderfer et al., 2011b).

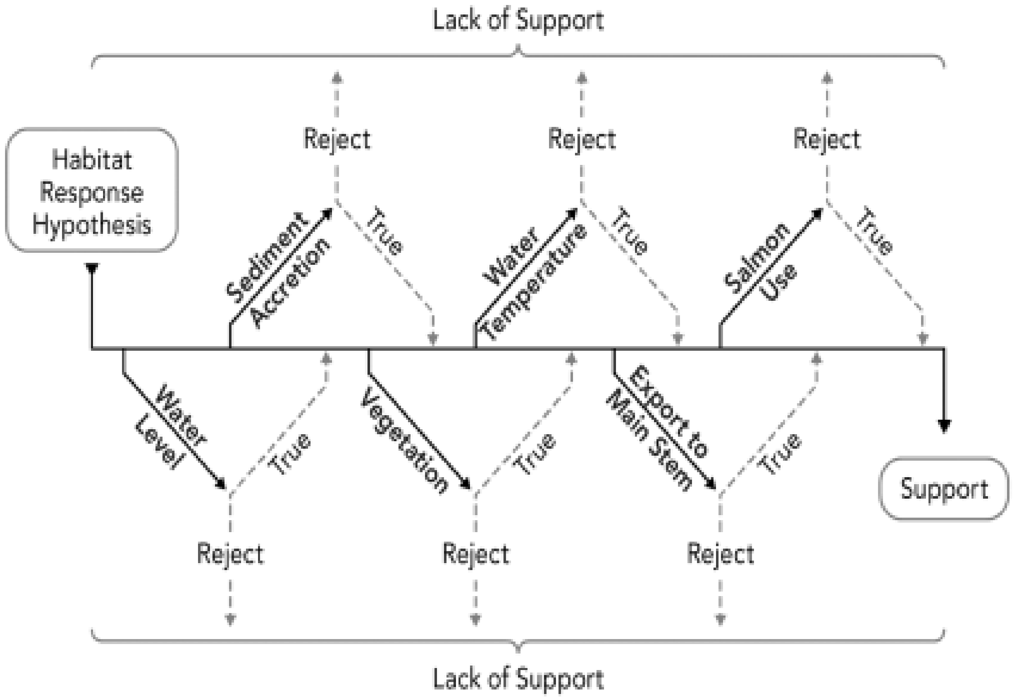


Figure 93. Conceptual Diagram of the Hypothetico-Deductive Method Illustrating the Overarching Working Hypothesis and the Testable Ancillary Hypotheses (From Diefenderfer et al., 2012).

Lines of Evidence

Diefenderfer et al. (2012) identified two lines of evidence from outside the LCRE: 1) Systematic review/scoring of global literature; 2) Trends in landscape condition. These authors noted five lines of evidence from the LCRE: 1) Analysis of spatial and temporal synergies; 2) Net ecosystem improvement model; 3) Qualitative meta-analysis of restoration projects; 4) Identification of site-scale ecological relationships; 5) Assessment of offsite benefits to juvenile salmon.

Data

To facilitate the eventual cumulative effects evaluation, researchers developed standardized monitoring protocols in the LCRE (Roegner et al., 2009). Providing this guidance was important and focused the action effectiveness data collection efforts on key response variables. Six “core” indicators and four “higher-order” indicators were identified (Table 63). The core monitored indicators (from Roegner et al., 2009) and higher-order indicators for a cumulative effects assessment are listed in Table 63.

These protocols have been used extensively in the estuary by restoration mangers, as well as those conducting research and monitoring (Roegner et al., 2009).

From 2005 through 2010, researchers simultaneously developed supporting material describing the ecological theory and lines of analysis (Johnson et al., 2012). Primary research investigated the cause-and-effect relationships between ecosystem controlling factors (e.g., hydrology, water quality), and structures (e.g., habitat, vegetation, substrate) and processes (e.g., prey flux) that affect salmon habitat and their performance (e.g., “realized function” such as increased growth and health, fitness). In addition, research focused on developing methods for meta-analyses and net ecosystem improvement assessments; and examining spatial and temporal synergies, including trajectories of change and site succession; all of which are contributing lines of analysis for the cumulative effects evaluation.

Table 63. Monitored Indicators by Category to Assess the Effectiveness of Tidal Reconnection Restoration (from Roegner et al., 2009).

Category	Indicator
Core Indicators – Ecosystem Controlling Factors and Structures	
Hydrology	Water surface elevation, catchment area, tidal exchange volume, wetland delineation
Water quality	Temperature, salinity, dissolved oxygen
Topography/ bathymetry	Elevation, sediment accretion rate, channel cross-sectional area
Landscape	Photo points, aerial photos
Vegetation	Percent cover by species, plant community composition
Fish	Presence, abundance, species composition, size structure
Higher Order Indicators – Ecosystem Processes and Realized Functions	
Habitat Size	Area-time inundation, wetted-channel edge length, floodplain wetted area
Material Flux	Flux rates for nutrients, chlorophyll, dissolved organic matter, plant biomass, total organic carbon, macro-invertebrates
Fish Usage	Residence time, diet, growth rate, fitness, prey availability, stock

Field research involved intensive, comparative studies paired by habitat type (tidal swamp vs. marsh), trajectory of time (immediate response compared to reference site conditions), and restoration action (tide gate replacement vs. culvert replacement vs. dike breach) (Johnson et al., 2012). In addition to site scale comparisons, field study investigated the distribution and changes of land cover (using remote-sensing data) in the LCRE. Forest cover, impervious surface, and wetlands are important landscape indicators of juvenile salmon habitat; hence, landscape-scale analysis include land cover changes from 2001 to 2006 and changes in area at three spatial scales: contributing watershed scale, historic floodplain reach scale, and site scale.

<u>Summary Results</u>

Diefenderfer et al. (2012) delivered to the Corps and region “An Evidence-Based Assessment of the Cumulative Effects of Tidal Freshwater and Estuarine Ecosystem Restoration.” Key results include:

1) global literature strongly supports benefits to salmon from tidal wetland reconnection: presence, residence, prey, and diet;

2) historically reconnected sites in the LCRE are emergent marshes with high potential fish access;

3) salmonid response at recent LCRE restoration sites is mixed; fast-response variables show restorative ecosystem processes;

4) net ecosystem improvement in prey and plant biomass indicates wetlands support salmonid foraging;

5) a particulate organic transport model indicates matter produced at restoration sites can be exported >7 km to the mainstem river;

6) stomachs of Chinook salmon and steelhead near rkm 15 are substantially fuller than fish exiting the hydropower system and guts contain large quantities of marsh-produced dipteran insects.

<u>Application: Adaptive Management of Ecosystem Restoration in the LCRE</u>

An adaptive management process was developed and is now being implemented under the CEERP (Figure 94). Key steps of the adaptive management processes include: strategize, decide, act, monitor/research, synthesis and evaluate, and adjust. This task was critical in providing guidance to for regional coordination among resource managers. For example, the adaptive management framework cycle identifies the role of synthesizing and evaluating scientific information, such that management decisions are grounded in the best available science. This synthesis occurred in 2012, and it has influenced the estuary program objectives for habitat restoration and RME in the estuary. For example, the Synthesis Memo highlighted key findings among the various action effectiveness studies to date and provided a list of suggestions for future, priority RME. These program adjustments, along with technical, pragmatic initiatives such as the development of a regional database, improve our ability to evaluate program success.

Figure 94. Columbia Estuary Ecosystem Restoration Program, Adaptive Management Process.

Major Lessons Learned from RPA Subaction 60.3

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Initial application of the cumulative effects methodology was successful. This quantitative assessment will be reported in winter 2012. Further application of this methodology will give the Action Agencies and other resource managers a means to periodically assess habitat restoration responses. Many of the methods and approaches that have been developed can be applied at different geographic scales (site-landscape-estuary) depending on the management concern or analytical question. However, the ability to do this in the future is dependent upon (or optimized by) implementation of action effectiveness studies (monitoring and research). For example, continued development of data sets to support ratio estimation between extensive data (temperature) and intensive data (fish growth) will be needed to optimize data collection efforts and complete comprehensive meta analysis in the future. Researcher's ability to extract lessons learned from individual studies, and relate, or compare to other studies in the estuary, in the ocean, and in the larger Columbia and Willamette rivers will be somewhat dependent the synthesis of data across studies and location. Because this is so important, annual coordination of action effectiveness priorities, study plans, and analysis should continue.

Lessons from the evaluation of cumulative effects (RPA Subaction 60.3) relative to CEERP implementation include: all lines of evidence from the LCRE indicate positive habitat-based and salmonid-based responses (two "necessary conditions"), except in cases of tide gate installation on small sloughs; on this basis, habitat restoration activities in the LCRE are likely having a cumulative beneficial effect (the "working hypothesis") on juvenile salmonids that access restored shallow-water areas or actively transit mainstem river habitats between the hydrosystem and lower-river tributaries and the ocean; tidal wetlands in the LCRE currently support juvenile salmonids, including interior basin salmonids, and this effect would be expected to increase over time as existing restoration projects mature and new ones are implemented.

Lessons Relative to RME Implementation

Evidence from restoration sites in the LCRE is limited, thus, assessment of global literature was critical to concluding the potential for success. In addition, adaptive learning from LCRE restoration monitoring is needed to both demonstrate and improve benefits over time. The use of reference sites to assess trends in the spatially complex and dynamic LCRE must be done carefully, as shown with RPA Subaction 60.1. Several remaining uncertainties that can inform decision making are identified in the report: juvenile salmon growth; spatial dynamics of prey and biomass flux (e.g., role of reed canarygrass), trends in ELHD and unmarked fish density; maximum potential function of tide gates in typical channel types; gaps in reference sites network; experimental assessment of project effectiveness. Thus, while Initial application of the cumulative effects methodology was successful, annual coordination of AEMR priorities, study plans, and analysis should continue to apply this method in the future.

***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, which could include the following:*

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.*
2. *Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.*
3. *Investigate the importance of early life history of salmon populations in tidal fresh water of the lower Columbia River.*
4. *Continue development of a hydrodynamic numerical model for the estuary and plume to support critical uncertainties investigations.*

***RPA Subaction 61.1 –** 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.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Five projects have contributed to this RPA since 2008, and collectively, these multi-year projects and others investigated the relationships among juvenile salmon condition, growth, and survival in the LCRE, plume and nearshore ocean. For results on salmonid growth and condition, see RPA Subaction 58.1.

- **BPA Project 1998-014-00** (Ocean Survival of Salmonids)
- **BPA Project 2003-009-00** (Canada-USA Shelf Salmon Survival Study)
- **BPA Project 2003-114-00** (COAST)
- **Corps AFEP EST-P-10-01** (Contribution to Salmon Recovery)
- **Corps AFEP EST-P-11-01** (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary)

For the plume and nearshore ocean, BPA Project 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 measurements of ocean conditions.

BPA Project 2003-009-00 (Canada-USA Shelf Salmon Survival Study) investigated habitat use in the nearshore ocean that was used to analyze the relative ecological importance of this environment.

BPA Project 2003-114-00 (Coastal Ocean Acoustic Salmon Tracking) provided estimates of segmented residency times and relative survival data (hydrosystem, estuary, plume, and nearshore ocean) within months of tagging. The ocean studies are the result of an ongoing research partnership between BPA, NOAA Fisheries, Oregon State University, Oregon Health Sciences University, and 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, as well as monitor the ocean conditions experienced by these fish. The primary focus of the projects has been 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. In the COAST study, initiated in 2005 by Kintama Research Services, Ltd., acoustic tags were used to track juvenile Chinook salmon migration and mortality through the FCRPS and into the coastal ocean. Annual survival rates of acoustic-tagged smolts in the coastal ocean varied by a factor of five or more and tracked NOAA Fisheries' 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.

The presence and abundance of Chinook salmon is negatively correlated with water temperature and depth and positively correlated with various production indices such as chlorophyll A concentration and zooplankton (copepod) and larval fish biomass (Brodeur et al., 2000 and 2004; Fisher et al., 2007 Peterson et al., 2010). These correlations between juvenile salmon abundance and environmental variables are generally weak and shift seasonally (Brodeur et al., 2004). Fish must grow quickly to accumulate energy reserves to escape predation, as well as starvation-based mortality in the ocean phase of their life cycle (Trudel et al., 2007; MacFarlane, 2010; Duffy and Beauchamp, 2011). Salmon growth rates are tied to environmental conditions (e.g., habitat, ocean conditions) (Quinn et al., 2005; Trudel et al., 2007). Trends in marine growth & survival are asynchronous among salmonid stocks, suggesting differential conditions based on differences in migration patterns (Wells et al., 2008). Marine survival and production of Columbia River Chinook, coho, and sockeye salmon seem to be strongly influenced by the growth conditions and food web quality off the west coast of Vancouver Island (Jacobson et al., 2012).

In the LCRE, Contribution to Salmon Recovery (Corps AFEP EST-P-10-01) conducted estuary-wide surveys on the seasonal timing and estuary distributions of each ESU that help Action Agencies identify specific reaches and habitats most used by interior, ESA-listed salmonids (among others). The results from the 2010-11 genetic surveys are being used to design higher-resolution studies targeting particular tidal-fluvial habitats.

Salmon Benefits (Corps AFEP EST-P-09-01) developed a conceptual model of direct and indirect juvenile salmon SBs resulting from habitat restoration in the lower Columbia River and estuary. (The conceptual model was presented in RPA Subaction 58.1.) This conceptual model might be used to investigate life-stage specific survival, or biological improvement, as realized by yearling ("ocean type") and subyearling ("stream type") salmon species.

Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary (Corps AFEP EST-P-11-01) has, to date, conducted site-scale, pre-restoration sampling for the proposed re-channelization at the SDR and landscape-scale sampling in an LRR. Restoration actions are pending; however, the research findings derived from this study address critical uncertainties and information gaps in the LCRE concerning juvenile salmon ecology in tidal freshwater (see RPA Subaction 61.3).

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) monitored juvenile salmon use of shallow-water habitats in Reaches A-H. This project analyzed salmonid densities, fish community composition, salmonid age-size structure, genetic stock identity, prey availability/salmon diet, residence times, spatial and temporal distribution, growth rates and habitat characteristics.

All juvenile salmon life histories use a variety of habitats within the estuary complex, from off-channel wetlands to main-channel areas. They use these habitats to feed and grow year-round, although such habitat use varies by season, stock of origin, life-history stage, longitudinal position in the river, and other factors. Direct effects are those resulting from fish residence in the shallow water-habitats. For example, small subyearling juvenile salmon typically reside in the estuary for the longest periods (Campbell, 2010) and utilize shallow, near-shore habitat created by most restoration projects (Bottom et al., 2008).These fish are expected to benefit directly from habitat restoration, specifically by increasing the amount of rearing and refuge habitat/space to live. These direct benefits associated with migration through and use of restored habitats are described in RPA Subaction 58.2. Indirect benefits are those acquired as off-site, but due to habitat restoration. For example, Snake River Basin Chinook and steelhead feed on wetland-derived insects during their migration from Bonneville Dam to the mouth of the Columbia River. These off-site benefits that contribute to the production and availability of prey resources, consumption by juvenile salmon, and subsequent growth are described in RPA Subaction 58.3. Both onsite and offsite benefits particularly contribute to two viability salmon population parameters: diversity and spatial structure, as well as abundance and productivity.

Other Key Findings Include:

Feeding and Growth. Juvenile salmon use shallow tidal freshwater habitats to feed and grow year-round (Johnson et al., 2011b). However, habitat use varies by season, stock of origin, life-history stage, and other factors. (This topic was covered in detail under RPA Subaction 58.3.)

Fish Community Composition. At the SDR (Reach G), salmon and non-salmon fish densities were highest in summer/fall and eight species accounted for 99 percent of the total catch. Fish community composition was similar across broad expanses of tidal freshwater segments in the LRR (Reach F). Most of the hatchery fish present at SDR were from the Spring Creek Group Tule Fall (49 percent) and upper Columbia summer/fall (35 percent) stock groups (Johnson et al., 2011b).

Genetic Stock Distribution. Snake River fall run fish were relatively rare in field samples but occurred most in Reaches E-H, comprising an estimated 4 percent of catches in Reach H. Both the genetic stock survey and PIT-tag 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-tag detector recorded entry by Snake River steelhead (H and W) and fall and spring Chinook (H), and upper Columbia River steelhead (H), and spring Chinook (H and W) (D. Bottom, personal communication). Genetic results also reveal that many ESUs are capable of expressing multiple juvenile life histories. For example, researchers identified subyearling and yearling spring Chinook salmon from the Willamette River ESU and several upper basin stocks that produced subyearlings that utilized shallow water, estuarine habitats (D. Bottom, personal communication).

Four genetic stocks contributed greater 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 comprised 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.

Surveys documented all ESUs using shallow estuarine habitats, and some upper Columbia River spring Chinook were detected at PIT-tag monitoring site at Russian Island (Corps AFEP EST-P-10-01; Dan Bottom, personal communication). Estuary distributions varied by ESU, with relatively high proportions of upper Columbia River stocks in Reaches F-H and lower Columbia River stocks distributed throughout 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. A mixture of representatives from lower river, upper river, and Willamette River ESUs were prevalent.

Low Diet Overlap with Forage Fishes. At the SDR, dietary overlap was generally minimal for the months that Chinook salmon and resident fish were collected, except for July 2011 when diets of killifish and stickleback overlapped significantly with Chinook salmon (Johnson et al., 2011b).

Abundance. Juvenile salmonid peak abundances (densities) for all ESUs/DPSs were observed in spring, summer, or early fall sampling, although juvenile coho and Chinook subyearlings were found year-round in the LCRE (Sather et al., 2009; Johnson et al., 2011b). Peak abundance numbers can be related to timing and numbers of hatchery releases.

Unmarked and Marked. Most of the unmarked Chinook captured at SDR were upper Columbia summer/fall (35 percent) and Spring Creek Group Tule Fall (31 percent) stock groups, though other stocks such as Snake River fall Chinook were also detected. Unmarked Chinook salmon were significantly larger at SDR compared to Lower River Reach and there were proportionally more marked hatchery Chinook salmon at SDR than at Lower River Reach (Johnson et al., 2011b).

Floodplain Lakes. Large floodplain lakes are tidally influenced, shallow, perennial lakes that are typically larger than 100 acres. In the LCRE, they are located in reaches F and G and are highly productive systems for a myriad of fish and wildlife species. Many floodplain lakes in the LCRE are publicly owned and have management goals consistent with conservation purposes. A literature review (PC Trask and Associates, 2012) of floodplain lakes (see Figure 95) found that juvenile fall Chinook salmon are the predominant salmonid using these lakes. During some sampling events, salmonid densities were greater in the lake than in the mainstem estuary (Envirosphere, 1985). Juvenile coho and sockeye salmon were also found in these lakes. Water temperature was routinely reported as a limiting factor for juvenile salmonid use in late summer. Furthermore, predation on juvenile salmonids was not a significant threat in floodplain lakes, and stomach content analysis indicated that Chinook primarily consumed cladocerans, copepods, and some insects.

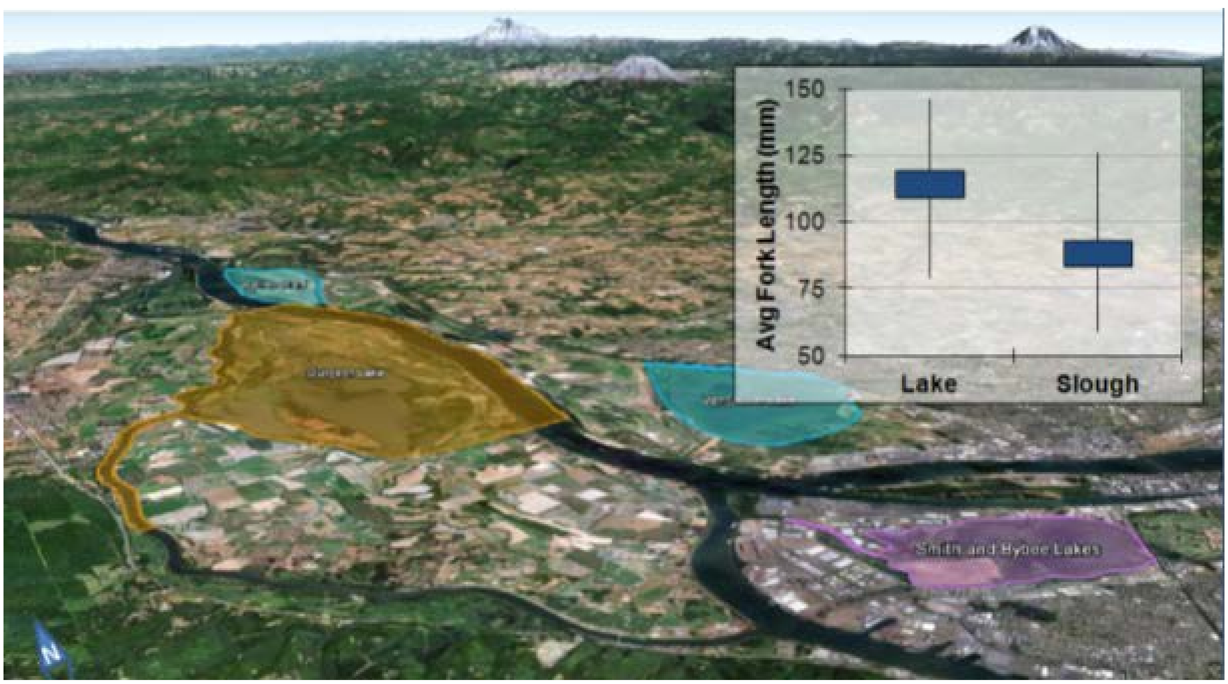


Figure 95. Floodplain Lakes Near the Willamette Confluence with the LCRE (Reach F) and Fish Fork Length Data Collected for Smith and Bybee Lakes and Adjacent Sloughs (Fishman et al., 1987 In PC Trask, 2012).

Salmon Stock Distribution and Estuary Restoration. Surveys in the lower LCRE funded by the Corps in 2002-2007 demonstrated that wetlands and other shallow estuarine habitats play a major role, onsite and offsite, in the LHD, food webs, and growth of juvenile Chinook salmon (Bottom et al., 2008; Maier and Simenstad, 2009; Roegner et al., In Prep). Recent studies in the lower Grays River (Roegner et al., 2010) and in the SRD area (Johnson et al., 2011b) have reinforced these results, documenting use of a diversity of wetland habitats by a suite of salmon species, including chum, Chinook, and coho salmon. Although fewer spring run fish from interior basin ESUs directly occupy shallow estuarine habitats than do ocean-type fish from the Lower Columbia and Upper Willamette ESUs, researchers found that all Chinook salmon ESUs reside in the lower 100 km of the estuary and use a variety of alternative habitat pathways for migration and feeding (Bottom et al., 2008; Roegner et al., 2008). Wetland habitats contributed to the LHD and growth of Chinook salmon by providing opportunities for diverse Columbia River ESUs to express subyearling migrant life histories and by producing insects and other invertebrate prey consumed by juvenile salmon, including yearling Chinook and steelhead, outside those habitats. Stable-isotope studies revealed that representatives of all ESUs sampled in the estuary had interacted directly with wetland food webs for weeks or months and grew substantially before entering the ocean (Maier and Simenstad, 2009). Despite historical declines in wetland detrital sources through diking, filling, and other changes (Sherwood et al., 1990), contemporary salmonid food webs appear disproportionately linked to wetland-derived prey (Maier and Simenstad, 2009).

Burla et al. (2010) found that Snake River steelhead benefited from the plume environment at a narrow period of time around their ocean entry. However, when large-scale ocean conditions turned unfavorable, the contribution of local plume conditions to the overall variability in steelhead survival was not significant. A similar evaluation revealed that the plume did not affect survival of Snake River spring-summer Chinook salmon, suggesting that the CR plume plays a different role as habitat for steelhead and Chinook. Findings suggest that steelhead may make a more direct and rapid migration to habitats in the Gulf of Alaska, underlying the finding why plume structure may benefit their success more directly than for yearling Chinook salmon that appear to reside for a longer time in coastal waters, closer to shore.

Emmett et al. (2004) found juveniles reside mainly near the surface in the plume (within the upper 12 m). The highest densities of subyearling Chinook were associated with high surface currents, yearling Chinook with higher turbidity. Pacific herring (most abundant forage fish) had highest densities at night. Juvenile salmonids were not associated with catches of forage fishes.

<u>Major Lessons Learned from RPA Subaction 61.1</u>

<u>Lessons Relative to Action Implementation – Estuary Habitat Restoration</u>

The 2008/2010 BiOp on Operation of the FCRPS establishes estuary restoration goals for 10-year survival improvements of 9 percent for ocean-type and 6 percent for stream-type ESUs. To support these goals, a qualitative assessment process was devised to identify limiting factors and to prioritize estuary restoration actions based on their estimated survival benefits. Restoration efforts assume that improvements in juvenile rearing habitats, performance, and survival in the estuary will benefit adult returns of at-risk stocks. Yet present RME activities (e.g., action effectiveness research, status and trend monitoring, and critical uncertainties research) rely on estuarine survival and performance metrics—for example, foraging success, growth, and condition—whose contributions to the viability of Columbia River salmon populations (measured as adult returns) have not been directly measured. The AA's are working to further develop connections to life stage specific improvements, with findings to date that include monitored fish characteristics in the LCRE (e.g. size, growth) that have been related to increased survival at the next life stage (plume, early ocean) for some ESUs. However, direct connections between ESUs/DPSs and these metrics is ongoing.. Estuary RME attempts to empirically quantify benefits to different populations and ESUs by assessing the contribution of the LCRE to specific life stage improvements, for example, measured as an increase in growth or biological fitness. Results from these studies could inform survival gains within a salmon population life cycle model, to infer an additive gain, to adult return. Life-stage specific survival improvements are described for both yearling and subyearling salmon species, and are characterized as direct and indirect benefits, respectively, and particularly contribute to two viability salmon population parameters: diversity and spatial structure.

There are large interannual fluctuations in abundance of salmonids during the ocean live stage despite relatively stable Columbia River Basin hatchery production, and factors that affect year-class strength may differ among stocks. However, results suggest that after juvenile salmonids enter the ocean, survival is set within the first year of marine residency and is related, in part, to food-web structure and growth conditions in the plume and coastal ocean (Jacobson et al., 2012). Regional managers may seek to prioritize actions that improve survival and condition prior to ocean entry. In addition, modelers who predict adult returns should also focus on identifying those factors in the first year of marine residence that drive salmonid survival.

Lessons Relative to RME Implementation

The following lessons from RPA Subaction 61.1 (ecological importance of tidal freshwater, estuary, plume, and nearshore ocean environments) are relevant to RME implementation: 1) RME addressing ecological importance must include functional attributes of juvenile salmon ecology such as feeding, growth, and fitness; 2) Data showed the importance of understanding factors affecting salmon populations over the entire salmon life cycle; 3) Findings should be applied to regional life cycle models to better understand the role of the estuary in contributing towards VSPs; 4) Juvenile salmon downstream migration occurs in a continuum of environments, with the tidal freshwater, estuary, plume, and nearshore ocean areas important elements in the entire life cycle, supporting the life cycle approach to RME implementation.

RPA Subaction 61.2 – *Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Three projects have contributed to this RPA subaction since 2008. Collectively, **BPA Project 2003-009-00** (Canada-USA Shelf Study), **BPA Project 1998-014-00** (Ocean Survival of Salmonids), and **BPA Project 2003-114-00** (Coastal Ocean Acoustic Salmon Tracking) examined causal mechanisms affecting survival such as food-web structure and growth conditions in the plume and coastal ocean. In addition, AFEP Project TPE-W-04-1 (Seasonal Effects of Transportation) 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 weekly SAR data collected by the Action Agencies 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.

Studies of Early Ocean Entry for Juvenile Salmonids Have Found:

Early marine growth is positively correlated with adult returns for Chinook, coho, and steelhead. Mortality of yearling Chinook appears to be regulated by bottom-up processes, whereas the smaller subyearlings may be regulated by other factors (Jacobson et al., 2012). This finding has implications for run forecasting, since food-web structure and quality prey (i.e., lipid-rich) availability are driven by large-scale atmospheric forcing associated with the PDO. The distribution and abundance of predators and the forage fish eaten by juvenile salmonids, or that buffer juvenile salmonids from predators, are also influenced by circulation patterns.

In some years, a larger Columbia River plume was associated with higher survival of some salmonid stocks (Jacobson et al., 2012). Plume characteristics can be predicted from a combination of river discharge and winds over the continental shelf.

Ocean mortality of Columbia River stocks during winter can be substantial (80-90%), though the cause of this high mortality is not certain. Winter mortality is expected to affect various stocks of Columbia River salmonids differently based on the migration patterns. Adult return and the marine survival of Columbia River summer and fall Chinook salmon, as well as coho, were strongly correlated to the growth conditions and prey quality off the west coast of Vancouver Island. These relationships may serve as leading indicators of adult salmon returns to the Columbia River one-two years before they migrate back to the river to spawn (Jacobson et al., 2012).

Marine survival and production of Columbia River Chinook, coho, and sockeye salmon seem to be strongly influenced by the growth conditions and food web quality off the west coast of Vancouver Island (Jacobson et al., 2012).

Salmonid ocean migration appears to be highly influenced by genetics rather than by varying ocean conditions (Weitkamp, 2012). However, it appears that salmonids alter their migration speed depending on ocean conditions. Salmonids migrate more quickly through areas of poor conditions and more slowly (i.e., feeding) in areas of improved conditions. Chinook salmon abundance and distribution along the coasts of Washington and Oregon is highly variable between cold and warm ocean years (Bi et al., 2011; Peterson et al., 2010).

Sharma and Quinn (2012) found ocean-type Chinook salmon from the upper Columbia and Snake rivers migrated primarily on the continental shelf, and stream-type Chinook salmon from these basins primarily migrate off the shelf to the open ocean (Figure 96).

Possibly due to spawning ground overlap (subyearling vs. yearling smolts; spring vs. fall adult run timing), Chinook salmon life history types from the lower Columbia River did not diverge significantly in their ocean migration routes. These findings could have implications for harvest management (e.g., migration corridors, time-area closures) since fishing pressure is more intense in the coastal ocean compared to the high seas and Chinook salmon from the upper Columbia and Snake rivers have larger proportions of stream-type than ocean-type life histories (Waples and Drake, 2004; Sharma and Quinn, 2012). Sub-yearling Chinook remain in coastal waters near their river of origin during their first year at sea, regardless of type, and proceed northward during their second year at sea (Trudel et al., 2009; Duffy and Beauchamp, 2011; Murphy et al., 2009; Tucker et al., 2011).

Food-web structure (prey abundance, composition, and quality at the lower trophic levels) is set by currents, which are affected by large-scale atmospheric forces. Food-web structure and predation affects the growth and survival of juvenile salmonids in their first weeks in the ocean. Migration rates during the first months at sea are higher during years of poor ocean conditions (Jacobson et al., 2012).

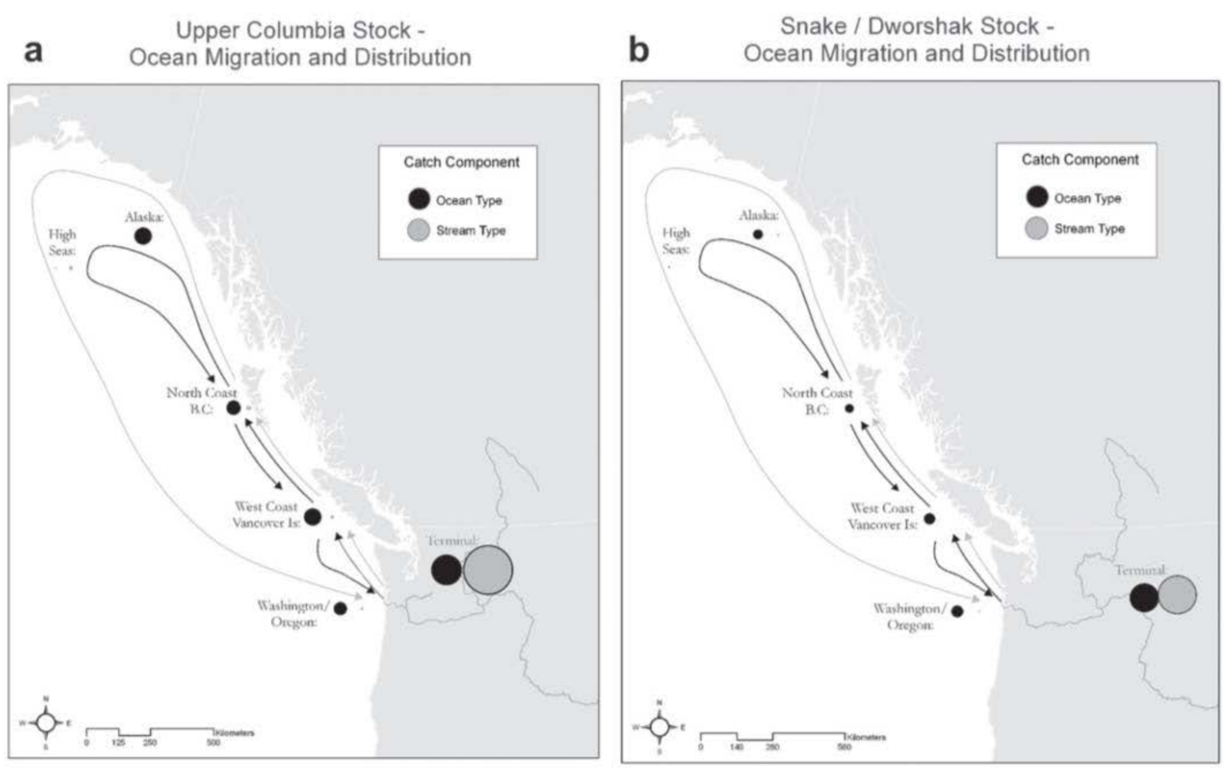


Figure 96. Recovery Patterns and Migration Pathways of Upper Columbia River (a) and Snake River Chinook Salmon (b). Arrows show outward and return migrations. Circle sizes indicate proportion of overall CWT recoveries in a particular area. From Sharma and Quinn, 2012.

Major Lessons Learned from RPA Subaction 61.2

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Habitat restoration should increase fitness, size, and condition of juvenile salmon through direct and indirect contributions of nutrients and organic matter that support salmon food webs in shallow-water, off-channel, and main channel habitats. These benefits from the LCRE will improve chances for survival during early ocean entry. The LCRE provides a transition zone from freshwater to seawater that is critical to prepare fish for entry into the ocean. The data support the premise that improved conditions in LCRE ecosystems support improved probability of survival during the first few weeks in the plume and nearshore ocean.

Lessons Relative to RME Implementation

Establishing statistical associations between environmental conditions during early ocean entry and smolt survival or SARs is difficult. Many interrelated abiotic and biotic variables are involved. Nonetheless, investigations of juvenile salmonid ecology and relationships with LCRE conditions (e.g. using multivariate modeling) are important to understand to support the LCRE restoration effort. As mentioned in RPA Subaction 61.1, RME should consider the estuary and plume environments a continuum due to their physical and biological coupling.

RPA Subaction 61.3 – *Investigate the importance of early life history of salmon populations in tidal fresh water of the lower Columbia River.*

Major Accomplishments and Findings in Implementing the RPA Subaction

Six projects have contributed to this RPA since 2008. Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary (Corps AFEP EST-P-11-01) investigated the importance of early life history of juvenile salmon in tidal freshwater habitat of the LCRE. CRE Contribution to Salmon Recovery (Corps Project AFEP EST-P-10-01) is a complementary study that assessed growth rates in tidal freshwater and their contribution to returning adults by analyzing otoliths from spawning salmonids in 2010-11. At the landscape scale, **BPA Project 2003-007-00** (Lower Columbia River Estuary Ecosystem Monitoring) monitored salmonid density, fish community composition, salmonid age-size structure, genetic stock identity, prey availability, residence times, spatial and temporal distribution, growth rates, and habitat characteristics throughout the LCRE to further investigate the importance of ELHD. **BPA Project 2009-020-00** (UW-CBR Internal Statistical/Technical Support to BPA) and **BPA Project 1989-107-00** (Statistical Support for Salmon) provided statistical support to the other projects supporting this RPA subaction.

A summary of GSI trends and timing are reported comprehensively in RPA Subaction 58.2. Please refer to that section for ELHD results from shallow-water habitats of the LCRE. In sum, 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. The following focuses on results and advances in measurements of juvenile salmon growth in the LCRE tidal freshwater.

Key Findings Include:

Bioenergetics and Growth. Feeding ecology and bioenergetics data showed that shallow *tidal freshwater* habitats in the SDR are making positive contributions to juvenile salmon growth and development (Johnson et al., 2011b; Storch and Sather, In Review). Feeding rates and gross conversion efficiency were sufficient for the allocation of energy to somatic growth for juvenile salmon. See RPA Subaction 58.3 for more detail.

Otolith Research to Validate Methods for Back Calculating Juvenile Salmon Sizes and Growth Rates. 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. 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 River 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-fresh 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 analyzed on adult otoliths. In this method, residency in tidal-fresh habitats might be inferred as the otolith region between the artificial strontium signature (i.e., applied to downstream migrants) and the natural strontium signature (i.e., 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. Chemical analysis of adult Chinook otoliths from the Grays River and Coweeman River was completed. Similar adult otolith analyses are planned for six other Columbia River tributaries (Lewis, Willamette, Sandy, Priest Rapids, Wenatchee, and Methow rivers) 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 (D. Bottom, personal communication).

Major Lessons Learned from RPA Subaction 61.3

Lessons Relative to Action Implementation – Estuary Habitat Restoration

Overall, recovery of listed species should benefit from efforts to restore shallow, tidally-influenced freshwater areas because juvenile fish, regardless of the rearing type, are captured in these habitats year-round. Unmarked Chinook salmon far out-numbered catches of marked Chinook salmon, indicating unmarked fish use shallow tidal freshwater to a greater extent than marked fish. The data support restoration of shallow tidal freshwater habitats to aid recovery of wild fish populations. In tidal freshwater, genetic stock composition for Chinook salmon varied depending on river reach, and stock diversity was higher in samples from SDR (rkm 188–202) compared to LRR (rkm 109–141). This indicates restoration strategies may need to consider longitudinal position (distance from the mouth) in the LCRE. Finally, managers should consider the spatial and temporal variability in fish communities during restoration planning processes as well as during evaluation phases (e.g., action effectiveness monitoring, and research).

Lessons Relative to RME Implementation

A summary of lessons learned about species - GSI - and timing are reported in RPA Subaction 58.2. Please refer to that section for lessons learned regarding ELHD in shallow-water habitats of the LCRE.

Stock-specific life-stage survival improvements resulting from habitat restoration in the LCRE could potentially be assessed. A sensitivity analysis might be performed that could suggest differential improvements for different life history strategies and stocks. This information could then be used by the ERTG in their assignment of SBs, thus providing higher resolution benefit analysis to a variety of juvenile salmonids. Under key findings for otolith research, 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. An important caveat on the available data is that sampling represents the shallow-water portion of the tidal freshwater environment, not the deeper main channel area. Future studies may be more inclusive of shallow and mainstem habitats.

Some studies sample monthly. However, even this leaves a potentially significant data gap respective to stock-migration timing, particularly for those stocks that exhibit a narrow migration period, such as Snake River Basin sockeye salmon. As such, the relatively small numbers that are encountered during those discrete sampling days and times may be significant (i.e., when distributed over a large area of potential estuarine habitat).

Results from migration and residence studies do not represent patterns of fish movement and residency for all populations of juvenile salmon using tidal freshwater. Smaller sized fish less than 95-mm cannot be tagged with a JSATS, hence conclusions about timing, pathways, and residency only characterize fish >95 mm. Future technology advances to permit tagging smaller fish are underway.

Although estuary studies evaluating ELHD of juvenile salmonids have occurred through the estuary, species-specific habitat use has still not been adequately characterized. And, few studies have assessed the relative proportion of fish-use in the mainstem compared to fish-use to shallower water areas (e.g., tributary confluences, tidal wetland channels, floodplain lakes, etc.). Johnson et al. (2011b) reported 3-11 percent of tagged juvenile salmonids migrated through off channel areas in the vicinity of the SDR. These fish were actively migrating when they were captured and tagged.

Johnson et al. (2011b) concluded, the presence of juvenile salmon in the year-round catch implies multiple life-history strategies are being expressed and, therefore, year-round sampling is necessary to obtain a holistic understanding of life-history strategies. And, RME has yet to effectively relate early life history types that contribute to adult returns from a diversity of ESUs.

RPA Subaction 61.4 – *Continue development of a hydrodynamic numerical model for the estuary and plume to support critical uncertainties investigations.*

Major Accomplishments and Findings in Implementing the RPA Subaction

From 2008, modelers worked to develop an advanced observatory for the Pacific Northwest coastal margin, including the Columbia River estuary and plume. CORIE served as the heart of the observatory with its modeling system, observation network, and cyber-infrastructure. Modeling was used to evaluate contemporary and future habitat changes caused by climatic and anthropogenic effects and to describe the temporal and spatial features of the Columbia River estuary and plume that are important for salmon in relation to ocean conditions. This work continued in 2009 and 2010. In 2010, the model was updated with annual predictions of the relative survival of juvenile coho and Chinook salmon in the Columbia River plume (based on ocean conditions). Around this time, Science and Technology University Research Network (SATURN) expanded upon CORIE and integrated networked sensors, platforms, models, data, analyses and social processes. Outputs from SATURN function as a contemporary, virtual Columbia River (see Figure 97) (*http://www.stccmop.org/datamart/virtualcolumbiariver*).

To address critical uncertainty with respect to historical changes and contemporary status of salmon habitat availability, **BPA Project 2003-010-00** (Historic Habitat Opportunities and Food-Web Linkages, later transferred to the Corps, AFEP EST-P-10-01) used hydrodynamic modeling to hindcast how salmon habitat availability has changed in response to human and climate alterations in river flow, temperature, tidal regime, and sediment budget over the last century.

In 2011, AFEP EST-P-10-01 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. Researchers simulated daily forecasts of circulation based on one full year (2000) of a simulation database. In 2011, AFEP EST-P-04-01 progressed on the development of an

ATIIM, although this is not technically a hydrodynamic model. The ATIIM integrates advanced terrain processing of LiDAR elevation data; in situ, modeled, or synthesized hourly water surface elevation data; and a wetted area algorithm to determine two- and three-dimensional inundation extent. Hydrologic processes metrics and other landscape metrics (such as channel density and topographic roughness) include: maximum inundated area, maximum frequency and duration, inundated area, and water volume fluxes. This study also quantified water-level variations relative to the various sources of external forcing as dominant and described the impacts of water-level variations on wetland vegetation patterns as a fundamental indicator of ecosystem processes.

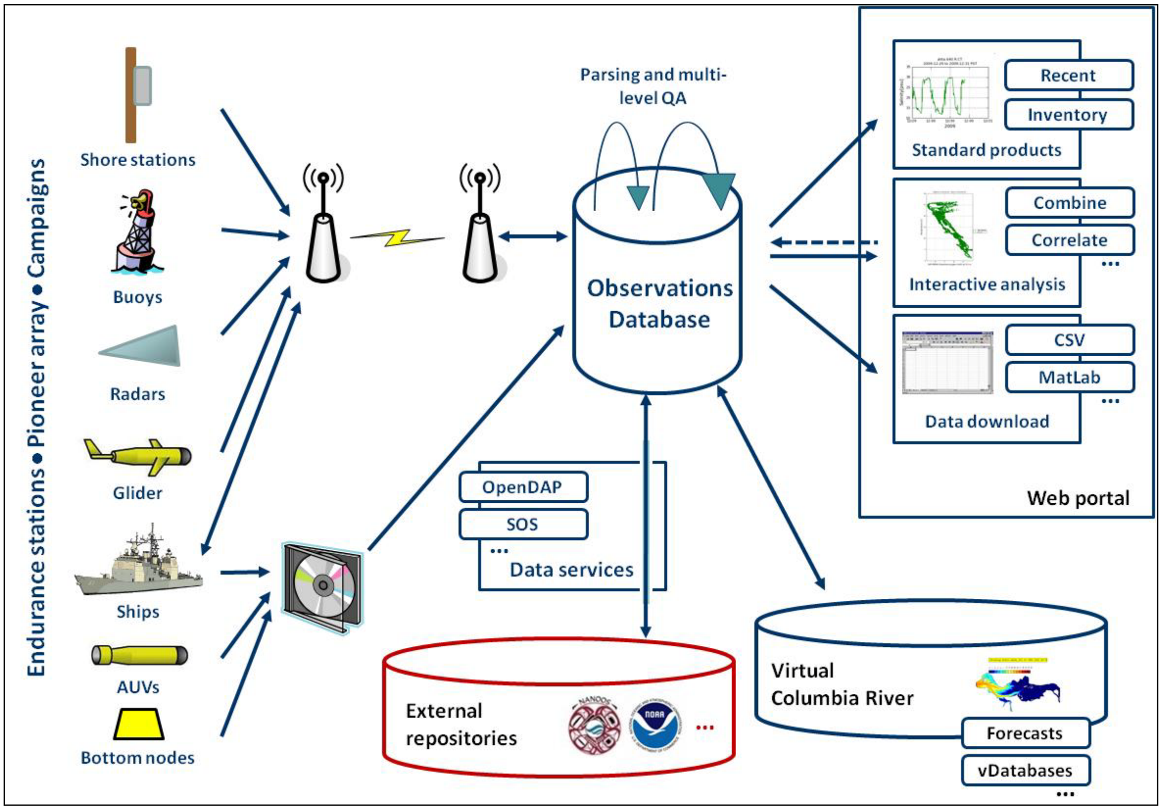


Figure 97. A High-Level View of the Science and Technology University Research Network (SATURN) Cyber-Infrastructure, with Focus on the Handling of Observational Data.

Following are key results from the study:

Biophysical Zones. Four zones were identified in the LCRE, based on physical dynamics and vegetation effects: 1) *the lower estuary zone* (rkm 0–21) is affected by tides and salinity intrusion; 2) *the energy minimum zone* (rkm 21–87) is affected by tides and river flow, but not by salinity intrusion; 3) *the tidal river zone* (rkm 87–229) is where river flow effects increasingly dominate in the landward direction over tidal effects; and 4) *the landslide-controlled zone* (rkm 229–235) consists of the final 6 km of the system below Bonneville Dam and is characterized by a distinctive vegetation assemblage and a much steeper bed slope than the tidal river than elsewhere in tidal freshwater of the LCRE. Water-surface elevation and duration of inundation affect plant communities integral to juvenile salmon habitats (Jay et al., In Revision).

Favorable Habitat Opportunity. The LCRE water-level regime is influenced by tides, river flow, hydropower operations, and atmospheric effects. Flows over 250 kcfs increase the *consistency* of favorable habitat opportunity in the LCRE, especially true when incorporating future sea level rise scenarios (Figure 98). In general, habitat patches suitable for juvenile salmonid use are more consistent through time in the lower estuary (dominated by tides) and fluctuate through time in the upper reaches (dominated by river discharge, muted tidal influence). To date, it appears that "ocean-type" interior, ESA-listed stocks spend more time in the LCRE upper reaches that exhibit more variable habitat patches suitable for juvenile salmonids (Jay et al., In Revision).

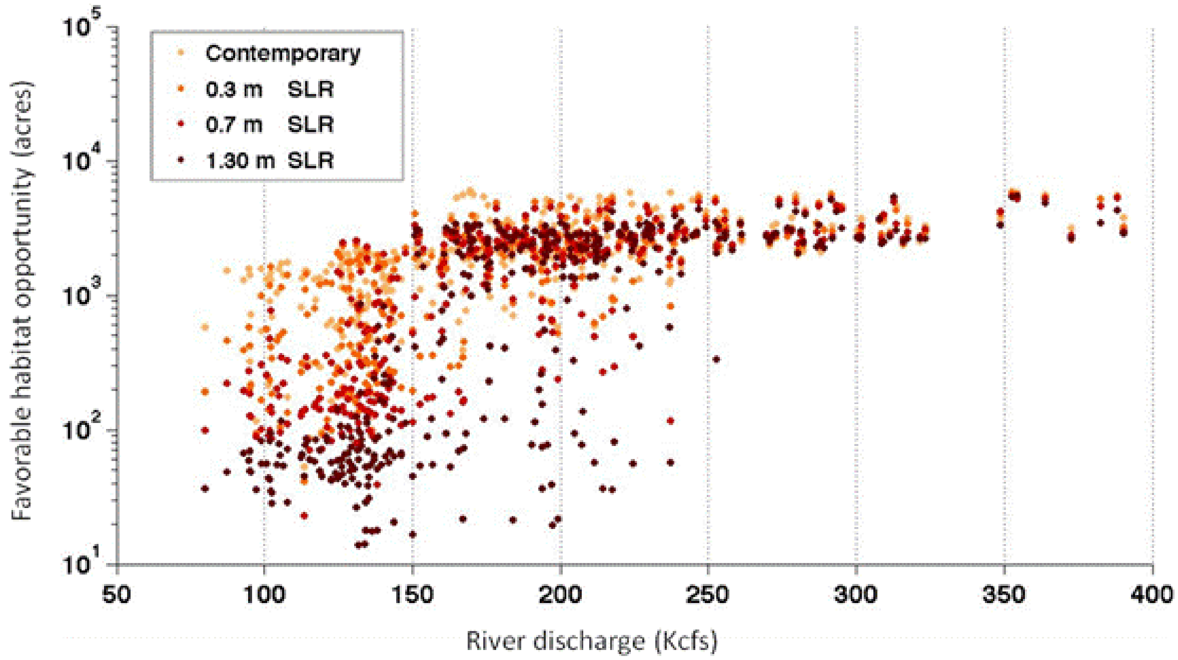


Figure 98. Modeling Suggests that There Are Important Habitat Opportunity Thresholds under Different River Discharge and Sea Level Rise (SLR) Scenarios (Rostaminia et al., 2012).

Habitat Opportunity Flow Threshold. Flows over 250 kcfs increase the overall consistency of favorable habitat opportunity in the LCRE, especially under future sea level rise scenarios. In general, habitat patches suitable for juvenile salmonid use are more consistent through time in the lower estuary (dominated by tides) and fluctuate through time in the upper reaches (dominated by river discharge, muted tidal influence).

Predation Flow Threshold Hypothesis. Emerging information suggests that during high river flow events forage fish such as herring, anchovy, and surf smelt may not be prominent in estuarine fish assemblages (Anderson et al., 2007; Weitkamp et al., 2012). It is possible that during high flow period juvenile salmonids will comprise a higher percentage of prey items in Caspian tern diets in the estuary.

Food Web Flow Threshold (Preliminary). At flows below 140 kcfs, researchers have noted that non-toxic red ciliate (*Myrionecta rubra*) blooms in the estuary (Figure 99). The ecological role of this ciliate and relation to juvenile salmonids is an area of active research.

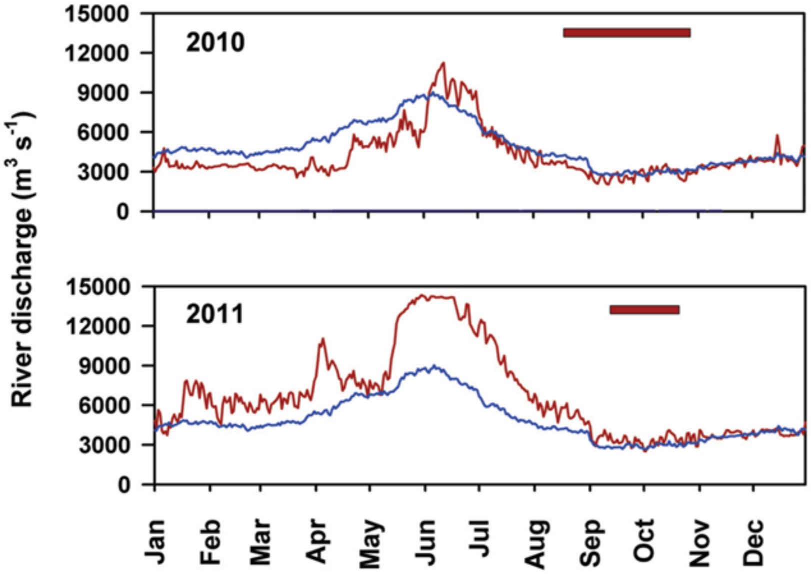


Figure 99. Instantaneous (Red) and Smoothed (3-day Running Average, Blue) river Discharge Volumes in m3 s-1 in 2010 and 2011 with the Approximate Timing of Red Water Blooms of M. rubra (red bar in figure) Shown (modified from Li et al., 2012).

Major Lessons Learned from RPA Subaction 61.4

Lessons Relative to Action Implementation – Estuary Habitat Restoration

In the future, SATURN may offer possible guidance on the optimal timing of steelhead smolt release that would maximize SAR ratios using extensions of the Virtual Columbia River daily forecasts with historically observed SAR ratios paired with in-simulation metrics of plume size and location. Other areas of interest include the role of plume fronts potentially linked to avian predation and the impact of coastal hypoxia on salmon behavior inside the estuary.

Understanding of relationships between natural (e.g., tides) and anthropogenic (e.g., power peaking) effects on ecosystem controlling factors (e.g., water-surface elevation), structures (e.g., vegetation communities), processes (e.g., detrital export), and tidal wetland development is foundational to implementation of successful ecological restoration projects, specifically habitat availability, food web process and flux, and subsequent juvenile salmonid feeding, growth and fitness.

Lessons Relative to RME Implementation

Hydrodynamic modeling identified the need for further refinements in the local grid and changes in ocean boundary conditions for the model. Researchers began exploratory computation of salmon habitat opportunity indices in the tidal fresh portion of the estuary, based on previously developed criteria for water depths, velocities, and temperatures. Plans for 2013 include detailed habitat-opportunity modeling in Reach F using a higher resolution grid. They also will explore methods for integrating the results of the habitat modeling into salmon life cycle models, including interior basin stocks. Of particular interest will be methods for integrating salmon performance measures within the estuary (as influenced by habitat opportunities and capacities) to the viability and recovery of populations. Application of the SATURN system is emerging as an integrative tool to interpret different circulation processes, variability, and change in the estuary and shelf environments, and these changing environs affect salmonid survival.

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.*
2. *Evaluate methods to develop or expand use of selective fishing methods and gear.*
3. *Evaluate post-release mortality rates for selected fisheries.*
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.*
5. *Investigate the feasibility of genetic stock identification monitoring techniques.*

RPA Subaction 62.1 – *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.*

Major Accomplishments and Findings

Since the release of the BiOp on the FCRPS, eleven projects were initiated or continued to fully address this RPA subaction. For example, **BPA Project 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 2011, WDFW and the PSMFC, with funding from 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.

Additionally through the Accord program, the Yakama Indian Nation and the CRITFC modified the scope of project 2008-502-00 and implemented enhanced fishery sampling for the 2012 fall season fisheries. The funding provided for an increase in funding for the tribal creel sampling program and funded new biological data collection within the fishery. The funding was utilized to add sampling time for the existing four creel monitors and provided funding for three staff members who collected biological data from the tribal fishery including some PIT-tag sampling.

Lessons Learned

The development and implementation of a modified catch sampling program to include PIT-tags has been more difficult than originally anticipated. However, in the last two years, the harvest managers have begun to implement changes in catch sampling programs to include Pit-tags. At this point in implementation the collection data needs to be analyzed to determine if it is useful in determining if harvest parameters can be determined using this technology and sample rate. As we continue to add fishery seasons, we should be able to determine if these efforts are providing quantifiable data to inform decision makers.

RPA Subaction 62.2 – *Evaluate methods to develop or expand use of selective fishing methods and gear.*

Major Accomplishments and Findings

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 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 Okanagan 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 2007-249-00** has been superseded by **BPA Project 2008-105-00** (Selective Gear Deployment) as the applied research has progressed into an implementation management tool.

Principal findings and accomplishments for **BPA Project 2007-249-00** (Evaluation of Live Capture Gear) and **BPA Project 2008-105-00** (Selective Gear Deployment) include both basic and applied research objectives. The highlights of which are:

1. Strengthened the viability and fitness of naturally produced Chinook populations by reducing the proportion of pHOS on spawning grounds.
2. Documented immediate release mortality of sockeye.
3. Selectively harvested sockeye and hatchery-origin Chinook while successfully releasing natural-origin Chinook and steelhead.
4. Tested the catch efficiency and immediate release mortality of different live capture gears, including purse seine, beach seine, tangle net, hoop net, dip net, weir and Merwin trap.

In addition, **BPA Project 2007-249-00** (Evaluation of Live Capture Gear) also facilitated the transition from gill net (non-selective) fishing to tangle net (selective) fishing by the tribal membership at large. This provided tribal members the opportunity to check out tangle nets from the program for personal use and provided tribal gill net fishermen with tangle net mesh so they can construct and reconfigure their personal nets. The project also constructed a salmon processing building for ice machine and fish storage.

BPA Project 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. Over the last four years project implementers have significantly increased production and outplanting in existing net pen rearing areas. This has resulted in an increase in the proportion of total commercial landed catch from SAFE areas.

RPA Subaction 62.3 – *Evaluate post-release mortality rates for selected fisheries.*

Three BPA projects were continued to support this RPA. **BPA Project 2007-249-00** (Evaluation of Live Capture Gear), which evolved into **BPA Project 2008-185-00** (Evaluate Live-Capture Fishing Gear for Salmon), incorporated monitoring protocols to assess fish condition after capture, holding, and release. This project tested the catch efficiency and immediate release mortality of different live capture gears, including purse seine, beach seine, tangle net, hoop net, dip net, weir and Merwin trap. This project was able to document the immediate release mortality of sockeye.

RPA Subaction 62.4 – *Support coded-wire tagging and coded-wire tag recovery operations that inform survival, straying, and harvest rates of hatchery fish by stock, rearing facility, release treatment, and location.*

BPA has funded the recovery and stock identification of coded-wire tags since the early 1980s. Since 2008, twenty projects have been funded that address this RPA subaction. These projects include CWT 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. BPA funding for these twenty projects in FY 2012 was $5,434,900. BPA also provided approximately $1,000,000 to fund the coded-wire tagging program for the Lower Snake River Compensation Plan, for total FY 2012 coded-wire tag program funding of over 6.4 million dollars.

Coded-wire tag insertion occurred at state hatcheries in Oregon, Washington, and Idaho, hatcheries operated under the Mitchell Act, and several tribal hatcheries. Tag recovery efforts were funded in sport, commercial, and tribal fisheries, at hatcheries, and via spawning ground surveys in numerous tributaries in Oregon, Washington, and Idaho. Tag decoding labs were funded in Oregon, Washington, and Idaho, with additional decoding funded at some tribal hatcheries. BPA funded the Regional Mark Processing Center operated by the PSMFC, and the data is used to inform studies of survival, straying, and harvest rates of hatchery fish by stock, rearing facility, release treatment, and location. Specific analyses were funded by BPA for hatchery operations, sport and commercial fishery management, run reconstruction, and other purposes.

The coded-wire tag recovery program has been expanded and received additional funding over the past two years through the addition of project 2010-036-00, the Lower Columbia River Coded Wire Tag Recovery Project, sponsored by the WDFW. In 2012, coded-wire tag recovery work conducted by PSMFC and WDFW that was occurring under project 1982-013-01 was transferred to project 2010-036-00 to increase tag recovery efficiency and coordination on the Washington side of the lower Columbia River. Crews working under project 2010-036-00 have begun recovering PIT-tag data and taking genetic samples as part of their coded-wire tag recovery protocol. PIT-tag data is uploaded to PTAGIS and genetic samples are sent to the Hagerman National Fish Laboratory. This is expanding data collection and increasing the efficiency among different types of tagging programs.

RPA Subaction 62.5 – *Investigate the feasibility of genetic stock identification monitoring techniques.*

Multiple BPA projects have studied salmonid genetics to advance Chinook and steelhead stock identification so that any or natural- or hatchery-origin Chinook or steelhead can traced to its stock of origin in sampling programs at dam or mainstem sampling programs and in ocean fisheries. PBT technologies have been developed to identify the specific hatchery stock and age of sampled hatchery fish. Additionally, Genetic Stock Identification (GSI) techniques utilizing SNPs technology have been developed to segregate wild runs of Snake River Spring/Summer Chinook and Snake River Steelhead by stock of origin.

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.

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.

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

RPA Subaction 63.1 – *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).*

For this subaction, several projects continue to be funded to support RME for populations associated with the implementation of RPA Actions 41 and 42 (Implement Conservation Programs to Build Genetic Resources, Reduce Short-term Extinction Risk and Assist in Promoting Recovery), see tables 7 and 8.

Information needed to support this RPA subaction includes two categories of RME: 1) population status and trend and 2) hatchery effectiveness monitoring. Metrics such as abundance and productivity by origin (i.e. hatchery or natural), stray rates of hatchery-origin fish, and life history characteristics enable managers to understand how the hatchery program is affecting the VSP parameters that indicate viability, and ultimately recovery.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)

Snake River Spring/Summer Chinook ESU and Steelhead DPS

Idaho

BPA Project 1989-096-00 (Genetic M&E Program for Salmon and Steelhead): This project is in its 11th sampling year. The primary goal of this project is to manage the genetic monitoring of Chinook salmon and steelhead populations in the Snake River Basin, with a particular focus on the effects of artificial propagation on both targeted and non-targeted populations. Information collected includes annual monitoring of genetics through juvenile sampling, and investigation of reproductive success in hatchery- and natural-origin fish in four river basins. The project has been successful in genotyping several of the populations identified in tables 7 & 8 of the RPA Actions 41 and 42 (for example, in the Grande Ronde, Imnaha, and Salmon river basins). By tracking the genetic diversity of the populations, it will be possible to determine whether diversity is changing over time for hatchery- and natural-origin fish. This study continues to collect important information on the genetic status of the Snake River Chinook ESU and steelhead DPS.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-Idaho Department of Fish and Game) began in 1992 and focuses on collecting information on the Snake River Chinook ESU (Salmon River, which are listed under ESA and Clearwater River Chinook, which are not listed) to determine the benefits and risks of hatchery supplementation. Information on the number and origin of adult salmon is collected through redd surveys and weir counts in the numerous subbasins of the Salmon and Clearwater rivers. The number of juveniles passing collection sites, and their subsequent survival to Lower Granite Dam, is also estimated on an annual basis. This study has been on-going for numerous years and provides important status and trend information concerning population tracking ("fish-in – fish-out").

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

Between 1998 and 2009, surveyors observed 24-384 redds, with total escapement estimated between 183-1,579 fish. Between 1997 and 2007, survival to Lower Granite Dam averaged 0.51 for natural-origin smolts and 0.31 for hatchery-origin smolts. Between years 1998 and 2004, the P:P geometric mean was 0.62 for natural-origin fish and 1.87 for hatchery-origin fish.

The information provided by this project shows that the hatchery program is successfully returning more fish than if they were left to spawn in the wild, and continues to gather information to inform whether the program is increasing viability and promoting recovery.

In a recent publication related to this project (Hess et al., 2012), the reproductive success of hatchery-origin fish that had successfully spawned in the wild was similar to natural-origin fish. **BPA Project 2007-403-00** (Spring Chinook Captive Propagation-Idaho) began in 1995 and concluded in 2010. The goal of the program was to provide a "safety-net" to preserve the genetic resources of Grande Ronde River spring/summer Chinook, which are part of the Snake River spring/summer Chinook ESU. Average survival for all stocks and broodyears was 62.3 percent with a standard error of 4.0. The lower and upper 95 percent confidence limits for marine survival for all stocks and broodyears were 54.1 to 70.5 percent respectively. This program, united with the IDFG efforts (2007-404-00), returned 3,778 maturing adults that have been used to aid in the restoration of self-sustaining natural runs of spring/summer Chinook to the Salmon River Basin. This project preserved genetic resources of the target populations and was successful in returning adults to these populations.

BPA Project 2010-057-00 (B-run Steelhead Supplementation Effectiveness Research) is linked to RPA Action 41, which focuses on B-run steelhead supplementation effectiveness research to better address the abundance, productivity, spatial structure, and diversity of B-run steelhead in the Clearwater River Basin. Starting in 2012, data is being collected by the antenna array systems on both the SF Clearwater and Lolo Creek and through radio telemetry on the SF Clearwater. Full implementation will be realized in 2014.

Oregon

BPA Project 1992-026-04 (Grande Ronde Early Life History of Spring Chinook and Steelhead) focuses on the Snake River ESU and DPS on the Grande Ronde River populations of Chinook salmon and summer steelhead. The objectives of this study are to collect or derive information pertaining to juvenile salmon migration and survival patterns both within and outside the Grande Ronde River Basin. Information collected includes migration timing, juvenile abundance, and life stage survival rates, and survival to Lower Granite Dam from four streams within the basin.

Findings indicate that spring Chinook salmon and steelhead exhibit fall and spring movements from natal rearing areas, but they do not begin their smolt migration through the Snake and lower

Columbia River hydrosystem until spring. Migration timing varied between years and populations. This information is important to determine life history characteristics of naturally produced fish from the study populations. **BPA Project 1998-007-02** (Grande Ronde Supplementation O&M and M&E on Lostine River) was initiated in 1997 to monitor and evaluate the Chinook salmon conventional hatchery program for the Lostine River (**BPA Project 1998-007-02**), and the SRCP and conduct the monitoring and evaluation of juvenile acclimation and adult returns for the Grande Ronde Basin Spring Chinook Captive Broodstock Program. This population is part of the Snake River spring/summer Chinook ESU. Escapement, spawner abundance and distribution are estimated through redd surveys and mark-recapture methods. In addition, life history characteristics information is collected through sampling of fish collected for broodstock and carcass surveys, which enable researchers to estimate VSP parameters, such as productivity and diversity. Genetic diversity is measured also through tissue sampling.

Results from this project have shown: 1) overall distribution of natural- and hatchery-origin female carcasses recovered above, within, and below the index areas was similar and no significant differences in overall distribution of carcasses has been detected; 2) survival of natural-origin Chinook salmon juveniles from the Lostine River screw trap to Lower Granite Dam has not been significantly different from hatchery-origin Chinook salmon juveniles within the same reach; 3) natural-origin Chinook salmon have significantly higher rates of smolt-to-adult survival than hatchery counterparts for a period of six brood years; and 4) significant differences were found between natural and hatchery mean brood year age class structure from 1997 to 2005, with hatchery-origin fish showing a younger age at return. The 2010 annual report concludes that increased production of juvenile hatchery fish for supplementation has lessened the risk of demographic extirpation. The information reported from this study is important because it is directly addressing critical uncertainties related to hatchery supplementation.

BPA Projects 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) report on fish culture activity (holding and spawning of adults, rearing juveniles, fish health monitoring, and redd surveys) for these programs, which are run in conjunction with the LSRCP. These projects are associated with this subaction because they also collect spawner (redd count) information.

The goal of **BPA Project 1998-016-00** (Escapement and productivity of spring Chinook and steelhead) is to collect information on the status, trends, and distribution of spawning activity, juvenile salmonids, and aquatic habitat conditions within the John Day River Basin. This project collects information on steelhead (mid-Columbia River steelhead DPS) and Chinook salmon (non-listed mid-Columbia Chinook ESU) in the John Day River. Information includes status and trend monitoring of distribution and abundance. Estimates are also made on origin of returning adults, which is important because there are no hatchery fish released into the basin. This project also estimates SARs for fish captured at screw traps (where estimates of total juveniles is also derived).

The information collected by this project is important because there are no hatchery fish released within the basin. While other variables need to be considered prior to using the John Day River Basin as a reference for other basins where hatchery programs are operating, it is difficult to find a large river basin within the Columbia River Basin that does not have a hatchery program. The ISAB and Ad Hoc Supplementation Workgroup (AHSWG) recommend that future work should include comparisons to a reference condition.

BPA Project 2007-083-00 (Grande Ronde Supplementation M&E on Catherine Creek/Upper Grande Ronde River) has been on-going for 11 years. The goal of the project is to monitor and evaluate supplementation of endemic spring Chinook salmon in Catherine Creek and the upper Grande Ronde River, which are part of the Snake River spring/summer Chinook ESU. In addition, this project collects information on summer steelhead of the same two river systems, and these steelhead belong to the Snake River steelhead DPS. Information collected for the Chinook salmon portion of the project includes: comparison of hatchery- and natural-origin juveniles for migration timing and survival to Lower Granite Dam, length, and weight. In addition, comparisons are made between hatchery-and natural-origin adults for migration timing (arrival at traps), SAR, progeny-per-parent ratios, abundance, age, length and sex frequencies, hatchery/natural ratios, occurrence of strays, spawn timing, redd distribution, prespawning mortality, and egg size. For the steelhead portion of the project, information collected includes: life history metrics including migration timing (arrival at traps), age, abundance, migration status (upstream (prespawn) or fallbacks (post-spawn)), length frequencies and sex ratios, occurrence of strays, and hatchery/wild ratios.

For Chinook salmon, hatchery-origin juveniles sampled at the upper Grande Ronde River acclimation facility had substantially greater mean fork length, weight, and K factors than natural-origin juveniles PIT-tagged and released. Survival probability of the entire group of upper Grande Ronde River hatchery-origin juveniles has been similar to that of natural-origin fish. Smolt-to-adult ratios for hatchery-origin fish have been consistently lower than for natural-origin fish. Differences in life history were evident between hatchery- and natural-origin juvenile outmigrants. There were few differences between life histories of hatchery- and natural-origin adults, other than age structure (more age 3 returns and less age 5 returns for hatchery fish).

This study continues to collect important information on abundance, productivity, and life history attributes of Snake River Chinook ESU and steelhead DPS.

BPA Project 2007-404-00 (Spring Chinook Captive Propagation-Oregon) began in 1995 and concluded in 2010. The goal of the program was to provide a “safety-net” to preserve the genetic resources of Grande Ronde spring/summer Chinook, which are part of the Snake River spring/summer Chinook ESU. This program, united with the ODFW captive broodstocks, returned 4,205 maturing adults over the course of 12 brood years that have been used to aid in the restoration of self-sustaining natural runs of spring/summer Chinook to the Grande Ronde River Basin. This project preserved genetic resources of the target populations and was successful in returning adults to these populations.

Washington

The goal of **BPA Project 2010-042-00** (Tucannon Expanded PIT-tagging) is to increase the detection of PIT-tagged steelhead (Snake River steelhead DPS) and spring Chinook salmon (Snake River spring/summer Chinook ESU) that enter the river upon return as adults. The primary purpose of the increased detection will assist managers in determining abundance and origin of primarily steelhead (Chinook redd count and carcass surveys are much more effective than steelhead surveys) entering the Tucannon River and detect fish that may stray into the river. In recent years, it has been observed that a large portion of returning steelhead are passing the Tucannon River and passing Lower Granite Dam (upstream of the mouth of the Tucannon River). This project is intended to assist managers in determining what proportion of fish find their back to the Tucannon River that may have previously strayed.

The tagging array was maintained in operation for all but 14 days in 2011, and the target of 3,000 steelhead tagged was nearly met (N = 2,855). Continued PIT-tagging of natural-origin fish captured at screw traps will help managers understand if stray rates of returning hatchery-origin fish are similar for natural-origin fish.

Snake River Sockeye Salmon ESU

The immediate goal of **BPA Project 2007-402-00** (Snake River Sockeye Salmon Captive Broodstock), which began in 1991, is to utilize captive broodstock technology to conserve the population’s unique genetics of the Snake River sockeye salmon ESU. The long-term goal is to reach interim abundance guidelines for delisting and provide for sport and tribal harvest. Methods related to RME for this project rely on sport fishery evaluation on Redfish Lake, smolt out-migration M&E at lake outlets, telemetry studies of mature adult sockeye salmon released to Sawtooth Valley lakes for natural spawning, and predator investigations in tributaries to Redfish and Alturas lakes.

Smolts leaving the lakes are sampled each year from traps located at Redfish Lake Creek, Alturus Lake Creek, and Petit Lake Creek. As an example, in migrant year 2009, 5,204 (1,392 natural- and 3,812 hatchery-origin), 602 (316 natural- and 286 hatchery-origin), and 3,008 (all natural-origin) fish were sampled at the Redfish, Alturus, and Pettit traps, respectively. From these numbers and trap efficiency trials, the total number of smolts is estimated and overwinter survival of hatchery-origin pre-smolt releases is estimated. Using fish that are PIT-tagged, survival to Lower Granite Dam is also estimated each year. For example, in the 2009 smolt migration year, survival ranged from 28-89 percent, depending on origin, or release group. Monitoring since 1991 has shown an increase in the number of natural-origin smolts leaving the three nursery lakes.

This is an important project that allows managers to understand how well the safety-net program is accomplishing the goals of the program. This project is documenting the safety-net program well and also has been including the full (historical) data set of most of the information collected. Future project objectives include evaluation of how the program is affecting viability and recovery of the Snake River sockeye ESU.

Lower Columbia River Chum Salmon ESU

The goals of **BPA Project 2008-710-00** (Development of an Integrated strategy for Chum Salmon Restoration in the tributaries below Bonneville Dam) include: 1) reintroduction of chum salmon (that are part of the lower Columbia River chum salmon ESU) into Duncan Creek by providing off-channel high-quality spawning and incubation areas; and 2) simultaneously evaluation of natural recolonization, direct adult supplementation, and hatchery fed-fry supplementation. Four criteria are used to evaluate the success of this program: 1) egg-to-fry survival rates in the renovated channels; 2) survival of the eggs and fry used in the Duncan Creek artificial rearing program; 3) survival and spawning-ground distribution of adult chum salmon produced from both the spawning channels and the artificial rearing program; and 4) the straying rate of non-program chum salmon into Duncan Creek. The monitoring portion of the Duncan M&E includes documenting and monitoring the physical attributes of the channels, including gravel composition, sedimentation load, dissolved oxygen (DO) levels, vertical hydraulic gradients and water temperatures in the hyporheic zone, and flow.

Preliminary estimates of the lower Columbia River chum salmon spawning populations (Ives Island, Horsetail, Multnomah and St. Cloud groups, excluding tributary spawners) for the fall 2007, 2008, and 2009 were 286, 230, and 230, respectively. Preliminary "apparent stray" rates are estimated at 3.1 - 11.3 percent. This program has been successful in reestablishing chum salmon below Bonneville Dam, although it is too early to understand any long-term effects of the program on viability of the target populations. This project is also important because it allows for assessment of whether the introduction program is effectively producing chum salmon in the target areas.

Basin-wide

Efforts to to facilitate the formation of a regional workgroup (currently designated the Columbia River Hatchery Effects Evaluation Team [CRHEET]) to coordinate monitoring of regional hatchery effectiveness, as well as implementation of the recommendations made by the AHSWG are on hold while NOAA Fisheries completes the ESA consultations on FCRPS mitigation hatcheries (see AMIP Amendment 6 of this document).

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

To assess the effects safety-net and conservation programs have on the viability and recovery of target populations, the projects that are associated with this subaction need to monitor and report on both hatchery effectiveness (e.g., compare productivity in a treatment stream to a reference condition) and VSP parameters (abundance, productivity, spatial structure, and diversity).

Most projects associated with this subaction are collecting information that is relevant to the implementation of this RPA. Some of the projects (e.g., 1996-043-00), have shown success in returning more fish to the stream using supplementation than fish that spawned naturally in the stream. Genetic information that has been collected (e.g., 1989-096-00) for populations that had been supplemented with hatchery-reared fish have shown genetic similarity to the within-basin hatchery source population, presumably because of the extensive use of native fish for hatchery brood stocks and minimal out-of-basin stock transfers (Van Doornik et al., 2011). Safety-net programs (e.g., 2007-402-00) have preserved genetic resources of the target populations and have increased adult abundance. Most projects collect life history information for both natural- and hatchery-origin fish and compare between the two. In general, life history characteristics are similar except juvenile size at migration (hatchery-origin fish are larger than natural-origin counterparts) and age-at-return, with hatchery fish returning at a younger age than natural-origin fish. In addition, natural-origin fish show consistent higher SARs than their hatchery cohorts.

However, two primary issues related to implementing this RPA subaction could be improved upon: 1) Improved synthesis, analysis, and reporting on information related to viability and recovery; and 2) further comparison of a reference condition (stream) to compare various metrics between the reference condition and the hatchery program (treatment). BPA is aiming to enable improved reporting and synthesis of findings across studies through the updated R,M&E reporting process that will be initiated in its pilot phase in 2013.

Synthesize, Analyze, and Report Information Related to Viability and Recovery

Most projects related to this subaction are reporting the information on annual basis. Future synthesis and analysis to assess status and trends as well as to determine whether or not a project is affecting viability or recovery will be reported in the future. In future, reporting results will be framed in terms of the VSP parameters, since these metrics are what NOAA Fisheries uses to determine viability (and ultimately recovery (as well as whether the limiting factors are addressed)).

Use a Reference Condition (Stream)

One project (**BPA Project 1998-007-02**, Grande Ronde Supplementation Operations and Maintenance and Monitoring and Evaluation on Lostine River) evaluated and reported information collected in a supplemented stream and compared it to a reference stream. Comparing information collected for the supplemented stream with a reference stream is a key factor in determining hatchery effectiveness (as outlined by the ISAB/ISRP and AHSWG), but difficult to accomplish because: 1) the lack of streams that are not supplemented, and 2) other factors (both biotic and abiotic) that need to be similar between streams. This information is already being collected in many streams where supplementation is not occurring (e.g., see 1989-098-00), so monitoring in additional streams is most likely not necessary. Factors such as abundance and productivity are key metrics that need to be compared between streams, unless there is a long-term data set prior to supplementation that can be used as the reference condition (before-after comparison). In theory, having both before-after and a reference stream increases the statistical power of the conclusions reached (Hillman et al., 2012 as an example).

Lessons Relative to RME Implementation

In most cases, restructuring and standardization of reporting, as required by the new format developed by BPA, should assist in increasing support of this subaction. Currently, most of the projects have not compiled their long-term data sets in their annual reports. New reporting templates implemented in pilot phase at the end of 2012 will provide project sponsors with opportunities to better coordinate, synthesize and analyze information so that findings will more fully address viability and recovery.

Coordination of analysis and reporting will assist the Action Agencies in comparing across projects. A possible venue for this coordination effort would be the establishment of CRHEET.

RPA Subaction 63.2 – *Determine the effect that implemented hatchery reform actions have on the recovery of targeted salmon and steelhead populations (Initiate in FY 2007-2009 Projects).*

For this subaction, the projects are being funded to support RME for populations associated with the implementation of RPA Action 40 (Ensure that Hatchery Programs Funded by the FCRPS Action Agencies as Mitigation for the FCRPS are not Impeding Recovery of ESUs or steelhead DPSs), Table 6.

Information needed to support this RPA subaction includes two categories of RME: 1) population status and trend, and 2) hatchery-reform monitoring. Metrics such as abundance and productivity by origin (i.e., hatchery or natural), stray rates of hatchery-origin fish, survival between treatments, and life history characteristics enable managers to understand how well hatchery-reform program is affecting the VSP parameters that indicate viability, and ultimately, recovery.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)

Upper Columbia River Steelhead DPS

The goal of **BPA Project 1993-056-00** (Advance Hatchery Reform Research) 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 current project uses upper Columbia River steelhead (DPS) to determine the effects of different rearing scenarios on survival and ultimately fitness. 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. For objective 1, information collected includes monitoring PIT-tagged fish as they migrate downstream from the hatchery release site to compare survival and migration timing between steelhead smolts that were reared for one year (traditional approach) and those that were reared for two years (treatment). In addition, weight, length, sex, and stage of maturity (from lethal subsampling) were collected. For objective 2, information collected in the laboratory included growth rate (length and weight over time), water quality (temperature, dissolved oxygen, pH, conductance, and total ammonium), and other behavioral information.

Initial findings from this project suggest that steelhead smolts that were reared for two years (S2) at the Winthrop NFH, survived to the first point of detection at significantly higher rates than age 1 year smolts (S1). In addition, S1 smolts had longer travel times through the hydro system, and that average size of smolts for both groups detected after release was higher than the average size of release, indicating some size selectivity after release. Researchers have also found that there was a gender bias of fish after release; fish sampled near the release site were male biased, while detections at Bonneville Dam showed the reverse. Physiological indices of smoltification indicated that levels of gill Na+-K+-ATPase activity in S1 parr were significantly lower than S1 “transitionals” and smolts from both groups. The assessment of smoltification suggests S2s were developmentally more uniform than the S1s at release. According to morphological and physiological assessments of maturation, the S1 group had a significantly greater proportion of males expected to mature a year after release (in 2012 at age 2) than the S2 fish (in 2012 at age 3). Behavioral aspects of the study are being initiated in the laboratory, results will be available in 2013.

This project will increase knowledge of the potential effects of a common hatchery practice, where steelhead are raised and released using a life history pattern (one-year in freshwater) that is not common for the species in general. By raising smolts to two years, and comparing the various metrics that are being collected through this study, it is anticipated that this project will be able to determine if the common practice is ultimately affecting the natural population's fitness.

To ensure support of this project for the subaction, the results and reporting should include how these findings may be affecting recovery.

Snake River Spring Summer Chinook ESU and Steelhead DPS

Two projects were initiated in 2010 and 2011, respectively, to address this RPA subaction regarding steelhead and Chinook populations in the Tucannon River (Snake River spring summer Chinook ESU and steelhead DPS, respectively): **BPA Project 2010-042-00** (Tucannon Expanded PIT-Tagging) and 2010-050-00 (Evaluation of the Tucannon Endemic Program). **BPA Project 2010-042-00** is reported on under RPA Subaction 63.1, and Project 2010-050-00 was implemented in 2011 and has not yet reported on implementation.

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

Research continues to determine whether hatchery reform actions are improving the ability to use hatcheries as part of increasing viability (and ultimately recovery) of targeted populations. These findings have direct applicability on broodstock management (including spawning timing) and rearing within the hatchery environment.

Other research (**BPA Project 1993-056-00**, Advance Hatchery Reform Research) has focused on the performance of steelhead smolts reared for two years perform compared to one-year old steelhead smolts. This is an important study to determine whether changing one of the life history characteristics of steelhead in the hatchery environment (freshwater residence time) affects survival and, ultimately, production of the targeted population. In addition, the study will be identifying behavioral and physiological traits under selection through laboratory-scale research. The results of this study will have important implications for improving the ability to raise fish in the hatchery that do not inhibit, but contribute to recovery.

In addition to above, many projects are in the early phases of meeting the actions identified in RPA Table 6 (e.g., transitioning to local broodstock for various steelhead programs), and as such, have not been reported on at this time.

Lessons Relative to RME Implementation

The projects associated with this subaction are in the initial phases of implementation. Reporting as required by the new format developed by BPA should ensure support of this subaction.

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.*

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

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.*

RPA Subaction 64.1 -- *Continue to estimate the relative reproductive success (RSS) 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 (Initiate in FY 2007-2009 Projects).*

For this sub-action, the projects are being funded to support RME for the specific populations described within the subaction.

Information needed to support this RPA subaction includes uncertainty research. Metrics such as abundance, origin, genotype, and age structure are needed to address this sub-action.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

<u>Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)</u>

Snake River Steelhead DPS

<u>Oregon</u>

One aspect of **BPA Project 1989-096-00** (Genetic M&E Program for Salmon and Steelhead) was discussed in the evaluation of RPA Subaction 63.1. This summary is specific to this RPA subaction which relates to RRS. Information collected included adult returns, age class, and genetic pedigree analysis that enabled the researchers to estimate reproductive success in hatchery- and natural-origin fish in three river basins (Lostine River, Catherine Creek, upper Grande Ronde River).

The reproductive success study in Little Sheep Creek (a tributary of the Imnaha River) analyzed both juvenile and adult life stages and found that RRS of pHOS was 30-60 percent that of their natural-origin counterparts. In a peer-reviewed published article from this study (Berntson et al., 2011), researchers found that the greatest effects on RRS were origin (natural vs. hatchery), length, return date, and the number of same-sex competitors. Natural parents were less negatively affected by same-sex competitors. Differential survival of juveniles and the behavior of offspring and/or spawning adults may all contribute to diminished fitness in hatchery-reared salmon, although it could not be determined to what extent these effects were of a persistent, heritable nature as distinct from an environmental effect associated with hatchery rearing and release strategies. These findings are consistent with other researchers (e.g., projects 2003-050-00 and 2003-054-00), and they provide managers and other stakeholders an understanding of hatchery effectiveness.

For the Catherine Creek RRS investigation, information for five brood years suggests that for adult-to-juvenile (estimated from the number of juveniles produced per parent), the geomean for RRS is 0.97 (1.04 for females, and 0.91 for males), and for adult-to-adult (number of adults returning per parent), the geomean of RRS is 0.83 (0.78 for female and 0.89 for males). While this information is preliminary (Berntson et al., unpublished), it is encouraging that the RRS is relatively (to other RRS studies) similar between the hatchery- and natural-origin Chinook salmon from this stream.

Snake River Fall Chinook ESU

Washington, Idaho, and Oregon

BPA Project 2003-060-00 (Evaluate the Relative Reproductive Success of Wild and Hatchery Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam) was completed. The study yielded valuable information on effective size and possible subpopulation structure. For additional information on RME for Snake River fall Chinook, please see RPA Subactions 64.3 and 65.1 below.

Upper Columbia Spring Chinook ESU

Wenatchee River

The goal of **BPA Project 2003-039-00** (M&E Reproductive Success and Survival in Wenatchee River) is to quantitatively evaluate the RSS of naturally spawning hatchery- and natural-origin spring Chinook salmon in the Wenatchee River (upper Columbia River spring Chinook ESU). This project: 1) directly measures the RSS of hatchery and natural-origin Chinook salmon in both natural and hatchery settings; 2) determines the degree to which any differences in reproductive success between hatchery and natural Chinook salmon can be explained by measurable biological characteristics such as run timing or size; and 3) estimates the relative fitness of hatchery-lineage Chinook salmon after they have experienced an entire generation in the natural environment. Information collected includes length, weight, spawning location, redd size, and other characteristics of the spawners and the environment where they spawn. DNA-based parentage analysis was used to measure the RSS (progeny/parent) of hatchery- and natural-origin spring Chinook salmon in the wild.

Findings reveal that both male and female hatchery-origin fish produced fewer juvenile progeny per parent when spawning naturally than did natural-origin fish, and that spawning location seemed to have the most significant effect on fitness (defined as the number of offspring assigned to an individual spawner) for both males and females. For females, it explained most of the reduced fitness observed for hatchery fish in this population. 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. 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.

This project is an important component of understanding the RRS for Chinook salmon. In addition, this project attempts to explain the mechanisms for reduced RRS of hatchery-origin fish, which will enable managers to make informed decisions on how to move forward with hatchery supplementation in the future if mechanisms can be manipulated, or to attempt to compensate for mechanisms that cannot be manipulated.

Lower Columbia River Steelhead DPS

Oregon

The goal of **BPA Project 2003-054-00** (Evaluate the Relative Reproductive Success of Hatchery-Origin and Wild-Origin Steelhead Spawning Naturally in the Hood River) was (the project has closed) to evaluate the RSS of hatchery- versus natural-origin steelhead in the Hood River (lower Columbia River steelhead DPS). Information collected primarily consisted of genetic sampling of returning adults passing Powerdale Dam (now removed).

Overall, the results of this study showed reduced reproductive success of hatchery fish in the natural environment, and these effects are seen in subsequent (F2) generations. The results of this study are consistent with results of other studies for steelhead (e.g., 2003-050-00 and 2003-063-00), which all suggest that regardless of origin of broodstock, steelhead appear to show lower RRS (non-local broodstock consistently show much lower RRS than local broodstock) than their natural-origin counterparts.

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

Relative reproductive success studies continue in the targeted populations highlighted for this subaction. Results for the majority of studies suggest that reproductive success of hatchery-origin fish is lower than their natural-origin cohorts. However, in some systems (e.g., Johnson Creek, Catherine Creek), RRS studies on spring/summer Chinook salmon using 100 percent natural origin broodstock have suggested that the RRS between hatchery- and natural-origin fish is similar. While further investigation is needed for some species, if the trend (lower RRS) seen in these studies is validated, it could have major implications on how hatchery programs are used for conservation purposes. One factor that has the potential to impact the results of all RRS studies is how long the hatchery program has been implemented. In many cases, (e.g., the upper Columbia Basin upstream of Wells Dam), hatchery-origin fish have dominated the spawning population for decades, so comparing the reproductive success of “natural-origin” fish that are most likely F2 returns from hatchery releases may not provide an accurate depiction of the effects of pHOS in the wild because local adaptation has been unable to express itself in the “naturally produced” population segment.

In summary, based on research by NOAA Fisheries (B. Berejikian presentation to the NWPCC, July 2012), the following conclusions on RRS studies can be inferred:

- Fitness loss appears real, but results vary among species, and it appears worse for steelhead;
- Domestication selection likely plays an important role in fitness loss for steelhead;
- New methods to mitigate domestication selection and ecological interactions are being developed, and
- The potential for supplementation to contribute to healthy salmon populations depends on continued development of new approaches.

Combining the information collected through RRS studies with hatchery reform research (e.g., 1993-056-00) will enable managers to have a better understanding of the factors that affect reproductive success and may lead to better hatchery practices that increases the likelihood of these programs assisting in recovery efforts.

A synthesis report of all RRS studies that are funded by the Action Agencies is intended in the near future. The report will outline important considerations, define what and what cannot be learned from RRS studies, and determine if RRS studies have a robust enough statistical design (experimental power) to support the conclusions.

***RPA Subaction 64.2 –** Determine if properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations (Initiate in FY 2007-2009 Projects).*

The intent of this subaction is similar to RPA Subaction 63.1. For this subaction, several projects continue to be funded to support RME for populations that are *not* associated with the implementation of RPA Actions 41 and 42 (Implement Conservation Programs to Build Genetic Resources, Reduce Short-term Extinction Risk and Assist in Promoting Recovery) Tables 7 and 8.

Information needed to support this RPA subaction includes two categories of RME: 1) population status and trend, and 2) hatchery effectiveness monitoring. Metrics such as abundance and productivity by origin (i.e., hatchery or natural), stray rates of hatchery-origin fish, and life history characteristics enable managers to understand how well the hatchery program is affecting the VSP parameters that indicate viability, and ultimately recovery.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)

Snake River Fall Chinook ESU

Oregon

This portion of **BPA Project 1990-005-00** (Umatilla Hatchery Monitoring and Evaluation) concerns fall Chinook salmon (Snake River fall Chinook ESU).The primary goal of this project is to monitor and evaluate different rearing and release scenarios by documenting travel time and survival from release to Three Mile Dam (Umatilla River Basin) and Columbia River dams. In addition, straying outside of the Umatilla River Basin is estimated.

Results of a six-year survival evaluation of yearling fall Chinook salmon that were March-released strayed (i.e., did not enter the Umatilla River) at a 23 percent higher rate than April releases (mean = 15.5 percent and 12.6 percent, respectively). The yearling fall Chinook program continues to produce a substantial number of precocious yearling salmon (mini-jacks), which reduces the program's potential to produce anadromous adults. The information provided by this project continues to be beneficial to understand the benefits and risks of various rearing and release strategies for fall Chinook salmon. Snake River spring/summer Chinook ESU and steelhead DPS

Washington, Idaho, and Oregon

The goal of **BPA Project 2010-031-00** (Snake River Chinook and Steelhead Parental Based Tagging) is to develop and evaluate a new genetic technology called, PBT, that can serve as a versatile tool for mass marking of steelhead and Chinook salmon in the Snake River Basin (Snake River spring/summer Chinook ESU and steelhead DPS). It is anticipated that this tool will have the capability to address aspects of hatchery reform, salmonid life history, harvest patterns, and trait heritability. The five objectives of this project are: 1) annual sampling of hatchery broodstock; 2) identification of SNP loci and assessment of their assignment power; 3) standardization of loci for PBT and integration with loci for GSI 4) creation of parental genetic databases; and 5) utilization of PBT methods to provide parentage assignments.

To date, this project has sampled and inventoried nearly 100 percent of hatchery broodstock (Objective 1) for steelhead (approximately 16,000 total individuals) and Chinook salmon (approximately 27,000 total individuals) from spawn years 2008, 2009, 2010, and 2011. In close collaboration with the CRITFC, the project identified and developed informative SNP loci for steelhead and Chinook salmon (Objective 2). The project standardized a set of 95 SNP loci for use in PBT of hatchery stocks within the Snake River Basin that can also be used in conjunction with an additional set of SNP loci identified for GSI methods in the Columbia River Basin (Objective 3). Using the PBT SNPs identified for each species, the project has genotyped nearly 100 percent of the sampled steelhead and Chinook salmon broodstock from spawn years 2008 and 2009 (Objective 4). The broodstock baselines will be used to provide parentage assignments for hatchery strays, CWT fish, and origin of hatchery kelts.

Results indicate that annual sampling, inventorying, and genotyping of all steelhead and Chinook salmon 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; thereby allowing an unprecedented ability to mark millions of Snake River smolts and an opportunity to address future objectives of parentage based research. The information collected in this project will assist in population reconstruction in addition to hatchery effectiveness monitoring and evaluation.

Idaho

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

In 2010, a total of 2,372 optical-camera-identified salmon passages were observed. Only one bull trout was incorrectly counted as a salmon in the DIDSON target validation analysis. The information collected from this project has shown success in using a monitoring system that could potentially be used in other remote areas, where logistical concerns prevent regular surveys. This stream (Secesh River) is particularly important because it has the potential to be used as a reference stream.

Oregon

The goal of **BPA Project 1997-015-01** (Imnaha River Smolt Monitoring) is to monitor spring Chinook salmon and steelhead (Snake River spring/summer Chinook ESU and steelhead DPS) emigrating from the Imnaha River and report the real-time information to the FPC. Information collected for this project includes migration timing and survival from capture to Snake and Columbia River dams. Both natural-and hatchery-origin juveniles are captured and compared, and many of the juveniles are PIT-tagged. In addition, SARs are estimated from juveniles passing Lower Granite Dam to adults returning to the dam.

The SAR for spring/summer Chinook from LGD to LGD that were transported as juveniles between 1998 and 2005 ranged from 0.46-6.0 percent. For juveniles traveling in-river during that same time frame, SARs ranged from 0.2-1.2 percent. Information in the appendices of the 2008 annual report (last reporting year) show that juvenile arrival timing from release in the Imnaha to Snake and Columbia River dams varies annually within about a two week period. The information collected from this report assists the FPC in their SMP.

The goal of **BPA Project 2010-032-00** (Imnaha River Steelhead Oncorhynchus mykiss Adult Monitoring Project) is to provide status information on Snake River steelhead in the Imnaha River Subbasin. In addition to population viability monitoring, a sub-goal is to ensure that the information can be used to inform the co-managers on potential fisheries. In 2011 (the first year of implementation), status information was collected through PIT-tag detections, weir interrogations, spawning ground surveys, scale analysis, and known-age fish. Stream flow and temperature was also collected.

Over 1,300 adult steelhead were estimated to have returned to the upper Imnaha River in 2011. Fish migrated upstream through the Columbia River Basin from late June, 2010 until early June, 2011. Steelhead began to enter the spawning tributaries of the upper Imnaha River in early May. Prior to spawning they displayed a variety of migration patterns and overwintering strategies. The majority of returning adults spent 2 years in freshwater before smolting. Based on steelhead tagged as juveniles, 58 percent of the adults returned after one year in the ocean and 42 percent after two years. Sex ratios were slightly biased toward females. Smolt size of the returning adults had apparent influence on survival and age-at-return. Larger smolts were more likely to return as adults and at an earlier adult age. Significant numbers of kelts left the Imnaha River after spawning but did not appear to survive well through the Snake River portion of their downstream emigration. Only one upper Imnaha kelt was detected at Bonneville Dam.

Mid-Columbia Steelhead DPS

Oregon

The goal of **BPA Project 2000-039-00** (Walla Walla River Basin Monitoring and Evaluation) is to provide ecological information in support of adaptive management for ESA recovery, population restoration, conservation, and preservation of cultural, social, and economic salmonid resources. The researchers emphasize monitoring of population status and trends to estimate "adults in and juveniles out" as a measure of salmonid population viability within the subbasin, and as evaluation of the spring Chinook (non-listed mid-Columbia River spring Chinook ESU) hatchery program. Project objectives answer specific management questions regarding VSP parameters of abundance, productivity, spatial structure, and diversity for reintroduced spring Chinook salmon, summer steelhead (mid-Columbia River steelhead DPS), and bull trout.

Adult steelhead returns have ranged from a low of 231 to a high of 1,205; the 10-year geometric mean for natural-origin steelhead returning to Nursery Bridge Dam, is 773; the 11-year average and geometric mean AAR (adult-to-adult (recruit per spawner) - return rate) are 1.39 and 1.09, respectively. The 10-year hatchery-origin percentage of the run (for the upper Walla Walla River population) is estimated at 4.5 percent, but it has declined recently to slightly over 2 percent, coincident with reduction of hatchery releases in Brood Year (BY) 2003. The six-year (2005-2010) geometric mean for juvenile production from the Walla Walla River is 30,251. The adult-to-adult replacement rate is estimated at 0.89 (geometric mean). The 2011 annual report concludes that "adult steelhead returns at NBD and productivity are approaching the minimum abundance threshold for the recovery goal. Given that these estimates exclude tributaries and the mainstem WWR below NBD it is possible that we may be achieving the recovery goals." This project exemplifies concise, long-term data set reporting. This is one of few projects that estimate the VSP parameters, and thus provide managers information regarding how well the population is doing in regards to viability. Since the proportion of hatchery-origin fish is currently low (4.5 percent) in the upper Walla Walla River, this stream may be a good candidate for a reference stream for other programs.

The objective of **BPA Project 2007-299-00** (Investigation of Relative Reproductive Success of Stray Hatchery & Wild Steelhead & Influence of Hatchery Strays on Natural Productivity in Deschutes) is to assess the effects that naturally spawning hatchery steelhead have on the viability of their wild steelhead counterparts in the Deschutes River Basin (mid-Columbia steelhead DPS). These effects will be evaluated by measuring adult-to-smolt and adult-to-adult reproductive success (fitness) of wild and hatchery steelhead in a BACI study design.

Current results are preliminary, however future results of this study will add to the knowledge of the potential effects of hatchery-origin steelhead spawning in the wild.

This portion of **BPA Project 1990-005-00** (Umatilla Hatchery Monitoring and Evaluation (M&E)) concerns steelhead (mid-Columbia steelhead DPS). Objectives of this project are to monitor and assess juvenile migration timing and survival of hatchery smolts to Three Mile Falls Dam and Columbia River dams. The project monitors hatchery smolt-to-adult survival, adult production, contributions to out-of-basin fisheries, annual returns to the Umatilla River, and straying; monitors abundance, composition, timing, and disposition of hatchery and natural steelhead returns to the Umatilla River; compares trends in smolt-to-adult survival and adult returns of Umatilla hatchery fish to nearby hatchery stocks to assess relative performance of Umatilla hatchery steelhead; monitors and compares progeny-per-parent productivity of natural- and hatchery-reared steelhead to quantify the adult production advantage of the hatchery program; and monitors and compares adult age structure and gender of hatchery returns.

Total number of adult steelhead produced by the 1991-2007 broods ranged from 178 to 1,660 and averaged 742. On average, 81.7 percent of adult production returned to the Umatilla River and only 0.18 percent were classified as strays. Parent-to-parent ratios ranged from 1.3 to 15.3 (mean = 7.6) for hatchery steelhead and 0.4-2.7 (mean = 1.1) for natural steelhead. Higher P-P ratios for hatchery steelhead equate to an approximately seven-fold adult production advantage for the hatchery program. Temporal trends in proportion of returns that were male were also similar for hatchery and natural steelhead, but consistently higher for hatchery fish. One-year ocean residency hatchery and natural origin adults are more likely to return as males than two year-ocean residents; a trend that is particularly evident for hatchery steelhead. Umatilla hatchery steelhead appear to have lower performance when compared to other hatchery steelhead.

Lower Columbia River Chinook ESU and Steelhead DPS

Oregon

The objective of **BPA Project 1988-053-03** (Hood River Production Monitoring and Evaluation - Warm Springs) is to collect information concerning the winter steelhead (lower Columbia River steelhead DPS) hatchery program and environmental information. Information collected includes migration timing and survival. Survival was high for released fish and outmigration timing of hatchery-origin steelhead was similar to natural-origin steelhead. Hatchery-origin steelhead are residualizing, but the project is unable to quantify the rate, and it cannot determine which of two release strategies is the most successful. Additional information from this program may be helpful in understanding what effect steelhead residualization may have on ecological interactions between hatchery- and natural-origin fish.

The goal of **BPA Project 1988-053-04** (Hood River Pelton Ladder Evaluation Studies) is to collect information related to the Hood River Production Program. This project collects information to estimate juvenile production with screw traps; harvest (all species); natural production of steelhead; natural production of cutthroat; natural production of bull trout; migration timing and other life history traits for adult summer and winter steelhead (lower Columbia River steelhead DPS), jack and adult spring and fall Chinook salmon, and coho. For hatchery production, for broodstock information collection includes; number of juveniles released and post release survival. The information collected through this project is important for understanding the effects of hatchery programs on natural populations.

The goal of **BPA Project 1988-053-15** (Parkdale NOAA Comparative Hatchery Study) is to implement one of the Hood River Production Program's objectives to "provide co-managers with the best available information for determining a long-term biologically sound and cost-effective spring Chinook salmon (lower Columbia River Chinook ESU) production strategy for the Hood River Basin that balances harvest needs with ecological considerations." The objective of this evaluation is to conduct a multi-year (2008-2018) comparative study of Hood River spring Chinook reared at three different hatchery facilities prior to being moved to the West Fork Hood River for final acclimation and release.

Findings indicate that smolting and maturation differs between rearing locations and differential winter and spring growth rates accounted for the difference in smolt quality and early maturation. In addition, the genetic composition of the broodstock affected smolt quality. These findings have important implications on how fish could be reared in the hatchery environment and the subsequent occurrence of fish that do not migrate after release and those that are maturing early. If fish released from the hatchery are not migrating, and are not accounted for upon return (as adults), then the SAR of the releases is biased low.

Washington

The goal of **BPA Project 2003-050-00** (Evaluate the Reproductive Success of Wild and Hatchery Steelhead in Natural and Hatchery Environments) was to investigate interactions and comparative reproductive success of wild and hatchery origin steelhead trout in Forks Creek, a tributary of the Willapa River in southwest Washington. The overall objective was to determine the factors influencing reproductive success (RS) in wild and hatchery-origin steelhead in natural and hatchery environments. The specific objectives were: 1) quantify the breeding pattern (i.e., selection of fish for spawning) in a production hatchery; 2) directly determine the realized RS of individual hatchery fish by DNA parentage analysis of the adults returning over 2-3 complete generations; 3) directly measure the effective population size (*Ne*) of the hatchery population over multiple generations; 4) determine any loss of genetic diversity in the hatchery population over two generations; 5) determine the realized heritability of key life history traits for hatchery fish released to the sea; 6) determine the realized reproductive success of wild and hatchery-wild hybrid parents spawning naturally; and 7) and compare those levels to those of the first generation of hatchery steelhead spawning naturally.

Using molecular markers, the project reconstructed the pedigree of a hatchery steelhead trout population over three generations since their establishment in 1994. From this pedigree, the project calculated the change in average inbreeding in the most recent generation to be 0.64 percent. The increase in inbreeding was likely due to the small effective population size maintained in the hatchery over three generations which the project attributed to a small proportion of returning fish spawned each year and high variance in reproductive success. Inbred fish were significantly shorter, weighed less, and returned to the hatchery later than outbred fish. This study is one of the first to show that small changes in level of inbreeding affected fitness-related traits in a steelhead hatchery population, and demonstrates the relevance of molecular-based pedigrees to study the effects that inbreeding in captivity and associated inbreeding depression may have on the conservation of wild populations.

For **BPA Project 2003-063-00** (Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington), the overall goal is to determine natural reproductive success and mean relative fitness of hatchery-origin and natural-origin steelhead (lower Columbia River steelhead DPS) in Abernathy Creek, Washington, and to assess the overall demographic effects of hatchery fish. Methods included capturing and genotyping juveniles and adults, recording migration patterns, life history characteristics, snorkeling, PIT-tagging fish to determine ecological interactions of both natural-origin and hatchery-origin fish.

Some findings include: juvenile hatchery-origin and natural-origin steelhead differ physiologically and morphologically as hatchery-origin juvenile steelhead were larger both in length and weight than natural-origin conspecifics; and hatchery-origin steelhead in Abernathy Creek have lower reproductive success in most years than natural-origin steelhead for both anadromous and non-anadromous life histories. This study is another important contribution to the understanding of how life history characteristics affect survival and how those factors may be manipulated to improve hatchery practices. In addition, the RRS study results can contribute to better understanding of how hatchery programs can increase abundance and productivity of targeted natural populations.

Mid-Columbia Spring Chinook ESU (Non-listed)

Washington

BPA Project 1995-063-25 (Yakima River Monitoring and Evaluation- YKFP) focuses on Yakima River spring Chinook salmon (mid-Columbia spring Chinook salmon ESU) which are not listed under the ESA. The goal of the project is to monitor, evaluate, and conduct research related to the YKFP. The project includes research occurring over many facets of artificial supplementation. The project has targeted research regarding RRS, ecological interactions between non-target taxa of concern and hatchery-origin salmon, effects of domestication on predation and competitive dominance, reproductive ecology, and effects of predation on natural production.

Results indicate that significant differences have been detected among hatchery- and natural-origin Chinook in approximately half of the traits measured through the monitoring plan and that these differences can be attributed to both environmental and genetic causes. The project detected differences in hatchery- and natural-origin fish after one generation of hatchery exposure for the following variables measured on adults: age composition, size-at-age, sex ratio, spawning timing, fecundity, egg weight, and adult morphology at spawning. Pedigree assignments based on microsatellite DNA showed that the eggs deposited by natural-origin females survived to the fry stage at a 5.6 percent higher rate than those spawned by hatchery-origin females. Significant differences in juvenile traits have also been detected: emergence timing and size of progeny, food conversion efficiency, length-weight relationships, agonistic competitive behavior, predator avoidance, and incidence of precocious maturation. Redd counts in the 2001-2010 period have increased significantly in both the supplemented upper Yakima River and non-supplemented Naches River relative to the pre-supplementation period (1981-2000), but the average increase in redd counts in the upper Yakima River (245 percent) was greater than that observed in the Naches River system (160 percent). Spatial distribution of spawners has also increased as a result of acclimation site location, salmon homing fidelity, and more fully seeding preferred spawning habitats. Growth manipulations in the hatchery appear to be reducing the number of precocious males produced by the YKFP and consequently increasing the number of migrants. However, post-release survival of treated fish appears to be significantly lower than conventionally reared fish. Ecological impacts to valued non-target taxa were generally within containment objectives, or impacts that were outside of containment objectives were not caused by supplementation activities. Natural production of Chinook salmon in the upper Yakima River Basin appears to be density dependent under current conditions and may constrain the benefits of supplementation.

The goal for **BPA Project 2002-031-00** (Growth modulation in salmon supplementation) is to compare the physiology and development of naturally rearing wild and hatchery-reared spring Chinook in the Yakima River Basin (mid-Columbia River spring Chinook ESU). The five objectives of this project are: 1) Monitor the incidence of age-2 precocious male maturation in the Yakima hatchery population; 2) Estimate the incidence of precocious maturation in migrating wild and hatchery Yakima River spring Chinook salmon; 3) Conduct a series of growth modulation experiments to control precocious maturation in the Cle Elum hatchery population for subsequent use in other hatchery facilities; 4) Collaborate with tribal and state biologists in developing and implementing production scale growth modulation protocols designed to reduce precocious male maturation while producing a successful smolt; and 5) Expanded minijack monitoring efforts over the past several years to other Columbia River hatchery programs in Washington and Oregon.

The most significant difference observed through the project between natural- and hatchery-origin fish was an approximate 50 percent incidence of early maturation of Cle Elum Hatchery-reared males (age-2 minijacks). This is approximately 10 times the estimate of early male maturation in wild spring Chinook salmon in the Yakima River. This demonstrates that hatchery rearing practices promote early male maturation. Early male maturation translates into as much as a 25 percent (depending on population) reduction in anadromous adult production. Modulation of growth rate and/or body energy stores at specific times of the year can reduce the incidence of precocious male maturation, but often at the expense of smaller smolt size and reduced juvenile and adult survival. Additional research is required to develop rearing regimes to reconcile these competing outcomes. This is an important project that may have profound impact on hatchery rearing guidelines.

The goal of Project 2008-458-00 (Upper-Columbia River Steelhead Kelt Reconditioning Project) is to increase the abundance of naturally-produced UCR steelhead on natural spawning grounds by as much as 10 percent through the use of kelt reconditioning. In 2012, eight natural-origin and eight hatchery-origin females were reconditioned that were captured as part of the Wintrhop NFH steelhead program. In addition, natural-origin males were captured and brought to the reconditioning facility, but were either released because of poor condition or died. Of the fish that were initially brought to the facility, two natural-origin and five hatchery-origin fish made it through the reconditioning process and were released. Since this is the first year of implementation, many of the methods will be refined and evaluated in the coming year.

Multiple DPSs of Steelhead

The goal of **BPA Project 2007-401-00** (Kelt reconditioning and reproductive success evaluation research) is to develop different scenarios of steelhead kelt reconditioning and release strategies to increase depressed populations. Fish used as part of this project originate from Okanogan River Basin (upper Columbia River steelhead DPS), Yakima River Basin (mid-Columbia River steelhead DPS), and the Snake River Basin (Snake River steelhead DPS). To test the efficacy of utilizing steelhead kelt reconditioning as a management and recovery tool, different scenarios were investigated ranging from little intervention (collect and return fish to river) to high intensity (collect and feed fish in captivity until re-maturation).

The results from this project suggested that kelts can be collected, can survive long term reconditioning and successfully be released back into the spawning streams. Future research is needed to identify to what extent reconditioned kelts spawn and thus to what extent they contribute to the restoration of steelhead populations.

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

Similar to RPA Subaction 63.1, to assess the effects of whether properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations, the projects that are associated with this subaction need to monitor and report on both hatchery effectiveness (e.g., compare productivity in a treatment stream to a reference condition) and VSP parameters (abundance, productivity, spatial structure, and diversity).

Many of the projects associated with this subaction are comparing information pertaining to life history characteristics, such as migrational timing, survival from release to downstream detection points, length, weight, and age-at-return. Most projects have not detected substantial differences in these characteristics except age-at-return, with hatchery-origin fish generally returning overall at younger ages. In addition, hatchery-origin fish consistently have reduced SAR compared to their natural-origin cohorts. Many of the hatchery programs create larger numbers of mini-jacks which do not migrate to the ocean and can negatively bias estimates of SAR. One study has found that faster growth at specific times during the hatchery rearing cycle is the reason for higher rates of early maturation (mini-jacking). But other research has shown a direct relationship between smolt size and survival; reducing early maturation should be considered in light of reduced survival of the fish released. Early results from a study to develop parental based tagging of Snake River Chinook and steelhead has shown promising results, which will enrich researchers' ability to reconstruct the various populations upstream of Lower Granite Dam and increase information on hatchery effectiveness. Another study has successfully used remote video technology to count salmon entering a stream, which may open opportunities to monitor other populations in remote locations. Some studies supporting this RPA have measured RRS, and for steelhead, have consistently showed that hatchery-origin fish that spawn in the wild have lower RRS than their natural-origin counterparts, even when the proportion of natural-origin fish taken for broodstock is substantial. However, two RRS studies for Chinook salmon have shown similar RRS for hatchery- and natural-spawning fish. Additional research is needed to identify the mechanisms reducing RRS of steelhead, which projects 2010-033-00 (see RPA Subaction 64.3) and 2003-039-00 (see RPA Subaction 64.1) are providing. Additional information concerning RRS can be found in RPA Subaction 64.1. Kelt reconditioning practices are not yet mature enough to demonstrate a large contribution abundance or productivity in targeted populations. However, programs have been successful in reconditioning and releasing mature, repeat spawning, adults.

As with RPA Subaction 63.1, there are two primary issues related to implementing this RPA subaction that could be improved upon: 1) Improved synthesis, analysis, and reporting on information related to viability and recovery; and 2) further comparison of a reference condition (stream) to compare various metrics between the reference condition and the hatchery program (treatment).

Synthesize, Analyze, and Report Information Related to Viability and Recovery

As with RPA Subaction 63.1, most projects related to this subaction are reporting the information on annual basis. Future synthesis and analysis to assess status and trends as well as to determine whether or not a project is affecting viability or recovery will be reported in the future. In future, reporting results will be framed in terms of the VSP parameters, since these metrics are what NOAA Fisheries uses to determine viability (and ultimately recovery).

Use a Reference Condition (Stream)

Only one project (**BPA Project 1995-063-25**, Yakima River Monitoring and Evaluation- YKFP), which is not related to in the RPA because the population (mid-Columbia River spring Chinook), evaluated information collected in a supplemented stream and compared it with a reference stream. See additional concerns regarding the use of a reference condition in Lessons Learned of RPA Subaction 63.1.

Lessons Relative to RME Implementation

As in RPA Subaction 63.1, in most cases, restructuring and standardization of reporting should assist in increasing support of this subaction. Currently, most of the projects have not compiled their long-term data sets in their annual reports. With the new BPA project reporting format, reporting will be coordinated on how to analyze information in such a way that it will address viability and recovery, as specified in this subaction.

Coordination of analysis and reporting will assist the Action Agencies in comparing across projects. A possible venue for this coordination effort would be the establishment of CHREET.

RPA Subaction 64.3 – *In collaboration with the other entities responsible for steelhead mitigation in the Methow River, BPA will fund a new RSS study for ESA-listed steelhead in the Methow River. BPA will also fund a new RSS 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 (Initiate in FY 2007-2009 Projects).*

For this subaction, projects are being funded to support RME for the specific populations described within the subaction.

Information needed to support this RPA subaction includes uncertainty research, including metrics such as abundance, origin, genotype, and age structure.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)

Snake River Fall Chinook ESU

Washington, Idaho, and Oregon

The original goal of **BPA Project 2003-060-00** (Evaluate the Relative Reproductive Success of Wild and Hatchery Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam) was to conduct genetic analyses on multiple samples of Snake River wild juvenile and adult fall Chinook salmon (Snake River fall Chinook ESU) and Lyons Ferry Hatchery broodstocks to estimate RSS. The project was originally planned in two phases, with Phase 1 including a pilot study with the goal to determine whether genetic variation between wild- and hatchery-origin Snake River fall Chinook salmon was large enough to allow accurate estimates of their relative contributions to natural production. If genetic differentiation was observed, the project would estimate hatchery and wild contributions to wild-born offspring and compare those with spawning grounds hatchery and wild fish proportions to measure RSS. After 2005, it was apparent from more recent wild-born juvenile samples that genetic differentiation from the Lyons Ferry Hatchery stock was small and estimating accurate hatchery and wild reproductive contributions would not be possible. Genetic divergence observed between earlier wild juvenile brood years and the hatchery stock no longer occurred. This was most likely the result of large proportions of hatchery fish present on spawning grounds after the 2001 brood year. However, the project concluded that hatchery fish were producing wild-born offspring, and potentially, the majority of them in recent years. The project then used the data set of wild, brood-year specific juvenile and adult samples to evaluate how changes in abundance and proportions of wild and hatchery fish on spawning grounds from 1990 to 2007 may be affecting productivity. The project accomplished this by estimating annual effective number of breeders (natural spawners) from the genetic data for wild juveniles and adults.

Estimates of effective number of breeders (Nb) provide an indication of overall reproductive success of the naturally spawning population without actual estimates of RRS. Data on effective number of breeders, and how those numbers change over time and conditions, are important elements in assessing contributions of hatchery-produced fish to recovery of Snake River fall Chinook salmon. These data in combination with other measures of productivity, such as wild smolt to adult survival, could provide information about population growth rate needed to assess recovery status.

While the primary objective of the study (evaluate whether genetic differentiation between wild and hatchery spawner components could be used to estimate relative contributions of each component to natural production) was accomplished, the project was unable to estimate RRS because of the reasons discussed above. Subsequently, a workgroup consisting of the Action Agencies, NOAA Fisheries and the NPCC[16] recommended that appropriate stakeholders identify the intent of RPA Actions 64 and 65 in relationship to Snake River fall Chinook salmon, and identify methods to meet the intent, and develop a targeted RPA based on that input. Based on these recommendations, a workshop was developed to begin the process of determining how to address the RPAs. The Snake River Fall Chinook Hatchery Effects Workgroup met on April 27, 2010, in Lewiston, Idaho, and met by conference call several times through August 2010. A report was completed (Blankenship et al., 2010) and concluded:

1. Based on logistical, technical, and process constraints, a pedigree-based parentage analysis to estimate RRS is not feasible for Snake River fall Chinook salmon. A promising alternative at this point appears to be a grandparental study design, but a number of details need to be considered. Approaches such as using controlled spawning areas or surrogate populations appear far less attractive. Other approaches yielding useful, but less direct RRS information, are possible.
2. Evaluating the effect of the hatchery programs on natural Snake River fall Chinook salmon productivity is very challenging, and the challenge is exacerbated by inadequacies in run reconstruction. The only approach the workgroup recognized as most appropriate was a model-fitting approach similar to that of Buhle et al. (2009). Again, however, a number of feasibility and statistical power details need to be considered. The option of using a surrogate population is highly undesirable, and other approaches yielding useful, but less direct information, are possible.

A letter dated February 2, 2012, was sent to BPA from NOAA Fisheries concerning monitoring needs associated with satisfying RPA Actions 64 and 65 as they relate to Snake River fall Chinook salmon. The monitoring actions associated with the letter are consistent with the two HGMPs that cover Snake River fall Chinook salmon, from the WDFW and the NPT. If the actions that are identified in the letter are implemented and evaluated, the letter from NOAA Fisheries states that the intent of RPA Actions 64 and 65, in regards to Snake River fall Chinook, will be satisfied.

[16] *Recommendations for implementing research, monitoring, and evaluation for the 2008 fisheries FCRPS BiOp.*

Upper Columbia Steelhead DPS

Washington

The goal of **BPA Project 2010-033-00** (Study Reproductive Success of Hatchery and Natural Origin Steelhead in the Methow) is to monitor and evaluate reproductive success of Methow River steelhead (upper Columbia River steelhead DPS) and a suite of demographic characteristics. Differences in the run-timing, spawn-timing, age-composition, length-at-age, sex-ratio, and spawning distribution are measured between hatchery- and natural-origin fish that may explain differences in RRS if it occurs.

Preliminary information regarding life history characteristics shows no significant differences between hatchery- and natural-origin fish that were passed upstream of the Twisp River (tributary to the Methow River) weir. Hatchery- and natural-origin females produced similar numbers of offspring (hatchery = 4.6 offspring per female; natural = 5.2 offspring per female). Hatchery males appeared to produce fewer offspring than natural-origin males (hatchery = 3.0 offspring per male; natural = 7.2 offspring per male).

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

Even though RRS has not been estimated for Snake River fall Chinook salmon, as directed under this subaction, information has been collected that shows little genetic differentiation between natural- and hatchery-origin fall Chinook. In addition, **BPA Project 2003-060-00** (Evaluate the Relative Reproductive Success of Wild and Hatchery Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam) documented reproductive success of hatchery-origin fall Chinook in terms of juvenile production.

For Methow River steelhead, the project (**BPA Project 2010-033-00**, Study Reproductive Success of Hatchery and Natural Origin Steelhead in the Methow) remains in its early phases. However, early indications are that the life history characteristics of the hatchery- and natural-origin populations are similar. This finding is not surprising considering that hatchery-origin fish have dominated the spawning grounds in the Methow River Basin for decades.

Lessons Relative to RME Implementation

Implementing the original intent of this subaction was not possible due to logistical issues (e.g., not capturing enough juveniles and genotyping a large enough percentage of the adults passing Lower Granite Dam). By implementing the actions identified in the latest HGMPS and the NOAA Fisheries letter from February 2, 2012, further information on the effects (positive and negative) of the hatchery program on the natural population will be understood.

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

RPA Subaction 65.1 – *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.*

For this subaction, the projects are being funded to support RME for the Snake River fall Chinook population (Washington, Idaho, and Oregon).

Information needed to support this RPA subaction includes hatchery effectiveness monitoring. Metrics such as abundance and productivity by origin (i.e., hatchery or natural), stray rates, and life history characteristics enable managers to understand how well the hatchery program is affecting natural-origin fish.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)

Snake River Fall Chinook ESU

Washington, Idaho, and Oregon

The goal of **BPA Project 1991-029-00** (RME of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) is for RME that will lead to the management and recovery of fall Chinook salmon (Snake River fall Chinook ESU). Research includes monitoring of redd counts, spawning site use, parr growth and survival, post-release performance of hatchery-origin fish through the Snake and Columbia rivers, comparison of different hatchery release strategies, and growth and food habits of Snake River fall Chinook salmon. Methods include aerial and underwater video surveys for redds, derived information based on redd and adult counts, and spawning habitat capacity. This information is used to estimate whether the recovery criteria are being met.

Redd counts in the Snake River Basin have risen substantially in the last few years and are the highest observed since surveys began under this project in 1991. One recovery criterion for Snake River fall Chinook salmon requires that the lower Snake River supports 1,250 redds constructed by natural-origin females. Redds exceeded 1,250 during six years, and the maximum redd count have recently exceeded the capacity estimate of 2,570. However, the percentage of pHOS was not estimated. 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. The investigators found less potential for interaction between acclimated and natural subyearlings than between directly released and natural subyearlings. 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 information collected under this project is comprehensive and important for managers to understand how life history characteristics are influenced by river conditions. Estimates of the status of the population occurring under this project are also important since it is tracking whether this population is trending towards recovery.

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

Researchers have been refining their methodology of reconstructing the adult run of fall Chinook salmon migrating past Lower Granite Dam, and this, along with redd surveys, has contributed to the understanding of fall Chinook abundance. However, the ability to assess origin remains a concern when applying information pertaining to percentage of pHOS on the spawning grounds (Milks et al., 2012). Lack of data on the origin of fish spawning upstream of Lower Granite Dam makes it more challenging to assess the effects of the hatchery program on productivity of the natural-origin component, thereby making it difficult to suggest changes in the hatchery program that may improve potential negative effects.

Lessons Relative to RME Implementation

Attempting to estimate “the effectiveness/fitness in nature of hatchery-origin fall Chinook salmon” upstream of Lower Granite Dam is logistically difficult because of the methods necessary to catch juveniles and the difficulty of assessing origin of returning adults. Continued refinement of methods to assess origin of adults and obtaining representative samples of juveniles will enable managers to understand how the hatchery program is affecting natural production and productivity.

RPA Subaction 65.2 – *Estimate fall Chinook hatchery program affects on the productivity of the fall Chinook salmon ESU.*

For this subaction, the projects are being funded to support RME for the Snake River fall Chinook population (Washington, Idaho, and Oregon).

Information needed to support this RPA subaction includes hatchery effectiveness monitoring. Metrics such as abundance and productivity by origin (i.e., hatchery or natural), stray rates, and life history characteristics enable managers to understand how well the hatchery program is affecting natural-origin fish.

In the following section, a summary of the projects that are addressing this RPA subaction is discussed.

Major Accomplishments and Findings in Implementing the RPA Subaction (2008-2011)

BPA Project 1991-029-00 (RME of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) conducts RME associated with management and recovery of fall Chinook salmon (Snake River fall Chinook ESU). Research includes monitoring of redd counts, spawning site use, parr growth and survival, post-release performance of hatchery-origin fish through the Snake and Columbia rivers, comparison of different hatchery release strategies, and growth and food habits of Snake River fall Chinook salmon. The information collected under this project is comprehensive and important for managers to understand how life history characteristics are influenced by river conditions. Estimates of the status of the population occurring under this project are important since it is tracking whether this population is trending towards recovery.

Major Lessons Learned

Lessons Relative To Mitigation Action Implementation

Researchers have been refining their methodology of reconstructing the adult run of fall Chinook salmon migrating past Lower Granite Dam, and this (along with redd surveys) has contributed to understanding fall Chinook abundance. However, the ability to assess origin remains a concern when applying information pertaining to percentage of pHOS on the spawning grounds (Milks et al., 2012).

Lack of data regarding the origin of fish spawning upstream of Lower Granite Dam makes it more challenging to assess the effects of the hatchery program on productivity of the natural-origin component, thereby making it difficult to suggest changes in the hatchery program that may impede recovery of listed fish.

Lessons Relative to RME Implementation

Please see discussion and analysis for RPA Subaction 65.1.

RPA Subaction 65.3 – *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.*

NOA Fisheries and other regional technical experts provided technical assistance to BPA in 2010 to support development of targeted solicitations for the new Snake River fall Chinook salmon 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.*

Caspian terns and double-crested cormorants consume large numbers of juvenile salmon and steelhead. The federal agencies have been addressing growing populations of Caspian terns and double-crested cormorants nesting in the estuary, as well as Caspian terns and double-crested cormorants in the mid-Columbia River that prey on juvenile salmon. The redistribution of Caspian terns from Rice Island, in the Columbia River estuary, to East Sand Island, nearer to the ocean, was successful in reducing predation rates. As intended, the relocation shifted the terns' diet away from juvenile salmon toward a more diverse diet of predominantly marine fish species. (At Rice Island, juvenile salmon comprised 75 to 90 percent of the terns' diet).

In November 2006, the USFWS and Corps signed separate RODs adopting the Caspian Tern Management Plan. NOAA Fisheries completed the BiOp for the proposed action on February 16, 2006. The goal of the CTMP is to reduce tern predation on juvenile salmonids by relocating two-thirds of East Sand Island Caspian terns to alternate nesting sites in Oregon and California. This will result in a tern colony size of approximately 3000 breeding pairs at East Sand Island. In 2008, the Corps began the implementation of the CTMP with the construction of a one-acre island in Fern Ridge Reservoir in Oregon. Since then an additional nine islands have been constructed, totaling 8.3 acres (Table 64). Because of water management practices, some of the islands constructed have not been available every year. At all of the islands constructed or enhanced through the CTMP, social attraction, tern decoys, and tern colony sounds were used in the spring to attract terns. For every acre of out-of-basin nesting habitat created, nesting habitat on East Sand Island has been reduced by 0.5 acres. By 2012, nesting habitat on East Sand Island was reduced to 1.5 acres (Figure 100). Approximately 6416 pairs of Caspian terns nested on East Sand Island in 2012 (Figure 101) and consumed approximately 4.9 million juvenile salmon (Figure 102). In comparison, in 1999, the colony consumed about 15 million salmon when located at Rice Island.

The tern colony at East Sand Island is approximately double the EIS goal of 3,125 breeding pairs. As a result, the overall percent of smolts consumed by the East Sand Island Caspian tern colony has not reached the FCRPS BiOp prospective targets (Table 65). While tern nesting habitat reduction is on target per the tern EIS (down to 1.5 acres in 2012), the number of terns nesting at East Sand Island remains higher than expected. This is due to terns nesting at densities much higher than previously observed. However, the poor nesting success seen at East Sand Island in the past three years may yet cause terns to seek alternative nesting habitat in future years. Further monitoring of the impact of Caspian terns on the survival of juvenile salmonids will be needed to determine whether additional alternative habitat should be constructed to allow a further reduction in Caspian tern nesting habitat at ESI to 1.0 acre (that being the smallest area possible under the CTMP).

Table 64. Status of Artificial Caspian Tern Nesting Islands for the 2012 Breeding Season. Productivity measured as offspring per nest. The Fern Ridge Reservoir site was not monitored in 2012 due to lack of nesting in 2008-2011 (Roby et al., 2013).

Location	Size (acres)	Completion Date	Social Attraction	Watered	Breeding Attempts	Productivity
Fern Ridge Reservoir (OR)	1.0	Feb 08	Yes	Yes	-	-
Crump Lake (OR)	1.0	Mar 08	No	Yes	115	0.43
East Link Unit, Summer Lake Wildlife Area (OR)	0.5	Dec 08	Yes	Yes	10	0
Dutchy Lake, Summer Lake Wildlife Area (OR)	0.5	Feb 09	No	No	0	0
Sump 1B, Tule Lake NWR (CA)	2.0	Aug 09	Yes	Yes	207	0
Gold Dike Unit, Summer Lake Wildlife Area (OR)	0.5	Sep 09	Yes	Yes	4	0
Orems Unit, Lower Klamath NWR (CA)	1.0	Sep 09	No	No	-	-
Sheepy Lake, Lower Klamath NWR, (CA)	0.8	Feb 10	Yes	Yes	212	0.66
Malheur Lake	1.0	Feb 12	Yes	Yes	232	0.84

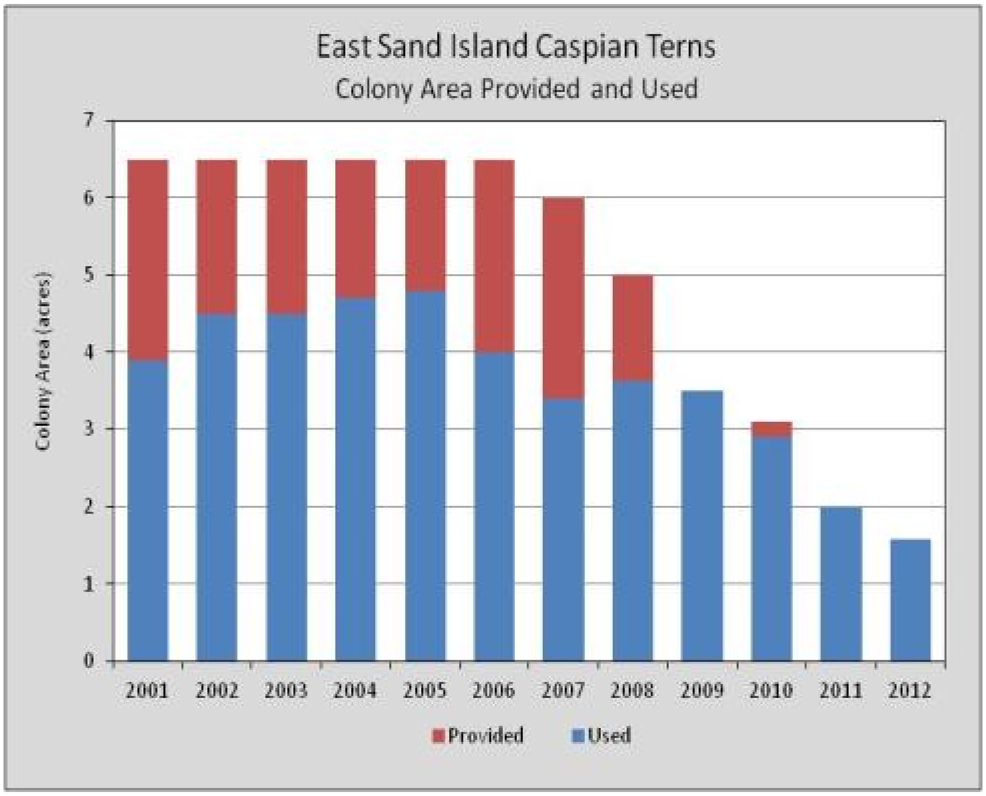


Figure 100. East Sand Island Tern Colony Area Provided and Used from 2001 through 2012 (Data from Roby et al., 2013)

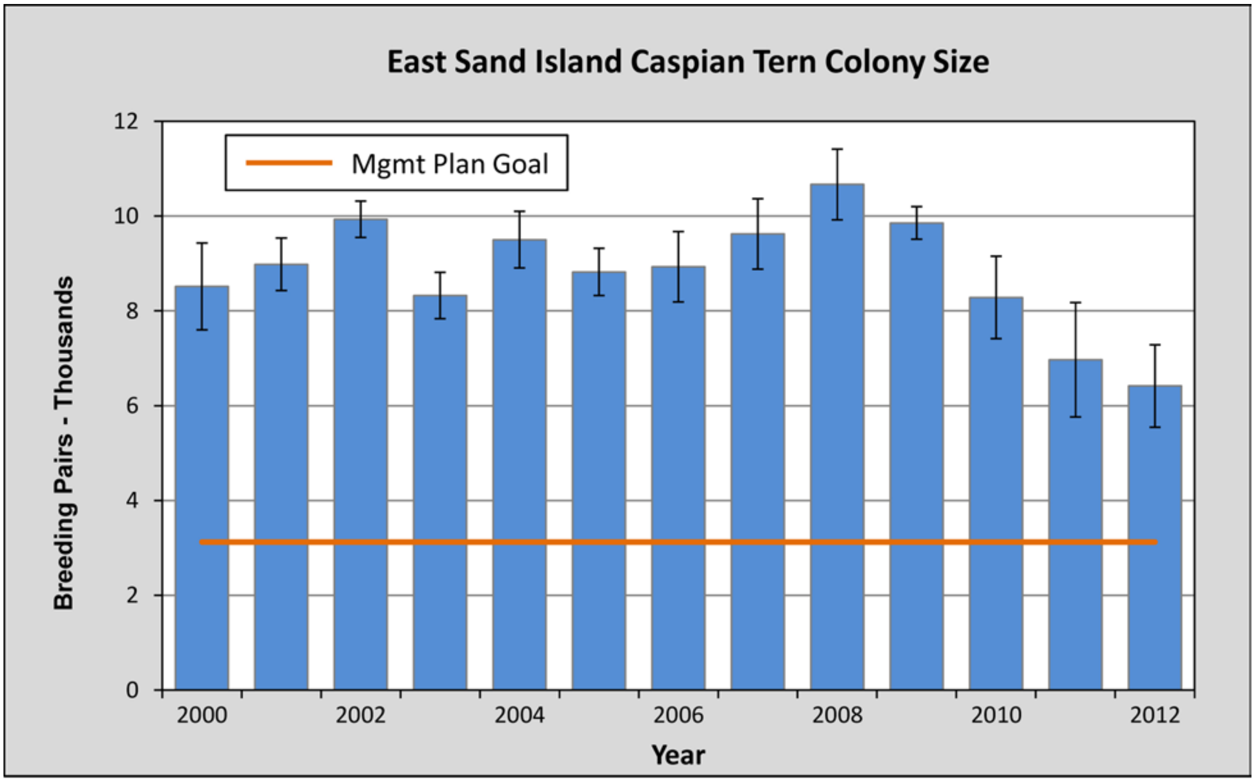


Figure 101. East Sand Island Caspian Tern Colony Size from 2000 to 2012 (from Roby et al., 2013).

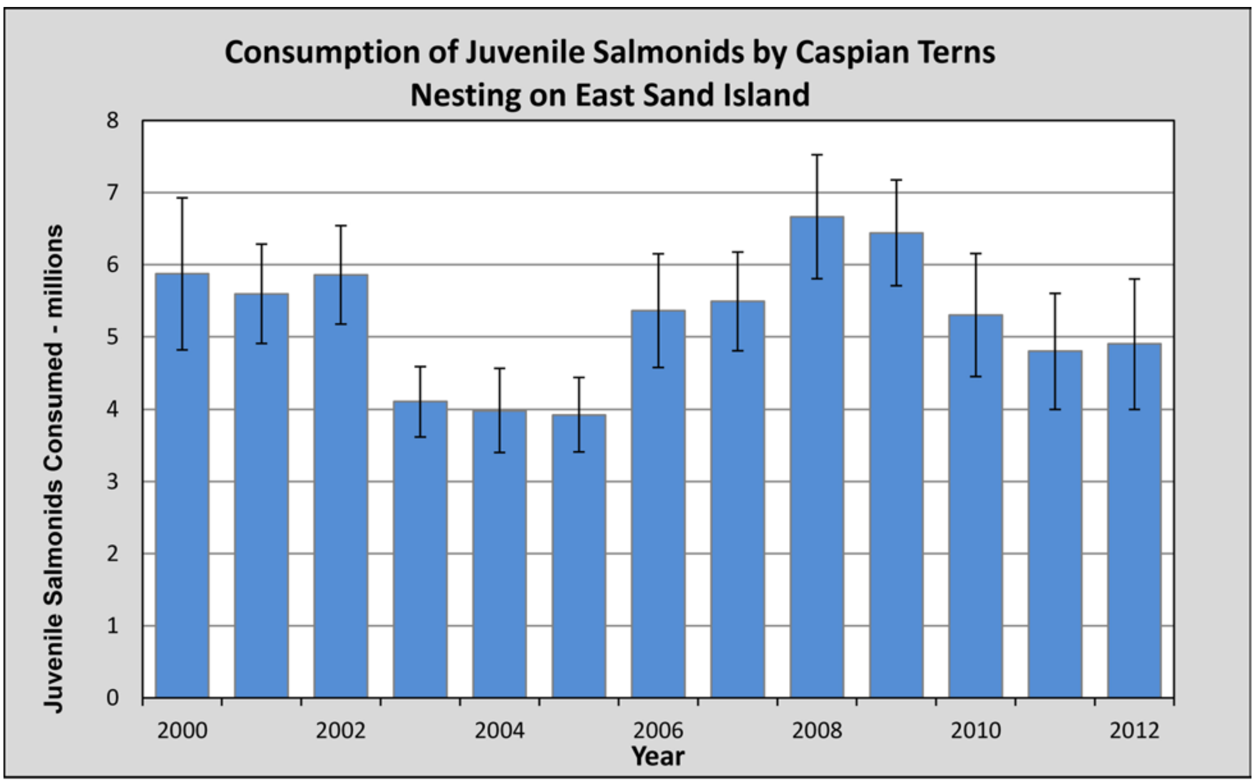


Figure 102. Smolt Consumption by the East Sand Island Caspian Tern Colony from 2000 to 2012 (from Roby et al., 2013).

Table 65. Percentage of Juvenile Salmonids Taken by Caspian Terns at East Sand Island. Estimates of the number of juvenile salmonids arriving at Tongue Point, lower Columbia River (Dey, 2012); the number of juvenile salmonids consumed by East Sand Island Colony Caspian terns (Roby et al., 2012), the percent of juvenile salmonids consumed by the East Sand Island colony of Caspian terns (PIT-tag based estimates from Roby et al., 2012), and FCRPS BiOp "current" and "prospective" estimates of ESI Caspian tern consumption of juvenile salmonids. "Prospective" estimates were based on a tern colony size of 3,125 breeding pairs (see Appendix F, Attachment F2 of the Comprehensive Analysis, and Section 7.2.5.1 of the Supplemental Comprehensive Analysis).

2011 Estimates					FCRPS BiOp	
Species	**Smolts Arriving at Tongue Point**	**Smolts Consumed by Terns at ESI (Based on Bioenergetics Modeling)**	**Percent Consumed Based on Two Previous Columns**	**Percent Consumed Based on PIT–Tag Detections**	**"Current" (2002-06) Percent Consumed**	**"Prospective" Percent Consumed**
Yearling Chinook	32,807,329	800,000	2.4%	1.4-1.9%	3.0%	1.0%
Subyearling Chinook	88,555,553	1,300,000	1.5%	0.5-0.8%	1.1%	0.4%
Coho	18,787,042	1,400,000	7.5%	-----	15.4%	3.6%
Steelhead	15,070,982	1,300,000	8.6%	6.4-8.4%	4.9%	1.7%
Combined	155,220,906	4,800,000	3.1%	-----	3.3%	-----

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.*

Development of the Double-Crested Cormorant Management Plan is addresses in RPA Action 46 above.

East Sand Island is home to the largest double-crested cormorant colony in western North America, consisting of about 12,300 breeding pairs in 2012 (Figure 103), which is about the same size as the previous year. Double-crested cormorants nesting at this colony consumed approximately 18.9 million juvenile salmonids (95 percent CI = 14.0 to 23.8 million) in 2012 (Figure 104). 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 NEPA, a process that is currently underway. From 2008 through 2012 the Action Agencies have monitored the cormorant population in the estuary and its impacts to outmigrating juvenile salmonids, and evaluated a number of alternatives to discourage nesting on East Sand Island and encourage nesting elsewhere.

BPA Project 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 reported at http://www.birdresearchnw.org.

An analysis of salmonid PIT-tags detected at the double-crested cormorant colony on East Sand Island indicated that all species of anadromous salmonids (i.e., Chinook salmon, coho salmon, sockeye salmon, steelhead, and even sea-run cutthroat trout) from all run-types (fall, winter, summer, and spring), and from all tagged ESUs were susceptible to cormorant predation. The numbers of PIT-tags from the various salmonid species and run-types that were recovered on the cormorant colony were roughly proportional to the relative availability of PIT-tagged salmonids released in the basin, suggesting that cormorant predation on salmonid smolts in the estuary was less selective than tern predation. Predation rates in excess of 10 percent and 30 percent, however, were observed for some groups of hatchery fall Chinook and hatchery coho salmon released downstream of Bonneville Dam. A comparison of per capita consumption rates of PIT-tagged fish between terns and cormorants nesting on East Sand Island suggests similar levels of take per nesting adult per colony, with an estimate of 1.5 and 1.8 PIT-tagged fish consumed per nesting tern and cormorant, respectively.

From 2008-2012, adult and juvenile double-crested cormorants were banded at East Sand Island in the Columbia River estuary with a federal numbered metal leg band on one leg and a field-readable plastic leg band engraved with a unique alphanumeric code on the other. The purpose of this work is to collect information on the survival and movements of double-crested cormorants from the East Sand Island colony, and to study dispersal patterns and recruitment of cormorants to other colonies using re-sightings of banded individuals. 2011 was the first year when a large-scale effort was mounted to color-band hatch-year cormorants at East Sand Island. Re-sight/recapture information from several banded cormorants has been received thus far, with most observations occurring during the post-breeding season. Re-sighting locations included western British Columbia, the northern

California coast, the lower Columbia River, and the Puget Sound area. Of particular note in 2011, one cormorant banded as a juvenile in 2010 on the East Sand Island colony was observed on the Sheepy Lake floating island in northeastern California. Banding and re-sighting efforts will allow us to determine inter-colony movements of double-crested cormorant.

Since 2008 the Action Agencies have funded studies that tested several techniques to discourage nesting by double-crested cormorants; human disturbance (2008-2009, 2011), destruction of nest structures prior to egg-laying (2011), pond liner installation (2009-2010), laser hazing (2008-2009), and reflective tape (2011). Of these techniques, only human disturbance in concert with nest destruction and a large visual barrier has been a feasible means to prevent cormorant nesting in a pre-defined area of the East Sand Island cormorant colony. Detections of radio-tagged cormorants and observations of banded cormorants displaced from the dissuasion area suggested the vast majority of cormorants hazed in the dissuasion area relocated west of the visual barrier and resumed nest initiation in 2011. A portion of the marked cormorants did appear to leave East Sand Island for one or more weeks during the breeding season; however, the timing of departure suggests the temporary colony abandonment was associated with bald eagle disturbance and subsequent cormorant nesting failure. Human disturbance appears to be a viable option for effectively preventing cormorant nesting on part of the colony, but requires significant infrastructure and labor-intensive hazing and monitoring on a daily basis.

The Action Agencies funded studies to test the feasibility of potential management techniques for reducing losses of juvenile salmonids to predation by double-crested cormorants in the Columbia River estuary. These studies sought to determine whether habitat enhancement and social attraction techniques can be used to induce double-crested cormorants to nest at alternative colony sites outside the Columbia River estuary where they have not previously nested and, if so, whether these techniques can be used to redistribute some of the double-crested cormorants nesting in the Columbia River estuary to alternative colony sites. Pilot studies designed to test the feasibility of employing habitat enhancement and social attraction to relocate nesting double-crested cormorants have shown some promise; cormorants were attracted to nest and nested successfully (raised young to fledging) on Miller Sands Spit and Rice Island, two islands in the upper Columbia River estuary where no previous successful cormorant nesting was known (Miller Sands Spit) or nesting had not occurred in recent years (Rice Island). Although habitat enhancement and social attraction techniques appear effective in establishing double-crested cormorant breeding colonies at sites where nesting attempts have previously occurred, results from the three-year study at Fern Ridge Wildlife Area, a two year study at Dutchy Lake in Summer Lake Wildlife Area, and a one-year study at Tule Lake Sump 1B suggest that habitat enhancement and social attraction techniques may require longer periods to successfully attract cormorants to nest at sites with no prior history of cormorant nesting, especially if no established breeding colonies exist nearby. The efficacy of habitat enhancement and social attraction techniques to establish new double-crested cormorant colonies outside the Columbia River basin remains uncertain. Developing methodologies to enhance the size of existing double-crested cormorant colonies, along with reestablishing colonies using habitat enhancement and social attraction techniques at sites where cormorants have historically nested, may be necessary to shift cormorants from the large colony on East Sand Island to alternative colony sites where ESA-listed salmonids are not as susceptible to cormorant predation.

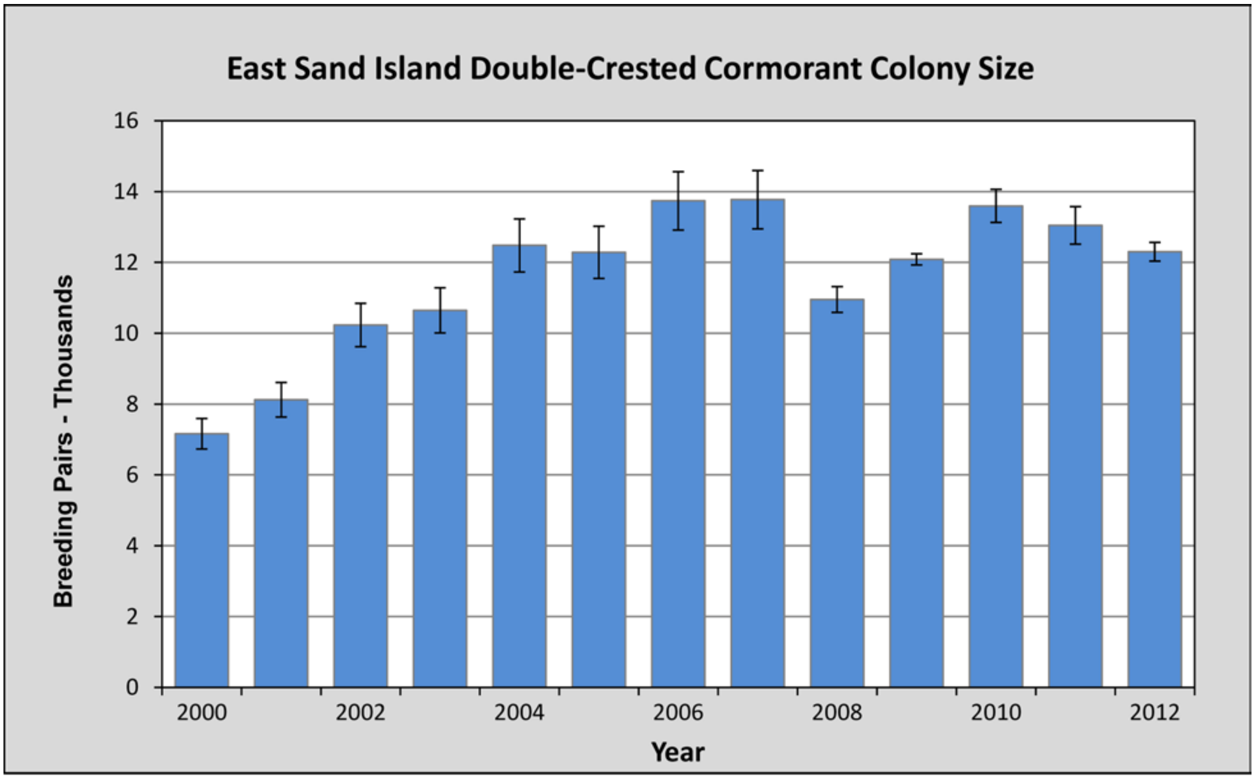


Figure 103. East Sand Island Double-Crested Cormorant Colony Size from 2000 to 2012 (from Roby et al., 2013).

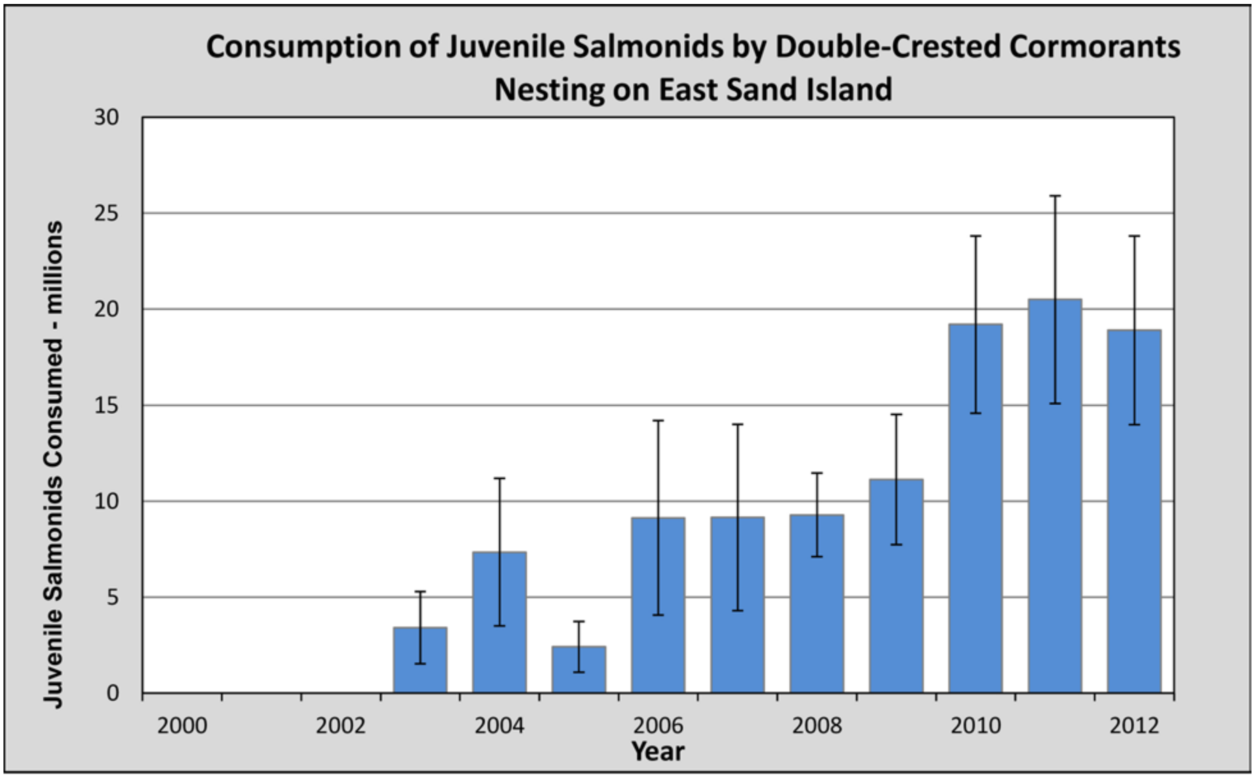


Figure 104. Smolt Consumption by the East Sand Island Double-Crested Cormorant Colony from 2000 to 2012 (from Roby et al., 2013).

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.*

The following summarizes RME actions implemented to monitor avian predator populations in the mid-Columbia River, evaluate their impacts on outmigrating juvenile salmonids, and inform development of an IAPMP per requirements of RPA Action 47. The IAPMP covers the FCRPS portion of the Columbia River Basin upstream of Bonneville Dam. Management at the Corps FCRPS dams have been managed independently of the IAPMP in coordination with FPOM and included in the FPP per requirements of RPA Action 48 (see RPA Action 48 for a summary of dam related actions taken by the Action Agencies including a description of studies undertaken to assess the new wire array structures at John Day and The Dalles dams). RME conducted under this RPA include a comprehensive monitoring and evaluation program to assess avian predation on the Columbia River plateau, including completion of multiple projects from 2008-2012 by the Action Agencies to support development of an IAPMP.

RME during 2008-2012 included annual monitoring of the impacts of avian predators on juvenile salmonids on the Columbia Plateau through 2012, development of a synthesis report summarizing pertinent RME 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 RME efforts 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.

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 and associated research efforts 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 2011 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 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 have 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 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 2004-2009 study period of the synthesis report and subsequently in 2010-2012. These nine bird colonies had the highest numbers of smolt PIT-tags present of any in the Columbia River 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 percent) and by Goose Island terns on upper Columbia summer steelhead (10.0 percent) were of notable concern during the study period. Predation rates by Foundation Island cormorants on Snake River summer steelhead (2.0 percent) and Snake River sockeye (1.7 percent) were not as high, but notable. Predation rates by gulls and pelicans nesting in the Columbia Plateau region were minor (generally <0.5 percent 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 outmigrating 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 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 percent by mass), followed by shad (15.0 percent). 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, as provided in Lyons et al., (2011b) is necessary 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.

To provide guidance for the development of the IAPMP regarding where potential management actions may be most warranted, an analysis (Lyons et al., 2011b) 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 River Basin, particularly for upper Columbia River and Snake River steelhead populations.

Subsequent monitoring and evaluation during 2010 and 2011 continued habitat-based RME 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, Washington) and on Goose Island (Potholes Reservoir, near Othelo, Washington), where a nearly equal number (approximately 420) of breeding pairs nested in 2011. Caspian tern nesting success at both colonies was also similar (approximately 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 outmigration), while less than 10 percent of the diet was salmonids during early April, June, and July.

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 percent) and by Foundation Island cormorants on Snake River steelhead (ca. 1.8 percent) 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 percent 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 1990s, increasing from about 100 adults on-colony in 1999 to about 2,200 adults on-colony in 2011.

During the Comprehensive Evaluation period of 2008 to 2011, biologists with NOAA Fisheries and PSMFC 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. NOAA Fisheries sampled, or assisted in sampling of, recently vacated nesting and loafing sites utilized by Caspian terns, double-crested cormorants, gulls, and pelicans 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. NOAA Fisheries 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, NOAA Fisheries PIT-tagged and released juvenile salmonids including 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.

RPA Action 69 – Monitoring Related to Marine Mammal Predation: *The Action Agencies will:*

1. *Estimate overall sea lion abundance immediately below Bonneville Dam. (Initiate in FY 2007-2010 Projects).*
2. *Monitor the spatial and temporal distribution of sea lion predation attempts and estimate predation rates. (Initiate in FY 2007- 2010 Projects).*
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).*

As part of RPA Action 69, the Corps continued to monitor sea lion predation at Bonneville Dam in 2012. For a more comprehensive summary of 2012 monitoring efforts, refer to the field report by Stansell et al., (2012).

RPA Subaction 69.1 – *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 2002 through 2012, the Corps visually monitored the abundance of California and Steller sea lions below Bonneville Dam (Figure 105). 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.

Corps biologists first gathered data on sea lion presence and predation at the dam in 2001, when six California sea lions were documented. By 2003, more than 100 different sea lions were documented. Not all sea lions counted were at the dam at the same time; usually about 30 were present on any one day. From 2002 through 2007, most of the pinnipeds present were California sea lions. Beginning in 2008, Steller sea lions, which are listed as threatened under the ESA, began arriving in larger numbers. By 2012, the total number of Steller sea lions seen at the Bonneville Dam tailrace was greater than the number of California sea lions seen (Figure 105).

RPA Subaction 69.2 – *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. From 2002 through 2012, the Corps has conducted land-based visual observations to monitor sea lion predation on adult salmonids, white sturgeon, and lamprey in Bonneville Dam tailrace observation area. The Corps also monitored the date and location of individual sea lion predation events. Table 66 summarizes estimated catch of salmonids by sea lions at Bonneville Dam from 2002-20012. **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.

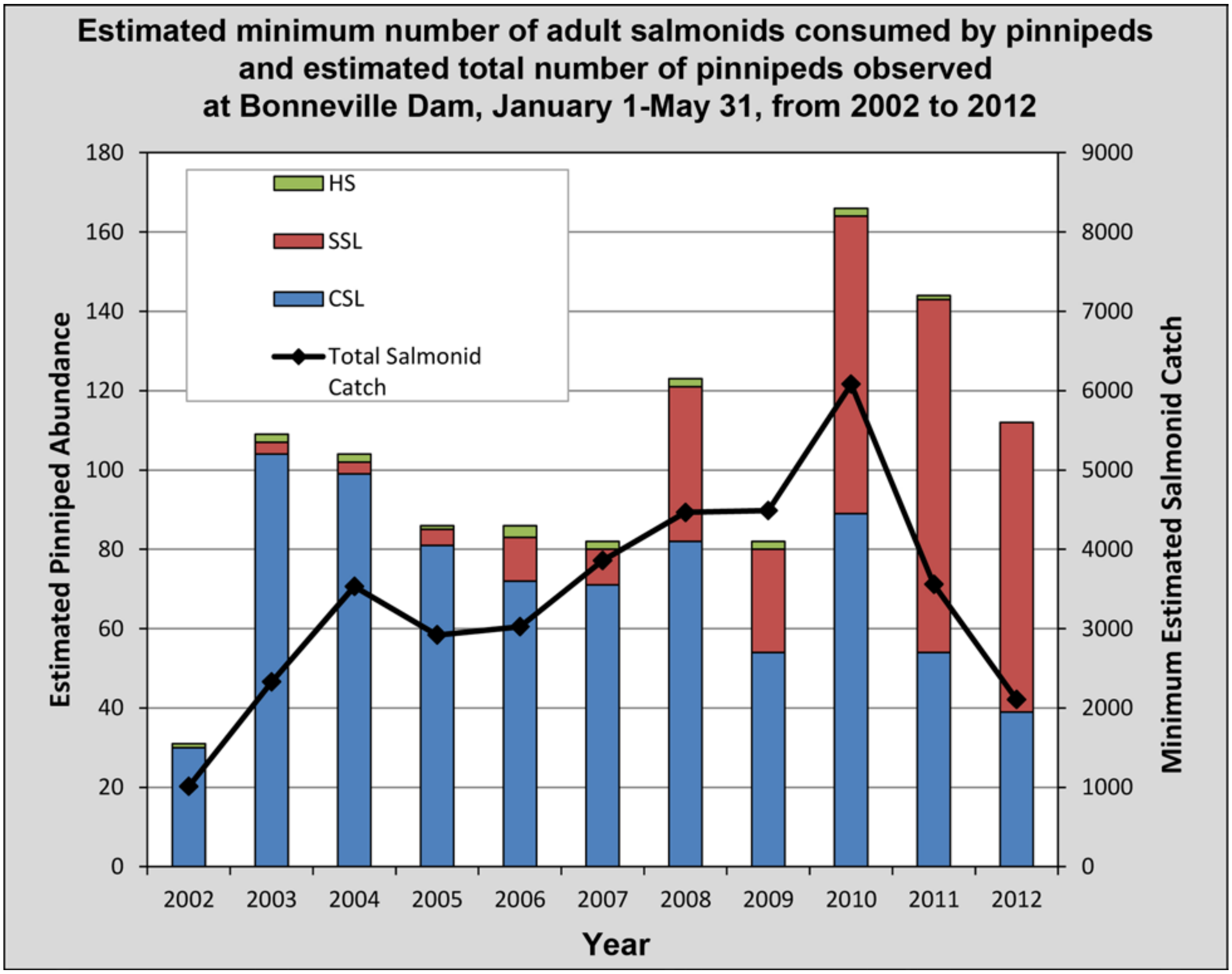


Figure 105. Estimated Minimum Number of Adult Salmonids Consumed by Pinnipeds and Estimated Total Number of Pinnipeds Observed at Bonneville Dam, January 1–May 31, from 2002 to 2012. Note: In 2005, regular observations did not start until March 18. Pinnipeds observed were California sea lions, Steller sea lions, and harbor seals. **Data from Stansell et al., 2012.**

Table 66. Summary of Estimated Catch of Salmonids by Pinnipeds at Bonneville Dam, 2002–2012 (Stansell et al., 2012).

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%

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)
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%
2012	171,665	1,227	0.7%	2,107	1.2%	2,360	1.4%

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.

RPA Subaction 69.3 – *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 annually from 2006-2012 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 five 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.

With funding from BPA, ODFW, and WDFW, two floating sea lion traps were deployed along the PH2 CC 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. There continued to be a large drop in both the California sea lion salmonid predation and California sea lion abundance in 2012 (Table 67) to levels not seen since 2003. These results show the impact of the three years of the California sea lion removal program conducted 2008 through 2010. This indicates that the removal program was gradually reducing the abundance and predation on salmonids caused by California sea lion. However, the unusual event of the influx of a large number of new California sea lion males at Bonneville Dam tailrace in 2010, coupled with the virtual halting of removal actions in 2011, make further analysis of this program challenging. It is also likely that reduction in predation on early Chinook runs is due to the removal of the returning California sea lion that tended to arrive earlier each year waiting for the arrival of Chinook salmon. The increasing presence and salmon predation by Steller sea lions at Bonneville Dam could also continue to complicate the issue if current trends persist. There was less clepto-parasitism observed in 2012 than in 2011, particularly by Steller sea lions on California sea lions, but it is unclear why this occurred (Table 68). This could be related to fewer opportunities for that behavior due to fewer California sea lions and less California sea lion predation overall. Lastly, the removal of 12 California sea lions at Bonneville Dam in 2012 obviously impacted the daily California sea lions abundance, which was lower for this year.

Table 67. Maximum Number of Salmonids Observed Consumed by Identified CSL at Bonneville Dam from January 1 through May 31, 2002 to 2012 (Stansell et al., 2012).

Year	Maximum Number of Salmonids Caught by an Individual California Sea Lion	Percentage of Salmonid Catches Attributed to Individual California Sea Lions
2002	51	85.6%
2003	52	67.7%
2004	35	54.3%
2005*	11*	8.9%*
2006	79	43.0%
2007	64	28.1%
2008	107	42.6%
2009	157	62.1%
2010	198	51.9%
2011	125	41.7%
2012	41	53.0%

** Began observation season late, didn't have opportunity to train observers on individual California sea lions identification.*

Table 68. Summary of Expanded Estimates of Cleptoparasitism Events Observed at Bonneville Dam , 2002 to 2012. Most involve salmonids (e.g., researchers observed 490 Chinook, 20 steelhead, 4 sturgeon, and 16 unidentified prey stolen in 2010, all sturgeon being SSL from SSL events) (Stansell et al., 2012).

Year	CSL from CSL	CSL from SSL	SSL from SSL	SSL from CSL	Other	Total
2002	0	0	0	0	0	0
2003	14	0	0	0	0	14
2004	366	22	0	0	0	388
2005	22	0	0	22	6	50
2006	12	0	0	5	0	17
2007	33	0	0	4	0	37
2008	161	0	4	135	5	305
2009	152	4	7	324	6	492
2010	58	2	37	801	0	898
2011	2	0	12	279	0	293
2012	2	0	55	35	0	92

RPA Action 70 – Monitoring Related to Piscivorous (Fish) Predation: *The Action Agencies will:*

1. *Continue to update and estimate the cumulative benefits of sustained removals of northern pikeminnow since 1990.*
2. *Continue to evaluate if inter and intra compensation is occurring.*
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.*

Major Accomplishments and Findings

Predation by large northern pikeminnow is a major source of mortality for juvenile salmonids in the lower Columbia and Snake rivers. The NPMP has implemented a removal fishery targeting northern pikeminnow since 1990. Biological evaluation of the removal program has been an ongoing program component since the removal fishery began. Friesen and Ward (1999) developed a model to estimate the benefits of removals to date based upon Beamesderfer et. al (1996) proposal that evaluations of the NPMP be based on indirect measures, such as mark-recapture estimates of exploitation. This model estimates changes in potential predation on juvenile salmonids by northern pikeminnow since implementation of the NPMP. Model inputs include: 1) an average population structure (age distribution, length at age, and natural mortality) for northern pikeminnow before implementation fisheries began in 1990; 2) Average rates of consumption of juvenile salmonids by northern pikeminnow; 3) age distribution of northern pikeminnow adjusted by observed exploitation and natural mortality; and 4) and index of age-specific predation on juvenile salmonids by northern pikeminnow. Model output is expressed as the percent of predation before implementation of the NPMP. Because of the uncertainty of some input values to the model, researchers use a calculation of a range of solutions based on a minimum maximum, and measure of central tendency for each uncertain parameter.

Friesen and Ward determined that, based on the period of full removal fishery implementation between 1991-1996, predation on juvenile salmonids by northern pikeminnow had decreased to 75 percent (median) of pre-NPMP levels. This model, with some slight modifications, is used today. Today the median reduction in pikeminnow predation is 38 percent based on cumulative removals to date. This has resulted in approximately 3-6 million juvenile salmonids not consumed annually by northern pikeminnow.

Major Lessons Learned

The major accomplishment of the NPMP is the ability to quantify system-wide benefits to reducing fish predation on juvenile salmonids. The importance of conducting extensive baseline abundance, distribution, and consumption research in the 1980s was critical in achieving the ability to evaluate the pikeminnow removal program. At the time, the expenditure for this research was a significant portion of total BPA investments in fish and wildlife.

RPA Subaction 70.1 – *Continue to evaluate if inter and intra compensation is occurring.*

Major Accomplishments and Findings

The response of northern pikeminnow and other piscine predators to exploitation is an important research need of the NPMP. A significant portion of the benefits ascribed to the removal program could be offset if northern pikeminnow growth-rate, diet, fecundity, and age at maturity change significantly due to implementation of the removal fisheries. Compensatory predation by smallmouth bass and walleye are also a concern. To date, the NPMP biological evaluation has not observed any significant changes in these measurements to conclude any inter- or intra-specific compensation occurring. (Parker et al., 1995; ODFW personal communication).

RPA Subaction 70.2 – *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.*

The benefits of monetarily increasing the NPMP's tiered reward system in 2004 are assessed by observing the change in exploitation rate and resultant increase in modeled benefit. Catches and catch per unit of effort have varied somewhat since the increase in the incentive program for public sector anglers within the Sport-Reward fishery. However, the general trend in exploitation rate has increased even though total catch has somewhat declined. The mean 2000-2003 exploitation rate is 13.4 percent (250mm/fl) and the 2004-2012 mean exploitation rate is 17.2 percent, an approximately 28 percent increase. As a result of the incentive program, predation on juvenile salmonids by northern pikeminnow has decreased to 21-54 percent of pre-NPMP levels, with a mean estimate of 63 percent (37 percent reduction) (ODFW personal communication).

Figure 106. 2004 Represents the Year the Program Incentive Increase Began.

RPA Subaction 70.3 – *Develop a study plan to review, evaluate, and develop strategies to reduce non-indigenous piscivorous predation.*

Major Accomplishments and Findings

The Action Agencies conducted a series of workshops beginning in September 2008, to review, evaluate, and develop strategies to reduce non-native piscivorous predation on juvenile salmonids. Within the workshop setting, regional participants identified critical uncertainties to be addressed through research. Research was considered beginning in 2009 to document the food habits of non-native predators in the lower Columbia River during the late summer and fall to assess the role of juvenile American shad in their diets and any impacts on their health and condition. Additional research to describe and compare relative density and diet of smallmouth bass between sites perceived to be "hot spots" and other nearby sites was also prioritized and implemented.

Collectively, the results from the first two research field seasons are the first to describe the diets of smallmouth bass, walleye, and CHC over a large spatial area in the mid-Columbia River during late summer and fall. Only smallmouth bass and walleye consumed relevant amounts (up to 27 percent by mass for walleye) of American shad. However, the influence of this diet item on their condition was not discernible because these fish showed only slight increases in condition indices that did not always correspond to a dietary shift that included an increase in shad consumption, and researchers could not discount the importance of other prey items. Results should be useful for future discussions regarding predation and shad management in the Columbia River.

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.*
2. *Supporting and participating in the Council's Columbia River Basin Fish and Wildlife Program project planning and review efforts.*
3. *Supporting the standardization and coordination of tagging and monitoring efforts through participation and leadership in regional coordination forums such as PNAMP.*
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.*
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.*
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.*

RPA Subaction 71.1 – *Organizing and supporting the Corps AFEP.*

Major Accomplishments and Findings

The main purpose of AFEP is to produce scientific information to assist the Corps in making informed biological, engineering, design, and operational decision for the eight mainstem Columbia and Snake river projects to provide safe and efficient passage through the mainstem corridor. ESA guidelines for the protection of listed species strongly influence the Corps' entire fish program. Through AFEP and the regional process, key research objectives and studies are developed, designed, and reviewed to answer key questions about behavior, survival, and the condition of fish as they migrate through the mainstem Colombia and Snake rivers, thus facilitating decisions on the operation and configuration of the river system.

Each year, AFEP convenes multiple regional meetings to develop and review studies designed and conducted to answer key questions relation to how best operate the hydropower system for maximized fish survival. From 2008-2012 the Corps held multiple regional meetings to: develop research objectives, review and prioritize research objectives, develop and review draft and final proposals, and prioritize which objectives and proposal are the most important given limited budgets. These AFEP meetings are primarily in the form of Study Review Work Group meetings and FFDRWG meetings. Special Study Review Work Group and FFDRWG meetings are also held on an as-needed basis.

The Study Review Work Group identifies information needs, develops potential research objectives, and provides technical review of proposals and draft reports. Through this processes, NOAA Fisheries ensures the research is aligned with the FCRPS BiOp and take is minimized through best practices, methods, and study designs. The FFDRWG provides comment and review on designs, construction methods, and construction schedules of new facilities or modification to existing structures to ensure fish considerations are fully considered and options vetted with the fish managers.

RPA Subaction 71.2 – *Supporting and participating in the Council's Columbia River Basin Fish and Wildlife Program project planning and review efforts.*

Major Accomplishments and Findings

BPA continued to work with NPCC staff in coordinating its FWP project planning and review efforts. Each FCRPS BiOp APR has been provided to the NPCC and, in 2010, the NPCC was briefed on the Anadromous Salmonid Monitoring Strategy to support the FCRPS BiOp and ESA recovery monitoring needs for fish populations and tributary habitat. BPA and the NPCC completed the RME and Artificial Production Categorical Review in 2011[17], and the Resident Fish Regional Coordination and Data Management Categorical Review in 2012[18] to support a comprehensive evaluation of the FWP's research and monitoring, data management projects and hatchery program.

BPA and the NPCC developed programmatic conditions to address ISRP concerns from the categorical reviews, which BPA began to address in 2012 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 RME issues and ensure Corps and BPA monitoring was integrated. In addition, Reclamation and BPA worked on a Tributary Habitat Monitoring Framework with NOAA's Northwest Fisheries Science Center and Regional Office to ensure tributary habitat and population monitoring is integrated to support the FCRPS BiOp and their respective programs.

Major Lessons Learned

Standardized and timely reporting of F&W Program projects relative to FCRPS BiOp RPA associations and management decisions can greatly assist the planning, review, and implementation of projects. Further improvements to FWP RME reporting were instituted by BPA through development of reporting tools and standard reporting templates for RME and RPA specific reporting.

RPA Subaction 71.3 – *Supporting the standardization and coordination of tagging and monitoring efforts through participation and leadership in regional coordination forums such as PNAMP.*

Major Accomplishments and Findings

BPA and Reclamation provided increased funding for PNAMP facilitation and products, and continued participation in the PNAMP Steering Committee and within various workgroup processes to support and advance standardization and coordination of monitoring. The following two BPA projects and one Reclamation project were continued to support this RPA subaction.

BPA Project 2007-216-00 (The Pacific NW Aquatic Monitoring Program Research, Monitoring and Evaluation (RM&E) Design and Protocols) was completed in 2010 with the publication of a special report "Tagging, Telemetry and Marking Measures for Monitoring Fish Populations" *http://www.pnamp.org/node/3656*. .

[17] http://www.nwcouncil.org/fw/reviews/2010/rmeap/

[18] http://www.nwcouncil.org/fw/reviews/2013/

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program): This project continues to provide facilitation, technical support and a collaborative forum for the standardization and coordination of fish and habitat monitoring. A regional information sharing charter continues to guide the Pacific Northwest Aquatic Monitoring Program forum with over 20 regional participating agencies. The Pacific Northwest Aquatic Monitoring Program forum has identified and been working on a number of concepts and associated products important to establishing a regional partnership for aquatic resource monitoring that bridge technical focus areas and individual agencies.

A key example of progress over the last couple years is the Pacific Northwest Aquatic Monitoring Programs ongoing coordination and technical support of the protocol library production tool (see at *www.monitoringmethods.org*). This tool supports documentation of protocols to capture monitoring designs for data collection and analysis methods for various indicators and metrics. In 2011, BPA started application of this tool with new requirements to all monitoring RME contracts requiring 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 are important. *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.

Action Agency staff participates with the Pacific Northwest Aquatic Monitoring Program staff by providing content review of data collection and analysis methodologies and provide agency endorsements for standardized methods and overall ratings for protocol quality. An example of a BPA approved method that was standardized across multiple agencies and participants was Fork Length measurement methods (*https://www.monitoringmethods.org/Method/Details/1550),* which differs from Postorbital or total length Figure 107. Quality ratings are subjectively based on the perception of the ability to use a protocol and repeat the study with little variation in bias and precision.

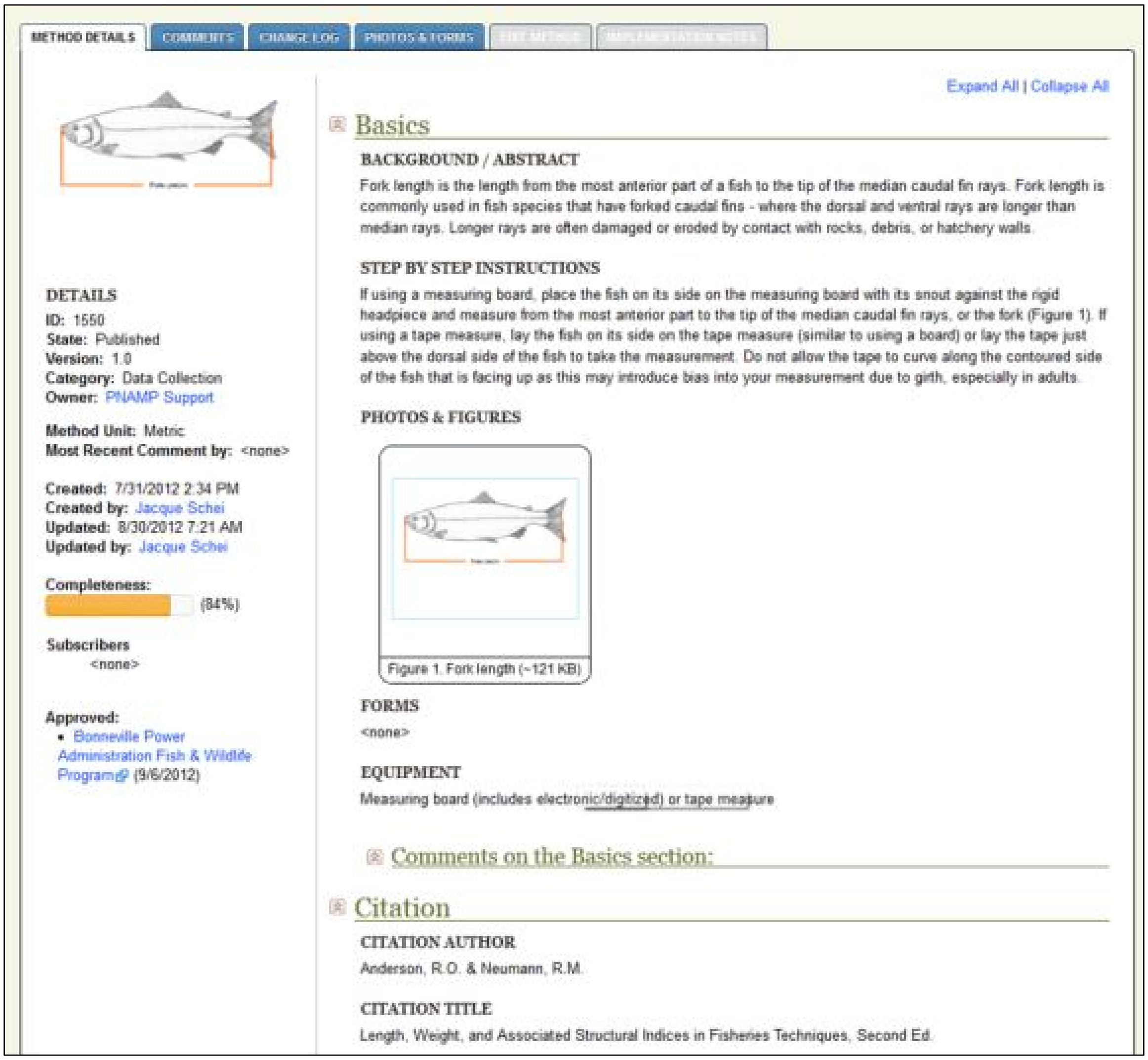


Figure 107. Example Methodology for Fork Length Measurements and BPA Approval.

Reclamation Projects: Reclamation directly participated in the Pacific Northwest Aquatic Monitoring Program 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 and supported documentation of their protocols in the *www.monitoringmethods.org* tool.

Reclamation also coordinated tagging efforts in the Methow IMW Project. Reclamation funded USGS-CRRL to develop a survival power analysis using PIT-tag detections (Reclamation 2013a, Appendix E5). Reclamation and USGS-CRRL then coordinated PIT-tagging efforts to include sufficient detections to meet statistical power requirements for a survival analysis. Reclamation and USGS also developed software applications for the analysis. Reclamation funded the purchase of PIT-tags for the Winthrop NFH's steelhead program to evaluate the success of the program and to use hatchery fish to determine PIT-tag reader efficiencies.

Major Lessons Learned

- Ongoing work to standardize methods across agencies will take time, but will improve overall efficiencies in monitoring by facilitating data exchange and improving interoperability of measurement data for regional assessments. As discussed in RPA Action 50.1 improvements to standards and documentation of exchange methods amongst tagging, genetics, age, and other metrics allow for third-party use of data with confidence that data was used properly based on documented objectives, methods, limitations and assumptions.

- Reclamation and USGS-CRRL determined that additional PIT-tag readers were needed in the Methow IMW to meet survival power analysis requirements. Reclamation funded USGS to install new readers.

RPA Subaction 71.4 – *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.*

Major Accomplishments and Findings

Improvements to metadata have been made in 2011/12 through documentation of protocols in *monitoringmethods.org*. Additional work was started and is ongoing to complete a metadata builder in *monitoringresources.org*, and a mechanism to attach metadata records with data sets in the databases. Additional support for data stewards to help facilitate state and tribal data management was initiated in 2012, as identified in the Coordinated Assessments strategy. Discussions are ongoing regarding the best way to implement this assistance for some tribes in relationship to existing data management support under the Tribal BiOp Accords. All High Level Indicators (HLIs) for fish have been mapped and identified, and habitat limiting factor HLIs have been standardized for salmonids.

Eleven BPA projects continued to support this subaction in the 2008 to 2012 period.

BPA Project 1982-013-01 (Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)) supports this RPA by funding the Regional Mark Processing Center Operations. The Regional Mark Processing Center (RMPC) provided essential regional services to state, federal, and tribal fisheries agencies involved in marking anadromous salmonids. These services include regional coordination of tagging and fin marking programs, maintenance of a regional database for CWT releases and recoveries, and production of printed and/or machine readable data reports. The regional CWT database is accessed through PSMFC's web based Regional Mark Information System (RMIS): *http://www.rmpc.org*.

BPA Project 1998-108-04 (StreamNet - Coordinated Information System (CIS)/ Northwest Environmental Database (NED)): To support this RPA, work was conducted by project leads and data stewards to improve metadata documentation for all monitoring projects by supporting development of PNAMP’s master-sample design, monitoring glossary, and protocol catalog projects. The project lead was an active participant in the PNAMP steering committee and PNAMP Data Management Leadership Team, and provided insight on the implementation of coordination and standardization tools and products developed by PNAMP. StreamNet also provided direct funding for a network of data management positions for Oregon, Washington, Montana, Idaho, and the USFWS. These staff supported data exchange for fish monitoring projects across the Columbia River Basin. To support data management and reporting components of the Columbia Basin Anadromous Salmonid Monitoring Strategy, StreamNet developed the Data Exchange Template (DET) in 2012 with state and tribal fish management agencies in the Coordinated Assessments project. This work supports development and sharing of fish High Level Indicators data for adult and juvenile abundance.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) participated in the PNAMP ISTM project to discuss attributes necessary to develop a monitoring design using an area-based sample. To help standardize monitoring procedures, the LCEP convened the Science Workgroup to standardize the application of the Roegner et al. (2009) protocol (at *www.monitoringmethods.org)* in the project’s protocol.

BPA Project 2003-017-00 (ISEMP) supported development of the data dictionaries in *www.monitoringmethods.org* related to habitat classifications. The ISEMP project also played a critical role in supporting the PNAMP ISTM project in development of the Master Sample which is now being managed under the *www.monitoringresources.org* Sample Designer tool.

BPA Project 2003-022-00 (Okanogan Basin Monitoring & Evaluation Program (OBMEP)) participated in the PNAMP steering committee and supported development of the data dictionaries in *monitoringmethods.org* related to habitat classifications and attended the Coordinated Assessments workshops resulting in the development of their data management strategy to exchange fish abundance data.

BPA Project 2003-072-00 (Habitat and Biodiversity Information System for Columbia River Basin) participated in the PNAMP steering committee and supported development of the data dictionaries in *monitoringmethods.org* related to habitat classifications.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination): The Pacific Northwest Aquatic Monitoring Program's Coordinated Assessments Project, in collaboration with Columbia Basin Fish & Wildlife Authority (CBFWA) and StreamNet, was an effort to develop integrated data-sharing for anadromous-fish-related data among the co-managers (state fish and wildlife agencies and tribes) and Action Agencies of the Columbia River Basin. The initial focus of the project was on three VSP abundance indicators for salmon and steelhead: natural-origin spawner abundance, SAR ratio, and recruit-per-spawner, but was expanded to include Juvenile out-migrant abundance to support tributary monitoring for the FCRPS BiOp. 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. The Coordinated Assessments project products and ongoing work plan may be viewed at *http://pnamp.org/project/3129*.

The Pacific Northwest Aquatic Monitoring Program'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 River 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.

The ISTM project provided additional support for the integration and interoperability of habitat data across multiple agencies collecting habitat data Figure 108. This project, in coordination with CHaMP, establishes the foundation to complete a CHaMP monitoring program and USFS PIBO.

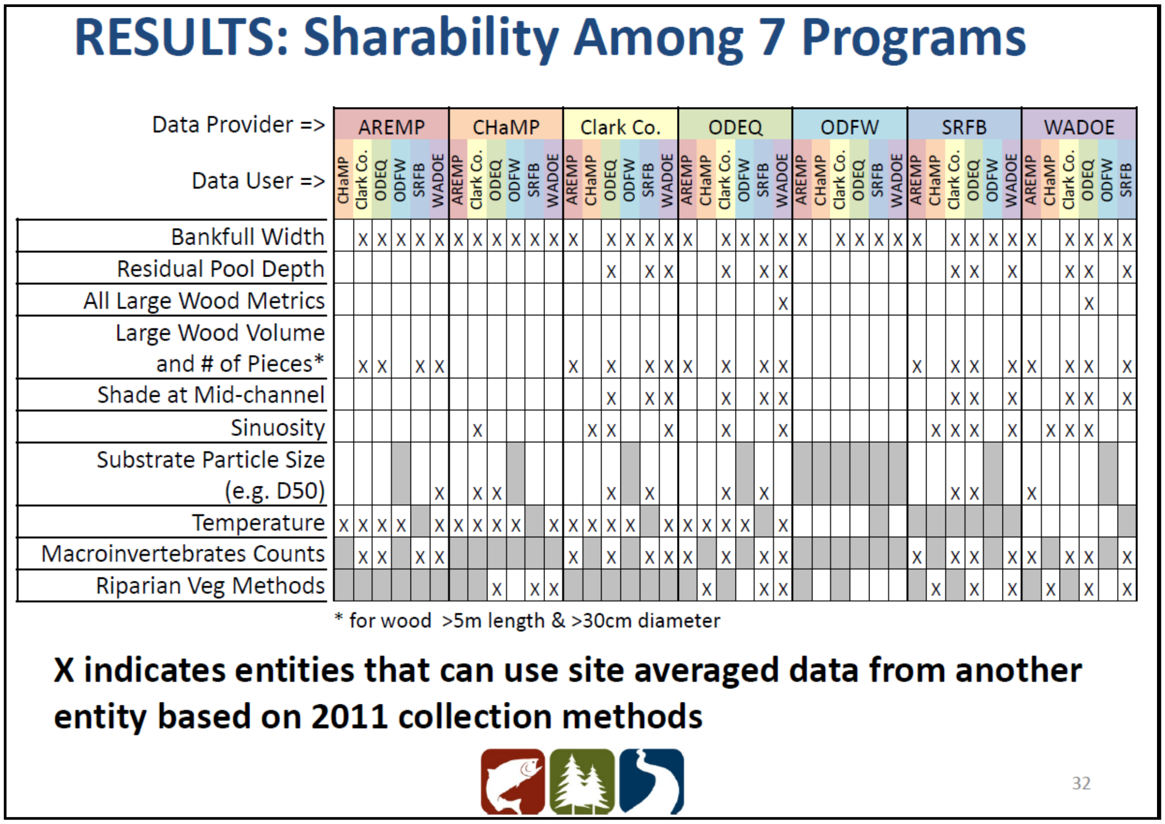


Figure 108. PNAMP Habitat Data Sharing Workgroup Product Example on Interoperability of Measurements Across Programs Based on Use of Different Methods.

BPA Project 2007-083-00 (Grande Ronde Supplementation Monitoring and Evaluation (M&E) on Catherine Creek/upper Grande Ronde River): For 2010 this project supported CTUIR participation in the Coordinated Assessments and ASMS workshops, but is now complete.

BPA Project 2008-507-00 (CRITFC's Tribal Data Network Accord Project) was implemented to demonstrate implementation of coordination and standardization tools though evaluation and application of handheld technologies for data capture (e.g., the Digital Pen). In addition, with staff support from this project the Coordinated Assessment identified priority gaps in tribal data management that were addressed in an expanded TDN project proposal which was submitted to the ISRP for assessment (http://www.cbfish.org/Proposal.mvc/Summary/RESCAT-2008-507-00). Ad hoc meetings to identify data management gaps, priorities, strategies, methods, and tools were held throughout the region with tribal fish and wildlife staff on an as-needed basis. StreamNet Steering Committee and technical committee meetings were attended, as well as PNAMP Steering Committee meetings.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program - Pilot (CHaMP-P)): Refer to the discussion under Pacific Northwest Aquatic Monitoring Program Project 2004-002-00 and Figure 108.

Reclamation Projects: Reclamation worked with monitoring entities in the Methow IMW to ensure that all entity monitoring methods were properly cataloged in MonitoringMethods.org, the collaborative regional database for monitoring protocols and metrics. A database coordinator for the Methow IMW was funded to identify data that is needed for model applications and catalog that data in a standardized format. The University of Idaho was contracted to develop an on-line data harvester tool that will collect and prepare data for analysis and reporting. Some entities requested a data sharing agreement to protect intellectual property rights, which Reclamation developed. Reclamation also developed a management strategy and schedule for data collection and reporting that provides ample opportunity to publish, but does not constrain management needs for timely reporting.

Major Lessons Learned

Standardization and coordination across agencies requires management support. Without top down support, most individuals continued to conduct work on a project-by-project case without standardization of data entry templates for various methods for fish data collection.

The ISTM project Habitat Data Sharing work identified that only limited data sets could be shared and used due to lack of interchangeable classifications used by sponsors. Not all data collected by different organizations or purposes can be used to support the FCRPS BiOp assessment today, but as integration studies (i.e., PIBO and CHaMP) continue in the future researchers may have opportunities to use and combine other data sets, or researchers may find it is inappropriate because the designs were for different purposes. Standard documentation of protocols and methods is an essential first step for coordination of monitoring programs and data sharing.

RPA Subaction 71.5 – *Coordinating the further development and implementation of Hydrosystem, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RM&E through leadership and participation in ongoing collaboration and review processes and workgroups.*

Major Accomplishments and Findings

The AAs provided leadership and participation in several regional processes and workgroups supporting the ongoing development and implementation of RM&E. This includes the following:

- AA/NOAA/NPCC BiOp RM&E workgroups for the coordination and advancement of BiOp RM&E strategies and RPA implementation. (2009 and 2010 Recommendations for Implementing RM&E for the FCRPS BiOp:*http://www.salmonrecovery.gov/Files/RME/RM&E%20Recommendations%20Report%20w%20revised%20Appendix.pdf*)
- PNAMP Collaboration Forum and associated Working Groups
- NPCC FWP RM&E Categorical Review Process; support for design development and proposal RPA review.
- Anadromous Salmonid Monitoring Strategy (Skamania Process) - Regional and Subregional Workgroups to identify and coordinate RM&E that would meet BiOp requirements for Fish Population and Tributary Habitat and Hatchery Action Effectiveness (ASMS 2010 draft)
- AFEP Program development and review workgroup processes and associated SRWG and FFDRWG regional technical work groups
- Development of Comprehensive Evaluation synthesis papers for the estuary, tributary and Hydrosystem.
- Support in development of the AA, NOAA Tributary Habitat RM&E framework document.

Two BPA projects supported the collaboration of the current Action Agencies, NOAA Fisheries, and the NPCC for implementation planning, annual/comprehensive progress reporting, and adaptive management of RME strategies.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program (ISEMP): The ISEMP project provided extensive coordination of the development and implementation of tributary habitat RM&E in the pilot watersheds

BPA Project 2004-002-00 (The Pacific Northwest Aquatic Monitoring Program Coordination Project) supported regional coordination and standardization of fish population and habitat monitoring programs over the 2008 -2012 period. See information for this project under RPA Subactions 71.3 and 71.4.

BPA Project 2003-072-00 (Habitat and Biodiversity Information System for Columbia River Basin): In Section 3 of the 2011 APR report an RPA association for **BPA Project 2003-072-00** was identified however this was an error and the association was removed. This project did not conduct work to support the RPA subaction.

AA, NOAA BiOp RME Workgroup: In 2011, the NPCC's RME/Artificial Production Categorical Review (ISRP, 2010) was concluded; and in 2012 the Resident Fish Regional Coordination and Data management Categorical Review in 2012, (ISRP, 2012) was concluded, which validated the incorporation of the Action Agencies/ NOAA Fisheries /NPCC RME RPA workgroup 2010 RPA Recommendation Report into project proposals for BPA's Fiscal Year 2012 contracts.

Major Lessons Learned

Integrated teams between the Action Agencies, NOAA Fisheries, and NPCC ensure better alignment in strategies for conducting work and development of annual reports to inform adaptive management of the FCRPS BiOp and Action Agency programs. For example, in the Estuary and Ocean workgroup, NPCC and NOAA Fisheries' absence resulted in difficult communication to managers, executives, ISRP and NPCC members and a perception of non-congruence in development of work plans for implementing estuary, ocean, and plume monitoring projects. Other processes and outcomes were less difficult and more successful with full participation of funding and regulatory agencies.

RPA Subaction 71.6 – *Coordinating implementation with other appropriate regional collaboration processes. This includes coordination related to statutory provisions for the federal government (BPA/NPCC), 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.*

Major Accomplishments and Findings

The Action Agencies are actively participating in regional forums and accomplishing this subaction through subactions 71.1-71.5 above. Coordination related to statutory provisions for the federal government (BPA/NPCC), federal agencies (Federal Caucus), and coordination with regional processes for federal/non-federal engagement (TMT, SCT, PNAMP) continued to support the FCRPS BiOp.

See the AMIP for further information on the ASMS, which outlined distinctions in monitoring requirements for the FCRPS BiOp and other regulatory needs to support ESA recovery monitoring needs.

Major Lessons Learned

Coordination through active participation in regional forums and workgroups takes significant staff time, but is essential to meet many RM&E RPA requirements that are highly dependent on common understanding and agreement among multiple federal, state, and tribal agencies.

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.*
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).*
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).*

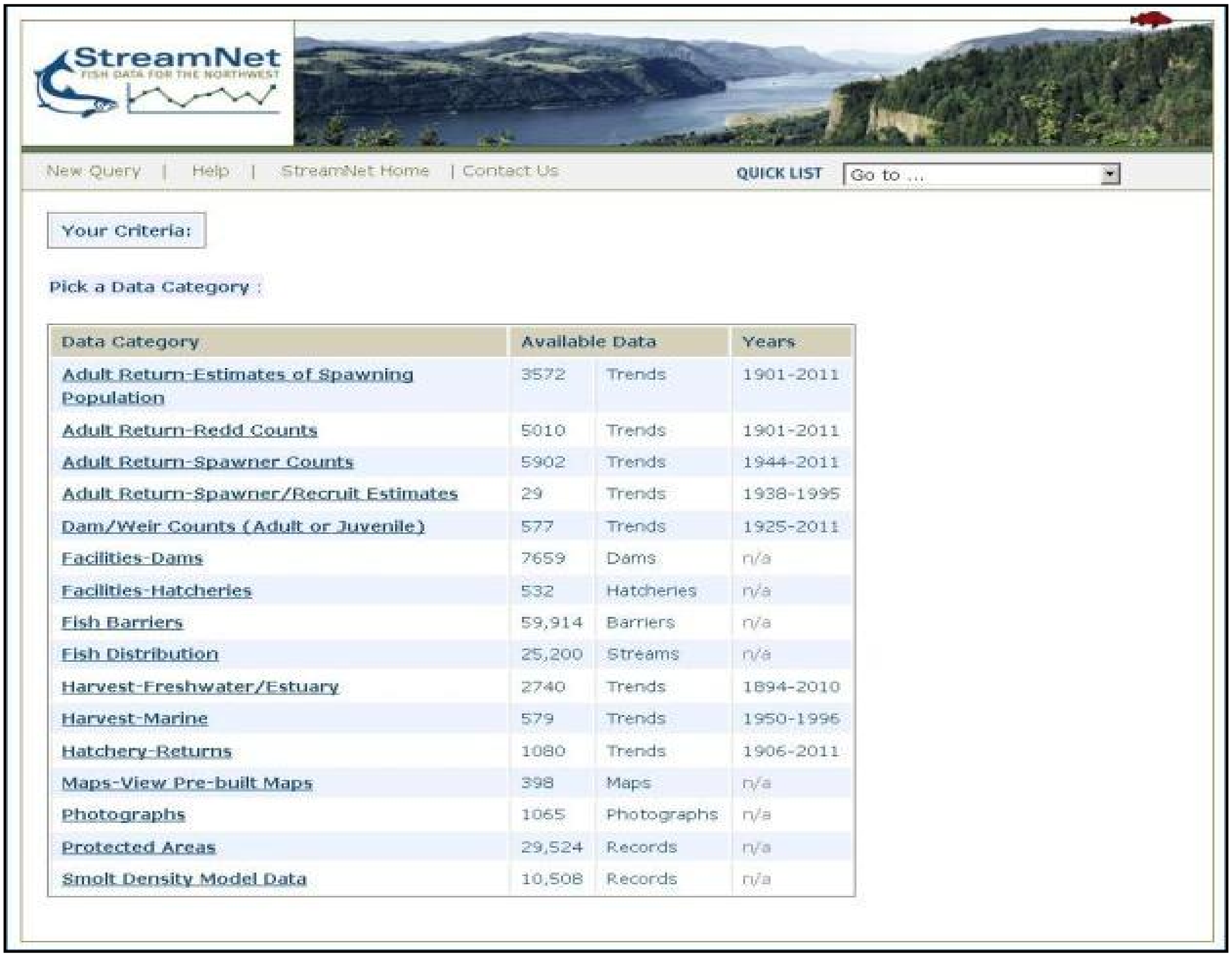
RPA Subaction 72.1 – *Continue to work with regional, federal, State and tribal agencies to establish a coordinated and standardized information system network to support the RM&E program and related performance assessments. The coordination of this development will occur primarily through leadership, participation, and joint funding support in regional coordination forums such as the NED workgroup, and PNAMP and the ongoing RM&E pilot studies in the Wenatchee River, John Day River, Upper Salmon River, and Columbia River estuary (Initiate in FY 2007-2009 Projects).*

Major Accomplishments and Findings

To address actions identified in the Implementation Plan, BPA, Reclamation, and Corps staff continued to advance standard project implementation metrics though adoption of standards in the ERTG and Expert Panel processes. Integration between Pisces and NOAA Fisheries implementation tracking system is discussed under RPA Action 73. In addition, one Reclamation, one Corps, and 12 BPA projects supported this subaction during the 2008 to 2012 period. Reclamation ensured that all RME data needed for analysis and reporting will be available using a web-based tool.

BPA Project 1989-062-01 (Annual Work Plan for Columbia Basin Fish and Wildlife Authority (CBFWA)): With PNAMP and StreamNet this project helped to lead and facilitate the Coordinated Assessments to continue efforts to map data flow for priority FCRPS BiOp fish and habitat data for agencies at the project level consistent with ongoing methods used by the NOAA Fisheries Northwest Fisheries Science Center in the Salmon Population Summary Database. In 2011, the needs assessment/work plan and state and tribal agency data strategy were completed (*http://www.pnamp.org/sites/default/files/ca_basinwide_data_sharing_strategy_final_draft_nov_10.pdf*), and in 2012 a Data Exchange Template was completed and posted at *http://www.pnamp.org/project/3129*.

BPA Project 1998-108-00 (StreamNet) continued the development of the StreamNet Databases and StreamNet Data Store at *http://www.streamnet.org* to manage fish data for BPA projects Figure 109. With PNAMP and CBFWA, this project also helped to lead and facilitate the Coordinated Assessments process in 2010-2012 to continue efforts to map data flow for priority FCRPS BiOp fish and habitat data for agencies at the project level consistent with ongoing methods used by the NOAA Fisheries Northwest Fisheries Science Center in the Salmon Population Summary Database.



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 109. Screenshot from the Web Pages of Streamnet.Org Depicting Data Types Stored in the Streamnet Database.

BPA Project 1990-080-00 (Columbia Basin PIT-tag Information): The project information for this RPA is already reported under the RPA Subaction 50.1 report.

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

BPA Project 1998-031-00 (Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)): Implement Wy-Kan-Ush-Mi Wa-Kish-Wit provided CRITFC staff the ability to participate in PNAMP the Data Management Leadership Team (DMLT) and the Coordinated Assessments. In addition, it continued to advance the data management and reporting components of the Columbia Basin Anadromous Fish Monitoring Strategy through ongoing collaboration tribal fish management agencies. This project RPA association was replaced and supported by CRITFC's Project 2008-507-00 in the future as that project actually develops the tools needed to support this RPA.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring Program) supported development of data exchange templates and standard data entry forms to exchange estuary monitoring data with the Oncor database being developed by the Corps. In addition, LCEP further developed its website to display the Columbia River estuary habitat classification and Catena GIS data at *http://maps.lcrep.org/*.

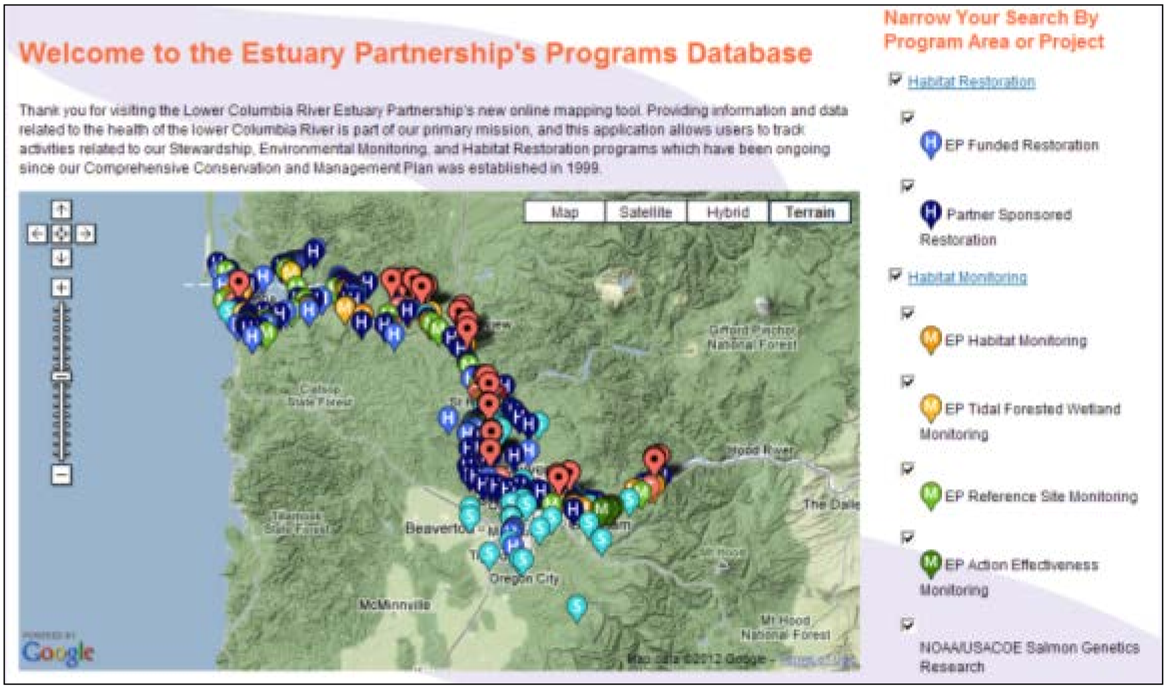


Figure 110. LCEP Mapping Tool.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program: This ISEMP project continued development and review of the Aquatic Resource Schema in the STEM databank and applied similar approaches to ensure consistency with standard metrics identified in RPA Subaction 71.4. The Status Trend and Effectiveness Monitoring (STEM) Databank (*https://www.webapps.nwfsc.noaa.gov/apex_stem/f?p=168:2:662373028707546*), was created to store and distribute biological and physical aquatic ecosystem data collected or compiled through ISEMP efforts. STEM houses fish, in-stream habitat, fine sediment, and water quality data from various state, federal, tribal, and contracted organizations from 2004 - 2010. The majority of data within the STEM Databank is from the upper Columbia River (Wenatchee and Entiat rivers) as data collection for ISEMP first began in the upper Columbia pilot subbasin, and these data were used as template data for development of the database. ISEMP discovered that migrating multiple datasets to a single, consistent, and defined database structure can be time consuming, but this vastly improved the efficiency of long-term data retrieval and use. These concepts have continued to influence the development of other ISEMP data management tools.

In addition, the ISEMP project and Columbia Habitat and Monitoring Program integrated habitat monitoring of the STEM databank with the CHaMP habitat data system for habitat monitoring contained in the CHaMP protocol and data monitoring database at *www.champmonitoring.org*.

ISEMP relies heavily on juvenile and adult PIT-tagging and interrogation at IPTDS. The development of IPTDS technology represented a significant advancement with regard to the estimation of juvenile and adult distribution, abundance, and survival. To efficiently access and store the large quantity of interrogation and diagnostic information, ISEMP developed the Instream PIT-Tag Detection Database. A server automatically accesses field data via cell phone or satellite modem and stores the information in a SQL database. IPTDS “site stewards” can access the SQL database as necessary to inform users about changes in site architecture and infrastructure or interruptions IPTDS operation that might affect how the data can be used and analyzed. Full details are provided in the ISEMP Lessons Learned Synthesis Report 2003-2011 at *https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P127284*.

BPA Project 2003-022-00 (Okanogan Basin Monitoring & Evaluation Program (OBMEP)): By the end of 2011, OBMEP began implementing a plan to not just upgrade the database software, but to create a comprehensive data management system that includes tools for data storage, data collection, quality assurance/quality control (QA/QC) of the data, and analysis and reporting. With the desire among agencies in the upper Columbia River region and that of BPA to make our data more accessible and shareable, researchers also began the ground work for the website component of the data management system that would enable entities outside of the Colville Tribes’ network to easily query and download portions of the data.

Summit Environmental Consultants Ltd. began building the habitat data collection template in ASP.NET, which was implemented in the summer of 2012. The new template is synchronized with the database, and data that are entered into the application are directly uploaded upon establishing a connection with the database. Any QA/QC of the data is tracked within the data management system and becomes a part of the data. By the end of 2012, OBMEP completed a dynamic reporting tool to provide a user-friendly interface that managers can use to create custom queries, easily analyze some data types, and produce standardized graphs and reports.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination): The Pacific Northwest Aquatic Monitoring Program continued the mission of NED in PNAMP through regional coordination of the 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 NOAA Fisheries contractor to integrate protocols into a region-wide data dictionary that is being coordinated through PNAMP.

BPA Projects 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database [NED]), **1989-062-01** (Annual Work Plan for CBFWA), **2004-002-00** (Pacific Northwest Aquatic Monitoring Program), and **2008-727-00** (Regional Data Management Support and Coordination) managed by PNAMP staff at the USGS continued to support the implementation of the Coordinated Assessments Projects through PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production.

While it was not PNAMP’s role to collect data or provide analysis of data, PNAMP provided facilitation to support development of white papers and work plans related to the Coordinated Assessments Project for fish and habitat. These 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. Through support of these projects, PNAMP also helped develop the *www.monitoringresources.org* tools to support upfront metadata documentation to support exchange of information.

BPA Project 2008-507-00 (Tribal Data Network) In addition to parallel support provided by project 1998-031-00, the project explored use of digital pens to support improved data transfer and QA/QC to biologist to improve data exchange processes.

BPA Project 2008-727-00 (Regional Data Management Support and Coordination): See project 2004-002-00 information above. This project was an extension of the Pacific Northwest Aquatic Monitoring Program project, because PNAMP staff helped manage the contracts. In 2012, the projects were fully integrated.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program): See **2003-017-00** summary related to ISEMP CHaMP Integrated history. CHaMP led the way in protocol documentation in the *www.monitoringmethods.org* tool to demonstrate the level of information required to support metadata development with creation of standard data entry forms for rapid exchange of data from the field to the data systems. Overall, the number of features and functions built for the CHaMP data management system, including those which are made available to staff and collaborators for field data management, QC/QA, and analysis, was impressive to most users and was sufficient for field implementation. In 2012, staff continued to use existing features and coordinate and share this work with other regional habitat programs through PNAMP. They also performed additional work to further define data requirements, both for upload and input, and output and use in other tools (e.g., RBT), through work among data management staff, monitoring coordinators, analysts, and crew supervisors, to improve the overall data management process prior to the field season.

To facilitate QA/QC data management, staff could explore expanding the use of some cloud features to pass data back and forth between crews and CHaMP support staff, and they could research providing an alternate tool for crew data transfer, (e.g., DropBox) or a place to email zipped files, if access to the cloud is difficult or impractical.

Reclamation Project: Reclamation continued funding for PNAMP and leadership participation on the PNAMP steering committee. Reclamation hired a data steward for the Methow IMW to ensure that all data is properly identified and cataloged including metadata. Reclamation is funding the University of Idaho to develop a data harvester tool which will collect data for analysis and reporting. Reclamation purchased field data digital recorders for efficient and accurate data collection.

Major Lessons Learned

Additional collaboration between the federal, state, and tribal organizations in development of standard data management systems for adult and juvenile fish abundance, as well as habitat data, are necessary to support the RME program and related performance assessments. To facilitate this collaboration and further advancement in data management, BPA has developed a draft data management strategy for the FWP program.

Further integration and use of web services between systems are necessary to support the NOAA Fisheries Salmon Population Summary Data Base (SPS) and NPCC HLIs assessments.

CHaMP provided a model of how standardized protocols and QA/QC procedures could be applied to habitat data, and it should be incorporated into other data systems to ensure data can be shared in a timely manner.

The USFWS data system and IDFG's Idaho Fish and Wildlife Information System demonstrated how standardization of data entry into common exchange formats and corporate data system for all USFWS and IDFG sponsors allowed for cost and time savings in the StreamNet project relative to other state and tribal systems. Lack of these standards increased time and cost for data entry and QA/QC procedure implementation.

Existing work documenting project contact information could be used to develop metadata records, thus saving time for sponsors in developing annual reports or metadata records used for information exchange and assessments.

ISEMP's lessons in data management practices have improved data flow, quality, and documentation of ISEMP and CHaMP's aquatic monitoring data. Researchers now readily acknowledge the surface nuances in data storage that have developed from differences in terminology, artifacts from agency templates, and lack of required uniformity in data storage, and it is working to amend these issues in an upfront manner.

The Methow IMW monitoring entities do not collectively use a common digital field data recording device. This hinders researcher's ability to collect and prepare data for analysis and reporting in a timely manner. Reclamation purchased data recorders that will be used in the 2013 field season to help alleviate this problem.

RPA Subaction 72.2 – *Contribute funding for data system components that support the information management needs of individual Hydrosystem, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RM&E (Initiate in FY 2007-2009 Projects).*

Major Accomplishments and Findings

As identified in RPA Subaction 72.1, multiple data management systems have been funded and are in the process of future interaction with support based on web services with the *www.monitoringresources.org* tools and each data system funded by the Action Agencies and NOAA Fisheries. The Action Agencies provided funding for multiple data management tools and data steward positions to support FCRPS BiOpRME efforts. In addition to information for tools developed and recommendations to support assessments provided in RPA Subaction 72.1, BPA further developed the Taurus tool to report on program Implementation HLIs and is using web services between contracting information management in *monitoringmethods.org* to document relationships to FWP H-Strategies and subsequent management questions to provide project sponsors with guidance on content to provide in annual reports. As mentioned before, 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 110), and improvements to the PTAGIS PIT-tag database are at *http://www.ptagis.org/*. To address actions identified in the Implementation Plan, BPA, Reclamation, and Corps staff continued to advance standard project implementation metrics though adoption of standards in the ERTG and Expert Panel processes. Integration between Pisces and NOAA Fisheries' implementation tracking system is discussed under RPA Action 73. In Addition to Action Agency staff work, nine BPA projects continued to address this subaction.

BPA Project 1989-062-01 (Annual Work Plan for CBFWA): See RPA Subaction 72.1 details.

BPA Project 1998-108-00: See RPA Subaction 72.1 details.

BPA Project 1990-080-00 (Columbia Basin PIT-tag Information): See RPA Subaction 72.1 details.

BPA Project 1996-019-00 (Data Access in Real Time (DART)): See RPA Subaction 72.1 details.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring): In 2011, the NPT acquired servers and hardware to support data capture.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program): See RPA Subaction 72.1 details.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination): In addition to details provided in RPA Subaction 71.1, PNAMP helped lead in the development of data tools in 2010 to advance sharing between data systems. These tools primarily support documentation for managing metadata and monitoring coordination. Figure 111 shows how the existing and planned Pacific Northwest Aquatic Monitoring Program tools (Sample Designer, Site Manager, Monitoring Methods, Metadata Builder, and Monitoring Explorer planned for completion of development at various times from 2013-2015) at *www.monitoringresources.org* support this RPA.

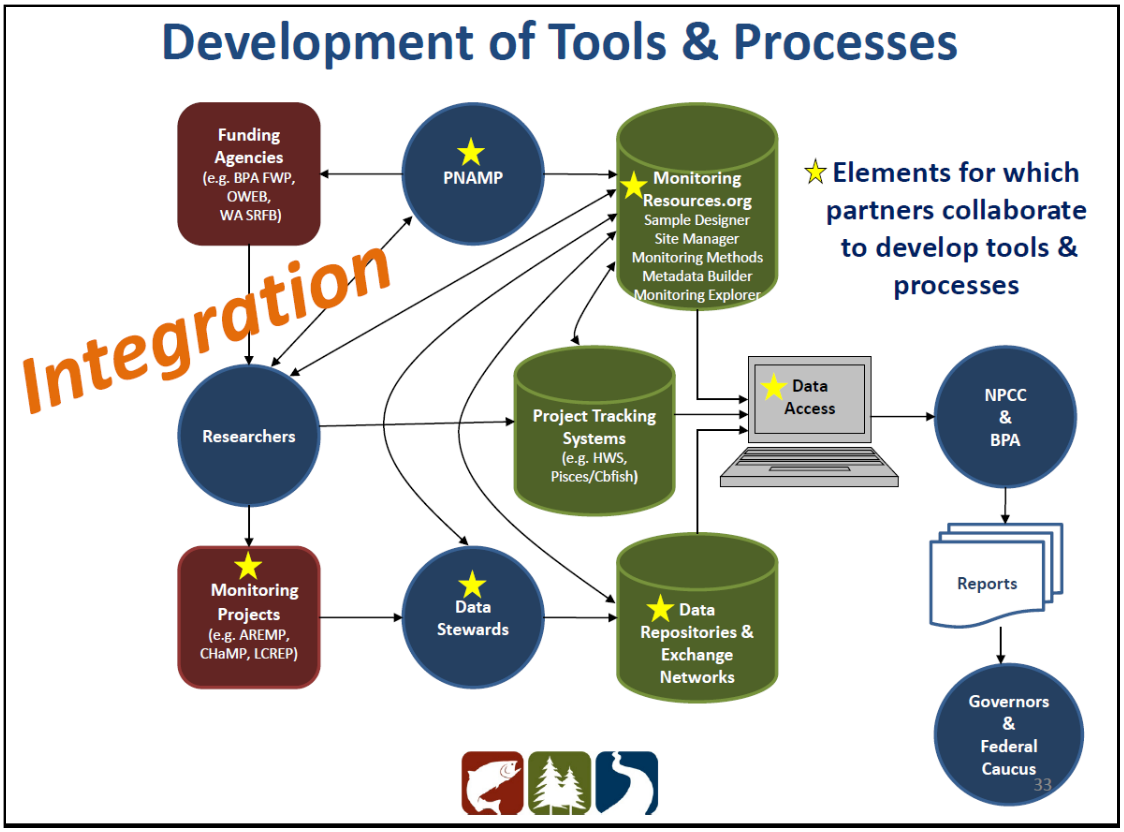


Figure 111. Diagram of Data Tools Developed by PNAMP in Relationship to Data Capture and Reporting.

BPA Project 2008-507-00 (Tribal Data Network): See RPA Subaction 72.1 details.

BPA Project 2008-727-00 (Regional Data Management Support and Coordination): See RPA Subaction 72.1 details.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program (ChaMP)): See RPA Subaction 72.1 details.

Reclamation Project: 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 coordinated in parallel with the Data Harvester development. A database to compile metadata for all datasets will be available. After evaluating several metadata software tools (e.g., Mercury, Metavist), researchers identified Morpho as the most current and effective tool for the 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 directly communicating the need and proposed use of the data. This pilot approach is being coordinated with PNAMP. The data harvester software is scheduled for completion in 2013.

Major Lessons Learned

Technological advances have made it easier and more cost effective to capture and store data, but resources to training and standardize data capture are essential to apply those savings across the Action Agencies' program as a whole.

Integration across data systems will reduce future development costs and analysis time. For example, integrating marking and tagging data systems (i.e., PTAGIS, RMIS, GAPs, the new SNPs database, and a scales database) will help assessments that use tagging, genetics, and age data.

Funding for data management efforts needed to be restructured to provide high priority data sets available to end users in the form of raw data, as well as higher level indicators. Expert Panels and the TRT are examples of consumers of raw data, while the TRT and NPCC members are consumers of higher-level derived data.

Additional advancement in data system components for FCRPS BiOp critical information management is still needed to meet the goals of this RPA.

Analytical tools are under development that need stronger collaboration between habitat improvement project data and monitoring data providers. Reclamation is reviewing data that was collected in its Reach-based Ecosystem Indicator program and data collected in the CHaMP project to develop a common habitat data nomenclature so both datasets can be used in analysis and reporting.

RPA Subaction 72.3 – *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).*

Major Accomplishments and Findings

The Action Agencies continued to support funding of staff and agency participation in work groups, such as the PNAMP DMLT, to advance the data strategy under RPA Subaction 72.1. Because NED expired and is no longer supported by all federal and state agencies, ongoing support and participation in the PNAMP DMLT is required to support this RPA. Eight BPA projects supported this subaction, primarily under PNAMP's DMLT workgroup. To support development of salmonid VSP attribute data management strategies in the "*Columbia River Basin Collaborative Data Sharing Strategy: Salmon and Steelhead Population Abundance and Productivity Indicators"* was developed under Phase Two of the Coordinated Assessments in 2011. These strategies for the states and tribes are located at *http://www.pnamp.org/sites/default/files/ca_basinwide_data_sharing_strategy_final_draft_nov_10.pdf and PNAMP data management roadmap "Guidance for Implementing Successful Data Management & Sharing"* (http://www.pnamp.org/project/3135). 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.

BPA Project 1982-013-01 (Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)): See RPA Subaction 71.3 for details on how this project supported tagging standards and provided a forum for managing CWT data and support the NPCC's Tagging Forum.

BPA Project 1989-062-01 (Annual Work Plan for CBFWA): See RPA Subaction 72.1 for details on how it supported development of the *Columbia River Basin Collaborative Data Sharing Strategy.*

BPA Project 1998-108-00 (): See RPA Subaction 72.1 for details on how it supported development of the *Columbia River Basin Collaborative Data Sharing Strategy.*

BPA Project 1998-031-00 (Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)): See RPA Subaction 72.1 for details.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination): From 2008-2012 PNAMP funding continued to provide staff for coordination of work sessions and regional collaboration discussions by the DMLT to continue implementation of NED recommendations. See RPA Subaction 72.1 for details on how it supported development of the *Columbia River Basin Collaborative Data Sharing Strategy.*

BPA Project 2008-507-00 (Tribal Data Network): See RPA Subaction 72.1 for details.

BPA Project 2008-727-00 (Regional Data Management Support and Coordination): See RPA Subaction 72.1 for details on how it supported development of the *Columbia River Basin Collaborative Data Sharing Strategy.*

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program (ChaMP)): See RPA Subaction 72.1 for details.

BPA Project 2008-505-00 (Streamnet Library): *StreamNet Librar*y has finished contribution to this RPA through PNAMP DMLT and participation in StreamNet in 2011 and has transferred it to Tribal Data Network Project (**2008-507-00**).

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

Major Lessons Learned

The development of products and tools such as the master sample tracking tool, monitoringmethods.org, and data exchange templates, and the requirement to apply these tools in project contracting are essential to the implementation of a data management strategy which will allow NOAA Fisheries to accept state and tribal VSP assessments in the SPS data system without re-running calculations themselves.

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.*
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.*
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).*

RPA Subaction 73.1 – *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.*

Major Accomplishments and Findings

The Action Agencies successfully implemented programs following government contracting requirements with quarterly and/or annual project implementation reporting. BPA has implemented an advanced project tracking system (PISCES and Taurus) to facilitate implementation and compliance monitoring and reporting. In addition, Contract Officer Technical Representatives conduct site visits and review contracting reports and annual reports to validate action implementation. This information is also provided to support evaluations of project-level effectiveness by the sponsors. For RME projects, BPA initiated development of the *www.monitoringmethods.org* tool and issued guidance to improve reporting of technical information. Improvements to annual RME reporting requirement and an online reporting system at *www.cbfish.org* for RPA results were released in 2012. These reports are tailored for each project to report on the implementation, results, and adaptive management implications for the RPA or FCRPS BiOp Strategies (Figure 112).

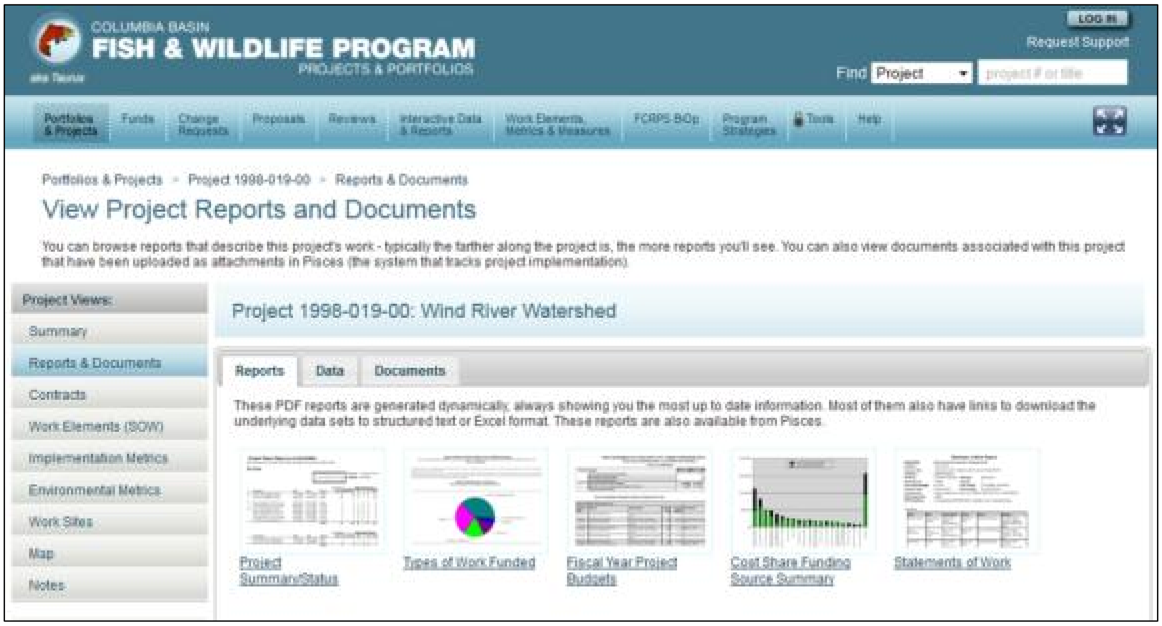


Figure 112. BPA Project Report Page Example for BPA Project 1998-019-00 "Wind River Watershed."

BPA Project 2011-006-00 (Upper Columbia Implementation and Action Effectiveness Monitoring) completed a pilot project to evaluate improved approaches to compliance monitoring through the use of a third party. Details of methods to evaluate implementation are provided in its annual report at *https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P126322*, should be completed in and reported in the 2013 APR.

Major Lessons Learned

Improvements to the Taurus tool supported rapid generation of implementation metric results. Implementation and compliance results were used by Expert Panels and the ERTG to validate their 2008 assessments of habitat quality improvements in the tributaries and SBUs in the estuary.

Tracking system coordination and standardization across agencies for RME actions as well as habitat restoration is important for supporting comprehensive assessments across large geographic areas. Further coordination regarding implementation and tracking will help reduce duplication and better utilize existing information to inform management between federal agencies.

Further training for development of guidance and tools was required for BPA's RME sponsors to achieve improvements to annual reports and metadata documentation to help communicate lessons learned to H'-strategies and RPAs. To ensure better compliance with RME reporting needs, BPA proposed implementation of a pilot project in October 2012 standardized due dates and formats of technical reports. These reports will be uploaded into Pisces and Taurus and made available for the public to review on BPA project documents and reports pages at *www.cbfish.org*, Figure 112.

RPA Subaction 73.2 – *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.*

Major Accomplishments and Findings

BPA updated the Pisces contract management system and Taurus project implementation reporting tools (*www.cbfish.org*) consistent with coordinated and defined data dictionaries. Taurus was also used to track and report on BPA's project FCRPS BiOp RPA associations at *http://www.cbfish.org/FcrpsBiOp.mvc/Index/2012/BiOpActions*, Figure 113.

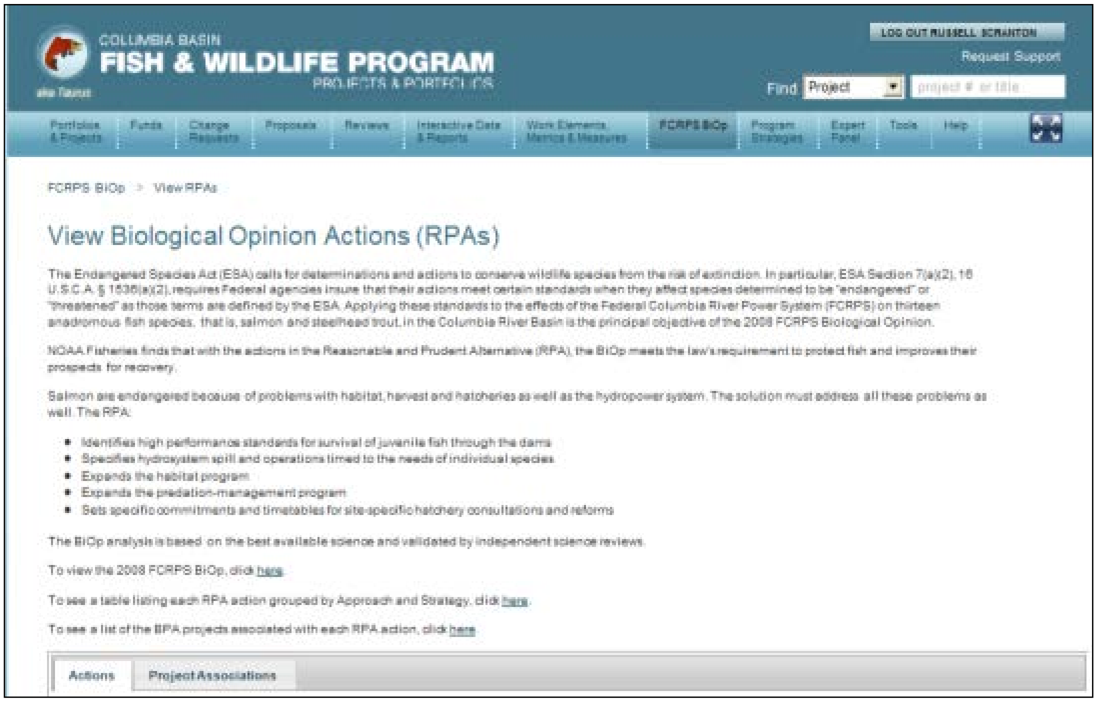


Figure 113. Taurus Web Page on BPA Support in Management of FCRPS BiOp RPA Actions.

The Corps, with assistance from BPA, began development of tools with Sitka Technologies for tracking planned restoration activities. Ongoing work will continue in 2013 to support further development of the tools outside the estuary to help plan and coordinate future restoration and monitoring actions.

To further support coordination and planning within the Action Agencies and beyond, of monitoring projects that support the FCRPS BiOp, BPA contracted PNAMP through Project 2008-727-00 which was consolidated into contract 2004-002-00 to develop a *www.monitoringresources.org* "Monitoring Explorer" tool. This was based on an initial pilot project action and report to create a monitoring inventory *http://www.pnamp.org/document/1344*. The pilot documented issues and problems with duplication of effort between contracting tools and limitation of technology to upload location data, which prevented further pursuit in 2008. By 2012, improvements to technology and available resources in the "Monitoring Explorer" tool would address primary issues and problems by relying on web services between existing project tracking systems, or by allowing individuals to document monitoring location and protocol data and act as an inventory and communication tool to locate and use relevant data.

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.

Major Lessons Learned

The Pisces contracting and Taurus reporting system supported successful implementation and tracking of projects needed for annual reporting requirements for RPA subactions 35 and 73 for BPA projects.

Additional coordination among Action Agency staff and other federal, state and tribal entities through the Monitoring Explorer tools at *www.monitoringresources.org* is needed to integrate monitoring across the northwest to support the FCRPS BiOp.

RPA Subaction 73.3 – *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 meta data for RM&E data design listed in Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring (Katz et al., 2006) (Initiate in FY 2008).*

Major Accomplishments and Findings

The Action Agencies have recorded project implementation and associated metric information for tributary habitat actions since implementation of tributary habitat actions became part of the FCRPS BiOp RPA in 2000. Examples of these data are presented in Section 3 for RPA Actions 35 and 37. These data for BPA and Reclamation currently are tracked in BPA's Pisces contracting database and reported in the Taurus database at *www.cbfish.org* for BPA-funded restoration actions. Actions for which Reclamation provides technical assistance are tracked in a separate 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, until 2008, NOAA Fisheries had independently integrated BPA project data into its Pacific Northwest Salmon Habitat Restoration Project Tracking (PNSHP) database as the comprehensive database of restoration actions. This database was integrated into PCSRF project tracking system at *https://www.webapps.nwfsc.noaa.gov/apex/f?p=227:1*.

In 2010, BPA developed an automated report through the Taurus system to annually provide habitat restoration action information to the NOAA Fisheries PSCRF system. The automated exchange of that information was completed in 2012 and occur annually to fully comply with this RPA. In addition, BPA completed a manual process to add project metrics from 2008 to 2010 from the Pisces habitat restoration projects not documented in a Taurus crosswalk tool into the NOAA PCSRF/PNSHP database. The list of BPA metrics and relationships to the NOAA Fisheries system is available at *http://www.cbfish.org/WorkElement.mvc/Landing*.

In the estuary in 2012, the Corps worked with BPA to further develop the Taurus reporting tool to integrate Corps project tracking to be consistent with BPA's Pisces reporting metrics, which are transferred to NOAA PNSHP and PCSRF systems for a comprehensive reporting system

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 have not been evaluated by BPA to determine how to apply lessons learned.

Major Lessons Learned

The comprehensive action tracking system has been essential for providing data used in the Expert Panel Process to compare 2008 projections to actual 2012 accomplishments and Tributary Habitat RM&E Comprehensive Evaluation synthesis papers to evaluate fish response to restoration actions in the IMWs and for ESU assessments in the Snake River Basin.

Standardization of metrics supported improvements to Expert Panel and ERTG evaluations for habitat improvement evaluations.

Integration of the Pisces and PNSHP data systems was costly to BPA's program. However, because integration was completed by BPA, the Corps was able to partner with BPA and integrate with systems that supported the need of the RPA at a lower cost.

Adaptive Management Implementation Plan (AMIP) Actions

In September 2009, the FCRPS BiOp was enhanced through an AMIP 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 NOAA Fisheries' 2010 Supplemental BiOp. The following section provides information on AMIP actions implemented by NOAA and the Action Agencies in 2010. Although many of these actions were under way or completed in 2010, some will be implemented later in the FCRPS 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 (AHSWG) Recommendations Report.

AMIP Category II – Acceleration & Enhancement of RPA Mitigation Actions (Actions A-D)

II. A. Estuary Habitat Improvement & Memorandum of Agreement on Columbia River Estuary Actions with State of Washington: *Under RPA Actions 36 and 37, the Action Agencies are implementing a major program of estuary habitat restoration and research. The 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.*

1. *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.*
2. *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 (RSIT). 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, NOAA Fisheries 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:*

1. ***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.*
2. ***Catfish:*** *document the distribution and predation rates of channel catfish.*
3. ***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.*

The action was completed on schedule in 2010.

For Action 1, research has determined that that juvenile shad are not contributing significantly enough to walleye survival to warrant a management action on adult shad.

For Action 2, juvenile shad have not been found to be a diet component of channel catfish.

For Action 3, diet analyses of smallmouth bass show that crustaceans comprise of 50-78 percent of their diet, walleye represents a majority of fish consumed with juvenile salmonids comprising less than 10 percent.

II. D. Spill:

Spring Spill: *Assess data from previous years and discuss with the RIOG parties each year to inform transport/spill operation decisions for the subsequent year. There is no longer a presumptive spill / transport operation for the spring the RPA action 29.*

This process was carried out in 2011 as specified in the AMIP.

Summer Spill: *To further enhance the summer spill program, the Action Agencies will develop an appropriate safeguard, based on adult returns, that continues summer spill at the Snake River projects through August 31, during the subsequent juvenile outmigration. Using this trigger, low abundance of naturally-produced Snake River fall Chinook in one year would trigger spill through August 31 at the Snake River projects the following year, regardless of the number of juveniles collected. The Agencies will coordinate with the RIOG in developing the trigger, to be in place for the 2010 juvenile fish migration.*

Completed on schedule in 2010. Consistent with this AMIP requirement, a June 11, 2010 letter from Witt Anderson to Barry Thom indicated that spill would continue through August 31 only in years following a year in which 400 or fewer natural-origin adult Snake River fall Chinook salmon are counted at Lower Granite Dam. However, pursuant to the opinion and order from the United States District Court for the District of Oregon dated August 2, 2011, the Action Agencies continued summer spill at the Snake River projects through August 31 in prior years, consistent with the Court's previous spill orders.

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

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.

A monitoring strategy was completed on schedule at the end of 2009. The ISRP's review of the Anadromous Salmonid Monitoring Strategy (ASMS) was subsequently 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 NPPC'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 2012. NOAA NWFSC continued to implement and distribute the Species Lifecycle Analysis Modules (SLAM) developed to date. Additional models developed by the ICTRT 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:

1. Modeling of hatchery-wild interactions based on ongoing analyses,
2. Incorporating habitat relationships into life cycle models,
3. Continued development of hydro scenarios for rapid response and long-term contingency planning, including initiation of COMPASS recalibrations and construct for John Day Dam drawdown and lower Snake River dam breaching,
4. Steelhead and subyearling Chinook salmon life-history characterizations,
5. Initiation of estuary effects distribution, and
6. 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, in 2011 BPA proceeded with partial implementation and evaluation 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:

- *Timely funding and implementation of intensive habitat actions to ensure, where practical, an adequate treatment effect.*
- *Sufficiently diverse representation of IMWs (geographically and with respect to limiting factors) and appropriate monitoring (e.g., temperature, flow) to detect climate change impacts.*
- *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.

The action was completed on schedule in 2010 as documented in the AA/NOAA/NPCC RM&E Workgroup "Recommendations for Implementing Research, Monitoring and Evaluation for the 2008 NOAA Fisheries FCRPS BiOp" (May 2010) consistent with the regional Anadromous Salmonid Monitoring Strategy. Under this assessment, the strategy for developing habitat and fish response relationships was expanded to include habitat and parallel fish status monitoring for at least one population per MPG to cover a sufficiently diverse representation of geographic areas and limiting factors. In 2011, the Action Agencies further assessed and summarized the results from existing monitoring, including responses to 2011 comments from the ISRP. In 2012, the ISEMP project provided a synthesis report of the IMWs, and the CHAMP project provided a synthesis report for habitat status monitoring. The CHaMP program is planned to be in full implementation by 2014.

III. F. Climate Change Monitoring & Evaluation - *This AMIP Action enhances or clarifies other RPA actions as follows:*

- *RPA Action 2 requires the inclusion of new climate change research findings in the Action Agencies' annual progress reports NOAA Fisheries will annually provide the Action Agencies with a literature review relevant to the implementation of the RPA.*

  On August 13, 2012 NOAAF provided the Action Agencies with a Northwest Fisheries Science Center review of new literature on climate science and oceanographic conditions relevant to Columbia River Basin salmonids (see Attachment A of FCRPS 2012). The NWFSC stated 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 noted 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 FCRPS 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:

1. Ocean Conditions / Indicators — NOAA will use its existing database *http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm*).
2. 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*).
3. 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/*.

- *Consistent with RPA Actions 56-61, data on habitat conditions and action effectiveness will be collected during ongoing and enhanced tributary habitat and ocean research. By December 2011,* *the Action Agencies and NOAA Fisheries will ensure that this information is appropriately managed in a database allowing changes to be tracked over time.*

The action is ongoing. BPA funded the creation of the CHaMP data system for tributary habitat status and trend monitoring associated with RPAs 56 and 57 at *http://www.champmonitoring.org*. BPA and NOAA 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 SATURN within the Center for Coastal Margin Observation & Prediction. Data related to food web and water quality (flow, temperature, dissolved oxygen, pH, plankton (nontoxic or pharmaceutical)) is stored at *http://www.stccmop.org/saturn*.

For ocean habitat conditions, data from BPA and NOAA 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*.

- *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 action is ongoing. The 2011 and 2012 reviews of new climate change literature provided by NOAA under AMIP Action III.F (AMIP pg. 25) were shared with the tributary habitat Expert Panels in advance of the workshops held in 2012 on the Expert Panel Website.

The Action Agencies are also tracking juvenile fish status and trends at monitoring sites throughout the estuary to support the early detection of substantial changes in abundance, productivity, or survival over time. These trends may be correlated with trends of habitat indicators (e.g., temperature); and by tracking habitat status and trends (including water quality and temperature) at monitoring sites throughout the estuary to detect changes in baseline conditions over time. These may be correlated with status and trends of juvenile fish densities.

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

- *Under RPA Action 7, the Action Agencies investigate the impacts of possible climate change scenarios on listed salmon and steelhead. As part of this effort, the Action Agencies will use new climate change information to improve regional hydrological models. In addition, the Action Agencies will review existing forecasting tools. As new procedures and techniques are identified with significant potential to reduce forecast error and improve forecast reliability, the Action Agencies will review these with the RIOG and other interested parties.*

This action is ongoing. The results of the work from the three agencies are available in three major reports and a summary report as part of the *Climate and Hydrology Datasets for use in the RMJOC Agencies' Longer-Term Planning Studies* at *http://www.bpa.gov/power/pgf/HydrPNW.shtml*. Reclamation, BPA, and the Corps engaged in a collaborative effort to focus on how water supply changes due to climate change could impact the Columbia River Basin and the operation of federal dams in the future. The RMJOC's four-part climate change reports were completed in 2011. The report titles and dates completed are:

Part I – Future Climate and Hydrology Datasets, dated December 2010;

Part II – Reservoir Operations Assessment for Reclamation Tributary Basins, January 2011;

Part III – Reservoir Operations Assessment: Columbia Basin Flood Control and Hydropower, May 2011; and

Part IV – Summary, Climate and Hydrology Datasets for Use in the River Management Joint Operating Committee (RMJOC) Agencies' Longer-Term Planning Studies, September 2011.

The reports can be found at *http://www.bpa.gov/power/pgf/HydrPNW.shtml*. BPA also solicited comments from stakeholders and the public on the Summary report in August 2011, and these are posted at: *http://www.bpa.gov/applications/publiccomments/CommentList.aspx?ID=134*.

- *Enhanced monitoring of adult status and trends, juvenile status and trends, habitat condition status and trend and IMWs (flows and temperature) will contribute to climate change assessments. Climate change information will be discussed with the RIOG and reported to the region annually.*

The action is ongoing. Enhanced monitoring in 2012 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 (Actions A-C)

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.*

The action was 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 tool 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.

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.*

The action was completed 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:

- *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.*
- *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.*
- *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.*
- *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 National Environmental Policy Act (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 addressed all above actions and was finalized 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. The plan can be found at *http://salmonrecovery.dev.bpa.gov/OldProd/Files/BiologicalOpinions/2011/2011%20Rapid%20Response%20and%20Long%20Term%20Contigency%20FINAL.PDF*

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 actions 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. The plan can be found at *http://salmonrecovery.dev.bpa.gov/OldProd/Files/BiologicalOpinions/2011/2011%20Rapid%20Response%20and%20Long%20Term%20Contigency%20FINAL.PDF*

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

A draft John Day MOP Plan of Study was submitted to the RIOG for review on March 26, 2012. Comments on the draft were received from the State of Oregon on April 27, 2012. Subsequently, the Corps submitted the final plan of study, along with responses to the comments received on the draft from the State of Oregon, to NOAA on July 26, 2012. Completion of this plan of study satisfies Long-term Contingency Action 7 identified in the Adaptive Management Implementation Plan (AMIP). The plan can be found at *https://www.salmonrecovery.gov/Files/BiologicalOpinions/2012/JDA%20MOP%20Final%20Plan%20of%20Study%20with%20letter%20comments%20and%20responses%20(071112).pdf*

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.*

The action was completed in 2010. The study plan can be found at *http://www.nww.usace.army.mil/Library/DamBreachingPlanofStudy.aspx*

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 2012, the Corps completed the Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers FCRPS Pools report which identifies 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. The report can be found at *https://www.salmonrecovery.gov/Files/BiologicalOpinions/2010/Thermal%20refugia%20report%20Feb%2014%202013.pdf*

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-tag 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 in 2012 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 RME to the USFS's Rocky Mountain Research stream and air temperature database (*http://www.fsJed.us/rm/boise/AWAE/projects/streamtemperature.shtml*). This project will provide "a mapping tool to help those in the western U.S. organize temperature monitoring efforts."

Amendment 4: *Under RPA Action 35, the Action Agencies are identifying tributary habitat projects for implementation and consider potential effects of climate change on limiting factors. As part of this action, the Action Agencies will continue to coordinate with NOAA 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 III. F (AMIP pg. 25) was shared with the Expert Panels in 2011. 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.*

The action was 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 was considered as appropriate during the 2012 expert panel evaluations.

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 Fisheries has postponed implementation of the CRHEET to allow for the undertaking of an extensive ESA consultation process on FCRPS mitigation hatchery programs (RPA 39). These consultations require significant involvement from many of the people proposed to participate in CRHEET. Recognizing this overlap, BPA agreed with NOAA Fisheries that CRHEET would best be informed by the outcomes of the consultations and so further development of CRHEET has been deferred.

Acronyms, Abbreviations, and Glossary

The "Action Agencies" refers to the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation.

AEMR	action effectiveness monitoring and research
AFEP	Anadromous Fish Evaluation Program
AHSWG	Ad Hoc Supplementation Workgroup
AMIP	Adaptive Management Implementation Plan
APR	Annual Progress Report
ASMS	Anadromous Salmonid Monitoring Strategy
ATIIM	area-time inundation index model
AWS	auxiliary water system
BA	Biological Assessment
BACI	before-after-control-impact
BDSS	beaver dam support structures
BGS	behavioral guidance screen
BIA	Bureau of Indian Affairs
BiOp	Biological Opinion
BIT	Biological Index Test
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
BRZ	Boat Restricted Zone
CBFWA	Columbia Basin Fish and Wildlife Authority
CC	corner collector
CCT	Colville Confederated Tribes
CFD	computational fluid dynamics
CEERP	Columbia Estuary Ecosystem Restoration Program
cfs	cubic feet per second
CHaMP	Columbia Habitat and Monitoring Program
CIG	Climate Impacts Group, University of Washington; is developing climate change streamflows for the Columbia River Basin
CLT	Columbia Land Trust
COAST	Coastal Ocean Acoustic Salmon Tracking
COMPASS	Comprehensive Fish Passage Model
COP	Configuration and Operational Plan
CORIE	Columbia River Ecosystem pilot environmental observation and forecasting system
Corps	U.S. Army Corps of Engineers
CREEC	Columbia River Estuary Ecosystem Classification
CREST	Columbia River Estuary Study Taskforce
CRFG	Columbia River Forecast Group, formed by the Action Agencies and Fish Accord partners
CRFM	Columbia River Fish Mitigation
CRHEET	Columbia River Hatchery Effects Evaluation Team
CRITFC	Columbia River Inter-tribal Fish Commission
CRRL	Columbia River Research Laboratory
CSS	Comparative Survival Study
CTCR	Confederated Tribes of the Colville Reservation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
CWT	coded wire tags

DART	Data Access Real Time
DMLT	Data Management Leadership Team
DPS	Distinct Population Segment
EDR	Engineering Design Report
EDT	Ecosystem Diagnostic and Treatment
ELHD	Early life history diversity
EPA	U.S. Environmental Protection Agency
ERDC	Engineering Research and Development Center
ERTG	Expert Regional Technical Group
ESA	Endangered Species Act
ESP	Ensemble Streamflow Prediction
ESU	Evolutionary Significant Unit
FCRPS	Federal Columbia River Power System
FFDRWG	Fish Facility Design Review Workgroup
FGE	fish guidance efficiency
FOP	Fish Operations Plan
FPC	Fish Passage Center
FPOM	Fish Passage Operations and Maintenance
FPP	Fish Passage Plan
FWP	Fish and Wildlife Program
GBT	gas bubble trauma
GIS	geographic information system
GPM	General Parr Monitoring
GRMW	Grande Ronde Model Watershed Program
GRTS	Generalized Random-Tessellation Stratified
GSI	genetic stock identification
HGMP	Hatchery and Genetic Management Plan
HSRG	Hatchery Scientific Review Group
HQI	Habitat Quality Improvement
IAPMP	Inland Avian Predation Management Plan
ICF	Initial Control Flow
ICTRT	Interior Columbia Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IJC	International Joint Commission
IMW	intensively monitored watershed
INPMEP	Idaho Natural Production Monitoring and Evaluation Project
IPTDS	instream PIT-tag detection sites
ISAB	Independent Scientific Advisory Board
ISEMP	Integrated Status and Effectiveness Monitoring Program
ISMES	Idaho Steelhead Monitoring and Evaluation Studies
ISRP	Independent Scientific Review Panel
ISTM	Integrated Status and Trends Monitoring
ISS	Idaho Supplementation Study
ITS	ice and trash sluiceway
JBS	juvenile bypass system
JFF	juvenile fish facility
JSATS	Juvenile Salmon Acoustic Transmitter System
kaf	thousand acre-feet
kcfs	thousand cubic feet per second

KMP	Kelt Management Plan
ksfd	thousand second foot per day; k = kilo = thousand; ksfd = 1,000 cfs (cubic feet per second) per day. kcfsd * 1.98347 = thousand acre-feet
KSR	Kelt-to-Spawner Return
LCR	Lower Columbia River
LCRE	Lower Columbia River Estuary
LCEP	Lower Columbia River Estuary Partnership
LHD	Life History Diversity
LIDAR	light detection and ranging
LRR	Lower River Reach
LSRCP	Lower Snake River Compensation Plan
LWD	Large Woody Debris
M&E	monitoring and evaluation
Maf	million acre-feet
MGR	minimum gap runner
MMPA	Marine Mammal Protection Act
MOP	minimum operating pool
MPG	major population group
NED	Northwest Environmental Data
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NREI	Net Rate Energy Intake
NPCC	Northwest Power and Conservation Council
NPHMP	Nez Perce Harvest Monitoring Project
NPMP	Northern Pikeminnow Management Plan
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
PASS	Project Alternatives Solution Study
PBT	Parentage Based Tagging
PCSRF	Pacific Coastal Salmon Recovery Fund
PDO	Pacific Decadal Oscillation
pHOS	hatchery-origin spawners
PH1	Powerhouse 1
PH2	Powerhouse 2 or second powerhouse
PIBO	Pacfish/Infish Biological Opinion
PIT	Passive Integrated Transponder
PNAMP	krj
PNNL	Pacific Northwest National Laboratory
PNSHP	Pacific Northwest Salmon Habitat Restoration Project Tracking
PSMFC	Pacific States Marine Fisheries Commission

PTAGIS	PIT-Tag Information System
QA/QC	quality assurance/quality control
QLE	Qualified Local Entities
Reclamation	U.S. Bureau of Reclamation
RMJOC	River Management Joint Operating Committee
RIST	Recovery Science Implementation Team
rkm	river kilometer
RM	river mile
RME	research, monitoring, and evaluation
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RRS	relative reproductive success
RSA	rapid site assessments
RSW	removable spillway weir
SAR	smolt-to-adult return
SATURN	Science and Technology University Research Network
SB	Survival Benefit
SBU	Survival Benefit Units
SBT	Shoshone-Bannock Tribe
SCT	System Configuration Team
SLED	sea lion exclusion device
SMP	Smolt Monitoring Program
SNP	single nucleotide polymorphism
SOR	System Operational Request
SRD	Sandy River Delta
STEM	Status Trend and Effectiveness Monitoring
SW	spillway weir
SWCD	Soil and Water Conservation District
SYSTDG	System Total Dissolved Gas
TDG	total dissolved gas
TMDL	total maximum daily load
TMT	Technical Management Team
TSP	Turbine Survival Program
TSW	top-spill weir
UCSRB	Upper Columbia Salmon Recovery Board
USBWP	Upper Salmon Basin Watershed Project
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VARQ	variable outflow flood control procedures
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WMP	Water Management Plan
WSF	Water Supply Forecast
YKFP	Yakima/Klickitat Fisheries Project
YN	Yakama Nation

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