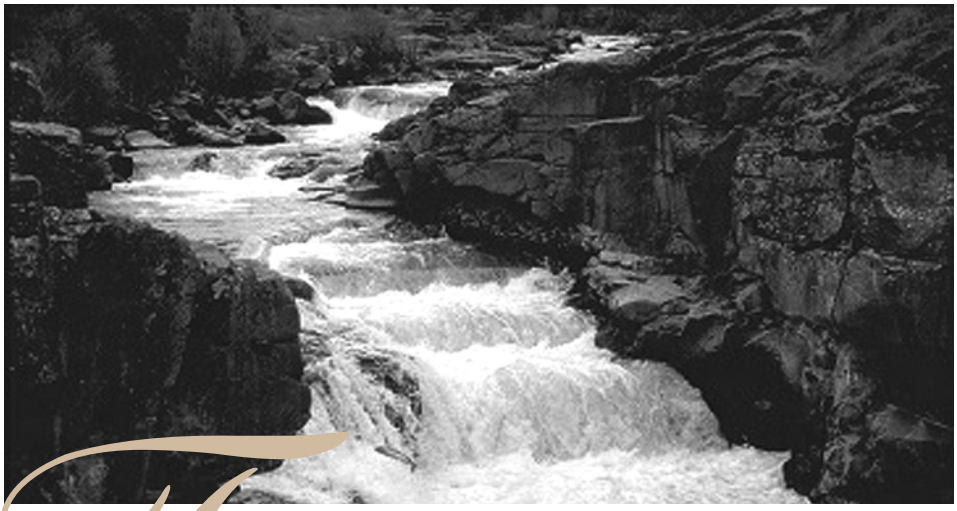
Protecting Salmon: Highlights

Endangered Species Act
Federal Columbia River Power System
2005 Progress Report

June 2006

In November 2004, NOAA Fisheries issued a new biological opinion on the operation of the Federal Columbia River Power System and 19 Bureau of Reclamation projects. This 2004 Biological Opinion considered the Action Agencies' Updated Proposed Action for the FCRPS (UPA) and provided NOAA Fisheries' scientific analysis of the proposed actions. In the UPA, the Action Agencies committed to continue implementing most of the actions from prior biological opinions, with the addition of several new actions, such as habitat protection in certain upper Columbia subbasins, and expanded control of predators that consume young salmon. All of these actions, old and new, are focused on achieving biological performance standards, achieving programmatic performance targets, or addressing factors that limit certain lifestages for specific evolutionarily significant units (ESUs) of salmon and steelhead. Progress reports are available at *www.salmonrecovery.gov/implementation.shtml*



hroughout the Columbia River basin, tribal, state, local, and federal parties are working to protect and restore stocks of salmon and steelhead. Thirteen stocks of these remarkable fish are listed as threatened or endangered under the Endangered Species Act (ESA). To create a better environment for these fish, many parties in the region are protecting and enhancing important habitats, reforming and better managing hatchery and harvest practices, and improving river conditions for migrating fish. The goal is to give fish healthier places to spawn and grow and a safer migration path to and from the ocean. No single action can recover species that have such complex life cycles - spawning and rearing in freshwater rivers but spending most of their lives in the ocean.

The federal agencies that manage the system of dams in the basin include the U.S. Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA), collectively known as the Action Agencies. They consult with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) on how they operate those dams, including activities that improve conditions for fish. Operating the dams for flood control, power production, irrigation, navigation and other uses affects the flow of the river and water conditions. The dams are also in the path of these fish as they migrate many miles to the ocean to mature and return upriver to spawn in inland streams and tributaries.
This report highlights some of the significant actions implemented by the Action Agencies in 2005 to protect ESA-listed salmon and steelhead affected by the operation and maintenance of the Federal Columbia River Power System (FCRPS).

This report focuses on efforts of the Action Agencies to achieve standards established for the FCRPS. Others in the region also continue to make significant contributions. Step-by-step, regional efforts are improving the quality of salmon habitat and increasing knowledge about salmon and steelhead life cycles and requirements. The agencies remain committed to continued collaboration and coordination with other regional parties working toward the common goal of recovery of Pacific salmon and steelhead populations. Progress reports of other efforts are available on Web sites listed at the end of this document.

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This report is produced by the U.S. Army Corps of Engineers, the Bureau of Reclamation, and Bonneville Power Administration.

2005 Conditions and Accomplishments

Adult Fish Returns

One way the Pacific Northwest tracks how well salmon and steelhead are doing is by comparing the numbers of fish that return each year to spawn. Many dams have fish counting stations where accurate tallies are made of the various species as they swim up the fish ladders. In 2005, 1,077,988 adult and jack salmon and steelhead were counted as they passed Bonneville Dam. Jack salmon are young males that mature and return to spawning grounds earlier than others in their age class. This number does not approach historical averages, is lower than 2000-2004 returns (Figure 1), and is slightly below the 10-year average.

As shown in Table 1, counts in 2005 of adult and jack summer Chinook, fall Chinook and sockeye passing Bonneville Dam all exceeded the 10-year average, and spring Chinook, steelhead, and coho counts were below the 10-year average. In a typical year, about 80 percent of all returning adult salmon are of hatchery origin.

Adult Fish Survival

Fish ladders on the lower Columbia and Snake River dams are very successful. Research on adult fish passage shows that adult fish survival is about 98 percent or higher at each dam for salmon and steelhead. NOAA Fisheries has found that "adult survival through the FCRPS is similar to survival under unimpounded conditions in the Snake and Columbia rivers."

In recent years, technological improvements have allowed better monitoring of adult passage patterns, timing and other behavior at the dams. As a result, dam operators can adjust operations at certain dams to improve conditions for migrating fish and can monitor and track the progress of returning adults.

Juvenile Fish Survival

Juvenile salmon and steelhead that migrate to the ocean through the Snake and Columbia rivers are either transported by barge or truck around the lower river dams or left "in river" to migrate past the dams. The percentage of fish that travel in-river versus the percentage transported depends upon a number of factors such as how much spill is provided and how well fish are attracted to juvenile fish bypass systems.

Approximately 98 percent of the transported juveniles survive to the point of release below Bonneville Dam. However, some scientists believe that "delayed mortality" occurs after the fish are released and that the 98 percent survival percentage is inaccurate. Research is ongoing to determine if any delayed effects can be minimized. For juvenile fish that migrate in-river, the Action Agencies use an empirical estimate to derive survival estimates. As a performance standard for the FCRPS, the 2004 Biological Opinion established juvenile survival percentages, including an average and range based on yearly water conditions, for each ESU. Survival estimates for four ESUs: Snake River spring/summer Chinook and steelhead and Upper Columbia spring/summer Chinook and steelhead are described below and illustrated in Figure 2.

Although the Columbia basin experienced drier than normal conditions in 2005, survival percentages were good for juveniles that migrated in-river. Of the yearling Snake River spring/summer Chinook that migrated in-river from the Lower Granite Dam tailrace (the area below the dam) to the Bonneville Dam tailrace, about 53 percent survived. This is slightly higher than the average in-river performance standard of 50.2 percent (38.3 to 57.7 percent range) for this ESU. This was a notable improvement from 2004, a similarly low

Table 1. **Salmon and Steelhead Returns at Bonneville Dam**

	2005	10-yr average
Spring Chinook	78,341	160,907
Summer Chinook	83,703	68,856
Fall Chinook	438,371	390,130
Steelhead	315,650	325,613
Sockeye	72,971	60,211
Coho	88,791	94,358
Chum and Pinks	161	242*

10-year average 1996 – 2005 and * 5-year average 2001 - 2005

Columbia River Basin

water year when survival was estimated at about 40 percent, and is a substantial improvement from 2001, which was a very dry year with only 28 percent in-river survival.

In-river survival estimates for Snake River steelhead migrants were possible only from Lower Granite Dam to John Day Dam due to lowerPassive Integrated Transponder, or PIT-tag, detection at Bonneville Dam. This problem should be resolved in the future, as a new detection system was installed in early 2006 in the Bonneville Second Powerhouse Corner Collector. Survival for steelhead to the tailrace of John Day Dam improved to 34 percent in 2005 from about 17 percent in 2004 but remained low compared to other recent years. The 2004 Biological Opinion average in-river performance standard for Snake River steelhead is 30.5 percent (4.5 to 42.9 percent range.

For upper Columbia River juvenile spring /summer Chinook, survival from McNary Dam to Bonneville Dam was about 76 percent and was similar to survival in 2002 and 2003 (approximately 75 and 77 percent) and up from 2004 (62 percent). This exceeded the average 2004 Biological Opinion performance standard of 67.3 percent (55.1 to 74.9 percent range).

Upper Columbia River steelhead survival was about 54 percent, still down from 70 percent in 2003 but up from 50 percent in 2004. Juvenile survival in both years exceeded the average 2004 Biological Opinion performance standard of 46.8 percent (16.2 to 61.6 percent range).

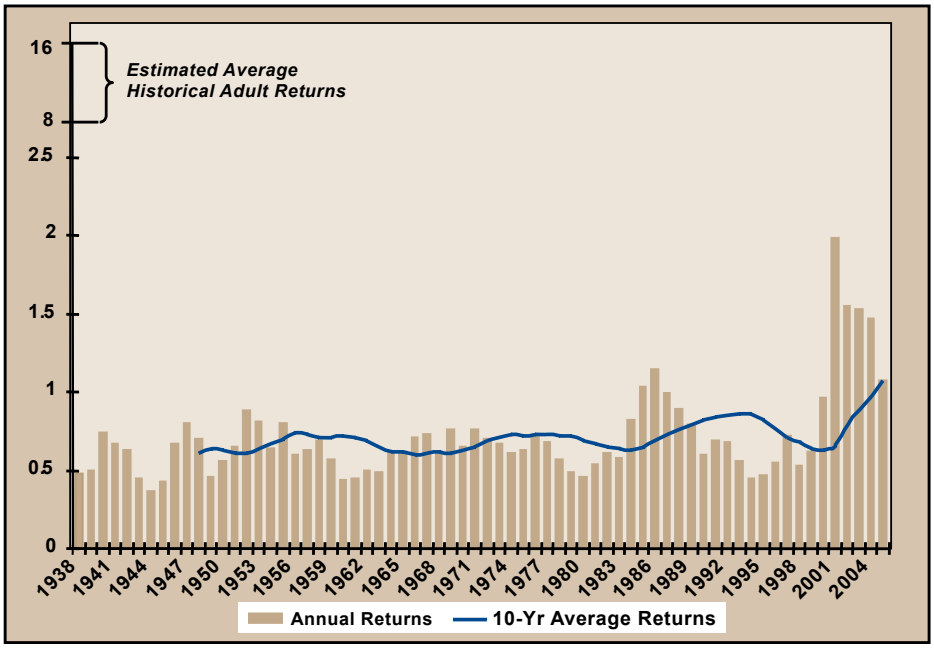


Fig. 1. **Adult and Jack Salmon/Steelhead Returns at Bonneville Dam, 1938 to 2005**

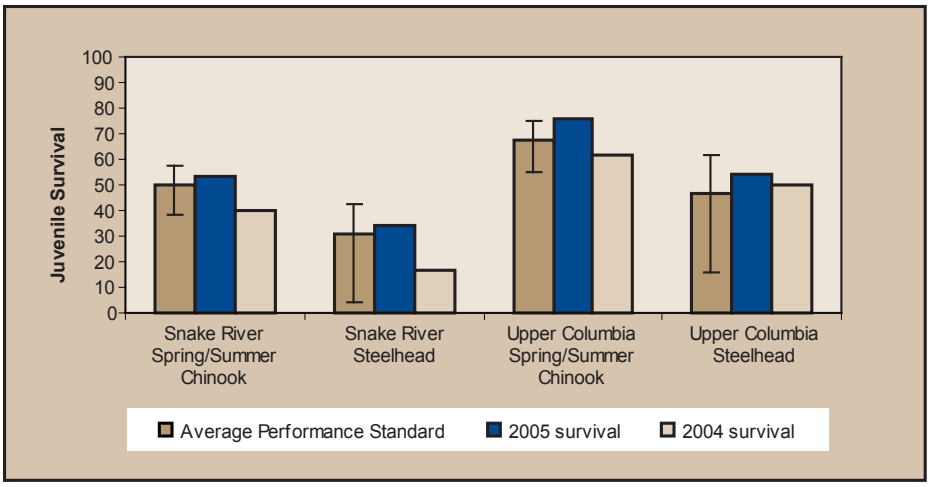


Fig. 2. **Juvenile Salmon and Steelhead In-river Survival Estimates for Certain ESUs**

Hydrosystem

Improvements for Fish at the Dams

Most salmon and steelhead in the Columbia River basin encounter one or more hydroelectric dams as they migrate to and from the ocean. Fish passage systems provide various routes to help salmon and steelhead get past the dams.

Over the past several decades, juvenile fish survival past the dams has improved dramatically. NOAA Fisheries data indicate that in-river spring/summer Chinook survival has improved to the point that it is now comparable to that of the 1960s when there were only four dams in the lower Columbia and Snake rivers (see Figure 3 for illustration). In-river survival through the eight dams for Snake River spring-summer Chinook over the past several years has ranged from 30 to 60 percent, depending on water conditions and other factors.

Juvenile fish migrate past the dams by several routes: through the turbines, through juvenile bypass systems, through spillways, or by collection and transport in barges or trucks. Turbine passage is often considered to be the least desirable juvenile bypass route, with a survival rate of 85 to 95 percent. Bypass systems and spill are meant to divert fish away from the turbines. Juvenile survival rates of 95 to 99 percent have been demonstrated through bypass systems and during spill periods at many dams. In 2005, the agencies continued to make improvements to fish passage, and some highlights are noted here.

Spill

Fish passage through the spillway is widely recognized as one important way to get juvenile fish through the dams. Water is "spilled" through spillway openings rather than being routed through turbines to generate power or being used for other purposes. The Action Agencies UPA includes spring and summer spill to help juvenile salmon and steelhead pass the lower Columbia and Snake river dams. During some summers when

flows are low, the agencies maximize collection and transport of juvenile fish and curtails summer spill at the Lower Granite, Little Goose, Lower Monumental, and McNary dams.

A discussion of agency efforts to manage total dissolved gas levels during spill is provided in the Water Quality section of this report.

Juvenile Bypass Systems

Juvenile fish bypass systems at each of the eight lower Columbia and Snake river dams guide fish away from turbines by means of submerged screens installed in front of the turbine intakes. As fish follow currents down toward the turbines, the screens guide the fish back up to channels in the dam. The fish are then either routed to the river below the dam (bypassed) or loaded into barges or trucks for transport past the remaining dams.

In 2005, at Lower Monumental Dam, the Corps made improvements to the juvenile fish barge loading facility. At Little Goose Dam, the juvenile bypass screen system was modified to improve reliability of the system. At Lower Granite Dam preliminary design documents were begun to modify the existing juvenile fish facilities for improved reliability. At Bonneville Dam a new trash rake was installed for improved debris cleaning and increased reliability of the fish facility. In addition, the Corps initiated improvements to the juvenile bypass system at the Bonneville Dam Second Powerhouse to increase fish guidance efficiency (a measure of how well fish are guided into the bypass).

Surface Passage System

Most juvenile salmon tend to stay in the upper 10 to 20 feet of the water column as they migrate downstream to the ocean. When approaching the dams, juvenile fish need to dive to depths of 50 to 60 feet to find passage routes such as a spillway opening to encounter a screen to be guided to a juvenile bypass channel. For several years, engineers and biologists have been pursuing new technologies that would provide more surface-oriented, less stressful, passage routes for juvenile fish. Surface passage has the potential to improve juvenile fish survival, save money and improve water quality.

One of the new surface passage technologies is a removable spillway weir (RSW), or "fish slide," that fits inside a dam spillway and allows juvenile fish to pass near the water surface under lower acceleration and lower pressure. As water spills over the weir, juvenile salmon and steelhead are carried over a raised spillway crest, similar to a waterslide.

A fish slide constructed for the Ice Harbor Dam in 2004 was installed in early 2005; that dam and Lower Granite Dam now each have this device. The Ice Harbor slide, in combination with other modifications that were made at the dam, should improve spillway passage conditions and efficiencies.

During 2005 summer spill operations at Lower Granite and Ice Harbor dams, researchers collected data to evaluate how well fish survive through conventional spillway operations compared to RSW operations.

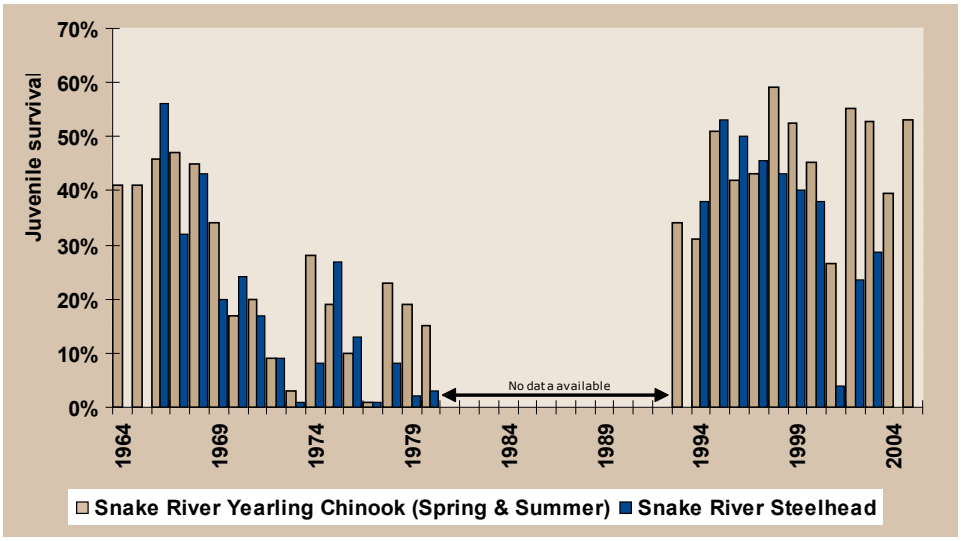


Fig. 3. **Snake River Chinook & Steelhead In-river Survival Estimates (steelhead estimates for 2004 and 2005 are unavailable due to lower PIT-tag detection at Bonneville Dam)**

The research indicates that spill effectiveness (percent of fish passed through the spillway divided by the percent of water passed through the spillway) was two to three times higher for RSWs than conventional spillbays. In other words, for a given amount of spill discharge, the fish slides were two to three times more effective at passing fish than a conventional spillbay. At Lower Granite Dam, juvenile fish survival at the dam was higher with the RSW operating (93.9 percent) than without (89.5 percent). Tests at Ice Harbor indicate that survival through the RSW was 99.4 percent, although overall survival at the dam was slightly higher when the RSW was not operating, at 99.6 percent, than with RSW operation, 98 percent.

At the Bonneville Dam Second Powerhouse, 2005 saw the second year of testing of the Corner Collector, another type of surface passage system. The tests yielded a survival rate of nearly 100 percent for spring Chinook, steelhead and fall Chinook. All passage routes combined at this dam produced a 94 - 99 percent survival rate, depending on the species.

At The Dalles Dam, the Corps conducted the second year of testing of juvenile passage with a "spill wall" in place. The tests indicate many fish pass through bays 1-6, but survival was lower than expected. During spring spill survival was 94 percent and only 93 percent during summer spill. Survival through bays 1-4 was 97 percent, but most of the fish passed through bays 5 and 6, which had lower survival. The Corps is working with regional tribes and state agencies to evaluate methods to direct more passage through bays 1-4.

The Corps plans to install fish slides or other surface passage systems at all eight lower Columbia and Snake river dams within the next several years. In 2005, the Corps continued design work for an RSW for the Lower Monumental Dam and construction will begin in 2006. The Corps also began to prepare preliminary engineering design for surface passage alternatives at the Little Goose and McNary dams in 2005.

A JUVENILE FISH BARGE PREPARES TO LEAVE THE LOADING DOCK AT LOWER GRANITE DAM.

Fish Transportation/Barging

Juvenile fish transportation began in the late 1960s as a research program on how to safely bypass juvenile salmon and steelhead around dams and reservoirs of the Corps' lower Snake and Columbia river dams. By 1981 fish were being transported from Lower Granite, Little Goose, and McNary dams. Transport was expanded in 1993 to include Lower Monumental Dam. Transported fish are released back to the river below Bonneville Dam.

The 2005 juvenile fish transport season was marked by below average river flows, lower than river conditions of 2003 and 2004. Normal spring river operations continued in 2005, although spills for juvenile fish were curtailed as anticipated average spring runoff fell below 70,000 cubic feet per second (cfs) in the lower Snake River. Consistent with the UPA, the Action Agencies curtail spill when river flows are low. The agencies implemented Court-ordered summer spill at all collector projects from June 20 to August 31.

Nearly 22 million juvenile salmon and steelhead were transported in 2005: 99.5 percent by barge and the remainder by truck

Tagging Fish for Research

Fish research is aided by the use of PIT tags, which are inserted into selected juvenile fish and "read" as the fish pass detectors at the dams. As the tag is read, data about that particular fish are fed into computers. Most of the lower Columbia and Snake river dams have juvenile PIT-tag detection capability, and the tagged fish are tracked through the river system. Adult PIT-tag detectors are in operation at Bonneville, McNary, Ice Harbor and Lower Granite dams enabling researchers to track progress of the PIT-tagged fish when they return as adults.

In 2005, plans were completed for a "high flow" PIT detection capability at the Bonneville Second Powerhouse Corner Collector. This will allow detection of PIT-tagged juvenile fish as they travel through a wider channel and at higher speed than through the existing PIT-tag detection facilities. It will improve total detection at the dam and record the number of tagged fish passing through the Corner Collector.

2005 Water Conditions and Operations

In addition to fish passage at the dams, operators control storage reservoirs to enhance fish survival. They augment river flows with water released from upstream dams to help juvenile migration and adult spawning, and to cool water temperatures. A Technical Management Team (TMT), representing federal agencies, states and tribes, meets year round to monitor fish migrations and stream flow forecasts and to shape operations for fish. The TMT may meet as often as weekly during the active juvenile fish migration period from April through August. This team also invites input from interested parties.

The Columbia and Snake rivers have limited reservoir storage compared with other major river systems, such as the Colorado. Storage in the Columbia and Snake rivers is about 25 percent of the average runoff compared to the Colorado River, where storage is more than twice the average annual runoff. Limited storage capability in the Columbia and Snake river systems can be managed to make modest adjustments in river flows for fish but cannot convert a dry water year into a much better one or save a huge runoff from a wet year for future dry years. This means that due to natural flows, flow objectives for juvenile fish cannot be physically achieved under many conditions or at many times of the year. However, the river operators provide as much flow as possible to help fish. Specific operating rules are used at individual reservoirs to provide salmon flows, protect resident fish and control floods.

The Columbia River basin had another dry year in 2005. Flows during spring were low through mid-April but increased substantially during late April through the remainder of the fish migration season. In March the Snake River water supply was as low as 46 percent of average at Lower Granite. The water supply at The Dalles Dam on the Columbia River was as low as 66 percent of average in March. May and June rainfall boosted the water supply to 63 percent of average at Lower Granite and 74 percent of average at The Dalles. When designing the UPA, the agencies anticipated fluctuating water conditions, both within year and from year to year throughout the basin. River operators fine tune actions, coordinating through the TMT. As shown in Table 2, flow objectives were not met this year.

To help address the added hazards of in-river migration that juvenile fish face in a dry year such as 2005, the UPA calls for spill to stop at certain dams, and for as many ju-

Table 2. 2005 Seasonal Flow Objectives and Actual Flows, in thousand cubic feet per second.

	McNary	Lower Granite	Priest Rapids
Spring			
Objective	220	85	135
Actual	196	66	123
Summer			
Objective	200	50	N/A
Actual	165	33	N/A

venile fish as possible to be collected and barged downriver. Accordingly, in 2005, no spring spill was provided at Lower Granite, Little Goose and Lower Monumental dams on the lower Snake River until May 17 when flows exceeded powerhouse capacities. Spill continued through about May 27 at Lower Granite and Lower Monumental dams, whereas at Little Goose Dam, spring spill ended on May 23. Spring spill for juvenile fish passage was provided at Ice Harbor Dam and the lower Columbia River dams. Because of mechanical failures at The Dalles Dam, spill was adjusted at The Dalles and John Day dams.

The UPA does not call for spill during the summer at the three lower Snake River collector dams and at McNary Dam on the Columbia River but calls for maximum transport of juvenile salmon. However, in early June 2005, the Oregon District Court directed the Corps to provide additional spill for fish as a result of a preliminary injunction granted to plaintiffs in NWF v. NMFS. The Corps was ordered to spill all water in excess of that required for station service at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams on the Lower Snake River from June 20 through August 31, and all flows above 50,000 cubic feet per second at McNary Dam on the Columbia River from July 1 through August 31. The agencies worked with the plaintiffs and others to develop a spill plan that minimized adverse impacts to fish, such as excessive total dissolved gas levels, and provided the best research opportunities to learn from the required operation.

Water Quality

The Action Agencies monitor water quality to measure temperature and dissolved gas in the river. When providing spill for fish passage, dam operators direct water through the spillways instead of through the turbines. At large dams, spilled water plunges to the river below the dam with enough force to supersaturate atmospheric gases in the water. These gases can build up to levels that are dangerous to salmon and other aquatic life. To avoid this, the agencies monitor total dissolved gas levels in the river and adjust patterns and quantities of spill to stay within allowable levels. In 2005, the Action Agencies met the state total dissolved gas criteria 97.5 percent of the time.

To help cool the lower Snake River temperatures in the summer, cold water is released from Dworshak Dam on the Clearwater River from early July through mid-September. The benefit of these cold-water releases was apparent as the agencies monitored temperatures in the Snake River, at Lower Granite Dam: temperatures there were within state standards for the entire season.

For a more thorough discussion of how the system was operated in 2005, see the TMT end of year review at http://www.nwd-wc.usace.army.mil/tmt/agendas/2005/1102.html.

Predator Control Actions

Some birds and fish consume large numbers of juvenile fish and are a major cause of mortality of ESA-listed fish. Some of these predators have thrived in part because of the federal hydrosystem. In 2005, the Action Agencies continued efforts to control specific predators and improve survival of juvenile fish.

Caspian Terns and Cormorants

Caspian terns and cormorants consume large numbers of juvenile salmon and are a major cause of mortality of ESA-listed fish. A program to redistribute Caspian terns from Rice Island in the Columbia River estuary to East Sand Island nearer to the ocean has yielded good results. The intent of the redistribution was to shift the terns' diets away from mostly salmon and toward a wider variety of fish. The Rice Island terns consumed about 15 million salmonids in 1999. In 2005, with the tern colony moved to East Sand Island, their juvenile salmonid consumption was about 3.6 million. A Tern Management Final Environmental Impact Statement jointly prepared by several agencies recommends that two-thirds of the Caspian terns be further redistributed to alternate sites in Oregon and California. For details, see https://www.nwp.usace.army.mil/pm/e/en_plan_avian.asp.

The agencies are also considering management actions to address a greatly increased population of double-crested cormorants in the Columbia River estuary. The nesting population increased on East Sand Island from around 100 birds in 1989 to about 12,500 breeding pairs in 2005. Although salmonids make up only about 5 percent of their diet, the cormorants still consumed an estimated 6.4 million of these juvenile fish in 2005.

In addition, a relatively small but stable population of Caspian terns (about 1,000 birds) that nests on Crescent Island above McNary Dam consumed an estimated 470,000 juvenile fish in 2004 and almost 440,000 in 2005. The agencies are evaluating alternatives to address this situation.

CASPIAN TERNS HAVE BEEN MOVED TO EAST SAND ISLAND AND CONSUMED ONLY 3.6 MILLION YOUNG SALMON IN 2005, COMPARED TO THE ESTIMATED 15 MILLION THEY CONSUMED IN 1999.

Accomplishments to Date

What are our goals and strategies?	What are our key initiatives?	What have we accomplished?
HYDROSYSTEM		
Increase the survival rates of fish passing through mainstem dams: • Configure dam facilities to improve juvenile and adult fish passage survival • Manage water to improve juvenile and adult fish survival • Operate and maintain fish passage facilities to improve fish survival	• Operate and maintain adult fish ladders and other fish facilities • Guide juvenile fish away from turbines • Improve passage routes through the dams for juvenile fish • Manage available water to improve conditions for migrating fish • Transport juvenile fish in trucks or barges past dams in a "spread-the-risk" approach • Track migrating fish with Passive Integrated Transponder (PIT) detection systems	• Adult fish survival through the system of dams is now similar to that of an undammed river • Juvenile survival through the hydrosystem is improved with bypass systems, surface passage systems, and spilling water during migration periods • Based on available water supply, water releases are supporting seasonal fish migrations • Transporting juvenile fish in trucks or barges around dams when this provides better survival than migrating in-river, with 22 million transported in 2005 • More accurate monitoring of fish migration with improved fish detection systems
PREDATOR CONTROL		
Reduce the number of juvenile fish consumed by predators: • Redistribute avian predators • Reduce fish predation	• Redistribute Caspian terns from Rice Island to East Sand Island • Provide incentives to reduce the number of large northern pikeminnow in the Columbia River • Address presence of sea lions at Bonneville Dam	• Fewer juvenile salmon are consumed by Caspian terns (from 15 million in 1999 to 3.6 million in 2005) • Since 2000, removed over 2.8 million northern pikeminnow from the Columbia River through the NPMP and have reduced their predation of juvenile salmon by about 30 percent • The NPMP rewards were increased in 2004 and are sustaining higher catches • Using a variety of techniques to discourage sea lion presence below Bonneville Dam • Designed sea lion exclusion gates for installation at Bonneville Dam fish ladders
HATCHERIES		
Use hatcheries to address biological priorities of salmon: • Implement safety-net programs to avoid extinction • Reduce potentially harmful effects of artificial production	• Intervene with artificial production techniques to avoid extinction of fish populations facing a high risk of extinction • Modify hatchery practices or facilities if needed	• Safety-net hatchery programs reduced the extinction risk of populations of Snake River sockeye, spring/summer Chinook, fall chinook and steelhead, and mid- and lower Columbia steelhead • Funded the final phase of draft Hatchery Genetic Management Plans. As these plans are reviewed and approved by NOAA Fisheries, they may be used to identify and prioritize facilities and practices for reform

Accomplishments to Date

What are our goals and strategies?	What are our key initiatives?	What have we accomplished?
HABITAT		
Improve tributary and/or estuary habitat used by salmon for spawning or rearing: • Protect and improve tributary habitat • Protect and improve estuary habitat	• Increase water quantity in tributary streams • Install or retrofit fish screens at tributary water diversions • Remove fish passage barriers and increase access to tributary habitat • Protect and enhance tributary riparian habitat • Protect, enhance, restore, and create habitat in the estuary	• Secured over 300 cfs of water in tributaries in 2005 with 17 cfs delivered in the Wenatchee, Entiat, and Methow subbasins; maintained another 230 cfs that were secured since 2000 • Fish screens installed or retrofitted at more than 85 water diversions (14 installed in 2005) • Since 2000, restored fish access to more than 1,280 miles of tributary habitat; 19 barriers or obstructions were removed in 2005 to restore access to more than 180 miles • Over 1,000 miles of tributary riparian habitat protected or enhanced; 38 miles added in 2005 • Over 660 acres of habitat in the estuary have been acquired at Crims Island, Crooked Creek, and Germany Creek • Over 300 acres of estuary habitat are being actively restored, with plans to restore another 900 acres
RESEARCH, MONITORING, AND EVALUATION		
Assess and maximize performance of actions: • Monitor status of salmon • Assess the effects of actions on salmon • Address and resolve areas of uncertainty	• Monitor status of fish within the hydrosystem corridor • Contribute information for use in a regionally developed network of monitoring and assessment programs • Integrate status monitoring with action effectiveness and critical uncertainty research strategies • Implement pilot studies to determine success or effectiveness of actions to improve fish survival • Coordinate with regional RM&E efforts to maximize the amount and quality of data given limited resources	• Monitoring juvenile and adult fish passing through the system of Columbia and Snake River dams; improved accuracy of fish counting • Conducting studies to determine and confirm the benefits of actions implemented in the hydrosystem, tributaries and estuary, and at hatcheries • Evaluating the survival and adult return rates of transported juvenile salmon compared to fish that migrate in the river • Monitoring and evaluating juvenile salmon use of the estuary and ocean plume • Implementing studies to determine the spawning effectiveness of hatchery fish • Funded development of a comprehensive marking strategy to improve monitoring of hatchery-origin fish and assess status of wild fish in natural spawning areas

Northern Pikeminnow

Northern pikeminnow are voracious consumers of juvenile salmon. Since 1990 BPA has funded the Northern Pikeminnow Management Program (NPMP) to reduce the numbers of larger pikeminnow and improve survival of juvenile salmon. In 2004, BPA increased the reward for the catch of this predator and increased the number removed by 25 percent over prior years. This reward structure was made permanent in 2005 to sustain the higher catches and resulted in the highest harvest rate of pikeminnow observed since program inception. The pikeminnow program has removed over 2.8 million northern pikeminnow from the Columbia River since 1990. Evaluation indicates that as a result pikeminnow predation on juvenile salmonids has declined 30 percent saving 2 to 4 million juvenile salmon annually that would otherwise have been eaten by this predator.

THIS ADULT SEA LION HAS ENTERED THE FISH LADDER AND IS OBSERVED AT THE BONNEVILLE DAM VIEWING WINDOW

Sea Lions at Bonneville

For many years sea lions, which are protected under the Marine Mammal Protection Act, have been swimming nearly 140 miles up the Columbia River to Bonneville Dam during the spring migration of adult salmon, steelhead and other anadromous fish. Generally arriving in mid- to late-February, the predominantly male California sea lions eat to gain weight and energy in preparation for the spring mating season in Southern California. Large numbers of sea lions were first seen at Bonneville Dam in 2002 when 30 were counted. Biologists have been gathering data on sea lions at the dam since then. In 2004, 101 sea lions were counted, and in 2005, the number was estimated at 87 or more. Not all of these were at the dam at the same time; usually about 30 were present on any one day. The amount of fish eaten by sea lions has increased every year from an estimated 0.4 percent (1,010 fish) of the total spring salmon run in 2002, to 3.4 percent in 2005 (2,920 fish).

In 2004, one sea lion entered the fish ladder at Bonneville Dam, either in search of fish or just exploring; by 2005 a few of these animals had learned to find and enter the fish ladders. The agencies are working with the NOAA Fisheries and Oregon and Washington departments of fish and wildlife to address this new challenge. A variety of harassment techniques that have worked elsewhere, such as above water pyrotechnics, underwater acoustics, rubber bullets, rubber tipped arrows, and others, are being used. Also, in 2005, the Corps completed designs for Sea Lion Exclusion Devices, or SLEDs, to be installed in early 2006 at the entrances to the dam fishways. The SLEDs consist of individual gates designed to exclude sea lions but allow fish passage. (As of spring 2006, at least one sea lion had learned how to slip through the installed SLEDs)

Habitat Protection & Improvement Actions

Recognizing that the Columbia River estuary and tributaries provide important habitats to salmon during their various life stages, the Action Agencies coordinate with other federal, state, and local partners to promote improvements in aquatic ecosystems. The Action Agencies are increasing the volume of water in streams, installing or retrofitting fish screens at water diversions to keep fish safely out of irrigation canals, removing barriers to fish passage and acquiring easements or other protective interests for riparian areas areas along tributaries.

In 2005, the Action Agencies increased their habitat improvement efforts in certain areas to address factors known to limit the survival of targeted evolutionarily significant units (ESUs) of fish. In the estuary, the Action Agencies seek to acquire ownership or development rights to intact patches of habitat and those that are good candidates for restoration.

Tributary Protection and Improvement

In tributary subbasins, the Action Agencies removed barriers, screened diversions and leased more in-stream flows to address a number of factors that limit the abundance, productivity, diversity, and distribution of Snake River spring/summer Chinook, Upper Columbia River spring Chinook, Snake River steelhead, Upper Columbia River steelhead and Mid-Columbia River steelhead. Because

MVID-EAST FISH SCREENS (BEFORE): Stream velocities and currents associated with this pair of rotating drum fish screens oriented perpendicular to the canal inlet could delay the return of some fish back to the river.

MVID-EAST SCREENS (AFTER): The new continuous belt fish screens (dark wedge near center of picture) on the MVID-East irrigation diverson were installed at an angle and guide fish past the canal inlet and safety back to the river.

biological improvements associated with actions implemented to address limiting factors are difficult to measure and take time to quantify, the Action Agencies sponsor and coordinate research, monitoring, and evaluation within a larger regional framework to evaluate and quantify these biological benefits. The Action Agencies also pursued long-term survival improvements through conservation easements, leases and land acquisitions. The following sections provide examples.

Streamflow Improvements

The Action Agencies, using various mechanisms such as water acquisition agreements and efficiency improvements, increased the water quantity in certain tributaries that provide important spawning and rearing habitat for ESA-listed fish.

Through a cooperative funding agreement with BPA, the National Fish and Wildlife Foundation operates the Columbia Basin Water Transactions Program (CBWTP). The CBWTP supports innovative, voluntary, grassroots water transactions to improve flows to Columbia Basin tributary streams and rivers, working in accordance with state water law. In 2005, its third full year of operation, the CBWTP completed 42 voluntary transactions around the region, each addressing a significant opportunity to restore instream flows. Over 100 transactions have been completed since the inception of the program.

In 2005, the CBWTP secured 307 cfs of streamflows throughout tributaries in the Basin, with 17 cfs added in the Wenatchee, Entiat, and Methow subbasins to benefit upper Columbia fish. When combined with actions completed in prior years and still maintained, this program delivered over 530 cfs of water to Columbia basin streams in 2005. For details, see the 2005 CBWTP Annual Report Summary at www.cbwtp.org.

A good example of progress made under the water transactions program comes from a CBWTP supported transaction by the Idaho Department of Water Resources along Beaver Creek, a tributary to the Salmon River.

Beaver Creek begins near the headwaters of the Salmon River at the southern end of the Sawtooth National Recreation Area. For about half a century, irrigation has dewatered the creek on a private inholding, and unfenced pasture has resulted in erosion and degradation of the stream channel. To help address the situation, the Idaho Department of Water Resources (IDWR) signed a 10-year water lease with new owners interested in restoring the system, which is historically significant for steelhead as well as spring and summer Chinook. Resulting enhanced flows have re-opened eight miles of spawning and rearing habitat and many smaller tributaries, while reducing sediment flows to the upper Salmon River. The long-term agreement also allows for improvement of the site based on ongoing studies by IDWR in cooperation with local efforts to restore the riparian areas.

Fish Screen Improvements

Installing or retrofitting fish screens at water diversions can prevent or alleviate the entrainment of adult and juvenile fish. Entrainment occurs when fish are diverted along with water into irrigation canals or other inappropriate habitats. Fish screens meeting NOAA Fisheries current specifications have been installed or retrofitted by the Action Agencies at more than 85 locations since 2000. In 2005, the Action Agencies screened 14 water diversions. These fish screens are reducing fish mortality and providing near-term survival benefits for ESA-listed fish. Planning and design work completed in 2005 will also lead to the implementation of additional projects in 2006 to 2007.

One example of these efforts is the replacement of fish screens at the Methow Valley Irrigation District (MVID)-East irrigation diversion site on the Methow River near Winthrop, Washington (see photos). Reclamation and BPA collaborated with the MVID, Washington Department of Fish and Wildlife (WDFW), Washington Department of Ecology (WDOE), and the Confederated Tribes and Bands of the Yakama Nation on this project.

The previous rotating drum fish screens were state-of-the-art when first installed. However, research showed that flow velocities and currents near the screens installed in this way could inhibit the ability of some fish to easily move past the screen and return to the river at certain times of the year. The research also indicated that design features such as the size and orientation angle of a fish screen across the canal inlet can significantly affect fish movement past the inlet and back into the river. To remedy this situation, new continuous-belt fish screens were in-

stalled at an angle to the canal inlet and were engineered to maintain a current that sweeps fish past the inlet and safely back to the river.

Fish Passage Improvements

The Action Agencies improve fish passage by removing obstructions that block access to spawning and rearing habitat. These obstructions include water diversions, culverts and other migration barriers. The Action Agencies increase access to high-quality spawning and rearing habitat by supporting projects to remove obstructions and reconnect streams with floodplains and side channels.

In 2005, the agencies helped remove at least 19 barriers or obstructions to fish, providing access to more than 180 miles of tributary fish habitat. Since 2000, these passage improvement efforts in tributaries have reopened fish access to over 1,280 miles of stream throughout the Columbia River basin.

An example of improved fish passage is provided by an irrigation diversion dam project on the East Fork Salmon River near Challis, Idaho (see photos). This gravel push-up dam impeded fish passage under low stream flow conditions. Frequent use of heavy machinery in the river to maintain this gravel push-up dam widened this stretch of the river and resulted in shallow river depths during the low stream flow season.

After careful evaluation, Reclamation engineers developed a design to replace the push-up dam with a roughened channel rock ramp. The resulting ramp looks like a natural riffle and provides a route for fish passage under all flow conditions. This site also will require significantly less in-stream access by heavy machinery to maintain water delivery to the irrigation canal. Reconstruction of this site opened access to 0.5 miles of prime instream spawning and rearing habitat used by Snake River spring/summer Chinook salmon and Snake River steelhead. The Custer County Soil and Water Conservation District sponsored and constructed this project with funding from BPA.

Riparian Protection and Enhancement

As a longer-term strategy to improve fish survival, the Action Agencies protect and enhance fish habitat through acquiring easements or other protective interests in land, treating and fencing riparian areas, and stabilizing stream banks.

In 2005, the agencies funded the protection and enhancement of more than 38 miles of anadromous fish habitat in at least seven subbasins. When added to actions implemented or secured in prior years, over 1,000 miles of habitat has been secured by the Action Agencies. These important fish habitats will continue to provide fish survival improvements for many years.

In 2005, in an effort to permanently protect high quality habitat in areas of strategic significance for fish, BPA cooperated with other entities to launch the Columbia Basin Riparian Easement Pilot to complement the CBWTP. The pilot began with the Methow Conservancy in the Columbia Cascade province of north-central Washington.

The Methow Conservancy purchased an easement permanently limiting future development on a 122-acre parcel with 1.75 miles of shoreline. Located at the confluence of Hancock Creek and the Methow River, this is an area rich with side channels and woody debris, a refuge for spring Chinook, steelhead and other species. The land parcel is in prime condition and is considered to be one of the most productive reaches of the upper Methow. The Action Agencies will continue to use this program to work cooperatively with others to protect important riparian areas.

EAST FORK SALMON RIVER (BEFORE): Before improvements were made, the river could wash away the gravel push-up dam several times each year and a bulldozer would be driven into the stream to repair the breach.

EAST FORK SALMON RIVER (AFTER): Large boulders buried in the stream bed (upper right) stabilize the stream channel, provide a natural avenue for fish passage, and significantly reduce the need for bulldozers.

THIS RIPARIAN AREA IS PROTECTED BY THE HANCOCK SPRINGS CONSERVATION EASEMENT ON THE METHOW RIVER

HABITAT IMPROVEMENTS IN THE COLUMBIA RIVER ESTUARY; SUCH AS RESTORATION OF TIDAL MARSH AND FOREST AREAS AT CRIMS ISLAND, WILL PROVIDE REARING AND FORAGING HABITAT FOR JUVENILE SALMON AND OTHER SPECIES.

Estuary Protection and Improvement

In the Columbia River estuary, the Action Agencies implemented projects that protect and enhance shallow water habitats and research to improve our understanding of estuary habitat. These estuary habitats provide refuge, food and rearing areas for juvenile salmon as they migrate and make their transition from freshwater to saltwater. The estuary habitat projects funded by the agencies focus primarily on improving the survival of fall Chinook. They also enhance conditions for the many other Columbia River fish that use and depend on the estuary.

In 2005, the Corps completed the vast majority of construction to restore 76 acres of tidal marsh and 115 acres of forest riparian habitat on Crims Island in the lower Columbia River. This project provides juvenile rearing and foraging habitat for fall Chinook, chum, and coho salmon, and adds nutrient input from woody and herbaceous vegetation. Snake River sockeye, steelhead, coastal cutthroat trout and other species will also benefit from restored linkages in the estuarine food web.

BPA continued to fund ongoing efforts to restore habitat in the Sandy River Delta. In 2005, 110 acres of floodplain and riparian habitat were revegetated, invasive wetland species were controlled and removed on 10 acres, invasive weeds were removed and native riparian forest shrubs were interplanted on 115 acres, and native riparian trees and shrubs were planted on 65 acres. The Sandy River drains significant salmon and steelhead habitat on the flanks of Oregon's Mount Hood.

BPA also funded the Chinook River project in the lower estuary of Pacific County, Washington. In 2005, critical information was gathered for the planning and design of restoration of approximately 800 acres by 2010.

The Action Agencies work with the Lower Columbia River Estuary Partnership (LCREP) to coordinate, secure and implement projects in the estuary. Three projects, Germany Creek, Fort Columbia and Grays River, are being implemented through LCREP to improve habitat for fall Chinook and other species.

Under the Germany Creek project, 155 acres were permanently acquired, approximately 2.5 acres of off-channel salmon rearing habitat restored, approximately 250 feet of chum spawning habitat rehabilitated, and riparian habitat enhanced.

A plan to reconnect approximately 96 acres of tidal wetland habitats in the lower river near Fort Columbia, Washington, was completed in 2005. Reconnecting the floodplain will reestablish the ecological benefits for endemic fish and wildlife species and give fish and wildlife access to restored habitats.

In 2005 LCREP also acquired 55 acres of riparian and floodplain habitat on Crooked Creek, a tributary to the Grays River.

Other accomplishments in the Columbia River estuary include the removal of two culvert barriers at Scappoose Bay, installation of fish-friendly bridges at the Malarkey Ranch to open over six miles of stream habitat, replacement of a tidegate at Skamakowa Creek, and breaching of two dikes in the Lewis and Clark River to reconnect 25 acres of floodplain. These projects are expected to further improve habitat used by listed and other fish.

Hatchery Actions

The Action Agencies continue to fund safety-net programs to reduce the extinction risk of at-risk populations of ESA-listed Snake River sockeye, Snake River spring/summer Chinook, and mid- and lower Columbia River steelhead.

One of those programs, the Snake River Sockeye Salmon Captive Broodstock Program, preserves this critically imperiled 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 to spawn or migrate downstream. Since 1999, 348 adults from the program have returned to Redfish Lake. This is a 20-fold increase over the total of 16 wild fish that returned from 1990 to 1998.

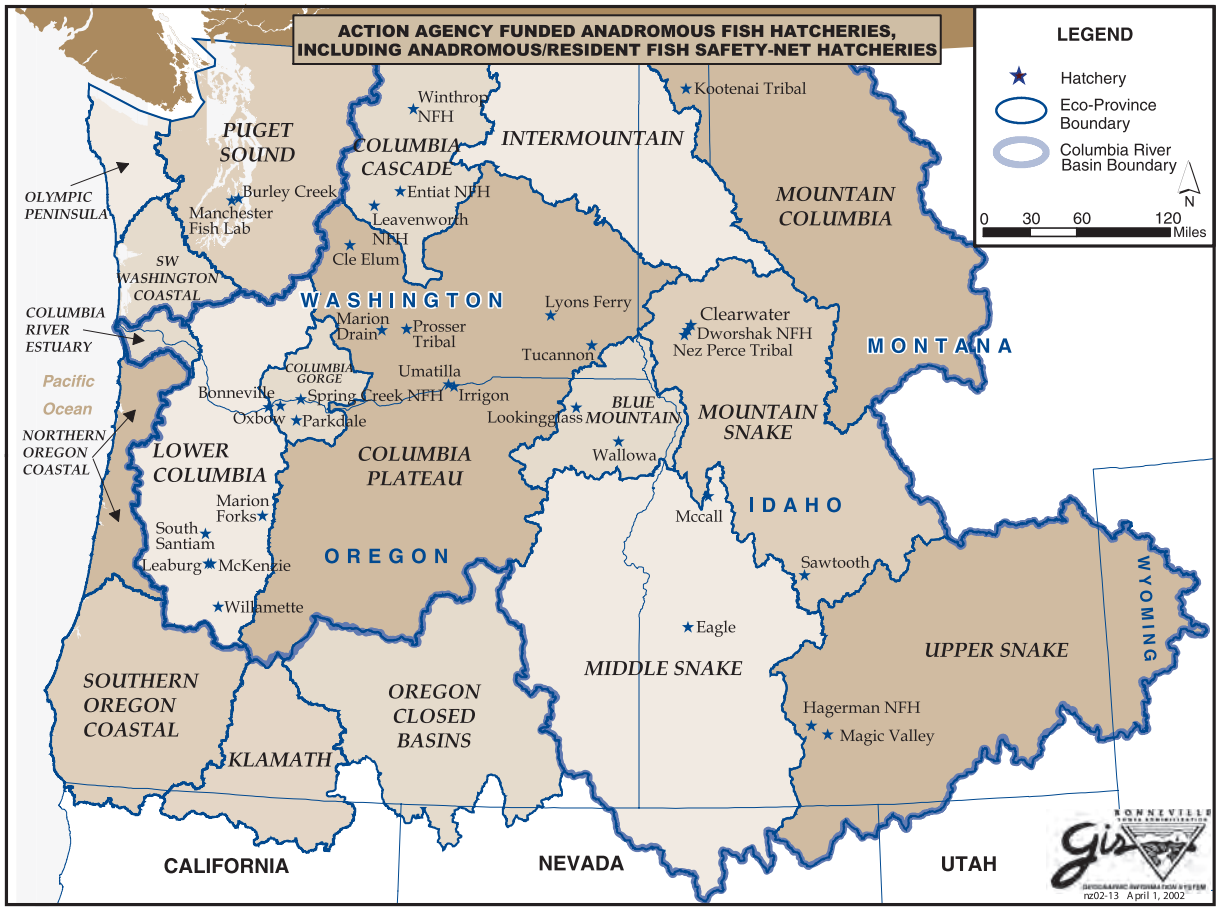
In the 2004 UPA, BPA proposed to construct and fund operation of new hatchery facilities at the Oxbow Hatchery, operated by the Oregon Department of Fish and Wildlife (ODFW). This would produce annually up to 150,000 additional Snake River tion capability would boost the fitness of the captive population and protect the integrity of the program. ODFW is developing a proposal for this work that will be considered for BPA funding.

In 2005, BPA executed a contract for modifications at NOAA Fisheries' Burley Creek Fish Hatchery. This serves as a broodstock spawning, incubation, and rearing station along with the Idaho Department of Fish and Game (IDFG) Eagle Fish Hatchery. Also, the IDFG has proposed to modify the Eagle Fish Hatchery to enable the production of additional broodstock adults. Their proposal is being reviewed and considered for BPA funding.

The modifications at Burley Creek and Eagle hatcheries will improve the security of the existing safety-net program and facilitate the production of additional broodstock adults and eggs to meet a 150,000 smolt target.

The Action Agencies also took steps in 2005 to expand the adult collection facilities at Lower Granite Dam to handle 6,000 adult fall Chinook in hatchery programs. In 2005, the Action Agencies began to fund the operation of the Lower Granite Dam adult trap at its current capacity and prepared preliminary designs for the facility expansion. The expansion is planned for completion in early 2007.

The Action Agencies also funded the final stages of development of draft Hatchery Genetic Management Plans (HGMPs) to identify hatchery reform actions that would reduce the negative impacts of hatchery operations on ESA-listed stocks. As the HGMPs are reviewed and approved by NOAA Fisheries, they will help the Action Agencies and others identify priority actions that would contribute



Research, Monitoring and Evaluation

The Action Agencies implement a research, monitoring and evaluation (RM&E) program that focuses on maximizing performance of management actions. The RM&E program is implemented in coordination with the Northwest Power and Conservation Council's Fish and Wildlife Program, the Corps' Anadromous Fish Evaluation Program, Reclamation's technical assistance activities, and RM&E activities of other agencies. The Action Agencies work closely with the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) – a forum for coordinating state, federal, and tribal aquatic habitat and ESA-listed salmonid monitoring programs – to collaboratively advance a regionally coordinated approach to fish monitoring. In 2005, a PNAMP charter was signed by 19 state, tribal, federal and regional entities.

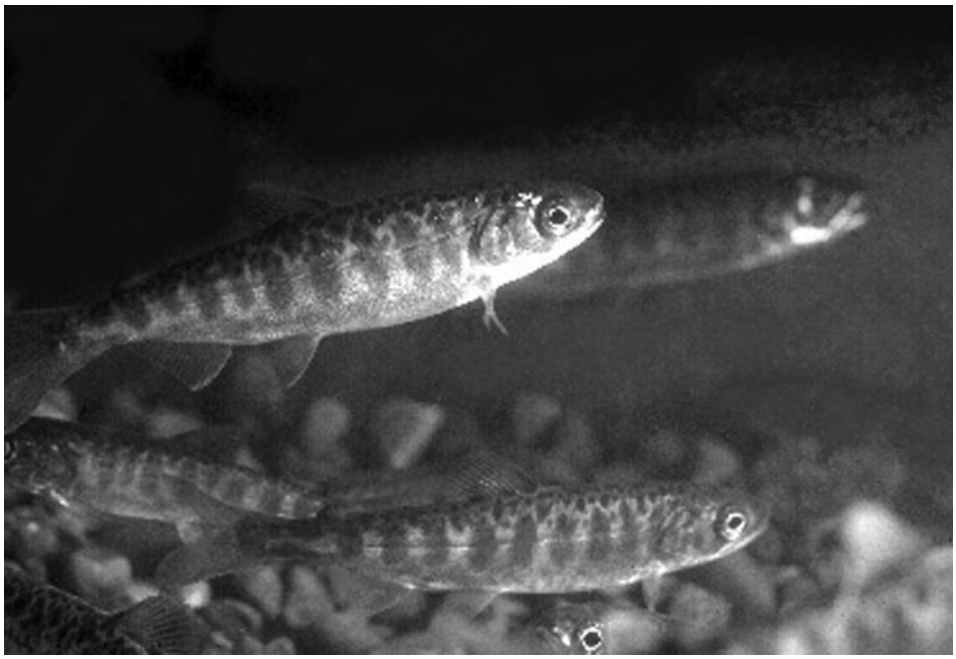
Status monitoring research estimates the status of fish populations and watershed conditions, and over time tracks indicators of habitat, water quality, water quantity and other factors that impact watershed health. In 2005, the Action Agencies continued to monitor the status of ESA-listed fish within the hydrosystem corridor and funded pilot monitoring programs in several Columbia River tributary subbasins and in the estuary. As they have for many years, the agencies funded the collection of daily adult and juvenile fish passage data at eight sites through the mainstem Snake and Columbia rivers, enabling statistical and analytical support for real-time hydrosystem operational decisions and providing critical information needed to determine and track the status of ESA populations and their environment.

In 2005, the Action Agencies expanded the coverage for detecting PIT-tagged fish and improved the ability to evaluate new and alternative technologies by installing additional fish detection systems on the Washington shore of Bonneville Dam. The agencies also pursued the development of detection systems for use in remote small stream locations to improve fish tracking capabilities. These actions will help improve understanding of the fate of adults migrating up-river: are they falling back at dams, turning off into tributaries or are there other reasons they do not pass the next dam upstream?

Action effectiveness studies help to pinpoint improvements to fish habitat and survival that result from certain management actions. Action effectiveness studies establish "cause and effect" or inferential relationships between fish conditions, habitat conditions, and/or management actions in a quantitatively rigorous approach. These studies can be especially useful when resources are limited and need to be prioritized.

In 2005 the Action Agencies funded studies of the effectiveness of hydrosystem, predator control, habitat and hatchery related management actions. In the hydrosystem, studies of the juvenile fish transportation program, turbine survival, water temperature, adult fish passage and dam specific survival and passage efficiency were conducted. The agencies also funded studies to evaluate and monitor the Northern Pikeminnow Management Program, avian predation rates on juvenile salmon in the lower Columbia River and predation rates of sea lions on adult salmon below Bonneville Dam. For habitat actions, studies of the cumulative effects of estuary habitat restoration actions on juvenile salmon survival and tributary pilot studies in the Wenatchee, John Day and Methow subbasins continued. BPA also continued to fund the monitoring and evaluation of its safety-net hatchery programs.

Critical uncertainties studies address areas of uncertainty in biological evaluations of the survival conditions and the needed survival improvements for specific fish stocks. For example, the question of whether and when it is best to transport juvenile fish around dams rather than leaving them in-river to migrate has been hotly debated in the region. To address this question, the agencies conduct research related to the fish transportation program and any negative effects that may result. Some study results suggest that the benefits of transporting juvenile fish may be reduced due to negative effects on returning adults, though these effects have been difficult to quantify. The agencies continue to fund a long-term study to evaluate trends in salmon life-history diversity and abundance, estuarine-habitat associations, and potential responses to historic habitat change. The Action Agencies continue to invest in research to resolve key uncertainties and improve analytical methods for population status assessments and survival improvement.



Conclusion

Efforts to protect and recover threatened and endangered fish in the Columbia River basin are comprehensive and reflect the complex life cycles of the fish themselves. Progress has been made each year by building step by step on each preceding year's successful effort. It will take many years to rebuild sustainable populations of some species. Each single recovery component, taken alone, may not produce dramatic results. But taken together, these multiple and carefully coordinated efforts are producing solid and measurable successes.

Regional Collaboration In High Gear

High-level tribal, state and federal agency representatives are jointly looking at options for a better way to stabilize salmon and steelhead populations in the Columbia River basin and bring these fish back to sustainable levels. Representatives from four states, seven tribes and four federal agencies are meeting almost daily to identify areas of concern and begin to negotiate long-term solutions. They are tackling issues of how best to operate the dams for fish and other uses, where and how to preserve existing good habitat and restore damaged areas, and how to improve hatchery and harvest management.

In October 2005, Judge James Redden of the U.S. District Court of Oregon directed NOAA Fisheries and the Action Agencies to collaborate with Columbia River basin states and tribes to produce a new proposed action for NOAA Fisheries to use as it develops a new biological opinion for operating the federal dams in the basin for salmon and steelhead. Although this collaboration is required by a Court order, participants are enthusiastic about the process and the likelihood of success.

The group has agreed on collaboration protocols and identified a 10-step process for getting to recovery of Columbia River basin salmon and steelhead. Multiple work groups are now addressing those 10 steps and beginning to fill in critical information, such as what factors are currently limiting the success of specific fish populations and what actions will help to correct those "limiting factors." The work groups will also look at how to monitor the results of a variety of actions for fish to determine what is working and to make any needed course corrections along the way.

While the new biological opinion will provide a solid foundation, the responsibilities for long-term recovery go beyond what the federal Action Agencies alone can accomplish. An important part of this effort is the development of local recovery plans. Local stakeholders are working with NOAA Fisheries to develop scientific, locally-supported recovery plans for each of the listed salmon and steelhead stocks in the Pacific Northwest. These plans describe how local, state and federal agencies and tribes will work together to help recover the fish.

Additional Resources:

Pacific Coastal Salmon Recovery Fund
www.nwr.noaa.gov/pcsrf/index.htm

Columbia River Inter-Tribal Fish Commission
www.critfc.org

Upper Columbia United Tribes
www.ucut.org

Columbia Basin Fish & Wildlife Authority
www.cbfwa.org

Northwest Power and Conservation Council
www.nwcouncil.org

Oregon Watershed Enhancement Board
www.oregon.gov/OWEB/index.shtml

Washington Salmon Recovery Office
www.governor.wa.gov/gsro/default.htm

Idaho Office of Species Conservation
http://osc.idaho.gov/

For web site links and more information on federal agency efforts for salmon and steelhead visit www.salmonrecovery.gov