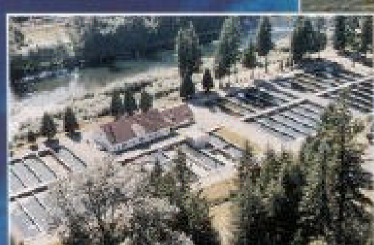
SAVING THE SALMON:

A History of The U.S. Army Corps of Engineers' Efforts to Protect Anadromous Fish on The Columbia and Snake Rivers



by

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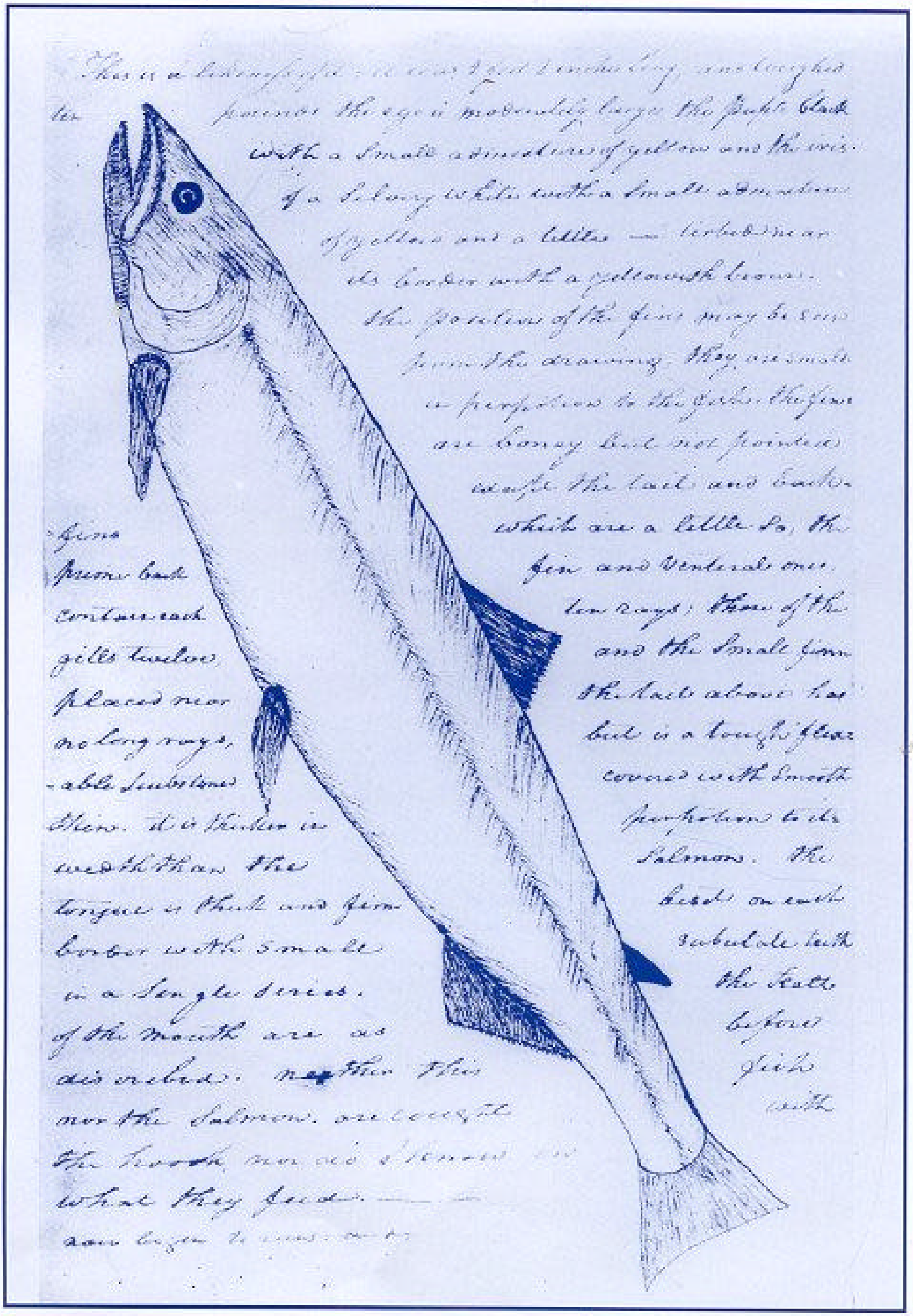

Explorer William Clark's Drawing of a Salmon.

Saving The Salmon:
A History of The U.S. Army Corps of Engineers' Efforts to Protect Anadromous Fish on The Columbia and Snake Rivers

Prepared for
U.S. Army Corps of Engineers,
North Pacific Division,
Portland and Walla Walla Districts

by
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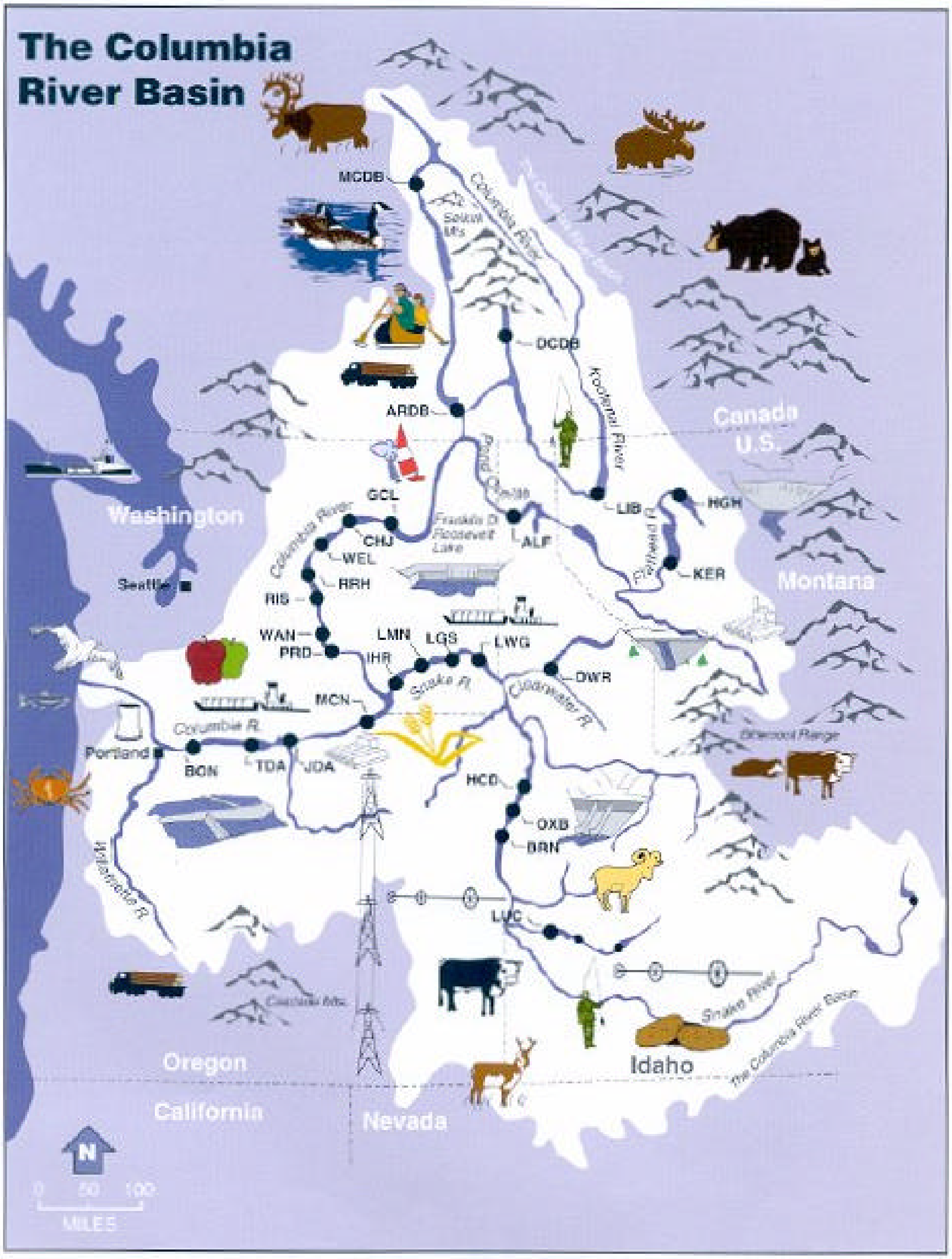
The Columbia River Basin
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Columbia River
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Kootenai River
ARDB
Canada
U.S.
Pend Oreille
LIB
HGH
Washington
GCL
Columbia River
CHJ
WEL
Franklin D. Roosevelt Lake
ALF
Flathead R.
KER
Montana
Seattle
RRH
RIS
WAN
PRD
LMN
LGS
LWG
IHR
DWR
Snake R.
Clearwater R.
MCN
Columbia R.
Portland
BON
TDA
JDA
HCD
Bitterroot Range
OXB
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Willamette R.
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Preface

Few environmental problems in the Pacific Northwest have proved more persistent than declining salmon populations. For more than a century, the U.S. Army Corps of Engineers (Corps) has been concerned with the fate of salmon in the Columbia River Basin. What follows is a history of the agency's involvement in the region's anadromous fisheries, focusing primarily on biological research.

The Corps began investigating the Columbia River in 1887, when Congress directed the engineers to report on the causes of the decline in the salmon runs. During the 1930s, the construction of the region's first large multipurpose dams brought a new sense of urgency to the problem of diminishing fish populations. From the early planning stages, the Corps recognized that Columbia River dams threatened salmon and steelhead by impeding their migration to and from the ocean. Accordingly, the Corps, with the assistance of fisheries agencies, designed and developed adult fish passage facilities for all of its multipurpose dams on the Columbia and Snake Rivers.

During the last 50 years, the Corps' investigations of Columbia Basin fisheries have intensified. Since the early 1950s, the engineers have devoted more than $60 million to fisheries research, producing hundreds of reports and studies. In addition, the agency has expended $1.1 billion on physical modifications to its dams and powerhouses to improve fish passage. Still, the system of dams on the Columbia and Snake Rivers continues to threaten migrating salmon. Fish migration, moreover, is not the only factor affecting salmon survival. Ocean harvest, ocean temperatures and currents, degradation of habitat, unscreened irrigation ditches, and hatchery management practices also contribute to the decline of anadromous fish runs. The listing of sockeye and chinook salmon under the Endangered Species Act in the early 1990s, as well as the consideration of listing the coho, indicated the severity of the problem.

Owing to the seriousness of the issue and the extent of the Corps' involvement, the agency contracted this history. Its purpose is to analyze the Corps' role in researching and constructing facilities designed to protect the anadromous fish affected by Columbia and Snake River dams. To place the Corps' efforts in historical context, we examined not only the work of scientists and engineers but also the longstanding involvement of the various users of the Columbia River. A diversity of interests, including small dam construction as well as commercial sports, and Native American fisheries, have impacted the management of the river system. Understanding the biological research required that the economic, political, and social context also be addressed, at least in part. To be sure, problems on the Columbia River - including salmon decline, environmental degradation, and conflict among various interests - have worsened considerably during the last several decades. It is useful, however, to realize that these are not recent developments in the Columbia River Basin. It is also useful to recognize that ideally, research is based on scientific premises, while many decisions regarding salmon have stemmed form economic, political, and social considerations.

Records on the use and protection of salmon are voluminous. Because the topic is far-reaching as well as complex, the amount of research materials available remains formidable. Many of the issues examined here, such as the history of commercial and sports fisheries, have already been extensively investigated. For this reason, our research on commercial and sports fisheries focused on secondary studies, and the coverage of these topics in the following history is not exhaustive. Few historians, however, have examined the development of scientific studies of the Columbia River salmon. Accordingly, we devoted much of our primary research to this topic.

In addition to the hundreds of government fisheries reports and journal articles produced over the last century, we consulted Corps and fisheries agencies files, newspaper articles, Native American publications, and a variety of archives and manuscript collections. We conducted interviews with Corps employees as well as biologists from state and federal fisheries agencies. We also consulted representatives of environmentalist organizations. By providing information not available in the written record, the interviews gave us a more complete view of what happened over the last half a century.

The complexity of the topic and its controversial nature complicated our research of biological studies. Although the technical details were available in government fisheries reports, political and social issues required examination of correspondence between agencies, as well as the minutes of various meetings involving the Corps, state and federal fisheries agencies, and the tribes. Some of these records proved to be elusive. Although the National Archives and Federal Records Center, the Corps, and the fisheries agencies provided much of the needed research material, their records were sometimes incomplete. Several agencies explained that, due to inadequate storage space, they had destroyed or misplaced their historical records. A few research materials were located in such places as basements and closets, where they remained uncatalogued in unmarked boxes. Moreover, some of the peripheral topics examined for this study remain very sensitive. Records concerning government experiments on the effect of radioactivity on Columbia River fish, for instance, contained classified material.

Because the use and protection of salmon carries implications for current problems on the Columbia and Snake Rivers, conducting interviews was sometimes difficult. Attitudes towards the Corps varied widely. Some biologists and historians we consulted characterized the agency as entirely cooperative, while others denounced it as the "evil empire" -- an opportunistic, expansive agency with no sympathy for those who value salmon. Some recognized that the Corps' position, like that of other water resource agencies, evolved over time. Others understood that the Corps, which is not a single-minded agency, employs a variety of individuals with different perspectives. This history outlines the development of attitudes toward fish protection within the Corps, and examines criticism of the agency, as well as opposition to its projects on the Columbia and Snake Rivers.

Debate is health, particularly when it involves an issue of such significance to the region. While conducting research for this project, however, we encountered many biologists and historians who portrayed the subject of salmon protection in categorical terms, dismissing arguments - and sometimes evidence - that did not support their points of view. To the extent possible, we attempted to prevent our research questions from becoming distorted by present fisheries controversies, and our investigation yielded few heroes or villains. In writing the following history, we sought neither to exonerate nor to vilify the Corps.

The fate of salmon in the Columbia River Basin will be determined by actions undertaken during the next decade. An examination of the biological research conducted over the last 50 years could assist scientists and policy makers in future decisions. We hope that this history will help them place the problem of declining fisheries in a broad, historical context.

Acknowledgements

The authors would like to thank the following U.S. Army Corps of Engineers repositories and their staffs: the Technical Libraries, Public Affairs Offices, and Visual Information and Printing Branches of the Portland and Walla Walla Districts; and the North Pacific Division records holdings in Portland. Gretchen Starke and Sallie Jones of the Bonneville Lock and Dam Project were especially helpful in locating materials from their records holdings. Edward M. Mains, formerly of the North Pacific Division, provided valuable information and helped locate historical records. Also, we appreciated the guidance of William F. Willingham, North Pacific Division Historian; A. Rudder Turner, Jr., North Pacific Division Environmental Specialist; and Sarah J. Wik, Fisheries Biologist, Walla Walla District.

Many federal and state fisheries agencies proved to be generous with their time as well as with their research materials. These included the National Marine Fisheries Service, Seattle and Portland; the Oregon Department of Fish and Wildlife, Portland; the Bonneville Power Administration, Portland; and the Northwest Power Planning Council, Portland. Individuals who were particularly helpful included Gerry Bouck, Bonneville Power Administration; Kirk T. Beiningen, Oregon Department of Fish and Wildlife; Gerald Collins, Carl Elling; and Robert Schoning, formerly of the National Marine Fisheries Service; Patricia Cook, National Marine Fisheries Service Librarian, Seattle; and Louise Donaldson, formerly of the U.S. Fish and Wildlife Service.

We also appreciate the assistance of the Washington State Historical Society in Tacoma and the Oregon State Historical Society in Portland; the Columbia River Maritime Museum and the Clatsop County Historical Society in Astoria, Oregon; the National Archives and Federal Records Center in Seattle; the Washington State Archives in Olympia; and the Special Collection Division and the Archives and Manuscripts Division at the University of Washington in Seattle.

William Lang, Director of the Center for Columbia River History in Vancouver, Washington, and William G. Robbins, Professor of History, Oregon State University in Corvallis, read portions of the report and offered valuable suggestions. Keith C. Petersen of the Washington State University Press in Pullman, and Kent D. Richards, Professor of History, Central Washington University in Ellensburg, shared their research and writing on the Snake River dams and off-reservation fishing rights, respectively.

For their assistance with editing and research, we are indebted to Alan Newell, Frank Grant, Bonnie Christensen, Carla Bush, Erik Arnold, and Kathryn Schneid of Historical Research Associates. Also, Patrick F. Diviney at the University of Washington, Tacoma, assisted in researching newspaper articles during the early phase of the project.

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Seattle, 1994

Columbia River History

1800	**Up to 16 Million Salmon and Steelhead Return Each Year to the Columbia and Snake Rivers**
1859	**First Irrigation Project Established in Columbia River Basin**
1878	**First Hatchery Established in Columbia River Basin, located on Clackamas River**
1880s-1890s	**Effects of Mining, Logging, Farming, and Fishing Become Apparent in Declining Salmon Runs**
1887	**Congress Directs U.S. Army Corps of Engineers to Investigate Causes of Declining Salmon Runs**
1912	**Ocean Commercial Trolling for Salmon Begins off Columbia River**
1910-1920	**Columbia Salmon Canneries Reach Peak Production**
1938	**U.S. Army Corps of Engineers Completes Bonneville Dam with Fish Passage Facilities on the Columbia River**
1941	**U.S. Bureau of Reclamation Begins Operating Grand Coulee Dam, Closing Upper Columbia River Basin to Salmon Migration**
1955	**U.S. Army Corps of Engineers, in Consultation with the Fisheries Agencies Establishes Laboratory at Bonneville Dam for Research on Anadromous Fish**
1956	**Native American Fishery at Celilo Falls Flooded by The Dalles Dam**
1961	**U.S. Army Corps of Engineers Begins Operating Ice Harbor Dam on Snake River**
1967	**Idaho Power Company Completes Hells Canyon Dam, Blocking Salmon From Upper Snake River**
1960s-1970s	**Nitrogen Supersaturation Kills Thousands of Salmon**

1975	**U.S. Army Corps of Engineers Begins Operating Lower Granite Dam, Columbia River Basin's Last Federal Dam**
1976	**Columbia River Inter-Tribal Fish Commission (CRITFC) Established**
1980	**Congress Creates Northwest Power Planning Council**
1991-1992	**National Marine Fisheries Service Lists Snake River Sockeye as Endangered Species and Snake River Spring, Summer, and Fall Chinook as Threatened, Later Changed to Endangered**
1993	**U.S. District Judge Malcolm F. Marsh Orders Federal Government to Improve Dam Operations, Lessening Their Hazards to Salmon**
1994	**Ocean Salmon Fishing Banned for First Time Off Northern Oregon and Washington Coasts**
1995	**Federal Government Dictates that More Water in Columbia and Snake Rivers Must be Used for Salmon Instead of Power Production and Irrigation**

(Based in part on time line provided in *The Oregonian*, January 29, 1995, page E-4).

Prologue

Nothing better symbolizes the bounty of nature in the Pacific Northwest than the annual run of salmon. The first Euroamericans to visit this region reported staggering numbers of anadromous fish. Their "multitudes," explorer Meriwether Lewis wrote in 1805, "are almost inconceiable."[1] Such lavish descriptions helped establish an image of abundance. What distinguishes salmon and steelhead from other wildlife in the Pacific Northwest is their considerable visibility. According to one fisheries biologist, "Environmentalists are satisfied just knowing the spotted owl exists even if they never come into contact with it in their daily lives." However, people expect to see salmon - and it is the prodigious numbers of these fish that makes them appealing.[2] The anadromous fish runs in the Columbia Basin serve as a reassurance that the Pacific Northwest has retained some of its natural heritage.

This perception of abundance intensifies the alarm that many Americans feel when confronted with evidence of the declining numbers of anadromous fish. Since 1990, the National Marine Fisheries Service (NMFS) has received petitions to list five salmon populations under the Endangered Species Act (ESA). The five populations included Snake River spring, summer and fall chinook, Snake River sockeye, and lower Columbia River coho. In December 1991, NMFS listed the Snake River sockeye as endangered - and the following spring, that agency listed Snake River chinook populations as threatened. Debates regarding these listings have focused national attention on the Pacific Northwest.

Other controversial ESA listings--such as the snail darter during the mid-1970s and the northern spotted owl during the early 1990s--also have polarized public opinion. The implications of the declining salmon runs, however, are more complex and far-reaching than those concerning other prominent ESA listings. As *The Seattle Times/Post Intelligencer* explained, "the consequences could far surpass those that followed similar action to safeguard the northern spotted owl."[3] Unlike the spotted owl, salmon are important to the region's economy. And owing to their migration between freshwater spawning grounds and coastal waters, these fish require a wide range of territory. The ESA listings could curtail a variety of activities occurring in this large area, including hydroelectric generation, agricultural irrigation, navigation, commercial and recreational fisheries, and Native America treaty fisheries.[4] The Pacific Northwest derives two-thirds of its electricity from hydro dams, while most of the nation obtains only one-tenth from that source.[5] The ESA listings, and the resulting plans for salmon recovery, could have a dramatic impact on the economy of the region. According to Senator Mark Hatfield of Oregon. "Every man, woman and child in the Northwest will be shaken as if by an earthquake."[6]

In searching for the causes of this crisis, many Americans have focused on the "killer dams" constructed since the late 1930s along the Columbia and Snake Rivers. Certainly hydroelectric development presents a major threat to salmon populations. However, the roots of the problem can be traced back to the 19th century, long before the first major dam appeared. Intensive harvesting and degradation of habitat began more than 100 years ago, and have continued throughout the 20th century. As early as the 1890s, the Oregon Fish and Game Protector warned that owing to "wastefulness and lack of intelligent provision for the future," salmon populations were "threatened with annihilation."[7] Conservation measures during the late 19th and early 20th centuries were timid and sporadic. The decline of anadromous fish runs, then, has been a longstanding problem. Efforts to protect wildlife and mitigate damage parallel recent changes in American attitudes toward the natural world, including an increasing recognition of the importance of habitat and the need for species diversity, as well as a growing sense of responsibility for maintenance of the environment. The preservation of these fish will likely remain one of the most controversial environmental issues in the Pacific Northwest.

Endnotes

[1]Meriwether Lewis, *History of the Expedition Under the Command of Captains Lewis and Clark* (New York: Bradford and Inskeep, 1814), p. 15.

[2]R. Dexter Van Zile, "Pacific Northwest Salmon Wars," *Puget Sound Magazine* 1 (Summer/Fall 1992): 13.

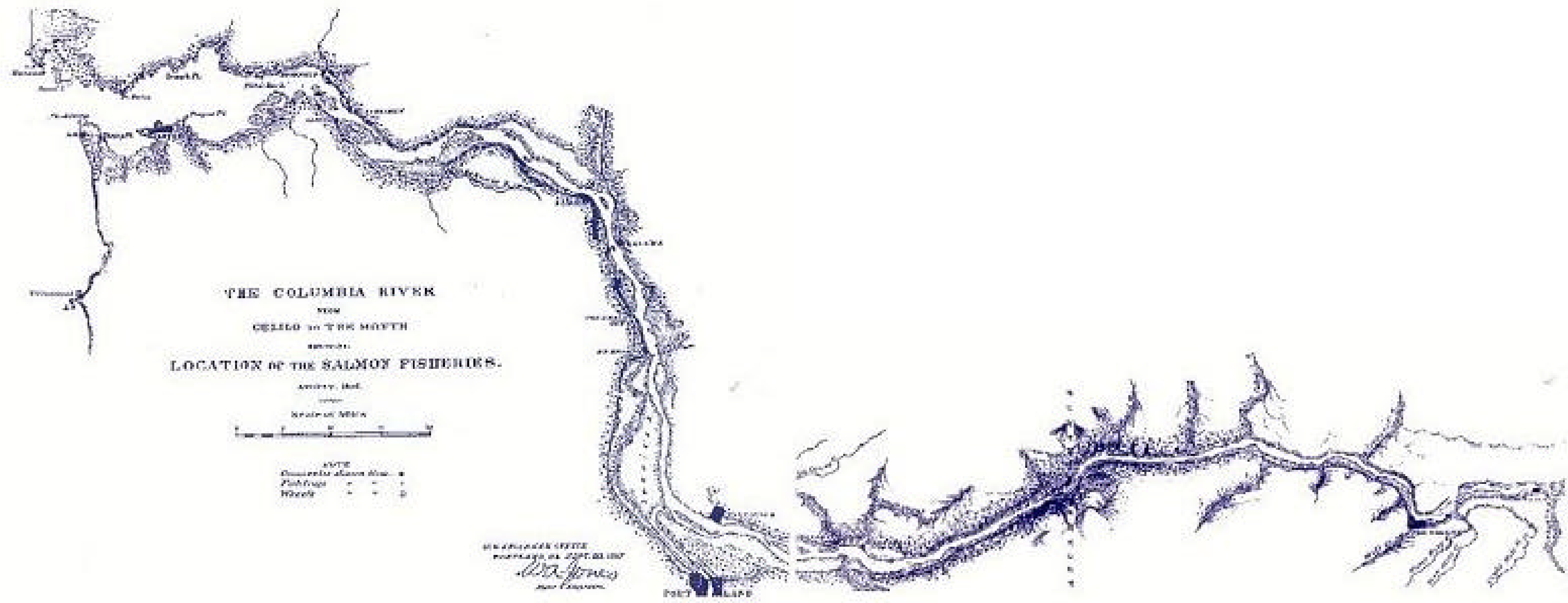
[3]Marla Williams and Jim Simon, "Last Chance for Salmon," *The Seattle Times/Post Intelligencer*, 31 March 1991, page A1.

[4]Eugene H. Buck, Amy Abel, and Betsy Cody, "Salmon and Smelt on the Pacific Cost: Endangered Species Act Issues," *Congressional Research Service Issue Brief*, IB91112, 9 October 1992, page 1.

[5]Nicholas, K. Geranios, "Northwest Must Buy, Not Sell Electricity," *The Seattle Times*, 27 June 1993, pp. B1-2.

[6]Williams and Simon, "Last Chance for Salmon," page A1.

[7]Robert T. Nelson, "Can BPA Stave Off Price Jolt?" *The Seattle Times,* 17 January 1993, page B1; Anthony Netboy, *The Columbia River Salmon and Steelhead Trout: Their Fight for Survival* (Seattle: University of Washington Press, 1980), pp. 36, 72-102.



Location of salmon fisheries
(W.A. Jones, *The Salmon Fisheries of the Columbia River*, Senate Document 123, serial set No. 2510)."

I. The Early Years

The Columbia/Snake River System

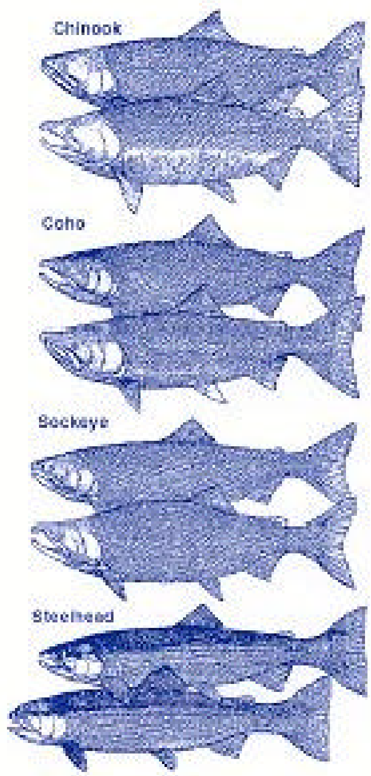
The Columbia is a river of superlatives. In terms of water volume, it is the second largest in the United States. From its source in British Columbia, this river flows 1,270 miles through four mountain ranges, draining 258,000 square miles--an area larger than France, Belgium, and the Netherlands combined.[1]

As the largest tributary of the Columbia, the Snake is itself one of the country's major rivers. From its source in Yellowstone National Park, this waterway flows through southern Idaho, irrigating 6 million acres of farmland. It then plunges into the continent's deepest gorge--Hell's Canyon. The Snake joins the Columbia near the cities of Pasco and Kennewick in Washington, where the river begins moving westward toward the Pacific Ocean.[2]

Before the construction of its major dams, the Columbia River's flow "fluctuated wildly." As the snow melted in the mountains during the late spring and early summer, the river sometimes became a maelstrom of raging water. The torrent was prominent at Celilo Falls, where the river plunged through a canyon 400 yards wide. Here the Columbia could rise as much as 50 feet between low and high water. Occasionally the river flooded hundreds of farms, mills, and homes.[3]

Owing to its vast size and dramatic force, the Columbia has been one of the nation's most romanticized rivers. From the outset of the arrival of Euroamericans in the area, descriptions of the Columbia assumed a larger-than-life quality. "It was the last great river to be discovered," historian and publisher Oral Bullard explained, "and it is shrouded in so much myth that it cannot fully escape from it."[4] During the early 19th century, Meriwether Lewis and William Clark provided the first widely read account of the area--and Americans eagerly awaited the publication of their journals. The explorers' tales of monumental landforms and fantastic wild creatures rapidly captured the imagination of readers.[5]

Few American rivers have received more attention from writers and artists than the Columbia. In 1836, readers marveled at Washington Irving's embellished descriptions of the region's "noble forests" and "silver sheet[s] of limpid water." Irving's popular account of the Astorian fur-trading enterprise at the mouth of the Columbia offered "literary charm and artistry," but was not based on first-hand experience or observation.[6]



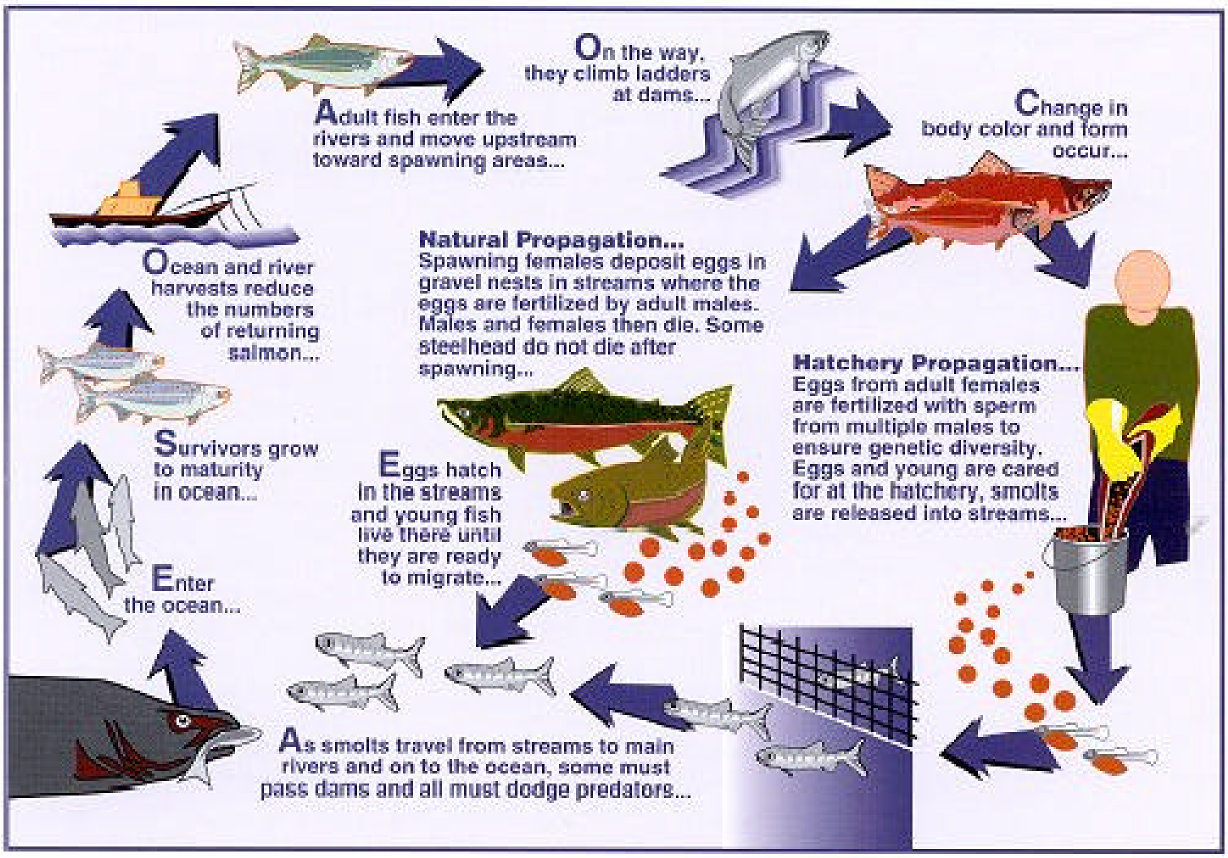
Similarly, the landscape paintings of Paul Kane and Abby Williams Hill offered idealized view of the Columbia River system. Such romantic images helped focus the nation's attention on the Columbia River, but they also fueled expectations--as well as misconceptions--that persisted into the 20th century. Historian William H. Goetzmann argues that the 19th-century Pacific Northwest was a "land of hearsay," and early Euroamerican portrayals suffered from "visual deprivation and verbal hyperbole." because the Columbia remains one of the world's foremost salmon rivers, perceptions of the river continue to affect how Americans view the decline of the fish runs.

One of the most prominent features of the Columbia River Basin is its production of salmon and steelhead. These are species that hatch in freshwater, migrate to the ocean where they mature, and then return to freshwater to spawn. The term "anadromous," Greek for "running upward," refers to this migratory behavior. Anadromous fish in this region include five species of salmon: chinook, coho, chum, sockeye, and pink. The Columbia and Snake Rivers also produce steelhead, which are large, anadromous rainbow trout, as well as smelt and lamprey. Shad are also present, but are not native to the area. Owing to their dwindling numbers and to the recent ESA listings, salmon and steelhead have become the most noteworthy of these fish.

Chinook, or king salmon, are especially remarkable. According to Francis A. Seufert, a 20th-century canner who operated on the Columbia River, this regal fish "really deserved to be called Royal Chinook. It had no peer in the canned salmon markets of the world." Chinook grew so large that Pacific Northwest residents called them "June Hogs." Exceptional individuals have grown to weigh as much as 125 pounds and to measure more than five feet in length. For short distances, these fish can accelerate faster than a car.

The anadromous habits of salmon inspired wonder in Major William A. Jones of the Corps. "There is something about these pilgrimages of theirs up the rivers," he marveled. Directed by Congress to investigate the fisheries of the Columbia River in 1887, Jones reported that anadromous fish expended "exhausting efforts without taking any food to keep up their strength."

Salmon begin their lives as pea-sized, pink eggs buried in the gravel of swiftly flowing streams. The fish hatch after approximately 50 days, and within 18 months they begin their migration to the sea. Usually during the spring runoff, the young fish undergo smoltification--a transformation that enables them to adapt to saltwater. They are then ready to begin on e of the most dramatic journeys in the animal world. As they travel downstream, smolts imprint on the sequence of odors they encounter. When the return, the fish follow the reverse sequence.[8] Some smolts travel down freshwater streams for 1,000 miles. Once they enter the ocean they can travel 4,000 miles a year. Within five years, the salmon return to the waters of their birth to spawn. Although steelhead can live to repeat this cycle, salmon generally do not eat during their upriver trek, and they die soon after spawning.[9]



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The adult runs, or migrations of fish populations, occur from April to November, Chinook migrate in spring, summer, and fall, while sockeye run from May to early September. Coho and pinks arrive in summer and fall, and chum, or dog salmon, run only in the fall. These anadromous fish return to their place of birth; they generally will not spawn in alternate locations. If the fish encounter an insurmountable obstruction along the journey to their home stream, they will die attempting to overcome it.[11] In general, juvenile fish migrate downstream during spring and early summer.

The anadromous habits of salmon inspired wonder in Major William A. Jones, the Corps' Portland Engineer Officer. Directed by Congress to investigate the fisheries of the Columbia River in 1887, he reported, "There is something about these pilgrimages of theirs up the rivers." Specifically, Jones marveled that anadromous fish expended "these exhausting efforts without taking any food to keep up their strength."[12] Scientists and sports fishers later learned that many spawning salmon do not cease feeding altogether during their upriver journeys.

Traditional Native American Use

When Euroamericans arrived in the Columbia River Basin in the late 18th and early 19th centuries, they reported that Native Americans made extensive use of the fish runs. Explorers in this area viewed the abundance of salmon and Indian fishing methods with astonishment and admiration. "I never saw so many fish collected together before," the American Charles Wilkes marveled, "and the Indians are constantly employed in taking them."[13] During the early 19th century, the American explorers Lewis and Clark observed more than one hundred Indian fishing camps along the Columbia River below the confluence of the Wenatchee River. Frequently the explorers noticed Native Americans drying salmon, which they then packed in large bundles to store or trade.[14]

By the time Euroamericans began exploring the Columbia River in the late 18th and early 19th centuries, much of the area's Indian populations had already been significantly diminished by small pox. It is therefore difficult to determine the numbers of fish that Indians harvested before Euroamerican contact. Still, the first explorers and settlers reported that the Indians were "quite numerous" in the Columbia River drainage and that their culture relied heavily on anadromous fish. In their classic study published in 1940, Joseph A. Craig and Robert L. Hacker estimated that the Columbia River Indians' annual salmon catch had been 18 million pounds per year--approximately three times the total annual catch from the river in recent years.[15]

Anadromous fish were more than a food source to the Native Americans living in the Columbia River Basin. Salmon remained the focus of some of their most important religious ceremonies. Indians believed that these fish represented supernatural beings who dwelled beneath the ocean. During the annual runs, these beings dressed in salmon flesh and prepared to sacrifice themselves. When a salmon died, its spirit returned to the sea. If the Indian harvesters were respectful and returned the salmon bones to the water, the supernatural beings could repeat the trip the next season. Most Indians in the Columbia River Basin had rituals to maintain good relations with the salmon people.[16] During the mid-1850s the importance of salmon to the economy and culture of Columbia River Indians was recognized in the treaties negotiated with the territorial governors of Washington and Oregon. These treaties guaranteed the tribes' right to continue fishing at their "usual and accustomed places."[17]

To harvest the anadromous runs, Indians employed a variety of fishing methods. Their equipment included haul seines, weirs, spears, and dip nets. This gear enabled them to catch fish in different river conditions. Haul seines consisted of large nets with sinkers on one edge and floats on the other. Seines hung vertically in the water, ensnaring the fish where the ends drew together. James Swan, a pioneer in Washington Territory, reported that "in seasons of plenty, great hauls are often made, and frequently a hundred fine fish of various sizes are taken at one cast of the seine."[18] Weirs were commonly used, especially along narrow channels. These consisted of a barrier that reached across a stream, guiding the fish into a rack. Two-pronged spears, too, proved to be successful fishing gear. Indians also fished from canoes, employing bone hooks and lines.[19]

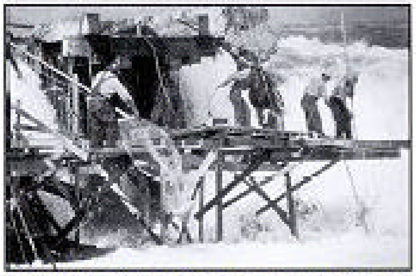
The Indians' use of dip nets particularly interested most Euroamerican observers. These mesh devices hung on a large hoop attached to a pole. To fish with a dip net, Indians constructed platforms above eddies. Although he could not see his catch, a fisherman pulled his net out of the water when he felt the weight of a trapped fish.[20] Indians generally used dip nets at cascades--narrow places where the river dropped steeply.

Celilo Falls Indian Fishery

One of the most prominent dipnetting sites on the Columbia was Celilo Falls, 200 miles east of the mouth of the river. The rapids at Celilo Falls concentrated the fish--and as many as 3,000 Indians gathered there at the height of a run.[21] Here, perched precariously on wooden platforms, fishermen trapped the leaping salmon in their nets. Sometimes they suspended each other above the roaring water in baskets, which positioned them for spearing salmon. Considerable agility was required to land a chinook--which could weigh more than 50 pounds--and fatalities did occur. When someone died in the icy water, all fishing stopped for a day. For the Indians, fishing spots were a family inheritance passed down from fathers to sons.[22] Celilo Falls continued to attract large numbers of Indians until 1956, when the construction of The Dalles Dam inundated this fishery.[23]. Today, the remnants of the platforms at Celilo Falls serve as reminders of the earliest days of fisheries along the Columbia River.

CELILO FALLS

Celilo Falls was one of the most significant American fisheries in the Columbia River Basin. The rapids at Celilo Falls concentrated the fish--and as many as 3,000 Indians gathered there during the peak of the runs. Perched precariously on wooden platforms, fisherman trapped leaping salmon in their dipnets. In 1956, the construction of The Dalles Dam flooded this fishery.



Indian dipnet fishery, Celilo Falls

Indian dipnet fishery, Celilo Falls

Salmon-dipping lodge below Fish Hook Ferry, Snake River, 1954

Indian Dipnet Fishery, Celilo Falls

Salmon drying on racks, Columbia River

Pre-Dam Mortality Rates and Causes of Fish Losses

One of the problems in understanding the decline of anadromous fish runs is the difficulty of determining the extent of the loss. There is little evidence regarding fish mortality rates in the Columbia Basin before the construction of the dams in the 1930s. To establish reasonable goals for fish enhancement programs, recent investigators have had to estimate the losses of previous eras.

Historical mortality rates have been separated into two periods: those that occurred before Euroamerican settlement (before the early 19th century) and those that occurred after settlement, but before major development (early 19th center to the 1920s). Mortality rates before the early 19th century were attributed to aboriginal fisheries and to natural phenomena, such as predation, disease, drought, floods, and landslides. Don Chapman, a wildlife biologist based in Idaho, estimated the Indian harvest rate before 1850 at 12 to 15 percent. Early losses from natural phenomena, on the other hand, have been nearly impossible to calculate, owing to the lack of records and data.[24]

Fish mortality from the early 19th century to the 1920s remained attributable to these sources. Causes of losses during this period, however, also included logging, commercial fishing, irrigation, mining, and grazing. Chapman estimated that harvest rates for the late 19th and early 20th centuries ranged from 80 to 88 percent during peak runs. Even so, harvests as high as 70 percent in a mixed-stock fishery such as the Columbia River would not necessarily prove harmful to the anadromous fish, provided that additional losses from environmental degradation did not also occur. The problem was that additional losses from sources other than commercial fishing accelerated after the 1920s, when some stocks had already become seriously depleted.[25] The result was a dramatic decline in nearly all anadromous fish runs.

The Northwest Power Planning Council (NPPC), established by Congress in 1980, estimated the extent of the decline of fish by subtracting current runs from those that occurred before development of the dams. Owing to the lack of evidence regarding the runs of previous eras, a variety of investigators have calculated the early numbers of fish based on historical catch records and analyses of available habitat and ranges of possible production.[26] These estimates of early Columbia River annual runs ranged from a high of 35 million to a low of 6.2 million. After reviewing the disparate estimates, the NPPC concluded that predevelopment run size ranged from 12.5 to 13 million fish. Because the current runs totaled approximately 2.5 million fish, the NPPC, using the subtraction method, estimated the loss to be almost 10 million fish, which falls between calculated recent loss range of 7 to 14 million.[27]

These estimates revealed the magnitude of the loss of anadromous fish. They also have helped agencies establish enhancement goals. However, their lack of precision complicated the issues involved in listing anadromous salmonids under the ESA. The question of responsibility for current losses, for instance, remained difficult to answer. Although the National Marine Fisheries Service (NMFS) and other agencies have studied the effect of the dams on fish mortality, the exact amount of loss that each dam could be assigned for mitigation was unknown.[28]

Commercial Fisheries

Early Euroamerican settlers in the Columbia Basin viewed anadromous fish as an inexhaustible resource. In the mid-19th century, even the most farsighted individuals could not have predicted that within a few decades the runs would suffer from overharvesting.[29] During the first half of the 19th century, there was more than enough salmon for Indians and Euroamerican settlers. Harvesting during this period was not intensive, and commercial ventures remained small in scale. Although Native Americans in the Columbia River Basin sold choice chinook to explorers and pioneers, the initial attempts of Euroamericans to market salted salmon to Hawaii, the Atlantic Coast, and Europe proved unsuccessful. The problem stemmed from spoilage and the poor taste.[30] These difficulties were overcome in 1866, with the arrival of Hapgood, Hume and company on the Columbia River.

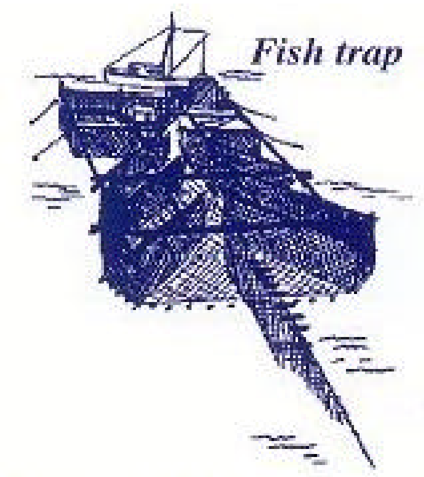
Hapgood, Hume and Company introduced the area to salmon canning. The canning process allowed the long-distance transportation of fish at inexpensive prices, which opened wide markets for salmon. Because anadromous fish store rich reserves of fat and vitamins in preparation for spawning, they have been especially attractive for eating.[31] During the late 19th century, canned salmon quickly became popular in many parts of the world, especially as cheap food for the working class.[32] Owing to its appealing color and quality, most canners preferred chinook.[33] Early cannery operators made rapid fortunes on their ventures.

Spectacular profits in the Columbia River drew others to the industry. By 1883, more than 50 canneries had operated in the area (see Table 1). Astoria, near the mouth of the Columbia River, became the center of canning operations. The burgeoning industry employed hundreds of laborers, mostly Chinese, who chopped the fish into chunks, soaked them in brine, and sealed them in tin cans. The work was fast-paced: some cannery workers could clean a 40-pound salmon in 45 seconds. It was also arduous labor, requiring 11-hour days.[34] In 1903, A.E. Smith revolutionized the industry by inventing a salmon-processing machine that became known as the "Iron Chink."[35] While many cannery workers were Asian, the fishermen who supplied the canneries tended to be European immigrants. During the early years of cannery operation, these laborers provided an inexpensive work force. In the late 19th and early 20th centuries, however, exclusionary laws restricted commercial fishing licenses in Washington and Oregon to U.S. citizens.[36]

CANNERIES

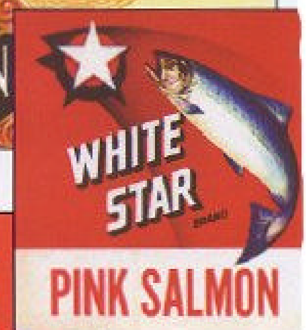
"Within the last two or three years, establishments for putting up fresh salmon in cans have been erected, and the business is already assuming considerable proportions. Three or four of these establishments are already in operation on the Columbia River, two of which (those of Messrs. Hume & Hapgood, and Mr. Hume), I visited during the canvass of the present year. At one of these establishments, while I was waiting for the steamer, between eight o'clock a.m. and four p.m., they caught, cut, canned, and sealed seven thousand two hundred and ninety-six cans of salmon."

SOURCE: "The Northwest Coast," by Hon. Selucius Garfield, Washington Territory, 1869, in Elwood Evans, Washington Territory: Her Past, Her Present and Elements of Wealth Which Insure Her Future (Olympia, 1877).

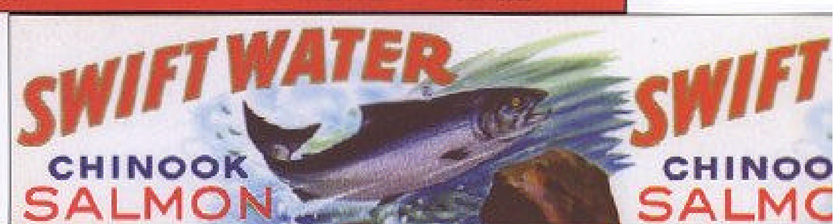


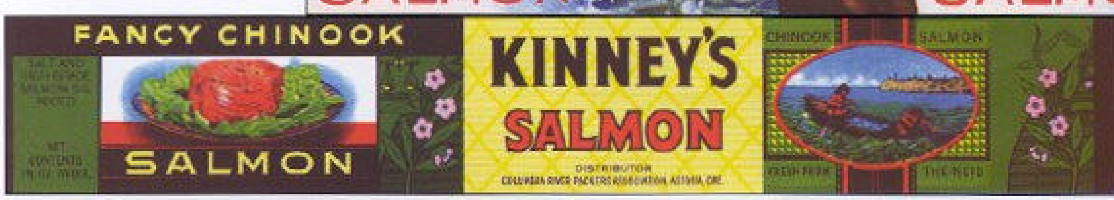
Fish Trap

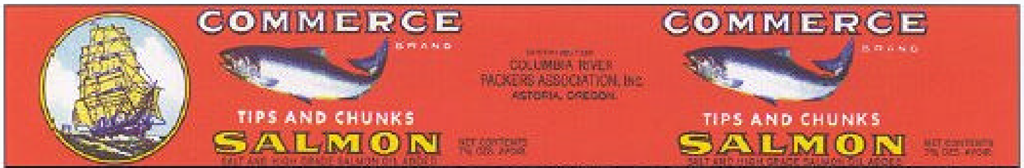
Fishermen competed for their share of the catch with a variety of equipment. These included gillnets, traps, seines, and fishwheels. Gillnets were the most numerous, in part because they were the most versatile. Constructed of linen, and later, nylon webbing, gillnets could be employed in fluctuating water levels and in muddy conditions. These devices ensnared moving fish by entangling them in the web by their gills.[37] Most gillnetters fished from the mouth of the Columbia River to Celilo Falls, 20 miles upstream. Fish traps, or pound nets, also were widely employed along the river. These were stationary devices consisting of a mesh webbing strung between posts driven into the river bottom. Fish traps exploited the salmon's tendency to swim upstream, guiding the fish through leads. Placed at the mouth of a river, these devices required little effort, and could capture a considerable number of fish. By the late 1920s, fishers had placed more than 400 traps in the Columbia river region.[38]



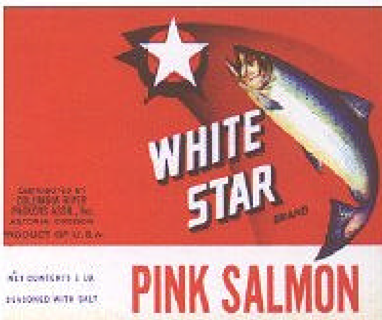
Various Canning Labels from the turn of the century.



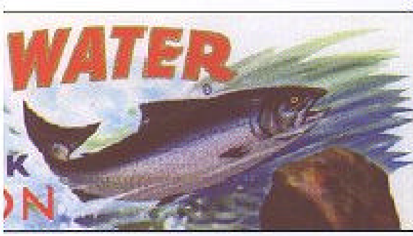




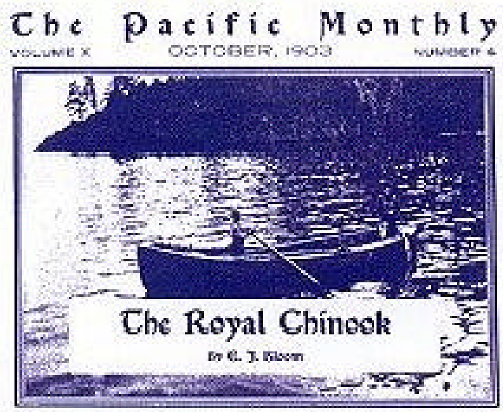
Cannery workers pack salmon for shipping.



Canning, Astoria, Oregon.



THE ROYAL CHINOOK



"During the busy season, the appearance of the river is one of the greatest animation. The water is dotted thickly with boats, and stretching away from each is the line of buoys supporting the net. At night, particularly, the scene is most picturesque. Most of the boats carry lanterns and many are supplied with charcoal stoves which are used to boil coffee, and also for the purpose of warmth, as the nights on the river are always chill. As the boats rock on the waves and the lights flicker and dance like fire-flies, the silence of the brooding night is broken only by the soft dip of an oar, the creak of an oarlock or the occasional hail of a boatman, until the east is suffused with a grayish light and the fishermen rouse themselves to garner their finny harvest."

Excerpt from article by E.J. Bloom, "The Royal Chinook," The Pacific Monthly, vol. 10 (Oct. 1903), p. 193.

Bountiful commercial catch

Commercial fishermen on the Columbia River

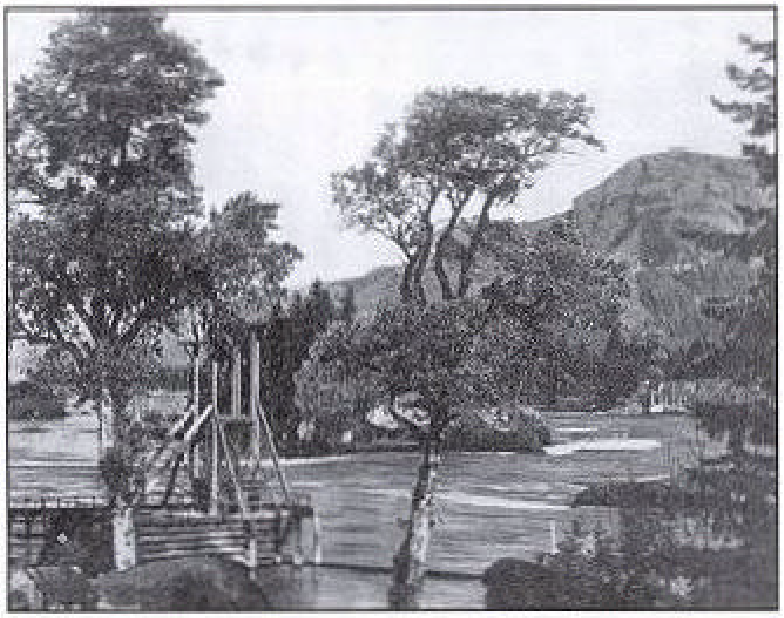
Seining for salmon

Although individuals could fish with gillnets and traps, seines usually were operated by crews of 20 to 40 men driving five to seven teams of horses. These large nets were most effective at low tide. One seine, operated by the Seufert Brothers Company near Celilo Falls, harvested 70,000 pounds of fish on a single day in 1947--two years before Oregon outlawed these devices.[39]

Seining for salmon
On the Columbia River

The most picturesque equipment used on the Columbia River was the fishwheel. These were large, visible contraptions that epitomize the early era of fisheries on the Columbia River. There were two types: stationary wheels and wheels mounted to scows. Both were constructed of large dipnets, kept in constant motion by the river's currents, that scooped the fish into a storage bin. From their introduction in 1879 to 1935, there were at least 79 stationary fishwheels along the Columbia River. Many of these were operated by canneries located in The Dalles area. The Seufert Brothers Company's fishwheel no. 5, the most famous of the devices, yielded a record catch of approximately 70,000 pounds of fish on a single spring day in 1913. This fishwheel average 146,000 pounds per season.[40] Such exorbitant harvests fueled the perception, particularly among the Astoria fishermen downriver, that fishwheels were wasteful contraptions with "very destructive powers."[41] After an acrimonious battle between fishermen and operators of these devices, fishwheels were outlawed in Oregon in 1926, and in Washington in 1934, thus signaling the end of an era on the Columbia River.[42]

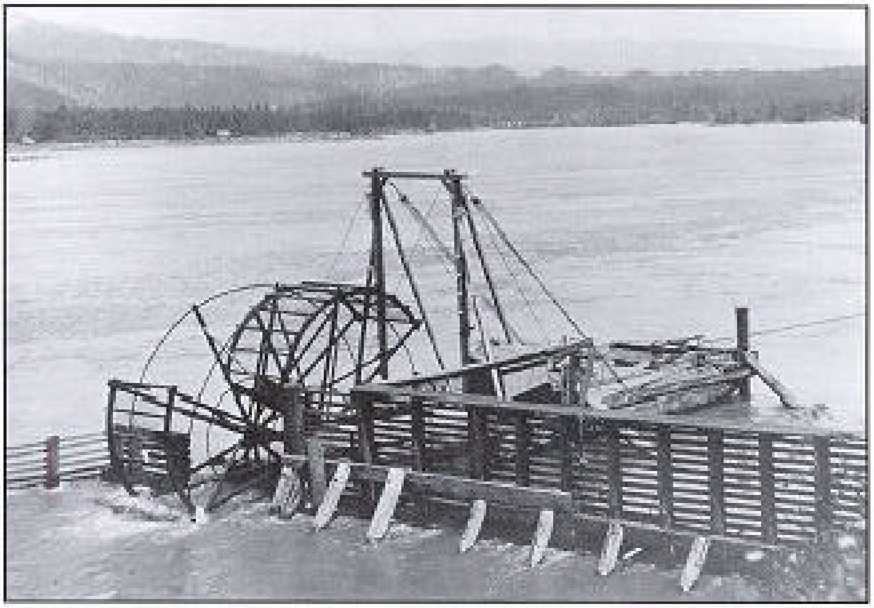
The Fishwheel



A scene on the upper Columbia showing the fishwheel in the foreground. The wheel is operated by the current, and the unwary fish is caught in one of the cups and dropped into a receptacle. The Pacific Monthly, 1903.

Together, these fishing methods resulted in phenomenal harvests. "The immense supply of the chinook salmon that forms the staple of this great commerce," wrote an observer in the 1870s, "is to be had for the taking."[43]

Scow Wheel on the Columbia River



Fishwheel on the Columbia River.
These picturesque devices were constructed of large dipnets, driven by the river's currents.

Captain Charles F. Powell of the Corps reported in 1882 that the "fishermen are irresponsible as a body and independent of each other."[44] The next year, nearly 43 million pounds of chinook were canned. By this time, the market for this fish was becoming saturated. Yet the fishing continued. In 1917, the Bureau of Fisheries concluded that "when the enormous number of fishermen engaged and the immense quantity of gear employed are considered, one sometimes wonders how any of the fish...escap."[45] The harvesting of fish in the Pacific Northwest during the late 19th and early 20th centuries is reminiscent of the rapid logging that occurred at the same time. Owing to the exploitation, historians have dubbed this period "The Great Barbecue."

Many of the fish were wasted. During the late 19th century, the catches arrived at canneries so quickly that excess fish lay rotting on the floors. These were simply swept into the river. In 1895, the U.S. Commission of Fish and Fisheries reported that the refuse from the canneries on the Columbia River amounted to 7 million pounds every year.[47] In 1884, a banner year for the canning industry, "tons and tons of salmon were thrown overboard by the fishermen because the canneries were unable to handle them."[48] As late as 1905, canneries remained "unable to dispose of all the fish that were being caught."[49] Such waste reveals the early fishing industry's shortsightedness and lack of concern for salmon runs. Nor was there much of a public outcry regarding the exploitation. According to a former worker in the fish canneries, the protesters who did emerge expressed more concern about the small than about the waste of salmon.[50]

Salmon on the floor of cannery, Astoria, Oregon

By the 1890s, harvests began to decline. During this period, biologists observed "a very great reduction in the number of salmon frequenting the headwaters of the Columbia River and its tributaries."[51] In 1894, the Oregon Fish and Game Protector warned that chinook populations were "threatened with annihilation."[52] After peaking in the mid-1880s, the total catch of these fish dropped sharply. Although a brief period of stability followed, this decline of chinook continued through the 1930s. The catches of sockeye and coho, too, were marked by a "pronounced fall" by the early 1920s.[53]

Concern for the fishing industry prompted sporadic and ineffectual conservation measures. As early as 1877, the legislature of Washington Territory declared a closed season--and the next year Oregon responded with similar measures. State governments also curtailed the use of certain types of fishing gear on the Columbia River. During the late 19th century Washington and Oregon prohibited fish traps, weirs, seines, and nets placed two-thirds of the way across fresh water streams, creeks, or lakes, if they prevented the passage of fish. Purse seines, which consisted of a long curtain of webbing drawn by a boat, were prohibited on the Columbia River in 1917 and in the coastal waters of both Washington and Oregon in 1922. Fishwheels, as noted, were banned in 1926 and 1934. However, many of these restraints were rarely enforced. Although Oregon created a Board of Fish Commissioners in 1887 and Washington established a Fish Commission in 1890, neither organization possessed sufficient funds to police the river and catch offenders. Hence, early restrictions on fishing did little to stop the decline of the salmon runs.[54]

During the late 19th and early 20th centuries, economic concerns prompted fisheries conservation.[55] "Everyone aimed to make all he could," explained one former cannery worker.[56] Measures were intermittent and short-sighted, hampered by a lack of comprehensive planning. Part of the problem was that there was little understanding, even among scientists, of the river conditions and habitat required to maintain anadromous fish populations. Nor was there much knowledge about their migrations. The Corps' report on the salmon fisheries of the Columbia River, printed in 1888, noted that "almost nothing" is known about where the salmon travel "how they fare, or what motives guide their course in their mysterious ocean sojourns."[57] Throughout the early 20th century, planners complained about the "meager and fragmentary data" available on the habits of fish.[58] As late as 1909, the Bureau of Fisheries reported that this topic was "shrouded in obscurity."[59]

Sports Fisheries

Harvest of Columbia River salmon was not limited to commercial fishers. During the late 19th century, the Columbia River became world-renowned for recreational fishing. One of the most famous anglers to visit this region was Rudyard Kipling, who pursued steelhead and salmon. Kipling's experience in Oregon so impressed him that he was moved to write, "I have lived! The American Continent may now sink under the sea, for I have taken the best that it yields, and the best was neither dollars, love, nor real estate."[60] In 1904, the Washington State Game and Fish Protection Association reported that there were "plenty of men" on the West Coast with "the time, money and inclination to get all the sport out of salmon fishing that there is in it."[61]

Sport fishers were especially interested in chinook, or "royal salmon," as Kipling called the fish.[62] Although some anglers noted that the chinook "affords the best sport," fishing for steelhead and sockeye was a popular activity as well.[63] Early anglers employed a variety of baits. Visiting sportsmen, who preferred to use flies to catch the prized chinook, dismissed the local anglers who fished with "half-fried, gelatinous roe of the salmon," and "murderous" spoons, or fishing lures.[64] These were spoon-shaped devices with a treble barbed hook. Some fishers objected to these lures because it was difficult to remove them from a fish without causing serious injury. In general, fishers using roe and spoons were more successful. However, anglers from the East, accustomed to fly-fishing for Atlantic salmon, persisted in this technique on the Pacific salmon.[65]


FLY FISHING

The First Columbia River Salmon Ever Caught with a Fly

By Captain Cleveland Rockwell

"The genial and enthusiastic lighthouse keeper at [Cape Disappointment] became much excited and expressed the profoundest regret that he had lived there ten years and never knew that salmon could be caught with a fly. He came on board to examine my tackle, and I supplied him with a few flies.

What was my astonishment to see him on the bay the very next day, and with the most extraordinary tackle which was ever presented to a salmon! He had sawed a strip from a redwood board and dressed it down to the thickness of an inch, and with a very respectable taper. Pieces of wire driven into the wood at suitable intervals served as guides, or rings, and for a reel, the iron wheels of a child's toy cart were rigged with a crank and securely lashed to the pole. Truly, in his case, necessity was the mother of invention, and with this remarkable outfit he succeeded in catching many a lusty salmon. Not being able to cast with this apparatus, he caught all his salmon by trolling.

In a week every rooster on the military post presented a most forlorn appearance; necks and tails had both been plucked to make salmon flies!

Many a salmon have I taken from the sparkling bay under Cape Disappointment since that day, but the lively adventure with a salmon remains an episode of supreme pleasure."

Excerpt from article by Captain Cleveland Rockwell, "The First Columbia River Salmon Ever Caught With a Fly," The Pacific Monthly, vol. 10 (October 1903), pp. 202 and 203.

The debate concerning spoons vs. flies became significant to anglers in the Pacific Northwest. Such well-known fishermen as Captain Cleveland Rockwell and Rudyard Kipling reported catching salmon with flies in the Columbia in 1876 and 1889. "What a thrill of excitement accompanied striking the hook into the solid tongue of that first salmon," Rockwell informed readers of *The Pacific Monthly,* "and how my heart rushed up into my throat as the alarmed fish made his first frantic rush for liberty!"[66] Many contributors to *Forest and Stream*, a national hunting and fishing journal, however, claimed that the Pacific salmon would not take a fly for various reasons. Some argued that the water of the Columbia was too muddy from spring runoffs during the fishing season; others claimed that the Pacific salmon had a different nature than that of its Atlantic counterpart. As one observer pointed out, many tourist anglers failed to catch salmon with flies because they did not know the best fishing spots or the best times to fish on the river.[67]

Many early sports anglers released the fish they hooked. Rudyard Kipling and his companions, for example, caught 16 fish weighing 140 pounds in one day; they released all but 3 of the fish.[68] Similarly, a writer for *Forest and Stream* reported catching 10 steelhead one day in 1899 and releasing all but 2.[69] Anglers such as Kipling apparently cared more about the sport than the product of the catch. Not all fishermen, however, were cautious about releasing the fish they hooked. One writer's description of the "murderous" spoon used by local anglers near the mouth of the river indicated that such fishing methods did not permit the live release of caught fish.[70] Early limits on the catching of salmon for personal use were liberal. In 1922, an attempt in Washington to restrict the catch to 3 salmon, 18 inches or greater in length, was so unpopular that within the year the limit was increased to 25 salmon, 10 inches or more in length.[71]

Early sports fishing organizations in Washington and Oregon attempted to implement measures for protection. In Washington, one of the oldest and most continually active of these was the Steelhead Trout Club of Washington. Sportsmen near Green River formed this organization in 1928, to monitor catches of net-scarred fish. Set nets were unlawful in Washington at the time, and the early members of the club sought stricter enforcement of what they felt were inadequate laws to protect the steelhead.[72]

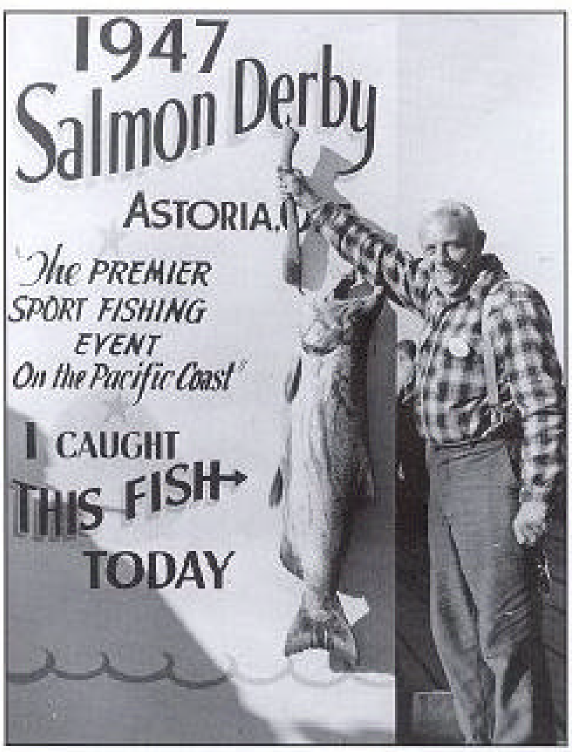
Another important early organization was the Washington State Game and Fish Protective Association. This group advocated the implementation of uniform game laws in the United States, including bag limits. The association began publishing *Pacific Sportsman*, a magazine for hunters and fishers, in 1904. The members of this group argued that the development of fly fishing on the West Coast could mean thousands of dollars in revenue for the state from fishers who would travel to Washington for the sport.[73]

The Washington State Sportsmen's Association (WSAA), which had attracted more than 6,000 members by 1920, served as an umbrella organization for various local sports organizations in the state. These included the Pierce County Sportsmen's Association and the Hoquiam Rod and Gun Club.[74] One of their objectives was to influence legislation that was advantageous to sportsmen.[75] In 1920, for example, the WSSA drafted a bill to separate commercial fish concerns from the state Game Department.[76] The Association began to publish *Western Sportsman,* an outdoor recreation magazine, in the late 1910s.

Organizations in Oregon included the Sportsman's League, established in 1913 to serve as a clearinghouse organization for state sport groups. Although many of the League's affiliates disbanded during the tumultuous years of World War I, later the group actively lobbied for legislation beneficial to sports hunters and fishers.[77] In 1919, the League submitted two initiative measures to the public, one that would create a Game Commission separate from the commercial interests, and another that would establish local control over fish propagation and the taking of fish from streams.[78] The League was also concerned with the location of fish hatcheries--members wanted more facilities on the smaller streams, more expert supervision, and the release of fish at a later age.[79]

SALMON DERBY

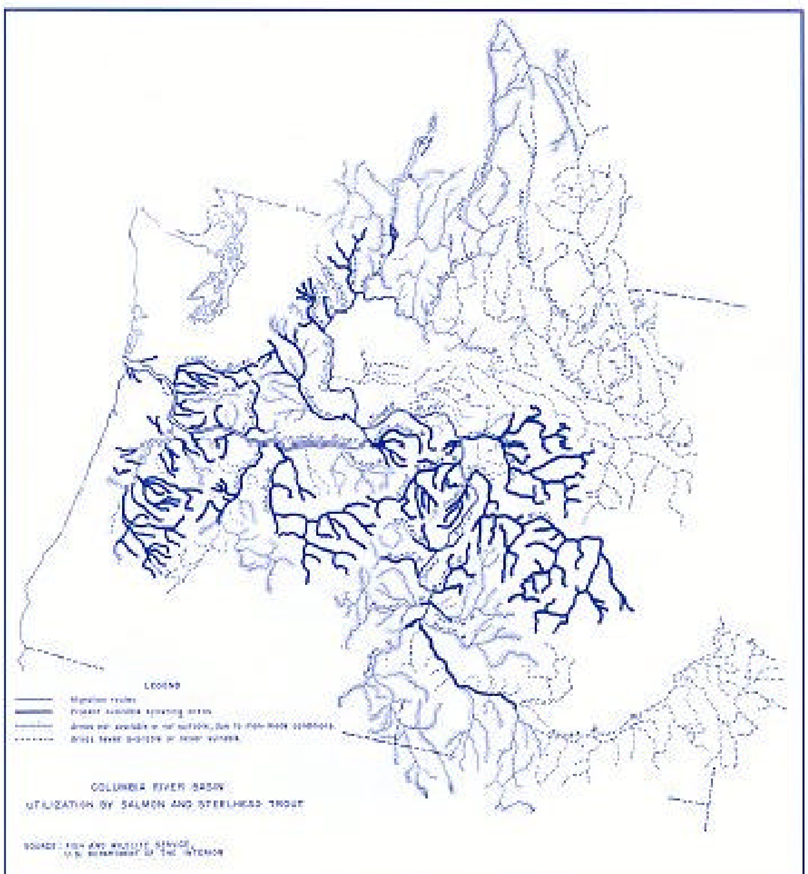
Astoria, located at the mouth of the Columbia River, had long been known for its canneries and commercial fishing. By the early 20th century, the town also had a established a reputation for sports fishing. Astoria's first annual salmon derby took place in 1936. That year, the lucky fisherman who caught the largest chinook received "some merchandise and the envy of a few fellow anglers." By 1939, the annual 7-day derby had attracted thousands of fishers, and winners received cash prizes. This event included a women's division, and the Evening Astorian Budget reported that sports fishers often landed salmon weighing 35 to 50 pounds. Here hopeful entrants weigh in their catches. Source: Astorian Budget, 22 Aug. 1941, p. 1.



Degradation of Habitat

Overharvesting of anadromous fish populations in the late 19th and early 20th centuries was an immediate, highly visible reason for the decline in the resource. A less obvious cause involved the destruction of habitat in the Columbia River Basin. As early as 1894, the U.S. Fish Commission reported that placer mining near Caldwell, Idaho, had significantly reduced salmon runs on the Upper Boise River.[80] In 1933, the Oregon State Game Commission claimed that "there is no question but that the pollution of the tributaries of the Columbia is a menace to the salmon industry." For decades, farming, grazing, mining, and lumbering operations had contaminated the Columbia and Snake Rivers.[81] These activities sometimes resulted in the construction of barriers that blocked spawning grounds. They also eroded the soil, which settled on the gravel of streambeds, hindering the reproduction of anadromous fish.[82]

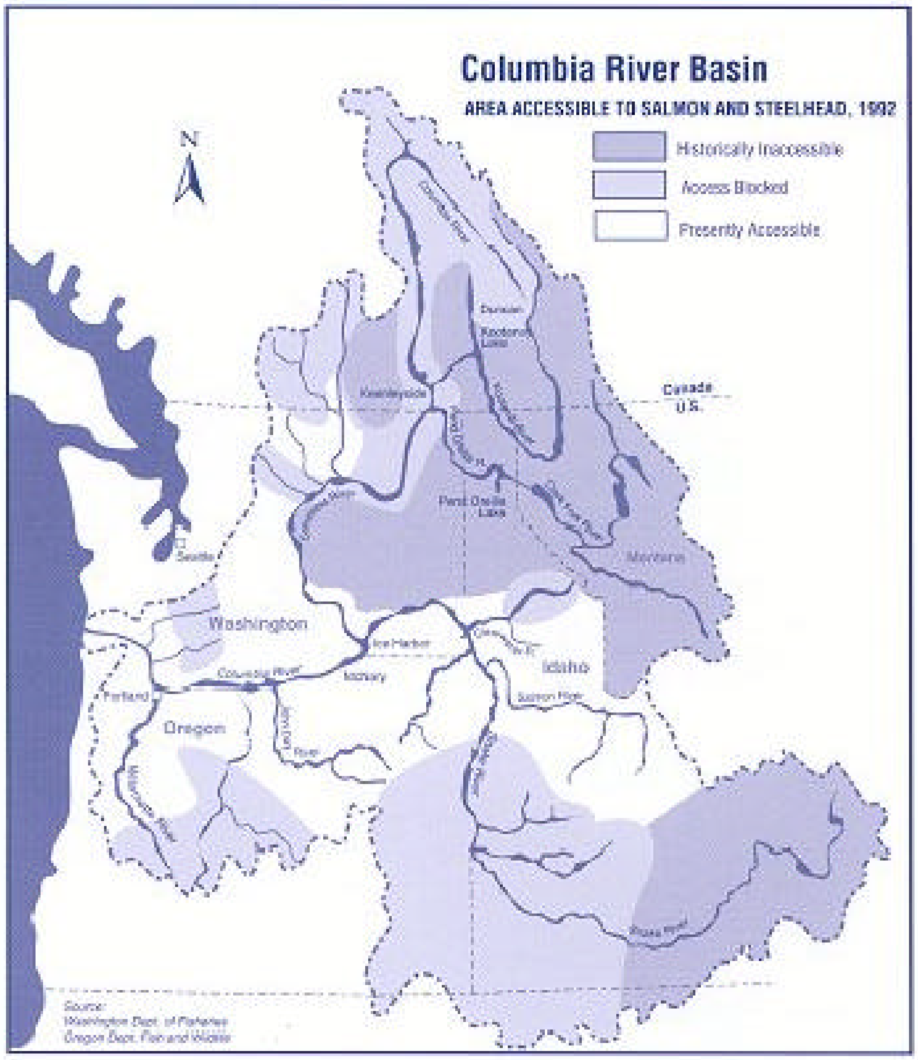
Irrigation also contributed to the loss of habitat in the Columbia Basin. Owing to the diversion of the rivers, many tributary streams dried up during low-water periods.[83] The building of unscreened diversion canals and small dams for agricultural production further hindered the migration of anadromous fish.[84] Canals drew fish onto fields, where they lay stranded.[85]



Map 1. Columbia River Basin Utilization by Salmon and Steelhead Trout, 1947

Small dams also proved to be destructive to fish populations, and early Euroamerican settlers in Oregon were aware of the potential damage. In 1848, the constitution for Oregon Territory directed that rivers and streams important for anadromous fish "shall not be obstructed by dams or otherwise, unless such dams or obstructions are so constructed as to allow salmon to pass freely up and down such rivers and streams." Yet many dams constructed during the late 19th and early 20th centuries did not comply with this provision.[86] In 1894, Hugh M. Smith of the U.S. Fish Commission argued that one dam on the Clackamas River in Oregon "is generally recognized as one of the greatest evils now affecting the fisheries of the Columbia basin."[87]

That same year, however, Marshall McDonald, the U.S. Commissioner of Fish and Fisheries, claimed that although "certain streams" had been "obstructed" by irrigation dams, the "vast extent of waters still available to salmon affording suitable breeding and feeding grounds, indicates that we must look to other causes to explain any ascertained deterioration in the salmon fisheries of the Columbia."[88] A decade earlier, an expedition to determine suitable locations for a salmon-breeding station revealed that small dams were useful for holding salmon for development of hatcheries.[89] The damage to Columbia River fish populations resulting from small dams was incremental and was not always immediately apparent. By the early 1930s, however, the Fish Commission of Oregon reported that dams on the Columbia River and its tributaries had taken "approximately 50 percent of the most important salmon producing area within the basin" (see Maps 1 and 2).[90] The Rivers and Harbors acts, passed between 1890 and 1899, authorized the Corps to prevent obstructions to navigation. However, many small dams in the Pacific Northwest were located on small tributaries that were not navigable.



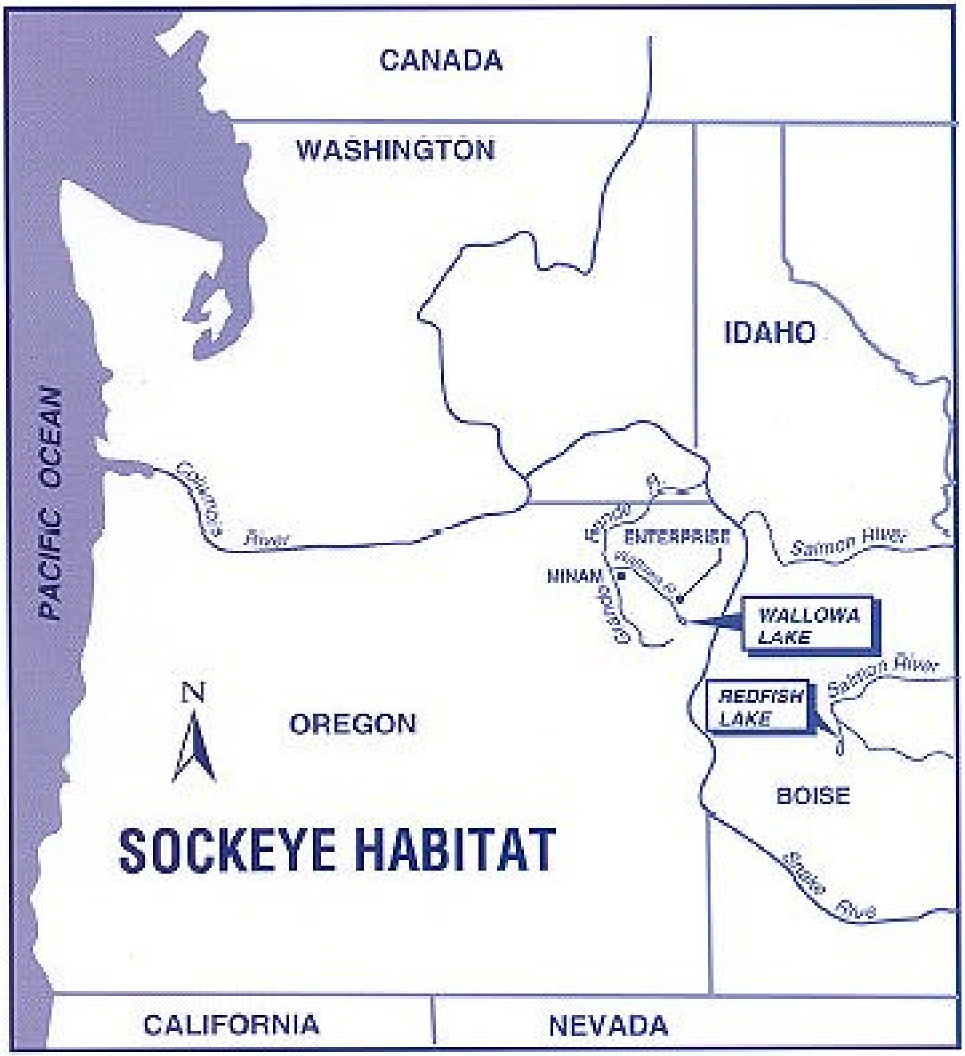
Map 2. Columbia River Basin area accessible to salmon and steelhead, 1992

Sockeye salmon were particularly vulnerable to small dams because the structures usually blocked small tributaries near their spawning grounds. During late summer and early fall when these fish migrated, tailwater depths of the dams remained too shallow to allow the fish to negotiate the barriers. Sockeye salmon spawned in lake tributary inlet or outlet streams and over wave-swept shoals within the confines of the lakes. Fry emerged in the spring and lived in lake environments for up to three years before migrating to the sea. In contrast, other species of Pacific salmon inhabited river environments during the early stages of development. Non-migratory sockeye salmon are commonly called "kokanee," "bluebacks," or landlocked salmon. Before the turn of the century, sockeye production lakes in the Snake River Basin supported both the anadromous and kokanee populations.

Non-migratory sockeye salmon called "Kokanee," "bluebacks," or landlocked salmon

One of the most dramatic examples of the effect of small dams on sockeye populations occurred at Wallowa Lake in the early 20th century. Here the Oregon State Fish Commission launched its first salmon factor operation on the Salmon and Grande Ronde Rivers. By placing wooden collection dams at the confluence of these rivers, state fish wardens were able to trap "virtually all" the salmon that migrated into the Wallowa River system (see Map 3). Eggs taken from these fish were used to produce young salmon which were released at Bonneville, east of Portland, on the Columbia River. This enterprise, reported local fish warden W.S. Burleigh in 1902, "eclipsed any other hatchery in the state for having turned out the greatest number of young fish." So successful was the operation that the Oregon State Commission decided "to stop the July run of Chinook and Blueback salmon."[91] During the early 20th century, the Fish Commission also introduced mysid shrimp into the Wallowa Lake, which resulted in reductions in the kokanee population. Meanwhile, lake trout populations expanded.

This activity destroyed the Wallowa River system's "red fish," named for the vivid color of the salmon when they were ready to spawn. The area's last reported sighing of the red fish occurred in 1902. Although the region had been known as a "piscatory paradise," some Wallowa County residents feared that anglers would no longer be attracted to their rivers and lakes. "Nearly everybody in Wallowa County goes fishing at one time or another," lamented an article in the *Enterprise Record Chieftain* in 1914. "Before the dam was put in...the creeks and rivers and lakes were alive with these migratory fish in season. All this came to an abrupt stop, of course, when the dam was placed across the river."[92]



Map 3. Sockeye habitat, Wallowa River system.

By 1914, residents in the Wallowa River area had become ready to take action. Encouraged by the Joseph Rod and Gun Club, residents decided to blow up the dam at the hatchery in the Wallowa River. They hoped that this drastic measure would restore the salmon runs to the area. The *Enterprise Record Chieftain* explained that the "ladder now at the dam is admitted to be a joke." J.H. Jackson, a county game warden, oversaw the explosion that removed the dam in the midst of a snowstorm on 4 June 1914. Photographer F.I. Vergere recorded the event, which was displayed with pride in local newspapers. Three years later a state game warden removed a screen from the outlet of Wallowa Lake to enable five million bluebacks to migrate to the ocean. Fisheries biologists at the time did not know that these fish lacked the migratory instinct of their genetic ancestors. Many of them became trapped in local irrigation ditches "where they were picked out of the water by the bucketful." The hope of restoring the sockeye to Wallowa Lake was never realized.[93]

Another area historically important for the production of sockeye is the Stanley Basin lake area in Idaho. This region contains six lakes: Alturas, Hell Roaring, Pettit, Stanley, Redfish, and Yellow Belly. Redfish, the largest of this complex, contained the last known stock of anadromous sockeye in the Snake River Basin. The NMFS designated this stock endangered in 1991 when only four fish returned to Redfish Lake.

Some Americans believe the main cause of the decline of this population of sockeye is the mainstem dams on the Snake and Columbia Rivers. Although biologists recognize that these dams and their associated reservoirs no doubt affected the decline, considerable evidence indicated that other factors contributed significantly to the decrease in numbers of Redfish Lake sockeye. A major factor was the construction of Sunbeam Dam downstream from Stanley Basin around 113, to provide electric power for gold dredges in Yankee Fork.[94] The dam included a fish ladder, but reports from early settlers and investigators in the area indicated that fish passage was blocked during most years, owing to improperly constructed pools and overflow weirs in the ladder. Idaho Fish and Game officials described the ladder as "useless."[95] After 20 years in operation, this dam was removed in 1934 to improve fish passage. Biologists believe that Sunbeam Dam was responsible for the complete loss of the early running stock of sockeye in Redfish Lake and no doubt was very detrimental to the late running stock that still exists.[96]

Sockeye populations fluctuated widely from year to year, particularly when they appeared at the edge of their geographic range, which included the Redfish Lake sockeye.[97] Barton Warren Evermann, in his report on the U.S. Fish Commission's investigations of salmon in the headwaters of Idaho, noted only 14 adult salmon in 1895. In earlier years, however, Evermann had documented thousands in the Stanley Basin. From 1954 to 1964 a trap operated at the Redfish Lake weir, and catches varied from 4,361 captured in 1955 to 11 captured in 1961.[98]

These observations attest to wide fluctuations in population size of this stock of sockeye. These wide variations occurred long before mainstem dams on the Snake River were constructed. In addition, the Stanley Basin Lakes have been managed primarily as a resident sport fishery for kokanee and trout from the early 1950s to the present. The management activities of the Idaho Department of Fish and Game included plantings of rainbow trout, construction of a migration barrier at Pettit Lake and introduction of opossum shrimp in several of the lakes.

This agency also poisoned Hell Roaring and Pettit Lakes to improve conditions for trout. Idaho Fish and Game biologists argued that by the time the state poisoned the lakes, the sockeye runs "had virtually disappeared" anyway.[99] Poisoning remained a standard practice to remove undesirable fish. These include squawfish, suckers, and carp--fish that compete with the desirable catches, such as trout. Idaho Fish and Game constructed the migration barrier at Pettit Lake in 1961 to prevent undesirable fish from entering the lakes. Similarly, this agency introduced opossum shrimp to provide an additional food source for trout. Biologists now know that opossum shrimp compete with kokanee and sockeye fry for zooplankton and are considered detrimental to sockeye and kokanee production.[100] These management activities, carried out from the 1950s to the present, proved detrimental to the maintenance of sockeye in the Stanley Basin.

From the early 1930s to 1982, the Idaho Department of Fish and Game planted various stocks of kokanee and sockeye from many locations to increase kokanee populations, and to attempt to restore sockeye populations in Redfish Lake. Scientists have yet to determine whether the sockeye and the kokanee are the same fish. According to one recent observer, it is "the sockeye's ambitious, restless nature that may be worth saving." Kokanee, in contrast, are "stay-at-home fish."[101] In evaluating the difference, another commentator offered, "Maybe the sockeye are really kokanee with an attitude."[102] Biologists questioned the success of the introduction of sockeye from Babine Lake, British Columbia in the 1980s. Although Tom Rogers of Idaho Fish and Game reported no adult returns, scientists did not operate the weir at Redfish Lake from 1981 through 1984, and some of the fish trapped from 1985 through 1990 could have come from the Babine Lake introductions. In any case, biologists wonder whether the genetic makeup of the existing few sockeye that remain is similar to the original stock.[103]

When construction began on large-scale multipurpose dams in the 1930s, salmon populations had already diminished. Decades of intensive harvesting and destruction of habitat had taken their toll. Many Americans of the early 20th century had inherited a perception that natural resources in the Pacific Northwest remained unlimited--and even scientists had little understanding of the consequences of intensive use of the Columbia River and its fish.[104]

Conservation Agencies

Fish Commission and Department of Fish and Wildlife, Oregon

In 1878, Oregon appointed its first "game protector," Hollis McGuire, to enforce the state's game laws. McGuire, who was the first to use the practice of clipping salmon to trace their migrations, drowned in 1898 while searching for a hatchery site on the Umpqua River. In that same year, the State created a Board of Fish Commissioners and included as its members the governor, secretary of state, and game protector. The State Board of Fish and Game Commissioners replaced the Board of Fish Commissioners in 1911, and then, in 1915, became the new Fish and Game Commission. Five years later, the state re-established the Board of Fish and Game Commissioners with separate fish and game commissioners. In 1921, Oregon separated commercial and sport fishing more completely by creating the Oregon State Game Commission to manage sport fish and game, and the Fish Commission of Oregon to manage commercial fishing and foodfish.[105] Ten years later the Oregon State Department of Police was assigned to enforce fish and wildlife laws. In 1975, the legislature again consolidated the two agencies, creating the Oregon Department of Fish and Wildlife.[106]

Washington State Department of Game

The Washington state Department of Game (renamed the Department of Wildlife in 1987) and the State Department of Fisheries share the duties of supervising fish populations in Washington's lakes, rivers, and streams. The Department of Fisheries, which existed as early as 1902, manages salmon and other food fish, while the Department of Game, created by initiative as an autonomous agency in 1934, manages other species, including steelhead trout.[107]

The Department of Fisheries' duties have included biological research, construction and maintenance of hatcheries, and patrolling for illegal fishing.[108] By 1947, the department had developed 13 salmon hatcheries and maintained one of the world's largest rearing-pond systems.[109] The Department of Fisheries began building fish ladders over falls in Washington streams and rivers in the 1950s, and in the 1960s constructed fish farms to supplement natural runs.[110] The department also remained responsible for enforcing an 1890 state law requiring dam builders to include effective fish ladders in their dams "or fully compensate for any result loss of salmon."[111] A later law, passed in 1943, required that both the Department of Fisheries and the Department of Game approved the construction of any hydraulic project in the state.[112]

Idaho Fish and Game Department

Idaho enacted its first comprehensive game laws in 1893 and six years later the state legislature established the Office of the State Fish and Game Warden.[113] One of the primary objectives of this agency was to propagate fish in the state. In 1907, Idaho funded state-run fish hatcheries to promote the distribution of food and commercial fishes. By 1932, the office had operated 11 hatcheries and 167 rearing ponds that produced nearly 30 million fish in two years.[114]

In Idaho, the rapid proliferation of hatcheries occurred with considerable support from federal agencies and the general population. In 1908, Congress authorized the Secretary of the Interior to sell Idaho 1,280 acres of land to establish a fish hatchery and game preserve. [115] That year, citizens of Sandpoint, Idaho, were so enthusiastic about the possibility of a state hatchery in their area that they voluntarily contributed $900 toward the purchase of land for the project.[116] By 1932, Idaho had worked closely with the Federal Bureau of Fisheries to build one of the largest hatcheries in the United States.

The Office of the Fish and Game Warden became the Idaho Fish and Game Department in 1939. In the late 1940s, the agency undertook a comprehensive fish and game study funded by the federal government.[117] As a part of this study, the Fish and Game Department completed the first fish census in Idaho. The two objectives of the study were to determine whether the fish population had outgrown the food supply and to identify problem areas for "trash fish." In their research, Fish and Game Department employees stunned fish with portable electricity generators and counted them as they floated to the surface. Although electro shocking became acceptable as a routine procedure, in the 1940s it utilized new techniques, and agency officials had to assure local reporters that it did not harm the fish. "It may possibly develop," one reporter quipped, "that they are actually benefited by the electricity coursing through them, as some humans are under such treatment."[118]

In 1961, Governor Mark Hatfield of Oregon proposed to the governors of Washington and Idaho that the three states form a tri-state commission to manage better all phases of the anadromous salmon and steelhead runs in the Columbia River system. Idaho officials, however, feared that the interests of the commercial fishing industry would overshadow the sports fishing that was predominant in their state. Although debate on the issue continued until the mid-1960s, Idaho Fish and Game Department officials did not support the plan.[119]

U.S. Bureau of Fisheries and U.S. Fish and Wildlife Service

In 1871, Congress, concerned with the role of fisheries research in the United States, created the position of Commissioner of Fish and Fisheries within the U.S. Treasury Department. The commissioner's original duties involved reporting to Congress on the diminution of food fishes in U.S. waters and recommending measures to prevent or remedy the loss of fish. The underfunded commissioners often depended on the fishing industry for transportation to study fish populations and facilities. Congress recognized the connection between commercial fishing and the agency in 1903, when it assimilated the U.S. Fish Commission into a newly created Bureau of Fisheries within the Department of Commerce and Labor. The Bureau had two, often-conflicting mandates: promoting and protecting the fishing industry while also conserving and protecting fish resources.[120]

President Franklin D. Roosevelt transferred the Bureau of Fisheries to the Department of the Interior in 1939. The following year, he combined it with the Department of Agriculture's Bureau of Biological Survey. This move created the Fish and Wildlife Service within the Department of the Interior. The Bureau of Biological Survey brought a tradition of concern for conservation and protection of wildlife into the merger, but the Fish and Wildlife Service continued to respond to opposing pressures, as conservation and sports groups battled ranchers, farmers, and commercial fishers over control of wildlife.[121]

In 1956, Congress separated the U.S. Fish and Wildlife Service into the Bureau of Commercial Fisheries and the Bureau of Sports Fisheries and Wildlife. In 1970, legislation moved the Bureau of Commercial Fisheries to the Commerce Department, where it became a part of the newly created National Oceanographic and Atmospheric Administration and was renamed the National Marine Fisheries Service (NMFS). The Bureau of Sports Fisheries and Wildlife remained as the U.S. Fish and Wildlife Service. The NMFS retained responsibility for anadromous fish.[122]

Hatcheries and Fish Culture

By the early 1870s, farsighted canners began experimenting with artificial propagation and establishing hatcheries. In response to a request from a group of Columbia River canners, Congress asked Livingston Stone of the U.S. Bureau of Fisheries to travel to the Columbia Basin in 1877 to locate a site for a hatchery station on that river system. There in 1877 he established the region's first artificial propagation operation on the Clackamas River.[125] (See Figure 1.)

Early fish culture development on the Columbia was erratic. The U.S. government operated the Clackamas River hatchery until 1880 when it left the site, only to return in 1889 when it took over operations from the Oregon State Board of Fish Commissioners, which had run the site for two years. Between 1880 and 1887, the only hatchery in Oregon was run by canning operator R.D. Hume on the Rogue River.[124] In his report on the fisheries of the Columbia, Major William A. Jones recommended the establishment of hatcheries, as well as a "weekly close season."[125]

Although the United States government completed much of the early work in artificial propagation on the Columbia, private organizations and the state governments contributed also.[126] In the 1890s, the U.S. Fish Commission, the Astoria Progressive Commercial Association, the Oregon State Fish Commission, and Hume operated fish hatcheries on the Columbia River system.[127] During the late 19th and early 20th centuries, many biologists believed that anadromous fish populations could be sustained solely by artificial propagation, which became "the only recognized tool of fishery management."[128]

Many of the early efforts to establish fish stations failed, owing to a lack of knowledge concerning the life cycle of the salmon. The state of Oregon, for example, opened several stations in the early 1900s only to close them a few years later because state officials had built in the wrong location.[129] Lack of funding also impeded initial state efforts to maintain fish stations. After several initial failures, however, Oregon took the lead in developing artificial propagation in that state and funded the operations with state money.[130]

CENTRAL SALMON HATCHERY, BONNEVILLE, 1909

Established in 1909, the Central Hatchery was heralded as the largest in the world. This facility, located at Bonneville, experimented with a variety of stocks and rearing techniques. By 1937, it had become one of seven hatcheries operated by the State of Oregon. At that time, the State of Washington also operated five hatcheries along the Columbia River.

Central Salmon Hatchery, showing the incubation building (left), sheds, and a residence (right), 1910s.

Central Salmon Hatchery in August 1921, showing ponds, buildings, and incubation building.

Fish culture activity intensified between 1887 and 1894, and salmon populations increased in 1890. However, this success was difficult to duplicate. Although artificial propagation resumed in 1900, fish populations did not increase significantly until 1915.[131]

Fish canners, demanding to know why the runs continued to decrease, eventually blamed the early release of the salmon fry. In response, the Oregon Fish and Game Commission in 1915 developed "the improved hatchery system," which included the use of feeding ponds to hold the young fish until they were large enough to survive in the rivers. This new system was more expensive to operate, since the fish in the ponds had to be fed until released, but the later liberations led to an increase in the fish runs between 1917 and 1918. Viewing the success of the state operations, the U.S. government began to use the same system.[132] The Mitchell Act, passed in 1938, funded state and federal hatcheries on the lower Columbia River. Its objective was to offset the impacts to fish resulting from the construction of Bonneville and Grand Coulee Dams, as well as the effects of logging and pollution.[133] The Mitchell Act required the Secretary of Commerce to "establish one or more salmon-cultural stations in the Columbia River Basin in each of the states of Oregon, Washington, and Idaho." In addition, this legislation mandated the construction of irrigation screens and other devices to facilitate fish migration.[134]

Since the late 19th century, hatcheries appeared to have presented a solution to the problem of declining salmon populations. Daniel J. Evans, who served as governor of Washington from 1963 to 1977, claimed that "it is pretty safe to say that the fish biologists and scientists can produce almost any kind of anadromous fish, and they can produce them in almost any amount, given the natural limitations of the streams and the food chain."[135]

Scientists, however, remained more cautious in evaluating the effectiveness of hatcheries. As early as 1977, the Commissioner of Fisheries reported that "artificial hatching has definite limitations. At best it is only a supplement for natural spawning."[136] Some biologists believe that hatcheries have contributed to the demise of the wild runs in the Columbia Basin. These biologists point out that large numbers of juvenile salmonids released from hatcheries compete with wild populations for space, food, and cover, and can contribute to increased populations of predators by providing an easily obtained source of food. Mixed-stock fisheries usually remained geared to harvest hatchery stocks at a rate that the wild populations could not tolerate, further reducing threatened wild populations.

In addition, improper mixing of hatchery and wild stocks both in the hatcheries and the streams weakened wild gene pools. Opponents of artificial propagation argued that wild fish remained genetically better equipped for survival. Hatchery salmon are not as "stream smart" as their wild counterparts. Because the fish are "less instinctual" and "less alert," some biologists feat that they experience greater difficulty migrating to the sea.[137] They are also more susceptible to disease and predators.[138] A higher percentage of wild fish survive to maturity from the smolt stage to adulthood. However, owing to care of the eggs, survival from egg to smolt is higher for hatchery fish.[139]

Summary

During the late 19th and early 20th centuries, a number of activities depleted fish populations, including commercial and sports fishing, farming, grazing, mining, and logging. As the most visible of these activities on the Columbia River, commercial fishing appeared to many observers to be primarily responsible. Historians such as Keith C. Petersen, however, concluded that salmon populations had largely stabilized by the 1930s,and that commercial fishers have become "popular and convenient scapegoats" for those seeking an easy explanation for the declining number of fish.[140]

By the 1930s, large multipurpose dams, which presented formidable barriers to migrating fish, had added to the causes of salmon loss. Long before their construction, however, other uses of the river revealed the region's tendency to view the Columbia River as a resource to be developed for economic gain. Building large dams was in keeping with this long-standing attitude toward the river and the salmon.

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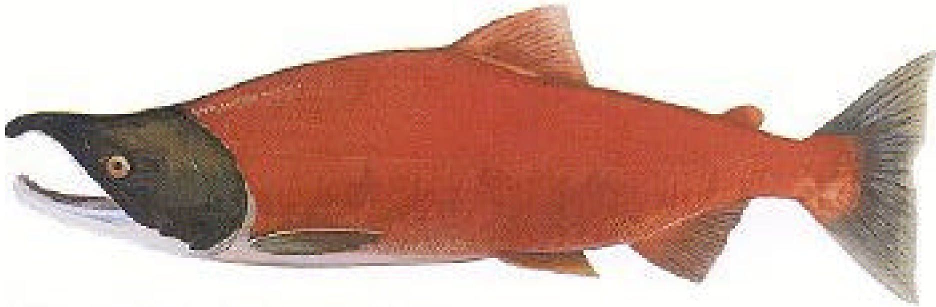
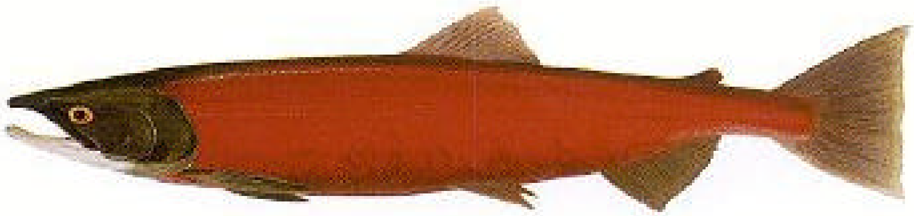
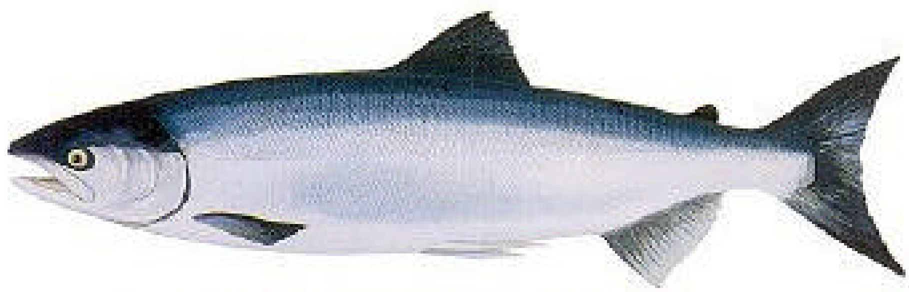


Sockeye Male - Freshwater Phase



Sockeye Female - Freshwater Phase



Sockeye - Ocean Phase

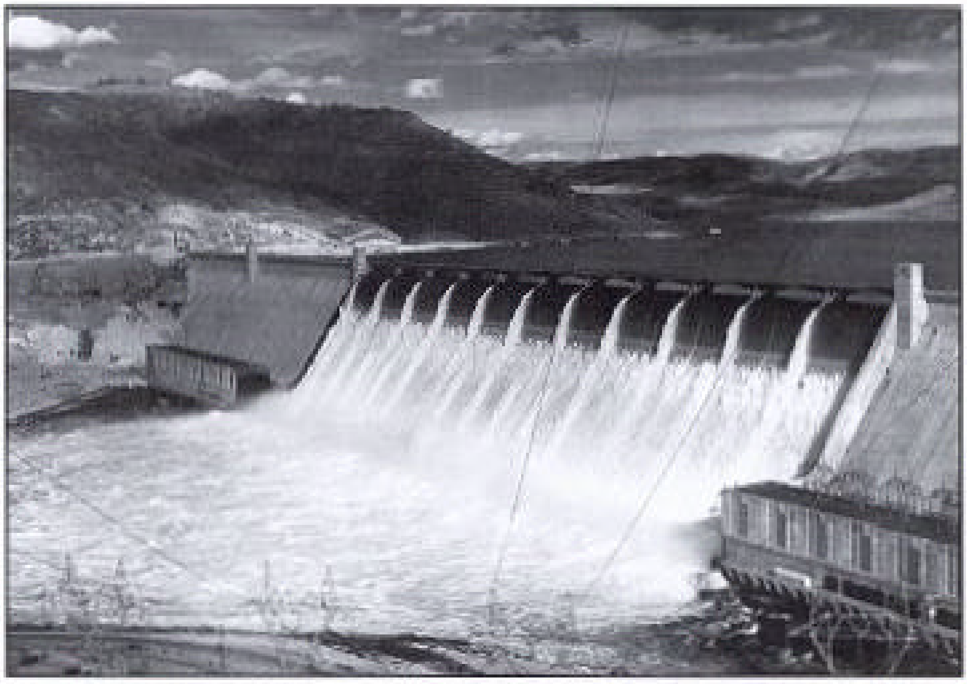
II. Multipurpose Development in the Columbia Basin

Support for Multipurpose Dams

Construction of large-scale hydroelectric projects in the Columbia River Basin created a myriad of problems for fisheries. Yet no 20-th-century development brought more economic benefits to the Pacific Northwest than the construction of hydroelectric projects along the Columbia and Snake Rivers. During the 1930s, the dams came to represent the hopes and high expectations that the arrival of the transcontinental railroad inspired a half a century earlier. In the midst of the depression, hydroelectric projects brought jobs to a region suffering from economic collapse and extensive unemployment. For farmers attempting to cultivate the arid lands east of the mountains, dams meant irrigation on a scale that remained beyond the funding capability of individuals or small companies. The construction of dams also brought improvements in navigation and flood control.[1]

Most important, the dams on the Columbia and Snake Rivers provided inexpensive power to the region. Residents in the Pacific Northwest still enjoy the lowest rate in the nation. According to a recent article in *The Seattle Times,* "virtually everybody" in the region "benefits from the investment by the federal government that resulted in electric power rates that are half what other regions pay."[2] It was this cheap electricity that attracted the aluminum industry to the shores of the Columbia. During the 1940s, the Boeing Company, initially dependent on spruce, looked to the new aluminum industry for raw materials for the construction of aircraft. By 1944, Boeing had employed nearly 50,000 workers in the Seattle area. Cheap electricity also encouraged the development of the Hanford Complex in central Washington.[3] Historically, Pacific Northwest residents had remained dependent on logging, farming, mining, and fishing. Hydroelectric projects stimulated economic and population growth. Without the dam along the Columbia and Snake Rivers, the region would be a very different place today.

Accordingly, in the 1930s, commentators celebrated dams as advancements of civilization. The Grand Coulee Dam, completed in 1942, particularly impressed folk singer Woody Guthrie. At the time, it was the largest masonry dam every constructed; proud residents of the Pacific Northwest boasted that it was the largest man-made structure in the world. So awed was Guthrie by the dam that he argued it "makes the Tower of Babel a plaything for a kid." He welcomed the electricity and irrigation the Columbia River projects brought to the region, for they kept people employed. To Guthrie, the Columbia river dams were a metaphor for progress, a force that would turn "darkness to dawn." In 1933, *Newsweek* proclaimed Grand Coulee Dam the "greatest power, reclamation, and flood control project ever conceived."[4] Four years later, an article in *Bird-Love,* a journal produced by the Audubon Society, reported that Pacific Northwest residents "are eager for a larger population and more industries." [5]



Grand Coulee Dam, completed in 1942.
Some residents boasted that it was the largest man-made structure in the world.

During the 1930s, relatively few Northwesterners objected to the construction of hydroelectric dams on the Columbia River. Vehement protests of large-scale dam construction would emerge in later decades. Most opposition came from the eastern United States, where some Americans disapproved of public power or objected to the expense of reclamation efforts in the remote West.[6] Scientists, worried about the effect of dams on the migration of anadromous fish, also raised concerns. Some feared that young fish would encounter problems passing through the turbines.[7] Fishing interests also feared that dams could reduce the salmon runs.[8]

Most residents in the region, however, remained enthusiastic. Support for irrigation projects had been firmly rooted in the West since the early 20th century, with the passage of the Newlands Act in 1902 and the establishment of the Reclamation Service. The national conservation movement, which emerged during the late 19th and early 20th centuries, applauded reclamation projects. Early conservationists were concerned that the nation's resources be used wisely and efficiently. Rivers, they believed, should be controlled to produce the maximum benefit to humans. Conservation at the turn of the century focused on eliminating waste, not on protecting habitat.[9]

By the 1930s, these ideals "came to maturity." Franklin D. Roosevelt, following the tradition of Theodore Roosevelt and Gifford Pinchot--two leaders of the early conservation movement--eagerly established federal water projects on the Columbia River. When campaigning in Portland for the presidency, Roosevelt promised that if he were elected, "the next hydroelectric development to be undertaken by the federal government must be on the Columbia River."[10] This would produce the large-scale resource planning that early conservationists "had dreamed" about.[11] Many Americans in the 1930s considered the completion of dams along the Columbia and Snake Rivers to be "conservation accomplishments."[12] In the 1930s, when the construction of dams got underway, the ecological awareness that would produce the environmental movement and the Endangered Species Act was four decades away.

Planning for the Columbia River projects began before Roosevelt became president in 1933. Throughout the early 20th century, state and local organizations promoted a variety of schemes to develop the Columbia River Basin. Washington sponsored surveys to generate interest in irrigation, while Oregon emphasized the potential for hydropower. As early as 1916, the Oregon State Engineer drafted plans for constructing power, navigation, and engineering projects in the river basin. These plans proved difficult to implement, because they required an estimated $30 million investment.[13] When the Roosevelt Administration encouraged federal involvement in resource planning, however, such large-scale projects become more feasible.[14]

The U.S. Army Corps of Engineers In The Columbia Basin

Bonneville Lock and Dam was the first of the mainstem federal facilities to be completed. The Corps, which had a longstanding presence in the Columbia River Basin, constructed this facility. Since 1824, the agency had been the principal developer of the nation's navigable waterways. The Corps established an office in Portland in 1871, and 75 years later located its North Pacific Division headquarters there. The Portland Engineer Office initially focused its efforts on developing the navigation potential of the region's rivers and harbors. After the Civil War, Congress became concerned about the obstruction of rivers by "bridges, wharves, dredging, dumping, and all manifold activities of a burgeoning industrial economy" that interfere with navigation.[15] Accordingly, in the 1880s Congress instructed the Corps to investigate some of these complaints, including the possible obstruction of the Columbia River by fish wheels, gillnets, and other salmon-catching devices. The Corps, which had agents in direct supervision of works constructed on the river, was to determine which structures should be under regulation "for the protection and amelioration of navigable waters."[16]

In response, the Chief of Engineers order Major William A. Jones, Portland Engineer Officer, to investigate the Columbia River fisheries in 1887. Jones devoted much of his report to salmon. He included information on such topics as the life cycle of the fish, depletion of runs, artificial propagation, and catching methods. In his discussion of fishing and navigation, Jones observed that due to the dams and fish traps established in the waters around Astoria during the fishing season, it was "a sort of miracle" that any fish escaped. On the question of fish traps, or weirs, Jones recommended legislation to place these devices under the supervision of a federal office who would regulate their use to maintain clear shipping channels on the river.[17]

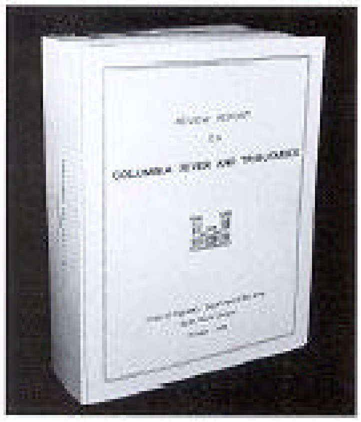
Major William A. Jones, Portland Engineer Officer

Concern about impediments in New York harbor and the excess of silt created through hydraulic mining in California prompted Congress to introduce national anti-obstruction legislation that provided broader powers for the Corps. A series of Rivers and Harbors acts passed between 1890 and 1899 prohibited the dumping of materials that would obstruct navigation on waterways, and required anyone wanting to change the "course, location, conditions or capacity" of waterways to obtain permission from the federal government before doing so.

The Rivers and Harbors Act of 1899 created the strongest "Refuse Act" in this series of bills. It outlawed the casting of "any refuse matter of any kind or description" into waterways and granted the Corps the power to arrest violators as well as to issue permits. Under the permit system, anyone wanting to engage in activities that would result in changes to a navigable waterway--including the Columbia River--had to submit a formal permit application and receive permission from the Corps. This permit system became part of the Corps' daily work in the early 20th century.[18] The Refuse Act granted the Corps broad powers to regulate pollution in the nation's waterways.[19]

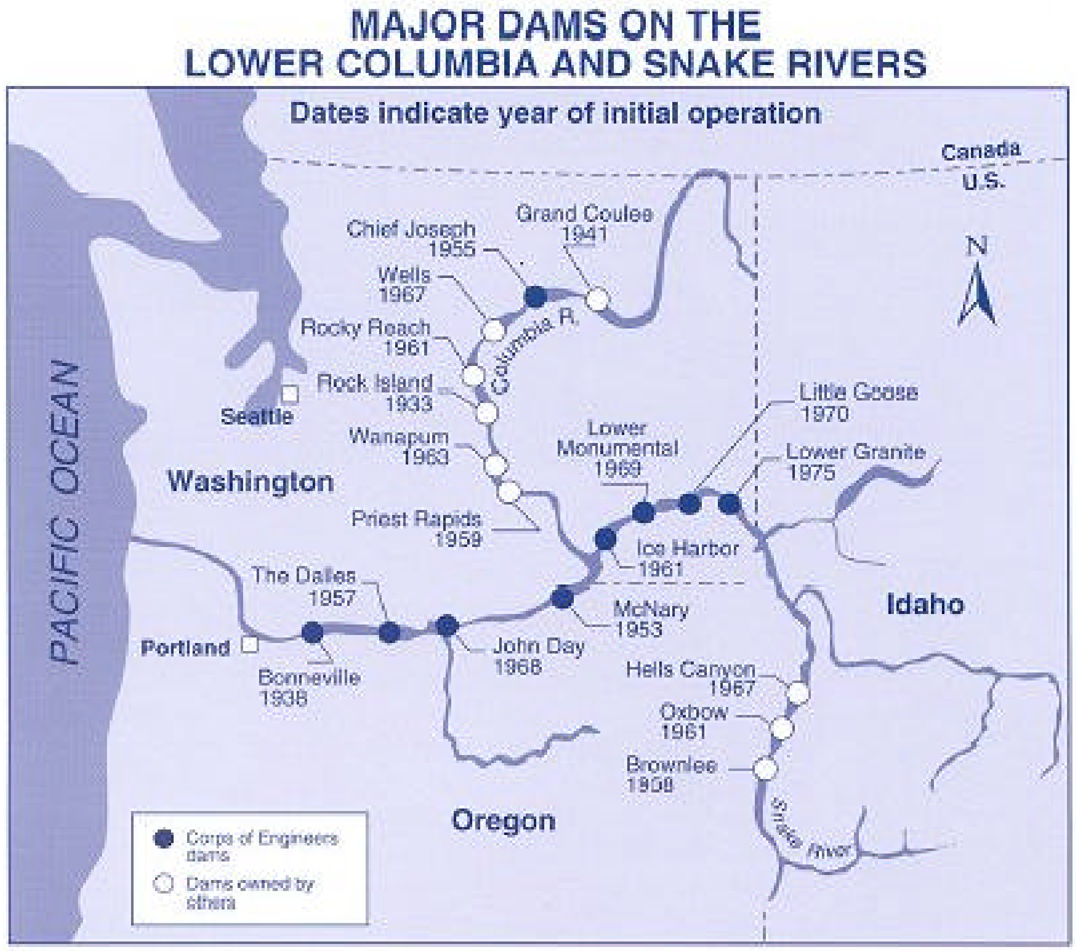
The Rivers and Harbors Act of 1927 further expanded the Corps' involvement in developing the nation's waterways. This legislation called for comprehensive river-basin studies on approximately 200 waterways. In response to a congressional request, the Corps in 1926 had submitted the cost estimates to survey much of the nation's navigable waterways, to determine their potential for multipurpose development. The agency's report, published as House of Representatives Document 308, called for a nationwide survey to identify streams for navigation improvements and hydroelectric power development. The Corps began work on the extensive study of the Columbia in

1927. The Seattle District surveyed the Columbia above the Snake River, while the Portland District engineers examined the lower river. In this massive undertaking, Corps workers compiled data on stream flows, topography, hydrography, foundations, irrigable lands, and flood-prone areas, to produce a ten-dam comprehensive plan for the Columbia River. Uppermost in the chain was the Grand Coulee Dam, completed by the Bureau of Reclamation in 1942. The Bonneville Dam remained lowermost in the chain.[20]



**Columbia River
308 Report**

In determining the viability of dam locations included in the Columbia River 308 report, the Corps took into account power, navigation, irrigation, and flood control. Of these four considerations, the Corps emphasized power development--a change from its earlier emphasis on navigation. The Corps had produced the most extensive study of the Columbia River, and the engineers assumed responsibility for future major decisions about the development of the river system. The 308 report formed a basis for subsequent review of the Columbia River and initiated a process of reviewing and updating reports on the river system that continues to the present.[21]



Map 4. Dates of construction of major dams of the lower Columbia and Snake Rivers.

Fish Facilities At Bonneville Dam

Completed in 1938, the Bonneville Dam surpassed previous hydroelectric projects in terms of its size and complexity. As the U.S. Commissioner of Fisheries explained in the early 1930s, there had "never before been built, in either America or Europe, a structure of such size that obstructed migratory runs of such magnitude." The Federal Emergency Administration of Public Works authorized the project in 1933, under provisions of the National Industrial Recovery Act.[22]

Many historians and scholars have claimed that the Corps' initial plans for Bonneville Dam did not include fish passages.[23] Anthony Netboy, for instance, wrote that "the earliest design published by the Corps of Engineers for Bonneville Dam had no provision for fishways. Had this plan prevailed, the entire salmon and steelhead resource above Bonneville would have been wiped out."[24] Such statements, however, are misleading.

Bonneville project after completion

Col. Gustave R. Lukesh, North Pacific Division Engineer, 1927 to 1931, and Portland District Engineer, July 27 to July 1930.

Historical records reveal that the Corps recognized the need for fish passages long before the construction of Bonneville Dam began in the early 1930s. More than a decade earlier, the agency had installed facilities to aid fish through the Ballard Locks in Seattle. In 1929, Division Engineer Colonel Lukesh noted that the tentative design of mainstem dams on the Columbia should consider impacts on fish. "Provision should be made," he wrote, "for the passage of upstream fish, especially salmon, migrating to breeding places."[25] Three years later, House Document 103 on the Columbia River and its tributaries explained that "the question of the necessary provision for the passage of fish over the dams...will require more definite determination. The salmon fishing industry is of great importance to the states of Oregon and Washington, and should not be endangered. For moderate heights of dams, fish ladders may provide for the passage of fish upstream for spawning, but for dams of 100 feet or more in height, no feasible plans have been developed." House Document 103 included fishways--or ladders--in the design and cost estimates for proposed dams.[26]

Similarly, Portland District Engineer Major Oscar O. Kuentz assured readers of *The Military Engineer* in 1933 that the Corps understood the importance of protecting anadromous fish. "Before the actual construction of any dam is started," he wrote, "studies must be made to determine the best method of passing the salmon over the high structures required for power and navigation."[27] His words revealed the Corps' understanding that more information regarding fish passage over large multipurpose projects was needed. Three years later, the *Engineering News-Record* noted that the original designs for Bonneville Dam included fish ladders.[28]

To relieve unemployment, construction began on Bonneville Dam before the Corps could refine details regarding fish passage.[29] When the facility was approved in 1933, the Corps immediately began work on fishways. The agency consulted with the U.S. Bureau of Fisheries, the fish and game commissions of Oregon and Washington, and a variety of regional fishing associations. Harlan B. Holmes, a biologist from Stanford who had joined the U.S. Bureau of Fisheries, became one of the primary consultants. He explained that although preliminary reports indicated "the presence of fishways," the "task of designing fishways remained to be done after the project was authorized." Holmes worked with Milo C. Bell, a hydraulic engineer from the University of Washington, and Henry F. Blood, a hydraulic engineer from Portland, as well as Corps staff on the plans for the fish facilities. The fishways design "evolved," Holmes later explained, and changed sometimes "day-to-day" during construction of the dam and powerhouse. Holmes portrayed his relations with the Corps in this effort as "entirely cordial and cooperative." The engineers, he recalled in 1971, "furnished us working space and we worked virtually as one staff."[30]

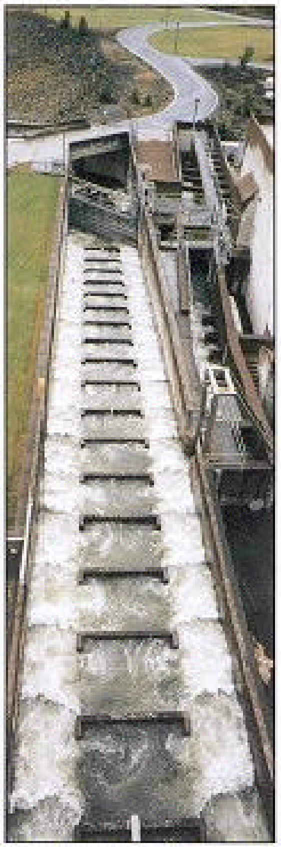
To facilitate this effort, the Corps formed a team of fisheries experts to draft a plan for passing migratory fish upstream and young fish downstream. The team's task was formidable, considering that fish passage facilities on the scale required had never been attempted, and the fisheries experts could not agree on the best type of fishway. "The magnitude of the problem of fish protection at Bonneville," Holmes explained in 1935, including "the size of the stream, the great fluctuation in a river flow, and consequent variations in water levels, the number and variety of fish to be handled, and the height to which they must ascen[d]--made it necessary to diverge from standard fishway practice as it is applied in smaller projects."[31] While most federal and Washington state fisheries biologists preferred locks to lift the fish, Oregon experts and commercial fishing interests argued for conventional ladders at Bonneville. The Oregon Fish Commission protested against the installation of unproven devices at Bonneville, which the agency feared might jeopardize salmon runs.[32]

In revising its plans to meet most of the Commission's concerns, the Corps increased the cost of the fish passage from $2.8 million to $3.6 million. This compromise plan was $900,000 less than what the Oregon fishers desired, but $1.1million more than the Public Works Administration wanted to pay for fish passage facilities. Senator Charles L. McNary of Oregon exerted "considerable" political pressure to obtain a commitment from the Public Works Administration to appropriate $3.2 million--sufficient to fund the key elements of the compromise plan.[33] Lobbying from fisheries agencies and commercial fishermen also helped convince Congress to increase the appropriatons.[34]

As constructed, the fish collection and bypass system at Bonneville included three reinforced concrete fish ladders and two pairs of fish lifts. The fish ladders resembled a stairway of 40-foot-wide compartments, each one foot higher than the last. Openings between the compartments encouraged the fish to swim, rather than leap, from pool to pool. The Corps constructed one ladder at each end of the spillway dam and one at the north end of the powerhouse. These ladders enabled the fish to ascend 70 feet to the pool behind the dam.[35]

The Corps placed fish lifts at the north end of the spillway dam and at the south end of the powerhouse. These structures operated on the principle of a navigation lock and were designed to accommodate 30,000 fish per day. Although previous dams used ladders and lifts, what made the Bonneville system unique was the combination of ladders and lifts.[36]

FISH COLLECTION AND BYPASS SYSTEM



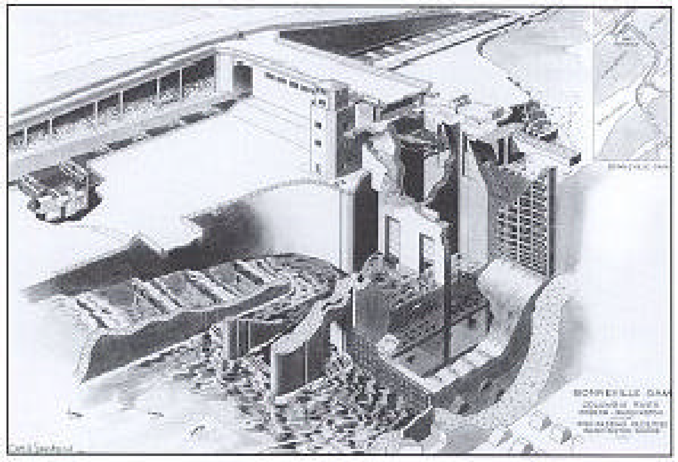
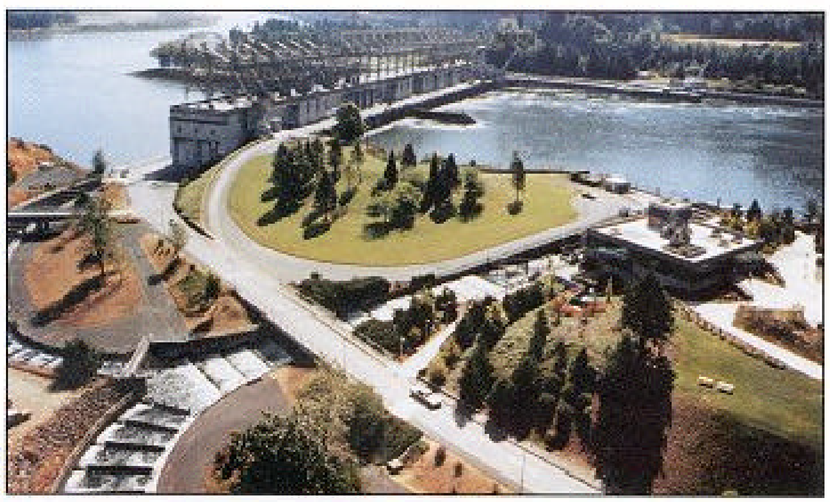


Diagram of Bonneville fish lock operation

Diagram of main fish collection channel at the powerhouse

The fish ladder is a stairstep to help lift the fish to the upper pool beyond the dam.



Fish passage system at Bonneville

Another new feature at Bonneville Dam was the fish collection system. The fish experts who designed the Bonneville fishways realized that their effectiveness depended on their ability to attract salmon, and fishways at earlier dams had not resolved this problem. After researching attraction, Holmes recommended the construction of a "unique" collection system that included "extensive and varied entrances" supplied with constant water velocity at a volume greater than that provided through the fishway proper.[37]

The Corps built the Bonneville fish passage facility according to Holmes' recommendations, and during the first 30 years of operation an average of one million fish annually passed through the system. In addition to constructing the fishways, the Corps redesigned and relocated the state fish hatchery at Bonneville. Built in 1909 by the Oregon Fish Commission, this facility was once the largest hatchery in the world. In addition to the fishways at Bonneville Dam, the Corps established counting stations, where employees identified and tallied adult returning salmon.[38]

Fish counter at Bonneville Dam

The cost of the collection and bypass system at Bonneville Dam reached nearly $7 million, which represented approximately 15 percent of the project cost.[39] Early estimates for the construction of fish facilities totaled half this amount. In evaluating the expenditures for the Bonneville Dam, President Roosevelt offered this comment in jest: "All I can hope is that the salmon will approve the [fishways] and find them really useful even though they cost almost as much as the dam and the electric power development."[40]

An article in *Collier's* pronounced the fishways at Bonneville "the most unique stairways and elevators of all time."[41] Similarly, *Scientific American* described the construction of fishways as a pioneering effort. This "immense experiment," the journal reported in 1938, "is undoubtedly the greatest thing of its kind reared anywhere up to date. The success of these fishways is a matter of world-wide interest."[42] Although Rock Island Dam, a public utility district facility completed in 1933, featured two fish ladders, biologists in the mid-1930s remained uncertain of their success.[43] President Roosevelt dedicated Bonneville Dam four years after construction began. The Bonneville Power Administration (BPA), a federal agency established in 1937, marketed the power generated by the dam.

President Franklin D. Roosevelt dedicated Bonneville in September 1937

Initially, the fish passage system at Bonneville appeared so successful that it served as the model for subsequent dams on the Columbia and Snake Rivers (see Map 4). Promoters of further dam development pointed to the success of the Bonneville fish passage system to demonstrate that dams and fish could coexist. Even skeptics, such as Dr. William L. Finley of the Izaak Walton League and Professor Lawrence E. Griffin of Reed College in Portland were surprised by the effectiveness of the Bonneville ladders. In 1938, Willis H. Rich, Director of Research for the Fish Commission, pronounced that operation of the ladders was "entirely successful."[44]

Later studies at Bonneville and other mainstem dams, however, revealed a mortality rate of at least 15 percent for juvenile salmon at each dam--a loss that threatened to destroy the fishery.[45] Moreover, biologists in the 1990s, with the benefit of hindsight, would look back at Bonneville construction and lament that "decisions were made without the knowledge."[46] As early as 1935, scientists such as Holmes suspected that large dams would require additional fish passage facilities to assist juvenile salmon migrating downstream. However, the Corps, in consultation with fisheries biologists, decided to focus first on the problems of adult passage.[47] From 1938 to 1975, the Corps and public and private utility companies constructed 15 additional dams on the Columbia and Snake Rivers (see Map 4). Throughout these decades, it became apparent that adult fish passage structures alone would not be sufficient to offset the effects of hydroelectric development in the lower reaches of the two rivers.[48]

Uses of Columbia and Snake River Dams

The Corps constructed its eight mainstem dams on the Columbia and Snake Rivers for a variety of purposes. Some of these, such as the production of power, have been objectives since the outset of construction, while others, such as flood control, evolved more gradually. Since the 1930s, the Corps has coordinated and balanced these sometimes-competing interests in its management of the dams in the Columbia Basin. The various uses of river water impact anadromous fisheries, either directly or indirectly, by requiring construction of large dams. The Corps indicated in 1980, however, that multipurpose activities in general do not result only in "positive or negative effects." Instead, "there are trade-offs which must be carefully weighed against each other as we all face new decisions about water use in our fugure."[49]

Navigation

Long before the arrival of Euroamericans, Indians used the Columbia River as a travel route. This waterway linked the regions east and west of the Cascade Mountains. During the early 19th century, Lewis and Clark used the Columbia to enter the region--and the Hudson's Bay Company, an English fur trading enterprise, would later travel this river to transport goods and staples to its outposts. Mid 19th-century pioneers, weary of the dusty Oregon Trail, sometimes loaded their supplies and cattle on rafts, completing the journey from Walla Walla to the Willamette Valley by water.[50]

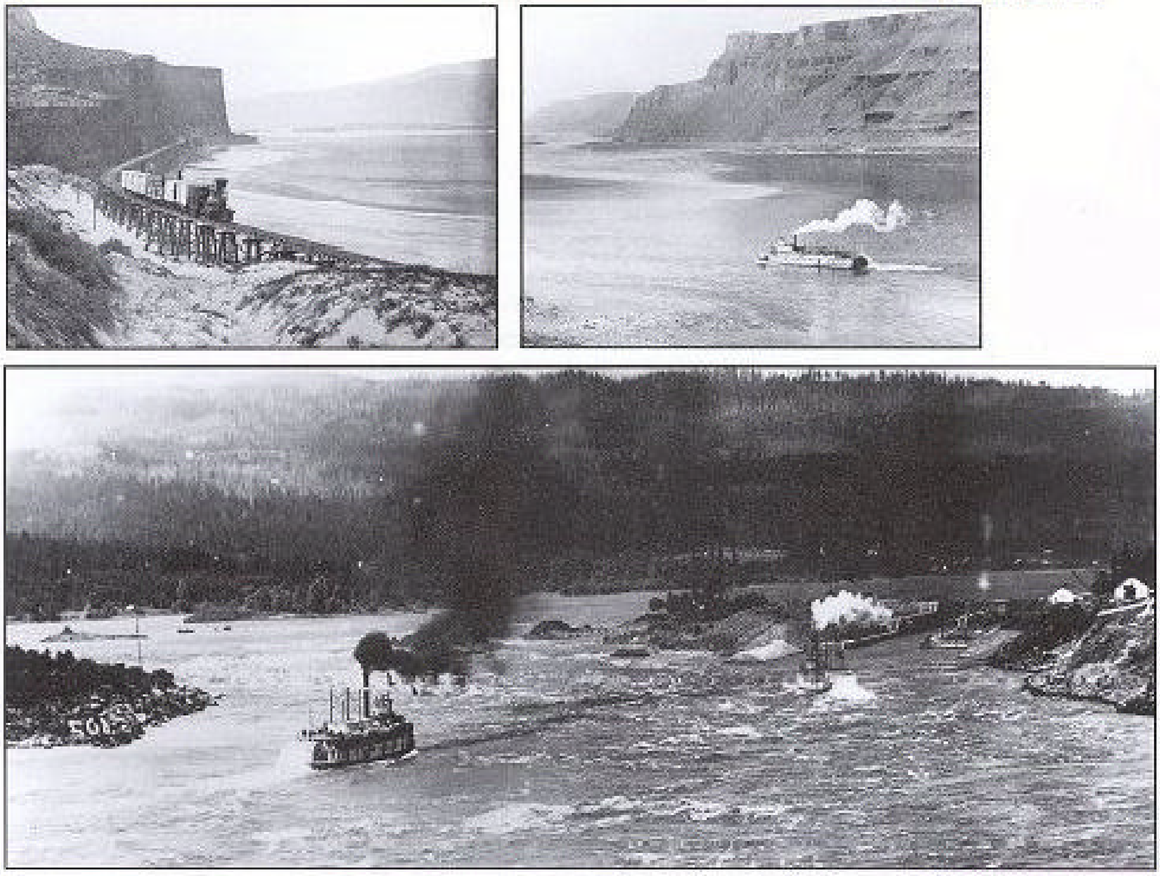
It was not always a smooth ride. Sudden storms, treacherous rocks, and roaring rapids made portages necessary, particularly at Kettle Falls, Celilo Falls, and the Cascades. Even so, throughout the early 19th century, the Columbia River provided a convenient means of transportation in a roadless land.[51]

By the 1850s, canoes and rafts gave way to steamers, sailboats, and barges. Competition among rival boat companies ended with the organization of the Oregon Steam Navigation Company (OSN) in 1860. This enterprise, which enjoyed a monopoly along the Columbia River, acquired elegant stern-wheelers--some of which were 200 feet long--to carry passengers and freight between Astoria and Lewiston. The falls along the way were traversed by small rail lines along the banks. In 1862, the OSN built a 6-mile railroad at the Cascades on the Washington shore and a 1.3-mile line running from The Dalles past Celilo Falls.

Because the OSN was a monopoly, residents of Washington Territory were antagonistic to the company. Western Washingtonians, who had no road between Puget Sound and the Columbia River, resented the company's diversion of immigrants to Portland, while dry-land farmers in the interior protested the OSN's seemingly exorbitant rates. The company operated for 20 years along the Columbia River. By 1909, the early era of river traffic had passed, replaced by an extensive network of rail lines. In the 1930s, water transportation reemerged with the construction of dams along the Columbia River. During this period, navigation improvements, such as the construction of the lock at Bonneville Dam encouraged the use of diesel-powered towboats and flat-bottomed barges to move bulk cargo.[52]

Transportation was a key consideration in the Pacific Northwest, an area physically isolated from centers of national trade and traversed by rugged mountain ranges that made highway and railroad construction difficult and expensive.[53] In the early 20th century, water transportation advocates, dreaming of the completion of an inland waterway to Lewiston, pushed for further development of the river system. As early as the 1920s, commercial groups such as the Umatilla Rapids Association and the Columbia Valley Association lobbied for a navigable water channel to transport agricultural products.

STERN WHEELERS, STEAMERS AND RAILROADS



The Portage Railroad bypassing the Celilo Falls area, and the streamers at Cascade Canal and Rapids.

The campaign for slack water to aid transportation became more intense during the national economic depression of the 1930s. At that time, the Columbia Valley Association and the Portland Chamber of Commerce barraged the Portland District of the Corps with information on the feasibility of barge traffic, particularly along The Dalles. Advocates of water navigation also pointed out that the high shipping rates of the railroads resulted in regional economic stagnation.[54] Supporters of navigation, such as Representative Walter Pierce of Oregon, argued that high freight rate led to the failure of irrigation projects. Cheap water transportation, he argued, would open more agricultural lands in the Northwest and provide homesteads to "the landless millions in the cities," who needed farmland.[55]

In 1934, navigation supporters formed the Inland Empire Waterways Association, which brought together farming and business interests, as well as county and city governments. This new organization was politically more powerful than earlier navigation advocates. Its approach to transportation development was more aggressive than the Corps wished to pursue. After construction of Bonneville Dam, the engineers, who at this time maintained a "cautious and conservative approach to river development," preferred to let sales of hydropower support future projects for irrigation, navigation, and flood control.[56]

The beginning of World War II created a new set of arguments for the development of slackwater navigation on the Columbia system. At that time, navigation advocates argued that materials and minerals could be shipped downriver to defense-industry plants. There was a 13-percent increase in tonnage upstream from Bonneville after 1938.[57]

The Inland Empire Waterways Association played a vocal role in the support for dam construction on the lower Snake River. This group argued for building dam son the main river because they desired the extension of water navigation to Lewiston, Idaho. Navigation supporters fought plans advocated by fisheries groups to construct dams on tributaries to the Snake, where facilities could produce more power and fewer impacts on anadromous fish runs. In 1945, Congress authorized the Corps to construct the lower Snake River dams. Two years later, the Inland Empire Waterways Association noted that the "one great serious handicap of this region is the excessive cost of transportation on the products we produce which are shipped to the markets and on the incoming products." Multipurpose development of the Columbia River System, this organization hoped, would alleviate this problem. The Inland Empire Waterways Association downplayed the potential impacts on fish, arguing that "development need not of itself constitute a threat of extinction or severe damage to the Columbia River salmon fishery if adequate corollary action for protection and replenishment of salmon runs...is taken."[58]

Navigation supporters cheered when the slack water resulting from Snake River construction finally reached Lewiston in 1975 marking the culmination of their dream of the Inland Waterway. One spokesman for the Corps predicted that the slack-water system would "benefit the nation" by "allowing economical movement of bulk raw materials to and from interior regions of the Columbia Basin."[59] In 1989, ships carried almost six million tons of freight on the Snake River. Wheat was the largest commodity shipped downriver, while gas, oil, waste, and scrap remained the largest cargoes carried upriver. By the early 1990s, the Columbia River had become the fourth-most-valuable navigation corridor in the world.[60]

Flood Control

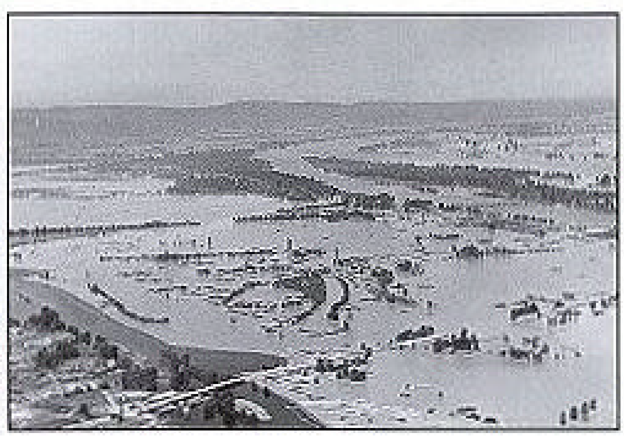
The Columbia Basin had a history of flooding. Small dikes and diversion channels constructed along the lower Columbia River could not always protect bottomland farms from inundation. Because the region was relatively undeveloped during the 19th century, mot floods did not cause severe damage. By the turn of the century, however, flooding became disastrous. In 1903, rising water at Willow Creek, a tributary of the Columbia River, killed 247 people. Although this catastrophe was well-publicized, many Americans continued to believe that flood control was a local, not a national concern.[61]

Before the 1930s, the Corps reflected this line of thinking in the Columbia Basin. Regional politicians attempted to convince the Corps to include flood control in its 308 surveys during the late 1920s. The engineers, however, did not consider it a prominent concern in planning multipurpose dams on the Columbia River until Congress passed the Flood Control Act of 1936.[62] This landmark legislation added nationwide flood control as a federal responsibility.[63]

The flood of 1948 in the Pacific Northwest further mobilized Congress to demand flood control in the area. This disaster caused $102,725,000 in property damage, destroyed 38,000 homes, and claimed 38 lives.[64] According to one observer, the deluge "focused the eyes of the whole United States upon the Pacific Northwest."[65] President Harry Truman ordered the Corps to reevaluate its survey of the Columbia Basin with a view to flooding. Truman's interest in flood control indicated the importance of this benefit in future multipurpose planning.[66]

FLOODING FROM THE COLUMBIA RIVER

1894 flooding in Portland, Oregon



1948 flooding in Vanport, Oregon

This emphasis on flood control created additional responsibilities for the Corps. To coordinate water storage for irrigation use and the maintenance of reservoir space to store spring flood water, the engineers cooperated with other agencies, particularly the Bureau of Reclamation, to determine storage rates.[67] To balance these and other multiple-use needs, the Corps established a Reservoir Control Center for the Columbia Basin and adjacent streams in 1968. The development of the center revealed the North Pacific Division's comprehensive responsibilities in the region, as well as the need for cooperation among the various owners in the river basin. The demands on the river, as recognized by the development of the Center, included power, navigation, fish passage, recreation, irrigation, and water quality as well as flood control.[68]

The completion of the lower Snake River dams and the construction of four dams, three in Canada and one in Montana, under the Columbia River Development Treaty with Canada, have greatly lessened the threat of flooding in the Columbia Basin.[69]

Irrigation

For more than a century, visitors and residents viewed the Columbia Basin as a barren, lifeless area. Even modern observers have described its landscapes as "desiccated" and "waterless as the moon."[70] In the 19th century, the federal government had difficulty granting this land to American settlers. The 1862 Homestead Act offered too little acreage for farming in an arid region, and the 1877 Desert Land Act granted larger tracts of land only to those willing to irrigate it for three years--a very costly enterprise for an individual farmer. Additionally, a general lack of rain during the long, hot summer convinced many early migrants that livestock was the only favorable crop for the waterless plateaus.

With the gold strikes in Idaho in the 1860s, demands for farm produce increased east of the Cascades, in the Inland Empire. In the 1870s, those few settlers who farmed the drier land learned techniques to conserve what little moisture there was in the soil. In the semiarid Walla Walla Valley, they raised grain and cattle to feed the growing mining population of Idaho.[71] Settlers quickly staked claims in the lowlands surrounding present-day Walla Walla, leaving latecomers the drier uplands and plateaus. Soon, farming because so successful in the lowland areas that, for a time, wheat supplanted the gold-based economy.

IRRIGATION OF THE REGION

Irrigation projects transformed the Inland Empire, particularly eastern Washington, into one of the most fertile agricultural areas in the nation.

Farm land irrigation system

Irrigation canals

View of the fertile valley

Migration to the Inland Empire continued throughout the late 19th and early 20th centuries. Settlers used dry farming techniques involving a deep initial plowing of the field, followed by frequent cultivation to retard loss of moisture in the soil.[72] Although it may have conserved moisture, this technique allowed too much wind erosion of the topsoil. During the drought and the Depression of the 1920s and 1930s, many "dry farms" ceased operations.

Federally supported irrigation and reclamation projects encouraged farming in the most arid sections of the Columbia Basin. The 1894 Carey Act, designed to facilitate state and private cooperation in irrigation projects, and the 1902 Newlands Act, which established the United States Reclamation Service (later the Bureau of Reclamation), marked the beginnings of planned, coordinated survey and development of the irrigation potentials in the region.[73] Private irrigation companies struggled and, by 1910 government-sponsored efforts had resulted in irrigating the principle growing districts of the Columbia Basin.

In the 1930s and 1940s, irrigation and flood control became prominent concerns. The Corps' 308 report stated in 1931 that dam construction should rest primarily on considerations of hydroelectric power development.[74] By 1947, however, one spokesman for the Corps had remarked that "no part of our land...can be wholly prosperous unless we have a prosperous hinterland." Irrigation in the Columbia Basin, he argued, should "go forward in step with the development of the revenue-producing projects in the area." The engineers recommended that Congress approve 13 projects that would provide irrigation to this area.[75]

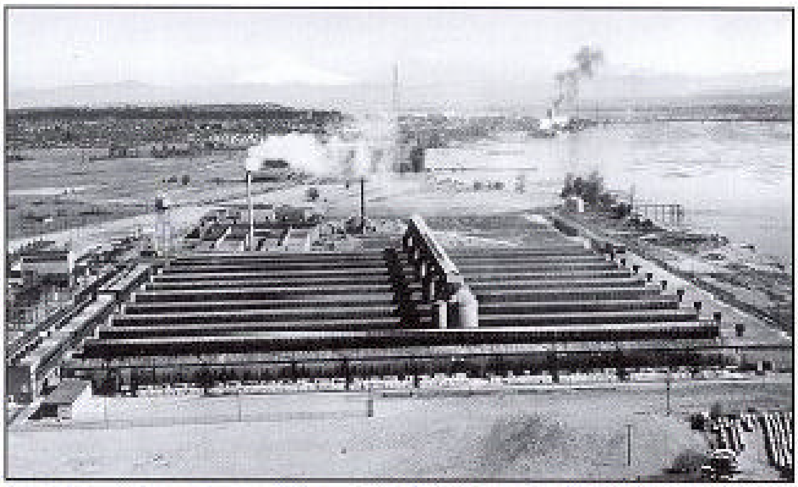
Irrigation projects transformed the Inland Empire, particularly eastern Washington, into one of the most fertile agricultural areas in the nation. As one historian put it, "there some of the worst land in the region has been converted into some of the best."[76] By the early 1990s, dams along the Columbia had provided irrigation for nearly three-million acres, which grew crops worth more than 2 billion dollars.[77] Without the use of river water for irrigation, the Columbia Basin region would be a very different area. However, the Corps has pointed out that withdrawal of water for agricultural purposes brought benefits and detriments to the Pacific Northwest. Irrigation provided employment not only for farmers but also for those working in food processing, equipment sales, and crop dusting. At the same time, the withdrawals of water for agriculture added chemicals and sediments to the river system.[78]

The removal of water also affected the habitat of fish. Of all industrial and municipal uses, agricultural development required the largest volume of water. In hot, dry years, irrigation hindered the migration of fish with reduced flow levels and dewatered side channels.[79] Diversion of salmon in irrigation channels presented additional hazards. Biologists in Idaho, for instance, complained in 1947 that irrigation projects killed fish. Canals encouraged them to "turn off on a side track," where they became trapped "in a little rivulet" that let them "high and dry in some field."[80]

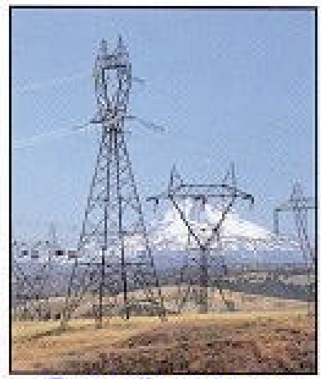
Power

Although the Corps designed its multipurpose dams in the Columbia Basin for many different uses, the primary function was the production of power. By the late 1930s, the generation of electricity had become a more important argument for dam construction than navigation. Power production in fact would "sustain navigation instead of the other way around."[81] Skeptics argued after the construction of Bonneville and Grand Coulee Dams that the small populations of the Pacific Northwest could not consume the energy produced by these two "white elephants." Some questioned whether the power generated in the Columbia Basin would be used by "rattlesnakes" and "sagebrush."[82]

BRINGING POWER TO THE REGION



Alcoa Aluminum plant at Vancouver, Washington



Powerlines across the region

The development of defense industries in the region during World War II soon quieted the skeptics. The availability of inexpensive power encouraged aluminum production, further diversifying manufacturing in the region. BPA supplied power to the Hanford Atomic Works near the confluence of the Columbia and Snake Rivers, resulting in an influx of new residents to Washington and Oregon.[83] Shipbuilding, which required large amounts of electricity, also provided employment for thousands who migrated to the Pacific Northwest during the 1940s.[84]

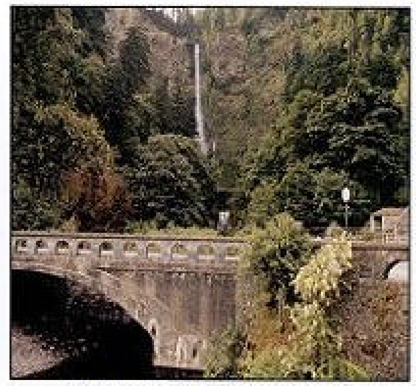
Power considerations were important to post-war planning in the Pacific Northwest. Increased demands for electricity in 1945 created considerable support for a new phase of major dam construction by the Corps, which maintained that the potential economic value of power exceeded that of irrigated lands, forests, minerals, fish, and other resources in the Columbia Basin.[85]

Recreation

The spectacular scenery of the Columbia, especially the 85-mile canyon on the lower river known as the Gorge, has attracted tourists from around the world for more than a century. Recognizing the area's potential, local and state boosters touted the Columbia River's scenic qualities as early as 1877. That year, a writer for *The West Shore* predicted that once eastern tourists became aware of the region's beauty they would flock to the river. "There is nothing in the far-famed Yosemite," he boasted, "to equal our magnificent scenery of the Columbia." Responding to the slogan, "See the Yosemite and die!," this writer countered, "See the Columbia and live," for "after once viewing its magnificent and awe-inspiring scenery, a continual longing recurs to behold it again."[86]

PANORAMIC VIEWS OF THE GORGE

View of the Columbia River Gorge



Multnomah Falls and the Columbia River Highway

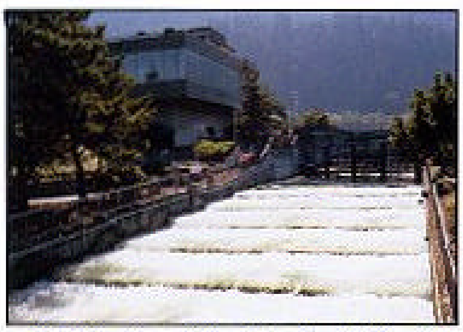
Early visitors could view the river by rail or steamer. The Northern Pacific Railway completed its line along the river in 1882, and the Regulator Steamship Line ran boats as far upriver as The Dalles.[87] Rail passengers often complained, however, of dizziness on the trip caused by the frequent curves in the road.[88]

The completion of the Columbia River Highway along the Oregon side of the river in 1916 further opened the area for recreation. Built to accommodate tourists, the road featured graceful arching bridges and intricate stonework.[89] In the early 20th century, middle-class tourists who drove this scenic thoroughfare called themselves "Thoreaus at 29 cents a gallon," the cost of gasoline at the time.[90] Although I-84 replaced much of the old highway, late 20th-century tourists named this scenic route as one of the area's major attractons.[91]

By 1965, an estimated two million people a year had traveled to the Columbia River Gorge for recreation purposes.[92] A U.S. Department of Agriculture report in that year noted that recreation in the gorge was well accepted and of "a diverse nature," so that it could "truly be classed as a primary use of public lands" in the area.[93] Most activities have focused on the river. In 1987, sightseeing, visiting historical sites, camping, picnicking, day hiking, fishing, swimming, and boating were the most frequently cited recreational draws to the gorge area.[94] By that time sailboarding had become a popular activity around Hood River, luring enthusiasts from all over the world to "take advantage of what's touted as the best combination of wind and waves in the Western Hemisphere.[95] The less adventurous traveled to the river for more refined attractions, such as the historical Columbia Gorge Hotel in Hood River, which offered superb views and elegant decor.

Historic Columbia Gorge Hotel in Hood River, Oregon

In recognition of the historical, recreational, and natural significance of the lower river, Congress passed the Columbia Gorge National Scenic Area Act in 1986.[96] Although some landowners along the river protested the limitations that this act placed upon development, a federal judge upheld the scenic status of the area in 1990.[97] Tourists to the Columbia River have been attracted by the human-made features as well as the natural beauty. From the beginning of its construction in the late 1930s, Bonneville Dam drew visitors. "The ancient and the new meet here at the dam," explained one observer at that time. "In the midst of this primeval splendor rises the handiwork of modern man, the result of the eternal conquest of nature and its forces."[98] Another source during the1930s described Bonneville Dam as "a showplace for tourists."[99] By 1947, Bonneville had drawn more than half a million visitors annually. One spokesman for the Corps noted that not all these came for recreation. "Some hard working engineers," he explained in 1948, intended to investigate the powerhouse. Instead, they became distracted by the viewing facilities and spent "most of their time at this fish ladder looking at the fish go by."[100] These facilities provided the public information about fish passage and the Corps' mitigation efforts for salmon and steelhead.


Fish ladder at the Bradford Island Visitors Center


Summer visitors at Bonneville Dam


Sailboarding at Hood River in the Columbia Gorge


Fish Hatchery at Bonneville Dam Project


Fish viewing at the Visitors Center

A Department of the Interior report in 1980 noted the area's appealing combination of nature and human construction. This agency argued that the gorge warranted protection because "natural and man-made forces have combined to create a visually distinctive, diverse, and dramatic landscape that prevails upon human perceptions in an appealing manner." The diverse appeal of the gorge is reflected in the top five attractions for visitors: Multnomah Falls, the Columbia River Scenic Highway, Bonneville Dam, a fish hatchery, and Cascade Locks.[101]

The inclusion of two Corps structures on the list of major tourist attractions at the gorge reveals the agency's promotion of recreation along the Columbia River. Besides attracting tourists by offering tours of its dams and the fish runs, the Corps has extended recreational activities along the Columbia River as part of its involvement in the development of dams, even at projects such as Bonneville, "where recreation was not an authorized project function."[102] Navigation locks at the dams allowed recreational boating as far upstream as Lewiston, Idaho, and the Corps built visitor centers with fish-viewing rooms, walkways for observing fish ladders, and picnic areas.[103] One writer for *The Seattle Times* noted with regret the flooding of the Celilo Falls caused by the construction of The Dalles Dam, but also described the pleasure of taking a visitor train at the site, where he was able to inspect the fishways and powerhouse.[104] The slack water resulting from dam construction drew an increased interest in boating, and the Corps, often in cooperation with local governments, constructed boat landings and campgrounds along reservoir areas.[105]

Visitor train at The Dalles Dam

Along the Columbia River, summer remained the peak season for most recreational activities. Natural stream flows were generally at their lowest levels during this period, and low rainfall or snowpack further reduced the amount of water available. In years of lower than normal flow, boat docks, launching ramps, and beaches became stranded and unusable. Low water levels affected scenic values, too, for stumps and other hazards to water recreation became exposed. Although these effects remained most visible in storage reservoirs, they were also evident in the region's streams and rivers.[106]

Operations at dams such as Bonneville also caused fluctuations in the water level. As the Corps' Director of Civil Works explained in 1970, the agency "recognizes the importance of recreational use of its reservoirs, and under its multipurpose concept of operation makes every effort possible to meet the needs of recreation within the constraints of other project purposes."[107]

Development on The Columbia and Snake Rivers

The construction of Bonneville and Grand Coulee Dams in the 1930s initiated the multipurpose development of water resources in the Columbia Basin. During this period, concerns regarding the lack of a market for power prevented Congress from approving additional large-scale dam construction. Despite pressure from development groups, the Corps, too, warned against the premature production of power. Engineers at the North Pacific Division believed that multipurpose projects should be economically justified. World War II, however, changed their position. As wartime industries flourished in the Pacific Northwest, creating a greater demand for power, Congress concluded that additional multipurpose dams were essential for defense and industry.[108]

Accordingly, the Rivers and Harbors Act of 1945 authorized McNary Dam, named for Oregon Senator Charles L. McNary, who lobbied for multipurpose development of the Columbia River throughout his career. This legislation also authorized four multipurpose projects on the lower Snake River, including Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. In 1950, two years after a devastating flood on the Columbia River, the Rivers and Harbors acts authorized construction of The Dalles and John Day Dams. Completed in 1957, The Dalles was one of the largest projects constructed by the Portland District. John Day Dam, named for an early 19-th century fur trader, featured the second largest powerhouse in the world. This project, completed in 1968, also provided one of the highest single-lift locks, and the slack-water pool, extending 75 miles to McNary Dam, greatly benefited navigation.[109] Noting the rapid pace of multipurpose development in the Columbia Basin, *Time* Magazine explained in 1958 that "In the Pacific Northwest, which is crying for more cheap electricity, a big bloc of voters believes that only the Government can afford the big dams the region wants."[110]

McNary Dam

Ice Harbor Dam

Lower Snake River Dams

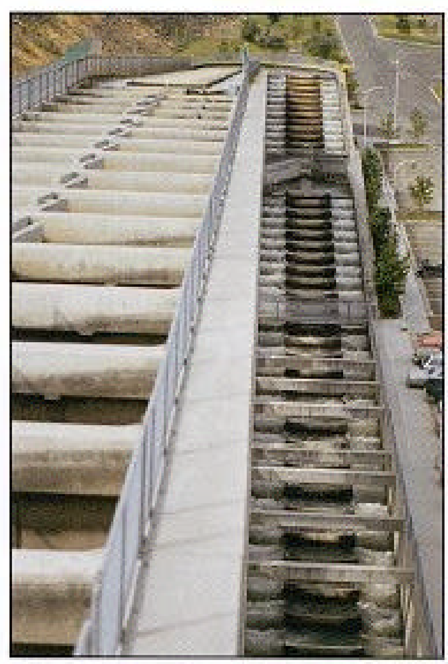
Lower Monumental Dam

Little Goose Dam

Lower Granite Dam

McNary, The Dalles, and John Day Dams included fish passages modeled in part on those at Bonneville. The apparent success of the adult fish facilities at Bonneville encouraged supporters of the Corps' 308 program to push strongly for completion of its multipurpose projects. Because Bonneville Dam passed one million fish of a variety of species annually, advocates of development argued that salmon runs could handle seven more.[111] Washington Senator Warren G. Magnuson, an enthusiastic supporter, touted the widely publicized slogan, "We Can Have Fish and Power Too!" Chambers of commerce, port authorities, businesses, and politicians adopted this rallying cry.[112]

John Day Dam fish ladder system

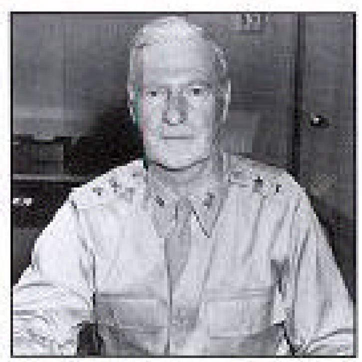


Fish ladders at The Dalles Dam

Not all biologists and fishery interests agreed. V.E. Benton of the Washington State Game Commission became one of the first to protest in 1937. Benton wanted the Corps to devote more money to the study of fish passages on the Columbia River.[113] Similarly, in 1941 the American Fisheries Society passed a resolution against high dams "until the economic and recreational aspects of the fishery resources have been adequately evaluated and provided for."[114] In the early 1940s, the Izaak Walton League also protested further dam construction. The Portland Chamber of Commerce, however, warned this organization of sports fishers not to "thwart human progress."[115]

The U.S. Fish and Wildlife Service feared that construction of The Dalles and the lower Snake dams would "exterminate the salmon."[116] During the mid-1940s, this agency attempted to obtain a moratorium on plans to dam the lower river, warning that the cumulative effect of additional high dams could severely deplete salmon populations. In response, the North Pacific Division explained that research regarding the effect of dams on fish remained inconclusive "because so many uncertainties exist, and because the development of the river for other needed purposes cannot be delayed indefinitely until all fisheries problems in connection with dams are solved." The Columbia Basin Inter-Agency Committee, formed in 1946 as a regional component of the Federal Inter-Agency River Basin Committee, did not support the proposed moratorium.[117] By 1949, the Oregon Fish Commission, an especially vigorous opponent of dam construction, had predicted that construction on the Snake River "will spell the doom of salmon and steelhead migrations up the Snake."[118]

Fisheries advocates increasingly requested more extensive studies of fish passage systems and fish mortality in dam turbines, at times antagonizing those who initially were sympathetic to their concerns. Exasperated by the protestors' animosity, Assistant Chief of Engineers Thomas Robins testified before Congress in 1941 that they were overstating the danger of the dams, especially the turbines, to juvenile fish. If you could put a mule through there, and keep him from drowning he would go through without being hurt."[119] Harlan B. Holmes, too, noted that different turbines varied in their impact on young fish--albeit in a less dramatic fashion.[120] The Inland Empire Waterways Association noted the Corps' statement regarding turbines with interest. Although this organization initially supported the fisheries advocates' demands for more research on the development of the fishways, by the late 1940s it had turned away from them.[121]



Assistant Chief of Engineers, Thomas Robins

Yet shortly after Congress authorized McNary and the Snake River dams, state fisheries agencies in Oregon and Washington conceded that "there can be no doubt that the majority of Federal Government projects are essential to the progressive advance of civilization."[122] During the mid-1940s, the U.S. Fish and Wildlife Service suggested that the advantages of multipurpose development could outweigh the detriment to fisheries resources. "The economic importance of water for purposes other than the propagation of fish is such that it cannot and should not be used solely for the sake of maintaining salmon runs. If conservation is wise use, it is the part of true conservation to choose the more valuable use of a resource whenever two or more uses conflict in such a way as to be mutually exclusive."[123] The Department of the Interior, too, concluded "that the overall benefits to the Pacific Northwest from a thorough-going development of the Snake and Columbia are such that the present salmon run must if necessary be sacrificed." The government's efforts, moreover, "should be directed toward ameliorating the impact of this development upon the injured interests and not toward a vain attempt to hold still the hands of the clock."[124] To some agencies, construction of major dams in the Columbia Basin seemed inevitable. The question became not how to stop it, but how best to mitigate damages.

Endnotes

[1]Schwantes, *The Pacific Northwest,* pp. 302-309.

[2]Nelson, "Can BPA Stave Off Price Jolt?" p. B1.

[3]Schwantes, *The Pacific Northwest,* pp. 326-330.

[4]Paul C. Pitzer, "The Mystique of the Grand Coulee Dam and the Reality of the Columbia Basin Project," *Columbia* 4 (Summer 1990): 28-38.

[5]William L. Finley, "Fish Protection and the Industrial Use of Waters," *Bird-Love* 39 (Mar./Apr. 1937): 123.

[6]Pitzer, "The Mystique of the Grand Coulee Dam," p. 28. See also Jim Marshall, "Dam of Doubt," *Collier's* 99 (19 June 1937): 19, 82-84.

[7]Neal Kendall, "The Bonneville Dam," Washington State Historical Society, Works Progress Administration Collection, p. 9.

[8]Willingham, *Water Power in the "Wilderness,"* p. 47.

[9]Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920* (Cambridge: Harvard university Press, 1959).

[10]A.L. Riesch Owen, *Conservation Under FDR* (New York: Praeger Publishers, 1983), p. vii; Willingham, *Water Power in the "Wilderness,"* p. 3.

[11]Roderick, Nash, ed. *The American Environment: Readings in the History of Conservation,* 2d ed. (Menlo Park, California: Addison-Wesley Publishing Company, 1976), p. 131.

[12]Owen, *Conservation Under FDR,* p. 105.

[13]Willingham, *Water Power in the "Wilderness,"* p. 1.

[14]Owen, *Conservation Under FDR,* p. vii.

[15]William F. Willingham, *Army Engineers and the Development of Oregon: A History of the Portland District U.S. Army Corps of Engineers* (Washington, D.C.: U.S. Government Printing Office, 1983), p. 46; Albert E. Cowdrey, "Pioneering Environmental Law: The Army Corps of Engineers and the Refuse Act," *Pacific Historical Review* XLIV (Aug. 1975): 332-333; William F. Willingham, *Northwest Passages: A History of the Seattle District U.S. Army Corps of Engineers, 1896-1920* (Seattle: U.S. Army Corps of Engineers, 1992), pp. 15-20.

[16]Jones, *Salmon Fisheries of the Columbia River,* pp. 7-8.

[17]Jones, *Salmon Fisheries of the Columbia River,* pp.50-52; Willingham, *Army Engineers and the Development of Oregon,* pp.192-195.

[18]Cowdrey, "Pioneering Environmental Law," pp. 333-36, 342, 349.

[19]According to some observers, however, the Corps used the act primarily to protect navigation. See, for example, Arthur E. Morgan, *Dams and Other Disasters: A Century of the Army Corps of Engineers in Civil Works* (Boston: Porter Sargent Publisher, 1971), p. 403.

[20]Willingham, *Northwest Passages,* pp. 20-28; Willingham, *Water Power in the "Wilderness*," pp. 1-4; Willingham, *Army Engineers and the Development of Oregon,* pp. 92-104; Mary Reed, *A History of the North Pacific Division* (Portland: U.S. Army Corps of Engineers, North Pacific Division, 1991), p. 48.

[21]Willingham, *Army Engineers and the Development of Oregon,* p. 95; Reed, *A History of the North Pacific Division,* p. 50.

[22]Willingham, *Water Power in the "Wilderness,"* pp. 4, 47.

[23]See, for example, Schwantes, *The Pacific Northwest,* pp. 308-309; Netboy, *The Columbia River Salmon,* p. 75; Jerald W. Schmunk to Editor, *Atlantic Monthly,* 25 March 1976, Public Affairs Correspondence Files, 360th General Army Information, Fish and Fish Facilities, Portland District, U.S. Army Corps of Engineers; Bullard, *Crisis on the Columbia,* pp. 45-46; 99-120.

[24]Netboy, *The Columbia River Salmon,* p. 75.

[25]Col. Lukesh to Chief of Engineers, 8 Mar. 199, National Archives Record Group 77, Columbia River File No. 7249.

[26]U.S. Congress, House, *Columbia River and Minor Tributaries,* 73d Cong., 1st Sess., 1932, H. Exec. Doc. 103, pp. 10, 1539, 1597, 1599, 1603. See also U.S., War Department, *Annual Report,* 1934, pp. 1334-1337.

[27]Oscar O. Kuentz, "The Lower Columbia River Project," *The Military Engineer* 25 (Jan./Feb. 1933), p. 44.

[28]"Fishways at Bonneville Dam to Cost $3,550,000," *Engineering News-Record* 116 (1 Feb. 1936), p. 235.

[29]Reed, *A History of the North Pacific Division,* p. 55; "We'll Take Hatcheries, But Give Us Dams, Too," *Oregon Journal,* Public Affairs Correspondence Files, 360b General Army Information, Fish and Fish Facilities, Portland District, U.S. Army Corps of Engineers, n.d.

[30]Harlan B. Holmes, "The Passage of Fish at Bonneville Dam," *Stanford Ichthyological Bulletin* 1 (3 May 1940), p. 182; Harlan B. Holmes to Anthony Netboy, 19 June 1971, Harlan B. Holmes papers, University of Washington Archives, Accession no. 2614, Box 2, Anthony Netboy file, pp. 2-3. See also Willingham, *Water Power in the "Wilderness,"* p. 47.

[31]Harlan B. Holmes, "Progress Report of Bonneville Dam Fishway Investigation," Design of Fishways at Bonneville folder, Bonneville Lock and Dam Project, Records Holdings, 14 Oct. 1935, p. 2.

[32]Willingham, *Water Power in the "Wilderness,"* p. 48.

[33]Willingham, *Water Power in the "Wilderness,"* p. 48.

[34] "Conservation," *Nature Magazine* 29 (Jan. 1937): 41.

[35]Frank N. Schubert, "From the Potomac to the Columbia: The Corps of Engineers and Anadromous Fisheries," unpublished manuscript, Office of History, U.S. Army Corps of Engineers, Fort Belvoir, Virginia, p. 51.

[36]Schubert, "From the Potomac to the Columbia: The Corps of Engineers and Anadromous Fisheries," pp. 52-53; Willingham, *Army Engineers and the Development of Oregon,* pp. 195-196.

[37]Willingham, *Water Power in the "Wilderness,"* p. 49; Willingham, Army Engineers and the Development of Oregon, pp. 196-197.

[38]Willingham, *Army Engineers and the Development of Oregon,* pp. 196-197; Willingham, *Water Power in the "Wilderness,"* p. 51.

[39]This figure represents 1930s dollars.

[40]Owen, *Conservation Under FDR,* p. 27.

[41]Richard L. Neuberger, "Climb, Fish, Climb!," *Collier's* 100 (6 Nov. 1937): 50.

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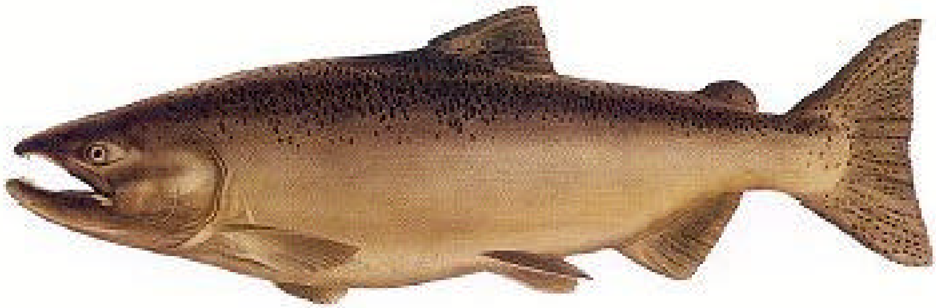
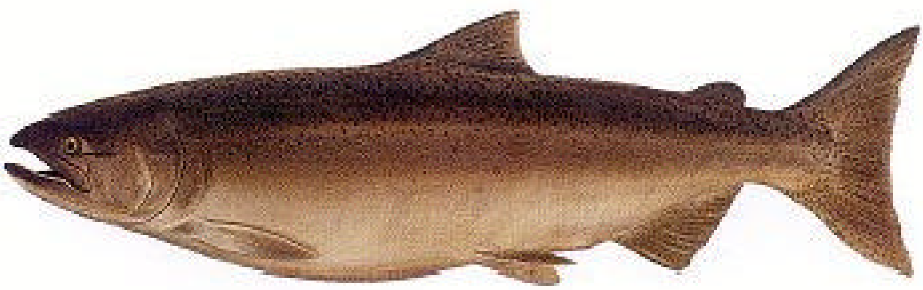
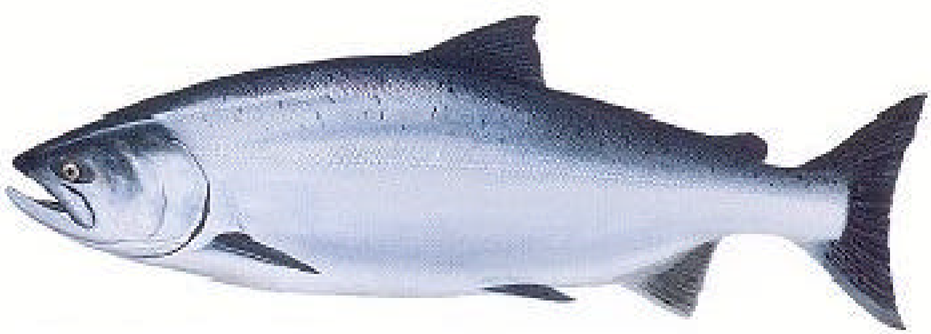


Chinook Male - Freshwater Phase



Chinook Female - Freshwater Phase



Chinook- Ocean Phase

III. Researching Causes of Fish Losses

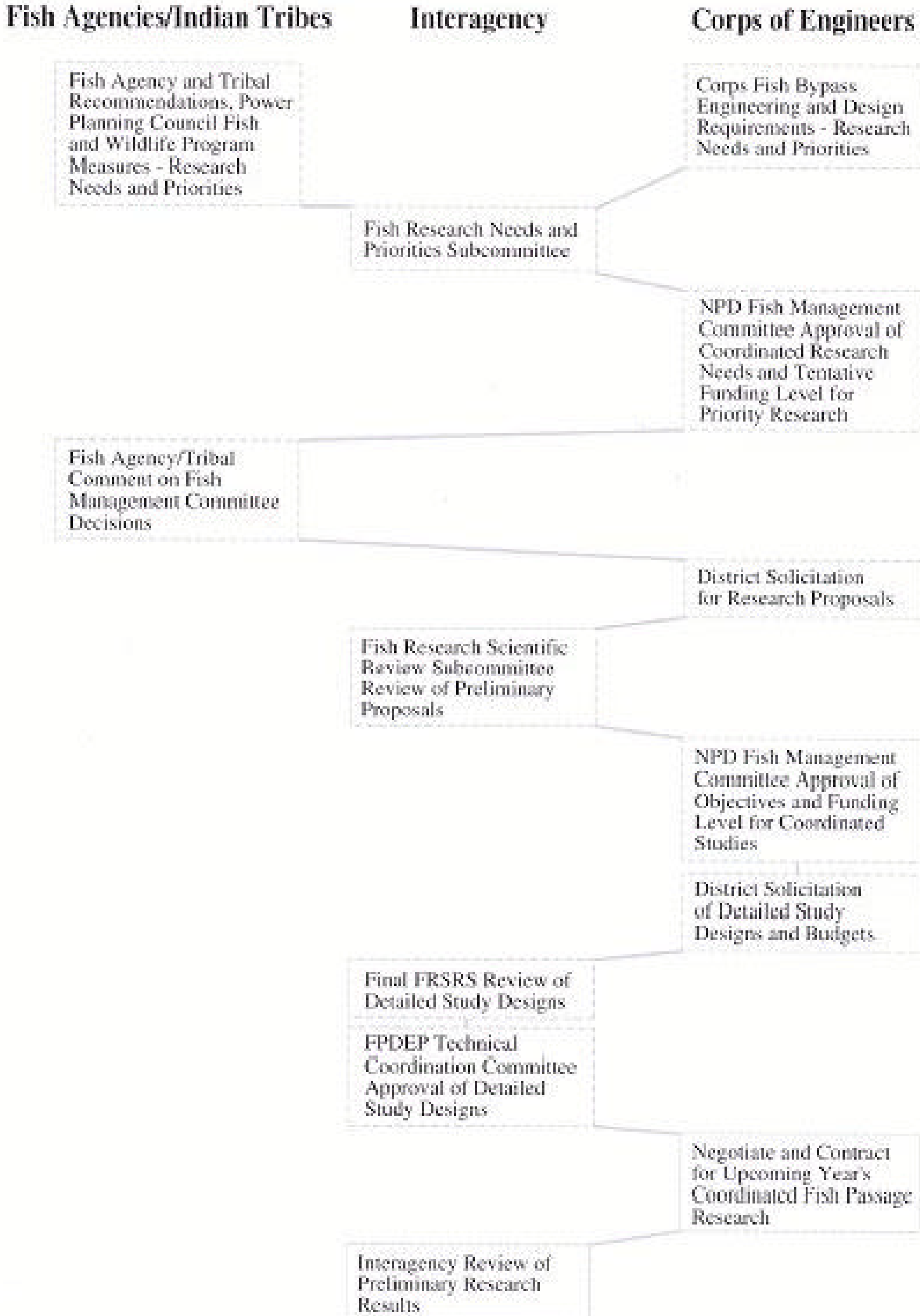
Studies

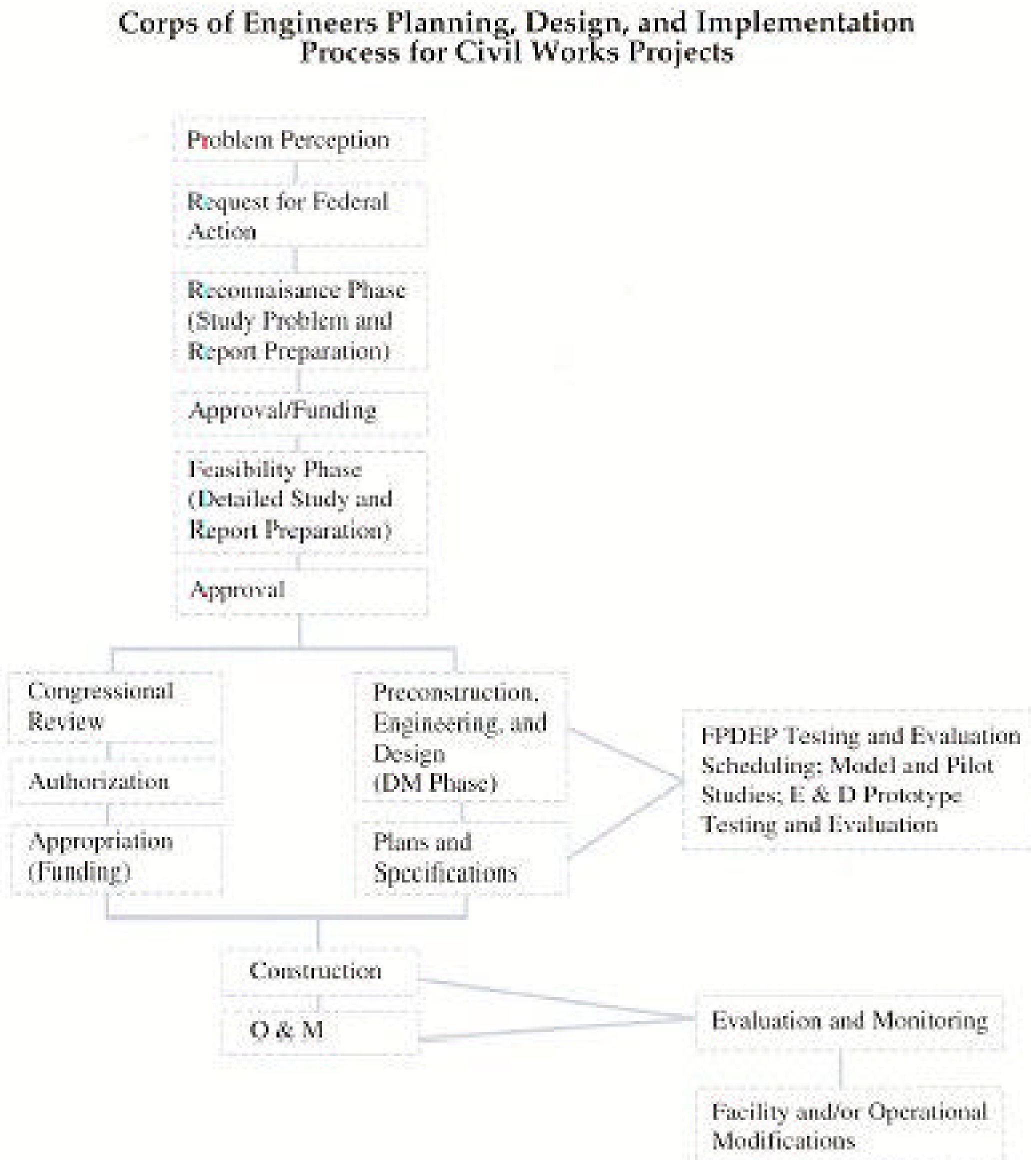
The Corps' interest in fish mortality on the Columbia River dates back to Major William Jones, who reported "an enormous reduction in the numbers of spawning-fish" to Congress in 1888.[1] He recommended further study of the problem. When the Corps built Bonneville Dam in the late 1930s, scientists still knew very little about the migratory behavior of Pacific salmon. Although biologists before this period had collected information on artificial propagation, fish screening, and fishway construction, their knowledge resulted from "trial and error rather than scientific research." Funding for such efforts was scarce, in part because state and federal agencies "failed to appreciate the value of fish research." During the 1930s this perception began to change, as Americans recognized that "the fishery was in serious jeopardy as a result of water-use developments and the dearth of factual information on fish protection and propagation."[2] From the beginning of its construction of large multipurpose dams on the Columbia River, the Corps recognized the need to discover more about fish mortality and to improve fish passage facilities. For more than five decades, this agency has researched the causes of fish losses at its dams.

The Fish and Wildlife coordination Act, first passed in 1934 and amended in 1946, required the Corps to cooperate and consult with the newly created U.S Fish and Wildlife Service and the states in considering damages to natural resources. By 1958, Congress had again amended the act to require that the Corps give the conservation and enhancement of fish and wildlife "equal consideration" with water development in the agency's project planning. According to Edward M. Mains, who worked as a biologist in the North Pacific Division office, this agency "has always been responsive to laws." The Corps "takes the Fish and Wildlife Coordination Act very seriously and makes a concerted effort to comply with its spirit and its intent."[3]

As part of that effort, the agency began developing a major research program in cooperation with the Bureau of Reclamation and the U.S. Fish and Wildlife Service. Initiated during the 1940s, this research effort was hampered by a wartime lack of funding and personnel.[4] In 1951, the Corps established and financed the Fisheries Engineering Research Program, later called the Fish Passage Development and Evaluation Program (FPDEP). This interagency program was a part of the Corps' effort to research and mitigate for fish losses that would result from the proposed construction of additional dams on the mainstem Columbia and Snake Rivers. Organizations such as The Pacific Fisheries Conference commended the Corps for "undertaking this work," noting in 1953 that "millions of dollars have been spent on fish ladders and more millions have been allocated for fish facilities on dams now being constructed without this essential knowledge."[5] (See Figures 2 and 3; and Table 8.)

North Pacific Division - Corps of Engineers
Fish Passage Development and Evaluation Program Chart for Development of Fish Research Studies





In the early 1990s, the FPDEP included representatives from the National Marine Fisheries Service, U.S. Fish and Wildlife Service, Columbia River Inter-Tribal Fish Commission, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, Washington Department of Fisheries, and Washington Department of Wildlife. The Bonneville Power Administration and the Northwest Power Planning Council sat as informal participants. This program aided the Corps in planning and implementing anadromous fish passage research for projects on the Columbia and Snake Rivers. For the first several years, the Fisheries Engineering Research Program focused on studies of adult fish migrating upstream. As the Corps completed additional dams in the 1950s and 1960s, however, the agency also funded research concerning juvenile fish passing downstream.[6]

Some historians claim that the Corps has consistently demonstrated flexibility and adaptability to changing public values throughout the decades.[7] Other observers agree that the agency, in general, has been receptive to public interest.[8] As more Americans became concerned about environmental issues in the late 1960s, the Corps increased its commitment to fisheries research. By 1970, the environmental movement had begun to influence federal wildlife policy, resulting in the passage of the National Environmental Policy Act (NEPA), which strengthened requirements for federal agencies to mitigate damages to fish and wildlife populations. At this time, the Corps employed more than 200 environmental specialists nationwide. In the 1960s and early 1970s, the Corps increased its research and mitigation efforts on the Columbia and Snake Rivers.[9]

Since the construction of Bonneville Dam, biologists have discovered a number of general causes of fish losses at multipurpose dams. These included the passage of juvenile fish through turbines or over spillways or in bypass systems; gas supersaturation of spillway discharges; predation; delays in migration (and the effects of power peaking); and degradation of spawning grounds.

Research at Bonneville

Ivan J. Donaldson, pictured left, conducting experiments on juvenile passage, Columbia River

In addition to funding research by other agencies, the Corps employed its own biologists. Ivan J. Donaldson was one of the first to work for the Corps. Donaldson grew up in central Oregon, near Maupin. As a child, he developed an early interest in the outdoors and in recreational angling along the Deschutes River. After attending what is now Oregon State University in Corvallis, Donaldson became the Corps' first biologist on the Columbia River. [10] He began researching at Bonneville Dam as the project's Resident Biologist in 1941, and as the Corps built additional dams on the Columbia River he was promoted to District Biologist. Donaldson continued to work for the engineers until his retirement in 1973.[11]

For the first few years his was a "lonely job." Yet the engineers at Bonneville rapidly learned of Donaldson's commitment and dedication to fish protection.[12] This facility "may be a partial exception," he noted, but "dams in general are still inimical to fish." An ardent conservationist, Donaldson suggested a variety of measures in 1942 to protect his "beloved fish," including experiments to determine mortality of downstream migrants, installation of traveling screens at the powerhouse and Bradford Island ladders, and the removal of predatory fish.[13] Initially, some engineers at Bonneville Dam did not "want to be bothered with the concerns of a scientist."[14] According to Donaldson, one engineer "in a high place" informed him, "I don't know anything about fish except that they are a damn nuisance." Donaldson also summed up the attitude of the engineers as "To Hell with the Fish. I'm here to build a dam." [15]

As Edward M. Mains explained, "engineers are engineers." In the early days of dam construction on the Columbia River, the Corps was primarily a construction agency that was "cost conscious" and "time conscious." Many of those involved in construction had little knowledge about the fisheries resource, while the actual work on the dams proved to be a "learning experience" for biologists as well as engineers. In any case, Mains remembered that Donaldson sometimes was not "politic with engineers." [16] Donaldson, too, noted his own "lack of tact."[17] Yet the Corps recognized the abilities of this biologist--and retained him for more than three decades.

Edward M. Mains served as the Corps' Research Program Director from the early 1960s to 1986

For all his frustration with the early engineers at Bonneville Dam, Donaldson noted the Corps' adaptability. "Fishery matters were forced on them," he explained in 1942, but "this construction agency was wise enough to listen to the fisheries people, and elaborate measures were taken to protect the salmon." In his estimation, the Corps' motto, "Let us try," demonstrated "a willingness to tackle a problem." During his early years at Bonneville Dam, Donaldson persisted in his attempts to convince the engineers to take fisheries issues seriously. He also encouraged the Corps in its early mitigation efforts to cooperate with the Fish and Wildlife Service and the State Fish and Game Commissions.[18]

After he retired, Donaldson recalled that initially the Portland District Office "flatly denied permission to do research." By 1945, however, the Corps had provided funds for research under the guidance of state and federal fisheries agencies. At first, working with these biologists was difficult for Donaldson, who explained that during the 1940s "anyone who belonged to the Corps of Engineers was a...pariah, a hated adversary," at least among fisheries scientists. The animosity was so intense at one meeting of the Pacific Fisheries Biologists that Donaldson "fled like a quail." Eventually, Donaldson overcame their opposition, once they realized he "was working for the fish."[19] Like the engineers, fisheries scientists soon came to recognize and respect Donaldson's persistence and dedication. Robert Schoning, who served as Director of the Fish Commission as well as NMFS, recalled that "there wasn't anyone who was more seriously concerned about fish."[20]

Robert Schoning was Director of the Fish Commission as well as Director of NMFS

Donaldson's interests and talents were not limited to fisheries biology. He also studied exotic gardening, fencing, and history. He wrote numerous essays on the development of fisheries research and the harvesting of anadromous fish in the Columbia Basin. His publications included a book on fishwheels. Although he had a fondness for "75-cent words," Donaldson generally wrote in a lively, readable format.[21] He authored many of the early fish reports concerning Bonneville Dam. One of Donaldson's most striking characteristics was his interest in Aldo Leopold and environmental ethics. "Is it true," he asked, "that all animals subservient to us should be sacrificed to our appetites?" He made it clear that he did not subscribe to that view.[22]

Donaldson's research at Bonneville provided a foundation for work at subsequent dams. Studies conducted at this facility during the 1940s aided the development of fish passage facilities at McNary Dam, which began operating in 1953. When biologists proposed construction of a fish tunnel at McNary Dam, they experimented with this idea at Bonneville Dam, covering a segment of the fish ladder to observe how fish were affected by a darkened area.[23]

Juvenile Fish and Turbines

Harlan B. Holmes, biologist with the Bureau of Fisheries

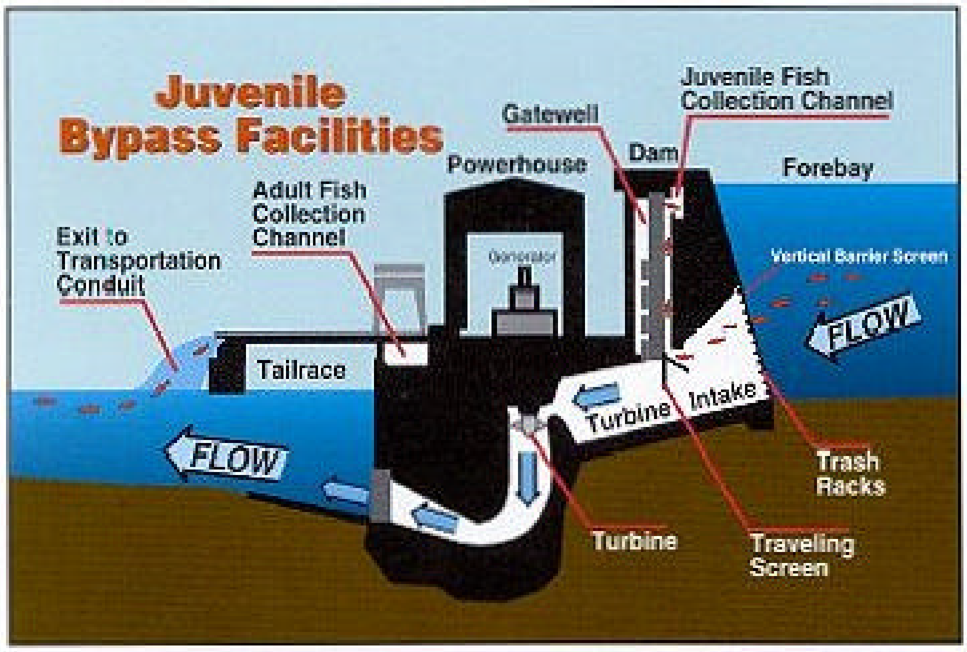
At Bonneville Dam, Donaldson also conducted valuable research on the migration of young fish. He kept records of smolts captured in the juvenile bypass traps, located at the north end of the spillway and the south end of the powerhouse. When the Corps constructed Bonneville Dam during the 1930s, few people understood the problems that young fish would encounter.[24] Harlan B. Holmes, a biologist with the Bureau of Fisheries, explained that research on adult fish proceeded first. In 1935, Holmes noted that preliminary studies on the hazards of turbines to young fish had not revealed "sufficiently frequent injuries to justify the tremendous expense of screening the power wheels at Bonneville."[25] One Corps report, produced in 1938, concluded that "Extensive laboratory and field tests indicate that there is little danger of injury to small fish passing through the Bonneville turbines."[26]

Later, Corps biologists and other researchers learned that losses to juveniles were higher than initially believed. Holmes was the first to measure the loss of young salmon passing a dam on the Columbia River. In 1947, he explained that "hydraulic turbines differ all the way from literal sausage grinders to a very satisfactory route for the passage of fish."[27]

Holmes had worked at Bonneville Dam since the mid-1930s, when he helped design the original fishways at that facility. Like Ivan J. Donaldson, he gained a reputation for commitment and dedication among fisheries biologists. Ivan's wife Louise, formerly of the U.S. Fish and Wildlife Service, recalled that Holmes "was always working at top speed and thinking at top speed."[28] Staff at the NMFS remembered that Holmes once amused and surprised his colleagues by disrobing and swimming in the icy fishways at Dryden Dam on the Wenatchee River--an activity he hoped would enable him to discover "the problems the fish might enounter."[29] By the time he retired in 1958, Holmes had worked on every major dam along the Columbia River.

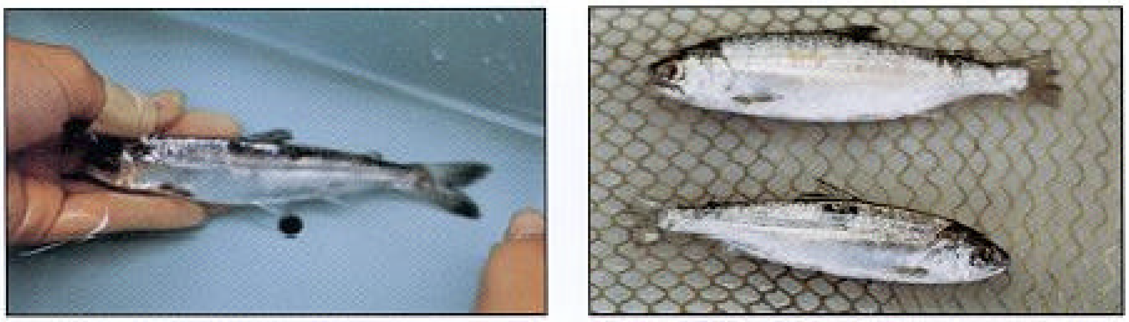
Although often compared to a blender, a turbine operates as a giant water wheel with large, smooth blades. While a blender's sharp blades rotate at around 3,000 RPM, a turbine turns more slowly, at around 85 to 90 RPM.

Juvenile salmon that move through a turbine are not sliced and diced. Even so, it is a stressful experience - and the Corps has installed screens in front of the turbines. Screens divert most of the fish from these devices, delivering them to the river below or routing them to be collected and transported around the remaining dams and reservoirs.



In 1952, Holmes estimated the mortality of juvenile fish at Bonneville Dam to be about 15 percent, but cautioned that this figure was not precise. In his experiments, Holmes marked young hatchery salmon by removing two fins, and released them in two groups: one above the dam and the other below. Scientists retrieved these fish when they returned to the river as adults. Initially, the Corps limited the distribution of his study, owing to disputes concerning its statistical methods. "The Corps of Engineers would not object to an adverse report on the effects of Bonneville Dam on the salmon fishery," Lieutenant Colonel L.W. Correll explained in 1952, "so long as the adverse findings are based on factual and conclusive data."[30] For all the Corps' caution, Homes' research carried immediate political implications. Hearing of his study, the Yakima Indian Nation (now Yakama) requested the "results of the analysis" to use as evidence in their claim against the federal government for Bonneville Dam's damages to their fisher. The U.S. Fish and Wildlife Service, however, instructed its officials to keep the report confidential, and Holmes' report did not appear in print.[31]

In 1961, nine years after Holmes' study, Dale E. Schoeneman, a biologist at the Washington Department of Fisheries, conducted further research on juveniles funded by the Corps' Fisheries Engineering Research Program. Schoeneman estimated direct mortality of juvenile chinook passing over the spillway at McNary Dam to be 2 percent, and those passing through the turbines to be 11 percent. By the 1970s, other researchers reported the estimation of a 15-percent juvenile mortality rate from all causes to be conservative.[32]



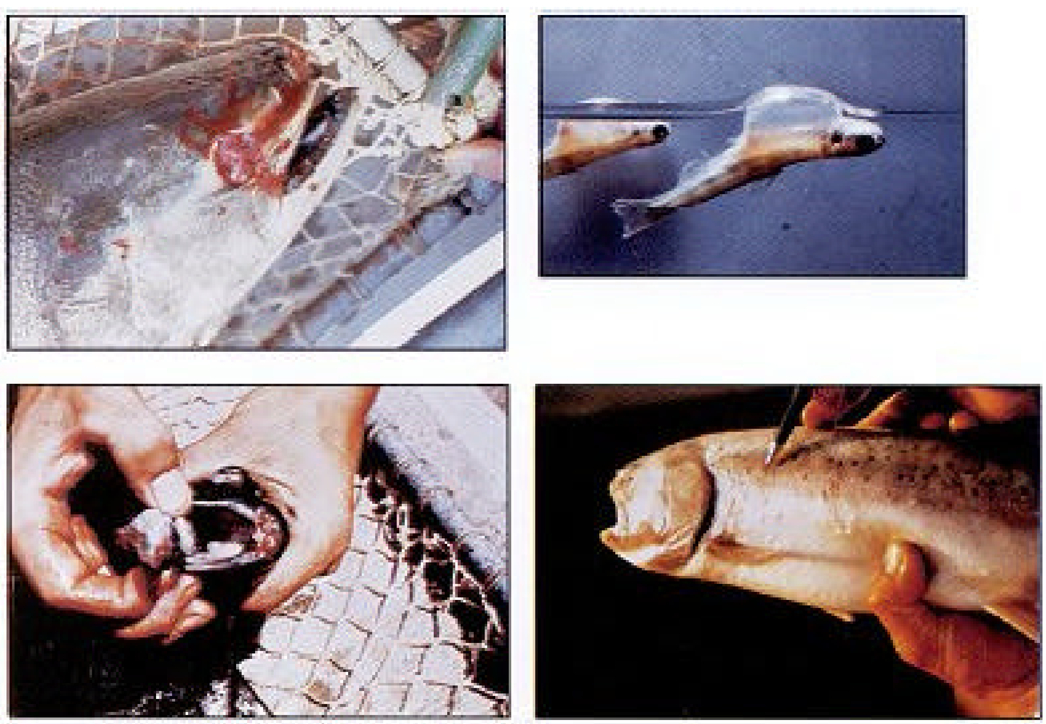
Fish injured by turbines, revealing descaling and loss of most of caudal fin

Additional studies in the 1970s demonstrated mortality to be as high as 30 percent for juvenile coho passing through turbines at Ice Harbor and Lower Monumental dams, when indirect mortality from predation in the tailrace was included. Indirect loss from predation varies from dam to dam and year to year, depending on variations in predator populations. The cumulative effect of juveniles passing through turbines of eight dams is substantial, even if the lowest turbine mortality estimate is used and predation is assumed to be zero. For example, an 11-percent loss for each dam results in only a 35-percent survival of juvenile migrants if they must pass through the turbines of all eight Corps dams on the lower Columbia and Snake Rivers. During the low flow years of 1973 and 1977--when only limited spill was available--almost all the juvenile migrants had to pass through turbines. At that time, biologists estimated losses of 95 to 99 percent[33] (see Figure 4).

Gas Bubble Disease

One of the most visible causes of fish loss, in terms of public awareness, is gas bubble disease. In the late 1960s, studies revealed that substantial numbers of young migrating salmon died of this condition. Although researchers first discovered gas bubble disease in fish hatcheries in the 1930s, it did not become a problem in the Columbia River system until the 1960s, when the Corps completed the dams on the lower Snake River. In 1970, the regional director of the NMFS noted that "It is only recently that the deleterious effects of supersaturation of nitrogen on salmonids have been discovered." Fisheries agencies were aware of "possible harmful effects of construction of dams," but they could not predict "the effect of dam operation upon the gas content of the river."[34]

As water plunges down a dam's spillway, the churning motion causes gas, mostly nitrogen, to be pressurized in the stilling basin and dissolved in the river. Entrained air that occurs naturally, such as in a waterfall, quickly returns to the atmosphere, just as dissolved nitrogen in a fast-moving river is rapidly freed. Dams, however, create slack-water, low-velocity pools that do not purge dissolved nitrogen picked up from entrained air. Supersaturation emerged as a major problem when dams were constructed so closely together that excess nitrogen could no longer escape into the open river. Fish absorbed the dissolved gas, which caused emboli and erupted in bubbles in their flesh and bloodstream. The symptoms are dramatic: salmon with gas bubble disease develop blistered scales as well as swollen and ruptured eyes. In 1971, the NMFS estimated that gas supersaturation killed 70 percent of the downstream migrants in the lower Snake River.[35]



Gas bubble disease, showing blisters or bubbles in the eye, mouth, and skin

The first indication of a problem to adult fish caused by gas supersaturation occurred in 1964. At this time, researchers noted a high rate of prespawning mortality caused by gas bubble disease in chinook at the McNary Dam spawning channel. The McNary spawning channel drew its water from the tailrace that was supersaturated with atmospheric gas during periods of high spill at upstream dams. The mortality probably resulted from the shallow water that provided fish little opportunity for the depth compensation that could occur if they were spawning naturally. Biologists documented the first substantial loss of adult salmon and steelhead in 1968. Based on the recovery of dead salmon, the Fish Commission of Oregon estimated that more than 20,000 summer chinook were missing in the area of study. The magnitude of this loss related to the delay of adult migrants in the tailraces of John Day where concentrations soared, up to 143 percent of saturation. Researchers also examined the relationship between dissolved gas supersaturation in the Snake River and the number of spring and summer chinook redds on the spawning grounds in the Salmon River system, and they noted that during years when supersaturation escalated, redd counts were low even after compensating for the size of the runs.[36]

Because gas bubble disease destroyed a large number of juvenile and adult fish, the public became alarmed. Regional newspapers in the early 1970s illustrated hundreds of dead fish floating downstream and called for "battle plans" to save the salmon.[37] In a telegram to Congressman Thomas S. Foley, a representative of Trout Unlimited worried that "high mortality is threatening all fish life in the entire Snake River System." His message ended with a single word: "Help."[38]

The Corps' response was immediate. By early 1971, its staff had organized the Nitrogen Task Force, which included a number of fisheries agencies, to ameliorate the problem. For several years, the Corps had been funding the NMFS to conduct nitrogen sampling at a yearly cost of approximately $12,000. The Corps also had funded the development of a mathematic model to demonstrate how nitrogen entrainment occurs. In the early 1970s, the Corps sponsored additional studies of structural and operational solutions to the problem.[39] In consultation with the fisheries agencies, the Corps developed an innovative solution to the problem. Hugh Smith, a hydraulic engineer in the North Pacific Division, advanced the concept of spillway deflectors, or "flip lips," to limit the plunge depth of water over the dam spillway. Installation of these devices, along with the placing of additional turbines at key dams, helped reduce the supersaturation of atmospheric gas and the occurrence of gas bubble disease.[40]

Predation

Evidence that predators might be a significant problem in the reservoirs created by the Corps dams emerged in the late 1960s and early 1970s. At that time, dam counts revealed increasing numbers of squawfish, which are particularly aggressive in pursuing young salmon. The NMFS began studying the problem in 1973, and continued research through 1978. During the first year of these studies, researchers conducted purse seining in the reservoirs of McNary, John Day, and Lower Monumental Dams, and in the tailraces of Little Goose and Lower Granite Dams. The first year demonstrated the abundance of squawfish and their presence in all locations. Later studies included the use of Merwin traps, which allowed easy marking for population estimates. In 1977, researchers estimated 106,000 and 164,000 squawfish were present in the tailrace areas of Little Goose and Lower Granite Dams, respectively.[41] The large numbers of squawfish in the reservoirs helped explain the high loss estimates of Howard L. Raymond and Carl W. Sims during low-flow years.

Merwin Trap

Three chinook smolts in stomach of squawfish captured in Lower Monumental Reservoir

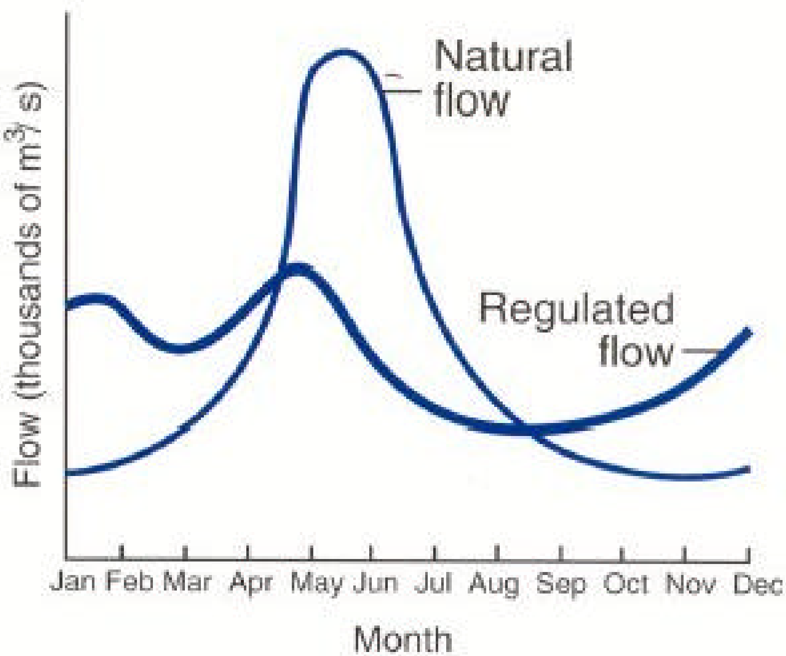
Several chinook smolts in large trout captured in Columbia River

Funding for research remained limited. As the Corps increasingly turned its attention to other investigations, including the study of fish screens in turbine intakes, the agency stopped supporting predation research in the late 1970s. The U.S. Fish and Wildlife Service and the Oregon Department of Fish and Wildlife continued these studies under the Northwest Power Planning Council's Fish and Wildlife program. These agencies further refined population estimates and developed a predation index, expanding the studies to include walleye and smallmouth bass.[42] They recommended a systemwide predation control and evaluation program, which is currently underway.

Delays in Migration

Young fish also encountered a delay in downstream migration. Research on the effects of the impoundments behind "river run" dams--all about 100 feet high, and reservoirs have a limited storage capability--on the Columbia River has demonstrated that the average impoundment detained young migrants about three days.[43] The dams controlled the freshets that once had rapidly carried young fish to the sea. Juvenile salmon, however, had evolved under this seasonal flooding, which aided their migration. In the impoundments, the water--and the fish--moved more slowly. This problem became especially significant in the upper river, where young fish were delayed almost a month in reaching the estuary.[44]

The delay in migration through the river extended the exposure of the young fish to hazards such as disease and predation. Delays of this magnitude prevented some migrants from making the transfer from fresh to salt waters.[45] During extremely low-flow years, such as 1973 and 1977, some steelhead and chinook smolts failed to migrate to the sea and remained in the reservoirs until the following spring, when they succeeded in traveling downstream[36] (see figure 5).



Comparison of Natural and Regulated Flow Regimes

The greater surface area and volume of the impoundments behind the dams also resulted in a shift in temperatures. The cooling trend that normally occurred in late summer and early fall was delayed approximately one month. High-water temperatures became critical, particularly to adult spawning salmon, which evolved to begin spawning as waters cool in the fall. Delays in this normal cooling trend result in poor spawning success of some stocks. Fall chinook are particularly affected. Also, temperature shifts improved the habitat of many of the competitors and predators of anadromous fish, to the detriment of young salmonids.

Power Peaking

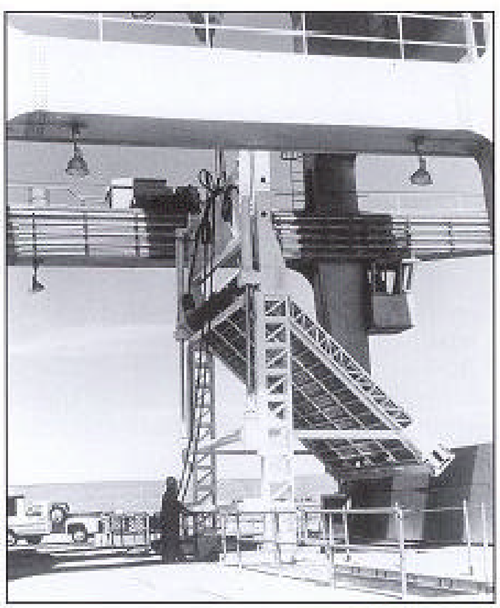
Power peaking also affected juvenile salmon. It generally occurred during daylight hours--at periods of high demand--and diminished at night and on weekends. Researchers studied the effect of power peaking on the diel (24-hour) movement patterns of juvenile salmonids from 1972 to 1986. They obtained data during the early studies by 24-hour sampling with purse seines in the forebays of dams, with concurrent 24-hour sampling of gatewells. These early studies revealed significantly greater movement of salmonids during daylight hours in both the reservoirs and from gatewells in August and September after peaking generally began. In contrast, earlier research conducted in years prior to peaking indicated most migrations occurred at night. Later studies utilizing hydroacoustics and juvenile radio tracking successfully determined passage rates into turbines, sluice gates, and spillbays on a diel basis.[47] This research enabled researchers to estimate hourly delays, along with detailed information on migration routes taken by juveniles under various modes of dam operations. However, even with this advanced technology, researchers could not accurately estimate loss occurring over short periods of time.

Bypass Systems

Bypass systems divert fish from entering turbine intakes and thus reduce or eliminate this source of loss. However, if a bypass system is not properly designed or operated, loss of migrants passing through could be as high or higher than the loss of migrants passing through the turbines.

Early bypass systems and fish-handling facilities were not as sophisticated as those of today. Researchers periodically noted high levels of descaling, particularly during low-flow years when smolts were probably stressed before arriving at the dam. For example, in 1973 and 1977 descaling rates average 13.9 percent and 13 percent at Little Goose and Lower Granite Dams, respectively.[48] These descaling rates included those caused by the bypass facility and those occurring before the fish arrived at the facility. Several improvements in the systems, including installation of debris collecting booms, improved traveling screens, and transportation channels, failed to rectify the problem completely. During periods of high rates of descaling, bypass-associated mortality could be significant. Fish descaled or otherwise stressed could be more susceptible to predation and disease and most likely would not survive. Current measurements of descaling at the improved bypass systems are very low, and biologists attribute much of the descaling that occurs to sources not associated with the bypass. In the early 1990s, research at Bonneville Dam demonstrated that mortality of fish passing through the bypass is higher than fish passing through the turbines, and most likely was due to predation at or near the release location of the bypass.

EARLY TRAVELING SCREENS



First prototype of Turbine Intake Traveling Screen, tested at Ice Harbor Dam in 1969.

Sectional view of Horizontal Traveling Screen, tested by the National Marine Fisheries Service in the 1960s.

Additional research will be needed to determine the best way to ensure the highest survival, particularly at dams where the fish are not transported. Collection and transportation reduces mortality, since the trip downstream eliminates several dams and reservoirs. Because each dam is different, with varying hydraulic conditions, data obtained at Bonneville Dam would not necessarily apply to the other hydroelectric facilities.

Loss of Spawning Grounds

Inundation of spawning grounds is one of the most serious dam-related causes of fish mortality. Usually, inundation completely destroys the spawning habitat. Consequently, substantially fewer adults return in subsequent years, particularly when hatcheries constructed to compensate for the losses fail to match the returns of the lost wild fish. The construction of John Day and McNary Dams eliminated important spawning grounds for fall chinook. In 1968, Leonard A. Fulton, a biologist with the NMFS, estimated that an average of 34,000 fall chinook spawned between John Day and McNary Dams. He indicated that significant numbers spawned in the area inundated by McNary Dam. Twelve years later, Charles O. Junge of the Oregon Department of Fish and Wildlife estimated losses of fall chinook caused by the lower river dams (Bonneville to McNary) from all causes to be 143,000 annually. However, he did not provide information regarding the precision of this estimate. The total loss from spawning ground inundation is between approximately 34,000 and 50,000 spawners.[49] These figures do not include substantial losses that resulted from the Idaho Power Company's construction of the Brownlee, Oxbow, Hells Complex, which destroyed adult passage, and the construction of Public Utility District (PUD) dams that inundated summer chinook spawning grounds. Nor do these figures reflect the losses that resulted from the Bureau of Reclamation's construction of Grand Coulee Dam in the late 1930s, which did not include fish passage facilities.

Interagency Cooperation

Throughout the decades since the construction of Bonneville Dam, the Corps actively research fish mortality and ways to reduce it. In this effort, the Corps has cooperated with a variety of federal and state fisheries agencies, often taking the lead in coordinating and funding research activities. As demonstrated, the Corps had organized and financed research efforts since the early 1950s. From the beginning of this undertaking, the Corps also looked to the fisheries agencies to help identify research needs and to request funding.[50] The Portland and Walla Walla Districts "relied heavily on the fisheries agencies," recalled Robert Schoning, a biologist who served as both Director of the Fish Commission and the NMFS. Schoning, who retired in 1986, had worked on the Columbia River since 1947.[51]

Some representatives of these agencies have found the Corps to be receptive to innovative approaches, especially since the late 1960s and early 1970s.[52] At this time, the Corps assured other federal agencies of its willingness to consider "new ideas for the prevention of fish losses."[53] The Corps also indicated that it would meet with representatives of fisheries agencies and make its staff available in research efforts.[54] One biologist praised the Corps in 1971 "on behalf" of the fisheries agencies. "I should like to commend the Corps," his letter read, "for their excellent cooperation in helping to solve the numerous fish problems relating to the Columbia River."[55]

Sometimes friction developed between the fisheries agencies and the Corps. The Fish Commission, for example, became frustrated with the Walla Walla District's attitude toward fish passage through the lower Snake River projects. In 1969, the Director of the Fish Commission informed the District Engineer that Walla Walla "has not demonstrated the degree of concern or response to fishery matters recently apparent in our dealings with biologists and related personnel attached to other Corps districts."[56] Yet even this complaint indicated that the Corps remained generally receptive to the concern of fisheries agencies.

The Corps financed much of the research for the NMFS' work on the Columbia and Snake Rivers. Owing to this arrangement, some biologists regarded the NMFS as biased toward the Corps' interests. To them, the funding process for research remained "fraught with conflict of interest." Michelle Dehart, manager of the Fish Passage Center during the 1980s and 1990s, worried that the same agency that assisted the Corps in evaluating fisheries studies could also proposed and receive funding for research. While the Corps consulted with a variety of agencies, moreover, there was no requirement to reach consensus. As a result, the Corps "funded the research it wanted to fund," at times disregarding the opposition of fisheries agencies. In Dehart's estimation, a larger problem was that the Corps financed research for management purposes--to determine the direction of mitigation measures--rather than to obtain "scientific information." Representatives of the Columbia River Inter-Tribal Fish Commission agreed.[57]

Schoning, too, recognized the frustration of biologists who feared that the Corps financed studies "to satisfy its project or program needs when the fish agencies thought higher priority studies were going unfunded." Even so, he noted that "it is logical that the Corps budgets for and funds research to meet its own requirements" He remained convinced

> *that the general attitude of Corps leadership, at least at the District and Division levels, is much more dedicated to helping the fish than many years ago when some of us perceived the attitude to be one of reluctantly accepting fish as a necessary bothersome aspect of providing power, irrigation, and navigation benefits. There are many indications that the Corps leaders as individuals as well as representatives of the organization truly care and will do everything reasonable to perform in the most responsive and responsible way.*

Edward M. Mains, the Corps' Research Program Director from the early 1960s to 1986, had inspired confidence and trust among some biologists. "Ed's primary concern was the fish," Schoning recalled.[58]

The Corps, Schoning suggested in 1983, was "unfairly maligned at times." He concluded that "Too often it is inferred by staff of the fisheries agencies that the [Corps'] only interests are in generating power, improving navigation, controlling floods, and providing irrigation water, and that fish care is a necessary evil of being in the water-use business." Schoning, on the other hand, witnessed "little evidence to support this perception." Although the "had their own agenda" in setting research priorities, Schoning characterized the engineers as "generally cooperative."[59]

This cooperation enabled biologists and engineers to learn much about the causes of fish losses at large multipurpose dams. Because so little was known about salmon mortality in the early days of construction of large multipurpose dams, the Corps and the fisheries agencies have pioneered studies of fish responses to passage facilities and river operations.

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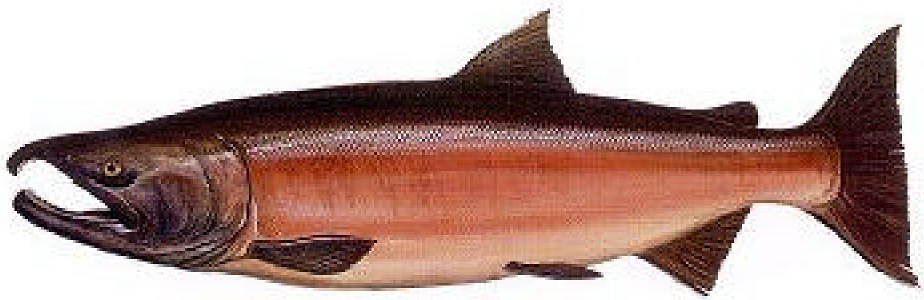
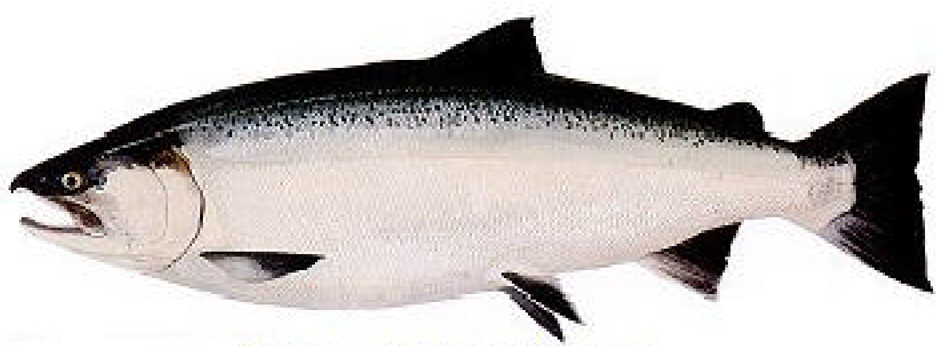


Coho Male - Freshwater Phase

Coho Female - Freshwater Phase



Coho - Ocean Phase

IV. Protection of Salmon

Research and Construction of Fish Passage Facilities

From the beginning of large-scale hydroelectric development, the federal government recognized that bid dams could affect fish populations. In 1934, Congress passed the Fish and Wildlife Coordination Act, which required federal agencies to consider fish losses resulting from their projects. This legislation mandated that federal agencies involved in dam construction consult with the Bureau of Fisheries and make "adequate provision, if economically practicable...for the migration of fish life from the upper to the lower and from the lower to the upper waters of said dam by means of fish lifts, ladders, or other devices." In 1946, Congress amended the Fish and Wildlife coordination Act to require that federal water development agencies consult with fish and wildlife agencies during the planning and construction of water resources projects. Another amendment in 1958 mandated that fish and wildlife conservation receive "equal consideration" with other river interests.[1]

As noted, the Corps was concerned with providing fish passages at Bonneville Dam before this act first became law. In fact, the engineers maintained responsibility for fish passages at its facilities. During the 1930s and 1940s, critics charged that as a construction agency the Corps remained ill-suited for conducting fisheries research and designing fish passages. Oregon Senator Charles McNary, for example, suggested that the Corps share management at Bonneville Dam with a proposed Columbia River administrator. The Chief of Engineers, however, successfully argued that the Corps should retain responsibility for fish passages. "Neither this Department nor any other agency," he explained in 1937, "will be in a position to assure the preservation of the highly important salmon fishery on the Columbia River unless it has full and complete control of the operation of the dam." In 1970, the Corps reasserted this responsibility. As Brigadier General Roy Kelley, North Pacific Division Engineer, put it, "We have the desire, manpower, and professional capability to effectively operate our fishway systems.[2]

As the Corps constructed additional dams on the Columbia and Snake Rivers, the agency continued to provide fish passage facilities (collection channels and ladders) for adult salmon and steelhead. The engineers who designed the adult facilities used the most current information available. However, very little biological data were available when the Corps constructed its earliest dams. It was not until later that research demonstrated that many of the facilities required modified dam-operation procedures or structural changes to improve their efficiency. As research provided new data, the Corps adjusted and improved the fish passages over the years.

Owing to the lack of knowledge during the years of construction, the early dams had no special facilities for juvenile bypass. Although some biologists during the 1930s expressed concern for young fish, many scientists and mot engineers were not knowledgeable or concerned about juvenile passage when they designed Bonneville, McNary, The Dalles, and Ice Harbor Dams.[3] When these dams were constructed, many biologists and engineers believed passage over the spillway or through the turbines would not cause substantial mortality. Scientists also believed that if fish ladders could guarantee excellent passage for adults, some loss of juveniles would not seriously jeopardize runs. Thus, the early dams featured no juvenile bypass facilities, or very limited facilities. Later research on juvenile fish passage demonstrated that young migrants suffered substantial mortality, and that dams with no or inadequate bypass facilities required modification.

By the 1900s, fish were collected at Lower Granite, Little Goose, and McNary Dams, and transported downstream by barge and truck. There the Corps worked to improve the turbine screens, fish holding, and transportation facilities.[4] At all mainstem dams, biologists periodically tested screening and bypass systems, to ensure design and installation of the most efficient systems. For example, testing of extended length screens began in 1991 for installation at Lower Granite, Little Goose, Lower Monumental, and The Dalles Dams. Turbine screens and bypass facilities were provided at John Day and Lower Monumental Dams. By the spring of 1993, collection and transportation was available at Lower Monumental Dam. In addition, Ice Harbor and The Dalles Dams featured ice-and-trash sluiceways that generally proved effective in recent years for passage of smolts. Screen bypasses to help divert juveniles from the turbines at these dams were scheduled for completion in the late 1990s.[5]

Before 1951, state fisheries agencies, universities, and the U.S. Bureau of Fisheries (later the U.S. Fish and Wildlife Service) conducted most fisheries research on the Columbia River. For the most part, investigations between 1929 and 1950 focused on the management of the fisheries, and on the abundance and character of the fisheries resources. However, as early as 1933, studies began to address the fish passage problems resulting from construction of Bonneville, Rock Island, and Grand Coulee Dams on the Columbia River. These studies included surveys of tributary streams to determine the distribution of salmonid populations in relation to the installation of irrigation diversion screens, to evaluate the relocation of the anadromous fish runs blocked by Grand Coulee Dam, and to review available knowledge on fish facilities for passing salmon at dams.[6]

By 1950, the large-scale development of the Columbia River Basin for hydroelectric power had been underway for nearly two decades. Three large dams affecting anadromous fish were already in operation (Rock Island, Bonneville, and Grand Coulee), and 15 additional major dams, including eight Corps facilities, would be constructed. The cost of constructing fish facilities at Corps projects was estimated to be $130 million, with an annual maintenance cost of $1 million in 1956.[7] The magnitude of the expenditures and the lack of definite criteria or standards for fish facilities--such as size and gradients of fishways, efficiency of orifices or fishway entrances, and effects of current velocities on fish movements--became major concerns to the Corps. These problems renewed the Corps' interest in improving fish passage research and facilities.

As noted, the Corps organized the Fisheries Engineering Research Program, later called FPDEP, during the early 1950s. At that time, Corps participants in the Columbia Basin Inter-Agency Committee convinced the North Pacific Division Engineer to recommend a fisheries research program, with costs to be drawn from construction funds. The Chief Engineer approved the program, and for the next 40 years recommendations and cost estimates were periodically updated and approved. Annual costs ranged from approximately $60,000 during the initial years to more than $3 million in the early 1990s (see Table 2).

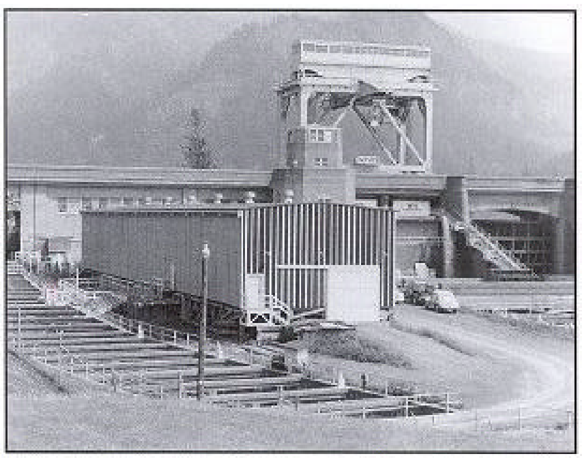
With funding approved for the Fisheries Engineering Research Program, the North Pacific Division retained Joseph Craig, a biologist formerly with the U.S. Fish and Wildlife Service and the Washington Department of Fisheries, to direct the program and coordinate with the fisheries agencies. When Joseph Craig retired from the Corps in the early 1960s, Edward M. Mains, a biologist and former Assistant Director of the Washington Department of Fisheries, served as the Research Program Director until 1986. At that time, Doug Arndt assumed the post.

Once a year, the Division Engineer held a meeting with the directors of the fisheries agencies and the District Engineers to review the previous year's research and to discuss additional concerns. Eventually the committee expanded to include coordination of specific fish-related dam construction and operations. During the 1970s, the Corps formed fish research planning and scientific review subcommittees as part of its Technical Coordinating Committee. These subcommittees determine needs, priorities, and the technical adequacy of research proposals from the fisheries agencies.

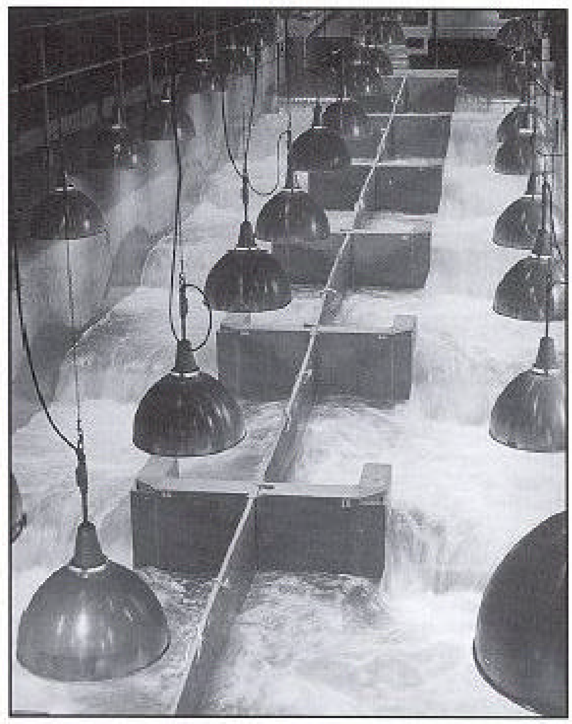
Fish Passage Research: Fisheries-Engineering Research Laboratory at Bonneville

During the first 30 years of operation, the system at Bonneville passed one million fish annually.[8] Biologists, however, did not understand its apparent success. "We are in the dark," worried one spokesman for the U.S. Fish and Wildlife Service.[9] Similarly, Ray Oligher, a Corps biologist who began working for the Walla Walla District in the mid-1950s, recalled that "we knew virtually nothing about ladders."[10] Although adult fishways had been used for many years, the large-scale fishway construction necessary on the Columbia River required more information on fish behavior and abilities than was available. As Brigadier General C.H. Corpening, Director of Civil Works, explained to Washington Senator Warren G. Magnuson in 1953, "A great deal of fundamental information on the passage of fish at dams is needed to assure safe passage and to permit the Corps of Engineers to exercise essential economy in expenditure of public funds and sound judgment in the engineering of the requisite facilities."[11]

First, the Corps had to address a number of issues: the rate at which fish ascend fishways; the maximum water velocity through which fish can swim; the effect of light on the rate of ascent in fishways; the size of fishway needed for a given number of fish; the maximum grade for a fishway that does not cause fish to tire or fail to ascend; and the maximum length of a fishway that does not fatigue fish. To obtain this information, the Corps funded and constructed a special laboratory for fisheries-engineering research at Bonneville Dam in 1955.[12]



Fisheries Engineering Research Laboratory at Bonneville Dam, completed in the early 1950s



Experimental fish ladders, Fisheries Engineering Research Laboratory at Bonneville Dam

Gerald B. Collins and Carl H. Elling of the Bureau of Commercial Fisheries outlined much of the research for this laboratory. Collins began his career as a fisheries biologist at Harvard, where he and his wife Susan conducted experiments on the migration of Bournedale herring. Collins' research on fish responses to variations in temperature and velocity of water attracted the attention of the U.S. Fish and Wildlife Service. "His idea of testing the reaction of migratory fishes in spawning streams is novel, to say the least," noted one spokesman for the agency in 1950, "and he is developing ways of testing the natural reactions of fish that may prove very important, especially to our salmon fishery."[13] Elling's research, on the other hand, focused on the Pacific Northwest, including Alaska. He attended Washington State University and had worked in salmon fisheries before joining the staff at the laboratory.

Collins, who became director of the Fish Passage Research Division at the Bureau of Commercial Fisheries, suggested Bonneville as the location for the laboratory, owing to the large numbers of fish and the variety of species available throughout the year.[14] He and Elling, who became assistant director, devoted their early years at the facility to investigating fundamental issues, such as salmon reaction to turbulence and the minimal depth and size of successful fishways. Before construction of the laboratory, Collins explained, "nobody had the opportunity to measure these things."[15]

Equipment at the laboratory included an experimental flume with two fish pools. Although the underwater sound equipment was, according to Collins, "kind of a clumsy thing" by today's standards, the devices used in the initial research were state-of-the-art at that time. Scott Blais of the Corps, in consultation with Collins, designed the laboratory and experimental fishway. At one point, this frustrated engineer likened Collins' request for 800 cubic feet per second (cfs) to test the swimming ability of fish to asking for "an engineering feat equal to the Panama Canal."[16] In his response, Collings conceded that "What is desirable, of course, may not always be possible." Yet he could not resist adding, "I have complete confidence in [the Corps'] ability to build another Panama Canal."[17]

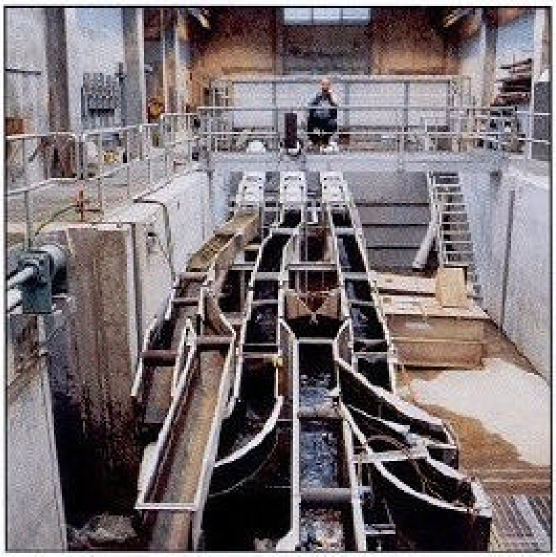
Carl Elling, left, Assistant Direct, and Gerald Collins, right, Director of the Fish Passage Research Division of the Bureau of Commercial Fisheries

Collins and Elling drew their staff from the University of Washington's Fish Passage Program and the U.S. Fish and Wildlife Service. State fisheries agencies, however, requested that the NMFS avoid attracting state personnel to the Bonneville laboratory. The University of Washington also proved to be an occasional source of competition. During the late 1950s and early 1960s, scientists at the university denounced the laboratory's experiments with lights to guide juvenile fish, partly owning to similarities in research in this area at the two facilities. Even so, the facility at Bonneville brought together a variety of biologists, and sometimes fostered camaraderie in the scientific community.[18]

Looking back on the Corps' involvement in the establishment of the laboratory, Collins recalled that the engineers initially "were quite resistant" to the idea of biologists working around the dam, particularly near the turbines. However, Collins added Wynn Farr, an engineer, to the laboratory's staff in the early 1960s--and the Corps become more at ease. "In general, we got a lot of cooperation from the Corps," Collins remembered, adding "we were absolutely dependent on the Corps for funding."[19] By the mid-1950s, the Corps coordinated regularly with the U.S. Fish and Wildlife Services as well as with state fisheries agencies in Oregon, Washington, and Idaho, to review the research programs. Although the Corps provided most of the funding, the U.S. Fish and Wildlife Service contributed money to researching specific areas, such as reservoir water quality in relation to fish.[20]

During the early years of the laboratory's operation, its staff celebrated the end of the year with "a whale of a part," which became known as the "Bonneville Bash." This annual event attracted scientists from as far away as Seattle. It brought together a diversity of personnel from the fisheries agencies and the Corps, signifying the fraternalism and common interests that the laboratory at Bonneville inspired. The facility continued to operate until 1980, when an unusually heavy snowfall and rainstorm collapsed the building. Shortly after the building collapsed, the Bonneville Hydraulics Laboratory, which had worked closely with the Fisheries Engineering Research Laboratory, shut down and its functions were transferred to the Waterways Experiment Station in Mississippi. This facility assumed much of the work previously conducted by the two Bonneville laboratories. In the 1990s, biologists conducted experiments at a smaller facility at the new powerhouse in the Bonneville Project.[21]

New laboratory at Bonneville revealing coded wire tag detection equipment, designed to detect and divert tagged fish into holding area.



Researchers removing tagged fish from tank for observation

Fish Passage Research: Adults

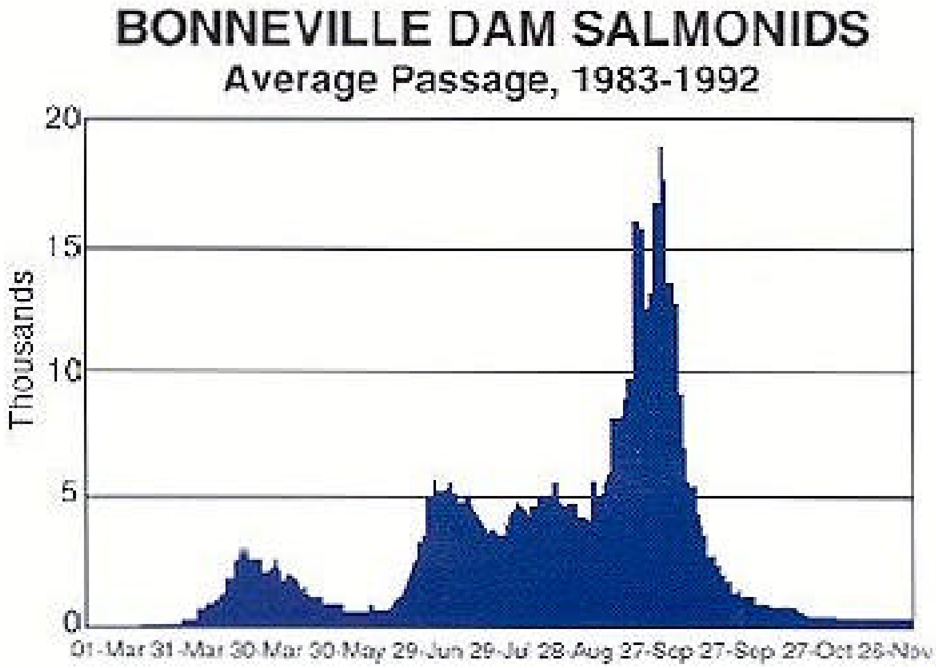
At the fisheries-engineering research laboratory at Bonneville, biologists measured the reaction of anadromous fish under controlled experimental conditions, while the fish actually migrated. Researchers diverted fish from one of the major fishways into the laboratory, where they observed and recorded the responses of salmon to full-scale prototype experimental fishways. Fish then swam out of the laboratory to continue their migration upstream.

Experiments conducted at the Bonneville laboratory during the 1950s provided data on the spatial requirements of salmon in fishways. These concerned the rates of movement of fish ascending fishways, and the effects of fishway slope on fish performance.[22] Collins, Elling, and other NMFS scientists measured both performance and physiological indices, such as blood lactate and inorganic phosphate, and found no evidence in the fish of fatigue from ascending fishways when proper hydraulic conditions were obtained.[23] They concluded that the ascent of a properly designed fishway was only a moderate exercise for fish, possibly similar to swimming at a "cruising" speed that can be maintained over long periods of time.[24] This research also indicated that resting pools thought to be necessary for the longer and steeper fishways planned for future construction would not be required.

Fish going up the fish ladder

Observers watch fish jumping up the ladder

Tests to measure swimming abilities indicated that the critical velocity of water occurred at flows between 8 and 13 feet per second (fps).[25] Velocities above this range proved to be an obstacle to a significant number of fish, although some individual fish had a much greater ability to sustain higher flows. The maximum observed swimming speed was 26.7 fps by a steelhead trout. Examination of fish preferences for light conditions revealed marked differences in species.[26] Chinook salmon appeared indifferent under the same conditions and moved randomly into both light and dark channels. Steelhead, given a choice of light and dark channels, selected a dark channel--and they moved more quickly through fishways that were darkened. However, steelhead passing through pipes and open channels demonstrated an increase in passage speed when light was added.[27] Presented with a choice of channels with a high velocity (13 fps) and a low velocity (3 fps), both salmon and steelhead showed a strong preference for the high velocity.



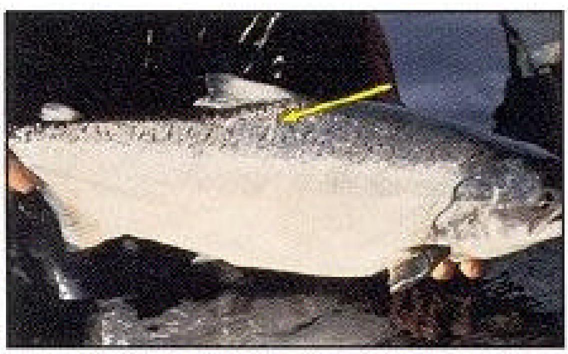
Adult Salmonid Passage at Bonneville Dam 1983-1992

Vertical slot fishway

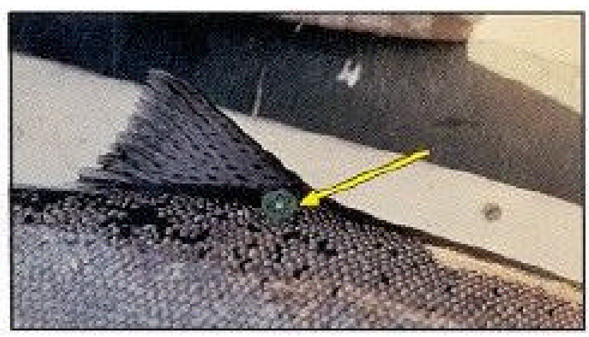
Another significant accomplishment of the Corps laboratory at Bonneville was the design and testing of the vertical slot fishway. A dramatic increase of shad had developed in the fishway at John Day Dam, where these fish would not swim through the orifice control section of the ladder. As a result dead shad blocked the area of the counting stations. So severe was the problem that it impeded the passage of salmon. Earlier behavioral work at the laboratory indicated that shad could pass readily through a vertical slot-type fishway. Accordingly, researchers designed a vertical slot-type fishway for John Day and tested it in the laboratory. Since the laboratory tests appeared successful, the Corps installed vertical slot fishways at John Day in 1970 and 1973, at Bonneville in 1974, and at Ice Harbor in 1979. Experts tested them at the dam sites, where they proved very effective.[28]

Despite the presence of fishways in Columbia River dams, personnel at state and federal fisheries agency expressed concern in the 1940s and 1950s about the effects of several proposed dams on the anadromous fish migration to and from spawning grounds in the Columbia and Snake River drainages. As a result, they attempted to measure these effects soon after the completion of Bonneville Dam. Robert W. Schoning and D.R. Johnson conducted the first study that indicated a delay in migrations in 1948.[29] Research focused on adult migrants, and suggested that the dam delayed these fish for two to three days. Several additional studies determined whether fish were entering fishways without delay or loss, passing successfully upstream. State and federal agencies, however, did not propose these studies until the late 1960s and early 1970s, after upstream dams such as The Dalles, McNary, Ice Harbor, and Priest Rapids began operation. Counts of fish passing these dams alerted fisheries scientists to problems, for count discrepancies and timing of peak counts indicated possible delays or losses of upstream migrants between Bonneville and the upstream dams.

Many of the earliest studies analyzed counts at the dams, or they marked fish with a variety of tags, including disks and darts (Floy tags). Estimates of delays ranged from one to four days, depending on the dam, stream flow, turbidity, and temperature. In 1966, Charles O. Junge, a biologist with the Oregon Department of Fish and Wildlife, noted that losses and delays of spring chinook appeared to be highest during high flows, wit spills in excess of 60,000 cfs at Ice Harbor Dam. Biologists conducted additional studies to determine behavior of adult fish and their patterns of movement approaching dams under a variety of conditions. They hoped to obtain information to improve the design of fishway entrances and flow patterns in the tailrace area of the dams.[30]



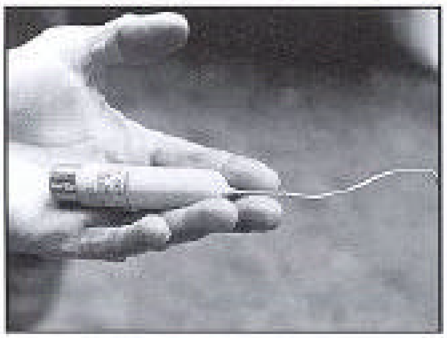
Floy fish tag



Peterson disc fish tag

Other studies funded by the Corps during the 1960s and 1970s focused on adult migration rates and routes through reservoirs, causes and rates of fallback, and the effects of power peaking.[31] Generally, these studies demonstrated that reservoirs were not a barrier for adult migrants. Adults were able to pass through deep, long reservoirs and locate spawning grounds without serious difficulty. Successful passage through a well-designed and well-operated fishway did not ensure that salmon or steelhead would overcome a dam entirely. It required the fish to locate the entrances to fishways, move into and through the fishways, enter the forebay, and swim upstream without falling back over the spillway or through the turbines. Flow patterns and velocities in the tailrace of the dam remained critical in determining whether fish could find and enter the fishways. Rates of fallback over a dam by steelhead and adult salmon varied with flow and spill, by dam and species. Power peaking caused delays, during periods of high flow, most likely owing to poor tailwater conditions and delayed entrance to fishways.[32]

RADIO TAGGING OF SALMON

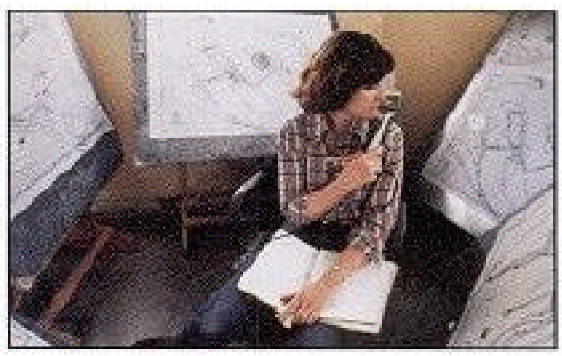


Radio tag

Researcher inserts radio tag into adult fish

Securing the tag antenna to the mouth

Signals from radio-tagged fish are then recorded



Location of tagged fish are then plotted at Bonneville Dam

In 1972, the Corps and NMFS began a major study using radio tracking and electronic tunnels to determine the causes of adult fish delays at dams. They began the study at John Day Dam in 1972, then moved to The Dalles and Bonneville. The study continued through 1980, at which time the Corps and the NMFS offered a number of recommendations to improve passage. Most of the recommendations related to operational procedures of the adult fishway system that needed modification under changing flow conditions, in the tailrace and in the system itself. Studies at John Day Dam also noted that industrial effluent from an aluminum plant upstream could be causing avoidance and delay particularly at the north ladder entrance. Later research conducted by the NMFS confirmed this suspicion. Elimination of the effluent rectified the problem.

Biologists completed additional special studies to determine the effect of spillway deflectors, zero flow, and increased temperature to reduce gas supersaturation. In 1981, the Corps began radio tracking and electronic tunnel studies to improve adult fish passage at Snake River dams. The studies focused on determining fish movement patterns immediately downstream from the dams under various spills and flow patterns, and on determining entry and exit patterns of fish inside the collection channels of the fishway systems. To reduce delay in passage, the Corps implemented various recommendations for operating the fishway systems, the turbines, and the spillways.

High turbidity accompanied by peak spring flows also affected adult passage. Ted Bjornn noted in his studies of adult salmon and steelhead in the lower Snake River that spring chinook ceased migrating during periods of high turbidity.[33] Experiments on zero flow yielded conflicting results. Studies of the effect of spillway deflectors on adult migrants demonstrated that they did not injure or seriously delay migrants. On the other hand, high water temperatures in the Snake River slowed the migration of fall chinook and steelhead from the Columbia into the Snake River in August and September. Fish preferred to remain in the cooler water of the Columbia until Snake River temperatures cooled.[34]

In general, the adult passage facilities constructed by the Corps proved to be effective in design and operation. Steve Pettit, a fish passage specialist for the Idaho Department of Fish and Game, praised the ladders in 1990, noting that "the Corps knows how to build them well."[35] This view remains widely held among fisheries scientists familiar with adult fish passage problems caused by dams.

Fish Passage Research: Juveniles

The migration of adult salmon and steelhead up the Columbia and Snake Rivers was just one focus of the Corps' Fisheries Engineering Research Program. The migration of juvenile fish downstream was also a concern. Early studies of downstream migration prompted attention to the survival of juveniles passing through turbines. Adequate diversion and bypass systems required study of the timing and magnitude of downstream migrations. The design of a system to handle hundreds of migrants a day would be very different from one designed to handle thousands or hundreds of thousands. Scientists knew very little about the timing and size of juvenile migrations in the Columbia River before the Corps implemented its research program in 1951. When Bonneville Dam was constructed during the late 1930s, Ivan J. Donaldson, a Corps biologist, began keeping records of smolts captured in the juvenile bypass traps. He placed the traps in the juvenile bypasses provided at the north end of the spillway and the south end of the powerhouse. He also placed a trap in the Tanner Creek bypass.[36] These records provided valuable data on species composition and timing, but offered little information on the magnitude of the various migrations.

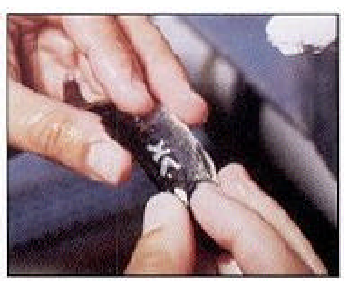
Migrational Characteristics and Survival

By 1955, other researchers had begun investigating the distribution, size, time, and current preferences of seaward migrant chinook salmon in the Columbia and Snake Rivers.[37] Howard L. Raymond, a biologist with the NMFS, completed the first major effort to investigate migration timing and magnitude in 1966. Raymond had a background in statistical analysis, and his facility with numbers sometimes dazzled his colleagues.[38] He described the outmigration of chinook, coho, sockeye, and steelhead passing Priest Rapids, Ice Harbor, The Dalles, and Bonneville Dams from 1964 to 1966. Raymond also provided survival estimates for 1966. This information was helpful in designing bypass systems for the remaining Corps dams (John Day, Lower Monumental, Little Goose, and Lower Granite). Raymond's studies were expanded to include more species, a larger expanse of the river, and improved accuracy. Carl Sims and Albert Giorgi continued the research until 1983. By 1975, sufficient data had become available to estimate the relationship among flow and survival and travel time for spring chinook and steelhead, which migrate in the spring as yearlings. The studies completed by these researchers indicated that travel time decreased significantly in the Snake River, as flows increased from 50 Kcfs to 80 Kcfs (thousand cubic feet per second). Concurrently, survival increased as flows increased throughout this range.

FISH BRANDING

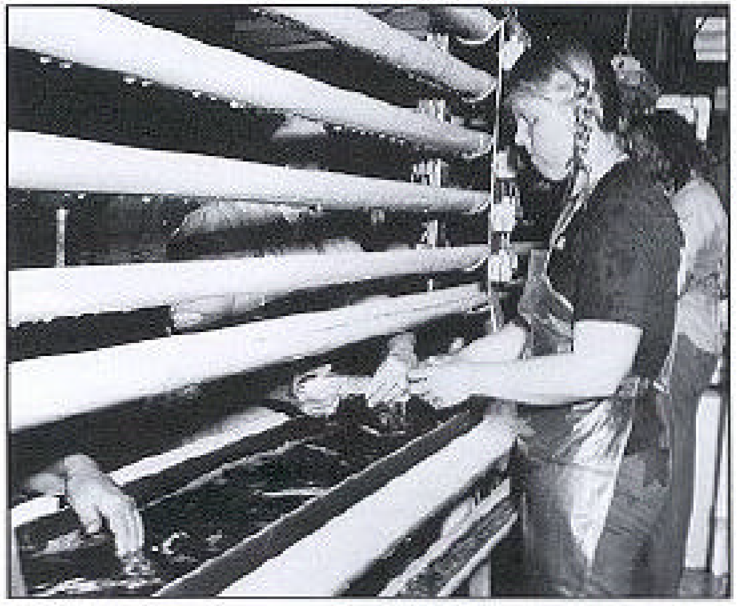
Some juvenile salmon are freeze-branded with liquid nitrogen, to determine their migration and survival rates

Researcher branding juvenile salmon



Juvenile recently branded

Juvenile recovered after branding



Researchers check juvenile salmon for brands

Biologists noted a similar relationship in the Columbia River downstream from Ice Harbor Dam. Flows here ranged between about 100 Kcfs and 240 Kcfs measured at The Dalles Dam. Data on the relationship between flows and survival above 80 Kcfs on the Snake River and above 240 Kcfs on the Columbia River were sparse and conclusions regarding the relationship beyond these ranges was not well established. Both Raymond and Sims cautioned that these estimates of survival were system survival estimates measured between the uppermost dams and Ice Harbor or John Day and The Dalles Dams, and that the estimates were seasonal estimates intended for annual comparisons. The flow and survival/travel time curves calculated from these data were not intended to be used to depict survival in specific areas or over short periods of time like days or weeks. In addition, during the period that scientists obtained much of the data, the Snake River dams featured only one, two, or three turbines. At that time, small increases in flows over 60 Kcfs resulted in spilling and a more dramatic increase in survival than would be evident once the dams featured a full complement of six turbines. Research had demonstrated that passage of smolts over the spillway resulted in higher survival than passage through turbines.

Purse seining in reservoirs of dams for juvenile migrants was often used to determine migrational characteristics

Researchers sampling juvenile fish on the Columbia River

These studies provided the basis for modification of flows and dam operations and resulted in the formation of the Committee on Fisheries Operations (COFO) in 1977. In recent years, however, power interests have questioned the validity of applying these data to control flows and dam operations, now that all mainstem hydroelectric facilities have a complete complement of turbines and juvenile bypass systems--and fish are collected and transported at Little Goose, Lower Granite, and McNary Dams. They have pointed out that no new data on survival have been obtained since 1983, and that data obtained on travel time indicates no improvement beyond 95 Kcfs in the Snake River and 240 Kcfs in the lower Columbia River. Albert Giorgi also has maintained that temporal changes in smolt development have a pronounced effect on observed migrational speed of salmon, making it difficult to confidently predict speed of migrants at a given water velocity. He claimed that new data are needed under current conditions.[39] Moreover, data available do not include survival/travel time and flow relationships for migrating sockeye, coho, or fall chinook.

The COFO, consisting of representatives of the fisheries agencies and the Corps, sought to plan dam operations and flows for each spring migration to achieve maximum survival. Howard L. Raymond of the NMFS, who had conducted some of the first and most extensive research on juvenile migrants, served as the primary representative of the fisheries agency. James Cayanus, a hydrologist who had worked in reservoir control, represented the Corps. This committee remained in operation until 1984, when the Water Budget Center was formed. During the 1980s, the center represented the fisheries agencies and tribes, and Cayanus continued to represent the Corps. The COFO and the Water Budget Center prepared an annual report on dam operations and flows. In conjunction with the COFO, the NMFS completed studies of migrational characteristics, including travel time and survival, which contributed to the evaluation of operations. This research also assisted in evaluating other measures implemented through the years to increase smolt survival, such as bypass systems and collection and transport systems. Where the Corps installed bypass systems, for example, smolt survival estimates should increase. Also, benefits from transportation from year to year should correspond to smolt survival estimates.

Turbine Bypass

From its beginning in 1951, the Corps' Fisheries Engineering Research Program attempted to discover a way to divert young migrants away from turbine intakes. The fisheries agencies, universities, and the Corps scientists contributed to this effort. Laboratory and field studies included the use of electricity, louvers, water jets, air jets, sounds, lights, and traveling screens. During the course of this research, biologists decided that a successful diversion system would need to divert up to 80 percent of the juvenile migrants from the turbines at a given installation. During the 1980's, state fisheries agencies and the tribes set a goal of 90 percent for Corps installations.

Investigations into the use of electricity included studies of electrical parameters harmful to fish, most effective in creating electrotaxis, and eliciting sensory avoidance responses. Success in laboratory experiments led to large-scale field tests using pulsed direct current to guide downstream migrants. Limitations to the practical uses of electrical guidance in diverting fish from turbines became apparent. Major field applications required guiding migrants of several species over a broad range of sizes. Since voltages needed to affect the small fish were lethal to large fish, researchers devised a sequence of electrical fields using elaborate systems of electrodes. The effectiveness of electricity to guide all juveniles decreased rapidly as the water velocity increased, thus limiting its potential application to situations where flow could be controlled to less than one fps.[40]

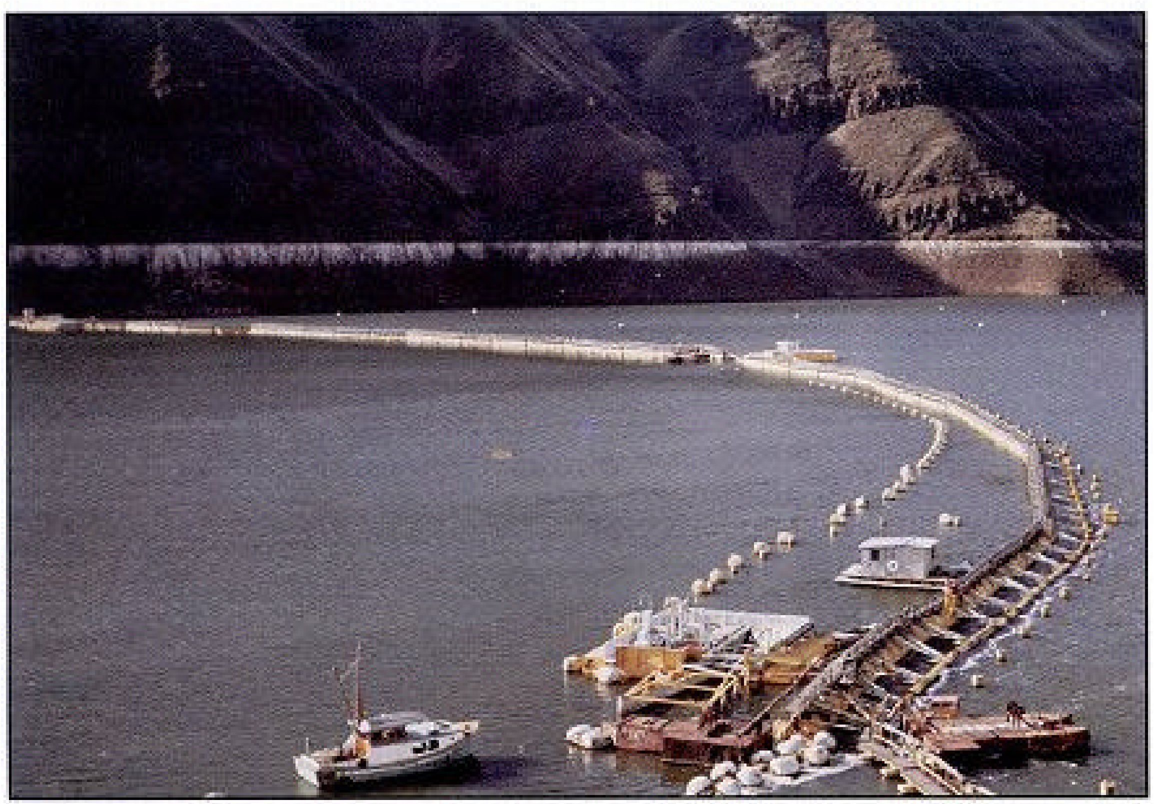
Experiments to guide downstream migrants with louvers in large-scale mixed and floating installations revealed that louvers were practical only where water flows could be carefully controlled and floating debris was not a problem. Electrical fields tested in conjunction with louvers proved no more effective than louvers alone.[41]

Biologists also examined the capacity of water and air jets to guide young migrants. Although water jets effectively diverted fish at appropriate approach velocities, the angle of array and jet pressure, the extensive maintenance of equipment, and the high volumes of water required made this technique impractical. A screen of bubbles created by air jets diverted young migrants effectively during daylight, but poorly during darkness--when most fish migrate--even when the bubble screen was lighted. The poor results in darkness precluded the use of this device as a functional method for collecting or guiding fish.

Additional experiments in the laboratory included sound as a medium for guiding fish. Broad-spectrum noisemakers did not divert fish successfully, but specific high-intensity frequencies produced orientative responses. A maximum-avoidance response was obtained with the low frequencies of 35 to 170 Hz, but problems associated with practical application precluded its use in large-scale installations at dams.[42]

Another area biologists examined involved arrays of fixed and moving lights for their potential in guiding young fish. Lights were found to be relatively ineffective during bright daylight and during periods of high turbidity, which are frequent at the time of major juvenile migrations in the Columbia and Snake Rivers. In research conducted from 1959 to 1962, Paul Fields, a biologist at the University of Washington, successfully used lights to divert smolts from the turbines toward the spillway. However, a practical application of this response for an effective diversion of smolts over a 24-hour period was not possible. During the late 1960s, Kenneth Liscom of the NMFS used lights to accelerate movement of smolts from a darkened gatewell through an orifice.[43] Researchers applied this information in later juvenile bypass systems.

Rotary screens had been used successfully on some installations on the tributaries of the Columbia and Snake Rivers to prevent young migrants from entering irrigation water diversions. The technical problems involved and the cost of such fixed mechanical devices for screening entire turbine intakes on a mainstem dam made this approach impractical. Scientists tested a continuously traveling screen suspended at an angle to the stream flow to divert young fish at the Stanfield Irrigation Canal near Echo, Oregon. Although successful in diverting fish in a 28-foot-wide flume in velocities up to six fps, it presented signification engineering and cost problems when extrapolated to full-size installation at a major dam. The Oregon State Game Commission and the Oregon Cooperative Wildlife Research Unit tested three "Rex" traveling screens in a diversion canal at Marmot Dam on the Sandy River, Oregon. The screen was effective in the canal, but again, it remained difficult to apply this technology at a large dam.[44]



Juvenile Migrant Recovery in forebay of Brownlee Dam, Idaho

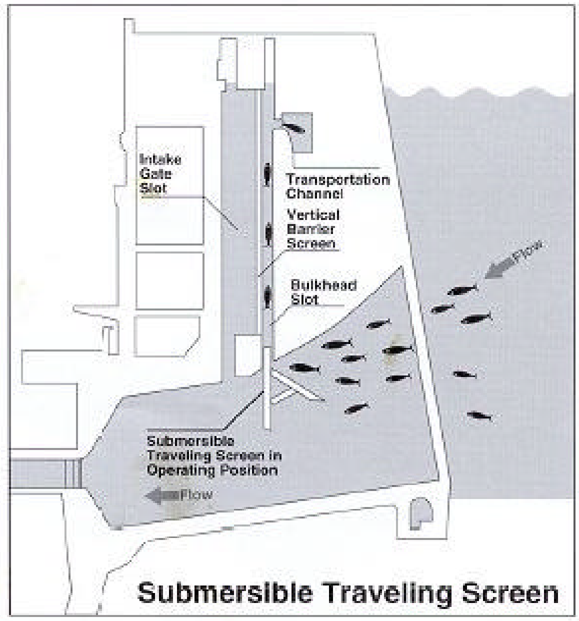
Biologists conducted the first attempt to divert and collect juvenile migrants at Brownlee, a large storage dam on the Snake River, in 1959. Here the Idaho Power Company installed a fingerling collection system in the dam's forebay to provide facilities for passage of juveniles. The system featured a shore-to-shore barrier net more than half a mile long and 150 feet deep, with surface collection traps. The net proved only partially successful. Many young fish passed under or through the barrier net, leaving the reservoir via the turbines or spillway.[45]

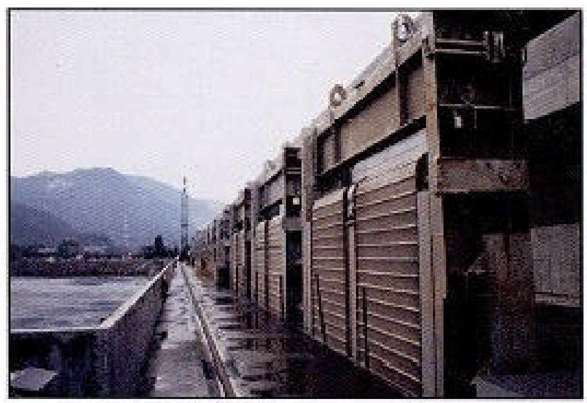
During the 1960s, the Corps funded studies to find a practical way to divert downriver migrants away from turbine intakes. At this time, the agency supported another large-scale research effort toward evaluating and reducing losses of smolts that passed through the Kaplan turbines used on the Columbia River. Engineers, working with biologists, designed and installed a giant recovery net that strained the entire discharge of a turbine at Bonneville Dam (13,000 cfs) in 1966. With this device and the use of specially designed release capsules, biologists studied the relationship of distribution to injury. Researchers also measured distribution of young fish in the turbine intake during the course of these studies.[46]

Researchers detailed the nature and extent of the injuries to juvenile migrants passing through turbines, and they related the injuries to various modes of turbine operation. Although engineers attempted several techniques to reduce losses, none sufficiently reduced turbine mortalities. Milo C. Bell, a hydraulics engineer at the University of Washington, addressed this problem in the late 1960s. Bell's association with the Corps dated back to the early fish facilities at Bonneville Dam. By the 1960s, he had become one of the most highly respected fish passage specialists in the region. He was "level-headed" and "savvy," Gerald B. Collins of the NMFS recalled, "and if he was going to be at a meeting, I felt good about it."[47]

In the 1960s, Bell conducted juvenile release experiments in a number of turbine-operating conditions at various dams. He demonstrated in 1967 that the best way to reduce mortality of smolts passing through the turbines was to operate them at maximum efficiency. The Corps expended no further effort in attempting to make turbines safe for passing fish, and instead implemented Bell's recommendation to operate turbines at maximum efficiency whenever possible, but the BPA's request for power sometimes resulted in some turbines not operating at maximum efficiency. For example, high demands for power often resulted in operating turbines at maximum overload, which produced more cavitation--the formation of partial vacuums in the water--and higher potential for loss of juveniles passing through turbines.[48]

In the early 1960s, Clifford W. Long and George R. Snyder, biologists with the Bureau of Commercial Fisheries, discovered that juvenile migrants collected in large numbers in turbine intake gatewells. Research later in the decade demonstrated that most salmon entering the turbine intakes concentrated in the upper one-third of the water column. This discovery led Long, known among his colleagues as an "idea man," to the concept of using traveling screens to divert smolts from the turbine intakes.[49] Long's enthusiasm convinced other fisheries-agency biologists to support his proposal to test a traveling screens at a Corps dam. However, it was left to Wynn Farr and Robert Pearce, engineers for the NMFS, to convince the Corps' engineers that this was a good concept. Initially, they resisted it. As Pearce recalled, one engineer at the Walla Walla District informed the biologists that they could install "that contraption" behind the trashracks only over his "dead body." By the spring of 1969, however, the biologists had convinced the engineers to test a prototype turbine intake traveling screen at Ice Harbor Dam. [50]





Set of later model Traveling Screens

The proposed diversion system, using existing gatewells, would collect the fish for subsequent passage around the dam. Once the fish had bypassed the dam, they could either be returned to the river to continue their migration or could be collected and transported downriver by barges or trucks. Results of this first test proved encouraging to the NMFS researchers and, by the time the Corps placed Little Goose Dam in operation in 1970, the engineers had a major effort underway to develop a juvenile bypass system utilizing screens.

Collection And Transportation

In 1968, the Corps funded a NMFS experiment at Ice Harbor Dam using trucks to transport juvenile salmon and steelhead. A major concern was whether juveniles transported several hundred miles--bypassing their normal migration routes--could find their way back to their point of origin as adults. The results appeared promising. Survival increased and the homing ability of adults was not seriously affected.[51]

These studies continued at Little Goose Dam, upon its completion in 1971, and at Lower Granite Dam in 1975. The research focused primarily on whether adult returns could be increased both to the fishery and to the parent stream or hatchery by collecting and transporting juveniles around several dams and reservoirs, thereby avoiding losses to young migrants. Initial results looked best for steelhead and successful enough for chinook salmon to convince the Corps to begin a major collection and transport operation from Little Goose, Lower Granite, and McNary Dams.[52]

With the encouraging results from both the traveling screen research and the transportation experiments, it appeared that biologists had within their grasp a solution to the juvenile migration problems. By combining a bypass and collection system with a transportation system, scientists could collect and transport fish from key dams to downstream locations. Thus, delays, turbine mortality, and other sources of loss could be eliminated from a large portion of the juvenile's migration route.

TRANSPORTATION RESEARCH

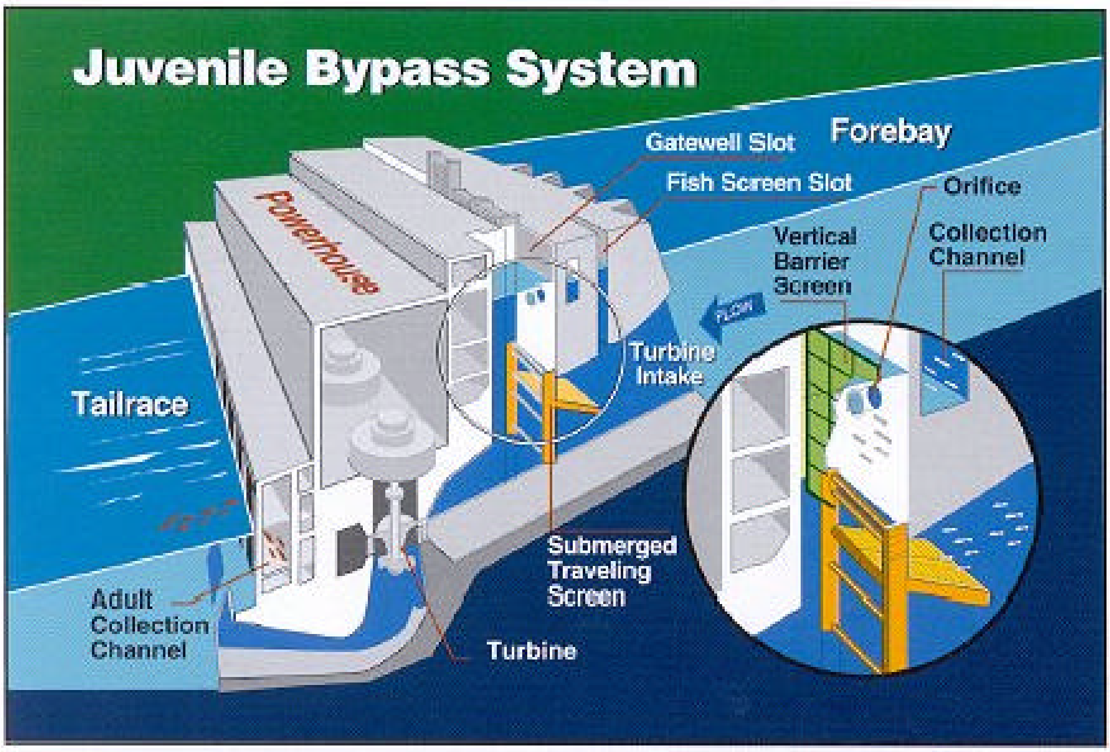
Transportation research included use of transport truck from upstream of the dams and PBY Aircraft for some experimental release of juvenile fish

Loading experimental fish from truck into PBY equipped with fish transport tank

Aerial release of experimental fish downstream from Bonneville Dam

Biologists from the NMFS proposed the idea in a request for funding by the Corps through the Columbia Basin Fisheries Technical Committee (CBFTC) in 1970. This committee, which reviewed all matters pertaining to fish passage activities on the Columbia River, included representatives from the Oregon Department of Wildlife, Oregon Department of Fisheries, Washington Department of Wildlife, Washington Department of Fisheries, Idaho Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. The committee approved the proposal on an experimental basis, and the NMFS subsequently submitted it to the Corps. In 1971, an experimental prototype collection and transport system was in place and operating at Little Goose Dam.[53] By 1973, the Corps had installed traveling screens in all three turbines and began diverting large numbers of fish into the gatewells.

It was immediately apparent, however, that the bypass conduit--a pipe embedded in concrete in the dam to collect fish from the gatewells--was inadequate. Before the installation of screens, the bypass conduit might have been sufficient to remove the few fish entering the gatewells at Little Goose and Lower Monumental Dams. However, the pipe was too small to provide sufficient attraction flow to entice the fish to leave the gatewells, and it became easily plugged with debris, causing descaling and injury. Earlier studies conducted at McNary and Ice Harbor Dams revealed the effectiveness of holes drilled into the gatewells to provide an escape route for juveniles to pass from the gatewell to the ice and trash sluiceway.[54] Using this knowledge, the Corps designed Lower Granite Dam with a walk-through fish passage gallery with 8-inch orifices leading to each gatewell. The agency also designed special slots to house traveling screens, and provided raceways where juveniles could either be collected for transportation or bypassed.



Cross section of powerhouse with Juvenile Bypass System

By 1978, the Corps had excavated a large channel through the dam at Little Goose, eliminating the collection conduit and its associated problems. In subsequent years, the Corps created similar channels at Lower Monumental and John Day Dams. The agency constructed a collection channel within the ice and trash sluiceway at McNary Dam. The Corps also provided collection and transportation facilities at McNary Dam.

Research on the effects of transportation has continued to the present. Changes in dam operations--including improvements in traveling screens, establishment of debris collectors in the forebay, and expansion of raceway capacities for holding fish--could produce differing results. Changes in equipment, such as trucks and barges, also could affect the outcome of transportation studies. Some fishery managers from various agencies have been skeptical regarding the mass transportation of smolts. As a result, nearly continuous evaluation has been required to maintain the option of using transportation to increase smolt survival. A major concern has been the impact, if any, of transportation on homing capabilities of adults returning to the Columbia and Snake Rivers. Early studies revealed no serious impairment of homing capabilities. In some related transportation studies, however, investigators found that the direct transportation of juvenile salmonids from hatcheries to distant downstream release sites usually impaired the homing of adults.[55] This research was not the same as conducting experiments on migrants at a dam after they had traversed several hundred miles before being collected and transported. Still, fishery managers expressed concern.

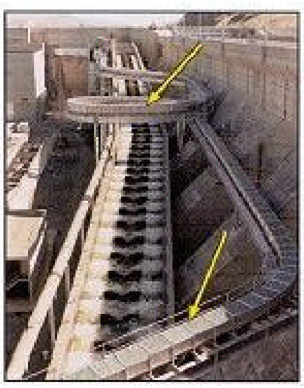
TRANSPORTATION OF JUVENILE FISH

Since 1971, the Corps has transported juvenile fish past the Snake and lower Columbia River dams. This program, initially called "Operation Fish Run," became known as the Juvenile Fish Transportation Program in the early 1980s. The Portland District, in cooperation with the Walla Walla District, carried the young salmon by truck and barge, releasing them below Bonneville Dam.

Corps personnel used trucks during early and late phases of the salmon runs, and they used barges during the remainder of the migrations. Each barge had the capacity to haul 50,000 pounds of smolts. Barges circulated river water, allowing the young fish to imprint during the trip downriver. Scientists devised a closed recirculating system in case the barge encountered a section of the river containing poor water quality. This system was capable of degassing the inflow to eliminate the potential for gas bubble disease in transported fish. The Corps contracted tug boats each year to move the barges upstream and downstream.

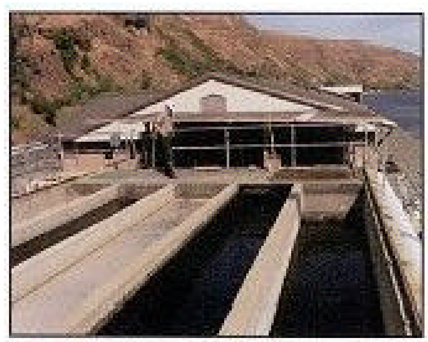
The Corps also used five fish tanker trailer with the capacity to haul 1,750 pounds of smolts at half a pound per gallon of water. Each trailer was equipped with a recirculating and aeration system. Because they offered a larger capacity, the barges hauled the majority of the smolts (80 to 90%) during spring smolt migration season. The barges and trucks featured compartments where smaller fish (chinook smolts) could be separated from larger smolts (steelhead) to reduce stress.

Source: James B. Athearn, A Review of Juvenile Salmonid Transportation Operations from 1981 to 1984, U.S. Army Corps of Engineers, Walla Walla District, 1985.



Juvenile Bypass Flume, Lower Goose Dam. Fish are diverted to collection and transport site.

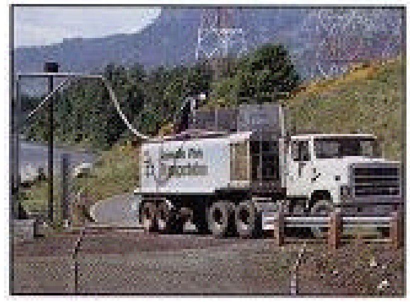
Large fish are separated from small after exiting the bypass flume



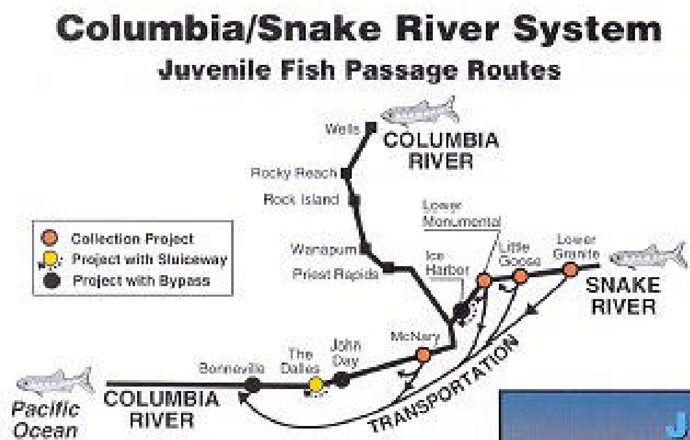
Holding raceways at Little Goose collection facilities

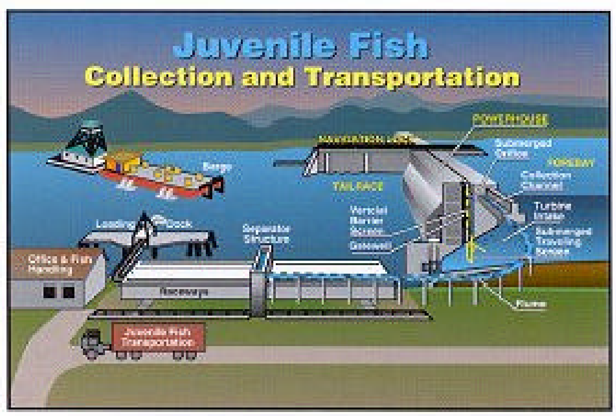
Loading fish transport barge at collection point

Fish are barged downstream. The trip from the Snake River to Bonneville takes about 16 hours.



When only small numbers of fish are collected, they are transported by truck





In 1985, Donn L. Park, a NMFS biologist, reviewed the complete research from 1968 through 1984, and prepared a comprehensive report. He concluded that homing was not seriously impaired and that "the current transportation program is in a position to provide fisheries managers a productive enhancement tool for the restoration of the Columbia River salmon and steelhead resurces."[56] However, some fisheries agencies and tribes remained skeptical, and managers continued to debate the effectiveness of the transportation program. As of 1993, agency guidelines set forth by the Fish

Transport Oversight Team, a now-disbanded interagency coordination group, called for all fish to be transported from Lower Granite Dam except groups of fish marked for research purposes. At Little Goose and Lower Monumental Dams, all fish were to be transported until flow forecasts indicated flows exceeded 100 kcfs for five consecutive days. If this flow occurred, steelhead were to be separated from the smaller chinook and transported; chinook were to be released to the river. The same guidelines applied at McNary Dam, although 220 kcfs was the target flow at that facility.[57]

Until the early 1990s, the use of screening and bypass systems had prompted little skepticism. Agencies had encouraged the Corps to accelerate installation of bypass systems at all its dams, although none had been completely evaluated to date.

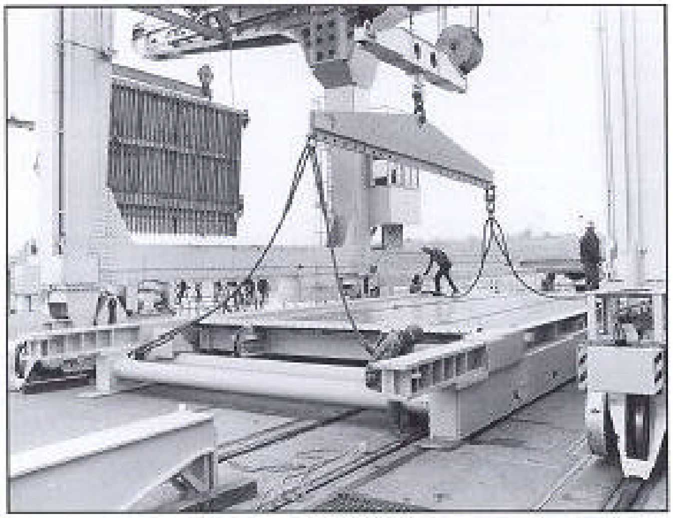
While Corps biologists conducted daily evaluations of the condition of fish (descaling and injury) at bypass and collection systems, comparisons of survival of smolts passing through either the turbines, spillway, or bypass system have not been made at any dam except Bonneville, where they have continued.[58] Some NMFS and Corps biologists questioned accelerating expensive installations of turbine screens and bypass systems where fish were not transported without additional information on survival, particularly when recent data obtained at Bonneville Dam indicated that survival through the bypass systems remained lower than survival through the turbines.[59] Expensive bypass systems seemed justified where fish were transported, because the loss or stress incurred in the collection process could be mitigated by transporting the fish past several dams and reservoirs.

The engineers expanded the collection and transportation system initiated at Little Goose to include Lower Granite Dam in 1975. This program, initially called "Operation Fish Run," became known as the Juvenile Fish Transportation Program in the early 1980s. In 1976, its second year, the Corps transported approximately 1.2 million smolts, which represented about one quarter of those arriving at Little Goose and Lower Granite Dams.[60] Although Operation Fish Run received a lot of publicity during 1975 and 1976, biologists considered the system to be experimental. By 1977, it had become apparent that, owing to the lack of snow pack, the flows in the Snake River would be unusually low for the spring of 1977. The Corps and the fisheries agencies realized that survival of downstream migrants would be even lower than that estimated for 1973 (5 percent), because screening and bypass systems were operational only at Lower Granite and Little Goose Dams. The Corps and fisheries agencies agreed that as many smolts as possible should be transported from these two dams to release locations downstream from Bonneville Dam.

To increase the transportation of the system, the Walla Walla District rented and equipped two barges. By August of 1977, workers had collected and transported 2.2 million smolts downstream. Fisheries agencies and tribes praised this emergency transportation operation and other activities the COFO carried out in 1977. In later years, the Corps expanded the system to include six barges for transporting fish from Lower Granite, Little Goose, and McNary Dams.[61] By 1981, the Corps regarded this program as operational. However, the fisheries agencies maintained it remained experimental.[62] The transportation of fish proved to be successful particularly in low-flow years, but by the late 1980s, the fisheries agencies had become convinced that the Corps relied too heavily on this system and neglected development of bypass systems at other dams. The lower-than-expected return of adult chinook was the primary reason the agencies became critical of the transportation system, although steelhead returned in record numbers at this time (see tables 3 through 7).[63]

The Corps continued to improve the collection and transportation systems at Lower Granite, Little Goose, and McNary Dams. By 1990, the agency had designed and constructed a new fish transportation flume and fish-holding facility at Little Goose am in an effort to reduce stress to juvenile migrants. The fisheries agencies and tribes pressed the Corps to improve bypass systems at Lower Monumental and John Day Dams, and to design and construct a bypass system at Ice Harbor Dam. The Corps, at its headquarters level, agreed to improve the bypass systems at Lower Monumental and John Day Dams. Their studies demonstrated, however, that full bypass systems at The Dalles and Ice Harbor Dams were not justified, owing to the apparent effectiveness of the existing sluiceway bypass system. In the late 1980s and early 1990s, the Senate Committee on Appropriations approved funds to design and construct bypass systems, including screens, at Ice Harbor and The Dalles Dams. Research proceeded to evaluate the effectiveness of screens at The Dalles Dam.[64]

The installation of screens and bypass systems--as well as changes in the operation and administration of fish passage research--have considerably improved the level of mainstem fish survival. Yet early operation and evaluation of these systems revealed the need for further refinements.[65] Debris continued to plug various components of the system, fish-guiding efficiency turned out lower than expected, and biologists observed stress to juvenile migrants passing through the systems.[66] After extensive study, the Corps made additional improvements.[67] The agency installed new traveling screens and debris-collecting log booms. Modeling and prototype testing of extended length screens during the 1990s will result in retrofitting Lower Granite, Little Goose, McNary, and The Dalles Dams with these devices. Fish-holding facilities and orifices also were modified. Research to improve these systems and to devise new systems for the remainder of the Corps dams continues. Biologists believe an important component of this research should be a thorough evaluation of the extended screens, including additional measurements of turbine mortality for nonguided fish and spillway mortality through a range of spill volumes, so that bypass efficiency can be properly assessed at each dam.



Extended Length Traveling Screens

Some state agencies and tribes pursued a new, controversial strategy of discontinuing transportation and drawing down reservoirs while providing more spill over the dams for juvenile fish. In April 1993, the states of Idaho and Oregon, along with several environmental agencies, sought a temporary restraining order to prevent the NMFS from granting the Corps a permit to collect and transport fish. The judge initially ruled in favor of the NMFS. Scientists for this agency pointed out that drawing down reservoirs would adversely affect salmon. They argued that juvenile bypass and collection facilities at Lower Granite and Little Goose Dams would have become inoperable, and spillway deflectors to reduce supersaturated gases would not have functioned properly. Adult fish ladders also would have been severely affected.[68]

Research conducted since 1980 has demonstrated that each hydroelectric project is unique regarding juvenile fish passage. Structural features of the turbine intakes, gatewells, and trashracks vary substantially from dam to dam. Solutions designed for diverting fish at one dam may not work at another. For example, the Corps and the NMFS researchers have been working since 1983 to improve the collection efficiency of traveling screens at Bonneville Dam.

Improving passage facilities for young fish has proved more difficult than those for adults. The development of passage facilities at the Bonneville second powerhouse demonstrates this point. The Corps designed the Bonneville second powerhouse, like Lower Granite Dam, with a juvenile bypass facility. This structure was ready for testing in 1982. During construction of the second powerhouse, moreover, the Corps modified the first powerhouse to include a juvenile bypass system. Major components of the Bonneville second powerhouse downstream passage system include submersible traveling screens to guide fish out of the turbine intakes into gatewells; vertical barrier screens through the downstream operating gate slots to prevent juvenile fish from returning to the turbine intakes; orifices to allow fish egress from gatewells into the bypass gallery; the juvenile fish bypass downwell; a sampler that automatically collects up to 10 percent of juvenile migrants passing through the bypass system; a dry separator connected to a wet separator in the migration observation room; and four raceways to hold fish from the wet separator. The Corps modified the first powerhouse by drilling orifices in the bulkhead slots to allow egress from gatewell slots, constructing a bypass and juvenile sampler, and installing submersible traveling screens to divert migrants from turbine intakes.

Evaluating the downstream migrant systems began in 1982, the first year of operation of the second powerhouse.[69] Researchers limited this evaluation to observation of the downstream migrant facility in the second powerhouse, because construction was still underway and traveling screens were not yet included in the system. Testing of fish guidance in 1983 yielded disappointing results. Less than 30 percent of the fish entering the turbine intakes were guided into the gatewells. Two major factors affected guidance: the fish did not concentrate near the surface, and they avoided the traveling screen. Testing continued in subsequent years, and the Corps implemented several operational and structural modifications. These included lowering the traveling screen 30 inches; streamlining the trashracks to provide more laminar flow; raising operating gates to increase flow into the gatewells; constructing and installing turbine intake ceiling extensions to provide a more gradual and ordered flows approaching the traveling screen; and making numerous minor changes in flow-control devices and sampling equipment in the fish examining rooms of the two powerhouses.

This research demonstrated the difficulty of passage problems and the length of time and extent of resources required to resolve these problems. Testing continues at Bonneville Dam to improve the fish passage facilities. Although the Corps has made progress in this area, final solutions to successful fish guidance will undoubtedly require additional research. The Corps will complete bypass systems for all its Columbia and Snake River dams by 1998.

Although screening and bypass systems will soon be installed and operational at all Corps dams, a debate concerning the restoration of upriver chinook runs has developed. Fisheries scientists disagreed as to the best way to improve runs in the Snake River. Some biologists believed that if the transportation system cannot successfully restore chinook runs, they would be doomed to extinction. Some were convinced that increasing flows and allowing the juveniles to migrate without transportation remained the best solution. Others have concluded that the transportation system has been successful and that the successive drought years of 1987 through 1992 were the main cause of recent stock declines. Some scientists believed that too many poor-quality smolts have been released from upriver hatcheries, and that these releases harmed, rather than aided, the recovery of fish runs. Gene Matthews of the NMFS stated in an issue paper that he believes the low adult return rate of spring/summer chinook indicated for transported fish in recent years resulted from the poor survival of the hatchery components that account for more than 5 percent of the smolts arriving at Little Goose and Lower Granite dams.[70] Poor harvest management and increased predation in reservoirs also prevent the recovery or runs.

In its design, construction, and operation of fish facilities, the Corps considers recommendations and criteria received from the fish and wildlife agencies.[71] Because biologists' understanding of fisheries issues has evolved over time, the agencies' advice was occasionally misleading. In 1971, for instance, the Corps tested slotted bulkheads (or gates) designed for use in empty turbine bays as a possible interim solution to the gas supersaturation problem caused by spilling water at dams. Although initial experiments demonstrated that the gates were very effective as an alternative means of passing water by a dam without causing supersaturation, no tests were completed with salmon to determine whether fish passing through the slots would be injured or killed by the high-velocity water jets. The Corps called for additional studies with fish to ensure that there was no problem with injury before proceeding to construct 27 of these gates at a cost of more than $100,000 each. However, most of the state and federal fisheries agencies rejected this request at a Nitrogen Task Force meeting held in the fall of 1971. Complaining that the Corps was too hesitant, the agencies--including the NMFS--urged the engineers to go forward with installation of the gates by the spring of 1972.[72]

The Corps complied, and the results were unfortunate. Many of the fish died from exposure to the high-velocity water jets, and regional newspapers denounced the venture as a "gamble that backfired."[73] As one Corps employee later observed, in general the engineers have enjoyed an "open, honest, sincere, and professional relationship" with fisheries agencies. When facilities are successful, "all share a sense of pride." When they do not meet expectations, "all must share that responsibility as well."[74] In any case, the Corps found an alternate use for the slotted bulkheads, which now provide the foundation docks for the 135-foot barges that transport juvenile fish downstream on the Snake River.

Since the 1930s, the Corps has assumed a major role in developing fish passage in the Columbia Basin. Other agencies, however, also sponsored research and construction of fish passage facilities. In the 1940s, the Bureau of Reclamation contributed to the transfer of salmon from Grand Coulee Dam, which blocked passage of fish runs. In the 1980s, the bureau initiated a major effort to improve fish passage on the Yakima River. Idaho Power Company, too, attempted a large-scale operation at Brownlee Dam in the late 1950s and early 1960s. Public Utility Districts included adult fishways in their mid-Columbia River dams, but did not attempt juvenile facilities until the 1970s.[75] Finally, BPA played a major role in sponsoring fisheries research on the Columbia and Snake Rivers.

Costs of Mitigation

In the early 1990s, the Corps' Fish Passage Development and Evaluation Program conducted approximately 50 studies of fish passage issues, including transportation, spill effectiveness, bypass effectiveness, adult migration, and gas supersaturation. This commitment to research ensured that expensive design modifications yield improvements in fish passage.[76] However, mitigation efforts regarding anadromous fish on the Columbia and Snake Rivers remained costly. The Fish and Wildlife Coordination Act mandated that mitigation expenses associated with water development projects be considered project costs. Approximately 90 percent of mitigation costs have been allocated to hydroelectric power generation. Mitigation costs have been allocated in proportion to each project's beneficial purposes. Since hydroelectric power production averaged 90 percent of project benefits, so did fish mitigation costs. Pacific Northwest customers using federally generated power helped pay for fisheries research and facilities when they paid their electric bills (see tables 9 and 10).[77]

Northwest Power Planning Council's Fish and Wildlife Program

The Pacific Northwest Electric Power Planning and Conservation Act brought significant changes to the management of the region's anadromous fisheries. Passed in 1980, this act authorized the states of Oregon, Washington, Idaho, and Montana to create a policy-making and planning body, called NPPC, for the long-term supply of energy. The NPPC is separate from the BPA, and is not an agency of the federal government. The governors of each of these states appoint two representatives to serve on the eight-member Council. This interstate organization has two objectives: to assure the region of adequate, reliable, economical power supply and to protect fish and wildlife in the Columbia Basin. In the early 1990s, the NPPC remained a unique organization in the United States--one that could potentially provide a prototype for the resolution of environmental issues in other regions.[78]

The Pacific Northwest Electric Power Planning and Conservation Act directed the NPPC to develop a Columbia River Basin Fish and Wildlife Program which the BPA financed. To pay for this program, the act authorized a $1.25 billion fund that the BPA could borrow against. The purpose of the wildlife program was to "protect, mitigate and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries."[79] Although BPA funded NPPC activities, federal agencies, including the Corps, paid for flow measures. After consulting with a variety of state and federal agencies, the program established the goal of doubling the current run of 2.5 million salmon and steelhead. However, it specified no time frame for accomplishing this goal.

The program outlined measures to mitigate losses and enhance the anadromous fish resources of the Columbia River. Several sections were devoted to the life cycle of the salmon and steelhead. These included measures intended to improve downstream migration, ocean survival, upstream migration, and propagation. Suggested remedies, presented in the form of measures or actions, were to be implemented at the earliest possible date. Under the act's provisions, each measure must complement existing and future activities of the federal and state fisheries agencies and appropriate Indian tribes in the region; be based on the best available scientific knowledge; use the alternative with minimum economics cost where equally effective means exist; be consistent with legal rights of Indian tribes in the region; and in the case of anadromous fish, provide for improved survival at and between hydroelectric facilities on the Columbia River system.[80]

The NPPC's Columbia River Basin Fish and Wildlife Program directly affected the Corps' operation of its facilities. Hydroelectric dams of the Columbia and Snake Rivers have greatly altered the natural flows that normally occurred during the downstream migration of salmon and steelhead smolts. The spring runoff was stored in reservoirs to be used during periods of low flow (late summer through winter). Regulating the river in this fashion produced more electricity in the fall and winter, but it also reduced river flows in the spring when juvenile salmon and steelhead migrate.[81]

Water Budget and Fish Passage Center

To increase spring flows, the NPPC established a "water budget" in 1982 to be used between 15 April and 15 June, the period when most juvenile salmonids migrate downriver. The water budget exemplified the effort to mitigate fish loss through changing operational procedures at the dams. It was based on the idea that large numbers of young fish would survive if they passed through the mainstem system of reservoirs and dams more rapidly. The water budget represented a volume of water earmarked to increase survival of juvenile migrants. The Council's objective was to simulate the effects of a spring freshet--a runoff from rains and melting snow that helped push young fish to the ocean before the construction of mainstem dams. Increased flows during the spring, the NPPC hoped, would "flush" the juvenile fish down the river, reducing their exposure to predators and other hazards.

Initially, the water budget did not specific spill. The original concept was that increased flow would speed migrants through the system, and the opportunity for more spill would be inherent in the use of the water budget. By the 1980's, however, the NPPC called for spill at dams without adequate bypass systems.[82]

Questions regarding the volume of water generated considerable controversy. Power regulators argued that sufficient water should be stored to provide firm power during drought years when flows are low. Fisheries agencies and tribes argued that the amount requested by power regulators was too low and that little could be accomplished with the volume of water the power regulators recommended for the water budget. After considering these positions, the NPPC established 78 kcfs-months for the water budget--58 kcfs-months to be available at Priest Rapids Dam, and 20 kcfs-months to be available at Lower Granite Dam. One kcfs-month equals 1,000 cubic feet per second of water for one month. This water was to be used during the spring months for increasing juvenile survival.[83]

The NPPC also directed the BPA to fund a Fish Passage Center (FPC), along with two managers (now a single fish passage manager), technical and clerical support, and the services of consultants when needed. The managers and their support staff were charged with planning and implementing the annual smolt-monitoring program; developing and implementing flow and spill requests; and monitoring and analyzing research results to assist in implementing the water budget and evaluating its effectiveness. A key part of the implementation required the incorporation of smolt monitoring into the FPC's activities in 1983. It enabled the FPC to determine when to use the water budget. Between 1981 and 1988, the Corps provided spill at John Day and Lower Monumental Dams on nights when larger numbers of migrants were present, based on hydroacoustic monitoring at the powerhouse. Some fisheries agency biologists questioned the adequacy of the resulting spill amounts and duration.

In 1983, the FPC began to implement the newly developed water budget concept in the Fish and Wildlife Program. That year also marked its initial smolt monitoring activities. The early period of the FPC was one of learning. At the conclusion of the first season, the FPC believed that accounting for water budget use needed clarifying. It suggested that the difference between firm power and actual flow be used as the basis for measuring water budget use. The Corps agreed to this method of accounting, and used it in subsequent years.[84]

The FPC carried out its activities with apparent success from 184 to 1986. However, no convincing information was available concerning improved survival as a result of these activities. FPC biologists complained that secondary power marketing and multiple use considerations took preference over fish. Its staff also believed that the coordination and consultation between power interests and the FPC resulted in some conflict, and that the runoff forecasts were not sufficiently accurate to plan use of the water budget. They also urged negotiating an agreement between Idaho Power and the BPA for use of Brownlee Dam storage.

The first low-runoff year that tested the effectiveness of the water budget occurred in 1987. At the end of that year's operation, the FPC concluded that the objectives of maintaining at least the specified minimum flows during the middle 80 percent of the juvenile fish migration were not met, owing to previously mentioned problems. The FPC staff also indicated that losses between McNary and John Day Dams may have been as much as 50 percent higher for steelhead and 25 percent higher for chinook, but provided no supporting data other than fish passage indices. The center concluded that the volume of water available for the water budget was insufficient in that low-flow year and that the spill provided at various dams was inadequate. Its staff voiced nearly identical complaints following the 1988 migration season.[85]

Because research revealed that survival of smolts passing over the spillway was substantially higher than that of smolts passing through turbines, some biologists believed that spilling water at dams would decrease juvenile mortality. Before 1983, these activities were carried out by the NMFS and the Corps under the COFO. However, from 1977 to 1982, when the COFO was in operation, there was no water budget or criteria for how much water should be spilled at dams that had no juvenile bypass systems. The COFO determine flow volumes and spills on the basis of cooperation and negotiation among the fisheries agencies, the power companies, and the Corps.[86]

Spilling water at John Day Dam.

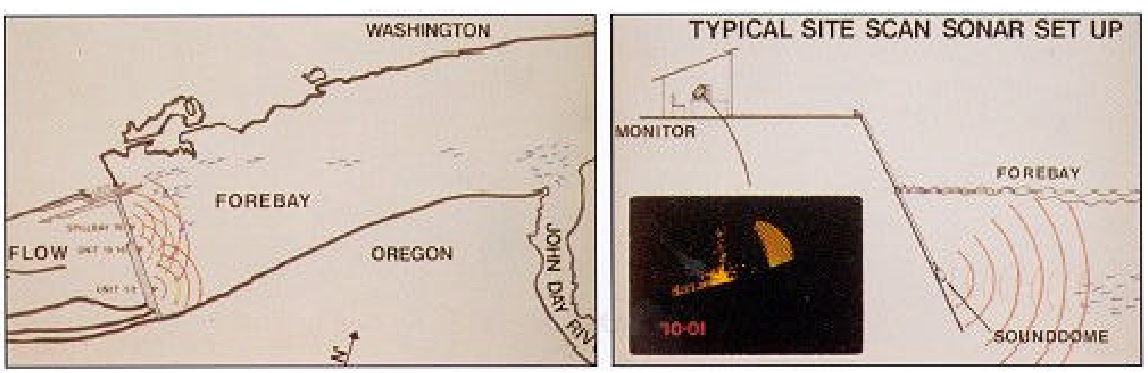
To resolve the continuing debate over spill, fisheries agencies and tribes, in consultation with BPA, prepared a fish-spill memorandum of agreement in 1989. This document specified the timing, location, volume, and duration of spill that would be provided at four of the mainstem dams under various conditions of runoff. Due to obligations to other interests, including power companies, the Corps did not sign the agreement. However, the agency complied with it during the springs of 1989 and 1990. The FPC deemed the 1989 and 1990 seasons successful insofar as spilling water was concerned, but again pointed out the inadequacy of the volume of water available for the water budget in 1989. In 1990, sufficient snow pack provided more flow than required to meet the water budget objectives. That year, the FPC judged passage for downstream migrants to be successful.[87] The center based this judgment on fish passage indices they developed and on smolt travel time data.

From 1983 to 1990, the FPC obtained substantial additional data on the relationship between flow and travel time, but made no attempt to obtain new data on system survival. Although fish passage indices for key dams were developed, biometricians and biologists have pointed out several sources of bias in this approach.[88] Several power entities, including the Corps, the BPA, and the public utility district's fisheries biologists charged that the FPC failed to demonstrate the effectiveness of the water budget or the spill plan and that this information remained critical to justify these programs and FPC-requested actions. Farmers in Orofino and Boise were not convinced that many of the actions proposed by FPC are the best use of the water.[89] The NPPC directed a "third party" to develop a proposal for measuring survival using the recently developed passive integrated transponder tag. In future years, information on survival of juvenile migrations might be used to evaluate better the effectiveness of the water budget.

Research financed mainly by the Corps has demonstrated that juvenile steelhead and salmon migrating downstream suffer various rates (usually exceeding 9 percent) of mortality as they pass through turbines. The best available data indicate that smolts suffer less mortality (0 to 5 percent) as they pass over the spillway. However, one study conducted at Lower Monumental Dam indicated that mortality to experimental releases of steelhead passing over a spillway without deflectors was 27.5 percent. Ice Harbor Dam, John Day, and The Dalles are not equipped with spillway deflectors.[90] The remedy or measures described in this section of the Columbia River Basin Fish and Wildlife Program are directed toward reducing this mortality by speeding construction of juvenile bypass systems and by employing spill at specific dams.

Although the Corps has been studying various methods of improving bypass systems at Lower Granite, Little Goose, McNary, and Bonneville Dams since 1975, the NPPC believed that the status of the runs on the Columbia and Snake Rivers required prompt action rather than the measured approach the Corps wished to pursue. The measured approach called for thorough evaluation of changes in facilities or in testing of prototype fish passage devices, such as extended-length screens, before embarking on large-scale construction. As a result, the NPPC encouraged the preparation of interim juvenile fish passage plans, while developing permanent solutions to passage problems at John Day, The Dalles, Bonneville, Lower Monumental, and Ice Harbor Dams, which lacked mechanical juvenile bypass systems when the NPPC first developed its Fish and Wildlife Plan.

The interim fish passage plans advocated spilling water at these dams when significant numbers of juvenile migrants were present. The fisheries agencies and tribes determined what constituted a significant number, which varied from a few hundred to tens of thousands, depending on the dam and season. The interim plans encouraged spilling sufficient water to achieve 90 percent survival for the middle 80 percent of the spring and summer migrants. However, biologists have expressed concern that excessive amounts of spill at dams with or without deflectors could result in greater mortality from atmospheric gas supersaturation and injury than would occur if a larger portion of the fish were allowed to pass through the turbines. Additional research is needed to determine the optimum fish passage route at specific dams to achieve the desired 90 percent survival. No spillway was to occur after August 15th. The Corps, fisheries agencies, and area Indian tribes coordinated an annual plan to determine the start of the spill at each dam.[91]



Typical site scan sonar set up and locations at John Day Dam

The smolt monitoring activities of the FPC comprised a key part of the spill program. These activities enabled the FPC to determine when sufficient numbers of migrants were present to trigger spill. In addition, the Corps provided fixed beam and hydroacoustics at key dams to enhance the FPC's ability to determine the presence of juvenile migrants. The hydroacoustics helped determine how effectively various levels of spill passed migrants over the spillway.

The Corps adhered to the memorandum of agreement regarding spill in 1990. In 1991 and 1992, the FPC asked for higher levels of spill. Although some extra spill was provided in 1991 and 1992, the FPC's requests were not always met. Corps biologists pointed out that the amount of spill is negotiated each year and is based on a number of factors, including availability of water.

Improving Juvenile Bypass

The NPPC's program, "Strategy for Salmon" (1992), called for the Corps to continue spilling water over dams until the engineers installed adequate turbine screens. "Strategy for Salmon" also required completion of interim screening of turbines at Lower Monumental Dam by March 1992 and Ice Harbor Dam by March 1993. In addition, it requested design, evaluation, and complete installation of extended-length screens at McNary Dam by March 1995; Lower Granite Dam, March 1996; Little Goose Dam, March 1996; John Day Dam, March 1998; and The Dalles Dam, March 1998. The program also called for continued research to evaluate transportation of smolts from Lower Granite, Little Goose, and McNary Dams and to improve the collection, holding, and transport facilities whenever possible. For example, the NPPC asked that the Corps evaluate techniques to improve transportation such as the use of cooler water in barges, reduced densities of fish in barges and broader dispersion of fish upon their release below Bonneville Dam. Furthermore, the program sought actions to reduce predation on salmonids with a goal of reducing the squawfish population by 20 percent. It also asked the NMFS to evaluate predation of adults by marine mammals. The NPPC also urged the Corps and fisheries agencies and tribes to evaluate drawing down reservoirs to speed the migrants' downstream passage, and to report by November 1993.

Harvest Management

Harvest management remained an important component of the NPPC's Columbia River Basin Fish and Wildlife Program. Overharvest of critically low natural stocks in a mixed-stock fishery could negate all efforts by the Corps, the BPA, fisheries agencies, and tribes to restore and improve upriver runs of salmon and steelhead. The NPC recognized this point in 1987 and has recommended various measures to reduce harvest of point in 1987 and has recommended various measures to reduce harvest of these naturally-produced stocks. However, the NPPC did not have the authority to regulate harvest or other river uses beyond the power and fish and wildlife program funded by the BPA. The NPPC measures included stronger consultation and coordination with fisheries managers (the Pacific Fishery Management Council, the North Pacific Fishery Management Council, and the state management agencies); development of known stock fisheries' and research on the ocean plume in the nearshore area of the Columbia River.[92]

The 1993 strategy called for further harvest restrictions to protect sockeye below the confluence of the Snake and Columbia Rivers. It also called for reducing the harvest of Snake River fall chinook to 55 percent of the run from levels greater than 70 percent in previous years. The strategy recommended continuing the ban on harvest of summer chinook, substantially reducing Canadian harvest of United States salmon, and banning the high seas drift net fishery. Additionally, it argued for voluntary lease or buy back for commercial fishing licenses, with harvest alternatives such as line-catch known-stock fisheries, and a review of sportfish regulations. The NMFS was also asked to prepare a unified annual report by 1 June of each year, outlining harvest and escapement of various Columbia River salmon stocks.[93]

Finally, the new strategy encouraged improved hatchery practices to better enable hatchery fish to survive in the natural environment and gave highest priority to habitat improvement and protection in the Columbia Basin. It recommended various actions to accomplish the above. Surprisingly, the strategy did not specifically mention the problem of disease in hatcheries. Substantial information indicated bacterial kidney disease (BKD) was a serious problem affecting spring and summer chinook reared in Columbia and Snake River hatcheries, and might have been a major cause of the less-than-expected adult returns from the hatcheries.[94]

Additional NPPC Requirements

The establishment of the NPPC represented an increasing sense of responsibility regarding hydroelectric power and the conservation of fish. Before 1980, the government had not required a comprehensive plan for restoring naturally producing salmon to compensate for the loss from large dams. Although previous legislation had required federal agencies to consider the needs of salmon, the objectives of the Council extended beyond earlier attempts to ensure the protection of anadromous fish. Responsibilities of the NPPC's Fish and Wildlife Program, for instance, included the establishment of construction schedules for the Corps' fish facilities.

Occasionally the NPPC's plans proved unrealistic. The Council set schedules for the Corps' construction of fish facilities without sufficient allowance for funding limitations imposed by Congress, or adequate time to execute projects. In 1986, the Corps explained that an apparent failure to comply with the "desires and schedules" of the fisheries agencies, tribes, and the NPPC "is more a matter of their not understanding our authorizations and capabilities than lack of good faith on our part."[95]

The NPPC's recommendation that the Corps install screens to divert juveniles from the turbines into bypass channels exemplified this point. In 1988, the Office of Management and Budget opposed a congressional allocation of $8.7 million for installation of screens to divert fish from the turbines on Columbia System dams. Accordingly, the Corps released only $4 million in funds, prompting complaints from the media that the agency appeared "to be dragging its feet on agreed-to projects."[96] As late as 1992, critics charged that the engineers approached the installation of the screens "kicking and screaming."[97] The Corps, however, questioned wither screens at The Dalles and Ice Harbor Dams provided the most effective protection for the cost. Even so, The Oregonian reported, "spending every penny of the $8.7 million in fiscal 1988 would not keep the accelerated program on schedule."[98]

Some NPPC schedules did not permit adequate testing of prototypes, or time to modify and retest prototypes, if modifications were needed. The NPPC's "Strategy for Salmon," for example, called for the installation of operational screening and bypass systems by March 1992 at Lower Monumental Dam and by March 1993 at Ice Harbor Dam. The deadline for completion of Lower Monumental facilities was listed as four months before the date that the document was issued, and the date for completion at Ice Harbor was established as five months after the document's release. Adherence to such a schedule would have proved difficult for any agency.[99]

Some of the measures established in the NPPC Fish and Wildlife Plan had been implemented previously. The NPPC plan for 1987, for example, called for fish densities to be held at half a pound per gallon in trucks, and 5 pounds per gpm (gallons per minute circulation rate) in barges. Yet the Corps had established these densities as routine as early as 1981, and continued them through the mid-1990s.[100]

As the numbers of agencies charged with protecting salmon runs increased, so did the difficulties involving interagency communication and coordination. In 1993, the Snake River Salmon Recovery Team pointed out that the Pacific Northwest Power Planning and Conservation Act was significant for according fish and wildlife equitable treatment in management and operation of the Columbia River hydroelectric power system. This legislation also remained noteworthy for requiring development of a comprehensive program to protect, mitigate, and enhance fish and wildlife in the Columbia River Basin. However, the Recovery Team concluded that the law "has not achieved desired results for the survival of anadromous fish," owing to "the lack of specificity in program measures" that often led "to disagreements over how measures are to be implemented."[101]

Ten years earlier, Robert W. Schoning had reached a similar conclusion. Schoning, who had served as Director of the Fish Commission as well as Director of the NMFS, worked on the Columbia River from 1947 until his retirement in 1986. "Who would have thought a few years ago," he asked in 1983, "that the Corps, BPA, electric utilities and NPPC would be working closely with the fisheries agencies," devoting "substantial time, effort, manpower, funds, and interest to improving the runs?" In his estimation, "They warrant more support and cooperation than they are getting from some sources. It is recognized that a larger and better coordination effort is needed."[102]

Lower Snake River Fish and Wildlife Compensation Plan

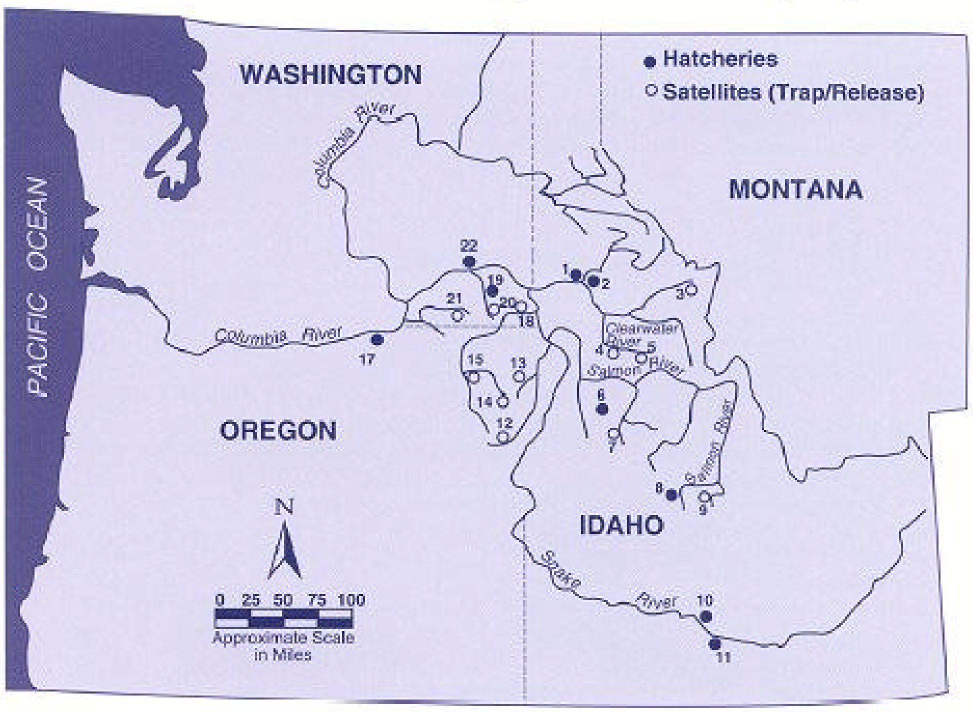
The Corps' construction of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams on the Snake River prompted congressional concern for the loss of wildlife habitat and anadromous and resident fisheries. For this reason, the Corps began developing the Lower Snake River Fish and Wildlife Compensation Plan in April 1966. After study and negotiation with the federal and state agencies, the Walla Walla District Engineer prepared a "Special Report: Lower Snake River Fish and Wildlife Compensation Plan" (LSRCP), which Congress approved with passage of the Water Resources Development Act of 1976[103] (see Map 5).

The LSRCP called for a sufficient number of anadromous fish hatcheries and associated trapping and holding facilities. These were to produce enough smolts to return 18,300 fall chinook adults, 58,700 spring chinook adults, and 55,100 steelhead adults to the project area. The first facility completed under the plan was the McCall Summer Chinook Hatchery. Constructed in 1979, this hatchery produced 9,050 pounds of summer chinook, and 5,850 pounds of spring chinook in 1983. In March 1982, the hatchery released 901,500 summer chinook in the South Fork of the Salmon River. During the next eight years, the Corps added a number of hatcheries and satellite facilities.[104]

A subcommittee of the Columbia Basin Fisheries Technical Committee determined overall production of the hatcheries. This committee calculated the number of smolts required to return the appropriate number of adults to compensate for the losses indicated. It based smolt-to-adult percent survival rates on return rates to various operating hatcheries. The committee also based the fall chinook rate (0.20) on returns to lower Columbia River hatcheries, and the spring/summer chinook and steelhead rates (0.87 and 0.50, respectively) on returns to hatcheries in Idaho. The committee assumed that these rates would continue to be valid in the future and might even improve with modified river conditions, such as the installation of bypass facilities, implementation of smolt transportation, and application of the water budget.[105]

Once overall production goals were established and accepted, biologists selected appropriate locations within the Snake River Basin for hatcheries and associated facilities. The primary problem was finding sufficient additional water of the appropriate quality to rear fish that was not already allocated to other uses. Scientists surveyed the Snake River drainage to locate suitable sites. They examined existing rearing facilities for expansion, surveyed tributary streams as water sources, and drilled test wells for new sources of water. Research proved to be successful in locating additional sites for rearing. Fisheries biologists and engineers formed a technical work group to determine the appropriate species and number to be reared at each facility. Production goals were achieved or exceeded for steelhead, but salmon released at some hatcheries dropped below the targeted goals, mostly because suitable broodstocks were not available to supply eggs.

Lower Snake River Compensation Facility Map



Lower Snake River Compensation Plan Program
Facilities in Washington, Oregon, and Idaho

IDAHO DEPARTMENT OF FISH & GAME
1. Clearwater Fish Hatchery
2. Powell
3. Crooked River
5. Red River
6. McCall Fish Hatchery
7. South Fork Salmon River
8. Sawtooth Fish Hatchery
9. East Fork Salmon River
11. Magic Valley Fish Hatchery

U.S. FISH AND WILDLIFE SERVICE
2. Dworshak National Fish Hatchery
10. Hagerman National Fish Hatchery

WASHINGTON DEPARTMENT OF FISHERIES
22. Lyons Ferry Fish Hatchery - Salmon

OREGON DEPARTMENT OF FISH AND WILDLIFE
12. Imnaha
13. Sheep Creek
14. Wallowa Fish Hatchery
15. Big Canyon
16. Lookingglass Fish Hatchery
17. Irrigon Fish Hatchery

WASHINGTON DEPARTMENT OF WILDLIFE
18. Cottonwood Creek
19. Tucannon Fish Hatchery
20. Curl Lake
21. Dayton Pond
22. Lyons Ferry Fish Hatchery - Steelhead

LSRCP HATCHERIES

McCall Summer Chinook Hatchery

Hagerman Fish Hatchery

Dworshak Fish Hatchery

Looking Glass Fish Hatchery

Yet achieving the targeted pounds of fish released or numbers released was not the ultimate goal of the program. The objective was to increase adult returns substantially, back to or above the project area. By the 1990s, salmon adult return rates remained below that needed for success. Rates ranged from 0.1 percent to 0.8 percent, with any facilities yielding return rates of about 0.2 percent. Although production goals for spring and summer chinook had not been reached at this time, production generally increased. Adult return rates, however, did not. Steelhead return rates met or exceeded the goals, ranging from 0.6 to 2.0 percent.[106] Some biologists remained concerned that the carrying capacity of some of the streams might be exceeded by the larger releases in recent years. Increasing the number of released fish might prove detrimental not only to naturally produced stocks, but also to hatchery stocks. In several Columbia River hatcheries, when production was increased beyond a certain level, the return rate decreased.[107]

Diseases that occurred periodically in hatcheries also affected the return rate of adults. Spring and summer chinook in LSRCP hatcheries, for example, displayed a very high incidence of BKD. Smolts that were severely infected had little chance of survival after release. For that reason, continued effort to reduce the detrimental effect of BKD seemed justified.[108]

By the early 1990s, scientists had viewed the steelhead portion of the LSRCP as successful, and they significantly improved the effectiveness of the chinook portion of the program. At that time, more than 12 million spring chinook smolts were released annually. If return rates improved merely to 0.5 percent, 20,000 adults would be added to the run.

Like many of the Corps' mitigation efforts, the LSRCP remained expensive. By 1990, expenditures had reached $109.3 million. At this point, the agency had spent approximately $463 million on fish facilities on the Columbia and Snake Rivers. Through 1992, the Corps' expenditures for fisheries research totaled $58 million. Most biologists remained hopeful that these expenditures will eventually yield success. The Corps' program shave had encouraging results. Since the 1970s, the numbers of steelhead have increased dramatically. The engineers plan to continue its longstanding support of research to improve fish survival and migration efficiency.

Yet, for all the improvements in fish passage facilities, transportation systems, and hatchery supplementation, annual runs of chinook and sockeye salmon have not significantly increased. As noted, the NMFS listed Snake River chinook populations as threatened and sockeye as endangered. It was too soon in the early 1990s to determine whether the recent programs of all the agencies would be able to save the salmon. The decline of anadromous fish populations has been a longstanding problem, dating back to the last century. Throughout this period, a variety of uses of the Columbia and Snake Rivers--including hydropower development and operation, hatchery practices, harvesting, and habitat degradation--has contributed to the loss of fish. The Corps recognized that improvements in each of these areas would be necessary to recovery the salmon. Saving the endangered and threatened runs would require more than mitigating the impacts of hydropower development and operation.

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[17]Collins Interview; Gerald B. Collins to C.J. Burner, 8 Mar. 1951, Gerald B. Collins, personal papers, pp. 1-2.

[18]Collins Interview.

[19]Collins Interview.

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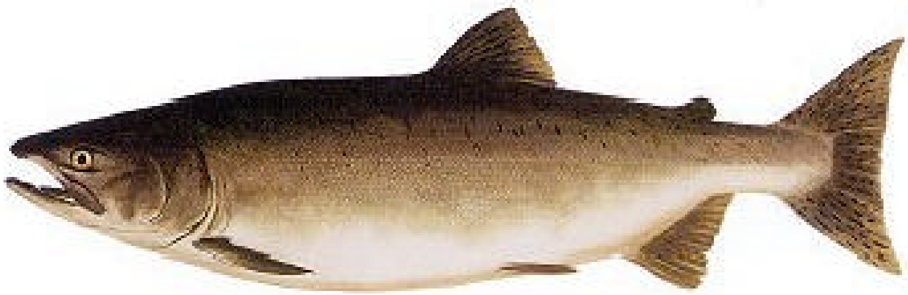
Pink Male - Freshwater Phase



Pink Female - Freshwater Phase

Pink - Ocean Phase

V. River Users in the Modern Era

"Salmon management is complicated," noted one observer in 1987, "because salmon biology is complicated." Anadromous fish originate in hatcheries and streams from California to Alaska, then intermingle in the ocean before returning to spawn. Compounding the difficulty in managing this resource are the diversity and number of users. Fisheries management concerns the interaction of people as well as their taking of salmon. For more than a century, recreational anglers, commercial fishermen, and Native Americans have competed for fish. As salmon and steelhead populations decreased, friction between the various users escalated, as did attempts to limit other fishers' access to anadromous fish.[1]

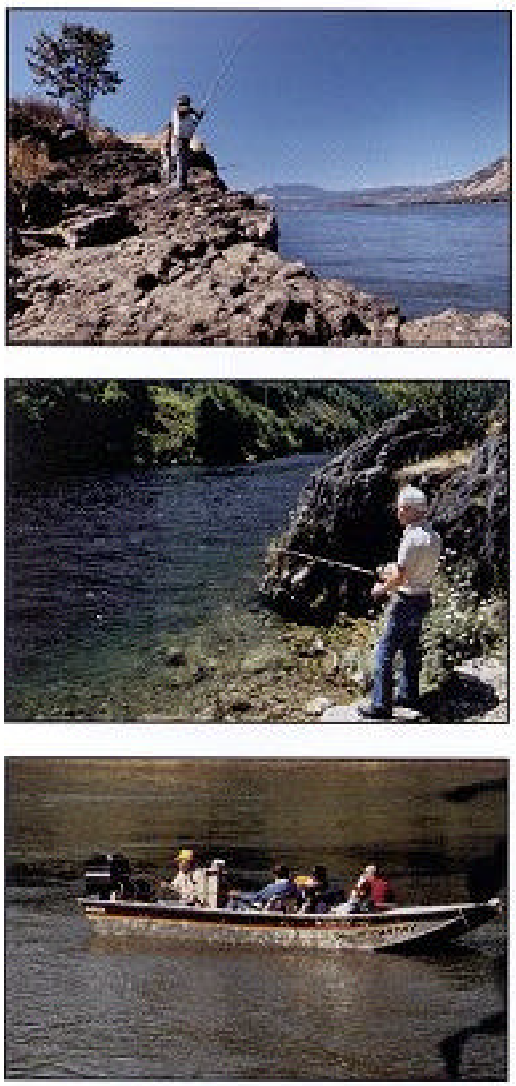
Sports And Commercial Fisheries

Fishing for sport is not new in the Pacific Northwest. By the late 19th century, the Columbia River Basin had become world-renown for recreational angling. For the next 100 years, many anglers in the West regarded the Columbia as the "gem" of river sports fishing.[2] After World War II, population growth as well as increased affluence and leisure time considerably augmented the numbers of recreational anglers. Interest in sports fishing grew rapidly in the late 1960s and early 1970s.[3] By the early 1990s, approximately one million sports fishermen resided in Washington and Oregon, averaging an annual catch of two salmon per angler.[4] Although early anglers generally fished from shore or from small rowboats, many modern fishermen use motor boats, increasing not only their catch but also their visibility on the river.[5]

On the mainstem Columbia, recreational anglers focus on the 140 miles of river below Bonneville Dam for spring chinook and summer steelhead. Sports fishermen venture to the Pacific Ocean for fall chinook and coho, and they land winter steelhead in the tributaries below Bonneville Dam. During the last two decades, reservoirs behind mainstem dams have supported a developing sport fishery for walleye and smallmouth bass.[6] Salmon are a prized catch, owing in part to their size and the difficulty of their capture. One favored spot is the mouth of the Columbia, where salmon still feed before embarking on their journey to spawn.

According to some anglers, however, no fish can compare to a steelhead. As one observer explained, "It is merely a species of fish, but it transcends. It is clever, tough, jut-jawed--a fighter, lovely, lonely, and courageous."[7] Many descriptions of the pursuit and landing of steelhead are highly dramatic. An article in Sports Illustrated, for example, portrayed the "atavistic elation" of steelhead anglers: this fish "makes an impact upon the adrenalin producing glands rather than the intellect... He can hurtle into the a split second after he is hooked, and flash hugely out in the murk, like a sword Excalibur thrust up from the depths--at once a gleaming prize and a symbol of battle."[8]

Steelhead enthusiasts include Cecil D. Andrus, governor of Idaho and former Secretary of the Interior. "There is no thrill greater," he suggested, "than to take that shock that starts in your fingertips on a fly rod, at the head of riffle, when a big steelhead takes your fly."[9] Steelhead are distinguished from rainbow trout, another popular quarry, by their larger size and anadromous behavior. Unlike salmon, steelhead generally do not die after spawning, and they will readily take a lure while on their upriver trek. The Columbia's tributaries, including the Snake, Salmon, Clearwater, and Grande Ronde, are well known steelhead streams that attract anglers even during the icy months of winter.[10]



Recreational sport fishing

With the increase in recreational angling came a growing number of regulations. Although Washington and Oregon share the Columbia River as a boundary, the two states established sport fishing regulations separately. Oregon first required angling licenses in 1909, and the next year the state prohibited angling at night and restricted gear to a hook and a line. At that time, Oregon established a trout bag limit at 75 per day. [11] Although Washington passed similar regulations, early 20th-century residents along the Columbia River recalled sneaking to tributary streams at night to spear salmon. [12] Like Oregon, Washington imposed bag limits; in the early 1920s the state restricted the daily catch for personal use to 25 salmon, 10 inches or more in length. By the early 1940s, Washington's daily limit was 6 salmon, 12 inches or more in length. Washington and Oregon sometimes disagreed about regulations for the mouth of the Columbia River. In the early 1960s, Oregon imposed a limit of 2 salmon, 22 inches or more in length for this area, while Washington allowed a daily bag limit of 3 fish, 20 inches or more.

By the late 1970s, four state agencies and five Indian tribes managed the sport fisheries of the Columbia River. In Washington, the Department of Fisheries oversees salmon, shad, smelt, and sturgeon, while the Department of Game controls steelhead and resident trout. In Oregon, the Department of Fish and Wildlife manages all fish species, as does the Department of Game in Idaho. The Confederated Tribes of Warm Springs Reservation manages the sport fishery on reservation lands in Oregon, and the Yakima Nation (now Yakama) and Colville Tribes oversee reservation lands in Washington.[13] The three states require anglers to record their catches of salmon and steelhead on punch cards, submitted annually to the appropriate agencies. Punch cards enable the state agencies to inventory the total catch for the season. [14]

During the last half of the 20th century, sports fishing became an important attraction for tourists. State officials recognized the value of recreational angling in the region's economy. In 1950, Alvin Anderson, the Washington State Director of Fisheries, argued that the prospect of catching a salmon "is one of our most tempting lures to the vacioner."[15] By the 1970s, the Northwest Steelhead and Salmon Council of Trout Unlimited had estimated that each fish caught by sportsmen in Washington brought $200 to the state's economy, benefiting tackle shops, marinas, restaurants, and motels. Sports fishing became important to the economies of Oregon and Idaho as well.[16]

As sports fisheries gained in numbers and economic value, conflicts with commercial fisheries also increased. Animosity between the two groups was longstanding. In 1920, The Western Sportsman, a publication of the Washington State Sportsmen's Association, denounced the commercial fishermen as "greedy" and "shortsighted." Their objective, this journal complained, was "to utterly clean out the food and fish and then expect the State to rebuild the fisheries for them." Recreational anglers resented that their license fees helped replenish the streams that commercial fishers harvested. As noted, pollution and irrigation also contributed to the loss of anadromous fish. However, in the early 20th century, many residents in the Pacific Northwest believed that commercial fisheries were primarily responsible for the decline of fish runs. The "wastage in our fisheries," argued The Western Sportsman, "is one of the greatest crimes of the age."[17]

By the 1920s, recreational anglers had gained political influence in Washington and Oregon. At that time, the Sportsmen's Association of Washington had attracted more than 6,000 members. This organization supported the designation of the steelhead as a game fish, and worked to separate the Game Fish and Commercial Fish Departments. In Oregon, too, the Sportsmen's League sought to divide the functions of the Fish and Game Commission. In 1921, the state's legislature created two separate commissions: the Fish Commission and the Oregon State Game Commission, renamed the Department of Fish and Wildlife in the mid-1970s.[18]

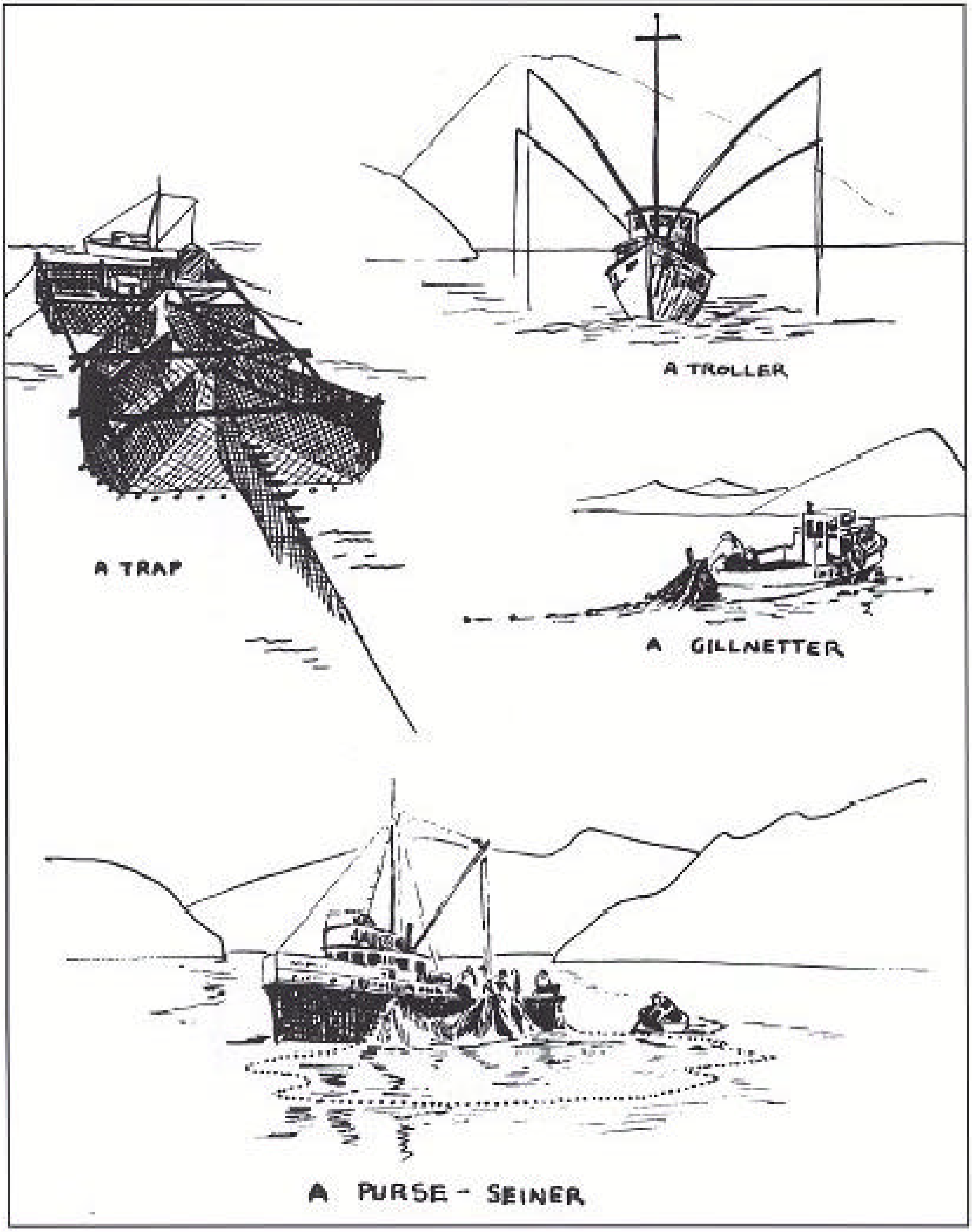
As completion of mainstem dams on the Columbia River further depleted salmon and steelhead populations, the rivalry between commercial and sports fishers intensified. In 1942, Oregon anglers introduced a measure on the ballot to close ocean feeding streams to gillnetting, an activity that ensnares fish by entangling their gills in linen or nylon webbing.[19] The Oregon Fishermen's Protective Union countered this measure by publishing an advertisement in The Oregonian, urging wartime voters to reject "this un-American measure which keeps Oregon salmon from your soldiers."[20] Although their attempt to close coastal streams to commercial fishing was unsuccessful, anglers joined their former gillnet opponents during the 1940s to prohibit traps and seines--or fixed gear. This coalition of sports and gillnet fishermen was able to convince voters to pass the measure to remove fixed gear on the Oregon shore of the Columbia River. Although the fixed-gear operators harvested fewer fish than the other two groups, they were not as numerous or as politically powerful.[21]

By the 1950s, the coalition between sports and gillnet fishermen began to deteriorate, giving way to furious "bickering."[22] Steelhead remained the focus of contention. Anglers from Washington complained that large numbers of this fish, propagated by their State Department of Game, were landing in Oregon's commercial nets. Although in 1957 the Oregon Fish Commission closed the Columbia River to commercial fishing of winter steelhead during December and January, this agency refused the sportsmen's request to ban commercial fishing beyond this time. Throughout the next decade, Oregon anglers continued to label the steelhead a game fish, allowed to be taken only with a hook and line. Washington agencies had considered steelhead a game fish since the 1920s. However, that state's commercial fishermen could land steelhead in Oregon. Although Oregon's House Bill No. 1302 declared steelhead a game fish in 1969, the measure also allowed commercial fishermen to catch them as they intermingled with salmon.[23] As a result, commercial fishermen in the early 1970s could harvest as many as 60,000 steelhead annually in Oregon.[24] In 1975, owing to the support of groups such as the Northwest Steelheaders Council of Trout Unlimited, recreational anglers were victorious in prohibiting the commercial sale of steelhead in Oregon.

Among the arguments that anglers employed against gillnetters was that "the steelhead is worth three times as much as a recreational attraction as it is when garroted and peddled across the counter in a fish market."[25] Summing up the position of anglers, one observer of the conflict between sports and commercial fishers noted, "It's a lot more sport to catch a salmon on a hook and line than to open a can."[26]

Commercial fishermen were equally adamant in their position. "Fish," sneered one packing-house operator, "are not for playing with."[27] For all the money sports fishing brought to the Pacific Northwest economy, some gillnetters saw angling as a frivolous activity. Commercial fishing was a long-standing industry in the Pacific Northwest. Unlike recreational angling, it "played a major part" in the initial economic development of the area.[28] In addition to catching salmon and steelhead, commercial fishing encompassed a wide variety of activities, including processing, distribution, support services, and fisheries management. Even after the "golden age" of late-19th century harvests, commercial fishing remained an important contributor to the regional economy.[29] The ocean salmon fishery established around 1910 further expanded the industry.[30]

After World War II, however, salmon became a luxury item rather than food for the working class, owing to a decrease in the resource and an increase in price. During the 1940s, fishers harvested salmon and steelhead with greater efficiency. Trollers hauled a large percentage of the catch, and advances in technology improved navigational aids, netting materials, and fish-hauling equipment.[31] The 1940s also brought an increase in regulations. Established in 1947, the Pacific Marine Fisheries Commission, for instance, oversaw ocean fisheries along the West Coast. This interstate commission, which included representatives from California, Oregon, Washington, Idaho, and Alaska, reviewed fisheries research data and south to develop unified positions on regional fisheries issues.[32]



Methods of Commercial Fishing on the Columbia River

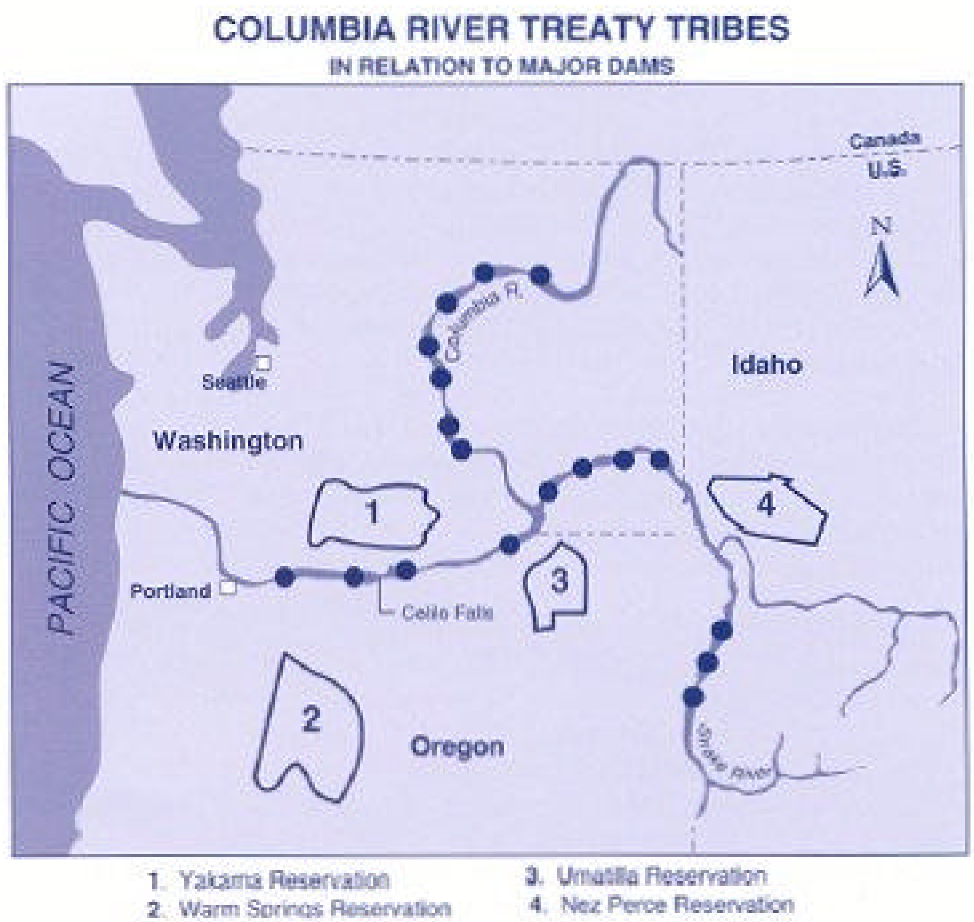
While the commercial fishing season once extended from May to October, Oregon and Washington agreed to limit the harvest period to a few weeks.[33] Since the early 1980s, fishery managers attempted to control fishing fleets to maintain a number of boats that approximates the amount of salmon available for harvest. By the 1990s, no new licenses or permits for commercial fishing boats were available from state governments in Washington and Oregon. These must be purchased from existing holders, usually at high prices.[34]

As the commercial fishing industry lost its profitability, it gradually declined in political power. In the 1980s and early 1990s, gillnetters lost ground in their competition with other uses of Columbia River resources. This erosion signaled the end of an era for one of the region's earliest and most lucrative industries. Yet as the conflict between commercial and sports fishers lessened, these groups increasingly focused their attention on the activities of water resources development agencies. The growing recognition of the recreational and economic value of salmon and steelhead provided fishers more incentive to look closely at mitigation efforts to protect these fish from the impacts of hydroelectric development.

Native American Fisheries

Tension between Native American fishers and other users of the Columbia River System dates from the 19th century. By the 1850s, an increasing number of European settlers in the area pressured the territorial governments of Oregon and Washington to secure title to much of the land occupied by Indians. In the Pacific Northwest, the U.S. recognized aboriginal title and sought to extinguish it to benefit Euroamerican immigrants. To this end, Isaac Stevens, governor and Superintendent of Indian Affairs in the new Washington Territory, hastily negotiated treaties with Native Americans in the Columbia Basin in 1854 and 1855. These agreements granted the Indians "the right to take fish, at all their usual and accustomed fishing grounds and stations...in common with all citizens of the Territory." During a seven-month period, Stevens negotiated eight treaties affecting approximately 40 tribes and bands of Indians in Washington Territory, as well as in sections of Oregon. At the same time, Joel Palmer, governor and Superintendent of Indian Affairs in Oregon Territory, arranged three treaties with Indians south of the Columbia River. Negotiated in the imprecise Chinook trade jargon, these agreements became a source of heated debate in the late 19th century (see Map 6).[35]

Initially, the problems between Indians and Euroamericans involved access to fisheries. Settlers along the Columbia River, particularly near The Dalles, became uneasy when Native Americans moved across private property to reach traditional fishing sites. In the 1880s, Indian agents complained that white residents intimidated Indian fishers, at times resorting to violence. Some settlers attempted to block the entrances to Indian fisheries--and the appearance of fishwheels, run by canning operations, worsened the problem by further restricting available fishing sites. Judge T.S. Lang, a resident of The Dalles, informed the Commissioner of Indian Affairs in 1887 of the Native Americans' plight: "I wish, dear sir, you could see the Indians as they sit about the rocks adjoining the fisheries," watching "tons" of salmon taken from the wheels and loaded into refrigerated railroad cars. "These Indians," he noted, "come constantly to me and beg of me to write to you for them."[36] Similarly, in 1894, an Indian agent worried that the Native American "with his dip-net will be unable to catch a supply of fish, either for himself or family, and thus all the benefits of the treaty of 1855 will be destroyed."[37]



Map 6. Columbia River Treaty Tribes

In 1905, the U.S. Supreme Court settled the question of access to off-reservation fishing sites in U.S. v. Winans. In this case, which focused on Stevens' treaty with the Yakima Indians, the court ruled that the treaty was not a granting of rights to the Indians but a grant of rights from them. As a result of this case, Yakama Indians retained the right of access to their "usual and accustomed" fishing places, as well as the rights to erect temporary structures on the river for curing salmon. In 1919, the Supreme Court reaffirmed Winans in Seufert Brothers Company v. U.S.[38]

The construction of mainstem dams on the Columbia River, beginning in the 1930s, further threatened Native American treaty rights. Indians feared that Bonneville would destroy salmon runs. This facility, one Yakama predicted in 1935, "will hurt the people worse than the Depression."[39] Similarly, a writer for the Works Progress Administration observed that Indians "all over the [n]orthwest" opposed the construction of Bonneville Dam.[40] Tensions mounted when the temporary cofferdams impeded spring migrations, and "the Indians descended menacingly on the army engineers in charge of construction." The Corps averted a crisis by blasting a hole through the structure.[41] Completion of the dam, however, flooded nearly 40 "usual and accustomed" fishing sites from its reservoir to The Dalles. In 1939, the Corps agreed to compensate the Treaty Tribes for the loss of their fisheries. Six years later, the Rivers and Harbors Act authorized the engineers to acquire in-lieu sites for the Indians. In 1954, however, the Indians remained disappointed that they had not yet received the sites promised them. By the 1960s, the Corps had provided five fishing sites totaling 40 acres under the authority of the 1945 Rivers and Harbors Act.[42]

In the 1990s, the Corps continued to implement legislation requiring the development and transfer of federal lands along the Columbia River for use by treaty Indians. As part of their commitment to provide lands for Indian treaty fishing in-lieu of those flooded by the construction of Bonneville Dam, the engineers expected to construct four sites in 1994.[43]

Treaty Indians also opposed construction of the McNary project, authorized in 1945 and funded in 1946. This dam flooded burial sites in an area that served as a crossroads for several tribes. Because the Indians did not reveal the exact location of the graves, engineers at the Walla Walla District suggested that the remains be left under the water. Although the tribes agreed to this approach in 1949, artifact hunters subsequently despoiled some of the sites, prompting protests from the Indians. Even so, tribal representatives attended the dedication of the dam, perhaps indicating their continued willingness to cooperate with water development agencies.[44]

Unresolved questions regarding Indian fishing rights intensified with the construction of The Dalles Dam, which inundated Celilo Falls in 1956. For centuries, Native Americans had fished with dipnets from precarious platforms at this location. By the early 1950s, it had become their principal remaining fishery on the Columbia River. Indian fishers at Celilo Falls sold their catch to commercial buyers and tourists, saving the remainder for their own consumption and for trade with other Native Americans. Salmon, then, provided both livelihood and food, as well as a focal point for religion and ceremony. Each year "a large influx" of Native Americans traveled from their reservations to Celilo Falls, usually from March to November.[45] In 1952, the U.S. Fish and Wildlife Service reported the tribal affiliations and approximate percentages of fishers at Celilo Falls as follows: Yakama 42%; Umatilla 10%; Warm Springs 9%; Nez Perce 5%; other 34%.[46]

Commercial and sports fishers aligned with Native Americans in their resistance to the construction of The Dalles Dam. At a public hearing in 1945, the Mid-Columbia Fisheries Association, an organization of fishing interests, summarized the importance of the fishery at Celilo Falls: "The salmon industry at the narrows of the Columbia River above The Dalles is not merely the oldest and best-established industry in our regional economy. It is much older than the white man and the white man's economy." This organization concluded that "no just compensation" could mitigate the destruction of this fishery.[47] Fisheries agencies, too, protested construction of The Dalles Dam.[48]

Throughout the early 1950s, the Indians continued to oppose this project, expressing themselves "through tribal action and through their legal counsel." In particular, the Yakama Nation vigorously protested construction of the dam, due to its destruction of the Celilo Falls fishery.[49] In response, the Corps "worked hard...to get the Indians, the attorneys, and the Government representatives together on a basis of payment for the taking of the fishing sites."[50] The Warm Springs Agency, however, worried that the compensation for flooded houses and salmon drying sheds would be inadequate. "In displacing these Indian families," the Superintendent informed the Corps, "you are not only taking their meager houses, but you are taking time from their homes" and "their way of life."[51] The U.S. Government, however, concluded that the benefits of hydroelectric generation, irrigation, navigation, flood control, and recreation outweighed the sacrifice of the dipnet fishery at Celilo Falls.[52]

By the mid-1950s, the Indian commercial catch at this location had reached nearly two million pounds annually. When the Corps completed The Dalles Dam in 1957, their catch dropped to 58,000 pounds.[53] Because flooding prevented further dipnet fishing at this facility, Indians began catching salmon in gillnets in the dam's backwaters. Although the government paid the Indians approximately $25 million for the loss of their ancestral fishery, many Native Americans resented the destruction of Celilo Falls.[54]

During the 1950s and 1960s, political activism among Native Americans increased. Joining the emerging civil rights movement, Indians in the Pacific Northwest south redress in the courts for the problem of decreasing salmon runs and increasing competition with other users. At that time, the primary question was whether Indian fishers were subject to state regulations.[55]

On the Columbia River, this issue had emerged during the late 19th century. Since 1890, the commercial fishing season had closed from August 26 to September 10 to protect the peak of the fall chinook run. Since 1943, a similar closed season had protected spring chinook and sockeye runs. Indians, however, continued to operate their fishery at Celilo Falls during these periods. They also provided their own management, forming a fish council of three representatives from each reservation to settle disputes concerning fishery rights.[56] In Tulee v. Washington, a federal court recognized in 1942 that prior to negotiation of the treaties the tribes established fishing regulations "through custom and tradition."[57] Although federal courts in the 1940s and 1950s also suggested that the states could limit the taking of fish in the interest of conservation, the issue was not clarified.[58]

Throughout the 1960s, Native Americans in the Pacific Northwest complained that the conservation regulations of fisheries agencies were discriminatory in their attempts to limit salmon catches outside the reservations. "The wild years," as one former official of the Washington Game Department has dubbed them, "started quietly with a little net fishing of a poaching type."[59] By the mid-1960s, protests had become militant. In defiance of state regulations, some Indians organized "fish-ins," deliberate attempts to get arrested for catching salmon illegally. Emotions ran high at fish-ins, and at times the demonstrations resulted in violence. One Indian protester was arrested 21 times and received a 15-year sentence. It took three or four wardens "to get the handcuffs on," he noted with pride. He also claimed that the State of Washington would "have to kill him to keep off the rivers." Some Native Americans feared that the state's objective was "to destroy our fishing equipment, chase us off the rivers, and save the fish for the white man."[60]

Arrests of Native Americans for Steelhead Fishing In Washington, 1962

The conflict gained considerable publicity throughout the nation when the actor Marlon Brando and the comedian Dick Gregory, both sympathetic to the Indians' cause, became involved in the demonstrations. While the fish-ins attracted the media's attention and provided visibility to the Indians, they also fueled tensions among Native Americans, sports fishers, and representatives of fisheries agencies. "Indians have become experts in public relations," complained one wildlife official, "and have pulled off some publicity stunts equal to the best of Madison Avenue or Hollywood."[61]

Actor Marlon Brando at Fish-In in Washington, 1964

Native American activists also turned to the courts. South of the Columbia River, the issue of Indian fishing rights culminated in U.S. v. Oregon. In this landmark case, a group of Pacific Northwest Indians, the Sohappy plaintiffs, argued that their subjection to state fishing regulations violated their 1855 treaty rights. In his 1969 decision, Judge Robert Belloni noted three limitations on the state's power to regulate the Indians' treaty rights: "The regulation must be necessary for conservation of fish; the state restrictions on Indian treaty fishing must not discriminate against Indians; and they must meet appropriate standards."[62] Belloni ruled that the state must give Native Americans the opportunity to harvest "a fair and equitable share of all fish which the state permits to be taken from any given run."[63] Because it upheld 1855 treaty fishing rights, the Belloni decision wielded "a major impact on the politics of fish and hydropower in the area."[64]

In Washington, Indian complaints that harvests were inequitable continued into the early 1970s. At that time, treaty tribes harvested 5 percent or less of the total annual catch of Columbia River salmon. According to the Washington Department of Fisheries, the average annual harvest from 1970 to 1973 was 6,231,044 salmon for non-Indians, and 328,888 for Native Americans.[65] In 1974, Judge George Boldt ruled on the question of inequitable harvesting and the subjection of Indians to state regulations. He interpreted the 1855 treaty phrase "in common" to suggest equal sharing among non-Indian and Native American fishers. "In common with," he concluded, "means sharing equally the opportunity to take fish at 'usual and accustomed grounds and stations.'" Treaty Indians, in other words, were entitled to 50 percent of the harvestable catch not needed for spawning escapement. Fish taken on the reservations and those used for ceremonial purposes were not be counted against the 50 percent Indian share.[66] Shortly after Boldt's ruling in 1974, Judge Belloni also adopted the 50-percent allocation and extended the concept to the harvest on the Columbia River.[67] In 1979, the Supreme Court upheld the Boldt decision.

Drawing in part on Winans, this case reaffirmed that the right to fish was reserved by the tribes, not granted to them. Although treaty Indians shared access to off-reservation sites with non-Indians, the state could not regulate Indian fishing to the same degree that it administered the non-Indian catch. Native Americans had a federally secured right to take fish, whereas others depended on state authorization for the privilege.[68]

The Boldt decision recommended that the 20 tribes involved in the lawsuit organize themselves into a unified group. The formation of a tribal consortium, Boldt believed, would enable the tribes to present a strong, united position in off-reservation fisheries management. His decision encouraged the states and tribes to work as partners in the regulation of the harvest, which is to be shared "in common."[69] Accordingly, the tribes developed the Northwest Indian Fisheries Commission. This group employed a staff of biologists, policy analysts, and computer specialists, who helped operate a diagnostic laboratory and more than 30 salmon and steelhead hatcheries throughout western Washington.[70]

Shortly after the Boldt decision, the Bonneville Power Administration and other federal agencies recommended that four Indian fish committees organize a single body to review federal hydroelectric operations in the Columbia River system. The fish committees represented the Confederated Tribes and Bands of the Yakama Indian Nation, Confederated Tribes of the Umatilla Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe of Idaho. In 1976, the established the Columbia River Inter-Tribal Fish Commission (CRITFC) to examine fisheries data for the Columbia and Snake Rivers. This organization, which resembled the former fish council at Celilo Falls, suggested Indian season regulations and salmon harvests allocation to the four tribes as well as to the states of Washington and Oregon.[71]

Debate concerning Native American fishing rights did not end with the court decisions of the late 1960s and early 1970s. To some observers, it seemed that the Boldt case sparked a "never-ending ruckus."[72] Others viewed the decision as a major battle in a 100-year "fish war."[73] Implementation of the court decisions in Oregon and Washington required increasing the Indian harvest of salmon through decreasing the catch of other fishers. Proposals to shorten the ocean season prompted strong objections from trollers, who argued that salmon caught in the sea were of better quality than those taken in the Columbia River System.

Few protests against the Boldt decision were more vociferous than those of sports fishers. Their concern centered on Indians taking steelhead in their nets. Steelhead, declared a game fish in Washington in 1925 and in Oregon in 1975, could be taken only with a hook and line. As noted, the considerable growth in the number of anglers in recent years complicated management of the fish. To conserve the anadromous trout, state agencies established limits on gear, bag, size, and duration of season. At the time of the Boldt decision, Washington operated eight hatcheries and nine rearing ponds, producing two million steelhead smolts each year. To take this prized fish by nets or traps, many anglers believed, "borders on sacrilege."[74] Some sports fishers, moreover, regarded the steelhead as "their fish."[75] The Indian treaties had not distinguished between food and game fish, and sportsmen resented Boldt's decision to allow Indians to sell steelhead.

Yet Native American fishers have harvested steelhead for subsistence and trade for centuries. Indians became commercial fishermen as early as the 1830s, when they sold their anadromous fish catches to fur traders, for their salt salmon operations.[76] To Indians, steelhead fishing held economic as well as cultural significance. As one observer put it, "There is no such thing as the classification 'game fish only' for people who are poor and hungry.&quott;[77] Like other fishers, Native Americans viewed anadromous fish in proprietary terms. "The salmon fish," explained Celilo Chief Tommy Thompson in 1938, "was created for my people."[78]

Indian fishers also pointed out that their upriver position placed them at a disadvantage in the commercial harvesting of salmon, since other users enjoyed first access to the runs (see Map 6, Columbia River Treaty Tribes). "We are first to conserve and last to be served," lamented one Indian of Nez Perce and Yakama ancestry who fished near Celilo Village. During the early 1990s, the Indian commercial harvest was limited to fall chinook and steelhead. In 1992, the tribal commercial harvest totaled 93,192 fish, while the ceremonial catch reached 3,730 fish.[79]

Resentment of Indian fishing was not limited to anglers and trollers. Some state fisheries agencies, too, resisted the Boldt decision from the outset. One observer accused the fisheries and game departments of urging non-Indians to ignore the law and of "actively harassing" Native American fishers.[80] In 1981 and 1982, the federal government joined Oregon and Washington in an undercover operation designed to expose alleged illegal sales of fish by Indians on the Columbia River. The widely publicized case, known as "salmonscam," once again brought the problems of anadromous fisheries management to the public's attention. This sting operation resulted in charges that a number of Indians were responsible for the disappearance of 40,000 fish between Bonneville and McNary Dams in the early 1980s.[81] Among those convicted was David Sohappy, Sr., a Yakama Indian and one of the original litigants in the case that became U.S. v. Oregon. Sohappy, "an impressive figure with long silver-gray hair and clear, piercing eyes," was a religious leader who was sentenced to five years in a federal penitentiary for selling 285 salmon and 32 steelhead. He was acquitted in the Yakama Tribal Court, and his harsh sentence generated sympathy for Native American fishers throughout the Pacific Northwest.[82] Of the 19 Indians indicted for illegal fishing and illegal sale of fish during "salmonscam," 3 pled guilty, 13 were convicted, and 9 received sentences.[83]

By the late 1980s, relations between Indians and other users of the Columbia River System had improved. According to Timothy Wapato, Executive Director of the CRITFC, the "two sides still differ on court-ordered allocation issues, but they've learned to respect each other." With the "stormy allocation battles of the 1970s" behind them, Indians and such organizations as the Northwest Gillnetters Association could "sit down at the same table and talk."[84] Still, Indian complaints of harassment--particularly by sports fishers--persist. "I take a lot of verbal abuse out there," noted one Indian fisher in 1993. Native Americans also charged anglers with deliberately damaging their nets. Yet the CRITFC claimed that the greatest difficulty for Native Americans in the early 1990s was not access or "equitable sharing," but the problem of "too few upriver fish, especially naturally spawning ones."[85] Legal analysts had noted this dilemma as early as the 1980s, asking, "What good is the right to a share of the fish if there are no more salmon in the rivers?"[86]

The court decisions of the late 1960s and early 1970s had provided the legal framework for limiting the anadromous fish harvests of non-Indian users of the Columbia River System. However, as fish runs continued to decline, Native Americans, like other fishers, turned their attention from each other to Corps operations. "The biggest single [salmon] killer now left is the dams," argued Timothy Wapato. " We need to address that."[87] Jack Donaldson, director of the Oregon Department of Fish and Wildlife, agreed that the "dams are now harvesting the fish, instead of the fishermen."[88] From the 1970s to the 1990s, the various fishers on the Columbia and Snake Rivers increasingly focused their opposition on hydroelectric development agencies.

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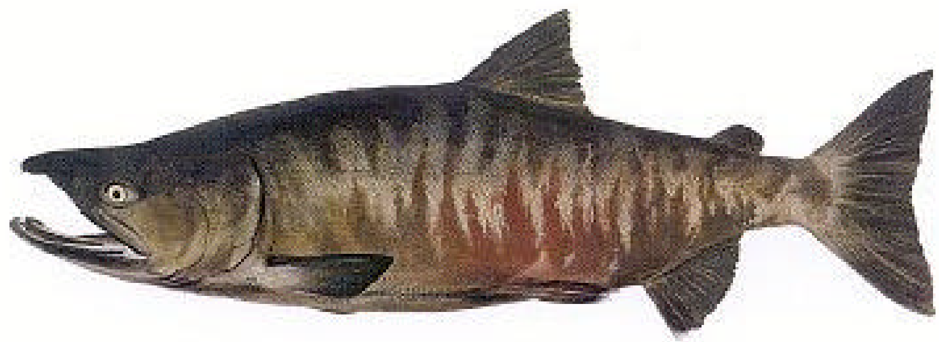
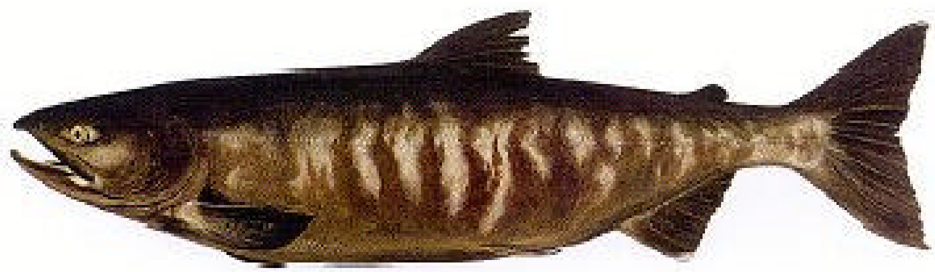


Chum Male - Freshwater Phase



Chum Female - Freshwater Phase

Chum - Ocean Phase

VI. Fish Politics and Controversies

"The river," historian Anthony Netboy noted in 1982, "seems to be managed more on a political than a biological basis."[1] Fishers, private and public utilities, fisheries agencies, and water resources developers each have fought for an advantage in the debates concerning anadromous fish in the Columbia Basin.

Even biologists, argued a U.S. District judge in 1993, "were losing sight of science and becoming advocates." He pointed out that state fisheries agencies in Idaho and Oregon had once supported the juvenile transportation program that they came to oppose during the late 1980s and early 1990s.[2] During the last half of the 20th century, advocacy of various positions on fisheries issues became more vocal and increasingly difficult for those charged with salmon management to ignore.

Snake River Dams

The Corps was not the first agency to attempt to dam the lower Snake River. Local organizations and federal agencies had investigated the possibility at various times since the late 19th century, mostly for irrigation purposes. These initial efforts failed. The Bureau of Reclamation made some preliminary studies of the river in the 1920s, but abandoned the area after issuing a negative report on its potential in 1926. Local dam supporters then turned to the Corps, which began studies of the river in the 1930s.[3] In 1945, Congress authorized the building of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams.

Construction on Ice Harbor, the first of these projects, did not begin until 1957. Fisheries advocates became more aggressive in their opposition to this dam than they had been in their protests against earlier projects on the Columbia River system. The Washington Departments of Fisheries and Game, the Oregon Fish Commission, and the Oregon Game Commission assumed active roles in the fight against Ice Harbor. They lobbied Congress and provided information to regional newspapers in their campaign to stop its construction. Ray Oligher, a biologist who began working for the Walla Walla District in the mid-1950s, recalled that the fisheries agencies claimed that "only over our dead bodies would there be dams on the lower Snake."[4] In 1955, the Fish Commission warned that Ice Harbor Dam would prove "extremely harmful to salmon and steelhead runs of the Snake River valued at many millions of dollars." This agency requested that construction be deferred to provide biologists additional time for research.[5]

Organizations such as the Inland Empire Waterways Association became frustrated with the protests, arguing the adequacy of existing fishways. This organization drew much of its support from Walla Walla, located 500 miles from the mouth of the Columbia River and the center of the salmon industry. The city's *Union-Bulletin* explained in 1955 that Snake River dams "would mean so much to the economy of this entire interior region."[6] Herbert West, president of the Inland Empire Waterways Association claimed that experiments on juvenile salmon at McNary Dam had resolved fish passage problems. He blamed fishes for declining salmon and steelhead runs and touted the benefits of hydropower, which would move the Pacific Northwest beyond its traditional dependence on natural resources.[7]

The Walla Walla District of the Corps supported West in the mid-1950s, downplaying the problems of fish passage, and pointing to commercial and sports fishing as the culprits in salmon decline. Fisheries agencies responded quickly. In 1955, Robert J. Schoettler, Director of the Washington Department of Fisheries, denounced West's claims as "completely misleading and false." That year, Brigadier General Louis Foote, North Pacific Division Engineer, reprimanded Colonel Myron Page for the Walla Walla District's outspoken, partisan support of West's position.[8]

Protests against Ice Harbor Dam, coupled with federal budgetary constraints, resulted in construction delays.[9] The growing demand for more power in the Northwest both helped and hindered the opposition to the construction of the Corps' dams. Congress agreed to authorize the dam projects "only because of their potential to produce power." In a benefits analysis of the four-dam system proposed for the Snake River, power production rated at 82.5 percent, with navigation benefiting the region only 15 percent. Irrigation, flood control, and recreation benefited only 2.5 percent. Since the primary function of the dams was power, not navigation, the fisheries advocates were able to develop a strong argument for the relocation of the dam sites to areas where they could produce more hydropower and interfere less with the salmon and steelhead runs. Lower Snake River dams would benefit navigation, but dams in other areas could produce more power and protect lower river fisheries.[10]

The battle between fisheries advocates and dam proponents, however, was not the only reason for the delay in the construction of Ice Harbor Dam. The cost of the dams also became an issue. In 1946 and 1949, Congress granted planning funds to the Corps for Ice Harbor--but no money for construction--and eliminated Harry Truman's 1950 budget request of $12 million for the project. Congressional sources cited money and concern about fish passages as reasons for refusing the funding request. Probably most members of Congress remained convinced of the adequacy of fishruns, but during the early 1950s a new president with new concerns about fiscal responsibility entered the White House. When Dwight Eisenhower became president in 1953, he instituted a policy of "no new starts" on costly federal multipurpose dam projects that did not include state or local participation. Lacking funds, the Corps delayed construction of the Ice Harbor Dam.

The engineers did not receive funds to being construction on Ice Harbor Dam until 1955, when Washington Senator Warren G. Magnuson, a strong support of river development, inserted a $1 million construction provision into the presidential budget. The agency began immediate work on the project, and Ice Harbor Dam became the first new dam start in the Eisenhower administration. Once construction began, the Corps continued to receive yearly funding from Congress for the project. The Corps started excavation in 1957, began filling the lake behind the dam in 1961, and opened the dam's navigational locks in 1962. Lyndon Johnson dedicated the facility in 1962.[12]

Conflict regarding the development of the lower Snake River reflected the nation's evolving attitudes toward development and the natural world. A half a century earlier, proposals to dam this area drew few protests. In any case, the debate regarding Ice Harbor Dam and the delay in construction provided scientists additional time to research the impact of dams on anadromous fish. The Corps further appeased some critics by hiring Milo C. Bell, "something of a folk hero to fishery biologist," to assist in designing Ice Harbor's fish ladders. Bell had worked with Harlan B. Holmes on the ladders at Bonneville and McNary Dams. Yet fisheries agencies did not abandon their battle against development of the lower Snake.

Sports Fishers on the Snake

From the 1970s, opposition to the Corps' lower Snake River projects became better organized and relied more heavily on litigation than had earlier protests. With the completion of the Ice Harbor Dam, sports fishers, Native Americans, and environmentalists found it difficult to halt other lower Snake River projects. The Corps completed Lower Monumental Dam in 1969 and Little Goose Dam in 1970.

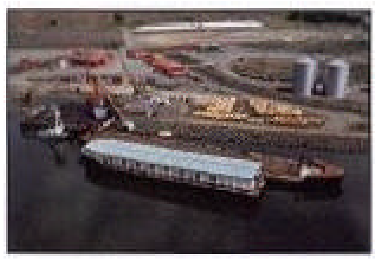
Sports fishers became especially aggressive in their attempts to block construction of Lower Granite Dam--the last of the authorized Snake River projects. In the early 1970s, according to one observer, "the anglers' voice, girded with determination, grew from gnat's size to giant's size."[14] Under the energetic leadership of Arthur Solomon, the Association of Northwest Steelheaders filed suit against the Corps in 1970 to stop construction on the Lower Granite project and to deauthorize the proposed Asotin Dam.[15] Cosigners in the suit included the Hell's Canyon Preservation Council, Trout Unlimited, the Washington State Departments of Game and Fisheries, and five sportsmen's groups. The Idaho Environmental Council and the Washington State Sportsmen's Council also joined the cause, as did the Sierra Club and the National Wildlife Federation. The Steelheaders Association charged that the Corps had not held hearings on the authorization for the dams, and that the engineers "were generally negligent, deceitful and presumptuous in dealing with the projects."[16] Moreover, the sports fishers claimed that Lower Granite Dam was not needed for hydroelectric power.[17]

In bringing this legal suit, the Steelheaders Association, which boasted 8,000 members by the mid-1970s, hoped to delay construction of Lower Granite Dam.[18] Because Congress had authorized the four Snake River dams in 1945 and the Corps had expended $38 million on fish passages for these facilities, the lawsuit placed the engineers in an "awkward position."[19] The engineers argued that construction of Lower Granite Dam began before enactment of the National Environmental Protection Agency legislation in 1969. Moreover, local agencies had invested in shipping with the knowledge that the slack water would reach Lewiston, Idaho. The Corps completed construction on Lower Granite Dam in 1975. At the dedication of this structure, Idaho Senator Frank Church remarked, "Creating a seaport as far inland as Idaho is a dream so large that it rivals the greatest engineering projects." Idaho Governor Cecil Andrus, also a speaker at the ceremony, was less enthusiastic. "Before I accept this structure," he noted, "I want to point out the cost of this system has been horrendous, both in dollars and in cost to our natural resources."[20]

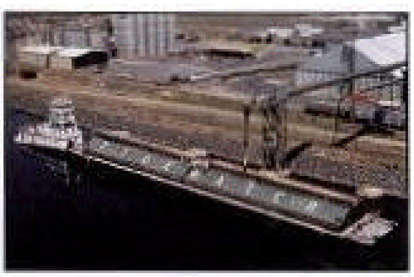
INLAND WATERWAY

Inland Waterway Ports as they appeared in the 1990s

Little Goose Reservoir

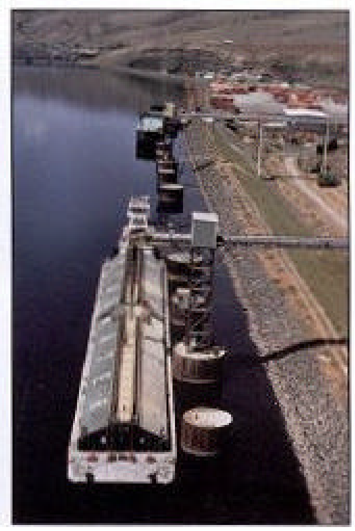


Port at Lewiston

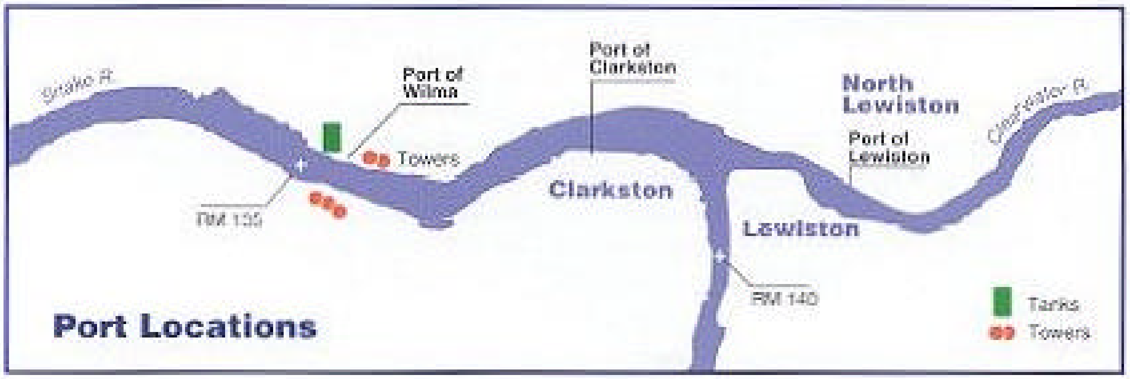


Port at Lewiston

Port of Umatilla



Port at Lewiston



In 1977, two years after the dedication of Lower Granite Dam, the Steelhead Association's lawsuit came to a close. The court ruled for the Corps on the grounds that the four dams had been constructed and already were in operation. However, the judge also ordered the Walla Walla District to file a special report on the Lower Snake River Compensation Plan, authorized by the Fish and Wildlife Coordination Act of 1958. This plan included proposals for the construction of fish hatcheries, improved fish passages and transportation of juvenile fish, and the acquisition of land for wildlife habitat. The Corps estimated the total mitigation cost at $98 million (see Chapter IV).[21]

Some opponents of the dams viewed their efforts as a crusade to save America's open streams. Carl R. Coggins of the Steelheaders Association, for example, asserted that the Bill of Rights guaranteed each person the right to "life, liberty, and the pursuit of happiness," and that "free-flowing rivers with their separate and priceless eco-systems are a vital part of man's individual happiness and should not be lost through destruction by dams, or any polluting force." This issue, he pointed out, was of national, not just local, concern."[22]

Many protestors worried about the impact of Lower Granite and the other dams on the area's wildlife. They argued that the dams and reservoirs would destroy natural runs of sport fish, impair shoreland riparian habitats of gamebirds, and flood canyon access roads. The groups were especially vociferous about the problems of nitrogen increases caused by the dams. One observer credited the Steelheaders Association with convincing the Corps to investigate nitrogen supersaturation at the dams. [23] The engineers' mitigation efforts substantially reduced fish mortality caused by supersaturation (see Chapter IV). Another observer claimed that "the people owe a considerable debt of gratitude" to the Steelheaders Association, which served as "a constant reminder to the Corps" that river users closely monitored its fish operations. [24]

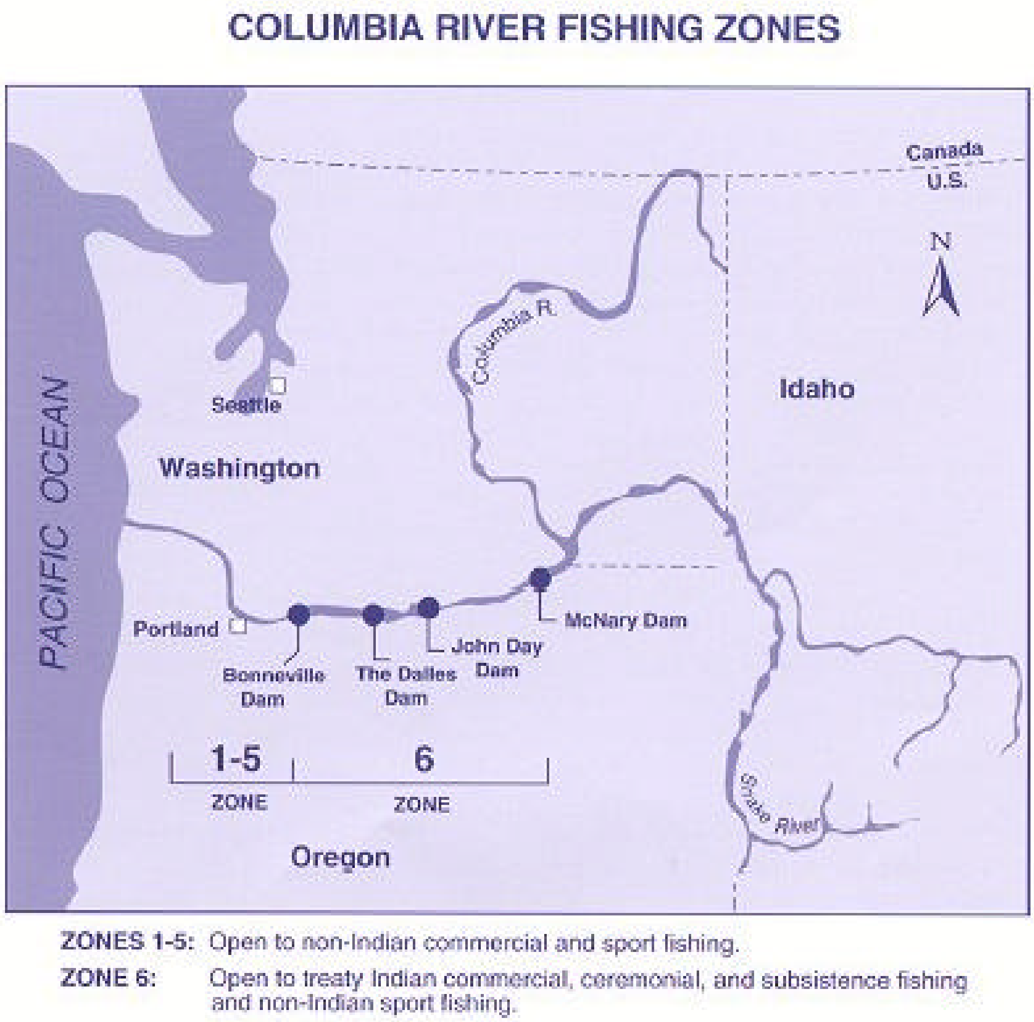
In the 1990s, the billboards illustrated organized opposition to large dams

Concerns of sports fishers on the Snake focused mostly on the steelhead, the principal game fish in the river system. Sports fishers complained of the difficulty of catching these prized fish in the deep pools created by the dams.[25] In response to their concerns, the Walla Walla District formed a steelhead study group with representatives from state, federal, and private fishing interests. The North Pacific Division also developed a steelhead research program within its Fisheries Engineering Research Program. The Corps' efforts emphasized the improvement of sport steelhead fishing in the new reservoirs on the lower Snake River.[26] Although the sports fishers ultimately failed to halt the construction of Lower Granite, they helped to focus national and regional attention on the problems associated with the building of dams on the nation's rivers.[27]

Tribal Fishery Concerns

Like sports fishers, Native Americans recognized the importance of organization and legal counsel. In the 1970s, the National Waterways Commission and the Department of the Interior acknowledged that the primary means of resolving water rights disputes would be the courts. Many of the Corps' mainstem dams are located in the fisheries agencies management Zone 6, the primary Indian commercial, ceremonial, and subsistence fishery (see Map 7). In the early 1970s, Native Americans expressed concern about water resources development and its impact on their fishing rights. In response, the Corps' North Pacific Division included an extensive list of water resources on reservation land in their Inventory of Problems and Areas of Concern, issued in 1973. The North Pacific Division hoped that involvement of Indians in the planning process would encourage amicable resolutions to fishing rights issues.[28]

During this period, the Umatilla Indians won an injunction against modifications to increase power at Bonneville, The Dalles, and John Day Dams. These modifications, the Indians pointed out, would raise water levels flooding fishing sites. To help resolve the problem, engineers cooperated with scientists in the Corps' research program to develop guidelines for peaking discharge. Meanwhile, however, Congress failed to pass a bill granting the North Pacific Division the authority to improve and protect in-lieu sites to replace traditional fishing grounds inundated behind Bonneville Dam. Additional power units at Chief Joseph Dam prompted similar concerns about water fluctuations from the Colville and Spokane Indians. Owing in part to its willingness to meet with the tribes and to schedule workshops, the Corps avoided a lawsuit in this instance.[29]



Map 7. Columbia River Fishing Zones

In 1974, the Umatilla Indians also sued the Corps to halt construction of a dam on Catherine Creek in northeastern Oregon. Authorized in 1965, this project would impair the clear, shallow water that the Indians fished by traditional methods. Judge Robert Belloni ruled that the dams would violate treaty rights, and the Corps did not appeal his decision. Belloni echoed the frustration of water resources developers when he considered the implications of this case: "Can any stream in the Northwest be dammed by a farmer or an irrigation district without violating the Treaty?" he asked. "Can ever a road, dam, or city be built without touching those rights? Where do we draw the line?"[30] Indian opposition to water resources development was not limited to Corps operations. The Yakama Nation, for instance, protested the Washington Department of Ecology's granting of permits for large irrigation projects that would encumber fish runs.[31]

CONTROVERSIAL EFFORT TO SAVE SALMON

One of the Corps' most controversial efforts to save salmon has involved the transportation of young fish past the dams. Initially called Operation Fish Run, it became the Juvenile Fish Transportation Program in the early 1980s. The Corps and the National Marine Fisheries Service experimented with a variety of methods, including barging, trucking, and transporting the fish by air.

Critics of the transportation program prefer spilling water over the dams to flush the young fish downstream. "Whet used to be transported on land and the fish were in the river," one tribal publication observed. "Now wheat is moved on the river, and young fish are transported on roads."

Also see Chapter 4 photos, pages 122 and 123, app. Table 4-7.

Throughout the 1980s and 1990s, the newly established CRITFC participated in planning Corps operations. During this period, the organization encouraged the Corps to spill water over the dams to assist juvenile salmon and steelhead migrating downstream.[32] The CRITFC criticized the engineers' transportation program, charging that moving 50 to 70 percent of the smolts around dams was "not satisfactory for all species of anadromous fish," mostly owing to the lack of a strong current to flush the young fish downriver. Transportation, the CRITFC argued, is unnatural. "Wheat used to be transported on land and the fish were in the river," one tribal publication observed. "Now wheat is moved on the river, and young fish are transported on roads." Many Native Americans preferred the Columbia as "a wild, free-flowing river."[33]

For them, the debate concerning the barging and trucking of juvenile salmon carried cultural and aesthetic overtones. To many groups opposed to the Corps' transportation program, spill over the dam appeared closer to natural conditions in the river. "It is the hydrosystem, not the ecosystem that is being conserved by transportation," the CRITFC noted. Moreover, this organization worried that the separator that diverted smaller smolts during collection injured the fish, as did the tagging process.[34] Charging that the engineers favored "volts over smolts," the CRITFC complained in themid-1980s that the Corps and BPA "control the fish passage research" with a "substantial fisheries staff that keep the understaffed tribes and fisheries agencies on the defensive."[35]

Environmental Crusade

Environmentalists raised similar objections to the Corps' transportation program, at times joining the tribes and sports fishers in their protests. Like Native Americans, environmentalists preferred that young fish remain in their natural environment. They warned that completion of Lower Granite Dam would destroy the salmon, leaving only "token 'zoo' runs."[36] Similarly, Ed Chaney, one of Idaho's most outspoken critics of the Bonneville Power Administration and Corps operations, argued against turning salmon into "aquarium" fish. His words revealed an interest in keeping anadromous fish in their natural habitat. "We're mucking around with Mother Nature," he warned, "and we don't know what we're doing."[37] The NMFS' attempts to airlift juvenile salmon and steelhead past lower Snake River dams in the early 1970s also prompted skepticism from preservation organizations, who joked that the fish "might as well be sent via Federal Express."[38] Other critics of transportation likened barges to "iron coffins" conveying the fish to "a watery grave."[39] One spokesman for Friends of the Earth complained in 1994 that the Corps has not "operated the river like a river." Barging the fish, he noted, represented a "technological solution that does not fix the problem."[40]

Environmentalism grew out of an increasing awareness in the 1960s and 1970s of the importance of ecosystems. While conservation had emphasized the wise use of resources as well as protection of individual species, environmentalism stressed a holistic approach to saving the natural world. In its broadest sense, environmentalism emerged from a variety of sources. These included the counterculture's questioning of traditional values; scientific concerns about pesticides, radiation fallout, and destructive game management techniques such as predator control; and, for some, increasing questioning of the assumption that the natural world exists solely for human use.[41]

In 1960, national conservation leaders had agreed that "the solution of the fish-dam problems in the Pacific Northwest constitutes one of the major conservation problems in the United States."[42] Within 20 years the issue became a crusade for some environmentalists. &qot;We're fighting a holy war," Ed Chaney explained. "The real obstacles are philosophical and religious."[43] Terms such as "battle" and "slaughter" appeared throughout popular descriptions of declining salmon runs, revealing a perception that this was a fight between good and evil.

Like other environmentalist organizations, the Sierra Club and National Audubon Society emphasized the importance of Columbia Basin ecosystems and riverine habitat. Portraying the salmon as "noble" fish, environmentalists emphasized the importance of species. In general, late 20-th century attitudes toward fish differed from perceptions of other animals, such as mammals. The media widely used phrases such as "trash" and "junk" fish, whereas many writers refrained from describing coyotes as "vermin" or "varmints," which were popular terms for these predators in earlier eras.[44] Although organizations concerned with wildlife protection extolled the value of individual animals such as wolves, and even individual game animals such as elk, few worried about the fate of a single fish, apart from the run. Salmon were significant for their remarkable numbers and their anadromous behavior. The preservation of biodiversity--as well as the salmon's place in the ecosystem and their importance as a symbol of nature in the Pacific Northwest--made protection of the runs a desirable environmentalist cause.[45]

In their efforts to salve salmon and steelhead, environmentalists questioned not only Corps operations but also the engineers' traditional approach to water resources development. It was no longer appropriate, they argued in the 1970s, for economic and technical considerations to drive decisions about flood control, navigation, and hydroelectric projects. Historically, decision-making for public works projects provided little place for public debate on proposed actions.[46] Like Native Americans, environmentalists encouraged the Corps and other agencies to let them present their positions during the initial phase in the engineers' planning and decision-making.

As sports fishers, Native Americans, and environmentalists increased in political strength during the 1970s, criticism of water resources development agencies became more frequent. An article in Field and Stream, for instance, denounced the Corps in 1972 as "a greedy and overbearing cabal of compulsive dammers."[47] Similarly, in his book, The River Killers, Martin Heuvelmans charged the Corps in 1974 with destroying the Columbia River, which had once been a "piscatorial paradise."[48] Concerned citizens wrote their senators that "Apparently, the Corps cannot stand to see a free-running river."[49] In 1980, one writer summed up opposition to river developers: "There is probably no organization on earth more despised by fishermen and other river users than the Army Corps of Engineers."[50]

Historians have noted the Corps' adaptability to public opinion as well as its responsiveness to changes in national objectives regarding water resources development.[51] The engineers initially "faced the 1970s as an agency steeped in tradition." Its original mission dated back more than a century--"long before the emergence of a strong environmental movement." Moreover, during the early 1970s, the Corps had continued to equate conservation with its traditional "wise use" objective, "with the emphasis on 'use.'" As early as 1969, however, Brigadier General William M. Glasgow, Jr., argued that the Corps could incorporate environmental concerns while preceding with its projects. "Coexistence is possible," he noted, and "the way to ensure it is to seek mutual understanding of each other's problems." Such expressions could be viewed as demonstrations of the Corps' responsiveness and flexibility.

Opposition to large dams in the Columbia River Basin intensified during the 1970s. This cartoon from a Sierra Club publications, published in the early 1970s, presents the Corps as a large, powerful force that bullied small, weak environmentalists

Most environmentalists, however, remained unconvinced during the early 1970s.[52] Using the newly established National Environmental Policy Act, they filed a number of lawsuits against the Corps and other water resources development agencies. In 1970, the Sierra Club, one of the nation's largest environmentalist organizations, joined the Steelheaders Association in their lawsuit to block construction of Lower

Granite Dam. Founded in 1892, the Sierra Club attracted mountaineers as well as activists interested in protecting the natural wonders of the West. By the late 20th century, this organization had become a leader in the conservation movement, increasingly using litigation to stop river development. "Court cases," explained one Sierra Club historian, "offered good chances for publicity" in the fight to preserve the environment.[59]

Environmental Legislation and Treaties

National Environmental Policy Act

Some historians claim that the passage of the NEPA in 1969 took the Corps by surprise. This legislation prompted mixed reactions from the engineers. One contingent believed the environmental movement a fad and suggested that the Corps "resist the act." Another factor feared that NEPA and growing public concern about the environment would damage the Corps' image. They recommended that the Corps "address itself primarily to the public relations problem" NEPA presented. A minority opinion held NEPA to be a sound piece of legislation and that "the Corps should take the lead in implementing the Act as best it could."[54] Chief of Engineers Lieutenant General Frederick J. Clarke, for instance, concluded the Corps would support NEPA without hesitation, if only out of political expediency. In the long run, he reasoned, the Corps' image "would take care of itself."[55]

When President Richard Nixon signed NEPA into law on 1 January 1970, supporters of the act hoped that it would "encourage productive and enjoyable harmony between man and his environment."[56] NEPA established environmental protection as a national goal, setting objectives to guide development projects.SUP57 The first comprehensive legislation of its kind, NEPA required federal agencies to consider the environmental consequences of their actions. To fulfill this obligation, agencies must employ an interdisciplinary approach to evaluate their projects; coordinate with the newly established Council on Environmental Quality; and complete an environmental impact statement (EIS). NEPA also required developers to consult other federal, state, or local agencies about their actions, and to make the results of consultation available for public scrutiny.[58] Historian Jeffrey Stine noted that "although NEPA asked the agencies to act responsibly with regard to the environment," the legislation left the ultimate decision of how to implement the act to the agencies themselves.[59] However, if agencies failed to consider impacts on the environment in their planning, courts had the power to stop the project until the agency complied with NEPA.

NEPA required agencies to justify and explain the environmental impact of their projects, which were subject to court review. Furthermore, phrasing in NEPA made the act retroactive, requiring the Corps to prepare EISs for its current projects, no matter what the stage of planning, design, or construction.[60] By 1975, the Corps had prepared 1,750 EISs for projects throughout the nation. Regarding the Corps' compliance with provisions of NEPA, General Clarke indicated that the engineers "learned earlier than most federal agencies" that they had "better be serious about the preparation of Environmental Impact Statements." Continuation of Corps projects, he explained, depended upon completion of EISs in a satisfactory manner.[61]

During the first two years of NEPA compliance, however, the Corps' preparation of EISs proved unsatisfactory, as did those of other federal agencies. In 1972, Stanford University professors Leonard Ortolano and William W. Hill analyzed 234 EISs for Corps water projects. Their report argued that the engineers' statements did not "seem to be written with the view of providing non-technically oriented readers with the kinds of insights and information that would be required if they were to participate effectively in the decision-making process"[62] As a result, the Corps soon found itself the target of numerous lawsuits. According to one attorney, NEPA "may have led to more lawsuits than all our other environmental laws combined."[63]

Environmental groups, in particular, challenged the Corps through NEPA-based litigation. Members of organizations such as the Sierra Club viewed themselves as monitors of NEPA compliance. Julie Cannon of the Sierra Club Legal Defense Fund commented in 1973 that NEPA "would be but empty rhetoric if the Sierra Club and other conservation organizations had not determined to watchdog its enforcement."[64] By October of that year, the Corps had battled 30 environmental lawsuits. This litigation prompted rapid development of the Corps' environmental policy and procedures. One senior Corps officer remarked that environmental litigation placed "external pressures" on the Corps, resulting in "healthy change."[65]

To protect the agency from litigation, the Corps improved the technical quality of their EISs between 1973 and 1976. William Hedeman, an environmental specialist with the Corps' Office of Counsel, pointed out that in 1973 "the Corps pulled out all stops to comply with NEPA."[66] In fact, some environmentalists argued that the Corps responded more quickly to NEPA than other federal agencies, owing to the military component of its leadership.[67] The engineers resolved to produce EISs that could withstand the scrutiny of federal courts. Their reports became less technical, integrating environmental protection with the Corps' planning of projects. Consequently, environmental lawsuits against the Corps declined after the mid-1970s.[68] This development resulted not only from the Corps' efforts to improve the quality of its EIS, but also from its enhanced public image, gained from close work with environmental groups.

In April 1970, General Clarke responded to what he felt was ill-informed criticism of the Corps by establishing the Environmental Advisory Board (EAB). The 6-member EAB included nationally known conservationists and environmental consultants to help the Corps consider environmental issues in all of its activities.[69] The creation of the EAB, General Clarke hoped, would improve the public's understanding of the Corps. The environmental community tended to be cautious in its reaction to the EAB. Although some environmentalists accused the Corps of merely trying to placate its critics, others conceded that the EAB represented the engineers' willingness to change their policy regarding environmental issues. "Public reaction to establishment of the board has been mixed," General Clarke observed, "ranging from guarded optimism to severe criticism." Later, in a letter to Congressman Henry Reuss, Clarke claimed that the EAB assisted the Corps "materially in the development of environmentally related policy."[70]

According to retired Corps biologist Edward M. Mains, "the Corps has always been responsible to laws."[71] In the 1970s, pressure from environmental groups provided powerful incentive. "NEPA," Stine noted, "gave the public, and therefore environmental organizations, immense potential power to influence the Corps' decision making process." Called the "quintessential piece of environmental legislation," NEPA assured that the federal government would consider the concerns of national environmental organizations.[72] Although disagreements continued between the Corps and the environmental community, NEPA helped make the Corps more accountable for its actions affecting the environment. By the early 1970s, activists concerned with "The Hard Corps and Our Soft Environment" noted that the agency has been constrained by lack of funding and personnel. Some environmentalists commended the Corps' approach to ecology problems as "far more advanced than many of the other federal agencies with environmental concerns."[73]

During the 1970s and 1980s, NEPA-based litigation served to "raise the consciousness of citizens and government officials."[74] Increased cooperation and communication led to better understanding between the engineers and river users. Although lawsuits leveled against the Corps and other agencies continued into the early 1990s, by 1993, some river users had backed away from extreme positions. The Northwest Indian Fisheries Commission, for instance, noted that the survival of the salmon will not be accomplished "by advocating removal of all dams or ending of all fishing." Instead, the chairman of this organization argued, "it is time for calm, rational action. It is time to get away from finger-pointing and to get on with the work that needs to be done to save the salmon resource for future generations."[75] During the fish-ins of the 1960s, such conciliatory words would have been difficult to imagine. The Columbia River Basin has a long history of conflict among fishers, and long-standing opposition to water development agencies. In the early 1990s, some participants demonstrated a willingness to set aside their differences and concentrate primarily on saving the salmon.

Endangered Species Act

Called the environmental decade, the 1970s produced landmark legislation for the protection of wildlife. The political consequences of the ESA of 1973 proved to be especially far-reaching. Resulting from a growing awareness of the importance of biodiversity, it was the nation's first comprehensive attempt to protect species from extinction. The U.S. Fish and Wildlife Service and the NMFS identified those animals and plants whose populations dropped so low that they appeared likely to become endangered as threatened, and those species that appeared in danger of becoming extinct as endangered. Called the "pit bull of environmental law," the ESA established a set of regulations preventing the harvesting, possession, sale, and delivery of threatened and endangered species. It also required the appropriate agencies to develop a plan to recover animal populations listed as threatened or endangered.

SPECIES, STOCK, AND POPULATION

In considering whether salmon should be listed under the Endangered Species Act (ESA), scientists wrestle with "species," "stock," and "population." Population is a defined group of individuals of one species that live in a particular geographic area. A "stock" is a race, strain or group of genetically closely related individuals within a species. Fishery biologists use the term frequently to identify the heritage of a particular hatchery population or to identify a particular spawning population within a species. The ESA defines a "species" as "any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." During the 1980s and 1990s, scientists disagreed over the interpretation of "distinct population segment."

In 1991, Robin Waples of the National Marine Fisheries Service (NMFS) proposed the following definition for application to Pacific Salmon: A population (or group of populations) will be considered "distinct" (and hence a species) if it represents an evolutionary significant unit (ESU) of the biological species. A population must satisfy two criteria to be considered an ESU:

- *It must be substantially reproductively isolated from other conspecific population units; and*
- *It must represent an important component in the evolutionary legacy of the species.*

To determine the extent of isolation, the NMFS uses information provided by tagged fish, natural recolonization rates observed in other populations, measures of genetic differences (electrophoresis or DNA analysis) between populations, and evaluations of the effectiveness of natural barriers.

If there is sufficient evidence to indicate reproductive isolation, then the next step is to determine whether a population is of substantial ecological/genetic importance to the species as a whole. Waples suggested that three questions are relevant in determining the ecological/genetic importance:

- *Is the population genetically distinct from other conspecific populations?*
- *Does the population occupy unusual or distinctive habitat?*
- *Does the population show evidence of unusual or distinctive adaptation to its environment?*

Waples described the types of information required to address the above questions and discusses the importance of each in making determinations. A framework and focal point for accomplishing the goal of the act in relation to Pacific salmon is provided by his paper.

SOURCE: Robins S. Waples, "Pacific Salmon and the Definition of Species' Under the Endangered Species Act," Marine Fisheries Review, 1991, vol 53.

Earlier wildlife legislation at the state and federal levels focused only on specific animals. During the late 19th century, market hunters, who harvested animals for profit, slaughtered exorbitant numbers of passenger pigeons and buffalo with alarming rapidity.[76] Although these animals once ranged the country in staggering numbers, they became nearly extinct by the turn of the century. Because this rapid destruction appeared highly visible, some Americans, particularly sportsmen, lobbied state governments in the 1880s and 1890s to enact laws prohibiting the taking of game in such wanton fashion.[77] The resulting wildlife legislation established restrictions on market hunting and the killing of breeding stock. Moreover, states established hunting and fishing license fees providing funding for "game-wardens" to enforce these new laws.

Differing laws from state to state, however, impeded the enforcement process. Those with migratory populations of wildlife remained reluctant to restrict hunting within their boundaries because such a policy would merely preserve the species for hunting in other states along the migratory routes.[78] Additionally, poaching presented a serious, unresolved problem. As a result, state laws generally proved ineffectual.

Historically, the federal government cooperated with state law and facilitated hunting and fishing in the United States, even opening federal lands for such activities. In 1900, Congress passed the Lacey Act to solve the problem of wildlife depletion and lack of coordination between states. This legislation forbade illegal interstate shipment of wildlife products in an effort to eliminate poaching for market purposes.[79]

To further replenish game and protect wildlife for the enjoyment of future generations, Congress passed the National Park Service Act of 1916. This legislation prohibited hunting in reserves such as Yellowstone, Yosemite, and Mount Rainier. It also, however, illustrate the ad hoc nature of U.S. wildlife protection policy by allowing the killing of predatory animals in the national parks for the benefit of livestock ranchers and park visitors. Employing hunters and offering bounties, the federal government nearly eradicated the wolf throughout the West. Later, owing to a lack of predators, national park managers noticed that prey populations unnaturally expanded and altered the park ecology by destroying plant communities and crowding other, native animals.[80] Wildlife legislation in the early 20th century extended protection only to select, "desirable," species.[81]

Before the mid-20th century, few advocates of wildlife protection understood how their actions affected habitat, or, in some cases, the species they intended to save. The lack of knowledge influenced attempts to conserve anadromous fish. For nearly a century, Americans believed that hatcheries could replenish anadromous fish stock without detrimental impact on the wild population. This approach "allowed other economic activities to proceed with the destruction of fish habitat under the illusion that they could replace lost production through artificial means."[82] Not until after World War II did habitat destruction reach such proportions that Americans fully recognized its impact on wildlife populations. Although the once-prolific passenger pigeon had become extinct in 1914, a movement for national legislation to save other species from that fate did not become serious until the 1960s and 1970s.[83] At that time, a holistic strategy for preservation sought "to preserve entire ecosystems regardless of present interest in any particular living component."[84]

In 1973, the ESA provided a program for the conservation of endangered or threatened species and designated areas essential to the species' survival and recovery. The spawning behavior of Pacific salmon made habitat protection and preservation vital to their survival.[85] Human activities in the Columbia River drainage degraded water quality and severely depleted salmon runs by the 1980s. Early in 1990, conservation groups filed petitions to list five salmon populations in the Columbia River drainage under the ESA.

Within 90 days of submission of a petition to have a species considered for listing as endangered or threatened, the corresponding federal agency decided whether to reject the petition, or accept it for further review. In the case of anadromous fish, the NMFS coordinated ESA activities, while the U.S. Fish and Wildlife Service remained responsible for freshwater, native species. Usually, within one year, the agency reached a final decision. If the agency proposed listing of the species as endangered or threatened, it identified critical habitat believed necessary for continued survival. Once a species was listed, the agency prepared recovery plans that identified mitigation measures to improve the species' status.

In April 1990, the NMFS announced that it would conduct a status review of these runs. The ESA required the NMFS to develop and implement a recovery plan for Snake River chinook and sockeye. To develop this recovery plan, the Regional Director, Roland Schmitten, appointed a team of seven fisheries scientists in the Northwest to review scientific and other information pertinent to the demise of the fish population. They then prepared a report detailing all known factors contributing to the problem and recommended a solution. In December of 1991, the ESA listed three of the proposed salmon runs and set aside critical habitat areas for the continued survival of the fish.

Supporters believed that the ESA would force a solution to the many problems anadromous fish face in the Columbia River and its tributaries. Many Americans, however, remained critical of the ESA. Some complained that the NMFS' inability to recognize salmon populations as genetically diverse impeded preservation efforts. Environmentalists argued that the mitigation plan for salmon in the Columbia River drainage took too long to develop. During years of negotiation with state and federal agencies, environmentalists feared that a shrinking gene pool worked against natural evolutionary processes.[86] They worried also that the ESA proved unwieldy in the private sector. "The ESA," Bob Doppelt, a spokesman for the Oregon-based Pacific Rivers Council conceded, "is an awkward tool for forcing changes on private landowners."[87] Without private-sector compliance, mitigation strategies appeared certain to fail.

Some American remained concerned about the ESA's focus on protecting species over economic concerns. Suspicious of "policies that place a heavy cost on working people and little on people who advocate them," Washington Senator Slade Gorton argued in 1993 that the cost of protecting salmon in the Columbia River drainage would exceed the impact if the species were lost.[88] The salmon's designation as an endangered species affected a variety of activities, including commercial and sports fishing, tourism, Native American fishing, logging, grazing, farming, and hydropower generation.

In the Columbia River Basin, the ESA proved to be milestone legislation. Through increasing the influence of the NMFS, this law affected the interaction of agencies concerned with anadromous fish protection. As the NMFS gained responsibilities in coordinating ESA activities, the Corps was required to look to this agency for direction. In particular, the Corps became involved in the ESA process at three stages. The first, proposed listing, required that the Corps review its actions to determine if it should be involved later. The second stage, emergency listing, required the NMFS to evaluate the Corps' actions and recommend alternatives if those actions were determined to jeopardize the species or its habitat. The Corps, however, was not bound to follow the NMFS recommendations. The third stage, final listing, required formal consultation between the Corps and the NMFS. Involvement at this stage was much the same as with the emergency listing process.[89] One important difference, however, was that the Corps could formulate its own opinion of impact.

To comply with the law, the Corps became involved early in the ESA process. Under section 7(a)(4) of the ESA, a federal agency must confer with the NMFS on any actions likely to jeopardize the continued existence of a species proposed for listing or any actions likely to destroy or adversely modify proposed critical habitat.[90] Accordingly, the Corps provided information to the NMFS in 1990 and 1991, so that fisheries biologists could determine the status of the salmon populations of the Columbia River drainage system. In 1991 alone, the Corps modified operations at five Columbia Basin reservoirs, modified six Columbia River dams, and completed three studies and nearly a dozen reports evaluating their actions in light of the December 1991 NMFS proposal to give salmon ESA protection.[91]

United States-Canada Salmon Treaty

Salmon, noted one reported in 1985, do not recognize international borders. For all the mitigation measures at Columbia and Snake River dams, thousands of salmon migrated north to Canada only to land in the boats of the fishermen there. This issue has, in fact, remained "one of America's thorniest border disputes." Fishermen, after all, could not determine the nationality of a chinook. For more than a century, they harvested "intermingled stock, depleting the salmon fisheries of both countries to dangerously low levels."[92]

After 15 years of negotiation, Canada and the United States reached an agreement in 1985 to reduce the interception of each other's salmon and "restore the fisheries by expanding enhancement programs and by limiting the catch for all parties."[93] Managers of hydroelectric dams, Native Americans, conservation groups, and the NPPC joined to support the treaty between the United States and Canada to regulate salmon fishing. The treaty protected the salmon originating in the Columbia River Basin from harvest at sea by Canadian and Alaskan fishermen. Supporters hoped that this agreement would increase the number of salmon that return to the Columbia River.

Negotiations for international agreements to limit the harvest of salmon and other fish date back to the turn of the century. In the early 1900s, sockeye salmon runs in the Fraser River Basin declined owing to canning and shipment to England. To resolve the problem, Great Britain and the United States signed a convention in 1908. The decline of sockeye, however, continued. For this reason, an international commission composed of three representatives each from Great Britain and the United States met in Seattle and Vancouver in 1918. This commission recommended regulating the times, seasons, and methods of sockeye salmon fishing.[94] Although both governments signed the recommendations, and the Canadian government approved them, the United States Senate did not ratify them until 1937.

The treaty established the International Pacific Salmon Fisheries Commission that same year. After five years of study, the representatives of the United States and Canada reached an agreement on the rehabilitation of the Puget Sound-Fraser River sockeye salmon. To save the sockeye, the commission recommended a combination of fishways around dams and other blockages, restocking with hatchery fish, and restricted fishing in Puget Sound, the Gulf of Georgia, and the Fraser River.[95] "The Americans will," one proponent of the treaty stated, "learn the farmer's first lesson, that he must save some seed for a future crop."[96]

The United States and Canada reached agreements for joint development of the Columbia River Basin. After two decades of study and negotiations, the two governments signed an agreement to manage use of the Columbia River in 1964. The terms of this agreement allowed Americans to use large areas in Canada for water storage to meet power and flood control objectives in the United States. Canada, on the other hand, received a share of the increase of power produced in the United States and payment for its storage contribution.[97]

The U.S.-Canada Salmon Treaty of 1985 intended to help rebuild West Coast salmon runs by limiting offshore catches of certain stocks. The treaty also ensured that fish were not over-harvested before reaching the river by limiting ocean fishing. In 1985, Timothy Wapato, executive director of the Columbia River Inter-Tribal Fish Commission, commented that the treaty made those "who represent the tribes feel good." The treaty afforded "control of the ocean fishery," which Wapato felt necessary to the "rehabilitation projects [that] can be undertaken in the Columbia River Basin under the Regional Power act."[98] Two years later, the Inter-Tribal Fish Commission continued to support the treaty. This agreement, he pointed out, remained "a key ingredient in the NPPC's efforts to rebuild upper Columbia River spring and summer chinook salmon runs."[99]

By 1994, however, relations between the United States and Canada had deteriorated on the issue of salmon protection. From 1985 to 1993, American interceptions of Canadian salmon increased from 6 million per year to 9 million. Canadians argued that there are no mainstem dams along the Fraser River, in contrast to American development of the Columbia and Snake Rivers. Negotiations failed to produce an equitable solution, and for a short time in 1994, Canada charged American fishing vessels a license fee for traveling up the Inside Passage on their way to Alaska. This incident reminded both nations that the salmon runs are a shared resource, and that protection remains a joint effort.[100]

The Salmon Summit

Causes of declining salmon and steelhead populations in the Columbia River Basin remain numerous. Many, such as destruction of habitat and overfishing, date back a century. Others, such as fluctuations in ocean temperatures, occur outside human control. Environmentalist organizations and state fisheries agencies in Oregon and Idaho place primary responsibility for dwindling anadromous fisheries on mainstem dams. Convinced that bypasses and collection and transportation systems do not provide adequate solutions to the problem, they request more radical mitigation measures.

To explore various ideas for fish protection, Senator Mark Hatfield of Oregon organized the Northwest Salmon Summit in Portland in 1990. Conducted prior to the listing of three Snake River salmon populations under the ESA, the Summit intended to reach a consensus among Pacific Northwest interests and formulate a plan to address the problem of depleting salmon runs.[101] In addition, participants expected to suggest an appropriate response to NMFS' pending listing. The Summit included the governors of Washington, Oregon, Idaho, and Montana, as well as 30 official members representing 28 organizations responsible for water management, power production or marketing, and fisheries management.

Participants divided into four separate task groups to study fish harvest, river flow, salmon production, and enforcement problems. The meetings began in October 1990 and continued into 1991. Although members developed various proposals, the divergent interests represented at the Summit did not reach an agreement on a fundamental approach to the problem. By the last formal meeting, held in early March 1991, Summit participants had not reached a consensus on a comprehensive plan of action or mitigation of impacts.

One of the most controversial proposals to emerge from the Summit was the idea of drawing down the reservoirs on the lower Snake River by as much as 100 feet or more. Proponents believed that increased spill and water velocity during the spring migration would flush the juvenile fish downstream, reducing their journey of approximately 30 days to 16 or 17 days, thereby increasing survival. In 1991, it seemed that the Summit participants reached an agreement for a one-year implementation plan.[102] However, concern for adverse impacts of lowered water levels on shipping, port operation, recreation, and farming reduced the scope of actions agreed upon.[103] Should the drawdown approach to saving salmon be implemented in the future, it will represent a major shift in fish passage protection policy for juvenile salmon and steelhead. Drawing down the reservoirs also will require a considerable investment of funds. Estimated construction costs for the various drawdown proposals range from $1 to $5 billion, depending on the amount of water reserved. These costs do not include lost power revenues.[104]

Although the Salmon Summit failed to agree on a plan to save the salmon, the meetings contributed to the NMFS decision not to invoke an emergency listing for the sockeye salmon. The Summit's efforts, however, did not prevent the ESA final listing.[105] The meeting succeeded in bringing a broad array of interests into recovery discussions. Participants, including the Corps, agreed to continue efforts to rebuild the depleted Columbia River salmon stocks.

Recent proposals to save salmon and steelhead include the idea of building a fish collection dam near Lewiston, Idaho, to divert fish into barges or a flume or pipeline. This structure would transport salmon and steelhead to a point below Bonneville Dam. Cost estimates for the collector dam range from $242 million to $1.2 billion.[106]

By the early 1990s, environmentalist groups and the tribes filed several lawsuits against the Corps and other water resource agencies. Owing to the complexity of the issue and its controversial nature, the fate of salmon and steelhead in the Columbia River Basin might be determined by litigation. Like the efforts to save the spotted owl, recovery efforts for anadromous fish are likely to be adjudicated.

Draft Recovery Plan Recommendations

When the NMFS listed three salmon species under the ESA in the early 1990s, the agency appointed a Snake River Salmon Recovery Team to develop recommendations. The seven-member team, which included biologists, engineers, and an economist, did not represent NMFS or act on its behalf. Donald Bevan, professor emeritus at the University of Washington, led the teams' investigations. Topics analyzed included habitat, fish passage through the Corps' eight mainstem dams, hatchery practices, harvest controls, and predators. Team members consulted with federal, state, and tribal agencies as well as with representatives from industry and environmentalist groups. In October 1993, the team produced a draft report outlining their recommendations. Its members plan to submit a final report of recommendations, which the NMFS will incorporate into its recovery plan.[107]

The team's draft report concluded that for all the energy and money poured into protection of salmon over the last half a century, "efforts have not succeeded." According to the team, continued decline of fish runs resulted from a flawed decision-making process "for all aspects of Columbia-Snake River Basin anadromous fisheries management and research." In particular, a lack of priority hampered investment decisions, owing to "the number of independent jurisdictions involved." Typically, decisions required the coordination of four state agencies, four Indian tribes, and a number of federal agencies and utilities. Although they resolved many issues by consensus, these groups arrived at some decisions "independently without respect to their impact on other jurisdictions." Infighting sometimes impeded attempts to coordinate on fisheries decisions. "The differing objectives of each organization," the team explained, led "to conflicts in interpretation, lengthy arguments, and decision paralysis."[108]

BIOLOGICAL OPINION

In a March 28, 1994 decision in the Oregon District Court, Judge Malcolm Marsh found fault with the National Marine Fisheries Biological Opinion of the Federal Columbia River Power System operations, required by the Endangered Species Act. He noted that the "NMFS has clearly made an effort to create a rational, reasoned process for determining how the agencies are doing in their efforts to save the listed salmon species." Even so, he found the process to be "seriously, significantly flawed because it is too heavily geared towards a status quo that has allowed all forms of river activity to proceed in a deficit situation - that is, relatively small steps, minor improvements and adjustments - when the situation literally cries out for a major overhaul." The NMFS expects to complete a new biological Opinion by early 1995. This effort will be coordinated with the NMFS Recovery Plan for listed Snake River Salmon species.

Source: Salmon Passage Notes, July 1994, p. 5.

The problem, in the teams' estimation, was that "no one" was "in charge." Nor did state and federal legislation provide much direction. Team members characterized laws pertaining to salmon conservation as being generally ineffective and inadequate. The Northwest Electric Power Planning and Conservation Act, as noted, lacked specificity, leading to disagreements regarding the implementation of measures. Accordingly, the region's approach to investment priorities often has involved "political compromises" rather than "science-based solutions." The team recommended that a single organization, the NMFS, be placed in charge of recovery efforts and "empowered to make final decisions when consensus cannot be obtained."[109]

In general, the team suggested the adoption of an "ecosystem approach" to rebuilding Snake River salmon runs. Short-term actions included improvements to the Juvenile Fish Transportation Program. Young fish could be released, for instance, below Bonneville Dam or in the ocean. Also, barge design could be improved to reduce stress and vulnerability to predators. Improvements to juvenile bypass systems included possible use of 40-foot extended length screens to replace 20-foot screens now in place. Continued experimentation with longer diversion screens was also recommended as was continued for augmentation measures. In addition, the team indicated the importance of monitoring gas supersaturation, suggesting that young fish be transported in areas with high levels.[110]

Recommended long-term options included improving juvenile collection facilities or building a new collector facility above Lower Granite Reservoir. Another recommendation involved modification or removal of the four lower Snake River dams to allow the river to flow at the natural level for a six-month migration period every year. Owing to social and economic factors, the team preferred improved collection and transport. For adult fish, the team recommended improvements in the ladders. Reservoir drawdowns below project design levels could affect the operation of these structures, impeding adult migrations. The team also recommended study of flow augmentation to control water temperature and dilute pollution in the rivers.[111]

Many of the team's recommendations included actions that the Corps had already initiated in by the early 1990s. The engineers devoted considerable effort, for example, to improvements to bypass and transportation systems. Throughout its history in the Columbia River Basin, the Corps expended substantial energy to save declining salmon and steelhead populations. As in the past, a combination of scientific research, funding availability, and public sentiments will continue to drive the agency's decision regarding protection measures. The final recovery plan of the NMFS will also affect future actions of the engineers. A century of conflict over the region's fisheries, however, indicates that whatever course the Corps pursues in its continuing mitigation effort will likely prove controversial.

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Epilogue

For more than a century, efforts to protect declining salmon runs have encountered a recurring problem: a lack of information. During the late 19th and early 20th centuries, scientists knew little about Columbia and Snake River habitat or fish migrations. As noted, the Corps' report on the salmon fisheries of the Columbia River, printed in 1888, pointed out that researchers remained largely unaware of the habits of anadromous fish as well as "what motives guide their mysterious ocean sojourns."[1] In 1909, the Bureau of Fisheries complained that this topic was "shrouded in obscurity."[2] Nor did researchers fully understand the decline of fish populations. As late as 1947, the Bureau of Reclamation explained that the "extent of depletion in Columbia River Salmon runs cannot be determined because of inadequate data."[2]

Since the late 19th century, scientists suspected that small dams, habitat destruction, pollution, and commercial harvesting impacted fish runs. By the 1930s, some also had worried that large multipurpose dams also would affect salmon populations. However, researchers did not understand how best to protect the fish. At Bonneville Dam, researchers remained "in the dark" about the effectiveness of ladders.[4] In the early and mid-20th century, fish passages for large dams represented a recent development.

From the beginning of its construction of multipurpose dams in the Columbia River Basin, the Corps sought to redress this lack of information. The Corps hired biologists and fish passage experts to design the ladders at Bonneville Dam. Since the early 1950s, the agency had devoted more than $60 million to fisheries research, producing hundreds of reports and studies. Moreover, the Fisheries Engineering Research Laboratory at Bonneville, constructed in 1955, represented on e of the largest facilities for fish study established by a water resources agency. By the 1960s, the Corps had become a leading agency in funding, coordinating--and sometimes initiating--research. From the 1930s to the 1960s, many studies conducted by the Corps and the fisheries agencies focused on adult fish passage. The research that the Corps sponsored enabled the engineers to design and construct innovative facilities for adults. This area marked the Corps' most successful effort to protect salmon from the hazards of its dams.

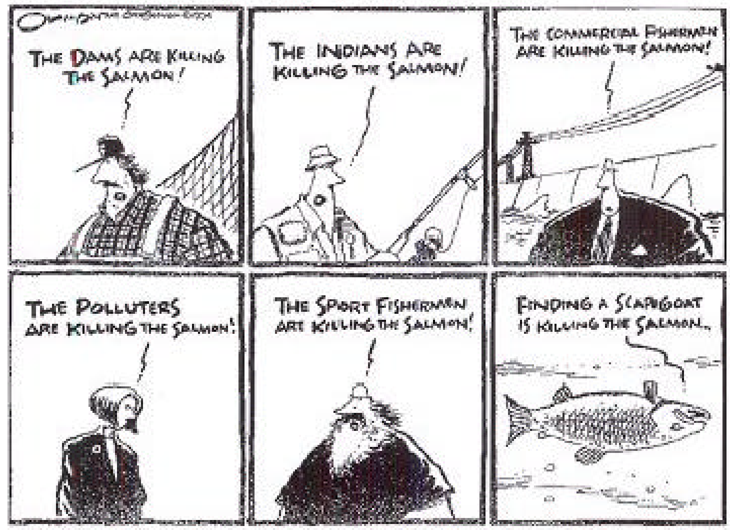
In addition to supporting the studies of the fisheries agencies, the Corps contributed its own biologists to the research effort. Throughout the last 50 years, the Corps employed a variety of scientists, from Ivan Donaldson to Edward M. Mains. As noted, Donaldson frequently complained about the attitude of the engineers in the mid-20th century, which he summed up as, "To Hell with the Fish." Donaldson, who developed a reputation among scientists as a "friend of the Salmon," became a gadfly to the engineers, educating them and prodding them to consider the effects of their projects on fish.[5] That the Corps retained him for more than 3 decades indicates his persistence as well as the agency's awareness of the significance of anadromous fisheries. Later, Mains, too, would inspire respect among biologists throughout the region for his concern for salmon. Scientists such as Donaldson and Mains influenced the development of attitudes within the Corps, encouraging the agency to devote more energy to protecting salmon.

In hindsight, one of the most significant shortcomings of the Corps' efforts to mitigate the impact of its projects involved research of juvenile fish. Studies of young salmon progressed more gradually than investigations of adults, frustrating scientists who worried about the impacts of large, multipurpose dams on the downstream migrations. Construction of large dams proceeded without sufficient knowledge of the effects on young salmon. By the late 1960s, concern for juvenile mortality had prompted the Corps to finance and coordinate increasingly extensive investigations of young fish. For the next 25 years, the Corps worked with the NMFS and state fisheries agencies to improve juvenile bypasses. In the 1970s, the Corps and the NMFS developed a transportation program to assist juvenile passage, and the engineers operated it throughout the next decade. Although investigations of adults continued into the 1990s, much of the research--and much of the controversy regarding protection of salmon--remained focused on juvenile fish. When the Corps completed its last dam on the Snake River, the agency began building elaborate facilities for young salmon. Critics, however, complained that the Corps has continued to emphasize technological solutions to the problem of downstream migration.

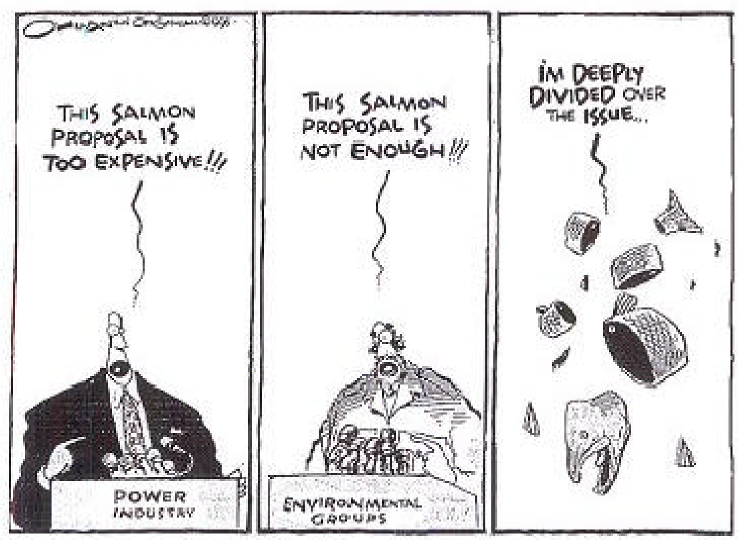
Additional developments in research included the increasing attention to fish diseases, predation, and degradation of habitat. From the 1960s and 1970s, the Corps and the fisheries agencies focused not only on design and construction of fish passages but also on the conditions of the salmon and the river. Although scientists became aware of gas bubble disease in the 1930s, few understood that it would prove to be such a difficult problem in the 1960s and 1970s, when the Snake River dams created a succession of slackwater pools, allowing a buildup of nitrogen. The Corps funded the NMFS and other agencies to conduct extensive research, and the engineers developed spillway deflectors, or "flip-lips," to limit the plunge depth of water over the dam spillway. Installation of these innovative devices, along with the placing of additional turbines at key dams, helped reduce the occurrence of gas bubble disease. In the 1970s, the Corps also financed studies of the effect of predation until the BPA assumed responsibility for researching this topic.

At that time, an increasing awareness of species diversity and the importance of ecosystems prompted legislation designed to save declining plant and animal populations. This concern was reflected in the Corps' efforts to mitigate the impacts of its multipurpose dams, as the agency expended its research activities on salmon during the 1970s. Environmentalists who opposed much of the Corps' water resources work in the early 1970s noted that the engineers' approach to "ecology problems" remained "far more advanced than many of the other Federal agencies with environmental concerns."[6]

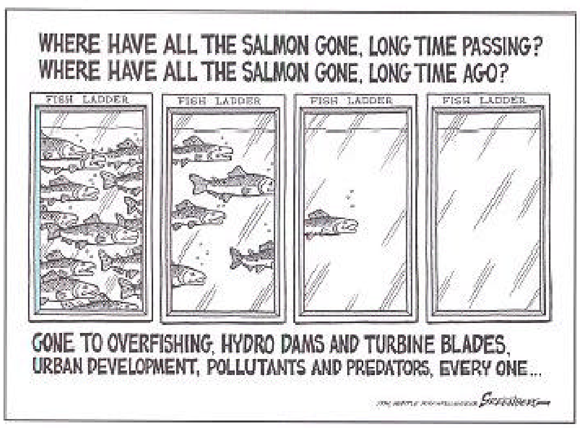
Development in the Corps' organizational structure also influenced the agency's efforts to protect salmon. During the early years of research and construction, the Portland and Walla Walla Districts retained responsibility for migration. By the 1970s, however, as problems on the Columbia River Basin worsened, Corps Headquarters in Washington, D.C., and the North Pacific Division in Portland assumed greater responsibility for the recovery of salmon populations. At that point, the districts often simply executed the decisions made at higher levels. This shift in responsibility indicated that the Corps recognized the severity of the problem on the Columbia and Snake Rivers and resolved to address them.



A sampling of political cartoons, indicating popular perceptions in the region.



Another recurring theme affecting Columbia River Basin fisheries involved longstanding conflict among various users. Historically, commercial and sport fishers competed for a declining resource, resulting in furious "bickering."[7] Although these two groups sometimes cooperated for political advantage, their animosity generally increased as the numbers of harvesters grew. Moreover, from the late 19th century, Native American fishers protested the loss of their traditional fishing sites. By the 1960s, conflicts between Indian and other fishers became increasingly militant, at times culminating in violence. While rivalry among the various fishers continued, some came to focus on the Corps and other agencies rather than on each other. Also, although many conservationists had supported the construction of multipurpose dams in the Columbia River Basin, environmentalists of the 1970s protested further construction of large hydroelectric facilities on the Snake River, often with the fervor of crusaders. Increasingly, the various interests, including sports and Indian fishers as well as environmentalists, turned to litigation against the Corps and other agencies.



Conflict has not been limited to fishers and environmentalists. The fisheries agencies, too, have not always agreed on the most effective course of action regarding salmon protection. The debate over transportation of juvenile fish in the 1990s revealed that scientists held diverse positions. In 1994, Robert W. Schoning, former Director of both the Fish Commission and the NMFS, reflected that "we still don't know the best way to protect the fish."[8] Moreover, fishers and agency biologists alike have tended to view the salmon populations in proprietary terms, resulting in infighting.[9] Malcolm F. Marsh, the "Salmon Judge" of the U.S. District Court, observed this trend in 1993. Even biologists, he argued, "were losing sight of science and becoming advocates."[10]

Continuing decline of anadromous fish has fueled this conflict. For all the efforts devoted to fish protection over the last half a century, salmon populations in the Pacific Northwest remain at risk of extinction. Forecasts for salmon became so dismal that in 1994, for the first time in history, fisheries agencies agreed to shut down all offshore coho and most chinook salmon fishing in Oregon and Washington.[11] As noted, a variety of causes have contributed to this decline, including ocean temperatures and currents, ocean harvest, habitat destruction, and hatcheries. Large, multipurpose dams remain a major cause of salmon mortality. Like fishers of the late 19th and early 20th centuries, dams present a tangible, visible focus for concern about salmon production. Other causes, such as ocean temperatures and currents, are difficult to identify and control. As the historian Courtland L. Smith has warned, however, blaming the dams for anadromous fish declines is simplistic and counterproductive. According to him, to focus on water resources development "is to miss the point. The dams are merely instruments of a technocratic society."[12] In one sense, to say that everyone in the region is responsible is to say that no one is. Yet all residents of the Pacific Northwest benefit from the electricity that the dams provide--and it comes at a cost. "I just want to catch fish," explained a sportsman from Portland in 1991. "But am I going to say tear down the dams, cut the water off to the farmer? You know I'm not; you know I can't. I light my house with hydroelectricity and set my table with food from desert fields, and that's called progress." Similarly, Idaho Trout Unlimited, an organization of sports fishers, conceded that "for every kilowatt generated, something is sacrificed." One spokesman from the group quipped, "Flip a switch, kill a fish."[13]

Deciding between the advantages of water resources development and the preservation of salmon runs will remain a difficult process for the region. For more than a hundred years, many policy makers viewed the Columbia River in terms of the economic benefits it has provided, as a transportation route, as a wellspring of commercial and sports fisheries, and as a source of hydropower. In the 1990s, they were forced to examine the region's--as well as the nation's--priorities. In 1950, advocates of dam construction assured residents of the Pacific Northwest that "fish and power and navigation can be made to live side by side."[14] Nearly half a century later, the region's residents are no longer convinced. "Our time of having it all is over," explained one reporter in 1991. "The choices must be made."[15]

In 1941, another observer of deteriorating anadromous fisheries warned that Euroamerican "Civilization meant the end of the bison of our plains." Hoping that Columbia River salmon would not share the same fate, he wondered "whether new and unique precautions" could save "the finest fish in North America."[16] At the end of the 20th century, as debates regarding salmon protection intensify, his words appear especially timely.

Endnotes

[1]Jones, *Salmon Fisheries of the Columbia River,* p. 31.

[2]Greene, "The Migration of Salmon in the Columbia River," p. 131.

[3]U.S. Bureau of Reclamation, *The Columbia River: A Comprehensive Report on the Development of the Water Resources of the Columbia River Basin for Irrigation, Power Production, and Other Beneficial Uses in Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming,* (Washington, D.C.: Government Printing Office, 1947) p. 355.

[4]Neuberger, "The Great Salmon Experiment," p. 235.

[5]Letter, Ivan Donaldson to H.K. Fairbanks, 6 June 1974, Donaldson Papers, Bonneville Lock and Dam Project, p. 2.

[6]Clusen, *Engineering a Victory for Our Environment,* pp. 3-28.

[7]Dufresne, "Troubled River," p. 74.

[8]Schoning Interview.

[9]Collins Interview.

[10]Judge Malcolm F. Marsh paraphrased in Dugger, "Science or Politics?" p. 7; Jessica Maxwell, "How to Save a Salmon," *Audubon* 96 (July/August 1994): 33.

[11]Maxwell, "How to Save a Salmon," p. 28.

[12]Smith, *Salmon Fishers of the Columbia,* p. 4.

[13]William and Simon, "Last Chance for Salmon," p. A4.

[14]Letter, Harry P. Cain to Alvin Anderson, 7 June 1950, Washington State Archives, Fisheries Central Files.

[15]Williams and Simon, "Last Chance for Salmon," p. A4.

[16]Neuberger, "The Great Salmon Mystery," p. 44.

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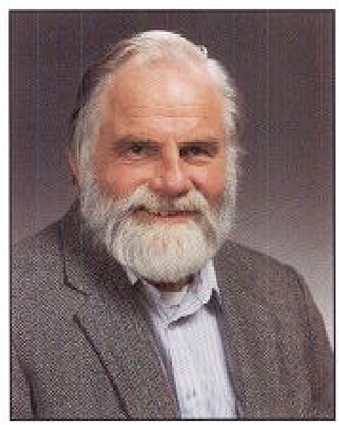
Lisa Mighetto received her Ph.D. from the University of Washington, with an emphasis in environmental history and the American West. She has published two books, *Wild Animals and American Environmental Ethics* (University of Arizona Press, 1991) and *Muir Among the Animals: The Wildlife Writings of John Muir* (Sierra Club Books, 1986). Her articles, many of which concern wildlife policy, have appeared in *Harper's Sierra, Pacific Historical Review, Pacific Historian, Environmental Review, The Alaska Journal,* and *Columbia*. She has served as a history consultant to the National Parks Foundation, Tacoma Art Museum, and Washington State Historical Society. Since 1991, she has worked as an historian for Historical Research Associates in Seattle.



Wesley J. Ebel received his Ph.D. from the University of Idaho, where he specialized in wildlife biology. He served as Director of the Coastal Zone and Estuarine Studies Division of the National Marine Fisheries Service, and his research on Columbia River salmon has spanned more than 25 years. Dr. Ebel pioneered research on the supersaturation of atmospheric gases and the effects of collection and transportation on juvenile salmon. He is the author of more than 40 articles, and his publication on gas bubble disease and juvenile transportation received the Best Paper Award from the American Fisheries Society and the Outstanding Publication Award from the National Marine Fisheries Service. He retired from the National Marine Fisheries Service in 1988, and now works as a consultant on fisheries issues.

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Historical Research Associates, Inc. (HRA) has provided cultural and environmental resource consulting services to private and public clients since 1974. Based in Missoula, Montana, HRA also maintains offices in Seattle and Washington, D.C.

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Photo Bibliography

Photo Description	Source	File Number
Opening Photos		
Sockeye Salmon	NRC	Gregory T. Ruggerone
Fish Transport, Bonneville Hatchery, and John Day Dam	NPD	--
William Clark's Salmon Drawing	NPD	643
Columbia Basin Map	NPD	--
Chapter I		
Columbia River Map, 1887	Senate Doc 123	No. 2510
Fish sketch	NPD	--
Fish life cycle	NPD	--
Celilo Falls Indian Fishery	NPD	H1477
All: Indian dipnet fishery, Celilo Falls	NPD	H372
top left: Salmon-dipping lodge	WSHS	--
top right: Indian dipnet fishery	NPD	H362
bottom left: Salmon drying racks	NPD	H361
Salmon canning labels	NMFS	Wesley Ebel
top: M.J. Kinney Cannery	CRMM	1902.55
bottom: cannery scene	CRMM	1985.55.1332
top: Fish trap	U of WA	5706
bottom left: Bountiful catch	NPD	--
bottom right: Commercial fishermen	*The Pacific Monthly*, 1903	--
top and middle: Seining for salmon	NMFS	Wesley Ebel
bottom: Columbia River fishwheel	*The Pacific Monthly*, 1903	
top: Scow wheel	OHS	4200-4390
bottom: Fishwheel	NMFS	--
Salmon cannery	OHS	88043-390-k
left: Salmon derby	CRMM	1979.27.11
right top: Salmon derby, 1940	CCHS	2050-101
right bottom: Salmon derby, 1948	CCHS	2042-101
Columbia River Basin Map	NPD	--
Columbia River Basin Map	WA Dept of Fisheries, OR Dept Fish/Wildlife	216
Kokanee	NPW	20
Sockeye Habitat Map	WA Dept of Fisheries, OR Dept Fish/Wildlife	216
Central Salmon Hatchery	NPD	--

Chapter II

Fish plates	USFWS	--
Grand Coulee Dam	NPD	G-55
Major Jones	COE Office of History	--
308 Report	NPD	H-171
Major Dams Map	NPD	--
top: Bonneville Project	NPD	--
bottom: Col. Lukesh	NPD	--
left: Fish ladder	NPD	--
top right: Diagram of fish lock	NPD	--
middle: Diagram fish collection	NPD	--
bottom: Fish passage system	NPD	--
top: Fish counter	NPD	--
bottom: Bonneville Dam dedication	NPD	H-206
left: Portage railroad	NPD	--
right: Sternwheeler on Columbia	U of WA	33545
bottom: Steamers at Cascades Canal	NPD	H-1525
left: 1894 flooding	NPD	--
right: 1948 Vanport flood	NPD	--
left top: Farm irrigation	NPD	IR234
bottom: Fertile valley	NPD	13883
right: irrigation canals	NPD	JDP-707
left: Alcoa Aluminum Plant	NPD	H-651
right: Powerlines	NPD	--
left: Crown Point view	NPD	--
right: Columbia River Highway	NPD	--
top: Columbia Gorge Hotel	NPD	G-1883B
bottom: Recreation photos	NPD	G-1883B
Train at The Dalles	NPD	TDA-1880
Lower Snake River dams	NPW	--
left: John Day fish ladder	NPD	JD-1270
right: Fish ladders at The Dalles Dam	NPD	TDA-1768
Thomas Robins	NPD	--

Chapter III

Fish plates	USFWS	--
Ivan J. Donaldson	NMFS	Louise Donaldson
top: Edward M. Mains	NPD	C7790A
bottom: Robert Schoning	NMFS	Robert Schoning
Harlan B. Holmes	NMFS	Elizabeth Holmes
Fish injured by turbines	NMFS	Wesley Ebel
Gas bubble disease	NMFS	Wesley Ebel
left: Merwin Trap	NMFS	Wesley Ebel
middle: Squawfish with smolts	NMFS	--
right: Rout with smolts	NMFS	--
left: Prototype of Traveling Screen	NMFS	--
right: Horizontal Traveling Screen	NPD	C37860

Chapter IV

Fish plates	USFWS	--
left: Research lab at Bonneville Dam	NMFS	--
right: Experimental fish ladders in lab	NMFS	--
Carl Elling and Gerald Collins	NMFS	Gerald Collins
New lab at Bonneville	NPD	B-9241
left: Fish going up fish ladder	NPD	--
right: Observers of fish jumping	NPD	B-129
Vertical slot fishway	NPD	B-6203
top left: Floy fish tag	NPD	FIS-0132
top right: Peterson disc fish tag	NPD	FIS-0131
bottom: Radio tag research	NPD	B-0739, 0734
top: Juvenile fish branding	NPD	FIS-0323
bottom: Researchers check branding	NPW	McN-430
Purse seining on the Columbia River	NPD	FIS-0360
Juvenile recovery at Brownlee Dam	NMFS	Wesley Ebel
Traveling screens	NPD	BII-3750
top and left: Aircraft and loading	NPW	LGr-M40
bottom right: Aerial release of fish	NMFS	Wesley Ebel
Juvenile fish transport at Little Goose Dam	NPW	--
left: Extended-length traveling screen	NPW	McN M474
right: Traveling screens	NPD	TDA-0821
Spillway at John Day Dam	NPD	JDA-1850
Scan sonar set up at John Day Dam	NPD	JDP-0657-8
LSRCP hatcheries	NPW	--

Chapter V

Fish plates	USFWS	--
Recreational sport fishing	NPD	FIS-0273-5
Methods of commercial fishing	U of WA	5706
top: Arrests for steelhead fishing	MOHI	86-5
bottom: Marlon Brando at Fish-In	MOHI	86-6

Chapter VI

Fish plates	USFWS	--
Inland Waterways Ports	NPW	--
1990's billboard illustration	NPW	--
Juvenile fish transport truck	NPD	--
Sierra Club cartoon	U of AK	--

Epilogue

Political cartoons	*Oregonian*	--
Political cartoon	*Seattle P-I*	--

Author Biographies

top: Lisa Mighetto	NPD	--
bottom: Wesley J. Ebel	NPD	--

Source Reference for Repository Locations

CCHS	Clatsop County Historical Society 1618 Exchange Street Astoria, Oregon 97103
CRMM	Columbia River Maritime Museum 1792 Marine Drive Astoria, Oregon 97103
COE Office of History	COE Office of History HQ COE Kingman Building Alexandria, Virginia
MOHI	Museum of History and Industry The Seattle Post-Intelligencer Collection 2700 24th Avenue East Seattle, Washington 98122
NMFS	National Marine Fisheries Service National Oceanic and Atmospheric Administration 7600 Sand Point Way NE Seattle, Washington 98115
NPD	U.S. Army Corps of Engineers North Pacific Division Visual Information Division P.O. Box 2870 Portland, Oregon 97208-2870
NPW	U.S. Army Corps of Engineers Walla Walla District Walla Walla, Washington 99362-9265
NRC	National Resources Consultants, Inc. 40552 21st Avenue West, Suite 200 Seattle, Washington 98199
OHS	The Library Oregon State Historical Society 1230 S.W. Park Avenue Portland, Oregon 97205
Oregonian	*The Oregonian* 1320 S.W. Broadway Portland, Oregon 97201
Seattle P-I	*The Seattle Post-Intelligencer* 101 Elliott Avenue West Seattle, Washington 98119
U of AK	University of Alaska Library Archives and Manuscripts Anchorage, Alaska

U of WA	University of Washington Libraries Special Collection Division Seattle, Washington 98195
USFWS	U.S. Fish and Wildlife Service Portland Eastside Federal Complex 911 NE 11th Avenue Portland, Oregon 97232
WSHS	Washington State Historical Society 315 North Stadium Way Tacoma, Washington 98403

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Appendix - Tables and Graphs

Acronyms List For Anadromous Fish History	
Acronym	**Definition**
BKD	Bacterial Kidney Disease
BPA	Bonneville Power Administration
CBFTC	Columbia Basin Fisheries Technical Committee
CFS	Cubic Feet Per Second
COFO	Committee on Fisheries Operations
CRITFC	Columbia River Inter-Tribal Fish Commission
EAB	Environmental Advisory Board
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FPC	Fish Passage Center
FPDEP	Fish Passage Development and Evaluation Program
FPS	Feet Per Second
GPM	Gallons Per Minute
HZ	Hertz
KCFS	Thousand Cubic Feet Per Second
LSRCP	Lower Snake River Fish and Wildlife Compensation Plan
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
OSN	Oregon Steam Navigation Company
PUD	Public Utility Department
WSSA	Washington State Sportsmen's Association

Table 1A
Columbia River Canned Salmon Pack

Salmon canning on the Columbia River began in 1866, with a pack of about 4,000 cases, valued at $64,000. Production increased rapidly to a peak of 629,400 cases in 1883, valued at $3,147,000; then fell to 356,000 cases, valued at $2,124,000, in 1887; the average output for intervening years being 351,091 cases, valued at $2,066,227.

Year	Number of Canneries	Chinook, Sockeye, Coho, Chum, and Steelhead	
		Cases	Value
1888	28	372,477	$2,234,862
1889	21	309,885	1,809,820
1890	21	435,774	2,407,456
1891	22	398,953	2,440,964
1892	24	487,338	2,679,069
1893	24	415,876	2,095,093
1894	24	490,100	2,501,126
1895	24	634,696	3,110,997
1896	24	481,697	2,261,826
1897	22	552,721	2,219,311
1898	23	487,933	2,073,226
1899	17	332,774	1,777,975
1900	16	358,772	2,282,296
1901	--	390,183	1,942,660
1902	14	317,143	1,644,509
1903	16	339,577	1,777,105
1904	20	395,104	2,242,678
1905	19	397,273	2,237,571
1906	19	394,898	2,149,062
1907	19	324,171	1,763,490
1908	14	253,341	1,380,708
1909	15	274,087	1,760,088
1910	15	391,415	2,544,198
1911	15	543,331	3,052,164
1912	15	285,666	2,319,856
1913	15	266,479	2,012,387
1914	17	454,621	3,595,989
1915	19	558,534	4,305,292
1916	20	547,805	4,361,075
1917	20	555,218	6,530,939
1918	20	591,381	7,466,924
1919	21	580,028	7,490,920
1920	22	481,545	6,198,617
1921	20	323,241	4,203,649
1922	23	392,174	5,206,993
1923	23	480,925	6,730,924
1924	22	500,872	6,219,404
1925	21	540,452	7,468,468
1926	21	479,723	6,744,064
1927	22	519,809	7,028,705
1928	24	446,646	5,903,462
1929	21	422,117	5,905,024
1930	21	429,505	5,658,177
1931	20	353,699	4,191,000
1932	15	296,191	2,474,586

1933	14	336,711	3,329,178
1934	13	362,721	3,462,919
1935	10	332,739	3,405,282
1936	11	316,445	3,833,055
1937	11	416,830	5,437,294
1938	10	307,990	3,893,755
1939	10	322,472	4,666,141
1940	11	386,999	5,379,826
1941	11	513,712	7,727,984
1942	12	464,401	8,156,445
1943	11	167,660	3,669,451
1944	10	196,762	4,259,433
1945	8	175,670	3,723,456
1946	11	209,471[2]	7,274,939
1947	10	347,306	11,457,000
1948	12	324,242	11,701,000
1949	12	178,122	4,729,000
1950	11	192,990	6,645,471
1951	10	203,125	7,187,547
1952	9	167,616	5,623,159
1953	8	153,748	4,818,014
1954	8	119,057	3,902,256
1955	8	161,557[3]	5,781,736
1956	8	167,121	6,255,425
1957	8	138,016	5,642,390
1958	7	149,258	6,568,272
1959	10	118,246	4,837,678
1960	8	72,770	3,400,598
1961	8	96,051	4,575,386
1962	8	92,044	4,114,306
1963	8	82,374	3,643,016
1964	8	88,226	3,754,866
1965	8	127,471	5,484,795
1966	7	103,868	4,834,498
1967	6	105,476	4,667,063
1968	6	61,290	2,752,611
1969	5	57,352	2,610,451
1970	6	66,356	3,421,567
1971	8	155,956	6,924,606
1972	7	41,538	2,287,720
1973	8	35,128	3,471,309

Source: *Pacific Fisherman*
58 (25 January 1960) (years 1888 to 1932);
64 (25 January 1967) (years 1933 to 1966).

[1]Totals from 1993 include minor quantities of Pinks caught in odd-numbered years.
[2]Includes 860 cases of Pinks
[3]Includes 1,044 cases of Pinks canned from Puget Sound fish.

Table 1B
Columbia River Canned Salmon Pack

Year	Number of Canneries	*All Species* Pounds Caught	*All Species* [1]Cases Packed	*Chinook* Number Cases	*Chinook* Value	*Chinook* Opening Halves
74	8	6,266,600	61,405	18,727	1,441,979	
75	6	8,243,100	5,785	4,528	401,860	
76	7	7,019,300	8,578	4,129	442,174	
77	5	5,433,500	2,547	1,559	149,664	96
78	3	5,041,000	4,399	3,342		
79		4,393,300	170	120		85
80		4,263,500				
81		2,329,100				
82		4,755,600				
83		1,249,500				
84		4,731,300				
85		5,382,500				
86		12,276,900				
87		11,354,700				
88		14,200,700				
89		9,411,800				
90		3,919,900				
91		5,015,800				

[1]From *Columbia River Fish Runs and Fisheries*, Oregon Department of Fish and Wildlife, Washington Department of Fisheries. Oregon Department of Fish and Wildlife, 1992 (Portland, Oregon).

All other data from various issues *Pacific Packers Report*, annual supplement to National Fisherman, 1974 to 1981; *Seafood Business Report,* 1982 to 1986; and *Seafood Business,* 1986 to 1991.

Table 2
North Pacific Division, Corps of Engineers
Fish Passage Development and Evaluation Program (FPDEP)
Fisheries Research Expenditures

Fiscal Year	Expenditures
1953	$60,333
1954	125,151
1955	704,053
1956	517,547
1957	485,394
1958	375,139
1959	169,392
1960	175,189
1961	217,421
1962	286,133
1963	219,118
1964	226,888
1965	235,726
1966	1 181,087
1967	197,661
1968	247,814
1969	194,565
1970	207,010
1971	1,022,330
1972	1,203,449
1973	1,434,546
1974	2,135,071
1975	1,959,429
1976	2,543,212
1977	2,839,259
1978	3,252,000
1979	3,390,681
1980	2,919,771
1981	2,029,200
1982	2,704,700
1983	2,301,000
1984	2,164,000
1985	1,949,000
1986	1,915,000
1987	1,991,000
1988	1,700,000
1989	2,167,000
1990	3,012,060
1991	4,136,000
1992	4,300,000
1993	5,500,000
Total	**$63,394,329**

Table 3
Experimental Releases of Transported Smolts
(Steelhead and Chinook from Ice Harbor Dam)

Year	Chinook	Steelhead
1968	83,315	-0-
1969	28,311	20,430
1970	20,332	52,217

Table 4
Summary of Juvenile Smolt Transportation By Year and Dam
1971 to 1991
(all species including experimental releases)

Year	Lower Granite Dam	Little Goose Dam	McNary Dam	Total
1971	0	263,000	0	263,000
1972	0	587,000	0	587,000
1973	0	423,000	0	423,000
1974	0	0	0	0
1975	222,500	740,500	0	963,000
1976	650,000	536,000	0	1,186,000
1977	1,762,767	515,824	0	2,278,591
1978	1,980,600	996,285	82,211	3,059,096
1979	2,367,446	1,453,615	1,247,120	5,068,181
1980	3,830,747	2,282,987	1,740,545	7,854,279
1981	2,730,747	1,464,991	4,112,993	8,308,731
1982	1,851,616	1,234,110	3,000,853	6,089,579
1983	2,368,049	868,937	4,326,013	7,562,999
1984	2,046,020	2,274,307	4,708,632	9,028,959
1985	4,459,438	2,008,980	8,319,074	14,787,492
1986	4,683,260	2,052,153	6,760,421	13,495,834
1987	5,470,665	1,910,026	9,655,789	17,036,480
1988	7,504,860	1,708,413	10,820,592	20,033,865
1989	6,780,031	2,310,508	6,366,463	15,457,002
1990	9,336,878	2,318,978	9,789,733	21,445,589
1991	8,420,639	2,245,587	4,808,476	15,474,702

Table 5
Juvenile Fish Transportation Program

1977	1,821,670	938,324	2,759,994
1978	1,580,724	1,478,372	3,059,096
1979	2,031,212	3,036,969	5,068,181
1980	3,019,232	4,835,047	7,854,279
1981	3,145,985	5,162,865	8,308,850
1982	2,152,901	3,936,678	6,089,579
1983	2,780,487	4,782,512	7,562,999
1984	1,030,026	7,998,833	9,028,859
1985	1,126,559	13,663,508	14,790,067

Table 6
Transport Summary of Juvenile Fish Trucked or Barged From Lower Granite, Little Goose, and McNary Dams, 1977 Through 1989

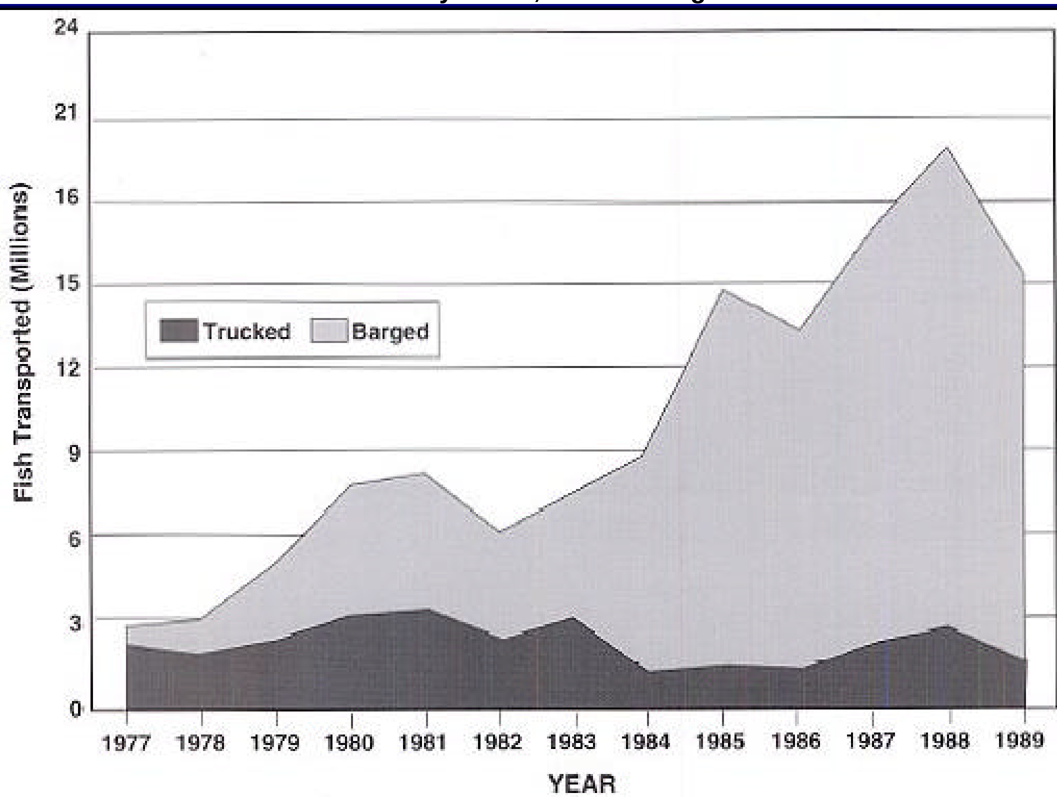

Table 7
Summary of Juvenile Fish Transportation From Lower Granite, Little Goose, and McNary Dams, 1977 Through 1989

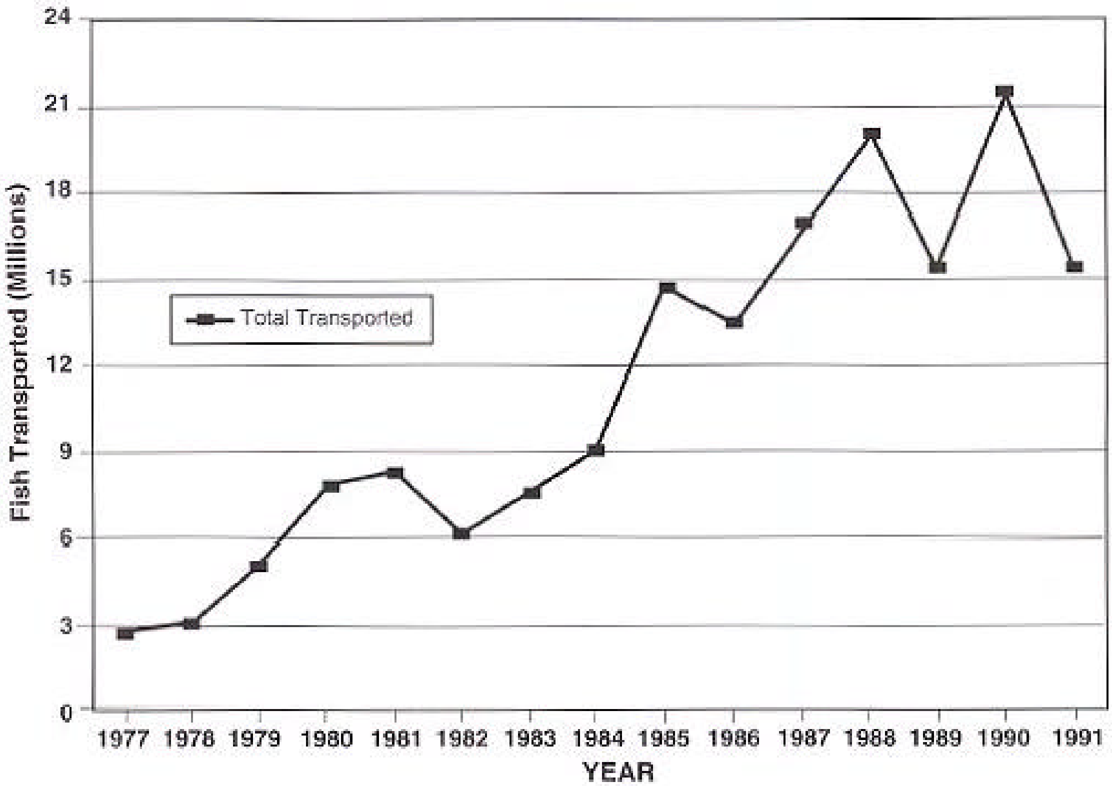

Table 8 Reports of the Fish Passage Development and Evaluation Program And the Fisheries Engineering Research Program Funded By the North Pacific Division		
Year	**Title**	**Contracted Agency or Firm**
1956	Buoyant Submerged Orifice Research	Portland District, Corps of Engineers
1956	The Control of Downstream Migrants by Means of Mechanical Screens	Oregon Game Commission
1956	Determination of the Normal Stream Distribution Size, Time, and Current Preference of Downstream Migrating Salmon and Steelhead Trout in the Columbia and Snake Rivers	State of Washington Department of Fisheries
1956	Determination of the Vertical and Horizontal Distribution of Seward Migrants, Baker Dam	Department of Fisheries
1956	The Effect of Sound Waves on Young Salmon	U.S. Fish and Wildlife Service
1956	Effect of Structures at Main Columbia River Dams on Downstream Migration of Fingerlings	Portland District, Corps of Engineers
1956	Enumeration Study - Upper Columbia and Snake Rivers	Idaho Department of Fish and game
1956	Fishway Attraction Water Supply Study	Walla Walla District, Corps of Engineers
1956	Guiding Downstream Migrant Salmon and Steelhead Trout. A Research Summary	University of Washington
1956	Investigations and Field Studies Relating to Numbers and Seasonal Occurrence of Migratory fish Entering the Columbia River Above Bonneville and the Snake River and Their Final distribution Among Principal Tributaries Thereto	Oregon Fish Commission
1956	Investigation of the Rate of Passage of Salmon and Steelhead Trout Through Bonneville Dam and The Dalles Dam Site As Compared to Unobstructed Sections of the Columbia River	Oregon Fish Commission
1956	Powerhouse Collection System and Transportation Flows, Bonneville Dam	Portland District, Corps of Engineers
1956	Research on Fishway Problems	U.S. Fish and Wildlife Service
1956	Research Relating to Mortality of Downstream Migrant Salmon Passing McNary Dam	State of Washington Department of Fisheries
1956	Research Relating to Study of Spawning Grounds in Natural Areas	State of Washington Department of Fisheries
1956	A Review of Studies in Guiding Downstream Migrating Salmon With Light	U.S. Fish and Wildlife Service
1956	Study of the Effects of Magnetic Fields on Salmon	U.S. Fish and Wildlife Service
1956	The Status of Field Scale Electrical Fish Guiding Experiments	U.S. Fish and Wildlife Service
1956	A Study to Determine the Effects of Electricity on Salmon and Steelhead Trout	University of Washington
1956	A Study to Investigate the Effects of Fatigue and Current Velocities on Adult Salmon and Steelhead Trout	University of Washington
1956	Submerged Orifice Research Powerhouse Fish Collection System, Bonneville Dam	Portland District, Corps of Engineers
1960	Buoyant Submerged Orifice Research	Portland District, Corps of Engineers
1960	The Control of Downstream Migrants by Means of Mechanical Screens	Oregon State Game Commission
1960	Effects of Structures at Main Columbia River Dams on Downstream Migration of Fingerlings	Portland District, Corps of Engineers
1960	Enumeration Study Upper Columbia and Snake Rivers	Idaho Department of Fish and Game
1960	Evaluation of the Ability of an Artificial Outlet to Attract Downstream Migrant Salmonids from the Reservoir of Lookout Point Dam	Fish Commission of the State of Oregon

1960	Experimental Studies on the Survival of the Early Stages of Chinook Salmon after Varying Exposures to Upper Lethal Temperatures	State of Washington Department of Fisheries
1960	Fish Passage Through Turbines	Walla Walla District, Corps of Engineers
1960	Fishway Attraction Water Supply Study	Walla Walla District, Corps of Engineers
1960	Guiding Downstream Migrant Salmon and Steelhead Trout	University of Washington
1960	An Investigation of the Effect of The Dalles Dam upon Migration Rates of Adult Salmonids, 1956 and 1957	Fish Commission of the State of Oregon
1960	Powerhouse Fish Collection System and Transportation Flows, Bonneville Dam	Portland District, Corps of Engineers
1960	Research on Fishway Problems	Bureau of Commercial Fisheries and U.S. Fish and Wildlife Service
1960	Research Relating to McNary Supplemental Spawning Channel	State of Washington Department of Fisheries
1960	Research Relating to Mortality of Downstream Migrant Salmon Passing McNary and Big Cliffs Dams	State of Washington Department of Fisheries
1960	Results of a Tagging Program to Enumerate the Numbers and to Determine the Seasonal Occurrence of Anadromous Fish in the Snake River and its Tributaries	Fish Commission of the State of Oregon
1960	The Status of Electrical Fish Guiding Experiments	U.S. Fish and Wildlife Service
1960	A Study to Determine the Effects of Electricity on Salmon and Steelhead Trout	University of Washington
1960	A Study to Investigate the Effects of Fatigue and Current Velocities on Adult Salmon and Steelhead Trout	University of Washington
1960	Submerged Orifice Research Powerhouse Fish Collection System, Bonneville Dam	Portland District, Corps of Engineers
1964	Propagation of Fall Chinook Salmon in McNary Dam Experimental Spawning Channel, 1957 Through 1963	Washington State Department of Fisheries
1966	The Accelerated Fish Passage Research Program of the U.S. Bureau of Commercial Fisheries - Summary of Progress Through 1964	North Pacific Division, Corps of Engineers
1966	Fallback of Adult Chinook Salmon at Ice Harbor Dam Spillway, May 1964	U.S. Bureau of Commercial Fisheries
1966	Indications of Loss and Delay to Adult Salmonids Below Ice Harbor Dam 1962 Through 1966	Fish Commission of Oregon
1966	Juvenile Fish Passage Through Turbines	Walla Walla District, Corps of Engineers
1966	Migrant Salmon Light-Guiding Studies at Columbia River Dams	University of Washington
1966	Research on Fishway Problems, May 1960 to April 1965	U.S. Bureau of Commercial Fisheries
1966	Research Relating to McNary Supplemental Spawning Channel, Five-Year Summary, 1960 Through 1964	State of Washington Department of Fisheries
1966	Review and Analysis of Fish Counts, Counting Technique and Related Data at Corps of Engineers Dams on the Columbia and Snake Rivers	Fish Commission of Oregon
1966	A Study to Identify the Race of Fall Chinook Whose Spawning Grounds Will be Inundated by the John Day Impoundment on the Columbia River	Fish Commission of Oregon
1967	A Compendium on the Success of Passage of Small Fish Through Turbines	North Pacific Division, Corps of Engineers
1967	Effect of Brownlee Reservoir on Migrations of Anadromous Salmonids	U.S. Bureau of Commercial Fisheries
1967	The Effect of Small Impoundments on the Behavior of Juvenile Anadromous Salmonids	Fish Commission of Oregon
1967	Fingerling Shad Studies at Bonneville Dam, November and December 1966	Portland District, Corps of Engineers

1967	Juvenile Downstream Migrant Fish Passage and Protection Studies at Willamette Falls, Oregon	Oregon State Game Commission
1967	McNary Supplemental Spawning Channel, 1957 Through 1966	Washington State Department of Fisheries
1967	References on Shad (*Alosa Sapidissima*)	U.S. Fish and Wildlife Service
1967	Sonic Tracking of Steelhead in the Ice Harbor Reservoir, 1967	Washington State Game Department
1967	Sonic Tracking of Steelhead in the Rocky Reach Reservoir, 1967	Washington State Game Department
1967	Standardization of Spill Patterns at Ice Harbor Dam	Fish Commission of Oregon
1968	The Feasibility of Rearing Sockeye Salmon in Reservoirs	Fish Commission of Oregon
1968	The Operation and Evaluation of the Carmen-Smith Spawning Channel, 1960 Through 1967	Oregon Fish Commission
1969	Evaluation of Fish Passage Facilities at Cougar Dam on the South Fork McKenzie River in Oregon	Fish Commission of Oregon
1969	Fish Passage Problems at Lower Columbia River Dams in 1968	Fish Commission of Oregon
1969	Hydraulic Model Studies of A Fish Guidance Screen	Washington State University
1969	Operational Studies at Dams on the Lower Columbia River With A Brief Analysis of Adequacy of New Spilling Techniques at Ice Harbor Dam	Fish Commission of Oregon
1969	A Study to Determine the Value of Using the Ice-Trash Sluiceway for Passing Downstream Migrant Salmonids at Bonneville Dam	Oregon Fish Commission
1970	Evaluation of Fish Facilities and Passage at Fall Creek Dam on Big Fall Creek in Oregon	Fish Commission of Oregon
1970	Evaluation of Fish Passage Facilities at the North Fork Project on the Clackamas River in Oregon	Fish Commission of Oregon and Portland General Electric Company
1970	Evaluation of Upstream Passage of Adult Salmonids Through the Navigation Lock at Bonneville Dam During the Summer of 1969	U.S. Bureau of Commercial Fisheries
1970	Fingerling Fish Mortalities at 57.5 FPS*	North Pacific Division, Corps of Engineers
1970	Fingerling Fish Research Effect of Mortality at 67-FPS Velocity	North Pacific Division, Corps of Engineers
1970	Operational Studies at Dams on the Lower Columbia and Snake Rivers	Fish Commission of Oregon
1970	Research o Gatewell-Sluice Method of Bypassing Downstream Migrant Fish Around Low-Head Dams	U.S. Bureau of Commercial Fisheries
1970	Sonic Tracking of Adult Steelhead in Ice Harbor Reservoir, 1969	U.S. Bureau of Commercial Fisheries
1970	Steelhead Fishing Method Study, Lake Sacajawea, Washington, Ice Harbor Reservoir	Tri-State Steelheaders
1970	Steelhead Fishing Project, Ice Harbor Reservoir, 1969	Washington State Game Department
1970	A Tagging Study to Investigate the Unexplained Loss of Spring and Summer Chinook Salmon Migrating Past Bonneville and The Dalles Dam	Oregon Fish Commission
1970	Tests of Fingerling Passage at Bonneville Dam	North Pacific Division, Corps of Engineers
1970	Use of a Hydroelectric Reservoir for the Rearing of Coho Salmon	Washington State Department of Fisheries
1971	Bonneville and The Dalles Dams Ice-Trash Sluiceway Studies, 1971	Oregon Fish Commission
1971	Effect of Peaking Operations on Passage of Adult Salmonids Over Columbia River Dams	Fish Commission of Oregon
1971	An Evaluation of the Rocky Reach Chinook Salmon Spawning Channel, 1961 Through 1968	Washington State Department of Fisheries
1971	Fecundity of Fall Chinook Salmon From the Upper Columbia River	Washington State Department of Fisheries

1971	Fish Passage Research at the Fisheries-Engineering Research Laboratory, May 1965 to September 1970	National Marine Fisheries Service
1971	A Nitrogen Model for the Lower Columbia River	Water Resources Engineers, Inc.
1971	Progress Report on Fish Protective Facilities at Little Goose Dam and Summaries of Other Studies Relating to the Various Measures Taken by the Corps of Engineers to Reduce Losses of Salmon and Steelhead in the Columbia and Snake Rivers	National Marine Fisheries Service
1971	Radio Tracking of Adult Spring Chinook Salmon Below Bonneville, 1971	National Marine Fisheries Service
1972	A Compendium on the Survival of Fish Passage Through Spillways and Conduits	North Pacific Division, Corps of Engineers
1972	Effect of Gas Supersaturated Columbia River Water on the Survival of Juvenile Salmonids, April to June 1972	National Marine Fisheries Service
1972	Effects of Hydraulic Shearing Action on Juvenile Salmon	National Marine Fisheries Service
1972	Effects of Low Flows Below Big Cliff Reservoir, North Santiam River, on Fish and Other Aquatic Organisms	Oregon State Game Commission
1972	Evaluation of Fish Passage in the Vertical Slot Regulating Section of the South Shore Ladder at John Day Dam	National Marine Fisheries Service
1972	Fingerling Fish Research, High-Velocity Flow Through Four-Inch Nozzle	North Pacific Division, Corps of Engineers
1972	General Guidelines for Adjusting Spill Distributions to Improve Fish Passage with Tentative Spilling Schedules for Bonneville and John Day Dams	Oregon Fish Commission
1972	Stilling Basin Hydraulics and Downstream Fish Migration	Washington State University
1972	Studies of the Relationships Between Adult Fish Passage and Powerhouse Operations	Oregon Department of Fish and Wildlife
1972	Survival of Fingerlings Passing Through a Perforated Bulkhead and Modified Spillway at Lower Monumental Dam, April Through May 1972	National Marine Fisheries Service
1973	Adult Fish Exposed to a High Velocity Jet	North Pacific Division, Corps of Engineers
1973	Evaluation of Fish Facilities and Passage at Foster and Green Peter Dams on the South Santiam River Drainage in Oregon	Fish Commission of Oregon
1973	Fisheries Handbook of Engineering Requirements and Biological Criteria	North Pacific Division, Corps of Engineers
1974	Side Entrance Fishway Studies	Oregon Department of Fish and Wildlife
1975	The Dalles Dam Powerhouse Adult Fish Collection System Studies	Portland District, Corps of Engineers
1975	Effects of Power Peaking on the Indian Fishery	Oregon Department of Fish and Wildlife
1975	John Day Powerhouse Adult Fish Collection System Studies	Portland District, Corps of Engineers
1975	Studies on Adult Fish Passage Over "A" Branch of Bradford Island Fishway at Bonneville Dam	Oregon Department of Fish and Wildlife
1976	Adjusting Spill Distribution to Improve Fish Passage at Corps Dams	Oregon Department of Fish and Wildlife
1977	The Effects of Altered Flow Regimes, Temperatures, and River Impoundment of Adult Steelhead Trout and Chinook Salmon	University of Idaho
1977	Effects of Reduced Nighttime Flows on Upstream Migration of Adult Chinook Salmon and Steelhead Trout in the Lower Snake River	University of Idaho
1978	Bonneville First Powerhouse Adult Fish Collection System Studies	Portland District, Corps of Engineers
1978	Passage Problems of Adult Columbia River Chinook Salmon and Steelhead, 1973 Through 1978	Oregon Department of Fish and Wildlife

1979	Effects of Atmospheric Gas Supersaturation on Survival of Fish and Evaluation of Proposed Solutions	National Marine Fisheries Service
1979	Effects of Dam Operations and Flow Regulation of Juvenile Salmon and Steelhead Migrations in the Snake and Columbia Rivers, 1973 Through 1978	National Marine Fisheries Service
1979	Effects of Peaking (Stranding) of Columbia River Dams on Juvenile Anadromous Fishes Below The Dalles Dam	Washington Department of Fisheries
1979	Effects of Power Peaking on Survival of Juvenile Fish at Lower Columbia and Snake River Dams	Private Consultant
1979	Effects of Spillway Bucket Roughness on Fingerlings	North Pacific Division, Corps of Engineers
1979	Ejection of Fingerlings in High-Velocity Jet	North Pacific Division, Corps of Engineers
1979	Equilibration with Packed Column Degassor	North Pacific Division, Corps of Engineers
1979	Evaluation of the Adult Salmonid Trap Installed in the Bradford Island "A" Branch Fish Ladder, Bonneville Dam	National Marine Fisheries Service
1979	Evaluation and Development of the Ice-Trash Sluiceway at The Dalles Dam as a Downstream Migrant Bypass	Oregon Department of Fish and Wildlife
1979	Evaluation of the Fingerlings Bypass System Outfalls at McNary and John Day Dams	Portland District, Corps of Engineers; Walla Walla District, Corps of Engineers; National Marine Fisheries Service
1979	Evaluation of Methods for Handling and Artificially Propagating Summer Chinook Salmon, 1974 Through 1978	State of Idaho Department of Fish and Game
1979	Feasibility of Using Siphons for Degassing Water	National Marine Fisheries Service
1979	Fingerling Passage at Bonneville Powerhouse	North Pacific Division, Corps of Engineers
1979	Fingerling Passage Through John Day Spillway	North Pacific Division, Corp of Engineers
1979	Fish Passage Through Turbine Tests at Big Cliff Dam	Walla Walla District, Corps of Engineers
1979	Ice Harbor Fall Chinook Trapping, 1978	University of Idaho
1979	Improving the Fingerling Protection System for Low-Head Dams, 1973 Through 1978	National Marine Fisheries Service
1979	Nitrogen Reduction, Fish Barge Water Supply	North Pacific Division, Corps of Engineers
1979	Radio-Tracking to Determine the Effects of Peaking on Adult Chinook Salmon and Steelhead	National Marine Fisheries Service
1979	Radio-Tracking to Determine the Effects of Spillway Deflectors on Adult Salmonids	National Marine Fisheries Service
1979	Radio-Tracking Studies Relating to Fallback at Hydroelectric Dams on the Columbia and Snake Rivers	National Marine Fisheries Service
1979	Radio-Tracking Studies of Chinook Salmon and Steelhead to Determine Specific Areas of Loss Between Dams	National Marine Fisheries Service
1979	Slotted Bulkheads for Skeleton Power Units	North Pacific Division, Corps of Engineers
1979	Special Drought Year Operation for Downstream Fish Migrants	Committee of Fishery Operations
1979	Spillway Deflectors to Reduce Buildup of Nitrogen Saturation	North Pacific Division, Corps of Engineers
1979	Study of Turbine Operations Under Peaking and High River Flow Conditions to Obtain Maximum Fish Passage Survival and Updated 1967 May Compendium	Private consultant

1979	Transportation of Smolts and Related Studies in the Snake and Columbia Rivers, 1973 Through 1978	National Marine Fisheries Service
1979	Vertical Slot Fishway Evaluation at Bonneville Dam	National Marine Fisheries Service
1984	Adult Salmonid Delay at John Day Dam, 1982 Through 1983	National Marine Fisheries Service
1984	Columbia River Outmigration: McNary Dam Passage and Enhanced Smolt Quality	Oregon State University
1984	Development and Evaluation of the Bonneville Dam First Powerhouse Sluiceway as a Juvenile Salmon Bypass System	Oregon Department of Fish and Wildlife
1984	Development and Evaluation of The Dalles Dam Trash Sluiceway as a Downstream Migrant Bypass System, and Indexing of Juvenile Salmonids Migrating Past The Dalles Dam	Oregon Department of Fish and Wildlife
1984	Development of an Improved Fingerling Protection System for Lower Granite Dam, 1984	National Marine Fisheries Service
1984	Effects of the Intermittent Operation of Submersible Travelling Screens on Juvenile Salmonids, 1982	National Marine Fisheries Service
1984	Evaluation of Adult Fish Passage at Bonneville Dam, 1982	Portland District, Corps of Engineers
1984	Evaluation of Adult Fish Passage at Bonneville Lock and Dam and John Day Dam	Portland District, Corps of Engineers
1984	Evaluation of Adult Fish Passage at Ice Harbor and Lower Monumental Dams, 1982	Portland District, Corps of Engineers
1984	Evaluation of Adult Fish Passage at Little Goose and Lower Granite Dams, 1981	Portland District, Corps of Engineers
1984	Evaluating the Effects of Stress on the Viability of Chinook Salmon Smolts Transported from the Snake River to the Columbia River Estuary	University of Idaho
1984	Evaluation of the Juvenile Collection and Bypass System at Bonneville Dam, 1983	National Marine Fisheries Service
1984	Evaluation of the Juvenile Collection and Bypass Systems at Bonneville Dam, 1984	National Marine Fisheries Service
1984	Evaluation of Juvenile Transportation and Related Research, 1979 Through 1983	National Marine Fisheries Service
1984	Evaluation of Juvenile Salmonid Losses to Predation by Northern Squawfish, *Ptychocheilus Oregoninsis*, in the Bonneville Dam First Powerhouse Forebay	Oregon Department of Fish and Wildlife
1984	Evaluation of Submersible Traveling Screens, Cycling of Gatewell Orifice Operations, and the Ice-Trash Sluiceway System for Juvenile Fish Protection at the Bonneville First Powerhouse, 1981	National Marine Fisheries Service
1984	Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake Rivers, 1984	National Marine Fisheries Service
1984	Fish Guiding and Orifice Passage Efficiency Tests with Subyearling Chinook Salmon, McNary Dam, 1984	National Marine Fisheries Service
1984	Hydroacoustic Assessment of Downstream Migrating Salmonids at Ice Harbor Dam, 1982 and 1983	BioSonics, Inc.
1984	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at John Day Dam in 1981	Portland District, Corps of Engineers
1984	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonid Passage at John Day and The Dalles Dams in 1982	Portland District, Corps of Engineers
1984	The John Day Dam Powerhouse Adult Fish Collection System Evaluations, 1979 Through 1980	Portland District, Corps of Engineers
1984	Juvenile Salmonid Transport Operations, 1981 Through 1983	Walla Walla District, Corps of Engineers

1984	Migrational Characteristics of Juvenile Salmon and Steelhead in the Columbia River System, 1979 Through 1983	National Marine Fisheries Service
1984	Migration Patterns of Salmonid Smolts in the John Day Dam Forebay, 1980 Through 1982	National Marine Fisheries Service
1984	Research to Develop an Improved Fingerling Protection System for John Day Dam, 1981	National Marine Fisheries Service
1984	Research to Develop an Improved Fingerling Protection System for Lower Granite Dam, 1982 Through 1983	National Marine Fisheries Service
1984	Research to Develop Passive Bar Screens for Guiding Juvenile Salmonids Out of Turbine Intakes at Low Head Dams on the Columbia and Snake Rivers, 1979	National Marine Fisheries Service
1984	Survival of Chinook Salmon Smolts Passing Dams and Entering Seawater as Related to Stress Level and Smolt Quality	University of Idaho
1984	Updated Compendium on the Success of Small Fish Through Turbines	North Pacific Division, Corps of Engineers
1985	Continuing Studies to Improve and Evaluate Juvenile Fish Collection at Lower Granite Dam, 1985	National Marine Fisheries Service
1985	Evaluations of Adult Fish Passage at McNary Dam and John Day Dam, 1985	Portland District, Corps of Engineers
1985	Evaluations of the Juvenile Collection and Bypass Systems at Bonneville Dam, 1985	North Pacific Division, Corps of Engineers
1985	Evaluation of the Rehabilitated Juvenile Fish Collection and Passage System at John Day Dam, 1985	National Marine Fisheries Service
1985	Evaluation of Transportation of Juvenile Salmonids	National Marine Fisheries Service
1985	Hydroacoustic Evaluation of Fish Collection Efficiency at Lower Granite Dam in Spring 1985	BioSonics, Inc.
1985	Response of Chinook Salmon and Steelhead Trout Smolts to Three Flumes Tested at Lower Granite Dam, 1985	University of Idaho
1985	Studies to Evaluate Alternative Methods of Bypassing Juvenile Fish at The Dalles Dam, 1985	National Marine Fisheries Service
1985	Survival of Chinook Salmon Smolts Passing Dams and Entering Seawater as Related to Stress Level and Smolt Quality, 1985	University of Idaho
1986	Determine Fish Guiding Efficiency of Submersible Traveling Screens at Lower Monumental Dam, 1986	National Marine Fisheries Service
1986	Evaluation of the Juvenile Collection and Bypass Systems at Bonneville Dam, 1986	North Pacific Division, Corps of Engineers
1986	Evaluation of Juvenile Salmonid Passage Through the Bypass System, Turbine, and Spillway at Lower Granite Dam, 1986	National Marine Fisheries Service
1986	Evaluation of the Rehabilitated Juvenile Fish Collection and Passage System at John Day Dam	National Marine Fisheries Service
1986	Evaluation of Transportation of Juvenile Salmonids, 1986	National Marine Fisheries Service
1986	Hydroacoustic Evaluation of Fish Guiding Efficiency at Little Goose Dam, 1986	Parametrix Inc., and Associated Fisheries Biologists, Inc.
1986	Initial Study to Evaluate Existing Juvenile Fish Collection at Little Goose Dam, 1986	National Marine Fisheries Service
1986	Research to Improve Subyearling Chinook Salmon Fish Guiding Efficiency at McNary Dam	National Marine Fisheries Service
1986	Studies to Evaluate Alternative Methods of Bypassing Juvenile Salmonids at The Dalles Dam	National Marine Fisheries Service

1986	Survival of Chinook Salmon Smolts with Stress Levels Similar to Those Encountered at Dams, 1986	University of Idaho
1986	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at Bonneville Dam, 1987	Portland District, Corps of Engineers
1987	Literature Review and Design Criteria of Behavioral Fish Guidance Systems	University of Washington
1988	Measurement of Low Frequency Sound at Bonneville, McNary, and Lower Granite Dams	University of Washington
1988	Review and Design Criteria of Behavioral Fish Guidance Systems	University of Washington
1988	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at Bonneville Dam, 1988	Portland District, Corps of Engineers
1989	Evaluation of Extended-Length Screening Concept, Lower Granite Dam	Walla Walla District, Corps of Engineers
1990	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at Bonneville Dam, 1989	Portland District, Corps of Engineers
1991	Evaluation of Hydroacoustic Techniques for Assessment of Juvenile Fish Passage at Bonneville Powerhouse I	BioSonics, Inc.
1991	Evaluation of the Use of the McNary Bypass System to Divert Adult Fallbacks Away From Turbine Blades	Washington Department of Fisheries
1991	Fisheries Handbook of Engineering Requirements and Biological Criteria, 1991	Portland District, Corps of Engineers
1991	Hydroacoustic Evaluation of Fish Behavioral Response to Fixed Bar Screens at Lower Granite Dam in 1989	BioSonics, Inc.
1991	Hydroacoustic Evaluation of Juvenile Fish Passage at Ice Harbor Dam in Spring 1987	BioSonics, Inc.
1991	Hydroacoustic Evaluation of Juvenile Salmonid Fish Passage at The Dalles Dam Fish Attraction Water Units in 1990	Portland District, Corps of Engineers
1991	Revised Compendium on the Success of Passage of Small Fish Through Turbines, 1991	Portland District, Corps of Engineers
1992	Bonneville Dam Second Powerhouse Fish Guidance Research - Velocity Mapping Studies	National Marine Fisheries Service
1992	Effects of Water-Borne Pollutants on Salmon Passage at John Day Dam, Columbia River, 1982 to 1986	National Marine Fisheries Service
1992	Evaluation of the Juvenile Fish Collection and Bypass Facilities at Bonneville Dam, 1984 to 1987	National Marine Fisheries Service
1992	Evaluation of the Juvenile Fish Collection, Transportation, and Bypass Facilities at Little Goose Dam, 1990	National Marine Fisheries Service
1992	Evaluation of Passage of Adult Chinook Salmon and Steelhead at the Lower Snake River Dam and Reservoir Projects	University of Idaho
1992	Evaluation of Transportation of Juvenile Salmonids From McNary and Lower Granite Dams - Results From Research 1984 to 1990	National Marine Fisheries Service
1992	Evaluation of Transportation of Juvenile Salmonids - Results of Stress and Disease Research, 1984 to 1990	National Marine Fisheries Service
1992	Evaluation of Transportation of Juvenile Salmonids - Results of Wild Fish Pilot Studies, 1988 Through 1990	National Marine Fisheries Service
1992	Fish Guidance Efficiency of Submersible Traveling Screens at Lower Monumental Dam, 1986	National Marine Fisheries Service

1992	Fish Guidance Efficiency Studies at Bonneville Dam, 1984 to 1989	National Marine Fisheries Service
1992	Fish Guidance Efficiency Studies at Little Goose Dam, 1986 and 1987	National Marine Fisheries Service
1992	FGE Studies at Lower Granite, 1984, 1985, 1987, and 1989	National Marine Fisheries Service
1992	Fish Guiding Efficiency Studies at Ice Harbor Dam, 1987	National Marine Fisheries Service
1992	Juvenile Fish Transportation: Impact of Bacterial Kidney Disease on Survival of Spring/Summer Chinook Salmon Stocks, 1988 to 1990	U.S. Fish and Wildlife Service
1992	The relationship Between Smolt Development and FGE, 1986 to 1989	National Marine Fisheries Service
1992	Relative Survival of Subyearling Chinook Salmon Passing Through Turbines, Bypass, or Tailrace of the Second Powerhouse or the Spillway at Bonneville Dam, 1987 to 1990	National Marine Fisheries Service
1992	Studies to Evaluate Alternative Methods of Bypassing Juvenile Fish at The Dalles Dam, 1985 and 1986	National Marine Fisheries Service
1992	Studies to Evaluate the Juvenile Fish Bypass System at McNary Dam, 1984, 1986, and 1987	National Marine Fisheries Service
1992	Survival of Chinook Salmon Smolts as Related to Stress at Dams and Smolt Quality	U.S. Fish and Wildlife Service
22 Reports in 36 years, 1956 through 1992. *Feet per second (FPS)		

Table 9
North Pacific Division
Estimated Costs (Construction, General), Fish Facilities
(Dollars in Thousands)

Estimated Total Cost		Actual Thru 30 Sep 90		FY 1991		FY 1992		Balance to Complete	
Dir Costs Fish Fac	Juvenile Fish Protec[1]	Dir Costs Fish Fac	Juvenile Fish Protec[1]	Dir Costs Fish Fac	Juvenile Fish Protec[1]	Dir Costs Fish Fac	Juvenile Fish Protec[1]	Dir Costs Fish Fac	Juvenile Fish Protec[1]
Columbia River									
Completed Work (Various Projects)									
$139,407	$46,707	$139,407	$46,707	$0	$0	$0	$0	$0	$0
Bonneville Second Powerhouse									
105,287	38,574	92,040	25,327	967	967	3,114	3,114	9,166	9,166
Mount St. Helens Sediment Control									
10,150	0	8,427	0	473	0	0	0	1,250	0
Subtotal									
254,844	85,281	239,874	72,034	1,440	967	3,114	3,114	10,416	9,166
Snake River									
Completed Work (Various Projects)									
99,048	22,489	99,048	22,489	0	0	0	0	0	0
Catherine Creek Lake, Oregon									
7,154	0	0	0	0	0	0	0	7,154	0
Columbia River Juvenile Fish Mitigation									
Ice Harbor Lock and Dam									
14,322	14,322	9	9	558	558	3,550	3,550	10,205	10,205
Little Goose Lock and Dam									
21,307	21,307	9,373	9,373	188	188	425	425	11,321	11,321
Lower Granite Lock and Dam									
18,148	18,148	4,235	4,235	1,722	1,722	1,972	1,972	10,219	10,219
Lower Monumental Lock and Dam									
27,840	27,840	96	96	6,109	6,109	8,797	8,797	12,838	12,838
McNary Lock and Dam									
43,393	43,393	1,045	1,045	2,514	2,514	5,790	5,790	34,044	34,044
Mitigation Study									
0	0	0	0	0	0	0	0	0	0
The Dalles Lock and Dam									
66,434	66,434	0	0	0	0	1,000	1,000	65,434	65,434

Lower Granite River Fish and Wildlife Compensation Plan									
143,336	3,978	109,277	2,715	16,330	218	8,552	770	9,177	275
Subtotal									
$440,982	$217,911	$223,083	$39,962	$27,421	$11,309	$30,086	22,304	$160,392	$144,336
Total									
$695,826	$303,192	$462,957	$111,996	$28,861	$12,276	$33,200	$25,418	$170,808	$153,502
[1]Includes Juvenile Fish Protection									

Table 10
U.S. Army Corps of Engineers
Lower Columbia/Snake Rivers Existing Anadromous Fish Mitigation
Capital and Associated Costs Through Fiscal Year 1987

Project/ Completion Date Measure	Bonneville[1] 1983-1982 Cost (000)	The Dalles 1957 Cost (000)	John Day 1968 Cost (000)	McNary 1953 Cost (000)	Ice Harbor 1962 Cost (000)	Lower Monumental 1969 (Cost 000)	Little Goose 1970 Cost (000)	Lower Granite 1975 Cost (000)	Total Cost
Project Hatcheries	None	None	$39,779	None	System	System	System	System	$39,779,000
Fish Ladders & Turbine Screens[2]	$120,843	$22,283	$31,924	$42,751	$11,570	$2,410	$17,560	$18,546	$267,887,000
Spillway Deflectors	$1,500	None	None	$5,000	None	$3,000	$2,400	$2,600	$14,500,000
Fish Loading & Handling[3]	None	None	None	$329	None	None	Unknown	Unknown	$329,000
Miscellaneous Fish Passage Improvements	-------	-------	-------	$19	$1,929	-------	$3,566	$1,905	$7,419,000
Project Totals	$122,343	$22,283	$71,703	$48,099	$13,499	$5,410	$23,526	$23,051	$32,914,000
Fish Barges & Trucks				←-----------------------$5,000--→					$5,000,000
System Hatcheries[4]					←------------------------$167,369---------est.-------------------→				$167,369,000
Research	←---$42,580---→								$42,580,000
System Totals	$214,949,000								
Project Plus	$544,863,000								

[1]Includes second powerhouse.
[2]Screen shave been installed for all turbines except at The Dalles, Ice Harbor, and Lower Monumental Dams.
[3]Fish loading and handling facilities have been installed at McNary, Little Goose, and Lower Granite Dams.
[4]Cost for eight completed hatcheries plus estimated cost for completion of final hatchery anticipated in Fiscal Year 1991.

Table 11
Annual Funding by Bonneville Power Administration
Of Northwest Power Planning Council's Fish and Wildlife Program
(Dollars in Thousands)

FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90	FY 91	Total
Program Title: Support Activities														
						21	515		355	1,803	3,251	3,310	6,441	15,696
Program Title: Hydro Operations/Downstream Migration														
400	422	539	1,028	1,970	3,045	3,912	5,156	4,509	3,579	5,073	7,281	6,748	7,278	50,940
Program Title: Upstream Migration														
				115	60	351	226	116						
Program Title: Snake River Basin Habitat														
					306	1,622	836	1,669	3,947	446	1,413	999	794	12,032
Program Title: Mid-Columbia Habitat/Passage Enhancement														
					710	1,268	491	595	1,622	26	1	3	1	4,717
Program Title: Lower Columbia River Basin Habitat														
			69		468	731	1,008	1,595	1,451	1,432	1,685	962	629	10,030
Program Title: Umatilla River Basin Habitat														
			164	146	165	755	682	167	531	823	1,022	898	964	6,317
Program Title: John Day River Basin Habitat														
				425	251	586	1,221	1,496	1,445	1,360	1,283	1,023	1,333	10,423
Program Title: Habitat Evaluation and Monitoring														
	96	145			49	211	157	575	332	309	414	57	18	2,363
Program Title: Fish Health/Artificial Propagation														
	611	572	520	1,215	1,527	3,473	2,001	2,390	6,366	1,562	4,983	3,751	3,606	32,577
Program Title: Supplementation														
										156	1,196	50	1,618	3,020
Program Title: Yakima River Basin														
						276	474	1,132	1,112	643	307	157	722	4,823
Program Title: Endangered Species Act Implementation														
													3,926	3,926
Program Title: Squawfish Management Program														
													5,570	5,570
Total Anadromous Fish Expense														
$400	$1,129	$1,256	$1,781	$3,871	$6,581	$13,206	$12,767	$14,244	$20,779	$13,633	$22,836	$17,958	$32,000	$163,341