# REVIEW OF THE HISTORY, DEVELOPMENT, AND MANAGEMENT OF ANADROMOUS FISH PRODUCTION FACILITIES IN THE COLUMBIA RIVER BASIN

Columbia Basin Fish and Wildlife Authority

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## INTRODUCTION

In 1987, 190 million juvenile salmon and steelhead were released from 64 hatcheries and 29 satellite facilities located in the Columbia River Basin (Table 1, Figures 1-3). Hatchery production supports the bulk of the current total annual adult production of 2.5-3.0 million salmon and steelhead. Hatchery fish comprise over 95 percent of the coho, 70 percent of the spring chinook, about 80 percent of the summer chinook, over 50 percent of the fall chinook, and about 70 percent of the steelhead produced in the Basin.1/ Except for small experimental groups, sockeye is the only major anadromous salmonid species in the Basin that is currently not raised in hatcheries.

The history of hatchery development, management, and operation in the Columbia River Basin spans a period of over 110 years. The passage of the Mitchell Act by Congress in 1938, which eventually led to the construction and modernization or funding of 39 hatchery facilities, was the single most important event influencing the development of hatcheries in the Basin. The annual catch from Mitchell Act production has averaged about 2.0 million adult salmon and steelhead per year for the period 1960-85.2/

Hatchery production has helped to support important treaty Indian, sport, and commercial fisheries during a period when most of the natural production became severely depressed. However, the general success of hatchery production has not been without cost to the natural production. Coho salmon populations in the

Table 1.-Anadromous fish rearing facilities-Columbia River Basin

| Map No. | Facility | General location | Operating agency[1] | Funding agency[1] | Year anadromous operation began[2] | Authorization/Project[1] | Production Releases (No.)[6] |
|---|---|---|---|---|---|---|---|
| | **Idaho Hatcheries** | | | | | | |
| 1 | Clearwater | Orofino | IDFG | USFWS | (1990) | Lower Snake Compensation | |
| 2 | Dworshak | Orofino | USFWS | USFWS, Corps | 1969 | Dworshak Dam/Lower Snake Compensation | 3,832,700 |
| 3 | Hagerman | Hagerman | USFWS | USFWS | 1969 | Lower Snake Compensation | 1,539,500 |
| 4 | Kooskia | Kooskia | USFWS | USFWS | 1966 | Special Congressional Appropriation | 764,000 |
| 5 | Magic Valley | Buhl | IDFG | USFWS | (1988) | Lower Snake Compensation | |
| 6 | McCall | McCall | IDFG | IDFG, USFWS | 1976 | Lower Snake Compensation | 1,076,500 |
| 7 | Niagara Springs | Buhl | IDFG | Idaho Power Co. | 1966 | Idaho Power Mitigation | 1,851,500 |
| 8 | Pahsimeroi | Challis | IDFG | Idaho Power Co. | 1970 | Idaho Power Mitigation | 704,000 |
| 9 | Rapid River | Riggins | IDFG | Idaho Power Co. | 1964 | Idaho Power Mitigation | 3,588,000 |
| 10 | Sawtooth | Stanley | IDFG | USFWS | 1985 | Lower Snake Compensation | 2,993,000 |
| | **Idaho Release Sites/Ponds/Traps[7]** | | | | | | |
| 11 | Crooked River | Crooked River | IDFG | USFWS | (1990) | Lower Snake Compensation | |
| 12 | Powell | Lochsa River | IDFG | USFWS | (1989) | Lower Snake Compensation | |
| 13 | Red River | Red River | IDFG | USFWS | 1986 | Lower Snake Compensation | |
| 14 | East Fork Salmon River | Challis | IDFG | USFWS | 1983 | Lower Snake Compensation | |
| 15 | South Fork Salmon River | Cascade | IDFG | USFWS | 1980 | Lower Snake Compensation | |
| | **Oregon Hatcheries** | | | | | | |
| 16 | Big Creek | Knappa | ODFW | NMFS, Oregon | 1938 | Mitchell Act | 9,240,000 |
| 17 | Bonneville | Bonneville | ODFW | NMFS, Oregon, Corps | 1909 | Mitchell Act/John Day Dam | 18,303,000 |
| 18 | Cascade | Cascade Locks | ODFW | NMFS | 1958 | Mitchell Act | 1,139,000 |
| 19 | Clackamas | Estacada | ODFW | NMFS, ODFW, PGE | 1979 | Mitchell Act/PGE Hydro projects | 934,500 |
| 20 | Eagle Creek | Estacada | USFWS | NMFS | 1957 | Mitchell Act | 1,575,000 |
| 21 | Gnat Creek | Westport | ODFW | NMFS | 1960 | Mitchell Act | 624,100 |
| 22 | Irrigon/Wallowa | Umatilla | ODFW | USFWS | 1985 | Lower Snake Compensation | 3,765,024 |
| 23 | Klaskanine | Astoria | ODFW | NMFS, Oregon | 1911 | Mitchell Act | 5,490,000 |
| 24 | Leaburg | Leaburg | ODFW | Corps | 1954 | Willamette River Projects | 116,500 |
| 25 | Lookingglass | Elgin | ODFW | USFWS | 1982 | Lower Snake Compensation | 1,678,400 |
| 26 | Marion Forks | Idanha | ODFW | Corps, Oregon | 1950 | Detroit and Big Cliff Dams | 745,634 |
| 27 | McKenzie | Leaburg | ODFW | Oregon | 1930 | Cougar Dam | 1,790,500 |
| 28 | Oakridge (Willamette) | Oakridge | ODFW | Oregon, Corps | 1911 | Lookout Point and Dexter Dams | 4,780,002 |

| Map No. | Facility | General location | Operating agency[1] | Funding agency[1] | Year anadromous operation began[2] | Authorization/Project[1] | Production Releases (No.)[6] |
|---|---|---|---|---|---|---|---|
| 29 | Oak Springs | Maupin | ODFW | Oregon | 1920 | State of Oregon | 72,000 |
| 30 | Oxbow | Cascade Locks | ODFW | NMFS, Oregon | 1938 | Mitchell Act | 369,000 |
| 31 | Roaring River | Scio | ODFW | Oregon | 1925 | State of Oregon | 71,500 |
| 32 | Round Butte | Madras | ODFW | PGE | 1972 | Round Butte Dam | 478,000 |
| 33 | Sandy | Sandy | ODFW | NMFS | 1950 | Mitchell Act | 1,030,500 |
| 34 | South Santiam | Foster | ODFW | Corps, Oregon | 1923 | Foster and Green Peter Dams | 582,000 |
| 35 | Warm Springs | Warm Springs | USFWS | USFWS | 1977 | Congressional Authorization | 720,000 |
| | Oregon Release Sites/Ponds/Traps[7] | | | | | | |
| 36 | Stayton | Aumsville | ODFW | Oregon, NMFS | 1970 | Mitchell Act | 5,767,500 |
| 37 | Big Canyon Creek | Minam | ODFW | USFWS | (1988) | Lower Snake Compensation | |
| 38 | Bonifer | Umatilla Reservation | Umatilla Tribe | BPA | 1983 | BPA/Umatilla Tribe | |
| 39 | Clatsop Econ. Dev. Comm. | Young's Bay | CEDC | CEDC | 1976 | Clatsop Economic Development Comm. | 1,662,000 |
| 40 | Dexter | Dexter | ODFW | Corps, Oregon | 1955 | | 947,500 |
| 41 | Imnaha | Imnaha River | ODFW | USFWS | 1982 | Lower Snake Compensation | |
| 42 | Little Sheep Creek | Little Sheep Creek | ODFW | USFWS | (1988) | Lower Snake Compensation | |
| 43 | Minthorn | Umatilla Reservation | Umatilla Tribe | BPA | 1986 | BPA/Umatilla Tribe | |
| 44 | Trojan | Trojan | ODFW/PGE | NMFS | 1982 | Mitchell Act | 93,500 |
| 45 | Wahkeena | Bonneville | ODFW | NMFS | 1961 | Mitchell Act | 98,500 |
| | STEP Program[1,3] | Oregon | ODFW | Oregon | 1980 | State of Oregon | |
| 46 | Herman Creek Ponds | Bonneville | ODFW | NMFS | 1975 | Mitchell Act | |
| | Washington Hatcheries | | | | | | |
| 47 | Abernathy | Longview | USFWS | USFWS, NMFS | 1959 | Mitchell Act | 1,023,500 |
| 48 | Beaver Creek | Cathlamet | WDW | NMFS | 1958 | Mitchell Act | 740,800 |
| 49 | Carson | Carson | USFWS | USFWS, NMFS | 1937 | Mitchell Act | 3,119,000 |
| 50 | Chelan PUD | Chelan | WDW | Chelan PUD | 1964 | Upper Columbia Hydro Dams | 208,500 |
| 51 | Cowlitz Salmon | Salkum | WDF | Tacoma CL | 1967 | Mayfield and Mossyrock Dams | 20,315,000 |
| 52 | Cowlitz Trout | Ethel | WDW | Tacoma CL | 1967 | Mayfield and Mossyrock Dams | 1,040,000 |
| 53 | Elokomin | Cathlamet | WDF | NMFS | 1954 | Mitchell Act | 7,524,500 |
| 54 | Entiat | Entiat | USFWS | USFWS | 1942 | Mitchell Act | 920,000 |
| 55 | Grays River[8] | Grays River | WDF | NMFS | 1961 | Mitchell Act | 2,622,000 |

| Map No. | Facility | General location | Operating agency[1] | Funding agency[1] | Year anadromous operation began[2] | Authorization/Project[1] | Production Releases (No.)[6] |
|---|---|---|---|---|---|---|---|
| 56 | Kalama Falls | Kalama | WDF | NMFS | 1959 | Mitchell Act | 5,148,500 |
| 57 | Klickitat | Glenwood | WDF | NMFS | 1950 | Mitchell Act | 7,052,500 |
| 58 | Leavenworth | Leavenworth | USFWS | USFWS | 1938 | Mitchell Act | 3,049,000 |
| 59 | Lewis River | Woodland | WDF | WDF, Pacific P&L | 1909 | Ariel, Yale and Swift Creek Dams, and WDF | 10,447,001 |
| 60 | Little White Salmon | Cook | USFWS | USFWS, NMFS | 1898 | Mitchell Act | 4,106,000 |
| 61 | Lower Kalama[8] | Kalama | WDF | WDF | 1895 | State of Washington/Mitchell Act | 4,076,500 |
| 62 | Lyons Ferry | Snake River | WDW/WDF | USFWS | 1983 | Lower Snake Compensation | 1,979,200 |
| 63 | Naches | Yakima | WDW | WDW | 1933 | State of Washington | 83,000 |
| 64 | Priest Rapids | Priest Rapids Dam | WDF | Grant PUD | 1972 | Priest Rapids Dam-Wanapum | 6,998,500 |
| 65 | Ringold Salmon[8] and Trout | Ringold | WDW/WDF | NMFS | 1962 | Mitchell Act | 1,280,000 |
| 66 | Rocky Reach | Wenatchee | WDF | Chelan PUD | 1970 | Rocky Reach Dam | 958,000 |
| 67 | Skamania | Washougal | WDW | NMFS | 1956 | Mitchell Act | 610,000 |
| 68 | Speelyai | Yale | WDF | Pacific P&L | 1958 | Ariel, Yale and Swift Creek Dams | 613,500 |
| 69 | Spring Creek | Underwood | USFWS | USFWS, NMFS, Corps | 1901 | Mitchell Act/John Day Comp./Corps | 10,639,936 |
| 70 | Toutle | Toutle | WDF | NMFS | 1952 | Mitchell Act | 1,236,000 |
| 71 | Tucannon[7] | Pomeroy | WDW | WDW, USFWS | 1971 | Lower Snake River Compensation | |
| 72 | Turtle Rock | Rocky Reach | WDF/WDW | Chelan PUD | 1961 | Chelan PUD | 219,000 |
| 73 | Vancouver | Vancouver | WDW | WDW/NMFS | 1936 | State of Washington/Mitchell Act | 86,500 |
| 74 | Washougal | Washougal | WDF | NMFS | 1958 | Mitchell Act | 9,532,500 |
| 75 | Wells Salmon | Azwell | WDF | Douglas PUD | 1968 | Wells Dam | 1,413,000 |
| 76 | Wells Trout | Azwell | WDW | Douglas PUD, BOR | 1968 | Wells Dam | 601,000 |
| 77 | Willard | Cook | USFWS | NMFS, USFWS | 1951 | Mitchell Act | 2,930,000 |
| 78 | Winthrop | Winthrop | USFWS | USFWS | 1942 | Mitchell Act | 1,105,000 |
| 79 | Yakima | Yakima | Yakima Tribe/WDW/Sp. Group | BIA/WDW/Sp. Group | 1937 | BIA/State of Washington | 56,500 |
| | Washington Release Sites/Ponds/Traps[7] | | | | | | |
| 80 | Alder Creek | Toutle | WDW | NMFS, WDW | 1973 | Mitchell Act | |
| 81 | Big White Salmon[4] | Underwood | USFWS | USFWS, NMFS, Corps | 1901 | Mitchell Act/John Day Comp./Corps | |
| 82 | Carson Depot Springs[5] | Cook | USFWS | NMFS | 1960 | Mitchell Act | |
| 83 | Cottonwood Cr. | Grande Ronde River | WDW | USFWS | 1985 | Lower Snake Compensation | |
| 84 | Curl Lake | Tucannon River | WDW | USFWS | 1985 | Lower Snake Compensation | |

| Map No. | Facility | General location | Operating agency[1] | Funding agency[1] | Year anadromous operation began[2] | Authorization/Project[1] | Production Releases (No.)[6] |
|---|---|---|---|---|---|---|---|
| 85 | Dayton | Dayton | WDW | USFWS | 1986 | Lower Snake Compensation | |
| 86 | Gobar | Kalama | WDW/Weyerhauser | NMFS, Weyerhauser | 1975 | Mitchell Act | |
| 87 | Nelson Bridge | Yakima | WDW/Sp. Group | WDW/Sp. Group | 1964 | WDW | |
| 88 | Nile Springs | Nile Valley | Yakima Tribe/WDF/Sp. Group | WDF | 1976 | Tribe/WDF | 52,107 |
| 89 | Sea Resources, Inc. | Chinook | Sea Res., Inc. | Sea Res./WDF | 1978 | Sea Resources, Inc. | |
| 90 | Grays R. Salmon Pond[8] | Grays R. | WDF | WDF | 1982 | Wash. Salmon Enh. 1977 | |
| 91 | Coweeman R. Net Pen | Coweeman R. | WDW | NMFS | | Mitchell Act | |
| 92 | Toutle R. Trap | Toutle R. | WDW | NMFS | | Mitchell Act | |
| 93 | Coal Creek Cooperative | Coal Cr. | WDW | NMFS | | Mitchell Act | |
| | | | | | | TOTAL: | 191,209,404 |

1. IDFG=Idaho Department of Fish and Game; NMFS=National Marine Fisheries Service; ODFW=Oregon Department of Fish and Wildlife; Oregon=State of Oregon General Funds; STEP=Salmon and Trout Enhancement Program (State of Oregon); USFWS=U.S. Fish and Wildlife Service; WDF=Washington Department of Fisheries; WDW=Washington Department of Wildlife; BPA=Bonneville Power Administration; BIA=Bureau of Indian Affairs; Corps=U.S. Army Corps of Engineers; Chelan PUD=Chelan County Public Utility Division; Douglas PUD=Douglas County Public Utility Division; Grant PUD=Grant County Public Utility Division; Pacific P&L=Pacific Power and Light; PGE=Portland General Electric; Tacoma CL=City Light; Sp. Group=Sports Group; BOR=Bureau of Reclamation

2. Dates in parentheses are scheduled completion dates.

3. The State of Oregon sponsored the hatching and release of salmon and steelhead through their STEP hatch box program in 1987.

4. No releases were made in 1987 from Big White Salmon, but it is still operational.

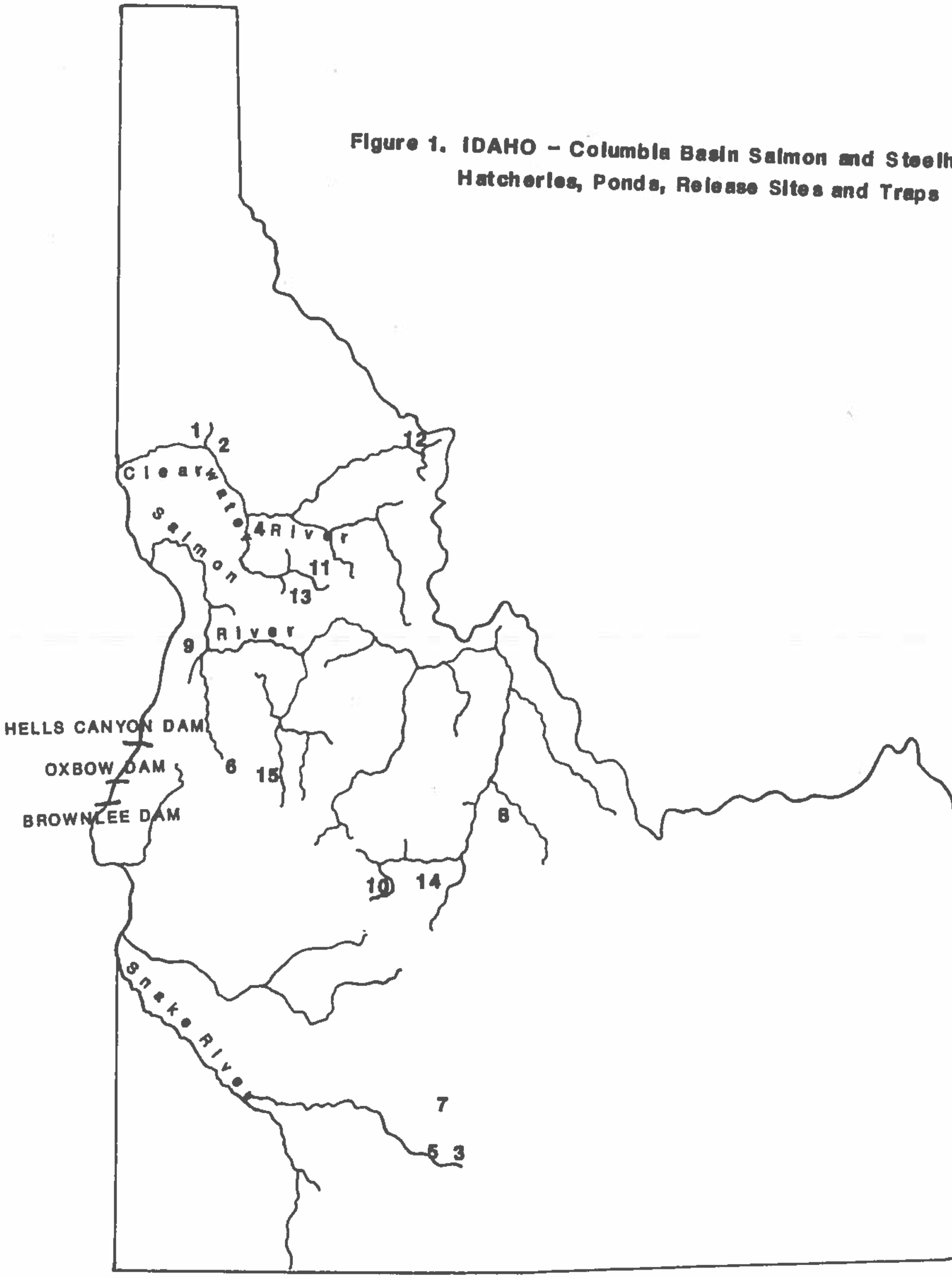
5. Carson Depot Springs is a separate sub-station of Little White Salmon/Willard Hatcheries and is used for egg incubation.

6. Total production (numbers of fish) for all species. Facilities without entries did not release fish in 1987 or are included with other facilities releases.

7. Unless otherwise noted, production release figures are included with other Mitchell Act and Lower Snake Compensation hatchery figures, as these facilities are for holding and release only.

8. Closed in 1988 due to budget shortfalls. May be funded in 1989.

Figure 1. IDAHO - Columbia Basin Salmon and Steelhead Hatcheries, Ponds, Release Sites and Traps



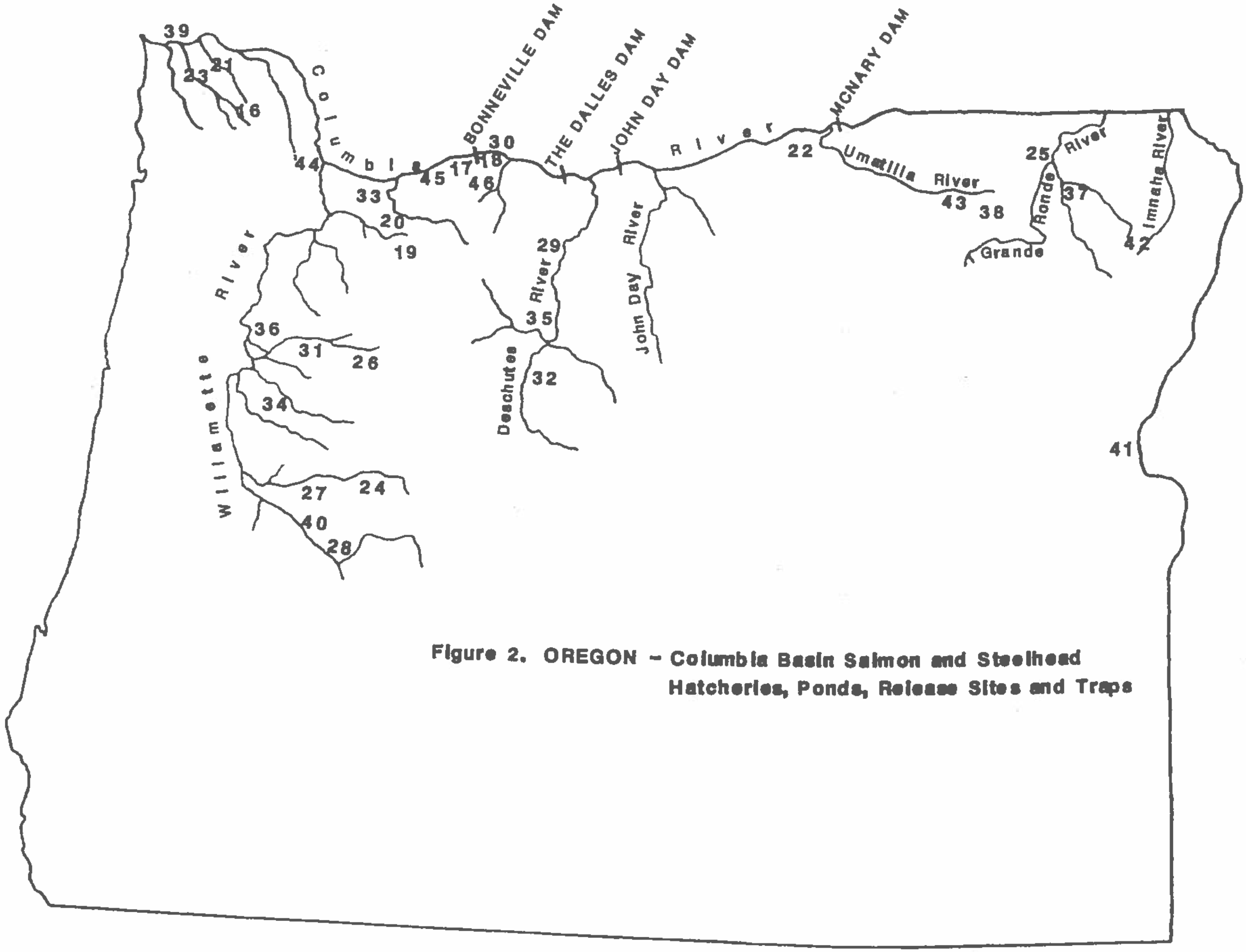



Figure 2. OREGON - Columbia Basin Salmon and Steelhead Hatcheries, Ponds, Release Sites and Traps

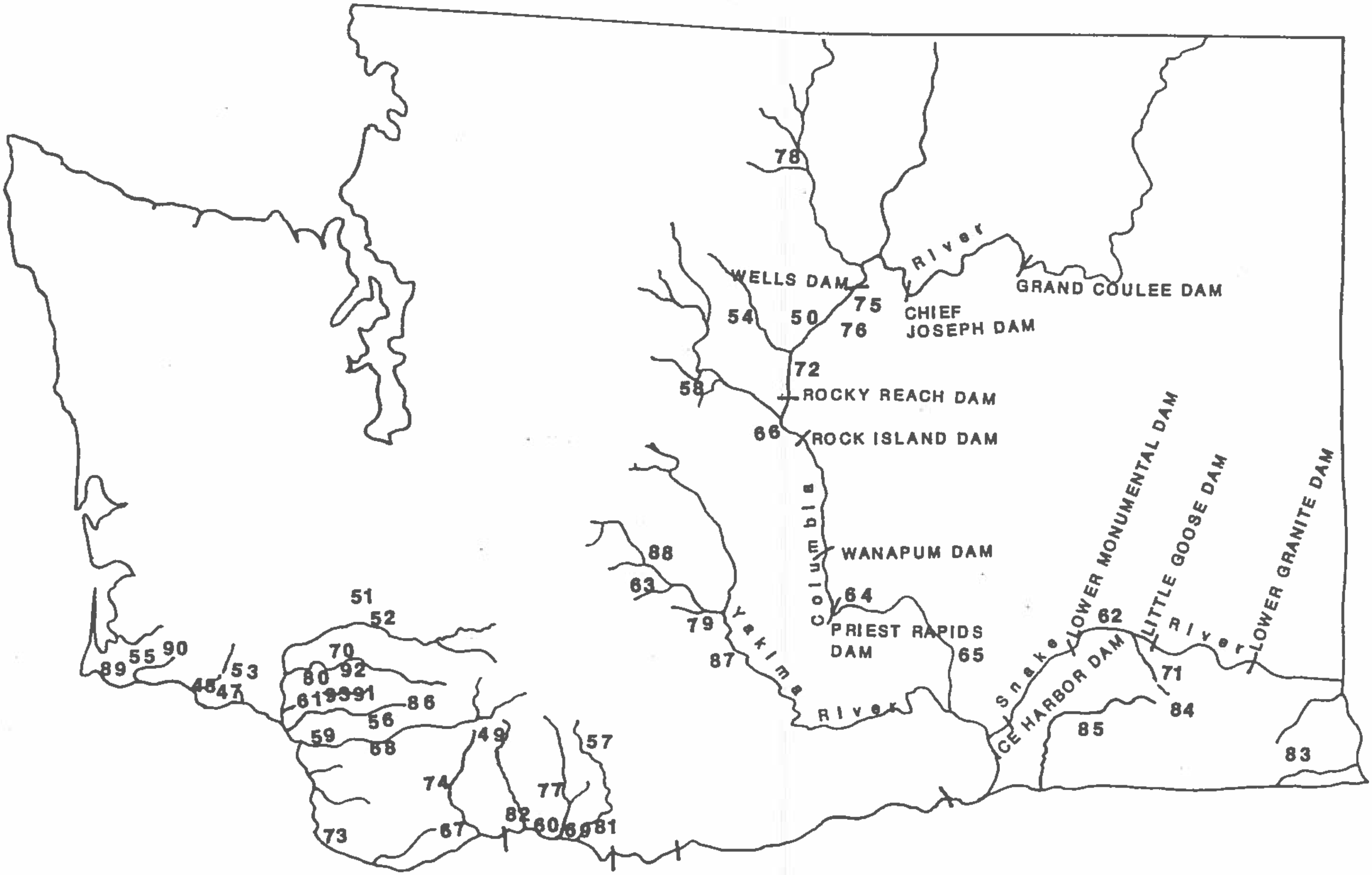



Figure 3. WASHINGTON - Columbia Basin Salmon and Steelhead Hatcheries, Ponds, Release Sites and Traps

Basin suffered substantial declines as a result of early irrigation development and other water use projects. The remaining natural coho production has been nearly eliminated because largely uncontrolled mixed-stock fisheries relied heavily on the more abundant hatchery coho and over-fished the less abundant natural coho stocks.

The Columbia River Basin Fish and Wildlife Program (Program), which was developed following the passage of the Pacific Northwest Electric Power Planning and Conservation Act of 1980, has been characterized as possibly the most ambitious effort in the world to restore fish and wildlife resources. No other legislation has held more promise for improving the anadromous fish resources of the Columbia River Basin. The Northwest Power Planning Council (Council) has estimated that annual losses in run size due to hydropower development and operation range from 5 to 11 million adult fish. In its amended Program of February 11, 1987, the Council established an interim goal of doubling the adult run size at the time; in effect increasing the runs by 2.5 million fish.

Plans are underway for the design and construction of four new anadromous fish hatcheries under the Council's Program. With the exception of some acclimation facilities, this is the first hatchery construction for anadromous fish that has been added to the Columbia River under the Program to compensate for hydropower losses. Unless major increases in survival of salmon and steelhead are achieved by improving mainstem passage, and by increasing the effectiveness of current hatchery production including off-station releases, new hatchery production in the Basin may have to be increased substantially to achieve the Council's doubling goal. The challenge will be to carefully integrate hatchery production and supplementation of natural production with other measures, including the application of more sophisticated harvest controls, to achieve the proper balance of natural and artificial production.

This report is in response to questions about the history, development and management of Columbia River fish hatcheries raised by the Council at various times. It is intended as a general review to provide a historical perspective and background for the Council and may serve as a ready reference for new members.

## HISTORICAL REVIEW OF HATCHERY DEVELOPMENT

### The Pre-Dam Period (1876-1933)

Development of fish propagation facilities in the Columbia River Basin followed the development and expansion of the commercial fishery. The first commercial cannery began operation on the Columbia River in 1866, and by 1883, 40 canneries were operating on the river.3/ Concerns about overfishing led to the construction of the first fish hatchery which was built on the Clackamas River in 1876 by an organization of commercial canners known as the Oregon and Washington Fish Propagating Company.4/

In the 1890's state and federal governments began artificial propagation on a large scale. Hatcheries and egg taking stations were constructed on the Kalama, Chinook, Wenatchee, Wind, Little Spokane, Methow, Klickitat, Little White Salmon, Big White Salmon, Sandy, and Clackamas rivers. Funds for constructing and operating these early facilities came from a variety of sources including an 1893 State of Washington law requiring license fees for all commercial fishermen, and funds authorized by federal statute. Responsibility for the operation of these early facilities often changed hands. For example, a facility built by the Columbia River Packer's Propagating Company on the upper

Clackamas River was operated privately from 1895-96, federally from 1897-98, and by the State of Oregon in 1899.5/

Most of these early facilities continued to operate until the 1930's when support for hatcheries waned considerably because of poor returns. In 1936, Canada concluded that hatcheries were not beneficial and terminated all salmon hatchery production.6/ During the Depression and World War II many of the early facilities constructed in the Columbia River Basin were closed. If it had not been for the rapid expansion of hydroelectric development, which began in the Basin during this time period, anadromous fish hatcheries probably would not have played as significant a role. The only hatcheries built around 1900 that are presently in operation are Lower Kalama (1895), Little White Salmon (1898), Spring Creek (1901), Lewis River (1909), Bonneville (1909), Klaskanine (1911), and Oakridge (1911). All of these hatcheries were modernized and expanded in the last 30 years to compensate for hydropower-related fish losses except for Lower Kalama Hatchery which was upgraded on several occasions with funds provided by the State of Washington.

The Construction of Hydropower Dams and Hatchery Development

Beginning in the 1930's, the anadromous fishery resources of the Columbia River were impacted as a series of large multipurpose dams for hydroelectric power, flood control, and navigation were constructed on the mainstem river. Concerns for the welfare of the fishery resources had very little influence over the path this development followed. Within a span of about 30 years, 40 percent of the habitat above Bonneville dam was destroyed by flooding of spawning and rearing habitat or was made inaccessible to anadromous fish. Loss of habitat for sockeye salmon was particularly severe. Nursery lakes for sockeye salmon historically amounted to at least 222,850 acres but by 1939 only

4 percent remained accessible.7/ Many unique and valuable salmon and steelhead stocks were eliminated during this short span of time. These losses determined to a great extent the pattern and scope of hatchery development in the Basin.

When Grand Coulee dam was completed in 1941, access by salmon and steelhead was blocked to 1,140 miles of the upper Columbia River drainage. To maintain the remaining runs from this area, returning salmon and steelhead were trapped at Rock Island dam and transported and released above temporary weirs on the Wenatchee and Entiat Rivers and at three newly constructed hatcheries operated by the U.S. Fish and Wildlife Service: Leavenworth, Entiat, and Winthrop National Fish Hatcheries. Sockeye were also released in the Okanogan River. The salvage operation helped to restore runs in these tributaries and may have preserved some of the genetic diversity of the fish that were trapped.8/ However, because the habitat in the tributaries where the fish were released was limited, the operation could not provide mitigation for the lost habitat above Grand Coulee dam.

Over the next 30 years hatchery production of sockeye salmon was eliminated, and production of other anadromous fish at Leavenworth, Entiat, and Winthrop steadily dwindled. A variety of problems plagued the operation of the hatcheries and emphasis on production gradually shifted from salmon to trout. Salmon production at Entiat and Winthrop was terminated in 1965 and only small numbers of coho and spring chinook continued to be reared at Leavenworth. As a result of efforts by the Grand Coulee Rehabilitation Committee, this trend in production was reversed in 1975 when Congress appropriated funds to rehabilitate the three hatcheries and return them to anadromous production.9/

In the early 1950's, salmon and steelhead runs below the blocked areas were showing signs of recovery, but between 1957 and 1975 eleven new dams were completed on the mainstem Columbia and lower Snake rivers. The decline of anadromous fish runs due to hydroelectric development continued and a number of attempts were made to mitigate and compensate for the tremendous losses. For example, artificial spawning channels were constructed at Priest Rapids, Turtle Rock, and Wells to replace lost spawning habitat which had been inundated by the construction of Priest Rapids, Wanapum, Rocky Reach, and Wells dams. After a number of years of operation these facilities failed because of excessive pre-spawning mortality of adult fish, poor survival of deposited eggs and fry, and generally poor production.10/ The artificial spawning channels were eventually converted to hatchery production.

Mitigation of fish losses was also attempted by providing passage for anadromous fish around the dams. Fish passage facilities have generally been successful in passing fish around the run-of-the-river or low dams. However, most attempts to provide passage around the high dams (e.g. Merwin, Pelton, and Brownlee dams) failed. The attempts at providing passage were very expensive and the failures served to further heighten the tragic and irretrievable loss of fish stocks that formerly migrated to the areas above the high dams.

In these and other instances, hatchery production was the only means available to compensate for the losses. However, the compensation provided generally has lagged years behind the initial fish losses and has included a number of species substitutions. For example, the four Lower Snake River dams were constructed between 1961 and 1975. The Lower Snake River Fish and Wildlife Compensation Plan was not authorized by Congress until 1976. The first hatchery facility (McCall Hatchery) was not completed until 1981, or 20 years after the impact on the fish runs began. In the interim, salmon and steelhead runs in the Snake River declined to low levels and at this time only steelhead are showing significant improvement. At least one species, Snake River fall chinook, was proposed for inclusion on the Endangered Species list. The final hatchery in the Plan (Clearwater) will not be completed until 1990, or nearly 30 years later. It will be well into the 1990's before these facilities are at full capacity.11/

Mitchell Act and the Columbia River Fishery Development Program

In response to the pending completion of Bonneville dam and the construction of Grand Coulee dam, Congress passed the Mitchell Act in 1938 in recognition of the loss of fish in the Columbia River due to dam construction and other human activities. Initially, funding was limited and early work was restricted to fish surveys on many of the tributaries to the Columbia River.

In 1946 an amendment to the Mitchell Act removed the limitations on subsequent appropriations and authorized the Secretary of Interior to work with the States of Washington, Oregon and Idaho to develop the salmon resources of the region. The Lower Columbia River Fishery Development Program (CRFDP) was formed in 1948 through a cooperative agreement among the three states and the Fish and Wildlife Service. The CRFDP is currently administered by the National Marine Fisheries Service. The 1950's saw the major hatchery construction phase in the Basin under the CRFDP. The first hatchery authorized was built in 1949, eleven years after the Bonneville dam was constructed. In 1956, the CRFDP was expanded to include the upper Columbia and Snake River drainages and the word "Lower" was dropped from the name.12/ The Mitchell Act program in the upper basin then accelerated after the loss of the tribal fisheries at Celilo Falls in 1957.

Although the intent of the Mitchell Act was to compensate for fish losses throughout the entire Basin, most of the hatchery facilities were located in the lower river below Bonneville dam. Of the 39 hatchery facilities (Table 1) authorized under the Act, or currently receiving Mitchell Act funding for operation, 25 are located below Bonneville dam, 10 in the Bonneville Pool and 4 above The Dalles dam. This was primarily the result of concern about the adverse effect of Bonneville dam and subsequent dams on anadromous fish, and acknowledged that the technology of the times could not assure survival of fish released from hatcheries constructed in the upper Basin. However, locating most of the Mitchell Act facilities in the lower river could not reverse the very large adverse impact on treaty Indian fisheries which are all located above Bonneville dam and must rely on the upriver runs. These runs were severely impacted by the construction and operation of the dams.

In addition to funding the expansion of artificial propagation, the CRFDP also has funded habitat improvement, construction and operation of fishways, and construction and operation of screens at irrigation diversions to protect downstream migrants.

Lower Snake River Fish and Wildlife Compensation Program

The Lower Snake River Fish and Wildlife Compensation Program (LSRCP) was authorized by Congress in 1976 mainly to replace wildlife and fish passage losses caused by the four Corps dams located on the lower Snake River (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams). The LSRCP requires expansion or construction of twelve hatcheries and eleven satellite facilities in Idaho, Oregon, and Washington (Table 1).13/

The facilities are being constructed by the Corps of Engineers at an estimated cost of $177 million. The U.S. Fish and Wildlife Service budgets for and administers funding for state and federal operation and maintenance of the fishery features of the LSRCP. An annual cost of about $9.5 million has been projected for operation and maintenance once all of the facilities are completed. The Fish and Wildlife Service also provides funding to each operating agency for evaluating the portion of the LSRCP under their jurisdiction. Studies funded under the LSRCP include general monitoring and evaluation of hatchery practices, and creel census and marking studies to determine contribution to the sport and commercial fisheries. The Nez Perce Tribe and the Confederated Tribes of the Umatilla Reservation are receiving funds to develop 5-year plans for their participation in the LSRCP. All anadromous fisheries compensation and most resident fisheries compensation costs are allocated to project power costs and are reimbursed to the U.S. Treasury by the Bonneville Power Administration14/ from power revenues.

Corps of Engineers

The U.S. Army Corps of Engineers has directly funded the construction or modernization and expansion of 19 hatcheries (including the construction of the LSRCP hatcheries) as mitigation and compensation for fish losses caused by the Corps' hydroelectric projects (Table 1). Between 1941 and 1968, 12 Corps' dams were constructed in the Willamette River Basin. Five fish hatcheries and a number of satellite facilities operated by the Oregon Department of Fish and Wildlife were modernized and expanded or constructed to produce salmon and steelhead in compensation for losses caused by these projects.

Extensive hydroelectric development by the Corps also occurred during this time period on the mainstem Columbia and Snake rivers with the construction of McNary (1953), The Dalles (1957), Ice Harbor (1961), Lower Monumental (1969), Little Goose (1970), John Day (1968), and Lower Granite (1975) dams. Spring Creek National Fish Hatchery was expanded in 1972 and Bonneville Hatchery in 1975 with funding from the Corps to partially compensate for the loss of salmon due to the inundation of spawning and rearing areas by John Day dam. The Corps of Engineers, from 1949-62, transferred funds to the U.S. Fish and Wildlife Service for the Lower Columbia River Fishery Development Program (Mitchell Act)15/ which was used to construct many of the Mitchell Act facilities. These funds provided partial mitigation for fish losses due to inundation of spawning and rearing habitat by Bonneville, The Dalles, and McNary dams.

Significant passage losses of juvenile and adult salmon and steelhead have occurred at the Corps' lower Columbia River projects for more than 30 years but no compensation has been provided for these losses.16/ Compensation is being provided for passage losses of chinook and steelhead occurring at the four lower Snake River projects under the Lower Snake River Fish and Wildlife Compensation Program, however, compensation has not been provided for coho and sockeye salmon.

In Idaho, the construction of Dworshak dam in 1971 by the Corps of Engineers removed the entire North Fork of the Clearwater River from anadromous fish access. Dworshak National Fish Hatchery was constructed at the mouth of the river below the dam to compensate for the fish losses and steelhead that were destined for the North Fork were trapped below the dam. Perpetual maintenance of the North Fork of the Clearwater steelhead stock is now dependent upon management and operation of the hatchery.

## Public Utility Districts and Private Power Companies

Public utility districts and private power companies funded the construction and/or the operation of 16 fish hatcheries (Table 1) to compensate for some level of fish losses caused by their water use projects. These include propagation facilities to compensate for fish losses from Idaho Power Company's three dams on the middle Snake River, the mid-Columbia PUD dams, Portland General Electric's projects on the Clackamas and Deschutes rivers, Tacoma Power and Light's Cowlitz River projects, and Pacific Power and Light's dams on the Lewis River.

## State and Other Federally Funded Enhancement Facilities

A number of facilities constructed in the Basin were funded by the states and by various federal statutes (Table 1). Only a few remain that are not receiving mitigation and compensation funding.

# DEVELOPMENT OF FISH CULTURE PRACTICES

While anadromous fish hatcheries have operated on the Columbia River for over 110 years, it is only in the last three decades that hatchery programs have become effective. Very little information on the biology and culture requirements of salmon and steelhead was available during the early years of fish culture. In the late 1800's and early 1900's most hatcheries only released unfed fry soon after the eggs were hatched. The young fish are particularly vulnerable at this stage and it is doubtful whether hatchery production contributed much in the way of adult returns because of poor survival. By 1905, annual hatchery production in the Columbia River had reached 62 million eggs and fry.17/

Most of the knowledge of fish culture in the early years was acquired through trial and error rather than by scientific methods. It was soon learned that increased survival and greater contribution to returns could be achieved by releasing fish that had been fed for an extended period. Ground liver, spleen, fish carcasses, animal by-products, and vegetable feedstuffs were used extensively for feed. This diet posed a number of problems that were not recognized at the time. For example, it was not known until the 1960's that salmon fed diets not fortified with proper levels of vitamins, antioxidants, and minerals could not effectively metabolize animal fats and that such hard fats caused anemia and degenerative changes to the fish's internal organs.18/ Feed containing untreated salmon carcasses also spread tuberculosis, bacterial kidney disease, and other serious fish diseases.

Increased research efforts in the late 1950's and early 1960's revolutionized fish culture practices. The development of the Oregon Moist Pellet (OMP) feed was a breakthrough in fish nutrition. Fish fed OMP experienced much greater survival and contributed more to the fishery than fish fed the old meat diets.19/ The development of vitamin fortifications made it possible to develop dry pelleted feeds which could be stored without refrigeration for extended periods and resulted in less feed wastage.20/ Dry and moist pelleted feeds are now produced to specific standards for protein, mineral, vitamin, fat and fiber content geared to the specific needs of the fish although much is yet to be accomplished to provide improved diets.

In the early years, hatchery success was measured primarily by the total numbers of fish released. By the early 1960's, better diets and larger hatcheries made it possible to increase the size of the fish released and marking experiments showed that much better survival could be achieved in some cases by releasing larger fish.21/ Marking experiments were also valuable in determining the best time to release the fish to optimize survival. Rearing and release strategies for hatchery fish also were improved because of advancements in understanding the process of smoltification. Smoltification is the combination of physiological and behavioral adaptations that enable juvenile salmon and steelhead to successfully migrate from their natal streams to the ocean and to survive and continue to grow in their new environment. While much is yet to be learned, substantial progress has been made in identifying factors that inhibit smoltification and seawater tolerance.22/

Advances in other areas of fish culture yielded a better understanding of optimum rearing densities, water treatment, and facility design. The development of specialized analytical instruments enabled better monitoring of dissolved oxygen, pH and other critical water quality parameters for rearing salmon and steelhead in the hatchery environment.23/ Substantial progress was also made in understanding fish pathogens and parasites and in developing means for their prevention, treatment, and control. This knowledge focused on the need for pathogen free water supplies and for additional rearing space rather than more intensive use of hatchery facilities already operating near capacity.

## PAST MANAGEMENT OF HATCHERY STOCKS

The management of Columbia River fish stocks has changed dramatically over the years, and has continued to change in response to declining fish runs, changing harvest patterns, expanded hatchery production, the acquisition of new knowledge, and court decisions. In the early years, the primary criteria for selection of most stocks for hatchery production were the accessibility and availability of broodstock and eggs and the relative commercial importance of the stocks. Stock transfers among hatcheries were very common and often were driven by the objective of meeting full station production without giving adequate consideration to the suitability of the donor stocks.

The stock concept had not evolved and salmon and steelhead were thought to be very similar over much of their range. Only after years of observation and lack of success with stock transfers did recognition of the importance of individual stocks emerge. In the meantime, basic knowledge of fish genetics was limited and it was convenient to use the stocks that were readily available. There also was little information available on the interaction between hatchery and natural or wild stocks. As a result, hatchery fish were planted throughout the Columbia River Basin without an adequate evaluation of the potential impact on the genetic integrity of native fish, competition for limited food resources, fish disease, or suitability of the hatchery fish for their new environment. Even less information was collected on the success or failure of these ventures.

The rapid increase in survival of hatchery fish that occurred in the 1960's was a boon to the sport and commercial fisheries but created new problems for fishery managers. Mixed-stock fisheries that relied heavily on hatchery fish often overfished individual natural stocks. One of the reasons this occurred was because any future benefits that could be derived from protecting a single stock by severely limiting fishing appeared small in comparison to the immediate loss of harvest of the more abundant hatchery stocks. Lack of adequate data for identifying individual stocks in mixed-stock fisheries was also a contributing factor.

By the 1970's, increased knowledge of the genetic differences among the stocks of salmon and steelhead accumulated through analysis of migration, life history, biochemical, and morphological information. Genetic data and theory suggested that genetic differences affecting survival of stocks increased with geographic separation from the stream of origin. It was recognized that relocation of stocks from distant geographic areas reduced their survival potential. New information on fish health also raised concerns over the effect of stock transfers on the spread of fish diseases throughout the Basin. As a result, more restrictive policies were adopted by the fishery agencies that limited the transfer of stocks into and throughout the Columbia River Basin. In addition, some streams were designated for management of self-sustaining natural production, and release of hatchery fish was prohibited.

The use of native stocks in hatchery programs has increased in recent years and greater emphasis has been placed on operating and managing hatcheries to retain, as much as possible, the characteristics of the stock from which the broodstock was obtained. For example, the practice was adopted at most hatcheries of taking eggs from the entire run rather than from just one segment of the run in order to maximize genetic variability. Practices were avoided that resulted in selective breeding or increasing the rate of inbreeding; for example, most hatcheries now avoid using a small number of males for spawning with a large number of females which was a common practice in the past that could have caused a reduction in genetic diversity.

The emphasis of salmon fishery management in recent years also shifted more toward regulating the rate of harvest on individual stocks in mixed-stock fisheries. This resulted from an increased emphasis on protecting stock diversity, from improvements in management of ocean and in-river fisheries, and from Federal court decisions regarding Indian treaty fishing rights that guaranteed the tribes the right up to a 50 percent share of the harvest from salmon and steelhead runs destined to pass through their usual and accustomed fishing areas.

## CURRENT OPERATION AND MANAGEMENT OF HATCHERIES

The anadromous fish hatchery facilities in the Basin are currently operated by the U.S. Fish and Wildlife Service, Washington Department of Fisheries, Washington Department of Wildlife, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, and Yakima and Umatilla tribes. A number of volunteer groups also participate in rearing salmon and steelhead through cooperative programs like Oregon's Salmon and Trout Enhancement Program. Coordination among the fish and wildlife agencies and tribes is maintained primarily through daily interagency contacts and also through a number of organizations including: 1) the Columbia Basin Fish and Wildlife Authority and it's Anadromous Fish Production Committee, 2) Pacific Northwest Fish Health Protection Committee, 3) technical work groups, and 4) meetings of professional organizations. Additional coordination is provided by the National Marine Fisheries Service for the Mitchell Act facilities, and by the U.S. Fish and Wildlife Service for the Lower Snake River Compensation Program facilities.

Much of the attention and debate relative to the current operation and management of hatcheries is focused on the following four major areas of concern:

1) Genetic risks associated with the operation and management of hatcheries;

2) The impact of hatcheries on fish health;

3) Improving the effectiveness of hatchery production; and

4) Hatchery performance in meeting compensation goals.

Genetic Risk

A major impact of hydropower and other development as well as over-fishing was the loss of diversity of fish stocks in the Columbia River Basin. As a result, it has become increasingly important to maintain the genetic health and integrity of the remaining fish populations. The Northwest Power Planning Council has acknowledged the importance of maintaining a genetically healthy resource by requiring an assessment of genetic risks of proposed actions in salmon and steelhead planning.

Genetic risk is defined as the possible detrimental alteration of a stock, including the probability of a reduction in the adaptability of a stock to its environment, resulting from a change in the quantity or kind of genetic information in the stock.24/ The total amount of genetic information which exists in a stock is commonly referred to as "genetic diversity".

Fish survive because they have inherited the kinds of genetic information needed to enable them to cope with environmental changes encountered during their life cycle. Timing of spawning and fry emergence, migration, growth, and resistance to disease are examples of traits necessary for survival which are affected by the fish's genetic makeup. Stocks with less genetic diversity may not have the right survival characteristics to overcome environmental challenges and may have a reduced chance for survival.

The management and operation of hatcheries pose two types of potential genetic risks: 1) risks associated with management practices used in artificial selection and propagation of hatchery stocks, and 2) risks associated with interactions between hatchery and other stocks which may change the quantity or kind of genetic information in other stocks.

1) Genetic Risks Associated With Management Practices Within The Hatchery

Management practices used in artificial propagation can alter the genetic composition of a hatchery stock through selection of those fish most adapted to hatchery conditions. Certain hatchery practices can result in selection for some genetic traits and against other traits which will decrease genetic diversity. For example, earlier run timing, which is the result of taking eggs predominately from the earlier returning hatchery fish, has been observed in several hatchery stocks.25/ Hatchery stocks with altered run timing may encounter adverse environmental conditions after introduction into the wild where optimum timing for spawning and fry emergence are critical for survival. This alteration would be a major problem for stocks used to supplement natural production. However, in some situations deliberate selection for a specific genetic trait such as run timing may be advantageous. Earlier or later run timing would be a useful trait if the management objective is to separate hatchery from wild stocks in the fishery and on the spawning grounds.

Hatchery operations also may inadvertently select for certain traits. An example is disease resistance which is a factor that may be selected for in the hatchery because of the higher rearing densities and other sources of stress in the hatchery environment. It is commonly believed that hatchery fish are less disease resistant than wild fish but there is a lack of data to support this contention.26/ In fact, just the opposite may be true because of the selection in the hatchery environment. On the other hand, inadvertent selection within the hatchery environment may result in the loss of other traits that are important for survival in the natural environment.

Hatchery practices that do not utilize eggs from each available female spawner can result in significant inbreeding and reduction in genetic diversity of a given hatchery stock.27/ Recent research results indicate that volumetric sampling of fertilized eggs from each female spawner can alleviate potential inbreeding problems caused by using a random, but limited, sample of eggs which originate from only a fraction of the available females. Problems from inbreeding might be detected through intensive monitoring and the minimum number of breeding individuals in a hatchery population needed to prevent inbreeding and conserve genetic diversity has been determined through computer modeling and can be controlled.28/

Viewpoints over the use and role of genetic selection in salmonid culture range from the position that any genetic selection is undesirable to the viewpoint that it can be used to solve many of our fish culture problems. Lack of information on the genetic effects of selection and the factors that influence genetic selection contribute to this divergence of views.29/ It will be difficult to counteract undesirable genetic effects due to hatchery practices until they have been identified and the genetics are better understood.30/ But in the meantime, practices within the hatchery environment that may result in the selection of undesirable traits, or the loss of desirable traits, should and are being avoided through careful management to reduce the potential risk.

2) <u>Genetic Risks Associated with Interactions Between Hatchery and Other Stocks</u>

Observations from a number of studies indicate the potential for negative genetic alteration of endemic stocks through interbreeding with hatchery fish.31/ There is also the potential for negative genetic alteration of endemic stocks because of competition from hatchery fish for food and rearing space.

The approach to minimizing genetic risks associated with interactions between hatchery and other stocks depends on the fishery management objective which can vary from stock to stock. Where stocks are being managed for self-sustaining natural production, the simplest approach to minimizing genetic risk is to manage for the greatest possible separation between the hatchery and endemic stocks.32/ This has been accomplished for some stocks of fish in the Columbia River Basin by prohibiting the release of hatchery fish in the habitat occupied by the endemic population.

However, there are many areas in the Basin where the habitat is severely underutilized and regaining self-sustaining natural production is limited or unlikely. Supplementation of natural production may be appropriate in this case, but a number of potential factors including interbreeding and competition for food and rearing space between hatchery and endemic fish must be considered in areas where natural stocks are present. Ideally, the stock selected for supplementation should be as genetically similar as possible to the existing local stock. This would minimize the risk of altering the genetic makeup of the local stock. Hatcheries used to supplement natural production should develop stocks adapted to both the hatchery and natural environment but almost nothing is known about how to accomplish this goal.33/ In addition, effective supplementation techniques need to be developed. The Supplementation Technical Work Group has developed a research work plan for determining whether this objective can be accomplished and the work identified should be completed as soon as possible.34/

Current Hatchery Practices Related to Genetic Concerns

While hatcheries can be designed and operated to accomplish a wide variety of objectives, two general types of hatchery production strategies currently are employed in the Basin. The first strategy produces smolts that are released primarily from the hatchery and migrate directly to the ocean. As adults these fish are expected to be captured or to return directly to the hatchery of origin. Many of these stocks have been raised in a hatchery environment for several generations, are genetically adapted to that environment, and are less likely to interbreed with natural stocks because the fish are returning to the point of release (the hatchery) and straying into natural production areas is minimal.

Maintaining the genetic diversity of these hatchery stocks is accomplished by allowing adequate escapement to enable the taking of eggs throughout the entire run, prohibiting selection practices that lead to inbreeding, and minimizing mixing of stocks. In recent years ocean and in-river fisheries have been regulated to protect unique hatchery stocks of this type (e.g. Spring Creek tule fall chinook).

The second general strategy for hatchery production being employed in the Basin is to produce fish that are expected to retain, as much as possible, the characteristics of the stock from which the broodstock was obtained. The purpose of these hatcheries is to maintain or increase the numbers of fish once produced in a system and to help conserve the native fish. Fish from these hatcheries may be planted in order to return as adults to supplement natural spawning. They are expected to substitute for fish from natural production and every effort is made to ensure that they remain as similar as possible to the natural stock and are adapted for rearing and reproducing in the stream.

The states and tribes require that all anadromous fish stock transfers are approved by the state agency or tribe with jurisdiction over the area where the stock is proposed for introduction. Specific areas have been identified strictly for natural production where hatchery releases are currently prohibited. In other areas where the natural habitat is severely underseeded, and where regaining self-sustaining natural production is otherwise unlikely or very limited, hatchery fish currently are being used to supplement natural production.

Today's management decisions regarding genetic concerns are made with some uncertainty because the information base is limited and the various theories about genetic risks lack rigorous scientific evidence. The need now is to develop the means to adequately measure, monitor, and evaluate genetic risks in order to reduce this uncertainty. Baseline information on the genetic variation of natural and hatchery stocks needs to be collected to determine which stocks are in need of attention and to be able to detect future changes in genetic variability. In the meantime, hatcheries represent a significant repository of genetic diversity that must be maintained through improved management.

Fish Health

Another major concern related to successful fishery management is the impact of hatchery operations on fish health. The health of fish depends on maintaining a delicate balance between ever present disease agents, the fish, and the fish's environment.35/

While disease organisms are present in the natural environment, possibly infecting individual fish, significant outbreaks of disease seldom occur unless environmental quality has deteriorated or the defense mechanisms of the fish have been impaired. In contrast to fish in their natural habitat, fish in hatcheries are unable to seek more desirable environmental conditions and are continually exposed to abnormal rearing densities that increase the opportunity for pathogens to spread from fish to fish.

In the Columbia River several fish diseases pose serious problems for the operation of hatcheries. Bacterial Kidney Disease (BKD) is a major disease problem in spring chinook salmon. Infectious Hematopoietic Necrosis (IHN) sometimes causes mortality of up to 90 percent in steelhead trout in the Columbia Basin.36/ Ichthyophthirius and other common parasites affecting the gills of smolts may drastically curtail the ability of fish to migrate and adapt to salt water. Coldwater disease causes serious, debilitating and long-term infections in coho salmon. These and other serious fish diseases have been difficult to control and present major obstacles to improving the effectiveness of hatchery production.

The control of fish diseases in hatcheries depends on a number of measures including: 1) provision of adequate rearing space, water exchanges, and appropriate ponds for the species and sizes of fish on hand, 2) prevention of the introduction of disease organisms into rearing units, especially those for eggs, fry, and fingerlings, 3) early disease detection and prompt action in treating fish health problems to prevent disease amplification and maximize survival, and 4) development and implementation of disease prevention and control programs.

Hatcheries in the Basin today are managed by competent professionals using the latest management practices required to produce healthy fish. However, limited funding for badly needed capital improvements has slowed the development of suitable rearing facilities and the construction or modernization of adequate broodstock holding facilities. In the case of inadequate broodstock facilities, valuable broodstock are lost to disease or adverse environmental conditions.

The key to preventing infectious diseases is to prevent the introduction of disease organisms. This can be accomplished by either developing additional pathogen free groundwater supplies or by disinfecting existing surface water supplies. However, the potential for developing additional groundwater sources is limited in many areas. Developing treatment facilities to remove disease organisms is very expensive and decisions to commit funds have been slow in coming.

When diseases do occur, only a few legally registered drugs and chemicals are available to control diseases in the hatchery, particularly during the early stages of infection. Fish pathologists employed by each agency regularly monitor fish health at their respective hatchery facilities. The Augmented Fish Health Monitoring Program, which was recently implemented by the States of Idaho, Oregon, and Washington, and the U.S. Fish and Wildlife Service with funding from the Bonneville Power Administration, increased the level of monitoring of fish health throughout the Basin.

The States of Washington, and Oregon, and the U.S. Fish and Wildlife Service each have formal fish health policies and implementation programs to detect and control infectious fish diseases. The State of Idaho is in the process of developing such a program. The fish and wildlife agencies and tribes also coordinate fish health activities by participation in the Pacific Northwest Fish Health Protection Committee which deals with fish health issues in the Columbia River Basin and elsewhere on the West Coast.

While much progress has been made in controlling fish diseases, many unanswered questions remain. Further work is needed to develop the means to control BKD and IHN, and to provide solutions to other fish health problems in the Columbia River. The Fish Disease Technical Work Group under the Northwest Power Planning Council has identified and prioritized key research activities that need to be completed at the earliest possible date.37/ In the meantime, badly needed capital improvements should be made at hatcheries to prevent the introduction of disease organisms and to provide suitable rearing and broodstock holding facilities.

## Improving Hatchery Effectiveness

Hatchery production in the Columbia River currently is approaching 200 million salmon and steelhead smolts per year. Substantial progress in doubling the current runs could be achieved by increasing the survival of these fish. While we can only speculate on the full potential for improving survival of hatchery fish, an increase in survival of just one-tenth of one percent would increase production by 200,000 adult salmon and steelhead.

One means of increasing survival of hatchery fish is to improve existing hatchery facilities. The hatchery facilities in the Columbia River Basin today range from older, antiquated facilities to newly constructed hatcheries. Hatcheries are very expensive to operate and maintain and for many hatcheries funding has been inadequate to cover basic maintenance needs. As a result, many of the older facilities are badly in need of repairs.

In a recent report to Congress, the U.S. Fish and Wildlife Service identified $17.4 million worth of essential repairs just to maintain current operations at its twelve hatcheries in the Basin. Hatcheries operated by other agencies need similar repairs. This maintenance includes rehabilitation or replacement of inadequate water supply intakes, repair of deteriorated and leaking raceways, rehabilitation of deteriorated and antiquated adult holding and spawning facilities, and repair of essential support facilities. Continued neglect of these essential repairs seriously jeopardizes maintaining production at current levels and for many facilities prevents substantive progress in improving the quality and survival of the fish produced. This trend needs to be reversed to ensure that the existing production facilities continue to contribute to, rather than hinder progress, in achieving the Council's interim goal of doubling the runs.

Survival of hatchery fish can also be increased by advancing fish culture technology through research. The Hatchery Effectiveness Technical Work Group has identified and prioritized key research activities designed to increase the effectiveness of hatchery production.38/ These activities include: 1) improving our knowledge about the role of fish nutrition in survival and perfecting better diets; 2) identifying husbandry practices, facility designs, improvements, and techniques that maximize fish quality and survival; and 3) developing release strategies to improve survival. The studies to improve hatchery effectiveness identified by the Technical Work Group should be completed at the earliest possible date in order to realize the full production potential of the large investment that has been made in Basin hatcheries by applying the research results on a production scale. At the same time, knowledge that already exists to improve hatchery effectiveness needs to be implemented as soon as possible.

<u>Hatchery Performance</u>

The large hydropower-caused fish losses, which severely impacted the commercial salmon fisheries, provided the impetus for the hatchery system we have today. Hatchery technology and development, and stock management evolved in the Basin in an attempt to keep pace with the mounting fish losses from hydropower development compounded by mixed stock harvest. Although hatcheries were never intended to fully compensate for the loss of stock diversity, productivity, and former abundance of salmon and steelhead in the Columbia River, and there is still the need to increase and reprogram hatchery production to address the impacts to the treaty Indian fishery, the current annual production of over 2 million adult salmon and steelhead by hatcheries is a major achievement.

However, many problems persist that prevent hatcheries from achieving their full potential in helping to compensate for salmon and steelhead losses. Latent bacterial kidney disease in hatchery spring chinook, which is activated by stresses encountered during migration and saltwater adaptation,<u>39</u>/ is suspected as a major cause of poor returns for many hatchery stocks of spring chinook. Steps are being taken to try to reduce the incidence of BKD in hatchery fish and to develop the means to control the disease.

Hatchery productivity has declined for some hatchery stocks in recent years and a number of hypotheses have been presented and continue to be debated to explain the decline in survival rates.40/ These hypotheses for explaining the decline in survival include: 1) poor oceanographic conditions in recent years such as lack of upwelling and high sea surface temperatures, 2) genetic deterioration of stocks, 3) accumulation of harmful fish pathogens in some populations, and 4) reaching or exceeding the carrying capacity of estuarine and ocean environments. Further research and experimentation is needed before definitive answers and a consensus among scientists can be reached on the relative importance of the major controlling mechanisms affecting survival.

The decline in survival of Spring Creek tule fall chinook in recent years is often cited to support the argument by the critics of hatcheries for a moratorium on new hatchery development. However, in the case of Spring Creek, the reduction in survival is attributed to the hatchery and its complex water treatment system not being managed properly, rather than some other factor that cannot be controlled. A number of corrective measures have been implemented at Spring Creek to improve the facility and its management. As a result, the quality of the fish produced and their survival are improving.

Spring Creek produces most of the Bonneville Pool hatchery fall chinook and historically the stock has been a major contributor to chinook fisheries on the Washington coast and in the Columbia River. The average return of Bonneville Pool hatchery fall chinook from 1970-1984 was 111,400.41/ The return in 1987 had declined to 9,100 and preliminary data indicate that about 10,000 returned in 1988.

A water treatment and reuse system was added to Spring Creek Hatchery when it was expanded in 1972 because the water supply was inadequate for the increased chinook production under the

John Day mitigation. This system uses biological filters to remove waste products from the water and aeration to replenish the dissolved oxygen before the water is reused. If reuse systems are not operated properly, particularly when the fish are growing rapidly and rearing densities are high, concentrations of waste products can reach levels where the fish become stressed. This stress may manifest itself in poor quality fish released and poor returns or, in extreme cases, in immediate mortalities.

Failure of the water reuse system at Spring Creek National Fish Hatchery coupled with other problems including heavy rearing densities in the hatchery rearing ponds precipitated an outbreak of bacterial gill disease in February 1985. Because of high mortalities the decision was made to immediately release all of the tule fall chinook into the more favorable environment in the river. These fish normally would have been released in March, April and May. Because of their poor condition and early release, survival was greatly reduced. Although a similar outbreak had not occurred in previous years, the same conditions in the hatchery that precipitated the outbreak of bacterial gill disease in 1985 probably did contribute to poor returns from previous brood years.

The Fish and Wildlife Service, in cooperation with the other fishery agencies and Indian tribes, has evaluated management of the hatchery over the past several years to determine what actions are necessary to restore the historical productivity of the hatchery and has taken several remedial steps including:

1) Moving production of upriver bright fall chinook from Spring Creek to Little White Salmon Hatchery. Bright fall chinook production was initiated at Spring Creek in 1982. Prior to 1982 the facility only reared tule fall chinook.

The hatchery had more disease problems following the introduction of bright fall chinook.

2) The rearing density of the facility was reduced substantially.

3) Additional water supplies are being developed to increase the water available for rearing which had declined in recent years.

4) The biological filtration system was rehabilitated and packed columns were installed in the aeration tower to decrease nitrogen levels;

5) The spring water source was disinfected to remove the salamander population which is a likely source of disease; and

6) A number of fish culture changes were made including reducing feeding rates, initiating continuous raceway cleaning, and prophylactic treatments for ectoparasites.

As a result of these changes, the quality of the fish released from the facility has improved dramatically and good jack returns this year are a strong indicator that overall survival is improving.

The potential for hatchery failures due to system breakdowns and human error can never be totally eliminated but much progress has been made in reducing the potential. Also, much greater emphasis is being placed on improving the quality of the fish released from hatcheries rather than on maximizing pounds and numbers released. Rearing densities have been reduced and water quality has been improved at a number of facilities.

The debate over the performance of hatcheries and their future role in compensating for fish losses is far from over. The lack of a long time series of comprehensive data for evaluating hatchery performance has hindered progress in resolving the debate. It is impossible to sort out the causes of variation in hatchery performance and fish survival without a number of years of comprehensive data. Much of the information that is currently used to evaluate hatchery performance was collected from very limited and specific experiments or to determine survival and contribution to the fisheries for a limited number of brood years. Ideally, performance of representative hatchery stocks should be monitored over a long period by collecting data on fish health, condition, overall performance at the hatchery and during downstream migration, and survival to adult and contribution to the fisheries.

It is only during the last year that data of this scope and nature has begun to be collected through the Augmented Fish Health Monitoring Program, the Smolt Monitoring Program for downstream migration, and through marking of the U.S.-Canada indicator stocks. These efforts were coordinated and integrated to ensure that the data are collected in a consistent and systematic manner to maximize its utility in evaluating the long-term performance of the representative stocks. The discontinuation of any components of the monitoring of the indicator stocks would greatly reduce the utility of the data and should be avoided. If anything, the effort should be expanded to include factors such as monitoring changes in genetic variability that may be occurring within these stocks.

# FUTURE ROLE OF HATCHERIES IN THE BASIN

The next five to ten years may be the most important period in the history of anadromous fish resource development in the Columbia River Basin. The objective of gravel-to-gravel management (i.e. management of a stock from deposition of the eggs in the gravel to return of the adults and subsequent egg deposition) may finally be achieved through implementation of the Pacific Salmon Treaty, U.S. v. Oregon settlement, and the Northwest Power Act. Natural and artificial production will be integrated into a comprehensive fish production program for the entire Basin, taking into consideration the unique problems of management of domestic and international fisheries outside the Basin. In addition, a more focused and intensive research effort and application of research results and other measures should continue to improve the control of fish diseases, reduce mainstem mortality, increase the effectiveness of hatchery production, and effectively supplement natural production with fish reared in hatcheries. Each of these actions has major implications for the future role of hatcheries.

## Pacific Salmon Treaty

The Pacific Salmon Commission, established pursuant to the Pacific Salmon Treaty between the United States and Canada, has coastwide responsibilities for management of intercepting salmon fisheries. The Treaty directs each party to conduct its salmon enhancement programs and fisheries to prevent overfishing and to optimize production. Each party also is to receive benefits equivalent to the production of salmon originating in its waters. Implementation of the Treaty through the Commission has already resulted in the control of Canadian and Alaskan harvest on Columbia River stocks.

With the current Pacific Salmon Treaty limit on interceptions, enhancement of Columbia River stocks of salmon is critically important for two major reasons. First of all, increasing production in the Columbia River helps to reduce the rate of harvest of weak stocks in the Canadian and other intercepting fisheries. The rate of harvest on all stocks in the intercepting fisheries is reduced as total production increases, provided that stock composition remains relatively constant. This increased protection applies to weak stocks in the Columbia River as well as stocks produced in other waters in the U.S. and Canada.

Secondly, limits on interceptions also ensure that the benefits of enhancement are received by the party making the investments in increased production. In the past, much of the benefit of increased production in the lower U.S. accrued to Canada and Alaska through increased harvest by those fisheries.

Thus increased artificial production as well as increased natural production in the Columbia River will play a significant role in attaining the objectives of the Treaty and rebuilding stocks coastwide. Therefore, it is important that rebuilding efforts within the Columbia River Basin are consistent with the objectives of the Treaty and compliment other rebuilding activities in order to realize the full benefits of the current and future investments in production in the Columbia River. A number of hatchery and wild stocks representing major production units in the Columbia River are being evaluated to better define stock migration characteristics and to monitor changes in harvest rates in the intercepting fisheries.

U.S. v. Oregon Settlement

The Columbia River Fish Management Plan (Plan) was recently completed after nearly five years of negotiations under U.S. v. Oregon to settle litigation over management of Columbia River salmon and steelhead. The Plan was filed with the U.S. District Court to comply with court orders to replace a five-year agreement that expired in 1982 and was recently approved by the court.

The Plan provides a framework for the fish and wildlife agencies and tribes to exercise their fishery management authorities in a coordinated and systematic manner to rebuild the fish runs in the Basin and provide for fair sharing of the harvest. Coupled with management of the ocean fisheries under the Magnuson Fishery Conservation and Management Act and the Pacific Salmon Treaty, the Plan provides the final link in harvest management of the wide ranging stocks of salmon and steelhead produced in the Columbia River Basin.

The Plan sets a goal of rebuilding upriver salmon and steelhead runs within 15 years by increasing artificial and natural production, reprogramming lower river hatchery production to the upper river, and through implementation of harvest guidelines. The Plan includes a number of short-term hatchery program adjustments which can be accomplished under existing hatchery production and funding levels. Many of the short-term hatchery program adjustments have been accomplished. The plan also includes a commitment by the parties to identify long-term program adjustments which will require additional production and funding.

A Production Advisory Committee (PAC) has been established to: 1) coordinate artificial and natural production, 2) develop annual reports containing pertinent production information, and 3) review and analyze existing and future production programs pertinent to the Plan. PAC will also work closely with the Technical Advisory Committee (TAC) to coordinate production and harvest management. TAC was established earlier under U.S. v. Oregon to develop and analyze data pertinent to harvest management of salmon and steelhead in the Columbia River.

## Pacific Northwest Electric Power Planning and Conservation Act

The Northwest Power Act provides a mandate to preserve and restore the Basin's fish runs. The Act also provides the framework for planning mitigation and compensation measures through the Council, and directs the Bonneville Power Administration to fund such measures. The system and subbasin planning process established under the Council's Program provides the forum and the resources for the fish and wildlife agencies and tribes, in consultation with other interested parties, to develop a Columbia Basin systemwide and integrated plan to achieve the Council's interim goal of doubling the present runs. System and subbasin planning will be the primary means of identifying the long-term production adjustments referred to in the Columbia River Fish Management Plan under U.S. v. Oregon.

Through system and subbasin planning, production strategies and production numbers will be developed for each stock in each subbasin. The potential of existing hatchery facilities to achieve production objectives will be evaluated and new hatchery production needed to achieve the objectives will be identified. The potential impact of hatchery management on natural stocks will be minimized by carefully evaluating genetic and other risk factors and through monitoring and evaluation of production measures. Passage mortality, habitat condition, and related environmental factors affecting survival, as well as harvest and escapement needs, will also be considered in evaluating alternatives to achieve subbasin production objectives.

The final system plan will establish the direction of hatchery development, and for the first time planning for hatchery and natural production and resulting harvest will be integrated into a comprehensive systemwide plan. To remain dynamic, the system plan will be modified and refined periodically by the fish and wildlife agencies and tribes, in consultation with other interested parties, and consistent with the Council's Program amendment process. Increased production resulting from implementation of the plan will help achieve the Council's interim doubling goal, assist in attaining the objectives under the Pacific Salmon Treaty, and help fulfill agreements reached under U.S. v. Oregon.

However, much of the anticipated progress under the Council's Program in improving existing hatchery and natural production and adding new production is dependent upon substantive progress in improving mainstem passage. The maintenance and improvement of self-sustaining natural production, and increased effectiveness of hatchery production above Bonneville dam are dependent on efforts to improve juvenile fish survival through flow enhancement, installation and improvement of juvenile fish bypass facilities, provision of interim spill at projects with inadequate or no bypass facilities, and improved transportation of fish around the dams and reservoirs.

Finally, progress under the Program will be hindered unless an adequate funding base is obtained for the existing hatcheries in the Basin. For several years funding of many hatcheries has been inadequate to cover operation and maintenance costs in addition to maintaining production levels. Maintenance at many hatcheries has been foregone in order to maintain production levels. Many of the facilities are badly deteriorated and in need of major rehabilitation. As a result, while production levels had been maintained until 1987, further postponement of major repairs at some hatcheries will result in the reduction of production levels because of facility conditions. The progress that has been made over the past four decades in compensating for anadromous fish losses is threatened unless an adequate and stable funding base for existing hatcheries can be secured.

## SUMMARY OF EXISTING AND FUTURE NEEDS RELATED TO HATCHERY PRODUCTION IN THE COLUMBIA RIVER BASIN

1. Substantial progress must be made in improving juvenile fish survival during downstream migration in order to maintain and improve natural production and increase the effectiveness of hatchery production above Bonneville dam. Progress in these areas will determine to a great extent the scope of new hatchery production in the Basin.

2. Further work is needed to develop the means to control BKD and IHN and to solve other fish health problems in the Columbia River. Critically needed research activities identified by the Fish Disease Technical Work Group, and capital improvements to hatcheries to prevent the introduction of disease organisms and to provide suitable rearing and broodstock holding facilities need to be completed at the earliest possible date.

3. Adequate funding must be secured to support the operation and maintenance needs of existing hatcheries in the Columbia River Basin. Deferral of essential repairs to existing hatcheries has occurred because of limited funding. This trend needs to be reversed to ensure that existing production facilities contribute to, rather than hinder, progress in achieving the Council's interim goal of doubling the runs.

4. Effective supplementation techniques need to be developed. The steps necessary to accomplish this objective, identified by the Supplementation Technical Work Group, need to be implemented as soon as possible.

5. Stocks used to supplement natural production should be maintained as genetically similar as possible to the existing local stocks.

6. The means to adequately measure, monitor, and evaluate genetic concerns need to be developed including the collection of baseline genetic information on stocks.

7. Hatcheries represent a significant repository of genetic diversity that must be maintained through improved management. Practices within the hatchery environment that result in the selection of undesirable traits, or the loss of desirable traits, should be eliminated to reduce genetic risk.

8. Data for evaluating long-term hatchery performance should continue to be collected in a systematic manner through the Augmented Fish Health Monitoring Program, the Smolt Monitoring Program, and through marking of the U.S.-Canada indicator stocks.

9. Studies to improve hatchery effectiveness identified by the Hatchery Effectiveness Technical Work Group should be completed at the earliest possible date in order to realize the full production potential of the large investment in hatcheries in the Basin by applying new research findings on a production scale. Knowledge that currently exists to improve hatchery effectiveness needs to be implemented as soon as possible.

10. Rebuilding stocks within the Columbia River Basin should be consistent with the objectives of the Pacific Salmon Treaty and compliment other restoration activities in order to realize the full benefits of the current and future investments in production in the Columbia River.

# FOOTNOTES

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