Go To Next Part

740,000 acre-feet in 1975 (Figure 39). Based on statistics available for 1966, the federal projects represented about 33 percent of the total water diverted. The Umatilla, Walla Walla, John Day, Deschutes, and Hood River basins collectively diverted about 2.3 million acre-feet; the Willamette River diverted 569,000 acre-feet (Pacific Northwest River Basins Commission 1971). Diversions in these two areas represented annual depletions of about 1 million and 0.2 million acre-feet, respectively.

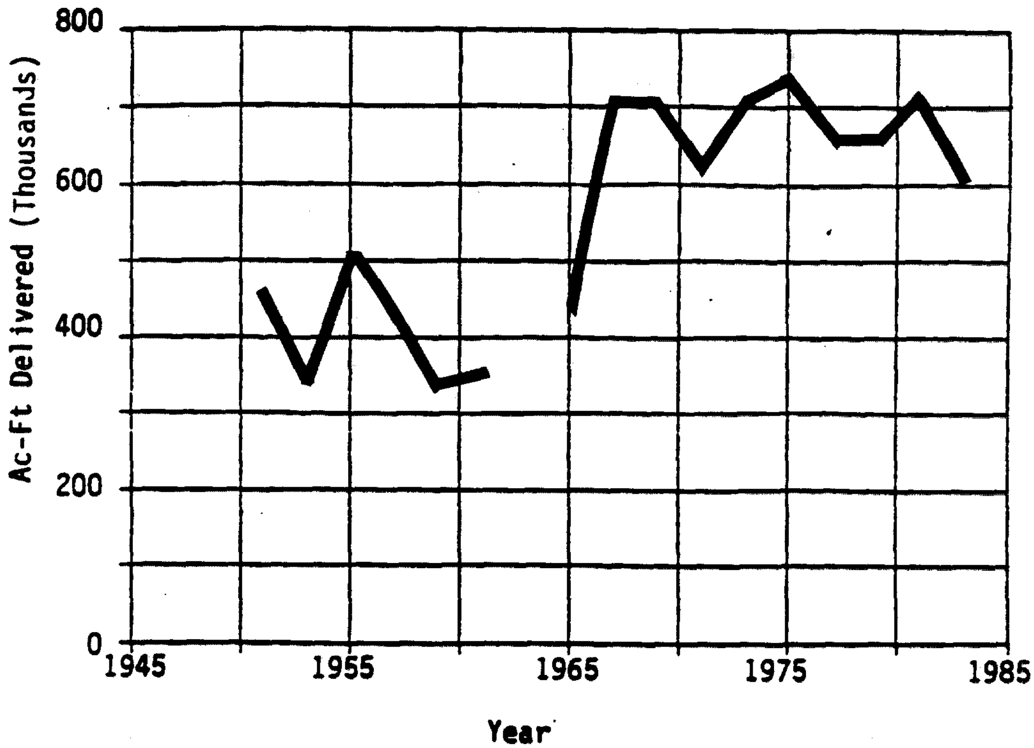

Figure 39. Total irrigation water diverted (acre-feet) by federal projects in the lower Columbia River area (BOR 1947-1983). (Discontinuous curve reflects data gaps.)

Irrigation development has been identified as the primary cause or a major contributor in reducing salmon and steelhead runs in lower Columbia River tributaries (Fulton 1968; 1970). The losses are due to unscreened diversions and relatively low flows during the summer. Major rivers known to be affected by irrigation in the lower Columbia River area include the Deschutes, Hood, John Day, McKenzie, Santiam, Touchet, Umatilla, and Walla Walla (Fulton 1968; 1970). Stober et al. (1979) also concluded that anadromous runs were almost eliminated throughout the Umatilla due to irrigation withdrawals and concomitant low flows. Of these eight drainages, the Touchet, Umatilla, and Walla Walla rivers were identified as being affected solely by irrigation withdrawals. Primary species affected in these three drainages were spring chinook and steelhead in the Umatilla, spring chinook in the Touchet, and steelhead in the Walla Walla. All of these drainages are located in areas that exhibited considerable irrigation development in the early to mid-1900s, a period when unscreened diversions were common. Fish habitat in the lower mainstem portion of the Columbia River probably has been affected by water diversions in the middle and upper portions of the basin. However, it is not possible to quantify these effects in terms of numbers of fish lost.

5.7.1.2 Columbia River Between Its Confluence with the Snake River and Chief Joseph Dam

Irrigation development in this area has consistently ranked second highest of the four areas. The first efforts occurred in the 1840s in the Yakima drainage and the 1850s in the Chelan-Okanogan area (Pacific Northwest River Basins Commission 1971).

Development proceeded rapidly after 1870 to 0.5 million acres irrigated in 1925 (Figure 40). Development leveled off until the 1950s, when rapid expansion occurred again. An important aspect of irrigation development in this area was that federal funding has supported a major part of the projects. The increase in the last 20 years is largely attributed to the Columbia Basin Project. The volume of water provided by federal projects has increased from about 1 million acre-feet in 1955 to 4.8 million acre-feet in 1979 (Figure 41). In 1966, a total of about 5.5 million acre-feet was diverted (Pacific Northwest River Basins Commission 1971). Of this, federal projects accounted for annual depletions of 2.6 million acre-feet for the Ferry-Stevens, Chelan-Okanogan, and Big Bend areas and 1.1 million acre-feet for the Yakima area.

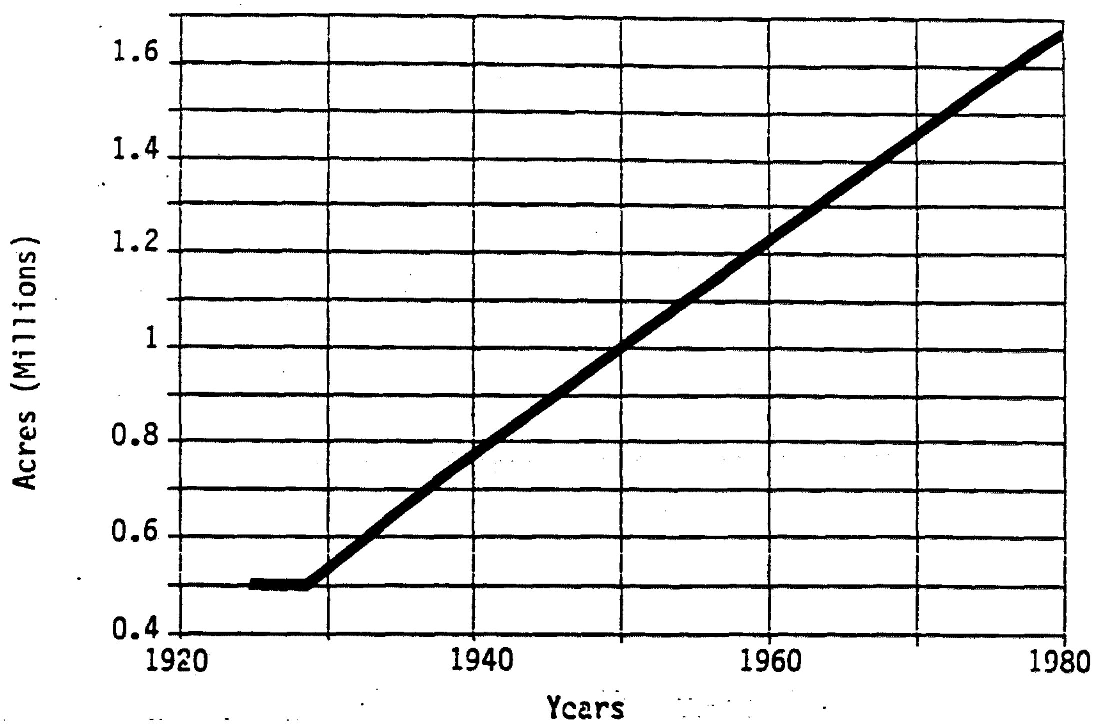

Figure 40. Total acres irrigated in the middle Columbia River area (Columbia River Water Management Group 1983).

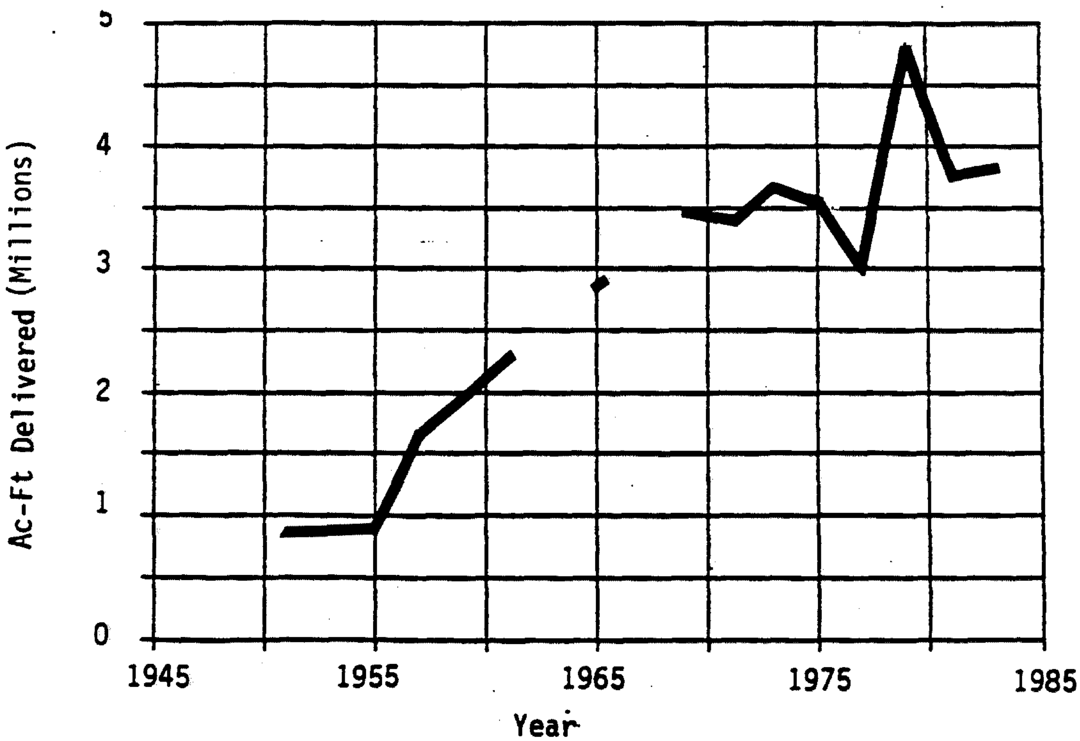

Figure 41. Total irrigation water diverted (acre-feet) by federal projects in the middle Columbia River area (BOR 1947-1983). (Discontinuous curve reflects data gaps.)

The predominant irrigation areas in this section are the Okanogan and Yakima, which have been important since the early 1920s (Table 28). The Columbia Basin Project, which provides water from mainstem pools, and the Big Bend area have become significant contributors since about 1960.

Most of the irrigation development in the middle Columbia area has been aided by multipurpose water projects. A total of 43 multipurpose dams in the middle Columbia area designate irrigation as a purpose. Multipurpose dams, by drainage, include 18 in tributaries of the Columbia River, seven in the Okanogan, seven in the Yakima, four in the Methow, four in the Wenatchee, and three in the Naches (Appendix C, Table C-1). Based on storage capacities, the largest projects include the North Dam (1,275,000 acre-feet) and O'Sullivan Dam (552,000 acre-feet) in the Columbia River drainage; and the Tieton Dam (203,500 acre-feet) and Cle Elum Dam (710,000 acre-feet) in the Yakima River drainage. A total of 12 dams, located in tributaries of the Columbia, Wenatchee, and Yakima Rivers (Tables 29, C-1), are exclusively for irrigation in the middle Columbia area. Except for several dams on the Columbia River tributaries, the storage capacity of these dams is small (less than 300 acre feet).

Salmon and steelhead resources have been affected by irrigation in the middle Columbia River. For example, in the Yakima River, predevelopment runs of about 600,000 salmon were drastically reduced from 1890 to 1905, which coincided with intense irrigation development (Davidson 1953; Stober et al. 1979). Dams, unscreened diversions, low flows, and high temperatures have contributed to the reductions primarily of spring chinook and steelhead. Other drainages affected by irrigation include the Methow and Wenatchee rivers (Fulton 1968; 1970). The Methow has been affected by irrigation withdrawals, while the Wenatchee was affected by unscreened irrigation diversions and low flows. Since 1970 when screening was completed at most sites in the middle Columbia area, problems with entrainment have decreased.

5.7.1.3 Columbia River Above Chief Joseph Dam

Irrigation development in this area began in the 1840s and 1850s at several locations in Montana. Development was slow and intermittent until the 1890s and 1900s, when completion of railroads spurred settlement. As a result of private and federally financed projects, irrigation has gradually

Table 29 - Total storage capacity of dams constructed exclusively for irrigation by major drainages in the Columbia River Basin.

	Storage Capacity Acre Feet		Storage Capacity Acre Feet	% Total
Lower Columbia[1]				
Columbia	190			
Crooked	6,310	Tualatin	54,738	
Deschutes	249,812	Umatilla	300	
Klickitat	15	Walla Walla	290	
Lewis	74	White	106	
Lukiamute	166	Willamette	2,286	
Santiam	91	Yamhill	862	
		TOTAL	315,240	29%
Middle Columbia[3]				
Columbia	27,120	Yakima	35	
Wenatchee	250			
		TOTAL	27,405	3%
Upper Columbia[4]				
Columbia	92			
		TOTAL	92	0%[5]
Snake River				
Big Wood	33,283	Owyhee	56,590	
Burnt	28,827	Payette	34,723	
Little Salmon	6,218	Powder	7,804	
Malheur	44,082	Salmon	308	
North Fork Payette	81	Snake	522,274	
		Weiser	3,954	68%
		TOTAL	738,144	
		BASINWIDE TOTAL:	1,080,881	100%

[1]See Table 20 regarding storage capacity of multipurpose and hydropower dams.

[2]Columbia Basin below the confluence with the Snake River.

[3]Columbia Basin between the confluence with the Snake River and Chief Joseph Dam.

[4]Columbia Basin above Chief Joseph Dam.

[5]0.009%

increased in the upper Columbia River area since the early 1900s (Figure 42). Although federal irrigation projects have contributed to irrigation since 1911, the greatest contribution occurred from 1967 to 1971 (Figure 43). In 1966, federal projects provided about 40 percent of the estimated 2 million acre-feet diverted in the upper Columbia River area (Pacific Northwest River Basins Commission 1971). This federal share represented an annual diversion of 0.7 million acre-feet.

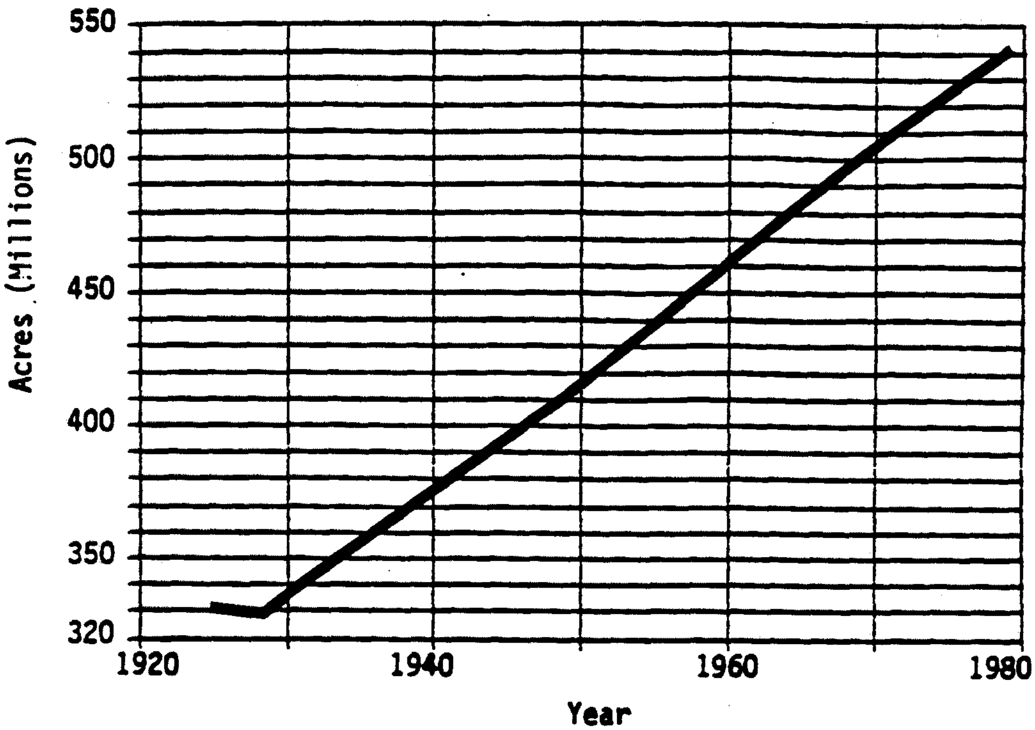

Figure 42. Total acres irrigated in the upper Columbia River area including some areas of Montana that were never used by salmon and steelhead (Columbia River Water Management Group 1983).

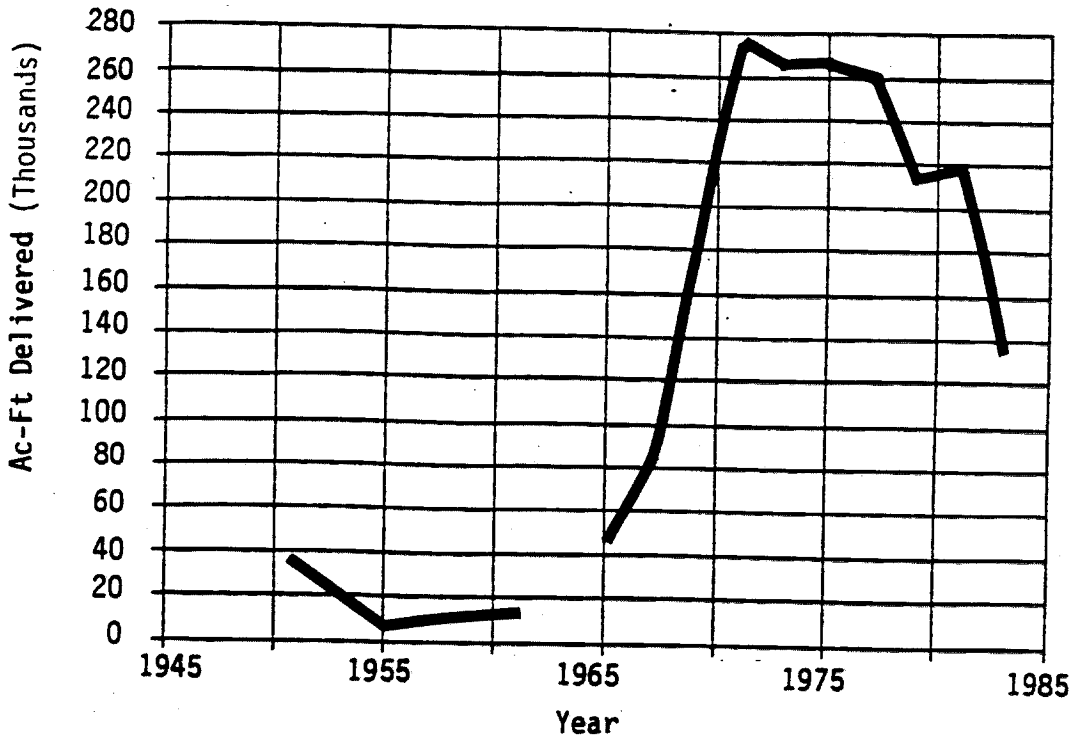

Figure 43. Total irrigation water diverted (acre-feet) by federal projects in the upper Columbia River area (BOR 1947-1983). (Discontinuous curve reflects data gaps.)

Multipurpose dam projects have provided most of the irrigation water in this area. Twelve multipurpose projects have specified irrigation as one of their several purposes. Of these, Grand Coulee Dam is the largest. Only one project has been constructed exclusively for irrigation in this area. The dominant irrigation areas in the upper Columbia River area include the upper Clark Fork, Bitterroot, and Flathead Irrigation District (Table 28); however, salmon and steelhead have never used these areas.

5.7.1.4 Snake River Area

Of the four Columbia River areas, the Snake River has continually ranked highest in amounts of land irrigated and water diverted. Irrigation development in the Snake River area began in the 1860s and grew rapidly due to private individuals and corporations (Pacific Northwest River Basins Commission 1971). Irrigated land in the Snake River area has increased from about 1.7 million acres in 1925 to 4.5 million acres in 1980 (Figure 44). The Boise Bureau of Reclamation Project of 1902 was the first federal irrigation project in the Snake River Basin. Although federal projects provided about 2 million acre-feet per year from 1947 to 1961, the largest contribution occurred after 1966 when volumes exceeded 7 million acre-feet annually (Figure 45). In 1966, the total amount of water diverted for irrigation in the Snake Basin was estimated at 21 million acre-feet (Pacific Northwest River Basin Commission 1971).

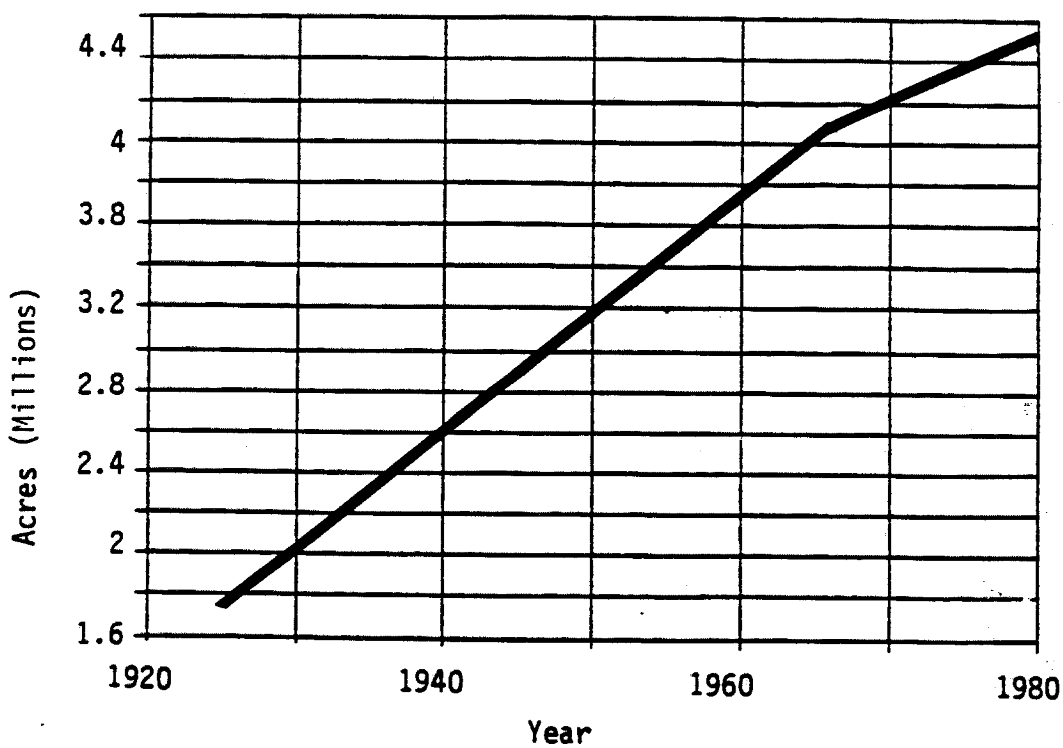

Figure 44. Total acres irrigated in the Snake River area (Columbia River Water Management Group 1983).

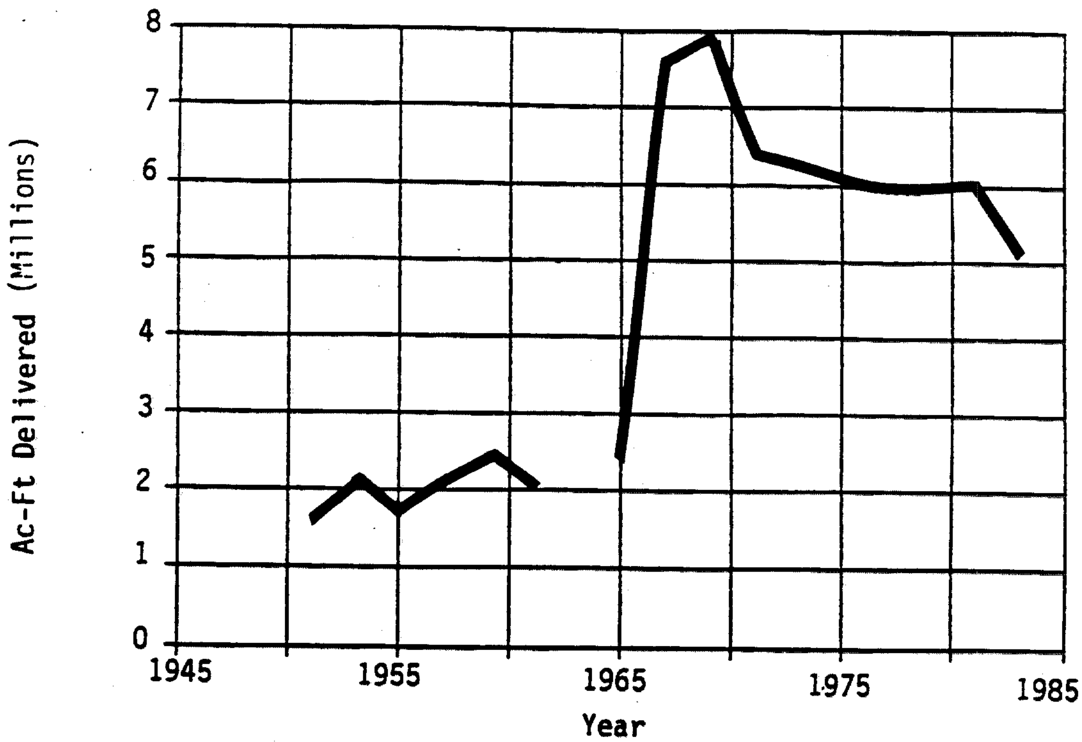

Figure 45. Total irrigation water diverted (acre-feet) by federal projects in the Snake River area (BOR 1947-1983). (Discontinuous curve reflects data gaps.)

The storage capacity of these dams is 738,144 acre-feet. In descending order, projects in the Snake, Owyhee, Malheur, Payette, Big Wood, and Burnt drainages store the largest quantities of water. A number of projects store over 20,000 acre-feet each. In addition to the irrigation dams, there are 37 multipurpose dams in the Snake River area (Appendix C, Table C-1). The majority of these dams are located in the Snake (13), Boise (5) and Payette (4) drainages. The largest storage capacity for the multipurpose dams include the Owyhee Dam (1,120,000 acre-feet) on the Owyhee River, Anderson (509,000 acre-feet) and Arrowrock dams (301,000 acre-feet) on the Boise River, and Cascade Dam (860,000 acre-feet) on the Payette River.

Although dams caused total elimination of fish runs in the Boise River, Burnt Creek, Pine Creek, and the Weiser River, irrigation withdrawals already had reduced the numbers of fish prior to dam construction. Anadromous fish losses in the remaining eight rivers were caused by a combination of several developments. Observations by Parkhurst (1950a, b, c) confirm diversion problems in many of the rivers listed above, as well as the Payette River. The Pacific Fishery Management Council (1985) also has identified irrigation diversions, in combination with dams or channelization, as reducing anadromous fish runs in the mainstem of the Snake River and Grande Ronde River. The most critical period for anadromous fish losses probably occurred during intensive irrigation development when diversions were unscreened (1880 to 1940s in Washington; 1880 to 1970s in Oregon and Idaho).

5.7.2 Impacts of Agriculture/Irrigation on Salmon and Steelhead

Agricultural practices have affected anadromous fish resources in the Columbia River Basin. The most severe impacts, not directly related to irrigation, are attributed to removal of stream corridor vegetation and channelization of streams. These practices have resulted in erosion, causing large amounts of sediment to flow into streams.

The impacts of irrigation activities on salmon and steelhead can be divided into four categories: 1) changes in water quality associated with return flows; 2) water level fluctuations and flow alterations due to diversions and dams; 3) obstruction to fish passage and loss of habitat due to dams; and 4) entrainment and impingement in intake systems (Stober et al. 1979).

Problems associated with return flows (irrigation water flowing off of irrigated fields back into streams) from irrigation include increases in temperature, sediment loads, phosphates and nitrates, pesticides, salinity, parasitic nematodes and coliform bacteria (Whitney and White 1984). The potential impacts on anadromous fish include temperature-caused effects on smolts, adult migration, and spawning; nematode infestations; direct toxicities (pesticides); habitat degradation (sediment); and alterations in nutrients and salinity. Although these problems exist throughout most of the Columbia River Basin, the most evident impacts are found in areas with concentrated irrigation efforts, such as the Yakima Valley and the lower mainstem sections of the Columbia River, where cumulative impacts of return flows are more pronounced (Whitney and White 1984).

Numerous problems have been associated with water level fluctuations and flow alterations due to water storage and withdrawals for irrigation. According to Stober et al. (1979), the major effects on anadromous fish include reduction in food sources; loss of important spawning, rearing, and adult habitat; increased susceptibility of juvenile salmonids to predation; delay in adult spawning migration; increased egg and alevin (fish that have hatched but not migrated out of the gravel) mortalities; stranding of fry; and delays in downstream migration. Except for food sources, all these impacts are related to the effects of flow alterations and water level fluctuations on the preferred depth, flow, substrate, temperature, and other habitat requirements for salmon and steelhead. Instream flow studies have shown that significant reductions in salmonid habitat have occurred on the mainstem Columbia during low water years (Karr 1982). Also, irrigation diversions often completely dry up or seriously dewater tributary streams in the upper basin, even in average water years (Chaney 1978).

Critical periods for salmon and steelhead include juvenile migration from April to June and adult spawning in the summer and fall. Water withdrawals during these periods can dewater eggs, trap pre-emergent fry, and strand young fish. Relatively higher water temperature during low flow combined with warm irrigation return flows also can inhibit salmon migrations, as observed in the Yakima, Okanogan, and Snake rivers (Stober et al. 1979). In addition, low water levels can concentrate fish, which makes them more susceptible to predation and disease.

Irrigation dams also represent temporary and permanent blockages to adult spawning migrations and smolt outmigration. See discussion in Section 4.3 on impacts of water storage projects on fish. As noted there, many storage projects are built and operated for irrigation purposes as well as for hydropower generation and other uses.

The impingement of juvenile salmon and steelhead on intake screens and entrainment into the intake systems also have contributed to fish losses due to irrigation. As water is withdrawn during the irrigation period (April to October), fish become stranded in the canals and eventually die. Based on surveys summarized by Corely (1963), fish losses in irrigation canals were large. The U.S. Bureau of Fisheries recovered 4,000 fish in irrigation canals on the Yakima River during one summer, which represented a potential loss of five million fish for the entire system. Similarly, the Oregon Fish Commission caught approximately 51,000 juvenile salmon in 14 different irrigation canals in 1956. An estimated 422,000 salmon fingerlings died in irrigation canals in the Lemhi River near Salmon, Idaho.

An important characteristic of the intake structures for irrigation was that no protective screens were used to direct fish until the 1930s in Washington and the 1960s and 1970s in Oregon and Idaho (National Marine Fisheries Service 1981; Easterbrook 1985). Assuming that irrigation began around 1890, this represents 40 to 60 years of unscreened diversions in Washington and 70 to 80 years in Oregon and Idaho.

However, the problem has not been eliminated, as shown in recent inspections of screens. Surveys on the Columbia River between McNary Dam and Lewiston, Idaho, revealed that 34 of 95 sites did not meet the federal criteria for intake velocities and/or screen mesh sizes (Swan 1981). Similar inspections at 205 intake sites between Bonneville Dam and Lewiston, Idaho, and between Priest Rapids and Wells Dam indicated that 24 sites had damaged screens or contained no screens at all (Swan et al. 1980). The installation of protective screens for irrigation intakes also has caused mortalities due to impingement (Swan et al. 1980), although there appear to be no studies quantifying losses.

5.7.3 Reducing the Adverse Effects of Agriculture/Irrigation

The adverse effect of farming could be controlled and probably eliminated through improved agricultural practices and enforcement of the laws designed to protect instream resources.

The installation of screens on intake structures is one measure used to compensate or minimize impacts due to irrigation. Most of the screens in Oregon and Idaho were installed using funds provided by the Mitchell Act, a multipurpose mitigation program described in Chapter 6. Most of the screens in Washington were installed with federal and state funds (Easterbrook 1985). Screens are maintained by the state and federal fish agencies. Although there are regulations concerning mesh size and approach intake velocities, screen inspections have identified problems in adhering to these requirements and in their enforcement (Swan et al. 1980).

The issue of protecting fish from flow depletion has been addressed only recently in the Columbia Basin (Thompson 1976b). Minimum stream flows in Washington have been established in the mainstem Columbia, Wenatchee, Methow, and Okanogan basins. The Oregon Water Policy Review Board has adopted minimum flows on over 300 streams throughout the state, but enforcement has not been strict. In Idaho, minimum flow requirements have been established in the mainstem Snake River and 12 tributaries of the Snake. Although minimum stream flows represent a potential mitigation measure for the effects of irrigation, they have not been implemented on a large scale in the Columbia Basin.

5.7.4 The Current Status of Agriculture/Irrigation Impacts on Fish

Agriculture currently affects anadromous fish habitat through soil erosion that causes sediment loading of streams. The toxic effects of herbicides and pesticides in runoff from farm lands is also a problem (Thompson 1976b). Farm practices, however, are tending towards minimizing erosion in order to conserve top soil. These efforts should help reduce the amount of sediment deposited in streams because of farming.

Impacts associated with irrigation continue to contribute to salmon and steelhead losses in the Columbia River Basin. A major problem in the basin is the effect of water storage, diversions and return flows on stream flow and therefore the amount of habitat available to salmon and steelhead. Flow alterations and water level fluctuations also affect the timing of life history events such as smolt out-migration. Although maintaining minimum flows for fish is becoming an important objective of fish managers, few such programs with primary considerations for fish have been implemented in the basin.

5.8 URBANIZATION/POLLUTION

5.8.1 Overview

Non-Indian settlement of the Columbia River Basin began in earnest around the mid-1800s, with many of the early immigrants settling in the Willamette Valley. In 1850, Congress passed the Donation Land Act (Act of Sept. 27, 1850, 9 Stat. 496), which gave settlers large tracts of federal land at no cost (Craig and Hacker 1940). Agriculture, mining, fishing and logging contributed to the early economy of the basin. Substantial growth occurred in the basin after completion of the transcontinental railroad around 1890. For example, from 1880 to 1890 population increased from 75,000 to 357,000 for the state of Washington; from 143,000 to 259,000 for Oregon; and from 33,000 to 89,000 for Idaho. Population also increased rapidly between 1900 and 1910 because of increased innovations in irrigation and the logging industry. Population from about 1900 to the 1980s has increased steadily (Figures 46, 47, and 48).

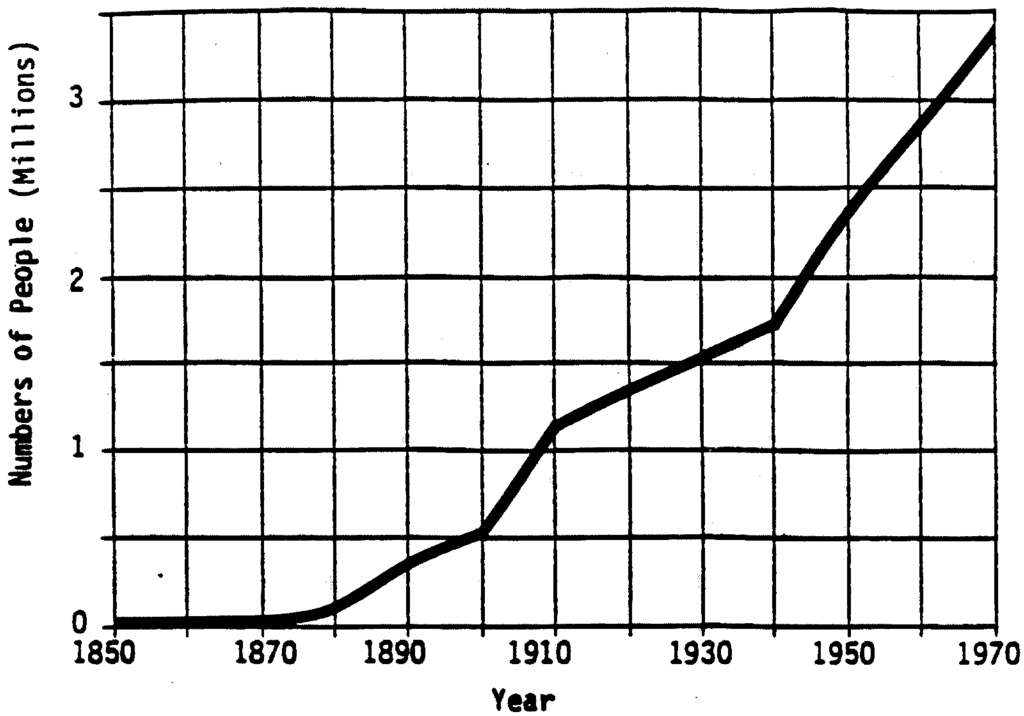

Figure 46. Population growth in Washington from 1850-1980 (U.S. Department of Commerce 1850-1980b).

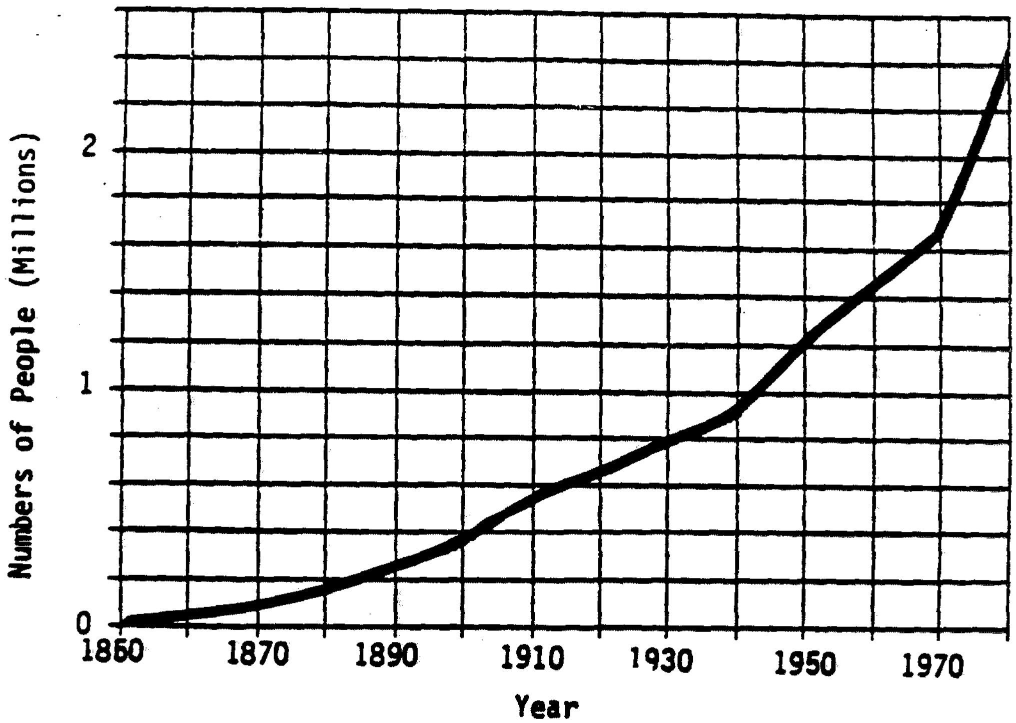

Figure 47. Population growth in Oregon from 1850-1980 (U.S. Department of Commerce 1850-1980b).

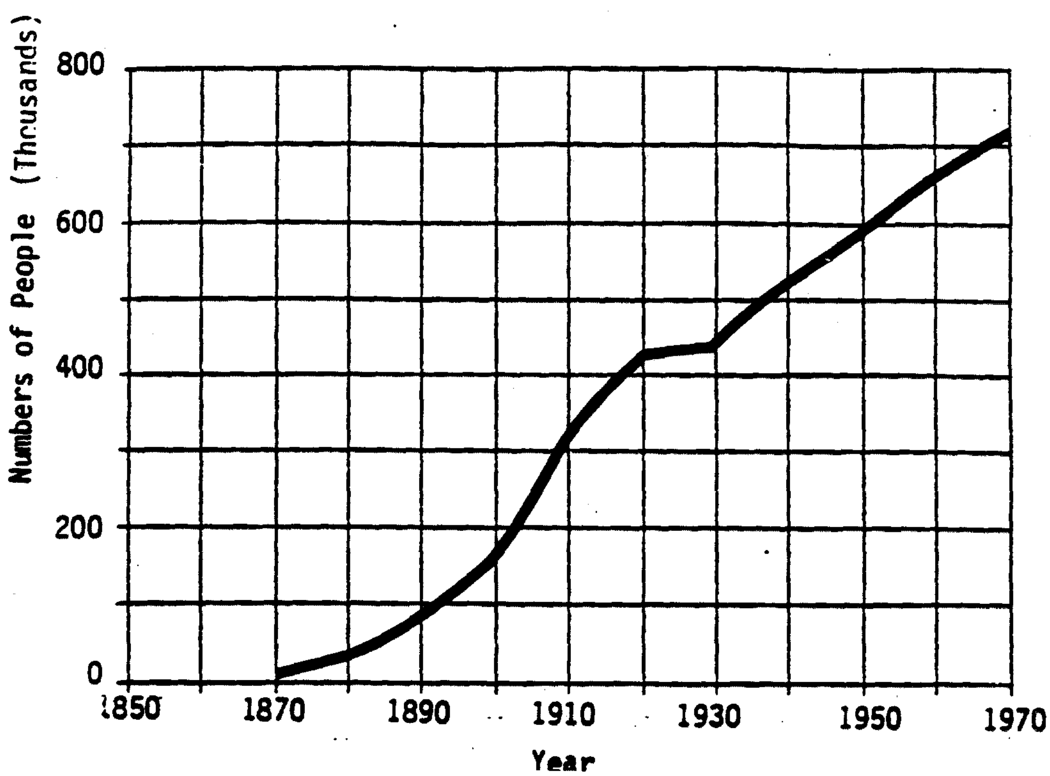

Figure 48. Population growth in Idaho 1850-1970 (U.S. Department of Commerce 1850-1970b).

Numbers of people employed in manufacturing also have been plotted (Figure 49, 50, and 51) as a means of characterizing manufacturing growth. The number of people employed in manufacturing has increased steadily except for the early 1930s (Great Depression) and 1974 to 1975 (general recession).

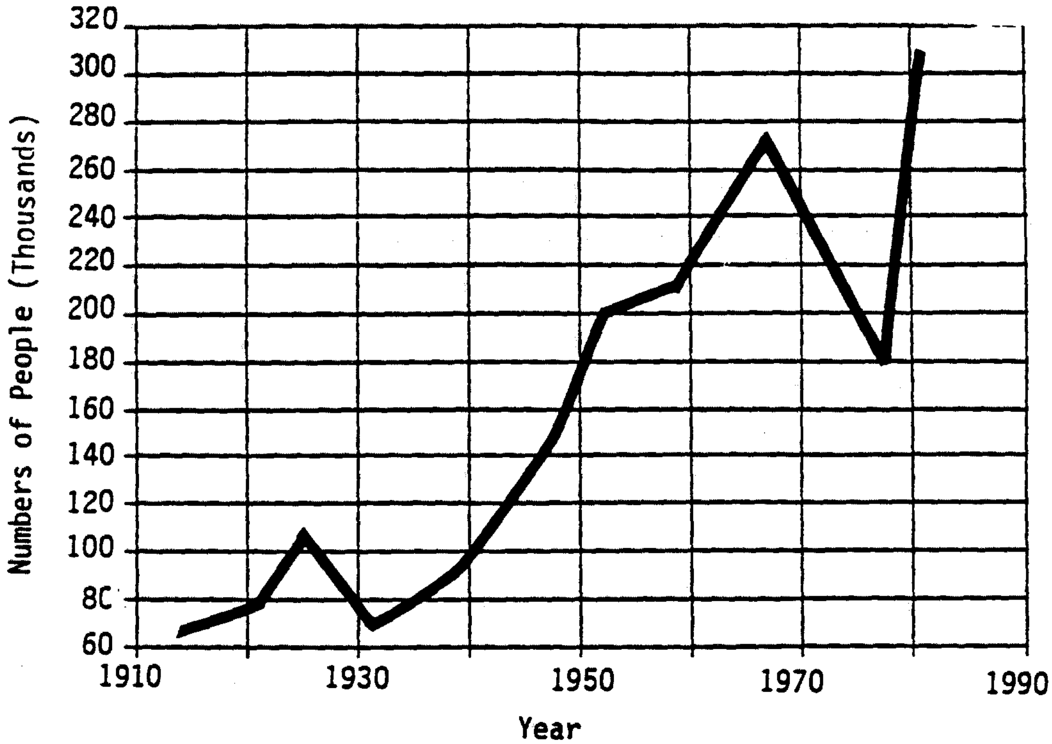

Figure 49. Numbers of people employed in manufacturing in Washington from 1910 to 1981 (U.S. Department of Commerce 1910-1981b).

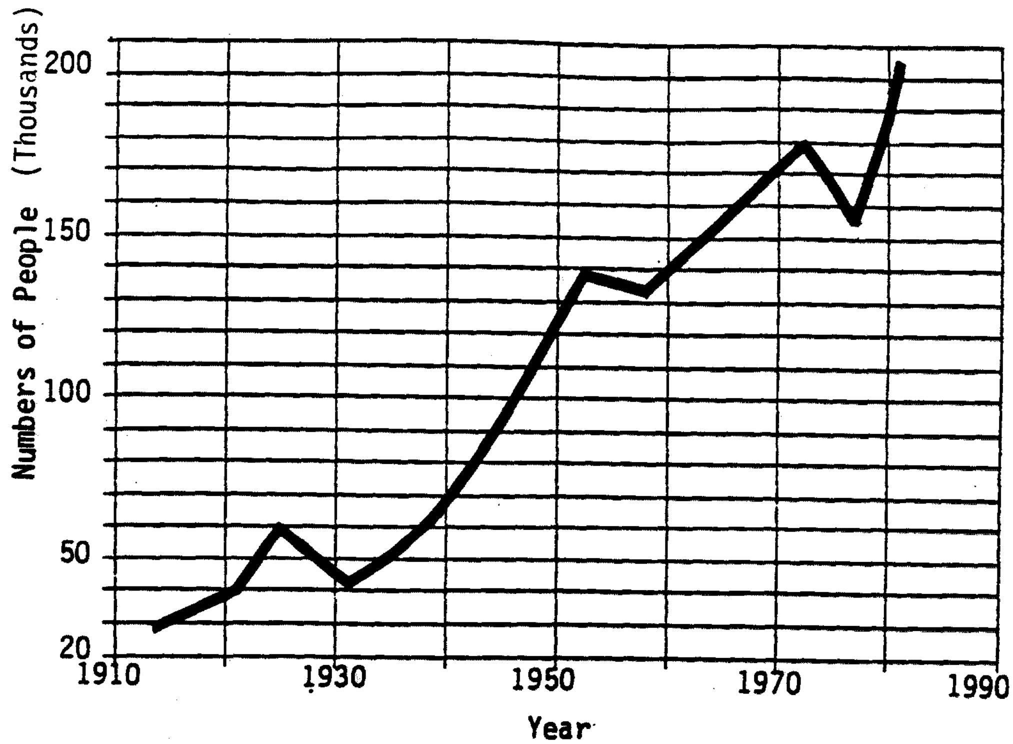

Figure 50. Number of people employed in manufacturing in Oregon from 1910 to 1981 (U.S. Department of Commerce 1910-1981b).

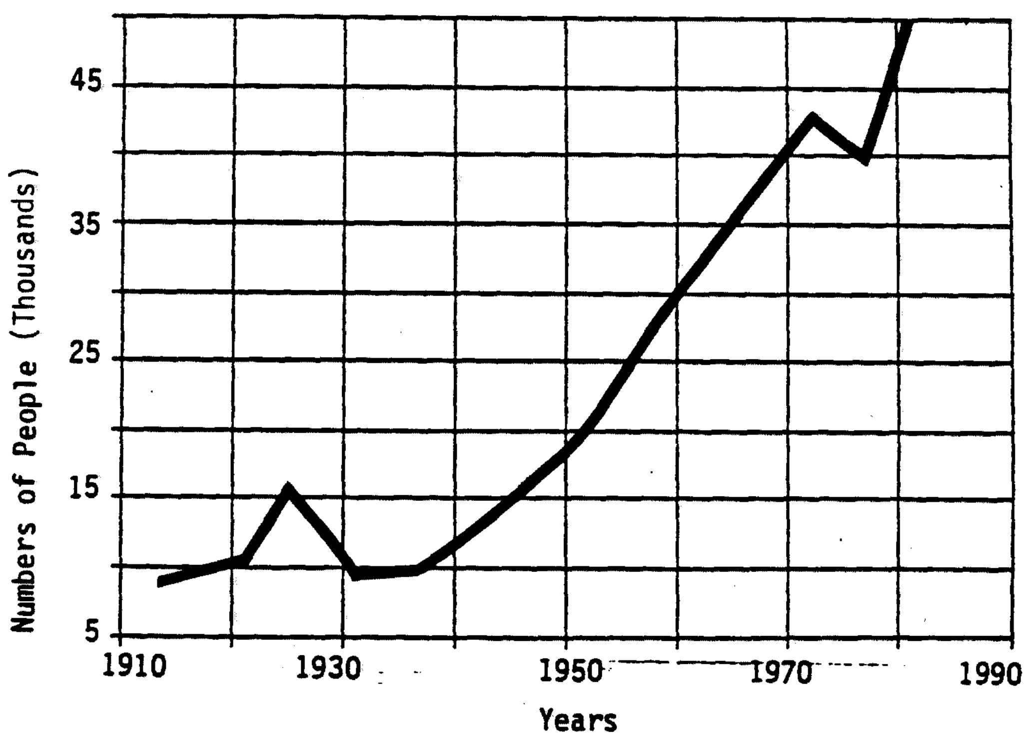

Figure 51. Number of people employed in manufacturing in Idaho from 1910 to 1981 (U.S. Department of Commerce 1910-1981b).

Urbanization of the basin brought many forms of disturbance that adversely affected the salmon and steelhead resources of the Columbia River Basin. Adverse impacts from land clearing, construction, road building, stream channelization, removal of riparian vegetation, and pollution are a few results. Of these, stream pollution in the form of discharges from various municipalities and industries probably has had the most adverse effect on the anadromous fish habitat in the Columbia Basin. Effluents from sewage treatment plants, pulp and paper mills, and aluminum plants produced most of the pollution, especially in the Willamette River Basin. Increased run-off, resulting in urban nonpoint source pollution, also has affected streams.

Concerns over water pollution were publicized in the 1940s when several studies were conducted in the Willamette River drainage and in the lower Columbia River (Fish and Rucker 1950; Fish and Wagner 1950). The Willamette River was the most heavily polluted drainage due to point source discharges (pollution from a relatively specific site as opposed to precipitation runoff). Other rivers with significant levels of local pollution included the lower Cowlitz, Umatilla, John Day, Deschutes, Klickitat, Wind, and Sandy rivers.

Major types of water pollution identified during the 1940s included reduced dissolved oxygen (DO) levels and direct toxicity due to sulfite liquours from the pulp and paper industry. Depressed DO levels were due largely to high concentrations of oxygen-consuming wastes. Metal toxicity resulted mainly from the effects of the metal mining industry.

Rapid population growth also demanded increased water supplies, which resulted in the development of dams exclusively for water supply in addition to multipurpose dams. Table 30 shows the number of dams in the Columbia River Basin used for municipal water. The two lower Columbia River areas and the two Snake River area analyses have been combined due to difficulties in separating data for these areas. The Snake River area tops the list with 24 dams used partly or exclusively for water supply. The lower Columbia River area totals 14 water supply dams; the Columbia River above Chief Joseph Dam has two; and the Columbia River area between the confluence of the Snake and Chief Joseph Dam has one.

Table 30 - Dams constructed for water supply purposes by major drainages in the Columbia River Basin.

	Built Exclusively for Water Supply Purposes	Built for More Than one Purpose, Including Water Supply
Lower Columbia River Area[1]		
Big Sandy	2	0
Columbia	5	0
Deschutes	0	1
Klickitat	1	0
Lewis	1	1
Willamette	1	1
Yamhill	2	0
	12	3
Middle Columbia River Area[2]		
Columbia	0	1
	0	1
Upper Columbia River Area[3]		
Columbia	0	1
Spokane	0	1
	0	2
Snake River Area		
Bruneau	0	1
Burnt	0	1
Clearwater	0	2
Grande Ronde	1	0
Lemhi	0	1
Little Salmon	0	1
North Fork Payette	0	1
Payette	0	3
Powder	1	0
Salmon	0	2
Snake	1	5
Wallowa	0	2
Weiser	0	2
	3	21
TOTAL FOR BASIN	15	27

[1]Columbia Basin below the confluence with the Snake River.

[2]Columbia Basin between the confluence with the Snake River and Chief Joseph Dam.

[3]Columbia Basin above Chief Joseph Dam.

The following sections describe urbanization and pollution and related impacts to salmon and steelhead resources in the six areas of the Columbia River Basin. Note that the two lower Columbia River areas and the two Snake River areas analyses have been combined due to difficulties in separating data for these areas.

5.8.1.1 Lower Columbia River Area

Population growth, urbanization, and the resulting water pollution are most extreme in the Willamette River Basin, especially in the middle and lower portions. During the 1940s, the accumulation of various wasteloads dumped into streams in the Willamette drainage created an "oxygen block" to migrating fall salmonids (Fish and Rucker 1950). Dissolved oxygen levels frequently decreased to below 3.0 parts per million throughout the summer in the lower Willamette River, particularly in the Portland harbor area. The low concentrations usually disappeared in mid- to late September with increased river discharge (Fish and Wagner 1950). According to Fish and Wagner (1950), Willamette River tributaries that suffered serious or potentially serious pollution problems were the Long Tom, Marys, Rickerall, South Santiam, Yamhill, Molalla, Pudding, Tualatin, and Clackamas rivers.

Drainages cited as potentially hazardous to fish life in 1943 because of pollution include Camas, Multnomah, and Columbia Sloughs and the lower Cowlitz River (Fulton 1970). The pulp and paper industry, as well as domestic sources, were responsible for this pollution.

In 1971, 19 thermal, 15 industrial, and 21 domestic point sources contributed to the pollution load in the lower Columbia River below Bonneville Dam (Fulton 1970). Besides localized increases in water temperature due to thermal effluents, pollutants included organic and inorganic solids (mostly wood products), suspended combustible solids (from pulp and paper mills), mercury compounds, phenols, cyanides, fluorides, chlorine, thiosulfates, organic phosphates, and acrolein.

Recent studies at the John Day fishway indicate that concentrations of heavy metals (cadmium, copper, lead, and zinc) and fluoride may be at concentrations high enough to modify behavior of migrating salmonids (Damkaer and Dey 1985). The source of these pollutants is discharge from a nearby Martin-Marietta aluminum plant. Although research results are inconclusive, it appears that fluoride concentrations near 0.5 milligrams per liter may delay migration of fall chinook salmon, by causing them to avoid the area (Damkaer and Dey 1985). Discharges of fluoride were greatly reduced in 1983 and thereafter when the aluminum plant began using a landfill storage system for pollutants (Damkaer and Dey 1985).

5.8.1.2 Columbia River Between Its Confluence with the Snake River and Chief Joseph Dam

The major cities in this region are Richland, Kennewick, Pasco, and Wenatchee, Washington. The major point source effluent of pollution identified for this area is the cooling water discharges from the dual-purpose Nuclear Reactor/Hanford Generating Project (HGP) and from Washington Public Power Supply System Nuclear Project No. 2 (WNP-2). These discharges are controlled by National Discharge Elimination System and other permits. There have been no ecologically significant thermal discharges in the Hanford Reach since January 1971 when the last single-purpose plutonium production reactor was closed down. Currently, no water quality problems due to non-point or point sources have been identified as adversely affecting the anadromous fish resources in this area.

5.8.1.3 Columbia River Above Chief Joseph Dam

Urbanization in this area has been largely confined to development along the Spokane and Coeur d'Alene River drainages. Pollution resulting from the urban surroundings of Spokane, Washington, and Coeur d'Alene, Idaho, have largely been masked by substantial pollution from the metal industry (both mines and smelting operations). As discussed previously (Section 3.1.1), these streams are outside the currently accessible natural habitat for salmon and steelhead.

5.8.1.4 Snake River Area

Urbanization and population growth in Idaho (Snake River Basin) have not been as great as in Washington and Oregon, as indicated by the population numbers and numbers of people employed in manufacturing (Figures 46 and 50). The main urban center in this area is Boise, Idaho. The probable effects of urbanization on anadromous fish include localized non-point source runoff of silt into streams, due to various population centers. Toxics or oxygen-consuming wastes in this subbasin do not appear to be a major problem with respect to the anadromous production.

5.8.2 Reducing the Adverse Effects of Urbanization/Pollution

Measures regarding reducing the adverse effects of urbanization and water pollution are mainly related to passage of the federal Clean Water Act. The goal of the Clean Water Act was to make all the nation's navigable waterways fishable and swimmable by 1985. This legislation provided impetus and backing for passage of state water pollution control legislation in Oregon, Idaho, and Washington. The Act's controls for point sources have resulted in the rehabilitation of many miles of stream. The nagging problem of control of non-point source pollution is still a largely unresolved issue.

5.8.3 The Current Status of Urbanization/Pollution Impacts on Fish

Population in the Columbia River Basin is expected to continue to increase well into the future. Currently, there is no extensive water pollution problems in the Columbia River Basin. Certain localized problems do exist, but their long-term effect on salmonids is unknown. Although control of non-point sources of pollution is still a problem, the Clean Water Act requires local and state governments to deal with this problem. Non-point source controls over existing and new developments are required in Oregon, Washington, and Idaho's stream protection legislation.

5.9 MISCELLANEOUS IMPACTS

5.9.1 Overview

This section of the report describes the effects of nuclear power production and major catastrophic natural events.

5.9.2 Nuclear Reactor Operations (Plutonium and Power Production)

Most nuclear plant development has occurred in a 50-mile section of the river known as the Hanford Reach, located downstream of Priest Rapids Dam and above Richland, Washington. This reach is an important production area for fall chinook salmon (see section 4.4.4). Three plants were constructed between 1943 and 1945, and were followed by six additional plants constructed between 1947 and the mid-1960s (Foster 1972, U.S. ERDA 1975). All of these plants were single-purpose graphite-moderated, water-cooled plutonium production reactors. Eight of the nine plants were shut down during 1964 to 1971. The ninth plant, the dual-purpose New Production Reactor (N-Reactor) and the Hanford Generating Project (HGP), has continued to operate, and is currently scheduled to continue operation until 1993.

Presently, two nuclear power generating plants are operating in the Hanford Reach; the Hanford Generating Project and the Washington Public Power Supply System Nuclear Project No. 2 (WNP-2). Both of these plants are water-cooled. The N-Reactor, which provides steam to HGP is also water-cooled. The only other large nuclear power plant operating in the Columbia River Basin is the Portland General Electric Trojan Plant located on the mainstem of the Columbia River near Rainier, Washington. It has operated since 1975 (Yundt 1985) and is also water cooled. The WNP-2 and Trojan plants have cooling towers, and amounts of heat and radioactivity released to the Columbia River are within regulatory guidelines.

Several nuclear plant facilities and operations have been investigated regarding effects on salmon and steelhead. Effects on aquatic habitats arising from operation of electrical power generating plants involve primarily the withdrawal of water for condenser cooling and the discharge of heated water to the river. Specific areas of concern include:

- Impingement of juvenile fish on intake structures;
- Entrainment of juvenile fish in the cooling water circulation systems;
- Effects of thermal discharges on juvenile and adult fish;
- Effects of chemical discharges (chlorine, mercury, heavy metals) on juvenile and adult fish; and
- Effects of radionuclides on juvenile and adult fish.

The majority of the environmental studies conducted to determine the potential effects of nuclear power development on aquatic resources in the Columbia River Basin have occurred in the Hanford Reach (Becker 1973, Neitzel 1979). During the early years of single-purpose, Pu-production reactor operations (1943-1971), chemicals, radionucleids and elevated temperatures in the cooling water discharges were major concerns (Becker 1973b). Of the potential impacts listed above, impingement and entrainment of juvenile chinook salmon at the Hanford plants were considered the most critical problems (Neitzel 1979). Although quantitative losses were not estimated, impingement and entrainment studies indicated that chinook salmon fry produced in Hanford Reach were the predominant fish affected. To minimize these losses, the HGP eliminated gaps in the screening system and installed screen rotation and continuous washing devices in 1976. There are no significant impingement or entrainment effects at Hanford intake today (Neitzel et al. 1982). Monitoring studies conducted at the Trojan Plant from 1972 to 1982 indicated minimal losses of salmon due to impingement and entrainment. Regarding radionuclides releases in reactor effluents, the last Pu-production reactor at the Hanford site using once-through cooling was closed in 1971. Both the WNP-2 and Trojan plants have cooling towers, and the limited volumes of warm water discharge (cooling tower blowdown) are limited to levels protective of aquatic life by federal and state regulations (Bullock 1985).

Although thermal, chemical, and radionuclides discharges are considered potentially harmful to salmonids, specific instances of nuclear plant discharges that have caused reductions in Columbia River salmon and steelhead populations have not been identified (Donaldson and Bonham 1964; Neitzel 1979; Neitzel and Page 1979; Neitzel et al. 1982). Furthermore, zero or minimal discharges are required by Federal and state operating licenses, and monitoring programs are conducted to assure compliance (Neitzel 1979).

5.9.3 Natural Events

The eruption of Mount St. Helens on May 18, 1980, caused extensive losses of salmon and steelhead resources in the Toutle River watershed. The debris avalanche, pyroclastic flows, and mudflows destroyed an estimated 136 of the 175 miles of anadromous fish habitat in the watershed (Martin et al 1984). The natural production of salmon and trout in the Toutle River was estimated to provide an annual catch of 52,000 fish. The natural runs of salmon and steelhead in the Toutle River were augmented by the Toutle salmon hatcheries, which provided an annual smolt production of 1.4 million coho, 3.2 million fall chinook, and 240,000 winter and summer steelhead. The hatcheries, which also were destroyed by the eruption, provided an estimated annual catch of 251,500 fish.

In addition, cyclical ocean and climatic conditions, such as "El Nino," affect fish populations by altering the environment. Climatic conditions affect the amount of runoff (streamflow) in two ways. During droughts (such as in 1977) and unusually warm or cold years the snowpack can melt too early or too late, the downstream migration of juvenile salmon and steelhead during the spring can be impaired to the point where large numbers of the fish don't reach the ocean. Also, forest fires, such as the 1970 Entiat River area fire, can devastate watersheds and fish habitat.

5.9.4. Other

Other impacts such as flood control, recreation, and navigation, have affected salmon and steelhead resources in the Columbia River Basin. These impacts are discussed in Section 4.3 because they are generally associated with operation of multipurpose dams.

A biological impact of concern is predation on salmon and steelhead smolts by predatory species which have been introduced to the Columbia River, e.g., walleye and smallmouth bass. These impacts are currently under investigation by the Bonneville Power Administration (Gray et al, 1984).

Chapter 6
MITIGATION OF LOSSES

6.1 INTRODUCTION

In certain instances, losses of fish in the Columbia River Basin have been identified and compensated. Mitigation generally has occurred because of construction and operation of dams and is not restricted to compensating just for the impact of hydropower. It should be noted that mitigation traditionally has taken the form of artificial production. This chapter's emphasis is artificial production, but information on other forms of mitigation, such as habitat restoration and laddering, is included in some cases.

Mitigation has not always replaced the same species and stocks that were affected (in-kind). As noted above, naturally produced fish frequently have been replaced by artificially produced fish. At times, different stocks or even different species have been substituted to compensate for losses.

Nor has mitigation always occurred in the location where the losses occurred (in-place). Major segments of upriver fish production have been moved to lower river areas. In other cases, a central hatchery located on one tributary has replaced production on several tributaries.

While the precise quantification of mitigation could be useful in analyzing fish losses at specific geographic sites, it is not essential for setting a losses figure for the whole basin. A comparison of current run sizes to predevelopment run sizes reflects any increases attributable to intervening mitigation.

Analysis of the mitigation of losses is helpful in understanding, in a qualitative manner, the biological loss associated with changes in production from natural to artificial production, and also with elimination and/or movement of production on a geographic basis.

This chapter provides information concerning three major types of salmon and steelhead mitigation that have occurred in the Columbia River Basin:

first, federal multipurpose mitigation programs; second, Northwest Power Planning Council fish and wildlife program measures; and third, mitigation funded under Federal Energy Regulatory Commission (FERC) licenses for nonfederal hydropower projects. Attempts to mitigate impacts of specific activities are discussed in Chapter 4.

6.2 MITIGATION

6.2.1 Overview of Columbia Basin Mitigation

One dramatic effect of mitigation activities for hydropower and for multipurpose developments has been to strengthen fish propagation in the lower Columbia River Basin without attempting to rebuild upriver runs (see Table 31). A related effect has been to increase the proportion of hatchery fish to the overall outmigration. In 1974, for instance, 40 public agency and tribal hatcheries released 155 million juvenile salmonids in the Columbia Basin -- five times as many as were released in 1960 (Netboy 1980). By the late 1960s, hatchery production of chinook, coho and steelhead surpassed natural production (Columbia River Fisheries Council 1981). In the 1970s hatchery smolts in the mid-Columbia area were estimated to comprise up to 74 percent of spring chinook outmigrants (1.4 million wild, 4 million hatchery), 71 percent of fall chinook outmigrants (1.5 million wild, 3.6 million hatchery), and 36 percent of summer chinook outmigrants (1.2 million wild, 2 million hatchery). Another 42 percent of summer chinook outmigrants came from artificial spawning channels (National Marine Fisheries Service 1981). By the late 1970s in the Snake River, spring chinook hatchery smolts were estimated to comprise up to 75 percent of the outmigration, and steelhead hatchery smolts comprised up to 80 percent. In short, hatchery production exceeded wild production for all of these stocks in the mid-Columbia and Snake areas. Because current hatchery production is higher than when these estimates were made, the current proportion of hatchery releases to natural fish is probably higher. Thus, the shift to lower basin production has been accompanied by a dramatic and accelerating shift from naturally-spawning runs to hatchery runs.

Table 31 - Hatchery Release Program under the Columbia River Fishery Development Program.

Basinwide Releases	Releases Above Bonneville Dam		Releases Below Bonneville Dam	
	Number	Percent	Number	Percent
Fall chinook	22,425,000	33	46,500,000	67
Coho	4,500,000	22	16,350,000	78
Spring chinook	4,280,000	70	1,900,000	30
Steelhead trout	320,000	13	2,120,000	87
All Species	31,525,000	32	66,870,000	68

Releases Above Bonneville Dam	Releases Above The Dalles Dam		Releases In Bonneville Pool (Between Bonneville and The Dalles dams)	
	Number	Percent	Number	Percent
Fall chinook	1,225,000	5	21,200,000	95
Coho	0	0	4,500,000	100
Spring chinook	100,000	2	4,180,000	98
Steelhead trout	180,000	54	140,000	44
All Species	1,505,000	5	30,020,000	95

(Information provided by the Columbia River Inter-Tribal Fish Commission)

6.2.2 Federally-Funded Mitigation

6.2.2.1 The Columbia River Fisheries Development Program

In addition to mitigation programs designed to minimize or compensate for salmon and steelhead losses due to individual projects in the Columbia River Basin, mitigation for the effects of federal development has generally been provided under the Mitchell Act of 1938 (Pub. L. No. 75-502, 52 Stat. 345, 16 U.S.C. § 755). The Mitchell Act was designed to mitigate for impacts resulting from water diversions, mainstem dams, deforestation, and pollution (H.R. Rep. No. 2235, 75th Cong., 3rd Sess. 1938, and Laythe 1948; Columbia River Inter-Tribal Fish Commission 1981; National Marine Fisheries Service 1984). Congress initially appropriated $500,000 under the Mitchell Act for surveys and improvements in the Columbia River Basin to benefit salmon and other anadromous fisheries. However, because of limited funds, the major initial accomplishment under the Mitchell Act was a census and survey of most of the Columbia River tributaries (Columbia River Inter-Tribal Fish Commission 1981).

A 1946 Congressional amendment to the Mitchell Act (Public Law 79-676) was passed which removed the Congressional funding limitations for the development of anadromous fisheries in the Columbia River Basin. The amendment also authorized the federal government to use facilities and services of state conservation agencies in Idaho, Washington, and Oregon in developing the salmon resources of the basin.

The 1946 amendment provided the foundation for the establishment of the Lower Columbia River Fishery Development Program (LCRFDP) in 1949. As a result of concern over water development projects in the basin, state and federal agencies recommended that the LCRFDP be used to maintain anadromous fisheries (National Marine Fisheries Service 1981). After endorsement by the Federal River Basin Inter-Agency Committee, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation, the Corps of Engineers submitted a request for Congress to appropriate $1 million in 1949 for salmon and steelhead restoration in the Columbia River Basin.

Overall coordination of the LCRFDP from 1949 to 1970 was provided by the U.S. Department of the Interior. From 1949 to 1956, the only states involved in the program were Washington and Oregon. State involvement was controlled by the area of coverage, which included the Columbia River drainage below McNary Dam. However, in 1956, Congress instructed that the program be implemented above McNary Dam. Subsequently, Idaho became a participant in

1957 and the word "lower" was dropped from the program name (LCRFDP is hereinafter CRFDP). Another change in the program organization was that overall coordination responsibilites were transferred to the U.S. Department of Commerce in 1970. The program currently is administered by the National Marine Fisheries Service in cooperation with the U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, Washington Department of Fisheries, Washington Department of Game, and Idaho Department of Fish and Game.

The CRFDP emphasized: expansion of artificial propagation; improvement of existing salmon rearing and spawning habitat in tributaries by removing log jams, splash dams, and natural rock obstructions; construction and operation of permanent fishways either to facilitate passage at partial barriers or provide access to areas not previously available to anadromous fish; and construction and operation of screens to protect downstream migrants from irrigation diversions (National Marine Fisheries Service 1981).

The majority of funds expended by CRFDP since 1949 were on fish culture (Delarm and Wold 1984). The program has helped build 22 hatcheries and three major rearing ponds. Except for the WDG and WDF Ringold rearing ponds located above the Snake River confluence, facilities and releases were concentrated in the lower Columbia River Basin (Figure 52).

Salmonid species (or races) reared at CRFDP facilities include fall and spring chinook, coho, and chum salmon, and winter and summer steelhead trout. The number of chinook, coho, and steelhead smolts released from CRFDP-funded facilities for the period 1960 to 1983 is shown in Figures 53 and 56. Chum salmon smolt releases for the period 1960 to 1978 are shown in Figure 57. Of the five species (or races) involved in the program, fall chinook salmon represented the largest number of smolts, with releases ranging from 46.6 million in 1961, to 95 million in 1977. The number of spring chinook smolt releases have been considerably lower, with numbers ranging from 800,000 in 1961, to 7.6 million in 1964 and 1981. Fall chinook salmon smolt releases reached peak numbers from 1976 to 1980; spring chinook releases peaked from 1979 to 1982. The number of coho salmon smolt releases has ranged from 6.4

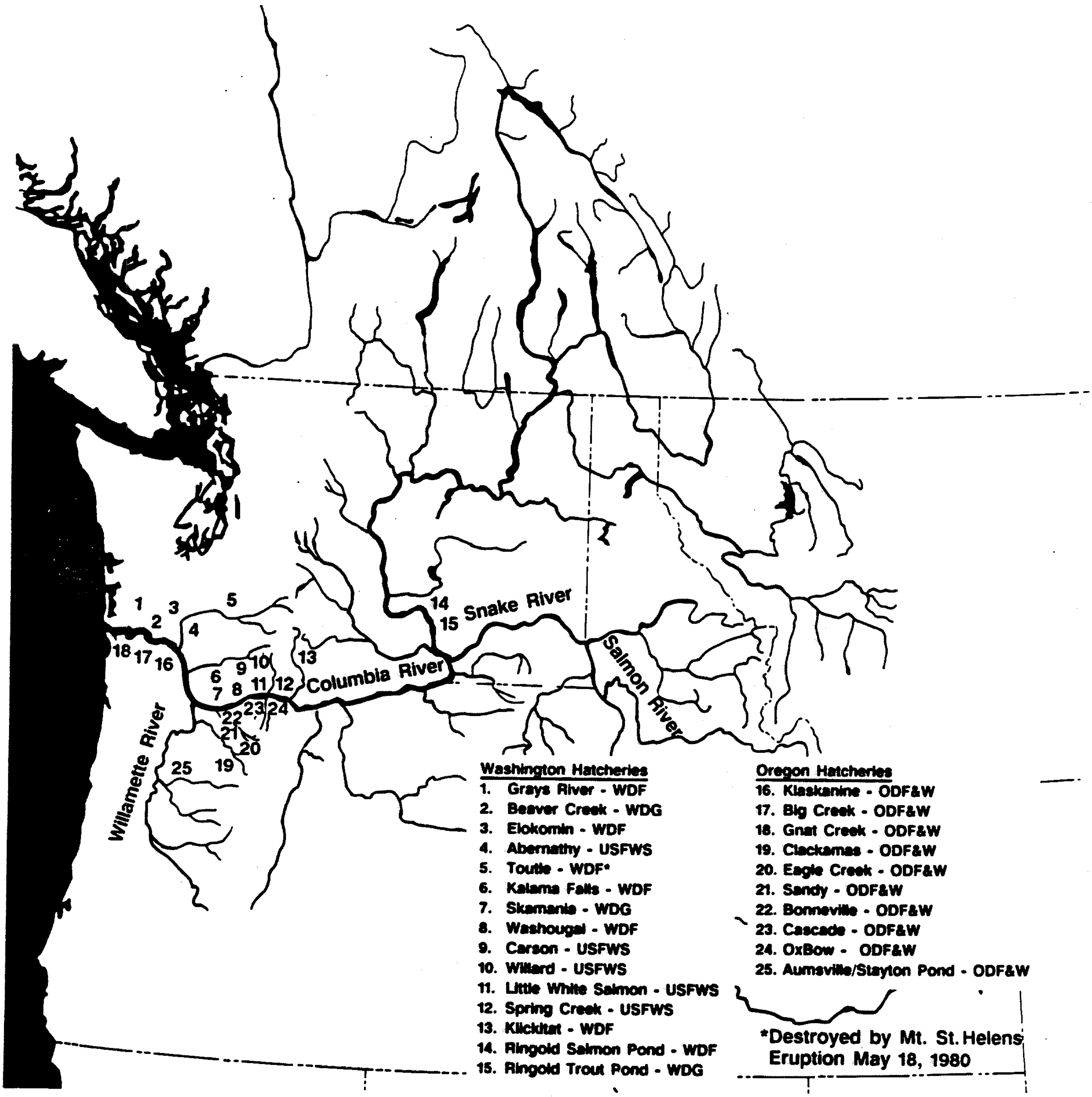

Figure 52. Hatcheries funded under the Columbia River Fisheries Development Program (Delarm and Wold 1984).

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