CHEHALIS RIVER BASIN FISHERY RESOURCES: STATUS, TRENDS, AND RESTORATION

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EXECUTIVE SUMMARY

The Chehalis River Basin Fishery Resources Study and Restoration Act (Public Law 101-452) requires the Director of the Fish and Wildlife Service (FWS) to "undertake a comprehensive study of the fishery resources and habitats of the Chehalis River Basin of Washington State, develop goals, recommend long- and short-term actions to maximize the restoration and conservation of those fishery resources, and report his findings to Congress."

The present report reviews existing information, sets goals, and presents a number of restoration recommendations. A second report, based on an ongoing survey of fishery habitat and scheduled for completion in 1993, will describe actual habitat conditions and further guide restoration. This report focuses on anadromous salmonids since they are clearly the most important fishery resources of the Chehalis Basin.

To guide activities under the Act, a steering committee composed of representatives of all relevant state agencies, Indian Tribes, and the public was formed in 1990. The committee recognized that a large amount of information about Chehalis Basin fishery resources already existed but that it needed to be gathered together in one report. The present report is the result of that task.

SUMMARY OF FINDINGS

Reviews of existing information on resource history, run status, and current habitat problems reveal that:

(1) Inner Grays Harbor water quality appears to have contributed to poor coho (and probably chinook and steelhead) smolt survival at least until 1989. Significant efforts to improve water quality have been taken. Results of clean-up will become known in a few more years. Further study of pollution may be necessary but can be delayed pending the outcome of ongoing survival evaluation.

(2) Wild coho and chum salmon populations have fallen well below levels that historically supported high catches.

(3) Chinook salmon and steelhead do not consistently use all potential habitat.

(4) Upper Chehalis River water quality particularly threatens adult spring and fall chinook, and reduces coho and steelhead rearing habitat.

(5) Dams and other barriers, logging, road building, agriculture, and urbanization have degraded salmon and steelhead habitat.

While natural salmon and steelhead production is apparently less than optimal in the Chehalis Basin, there is every indication that, with careful planning and implementation, production can be improved. The Basin contains several thousand miles of stream habitat, much of which is in relatively good condition. The lack of large-scale, main stem dams, as found on the Columbia, also increases the prospects for successful restoration.

Healthy fisheries are an important component of the Basin's economic infrastructure. Rebuilding salmon and steelhead habitat can help rebuild the Basin's economic vitality. When depressed runs are restored, harvest constraints can be eased, allowing harvest of not only the restored runs, but intermingled, healthy runs as well. Moreover, good recreational fishing opportunity can attract new industry to an area. The recommendations proposed in this report will create jobs for local workers both during restoration and after healthy fish populations are rebuilt.

PROPOSED FISHERY RESTORATION GOAL

The findings have led to formulating a general goal:

> **"to optimize natural salmon and steelhead production while maintaining the existing genetic adaptation of wild spawners and allowing the highest compatible level of hatchery production".**

Natural production will be restored when the total estimated wild catches consistently lie within the range of historical estimates, and when wild escapement goals are consistently met. This means:

(1) Expanding spring chinook salmon wild production to its full potential range.

(2) Sustaining the recent increase in Chehalis River System fall chinook salmon by improving water quality throughout the Chehalis River System.

(3) Doubling Chehalis River System coho salmon smolt-to-adult survival, compared to the 1989 level, so that Chehalis River System smolt survival equals Humptulips River System smolt survival.

(4) Increasing chum salmon run sizes to historical levels.

(5) Ensuring that wild winter steelhead fully and consistently use the spawning habitat in each available Chehalis River Basin sub-basin.

(6) Evaluating existing wild summer steelhead populations in Chehalis Basin tributaries.

RESTORATION CRITERIA

Habitat Condition

Habitat restoration projects in the Chehalis watershed may not produce results unless recent effluent treatment upgrades at the two inner Grays Harbor pulp mills result in significant improvement of survival. If survival has improved sufficiently, then habitat restoration throughout the basin should be successful, and projects using promising and cost-effective techniques should be initiated to begin restoration. If survival has not improved, further efforts should be directed to solving the poor inner Harbor survival problems before extensive watershed habitat restoration proceeds. Since it will take at least two more years before results of tagging studies can confirm clean-up effectiveness, preliminary habitat restoration projects should be started and evaluated. Once the inner Harbor water quality allows reasonable smolt survival, proven habitat restoration projects can begin throughout the Basin on a larger scale. Selection of habitat restoration projects will be guided by the ongoing habitat survey.

Hatchery Role

Hatchery production supports a large share of the catch in several fisheries. However, once habitat problems have been corrected, the hatchery role in fishery restoration should be to augment, rather than replace, natural production. Hatcheries may produce fish poorly adapted for wild survival and can jeopardize the health and sustainability of wild runs, so programs must be developed cautiously. Ongoing State and Tribal processes should continue to carefully evaluate all hatchery programs to help understand how they are contributing to fisheries and whether there is negative interaction with wild stocks. Artificial enhancement can and should be utilized wherever it will not harm the integrity of wild stocks. However, emphasizing hatchery production to the detriment of efforts to restore naturally reproducing populations is not an acceptable policy option.

Public and Interagency Involvement

Public and interagency cooperation is vital to the success of restoration. This requires the active participation of the tribes and agencies named in the Chehalis Act as the Restoration Plan is implemented. These key entities will identify and explore avenues of cooperation with all interested private organizations and agencies not already involved. The public was invited to a Basin-wide fisheries conference in the fall of 1992 where study findings were presented and suggestions for restoration priorities sought.

The FWS recommends that the Chehalis Basin Steering Committee, formed under the Chehalis Basin Fishery Restoration Study Act, be continued to provide policy guidance to the restoration proposed in this report. They will guide restoration to ensure each project would restore fish, be cost-effective, meet cost-share requirements, and contain appropriate evaluation components.

It is also critical that all <u>existing</u> programs designed to protect, restore, and enhance fisheries and their habitat continue to be fully supported and funded.

RESTORATION OBJECTIVES

The overall life-span of the restoration project is 20 years, assuming full funding is made available. Some tasks can be completed in one or several years while others will be accomplished gradually over the 20 years. Since all restoration projects will at least initially be evaluated for fish restoration effectiveness, these recommendations will need to be revised over time. Projects found to be ineffective will not be further pursued. The costs of these evaluations has been included in the project costs estimated below.

The following objectives are proposed:

OBJECTIVE 1: Restore or improve natural spawning or rearing habitat.

OBJECTIVE 2: Improve water quality to meet State standards year-round in the middle and upper Chehalis River System.

OBJECTIVE 3: Ensure that environmental conditions causing poor smolt survival in inner Grays Harbor are remedied.

OBJECTIVE 4: Ensure that storage dam operation and surface water withdrawal is compatible with fish production.

OBJECTIVE 5: Extend the range of salmon and steelhead within the Basin to achieve optimum habitat use.

OBJECTIVE 6: Optimize opportunities for artificial enhancement without jeopardizing wild stocks.

OBJECTIVE 7: Use fisheries harvest management techniques and increased enforcement to increase run sizes.

OBJECTIVE 8: Increase public awareness of the values of fisheries to the Chehalis Basin.

FUNDING NEEDS

Some restoration has occurred and will continue under existing federal, state, local, and volunteer programs. The proposed habitat restoration projects complement existing programs but should not replace them.

Since it is important that restoration techniques be demonstrated to be effective before they are fully implemented, it is recommended that restoration be funded gradually over 20 years. After careful review of the size and scope of all tasks necessary for full restoration, it is recommended that a total of $1 million be committed to Chehalis restoration from interested agencies in each of the 20 years. This level of funding is expected to restore significant fish populations, ultimately stimulating the economic recovery of the Chehalis Basin. The Fish and Wildlife Service is not prepared at this time to request additional funds for its share of this work. However, funds may become available by reprogramming from lower priority activities or through other sources.

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LIST OF ACRONYMS AND ABBREVIATIONS

BOD	Biological Oxygen Demand
BPA	Bonneville Power Administration
BRW	Black River Watch
CBFTF	Chehalis Basin Fishery Task Force
CD	Conservation District
cfs	Cubic Feet per Second
CRC	Chehalis River Council
CRTAB*	Chehalis River Technical Advisory Board
CRPMP	Coordinated Resource Production and Management Plan
DO	dissolved oxygen
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FRI	Fishery Research Institute of University of Washington
FWE	Fish and Wildlife Enhancement Office of FWS
FWS	U.S. Fish and Wildlife Service
GHRPC	Grays Harbor Regional Planning Commission
GHCD	Grays Harbor Conservation District
GIS	Geographical Information System
IFIM	Instream Flow Incremental Method
LCCD	Lewis County Conservation District
LCWQB*	Lower Chehalis Water Quality Board
LLTK	Long Live the Kings

*Note: the official name now appears as "Chehalis River Technical Advisory Board" in the Lower Chehalis River Basin Water Quality Management Study

List of acronyms and abbreviations, continued.

mgd	million gallons per day
MLLW	Mean Lower Low Water
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
OFM	Washington Office of Financial Management
ONF	Olympic National Forest
OPIN	Olympic Peninsula Information Network
PCB	Polychlorinated Biphenyl
PMFC	Pacific Marine Fisheries Council
ppb	parts per billion
PP&L	Pacific Power and Light
ppm	parts per million
ppt	parts per trillion
PSC	Pacific Salmon Commission
PSMFC	Pacific States Marine Fisheries Commission
QFiD	Quinault Fisheries Division of the Quinault Indian Nation
RM	River mile
SCS	U.S. Soil Conservation Service
TCCD	Thurston County Conservation District
TCDD	Tetrachloro Dibenzodioxin
TCDF	Tetrachloro Dibenzofuran
TFW	Timber, Fish, and Wildlife Agreement
TMDL	Total Maximum Daily Load (of permissible pollution)
TSS	Total suspended solids
TU	Trout Unlimited

List of acronyms and abbreviations, continued.

USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDA	Washington Department of Agriculture
WDCD	Washington Department of Community Development
WDOE	Washington Department of Ecology
WDF	Washington Department of Fisheries
WDG	Washington Department of Game, now WDW
WDNR	Washington Department of Natural Resources
WDW	Washington Department of Wildlife, formerly WDG
WLA	Waste Load Allocation
WWFRO	Western Washington Fishery Resource Office of the FWS
WPPSS	Washington Public Power Supply System

Chapter 1: DESCRIPTION OF THE BASIN

The Chehalis River Basin, as defined in the Act, includes all the rivers and streams entering Grays Harbor and the land they drain (Figure 1), plus the waters of Grays Harbor itself. The Basin is the second largest in the State of Washington, the Columbia being the only one larger, and includes all of Grays Harbor County, most of Lewis County, parts of Mason and Thurston Counties, and small parts of Pacific and Wahkiakum Counties. The Chehalis Basin includes about 27,000 acres of saltwater in Grays Harbor itself (SCS 1975) and about 3,353 stream miles (Phinney *et al.* 1975). These waters provide a complex and diverse ecosystem with spawning and rearing areas that support several economically valuable species of anadromous fish (primarily salmon, steelhead, and sea-run cutthroat trout), whose restoration is the subject of this report.

PHYSICAL DESCRIPTION

The Chehalis River originates in the Willapa Hills in southwest Washington and flows into the Pacific Ocean via Grays Harbor. The main Willapa Hills tributaries of fishery interest are Elk Creek, which enters near the town of Doty, and the South Fork Chehalis, which enters near the town of Adna (Figure 2).

The river then flows east from the Willapa Hills into the Puget Trough, the lowland separating the Willapa Hills from the southern Cascades. At that point, the river flows north and receives two very important fish-bearing tributaries from the Cascade foothills. The Newaukum River enters near the town of Chehalis, and the Skookumchuck River joins the Chehalis River near Centralia (Figure 2).

From that point, the Chehalis Valley widens and turns to the northwest, where the Black River drains the southern Puget Lowlands, joining the Chehalis east of the Black Hills on the Chehalis Indian Reservation. Cloquallum Creek enters west of the Black Hills, near the town of Elma.

The river then turns to the west and drains the southern flank of the Olympic Range (Figure 2). The principal fish-producing streams of this region are the Satsop, Wynoochee, Wishkah, Hoquiam, and Humptulips Rivers. The Satsop enters the Chehalis River near the town of Satsop, and is the last major tributary upstream of tidal influence. The Wynoochee, Wishkah, and Hoquiam enter successively downstream at the towns of Montesano, Aberdeen, and Hoquiam. Near the Wishkah, the Chehalis widens into Grays Harbor, which is approximately 15 miles long and 13 miles wide.

The Humptulips River also drains the southern Olympics but, unlike the Chehalis tributaries, the Humptulips independently enters the north side of Grays Harbor. On the southern side of Grays Harbor, two small rivers, the Elk and the Johns, drain from the northern Willapa Hills. Grays Harbor joins the Pacific Ocean through a narrow channel north of the fishing town of Westport.

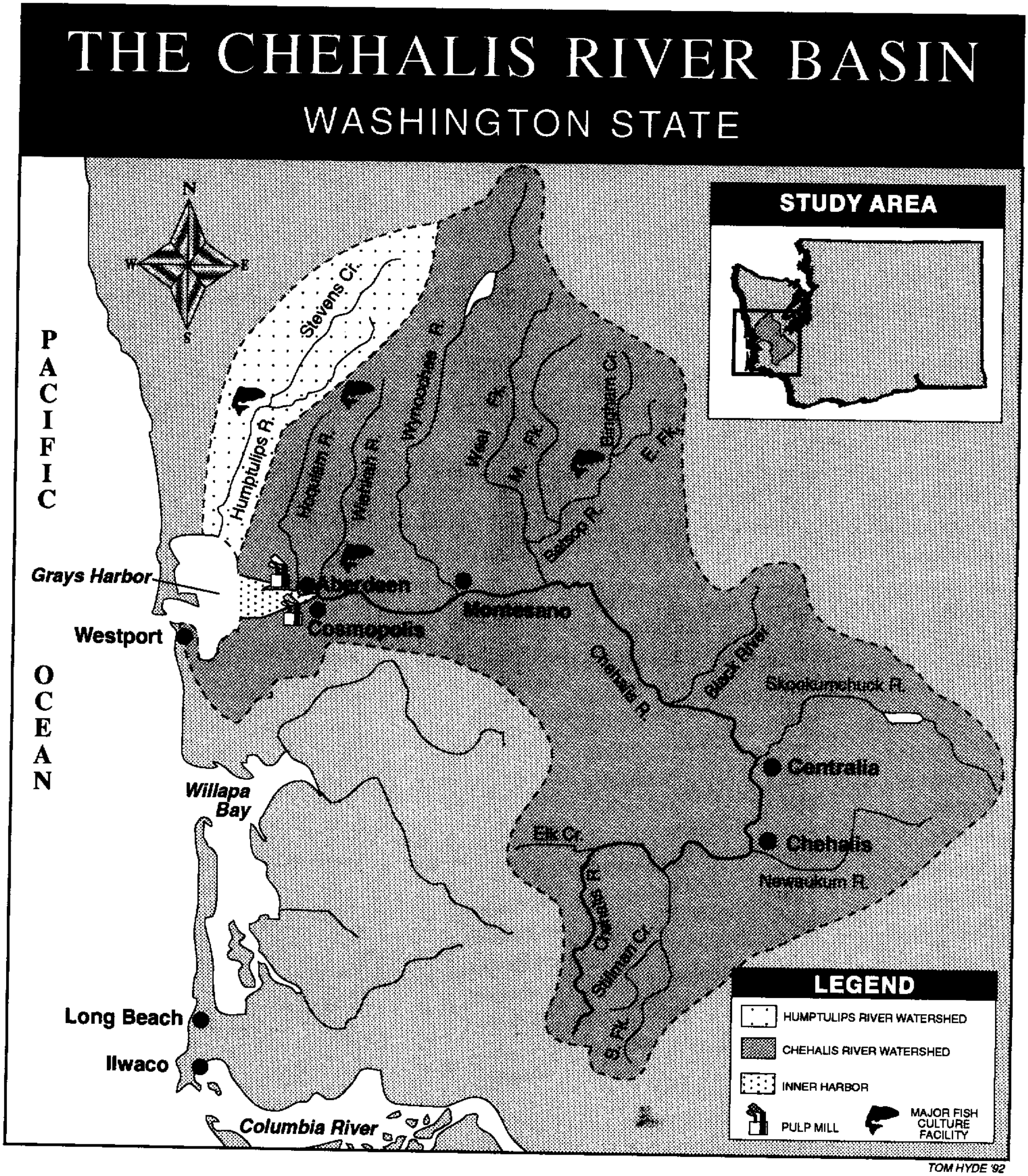

Figure 1. Location of Chehalis Basin in western Washington.

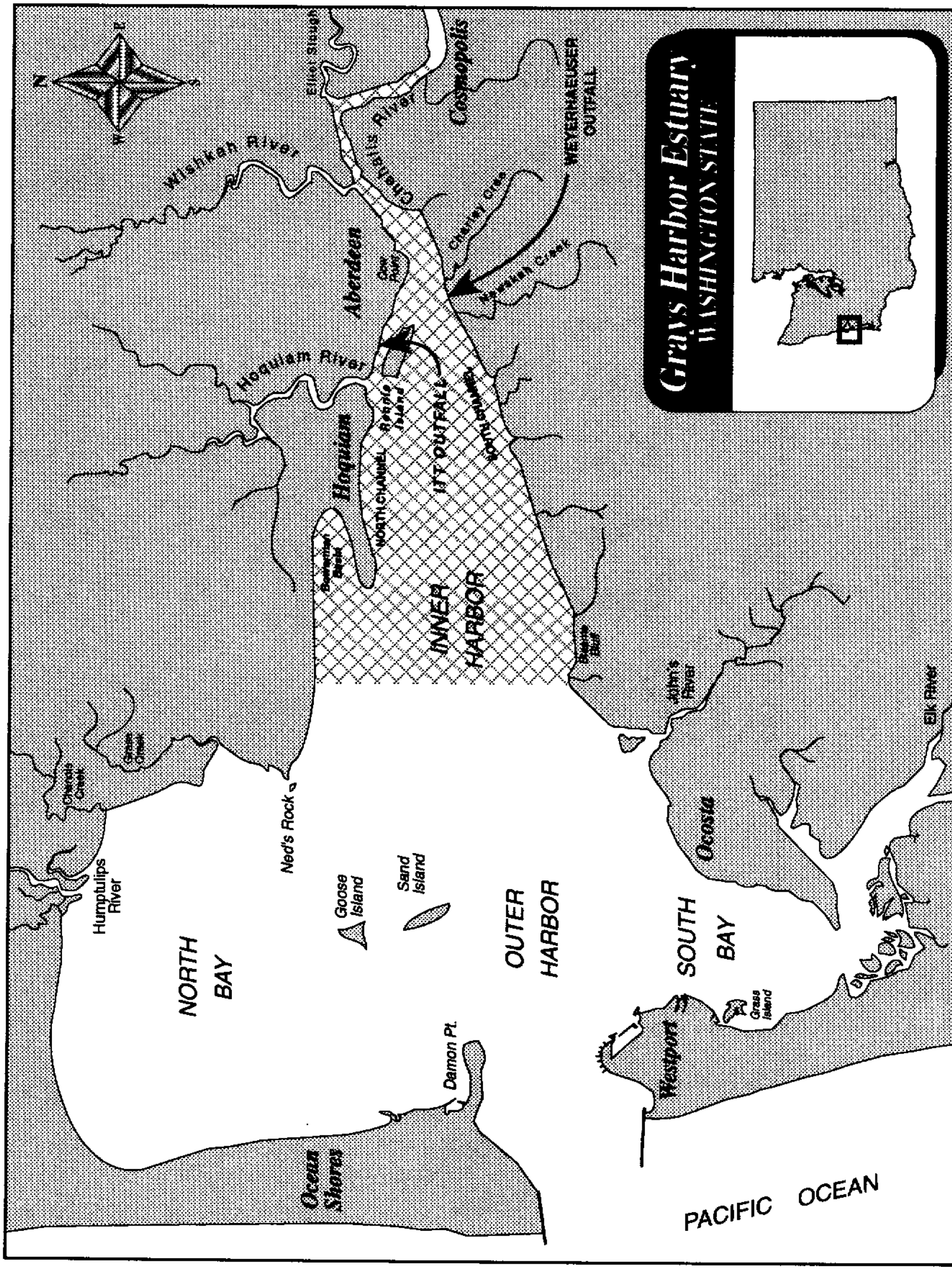

Figure 2. Grays Harbor estuary.

For habitat management, it is convenient to divide the Basin into three parts: Grays Harbor, including all the tidal waters bearing that name, the Humptulips River System, and the Chehalis River System (Figure 1).

The distinction of inner from outer Grays Harbor (Figure 2) is useful because the inner Harbor has suffered more water pollution than the outer Harbor, and because Chehalis System fish must migrate through the inner Harbor whereas Humptulips System fish pass only through the outer Harbor (Figure 2).

HYDROGRAPHIC DESCRIPTION

River system	Area drained (square miles)	Streamflow (cfs) Maximum	Streamflow (cfs) Mean annual	Streamflow (cfs) Minimum
Chehalis at Porter	1,294	34,600	4,262	164
Satsop	299	46,600	1,968	166
Humptulips	130	33,000	1,320	32
Wynoochee	179	24,500	1,275	23
Newaukum	155	7,400	506	12
Cloquallum Creek	65	3,650	375	63
Wishkah	58	7,400	A	33
Skookumchuck	62	6,710	247	16
Hoquiam	A	A	A	6
Black	61	1,700	162	5

A Not available.

Table 1. Relative size and stream flows of major tributaries to the Chehalis Basin (Mahlum 1976).

Annual rainfall varies from 40 inches in Centralia to 220 inches in the southern Olympics (Harper, in prep.); about 85 percent falling between October and April. Peak streamflows usually occur between November and March. After April, flow gradually subsides to late August or early September lows (Figure 3).

Mean annual freshwater flow into Grays Harbor has not been directly measured but is estimated at 11,208 cfs (Mahlum 1976). Table 1 illustrates the relative sizes of the Chehalis River near Porter and other significant tributaries based on streamflow data.

Rainfall, not snow melt, almost exclusively drives the annual rise and fall of streamflow throughout the Basin.

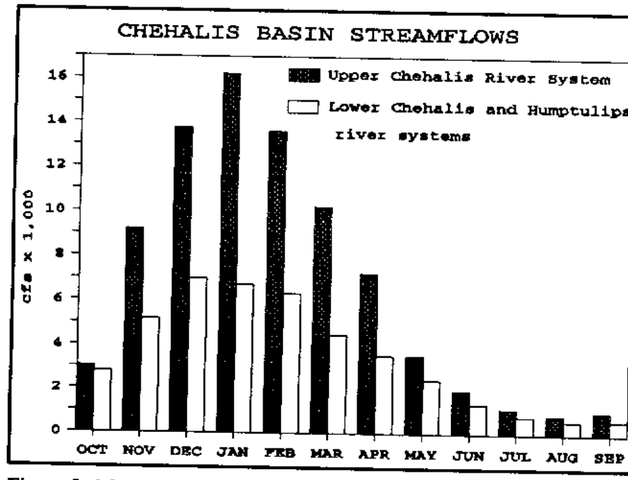

Figure 3. Mean monthly streamflows in the Chehalis Basin.

ECONOMIC AND SOCIAL DESCRIPTION

The Chehalis Basin is generally rural. The primary industries are forest products, followed by agriculture, tourism, and fishing. The area has higher unemployment than the state as a whole due primarily to increasing automation in the wood products industry and declining timber production (GHRPC 1992). Its inhabitants urgently seek economic diversification in the face of recent declines in availability of old growth timber from federal lands, primarily to the north of the Basin; old growth timber had until recently provided significant economic value in the Basin. Fishery development is seen as part of general tourism promotion in Grays Harbor County (Larry Wilder, Grays Harbor Tourism Council, pers. comm.).

Demographics

The Basin's population of about 117,000 has remained steady over the last ten years (Table 2). The largest incorporated area is the Aberdeen-Cosmopolis-Hoquiam complex. This area lost about eight percent of its population probably due to timber industry declines and cessation of construction at the Satsop nuclear plants. Small timber-dependent towns close to Aberdeen, such as Montesano and Elma, have similarly declined (OFM 1991).

The next largest concentration of population is in Centralia and Chehalis. This area has grown slightly, probably reflecting the residential sprawl from Olympia. The only other rapidly growing community is Ocean Shores, which is residential but depends largely on recreation.

About half of the Basin residents live in unincorporated areas (Table 2), primarily in Lewis and Thurston Counties. This population has grown rapidly, due to suburban expansion south from Olympia, but the trend is slowing. For example, from 1970 to 1980 the Black River watershed population doubled, but from then to 1990 it grew only 37 percent (Palmer, in prep.).

Category	1990 population	Percent of total	Change since 1980
Total	116,970	100.0	+1.1
Unincorporated	56,488[A]	48.3	+4.7
Incorporated	60,482	51.7	-2.1
Unincorporated[A]			
Lewis County	29,027	51.4	+8.2
Thurston County	24,603	43.6	+14.6
Grays Harbor County	25,858	5.0	-0.1
Incorporated			
Aberdeen-Cosmopolis-Hoquiam	27,615	45.7	-8.1
Centralia-Chehalis	18,480	30.6	+4.7
Montesano	3,270	5.4	-10.7
Elma	2,420	4.0	-11.0
Ocean Shores	2,262	3.7	+27.3
Westport	1,935	3.2	-1.0
McCleary	1,515	2.5	+6.8
Tenino	1,295	2.1	+1.2
Pe Ell	580	1.0	-6.0
Oakville	580	1.0	+8.0
Bucoda	530	0.9	+2.1

[A] Populations of unincorporated areas not entirely in Grays Harbor Basin were estimated from data in OFM (1991).

Table 2. Chehalis Basin population (OFM 1991).

Economic Base

Forest Products

The Grays Harbor economy has always been cyclical, but has especially suffered from a combination of increased automation (GHRPC 1992) and reduced old growth timber harvest. The two largest wood products plants in the Basin are the ITT-Rayonier pulp mill in Hoquiam and the Weyerhaeuser pulp mill in South Aberdeen. The Aberdeen area also supports many smaller plants making plywood, doors, veneer, and other wood products. The export of logs and lignin liquor through the Port of Grays Harbor is important to the local economy (GHRPC 1992). Log exports are mainly to Japan, China, and Korea.

Agriculture

In 1987, agriculture in the Chehalis Basin generated an estimated $96 million per year from about 200,000 acres (WDA, unpublished 1987 data, WDA 1991). Lewis County has a greater amount of land in agriculture than other Basin counties. Farmland is about equally divided between pasture and crops. Farms average about 100 acres, and slightly over half the operators derive most of their income from non-farming sources. About 80 percent of farm income came from livestock and their products, such as beef, milk, and eggs. Of the remaining 20 percent, hay is the predominant crop while peas and corn are also important. The GHRPC (1992) lists other specialty crops such as cranberries, oysters, farm-raised trout, and Christmas trees.

Tourism

Grays Harbor County attracts more tourists than other coastal Washington counties. Tourism to Grays Harbor and Pacific Counties generated about $50 million in 1989, up $5 million from 1988 (ICF Technology Inc. 1988). Most visitors to these counties were Puget Sound residents, and less than 10 percent came from out of state (ICF Inc. 1988). Local government is promoting sport fishing as a basis for increased tourism to help compensate for some of the losses in the timber industry (Larry Wilder, Grays Harbor Tourism Council, pers. comm.). The goal is year-round sport fishing opportunity, supported by increased runs of spring and fall chinook salmon and summer steelhead (Larry Wilder, Grays Harbor Tourism Council, pers. comm.). The result of fishery improvement is expected to be reflected in increased sport fishing-related purchases at restaurants, bars, motels, and sporting goods and grocery stores.

Fishing and Related Activities

The Basin has important commercial, charter, and private sport fisheries (Table 3) and related businesses. Marinas serve commercial and recreational boats at Ocean Shores, Aberdeen, Hoquiam, and Westport. Grays Harbor also has boat construction and repair businesses, retail fishing supply houses, and associated accommodations (GHRPC 1992).

Commercial Fisheries

Most commercial fishing boats based in Grays Harbor fish outside the Harbor on chinook and coho salmon, bottomfish, and crab. The two major commercial salmon fisheries based in Grays Harbor are the troll and gillnet fisheries. The catch is processed at plants in Westport, Hoquiam, and Taholah. The amount of Washington salmon available to commercial fisheries and processors depends primarily on run sizes and harvest and escapement goals (ICF Technology, Inc. 1988), although allocation of catch to sport fisheries clearly constrains commercial opportunities in many years (Stone, WDF, pers. comm.).

Type	Fishing grounds	Target species
<u>Sport</u>		
Freshwater	Grays Harbor tributaries	Local steelhead, coho, chinook, chum cutthroat trout, white sturgeon
Saltwater	Ocean	Mixed stock coho and chinook
	Grays Harbor, north and south jetties, Westport and Ocean Shores marinas	Local coho and chinook and net pen stocks
<u>Commercial</u>		
Non-Indian		
Gillnet	Grays Harbor	Fall chinook, coho, chum, sturgeon
Troll	Marine areas outside Grays Harbor	Mixed stock coho and chinook
Indian gillnet		
Quinault Nation	Grays Harbor, Humptulips, and lower Chehalis	Spring and fall chinook, coho, chum, steelhead, sturgeon
Chehalis Tribe	Middle Chehalis River	Spring and fall chinook, coho, chum, steelhead
Indian troll		
Quinault Nation	Washington coastal and marine areas	Mixed stock chinook and coho

Table 3. Major fisheries of the Chehalis Basin and their target species (D. Stone and J. Devore, WDF, pers. comm.).

<u>Ocean Troll Fishery</u>. The troll fishery operates off the coast and targets mixed stocks of coho and chinook in a heavily regulated fishery. Westport is the primary troll fishing port in the Basin, and can be expected, along with Ilwaco and Neah Bay, to remain one of the major commercial ports on the Washington coast.

Terminal Area Fisheries. Grays Harbor itself supports local commercial fisheries, as well as sport fishing and oyster culture. Fish species of economic importance within the Harbor include local runs of chinook, coho, and chum salmon, steelhead, and cutthroat trout. Sturgeon, largely originating from the Columbia River, support sport and commercial fisheries in Grays Harbor and the lower Chehalis (John Devore, WDF, pers. comm.). Both the non-Indian and Indian commercial gillnet fisheries operate inside Grays Harbor. Both harvest chinook, coho, and chum salmon. In addition, the Indian fishery harvests steelhead.

Sport Fisheries

The two major recreational fisheries are the river sport fishery and the charterboat fishery. The Basin attracts anglers from outside Grays Harbor, principally from the Puget Sound metropolitan area but from neighboring states as well.

Marine Sport Fishery. The charter salmon fishery has traditionally fished only the mixed stocks of chinook and coho salmon in the ocean, but some boats have begun fishing inside Grays Harbor for local coho. There is also a sport fishery by private boats in the ocean. Westport is the primary charter fishing port in the Basin. The recreational coastal Washington salmon fishery provided about 160,000 annual trips during 1986-1988, of which slightly over half were by charter boat, and most of the rest by private boat (ICF 1988). As salmon stocks have declined many of the charter operators have increasingly turned to bottom fishing.

River Sport Fishery. The river sport fishery targets primarily on steelhead, coho, chinook, and chum salmon, and white sturgeon. The ICF (1988) analysis showed relatively little bank fishing, but may have underestimated the fishing effort along the lower Chehalis, Humptulips, Wynoochee, and Satsop Rivers.

Value of Salmon Fisheries

Pacific Northwest

The economic value of salmonid fishing in the Pacific Northwest (northern California, Washington, Oregon, and Idaho) was studied by the Oregon Rivers Council (1992). They reported that recreational users valued the experience of fishing at about $50/day in 1990 dollars. However, Pacific northwest residents were also willing to pay for the expansion of Columbia River salmon runs by paying higher utility bills at the rate of about $70 per fish, if one includes the value placed on the mere existence of the resource and the continued option of fishing, as well as the value of fishing experience itself (Oregon Rivers Council 1992).

Combined commercial and recreational salmon, trout and steelhead fisheries produced $1.3 billion in annual personal income in direct, indirect, and induced economic impacts, and supported 63,000 jobs in 1990 (Oregon Rivers

Council 1992). The commercial fishery generated $320 million in total personal income and 15,000 jobs (Oregon Rivers Council 1992). The recreational fishery added $930 million and 48,000 jobs (Oregon Rivers Council 1992). Fish-related budgets for state and federal agencies contributed at least $200 million annually and generated indirect and induced income and jobs (Oregon Rivers Council 1992).

Washington State

Salmon fishing contributed $415 million to the state and provided about 21,000 jobs in 1988; commercial salmon fisheries contributed about $136 million annually in personal income and 6,800 jobs (Oregon Rivers Council 1992). The recreational salmonid fishery produced a personal income impact of $279 million and generated about 14,250 jobs (Oregon Rivers Council 1992).

Coastal Washington

Fishing generated $48 million in income and provided about 1,000 jobs in 1988; the non-Indian commercial fisheries in 1982-1985 in Pacific and Grays Harbor Counties generated total sales and employment income of $14 million and provided 350 full-time-equivalent jobs (Table 4) (ICF Technology, Inc. 1988). By gear type, the troll fishery between Cape Flattery and the Columbia River generated income of $11.8 million from 1980 to 1989, while the non-Indian gillnet fishery in Grays Harbor and Willapa Bay produced $1.2 million (Oregon Rivers Council 1992).

	Commercial fishery	Recreational fishery
Total annual sales	$8.5 million	$22 million
Household income	$6 million	$12 million
Employment	300 FTE[A]	650 FTE
Net economic value	-$250,000[B]	$6 million

A Full-time equivalents.
B Some salmon fishermen operate profitably fishing for other species.

Table 4. 1985 Washington coastal salmon fisheries economic values (ICF 1988).

The recreational fishery generated a total household income during 1982-1985 of $34 million annually and 650 full-time-equivalent jobs (Table 4) (ICF Technology, Inc. 1988).

Westport

Commercial fishing. Commercial fishing and fish processing generated a total of $46.7 million in 1988, $33 million in sales and $13.7 million in income, and accounted for 758 jobs at the peak of the season, or 76% of all marina jobs (CH2M Hill-Northwest 1989). However, salmon was only 2.6 percent (0.9 million pounds) of the total seafood landed (28.7 million pounds), which consisted primarily of crab, shrimp, and rockfish (CH2M-Hill Northwest 1989). The personal income impact of the non-Indian troll ocean salmon fishery for Westport was $770,000 in 1991 (Pacific Fishery Management Council 1992).

Recreational Activities. Charter boat and recreational fishing and other tourism generated $6.6 million, $4.7 million in sales and $1.9 in personal income, and provided 132 jobs in 1988 (Lattin 1992). Virtually all recreational income came from outside the Westport area; 90 percent of the visitors were non-local Washington residents and 10% were from out of state (CH2M-Hill Northwest. 1989). Salmon played a larger role in the sport fishery than in the Westport commercial fishery. In 1988 roughly 50% of the charter trips were for salmon fishing; 40% for bottom fishing, and 10% for whale- or bird-watching (CH2M-Hill Northwest 1989). The economic impact of an estimated 66 private, recreation boats in the Westport Marina was not documented (CH2M-Hill Northwest 1989).

Trends in Economic Impact

Washington State

The combined ocean troll and recreational income in 1991 was 67% less than the 1976-1990 average (PFMC 1992). The estimated total state personal income generated in Washington by the non-Indian troll fleet was $2.5 million, an 84 percent decline from the 1976-1990 average, and the decrease was similar for the coastal areas, and spread evenly across Neah Bay, Westport, and Ilwaco (PFMC 1992).

Washington Coast

Non-Indian troll-caught coho landed in Grays Harbor have declined from an average of 207,500 fish for 1976-1980 to 19,300 fish for 1986-1991; Westport recreational ocean salmon fishing effort declined from 210,300 trips to 52,600 trips over the same period (PFMC 1992).

Westport

In 1980 there were 250 charter fishing vessels moored at the Westport Marina; over the next 11 years, it dropped to 65 (Stevens 1992). Estimates of personal income from the recreational ocean salmon fishery declined from the 1976-1990 average of $9.8 million (1991 dollars) to $4.1 million in 1991 (PFMC 1992).

Benefits of Stock Recovery

The potential benefits of recovery extend beyond the direct economic benefits of each additional fish because restoring a depressed wild salmon stock removes harvest constraints and thus allows more efficient harvest of all intermingled healthy runs (Oregon Rivers Council 1992). Moreover, good recreational fishing opportunity aids in attracting new industry to an area (Oregon Rivers Council 1992). Although it is difficult to accurately predict the economic benefits of salmon restoration, recovered salmon runs would obviously be positive for the region's economy.

The ICF (1988) study predicted a 10 percent increase in fishing would result in $1.3 million more in household income for the recreational fishery. Benefits would go almost entirely to boat fisheries, with the charter fleet gaining about 75 percent and the private and rental boat fishery, 25 percent. They also predicted a 10 percent increase in fishing, with no change in daily catch rate and no offsetting decline in any other fishery, would result in $634,000 more household income for the commercial fishery of the two counties. Benefits would be split between the ocean troll and the gillnet fleets.

Healthy fisheries are an important component of the Basin's economic infrastructure. Rebuilding the salmon and steelhead habitat is critical to the economic well-being of the Basin. The salmon restoration recommendations in this report will produce economic benefits by creating jobs for local workers.

Value of Sturgeon Fisheries

Commercial Fishery

The 1982-85 ex-vessel value of all Washington commercial sturgeon landings averaged $350,000 annually (ICF 1988). About 15 percent of the statewide commercial sturgeon harvest originated in Grays Harbor, primarily from the gillnet fishery (ICF 1988).

Recreational Fishery

Less than 10 percent of the Washington sport harvest comes from Grays Harbor; the majority comes from the lower Columbia River (ICF 1988). Sport sturgeon fishing generated about $323,000 annually in Pacific and Grays Harbor Counties during the study period (ICF 1988). About 96 percent of the expenditures involved in-state dollar transfers rather than new money for the state. The recreational sturgeon fishery had a much different makeup than the salmon fishery. About two-thirds of the income was generated by bank fishing trips, and about one-third by private or rental boats (ICF 1988).

Social Values Connected with Fishing

Tribal Fishing

The Tribes' fishing rights are indispensable to maintaining a cohesive tribal society. Two tribes fish the Grays Harbor Basin; the Quinault Indian Nation and the Chehalis Indian Tribe. Their goal is to perpetuate their salmon-dependent culture and promote the economic welfare of their members.

River Sport Fishing

The Chehalis and its primary tributaries downstream of Porter support a significant sport fishery. The Washington Department of Fisheries recently emphasized sport fisheries while maintaining, but not increasing, commercial fisheries (WDF 1991). However, under the present management scheme there is little fishing opportunity upriver from Porter, where there were once larger runs of all species. River sport fishing is an important cultural interest of Basin residents so there is high interest in restoring fishing opportunity. Public participation in fishery enhancement projects seems motivated as much by civic pride and commitment to the local community as by expectation of economic development.

Marine Fishing

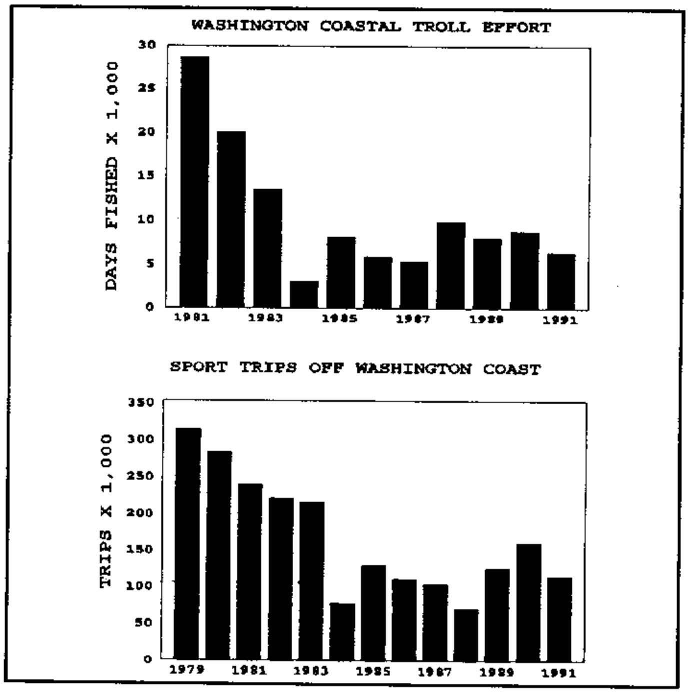

Figure 4. Washington ocean salmon fishing effort (PFMC 1992).

Many of the Basin's families are connected to fishing. The community of Westport, in particular, is based on ocean fishing with success tied directly to the size of health of fish runs. Charterboat and ocean troll fishing has decreased statewide (Figure 4) along with reduced seasons. However, groups representing both these interests have promoted rebuilding Grays Harbor stocks, even though they often harvest mostly Columbia River fish. In 1991, charterboats began fishing inside Grays Harbor to exploit the very abundant Chehalis coho run of that year (Mark Cedergreen, Westport Charter Association, pers. comm.).

Chapter 2: HISTORICAL ACCOUNT OF THE FISHERY RESOURCES AND HABITATS

The history of Chehalis Basin fish runs and habitats is one of pristine productivity, then gross degradation, followed by partial recovery. The recorded history has seen several revolutions in fishing methods and areas, and in industries and processes affecting fish habitat. In the first several decades of this century, unregulated log transport and fishing, overlapping in time with inadequate water pollution control in the inner Harbor, contributed to declining salmon and steelhead catches in the Grays Harbor area.

In response, the State imposed fishing regulations and later saw to the removal of splash dams (see discussion on logging later in this chapter) and restocked the streams behind them. Research into habitat quality began in 1940 and prompted a series of water cleanup efforts that continue (Pine and Tracey 1971; Seiler 1989). Unfortunately, this did not promote a speedy recovery of fish stocks and a long period of depressed terminal catches followed.

All the while, increasing marine interception may have masked potential recovery of coho and chinook (John Campbell, Weyerhaeuser Corp., pers. comm.). During the 1950s, chum salmon joined chinook, coho, and steelhead on the list of depressed runs (Ward *et al.* 1971), and steelhead catch monitoring had been discontinued (WDW unpublished records), adding to the frustration.

Accurate catch and escapement monitoring began around 1969. The 1970s brought about an era of increasing understanding of the fishery and habitat resource, and increasing participation by all groups having a stake in those resources.

Since catch is a result of fishing efficiency, environmental conditions, and fish production, this report will provide a history of fishing on Chehalis Basin runs, a brief description of the Basin's environmental history, and a history of hatcheries.

HISTORY OF FISHING ON CHEHALIS BASIN SALMON AND STEELHEAD

The history of fishing for salmon, and to a lesser degree, steelhead, has seen a growing diversity of fishing gear and expansion of fishing areas. Fishing on Chehalis Basin runs progressed seaward as each new fishery became the first to intercept fish along the migratory path of returning adults. Ultimately, Chehalis Basin fishery managers lost their ability to ensure a surplus of fish for harvest and spawning within the Chehalis River Basin.

Chehalis River Basin Fisheries

Fisheries have tended toward multiple gear types and expansion of fishing grounds. Before European contact, various Indian tribes or bands fished Grays Harbor for salmon, steelhead, cutthroat trout, and sturgeon with weirs and other terminal gear (GHRPC 1992). Settlers began arriving in the 1850s and, by 1877, were using fish traps (GHRPC 1992) downstream of Indian weirs to supply a salmon cannery. Thus began the conflict between upriver and downriver fisheries that continues even to some degree today.

Later, fish traps were built along the shores of Grays Harbor; next, Grays Harbor gillnetters jumped ahead of the trap fishery by exploiting open waters of the Harbor (Wendler and Deschamps 1955b). By 1892, when the commercial catch was first reported (WDF, unpub. records), set and drift gillnetting were legally recognized along with trapping. By 1934, harvests had declined and the trap and setnet fisheries were outlawed, apparently to stabilize harvest (Wendler and Deschamps 1955b).

In the 1950s, nylon gillnets were introduced and quickly replaced cotton and linen nets, making the Grays Harbor drift gillnet fishery more efficient.

In 1974, the Federal Court ruled that western Washington tribes having signed treaties with the United States in the 1850s reserved half the harvestable fish passing through their usual and accustomed -- that is, historic -- fishing grounds (for example, see Northwest Indian Fisheries Commission 1989). This resulted in a reallocation of catch by a reduction in mixed-stock, open-ocean fisheries and increased terminal area returns and stream-by-stream fishery management throughout western Washington (Dr. Percy Washington, Gaia Inc., pers. comm.). Locally, it also led to expansion of Quinault tribal fisheries off the Quinault reservation and onto Grays Harbor and the Humptulips and Chehalis rivers (Hiss *et al.* 1982).

Marine Interception

Virtually all fishing on Chehalis Basin salmon originally occurred inside the Basin, but, around 1935, fishing boats were fitted with economical diesel motors. Trollers began to exploit the mixed stocks in the ocean (Wendler and Deschamps 1955b). Boats could now easily run to ocean fishing grounds and intercept fish before the runs reached Grays Harbor, Willapa Bay, and the Columbia River. The ocean troll fishery increased tenfold from 1940 to 1970 (Grays Harbor Regional Planning Commission 1992). This resulted in loss of harvest control by local managers (Washington 1988 draft). In the late 1940s, charterboats joined trollers in the marine fishery. By 1950, WDF began keeping catch records from this fleet. The fleet continued to grow steadily and peaked in 1977 (Ward and Hoines 1985).

As ocean fleets developed at all Pacific coast ports, Chehalis Basin chinook and coho were caught off the coasts of Alaska, Canada, and Oregon as well as Washington (now known from coded-wire tagging data). Prior to 1976, individual states managed marine fisheries. But, in that year, the Magnuson Fishery Conservation and Management Act created the Pacific Fishery Management Council, with the duty of setting fishing seasons and limits for marine waters between 3 and 200 miles off the coasts of California, Oregon, and Washington.

However, the Act did not address the issue of Canadian interceptions. The Pacific Salmon Commission (PSC) was formed in 1985, as a result of the Pacific Salmon Treaty between the United States and Canada, to prevent overfishing, increase salmon production, and ensure each country receives benefits equal to its own production (PSC 1988).

Although recent increases in Washington coastal chinook escapements might be attributable to reductions in interception under the Treaty, to date the Treaty has not entirely satisfied the desire for increased terminal fishing opportunity in Grays Harbor. Further significant changes in U.S. and Canadian fishing patterns will depend on continuing international negotiation.

While the overall catches of chinook and coho have declined over the past 20 years, catch reductions were not equally shared coastwide (Figure 5). Marine chinook catch landed in Washington decreased more than that of Canada over the last 20 years, while the southeast Alaskan catch remained about the same. Washington coho landings decreased more than those of Oregon, while the Canadian catch remained about the same.

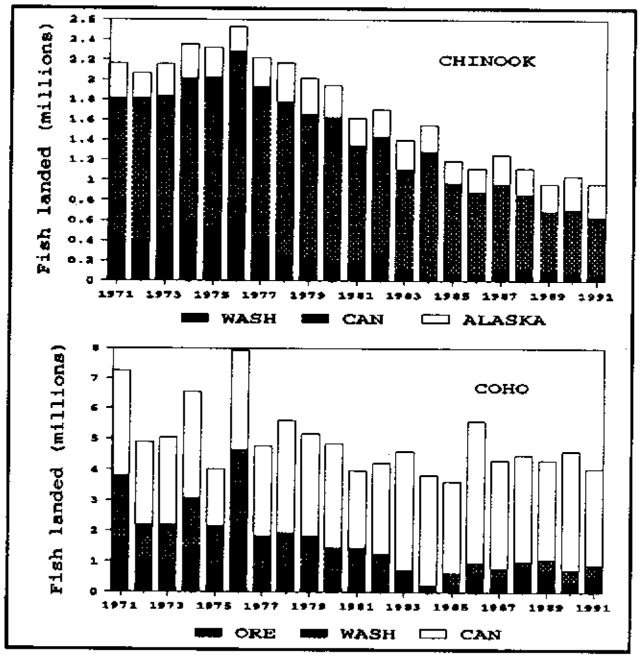

Figure 5. Landings from ocean troll and recreational fisheries (PFMC 1992).

HABITAT HISTORY

Fish habitat in the Basin has been subjected to progressive degradation from agriculture, pulp production, gravel mining, dams, urbanization, and dredge and fill practices. Over the last 50 years, there has been a movement, now accelerating, that has partially succeeded in slowing habitat deterioration. As the primary economic focus in the Basin changed through time, the habitat battleground has constantly shifted.

Historically, agriculture was the first land use to conflict with natural fish production. Later, the heyday of logging and pulp production resulted in gross abuses to salmon habitat. As the Basin developed, gravel was mined from the rivers for road building, at the expense of salmon spawning grounds. While all these economic developments have ultimately had to concede a place for the fish, they have given us a legacy of partially resolved technical and political questions. Chapter 5 describes how each economic development has impacted fishery habitat; the history of these developments is addressed here.

Agriculture

Agriculture exacted a price from the fishery resource beginning when the Basin was first opened to cultivation. The story of agriculture and ranching is one of early fish habitat damage, historically largely undocumented and unredressed, followed by a recent movement toward compatibility with aquatic habitat. In 1857, the City of Hoquiam was founded, with agriculture as its economic base. The demand for dairy products for the Fraser River gold rush stimulated Hoquiam's development. Bringing land under cultivation had four effects:

Removing Side Channels, Sloughs, and Ponds.- Farmers diked certain riverfront land on the Chehalis and its principal tributaries, especially the Wynoochee, Satsop, and Humptulips, and to a lesser degree the Skookumchuck and Newaukum (GHRPC 1992). This destroyed winter cover and feeding areas for juvenile coho salmon and cutthroat trout. River confinement is also thought to have stimulated scouring, thus artificially lowering river elevations.

Straightening Small Streams.- Straightening of small tributary streams to allow more convenient grazing and farming resulted in loss of total stream area and the essential habitat variation of the riffle/pool complex. Examples are Hanaford Creek and Bloom's Ditch (Phinney *et al.* 1975).

Clearing the Bank of Trees.- This removed the shade tree canopy along some tributaries, contributing immediately to warmer water, and, over the long term, to less input of woody debris for fish cover.

Snagging, or Logjam Removal.- In the 1880s, the USACE cleared many streams of logjams, which were apparently thought to promote erosion, flooding and channel shifting wherever jams were located.

Logging

This section will describe some of the damaging timber harvest practices now prohibited by existing WDNR regulations. The effects of past timber harvest practices, although sometimes obvious, are usually maddeningly difficult to measure and link to specific degrees of fishery damage.

History of the Industry

In the early 1880s, timber harvest joined agriculture as a major economic activity (Grays Harbor Regional Planning Commission 1992). In 1882, Grays Harbor's first sawmill was built on the Hoquiam. In 1909, the demand for logs grew quickly for use in rebuilding San Francisco after the fire and earthquake. Thus arose the need to quickly transport many logs from the woods to the Harbor. Before the advent of modern logging equipment and practices, the most efficient way to transport logs to the mills was by water; giving rise to the era of splash dam logging. Logging and driving companies constructed a system of log dams to maintain ponds for holding logs and to create a supply of water to move their cut timber (Wendler and Deschamps 1955b). Log splashing usually occurred weekly. The gates of each dam were suddenly opened and the logs behind the dam sluiced through the gate and carried downstream by the flow.

This was apparently the most ecologically damaging period the Basin has known (Wendler and Deschamps 1955a). Almost all the structures were total blocks to anadromous fish and eliminated considerable spawning and rearing areas (Figure 6). These barriers effectively blocked over 60 percent of the salmon spawning and rearing streams of Grays Harbor. The average splash dam was in place about 20 years.

The downstream impacts included:

(1) mechanical injury to eggs and fish spawning below the dam,
(2) destabilization of gravel beds by moving logs or suddenly increased flows, with the resultant disappearance of distinct riffles and pools,
(3) channel instability,
(4) deposition of bark over a large part of the stream bottom between splashes,
(5) unnatural shading of many miles of tidewater by log rafts, and
(6) loss of fish cover by clearing woody debris from stream channels.

In the 1930, the timber industry began undergoing a technical revolution as roads and railroads began to replace rivers for log transport (Wendler and Deschamps 1955b), and the dams became obsolete. Many operators abandoned the installations without attempting to remove them. Some fish ladders were constructed where feasible, but many did not work efficiently. Many dams blocked migrating fish until they either rotted out, washed out, or were removed by WDF in the early 1950s. After removal, rapid natural recolonization was observed in several instances. In addition, hatchery-reared fish, usually coho fry, were at times planted upstream to speed recovery.

A significant change occurred in the logging industry in 1962 when very high winds blew down extensive timber, creating the need to remove a large number of logs before decay set in. The permanent effect was that Japan became a major buyer, and Weyerhaeuser Company a major exporter, of Chehalis Basin logs (Felver 1982, quoted by Grays Harbor Regional Planning Commission 1992).

Continuing Effects of Old Logging Practices

Shade Removal. Economically valuable trees were usually removed down to the streambank until the last decade. Until shade trees grow back, an exposed stream tends to become warmer and, if it gets too warm, salmon and steelhead cannot use it. If this happens to a number of streams, temperatures may increase downstream as well.

Sources of Instream Fish Cover Removed. Lack of woody debris naturally entering the stream over the years resulted in lost habitat complexity until some point in the last decade. This situation especially hurts juvenile coho and adult chinook and, to a lesser extent, juvenile steelhead, because it denies them instream cover. Further misguided efforts to remove logging

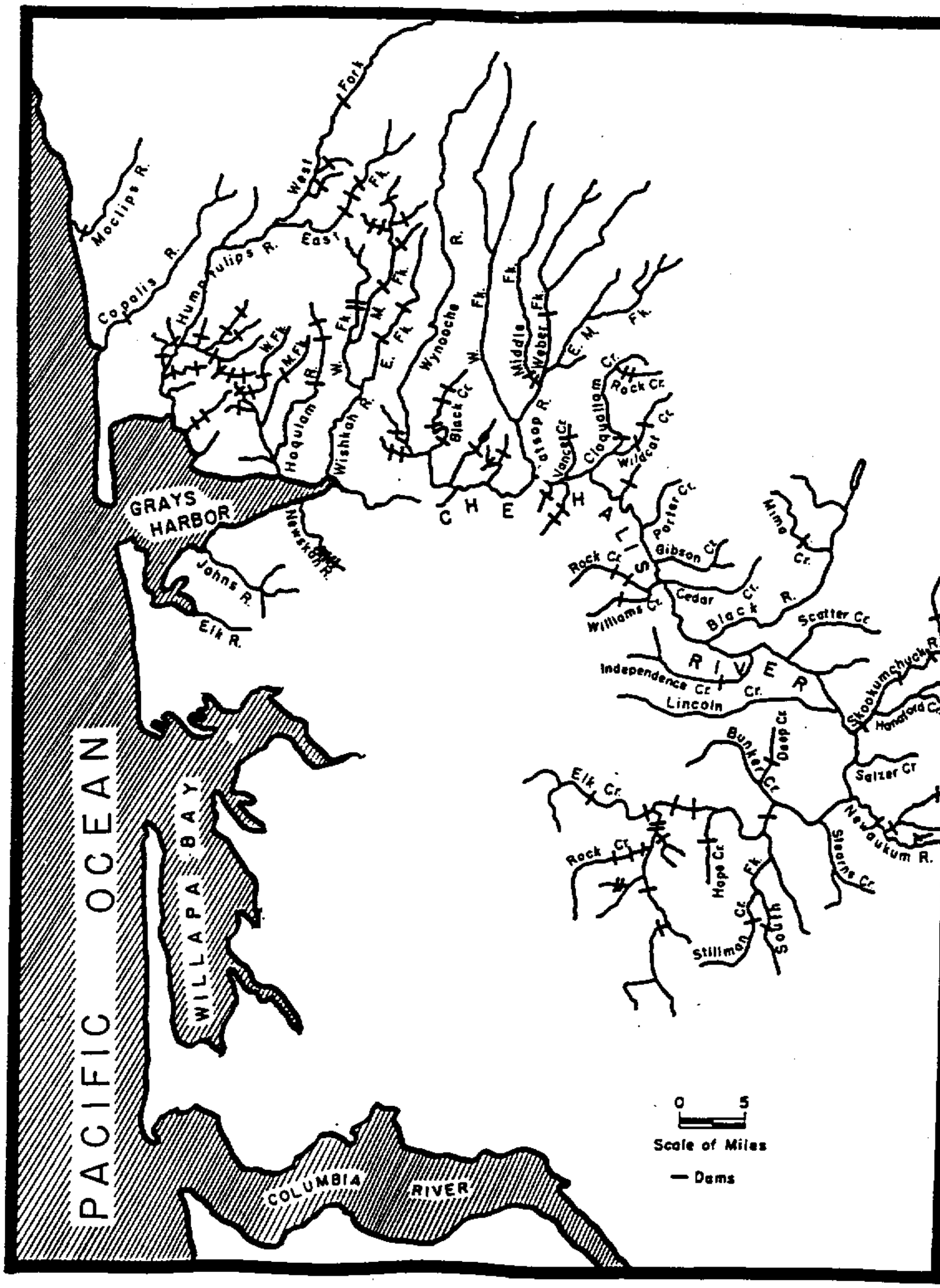

Figure 6. Past location of splash dams (Wendler and Deschamps 1955b).

debris from streams in the previous decades may have actually diminished productivity in many areas. The upper Chehalis, from Fisk Falls at Mile 113 upstream to several miles beyond the Forks of the Chehalis, exemplifies this problem.

Stream Channel Destabilized. Logging can also reduce fish production by reducing the stability of the watershed and the streambed. To the degree that logging roads and other activities accelerated the natural process of slope failure, they led to an unnaturally high rate of bedload and silt accumulation (Cederholm and Reid 1987). This can lead to an unstable streambed, in which high flows tend to rapidly shift the channel, scour spawning gravels, and wash fry that cannot hold their position against the flow downstream. Porter Creek is a likely case of gravel and sand loss attributable to logging.

Recent Forest Practices Improvements

The current trend seems to be slow but steady progress toward compatibility between forestry and fishery resources. The last decade has seen intense interagency effort to make timber harvest compatible with fishery values. In 1980, in Phase II of *U.S. vs. Washington*, Judge William Orrick ruled that fish habitat protection was a treaty right (Cohen 1986). This led to tribal participation in fish habitat protection on the technical and management levels. The specter of continual controversy over the relation between fisheries and forest practices led to the development of the Timber, Fish, and Wildlife Agreement (TFW), wherein all principal parties influenced by forest practices have an opportunity to participate in reducing the detriments.

The 1990 decision to list the Northern Spotted Owl as a federally threatened species resulted in a reduction of old growth timber harvest which should reduce some stream degradation to the benefit of salmon and steelhead.

Gravel Mining

As the Basin population grew and roads replaced rivers for log transport, gravel for roads and general construction came into high demand. Gravel extraction from the wetted channel became popular shortly after the end of the splash dam era, since river-run gravel is especially useful for road-building. At first, draglines and clamshell buckets were commonly used to remove gravel from pits in the main river channel.

By 1945, WDF required permits for such work, and applications increased annually (WDF 1986). In the 1950s, WDF recognized the damage and prohibited gravel mining in the wetted channel. However, gravel mining was allowed to continue on the dry bars during low water. The Humptulips was the main gravel producer, followed by the Satsop and Wynoochee.

Since then, progressively stricter state and county regulation has eliminated the most damaging effects, and has also successfully encouraged operators to seek gravel from off-channel sources. In 1960, WDF permits further restricted gravel mining by requiring gravel removal by bar scalping, as opposed to pit construction (WDF 1986). Bars had to be smoothly sloped after scalping to avoid trapping fish as the river rose and fell. In 1975, WDF further restricted gravel removal by closing the Humptulips to new bar scalping above RM 15 (WDF 1986). The wisdom of this move was confirmed by Collins and Dunne (1986, quoted in Mark *et al.* 1986) who showed that gravel mining on the Humptulips had been taking up to 10 times more than the river could replenish in an average year.

Gravel scalping is still permitted up to the transport rates derived by Collins and Dunne (1988) for the Humptulips, Wynoochee, and Satsop. Annual removal is divided equally among gravel removal applicants for river of interest. Special state legislation after the 1990 flood allowed a single gravel removal operator to remove seven times the transport rate on the Humptulips to help reduce the risk of flood damage. A special provision of the legislation closed the Humptulips to further gravel removal for 7 years. Presently, there are 6 years remaining on this provision. The Satsop and Wynoochee rivers receive only an average of one to two applications per year. The added restrictions on gravel bar scalping (removal) combined with decreased demands has made this type of gravel removal nearly economically unfeasible.

Urbanization

As the Basin was settled, urbanization permanently altered the aquatic resource. Streets, buildings, bridges, culverts, and levees appeared, and towns required water supplies and sewage disposal. Streets and buildings created urban stormwater runoff, exacerbating both flooding and streambed instability. Culverts under roads and city streets were seldom designed to allow fish to pass upstream.

Those towns not built on filled land often encroached onto floodplains -- a process still in full force today in the upper Chehalis. Levees were built in Centralia, Aberdeen, and Cosmopolis to protect development in the path of the river, but levees typically cut off seasonally valuable fish habitat.

Water rights were granted to cities, industries, and individual homeowners on the philosophy that the best use of water was always for economic development, i.e., use outside the natural stream. Only in the 1970s was action begun to protect instream resources (Mahlum 1976).

Originally, all urban sewage was discharged untreated into the nearest water body; sewage plants were not in operation, for instance, in the Aberdeen area until 1957 (GHRPC 1992). This made parts of the middle and lower Chehalis River uninhabitable for fish for at least the summer and early fall (WDOE et al. 1974).

Estuarine Dredging and Filling

Since the turn of the century, log exports have driven the Grays Harbor shipping industry, requiring a navigation channel from the ocean to the inner

Harbor log docks. In 1911, the Port of Grays Harbor was organized for the purpose of dredging, filling, and wharf construction. The increasing size of log-export vessels forced successive deepening of the navigation channel from Westport to Cosmopolis in 1923, the late 1940s, 1973, and 1990. The most important historical effect of dredging has been filling of wetlands, particularly in the vicinity of the Cow Point (Figure 2) (GHRPC 1992).

Landfills in the Grays Harbor tidelands created much of downtown Aberdeen and Hoquiam, and removed extensive rearing habitat for chum, chinook, and coho salmon. Dredged material, along with sawdust and bark from sawmills, was used to fill the tidelands. Wetland filling is now regulated by the USACE and has been substantially reduced. However, the full range of other environmental effects of dredging and of dredged material disposal has only been addressed in the two most recent navigation channel widening and deepening episodes, particularly the current one. The most recent harbor deepening, soon to be completed, is the first to have extensive environmental evaluation built into the project (Ging 1988).

Dams and Diversions

Besides the splash dams described above, other relatively small dams and diversions have been constructed in the Basin over the years (USDA et al. 1974; GHRPC 1992) for municipal and industrial use. A few of these dams have blocked access to upstream spawning and rearing habitat (Phinney *et al.* 1975). The incremental effect of numerous withdrawals in some streams has seriously reduced flow, reducing spawning and rearing habitat and exacerbating poor water quality (Fraser 1986).

The Skookumchuck and Wynoochee Reservoirs are by far the two largest dams in the Chehalis Basin. The Skookumchuck was finished in 1970, and the agreed-upon fishery mitigation was fully in place shortly thereafter (Hiss et al. 1982). The Wynoochee Dam was completed in 1974. Unlike the Skookumchuck, the Wynoochee mitigation is yet to be completely agreed upon (for example, see Riley 1992).

Industrial Waste Disposal

Water quality in Grays Harbor is intimately linked to pulp production. Since its inception in the late 1920s, pulp production appears to have depressed fish survival and created conditions popularly known as the "pollution block" (WDF 1971). At least until very recently, the pollution block limited the effectiveness of potential improvements in habitat and hatchery production throughout the Chehalis system. However, successive changes to mill waste treatment and pulp-making processes have led to stepwise estuarine water quality improvements near the mills. Research in the 1940s identified lack of dissolved oxygen in the inner Harbor as the prime suspect (Eriksen and Townsend 1940). When pollution was controlled enough to restore sufficient oxygen for fish in the inner Harbor, fish survival still appeared poor, and investigators attempted to identify toxic substances that waste treatment failed to remove. The most recent evaluation of fish survival (Schroder and Fresh 1992) suggests toxicity from unidentified substances as recently as

1989. However, effluent clean-up since that date may have finally removed the "block". Data on fish survival through the presumably cleaner inner Harbor will be available over the next several years. A detailed account of inner Harbor water quality appears in Chapter 4.

Chapter 3: HISTORY AND CURRENT STATUS OF FISH POPULATIONS

Anadromous fish of sport and commercial value using the Chehalis Basin are spring- and fall-run chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), winter and summer run steelhead trout (*O. mykiss*), sea-run cutthroat trout (*O. clarki*), white sturgeon (*Acipenser transmontanus*), green sturgeon (*A. medirostris*), and American shad (*Alosa sapidissima*). The primary forage fish resources are Northern anchovy (*Engraulis mordax*) and longfin smelt (*Spirinchus thaleichthys*).

CHINOOK SALMON

There is a continuum of chinook entry into Chehalis Basin streams from March through December. Chehalis Basin chinook salmon are managed as separate spring and fall runs. Spring chinook return between March 1 and August 31 to the Chehalis Indian net fishery in the vicinity of Oakville. Fall chinook begin entering the Satsop as early as September and return to other tributaries later. Fall chinook return to the Grays Harbor fisheries after September 1 (Stone, WDF, pers. comm.).

Terminal Area Run Size and Escapement Goals

__Spring Chinook__

Terminal area run size, that is, escapement plus Chehalis Basin catch, has been sufficient to meet the escapement goal in three of the past five years, although the goal was never met from 1970 to 1985 (Table 5; Figure 7).

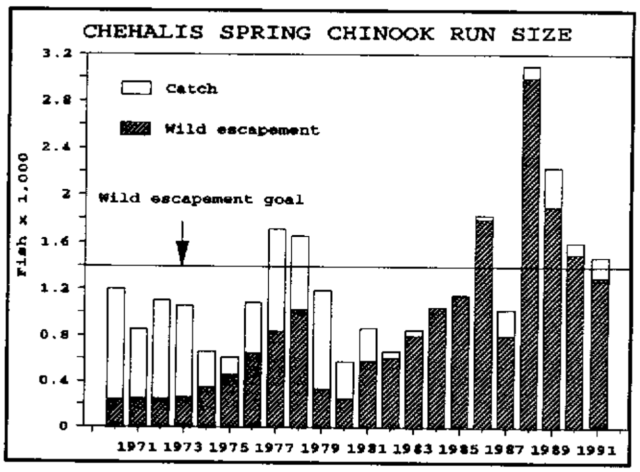

Figure 7. Chehalis Basin spring chinook salmon terminal area run size (WDF, unpublished data).

Drastic cutbacks in all fisheries, but particularly the Chehalis tribal fishery, may have contributed to recovery (Deschamps, Chehalis Tribe,; Stone, WDF, pers. comm.). Cyclical improvement in early marine survival since the 1983 *El Niño* event may also be contributing. Despite the overall increase in escapement, Wynoochee spring chinook are thought to be non-existent (Stone, WDF, pers. comm.); they were cited as at high risk of extinction by Nehlsen et al. (1991).

	Wild escapement goal met			Terminal run size	
	Goal	Last brood cycle[A]	Period of record[A]	Last brood cycle	Period of record[D]
Chinook					
Spring run	1,400	3/5	4/22	2,023	1,614
Fall run	14,600	4/5[B]	5/23	39,818	21,587
Coho	35,400	3/3	16/25	166,674	104,387
Chum	21,000	1/4	7/23	53,247	44,725
Steelhead					
Winter run					
Chehalis system					
Hatchery	C	C	C	4,884	4,405
Wild	8,600	1/4	5/9	11,032	11,779
Humptulips system					
Hatchery	C	C	C	1,395	2,841
Wild	1,600	4/4	8/8	4,152	4,412
Summer run	C	C	C	688	1,035

A. First number stands for number of years goal was met or exceeded; second number stands for number of years considered.
B. Disputed by QFiD, who claim escapement goal was met in all 5 most recent years
C. Meeting hatchery escapement goals is seldom a limiting factor in fishery management.
D. Periods of record are: spring chinook, 1970-1991; fall chinook, 1969-1991; coho, 1967-1991; chum, 1969-1991; Chehalis winter steelhead, 1982-83 to 1990-91; Humptulips winter steelhead, 1978-79 to 1990-91; summer steelhead 1981-1989.

Table 5. Chehalis Basin wild salmon and steelhead escapement goals and the number of years in which the escapement goal was recently met.

Fall Chinook

Although the wild escapement goal was never met from 1969 to 1983, runs have exceeded or met the goal for the last five years (Table 5, Figure 8) and parallel the positive trend for spring chinook. All the probable factors allowing spring chinook recovery are likely affecting fall chinook as well. Hatchery production is a small part of the Chehalis Basin fall run, apparently

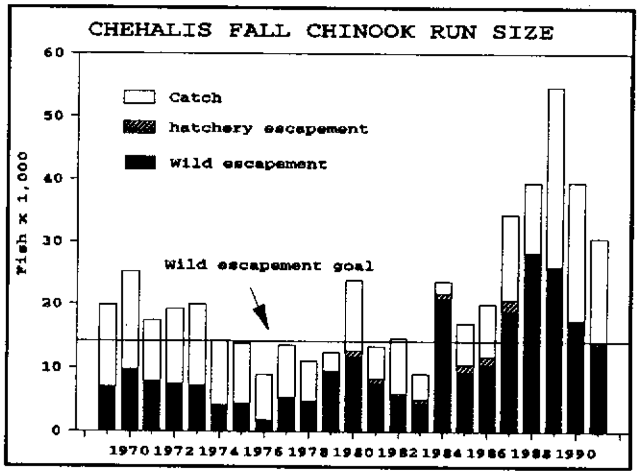

Figure 8. Chehalis Basin fall chinook terminal area run size (WDF unpublished data).

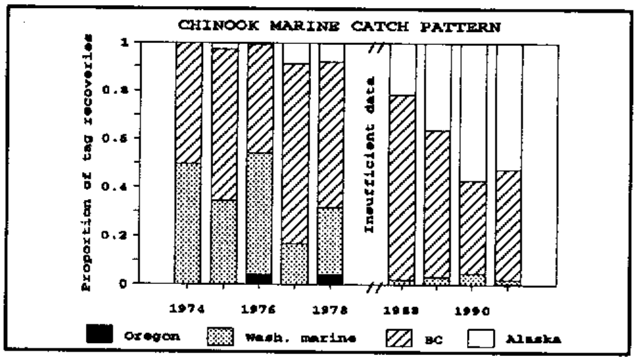

Figure 9. Fall chinook marine interception patterns (PFMC and WDF data).

because of poor post-release survival of Simpson Hatchery smolts (Brix, WDF, pers. comm.). Hatchery production has had relative success on the Humptulips, the difference possibly being due to the inner Harbor pollution block mentioned earlier.

Fall Chinook Marine Interception

Fall chinook are caught primarily in the ocean troll fisheries off southeast Alaska and northern British Columbia. British Columbia fisheries caught 68.9 percent of the Chehalis fall chinook marine catch throughout the period for which tag returns are available (Figure 9). The remaining marine catch went to Alaska, at 19.7 percent, and Washington at 11.2 percent.

Juvenile Chinook Production

Seiler *et al.* (1992a) enumerated the capture of chinook salmon in a floating inclined plane trap between Oakville and Rochester between 1985 and 1990. Estimates of emigration could not be made because trapping efficiency was not evaluated. The following table roughly indicates the weak relation between smolt abundance and the previous year's adult escapement upstream of Porter; little is actually known about the relation between adult escapement and smolt production.

Brood year	Adult escapement	Smolt catch
1985	2,826	17,337
1986	3,133	20,964
1987	5,034	39,164
1988	6,152	121,479
1989	5,628	10,002
1990	1,963	16,537

Current Fall Chinook Total Run Size and Historical Levels

Chehalis Basin chinook abundance is within the same order of magnitude as that reconstructed from historical catch data (Table 6), given the assumptions outlined below. This suggests current run size is a base level of natural production, to be reinforced by improving inner Harbor and upper Chehalis water quality, and by assuring optimum wild escapement through refinements in habitat assessment and fishery management. It is important that any hatchery programs be enhancement, not replacement, of the base level.

The following are assumptions supporting estimates of total chinook run size in Table 6.

I. HISTORIC PERIOD

The Grays Harbor Catch Reporting Area non-Indian gillnet catch, averaged over the period 1910-1919, plus present Chehalis Basin spring and fall chinook escapement is a conservative estimate of potential healthy total run size, based on the following assumptions:

A. **The Grays Harbor Catch Reporting Area represented the Chehalis Basin even though the Area included all the rivers of the northern Washington coast to Cape Flattery.** Catch records beginning in 1936 divided Grays Harbor Area catch into only two categories: Grays Harbor commercial gillnet catch, and north coastal Indian catch, thus implying that:

   1. North coastal non-Indian catch was negligible in comparison to north coastal Indian catch;
   2. the Grays Harbor Indian catch was negligible in comparison to the Grays Harbor non-Indian catch; and
   3. sport catch throughout the Area was negligible.

B. **The average catch from 1910 to 1919 represented a healthy run (following a method used by Chapman (1986) for the Columbia River.**

   1. The 10-year catch averaging period is the shortest that results in an easily interpreted catch trend because undue weight is not given to unusually high or low brood cycles.
   2. The Grays Harbor non-Indian gillnet catch trend increased from the initial 1890-1899 period, reached its highest value during the 1910-1919 period, and declined from then until now. This suggests:
      a. Fishing pressure increased to maximum efficiency until the peak period, and overfishing did not seriously affect the population prior to the start of catch reporting in 1890.
      b. Terminal area overfishing (Wendler and Deschamps 1955b) combined with the onset of splash dam logging (Wendler and Deschamps 1955a) initiated a stock decline after the peak catch period.
      c. Because marine interception became significant only after the peak period (Wendler and Deschamps 1955b), the peak period catch is still a reliable estimate of total catch, if one accepts that:
         1.) Washington marine catch represents coastal marine fishing effort in general; and
         2.) Washington marine fishing increased at the same rate prior to inception of marine catch records in 1936 (WDF 1971), as it did during its expansionary period thereafter, i.e., it was negligible prior to the 1920s.

C. **Average historical spawning escapements were similar to current escapements.**

II.CURRENT PERIOD

Estimated terminal catch plus marine catch plus spawning escapement, averaged over 1987-1990, reasonably estimates total wild run size of Chehalis Basin fall chinook, based on the following assumptions:

A. **The ratio of 1987-1990 marine area expanded tag returns to terminal area expanded tag returns multiplied by the terminal area catch, adequately estimates marine interception of Chehalis Basin chinook (Table 7).** This rests on four propositions:

   1. *Terminal tag recoveries represent all commercial salmon fisheries.* Any resulting upward bias in total catch would not be excessive since fall chinook sport catch averaged only about eight percent of the terminal area catch (WDF, unpublished data).

Current period

Catch year[B]	Escapement[C]	Terminal area wild fall run catch[A] Humptulips R.	Chehalis R.	Chehalis Basin
1987	18,850	4,878	7,517	
1988	28,150	7,376	3,610	
1989	26,100	11,320	18,294	
1990	17,500	7,978	13,457	
Mean	22,650	7,888	10,720	
Total catch/terminal catch[D]		1.60	4.07	
Estimated total catch		12,621	43,634	56,251
Estimated run size (catch plus escapement)				78,901

Historical period

Catch year[E]	Grays Harbor Area non-Indian gillnet catch[F]
1910	64,458
1911	50,269
1912	52,521
1913	84,647
1914	34,743
1915	43,885
1916	43,884
1917	49,460
1918	29,386
1919	26,946
Mean catch	48,020
Historic escapement[G]	+22,650
Estimated wild run average size	70,670

A. Source: WDF unpub. run reconstruction data provided by Dick Stone, Montesano.
B. Tag recovery data unavailable for prior years.
C. Source: WDF unpub. data. provided by Dick Stone, Montesano.
D. See Table 7.
E. See Table 8 for explanation of choice of base period.
F. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.
G. Assumed to be the same as current escapement.

Table 6. Estimation of historic and current Chehalis Basin wild chinook populations (see text for assumptions).

2. *Fall chinook interception represents Chehalis Basin chinook as a whole.* No tagging studies have been performed on Chehalis spring chinook, but they are assumed to have the same far-northerly distribution as coastal Washington chinook stocks in general (Fraidenburg 1982; Scott 1992 draft).
3. *Separate calculation for Humptulips and Chehalis systems adequately accounts for differing terminal exploitation rates due to heavier exploitation of Humptulips fall chinook than Chehalis fish* (WDF, unpublished data).
4. *Hatchery and wild fish contribute to marine and terminal fisheries in essentially the same way.* This is the accepted assumption in interpretation of PSC indicator stocks coastwide (Scott 1992 draft).

B. **Spring chinook catch was omitted from calculations for simplicity, because this fishery would have added an average of only about 200 fish to the Chehalis system catch.** Including this catch would also have added to the bias described in Item I.A.1. above.

Catch year	Origin	Expanded tag recoveries		
		Che. basin	Marine	Ratio (Che.+Mar.)/Che.
1987	Simpson	3	19	
1988	Simpson	22	79	
1989	Simpson	31	158	
1990	Simpson	61	103	
Total		117	359	4.07
1987	Humptulips	154	32	
1988	Humptulips	129	51	
1989	Humptulips	75	83	
1990	Humptulips	129	124	
Total		487	290	1.60

Table 7. Tag recovery data used to expand terminal wild chinook catch to estimate total catch including interception.

COHO SALMON

Chehalis Basin coho are biologically divided into two groups based on spawn timing, but for fisheries management are treated as a single group (Stone, WDF, pers. comm.). The largest, "normal" spawn timing group consists of both hatchery and wild fish, which peaks in the Grays Harbor fishery in early October and spawn in early December throughout the Chehalis Basin. The later-spawning group is virtually all wild, returns in late November and December and spawns in January-February, primarily in the major lower Chehalis tributaries.

Terminal Area Run Size and Escapement Goals

Combined Normal- and Late-timed Spawners

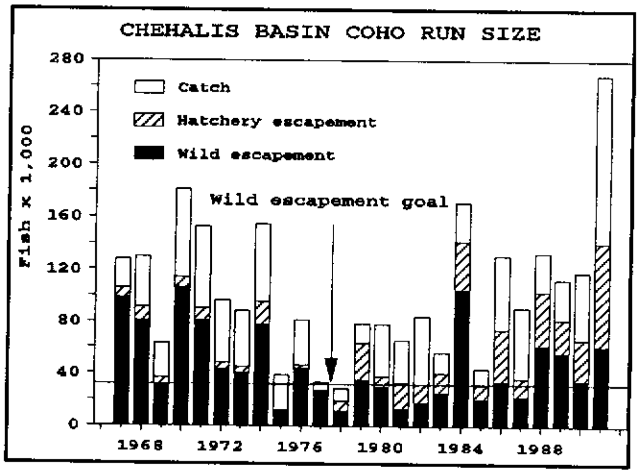

Figure 10. Chehalis Basin coho salmon terminal area run size (WDF unpublished data).

Although the terminal catch has been tending to increase, until recently wild escapement often fell short of the goal (Table 5). The wild escapement goal has been met in all four of the past years but was only met in eight of the past seventeen years; this despite increasing terminal runs over those years (Figure 10). Local underescapement is common even when the overall goal is met, although not consistent in any one sub-basin (Stone, WDF, pers. comm.). Wild underescapement may result from low survival of wild coho, sometimes combined with heavy harvest.

Late-timed Spawners

Late-spawning wild coho have been documented in Bingham Creek, a tributary of the East Fork Satsop (Dave Seiler, WDF, pers. comm.), the upper Wynoochee River (USACE, Seattle District, unpub. records), and the Wishkah River (Terry Balzell, LLTK, pers. comm.) and may use other streams as well (Seiler, WDF, pers. comm.). Late-spawning coho have always been far fewer than normal-timed coho, but the late run has been particularly small in the last several years, perhaps due to unintentionally heavy hatchery brood stocking or poor survival of late-timed hatchery coho after release (Seiler, WDF, pers. comm.).

Marine Interception

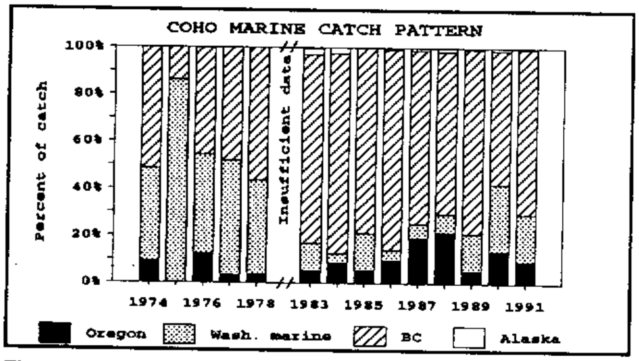

Figure 11. Chehalis Basin marine coho catch distribution (PSMFC and WDF unpublished data).

The British Columbia fisheries, mostly off the west coast of Vancouver Island, accounted for an average 82.7% of the marine catch of Chehalis coho salmon throughout the last 15 years (Figure 11). Oregon fishers harvested an average of 7.3%. The Washington share varied from 3.9 to 15.6%.

Juvenile Production

The number of natural coho smolts produced annually in the entire Chehalis Basin above the town of

Brood year	Escapement	Hatchery-reared fry release (brood year+1)	Low Flow index[A] (brood year+1)	Smolt Production (brood year+2)
1974	78,000	525,000		116,000
1975	10,000	90,000		47,000
1984	80,000	3,383,000	7.81	884,000
1985	8,000	3,700,000	6.02	400,000
1986	32,000	2,900,000	4.62	500,000
1987	18,800	2,500,000	7.57	225,000
1988	33,000	2,500,000	6.56	771,000
1989	30,000	2,700,000	8.05	300,000

A. Indicates summer low streamflow, an important limiting factor in coho smolt production.

Table 8. Juvenile coho production from the Upper Chehalis River system (Brix and Seiler 1977, 1978; Seiler et al. 1992b; WDF unpublished records).

Porter (Table 8) was estimated by trapping downstream migrants in 1976, 1977, and from 1986 to 1991 (Brix and Seiler 1977, 1978; Seiler *et al.* 1992b). The upper Chehalis is producing roughly as many coho smolts per square mile and per spawner as other western Washington streams (Seiler 1987, 1989). The upper Chehalis system produces exceptionally large, healthy smolts compared with several other western Washington rivers (Schroder and Fresh 1992).

Smolt production from the 1974 brood year was lower than other years perhaps because smolt trapping was not begun until April 15 (Brix and Seiler 1977), by which time some of the smolts had already migrated past the trap site, (Table 8) (Brix and Seiler 1978). Smolt production from the 1984 brood year corresponds to full seeding of the spawning grounds (Seiler 1987).

To estimate the total Chehalis Basin coho run size for an average water year, assuming the "pollution block" were removed, Seiler (1987) used the smolt production of Bingham Creek, where 5 years of trapping showed production averaged around 34,900 per year. Expanding this number in direct proportion to the number of accessible miles of stream in the upper Chehalis system suggested that the system would produce 1,000,000 smolts in a normal water year with adequate spawning. Since the upper Chehalis covers 920 square miles, and the whole Basin is 2,500 square miles, the Basin should produce two to three million smolts (Seiler 1987). At a 10 percent smolt-to-adult survival, this would create a total run -- that is, marine interception plus terminal run -- of 200,000 to 300,000 adults. This exceeds even the estimated historic high run size described below.

Catch year	Origin of tag group	Tags recovered from catch Marine[A]	Che. Basin[B]	Ratio (Mar.+Che.)/Che.
1984	Chehalis system wild	949	288	
	Humptulips system wild	452	63	
1985	Simpson Hatchery	311	142	
	Chehalis system wild	481	61	
1986	Chehalis system wild	1,083	540	
	Humptulips Hatchery	3,198	367	
	Humptulips system wild	682	56	
1987	Chehalis system wild	329	425	
1988	Simpson Hatchery	366	83	
	Humptulips Hatchery	1,702	296	
Total	Chehalis system	3,519	1,539	3.29
	Humptulips system	6,034	782	8.72

A. Sources: Pacific States Marine Fishery Commission database, September 1991 and Washington Department of Fisheries tag recovery publications.

B. Sources: Washington Department of Fisheries tag recovery publications and database, September 1991.

Table 9. Data used to calculate expansion factors for coho catch estimates.

Current Coho Run Size and Historical Levels

Table 9 indicates how the expansion factors for Chehalis Basin coho catches were calculated. The current Chehalis Basin wild coho population is about 135,000 fish, clearly less than the 229,000 reconstructed from historical catch data (Table 10). The current hatchery run size is about 131,000 (Table 11) so the combined wild and hatchery population of 266,000 appears to only slightly exceed the historical level. This suggests that hatchery production has replaced, not added to, natural production.

The rapidly increasing hatchery influence since the late 1970's, approaching half the total escapement in 1990, raises concern regarding the long-term adaptability of the total run to the Chehalis Basin.

Terminal tag recoveries may or may not represent all estuarine and river sport fisheries, depending on the year of recovery. The resulting tendency to overestimate total catch may be more substantial than for chinook, since coho sport catch averaged about 17.8 percent of the terminal area catch of Chehalis Basin coho (WDF, unpublished data).

Current period

Catch year[B]	Escapement[C]	Terminal area wild coho catch[A] Humptulips R.	Chehalis R.	Chehalis Basin
1984	104,617	3,416	16,647	
1985	20,643	1,779	5,500	
1986	33,683	6,359	28,954	
1987	22,642	2,734	36,625	
1988	41,003	2,839	4,441	
Mean	44,518	3,425	18,433	
Marine/terminal[D]		8.72	3.29	
Estimated total catch		29,866	60,645	90,511
Estimated run size (catch plus escapement)				135,029

Historical period

Catch year[E]	Grays Harbor Area non-Indian gillnet catch[F]
1905	158,783
1906	144,494
1907	128,769
1908	115,929
1909	118,753
1910	251,734
1911	388,104
1912	242,152
1913	89,257
1914	200,438
Mean catch	184,000
Historic wild escapement[G]	+44,518
Estimated wild run average size	228,518

A. Source: WDF unpub. run reconstruction data provided by Dick Stone, Montesano.

B. Tag recovery data unavailable for prior years.

C. Source: WDF unpub. data. provided by Dick Stone, Montesano.

D. See Table 9.

E. See Table 8 for explanation of choice of base period.

F. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.

G. Assumed to be the same as current escapement.

Table 10. Chehalis Basin estimated historical and current wild coho run sizes.

Catch year[B]	Escapement[A]	Terminal area hatchery coho catch[A]		
		Humptulips system	Chehalis system	Chehalis Basin
1984	36,589	1,803	7,540	
1985	10,873	1,074	3,608	
1986	40,448	15,782	6,038	
1987	13,667	8,106	7,215	
1988	60,330	19,676	2,834	
Mean	32,381	9,288	5,447	
Marine/terminal[C]		8.72	3.29	
Est. total catch		80,991	17,921	98,912
Est. average run size				131,000

A Source: WDF unpublished run reconstruction data provided by Dick Stone.
B Tag recovery data unavailable for prior years.
C See Table 9.

Table 11. Chehalis Basin estimated hatchery coho catches and run size.

CHUM SALMON

Terminal Area Run Size and Escapement Goal

There are no known sub-stocks of chum salmon in the Chehalis Basin based on spawn timing or location. Run size has averaged 53,000 over the last four years (Table 5, Figure 12). The trend toward larger run sizes (Figure 12) may have to do with improving estuary rearing conditions or ocean survival. However, failure to meet the escapement goal has become more common in the past several years and may jeopardize sustained recovery. Adequate escapement, particularly with chum, depends on accurately predicting the terminal run size since virtually all catch is in the terminal area. Unfortunately, this is difficult due to unpredictable year-to-year differences in marine survival and age at return.

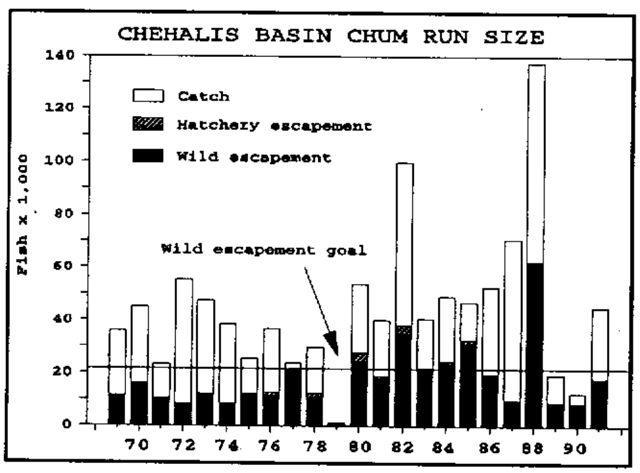

Figure 12. Chehalis Basin chum salmon terminal area run size (WDF unpublished data).

Current Run Size and Historical Levels

The Chehalis Basin chum population appears more depleted, compared to historical levels, than any other species (Table 12).

Current period

Catch year	Wild Escapement[A]	Chehalis Basin catch[A]
1981	18,050	20,900
1982	35,100	61,550
1983	21,000	18,700
1984	23,700	24,200
1985	31,300	14,200
1986	19,550	33,000
1987	9,500	60,950
1988	62,200	75,250
1989	9,100	10,411
1990	9,000	3,600
Mean	23,850	30,186
Estimated average run size		54,000

Historical period

Catch year	Grays Harbor Area non-Indian gillnet catch[B]
1910	134,616
1911	211,207
1912	200,687
1913	72,539
1914	132,724
1915	84,491
1916	84,490
1917	43,187
1918	27,750
1919	184,124
Mean	117,581
Current escapement	+23,850
Estimated average wild run size	141,000

A. Source: WDF unpub. data. provided by Dick Stone, Montesano.
B. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.

Table 12. Chehalis Basin historical and current chum salmon run sizes.

STEELHEAD

Terminal Area Run Size and Escapement Goals

Steelhead are managed separately as winter and summer runs (Bill Freymond, WDW pers. comm.). WDW defines winter run fish as those caught in the Chehalis Basin between November 1 and April 30. Summer steelhead are caught between May 1 and October 31 (WDW 1991a). Harvest management plans assume negligible marine interception in the coastal salmon fisheries (QFiD and WDW 1991).

Winter Run

Winter steelhead are managed for both hatchery and wild harvest except on certain upper Chehalis tributaries where sport fishing is regulated primarily to provide sufficient wild escapement (Freymond 1989). The dual goal of providing hatchery harvest opportunity while allowing wild escapement is supported, more so in the Humptulips system, by high early season harvest and lower late season harvest (QFiD and WDW 1991). This is possible because hatchery fish tend to return to the rivers earlier than wild fish, due to historical selection for early-returning fish (Royal 1972). Chehalis Basin hatchery fish follow this pattern to the degree that they were derived from Chambers Creek stock, and not from later-returning local brood stock (QFiD and WDW 1991). The greater timing separation and lower overall hatchery influence on the Humptulips coincides with consistent achievement of the wild escapement goal in that system compared to the Chehalis system (Figure 13).

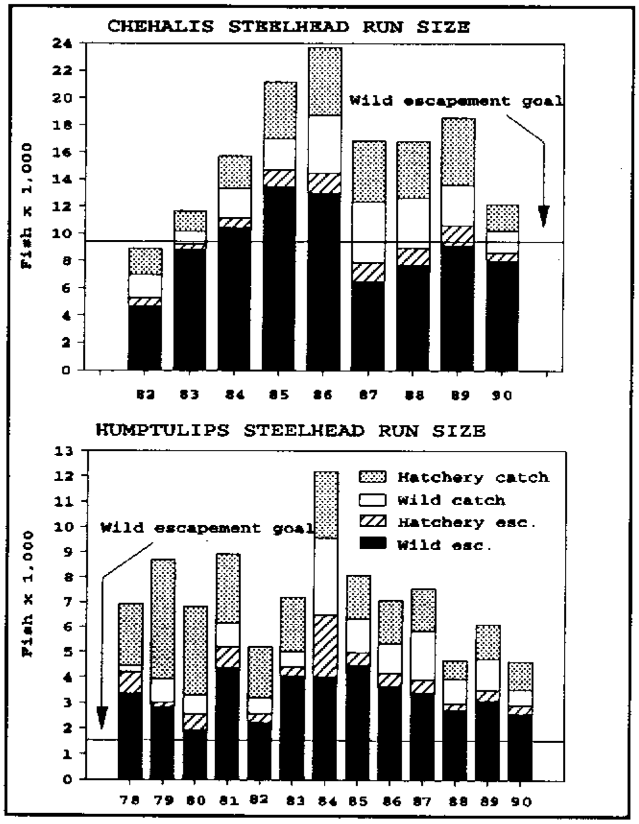

Figure 13. Chehalis and Humptulips steelhead run sizes (QFiD and WDW 1990).

Chehalis River System. Chehalis system runs have averaged about 11,000 hatchery fish over the last 3-year hatchery life cycle, and 13,000 wild fish over the last 4-year wild life cycle (Table 5). Wild escapement goals were met in five of the last eight years but only two of the last four (Table 5, Figure 13). Increased harvest of wild fish in the last several years coincides with decreased wild escapement. Hatchery programs expanded until 1985, and then remained roughly the same (Figure 13). An increase in winter steelhead releases into the Chehalis Basin is likely since the Aberdeen Hatchery will no longer be allowed to release fish outside the Chehalis Basin, due to disease considerations (Bob Paulsen, WDW, pers. comm.).

Humptulips River System. Humptulips runs have averaged about 1,700 hatchery fish over the last three years and 4,600 wild fish over the last four. The winter steelhead run appears to be in good condition, insofar as the wild escapement goal has been consistently exceeded (Table 5; Figure 13).

Hatchery programs have made up less of the run since 1985, due to quarantines of Lake Quinault and Quinault National Fish Hatchery stocks (Paul Huffman, Quinault Nation, pers. comm.). Hatchery contributions are expected to return to prior levels because of better hatchery techniques, use of conditioning ponds, and development of local Humptulips brood (Paul Huffman, Quinault Nation, pers. comm.).

Summer Run

Skamania-stock summer steelhead were introduced as a hatchery run in 1979 (Paulsen, pers. comm.). Runs have averaged about 700 adults over the last three years (Table 5), and have supported sport fisheries primarily on the Wynoochee and Humptulips, but to a lesser degree on the main stem Chehalis and Satsop rivers (Figure 14). The Wynoochee and Satsop catch has declined since the early 1980s, for unknown reasons (Paulsen, WDW, pers. comm.), and a decline on the Humptulips is due to shortage of brood stock at the Aberdeen Hatchery.

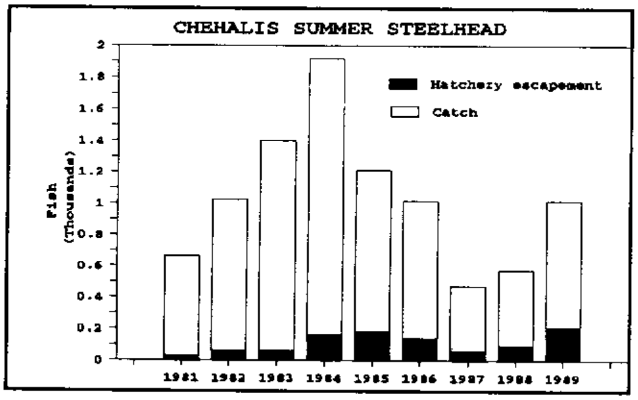

Figure 14. Chehalis Basin summer run steelhead.

Current Total Run Size and Historical Levels

The Grays Harbor non-Indian gillnet catch was at its highest during the 1894-1903 period, and declined from that period to 1935. This suggests that fishing pressure may have reached maximum efficiency before catch reporting began in 1894; thus, the base period estimate may be weaker than for salmon and may underestimate run size. For simplicity, summer steelhead were not included since they contribute a relatively small number of fish to the Chehalis Basin catch. Marine catch is negligible.

The average current wild steelhead run size is about 17,000 fish while the historic run size is estimated to have been about 20,000 (Table 13). Hatchery run size is currently about 7,000 (Table 5). While the Chehalis Basin wild winter steelhead population may be somewhat less than what it was historically, it falls into the same order of magnitude as that reconstructed from historical catch data (Table 13). This should be interpreted as a base level of natural production, to be reinforced by assuring optimum wild escapement through full utilization of all available habitat and refinements in fishery management. Any additional hatchery programs should be considered additional, rather than replacement, production.

Current period

Catch season	Escapement[A]	Catch[A]	Run size
1982-83	6,958	2,322	
1983-84	12,954	1,498	
1984-85	14,530	5,236	
1985-86	17,960	3,616	
1986-87	16,666	5,464	
1987-88	9,945	6,412	
1988-89	10,474	4,616	
1989-90	12,235	4,208	
Mean	12,715	4,172	17,000

Historical period

Catch year	Grays Harbor Area non-Indian gillnet catch[B]
1894	4,898
1896	6,817
1897	5,076
1898	11,620
1899	11,378
1900	7,092
1902	3,673
1903	4,898
Mean	6,932
Current escapement	12,715
Estimated wild run size	20,000

A. Source: QFiD and WDW (1991).

B. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.

Table 13. Estimation of historical and current Chehalis Basin wild winter steelhead run sizes.

STURGEON

Commercial catch of mixed white and green sturgeon increased from the 1940s, when catch recording began, peaked in 1964, declined to 1977, and now appears to be increasing slowly (Figure 15). It is thought that Grays Harbor catch represents a small part of a single spawning population centered around the Columbia River (Devore, WDF, pers. comm.). Two arguments support this: the migration of tagged sturgeon throughout the coastal area from Tillamook Bay to the Quileute River; and the scarcity of juveniles in most streams smaller than the Columbia River (Stone, WDF, pers. comm.; Devore, WDF, pers. comm.). The Lower Columbia population is considered healthy and not apparently density-dependent; that is, (1) nearly constant numbers of fish now reach fishable size each year, resulting in a population composed of fish of many ages, and (2) individual growth rates are relatively rapid, compared to other populations. Devore (WDF, pers. comm.) believes this implies that the habitat is close to being fully seeded.

White Sturgeon Population Status

This species supports the majority of both sport and commercial fisheries in the Chehalis Basin. In response to reduced stock size (Figure 15), management reduced harvest rates, which succeeded in reversing the decline and also increasing individual fish size. In particular, the directed commercial setline and gillnet fishery on the Columbia River has been eliminated, and commercial catch has been cut in half. Grays Harbor fisheries have also been more regulated and the July commercial fishery has been eliminated. The sport season remains open year-round (WDF 1992). Mathematical modeling indicates that the minimum and maximum sport size limits of 48 and 60 inches, effective both in the Chehalis Basin and on the Columbia River (WDF 1992), seem to be maintaining sustainable harvest and protecting spawning-sized females. Recent relatively level catches are thought to represent the optimum sustained yield (Stone, WDF, pers. comm.).

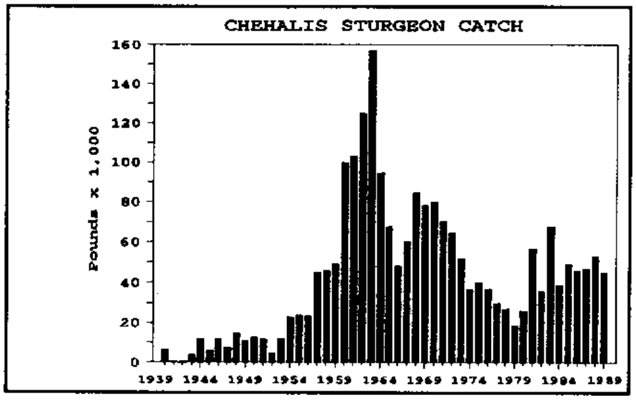

Figure 15. Chehalis Basin white and green sturgeon commercial landings.

Catches in Grays Harbor probably come predominantly from the Columbia River spawning stock, the only well-documented spawning population in Washington and Oregon, although there is much white surgeon habitat available for potential production in the Chehalis Basin in the form of cobbly riffles with high velocity (J. Devore, FWS, pers. comm.). A few juveniles, apparently a few months old, were seined from the main stem Chehalis during summer in the early 1970's (John Wolfe, FWS, pers. comm.). Wolfe believes white sturgeon historically occurred in the Chehalis up to the Newaukum.

WDF's policy is to promote exclusively natural production, at least until the potential for disease transmission in Columbia River experimental hatcheries has been brought to manageable levels through research and development, and the risk of genetic weakening through interbreeding with hatchery fish has been adequately assessed (Devore, WDF, pers. comm.).

Green Sturgeon Population Status

This species supports a small percentage of the commercial fisheries in Grays Harbor. It is not known to what degree green sturgeon caught in Grays Harbor originate from Grays Harbor as opposed to other river basins. Green sturgeon are suspected to spawn in estuaries throughout the northwest, and Grays Harbor is a likely spawning ground, along with Willapa Bay (Devore, WDF, pers. comm). Spawners do not migrate far upstream from tidewater, and occur in the Chehalis below Montesano. Green sturgeon are far fewer than whites, and there has been no accurate assessment of their population. Green sturgeon and white sturgeon are covered by the same fishing regulations.

AMERICAN SHAD

American shad (*Alosa sapidissima*) were introduced to the Pacific coast in 1871, 1885, and 1886 (Craig and Hacker 1940). The Grays Harbor shad catch very likely represents a local spawning stock, based on the high degree of homing tendency in Atlantic coast populations (Dadswell *et al.* 1987). Shad have been observed in the Chehalis River as far upstream as Rainbow Falls (RM 97), but the greatest concentration of shad spawning is likely near Rochester (Wolfe, FWS, pers. comm.). Young-of-the-year shad were captured from Montesano and points downstream; most apparently move downstream in August-October (WDF 1971). American shad juveniles and adults occurred frequently in experimental seine samples from the inner Harbor but never occurred in large numbers in any one sample (Simenstad and Eggers 1981).

The stock may have been depleted, because the first reported catch, in 1945, was much larger than that of any subsequent year (Figure 16). Few catches have been reported from the Grays Harbor Catch Reporting Area over the last ten years. Some caution is warranted, however, in using catches as the sole measure of stock success because 1) the weak market for shad may control reported catches, i.e., small catches may not be reported if they are never sold, and 2) decreases in shad catches could be due to spring chinook closures since shad are mainly captured incidentally to spring chinook.

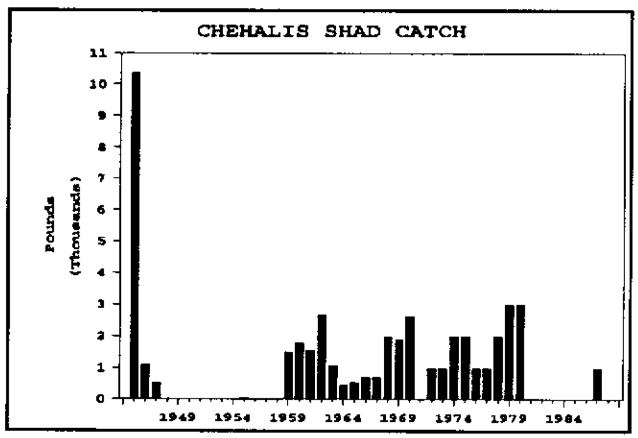

Figure 16. Chehalis Basin American shad commercial catch, 1945-1989 (Ward et al. 1970; WDF 1990).

Habitat problems for Chehalis Basin shad have not been identified, but it is known that shad recovery in the Delaware River coincided with reduction of point source pollution and consequent increases in dissolved oxygen (Maurice *et al.* 1987). In the Sacramento River, pollution was a potentially important shad stressor (Stevens *et al.* 1987). Juvenile shad are in the Chehalis during July and August, the time when water quality is at its worst.

FORAGE RESOURCES

Forage fish for salmon are not regulated in fishery management. Chinook and chum salmon juveniles prey upon larval northern anchovy in the deeper waters of Grays Harbor but do not use other baitfish species, even if other baitfish are relatively abundant (Simenstad and Eggers 1981). The authors found that northern anchovy were present from June through October, with adults occurring at Westport and juveniles at Moon Island and Cow Point; longfin smelt were prey for sea-run cutthroat trout in Grays Harbor from May through October.

Simenstad and Eggers (1981) gave evidence that standing stock of open-water zooplankton limits the population of juvenile salmonids in Grays Harbor. Sources of plankton are the Chehalis River downstream to Moon Island; the estuary itself, especially at Moon Island and Cow Point, and marine waters east to the vicinity of Stearns Bluff (Figure 2).

Regarding epibenthic zooplankton, Simenstad and Eggers (1981) concluded that (1) standing stocks may be critical to growth and survival of juvenile salmon; (2) juvenile salmonids fed selectively for sparsely distributed prey, which means the total area of shallow waters below the low tide line may limit the number of juvenile salmonids which can feed there; and (3) sources of productivity for bottom-dwelling prey of salmon were organic debris from the rivers, eelgrass beds, and saltmarshes, and diatom growth on the mudflats.

Chapter 4: HATCHERY PRODUCTION OF SALMONIDS

Fish culture originally had the goal of augmenting fish production to whatever degree might prove feasible, and later of compensating for the clearly harmful effects of splash dam logging (Grays Harbor Regional Planning Commission 1992). However, hatcheries can outlive their original purposes, and can in fact stimulate the evolution of fishery management. Stone (1989) described the main features of the WDF hatchery program in a speech to the Chehalis Basin Fishery Task Force. The following information represents his view of a general agreement among tribal and WDF staff:

> "Hatchery production is used to produce fish for harvest and brood stock for programs to supplement wild production through off-station releases, primarily of fingerlings. Hatchery harvest depends mainly on on-station coho releases. Hatchery coho returns to the Humptulips and Satsop rivers are managed to provide fishing opportunity in addition to natural production. The current management strategy is to take advantage of the earlier timing of hatchery coho in the Humptulips, and of the sport opportunity created by large numbers of hatchery coho in the Satsop. Future production may include adding fall chinook to the existing coho netpen program at the Westport Boat Basin".

> "Supplementation through off-station releases involves fall chinook as well as coho. Fall chinook supplementation involves the Humptulips, Mayr Brothers, Lake Aberdeen, and Satsop hatcheries, which provide holding and spawning for wild brood stock from the Humptulips, Wishkah, Wynoochee, and upper Chehalis rivers, respectively. Coho supplementation involves the Humptulips and Satsop hatcheries, which outplant hatchery stock fingerlings, although less extensively than in former years because the utility of this practice in being increasingly questioned".

On the same occasion, Freymond (1989) described the current WDW hatchery program:

> "Hatchery production is used to maintain existing opportunities for winter and summer steelhead harvest. Hatchery harvest depends on both on-station and off-station releases. The current management strategy in the Humptulips, Hoquiam, and Wishkah rivers is to take advantage of the earlier timing of hatchery winter steelhead for selective harvest of hatchery production. However, on the Wynoochee, Skookumchuck, and Newaukum rivers the strategy is to optimize survival by using native winter steelhead stock from the Aberdeen Hatchery and the Skookumchuck Dam".

HATCHERY HISTORY

When fish culture began in the 1890s, fish were regularly introduced from outside the Basin (Stone, WDF, pers. comm.). Around the turn of the century, the first local salmon hatcheries were built (Grays Harbor Regional Planning

Commission 1992). However, several decades elapsed before technical rearing practices allowed hatcheries to significantly contribute to the catch (Deschamps, quoted in GHRPC 1992). The principal remedy for logging abuses was thought to be hatcheries, primarily to produce coho fry for stocking upstream of reaches formerly blocked by splash dams; however, no scientific evaluation of these early activities was reported (Wendler and Deschamps 1955a).

In the late 1930s it became known that fish released as fry generally survived poorly to adult compared to larger fish that were ready to migrate to sea. This led to closure of all fry stations and construction of hatcheries capable of rearing fish to smolt size (Wendler and Deschamps 1955b).

In 1936, the WDG opened the Aberdeen Fish Hatchery on Lake Aberdeen (John Kugen, WDW, pers comm.). This was the first local hatchery capable of rearing fish to smolt size, resulting in much higher survival than had been possible before. This was followed for salmon in 1949, with the opening of Simpson Salmon Hatchery on the East Fork Satsop River (WDF, unpublished records).

In the 1960s, the Oregon Moist Pellet was introduced, apparently resulting in increased fish survival in hatcheries, which led to further hatchery expansion and higher adult contribution to the catch (Deschamps, quoted in GHRPC 1992).

The Satsop Springs facility, several miles downstream of Simpson Hatchery, was opened in 1963 as a chum eyed egg channel. In 1977, Satsop Springs was expanded and became operational as a major salmon rearing station in the early 1980s (Dick Stone, WDF, pers. comm.).

WDW began developing more local steelhead brood stocks in 1971 (Kugen, WDW, pers. comm.). The USACE built a barrier dam and fish trap at Wynoochee River RM 47.8, to collect adult salmon and trout and truck them upstream of Wynoochee Dam. WDW used the dam to capture local brood, taking steelhead to the Aberdeen Hatchery and allowing the surplus to be trucked upstream. In 1979, WDW broadened the base of local brood stocks by constructing a trap on Van Winkle Creek (Kugen, WDW, pers. comm.).

In 1975, the expansion of hatchery salmon influence continued as WDF opened the Humptulips Hatchery (WDF, unpublished records). This watershed formerly depended primarily on wild runs, although there had been an egg-taking station in the first half of the century and the system received extensive plantings of hatchery stocks prior to the hatchery opening.

In the same year, WDW began transporting steelhead smolts reared at Aberdeen to the Mayr Brothers Pond on the Wishkah for conditioning before release (Paul Huffman, Quinault Nation, pers. comm.). This pond has become a major cooperative rearing project among Long Live the Kings, WDF, WDW, and QfiD.

In 1977, WDF reported underseeding of natural coho habitat in the upper Chehalis, based on smolt trapping studies and estimates of available habitat (Brix and Seiler 1977, 1978). These studies led to extensive coho fry stocking, primarily from the Simpson Hatchery, to fully utilize upper Chehalis habitat (WDF, unpublished records).

Chinook and coho rearing ponds were added to the Satsop Springs facility in 1979 (Stone, WDF, pers. comm.).

In the early 1980s, Chehalis Basin production capacity was further increased when the WDF Skookumchuck Ponds opened below the Skookumchuck Dam (Stone, WDF, pers. comm.). However, these ponds were not constructed to mitigate for the dam, nor to provide fish for any specific area (Bruya 1990). Consequently, several years later, all coho from the Skookumchuck Ponds were released into southern Puget Sound via netpens, because smolts released there survived to adulthood much better than smolts released into the upper Chehalis (Stone, WDF, pers. comm.).

In 1988, the USACE supported Aberdeen Hatchery expansion to mitigate for nearly all annual losses of steelhead and cutthroat trout due to construction of the Wynoochee Dam. As a result, hatching space was approximately doubled to its present capacity of 1.65 million eggs (Kugen, WDW, pers. Comm.).

In 1991, WDF and WDW began making joint use of the Loomis Ponds and Humptulips Hatchery for both salmon and steelhead production (Paul Huffman, Quinault Indian Nation, pers. comm.).

HATCHERY STOCKS

Most hatchery stocks originated from local stocks then shifted to outside strains, but over the years there has been a move to develop 100 percent local, perhaps wild or native brood sources. The sustainability of hatchery production has recently been questioned by research in fish genetics (Miller 1990, Hindar *et al.* 1991, Johnsson and Abrahams 1991), behavior (Solazzi *et al.* 1990), and disease (Steward and Bjornn 1990). There has also recently been a shift to restricting hatchery stocks to within-basin transfers only (Bob Paulsen, WDW, pers. comm.) or even within sub-basins (Stone, WDF, pers. comm.). Most Chehalis Basin wild salmon and steelhead populations have had extensive outside influence, although few introductions have occurred within the last ten years (Stone, WDF, pers. comm.). The variety of stocks and facilities is listed below.

AVAILABLE BROOD STOCKS

Spring chinook
- Chehalis wild

Fall chinook
- Upper Chehalis wild
- Satsop hatchery
- Wishkah wild
- Humptulips wild

Coho
- Simpson hatchery
- Bingham Creek wild

Satsop Springs hatchery
Wynoochee Dam wild
Wishkah wild
Humptulips hatchery

Winter steelhead

Early run

VanWinkle Creek hatchery

Late run

Skookumchuck wild
Wynoochee Dam wild

Summer steelhead

VanWinkle Creek hatchery

Spring Chinook Salmon

Spring chinook have never been successfully propagated in a Chehalis Basin hatchery. Small-scale attempts to culture Skookumchuck spring chinook were made in the late 1970s, with only limited success because brood stock was difficult to collect and survival was poor. In 1977 and 1978, Cowlitz spring chinook were introduced into the Wynoochee (Stone, WDF, pers. comm.). QFiD personnel have intermittently found chinook with spring timing in the Wynoochee since 1987 (Chitwood, QFiD, pers. comm.). Now, with increasing emphasis on developing a year-round sport fishery, some parties propose restoring Wynoochee spring chinook with upper Chehalis stock (Dave Hamilton, CBFTF, pers. comm.).

Fall Chinook Salmon

Fall chinook hatchery brood stock was transferred from the Kalama in the 1890s, later from Green River via the Deschutes, then from the Elk and Trask Rivers of coastal Oregon in the early 1970's, and most recently, from the Willapa Hatchery in the late 1970's (Johnson and Longwill 1991). Most non-native introductions have been made to the Satsop and, for this reason, WDF does not now allow Satsop Hatchery fall chinook releases outside the Satsop drainage (Rick Brix, WDF, pers. comm.).

Coho Salmon

Coho hatchery brood stock have also come from numerous sources, beginning with introductions from the Kalama in the 1890s (Stone, WDF, pers. comm.). Fry releases from the Willapa Hatchery to the upper Chehalis have been frequent throughout the history of hatchery production (Stone, WDF, pers. comm.). Quileute summer coho were also used on one occasion. The latest import was Hoodsport stock in the early 1980s. Unlike fall chinook, coho introductions have been spread throughout the Basin, so no efforts are now made to confine current releases to one area (Brix, WDF, pers. comm.).

Chum Salmon

Chum introductions have been infrequent. Willapa and Hoodsport stock were brought to the Satsop Hatchery in the mid-1970's (Stone, WDF, pers. comm.). Chum production now depends entirely on natural production because hatchery programs were not clearly successful (Stone 1989).

Winter Run Steelhead

Winter steelhead stocks from outside the Basin were historically used but introductions decreased as hatcheries developed local brood stock sources. Chambers Creek winter stock was released widely in the upper Chehalis beginning in 1936 (WDW unpublished records). These records also show that many releases were made from the Mossyrock Hatchery in the lower Columbia drainage starting in 1943, that sporadic introductions from the Puyallup Ponds were made starting in 1977, and that Bogachiel stock (which originated at Chambers Creek) has been used since 1982. More recently, Cook Creek stock from Quinault National Fish Hatchery was released into the Humptulips.

Native brood stock now supports programs that release smolts at Skookumchuck Dam and Aberdeen Hatchery (Freymond 1989), and a local winter steelhead brood stock is being developed at the Humptulips and Mayr Brothers hatcheries (Huffman, Quinault Nation, pers. comm.).

Summer Run Steelhead

The first recorded summer steelhead release was made in 1926 by the WDG from the Washougal Hatchery on the lower Columbia (Kugen, WDW, pers. comm.). No further introductions are on record until 1974, when summer steelhead from Skamania Hatchery were released from Aberdeen Hatchery (WDW unpublished records). These records show that releases of lower Columbia stock became routine in the Wynoochee and Humptulips rivers by 1980, when the WDW Aberdeen Hatchery had developed a local population, derived from Skamania stock, in Van Winkle Creek.

Increasing pressure to develop a year-round sport fishery focused renewed attention on summer steelhead introductions, because no local brood stock was apparent (Harry Senn, pers. comm.). Harvest is managed exclusively for hatchery production (Bob Paulsen, WDW, pers. comm.). Wild steelhead release regulations are in effect June 30 through November 1 in all Chehalis Basin streams to protect naturally produced summer steelhead.

Other Salmonids

In addition to these intensely managed species, cutthroat trout and resident rainbow trout have been released from many non-Chehalis sources. However, sea-run cutthroat trout hatchery programs have increasingly used local brood stock since 1983; Jay Hunter (WDW, pers. comm.) lists Skookumchuck, Elk, Johns, and Wishkah rivers and Chenois Creek as brood stock sources.

HATCHERY FACILITIES AND PRACTICES

Since their creation, hatcheries have tended toward improved rearing efficiency and more hatcheries and satellite stations as illustrated in table below. Over the years, emphasis has changed from off-station to on-station releases, and from fry to smolt release.

FISH CULTURE FACILITIES

Within the Basin

- South Fork Newaukum:
  - Merryman's Ponds (Onalaska School) -- coho
- North Fork Newaukum:
  - Cole's Pond -- steelhead
- Skookumchuck:
  - Skookumchuck Ponds -- coho
  - PP&L/WDW ponds -- steelhead
- Main stem Satsop River:
  - Mitchell Creek Pond -- sea-run cutthroat trout
  - Muller Hatchery -- coho
- East Fork Satsop:
  - Simpson Hatchery -- fall chinook, coho
  - Satsop Springs -- fall chinook, coho, chum
- Van Winkle Creek:
  - Aberdeen Hatchery -- winter and summer steelhead; sea-run cutthroat trout; coho and chinook
- Wishkah River:
  - Mayr Brothers Hatchery -- fall chinook, winter steelhead
- Humptulips River:
  - Loomis Ponds -- winter steelhead
  - Humptulips Hatchery -- fall chinook, coho, winter steelhead
- Inner Grays Harbor:
  - Hoquiam Netpens -- coho
- Outer Grays Harbor:
  - Westport Netpens -- coho
  - Ocean Shores Netpens -- coho

Outside Chehalis Basin but often used to stock steelhead in Chehalis Basin

- WDW Chambers Creek near Tacoma
- WDW Mossy Rock State Hatchery
- WDW Puyallup Ponds
- WDW Shelton Hatchery
- USFWS Quinault National Fish Hatchery at Cook Creek
- Washougal Hatchery (Skamania stock summer steelhead)

Construction contemplated

- Chehalis Tribal Hatchery on Cedar Creek -- fall chinook, spring chinook, coho, chum, winter steelhead

Rehabilitation contemplated

- Outer Grays Harbor: Sea Farms of Norway at Westport -- species undetermined
- Wynoochee: Briscoe Ponds -- fall chinook

Hatcheries were usually not sited or sized to make up for a specified amount of local habitat damage, nor to restore populations to a particular level. Only in the last two decades have such concepts begun to be accepted. Rather, hatcheries were expected to increase total catch as much as possible. In that sense, coho and steelhead efforts were successful throughout the Basin, and fall chinook were successful on the Humptulips. Chum enhancement has not noticeably increased catch anywhere in the system and has been discontinued (Dick Stone, WDF, pers. comm.). Sea-run cutthroat releases have been extensive but never evaluated (Jay Hunter, WDW, pers. comm.).

Some believe hatcheries pose a danger to natural fish production unless the program is carefully designed and managed (Oregon Trout 1990; Hilborn 1992). Investment in a hatchery leads to demand for efficient harvest of hatchery fish, which may overharvest intermingled wild fish (Bakke 1987), unless the hatchery program provides for harvest at a separate time or place. Importation of an exotic hatchery stock, or artificial selection for favorable hatchery traits using a native stock, may decrease fitness of natural spawners if these cross with hatchery-reared strays (Hindar *et al.* 1987). Hatchery fish released at an improper time, place, size, or number can competitively displace naturally produced fish (Solazzi *et al.* 1990). Finally, hatcheries may serve as incubators of disease and magnify their effect on wild fish (Goodman 1990). Proper management can reduce or avoid most of these effects, but the general theme of recent research is that every existing or proposed hatchery should have specific goals, safeguards, and evaluation for compatibility with the native stock with which it shares a gene pool.

HATCHERY FISH PRODUCTION

Species/run	Percent hatchery fish		
	Entire Chehalis Basin	Chehalis System	Humptulips System
Summer steelhead[A]	100.0	100.0	100.0
Coho	43.5	31.2	71.6
Winter steelhead	29.8	29.0	31.9
Fall chinook	4.4	B	13.7
Chum	1.8	C	C
Spring chinook	0.0	0.0	0.0

A There is probably some limited summer steelhead natural reproduction but the amount is undetermined.
B There is some contribution from cooperative rearing projects but it is presently unquantified.
C Data not available.

Table 14. Hatchery contributions to Chehalis Basin anadromous salmonid runs (WDF and WDW unpublished data; QFiD and WDW 1990).

Several early Chehalis Basin hatcheries produced an annual average of 300,000 chinook fry and one million coho fry in the Basin between 1905 and 1938 (Wendler and Deschamps 1955b). This program was considered ineffective even in its day, in view of continued declines in catches.

During the last two decades, hatchery production has increased overall, although more so in some species than others. Coho and steelhead hatchery programs are now reasonably successful, contributing about 40 and 30 percent to the Chehalis Basin catches of each species, respectively (Table 14). On the other hand, fall chinook and chum programs have not made significant contributions despite long-standing hatchery programs. Hatchery production accounts for most of the summer steelhead catch, but this run contributes a very small number of fish to the total catch. Success of extensive cutthroat trout releases is impossible to determine, since it has not been evaluated.

Fall Chinook Salmon

Fall chinook production has been erratic, although smolt production has increased over the last two decades (Figure 17) and has largely replaced fry releases. The Satsop River hatchery program began before 1970 but production was discontinued in 1979 due to dwindling numbers of adults returning to the Simpson Hatchery (WDF unpublished records). In 1987, production was resumed using the Satsop Springs facility for adult capture and rearing and the Simpson facility for hatching. The Humptulips River program began in 1975 and suffered a similar shortage of brood stock. Although the hatchery goal until 1991 was to take one million eggs annually, typical egg-takes in the last brood cycle have been under 150,000, because adult fish do not readily enter the hatchery; the program will continue with an egg-take goal of 500,000 (Mark Kimball, WDF, pers. comm.). On-station releases are given priority at all hatcheries, since they appear to survive better than off-station releases (Stone, WDF, pers. comm.).

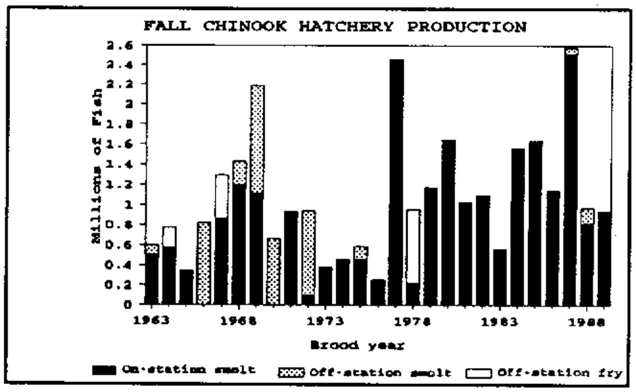

Figure 17. Hatchery-reared fall chinook released into the Chehalis Basin (WDF unpublished data).

Coho Salmon

Coho production at Simpson Hatchery increased (Figure 18), first in mitigation for the Skookumchuck Dam, and later in response to concerns about underseeding (Brix and Seiler 1977, 1978). Fry and fingerlings in excess of hatchery capacity are outplanted to many sites in the upper Chehalis system. On-station smolt releases have also increased over the last decade.

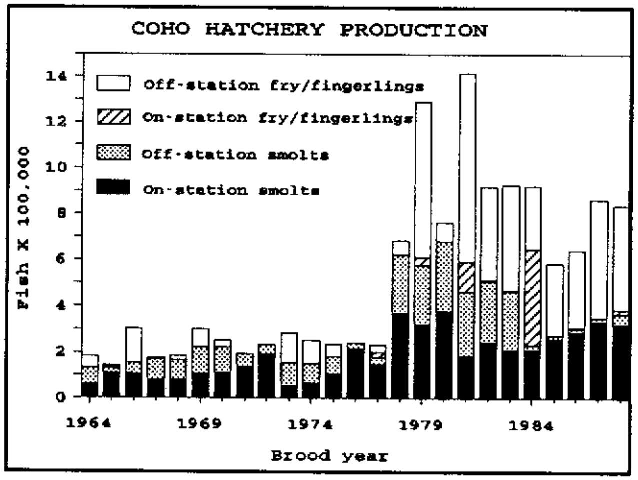

Figure 18. Hatchery-reared coho releases into the Chehalis Basin (WDF unpublished data).

Chum Salmon

The modern hatchery chum program began at Simpson Hatchery in 1965. Releases were particularly heavy between 1978 and 1982 (Figure 19). The last chum returning to the hatchery was recorded in 1987, and production was discontinued at that point (WDF unpublished records).

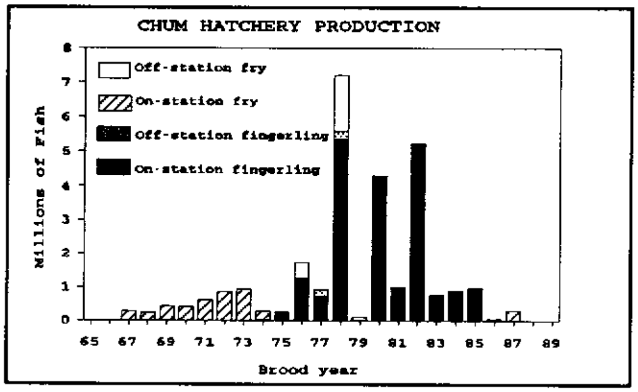

Figure 19. Hatchery-reared chum salmon released into the Chehalis Basin (WDF unpublished data).

Winter Steelhead

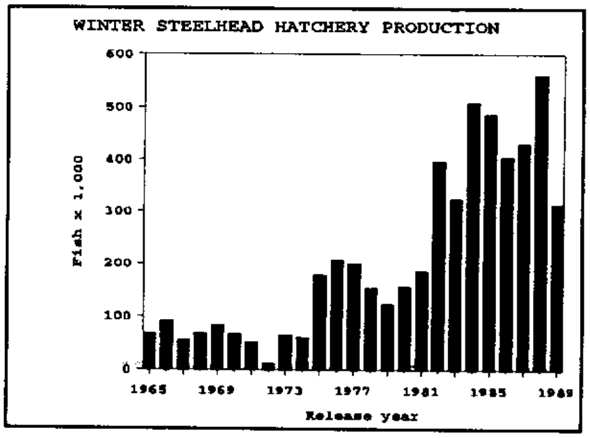

Figure 20. Hatchery-reared winter steelhead released into the Chehalis Basin (WDW unpublished data).

Winter-run steelhead production has been emphasized in hatchery programs. Small numbers were released annually since the early 1950s, but the program has grown since 1970 (Figure 20). In 1975, on-station releases became a significant part of production, and continue to make up about a third of each year's releases.

HATCHERIES AS A TOOL FOR REBUILDING WILD STOCKS

Hatcheries have partially succeeded in that they now contribute heavily to catches of some species, but there is only speculation on the success of hatcheries in rebuilding natural production. In some cases, hatcheries may have actually helped this rebuilding, because natural spawning was the intended result of many off-station releases of hatchery-reared chinook, coho and winter steelhead. The contribution of planted hatchery fish and strays to natural production in the Chehalis Basin has not been studied. However, there are numerous biological concerns about the wisdom and feasibility of using hatcheries to rebuild wild stocks. Recent studies and reviews of hatchery supplementation of wild stocks elsewhere makes this point highly debatable because of genetic, competition, and harvest management concerns (Nickelson *et al.* 1986; Miller 1990; Hilborn 1992).

Chapter 5: CAUSES OF DECLINE

ENVIRONMENTAL PROBLEMS IN GRAYS HARBOR AND THE LOWER CHEHALIS RIVER

Pulp Mill Effluents

In 1928, Grays Harbor Pulp and Paper Co. (now ITT-Rayonier) began discharging untreated acid waste into the Harbor (GHRPC 1992). The effluent killed alarming numbers of fish, crab, and shrimp (Wendler and Deschamps 1955b) and by 1940 prompted the Washington Water Pollution Control Commission (now WDOE) to investigate. The Commission concluded that mill waste was virtually smothering fish by taking dissolved oxygen out of the water and that the waste would have poisoned the fish had it not smothered them first (Pine and Tracy 1971). In 1957, the Weyerhaeuser Company opened the area's second pulp mill in Cosmopolis (GHRPC 1992). Their effluent was pumped to the Harbor via a series of ponds and discharge structure in South Aberdeen. Like ITT, Weyerhaeuser came under pressure to improve water quality (GHRPC 1992).

The industrial processes, treatment procedures, and resulting effluent of the two mills have been described by Hallinan (1989), Reif (1989a), and Johnson *et al.* (1990). Work on pollution effects on salmon has been well summarized by the reviews of WDF (1971), Seiler (1987, 1989), and Schroder and Fresh (1992) and much of what is reported here is based on these works.

Differential Adult Production

Seiler (1987) reported that Humptulips River chinook production averaged 33.6 percent of the Chehalis Basin total over the previous 17 years, although the Humptulips system watershed area is only about 10 percent of the Chehalis Basin total area. Recent wild steelhead run size estimates (QFiD and WDW 1991) suggest disproportionately high production from the Humptulips relative to the Chehalis River System, since Humptulips wild steelhead made up 28.0 percent of the Basin's wild steelhead runs in the 1984-1990 period.

Differential Smolt Survival to Adult Catch

In the early 1970s, a group of Satsop hatchery fall chinook was released into the Humptulips and survived to adult 18 times as well as on-station releases (Fuss *et al.* 1981). Several recent studies summarized by Seiler (1989) agree that coho smolts originating in the Chehalis system contribute to the marine catch no more than half as well as smolts coming from the Humptulips system. Seiler (1987) considered steelhead to be affected by poor water quality in the inner Harbor in the same way as coho.

Poor Smolt Survival in the Estuary

WDF coordinated a series of studies of inner Harbor pollution on salmon. Primary findings included (Schroder and Fresh 1992):

- Inner Harbor fish were more highly stressed and less able to resist disease than fish from North Bay;
- smolts move in and out with the tide and rest in low-velocity areas, i.e., coho spend considerable time in areas most likely to be polluted;
- Inner Harbor fish showed four times the mortality of North Bay fish during long-term observation;
- in the short term, full-strength Weyerhaeuser effluent was intermittently lethal to coho smolts;
- over the long-term, liver enzymes involved in the metabolism of toxicants and other foreign compounds increased in fish exposed to dilutions of Weyerhaeuser effluent at 30 percent and higher;
- swimming stamina was reduced when smolts were forced to swim in effluent solutions from either mill;
- in lab experiments, coho usually avoided low concentrations of Weyerhaeuser effluent, but failed to avoid any odors after exposure to ITT effluent.

In a variety of other tests over recent years, effluent from both plants was variously lethal or toxic to a variety of non-salmonid tests organisms (WDF 1971; WDE 1975; Hallinan 1989; Reif 1989a,b; Johnson *et al.* 1990; Schroder and Fresh 1992).

Toxic Chemicals in Mill Effluent

Studies reviewed and/or conducted by Reif (1989b), Johnson *et al.* (1990) and Schroder and Fresh (1992) analyzed effluent of both mills for metals and a variety of organic compounds including herbicides, pesticides, guaiacols, catechols, dioxins, furans, cadmium, copper, lead, nickel, zinc, chloroform, 4-methylphenol, and resin acids.

Schroder and Fresh (1992) stated that, at 30 percent dilution, all potential toxins in the effluent would fall below detection limits. This suggested that unidentified constituents of the effluent affected mortality. Over 4,000 chlorinated organic chemicals may occur in pulp mill effluent, but the effects on fish are known only for a few of them. They hypothesized that the bioassay organisms were responding to either (1) different chemicals than the ones that could be analyzed in correlation, (2) lower concentrations of chemicals than previously reported to be toxic or (3) other toxicants not analyzed.

WDF's Conclusions and Recommendations

WDF's general conclusions (Schroder and Fresh 1992) were that:

(1) many potentially toxic chemicals were in the effluents;
(2) Weyerhaeuser tended to have more detectable compounds than ITT;
(3) all chemicals were typical of pulp mills;
(4) all known chemical concentrations were below known danger levels for aquatic organisms; and
(5) none of the compounds could be directly linked to salmon survival.

Schroder and Fresh (1992) recommended continuing to coded wire tag coho smolts at least until the 1992 brood year; resuming hatchery fall chinook tagging; and investigation into the role of sediment contamination in the pollution block. In the event that tagging does not indicate improved survival, they recommended investigating the interaction of the intensity and location of parasite infestation, particularly *Nanophyetus*, with effluent composition.

Relative Importance of Effluents to Fish Mortality

Through painstaking research, the agencies ruled out virtually every other hypothesis for Chehalis system smolt mortality. Some of the substantiating evidence follows.

(1) Upper Chehalis coho smolt production is similar to production in other western Washington rivers (Seiler 1987).

(2) Northern squawfish (*Ptychocheilus oregonensis*) could only be consuming about seven percent of hatchery smolts and less than one percent of wild smolts in the Chehalis River (Schroder and Fresh 1992).

(3) Upper Chehalis waters do not have chronic or widespread toxicity problems (Michaud 1989).

(4) Neither the Aberdeen, Hoquiam, and Cosmopolis sewage treatment plants were impairing aquatic organisms (Schroder and Fresh 1992).

(5) Physiological tests determined that coho smolts usually entered the lower Chehalis as robust, stress-free fish (Schroder and Fresh 1992).

Recent Clean-up of Pulp Mill Effluent

In 1990, both mills began substituting oxygen or other chemicals for chlorine in the bleaching process, and took steps to prevent accidental spills of toxic materials into the mill waste stream. Each mill also took unique steps to further reduce effluent toxicity (Reif 1989a; Johnson *et al.* 1990).

Monitoring Pulp Mill Effluent

The NPDES requires pulp mills to obtain discharge permits administered by WDOE. These permits require certain basic water quality levels to be maintained in terms of BOD, pH, TSS, and fecal coliform bacteria. In addition, they require both mills to pass acute and chronic bioassay tests every two months (Don Kjosness, WDOE, pers. comm.). Several other tests, particularly for total dioxin and AOX -- a measure of absorbable organic chlorides -- have been proposed by WDOE and are being considered by the Water Pollution Control Board.

Sediments

The EPA found no difference in detected metals between the inner Harbor and North Bay (Schroder and Fresh 1992). However, sediment chromium was slightly above the EPA criterion for damage to Puget Sound benthic infauna, and nickel was about four times the criterion. Concentrations of 4-methylphenol and N-nitrosodiphenylamine were predicted to adversely affect sediment benthic infauna. EPA also found Dioxin in sediments below both mill outfalls (Schroder and Fresh 1992). WDOE sediment chemistry revealed that "Chromium and nickel were somewhat elevated" at both outfall sites, and "exceeded the most stringent proposed Apparent Effects Threshold values" at the ITT site (Reif 1989b).

Bioaccumulation

In 1990, FWS sampled sediment, eelgrass (*Zostera marina*), amphipods (*Corophium* species), clams, mud shrimp, crabs (*Cancer magister*), salmon, and flatfish in Grays Harbor (Frederick 1991). Dioxins and furans were detected in several samples, with highest levels of dioxin in amphipods and crabs (Frederick 1991). Contamination of amphipods may be a potential contributor to delayed salmon smolt mortality.

Future Outlook

Studies of the relation between water quality, sediments, and fish survival should be broadened by looking at both water and sediment pathways. Fish can pick up contaminants either by absorbing them through their gills directly from the water or by feeding on contaminated organisms. Contaminants, including dioxins, can get into the water either directly from mill outfalls or by resuspension from the sediment. That is, contaminants either redissolve into the water or ride up into the water on clay particles. Resuspension may result from wave and tidal action, or from dredging and spoil disposal.

To summarize the current status of inner Harbor pollution in relation to salmon production, (1) an unidentified substance intermittently present in pulp mill effluent as late as 1989 was weakening coho smolts after short-term exposure and probably contributed to mortality, (2) both mills have since upgraded their waste treatment, and (3) the first results of post-cleanup fish tagging studies will begin in 1992 to indicate whether the pollution block has been reduced. A number of years of fish tagging will be required to make final conclusions about the success of cleanup.

Current Harbor Dredging and Fish Survival

Regulatory agencies thoroughly examined the current harbor deepening and spoil disposal project and ultimately agreed that operations would not significantly diminish fish survival (USACE 1990, Ging 1989). Potential negative effects were considered and either minimized by requiring judicious operating plans or mitigated through habitat enhancement.

The USACE (1990) arguments against negative effects of dredging and spoil disposal notwithstanding, sediment contamination with potentially toxic chemicals is widespread enough to be a concern (Table 15). Their own argument that winds and tides resuspend sediment throughout the harbor (USACE 1990) implies that dioxin and other contaminants, even though bound to sediment particles, remain available to the food chain that may lead to salmon and shorebirds.

Parasitism in the Lower Chehalis

Parasitism was identified by Schroder and Fresh (1992) as the only contributor to low survival aside from the inner Harbor environment. Biopsies indicated that both Chehalis and Humptulips systems had low pathogen infestation overall, and similar species composition of parasites. One notable exception was the kidney fluke *Nanophyetus salmincola*, which occurred more frequently in the lower Chehalis system and the inner Harbor than in the Humptulips or North Bay. The authors stated that parasitism alone could not account for differential survival between the two systems because (1) infestation was highly variable within and between watersheds; (2) no linkage had previously been noted between parasite infestation and survival in the absence of additional stressors; and (3) other coho populations that had high survival rates had higher levels of the parasite. However, heavy parastism by *Nanophyetus* coupled with additional stressors can cause coho to die prematurely (Schroder and Fresh 1992).

CHEHALIS-CENTRALIA TEMPERATURE AND OXYGEN BLOCK

Chinook salmon attempt to hold in the Chehalis River between Centralia and Chehalis before gradually moving upstream to spawn in early fall; important chinook spawning grounds lie upstream. In late summer, a complex combination of natural and human-induced conditions often results in the reach being 1) unsuitable for chinook holding and/or 2) impassable for adults migrating upstream, because of high temperature and/or low dissolved oxygen (Hiss *et al.* 1983a). The marginal conditions also make fish particularly susceptible to mortality from pollution, such as sudden spills of toxic material or oxygen-robbing waste (Pickett 1992).

Near Weyerhaeuser diffuser (WDE Sites 33-36, USACE Site 9)

Furans:

* 2,3,7,8 TCDF well above detection limits in flounder and clams.
* Same substances verified near detection levels by FWS the following year.
* Substance also occurred in chinook juveniles at the same site (Frederick 1991).

Total aliphatics: Levels were higher in amphipods (WDE Sites 33-36, USACE Site 9).

ITT outfall (WDE Sites 37 and 38, near USACE sites 7 and 8)

Sediment guaiacols: Were found only near here.

Inner Harbor From Elliott Slough to Crossover Channel

Elutriate bioassay: Sediment elutriate was toxic to oyster larvae in bioassay.

Sediment Resin acids: Were at highest levels in inner navigation channel.

Inner Bowerman Basin

Dioxins and furans:

* Total TCDD, 2,3,7,8-TCDD, various higher chlorinated dioxins, Total TCDF, 2,3,7,8-TCDF, and various higher chlorinated furans, were found well above detection limits in amphipods.

Total aliphatics: High levels occurred relative to other Grays Harbor sites sampled;

South Bay: Levels of 2,3,7,8-TCDF well above detection limits were found in Dungeness Crab liver.

North Bay: Levels of 2,3,7,8-TCDF well above detection limits were found in Dungeness Crab liver.

Table 15. Summary of sediment contamination in Grays harbor (Johnson and Coots 1989; USACE 1990; Frederick 1991).

Temperature

Chinook salmon prefer temperatures between 7 and 14 degrees centigrade (45 to 58 degrees fahrenheit); salmon and trout show stress when temperatures exceed 18 degrees for more than a few hours or days (Bell 1984). Adult Nooksack River spring chinook absolutely require temperatures below 23 degrees centigrade (75 degrees fahrenheit) (Mike Barclay, Nooksack Indian Tribe, pers. comm.). The Washington Administrative Code states that "Temperature shall not exceed 18.0 °C due to human activities" (WAC 173-201-045(2)(c)(iv)) in waters classified as are the Chehalis streams.

Present Condition. Throughout the mid-Chehalis, the temperature standard is routinely exceeded from June to September, particularly near Centralia (Hiss *et al.* 1983a; Aroner 1991; Pickett 1992). Clearly, these conditions are unsuitable for holding adult salmon. If temperatures remain high enough throughout the night, migration through the area could also be blocked.

Efforts to reduce temperature have been very local; temperature controls have been engineered into the Skookumchuck Dam, and are under study for the Wynoochee Dam, but temperature problems in the Chehalis Basin have not been studied in detail (Pickett 1992).

Causes. Shade removal, resulting from logging (Newman, Weyerhaeuser Co., pers. comm.), agriculture, and residential and industrial development (Barber, WDF, pers. comm.), has contributed to seasonally recurring high temperatures (Pickett 1992). Although current logging regulations sometimes require a certain number of mature trees per length of stream bank to contribute to instream woody debris, this arrangement guarantees only partial shading from a thin row of large trees, rather than the potentially more complete shading and cooling effect of a naturally dense growth of shrubs and trees of various heights. Some farmers maintain pastures and crops directly adjacent to the streambank and thus prevent shade trees and shrubs from establishing. Numerous water withdrawals cumulatively reduce instream flow thereby raising temperatures.

Oxygen

Salmonids require a concentration of at least five mg/l dissolved oxygen in the water for survival (Bell 1984) although six mg/l is still considered stressful. The WAC states that "freshwater dissolved oxygen shall exceed 8.0 mg/l" (WAC 173-201-045(2)(c)(ii)(A)), except that because of naturally low water velocity in some reaches, the "Chehalis River from Scammon Creek (RM 65.8) to Newaukum River (RM 75.2) dissolved oxygen shall exceed 5.0 mg/l from June 1 to September 15." (WAC 173-201-080(8)).

Present condition. The Chehalis-Centralia area between Miles 66 and 76 has been the site of low dissolved oxygen in late summer and fall (Bernhardt 1974). Dissolved oxygen violations were also recorded at Centralia, Porter, Montesano, and in the Satsop River (Hiss *et al.* 1983a; Aroner 1991; Pickett 1992).

Causes. Seasonally recurring low dissolved oxygen is attributed to nutrient enrichment and treatment plant effluent (Pickett 1992). Water withdrawal exacerbates the problem (Figure 22), by cumulatively reducing instream flow, raising temperatures, and lowering the ability of the water to retain oxygen.

A total phosphate-phosphorus standard of 100 micrograms per liter applies to the Chehalis Basin (Aroner 1991). Excessive nitrogen or phosphorus loading supports a boom-and-crash cycle of algal growth; this occurred often at Centralia and sometimes at Porter and Montesano (Aroner 1991).

At Centralia, ammonia, total phosphorus, and ortho-phospohorus all showed a negative correlation to discharge, which may be the result of point source discharges providing most of the loading (Pickett 1992), while nonpoint sources dominate in the other reaches.

Effects on Fish

The combination of high temperatures and low oxygen probably form a block to fish migration, particularly for spring chinook. These fish reach the Oakville area in May and June and hold there until spawning in the Newaukum and upper Chehalis from late August until early October. If the range of summer steelhead is to be extended to the upper Chehalis, the same concern may limit their migration. Wolfe (FWS, pers. comm.) believes deteriorating temperatures and oxygen levels over the last several decades have also hurt American shad.

High summer temperatures and low oxygen may prevent juvenile salmon and trout from using otherwise suitable rearing areas in the main stem Chehalis. In August 1989 spot-check snorkeling surveys, no juvenile coho or steelhead were found in habitat where expected (Bisson, Weyerhaeuser Co., pers. comm.).

Total Maximum Daily Load Process

TMDL is a WDOE program intended to achieve full and permanent compliance with water quality standards in river systems where existing point-source pollution controls have not achieved the standards (WDOE 1990). TMDL is required by the Clean Water Act when conventional technology-based controls fail to protect water quality. In the Chehalis system, the process includes all waters from Porter upstream. WDOE has identified biological oxygen demand and coliform bacteria as the key pollutants and will now determine the total amount of pollutants that can be assimilated without harming designated uses. This level of pollution is called the Total Maximum Daily Load (TMDL) which is being determined by intensive monitoring of Basin water quality and modeling to predict water quality conditions at the most susceptible times and locations. This phase will be completed by September 1993.

After WDOE identifies point sources and nonpoint sources, the agency establishes a forum in which representatives of each pollution source allocate shares of the TMDL among themselves in a binding agreement with WDOE. This Waste Load Allocation (WLA) agreement also allows a share for anticipated increases in polluting activities. At that point, WDE implements pollutant load reductions by incorporating WLA into wastewater discharge permits, developing and promoting more effective waste management practices, and educating the public.

DAMS AND DIVERSIONS

Probably because of the Basin's relatively low gradient, the two largest dams, on the Wynoochee and Skookumchuck rivers, were built relatively far upstream on tributaries. While they and other smaller dams have taken a toll on fish production, the Basin has escaped the major impacts associated with large-scale dams as has occurred on the Columbia River.

Wynoochee Dam

Wynoochee Dam was built by the USACE at RM 50 of the Wynoochee River in 1972. The reservoir stores about 70,000 acre-feet from a 70-square-mile drainage area. The city of Aberdeen now operates and maintains the dam under the Water Resources Development Act as amended in 1990 (BPA 1992). The dam controls flooding, provides recreation, augments low flows, and provides municipal and industrial water for the City of Aberdeen (via a diversion at RM 8.1). There is currently a joint Aberdeen/Tacoma project to develop hydropower at the dam.

Upstream Adult Passage. Chinook and coho salmon, steelhead, and sea-run cutthroat trout spawned upstream of the dam site before construction (Findlay 1967), and numbers of all but chinook were estimated.

Species	Spawning escapement	
	Reservoir site	Upstream of reservoir
Fall chinook	unknown	unknown
Spring chinook	unknown	unknown
Coho	0	1,500
Steelhead	1,000	400
Sea-run cutthroat trout	330	165

The Wynoochee project included a barrier dam and fish trap two miles downstream of the main dam. All migrating adult salmonids are trapped and trucked for release upstream of the reservoir. This facility has apparently provided adequate upstream passage in most years (Ging, FWS, pers. comm.).

To substitute for combined steelhead and cutthroat production lost to inundation, USACE agreed to provide WDW with funds for expansion of the Aberdeen Hatchery to rear 170,000 steelhead smolts, calculated to produce 1,700 adult steelhead, in addition to its then-existing programs. Chinook salmon were not considered in the mitigation arrangement (USACE 1967) apparently because their abundance was not determined.

Downstream Smolt Passage. To allow downstream smolt passage, the dam was built with six outlet pipes at various elevations so that smolts might locate them at any pool elevation. These open into the tailrace at the foot of the dam. Experiments (Dunn 1978; LaVoy and Fenton 1979) have shown that this arrangement was killing a number of coho and steelhead smolts. This work also demonstrated delayed migration past the dam and the possibility of mortality in the tailrace. As a remedy, the USACE subsequently constructed a baffle in the tailrace but visual observation indicated no improvement, and the baffle was removed (Dunn, FWS, pers. comm.). Costello (1984) wrote that induced mortalities and egression delay were due to failure of the original mitigation measures to (1) account for fish migrational behavior, (2) meet biological and engineering criteria set forth in the multilevel outlet design, and (3) account for circulation and velocity patterns in Wynoochee Lake, especially the forebay.

Mitigation. Agency attention shifted to further evaluating the effect of the dam on total adult returns (Mathews 1980), culminating in the recommendation by Hiss *et al.* (1983b) to provide additional mitigation for the equivalent of 806 adult coho and 254 adult anadromous trout annually.

Interest in resolving mitigation was renewed in 1990 with the transfer of operation and maintenance responsibilities from the USACE to Aberdeen. Aberdeen and Tacoma have been successful at obtaining federal funds of $1.3 million for the additional mitigation. Negotiations are ongoing between the USACE, Tacoma, Aberdeen, WDF, and WDW to determine the best mitigation package. The currently proposed hatchery project is being challenged in the environmental review process.

Skookumchuck Dam

Skookumchuck Dam was built in 1970 and is managed by Pacific Power and Light Company (PP&L) of Portland, Oregon. The project provides water for two coal-fired power plants south of Bucoda. The dam can store up to 35,000 acre-feet (Mahlum 1976), and maintains summer flows, of which up to 30 cfs have been diverted at Mile 7.8 and pumped to the plants. The diverted water is turned into steam at the power plant, and not returned to the river.

Dam construction permanently inundated approximately two miles of former spawning habitat, and, since it has no fish ladder, blocked access to 12 additional miles of spring chinook, fall chinook, coho and steelhead spawning area above the reservoir (Hiss *et al.* 1982). This resulted in an estimated loss of 500 spring chinook, 311 fall chinook, 1,800 coho (Finn 1973) and about 700 steelhead spawners (WDG 1970). Half the potential coho rearing area (Finn 1973) and 90 percent of the potential steelhead spawning grounds on the Skookumchuck were above the dam (PP&L 1979).

The power company mitigates this loss under agreements with WDF and WDW by:
- guaranteeing adequate downstream spawning and rearing flow for chinook,
- artificially rearing coho, and
- providing both artificial rearing and fish passage for steelhead (PP&L 1979).

Although trap and haul enables WDW to pass steelhead upstream of the dam, WDF does not use the trap to pass coho, because WDF considered the other aspects of mitigation sufficient. Expanding the season for trap-and-haul operations to include salmon could restore access to potential coho spawning and rearing habitat.

Hoquiam River System Dams

Three diversion dams exist in the Hoquiam system and supply municipal water to the City of Hoquiam. These affect passage for up to 10.2 river miles upstream, depending on whether the fish ladders are passable at all flows.

Location of dam	Stream mile	Accessible miles upstream	Ladder present
North Fork Little Hoquiam	2.0	2.0	no
Davis Creek	0.3	1.7	yes
West Fork Hoquiam	10.7	8.3	yes
Total		12.0	

The Stream Catalog (Phinney *et al.* 1975) states that North Fork Little Hoquiam Dam is a total barrier to all species, and that the dams on Davis Creek and the West Fork Hoquiam, while equipped with fishways, may periodically not pass chinook, coho, or chum; coho in particular were reluctant to use the West Fork fishway. However, QFiD has been evaluating escapement on the West Fork since 1985 and has built a trap in the fish ladder. They discovered that, with proper flows, chinook, chum, and coho salmon, steelhead, and cutthroat trout all use the ladder. For example, an average of 300 coho move upstream past the ladder each year (Chitwood, QFiD, pers. comm.).

The three dams also tend to fill with silt and organic debris, which has been periodically flushed downstream. The flushing has been known to cause fish mortality (Chitwood, QFiD, pers. comm.) and degrade spawning gravels for some distance downstream (Bill Banks, City of Hoquiam, pers. comm.). An alternative silt removal procedure may exist to remove this danger.

Water Withdrawal

There have never been any calculations of fish flow requirements in the Chehalis Basin except that WDF and WDW settled on flow agreements with the Corps after construction of Wynoochee Dam and with Pacific Power and Light upon construction of Skookumchuck Dam.

The State of Washington has granted thousands of surface water rights and claims, divided into categories of "Industrial and Commercial" (833 cfs), "Municipal" (590 cfs), and "Individual and Community Domestic" (197 cfs) (Joe Cason, WDOE, pers. comm.; Harper, in prep.). The principal industrial uses are pulp manufacture and power generation. There is also extensive irrigation pumping for individual farms.

Aberdeen draws all its municipal water from the Wishkah River. Hoquiam obtains its supply from three dams in the Hoquiam system. Centralia and Chehalis get water from the North Fork Newaukum when water conditions permit, and Chehalis also pumps some of its supply from the Chehalis River.

Cumulative negative impacts of reduced stream flows occur in some Chehalis Basin locations. Low flows can block upstream passage, reduce total available rearing habitat, and exacerbate water quality and temperature problems.

Other non-consumptive water uses are the fish hatcheries on the Satsop River, Van Winkle Creek, and the Humptulips River; several satellite rearing ponds; and several private trout farms, primarily on the Black River;

<u>North Fork Newaukum</u>

The cities of Centralia and Chehalis operate run-of-the-river intake structures at Mile 12.6 on the North Fork of the Newaukum River. This ordinarily supplies the cities with municipal and industrial water. The cities have rights to virtually all the water during low flow, and this would happen if they relied entirely on the Newaukum. In previous years, this diversion has almost certainly resulted in reduced habitat and warmer temperatures for spring chinook, which regularly attempt to spawn in the North Fork Newaukum.

In the spring of 1991, increased suspended solids from a landslide about one mile upstream rendered the supply system inoperable. This caused the cities to rely on a combination of wells and diversions from the main stem Chehalis (Louis Ciolli, City of Chehalis, pers. comm.).

If all the cities' water needs could be met from alternative sources, North Fork Newaukum flow could be permanently allocated to support larger spring chinook, coho, and steelhead populations. If the cities find it feasible to reactivate the diversion, an agreement to protect instream resources would be very desirable. The City of Centralia is now applying for a WDOE grant to study this issue.

<u>Wynoochee River</u>

The Cities of Aberdeen and Tacoma (1985) describe Wynoochee flow considerations as follows:

(1) Presently 117 cfs is withdrawn from the Wynoochee River by the City of Aberdeen for industrial water supply at RM 8.1, approximately 43 miles below the Wynoochee Dam. The City's existing water right permits the maximum withdrawal of 300 cfs. The 1985 projections by the City indicated that no increase would be necessary for the next 20 years, unless a new water-consuming industry settles there. Water releases

from the dam are scheduled according to industrial needs in Aberdeen.

(2) Aberdeen must leave 120 cfs below Mile 8.1 for fish passage.

(3) Application has been made to WDOE for withdrawal of 35 cfs for future irrigation at RM 27 during June, July, and August. The current irrigation withdrawal is approximately 3 cfs.

(4) Minimum allowable releases from the dam to maintain fish habitat are 190 cfs, except as necessary between May 1 and June 30, when it is reduced to 140 cfs to complete refilling the reservoir.

(5) The dam operator must not fluctuate water levels more than one ft/hr immediately downstream of the dam when flows are less than 2,500 cfs, to avoid stranding fish downstream.

More liberal releases of water in the late summer and early fall could benefit summer steelhead, spring chinook, and possibly fall chinook even in drought years. Proposed Wynoochee hydropower addition (BPA 1992), to the degree that it reduces fall drawdown and winter storage capacity, is expected to add more flexibility for enhancing instream flow, especially below the Aberdeen diversion. If an Instream Flow Incremental Method (IFIM) study were conducted on the Wynoochee, the amount of flow needed for improved fish rearing and holding would be much clearer. Further changes in reservoir operation, whether or not they are related to hydropower addition, would probably have to be approved by the City of Aberdeen, Tacoma City Light, Quinault Indian Nation, and the State and federal resource agencies.

Agricultural Irrigation Withdrawals

Irrigated acreage has declined during the past decade (USDA unpublished data)

County	Irrigated Acres 1987	Irrigated Acres 1982
Grays Harbor	3,270	4,256
Lewis	7,242	7,971
Thurston	3,513	6,218
Total	14,015	18,445

and new irrigation development is not expected to increase substantially, with the possible exception of the Wynoochee, as mentioned above. The main agricultural centers, based on lands having surface water rights, are the South Fork Chehalis, Newaukum, and Black River valleys (Mahlum 1976). Irrigation water is mostly lost to the river by evaporation or percolation into the water table.

WDF (Phinney *et al.* 1975) recognized irrigation's potential to greatly reduce fish habitat, and listed particularly susceptible streams. The following year, WDOE closed many Basin streams to further water appropriation to protect instream flows. These included the South Fork Chehalis, Skookumchuck, Black, and Wynoochee rivers and 17 of their tributaries.

FOREST PRACTICES

Splash Dams

There are still lingering effects of splash dams and log driving in the Chehalis Basin: (1) the stream bottom may have been scoured down to bedrock, especially in the upper Chehalis and the South Fork; (2) the channel may have been straightened; (3) pools may have been obliterated; and (4) creation of new pools may be retarded by up to a century due to absence of sufficiently large woody debris entering the stream. As a consequence, salmon spawning and rearing habitat has not recovered (Jeff Cederholm, WDNR, pers. comm.). See pages 18-19 for further discussion of splash dams.

Logging-associated Landslides

Logging-associated landslides most often are associated with failure of logging roads, some of which are built on slopes whose stability cannot be accurately predicted. During major rainstorms, some of these ongoing landslides trigger sudden flows of boulders, trees, and smaller material into streams. During these events, known as debris torrents, debris typically travels down the streambed for less than a mile and creates a blockage. If this jam is within an area formerly accessible to anadromous fish, potential habitat is lost, the degree of damage depending on the number of accessible and useful miles upstream. Blockage may persist for a few days or many years, until a subsequent high flows break the debris dam. Debris torrents also can remove all potential spawning gravel, vegetative cover, and pool-maintaining woody debris in their path.

A clear example of an impassable debris jam exists on Thrash Creek, a tributary of the upper Chehalis, (Bisson *et al.* 1986). Bisson (Weyerhaeuser Co., pers. comm.) suggests that debris jams may also be affecting fish access to parts of Cinnabar, George, and Big creeks. Warren Sorensen (Weyerhaeuser Co., pers. comm.) observed evidence of fresh debris torrents on Swem, Smith, and Ludwig creeks after the severe rainstorms of January and February of 1990.

Streams made accessible by fish ladders or culverts are susceptible to blockage by any form of accelerated erosion. Increases in large bed load -- that is, gravel, cobble, and boulders moving down the streambed -- can plug, bury, or otherwise destroy fish access. For example, on Roger Creek, a tributary to the upper Chehalis, accelerated erosion rendered the fish ladder at the creek mouth ineffective (Brian Benson, WDF, pers. comm.).

Sedimentation

Logging-induced sedimentation clearly reduces fish populations (Cederholm and Reid 1987) by reducing water circulation around eggs and alevins in the spawning beds. Construction, use, and maintenance of forest roads contributes sediment to streams by mass slope failures or surface erosion of the road. In areas of steep slope and unstable soils, mass failures are often the primary path, but in more stable areas, erosion of road surfaces may be the predominant sediment source (Bilby et al. 1989). Sedimentation may also occur around improperly constructed culverts, and to a lesser degree from the logged-off land itself (Larse 1970).

Stream Clearance

Harvest of all streamside timber occurred until the early 1980s. While this practice is now allowed only in exceptional situations, there are many streams where the amount of large woody debris and the composition and structure of riparian vegetation was degraded as a result of this activity, according to Bilby and Ward (1991). They worked in the Chehalis Basin, and concluded that

(1) Compared to old growth stream reaches, streams flowing through areas clearcut within the previous five years tended to have:

    (a) smaller debris pieces (i.e., less stable fish cover);
    (b) fewer pools (i.e., less coho rearing area during the summer), and
    (c) less accumulated spawning gravel.

(2) Compared to clearcut stream reaches, stream reaches passing through second growth approximately 50 years old tended to have even less woody debris than recently clearcut areas. Clearcutting had created riparian stands composed largely of red alder, but this type of vegetation might not supply sufficient large woody debris, especially to larger streams.

Forestry Chemicals

Forestry herbicides are used to kill hardwoods so that planted conifers can grow without competition. Forest spraying has also been done for pest control or to apply fertilizer. Forestry chemicals can enter steams either by runoff or direct application over streams. In the Chehalis Basin, regulations cover permissible chemicals, methods of application, and timing, but they remain a common concern (CRC 1991). The direct effect of forest spraying on aquatic life has not been documented in the Basin.

Current Forest Practices

Timber harvest continues to reduce abundance of the largest and most persistent forms of wood, and thus impedes habitat recovery. For example, salvage of red cedar after timber harvest is still a common practice in the Pacific Northwest (Bilby and Ward 1991). Bilby (1984) studied the effect of debris removal on Salmon Creek, a tributary in the Upper Chehalis sub-basin. Removal of any type of large woody debris destabilizes the wood remaining in the channel, thus allowing flushing of wood downstream, contributing to the decrease in the amount of woody debris in natural fish rearing areas, and destabilizing the stream channel (Bilby 1984).

AGRICULTURE

Grazing Practices

Range management has also damaged the fishery resource. Livestock are at times still given free access to streams. They trample the bank, accelerating erosion and reducing bank vegetation and instream cover. SCS has recognized instream values and has begun to assist farmers to remedy these problems.

Sedimentation

Agricultural practices tend to increase stream siltation and sedimentation. When streambank vegetation is cleared for grazing or row crops, there is an increase in bank erosion. Cattle trampling streambanks causes sedimentation. Run-off from tilled farmlands results in a higher silt load.

Agricultural Pollution

Agricultural pollution has long been recognized as a major detriment to water quality and fish survival in the Chehalis Basin (Pickett 1992), and is the object of extensive improvements statewide (Troy Colley, Grays Harbor Conservation District, pers. comm.). Agricultural sources include farms, feedlots, and tree plantations. Agricultural pollution falls into two major categories: animal waste and toxic chemicals.

Improper animal waste management, especially from dairy herds, allows plant nutrients and pathogenic bacteria to enter surface waters (Diane Harvester, WDOE, pers. comm.). Manure is at times improperly collected, stored, or spread on fields, then rain washes bacteria and nutrients into the stream, contributing to contamination and overnourishment (Pickett 1992). In particular, there is a problem with low DO on the Black River and Gerrard Creek (Diane Harvester, WDOE, pers. comm.).

Pesticides and herbicides may enter streams when improperly applied or when equipment is improperly cleaned. The degree of pollution cannot be easily assessed because these chemicals tend to enter the stream from one particular spill or other event, do their damage, then dilute or break down before they can be identified or traced to their source. Lincoln and Independence Creeks have had several fish kills in recent years, probably caused by improper application of agricultural chemicals (Jay Hunter, WDW., pers. comm.).

Aquaculture

There are four commercial fish farms located in the vicinity of Rochester to take advantage of abundant groundwater. Aquaculture discharge poses a potential risk to natural fish production from either chronic conditions, such as from removal of fish wastes and algae during pond cleaning, or short-term events, such as accidental spills of toxic chemicals used to sterilize ponds after disease outbreaks. Such events have never been proven to occur, but were among the many hypotheses considered during the investigation of the 1989 Black River fish kill. Aquaculture pond discharges are regulated under state and federal law, and are monitored periodically for compliance.

URBANIZATION AND INDUSTRIALIZATION

Stormwater Runoff

Urbanization creates impermeable surfaces in the watershed due to roofs, streets, and parking lots. The Puget Sound Water Quality Authority (1990) lists five effects of urbanization on water quantity:

(1) Peak storm runoff volume and stream discharge increases.
(2) Runoff reaches streams much more quickly.
(3) Flooding increases in frequency and severity.
(4) Stream velocities are higher.
(5) Streamflow during dry weather is reduced because less water has soaked into the ground and moved slowly into the stream.

All these problems degrade fish habitat by creating wider, less stable stream channels and accelerating stream bank erosion. The resulting sediment fills ponds, streambeds, and stormwater facilities (Pressley and Hartigan 1991). Urbanization-related sedimentation is considered an issue within the Chehalis Basin (CRC and Lewis County CD 1992); of their 20 recommendations to reduce ecological damage associated with improper stormwater management, six are in some way related to sedimentation.

Surface runoff that would have otherwise seeped into the ground instead washes dust, soot, leaves, and whatever else is on the pavement into streams. This material tends to decompose in the water, thus increasing the oxygen demand. The contribution to total instream BOD is difficult to measure but the increase is directly proportional to the amount of impermeable land in the watershed, unless good stormwater management systems are in place. Stormwater also carries unwanted chemicals such as oil, fertilizer, and herbicides into streams. These problems are common to most urbanized areas (Puget Sound Water Quality Authority 1990), although poorly documented in the Chehalis Basin. One example is the Southwest Washington Fairgrounds where stormwater collecting from the surrounding areas is considered by WDOE to potentially threaten Salzer Creek with contaminated runoff (Pickett 1992).

Bank Hardening

Farmers, seeking to protect their fields from stream erosion, harden the streambank with rock riprap, tires, or other materials. Many non-agricultural miles of Chehalis Basin streams have also been riprapped, primarily to protect roads and urbanized areas. Pressure to harden the bank is particularly heavy in the Newaukum system, where agriculture is widespread and the bank is largely loose sand and gravel. Aside from the effects of vegetation removal (and resulting increased temperatures) which usually go along with bank hardening, other detrimental changes (Fraser 1987) include:

(1) loss of local variation in water velocity;
(2) loss of collecting places for woody debris and other instream cover;
(3) excessive deepening in the protected reach;
(4) acceleration of bank erosion downstream; and
(5) loss of bank gravel needed for maintaining downstream spawning habitat.

Bank protection has degraded fish habitat in the main stem Chehalis, Skookumchuck, Satsop, Wynoochee, Humptulips, Newaukum, and Skookumchuck rivers. Measures to make up for lost fish habitat, such as substituting dense willow plantings for riprap rock, or anchoring fallen trees to add instream cover and trap gravel, can be applied to certain sites.

Municipal Sewage

Sewage treatment effluent produces biological oxygen demand and coliform bacteria with the potential for exceeding regulated levels in unusual conditions. Sewage plants also potentially release heavy metals, pesticides, and toxic petroleum-based chemicals. There are sewage treatment plants in Chehalis, Centralia, Elma, McCleary, Montesano, Aberdeen, Cosmopolis, and Hoquiam. The plants are periodically tested to ensure compliance with WDOE regulations for oxygen demand and bacteria. In addition, the Chehalis and Centralia plants will be given consideration in the WLA process mentioned earlier. The McCleary plant discharges into Wildcat Creek, a tributary of Cloquallum Creek, which enters the Chehalis. Water quality in the creek may still be limited due to nutrient enrichment, and WDOE has recommended addressing eutrophication prior to future expansion of the plant (Pickett 1992). The Aberdeen, Cosmopolis, and Hoquiam plants contributed insignificantly to the toxicity of inner Harbor water in 1988 and 1989 (Schroder and Fresh 1992). This information, along with the recent increases in inner Harbor dissolved oxygen to the point that WDOE standards are seldom violated, argues against treating inner Harbor municipal sewage as a major fish habitat concern.

Septic System Leakage

Failing septic systems are given high priority in water cleanup efforts by the Chehalis River Council, in part because previous WDOE-sponsored watershed studies, known as Early Action Watershed Plans, indicated it was a pervasive problem elsewhere in western Washington (CRC and Lewis County CD 1992). A septic system can fail if (1) it is too small for its present load, (2) it is built on land that is either too porous or not porous enough, (3) the tank is not pumped periodically to remove the sludge, or (4) tree roots have grown into the drainfield and blocked the pipes. In each case, sewage finds a way out of the system before it has been fully treated and contaminates groundwater or surface water.

Septic system failure is thought to be widespread in the Chehalis Basin because the rural land is not served by sewer systems (CRC and Lewis County CD

1992). The effect on surface water is expected to increase in areas like the Black River which has seen a rapid increase in rural residences (Blocher 1991).

Industrial Chemical Storage and Disposal

Waste chemicals are nonpoint sources when they enter the stream either because of poor storage or when they are dumped by hand. One example is of the American Crossarm Company near Chehalis, where old leaking electrical condensers were stored. Floodwaters rose, destroyed the berm around the site, and carried off unknown amounts of PCB-laden oil (Craig Harper, CRC, pers. comm.). Several possibilities of improper industrial waste disposal were also proposed during the Black River fish kill investigation and, although none was verified, it was clear that, where river conditions were already marginal, a seemingly small event could trigger a fish kill (Van Dyk 1989).

Log Storage Runoff

Large stacks of logs are stored in Centralia, Montesano, Aberdeen, Cosmopolis, and Hoquiam before shipment to mills. In storage, logs are sometimes treated with preservatives, which can wash into surrounding waters unless adequate settling basins are used. Schroder and Fresh (1992), in their analysis of contamination of Grays Harbor receiving waters and suspended solids, identified several compounds typical of wood storage potentially toxic at higher concentrations. A wood waste landfill on Dillenbaugh Creek has been suspected of leaching toxic materials into the creek (Pickett 1992).

Land Application of Food Processing Waste

National Frozen Foods holds a Washington State Discharge Permit to apply food processing waste to land near Salzer Creek. In the summer of 1979, the failure of a wastewater pipe caused a spill directly into the creek, resulting in very low DO levels at Centralia (Pickett 1992) and killing a number of spring chinook salmon (Jim Fraser, WDF, pers. comm.). An alarm system to show loss of pressure now ensures prompt action to minimize spills.

GRAVEL MINING

Chehalis Basin gravel mining near Rochester and Elma from the 1940s to the early 1980s probably damaged shad and sturgeon (John Wolfe, FWS, pers. comm.). Gravel operations consisted of pits in the active channel. Wolfe hypothesizes that, since shad eggs drift with currents before settling, they may settle in silt holes and suffocate. Entrapment in mined pits also probably occurred.

Collins and Dunne (1986, quoted in Mark *et al.* 1986) listed the possible negative fishery effects of gravel mining as elimination of fish habitat such as pools, side channels, and eddies; lowered water table and consequent damage to riparian vegetation; and increased bank erosion. Collins and Dunne (1988) cited evidence that gravel was being removed faster than the natural rate of replenishment on the Humptulips and other southern Olympic rivers.

Three kinds of gravel mining have been used in the Basin: in-channel excavation; bar scalping; and off-channel pit excavation. Although in-channel excavation is now prohibited, the other two types continue. Two main fishery issues remain unsettled. First, is the annual gravel harvest limit low enough to ensure against downcutting the river bed and depleting the gravel available for fish in coming years? Second, will present operations destabilize the mined bars or cause channel shifts that make the gravel less suitable for spawning and incubating salmonid eggs?

SEDIMENTATION

Sedimentation occurs in the form of (1) siltation, that is, deposition of mud and silt carried by the stream and then deposited as flows recede, and (2) bedload aggradation, that is, excessive addition of sand, gravel and boulders which the stream pushes along its bed. Siltation can smother gravel beds, making them unsuitable for fish spawning or incubation. It can also decrease production of aquatic insects, upon which fish depend for food. Bedload aggradation causes the channel to widen and shift position more than normal, thus potentially drying incubating eggs and rearing fry. There are five sources of sedimentation: timber-related activities; urbanization; flushing of sediments from behind dams; runoff from tilled farmlands; and natural slope failures. All but the last have already been discussed.

Natural slope failure is presently the most obvious source of sedimentation. For example, recent movement of a chronically unstable slope on the North Fork Newaukum created a landslide that entered the stream, and raised the suspended solids in the water to the point that it was not suitable for municipal use for many months (Ciolli, City of Chehalis, pers. comm.).

EFFECTS OF FISHING

Every fishery has the potential to overfish the wild stock so that it fails to meet its escapement goal. Bycatch, marine interception, terminal harvest, and poaching singly or together could theoretically contribute to overfishing. State and tribal fishery managers make every effort to avoid overharvest in the terminal area.

Bycatch

Bycatch is the incidental catch of salmon and steelhead in a fishery that targets another species. Many workers have studied bycatch of North American salmonids in the Japanese squid fishery (Myers *et al.* 1990; Burgner *et al.* 1992; Ishida and Ogura 1991; Yatsu and Hayase 1991), the Alaskan groundfish trawl fishery (Myers and Rogers 1988), and the Japanese salmon gillnet fishery (Harris 1988; Burgner *et al.* 1992), and, despite emotional arguments to the contrary, high seas bycatch has not been shown to have damaged Washington stocks (Dr. Kate Myers, University of Washington, pers. comm.).

Interception

Interception is the catch of a given salmon stock outside its terminal area, where a salmon fleet fishes on a mix of stocks bound for different rivers. Interception may occur on the high seas or in coastal waters. The high seas are defined for this report as marine waters outside the 200-mile national fishery management zone.

High Seas Japanese Salmon Gillnet Fisheries. There is little or no catch of Washington chinook, coho, or chum salmon or steelhead in this fishery (Harris 1988; Walker 1990).

U.S. and Canadian Coastal Salmon Sport and Troll Fisheries. Marine fisheries within 200 miles of the Washington, British Columbia, and Alaskan coast intercept large numbers of chinook and coho bound for the Chehalis Basin. This remains a major influence on terminal run size, and appears to contribute to the difficulty in meeting wild escapement goals. Grays Harbor coho have been a limiting stock in U.S. ocean salmon fisheries management and have limited access to other stocks in terminal fisheries (Dick Stone, WDF, pers. comm.). Marine fisheries do not intercept enough Chehalis Basin chum salmon or steelhead to affect terminal fishery management.

Terminal Area Fisheries

Fishery managers make pre-season, in-season, and post-season run size estimates. The pre-season estimates help to set the fishing regulations and in-season estimates provide an opportunity to adjust regulations based on how the season is progressing. Overfishing in the directed fishery results when fishery managers overestimate the run size before or during the season, and consequently allow too much fishing. Inaccurate pre-season predictions may result from variation in migration route, variations in marine survival, and/or changes in time and intensity of mixed-stock fishing pressure. Differences between pre-season and post-season estimates of Grays Harbor terminal area natural coho run sizes clearly show the magnitude of the problem (Salmon Technical Team 1991).

Catch year	Forecast	Post-season return
1984	28,700	106,900
1985	56,400	22,200
1986	51,600	42,000
1987	103,300	62,000
1988	26,400	68,100
1989	43,000	70,800

Inaccurate in-season run size updates during terminal fisheries, resulting from unusual entry timing into the terminal area, variations in effort, and variations in catchability caused by temperature patterns, flow regimes, and tidal influences, add to difficulty in consistently meeting escapement goals.

Incidental overfishing in the terminal fishery also results when the fishing period of a harvestable stock overlaps with the presence of a non-harvestable species or the wild component of the same species. For example, in 1988 a strong return of hatchery coho was predicted but wild Chehalis coho were predicted to fall short of the escapement goal (Samuelson 1989), and terminal fisheries were regulated in an attempt to selectively harvest the hatchery fish. However, run reconstruction (Dick Stone, WDF, pers. comm.), as illustrated below, showed that both hatchery and wild Chehalis coho experienced the same harvest rate.

Chehalis system coho	Hatchery	Wild
Terminal area catch	2,834	4,441
Terminal area run	26,671	41,040
Exploitation rate	10.6%	10.8%

Fortunately in this case, the terminal run size was initially underestimated and as a result the wild escapement goal was met.

Poaching

This perennial problem adds much uncertainty to fishery management. Poaching includes all forms of unreported catches and, although it causes inaccuracies in post-season run estimates, does the most harm by reducing the number of spawners. The topic raises many virtually unanswerable questions. Does it make sense to account for poaching in managing terminal fisheries? Does annual variability in poaching contribute to the difficulty in predicting run sizes? Was poaching a major factor in the historical decline of the catches? What can be done to control poaching?

Poaching may have extinguished the native Wynoochee spring chinook run in the early 1950s, shortly after a road was built to the Wynoochee Falls 50 miles upriver (Dick Stone, WDF, quoting Jack Thompson, pers. comm.). Poachers desire fish for personal food, and roe for bait, either for personal use or for sale.

LOCATION, QUANTITY, AND UTILIZATION OF EXISTING HABITAT

Habitat information is briefly reviewed here. Data from the FWS habitat survey begun on March 1, 1992, will totally meet the requirements of this section, and will be reported and analyzed in Volume II.

Adult Holding Habitat

Holding habitat is the freshwater area used by adult spring chinook and summer steelhead while waiting to spawn. Spring chinook holding has been documented in the Skookumchuck from the dam down to Bucoda, in the South Fork and main stem Newaukum at least downstream to Mile 4, and the main stem Chehalis at least downstream to the vicinity of Adna (Hiss *et al.* 1983a), based on underwater visual observations. Some holding must also occur in the main stem Chehalis between Chehalis and Oakville, based on occurrence of adult chinook in fish kills (Gene Deschamps, Chehalis Tribe, pers. comm.). Quantity of habitat has not been studied, but is presently being documented during the FWS habitat surveys.

Spawning Habitat

Location of accessible streams and occurrence of spawning spring chinook, fall chinook, coho, and chum are listed in the "Stream Catalog" (Phinney *et al.* 1975). However, more recent spawner surveys have led to some extensions and deletions of actual spawning grounds, for example in the case of spring chinook (Hiss *et al.* 1985). Steelhead spawning grounds are listed by stream and available miles for the entire watershed in WDW unpublished files. Extent of utilization is estimated annually in spawning ground surveys for spring chinook, fall chinook, coho, chum, and winter steelhead. Summary escapement data for the Basin was presented in Chapter 3. Sea-run cutthroat trout and a few Dolly Varden char can be expected to migrate at least as far upstream to spawn as steelhead and coho, but agencies do not estimate their escapement. American shad may spawn as far upstream as Rainbow Falls, and white sturgeon as far as Centralia, but this is known only from chance encounters, not systematic observation. Total habitat accessible to anadromous fish will be documented during the FWS habitat surveys, as will the extent of spawning gravel for chinook.

Juvenile Rearing Habitat

Freshwater Rearing

Generally, salmonids can be expected to rear at least as far upstream as they spawn, and, for species rearing in summer, disperse as far downstream as high temperatures permit. Juvenile chinook salmon emerge from the gravel in March and some remain in freshwater until October but virtually all migrate to saltwater by the end of summer (WDF 1971). Coho emerge from the gravel in March and April, and rear in freshwater for one year. Quantity of summer rearing habitat for coho has been roughly estimated for use in setting habitat-based escapement goals (Stone, WDF, pers. comm.). However, smolt trapping studies (Seiler 1987) indicate that coho escapement could be larger than those based on coho habitat quantity. One possible explanation is that there is much more habitat than indicated in the stream catalog (Phinney *et al.* 1975). Quantity of summer rearing habitat for steelhead has been roughly estimated for use in setting habitat-based escapement goals (WDW unpublished files).

Estuarine Rearing

Juvenile chinook, coho, and chum salmon use Grays Harbor for rearing before entering the ocean; extent of use by each species has been well documented (Simenstad and Eggers 1981).

These authors concluded that:

(1) Chehalis Basin chinook migrate out of streams at age 0.

(2) Regarding migration route, juvenile outmigrant chinook

- (a) reach Sand Island above Cosmopolis by early April,
- (b) tend to concentrate in the inner Harbor, mainly near Cow Point on the north bank opposite the Weyerhaeuser pulp mill outfall (Figure 2), and
- (c) reach Stearns Bluff on the south bank of Grays Harbor opposite Point New by mid-April.

(3) Chinook initially use the intertidal zone, but shift to open waters of the Harbor by August.

(4) Hatchery chinook depend on the estuary for a shorter period than some naturally-spawned individuals.

(5) Chinook fingerlings released from hatcheries in early June were at Westport by mid-June and left shortly thereafter.

The authors speculate that early summer may be a critical time in their life history, because growth was depressed until most fish left the area, at which time the remaining fish resumed growing. In Oregon, late summer estuarine residents contributed most heavily to the adult return (Reimers 1973).

Coho yearlings were abundant in the inner Harbor from mid-April to early June (Simenstad and Eggers 1981). In a sense, the Harbor is less important to coho than to chinook because individual fish pass through more quickly and do not take time to grow there (Moser *et al.* 1989). These investigators found that radio-tagged coho released in the lower Chehalis River generally migrated in the direction of the current; however, most tagged fish also tended to hold their position in areas of low current velocity near large structures such as pilings and docks, particularly around Cow Point. Holding periods ranged from several hours to 12 days. Fish then used either the North or South Channel to migrate to the outer Harbor.

Juvenile chum salmon also rear in the shallow intertidal zone; migration into the estuary probably starts in January and continues through mid-May (Simenstad and Eggers 1981). Chum depend more on the shallow intertidal zone than other juvenile salmon for food supply, since they enter the estuary at a size too small to prey on large, open-water zooplankton, depending instead on relatively smaller epibenthic crustaceans (Hiss and Boomer 1986a).

Other salmonid species seem to depend less on the estuary as a nursery ground, although steelhead were present in low numbers from mid-May to late July, cutthroat smolts were found in July, and Dolly Varden juveniles were found in March (Simenstad and Eggers 1981).

ANTICIPATED HABITAT PROBLEMS

Centralia Area Flood Control

The USACE has proposed to rehabilitate 7,000 feet of existing levee along the Skookumchuck River within the City of Centralia, and to add 1,300 to 1,700 feet of new levee. This could cause more rapid winter velocities in the main stem and remove low-velocity side channels that serve as refuge for overwintering coho salmon and cutthroat trout. This project has been indefinitely postponed because the cities of Centralia and Chehalis could not obtain the additional sponsors required by USACE.

Another flood control project has been proposed on Salzer Creek, which enters the Chehalis between the cities of Centralia and Chehalis. The object is to quickly remove floodwater from the county fairgrounds and airport. Floodwaters come from both the creek and from the Chehalis, which backs up into this area in high water. This project is also in abeyance until the cities get additional sponsors. Issues may arise regarding preservation and restoration of riparian habitat, fish access to potential off-channel rearing areas, and fish safety if floodwater pumping is involved.

Satsop Energy Development

Construction of both Satsop nuclear plants has been halted until regional power needs are re-assessed. The Bonneville Power Administration (BPA) is reviewing proposals by potential contractors such as Washington Public Power Supply System (WPPSS). The earliest that BPA may decide to begin reactivating the nuclear projects is 1993 (Jason Zeller, Washington Energy Office, pers. comm.). A Final Environmental Statement has been prepared (Nuclear Regulatory Commission 1985) and would have included an agreement with the City of Aberdeen to allow 67 cfs, taken out of the city's water right, to remain instream to compensate for the plant's withdrawal of water from the Chehalis River near Satsop (Cities of Aberdeen and Tacoma 1985).

Urbanization

Issues in the rapidly growing suburban area around Grand Mound, Centralia, and southern Thurston County generally include:

(1) predicting the effect of increases in municipal well withdrawal on groundwater supply and reduced seepage to the river,
(2) ensuring that the new Grand Mound Sewage Treatment Plant will not increase the risk of more fish kills on the Black and Chehalis Rivers,
(3) mitigating the effect of vegetation removal during new construction, and

(4) countering the permanent effect of urban runoff on an already delicate river system.

Growing suburban development and light industry in the upper watershed will degrade fish habitat by increasing the intensity of storm runoff, making high flows higher and perhaps low flows lower. This means more scouring of spawning beds in the winter and less rearing area in the summer.

Industrial Expansion

The Grays Harbor Navigational Improvement salmon mitigation site, an artificial slough managed for early estuarine fish rearing, may be threatened by potential development of nearby lowlands for industry or log storage (Gwill Ging, FWE, pers. comm.). Runoff from the adjacent developments could pollute the slough and thus reduce rearing habitat value for juvenile salmon.

Aquaculture

Aquaculture in the Black River area has been criticized on the grounds that it increases the risk of groundwater depletion. If so, an increase in aquaculture could reduce instream flow now coming from local infiltration, since the Black River valley has a strong groundwater connection to the main stem Chehalis.

Bank Protection

Until recently, agricultural agencies assisted farmers and ranchers in stabilizing eroding streambanks. This process permanently removed key salmonid habitat features including undercut banks, instream woody debris, and shading vegetation (Chapman and Knudsen 1980). Currently, agricultural and fishery agencies usually cooperate to make up for the loss by planting shade trees along the protected bank (Rich Bainbridge, SCS, pers. comm.). Some projects include other added habitat features, such as boulder groins to create pools and eddies, anchored trees to provide instream cover, or dense willow plantings to reduce the need for rockwork. However, since improper bank protection upstream accelerates erosion downstream, the demand for more riprap continues. Although one riprap project with suitable considerations for fish will likely not cause long-term deleterious effects on fish populations, the cumulative effects of numerous riprap projects will be negative.

Chapter 6: FEDERAL, STATE, TRIBAL, AND LOCAL GOVERNMENT ROLES AND RELATIONSHIP TO PRIVATE FISHERY CONSERVATION ACTIVITIES

FEDERAL GOVERNMENT

U.S. Department of the Interior, Fish and Wildlife Service

The Fish and Wildlife Service is part of the Department of the Interior. The Service is divided for most operational functions into seven geographical regions. Region One, with its office in Portland, Oregon, covers Washington, Oregon, California, Idaho, Nevada, and Hawaii. Region Eight, having nationwide coverage, conducts basic research for the Fish and Wildlife Service.

Portland Regional Office

The Portland Regional Office administers all Service activities in Region One except basic research. Of concern in the Chehalis Basin, are Fisheries and Federal Aid, Fish and Wildlife Enhancement, and Refuges and Wildlife programs.

Fisheries and Federal Aid

The Assistant Regional Director for Fisheries and Federal Aid has two primary responsibilities. The Division of Federal Aid is responsible for funding state programs to increase sport fish populations and sport fishing access through federal taxes on sport fishing equipment and motor boat gasoline and oil. The Washington Departments of Fisheries and Wildlife receive approximately equal federal funding and have programs in the Chehalis Basin (Jerry Davis, FWS, pers. comm.).

Through the Division of Fisheries, FWS plays an important role in restoring depleted fish stocks of national, interjurisdictional significance, in this case the Pacific salmon. The Western Washington Fishery Resource Office (WWFRO) in Olympia conducts applied fishery research and planning to restore depleted salmonid stocks, evaluate programs of National Fish Hatcheries, and help determine the effects of the Pacific Salmon Treaty on local stocks. In the early 1980s, WWFRO assessed the status of Chehalis spring chinook. Recently, WWFRO has taken the lead responsibility to satisfy the requirements of the Chehalis Basin Fisheries Resource Restoration Study Act.

There are no National Fish Hatcheries in the Chehalis Basin. In the recent past, winter steelhead smolts from Quinault National Fish Hatchery were released into the Humptulips River, but production has been transferred to the Humptulips Hatchery.

The Olympia Fish Health Center has performed fish health certification and diagnostic services for Sea Farms of Washington, Global Aqua, and Swecker's Sea Farms on the Black River (Kim True, OFHC, pers. comm.).

Fish and Wildlife Enhancement

Fish and Wildlife Enhancement (FWE) local offices within the Region conduct environmental review of federal projects under the Fish and Wildlife Coordination Act, and other development requiring federal permits. This component of the Service also deals with endangered species (except anadromous salmonids), contaminants, wetlands, and habitat restoration.

The Olympia Field Office of Fish and Wildlife Enhancement covers the Chehalis Basin. FWE has contributed to protection of the Basin's fishery resource principally through environmental review, but also through contaminant monitoring in recent years.

Environmental Review. FWE's environmental review work helped shape two major federal projects: (1) the widening and deepening of the Grays Harbor navigation channel; and (2) the construction and hydropower addition to the Wynoochee Dam. They have also reviewed several Corps flood control projects in the vicinity of Centralia.

Contaminant monitoring. Recent contaminant monitoring has become the pivotal factor in discussions of acquisition of additional land for the Grays Harbor Wildlife Refuge at Bowerman Basin, just west of Hoquiam (Frederick 1991). Additional Service monitoring now under consideration for a wider area of the Harbor may also shed light on the salmon smolt survival issue.

Habitat Restoration. The new Washington Ecosystems Project provides fish and wildlife habitat restoration to landowners and may be useful in Chehalis Basin restoration recommendations for specific habitat improvements. Providing at least some of the project is on private land, partial funding may be available on cooperative restoration projects.

Refuges and Wildlife

All the National Wildlife Refuges of western Washington are administered through the Nisqually Wildlife Refuge Complex near Olympia. The only refuge within the Basin is the Grays Harbor Refuge, located in Bowerman Basin just west of Hoquiam. The Refuge was recently established to protect large, seasonal concentrations of migratory shorebirds. Acquisition of further land is conditioned upon absence of significant contamination, particularly dioxins and furans concentrated in intertidal crustaceans that form the bulk of shorebird prey.

Seattle National Fishery Research Center

The Seattle National Fishery Research Center provides basic research in fish genetics, populations, physiology, and pathology for Service offices and other federal agencies. Center personnel have been involved in Chehalis Basin fisheries issues by studying the role of water pollution in poor survival of Chehalis System coho smolts. This work has been reported in Schroder and Fresh (1992).

U.S. Department of Agriculture, Forest Service

Although the Forest Service has jurisdiction over only a small portion of Chehalis Basin forest lands, it has an aggressive program of fish habitat management and recreational fishery development. Within the Chehalis Basin, the Olympic National Forest is divided into two Ranger Districts. The upper Humptulips watershed is in the Quinault Ranger District while the upper Satsop and Wynoochee watersheds are in the Hood Canal District. The Forest Service is responsible for integrated management in these areas. Management means designing timber harvest to minimize ecosystem damage, mitigating for unavoidable damage, and restoring the effects of past degradation. In working toward these goals, the Forest Service has recently begun to assess resource conditions throughout rivers originating on National Forest land, even if the greater portion of a particular stream, and the runs of anadromous fish it supports, lies outside Forest boundaries.

U.S. Department of Agriculture, Soil Conservation Service and Related Agencies

The Soil Conservation Service is responsible for improving agricultural practices through technical support. Local offices assist Conservation Districts in practically every county of each state. Local offices of the Agricultural Stabilization and Conservation Service administer financial support to farmers.

The Conservation Districts can support individual farmers in riparian habitat restoration including stream fencing and revegetation programs, improved grazing practices, agricultural waste management, and improved irrigation practices. Recently, the Conservation Districts have become active in public outreach and planning to improve water quality and urban runoff management. (Individual Districts are described under local governments.)

U.S. Environmental Protection Agency

EPA's Region Ten headquarters is in Seattle. EPA contributes to habitat protection and improvement through its regulatory functions, grants to state (WDOE) and local groups, and design of citizen monitoring programs.

Regulatory Functions

EPA is directly responsible for NPDES permits on federal lands and Indian reservations; EPA delegates this authority to WDOE on state and private lands (Bev Poston, EPA, pers. comm.). EPA supports WDOE in routine testing of pulp mill waste and provided extra technical and financial assistance during the 1987-1990 smolt survival study as reported by Schroder and Fresh (1992).

In addition, the agency has recently been assigned the task of coastal zone management planning nationwide (EPA 1991). This mandates states to require very specific pollution control measures in whatever coastal areas they identify as needing help. Each state must provide for the implementation of measures in conformity with detailed guidance related to agricultural, urban, and forestry runoff, marinas, dams, levees, and shoreline erosion.

Streamwalk Program

EPA is now designing a database and data retrieval system to support citizen monitoring of the aquatic and riparian environment throughout the Pacific states. It is developing a list of variables, a field protocol, a monitoring plan describing frequencies and locations, and instructions on recording, managing and retrieving data. The agency is designing a regional GIS database to which physical and chemical data can be attached. The database will be compatible with technical criteria set forth by the Adopt-a-Stream Foundation, although EPA will require fewer variables to be measured than the Foundation.

U.S. Department of Commerce, National Marine Fisheries Service

NMFS's Regional Office and Northwest Fisheries Science Center are located in Seattle. There is also a research station in Manchester, Washington. The agency performed a key part of the research in the smolt survival study using its marine netpens (Schroder and Fresh 1992). NMFS also regulates domestic fisheries in the 3-to-200-mile U.S. fishing zone through the PFMC.

U.S. Department of Defense, Army Corps of Engineers

The USACE civil works mission is primarily navigation and flood control but also development of water supply. Water resource development activities assigned to the Corps in the Chehalis Area are administered by the Seattle District. These projects and the procedures leading up to them are described in a recent review (USACE 1991). The USACE is also responsible for protecting wetlands under Section 10 of the Rivers and Harbors of 1899 and Section 404 of the Clean Water Act.

Navigation

Grays Harbor navigational channel dredging for widening and deepening is nearing completion; all dredging is complete, but a railroad bridge still needs to be widened. Fish and crab mitigation is in place and under evaluation. Maintenance dredging will be ongoing.

Flood Control and Floodplain Management

A 4.2-mile levee is planned for Cosmopolis to Aberdeen, with mitigation by installation of one floodgate and upgrading four existing floodgates for fish passage into south bank streams, and wetland creation to replace levee fill.

USACE is presently planning a floodgate and pumping station on Salzer Creek

(USACE 1990b); the plan is complete but project is on hold because of lack of matching local funds.

Skookumchuck flood control projects being considered are

(1) dam modification for added flood control -- City of Centralia cannot afford to sponsor it but is looking for way to raise funds; and

(2) Lower Skookumchuck levee construction -- City will not consider this unless comparative cost of dam modification is greater.

__Water Supply__

USACE constructed Wynoochee Dam in 1972 for flood control, water supply, recreation, and fish habitat improvement (Findlay 1967). Current issues include:

(1) ongoing fish mitigation dispute (Mike Scuderi, USACE, pers. comm.);
(2) potential title transfer to Aberdeen which would allow development;
(3) rule curve change which might improve smolt migration through dam (Scuderi, USACE, pers. comm.).

STATE OF WASHINGTON

Washington Department of Fisheries

WDF preserves, protects, perpetuates, and manages the food fish resources of the State of Washington (WDF 1990). The agency is charged with balancing the needs of all user groups for the overall benefit Washington citizens. The Director is appointed by the Governor. The Department consists of several divisions having distinct functions. The agency is funded by direct appropriation from the general fund of Washington state.

__Harvest Management__

Harvest Management contributes to decisions for Washington-based commercial and sport fisheries in cooperation with Indian Tribes, PFMC, and PSC. WDF also produces annual sport fishing regulations for salmon, sturgeon, and shad and pre- and post-season stock assessment reports for salmon.

Most WDF harvest management activities for the Chehalis Basin are conducted at the Coastal Lab in Montesano. They cooperatively manage terminal salmon harvest and balance terminal fishing opportunity to allow equal catch by Indian and non-Indian fisheries. They also attempt to balance the needs of commercial and sport non-Indian fisheries. Coastal Lab personnel also conduct routine spawning ground surveys, ensure that non-Indian commercial catch is properly recorded and reported, participate in planning forums, and, along with the Salmon Culture Division, help develop and manage cooperative rearing projects.

For management of coho and chinook, State and Tribal co-managers divides the Basin into two river systems, the Humptulips and the Chehalis, but manages chum in the Basin as a single entity because of the difficulty of assigning chum catch and escapement to a particular river system.

Habitat Management

WDF divides the Basin into four habitat management regions, each with its own Habitat Manager, whose primary duty is to inspect projects for which Washington State Hydraulic Permits are required, and ensure that fish habitat is not compromised. Habitat managers may also represent the agency in watershed planning forums and local habitat improvement projects.

Salmon Culture

The Salmon Culture Division in Olympia coordinates WDF hatchery programs statewide, and determines the number of fish reared annually and site of release. The Division also provides eggs and fry to cooperative rearing projects. WDF Chehalis Basin hatchery facilities are the Simpson Hatchery on the East Fork Satsop and the Humptulips Hatchery. WDF also shares in certain operations of the Mayr Brothers Hatchery on the Wishkah. In addition, WDF owns and manages rearing ponds at the Skookumchuck Dam.

Research and Planning

The Research and Planning Division monitors salmon smolt production from several tributaries of the Basin, and counts all upstream and downstream migrants on Bingham Creek. The Division also coordinated the 1987-1990 smolt survival study (Schroder and Fresh 1992). This division is also responsible for completing three planning processes. In 1985, WDF began developing CRPMP process to guide fishery restoration and land use in Washington watersheds (Anonymous 1986). These Plans formalize agreement among all fishery restoration and management agencies and tribes. They state management goals and criteria and list the principal habitat problems.

The second is the Sport Fishery Enhancement Plan (WDF 1989a), a statewide effort to maximize sport fishing opportunities and thus increase economic contribution to Washington. For the Chehalis Basin, the Plan recommends that Humptulips fall chinook production increase from 500,000 smolts to 1 million.

The third is the recent Salmon 2000 Report (Appleby *et al.* 1992) which calls for integrated planning of enhancement projects, a recognition of the importance of wild stocks, and management of fish culture with ecological and genetic criteria.

Washington Department of Wildlife

WDW preserves, protects, and perpetuates Washington's wildlife resource, while providing maximum recreational opportunity (WDW 1991b). WDW manages Washington's game and sport fish (including steelhead and trout). The agency is responsible to the Washington Wildlife Commission, which represents citizens with an interest in sport fishing and wildlife in various regions of the State. The Director is appointed by the Governor.

Fisheries Management Division

The Division produces annual pre-season sport fishing regulations for winter and summer run steelhead trout, sea-run cutthroat trout, and resident game fish. Winter steelhead terminal commercial harvest is managed jointly with the Quinault Nation to allow equal catch by Indian and non-Indian fisheries.

WDW conducts routine steelhead spawning ground surveys, sees that commercial catch of this species is properly recorded and reported, participates in planning forums, and develops and manages cooperative rearing projects. WDW divides the Basin into two river systems, the Humptulips and Chehalis, for estimating commercial catch and hatchery escapement, but divides the Basin into 15 separate river systems in estimating sport catch and wild escapement.

Steelhead Culture

WDW's only hatchery in the Basin is at Lake Aberdeen. WDW also shares in the cost of steelhead production at the Mayr Brothers Hatchery on the Wishkah and at the WDF Humptulips Hatchery. In addition, PP&L, in coordination with WDW, operates an adult steelhead trap at the Skookumchuck Dam. Progeny are reared to smolts in a rearing pond at the base of the dam and released volitionally each spring. WDW also supports a number of cooperative rearing projects.

Washington Department of Ecology

WDOE is responsible for water resource development and water quality management as well as other environmental programs throughout the State of Washington. Its Director is appointed by the Governor but receives advice and guidance from the Ecological Commission. The agency is funded by direct appropriation from the state's general fund as well as numerous dedicated sources and federal grants.

WDOE is divided into Offices, Programs, and Sections on the state level, with many parallel sections at the regional level. Five parts of the agency deal in some way with fish habitat in the Chehalis Basin which is in WDOE's Southwest Region.

Office of Central Programs and Enforcement

Central Programs

Central Programs cover four areas:

(1) environmental review and sediment management, which reviews EISs, and projects dealing with disposal of dredged material (the Water Quality Program also participates in this activity);
(2) enforcement support functions with the Shorelands and Water Quality Programs and the Southwest Region, as well as other programs;
(3) spill management investigated the 1989 Black River fish kill and oil and other spills; and
(4) regulation of major industrial sources such as pulp mills. In Grays Harbor, this Section routinely monitors chemical content and biological effects of pulp mill effluent as called for in National Pollution Discharge Elimination System permits. The Water Quality Program is an active participant in this effort.

Environmental Investigations and Laboratory Services Program:

This Program is responsible for water quality monitoring. It conducts ambient monitoring for surface and ground water as well as special investigations such as toxic discharges. This program performed much of the bioassay and chemical analysis in the Grays Harbor smolt survival study (Schroder and Fresh 1992).

This office supports the TMDL study and modelling of biological oxygen demand and coliform bacteria (WDOE 1990).

Office of Water and Shorelands

Shorelands and Coastal Zone Management Program

This Program provides advice on hydrology and water resources for flood control, and acts as a liaison with the Adopt-a-Stream Foundation. The Program also administers the Shoreland Management Act, local government master programs, and Coastal Zone Management grants. They also implement wetlands and shellfish programs.

Water Resources Program

The purposes of this Program are:

(1) regulate and maintain official records of surface and ground water rights and claims;
(2) review Federal Energy Regulatory Commission licenses for hydroelectric power;
(3) assists in biological investigations and establish and regulates instream flow requirements of various streams for fish species; and
(4) adjudicate water rights claims.

Water Quality Program

This program establishes water quality programs for point and nonpoint sources and adopts and administers surface and ground water standards by:

(1) maintaining liaison with the SCS;
(2) developing stormwater management programs and guidelines; and
(3) overseeing nonpoint watershed planning, particularly in Puget Sound;
(4) developing agricultural policy and writes discharge permits, working with Central Programs, the Southwest Region;
(5) promulgating forest practices rules with the Forest practice Board and evaluating the effect of forest practices on water quality, working through the Timber, Fish, and Wildlife Process;
(6) developing aquaculture policy and fish farm waste discharge permits, working with Central Programs and the Southwest Region; and
(7) setting effluent limits and writing permits for wastewater treatment plants and other industrial activities.

Water Quality Financial Assistance Program

This program administers funds under Washington's Centennial Clean Water Fund. The program supports the Chehalis River Council and the Grays Harbor Regional Planning Commission in producing water quality improvement plans, and is the most commonly-sought funding source for the Conservation Districts' habitat restoration projects. The program also administers state and federal grants for local government water quality programs. This includes grants to GHRPC, CBFTF, and local conservation districts.

<u>Southwest Regional Office</u>

The Southwest Regional Office covers the Olympic Peninsula and southwest Washington. The Region participates along with the Central Office in the Spill Response Team. It also includes two Sections that implement programs of Water Resources and Water Quality programs. Responsibilities for the TMDL and WLA processes are coordinated through this office. The regional office conducts inspections of facilities, investigates general complaints, and initiates enforcement actions for water quality violations. NPDES and State Waste discharge permits are written and administered in the regional office.

Washington Department of Natural Resources

WDNR manages the State's public timber and mining resources and its subtidal shellfish beds. It implements the Forest Practices Act, manages the Aquatic Lands Program, and conducts research in fish habitat restoration.

Forest Practices Board

The Forest Practices Board was formed under The Forest Practices Act of 1974 to regulate forest practices on private and state land. The Board has representatives from the Washington Departments of Natural Resources, Agriculture, Trade and Commerce, and Ecology, timber interests, the Tribes, and the counties.

The Board's rules are adopted following the Washington Administrative Procedures Act, which requires public notice and a hearing (Dan Bigger, WDNR, pers. comm.). At the same time, an EIS procedure begins as specified in SEPA and culminates in a 30-day review period, after which the new regulations go into effect (Bigger, WDNR, pers. comm.). The approved rules become a part of the Washington Administrative Code Title 222; and are published, along with explanatory text, in the Forest Practice Rules and Regulations (Washington Forest Practices Board 1988), for use by timber operators.

Timber, Fish, and Wildlife Process

WDNR, working with other state agencies, the Northwest Renewable Resources Center, and various Indian tribes, developed a revolutionary process in 1986 to facilitate regulation of logging practices on state and private timberlands under jurisdiction of the Forest Practices Act. Under this agreement, a number of government agencies, tribes, and associations suddenly became reviewers of timber practices. TFW participants address the issues of streamside buffer zones, accelerated erosion and slope failure from road construction, the value of instream woody debris, and other technical habitat questions. The current trend is toward intensive research to adapt general rules to individual timber sales, and thus to balance profit with environmental safety for fish and wildlife.

The principal product of TFW negotiations in the mid-1980s was the 1988 revision (Washington Forest Practices Board 1988) of the Forest Practice Rules and Regulations giving fishery and environmental agencies an avenue for commenting on proposed timber sales and helping design activities to reduce risk to fish. However, several controversies demanded rule revision. (1) Optimum fish habitat protection required exhaustive negotiation between timber operators and state habitat biologists (Randy Carman, WDF, pers. comm.). (2) FEMA considered State timber practices to be causing an unacceptable increase in flood insurance claims (Bigger, WDNR, pers. comm.). (3) A Snohomish County court ruled against the Forest Practices Board for failing to consider cumulative impacts (Bauersfield, WDF, pers. comm.).

Aquatic Lands Program

This is a grant program for local entities to improve the quality of state lands for fish and wildlife and public access.

Stewardship Incentive Program

The recently created Stewardship Incentive Program offers cost-sharing to private landowners in fish and wildlife habitat restoration. This program serves agriculture as well as timber lands, and is coordinated with local Conservation Districts.

Fish Habitat Research

WDNR is authorized to conduct research on cost-effective means to quickly restore the fish-rearing capacity of lands where logging has occurred. In the Chehalis Basin, the agency has installed many instream habitat enhancement features in Porter Creek and is evaluating their success.

INDIAN TRIBES

Quinault Indian Nation

The Quinault Indian Nation is a recognized successor-in-interest to the tribes and bands which were party to the Treaty with the Quinault, 12 Stat. 971. The decision in United States v. Washington, which was affirmed by the United States Supreme Court, authoritatively holds the Treaty with the Quinault and other Stevens Treaties secure to the tribal treaty signatories a right to harvest on a river-by-river, run-by-run basis one-half of the harvestable salmon and steelhead passing through usual and accustomed tribal fishing grounds and stations.

The Quinault Nation's presently adjudicated usual and accustomed fishing grounds and stations include the Queets, Raft, Quinault, Moclips, and Copalis Rivers, the Grays Harbor watershed, including the lower portions of the Chehalis River basin, and the adjacent waters of the Pacific Ocean. Quinault fisheries inside the Grays Harbor watershed presently operate primarily in the Humptulips River, North Bay, the inner Harbor, and the mainstem of the Chehalis River from the Harbor to the vicinity of Montesano.

The Quinault Nation is the only tribe fishing within the United States v. Washington Case Area that has been adjudicated by the federal district court to possess complete self-regulatory status. As the result of this status, tribal members exercising Quinault treaty rights are not subject to state regulation and are regulated exclusively by the Quinault Indian Nation. The Nation's self-regulating status also exempts the Quinault Nation from state permit requirements for fishery research and enhancement activities. Although the Nation and its members are exempt from state fishery regulation, the Nation's Fisheries Division routinely consults with the WDF and WDW with respect to its salmon and steelhead management, research and enhancement activities.

The Nation's fisheries management goals are:

1. Protect and enhance the Quinault Indian Nation fisheries resources.

2. Protect and enhance the self-regulatory capabilities of the Quinault Indian Nation.

3. Protect and enhance the fisheries of the Quinault Indian Nation.

Several fisheries operate within the Nation's usual and accustomed fishing area. River fisheries are managed cooperatively between the State of Washington and the Nation. Marine fisheries are negotiated with the Pacific Fisheries Management Council, the International Halibut Commission and the Pacific Salmon Commission. Management authority rests with the Fisheries Manager, the Quinault Fish and Game Commission and three fish committees, one each for the Queets River, the Quinault River and Grays Harbor (off-reservation). Technical expertise is provided to the management authorities by the staff of the Quinault Fisheries Division, part of the Nation's Department of Natural Resources.

The Fisheries Division is comprised of 25 full-time and up to 20 seasonal staff. The division is divided into three sections; harvest management, technical services, and resource enhancement. Harvest management staff are responsible for analyzing catch and tag data, modeling runs, determining harvest options, and reporting to regional data management centers. Technical services activities include catch monitoring, bio-sampling, spawning escapement estimation, juvenile assessment, tagging projects and wild stock supplementation efforts. Resource enhancement covers a wide range of fish culture work including broodstock capture, spawning, incubation, rearing, tagging, feeding, and caring for cultured fish.

Chehalis Indian Tribe

The Chehalis Tribe's goal is to promote the economic welfare of its individual members and the Tribe as a whole through tribal commercial fishing and other tribal businesses (Gene Deschamps, Chehalis Tribe, pers. comm.). Since the formation of the Reservation, Federal law has recognized the Chehalis Tribal right to fish on the Reservation. However, the Tribe has claimed it should be allowed to fish the Chehalis River off-reservation. This was denied in a recent court decision, which the Tribe appealed to the Ninth Circuit Court. Until resolved, the Tribe confines its fishing to the Reservation. A decision favoring the Tribe would lead to a guaranteed harvest share and expand the Tribe's fishing area.

The number of harvestable fish available to the Tribe presently depends largely on negotiations between the State and the Quinault Nation. Chehalis tribal fisheries are managed under pre-season catch quotas annually set by written agreements between WDF, WDW, and the Quinault Nation, based on modeling of predicted run sizes.

The Tribe has not been able to harvest many hatchery fish in the Chehalis

Basin because the reservation is upriver of major existing hatcheries. To address this, the Tribe is proposing a major hatchery at Cedar Creek, which enters the Chehalis just downstream of the Reservation. A feasibility study has been prepared (Jones *et al.* 1987) and the Tribe anticipates publishing an EIS shortly.

LOCAL GOVERNMENTS

Counties

The Chehalis Basin includes most of Grays Harbor, a large part of Lewis, smaller parts of Mason, Thurston, and Pacific, and very small parts of Wahkiakum and Pacific counties. Grays Harbor and Thurston counties have been most active in aquatic habitat protection. Grays Harbor County Regional Planning Commission has attempted to review the county Shoreline Management Plan to make sure fish habitat and water quality are considered. Thurston County Health Department has been active in monitoring and protecting water quality, particularly in the Black River system (Blocher 1991).

Grays Harbor Regional Planning Commission

The GHRPC was created under the Area Redevelopment Act, PL-8716, primarily for furthering local economic development (Bill Banks, City of Hoquiam, pers. comm.). Membership in GHRPC includes nine cities in Grays Harbor County, the County itself, the Grays Harbor Public Utility District, Port of Grays Harbor, the Grays Harbor Transit District, two local school districts, and the Grays Harbor Parks and Recreation District. GHRPC has no regulatory authority of its own but helps the County and cities develop their respective zoning ordinances.

This group recognizes the potential value of improved fish runs for economic recovery, and works under the assumption that fishery restoration is compatible with the present practices of Grays Harbor industries. They have advocated the priority of (1) extensive fish habitat restoration in the middle and upper Basin and (2) comprehensive public education. They have called for a large volunteer program to achieve these objectives.

Cities

All cities in the Chehalis Basin are responsible for managing their wastewater, whether from storm runoff or from municipal sewage, to maintain adequate water quality. Additionally, the cities of Centralia, Chehalis, Aberdeen, and Hoquiam withdraw surface water for municipal needs. They are legally responsible for withdrawing no more than their water rights specify. Centralia and Chehalis have the option of drawing from either surface or groundwater or a combination of the two. While they have no statutory responsibility to choose the source based on the least ecological effect, they have the option of managing for this purpose.

Port of Grays Harbor

The Port exists to promote trade and commerce within Grays Harbor County (GHRPC 1992). The Port manages all shipping traffic in the Harbor and co-sponsored the recent widening and deepening of the navigation channel. The Port is interested in increasing tourism though enhanced fishing opportunities so manages coho netpens at Aberdeen, Westport, and Ocean Shores.

PRIVATE FISHERY CONSERVATION AND MANAGEMENT ACTIVITIES

Chehalis Basin Fishery Task Force

The CBFTF, formerly the Grays Harbor Fishery Enhancement Task Force, is a non-profit, non-partisan group of fishery, business, and community leaders allied to enhance salmon, steelhead, and sea-run cutthroat trout resources, and to restore habitat critical to these species, in the Chehalis River Basin (CBFTF 1991). It sees its role as identifying fishery enhancement and habitat restoration projects, soliciting grants and donations, matching projects with appropriate funding, enlisting community support to maintain projects, and fostering mutual support among fishery user groups. The Task Force is one of 12 regional fishery enhancement groups statewide partially funded under the WDF Regional Salmon Enhancement Program. The Task Force supported 11 fish rearing projects (four major hatchery operations, three smolt rearing stations, and four fry hatching stations) and one cooperative educational effort in 1992 (CBFTF 1992).

Long Live the Kings

Long Live the Kings (LLTK) works toward restoring chinook salmon runs on streams with depleted natural production, and specializes in rapidly mobilizing support and resources for new fish culture programs. LLTK sponsors a fall chinook hatchery program on the Wishkah River, in coordination with CBFTF. LLTK is trying to rebuild wild stocks using short-term artificial enhancement of wild brood stocks.

Black River Watch

This citizen group monitors water quality in the Black River and thus forestall fish kills such as occurred in September of 1989. It is supported and guided largely by the Thurston County Department of Environmental Health, The Chehalis Indian Tribe, and several of the commercial trout farms in the Black River watershed.

Trout Unlimited

Trout U a nationwide sport fishing group whose Grays Harbor Chapter works with the CBFTF in supporting three major fish rearing projects: fall chinook, coho, and chum salmon at the Satsop Springs ponds on the East Fork Satsop;

sea-run cutthroat trout at the Mitchell Creek Pond on the East Fork Satsop; and winter steelhead at Loomis Ponds on the Humptulips River.

Weyerhaeuser Corporation

Weyerhaeuser supports fishery projects in the Basin by channeling funds through Long Live the Kings and by supporting a full-time fishery enhancement project coordinator for the CBFTF. The company also supports extensive, long-term research on forestry effects on fisheries.

Grays Harbor Conservation District

All Conservation Districts, although essentially administered by the SCS, act as private organizations in that they are governed by a local volunteer board. The GHCD is based in Montesano. The District specializes in school programs in ecological awareness and in salmon enhancement (Troy Colley, GHCD, pers. comm.). They also provide assistance to farmers in streambank protection and elimination of nonpoint pollution. GHCD proposes to conduct a survey of land use and riparian condition throughout the Basin, including all other counties, to assist in repairing habitat damage associated with agriculture.

Lewis County Conservation District

The LCCD, located in Chehalis, supports fish habitat improvement in three ways. First, it supports administration of the Chehalis River Council, a citizen group working to improve water quality in the upper Chehalis. Second, it has incorporated shrub and tree planting into bank protection measures. Third, LCCD proposed a multi-million-dollar dairy waste digester to reduce dairy waste run-off into streams from the farms along the South Fork Chehalis.

Thurston Conservation District

TCCD emphasizes habitat restoration projects in cooperation with private landowners. The Long Range Plan of 1992 (Thurston CD 1992) specifies the CD as leading fishery habitat protection in the areas of farm planning, riparian protection, and in providing plants for streambank revegetation.

Columbia-Pacific Resource Conservation & Development Council

The Council was formed to combine SCS and private industry funds to address certain resource problems facing Grays Harbor, Pacific, and Wahkiakum counties. It is based in Aberdeen. The Council has entered into a contract with the USFS to develop an enhancement plan for spring chinook and steelhead in the Wynoochee (Walls 1991).

Grays Harbor Poggie Club

This group represents local sport fishers and maintains a coho net pen in Aberdeen. The club works mainly through the CBFTF.

Grays Harbor Gillnetters

This group represents the non-Indian commercial fleet fishing within Grays Harbor. The Gillnetters operate coho egg box programs on the Hoquiam and Johns rivers under the CBFTF. The resulting fry are released in the two respective sub-basins.

Washington Trollers Association

This is one of several groups representing the joint interests of trollers based throughout western Washington. The Association also rears Wynoochee native coho on Hillian Creek, a tributary of the Wynoochee. They sponsor a cooperative coho smolt rearing project with the Onalaska School District at Merryman's Pond on the South Fork of the Newaukum.

Elma Game Club

This group works in the Satsop sub-basin with TU to jointly hatch and rear coho at the Muller Hatchery and to rear sea-run cutthroat trout at the Mitchell Creek Pond. Both are located on the main stem Satsop River.

Chehalis Basin Technical Advisory Board

Also known as the Lower Chehalis Water Quality Board, this group existed to provide technical advice and review for the GHRPC in preparation of the Lower Chehalis Water quality Study (GHRPC 1992). The Board's job is now complete.

Chehalis River Council

The mission of the CRC is "to promote conservation and restoration of the Chehalis Basin, with consideration for current and potential uses, through (1) fostering recognition by all land and water users of the direct link between individual actions or inactions and water quality, (2) facilitate citizen empowerment, (3) seek solutions to resource problems, and (4) foster communications among Chehalis Basin interest groups, and work with all interested citizens within the Chehalis Basin" (CRC 1991). As described in the CRC newsletter (Lewis County CD 1990), the primary goal is to develop a plan to identify, correct, and prevent nonpoint source pollution, and thus protect beneficial uses of water. The WDOE provides technical assistance and administers grants from the State Centennial Clean Water Fund to prepare watershed plans. The Upper Chehalis Action Plan will enable the CRC to apply for an implementation grant through the Centennial Clean Water Fund.

The CRC roster includes Trout Unlimited, the Washington Environmental Council, Grays Harbor, Lewis, and Thurston Conservation Districts, the City of Centralia, Lewis County Public Works, the Chehalis Tribe, the Thurston County Office of Water Quality, the Washington State Dairy Federation, and the Weyerhaeuser Company.

Educational Activities

Grays Harbor College has a two-year fishery technician program with a demonstration hatchery and habitat improvements on local streams.

The Onalaska Public School District has strongly promoted a fisheries and natural resources curriculum complete with a full-scale coho rearing pond.

The SCS is very active in natural resource education and outreach, especially through the Grays Harbor Conservation District. They have emphasized land management to protect and restore fish habitat, primarily on agricultural lands. The main focus has been farmers and, more recently, school programs.

Chapter 7: ONGOING RESEARCH AND NEEDS FOR ADDITIONAL INFORMATION

Attempts to address declines of the fisheries resource have not only been based on research, but also on such obvious problems as declining catch, visible pollution, and fish mortality. Therefore, "research" is broadly interpreted here to include scientific studies as well as habitat information, hatchery records, fish tag returns, annual catch reports, and professional opinion.

This analysis of ongoing research and needs for additional information will be addressed relative to fisheries restoration possibilities. The concept of restoration itself has changed, and will probably continue to change, as fishery managers and concerned citizens weigh the risks and rewards of new fisheries enhancement initiatives. Restoration has been, and can be, approached through habitat management, hatchery production, and fishing regulation, or some combination of these three general approaches.

HABITAT MANAGEMENT

Water Quality

Inner Grays Harbor Water Quality

Inner Harbor water quality has apparently been the most critical factor influencing restoration of Chehalis salmon and steelhead; it contributed to poor coho smolt survival at least until 1989 (Schroder and Fresh 1992). The same conditions may have reduced chinook salmon and steelhead smolt survival. Results of pulp mill effluent clean-up efforts will become known in a few more years. Further study may be necessary but can be delayed pending the outcome of ongoing (plus expanded) survival evaluation (Schroder and Fresh 1992).

Current Additional Information Needs

Coho tagging.- Ongoing Chehalis Basin wild and hatchery coho coded-wire tagging programs should be continued to evaluate success in cleaning up inner Harbor water quality (Schroder and Fresh 1992).

Fall chinook tagging.- Fall chinook from Satsop Springs and the Humptulips Hatchery should be coded-wire-tagged to verify whether this species suffers from a pollution block (Schroder and Fresh 1992). This would also allow more accurate estimation of marine interception. Work should begin with the 1993 release and continue through 1996. Sufficiently large release groups of zero-age chinook are available for tagging at both Humptulips and Satsop Springs, but tagging has been precluded by lack of funding (Johnson, WDF, pers. comm.).

Contaminant studies.- Dioxins, furans, and related compounds should be studied for both their extent in the Grays Harbor environment and benthic organisms, and their effects on salmonid prey organisms. The links between the contaminants, the prey organisms, and the salmonids should also be studied.

Feasibility of oyster larvae bioassays.- Studies to evaluate effluent bioassays on oyster larvae should be completed. If feasible, the bioassays should be required on at least a quarterly basis for continued NPDES licensing of pulp mills.

Potential Additional Information Needs

If coded-wire tagging studies indicate salmon survival has not improved, the following studies should be conducted.

Parasite/contaminant studies.- The combined effects of parastism by *Nanophyetus* (a liver fluke) and/or *Ceratomyxa* (a myxosporidian known to cause salmonid mortalities) and exposure to various pulp mill effluents on coho smoltification should be investigated (Schroder and Fresh 1992).

Further effluent toxicity tests.- Although waste treatment at both Grays Harbor pulp mills has been upgraded, the new effluent has not been retested for toxicity to salmonids. One argument is that fish are less likely to be killed by dioxins as a group now than before, because dioxins produced in oxygen bleaching are below detection limits. The rebuttal is that detection limits may be greater than the highest safe dose for long-term fish survival. Detection limits are set by equipment capability, technique, precision, and cost. There is a chance that although total dioxins are reduced, TCDD, the more toxic of the 135 forms of dioxin, may be more abundant now than before (Malek, EPA, pers. comm.). It is also possible that a synergistic effect of a variety of contaminants could be affecting salmonids; toxicity tests similar to those reported by Schroder and Fresh (1992) should be conducted for all salmonid species if tagging does not indicate improved survival.

Sediment as a contaminant reservoir.- If sediments serve as a reservoir of contaminants that are killing fish, then cleanup of mill waste may not immediately resolve the problem, and the need would arise for a more comprehensive picture of the distribution of the most toxic substances as body burden in salmon prey organisms.

Long-term survival of contaminated fish.- If contaminant analysis shows tainted juvenile salmon in the inner Harbor and clean fish in North Bay, fish might be captured from each area and held for a number of months in uncontaminated saltwater, with mortality and condition at death observed. This experiment would differ from previous studies (Schroder and Fresh 1992) on long-term survival in that the experimental groups of fish would be assumed to have eaten contaminated or clean prey, respectively.

Upper Chehalis River System Water Quality

As seen in Chapter 5, the water quality problem in the mid-Chehalis is reasonably well documented. However, there are a number of areas where information could be improved.

Continuous water quality monitoring.- There are some problems with existing water quality monitoring. For example, oxygen is measured each month at one time of day, although periods of daily oxygen lows lasting less than a month are strongly suspected. Continuous oxygen monitoring should be invoked, especially at known problem locations. Nutrient levels should be monitored often enough to detect changes in loading over the season. Enough stations need to be chosen to isolate the effects of all major point sources, and define the relative importance of tributaries as nonpoint sources. Monitoring should occur annually from July through mid-October.

Extent of water quality problems.- Existing plans for analysis have apparently not yet been focused sharply on all degraded qualities of the water. In particular, no plans have been made to use existing temperature models to determine how increased shading may reduce the temperatures. The models should be used to predict the cooling effect of bank revegetation, with the goal of directing tree planting efforts where they can do the most good.

Acute toxic contamination.- Additional information is needed to further reduce the risk of acute toxic contamination, for example from improper or illegal waste disposal from agriculture or light industry.

Relation between water quality and quantity.- Detailed investigations are need to increase understanding of the relation between water quality and water quantity. For example, municipal and agricultural water withdrawal may influence temperature and nutrient concentration.

Septic contamination of river.- A hydrological study is desirable to determine whether the aquifer in the vicinity of Centralia has a net flow into or out of the Chehalis river during the summer. This would help the CRC and the Lewis County Conservation District decide how much emphasis to place on the connection between septic systems and river nutrient loading. It would also help the City plan for future water supply.

Water Quantity

Dams

Wynoochee Dam

There may be opportunity for further enhancement of Wynoochee River summer flows, since the City of Aberdeen now uses far less than its water right. The history of determining actual Wynoochee "fish flows" should be reviewed, and arguments for and against a full-scale instream flow study should be made explicit. If an instream flow study were chosen as the basis for negotiating flows, the necessary field work could be completed in one to two years.

Skookumchuck Dam

Work should be done to determine the feasibility of using the trap at Skookumchuck Dam to pass coho salmon above the dam. If feasible, this process could open additional spawning and rearing area. There is concern, however, that the large, reservoir-reared coho smolts would prey on spring chinook fry (Stone, WDF, pers. comm.).

North Fork Newaukum Diversion Dam

The three sources for the cities of Centralia and Chehalis are the North Fork Newaukum River, the main stem Chehalis, and wells, the principal one being north of Centralia. The primary issue is whether increased use of the city well would deplete Chehalis River instream flow as much as existing surface withdrawals do. A hydrological study might be able to answer this.

The feasibility of informally protecting instream flow on the North Fork Newaukum should be investigated. An instream flow study of habitat available at different flows would help resolve this question.

Conservation of Irrigation Water

Information is needed to support meeting the established WDOE base flows on all streams by promoting voluntary conservation of irrigation water. Irrigated agriculture in the upper Chehalis River System centers around the Newaukum and South Fork Chehalis sub-basins, where most streams have been closed to further water appropriation since 1975 to protect water quality and fishery resources. Basic information, such as instream flow studies and continual monitoring of streamflows is needed to assess the present situation and monitor rehabilitation programs.

Agricultural Practices

GIS-based soils and land-use maps are necessary components for 1) helping to determine regions where streams flow through mostly farmland, and 2) guiding recommendations for fencing and vegetation in streambank restoration projects.

Forest Practices

Timber, Fish, and Wildlife Ambient Monitoring

The Chehalis Basin is particularly important for forestry research because of its large size and extent of land in commercial timber (Jeff Light, Weyerhaeuser Co., pers. comm.). Past TFW ambient monitoring has been conducted by Quinault Nation on Brittain and Elwood Creeks, tributaries of the Humptulips, and on an unnamed tributary of the West Fork Satsop (Dave Schuett-Hames, NWIFC, pers. comm.). Not enough ambient monitoring had been done to date in the Chehalis Basin or in southwest Washington as a whole; a special need exists for documenting baseline conditions in old growth, for no such data exists at present in southwest Washington. This area is geologically different enough from the rest of western Washington to warrant special attention, because of the abundance of basaltic formations and marine sediments. Specific needs are to monitor (1) old growth sites, including those already studied by Dr. Bilby of Weyerhaeuser Co., and (2) streams in managed forest over a wider range of gradient, channel confinement, and channel size than present resources have allowed. Current FWS habitat inventory effort is the most intensive and extensive to date in the Basin, and results are expected to be useful to evaluate future timber harvest (Dave Schuett-Hames, NWIFC, pers. comm.). Streams of particular interest because of previous or ongoing research are Thrash, Stillman, and Bingham creeks (Light, pers. comm.).

Porter Creek Habitat Restoration

The Washington Department of Natural Resources is evaluating habitat enhancement designed to increase coho overwintering habitat in Porter Creek. Large, woody debris in the streambed is essential for habitat complexity (Cederholm and Reid 1987). As in many Chehalis Basin streams, timber removal from the entire stream corridor 40 to 50 years ago destroyed the pools and instream winter cover, which in turn reduced coho smolt production. By constructing instream winter cover, coho production should be restored. The rationale for introducing cover now rather than waiting for nature to take its course is that nature may take 100 years to replace as much natural, large woody debris as could be artificially placed in one or two years (Jeff Cederholm, WDNR, pers. comm.).

Experimental design consists of 1,500 meters of untouched control area, and two test areas of the same size, one featuring log weirs and cabled log clusters, and the other featuring debris pieces placed at the lowest possible cost, with minimal attention to permanence, clustering, or high-water access (Jeff Cederholm, WDNR, pers. comm.). Fish populations are estimated twice a year and outmigrants are counted below each reach. Temperatures are also monitored. Data has been collected for two years pre-project and two years during construction. Two or three years of post-project monitoring are planned. Results should provide good direction for habitat modification as a restoration technique.

Urbanization

Urbanization in northern Lewis and southern Thurston Counties raises several water quality questions. Monitoring should be incorporated into the design and development of the new Grand Mound sewage treatment plant to avoid an increase in fish kills in the area. Also, application of WDOE's 900-page manual of best management practices for stormwater runoff management, developed for Puget Sound, should be applied and evaluated in the Chehalis Basin.

Gravel Mining

The most common form of gravel removal affecting fish habitat is bar scalping. State and county regulations reduce many detrimental effects but a few risks remain unaddressed due to lack of reliable data on instream gravel transport rates. Two main fishery issues remain unsettled. 1) Is the annual gravel harvest limit low enough to ensure against downcutting the river bed and depleting the gravel available to both fish and miners in coming years? 2) Will present operations destabilize the mined bars or cause channel shifts that make the gravel less suitable for spawning and incubating salmonid eggs? Grays Harbor County is working with the Quinault Indian Nation to monitor the location and amount of gravel removal and find the answers to these questions.

Enhanced Rearing Habitat

Gravel Pit Rehabilitation

Recent work by Samuelson *et al.* (1989) has demonstrated that converting abandoned gravel pits to salmon rearing ponds in the lower Chehalis and Humptulips River Systems may help to increase production. Any additional fish production at these projects should be evaluated to determine whether additional sites should be developed.

Side Channel Habitat Enhancement

Existing aerial photos should be reviewed for the purpose of identifying side channels, sloughs, and gravel pits blocked off from the river as of 1992. Site visits should begin in 1993. Site-specific plans, construction, and post-project evaluation should be developed. Fish production at these projects will also be evaluated.

Enhanced Spawning Habitat

WDF created a chum salmon spawning channel on the lower Satsop River in 1985 by excavating the floodplain, placing spawning gravel, and ensuring fish access from the river (Randy Young, WDF, pers. comm.). No subsequent evaluation has been conducted (Dave King, WDF, pers. comm.).

Grays Harbor College students have rehabilitated the Weyerhaeuser-Briscoe gravel pits on the Wynoochee River for chum salmon spawning and coho rearing (Samuelson *et al.* 1989). They have also rehabilitated parts of Alder Creek and Swano Lake in South Aberdeen. All these projects should be subjected to continuing, organized evaluation so that decisions can be made about the efficacy of additional similar projects.

WILD STOCK MANAGEMENT AND ROLE OF HATCHERIES

To maximize opportunities for artificial enhancement without jeopardizing wild stocks, adequate information on the history of introduced stocks and release locations is needed. Although this exists, it has not been analyzed, because most of the data is on paper only, and not computerized. A complete river-by-river history of stock identity would be useful in sketching the degree of similarity between hatchery and native stock for each river system in the Basin, at a minimum for fall chinook and winter steelhead. For example, the Satsop received more outside fall chinook transfers than the rest of the Basin (Brix, WDF, pers. comm.); verifying this observation against actual release records could confirm or modify the present policy of limiting transfers of Satsop chinook outside that system.

This information would allow fishery management agencies to formally agree on the role of hatcheries in augmentation, supplementation, and wild stock management in each sub-watershed and each segment of Grays Harbor where a particular fishery operates.

Further research is also needed on the genetic, disease, and ecological interaction effects of supplementation of wild stocks using hatchery-reared fish. Population simulation models should be developed to evaluate the sizes and locations of enhancement facilities that can be established without causing harm to wild stocks.

REGULATION OF FISHING

Current management of Chehalis Basin terminal salmon and winter steelhead has at times resulted in overharvest (Figures 8, 10, 12, and 13, Table 5). Managers will have more success if the following information needs are met.

Escapement Goals

The total spawning habitat available for coho, chinook, and steelhead is thought to be greater than previously estimated. If true, habitat-based escapement goals could be adjusted so that escaping adults more fully utilize all available habitat. This is why one goal of the current FWS habitat survey is to begin assessing the quantity of coho and steelhead spawning and rearing habitat and chinook spawning habitat. Some additional work will be needed over the next several years to enable refinement of the goals.

Escapement Estimation Evaluations

Current QFiD spawning escapement evaluation work should continue. They count the number of fish passing upstream at a trap in the fish ladder of the West Fork Hoquiam diversion dam. Spawning surveys are then conducted on the stream so that, on an annual basis, estimated escapements are compared to actual populations, species composition on the spawning grounds are verified, and within-species sex composition is determined.

Stock Status

Fall Chinook

It is presently difficult to accurately assess the marine catch of fall chinook. Numerical stock status information could be greatly enhanced by coded-wire tagging representative groups from Simpson and Humptulips hatcheries. Caution would be necessary in using Simpson fall chinook as an indicator for wild stocks since Simpson Hatchery fall chinook are a mixture of a number of imported stocks (Stone, WDF, pers. comm.).

Spring Chinook

Restoration of Wynoochee spring chinook is an important goal of the CBFTF. WDF personnel do not believe any native Wynoochee spring chinook exist (Stone, WDF, pers. comm.). The details of a restoration program depends partly on the present distribution and abundance of any spring chinook (likely Cowlitz stock) returning to the Wynoochee, which has not been systematically assessed. The first step required to support restoration is to assess the river's potential to support pre-spawning adults through the summer. Agencies need to know the river entry timing and spawning distribution of any existing spring-summer chinook. This could probably best be done by a systematic snorkeling survey.

Chum

Harvest managers are presently using a single, relative index for annual chum escapement estimation. Ascertainment of chum escapement numbers, by system, could greatly enhance chum management (Dick Stone, WDF, pers. comm.).

Coho

Ongoing investigations of Bingham Creek and upper Chehalis smolt production should be continued, as should coded-wire tagging of wild and hatchery coho in the Basin. Evaluation of escapement estimation techniques should continue.

Winter Steelhead

Freymond (1989) cited a need for more accurate sport catch reporting throughout the Chehalis Basin. He also encouraged that river of origin be specified in catch reporting for both sport and commercial fisheries.

Summer Steelhead

Return rates of hatchery fish to certain rivers has decreased in recent years, for unknown reasons. If management decides to emphasize this run, it might be advisable to investigate reasons for decline in post-release survival.

Smolt Survival Studies

Steelhead smolt survival studies conducted by QFiD should continue. For several years, steelhead yearlings have been coded wire tagged at Wishkah Ponds prior to transfer to Loomis Ponds on the Humptulips. Loomis Ponds are the imprinting and release site for a steelhead enhancement program. Data from tag recoveries are used for exploitation analysis, estimates of marine survival, and contribution to the high seas and terminal area fisheries.

Interception

Terminal area recovery and consistent reporting of coho coded-wire tags has usually not been adequate to estimate marine interception in most years. Terminal area catch is often only partially or inconsistently sampled or reported from one year to another with the exception that Quinault Indian Nation gillnet fisheries are systematically sampled for biological and tag recovery data and catches are consistently reported.

Complete and consistent tagging and recovery information would be useful to estimate not only the effectiveness of the Pacific Salmon Treaty in reducing interceptions, but also the total run size, and hence, the true measure of rebuilding. Ideally, coded-wire tagging studies of chinook and coho, at least from the hatcheries, would be useful indefinitely as index stocks. This will require a consistent system of estimating tag recoveries for all terminal fisheries. This, in turn, requires:

(1) expanding mark sampling to include the Chehalis and Humptulips system river and estuary sport fisheries and expand carcass sampling;
(2) estimating the portion of the catch mark sampled in these fisheries, probably through creel census;
(3) developing improved sport catch estimates for these two systems for years when creel census is not feasible; and
(4) ensure consistency in designating and recording tag recovery areas for all terminal fisheries as is done for all Quinault gillnet fisheries.

SUMMARY OF ADDITIONAL INFORMATION NEEDS

Current information provides significant data on the extent of available habitat and degraded areas. There are, however, numerous information gaps. The FWS habitat inventory being conducted under the Chehalis River Basin Fishery Resources Restoration Study Act during 1992 is designed to fill these gaps. However, some other gaps will remain and these can be addressed to a reasonable degree by a modest program of future investigation as shown below.

Topic	Periodicity	Data type
CURRENT INFORMATION NEEDS		
Coho tagging	Annually	Coded wire tagging and recovery
Fall chinook tagging	Annually	Coded wire tagging and recovery
Extent of dioxin and furans in Grays Harbor	Once	Sampling sediments and benthic animals
Oyster bioassay feasibility	Once, then quarterly	Regulatory bioassay
Continuous temperature, oxygen, and nutrient monitoring	Daily in summer	Chemical tests
Extent of water quality degradation in Upper Chehalis	Once	Chemical tests to determine which parameters are deleterious
Acute toxic contamination	Once	Planning for spills, etc.
Relation between water quality and water quantity	Once	Model development
Septic link verification	Once	Hydrological study
Wynoochee flow augmentation	Once	Instream flow study
Newaukum Diversion	Once	Instream flow study
Agricultural water conservation	Once	Investigation followed by planning process
Instream gravel mining	Once	Gravel deposition and scour rates
Side channels and gravel pits	Undetermined	Photography, survey, fish trapping
Evaluation of enhanced spawning	Continual	Assessment of fish use
History of stock introductions	Once	Hatchery records
Genetic, disease, and ecological concerns re. hatchery/wild	Ongoing	Scientific research
Hatchery/wild population simulation	Once for each stock	Modeling
Reassessment of escapement goals	Once	Use all habitat survey data

Total chinook and coho run sizes	Annually	Coded wire tag recoveries
Timing and distribution of Wynoochee spring chinook	5 years	Snorkel and spawner survey
Survival of summer steelhead	Once	Undetermined
Escapement estimation evaluation	Ongoing	Surveys and analysis
Smolt survival studies	Ongoing	Coded wire tagging and recovery
Spring/fall chinook competition studies	Once	Biological investigations
POTENTIAL INFORMATION NEEDS		
Parasite/contaminant studies	Once	Physiological tests and bioassays
Effluent toxicity tests	Once	Bioassays
Sediments as contaminant reservoir	Once	Sediment sampling
Long-term fish survival	Once	Long-term seawater survival tests

Restoration Monitoring and Evaluation

It will be necessary to monitor the effectiveness of the restoration program so that mid-course correction can be made, if necessary. Each type of proposed habitat improvement activity will require post-project monitoring to determine relative effectiveness in restoring fish populations.

Chapter 8: RESTORATION PROGRAM RECOMMENDATIONS

PROPOSED FISHERY RESTORATION GOAL

Based on the findings in this report, there is high potential for restoring salmon and steelhead runs in the Chehalis Basin. The following is a general Chehalis Basin fisheries restoration goal.

> **To optimize natural salmon and steelhead production while maintaining the existing genetic adaptation of wild spawners and allowing the highest compatible level of hatchery production.**

Natural production will be restored when the total estimated wild catches consistently lie within the range of historical estimates, and when wild escapement goals are consistently met. This leads to the following goals for each species.

(1) Doubling Chehalis River System coho salmon smolt-to-adult survival, compared to the 1989 level, so that Chehalis River System smolt survival equals Humptulips River smolt survival.

(2) Increasing chum salmon run sizes to historical levels.

(3) Sustaining the recent increase in Chehalis River System fall chinook salmon by improving water quality throughout the Chehalis River System and ensuring escapements that fully and consistently utilize the wild spawning habitat.

(4) Expanding spring chinook salmon wild production to its full potential range.

(5) Ensuring that wild winter steelhead fully and consistently use spawning habitat in each available Chehalis River Basin sub-basin.

(6) Evaluating existing wild summer steelhead populations in Chehalis Basin tributaries.

RESTORATION CRITERIA

Criteria for Habitat Improvements

Habitat restoration projects in the Chehalis watershed may not be cost-effective unless recent effluent treatment upgrades at the two inner Grays Harbor pulp mills result in significant improvement of survival. If survival has improved sufficiently, habitat restoration throughout the basin will be worthwhile and projects using promising techniques should be initiated to begin restoration. If survival has not improved, further efforts should be directed to solving the poor inner Harbor survival problems before extensive watershed habitat restoration proceeds. Since it will take at least two more years before results of tagging studies can confirm clean-up effectiveness, preliminary habitat restoration projects should be started and evaluated. Once the inner Harbor water quality allows reasonable smolt survival, proven habitat restoration projects can begin throughout the Basin on a larger scale. Selection of habitat restoration projects will be guided by the ongoing habitat survey.

Criteria for Hatchery Programs

Hatchery production supports a large share of the catch in several important fisheries. However, once habitat problems have been corrected, the primary hatchery role in fishery restoration should be to augment, rather than replace, natural production. Hatcheries may produce fish poorly adapted for wild survival and can jeopardize the health of wild runs, so programs must be developed cautiously. Any new hatchery initiatives should meet these concerns by either (1) being phased out after reaching optimum natural production, or (2), if permanent, support harvest at a time and place that does not preclude meeting the wild escapement goal.

Ongoing State and Tribal processes are designed, and should continue, to carefully evaluate all hatchery programs for both their likely production contributions and their potential interaction with wild stocks. Artificial enhancement can and should be utilized wherever it will not harm the integrity of wild stocks. The key to successful integration of hatchery and wild production is

1) choosing locations and stocks that do not conflict biologically or in harvest strategies with natural runs, and/or
2) possible acceptance of hatchery stock overescapement.

Restoration Project Evaluation

It will be necessary to monitor the effectiveness of the restoration program so that mid-course corrections can be made, if necessary. The FWS recognizes the immediate need to extend the existing coded wire tagging program to evaluate relative survival of hatchery fall chinook from the Chehalis and Humptulips River Systems. Most other proposals to study inner Harbor water quality and environmental contaminants should be postponed until the effect of the 1989 waste treatment improvements at both Grays Harbor pulp mills is adequately evaluated. If survival does not increase significantly, additional studies leading to further water quality remedial actions will be necessary.

Some types of both hatchery and habitat restoration projects have not yet been proven for their effectiveness. Therefore, it is recommended that all unproven restoration projects initially include careful evaluation to determine how well they produce additional fish. As the most productive restoration techniques become apparent, they will be emphasized in the restoration efforts. The general type of restoration projects needing evaluation include

spawning channels,
off-stream rearing habitat,
acclimation ponds,
remote site incubators,
fry, pre-smolt, and smolt stocking,
addition of woody debris,
stream fencing,
riparian vegetation improvements,
changes in instream flows,
reduction in streambed sediments, and
changes in water quality.

Information ascertained through the ongoing habitat survey will be used to identify highest priority restoration projects. The first of these most dramatic cases will serve as pilot projects, having evaluation built in as an integral part of the project.

Public and Interagency Involvement

Public and interagency cooperation is vital to the success of restoration. This requires the active participation of the tribes and agencies named in the Chehalis Act as the Restoration Plan is implemented. These key entities will identify and explore avenues of cooperation with all interested private organizations and agencies not already involved. The public will be invited to a Basin-wide fisheries conference in the fall of 1992 where study findings will be presented and suggestions for restoration priorities sought.

The FWS recommends that the Chehalis Basin Steering Committee, formed under the Chehalis Basin Fishery Restoration Study Act, be continued to provide policy guidance to the restoration proposed in this report. Furthermore, a Chehalis Basin Fishery Restoration Project Review Team should be formed to strategically plan Chehalis Basin fisheries restoration and implement all the restoration recommendations detailed below. The Team would be composed of representatives of each relevant agency, tribe, and the public and would meet regularly to review project proposals. Each project proposal would be evaluated for its likelihood to restore fish, cost-effectiveness, cost-share requirements, and performance evaluation. All proposed habitat and artificial production proposals should be subjected to the planning criterion path presented in the "Salmon 2000" report (Appleby et al. 1992).

It is also critical that all existing programs designed to protect, restore, and enhance fisheries and their habitat continue to be fully supported and funded.

RESTORATION OBJECTIVES

To achieve full restoration, the primary emphasis should be on habitat improvement because state, local, and tribal hatchery projects are already relatively well-developed and state and tribal harvest managers continue to work together to maximize harvest while allowing adequate escapement.

The overall life-span of the restoration project is 20 years, assuming full funding is made available. Some tasks can be completed in one or several years while others will be accomplished gradually over the 20 years. Since all restoration projects will at least initially be evaluated for fish restoration effectiveness, these recommendations will need to be revised over time. Projects found to be ineffective will not be further pursued. The costs of these evaluations has been included in the project costs estimated below.

Objectives

FWS recommends that the following objectives be simultaneously pursued to achieve full restoration of Chehalis Basin fishery resources. A general description of the tasks required is provided under each objective. Tasks have been prioritized as follows:

PRIORITY 1: Expected to produce excellent results and/or should be at least begun for evaluation.

PRIORITY 2: Expected to produce very good results but not necessary to start immediately.

PRIORITY 3: Expected to produce good results.

OBJECTIVE 1: Restore or improve natural spawning or rearing habitat.

PRIORITY 1:

* *Open access to spawning grounds blocked by landslides, culverts, dams, or water diversions.*
* *Reopen and rehabilitate side channels and oxbows or convert abandoned gravel pits to salmon rearing ponds.*
* *Create additional groundwater-fed spawning channels.*
* *Restore habitat degraded by logging, agriculture, road building, and urbanization by planting trees for shade, fencing streams to eliminate livestock and protect trees, adding or removing woody debris as appropriate, and/or building sediment ponds to reduce flash runoff.*

PRIORITY 3:

* *Determine whether existing gravel removal operations reduce spawning success.*

OBJECTIVE 2: Improve water quality to meet State standards year-round in the middle and upper Chehalis River System.

PRIORITY 1:

* *Initiate routine monitoring to detect critical seasonal water conditions in the middle Chehalis River.*

PRIORITY 3:

* *Determine how increased flow in the main stem Chehalis could help to reduce temperature and oxygen problems.*
* *Determine link between septic system seepage and Chehalis water quality.*
* *Determine how to prevent fish kills from acute toxic chemicals, especially when fish are stressed from high temperatures and low oxygen.*

OBJECTIVE 3: Ensure that the environmental conditions causing poor smolt survival in inner Grays Harbor are remedied.

PRIORITY 1:

* *Coded-wire tag two 250,000-fish groups of Chehalis and Humptulips chinook salmon to evaluate relative survival.*
* *Continue coded-wire tagging of Chehalis and Humptulips wild and hatchery coho salmon to evaluate relative survival.*

PRIORITY 3:

* *Determine the extent of dioxins, furans, and related compounds in the Grays Harbor environment and benthic organisms, and the links between contaminants, prey organisms, and salmonids.*
* *Further investigate effluent toxicity, parasite and contaminant relationships, and sediment as a contaminant reservoir (only if coho and chinook tagging studies indicate poor survival continues).*

OBJECTIVE 4: Ensure that storage dam operation and surface water withdrawal is compatible with fish production.

PRIORITY 2:

* *Conduct Wynoochee River instream flow studies if necessary and negotiate improved flows for fish.*
* *Determine how to improve smolt passage at Wynoochee Dam and implement improvements.*
* *Reduce inflow of organic material and nutrients.*

PRIORITY 3:

* *Develop an agreement to protect instream flows in the North Fork Newaukum River.*
* *Encourage meeting established WDOE base flows on all streams by promoting voluntary conservation of irrigation water.*

OBJECTIVE 5: Extend the range of salmon and steelhead within the Basin to achieve optimum habitat use.

PRIORITY 2:

* *Restore full natural production of spring chinook to the Wynoochee River*
* *Manage all salmon and steelhead hatchery programs and fisheries to provide recreational fisheries while meeting wild escapement goals that consistently and fully utilize all wild spawning habitat in the Basin.*

OBJECTIVE 6: Optimize opportunities for artificial enhancement without jeopardizing wild stocks.

PRIORITY 1:

* *Develop remote-site incubation to increase chum production and possibly extend the range of chum within the Basin.*

PRIORITY 2:

* *Continue experimentation in developing fall-run brood stock and rearing at Satsop Springs for eventual in-river directed harvest.*
* *Investigate reasons for decline in post-release steelhead survival in recent years.*

PRIORITY 3:

* *Conduct a complete review and summary of all historical artificial stock introductions to help with decisions about future management.*
* *Evaluate cooperative rearing projects for their contributions to fisheries and gradually phase out inefficient projects.*

OBJECTIVE 7: Use fisheries harvest management techniques and increased enforcement to increase run sizes.

PRIORITY 1:

* *Revise estimates of available salmon habitat and refine escapement goals to optimize natural habitat use.*

PRIORITY 2:

* *Improve chum salmon stock assessment by refining absolute value of chum escapement and redefining escapement goal.*
* *Improve terminal area sport and commercial salmon and steelhead catch sampling to ensure that stock estimates are accurate and consistent.*
* *Increase enforcement to reduce poaching of salmon and steelhead.*

OBJECTIVE 8: Increase public awareness of the values of fisheries to the Chehalis Basin.

PRIORITY 3:

* *Develop an education program for Chehalis Basin schools.*
* *Develop a video supporting the value of Chehalis Basin fisheries restoration.*
* *Sponsor a contest to develop a logo for Chehalis Basin fisheries restoration program.*
* *Ensure that all restoration projects are identified by at least small signs carrying the restoration program logo.*

FUNDING NEEDS

Some restoration has occurred and will continue under existing federal, state, local, and volunteer programs. The proposed habitat restoration projects complement existing programs but should not replace them.

Since it is important that restoration techniques be demonstrated to be effective before they are fully implemented, it is recommended that restoration be funded gradually over 20 years. After careful review of the size and scope of all tasks necessary for full restoration, it is recommended that a total of $1 million be committed to Chehalis restoration from interested agencies in each of the 20 years. This level of funding is expected to restore significant fish populations, ultimately stimulating the economic recovery of the Chehalis Basin. The Fish and Wildlife Service is not prepared at this time to request additional funds for its share of this work. However, funds may become available by reprogramming from lower priority activities or through other sources.

RESTORATION PLAN

The Chehalis Basin Fisheries Restoration Program has begun and restoration of the anadromous populations will require a 20-year program of implementation. The following step-down plan represents the first 6 years of scheduling for actions and responsibilities in the Restoration Program. Adjustments to the step-down plan will be necessary each year to adapt to continuing changes in program needs. Funding levels represent only the federal contribution to restoration.

STEP-DOWN PLAN

Action	Fiscal Year* 94	95	96	97	98	99
Restore/improve natural spawning or rearing habitat (FWS/WDF/WDW/Tribes/CBFTF)						
Open access to spawning grounds	$55	120	100	75	75	50
Reopen side channels	105	120	100	50	25	25
Create spawning channels	30	50	40	40	40	
Restore degraded stream habitat	102	200	150	120	100	50
Determine effects of gravel removal						50
Improve middle and upper Chehalis water quality (WDOE,Tribes,FWS)						
Chehalis River water quality monitoring		100	100	25	20	20
Determine flow/temperature relation in main stem Chehalis					50	50
Work on septic contamination					50	50
Prevent fish kills					50	50
Ensure adequate smolt survival in Inner Grays Harbor (FWS,WDF,WDOE,Tribes)						
Tag Chehalis Basin chinook		75	75	75	75	75
Continue tagging Chehalis coho *						
Understand dioxins in the Grays Harbor food chain					200**	200**
Reduce impacts of dams and diversions on salmonids (FWS,WDOE,WDF,WDW,Tribes)						
Wynoochee River instream flow			50	50		
Improve smolt passage at Wynoochee Dam			30	30	30	50
Protect North Fork Newaukum River instream flows						50

Action	Fiscal Year* 94	95	96	97	98	99
Seek voluntary conservation of irrigation water						40
Restore salmon and steelhead to original ranges (FWS,WDF,WDW,Tribes,CBFTF)						
Restore Wynoochee spring chinook			50	50	40	40
Ensure all spawning and rearing habitat is fully utilized			50	30	30	20
Maximize artificial enhancement without jeopardizing wild fish (FWS,WDF,WDW,Tribes,CBFTF)						
Use remote incubators for chum		75	70	50		
Explore expansion of Satsop wild brood for directed harvest				50	30	
Improve steelhead post-release survival				50	50	50
Complete artificial enhancement review					30	
Evaluate cooperative rearing projects						75
Improve harvest management and enforcement (WDF,WDW,Tribes)						
Refine habitat-based escapement goals		100	50	50		
Improve chum escapement estimates and goals				50	50	
Improve catch sampling				50	50	50
Increase fisheries enforcement				50	100	100
Increase public awareness of Chehalis fisheries (FWS,WDF,WDW,Tribes,CBFTF)						
Develop school program		50				
Develop Chehalis fisheries video			30			
Develop Chehalis fisheries logo		5				

Action	Fiscal Year*					
	94	95	96	97	98	99
Supply signing for restoration projects		5	5	5	5	5
Program administration, coordination and evaluation (FWS)						
Program administration	30	30	30	30	30	30
Program coordination	50	30	30	30	30	30
Program evaluation		40	40	40	40	40

* presently funded by WDF
** necessary only if evaluations show smolts continue to die in the estuary

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