MAIN STEM WILLAMETTE SUBBASIN

Fish Management Plan

Oregon Department of Fish & Wildlife

MAIN STEM WILLAMETTE SUBBASIN FISH MANAGEMENT PLAN

Prepared by

Tom Rien
Mary Jo Wevers
Jay Massey
Joe Wetherbee
John Haxton
Mark Wade

Oregon Department of Fish and Wildlife

March 1992

TABLE OF CONTENTS

CONTENTS (continued)

CONTENTS (continued)

INTRODUCTION

A high priority of the Willamette Basin Fish Management Plan (ODFW 1988) was the preparation of plans for subbasins within the Willamette basin. The Main Stem Willamette Plan was developed to provide specific direction for management of the fish resources of the main stem of the Willamette River. The scope of this plan includes the main stem Willamette River within the boundaries of ODFW's Northwest Region, from river mile (RM) 32.5 to the mouth of the Middle Fork Willamette at RM 187. A separate plan covers the main stem Willamette River within ODFW's Columbia Region, from the mouth of the Willamette to RM 32.5. Separate mini-plans will be written for standing waters along the Willamette River.

ODFW is committed to the planning process as an integral part of all current and future management by the agency. The Molalla and Pudding Plan is one element of the Department's planning efforts. Species plans for coho, steelhead, trout and warmwater game fish have been adopted, and a management plan for chinook salmon is being prepared. These statewide plans guide the development of more localized plans for individual river basins and subbasins.

These plans serve several needed functions. They present a logical, systematic approach to conserving our aquatic resources. They establish management priorities and direct attention to the most critical problems affecting out fisheries so that the Department's funds and personnel can be used accordingly. They inform the public and other agencies about the Department's management programs and provide them with the opportunity to help formulate those programs.

The Main Stem Willamette Plan was developed by the Oregon Department of Fish and Wildlife with the assistance of the five public advisory committees for the Willamette subbasin and the general technical advisory committee for the Willamette subbasin. The public advisory committees represented user groups and interested members of the community at large. The function of these committees was to help identify objectives and actions and to serve as a sounding board for public interests. The public advisory committee members are identified in each of the tributary subbasin plans.

The technical advisory committees were composed of representatives of federal and state fishery and land management agencies and electrical utilities. These committees contributed information used in the plans and reviewed drafts of the plans. The technical advisory committee for the Willamette subbasin reviewed drafts of all plans prepared for the subbasin. Members of this committee were:

Member	Affiliation
Neil Armantrout	Bureau of Land Management
Ken Bierly	Division of State Lands
Steve Brutscher	Water Resources Department
Doug Cramer	Portland General Electric
Clayton Hawkes	National Marine Fisheries Service
Dave Hohler	Mt. Hood National Forest
Kathi Larson	U.S. Fish and Wildlife Service
Rock Peters	U.S. Army Corps of Engineers
Clyde Scott	Soil Conservation Service
Del Skeesick	Willamette National Forest
Clint Smith	Department of Forestry

The habitat, steelhead, and salmon sections of the plan were originally prepared as part of the Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin (ODFW 1990, Columbia Basin Fish and Wildlife Authority 1990). Those sections have since been modified to fit ODFW's format for subbasin plans and to comply with the ODFW's Natural Production and Wild Fish Management policies (OAR 635-07-521 through 635-07-529).

The plan is divided into sections that deal with habitat, the major fish species or groups of species, and angling access. Each of these sections contains:

1. Background and Status--historical and current information on the topic of that section that helps explain the context of the policies, objectives, and actions that follow.

2. Policies--constraints or principles developed specifically for management activities in the subbasin related to that species or topic.

3. Objectives--what is intended to be accomplished.

4. Actions--solutions or methods for accomplishing the objectives.

GENERAL CONSTRAINTS

Besides the statewide species plans and the Willamette Plan, the Main Stem Willamette Plan must also conform to other established constraints such as federal acts (e.g., Wild and Scenic Rivers, Wilderness, Endangered Species), state statutes, administrative rules, memoranda of understanding and other policies.

Legal Considerations

The Department of Environmental Quality (DEQ) has developed state water quality standards that are in compliance with federal water quality standards. State water quality standards are specifically directed at fish bearing waters. DEQ administrative rules (Chapter 340, Division 41) address water quality standards basin by basin. There are 26 minimum perennial streamflows (MPS) in the basin (4 of which are on the main stem Willamette River) that have not yet been converted to in-stream water rights (IWR).

Senate Bill 140 (ORS 537.332 through 537.360) directed the Water Resources Commission to convert minimum stream flows into in-stream water rights following review. In 1989 the Oregon Fish and Wildlife Commission adopted administrative rules (OAR 635-400-000 through 635-400-040) regarding in-stream water rights. Minimum streamflows were adopted for 4 locations in the main stem Willamette River above RM 32.5. Although legislation does not guarantee the availability of these flows, it does give minimum flows priority over water rights obtained subsequently.

House Bill 2990 of 1985 (codified in part as ORS 543.015 and ORS 543.017) provides strict standards to protect anadromous fish, resident game fish and recreation from adverse effects of hydroelectric development. Its general impact has been to halt hydro development on anadromous fish streams.

The Oregon Forest Practices Act (Forest Practices Act) (ORS 527.610 to 527.730) was adopted in 1972. Commercial timber operations on state and private land are regulated by the act, which is administered by the Oregon Department of Forestry. Forest management activities on U.S. Forest Service and Bureau of Land Management lands are designed to comply with Forest Practices Act rules and state water quality standards. The Forest Practices Act does not apply within the urban growth boundary of towns and cities.

The Oregon Removal-Fill Law requires a permit for the removal or filling of 50 cubic yards or more of material in natural waterways. The Division of State Lands oversees the program, reviews applications and issues permits, and enforces the law.

The Oregon Riparian Tax Incentive Program of 1981 provides a tax exemption to land owners for riparian lands included in a management plan developed by the land owner and ODFW personnel.

The Oregon Land Conservation and Development Commission has developed statewide planning goals. Goals that affect fishery resources include Goal 5, which addresses fish and wildlife areas and habitats, and Goal 6, which addresses water quality.

Oregon Senate Bill 523 of 1985 initiated a coordinated effort among state resource agencies for planning and management of the state's water resources.

ODFW goals and policies for commercial and sport fishing regulations, fish management, and salmon hatchery operation, including the Natural Production and Wild Fish Management policies, are adopted as Oregon Administrative Rules (OAR).

County land use plans contain goals and policies for riparian protection, erosion prevention, and fish and wildlife habitat protection.

Procedures Developed by ODFW

A Department Guide for Introductions and Transfers of Finfish into Oregon Waters (1982) and Fish Disease Control Guidelines (1979) provide direction for management of fish.

Agreements with Other Agencies

Each of the land and water management agencies in the Willamette basin has regulatory authority over some aspect of land or water use, or has overall responsibility for specific land or water areas. Each agency has its own policies, procedures, and management directives associated with its area of responsibility. No single agency has total jurisdiction over an entire river basin. For this reason, coordinated involvement and cooperation among fishery, land, and water managers is necessary to achieve comprehensive management of a watershed to the benefit of the entire system and its resources.

Memoranda of understanding among ODFW and the Bureau of Land Management (BLM), the U.S. Forest Service (USFS), and the U.S. Army Corps of Engineers (USACE) describe cooperative activities for protecting and improving fish habitat on federal lands. Contractual agreements exist with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service concerning Columbia River and ocean salmon fisheries, marine fish investigations, and hatchery production. Annual contracts with the USACE have been established to mitigate for fish production lost as a result of USACE projects.

ODFW comments on USFS and BLM project proposals as well as the general land management plans. The plan review process provides a forum for the state to address habitat improvement or protection for fishery resources. The BLM has initiated its planning process for western Oregon. USFS and BLM fish habitat improvement projects require close coordination with the Department of Fish and Wildlife's Salmon and Trout Enhancement Program (STEP).

ODFW and the state Water Resources Department (WRD) have a memorandum of understanding to coordinate review and action on water rights applications that conflict with protection of fish and wildlife habitats (Memorandum of

Understanding, Oregon Department of Fish and Wildlife - Oregon Water Resources Department 1990). WRD is currently updating its management programs for the Willamette basin. Programs affect future water rights, set priorities for water use, and prescribe actions to solve water problems. ODFW, along with other state natural resource agencies, has identified issues that ODFW will cover and contribute to the Water Resources Department's planning process. Final adoption of new programs is expected in 1991.

The Governor's Watershed Enhancement Board provides an opportunity for private individuals as well as organizations to become involved in watershed rehabilitation projects. An Oregon Fish and Wildlife Commission member is a member of this board.

General Policies

The following general policies apply to all subbasin plans in the Willamette basin, including the main stem Willamette subbasin.

Policy 1. To the extent authorized by law, the Department shall seek compensation for losses of production due to development and other man-made causes.

Policy 2. Hatchery production shall be evaluated to determine if benefits exceed costs.

Policy 3. The number of hatchery fish stocked in the Willamette basin, regardless of species and size, shall not be increased and stream systems not currently receiving hatchery fish shall not be stocked, with the following exceptions:

(a) Experimental programs where the number of fish released is relatively small and a planned and funded evaluation program exists;
(b) Rehabilitation programs for native species;
(c) As provided for in subbasin plans adopted by the Commission in public hearing; and
(d) Special situations approved by the Commission in public hearing.

Policy 4. Stocking levels and areas shall be addressed in subbasin plans.

HABITAT

Background and Status

Basin Description

The Willamette basin is roughly rectangular in shape with a north-south dimension of approximately 150 miles and an average width of 75 miles. It is bounded on the east by the Cascade Range, on the south by the Calapooya Mountains, and on the west by the Coast Range. The main stem of the Willamette River flows through the valley floor, which is nearly level to gently rolling, broken by several groups of hills and scattered buttes.

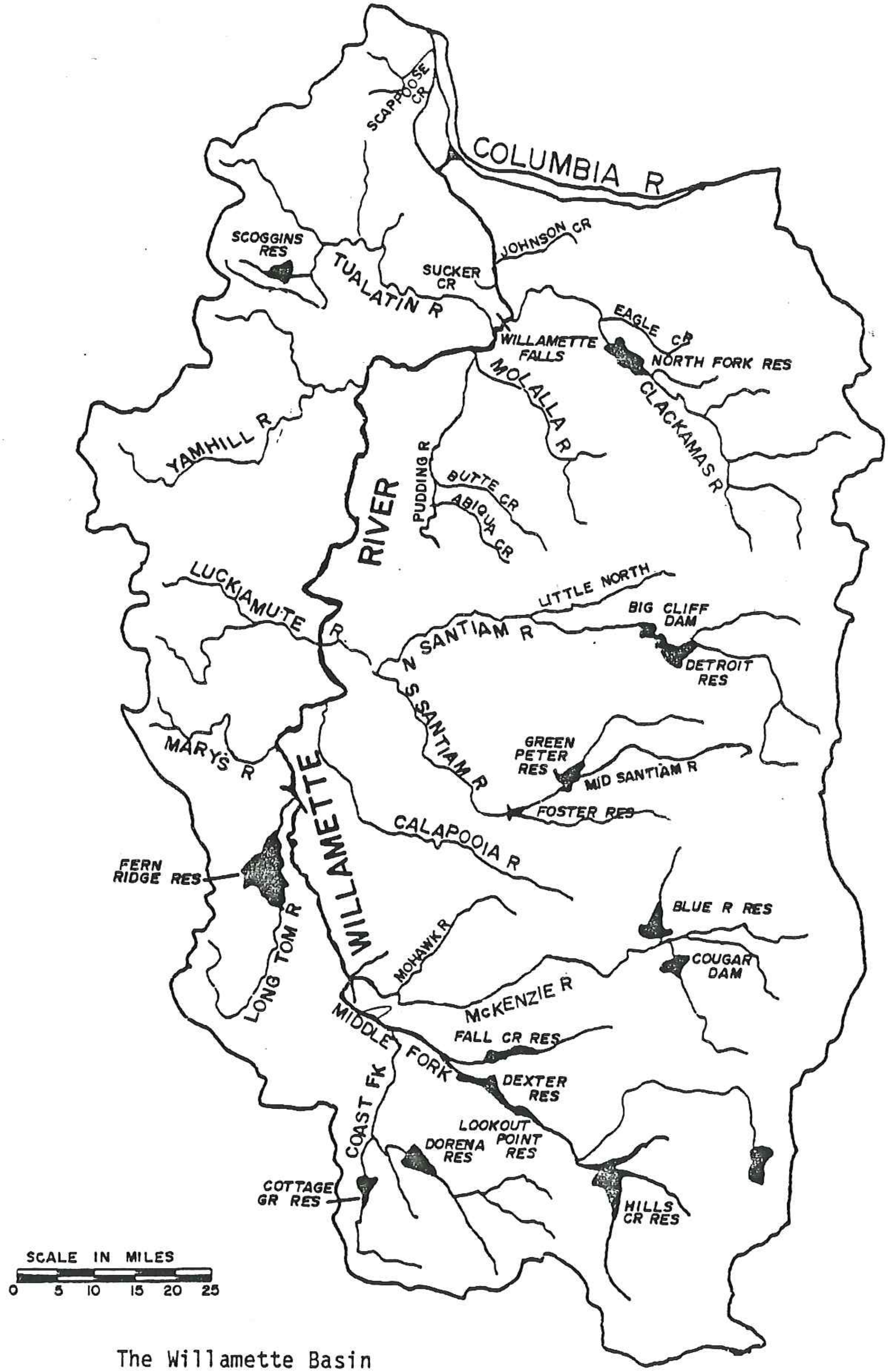
The Willamette Valley floor has a very gentle, north-facing slope. Sedimentary and volcanic rock underlies valley fill in the southern portion of the valley. Here, the valley floor contains easily eroded fluvial deposits. Basalt flows are found near Eugene and between Salem and Portland. The northern one-third of the Willamette River is incised in this bedrock, which historically has shown very little shifting.

Soils in the Willamette floodplain are typically deep and well-drained (Franklin and Dyrness 1973). Textures range from sandy loam to silty clay and are subject to erosion. Soils on the valley floor, derived from silty alluvial deposits, were mostly formed under grassland vegetation.

Four vegetation assemblages are found in the Willamette Valley -- deciduous forest, coniferous forest, grasslands, and riparian communities (Franklin and Dyrness 1973). Riparian assemblages along the main stem Willamette are dominated by Douglas fir and deciduous hardwoods such as black cottonwood, Oregon white ash, bigleaf maple, red alder, and willow.

Historically, dense woodland covered much of the main stem Willamette floodplain, extending on the average approximately one to two miles on either side of the river. (Sedell and Froggatt 1984). Agricultural practices in the Willamette Valley, which began in the mid-1800s, have drastically altered riparian vegetation along the main stem. The best farmland is usually on active floodplains, and much of the land adjacent to the main stem Willamette was cleared of forest. Removal of riparian vegetation tends to accelerate bank and channel erosion, which in turn contributes to turbidity and sedimentation of river substrates.

Removal of riparian forests and downed wood together with channelization has resulted in a decrease in the number of marshes, multiple channels, oxbow lakes, and other complex aquatic habitats normally associated with rivers. The main stem Willamette presently consists of one main channel that receives less organic litter and large woody debris than it did historically. Large woody structures that retain spawning gravels are not as abundant as in the past. Additionally, the main stem is subject to greater erosional forces from constrained flows, which tends to scour spawning gravels and displace them downstream.



The Willamette Basin

Climatic conditions in the Willamette basin include dry, moderately warm summers and wet, mild winters. The mean annual precipitation of approximately 40 inches near the center of the valley floor occurs primarily during the winter months. In winter, rainfall results from frequent storms moving in from the Pacific Ocean. In summer, precipitation results from occasional shower and thunderstorm activity. Precipitation tends to be of low intensity for extended periods of time. Measurable precipitation falls approximately 160 days a year.

The Willamette River (EPA Reach 1708.0001.007.00.00) forms at the confluence of its Coast Fork and Middle Fork near Springfield and flows northward in a braided, meandering channel for 54 miles. Through most of its remaining length it flows through a well-defined channel with no rapids and one falls, Willamette Falls, located at RM 26.6 near Oregon City. Its total length is 187 miles. It empties into the Columbia River at RM 101.5.

Historically, the main stem Willamette River was a meandering, braided stream with many side channels and sloughs (Hughes and Gammon 1987). Flooding was a nearly annual event during the wet winter months. Flows were naturally low in the summer months and prevented passage of some anadromous stocks past Willamette Falls. The main stem channel of the Willamette has been highly modified by human activity. Sedell and Froggatt (1984) estimate that 75 percent of the original shoreline has been lost through channelization projects. Much of the original fish habitat has been lost.

Stream gradient is relatively gentle, averaging 2.8 feet per mile from the river's origin (RM 187) to the Newberg Pool (RM 52), and averaging 0.12 feet per mile from the upstream end of the Newberg Pool to Willamette Falls (RM 26.5) (Hines et al. 1977). The gradient of river segments between mouths of larger tributaries can vary substantially (Table 1). The upper main stem (above RM 55) has shallow channels with relatively high gradients producing fast flows (Hines et al. 1977). The lower main stem (below RM 55) has a deeper channel with relatively smooth, slow moving water.

Table 1. Willamette River reach gradients between mouths of major tributaries (Water Resources Research Institute and Hines et al. 1977).

River Mile		Reach Description	Gradient
From	To		(ft/mi)
187.0	171.8	Coast Fk./Middle Fk. to McKenzie R.	4.9
171.8	149.0	McKenzie R. to Long Tom R.	5.0
149.0	132.1	Long Tom R. to Mary's R.	2.8
132.1	119.5	Mary's R. to Calapooia R.	1.9
119.5	109.0	Calapooia R. to Santiam R.	1.9
109.0	107.5	Santiam R. to Luckiamute R.	4.0
107.5	88.1	Luckiamute R. to Rickreal Cr.	1.4
88.1	54.9	Rickreal Cr. to Yamhill R.	2.1
54.9	35.7	Yamhill R. to Molalla R.	0.2
35.7	28.4	Molalla R. to Tualatin R.	0.1
28.4	26.5	Tualatin R. to Willamette Falls	0.1
26.5	0	Willamette Falls to Mouth	<0.1

Gravel and cobble are common in upper reaches of the Willamette River. Substrate embeddedness is generally less than 50 percent in the upper reach (Hughes and Gammon 1987).

In terms of discharge, the main stem Willamette River is the 12th largest river in the United States (Gleeson 1972) and the 10th largest river in the contiguous United States (Sedell and Froggatt 1984). The river receives the highest runoff per unit drainage area than any of the large rivers in the nation (Huff and Klingeman 1976).

Average annual flow in the Willamette increases five-fold between the river's origin (5,600 cubic feet per second) and Willamette Falls at RM 27 (29,000 cfs) (WRRI 1979). Monthly flows vary substantially (Table 2). Mean high flows exceed mean low flows five- to seven-fold. Highest discharges generally occur in December or January while lowest discharges occur in July or August. Flows in the main stem Willamette are largely regulated by the 13 U.S. Army Corps of Engineers (USACE) dams on tributary systems. Impoundment projects are regulated to reduce flooding in the winter and increase flows during the summer.

Table 2. Monthly and annual discharges for the main stem Willamette River at three stations above Willamette Falls for 1977-1986 (unpublished data, USGS 1988).

Station	USGS gage number	Mean discharge (cfs)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Harrisburg	14166000	15,799	15,042	11,308	10,409	9,014	7,218	4,677	5,089	7,445	8,476	14,211	22,909	10,947
Albany	14174000	21,203	21,683	15,439	13,373	10,364	8,118	5,045	5,313	4,073	9,447	17,181	30,439	13,730
Salem	14191000	35,645	36,218	26,035	23,050	17,260	13,530	7,514	7,107	11,040	14,553	29,866	50,982	22,580

The USACE (1982) estimated that controlled releases have increased mean and minimum flow over historical levels by 54 percent and 111 percent, respectively, at Albany and by 66 percent and 138 percent, respectively, at Salem. Summer water releases serve to maintain minimum flows adopted by the Water Policy Review Board (Table 3). Minimum flows are intended to protect fish production by increasing available habitat, increasing fish passage at Willamette Falls, and diluting pollution.

Table 3. In-stream water rights for the main stem Willamette River above Willamette Falls adopted by the Water Policy Review Board.

Location (River mile)	Minimum flow (cfs) Natural	Minimum flow (cfs) Storage release	Date
RM 38.4[a]	1,500	4,700	6-22-64
RM 84.2[a]	1,300	4,700	6-22-64
RM 119.3[a]	1,750	3,140	6-22-64
RM 173.7-187[b]	2,000	0	11-3-83

[a] These have not yet been certified; their conversion is being contested.
[b] This MPS has been converted.

The quality of the fish assemblages generally decreased by the 1940s due to serious pollution problems and loss of habitat (Dimick and Merryfield 1945), but recent studies by Hughes and Gammon (1987) indicate a reversal of this trend. Increased summer flows from USACE dams have contributed to these improvements. Higher summer flows combined with passage improvements at Willamette Falls and hatchery inputs have allowed historically absent anadromous runs of summer steelhead, coho, fall chinook, and sockeye to become established in the basin above Willamette Falls. Prior to these changes, winter steelhead and spring chinook were the only anadromous salmonids that had access to this area.

Land Use

Land use practices affecting the Willamette River today are much the same as in the early days of settlement. Agricultural activities and urban development still dominate land use adjacent to the main stem. Land use influences fish productivity in the Willamette River through effects on water quantity, quality, and system diversity. Controlling the affects of land-use activities on the main stem is complicated by the relatively large amount of privately owned land in the basin.

Less than 2 percent of the land along the Willamette main stem is public land (Table 4). The state, U.S. Bureau of Land Management and U.S. Forest Service own small amounts of land while the vast majority is privately owned.

Table 4. Land ownership along a 1-mile buffer strip on either side of the main stem Willamette River (acres, square miles, and percent of total) (Oregon Water Resources Dept. 1989).

Land Type	Acres	Square Miles	Percent
Private	229,590.76	358.74	98.1
State	3,734.99	5.84	1.6
BLM	90.66	0.14	<0.1
USFS	524.72	0.82	0.2
Total	233,941.13	365.54	

Recreational activities along the Willamette River corridor are numerous and include boating, swimming, fishing, hunting, hiking, camping, picnicking, and sight-seeing.

Forestry

Some areas along the Willamette main stem are wooded, however these areas are relatively small and are generally not used for timber production. Although little logging activity occurs along the main stem Willamette, forestry practices in the upper reaches of the Willamette's tributaries influence water quality down stream.

Agriculture

Agriculture is very important to the area's economy and is the predominant land use along the Willamette main stem (Water Resources Department 1978, 1980). Grains, grass and legume seeds, vegetables, tree fruits and nuts, field crops and specialty products make up the bulk of the agricultural revenues from the Willamette basin (Oregon State University Extension Service 1988). Rangeland accounts for only a very small portion of the lands adjacent to the main stem (Water Resources Department 1978, 1980). Most of the rangeland in the basin occurs along main stem tributaries.

Approximately 1.4 million acres of the Willamette basin are used for crop production and about 25 percent of this acreage is irrigated (Water Resources Department, unpublished data). Yamhill, Polk, Marion and Linn counties, located primarily in the middle Willamette basin, account for approximately 60 percent of the total acreage.

Agricultural practices affect fish production through water withdrawals for irrigation, accelerating erosion which leads to sedimentation of waterways, and altering water quality. Anderson (1954) estimated that the agricultural lands in the Willamette basin located above Salem contributed 22 percent of the total annual sediment production of the basin. Erosion problems in agricultural areas are often associated with removal of riparian vegetation. Water quality in farmlands is frequently poor due to fertilizers and agricultural chemicals leaching from the soil.

In 1954, Anderson estimated that the eroding main channel of the Willamette River contributed 54 percent of the total sediment yield of the Willamette basin above Salem. Attempts to decrease erosion along the Willamette River have focused on preventing the natural meandering character of the river through the construction of bank revetments. The result of revetment construction has been the removal of secondary channels and channelization of the river. Much of this activity increased the amount of land available for agricultural production and urban development, but at the cost of decreasing fish production. Channelization in the 15.5-mile reach from Harrisburg to the mouth of the McKenzie resulted in a loss of most of the many secondary channels and a subsequent four-fold decrease in surface water volume available (Sedell and Froggatt 1984) (Fig. 1). The only place juvenile chinook were observed during a study of revetted and unrevetted sections of the Willamette was in secondary channels and backwater areas that have largely been lost to agricultural production (Li et al. 1984). Stream area and angler access have been decreased. Larval fish have shown a preference for natural banks over revetments in the Willamette (Li et al. 1984).

Mining

Although once common in the Willamette River, inwater aggregate mining is now relatively rare (Klingeman 1976). Today, aggregate mining is primarily limited to bar scalping and removal from behind previously constructed berms. Dredging is only allowed below RM 57. Recently this boundary has been challenged by members of the aggregate industry.

Mining activities in and adjacent to the Willamette main stem are confined primarily to sand and gravel (aggregate) extraction. Hauling aggregate is expensive, consequently mining sites are usually located near urban areas where the aggregate is used for construction. In 1976, the Willamette River supported about 20 mining sites (Oregon State Parks and Recreation Branch, Department of Transportation 1976).

Mining activities can result in an increase in water turbidity, which can delay migrating fish (Bottom et al. 1985). Also, dams constructed in the upper basin may be limiting the amount of gravel recruited to the main stem. Consequently, the potential exists for gravel supplies to become depleted faster than they are being replenished.

The Port of Portland, Ross Island Sand and Gravel and other operations dredge large amounts of gravel in the lower Willamette (Table 5).

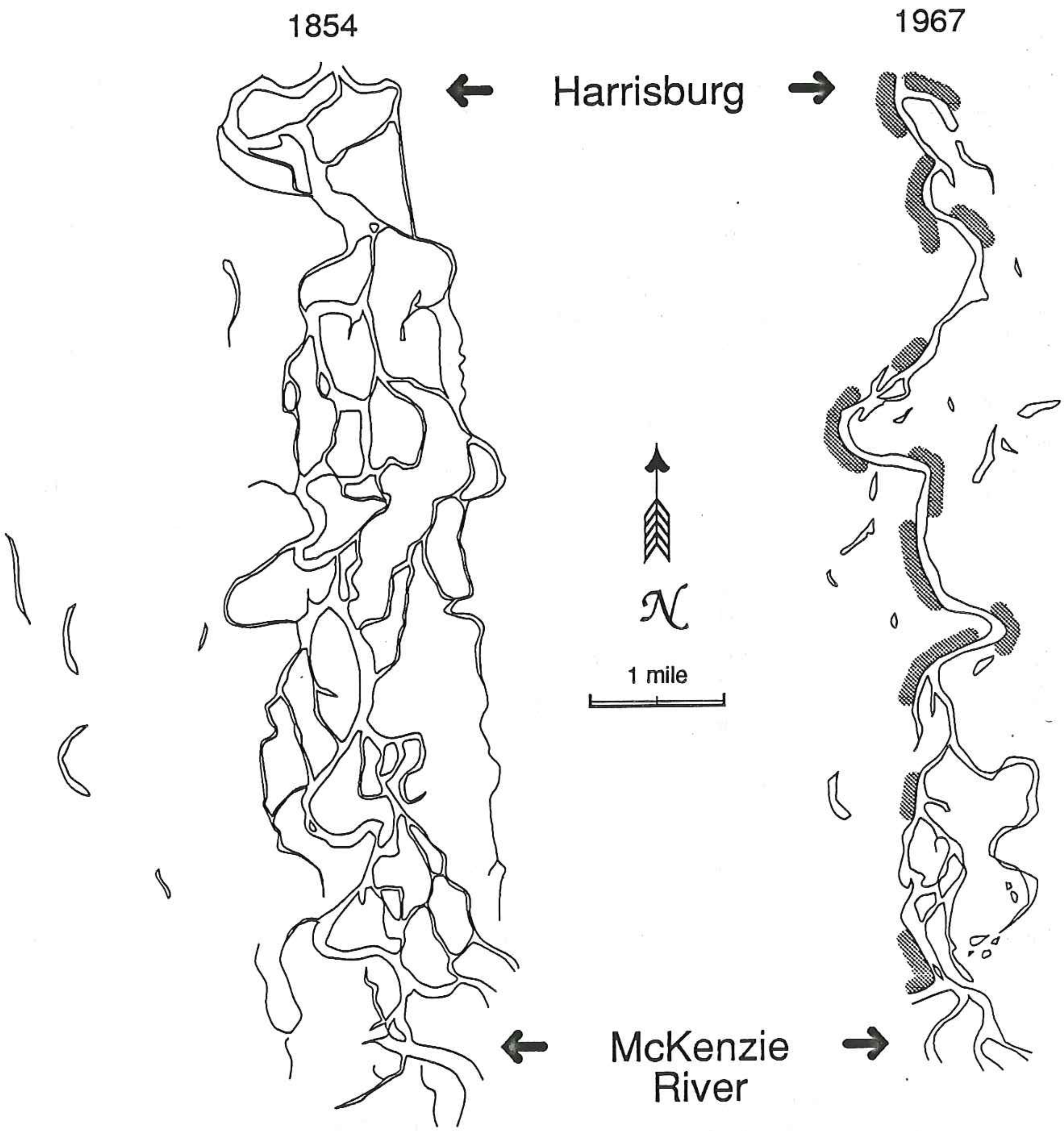


Figure 1. Outlines of the Willamette River between the mouth of the McKenzie River and Harrsiburg, Oregon in 1854 and 1967. (The shaded sections on the 1967 map are revetments). (Bottom et al. 1985 as adapted from Sedell and Froggatt 1984 and Hjort et al. 1983).

Table 5. Dredging projects in the lower Willamette River (RM 0.0-25.0) and permitted cubic yards of gravel removal (actual amounts may be less) (Division of State Lands, data base report 1989).

State Permit Number	Removal Amount	Permittee	River Mile
RP 4	60,000	Fisher Land Co.	1.0
RP 26	900,000	Ross Island Sand & Gravel	15.0
RP 107	350,000	Lone Star Northwest	17.2-20.0
RP 111	200,000	Lone Star Northwest	14.0-16.5
RP 113	200,000	Lone Star Northwest	20.3-25.0
RP 1055	20,000	Schnitzer Investment Corp.	3.6
RP 1076	20,000	Oregon Yacht Club	16.0
RP 2080	5,000	Port of Portland	1.0-11.0
RP 2175	3,000	Portland Rowing Club	16.8
RP 2500	10,000	GATX Tank Storage Term. Corp.	4.0
RP 3074	4,000	Lone Star Northwest	13.5-14.0
RP 3081	5,000	Linnton Plywood Assoc.	4.9
RP 3158	4,000	Bunge Corp.	11.4
RP 3294	10,000	Schnitzer Steel Products Co.	4.1
RP 3505	1,500,000	Port of Portland	7.0-11.5
RP 3688	5,000	Riedel International	7.5
RP 3701	10,000	Schnitzer Steel Products Co.	3.6-4.0
RP 4080	500	Penwalt Corp.	7.3
RP 4105	8,000	Chevron U.S.A., Inc.	7.8
RP 4327	35,000	Aqua-Marine Construction, Inc.	8.1
RP 4427	500	NW Natural Gas Co.	6.4
RP 4457	14,000	McCall Oil	7.8
RP 4529	10,000	Oregon City Boom	25.0
RP 4531	15,000	James River II, Inc.	9.6
RP 4612	500	L & S Marine, Inc.	5.9
RP 4631	100,000	Ross Island Sand & Gravel	14.0-15.0
RP 4667	50	Station L Rowing Club	14.9
RP 4710	6,000	Lone Star Northwest	11.3
RP 4868	3,500	Lakeside Industries	8.5
RP 4896	8,000	Georgia Pacific Corp.	3.7
RP 4995	9,000	REH, Inc. Riverside Ind. Park	6.0
RP 5041	600	Louis Dreyfus Corp.	12.0

Residential and Commercial Development

Oregon's largest cities occur along the Willamette River (Table 6). Beyond the metropolitan and smaller urban areas, little residential development exists as most land is state owned or zoned as agricultural land (Oregon State Parks and Recreation Branch, Department of Transportation 1976; Water Resources Department 1978, 1980).

Table 6. Incorporated towns and cities along the main stem Willamette River above RM 32.5.

Town	County	Population[a]	Location[b]
Albany	Linn	29,462	RM 118
Corvallis	Benton	44,757	RM 132
Dundee	Yamhill	1,663	RM 52
Eugene	Lane	112,669	RM 182
Harrisburg	Linn	1,939	RM 161
Independence	Polk	4,425	RM 95
Newberg	Yamhill	13,086	RM 50
Salem	Marion	107,786	RM 84
Springfield	Lane	44,683	RM 185
Wilsonville	Yamhill	7,106	RM 39
Oregon City	Clackamas	14,505	RM 27
Portland	Washington	379,000	RM 3-19

[a] April 1, 1990 census, Center for Population Research and Census, School of Urban and Public Affairs, Portland State University, OR.

[b] RM = river mile

Urban and industrial effluent discharged into the Willamette River was once so great that the pollution in the Willamette was described as a "state shame" (Gleeson 1972). Urban areas and pulp and paper mills used to dump sewage directly into the Willamette without treatment of any kind. Public acknowledgment of the problem began in Portland in the mid-1920s. By the late 1950s most major cities on the Willamette were instructed to install secondary waste treatment facilities. By 1960 all municipalities below Salem were instructed to do so (Gleeson 1972). Pulp and paper mills had primary waste treatment facilities installed by 1969 and secondary facilities by 1972 (Gleeson 1972). Since 1972 all industrial and municipal plants have facilities for secondary treatment of waste-water (Rickert et al. 1976). Following the vigorous campaign to clean up point sources of pollution, the Willamette River attained the status of being the largest river in the United States that had secondary waste-water treatment for all known municipal and industrial sources (Rickert et al. 1976).

Water quality problems, however, are a continuing concern and can be locally devastating to aquatic life in the Willamette River. In developed areas, storm water runoff carrying pollutants from surrounding roads, parking lots, and roof tops deteriorates water quality. Trace metals can be highly concentrated in industrial sloughs, such as at Fourth Lake near Albany (Rickert et al. 1977a). Levels of nitrogen and phosphorous in the Willamette often exceed the generally accepted threshold levels (Rickert et al. 1977b). Water rights for 381 cfs have been allocated for municipal uses along the main stem Willamette between RM 32.5 and 145.5.

Dams and Hydropower Projects

Flows and water quality of the main stem Willamette River are highly influenced by 13 USACE dams, all of which are located on tributary streams. Operation of these projects provide flood control, navigation and pollution abatement for the main stem Willamette. Operations have modified water flow and temperature, which has resulted in a mix of beneficial and detrimental effects on fish production. Change in flows has relieved passage problems at Willamette Falls and has helped to increase flows during the dry summer months. However, water released from dams is cooler in late spring and summer and warmer in the fall than before regulation by dams (Morse et al. 1987, 1988). The degree of influence is related to the distance that the dams are above the mouth of the corresponding tributary. In general, releases from Lookout Point Dam and its associated re-regulation dam, Dexter, have more of an effect on water temperatures than the other dams in the system (Hines et al. 1977). Periods of minimum and maximum temperatures coincide with high and low periods of flow, respectively. Water temperatures are often higher downstream than upstream, especially during the summer months, but daily fluctuations are lower downstream than upstream (Table 7). In the summer months, water temperature is directly correlated with discharge (USACE 1982). Discharge, in turn, is highly dependent on releases from the dams. The combined factors of discharge and water temperature determine the potential for dilution of pollutants downstream (Rickert et al. 1980).

Native species of anadromous salmonids are not adapted to present temperature regimes. Release of cool water in April and May can delay migration of juvenile anadromous salmonids and subject them to higher risks of bacterial infection due to the higher water temperatures encountered in the lower main stem (Buchanan 1977). Release of warm water in September through November subjects eggs of fall spawning species such as spring chinook to an increased risk of disease and mortality (E. Smith, ODFW, personal communication).

Table 7. Monthly mean[a] and mean diurnal fluctuation (MDF)[b] in water temperatures (°F) at three sites on the Willamette River (unpublished data, USGS 1988 and USACE 1982).

Month	Harrisburg (RM 161) Mean	Harrisburg (RM 161) MDF	Albany (RM 118) Mean	Albany (RM 118) MDF	Salem (RM 84) Mean	Salem (RM 84) MDF
Jan	42	1.7	43	0.9	42	0.7
Feb	44	1.5	44	1.1	44	0.6
Mar	47	1.9	48	1.4	48	0.8
Apr	50	2.4	51	2.0	51	1.2
May	53	3.5	56	2.4	55	1.6
Jun	58	3.8	60	2.8	63	2.0
Jul	63	4.1	66	3.2	67	2.1
Aug	62	3.3	65	2.8	67	2.0
Sep	54	2.6	60	2.4	61	1.3
Oct	57	1.7	57	1.6	57	0.8
Nov	49	1.4	48	1.2	46	0.7
Dec	43	1.4	43	1.0	43	0.7
Mean annual	68	2.4	72	1.9	74	1.3

[a] Unpublished data, USGS 1988.
[b] USACE 1982.

Reaches of the main stem Willamette River protected from further hydroelectric development by the Northwest Power Planning council are identified in Table 8.

Table 8. Reaches of the main stem Willamette River protected for anadromous fish under the Northwest Power Planning council's hydroelectric planning authority.

Water body	Reach (RM)
Willamette R.	0-187
Bonneville Channel (RM 134 of the Willamette River)	0-7

Diversions and Withdrawals

The naturally occurring low flows of summer are often aggravated by the withdrawal of water for crop irrigation and municipal uses. Currently, there are about 400,000 acres of irrigated farmland in the Willamette basin. Water rights for 923 cfs and 892 acre feet per year have been allocated for irrigation from the Willamette main stem alone (Table 9) (Oregon Water Resources Department 1988b). In an effort to minimize the effects of water withdrawal on aquatic life, the Oregon Water Resources Board has set minimum perennial streamflows (Table 3). ODFW's Habitat Conservation Division is currently developing a report on the status of screening needs in the state and setting state-wide priorities for screening. Screening needs in the Willamette River will be addressed according to their priority state-wide.

Table 9. Water rights for the upper, middle and lower Willamette River by use (Oregon Water Resources Department 1988).

Region	Agricultural	Municipal	Industrial	Recreational	Total
Upper (RM 145.5-187)					
cfs	235	0	0	117	352
acre-ft/yr	0	0	0	0	0
Middle (RM 32.5-145.5)					
cfs	688	381	<1	<1	1070
acre-ft/yr	892	0	0	0	892
Lower					
cfs	73	7	0	0	80
acre-ft/yr	74	0	0	0	74
Total					
cfs	996	388	<1	117	1502
acre-ft/yr	966	0	0	0	966

Policies

Policy 1. The Department shall actively pursue and promote habitat protection and improvement necessary to achieve the objectives for management of the subbasins' fish resources.

Policy 2. The Department shall coordinate with and advise agencies that manage the land and water resources of Willamette subbasins.

Policy 3. Habitat protection shall be emphasized over habitat rehabilitation and enhancement.

Policy 4. Potential losses of fish production from habitat alteration shall be prevented or reduced to the extent possible.

Objectives

Objective 1. Maintain or improve upstream and downstream passage for fish at dams, water diversions, other obstacles, and existing passage facilities.

Assumptions and Rationale

1. Adequate fish passage is necessary to maintain healthy runs of anadromous stocks.

Actions

1.1 Ensure that existing diversions are properly screened and maintained and that adequate passage is provided at obstructions.

1.2 Negotiate with the USACE to regulate flow by releasing water from dams on tributaries to improve passage of adult salmonids in the main stem Willamette River.

1.3 Operate the Sullivan Plant (Portland General Electric) and fish protection facilities according to the interim criteria developed by ODFW, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Portland General Electric until those criteria are redefined through Action 1.4.

1.4 Conduct a study that will 1) adequately estimate the number of juvenile salmonids killed and injured as a result of operation of the Sullivan Plant, 2) evaluate the efficiency of the bypass system and associated injury and mortality of juveniles, and 3) refine operating criteria for the Sullivan Plant that will reduce loss of downstream migrants.

1.5 Construct (Portland General Electric) facilities for sampling fish passing through the bypass system.

1.6 Finalize protection standards for operation of the Sullivan Plant.

1.7 In coordination with other fishery agencies, determine 1) unavoidable losses and required compensation (such as increases in wild and hatchery production to replace losses), and 2) avoidable losses and required mitigation (such as reduction in losses through change in power plant operation and passage facility improvements).

1.8 Negotiate through Portland General Electric to obtain compensation and mitigation.

1.9 Evaluate the measures undertaken to ensure that the compensation and mitigation levels agreed upon are being met.

1.10 Assign an Oregon Department of Fish and Wildlife employee responsibility for overseeing the development and implementation of compensation and mitigation measures and coordination with other fishery agencies and Portland General Electric.

1.11 Develop plans, justifications, and cost estimates for passage improvements and construction of an adult trapping facility to determine passage efficiency; submit a proposal to appropriate funding agencies.

1.12 Negotiate with the Corps of Engineers to regulate flow by releasing water from dams on tributaries to improve passage of adult salmonids in the main stem Willamette River, especially at Willamette Falls.

1.13 Work with Portland General Electric to identify and correct stranding problems at the base of Willamette Falls.

1.14 Assign an ODFW employee with the necessary authority and access to agency resources the responsibility for identifying upstream passage problems and facility deficiencies and for developing and implementing measures to improve passage.

Objective 2. Reduce delay, stranding, injury, and mortality of adult salmon and steelhead at Willamette Falls.

Assumptions and Rationale

1. Adult salmon and steelhead can be delayed, injured or killed during passage at Willamette Falls.

Actions

2.1 Assign an ODFW employee with the necessary authority and access to agency resources the responsibility for identifying upstream passage problems and facility deficiencies and for developing and implementing measures to improve passage.

2.2 Develop plans, justifications and cost estimates for passage improvements and construction of an adult trapping facility to determine passage efficiency; submit a proposal to appropriate funding agencies.

2.3 Negotiate with the Corps of Engineers to regulate flow by releasing water from dams on tributaries to improve passage of adult salmonids in the main stem Willamette River, especially at Willamette Falls.

2.4 Work with Portland General Electric to identifyand correct stranding problems at the base of Willamette Falls.

Objective 3. Protect necessary in-stream flows for fish production.

Assumptions and Rationale

1. In-stream flow may be insufficient at times for optimum fish production.

2. Establishment of in-stream water rights will result in maintaining or increasing fish production where flows are available to satisfy those rights.

3. In-stream water rights can be established through existing legislation.

4. Improvements in stream flow will require the support and coordination of the regulatory agencies and water users.

Actions

3.1 Establish optimum flows needed for fish passage and production in the main stem Willamette.

3.2 Apply for in-stream water rights for additional main stem reaches above Willamette Falls.

3.3 Re-apply for in-stream water rights for existing rights that are inadequate.

3.4 Recommend that the Water Resources Department monitor large water withdrawals such as Alton-Baker canoe way and the Eugene mill race.

Objective 4. Maintain high water quality.

Assumptions and Rationale

1. High quality water is essential for fish production.

2. Fish production in the main stem Willamette has declined because of poor water quality.

Actions

4.1 Encourage the Department of Environmental Quality to increase monitoring of sewage and industrial effluents entering the main stem.

Objective 5. **Protect riparian and in-stream habitat from degradation associated with agricultural, residential and commercial development, and other human activities.**

Assumptions and Rationale

1. Much of the main stem Willamette River has been extensively altered by development.

2. Presently, the Forest Practices Act and city and county plans do not provide adequate protection for riparian and in-stream habitat within the Willamette Greenway.

Actions

5.1 Continue to recommend to the Division of State Lands and the USACE that inwater aggregate mining be limited to areas below RM 57.

5.2 Recommend to the Department of Geology and Mineral Industries that future applications for aggregate mining in the Willamette Greenway be denied.

5.3 Recommend that the Division of State Lands strictly enforce timing guidelines for inwater work.

5.4 Develop and recommend riparian protection criteria to improve protection of the Willamette River floodplain (need input from HCD).

5.5 Urge counties to discourage agricultural expansion into the Willamette Greenway.

5.6 Urge other agencies to prevent further alteration of side channels, sloughs, and other aquatic habitat areas along the main stem margins and floodplain from channelization, filling, and other development.

5.7 Continue to urge the USACE to provide vegetative buffers along revetments.

5.8 Encourage participation of the state in the federal program which calls for no net reduction of wetlands, Executive Order 11990 on Wetlands Protection.

5.9 Encourage landowners to participate in the tax incentive program to protect riparian areas and vegetation along the Willamette River.

5.10 Consider acquisition of land along the Willamette corridor where appropriate for habitat protection and enhancement through the BPA program.

Objective 6. Develop subbasin specific knowledge that integrates fish distribution and abundance information, habitat characteristics and potential for improvement, and sensitive watershed areas into the Department's Habitat Database system.

Assumptions and Rationale

1. Better understanding of factors that affect fish distribution and abundance will lead to more effective habitat protection.

2. Computerized information will readily allow access by anyone in ODFW for habitat protection issues.

Actions

6.1 Inventory stream and watershed characteristics that affect fish production.

6.2 Promote increased interagency sharing of inventory information.

6.3 Ensure that all survey information is entered into the Habitat Database system.

Objective 7. Minimize any impacts of Portland Harbor Development on fish passage and fish rearing.

Assumptions and Rationale

1. Much of Portland Harbor fish habitat has been altered by development.

2. Continued loss of habitat could reduce resident fish populations and affect migratory species.

Actions

7.1 Continue to evaluate effects of harbor structures on juvenile and adult passage.

7.2 Use existing data on fish habitat requirements and impacts to evaluate fill and removal proposals for Portland Harbor.

WINTER STEELHEAD

Background and Status

Origin

The native Willamette winter steelhead is a "late run" or late-returning stock. The early-run Big Creek stock was introduced into the Willamette system to provide an earlier fishery.

Life History and Population Characteristics

Distribution

Winter steelhead migrate through the main stem Willamette River to reach spawning and rearing grounds in Willamette River tributaries. As recently as 1969, winter steelhead spawned and reared in the Willamette main stem above RM 100 (Fulton 1970). Good spawning areas were believed to be scattered throughout this upper reach. Presently, spawning and rearing in the main stem is believed to be minimal or non-existent.

Run Timing

Tagging studies indicate that the native Willamette stock enter the Columbia primarily in March and April and move rapidly upstream (Korn 1961).

All steelhead passing Willamette Falls from November through February are considered winter run. Winter steelhead passing the falls prior to February 15 are considered to be primarily Big Creek stock. Winter steelhead passing after that date are classified as Willamette stock. During March through May separation of winter and summer runs is based upon coloration and fin marks.

Run Size

Total run size of winter steelhead entering the Willamette main stem above RM 32.5 can be estimated from counts made at Willamette Falls. Since 1971 the early run of winter steelhead above Willamette Falls, which is composed of both hatchery and naturally produced fish, has fluctuated between 1,878 and 8,599 fish (Table 10). The late run, which is thought to be 85 percent naturally produced and 15 percent hatchery produced, ranged between 3,034 and 18,495 fish. The total average run size during 1971-90 was about 15,900 fish.

Table 10. Number of winter steelhead migrating past Willamette Falls, 1971-90 (Foster 1990 and unpublished data, ODFW 1991).

Year	Early stock[a]	Late stock[b]	Total
1971	8,152	18,495	26,647
1972	6,572	16,685	23,257
1973	6,389	11,511	17,900
1974	5,733	9,091	14,824
1975	3,096	3,034	6,130
1976	4,204	5,194	9,398
1977	5,327	8,277	13,604
1978	8,599	8,270	16,869
1979	2,861	5,865	8,726
1980	6,258	16,097	22,356
1981	7,662	9,004	16,666
1982	6,117	6,894	13,011
1983	4,596	4,702	9,298
1984	6,664	10,720	17,384
1985	4,549	16,043	20,592
1986	8,475	12,776	21,251
1987	8,543	7,630	16,765
1988	8,371	15,007	23,378
1989	4,211	5,361	9,572
1990	1,878	9,229	11,107

[a] November 1 through February 15. These are mainly introduced Big Creek stock.

[b] February 16 through May 15. These are mainly indigenous Willamette stock.

Juvenile Life History

Big Creek hatchery smolts released in Willamette tributaries migrate over Willamette Falls from late April to late May (Buchanan and Wade 1982). Smolt migration of Willamette winter steelhead past Willamette Falls begins in early April and extends through early June (Howell et al. 1985).

Weekly mean lengths of naturally produced smolts sampled at Willamette Falls (1976-1978) ranged from 170 mm to 220 mm. Larger smolts migrated significantly earlier than the smaller smolts (Buchanan et al. 1979).

Hatchery Production

No hatcheries produce winter steelhead on the main stem Willamette River. No hatchery releases of winter steelhead occur in the main stem Willamette.

Angling and Harvest

Harvest in the upper main stem occurs between Salem and Independence (RM 85 to RM 95). The average annual sport catch of winter steelhead in the main stem Willamette from 1976 through 1988 was 216 fish above Willamette Falls (Table 11).

Table 11. Sport catch of winter steelhead by run year in the main stem Willamette River above Willamette Falls, 1976-88 (ODFW 1990).

Run year	Catch
1976	10
1977	111
1978	125
1979	299
1980	264
1981	110
1982	119
1983	165
1984	248
1985	279
1986	361
1987	561
1988	157

Based on estimated passage timing of Willamette and Big Creek stocks at Willamette Falls in the 1978-1979 run years, approximately 7 percent of the catch in the Willamette River above Willamette Falls was Big Creek stock, 93 percent Willamette stock (ODFW 1989 and unpublished catch data, ODFW 1989).

Harvest of winter steelhead in the Willamette main stem is subject to general Oregon Department of Fish and Wildlife angling regulations for steelhead.

Management Considerations

Little, if any, winter steelhead production occurs in the main stem Willamette River, but fish migrate through the main stem to reach spawning and rearing grounds in Willamette River tributaries.

Run size estimated at Willamette Falls has averaged about 15,900 fish from 1971 through 1990. Annual run size during recent years has decreased, relative to earlier years.

Policies

Policy 1. Escapement of late-run winter steelhead to tributary subbasins has priority over harvest in the main stem Willamette River.

Objectives

Objective 1. Increase the average annual run size to about 33,000 winter steelhead into the Willamette River.

Assumptions and Rationale

1. This represents the cumulative run size objectives for native wild and hatchery stocks in the tributary subbasin plans.

Actions

1.1 Implement actions in the tributary subbasin plans to increase run sizes.

Objective 2. Increase the average annual run of indigenous late-run (15 February-15 May) winter steelhead above Willamette Falls to about 17,000 fish, which includes a spawning escapement of 14,400 fish for natural production.

Assumptions and Rationale

1. This represents the cumulative objectives for late-run steelhead in the plans for tributary subbasins above Willamette Falls.

Actions

2.1 Verify spawning escapement objectives for native Willamette stocks.

2.2 Improve methods to monitor spawning escapement.

2.3 If the escapement objectives are not met, develop methods to selectively harvest hatchery fish (such as fin-marking hatchery fish for identification) for change hatchery release locations.

2.4 Investigate the life history characteristics and determine the habitat requirements of adults and juveniles.

Objective 3. Provide a potential average annual sport catch of 1,000 winter steelhead in the lower main stem Willamette.

Assumptions and Rationale

1. The average annual sport catch of winter steelhead in the main stem Willamette below Willamette Falls was 1,026 from 1975 through 1986. Current harvest levels seem to satisfy angler demand.

Actions

3.1 Continue to monitor the harvest of winter steelhead in the subbasin through punchcard returns.

3.2 Habitat quality and passage conditions will be maintained or improved.

Objective 4. Increase the average annual sport catch of winter steelhead above Willamette Falls to 500 fish.

Assumptions and Rationale

1. An average annual run of 6,000 early-run winter steelhead will be maintained above Willamette Falls. The combined run size goal for early-run winter steelhead in tributary subbasins above Willamette Falls is 6,175 fish. The average annual run of early-returning winter steelhead over Willamette Falls during 1981-90 was about 6,100 fish.

2. The average annual run size for late-run winter steelhead above Willamette Falls will be increased to 14,500 fish. This figure represents the combined run size goal for late-run winter steelhead in tributary subbasins above Willamette falls. The average annual run of late-run winter steelhead over Willamette Falls during 1981-90 was about 9,700 fish.

3. The average annual sport catch of winter steelhead above Willamette Falls during 1984-88 was 320 fish.

4. Restrictions on harvest may be triggered by substantial declines in the late-run component as measured at Willamette Falls.

5. Emphasizing angling opportunities for winter steelhead on the main stem Willamette River will more widely distribute the harvest in the Willamette basin above Willamette Falls.

6. This objective will provide increased angling opportunity and diversity on the main stem Willamette River.

7. The harvest objective will be achieved by angler catch of migrating fish resulting from natural production and hatchery releases in Willamette tributaries.

8. It is assumed that increased information for anglers will lead to increased angler efficiency.

Actions

4.1 Publicize counts at Willamette Falls to indicate prime times for angling opportunities.

4.2 Direct anglers to public access sites for winter steelhead angling on the main stem Willamette.

4.3 Continue to monitor the harvest of winter steelhead in the subbasin through punch card returns.

4.4 Design and conduct a creel to monitor the fishery.

SUMMER STEELHEAD

Background and Status

Origin

Summer steelhead are not native to the Willamette subbasin. They were introduced to several tributaries during the late 1960s including the Clackamas (1968), Santiam (North Santiam, 1966; South Santiam, 1969), and the McKenzie (1968) subbasins. More recently, summer steelhead were introduced in the Middle Fork of the Willamette River (1981) and Molalla subbasin (1984). During some years, hatchery summer steelhead were released in the main stem Willamette River, but a consistent release program was not developed.

Natural production of summer steelhead is not considered desirable since the potential exists for negative interactions with native Willamette winter steelhead. Summer steelhead in the Willamette basin are managed for production and harvest of hatchery fish (OAR 635-500-211).

Life History and Population Characteristics

Distribution and Abundance

Little successful spawning by summer steelhead is suspected to occur in the main stem Willamette River. In general, the main stem Willamette is considered a corridor for the migration of hatchery smolts and adults resulting from tributary releases and is not considered an area with potential for natural production.

Run Size

The run size of summer steelhead entering the upper Willamette main stem can be estimated from counts made at Willamette Falls. The average annual run size during 1985-90 was about 25,600 fish (Table 12). Run size has generally increased in recent years.

Table 12. Run size of summer steelhead over Willamette Falls (Foster 1990 and ODFW, unpublished data).

Run year	Run size
1975	2,910
1976	3,876
1977	9,244
1978	15,172
1979	7,638
1980	11,222
1981	15,224
1982	12,571
1983	5,301
1984	25,002
1985	22,223
1986	40,719
1987	23,742
1988	36,940
1989	6,841
1990	23,428

Hatchery Production

No hatcheries are located in the subbasin. Skamania stock summer steelhead have been released in the main stem Willamette, but infrequently and in low numbers. Smolts have not been released since 1975, while fingerlings were released in 1977, 1980, and 1984 (Table 13). Currently, no releases of hatchery summer steelhead are made in the main stem Willamette.

Table 13. Releases of hatchery Skamania summer steelhead in the main stem Willamette River (ODFW, unpublished data).

Brood year	Release date	Hatchery	Number released	Size released
1975	1/78	Leaburg	11,718	smolt
1977	1/78	Roaring River	24,668	fingerling
1980	12/80	Roaring River	40,230	fingerling
1984	12/84	McKenzie	11,172	fingerling

Harvest

During 1977 through 1988, anglers were estimated to have harvested an annual average of 136 adult summer steelhead above Willamette Falls (Table 14). Catch has generally been higher during recent years, averaging 250 fish during 1984-88, which is probably the result of an expanded hatchery release program in Willamette tributary streams and strong run sizes.

Sport catch of summer steelhead in the main stem Willamette is subject to general ODFW angling regulations for steelhead and trout.

Table 14. Sport catch of summer steelhead in the main stem Willamette River above Willamette Falls as estimated from tag return data (ODFW 1990).

Run year	Harvest
1977	4
1978	38
1979	71
1980	72
1981	121
1982	47
1983	17
1984	216
1985	242
1986	299
1987	168
1988	331

Management Considerations

The main stem Willamette River primarily serves as a corridor for the downstream emigration of smolts bound for the Columbia River and the Pacific Ocean and for the upstream migration of adults bound for tributary subbasins of the Willamette system. Warm water (above 63 degrees Fahrenheit) in the main stem increases the incidence of bacterial (especially Aeromonas spp.) infection markedly (Buchanan 1975). Disease problems are aggravated by late smolt emigration resulting from delayed passage or small size at release (smaller than five fish per pound). Low water levels and high temperatures during the smolt emigration period in 1987 is suspected to have been the major reason for the reduced run size to the Willamette system in 1989.

Objectives

Objective 1. Increase the recreational catch of summer steelhead above Willamette Falls to an average annual minimum of 500 fish.

Assumptions and Rationale

1. The average annual run size for summer steelhead above Willamette Falls will be increased to 32,000 fish which represents the combined run size goal for summer steelhead in tributary subbasins above the Falls. The average annual run of summer steelhead above Willamette Falls during 1985-90 was about 25,600 fish.

2. The average annual sport catch of summer steelhead during 1984-88 was about 250 fish in the upper main stem.

3. Emphasizing angling opportunities for summer steelhead on the main stem Willamette River will more widely distribute the harvest in the Willamette basin above Willamette Falls.

4. This objective will provide increased angling opportunity and diversity on the main stem Willamette River.

5. The harvest objective will be achieved by angler catch of migrating fish resulting from hatchery releases in Willamette tributaries.

6. It is assumed that increased information for anglers will lead to increased angler efficiency.

Actions

1.1 Publicize counts at Willamette Falls and availability of fish in the main stem Willamette to indicate prime times for angling opportunities.

1.2 Direct anglers to public access sites for summer steelhead angling on the main stem Willamette.

1.3 Continue to monitor the harvest of summer steelhead in the subbasin through punch card returns.

1.4 Design and conduct a creel to monitor the fishery.

SPRING CHINOOK SALMON

Background and Status

Origin

Spring chinook are the only race of salmon native to the Willamette River system above Willamette Falls. Currently, most (about 75 percent of the 1970 brood) of the spring chinook are believed to be of hatchery origin (Bennett 1988).

Willamette River wild spring chinook are currently listed as a stock of concern due to declining populations, diminished habitat, and possible genetic impacts on wild fish from the large hatchery program. Spring chinook in the main stem Willamette River should be given a high priority with respect to future management funding and staffing.

Life History and Population Characteristics

Distribution

The main stem Willamette River is used by spring chinook throughout its length as a corridor for migrating adults and smolts. The main stem has little potential for spawning habitat, but may provide rearing habitat for juveniles. Rearing distribution is unknown.

Run Timing

Mattson (1963) reported that wild spring chinook entered the Willamette River in February, peaked during April, and completed the migration from the Columbia River in late May. Willamette spring chinook pass Willamette Falls in May and June (Howell et al. 1985).

Run Size

Run size of spring chinook into the upper main stem can be estimated by counts made at Willamette Falls (Table 15). The average annual run size during 1975-90 was about 42,000 fish. Run size has been generally increasing over the past 15 years.

Before the mid-1950s, most returning adults were progeny from naturally produced adults (Howell et al. 1985). The largest Willamette run on record was 156,033 adults in 1953. Runs averaged close to 52,000 adults (natural and hatchery produced) from 1946 through 1970 (Bennett 1988). Marking studies of the 1970 brood indicated that 25 percent of the 46,500 returnees were naturally produced (Bennett 1988). Since then, run size has appeared to be related to the number of hatchery smolts released in the Willamette system (Howell 1986).

Table 15. Estimated adult run size, including jacks, of naturally produced and hatchery Willamette spring chinook over Willamette Falls, 1971-90 (Foster 1990, ODFW unpublished data).

Run year	Run size
1975	19,079
1976	22,154
1977	40,012
1978	47,512
1979	26,623
1980	26,973
1981	30,057
1982	46,195
1983	30,589
1984	43,452
1985	34,533
1986	39,155
1987	54,832
1988	70,451
1989	69,180
1990	71,273
Average (1975-90)	42,004

Location of Spawning

A report on spawning surveys conducted in the late 1940s (Mattson 1948) did not report Willamette spring chinook spawning in the main stem Willamette. It is possible, however, that spring chinook spawn in the main stem Willamette above the mouth of the McKenzie River (RM 172).

Juvenile Life History

Mattson (1962) reported three distinct periods for migration of juvenile spring chinook, 1) a late winter-spring movement, 2) a late fall-early winter movement, and 3) a second spring movement. Lengths of migrants varied from 1.3 inches to 5.5 inches.

Hatchery Production

Description of Hatcheries

No hatcheries are located on the main stem Willamette.

Supplementation History

Numbers of hatchery spring chinook released into the main stem Willamette above Willamette Falls during 1977 and 1982-87 are shown in Table 16.

Hatchery smolts are released in both fall and spring. Size at release has varied from four to 20 fish per pound since 1975. In recent years, the hatchery program has called for release of fish at eight per pound in fall and nine per pound in spring. Size and time of release are being evaluated to determine the best release strategy. Smolts released at a smaller size tend to produce fish that return as older and larger adults.

Table 16. Releases of hatchery Willamette spring chinook in the main stem Willamette River above Willamette Falls (unpublished data, ODFW).

Brood year	Release date	Hatchery	Number released	Size released	Brood collect. site
1975	3/77	Sandy	15,740	Smolts	--
1981	11/82	McKenzie	279,114	Smolts	Dexter
1982	3/83	Willamette	501,146	Fry	Dexter
	3/84	McKenzie	325,267	Smolts	Dexter
1984	7/85	Willamette	172,739	Fingerling	Dexter
1985	6/86	Willamette	426,893	Fingerling	Dexter
	9, 10/86	Willamette	60,658	Smolts	Dexter
	4/87	Willamette	19,569	Smolts	Dexter

Angling and Harvest

Annual sport catch above Willamette Falls averaged 519 adults during 1978-89 (Table 17).

Fisheries in the Columbia River and Willamette River below Willamette Falls are managed to meet escapement objectives for above Willamette Falls. Escapement objectives have ranged from 30,000 to 45,000 fish depending on the predicted run size entering the Columbia River (ODFW 1988).

Table 17. Sport catch of spring chinook salmon in the main stem Willamette River (ODFW 1990).

Year	Sport harvest
1978	671
1979	237
1980	484
1981	428
1982	508
1983	370
1984	532
1985	224
1986	289
1987	524
1988	952
1989	1,012
Average (1978-89)	519

Management Considerations

Willamette River wild spring chinook are currently listed as a stock of concern due to declining populations, diminished habitat, and possible genetic impacts on wild fish from the large hatchery program.

The extent and distribution of natural spawning and rearing in the main stem Willamette River is unknown. Spring chinook did not historically use the main stem for spawning. It is possible that release of warm water below dams during egg incubation currently limits natural production, but other factors may also be responsible. Production potential may have been lost due to gravel mining. The area above the mouth of the McKenzie River probably holds the most potential for natural production. The potential for increasing natural production in the main stem Willamette is unknown.

The main stem Willamette is the corridor for the annual emigration of over 5 million hatchery smolts and an unknown number of naturally produced smolts in the Willamette system. Many juvenile spring chinook spawned in tributaries rear in the main stem Willamette for up to one year.

Angler catch in the main stem Willamette above Willamette Falls has averaged about 1 percent of the adults passing Willamette Falls. Among the factors that limit angler success in the Willamette River above Willamette Falls are 1) the decline in willingness of Willamette spring chinook to take bait or lures as residence time in fresh water increases, 2) peak timing for passage above Willamette Falls appears to be genetically dictated to occur relatively late, 3) residence time in the main stem Willamette River may be of short duration, and 4) knowledge of most efficient angling techniques and locations and timing for best angling success is lacking. Angler effort and catch above Willamette Falls may be expected to increase if run sizes remain strong and anglers discover more efficient means of catching the fish.

Objectives

Objective 1. Maintain an average annual run size of 100,000 Willamette spring chinook (adults and jacks) entering the Columbia River.

Assumptions and Rationale

1. Runs in excess of 100,000 fish occurred historically, when production was primarily from natural production. for example, the run in 1953 was estimated to be about 125,000 fish.

2. Runs have averaged more than 100,000 fish since 1987.

Actions

1.1 Increase the survival of fish produced in hatcheries.

a) Develop an improved program of disease prevention.

b) Continue the monitoring programs for viruses and bacterial kidney disease at hatcheries.

c) Investigate potential associations among anemias, blood viruses, and fungal and bacterial pathogens.

d) Refine programs of antibiotic treatments.

e) Where possible, shift hatchery production from disease-prone to disease-free stations.

f) Monitor survival rates by tagging representative groups of smolts at all hatcheries.

g) Modify or eliminate hatchery programs with average survival rates (return to freshwater) less than 1 percent.

h) Where practical, increase production at facilities that demonstrate high survival rates.

1.2 Refine and implement criteria for the timing, size, and location of hatchery releases.

a) Determine the most effective month for smolt releases.

b) Until Action 1.2 a) is completed, target smolt production for one-third or less of the release in the fall at eight smolts per pound and two-thirds or more of the release in March at 12 smolts per pound. This action will maintain return levels and increase the proportion of older adults, which is more consistent with historical age composition and will increase the average size at return.

c) Monitor survival of smolts produced at Marion Forks Hatchery that are released outside of the North Santiam system.

1.3 Refine run-size estimation procedures; incorporate pounds of smolts released as a basis for estimation.

Objective 2. Provide optimal conditions for natural production and migration of spring chinook salmon in the main stem Willamette.

Assumptions and Rationale

1. Wild Willamette spring chinook have been identified as a stock of concern. This objective addresses some of the problems with the stock.

2. The main stem Willamette provides habitat for rearing of juvenile spring chinook.

3. It is possible that spring chinook spawn in the main stem Willamette above the mouth of the McKenzie River.

Actions

2.1 Implement habitat protection actions outlined under objectives for Habitat Protection.

2.2 Determine rearing areas for juvenile spring chinook in the main stem Willamette River.

2.3 Determine extent of spawning in the main stem above the mouth of the McKenzie River.

2.4 Determine status of the wild population in the main stem Willamette River via marketing and/or other studies.

Objective 3. Return an annual average run of 3,600 spring chinook salmon to the lower Willamette as a result of main stem releases of smolts.

Assumptions and Rationale

1. The run size is based on a 0.018 smolt-to-adult survival rate given annual releases of 200,000 smolts to the main stem below Willamette Falls.

2. Spring chinook smolts released below Willamette Falls contribute to angler catch at higher rates than smolts released in tributaries above Willamette Falls.

3. Smolts released below Willamette Falls had a higher smolt-to-returned-adult survival rate in the main stem than comparable releases in the South Santiam River.

Actions

3.1 Release 200,000 spring chinook smolts each year into the Willamette River below Willamette Falls.

Objective 4. Provide the following annual runs above Willamette Falls based on the predicted size of the runs entering the Columbia River:

Preseason Prediction of Run Size Entering the Columbia River	Run Size Guideline Above Willamette Falls
Less than 70,000	30,000
70-79,999	30,500-35,000
80-89,999	35,500-40,000
90,000-100,000	40,500-45,000
Greater than 100,000	45,000

Assumptions and Rationale

1. This objective is based on cumulative run size objectives for subbasins above Willamette Falls

Actions

4.1 Determine if adults counted in the Willamette Falls ladder drop back below the falls and re-ascend the ladder, thus inflating the passage counts.

4.2 Reduce excess returns to adult collection facilities.

a) Where possible, delay opening adult collection facilities so that more fish can be harvested by anglers.

b) Transport excess adults to spawning areas where escapement is inadequate.

c) Determine the utility of transporting early returning adults downstream for recycling through sport fisheries.

d) Where alternative uses are not possible, kill and sell excess adults and use proceeds to improve hatchery programs.

e) Investigate regulation changes for areas above Willamette Falls that could increase upriver harvest of hatchery fish (such as limits, season length, gear types, legal areas).

f) Release smolts in locations that will concentrate adult returns in areas with heavy angler use or that are conducive to increased angling pressure.

g) Publicize counts at Willamette Falls to indicate prime times for angling opportunities.

Objective 5. Apportion the harvest in the sport and commercial fisheries in lower Willamette and Columbia rivers according to the following guidelines:

1. **The commercial share shall be 24% when expected runs are similar to 1981-86 (50,000-90,000).**

2. **The commercial share may increase to 30% when expected runs are greater than 90,000 fish.**

3. **At run sizes less than 50,000 fish, the Columbia River Compact shall determine the allocation in a public hearing.**

Assumptions and Rationale

1. The allowable catch in the lower Willamette and Columbia river fisheries equals the run entering the Columbia minus the escapement goal for the Clackamas River and the target run size above Willamette Falls.

2. Sport catch represents the proportion of the harvest taken by sport anglers in the lower Columbia, lower Willamette, and the Clackamas rivers.

3. Commercial catch represents the proportion of the harvest taken during the winter gill-net season.

4. Since 1991 the Columbia River Compact has allocated 24% of the harvest to the commercial fishery to crop the Willamette stock while limiting harvest of depressed upper Columbia River stocks of chinook salmon. During that period the annual run size averaged about 70,000 fish.

Actions

5.1 Continue to monitor the catch in the fisheries as close as possible.

Objective 6. Increase the recreational catch of spring chinook salmon above Willamette Falls to an average annual minimum of 1,500 fish.

Assumptions and Rationale

1. The average annual catch of spring chinook during 1978-89 was 519 fish in the upper main stem. Catch averaged about 975 fish in 1988 and 1989 when runs over Willamette Falls approximated 70,000 fish.

2. Recent strong run years have generated an increased awareness among anglers of the opportunities that exist to harvest spring chinook above Willamette Falls. This level of interest is expected to persist, and likely increase, as knowledge of the fishery develops.

3. Achieving the harvest objective will not have significant detrimental impact on escapement of native spring chinook into tributary subbasins of the Willamette River above Willamette Falls.

4. Emphasizing angling opportunities for spring chinook on the main stem Willamette River will more widely distribute the harvest in the Willamette basin above Willamette Falls.

5. This objective will provide angling opportunity and diversity on the main stem Willamette River.

6. The harvest objective will be achieved by angler catch of migrating adults resulting from smolt releases in tributary systems.

7. It is assumed that increased information for anglers will lead to increased angler efficiency.

Actions

6.1 Continue to monitor the harvest of spring chinook in the Willamette River through punch card returns.

6.2 Publicize counts at Willamette Falls to indicate prime times for angling opportunities.

6.3 Design and implement creel studies to
   1) monitor development of the sport fishery, and
   2) determine the percentage of wild fish harvested in the sport fishery.

FALL CHINOOK SALMON

Background and Status

Origin

Fall chinook were first introduced to the Willamette River above Willamette Falls in 1964 (Hansen 1978). The early spawning "tule" stock has been the only stock released into the river. The run is composed of both hatchery and naturally produced fish. It has been estimated that from 1981 to 1987, 28 percent of the adults returning to Willamette Falls were naturally produced (Smith et al. 1987).

Life History and Population Characteristics

Distribution

Fall chinook distribution in the Willamette River is dictated primarily by the location of smolt releases. The majority of adults occur above RM 132 (Corvallis).

Run Size and Timing

From 1981 through 1987, the Willamette main stem run has averaged about 3,100 fish (Table 17). Assuming an average natural production component of 28 percent, natural production accounted for an annual average of about 860 chinook.

Tule fall chinook pass Willamette Falls from mid-August through late September, with the peak of the run occurring from early to mid-September.

Age and Sex Ratio

Scales taken from chinook carcasses in the Willamette River revealed that virtually all of the chinook return as 3- and 4-year-olds (Hansen and Williams 1979) (Table 19). The sex ratio of fall chinook in the Willamette River was variable during the years sampled (1976-1978) (Table 19).

Spawning Time and Location

Spawning probably occurs shortly after entry, primarily mid-September through early October. Fall chinook spawn in the Willamette River from RM 50 (Newberg) to RM 187 (Springfield). Based on spawning surveys (1976-1988), about 60 percent of the fall chinook spawn between RM 132 (Corvallis) and RM 175 (Coburg) (Table 18).

Table 18. Fall chinook spawning redds by reach (river mile) and estimated run size in the Willamette River (Hansen 1977, 1978; Hansen and Williams 1979; Smith et al. 1982, 1983; Smith et al. 1985; ODFW unpublished data).

Reach	Run year												
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
50.0 - 71.9	10	1	14	51	170	18	86	11	--	--	8	45	34
71.9 - 84.0	55	23	136	92	218	40	120	30	--	--	36	35	30
84.0 - 96.1	12	4	24	6	11	15	16	9	--	--	1	5	5
96.1 - 119.3	36	10	99	40	43	49	147	51	--	--	45	44	30
119.3 - 132.1	5	12	14	4	2	7	53	6	--	--	0	40	--
132.1 - 147.4	58	81	237	24	10	102	132	43	--	--	7	11	--
147.4 - 161.2	139	199	468	68	10	101	250	76	--	--	42	103	--
161.2 - 174.8	117	160	38	124	10	260	249	192	--	--	45	270	--
174.8 - 187.0	42	15	14	5	1	30	15	15	--	--	5	123	--
Redd total	474	505	1,423	414	475	622	1,068	433	--	--	189	676	--
Fish/redd factor[a]	4.4	3.8	2.7	3.8	3.2	6.8	4.0	4.7	--	--	6.5	5.4	--
Run size[b]	2,090	1,929	3,771	1,569	1,506	4,236	4,261	2,018	--	--	1,223	3,644	--

[a] The fish/redd factor was calculated by dividing the number of fish passing Willamette falls by the total number of fall chinook redds counted above Willamette falls.

[b] Run size was calculated by multiplying the fish/redd factor by the redd total.

Table 19. Age structure and sex ratio of fall chinook in the Willamette River as determined from carcasses (Hansen and Williams 1979).

Year	Age				Sex	
	2	3	4	5	Male	Female
1976	1	34	15	3	42 (74%)	15 (26%)
1977	0	43	9	0	20 (38%)	33 (62%)
1978	0	2	7	0	5 (45%)	6 (55%)
Total	1 (1%)	79 (69%)	31 (27%)	3 (3%)		

Juvenile Life History

Fry begin to emerge from the gravel beginning in late December with peak emergence occurring in mid-January (Howell et al. 1985). Fall chinook juveniles emigrate from the Willamette River primarily in late April and May, at about five months of age, and generally less than 4 inches long (Hansen 1978).

Hatchery Production

Description of Hatcheries

No hatcheries are located on the Willamette River. Fall chinook smolts released into the Willamette River are reared at Aumsville and Stayton ponds (see the Santiam and Calapooia Subbasin Plan).

Hatchery Releases

Fall chinook were initially released to establish a naturally sustained run above Willamette Falls. Today, they are released to produce fish for ocean and Columbia River fisheries.

Smolts are released at Wheatland (RM 72), Peoria (RM 142), McCartney Park (RM 156), Harrisburg (RM 161), and Marshall Island (RM 168) (Table 20). About 1.2 million smolts have been released annually. Fall chinook smolts are released in late April and early May at a size of about 55 to 65 fish per pound.

Table 20. Releases of fall chinook smolts into the Willamette River (unpublished data, ODFW).

Brood year	Release year	Hatchery	Number released	Release site[a]
1978	1979	Stayton Pond	190,665	Harrisburg
1978	1979	Stayton Pond	826,893	Marshall Island
1979	1980	Stayton Pond	338,471	Peoria
1979	1980	Stayton Pond	285,434	McCartney Park
1979	1980	Stayton Pond	117,990	Harrisburg
1979	1980	Stayton Pond	1,069,288	Marshall Island
1980	1981	Stayton Pond	308,389	Peoria
1980	1981	Stayton Pond	250,561	McCartney Park
1980	1981	Stayton Pond	510,596	Marshall Island
1981	1982	Stayton Pond	234,040	Peoria
1981	1982	Stayton Pond	303,050	McCartney Park
1981	1982	Stayton Pond	134,301	Harrisburg
1981	1982	Stayton Pond	324,519	Marshall Island
1982	1983	Stayton Pond	258,708	Peoria
1982	1983	Stayton Pond	1,166,966	Marshall Island
1983	1984	Stayton Pond	231,072	Peoria
1983	1984	Stayton Pond	121,738	McCartney Park
1983	1984	Stayton Pond	326,715	Harrisburg
1983	1984	Stayton Pond	586,571	Marshall Island
1984	1985	Stayton Pond	828,558	Marshall Island
1985	1986	Stayton Pond	399,807	Wheatland
1985	1986	Stayton Pond	225,829	Peoria
1985	1986	Stayton Pond	377,606	Marshall Island
1986	1987	Stayton Pond	204,255	Wheatland
1986	1987	Stayton Pond	378,258	Peoria

(continued)

Table 20 continued.

Brood year	Release year	Hatchery	Number released	Release site[a]
1986	1987	Stayton Pond	60,893	McCartney Park
1986	1987	Stayton Pond	105,320	Harrisburg
1986	1987	Stayton Pond	598,103	Marshall Island
1987	1988	Stayton Pond	347,158	Wheatland
1987	1988	Stayton Pond	257,437	Peoria
1987	1988	Stayton Pond	211,603	McCartney Park
1987	1988	Stayton Pond	131,402	Harrisburg
1987	1988	Stayton Pond	371,181	Marshall Island
1988	1989	Stayton Pond	401,556	Wheatland
1988	1989	Stayton Pond	309,936	Peoria
1988	1989	Stayton Pond	182,975	McCartney Park
1988	1989	Stayton Pond	308,491	Harrisburg
1988	1989	Stayton Pond	119,920	Marshall Island

[a] Wheatland -- RM 72, Peoria -- RM 142, McCartney Park -- RM 156, Harrisburg -- RM 161, Marshall Island -- RM 168 (some fish may have been released above RM 168).

Angling and Harvest

Harvest of fall chinook from the Willamette River above Willamette Falls is low, averaging about 11 fish annually from 1977 through 1989 (Table 21).

Harvest of fall chinook must comply with ODFW angling regulations. Harvest is monitored through the return of salmon and steelhead tags.

Table 21. Harvest of tule stock fall chinook from the Willamette River above Willamette Falls (ODFW 1990).

Year	Sport harvest
1977	0
1978	0
1979	24
1980	3
1981	9
1982	20
1983	0
1984	32
1985	12
1986	14
1987	15
1988	8
1989	4

Management Considerations

Fall chinook are not native to the Willamette River above Willamette Falls. Competition between fall chinook and native species present in the main stem Willamette River is undesirable. Since 1979, about 1.2 million smolts have been released into the Willamette main stem annually.

The Willamette River accounts for about 20 percent of the total redds in the index area above Willamette Falls (1979-1987). Production from these spawners has never been confirmed. However, natural production has been estimated to account for about 30 percent of the fall chinook returning above Willamette Falls.

Tule stock fall chinook do not contribute significantly to Willamette River fisheries. Annual harvest averaged only 11 fish during 1977-89. The main contribution of Willamette fall chinook is to ocean and Columbia River fisheries.

Policies

Policy 1. Fall chinook salmon in the main stem Willamette River shall be managed for natural production of existing populations.

Objectives

Objective 1. Provide optimal conditions for natural production and migration of fall chinook salmon in the main stem Willamette.

Assumptions and Rationale

1. Fall chinook do not contribute significantly to fisheries in the main stem Willamette.

2. Re-allocating hatchery smolts to the Santiam subbasin may increase survival of smolts and decrease the costs associated with the Willamette basin fall chinook program.

3. Information on spawning distribution and abundance is necessary to assess the amount of natural production which may continue after termination of hatchery releases.

4. Fall chinook may compete with native spring chinook for rearing areas in the main stem Willamette and in Willamette tributary streams.

Actions

1.1 Implement habitat protection actions outlined under objectives for Habitat Protection.

1.2 Continue spawning surveys in the main stem Willamette to monitor natural production.

SHAD

Background and Status

Origin

The American shad is an anadromous species native to the Atlantic coast of North America. Shad were successfully introduced into the Willamette and Columbia rivers during the late 1800s.

Life History and Population Characteristics

Shad are relatively abundant in the Willamette River below Willamette Falls. They are found in fewer numbers above the falls.

Shad migrate into the lower Willamette River up to Willamette Falls from late May to early July, peaking in June (Bennett 1989). They are unable to pass upstream through the fishway at Willamette Falls, but a small migration occurs through the navigation locks to upstream spawning and rearing areas. One juvenile was recorded at RM 5 on the Yamhill River in 1978 (personal communication on 15 November 1990 from J. Haxton, ODFW, McMinnville, Oregon).

Hatchery Production

The first planting of shad in the Willamette River occurred in 1885 when 50,000 fry were released into the Willamette River at Portland. The following year 550,000 fry were stocked in the Willamette at Albany (RM 118). There have been no further releases of shad in the Willamette River.

There is no hatchery production of shad in the Willamette.

Angling and Harvest

Shad were commercially harvested in Multnomah Channel until 1967. Commercial catches in the channel peaked during the early 1950s at just over 50,000 pounds annually. Commercial catch then declined due to a depressed market until lack of participation resulted in closing the fishery in 1967.

An active sport fishery is concentrated between the mouth of the Clackamas River (RM 25) and Willamette Falls (RM 26.5). Catch estimates for this reach have been made since 1976. Expanded sampling have provided estimates of both bank and boat catch and effort since 1977. During 1977-88 boat anglers have taken an average of 14,222 shad annually and bank anglers an average of 887 shad for a total average annual harvest of 15,109 (Bennett 1989) (Table 22). Approximately 94% of the catch has been from boats and 6% from the shoreline.

A small amount of angling effort is expended in the lower Willamette River section in Multnomah Channel and in the upper Willamette River above the Falls, but effort and catch are not monitored.

Table 22. Estimated angler trips and catch of shad on the lower Willamette River (RM 25-26.5), 1976-88 (Bennett 1989).

Year	Angler trips	Catch
1976[a]	---	10,700
1977	4,795	8,156
1978	4,024	5,756
1979	7,240	15,096
1980	11,375	15,456
1981	9,526	20,360
1982	13,401	21,691
1983	13,446	36,828
1984	10,058	19,803
1985	10,454	16,158
1986	7,629	5,795
1987	7,569	4,937
1988	7,003	11,272[b]
1977-88 avg.	8,877	15,109

[a] Includes shad caught and released.

[b] Does not include 213 shad caught and kept by chinook and sturgeon anglers.

Management Considerations

A concerted effort has been made to stimulate sport angling by informing anglers of local fishing opportunities and success through the fishing reports distributed by ODFW. Publications and news releases have also promoted the sporting and eating qualities of shad.

Policies

Policy 1. Shad shall be managed for sport angling in the Willamette River.

Objectives

Objective 1. Increase public awareness of the sport angling opportunities for shad.

Assumptions and Rationale

1. Substantial runs of shad enter the Willamette and can be harvested below Willamette Falls.

2. Shad populations are underutilized by sport anglers and can withstand greater harvest.

3. Many people are not aware of the excellent sporting and eating qualities of shad.

Actions

1.1 Continue to publicize the angling opportunities for shad through ODFW fishing reports and news releases.

1.2 Improve bank angling opportunities where possible.

Objective 2. Monitor the catch and angling effort of the sport fishery.

Assumptions and Rationale

1. Sufficient data on the shad fishery is collected in conjunction with present sampling programs for other species.

Actions

2.1 Continue to collect data on the shad fishery in conjunction with sampling programs for spring chinook and winter steelhead on the lower Willamette River.

STURGEON

Background and Status

Origin

White sturgeon are native to the Willamette River below Willamette Falls. Sturgeon in the lower Willamette are part of the larger lower Columbia River stock. Sturgeon are not thought to be indigenous above Willamette Falls. Releases of sturgeon in the Willamette River above Willamette Falls have established small populations there.

Life History and Population Characteristics

Distribution

White sturgeon are found in the Willamette River primarily below Willamette Falls. Sturgeon are known to migrate between the Columbia River and the lower Willamette River. Sturgeon do not migrate over Willamette Falls but may pass through the navigation locks into reaches of the main stem above the falls.

Transplants of white sturgeon have established small populations above the falls. However it is thought that there is no significant natural reproduction of sturgeon in the Willamette above Willamette Falls.

It is thought that there is adequate natural reproduction to provide recruitment to stocks below Willamette Falls. Hatchery sturgeon released above Willamette Falls may be needed to supplement natural production in the upper Willamette, however fall-back of hatchery sturgeon into the lower Willamette can occur.

Size

Sturgeon caught in the Willamette River above Willamette Falls during 1959-65 ranged from about 24-86 inches in length and 55-100 pounds (Table 23).

Size and Age at Reproduction

Female white sturgeon do not spawn until they are 15-20 years of age and over 5 feet long (Anderson 1988). Males mature several years earlier at about 12 years of age and approximately 4 feet in length.

Table 23. Size of sturgeon caught from the Willamette River (unpublished data, ODFW).

Date	Site	Length (inches)	Weight (lbs.)
1959	Wheatland (RM 72)	undersized	
	Buena Vista (RM 107)	>20	---
	Harrisburg (RM 161)	---	100
1960	Corvallis (RM 132)	---	94
	"	60	---
	Mouth of Long Tom (RM 149)	72	100
	"	48-72	100
	Irish Bend (RM 154)	undersize	
1961	Mouth of Long Tom (RM 149)	---	108
	"	86	---
	Irish Bend (RM 154)	51	55
	"	72	100
1962	Wilsonville (RM 39)	71.5	110
1965	RM 64	24-30	---

Migratory Behavior

Hatchery sturgeon released above Willamette Falls may move down the Willamette River to the Columbia.

Releases of tagged sturgeon from Bonneville holding ponds were made in the Willamette River above Willamette Falls in 1950 and 1951 to examine migration tendencies and survival. In 1950, 511 sturgeon were transplanted above the falls. Recoveries of tagged sturgeon were monitored at Willamette Falls until mid-October of that year. Of 424 fish that were tagged, 170 were found dead in the head racks of the Crown Zellerbach paper plant. In July 1951, 319 sturgeon were released in the Willamette River above Willamette Falls. A total of 295 fish were tagged. During the following month, 35 dead sturgeon were recovered at the paper plant. Recovery of dead sturgeon may indicate downstream movement or it may be due to handling mortality.

Hatchery Production

Description of Hatcheries

Two private hatcheries on the Columbia River, one at Covert's Landing located four miles below Bonneville Dam and the other at Troutdale, are currently producing sturgeon. A stipulation of the agreement ODFW has with private hatcheries is that up to 5,000 fingerlings per female spawned shall be provided to ODFW if requested. ODFW requested fry in 1983 and 1987 from Covert's Landing. Attempts to rear them at Roaring River Hatchery and St. Louis Pond were not successful due to water temperature problems. Sturgeon released in the Willamette River above Willamette Falls during 1989 and 1990 were reared at private hatcheries and Roaring River and Bonneville hatcheries. Since 1988, a condition of the private hatchery permit has required 1,000 3-6 inch fingerlings be provided to the state for each spawned female.

Transplants and Hatchery Releases

Transplants of sturgeon have been made in the Willamette River above Willamette Falls as early as the 1920s. More recently, transplants were made in 1950 and 1951 (Table 24).

Table 24. Releases of white sturgeon in the Willamette River above Willamette Falls, 1950-89 (unpublished data, ODFW).

Year	No. released	Size	Release site
1950	67	---	RM 107
	171	---	RM 100
	273	---	Peoria (RM 141)
1951	122	12-54 inches	Peoria (RM 141)
	197	12-54 inches	Harrisburg (RM 160)
1989	1,813	98/lb	Wheatland (RM 72)
1989	1,961	124.5/lb	RM 35
	1,961	124.5/lb	Salem (RM 84)
	1,961	124.5/lb	Independence (RM 96)
	1,961	124.5/lb	Corvallis (RM 132)
	1,961	124.5/lb	Peoria (RM 141)
1990	270	108/lb	San Salvador (RM 57)

Apparently enough of the sturgeon released during 1950-51 survived to support a popular fishery in the Willamette River above Willamette Falls during the 1960s. It is likely that some reproduced.

About 11,600 hatchery sturgeon were released in the Willamette River above Willamette Falls in 1989 (Table 24). The 270 hatchery sturgeon released in 1990 were tetracycline marked for later recognition. It will take approximately 10 years for the 1989-90 hatchery releases to reach legal size (40 inches).

Angling and Harvest

Limited fisheries occur in the upper river particularly near Wilsonville (RM 38) and the mouth of the Long Tom River (RM 149). The annual average catch of sturgeon in the Willamette River above Willamette Falls during 1986-89 is estimated to be 28 fish (Table 25). Estimated harvest ranged from a low of 4 in 1989 to a high of 39 in 1988.

Table 25. Estimated catch of sturgeon in the Willamette River above Willamette Falls based on returned sturgeon catch records, 1986-89 (ODFW, Portland, Oregon).

Year	Catch
1986	37
1987	17
1988	39
1989	4

Sturgeon angling is increasing in popularity. This can be attributed to close proximity of the angling area to large population centers, high catchability, and an increased public appreciation of sturgeon as a game fish with fine eating qualities (Bennett 1989). Large sturgeon (over 72 inches) provide an exciting catch and release fishery and increased angling diversity in the Willamette.

The sturgeon fishery is open year round on the Willamette River. The daily catch limit is 2 sturgeon, and the weekly limit is 6. There is a minimum size limit of 40 inches and a maximum limit of 72 inches.

Management Considerations

White sturgeon in the Willamette River above Willamette Falls are currently listed as a stock of concern due to insufficient information regarding their status. Sturgeon should be given a high priority with respect to future population and habitat inventory and monitoring activities in the Willamette River above Willamette Falls.

Sturgeon are vulnerable to over-harvesting since they are long-lived and do not reproduce until they reach an advanced age. Above Willamette Falls, exploitation rates may be particularly high and recruitment low because the population is relatively isolated. Lower Columbia and lower Willamette sturgeon cannot readily migrate above Willamette Falls. The population above Willamette Falls may benefit from supplementation with hatchery fish.

Water quality in the Willamette River may constrain sturgeon production. Being long-lived, sturgeon above Willamette Falls may bio-accumulate relatively high concentrations of organic toxicants such as dioxin from paper mills and other sources of pollution.

Objectives

Objective 1. Evaluate the population of white sturgeon in the upper Willamette River.

Assumptions and Rationale

1. Historically, sturgeon have occupied the lower Willamette River. Transfers of lower Columbia sturgeon above Willamette Falls have established a small population.

2. Sturgeon above Willamette Falls are listed by ODFW as a stock of concern because of insufficient information regarding their status. Monitoring the distribution, abundance, and population structure of sturgeon will provide an indication of their status.

Actions

1.1 Begin biological sampling to determine distribution, age, growth, and relative abundance of sturgeon in the Willamette.

1.2 Identify and develop habitat protection and improvement needs.

1.3 Develop habitat protection and improvement plans.

1.4 Implement habitat protection actions outlined under objectives for Habitat Protection.

Objective 2. Determine the impact of harvest on the abundance and long-term persistence of the sturgeon populations above Willamette Falls.

Assumptions and Rationale

1. The isolated populations of sturgeon above Willamette Falls may be particularly vulnerable to harvest.

2. Several fisheries have developed above Willamette Falls, and little information regarding these fisheries is available.

3. Catch data from returns of sturgeon tags have been available since in 1986.

Actions

2.1 Continue to estimate sport catch and effort above Willamette Falls by conducting angler surveys and analyzing returns of sturgeon punch-cards.

Objective 3. **Provide additional angling opportunities for sturgeon above Willamette Falls through the periodic release of hatchery sturgeon.**

Assumptions and Rationale

1. Angler interest in sturgeon has been increasing.

2. Sturgeon populations above Willamette Falls may be over-harvested.

3. The fishery is likely to disappear if sturgeon populations are not supplemented.

4. Periodic releases of hatchery sturgeon will supplement the existing population above Willamette Falls and provide for future fisheries.

5. Monitoring is needed to evaluate the success of hatchery releases providing for a fishery.

Actions

3.1 Develop and implement a hatchery release program above Willamette Falls.

3.2 Monitor the abundance, growth, and distribution of hatchery sturgeon released in 1989, 1990, and in the future.

3.3 Monitor the contribution of hatchery releases to the sturgeon fishery.

3.4 Using data from monitoring studies evaluate the sturgeon hatchery release program and implement any necessary changes.

TROUT

Background and Status

RAINBOW TROUT

Origin

Rainbow trout may be indigenous to the Willamette River, however the origin of main stem rainbow trout is unknown. Historically, Willamette Falls was a barrier to upstream migration of rainbow trout. However winter steelhead, which occasionally revert to resident rainbow, were always able to ascend the falls. Rainbow populations above Willamette Falls may have descended from local indigenous stock, residual winter steelhead, or early introductions of hatchery trout.

Willamette basin rainbow trout are currently listed by ODFW as a stock of concern due to insufficient information regarding their status. Rainbow trout should be given a high priority with respect to future population and habitat inventory and monitoring activities in the Willamette basin.

Life History and Population Characteristics

Distribution

A survey of the Willamette River by Dimick and Merryfield (1945) indicated that rainbow trout were present in the upper river above RM 145. In a more recent electrofishing survey (Hughes and Gammon 1987) rainbow trout were found at sites between RM 161-175. Rainbow trout are believed to be present from the confluence of the Middle Fork of the Willamette (RM 187) to Salem (RM 85), possibly farther downstream (personal communication on 23 August 1990 with M. Wade, ODFW, Springfield, Oregon).

Distribution of rainbow trout in the main stem Willamette varies from season to season (Dimick and Merryfield 1945). Rainbow trout found in the main stem Willamette during the summer and fall may originate in tributary streams of the Willamette.

Abundance

Limited sampling with seines and electrofishing in the Willamette from the mouth of the McKenzie River (RM 174) to Peoria (RM 141) in July 1989 showed that rainbow trout were most plentiful from the McKenzie River down to Harrisburg (RM 160), averaging about 5 trout per seine haul (intra-department memo dated 27 July 1989 to J. Griggs from J. Hutchison, ODFW, Springfield, Oregon). From Harrisburg to Peoria abundance of rainbow declined slightly, averaging about 2 fish per seine haul. Rainbow are rarely found in the main stem below Corvallis (RM 132).

Spawning Location

Rainbow trout found in the Willamette main stem may spawn and rear in tributary systems. Spawning may also occur in the main stem.

Hatchery Production

There have been no releases of hatchery rainbow trout into the Willamette River for several decades (personal communication on 27 March 1990 from J.Hutchinson, ODFW, Springfield, Oregon). No releases are currently made, although hatchery rainbow may drift into the Willamette from releases made in tributary streams.

Angling and Harvest

A seasonal fishery for rainbow trout occurs near Eugene during the spring. Anglers are particularly successful during low-water years. Trout up to 18 inches in length are commonly taken.

Harvest levels of rainbow trout from the main stem Willamette are largely unknown.

Daily catch limit for trout is 5 fish. The minimum size limit is 8 inches above the falls. Above Willamette Falls, the main stem between RM 25.5-132 is open for trout angling from the fourth weekend in May to the end of October. The main stem between RM 132-187 is open from the fourth weekend in April to the end of October.

Management Considerations

Agricultural practices such as grazing, removal of riparian vegetation and channelization of the main stem Willamette have eliminated shoreline habitat and cover for trout. Inputs of sediment, fertilizers, herbicides, and pesticides from agricultural lands degrade water quality.

Waste water from urban and industrial sources, including pulp and paper mills, released into the Willamette River increase water turbidity and color and may contain harmful substances such as dioxin.

In the Willamette River, high temperatures and poor water quality during the summer contribute to mortality of rainbow trout. High temperatures are also favorable for *Ceratomyxa shasta*, a disease organism which may affect rainbow trout. Rainbow trout from the Willamette have not been tested for resistance to the disease.

Rainbow trout in the Willamette basin are currently listed as a stock of concern because of insufficient information regarding their status. More information is needed concerning the status of rainbow trout in the main stem Willamette River.

CUTTHROAT TROUT

Origin

Willamette cutthroat trout are classified as the same subspecies as the sea-run coastal variety (Moring 1978). Anadromous stocks do not occur above Willamette Falls. Instead, cutthroat often migrate shorter distances within streams and rivers, utilizing larger rivers of the Willamette system for accelerated growth (Moring 1978). There are non-migratory populations above Willamette Falls, as well.

Willamette basin cutthroat trout are currently listed as a stock of concern due to insufficient information regarding their status. Cutthroat trout should be given a high priority with respect to future population and habitat inventory and monitoring activities in the Willamette basin.

Life History and Population Characteristics

Distribution

Cutthroat trout are believed to be distributed along the entire Willamette River, although there have been few surveys and there is little information. Cutthroat trout are more abundant in the main stem Willamette above Willamette Falls. A survey by Dimick and Merryfield (1945) indicated that the distribution of cutthroat trout in the Willamette main stem was partially dependent upon season. During the early summer cutthroat were found from about RM 95, near Independence, upstream to RM 187. As the summer progressed, cutthroat moved upstream and tended to concentrate between RM 135-175. A more recent electrofishing survey during August (Hughes and Gammon 1987) found cutthroat trout at sites between RM 134-179.

Cutthroat trout are believed to be present year round from the confluence of the Middle Fork of the Willamette (RM 187) to Corvallis (RM 132) (personal communication on 23 August 1990 with M. Wade, ODFW, Springfield, Oregon). Cutthroat trout are rarely found in the main stem below Corvallis, possibly because of their susceptibility to *Ceratomyxa shasta*.

Abundance

There is little information concerning abundance of cutthroat trout in the main stem Willamette River. Limited sampling with seines and electrofishing in the Willamette River from the mouth of the McKenzie River (RM 174) to Peoria (RM 141) in July 1989 showed that cutthroat trout were most plentiful from the McKenzie River down to Marshall Island (RM 168), averaging about 4 trout per seine haul (intra-department memo dated 27 July 1989 to J. Griggs from J. Hutchison, ODFW, Springfield, Oregon). From Marshall Island to Peoria, cutthroat averaged 3 trout per seine haul.

Average Adult Age Structure

Usually, young cutthroat (age 0 and 1+) are not found in the main stem Willamette. Spawning and rearing usually take place in smaller tributary streams (Moring and Youker 1979). Older, larger cutthroat predominate in the main stem Willamette River.

About 97% of the cutthroat sampled from the Willamette River with electrofishing gear and seines during 1976-79 were age 2+ or older fish (Moring and Youker 1979) (Figure 2). Most of the cutthroat sampled from small tributaries to the Willamette were age 2+ and younger.

Average Adult Size

Nicholas (1978) found the growth of Willamette cutthroat accelerates when fish enter the main stem Willamette from tributary streams. He also found that cutthroat residing in small tributary streams were generally smaller than those found in the main stem Willamette. This supports the hypothesis that at some point in their life cycle small cutthroat trout migrate from tributary streams to the main stem Willamette.

Age-specific length of cutthroat trout sampled from the Willamette River during 1976-79 is shown in Figure 3 (Moring and Youker 1979). The broad size range for a given age may result from cutthroat originating from different tributary systems. Length at age appears to vary with the drainage and location of the fish within the drainage system (Nicholas 1978, Moring and Youker 1979).

Generally, male cutthroat mature earlier than female cutthroat (Nicholas 1978, Moring and Youker 1979). Some cutthroat mature at two years of age. Most, however, mature at age 3 or older. Of 18 mature cutthroat sampled from the Willamette River, 4 were age 2, 7 were age 3, 6 were age 4, and 1 was age 5 (Moring and Youker 1979).

Time of Spawning

Cutthroat spawn earlier than rainbow trout, usually during the winter months. In the Willamette basin, cutthroat generally spawn between January and March (Nicholas 1978). Recently spent fish have been found in large rivers in March (Moring and Youker 1979).

Spawning Areas

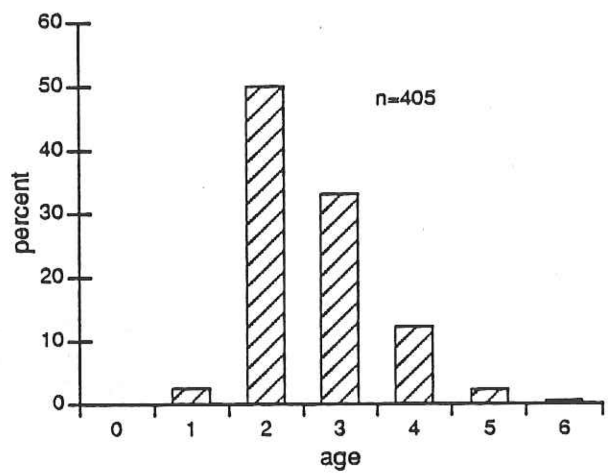
No reports have been made of cutthroat trout using the Willamette River for spawning (Dimick and Merryfield 1945, Nicholas 1978, Moring and Youker 1979). However it is suspected that in addition to spawning in tributary streams, cutthroat spawning may also occur in larger tributaries and in the Willamette main stem.

Movement and Migration

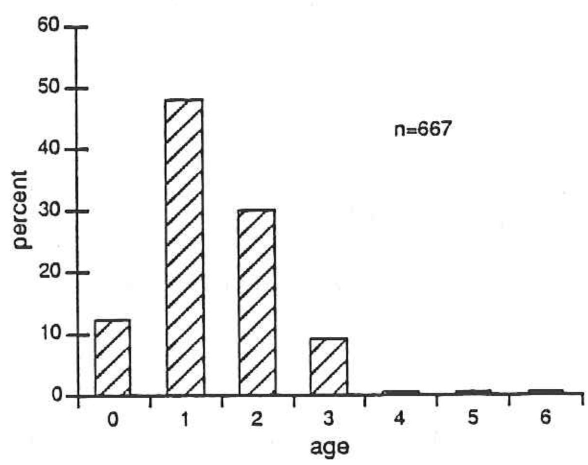
Movements of cutthroat to and from the main stem Willamette have been observed (Moring et al. undated, Moring 1977). Moring et al. (undated) found that extensive movement occurs primarily in large rivers. Potamodromous cutthroat are residents of larger rivers moving to small tributaries for spawning and immature fish moving from tributaries to forage areas in large

Figure 2. Age structure of cutthroat trout populations in the Willamette River and some of its smaller tributaries 1976-79 (from Moring and Youker 1979).

a. Willamette River



b. West-side tributaries



c. East-side tributaries

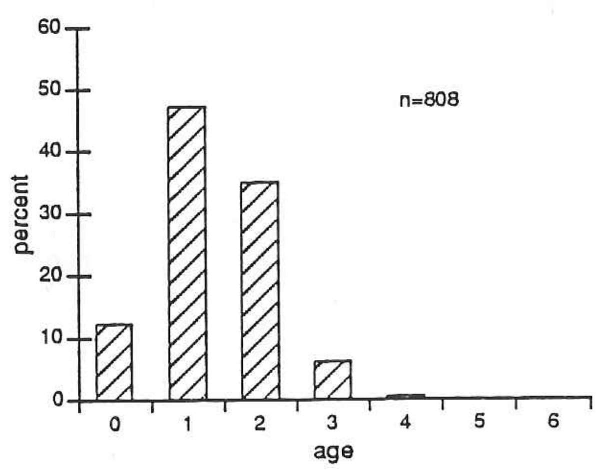
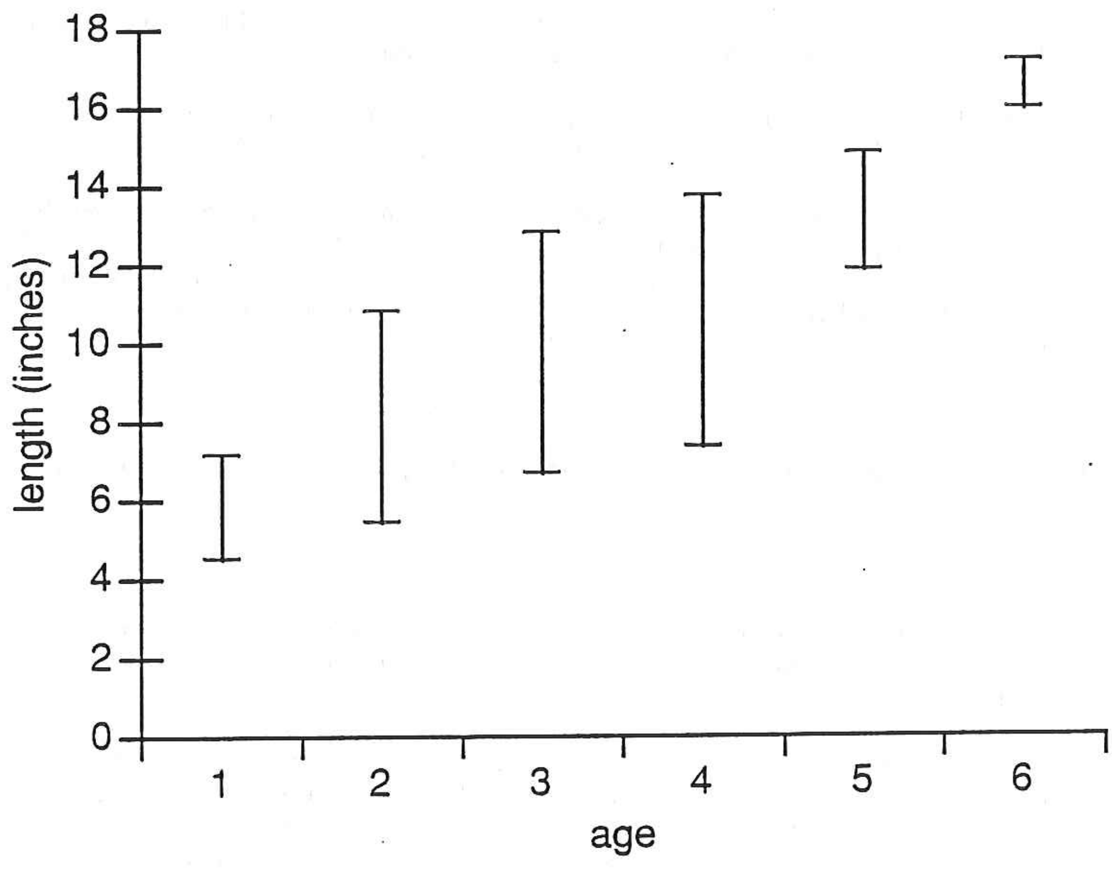


Figure 3. Age specific size range (inches) of cutthroat trout from the Willamette, based on scale samples collected 1976-79 (from Moring and Youker 1979).



rivers. Adults generally migrate to small tributaries in fall and winter, spawn in late winter or early spring, and then migrate back to larger rivers soon afterward.

Wetherbee (unpublished data from J.J. Wetherbee, ODFW, Salem, Oregon) tagged a number of cutthroat trout during spawning periods in 1955-57 in several small west-side tributaries of the Willamette River. Two fish tagged in Marys River during the winter were subsequently recovered in the Willamette near Harrisburg (RM 161) the following spring.

Movement of cutthroat within the Willamette River and between the Willamette and its tributaries was studied during 1976-79 (Moring and Youker 1979). Of 428 trout captured and tagged in the Willamette, 5.1%, or 22 fish, were recaptured within one month. Two-thirds of the recoveries were made near the tagging locations. The remaining one-third were made more than 4 miles from the location of original tagging, in the Willamette River and in the McKenzie River. A few cutthroat tagged in the McKenzie and Middle Fork Willamette rivers were later recovered in the main stem Willamette River, more than 4 miles from the location of original tagging.

Cutthroat have been observed to home to small tributaries in two successive years (Nicholas 1978). The degree of straying is unknown.

Not all upstream migrants are mature fish on a spawning run (Nicholas 1978). Movements of some cutthroat may be more local in nature, occurring in response to seasonal changes in temperature and flow, or to improve forage location. Other populations may not move at all, but reside in a specific reach permanently (Dimick and Merryfield 1945).

Hatchery Production

No hatchery releases of cutthroat have been made in the Willamette River.

Angling and Harvest

The main stem Willamette supports a popular cutthroat fishery from Harrisburg (RM 161) to Peoria (RM 141). Harvest levels of cutthroat trout from the main stem Willamette are largely unknown.

Daily catch limit for trout is 5 fish. The minimum size limit is 8 inches above the falls. Above Willamette Falls, the main stem between RM 25.5-132 is open for trout angling from the fourth weekend in may to the end of October. The main stem between RM 132-187 is open from the fourth weekend in April to the end of October.

Management Considerations

Agricultural practices such as grazing, removal of riparian vegetation and channelization of the main stem Willamette have eliminated shoreline habitat and cover for trout. Inputs of sediment, fertilizers, herbicides, and pesticides from agricultural lands degrade water quality.

Waste water from urban and industrial sources, including pulp and paper mills, released into the Willamette River increase water turbidity and color and may contain harmful substances such as dioxin.

Forestry and agricultural land use practices along tributary streams impact spawning and rearing of migratory cutthroat.

Cutthroat trout in the Willamette basin are currently listed as a stock of concern because of insufficient information regarding their status. More information is needed concerning the status of cutthroat in the main stem Willamette and the use of main stem habitat by potamodromous cutthroat.

WHITEFISH

Origin

Whitefish are a member of the trout and salmon family Salmonidae and are native to larger streams in the Willamette basin. There is no hatchery production of whitefish.

Life History and Population Characteristics

Distribution

The distribution of whitefish is similar to that of trout. Dimick and Merryfield (1945) found whitefish in the main stem Willamette from Peoria (RM 141) to the mouth of the Santiam River (RM 108). Hughes and Gammon (1987) found a wide distribution in the Willamette, from RM 177 near Eugene to RM 25, Willamette Falls. Whitefish are believed to be present in the upper Willamette, from the confluence of the Middle Fork of the Willamette (RM 187) to Willamette Falls (RM 25) (personal communication on 23 August 1990 with M. Wade, ODFW, Springfield, Oregon).

Abundance

Limited sampling with seines and electrofishing in the Willamette River from the mouth of the McKenzie River (RM 174) to Peoria (RM 141) in July 1989 showed that whitefish were more abundant than rainbow and cutthroat trout from the confluence of the Coast Fork (RM 187) down to Harrisburg (RM 161) (personal communication on 23 August 1990 with M. Wade, ODFW, Springfield, Oregon).

Average Adult Age Structure and Size

Mountain whitefish mature at 3 to 4 years of age (Daily 1971). There is no information for whitefish collected from the Willamette River. Length at maturity in most waters is less than 12 inches (ODFW 1987).

Time of Spawning

Spawning is thought to occur in the late fall (Dimick and Merryfield 1945).

Spawning Areas

Spawning areas in the Willamette River and basin are unknown.

Habitat Requirements

Mountain whitefish have habitat preferences and a diet similar to trout.

Movement and Migration

It is thought that whitefish inhabit the main stem Willamette and some west-side tributaries during the winter, and migrate back to east-side tributaries in the spring or early summer (Dimick and Merryfield 1945).

Angling and Harvest

There is no information concerning harvest of whitefish in the Willamette River.

Although whitefish can be caught on natural bait and flies, they are seldom sought by anglers. Whitefish have a potential for increased sport use.

Whitefish may be taken from any water open to salmon, steelhead or trout angling during the entire year. There is no bag limit.

Management Considerations

Agricultural practices such as grazing, removal of riparian vegetation and channelization of the main stem Willamette have eliminated shoreline habitat and cover for whitefish. Inputs of sediment, fertilizers, herbicides, and pesticides from agricultural lands degrade water quality.

Waste water from urban and industrial sources, including pulp and paper mills, released into the Willamette River increase water turbidity and color and may contain harmful substances such as dioxin.

Forestry and agricultural land use practices along tributary streams impact spawning and rearing of whitefish.

Policies

Policy 1. No hatchery-produced resident trout shall be released in the main stem Willamette River.

Objectives

Objective 1. Maintain the genetic diversity and adaptiveness of wild trout and whitefish populations.

Assumptions and Rationale

1. Willamette basin rainbow and cutthroat trout have been identified as stocks of concern. This objective addresses some of the problems with the stocks in the Willamette River.

2. Information on life history characteristics of cutthroat trout populations, such as migration behavior and habitat requirements, is needed in order to effectively manage and protect cutthroat

populations and their habitat. Information on life history characteristics of cutthroat trout in tributary systems of the Willamette is necessary for effective protection and management of cutthroat trout in the main stem Willamette River.

4. Monitoring the distribution and abundance of populations of wild trout in the Willamette River and tributary subbasins will provide an indication of population health and adaptiveness.

5. Cutthroat trout reside year-round in the Willamette basin. As well as providing for a fishery, they serve as a tangible indicator of water quality and watershed health.

Actions

1.1 Initiate life history studies of rainbow and cutthroat trout in the Willamette River and its tributaries to determine spawning and rearing locations and migration patterns.

1.2 Assess the migratory patterns of cutthroat trout and the effects of fishing pressure on populations by conducting tagging studies in the main stem Willamette and tributary systems.

1.3 Determine the timing and magnitude of in-stream movement of cutthroat trout by using drift boat electrofishing gear or seining from March through June from Armitage Park on the McKenzie to Harrisburg on the Willamette.

1.4 Review age structure, longevity, and age at maturity for cutthroat trout populations previously studied throughout the Willamette basin.

1.5 Determine the resistance of wild cutthroat trout populations in the Willamette River above Peoria and below Corvallis to *Ceratomyxa shasta*.

1.6 Estimate the genetic variation within and between cutthroat trout populations in the Willamette above Peoria and below Corvallis by electrophoretic or mitochondrial DNA examination.

1.7 Collect morphometric measurements and meristic data for scales, fin rays, pyloric caeca and vertebrae from cutthroat trout randomly chosen from samples collected in the Willamette above Peoria and below Corvallis.

1.8 Identify life history types of Willamette basin cutthroat trout based on migratory behavior, geographical location in the basin, habitat use, and other life history characteristics.

1.9 After obtaining sufficient life history information on cutthroat trout, select index river reaches in the Willamette to be sampled on a regular basis to establish trends in wild trout and whitefish distribution and abundance.

1.10 Determine the resistance of wild rainbow trout populations in the Willamette basin to *Ceratomyxa shasta* as part of an effort to determine their relationship to winter steelhead and possible origin.

Objective 2. Protect and restore wild trout and whitefish habitat.

Assumptions and Rationale

1. Protection and enhancement of wild trout and whitefish populations can be achieved principally through habitat protection and improvement.

2. Habitat protection and improvement in Willamette tributary systems is necessary for the protection and enhancement of trout populations in the main stem Willamette.

Actions

2.1 After obtaining sufficient life history information on spawning and other habitat needs of wild trout and whitefish, identify critical Willamette River and tributary reaches that require protection and enhancement.

2.2 Develop habitat improvement plans.

2.3 Work with volunteers, sporting clubs, landowners and agencies to identify and implement habitat improvement projects for wild trout along the main stem Willamette River.

2.4 Implement habitat protection actions outlined under objectives for Habitat Protection.

Objective 3. Minimize the potentially negative effects of hatchery fish on the production and genetic integrity of wild trout and whitefish.

Assumptions and Rationale

1. Hatchery steelhead and trout are released in Willamette tributary streams and rivers. Hatchery fish and any potential hatchery offspring may drift into the main stem Willamette and compete with native trout for food and habitat.

2. Cape Cod stock is thought to contribute less than 10% to rainbow trout natural production in Willamette tributary subbasins.

Actions

3.1 While using drift boat electrofishing gear from March through June to sample wild trout populations from Armitage Park on the McKenzie River to Harrisburg on the Willamette River, obtain data to determine the ratio of hatchery trout to wild trout.

3.2 Conduct investigations designed to assess the impacts of hatchery programs on wild trout in the main stem Willamette.

3.3 Pursue the best hatchery release programs in Willamette tributary subbasins to minimize drift of hatchery trout into the Willamette main stem.

3.4 Explore the feasibility of modifying current fish cultural practices to minimize natural production of hatchery rainbow trout and summer steelhead in Willamette tributary subbasins.

3.5 Maximize harvest of hatchery trout and steelhead in Willamette tributary subbasins.

Objective 4. **Provide angling opportunities for trout and whitefish under the basic yield management alternative for trout (Oregon Department of Fish and Wildlife 1987).**

Assumptions and Rationale

1. ODFW's Trout Plan (ODFW 1987) sets management options for trout, one of which is Basic Yield.

2. These waters are managed to use their natural productivity to grow trout and whitefish to a harvestable size. Most of the trout available to the angler are either from natural production or from drift of catchable rainbow from hatchery releases made upstream.

3. The fishery may provide for the non-consumptive as well as consumptive use of wild trout. However, the fisheries on these waters tend to be of a general, consumptive nature.

4. Other species may be present and may have fishery values equal to or greater than trout.

5. Special regulations may be needed to protect wild populations without seriously restricting the major fisheries.

6. Whitefish population levels are adequate to support an increased sport fishery.

7. Many people are not aware of the excellent sporting and eating qualities of whitefish.

Actions

4.1 While conducting monitoring activities and creel programs designed for other purposes or fish species, collect information on fishing pressure and harvest of trout and whitefish.

4.2 Evaluate angling pressure and harvest rates of wild trout through tagging programs and creel studies on key reaches of the Willamette River to determine consumptive use and impacts on wild populations.

4.3 Publicize information on distinguishing characteristics of whitefish and angling opportunities.

WARMWATER GAME FISH

Background and Status

Origin

Warmwater game fish are not native to the Willamette River. There is little documentation of introductions of warmwater fish in the Willamette. Channel catfish were first released into the Willamette in 1893. Largemouth bass and panfish have probably existed in standing and running waters in the Willamette basin since the 1800s. The first introductions of smallmouth bass were made in the early 1900s.

Life History and Population Characteristics

Distribution

Warmwater game fish are found primarily in sloughs, old channels, oxbow lakes, and other backwater areas of the Willamette. Largemouth and smallmouth bass, black and white crappie, bluegill, pumpkinseed, warmouth, green sunfish, yellow perch, brown, yellow, and black bullhead are widely distributed throughout the slower flowing portions of the Willamette River (ODFW 1980). Walleye are found below Willamette Falls. Walleye are also found in the Middle Fork Willamette River and may become established downstream in upper reaches of the main stem Willamette. Channel catfish have been released into the Willamette and some of its tributaries. However self-sustaining populations have not developed because channel catfish rarely spawn in the cooler waters of the Willamette. Bullfrogs are also included under warmwater game fish by state statute.

Warmwater game fish and their locations in the Willamette River are listed in Table 26. Appendix A lists species found in sloughs along the Willamette River.

Age structure

Age 2+ fish were the predominant age class of largemouth bass sampled from the Willamette River between Salem and Harrisburg during 1987 and 1988 (Table 27).

The average electrofishing catch rate of 0-age largemouth and smallmouth bass in Lambert Slough was 43.3 bass per acre in 1978, 14.4 bass per acre in 1979, 43.3 bass per acre in 1980, and 55.4 bass per acre in 1981 (Temple and Bisbee 1981).

Of a total of 24 largemouth bass taken from Jackson Bend Slough in 1978, 29% were age I, 29% age II, 29% age III, and 13% age IV (Table 26) (unpublished data, R. Temple, ODFW, Portland, Oregon).

Table 26. Distribution of warmwater game fish in the Willamette River, 1945, 1983, and 1986-89 (Dimick and Merryfield 1945; Hughes and Gammon 1987; unpublished data, D. Ward, ODFW, Clackamas, Oregon; unpublished data, M.K. Daily, ODFW, Salem, Oregon).

	Species[a]											
Location	SB	LB	Wm	Bg	Pk	WC	BC	YP	Wa	BrB	YB	CC
RM 1	X[d]	X	X[d]	X	X	X	X	X	X[d]	X[d]	X[d]	X[d]
3	X[d]	X	X[d]	X	X	X	X	X	X[d]	X	X	X[d]
17	X[d]	X	X[d]	X	X	X	X	X	X[d]	X	X[d]	X[d]
19		X						X[c]				
22	X[c]											
25		X								X[b]		
29		X		X[b]	X[b]	X[b]	X[b]				Xb	
39		X[b]		X[b]	X[b]	X[b]	X[b]				X[b]	
48												
51		X[b]		X[b]								
58		X[b]		X[b]							X[b]	
70		X[b]									X[b]	
77		X[b]				X[b]					X[b]	
85		X[b]									X[b]	
93		X[b]									X[b]	
105		X[b]									X[b]	
113		X[b]	X[b]								X[b]	
122		X[b]	X[b]									
128		X[b]	X[b]	X	X[b]						X[b]	
133		X[b]				X[b]	X[b]					
144		X[b]		X[b]	X[b]						X[b]	
149												
160		X[b]										
168												
176												

[a] SB = smallmouth bass, LB = largemouth bass, Wm = warmouth bass, Bg = bluegill, Pk = pumpkinseed, WC = white crappie, BC = black crappie, YP = yellow perch, Wa = walleye, BrB = brown bullhead, YB = yellow bullhead, CC = channel catfish.

[b] Recorded in the Dimick and Merryfield (1945) study only.

[c] Recorded in the Hughes and Gammon (1987) study only.

[d] Recorded in the Portland Harbor study (D. Ward, unpublished data 1986-89) only.

Table 27. Age-frequency of largemouth bass electrofished from the Willamette River from Salem (RM 85) to Harrisburg (RM 161) in June and July of 1987 and 1988 (n=106) (unpublished data, K. Daily, ODFW, Salem, Oregon).

	Age								
	0+	1+	2+	3+	4+	5+	6+	7+	8+
No. of fish	4	17	44	19	5	10	5	0	2
% of sample	3.8	16.0	41.5	17.9	4.7	9.4	4.7	0.0	1.9

Table 28. Age specific length of largemouth bass taken from Jackson Bend Slough, RM 63.7 on the Willamette River, during 1978 (unpublished data, R. Temple, ODFW, Portland, Oregon).

	Age class			
	I	II	III	IV
Average fork length (inches)	2.9	7.1	10.5	14.3
Range (inches)	2.1-4.8	6.7-9.2	10.0-12.6	14.2-14.5
N	7	7	7	3

Average size

There is no long-term data on size of warmwater game fish for any one species at any particular site. The average size of largemouth bass sampled from four reaches on the Willamette River in 1976 ranged from 11.8-16.3 inches in length and 1 lb. 6 oz. to 2 lb. 4 oz. in weight (Table 29).

Table 29. Average fork length of largemouth bass in the Willamette River, 1976 (unpublished data, ODFW).

Reach	N	Ave. F.L. (inches)	Ave. weight (lbs. & oz.)
Lambert Slough to Wheatland RM 65-72	15	13.6	2 lb. 2 oz.
Wheatland to Salem RM 72-84	4	11.8	1 lb. 8 oz.
Salem to Independence RM 84-96	8	13.0	1 lb. 6 oz.
Corvallis area RM 132	1	16.3	2 lb. 4 oz.

The age specific mean calculated fork length of largemouth bass collected from the Willamette River between Salem and Harrisburg is shown in Table 30.

Table 30. Age specific mean calculated fork length for largemouth bass collected from the Willamette River from Salem (RM 85) to Harrisburg (RM 161) during 1987 and 1988 (unpublished data, K. Daily, ODFW, Salem, Oregon).

		Mean length	Mean calculated length (inches) at age							
Age	No.	(inches)	1	2	3	4	5	6	7	8
0+										
1+	2	5.96	4.20							
2+	28	8.66	2.48	6.93						
3+	15	9.92	2.40	5.81	8.70					
4+	4	12.20	2.21	5.40	7.79	10.64				
5+	8	13.74	2.81	5.98	9.11	11.14	12.50			
6+	3	14.82	2.18	5.28	7.62	9.84	12.12	13.74		
7+										
8+	1	15.50	3.10	6.31	9.19	10.79	11.94	13.26	14.06	14.58
Mean fork length			2.77	5.95	8.48	10.60	12.19	13.50	14.06	14.58
Mean annual increment			2.77	3.18	2.53	2.12	1.58	1.31	0.57	0.52
Number of fish			61	59	31	16	12	4	1	1

The average length of 0-age bass sampled from Lambert Slough during 1978-81 ranged from 2.1-2.3 inches (Temple and Bisbee 1981). In 1978 age I bass from Jackson Bend Slough averaged 2.9 inches, age II bass 7.1 inches, age III bass 10.5 inches, and age IV bass 14.3 inches (Table 26) (unpublished data, R. Temple, ODFW, Portland, Oregon).

Average lengths of warmwater game fish found in Willamette River sloughs during gill netting and electroshocking surveys are presented in Appendix B.

Hatchery Production

Hatchery produced fish are used primarily to establish populations of warmwater fish in the wild (ODFW 1987). Hatchery fish are obtained or reared for specific release programs. Largemouth bass, smallmouth bass, and channel catfish are either purchased or raised. Other species are captured and transplanted.

Description of Hatcheries

The St. Paul Warmwater Rearing Ponds is ODFW's only warmwater fish culture station. The site was developed in 1962 to provide facilities for rearing and interim storage of wild fish prior to release. Fish produced are distributed statewide in response to annual management needs.

The St. Paul complex is a low-technology, extensive-culture facility located in the Willamette Valley about 20 miles north of Salem. The station consists of ten one-acre dug-and-diked ponds, a hatchery building, storage shed, well, and pond drain system. The ponds are 100' x 400' and average five feet deep. Well water is delivered to the ponds via irrigation pipe. Water is abundant throughout the year and has a temperature range of 54-56°.

Largemouth bass fingerlings are generally produced from the spawning of broodstock on site. They are occasionally obtained from Willamette River back waters or private ponds and reared to a larger size at St. Paul. Fingerling bass are removed from the ponds 2 to 4 months later for stocking.

Smallmouth bass have been reared at St. Paul on several occasions. Off-station sources of smallmouth bass fry have been limited to federal hatcheries, sources which are increasingly variable and uncertain.

Sunfishes are reared only as needed for specific projects. A brood stock of redears is maintained for experimental uses. Other species are generally obtained from wild populations as needed. Reproduction is generally quite successful, and large numbers of zero-age fish can be produced.

Attempts at channel catfish at St. Paul ponds have not been successful. Channel catfish fingerlings are purchased from a private hatchery in Chico, California.

Cool, wet weather in spring and early summer coupled with a predominantly north wind during summer produces less than optimum temperatures for warmwater fish. Spring weather directly affects spawning activity of largemouth and smallmouth bass. Unstable temperatures due to intermittently rainy and sunny weather or rapid cooling due to wind driven circulation of the shallow ponds may cause intermittent or late reproduction, or no reproduction at all.

Food production for early spawning species such as crappies, and the black basses is also affected by cool spring weather. Both phytoplankton and zooplankton abundance are depressed by periods of cool weather. Phytoplankton blooms, needed to furnish food for zooplankton and insects, are diminished by reduced solar insolation. Since zooplankton is the primary food of most bass and sunfish, maintenance of a productive pond environment is critical to survival and growth. Pond fertilization is done to enhance plankton growth. Most species reared at St. Paul are not maintained on artificial diets.

Hatchery Releases

Releases of warmwater game fish into the Willamette River and its sloughs during 1928-90 are presented in Table 31. Early records show a wide variety of species were released into the Willamette, including bass, catfish, crappie, bluegill, and warmouth. In more recent years, channel catfish have been released into the Willamette.

Angling and Harvest

Interest in angling for warmwater species in the Willamette River and its sloughs has increased in recent years. Bass, bluegill, and crappie are the species harvested most frequently. Lambert Slough probably receives the heaviest warmwater angler use of any Willamette River slough above Oregon City.

The bag limit for bass is 5 per day with no more than 3 over 15 inches. There is no bag limit for bluegill, catfish, crappie, other sunfish and yellow perch.

Table 31. Releases of warmwater game fish into the Willamette River, 1927-1990 (unpublished records, A. Smith, ODFW, Portland, Oregon).

Date	Site	Species	No. stocked
1927	Multnomah Channel	Bass	51,000
		Catfish	78,500
		Crappie	81,300
1928	Willamette River	Bass	400
		Catfish	600
		Crappie	4,000
	Multnomah Channel	Bass	491,229
		Catfish	231,326
		Crappie	518,300
1933	Willamette River	Spiny-ray	130,858
	Multnomah Channel	Spiny-ray	394,779
1934	Willamette River	Spiny-ray	17,775
	Multnomah Channel	Spiny-ray	1,444,754
1935	Multnomah Channel	Spiny-ray	393,680
1936	Willamette River	Black Bass	148,200
		Bluegill	2,500
		Catfish	359,000
		Crappies	127,350
		Warmouth	500
		Bull Frogs	181,550
1937	Willamette River	Black Bass	27,900
		Catfish	210,000
		Crappies	32,600
	Multnomah Channel	Black Bass	48,916
		Calico Bass	20,000
		Catfish	119,025
		Crappies	256,730
		Ring Perch	25
		Bull Frogs	535,000
1944	Willamette River	Largemouth Bass	300
	Multnomah Channel	Catfish	55,000
		Crappies	95,000
		Largemouth Bass	89,625

(continued)

Table 31 continued.

Date	Site	Species	No. stocked
1945	Willamette River	Catfish	10,000
		Crappies	15,000
	Multnomah Channel	Bluegill	10,000
		Calico Bass	35,000
		Catfish	330,000
		Crappie	135,000
		Largemouth Bass	53,000
		Warmouth	5,200
		Bull Frogs	130,000
1946	Multnomah Channel	Bluegill	1,825
		Calico Bass	20,000
		Catfish	96,745
		Crappie	217,125
		Largemouth Bass	120,475
		Sunfish	25,250
		Yellow Perch	4,275
		Bull Frogs	29,100
1962	Willamette River	Channel Catfish	52,500
1963	Willamette River	Channel Catfish	3,800
1978	Lambert Slough	Channel Catfish	738

Management Considerations

Sub-optimal water temperatures, lack of habitat, and competition with non-game fish constrain production of warmwater fish in the Willamette River. Warmwater game fish can negatively impact native fish species.

Policies

Policy 1. Management proposals that initiate or expand hatchery programs for warmwater game fish or that alter the distribution of warmwater game fish shall be reviewed and evaluated for potential effects on indigenous species.

Objectives

Objective 1. Maintain populations of warmwater game fishes.

Assumptions and Rationale

1. Little is known about warmwater fish species presence, distribution, abundance, and population characteristics in the Willamette River. Data on warmwater fish in the Willamette River and its sloughs has

come from a limited number of fish population inventories and creel studies.

2. Monitoring the distribution and abundance of warmwater game fish populations in the subbasins will provide an indication of population status.

3. Protection of existing warmwater populations can be achieved principally through habitat protection.

Actions

1.1 Inventory reaches and sloughs of the Willamette River for warmwater fish population distribution and abundance.

1.2 On priority waters where long-term data sets are necessary to understand population dynamics, carry out routine sampling programs to determine the species composition, distribution, and population structure of warmwater game fish. Possible priority waters include Lambert Slough and the Willamette River reach from Independence to Albany.

1.3 Implement habitat protection actions outlined under objectives for Habitat Protection.

Objective 2. Implement an evaluation of introducing channel catfish into the main stem Willamette River and carry out the introduction if the evaluation is positive.

Assumptions and Rationale

1. The potential exists for providing additional angling opportunity and diversity through a stocking program for channel catfish.

2. Angling opportunities for channel catfish are limited at present.

3. Suitable habitat for channel catfish is available.

4. Channel catfish seldom, if ever, reproduce in the Willamette system.

5. Little is known concerning the survival, growth, diet and habitat use of channel catfish in the Willamette.

6. Channel catfish in the Willamette may prey on chinook and steelhead smolts and cutthroat trout. channel catfish was the second most important predator in a study of predation by resident fish on juvenile salmonids in the John Day Reservoir (Poe et al. 1988).

7. The decline of the Oregon Chub, which formerly occurred along the main stem Willamette River, is partially attributed to introductions of warmwater fish species. Expanding predator populations, such as warmwater game fish populations, may limit opportunities to

reestablish Oregon chub in portions of its former range. The effect of releases of channel catfish on the reestablishment and persistence of Oregon chub is unknown.

Actions

2.1 Determine the suitability of the main stem Willamette River for a channel catfish program.

2.2 Determine the effects of a channel catfish program on native fish species.

2.3 If acceptable and feasible, design and implement a channel catfish program for the main stem Willamette River.

2.4 Stock channel catfish only in areas where the Oregon chub does not occur.

2.5 Stock channel catfish only below the mouth of the Long Tom River (R.M. 149) to reduce competition with cutthroat trout.

2.6 Evaluate the success of channel catfish releases by designing and carrying out a monitoring program.

2.7 When sampling channel catfish, examine their stomach contents to determine potential predation effects on indigenous fish.

2.8 Review life history information and habitat requirements of channel catfish in the Columbia River system to assess potential predation effects on indigenous fish in the Willamette.

2.9 Collect creel information to evaluate the contribution of stocked channel catfish to the fishery and to determine the overall catch rate.

Objective 3. Implement an evaluation of quality management of largemouth bass to provide angling diversity in selected main stem Willamette River sloughs.

Assumptions and Rationale

1. Selected reaches and sloughs of the Willamette may be able to provide a better than average opportunity to catch mid- to large-sized largemouth bass.

2. Angler demand for angling diversity may warrant more intensive management of largemouth bass in these areas.

Actions

3.1 Identify potential sites along the Willamette River for more intensive management of warmwater game fish. Possible sites include Lambert Slough and Jackson Bend Slough.

3.2 Determine the effects of quality largemouth bass management on native fish species.

3.3 If acceptable and feasible, design and propose angling regulation changes to implement quality largemouth bass management.

3.4 Evaluate the success of quality largemouth bass management by designing and carrying out a monitoring program.

Objective 4. Provide a diversity of warmwater angling opportunities for other species and in remaining reaches of the Willamette through basic yield management.

Assumptions and Rationale

1. Basic yield management requires little intervention in natural processes affecting production.

2. Running waters will be managed under general statewide regulations for warmwater game fish.

3. Anglers will find variety in species and sizes.

4. Catch rates will be highly variable.

5. In recent years the bass fishery has expanded. There are concerns that largemouth and smallmouth bass populations have been over-harvested.

6. Smallmouth bass are more limited in distribution than largemouth, and are more vulnerable to over-harvesting than largemouth.

Actions

4.1 Collect data on the distribution, abundance, fishing pressure, and harvest of warmwater game fish.

4.2 Evaluate angling pressure, harvest rates, and angler satisfaction through creel studies.

4.3 Evaluate harvest rates of smallmouth and largemouth bass in the Willamette and its sloughs and determine the impacts of current harvest levels on population health.

4.4 If necessary, propose methods to reduce the harvest of largemouth and smallmouth bass.

Objective 5. Increase public awareness of warmwater angling opportunities in the subbasins.

Assumptions and Rationale

1. Some warmwater game fish may be underutilized.

2. ODFW's weekly fishing report can be used to provide current information to attract anglers during times of good fishing.

3. Publications can direct people to angling opportunities in specific areas.

Actions

5.1 Provide warmwater fishing information to be included in the weekly fish reports.

5.2 Publish a guide for warmwater fish in the mid-Willamette Valley.

5.3 Continue to direct anglers to warmwater fishing opportunities in the subbasins when they contact district offices for information.

5.4 Consider involving the public in habitat enhancement projects, sampling studies, and volunteer creel programs.

Objective 6. Work with the Health Division and Department of Environmental Quality on the issue of possible contamination of warmwater fishes in the lower Willamette River adjacent to sites of discharge of hazardous wastes.

Assumptions and Rationale

1. There are a number of sites in the lower Willamette River that are directly or indirectly releasing hazardous wastes into the aquatic environment.

2. Some toxic substances can be concentrated in fish tissue.

3. Ingesting contaminated fish can be a health hazard.

Actions

6.1 Coordinate with DEQ and the Health Division on a testing program to assess the potential health risks of eating warmwater fish from the lower Willamette River adjacent to sites of release of toxic substances.

6.2 Coordinate signing with DEQ to inform the angling public of areas to be avoided where potentially contaminated fish may be harvested.

OREGON CHUB

Background and Status

Origin

The Oregon chub is a small minnow historically recorded only from the Willamette and Umpqua basins in Oregon. The Willamette population is now considered to be genetically discrete from the Umpqua population, which will most likely be classified as separate species (Markle et al. 1990).

Life History and Population Characteristics

Oregon chub have been found in quiet waters such as sloughs and overflow ponds at low elevations in the Willamette valley (Dimick and Merryfield 1945). They prefer shallow, warm water with depositional substrates having abundant aquatic vegetation (Markle et al. 1990).

Prior to 1970, Oregon chub were collected from 21 Willamette valley sites, mainly along the Willamette River, as far downstream as Oregon City (RM 25) (Markle et al. 1990). Since 1970, no Oregon chub have been found along the main stem Willamette River. Currently, the Oregon chub is thought to occur only at sites near Lookout Point and Dexter reservoirs in the Middle Fork Willamette subbasin, in a beaver pond in the Gray Creek system of Muddy Creek in the Coast Range subbasin, and possibly in the lower North Santiam River in the Santiam subbasin.

The Oregon chub spawns in the spring and early summer (Markle et al. 1990). Spawning occurs in aquatic vegetation. Fecundity of females taken from Shady Dell Pond in the upper Willamette basin ranged from 147 to 671 (Markle et al. 1990).

Oregon chub feed primarily on zooplankton and midge larvae (Markle et al. 1990).

Hatchery Production

There is no hatchery production of Oregon chub. Fish captured for introductions into new sites may be held for short periods of time in isolated ponds at the St. Paul rearing facilities. It is more likely that they would be transferred directly to re-introduction sites.

Management Considerations

Although the Oregon chub is not presently on the federal list of threatened or endangered species, it is on the Federal Register as a category 2 species. Additional information is needed regarding its status. Markle and Pearsons (1990) have submitted a petition to list the Oregon chub as an endangered species.

The Oregon chub is currently listed by the state as a protected species due to the decline in its distribution and abundance in the Willamette Valley.

The Oregon chub should be given a high priority with respect to future management activities in the Willamette basin.

The apparent decline of the Oregon chub in the Willamette system correlates with the construction of dams and flood control projects in the Willamette Valley. Historically the main stem Willamette had a braided channel with numerous secondary side channels and wetlands (Sedell and Froggatt 1984). During winter and spring flooding events, Oregon chub could have been widely dispersed in the flood plain to pond and slough habitats where spawning and juvenile rearing would take place. With recent flood control projects, channelization of the main stem and loss of backwaters, sloughs, and ponds, the dispersal opportunities and available habitat for Oregon chub is now greatly reduced.

Oregon chub may also be vulnerable to predation by introduced fish species such as bass. Introduced warmwater fish are often the dominant inhabitants of quiet waters along the main stem Willamette. They are probably a major detriment to recolonization, if not the cause of the decline of the Oregon chub.

Objectives

Objective 1. Establish new populations of Oregon chub in isolated waters along the main stem Willamette River where possible.

Assumptions and Rationale

1. Oregon chub have been identified by the state as a protected species. This objective addresses some of the problems with this species.

2. A preliminary list of introduction sites in the Willamette valley has been prepared by an interagency task force (ODFW et al. 1990). Further investigation and review may identify potential sites along the main stem Willamette.

3. Introductions will be confined to the historic distribution of the Oregon chub.

4. Introductions of Oregon chub will be approved through the ODFW stocking policy review process.

5. Many of the following actions cannot be accomplished under current levels of funding. If funding continues to be limiting, ODFW will pursue actions according to priority as funds become available.

Actions

1.1 Evaluate potential sites for introductions in isolated waters along the main stem Willamette.

1.2 Stock Oregon chub in selected, appropriate sites according to Guidelines for Re-introducing Oregon chub into their Historic Range (ODFW et al. 1990).

1.3 Conduct systematic monitoring of introduced populations.

1.4 Develop criteria to define a successful introduction of Oregon chub.

1.5 Determine the causes of unsuccessful introductions.

1.6 Restock sites if warranted.

Objective 2. Promote greater public understanding and appreciation of the status of Oregon chub.

Assumptions and Rationale

1. The status and importance of the Oregon chub is recognized by only a small portion of the general public.

Actions

2.1 Publicize efforts taken and their rationale for protecting and enhancing populations of Oregon chub.

2.2 Educate anglers and angling groups about the status of the Oregon chub and the risks of introducing exotic species into potential Oregon chub habitat.

SAND ROLLER

Background and Status

Origin

The sand roller, *Percopsis transmontana*, a member of the trout-perch family, is native to the Columbia River and its tributaries, including the Willamette.

Life History and Population Characteristics

Sand rollers are generally found in low gradient reaches of rivers and streams. During daylight hours they hide among large submergent objects such as root wads and under banks. At night they move out in small schools to feeding areas over sandy substrates (personal communication on 23 October 1990 from P. Reimers, ODFW, Charleston, Oregon). Because of their secretive nature during the day, sand rollers often go uncollected during routine stream sampling. Current records for the subbasins may underestimate their distribution.

Sand rollers have been collected from the main stem Willamette near Eugene, Peoria, and Albany (Table 32). They are also found in oxbow lakes along the Willamette (personal communication on 23 October 1990 from C. Bond, Oregon State University, Dept. of Fisheries and Wildlife, Corvallis, Oregon).

Table 32. Records of sand rollers collected from the main stem Willamette River (D. Markle, Oregon State University, Dept. of Fisheries and Wildlife, Corvallis, Oregon).

Date	Reach	Site
3-2-44	RM 142	Peoria Ferry
3-19-44	RM 142	Peoria
8-7-50	RM 187	South of Eugene
8-10-65	RM 187	Near Eugene
Undated	RM 187	Near Eugene
Undated	RM 118	At Albany

Sand rollers collected from the Columbia River ranged in age from 1 to 6 years (Gray and Dauble 1979). Sand rollers usually attain sexual maturity at age II. All fish are mature by age III.

Gravid females were collected from sites in the Columbia River from June through mid-July (Gray and Dauble 1979). Females collected from January through July contained 1,106 to 3,369 eggs. Carlander (1969) reports that a single female contained 4,748 eggs. Spawning occurs in the Columbia River in midsummer when water temperatures range from 57-61° F (Gray and Dauble 1979). Emergent fry were collected in mid-August in the Columbia River. Larger fry were collected in mid-September.

Aquatic insects are the main food of sand rollers. Zooplankton may contribute a greater portion of the diet of immature fish (Gray and Dauble 1979).

Management Considerations

The sand roller is currently listed as a stock of concern statewide. Populations are suspected of being at low levels, but its exact status is unknown. The sand roller should be given a high priority with respect to future population and habitat inventory and monitoring activities in the main stem Willamette.

Sand rollers may be susceptible to habitat degradation and water diversions found in lower reaches of rivers and streams in the subbasins. Channelization of rivers and streams and removal of riparian vegetation reduces the structural complexity required by sand rollers.

Objectives

Objective 1. Determine the distribution, relative abundance, and habitat use of sand rollers in the main stem Willamette.

Assumptions and Rationale

1. Sand rollers have been identified by the state as a stock of concern. This objective addresses some of the problems with this species.

2. Determining the distribution and relative abundance of populations of sand rollers will provide an indication of their health.

3. Information on the distribution and habitat use of sand rollers in the subbasins is necessary in order to implement habitat protection actions.

4. Many of the following actions cannot be accomplished under current levels of funding. If funding continues to be limiting, ODFW will pursue actions according to priority as funds become available.

Actions

1.1 While conducting routine inventory for other fish species, collect more detailed data for sand rollers when present.

1.2 Use inventory data to determine the relative abundance of sand rollers in the main stem Willamette River.

1.3 Use inventory data to determine the habitat requirements of sand rollers in the main stem Willamette River.

Objective 2. Protect, restore, and enhance sand rollers habitat.

Assumptions and Rationale

1. Protection and enhancement of sand roller populations can be achieved principally through habitat protection and improvement.

Actions

2.1 Advocate riparian protection for river reaches containing sand rollers.

2.2 Develop habitat protection and improvement plans where needed.

2.3 Work with volunteers, landowners, and agencies to implement habitat protection and improvement projects in reaches used by sand rollers.

2.4 Implement habitat protection actions outlined under objectives for Habitat Protection.

CRAYFISH

Background and Status

Origin

Three species of crayfish are native to Oregon (Hobbs 1976). These species, their subspecies and intergrades are spread statewide, with overlapping distributions. An introduced species found in the Rogue River is not known to occur in the Willamette.

Life History and Population Characteristics

Crayfish breed in the summer, with the first egg-bearing females appearing as early as September. Eggs are carried over the winter and hatch late April to late June. The young are attached to the female by a thread-like material for a short time. Size achieved by zero-age crayfish during the first summer is quite variable due to the long period over which eggs hatch. Age determination by the length-frequency method is extremely difficult.

Females mature at about 18-30 months. Fecundity increases with size and perhaps age. There is evidence to suggest that some or perhaps all females do not breed each year.

Hatchery Production

There is no hatchery production of crayfish in the Willamette. No commercial crayfish culture operations have yet been successful in the state.

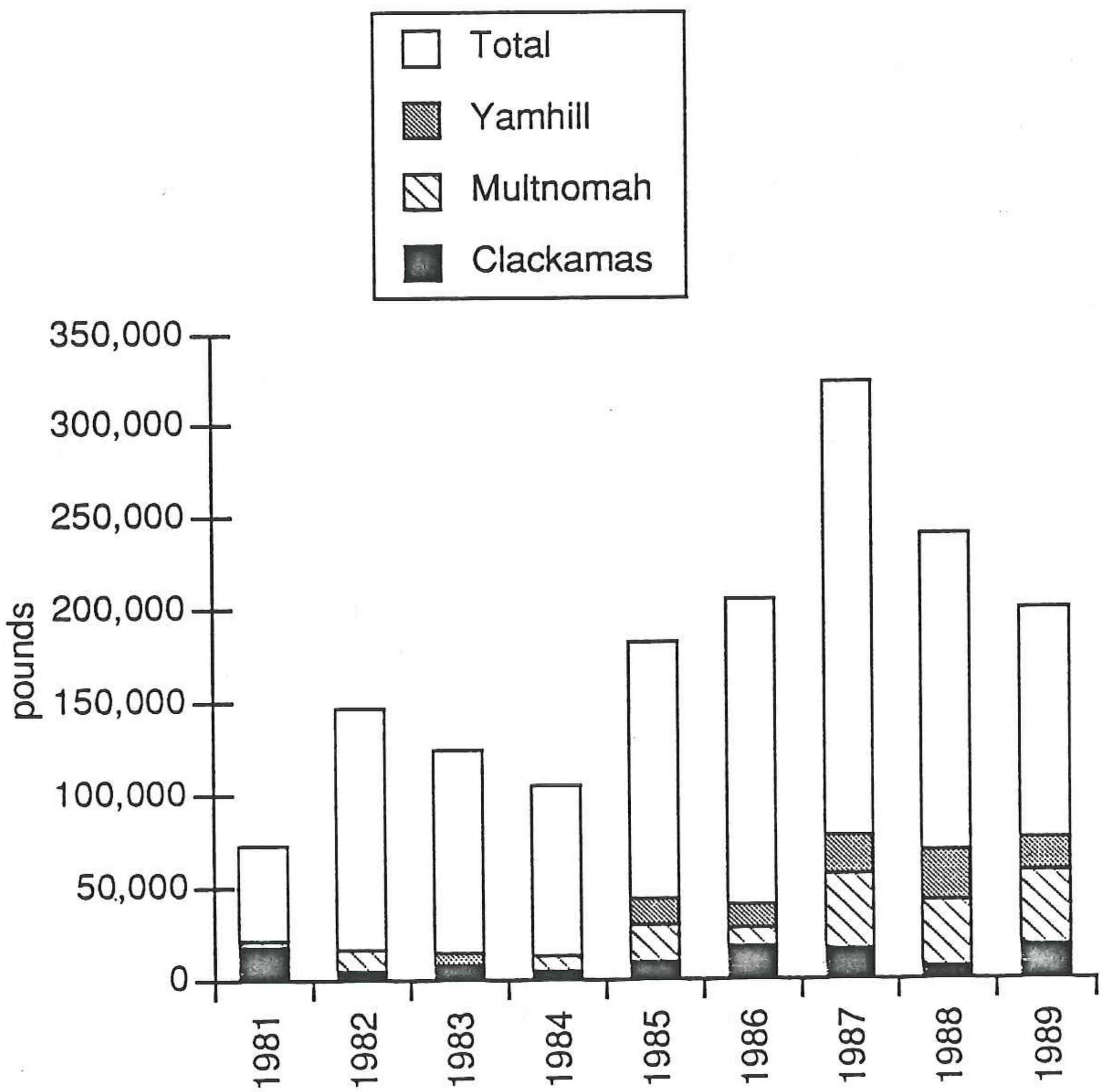
Harvest

Crayfish have been fished commercially in Oregon since before 1893 when records were first kept. Markets for restaurant food dictate the size of landings. The Willamette River system below Willamette Falls is one of the main sources for most of the landings. Counties within the Willamette basin accounted for about 28% of the statewide commercial harvest in 1988 and 38% in 1989 (Figure 4) (unpublished data, ODFW, Portland, Oregon). Most of the Willamette basin harvest occurs in Multnomah, Clackamas, and Yamhill counties. There are no estimates of commercial landings specifically for the main stem Willamette River.

The commercial crayfish season is open from April 1 through October 31. Crayfish may be taken only by crayfish pots or ring nets. Only crayfish 3-5/8 inches or longer in length may be taken. Undersized crayfish must be returned unharmed to the water. Any crayfish caught with eggs attached must be returned unharmed to the water. Gear must be labeled with an identification number issued by ODFW.

Recreational use of the resource is widespread in the Willamette basin for bait and direct consumption. The area around Independence (RM 95) has a relatively large sport fishery. Estimates of sport harvest levels in the Willamette are unavailable.

Figure 4. Commercial crayfish landings in Oregon and in three Willamette basin counties, 1981-89 (unpub. data, ODFW). The minimum size regulation was increased from 3 1/2" to 3 5/8" in 1988.



No license is required to take crayfish in the recreational fishery. The daily bag limit is 100 per person. The season is open the entire year at all hours.

Management Considerations

Crayfish are the most important freshwater invertebrate to Oregon's fisheries. They provide for both commercial and recreation fisheries in the lower Willamette River and a recreational fishery above Willamette Falls. They are also important fish forage.

Water pollution, particularly pesticides and some industrial wastes, and flow depletions are the most serious threats to crayfish populations. There several sites on the lower Willamette River where seepage of hazardous materials, including dioxin, into the river is a problem. There is a concern about consumption of potentially contaminated crayfish from the Willamette River adjacent to these sites (Al Smith, ODFW Warmwater Fish Manager, personal communication).

Objectives

Objective 1. Assess the population status and commercial harvest of crayfish in the Willamette River.

Assumptions and Rationale

1. Present commercial catch information is reported only by date and county.

2. Information should be collected for the most heavily fished waters, such as the Multnomah Channel.

3. Data can be collected at reasonable cost from commercial operators.

Actions

1.1 While conducting routine surveys, determine the size and relative abundance of crayfish.

1.2 Require commercial harvesters to use a logbook to record effort and catch for all crayfish harvest.

Objective 2. Determine the size and importance of the recreational crayfish harvest in the Willamette River.

Assumptions and Rationale

1. Currently there is no measure of the impact of the recreational harvest or the fishery potential of crayfish.

2. There are no estimates of current harvest or effort.

3. Recreational harvest is widespread and appears to be increasing.

Actions

2.1 While conducting routine surveys, determine the size and relative abundance of crayfish.

2.2 Conduct creel studies in key areas to evaluate harvest and effort.

Objective 3. Raise concern with Department of Environmental Quality on the need for testing lower Willamette River crayfish for dioxin and other potential toxic substances and manage the fishery according to the findings.

Assumptions and Rationale

1. There are several sites adjacent to the lower Willamette River seepage of toxic chemicals into the river occurs.

2. There has been a concern voiced about the potential health risk of eating crayfish from the lower Willamette that have been exposed to contaminants.

Actions

3.1 Initiate contact and coordinate with DEQ and Health Division on a testing program to assess potential health risks of eating lower Willamette River crayfish.

ANGLING ACCESS

Background and Status

The Oregon State Land Board has declared the main stem Willamette River navigable based on historical use of the river for vessel navigation and log drives (Oregon State Land Board 1983). Under this classification river banks below the ordinary high water mark would be publicly owned and could be used for public angling.

The main stem Willamette River has boat access at 48 sites from the river mouth to the confluence of the Coast and Middle forks. An additional site at Lambert Slough, which is currently privately owned, provides access to the lower 2 miles of this popular slough and to Jackson Slough. Currently the nearest access is 7 miles away.

Boat access sites on the main stem Willamette are concentrated around urban centers such as Portland. Opportunities for bank anglers are more limited than for boat anglers.

Conflicts between anglers and landowners primarily involve trespass, littering, and damage to vegetation. Incentives need to be developed to encourage private landowners to allow public access and to encourage anglers to respect property rights and to minimize disturbance to wildlife.

Policies

Policy 1. The Department shall seek to provide access for boat and bank angling that will satisfy public need for a variety of angling opportunities and a dispersion of angling effort along the main stem Willamette River.

Policy 2. Acquisition and development of angler access sites shall be consistent with guidelines and objectives for management of fish species and habitat.

Objectives

Objective 1. Provide and maintain 49 permanent boat access sites on the main stem Willamette River.

Assumptions and Rationale

1. It is necessary to work with other agencies, public groups, and private landowners to provide and maintain access sites.
2. Boat anglers primarily use the rivers for day-trips. Consequently, access sites need to be relatively close together.
3. Existing access sites meet the objective, except for Lambert Slough.

4. As fisheries for spring chinook and summer steelhead expand above Willamette Falls, additional access needs may arise.

5. An additional access site between McCartney Park (RM 157) and Peoria (RM 141) may be desirable.

6. Some boat access sites are poorly maintained or are in need of improved or expanded facilities.

7. ODFW may need to acquire boat access sites currently owned by other parties or agencies in order to assure continued operation of facilities.

8. Many of the following actions cannot be accomplished under current levels of funding. If funding continues to be limiting, ODFW will pursue actions according to priority as funds become available.

Actions

1.1 Maintain the ramp at San Salvador at RM 59.

1.2 Acquire and improve the facilities at Lambert Slough at RM 65 on the Willamette River.

1.3 Provide a breakwater to slow the current at the bottom of Willamette Park Boat ramp, RM 134.

1.4 Dredge the sand bar forming near the Peoria access site, RM 141.

1.5 Provide a breakwater to slow the current at the bottom of the McCartney Park boat ramp, RM 157.

1.6 Work with the county to maintain the facilities at Brown's Landing at RM 167.

1.7 Acquire and improve the facilities at Christensen's Landing at RM 168.

1.8 Work with the county to maintain the facilities at Hileman Landing at RM 174.

1.9 Consider the need for and the feasibility of acquiring and developing an access site between McCartney Park (RM 157) and Peoria (RM 141).

Objective 2. Increase bank angling access along the Willamette River.

Assumptions and Rationale

1. Additional bank angling access would increase angling opportunities.

2. Much of the shoreline along the Willamette River is privately owned.

3. Private landowners often attempt to prevent public access on their property.

Actions

2.1 Identify potential sites for bank angling access along the Willamette River.

2.2 Acquire additional sites for bank angling where desirable.

2.3 Develop incentives to encourage private landowners to allow public access.

2.4 Develop incentives to encourage anglers to respect property rights and minimize disturbance to wildlife.

PLAN ADOPTION AND REVIEW

The Main Stem Willamette Plan should not be viewed as the final statement on the management of the fish and fisheries in the subbasin. Planning is a continuing process. As conditions of the resources and desires of the public change and as new information is obtained, the plan must be responsive and evolve as well. The Main Stem Willamette Plan will be rewritten as needed and presented to a public advisory committee. The final draft will be presented to the Fish and Wildlife Commission for adoption. Every 2 years public meetings will be held to review progress made in implementing the plan. These meetings are intended to provide an opportunity for the public to comment on management direction and progress. This review will precede the preparation of ODFW's biennial budget, which is submitted to the legislature for funding.

This plan is intended to provide both long-term and short-term direction for management of the fisheries in the subbasin. As conditions for the resources and desires of the public change and as new information is obtained, the plan must be responsive and evolve as well.

Upon adoption by the Oregon Fish and Wildlife Commission, the policies and objectives will become Oregon Administrative Rules. Revision of these rules requires action by the Commission. The entire plan, including policies and objectives, will be formally reviewed and revised every 5 years. Emergency changes in administrative rules can be made by the Commission in accordance with the Administrative Procedures Act when needed.

Progress made implementing the actions in the plan will be reported by the Department every 2 years. At that time, implementation priorities will also be reexamined and adjustments made where necessary.

PRIORITY OF ACTIONS

The Main Stem Willamette Fish Management plan proposes many actions, more than can be completed within existing budgets. Some actions are currently on-going actions of ODFW and only need to be continued or modified. Other actions are new and need funding before they can be implemented. In order to achieve the objectives of this plan within ODFW's budgetary and staff limitations, priorities for funds and effort must be identified.

High priority actions were identified for habitat protection, species or species groups, and access (Table 34). These priorities reflect what ODFW and the citizens advisory committee believe are the most important actions that should be addressed in the Main Stem Willamette Fish Management Plan. The first actions identified in Table 33 are habitat protection actions which affect more than a single stock or species of fish. The current funding status for each action is indicated. A "yes" in the currently funded column denotes that funding for that action is presently budgeted under existing programs, however current funding may not be adequate. If additional funds are needed, it is noted in the next column.

Table 34. High priority actions in the Main Stem Willamette Fish Management Plan and funding status.

Actions	Currently funded	Remarks on funding status
Reduce the impacts of agricultural, residential and commercial development on fish production	Yes	Included in base budget
Maintain or improve upstream and downstream passage for fish	Yes	Included in base budget
Conduct creel programs to monitor the winter and summer steelhead, spring chinook, and trout sport fisheries	No	Additional funding needed to implement creel surveys
Investigate and implement methods designed to increase the sport harvest of spring chinook	No	Partially funded by base budget; additional funding needed for method implementation

(continued)

Table 34 continued.

Actions	Currently funded	Remarks on funding status
Conduct biological sampling of white sturgeon	No	Additional funding needed to design and implement sampling program
Protect and enhance the productivity of naturally produced trout	No	Partially funded by base budget; additional funding needed for surveys and research investigations
Monitor the natural production and harvest of warmwater game fish	No	Partially funded by base budget; additional funding needed for surveys
Evaluate the channel catfish program and its suitability in the subbasin	No	Partially funded by base budget; additional funding needed for monitoring programs
Protect and enhance populations of sensitive species and stocks of concern	No	Partially funded by base budget; additional funding needed for surveys and habitat improvement
Provide and maintain angling access	No	Maintenance of existing sites is funded in the base budget; additional funding needed for acquisition and development of new sites

REFERENCES

Anderson, R.S. 1988. Columbia River sturgeon. Washington Sea Grant, Columbia River Series. 20 pp.

Bennett, D.E. 1989. 1988 lower Willamette and Clackamas River steelhead and Willamette River white sturgeon and shad recreational fisheries. Oregon Department of Fish and Wildlife.

Bennett, D.E. 1988. 1987 Willamette River spring chinook run. Columbia River Management, Oregon Department of Fish and Wildlife, Clackamas.

Bennett, D.E. 1989. 1988 Willamette River spring chinook salmon run and lower Willamette and Clackamas River steelhead and Willamette River white sturgeon and shad. Oregon Department of Fish and Wildlife, Columbia River Management.

Buchanan, D.V., R.M. Hooton, M.G. Wade and J.E. McCrae. 1979. Willamette River steelhead. Annual progress report of the Oregon Department of Fish and Wildlife.

Buchanan, D.V. and M.G. Wade. 1982. Development and assessment of steelhead in the Willamette River basin. Annual progress report of the Oregon Department of Fish and Wildlife.

Campbell, C.J. and M.K. Daily, eds. 1974. 1973 annual report, Fishery Division. Oregon Wildlife Commission, Portland, Oregon.

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology, Volume I. Iowa State University Press, Ames, Iowa.

Daily, M.K. 1971. The mountain whitefish: A literature review. Univ. Idaho Forest, Wildlife and Range Expt. Station Paper No. 8. 18 pp.

Daily, M.K., R. Herrig and R. Temple. 1986. Warmwater fish management - Oregon. Oregon Department of Fish and Wildlife Annual Progress Report.

Daily, M.K., R. Perkins and J. Johnson. 1990. Umpqua River smallmouth bass investigation, 1982-88. Oregon Department of Fish and Wildlife Information Report.

Dimick, R.E. and F. Merryfield. 1945. The fishes of the Willamette River system in relation to pollution. Oregon State College, Engineering Experiment Station. Bulletin 20.

Frazier, P.A. 1988. Fish Passage at Willamette Falls in 1987. Annual Report. Columbia River Management, Oregon Department of Fish and Wildlife, Clackamas.

Frazier, P.A. 1989. Fish Passage at Willamette Falls in 1988. Annual Report. Columbia River Management, Oregon Department of Fish and Wildlife, Clackamas.

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin -- past and present. United States Department of Commerce, Special Scientific Report, Fisheries No. 618, Washington, D.C.

Gray, R.H. and D.D. Dauble. 1979. Biology of the sand roller in the central Columbia River. Trans. Amer. Fish. Soc. 108: 646-649.

Hansen, H.L. 1978. Stock assessment and enhancement of fall salmon species in the Willamette River system. Federal Aid Progress Reports, Fisheries. Oregon Department of Fish and Wildlife.

Hansen, H.L. 1979. Stock assessment and enhancement of fall salmon species in the Willamette River system. Federal Aid Progress Reports, Fisheries. Oregon Department of Fish and Wildlife.

Hansen, H.L. and R.H. Williams. 1979. Stock assessment and enhancement of fall salmon species in the Willamette River system. Federal Aid Progress Reports, Fisheries. Oregon Department of Fish and Wildlife.

Hobbs, Jr., H. H. 1976. Crayfishes (Astacidae) of North and Middle America. U.S.E.P.A. Water Pollution Control Research Series 18050 ELD05/72.

Howell, P.J. 1986. Willamette Basin fish management plan: status and progress report. Oregon Department of Fish and Wildlife, Portland.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Kendra, and D. Ortmann. 1985. Stock assessment of Columbia River anadromous salmonids. Two volumes. Final Report to Bonneville Power Administration (Contract No. DE-AI79- 84BP12737), Portland, Oregon.

Hughes, R.M. and J.R. Gammon. 1987. Longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. Trans. Amer. Fish. Soc. 116(2): 196-209.

Korn, L. 1961. A winter steelhead tagging program on the Columbia River. Fish Commission of Oregon, Contribution No. 26, Portland, Oregon.

Markle, D.F. and T.N. Pearsons. 1990. Petition to list the Oregon chub, *Oregonichthys crameri*, as an endangered species. Manuscript. Oregon State University, Corvallis, Oregon.

Markle, D.F., T.N. Pearsons and D.T. Bills. 1990. Natural history of *Oregonichthys* (Pisces: Cyprinidae) with a description of a new species from the Umpqua River of Oregon. Copeia in press.

Mattson, C.R. 1948. Spawning ground studies of Willamette River spring chinook salmon. Fish Commission of Oregon Research Briefs 1(2):21-32.

Mattson, C.R. 1962. Early life history of Willamette River spring chinook salmon. Fish Commission of Oregon, Portland.

Mattson, C.R. 1963. An investigation of spring chinook salmon of the Willamette River system,1946-51. Fish Commission of Oregon, Portland.

McMahon, T.E. and J.W. Terrell. 1982. Habitat suitability index models: Channel catfish. U.S.D.I. Fish and Wildlife Service. FWS/OBS-82/10.2. 29 pp.

Moring, J.R. 1975. Catchable rainbow trout evaluation. Progress report. Oregon Department of Fish and Wildlife.

Moring, J.R. 1978. Proceedings of the wild trout--catchable trout symposium, February 15-17, 1978. Oregon Department of Fish and Wildlife, Research Division.

Moring, J.R. and R.M. Hooton. 1978. Oregon rainbow and cutthroat trout evaluation. Progress report. Oregon Department of Fish and Wildlife, Portland, Oregon.

Moring, J.R., and R.L. Youker. 1979. Oregon rainbow and cutthroat trout evaluation. Final Report. Oregon Department of Fish and Wildlife, Portland, Oregon.

Moring, J.R., R.L. Youker, and R.M. Hooton. Undated. Movement patterns of potamodromous cutthroat trout of the Willamette valley, Oregon. Oregon Department of Fish and Wildlife, Portland, Oregon.

Nicholas, J.W. 1978. A review of literature and unpublished information on cutthroat trout (*Salmo clarki clarki*) of the Willamette watershed. Information report series, Fisheries No. 78-1. Oregon Department of Fish and Wildlife, Portland, Oregon.

Oregon Department of Fish and Wildlife. 1980. Willamette basin fish management plan. Portland, Oregon.

Oregon Department of Fish and Wildlife. 1987. Trout plan. ODFW, Portland, Oregon.

Oregon Department of Fish and Wildlife. 1987. Warmwater game fish management plan. Portland, Oregon.

Oregon Department of Fish and Wildlife. 1988. Willamette Basin fish management plan. Fish Division, Portland.

Oregon Department of Fish and Wildlife. 1989a. Oregon salmon and steelhead catch data, 1975-86. Fish Division, Portland.

Oregon Department of Fish and Wildlife. 1989b. Oregon salmon and steelhead catch data, 1976-88.

Oregon Department of Fish and Wildlife, Oregon State University Fisheries and Wildlife Department, and Willamette National Forest. 1990.

Conservation agreement for the Oregon chub in the Willamette Valley, Oregon. Draft report.

Oregon State Land Board. 1983. Report and recommendation on the navigable waters of Oregon. Division of State Lands, Salem, Oregon.

Poe, T.P., H.C. Hansel, S. Vigg, D.E. Palmer and L.A. Pendergast. 1988. Predation by northern squawfish, walleye, smallmouth bass, and channel catfish in a main stem Columbia River reservoir: I. Feeding ecology during the salmonid smolt out-migration. in Predation by resident fish on juvenile salmonids in John Day Reservoir. Vol.I-Final Report of Research. U.S.D.O.E. Bonneville Power Administration, Division of Fish & Wildlife.

Richen, J.D., J.R. Schleuning, B. Headley, S. Dotteren, S. Knoll, and J. Alles. 1973. Lower Willamette management plan. Lower Willamette River Study Team. SRG Partnership and State Land Board. Portland, Oregon.

Sedell, J.R. and J.L. Froggatt. 1984. Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon USA, from its floodplain by snagging and streamside forest removal. Internationale Vereinigung fuer Theoretische und Angewandte Limnologie Verhandlungen 22: 1828-1834.

Smith, E.M., R.H. Williams, J.C. Zakel. 1982. Willamette River salmon studies. Oregon Department of Fish and Wildlife. Annual Progress Report.

Smith, E.M., R.H. Williams, and J.C. Zakel. 1983. Willamette River salmon studies. Annual Progress Report, Oregon Department of Fish and Wildlife, Portland.

Smith, E.M., J.C. Zakel, W.H. Day, K. Homolka, M.A. Buckman. 1987. Willamette River salmon studies. Annual Progress Report, Oregon Department of Fish and Wildlife.

Temple, R. and L. Bisbee. 1981. Warmwater game fish management. Oregon Department of Fish and Wildlife Progress Report.

Ward, D.L., P.J. Connolly, and R.A. Farr. 1987. Feasibility of evaluating the impacts of water way development on anadromous and resident fish in Portland harbor. Oregon Department of Fish and Wildlife, Portland.

APPENDICES

APPENDIX A
Warmwater Game Fish

Table A-1. Warmwater game fish found in Willamette River sloughs during gill netting and electroshocking surveys in 1967, 1969, 1972, 1976, 1979, 1988, and 1990 (unpublished data, ODFW).

Slough and location	Species[a]											
	SB	LB	Wm	Bg	Pk	WC	BC	YP	Wa	BrB	YB	CC
Unnamed RM 54.5			X	X		X	X			X	X	
Unnamed RM 55.2	X	X										
Unnamed RM 57.4			X	X	X	X	X			X	X	
Unnamed RM 57.6		X				X	X					
Unnamed RM 60.6		X	X	X		X					X	
Unnamed RM 61.5						X				X	X	
Unnamed RM 62.6				X		X	X					X
Jackson Bend Sl. RM 63.8			X	X		X	X			X	X	
Unnamed RM 65.3		X				X						
Fairfield Sl. RM 67.1			X	X		X				X	X	
Unnamed RM 67.6			X	X		X						
Eldridge Sl. RM 69.0				X		X				X	X	
Unnamed RM 69.5			X			X				X	X	
Unnamed RM 69.7			X			X				X	X	
Unnamed RM 70.3				X		X	X					
Unnamed RM 73.2						X					X	
Pumphouse Sl. RM 73.5		X				X				X		
Windsor Island Sl. RM 73.8						X					X	
Unnamed RM 74.0						X						
Unnamed RM 74.6		X	X	X		X	X			X	X	
Spring Valley Sl. RM 74.7		X	X	X		X	X				X	
Unnamed RM 75.3		X	X	X		X	X				X	
Unnamed RM 77.7						X						
Darrow Rocks Sl. RM 78.0						X				X		
Willamette Sl. RM 83.8		X	X	X	X	X					X	

(continued)

Table A-1 continued.

Slough and location	Species[a]											
	SB	LB	Wm	Bg	Pk	WC	BC	YP	Wa	BrB	YB	CC
Boat Barn Sl.												
RM 84.5		X	X	X	X		X					
Unnamed												
RM 87.2				X		X	X					
Rickreall Sl.												
RM 88.1		X	X	X	X	X	X			X		
Roberts Sl.												
RM 91.4	X	X	X	X	X	X	X					
Murphy Sl.												
RM 98.3						X	X				X	
Judson Sl.												
RM 100.5			X	X		X	X					
Unnamed												
RM 103.0			X	X		X	X			X	X	
Luckiamute Sl.												
RM 107.7		X	X	X	X	X	X			X		
Black Dog Sl.												
RM 111.2		X		X	X	X	X					
Little Willamette R.												
RM 121.5		X	X			X	X				X	
Unnamed												
RM 122.0						X					X	
Collins Bay												
RM 122.5			X	X		X	X			X		
Unnamed												
RM 122.9				X		X					X	
Unnamed												
RM 123.2				X		X					X	
Unnamed												
RM 123.8		X	X	X		X				X		
Unnamed												
RM 125.0		X				X						
Unnamed												
RM 130.4						X						
East Channel												
RM 132.5						X					X	
Booneville Channel												
RM 134.6						X	X					
Unnamed												
RM 134.7						X						
Unnamed												
RM 137.5		X				X						
Unnamed												
RM 139.8				X		X						
Albany Channel												
RM 141.7		X				X	X					
Unnamed												
RM 143.1						X						
Unnamed												
RM 146.0				X		X	X					
Unnamed												
RM 147.3		X				X				X		
Unnamed												
RM 148.3		X	X	X		X	X					
Unnamed												
RM 148.5		X				X					X	

(continued)

Table A-1 continued.

Slough and location	SB	LB	Wm	Bg	Pk	WC	BC	YP	Wa	BrB	YB	CC
	Species[a]											
Unnamed RM 151.1				X		X					X	
Unnamed RM 151.3				X		X						
Unnamed RM 152.7		X		X		X	X	X		X	X	
Unnamed RM 155.1		X		X		X	X				X	
Unnamed RM 156.7						X					X	
Unnamed RM 157.6						X						

[a] SB = smallmouth bass, LB = largemouth bass, Wm = warmouth bass, Bg = bluegill, Pk = pumpkinseed, WC = white crappie, BC = black crappie, YP = yellow perch, Wa = walleye, BrB = brown bullhead, YB = yellow bullhead, CC = channel catfish.

Appendix B
Warmwater Game Fish - Average Length

Table B-1. Average fork length in inches and sample size () of warmwater game fish found in Willamette River sloughs during gill netting and electroshocking surveys in 1967, 1969, 1972, 1976, 1977, 1979, 1988, and 1990 (unpublished data, ODFW).

	Species[a]										
Slough	SB	LB	Wm	Bg	Pk	WC	BC	YP	BrB	YB	CC
Unnamed RM 57.4			6(9)	6(51)	6(1)	6(35)	6(8)		8(64)	9(3)	
Unnamed RM 62.6				5(1)		9(1)	8(1)				16(1)
Unnamed RM 63.5		14(2)									
Jackson Bend Sl. RM 63.8		12(9)									
Lambert Sl. RM 64.8		12(53)									
Fairfield Sl. RM 67.1		11(3)									
Unnamed RM 67.6			4(2)	4(2)		7(15)					
Eldridge Sl. RM 69.0		10(1)									
Unnamed RM 69.5			5(1)			6(7)			11(1)	8(3)	
Unnamed RM 73.2						6(19)				10(2)	
Pumphouse Sl. RM 73.5						5(14)			9(1)		
Windsor Island Sl. RM 73.8		14(9)									
Unnamed RM 74.0						5(6)					
Unnamed RM 74.6		3(3)	5(5)	5(22)		6(55)	7(11)			8(7)	
Spring Valley Sl. RM 74.7		4(3)	5(5)	5(22)		6(58)	6(12)			7(7)	
Unnamed RM 77.7						6(13)					

(continued)

Table B-1 continued.

Slough	Species[a]										
	SB	LB	Wm	Bg	Pk	WC	BC	YP	BrB	YB	CC
Darrow Rocks Sl. RM 78.0						6(4)				8(1)	
Willamette Sl. RM 83.8		9(6)	4(10)	4(49)	4(11)	7(15)				7(1)	
Boat Barn Sl. RM 84.5		8(10)	6(1)	4(24)	3(10)		8(2)				
Unnamed RM 87.2				4(4)		8(37)	6(1)				
Rickreall Sl. RM 88.1		7(8)	4(1)	5(1)	2(7)	6(3)	5(6)		8(1)		
Roberts Sl. RM 91.4	6(3)	9(8)	5(1)	5(15)	3(2)	8(17)					
Murphy Sl. RM 98.3						5(50)	4(1)			10(2)	
Unnamed RM 103.0			6(4)	5(10)		8(40)	5(8)		7(1)	11(1)	
Luckiamute Sl. RM 107.7		10(11)	5(4)	5(39)	3(1)	6(62)	6(8)		8(3)		
Black Dog Sl. RM 111.2		11(14)		3(26)	3(1)	7(6)	5(3)				
Collins Bay RM 122.5			4(1)	4(54)		6(82)	5(32)		9(23)		
Unnamed RM 122.9				5(3)		6(7)					
Unnamed RM 125.0		10(1)				8(5)					
Unnamed RM 127.0						10(17)					
Booneville Channel RM 134.6						5(37)	6(2)				
Albany Channel RM 141.7		8(1)				6(27)					
Unnamed RM 146.0				5(11)		6(72)	4(19)				
Unnamed RM 148.3		4(3)		4(1)							
Unnamed RM 148.5		11(1)				11(5)				10(2)	

(continued)

Table B-1 continued.

Slough	Species[a]									
	SB	LB	Wm	Bg	Pk	WC	BC	YP	BrB	YB	CC
Unnamed RM 152.7		5(8)		5(20)		9(11)	7(18)	7(1)	9(2)	9(1)	
Unnamed RM 155.1		5(6)		4(4)		7(4)	7(2)			9(2)	

[a] SB = smallmouth bass, LB = largemouth bass, Wm = warmouth bass, Bg = bluegill, Pk = pumpkinseed, WC = white crappie, BC = black crappie, YP = yellow perch, BrB = brown bullhead, YB = yellow bullhead, CC = channel catfish.