Columbia Basin System Planning

SALMON and STEELHEAD PRODUCTION PLAN

WASHOUGAL RIVER SUBBASIN

September 1, 1990

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Washington Department of Fisheries
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INTRODUCTION

The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program calls for long-term planning for salmon and steelhead production. In 1987, the council directed the region's fish and wildlife agencies, and Indian tribes to develop a systemwide plan consisting of 31 integrated subbasin plans for major river drainages in the Columbia Basin. The main goal of this planning process was to develop options or strategies for doubling salmon and steelhead production in the Columbia River. The strategies in the subbasin plans were to follow seven policies listed in the council's Columbia River Basin Fish and Wildlife Program (Appendix A), as well as several guidelines or policies developed by the basin's fisheries agencies and tribes.

This plan is one of the 31 subbasin plans that comprise the system planning effort. All 31 subbasin plans have been developed under the auspices of the Columbia Basin Fish and Wildlife Authority, with formal public input, and involvement from technical groups representative of the various management entities in each subbasin. The basin's agencies and tribes have used these subbasin plans to develop the Integrated System Plan, submitted to the Power Planning Council in late 1990. The system plan will guide the adoption of future salmon and steelhead enhancement projects under the Northwest Power Planning Council's Columbia Basin Fish and Wildlife Program.

In addition to providing the basis for salmon and steelhead production strategies in the system plan, the subbasin plans attempt to document current and potential production. The plans also summarize the agencies' and tribes' management goals and objectives; document current management efforts; identify problems and opportunities associated with increasing salmon and steelhead numbers; and present preferred and alternative management strategies.

The subbasin plans are dynamic plans. The agencies and tribes have designed the management strategies to produce information that will allow managers to adapt strategies in the future, ensuring that basic resource and management objectives are best addressed. Furthermore, the Northwest Power Planning Council has called for a long-term monitoring and evaluation program to ensure projects or strategies implemented through the system planning process are methodically reviewed and updated.

It is important to note that nothing in this plan shall be construed as altering, limiting, or affecting the jurisdiction, authority, rights or responsibilities of the United States, individual states, or Indian tribes with respect to fish, wildlife, land and water management.

PART I. DESCRIPTION OF SUBBASIN

Location and General Environment

The Washougal River is located in southwest Washington, originating in Skamania County and flowing southwesterly into Clark County, joining the Columbia River at River Mile (RM) 121 at the town of Camas. The drainage area encompasses approximately 240 square miles.

This region lies in a geographical area known as the Willamette-Puget Trough, formed by the Cascade and Pacific Coast Mountain ranges. The climate of the region is influenced by this geography, allowing moist air flowing up the Columbia River from the Pacific Ocean to moderate the seasonal extremes. Summers are cool and relatively dry and winters are wet but mild.

Annual rainfall varies considerably throughout the subbasin, primarily a result of elevation differences. At the town of Camas, annual rainfall averages about 50 inches. Within the upper tributary regions annual rainfall averages 110 inches. Since there are no permanent snowpacks, reservoirs, or other impoundments on the river, streamflow is a direct result of rainfall and groundwater runoff. The 37-year average discharge is 873 cubic feet per second (cfs), with a peak record discharge of 40,400 cfs during the flood of December 1977. The flashy nature of the river is due, in part, to the topography of the basin as well as natural perturbations of the environment. Large portions of the upper watershed were completely burned in a series of large forest fires in 1902, 1927, and again in 1929. The lighter forest regrowth, with reduced water storage capacity, contributes to the fluctuations in streamflows.

Soils in the subbasin are derived from weathered bedrock overlying basalt formations of volcanic origin. Lower floodplain soils are alluvial deposits of the Columbia and Washougal rivers. The Washougal gradient becomes increasingly steep farther upstream into Skamania County.

The towns of Camas and Washougal are located on the short confined floodplain at the mouth of the river. Treated municipal wastes from both towns are discharges into the Columbia rather than the Washougal River. Industrial development is limited, but growing. The major pollution concern is effluent from the Crown Zellerbach kraft pulp mill in Camas, which has long been recognized as a cause of fish mortality.

Residential development is scattered along State Route 140, following the river upstream from Washougal. Rugged topography has limited agricultural development to the dike floodplain.

Fisheries Resources

This subbasin is relatively small compared to other major rivers entering the Columbia River. The mainstem, or what is known as the Washougal, runs approximately for 33 miles from headwaters to mouth. Along its course numerous short tributaries join the mainstem, the West Fork Washougal being the largest, running for about 11 miles and joining the mainstem at RM 14.4. Above this point the mainstem becomes increasingly steep. Salmon Falls, at RM 14.5, was considered a barrier to salmon migration until a fishway was constructed in the 1950s. Dougan Falls, at RM 21, is now considered the upper limits to salmon migration, although coho can ascend the falls at certain water flows. Dougan Falls is recognized as a low water barrier to steelhead. Above this point, the stream gradient increases and additional cascades and falls limit the number of fish that can access the waters for spawning.

By the time early investigators conducted fish surveys on the Washougal River, serious habitat damage had already occurred. The upper watershed lies in the Yacolt Burn where a series of large forest fires had completely deforested the steep hills, resulting in severe floods and erosion. The Cotterell Power Company operated three small hydropower dams on the river that were considered low water barriers to fish migration since the fish ladders were inefficient. The last of these dams was removed in 1947. Fish also had to contend with pollution from sulfite waste liquor from the pulp mill at the mouth of the river at Camas. Even into the 1960s, fish releases from the salmon hatchery had to be timed so that the juvenile fish were passing the pulp mill on vacation weekends when the plant was closed. Former gravel mining operations on the river removed much of the spawning gravel in the lower 20 miles of river. Today, this stretch of river flows over bedrock and large boulders for most of its course.

In 1935 the largest fish run was steelhead. Investigators counted 539 steelhead below Dougan Falls (Bryant 1949). In 1934, coho salmon had their first good run in 22 years.

In 1951 the Washington Department of Fisheries estimated the fall chinook escapement to be about 3,000 fish. Minimum coho escapement was estimated at 3,000 fish. Coho were said to spawn mainly in the tributaries below falls in the Little Washougal River, Winkler Creek, and the West Fork. Chum escapement was estimated to be around 1,000 fish, spawning in the lower reaches.

By 1973 the largest salmon run was early stock hatchery coho. Minor mainstem spawning occurred and spawning was light to moderate in the tributaries. The average fall chinook run from 1967 through 1971 was 700 fish. Natural spawning was heaviest in the mainstem between RM 12 and 15. Little mention of chum is made in this report (WDF 1973).

The Washougal River is currently managed for fall chinook, late-returning coho (Type N), and summer steelhead. Like most salmon stocks originating within tributaries below the Bonneville Dam, Washougal salmon are managed on a hatchery basis. Steelhead are managed on both a natural and hatchery stock basis.

Two hatcheries are located on the Washougal River, the Washougal Hatchery and the Skamania Hatchery. The Washougal Hatchery is a major producer of coho and chinook. Located 16 miles northeast of the town of Washougal, it was completed in 1958, the sixth station to be constructed under the Columbia River Fisheries Development Program. The facility contains 12 18' x 140' ponds, 12 standard sized ponds, three large rearing and release ponds, and an adult holding pond. Release capacity for the station is 9.3 million juveniles. Incubation includes vertical incubators and fiberglass troughs. Eyeing capacity is 14.6 million eggs with hatching capacity at 9.8 million fry. Water is supplied by pumps on the Washougal River, gravity from Bob's and Boyles creeks, and "C" Creek. Funding for operations is provided by the National Marine Fisheries Service through the Columbia River Fisheries Development Program.

In 1956, the Skamania Hatchery was completed on the North Fork Washougal River and a program initiated to enhance summer steelhead. This hatchery program will be described in the steelhead section of this report.

PART II. HABITAT PROTECTION NEEDS

History and Status of Habitat

Prior to any active state or federal regulation of forest practices, significant damage was done to the region's fisheries resources. Indiscriminate logging through streams, the use of splash dams to transport logs, and poor road construction and associated siltation problems reduced or eliminated anadromous fish from many streams. Other kinds of problems, more notably destruction of riparian vegetation, land reclamation and non-point source pollution was caused by agricultural development. Urbanization, port development, and flood control works further impacted stream habitat. Today, numerous laws limit many major impacts, but the cumulative loss of habitat continues.

Habitat management for fish production embraces two elements that fish managers have varying degrees of control over -- management of the water and management of the physical habitat structure including the riparian edge. Management of flows in general are not constrained by dams or diversions. Flows are primarily the result of the status of the watershed as a whole, and the cumulative effect of land management.

Physical modification of the aquatic habitat is controlled by federal and state statutes. This overlapping patchwork of regulation is designed to limit impacts to public stream and shoreline resources. Rules governing development are generally poorly understood by the public. Laws that set standards for, regulate, or otherwise disclose for public and agency comment, development that could degrade stream and shoreline resources are listed below.

Federal

1) Clean Water Act, Section 404 and 10, U.S. Army Corps of Engineers with state of Washington, Dept. of Ecology certification.

2) National Environmental Policy Act (NEPA), Federal Agency taking action

Washington State

1) State Water Quality Laws RCW 90.48, Dept. of Ecology, Washington

2) State Surface Water Codes RCW 90.03, Dept. of Ecology

3) State Groundwater Codes RCW 90.44, Dept. of Ecology

4) Shorelines Management Act, local government with state oversight by Dept. of Ecology

5) Hydraulics code RCW 75.20.100 and 103, Washington Dept. of Fisheries or Dept. of Wildlife

6) Minimum Flow Program, Dept. of Ecology

7) State Environmental Policy Act (SEPA), local government or Dept. of Ecology

8) Flood Control Statutes, local government

9) Forest Practices Act, Dept. of Natural Resources.

In many cases, important factors affecting the quantity and quality of stream habitat are outside the direct regulatory authority of the fisheries management agencies. Interagency cooperation is one important way this difficult management situation can be counteracted. Better interagency communication of goals and objectives within watersheds, and then, cooperative administration and enforcement of rules could improve habitat protection.

A good example from Washington of how interagency cooperation strengthens a regulatory program, is the procedure the Department of Natural Resources uses to review forest practice applications. These new rules and agreements, implemented through the interagency framework commonly referred to as the Timber/Fish/Wildlife (TFW) agreement, encourage interdisciplinary review of individual forest practice applications.

In spite of the best efforts of numerous state and federal agencies, and the imposition of regulatory programs some of the public deem onerous and excessive, there is a gradual loss of stream habitat. This cumulative loss is occasioned by the routine development of natural resources and dedication of shoreline and water resources to other uses. These incremental losses have, and will, continue to result in reduced anadromous fish production in the Columbia Basin and its tributaries. Subbasin planning needs to address the problem of cumulative habitat loss if the goals of the Northwest Power Planning Act are to be achieved.

Constraints and Opportunities for Protection

Listed below are the federal, state, and local agencies and Indian tribes that have statutory or proprietary interests and mandates over elements of the physical and biological resources affecting salmon and steelhead production in this subbasin.

Federal
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- National Marine Fisheries Service
- United States Coast Guard
- United States Forest Service
- U.S. Soil Conservation Service (SCS)
- Bureau of Land Management (BLM)
- U.S. Department of Energy (Hanford Reservation)
- Federal Energy Regulatory Commission (FERC)
- Bonneville Power Administration (BPA)

Tribes
- Confederated Tribes of the Warm Springs Indian Reservations
- Confederated Tribes of the Umatilla Indian Reservation
- Yakima Indian Tribe
- Nez Perce Tribe

Washington State
- Washington Department of Fisheries
- Washington Department of Wildlife
- Washington Department of Natural Resources
- Washington Department of Ecology
- Washington Department of Agriculture

Washington County
- Clark County
- Skamania County

Habitat Protection Objectives and Strategies

In general, all the fisheries management agencies subscribe to some statement of "no net loss" of existing habitat as a management goal. Even though this goal is difficult to attain, it is an appropriate policy, one that subbasin planning should support and the only one that will protect the production potential of entire river systems for the long term.

Washington Habitat Management Objectives

1) No net loss of existing habitat.

2) No degradation of water quality.

3) No decrease of surface water quantity.

4) Increase security for existing habitat.

5) Increase salmonid use of under utilized habitat.

Strategies

Habitat protection is an area that does not lend itself to easily implemented strategies. As a result, there is a danger that this portion of subbasin planning may be given less attention than it should receive. The struggle to prevent cumulative loss of habitat is ultimately one of public policy.

Existing methods for implementing these kinds of guidelines generally are outside the normal activities of the Northwest Power Planning Council. The typical approach is through regulatory programs. However, this defensive approach to habitat protection has not resulted in the desired level of protection. "Stewardship of the public resources requires more than a defensive philosophy..." (Restoring the Balance, 1988 Annual Report of the California Advisory Committee on Salmon and Steelhead Trout). Being based on prescriptive ordinance, existing habitat protection programs by definition deploy defensive measures.

The combination of an effective public education program, an aggressive regulatory program with stiff penalties, tax incentives for riparian landowners, and demonstrated resource benefits to local residents is likely the only way the production potential of the region's stream habitat resources will be preserved. Within these broad categories, there is ample opportunity for the Northwest Power Planning Council to take a leadership and coordinating role. However, the day-to-day business of protecting small habitat units will continue to be the burden of the agencies and tribes. The effectiveness of these programs will depend on agency staffing levels of field management and enforcement positions, public and political acceptance of program goals, local judicial support and perhaps most importantly, the level of environmental awareness practiced by the individual landowner.

The area of cumulative habitat loss is one the Northwest Power Planning Council must be involved in for the sake of the investments made in the Columbia River Basin Fish and Wildlife Program to date. Unless the cumulative loss of habitat can be halted, today's losses will become tomorrow's "debt to the past" and the "investment in the future" will have been ill spent.

An excellent example of getting out in front of habitat problems before they happen is the "protected areas" program accomplished through the auspices of the Northwest Power Planning

Council. Inventory of indispensable habitat and recommendation packages such as this, developed in the full light of public participation, stand as strong statements of intent to protect habitat.

The Northwest Power Planning Council could support the regulatory habitat protection work of the agencies and tribes and become more involved by:

1) Continuing to broaden the public education and information program it already supports.

2) Hosting a habitat protection symposium entitled, "Are the Investments Being Protected?"

3) Purchasing riparian property adjacent to critical habitat.

4) Purchasing water rights if they can revert to instream uses.

5) Publishing additional inventories of "key" habitat for specific stocks that must receive <u>absolute</u> protection if the goals of the act are to be realized.

6) Working with state and federal government for the development and passage of improved habitat protective legislation.

PART III. CONSTRAINTS AND OPPORTUNITIES FOR ESTABLISHING PRODUCTION OBJECTIVES

In terms of identifying objectives, general considerations focus on United States vs. Oregon negotiations and the need to use this planning process as a means to fulfill the implementation of that decision. At the core of this agreement is the objective to rebuild weak runs to full productivity and to achieve fair sharing of the available harvest between the Indian and the non-Indian fisheries. A secondary objective is to rebuild upriver spring and summer chinook runs that would restore fisheries within 15 years. Harvests would be managed so that natural steelhead and other salmon runs also continue to rebuild. The rebuilding is to be accomplished through a systematic harvest management approach as well as implementation of appropriate production measures.

Consistent with United States vs. Oregon is the need to maintain flexible and dynamic plans that can be evaluated at defined intervals and modified whenever conditions change or new information becomes available. Long-term plans should also work to avoid disputes among the parties and attempt to resolve disagreements over fishing regulations and the collection and interpretation of management data.

As an extension of these objectives, subbasin plans should:

1. Achieve a balance with the stock of any given type (such as spring and fall chinook).

2. Work toward harvest stability within the subbasins.

3. Provide equitable opportunity to each user group.

4. Maintain habitat and improve where possible.

5. Manage for the consistent escapement of escapement allowances.

6. Optimize production and maximize long-term net benefits.

7. Use indigenous stocks where feasible and maintain stock diversity of all species to ensure perpetual existence and ability to adapt to change.

Though the agreement focuses on above Bonneville stocks and the need to rebuild the natural components on the runs, it does not ignore the fish runs returning to tributaries below Bonneville Dam. And in some cases, such as Washougal coho, it is intimately tied to providing upriver opportunities to tribal fisheries. Further mention is made within the discussion of each of the stocks.

Lower river production acts as a major producer for ocean fisheries in helping to provide maximum opportunity on a consistent basis. Key to this is the Pacific Salmon Treaty. Negotiated in 1985, the major principles of this treaty attempt to 1) prevent overfishing and provide for optimum production, and 2) provide for each party to receive benefits equivalent to the production of salmon originating in its waters.

In fulfilling their obligations, the parties will cooperate in management research and enhancement. In addition, the parties will take into account the following items:

1. The desirability, in most cases, of reducing interceptions.

2. The desirability, in most cases, of avoiding undue disruption of existing fisheries.

3. Annual variation in abundance of the stocks.

PART IV. ANADROMOUS FISH PRODUCTION PLANS

FALL CHINOOK SALMON

Fisheries Resource

For management purposes, there are four stocks of fall chinook within the Columbia River -- lower river hatchery (LRH), lower river wild (LRW), Bonneville Pool Hatchery (BPH), and upriver brights (URB). BPH and LRH fall chinook are informally called "tules." Fall chinook returning to the Washougal are lower river hatchery fish. Native fall chinook have been reported in the Washougal (WDF and USFWS 1951), but a distinct stock no longer exists. Natural spawning does occur, but these fish are identified as hatchery strays. There are no natural spawning escapement goals.

Brood stock for the Washougal Hatchery is usually obtained from local returning stocks. However, transfers of other stocks into the system is a common practice. In recent years, such stocks as Kalama, Bonneville, Toutle, Cowlitz, Elochoman, and Grays River stocks have also been imported to fill hatchery needs.

Table 1 provides terminal return information. Based on coded-wire tags (CWT), Washougal River annual sport catch of fall chinook has ranged widely, from 34 to 1,283 adult chinook, with a 1977 through 1987 average of 356 adults. In addition, jacks are commonly taken along with adult fish. Natural escapement is estimated using spawning ground counts within selected index areas. Natural spawning has ranged from about 300 to 3,500 adults, with a 1977 through 1987 average of 1,838 fish. Again, these fish are considered hatchery strays. Returns to the hatchery over the last 10 years has varied from about 1,700 to over 10,000 fish, with an average of about 3,700 adult chinook. Total returns to the system, including sport catches, natural spawning, and hatchery returns has averaged about 5,900 adults and 850 jacks.

Table 1. Washougal fall chinook stock abundance and harvest information.

YEAR	Sport Catch /1		Natural Escapement /2		Hatchery Escapement		Total Returns	
	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults
1977	88	34	99	1553	0	3317	187	4904
1978	201	251	0	593	0	2801	201	3645
1979	34	50	0	2388	0	2480	34	4918
1980	93	741	285	3152	121	1717	499	5610
1981	128	428	52	1789	101	3659	281	5876
1982	65	240	29	301	243	2565	337	3106
1983	114	103	0	2677	62	3996	176	6776
1984	78	340	22	1195	159	1957	259	3492
1985	182	168	260	1723	5633	2298	6075	4189
1986	184	361	318	1271	586	10402	1088	12034
1987	79	1283	47	3578	104	5704	230	10565
average	113	364	101	1838	637	3718	852	5920

1/ punch card information
2/ Stock Assessment, 1985

Based on hatchery returns, the female composition averages about 44 percent, but has ranged from a low of 28 percent and a high of 56 percent. Eggs per female averages 4,354, with an egg-to-smolt survival rate of 92.5 percent. The majority of the chinook returning to the hatchery are 3- and 4-year-olds, with a 1982 through 1987 average of 43.7 percent and 35.5 percent, respectively. Jacks, which are considered to be 2-year-olds with only a single ocean year, constitute 16.3 percent, while 5-year-olds constitute 4.5 percent. Information pertaining to natural spawning chinook show the same general trends, but with a higher percentage of 4-year-olds (Tables 2 and 3). Length-frequency information was not available.

Adult chinook move into the Washougal River late September through the middle of November (Table 4). The holding period is relatively short with spawning occurring from the first of October through November. Incubation takes place from early October through January, with emergence sometime in February. Under natural conditions, lower river hatchery chinook generally migrate downstream as subyearlings, leaving the river by late summer or fall. A small percentage of juveniles do remain in the system throughout the winter, outmigrating as yearlings (Reimers and Loeffel 1967). In terms of numbers, fingerlings constitute the majority of the releases from the Washougal Hatchery, leaving the facility by June or July. Annual releases of these fish are in the neighborhood of 5.5 million to 6 million fingerlings. In addition, summer releases from the hatchery also constitute an important part of the hatchery program, with releases averaging about 350,000 fish annually. Table 5 presents release totals for brood years 1975 through 1986.

Specific Considerations

In general, the primary objective for most lower river chinook production is directed at providing harvest opportunities outside the Washougal River. This includes ocean fisheries and mainstem Columbia fisheries. Current escapement goals are thus focused on achieving hatchery escapement. There are no natural spawning goals.

Lower river chinook stocks are generally harvested to their maximum limits. Because of the difficulty in achieving escapement goals, these fish often constrain subsequent coho fisheries. LRH chinook are not considered to contribute significantly to terminal fisheries within the tributaries. Generally, the terminal recreation fisheries harvests about 10 percent of the total number of chinook entering any particular tributary. Surpluses are taken at the hatcheries.

Table 2. Washougal fall chinook sex ratios and fecundity.

RETURN YEAR	Males	Females	Jacks	Total Adults	Percent Females	Eggs/ Female	Egg/smlt Survival
1979	1261	1040	?	2301	0.45	4402	0.886
1980	1096	573	121	1669	0.34	4510	0.912
1981	1628	2031	101	3659	0.56	4818	0.879
1982	1282	1283	243	2565	0.50	4144	0.937
1983	2221	1775	62	3996	0.44	4036	0.978
1984	929	1028	159	1957	0.53	4577	0.908
1985	1365	914	5425	2279	0.40	4661	0.935
1986	7458	2944	586	10402	0.28	4147	0.916
1987	3760	1944	104	5704	0.34	3849	0.975
1988	2575	2644	225	5219	0.51	4391	
average	2358	1618	781	3975	0.44	4354	0.925

Table 3. Washougal fall chinook stock size and age composition.

AGE FW.OCEAN	% of Total	Mean Fk Length	Sample Size
Natural /1			
1.1	5.5	NA	1112
1.2	19.7	NA	4205
1.3	66.7	NA	14232
1.4	8.4	NA	1783
Hatchery /2			
1.1	16.3	NA	5503
1.2	43.7	NA	14711
1.3	35.5	NA	11975
1.4	4.5	NA	1514
1.5	0.02	NA	6

1) From WDF Scale Card Data Summary 1977-1987

2) WDF Scale Card Data Columbia River staff memos Summary 1982-1987

Table 4. Washougal fall chinook freshwater life history.

	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
ADULT IMMIGRATION							-----	-----	-----			
ADULT HOLDING							-----	-----	-----			
SPAWNING								-----	-----			
EGG/ALEVIN INCUBATION								-----	-----	-----	-----	
EMERGENCE											-----	-----
REARING	-----	-----	-----	-----	-----	-----*					-----	-----
JUVENILE EMIGRATION			-----	-----	-----							

* = fall release of hatchery fish

Table 5. Washougal fall chinook hatchery production.

Brood Year	Number Released Fry	Fingerlings	Smolts
1975		1,599,724 a	416,064
1976		3,783,532 b	636,000
1977		6,258,966	410,000
1978		4,673,388 c	413,585 d
1979		6,093,931 e	
1980		6,045,244 f	396,800
1981	1,016,000	5,719,500	
1982	168,000 g	6,187,600 h	359,700
1983		5,846,662 i	369,826
1984	25,000	5,705,250 j	331,500
1985		5,808,200 k	354,800
1986		5,844,000	363,000

a 493,850 Kalama Falls stock
b 1,982,519 Bonneville stock
c 1,635,478 Toutle stock
d Toutle stock
e 840,100 Cowlitz stock; 1,084,000 Toutle stock
f 4,223,500 Bonneville stock
g WF Washougal River
h 2,084,500 Bonneville stock
i 384,400 Kalama Falls stock
j 79,750 Grays River stock; 1,896,500 Kalama Falls stock
k 1,651,100 Abernathy stock; 568,900 Cowlitz; 75,600 Elokomin stock

When considering objectives, focus is therefore directed onto hatchery escapement and the relationship to harvest management regimes. Because of the widespread intertributary transfers of the lower river hatchery stocks, maintaining distinct genetic populations does not receive the importance as in the upriver areas. Disease considerations are more important.

Production increases of LRH fish in the Washougal or any other system should not conflict with United States vs. Oregon. In addition, production increases should take into account estuary survival rates. The Monitoring and Evaluation Plan, under the auspices of the Monitoring and Evaluation Group (MEG) is considered responsible for guidance of this plan.

Objectives

Biological Objectives

1. Manage both lower river hatchery (LRH) and upriver bright (URB) fall chinook as a hatchery stocks.

2. Release 5 million fingerling LRH chinook on an annual basis. This would require a brood stock of 2,400 adults

3. Release 1 million fingerling URB chinook on an annual basis. This would require a brood stock of about 500 adults.

4. Develop the latest upriver bright run timing possible to allow for the extended fishery.

Utilization Objectives

1. Maximize fall chinook fishery opportunities through the use of both LRH and URB fall chinook.

2. Provide LRH production levels that will result in potential terminal harvest opportunities of an estimated 4,200 adults fish.

3. Establish a late fall/winter run of upriver brights at Washougal Hatchery to provide for terminal fishing opportunities at levels that would support a potential annual subbasin harvest of 700 adults.

Alternative Strategies

Modeling results for each strategy are presented in Table 6a as fish produced at "maximum sustainable yield" (MSY). The sustainable yield of a fish population refers to that portion of the population that exceeds the number of fish required to spawn and maintain the population over time. Sustainable yield can be "maximized," termed MSY, for each stock at a specific harvest level. The MSY is estimated using a formula (Beverton-Holt function) that analyzes a broad range of harvest rates. Subbasin planners have used MSY as a tool to standardize results so that decision makers can compare stocks and strategies.

In MSY management, managers set a spawning escapement level and the remaining fish (yield) could theoretically be harvested. In practice, a portion of the yield may be reserved as a buffer or to aid rebuilding. Thus, managers may raise the escapement level to meet a biological objective at the expense of a higher utilization objective.

The amount of buffer appropriate for each stock is a management question not addressed in the subbasin plans. For this reason, the utilization objective, which usually refers to harvest, may not be directly comparable to the MSY shown in Table 6a. At a minimum, a strategy should produce an estimated MSY equal to or greater than the utilization objective. A MSY substantially larger than the subbasin utilization objective may be needed to meet subbasin biological objectives.

Estimated costs of the alternative strategies below are summarized in Table 6b.

STRATEGY 1: Natural Stock Enhancement.

NO ACTIONS IDENTIFIED

STRATEGY 2: Artificial Propagation and New Stock Introduction.

This strategy would consist of actions that focus on hatchery improvements. Such actions would not only apply to fall chinook, but also benefit coho and possibly spring chinook (if introduced as an additional hatchery component). This strategy would include the reprogramming of the Washougal Hatchery to include 1 million upriver brights, to be reared on station.

This strategy assumes that increased production of lower river hatchery and upriver bright chinook will survive at current rates. It also assumes that disease problems will not become a major constraint, either in terms of inriver brood-stocking and rearing or transfer of stocks into the system from other watersheds.

ACTIONS: 1-8

1. Improve water resources to Washougal Hatchery with the addition of an auxiliary intake. Additional water will be used primarily during April and May when coho production stresses the present capacity of the system. Water resources are available.

2. Formalize the bottom and sides of large rearing hatchery pond (lagoon). It would entail asphalting the pond to provide healthier conditions and improve handling of fish.

3. Cover the two banks of standard ponds (24 ponds total) with netting to protect from bird predation.

4. Provide additional hatchery incubation by 20 percent to eliminate potential space constraints. This would help chinook as well as coho production.

5. Construct rearing ponds for the addition of 1 million Type-S coho. Improved water resources, as suggested in Action 1, would also be needed to support this program.

6. Add an adjustable valve to make use of Bob's Creek overflow. This would increase the water quality to the upper bank of standard ponds (1-12) during the spring.

7. Configure plumbing to allow Boyles Creek water to go directly to the head of the lower bank of standard ponds (13-24). Water would be cooler and have less pathogen load than Washougal River water. Currently Boyles Creek water has to be mixed with the outflow of ponds (1-12) if it is to be used in the lower bank of standard ponds.

8. Introduce upriver brights for rearing at the Washougal Hatchery with release of 1 million fingerlings on an annual basis. Original brood stock should be a late-timed component with the recommendation that adults come from the trap at Bonneville Dam. Eggs will be transferred to the Washougal. A minimum of four years is needed to establish a self-supporting program.

Returns of upriver brights will be selectively bred to produce an ever-increasing later run timing. To eliminate mixing, lower river hatchery chinook will not be taken for brood stock after October 30. To accommodate the 1 million upriver bright chinook, the current LRH chinook program must be reduced by 1 million.

Since 1 million LRH fall chinook will be displaced through this action, reduction is potential coastal ocean fishery can be expected. However, the aggregate impact will be small.

STRATEGY 3: Artificial Propagation with Additional Supplementation.

This strategy would include those actions in Strategy 2, with the addition of an off-station net pen program to compensate for the loss of 1 million lower river hatchery fish. Implementation of this strategy assumes that a net pen site can be located and that the necessary permits would be granted. Net pen rearing within this system has not been tried before, thus rearing success and return to the system may not be easily predicted.

ACTIONS: 1-9

1-8. -

9. Identify a site for a net pen rearing program within the lower Washougal, such as in the Camas Slough area, to rear 1 million lower river hatchery chinook.

Recommended Strategy

Strategy 3 is the recommended strategy. It fulfills the objectives and compensates for the lost on-station production of the lower river hatchery fish. Upriver brights would be introduced into the system to provide additional opportunities in Washougal River.

Table 6a. System Planning Model results for fall chinook in the Washougal Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:

1. Maximize fall chinook fishery opportunities through the use of both LRH and URB fall chinook. 2. Provide LRH production levels that will result in potential terminal harvest opportunities of an estimated 3,500 adults fish. 3. Establish a late fall/winter run of URB at Washougal Hatchery to provide for terminal fishing opportunities at levels that would support a potential annual subbasin harvest of 700 adults.

Biological Objective:

1. Manage both LRH and URB as hatchery stocks. 2. Release 5 million fingerling LRH chinook on an annual basis. This would require a brood stock of 2400 adults. 3. Release 1 million fingerlings URB on an annual basis. This would require a brood stock of about 500 adults. 4. Develop the latest URB run timing possible to allow for the extended fishery.

Strategy[1]	Maximum Sustainable Yield (MSY)[2]	Total Spawning Return[3]	Total Return to Subbasin[4]	Out of Subbasin Harvest[5]	Contribution To Council's Goal (Index)[6]
Baseline	568 -C	6,207	7,102	47,442	0(1.00)
All Nat	568 -C	6,207	7,102	47,442	0(1.00)
1	568 -C	6,207	7,102	47,442	0(1.00)
2	568 -C	6,207	7,102	47,442	0(1.00)
3*	899 -C	6,261	7,489	49,739	2,685(1.05)

*Recommended strategy.

[1]Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

1. Natural stock enhancement. Pre Mainstem Implementation.
2. Artificial propagation and new stock introduction. Pre Mainstem Implementation.
3. Artificial propagation with additional supplementation. Pre Mainstem Implementation.
4. Introduce Up river brights into the Washougal. Pre Mainstem Implementation.

[2]MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

[3]Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

[4]Total return to the mouth of the subbasin.

[5]Includes ocean, estuary, and mainstem Columbia harvest.

[6]The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

Table 6b. Estimated costs of alternative strategies for Washougal fall chinook. Cost estimates represent new or additional costs to the 1987 Columbia River Basin Fish and Wildlife Program; they do not represent projects funded under other programs, such as the Lower Snake River Compensation Plan or a public utility district settlement agreement. (For itemized costs, see Appendix C.)

	Proposed Strategies		
	1	2	3*
Hatchery Costs			
Capital[1]	0	0	0
O&M/yr[2]	0	0	25,000
Other Costs			
Capital[3]	0	1,300,000	2,300,000
O&M/yr[4]	0	0	40,000
Total Costs			
Capital	0	1,300,000	2,300,000
O&M/yr	0	0	65,000

* Recommended strategy.

[1] Estimated capital costs of constructing a new, modern fish hatchery. In some subbasins, costs may be reduced by expanding existing facilities. For consistency, estimate is based on $23/pound of fish produced. Note that actual costs can vary greatly, especially depending on whether surface or well water is used and, if the latter, the number and depth of the wells.

[2] Estimated operation and maintenance costs per year directly associated with new hatchery production. Estimates are based on $2.50/pound of fish produced. For consistency, O&M costs are based on 50 years.

[3] Capital costs of projects (other than direct hatchery costs) proposed under a particular strategy, such as enhancing habitat, screening diversions, removing passage barriers, and installing net pens (see text for specific actions).

[4] Estimated operation and maintenance costs per year of projects other than those directly associated with new hatchery production. For consistency, O&M costs are based on 50 years.

SPRING CHINOOK SALMON

Fisheries Resource

Spring chinook are not resident fish of the Washougal River, nor have introduction attempts occurred in the past.

Specific Considerations

Because of warm water temperatures, spring chinook cannot successfully propagate in the Washougal River. The purpose, however, would involve annual releases into the Washougal to provide harvest opportunities on the returning adults, with no intent of capturing brood stock.

Objectives

Biological Objectives

1. Manage spring chinook on a hatchery basis.

2. Release 100,000 yearling spring chinook on an annual basis. This would require a brood stock of about 50 additional adults to be programmed at Kalama Falls Hatchery.

Utilization Objective

Create an early sport fishery opportunity by introducing a spring chinook program at the Washougal Hatchery with potential terminal harvest level of 500.

Alterative Strategies

Planners did not model the following strategies. Estimated costs, however, of the alternative strategies below are summarized in Table 6c.

STRATEGY 1: Natural Stock Enhancement.

NO ACTIONS IDENTIFIED

STRATEGY 2: Supplementation.

NO ACTIONS IDENTIFIED

STRATEGY 3: Artificial Propagation.

This strategy involves the introduction of spring chinook into the system. A major assumption is that a brood stock source will be available on an annual basis for transfer into the Washougal River. Disease and lack of brood stock may preclude transfer in some years. One constraint that was brought out during the public meeting process was the fear that terminal harvest of spring chinook could result in illegal snag fisheries. This problem has occurred with other stocks in other rivers. A number of factors, such as concentration in holding areas, release patterns, and angler access to harvest fish throughout the system, will determine the extent of temptation to use snagging equipment.

ACTIONS: 1

1. Release 100,000 spring chinook from the Washougal Hatchery. Fish would be transferred as fingerlings from Kalama Falls Hatchery or another appropriate hatchery and released as yearlings during the subsequent spring. This program is linked to the upriver bright program in that pond space for the rearing of spring chinook will not be available unless the upriver bright proposal is instigated. Because of water temperatures in the Washougal, adults will not survive until spawning. Therefore plans must include annual transfer of fingerlings to the Washougal.

STRATEGY 4: Introduction of New Stock and Hatchery Improvements.

This strategy includes the introduction of spring chinook into the system and the proposed hatchery improvements as identified in the fall chinook section. Assumptions and constraints are addressed in Strategy 2, fall chinook.

ACTIONS: 1, 2

1. -

2. Hatchery improvements, as noted in the fall chinook action section, will help assure that the Washougal facility can adequately support a spring chinook program.

Recommended Strategy

Strategy 4 is the recommended strategy, which is to proceed with the introduction of spring chinook into the Washougal River. No modeling of this stock was done. From other release programs, it was estimated that production of 100,000 smolts would provide returns of about 500 adults back to the river.

Table 6c. Estimated costs of alternative strategies for Washougal spring chinook. Cost estimates represent new or additional costs to the 1987 Columbia River Basin Fish and Wildlife Program; they do not represent projects funded under other programs, such as the Lower Snake River Compensation Plan or a public utility district settlement agreement. (For itemized costs, see Appendix C.)

	Proposed Strategies			
	1	2	3	4*
Hatchery Costs				
Capital[1]	0	0	230,000	230,000
O&M/yr[2]	0	0	25,000	25,000
Other Costs				
Capital[3]	0	0	0	1,300,000
O&M/yr[4]	0	0	0	0
Total Costs				
Capital	0	0	230,000	1,530,000
O&M/yr	0	0	25,000	25,000

* Recommended strategy.

[1] Estimated capital costs of constructing a new, modern fish hatchery. In some subbasins, costs may be reduced by expanding existing facilities. For consistency, estimate is based on $23/pound of fish produced. Note that actual costs can vary greatly, especially depending on whether surface or well water is used and, if the latter, the number and depth of the wells.

[2] Estimated operation and maintenance costs per year directly associated with new hatchery production. Estimates are based on $2.50/pound of fish produced. For consistency, O&M costs are based on 50 years.

[3] Capital costs of projects (other than direct hatchery costs) proposed under a particular strategy, such as enhancing habitat, screening diversions, removing passage barriers, and installing net pens (see text for specific actions).

[4] Estimated operation and maintenance costs per year of projects other than those directly associated with new hatchery production. For consistency, O&M costs are based on 50 years.

COHO SALMON

Fisheries Resource

Coho returning to the Columbia River are managed according to two major stocks. The early-returning fish are referred to as the south-turning or S-type fish because they contribute well to the more southern ocean fisheries. They are generally recognized as Toutle River origin fish. The late-returning coho are referred to as north-turning or N-type fish because they contribute more heavily to the northern ocean fisheries. They are generally recognized as Cowlitz origin hatchery fish. Coho returning to the Washougal River include both types and are managed accordingly.

For discussion purposes, background information for Type-S and Type-N coho will be treated separately. Because of closely related management ties, however, objectives and strategies will be treated collectively. Washougal coho are intrinsically tied to United States vs. Oregon, whereby the Washougal Hatchery will be used to rear coho for transfer into the Klickitat; on-station releases into the Washougal River will exist only for brood stock maintenance.

The following information is based on recent historical data, pertaining to past release programs. Future production and release strategies will be significantly different.

Type-S Coho

Prior to 1982, data for lower river coho were not separated into the "N" or "S" components. Thus information summarized in this section refers to data beginning in 1982. Washougal Type-S coho are managed as hatchery fish. Adult straying does occur, but the number and success of natural spawning in the Washougal has not been assessed. Escapement to the subbasin is dependent on a number of factors, some of which include estuary and ocean survival, ocean interceptions and pre-terminal harvests within the Columbia River.

Terminal returns have averaged about 9,000 adults, but actual annual returns widely fluctuate (1987 realized only 642 adults while 1982 had a return of over 18,000). The inriver sport harvest varies from year to year. Based on punch-card information, in 1983 only 79 adults were taken. In 1982, 1,144 adults were listed. The average is about 500 adults, or 5 percent of the returning adults.

Achieving the hatchery goal is largely a function of ocean and mainstem fisheries. Fisheries are not managed on specific hatchery needs. Rather, they are managed according to total escapement needs to all hatcheries. Deficits are made up by transfers from other stations.

Returning adults are primarily 3-year-olds, with one freshwater year and two ocean years. Length-frequency information is not available. Female composition averages about 39 percent, with eggs per female averaging 2,355. Egg-to-smolt survival is generally about 87 percent.

Adult migration into the Washougal River occurs from the beginning of September through November. Holding is relatively short, with spawning commencing about mid-October and going through November. Incubation extends from late October through January, with emergence occurring in late January and early February. The duration of hatchery rearing depends upon the release strategy. Fry, fingerlings and smolts have all been released. More recently, however, it has been fingerling and smolt releases. Fingerling releases have not been consistent from year to year, and largely dependent upon hatchery capacity and the need to move fish out to maximize yearling production. Yearling releases from Washougal Hatchery are generally in the neighborhood of 1 million fish.

Fingerling off-station releases have occurred, and selected Washougal tributaries for fingerling production have been identified by the habitat division of the Washington Department of Fisheries (Johnson 1988). Yearlings are released on station.

Tables 7 through 11 provide details of the above information.

Table 7. Washougal coho (type-S) stock abundance and harvest information.

YEAR		Sport Catch		Natural Escapement		Hatchery Escapement		Total Returns	
		Jacks	Adults	Jacks	Adults**	Jacks	Adults	Jacks	Adults
1977 *		293	111	NA	NA	274	1477	567	1588
1978 *		322	402	NA	NA	8500	9165	8822	9567
1979 *		350	547	NA	NA	186	7252	536	7799
1980 *		62	488	NA	NA	920	13532	982	14020
1981 *		369	671	NA	NA	1850	12830	2219	13501
1982		301	1144	NA	NA	1079	16956	1380	18100
1983		89	79	NA	NA	440	4483	529	4562
1984		92	597	NA	NA	481	7341	573	7938
1985		327	264	NA	NA	1434	4489	1761	4753
1986		145	725	NA	NA	48	16999	193	17724
1987		5	91	NA	NA	18	551	23	642
	averages 1982-1987	160	483			583	8470	743	8953

* Prior to 1982 coho were not separated into the early and late runs.
** Considered minimum escapement.

Table 8. Washougal coho (type-S) sex ratios and fecundity.

RETURN	Males	Females	Jacks	Total Adults	Percent Females	Eggs/ Female	Egg/smlt Survival
1979	3794	2948	186	6742	0.44	2449	0.72
1980	6887	6675	765	13562	0.49	2653	0.91
1981	6919	3729	1865	10648	0.35	2515	0.84
1982	8521	5490	1079	14011	0.39	2522	0.87
1983	2723	1760	440	4483	0.39	2124	0.88
1984	4718	2623	481	7341	0.36	2650	0.38
1985	2554	1935	1434	4489	0.43	2269	0.91
1986	8982	8017	48	16999	0.47	2240	0.88
1987	386	165	18	551	0.30	2073	*
1988	401	179	24	580	0.31	2056	*
			10 year average =		0.39	2355	0.80

Table 9. Washougal coho (type-S) Age data (1982-1987).

AGE FW.OCEAN	% of Total	Mean Fk Length	Sample Size
1.1	7.6	NA	4,467
1.2	92.4	NA	54,398
TOTAL			58,865

Table 10. Washougal coho (type-S)* freshwater life history.

	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
ADULT IMMIGRATION							-------	-------	-------			
ADULT HOLDING							----	-------	-------			
SPAWNING								----	-------			
EGG/ALEVIN INCUBATION								----	-------	-------	-------	--
EMERGENCE											-------	----
REARING	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
JUVENILE EMIGRATION		----	----									

* Life cycle for hatchery reared fish;
Type-S coho are shipped off-station in March, normal on-station releases occur in early May.

Table 11. Washougal hatchery production (type-S).

Brood Year	Number Released Fry	Fingerlings	Smolts
1975	204,000 a		968,704
1976	233,937 b	848,000	2,085,990
1977			1,277,500
1978	166,600		
1979	402,495 c	229,000 e	1,410,682
1980	932,750 d	1,444,282 f	1,346,710
1981			906,300
1982		401,800 g	1,062,570
1983			1,064,760
1984		151,000 h	1,075,300
1985			26,082
1986		78,850 i	

a Canyon Creek release
b WF Washougal release
c 352,895 Canyon Creek release
d 69,000 McCloskey Ck; 211,900 Canyon Ck; 402,850 WF Washougal rele
e 189,000 WF Washougal release
f 202,000 WF Washougal release
g 83,000 WF Washougal; 83,000 McCloskey Ck; 22,000 Cougar Ck releas
h 42,000 Canyon Ck; 87,000 WF Washougal; 6,000 Cougar Ck;
7,000 Jones Ck; 9,000 Boulder Ck releases
i 13,650 Jones Ck releases

Type-N Coho

When considering Type-N coho in general, the majority of the harvest occurs in the ocean (74 percent) and mainstem Columbia (24 percent) (Stock Assessment Report 1985). Since it is managed strictly as a hatchery stock, escapement is based only upon hatchery needs. Since this coho is considered a single stock, regardless of its river of origin, interhatchery transfers, based on need, have been common practice.

The Washougal River is a major producer of Type-N coho. Annual yearling production has been 2 million fish. Fingerling releases range from about 100,000 to 400,000 fish. Adult returns to the subbasin have ranged from about 3,000 to 12,000 fish, with an average of 5,800. Current program goal is 3 million fish, with 2.5 million destined for Klickitat, while 0.5 million fish remaining for on-station production.

The majority of the fish return to the hatchery. Natural spawning does occur, primarily as a result of straying, but no consistent surveys have been conducted to determine actual numbers.

Inriver harvest is restricted to sport fisheries. Based on punch-card data, annual catches vary considerably. Harvest of Type-N coho in 1982 was recorded as 60 adults while in 1986, 1,899 fish were taken. The average is about 500 fish. This translates into about 9 percent of the total adults returning to the river.

The average composition of females is 27 percent, with the average number of eggs per female is 2,390. Hatchery egg-to-smolt survival is 85.5 percent. Fish generally return as 3-year-olds (88.1 percent). The remainder return as 2-year-old jacks.

Type-N coho are about two months later than Type-S coho. The first fish move in at the beginning of November and continue through December. Adult holding goes through late January with spawning occurring mid-December through January. Incubation is normally completed by the end of March, with emergence up through April. Juveniles normally spend one year in fresh water before outmigration, which takes place in May and June.

As mentioned previously, juveniles have usually been released from the hatchery as yearlings. Fingerling releases were commonly planted off station in such tributaries as Deer, McCloskey, Duncan, Canyon, and Salmon creeks. Tables 12 through 16 provide more detailed information for Type-N coho.

Specific Considerations

Past coho programs for the Washougal Hatchery have been inbasin releases directed toward an overall objective to provide for ocean fisheries. Current and future objectives are significantly different, as stated within the United States vs. Oregon agreement. Although the non-Indian ocean, non-Indian lower river and Indian harvests of coho are not subject to formal allocations, attempts are being made to satisfy treaty Indian needs for both early and late runs. This need has been translated into upriver release programs using primarily two lower river hatcheries as rearing facilities. One of these is an Oregon facility, Cascade Hatchery. The other is the Washougal Hatchery.

The agreement originally called for 0.5 million early coho and 2 million late coho to be transported from the Washougal Hatchery, or other appropriate hatcheries, to the Klickitat Hatchery where they will be released. Production capacity at the Washougal Hatchery is currently 2 million late coho and 1 million early coho. Thus, the agreement identified a transfer of 100 percent of the late coho and 50 percent of the early coho to Klickitat. Since the original agreement, there have been modifications, but the total amount of coho that is transferred remains the same.

Early coho have been discontinued at Washougal Hatchery. Instead, all coho production will involve late coho. The production goal is 3 million fish, with 2.5 million being transferred to Klickitat and 0.5 million remaining at Washougal for on-station release to maintain the brood stock program. All fish will be reared to yearlings.

Since Klickitat releases are high priority, establishment of consistent objectives specifically for the Washougal River, other than the 0.5 million on-station release, will be limited.

Table 12. Washougal coho (type-N), stock abundance and harvest information.

YEAR	Sport Catch		Natural Escapement		Hatchery Escapement		Total Returns	
	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults
1982 **	17	60	NA	NA	687	4917	704	4977
1983	56	93	NA	NA	836	4105	892	4198
1984	417	754	NA	NA	1065	6375	1482	7129
1985	145	204	NA	NA	965	2743	1110	2947 *
1986	336	1899	NA	NA	158	10443	494	12342 *
1987	4	63	NA	NA	39	3196	43	3259
averages	163	512			625	5297	788	5809

* Does not include natural escapement.
**Information not available for previous years.

Table 13. Washougal coho (type-N) sex ratios and fecundity.

RETURN YEAR	Males	Females	Jacks	Total Adults	Percent Females	Eggs/ Female	Egg/smlt Survival
1982	3433	1484	687	4917	0.30	2827	83.9
1983	3034	1071	836	4105	0.26	2007	87.7
1984	4814	1561	1065	6375	0.24	2262	89.4
1985	1720	1023	965	2743	0.37	2634	82.8
1986	8241	2202	158	10443	0.21	2341	84.0
1987	2339	857	39	3196	0.27	2490	*
1988	2326	674	215	3000	0.22	2166	*
averages	3701	1267	566	4968	0.27	2390	85.6

Table 14. Washougal coho (type-N) stock size and age information.

AGE FW.OCEAN	% of Total	Mean Fk Length	Sample Size
1.1	11.9	N/A	4730
1.2	88.1	N/A	35859

Table 15. Washougal coho (type-N) freshwater life history.

	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
ADULT IMMIGRATION									----	----		
ADULT HOLDING									----	----	----	
SPAWNING										----	----	
EGG/ALEVIN INCUBATION	----	----									----	----
EMERGENCE	----	----										
REARING	----	----	----	----	----	----	----	----	----	----	----	----
JUVENILE			----	----								

Table 16. Washougal hatchery production, coho (type-N).

Brood Year	Number Released: Fry	Fingerlings	Smolts
1975			1,591,088
1976			
1977			942,648
1978	241,680 a		329,653
1979	63,000		1,698,093
1980		393,450 b	1,653,271
1981		121,468 c	2,145,703
1982		174,000 d	2,035,630
1983		94,700 e	2,118,900
1984		80,000	1,951,300
1985		294,000 f	547,818
1986		150,800 g	

a 150,480 Deer Creek releases
b 86,000 WF Washougal
c 16,300 McCloskey Dreek; 16,300 Canyon Creek releases
d 25,000 McCloskey Ck; 106,300 WF Washougal; 42,700 Canyon Ck
e 42,700 Cougar Ck; 32,000 Canyon Ck
f 54,000 Canyon Creek
g 42,700 Canyon Creek

Objectives

Biological Objectives

1. Maintain coho management on a hatchery basis, including both early and late types.

2. For Type-N coho, achieve an annual release of 3 million from the Washougal Hatchery. Transfer 2.5 million coho to the Klickitat facility and retain 0.5 million fish for brood stock purposes. All fish should be reared to yearlings.

3. Restore Type-S coho production to previous levels, prior to the Klickitat transfer program. This would require additional production of 1 million coho to be released on station. Brood stock needs for this level of production are 1,100 adults.

4. Utilize existing habitat in the Washougal and tributaries for natural production.

Utilization Objectives

1. Maintain ocean fishery harvest opportunities in addition to increasing terminal harvest opportunities for recreational and tribal fisheries.

2. For Type-N coho, satisfy United States vs. Oregon obligation for annual transfer of 2 million juvenile coho to Klickitat Hatchery. No terminal harvest objectives will be identified.

3. Reintroduce Type-S coho to provide potential harvest opportunities of 7,800 fish within the terminal region.

Alternative Strategies

Modeling results for each strategy are presented in Tables 17a and 17b as fish produced at "maximum sustainable yield" (MSY). The sustainable yield of a fish population refers to that portion of the population that exceeds the number of fish required to spawn and maintain the population over time. Sustainable yield can be "maximized," termed MSY, for each stock at a specific harvest level. The MSY is estimated using a formula (Beverton-Holt function) that analyzes a broad range of harvest rates. Subbasin planners have used MSY as a tool to standardize results so that decision makers can compare stocks and strategies.

In MSY management, managers set a spawning escapement level and the remaining fish (yield) could theoretically be harvested. In practice, a portion of the yield may be reserved as a buffer or to aid rebuilding. Thus, managers may raise the escapement level to meet a biological objective at the expense of a higher utilization objective.

The amount of buffer appropriate for each stock is a management question not addressed in the subbasin plans. For this reason, the utilization objective, which usually refers to harvest, may not be directly comparable to the MSY shown in Tables 17a and 17b. At a minimum, a strategy should produce an estimated MSY equal to or greater than the utilization objective. A MSY substantially larger than the subbasin utilization objective may be needed to meet subbasin biological objectives.

Estimated costs of the alternative strategies below are summarized in Table 17c.

STRATEGY 1: Natural Stock Enhancement.

The strategy is not intended to replace the hatchery program that currently exists, but to supplement production through enhancement of natural production and survival. It should be noted that modeling of this strategy assumes increased juvenile survival rates. The level of increase is largely unknown. However, certain rates were selected for modeling, based on the assumption that they are somewhat accurate.

ACTIONS: 7, 8

7. Inventory diversions to identify needed screening improvements.

8. Continue with the off-station release programs to the extent that surplus fish will be planted in appropriate tributaries.

STRATEGY 2: Artificial Propagation.

This strategy includes actions that would improve the hatchery production operations that currently exist. It would also include provisions for additional rearing ponds for lost production of the early coho. This strategy also involves transfer of the majority of the late coho to Klickitat, resulting in a decrease in production and return to the Washougal River.

ACTIONS: 1-9, 11

1. Improve water resources to Washougal Hatchery with the addition of an auxiliary intake. Additional water will be used primarily during April and May when coho production stresses the present capacity of the system. Water resources are available.

2. Formalize the bottom and sides of large rearing hatchery pond (lagoon). It would entail asphalting the pond to provide healthier conditions and improve handling of fish.

3. Cover the two banks of standard ponds (24 ponds total) with netting to protect from bird predation.

4. Provide additional hatchery incubation by 20 percent to eliminate potential space constraints. This would help chinook as well as coho production.

5. Add an adjustable valve to make use of Bob's Creek overflow. This would increase the water quality to the upper bank of standard ponds (1-12) during the spring.

6. Configure plumbing to allow Boyles Creek water to go directly to the head of the lower bank of standard ponds (13-24). Water would be cooler and have less pathogen load than Washougal River water. Currently Boyles Creek water has to be mixed with the outflow of ponds (1-12) if it is to be used in the lower bank of standard ponds.

7. -
8. -

9. Construct an acclimation pond on the Klickitat River to allow earlier transfer of coho, thus relieving water and space constraints at Washougal Hatchery.

11. Construct rearing ponds for the addition of 1 million Type-S coho. Improved water resources, as suggested in Action 1 would also be needed to support this program.

STRATEGY 3: Combined Natural and Artificial Production.

This strategy includes the implementation of Strategy 2 along with Action 10, which would supplement hatchery stock production of the early stock, with an additional release of 1 million coho. This strategy assumes that a net pen site could be located within the lower Washougal. Like the fall chinook proposal, this activity would be new; survival and returns rates are unknown.

ACTIONS: 1-11

1-9. -

10. Develop net pen program in Camas Slough to rear 1 million yearlings. This could be considered an option for the reintroduction of Type-S coho.

11. -

Recommended Strategy

Strategy 2 in the recommended strategy. This adheres to the United States vs. Oregon agreement of providing tribal opportunity of late coho and attempts to replace the lost production of early coho. While the subbasin returns of late coho fall from about 30,000 to 10,000 adults, hatchery improvements along with expanded rearing facilities should increase the early coho production from about 10,000 to 12,600 fish, based on the System Planning Model.

Table 17a. System Planning Model results for early-run coho in the Washougal Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
1. Maintain ocean fishery harvest opportunities in add. to increasing terminal harvest opp. for recreational and tribal fisheries, 2. For type-N, satisfy U.S. v Oregon obligation for annual transfer of 2 million juveniles to Klickitat Hatchery. No terminal harvest objectives will be identified. 3. Reintroduce type-S to provide potential harvest opportunities of 7,800 fish within the terminal region.

Biological Objective:
1. Maintain coho man. on a hatchery basis, including both early and late types. 2. For type-N, achieve an annual releases of 3 million from the Washougal Hatchery. Provide 2.5 million transfer to Klickitat facility with 0.5 million retained for brood stock. Rear fish to yearlings. 3. Restore type-S prod. to previous levels, prior to the Klick. transfer program. 1 million add. prod. released on-station. Brood stock 1,100 adults. 4. Utilize existing habitat in the subbasin for natural spawning.

Strategy[1]	Maximum Sustainable Yield (MSY)[2]	Total Spawning Return[3]	Total Return to Subbasin[4]	Out of Subbasin Harvest[5]	Contribution To Council's Goal (Index)[6]
Baseline	113 -N	10,647	11,321	38,304	0(1.00)
All Nat	113 -N	10,647	11,321	38,304	0(1.00)
1	113 -N	10,647	11,321	38,304	0(1.00)
2*	135 -N	12,676	13,478	45,603	9,456(1.19)
3	135 -N	12,689	13,492	45,649	9,516(1.19)

*Recommended strategy.

[1]Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

1. Natural stock enhancement. Pre Mainstem Implementation.
2. Artificial propagation. Pre Mainstem Implementation.
3. Combined natural and artificial production. Pre Mainstem Implementation.

[2]MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

[3]Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

[4]Total return to the mouth of the subbasin.

[5]Includes ocean, estuary, and mainstem Columbia harvest.

[6]The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

Table 17b. System Planning Model results for late-run coho in the Washougal Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
1. Maintain ocean fishery harvest opportunities in add. to increasing terminal harvest opp. for recreational and tribal fisheries. 2. For type-N, satisfy U.S. v Oregon obligation for annual transfer of 2 million juveniles to Klickitat Hatchery. No terminal harvest objectives will be identified. 3. Reintroduce type-S to provide potential harvest opportunities of 7,800 fish within the terminal region.

Biological Objective:
1. Maintain coho man. on a hatchery basis, including both early and late types. 2. For type-N, achieve an annual releases of 3 million from the Washougal Hatchery. Provide 2.5 million transfer to Klickitat facility with 0.5 million retained for brood stock. Rear fish to yearlings. 3. Restore type-S prod. to previous levels, prior to the Klick. transfer program. 1 million add. prod. released on-station. Brood stock 1,100 adults. 4. Utilize existing habitat in the subbasin for natural spawning.

Strategy[1]	Maximum Sustainable Yield (MSY)[2]	Total Spawning Return[3]	Total Return to Subbasin[4]	Out of Subbasin Harvest[5]	Contribution To Council's Goal (Index)[6]
Baseline	77 -N	7,277	7,738	25,559	0(1.00)
All Nat	77 -N	7,277	7,738	25,559	0(1.00)
1	77 -N	7,277	7,738	25,559	0(1.00)
2*	25 -N	2,357	2,506	8,278	- 22,512(0.32)
3	25 -N	2,357	2,506	8,278	- 22,512(0.32)

*Recommended strategy.

[1]Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

1. Natural stock enhancement. Pre Mainstem Implementation.
2. Artificial propagation. Pre Mainstem Implementation.
3. Combined natural and artificial production. Pre Mainstem Implementation.

[2]MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

[3]Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

[4]Total return to the mouth of the subbasin.

[5]Includes ocean, estuary, and mainstem Columbia harvest.

[6]The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

Table 17c. Estimated costs of alternative strategies for Washougal coho. Cost estimates represent new or additional costs to the 1987 Columbia River Basin Fish and Wildlife Program; they do not represent projects funded under other programs, such as the Lower Snake River Compensation Plan or a public utility district settlement agreement. (For itemized costs, see Appendix C.)

	Proposed Strategies		
	1	2*	3
Hatchery Costs			
Capital[1]	0	1,642,890	0
O&M/yr[2]	0	178,575	178,575
Other Costs			
Capital[3]	400,000	4,200,000	5,200,000
O&M/yr[4]	5,000	55,000	95,000
Total Costs			
Capital	400,000	5,842,890	5,200,000
O&M/yr	5,000	233,575	273,575

* Recommended strategy.

[1] Estimated capital costs of constructing a new, modern fish hatchery. In some subbasins, costs may be reduced by expanding existing facilities. For consistency, estimate is based on $23/pound of fish produced. Note that actual costs can vary greatly, especially depending on whether surface or well water is used and, if the latter, the number and depth of the wells.

[2] Estimated operation and maintenance costs per year directly associated with new hatchery production. Estimates are based on $2.50/pound of fish produced. For consistency, O&M costs are based on 50 years.

[3] Capital costs of projects (other than direct hatchery costs) proposed under a particular strategy, such as enhancing habitat, screening diversions, removing passage barriers, and installing net pens (see text for specific actions).

[4] Estimated operation and maintenance costs per year of projects other than those directly associated with new hatchery production. For consistency, O&M costs are based on 50 years.

SUMMER STEELHEAD

<u>Fisheries Resource</u>

Summer steelhead are indigenous to the Washougal Basin. Historically the run size has fluctuated widely due to a number of events and human activities. Some of the detrimental actions included gravel mining, passage constraints due to dams, logging, which occurred subsequent to the burns in 1902 and 1929, and effluent release from the Camas paper mill. In more recent years, the removal of the dams and the construction of a fishway over Salmon Falls has opened up much of the mainstem river to spawners, as well as the lower Little Washougal, the lower half of the West Fork and several small tributaries.

Lavier (1973) described the Washougal River as originally being a summer run steelhead stream. Cowlitz and Skamania hatchery stocks were introduced into the system in the late 1950s and are assumed to have interbred with the wild stock. In addition, Cowlitz fish may have strayed after the eruption of Mount St. Helens in May 1980 (Howell et al. 1988). Summer steelhead escapement to the Washougal between 1925 and 1933 has been estimated to have averaged 2,500 fish (Anonymous 1976). In 1953, when spawning surveys were initiated, estimates of wild fish ranged over 500. By 1974 the wild run had dropped to an undetermined, but much lower level. Schuck (1980) estimated the wild run comprised 6.6 percent (282 fish) of a total run of 4,268 summer steelhead returning to the Washougal in 1979. A spawning population of about 100 fish occurs in the West Fork Washougal above the Skamania Hatchery (Hull and Allee 1971, Royal 1972). Average total run size in recent years is about 2,525 adults (1964-1984). The exact numbers of spawning wild fish are not known, but are believed to be very low. Table 18 summaries steelhead punch-card returns.

Hatchery fish are planted in the Washougal using brood stock originating from wild Washougal and Klickitat adults. Since the first hatchery returns, the brood stock has consisted of adults returning to and trapped on the West Fork Washougal. Hatchery run size increased steadily until the mid-1960s when it reached 3,000 to 4,000 adults (Table 19). A major increase in return numbers took place after the hatchery switched to using the Oregon moist pellet (OMP) diet in 1963. Prior to the use of OMP, returns from the smolt planting program were no higher than 1.7 percent, regardless of the release strategy. With the OMP diet, smolt-to-adult return rates increased to about 3 percent (Hull and Allee 1971). Later studies showed that the best returns were from fish released at about eight fish per pound and that spring releases were more successful than fall releases. Table 20 presents hatchery release numbers along with subsequent adult returns. Hatchery releases in the Washougal River originally occurred at Skamania Hatchery. It was not until 1969 that off-station releases started.

Infectious hematopoietic necrosis (IHN) was first reported in the Skamania Hatchery in 1981. It was again reported in 1982; by 1983 IHN was found in both the winter and summer steelhead stocks in addition to cutthroat fry. No major outbreaks have occurred since 1986 (Roberts et al. 1987). The blood poisoning fluke <u>Nanophyetus</u> has been reported in Vogel Creek, the secondary water source to the hatchery (Randolph 1986). The chronic occurrence of coldwater disease has been reported during all but the warm summer months. Losses are generally low, but mortality of fry can sometimes exceed 50 percent. Oxytetracycline is used for treatment. Mortalities also occur from <u>Columnaris</u>, <u>Trichodina</u>, <u>Epistylis</u>, and <u>Costia</u>. Losses due to these infestations are generally minor.

Small run sizes have made sampling the wild population for age characteristics difficult. Of a sample size of seven fish (Schuck 1980), all fish were found to have two years of freshwater residency before they migrated to salt water. One male, at 57 cm, exhibited a one-year marine residency, as identified through scale analysis. Four fish (two males, two females) with a mean length of 76.4 cm, resided in marine water for two years, while another male, at 97 cm, showed a three-year residency.

Hatchery age classification shows that the majority of fish return after two ocean years. Schuck (1980) reported that, based on 96 scale samples, one year of ocean residency accounted for 3 percent of the total return, averaging 58.7 cm, males and females combined. Two year ocean residency accounted for 88 percent, mean length of 77.3 cm, while three-year ocean residency was 8 percent, mean length of 88.9 cm. About 3 percent of the fish (two males and one female) returned as repeat spawners (Table 21). The male-female ratio of returning hatchery fish varies, but averages about 0.72-to-1. Randolf (1986) reports an average fecundity from all summer stocks from 1976 through 1985 to be 4,170 eggs per female. Typical survival is 67.5 percent from egg to smolt.

Time of spawning has changed for the hatchery stock over time. The original peak was in late March. This has been moved back to January and February timing by purposely spawning the earliest maturing fish (Table 22).

Table 18. Summary of Washougal steelhead punch card returns for winter and summer stocks (1981-1988).

Summer Steelhead		Winter Steelhead	
Year	Catch	Year	Catch
1981	5042	1981	1939
1982	1749	1982	1377
1983	465	1983	1927
1984	1576	1984	3195
1985	3160	1985	1901
1986	1977	1986	2101
1987	1219	1987	2005
1988	1436	1988	1576
averages	2078		2003

Table 19: Number of steelhead adults captured at Skamania Hatchery (1956-1968).

Year	Wild	Htchry	Total	Mean Length
1956	136	0	136	NA
1957	153	0	153	NA
1958	114	0	114	NA
1959	80	28	108	25.8
1960	166	432	598	23.3
1961	107	516	623	24.4
1962	85	699	784	25.8
1963	115	657	772	26.3
1964	178	721	899	23.5
1965	214	3442	3656	26.3
1966	266	3255	3521	26.6
1967	43	3134	3177	27.0
1968	na	na	3750	27.5

Table 20: Steelhead smolts released from Skamania. Hatchery and subsequent return rates (1958-1986).

Release Year	Number Released	Subsequent Adult Returns	% Return to Catch
1958	90110	385	0.43
1959	52570	354	0.67
1960	38750	671	1.73
1961	118300	802	0.68
1962	NA		
1963	NA		
1964	32000	1108	3.46
1965	45130	1078	2.39
1966	94540	2919	3.09
1967	60000	3642	6.07
1968	65000	3647	5.61
1969	NA		
1970	NA		
1971	NA		
1972	60000	661	1.10
1973	50000	1599	3.20
1974	25000	351	1.40
1975	30000	1194	3.98
1976	58055	2344	4.04
1977	26976	549	2.04
1978	NA		
1979	114896	5042	4.39
1980	998434	1749	0.18
1981	127407	465	0.36
1982	103099	1576	1.53
1983	210044	3160	1.50
1984	134245	1977	1.47
1985	92842	1219	1.31
1986		1436	

Table 21. Age distribution of returning Skamania stock summer steelhead to hatchery 1958-77, based on size at release. (Hull and Allee 1971, Howell et al. 1985).

Release Year	Size No./lb	0-ocean	1-ocean	2-ocean	3-ocean	4-ocean
1958	8.5		8.4	75.6	16.0	
1958	15.0			100.0		
1958	7.0		53.0	47.0		
1959	8.0	6.2	42.1	50.7	1.0	
1959	7.5	22.7	32.4	38.6	5.5	0.7
1960	7.0	15.8	36.3	47.1		0.8
1964	8.0			86.9	13.1	
1964	6.5			88.5	11.5	
1965	6.5		8.2	91.8		
1972	na		3.6	59.9	35.7	0.8
1973	na		2.3	86.0	11.1	0.6
1974	na		6.8	86.6	5.1	1.4
1975	na		2.3	93.6	3.9	0.2
1976	na		7.5	85.9	5.9	0.6
1977	na		0.7	85.8	11.7	1.8

Table 22. Freshwater life history of Washougal summer steelhead.

	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
ADULT IMMIGRATION	- -	- -	——	——	——	- -	——	——	——	- -	- -	- -
ADULT HOLDING		- -	- -	——	——	——	——	——	——	- -		
SPAWNING	- -	- -	- -							- -	——	——
EGG/ALEVIN INCUBATION	——	——	- -	- -							- -	- -
EMERGENCE	——	——	——	- -	- -	- -						
REARING	——	——	——	——	——	——	——	——	——	——	——	——
JUVENILE EMIGRATION	——	- -	- -								- -	- -

Fourteen years of angling data, collected between 1971 and 1984, show that wild adult steelhead enter the basin between March and November, with two distinct peaks (McMillan 1985). The first occurs from March to July and comprises about 38 percent of the steelhead recorded. The second peak begins in August, extends into November, and comprises the other 62 percent of the summer run stock. Howell et al. (1985) identify January to April as the spawning period, with February and March as the peak months. Emergence occurs from March through May. Juveniles emigrate in April or May at an average length of 160 mm and an age of 2 years.

Summer steelhead harvested in the Washougal Basin is estimated from punch-card returns. Since the mid-1960s, it has varied from a low of 272 in the 1964-1965 season to a high of 5,042 fish in the 1981-1982 season. The average catch for the last eight seasons was estimated at 2,078 fish, with the most recent five-year average at 1,874 fish. About 55 percent of the sport harvest occurs in May and June, with some catches into July. Catch drops off considerably in August. This implies a strong contribution of the Skamania Hatchery stock and a weak showing of wild fish, which would return over a longer time period. The primary management goal is to harvest hatchery fish while allowing escapement of natural fish. Harvest is monitored through sport steelhead permit card return and limited creel surveys.

Specific Considerations

Washougal summer steelhead are managed for wild and hatchery stocks. The wild stock is protected through regulations requiring release of unmarked fish. Recent run sizes of wild fish are unknown, but are considered to be very low as compared to the hatchery stock. IHN also contributes to unpredictable numbers of smolt releases. Low summer flows and high public use of the river (swimming, tubing, and snagging) impacts the adult population through harassing and/or killing of holding fish. Continued urbanization of the watershed has created runoff fluctuations not conducive to stable flows. There is also a water quality concern from the pulp mill on the lower section of the river.

Objectives

Stock: Washougal Natural Summer Steelhead

Utilization Objective: Zero; catch and release only. The utilization component is secondary to the biological component for this stock.

Biological Objective: Maintain the biological characteristics of the natural stock. The biological component has priority within the subbasin. This population is managed for maximum sustained population.

Stock: Washougal Hatchery Summer Steelhead

Utilization Objective: 2,125 fish for sport harvest. The utilization component has priority within the subbasin for this stock.

Biological Objective: Maintain the biological characteristics of the hatchery stock or the natural fish. The biological component is secondary to the utilization component for this stock.

Alternative Strategies

Modeling results for each strategy are presented in Table 23a as fish produced at "maximum sustainable yield" (MSY). The sustainable yield of a fish population refers to that portion of the population that exceeds the number of fish required to spawn and maintain the population over time. Sustainable yield can be "maximized," termed MSY, for each stock at a specific harvest level. The MSY is estimated using a formula (Beverton-Holt function) that analyzes a broad range of harvest rates. Subbasin planners have used MSY as a tool to standardize results so that decision makers can compare stocks and strategies.

In MSY management, managers set a spawning escapement level and the remaining fish (yield) could theoretically be harvested. In practice, a portion of the yield may be reserved as a buffer or to aid rebuilding. Thus, managers may raise the escapement level to meet a biological objective at the expense of a higher utilization objective.

The amount of buffer appropriate for each stock is a management question not addressed in the subbasin plans. For this reason, the utilization objective, which usually refers to harvest, may not be directly comparable to the MSY shown in Table 23a. At a minimum, a strategy should produce an estimated MSY equal to or greater than the utilization objective. A MSY substantially larger than the subbasin utilization objective may be needed to meet subbasin biological objectives.

Estimated costs of the alternative strategies below are summarized in Table 23b.

STRATEGY 1: Natural Stock Enhancement.

This strategy is aimed at reducing pre-spawning mortality and stimulating local public involvement. The System Planning Model shows a minimal increase, but does afford stream habitat protection that will also benefit other stocks.

ACTIONS: 3, 4

3. Establish fish sanctuaries to reduce pre-spawning loss from 20 percent to 10 percent.

4. Stimulate local involvement through such programs as "Adopt a Stream." Such actions would help protect habitat.

STRATEGY 2: Supplementation.

This strategy involves building two conditioning ponds.

ACTIONS: 1

1. Build two conditioning ponds on the river capable of rearing 50,000 steelhead smolts each. This action would produce a better quality smolt, reduce handling stress, reduce IHN risk, improve imprinting, and spread harvest opportunity by redistributing returning adults.

STRATEGY 3: Artificial Propagation.

This strategy consists of those actions identified in Strategies 1 and 2, in addition to Actions 2 and 5.

ACTIONS: 1-5

1. -

2. Reassess Skamania Hatchery facility goals and examine feasibility of alternate water supplies so fish from the hatchery are not restricted to the Washougal River due to IHN virus. Include development of a temporary program to supplement natural fish with fish from a natural brood stock. Released fish would not be marked (fin clipped) to prevent harvest and to provide addition spawning of the wild/natural run.

3. -
4. -

5. Increase summer smolt plants by 25,000 smolts, from 125,000 to 150,000 fish.

Recommended Strategy

Strategy 3 is the recommended strategy. This strategy enhances natural production, protects habitat, improves the viability of the hatchery stock while increasing the number of hatchery smolts planted.

Table 23a. System Planning Model results for summer steelhead (A's) in the Washougal Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
Provide a sport harvest of 2,125 hatchery fish.

Biological Objective:
Maintain genetic fitness and diversity of wild fish.

Strategy[1]	Maximum[2] Sustainable Yield (MSY)	Total[3] Spawning Return	Total[4] Return to Subbasin	Out of[5] Subbasin Harvest	Contribution[6] To Council's Goal (Index)
Baseline	3,010 -N	1,133	4,427	109	0(1.00)
All Nat	3,155 -N	1,160	4,444	109	17(1.00)
1	3,155 -N	1,160	4,444	109	17(1.00)
2	3,551 -N	1,243	4,932	121	517(1.11)
3*	4,033 -N	1,342	5,524	136	1,124(1.25)

*Recommended strategy.

[1]Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

1. Natural stock enhancement. Pre Mainstem Implementation.
2. Supplementation. Pre Mainstem Implementation.
3. Artificial propagation. Pre Mainstem Implementation.

[2]MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

[3]Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

[4]Total return to the mouth of the subbasin.

[5]Includes ocean, estuary, and mainstem Columbia harvest.

[6]The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

Table 23b. Estimated costs of alternative strategies for Washougal summer steelhead. Cost estimates represent new or additional costs to the 1987 Columbia River Basin Fish and Wildlife Program; they do not represent projects funded under other programs, such as the Lower Snake River Compensation Plan or a public utility district settlement agreement. (For itemized costs, see Appendix C.)

	Proposed Strategies		
	1	2	3*
Hatchery Costs			
Capital[1]	0	0	115,000
O&M/yr[2]	0	0	12,500
Other Costs			
Capital[3]	0	750,000	750,000
O&M/yr[4]	0	30,000	30,000
Total Costs			
Capital	0	750,000	865,000
O&M/yr	0	30,000	42,500

* Recommended strategy.

[1] Estimated capital costs of constructing a new, modern fish hatchery. In some subbasins, costs may be reduced by expanding existing facilities. For consistency, estimate is based on $23/pound of fish produced. Note that actual costs can vary greatly, especially depending on whether surface or well water is used and, if the latter, the number and depth of the wells.

[2] Estimated operation and maintenance costs per year directly associated with new hatchery production. Estimates are based on $2.50/pound of fish produced. For consistency, O&M costs are based on 50 years.

[3] Capital costs of projects (other than direct hatchery costs) proposed under a particular strategy, such as enhancing habitat, screening diversions, removing passage barriers, and installing net pens (see text for specific actions).

[4] Estimated operation and maintenance costs per year of projects other than those directly associated with new hatchery production. For consistency, O&M costs are based on 50 years.

WINTER STEELHEAD

Fisheries Resource

The wild component of Washougal winter steelhead is native, although some genetic influence has probably been exerted through introduced Chambers Creek, Cowlitz and Elochoman Hatchery fish. In addition, some interbreeding has likely occurred with winter steelhead strays from the Cowlitz River system after the eruption of Mount St. Helens in 1980 (Stock Assessment Report 1984).

Accurate run size and harvest estimates of wild fish do not exist. The stock is harvested in the mainstem Columbia sport fishery as well as in the Washougal. An interim escapement goal of 630 fish has been established for this stock.

Wild steelhead use spawning and rearing habitat throughout the mainstem Washougal and in the West Fork, Stebbins Creek, Cougar Creek and the Little Washougal River. Timing of adult migration most likely occurs January through May, with peak movement in March (Table 25). Like steelhead smolts in other southwestern Washington streams, wild juveniles in the Washougal probably outmigrate in April and May at an age of 2-years and approximate size of 160 mm.

Approximately 110,000 smolts are released annually in the Washougal (Table 24). These are Skamania origin steelhead, reared primarily at the Skamania Hatchery on the Washougal, but also at the Vancouver and the Beaver Creek facilities.

Accurate harvest and escapement estimates of returning Skamania Hatchery origin steelhead are not available. Harvest of the stock occurs primarily in the Washougal River. Of the winter run adults returning to the hatchery in 1982-1983, 34 arrived in December, 139 in January, 106 in February, 16 in March and one in April. These fish spawn from about the middle of January through February. Fecundity averages about 4,700 eggs per female. Fish are usually released in April and May at four to seven fish per pound following a year of freshwater rearing. Skamania hatchery-origin winter steelhead have been afflicted with IHN virus in recent years (WDG 1984).

Table 24: Washougal winter steelhead smolt releases.

Year	Washougal	North Fork	Total
1962	65,500		65,500
1963	68,560		68,560
1964	101,098		101,098
1965	106,340		106,340
1966	74,822	22,000	96,822
1967	75,955		75,955
1968	61,049		61,049
1969	95,030		95,030
1970	79,760		79,760
1971	74,414		74,414
1972	56,557		56,557
1973	72,566		72,566
1974	12,240	43,678	55,918
1975	40,084		40,084
1976	46,874		46,874
1977	50,579		50,579
1978	73,470		73,470
1979	93,956		93,956
1980	85,680	20,100	105,780
1981	86,561	22,965	109,526
1982	94,655		94,655
1983	69,280	37,772 a	107,052
1984	68,294	37,733	106,027
1985	88,179	5,989	94,168
1986	74,407	25,075	99,482
1987	194,010 b		194,010
1988	87,797	87,501	175,298
1989	64,711	64,418	129,129
10 year average	91,357	37,694	121,513

a/ 12,672 released as fingerlings
b/ 53,286 released as fingerlings

Table 25. Freshwater life history of Washougal River winter steelhead.

	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
ADULT IMMIGRATION	- - ----	------	-- - -	-							- - -	- - - -
ADULT HOLDING	------	------	-- - -	-							- - -	- - - -
SPAWNING	- - -	------	------	- - -								- -
EGG/ALEVIN INCUBATION	- - -	- - --	------	- - - -	- -							- - - -
EMERGENCE	- - -	- - --	------	------	- - - -							
REARING	------	------	------	------	------	------	------	------	------	------	--	
JUVENILE EMIGRATION	- - - -	------	------	- - -								- - - -

Specific Considerations

Wild and hatchery winter steelhead are managed separately through use of wild fish release regulations. Wild fish run sizes are unknown, but are considered to be low. The escapement goal is 630 adults. Hatchery releases are made from the Skamania Hatchery. IHN contributes to unpredictable hatchery releases. Continued urbanization of the watershed has created runoff fluctuations not conducive to stable flows. There is also water quality concern from the pulp mill on the lower section of the river.

Objectives

Stock: Washougal Natural Winter Steelhead

Utilization Objective: Zero; catch and release only. The utilization component is secondary to the biological component for this stock.

Biological Objective: Maintain the biological characteristics of the natural stock. The biological component has priority within the subbasin. This population is managed for maximum sustained population and current minimum escapement goal is 630 fish.

Stock: Washougal Hatchery Winter Steelhead

Utilization Objective: 2,750 fish for sport harvest. The utilization component has priority within the subbasin for this stock.

Biological Objective: Maintain the biological characteristics of the hatchery stock including differential run time than natural fish. The biological component is secondary to the utilization component for this stock.

Alternative Strategies

Modeling results for each strategy are presented in Table 26 as fish produced at "maximum sustainable yield" (MSY). The sustainable yield of a fish population refers to that portion of the population that exceeds the number of fish required to spawn and maintain the population over time. Sustainable yield can be "maximized," termed MSY, for each stock at a specific harvest level. The MSY is estimated using a formula (Beverton-Holt function) that analyzes a broad range of harvest rates. Subbasin planners have used MSY as a tool to standardize results so that decision makers can compare stocks and strategies.

In MSY management, managers set a spawning escapement level and the remaining fish (yield) could theoretically be harvested. In practice, a portion of the yield may be reserved as a buffer or to aid rebuilding. Thus, managers may raise the escapement level to meet a biological objective at the expense of a higher utilization objective.

The amount of buffer appropriate for each stock is a management question not addressed in the subbasin plans. For this reason, the utilization objective, which usually refers to harvest, may not be directly comparable to the MSY shown in Table 26. At a minimum, a strategy should produce an estimated MSY equal to or greater than the utilization objective. A MSY substantially larger than the subbasin utilization objective may be needed to meet subbasin biological objectives.

Estimated costs of the alternative strategies below are summarized in Table 27.

STRATEGY 1: Natural Stock Enhancement.

This strategy seeks to improve local public involvement. The System Planning Model shows a minimal increase, but does afford stream habitat protection that will also benefit other stocks.

ACTIONS: 3

3. Stimulate local involvement through such programs as "Adopt a Stream." Such actions would help protect habitat.

STRATEGY 2: Supplementation.

This strategy consists of the use of conditioning ponds prior to release. This would involve construction of a rearing facility that would promote a better distribution of returning adults and increase the number of harvestable fish to areas most accessible. Although hatchery plantings would not be increased, a new hatchery is needed with dependable water quality and quantity. Outplanting and conditioning ponds would spread out the harvest and availability of returning hatchery adults.

ACTIONS: 1

1. Build conditioning pond on the river capable of rearing 150,000 steelhead smolts (50,000 additional).

STRATEGY 3: Artificial Propagation.

This strategy consists of improving hatchery production facilities and boosting production. This strategy also includes the other actions listed in the previous strategies.

ACTIONS: 1-3

1. -

2. Reassess Skamania Hatchery facility goals and examine feasibility of alternate water supplies so fish from the hatchery are not restricted to the Washougal River due to IHN virus. Include development of a temporary program to supplement natural fish with fish from a natural brood stock. Released fish would not be marked (fin clipped) to prevent harvest and to provide addition spawning of the wild/natural run.

3. -

Recommended Strategy

Strategy 3 is the recommended strategy. This strategy enhances natural production, protects habitat, improves the viability of the hatchery stock while a rearing pond would allow increased harvest rate of hatchery fish. The following table summarizes the model output.

Table 26. System Planning Model results for winter steelhead in the Washougal subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
Provide a sport harvest of 2,750 hatchery fish.

Biological Objective:
Achieve utilization of existing and potential habitat for natural production. Maintain genetic fitness and diversity of wild fish.

Strategy[1]	Maximum[2] Sustainable Yield (MSY)	Total[3] Spawning Return	Total[4] Return to Subbasin	Out of[5] Subbasin Harvest	Contribution[6] To Council's Goal (Index)
Baseline	2,495 -N	922	3,466	229	0(1.00)
All Nat	2,532 -N	890	3,469	229	3(1.00)
1	2,532 -N	890	3,469	229	3(1.00)
2	2,853 -N	952	3,855	255	416(1.11)
3*	3,344 -N	1,059	4,458	295	1,059(1.29)

*Recommended strategy.

[1]Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

1. Natural stock enhancement. Pre Mainstem Implementation.
2. Supplementation. Pre Mainstem Implementation.
3. Artificial propagation (Strategies 1 and 2). Pre Mainstem Implementation.

[2]MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

[3]Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

[4]Total return to the mouth of the subbasin.

[5]Includes ocean, estuary, and mainstem Columbia harvest.

[6]The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

Table 27. Estimated costs of alternative strategies for Washougal winter steelhead. Cost estimates represent new or additional costs to the 1987 Columbia River Basin Fish and Wildlife Program; they do not represent projects funded under other programs, such as the Lower Snake River Compensation Plan or a public utility district settlement agreement. (For itemized costs, see Appendix C.)

	Proposed Strategies		
	1	2	3*
Hatchery Costs			
Capital[1]	0	0	0
O&M/yr[2]	0	25,000	25,000
Other Costs			
Capital[3]	0	1,000,000	1,000,000
O&M/yr[4]	0	30,000	30,000
Total Costs			
Capital	0	1,000,000	1,000,000
O&M/yr	0	55,000	55,000

* Recommended strategy.

[1] Estimated capital costs of constructing a new, modern fish hatchery. In some subbasins, costs may be reduced by expanding existing facilities. For consistency, estimate is based on $23/pound of fish produced. Note that actual costs can vary greatly, especially depending on whether surface or well water is used and, if the latter, the number and depth of the wells.

[2] Estimated operation and maintenance costs per year directly associated with new hatchery production. Estimates are based on $2.50/pound of fish produced. For consistency, O&M costs are based on 50 years.

[3] Capital costs of projects (other than direct hatchery costs) proposed under a particular strategy, such as enhancing habitat, screening diversions, removing passage barriers, and installing net pens (see text for specific actions).

[4] Estimated operation and maintenance costs per year of projects other than those directly associated with new hatchery production. For consistency, O&M costs are based on 50 years.

PART V. SUMMARY AND IMPLEMENTATION

Objectives and Recommended Strategies

Fall Chinook

Objectives attempt to provide late season opportunity for chinook through the introduction of an upriver bright stock. Planners recommend Strategy 3, which would be to release 1 million upriver bright fish on an annual basis, which would ultimately result in perpetuation of a late-returning stock to the Washougal. It would be managed on a hatchery stock basis. This program would require hatchery displacement of 1 million lower river hatchery chinook, to be moved to net pen facilities within the river. Actions would also consist of a number of hatchery improvements.

Spring Chinook

Spring chinook do not presently exist in the Washougal River. The objective is to introduce a Kalama-type stock into the system via annual releases of 100,000 yearlings to provide early season opportunity (Strategy 4). Since habitat conditions are not conducive for natural spawning of spring chinook, this stock would be managed on a hatchery stock basis, with brood stock obtained from outside the watershed (most likely the Kalama stock will continue to be used).

Coho

Past coho programs for the Washougal Hatchery have been inbasin releases directed toward an overall objective to provide for ocean fisheries. In the past, this included inriver releases of both early- and late0returning coho for a combined total of 3 million fish. Future objectives are significantly different, as stated within the United States vs. Oregon agreement. The agreement calls for a late-returning coho production of 3 million, with 2.5 million being transferred to Klickitat and 0.5 million remaining at Washougal for on-station release to maintain a brood stock program. No early-returning coho would be produced. Planners recommend Strategy 2, reestablishing late coho through the use of rearing ponds located in the lower river. Early coho may be maintained and possibly increased if the identified actions are implemented (Strategy 2).

Summer Steelhead

Objectives focus on maintaining and enhancing the wild stock and providing a sport harvest of 2,125 hatchery fish. Planners recommend Strategy 3, increasing smolt releases by 25,000 through combination of conditioning ponds and higher levels of hatchery production.

Winter Steelhead

Objectives focus on maintaining and enhancing the wild stock and providing 2,750 hatchery fish for sport harvest. Planners recommend Strategy 3, improving hatchery production facilities and boosting production by 50,000 smolts.

Implementation

In the summer of 1990, the Columbia Basin Fish and Wildlife Authority submitted to the Northwest Power Planning Council the Integrated System Plan for salmon and steelhead in the Columbia Basin, which includes all 31 subbasin plans. The system plan attempts to integrate this subbasin plan with the 30 others in the Columbia River Basin, prioritizing fish enhancement projects and critical uncertainties that need to be addressed.

From here, the Northwest Power Planning Council will begin its own public review process, which will eventually lead to amending its Columbia River Basin Fish and Wildlife Program. The actual implementation schedule of specific projects or measures proposed in the system plan will materialize as the council's adoption process unfolds.

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APPENDIX A
NORTHWEST POWER PLANNING COUNCIL
SYSTEM POLICIES

In Section 204 of the 1987 Columbia River Basin Fish and Wildlife Program, the Northwest Power Planning Council describes seven policies to guide the systemwide effort in doubling the salmon and steelhead runs. Pursuant to the council's plan, the basin's fisheries agencies and Indian tribes have used these policies, and others of their own, to guide the system planning process. The seven policies are paraphrased below.

1) The area above Bonneville Dam is accorded priority.

Efforts to increase salmon and steelhead runs above Bonneville Dam will take precedence over those in subbasins below Bonneville Dam. In the past, most of the mitigation for fish losses has taken the form of hatcheries in the lower Columbia Basin. According to the council's fish and wildlife program, however, the vast majority of salmon and steelhead losses have occurred in the upper Columbia and Snake river areas. System planners turned their attention first to the 22 major subbasins above Bonneville Dam, and then to the nine below.

2) Genetic risks must be assessed.

Because of the importance of maintaining genetic diversity among the various salmon and steelhead populations in the Columbia River Basin, each project or strategy designed to increase fish numbers must be evaluated for its risks to genetic diversity. Over millions of years, each fish run has evolved a set of characteristics that makes it the best suited run for that particular stream, the key to surviving and reproducing year after year. System planners were to exercise caution in their selection of production strategies so that the genetic integrity of existing fish populations is not jeopardized.

3) Mainstem survival must be improved expeditiously.

Ensuring safe passage through the reservoirs and past the dams on the Columbia and Snake River mainstems is crucial to the success of many efforts that will increase fish numbers, particularly the upriver runs. Juvenile fish mortality in the reservoirs and at the dams is a major cause of salmon and steelhead losses. According to estimates, an average of 15 percent to 30 percent of downstream migrants perish at each dam, while 5 percent to 10 percent of the adult fish traveling upstream perish. Projects to rebuild runs in the tributaries have and will represent major expenditures by the region's ratepayers -- expenditures and long-term projects that should be protected in the mainstem.

4) Increased production will result from a mix of methods.

To rebuild the basin's salmon and steelhead runs, fisheries managers are to use a mixture of wild, natural and hatchery production. Because many questions still exist as to whether wild and natural stocks can coexist with significant numbers of hatchery fish, no one method of production will be solely responsible for increasing fish numbers. System planners were to take extra precaution when considering outplanting hatchery fish into natural areas that still produce wild fish. The council is relying on the fish and wildlife agencies and tribes to balance artificial production with wild and natural production.

5) Harvest management must support rebuilding.

Like improved mainstem passage, effective harvest management is critical to the success of rebuilding efforts. A variety of fisheries management entities from Alaska to California manage harvest of the Columbia Basin's salmon and steelhead runs. The council is calling on those entities to regulate harvest, especially in mixed-stock fisheries, in ways that support the basin's efforts to double its runs.

6) System integration will be necessary to assure consistency.

The Northwest Power Planning Council intends to evaluate efforts to protect and rebuild Columbia River Basin salmon and steelhead from a systemwide perspective. Doubling the runs will require improvements in mainstem passage, fish production and harvest management -- three extremely interdependent components. System planners from all parts of the basin are to coordinate their efforts so, for example, activities in the lower Columbia are consistent with and complement the activities 800 miles upstream in Idaho's Salmon River. The fisheries management organizations and their plans vary from subbasin to subbasin, but the council is calling upon the agencies and tribes to help resolve conflicts that arise.

7) Adaptive management should guide action and improve knowledge.

System planners were to design projects so that information can be collected to improve future management decisions. By designing projects that test quantitative hypotheses and lend themselves to monitoring and evaluation, managers can learn from their efforts. This learning by doing is called "adaptive management." Using such an approach, managers can move ahead with plans to rebuild the Columbia Basin's salmon and steelhead runs, despite many unanswered questions about how best to accomplish their goal. With time, the useful information revealed by these "experiments" can guide future projects.

APPENDIX B
SMART ANALYSIS

To help select the preferred strategies for each subbasin, planners used a decision-making tool known as Simple Multi-Attribute Rating Technique (SMART). SMART examined each proposed strategy according to the following five criteria. In all cases, SMART assumed that all of the Columbia River mainstem passage improvements would be implemented on schedule.

1) Extent the subbasin objectives were met

2) Change in maximum sustainable yield

3) Impact on genetics

4) Technological and biological feasibility

5) Public support

Once SMART assigned a rating for each criteria, it multiplied each rating by a specific weight applied to each criteria to get the "utility" value (see following tables). Because the criteria were given equal weights, utility values were proportional to ratings. The confidence in assigning the ratings was taken into consideration by adjusting the weighted values, (multiplying the utility value by the confidence level) to get the "discount utility." SMART then totaled the utility values and discount utility values for all five criteria, obtaining a "total value" and a "discount value" for each strategy.

System planners used these utility and discount values to determine which strategy for a particular fish stock rated highest across all five criteria. If more than one of the proposed strategies shared the same or similar discount value, system planners considered other factors, such as cost, in the selection process. Some special cases arose where the planners' preferred strategy did not correspond with the SMART results. In those cases, the planners provide the rationale for their selection.

SUBBASIN: Washougal

STOCK: Spring Chinook

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	5	0.9	20	100	90
2 CHG MSY	7	0.9	20	140	126
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	9	0.9	20	180	162
5 PUB SUPT	5	0.9	20	100	90

TOTAL VALUE 580

DISCOUNT VALUE 522

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Spring Chinook

STRATEGY: 4

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	6	0.9	20	120	108
2 CHG MSY	8	0.9	20	160	144
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	9	0.9	20	180	162
5 PUB SUPT	5	0.9	20	100	90

TOTAL VALUE 620

DISCOUNT VALUE 558

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Fall Chinook

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	5	0.9	20	100	90
2 CHG MSY	3	0.9	20	60	54
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	6	0.9	20	120	108
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 480

DISCOUNT VALUE 432

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Fall Chinook

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	7	0.9	20	140	126
2 CHG MSY	3	0.9	20	60	54
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	6	0.9	20	120	108
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 520

DISCOUNT VALUE 468

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Coho

STRATEGY: 1

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	2	0.9	20	40	36
2 CHG MSY	2	0.9	20	40	36
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	6	0.9	20	120	108

TOTAL VALUE 400

DISCOUNT VALUE 360

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Coho

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	4	0.9	20	80	72
2 CHG MSY	3	0.9	20	60	54
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	6	0.9	20	120	108

TOTAL VALUE 460

DISCOUNT VALUE 414

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Coho

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	5	0.9	20	100	90
2 CHG MSY	3	0.9	20	60	54
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	6	0.9	20	120	108

TOTAL VALUE 480

DISCOUNT VALUE 432

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Summer Steelhead

STRATEGY: 1

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	4	0.9	20	80	72
2 CHG MSY	2	0.9	20	40	36
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 480

DISCOUNT VALUE 432

CONFIDENCE VALUE 0.9

SUBBASIN: WAshougal

STOCK: Summer Steelhead

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	5	0.9	20	100	90
2 CHG MSY	4	0.9	20	80	72
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 540

DISCOUNT VALUE 486

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Summer Steelhead

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	5	0.9	20	100	90
2 CHG MSY	6	0.9	20	120	108
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	6	0.9	20	120	108
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 540

DISCOUNT VALUE 486

CONFIDENCE VALUE 0.9

SUBBASIN: Washougal

STOCK: Winter Steelhead

STRATEGY: 1

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	2	0.9	20	40	36
2 CHG MSY	4	0.9	20	80	72
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 480

DISCOUNT VALUE 432

SUBBASIN: Washougal

STOCK: Winter Steelhead

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	3	0.9	20	60	54
2 CHG MSY	5	0.9	20	100	90
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 520

DISCOUNT VALUE 468

SUBBASIN: Washougal

STOCK: Winter Steelhead

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	4	0.9	20	80	72
2 CHG MSY	6	0.9	20	120	108
3 GEN IMP	3	0.9	20	60	54
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 560

DISCOUNT VALUE 504

APPENDIX C
SUMMARY OF COST ESTIMATES

The cost estimates provided in the following summary tables represent new or additional costs necessary to implement the alternative strategies. Although many strategies involve projects already planned or being implemented under the Columbia River Basin Fish and Wildlife Program or other programs, such as the Lower Snake River Compensation Plan, the associated costs and hatchery production do not appear in the following tables.

In many cases, the following costs are no more than approximations based on familiarity with general costs of similar projects constructed elsewhere. Although the costs are very general, they can be used to evaluate relative, rather than absolute, costs of alternative strategies within a subbasin.

Particular actions are frequently included in strategies for more than one species or race of anadromous fish. In these cases, the same costs appear in several tables, but would only be incurred once, to the benefit of some, if not all, of the species and races of salmon and steelhead in the subbasin.

Subbasin planners used standardized costs for actions "universal" to the Columbia River system, such as costs for installing instream structures, improving riparian areas, and screening water diversions (see the Preliminary System Analysis Report, March 1989). For other actions, including the removal of instream barriers, subbasin planners developed their own cost estimates in consultation with resident experts.

Planners also standardized costs for all new hatchery production basinwide. To account for the variability in fish stocking sizes, estimates were based upon the cost per pound of fish produced. For consistency, estimated capital costs of constructing a new, modern fish hatchery were based on $23 per pound of fish produced. Estimated operation and maintenance costs per year were based on $2.50 per pound of fish produced.

All actions have a life expectancy, a period of time in which benefits are realized. Because of the variation in life expectancy among actions, total costs were standardized to a 50-year period. Some actions had life expectancies of 50 years or greater and thus costs were added as shown. Other actions (such as instream habitat enhancements) are expected to be long term, but may only have life expectancies of 25 years. Thus the action would have to be repeated (and its cost doubled) to meet the 50-year standard. Still other actions (such as a study or a short-term supplementation program) may have life expectancies of 10 years after which no further action would be taken. In this case, operation and maintenance costs were amortized over 50 years to develop the total O&M per year estimate. Capital costs, being up-front, one-time expenditures, were added directly.

Subbasin planners have estimated all direct costs of alternative strategies except for the purchase of water rights. No cost estimates have been or will be made for actions that involve purchasing water. Indirect costs, such as changes in water flows or changes in hydroelectric system operations, are not addressed.

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Washougal River
Stock: Fall Chinook

Action	Cost Categories*	Proposed Strategies 1	2	3**
Habitat Enhancement	Capital:			
	O&M/yr:			
	Life:			
Screening	Capital:			
	O&M/yr:			
	Life:			
Net Pens	Capital:			400,000
	O&M/yr:			40,000
	Life:			20
Misc. Projects	Capital:		1,300,000[a]	1,300,000[a]
	O&M/yr:		0	0
	Life:		50	50
Hatchery Production	Capital:			[b]
	O&M/yr:			25,000
	Life:			50
TOTAL COSTS	Capital:	0	1,300,000	2,300,000
	O&M/yr:	0	0	65,000
	Years:		50	50
Water Acquisition		N	N	N
Fish to Stock	Number/yr:			1,000,000
	Size:			J, 100/lb.
	Years:			50

* Life expectancy of the project is defined in years. Water acquisition is defined as either Y = yes, the strategy includes water acquisition; N = no, water acquisition is not part of the strategy. The size of fish to stock is defined as E = eggs; F = fry; J = juvenile, fingerling, parr, subsmolt; S = smolt; A = adult.

** Recommended strategy.

[a] Integrated with spring chinook and coho programs.

[b] Estimated capital costs are associated with net pens, for which planners have calculated costs independently (see above).

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Washougal River
Stock: Spring Chinook

Action	Cost Categories*	Proposed Strategies 1	2	3	4**
Habitat Enhancement	Capital:				
	O&M/yr:				
	Life:				
Screening	Capital:				
	O&M/yr:				
	Life:				
Barrier Removal	Capital:				
	O&M/yr:				
	Life:				
Misc. Projects	Capital:				1,300,000[a]
	O&M/yr:				0
	Life:				50
Hatchery Production	Capital:			230,000	230,000
	O&M/yr:			25,000	25,000
	Life:			50	50
TOTAL COSTS	Capital:	0	0	230,000	1,530,000
	O&M/yr:	0	0	25,000	25,000
	Years:			50	50
Water Acquisition		N	N	N	N
Fish to Stock	Number/yr:			100,000	100,000
	Size:			S, 10/lb.	S, 10/lb.
	Years:			50	50

* Life expectancy of the project is defined in years. Water acquisition is defined as either Y = yes, the strategy includes water acquisition; N = no, water acquisition is not part of the strategy. The size of fish to stock is defined as E = eggs; F = fry; J = juvenile, fingerling, parr, subsmolt; S = smolt; A = adult.

** Recommended strategy.

[a] Integrated with fall chinook and coho programs.

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Washougal River
Stock: Coho

Action	Cost Categories*	Proposed Strategies 1	2**	3
Screening	Capital:	200,000	200,000	200,000
	O&M/yr:	5,000	5,000	5,000
	Life:	25	25	25
Acclimation Ponds	Capital:		500,000	500,000
	O&M/yr:		50,000	50,000
	Life:		10	10
Net Pens	Capital:			400,000
	O&M/yr:			40,000
	Life:			20
Misc. Projects	Capital:		1,300,000[a]	1,300,000[a]
	O&M/yr:		0	0
	Life:		50	50
Hatchery Production	Capital:		1,642,890	[b]
	O&M/yr:		178,575	178,575
	Life:		50	50
TOTAL COSTS	Capital:	400,000	5,842,890	5,200,000
	O&M/yr:	5,000	233,575	273,575
	Years:	50	50	50
Water Acquisition		N	N	N
Fish to Stock	Number/yr:		1,000,000	1,000,000
	Size:		S, 14/lb.	S, 14/lb.
	Years:		50	50

* Life expectancy of the project is defined in years. Water acquisition is defined as either Y = yes, the strategy includes water acquisition; N = no, water acquisition is not part of the strategy. The size of fish to stock is defined as E = eggs; F = fry; J = juvenile, fingerling, parr, subsmolt; S = smolt; A = adult.

** Recommended strategy.

[a] Integrated with spring chinook and fall chinook programs.

[b] Estimated capital costs are associated with net pens, for which planners have calculated costs independently (see above).

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Washougal River
Stock: Summer Steelhead

Action	Cost Categories*	Proposed Strategies 1	2	3**
Habitat Enhancement	Capital:			
	O&M/yr:			
	Life:			
Screening	Capital:			
	O&M/yr:			
	Life:			
Barrier Removal	Capital:			
	O&M/yr:			
	Life:			
Conditioning Ponds	Capital:		150,000	150,000
	O&M/yr:		30,000	30,000
	Life:		10	10
Hatchery Production	Capital:			115,000
	O&M/yr:			12,500
	Life:			50
TOTAL COSTS	Capital:	0	750,000	865,000
	O&M/yr:	0	30,000	42,500
	Years:		50	50
Water Acquisition		N	N	N
Fish to Stock	Number/yr:			25,000
	Size:			S, 5/lb.
	Years:			50

* Life expectancy of the project is defined in years. Water acquisition is defined as either Y = yes, the strategy includes water acquisition; N = no, water acquisition is not part of the strategy. The size of fish to stock is defined as E = eggs; F = fry; J = juvenile, fingerling, parr, subsmolt; S = smolt; A = adult.

** Recommended strategy.

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Washougal River
Stock: Winter Steelhead

Action	Cost Categories*	Proposed Strategies 1	2	3**
Habitat Enhancement	Capital:			
	O&M/yr:			
	Life:			
Screening	Capital:			
	O&M/yr:			
	Life:			
Barrier Removal	Capital:			
	O&M/yr:			
	Life:			
Misc. Projects	Capital:		200,000	200,000
	O&M/yr:		30,000	30,000
	Life:		10	10
Hatchery Production	Capital:		[a]	[a]
	O&M/yr:		25,000	25,000
	Life:		50	50
TOTAL COSTS	Capital:	0	1,000,000	1,000,000
	O&M/yr:	0	55,000	55,000
	Years:		50	50
Water Acquisition		N	N	N
Fish to Stock	Number/yr:		50,000	50,000
	Size:		S, 5/lb.	S, 5/lb.
	Years:		50	50

* Life expectancy of the project is defined in years. Water acquisition is defined as either Y = yes, the strategy includes water acquisition; N = no, water acquisition is not part of the strategy. The size of fish to stock is defined as E = eggs; F = fry; J = juvenile, fingerling, parr, subsmolt; S = smolt; A = adult.

** Recommended strategy.

[a] Estimated capital costs are associated with the conditioning ponds, for which planners have calculated costs independently (see above).