Columbia Basin System Planning

SALMON and STEELHEAD PRODUCTION PLAN

YAKIMA RIVER SUBBASIN

September 1, 1990

YAKIMA RIVER SUBBASIN
Salmon and Steelhead Production Plan

September 1, 1990

Lead Agency: Confederated Tribes and Bands
of the Yakima Indian Nation
P.O. Box 151
Toppenish, Washington 98948-0151

Co-writers: Washington Department of Fisheries
115 General Administration Building
Olympia, Washington 98504

Washington Department of Wildlife
600 Capitol Way North
Olympia, Washington 98501-1091

Columbia Basin System Planning

Funds Provided by
the Northwest Power Planning Council,
and the Agencies and Indian Tribes of the
Columbia Basin Fish and Wildlife Authority

Table of Contents

Under separate cover are two supplements to the Yakima River Subbasin Plan:

SUPPLEMENT 1, Appendices 1-7

SUPPLEMENT 2, Summary of Objectives and Strategies

ACKNOWLEDGMENTS

Members of the System Planning Group would like to acknowledge the wide array of people who participated in the technical advisory groups and public advisory groups throughout the Columbia Basin. Their valuable time and effort have helped shape this and other subbasin plans.

Special recognition also goes to the individual writers from the various fish and wildlife agencies and Indian tribes who have spent countless hours writing and rewriting the plans.

The System Planning Group also wants to acknowledge Duane Anderson of the Northwest Power Planning Council's staff for his assistance and expertise in computer modeling. Eric Lowrance and Leroy Sanchez from the Bonneville Power Administration also deserve recognition for developing the useful salmon and steelhead distribution maps, which appear in many of the subbasin plans.

Last, but not least, the System Planning Group recognizes the members of the System Planning Oversight Committee and the Columbia Basin Fish and Wildlife Authority's Liaison Group for their guidance and assistance over the past several months.

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 Yakima Subbasin is located in south-central Washington. It drains an area of 6,155 square miles and contains about 1,900 river miles of perennial streams. The subbasin is centered around the city of Yakima and includes most of Yakima and Kittitas counties as well as small portions of Benton and Klickitat counties. The Yakima Indian Reservation is located in the southwest corner of the subbasin just south of the city of Yakima. The Yakima River originates near the crest of the Cascade Range above Keechelus Lake at an elevation of 6,900 feet and flows 214 miles southeastward to its confluence with the Columbia (RM 335.2). Major tributaries include the Kachess, Cle Elum and Teanaway rivers in the northern part of the subbasin, and the Naches River in the west. The Naches has four major tributaries, the Bumping, American, Tieton and Little Naches rivers. Ahtanum, Toppenish and Satus creeks join the Yakima in the lower subbasin.

Six major reservoirs are located in the subbasin. The Yakima River flows out of Keechelus Lake (157,800 acre feet), the Kachess River from Kachess Lake (239,000 acre feet), the Cle Elum River from Cle Elum Lake (436,900 acre feet), the Tieton from Rimrock Lake (198,000 acre feet), and the Bumping from Bumping Lake (33,700 acre feet). The North Fork of the Tieton River connects Clear Lake (5,300 acre feet) with Rimrock Lake. All reservoirs except Rimrock and Clear Lake were natural lakes before impoundment.

Six major diversion dams are on the mainstem Yakima, and several smaller dams are on the Naches. From uppermost to lowermost, the Yakima dams are Easton (RM 202.5), Roza (RM 127.9), Wapato (RM 106.6), Sunnyside (RM 103.8), Prosser (RM 47.1) and Horn Rapids (RM 18.0). The major dams on the Naches are Wapatox (RM 17.1) and Naches Cowiche (RM 3.6).

Topography in the subbasin is characterized by a series of long ridges extending eastward from the Cascades and encircling flat valley areas. Elevations in the subbasin range from about 7,000 feet in the Cascades to about 350 feet at the confluence of the Yakima and Columbia rivers.

Seven soil associations exist in the Yakima Subbasin. Four of these associations, (Weirman-Zillah, Renslow-Ritzville, Naches-Woldale and Warden-Shano), comprising about 18 percent of the subbasin's area, are located in gently sloping areas and are subject to intensive irrigated agriculture. These soil types are fine textured and easily eroded (Anonymous, USDA 1974).

Vegetation in the subbasin is a complex blend of forest, range and cropland. Over one-third of the land in the Yakima Subbasin is forested. Rangeland lies between cultivated areas, located in the fertile lower valleys, and the higher-elevation forests. Cropland accounts for about 16 percent of the total subbasin area of which 77 percent is irrigated.

The climate of the Yakima Subbasin ranges from cool and moist in the mountains to warm and dry in the valleys. Annual precipitation near the Cascade crest ranges from 80 inches to 140 inches, whereas the lower elevations in the eastern part of the subbasin receive 10 inches or less. Summer temperatures average 55 degrees Fahrenheit in the mountains, and 82 F in the valleys. Average maximum winter temperatures range from 25 degrees to 40 degrees Fahrenheit, while average minimum winter temperatures range from 15 degrees to 25 degrees Fahrenheit. Minimum temperatures of minus 20 F to minus 25 F have been recorded in most areas.

Irrigated agriculture is the economic base of the Yakima Subbasin. In 1982, about 400,000 irrigated acres produced an estimated gross crop value of $500 million. Major crops include apples, cherries, peaches, pears, prunes, sugar beets, grapes, mint, grain, corn, hops and alfalfa. Livestock production and forestry are also important contributors to the economic base. The major industries in the subbasin are related primarily to the processing of agricultural and forest products.

Riparian conditions are extremely varied, ranging from severely degraded to nearly pristine. Good riparian habitat generally is found along forested, headwater reaches, whereas degraded riparian habitat is concentrated in the valleys, frequently associated with agricultural activity, especially grazing.

Water Resources

Water is central to the productivity of the agricultural economy and the fisheries of the Yakima Subbasin. While the water resources of the subbasin are subject to problems of both quantity and quality, quantitative concerns are more important. Water quality in the Yakima Subbasin is good to excellent in the upper reaches, but only fair to poor in the lower valley. As the Yakima River passes through the Kittitas Valley (headwaters to Roza Dam), it receives pollutants from irrigated pasture lands and municipalities. Although almost all water quality indices suffer a progressive deterioration through this section, overall water quality would still be considered good as the river passes Roza Dam.

Through its middle reaches (Roza to Sunnyside Dam), the Yakima River receives treated wastes from Yakima, Selah, Union Gap, and Terrace Heights as well as irrigation returns from the Ahtanum Creek and the Moxee area. Normally, however, water quality is only slightly degraded because pollutants are diluted with large volumes of high quality water from the Naches River. Water quality can therefore still be considered good as far as Union Gap.

Water quality degrades rapidly in the lower subbasin (Sunnyside Dam to Columbia River). Most of the summer flow is diverted at Wapato and Sunnyside dams, and large volumes of warm, turbid irrigation water with a high content of nutrients, suspended sediments and fecal bacteria are added a short distance downstream. While irrigation return flows comprise about 5 percent of the yearly Yakima River flows in the reach from Sunnyside Dam to Wilson Creek, below Sunnyside Dam this percent increases to more than 30 percent on an annual basis, and to more than 80 percent in the summer months (Anonymous 1974). The summertime concentrations of (nitrate + nitrite) orthophosphate, chlorophyll A, specific conductance and turbidity all reflect the virtual transformation of the Yakima River below Granger (RM 83) to a seasonal irrigation return; in all cases, concentrations rise to levels approaching those observed in irrigation drains (Mongillo and Falconer 1980). However, those levels are not acutely toxic to fish.

Water temperatures and substrate quality present problems in the lower Yakima. Mean July temperatures at Kiona range from 70 F to 78 F, with maximum July temperatures occasionally reaching 80 F. Although a survey of particle size distribution of substrate materials in the lower river has never been conducted, the deposition of fine materials is undoubtedly a problem, especially between Union Gap and Kiona. Eleven major irrigation drains enter the Yakima River in this reach, discharging between 122,000 and 127,000 tons of suspended sediments yearly (USGS Open-File Report 78-946). It is possible that much of this material settles out before reaching Kiona as summertime turbidity begins rising at Union Gap, peaks in the vicinity of Granger, and falls at Kiona to levels not substantially greater than those observed at Union Gap (Mongillo and Falconer 1980).

Pesticide contamination is also a potential problem to fish in the lower Yakima. In 1985 the Washington Department of Ecology's Water Quality Investigations section conducted an evaluation of the hazards to human health and aquatic life presented by toxic chemicals (DDT and metabolites, 15 additional organochlorine pesticides, PCBs and mercury) in water, sediments and fish tissues. Major organochlorine compounds detected in fish were DDT, DDE, dieldrin and PCB-1260. Fish in the lower river had higher concentrations than fish in the upper river, and resident fish had higher concentrations than juvenile anadromous salmonids. Concentrations of all substances were, however, well below FDA "action levels." The concentrations of all substances in fish tissues were not high enough to suggest the possibility of impaired reproduction. DDT, DDE, DDD, dieldrin and endosulfan, evidently of historic origin, were detected in water samples taken from irrigation drains (Sulphur Creek, Birchfield Drain, Granger Drain, and Snipes/Spring Creek) and in one instance from the Yakima River at Kiona. All were present in concentrations below those known to be acutely toxic to aquatic life. However, concentrations in a number of tributaries (Birchfield Drain, Sulphur Creek, Granger Drain and Snipes/Spring Creek) were above levels considered safe to aquatic animals subjected to chronic exposure. The implications of the water quality violations observed in these drains were as follows.

1) Sensitive species living in or in the immediate vicinity of affected drains might be adversely affected either through direct, possibly synergistic, toxicity; or through impaired reproduction.

2) Birds feeding on fish from affected drains might have lower than normal reproductive rates.

3) Fish in affected drains might not meet FDA standards for human consumption (Johnson et al. 1986).

Water Supply

Water supplies in the Yakima Subbasin are severely overtaxed by the competing demands of irrigation and instream flows for fish production. Moreover, except for a minimum flow below Prosser Dam and a court-ordered minimum flow for egg incubation in the Yakima from Easton Dam to the Teanaway, there are no binding minimum instream flows for fish (the Washington Department of Energy is prevented by state law from requiring existing water rights to meet new instream flow requirements). Subject only to the above exceptions, current instream flows represent the difference between available water (storage plus runoff) and irrigation and other demands. As available water and demand are rather precariously balanced, instream flows are rarely optimal anywhere in the subbasin, and may be catastrophically low for fish production in drought years.

In an average year, the total available water supply in the subbasin is barely adequate for irrigation and never adequate for optimal fish production. To satisfy irrigation needs, a great volume of water is released during the irrigation season, resulting in flows in many reaches of the mainstem Yakima that are much greater than optimal. The lack of water in the subbasin for fish production is felt in the main river primarily after the irrigation season ends, when releases are cut back dramatically to refill the reservoirs, and flows in most mainstem reaches become suboptimal or even critically low for fish. Note, however, that instream flows can become critically low even during the irrigation season, especially in reaches below diversion dams. Moreover, instream flows in many tributaries (the Teanaway River and Taneum, Manastash, Big, Wenas and Ahtanum creeks) are impacted by irrigation withdrawals more severely than the main Yakima, and the lower reaches of these streams are virtually or actually dewatered by late spring or early summer. In dry years, water supply is wholly inadequate everywhere in the subbasin. Based on the historical record, rationing of irrigation water will be necessary in nine of 52 years (17.3 percent), and instream flows will be extremely low or nonexistent throughout the subbasin.

Water supply in the subbasin is provided by natural runoff, irrigation return flows and storage (ground water use is negligible). Although the mean total subbasin runoff (3.4 million acre feet) is 1.5 times the irrigation demand (2.3 million acre feet), problems still arise because only 1.07 million acre feet can currently be stored, and because much of the runoff occurs quickly, in May and June (Yakima River Basin Water Enhancement Project Phase II Status Report 1985). The irrigation season extends from April through mid-October, and natural runoff is normally adequate to meet demands through June. By the first week of July, however, stored waters are required to meet delivery demands. Since storage capacity and normal irrigation demand from July 1 through the end of the season are almost identical, releases must be carefully timed, especially if precipitation is less than normal. Moreover, it is desireable that there be some "carryover" of stored water from one season to the next, as the reservoir system would not refill following two consecutive dry years.

The Yakima River Basin Water Enhancement Project Phase II Status Report made a series of predictions based on a 52-year period of record (1926-1977) regarding the adequacy of irrigation supplies and anadromous fish production assuming the present demand and operating policies were maintained. As previously mentioned, some degree of rationing of irrigation water would be necessary in nine of 52 years, with less than 70 percent of "current diversions" (defined as the mean over the non-drought years from 1973 to 1982) being delivered in three years, and a lesser degree of rationing in six others. In the most water--deficient year, a repetition of the 1941 supply conditions, "proratable irrigators" (see Part III, Legal Considerations) would receive less than 40 percent of current supply. From a fisheries perspective, mean discharge by reach would probably resemble Table 1, with most reaches of the Yakima experiencing critically low or fluctuating flows at some time of the year, and significantly suboptimal or supra-optimal mean flows throughout the entire year. An IFIM-based (instream flow incremental method) analysis (Stemple 1985) indicated total anadromous spawning runs would reach equilibrium at 17,600 adults under current conditions. Mean run size to the Yakima Subbasin for all anadromous fish from 1983 through 1987 (years in which runs have been increasing) has been 7,018 fish.

A summary of specific adverse impacts on the subbasin's fisheries attributable to a problematic water supply would include:

1) Passage problems associated with diversions. Problem diversions include both those that physically impede spawning adults and unscreened diversions that entrain juveniles. Currently, these are found primarily in tributaries.

   Researchers have not conducted a thorough stream inventory in over a decade, and a new effort is urgently needed. Fortunately, a new effort is under way -- the Bureau of Reclamation has contracted with the Northwest Power Planning Council to conduct a water supply availability analysis for the purpose of locating and devising solutions to problems of instream flow, and evaluating instream and riparian habitat. This study was required as a part of the pre-planning process for the Yakima/Klickitat Hatchery and should provide the information necessary to prioritize currently underutilized tributaries as potential production areas and candidates for outplanting.

2) Passage and rearing habitat restrictions resulting from low flows. Problems occur both in tributaries and the mainstem. Most of the tributaries in the subbasin suffer from severe low flow problems in the summer and early fall, and most are attributable to irrigation diversions in their lower reaches (an important exception is the low flow problems in the Satus system, which are attributable to the combination of a low water table, permeable soils and low precipitation). Mainstem reaches also suffer periodic episodes of critically low flow, the most significant of which occur in the Yakima from Keechelus Dam to Easton Dam, in the Yakima from Easton Dam to the Cle Elum River, in the Yakima from Sunnyside Dam to the Chandler power plant outlet, and in the Naches from Wapatox diversion to the Yakima confluence. The Keechelus/Easton and Easton/Cle Elum situations are attributable to the absence of releases from Keechelus Reservoir during refilling and maintenance periods, and the others are attributable to diversions.

Table 1. Mean monthly flows and flow-related data in selected reaches of the Yakima Subbasin.
First figure represents calculated mean with present demand and operating scheme for the period 1926-1977.
Second figure represents the mean of actual flows over the period 1981-1987.
NOTE: Number in parenthesis after location name is mean unregulated discharge.
Critical flow is the critical low flow by the "Montana Method," 1/10 mean unregulated discharge.
Flow fluctuations >300% in a 24-hr period are indicated in the last row for each reach/tributary.
"N.D." indicates data not available or not yet analyzed.

LOCATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
		MEAN MONTHLY DISCHARGE (cfs)											
Yakima, Keechelus to Easton (339 = mean annual discharge)	'26-'77	110	143	205	116	59	49	112	620	744	686	747	465
Yakima, Keechelus to Easton (339 = mean annual discharge)	'82-'87	159	48	90	110	107	49	137	604	526	570	862	426
IFTAG Optimal Flow		125	100	100	100	125	125	125	125	100	100	100	125
Critical Flow		35	35	35	35	35	35	35	35	35	35	35	35
Mean Number Days < Critical	'82-'87	12	18	10	4	5	17	12	<1	0	0	0	<1
No. Days >300% Change	'82-'87	1	1	<1	<1	<1	<1	1	<1	0	0	0	<1
Kachess R., Easton (295)	'26-'77	170	99	110	66	31	18	30	306	496	632	806	779
Kachess R., Easton (295)	'81-'86	184	4	2	2	21	27	87	353	586	728	956	704
IFTAG Optimal Flow		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Critical Flow		30	30	30	30	30	30	30	30	30	30	30	30
Mean Number Days < Critical	'82-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'82-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Yakima R., Easton (945)	'26-'77	186	473	661	462	338	322	501	966	773	479	593	235
Yakima R., Easton (945)	'82-'87	232	295	243	389	392	440	457	618	456	431	726	320
IFTAG Optimal Flow		400	350	350	275	275	275	275	275	225	225	225	400
Critical Flow		95	95	95	95	95	95	95	95	95	95	95	95
Mean Number Days < Critical	'82-'87	5	1	0	0	0	0	<1	0	2	2	0	0
No. Days >300% Change	'82-'87	0	2	1	2	0	1	2	0	0	1	0	0
Cle Elum R., Roslyn (950)	'26-'77	183	417	574	303	199	183	263	1439	2346	2443	2363	502
Cle Elum R., Roslyn (950)	'81-'86	326	199	147	162	154	134	242	862	1690	2917	2916	749
IFTAG Optimal Flow		200	200	200	200	275	275	275	275	300	300	300	200
Critical Flow		95	95	95	95	95	95	95	95	95	95	95	95
Mean Number Days < Critical	'82-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'82-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Yakima R., Cle Elum (2100)	'26-'77	469	1019	1411	963	741	762	1165	2815	3398	3036	3065	856
Yakima R., Cle Elum (2100)	'82-'87	536	620	531	857	808	978	1057	2070	3022	3441	3706	1199
IFTAG Optimal Flow		650	600	600	525	525	500	500	500	600	600	600	650
Critical Flow		210	210	210	210	210	210	210	210	210	210	210	210
Mean Number Days < Critical	'82-'87	1	0	0	0	0	0	0	0	0	0	0	0
No. Days >300% Change	'82-'87	1	1	0	2	1	0	0	0	0	0	0	4
Yakima R., Ellensburg (2250)	'26-'77	775	1260	1829	1519	1406	1779	2436	3915	3912	3054	3077	1190
Yakima R., Ellensburg (2250)	'82-'87	769	882	1218	1579	1513	2179	2212	3221	3511	3406	3588	1345
IFTAG Optimal Flow		1000	1000	750	750	900	900	750	750	750	750	750	750
Critical Flow		225	225	225	225	225	225	225	225	225	225	225	225
Mean Number Days < Critical	'82-'87	0	0	0	0	0	0	0	0	0	0	0	<1
No. Days >300% Change	'82-'87	1	0	4	1	1	0	0	0	1	0	0	0

Table 1. Mean monthly flows and flow-related data in selected reaches of the Yakima Subbasin.
First figure represents calculated mean with present demand and operating scheme for the period 1926-1977.
Second figure represents the mean of actual flows over the period 1981-1987.
NOTE: Number in parenthesis after location name is mean unregulated discharge.
Critical flow is the critical low flow by the "Montana Method," 1/10 mean unregulated discharge.
Flow fluctuations >300% in a 24-hr period are indicated in the last row for each reach/tributry.
"N.D." indicates data not available or not yet analyzed.

LOCATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
		MEAN MONTHLY DISCHARGE (cfs)											
Yakima R., Umtanum (2400)	'26-'77	986	1465	1984	1573	1477	1828	2773	4406	4359	3276	3317	1473
Yakima R., Umtanum (2400)	'82-'87	1053	1008	920	1655	1864	2511	2437	3286	3792	3766	4014	1957
IFTAG Optimal Flow		1000	1000	750	750	900	900	750	750	750	750	750	1000
Critical Flow		240	240	240	240	240	240	240	240	240	240	240	240
Mean Number Days < Critical	'82-'87	0	0	0	0	0	0	0	0	0	0	0	0
No. Days >300% Change	'82-'87	0	1	2	1	0	0	0	0	0	0	0	0
Yakima R., Pomona (2433)	'26-'77	368	813	1262	841	742	826	1330	2630	2324	1163	1246	365
Yakima R., Pomona (2433)	'81-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
IFTAG Optimal Flow		800	800	750	750	900	900	750	750	750	750	750	750
Critical Flow		240	240	240	240	240	240	240	240	240	240	240	240
Mean Number Days < Critical	'81-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'81-'87	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Yakima R., Yakima (~4200)	'26-'77	826	1474	2290	1855	1782	1824	2861	5669	5411	2535	2089	2095
Yakima R., Yakima (~4200)	'82-'87	1699	1896	1752	3106	3522	4945	4054	6002	6052	3724	3301	2692
IFTAG Optimal Flow		800	800	750	750	900	900	750	750	750	750	750	750
Critical Flow		420	420	420	420	420	420	420	420	420	420	420	420
Mean Number Days < Critical	'82-'87	0	0	0	0	0	0	0	0	0	0	0	0
No. Days >300% Change	'82-'87	0	0	0	2	2	0	0	0	0	0	0	0
Bumping R., Nile (293)	'26-'77	110	213	246	204	176	93	145	498	807	391	334	299
Bumping R., Nile (293)	'81-'86	203	183	225	241	195	281	202	405	757	273	147	320
IFTAG Optimal Flow		150	150	150	150	150	200	200	200	100	100	150	150
Critical Flow		30	30	30	30	30	30	30	30	30	30	30	30
Mean Number Days < Critical	'81-'86	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'81-'86	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Tieton R., Rimrock (510)	'26-'77	149	91	192	194	200	29	141	620	1033	882	868	1762
Tieton R., Rimrock (510)	'81-'86	268	133	155	228	315	433	284	650	911	729	704	1353
IFTAG Optimal Flow		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Critical Flow		50	50	50	50	50	50	50	50	50	50	50	50
Mean Number Days < Critical	'81-'86	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'81-'86	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Tieton R., Canal Hdwks (562)	'26-'77	162	111	237	240	253	96	221	530	804	585	555	1483
Tieton R., Canal Hdwks (562)	'81-'85	285	146	208	327	427	410	300	524	705	387	316	1143
IFTAG Optimal Flow		200	200	200	200	125	125	125	125	200	200	150	150
Critical Flow		55	55	55	55	55	55	55	55	55	55	55	55
Mean Number Days < Critical	'81-'85	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'81-'85	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Naches R., Cliffdell (1210)	'26-'77	242	472	631	537	533	537	1126	2195	2142	871	490	406
Naches R., Cliffdell (1210)	'82-'87	368	466	520	747	674	1060	1250	2179	2170	709	323	440
IFTAG Optimal Flow		400	400	300	300	300	300	300	300	300	300	500	500
Critical Flow		120	120	120	120	120	120	120	120	120	120	120	120
Mean Number Days < Critical	'82-'87	0	0	0	0	0	0	0	0	0	0	0	0
No. Days >300% Change	'82-'87	0	1	0	1	1	0	0	0	0	0	0	1

Table 1. Mean monthly flows and flow-related data in selected reaches of the Yakima Subbasin.
First figure represents calculated mean with present demand and operating scheme for the period 1926-1977.
Second figure represents the mean of actual flows over the period 1981-1987.
NOTE: Number in parenthesis after location name is mean unregulated discharge.
Critical flow is the critical low flow by the "Montana Method," 1/10 mean unregulated discharge.
Flow fluctuations >300% in a 24-hr period are indicated in the last row for each reach/tributry.
"N.D." indicates data not available or not yet analyzed.

LOCATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
		MEAN MONTHLY DISCHARGE (cfs)											
Naches, below Wapatox (1768)	'26-'77	124	357	684	556	564	447	1363	3065	3078	1127	534	1380
Naches, below Wapatox (1768)	'82-'87	290	347	301	752	922	1866	1516	3034	2868	809	220	940
IFTAG Optimal Flow		500	400	400	400	400	400	400	400	400	400	400	500
Critical Flow		180	180	180	180	180	180	180	180	180	180	180	180
Mean Number Days < Critical	'82-'87	14	14	16	17	9	0	0	0	0	4	16	1
No. Days >300% Change	'82-'87	1	4	2	5	3	0	0	0	0	0	0	4
Yakima R., Parker (4517)	'26-'77	793	2477	3351	2876	2902	2689	2804	4475	3987	626	200	200
Yakima R., Parker (4517)	'82'-87	1099	1982	1777	3044	3684	4669	2295	3000	2787	588	385	400
IFTAG Optimal Flow		700	700	700	700	600	700	800	800	800	800	800	800
Critical Flow		450	450	450	450	450	450	450	450	450	450	450	450
Mean Number Days < Critical	'82-'87	7	0	0	0	0	0	2	3	9	19	21	21
No. Days >300% Change	'82-'87	0	0	0	2	1	0	1	6	1	2	1	2
Yakima R., Prosser (5620)	'26-'77	265	1261	1952	1445	1445	1354	1814	3769	3531	359	50	200
Yakima R., Prosser (5620)	'82-'87	1662	2379	1729	3095	3838	5012	2587	2887	2909	715	382	710
IFTAG Optimal Flow		1000	1000	800	800	800	800	700	700	800	800	800	800
Critical Flow		560	560	560	560	560	560	560	560	560	560	560	560
Mean Number Days < Critical	'82-'87	2	<1	0	2	0	0	2	3	10	18	25	9
No. Days >300% Change	'82-'87	0	1	0	0	0	1	0	0	0	0	0	0
Yakima R., Kiona (5600)	'26-'77	2133	3393	4292	3909	4056	4006	4146	5664	5518	1674	1382	1685
Yakima R., Kiona (5600)	'81-'85	2319	2764	3579	5031	5758	3980	4481	4751	1902	1627	2106	2106
IFTAG Optimal Flow		1300	1300	900	900	900	900	800	800	800	800	800	1300
Critical Flow		560	560	560	560	560	560	560	560	560	560	560	560
Mean Number Days < Critical	'81-'85	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
No. Days >300% Change	'81-'85	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

3) Adverse impacts to spawning and rearing habitat associated with rapid daily flow fluctuations below storage reservoirs and diversion dams. Areas having such problems include both tributaries and mainstem reaches, and are usually confined to areas immediately below reservoirs. The Yakima above Easton Dam, the Cle Elum River, the Kachess River, the Yakima from Roza Dam to the Naches confluence, the Tieton River and the Bumping River all suffer episodes of severe flow fluctuation (more than 300 percent in 24 hours) several times a year (Mongillo and Falconer 1980).

4) Deposition of fine sediments on fall chinook spawning beds in the lower river. This problem is exacerbated by the low instream flows in the Yakima from Union Gap to Kiona during the irrigation season.

5) False attraction flows associated with irrigation returns and wasteways. This problem is also more severe in the lower river from Union Gap to Kiona, as low instream flows increase the attractiveness of returns.

6) Impaired upstream and downstream migration and degraded spawning and rearing habitat caused by annual river channel berming at small diversions without permanent headwork structures.

7) Degraded rearing habitat caused by prolonged, excessively high flows. Such problems occur in the Yakima from the Cle Elum River to Roza Dam during irrigation season, and in the Bumping and Tieton rivers during the "flip flop" portion of the irrigation season and sometimes during spring runoff.

8) High temperatures in the lower river in July and August. These temperatures reduce rearing habitat quality to marginal, and when above 75 degrees Fahrenheit, would constitute at least a partial thermal block to stocks with late summer spawning runs, such as summer chinook and sockeye.

9) Pesticide concentrations above levels considered safe for chronic exposure to fish in irrigation returns. This situation could conceivably contribute to the very low egg-to-smolt survival rates of fall chinook spawning above Prosser Dam, especially those spawning in and just downstream from Marion Drain and downstream of Prosser Dam.

Land Use

Patterns of land ownership within the Yakima Subbasin are complex (Table 2). Within the boundaries of the drainage, 62 percent of all land is publicly owned and 38 percent is private. Since the Yakima Subbasin is only approximately coterminous with Yakima and Kittitas counties, a more detailed description of ownership patterns in the subbasin is afforded by the patterns observed within these counties.

Table 2. Land ownership in Kittitas and Yakima counties (in acres).

Land Owner	Kittitas County	Yakima County
Federal		
National Forest	400,670	509,452
Department of Defense	102,430	160,701
Public Domain	15,048	29,084
Fish and Wildlife Service	---	1,764
State		
Dept. of Natural Resources	141,295	150,397
Department of Game	139,487	63,925
Dept. Parks and Recreation	7,993	211
Yakima Indian Reservation		1,300,000
County	210	963
Municipal	512	2,732
Private	664,591	721,420
TOTAL	1,482,880	2,731,520

More than 70 percent of the public land in Kittitas and Yakima Counties is federally owned, 26 percent is state owned and the remainder is owned by local governments. Most high elevation forests are on federal and state-owned lands. The semiarid land that makes up the Yakima Firing Center straddles Kittitas and

Yakima counties, and is used for military maneuvers and livestock grazing. The Yakima Indian Reservation in southern Yakima County comprises 25 percent of the bi-county area. Most of this land is tribally owned, with only a small portion within the reservation being "deeded land." City and county ownerships are on valley floors near population centers. Privately owned lands are primarily used for agriculture, housing, commerce and industry, and are generally situated in valleys and on foothill slopes, where irrigation and transportation are accessible. Private corporate land holdings such as Burlington Northern and Boise Cascade are generally in forested areas.

The predominant types of land use in the Yakima Subbasin include irrigated agriculture (1,000 square miles), urbanization (50 square miles), timber harvesting (2,200 square miles) and grazing (2,900 square miles). Although the area affected by timber harvesting and grazing is roughly five times the area affected by agriculture and urbanization, the intensity of activity makes agriculture and urbanization of primary importance to water quality.

A change from row crops to hay in the Kittitas Valley has gradually occurred, and there has been a shift from row crops to permanent crops (such as grapes, apples and pears) in the lower valley. These changes affect the amount of water needed for irrigation, the methods of applying irrigation water, and the quality of water draining from fields and returning to the Yakima.

Mining, wilderness designation, and hydroelectric projects are minor land uses in the Yakima Subbasin. Approximately 7.3 percent (about 450 square miles) of the subbasin lies within four wilderness areas, the William O. Douglas Wilderness Area (Bumping River drainage), the Alpine Lakes Wilderness Area (Waptus River drainage), the Goat Rocks Wilderness Area (North and South Fork Tieton River drainage), and the Norse Peak Wilderness Area (Little Naches drainage). Unfortunately, because all of the habitat would otherwise be excellent, all of the area within the Alpine Lakes and Goat Rocks wilderness areas lies above impassable dams and is inaccessible to anadromous fish. There is virtually no active mining in the subbasin, although claims have been filed on Swauk Creek and the Cooper River, and there are large, inactive coal mining sites near Rosalyn. There are three small-scale hydroelectric projects associated with irrigation canals -- the Roza project (73,690 megawatts per year), the Chandler project (68,030 megawatts per year) and the Naches Drop project on Wapatox Canal. The primary purpose of the Roza hydroelectric project is to provide power for pumping facilities along its distribution system, while power from Chandler goes to the Bonneville Power Administration grid.

PART II. HABITAT PROTECTION NEEDS

History and Status of Habitat

Description of Habitat

Watershed Characteristics

The Yakima River Subbasin lies between two physiographic provinces, the Cascade Mountains and the Columbia Subbasin. The principal rock of the Columbia Subbasin is a series of basalt flows of tertiary age that lap onto the western edge of the Cascade Mountains. Subsequent folding of the basalt has formed a series of southeast trending ridges and valleys that extend from the Cascades to the broad plains of the Columbia River.

Glaciation down the Yakima and Naches valleys resulted in partial filling of Cle Elum, Kittitas and upper and lower Yakima valleys with rock from glacial outwash. Extensive portions of the eastern and southeastern subbasin is mantled by loess, a wind-deposited silt derived from outwash deposits.

As much as 81 percent of the soils and landforms in the subbasin are not suitable as cropland. In the north and west, where the relief is steep to very steep, the landscape is dissected by canyons, ravines and stream courses. The soils are part of the Rough Mountainous Land Association and were formed in glacial till or outwash. They are of variable depth, stony, broken by outcrops of underlying rock, and valuable for timber production, summer grazing, wildlife habitat, recreation and, chiefly, as a watershed. In its role as watershed, this area merits protection from fires, erosion and uncontrolled development. The Rough Mountainous Land Association makes up 48 percent of the subbasin. Soils on the ridgetops generally consist of the Rock Creek-Starbuck Association, and are shallow, well drained and stony, and are formed in loess and loess mixed with weathered basalt. Topography is gently sloping to very steep along the drainages and hillsides. This association is valuable chiefly as range or wildlife habitat although carrying capacity is low. Much of the area has been overgrazed. The Rock Creek-Starbuck Association makes up 33 percent of the subbasin (Anonymous 1974).

Intensive, irrigated agriculture occurs only on the remaining 19 percent of the soils of the subbasin, which lie in valley bottoms and along the shoulders of the ridges. Most of the soils in this area are very fine, wind-deposited silts and sands with large erosion potential on slopes in excess of 2 percent (Boucher 1984).

The climate in the subbasin varies from desert at some of the lower elevations to moist alpine on the higher Cascade slopes. Temperatures in the winter are fairly moderate. The Selkirk Mountains in Idaho and the Rocky Mountains in British Columbia shield the area from the very cold air masses that sweep down from Canada into the Great Plains. The predominantly westerly winds in the winter allow the area to benefit from the coastal maritime influence. In the summer, air from the interior of the continent usually results in high temperatures.

A sharp precipitation gradient in the subbasin falls off in a generally southeasterly direction. Orographic cooling of moist maritime air passing over the Cascades results in heavy precipitation on the windward slope and near the crest, and a rain shadow to the east. In a distance of 10 miles, annual precipitation falls from 100 inches or more at the crest of the Cascades to 48 inches at Bumping Lake and to 26 inches at Rimrock Dam. Within the next 15 to 20 miles, precipitation decreases to 8 to 10 inches on the valley floor. Virtually all of the streams in the subbasin originate at higher elevations where annual precipitation is 60 inches or more.

The rainy season in the valleys occurs during November through January, when about half the annual precipitation occurs. Snowfall in the valleys ranges from 20 to 25 inches and from 75 inches at 2,500 feet to over 500 inches at the summit of the Cascades. It is this mountain snowpack that provides the water for irrigated agriculture.

Forests predominate at higher elevations. Moisture and topography dictate the character of the forests in the subbasin. Along the eastern fringe of the timber zone, timber stands are scattered and occur mainly as narrow bands of trees in canyon bottoms. These meandering strips of timber merge into sparse ponderosa pine and Oregon white-oak forests, which in turn give way to denser stands of mixed species in the higher moisture and elevation zones. As a result, a large portion of the timber volume is in a 30-mile-wide band following the crest of the Cascades. Forests in the subbasin are heterogenous in species composition, age and size class. This is partly due to partial cutting, a silvicultural technique that is prevalent on the Yakima Indian Reservation (but not the upper Yakima, where even-aged management and clearcutting is the norm), and partly to the sharp gradient in moisture transition zones. In recent years, large acreages have been clearcut in the Snoqualmie Pass area and in the upper Little Naches drainage. The cumulative effect on the ecological integrity of the streams that drain the cuts is a matter of great concern.

Between the forests and the valley floor lie the rangelands. Almost all native grazing lands in the subbasin are supported by highly fragile soils that are easily eroded. The four major plant associations in the Yakima Subbasin are the big sagebrush-bluebunch wheatgrass association (40 percent of existing rangeland), the three-tip sagebrush-Idaho fescue association (5 percent existing rangeland), the bitterbrush-bluebunch wheatgrass association (35 percent existing rangeland) and the Sandberg bluegrass-stiff sagebrush association (20 percent existing rangeland). Except for the small three-tip sagebrush-Idaho fescue association, over 50 percent of all grazing associations are in fair to poor condition today. The increased runoff and erosion from these areas may have a significant impact on water quality.

Riparian conditions are highly variable, with good to excellent conditions occurring mainly along the upper reaches of subbasin streams, and fair to poor conditions along reaches in the valley bottom. Riparian degradation is primarily the result of agricultural practices, especially grazing and streamside tillage or mowing, but recreational development is having an increasing impact, especially along the Yakima River in the critical reach from the city of Cle Elum to Easton Dam.

Stream Characteristics

As the data summarized in Table 1 illustrates, the instream flow problem in the Yakima River is not so much that flows are consistently suboptimal or critical. Rather, fluctuations in flow cause periodic suboptimal or critical situations and, somewhat surprisingly, many reaches suffer from a decided excess of flow during the irrigation season (note that "critical" is used here as defined by the "Montana Method" of instream flow assessment: discharge one-tenth or less of the mean annual discharge). A more pertinent measure of lack of instream flow is the mean number of days per month discharge was less than optimal or less than critical. The latter statistic has been computed for some of the reaches in Table 1. In descending order of severity, the worst major reaches in the Yakima system in the period 1982 through 1987 have been the Yakima from Keechelus Dam to Easton Dam (397 days), the Naches below Wapatox diversion (91 days), the Yakima below Sunnyside Dam (Parker gauge, 81 days), the Yakima below Prosser Dam (71 days) and the Yakima below Easton Dam (10 days). Note that episodes of critically low flow in the reach of the Yakima from Easton Dam to the Cle Elum confluence can be especially damaging when they occur in the late spring and early summer (May through early July). This reach includes the most heavily used spring chinook spawning area in the entire subbasin, and contains numerous braids and side channels. Newly emergent fry are attracted to side channels and braids. When discharge falls to critical levels in the late spring, it is probable that large numbers of spring chinook fry are trapped in isolated side channels where they are killed either directly, from physical stranding, or indirectly, from predation.

Mongillo and Falconer (1980) assessed the frequency of critically low flows in the Yakima system for the very dry years of 1973 and 1977 and found a similar but more severe situation. In descending order, the most frequently critical reaches in these five years were Keechelus to Easton (143 days), Parker (142 days), Prosser (96 days), the Naches below Wapatox, and the Yakima at Pomona (both 48 days), and the Yakima at Easton (20 days). (It should be noted that the period Mongillo and Falconer investigated preceded flip-flop operations. Therefore, the precise ordinal pattern they observed should not be expected to reflect the current situation exactly.)

Another important measure of the quality of instream flow is the lack of rapid, large-scale fluctuations. Mongillo and Falconer (1980) proposed that fluctuations equal to or greater than 300 percent in 24 hours be considered unacceptable. By this criterion, the worst major reaches in the Yakima system from 1982 through 1987 have been the Yakima from Keechelus Dam to Easton Dam (30 days); the Naches below Wapatox (19 days); the Yakima at Parker (16 days); the Yakima at Cle Elum and the Yakima at Easton (both nine days); the Yakima at Ellensburg (eight days); and the Yakima at Umptanum, the Yakima at Yakima and the Naches above Wapatox (all four days). Mongillo and Falconer determined that the order of the most severely fluctuating reaches in 1973 through 1979 was the Yakima from Keechelus Dam to Easton Dam (six days); the Yakima at Pomona (three days); the Yakima at Parker and Prosser (both two days); and the Yakima at Easton and the Naches below Wapatox (both one day). Compared to the period 1973 through 1977, severe fluctuations over the last six years have become more frequent and occur in different reaches. These changes may be attributable to flip-flop system operation.

It should be noted that the preceding analysis of instream flows has been limited to major reaches of the mainstem Yakima and Naches rivers. The situation in the lower reaches of many tributaries is considerably worse, especially in the lower reaches of the Teanaway River, and Big, Taneum, Manastash, Swauk, Wenas and Ahtanum creeks.

In the mainstem Yakima above Sunnyside Dam, and in all of the Naches system, temperatures rarely exceed 70 degrees Fahrenheit (21 degrees Celsius) (Tables 3 and 4). However, summer temperatures at Prosser and Kiona frequently exceed 75 F and occasionally reach 80 F in July and August. These high temperatures preclude summer rearing of salmonids in the lower river. The precise downstream boundary for rearing habitat in the summer probably varies from year to year, sometimes being as high as Sunnyside Dam (RM 103.8), and sometimes as low as Marion Drain (RM 82.6). In a survey in the summer of 1988, temperatures in all tributaries except the lower portions of the Satus Creek and Toppenish Creek drainages were observed to be well within the acceptable range for summer rearing of salmonids. The 1988 survey was the initial phase of a Bureau of Reclamation water supply analysis study of all Yakima tributaries. When completed in 1990, it will supply needed temperature data, as well as many other kinds of hydrologic data, necessary for the selection of outplanting sites for smolts produced by the Yakima/Klickitat Hatchery (see Part IV, Alternative Strategies).

In general, stream gradients in the subbasin vary from 0.1 percent or less in the lower mainstem Yakima to 1 percent to 2 percent in the tributaries. Gradients reach or exceed 3 percent only in the steepest drainages, such as the North and South Forks of Simcoe Creek and the North Fork of Toppenish Creek. Production potential is almost never limited by gradient in the Yakima Subbasin except at the extreme headwaters of some streams.

Particle size distribution of streambed material has been quantified only in a few reaches of the upper Yakima and the Little Naches (Wasserman et al. 1984, Fast et al. 1986), but field biologists have qualitatively observed that substrate quality, especially as regards deposition of fine materials, generally falls off along a downstream gradient. In the mainstem Yakima, substrate quality is worst in the reach from Sunnyside Dam to Kiona, and improves somewhat from Kiona to the Columbia confluence as fine materials settle out and/or are resuspended by river flows augmented with irrigation returns. Except for fall chinook, which spawn entirely below Sunnyside Dam, planners do not feel spawning habitat is limiting in the subbasin.

Cover for summer rearing, in the form of large substrate or large organic debris (LOD), is lacking in most tributaries in agricultural areas, and in the lower Little Naches, the lower mainstem Naches, the North Fork of the Teanaway and the Yakima River between Ellensburg and Roza Dam. However, lack of streamside cover for overwintering, particularly when flows are low, may represent a more serious limitation. Spring chinook and steelhead juveniles are known to move from the upper Yakima and Naches in the winter, many moving as far downstream as Prosser. Biologists have interpreted this movement as a search for winter cover. At normal flows, the margins of the Yakima River near the Naches confluence include LOD, undercut banks and rubbly areas, and may afford abundant overwinter cover. Since 1983, the mean depth of this reach through the winter months (October to February) has varied by as much as two feet. The associated variation in the availability of overwinter cover may have strongly influenced egg-to-smolt survival.

Table 3. Physical and chemical water quality, Yakima River at Union Gap gauging station (RM 106.8), 1980-1985.
Data from USGS Water Data Reports WA-80-2, WA-81-2, WA-82-2, WA-83-1, WA-85-1 and USGS Open-File Report 84-145-B.

STATION AND YEAR	MONTH	DISCH. (cfs)	SPEC. COND. (us/cm)	pH	TEMP. (DEG C)	TURBIDITY (NTU)	DISS. OXYGEN (mg/l)	COLIFORM FECAL BACTERIA UM-MF (counts per 100 ml)	HARDNESS (mg/l as CaCO3)	ALKA-LINITY (mg/l as CaCO3)	SODIUM (mg/l)	NITROGEN (NO2 + NO3) (mg/l)	PHOS-PHORUS (Total) (mg/l)	SEDIMENT DISCH. (t/day)
UNION GAP (1985)	NOV	1640	158	7.2	6.5	2.3	12.5	67	64	74	9.6	0.2	0.06	22
	JAN	1370	153	7.4	0	2.5	12.9	54	61	79	8.9	0.38	0.06	26
	MAR	1530	175	7.7	8	2.9	11.9	12	69	81	11	0.26	0.05	41
	MAY	2980	110	7.8	11	4.6	11.2	54	48	47	6	0.11	0.08	129
	JUL	3760	102	7.4	19	7.3	8.7	170	40	54	4.2	0.43	0.09	335
	SEP	2750	133	8.2	14	2	12.6	120	48	60	7.2	0.21	0.07	82
UNION GAP (1984)	NOV	2270	146	8.4	7.5	1	9.8		52	54	7	0.23	0.05	61
	JAN	5660	112	8.2	2.5	17	12.5	110	41	44	4.9	0.18	0.14	2340
	MAR	3020	134	8.4	7.5	3.1	12.4	4	52	60	7	0.27	0.05	122
	MAY	2820	117	8.3	11	4.4	9.6	24	44	52	5.5	0.1	0.05	175
	JUL	3390		7.9	15.5	6.2	10.4	52	39	42	4.9	0.1	0.05	384
	SEP	3290	107	7.4	15.5	9.1	10.2	180	42		5.7	0.18	0.06	320
UNION GAP (1983)	NOV	1920	167	8.6	8.5	2.4	13.6	47	64	73	8.9	0.29	0.11	124
	JAN	8800	108	8.6	3.5	35	12.6	210	43	47	4.9	0.28	0.2	4210
	MAR	11200	142	7.8	6.5	34	11.5	93	49	54	5.6	0.26	0.18	6020
	MAY	5060	106	8.4	13	2.1	11.9	65	43	47	4.8	0.1	0.06	164
	JUL	3620	112	8.3	18	3.5	11	160	41	47	5.1	0.17	0.08	440
	SEP	2900	113	8.3	18	5.4	11	150	42	45	5.8	0.18	0.07	227
UNION GAP (1982)	NOV	1650	166	8.2	11.5	1.6	11.5	35	67	69	10		0.07	45
	JAN	1140	157	8.2	0.5	2.9	13.2	33	59	70	8.4	0.67	0.11	86
	MAR	5550	125	7.8	7.5	5.6	12.1	120	44	53	5	0.17	0.05	435
	MAY	4630	105	8	10.5	4.6	12	55	42	46	4.9	0.12	0.09	438
	JUL	3420	104	8.1	17.5	6.4	9.4	110	39	46	4.8	0.15	0.09	443
	SEP	2840	117	7.8	19.5	4.4	9.8	680	46	52	5.6	0.18	0.06	123
UNION GAP (1981)	NOV	1720	156	7.7	5.2	0.7	11.7	34	59	66	8.5	0.3	0.09	42
	JAN	3180	129	7.8	2.4	1.5	13.2	20	47	49	6.1	0.34	0.06	86
	MAR	3270	131	7.7	7	4.5	12.4		51	48	6.5	0.11	0.06	256
	MAY	3070	108	8	12.2	5.5	11.7	9	41	47	5.7	0.08		182
	JUL	3160	112	7.6	16.6	5.6	9.6	55	42	37	5.5	0.57	0.08	341
	SEP	2950	110	8.4	17.9	5.5	9.9	120	43	47	5.7	0.1	0.05	191
UNION GAP (1980)	NOV	1070	167	7.7	6.9	3.6	11.9	230	67	71	11	0.36	0.09	37
	JAN	1100	147	7.3	0	3.3	14.1	20	53	61	8.4	0.36	0.11	47
	MAR	4060	139	7.8	5.5	4.5	12.3	230	58	58	6.9	0.75	0.11	428
	MAY	4330	93	7.8	10.1	5.6	11.1	140	35	34	4.4	0.18	0.07	246
	JUL	3220	100		19.9	5.9	9.4	22000	38	46	4.9	0.15	0.11	252
	SEP	2630	132		16.4	2.6	9.8	220	51	49	6.6	0.16	0.09	142
UNION GAP MEAN 1980-85	NOV	1712	160	8.0	7.7	1.9	11.8	83	62.2	67.8	9.2	0.28	0.078	55
	JAN	3542	134	7.9	1.5	10.4	13.1	75	50.7	58.3	6.9	0.37	0.113	1133
	MAR	4772	141	7.9	7.0	9.1	12.1	92	53.8	59.0	7.0	0.30	0.083	1217
	MAY	3815	107	8.1	11.3	4.5	11.3	58	42.2	45.5	5.2	0.12	0.070	222
	JUL	3428	106	7.9	17.8	5.8	9.8	3758	39.8	45.3	4.9	0.26	0.083	366
	SEP	2893	119	8.0	16.9	4.8	10.6	245	45.3	50.6	6.1	0.17	0.067	181

Table 4. Physical and chemical water quality, Yakima River at Kiona gauging station (RM 29.9), 1980-1985.
Data from USGS Water Data Reports WA-80-2, WA-81-2, WA-82-2, WA-83-1, WA-85-1 and USGS Open-File Report 84-145-B.

STATION AND YEAR	MONTH	DISCH. (cfs)	SPEC. COND. (us/cm)	pH	TEMP. (DEG C)	TURBIDITY (NTU)	DISS. OXYGEN (mg/l)	COLIFORM FECAL BACTERIA UM-MF (counts per 100 ml)	HARDNESS (mg/l as CaCO3)	ALKA--LINITY (mg/l as CaCO3)	SODIUM (mg/l)	NITROGEN (NO2 + NO3) (mg/l)	PHOS-PHORUS (Total) (mg/l)	SEDIMENT DISCH. (t/day)
KIONA (1985)	NOV	2660	263	8	7	4	12.5	200	110	120	16	1.2	0.08	115
	JAN	2000	250	7.8	2.5	1.6	13.7	73	100	114	15	1.2	0.08	32
	MAR	2390	252	8.2	7.5	5.6	11.4	28	110	118	16	0.96	0.1	142
	MAY	2130	191	7.8	15	9.6	9.8	30	77	86	10	0.6	0.12	178
	JUL	1140	307	7.9	25.5	8.5	7.7	150	120	133	17	1.2	0.15	86
	SEP	2690	289	8.1	16.5	19	9.1	420	110	125	16	1.3	0.1	421
KIONA (1984)	NOV	4630	210	8.4	7	12	11.2	160	80	83	11	0.76	0.13	1050
	JAN	4650	194	8.2	0	6.6	14.4	120	76	80	11	0.76	0.1	490
	MAR	4090	200	7.8	7.5	5.9	12.2	83	77	83	11	0.69	0.05	232
	MAY	4320		7.8	14.5	9.8	8.8	210	72	78	9.5	0.55	0.11	595
	JUL	1770	249	7.9	11	7.4	11.8	54	100	102	14	0.94	0.07	105
	SEP	1740	294	8	17.5	9.9	9.4	52	120	121	16	1.1	0.07	127
KIONA (1983)	NOV	2880	266	7.6	12	4.3	9.7	190	100	114	15	1.1	0.12	311
	JAN	2790	255	8.1	1.5	2.1	13.9	37	94	103	15	1.1	0.12	701
	MAR	7530	186	8.2	7.5	8.2	11.1	210	70	65	9.8	0.55	0.15	2260
	MAY	8170	145	7.5	12	19	10.5	80	56	59	6.6	0.43	0.11	1390
	JUL	2440	280	8.1	23	8.2	9.2	510	110	115	15	1.4	0.19	323
	SEP	2250	265	8.2	13.5	5.7	9.9		100	112	15	1.1	0.08	152
KIONA (1982)	NOV	2060	312	8.1	12	5	10.2	270	120	130	18	1.5	0.08	145
	JAN	2380	270	8.2	0	2	15.1	120	100	110	15	1.3	0.09	39
	MAR	6720	176	7.4	7.5	10	10.9	380	69	75	9	0.45	0.06	1610
	MAY	3390	190	8.4	12	5.1	10.6	120	74	80	9.8	0.35	0.07	220
	JUL	2170	276	8.6	23.5	4.8	10.2	180	100	109	14	0.98	0.18	117
	SEP	2210	253	7.6	20.5	1.3	9.2	270	100	115	15	0.98	0.08	167
KIONA (1981)	NOV	3040	247	7.8	6	4.7	11.6			98		1.1	0.12	131
	JAN	7960	175	7.9	6.1	5.1	12	700	60	60	9.3	0.68	0.15	2110
	MAR	4500	201	7.9	8	6.9	11.6	21	72	68	10	0.62	0.11	389
	MAY	1150	304	8.7	15.3	5.2	12.3	20	120	130	19	1.1	0.2	56
	JUL	1920	284	7.9	18.9	10	9	250	110	100	15	1.3	0.17	202
	SEP	2070	297	8.2	19.5	6.3		89	110	76	15	1.2	0.14	240
KIONA (1980)	NOV	1850	308	7.4	10	5.2	10.2	63	123	130	20	1.9	0.13	170
	JAN	4770	245	7.8	2.1	3	14.7	28	94	100	16	1.2	0.15	3786
	MAR	10000	195	7.9	7.6	46	11	88	74	74	10	1.1	0.42	9612
	MAY	8320	124	7.9	15.6	21	9.6	310	50	50	6.5	0.36	0.16	2853
	JUL	1360	306	8.4	23.6	7.3	8.6	100	116	120	17	1.6	0.14	99
	SEP	1750	319	8.6	20.6	6.9	10.4	200	114	120	17	1.7	0.09	94
KIONA MEAN 1980-85	NOV	2853	268	7.9	9.0	5.9	10.9	177	88.8	112.5	13.3	1.26	0.110	320
	JAN	4092	232	8.0	2.0	3.4	14.0	180	87.3	94.5	13.6	1.04	0.115	1193
	MAR	5872	202	7.9	7.6	14.1	11.4	135	78.7	80.5	11.0	0.73	0.148	2374
	MAY	4580	191	8.0	14.1	11.6	10.3	128	74.8	80.5	10.2	0.57	0.128	882
	JUL	1800	284	8.1	20.9	7.7	9.4	207	109.3	113.2	15.3	1.24	0.150	155
	SEP	2118	286	8.1	18.0	8.5	9.6	206	109.0	111.5	15.7	1.23	0.093	200

Tables 3 and 4 summarize 12 important water quality parameters in terms of monthly means observed at a midriver (Union Gap) and a lower river (Kiona) site from 1980 through 1985. Not surprisingly, the concentration of all dissolved and suspended materials is greater at Kiona than Ahtanum, and is greater during the irrigation season at both stations. Although dissolved oxygen concentrations are good at both stations at all times, some observers suspect there may be localized zones of low dissolved oxygen, especially at the bottom of deeper holes in the lower river during the summer.

When flows are low and the pH is high in a 10-mile stretch downstream of the Prosser Municipal Sewage Treatment Plant, there is the potential for the buildup of toxic concentrations of ammonia. This problem is more fully discussed under "Residential and Commercial Development" below.

A summary of aquatic habitat provided by major reaches of Yakima and Naches rivers and their principal tributaries is provided in Appendix 1 (Supplement 1).

Land and Water Use

Forestry

Concern over the current and future impact of timber harvest on fish production is high. Concern is focused on three main issues, impacts of road construction, cumulative impacts of multiple large clearcuts in a single watershed, and the impacts of logging in riparian areas.

The many potentially adverse impacts of logging and access road construction on fish production have been extensively documented (see Salo and Cundy 1987 for a recent summary). Of particular concern in the Yakima Subbasin is the loss of riparian habitat following construction of streamside roads, and increased sediment loading from erosion or mass failure of cuts and fills. The Little Naches watershed exemplifies both of these issues. Deposition of fine sediments (less than 0.85 mm diameter) in the Little Naches River has nearly doubled (10 percent to 18 percent in the North Fork, 8 percent to 15 percent in the main Little Naches) following logging operations in the drainage over the past several years. There is also some concern that large clearcuts may generate an earlier, more intense runoff pattern with peak flows rising to destructive levels and low flows falling to the critical level (L. Wasserman, Yakima Indian Nation, pers. commun.). Moreover, about four miles of the main access road to the drainage was built in the riparian zone, entailing substantial channelization of the lower river.

Floods and attendant erosion and streambed degradation following "rain on snow events" in heavily clearcut watersheds are another major worry. Large clearcuts allow a much deeper snowpack than does a canopied forest, and a warm rain can result in extremely high volumes of runoff. The U.S. Forest Service is generating "rain on snow" hazard zonation maps, but unfortunately only for westside forests. A similar study is urgently needed in the Yakima Subbasin so that cuts in hazardous areas can be staged to minimize risk.

An increasing body of evidence (see review in Salo and Cundy 1987) indicates that salmonid population densities increase in proportion to the hydraulic complexity created by a matrix of large organic debris (LOD). Past logging operations have cut to the water's edge, removing the source of LOD, and sometimes have entailed the removal of "log jams." Regulations mandating the creation of riparian management zones in the current Washington forest practices rules and regulations should, if conscientiously enforced, prevent such abuses in the future.

Agriculture

Apart from passage and instream flow problems associated with diversion dams, the major impacts of agricultural practices on fish production include sediment and thermal loading, riparian degradation and pesticide pollution.

During the irrigation season, turbidity (and presumably sediment deposition) begins rising downstream of Union Gap as major irrigation returns begin to enter the river. Thermal loading is also associated with irrigation returns because return waters have been heated in the fields and because return water is turbid and absorbs sunlight. As summarized in Table 5, the top five sources of sediment loading to the Yakima River, which together account for the introduction of over 200 tons of suspended solids per day, are found between Union Gap and Spring/Snipes Creek. All of the sources in Table 5 are either man-made irrigation returns or natural streams receiving large irrigation returns. By far the worst source is Sulphur Creek, which drains lands irrigated by the Roza and Sunnyside Valley irrigation districts. Boucher (1982), in a study of the lands drained by Sulphur Creek, found that one tract in his study area acted as a sediment sink (sediment output was less than input). This tract differed from others in the study in having relatively less acreage in row crops (such as asparagus, beans, corn and mint) and more in alfalfa or pasture; and in a greater use of sprinkler irrigation. The tract in question acted as a sediment sink in spite of the fact that its slopes were relatively steeper than other study areas.

Table 5. Suspended solid discharge from various sources in the Yakima Subbasin.

Source	Location	Suspended Solids (tons/day)
Sulphur Creek	RM 61.0 Yakima River	191.1[1]
Spring/Snipes Creek	RM 41.8 Yakima River	17.3[1]
Marion Drain	RM 82.6 Yakima River	13.4[1]
Ahtanum Creek	RM 106.9 Yakima River	13.0[2]
Granger Drain	RM 85.7 Yakima River	12.1[1]
Moxee Drain	RM 107.6 Yakima River	11.8[1]
Wenas Creek	RM 122.4 Yakima River	10.7[2]
Wilson Creek	RM 147.0 Yakima River	4.8[1]

[1] Agricultural Return Flow Management in the state of Washington, 1975. Prepared for WDOE by CH2MHill.

[2] Mean of 1975 and 1976 irrigation seasons as reported in USGS Open-File Report 78-946.

Agricultural degradation of riparian areas is, as has been mentioned, primarily the result of streamside grazing, tillage, mowing and compaction, and of bank stabilization projects necessitated by riparian degradation. Pesticide pollution is currently a sèrious concern only in, and possibly immediately downstream of, irrigation returns.

Residential and Commercial Development

Residential and commercial development has impacted the subbasin's fisheries in three principal ways by 1) degrading the riparian zone and water quality of tributaries flowing through developed areas; 2) periodically degrading the water quality of the Yakima River below the Prosser Municipal Sewage Treatment Plant; and 3) reducing riparian quality along major spring chinook spawning areas in the upper Yakima.

The water quality of the lower reaches of Ahtanum and Wide Hollow creeks, have been seriously degraded by a number of factors. A serious problem an Ahtanum Creek is the pasturing of cattle and horses where they have free access to the stream.

This is not, strictly speaking, an urban problem, but an "exurban problem," involving the cumulative impact of numerous individuals living on the fringes of Yakima who keep a small number of horses or run a few cattle on their own property. A serious septic tank and sewage problem also exists in the same areas, which are not now included in the Yakima Municipal sewage network. The lowermost reaches of both streams are also impacted by storm sewer discharges and the miscellaneous urban and industrial pollutants that wash off city streets.

The Prosser Municipal Sewage Treatment Plant cannot process the volume of sewage it now receives, and there are plans to build a new, larger facility. However, until such a facility is built, the old plant must not discharge wastes into the Yakima River when instream flows are low. When discharged into the river when flows are low and the pH is high, conditions which occur frequently in the summer, ammoniacal wastes will present a hazard to aquatic life.

A vicious cycle of sorts has been occurring with the increasing number of summer homes built along the Yakima River from Cle Elum to Easton. The cycle starts when the landowner clears most or all riparian vegetation for an unobstructed view of the river, often sowing a grassed lawn to the water's edge. The removal of woody vegetation destabilizes the bank, which begins to slough off and prompts the landowner to riprap the bank. In the process, the stream has been widened, pools have been lost, fines have been added to spawning gravel and the stage has been set for accelerated erosion downstream.

Dams and Hydropower Projects

Three fairly small hydropower projects already exist in the subbasin, and developers have applied for permits to build many more small-head hydro projects. The existing projects, Roza, Chandler and Wapatox, all have the potential of reducing instream flows to serious levels (see spring chinook salmon production plan for details), although the constraints put on juvenile rearing and upstream migration stemming from Chandler and Wapatox are probably more severe than Roza. Small-head hydro projects could seriously reduce steelhead production and (the potential for) coho production, and all must be thoroughly screened before being licensed.

Pursuant to Section 1103(c)(2) of the Columbia River Basin Fish and Wildlife Program, all rivers and tributaries in the Yakima Subbasin have been classified as meriting or not meriting inclusion as an area to be protected from future hydropower development. In general, the designations appear appropriate to Yakima planners, except for several instances in which a mainstem reach was not protected while upstream tributaries were (Dry Creek from Seattle Creek to the North Fork, the Teanaway River from the North Fork to the Middle Fork); and for a number of tributaries that are not currently significant producers of anadromous fish, but which have significant production potential (Agency Creek, the North Fork of Toppenish Creek, Toppenish Creek above the North Fork, the forks of Ahtanum Creek, the forks of Cowiche Creek, Little Rattlesnake Creek and the North Fork of Rattlesnake Creek, Jack Creek, and Cole Creek).

A more significant implication of the existing protected areas is, ironically, that such designation might be construed as prohibiting the construction of headwater impoundments that would serve mainly or totally to enhance anadromous habitat. The Yakima Subbasin contains a number of tributaries do not now produce anadromous fish mainly or solely because of seasonal low flows, usually in the lower reaches. Construction of small to moderate-sized impoundments at the headwaters of such tributaries would, in some cases, provide enough water for adequate instream flows in the summer and fall. It should be noted that there are at least two provisions in the Columbia River Basin Fish and Wildlife Program that permit projects of this type in "protected areas." The first, Section 1103(b)(8), states that the Northwest Power Planning Council will amend protected area status to reflect the needs of subbasin plans. The second, Section 1303(e)(3)(g) permits the petition for exception from protected status for projects with exceptional fish and wildlife benefits.

Diversions and Withdrawals

Withdrawal of water from the Yakima River and restriction of inflow during reservoir filling are the most significant factors limiting fish production in the Yakima Subbasin today. In the mainstem Yakima and Naches, the impact is most severe on newly-emergent fry and outmigrating smolts, and possibly on overwintering pre-smolts. Low flows in the Easton reach of the Yakima, especially sudden drops occurring in the late spring, can directly or indirectly kill large numbers of spring chinook fry that become stranded or isolated in side channels. Low flows in April and May in the Yakima below Sunnyside Dam and in the Naches below Wapatox Dam greatly increase the mortality of outmigrating smolts, probably by increasing vulnerability to predatory fish and birds. Low fall and winter flows in the Yakima in the vicinity of the Naches confluence and in the Yakima Canyon can drastically limit the accessibility of shoreline cover, forcing pre-smolts to endure the winter unprotected, and probably increasing overwinter mortality.

The effect of diversions and water withdrawal in tributaries is more severe than in the mainstem, both because the diversions frequently lack effective fish passage and protective devices, and because proportionately more water is diverted. The impact of diversions in tributaries covers the entire life cycle, from egg to returning adult, and impacts steelhead and coho more heavily than chinook, as the former spend relatively more of their juvenile life cycle in smaller tributaries. For a full discussion of this issue see the spring chinook and steelhead fish production constraints sections.

Constraints and Opportunities for Protection

Legal Considerations

Since the adoption of the 1917 Water Code, the state of Washington has allocated water based on the Prior Appropriations Doctrine. In many cases, the amount of water allocated has resulted in many overappropriations and the reduction in corresponding anadromous fish runs. Instream flow protection started with Chapter 75.20 RCW (1949), with Department of Fisheries and Department of Wildlife recommendations for low flow conditions and stream closures to further appropriations of water. Since 1969, beginning with passage of the Minimum Water Flows and Levels Law (RCW 90.22), the state law has acknowledged a greater need to protect instream flows for fisheries and other instream values through developing basinwide flow protection programs. In addition, the 1917 Water Code provided that water permits would not be granted that could prove "detrimental to the public welfare" (RCW 90.03.290).

Both the Minimum Water Flows and Levels Law, and the Water Resources Act of 1971 (RCW 90.54) direct the Department of Ecology to set minimum or base flows that protect and preserve fish and other instream resources. Because minimum or base flow regulations do not affect existing water rights, reductions in anadromous fish runs in overappropriated streams will continue to be a problem. The Water Resources Act specifically lists fish and wildlife maintenance and enhancement as a beneficial use. It further directs the Department of Ecology (DOE) to enhance the quality of the natural environment where possible.

The state statutes, however, do not define the extent of instream resource protection, leaving to the DOE the task of determining adequate protection levels for instream flows. This has caused increasing controversy in recent years and resulted in an attempt by the DOE to define the level of flow that was to be provided for fish in the state's streams. The Department of Ecology's 1987 effort to set a standard of "optimum" flows for fish was challenged by out-of-stream water users via the Washington Legislature in 1988. The 1988 Legislature put a moratorium (which has now been lifted) on the DOE's recommended standard and established a Joint Legislative Committee on Water Resources Policy to address Washington's water future. To date, the committee has yet to define the level of protection that will be afforded fish resources.

Lacking any legislative direction on instream flow protection levels, water continues to be allocated from state streams under past practices. All water right applications are reviewed by the Department of Fisheries (WDF) and the Department of Wildlife (WDW), under RCW 75.20, prior to issuance by the Department of Ecology. The Department of Ecology considers WDW and WDF comments before making a decision regarding the issuance of a permit for withdrawal. WDF and WDW comments are recommendations only, and can be accepted or ignored by the Department of Ecology. Current DOE practice is to issue water permits if water, above that recommended to be retained instream, is available for allocation. Virtually all domestic use requests are approved as are many non-domestic requests. The impacts of specific withdrawals on fish resources is, however, often unclear, and the cumulative impact of new withdrawals is less instream flow and more negative impacts on fish.

The majority of Washington's streams do not have minimum flows established. Yet the Ecology Department continues to issue permits for diversion and water withdrawal. It is unlikely that the current system will change until the Joint Legislative Committee on Water Resources Policy defines state policy in this area. The committee's decision could have a major impact on the future of the state's fisheries resources.

The fisheries agencies have requested that for most streams, instream flows be protected at levels that would maintain existing fish production, including the full range of variations that occurs naturally due to environmental conditions. For some streams, like the Yakima River, the fisheries agencies request flows to levels that would achieve potential production. This potential production would be determined by analyzing what could reasonably and practically be expected to return to the stream in the future.

In those streams that have already been overappropriated, establishment of instream flows may limit losses of fish resources to that which has already occurred. In many of these streams, restoration of instream flows is requisite for increasing or reestablishing fish runs.

In support of the continuing investments by the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program, the following recommendations are made relative to instream flows and fisheries resources:

1) No new out-of-stream appropriations of any kind should be issued unless appropriate instream flow levels are established for the stream to be impacted either through comment on the water right application or through the adoption of an instream flow regulation.

2) There should not be any exceptions to the minimum flow levels, including domestic use.

3) Minimum flows should be impacted only if concurrence is obtained from the state and federal fish resource agencies and tribes and adequate mitigation is provided.

4) Minimum instream flow levels should be adequate to protect existing and potential (where appropriate) fish production.

5) State law should be changed so that saved, purchased or donated water can be dedicated to instream flows.

Critical Data Gaps

1. The relationship between instream flows and habitat availability in two general areas: 1), the Yakima River from Easton Dam to the Cle Elum confluence; and 2), the Yakima River in the vicinity of the Naches confluence and the Yakima Canyon, as well as the Naches River from its mouth to the Tieton confluence. Of particular interest in the Easton reach of the Yakima is the relationship between spring flows in the mainstem and flows in the side channels, especially mainstem flows at which side channels become isolated or dewatered. Such information is extremely critical to managers wishing to protect spring chinook fry in this major spawning area. The accessibility of streamside cover as a function of discharge in the Yakima Canyon and the lower Naches must also be determined. Most spring chinook overwinter in these areas, and a knowledge of the relationship between accessible habitat and discharge would allow managers to define flows below which overwinter mortality could be severe.

2. The relationship between instream flows and smolt survival in at least two known areas of high smolt mortality: the Naches River between Wapatox Dam and the Naches power plant outfall and, especially, the Yakima River between Sunnyside Dam and Prosser Dam.

3. The location of high risk zones for landslides and rain-on-snow events, and the generation of new, ground-truthed soils maps. This information is essential if logging is to be compatible with a healthy aquatic environment.

Habitat Protection Objectives and Strategies

Forestry

The subbasin plan proposes seven actions to make forestry more compatible with the preservation of high quality fish habitat:

1. Conduct a study to determine the cumulative impact of numerous cuts of different age (years after cutting) and size within the same watershed, and use the information gained to modify the Wenatchee Forest Management Plan and the Washington State Forest Practices Regulations.

2. Ensure the integrity of riparian (streamside) habitat by maintaining adequate riparian management zones (RMZs) along streams in all logging sites.

3. Develop baseline information on existing habitat quality and the impacts of forest practices.

4. Locate all new logging and forest access roads in stable, non-erodible areas, and outside RMZs.

5. Develop landslide and rain-on-snow hazard zonation maps and restrict the size or timing of new cuts in hazardous areas.

6. Except when clearly needed for fire control, forest management or other long-term purposes, make the abandonment of logging roads a condition of as many timber sales as possible.

7. Ensure the compatibility of the Yakima Subbasin Plan and drainage-specific timber management plans formulated by the participants in the Timber, Fish and Wildlife (TFW) Agreement and the Wenatchee National Forest.

Funding for the studies of cumulative effects, baseline habitat assessment, and landslide and rain-on-snow hazard mapping might come from a number of sources. The internal funding mechanism of the TFW Agreement can be expected to provide some of the necessary funding, but not all. The Northwest Power Planning Council and the Bonneville Power Administration should consider funding some of the programs, especially those with implications for the entire Columbia Basin. Additional potential funding sources might include monies appropriated by State Referendum 39; the federal Clean Water Act, Section 205(j); and the Centennial Clean Water Act.

Regulatory and enforcement mechanisms for forest practices on state and private land already exist in the Timber, Fish and Wildlife Agreement. Under that agreement, regulations governing forest practices on state and private lands will be changed to reflect new scientific data gathered by Timber, Fish and Wildlife investigators. Forest practices on national forest lands would probably follow suit, as it is the policy of the Forest Service always to employ Best Management Practices.

Agriculture

Planners propose five general objectives for agricultural practices in the subbasin:

1. Endorse new state legislation to regulate agricultural practices much as the existing Forest Practices Act regulates forestry. Such legislation should, in addition to promoting productive and profitable agricultural activity, ensure that agricultural practices are environmentally sound. It should, in particular, address the maintenance of high water quality (sediment discharge, temperature, pesticide and herbicide pollution), the problem of non-point source pollution, and the preservation of riparian habitat.

2. Reduce discharge of suspended sediments into the Yakima River from irrigation returns and wasteways, if possible, to a level consistent with its designation as a "Class A" water (turbidity less than or equal to 5 NTU). Sediment loading can be reduced by the following four measures.

   First, ongoing programs to implement Best Management Practices (BMPs) for on-farm erosion control and water conservation (such as installation of closed-conduit delivery systems that facilitate conversion to sprinkler irrigation) should be accelerated, and definitely should not be put on hold pending further studies. Unfortunately, this situation is occurring in the subbasin. Project monies appropriated under Referendum 39 have been transferred to the Centennial Clean Water Commission and reallocated for new studies. Consequently, successful BMP implementation programs, such as the one administered by the Roza Irrigation District, have been deferred. Yakima planners submit that this policy is counterproductive. It is suggested that Yakima River Basin Water Enhancement Project, Washington Department of Energy and the Soil Conservation Service intercede, and attempt to persuade the Centennial Clean Water Commission to reverse itself in this matter.

   Second, whenever feasible from a financial and operational standpoint, riparian corridors on natural waterways should not be cultivated, but instead left fallow or planted in grasses to generate "vegetative filter strips" to "strain out" suspended solids in runoff. The Soil Conservation Service, as well as all fisheries and wildlife managers, should encourage farmers whose land is intersected by streams to enroll in the Department of Agriculture's vegetative filter strip program. This program, one of many programs comprising the Conservation Reserve Program, provides payments of up to $50,000 per year to farmers who create and maintain vegetative filter strips.

Third, the possibility of converting the lower sections of drains into sediment traps should be investigated. This might be accomplished by redesigning the water course into a series of meanders with alternating sections of dense aquatic and riparian vegetation, or simply by using low dams at the mouth of wasteways to create settling ponds. While such measures would probably be reasonably effective, and might create new, valuable wetlands for waterfowl, they would also be very expensive. To take only one consideration, huge volumes of deposited sediments would have to be dredged out on a nearly annual basis.

Finally, the subbasin planners endorse most of the elements of the failed Senate Bill 5.2519, the so-called "Early Implementation" bill. One of the elements of this bill, the construction of a reregulating reservoir on Roza Canal at the Sulphur Creek Wasteway, would reduce the sediment input from the worst single source of sediment loading in the subbasin. If a new Early Implementation Bill containing this element were submitted to Congress without conditions impacting fish adversely in some other context, Yakima planners would urge its support.

3. Habitat quality in riparian corridors should be protected by controlling the timing and intensity of livestock grazing.

Objective 3 is a major element of several species production plans and will be described here only in general.

A large-scale riparian fencing program targeted on tributaries and mainstem reaches in present production areas and areas into which future outplants will be made should be implemented. The program would entail A) voluntary riparian easements on private lands; B) governmentally financed installation and maintenance of fencing, watering gaps and, where appropriate, piping and watering troughs outside the exclosure; and C) the imposition of a carefully controlled grazing program <u>inside</u> the fenced area after a certain degree of riparian recovery had occurred.

4. The stocking densities on rangeland currently in good condition should be maintained, and the grazing pressure on deteriorating range should be reduced.

   The conservation and enhancement of rangeland in upland areas is necessary if grazing pressure is to be diverted from riparian areas. Range conditions in the Yakima Subbasin could be improved by institution of site-specific programs of intensive management. On the Yakima Indian Reservation, it is suggested that the Tribal Range and Wildlife departments collaborate in the drafting of a new, integrated grazing strategy and a revision of grazing regulations, and that the BPA-funded fencing program be an integral part of the strategy (see strategies for spring chinook and steelhead for details). Off the reservation, this measure would be best promoted by enlisting the Washington Department of Ecology, the Washington Department of Agriculture and the Soil Conservation Service in a campaign to persuade the Washington Department of Natural Resources, the Wenatchee National Forest, the Bureau of Land Management, and the Department of Defense (Yakima Firing Center) to develop and implement similar programs of intensive management.

   It should be noted that the restoration and enhancement of reservation uplands and riparian corridors for the benefit of fish, wildlife and cattle production ultimately will require that the density of wild horses be controlled in some manner. It is suggested that the Tribal Wildlife Department, in consultation with the Tribal Fish and Wildlife Committee and Tribal Council, develop a strategy for this key element, range and riparian management.

5. The concentration of organochloride pesticides and dieldrin in Sulphur Creek, Birchfield Drain, Granger Drain and Spring/Snipes Creek should be reduced to levels not hazardous to aquatic organisms subjected to long-term exposure.

   The reduction of pesticide pollution in irrigation returns, entails two measures. Where plans do not yet exist, the Department of Ecology, Soil Conservation Service, Yakima River Basin Water Enhancement Project, soil conservation districts, and irrigation districts should work with individual farmers to design, fund and implement on-farm plans to reduce erosion in the targeted waterways. Where existing projects have been deferred pending further research, they should be restarted immediately. It should be noted that, although pesticides are generally very insoluble in water, they do adhere to soil particles. Thus, pesticide pollution of water courses is usually the result of erosion from agricultural lands. The Washington

Department of Ecology should also work with Department of Agriculture inspectors, applicators and farmers to reduce the incidence of accidental contamination of water courses.

Residential Development

Yakima planners propose the following objectives for residential development.

1. Do not disturb riparian zones bordering important spawning and rearing areas.

   As residential impacts on riparian areas bordering important spawning areas are currently concentrated in Kittitas County, initial efforts should be concentrated there. The Kittitas County Planning Department regulated shoreline development in Kittitas County, and the Washington Department of Fisheries approves construction (issues Hydraulic Permits) for construction in or on the shores of salmon-bearing streams. These two entities should work together to ensure that the requirements of Section 19 of the Kittitas County Shoreline Master Program, "Protection of Natural Shoreline Features," are met in full. Section 19 states that "all construction shall be designed to protect adjacent shorelines against erosion," and goes on to state that "buffer strips of vegetation between shoreline developments and associated water bodies are encouraged, and private and public landowners shall be responsible for the preservation of vegetation to minimize erosion within the shoreline area."

   This regulation, if strictly enforced, would have prevented many of the existing adverse residential impacts on the upper Yakima, but still does not provide for some essential features of salmonid habitat. In particular, it does not require the preservation of trees and other large woody vegetation to provide shade and rearing microhabitat. The Kittitas Planning Department, the Yakima Indian Nation and the WDF should negotiate a more comprehensive minimum "riparian management zone" requirement for future development that more effectively protects riparian areas in the most important spring chinook spawning and rearing habitat in the subbasin. It is suggested that these requirements be modeled on the existing RMZ regulations in the Washington Forest Practices Act. Variances should not be issued for non-conforming developments even if adjacent areas are non-conforming. In the absence of new and enforced RMZ regulations, the WDF and the Yakima Indians are encouraged to continue their close scrutiny of hydraulic permit applications.

2. Reduce septic contamination of streams flowing through urban areas.

   In the Yakima Subbasin, septic contamination is most problematic in Ahtanum Creek and Wide Hollow Creek. It is recommended that WDOE continue its efforts in these areas to enforce existing laws relating to septic tank leakage and the discharge of septic wastes into storm drains.

Consumptive Water Use

Yakima planners propose the following general and specific objectives in the area of consumptive water use and resultant instream flows.

1. In general, improve flows for spawning, rearing and migration throughout the Yakima Subbasin.

   Flow reduction in reaches with high flows and flow augmentation in reaches with low flows would increase the amount of usable habitat, and would increase the carrying capacity of the subbasin. Improved flows in certain reaches during adult and juvenile migration periods would also improve migration survival rates.

2. A specific and very important objective is that discharge in the reach of the Yakima River between Easton Dam and the Cle Elum River be high enough to provide adequate flows in braids and side channels.

   This objective is critical from April through early July, while newly emergent spring chinook fry remain in the area. A preliminary prescription is that total flow in the reach not fall below approximately 90 cfs. This flow is based on IFIM (instream flow incremental methodology) data (Dell Simmons, USFWS, pers. commun., 1990), which indicates that side channel flow will be a perilously low 2 cfs when total discharge is 90 cfs, and that side channels will be totally dry when total discharge is about 80 cfs (see spring chinook limiting factors section).

   Yakima planners strongly endorse a plan that has recently (April 1990) been at Yakima River Basin Water Enhancement Project (YRBWEP; see next section) meetings (Bob Tuck, YIN fisheries consultant, pers. commun., 1990). Under this proposal, facilities would be built to divert as much as 35,000 acre feet of late winter and spring flood flows from Cabin Creek and Silver Creek. This water would be routed to Kachess Reservoir, which rarely fills, and would be used primarily or entirely to augment instream flows for the benefit of anadromous fish. Specifically, the amount of water added to Kachess Reservoir would be "on call" for fisheries use, but would be withdrawn from <u>Keechelus</u> Reservoir, <u>not</u> Kachess. Such a shift in the point of withdrawal would allow instream flows to be supplemented in the Keechelus to Easton reach, as well as the Easton to Cle Elum reach. (The newly-accessible 11 miles of the Keechelus to Easton reach would undoubtedly afford the best habitat in the subbasin if critically low flows during the period of reservoir refilling -- mid-October through April -- could be eliminated.)

A preliminary analysis of the Cabin Creek/Silver Creek diversion plan indicates it could solve the instream flow problems in all mainstem areas between Keechelus Dam and the Cle Elum confluence. Water year 1988 (October 1, 1987 through September 30, 1988) was the worst year in the decade in terms of instream flows in the upper Yakima during the period of reservoir refilling. With the help of daily mean flow records from the Bureau of Reclamation's Hydromet data base, Yakima planners have determined that 18,113 additional acre-feet of flow would have rectified all upper Yakima flow problems in water year 1988. An additional 18,113 acre-feet of flow would have maintained at least 50 cfs in the Keechelus to Easton reach from October 1 through March 31, and 160 cfs in the Easton to Cle Elum reach from April 1 through July 31. A flow of 50 cfs in the Keechelus to Easton reach would have accommodated incubation needs here easily (incubation flows in the Easton to Cle Elum reach are already provided under a court order). As evaluated by existing IFIM data, a flow of 160 cfs between Easton and Cle Elum would have maximized fry rearing habitat in both the main channel and the side channels. In addition, a target flow of this magnitude would provide a "buffer" against sudden, unforseen changes in meteorological conditions that might otherwise cause a sudden drop in river flow and the dewatering of side channels.

To reiterate, Yakima planners endorse a Cabin Creek/Silver Creek diversion plan as outlined above very strongly. The Power Planning Council is encourage to do all in its power to aid any legislative initiative containing this element.

Although the general goals are achievable with major changes to the existing storage and operational system in the subbasin, no concrete proposal to effect all of the needed improvements exists at the present time. Accordingly, subbasin planners encourage the identification and support of new proposals, such as the Cabin Creek/Silver Creek diversion plan, that would improve instream flows. These measures should include conservation strategies to reduce irrigation diversions, new storage to provide water for instream flows and irrigation, and operational changes resulting in improved flows. Studies to identify, evaluate and refine potential measures for improving water supplies and instream flows should be encouraged. The Yakima River Basin Water Enhancement Project group, in consultation with Washington Departments of Fisheries and Wildlife, and the Yakima Indian Nation, should review proposals and identify those with the best potential for enhancing fish production. All groups interested in improving fisheries in the Yakima Subbasin should support implementation of acceptable flow enhancement efforts.

In addition to the Cabin Creek/Silver Creek diversion plan, two other measures to improve instream flows are feasible now. First, flows could be increased and passage of adults and juveniles improved if diversions for hydropower generation at Wapatox, Chandler and Roza dams were subordinated to instream flows. Second, passage of smolts below Sunnyside Dam would be improved by rebuilding and automating antiquated check structures on Sunnyside Canal, and implementing a specific operational program to use resultant saved water in an optimal manner (see strategies for spring chinook, Part IV). Both hydropower subordination and renovation of Sunnyside Canal were addressed in detail by the Early Implementation Bill (5.2519) and the Comprehensive Yakima River Basin Water Enhancement Project Bill (5.2322). As the comprehensive measure has failed, the re-introduction of revised and scaled-down legislation seems likely. Support from the fisheries community for some form of legislation that, at a minimum, entails subordination of hydropower, the renovation of Sunnyside Canal, and the implementation of the Cabin Creek/Silver Creek diversion plan is strongly recommended.

PART III. CONSTRAINTS AND OPPORTUNITIES FOR ESTABLISHING PRODUCTION OBJECTIVES

Institutional Considerations

The principal land and water managers or administrators affecting fish production are grouped by type and summarized below.

Federal
- Bureau of Reclamation (BOR)
- Corps of Engineers (COE)
- Bureau of Land Management (BLM)
- U.S. Forest Service (USFS)

State
- Department of Natural Resources (DNR)
- Department of Ecology (DOE)
- Washington Department of Wildlife (WDW)
- Washington Department of Fisheries (WDF)

Tribal
- Yakima Indian Nation

Local
- Kittitas PUD
- Benton PUD
- Yakima PUD
- Municipal Governments
- Yakima, Kittitas, Benton and Klickitat County Governments

Irrigation Districts

There are 162 irrigation districts in the Yakima Subbasin. Most districts are quite small and are represented by the Yakima River Basin Association of Irrigation Districts (YRBAID). The six major irrigation districts are:

- Kittitas Reclamation District
- Yakima Tieton Irrigation District
- Roza Irrigation District
- Sunnyside Valley Irrigation District
- Wapato Irrigation Project
- Kennewick Irrigation District

Several of the more prominent minor irrigation districts include:

Ellensburg Town Canal
West Side Irrigation District
Cascade Irrigation District
Selah-Moxee Irrigation District
Naches-Selah Irrigation District
Union Gap Irrigation District
Columbia Irrigation District

Utilities
Pacific Power and Light
Puget Sound Power and Light
Benton County Rural Electrification Authority
Pacific Northwest Utilities Conference Committee

Major Private Landowners
Boise Cascade Corporation
Plum Creek Corporation (division of Burlington Northern Railroad)

Existing Cooperation

Two large and long-standing cooperative projects involving fisheries and land and water managers exist in the Yakima Subbasin. These projects, the Yakima/Klickitat Production Project and the Yakima River Basin Water Enhancement Project have a major impact on subbasin planning.

Yakima/Klickitat Production Project

The Yakima/Klickitat Production Project, as part of the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program, embodies elements of system planning and is consistent with system planning policies. Both activities are intended to:

1) Contribute to the doubling of Columbia Basin runs of salmon and steelhead.

2) Assess and minimize genetic risks associated with project activities.

3) Be planned from a systemwide perspective that ensures compatibility with other projects and out-of-subbasin constraints.

4) Entail an inbasin harvest management plan that supports rebuilding.

5) Employ the principles of adaptive management.

Systemwide integration of the hatchery project is addressed by making provision (in the inbasin harvest management plan and elsewhere) for system integration. In addition, the Power Planning Council's computerized System Planning Model (SPM) will be extensively employed in formulating and analyzing supplementation strategies under both activities.

The agencies and other parties cooperating in the Yakima/Klickitat Production Project include the Yakima Indian Nation, Washington Departments of Wildlife and Fisheries, U.S. Fish and Wildlife Service, Bureau of Reclamation, several irrigation districts, and Northwest Power Planning Council. The parties with fish management responsibility include WDF, WDW and Yakima Indians.

Yakima River Basin Water Enhancement Project

The largest effort involving fisheries interests and land and water managers in the valley consists of the Yakima River Basin Water Enhancement Project.

In 1979 Congress, at the request of the state of Washington and others, passed Public Law 96-162 directing the Secretary of the Interior to conduct a feasibility study for the proposed Yakima River Basin Water Enhancement Project. The primary objectives of the project were to:

1) Provide supplemental water to presently irrigated lands.

2) Provide water for new irrigation development on the Yakima Indian Nation.

3) Provide water to increase streamflows to protect and enhance anadromous fish (measures which included improvement of fish passage and protective facilities).

4) Develop a comprehensive management plan for the subbasin to enable efficient utilization of the water supply.

In Phase 1 of the study, a core group consisting of the Bureau of Reclamation and the Washington Department of Ecology determined that an economically justifiable plan could be developed to meet a range of supplemental irrigation and instream flow water needs. In 1981, the Phase 1 Study Team Report recommended the study continue and that the necessary legislation and funding be pursued for early construction of a reregulating reservoir (the East Selah facility) for construction of fish passage and protective facilities at 20 diversion sites, and for the facilitation of the development of a water bank system.

The Northwest Power Planning Council, Bonneville Power Administration, the state of Washington, Yakima Nation, Bureau of Reclamation, various Yakima Subbasin irrigation entities and municipalities, and the Bureau of Indian Affairs cooperatively began construction of the fish passage and protective facilities in 1984. All projects are scheduled for completion in 1989. Although interest in the East Selah reregulating reservoir and the development of a water banking system continues, final decisions as to their inclusion in the water enhancement project are not expected until a subbasinwide plan is developed.

Phase 2 of the project began in 1982. This study divided the subbasin into off-reservation and on-reservation components, and for each component quantified water requirements especially as related to supplemental irrigation and instream flow. Other work included:

1) Refinement of system operation models used to evaluate the availability and demands upon water supplies.

2) Identification and preliminary evaluation of potential non-storage opportunities.

3) Evaluation of potential sites for new storage.

In 1985, the Phase 2 Status Report presented specific alternative development plans for the subbasin. A major conclusion of the report was that any generally acceptable plan would entail a combination of new storage and water conservation. Another conclusion was that water resource needs on and off reservation could effectively be addressed separately from both a physical and an operational perspective.

A Plan Formulation Summary Report, completed in 1986, compared four alternative plans and recommended a further, more detailed analysis. Conservation received special emphasis, and a package of such measures were recommended for early implementation.

A policy group consisting of federal, state, and Yakima Indian Nation representatives was formed in 1987. This group solicited agency and public participation in four work groups addressing site selection for new storage, water conservation, instream flows and fish production objectives, and legal and institutional problems.

The Yakima River Basin Water Enhancement Project team attempted to develop a Plan Formulation Working Document, which was to consist of a final analysis of alternative off-reservation development plans. It was originally intended that the working document be completed in 1989. However, many of the elements of the document addressed actions that were incorporated in Senate Bill S.2322 (see below). When this bill died in committee, the completion date for the working document was indefinitely postponed, and the off-reservation portion of the Yakima River Basin Water Enhancement Project process was thrown into disarray. When the Yakima Water Enhancement Project process has been reorganized, a new attempt will be made at formulating the Plan Formulation Working Document, which will serve as the vehicle for selection of the preferred off-reservation development option. It should be noted that the on-reservation YRBWEP process is still on schedule, and the Yakima Indian Nation expects to have development alternatives formulated by late 1991.

In April 1988, the policy recommendations of the four work groups referred to above resulted in the submission to the Senate Committee on Energy and Natural Resources of Senate Bill S.2322, a bill "to authorize certain elements of the Yakima River Subbasin Water Enhancement Project." This bill was not represented as a final resolution of the water problems in the subbasin, but as a vehicle to initiate serious discussion and negotiations for a workable compromise. The preliminary bill contained all the elements of a comprehensive solution. Specifically, there were five elements to the proposal:

1) Operational and physical measures to increase the efficiency of existing irrigation projects.

2) The provision of institutional and economic incentives to promote such practices of water conservation as appear warranted by a comprehensive study of the issue.

3) The improvement of fish passage in three reaches of the Yakima River (below Roza and Prosser Dams) and one reach in the Naches (below Wapatox Dam) by elimination of diversions for hydroelectric power generation.

4) The improvement of fish passage and rearing habitat through an augmentation and adjustment of instream flows made possible by enlarging Bumping Lake from 33,000 to 458,000 acre feet.

5) The partial fulfillment of Yakima Indian Nation treaty rights regarding off-reservation water for anadromous fish production and on-reservation irrigation.

There are at least 10 additional examples of interagency cooperation in the Yakima Subbasin, all smaller in scale than the Yakima River Basin Water Enhancement Project or the Yakima/Klickitat Production Project. These additional agreements, instances of cooperative management and institutional considerations are as follows.

<u>Kittitas Reclamation District vs. Sunnyside Valley Irrigation District</u>

In 1980, Judge Quackenbush of the Federal District Court in Spokane, Washington, ordered instream flows in specific river reaches below Easton and Cle Elum dams to protect spring chinook spawning and incubation. The order is considered an interim action until a more permanent solution is reached. As a result of the court order, a System Operation Advisory Committee, comprised of irrigation districts, WDF, USFWS and the Yakima Nation was organized. The committee meets as necessary with the Bureau of Reclamation Yakima Project supervisor to advise him in the development of an annual operation plan that will meet project operations, institutional constraints, and flows for fish.

The operation plan to meet fishery flows is generally referred to as "flip-flop" operation because of the way releases are made from reservoirs in the upper Yakima and Naches systems. The operation plan, in general, attempts to meet the irrigation demands below the confluence of the Yakima and Naches rivers.

The objective of this plan is to reduce the elevation at which spawning occurs within the riverbed in the Easton Dam to Teanaway reach of the upper Yakima River and in the Cle Elum River below Cle Elum Dam. Through such regulation, it is possible more fully to provide flows for egg incubation during winter and early spring while also storing water for the next irrigation system. It is generally held that for flip-flop to be effective, it must entail the maintenance of an incubation flow that is at least 50 percent of the spawning flow.

Minimum Instream Flow Agreements

The Bureau of Reclamation's Yakima Project has an agreement with the U.S. Fish and Wildlife Service to provide instream flows for fishery purposes below Prosser Dam. Present operations maintain the following flows.

March 1 to July 10: 200 cubic feet per second (smolt outmigration and spring chinook and steelhead spawning run)

July 10 to September 1: 50 cfs

September 1 to November 30: 200 cfs (fall chinook, coho and steelhead spawning run)

December 1 to March 1: 50 cfs

There are additional, informal agreements between the BOR and fish managers to try to maintain flows of 200 cfs below Sunnyside Dam, and 100 cfs below Easton Dam. Similarly, there is an informal agreement between Pacific Power and Light Company and fisheries managers to attempt to maintain a flow 125 cfs below Wapatox Dam from September through March, and a flow of 300 cfs from April through August. Under flip-flop system operation, this latter flow is impossible to achieve.

Timber, Fish and Wildlife Project

The Timber, Fish and Wildlife Project (TFW) is a new process for consultation between natural resource management entities and Washington's public and private timberlands managers. It is to be based upon cooperative research, monitoring and evaluation. The participants in this project include the WDW, WDF, the Washington Environmental Council, the Audubon Society, Washington Department of Natural Resources, Washington Department of Ecology, the Washington Forest Protection Agency, 18 individual Indian tribes, the Northwest Indian Fisheries Commission, and a large number of representatives from the timber industry in Washington state.

The adaptive management policy embodied by the TFW Project was adopted by the Washington State Forest Practices Board in 1988. Based on annual evaluation, resource management plans, and "cooperative research, monitoring and evaluation," this policy is designed to modify forest practices regulations management. The Department of Natural Resources is charged with reporting to the Forest Practices Board on opportunities to modify regulations when baseline data, monitoring, evaluation, or the use of interdisciplinary teams show that such adaptive management will better meet the objectives and policies of the board.

The TFW Project has added a process of cooperative problem solving to the existing state administrative management of private and state forest lands. The agreement provides for two new management systems, one based on subbasinwide management plans, the other based on new forest practice rules that went into affect January 1, 1988. Early in the negotiation process, the parties recognized there were opportunities for developing site-by-site watershed management plans of five- to 10-year's duration. For those timberland owners who choose not to participate in the voluntary subbasin planning approach, jointly developed forest practices regulations will govern (Timber,Fish and Wildlife Project Tribal Funding Proposal, April 1988).

The precise Timber, Fish and Wildlife related projects in the Yakima Subbasin have not yet been determined. Cooperative monitoring, evaluation and research activities are likely to include:

1) Those relationships or processes about which basic fisheries understanding is limited, such as ambient monitoring of streams, stream temperature, riparian management zones, cumulative effects of clearcutting large percentages of drainages in areas of intermingled land ownership, mass wasting and sedimentation following logging operations.

2) Evaluation of the degree to which specific regulations or other Timber, Fish and Wildlife components are meeting agreed upon resource objectives.

3) Information such as landslide hazard zonation maps needed to facilitate site-specific planning.

4) Monitoring information to assess overall effectiveness of the agreement in meeting timber and public resource needs.

Cooperation Among the WDW, the Yakima Nation, and Northwest Steelheaders' Club to Produce Hatchery Steelhead

The Washington Department of Wildlife and the Yakima Indian Nation have for several years collaborated in the management of the Yakima Trout Hatchery and the Naches Hatchery for the production of steelhead, rainbow trout and brook trout (cooperative use of Naches Hatchery involves only steelhead). Associated with this agreement is an agreement among the WDW, the Yakima Indian Nation and the Yakima Chapter of the Northwest Steelheaders' Club for the steelheaders to finish the feeding and rearing of a portion of the annual steelhead production at their Nelson Springs raceway. A part of this latter agreement is that rearing would be supervised by the WDW, and that the fish would be released from the Nelson Springs site. The current agreement calls for the production of about 180,000 steelhead from native Yakima brood stock.

It should be noted that steelhead production plans in the Yakima Subbasin from now until the Yakima/Klickitat Production Project comes on line in 1995 are in a transitional phase, and may well be scaled down until certain genetics issues have been resolved. For further discussion of this matter, refer to the section on existing hatchery production of steelhead.

The Technical Work Group for the Yakima/Klickitat Production Project

The Yakima/Klickitat Production Project Technical Work Group, which is responsible for reviewing and directing hatchery planning, is made up of representatives of the Yakima Indian Nation, Columbia River Inter-Tribal Fish Commission, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Bonneville Power Administration, Bureau of Reclamation, U.S. Forest Service, Washington Department of Fisheries, Washington Department of Wildlife, Washington Department of Ecology and the Yakima Irrigation District.

The Technical Work Group comprises a number of subcommittees and task forces, the most important of which are the Experimental Design Work Group and the Tributary Task Force. The Experimental Design Group is charged with the development of all experimental programs associated with the Yakima/Klickitat Production Project as well as the evaluation and approval of any fisheries enhancement program proposed for the subbasin. The Tributary Task Force is charged with devising solutions to problems on Yakima Subbasin tributaries that currently limit or preclude the production of anadromous fish.

Cooperative Spring Chinook Spawner Surveys

Since 1980 the Yakima Indian Nation, the Washington Department of Fisheries, Bureau of Reclamation, several irrigation districts, and the U.S. Fish and Wildlife Service have conducted cooperative spring chinook spawner surveys. These surveys will be funded by a provision of the United States-Canada Pacific Salmon Treaty in Fiscal Years 1989 and 1990.

Agreements Among the Yakima Indian Nation, WDF, BOR and Pacific Power and Light Company for Operation of Adult and Juvenile Counting Facilities

Under a memorandum of understanding between the Yakima Indian Nation and the Bureau of Reclamation, the Yakima Indian Nation operates the BOR's smolt trap on Chandler Canal. Under a similar agreement among the Yakima Indian Nation, BOR and Washington Department of Fisheries, and between the Yakima Indian Nation and Pacific Power and Light, tribal personnel operate the adult counting facilities at Roza and Prosser Dams, and the juvenile trap at Wapatox Dam, respectively.

Agreements Among the Wenatchee National Forest, WDW and WDF

The Wenatchee National Forest, Washington Department of Wildlife and Department of Fisheries have signed a memorandum of understanding to protect, maintain and enhance fish and wildlife resources within the national forest. Specifically, this memorandum of understanding commits its signatories to annual meetings in which proposed Wenatchee National Forest projects will be discussed and perhaps modified to limit potential adverse impacts on fish and wildlife. Importantly, the Wenatchee National Forest agrees not to start any project, or continue a project with unforseen detrimental consequences to anadromous fish, until consensus is reached on its impact and proper implementation.

The Wenatchee National Forest is also completing a 10-year management plan for the forest. In the proposed plan, the forest states it will, "whenever possible and consistent with management prescriptions, provide habitat for fish and wildlife populations established in the goals of the Washington State Departments of Wildlife and Fisheries." A key aspect of providing for fish habitat is the implementation of protective management prescriptions in riparian areas. The management plan also calls for a thorough inventory of fish-producing streams and for the elucidation of a number of basic relationships between silviculture and fish ecology.

Agreement Between the WDW and Yakima Indian Nation Not to Outplant Steelhead Above Roza Dam Before 1995

The Yakima Indian Nation and the Washington Department of Wildlife have not yet agreed whether Yakima/Klickitat Production Project steelhead smolts are to outplanted above Roza Dam. Both parties have agreed, however, that a rainbow-steelhead interaction study should condition any future outplants, and that none will be made prior to 1995.

<u>Opportunities for Additional Cooperation</u>

There are at least three major opportunities for additional cooperation between fisheries and land and water managers. In rough order of priority, these are as follows.

1. There is an opportunity for cooperation among fisheries agencies, the Bureau of Reclamation, irrigation districts, Bonneville Power Administration, and individual irrigators to modify existing patterns of water use to provide minimum instream flows in a number of tributaries. This type of activity might take the form of on-farm conservation, converting farmers from surface water to well irrigation, rerouting drains or wasteways into periodically dewatered streams, buying water rights or land from willing sellers to provide instream flows, or constructing headwater impoundments to provide flows for low flow periods.

2. Cooperation among the same parties will also be necessary if the many small-scale irrigation diversions that are unscreened or that restrict adult passage are to be fixed. Many (but not all) of these diversions have been identified in the so-called Phase II passage improvements of the Yakima River Basin Enhancement Program (Section 803(b)(4), Appendix A Table, pp 230-232, Columbia River Basin Fish and Wildlife Program). The need to complete the list of screening projects (including needed improvements on Toppenish Creek, Simcoe Creek and Ahtanum Creek) and to implement them is

clear. The Yakima Subbasin Planning Technical Work Group unanimously supports the early implementation of the Phase II projects, even though the list is incomplete.

3. A real opportunity exists for the Yakima Indian Nation, WDF, WDW, U.S. Forest Service, private individuals and the Bonneville Power Administration to cooperate in the rehabilitation of degraded portions of streams. Specifically, this effort would involve tributaries with a degraded channel or riparian corridor, usually as a result of overgrazing and/or channelization and bank stabilization projects. An example of the type of cooperative effort that is needed is provided by the ongoing projects in Oregon's Fifteenmile and Grande Ronde River drainages. There, BPA has funded a program in which landowners (usually ranchers) grant 15-year riparian easements to the Oregon Department of Fish and Wildlife, which using BPA funds, installs and maintains fenced exclosures and watering facilities. Full riparian recovery has often resulted in a raised water table and in greatly increased bank storage. It has been estimated (S. Williams, ODFW, pers. commun.) that full riparian recovery increases salmonid carrying capacity by at least 100 percent. The program enjoys an increasing popularity with landowners who are attracted by its benefit to fish and wildlife, elimination of the need for costly bank stabilization work, and opportunity to design riparian fencing to promote the efficient utilization of pastures.

4. Presently, small irrigators are not required to notify the Yakima Project superintendent of changes in the amount of water they will be diverting. As a consequence, the Bureau of Reclamation must estimate how much water should be released from storage to meet expected demand. When actual needs are underestimated, serious instream flow problems can occur, especially in the Yakima River below Sunnyside Dam. The Yakima Project needs to implement a convenient, free "diversion reporting system," and to educate small irrigators of the need of their cooperation.

The list of unresolved issues and problems includes, of course, the list of opportunities for additional cooperation, and several other matters of a more problematic nature. These disputes concern the distribution and harvest management of anadromous fish within the subbasin, and involve the Yakima Indian Nation, WDW and WDF. These will be discussed in further detail in the anadromous fish production plans.

Legal Considerations

The legal considerations for fisheries enhancement in the Yakima Subbasin include federal acts and the decisions of federal courts, the Treaty of 1855 and the Yakima Nation Law and Order Code, state water laws and adjudicated water rights.

Federal Acts and Court Decisions

As a condition to the development of water resources by the Bureau of Reclamation, the Secretary of the Interior set forth the condition that existing and vested water rights in the Yakima Subbasin be settled. This led to the "limiting agreements of 1905," in which 50 appropriators on the Yakima and Naches rivers voluntarily agreed to limit their diversions to certain maximum monthly quantities. The entitlements listed in this agreement and a smaller number of entitlements, the "heretofore recognized" entitlements, made up of users who did not sign the limiting agreement but are known to have been diverting water at that time, make up a class of water users since designated as "non-proratable." The federal district court, in the 1945 Consent Decree, determined the quantities of water to which all the users in the valley (save lower river diverters, whose supply is obtained from irrigation return flows) are entitled, and assigned the highest priority to non-proratable entitlements. In years of water shortage, non-proratable entitlements are to be served first from the available water supply, with remaining supplies being rationed equally among the proratable entitlements. Two of the major irrigation districts, the Kittitas Reclamation District and the Roza Irrigation District, have water entitlements that are entirely proratable. The water supply for the Wapato Project is 53 percent proratable, while the supplies for the Sunnyside Valley Irrigation District and Yakima Irrigation District are, respectively, 31 percent and 33 percent proratable.

Water for irrigation districts not having adequate natural flow rights, including most proratable entitlements, is obtained through contract with the Bureau of Reclamation, which furnishes the water out of storage, natural flows and return flows. Users with water supply contracts must pay a proportionate share of dam and reservoir costs. The present contract water supply of 1,741,904 acre feet is totally subscribed.

Incubation flow releases, in the event of a water shortage, will be deducted from the proratable supply.

The Treaty of 1855 and The Yakima Nation Law and Order Code

The United States Treaty with the Yakimas (12 Stat. 951), June 9, 1855, substantially describes the reserved rights of the Yakima Indian Nation. The Yakima Subbasin was encompassed within lands ceded by the Yakima Nation to the United States government.

The Confederated Tribes and Bands of the Yakima Indian Nation, as the legal successor in interest to the treaty, reserved hunting and fishing rights for itself and its members (see United States vs. Oregon and Washington). In the context of water rights and the fishery, a critical element of the treaty is Article III, which states:

> The exclusive right of taking fish in all the streams, where running through or bordering said reservation, is further secured to said confederated bands and tribes of Indians, as also the right of taking fish at all usual and accustomed places, in common with the citizens of the Territory, and of erecting temporary buildings for curing them; together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land.

As a result of the treaty reservation to fish, the tribe retains substantial governmental authority over activities that affect hunting and fishing. The right of treaty tribes to co-manage and participate in fishery management decisions affecting the Columbia River and its tributaries has been affirmed by the federal courts (see United States vs. Washington and United States vs. Oregon). These decisions entitle the tribe to one half of the harvestable fish that pass through recognized tribal fishing grounds. The Boldt II decision includes hatchery-bred fish as part of the harvestable population, and provides for the protection of the fishery from environmental degradation.

The Yakima Indian Nation tribal government, as legal successor in interest to the signatories of the Treaty of 1855, enacts fishery and other regulations affecting its tribal members under provisions of the Yakima Indian Nation Law and Order Code.

State Water Laws and Adjudicated Water Rights

The state of Washington in 1977 filed a general adjudication case of the Yakima River system Washington vs. Acquavella et al., Yakima County Superior Court Case No. 77-02-0148-5, seeking to redefine amounts and priorities for all subbasin water rights. The outcome of this case will affect the future availability of water for instream flows and the fishery in general. The case is, however, enormously complex and is not expected to be decided for five years or more.

Two points of state water law complicate improvement of overall subbasin water availability through conservation. The first is the "beneficial use doctrine," under which water not put to beneficial use reverts to the state. Changes to allow water users to benefit directly from the water they save, either by selling it, or by using it as a reserve to be drawn upon during droughts, would benefit fish. The second point concerns the water rights of lower river users whose supply consists largely of return flows. Conservative irrigation necessarily entails reduced return flows. Some compensatory modifications in operating procedures might be necessary to ensure an adequate water supply to lower valley users.

Yakima River Subbasin Comprehensive Legislation

This bill was not enacted into law. Its general objectives do, however, merit brief summary as they include all the elements that would be required in a comprehensive solution to the water problems in the subbasin. The objectives were:

1) To meet optimum instream target flows in all years.

2) To provide increased non-proratable water supplies from the Yakima River for on-reservation irrigation needs.

3) To provide off-reservation non-proratable irrigation water supplies and enhance proratable irrigation supplies. At a minimum, off-reservation proratable irrigation supplies would not be reduced below present levels.

PART IV. ANADROMOUS FISH PRODUCTION PLANS

Prior to 1870, spring chinook, as well as other stocks of anadromous fish, were much more abundant in the Yakima Subbasin than they are now. Before the ocean and lower Columbia exploitation of salmon and steelhead in the late 19th century and early 20th century, and before the valley was developed, the Yakima supported large runs of spring, summer and fall chinook, summer steelhead, coho and sockeye. Sockeye and summer chinook are now extinct in the subbasin and, except for an occasional hatchery stray spawning naturally in lower tributaries, coho are extinct as well.

Davidson (1965) used Bryant and Parkhurst's (1950) estimate of the total area of suitable spawning gravels available in 1947 and the mean size of a spring chinook redd to estimate a historic run size of 500,000 fish for all races of chinook salmon. Smoker (1956) presented data showing that Yakima spring chinook recruits (ocean and Columbia catches plus terminal catch and escapement) represented about 13.8 percent of the total Columbia spring chinook run in the early 1950s. As spring chinook runs to the Columbia from 1877 through 1887 have been estimated at 30 million pounds (Cleaver 1951), or about 1.8 million 17-pound fish, spring chinook runs to the Yakima may have been as large as 250,000 fish. Fall and summer chinook may therefore have numbered around 250,000 fish also (Table 6).

Smoker (1957) also estimated that the historic steelhead run numbered about 100,000 fish. Mullan (1983) estimated that coho comprised 19 percent of the runs over Roza from 1949 through 1967 and therefore, with a historic run of 600,000 fish, may have numbered as many as 114,000 fish. Assuming this was the case, the run sizes of spring chinook, summer/fall chinook and steelhead must be reduced 19 percent to 202,500 fish, 202,500 fish and 81,000 fish, respectively.

Estimation of the historic magnitude of the sockeye run is difficult, as the run was eliminated before counting stations were established. However, Mullan (1984) presented statistics from which the estimated the historic sockeye run can be estimated. From this document, it can be determined that the historic nursery area of the Yakima Subbasin was 6,597 acres, and that the mean productivity of Lake Wenatchee from 1947 through 1981 was 15.6 adults per acre. Assuming historic Yakima nursery lakes were as productive as 20th century Lake Wenatchee, the sockeye run would have numbered at least 103,000 fish. A truer estimate of the historic Yakima run size would, however, probably be more than 200,000 fish as the 20th century Wenatchee runs incorporate smolt losses at up to seven mainstem Columbia dams. Assuming adult returns directly proportional to surviving smolts below Bonneville, and a mean smolt survival of 85 percent per project, the adjusted productivity of Lake Wenatchee over the period 1947 through 1981 is about 32 adults per acre. At this rate, the historic Yakima run size would have been 211,104 fish.

Table 6. Estimated historic run sizes of anadromous fish in the Yakima River Subbasin.

Species/race	Historic Run Size
Spring chinook	~200,000
Summer/fall chinook	~200,000
Summer steelhead	~80,000
Early coho	~110,000
Sockeye	~200,000
TOTAL	~790,000

Except for fall chinook, it is generally believed that the production of anadromous salmonids in the Yakima Subbasin is currently limited by rearing habitat, and not by spawning habitat (Stemple 1985). If such were the case in historic times, "spawning-habitat-limited" estimates of historic run size would be too large. It is submitted that historic production may not have been limited by rearing habitat. Biologists are certain that the amount of optimal rearing habitat was much greater before the valley was developed than it is now. For instance, it is possible that the entire river, and not just the reaches above Marion Drain, provided year-round rearing habitat in historic times. Substantial summertime discharge (probably three to four times current values), fewer unshaded riffles, and the absence of irrigation-mediated thermal loading may have combined to keep summer temperatures in the lower river well within the tolerance of anadromous juveniles all the way to the Columbia. Moreover, a pristine riparian corridor and watershed for the main river and all tributaries no doubt was associated with rearing conditions approaching optimal in many areas that are now unusable or marginal, especially in tributaries.

Estimates of the catch of salmon and steelhead by Yakima Indians in historic times are not inconsistent with runs on the order of 800,000 fish. Affidavits from Yakima Indian elders

(Swindell 1942, Robison 1957) indicate there were probably about 800 families using the fishing locations along the Yakima River and tributaries each season in pre-development times. Statements in these affidavits also indicate that each family caught between 200 and 300 fish. Thus, annual harvest was between 160,000 fish and 240,000 fish. If exploitation was between 25 percent and 50 percent, the lower catch figure implies run sizes between 320,000 and 640,000 fish, whereas the higher figure implies run sizes between 480,000 and 960,000 fish.

SPRING CHINOOK SALMON

Fisheries Resource

Natural Production

History and Status

The historic spawning areas of spring chinook included the Yakima River above the city of Ellensburg, the Naches River, the Cle Elum River below Lake Cle Elum, the Tieton River (including North and South forks), Rattlesnake Creek and the Bumping, Little Naches and American rivers. With the exception of the Tieton system, which is now inaccessible above Rimrock Dam and is compromised by reservoir operations below, and the Yakima River above Easton Dam, which was inaccessible until a new ladder was completed in 1989, significant spawning still occurs in these areas, especially in the Yakima above Ellensburg, the upper Naches and the American. Many of the larger tributaries were also used in historic times. Spawning tributaries that may have been important historically, but are seldom or never used now include:

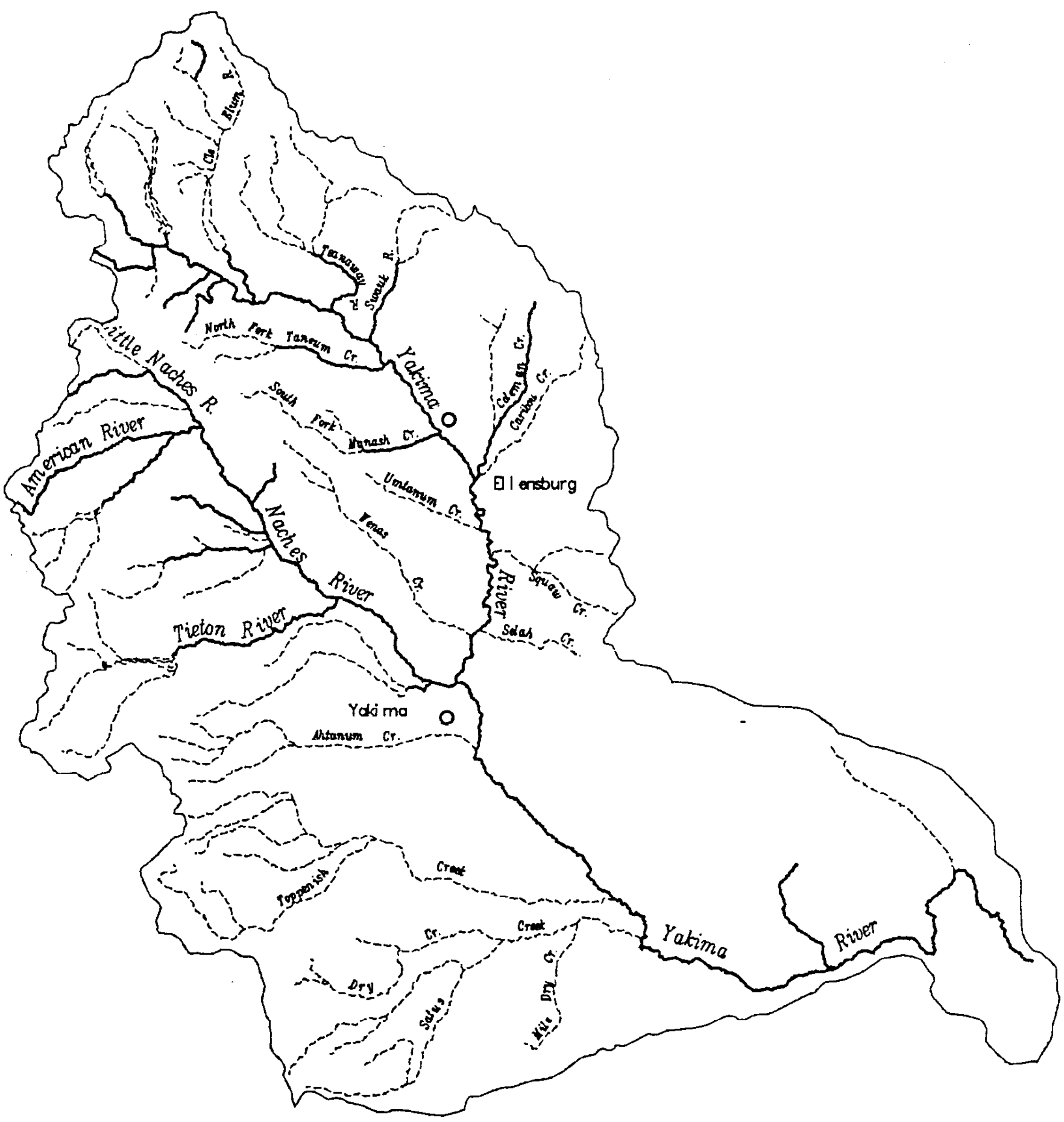
Cooper, Waptus and Cle Elum rivers above Cle Elum Dam
Teanaway River and its tributaries
Taneum, Swauk, and Manastash creeks
Wenas Creek
Tieton River and forks
Cowiche Creek
Ahtanum Creek and tributaries
Logy Creek

The history of anadromous fish in the Yakima Subbasin may be divided into four phases. The first, covering the pristine conditions of 1850 through the period of early development ending about 1900, was a period of epic destruction. Roughly 90 percent of the fishery was lost in this period. A large measure of this decline was attributable to lower Columbia and ocean fisheries. The inbasin causes of this decline included the following factors (Davidson 1965; L. Wasserman, Yakima Indian Nation, pers. commun.).

1) The construction of unladdered dams (especially Pomona Dam around 1880 and Sunnyside Dam in 1893) that completely blocked spawning adults during at least part of their run.

2) The entrainment of thousands of fry and smolts in newly constructed diversion canals, few of which were screened before 1934.

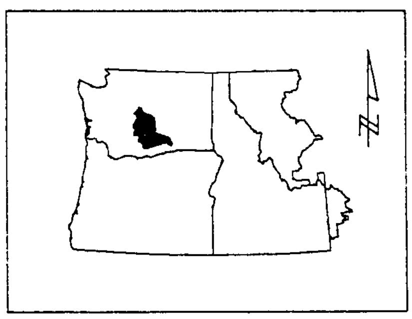
YAKIMA SUBBASIN



SPRING CHINOOK DISTRIBUTION*

——————— PRESENT/POTENTIAL

- - - - - - - - - - ABSENT



* Due to the limitations of scale, all streams which support anadromous fish are not shown on this map.

GIS GEOGRAPHIC INFORMATION SYSTEM
BONNEVILLE POWER ADMINISTRATION

3) The periodic destruction of spawning beds by driving logs downriver on large volumes of water suddenly released from dams like the one at Pomona.
4) The historic indiscriminate and intensive local fishery by non-Indians.

5) The general disregard of the wholesale destruction of the fishery.

6) The elimination of braids and natural floodways associated with diking and channelization projects.

7) The drastic reduction in the number of beavers and beaver ponds, and the resultant loss of natural water storage and rearing habitat.

The second phase, from 1900 through 1941, saw the construction of the major, permanent features of the current irrigation system in the subbasin, and the continued deterioration of the fishery. Major problems during this period included lack of controls on the ocean fishery, and, inside the Yakima Subbasin, the dewatering of extensive areas of spawning and rearing habitat as well as the construction of barriers to spawning fish and the advent of major dam construction on the mainstem Columbia.

By 1900, all of the natural summer flows had been appropriated, and there were water filings for several times the existing supply. By August of 1905 and 1906, the Yakima discharged into the Columbia only the return flows from lower canals. Responding only to the agricultural aspect of this emergency, the Washington Legislature passed the Reclamation Enabling Act in 1905, which permitted the Bureau of Reclamation to take over irrigation projects in the Yakima Valley, while making no provision for protection of fish resources.

In 1904, 1905 and 1906, unladdered temporary dams were completed at Lake Kachess, Lake Cle Elum and Lake Keechelus (permanent dams were finished in 1912, 1933 and 1914, respectively). When Bumping Lake Dam was completed in 1910, also without a fishway, the destruction of the sockeye run was complete. Smaller dams and diversions were being constructed in tributaries from the late 1800s through the 1920s. When unladdered Rimrock Dam and the ineffectively laddered Easton Diversion Dam were completed in 1925 and 1929, respectively, the geographic distribution of anadromous fish was reduced roughly to its present extent. By 1920 it is estimated the runs of all anadromous fish had declined to 12,000 fish (Davidson 1965).

The state of Washington and the federal Bureau of Fisheries began an extensive diversion canal and irrigation ditch screening program in 1930. This project was accelerated in 1936 when the Works Progress Administration became involved, and by 1941 most of the larger diversion canals were screened in some fashion. The existence of anadromous fish in the Yakima Subbasin today is largely attributable to this effort.

Except for increases in logging and road building, 1941 through 1980 were years of relative environmental stability within the subbasin. Nevertheless, runs of spring chinook (and other anadromous fish) continued to decline. Yakima Subbasin escapements were reduced to perilously low levels (the estimated mean escapement in the decade of the 1970s was 384 fish) at the same time as additional dams on the Columbia increased smolt mortalities.

During this period the fishery was reduced or eliminated. Spring chinook sport fishing in the Yakima River was phased out in the mid-1960s, and the Yakima Indian Nation restricted its harvest and/or fishing methods when runs were poor or especially vulnerable (as by low flows). Commercial fishing on spring chinook in the Columbia River has been contingent upon achieving a minimal run size at Bonneville Dam, which has not been met since 1977 (commercial fishing on summer chinook has been eliminated for similar reasons since 1973).

Finally, in response to a series of disastrously dry years in the late 1970s, a series of measures to reduce terminal harvests were taken. A court order directed the Yakima Nation to refrain from fishing entirely in 1979 and institute a males-only fishery in 1980. The Yakima Nation has restricted terminal harvest rather severely since 1980. Ultimately, three legislative and judicial developments in 1979 and 1980 laid the groundwork for a major recovery effort.

The first development, the initiation of the Yakima River Basin Water Enhancement Project, occurred in 1979 with the passage of Public Law 96-162. The second and third developments, the Kittitas ("Quackenbush") decision and the passage of the Northwest Electric Power Planning and Conservation Act (Northwest Power Act) occurred in 1980. The Quackenbush decision ordered that spring chinook redds in the Yakima River be protected and led to an immediate improvement in reproductive success of upper Yakima salmon. The Northwest Power Act resulted in the creation of the Northwest Power Planning Council. In accordance with its responsibilities to protect and enhance fisheries, the council promulgated the Columbia River Basin Fish and Wildlife Program, the implementation of which is to be funded primarily by the Bonneville Power Administration. Critical elements directed specifically at the Yakima Subbasin include:

1) Initiation of a 10-year study in 1982 (the Yakima River Spring Chinook Enhancement Study) to determine basic biological statistics for wild Yakima River spring chinook and to investigate outplanting strategies.

2) The construction of 20 major fish passage and protective facilities (the "Phase-I" Project) and the planning of similar work on 53 smaller facilities (the "Phase-II" Project) on the Yakima and its tributaries.

3) The construction of a major juvenile counting facility on Chandler Canal.

4) The construction of an experimental hatchery and associated structures (to be completed in about 1995) for the supplementation of anadromous runs in the Yakima and Klickitat subbasins.

The period from 1980 to the present has seen the steady and sometimes significant recovery of the spring chinook population in the Yakima Subbasin. From 1983 through 1986 total run size doubled with each year. Runs in 1987, 1988 and 1989 have fallen off due to the persistent effects of the low escapement of 1979 (1987 return), and low flows in both the Yakima and the Columbia during outmigration (1988 return). The explanation for the low return in 1989 is still unclear.

In the early 1980s valley fisheries experts agreed that the most significant factor limiting production of anadromous fish in the subbasin was inadequate, obsolete and deteriorating fish passage systems (ladders and juvenile screening systems), and that the problems associated with mainstem (Yakima) facilities were the most severe. Accordingly, the reconstruction of passage facilities at all Yakima River mainstem dams, as well as a number of tributary sites, was adopted into the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. All of these facilities (the Phase-I projects) were rebuilt between 1984 and 1989. A series of evaluations have indicated that the new ladders and smolt bypass systems pass fish rapidly and safely. (Independent Yakima Indian Nation studies have, however, indicated a possible problem with predation at the Prosser facility.) Because of the recent completion of these passage and protective facilities, the effects of reduced subbasin losses of outmigrating smolts have not yet become evident, but biologists anticipate major improvements.

Two additional factors improving the prognosis for the Yakima Subbasin fishery are the implementation of the United States-Canada Pacific Salmon Treaty of 1985 and the adoption of the Columbia River Management Plan in 1988 by the United States, the states of Washington and Oregon, and the Warm Springs, Nez

Perce, Umatilla, and Yakima tribes (United States vs. Oregon, No. 68-513). The plan was approved by the federal court in October 1988. The Pacific Salmon Treaty is intended to rebuild naturally spawning chinook stocks, as measured by a number of "indicator stocks" including Yakima Subbasin spring chinook, by 1998. A primary means of rebuilding is the imposition of area-specific catch ceilings in Canadian and United States ocean fisheries. The Columbia River Fish Management Plan provides a framework within which the signatories will coordinate their efforts to protect, rebuild and enhance upper Columbia runs of anadromous fish while providing equitable fisheries for treaty Indian and non-Indian fisheries. A requirement of the Columbia River Fish Management Plan is the development of tributary harvest and production plans to be developed jointly by the relevant states and tribes.

Life History and Population Characteristics

Records of adult spring chinook passage at Prosser Dam (RM 47) have been kept since 1982. As reflected by these records, spring chinook begin ascending the Yakima in late April (the earliest observation was on April 11) and have all entered the Yakima by late July (the latest observation was on July 29) (Table 7). Median passage at Prosser has been between May 12 and May 28. Median passage date at Roza Dam, 81 miles above Prosser, has been between May 29 and June 17. Migration rates between Prosser and Roza have therefore been between 3.2 miles and 4.8 miles per day. Based on videotapes of migrating fish passing the viewing window at Prosser in 1988, there is some evidence that large, 5-year-old fish (American River stock?) may return first.

Total runs of spring chinook have been increasing since 1979. Indeed, as reflected in Table 8, run size doubled every year from 1983 to 1986 (1,324 fish to 9,452 fish). Runs have diminished somewhat since 1986 falling to 4,390 fish in 1987, 4,500 in 1988 and 4,920 in 1989 (incompletely analyzed data from 1988 and 1989 is omitted from Table 8). Differences among years are probably attributable to varying passage conditions on the Columbia and varying ocean survival rates.

Table 7. Duration of various portions of the life cycle of wild Yakima Subbasin spring chinook.

	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
Adult Imm'n		X	X	X	X																								
Spawn							X	X	X																				
Inc'n							X	X	X	X	X	X	X	X	X	X	X												
Emerg														X	X	X	X												
Rear														X	X	X	X	X	X	X	X	X	X	X	X	X			
JV Emm'n																						X	X	X		X	X	X	X

The average adult age structure for wild Yakima spring chinook in all parts of the subbasin is summarized in Table 9. Yakima spring chinook are made up primarily of 2-ocean (4-year-old) fish. It is, however, also evident that American River spawners include many more 3-ocean (5-year-old) fish. This fact, along with the fact American River chinook spawn six to eight weeks earlier than upper Yakima chinook, suggests the American River fish represent a separate substock. Indeed, American River spring chinook are electrophoretically distinct from upper Yakima fish, and from all other Columbia Basin stocks (letter from Lee Blankenship, WDF, to Dave Fast, Yakima Indian Nation, 1989). Spring chinook in the Naches system exclusive of the American are felt to represent a variable mixture of American and upper Yakima fish.

Table 8. Escapement, catch and total run size of wild Yakima spring chinook, 1983-1987.

	Brood Year				
Escapement	'83	'84	'85	'86	'87
Hatchery [1]	unk	470	151	39	73
Wild [2]					
U. Yakima	1007	1155	2405	3929	1929
American	101	261	350	1456	545
Naches	132	418	659	2631	1082
Total	1240	2304	3565	8055	3629
Tribal catch	84	289	865	1368	546
Hatchery fish removed at Roza	0	0	0	29	215
Total run	1324	2667[3]	4527[4]	9452	4390

[1] Counts from fishery, spawning ground expanded by sampling rate.

[2] Escapement to various subsystems estimated by subtracting dam counts and inriver catches.

[3] Includes 84 fish taken for brood stock.

[4] Includes 97 fish taken for brood stock.

Table 9. Mean adult age structure, wild Yakima Subbasin spring chinook, 1980-1987. Ages were determined by a comparison of the (mid-eye hypural) length distribution of carcasses on the spawning grounds with an age/length probability table. The table was generated from over 600 scale-aged fish of known length.

	Percent 1-ocean		Percent 2-ocean		Percent 3-ocean	
	Male	Female	Male	Female	Male	Female
American	4.1	0.0	58.0	61.9	37.8	38.1
Naches	6.4	2.0	64.2	74.0	31.5	24.0
Up. Yakima	17.8	1.7	77.4	95.8	4.7	2.5
Subbasin	13.1	1.9	68.7	88.3	18.2	9.8

Table 10 summarizes sex ratios observed in spawner surveys from 1980 through 1987. Females outnumber males roughly two to one for the subbasin as a whole, although this ratio is even more skewed in the upper Yakima and approaches one to one in the American.

The mean length (mid-eye hypural) of wild male and female spring chinook is summarized in Table 11. Age-specific weight data is extremely limited, but Yakima Indian Nation field biologists estimate the typical weights of 3-year-olds (jacks), 4-year-olds and 5-year-olds at two to four pounds, 12 to 15 pounds, and 20 to 25 pounds, respectively.

Table 10. Mean sex ratio (percent), wild Yakima Spring chinook, 1980-1987.

	Males	Females
U. Yakima	31.7	68.3
American	49.5	50.5
Naches	37.3	62.7
Subbasin	33.8	66.2

Table 11. Mean adult length (mid-eye to hypural in cm) by ocean age, wild Yakima spring chinook, 1980-1987.

	Males	Females
1-Ocean	43.8	46.6
2-Ocean	59.5	60.1
3-Ocean	78.5	73.8

The spawning periods summarized in Table 7 are consistent with observations made since the early (1957 through 1961) spawning ground surveys conducted by Major and Mighell (1969). In general, spawning in the American River precedes spawning in the rest of the Naches system by about four weeks, and spawning in the Naches system exclusive of the American precedes spawning in the upper Yakima and Cle Elum rivers by about two weeks. Spawning typically begins in late July and peaks in the second week of August in the American, whereas spawning in the rest of the Naches system begins in the last week of August and peaks in second week of September. As mentioned, the spawning period in the upper Yakima is about two weeks later than anywhere on the Naches, beginning the first or second week of September and peaking in the third week of September. Spring chinook spawning has ceased in all areas by the middle of October. Unlike the Naches system, there is no indication that spawning periods in the upper Yakima are a function of location (later at downstream locations).

The age-specific mean fecundities for wild Yakima spring chinook summarized in Table 12 were determined from a length-fecundity relationship and a knowledge of age-specific mean lengths. The mean fecundity of 4,409 eggs per female for fish of all ages from 1980 through 1987 was weighted by the age distributions observed in those years.

Table 12. Mean age-specific fecundity for wild Yakima spring chinook, 1980-1987.

Age	Eggs/Female
1-Ocean	1,367
2-Ocean	4,005
3-Ocean	6,670
All Ages	4,409

A number of redds on the upper Yakima were capped in 1984, 1985 and 1986, and fry traps were monitored below spawning areas on the American River and the Upper Yakima in 1983 and 1984. These studies have shown that emergence begins as early as mid-March and continues through the first half of June. The period of median emergence in individual redds spans the last week of March through the first week in May, with an overall mean in mid-April. Within a given redd, the total period of emergence is extremely variable, taking as few as 10 days or as many as 73 days.

From 1984 through 1986, between 2,215 and 2,303 temperature units were required for 100 percent emergence. Not surprisingly, emergence generally occurs somewhat later in headwater areas with lower water temperatures. The median emergence date for all fish in the upper Yakima and the American rivers are virtually identical, however, in spite of the significantly lower water temperatures in the American River. This synchrony occurs because, as has been mentioned, spawning occurs six to eight weeks earlier on the American River. It would thus appear that a mid-April median emergence date has considerable survival value in the Yakima system.

Spawning in the Yakima system is concentrated in headwater areas whereas rearing areas fluctuate seasonally and extend much farther downstream. Moreover, as all rearing habitat is not equally suitable for fry and parr, or for summer and winter rearing, there are at least two inbasin migrations preceding the smolt outmigration.

From fry traps on the American River and the upper Yakima monitored in 1983 and 1984 and from systematic beach seining and electroshocking surveys in 1983 through 1987 (Wasserman et al. 1983, 1984; Fast et al. 1985, 1986, 1987) it has become obvious that most spring chinook fry move downstream soon after emergence. In the early spring (March through April), some fry are found as far downstream as Prosser, although very few are found below the reach from Selah to the Naches confluence. By summer, almost no young-of-the-year (YOY) are found below the Naches confluence, and the highest concentrations are found in the Yakima Canyon (RM 135).

Similarly, fry emerging from American River spawning areas have moved into the middle Naches by late summer, whereas fry from the upper Naches have moved into the lower Naches or the Yakima River in the vicinity of the Naches confluence. The lower reaches of a number of tributaries below major spawning areas on the Naches and Yakima rivers are lightly utilized (perhaps as thermal refuges) in the summer by spring chinook YOY. On the Yakima, these tributaries include Big, Little, Swauk, Manashtash, Taneum and Umptanum creeks, but not the Teanaway River, nor Ahtanum, Satus and Toppenish creeks. Tributaries used for summer rearing in the Naches system include the Little Naches River, and Quartz, Nile, Rock, Milk, Rattlesnake, Thorton and Cowiche creeks. The fall distribution of spring chinook YOY in the mainstem Yakima is much like the summer, except that very few fish are found above Cle Elum. Whether because growth rates are higher in downstream areas or larger fish seek downriver habitat, the size of fish in the fall increases as one proceeds downstream.

As the water temperature drops in late October, many YOY begin a second migration from tributaries and summer-rearing areas of the upper Yakima to sites lower in the drainage (below Prosser Dam). A similar movement has been observed on the Warm Springs River and the Lemhi River, and has been interpreted as a search for appropriate overwintering habitat triggered by falling temperatures (Bjornn 1971). Experimental releases of marked fish suggest that the "winter migrants" are coming from both the Naches and upper Yakima rearing areas. Additional data on this subject is available from the Yakima Indian Nation Fisheries Department.

Outmigration of typical spring smolts does not become heavy until the second week of April (Table 7), although atypically large smolts pass Prosser in small numbers in March. From 1983 through 1987, the dates of 50 percent passage have been between April 22 and May 9, while dates of 75 percent passage have ranged from April 30 through May 18. Outmigration of spring chinook smolts dwindles to a few individuals per day by late June, and by convention has been declared finished by the first of July.

Although brood year egg deposition and smolt passage at Prosser can both be estimated accurately, a fair degree of uncertainty is still involved in estimating egg-to-smolt survival. The problem arises from the fact that a substantial number of fish are lost during migration before reaching Prosser Dam and the counting station. If expressed in terms of "smolts at Prosser," egg-to-smolt survival is underestimated by a factor equal to the migration losses incurred in moving from staging areas to Prosser (the "smolt-to-smolt" mortality rate). If survival from egg to smolt is not to be confounded with the "pre-Prosser" losses suffered by emigrating smolts, the smolt-to-smolt survival rate must be determined. As will be seen, smolt-to-smolt survival rates are important in their own right; they appear to be small enough to represent a very serious limiting factor on smolt outmigration.

Smolt-to-smolt survival has been estimated for both hatchery and wild fish. The survival of hatchery smolts from release points ranging from 57 miles to 145 miles above Prosser has been poor since monitoring of outmigrations began in 1983. Over the past five years, the mean survival of hatchery spring chinook, steelhead, fall chinook and coho has been 30 percent, 25 percent, 27 percent and 48 percent, respectively.

Releases of marked wild spring chinook smolts trapped at Roza and Wapatox dams in 1988 allowed the estimation of wild smolt-to-smolt survival rates through three major portions of the outmigration -- from Wapatox Dam on the Naches to Sunnyside Dam on the Yakima; from Sunnyside Dam to Prosser Dam; and from Prosser Dam to the Columbia. Eleven distinctively marked groups of wild Naches spring chinook smolts were released immediately below Wapatox Dam, and 12 groups of upper Yakima smolts were released from the upstream face of Roza Dam (four groups), above Sunnyside Dam (four groups), and several hundred yards below Sunnyside Dam (four groups). The mean survival of the "above Roza", "above Sunnyside" and "below Sunnyside" groups to Prosser was 56 percent, 61 percent and 54 percent, respectively (mean was 57 percent). As there was no significant difference among survival rates for upper Yakima smolts released at these locations, it was concluded that essentially all losses in the reach investigated occurred between Sunnyside Dam and Prosser Dam, and that the survival through this reach is on the order of

57 percent. The mean survival of Naches smolts from Wapatox to Prosser was 40 percent, and this value was assumed to be characteristic of the reach. The Naches confluence is upstream of Sunnyside Dam. Thus, the product of the survival from Wapatox to Sunnyside and Sunnyside to Prosser (0.57) should be 0.40, and:

(S Wapatox to Sunnyside)(0.57) = 0.40
(S Wapatox to Sunnyside) = (0.40)/(0.57) = ~0.70.

Finally, the mean survival to McNary Dam of all upper Yakima smolts was about 39 percent, indicating survival from Prosser to McNary was about 68 percent (.57 x .68 = ~.39). Assuming equal survival over the nearly equal distances from Prosser to the Columbia confluence, and from the confluence to McNary Dam, survival through each of these reaches would be on the order of 82 percent (.82 X .82 = ~.68).

Cumulative survival for wild spring chinook smolts from Roza Dam to the Columbia is thus (0.57)(0.82) = ~0.47, and cumulative survival from Wapatox to the Columbia is (0.40)(0.82) = ~0.33.

The mean survival to Prosser of <u>acclimated</u> hatchery spring chinook smolts has been about 60 percent of the rate observed for wild smolts in 1988. (Stress-related mortalities will be minimized by pond acclimation; thus, the proper hatchery rates to compare to the wild smolt survival rate should involve acclimated releases.) In the absence of additional data, researchers assume cumulative inbasin survival of hatchery spring chinook smolts will be 40 percent lower than the wild rate. It is speculated that this difference may be attributable to the failure of hatchery-reared fish to learn appropriate predator avoidance behavior (see below).

From 1984 to the present, an increasing number of screens and smolt bypasses at large and medium-sized diversion dams were rebuilt, and by 1987, smolt bypasses at all of the major diversions dams (except Wapatox) were rebuilt. Nevertheless, smolt survival rates remain low.

It has been speculated that poor smolt survival, even after correction of the problems at diversion dams, is attributable to predation in reaches of the open river, particularly those reaches below major diversions, which can be rather severely dewatered during dry springs. The predator under greatest suspicion is the northern squawfish, although gulls are known to feed heavily on smolts in a few locations. The specific mechanism proposed is as follows. River flows, water velocities and mean depths in the middle and lower reaches of the river drop substantially during the course of the outmigration as irrigation demands rise. In a dry spring, these drops are earlier and more pronounced. Accordingly, the inbasin residence time and predatory vulnerability of outmigrants is increased. As the river shrinks and fewer near-shore refuges are accessible, smolts and predators are concentrated in smaller areas, and the consumption rates of predators (the functional response) increases. Smolts in the end of the outmigration, in mid to late May, are especially unlucky, as increasing water temperatures further accelerate predator consumption rates.

Available data from the literature indicates smolt losses of the magnitude observed in the Yakima could be mainly or entirely attributable to squawfish predation. In the last two weeks of April 1987, when 57 percent of the 1987 spring chinook outmigration occurred, the passage at Prosser was estimated at 141,800 spring chinook smolts. Assuming that one-fourteenth of this number entered the reach from Sunnyside Dam to Prosser Dam each day of these two weeks, the mean smolt density in the Sunnyside to Prosser reach was 1,130 smolts per square kilometer during this period. Vigg (1988) developed a functional response relationship for squawfish in the John Day Reservoir predicting smolt consumption (smolts per predator per day) as a function of smolt density. This relationship suggests squawfish in the Sunnyside to Prosser reach in the last two weeks of April 1987 would have been consuming about 0.3 smolts per day. (Note that this figure is probably low, as the area of the reach used in the density calculation was based on bank-full flow; flows in late April 1987 were not bank full, and density was probably at least twice as great as the figure used. A consumption rate of 0.3 smolts per predator per day may, however, be fairly descriptive of the mean rate over the entire outmigration period.) The total outmigration in the spring (February through June) of 1987 was 252,000 smolts. Assuming 57 percent of this figure was lost in the Sunnyside to Prosser reach, the total number entering the reach was 252,000 divided by 0.57 or 442,000 fish, and the loss was therefore 190,000 smolts. If squawfish feed at a rate of 0.3 smolts per squawfish per day over a 68-day period (April through the first week of June), it would take 190,000/(68 X 0.3) or about 9,300 squawfish to consume 190,000 smolts. If the mean feeding rate were one smolt per day, the necessary population would be only 2,800 squawfish.

Squawfish populations as large as 9,300 could easily reside in the Yakima system. The total area of the mainstem Yakima and Naches drainage (at bank-full flows) is about 3,030 hectares. If squawfish densities in the Yakima are comparable to the 12 fish per hectare observed in Lake Washington (Bartoo 1977), as many as 36,360 fish could reside in the drainage.

It is believed that instream flows play the dominant role in determining egg-to-smolt survival, although the specific mechanism probably varies from year to year. Corrected for losses before counting at Prosser, egg-to-smolt survival for brood years 1981 through 1987 (outmigrations of 1983-1989) has ranged from 2.2 to 18.1 percent, and has dropped substantially the last four years. Insufficient instream flows are suspected of contributing to this decline. Egg-to-smolt survival for the 1985 and 1986 broods was substantially lower than for the 1984 brood, even though the 1984 brood experienced worse flow conditions during the smolt outmigration. However, mean overwinter flows in the principal overwintering areas were much lower for the 1985 and 1986 broods, and this may have been more important. Egg-to-smolt survival for the 1987 brood (1989 outmigration) was only 2.2 percent, the lowest ever recorded in the Yakima. These rates were observed in spite of the fact that overwintering and outmigration flows were, respectively, the third and second best in the decade of the 80s. The poor survival of the 1987 brood is probably attributable to numerous episodes of very low flows in upper Yakima spawning areas in the period immediately after emergence (see Table 13). There is thus reason to suspect that insufficient instream flow can limit spring chinook smolt production at three phases of the life-cycle: as newly-emergent fry in upper Yakima spawning areas; as overwintering pre-smolts in the Yakima Canyon and areas near the Naches confluence; and as outmigrating smolts in the middle and lower river (particularly in the reach from Sunnyside Dam to Prosser Dam).

The Beverton and Holt recruitment equation is believed to describe density-dependent egg-to-smolt survival. This equation was rearranged to estimate zero-density egg-to-smolt survival as a function of mean observed egg-to-smolt survival, mean observed egg deposition, and estimated smolt capacity. The estimate, 21.6 percent, agrees well with independently derived estimates (26 percent) for upriver spring chinook reported in the Data Standardization Report.

Table 13. Estimated egg-to-smolt and smolt-to-adult survival rates for Yakima spring chinook 1981 through 1986 brood years. Mean discharges at critical places and times have been included.

Brood Year	Egg to Smolt Surv.[1] (%)	Smolt to Adult Surv.[2] (%)	Early Rearing Flows[3] (cfs)	Rearing Flows[4] (cfs)	Over Winter Flows[5] (cfs)	smolt flows[6] (cfs)
1981	18.1 (8.7)	2.1 (3.0)	EN=876 0 days<90 cfs 0 days<76 cfs	CE=2836 EB=3220 YC=3611	YC=1468 TH=2863	PK=4778
1982	13.2 (6.4)	2.1 (4.2)	EN=414 0 days<90 cfs 0 days<76 cfs	CE=2594 EB=2814 YC=3264	YC=1742 TH=3834	PK=2560
1983	12.0 (5.8)	1.8 (3.6)	EN=800 0 days<90 cfs 0 days<76 cfs	CE=3303 EB=3435 YC=3333	YC=892 TH=1577	PK=2023
1984	12.4 (6.0)	N.D.	EN=383 0 days<90 cfs 0 days<76 cfs	CE=3058 EB=2884 YC=3608	YC=924 TH=2035	PK=1291
1985	8.6 (4.1)	N.D.	EN=255 0 days<90 cfs 0 days<76 cfs	CE=2808 EB=2832 YC=3225	YC=687 TH=1443	PK=1756
1986	3.9 (1.9)	N.D.	EN=246 14 days<90 cfs 7 days<76 cfs	CE=2527 EB=2005 YC=2812	YC=586 TH=897	PK=1423
1987	2.2 (1.1)	N.D.	EN=203 38 days<90 cfs 20 days<76 cfs	CE=2575 EB=N.D. YC=2782	YC=1037 TH=1800	PK=3267

[1] Upper figure for egg-to-smolt survival expressed in terms of smolts before losses in transit ("headwater smolts"). Lower figure in terms of smolts counted past Prosser.

[2] Upper figure for smolt-to-adult survival in terms of headwater smolts, lower figure in terms of smolts counted past Prosser.

[3] Early rearing flows are measured in the Easton reach (EN), the reach of the Yakima from Easton Dam to the Cle Elum confluence. This is the most important spawning and early rearing reach in the system. The first figure represents mean flow in the period April 1 through July 7, when reservoirs usually begin irrigation releases. Note that IFIM data indicates side channels are dry when total flow through the reach is 76 cfs or less. Flows in side channels are critically low (~2 cfs) when total flow is 90 cfs. Accordingly, the second and third figures represent the number of days flows were less than 90 or 76 cfs, respectively, from April through July.

[4] Rearing flows are mean flows June through September.

[5] Overwinter flows are mean flows October through February. Flows were monitored at Easton (EN), Cle Elum (CE), Ellensburg (EB), the Yakima Canyon at Umptanum (YC), and the Yakima River immediately below the Naches confluence at Terrace Heights (TH).

[6] Smolt flows are April through May mean flows at Parker (PK), just below Sunnyside Dam.

Corrected smolt-to-adult return rates for the 1982 and 1983 brood years (1983 and 1984 outmigrations) have both been around 2 percent. This figure is twice the value reported in the Data Standardization Report for stocks negotiating four mainstem dams, and may well reflect unusually good passage flows in the Columbia. Return rates for recent brood years may not turn out to be so high.

The "standard" (System Planning) density-based estimate of spring chinook smolt capacity in the Yakima Subbasin under present conditions is 2.444 million fish. It should be noted that smolt capacity based on IFIM (instream flow incremental method) analysis is only 1.495 million fish. As both estimates involve a number of large-scale assumptions, it is impossible to be sure which is the more accurate.

Supplementation History

The release numbers and return rates (when known) of hatchery spring chinook released in the Yakima Subbasin since 1958 are summarized in Table 14. Returns are incomplete for all smolts released after 1984, and for all fry or parr released after 1983.

The main purpose of releases made before 1983 was to increase returns and harvest. Supplementation of natural production was a (distant) secondary objective for the early releases. Except for the release made in Rattlesnake Creek in 1985, all releases after 1982 were made in the context of the Yakima River Spring Chinook Enhancement Study. The goals of the portion of this study dealing with artificial production are to determine the optimal release strategy in terms of season and age of fish at release (June fry versus September parr versus November pre-smolt versus April smolt); manner of release (immediate release from truck to river versus volitional release from acclimation pond); and type of fish to be released (Leavenworth/Carson stock versus Leavenworth/Yakima hybrid versus hatchery-reared wild Yakima).

In light of the low returns of hatchery fish and the spawning timing of the hatchery stocks employed (Leavenworth and Klickitat fish spawn in mid-August whereas wild Upper Yakima/Naches fish spawn in mid to late September), it is presumed that hatchery fish have contributed little to natural spawning. Since 1986, it has been the policy to maximize recovery of coded-wire tags by removing and sacrificing all hatchery fish entering the fish trap on the Roza Dam fish ladder.

Although the results are preliminary, several points bear mentioning. First, the mortality from upriver release sites to Prosser Dam can be severe, especially when spring runoff is low. Since 1983, the mean survival from release point to Prosser Dam has been about 30 percent, ranging from 8.4 percent to 65 percent. Second, volitional releases from acclimation ponds appear to be more successful, both in terms of smolt survival and adult return, than direct river releases. The two releases (1983 and 1984) with nearly complete returns indicate that volitionally-released, pond-acclimated fish have smolt survival and adult return rates that are, respectively, 1.7 times and 1.4 times greater than non-acclimated fish.

Anticipated supplementation activities are extremely numerous. Indeed, the future of the fishery in the Yakima Subbasin for the foreseeable future depends very heavily upon the supplementation programs that will be implemented when the Yakima/Klickitat Production Facility comes on line. The details of future supplementation programs will be summarized later (for further details see Report to the Northwest Power Planning Council on Refined Project Goals and Harvest Management Plan for Yakima/Klickitat Central Outplanting Facility). The eventual smolt-to-adult return rate for supplementation fish from the Yakima/Klickitat Production Facility is anticipated to be from four to 10 times the mean rate (0.106 percent) observed to date.

Table 14. History of spring chinook supplementation in Yakima Subbasin.

Rel. Date	Hatchery and Stock	Size (#/lb)	Number Released	Release Site	Return Rate (%)
8/59	Klickitat (Klickitat)	143 (fry)	20,000	Upper Yakima	N.D.
5/61	Leavenworth (Icicle)	330 (fry)	18,000	Upper Yakima	N.D.
2/62	Leavenworth (Icicle)	1000 (fry)	5,000	Upper Yakima	N.D.
12/62	Leavenworth (Icicle)	1000 (fry)	5,000	Upper Yakima	N.D.
1963	N.D.	N.D.	12,500	Nile Springs	N.D.
1964	N.D.	N.D.	10,000	Nile Springs	N.D.
6/73	Klickitat (Klickitat)	58 (fry)	162,400	Naches River	N.D.
6/73	Klickitat (Klickitat)	58 (fry)	162,400	American R.	N.D.
1975	N.D.	N.D.	8,580	Nile Springs	N.D.
4/76	Ringold (Ringold)	3 (smolt)	7,230	Nile Springs	N.D.
9/76	Klickitat (Klickitat)	29 (parr)	42,775	Nile Springs	N.D.
3/77	Klickitat (Klickitat)	19 (smolt)	13,300	Nile-Richland	N.D.
3/78	Klickitat (Cowlitz)	7 (smolt)	2,462	Nile Springs	N.D.
4/79	Carson (Carson)	20 (smolt)	50,000	Upper Yakima	N.D.
4/79	Klickitat (Carson)	12 (smolt)	25,000	Nile Springs	N.D.
4/80	Klickitat (Klickitat)	10 (smolt)	24,000	Nile Springs	N.D.
4/80	Leavenworth (Carson)	18 (smolt)	30,260	Upper Yakima	N.D.
4/81	Klickitat (Klickitat)	14 (smolt)	33,616	Nile Springs	N.D.
4/81	Leavenworth (Carson)	20 (smolt)	400,221	Upper Yakima	N.D.
4/82	Leavenworth (Carson)	14 (smolt)	100,050	Nile Springs	0.19
4/82	Leavenworth (Carson)	14 (smolt)	401,714	Upper Yakima	0.07
4/83	Leavenworth (Carson)	17.6 (smolt)	99,725	Nile Springs	0.08

Table 14 continued. History of spring chinook supplementation in Yakima Subbasin.

Rel. Date	Hatchery and Stock	Size (#/lb)	Number Released	Release Site	Return Rate (%)
4/83	Leavenworth (Carson)	19.5 (smolt)	97,725	Upper Yakima	0.05
4/84	Entiat (Carson)	19 (smolt)	29,636	Nile Springs	0.13
4/84	Entiat (Carson)	25 (smolt)	42,552	Upper Yakima	0.04
6/84	Leavenworth (Carson)	66 (fry)	102,837	Upper Yakima	0.02
9/84	Leavenworth (Carson)	25 (parr)	102,833	Upper Yakima	0.03
11/84	Leavenworth (Carson)	21.6 (parr)	108,305	Upper Yakima	0.04
4/85	Leavenworth (Carson)	18 (smolt)	45,195	Upper Yakima (pond-acc'd)	0.13
4/85	Leavenworth (Carson)	21.6 (smolt)	42,210	Upper Yakima	0.08
4/85	Leavenworth (Carson)	11 (smolt)	25,794	Rattlesnake	0.05
6/85	Leavenworth (Carson)	66 (fry)	100,750	Upper Yakima	N.A.
9/85	Leavenworth (Carson)	25 (parr)	101,724	Upper Yakima	N.A.
11/85	Leavenworth (Carson)	22 (parr)	101,522	Upper Yakima	N.A.
3/86	Leavenworth (wild Yak)	17.1 (smolt)	33,052	Upper Yakima (pond-acc'd)	N.A.
3/86	Leavenworth (hybrid)	17.2 (smolt)	46,476	Upper Yakima (pond-acc'd)	N.A.
3/86	Leavenworth (Carson)	20.6 (smolt)	51,846	Upper Yakima (pond-acc'd)	N.A.
4/86	Leavenworth (Carson)	19.9 (smolt)	50,657	Upper Yakima	N.A.
4/87	Leavenworth (Carson)	20.6 (smolt)	50,519	Upper Yakima (pond-acc'd)	N.A.
4/87	Leavenworth (Carson)	19.9 (smolt)	50,113	Upper Yakima	N.A.
4/87	Leavenworth (hybrid)	17.2 (smolt)	52,392	Upper Yakima (pond acc'd)	N.A.
4/87	Leavenworth (wild Yak)	17.1 (smolt)	56,841	Upper Yakima (pond acc'd)	N.A.

Fish Production Constraints

Spring chinook production in the Yakima Subbasin is limited by four types of constraints. In order of descending importance, these constraints are:

1) Those associated with suboptimal instream flows.
2) Those associated with passage around irrigation diversions.
3) Degraded riparian and instream habitat.
4) Excessive temperatures.

1) Suboptimal Instream Flows

Low instream flows during the period of reservoir refilling (roughly mid-October through early July) probably constitute the greatest constraint on spring chinook production in the Yakima Subbasin. Low flows from October through February probably do not impact incubation significantly in most years, because the Federal Court has ordered that sufficient incubation flows be provided redds in the upper Yakima and the Cle Elum. However, critically low flows still occur in the upper Yakima in the period immediately after emergence -- mid April through early July. As has been mentioned, there is some evidence that flows below 90 cfs in the Easton reach have strongly depressed smolt production in recent years, probably by stranding or increasing the predatory vulnerability of fry, especially in side channels and braids. It should be noted that the Easton reach is at lest 50 percent side channel, that side channels are nearly dry at a total flow of 90 cfs, and that spring chinook fry strongly prefer and actively seek out side channels for early rearing. Low flows in the winter may also reduce production by substantially reducing the availability of overwinter habitat. The type of microhabitat typically used by overwintering spring chinook--interstices among boulders, rubble and rip rap; undercut banks; and especially submerged brush and root wads--is usually associated with the bank. It is obvious that a water level several feet lower than normal could dewater most of these areas.

Low flows in April and May also impact spring chinook at the outmigrating smolt stage. Low spring flows increase the inbasin travel time and vulnerability of outmigrating smolts. As mentioned previously, there are preliminary indications that low flows in the reach from Sunnyside Dam to Prosser Dam may be especially conducive to high predatory mortality. It should be noted that a long inbasin outmigration, even without large predatory losses, could have severe impacts if passage on the Columbia were also slow. The time window for successful ocean entry remains open only a bit more than a month. In five of the last six years, over three weeks have elapsed between the point of 25 percent and 75 percent cumulative passage. In the exceptional year 1983, the middle half of the run passed Prosser in two weeks. The only year of the past six in which mean flows below Parker in April and May were more than 70 percent of the historical mean was also 1983.

Sustained high flows also pose problems. An IFIM (instream flow incremental method) analysis of the Yakima Canyon has indicated (Crase 1985) that flows are higher than optimal for spring chinook during the pre-flip-flop portion of the irrigation season. After flip-flop, flows in the lower Naches and (especially) the Tieton are much above optimal.

Finally, there are adverse impacts associated with abrupt changes in flow. Sudden increases in flow cause fish to vacate feeding territories and migrate to new areas. This forced relocation increases competition and stress, reduces growth, and increases the likelihood of mortality either through predation or by being displaced to unsuitable downriver habitat. The adverse impacts of sudden decreases in flow are obvious; if fish are not able to relocate to nearby pools or runs, they are stranded and killed. The impacts of sudden decreases in flow will be especially severe in braided areas, such as the Easton reach of the Yakima, and the Naches below Wapatox. Abrupt changes in flow in the Yakima Subbasin are concentrated in reaches below storage reservoirs and diversion dams, especially the Yakima River between Keechelus and Easton dams, the Yakima River below Easton, the Cle Elum River, the Naches below Wapatox diversion and the Yakima below Roża, Sunnyside and Prosser dams (Mongillo and Falconer 1980).

Upstream passage of adults may also be impeded by low flows, particularly below Horn Rapids, Prosser, Sunnyside, Wapatox and Roza dams. Impaired passage may not be directly lethal, but it may delay and exhaust fish to such a degree that they are easily caught by poachers. Adult passage below all dams but Sunnyside is adequate at all but the lowest commonly observed flows. Between Sunnyside Dam and Zillah Wasteway, however, upstream migration is severely restricted when flows are less than 300 cfs to 400 cfs (Payne 1982). During April and May of 1981, 1985, 1986, 1987 and 1988, mean daily discharge below Sunnyside has been less than 400 cfs a total of 13 days, four days, 15 days, 9 days and 10 days, respectively.

Low fall flows prevent spawning adults from ascending four major tributaries that would otherwise contribute substantially to production. These tributaries--the Teanaway River and Big, Taneum, Manastash and Ahtanum creeks--were productive historically, and even today afford good to excellent spawning and rearing habitat in their upper reaches. Natural runoff in these tributaries is fully appropriated for irrigation, and from late spring through late fall, virtually all water is diverted from them once they reach the valley floor. Although all also suffer from unscreened or poorly screened diversions and assorted barriers to upstream migration, these problems are relatively easily rectified. The difficult problem is obtaining more water.

The Little Naches River is a special case of a spawning tributary currently producing below capacity. A moderate amount of spawning has been documented in the Little Naches up to Salmon Falls (RM 4.4), which was until 1988, an impassible natural barrier for spring chinook. The river below the falls was degraded by a series of floods in the late 1970s and by an emergency floodplain reclamation project that removed deposited bedload material, widened the channel and, unavoidably, destroyed the riparian corridor. An extensive restoration project in this area was completed the same time as the fishway at Salmon Falls. The fishway opens up about 18 miles (252,853 square yards) of pristine habitat; spawning gravel is very abundant, the riparian zone is excellent, summer flows are adequate and large organic debris and instream cover are plentiful.

Assuming 252,853 square yards, 0.12 smolts per square yard (Easterbrooks and Kessler 1984), and 2 percent smolt-to-adult survival, the new habitat should support upwards of 600 adults. The ultimate limiting factor for this new system will probably be instream flows during the summer. Obviously, the major limiting factor now is that no spring chinook have been imprinted on the area above the falls. A major release of hatchery-reared fry from Little Naches brood stock would seem to be in order.

False attraction flows from wasteways and power plant discharges are a relatively minor problem that can become serious at some places when flows in the Yakima are very low. Three sites in particular, the Sulphur Creek Wasteway, the Snipes Creek Wasteway (Roza Wasteway No. 6), and the wasteway from the Wapato Irrigation Project's Satus No. 3 pumping station, can become troublesome. Sulphur Creek spills 250 cfs to 500 cfs in April and May from Sunnyside and Roza Canals, Snipes Creek 40 cfs to 80 cfs from Roza Canal, and the Satus No. 3 pumping station wasteway can spill as much as 100 cfs. Adults homing to the upper Yakima are thus attracted to all of these wasteways, the more so when flows in the Yakima River are low. (It should, however, be noted that the problem with the Satus pumping station wasteway is worse for steelhead than spring chinook, as the water it discharges contains a considerable component of Toppenish Creek water with the balance consisting of middle Yakima water diverted at Wapato Dam.) There is no barrier to adults on Sulphur Creek or the Satus pumping station wasteway, and a temporary barrier, which has been breached a number of times, has was installed in Snipes Creek in 1987. Permanent barriers should be installed at all sites.

2) Irrigation Diversions

Approximately 67 small to medium diversions (the "Phase II" diversions) have inadequate (or nonexistent), obsolete or deteriorating screening. These diversions are located in present production areas for spring chinook and steelhead, and collectively constitute a major hazard for dispersing fry and outmigrating smolts. Migrating fry stay close to shore, where they are vulnerable to entrainment in even the smallest of diversions, and they actively seek out the highly productive, low-velocity habitat found in smaller ditches. Indeed, it is the opinion of the WDF and Yakima Indian Nation that the cumulative losses at all these sites can easily equal the pre-reconstruction losses at one of the mainstem diversions. This contention is corroborated by the fact personnel from the WDF salvaged 10,000 spring chinook and 2,000 steelhead parr from just one of the Phase-II diversions, the Selah-Naches Canal, in September of 1987 (J. Easterbrooks, WDF, pers. commun. 1988).

From studies of fry impingement at Wapatox diversion (Eddy 1988) and from numbers of spring chinook parr salvaged from Wapatox and Selah/Naches canals (J. Easterbrooks, WDF, pers. commun. 1989), researchers have estimated that Phase-II diversions are responsible for killing 0.02 percent of all upstream fry production per cfs diverted, and 36 percent of all smolts passing through the headworks (see Appendix 2, Supplement 1, for details of estimates).

It should be noted that the list of Phase II projects in the Appendix A table of the Columbia River Basin Fish and Wildlife Program is incomplete, if one considers <u>potential</u> as well as present production areas. Collectively, numerous totally unscreened diversions exist on Big Creek, Manastash Creek, Cowiche Creek, Wide Hollow Creek, Ahtanum Creek, Simcoe Creek, and the North Fork of Simcoe Creek. It should also be noted that the existing Phase-II Project also does not address building barriers at the mouths of wasteways that present false attraction problems.

The Wapatox diversion, a "Phase-II type" diversion in every respect except size, deserves special mention. This diversion, the largest on the Naches River, bypasses smolts and parr poorly, and represents a major hazard to fry. Fry that do not move directly into the bypass ports on the sides of the canal are quickly (within two hours) impinged on the screens and then, as the screens rotate, carried over to the other side. Newly emergent fry (particularly the very small steelhead fry) need not be impinged and "carried over" to be entrained, as the mesh of the screens is wide enough to allow them to pass through directly. It has been estimated that the Wapatox bypass system successfully passes no more than 2.5 percent of the fry diverted at the headworks (Eddy 1987) and 64 percent of the smolts (J. Hubble, Yakima Indian Nation, pers. commun.).

The overall magnitude of the losses attributable to entrainment at Wapatox diversion has been estimated to be on the order of 6 percent of all outmigrating spring chinook smolts, 5 percent of steelhead smolts, and 1.2 percent of the upstream production of spring chinook and steelhead fry (Appendix 2, Supplement 1). A much more serious impact is attributable not to entrainment, but to the dewatering of the reach between the diversion dam and the powerplant outfall. As was mentioned in the smolt-to-smolt survival section, releases of 11 marked groups of wild Naches spring chinook smolts indicated 30 percent were lost between Wapatox Dam and Sunnyside Dam. Researchers have hypothesized that most or all of this loss occurs between Wapatox Dam and the powerplant outfall, and that the proximate cause is stranding in braids of the lower Naches and, especially, predation exacerbated by low flows. This hypothesis is corroborated by the fact habitat quality in the lower Naches is excellent except for frequent episodes of critically low instream flow, and by the fact that other experimental releases of wild smolts indicated no significant mortality in the Yakima River between the Naches confluence and Sunnyside Dam.

One final comment should be made about diversions in the Yakima system. Predatory birds (primarily gulls and herons) and predatory fish have been observed feeding on smolts below the outfall from the Chandler Canal bypass. Moreover, as the mean recovery rate of branded wild chinook released at the head of Chandler Canal during April and May of 1987 was only 70 percent, there is a possibility that piscivorous fish are congregating inside the canal upstream of the screens and consuming a considerable number of smolts (Yakima Indian Nation, unpubl. data). The situation at Prosser Dam and Chandler Canal may be, however, unique. Unlike other mainstem bypasses, the outfall there does not open into a deep, fast-flowing part of the river, but into a run that is often no deeper than 1 to 2 feet during the smolt outmigration. Also unlike other mainstem bypasses, smolts must traverse about 0.7 miles of canal before encountering the screens, about half of which is wide and unlined. The water velocities in the unlined portion are quite slow (about one foot per second), and would not impair the hunting efficiency of a predatory fish. Squawfish up to 20 inches have been taken by hook and line at the outfall, and many squawfish up to 17 inches were electrofished from Chandler Canal when it was dewatered in November 1984 (Wasserman et al. 1984). Thus, at least at the Chandler Canal bypass, predators may be reducing spring chinook production significantly.

3) Degraded Riparian and Instream Habitat

With the exception of overgrazed and channelized sections of the Yakima River from Yakima to Wenas Creek, and Ellensburg to Taneum Creek, the riparian and instream habitat within present and potential spring chinook production areas is not severely degraded. However, recreational home development on the upper Yakima, while doing little damage now, nevertheless poses the largest threat to the ecological integrity of the present spring chinook production area. The cumulative impacts of large-scale residential development in the upper Yakima drainage--bank stabilization work, removal of riparian vegetation, septic tank leakage and so on--could be significant.

4) Excessive Temperatures

Water temperatures frequently exceed 75 degrees Fahrenheit in the Yakima River below Sunnyside Dam in July and August. As a result, no spring chinook rear in the lower river in the summer. There has been some fear that release of warm surface waters from Bumping and Kachess lakes could excessively warm the upper Naches and Yakima rivers in years of low flow (Crase 1985).

Hatchery Production

No spring chinook hatcheries exist in the subbasin now. The Yakima/Klickitat Production Project is being developed. The fundamental goal of the hatchery project is experimental--testing the assumption that new artificial production can be used to increase harvest and enhance natural production while maintaining genetic resources.

The practical goal of the project is to increase both the status (seeding) and productivity (recruits per spawner) of all existing natural stocks in the subbasin using harvest management, and boosting juvenile survival through artificial incubation and rearing.

Projected benefits of the Yakima/Klickitat Production Project, and for all strategies in the Yakima Subbasin Plan, have been estimated for spring chinook using two computer models developed by the Northwest Power Planning Council's Monitoring and Evaluation Group (MEG) -- the Tributary Parameter Model (TPM) and the System Planning Model (SPM). The simulations by which the benefits of the Yakima/Klickitat Production Project were estimated entailed the following provisions and assumptions.

1) The modeled scenario was "post build-up" -- after the period of deliberately increased escapements, when full seeding of the habitat with natural spawners has been attained, and the maximum sustained yield (MSY) harvest rate for a supplemented population has been determined. A conservative harvest rate is expected during the build-up of the population to promote maximum escapement.

2) Smolt-to-adult return rates for "hatchery fish" were set at the anticipated maximum, 61 percent of the natural rate. This degree of "supplementation success" is, of course, highly speculative. It is based on the observation that mean survival to Prosser for acclimated hatchery smolts is 61 percent as large as the rate observed for marked wild smolts. The System Planning Model has a parameter for hatchery smolts called "post-release survival." In all simulations, this parameter was set at 0.61. All other smolt survival rates were the same for hatchery and wild fish.

3) Baseline reach-specific smolt-to-smolt survival rates for spring chinook were estimated from data provided by the 1988 release of marked, wild smolts. These baseline values were adjusted downward to account for losses at improperly screened diversions (Appendix 2, Supplement 1).

4) Maximum sustained yield was estimated for the combined yield of both natural and hatchery fish.

5) The unsupplemented American River population was modeled separately from the rest of the subbasin. This was done to avoid "overwhelming" the unique population parameters of the American system by the averaging process at the heart of the TPM procedure. However, the MSY terminal harvest rate for the supplemented portion of the subbasin was also applied to the American River, as there is no practical way to harvest American fish selectively, and no such program is planned. Separate modeling of American fish thus permits a truer estimate of the impact of higher, hatchery-driven exploitation rates on the unsupplemented population.

Under these conditions, the TPM/SPM procedure indicated that MSY terminal harvest would be 1,424 fish with no hatchery, current habitat quantity and quality, and expected improvements in smolt survival at mainstem Columbia Dams. The simulation also predicted an escapement to the subbasin of 4,910 fish, a total catch to all fisheries of 2,539 fish, and a terminal exploitation rate of 29 percent. Under the same habitat conditions, the TPM/SPM procedure predicted that implementation of the Yakima/Klickitat Production Project would boost MSY terminal harvest to 4,867 fish, escapement to 9,358 fish, total harvest to 6,938 fish, and terminal exploitation rate to 52 percent. Note that the American River's contribution to harvest and return is included in these figures. These goals are achievable with the current hatchery production goal of 1.6 million smolts (10-year production level) (see next section), and a smolt-to-adult return for supplementation fish that is 61 percent of the natural rate.

It should be noted that the American River spawning escapement at MSY _without_ a hatchery was 256 fish. Under the "existing habitat/supplemented MSY" scenario, spawning escapement in the American declines to 19 fish. This drop is mostly attributable to the poor smolt-to-smolt survival of American River fish under current conditions. Passage improvements are anticipated to reverse this impact.

As summarized in Table 15, the Yakima/Klickitat Production Project will produce spring, summer and fall chinook, summer steelhead and coho for release in the Yakima Subbasin, and spring chinook and summer steelhead for the Klickitat Subbasin. The facility may also produce sockeye for the Yakima Subbasin if Lake Cle Elum sockeye reintroduction study [Program Measure 800(b)(7)] indicates reintroduction is possible. The Yakima/Klickitat Production Project is designed to accommodate 2,532,300 spring chinook eggs and to produce 1,646,000 smolts for release in the Yakima system. Comparable figures for the Klickitat system are 4,603,200 eggs and 2,992,100 smolts. Full production will be phased in over two five-year periods.

Table 15. Designed egg and smolt capacity of the Yakima/Klickitat Production Facility.

	Egg Capacity (X 1000)		Smolt Capacity (X 1000)	
Stock	5-year	10-year	5-year	10-year
Yakima sp. chin	1,180.8	2,532.3	715.5	1,646.0
Yakima su. chin	240.0		156.0	
Yakima fall chin	4,286.0		3,600.0	
Yakima steelhead	303.8		197.4	
Yakima coho	2,697.0		2,009.2	

Each stock associated with this project will be propagated in an idiosyncratic way. For Yakima River spring chinook, the supplementation program will manage for two stocks, Naches and upper Yakima. The Yakima spring chinook production program will also entail four facilities. Naches River brood stock will be collected at one of two sites on the Naches River, Cowiche Dam (RM 3.6), or the Oak Flats rearing facility (RM 18.5). Naches fish will be reared to the smolt stage at the Oak Flats site. At full production, this station will produce 450,000 smolts to be acclimated and released from a number of sites scattered through the Naches drainage. Upper Yakima brood stock will be collected at Roza Dam, and will be spawned and reared to the smolt stage at a rearing facility near Thorp on the upper Yakima (about RM 165). At full production, this station will produce 1,130,000 smolts to be acclimated and released from a number of sites scattered through the upper Yakima drainage.

As the hatchery is to be adaptively managed, it is not yet possible to describe the specific supplementation strategies that will ultimately be employed. The first strategies are expected to be based on the results of the Yakima River Spring Chinook Enhancement Study (which will be complete before the facility comes on line), and any other relevant studies available at the time. Preliminary results from the enhancement study indicate that volitional release from acclimation ponds result in better smolt survival and adult returns than trucking and immediate release. Accordingly, the construction of a series of acclimation facilities throughout the subbasin has been made a part of total facility design, and short- and long-term acclimation will be one strategy to be investigated. It also appears at this time that smolt releases produce much better returns than fall releases of parr or spring releases of fry. Therefore, the current inclination is to focus on releasing smolts. Presently, it is anticipated that smolts will be reared to 10 to 17 fish per pound and allowed volitional outmigration beginning some time between April 1 and April 30, or as coordination with water budget or other flow strategies may dictate.

Another anticipated strategy associated with the hatchery development will be the attempt to supplement natural populations in existing areas and to reestablish natural populations of spring chinook in tributaries and mainstem reaches that have only recently been made suitable for natural production. Table 16 lists the potential acclimation and release sites for Yakima/Klickitat Production Project spring chinook, many of which still require solution of passage and instream flow problems.

The Tributary Task Force of the Yakima/Klickitat Production Project Technical Work Group is currently investigating solutions to the problems that now preclude natural production of spring chinook in many of the sites listed in Table 16. At the present time, it appears as though a solution may be feasible for many tributaries on the list.

There are a number of critical uncertainties regarding project goals for spring chinook. These uncertainties, which will drive the experimental design of the initial releases, include those relating to natural productivity, optimal supplementation strategies, genetic risks of supplementation and adverse species interactions.

Table 16. Potential acclimation and release sites for Yakima/Klickitat spring chinook.

Site	Presently Used by Spring Chinook?	Suitable as YKPP Hatchery Outplanting Site? (per BOR study)	Problems
Cabin Creek	No	Yes, with improvements	Cascade (adult passage).
Yakima above Easton*	Yes	Yes, with improvements	Instream flows; access recent.
Big Creek	No	Yes, with improvements	Diversions, instream flows.
Yakima, Easton to Roza*	Yes	Yes	Phase-II screens.
Teanaway River*	Yes	Yes, with improvements	Diversions, instream flows.
Taneum Creek	No	Yes, with improvements	Instream flows.
Cle Elum R., below dam*	Yes	Yes	None.
Manastash Creek	No	Yes, with improvements	Diversions, instream flows.
Yakima from Roza Dam to Ahtanum confluence	Yes	Yes	Phase-II screens.
Naches River*	Yes	Yes	Phase-II screens.
Tieton River below Rimrock Dam	Yes	No	Severe instream flow problems.
Bumping River below Bumping Dam*	Yes	Yes	None precluding outplants.
Rattlesnake Creek*	Yes	Yes	None precluding outplants.
Little Naches above Salmon Falls*	Yes	Yes	None (access recent).
Ahtanum Creek	No	Yes, with improvements	Diversions, instream flow.
Logy Creek	No	No	Yakima planners believe instream flow problems in Satus Creek, to which Logy is a tributary, can be overcome in short term.

* Selected by YKPP for spring chinook acclimation pond.

Although more is known about the natural productivity of spring chinook than any other species in the subbasin, critical uncertainties remain in the areas of smolt capacity and the determinants of survival rates of specific life stages (see data gaps section).

Smolt-to-adult survival for fish produced as they will be in the Yakima/Klickitat Production Project is unknown. These rates and their determinants should be ascertained as quickly as possible. Later work might address the survival of outplanted fry to the smolt stage.

Assessment of the genetic risk to the natural stock of supplementation has been assigned the highest priority. With assistance from the Experimental Design Work Group, a systematic analysis of genetic indicators and strategy for monitoring these factors will be developed.

Harvest

As detailed in Table 8, harvest of spring chinook in recent years (1983-1987) has ranged from 84 fish in 1983 to 1,368 fish in 1986. The exploitation rate in these years has ranged from 6.3 percent in 1983 to 19.1 percent in 1985. Since 1979, the mean exploitation rate has been 14.2 percent.

In recent years the spring chinook fishery has been limited to a tribal subsistence fishery. Fisheries resource managers from the Yakima Indian Nation currently seek to limit exploitation in the tribal fishery to 25 percent or less, and to restrict harvest as may be necessary to ensure current escapement exceeds that of the brood year.

Seasons for subsistence fishing by tribal members for spring chinook are set by the Yakima Tribal Council after consultation with tribal fisheries staff and the Washington Department of Fisheries. Fishing time is strictly limited by setting a series of short open periods spanning the migration period (April through June). Estimates of effort and catch per unit effort allow the estimation of catch per fishing day, and pre-season run size estimates allow fisheries managers to estimate the maximum length of a season consistent with escapement goals.

The Yakima Indian Nation monitors effort and catch at all sites during peak hours throughout the season. Catch is estimated from a simple time expansion of the catch observed during the period monitored. The Yakima Indian Nation employs a number of wardens to enforce seasonal fishing regulations.

Yakima spring chinook are caught in sport and commercial fisheries from Oregon to southeast Alaska. Contribution to all ocean fisheries is not well known. Pending future coded-wire tag analysis of several upper Columbia River stocks, it is assumed that the ocean harvest rate is about 10 percent of any run.

According to the maximum sustained yield (MSY) harvest rates estimated in the benefits analysis, the runs entering the Yakima River should consistently meet escapement needs, while at the same time provide additional terminal harvest opportunities for both treaty and non-treaty fishers.

Table 17 summarizes potential harvest management plan and critical run sizes in the rebuilding schedule for Yakima River spring chinook under the Yakima/Klickitat Hatchery Project.

Table 17. Yakima River spring chinook harvest and brood stock collection schedule under Yakima/Klickitat Production Project.

Brood stock collection goal: 970
Brood stock percentage: 20 percent
Interim escapement goal: 6,000 adults
Harvest rate schedule: 20 percent on runs below interim escapement goal; 30 percent on runs to 12,000; thereafter by agreement of agencies.

Run Size	Hatchery Brood Stock	Harvest	Natural Escapement
1,000	160	By Agreement of Parties	
2,000	320	400	1,280
3,000	480	600	1,920
4,000	640	800	2,560
5,000	800	1,000	3,200
6,000	960	1,200	3,840[1]
9,000	970	1,800	6,230[2]
10,000	970	3,000	6,030
11,000	970	3,300	6,730
12,000	970	3,600	7,430
>12,000	970	By Agreement of Parties	

[1] Brood stock collection goal achieved.
[2] Interim escapement goal achieved.

Specific Considerations

Spring chinook runs into the subbasin have been increasing from 1983 through 1988, ranging from 1,324 fish (1983) to 9,452 fish (1986). Runs in 1987 (4,390 fish), 1988 (4,247 fish) and 1989 (4,920 fish) have fallen off somewhat, probably because of relatively lower flows during early post-emergent and overwintering. Terminal exploitation rates have ranged from 6 percent in 1983 to 19 percent in 1985. Indeed, harvest has been so low that escapement from 1983 through 1987 has averaged three times the brood year escapement. Although smolt capacity estimates must be expanded to include the potential production from currently inaccessible tributaries, the current best estimates (Tributary Parameter Model/System Planning Model procedure) indicate the system may be producing at about one quarter of its unsupplemented capacity.

At the present time, spring chinook management focuses on rebuilding natural runs by restricting harvest (which is currently limited to a tribal subsistence fishery) such that current escapement always exceeds that of the brood year. It is also a tenet of current spring chinook management that the genetic composition of the existing natural run be conserved to the maximum extent possible.

The major constraints to spring chinook production are, in order of decreasing importance, 1) inappropriate instream flows (too low or too high), 2) upstream and downstream passage at diversions, 3) degraded riparian and instream habitat, and 4) excessive temperatures in the lower river.

Although the adverse effects of excessive flows during the irrigation season are not so obvious as low flows, IFIM (instream flow incremental method) analysis indicates their impact on juvenile rearing capacity in the mainstem Yakima River may be greater than low flows typical of the system (Stemple 1985). Excessive river flows eliminate many of the low velocity, shallow runs preferred by juvenile chinook, and may flush fry and smaller parr into lower reaches, which become too hot in the summer. Inadequate instream flows, on the other hand, can affect all phases of the spring chinook life cycle. In addition to reducing juvenile rearing capacity, inadequate flows can impair the upstream migration of adults, the downstream dispersal of fry from headwater spawning areas, the accessibility of streamside overwintering habitat, and especially the safe and timely outmigration of smolts.

The most severe passage problems in the subbasin at this time are all associated with irrigation diversions. One class of passage problem involves small, unscreened or poorly screened diversions (most of which are among the so-called Phase-II screens) that entrain and kill a significant percent of fry and pre-smolts. The other class of passage problem occurs in tributaries with substantial headwater production potential that currently cannot be used because lower reaches are dewatered during the fall spawning run.

With several exceptions (lower Manastash and Big creeks; the Teanaway River; and sections of the Yakima River between Yakima and Wenas Creek, and between Ellensburg and Taneum Creek), the most severe instances of degraded riparian habitat in the subbasin occur in tributaries or mainstem reaches with little or no spring chinook production potential. Many of the reaches of the mainstem Yakima with severe riparian problems occur in the lower river, where rearing is precluded by high summer temperatures anyway. The tributaries with the most severe riparian problems (the Satus and Toppenish systems) are, for the most part, not suitable for spring chinook. Thus, deteriorated riparian habitat is not considered to be a major limiting factor on spring chinook production.

Except for the mainstem Yakima below Sunnyside Dam, summer temperatures in current or potential spring chinook rearing habitat do not become excessive when instream flows are adequate.

In a series of System Planning Model runs using Yakima spring chinook input parameters ("Production Constraints and Opportunities Analysis," Northwest Power Planning Council, July 21, 1988), it was discovered that increasing hatchery or natural smolt capacity in the subbasin increases the size of returns, but does not affect population resiliency. For example, a proportionately larger escapement is required to utilize more capacity. On the other hand, egg-to-smolt survival rates affect both run size and population resiliency (improving survival yields more recruits per spawner). Population resiliency can be quantified as MSY proportion (proportion surplus to spawning need). If the MSY proportion is high, a correspondingly large sustainable harvest rate is possible. In the Yakima, MSY run size increases almost in direct proportion to subbasin smolt capacity. Increases in the survival of outmigrating smolt while still in the subbasin (smolt-to-smolt survival) effectively increase both net smolt capacity and egg-to-smolt survival. Thus, in light of the low smolt survival rates observed in the Yakima Subbasin, it can be expected that the most productive enhancement strategies would entail substantial improvements in smolt-to-smolt survival rates.

The same SPM analysis cited above showed that enhancing natural production of spring chinook by outplanting smolts is a viable option. The important implication of the SPM analysis of supplementation is that supplementation does increase MSY run size, but not quite in proportion to the total increase in smolt capacity. That is to say, adult returns from a system driven by a smolt capacity divided equally between hatchery and natural production will not be twice the return generated by the natural component alone, but somewhere between 1.6 times and 1.9 times this figure.

In connection with the topic of supplementation, it must be noted here that hatchery supplementation has already been designated as the fundamental approach to be used in enhancing anadromous populations in the Yakima Subbasin. The Northwest Power Planning Council supported the Yakima/Klickitat Production Project planning process in its November 10, 1987 response to public comments on an earlier council staff issue paper on the Yakima/Klickitat Hatchery. On Page 18 of the response, the council made the following statement on the relationship of subbasin planning to the hatchery project:

> As noted in the issue paper, the fish and wildlife agencies, Indian tribes and others in the Columbia River Basin have started planning to double salmon and steelhead runs throughout the Basin consistent with systemwide policies. That process is expected to take about 31 months. In the meantime, this [hatchery] production project is expected to go forward. The production levels resulting from this project may not represent the ultimate levels for the Yakima and Klickitat Subbasins, <u>but those objectives must take this project into account. As a result, planners in the Yakima and Klickitat Subbasins should coordinate with the developers of this project to ensure consistency and integration of effort. They should consider this project as a given in the Yakima and Klickitat Subbasins. Any proposals for additional production in these subbasins must be consistent with the project, including its experimental features. The Monitoring and Evaluating Group will be expected to analyze and integrate the system and subbasin plans with this project</u> [emphasis added].

Thus, a major point of difference between the Yakima Subbasin Plan and most other plans is that there are no fundamental mutually exclusive enhancement alternatives. Net smolt production can be increased by improving one or more of the five determinants of smolt production: total egg deposition, egg-to-emergent fry survival, fry-to-late summer parr survival, overwinter survival, and outmigrant smolt survival. Accordingly, strategies for each species will consist of a combination of individual enhancement actions focused on one or more of the five stanzas of smolt production. The hatchery is considered a given and will be part of all strategies for all species. The other elements have been independently evaluated with the TPM/SPM procedure, and ranked in terms of projected fish production increases. In order of size of anticipated increases, these elements have been added together in a series of "partial cumulations," which have also been evaluated by the TPM/SPM procedure. (Note that "partial cumulation" refers to a plan that integrates some of the possible actions--Actions 1, 2, and 3 only.) Preferred strategies will consist of the partial cumulation that best conforms to the policies of system planning.

All proposed enhancement strategies assume continuation of the current water supply and irrigation demand. Specifically, the existing storage capacity, irrigation system operations policies and instream flow cycles have all been assumed to be essentially permanent. Future legislative or judicial developments may, however, alter the "hydrological status quo" substantially.

The impact of an improved hydrograph has, however, been investigated in another context. The Yakima River Basin Water Enhancement Project team used IFIM (instream flow incremental method) techniques to estimate the total number of anadromous spawners at full seeding under existing conditions and under conditions of improved instream flow (Anonymous 1987). The "improved" scenario included all of the existing, non-hydrological problems (such as inbasin smolt losses, riparian conditions, and inaccessible tributaries), but assumed optimal instream flows in all reaches of the mainstem Yakima, Naches and a number of tributaries. These optimal flows were made possible by full implementation of all of the measures (Bumping Lake expanded to 400,000 acre feet, 20 percent reduction in irrigation demand from conservation) in the failed Comprehensive Water Enhancement Bill, S.2322.

Although the techniques of simulation used by subbasin planners and the Water Enhancement Project team involved radically different approaches, the estimates of spring chinook, fall chinook and steelhead spawners at full seeding under existing conditions were reasonably comparable. The IFIM-based estimate was 17,600 spawners (steelhead, spring chinook and fall chinook combined); the subbasin planning estimate, adjusted for terminal harvest and pre-spawning mortality, was 19,095 spawners. Thus, the "starting point" estimate is comparable between procedures.

In subbasin planning, it was estimated that improving all qualitative aspects of the environment under the existing pattern of instream flow would result in a fourfold increase in total production. The Water Enhancement Project team, on the other hand, estimated that optimizing instream flows under existing conditions of habitat quality would result in a sevenfold increase in adult production. These results substantiate the widely held opinion that instream flows are the most significant limiting factor in the subbasin. They also indicate that the full implementation of all elements in the subbasin plan in addition to some water enhancement program like S.2322 would probably increase the production of anadromous fish in the subbasin by more than an order of magnitude.

A final consideration in setting objectives is that it is generally believed that the existing run of spring chinook retains most of the genetic characteristics of the native, wild population, and that it is uniquely adapted to the sometimes rigorous conditions in the subbasin. Moreover, there is evidence for the existence of at least two substocks of spring chinook in the subbasin, a substock spawning in the Naches and upper Yakima comprised primarily of 4-year-old fish, and an earlier-spawning substock in the American River with a large proportion of 5-year-old fish. The local adaptations embodied in these substocks should also be considered.

Critical Data Gaps

In order of importance, critical data gaps include:

1) The cause and magnitude of smolt loss.

   Researchers repeatedly observed smolt losses of 50 percent to 80 percent from upriver release points to Prosser Dam. Preliminary studies have indicated that serious losses occur below Wapatox, Sunnyside and Prosser dams, and these areas should be among the first investigated. Investigations should not, however, be limited to these reaches, but should include the entire mainstem Yakima and Naches. Special attention should be focussed on the Yakima Canyon, and particularly the Roza pool. Although experimental releases of spring chinook above Roza Dam reflected only the mortality attributed to the reach below Sunnyside Dam, large squawfish are very frequently observed in videotapes of fish passing the ladder at Roza. The release point for the 1988 "above-Roza" test groups was on the face of the dam, within several hundred feet of the screens and bypass orifices. It is, in retrospect, quite likely that the smolts moved almost immediately into the bypass, precluding detectable predation. Special attention should also be given to the Yakima River from Ellensburg to Cle Elum, as anglers report frequent catches of large squawfish in this area.

   Although predatory losses to squawfish should obviously be investigated, a smolt survival study should not be limited to squawfish predation. Losses to all potential predators--bass, channel catfish and resident rainbow, as well as gulls and herons--and to non-predatory sources as well, must be investigated. Non-predatory losses would include residualization, disease, water quality (temperature, dissolved oxygen, toxins), entrainment in Phase-II diversions and physical stranding.

2) Quantification of the relationship between instream flow and smolt production.

   This relationship must be defined for spring flows in reaches above major rearing areas, for winter flows and water surface elevations in suspected overwintering areas, and for summer flows in major rearing areas.

3) Refinement of carrying capacity.

   All available estimators entail fairly bold assumptions, including the estimate based on weighted usable area (IFIM technique). These assumptions must be checked and revised as necessary.

4) Determination of the relationship between duration of inbasin outmigration and subsequent adult returns.

5) Determination of the "outmigrant-to-adult" return rate for spring chinook passing Prosser in the late fall and winter.

   As about one-fourth of brood year outmigration has been observed in the winter, this is an issue of some importance. It would also be useful to know whether the magnitude of winter movement is related to egg deposition and/or rearing density in suspected overwintering areas. If returns from winter migrants were poor, and if the magnitude of winter movement were positively correlated with rearing density, certain remedial measures (such creating artificial overwintering habitat) would be in order.

6) Quantification of habitat.

   A thorough, quantitative habitat inventory, with particular emphasis on riparian conditions, must be conducted.

Objectives

The incremental production attributable to specific action elements will be estimated by the TPM/SPM procedure. The first step in this procedure is to estimate the quantitative impact of a specific action element on local (reach-specific) population parameters. These parameters drive the System Planning Model, and include zero-density egg-to-smolt survival, smolt-to-smolt survival, pre-spawning adult survival and smolt carrying capacity. The Tributary Planning Model is used to "integrate" a host of reach-specific impacts over the entire subbasin, and to calculate four new global parameters. These new, integrated parameters are then used in the System Planning Model to estimate resultant changes in MSY. As each of the objectives listed below entails a quantitative change in one or more of the SPM parameters, the explanation of each objective will include a numerical estimate of the impact on SPM parameters.

Utilization Objective

Maximize sustainable yield in a way that is consistent with long-term conservation of genetic fitness and the experimental goals of the Yakima/Klickitat Production Project.

A TPM/SPM simulation of a spring chinook fishery supplemented as envisioned by hatchery planners indicates the MSY terminal harvest under existing habitat conditions is 4,866 adults, almost three times the unsupplemented MSY of 1,776 adults. Estimated terminal MSY for a supplemented fishery under conditions of maximal improvement of habitat quality and quantity is 15,519 fish. The objective for terminal harvest is 15,000 fish in this analysis.

Biological Objectives

1. Increase egg deposition by increasing the amount of usable habitat and decreasing pre-spawning mortality.

   Spring chinook should also be outplanted to areas with production potential outside current production areas, such as the Yakima River above Easton Dam, a number of upper Yakima and mid-Yakima tributaries, and the Little Naches system. It is proposed that the smolt capacity of the subbasin be increased by up to 37 percent by making tributaries and mainstem reaches outside current production areas fully and safely accessible to spawning adults and rearing juveniles.

   It is also proposed that pre-spawning mortality be reduced 50 percent. Currently, it is estimated that about 20 percent of all spring chinook escaping legal fisheries are lost, probably to naive "brown trout" fishermen and hard-core poachers, as well as through "false attraction" and entrapment in unscreened wasteways. The objective, then, is to reduce pre-spawning mortality to 10 percent.

2. Increase fry-to-parr survival.

Two of the four measures intended to increase fry-to-parr survival--building a modern bypass system at Wapatox and rebuilding all bypass systems at Phase-II diversions--will result in the loss of fewer fry, and were therefore be reflected in the System Planning Model as increases in zero-density egg-to-smolt survival (So). The other measures--riparian restoration and subordinating diversions for power generation at Wapatox to minimum instream flows--were assumed to increase smolt capacity (K), but not So.

Entrainment at Wapatox diversion is responsible for the loss of at least 1.2 percent of all upstream fry production. Accordingly, rectification of this problem was modeled by a 1.2 percent increase in So for all fish spawned upstream. Phase-II screens are estimated to kill 0.02 percent of all upstream fry production per cfs diverted. Rectification of each Phase-II bypass system was therefore modeled by increasing So by a multiple of 1/[1 - (.0002Q)] for all fish spawned above the diversion (see Appendix 2, Supplement 1 for details).

Riparian restoration was modeled by assigning affected reaches a higher habitat quality rating in the Smolt Density Model (SDM), the Northwest Power Planning Council's official subbasin smolt capacity estimator. Similarly, power subordination at Wapatox was modeled by assigning the Wapatox reach a higher quality rating. The SDM assigns a higher density (smolts per square meter at carrying capacity) to reaches with higher quality ratings, and higher densities generate higher smolt capacity estimates.

Over all reaches targeted for riparian enhancement, this procedure resulted in a net spring chinook smolt capacity increase of 100,227 smolts. This relatively modest gain is attributable to the fact that the reaches in which riparian restoration would benefit spring chinook, while limited primarily by riparian factors, were nevertheless still in relatively good condition; quality ratings generally increased only from "fair" to "good" or "good" to "excellent." On the other hand, power subordination at Wapatox increased smolt capacity in the reach by a substantial 314,711 smolts. The magnitude of this effect is attributable to the fact that habitat quality in the Wapatox reach is excellent in all respects save instream flows. The impact of Wapatox diversions on instream flows is frequently severe, and the quality rating assigned the reach in its present condition is poor. Power subordination changes the rating to excellent.

3. Increase overwinter survival.

The single proposal intended to increase overwinter survival of spring chinook pre-smolts--making 18 smaller canals accessible as "off-channel winter refuges" through the winter--was assumed to impact two SPM parameters: smolt capacity (K), and So.

The impact of off-channel winter refuges on carrying capacity can be quantified by estimating the number of pre-smolts that would use the refuges, and then determining the fraction of this number that would not have survived but for provision of refuges. The number of fish using a refuge (Nu) can be estimated by:

$$Nu = SUM\{ (Ai)(di) \}$$

where Ai = the area of refuge of a given habitat class; and
di = the density of use (fish/sq. meter) expected for habitat of a given class.

The number of fish "saved" by the refuges (Ns) would be:

$$Ns = (Nu)(Sref) - (Nu)(Sriv) = Nu(Sref - Sriv)$$

where Sref = the overwinter survival of fish in refuges; and
Sriv = the overwinter survival of winter migrants in the open river.

Finally, carrying capacity (K) would be increased by a multiple equal to:

$$(Ki + Ns)/Ki$$

where Ki = the pre-refuge smolt capacity.

It has been assumed that So will be increased by a multiplicative factor equal to the increase in carrying capacity, (Ki + Ns)/Ki.

All the variables in the preceding expressions have been estimated. Field measurements have provided Ai. Densities of winter use for habitat of various types (di) were taken from recent studies (C. Stewart, graduate student, University of Idaho, pers. commun.) (Appendix 4, Supplement 1) in which spring chinook densities were observed to vary from 0.15 (no cover other than depth) to 11.93 fish per square meter (all of the habitat consisting of submerged brush). The overwinter survival of fish in off-channel refuges (Sref) can be expected to be quite high. Bryant (American Fisheries Society address 1988) found nearly complete overwinter survival of juvenile coho in off-channel habitat in southeast Alaska, and Yakima Indian Nation studies on Lost Creek Pond, a side channel of the Naches River indicated overwinter survival of juvenile chinook might be on the order of 80 percent. It will be assumed that Sref is 80 percent. Overwinter survival of winter migrants was 20 percent for branded Naches system spring chinook winter migrants (Fast et al. 1986), but this figure may apply only to fish that were unable to find appropriate winter habitat, and may therefore be lower than would be expected for overwintering spring chinook in general. As no estimates of overwintering survival for non-migrant spring chinook pre-smolts could be found, the 37 percent figure for juvenile coho in a tributary of the Alsea River (Hall 1984) was used for Sriv.

As modeled by the Tributary Planning Model, the net benefit of off-channel winter refuges would be to increase K by 59,763 fish, and to increase So by about one percent.

4. Increase smolt-to-smolt survival (Sss) by halving mortalities in large areas of open river where losses are known to be high, and eliminating smolt losses associated with diversions (Wapatox and the Phase-II group).

   Wapatox is estimated to entrain and kill about 6 percent of upstream smolt production, and is assumed to cause an additional 25 percent loss between the dam and the powerplant outfall due to dewatering (see smolt-to-smolt survival section and Appendix 2). Rectification of the entrainment problems at Wapatox were therefore modeled by increasing Sss by a multiple of $1/(1 - 0.06) = \sim 1.06$, and rectification of the dewatering problem was modeled by increasing Sss by a multiple of $1/(1 - 0.25) = \sim 1.33$. The combined impact of Wapatox improvements is thus to increase Sss from the "Wapatox reach" upstream by a multiple of $(1.06)(1.33) = \sim 1.41$.

   Phase-II diversions are assumed to kill 36 percent of all smolts entering the headgates, and it is assumed that the percent of the mean river discharge (in April and May) diverted by the canal also represents the percent of the smolt outmigration diverted through the headgates (see Appendix 2 for details). Letting PDD denote "percent discharge diverted in channel," the effect of rebuilding a Phase-II screen on Sss was modeled by increasing the local Sss value by a multiple of $1/[1 - (PDD)(.36)]$.

It was assumed that smolt losses in the three open-river reaches with major problems could be halved (see alternative strategies section for justification and specific proposals). The resultant smolt survival rates [1-(mortality)/2] are considered baseline rates, and are the rates that are lowered by other agents, such as Phase-II diversions.

The cumulative effect of all measures intended to improve Sss, as estimated by the Tributary Parameter Model, is to increase the "integrated" Sss from about 50 percent (existing conditions) to 75 percent (full implementation).

5. Conserve genetic fitness of the existing natural stock, and preserve intact the genetic resource represented by the American River substock.

   Although the Naches/upper Yakima substock will be supplemented, efforts to conserve genetic fitness are anticipated. The American River substock has been designated a "genetic refuge" within the context of supplementation actions planned for the system.

Alternative Strategies

As described earlier, all strategies in the Yakima Subbasin are cumulative. The nine such strategies for spring chinook are summarized below.

Strategy 1: Implementation of Yakima/Klickitat Production Project with existing habitat.

Strategy 2: Strategy 1 plus additional habitat.

Strategy 3: Strategy 2 plus halving open-river smolt losses.

Strategy 4: Strategy 3 plus rebuilding Phase-II screens.

Strategy 5: Strategy 4 plus provision of off-channel winter refuges.

Strategy 6: Strategy 5 plus rescreening and power subordination at Wapatox.

Strategy 7: Strategy 6 plus riparian restoration.

Strategy 8: Strategy 7 plus reduced pre-spawning adult mortality.

Strategy 9: Strategy 8 plus making the Teanaway River usable.

Modeling results for each strategy are presented in Table 19 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 19. 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 Tables 20 and 21.

STRATEGY 1: Hatchery production (Yakima/Klickitat Production Project) with existing habitat.

The TPM/SPM procedure indicates that escapement to the subbasin, terminal harvest and total harvest to all fisheries under current conditions <u>without</u> a hatchery are 4,910 fish, 1,424 fish and 2,539 fish, respectively. Comparable figures for current habitat supplemented as planned are 9,353 fish, 4,864 fish and 6,933 fish, respectively. Terminal harvest rate at MSY is 29 percent under the unsupplemented scenario, and 52 percent under supplementation. An important aspect of Strategy 1 is that spawning escapements to the American River will drop precipitously, from 256 fish under the unsupplemented scenario to 20 fish under supplementation. It is important to note that this threatening development will be rectified by subsequent actions that improve smolt survival for American River fish.

Note that the simulation of Strategy 1, as well as the simulation of all spring chinook strategies, assumed all of the conditions previously listed in the section describing the projected benefits of the Yakima/Klickitat Production Project: full seeding and MSY management; an optimal supplementation success of 61 percent; smolt survival rates based on the 1988 release of wild spring chinook smolts and the impacts of diversions as summarized in Table 2; combined hatchery/natural MSY; separate modeling of the unsupplemented American River run; and full implementation of planned improvements to fish passage facilities on mainstem Columbia dams. Initiating input parameters for the System Planning model include 0.26 for zero-density egg-to-smolt survival, and 0.2 for pre-spawning adult mortality.

ACTIONS: 1

1. Implement the Yakima/Klickitat Production Project using existing habitat.

   The spring chinook program under the Yakima/Klickitat Production Project will involve the collection of about 970 wild and natural Yakima River adults to produce about 1.6 million smolts. All fish will be outplanted after acclimation at release sites. Genetic viability will be protected by all of the general measures alluded to previously, with two provisions specific to spring chinook -- the maximum proportion of a run taken for brood stock will not exceed 20 percent, and the American River will not be supplemented.

   The proposed harvest management plan for spring chinook under the Yakima/Klickitat Production Project reflects a commitment to supplementation experiments and to meeting hatchery production goals, while rebuilding natural runs and harvest opportunities. The hatchery brood stock goal of 970 adults, with a brood stock collection constraint of 20 percent for genetic conservation, will be met at run sizes in excess of 6,000 fish. The interim natural escapement goal of 6,000 fish will be met at run sizes of slightly less than 9,000 fish.

   Terminal harvest rates for all fisheries will be 20 percent on runs less than 9,000 fish, 30 percent on runs of 9,000 to 12,000 fish, and by agreement of the parties at runs in excess of 12,000 fish. The harvest rate is fixed at 30 percent on runs up to 12,000 to obtain a range of escapements above the interim goal. This data will serve as an empirical basis for identifying MSY escapements. When MSY escapement has been established, harvest rates will be set at MSY levels.

As the Yakima/Klickitat Production Project has already been adopted into the Columbia River Basin Fish and Wildlife Program, the Yakima Subbasin Plan requests nothing further in this regard.

STRATEGY 2: Strategy 1 plus expanded habitat.

The TPM/SPM procedure simulated MSY for a supplemented fishery under current conditions of habitat quality and with production area increased by the addition of the "expanded" areas. At MSY, escapement to the subbasin, terminal harvest and total harvest to all fisheries were 10,856 fish, 5,319 fish and 7,723 fish, respectively. Terminal harvest rate at MSY was 49 percent. The "mixed-stock" impact on American River runs is still fairly severe, as spawning escapement is estimated at 43 fish, down 213 from the unsupplemented MSY escapement of 256 fish.

ACTIONS: 1-3

1. -

2. Expand habitat by building all needed (currently unplanned) screens and fishways on all of the following tributaries (Appendix 3).

   Two orders of additional habitat are considered, "expanded" and "maximum." The new habitat termed expanded consists of tributaries and mainstem reaches that have just been made accessible and are not yet colonized, or are presently unusable but targeted by existing expansion projects. It also includes tributaries with relatively easily solved problems that are <u>not</u> targeted by an existing project.

   Maximum habitat consists of the expanded areas <u>plus</u> the Teanaway River system, a large, diverse drainage with great spring chinook production potential and, unfortunately, severe instream flow problems in its lowermost reaches. The Teanaway is addressed separately because permanent solution of its instream flow problems will be qualitatively more difficult and costly than the problems afflicting any other tributary.

The specific tributaries (and mainstem reaches) comprising the expanded group are Cabin Creek; the Yakima above Easton Dam; Big, Taneum, Manastash, Ahtanum, and Logy creeks; and the Little Naches above Salmon Falls. The problems to be solved on the areas in the expanded group, as well as the Teanaway, are be briefly summarized in Table 18 (see Appendix 3, Supplement 1 for details).

3. The Northwest Power Planning Council assist with projects to augment instream flows by assuming some of the costs with other benefitting governmental and private parties, and by vigorously supporting such legislative initiatives as may improve instream flows.

   Specific legislative initiatives deserving strong support include any bill providing for moderate-sized headwater impoundments on the Middle Fork of the Teanaway River, and on Taneum and Manastash Creeks; and any bill providing for a project that would divert peak flows from Cabin and Silver creeks to Kachess Reservoir for the purpose of augmenting instream flows in the upper Yakima River. The headwater impoundments were proposed in a Bureau of Reclamation study of the potential of storing spring runoff in tributaries for release in low flow months to enhance instream flows for anadromous fish (CH2MHill 1989). The proposals included in the CH2MHill study include options that would completely resolve the flow problems that currently prevent spring chinook production in these tributaries. Similarly, the Cabin Creek/Silver Creek diversion plan would resolve existing instream flow problems, which limit spring chinook production in the Yakima River from Easton Dam to the Cle Elum confluence, and (especially) from Keechelus Dam to Easton Dam. It is likely that a new bill containing these elements will arise from the Yakima River Basin Water Enhancement Project process. Yakima subbasin planners urge its support.

Table 18. Problems to be solved on the Yakima River and selected tributaries.

Area	Work Needed and Not Planned
Cabin Cr.	Blasting to create pools and construction of fishway to give access above impassible cascade. Alternative: trap and haul.
Yakima above Easton	Instream flow augmentation.
Big Cr.	Screens and repairs on two ditches, one fishway, increased instream flows for rearing and adult passage, instream structures to concentrate flow.
Taneum Cr.	Increased instream flows for rearing and adult passage.
Manastash Cr.	Screens on eight ditches, two fishways, minor instream earthwork, increased instream flows for rearing and adult passage.
Ahtanum Cr.	Screens on seven ditches, augmentation of summer instream flows.
L. Naches above falls	None.
Logy Cr.	Instream structures to concentrate flow.
Teanaway R.	Adult passage flows in lowermost four miles. Possible solutions include: trap-and-haul; buying water rights or land from willing sellers; converting irrigator's sources from river water to ground water; installation of instream structures to concentrate and deepen flows; and construction of a moderate-sized impoundment (possibly on the Middle Fork) to increase instream flows.

STRATEGY 3: Strategy 2 plus halving open-river smolt losses.

The incremental action added in this strategy, halving smolt losses in the open river, is probably the most important single action that could be taken in the Yakima Subbasin. Yakima Subbasin planners endorse the study of the cause or causes of poor smolt survival in the Yakima River now being conducted under the Pre-facility Working Plan of the Yakima/Klickitat Production Project. They propose that the findings of this study be incorporated in an enhancement program designed to reduce smolt losses in the Yakima to half their current value, and that the Fish and Wildlife Program be amended to fund such a program. Legislative initiatives that would lessen the severity of this problem should also be supported.

The fish production benefits of reducing smolt losses by 50 percent are large. At MSY, the TPM/SPM procedure indicates a supplemented spring chinook population with "expanded habitat" and half the current smolt losses would support an escapement of 18,298 fish, a terminal harvest of 10,064 fish, and a harvest to all fisheries of 14,121 fish. Terminal harvest rate at MSY would be 55 percent.

Known Remedial Actions: Four measures to reduce smolt losses in the Yakima are obvious, and can be proposed in advance of a study. Three of these measures would aid outmigrants by increasing flows in the mainstem Yakima, and one would improve smolt survival in Chandler Canal.

ACTIONS: 1-6

1. -
2. -
3. -

4. Conduct a thorough study of smolt losses in the Yakima Subbasin, and commit in the Columbia River Basin Fish and Wildlife Program to implement justified corrective actions specifically including a predator control program.

   The initial focus of the smolt loss study should be the relative contribution of various possible causes to total observed mortality. The study should investigate the magnitude of losses attributable to disease, water quality (temperature, dissolved oxygen, toxic pollution), physical stranding, bypass facilities and, in particular, to predation by fish and birds. It should be noted that Experimental Design Work Group is currently drafting a detailed proposal for all elements of the study, and will implement a feasibility study in the spring of 1990 with substantive work in 1991 and possibly 1992. Yakima Subbasin planners recommend funding support for these studies and especially for the corrective measures they identify.

5. Narrow and line a short section of Chandler Canal.

   Smolt losses in Chandler Canal could be reduced by lining and narrowing a section of unlined canal upstream of the bypass. There is evidence of a significant loss (30 percent to 50 percent) of late-migrating smolts in the section of canal above the screens and bypass. As numerous large squawfish have been electrofished from the canal after it was drained for maintenance (Wasserman et al. 1984), researchers have speculated that observed smolt losses are attributable to squawfish predation. Predatory smolt losses could only be occurring in the slow-moving, unlined section of canal, as velocities in the existing lined section are simply too great (more than four feet per second) for even large fish to maintain position and feed effectively. Yakima Subbasin planners recommend funding support for the lining of Chandler Canal.

6. Strongly support legislative initiatives that include proposals to subordinate diversions for power production at Roza, Chandler and Wapatox dams; to install new, automated check structures on Sunnyside Canal; and to modernize, consolidate and install reregulating reservoirs on smaller irrigation districts in the subbasin.

   Observations at the Chandler smolt counting facility and elsewhere have shown that smolt survival generally increases with river flow. Flows in the middle and lower Yakima River can be improved in three ways. First, diversions for power generation at three hydroelectric facilities (Roza, Wapatox and Chandler) could be subordinated to instream flows. Second, the diversions required by Sunnyside Canal could be reduced by automating antiquated check structures. Finally, the frequency and severity of short periods of extremely low flows ("water holes") below Sunnyside Dam could be reduced by requiring or convincing private irrigators to inform the Bureau of Reclamation in advance of anticipated changes in diversions; by consolidating and modernizing smaller irrigation districts; and by building reregulating reservoirs on as many delivery systems as possible.

Power subordination would directly and immediately improve instream flow by reducing diversions. The Draft Yakima River Basin Early Implementation Program (1987) stipulated that hydropower diversions should be eliminated whenever instream flows below Roza, Prosser and Wapatox dams could not otherwise be maintained at or above 400 cfs, 450 cfs and 400 cfs, respectively. (Note that the minimum instream flow below Wapatox increases to 500 cfs in September and October.) The Early Implementation document also estimated that power subordination would preclude the generation of 4,260 megawatt hours at Roza and 14,730 megawatt hours at Chandler. Subordination at Chandler would also require about $440,000 to modify control structures on the Kennewick Irrigation District's main canal, which draws its flows from the Chandler Canal. Power subordination at Wapatox would preclude the generation of 11,520 megawatt hours (L. Pendergast, Pacific Power and Light, pers. commun.).

Automation of check structures on Sunnyside Canal would improve flows by a more circuitous route. Although rebuilt, automated check structures would reduce necessary diversions; the savings would be significant only over the course of an entire season. It has been proposed that the water saved during the entire period of storage control be held in storage until the following spring, when the entire block of water could be released over a short period for maximal effectiveness. In 1985, an experimental three-day release of a 5,000-acre-foot-block of water showed "pulsed flushing" can be an effective way of accelerating outmigration (Fast et al. 1985).

"Water holes" below Sunnyside Dam during the irrigation season reflect the fact that the Bureau of Reclamation has a limited ability to regulate river flow during the period of storage control, the period in which flows in the Yakima River are regulated primarily by reservoir spills. This lack of control is attributable to many things, but a major problem is the sheer number of private irrigation systems and irrigation districts of all sizes upstream of Sunnyside Dam. Individuals with private irrigation systems collectively use a substantial amount of water. As these individuals are not required to inform the BOR of changes in the amount of water they intend to divert, and most do not, the BOR must guess what their collective demand will be and how much water to spill from reservoirs to meet it. A similar problem involving irrigation districts is that individual irrigators switch at will from non-use of their allotment to use. When a large number of individuals do this simultaneously, wastage to the river drops, diversion into the main feeder canal must be increased, and instream flows in the Yakima are reduced.

Sudden temperature increases can have a similar effect, as evaporation can reduce discharge in feeder canals as much as 50 percent, necessitating proportionately larger diversions. All of the problems involving irrigation districts would be reduced substantially if smaller districts were consolidated, delivery systems were modernized to increase efficiency and control, and reregulating reservoirs were widely employed.

With the exception of the proposal that individuals with private irrigation systems report anticipated changes in diversion, all of the measures intended to improve instream flow in the mainstem Yakima were included in the failed Senate Bill S.2519, the so-called "Early Implementation" Bill. Work on a new "early implementation bill" is proceeding and it is probable that a new bill containing all of the proposals detailed above will be submitted in the near future. Yakima Subbasin planners recommend support for legislation containing the elements listed above.

STRATEGY 4: Strategy 3 plus the renovation of bypass facilities on all Phase-II diversions.

The TPM/SPM procedure predicts addition of Phase-II rescreening to Strategy 3 will boost escapement, terminal harvest and total harvest to 20,680 fish, 11,788 fish and 16,388 fish, respectively, with a terminal harvest rate of 57 percent. Importantly, projected spawning escapement on the American River increases to 224 fish, 88 percent of the unsupplemented figure. This rebound is due to the fact a great many Phase-II diversions are located on the middle and lower Naches, and thus have a disproportionate impact on American River smolt survival rates.

Note that these estimates were based on extrapolations from Wapatox and Selah/Naches diversions. These facilities are located on the middle Naches and are fairly distant from existing primary spawning areas. Fry losses may be much greater at facilities closer to major spawning grounds. Accordingly, the benefits predicted by the TPM/SPM procedure should be viewed as conservative.

ACTIONS: 1-7

1-6. -

7. Renovate bypass facilities on all Phase II diversions. Install adult barriers on Sulphur Creek and Snipes Creek to prevent the loss of spawners through false attraction.

   In its March 1989 meeting, the Northwest Power Planning Council amended Section 803(b) of the Columbia River Basin Fish and Wildlife Program as follows.

   > 803(b)(8) - Bonneville shall fund the planning and design of fish passage facilities for the irrigation diversions in the Yakima River Basin listed in Appendix A Table of the Columbia River Basin Fish and Wildlife Program. The design will begin with the highest priority facilities as established by a pre-design memorandum and the Yakima Passage Technical Work Group. Bonneville shall not fund any construction of these facilities until the Council has adopted the subbasin plan for the Yakima basin, developed under Section 205(a). The Yakima Indian Nation and the fishery agencies shall make a good faith effort to secure cost-sharing funding for the construction of Yakima Basin fish passage facilities listed in Appendix A Table.

   Section 1403(4.5) was amended by adding the following language.

   > Beginning in FY 1989, plan and design fish passage facilities for the irrigation diversions in the Yakima Basin listed in Appendix A Table.

   As these sections indicate, design work for the Phase-II project is currently under way, and construction will begin when the Yakima Subbasin Plan is adopted. These sections are gratifying to Yakima planners, all of whom feel the renovation of Phase-II screens would have a very beneficial impact. It should, however, be noted that Yakima planners feel it would be appropriate to add to the list of Phase-II projects the installation of adult barriers on Sulphur Creek and Snipes Creek to prevent the loss of spawners through false attraction.

STRATEGY 5: Strategy 4 plus provision of off-channel winter refuges.

ACTIONS: 1-9

1-7. -

8. Provide off-channel winter refuges.

   Assuming utilization and survival rates in initial small-scale trials are encouraging, planners propose that 18 smaller canals be run in the winter to provide slow-moving pool habitat for pre-smolts. This measure would require little support from the Northwest Power Planning Council and BPA other than, perhaps, the underwriting of liability associated with the project. If all of these "canal refuges" function as planned (Appendix 4, Supplement 1), addition of this element to Strategy 4 will boost MSY escapement, terminal harvest and total harvest to 20,879 fish, 12,110 fish and 16,752 fish, respectively. Terminal harvest rate at MSY will be 58 percent. American River spawning escapement declines slightly, with the 1 percent increase in terminal exploitation, to 202 fish.

   It should be noted that this measure, while unproven and as modeled, yielding only modest benefits, entails little risk or cost.

9. Investigate the feasibility of funding a study of the benefits of providing artificial "reefs" of angular riprap material in a tributary lacking appropriate overwintering cover. The channelized lower reaches of the Little Naches would be an excellent site for such a study.

   Spring chinook (and steelhead) are known to burrow into rubble in the winter, and studies in Idaho have shown overwinter survival is positively correlated with the availability of this type of habitat. If a pilot study in the Little Naches were promising, a larger project might be implemented in major overwintering areas, such as the lower Naches and the Yakima in the vicinity of the Naches confluence.

STRATEGY 6: Strategy 5 plus Wapatox rescreening and power subordination.

The TPM/SPM procedure indicates that the addition of this element to Strategy 5 will produce an MSY escapement of 23,536 fish. Terminal harvest, total harvest and terminal harvest rate will be 13,651 fish, 18,899 fish and 58 percent, respectively. The incremental impact on American River fish is, as might be expected, substantial; spawning escapement increases 142 fish from Strategy 5, to a total of 344 fish, and for the first time exceeds the figure for the unsupplemented scenario.

ACTIONS: 1-10

1-9. -

10. Rescreen Wapatox diversion and subordinate power production to instream flows.

    Losses of fry, smolts and production potential attributable to the Wapatox diversion should be essentially eliminated by subordinating power production to instream flows and installing new screens for the water that would still have to be diverted for Wapatox irrigators and the city of Yakima. Diversions for power production should be halted when flows below the dam cannot otherwise be maintained at or above 400 cfs from November through August, and 500 cfs in September and October.

    Planners propose that the rescreening of Wapatox diversion and, if possible, the subordination of diversions for power generation occur. If it is impossible for the Bonneville Power Administration to compensate Pacific Power and Light for revenues precluded by subordination, it is requested that the Power Planning Council and BPA encourage any legislative initiative including this element.

STRATEGY 7: Strategy 6 plus riparian restoration.

Planners used the TPM/SPM procedure to estimate the benefits of adding riparian restoration to Strategy 6. At MSY, escapement, terminal harvest and total harvest were 24,316 fish, 13,860 fish and 19,283 fish, respectively. Terminal harvest rate was 57 percent. Spawning escapement on the American River increases to 370 fish.

The incremental benefits of riparian restoration -- 780 fish to escapement, 209 fish to terminal harvest and 384 to total harvest -- are extremely conservative. In making the preceding estimate, the proximate effect of riparian enhancement was, as per instructions from MEG, limited to improvements in smolt capacity. Yakima planners feel it is probable that a fully recovered riparian corridor would also improve egg-to-emergent fry survival (cleaner gravel), fry-to-late-summer-parr survival (better rearing habitat), and overwinter survival (much better overwintering cover). Collectively, such improvements could increase zero-density egg-to-smolt survival substantially. If such impacts had been considered, incremental benefits would have been more impressive.

ACTIONS: 1-11

1-10. -

11. Restore riparian habitat.

    Planners propose that a large riparian restoration project in the Yakima Subbasin occur (Appendix 5, Supplement 1). Most of the funds for the project would be used to pay for fencing materials and for the labor of installation and maintenance. Fencing on private property would be entirely voluntary. Implementation would be prioritized on two levels, with the first priority being productive potential, and the second being the fencing of headwater reaches before downstream reaches. Under assumptions employed here, landowners would not be charged for installation or maintenance, but would be required to grant the administering entity a riparian easement, and to agree not to damage the fence or to graze the fenced area for the period of the easement. The duration of this period would vary and would represent an estimate of the time necessary for the initial stages of riparian restoration, such as bank stabilization and revegetation to a successional stage resistant to grazing.

    The riparian restoration project proposed here is a long-term effort modeled on projects on Fifteenmile Creek, the Grande Ronde River and various Bureau of Land Management lands in the Prineville District in Oregon. Because steelhead habitat is concentrated in the upper portions of many drainages, and it is in these areas that overgrazing and riparian damage is most common, the major beneficiary of a riparian restoration project is steelhead, not spring chinook.

The general nature of the project will, however, be described here, and details will be added in the steelhead section.

The first phase of the project should consist of a thorough, quantitative inventory of riparian habitat. Although qualitative information on riparian conditions in the subbasin is sufficient to identify large areas of severe damage, many smaller or less severely damaged areas have undoubtedly escaped detection. Following the inventories, it will be necessary to eliminate the significance of non-riparian limiting factors before targeting a specific area for restoration.

Implementation would consist primarily of fencing the riparian corridor on a prioritized basis. Enhancement with instream structures would be limited to devices (evergreen-tree riprap, rock jetties) to stabilize crumbling cutbanks. As most riparian degradation in the subbasin is the result of overgrazing, and cattle production is a major element of the economic foundation of the subbasin, all projects should be designed to enhance grazing potential as well as fish and wildlife production. Where the riparian corridor is subdivided by numerous small parcels of privately owned land, fenced areas would necessarily be relatively narrow, with frequent crossings or watering gaps. Where the targeted stream occurs within a larger holding, it might be preferable to fence a wider area, creating a special-use pasture. Such instances would, of course, require provisions for watering stock outside the enclosed area.

Although the proposed riparian restoration program consists primarily of fencing, controlled post-recovery grazing, and bank stabilization, one additional element should be considered -- the liberation and/or protection of beaver. Establishment of beaver colonies, especially in the upper reaches of smaller streams with naturally low flows, might increase the rearing capacity of affected streams dramatically, and could conceivably eliminate the problem of late summer intermittency. It is proposed that the liberation and/or protection of beaver within restoration projects be experimentally investigated and implemented wherever appropriate.

As many of the areas most in need of riparian rehabilitation occur on the Yakima Indian Reservation, the project on the reservation deserves special mention. If agreed to by the Tribal Council, high priority riparian areas on the reservation would be fenced and designated as special-use pastures. Where possible, riparian corridors would be incorporated into much wider grazing management units. These units would receive total rest until banks had stabilized and vegetation had reached a successional stage resistant to short-term grazing. At this point, controlled grazing would be permitted within the management unit. Although details would be site-specific, grazing in such special-use pastures (and in smaller areas as well) would generally entail high intensity use in the early spring, just after the period of peak runoff, and complete rest during the main growing season in the late spring and summer. Eventually, many of these special-use areas could be used as winter range as well. Creation of special-use riparian pastures would generally entail the development of upland springs, or gravity pumping from the stream, to provide stock water during the period of summer exclosure.

As has been mentioned, the restoration and enhancement of reservation uplands and riparian corridors for the benefit of fish, wildlife and cattle production eventually will require that the density of wild horses be controlled in some manner. The Tribal Wildlife Department, in consultation with the Tribal Fish and Wildlife Committee and Tribal Council, should consider some measure to control the numbers of wild horses, such as periodic tribal round-ups.

The particular approach to restoring riparian habitat on rangeland advocated here is one that emphasizes benefits to the cattleman and thereby makes voluntary acceptance much more likely. In Oregon, such projects have clearly improved both fish and wildlife habitat and cattle production. In a project of the scope necessary for the Yakima Subbasin, benefits to cattlemen must be clear enough to provide strong incentive for cooperation.

Riparian restoration projects benefitting spring chinook comprise fewer streams and stream miles than do projects benefitting steelhead exclusively. Restoration projects benefitting spring chinook (and steelhead) are:

A) The lower 2.5 miles of Logy Creek.
B) The Yakima River from the Naches confluence to Wenas Creek (6 miles).
C) Eight miles of the Yakima River between Wilson and Taneum Creek.

Appendix 5 in Supplement 1 lists all areas targeted for riparian restoration, whether benefitting spring chinook, steelhead, or both. Appendix 5 also summarizes associated costs.

STRATEGY 8: Strategy 7 plus halving pre-spawning adult mortality.

The strategy to reduce pre-spawning mortality has four parts: 1) subordinating power generation at Roza, Chandler and Wapatox; 2) erecting interpretive signs in and around Naches River campgrounds; 3) eliminating outplants of catchable rainbow in the Naches drainage; and 4) hiring four additional conservation officers.

The TPM/SPM procedure was used to estimate the benefits of adding a 50 percent reduction in pre-spawning adult mortality to Strategy 7. At MSY, escapement, terminal harvest and total harvest were 25,016 fish, 15,010 fish and 20,592 fish, respectively. Terminal harvest rate was 60 percent. American River spawning escapement increases 50 fish to a total of 420.

ACTIONS: 1-15

1-11. -

12. Subordinate power generation at Roza, Chandler and Wapatox dams. Power subordination will speed passage by improving instream flows, especially below Sunnyside Dam, and will increase the fitness and decrease the vulnerability of spawning adults.

13. Erect interpretive signs in and around Naches River campgrounds. The signing project will consist of the placement of a large interpretive sign in each Naches River campground and at least four smaller "legal warning" signs on trails leading to campgrounds. As harassment and killing of salmon by naive vacationers camping along the Naches and American rivers is a known problem, it is expected that these signs will reduce "unwitting" poaching. The signing project, a cooperative venture of the Washington Department of Fisheries and the Wenatchee National Forest, is already under way, and should be completed the summer of 1990.

14. Eliminate outplants of catchable rainbow trout in the Naches drainage. Eliminating these plants of catchable rainbow will reduce angling pressure and thus much "inadvertent" salmon harvest.

15. Hire four additional conservation officers. Significantly reducing the impact of hard-core poachers would probably require the hiring and training of at least four more conservation officers (J. Cummins, WDW, pers. commun.). As the total cost of a fully equipped and trained conservation officer is about $50,000 per year, the cost of adequately intensified enforcement would be $200,000 per year.

STRATEGY 9: Strategy 8 plus making the Teanaway River system suitable for natural production of spring chinook.

As the Phase-II project covers the renovation of all irrigation bypass systems on the Teanaway, the only remaining obstacle to reintroducing spring chinook is insufficient instream flows for adult passage and juvenile rearing in the lower three to four miles of mainstem. The Teanaway is potentially more productive than any other Yakima tributary system except the Naches. At present, poor instream flows in the late summer and fall preclude meaningful natural production of spring chinook.

Planners used the TPM/SPM procedure to estimate the benefits of adding the Teanaway system to Strategy 8. At MSY, escapement, terminal harvest and total harvest were 26,303 fish, 15,519 fish and 21,388 fish, respectively. Terminal harvest rate was 59 percent. American River spawning escapement increases by 29 fish to 449 fish, which is 175 percent of the unsupplemented figure.

The incremental benefits of reintroducing spring chinook to the Teanaway (1,294 additional fish in the escapement, 515 additional fish in terminal harvest and 804 fish in total harvest) are conservative estimates. Much of the drainage was considered "fair spawning and rearing habitat" instead of "good" because existing low flows and lack of large woody debris combine to limit holding pools and security cover for adults. If one or both of these habitat elements were added, total production might be increased by about 30 percent.

ACTIONS: 1-16

1-15. -

16. Increase instream flows for adult passage and juvenile rearing in the lower three to four miles of the Teanaway River.

The Tributary Task Force of the Yakima/Klickitat Production Project Technical Work Group should determine the most cost-effective solution to the instream flow problems on the lower Teanaway by late 1990. The Northwest Power Planning Council and BPA should consider implementing at least a portion of the group's plan. Presently, it appears as though a permanent solution would entail a combination of buying water rights or land from willing sellers, converting agreeable farmers from surface water to well irrigation, and perhaps the building of a headwater impoundment (Appendix 2). Three actions are recommended:

A) For the short term, arrangements should be made to implement a trap-and-haul program to assist returning spawners in negotiating the lower four miles of mainstem. Such a program would consist of the construction of an inexpensive portable trap and weir (see Appendix 2), and the procurement of a tank truck and technicians to guard, load, transport and release spawners over a two to three month terminal spawning run.

It should be noted that such a program could be continued indefinitely, should a permanent solution to the instream flow problems be impossible. Indefinite continuation of a trap-and-haul operation on the Teanaway would solve the adult passage problem, and would make the system usable by spring chinook, although the problem of lost rearing habitat in the lowermost 3-4 miles would remain.

B) Eventually, water rights or land should be purchased from willing sellers along the Teanaway, so that diversions can be eliminated and passage flows improved.

C) An alternative policy that should be pursued in conjunction with the purchase of land or water rights is the drilling of wells to allow agreeable farmers to switch from surface water to groundwater for irrigation.

A trap-and-haul program does not fully resolve the passage problem on the Teanaway, because it must be continued indefinitely. Purchase of water rights or converting irrigators to groundwater irrigation are superior solutions because they are permanent and, if implemented on a wide enough scale, would allow adult passage to occur naturally (without human assistance).

It is, however, possible that the number of landowners willing to sell water rights or convert to well irrigation would be insufficient for a full resolution of the passage problem. In this event, the construction of a headwater impoundment would probably be necessary. Several potential upper Teanaway impoundment sites have been identified in the past, and one site on the Middle Fork is currently being investigated (see Appendix 2). It is probable that a new "early implementation" bill will be submitted to Congress in the near future, and it may well provide for an impoundment on the Teanaway. Legislation providing for funding of a <u>moderate-sized</u> impoundment on the upper Teanaway could solve instream flow problems on the lower river. Ideally, the impoundment (or impoundments) would be located high in the drainage, above most spawning and rearing habitat, and away from populated areas where the visual impact of drawdowns would be minimized. It should be noted that the potential site on the Middle Fork largely meets these criteria.

Recommended Strategy

The Yakima planners recommend Strategy 9, which consists of supplementation, habitat expansion, halving of outmigrating smolt losses, rebuilding of Phase-II screens, off-channel winter refuges, rescreening and power subordination at Wapatox, riparian restoration, reduced mortality of pre-spawning adults, and the implementation of measures to make the Teanaway River usable by spring chinook.

This strategy is recommended because it enhances the population at all points of the freshwater life-cycle, and is in this sense complete. The freshwater portion of the life history of anadromous salmonids consists of spawning migrations into terminal areas; egg deposition and incubation; emergence and early rearing; overwintering of pre-smolts; and smolt outmigration. As was discussed at some length in previous sections, the combined elements of Strategy 9 address all of these phases. It should be noted that it is currently impossible to specify which point in the freshwater portion of the life-cycle represents the "bottleneck" in the Yakima Subbasin, or even whether a consistent, single bottleneck exists. Indeed, on the basis of the limited data available, it is probable that the production bottleneck occurs at a different point each year. It was primarily this consideration that drove Yakima Subbasin planners to prefer the most comprehensive enhancement strategy.

Table 19. System Planning Model results for spring chinook in the Yakima Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
Maximize sustainable yield in a way that is consistent with long-term conservation of genetic fitness and the experimental goals of the Yakima/Klickitat Production Project.

Biological Objective:
1. Increase egg deposition by increasing the amount of usable habitat, and decreasing pre-spawning mortality. 2. Increase fry-to-parr survival. 3. Increase overwinter survival. 4. Increase smolt-to-smolt survival. 5. Conserve genetic fitness of the existing natural stock, and preserve intact the genetic resource represented by the American River substock.

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	1,369 -C	2,680	4,719	1,063	0(1.00)
All Nat	9,039 -C	7,816	17,723	3,916	22,883(3.75)
1	4,864 -C	3,592	9,353	2,069	8,144(1.98)
2	5,319 -C	4,430	10,856	2,404	10,792(2.30)
3	10,064 -C	6,587	18,298	4,057	23,908(3.87)
4	11,788 -C	7,114	20,681	4,600	28,122(4.38)
5	12,110 -C	7,015	20,879	4,642	28,470(4.42)
6	13,651 -C	7,908	23,536	5,248	33,168(4.98)
7	13,860 -C	8,365	24,316	5,423	34,544(5.15)
8	15,010 -C	9,006	25,016	5,582	35,782(5.29)
9*	15,519 -C	9,706	26,303	5,869	38,050(5.57)

*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. Implementation of Yakima/Klickitat Production Project with existing habitat. Post Mainstem Implementation.
2. Strategy 1 plus additional habitat. Post Mainstem Implementation.
3. Strategy 2 plus halving open-river smolt losses through improved flows in the Yakima system. Post Mainstem Implementation.
4. Strategy 3 plus rebuilding Phase-II screens. Post Mainstem Implementation.
5. Strategy 4 plus provision of off-channel winter refuges. Post Mainstem Implementation.
6. Strategy 5 plus rescreening and power subordination at Wapatox. Post Mainstem Implementation.
7. Strategy 6 plus riparian restoration. Post Mainstem Implementation.
8. Strategy 7 plus reduced pre-spawning adult mortality. Post Mainstem Implementation.
9. Strategy 8 plus making the Teanaway River usable. Post 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 20. Estimated costs of alternative strategies for Yakima spring chinook (Strategies 1-5). 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	5
Hatchery Costs					
Capital[1]	0	0	0	0	0
O&M/yr[2]	0	0	0	0	0
Other Costs					
Capital[3]	0	2,568,010	4,913,110	4,913,110	4,913,110
O&M/yr[4]	0	89,729	191,867	191,867	198,907
Total Costs					
Capital	0	2,568,010	4,913,110	4,913,110	4,913,110
O&M/yr	0	89,729	191,867	191,867	198,907

* 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.

Table 21. Estimated costs of alternative strategies for Yakima spring chinook (Strategies 6-9). 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			
	6	7	8	9*
Hatchery Costs				
Capital[1]	0	0	0	0
O&M/yr[2]	0	0	0	0
Other Costs				
Capital[3]	6,723,110	6,845,540	6,845,540	6,852,140
O&M/yr[4]	225,907	252,774	452,774	479,024
Total Costs				
Capital	6,723,110	6,845,540	6,845,540	6,852,140
O&M/yr	225,907	252,774	452,774	479,024

* 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

Fisheries Resource

Natural Production

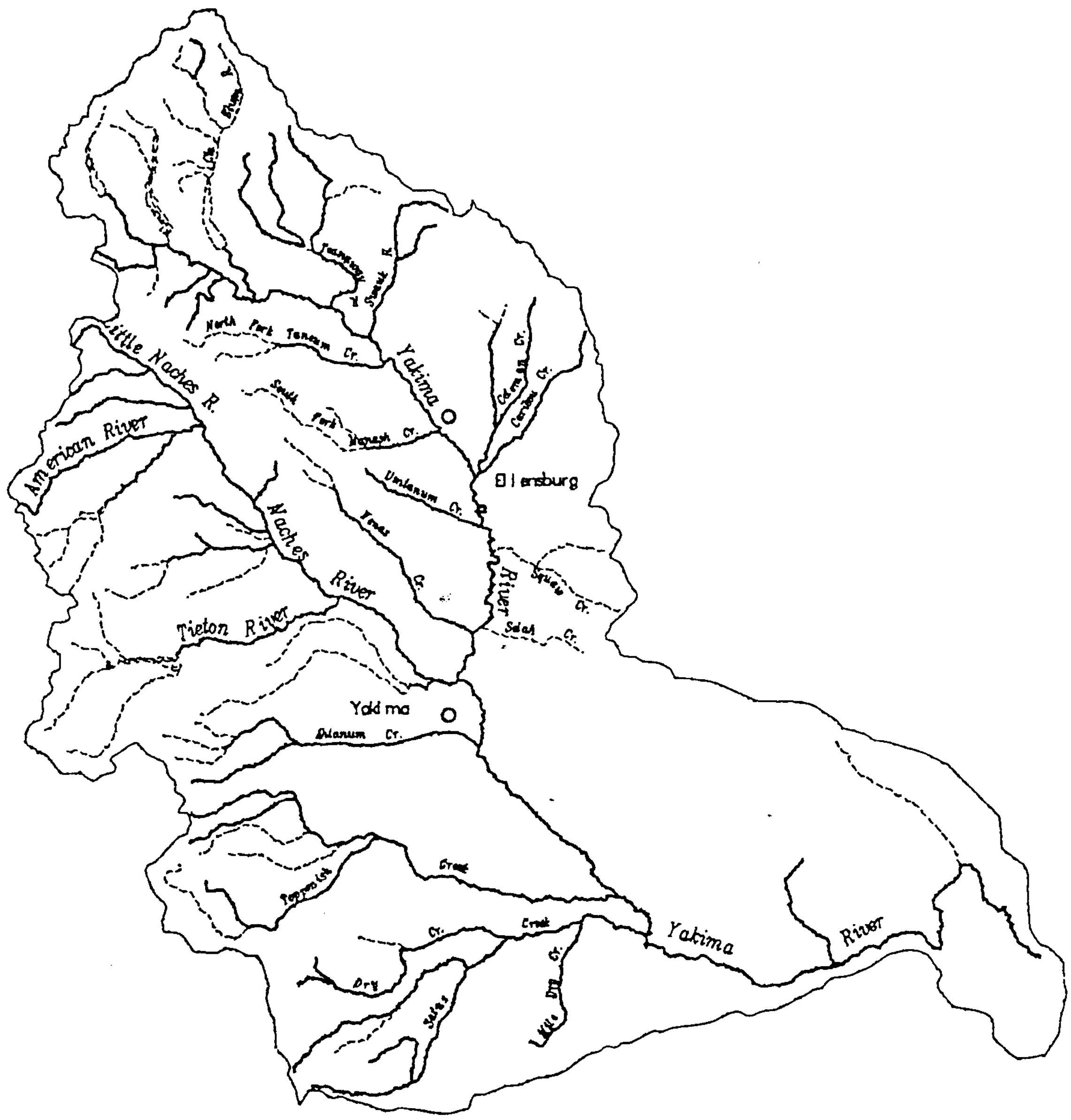
History and Status

Steelhead historically were found in all the reaches of the mainstem Yakima and its tributaries that supported spring chinook, and in many other tributaries as well. As steelhead spawners prefer smaller streams with steeper gradients than spring chinook, virtually all accessible permanent streams and some intermittent streams once supported spawning steelhead. As even today some steelhead spawn in such lower valley tributaries as Spring and Snipes creeks, it seems probable there was historically no downstream limit to their distribution.

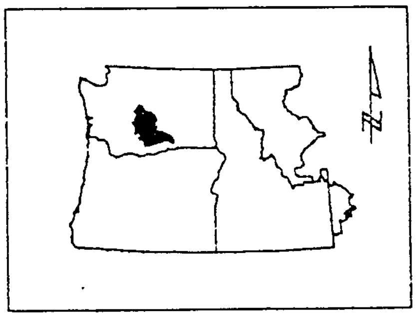
The present production areas for steelhead are concentrated below the Naches confluence, and in and around Toppenish and, especially, Satus Creek. Very little production currently occurs above Roza Dam because until 1987, it was not usually possible to operate the ladder at the dam throughout the fall and winter, when much of the spawning migration occurs. The old ladder was operable only at full pool. Routine maintenance and fairly frequent icing problems required that the pool be lowered, dewatering the ladder. Maintenance and ice flows still require the lowering of the pool (ice damages the hydroelectric turbines that draw water from Roza Canal), but the new ladder has both a full-pool and low-pool entrance. Since 1983, fewer than 80 (and usually fewer than 20) steelhead spawners have been counted over Roza Dam.

A highly provisional estimate of the current distribution of steelhead production is that 50 percent occurs in the Satus Creek drainage, 10 percent in the Naches drainage, 20 percent in the Yakima drainage between Roza and Wapato dams, and 20 percent in the Yakima drainage (exclusive of Satus Creek) below Wapato Dam. This distribution is based on relative smolt counts at Wapatox and Prosser in recent years, on redd counts (and inferred escapement) in the Satus drainage in 1988, and on the estimated smolt capacity of the Yakima drainage between Roza and Wapato dams and below Wapato Dam.

YAKIMA SUBBASIN



SUMMER STEELHEAD DISTRIBUTION*



——————— PRESENT/POTENTIAL

- - - - - - - - - - ABSENT

* Due to the limitations of scale, all streams which support anadromous fish are not shown on this map.

GIS GEOGRAPHIC INFORMATION SYSTEM

BONNEVILLE POWER ADMINISTRATION

Outmigration at the Wapatox smolt trap on the middle Naches from 1985 through 1987 averaged about 10 percent of the total subbasin outmigration as monitored at Prosser smolt trap on the lower Yakima. Accordingly, researchers have assumed that the Naches drainage contributes 10 percent of total production. It was estimated that about 938 redds were deposited in the Satus drainage in 1988. As each female digs an average of 1.2 redds (Thompson 1984), and the Yakima steelhead run is estimated to be 67 percent female, the total escapement to the Satus system in 1988 was:

(938 redds/1.2 females per redd)/(0.67 females) = 1,667

Total escapement to the subbasin for the 1987-1988 run was 2,459 wild fish. The Satus escapement thus represented 1,667/2,459 or 68 percent of the total. As Yakima steelhead and their redds are small, and the redds may occasionally be confused with purely hydraulic disturbances of the streambed, it seems appropriate to discount some of the counts and to assume that the Satus escapement probably accounted for about 50 percent of the total escapement and the Naches drainage for 10 percent. The remaining 40 percent must occur in the mainstem Yakima and tributaries between Roza and Wapato dams, and in the Yakima drainage exclusive of Satus below Wapato Dam. The Northwest Power Planning Council smolt capacity estimates are approximately equal in the latter two segments. Accordingly, 20 percent of total current production was assigned to each.

All of the previously described historic developments that reduced the abundance and distribution of spring chinook had a similar effect on steelhead. However, because steelhead prefer smaller tributaries for rearing than spring chinook, and the instream flow, passage and riparian problems in Yakima tributaries have been relatively more severe than in the mainstem, steelhead have been more severely impacted by diversions and riparian degradation. The completion of Roza Dam in 1940 must be underscored as a species-specific milestone, as the inability to operate its ladder through the fall and winter effectively eliminated about half of the habitat otherwise accessible to steelhead.

Life History and Population Characteristics

Judged by counts at Prosser Dam, adults begin entering the Yakima River in September, cease movement during the colder parts of December and January, and resume migration from February through June (Table 22). The run has two peaks, one in late October, and one in February or March. The relative numbers of wild (natural) fish returning during the fall and winter-spring migration periods varies from year to year, perhaps depending on the duration of a "thermal window" in the fall, fall flows, or fall turbidity. One would expect, however, that the Skamania stock hatchery steelhead released prior to 1987 would return primarily in the earlier period, as managers have selected for early spawning (December through February) in this stock. Indeed, provisional figures from Prosser Dam counts for the 1987 and 1988 run indicate that over 70 percent of the hatchery returns occurred before January. Note that the fact that the distribution of hatchery returns is disproportionately concentrated in the fall peak does not imply that all or most steelhead returning in the fall are hatchery fish. Hatchery fish are estimated to have contributed no more than 10 to 20 percent of the total run in recent years (see below).

As a component of pre-implementation studies, the Yakima/Klickitat Production Project is conducting a multi-year radio-tagging study on Yakima River steelhead spawners. The first year of this study began in October of 1989 and will continue through April of 1990. In it, a fraction of the fish passing Prosser Dam each week are radio tagged and released in the vicinity of the dam. All experimental fish are monitored on a weekly basis with a number of stationary receiving units as well as mobile units which are hand-carried or mounted in aircraft, boats or pickup trucks. A similar but more intensive program is planned for 1990-1991. To date, the findings indicate that the vast majority of "fall-run" steelhead spawners overwinter in the mainstem Yakima, primarily in a reach containing numerous deep holes below the Satus Creek confluence. It was also noted that virtually no fish ascended Satus Creek or any other spawning tributary during two periods of high water in December and January, indicating that the "trigger" for entering tributaries has a thermal or photoperiodic component. Most of the implanted radio tags have a motion sensor which can detect spawning activity. Thus, it is anticipated that the spawning distribution of Yakima steelhead and the relative utilization of various parts of the drainage will be much better understood when the study is completed.

The hatchery contribution to adult returns before the most recent brood years is not known with any certainty. (The viewing window at Prosser adult counting station did not become fully functional until the fall of 1987, before which time adipose-fin clipped hatchery fish could not reliably be identified.) Although a provisional estimate of the hatchery component of the last two returns is around 10 percent, hatchery contribution has almost certainly varied from year to year. The escapement figures in Table 23 assume hatchery contribution was a constant 20 percent. Planners made this assumption because 20 percent of the fish in the 1986 and 1987 run brood stock take were hatchery fish, and because on average around 20 percent of the smolts passing Prosser since 1983 have been hatchery fish.

Table 22. Duration of various parts of the life cycle of Yakima Subbasin summer steelhead.

	MAMJJASONDJFMAMJJASONDJFMAMJJ
Adult Imm'n	XXX XXXXX
Adult Holding	XX
Spawn	XXX
Inc'n	XXXXX
Emerg	XXXX
Rear	XXXXXXXXXXXXXXXXXXXXXX
JV Emm'n	XXXX

Table 23. Escapement, catch and total run size of Yakima summer steelhead, 1981-1988 broods. From 1985 brood on, total run size estimated by Prosser passage plus below-Prosser catch. Before 1985 brood, total run size estimated by (total catch)/(1984 exploitation rate).

	Brood Year								
	'81	'82	'83	'84	'85	'86	'87	'88	'89
Escapement									
Hatchery	16	53	58	72	138	276	368	0	0
Wild	64	210	230	286	550	1104	1472	2198	856
Total	80	263	288	358	688	1380	1840	2198	856
Harvest									
Sport									
Naches	22	22	88	63	223	68	142	51	21
Yakima	153	547	516	691	1258	636	372	344	121
Tribal	N.D.	6	26	28	25	24	6	0	0
Total	175	575	630	782	1506	728	520	395	142
Brood Stock Removal	0	0	0	0	0	119	131	100	168
Total Run	255	838	918	1140	2194	2227	2491	2693	1166

As summarized in Table 23, the size of the Yakima steelhead run increased by more than an order of magnitude from 1981 to 1988, and then abruptly fell by more than 50 percent in 1989. As of the time of writing (March 1990), it appears as though run size may fall by another 50 percent in 1990 (total count over Prosser Dam through March 22, 1990 equaled 794 fish).

Part of the 1981 through 1988 recovery may be attributed to the near extinction of the run in the very dry years of the late 1970s. Through the early part of the 1980s, juvenile steelhead reared in the virtual absence of intraspecific competition, and probably enjoyed unusually high survival rates. This period of recovery was also aided by a high runoff and good instream flows from 1980 through 1984, and by a change in sport fishing regulations. Before the 1985-1986 run, wild fish were legal, the season was year-round and the catch limit was usually two fish. Beginning January 1, 1986, it became illegal to keep wild fish in the sport fishery. The 1985-1986 season, with a catch limit of one fish, was open year-round through March 1986 and then closed April and May. Since the 1986-1987 season, fishing has been permitted June through March only, and the catch limit has been one fish. These regulation changes permitted larger escapements, larger numbers of outmigrants and consequently larger returns.

The disturbing recent decline in run sizes cannot be fully explained at the present time, although several possible contributing factors can be identified. The four most obvious factors are 1) Columbia-wide trends in the run size of summer steelhead, reflecting oceanic and Columbia mainstem mortality; 2) declining smolt outmigrations, reflecting the generalized impact of a four-year drought in the Yakima Subbasin; 3) reduced smolt-to-smolt survival in recent years, also associated with the drought; and 4) possibly some measure of increased density-dependent mortality, at least within the relatively small Satus drainage, associated with large recent increases in spawning escapements.

It should be noted that the estimates summarized in Table 23 required two major assumptions, neither of which is adequately corroborated. The first is that sport fishing effort and catch per unit effort was the same in the 1984-1985 season as in earlier seasons. This assumption was necessitated by the fact steelhead were not counted at Prosser before the 1984-1985 run, precluding the straightforward estimation of earlier run sizes as the sum of the Prosser count and below-Prosser catches (the method used since 1984-1985). As the last run subject to liberal sport fishing regulations was also 1984-1985, the exploitation rate observed on this run (68.6 percent) was applied to WDW catch estimates on earlier runs to estimate total run size. The second questionable assumption was that hatchery fish make up 20 percent of the run, an assumption applied to all runs but 1987-1988, for which hatchery composition was empirically determined.

There is a great deal of uncertainty regarding the adult age structure of Yakima steelhead. Virtually all that is currently known about adult age structure was gleaned from an analysis of 123 scales taken from wild females captured for brood stock from the 1985-1986 and 1986-1987 runs (only the number of males in the brood-take was recorded). Researchers have therefore assumed that the age structure of wild males and females is the same. This assumption is supported somewhat by the close similarity between length distributions of male and female kelts observed in the Satus system in 1981 and 1982.

The age structure summarized in Table 24 reflects a nearly even mix of 1-ocean and 2-ocean spawners. This type of age distribution was also observed in a much smaller scale analysis conducted in 1983 (Howell et al. 1985).

The sex ratios observed in three years of brood stock collection were very similar; 65 percent of the fish in the 1985-1986 collection were females, 63 percent were females in the

1986-1987 collection, and 73 percent were females in the 1987-1988 collection. Thus, planners have assumed an average sex ratio of 67 percent females and 33 percent males.

Table 24. Mean adult age structure for Yakima Subbasin summer steelhead 1986 and 1987 broods. (Male and female age structure assumed identical.)

Age	Percent
1-ocean	52.0
2-ocean	47.3
3-ocean	0.7

The age-specific mean fork lengths observed in the brood stock sample were 60.5 cm for 1-ocean fish and 71.5 cm for 2-ocean fish. Only one 3-ocean fish, with a fork length of 86.4 cm, was in the sample. No age-weight data exists, but Yakima Indian Nation field biologists estimate Yakima steelhead weigh between four and 12 pounds in the Yakima.

Checks on two of the scales from the brood stock collection indicated spawning had occurred in January. However, the rest of the sample, collected as late as April first, indicated spawning had not yet occurred. The observations on Satus Creek in 1988 indicate that spawning activity is concentrated in April and May, peaking the last two weeks of April and the first week of May. (Scale analysis indicated 5.9 percent of the fish collected for brood stock from the 1986-1987 run were repeat spawners.)

Age-specific mean fecundities are based on 22 wild females from the 1986-1987 brood stock collection for which both age and fecundity were determined. The mean observed fecundity for 1-ocean and 2-ocean fish was, respectively, 4,858 and 7,119 eggs per female. Researchers developed a length-fecundity relationship from this data. When applied to the length of the single 3-ocean fish observed, planners estimated 9,904 eggs per female. Applying these age-specific fecundities to the age structure previously described, planners estimated an overall fecundity of 5,963 eggs per fish.

Steelhead redds have never been capped, and spring chinook fry traps have been placed where steelhead are virtually nonexistent (upper Yakima) or very rare (American River). Hence, estimated emergence timing is quite rough, and is based on the earliest dates fry were observed either in electroshocking surveys or smolt traps. From these observations it would appear that steelhead from the lower part of the subbasin (Satus/Toppenish systems) emerge earlier (May through June) than steelhead in the Naches system (June through August). This asynchrony is doubtless the result of the relatively lower water temperatures in the Naches.

Rearing migrations in the Yakima are much less well understood for steelhead than they are for spring chinook. Because steelhead juveniles are found in small tributaries throughout the summer, biologists feel that the fish are much less inclined to migrate downstream for early rearing than spring chinook. However, intraspecific competition alone, particularly in areas of heavy spawning, would guarantee a fair measure of downstream dispersal of fry. Moreover, in 1988 researchers observed a considerable amount of spawning in Satus Creek tributaries that become intermittent by late spring or early summer. Obviously, such fish must have evolved a behavior pattern to cope with an intermittent spawning environment. Preliminary observations in Mule Dry Creek, a tributary of Satus Creek that dries up in its lower reaches in the late spring, indicate that fry and yearlings move upstream into perennial reaches as lower sections become dry.

Although most steelhead juveniles overwinter in tributaries, a small proportion (about 8 percent of total outmigration in 1987) move as far downriver as Prosser. At Prosser, virtually all winter movement occurs in February, more than a month after the peak of spring chinook movement. Data from Wapatox smolt trap indicates that roughly half as many juveniles and pre-smolts leave the upper river in the fall and winter as do smolts in the spring. (As Wapatox trap has never been operated later than December 1, the relative number of fall and winter emigrants in the Naches may be larger than has been actually observed.)

As monitored at Prosser, the spring smolt outmigration begins in April and essentially ends by mid-June. The midpoint of the outmigration generally occurs in the first week of May (Fast et al. 1986). The midpoint of outmigration at Wapatox is also generally around the first week in May. Given the distances involved and smolt migration rates observed, the midpoint of the outmigration of Naches steelhead would not occur at Prosser for at least another week. Thus, as many as half the smolts leaving the Naches must negotiate the perilous lower river in late May and early June.

The age composition of Yakima Subbasin steelhead smolts has been determined from length frequencies observed at Prosser and a relationship between age (as determined from scale analysis) and length for steelhead smolts (see Preliminary Information Report, July 8, 1980). This analysis shows age composition has been remarkably constant since 1983. The mean proportion of age-I+, age-II+ and age-III+ smolts over this period has been 45.7 percent, 48.6 percent and 5.7 percent, respectively. It should be noted that these figures describe the aggregate age composition for smolts originating in all parts of the subbasin. The aggregate age composition conforms rather closely to an estimate made on Satus smolts in 1981, in which the proportion of age-I+, age-II+, and age-III+ smolts was 43 percent, 54.3 percent and 1.7 percent, respectively.

An analysis of 181 scales from Naches system steelhead juveniles collected at Wapatox trap in the spring of 1988 (Yakima Indian Nation, unpubl. data) showed that 17 percent were age-I+ fish, 83 percent were age-II+ fish, and none were age-III+ fish. The mean fork length of the age-I+ fish was only 108 mm, whereas the mean length of age-II+ fish was 167 mm. Although observations of "smolt-like" appearance were not made, it is probable that most or all of the yearlings were not smolts, but dispersing parr, and that the proportion of age-II+ smolts among Naches system steelhead approaches 100 percent. This interpretation is consistent with a smaller collection of scales collected in 1985 that showed all visually identified smolts were age-II+ fish.

It is not surprising that smolts from the Naches system should be older than those rearing elsewhere. Water temperatures in the Naches drainage -- and presumably growth rates as well -- are lower than anywhere else in the subbasin.

The estimation of egg-to-smolt and smolt-to-adult survival for wild Yakima steelhead involved a great many assumptions. In addition to the difficulties in estimating smolt losses incurred before Prosser (smolt-to-smolt survival), allowance must be made for the fact that fish from a single brood year may spend from one to three years in freshwater and one to three years in the ocean. The accuracy of the final estimates probably does not justify a full explanation of the computations they entailed (interested readers are referred to the Preliminary Information Report). A summary of the results of these calculations is presented in Table 25.

Table 25. Estimated egg-to-smolt and smolt-to-adult survival rates for Yakima Subbasin summer steelhead, 1982 through 1986 brood years. Note that the estimation of "headwater smolts" is highly speculative, and egg-to-smolt and smolt-to-adult survival rates should be considered no more than rough approximations.

Brood Year	Escapement	# Eggs Deposited (x 1000)[1]	Brood Year Headwtr Smolts	Survival (%) Egg to Headwtr Smolt	Survival (%) Headwater Smolt to Adult
1982	263	1,003.7	101,347	10.1	N.D.
1983	288	1,099.1	80,593	8.0	1.4
1984	358	1,366.2	109,818	8.0	2.8
1985	688	2,625.6	143,588	5.5	N.D.
1986	1,380	4,946.1	173,717	3.5	N.D.

[1] Number eggs = (escapement)(fraction females)(mean fecundity).

Managers have not made releases of marked, wild steelhead comparable to the releases of wild spring chinook. However, the similarity between survival rates (release point to Prosser) for non-acclimated, hatchery-reared steelhead and spring chinook (25 percent and 27 percent, respectively) suggest that smolt-to-smolt survival rates for wild steelhead and wild spring chinook might also be comparable. However, in four simultaneous releases of marked wild steelhead and spring chinook smolts at the headgates of Chandler Canal, the mean loss of steelhead was 11 percent less than spring chinook. Researchers have speculated that the primary cause of smolt loss in Chandler Canal and the open river is predation by piscivorous fish (see spring chinook smolt-to-smolt survival). Under this assumption, it is reasonable to expect a higher smolt-to-smolt survival rate for steelhead smolts, which are 60 mm to 80 mm longer than spring chinook smolts. Planners assumed this and assigned the smolt-to-smolt survival rates of spring chinook with 11 percent less mortality to steelhead in major reaches of the subbasin. Specifically, the baseline smolt-to-smolt survival rates for steelhead were 82 percent from Prosser Dam to the Columbia; 62 percent from Sunnyside Dam to Prosser Dam; and 76 percent from a point below Wapatox Dam to Sunnyside Dam and 72 percent from a point above Wapatox Dam to Sunnyside. Thus, cumulative smolt-to-smolt survival from a point on the Yakima above Sunnyside Dam to the Columbia is 51 percent, whereas cumulative survival from a point above Wapatox to the Columbia is 37 percent.

As with the case for spring chinook, smolt capacity was estimated with the Northwest Power Planning Council's standard estimator. For the subbasin under current conditions of accessibility and habitat quality, smolt capacity was estimated at 508,861 smolts. It should be noted that areas that have recently been made fully accessible, but have yet to generate significant natural production (such as the Little Naches above Salmon Falls, upper Toppenish Creek and, especially, the Yakima above Roza Dam) were not included in this estimate. A System Planning Model simulation of the Yakima Subbasin assuming this smolt capacity indicates MSY adult escapement to the subbasin would be 3,626 fish under existing conditions within the Yakima Subbasin and the Columbia mainstem; or 4,107 fish under existing conditions within the Yakima but with projected passage improvements in the Columbia mainstem (see Strategies section).

Supplementation History

Yakima Subbasin steelhead have been supplemented with annual smolt releases ranging from 15,900 fish to 141,780 fish (mean is 63,500 fish) since 1961. The last 10 years' releases are summarized in Table 26. These releases were intended primarily to increase harvest. Stocks released included Priest Rapids; Klickitat and Columbia River (through 1971); Skamania (1972 through 1986); and, since 1987, hatchery-reared natural Yakima. Before 1975, most releases were made in the Yakima River above Roza Dam, and only occasionally in Naches tributaries (Buckskin Creek, Milk Creek, Oak Creek), and in Ahtanum Creek. From 1975 through 1985, releases were made solely at the Nelson Springs raceway on Buckskin Creek, a tributary of the Naches. In the last two years, managers have released hatchery-reared native Yakima fish in a number of Naches tributaries (Bumping and American rivers, Rattlesnake and Crow creeks and a number of tributaries of the Little Naches above Salmon Falls), as well as from Nelson Springs. Non-native hatchery steelhead were never released in the Satus or Toppenish drainages, although about 50,000 hatchery-reared natural Yakima steelhead smolts were released in Toppenish Creek in 1989.

Although the history of steelhead supplementation in the Yakima Subbasin is extensive, very little is known of the performance of hatchery steelhead. Hatchery fish are estimated to have comprised from 10 percent to 20 percent of the run in the last five or six years. Hatchery contribution in earlier years cannot be determined.

Table 26 makes it quite clear that hatchery steelhead are not contributing much to the fishery in recent years because about 75 percent of them never make it out of the subbasin. The return rate for hatchery smolts counted past Prosser is, however, quite good, slightly exceeding the values published for wild steelhead reared above four mainstem Columbia dams. Indeed, if most of a typical 80,000-smolt release could somehow be spared significant mortality before reaching Prosser, the figures in Table 26 indicate one could expect a return roughly equal to the best of the recent returns (about 2,800 fish).

It does not seem likely that the genome of the existing run has been altered significantly by introduced stocks. The reproductive failure of most of the fish released before 1975 was assured when they were released above Roza Dam. The fish released since 1975 were Skamania stock, and so should be ready to spawn between December and February, not between April and May when native stocks spawn. These arguments for the "racial purity" of Yakima Subbasin steelhead apply to native fish spawning in the mainstem Yakima and Naches. They are, however, even stronger when applied to the Satus (and to a slightly lesser degree, the Toppenish) system, which can only have received a few strays.

The future of Yakima Subbasin steelhead is, like that of spring chinook, very much affected by supplementation activities anticipated from the Yakima/Klickitat Production Project. These activities will be discussed under "Hatchery Production."

Table 26. History of hatchery summer steelhead smolt releases in the Yakima Subbasin, 1977-1987.

Year of Release	Release Number	Release Site	Smolt Survival to Prosser (percent)	Returns: Per Fish Released (percent)	Returns: Per Smolt at Prosser (percent)
1977	57,570	Nelson Sp	24.2 [1]	N.D.	N.D.
1978	71,330	Nelson Sp	24.2 [1]	N.D.	N.D.
1979	61,500	Nelson Sp	24.2 [1]	N.D.	N.D.
1980	64,745	Nelson Sp	24.2 [1]	N.D.	N.D.
1981	77,140	Nelson Sp	24.2 [1]	N.D.	N.D.
1982	52,216	Nelson Sp	24.2 [1]	N.D.	N.D.
1983	64,810	Nelson Sp	20.7	0.72 [2]	3.5 [2]
1984	49,289	Nelson Sp	27.7	1.0 [2]	3.4 [2]
1985	88,484	Nelson Sp	40.6	N.D.	N.D.
1986 [3]	108,630	Nelson Sp	19.4	N.D.	N.D.
1987	85,395	Nelson Sp	19.3	N.D.	N.D.
1987 [4]	56,385	L. Naches	16.0	N.D.	N.D.
1988 [5]	97,915	L. Naches	25.9	N.D.	N.D.

[1] Assumed value; represents 1983-1988 mean.
[2] Provisional figures; 1987-88 run data not fully analyzed.
[3] 45,730 fry were also released 12/4/86 in Naches tributaries.
[4] 85,832 fry were also released 10/27/87 in Naches tributaries.
[5] 12,200 fry were released 3/9/88 in Naches tributaries.

Fish Production Constraints

The same factors that limit spring chinook production also limit steelhead production, although the order of priority is somewhat different, and low spring flows in the upper Yakima have a negligible effect now because of the virtual absence of steelhead in this region. Problems associated with irrigation diversions should be first on the list, followed by suboptimal instream flows, degraded riparian and instream habitat, and excessive temperatures in the lower portions of the Toppenish and Satus drainages.

1) Irrigation Diversions

Poorly screened and unscreened diversions, especially those on spawning tributaries, pose a bigger threat to steelhead than to spring chinook. Compared to spring chinook, steelhead spawners prefer much smaller tributaries, and steelhead fry and parr are more inclined to remain near their spawning grounds, at least through their first summer. Steelhead fry emerge at a smaller size and considerably later than spring chinook--in late June and early July throughout much of the subbasin, and as late as August in the Naches system. Thus, irrigation season is in full swing during steelhead emergence and the combination of declining natural flows, large irrigation withdrawals and the small size of newly emergent fry maximizes the possibility of entrainment.

A class of diversion merits special mention. This type of diversion is located on a tributary that has good flows and habitat in its upper reaches all year, and adequate flows in its lower reaches to pass juveniles and adults when necessary (October and November for spawners and winter migrants, and February through April for both spawners and smolts). The tributary on which this class of diversion is located already has everything it needs to be a substantial producer of steelhead except one thing, adequate passage. Dams that present total barriers to spawning adults and/or have large, unscreened diversions effectively remove these tributaries from production. Such diversions are known on Manastash Creek, Taneum Creek, Cowiche Creek, Ahtanum Creek, Simcoe Creek, the North Fork of Simcoe Creek, the Wilson/Naneum system, Swauk Creek and Reecer Creek, and there are undoubtedly others. Of course, until 1988, the largest diversion of this type in the subbasin was Roza Dam.

2) Suboptimal Flows

Suboptimal flows limit steelhead production in the same ways they limit spring chinook production. There may be, however, some species-specific differences in emphasis. Passage in tributaries requires substantial flows from October through early December for spawners and juveniles seeking downstream winter habitat, and from March through late April or early May for spawners and smolts. The impact of suboptimal flows in the mainstem Yakima in summer and winter may not be as critical for steelhead as it seems to be for spring chinook, as steelhead tend to remain in tributaries for much of their juvenile phase, and have not been observed moving past Prosser in the winter at rates comparable to spring chinook. The low flows between Sunnyside and Prosser may also affect Naches system steelhead more severely than Naches spring chinook, as steelhead smolts tend to leave the Naches later, when conditions are worse. (Naches system smolts must negotiate up to four dams and all 57 miles of the Sunnyside to Prosser reach, whereas Satus smolts have only one dam and the lower 12.5 miles of the reach. In terms of discharge, the reach from Satus Creek to Prosser Dam benefits from the outflows of Satus and Toppenish Creeks, as well as a number of irrigation drains. This possible difference in predatory vulnerability may account for the relative lack of steelhead in the Naches system.)

3) Degraded Riparian and Instream Habitat

Mongillo and Falconer (1980) did a regression analysis of the environmental factors affecting the abundance of trout in small streams in Yakima, Kittitas and Benton counties. They subdivided their study sites into "controls," or sites outside of irrigation districts, and "agriculturally disturbed" sites within irrigation districts. In all counties except Yakima, there was a significant difference between control and disturbed sites for all sizes of trout, expressed as numbers and kilogram per hectare of habitat In all counties including Yakima, there was a significant difference between control and disturbed for numbers of larger trout (more than 150 mm) per hectare. Control streams in Benton, Kittitas and Yakima counties had, respectively, 19.5 times, 9.9 times and 1.5 times more large trout than disturbed streams. They found the main ecological factors regulating trout standing crop in Benton County were bank cover, substrate, flow, turbidity, and nitrate concentration. Bank cover, substrate, and flow were most important in Kittitas County, whereas bank cover was the main limiting factor in Yakima County. The single factor that most distinguished disturbed sites from controls was bank cover. Thus, the agricultural practices most implicated in habitat degradation in smaller streams are riparian grazing and mowing.

Steelhead are indistinguishable from rainbow trout in habitat requirements before smoltification. While significantly increased natural steelhead production may be impossible without widespread improvements in passage, the increases following passage improvements will be compromised without equally widespread improvements in habitat. As mentioned, most aspects of a degraded aquatic habitat improve as the riparian corridor improves. Fenced exclosures are a proven technique for restoring riparian habitat, and Bonneville Power Administration and Bureau of Land Management projects in Oregon are proving that fenced exclosures on a wide scale are both feasible and effective.

4) Excessive Temperatures

Again, with some differences in emphasis, steelhead are affected by excessive temperatures in the same way as spring chinook. Summer rearing in the mainstem Yakima is essentially restricted to areas above Sunnyside Dam, although, except for older fish, this is probably not so consequential as for spring chinook. Excessive temperature in tributaries is much more important for steelhead. As most overheating of tributaries is a function of a degraded riparian corridor, the importance of the riparian factor is re-emphasized.

Hatchery Production

Description of Hatcheries

Three hatchery facilities in the subbasin produce at least some steelhead. Two of the facilities, the Yakima Trout Hatchery and Naches Hatchery, are owned by the Washington Department of Wildlife. The third, the Nelson Springs raceway, is leased by the Yakima Chapter of the Northwest Steelheader's Club from Suntides Golf Course Corporation. The Yakima Trout Hatchery is located in Yakima, just beyond the west end of the Yakima Airport. The Naches Hatchery is located near the Naches River, five miles from Yakima, and the Nelson Springs raceway is located on Buckskin Creek, a tributary 3.3 miles up the Naches.

The Yakima Trout Hatchery was built in 1934, and consists of 10 40-foot circular raceways, 20 raceways (100' X 10' X 3') and an incubation building. Water is supplied mainly from Spring Creek and secondarily from a 1,000-gallon-per-minute well and an unnamed ground water source from the area around the airport.

Naches Hatchery was built in 1922 and consists of 11 raceways and nine rectangular cement tanks. Eight of the raceways are 165' X 15' X 2.5' and three are 120' X 10' X 2'. Six of the tanks are 43 inches wide, 33 feet long and 14 inches deep, and three are 8.5 feet wide, 45 feet long and 20 inches deep. Water is supplied from four sources, an 80-gpm spring system, a 320-gpm open pond infiltration system, a 600-gpm infiltration trench, and a 250-gpm emergency supply from an irrigation canal. The WDW has no right to irrigation water, and is only occasionally granted permission to use it on a temporary basis.

The Nelson Springs raceway was built in 1975. It consists of a 200' X 13' X 3' raceway with a 7-cfs spring water source. The Yakima Trout Hatchery produces steelhead from natural Yakima brood stock, Goldendale rainbow trout and Eastern brook trout. The Naches Hatchery produces rainbow trout, natural Yakima steelhead and a few kokanee. The Nelson Springs raceway is used for the final rearing of steelhead smolts and for summer rearing of rainbow trout.

The primary purpose of hatchery steelhead production has been to provide a basis for the steelhead sport fishery and, from 1987 through 1989, to augment natural production in barren or underseeded habitat. Hatchery-reared native Yakima steelhead smolts have been exclusively released since 1987. Adult holding and spawning has occurred at the Yakima Trout Hatchery. Roughly half the eggs have been transferred to the Naches Hatchery in March or early May, where they were incubated and reared until being transferred to Nelson Springs raceway in late October for final rearing and release. Nelson Springs production has always been intended to provide for a sport fishery. The eggs remaining at the Yakima Trout Hatchery were incubated and reared there and, from 1987 through 1989, released as smolts in the Naches system (especially the Little Naches above Salmon Falls) in an attempt to boost natural production. However, because wild steelhead are now protected and recent hatchery exploitation rates have approached 100 percent, hatchery steelhead have contributed little to natural production.

Hatchery-reared natural Yakima steelhead first began to return during the 1988-1989 cycle. Some of the returning hatchery adults in this cycle will be 1-ocean "hatchery-reared natives," and some will be 2-ocean and 3-ocean Skamania fish. Thus, it is too soon to say what the contribution of hatchery-reared native Yakima steelhead will be.

As mentioned, from 1987 on, all hatchery-reared steelhead released in the subbasin will be natural Yakima stock. From 1987 through 1989, these releases occurred in underseeded or newly accessible areas such as the recently opened Little Naches drainage. However, from 1990 until the Yakima/Klickitat Production Project comes on line in 1995, releases of hatchery-reared steelhead may be restricted to fish needed for experimental purposes and, possibly, to a minimal number needed to sustain the existing sport fishery. These interim changes were recommended by the Experimental Design Work Group of the Yakima/Klickitat Production Project, and are subject to policy level approval by decision makers in the Washington Department of Wildlife.

Specifically, the Experimental Design Work Group recommended that no non-experimental outplanting of hatchery-reared natural Yakima steelhead occur until genetic studies have determined the number and geographic distribution of distinct substocks within the Yakima Subbasin. The Design Group was motivated to suggest these changes because brood stock is currently collected at Prosser, and therefore consists of a mixture of all the fish in the subbasin, potentially including a number of different substocks. By outplanting this unknown mixture of stocks throughout the subbasin, possibly in areas outside of "ancestral drainages," the genetically sophisticated production program proposed by the Yakima/Klickitat Project could be compromised. Thus, the Experimental Design Work Group recommends that only as many steelhead be reared as are needed for rainbow/steelhead interaction studies and smolt-to-smolt survival studies now being conducted as pre-facility measures of the Yakima/Klickitat Production Project (see Anticipated Production Facilities section).

If the WDW decides some provision must be made for steelhead sport fishermen between now and the time substock distribution has been determined, the Experimental Design Work Group recommends that the production level be kept as low as possible, and that fish be released in such as way as to eliminate or greatly reduce the possibility of successful spawning, either by some technique likely to result in nearly total terminal harvest, or by making releases in a barren or one in which spawner access can be prevented.

Steelhead smolt production from 1977 through 1988 (Table 26) has ranged from 49,289 smolts to 141,780 smolts (with a mean of 76,136 smolts). A progressively worsening water shortage at the Yakima Trout Hatchery has caused serious overloading and forced the release of 45,730 fry in December of 1986 and 85,832 fry in October of 1987. The production goal for 1990 is 160,000 smolts. Production from 1991 through 1995 may be limited to the 45,000 smolts needed for Yakima/Klickitat Production Project experiments (see previous paragraph).

Managers have attempted to take brood stock from the early and late portions of the run in proportion to early and late natural run sizes. Fry are graded and, in the event of water shortages, it is the smaller fish that are outplanted.

Statistics describing hatchery steelhead production in the Yakima Subbasin are nearly nonexistent. Regarding the Skamania fish released before 1987, the size and timing of the 1986-1987 return, egg-to-smolt survival, smolt age, outmigration timing and survival to Prosser have been empirically determined (see supplementation history section). All other statistics have been inferred, mainly by assuming that the values for Skamania stock reported in Volume II of Stock Assessment of Columbia River Anadromous Salmonids apply to fish released in the Yakima. The same situation holds for hatchery-reared natural Yakima steelhead, except that return rates and the timing of returns will remain empirically unknown until the 1987 release completes its life cycle in 1990. (The first release of hatchery-reared natural Yakima steelhead will include some 3-ocean fish, and thus will not be complete until 1990. Hatchery-reared natural Yakima fish from the 1987 release will be distinguishable from 1986 Skamania fish because the latter were not coded-wire tagged.) It is reasonable to assume that hatchery-reared natural Yakima steelhead will share many characteristics with "natural" fish.

Egg-to-smolt survival for Skamania stock has averaged around 65 percent, whereas egg-to-smolt survival for natural Yakima fish has been lower, around 50 percent (T. Scribner, Yakima Indian Nation Hatchery Manager, pers. commun.). All smolts are released as 1-year-olds.

The timing of the outmigration of hatchery steelhead smolts has been about the same as the wild outmigration, in spite of the greater distance hatchery fish must travel (Fast et al. 1986). The bulk of the steelhead outmigration, hatchery and wild, probably reaches the Columbia between the first and third week of May.

Water quality and quantity are problems at the Naches Hatchery and especially the Yakima Trout Hatchery. The Naches facility suffers from high water temperatures in the summer, and the single-pass design of its raceways exacerbates the water supply problem. The Naches Hatchery is 66 years old and needs a major overhaul. Problems at the Yakima Trout Hatchery include excessive temperatures, occasional introductions of silt, and a severe and worsening water shortage. The main cause of the water shortage is the reduced summer discharge of Spring Creek, the major water supply. Managers believe that widespread local conversion from flood to sprinkler irrigation, and the piping and pressurization of delivery systems have been too efficient; without the surcharge of water from irrigation seepage, the water table has fallen and is no longer able to provide ample summer flows to Spring Creek (S. Robards, WDW, pers. commun.). Under present circumstances it may be impossible to restore the high quality water supply the hatchery once enjoyed.

Even aside from water quality problems, culture of natural steelhead has proved difficult. Adult brood stock have been very "spooky," and 17 percent were lost in the first year. It has also been difficult to induce the equally nervous fry to begin feeding. Consequently, growth rates and conversions have been low. Adult holding problems have been reduced providing cover in the form of floating slabs of styrofoam, and progress is being made on the problem of inducing fry to feed.

As mentioned, the survival of smolts to Prosser has been poor, averaging around 25 percent. There is some evidence that this low survival rate is attributable mainly to smolt quality. Since 1983, increased survival of hatchery steelhead has been associated with size and condition factor, whereas the release date and, surprisingly, even river flows have had less effect (see Fast et al. 1986 for details). For example, hatchery steelhead were released on April 8 in 1985, perhaps a week later than desirable, and nine days later than the 1986 and 1987 releases. Moreover, the flows in the Sunnyside to Prosser reach at the time of release were quite low. Nonetheless, the survival rate of the 1985 release was 1.5 times higher than the next highest rate observed. Unlike the fish in other years, the fish from in 1985 were large, their condition factor approached that of wild fish, and there were relatively few observations of fish with stubbed fins or serious descaling.

Anticipated Production Facilities (Yakima/Klickitat Production Project)

With a slightly more stringent emphasis on conserving genetic fitness, the goals of the Yakima/Klickitat Production Project for summer steelhead are almost exactly analogous to the goals for spring chinook -- to maximize harvests within the subbasin while maintaining genetic fitness, and conserving a wild, unsupplemented run of fish in Satus Creek to serve as a possible "gene bank" and an experimental control on supplementation. An additional consideration for steelhead is that steelhead enhancement not occur at the expense of rainbow trout populations in the Yakima River above Roza Dam. Accordingly, a subsidiary goal of the Yakima/Klickitat Production Project steelhead program is to elucidate the magnitudes and type of impacts of steelhead on resident rainbow by conducting an extensive rainbow-steelhead interaction study.

The computer simulation by which the benefits of the Yakima/Klickitat Production Project were estimated entailed the following provisions and assumptions:

1) The modeled scenario was "post build-up," after the period of deliberately increased escapements, when full seeding of the habitat with natural spawners has been attained, and the MSY harvest rate for a supplemented population has been determined. A selective harvest of "hatchery" fish during the build-up of the steelhead population may be employed to ensure maximum escapement of natural fish and reduce adverse genetic impacts. A selective harvest management plan would be employed only during the build-up of the population, and during the initial "probationary" period of the supplementation program. Thus, the simulation treated hatchery and natural fish identically, and both were subject to the same terminal harvest rate.

2) Smolt-to-adult return rates for "hatchery fish" were set at the anticipated maximum -- 61 percent of the natural rate. This degree of "supplementation success" is, of course, highly speculative and is based on the relative survival to Prosser of acclimated hatchery and wild spring chinook smolts (no comparable hatchery and wild releases of steelhead have been made). The assumption behind this approach is that the impact of a supplementation hatchery like the Yakima/Klickitat Production Project will be primarily behavioral, perhaps consisting of the failure to learn appropriate predator avoidance behavior prior to

release. Under this assumption, the fact adult return rates for hatchery steelhead smolts surviving to Prosser are comparable to return rates for natural fish suggests that the "slow learners" in the hatchery group have been eliminated, and that hatchery and wild smolts can be considered equivalent after Prosser. Again, on the basis of observations of spring chinook, it has been assumed that 61 percent of Yakima/Klickitat Production Project smolts will learn appropriate behavior and perform as well as wild smolts.

The System Planning Model has a parameter for hatchery smolts called "post-release survival." In all simulations, this parameter was set at 0.61. All other smolt survival rates were the same for hatchery and wild fish.

3) The reach-specific smolt-to-smolt survival rates for steelhead were the spring chinook rates adjusted for 11 percent less mortality (see smolt-to-smolt survival discussion).

4) Maximum sustainable yield was estimated for the combined yield of <u>both</u> natural and hatchery fish.

5) The unsupplemented Satus population was modeled separately from the rest of the subbasin. Planners did this to avoid "overwhelming" the unique population parameters of the Satus system by the averaging process at the heart of the TPM procedure. However, the MSY terminal harvest rate for the <u>supplemented</u> portion of the subbasin was also applied to the Satus system, as there is no practical way to harvest Satus steelhead selectively, and no such program is planned. Separate modeling of Satus fish thus permits a truer estimate of the impact of higher, hatchery-driven exploitation rates on the Satus population. Note that the contribution of Satus fish to MSY yield and escapement is included in reported totals.

Under these conditions, the TPM/SPM procedure indicated that MSY terminal harvest would be 780 fish with <u>no</u> hatchery, current habitat quantity and quality, and expected improvements in smolt survival at mainstem Columbia dams. The simulation also predicted an escapement to the subbasin of 4,109 fish, a total catch to all fisheries of 1,606 fish, and a terminal exploitation rate of 19 percent. Under the same conditions, the TPM/SPM procedure predicted that implementation of the Yakima/Klickitat Production Project would boost MSY terminal harvest to 4,440 fish, escapement to 6,831 fish, total harvest to 5,812 fish and terminal exploitation rate to 65 percent. These goals are achievable with the current hatchery production goal of 400,000 smolts, and a 61 percent supplementation success.

As summarized in Table 15 in the spring chinook section, the hatchery will produce 400,000 smolts from 615,500 eggs. This magnitude of egg-take would require about 240 spawners. It should be noted that 240 adults represents an initial estimate of the minimum effective population size to ensure that the genetic variability within the hatchery population is equivalent to the genetic variability in the natural population (240 adults should eliminate the possibility of genetic "founder effects" in the hatchery).

Brood stock for fish to be outplanted to the Naches system will be collected at Cowiche Dam on the Naches River in facilities to be built at the same time as the hatchery. Brood stock for lower Yakima steelhead (such as those to be outplanted to Ahtanum Creek, Toppenish Creek, Simcoe Creek and the Yakima below the Ahtanum confluence) will be collected at a facility to be built on Satus Creek. In the event it is agreed to outplant Yakima/Klickitat Production Project steelhead smolts in the upper Yakima, brood stock will be collected at Roza Dam.

The reason for multiple collection sites is the goal of preserving local adaptations and genetically distinct substocks by outplanting juveniles only to their parents' natal drainage. In the case of previously barren drainages, outplants should consist of the progeny fish spawning in similar drainages. Currently, it is felt that there <u>might</u> be as many as three separate substocks of steelhead in the subbasin; a large population of fast-growing, "early smolting" fish in the Satus system adapted to warm water, low flows and intermittent streams; a smaller population of slower growing, "later smolting" fish in the Naches adapted to much colder water and higher flows; and a vestigial run of upper Yakima fish adapted to intermediate conditions. If the existence of these three substocks should be confirmed, brood stock for supplementing the Toppenish/Simcoe and Ahtanum Creek systems, as well as the mainstem Yakima below the Ahtanum confluence, should be taken from Satus Creek. Similarly, brood stock for outplants to Naches tributaries should be taken from Naches runs, and brood stock for upper Yakima outplants should be collected at Roza.

Collection of fish for brood stock is not anticipated to exceed 10 percent of the total run of a given substock. Thus, assuming they represent genetically distinct substocks, 10 percent or less of the escapement to the Naches, Satus or the upper Yakima substocks would be taken. It is evident that the necessity of collecting gametes from 240 adults, to avoid genetic founder effects, conflicts with the brood stock cap of 10 percent, which was set to avoid imposing an excessive hatchery influence on the natural population. This conflict would be severe for small (in terms of abundance) substocks. Should it become necessary to do so, the Yakima/Klickitat Production Project will preserve small native substocks either by treating them like the Satus stock, and preserving them in an unsupplemented genetic sanctuary; or by implementing appropriate brood stock collection and rearing procedures to supplement the stock individually. Individual supplementation of small substocks might entail the partial spawning of adults. If adults partially spawned in the hatchery can successfully complete spawning in their ancestral drainage, the conflict between minimal effective population size and minimal impact on natural populations might be resolved.

In general, the release strategies for steelhead will be very similar to spring chinook, with a heavy initial emphasis on experimental releases of smolts from acclimation ponds, and expanding natural production into currently unused areas. The rearing regime for smolts will incorporate at least 6,500 thermal units (TUs), with volitional releases beginning April 1 or as coordination with "water budget" or other flow strategies may dictate. Temperature of rearing water will not exceed 52 degrees Fahrenheit in the two weeks preceding release.

Managers have determined the list of tributaries and mainstem reaches that are candidates for outplants of Yakima/Klickitat Production Project steelhead. These sites will be discussed in the alternative strategies section.

Constraints and Critical Uncertainties

Physical production constraints at production facilities, such as water supply and temperature, are expected to be minimal. Planners anticipate that the cultural problems associated with raising wild fish, such as holding spooky adults and initiation of feeding in fry, will be solved by the time the hatchery comes on line. There are, on the other hand, a number of critical uncertainties as to how to achieve the project's goals that will drive the experimental design of the initial releases. These uncertainties are:

1) Natural Productivity

   The critical uncertainties here concern the carrying capacity of the subbasin and estimation of survival rates by life stage. Specific questions include the possible existence of distinct substocks in the subbasin; the location of natural spawning and rearing areas; substock-specific fry-to-smolt, egg-to-smolt, and smolt-to-adult survival rates; substock specific differences in adult run timing, spawning timing, smolt age class composition and outmigration timing; and the carrying capacity of each part of the subbasin and of the subbasin as a whole.

2) Supplementation Success

The initial uncertainty here is the survival of outplanted supplemental smolts to the adult stage. Later work might address survival of outplanted fry.

3) Genetic Risk

Assessing and minimizing the genetic risk to the natural stock has been assigned the highest priority. Conservation of locally adaptive genetic characteristics dictates that the essentially wild population in the Satus system not be supplemented at all, and that the genetic integrity of populations in the Naches and upper Yakima be protected as much as possible (see alternative strategies section). It has been noted that Naches steelhead have been supplemented frequently with non-native stocks, but survival and spawning escapement of hatchery fish has been very low. As the Satus system has never received steelhead outplants, it is generally felt that the genetic composition of steelhead throughout the subbasin retains many "wild" characteristics and should be conserved. Specific guidelines for genetic conservation are being developed by the Experimental Design Work Group and the Monitoring and Evaluation Group.

4) Interaction

The potential impact of steelhead on resident rainbow trout populations above Roza Dam is a major concern. A subcommittee of the Yakima/Klickitat Production Project Technical Work Group, the Interactions Experimental Design Team, is developing specific questions and hypotheses.

Harvest

Since 1979 the only terminal fishery to target steelhead has been the sport fishery. The peak years of the sport fishery occurred in the mid-1960s, when total harvest averaged over 2,000 fish. As detailed in Table 23, the sport catch in recent years has been well less than half this figure, and has declined as the fishery became more restrictive. The exploitation rate of returning hatchery fish has, however, been very high. For instance, total terminal sport harvest from the 1986-1987 run was 514 fish. Assuming anglers obeyed regulations, and all 514 were hatchery fish, and that hatchery fish comprised 20 percent of the total run of 2,491, this represents an exploitation rate of 103 percent: (514/.2(2491) = 1.03). Obviously, either some wild fish were misidentified and kept, or the hatchery return was greater than 20 percent. The point to be made, however, is that the present management scheme precludes rebuilding natural runs to underseeded areas with escapements of hatchery-reared natural Yakima fish; very few hatchery fish are identifiable as such escape.

Recreational steelhead fisheries in the Yakima River currently are designed to harvest most, if not all, hatchery steelhead while reserving all wild and natural fish for spawning. Tribal subsistence dip net fisheries in the Yakima River are not selective with respect to adipose-clipped steelhead. Although steelhead are not a target in the tribal dip net fishery, an incidental steelhead harvest is necessary to allow target fisheries on fall chinook and coho that enter the river coincidentally with summer steelhead.

The current goal of sport fishery management is to rebuild wild runs by focusing harvest on fin-clipped hatchery fish until the wild and natural run reaches 9,000 fish. While this strategy maximizes protection of the genetic integrity of the wild stock and speeds rebuilding of wild populations in current production areas, it leaves the reseeding of newly accessible areas entirely to colonization by strays. Moreover, such a scheme precludes rebuilding naturally propagated steelhead runs by supplementation so long as there is no cap on exploitation of hatchery fish, or so long as hatchery-reared fish specifically intended to rebuild underutilized areas are indistinguishable from those intended to support a sport fishery.

The goal of the harvest management plan to be implemented under the Yakima/Klickitat Production Project is to provide meaningful terminal sport and tribal fisheries while rebuilding natural escapements. Under the Yakima/Klickitat Production Project Master Plan supplementation goal, adipose-clipped steelhead will spawn naturally to rebuild the natural stock to maximum sustained yield (MSY) levels. Accordingly, terminal harvest rates on adipose-clipped hatchery steelhead are not anticipated to exceed 55 percent in all fisheries during the rebuilding phase. Such a restriction on the harvest of hatchery fish represents a departure from Washington Department of Wildlife policy, which generally allows intensive harvests of clipped hatchery fish.

The harvest management plan also reflects a commitment to supplementation experiments and to meeting hatchery production goals. The hatchery brood stock goal of 240 adults, to be taken from an escapement of 2,400 naturally-produced adults, will be met at runs sizes in excess of 2,525 fish. The interim escapement goal of 9,000 adults will be achieved at runs of 10,250 fish.

Terminal harvest rates will be restricted until the interim natural escapement goal is reached. So long as the wild/natural escapement is less than 2,400 fish, retention of unclipped fish will be prohibited in the sport fishery, and tribal harvest will be limited to 5 percent of the wild/natural run. For wild/natural runs between 2,525 and 10,250 fish, retention of unclipped steelhead will not be all allowed in the sport fishery, and the tribal harvest rate will be 10 percent. Harvest rate on unclipped steelhead will not exceed 55 percent in all terminal fisheries up to the interim natural escapement goal. Induced variation in annual escapements above the interim goal will provide an empirical basis for selection of an MSY escapement goal.

Columbia River summer steelhead do not contribute significantly to ocean fisheries. Sport catch of steelhead is minimal in the ocean, and the sale of steelhead in non-treaty commercial fisheries is prohibited.

Yakima River steelhead will contribute to treaty commercial and non-treaty recreational fisheries in the mainstem Columbia River. The Columbia River Fish Management Plan stipulates that mainstem fisheries will be regulated on the basis of aggregate escapement goals at Bonneville Dam for the wild and natural components of the runs, and that tributary fishing opportunities will be maintained. Harvest rates on Yakima River steelhead in mainstem fisheries have been about 15 percent for unclipped fish and 20 percent for adipose-clipped fish

Using the TPM/SPM procedure, all but the least comprehensive supplementation strategies will meet escapement needs while providing additional terminal harvest opportunities for both treaty and non-treaty fishermen.

Specific Considerations

Steelhead runs in the subbasin have varied dramatically from 1981 through 1989, increasing from 255 fish in 1981 to 2,693 fish in 1988, and then falling to 1,116 in 1989, with another drop predicted for 1990. Terminal exploitation rates have ranged from 14.7 percent in 1988 to 68.6 percent in 1985. Terminal exploitation has declined steadily since the imposition of wild-release regulations in 1986, and in recent years has approximated the estimated proportion of hatchery fish in the run. If smolt capacity estimates are expanded to include the potential production from currently inaccessible tributaries, and smolt survival rates are adjusted for anticipated improvements, the TPM/SPM procedure indicates the system was producing at about one-tenth of its unsupplemented capacity in 1988.

At the present time, steelhead management focuses on rebuilding natural runs by restricting mainstem treaty Indian net fisheries, and by limiting sport harvest to adipose-clipped hatchery fish. It is also a tenet of management that the genetic composition of the existing natural run be conserved to the maximum extent possible.

The major constraints on steelhead production are, in order of decreasing importance: 1) upstream and downstream passage at Yakima Basin diversions, especially those on spawning tributaries; 2) inappropriate instream flows (too low or too high) in the mainstem as well as tributaries; 3) degraded riparian and instream habitat; and 4) excessive temperatures in the lower reaches of some tributaries and the mainstem Yakima.

1) Passage and Entrainment

Steelhead are much more susceptible to existing passage and entrainment problems in the subbasin than spring chinook. This is because steelhead spend more of their juvenile life in tributaries than spring chinook, and problems associated with diversions are relatively more severe on tributaries. Entrainment of newly emerged steelhead fry is a particular problem because steelhead emerge when diversions are at or near maximal, and they emerge at a size that often allows passage directly through the mesh of many screens.

The most severe passage problems in the subbasin at this time are all associated with irrigation diversions. One class of passage problem involves small, poorly screened diversions in present production areas (the so-called Phase-II screens) that entrain and kill a significant percent of fry and pre-smolts. The other class of passage problem occurs in tributaries with substantial headwater production potential that cannot be used at all because lower reaches are totally blocked by diversion dams.

2) Suboptimal Instream Flows

The impact of excessive instream flows in the mainstem Naches and Yakima -- the reduction of late spring and summer rearing habitat -- is considered less severe than the impact of inadequate flows. Inadequate instream flow in the mainstem is considered to have an especially severe impact on smolts because it can increase their vulnerability to predators dramatically. There is evidence that steelhead smolts, like spring chinook smolts, produced above Sunnyside Dam suffer heavy losses before reaching Prosser Dam. Since 1983, mean survival of hatchery steelhead released at Nelson Springs and in tributaries of the Little Naches to the Prosser counting station has been just 25 percent. No empirical estimates of wild smolt survival have been made, but it would seem likely that the survival of wild steelhead smolts originating above Sunnyside Dam would be comparable to spring chinook (around 50 percent). Any enhancement strategy for the Yakima Subbasin must therefore eventually address the problem of smolt losses within the subbasin.

While the ultimate cause of poor smolt survival is inadequate instream flow in the mainstem, the proximate cause is probably predation. Remedial measures can thus focus on the problem at two points.

Suboptimal instream flows limit steelhead production in the same general ways they limit spring chinook production, but with some species-specific differences in emphasis. The impact of suboptimal flows in the mainstem Yakima in the summer and winter may not be as critical to steelhead as spring chinook, as steelhead rearing is relatively more concentrated in tributaries, even in the winter. Upriver steelhead will, as mentioned, probably suffer smolt losses in middle and lower mainstem Yakima reaches comparable in magnitude to spring chinook, but Satus/Toppenish fish will enter the Yakima near the end of the worst mainstem reach and thus avoid much of the problem. Minimal instream flow requirements for tributaries that are candidates for outplanting, such as those with adequate flows and habitat conditions in at least their upper reaches, are sufficient discharge in lower reaches to pass spawning adults and pre-smolt juveniles from October through early December, and spawning adults and outmigrant smolts from March through early May.

3) Riparian Degradation

The most severe instances of degraded riparian habitat in the subbasin occur in tributaries or mainstem reaches with considerable existing or potential steelhead production potential. Because steelhead are much more likely than spring chinook to spend their first year of life near tributary spawning grounds, the general condition of tributary environment plays a relatively larger role in early survival. Previous studies have shown that the abundance of trout in small streams in the subbasin is strongly associated with bank cover, the absence of which is usually attributed to streamside grazing or cultivation. Maximum success of tributary outplants therefore presuppose some type of riparian restoration.

4) Excessive Water Temperature

With some differences in emphasis, steelhead are affected by excessive temperatures in the same way as spring chinook. Summer rearing in the mainstem is basically limited to areas above Sunnyside Dam although, except for some older fish requiring deeper water and higher flows, this is probably not so consequential as for spring chinook. As most overheating of tributaries is a function of a degraded riparian corridor, the importance of riparian restoration is re-emphasized.

It should, however, be noted that Toppenish Creek represents somewhat of a unique case in this regard. Summer temperatures are excessive in middle and lower Toppenish Creek, and a degraded riparian corridor does contribute to the problem. However, thermal problems here are significantly exacerbated by relatively large amounts of heated irrigation return water discharged into the middle creek.

Except for the mainstem Yakima below Sunnyside Dam, and the lower portions of the Satus and Toppenish drainages, summer temperatures in current or potential rearing areas do not become excessive.

As was mentioned in the spring chinook section, a series of System Planning Model runs using Yakima spring chinook and steelhead input parameters (Production Constraints and Opportunities Analysis, Northwest Power Planning Council, July 21, 1988) implied that the most productive enhancement strategies would entail substantial improvements in smolt-to-smolt survival rates. The same SPM analysis showed that enhancing natural production of steelhead by outplanting smolts is a viable option.

Also mentioned earlier, hatchery supplementation has already been designated as the fundamental approach to be used in enhancing anadromous populations in the Yakima Subbasin. The Northwest Power Planning Council has stated that subbasin planners are to consider the Yakima/Klickitat Production Project a given, and to fashion plans that are compatible. As a consequence, Yakima planners were constrained to the consideration of supplemented, natural populations. Strategies for steelhead enhancement will consist of a combination of individual enhancement actions focused on one or more of the five fundamental "stanzas" of natural smolt production, 1) egg deposition, 2) survival from egg to emergent fry, 3) survival from emergent fry to late-summer parr, 4) overwinter survival, and 5) survival of outmigrating smolts (smolt-to-smolt survival). Again, one element, the Yakima/Klickitat Production Project, is a part of all strategies.

The other elements have been integrated in a sequence of "partial cumulations," which have been evaluated by the TPM/SPM procedure. The preferred strategy will be the cumulation that best conforms to the policies of system planning, and that most comprehensively eliminates the factors limiting production.

All proposed enhancement strategies assume continuation of the current water supply and irrigation demand. Specifically, planners have assumed the existing storage capacity, irrigation system operations policies and instream flow cycles to be essentially permanent. Future legislative or judicial developments may alter the "hydrological status quo" substantially.

It is generally believed that the existing run of steelhead retains many of the genetic characteristics of a native, wild population, and that it is uniquely adapted to the subbasin. Moreover, there may be as many as three substocks of steelhead in the subbasin, a substock in the Satus drainage comprised of fast-growing fish with a large proportion of yearling smolts adapted to high temperatures and low flows; a slower-growing population in the Naches with mostly 2-year-old smolts adapted to much colder temperatures and higher flows; and a vestigial population in the upper Yakima adapted to intermediate conditions. The local adaptations embodied by these populations should also be conserved.

A final consideration for steelhead enhancement concerns outplanting Yakima/Klickitat Production Project smolts in the upper Yakima, and concerns of potential adverse impacts on resident trout. This issue is being resolved through the development of the Yakima/Klickitat Production Project.

Critical Data Gaps

Compared to spring chinook, the knowledge of Yakima steelhead is very incomplete. All of the data deficiencies described for spring chinook apply to steelhead as well. In addition, and in rough order of priority, the understanding of Yakima steelhead suffers from the lack of knowledge concerning:

1) Spawning timing and places.

   The timing and distribution of spawning in the Satus and, to a lesser degree, the Toppenish drainage are fairly well known. However, timing and distribution for the vestigial run above Roza and the small Naches system run are almost totally unknown.

2) Adult age distribution.

What is known about adult age distribution is almost wholly attributable to a scale analysis of 123 scales taken only from females in two successive runs of fish, the earlier of which (1985 and 1986) comprised the returning adults from an especially successful outmigration. Age analysis of other runs is badly needed to correct whatever distortions the strong returns from the 1984 outmigration may have introduced into the available data. An analysis of the age distribution of males is, of course, imperative. Scales from adults in the Satus runs of 1980-1981 and 1981-1982 and from brood stock collected from the "general Yakima" run of 1987-1988 are now in progress.

3) Egg-to-smolt and smolt-to-adult survival.

Egg-to-smolt survival estimates are currently quite tentative because their estimation entails knowledge of a great many things that are only partially understood. Estimates of egg deposition are quite approximate because nothing is known of pre-spawning mortality, and knowledge even of sex ratio and mean fecundity is based on a small sample of three runs. While outmigration to Prosser is known quite well, the survival of smolts from staging areas to Prosser (the "smolt-to-smolt" survival rate) is not. Current estimates of egg-to-smolt survival reflect the population in aggregate. Almost certainly there are differences in survival rates between spawning populations that must be determined if planning is to be as precise as desired.

Estimates of smolt-to-adult survival would be more solid if the age distribution of returning adults were more definitely known, and if the smolt-to-smolt survival rate were known for wild fish.

4) Tendency of early parr to move downstream to dewatered areas in summer where they may be lost.

A good many tributaries in the subbasin are currently unproductive because flows in their lower reaches are inadequate during the critical "time windows" in the fall and spring. In some of these streams, it may be possible to arrange for adequate flows during critical time windows, but not during the summer. From a number of perspectives, including cost-benefit analysis, it would then be important to know what percent of the new production would be lost as fry or parr disperse into these downstream reaches and are subsequently stranded.

5) Presence of distinct substocks.

The difference in habitat types in the Yakima Subbasin is such that different substocks of steelhead, perhaps analogous to the American/upper Yakima substocks of spring chinook, would not be surprising.

Objectives

The incremental production attributable to specific actions may be estimated by the TPM/SPM procedure. The first step in this procedure is to estimate the quantitative impact of a specific action on local (reach specific) population parameters. These parameters drive the System Planning Model, and include zero-density egg-to-smolt survival, smolt-to-smolt survival, pre-spawning adult survival and smolt carrying capacity. The Tributary Planning Model is used to "integrate" a host of reach-specific impacts over the entire subbasin, and to calculate four new global parameters. These new, integrated parameters are then used in the System Planning Model to estimate resultant changes in MSY. As each of the objectives listed below entails a quantitative change in one or more of the SPM parameters, the explanation of each objective will include a numerical estimate of the impact on SPM parameters.

Utilization Objective

Develop a terminal harvest of at least 4,000 fish.

It has been difficult to formulate a precise numerical MSY target for steelhead, but for this analysis, planners are using an assumed annual sport catch of 2,000 fish (yield recorded in the early 1960s period of peak catch). As an equal tribal harvest was assumed, the terminal harvest goal was set at a minimum of 4,000 fish.

Biological Objectives

1. Increase rearing habitat.

   If all habitat outside current production areas were put into production, steelhead egg capacity and smolt capacity would increase more than twofold.

2. Increase fry-to-parr survival.

   Two of the four measures intended to increase fry-to-parr survival -- building a modern bypass system at Wapatox and rebuilding all bypass systems at Phase-II diversions -- will result in the loss of fewer fry, and were therefore reflected in the System Planning Model as increases in zero-density egg-to-smolt survival (So). The other measures -- riparian restoration and subordinating diversions for power generation at Wapatox to instream flow requirements -- were assumed to increase smolt capacity (K), but not So.

Because steelhead specific data is sparse, estimates of the loss of steelhead fry through entrainment at Wapatox diversion and at all Phase-II diversions were based on observations of spring chinook. Entrainment at Wapatox diversion was therefore held to be responsible for the loss of at least 1.2 percent of all upstream fry production, and Phase-II diversions were estimated to kill 0.02 percent of all upstream fry production per cfs diverted (see Appendix 2, Supplement 1). Rectification of the entrainment problem at Wapatox was modeled by a 1.2 percent increase in So for all fish spawned upstream. Renovation of Phase-II screens was modeled by increasing So by a multiple of $1/[1 - (.0002Q)]$, where Q is mean diversion in cfs, for all fish spawned above the diversion.

Planners modeled riparian restoration by assigning affected reaches a higher habitat quality rating in the Smolt Density Model (SDM), the Northwest Power Planning Council's official subbasin smolt capacity estimator. Similarly, power subordination at Wapatox was modeled by assigning the Wapatox reach a higher quality rating. The SDM assigns a higher density (smolts per square meter at carrying capacity) to reaches with higher quality ratings, and higher densities generate higher smolt capacity estimates.

Over all targeted areas, riparian enhancement was estimated to produce a net steelhead smolt capacity increase of 99,586 fish. In light of the mileage of streams involved, this improvement may be considered by some relatively modest. Improvements were not larger because steelhead streams needing riparian rehabilitation consisted mainly of small tributaries, and because the impact of riparian improvement in the TPM/SPM procedure was limited to increases in smolt capacity (see alternative strategies). Power subordination at Wapatox increased smolt capacity in the affected reach by 22,626 fish. The magnitude of this effect is attributable to the fact that the Wapatox reach comprises a considerable area, and habitat quality in the reach is excellent in all respects save instream flows. The impact of Wapatox diversions on instream flows is frequently severe, and the quality rating assigned the reach in its present condition is poor. Power subordination changes the rating to excellent.

3. Increase overwinter survival.

The single proposal intended to increase overwinter survival of steelhead pre-smolts -- making 18 smaller canals accessible as "off-channel winter refuges" through the winter -- was assumed to impact two SPM parameters, smolt capacity (K), and So.

The impact of off-channel winter refuges on carrying capacity can be quantified by estimating the number of pre-smolts that could use the refuges, and then determining the fraction of this number that would not have survived but for provision of refuges. The number of fish using a refuge (Nu) can be estimated by:

$$Nu = SUM\{ (Ai)(di) \}$$

where Ai = the area of refuge of a given habitat class; and
di = the density of use (fish/sq. meter) expected for habitat of a given class.

The number of fish "saved" by the refuges (Ns) would be:

$$Ns = (Nu)(Sref) - (Nu)(Sriv) = Nu(Sref - Sriv)$$

where Sref = the overwinter survival of fish in refuges; and
Sriv = the overwinter survival of winter migrants in the open river.

Finally, carrying capacity (K) would be increased by a multiple equal to:

$$(Ki + Ns)/Ki$$

where Ki = the pre-refuge smolt capacity.

It was assumed that So and K would be increased by the same factor, (Ki + Ns)/Ki.

All the variables in the preceding expressions have been estimated. Field measurements have provided Ai. Densities of winter use for habitat of various types (di) were taken from recent studies (C. Stewart, graduate student, Univ. of Idaho, pers. commun.) (Appendix 4) in which steelhead densities were observed to vary from 0.21 (no cover other than depth) to 28.37 fish per square meter (all of the habitat consisting of submerged brush). The overwinter survival of fish in off-channel refuges (Sref) can be expected to be quite high. Bryant (American Fisheries Society address 1988) found nearly complete overwinter survival of juvenile coho in off-channel habitat in southeast Alaska. Yakima Indian Nation studies on Lost Creek Pond, a side channel of the Naches River, indicated overwinter survival of juvenile spring chinook might be on the order of 80 percent. It will be assumed that Sref is 80 percent. Overwinter survival of steelhead juveniles in natural streams (Sriv) has been estimated at 40 percent (L. Brown, WDW, pers. commun.).

As modeled by the Tributary Planning Model, the net benefit of off-channel winter refuges would be to increase K by 86,909 fish, and to increase So by about 0.7 percent (from 0.0516 to 0.0584).

4. Increase smolt-to-smolt survival.

The overall objective proposed for smolt-to-smolt (Sss) survival has two components. First, it is proposed that mortalities be halved in large areas of open river where losses are known to be high. Second, the smolt losses associated with diversions (Wapatox and the Phase-II group) should be eliminated.

Wapatox is estimated to entrain and kill about 4.8 percent of upstream smolt production, and is assumed to cause an additional 20 percent loss between the dam and the powerplant outfall due to dewatering (see smolt-to-smolt survival discussion and Appendix 2). Rectification of the entrainment problems at Wapatox were therefore modeled by increasing Sss by a multiple of $1/(1 - 0.048) = \sim 1.05$, and rectification of the dewatering problem was modeled by increasing Sss by a multiple of $1/(1 - 0.20) = \sim 1.25$. The combined impact of Wapatox improvements is thus to increase Sss from the "Wapatox reach" upstream by a multiple of $(1.05)(1.25) = \sim 1.31$.

Phase-II diversions are assumed to kill 36 percent of all smolts entering the headgates, and it is assumed that the percent of the mean river discharge (in April and May) diverted by the canal also represents the percent of the smolt outmigration diverted through the headgates (see Appendix 2 for details). Letting PDD denote "percent discharge diverted," the effect of rebuilding a Phase-II screen on Sss was modeled by increasing the local Sss value by a multiple of $1/[1 - (PDD)(.36)]$.

Planners assumed that smolt losses in the three open-river reaches with major problems could be halved (see alternative strategies section for justification and specific proposals). The resultant smolt survival rates -- (mortality)/2 -- are considered baseline rates, and are the rates that are lowered by other factors, such as Phase-II diversions.

The cumulative effect of all measures intended to improve Sss, as estimated by the Tributary Parameter Model, is to increase the "integrated" Sss from about 46 percent (existing conditions) to 75 percent (full implementation).

5. Conserve genetic fitness of the existing natural stock, and preserve intact the genetic resource represented by the Satus Creek population.

   Although populations in the Naches and upper Yakima will be supplemented, every possible effort to conserve genetic fitness will be made. The Satus Creek population, on the other hand, will not be supplemented. It will be preserved as a "genetic refuge," and might be used as an experimental control for supplemented populations elsewhere in the basin.

6. Assess possible adverse impacts on resident rainbow trout in the Upper Yakima.

   The Interactions Study Group of the Yakima/Klickitat Hatchery Technical Work Group should carry out its plan to assess the impacts of outplanted steelhead on resident rainbow above Roza Dam. Proposals for monitoring activities are presently being developed by Experimental Design Work Group.

Alternative Strategies

As described earlier, all strategies in the Yakima Subbasin are cumulative. The seven strategies for steelhead are summarized below.

Strategy 1:	Implementation of Yakima/Klickitat Production Project with existing habitat.
Strategy 2:	Strategy 1 plus additional habitat.
Strategy 3:	Strategy 2 plus halving open-river smolt losses.
Strategy 4:	Strategy 3 plus rebuilding Phase-II screens.
Strategy 5:	Strategy 4 plus provision of off-channel winter refuges.
Strategy 6:	Strategy 5 plus rescreening and power subordination at Wapatox.

Strategy 7: Strategy 6 plus riparian restoration.

Modeling results for each strategy are presented in Table 28 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 28. 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 Tables 29 and 30.

STRATEGY 1: Hatchery production with existing habitat.

At MSY, the TPM/SPM procedure indicates that terminal harvest will be 780 fish with no hatchery, current habitat quantity and quality, and expected improvements in smolt survival at mainstem Columbia dams. The simulation also predicts an escapement to the subbasin of 4,109 fish, a total catch to all fisheries of 1,605 fish, and a terminal harvest rate of 19 percent. Under the same habitat conditions, the TPM/SPM procedure predicts implementation of the Yakima/Klickitat Production Project would boost MSY terminal harvest to 4,440 fish, escapement to 6,831 fish, and total harvest to 5,812 fish, with a terminal harvest rate of 65 percent. These goals are achievable with a hatchery production of 400,000 smolts, and a 61 percent supplementation success. It should be noted that the Satus return at MSY without a hatchery was 1,406 adults. Under the "existing habitat/supplementation MSY" scenario, Satus system returns decline to 730 fish due to higher harvest rates.

The simulation of Strategy 1, as well as the simulation of all steelhead strategies, assumed all of the conditions previously listed in the section describing the projected benefits of the Yakima/Klickitat Production Project: annual production of 400,000 smolts; full seeding and MSY management; supplementation success of 61 percent; smolt survival rates based on the 1988 release of wild spring chinook smolts and the impacts of diversions as summarized in Appendix 2; combined hatchery and natural MSY; separate modeling of the unsupplemented Satus Creek run; and full implementation of planned improvements to fish passage facilities on mainstem Columbia dams. Initiating input parameters for the system planning model include 0.05 for zero-density egg-to-smolt survival of Naches and upper Yakima populations, and 0.07 for lower Yakima populations (see Appendix 6, Supplement 1); and 0.1 for pre-spawning adult mortality. The impact of interspecific interactions was not considered.

ACTIONS: 1

1. Implement the Yakima/Klickitat Production Project with existing habitat.

   The steelhead program under the Yakima/Klickitat Production Project will involve the collection of at least 240 wild and natural Yakima River adults to produce 400,000 smolts. Managers will allow voluntary outmigration of all smolts after acclimation at seminatural ponds distributed throughout the drainage. Brood stock collection, incubation/rearing, and release will all be substock-specific.

   The co-managers of the Yakima/Klickitat Production Project -- the WDW, WDF and Yakima Indian Nation -- have not, however, determined whether Yakima/Klickitat Production Project steelhead smolts will be outplanted above Roza Dam. They have agreed that no Yakima/Klickitat Production Project steelhead will be outplanted above Roza Dam prior to 1995 except as may be needed for experimental studies of interactions between resident rainbow trout and outplanted steelhead. After 1995, outplanting steelhead above Roza Dam will depend upon a policy level decision, which will be informed by the results of the rainbow/steelhead interaction study.

However, strictly from the perspective of system planning and the goal of doubling anadromous runs, outplanting above Roza is appropriate, as over half the available, unused habitat is there. Yakima planners recognize that outplanting above Roza would accelerate the rebuilding of steelhead populations, although possibly with some adverse impact on the growth or survival rates of existing resident trout populations. The plan proposes that the upper Yakima and its tributaries be made accessible to and usable by steelhead, whether Yakima/Klickitat Production Project co-managers decide on outplants, as straying and colonization is inevitable and is in fact occurring at the present time.

In addition, the plan endorses the interaction study elaborated by the Interactions Group of the Yakima/Klickitat Production Project Technical Work Group. A properly designed and executed study will allow the Experimental Design Work Group to assess the risks entailed by outplanting, and will allow policy makers to make a reasonable decision.

In the event policy makers decide to proceed with outplants of steelhead above Roza Dam, brood stock should be taken from upper Yakima fish or from the Yakima substock adapted to the most similar habitat. Brood stock should be collected at Roza if the existing population in the upper Yakima is found to be genetically distinct and not descended from historic, non-native outplants. Similarly, if Naches and lower Yakima steelhead represent native substocks, brood stock for Naches outplants will be collected at a site on the Naches River, and brood stock for the lower Yakima (the Yakima drainage below and inclusive of Ahtanum Creek) should be collected at a site on Satus Creek. Note, however, that it will be possible to collect all brood stock at Prosser Dam if all Yakima steelhead are genetically indistinguishable, or if different substocks can be distinguished by run timing or some other, easily recognized attribute.

The proposed harvest management plan for steelhead under the Yakima/Klickitat Production Project reflects a commitment to supplementation experiments and to meeting hatchery production goals, while rebuilding natural runs and harvest opportunities (see previous section for details). It should be noted that the details of harvest management <u>during the rebuilding phase</u> are irrelevant from the perspective of estimating ultimate benefits, as all Yakima steelhead will ultimately be treated as a single, "supplemented stock" and managed for overall MSY escapement when the rebuilding process is complete.

STRATEGY 2: Strategy 1 plus expanded habitat.

The TPM/SPM procedure simulated MSY for a supplemented fishery under current conditions of habitat quality and with production area increased by the addition of the areas listed above. At MSY, escapement to the subbasin, terminal harvest and total harvest to all fisheries were 11,715 fish, 5,272 fish and 7,625 fish, respectively. Terminal harvest rate at MSY was 45 percent. The "mixed-stock" impact on the Satus run was reduced somewhat, as escapement was estimated at 1,163 fish.

ACTIONS: 1-3

1. -

2. Expand habitat by constructing all needed (currently unplanned) (Appendix 3) screens, fishways and culverts on all of the following tributaries.

   Natural production of steelhead could be greatly increased in the following currently underutilized tributaries and mainstem reaches: the Yakima River from Roza Dam to Keechelus Dam; Cabin Creek (including Cole and Log Creek); Big Creek; the Teanaway River (including the North, West and Middle forks, as well as several small tributaries to the North Fork); Taneum Creek (including North and South forks); Manastash Creek (including North and South forks); Umtanum Creek; Cowiche Creek (including the North and South forks and Reynold's Creek); the Little Naches above Salmon Falls (including North and South forks, Bear Creek and Blowout Creek); Wide Hollow Creek; Ahtanum Creek above Tampico (including North, Middle and South forks); and Toppenish and Simcoe Creek above their Wapato Irrigation Project diversions.

   This list represents the largest group of tributaries and mainstem reaches with a reasonable expectation of being put back into production in the near future. Substantial steelhead production potential also exists in tributaries upstream of major unladdered dams (e.g., Cle Elum Dam), and in the very heavily diverted

Wilson/Naneum system. However, the problems of access and passage afflicting these and similar systems are not likely to be resolved for a long time.

The problems to be solved in the areas into which steelhead production might be expanded are briefly summarized in Table 27 (see Appendix 3 for details). Note that the problems listed below address only the fundamental considerations of passage and instream flow. Less critical matters, such as riparian restoration, are discussed separately.

3. The Northwest Power Planning Council assist with projects to augment instream flows by assuming some of the costs with other benefitting governmental and private parties, and by vigorously supporting such legislative initiatives as may improve instream flows.

   Conditioned on Yakima Indian Nation approval, support is specifically requested for a possible legislative initiative (on-reservation Yakima River Basin Water Enhancement Project) to construct a small headwater impoundment on the South Fork of Ahtanum Creek to eliminate summer flow problems on middle Ahtanum Creek.

Table 27. Problems to be solved in the Yakima River and selected tributaries.

Area	Work Needed and Not Planned
Cabin Cr.*	Blasting to create pools. Alternative: trap and haul.
Yakima above Roza*	None.
Big Cr.*	Screens and repairs on two ditches; one fishway; increased instream flows for rearing.
Teanaway R.*	Usable, and being used, at present time. However, additional rearing flows in lowermost 3-4 miles of mainstem Teanaway would improve production somewhat.
Taneum Cr.*	Increased rearing flows.
Umtanum Cr.	Increased rearing flows.
Manastash Cr.*	Screens on eight ditches, two fishways, minor instream earthwork, increased instream flows for rearing.
Cowiche Cr.**	Screens at four diversions and fishways at two.
L. Naches above falls**	None.
Wide Hollow Cr.*	None.
Ahtanum Cr.*	Screens on seven ditches, augmentation of summer instream flows (would expand rearing area, but is not essential).
Upper Simcoe Cr.**	Screens at three diversions and a fishway at one; increased rearing flows would substantially boost production in lowermost 4-5 miles, but are not essential.
Upper Toppenish Cr.**	Increased instream flows below Toppenish Lateral Canal, many culvert repairs.

(continued)

Table 27 continued.

---

* Suitable for Yakima/Klickitat Production Project outplanting in the Bureau of Reclamation's Water Supply Analysis (Anonymous, 1990).

** Selected by Yakima/Klickitat Production Project planners to receive steelhead acclimation ponds. Other sites slated for steelhead acclimation ponds include Rattlesnake Creek and the Bumping River.

STRATEGY 3: Strategy 2 plus halving open-river smolt losses.

The strategy to reduce open-river losses of steelhead smolts in the Yakima Subbasin is precisely the same as for spring chinook (for details see spring chinook alternative strategies).

The benefits of reducing smolt losses by 50 percent are large. At MSY, the TPM/SPM procedure indicates a supplemented steelhead population with "expanded habitat" and half the current smolt losses would support an escapement of 20,974 fish, a terminal harvest of 10,487 fish, and a harvest to all fisheries of 14,700 fish. Terminal harvest rate at MSY would be 50 percent. Satus Creek escapement is estimated at 1,298 fish under this scenario.

ACTIONS: 1-6

1. -
2. -
3. -

4. Conduct a thorough study of smolt losses in the Yakima Subbasin, including provisions to fund and implement justified corrective actions specifically including a predator control program.

5. Narrow and line a short section of Chandler Canal.

6. Support legislative initiatives that include proposals to subordinate diversions for power production at Roza, Chandler and Wapatox dams; install new, automated check structures on Sunnyside Canal; and modernize, consolidate and install reregulating reservoirs on smaller irrigation districts in the subbasin.

STRATEGY 4: Strategy 3 plus the renovation of bypass facilities on all Phase-II diversions.

The justification for the Bonneville Power Administration's renovating Phase-II screens was presented in the spring chinook section. The TPM/SPM procedure predicts addition of Phase-II rescreening to Strategy 3 will boost escapement, terminal harvest and total harvest to 23,862 fish, 12,647 fish and 17,440 fish, respectively, with a terminal harvest rate of 53 percent. Satus Creek escapement is projected at 1,322 fish.

As was noted in the spring chinook section, these estimates are based on extrapolations from Wapatox and Selah/Naches diversions. These facilities are located on the middle Naches and are fairly distant from existing primary spawning areas. Fry losses may be much greater at facilities closer to major spawning grounds. Accordingly, the benefits predicted by the TPM/SPM procedure should be viewed as conservative.

ACTIONS: 1-7

1-6. -

7. Renovate bypass facilities on all Phase II diversions. Install adult barriers on Sulphur Creek and Snipes Creek to prevent the loss of spawners through false attraction.

STRATEGY 5: Strategy 4 plus provision of off-channel winter refuges.

The strategy for improving overwinter survival of steelhead by using 18 smaller canals as "off-channel winter refuges" is the same as for spring chinook.

If all of these "canal refuges" function as planned (see Appendix 4), addition of this element to Strategy 4 will boost MSY escapement, terminal harvest and total harvest to 26,285 fish, 14,194 fish and 19,473 fish, respectively. Terminal harvest rate at MSY will be 54 percent. Satus Creek escapement is estimated at 1,303 fish.

ACTIONS: 1-9

1-7. -

8. Provide off-channel winter refuges.

9. Investigate the feasibility of funding a study of the benefits of providing artificial "reefs" of angular riprap material in a tributary lacking appropriate overwintering cover. The channelized lower reaches of the Little Naches would be an excellent site for such a study.

STRATEGY 6: Strategy 5 plus Wapatox rescreening and power subordination.

The TPM/SPM procedure indicates that the addition of this element to Strategy 5 will produce an MSY escapement of 28,190 fish. Terminal harvest, total harvest and terminal harvest rate will be 15,223 fish, 20,884 fish and 54 percent, respectively. Satus Creek escapement remains at 1,303 fish.

ACTIONS: 1-10

1-9. -

10. Subordinate power production to instream flows and rescreen Wapatox diversion. If it is impossible for the Bonneville Power Administration to compensate Pacific Power and Light for revenues precluded by subordination, it is requested that any legislative initiative that includes this element be supported. The instream flows triggering subordination of hydropower diversion are the same for steelhead as for spring chinook.

STRATEGY 7: Strategy 6 plus riparian restoration.

Planners used the TPM/SPM procedure to estimate the benefits of adding riparian restoration to Strategy 6. At MSY, escapement, terminal harvest and total harvest were 29,704 fish, 16,040 fish and 22,006 fish, respectively. Terminal harvest rate was 54 percent. Satus Creek escapement increases to 1,820 fish, exceeding baseline escapement by 29 percent.

Estimates of incremental benefits of riparian restoration -- 1,514 fish to escapement, 817 fish to terminal harvest and 1,122 fish to total harvest -- are extremely conservative. In making the preceding estimate, the proximate effect of riparian enhancement was, as per instructions from the Monitoring and Evaluation Group, limited to improvements in smolt capacity. Yakima planners feel it is probable that a fully recovered riparian corridor would also improve egg-to-emergent fry survival (cleaner gravel), fry-to-late summer parr survival (better rearing habitat), and overwinter survival (much better overwintering cover). Collectively, such improvements could increase zero-density egg-to-smolt survival substantially. If such impacts had been considered, incremental benefits would have been more impressive.

ACTIONS: 1-11

1-10. -

11. Restore riparian habitat.

    Planners support a large riparian restoration project in the Yakima Subbasin to improve steelhead production (see Appendix 5 for targeted areas and associated costs). Most of the funds for the project would be used to pay for fencing materials and for the labor of installation and maintenance. Fencing on private property would be entirely voluntary. The details of a riparian restoration to benefit steelhead are the same as for spring chinook.

Recommended Strategy

Planners recommend Strategy 7, which consists of supplementation, habitat expansion, halving of outmigrating smolt losses, rebuilding of Phase-II screens, off-channel winter refuges, rescreening and power subordination at Wapatox, and riparian restoration. As was the case with spring chinook -- and as will be the case for all other targeted species -- this strategy was recommended because it addresses all phases of the freshwater life-cycle. In a system like the Yakima, in which production may be limited at a different point from year to year, the strategy with the best long-term effectiveness will be the most comprehensive one.

Table 28. System Planning Model results for summer steelhead (A's) in the Yakima Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
Develop a terminal harvest of a minimum of 4,000 fish.

Biological Objective:
1. Increase rearing habitat. 2. Increase fry-to-parr survival. 3. Increase overwinter survival. 4. Increase smolt-to-smolt survival. 5. Conserve genetic fitness of the existing natural stock, and preserve intact the genetic resource represented by the American River Substock. 6. Assess possible adverse impacts on resident rainbow trout in the Upper Yakima.

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	616 -C	2,709	3,626	729	0(1.00)
All Nat	9,103 -C	10,860	21,169	4,252	30,748(5.84)
1	4,440 -C	2,152	6,831	1,372	5,618(1.88)
2	5,272 -C	5,799	11,715	2,353	14,178(3.23)
3	10,487 -C	9,438	20,974	4,213	30,406(5.78)
4	12,647 -C	10,094	23,863	4,793	35,468(6.58)
5	14,194 -C	10,882	26,285	5,279	39,714(7.25)
6	15,223 -C	11,671	28,190	5,661	43,053(7.77)
7*	15,058 -C	11,544	27,885	5,600	42,518(7.69)

*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. Implementation of Yakima/Klickitat Production Project with existing habitat. Post Mainstem Implementation.
2. Strategy 1 plus additional habitat. Post Mainstem Implementation.
3. Strategy 2 plus halving open-river smolt losses. Post Mainstem Implementation.
4. Strategy 3 plus rebuilding Phase-II screens. Post Mainstem Implementation.
5. Strategy 4 plus provision of off-channel winter refuges. Post Mainstem Implementation.
6. Strategy 5 plus rescreening and power subordination at Wapatox. Post Mainstem Implementation.
7. Strategy 6 plus riparian restoration. Post 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 29. Estimated costs of alternative strategies for Yakima summer steelhead (Strategies 1-4). 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	0	0
O&M/yr[2]	0	0	0	0
Other Costs				
Capital[3]	0	385,462	2,730,562	2,730,562
O&M/yr[4]	0	11,828	113,966	113,966
Total Costs				
Capital	0	385,462	2,730,562	2,730,562
O&M/yr	0	11,828	113,966	113,966

* 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.

Table 30. Estimated costs of alternative strategies for Yakima summer steelhead (Strategies 5-7). 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		
	5	6	7*
Hatchery Costs			
Capital[1]	0	0	0
O&M/yr[2]	0	0	0
Other Costs			
Capital[3]	2,730,562	4,530,562	5,571,420
O&M/yr[4]	121,006	148,006	285,818
Total Costs			
Capital	2,730,562	4,530,562	5,571,420
O&M/yr	121,006	148,006	285,818

* 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.

FALL CHINOOK SALMON

Fisheries Resource

Natural Production

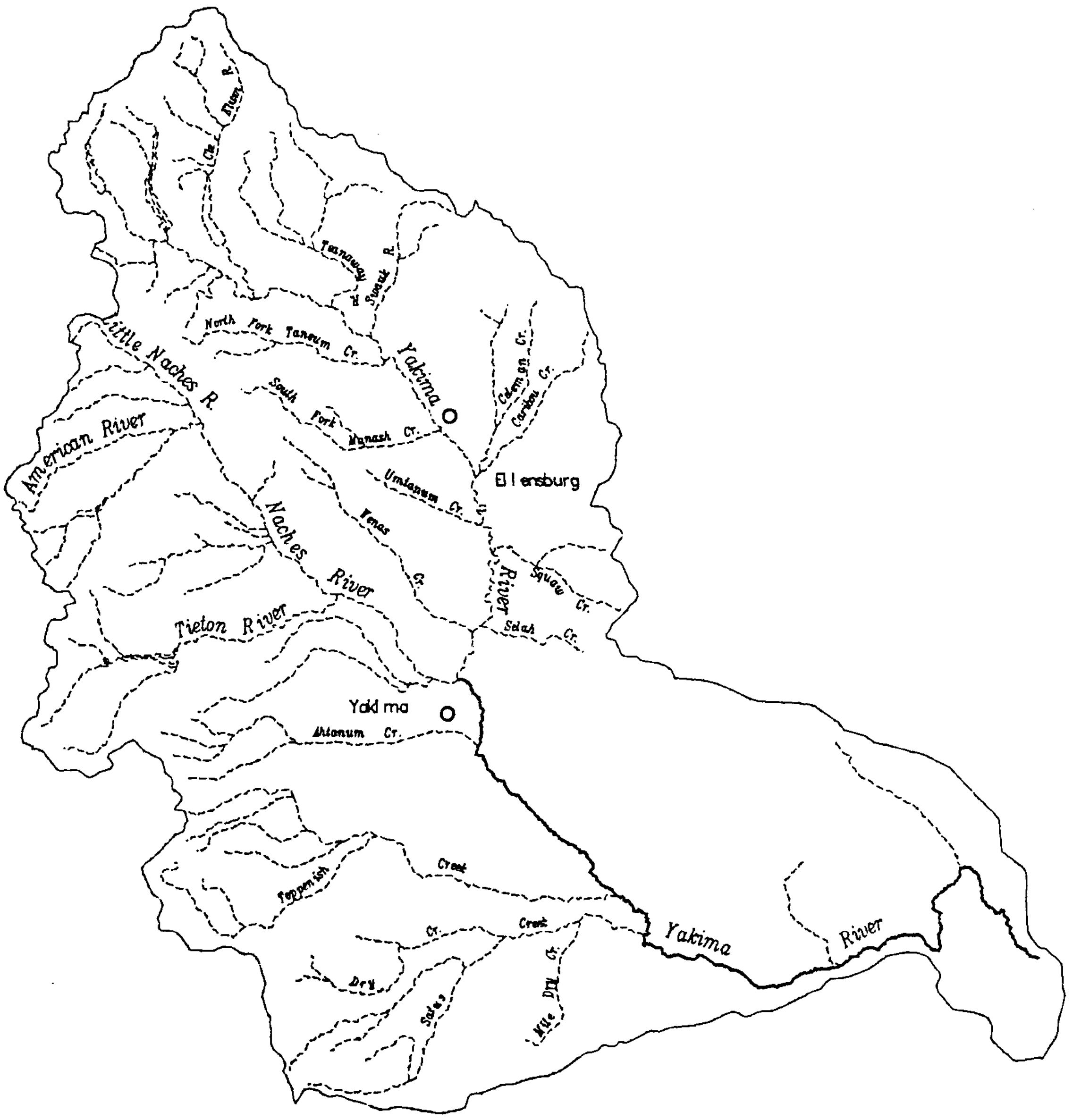
History and Status

Little is known about the historic distribution of fall chinook although managers generally believe the production area was confined to the Yakima mainstem from the area of Sunnyside Dam to the Columbia confluence. In the relatively recent past (1963 to 1982), Batelle Laboratories conducted aerial redd counts in the Yakima River below Benton City. The average count was 166 redds (1987 count was 197 redds), but year-to-year variation in water conditions and counting accuracy make these figures unreliable. Since 1983, biologists have observed fall chinook production in the same areas, but virtually nothing is known of the population that spawns below Prosser Dam. This ignorance is unfortunate, as a 1987 spawner survey indicated 63 percent of fall chinook redd deposition occurred below Prosser. The 1987 survey documented concentrations of spawning activity in the Yakima River from Zillah to Mabton, and from Benton City to the Columbia confluence. Because there were too many live fish to count in the vicinity of Horn Rapids Dam (below-Prosser population) on the last day of the survey, when a helicopter reconnaissance was made, managers have assumed that more redds were deposited by the below-Prosser population than were counted in the survey. Thus, a truer disposition of production might be 30 percent above Prosser, and 70 percent below.

One known, consistent spawning area over the last several years is an irrigation return drain for the Wapato Project known as Marion Drain. The Yakima Indian Nation fisheries staff has surveyed 17 miles of the drain in five of the last six years and has consistently found a moderate amount of spawning activity. Fall chinook redd counts at Marion Drain from 1983 through 1989 were 101, 81, 77, 117, 75, 12 and 115 redds, respectively.

Spawning timing and the coloration of spawners suggest that Yakima River fall chinook are an upriver bright substock. This is true for both the Marion Drain and mainstem populations.

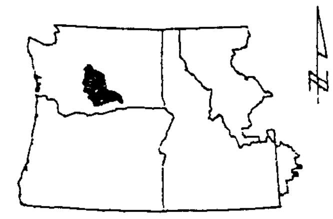
YAKIMA SUBBASIN



FALL CHINOOK DISTRIBUTION*

———— PRESENT/POTENTIAL

-------- ABSENT



GIS GEOGRAPHIC INFORMATION SYSTEM
BONNEVILLE POWER ADMINISTRATION

* Due to the limitations of scale, all streams which support anadromous fish are not shown on this map.

Because fall chinook spawn low in the subbasin, they have been relatively less affected by the passage problems associated with the construction of mainstem Yakima dams and more by the degradation of water quality. Water quality in the lower river has been very poor since the early days of the 20th century. In 1905 and 1906, the lower Yakima carried nothing but return flows from lower valley irrigation canals. Except for the fact return flows from lower valley canals are larger, the situation today is not very different, especially in dry years like 1977 and 1979.

Life History and Population Characteristics

Judged by counts at Prosser Dam, the spawning run begins around the second week in September, peaks the third or fourth week of October, and is complete by the third week of November (Table 31). The limited observations of hatchery spawners suggest a similar timing.

Table 31. Duration of various parts of the life cycle of Yakima Subbasin fall chinook.

	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
Adult Imm'n							X	X	X																				
Spawn								X	X																				
Inc'n								X	X	X	X	X	X																
Emerg												X	X																
Rear												X	X	X	X	X													
JV Emm'n															X	X	X												

As summarized in Table 32, the run size of the above-Prosser portion of the Yakima Subbasin fall chinook run has ranged from 227 fish in 1988 to 1,332 fish in 1984. If one assumes 30 percent of the total population of fall chinook spawns above Prosser, total run size has varied from 757 to 4,440 fish. Although hatchery upriver bright smolts have been released at Sunnyside Dan since 1984, it has not been possible to distinguish wild from hatchery spawners until the 1987 return, when 3.9 percent of the above-Prosser return was of hatchery origin. This fact, and the fact that mean Sunnyside-to-Prosser survival for hatchery upriver bright smolts has been but 30 percent, support the current belief that the majority of returning fish have been wild.

Table 32. Escapement, catch and total run size of Yakima upriver bright fall chinook spawning above Prosser Dam, 1983-1989. (Fall chinook passage at Prosser was first monitored in 1983. In 1987, it was estimated that roughly 30 percent of fall chinook spawning occurred above Prosser. This rate has been assumed for earlier years also. It has been assumed that runs are essentially wild.)

	Return Year						
	'83	'84	'85	'86	'87	'88	'89
Escapement:							
Above Prosser	380	1332	283	1214	544	227	671
Below Prosser	887	3108	660	2833	1269	530	1566
Total	1267	4440	943	4047	1813	757	2237
Harvest:							
Sport	0	0	0	0	0	0	0
Tribal	0	0	0	0	0	0	0
Total Run	1267	4440	943	4047	1813	757	2237

There is a great deal of uncertainty regarding the adult age structure of Yakima fall chinook. All that is known about the age structure of Yakima fall chinook is that it has averaged 43 percent jacks (age-II fish) in the period 1983 through 1987. This is quite close to the proportion of jacks reported in Howell et al. (1984) for the freshwater returns of upriver brights to Oregon, Washington and Idaho from 1970 through 1984. Therefore, the age structure reported in Howell et al. has been assumed to describe Yakima River upriver brights (Table 33).

Table 33. Assumed mean adult age structure, Yakima Subbasin fall chinook (Howell et al. 1984).

Age	Percent
Age-II (jacks)	36.8
Age-III (adults)	22.6
Age-IV (adults)	32.5
Age-V (adults)	8.1

As Yakima Subbasin fall chinook are believed to be a substock of Hanford Reach upriver brights, and as no subbasin-specific data exists, age-specific sex ratios were taken from the description of Hanford Reach upriver brights in Howell et al. (1984) (Table 34).

Table 34. Assumed age-specific sex ratios of Yakima Subbasin fall chinook (Howell et al. 1984).

Age	Percent Males	Percent Females
Age-II	100	0
Age-III	83	17
Age-IV	38	62
Age-V	29	71

Again, as no subbasin-specific data exists, mean age- and sex-specific fork lengths for Hanford Reach upriver brights as reported in Howell et al. were assumed (Table 35). No weight data has been reported.

Table 35. Assumed mean age- and sex-specific fork lengths (cm) for Yakima Subbasin fall chinook (Howell et al. 1984).

Age	Fork Length (cm) Males	Fork Length (cm) Females
Age-II	48.5	-
Age-III	68.2	73.6
Age-IV	93	86.3
Age-V	106.1	94.7

Managers have never conducted regular spawning surveys for Yakima River fall chinook. They have, however, monitored Marion Drain in the fall of 1983, and observed spawning activity from the second week of October through the second week of November, with a pronounced peak in the first 10 days of November (Hallowed 1984).

Age-specific mean fecundity was based on age-specific mean lengths of Hanford Reach upriver brights reported by Howell et al. (1984) and the length-fecundity relationship for fall chinook developed by Mathews and Meekin (1971). The latter relationship took the following form:

Eggs = 214(FL in inches) - 2434.

As the mean lengths of females of ages III through V were 73.6 cm (29 inches), 86.3 cm (34 inches), and 94.7 cm (37.3 inches), respectively, the corresponding fecundities are 3,772 eggs (age III), 4,842 eggs (age IV) and 5,548 eggs per female (age V).

Given the age distribution of Yakima upriver brights, the age-specific proportion of females and the age-specific fecundities estimated above, one can estimate the mean fecundity per female. The Yakima run is assumed to be 29.7 percent female:

(0.0 female IIs)(0.368 total IIs) +
(0.17 female IIIs)(0.226 total IIIs) +
(0.62 female IVs)(0.325 total IVs) +
(0.71 female Vs)(0.081 total Vs) = 0.297 = 29.7 percent.

Therefore, of all Yakima females, 12.8 percent -- (.226)(.17)/.297 -- are age-III fish, 67.8 percent -- (.325)(.62)/.297 -- are age-IV fish, and 19.4 percent -- (.081)(.71)/.297 are age-V fish. Mean fecundity per female is thus:

0.128(3772) + 0.678(4842) + 0.194(5548) = 4842.

The emergence period of the above-Prosser population of fall chinook can be pinned down with a fair degree of certainty, but the emergence timing of the below-Prosser population is totally unknown. Newly-emergent chinook fry have occasionally been observed at the Prosser smolt trap as early as late January. Observations of chinook fry (fork length 35 mm to 40 mm) become frequent at Prosser by mid-February, and fry continue to be observed through the first few weeks of March. It would therefore appear that the emergence period ranges from late January through March, with a peak in late February and early March. Such timing is supported by observations made in Marion Drain in the winter and spring of 1983-1984, when dates of redd deposition and mean weekly temperatures were recorded (Hallowed 1984). Redd deposition in 1983 occurred in two peaks, one in the second week of October, and one in the second week of November. Assuming 1,600 temperature units are required for fall chinook emergence (Piper et al. 1982), fry from the mid-October redds would have begun emerging in the second week of February, while fry from the mid-November redds would have begun emerging in the first and second weeks of March.

The thermal profile of the lower river is generally several degrees lower than in Marion Drain. Thus, one might assume that fall chinook not spawning in fairly warm irrigation returns would emerge somewhat later, perhaps peaking in mid-March.

Although fall chinook fry emerge in late February and early March, fall chinook are not seen in significant numbers at Prosser until smolts are observed in the last week in April or the first week in May. When first observed, these O-age smolts are 79 mm to 88 mm long (Fast et al. 1986), and thus have been rearing for about two months somewhere in the drainage above Prosser. Since 1983, the outmigration of fall chinook smolts as monitored at Prosser has been 50 percent complete between May 20 and May 30, and has been 95 percent complete between June 17 and July 8.

The estimation of egg-to-smolt and smolt-to-adult survival for wild Yakima fall chinook involved a great many assumptions. In addition to the difficulties in estimating the smolt losses incurred by the above-Prosser population prior to being counted (smolt-to-smolt survival), smolt-to-smolt survival rates for the unmonitored below-Prosser population must be estimated, and allowance must be made for the fact that fish from a single brood year may spend from one to four years in the ocean. Estimates of egg-to-smolt and smolt-to-adult survival for the above-Prosser population of wild Yakima fall chinook are summarized in Table 36. The figures in Table 36 incorporate two major assumptions. The first is that egg deposition above Prosser may be estimated by the product of escapement, percent females in the run (29.7 percent), and mean fecundity (4,842 eggs per female). The second is that the returns from a given brood year will be distributed over successive runs in the same proportions as are observed in the age distribution of Hanford Reach adults. For example, the returns for the 1983 brood year (1984 outmigration) would consist of 36.8 percent of the 1985 return, 22.6 percent of the 1986 return, 32.5 percent of the 1987 return and 8.1 percent of the 1988 return.

Table 36. Estimated egg-to-smolt and smolt-to-adult survival rates for the above-Prosser population of Yakima Subbasin fall chinook, 1983-1987 brood years.

Brood Year	Escape ment	Number Eggs Deposited[1]	Number of Smolts[2]	Survival (percent) Egg to Smolt	Smolt to Adult
1983	380	546,468	44,885	8.2	1.3[3]
1984	1332	1,915,515	73,956	3.9	N.D.
1985	283	406,975	37,868	9.3	N.D.
1986	1214	1,745,822	208,374	11.9	N.D.
1987	544	782,312	N.D.	N.D.	N.D.

[1] Number eggs = (escapement)(fraction females)(mean fecundity), = (escapement)(0.297)(4842).

[2] Smolt outmigration at Prosser for given brood year: e.g., '84 smolt outmigration for '83 brood. Adjusted for pre-counting losses in Chandler Canal.

[3] Estimated as ('84 smolts)/(36.8 percent '85 return + 22.6 percent '86 return + 32.5 percent '87 return + 8.1 percent '88 return).

The estimated smolt-to-adult survival for above-Prosser fall chinook is about 33 percent lower than the 2 percent figure assumed by the Idaho Department of Fish and Game for lower Snake River fall chinook. A difference of this magnitude for a single year could easily be due to natural variation. The observed mean egg-to-smolt survival rate of 8.3 percent is, however, quite low. Such low values are probably due to high levels of predation and deposited sediments in the reach in which spawning occurs (Sunnyside Dam to Prosser Dam).

Zero-density egg-to-smolt survival (So) for the above-Prosser population was estimated by rearranging the Beverton and Holt equation as was done for spring chinook and steelhead. The estimate was 9 percent. A much more speculative approach was used to estimate So for below-Prosser populations. For fall (and summer chinook), egg-to-smolt survival is the product of two rates -- survival from egg to emergent fry, and survival from emergent fry to smolt. Egg-to-fry survival for the lower fall

Smolt capacity under existing conditions was estimated at 3.921 million with the Northwest Power Planning Council's standard method.

Supplementation History

Managers have released an average of 1.1 million non-native upriver bright smolts in the Yakima River between 1983 and 1987 (Table 37). These releases are part of the John Day mitigation program. Because the great majority of these fish were released below Prosser Dam, the return rates and smolt survival rates are unknown.

In a test of fish cultural techniques proposed for use in conjunction with the Yakima/Klickitat Production Facility, three rearing pens were installed in the inlet of the Wapato Irrigation Canal in 1987, and were stocked with three densities (0.4 pound, 0.75 pound and 1.0 pound per cubic foot) of upriver bright fall chinook fry on April 19, 1988. Replicated coded-wire tags (CWT) were provided for all fish in each treatment group. These fish were successfully reared until May 18, 1988, when they were released into the canal bypass at roughly twice their size when stocked. Survival to Prosser was not correlated with rearing density, but was directly proportional to mean release size.

This cultural technique is an important innovation, as it makes economic use of the almost unlimited water supply of major irrigation canals. The water supply in the Wapato Canal inlet alone is sufficient to accommodate the entire anticipated production (3.6 million smolts) of the Yakima/Klickitat Production Project.

Fish Production Constraints

In order of priority, the main factors limiting fall chinook production in the Yakima Subbasin are 1) smolt and pre-smolt mortalities, especially in the reach from Sunnyside Dam to Prosser Dam; 2) the heavy deposition of fine sediments in spawning areas below Sunnyside Dam; and 3) water quality in the lower river.

The above-Prosser population must contend with the high smolt losses in the Sunnyside to Prosser reach, as well as with whatever mortalities may occur at the Prosser Dam bypass and in the open river from Prosser to the Columbia. It is strongly suspected that fall chinook smolt mortalities are mainly attributable to squawfish predation. The above-Prosser population is probably also more severely impacted by sedimentation than lower river fish, as there is some evidence suspended material settles out before reaching lower river spawning areas. The possibility of localized areas of critically low dissolved oxygen concentration, particularly at the bottoms of deeper pools during periods of low flow, also exists throughout the lower river. Water temperatures may also impact the later segments of the fall chinook outmigration adversely.

Hatchery Production

Description of Hatcheries

No fall chinook hatcheries now exist in the subbasin, however, the goal of the fall chinook portion of the future Yakima/Klickitat Production Project is to increase natural production to permit a significant increase in fishing opportunities for treaty and non-treaty fishermen. In contrast to spring chinook and steelhead, somewhat less emphasis is placed on maintaining the genetic integrity of existing natural runs. Past hatchery releases used the same general stock of fall chinook, upriver bright, as the existing natural run.

The computer simulation by which the benefits of the Yakima/Klickitat Production Project were estimated entailed the following provisions and assumptions.

1) The modeled scenario was "post build-up" -- after the period of deliberately increased escapements, when full seeding of the habitat with natural spawners has been attained, and the MSY harvest rate for a supplemented population has been determined. The simulation treated hatchery and natural fish identically, and both were subject to the same terminal harvest rate.

achievable with the current hatchery production goal of 3.6 million smolts, and 79 percent supplementation success.

As summarized in Table 15 in the spring chinook section, the Yakima/Klickitat Production Project will produce 3.6 million fall chinook smolts from 4.3 million eggs. This magnitude of egg-take would require about 1,284 spawners.

Unmarked upriver bright fall chinook adults will be collected at Prosser Dam. Initially, eggs from mid-Columbia upriver bright stocks may have to be imported until returns to the Yakima are large enough to support production goals.

If temperatures permit, spawning and incubation to the eyed stage will occur at Prosser. If temperatures at Prosser are too high, spawning and incubation may occur at the Buckskin facility on the Naches River (RM 3.3). Fry will be reared to the pre-smolt stage at Buckskin, and final rearing and release may occur in floating pens tethered in the intake structure of Wapato Dam (1.8 million smolts) and ponds to be built immediately below Prosser Dam (1.8 million smolts). All hatchery smolts will be marked. Smolts will be reared to a size greater than 100 fish per pound. Releases will occur in May, and will be coordinated with the John Day Acclimation Study. All activities associated with the John Day Acclimation Program in the Yakima Subbasin will be under the jurisdiction of the Yakima/Klickitat Production Project.

Outplanting to natural tributaries is not currently anticipated, except for possible experimental releases in lower Toppenish Creek and several Wapato Irrigation Project return canals. Current production in Marion Drain suggests this proposal has some merit.

Constraints and Critical Uncertainties

Physical production constraints at the hatchery, such as water supply and temperature, are expected to be minimal. On the other hand, there are a number of critical uncertainties as to how to achieve Yakima/Klickitat Production Project goals that will drive the experimental design of the initial releases. These uncertainties are as follows.

1) Natural Productivity

Current information on the natural productivity of fall chinook in the Yakima Subbasin is very limited. The size and timing of above-Prosser escapements have been monitored for six years, as have the sizes of the last six smolt outmigrations (from the upriver population). Production below Prosser is, however, unknown. Some method must be while rebuilding natural runs and harvest opportunities. A potential harvest management plan, as summarized in Table 38, shows how natural escapements can be provided to rebuild runs on the principle that escapement will always exceed that needed to sustain current runs until MSY is reached. Table 38 also details the relationship between catch and brood stock collection at various run sizes.

Table 38. Yakima River fall chinook potential harvest and brood stock collection schedule. (This table summarizes a harvest management plan and critical run sizes in the rebuilding schedule for Yakima River fall chinook under the Yakima/Klickitat Production Project.)

Brood stock collection goal: 1,284 fish
Brood stock percentage: 60 percent
Interim escapement goal: 10,000 adults
Harvest rate schedule: 20 percent on runs below interim escapement goal; thereafter by agreement of agencies.

Run Size	Hatchery Brood Stock	Harvest	Natural Escapement
1,000	480	200	320
2,000	960	400	640
3,000	1,284	600	1,116[1]
14,100	1,284	2,820	10,000[2]
>14,100	1,284	by agreement of parties	

[1] Brood stock collection goal achieved.
[2] Interim escapement goal achieved.

Yakima River fall chinook are caught in sport and commercial fisheries from Oregon to Alaska. Ocean harvest rates, particularly in the northern range of upriver bright fall chinook, are high. Forty percent or more of each run may be harvested off the coast of Alaska. Yakima fall chinook will also contribute to non-treaty fisheries in the lower Columbia. Harvest rates below Bonneville of 20 percent to 25 percent should

A mean of 1.1 million out-of-subbasin fall chinook smolts have been released in the subbasin since 1983.

The major constraints on fall chinook production are, in order of decreasing importance, 1) loss of smolts in the open river from Sunnyside to Prosser Dam and in the immediate vicinity of Prosser Dam itself; 2) sedimentation of spawning gravel between Sunnyside Dam and Kiona; and 3) water quality in the Yakima River from Prosser Dam to the Columbia confluence.

The Yakima Subbasin is in many ways an ideal site for a fall chinook supplementation program, as genetic risks are low and all factors limiting production affect egg-to-smolt survival in one way or another. The main suspected obstacles to production of fall chinook -- predation on newly emergent fry and fingerlings, and the smothering of eggs and fry by fine sediments -- would be circumvented by incubating eggs and rearing pre-smolts in artificial facilities. Moreover, loss of smolts in the Sunnyside to Prosser reach would be eliminated, at least for fish reared in the Prosser ponds.

Tribal members have voiced a strong interest in the possibility of establishing a productive fall fishery. Thus, the success of the fall chinook program (and the coho program as well) is a matter of great importance to the Yakima Indian Nation.

There may be an opportunity to increase fall chinook carrying capacity as well as egg-to-smolt survival. The Wapato Irrigation Project has not exercised its full right to divert water in the fall and winter, as there has been little agricultural reason to do so. There may, however, be a fishery related reason; a number of irrigation returns on reservation land could easily be used for natural production of fall chinook if they were operated through the winter. This proposal has some plausibility as natural spawning and rearing of fall chinook already occurs in one irrigation return, Marion Drain. There may also be a possibility of establishing a natural population of fall chinook in the lower 10 miles of Toppenish Creek.

It should be noted that all proposed enhancement strategies assume continuation of the <u>current</u> water supply and irrigation demand. Specifically, the existing storage capacity, irrigation system operations policies and instream flow cycles have all been assumed to be essentially permanent.

Objectives

The incremental production attributable to specific action elements will be estimated by the TPM/SPM procedure. The first step in this procedure is to estimate the quantitative impact of a specific action on local (reach specific) population parameters. These parameters drive the System Planning Model, and include zero-density egg-to-smolt survival, smolt-to-smolt survival, pre-spawning adult survival and smolt carrying capacity. The Tributary Planning Model is used to "integrate" a host of reach-specific impacts over the entire subbasin, and to calculate four new global parameters. These new, integrated parameters are then used in the System Planning Model to estimate resultant changes in MSY. As each of the objectives listed below entails a quantitative change in one or more of the SPM parameters, the explanation of each objective will include a numerical estimate of the impact on SPM parameters.

Utilization Objective

Maximize natural production and harvest opportunity to treaty and non-treaty fishermen in the Columbia River and terminal fisheries.

Computer simulations indicate successful implementation of the most comprehensive fall chinook strategy would result in sustainable terminal and Columbia River harvests of 4,709 fish and 6,212 fish, respectively. The 4,700-fish terminal harvest is assumed to be divided equally between the tribal and sport fisheries. Tribal fishermen would regularly harvest more salmon in the fall than they have in any season since the inundation of The Dalles Dam in 1957. This magnitude of catch should satisfy a large measure of their strong desire to reestablish a meaningful fall fishery. Sportsmen, on the other hand, would be harvesting salmon at rates approaching steelhead harvests in the halcyon days of the early 1960s.

It is important to note that management of terminal harvest has a very large impact on proportionate catch distribution for runs subject to very intense pre-terminal exploitation, such as fall chinook (and coho). There can be as much as a fourfold difference in sustainable terminal harvest of fall chinook between a fishery managed for MSY to all fisheries and one managed for a terminal MSY. The latter type of management entails much higher terminal harvest rates as well as a substantial drop in total MSY (MSY to ocean, Columbia River and terminal fisheries). In the most extreme case involving Yakima fall chinook, an extra 5,000 fish can be added to the terminal predator control program would increase So 28 percent, from the current estimate of 0.39 to 0.50.

4. Increase smolt-to-smolt survival.

   The goal for smolt-to-smolt survival (Sss) is to halve mortalities in the open river. Quantitatively, the goal is reflected as follows. Wild fall chinook Sss in the Sunnyside to Prosser reach is currently estimated at 0.495 (mortality = 0.505), while Sss from Prosser to the Columbia is estimated at 0.694 (mortality = 0.306). Implementation of this objective will change Sunnyside to Prosser Sss to 1 - 0.505/2 = 0.748, and Sss from Prosser to the Columbia to 1 - 0.306/2 = 0.847. Thus, Sss for fall chinook spawned above Prosser will be (0.748)(0.847) = 0.634. When these new values are substituted into appropriate reaches in the Tributary Planning Model, the new global Sss is 0.813. Under the assumption of equivalent local Sss for hatchery and wild smolts, the new Sss for hatchery fish will be [(0.6340) + (0.847)]/2 = 0.740. Under this scenario, then, supplementation success becomes 0.740/0.813 or 91 percent.

5. Conserve phenotypically adapted genotypes and develop facilities and procedures to estimate total subbasin smolt outmigration and adult return.

   Although continuing large-scale introductions of non-native fish have probably altered the native genotype, progeny of natural spawners that return to spawn themselves obviously possess adaptive characteristics, whatever their origin. These fish should be selected as brood stock.

   At present, fall chinook outmigration and adult return can be monitored only at Prosser Dam, which means approximately 70 percent of the population cannot be monitored. Development of facilities and techniques for monitoring smolt outmigration and escapement for the population spawning below Prosser is essential to managing the fall chinook fishery.

Alternative Strategies

As described earlier, all strategies in the Yakima Subbasin are cumulative. The four, "cumulating" strategies for fall chinook are summarized below.

exploitation rate of 19 percent. Under the same habitat conditions, the TPM/SPM procedure predicts implementation of the Yakima/Klickitat Production Project would boost MSY terminal harvest to 2,998 fish, escapement to 6,380 fish, total harvest to 28,484 fish and terminal exploitation rate to 47 percent. These goals are achievable with the hatchery production goal of 3.6 million smolts, and a 79 percent supplementation success.

Note that the simulation of Strategy 1, as well as the simulation of all fall chinook strategies, assumed all of the conditions previously listed in the section describing the projected benefits of the Yakima/Klickitat Production Project: production of 3.6 million smolts; full seeding and MSY management; an optimal supplementation success of 79 percent; smolt survival rates based on the 1988 release of wild spring chinook smolts and the mean survival of hatchery smolts over the past six years; combined hatchery and natural MSY; and full implementation of planned improvements to fish passage facilities on mainstem Columbia dams. Initiating input parameters for the System Planning model include 0.39 for zero-density egg-to-smolt survival and 0.1 for pre-spawning adult mortality. The impact of interspecific interactions was not considered.

ACTIONS: 1

1. Implement the Yakima/Klickitat Production Project with existing habitat.

    The fall chinook program under the Yakima/Klickitat Production Project will involve the collection of at least 1,284 wild and natural Yakima River adults to produce at least 3.6 million smolts. Eggs from non-native upriver bright stock may have to be imported in the initial years of operation if natural returns at Prosser are insufficient. All smolts will be released from acclimation and rearing sites at Wapato and Prosser dams. Genetic viability will be protected by all of the general measures alluded to previously, with two provisions specific to fall chinook; the maximum proportion of a run taken for brood stock will not exceed 60 percent.

    The proposed harvest management plan for fall chinook under the Yakima/Klickitat Production Project reflects a commitment to supplementation experiments and to meeting hatchery production goals, while rebuilding natural runs and harvest opportunities (see previous section for details). It should be noted that the details of harvest management <u>during the rebuilding</u>

The benefits of adding Strategy 3 to Strategy 2 were simulated by the TPM/SPM procedure. At MSY, the procedure indicated that a supplemented fall chinook population with half the current smolt losses and an So of 0.50 would support an escapement of 8,072 fish, a terminal harvest of 4,601 fish, and a harvest to all fisheries of 36,848 fish. Terminal harvest rate at MSY was 57 percent.

ACTIONS: 1-6

1-4. -

5. Conduct a thorough study of the losses of fall chinook pre-smolts in the Yakima Subbasin, including a provision to implement justified corrective actions specifically including a predator control program.

6. Support legislative initiatives that include proposals to modernize, consolidate and install reregulating reservoirs on smaller irrigation districts in the subbasin. In particular, the Centennial Clean Water Commission should not reallocate funds originally appropriated for water conservation and erosion control projects to new and largely redundant studies, but use them to continue existing programs. The Northwest Power Planning Council itself, however, should consider funding a study of the size distribution of streambed materials in lower river spawning grounds. Such information could be analyzed by techniques described by Bjornn (1987) to predict the impact on fall chinook production of changes in land-use practices, and would provide a focus and perhaps a goal to existing programs of erosion control.

STRATEGY 4: Strategy 3 plus additional spawning and rearing habitat.

The additional habitat proposed here consists of two canals in the Wapato Irrigation Project, Lateral Drain 4 and Wanity Slough, and the lower 10 miles of Toppenish Creek. Bringing these areas into production would increase carrying capacity by 288,000 smolts. Other than acclimating and outplanting smolts, this project requires only that three diversions on Wanity Slough be screened, and that the headworks to Wanity Slough be regularly maintained or rebuilt (Appendix 7).

The benefits of adding an additional 288,000 smolts to Strategy 3 are as follows. At MSY, escapement, terminal harvest and harvest to all fisheries are 8,410 fish, 4,709

[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. Implementation of Yakima/Klickitat Production Project with existing habitat. Post Mainstem Implementation.
2. Strategy 1 plus halving open-river smolt losses. Post Mainstem Implementation.
3. Strategy 2 plus increasing zero-density egg-to-smolt survival to 0.50. Post Mainstem Implementation.
4. Strategy 3 plus expanding production area. Post 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.

SUMMER CHINOOK SALMON

Fisheries Resource

Natural Production

Little is known about the historic distribution of summer chinook although managers generally believe the production area was confined to the middle Yakima River, from just below Sunnyside Dam upstream perhaps as far as the area of Roza Dam; and to the lower Naches, from the mouth to the Tieton. In the relatively recent past (1962 to 1970), the Washington Department of Fisheries conducted aerial redd counts in the Yakima River from the Yakima/Union Gap area to Granger (Schwartzberg and Roger 1986). The average count was 12 redds, and flights were discontinued in 1970. No redds have been observed since 1970, and summer chinook are considered extinct in the subbasin.

The developments that impacted spring chinook production also impacted summer chinook. Very low flows and high temperatures in the lower river in July and August, the normal migration period for summer chinook adults, have characterized the Yakima since the late 19th century. These factors and mainstem mortalities on the Columbia River are probably responsible for the ultimate extermination of the run.

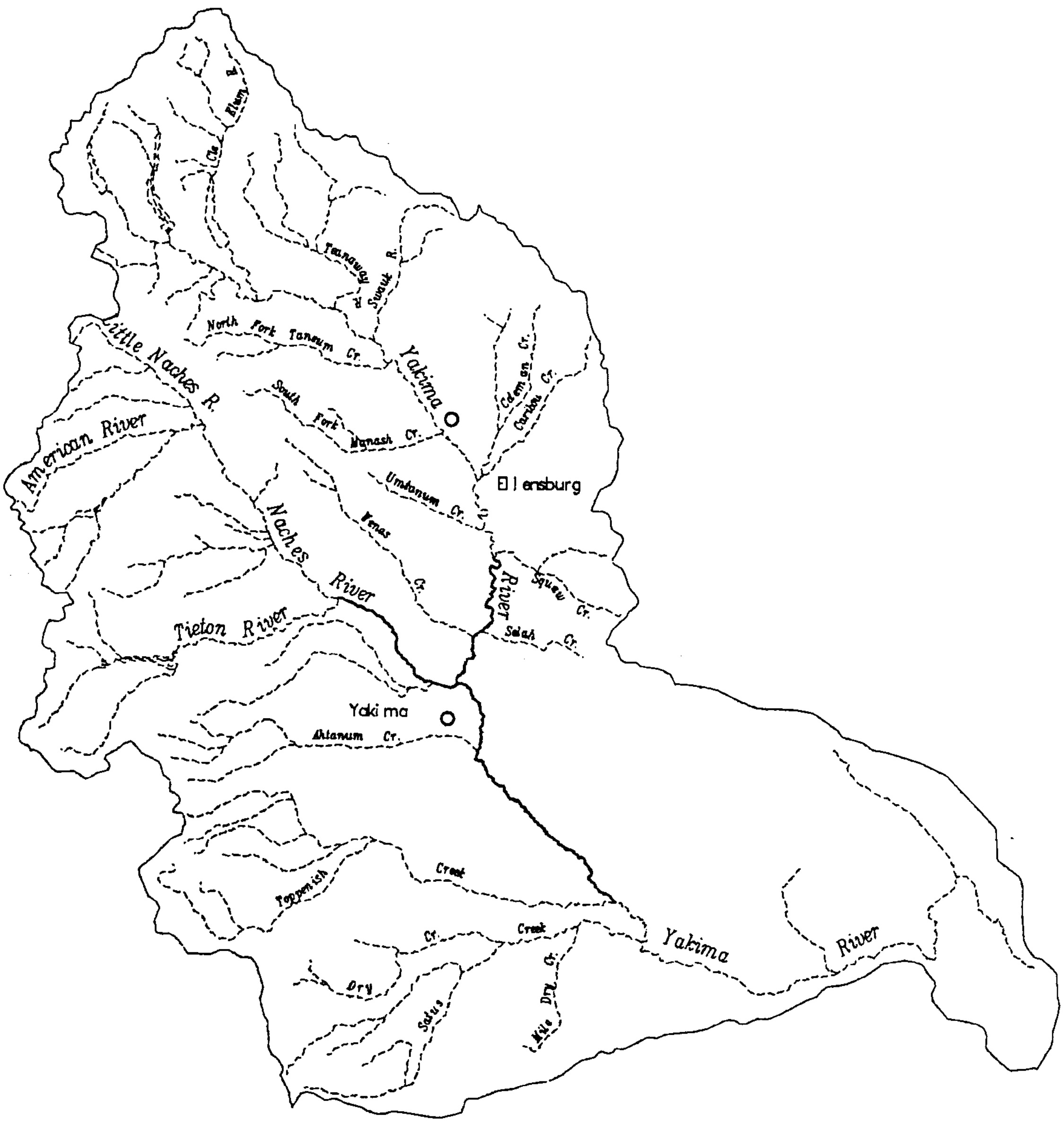
Hatchery Production

Description of Hatcheries

No summer chinook hatcheries exist in the subbasin now, however, the Yakima/Klickitat Production Project proposes to reintroduce the stock to the subbasin.

Potential unsupplemented summer chinook production was simulated with the TPM/SPM procedure using Preliminary Information Report (July 8, 1988) input parameters from Wenatchee summer chinook and existing habitat conditions in the Yakima. At MSY, subbasin escapement, terminal harvest, terminal harvest rate and total yield to all fisheries were, respectively, 2,898 fish, 1,246 fish, 43 percent and 2,305 fish. This simulation was initiated by a "hypothetical" summer chinook population numbering 115 adults, the number needed by the Yakima/Klickitat Production Project program, and the age, sex ratio and fecundity parameters of Wenatchee summer chinook. Addition of an annual 156,000-smolt supplementation program added little to the benefits of this hypothetical scenario; escapement increased to 3,172 fish, terminal harvest to 1,396 fish, terminal harvest rate to 44 percent and total yield to 2,555 fish. Thus, the natural production potential of the subbasin is substantial, and the

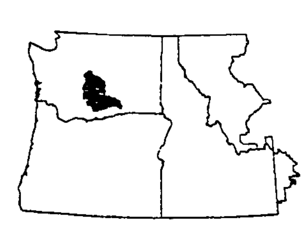
YAKIMA SUBBASIN



SUMMER CHINOOK DISTRIBUTION*

PRESENT/POTENTIAL

ABSENT



* Due to the limitations of scale, all streams which support anadromous fish are not shown on this map.

GIS GEOGRAPHIC INFORMATION SYSTEM

BONNEVILLE POWER ADMINISTRATION

(Note that wild Wenatchee summer chinook smolt as young-of-the-year, much like fall chinook.)

Constraints and Critical Uncertainties

Physical production constraints at the hatchery, such as water supply and temperature, are expected to be minimal. On the other hand, there are a number of critical uncertainties as to how to achieve the project's goals that will drive the experimental design of the initial releases. These uncertainties are as follows.

1) Natural Productivity

As summer chinook are extinct in the Yakima Subbasin, the highest priority has been assigned to the uncertainties of natural productivity.

A major obstacle to the reestablishment of summer chinook in the subbasin are the high temperatures and low flows in the lower river in July and August. This period of poor conditions in the lower river is incompatible with the general features of summer chinook life history in the Wenatchee River (Sanford 1988). In the Wenatchee, the peak of the spawning run is July and August. If present conditions persist, it seems probable that returning summer chinook may occasionally be forced to hold in the Columbia until the Yakima cools sufficiently. Pre-spawning mortality among fish in a stalled migration is a major concern. Another concern is the fact that Wenatchee summer chinook spawn from early October through early November; fish spawning in the lower Naches earlier than mid-October would encounter the high flows of flip flop systems operation, and shoreline redds would be dewatered when the reservoirs were shut down. Current lower river conditions in July and August would also impact summer chinook smolt outmigration adversely. Most Wenatchee summer chinook smolt as 0-age fish and their outmigration occurs from April through August with a peak in June and July. Currently, temperatures and flows in the middle and lower Yakima for an outmigration with this temporal pattern are poor. The predatory vulnerability of small, 0-age fish in a June through July outmigration would also be great.

2) Supplementation Success

Reestablishment of summer chinook depends entirely upon the success of supplementation. Thus, along with natural productivity, the highest priority has been assigned to establishing the determinants of smolt-to-adult survival for production, 1) egg deposition, 2) survival from egg to emergent fry, 3) survival from emergent fry to late-summer parr, 4) overwinter survival, and 5) survival of outmigrating smolts (smolt-to-smolt survival). One element, the Yakima/Klickitat Production Project, is a part of all strategies. The other elements have been integrated in a sequence of "partial cumulations," which have been evaluated by the TPM/SPM procedure. The preferred strategy will be the cumulation that best conforms to the policies of system planning.

The major constraints on potential summer chinook production are, in order of decreasing importance, 1) high temperatures and low flows in the Yakima River below Sunnyside Dam in July and August; 2) loss of smolts in the open river; and 3) water quality in the Yakima River below Sunnyside Dam.

Probably the greatest obstacle to reestablishing summer chinook is the temperature and flow problem in the lower river. Subordination of power generation at Roza, Chandler and Wapatox would alleviate some of the flow problems in the lower Yakima and Naches, but the thermal problems would remain. The main causes of overheating are large expanses of slow-moving, shallow water exposed to full sunlight, and warm, silt-laden irrigation returns (B. Caldwell, USFWS/Fisheries Assistance Office, pers. commun.). Power subordination would "free up" enough water to improve passage, but projected improvements in water temperatures in the middle and lower Yakima are described as "slight" (Yakima River Subbasin Early Implementation Program Executive Summary and Environmental Analysis, Pacific Northwest Region, BOR, February 1987). The impact of possible reductions of irrigation return flows and/or the reduction of the suspended sediment concentration of returns is unknown.

Losses of smolts to predators may limit the production potential of summer chinook more than any other species in the subbasin, either existing or slated for reintroduction. Natural summer chinook smolts are as small and vulnerable as fall chinook, and their outmigration is later than any other species, when water temperatures and the feeding rate of piscivorous fish are highest. Perhaps most importantly, the smolt run at the peak of the summer chinook outmigration would consist almost entirely of summer chinook. As the only available salmonid prey, summer chinook smolts would probably suffer depensatory mortality.

Water quality is near its lowest ebb during the summer chinook spawning run and outmigration. The possibility of direct or indirect mortalities attributable to low dissolved oxygen and pollutants would be higher for summer chinook than any other species. All proposed enhancement strategies assume continuation of the current water supply and irrigation demand. Specifically, planners have assumed the existing storage capacity, irrigation riparian restoration and subordinating diversions for power generation at Wapatox to instream flow requirements -- were assumed to increase smolt capacity (K), but not So.

Because summer chinook-specific data is lacking, estimates of the loss of summer chinook fry through entrainment at Wapatox diversion and at all Phase-II diversions were based on observations of spring chinook. Entrainment at Wapatox diversion was therefore held to be responsible for the loss of at least 1.2 percent of all upstream fry production, and Phase-II diversions were estimated to kill 0.02 percent of all upstream fry production per cfs diverted (see Appendix 2). Rectification of the entrainment problem at Wapatox was modeled by a 1.2 percent increase in So for all fish spawned upstream. Renovation of Phase-II screens was modeled by increasing So by a multiple of $1/[1 - (.0002Q)]$, where Q is mean diversion in cfs, for all fish spawned above the diversion. Before any impacts, So was, as per instructions from the Monitoring and Evaluation Group, assumed to be 0.50.

Planners modeled riparian restoration by assigning affected reaches a higher habitat quality rating in the Smolt Density Model (SDM), the Northwest Power Planning Council's official subbasin smolt capacity estimator. Similarly, planners modeled power subordination at Wapatox by assigning the Wapatox reach a higher quality rating. The SDM assigns a higher density (smolts per square meter at carrying capacity) to reaches with higher quality ratings, and higher densities generate higher smolt capacity estimates.

Over all targeted areas, riparian enhancement was estimated to produce a net summer chinook smolt capacity increase of 201,300 smolts. Power subordination at Wapatox increased smolt capacity in the affected reach by 496,568 smolts. The magnitude of this effect is attributable to the fact that the Wapatox reach comprises a considerable area, and habitat quality in the reach is excellent in all respects save instream flows. The impact of Wapatox diversions on instream flows is frequently severe, and the quality rating assigned the reach in its present condition is fair. Power subordination changes the rating to excellent.

4. Increase smolt-to-smolt survival.

The goal for smolt-to-smolt survival (Sss) is to halve mortalities in the open river. This goal was translated into model parameters by a process exactly analogous to that used on fall chinook. When the adjusted rates for natural fish were substituted into appropriate reaches in the Tributary Planning Model, a new global Sss is 0.5843 was

Estimated costs of the alternative strategies below are summarized in Table 42.

STRATEGY 1: Hatchery production with existing habitat.

The TPM/SPM procedure predicts implementation of the Yakima/Klickitat Production Project will generate an MSY escapement of 3,172 fish, a terminal harvest of 1,396 fish and a total harvest of 2,555 fish. The terminal exploitation rate at MSY will be 44 percent. These goals are achievable with the hatchery production goal of 156,000 smolts.

Simulation of Strategy 1, as well as the simulation of all summer chinook strategies, assumed all of the conditions previously listed in the section describing the projected benefits of the Yakima/Klickitat Production Project: production of 156,000 smolts; full seeding and MSY management; hatchery smolt-to-smolt survival rates equivalent to hatchery spring chinook, and natural rates equivalent of natural fall chinook; combined hatchery and natural MSY; and full implementation of planned improvements to fish passage facilities on mainstem Columbia dams. Initiating input parameters for the System Planning model include 0.5 for zero-density egg-to-smolt survival and 0.2 for pre-spawning adult mortality. The impact of interspecific interactions was not considered.

ACTIONS: 1

1. Implement the Yakima/Klickitat Production Project with existing habitat.

   The summer chinook program under the Yakima/Klickitat Production Project will involve collecting 115 wild and natural Wenatchee River adults to produce 156,000 smolts. If supplementation is successful, all brood stock will eventually be taken from returning Yakima River spawners. There will be no initial cap on the proportion of returning adults taken as brood stock. All smolts will be released from the Oak Flats acclimation and rearing site on the Naches River.

   No harvest management plan has been proposed for summer chinook at this time.

2. -
3. -
4. -

5. Renovate bypass facilities on all Phase II diversions. Install adult barriers on Sulphur Creek and Snipes Creek to prevent the loss of spawners through false attraction.

STRATEGY 4: Strategy 3 plus Wapatox rescreening and power subordination.

The TPM/SPM procedure indicates that the addition of this element to Strategy 3 will produce an MSY escapement of 10,946 fish. Terminal harvest, total harvest and terminal harvest rate will be 6,786 fish, 10,787 fish and 62 percent, respectively.

ACTIONS: 1-6

1-5. -

6. Rescreen Wapatox diversion and subordinate power production to instream flows.

   Planners propose that the Northwest Power Planning Council amend its Columbia River Basin Fish and Wildlife Program to provide for the rescreening of Wapatox diversion and, if possible, the subordination of diversions for power generation. If it is impossible for the Bonneville Power Administration to compensate Pacific Power and Light for revenues precluded by subordination, it is requested that the Power Council and BPA encourage any legislative initiative including this element.

   The instream flows triggering subordination of hydropower diversion are the same for summer chinook as for spring chinook.

STRATEGY 5: Strategy 4 plus riparian restoration.

The TPM/SPM procedure was used to estimate the benefits of adding riparian restoration to Strategy 4. At MSY, escapement, terminal harvest and total harvest were 11,956 fish, 7,413 fish and 11,782 fish respectively. Terminal harvest rate was 62 percent.

ACTIONS: 1-7

Table 41. System Planning Model results for summer chinook in the Yakima Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
Until the possibility of re-establishing a run is determined, utilization objectives are premature.

Biological Objective:
1. Increase rearing habitat. 2. Increase egg-to-emergent fry survival. 3. Increase fry-to-parr survival. 4. Increase smolt-to-smolt survival.

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	789 -C	1,075	2,134	780	0(1.00)
All Nat	6,833 -C	3,495	11,202	4,094	17,173(5.25)
1	1,396 -C	1,421	3,172	1,159	1,966(1.49)
2	4,361 -C	2,424	7,391	2,701	9,956(3.46)
3	4,858 -C	2,485	7,964	2,911	11,042(3.73)
4	6,786 -C	3,328	10,946	4,001	16,688(5.13)
5*	7,413 -C	3,635	11,956	4,369	18,600(5.60)

*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. Implementation of the Yakima/Klickitat Production Project with existing habitat. Post Mainstem Implementation.
2. Strategy 1 plus halving open-river smolt losses. Post Mainstem Implementation.
3. Strategy 2 plus renovating all Phase-II screens. Post Mainstem Implementation.
4. Strategy 3 plus Wapatox rescreening and power subordination. Post Mainstem Implementation.
5. Strategy 4 plus riparian restoration. Post 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.

COHO SALMON

Fisheries Resource

Natural Production

Little is known of the historic distribution of Yakima Subbasin coho although managers believe the production areas in the Yakima mainstem were mainly restricted to the reaches above the mouth of the Teanaway River, and that virtually all major upper Yakima tributaries (the Teanaway River and Taneum, Manastash, Swauk, Big and Umtanum creeks) supported coho. The Naches River and tributaries above the Tieton are also considered to have produced substantial numbers of coho. A smaller amount of production also occurred in the upper Tieton (above Rimrock), the upper Cle Elum and its tributaries (above Cle Elum Dam), and Ahtanum and Logy creeks (Bryant and Parkhurst 1950, Anonymous 1967, Mongillo and Falconer 1980, Smoker 1956). In 1986, spawning coho from 1985 outplantings were observed in Ahtanum Creek and Snipes Creek, and in 1989, spawning was observed in Wide Hollow and Cowiche Creeks and the lower Naches River as well. However, even with the production observed at these sites and possibly other, undetected sites, natural production of coho is very low.

All of the factors affecting spring chinook also affected coho. Coho, however, have suffered the additional impacts of impaired passage of spawners at the old fish ladder at Roza and, more importantly, extremely heavy harvest exploitation in the ocean and Columbia River fisheries. Since construction of Mitchell Act hatcheries in the 1960s and 1970s, harvest rates on the lower Columbia have been designed to maximize harvest of lower mainstem hatchery stocks, which could sustain high exploitation rates. During the same period, Columbia origin coho harvest rates exceeded 90 percent, and effectively wiped out weak, natural upper Columbia stocks (J. Easterbrooks, WDF, pers. commun.).

Managers have planted coho in the upper Yakima since at least the late 1940s with the primary intention of creating a terminal fishery. Outplantings were sometimes fairly massive (750,000 were released in October 1979), but were evidently not of sufficient magnitude or duration to sustain natural production. The Prosser Dam adult counting station was first operated through the fall in 1983; thus returns to the Yakima may be estimated only for releases made in 1982 or later (Table 43). Although survival of outmigrants to Prosser has been relatively good in recent years, the mean return rate to date has been 0.09 percent.

Table 43. History of recent hatchery coho smolt supplementation in the Yakima Subbasin, 1983-1987. (Analysis restricted to those years for which returns can be estimated. Data from 1988 and 1989 not yet analyzed.)

Year of Release	Smolts Released	Smolt Survival(%)	Adult Returns	Smolt-to-Adult Survival(%)
1982	53,820	No Data	36	0.07
1983	19,424[1]	--	--	--
1984	0	--	--	--
1985	260,690	42.6	229	0.09
1986	84,879[2]	56.4	94	0.11
1987	440,309	45.2	--	--

[1] Released below Prosser Dam.
[2] Reared in Nile Pond on the Naches River, volitional release.

Under the United States vs. Oregon Columbia River Fish Management Plan, managers will plants 700,000 coho smolts in the Yakima each year of a five-year period to promote and diversify local fishing opportunities for the Yakima Indian Nation. The program uses fish from lower Columbia River hatcheries and will be evaluated after the fifth year.

Hatchery Production

Description of Hatcheries

No coho hatcheries exist in the subbasin, although the Yakima Indian Nation has used Nile Pond (RM 29.4 Naches River) to rear coho fry to the smolt stage from 1986 through 1988. Most of the Nile Pond production was released volitionally on site.

Like other Yakima/Klickitat Production Project programs, one of the principle goals of the coho program is to increase subbasin fishing opportunities for treaty and non-treaty fishermen. However, the coho program is unique in its goal of maximizing hatchery production instead of a combination of natural and hatchery production. Emphasis was placed on hatchery production because it is widely believed that heavy pre-terminal exploitation will preclude meaningful natural production.

potential in each reach and starting with an So of 0.17 instead of 0.26.

3) The impact of Phase-II screens and Wapatox on zero-density egg-to-smolt survival and smolt-to-smolt survival was estimated exactly as it was for spring chinook.

4) Maximum sustained yield was estimated for maximum hatchery production only.

5) The age distributions, sex ratios and age-specific fecundities reported by Howell et al. (1984) were assumed for Yakima/Klickitat Production Project fish.

6) As per instructions from the Monitoring and Evaluation Group, "pre-impact" zero-density egg-to-smolt survival was assumed to be 0.17, and pre-spawning adult mortality was assumed to be 0.10.

7) The hatchery smolt production capacity was set at 2 million smolts from 2.679 million eggs produced by 2,350 spawners.

8) The smolt survival rates expected after completion of passage projects at mainstem Columbia dams were assumed.

The TPM/SPM procedure predicts implementation of the Yakima/Klickitat Production Project coho program will, under current conditions, generate an MSY escapement (to the Yakima) of 2,929 fish, a terminal harvest of 59 fish, and a total harvest of 14,353 fish, 99 percent of which occurs below Bonneville Dam. As will be seen below, the disproportionate weighting of harvest to the estuarine and oceanic fishery can be lessened to some degree by increasing terminal harvest rates.

It should be noted that these simulations indicated natural escapements would be virtually nonexistent, never exceeding seven fish. Moreover, hypothetical, unsupplemented coho populations quickly became extinct under simulation, whether managed for hatchery or natural MSY.

As summarized in Table 15, the Yakima/Klickitat Production Project will produce 2,009,000 smolts from 2,679,000 eggs. This magnitude of egg-take will require about 2,350 spawners.

Initially, managers may have to collect coho adults for the Yakima River Enhancement Program externally, using the best source of early run fish available (hatchery planners have discussed Cascade Hatchery in this regard). Ultimately, all fish will be collected at Prosser Dam prior to the intensive terminal fishery at Prosser, Sunnyside and Wapato dams. Initial emphasis on hatchery production and lack of genetic risk dictate that

Harvest

No terminal sport or tribal coho fishery now exists, nor has there been a fishery targeting coho for over 30 years.

Early-run coho, like those to be outplanted in the Yakima, are caught in sport and commercial fisheries off the Pacific coast from California to British Columbia. These fish tend to contribute more to fisheries to the south than other coho stocks. They are also generally harvested at a higher rate in the ocean (60 percent to 80 percent) than more northerly migratory coho stocks. Yakima early coho will also contribute to non-treaty fisheries in the lower Columbia (below Bonneville Dam). Their early migration timing overlaps fall chinook. Thus early-run coho will to some degree avoid the higher harvest rates in the mainstem on late-returning hatchery coho.

Hatchery planners and managers anticipate that Yakima coho will be treated as a hatchery stock for mixed-stock harvest management purposes.

It is likely that 90 percent or more of the coho run will be harvested before it enters the Yakima River. Should it develop that the Yakima harvest and escapement needs cannot be met by returns alone, hatchery brood stock may have to be imported. Moreover, heavy pre-terminal harvests will almost certainly necessitate explicit management for terminal MSY. However, it should be noted that no terminal harvest management plan for coho will be formally established until U.S. vs. Oregon releases have been evaluated.

A potential hatchery management plan (developed by Yakima/Klickitat Production Project planners) is summarized in Table 44, which details the schedule of brood stock collection and harvest for runs of various sizes.

rainbow/coho interaction studies. As native coho are probably extinct, planners are not concerned about the potential genetic impacts of an enhancement program.

The major constraints on coho production are, in order of decreasing importance, heavy ocean and estuarine exploitation, and the loss of smolts in the Yakima River. The possibility of adverse impacts of juvenile coho on rainbow trout and spring chinook will be minimized by releasing most coho smolts below Wapato Dam and by permitting a high harvest rate on returning adults.

In light of the fact natural coho production is neither sought nor feasible under existing pre-terminal harvest rates, implementing the Yakima/Klickitat Production Project and improving smolt-to-smolt survival are the only viable enhancement options.

Objectives

Utilization Objective

Develop a sustainable terminal harvest of 2,000 fish.

An important general goal of the Yakima Subbasin Plan is establishing a strong fall fishery within the Yakima Subbasin. Accordingly, it is important that the coho program maximize terminal MSY. Computer simulations indicate that the Yakima/Klickitat Production Project coho program, in combination with programs to halve smolt losses in the open river, rebuild Phase-II screens, and the Wapatox project, could generate a sustainable terminal harvest of 2,161 fish, if the fishery is managed for terminal MSY. Consonant with the need to generate the largest fall fishery possible, it is proposed that the harvest goal be set at 2,000 fish.

Biological Objectives

1. Establish an effective acclimation/on-site release program for coho smolts reared at the proposed Oak Flats and Wapato Dam facilities.

2. Reduce loss of smolts in subbasin by at least 50 percent.

   Losses of smolts to predators or trauma may limit the potential production of hatchery coho more than any other factor. Further studies in this regard are recommended.

The potential benefits of the proposed coho program were analyzed by the TPM/SPM procedure. Under current conditions (see conditions of analysis listed in the previous discussion of projected benefits from the Yakima/Klickitat Production Project), this procedure indicated that maximum sustainable subbasin escapement, terminal harvest and total harvest would be 2,929 fish, 59 fish and 14,353 fish, respectively. Terminal harvest rate at MSY was estimated at 2 percent.

Under management for maximum sustained yield to all fisheries, terminal harvests increase as smolt-to-smolt survival rates increase. Terminal harvests increase substantially when improved smolt-to-smolt survival is combined with management for maximum sustained terminal harvests. Management for terminal MSY does, however, entail a trade-off in the form of reduced total harvest. In this scenario, management for terminal MSY entails a terminal harvest rate of 4 percent, and generates a terminal harvest of 94 fish, with an escapement and total harvest of 2,336 and 11,494, respectively. Thus, 45 fish were added to the terminal harvest at a cost of 2,859 fish in the harvests below Bonneville. From the perspective of Yakima Subbasin managers, this trade-off becomes more acceptable -- the increase in terminal harvest becomes more substantial and the net loss in total catch becomes proportionately lower -- as smolt-to-smolt survival rates increase. The final strategy to be presented increases coho smolt-to-smolt survival to the maximum practicable rate. Only under this scenario does the trade-off becomes reasonable, even to a manager primarily concerned with the Yakima Subbasin. Therefore, MSY will be computed in terms of terminal harvest only for the last strategy, Strategy 4. It should be understood that "MSY" under Strategies 1-3 refers to maximum sustained yield to all fisheries.

ACTIONS: 1

1. Implement the coho supplementation program under the Yakima/Klickitat Production Project.

   Except for small releases in Wide Hollow Creek, all coho will be released as smolts from rearing and acclimation facilities at the proposed Oak Flats facility on the Naches River (600,000 smolts) and Wapato Dam on the Yakima (1.4 million smolts). All smolts will be adipose clipped and coded-wire tagged. Rearing and acclimation facilities will be designed to produce two million smolts from 2.7 million eggs. This level of production will require the collection of 2,350 adults for brood stock. Brood stock may

1. -
2. -
3. -
4. -

5. Renovate bypass facilities on all Phase II diversions. Install adult barriers on Sulphur Creek and Snipes Creek to prevent the loss of spawners through false attraction.

STRATEGY 4: Strategy 3 plus Wapatox rescreening and power subordination.

The TPM/SPM procedure, when used to calculate MSY to <u>all</u> fisheries, indicates that the addition of this element to Strategy 3 will produce an MSY escapement of 5,424 fish. Under this scenario, terminal harvest, total harvest and terminal harvest rate are 922 fish, 27,390 fish and 17 percent, respectively. However, when the procedure is used to estimate <u>terminal</u> MSY, escapement, terminal harvest, total harvest and terminal harvest rate become 5,025 fish, 2,161 fish, 26,682 fish and 43 percent, respectively. In this case, management for terminal MSY increases terminal harvest 134 percent at a cost of a 2 percent reduction in total harvest. As the principle goal of the coho program is to create a meaningful terminal fishery, this trade-off is more than reasonable, and it should be understood that Strategy 4 includes the stipulation of management for terminal MSY.

ACTIONS: 1-6

1-5. -

6. Rescreen Wapatox diversion and subordinate power production to instream flows.

   Planners propose that the Northwest Power Planning Council amend its Columbia River Basin Fish and Wildlife Program to provide for the rescreening of Wapatox diversion and, if possible, the subordination of diversions for power generation. If it is impossible for the Bonneville Power Administration to compensate Pacific Power and Light for revenues precluded by subordination, planners request the Power Council and BPA encourage any legislative initiative including this element.

[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. Implementation of Yakima/Klickitat Production Project coho program with existing subbasin smolt losses. Post Mainstem Implementation.
2. Strategy 1 plus halving open-river smolt losses. Post Mainstem Implementation.
3. Strategy 2 plus renovating Phase-II screens. Post Mainstem Implementation.
4. Strategy 3 plus Wapatox rescreening and power subordination. Post 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.

SOCKEYE SALMON

Fisheries Resource

Estimation of the historic magnitude of the sockeye run is difficult since the run was eliminated before counting stations were established. Four sockeye nursery lakes were accessible prior to various dam constructions: 1,240-acre Keechelus Lake (blocked 1904); 2,744-acre Kachess Lake (blocked 1904); 1,982-acre Cle Elum Lake (blocked 1909-1910); and, 631-acre Bumping Lake (blocked 1910). Assuming that the 6,597 acres of lakes produced at least 15.7 adults per acre (production average for Lake Wenatchee, an ultraoligotrophic nursery lake in the Wenatchee Subbasin), and probably better (no major hydroelectric projects in the Columbia River prior to the 1930s), the historical run size has been estimated at 200,000 adult sockeye.

Since the late 1980s, the National Marine Fisheries Service has been contracted by the Bonneville Power Administration to conduct a sockeye feasibility study in Cle Elum Reservoir as part of the Yakima/Klickitat Production Project. The study is designed to test whether an adequate proportion of a population of sockeye smolts can utilize limited surface spills at Cle Elum Dam to emigrate from the reservoir, and if so, whether a sufficient proportion will survive downriver migration. The study will examine the degree to which sockeye can adapt to the altered condition within the Cle Elum drainage, if the initial questions on the feasibility of escape from the reservoir and subsequent smolt survival are answered positively. Assuming all feasibility questions are resolved, the study would consider the optimal method of providing adults access to the lake (trap and haul, or the construction of a fish ladder or lift).

Sockeye are taken from the Wenatchee Subbasin as they pass Tumwater Dam (originally collected at Dryden Dam) and reared at the National Marine Fisheries Service Mountlake Hatchery in Seattle. The sockeye are released above and below the Cle Elum Dam at varying sizes. By monitoring brands and PIT tags at Prosser trap and McNary Dam (also brands at Rosa Dam), researchers have preliminarily determined that juvenile sockeye move downriver rapidly. The Cle Elum Reservoir appears to afford adequate rearing habitat, but the surface discharge for flood control is not providing sufficient passage. A more costly bypass system may be necessary.

During the 1800s, the Yakima River sockeye was an important component in the sockeye fisheries of the Columbia River, and this highly preferred salmon was pursued for subsistence and ceremonial purposes by the Yakima Tribe. No significant return of adult sockeye to the Yakima Subbasin is expected from the Cle

Alternative Strategies

Planners propose one strategy. No sockeye stock in the Columbia River System was modeled due to the insufficient quantity and quality of data on the sockeye species to provide confidence in any potential System Planning Model output.

STRATEGY 1: Feasibility of Reintroduction.

ACTIONS: 1

1. Support sockeye feasibility study. Study is currently under way through the National Marine Fisheries Service whereby Lake Wenatchee origin sockeye are being reared in Cle Elum Reservoir to determine whether it is possible to establish an anadromous run.

Recommended Strategy

Planners recommend implementing the only strategy proposed, Strategy 1.

PART V. SUMMARY AND IMPLEMENTATION

Objectives and Recommended Strategies

A complete summary of all objectives and strategies proposed in the Yakima River Subbasin Plan appear in a separate document entitled "Supplement 2, Summary of Objectives and Strategies" for the Yakima River Subbasin Salmon and Steelhead Production Plan.

Spring Chinook

The terminal harvest objective for spring chinook is to maximize sustainable yield in a way that is consistent with long-term conservation of genetic fitness and the experimental goals of the Yakima/Klickitat Production Project. An additional objective is to preserve the substock of spring chinook in the American River.

Planners recommend Strategy 9, which consists of supplementation, habitat expansion, halving of outmigrating smolt losses, rebuilding of Phase-II screens, off-channel winter refuges, rescreening and power subordination at Wapatox, riparian restoration, reduced mortality of pre-spawning adults, and the rendering of Teanaway River usable for fish.

Summer Steelhead

The objectives for steelhead enhancement are similar to those for spring chinook -- maximize harvest within the subbasin while preserving genetic fitness. Analogous to spring chinook, an unsupplemented "genetic sanctuary" of steelhead is to be maintained in Satus Creek under the Yakima/Klickitat Production Project. An additional consideration for steelhead is that steelhead enhancement not adversely impact resident rainbow trout populations currently concentrated in the Yakima River above Roza Dam.

Planners recommend Strategy 7, which consists of supplementation, habitat expansion, halving of outmigrating smolt losses, rebuilding of Phase-II screens, off-channel winter refuges, rescreening and power subordination at Wapatox, and riparian restoration.

Fall Chinook

The objective for fall chinook enhancement is to maximize natural production and harvest opportunity to treaty and non-treaty fishermen in the Columbia River and terminal fisheries. Computer simulations indicate successful implementation of the preferred strategy would result in sustainable terminal, Columbia

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.

LITERATURE CITED
AND OTHER REFERENCES

Anonymous. 1967. Supplementary follow-up report for Yakima Project, Roza Division, Yakima River, Washington. USDI, Fish and Wildlife Service, Portland, Oregon.

Anonymous. 1974. Yakima-Kittitas resource conservation and development plan. USDA, Soil Conservation Service, Spokane, Washington.

Anonymous. 1985. Yakima River basin water enhancement project Phase-II status report. Report to the regional director, Pacific Northwest Region, Bureau of Reclamation and the director, Department of Ecology, State of Washington.

Anonymous. 1987. Yakima River basin early implementation program: executive summary, supporting material, environmental analysis. Bureau of Reclamation, Pacific Northwest Region, and Department of Ecology, State of Washington.

Anonymous. 1988. System planning model sensitivity analysis. Report by the Northwest Power Planning Council's Monitoring and Evaluation Group, February 18, 1988.

Anonymous. 1990. Water Supply Analysis to Bonneville Power Administration: Yakima/Klickitat Production Project. Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho, March, 1990.

Bartoo, N.W. 1977. Population parameter estimates and energy budgets for peamouth, northern squawfish and yellow perch in Lake Washington. Doctoral Dissertation. University of Washington, Seattle, Washington.

Beamsderfer, R.C. and B.E. Rieman. 1988. Predation by resident fish on juvenile salmonids in a mainstem Columbia reservoir: Part III. Abundance and distribution of northern squawfish, walleye and smallmouth bass. In T.P. Poe and B.E. Rieman, editors. Predation by resident fish on juvenile salmonids in John Day Reservoir 1983-86. Final Report (Contracts DE-AI79-82P34796 and DE-AI79-828BP35097) to Bonneville Power Administration, Portland, Oregon.

Bjornn, T.C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, streamflow, cover and population density. Transactions of the American Fisheries Society 100:423-438.

Eddy, B.R. 1987. Wapatox Canal fish screening facility efficiency study: 1986 data report. Report to Pacific Power and Light, 920 S.W. Sixth Ave., Portland, Oregon. January 11, 1987.

Eddy, B.R. 1988. Wapatox Canal fish screen facility passage effectiveness evaluation 1986-1987. Pacific Power and Light Environmental Services, August 1988.

Eichler, G.L., M.C. Bell, C.J. Campbell, R.E. Craven and M.A. Wert. 1987. Turbine-related fish mortality: review and evaluation of studies. Report prepared for Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, California, C. Sullivan Project Manager. Research Project 2694-4.

Fast, D.E., J. Hubble and B. Watson. 1985. Yakima River spring chinook enhancement study: 1985 annual report to Bonneville Power Administration. Project 82-16.

Fast, D.E., J. Hubble and B. Watson. 1986. Yakima River spring chinook enhancement study: 1986 annual report to Bonneville Power Administration. Project 82-16.

Fast, D.E., J. Hubble and B. Watson. 1987. Yakima River spring chinook enhancement study: 1987 annual report to Bonneville Power Administration. Project 82-16.

Hallowed, J.J. 1984. A study of fall chinook (Oncorhynchus tshawytscha) in Marion Drain on the Yakima Indian Reservation. Yakima Indian Nation Information Report 84-7.

Hall, J.D. 1984. Evaluating fish response to artificial stream structures: problems and progress. In Pacific Northwest Stream Habitat Workshop, Humboldt State University, Arcata, California, October 10-12, 1984.

Howell, P., K. Jones, D. Scarnecchia, L. Lavoy, W. Kendra and D. Ortman. 1984. Final report: stock assessment of Columbia River anadromous salmonids (2 vols.). Bonneville Power Administration Project No. 83-335. 1,032pp.

Johnson, A., D. Norton and B. Yake. 1986. Occurrence and significance of DDT compounds and other contaminants in fish, water, and sediment from the Yakima River Basin. Washington Department of Ecology, Water Quality Investigations Section, Olympia, Washington. Report 86-5.

Major, R.L. and J.L. Mighell. 1969. Egg to migrant survival of spring chinook (Oncorhynchus tshawytscha) in the Yakima River, Washington. Washington Fishery Bulletin 67(2):347-359.

Schwartzberg, M. and P.B. Roger. 1986. An annotated compendium of spawning ground surveys in the Columbia River Basin above Bonneville Dam, 1960-1984. Columbia River Inter-tribal Fish Commission Technical Report 86-1.

Smoker, W.A. 1956. Evaluation of the potential salmon and steelhead production of the Yakima River to the commercial and recreational fisheries. Report to the Washington Department of Fisheries. 19pp.

Stemple, J.M. 1985. Conversion of weighted usable area to potential fish production in the Yakima Basin. U.S. Fish and Wildlife Service, Olympia, Washington, Moses Lake Suboffice. Report of June 1985.

Swindell, E.G. 1942. The hunting and fishing rights of the Washington and Oregon Indians. U.S. Department of the Interior, Office of Indian Affairs, Division of Forestry and Grazing, Los Angeles, California. July 1942.

Tudor Engineering. 1989. Yakima Indian Nation water and energy development: flow augmentation reservoirs and screening study.

Vigg, S., T.P. Poe, L.A. Pendergast and H.C. Hansel. 1988. Predation by resident fish in a mainstem Columbia River reservoir: Part II. Consumption rates of northern squawfish, walleye, smallmouth bass, and channel catfish. In T.P. Poe and B.E. Rieman, editors. Predation by resident fish on juvenile salmonids in John Day Reservoir 1983-86. Final Report (Contracts DE-AI79-82P34796 and DEAI79-828BP35097) to Bonneville Power Administration, Portland, Oregon.

Vigg, S. 1988. Functional response of northern squawfish predation to salmonid prey densities in McNary tailrace, Columbia River. In T.P. Poe and B.E. Rieman, editors. Predation by resident fish on juvenile salmonids in John Day Reservoir 1983-86. Final Report (Contracts DE-AI79-82P34796 and DE-AI79-828BP35097) to Bonneville Power Administration, Portland, Oregon.

Wasserman, L. and J. Hubble. 1983. Yakima River spring chinook enhancement study: 1983 annual report to Bonneville Power Administration. Project 82-16.

Wasserman, L., J. Hubble and B. Watson. 1984. Yakima River spring chinook enhancement study: 1984 annual report to Bonneville Power Administration. Project 82-16.

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.

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: YAKIMA

STOCK: SPRING CHINOOK

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	8	0.6	20	160	96
2 CHG MSY	9	0.6	20	180	108
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 760

DISCOUNT VALUE 582

CONFIDENCE VALUE 0.76578947

SUBBASIN: YAKIMA

STOCK: SPRING CHINOOK

STRATEGY: 4

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	9	0.6	20	180	108
2 CHG MSY	9	0.6	20	180	108
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 780

DISCOUNT VALUE 594

CONFIDENCE VALUE 0.76153846

SUBBASIN: YAKIMA

STOCK: SPRING CHINOOK

STRATEGY: 7

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	9	0.6	20	180	108
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 780

DISCOUNT VALUE 588

CONFIDENCE VALUE 0.75384615

SUBBASIN: YAKIMA

STOCK: SPRING CHINOOK

STRATEGY: 8

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	9	0.6	20	180	108
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 780

DISCOUNT VALUE 588

CONFIDENCE VALUE 0.75384615

SUBBASIN: YAKIMA

STOCK: SUMMER CHINOOK

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	10	0.6	20	200	120
2 CHG MSY	9	0.6	20	180	108
3 GEN IMP	7	0.9	20	140	126
4 TECH FEAS	4	0.9	20	80	72
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 760

DISCOUNT VALUE 570

CONFIDENCE VALUE 0.75

SUBBASIN: YAKIMA

STOCK: SUMMER CHINOOK

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	10	0.6	20	200	120
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	7	0.9	20	140	126
4 TECH FEAS	5	0.9	20	100	90
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 800

DISCOUNT VALUE 600

CONFIDENCE VALUE 0.75

SUBBASIN: YAKIMA

STOCK: FALL CHINOOK

STRATEGY: 1

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	6	0.6	20	120	72
2 CHG MSY	9	0.6	20	180	108
3 GEN IMP	4	0.9	20	80	72
4 TECH FEAS	6	0.9	20	120	108
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 640

DISCOUNT VALUE 486

CONFIDENCE VALUE 0.759375

SUBBASIN: YAKIMA

STOCK: FALL CHINOOK

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	8	0.6	20	160	96
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	4	0.9	20	80	72
4 TECH FEAS	4	0.9	20	80	72
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 680

DISCOUNT VALUE 504

CONFIDENCE VALUE 0.74117647

SUBBASIN: YAKIMA

STOCK: EARLY COHO

STRATEGY: 1

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	9	0.6	20	180	108
2 CHG MSY	9	0.6	20	180	108
3 GEN IMP	2	0.9	20	40	36
4 TECH FEAS	8	0.9	20	160	144
5 PUB SUPT	6	0.9	20	120	108

TOTAL VALUE 680

DISCOUNT VALUE 504

CONFIDENCE VALUE 0.74117647

SUBBASIN: YAKIMA

STOCK: EARLY COHO

STRATEGY: 2

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	10	0.6	20	200	120
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	2	0.9	20	40	36
4 TECH FEAS	8	0.9	20	160	144
5 PUB SUPT	7	0.9	20	140	126

TOTAL VALUE 740

DISCOUNT VALUE 546

CONFIDENCE VALUE 0.73783783

SUBBASIN: YAKIMA

STOCK: STEELHEAD

STRATEGY: 3

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	9	0.6	20	180	108
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	6	0.6	20	120	72

TOTAL VALUE 760

DISCOUNT VALUE 534

CONFIDENCE VALUE 0.70263157

SUBBASIN: YAKIMA

STOCK: STEELHEAD

STRATEGY: 4

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	10	0.6	20	200	120
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	7	0.6	20	140	84

TOTAL VALUE 800

DISCOUNT VALUE 558

CONFIDENCE VALUE 0.6975

SUBBASIN: YAKIMA

STOCK: STEELHEAD

STRATEGY: 7

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	10	0.6	20	200	120
2 CHG MSY	10	0.6	20	200	120
3 GEN IMP	6	0.9	20	120	108
4 TECH FEAS	7	0.9	20	140	126
5 PUB SUPT	6	0.6	20	120	72

TOTAL VALUE 780

DISCOUNT VALUE 546

CONFIDENCE VALUE 0.7

SUBBASIN: KLICKITAT

STOCK: SPRING CHINOOK

STRATEGY: 1

CRITERIA	RATING	CONFIDENCE	WEIGHT	UTILITY	DISCOUNT UTILITY
1 EXT OBJ	8	0.6	20	160	96
2 CHG MSY	9	0.6	20	180	108
3 GEN IMP	3	0.6	20	60	36
4 TECH FEAS	6	0.6	20	120	72
5 PUB SUPT	8	0.9	20	160	144

TOTAL VALUE 680

DISCOUNT VALUE 456

CONFIDENCE VALUE 0.67058823

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

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Yakima River
Stock: Spring Chinook

Action	Cost Categories*	Proposed Strategies[a] 1	2	3	4	5 (cont.)
Habitat Enhancement	Capital:		82,520	2,373,940[d]	2,373,940	2,373,940
	O&M/yr:		1,900	47,728	47,728	47,728
	Life:		50	50	50	50
Screening	Capital:		1,544,890	1,544,890	1,544,890[g]	1,544,890
	O&M/yr:		20,329	20,329	20,329	20,329
	Life:		50	50	50	50
Barrier Removal	Capital:		184,000	184,000	184,000	184,000
	O&M/yr:		(no est.)	(no est.)	(no est.)	(no est.)
	Life:		50	50	50	50
Misc. Projects	Capital:		756,600[b]	810,280[e]	810,280	810,280
	O&M/yr:		67,500	123,810[f]	123,810	130,850[h]
	Life:		50	50		50
Hatchery Production[c]	Capital:					
	O&M/yr:					
	Life:					
TOTAL COSTS	Capital:	0	2,568,010	4,913,110	4,913,110	4,913,110
	O&M/yr:		89,729	191,867	191,867	198,907
	Years:		50	50	50	50
Water Acquisition		N	N	N	N	N
Fish to Stock	Number/yr:					
	Size:					
	Years:					

* 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] Strategies are cumulative.

[b] Includes trap-and-haul operations on Cabin and Manastash creeks, and shoring up and lining 1.2 miles of KRD canal (South Branch), to enable extra water to be spilled into Taneum Creek to augment instream flows.

[c] Costs for new production already obligated under the Columbia River Basin Fish and Wildlife Program.

[d] Includes $2,291,420 capital and $45,828 O&M, a rough estimate of cost of concrete lining, narrowing of approach to screens in Chandler Canal.

[e] Includes $53,680 for four 16-foot boats, 150 hp jet motors and trailers (life expectancy = 12 yrs), initially costing $10,000, increasing in cost 20 percent each purchase.

Subbasin: Yakima River
Stock: Spring Chinook (continued)

Action	Cost Categories*	Proposed Strategies[a] 6	7	8	9**
Habitat Enhancement	Capital:	2,373,940	2,496,370[d]	2,496,370	2,496,370
	O&M/yr:	47,728	74,595[e]	74,595	74,595
	Life:	50	50	50	50
Screening	Capital:	3,354,890[b]	3,354,890	3,354,890	3,354,890
	O&M/yr:	47,329	47,329	47,329	47,329
	Life:	50	50	50	50
Barrier Removal	Capital:	184,000	184,000	184,000	184,000
	O&M/yr:	(no est.)	(no est.)	(no est.)	(no est.)
	Life:	50	50	50	50
Misc. Projects	Capital:	810,280[c]	810,280	810,280	816,880[g]
	O&M/yr:	130,850	130,850	330,850[f]	357,100
	Life:	50	50	50	50
Hatchery Production[i]	Capital:				
	O&M/yr:				
	Life:				
TOTAL COSTS	Capital:	6,723,110	6,845,540	6,845,540	6,852,140
	O&M/yr:	225,907	252,774	452,774	479,024
	Years:	50	50	50	50
Water Acquisition		N	N	N	Possibly[h]
Fish to Stock	Number/yr:				
	Size:				
	Years:				

* 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] Strategies are cumulative.

[b] Includes $1,800,000 capital and $27,000 O&M for screening Wapatox diversion.

[c] Miscellaneous costs for screening Wapatox diversion and subordinating diversions to instream flow include the costs of PP&L's foregoing the generation of 11.52 megawatt-hours of electricity. The dollar cost of this loss of opportunity has not been estimated.

[d] Includes $122,430 for costs of installing 33 miles of fencing in riparian areas on private property.

[e] Includes $26,867 for planning and administrative overhead, at 73 percent of capital costs for projects on private property, included with maintenance costs of fencing estimated at $760 per mile per year.

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Yakima River
Stock: Summer Steelhead

Action	Cost Categories*	Proposed Strategies[a] 1	2	3	4 (cont.)
Habitat Enhancement	Capital:		41,950[b]	2,333,370[g]	2,333,370
	O&M/yr:		2,000[c]	47,828	47,828
	Life:		50	50	50
Screening	Capital:		250,900[d]	250,900	250,900[i]
	O&M/yr:		2,528	2,528	2,528
	Life:		50	50	50
Barrier Removal	Capital:		19,646	19,646	19,646
	O&M/yr:		(no est.)	(no est.)	(no est.)
	Life:		50	50	50
Misc. Projects	Capital:		72,966[e]	126,646[h]	126,646
	O&M/yr:		7,300[f]	63,610	63,610
	Life:		50	50	50
Hatchery Production[j]	Capital:				
	O&M/yr:				
	Life:				
TOTAL COSTS	Capital:	0	385,462	2,730,562	2,730,562
	O&M/yr:		11,828	113,966	113,966
	Years:		50	50	50
Water Acquisition		N	N	N	N
Fish to Stock	Number/yr:				
	Size:				
	Years:				

* 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] Strategies are cumulative

[b] For blasting and instream work with heavy equipment to make cascades on Cabin Creek negotiable by steelhead in spring.

[c] For five days instream heavy equipment work every other year.

[d] For new screens on streams supporting only steelhead; not covered by spring chinook screening project.

[e] For culvert replacement and repair in Toppenish Creek drainage.

[f] For culvert maintenance, assumed to be 1 percent of installation costs annually.

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Yakima River
Stock: Summer Steelhead (continued)

Action	Cost Categories*	Proposed Strategies[a] 5	6	7**
Habitat Enhancement	Capital:	2,333,370	2,333,370	3,374,228[e]
	O&M/yr:	47,828	47,828	185,640[f]
	Life:	50	50	50
Screening	Capital:	250,900	2,050,900[c]	2,050,900
	O&M/yr:	2,528	29,528	29,528
	Life:	50	50	50
Barrier Removal	Capital:	19,646	19,646	19,646
	O&M/yr:	(no est.)	(no est.)	(no est.)
	Life:	50	50	50
Misc. Projects	Capital:	126,646	126,646[d]	126,646
	O&M/yr:	70,650[b]	70,650	70,650
	Life:	50	50	50
Hatchery Production[g]	Capital:			
	O&M/yr:			
	Life:			
TOTAL COSTS	Capital:	2,730,562	4,530,562	5,571,420
	O&M/yr:	121,006	148,006	285,818
	Years:	50	50	50
Water Acquisition		N	N	N
Fish to Stock	Number/yr:			
	Size:			
	Years:			

* 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] Strategies are cumulative.

[b] Includes $7,040 O&M for 11 weeks' salary for two biologists working half time.

[c] Includes $1,800,000 capital and $27,000 O&M for screening Wapatox diversion.

d Miscellaneous costs for screening Wapatox diversion and subordinating diversions to instream flow include the costs of PP&L's foregoing the generation of 11.52 megawatt-hours of electricity. The dollar cost of this loss of opportunity has not been estimated.

[e] Includes $1,040,858 for fencing and bank stabilization projects on 163 miles of streams supporting only steelhead; not covered by spring chinook projects.

ESTIMATED COSTS FOR ALTERNATIVE STRATEGIES

Subbasin: Yakima River
Stock: Fall Chinook

Action	Cost Categories*	Proposed Strategies[a] 1	2	3	4**
Habitat Enhancement	Capital:		2,291,420[b]	2,291,420	2,291,420
	O&M/yr:		45,828	45,828	45,828
	Life:		50	50	50
Screening	Capital:				1,007,480[d]
	O&M/yr:				15,000
	Life:				50
Barrier Removal	Capital:				
	O&M/yr:				
	Life:				
Misc. Projects	Capital:		53,680[c]	53,680	253,680[e]
	O&M/yr:		56,310	56,310	60,310
	Life:		50	50	50
Hatchery Production[f]	Capital:				
	O&M/yr:				
	Life:				
TOTAL COSTS	Capital:	0	2,345,100	2,345,100	3,552,580
	O&M/yr:		102,138	102,138	121,138
	Years:		50	50	50
Water Acquisition		N	N	N	N
Fish to Stock	Number/yr:				
	Size:				
	Years:				

* 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] Strategies are cumulative

[b] For lining and narrowing Chandler Canal.

[c] For two "squawfish control officers."

[d] For screening four large diversions on Wanity Slough. O&M costs assumed to be 1.5 percent of installation costs.

[e] Includes $200,000 capital and $4,000 O&M (2 percent of installation costs) for installing permanent structure at head of Wanity Slough to divert water from Yakima River.

[f] Costs for new production already obligated under the Columbia River Basin Fish and Wildlife Program.

[g] Includes $122,430 capital and $26,867 O&M for 33 miles of fencing in riparian areas on private property.

[h] Costs for new production already obligated under the Columbia River Basin Fish and Wildlife Program.