WILD TROUT, STEELHEAD AND SALMON IN THE 21st CENTURY

Proceedings of a Conference
Portland, Oregon
July 19, 1986

Sponsored by
Oregon Trout
Oregon Sea Grant
American Fisheries Society

PROCEEDINGS
OF

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Dan Guthrie, Editor

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Preface

The novelist Henry James once said, "Summer afternoon, summer afternoon; to me those have always been the two most beautiful words in the English language." That may be true in the England beloved by James, but in the Pacific Northwest, anglers favor a lustier pair of words—"wild fish." Otherwise, why would 200 people show up on a sunny Saturday in July to hear representatives of government agencies, Indian tribes and private organizations talk about the prospects for wild salmon and trout in the 21st century?

The occasion was a 1986 symposium held in Portland and sponsored by Oregon Trout, the American Fisheries Society and the Oregon Sea Grant Program. The impetus behind the symposium was a reversal in the fortunes of wild fish. For centuries beyond knowing, salmon and trout had thrived in Northwest waters, only to fall victim in the last hundred years to dams, irrigation, logging, plows, cows, agricultural chemicals and fisheries. Even the hatcheries conceived to restore fish runs had backfired by replacing a palette of genotypes with a few stocks chosen for their convenience and commercial payoff.

The papers presented during the symposium addressed the wild fish question from one of four perspectives: management concerns, habitat needs, rebuilding efforts, and case histories of selected fisheries. Most of the speakers were cautionary. As for the few optimists, they dispensed their cheer in small doses. Yet by the day's end the mood was anything but defeatist. There is an uplifting power in knowing the anatomy of the problem, no matter how gigantic.

Among those who spoke on management, Jim Lichatowich struck a philosophical note when he defined a wild population as: " . . . a population having sufficient genetic diversity to continue the process of evolution. A wild population is capable of adapting to the changing physical and biological habitat." He called for a more encompassive approach, saying that wild fish management is ecosystem management, and that fisheries personnel should lift up their eyes to the hills. (This call is not a new one, but fisheries managers, who hate to get their feet dry, still resist hearing it.) Jim went one step further to postulate a direct relationship between wild fish survival and an ecosystem's livability for humans.

Other management-oriented speakers were more concerned with the mechanics, economics and politics of maintaining wild fish in the 21st century. Fred Everest revealed how a project that increased spawning grounds on a Clackamas Basin tributary actually degraded it for wild steelhead populations. It seems the real constraint was a shortage of rearing habitat, which the new spawning gravels replaced. Fred's point: Before engaging in wholesale makeovers of streams, we need to evaluate our efforts to enhance wild fish. Larry Schoenborn contrasted the Northwest's sport fishing to that of the Great Lakes, where introduced salmon and steelhead have created a multibillion-dollar industry. According to Larry, similar economic success is possible in

Oregon, given enhanced fish runs and reduced commercial and Indian harvests. Jim Martin counseled against division among the ranks of fishermen, and he cautioned wild-fish advocates, sometimes perceived as "flyfishing yuppies," against making their cause a holy war. He called for an end to the periodic salmon allocation battles that weaken the voice of fisheries on larger issues.

The papers on habitat needs sought recovery of stream conditions that once supported approximately 14 million breeding salmon in the Columbia Basin alone, vs. the present run of approximately 2.5 million. Jim Sedell, Gordon Reeves and Fred Everest called for a strategy that would bring back the extensive riparian vegetation eliminated in the last century by logging, grazing, farming, road-building, channelization and mining. In turn, this vegetation would stabilize banks and, in time, add structure to the stream in the form of woody debris. Moreover, the cost would be less than if the stream were artificially restructured, and the woody debris would withstand a greater range of environmental conditions than do such artificial structures as gabions, riprap, boulder weirs and log weirs.

Wayne Elmore spoke for improval of riparian habitat in arid Eastern Oregon where riparian systems not only reduce erosion and clarify water, they also recharge aquifers. He cited examples of streams whose riparian vegetation, water tables and trout fisheries were revived by a combination of grazing management, juniper removal and prescribed burns. Wayne recognized the Oregon Cattlemen's Association for recently adopting a riparian management policy that seeks to stabilize streams and improve stream flows. Such a policy is a hopeful signal, since recovery of rangeland streams will require the cooperation of ranchers.

The matter of water was taken up by Tom Simmons, who proposed that the frontier system of issuing water rights be modified to meet emerging public needs. He objected to entrusting those rights to the agricultural sector at the expense of recreation, industry, municipalities, fisheries, and the aesthetic and environmental values of flowing rivers. Too many water permits have been granted, he said, and there were already too many in 1975 when the State Engineer announced that no more should be issued—yet another 23,000 of them *were* issued in the subsequent 11 years, bringing the total to more than 100,000. Tom described means whereby Oregon might fashion a reasonable balance between instream and out-of-stream allocation of water. Without instream water, of course, any talk about the future of wild fish is a mockery.

The papers on rebuilding wild fish populations began with Bill Bakke's semantic discourse on enhancement, mitigation and restoration. Bill asserted that *mitigation*, meaning "to make mild or less painful," is a popular word among politicians and agency personnel, who shy away from using *restoration*, a more substantive and aspiring word.

Kai Lee reviewed the Northwest Power Planning Council's fish and wildlife program, which costs Northwest ratepayers upwards of $30 million a year plus another $60 million or so in power revenues lost because of water spilled over dams to facilitate the seaward migration of young salmonids. (The figure on lost revenues presumes that a market exists for power sales during the spring migration.) Kai defined the Power Council's role as that of an investment banker whose "basic asset is the gene pool, the store of information that underlies all the biological productivity of salmon and steelhead runs." Thus he deplored recent Council decisions that deemphasized wild fish in favor of increased hatchery propagation.

Tim Wapato, executive director of the Columbia River InterTribal Fish Commission, supported mitigation efforts proposed by the Power Council, and he defended his earlier admonition that the Council should not get married to wild fish. He was also in favor of outplanting hatchery fish as a means of rebuilding natural runs. Unfortunately, Tim did not submit a manuscript for this collection.

Brian Brown and Dale Evans continued the scrutiny of efforts to rebuild fisheries in the Columbia Basin. They downplayed the need at this time for stream rehabilitation projects, pointing instead to poor dam passage as the real problem. According to them: "There are few areas in the upper basin where spawning and rearing habitat are the primary factors limiting production. Wild fish, even more than hatchery stocks, depend upon improved survival at and between (hydropower) projects on the Columbia and Snake rivers." Brian and Dale chastised the Corps of Engineers for delaying installation of the fish bypass facilities and turbine screens recommended repeatedly by the Power Council, government fish agencies and tribes.

The final four papers in this volume are case histories involving very different fisheries and rivers. Doug Cramer wrote on Oregon's Clackamas River, Bob Tuck on Washington's Yakima Basin, Bill Wilson on Alaska's Noatak River, and Bill Hosford and Steve Pribyl on Oregon's Blitzen River. Some of the same problems recurr, such as the competition between wild and hatchery stocks. But each story has many peculiarities. There are differences in watershed dynamics, land-use practices, previous exploitation, fishing pressures, genetic assets and human desires. Taken together, the case histories provide a feel for what fisheries management is all about.

This symposium took place three years ago. For proponents of wild fish, its contents have, if anything, become more crucial with the passing of time. In 1986, 101 historical salmon and steelhead runs had been lost in the Columbia Basin, according to information compiled by Oregon Trout. Two more can now be added to that ignominious list—Snake River coho, lost in 1987, and Salmon River Sockeye in 1989. Still more stocks disappeared historically from rivers draining the Coast Range, where Oregon Trout estimates that another 40 are threatened. The fate of remaining wild salmon and steelhead in the 21st century depends on how we manage fisheries and resolve hatchery questions. It depends on how we reduce hydropower mortality and allocate water. And it depends on how we enhance riparian zones and influence land-use practices. The following papers can help us deliver wild fish to the future.

Dan Guthrie
Oregon Sea Grant
September 1989

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MANAGEMENT
OF
WILD SALMONIDS

Misfortunes one can endure—they come from outside, they are accidents. But to suffer for one's one faults—oh! there is the sting of life.

—Oscar Wilde

It is a matter of regret that many low, mean suspicions turn out to be well founded.

—Edgar Howe

God sends meat and the Devil sends cooks.

—English proverb

The higher a monkey climbs, the more you see of its behind.

—Gen. Joseph "Vinegar Bends" Stillwell

Speak to the earth, and it shall teach thee.

—Bible, *Job*

Wild Fish Management

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Why wild fish? What brings so many of you to a Saturday morning meeting to hear words about them? If I took a poll, I'm sure it would show many different reasons for your interest. However, I also believe that if we looked deep enough, we would get to a common thread, which is this: All of us recognize that we and the fish have to live in our ecosystem; and to the extent that we manage the ecosystem so wild fish survive, we will also make it a more livable place for us.

What are wild fish? Some people define them by the absence of hatchery fish. To such people, a fish is wild if it has no ancestors of hatchery origin. Others define wild fish as progeny of parents that spawned in the natural habitat, regardless of the parents' history. Both definitions focus on the individual fish and its history. The focus on individuals is misplaced because it is not the individual that persists, it's the population. Individuals contribute to the persistence of the population by serving as vehicles for passing genetic material from one generation to the next. In addition, individuals are important because of their ability to take a fly, something a population cannot do. If the goal of management is to look beyond the individual fish and ensure the persistence of the population, then the definition of wild fish, to be relevant and helpful to management, needs to be stated in terms of the population.

My definition of a wild population is this: *It's a population having sufficient genetic diversity to continue the process of evolution; a wild population is capable of adapting to the changing physical and biological habitat.* This definition is contextual in that it considers the population and its genetic makeup in the context of the physical and biological habitat. Whether for purposes of definition or management, wild fish cannot be described or managed out of the context of the fishes' habitat and ecosystem. Wild fish management is ecosystem management.

Management that attempts to nurture reproductive capacity and ensure the persistence of a renewable resource like wild fish is essentially a continuous problem-solving process. Problems are created by the thousands of people who in some way, big or small, use part of the resources of the ecosystems; individuals like you and me, trying to maximize their own recreational, esthetic or economic interests. Individuals pursuing the goals of their own value systems often are destructive to the health of the ecosystem, especially as it relates to production of wild fish.

While a healthy trout population may be the goal of anglers, many other users disagree. They look at the same river but their vision translates to a different image. For example, the power engineer may see the river as a series of equations describing potential electrical production, while to the irrigator it represents crops. Add to these the views of the factory owner, the municipal water department, and the building contractor, and the multiplicity of goals for the same watershed becomes apparent. Historically, various users have exploited their part of the watershed independent of the needs of other users. Conflicts created by this approach are especially difficult to resolve because individualism and the individual's right to pursue economic dreams have played such a strong role in shaping our national character and attitudes (Bellah et al., 1985).

Aldo Leopold (1966) said: "Conservation is a state of harmony between men and land." I believe ecosystem management (wild fish management) is the attempt to foster that harmony through the appropriate choice of solutions to the problems created by the diverse array of resource users in an ecosystem. The rest of this discussion will focus on the characteristics of good solutions to problems in wild fish management. I found the basis for these ideas in the writings of Wendell Berry (1981), a great practical ecologist. Practical because Wendell is, first of all, a farmer, so he understands that we have to use our ecosystems to enjoy the fruits of productive stewardship. He also understands that effective management nurtures the ecological processes of the land and water.

The following are a few guidelines that characterize good solutions.

A good solution solves not only the immediate problem, but radiates secondary benefits through the ecosystem

An example of this kind of solution is the restoration of Bear Creek's riparian zone. Bear Creek is a tributary of Crooked River in Central Oregon. Wayne Elmore's paper, also in this symposium, gives more details on its restoration. Prior to restoration, Bear Creek was dry during parts of the summer, and trout populations had been absent since the 1960s. Then the stream was fenced, the pasture allowed to rest for five years, and felled junipers were anchored to the stream bank. Today, the stream banks have stabilized, the lower pasture has quadrupled in grazing capacity, and trout populations have returned. Several anglers with limit catches were checked this year (personal communication, Wayne Elmore, BLM, July 7, 1986). Restoration of the riparian zone on Bear Creek has checked soil erosion, increased forage for cattle, and with year-round flows the trout population has been reestablished. Restoration of a healthy riparian zone has radiated benefits to more than one part of the ecosystem, and has begun the process of recreating the harmony Aldo Leopold envisioned.

A good solution does not create other problems

This, the flip side of the previous guideline, may be illustrated by some aspects of Oregon's hatchery program for coho salmon (*Oncorhynchus kisutch*). During the 1940s and '50s, the catch of coho was at a low compared with the previous two decades (Oregon Department of Fish and Wildlife, 1982). Biologists placed part of the blame for the decline in production on the degradation of freshwater habitat and overfishing (McKernan et al., 1950). To circumvent freshwater rearing and increase production for the fishery, managers turned to hatchery technology. The hatcheries made a dismal showing in the1940s and '50s. But research and experience during those decades brought advances in nutrition, disease control and prevention, and hatchery practices. So in the 1960s, as the survival of hatchery fish increased and the fishery began growing, it was logical to assign credit to the new hatchery technology (Lichatowich and McIntyre, 1987). Growth in hatchery programs and the catch continued into the 1970s, when adult production crashed even though production of hatchery-reared coho continued to increase (ODFW, 1982).

Although degradation of freshwater habitat was a factor in the decline of wild coho salmon, we now know that the major reason for the increase in survival of coho in the '60s was the improvement in ocean conditions; conversely, the crash after 1977 was the result of a return to poor ocean conditions (Nickelson, 1986). By seeking a narrow, technological solution to the production lows of the 1940s and '50s, and ignoring the broader ecosystem view, several additional problems were created:

- As catch increased in response to greater hatchery production, wild stocks were overfished while spawning escapements declined drastically (Lichatowich and McIntyre, 1987).

- The commercial fishing fleet increased in part because of the stepped up coho production. The number of licenses issued to individual fishermen increased from 2,565 in 1960 to 8,566 in 1978 (Carter, 1981). Most of this increase probably was based on the assumption that hatchery technology would maintain high populations. With the crash in production in 1977, coastal fishermen and local economies again were faced with hard times.

- Since wild coho smolts appear to survive ocean rearing at a higher rate than hatchery fish during low upwelling (Nickelson, 1986), the loss of wild production due to overharvest probably meant that coho production after the 1977 crash was lower than it would have been if wild stocks had remained at optimum levels.

- To counteract effects of overharvest and bring coastal streams up to full seeding, surplus hatchery fry were planted in coastal streams. We now know that the hatchery fry displaced wild coho fry, further reducing their numbers. Subsequently, when the hatchery coho returned as adults and spawned in streams where they had been stocked, their progeny showed poor survival, which further reduced total production (Solazzi et al., 1983, and Nickelson et al., 1985).

Instead of resolving problems of coho production, the heralded hatchery programs generated biological and economic problems.

Good solutions are disciplined

By disciplined, I mean biological problems receive biological solutions, and economic problems receive economic solutions. In the previous example of the coho fishery, what was primarily an economic and social problem—managing fleet size and fishing methods to correspond with swings in biological productivity—was approached as though it were a biological problem, one that could be solved by the use of narrow technology. The result was a negative effect on both the biological and economic components of the ecosystem.

Good solutions do not diminish diversity, and they use native material as much as possible

In his novel *Ragtime*, E.L. Doctorow describes a meeting between the tycoons Henry Ford and J.P. Morgan. At that meeting Morgan praises Ford's assembly line as an ingenious replica of the organic world where organisms are fashioned from interchangeable parts. No doubt the use of the machine as a model for biological systems has led to many advances in biology, not the least of which is the ability to transplant organs from one individual into another. Yet there's something disturbing about the application to biology of another feature of Ford's assembly line—what I will call the economy of scale. By this I mean the use of large, centralized production facilities that standardize operations for maximum economic efficiency. This results in uniformity in the process and product. One only has to look at today's public and private hatcheries to confirm this trend. The dominant force in the design of these ever larger facilities seems to be economic.

I would not be concerned if the megahatcheries were chicken farms where the product goes directly from farm to processor to consumer. In fact I appreciate the $.59 per pound chicken produced by the economy of scale. However, a hatchery fish has to live in and interact with the natural ecosystem between the time of its release and ultimate capture or return to a hatchery.

I believe the basic premises of the economy of scale are in direct conflict with the conservation of diversity. I am not aware of any example in the temperate climatic zone where nature has evolved anything similar to the economy of scale. In fact nature seems to employ the opposite approach: the use of phenotype diversity to spread the risk associated with fluctuating environments (Den Boer, 1968). To the extent that megahatcheries maintain uniformity in the production process and thus exert selection pressure on the hatchery stock toward phenotypic sameness, they will have a negative impact on the wild stocks of fish in the vicinity.

Where economy of scale of megahatcheries comes into contact with the natural diversity in aquatic ecosystems, there is going to be conflict and wild fish are going to suffer. How well the problem is resolved in the future depends on our ability to separate the social, economic and biological aspects of the problem, and approach their solution in a disciplined way as described above.

Ricker (1972) says that we have about 10,000 stocks of salmon and steelhead in the North Pacific region. How much of that diversity we should conserve we don't know. Plant geneticists have recognized for a long time the need to conserve genetic diversity in major food crops. In fact we are now conserving 30,000 wheats, 20,000 rices, and 15,000 sorghums, which may not be enough to ensure adequate food production in the future (Harlan, 1972). Larkin (1980) suggests that fisheries science is about 20 years behind plant breeders in the application of genetic information to management. If he is right, by the 21st century we should have a better understanding of genetics and possess the ability to make informed decisions about the conservation of genetic diversity. But Larkin may be too optimistic. In the meantime, our solutions to problems should conserve what diversity we have left.

Good solutions prevent problems

One of the purposes of progressive fisheries management is to make decisions that avoid problems, especially problems that result in permanent damage to the reproductive capacity of the ecosystem. However, as I pointed out earlier, conservation can and does conflict with other uses of an ecosystem's resources. When this happens, the accepted procedure is to calculate a cost/benefit analysis to aid the decision maker. In the management of renewable resources the analyses of costs and benefits present special problems.

Our use of the ecosystem is often going to change fish habitat. To cope with these changes, wild fish populations rely on the adaptive potential inherent in their genetic diversity. The nature and magnitude of future changes in the ecosystem are impossible to predict, and equally impossible to predict are the amount and type of genetic diversity wild populations will need to cope with those changes. Now, when a manager must decide between protecting genetic diversity but at an economic cost, and allowing an economic gain but with a loss of genetic diversity, how can the cost of the latter be calculated? It involves putting a dollar figure on future problems that can't be described, problems that may occur if the population does not have sufficient genetic diversity to cope with habitat changes. I don't believe we have the ability to forecast such costs.

However, costs can always be calculated with hindsight. For example we can go back now and do a cost/benefit analysis for the decisions that led to the collapse of the fishery on California sardines (*Sardinops sagax*). But such calculations wouldn't restore the sardines.

LITERATURE CITED

Bellah, R.N., R.M. Madsen, W.M. Sullivan, A. Swidler, and S.M. Topton. 1985. Habits of the heart. University of California Press.

Berry, W. 1981. The gift of good land. North Point Press, San Francisco.

Carter, N.C. 1981. Multi-fishery activity in Oregon commercial fishing fleets: an economic analysis of short-run decision-making behavior. Doctoral dissertation. Oregon State University, Corvallis, Oregon.

Den Boer, P.J. 1968. Spreading the risk and stabilization of animal numbers. Acta Biotheoretica 18: 165-194.

Harlan, J.R. 1972. Genetics of disaster. Journal of Environmental Quality 1: 212-215.

Larkin, P. 1980. Pacific salmon: scenarios for the future. Donald L. McEman Lectures in Marine Affairs. University of Washington Sea Grant. Seattle, Washington.

Leopold, A. 1966. A sand county almanac. Oxford University Press. New York.

Lichatowich, J.A. and J.D. McIntyre. 1987. Use of hatcheries in the management of Pacific anadromous salmon. Dadswell, M.J.; Klauda, R.J.; Moffit, C.M.; Saunders, R.L., eds. Common strategies of anadromous and catadromous fishes. American Fisheries Society, Symposium No. 1.

McKernan, D.L., D.R. Johnson, and J.I. Hodges. 1950. Some factors influencing the trends of salmon production in Oregon. Transactions of the 15th North American Wildlife Conference 15: 427-449.

Nickelson, T.E., L.A. Van Dyke, and D.L. Bottom. 1985. Coastal coho production factors. Oregon Department of Fish and Wildlife. Progress Report. Project No. AFS-74-4. Portland, Oregon.

Nickelson, T.E. 1986. Influences of upwelling, ocean temperature and smolt abundance on marine survival of coho salmon (*Oncorhynchus kisutch*) in the Oregon Production Area. Canadian Journal of Fisheries and Aquatic Sciences 43: 527-535.

Oregon Department of Fish and Wildlife. 1982. Comprehensive plan for production and management of Oregon's anadromous salmon and trout. Part II. Coho Salmon Plan, Oregon Department of Fish and Wildlife, Portland, Oregon.

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations. Simon, R.C.; Larkin, P.A., eds. The stock concept in Pacific salmon. H.R. MacMillan Lectures in Fisheries. University of British Columbia. Vancouver, B.C.

Solazzi, M.F., S.L. Johnson, and T.E. Nickelson. 1983. The effectiveness of stocking hatchery coho presmolts to increase the rearing density of juvenile coho salmon in Oregon coastal streams. Oregon Department of Fish and Wildlife. Information Report No. 83-1. Portland, Oregon.

Salmonid Habitat: New Beginnings through Enhancement, But Not without Uncertainty, Risk and Failure

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Introduction

Salmonid resources of the West Coast have declined dramatically over the last four decades. Much of the decline can be attributed directly to loss of natural habitats resulting from human activities, such as hydropower development, forest management and livestock grazing. Public and private organizations have recognized in the last decade that wild fish produced in healthy natural habitats are one key to restoring the valuable salmonid stocks of the Pacific Coast. Consequently, rehabilitation and enhancement of natural habitats has become a focal point for sportsmen, biologists, administrators and legislators in recent years.

Salmonid habitat improvement is riding a wave of grass-roots support all along the Pacific Coast. In the next decade as much as $100 million will be spent on enhancement efforts from California to Alaska. A substantial portion of that will go to anadromous trout and salmon habitat. We applaud the effort, but money alone will not produce additional fish. More knowledge is needed to make sure the money is spent wisely.

Enhancement of natural habitats is a risky business because most of the work is done without adequate knowledge of the factors limiting production of salmonids in streams. Consequently there is a significant probability that much of the current and future investment in habitat enhancement will be wasted. The exact amount of waste might never be known since few projects are adequately evaluated at present. Unfortunately, the funding for habitat enhancement has, in most cases, arrived before the knowledge needed to use it effectively. Habitat managers are doing the best they can with the knowledge they have, but the work is still largely experimental and frought with uncertainties.

There is a proven way to ensure efficient investment of habitat improvement funds. The way can be summarized in one word: ***evaluation***. Detailed evaluations of enhancement efforts can provide quick feedback of vital information to enhancement planners and executors, identifying techniques that succeed and eliminating those that fail.

Here are two examples of how this process has worked in the enhancement/evaluation project on Fish Creek, a tributary of the Clackamas River in northwest Oregon.

The Project

Construction and evaluation of salmonid habitat improvements on Fish Creek began simultaneously in 1982 when the Pacific Northwest Forest and Range Experiment Station (PNW) entered into an agreement with the Mt. Hood National Forest to evaluate fish habitat improvements constructed there by Estacada Ranger District personnel. Several factors that possibly limit production of salmonids in the basin were identified during the first year of the study, and the scope of the habitat improvement effort was subsequently enlarged.

The habitat improvement program and the evaluation of improvements were both expanded in mid-1983 when the Bonneville Power Administration (BPA) entered into an agreement with the Mt. Hood National Forest to provide additional funding for work on Fish Creek. Habitat improvement work in the basin is designed to increase the annual number of outmigrating smolts for chinook, salmon and steelhead.

The primary objectives of the basinwide evaluation include:

1. Evaluation and quantification of changes in salmonid spawning and rearing habitat resulting from a variety of habitat improvements;
2. Evaluation and quantification of changes in fish populations and biomass resulting from habitat improvements;
3. Evaluation of the cost-effectiveness of habitat improvements developed with BPA and Forest Service funds on Fish Creek.

Several prototype enhancement projects were constructed and evaluated during the first three years of the study. The intention was to identify successful techniques that could then be broadly applied within the basin. This stepwise procedure has been largely successful in identifying the most promising enhancement techniques for the Fish Creek basin.

Description of the Study Area

The Fish Creek basin lies in north central Oregon on the west slope of the Cascade Range and drains into the upper Clackamas River (Fig. 1). The watershed is 21 km long, averages approximately 10 km in width, and covers 171 km^2. The terrain is steep and mountainous with bluffs in the lower canyons typical of the Columbia River Basalt formation. The valley bottoms are typically narrow with incised stream channels and narrow flood plains.

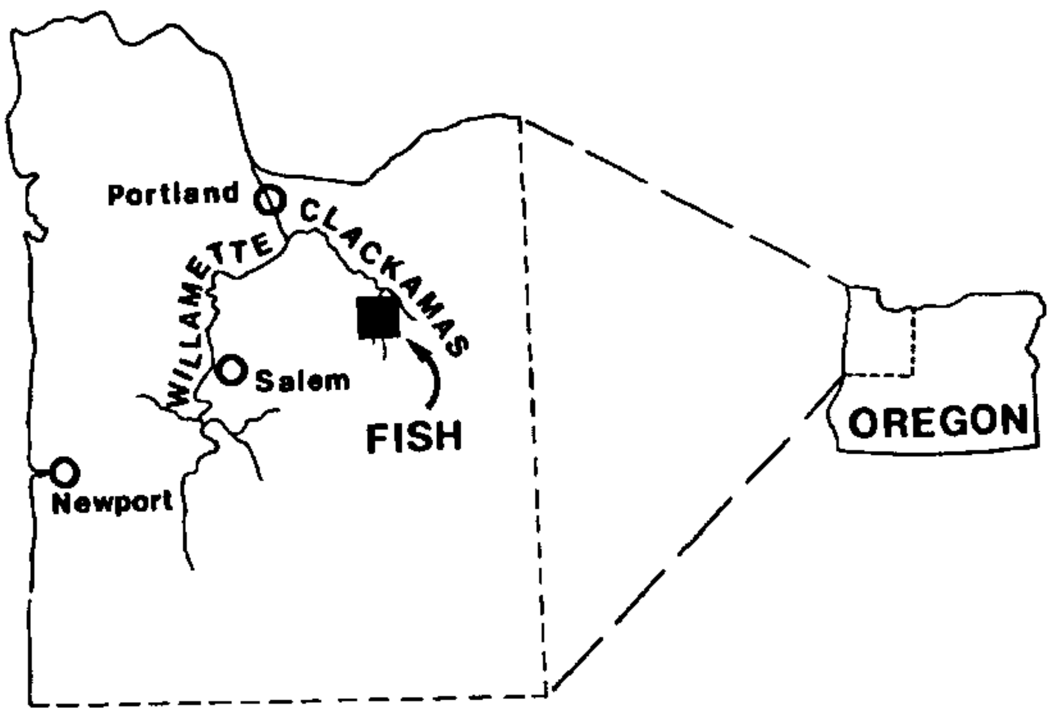


Figure 1. The Fish Creek basin is located in northwest Oregon.

Fish creek heads near the summit of the Cascade Mountains at an elevation of about 1,400 m and flows generally north for about 21 km to its confluence with the Clackamas River about 14 km east of North Fork Reservoir. The channel gradient is steep throughout this distance, generally exceeding 5 percent except for the lower 6 km where gradients average 2 percent. The steep gradient and volcanic geology create a stream with predominantly riffle environment and boulder substrate. The main stem of Fish Creek is 5th order as defined by Strahler (1957), and the annual flow variation near the mouth ranges from 0.5 m^3/sec in late summer to more than 100 m^3/sec during winter freshets.

The Fish Creek basin supports a significant population of anadromous salmonids, including summer and winter steelhead (*Salmo gairdneri*), spring chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*). Approximately 16 km of habitat are used by anadromous salmonids, including the lower 4.7 km of Wash Creek, a major tributary of Fish Creek. The upper reaches of both Fish and Wash creeks are blocked to anadromous salmonids by major waterfalls.

Habitat Evaluation

Habitat conditions in the Fish Creek basin were surveyed by the Forest Service in 1959, 1965 and 1976. The 1965 survey, conducted after the December 1964 flood, noted an apparent shortage of spawning gravel for anadromous salmonids in the basin. Similar conclusions were reached following the 1976 survey. Consequently, the initial efforts in 1981 and 1983 to improve habitat were directed towards increasing the quantity of spawning habitat for steelhead.

Subsequent habitat analyses initiated in 1982 and continued each year thereafter (Everest et al., 1984, 1985, 1986) have revealed a different picture. The general distribution of spawning and rearing habitat of each species of anadromous salmonid in the basin was identified. The amount of usable spawning gravel was quantified (Table 1), and rearing habitat available to each species was divided into major habitat types and quantified (Table 2). Fish populations in the basin also were quantified by habitat type (Table 2) so habitat preferences and utilization by each species could be identified. An attempt was made to identify habitat preferred by each species in summer and in winter.

Table 1. Natural spawning gravel for anadromous salmonids in the Fish Creek system in 1982, and additional spawning gravel created by boulder berms, 1985.

Species	Natural gravel (m^2)	Berm gravel (m^2)	Percent increase from berms
Chinook	190	0	0
Coho	570	0	0
Steelhead	1,350	205	15

The results of the detailed habitat analysis indicated that, for steelhead, rearing rather than spawning habitat was limiting smolt production in the basin (Table 3). Assumptions used in this type of analysis should be based on local data whenever possible. Preferred rearing habitats of steelhead in summer (Table 2) and winter were also identified. Densities of age 0+ steelhead were found to be highest in side channels and along the margins of riffles in summer. Age 1 and older steelhead preferred summer habitats consisting of deep bouldery riffles, and pools with boulder substrate. Winter habitat for both age groups consisted of loose bouldery substrate in riffles, pools and glides where fish can hide in stable interstitial spaces.

Young coho salmon were found to prefer off-channel beaver ponds and side channels, both in summer and in winter.

Table 2. Areas of rearing habitats available to each species of anadromous salmonid in Fish Creek, and associated densities and biomass.

FISH CREEK, SEPTEMBER 1983

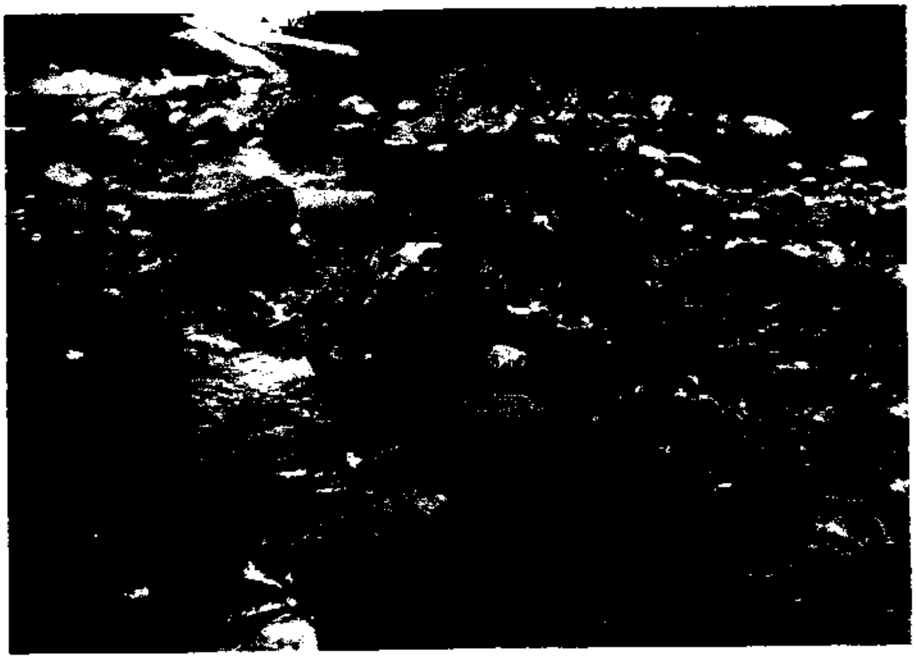
SPECIES	HABITAT	AREA IN SYSTEM	NUMBER FISH ESTIMATE BY HABITAT	BIOMASS(g) FISH ESTIMATE BY HABITAT	#/m^2	g/m^2
COHO	Alcove	1,170	220	1,080	0.19	0.92
	Riffle	104,820	5,340	29,680	0.05	0.28
	Sidechannel	2,230	130	380	0.06	0.17
	Pool	9,160	1,500	6,900	0.16	0.75
	Beaver pond	300	240	670	0.80	2.24
	Total	117,680	7,430	38,710	0.06	0.33
CHINOOK	Alcove	1,170	10	30	0.01	0.03
	Riffle	104,820	490	1,960	0.01	0.02
	Sidechannel	2,230	—	—	—	—
	Pool	9,160	640	2,950	0.07	0.32
	Beaver pond	300	—	—	—	—
	Total	117,680	1,140	4,940	0.01	0.04
0+STHD	Alcove	2,450	610	1,710	0.25	0.70
	Riffle	219,360	53,870	150,840	0.25	0.69
	Sidechannel	6,200	1,760	5,610	0.28	0.90
	Pool	20,850	3,780	12,470	0.18	0.60
	Beaver pond	300	10	30	0.03	0.11
	Total	249,169	60,030	170,660	0.24	0.68
1+STHD	Alcove	2,450	90	2,370	0.04	0.97
	Riffle	219,360	23,760	427,140	0.11	1.95
	Sidechannel	6,200	340	5,780	0.05	0.93
	Pool	20,850	2,800	53,960	0.13	2.59
	Beaver pond	300	0	0	—	—
	Total	249,160	26,990	489,250	0.11	1.96
ALL SALMONIDS	Alcove	2,450	930	5,190	0.38	2.12
	Riffle	219,360	83,460	609,620	0.38	2.78
	Sidechannel	6,200	2,230	11,770	0.36	1.90
	Pool	20,850	8,720	76,280	0.42	3.66
	Beaver pond	300	250	700	0.83	2.33
	Total	249,160	95,590	703,560	0.38	2.82

Table 3. Smolt production capability of steelhead trout spawning and rearing habitat in the Fish Creek basin, 1983.

Spawning	
area per redd	$2.5m^2$
gravel in system	$1,350m^2$
potential redds	540
potential eggs	1,118,000
potential fry	356,400
potential parr	71,300
potential smolts	17,800
Rearing	
area per smolt	$24m^2$
area in system	249,160
potential smolts	10,400

Description of Habitat Improvements

Construction of habitat improvements began before the detailed habitat evaluations were completed. The first prototype project we wish to use as an example of the benefits of evaluation consisted of a series of boulder berms constructed to enhance spawning habitat by impounding bedload gravels moving downstream on freshets. By 1983, 26 boulder berms had been constructed with heavy equipment by removing the armor layer from the stream bed at specific locations and stacking the boulders in a V-shaped curve oriented downstream (Fig. 2). Finished berms ranged from 1 to 1.5 meters in height and were up to 30 m long. All but three of the berms extended from bank to bank across the stream. Several berms built in 1981 and 1983 did capture suitable spawning gravels on subsequent freshets and the gravels were used later as reproductive areas by steelhead.



Before

After

Figure 2. Boulder berm sites on Wash Creek before and one month after construction.

The second project we would like to use as an example of the benefits of evaluation is an off-channel rearing pond designed to enhance coho salmon production in the Fish Creek basin (Fig. 3). The rearing pond was developed by building a gravity-feed pipeline from Fish Creek to an ancient flood terrace on the east bank of Fish Creek about 200 m below the pipeline intake. The pipe is about 135 m long, 25 cm in diameter, and can deliver about 35 l/sec to the pond. The pond, which formerly was dry in summer, is approximately 90 m long and 60 m wide. Depth varies from about 0.2 m to 1.25 m, and the surface area is about 0.5 hectares. Pond volume is about 3,600 m^3. Water from the pipeline maintains a near constant water level in the pond year-round.

A second source of water was developed by diverting a small tributary at the northeast end of the pond. The stream formerly bypassed the pond but now flows directly into the north end.

After completion the pond was stocked in 1984 with native coho fry to assess its potential for coho smolt production.

Figure 3. Off-channel rearing pond covers 0.5 hectare and simulates a large beaver pond.

Evaluation Results

Casual observation suggests that both types of projects increased fish production. The boulder berms were designed to increase spawning area, which they did, and the newly created spawning habitat was used by adult steelhead. At first glance this looks like an enhancement success story, but a detailed evaluation has indicated otherwise.

Enhancement of spawning habitat was based on the premise that lack of available spawning gravel was limiting steelhead production in the basin. Our detailed habitat analyses indicated that prior to construction of the berms, spawning habitat was more than adequate to seed available rearing areas. The factors limiting production were summer and winter rearing habitat for age 1 and older steelhead.

It is doubtful that additional spawning habitat created by the berms improved smolt production in the Fish Creek basin. Even though adult steelhead have been observed spawning on gravels behind the berms, the system contains sufficient gravels that spawning could have occurred elsewhere if the berms had never been built. The berms probably resulted in a redistribution of spawning activity rather than an increase in the number of spawners.

On the negative side, the berms were built in riffles with boulders and cobbles taken from the wetted perimeter of the stream bed. Bouldery riffles are a preferred summer rearing habitat and also provide winter habitat for age 1 and older steelhead. Construction of the berms resulted in a loss of both types of habitat, because boulders were removed from a relatively even distribution on the stream bed and consolidated into berms. Since this was a prototype project, it affected only a small area of the total stream bed (less than 5 percent), so it is improbable that steelhead smolt production was significantly reduced.

If an immediate intense evaluation of the prototype berms had not been made, the first appearance of success might have led to a more extensive berm construction project that could have seriously impaired steelhead smolt production in the basin. Findings from the evaluation of the berms were quickly channeled into the enhancement planning process, and future enhancement emphasis will be placed on other types of projects.

The second project—construction of the off-channel coho salmon rearing pond—was initiated after the detailed habitat analysis. The analysis indicated that beaver ponds were the most productive habitat type in the system for coho (0.8 fish/m^2 in 1983) and also the habitat in shortest supply (about 0.1 percent of total habitat). Creation of simulated beaver ponds appeared to have a high probability of increasing coho smolt production in the basin. The approximately 5,000 m^2 pond previously described was developed in 1983 and stocked with 1,326 coho fry in the spring of 1984.

Outmigrant smolts from both Fish Creek and the pond were counted in the spring of 1985. A total of 493 smolts from the small population of introduced fry left the pond between April 15 and June 8, 1985. Their mean length was 124.6 mm, substantially greater than the 113.3 mm mean length of Fish Creek smolts.

The off-channel pond, even though it was not fully stocked with fry, made a significant contribution to coho salmon smolt production from Fish Creek in 1985. The creek produced 2,606 coho smolts while the pond contributed another 493, which represented an 18.9 percent addition to the run. This contribution is particularly remarkable since the pond represents only about 2.5 percent of the habitat area of Fish Creek. The total carrying capacity of the pond remains unknown, but potential coho smolt production may be as much as four times greater than was observed in 1985.

The prototype project proved successful in terms of creating new habitat and increasing coho salmon smolt production from the Fish Creek basin. A detailed benefit-cost analysis has not been completed, but a preliminary analysis indicates that the project will be cost effective. Based on the success of the first pond, a second pond is now being developed.

Knowledge and Habitat Improvement

"Knowledge is power," according to an old quote. With habitat improvement projects, knowledge can mean the difference between success and failure. Biologists often work at the low end of the knowledge scale when attempting to enhance habitat by manipulating the physical structure of streams. Consequently, the risks of failure are high with most projects. There is a positive relationship between knowledge and success, and managers should strive to work at the upper end of the knowledge scale. Aquatic ecosystems are so complex that simple answers and guesswork rarely lead to successful enhancement projects.

The Evaluation Process

There is a systematic sequential process that must be followed if risk of project failure is to be minimized. The process is detailed and can only be described in general terms here. The enhancement/evaluation process has both temporal and spatial aspects. The procedure must begin with an evaluation of the present habitat conditions in a unit as large as a stream subbasin. Reach or site studies are inadequate because they provide no context for decision making. Once an inventory of habitat conditions has been completed, an intelligent assessment of limiting factors can be made, and the most promising enhancement techniques can be selected. After the type of improvements and their location in the basin have been determined, an evaluation of the improvements can be planned. The evaluation should include documentation of changes in physical habitat resulting from improvements, documentation of changes in smolt production, and a study of cost/effectiveness.

A sequential summary of the habitat improvement/evaluation sequence follows:

1. Identification of limiting factors
2. Identification of appropriate enhancement techniques
3. Construction of improvement
4. Documentation of habitat changes
5. Quantification of smolt output
6. Calculation of cost effectiveness

As habitat enhancement and evaluation proceed in concert, a knowledge base will eventually be built that allows reasonable predictions of the effectiveness of enhancement without detailed evaluations. The ability to make such predictions, however, is probably a decade or more away if the present minor investment in evaluation continues. We recommend a much greater emphasis on evaluation of enhancement projects until a knowledge base with predictive capability is established.

LITERATURE CITED

Everest, F. H. and J.R. Sedell. 1984. Evaluation of fisheries enhancement projects on Fish Creek and Wash Creek, 1982 and 1983. U.S. Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon. 98 pp.

Everest, F. H., J. R. Sedell, G. H. Reeves and J. Wolfe. 1985. Fisheries enhancement in the Fish Creek basin—an evaluation of in-channel and off-channel projects, 1984. U.S. Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon. 228 pp.

Everest, F. H., G. H. Reeves, J. R. Sedell, J. Wolfe, D. Hohler and D. A. Heller. 1986. Abundance, behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon, as influenced by habitat enhancement. U.S. Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon. 100 pp.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Am. Geophys. Union Trans. (EOS) 38: 913-920.

Harvest Management: Will It Work?

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Fisheries management in the 21st century? Good grief, that's only 13 years away! We'd better take a close look at the effectiveness of harvest management today if we are to speculate on trends for the future. We'll also try to look at the future for wild fish as well.

Recent Trends

In the last 20 years we've made tremendous strides by developing sophisticated fisheries management tools. Witness our computer models, coded-wire tags, microchip tags, digitized scale analysis, and sophisticated electrophoretic techniques. As a result, management is rapidly getting more high tech—and more expensive—as it gathers and analyzes far more data.

We can define the issues with greater technical know-how now, but can we solve the problems more rationally? Only if our policies and decision-making rationale keep up with the technical advances. For example, we can now use coastwide tagging and recovery information from salmon caught in various fisheries to define migrations and interceptions; yet we still debate endlessly the issue of fair entitlements among competing fisheries. Stronger policy and a regional management system will be needed to fully benefit from the technical data we are gathering. And as always, management costs are rapidly going up.

We've come a long way recently in getting together to make management decisions, as the Pacific Salmon Commission and the management councils established under the Magnuson Act prove. We've also made significant progress in resolving Indian fisheries disputes on the Klamath and Columbia rivers, Puget Sound and the Washington coast.

These forums for regional management provide better coordination and an opportunity for all interested parties to settle disputes. The flip side is that they are expensive, time-consuming and bureaucratic. It is increasingly difficult to pin down when and where the critical management decisions will be made and who will make them. The average citizen can easily get lost in the maze. Accountability may be lost when decisions are made by committees, commissions, or councils rather than by "fish czars."

"Cooperative Management" is the buzz word of the 1980s. And it's true there's much better cooperation among traditional adversaries in the fishing community. Indians, trollers, gillnetters, sportsmen and environmentalists all have learned how to handle conflict in a more compromising spirit. Gross political maneuvers and court battles are giving way to negotiated settlements. Increasingly, the enemies of old are able to form effective coalitions on issues of mutual concern, such as fishing treaties with Canada, development of offshore oil fields, or the slashing of federal fisheries programs.

We are beginning to plan the development of fisheries, and this has reinforced the need to integrate harvest and production efforts. We've seen how poorly planned enhancement can threaten important conservation and allocation objectives by resulting in unacceptable harvests of mixed stocks. Canada's "SEP," Washington's enhancement programs and Oregon's private hatcheries are examples of "free lunches" that turned out to be costly in terms of dollars, fish and politics.

The management plans for the future must be logical and clear on the many points involving production, harvest and harvest constraints. The Northwest Power Planning Council is working with fish agencies and tribes to develop such a plan for the Columbia Basin. The challenges are great because we must begin with today's fisheries, which are separate if not downright uncoordinated. We must plan the evolution to a better system without paralyzing the process now in place. The Pacific Salmon Commission's long-term plan for rebuilding chinook salmon may function as a model here.

The problem with planning is that we can't predict the needs and policies of future generations adequately. We have trouble evaluating tradeoffs, especially when mixing tangible and intangible benefits. We are hesitant to take risks, and we have a lot of biological, economic and political uncertainty to deal with. In spite of all this, we will keep planning for future production and harvest because the alternative is even more risky.

Management Report Card

Considering all these trends, how well are we doing our job? I give management a C+.

Fish runs are up substantially from the Fraser to the Sacramento rivers. The Columbia River runs are up dramatically because of increased hatchery production, reduced dam mortalities, less interception of mixed stocks at sea, and better ocean survival of smolts. We can take credit for some of this.

Overall, mixed stock harvest rates are being reduced in most ocean and some inland fisheries. Treaty Indians have been taking most of the heat for causing this, even though it will benefit the full array of stocks and fishermen in the long run by assuring a more dependable production base for the resource. We have actually pioneered a selective harvest strategy for hatchery steelhead in the Columbia River, which is a historic experiment with substantial implications for the future.

We have written more management plans than ever before, and we are beginning to deal more successfully with issues of economics, allocation and entitlement. In particular, Oregon can be proud of its coho and steelhead plans and of its leadership in basin planning efforts. The prospect of a Columbia Basin plan complete with a full complement of subbasin plans is exciting. We are settling more disputes around the planning table than in the courtroom, and that's good.

However, everything's not rosy in fish management today. There is a growing reliance on hatchery fish, which leads to a free-lunch mentality among some people. The question used to be: "Can we afford those expensive hatchery fish?" Now it's being replaced by: "Can we afford to protect those wild fish?"

One unfortunate side effect of the enhancement fad along the Pacific Northwest coast has been the unreasonable expectation that most benefits will accrue to mixed stock ocean fisheries. Anything less is regarded as tantamount to fraud, and is blamed on Indians, environmentalists or wild fish managers. The issue of mixed stock harvest constraints is one of values, discipline, and reasonable expectations for enhancement investment.

Meanwhile, wild fish advocates are becoming more militant and are rapidly moving to the more extreme edges of the conservation community. There is a disquieting trend for wild fish advocacy to be perceived as the latest *cause celebre* for the flyfishing yuppie. This perception by managers and by others in the conservation community will weaken the impact of groups such as Oregon Trout. We must pick our issues well and develop credible positions if we are to gather the support to win battles over the Salt Caves project, offshore petrochemical development, the Bonneville Power Administration's intertie proposal, and a sensible genetic resources management plan for Columbia River fish resources. We cannot afford to be perceived, and written off, as fringe-element radicals.

As always the pressure to develop the habitat is tremendous. Issues such as grazing, buffer strips, wilderness and roadless area management, spill versus electricity, and irrigation versus instream flow are always at the heart of the battle to protect the habitat base. The political pendulum swings from protection to development and back again regularly. We'll have to be "heads up" on the Northwest Power Plan, the forest plans and offshore development plans to be sure that fish receive adequate consideration.

The costs of protecting habitat, producing fish, restoring habitat or building hatcheries, and controlling harvest are fast increasing. Traditional sources of money, such as federal funding programs, are being cut. Because of political priorities, in many agencies harvest and hatchery programs are getting the lion's share of remaining budgets at the expense of habitat protection and enhancement programs.

Challenges for the Future

To meet the formidable challenges of the future will require a change of focus. To date, we have focused most of our energy on day-to-day issues. We must plan a long-term strategy.

We need to develop a more comprehensive policy foundation for fisheries management. For example, if we can describe a rationale for allocation, we might remove periodic allocation battles as a source of acrimony that drains our collective energy and blunts our effectiveness on larger issues. Such holy wars, while providing recreation and entertainment for many, hurt us all in the long run.

We need a policy for management expense and funding sources. We must avoid the natural evolution to dependence on more, and more expensive, high technology. We must come to grips with questions such as: "Can we ever have enough (or too much) habitat, hatchery fish, information, or coordination between entities?" We must discipline ourselves to spend our management money and energy wisely. We must develop long-term strategies for secure funding of the most important management functions.

We need a strategy for long-term habitat protection—and this is one of the greatest of our challenges. Grazing, logging, sea mining, power production, small hydro operations, estuarine and nearshore development, and water policy will be the issues that shape resources in the 21st century. Today, most of our efforts are focused on project-by-project, incremental losses. We must find a way to address these issues holistically and strategically as a state and a region. Power council planning, forest planning, and strategic water policy initiatives are unique opportunities. We must not let them get by us!

We can make it happen by building strong political coalitions. We need networks for communication and coordination between all the conservation interests. We must avoid the splintering of our effectiveness that comes from dissension within our team. We must involve the whole diversity of conservationists, Indians, trollers, flyfishermen, plunkers, plugpullers, environmentalists, fishery managers and bird watchers.

Let's return to the conservation philosophies of Aldo Leopold, Ernest Thompson Seton and Haig Brown. Professional managers should look to the wisdom of Riker, Allen, Warren and Larkin. These people focused on a broad conservation movement with sound philosophical and scientific foundations. We can learn much from them. Let's set aside devisive issues, plan for the long haul, and form our coalitions. We have plenty of challenges ahead for the 21st century if we keep fish a meaningful part of our heritage.

Who will Catch Tomorrow's Fish, and Where? An Angler's View

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Thank you Oregon Trout, Oregon Sea Grant and the American Fisheries Society for inviting us to today's symposium on wild trout, steelhead and salmon in the 21st century. The program is both interesting and enlightening because it features topics that are of concern now and will remain so throughout the next century.

Why am I among the first speakers? Were the organizers afraid of what I might say if I had a chance at rebuttal?

No. Today should be a day of harmony. We'll become more aware of our problems, some probably that we never knew existed; and we'll hear about proposed answers to many of these problems that affect a resource we love and enjoy so much.

I'd like to think I was chosen as a speaker because of the wonderful opportunities I've had fishing with top guides, sportsmen and biologists—with Curty Gowdy, Nancy MacHugh, Bob Toman and Dr. Howard Tanner—from Florida to Alaska and from Mexico to the Great Lakes. I've been able to sample the fishing at over 120 locations and can offer some comparisons.

This symposium is timely. In 1985 recreational fishing was the nation's fastest-growing participation sport, along with aerobics. Compared to 1984, 6.1 million more adults fished at least three times. Among the sexes fishing is the most popular participation sport for men, with 46 percent wetting a line at least three times last year, while 27 percent of the women fished at least three times.

It would be interesting to know if more people went fishing in Oregon and Washington last year. I doubt it. We have our problems. In Michigan, however, recreational fishing became the state's number one industry in 1985. It had been number two, behind the automotive industry, for many years. Because of our abundance of water, beautiful streams, coastline and scenery, we in Oregon and Washington have the opportunity to follow Michigan's lead. There are very few states with our potential.

I have now done six shows on Lake Michigan. For the first two we needed only four hours to land 17 chinook, plus another 12 that were hooked and lost. Shooting only during bright sunlight at Sturgeon Bay, Wisconsin, the guide and I landed seven German browns including four over 10 pounds.

I have just returned from Lake Michigan. In downtown Chicago, on the lake's shore about half a mile from the world's tallest building, I landed a 20-pound chinook hooked while we were letting our lines out. During the day we landed other chinook and coho, along with six lake trout that included 13 and 17 pounders.

The next day, my first ever in Indiana, we got a doubleheader at Michigan City: a Skamania steelhead and a chinook, caught while letting out lines. Within the first hour I landed a 20-pound steelhead, and later the guide landed 15 and 18 pounders.

It was interesting to find that Indiana steelhead are doing well. Because of the pioneering introductions there, steelhead programs will be expanded soon to neighboring states.

The average size of those Midwest steelhead is much larger than ours. Each season Indiana logs a new record. Last summer it was over 25 pounds, and new records will continue to be set, probably every year.

Why? The answer is very interesting. This is Indiana's tenth year since initially planting steelhead, and many of the biggest fish are now 10 years old. Their steelhead have no great obstacles to overcome in their spawning and post-spawning migrations. Also, they have no problems with readapting to salt water or coping with seals and other marine mammals.

Why do I bring up the Great Lakes? They are just one example, involving every state that even touches them, of improved recreational fisheries in the U.S.

North Dakota and South Dakota now have wonderful chinook fishing on Lake Sakakawea and Lake Oahe—reservoirs, each 180 miles long, on the Missouri River. They are also stocking an improved version of the walleye from Holland, which is larger and not as sensitive to barometric conditions.

Striped bass plantings have generated enthusiasm in quite a few states, including Utah, Arizona and the Midwest and South.

We have always had lots of competition for the tourist's and recreational fisherman's dollar. Alaska fishing boggles the imagination. British Columbia, Mexico, Montana, Idaho and Wyoming fishing is all it's cracked up to be. While visiting with anglers from the Rockies and the Plains states, I have found as much interest in a fishing trip to the Great Lakes as there is in heading our direction.

Are we standing still? No, not quite. Our summer steelhead runs are the bright spot. Our wildlife departments in Oregon and Washington have successfully introduced runs of these fish in almost every stream that will support them. They're working hard on this with excellent results. This is great because steelhead are the most special fish I've experienced.

We do have more than our share of problems, however. Here are a few, as I see them:

First, we must come to the realization that our migratory runs are worth far more recreationally than commercially. The studies are there. The figures are available.

- Why do we allow a gill-net fishery on our spring chinook?
- Why do we allow *any* gill-net fishery on the Columbia?
- This river could be our economic diamond mine but today we can't even let our old-timers plunk off the bank during parts of the year.
- And how can tourists plan a vacation to fish this river when we don't even know ourselves when or if it will be open?

Second, the tribal fishery needs to recognize the value of recreational fishing. Now, I'm not here to throw rocks at people I admire very much. In fact, I'm eager to listen to Tim Wapato and Bob Tuck later in the program. But I do have an idea and a challenge:

- Please investigate the potential of the economics of a recreationally based, tourism-oriented fishery on your waters.
- It could be powerful. I can envision lodges, guides, businesses and employment stemming from this.
- By way of comparison, next week I am doing a show at a brand new fishing lodge owned and operated by native Indians 90 miles from Nome, Alaska.

Third comes the uncertainty of our ocean seasons. How can can we promote tourism in this area when we don't know what we are doing ourselves and have so many different regulations for different areas?

Here's my list of a few more problems that need attention:

1. We need more steelhead and salmon using our natural spawning gravel. There should be emphasis on this in our stocking programs.

2. We need to eliminate the semiprofessional troll fishermen who are trolling part time to gain tax writeoffs.

3. Seals: we have too many. What can be done?

4. Catch-and-release programs call for a greater education effort. Which fish should be released? Why? Which saved?

You'll hear about other topics of concern from other speakers. They'll talk about the problems of habitat, water quality and quantity, forest practices, dams and irrigation. I'm looking forward to what these speakers have to say. We all are or we wouldn't be here.

HABITAT

AND

WILD SALMONIDS

What does education often do? It makes a straight-cut ditch of a free, meandering brook.
—Thoreau

It doesn't help to run faster if you're on the wrong road.
—German proverb

For men may come and men may go,
But I go on forever.
—Tennyson, The Brook

Though you drive away nature with a pitchfork, she always returns.
—Horace

Nothing means nothing, but it isn't really nothing, because nothing is something that isn't.
—Darryl Dawkins.

Recouping Our Habitat Losses with a Riparian Vegetation Strategy

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Introduction

In Western Oregon, most of the 17,000 miles of fish-bearing waterways are small streams averaging less than 9.5 feet in width. The most productive year-round habitats for salmonids are small streams and side channels associated with mature and old-growth coniferous forests. Here, dense vegetative canopies help keep waters cool, and tree litter-fall delivers nutrients to the stream. Large organic debris and fallen trees greatly influence the physical and biological characteristics of both small and large streams and rivers.

In the last 5 years, the major controversy surrounding fisheries-forestry interactions in Western North America has been the development of criteria for management of streamside forests. The central question in the controversy asks what quantity of merchantable timber volume must be left adjacent to fish-bearing streams to protect habitat quality and provide adequate future recruitment of large wood to stream channels for maintenance of fish and wildlife habitat.

All of the Western Forest Service Regions, the Bureau of Land Management in Oregon and Washington, and the states of Oregon and Washington have specific criteria for management of streamside forests which require leaving a designated number of large conifer trees for fish and wildlife habitat. Standards and prescriptions for these areas are highly variable, but the common theme is to leave a "proper mix" of deciduous and coniferous vegetation along streamsides. We contend that active silvicultural management of Riparian Management Areas (RMA's) is the only way long-term fisheries habitat needs will be met. Silviculturalists need to develop a deeper understanding of RMA's, both at the research and case history study levels, and fisheries biologists need to become more silviculturally oriented and less focused on fish habitat enhancement, to assure maintenance of high-quality fish habitat. Indeed, the fisheries biologist must focus on the watershed and riparian vegetation if streams are to become habitat-sustaining, as opposed to welfare-dependent, ecosystems.

In this paper we will: 1) describe the important historical characteristics of streams and habitat changes; 2) examine trends in composition of some streamside forests; and, 3) argue that restoration, maintenance and enhancement of stream habitats depend primarily on silviculture rather than structural improvements in stream channels.

History of Wood in Northwest Waterways

Most early descriptions of Northwest streams and rivers were recorded in British and United States Army journals. They tell, for example, of valleys so wet that early travel was confined to edges of the hills (Dicken and Dicken, 1979). Oregon's Tualatin Valley was "mostly water connected by swamps" (Ogden, 1961, p. 122). Much of this flooding resulted from beaver dams, accumulated sediment, fallen trees and living vegetation in the channels. The valley bottoms had long accumulated alluvial silt and inorganic material, so the fertile land was drained for agriculture early in the time of settlement. This condition was described for Willamette Valley streams in 1910:

> "Many of the smaller streams . . . through these flat sections of the valley flow sluggishly and frequently overflow their banks during periods of heavy winter rainfall . . . Most of these have sufficient grade to carry even more water than ordinarily comes to them; seldom less than 3 feet, and usually more, of fall per mile. The annual overflow is caused from the obstructing of the channel by the growth of trees and the extension of their roots, the dams thrown across the channels by beavers and the consequent accumulation of sediment and other debris, etc. . . . It is common condition, however, and usually all that is necessary is a clearing out and opening up of the clogged channel of the stream to afford entire relief . . . to the farmer . . . ." (Oregon State Agricultural College soils scientist I. A. Williams, 1914, p. 13.)

Streams of Washington state's Puget Sound lowland were also a network of sloughs, islands, beaver ponds and driftwood dams with no main channel. The Skagit River lowlands encompass about 198 square miles, of which over 50 square miles once were marsh, sloughs and wet grass meadows. Maps of the lower Nooksack and Snohomish rivers in Washington show large areas of sloughs, swamps and grass marshes before 1900 (Reports of the Secretary of War, 1875-99).

The channels of both high- and low-gradient rivers contained large amounts of woody debris, regardless of the nature of their bed material. The lower Siuslaw River and North Fork Siuslaw River were so filled with fallen trees that trappers could not explore much of these systems in 1826 (Ogden, 1961).

In 1870 the Willamette River flowed in five separate channels between Eugene and Corvallis. Early reports of the Secretary of War (1875-99) refer to many obstacles to navigation of the Willamette River above Corvallis, and describe the river banks as heavily timbered for half a mile on either side. Over 5,500 drifted, dead trees were pulled from a 50-mile stretch of river in a 10-

year period (Sedell and Frogatt, 1984). These trees ranged from 5 to 9 feet in diameter and from 90 to 120 feet in length. The river was also confined to one channel by engineering activities.

In both Oregon and Washington, other rivers were completely blocked by driftwood in the lower, main channels. The Skagit River had a driftwood jam three-fourths of a mile long and one-fourth of a mile wide. The Stillaguamish River was closed by six driftwood jams from the head of tidewater to river mile 17. Drifted, dead trees were so numerous, so large, and so deeply imbedded in the bottom that a stream "snag boat" operated for 6 months to open a channel only 100 feet wide.

Driftwood jams in high-gradient river systems were often located where the channel gradient abruptly decreased, as described for a section of the South Fork of the Nooksack River:

> ". . . we came to a place where the river during freshets had ground sluiced all the earth away from the roots of the trees, and down some 6 feet to the gravel. This covered a region of country a mile in width by five in length. Overgrown yellow fir timber had once covered most of that section. If the river below there was only clear of jams that place would be paradise of hand loggers. On the gravel lay many million feet of sound fir timber, which only needed to be junked up during the summer and the winter freshets would float the logs down to the sea. Immediately below this place, the jams first extend clear across the river, and for the next 20 miles there is a jam across the river nearly every mile." (Morse, 1883, p. 9.)

Large, woody debris was obviously an important part of early river systems of the Pacific Northwest. However, human objectives dictated that debris be cleared from river channels. Throughout North America, people have systematically cleaned downed trees and woody debris from streams for over 150 years (Sedell et al., 1982; Sedell and Luchessa, 1982). From the mid-1800s to about 1920, large and intermediate-sized rivers in North America were cleaned of drift jams and downed trees so steamboats and rafts could navigate. From the 1880s to around 1915, small rivers and streams were cleaned of debris so logs could be transported from the woods to the mills. Many streams had several splash dams built to temporarily augment the flow in order to float logs (Sedell and Luchessa; 1982, Sedell and Duval, 1985). The net effect of channel clearance and splash damming was to remove large quantities of woody debris from medium to large-sized streams, which significantly changed both physical and biological conditions (Harmon et al., 1986).

During the 1950s and 1960s, West Coast fishery managers feared that woody debris in streams restricted fish passage, supplied material for log jams, and caused channel scouring during floods (Narver, 1971, Hall and Baker, 1982). Knowledge of the great ecological value of organic debris had not then been developed, and indeed, during times of extreme water flow, all of the managers' fears might be well founded (McKernan et al., 1950; Gharret and Hodges, 1950). But the result of these fears put fishery biologists into the role of river engineer, a part for which they were not well trained.

Debris is not now removed on the same scale as in the 1950s and 1960s, but removal is still a large part of salmon enhancement programs in several Western states, and it is mandated by virtually every state Forest Practices Act in the Western United States and Canada. The combination of debris removal for fish passage in watershed headwaters, early-day splash damming, and snag and logjam removal from large rivers has left entire drainage systems almost devoid of large wood (Sedell and Swanson, 1984) and fish habitat.

Habitat Losses in the Northwest

Many agencies and researchers have inventoried habitat condition in managed and unmanaged stream reaches during the last 50 years. We have examined some of these records and recently resurveyed streams where the prior inventory methods were well documented. The results indicated that, whether on the west or east side of the Cascades in Oregon and Washington, large pool habitat had decreased an average of more than 45 percent (Table 1). Large pools are important as resting pools for adult salmon and steelhead trout as well as rearing habitat for juveniles. During times of drought, most of these pools are a refuge for fish until the rains come. What the surveys and resurveys have shown is that pools have become smaller and less frequent, and riffles or bedrock sections of streams have become more prevalent and elongated. This translates into, at least, a 50 percent loss of juvenile coho salmon-rearing habitat. Winter habitat has become another bottleneck because of this stream channel simplification.

Table 1. Percentage loss of large pool habitat in streams and rivers in Oregon and Washington during the past 20-50 years, based on surveys conducted by the authors, colleagues, and state and federal agencies.

Oregon Cascades	
N. Fork Breitenbush River	69
Fish Creek	40-60
Coastal Oregon Streams	50
Central (n=8)	
Western Washington (n=33)	25-33
Eastern Oregon	
Grande Ronde River	
Meadow Creek	46
N. Fork Catherine Creek	22
S. Fork Catherine Creek	53

Trends in Composition of Streamside Forests

Mature and old-growth forests have historically supplied large trees to stream channels. However, over 85 percent of the streams used by anadromous fish in western Oregon and Washington have RMA's with greatly altered tree size and species composition. Most big cedars and Douglas-firs (*Pseudotsuga menziesii*) along third-order and larger streams in the Cascade and Coast Range mountains have been, or are about to be, removed. Repeated streamside salvage sales in National Forests have created residual hemlock stands along many streams instead of mixed stands of cedar, fir and hemlock. Over 70 percent of coniferous trees more than 14 inches dbh are currently harvested within 100 feet of fish-bearing streams on privately owned industrial forest land in western Oregon.

Stocking densities of conifers approach 50,000 board feet per acre along well-stocked slopes in the Pacific Northwest. This figure is commonly used in Oregon to represent a fully stocked stand of Douglas-fir. However, recent surveys in western Oregon indicate fewer conifers more than 12 inches dbh than expected in RMA's, with volume ranging from 8,000 to 25,000 board feet per acre (Oregon Department of Forestry, 1986; Andrus and Froelich, in press). The reasons for the decline in stocking density are twofold. Conifer volumes are naturally low due to competition from salmonberry (*Rubus spectabilis*), red alder (*Alnus rubra*), vine maple (*Acer circinatum*) and big-leaf maple (*A. macrophyllum*) in many terrace areas adjacent to streams where soils remain perennially moist (Andrus and Froelich, in press).

There is ample evidence to suggest that a second reason for lower conifer volume in RMA's is successive harvest and salvage operations (Table 2). The reduction of large conifers in RMA's recently examined is a result of no conifer restocking inside the RMA flagging. Progressive reduction in coniferous trees on the Yaquina River and an unnamed Class I tributary (Table 2) is a result of intense competition with hardwoods on moist terraces. In order to maintain the structural and functional ecosystem diversity of RMA's for fish and wildlife, and realize the potential of RMA's for timber production, these areas must be restocked with young conifers.

Current research in Oregon and Washington (Grette, 1982; Long, 1987) indicates that total large wood volumes in streams are dominated by preharvest or disturbance debris. Long (1987) studied a coastal Oregon basin forested with 50-year-old second-growth timber. He found that preharvest debris constituted 63 to 70 percent of the total number of pieces found in the fourth-order basin. Preharvest wood accounted for over 85 percent of the total wood volume within all stream orders. Intensively managed second-growth forests are not replacing large woody debris volumes previously supplied by old-growth forest. Wood-related fish habitat structure in streams with intensively managed RMA's is currently dependent on wood supplied by the previous stand.

Table 2. Changes in large conifer densities (trees/acre) within Riparian Management Areas.

Location/stream	Pristine Forest (70+ yrs. ago)	Recently Harvested	RMA Stand
Cascade Mountains			
Unnamed Class I			
within 50 feet of both sides	31	17	0
Coast Range Mountains			
Yaquina River			
within 50 feet	16	6	3
within 100 feet	17	11	1
Siuslaw			
within 50 feet	14	17	3
within 100 feet	16	30	5
Wolf Creek at K-line			
within 50 feet	33	38	18
within 100 feet	19	34	11

Debris Substitutes

Streams in RMA's need a continual supply of living, dead and down large woody debris to maintain complexity of aquatic habitats. Silvicultural proposals for assuring that these needs are met have been discussed previously. Debris substitutes for large trees in RMA's are conceptually popular with both timber and fisheries managers. Intensive habitat manipulation that relies on introduction of debris substitutes into stream channels for stream rehabilitation or enhancement has broad support throughout the West. The fisheries programs of many agencies emphasize construction of boulder berms, gabion structures of various configurations, boulder clusters, side channels and off-channel ponds as primary techniques for habitat improvement.

From an ecological perspective, these techniques of habitat management often are soundly based. They are ideally suited to the goal of maintaining such natural wild stocks as still exist and to preserving genetic variability where possible. In the face of increasing concern about impacts of large-scale hatchery production on both genetic constitution of stocks and carrying capacity of the environment, this rationale may be one of the strongest arguments for emphasis on improving quality and quantity of stream habitat.

But we must emphasize that habitat rehabilitation must never be viewed as a substitute for habitat protection. This point has often been made (e.g., Narver, 1976; Powers, 1973), but it deserves frequent reinforcement. Communication between fishery managers and foresters is an essential element of habitat protection (e.g., Toews and Brownlee, 1981). In almost every instance, preventing initial habitat degradation would be more economical of total resources than repairing it, and some damage simply is not reversible. Past mistakes require efforts to rehabilitate many streams, but our efforts in habitat management must continue to put an equally strong priority on protection and rejuvenation of watershed and stream resources. Building expensive instream structures without solving the problems associated with management of riparian vegetation allows managers to sidestep difficult decisions.

When permanent enhancement devices are placed in a stream, we are attempting to permanently locate the stream in a fixed position or condition. The dynamic interaction of the stream with the riparian vegetation often is ignored. The low-gradient streams valuable to fish evolved by continual channel adjustments as flows and sediment loads varied. These small, annual adjustments allowed streams to withstand the wide range of dynamic forces that occur with rapidly fluctuating stream flows. In contrast to enhancement structures, riparian vegetation and trees can maintain themselves in perpetuity as new vegetation replaces dead vegetation. Riparian vegetation allows streams to function in ways that enhancement structures cannot replicate. The diversity and resiliency this vegetation provides allows riparian systems to withstand a large range of environmental conditions.

Stream habitat enhancement projects on the West Coast have improved spawning and rearing habitat for salmonids and probably increased fish production in some areas. Analysis of enhancement projects, however, shows that substituting other structures for large woody debris can be expensive. The cost of placing individual boulders in the Keogh River, for example, was $22 to $24 per boulder (in 1977 Canadian dollars), depending on whether the boulders were placed with heavy equipment or by helicopter (Ward and Slaney, 1979). Planning estimates of costs for boulder placement in Western Oregon streams average $35 per boulder (House and Boehne, 1985). Installing gabions for retaining spawning gravel in tributaries of the Coos River, in Oregon, cost $225,000 in 1981. Cost per individual gabion ranged from $300 in a fourth-order stream to $1,700 in a sixth-order stream (Anderson, 1982). An average cost of $1,200 for material and labor per gabion does not include engineering design or road access costs (House and Boehne, 1985). To adequately restructure one mile of stream costs between $12,000 and $20,000, with a possible project longevity of 20 to 30 years. Forest managers must weigh the cost of replacing lost debris with enhancement structures against the cost of providing woody debris to streams through management of RMA's. In many instances, after-the-fact substitution of debris may cost much more than allowing debris to be recruited to the channel naturally. Even where structural enhancement is warranted, using native materials, such as bunches of logs, to achieve the hydraulic diversity necessary for productive fish habitat may be the most cost-effective means of treating extensive stream reaches (Lisle, 1982).

Another problem with fisheries programs designed around enhancement structures is the general difficulty in finding suitable construction sites. From a logistic standpoint, not all stream miles could be improved with enhancement devices even if unlimited funding were available. For example, one BLM District in Oregon has 528 miles of streams producing anadromous fish, and only 60 miles are feasible for structural rehabilitation. Approximately 90 percent of the stream miles can not be "artificially" rehabilitated because of access problems and other constraints, and must be managed for vegetative diversity in RMA's to maintain acceptable levels of fish production.

Conclusions

Forest practices over the past few decades have led to long-term declines in critical woody debris and debris-related fish habitat in small and large streams in the Pacific Northwest, particularly those that have undergone extensive channel cleaning. In some cases a short-term increase in woody debris (slash) has been associated with timber harvest activities, but small unstable debris from this source often is transported downstream within a few years. RMA's presently in young-growth or heavily harvested and salvaged condition are the only potentially significant sources of debris for the future, unless debris is furnished by massive blowdowns or debris avalanches. Maintaining RMA complexity for all forest resources is an important stewardship responsibility of land managers.

Managing streamside vegetation is managing fish habitat. Silvicultural prescriptions designed to make RMA's ecologically and biologically diverse are lacking. Ecological diversity represents a structural diversity of dead wood and varying canopy heights, and a varied vegetative community. Maintaining biological diversity and fish habitat for several salmonid species and other game fish involves much more than set-aside leave strips. Additional research and administrative studies are needed. Knowing how various tree species and debris sizes function through time in channels of different width, gradient, and valley form will aid decisions regarding where, what kind, and how many trees can be selectively removed from RMA's during timber harvest and thinning without devaluing fish habitat and other important functions of RMA's.

LITERATURE CITED

Anderson, J.W. Anadromous fish projects. 1981. USDI-BLM Coos Bay District. *In* T.J. Hassler (ed.), Proceedings: Propagation, enhancement, and rehabilitation of anadromous salmonid populations and habitat in the Pacific Northwest, October 15-17. 1981. California Coop. Fish. Res. Unit, Humboldt State University, Arcata, California. pp. 109-114.

Andrus, C. and H. Froelich. 1988. Streamside forest development following logging or fire in the Oregon Coast Range: wildlife habitat provided and value of included timber. *In* K.J. Raedeke (ed.), Proceedings of the Riparian Wildlife and Forestry Interactions Symposium, Feb. 11-13, 1987. University of Washington, Seattle.

Dicken, S.N. and E.F. Dicken. 1979. The making of Oregon: a study in historical geography. Vol. I. Oregon Historical Society, Portland, Oregon. 107pp.

Gharrett, J.T. and J. I. Hodges. 1950. Salmon fisheries of the coastal rivers of Oregon south of the Columbia. Oregon Fish Commission contribution 13. Portland, Oregon. 31 pp.

Grette, G.B. 1985. The abundance and role of large organic debris in juvenile salmonid habitat in streams in second growth and unlogged forests. Master of Science Thesis, University of Washington, Seattle.

Hall, J.D. and C.D. Baker. 1982. Rehabilitating and enhancing stream habitat: I. Review and evaluation. *In* W.R. Meehan (ed.), Influence of forest and rangeland management on anadromous fish habitat in western North America. USDA For. Serv. Gen. Tech. Rep. PNW-138. Pacific Northwest For. and Range Exp. Stn., Portland, Oregon.

Harmon, M.E., J.R. Franklin, F.J. Swanson, P. Sollins, J.D. Lattin, S.V. Gregory, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack, Jr., and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. *In* Advances in ecological research. London. Academic Press. Vol. 15, pp. 133-302.

House, R.A. and P.L. Boehne. 1985. Evaluation of instream enhancement structures for salmonid spawning and rearing in a coastal Oregon stream. N. Amer. J. Fish. Manage. 5:283-295.

Lisle, T.E. 1982. Roughness elements: a key resource to improve anadromous fish habitat. *In* Proceedings: Propagation, enhancement, and rehabilitation of anadromous salmonid populations and habitat in the Pacific Northwest, October 15-17. 1981. California Coop. Fish. Res. Unit, Humboldt State University, Arcata, California.

Long, B.A. 1987. Recruitment and abundance of large woody debris in an Oregon coastal stream system. Master of Science Thesis, Oregon State University, Corvallis.

McKernan, D.L., D.R. Johnson, and J.I. Hodges. 1950. Some factors influencing the trends of salmon populations in Oregon. Transactions of the 15th North American Wildlife Conference, 1950:427-449.

Morse. 1883. Morse's monthly: A Puget Sound magazine for the people of the Northwest. Snohomish City, Washington Territory. 1(1): 1-14. Available from Washington State Archives, Olympia, Washington.

Narver, D.W. 1976. Stream management for West Coast anadromous salmonids. Trout 17:7-13.

Ogden, P.S. 1961. "Peter Skene Ogden's Snake Country Journal 1826-1827." K.G. Davies, ed. Vol. 23 pp. lvii-lxii, 143-163. Hudson's Bay Record Soc., London.

Oregon State Department of Forestry. 1987. Streamside management concepts and recommendations. 2600 State Street, Salem, Oregon 97310.

Powers, G. 1973. Salmon management—myths and magic. Pages 427-439. *In* M.W. Smith and W.M. Carter (eds.), Proceedings, International Atlantic Salmon Symposium, 1972 September 20-22; Huntsman Marine Laboratory, St. Andrews, New Brunswick, Special Publication Series 4. International Atlantic Salmon Foundation, New York.

Rainville, R.C., S.C. Rainville, and E. L. Linder. 1985. Riparian silvicultural strategies for fish habitat emphasis. Proceedings of the 1985 Society of American Foresters National Convention, Ft. Collins, Colorado, July 28-31, Bethesda, Maryland. pp. 186-196.

Reports of the Secretary of War, Reports of the Chief of Engineers 1875-99. *In* House executive documents, sessions of Congress. U.S. Government Printing Office, Washington, D.C. Annual reports.

Sedell, J.R., P.A. Bisson, J.A June, and R.W. Speaker. 1982A. Ecology and habitat requirements of fish populations in South Fork Hoh River, Olympic National Park. pp. 47-63. *In* E.E. Starkey, J.F. Franklin, J.W. Mathews (eds.), Ecological research in national parks of the Pacific Northwest. Oregon State Univer., For. Res. Lab., Corvallis.

Sedell, J.R. and W.S. Duval. 1985. Water transportation and storage of logs. *In* W.R. Meehan (ed.), Influence of forest and rangeland management on anadromous fish habitat in western North America. USDA For. Serv. Gen. Tech. Rep. PNW-186. Portland, Oregon.

Sedell, J.R. and J.L. Froggatt. 1984. Importance of streamside forests to large rivers: The isolation of the Willamette River, Oregon, U.S.A., from its flood plain by snagging and streamside forest removal. Verh. Int. Ver. Limnol. 22:1828-1834.

Sedell, J.R. and F.J. Swanson. 1984. Ecological characteristics of streams in old-growth forests of the Pacific Northwest. pp. 9-16. *In* W.R. Meehan, T.R. Merrell Jr., T.A. Hanley (eds.), Fish and wildlife relationships in old-growth forests. Am. Inst. Fish. Res. Biol., Juneau, Alaska.

Toews, D.A. and M.J. Brownlee. 1981. A handbook for fish habitat protection on forest lands in British Columbia. Canada Department of Fisheries and Oceans, Vancouver, British Columbia.

Ward, B.R. and P.A. Slaney. 1979. Evaluation of in-stream enhancement structures for the production of juvenile steelhead trout and coho salmon in the Keogh River: progress 1977 and 1978. Fish. Tech. Circular 45, British Columbia Ministry of Environment, Victoria.

Williams, I.A. 1914. Drainage of farm land in the Willamette and tributary valleys of Oregon. The Mineral Resources of Oregon 1(4): 140-180. Oregon Bureau of Mines and Geology, Salem, Oregon.

Processes of Riparian Systems: Back to Basics

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Riparian zones are the areas of transition between aquatic and terrestrial zones. They are influenced by surface as well as subsurface water, and that influence is most evident in their distinctive vegetation complex. Typically, riparian zones are the green borders of rivers, streams, springs, lakes, bogs and wet meadows.

The condition of riparian areas has become a major conservation issue in the United States. Although they make up less than one percent of the land base in most Western states, they are considered by many groups to be both extremely productive and seriously degraded. Past management of riparian zones on federal lands has been the responsibility of wildlife professionals, and improvements have been evaluated in relation to responses in wildlife habitat for fisheries, big game and nongame species. The most common management technique used for habitat improvement has been corridor-exclusion fencing, which has been difficult to maintain and is basically opposed by livestock growers and many public land managers.

However, riparian areas are much more than wildlife habitat. They are systems that include several important processes. I am going to talk primarily about valley fill or alluvial riparian systems, whose functions are readily observed.

These processes of riparian systems include:

1. **Physical filtering of water**. Riparian vegetation can withstand high velocities of water and still remain intact. One of its functions is to slow the flow of water while literally combing out sediments and debris. This water-purification process also helps build banks, causing channels to become narrow and deep where they were wide and shallow. Vegetation, such as grasses, sedges, and rushes, lays down under high flows to form a protective blanket. This process reduces bank cutting and aids in deposition of sediments. Where deposition has occurred over time, extensive wet meadows or flood plains will develop.

2. **Bank stability.** The diversity of grasses, forbs, sedges, rushes, shrubs and trees produces fibrous roots and tap roots that bind and hold settled soils in place. The binding effect of the roots helps maintain the positive factors of the bank-building processes during high flows. A combination of woody rooted and fibrous species has a reinforcing effect. The woody rooted species provide physical protection against the hydraulic forces of eroding water while allowing forbs, grasses and sedges to bind the finer particles. In combination, this diversity of plant species proves much more effective in stabilizing banks than is any one type by itself.

3. **Water storage and recharge of underground aquifers**. Aquifers in many areas of the West are going dry even though one of the processes of riparian systems is to help recharge them. For many degraded riparian systems, all the flows are contained in the channel and cannot access the banks or flood plains where the water can spread. It is widely accepted that we can lower a water table and drain a stored underground aquifer through channelization or erosion. It is not readily accepted, however, that we can reverse that process and store water through recovery of riparian systems and deposition in formerly degraded channels. Riparian systems slow the flow of water and allow it to spread and soak into the sponge-like banks, thereby raising water tables. When banks rebuild through filtering of sediments, they increase the surface area for water absorption and improve recharge of aquifers by allowing gravity to work on the stored water.

The upland areas must not be excluded in our discussion, because they are an integral part of the riparian system. Overland and subsurface flows also influence sediment loads, water cycles and recharge of aquifers. First-order watersheds (those with single unbranched streams) are uppermost in a system and vary in size from small forested areas to rather large rangeland areas. Even when small, they are critical to the total recovery of a system. First-order watersheds generally make up the major portion of any stream system. They are also the only areas within the system with physical integrity, since all other stream orders are a mixture of upstream reaches.

Other processes that have shown a substantial improvement because of riparian recovery include increases in the base flow (minimum flow period), reduction in buildup of ice, and physical filtering of sediments by ice. In Central Oregon, the Bureau of Land Management (BLM) is studying these processes to better understand their role in the total cycle of the riparian system. Results will be forthcoming over the next several years.

Riparian Systems over Time

The Past

We can go back more than 2,000 years to Babylon, built during the sixth century B.C., and see evidence of poor land management practices. Babylon died not because of war or pestilence, but because its irrigation ditches became clogged with silt. The silt came from the uplands and the stream channels, eroding and depleting both the fertility of the land and the water tables. Moses stood on Mount Nebo and described the land of milk and honey where now a silt-laden Jordan River flows along erodied gullies and hillsides of bedrock.

Other areas such as Africa and, yes, even the United States, also are experiencing the scourge of desertification. Streams that pioneers camped beside on their way to the land of milk and honey have since become dry or intermittent. Many of the stream channels and marshes where Native Americans hunted and fished are now raw eroded banks with sagebrush and other dryland vegetation growing to their rims.

Past forest practices, which allowed road construction along streams and construction of landings and skid trails in creek bottoms, also have created severe problems in regeneration and improvement of riparian areas. Users and managers alike share the blame.

The Present

Today, livestock grazing practices are receiving most of the criticism for the long-term decline in riparian conditions in both our forests and rangelands. Members of the Oregon Cattlemen's Association recognized the potential of riparian recovery and recently adopted a resolution supporting a "flexible riparian management concept." Ranchers such as E. J. Kropf of the Bonnieview Ranch near Prineville, Oregon, have incorporated management of riparian areas into their total ranch plans. Kropf's observations are worth noting:

> "A cow has never awakened in the morning and said, 'I'm going to gain as much weight today as I possibly can.' Instead, they will lay along the creeks, eat everything that is green, and stay there and lose weight. Not only can the cattle be detrimental to the riparian zone, they can also be detrimental to themselves weight-gain-wise. It is important to stabilize our streams and improve our flows from a land management standpoint and as an economic benefit to the ranching industry, especially in difficult times such as now."

Kropf, who is working under today's conditions, definitely has his eyes on the future.

Leaders from the Oregon Cattlemen's Association and the environmental community recently formed the Oregon Watershed Improvement Coalition with the help of the Pacific Northwest Section of the Society for Range Management. The committee consists of five members from each group plus one advisor apiece from the BLM, U.S. Forest Service, and Oregon State University Rangeland Resources Department. The main thrust of the group is in working together to improve riparian conditions in Eastern Oregon and increase understanding of riparian systems management through education. Bob Skinner, Oregon Cattlemen's Association President and Coalition member, has said: "The riparian controversy will not go away and we must work together to solve the problem. There are too many benefits for all of us (to do otherwise)."

The Future

We must now face the future and accept what the past has to teach us. Management of riparian systems with an eye to positive improvement will result in systems that recharge underground aquifers by rebuilding water tables that have been depleted through misuse and erosion. Five miles of Camp Creek (in Central Oregon) were placed under management in 1966. In the 1800s the area was a complex of wide wet meadows and marshes. Overuse by livestock caused accelerated erosion, and by 1905 the creek was in an eroded channel 20 feet deep, flows typically were intermittent in the summer, and the meadow-marsh complex was gone.

Since 1966, the 5-mile ungrazed section has filtered out sediments from the stream and raised the channel by as much as 6 feet. The green zone adjacent to the stream increased from a few feet to over 100 feet. The most dramatic recovery, however, was observed in 1977 and 1981 during drought periods. The only perennial flow in the entire Camp Creek watershed was within the recovered section.

Another example is Bear Creek, also in Central Oregon. This stream has developed a trout fishery in less than 10 years where none existed for over 50 years. According to local ranchers, side streams that now have perennial flows had been dry as long as they can remember. Management solutions included sound grazing techniques designed for the area, removal of competing juniper on some sites, and prescribed burns.

We must not forget wildlife habitat as a product of the riparian system, because it has been the primary force behind recognizing the problem. Vegetation, the key to a functioning riparian system, provides habitat for 80 percent or more of the wildlife species in many areas—species that depend on these systems for all or some part of their life cycle. Here, in one place, are found all the essentials: food, cover and water.

Riparian systems are the water collectors. They work like a funnel whose mouth is in the uplands and small end in the riparian areas. Managers must therefore include the uplands in plans for total system recovery. If we look only at the riparian areas in management, we ignore a major portion of the system. Water is an elusive natural resource that we must manage wisely to maintain life.

The wise use of our natural resources is a challenge for everyone, a challenge requiring cooperation and commitment from private landowners, local groups, and state and federal agencies. Within the Bureau of Land Management in Oregon, there is a long-term commitment to a management course that will enhance the processes of riparian systems and, through research and education, increase public understanding of the relationship between riparian ecology and water.

Bill Levell, the BLM Director for Oregon and Washington, best summed up our approach to restoration of riparian areas in Oregon in a 1986 memo:

"Riparian Management: Full *Stream* Ahead!"

Oregon's Water: Past and Future

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Introduction

When the American frontier moved west, stimulated by the prospect of free land, free water and gold for the taking, it brought along a unique society. The pioneers consisted of people from the East who had not realized the Great American Dream. They were restless, adventurous, willing to take risks; but above all they were seeking their fortunes. Fortune then, as today, was to own property and make money, and for some to build a new America. To them the possibilities seemed limitless. Land, water and all other natural resources were available, waiting to be claimed by the individuals who arrived first. The concept of waste was unheard of. Resources seemed to be infinite in supply—if timber or game was exhausted in one region, the pioneers continued west to new frontiers. The technology for conservation did not exist. Therefore, extravagant portions of a resource were claimed to compensate for natural losses. Water was no exception, and therein lies the root of today's problem.

That is our unique heritage. It's the American West, the cowboy, the Forty-Niner. It's a myth romanticized by Hollywood. It is also a hard reality where allocation of the West's scarce water is concerned.

From the boomer days of the gold rush, water availability has been recognized as the real gold for the frontiersman, without which he could neither realize his dream nor survive. American settlers' rights to use water have been recognized in state constitutions, in statutes, and in a plethora of common law decisions. But above all, ownership of the right to use water was established from the outset in the minds of the people who used it for a livelihood. This has been so for over 100 years. It is this reality that creates the major ethical considerations for today's changing society. Of course there are other barriers to change—some political, others legal, technological or institutional. However, American society in the past has historically found ways to dismantle legal and institutional barriers that stood in the path of the will of the majority.

The Prospect of Changes in Water Policies

Gone are the days of an agrarian-dominated society. Demands of an urbanized public that prizes recreation, fishing, and the aesthetic and environmental values of flowing rivers are displacing past consumptive uses. Economic development now includes tourism, which depends on instream flows and their attendant values. Economic development also means industrial growth, which depends on maintenance of instream flows to accept effluents; and it means population expansion in cities and towns, where instream flows must remain high to meet municipal needs.

The question is, how do we modify past water-use policies to make them suitable for the 21st century? The challenge is to fashion a reasonable balance between instream and out-of-stream allocation of water, and to do this without serious economic dislocation of agriculture. That sounds simple enough, but the reality of implementing future-looking management practices is another matter. It will require selective and evolutionary changes that do not destabilize the agriculture industry.

There are advantages to starting the process in Oregon:

1. It has no constitutional barriers.
2. Existing state statutes were progressive at the time of enactment, but these statutes have never been tested in the courts for interpretation in matters of public interest.
3. Oregon citizens have a strong environmental ethic.
4. The state has not been ravaged by uncontrolled development, in part because of its effective land-use laws, which means it has something of great value to protect for future generations—its water resources.
5. The economic base of the state appears to be shifting from agriculture toward high-tech industry and tourism, a shift that will increase demands for instream flows.
6. There is growing awareness in the state legislature of the need for change in water policies.
7. And as a last resort, Oregon has the initiative process, a process that could be used to make sweeping changes in water policy, since most of the state's population is in urban areas of the Willamette Valley.

A Short History of Oregon Water Laws

Oregon, along with the other Western states, has allocated water from its earliest days by the Doctrine of Prior Appropriation: first in time, first in right. Briefly put, the first person to divert water for "beneficial use without waste" was given a water right. Over the years these rights have become tantamount to a property right and are so regarded by many people.

In 1909, Oregon enacted its first water statute, a statute that articulated the Doctrine of Prior Appropriation and that remains on the books today. In essence it established a water allocation system to support an agrarian society. Rights were granted to all who could divert water to a beneficial use. These grants were made without consideration of water as a finite resource or for future social or economic needs. No conservation ethic was evident. Often, rights were granted in wasteful quantities. No provisions were or have been made to respond to changes in technology or in social and economic values. Given today's technology, many rights are in excess of the amounts needed.

By 1950 many Oregonians were expressing growing concern about management of the water resource and future needs of the state. The 1953 Legislative Assembly authorized the appointment of a committee to address these concerns and report back to the 1955 assembly.

After considerable debate, that legislature enacted a futuristic water resources law, including a groundwater act. The new law recognized the use of water for public benefits through a minimum stream flow program. It laid down a requirement for planning for the future and development of water resources. And it called for moderation of the 1909 policy of automatically granting all requests for water permits.

The 1955 act was supplemental to the 1909 law, which was left intact. It established a Water Resources Board with discretionary authority to make policy, and a State Engineer office responsible for issuing water permits and certificates. Each administrative body received its own staff and budget. The result was a continual political struggle between competing forces, with advocates of past policies pitted against those looking toward the future and greater accommodation of the public interest. Single purpose users accustomed to the 1909 law have, so far, dominated the contest.

The imbalance was exacerbated in 1975 when legislation was passed that merged the Water Resources Board with the State Engineer, creating a single agency with a single staff and budget. Subsequently, water resource management through the budgetary process has been the rule. Since 1975, the agency, the executive office, and the legislature, each exercising its own particular authority, have entered into an alliance of prioritizing the issuance of water permits to the detriment of other effective water resource management activities.

In the last 11 years approximately 23,000 water permits have been issued. They represent about one-fifth of all water rights in existence in the state (approximately 100,000). This has caused massive overappropriations of most Oregon streams, streams that were described as overappropriated in the mid-1940s by the State Engineer, who issued a report saying even then that *no more water permits should be issued.* The recent run on permits has taken place in the absence of records reflecting the current level of appropriation.

Since 1975, there has been little planning for the future of Oregon water. Only two basin programs have been updated; six minimum stream flows were established between 1975 and 1985; and some basin programs are more than 20 years out of date.

Water permits and certificates continue to be issued without determination of the public interest. Once water rights are issued and certificated, they become vested rights and can not be reevaluated under existing law. Most of the state's water has been or will be allocated to one industry for consumptive use unless action is taken now. Little unallocated water will remain for public use or for future economic growth. The situation is critical.

It was with this realization that a few Oregonians established Waterwatch of Oregon, Inc., a non-profit, public interest corporation dedicated to bringing balance between the private and public uses of the state's water resources; to providing for present and future economic development of the state and the general welfare of its citizens through education, research, and participation in the public, administrative, executive, and judicial processes; and to protecting the public interest and invoking the public trust.

ENHANCEMENT, RESTORATION, MITIGATION

We do not succeed in changing things according to our desire, but gradually our desire changes.

—Marcel Proust

Insanity is doing the same thing over and over again, but expecting different results.

—Jane Fulton

Good pitching always stops good hitting, and vice versa.

—Casey Stengel

The best carpenters make the fewest chips.

—German proverb

Is it progress if a cannibal uses a fork?

—Stanislaw Lec

Enhancement, Restoration and Mitigation: How are They Different?

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Mitigation, restoration and enhancement are popular words in Northwest fish circles. They are hopeful words, too, creating the impression that something is to be done to improve fish populations damaged by human activities or natural disasters. But they are not precisely used words. Instead, they tend to be used interchangeably, not only by fisheries biologists but by politicians, administrators and judges, who sometimes wrap them all in another word: compensation.

The dictionary stands ready to assist us in clarifying this confused state. There, we find the following distinctions:

- ***Enhancement*** means making greater, augmenting, intensifying
- ***Restoration*** means bringing to a former or normal condition
- ***Mitigation*** means making milder, less severe, less rigorous or less painful

A Congressional mandate for the Columbia River, the Pacific Northwest Electric Power Planning and Conservation Act, was established in 1980. Under that act a fish and wildlife program has been developed in cooperation with government fish and wildlife agencies and Columbia Basin tribes. Congress directed the Power Planning Council to "promptly develop and adopt . . . a program to protect, mitigate, and enhance fish and wildlife including related spawning grounds and habitat on the Columbia River and its tributaries." There we find two of our words: *mitigate* and *enhance*. *Restore* was left out. Why?

On the Columbia, where 9,000 miles of spawning streams have been taken out of production and anadromous runs have declined from at least 14 million fish to 2.5 million fish, it seems that mitigation is too mild. Is the obligation only to make things less painful? We have had a lot of mitigation. We have mitigated ourselves into our present situation.

To enhance means, I repeat, to make greater. This is a more positive and therefore a more attractive term. We are making improvements, pushing beyond partial recovery. However, when we replace self-sustaining stocks of salmon and steelhead—stocks of many sorts, each nicely adapted to local environmental conditions in a vast and diverse basin—with a few hatchery stocks, can we call that making something greater? Is it an improvement if we use leftovers from a century of development within an ecosystem, and act as though the ecosystem didn't exist?

Now, as for *restore*, that's a different kind of word. Politicians stay away from the term because it suggests something has gone wrong. It doesn't appear in the Congressional mandate for the Columbia River fish runs. Fish biologists who work in the field, better known as dirt biologists, often can be heard using the word, but their administrators don't use it much, maybe for the same reasons the politicians don't. Maybe they, too, have looked in the dictionary and found that *restore* means to bring something to its former condition.

Bringing individual stocks of salmon and steelhead and the ecosystems they inhabit back to their former condition is a major challenge. Why should we set our sights any lower? Certainly, through the Power Act we have the best opportunity ever to do just that, but whether we will is uncertain.

Protect is another interesting word. It appears in the Congressional mandate for the Columbia River but not in this program. There is some question whether it means to maintain what we have, or to provide fish with a crash helmet as they go whirling through hydro dams.

By studying these words, can we discover our charge as fishery managers, administrators, biologists, concerned members of the public? Do these words help us to define our responsibility to the resource? Do they help us become better harvest managers, users and decision makers?

The following speakers are persuasive people of integrity and power, and they are setting the direction of salmon and steelhead recovery in the vast Columbia Basin. Let's hear what they have to say about enhancement, restoration, and mitigation as each applies to Columbia River salmon and steelhead—especially to wild stocks.

Is There a Conflict between Protection and Enhancement?

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The Northwest Power Act of 1980[1] significantly shifted the balance among the multiple uses of the Columbia River, explicitly highlighting the hydropower system's responsibility to "protect, mitigate, and enhance fish and wildlife"[2] affected by hydropower development and operations. In describing the fish and wildlife program[3] to be developed by the Northwest Power Planning Council[4] the Act further specifies that "Enhancement measures shall be included in the program to the extent such measures are designed to achieve improved protection and mitigation."[5]

Enhancement means trying to put more fish in creels, nets, boats and on the spawning grounds. That is a result all desire. Yet short-sighted enhancement efforts in the past have damaged fish stocks and the fishermen who benefit from them. As we move forward with major new fish-production projects in the Columbia River Basin, I should like to pause for a moment to examine the connection between protection and enhancement.

To put that relationship in context, it is useful to review the major themes of the Council's fish and wildlife program. The program is being implemented at a cost to ratepayers of the Bonneville Power Administration approaching $100 million per year. That figure includes power sales

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1 Pacific Northwest Electric Power Planning and Conservation Act, PL 96-501, 16 U.S.C. 839 *et seq.*, cited hereafter as "Northwest Power Act."

2 *Ibid.*, Section 4(h) (2) (A), 16 U.S.C. 839b (h) (2) (A).

3 Northwest Power Planning Council, *Columbia River Basin Fish and Wildlife Program*, (Portland, 1984) as amended. Cited below as "1984 Program."

4 The Council's charter appears in the Northwest Power Act, primarily in Sections 4 and 6. See 16 U.S.C. 839b, d.

5 *Ibid.*, Sec. 4(h) (5), 16 U.S.C. 839b (h) (5). See also Sec. 4(h) (8) (A), 16 U.S.C. 839b(h) (8) (A), which calls for "offsite" protection and mitigation as part of a basinwide approach to rebuild Columbia Basin fish runs.

lost because water is being used to protect or enhance fish rather than to generate electricity. While the dollar amount is large, direct outlays represent about one percent of BPA's revenues.[6]

Protection. The Council's program has formalized and extended significant changes in mainstem hydro operations: a water budget which restores part of the spring freshet;[7] spill to protect migrants at dams that do not have other ways of passing fish around the turbines;[8] and transportation in barges and trucks, primarily to protect Snake River stocks.[9] The Council is working with the Corps of Engineers to speed construction of bypass at dams. The Council's 1986 power plan provides for no new hydro development except where there are already dams, pending completion of a regionwide rivers assessment.[10]

Mitigation. The Council has estimated the loss of salmon and steelhead due to hydropower at 5-11 million adults—that is, between three and five times current run size.[11] Practically and realistically, however, biological and social limits may prevent our reaching even the lower limit of this hydro responsibility. Remember, the Columbia today is no longer the ecosystem that once nurtured the largest salmonid runs in the lower 48 states.[12]

Enhancement. The Council program launches major efforts at reopening and rehabilitating upriver habitat, notably in the Yakima River Basin in Washington.[13]

The Council has also supported in concept the fish agencies' and tribes' work toward a basinwide management plan covering harvest and production. That plan would form

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6 Direct obligations in fiscal year 1986 were projected at $34 million, out of a total BPA revenue estimate of $2.9 billion. U.S. Department of Energy, Bonneville Power Administration, *Bonneville Power Administration Budget for Fiscal Year 1987*, January 1987, pages BP-8 and BP-49. Actual spending for the fiscal year is substantially lower than the projected figure because of contracting delays and other problems.

7 1984 Program, Section 304.

8 1984 Program, Section 404.

9 Northwest Power Planning Council, *Columbia River Basin Fish and Wildlife Program*, 1986 draft amendments, September 1986, section 404. This document is cited below as "1986 Draft Program Amendments."

10 Northwest Power Planning Council, *Northwest Conservation and Electric Power Plan* (Portland, 1986) vol. I, pp. 7-6 and 7-7.

11 1986 Draft Program Amendments, Sec. 201.

12 For a helpful review, see C. Wilkinson and D. Conner, "The Law of the Pacific Salmon Fishery: Conservation and Allocation of a Transboundary Common Property Resource," 32 Kansas Law Review 17 (1983).

13 1984 Program, Section 904.

> the central elements of a settlement in *U.S.* v. *Oregon*.[14] A coherent, consistent approach to harvest and production of fish would be unprecedented in the modern history of the Columbia Basin. The *U.S.* v. *Oregon* plan would be a major step forward, reflecting a new spirit of cooperation among tribes and states, among states and federal agencies,[15] and between Canada and the U.S.[16] That spirit is given economic substance, to a significant degree, by ratepayers' funding under the Northwest Power Act.

The Columbia River Basin Fish and Wildlife Program, in sum, is the landward side of the world's largest attempt to rehabilitate an entire ecosystem.

The Council's role within this effort is that of investment banker: financing healthy growth, assuring the value of the investment, taking the long view—but not second-guessing those with management responsibility for the resource. In that collaborative spirit we work with the fisheries agencies and Indian tribes of the Basin, as well as Bonneville Power, the Army Corps of Engineers, the Bureau of Reclamation, and the hydro project operators licensed by the Federal Energy Regulatory Commission.[17]

From that investment banking perspective, it is clear that the basic asset is the gene pool, the store of information that underlies all the biological productivity of the salmon and steelhead runs. The centrality of the gene pool can be an inconvenient fact, however. That is why I am struck by a change in the way people talk about "wild" fish and the genetic resource they represent. As fish populations declined, those harvest interests with the least political clout—the Indian tribes, the state of Idaho, sportsfishers and environmentalists—all took a preservationist "gravel to gravel" view: wanton harvest must be controlled, lest irreversible damage be done to irreplaceable wild fish.[18]

Today, as conflict gives way to optimism that runs can and will be rebuilt, the emphasis has shifted. The near-term objective is increasingly described as reopening the fishery and increasing the numbers of fish that can be caught. That is why the Power Council, which adopted a position

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[14] *U.S. et al.* v. *Oregon et al.*, Civ. No. 68-513 (D. Ore.)

[15] See, e.g., *A New Management Structure for Anadromous Salmon and Steelhead Resources and Fisheries of the Washington and Columbia River Conservation Areas*, report of the Salmon and Steelhead Advisory Commission to the Secretary of Commerce, 31 July 1984 (Seattle: National Marine Fisheries Service).

[16] *Treaty between the Government of the United States of America and the Government of Canada Concerning Pacific Salmon*, ratified March 7, 1985. U.S. implementation of the treaty is authorized in Pub. L. 99-5, 16 U.S.C. 3641.

[17] See Northwest Power Act, Sec. 4(h) (11) (A), 16 U.S.C. 839b(h) (11) (A), and 1984 Program, Sec. 1304(a).

[18] See, for example, J. Marsh and J. Johnson, "The Role of Stevens Treaty Tribes in the Management of Anadromous Fish Runs in the Columbia Basin," Fisheries 10:4, pp. 2-5 (1985).

favoring wild and natural production of fish[19] in 1982 at the behest of the tribes and fish agencies, is now admonished, "Don't get married to those wild fish."[20]

Well, it's been a nice romance.

But let's not forget that humankind has been remarkably unsuccessful in amending the laws of Nature.[21] From the standpoint of fish populations—the *long*-run perspective shared by ratepayers—the biological value of wild and naturally reproducing stocks is precisely that fish adapted to an ecological niche are likely to be highly productive. That is, after all, why they occupy that niche.

What the harvest community is saying is important nonetheless. Substantial rebuilding of salmon and steelhead through natural production alone may not be feasible given the highly developed state of the Columbia Basin. Populations that must traverse up to nine mainstem dams simply cannot produce a sustained harvestable surplus by natural means; attempting to do so would require harvest to be severely curtailed all along the West Coast of North America for a longer time than politics or economics can sustain.[22] So artificial production, in the form of hatchery supplementation at least, is likely to be undertaken on a large scale in the Columbia Basin.

That course would dictate construction of large hatcheries, some designed to support outplanting in the upper river. For example, the Lower Snake River Compensation Plan has added 12 major new hatcheries. Under the Council's program new facilities are being planned for the Yakima Basin[23] and proposed for northeast Oregon.[24] All these projects could lead to hatchery-bred juveniles being planted in Columbia River tributaries from the Hood River to the Wenatchee, and as far up the Snake as the Imnaha.[25]

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19 See 1984 Program, Sec. 704(d) (specifying projects for habitat improvement and restoration of migratory fish passage at sites throughout the Columbia Basin) and Sec. 704(h) (1) (establishing priority to improving production at existing hatcheries, in preference to building new hatcheries).

20 S. Timothy Wapato, executive director, Columbia River InterTribal Fish Commission, in oral comments to the Northwest Power Planning Council, Ketchum, Idaho, 11 June 1986.

21 See, among other sources, B. Brown, Mountain in the Clouds (New York: Simon and Schuster, 1982) Chap. 6.

22 Coastwide annual harvest of chinook salmon was reduced by 1.5 million between 1976, the year the Magnuson Fish Conservation and Management Act was adopted, and 1984, when data were compiled for the U.S.-Canadian Pacific salmon treaty. Jean Edwards, Columbia River InterTribal Fish Commission, reporting data from the U.S.-Canada chinook technical team. The 1984 chinook catch of 1.9 million fish thus represents just more than half the level of 1976. While regulation accounts for only part of the decrease, it is widely believed that continued large-scale reductions in the catch of salmon species returning to the Columbia Basin will be difficult to maintain.

23 1984 Program, Sec. 704(i) (3).

24 1986 Draft Program Amendments, Sec. 704(i) (3).

25 Detailed basinwide plans for supplementation are expected to be developed by fisheries management entities within the framework of a settlement in *U.S.* v. *Oregon*. At this writing, however, public drafts of such plans have not been released.

Will it work? No one knows. There have been few scientifically rigorous studies of supplementation, and nothing has been done in a drainage as large and as diverse as the Columbia system.[26] Because it is largely untested, the outplanting technique may not succeed in rebuilding all or even any runs.

If supplementation fails to work as hoped, we shall have built a second set of mega-mitigation facilities, like those funded under the Mitchell Act[27] in the lower river. This time, however, the mitigation will be provided above the tribes' usual and accustomed fishing grounds.[28] But as before, the high levels of harvest permitted by extensive artificial production can diminish or even exterminate many of the remaining wild and naturally self-sustained stocks caught in mixed-stock fisheries.[29] As in the lower river, stocks like the hatchery-reared tule fall chinook may increasingly dominate the Columbia's fish runs. Pressures on upriver stocks will be exacerbated, moreover, if BPA continues to suffer from low revenues—making it difficult to spill water or to fund projects—and if the Corps continues to have difficulty installing bypass systems at mainstem dams.

None of this is the worst that could happen to the fish or the fishermen of the Columbia. But neither is "the return of the tules" what the ratepayers expect to emerge from the world's largest effort at biological restoration.

Although it is impossible to assure success, we must try. The sheer size of the mitigation responsibility—together with the enormous promise of the cooperation built during the negotiation of the U.S.-Canada treaty—demands a good-faith attempt to rebuild the salmon and steelhead lost from hydropower development and operations.

So, what should ratepayers be careful about as we venture together into this unknown territy?

Seeking at least a partial answer, the Council asked geneticist Larry Riggs to think through the place of genetic factors in rebuilding the Columbia Basin's fish runs. From the investment banker's point of view, what one cares about most is the gene pool, the fundamental biological asset.

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[26] See Northwest Power Planning Council, *Production Investment Policies*, issue paper, July 1985, p. 10.

[27] 16 U.S.C. 755.

[28] On the legal significance of these words, see Wilkinson and Conner, *op. cit*., pp. 46-48.

[29] Note that the U.S.-Canada treaty fixed the size of the harvest of chinook salmon. Under this regime, adding hatchery chinook can reduce the impact of mixed-stock fishing on wild stocks. Such an approach to harvest may be a useful supplement to efforts to develop known-stock fisheries.

Dr. Riggs' conclusions are set out in a technical discussion paper.[30] Riggs identifies roughly a dozen places in the basin where wild and natural production of salmon or steelhead should be optimized—what he calls Category A or B opportunities. Consider Table 1, taken from Riggs' paper. It suggests places where we should put the highest priority on preserving wild and natural fish stocks.

Riggs also discusses ways that fish managers can improve artificial production. For example, he points to the practice, now used by the Grant County Public Utility District and the Washington Department of Fisheries, of taking hatchery broodstock in part from the wild run, so that the superior survival characteristics of naturally reproducing fish are not bred out of hatchery stocks.

Larry Riggs' study is an important element of a broad framework within which enhancement can be carried out as part of an integrated approach to protection and mitigation.[31] I see in that framework some implications for wild and natural stocks:

Improved **mainstem survival** of downstream migrants should protect naturally reproducing stocks. Fish migrating in the spring and early summer now benefit from the augmented flows and spills of the Council's program. In 1986 the Council extended spills into the summer, to protect late-migrating stocks—including a significant portion of the wild runs.[32] It is important that hydro project operators give wild and natural stocks the benefit of the doubt when making decisions on spill and other operations, especially when the increased costs of doing so are small and unclear; the Council should work to improve project operations accordingly.

Mechanical bypass will provide year-round benefits to migrants as they pass mainstem dams. The Corps of Engineers has been approached by a wide coalition of power and fishery interests, urging expeditious installation of screens and collection facilities at the remaining federal dams.

In designing **harvest regulations**, the tribes and agencies are responsible for assuring escapement to spawning grounds and hatchery collection points. River fishery regulations developed in *U.S. v. Oregon* can provide an important opportunity to explore new approaches to harvest; these can significantly improve the survival of naturally reproducing stocks by improving targeted fisheries.

Enhanced production of fish should reflect a biologically conservative approach, in order to protect genetic quality and biological productivity over the long term. Hatchery production for both supplementation and on-station release should reflect genetic

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30 Northwest Power Planning Council, "Genetic Considerations in Salmon and Steelhead Planning," technical discussion paper, June 1986.

31 Northwest Power Planning Council, "Salmon and Steelhead Planning," issue paper, June 1986.

32 1984 Program, Sec. 404, as amended in February 1986.

TABLE 1

OPPORTUNITIES FOR GENETIC RESOURCE MANAGEMENT IN THE COLUMBIA BASIN

Subbasin	Fall Chinook	Spring Chinook	Summer Chinook	Coho Early	Coho Late	Winter Steelhd	Summer Steelhd	Chum Salmon	Sockeye Salmon	Sea Run Cutthroat
LOWER COLUMBIA										
Willamette	C,D	A,C,D	---	C,D	A,B,C,D	C,D	D,E	---	B	B
Cowlitz	C,D	D,E	---	C,D	C,D	B,C,D	B,C,D	---	---	---
Lewis--North Fork	A,B,C	D,E	---	A,B,C	A,B,C,D	B,C,D,E	B,C,D,E	B,C	---	---
East Fork	A,B,C	D,E	---	A,B,C	A,B,C,D	A,B,C	A,B,C	B,C	---	---
Sandy	A,B	C,D	---	D,E	B,C,D	B,C,D	D,E	---	---	---
BONNEVILLE-SNAKE										
Wind	B,C,D	D,E,F	---	A,B	---	A,B,C,D	B,C,D	---	---	---
Klickitat	D,E	C,D,E	F	C,D	---	A,C,D	B,C,D	---	---	---
Big White Salmon	C,D	F	---	A,B	---	A,B	A,B,C,D	---	---	---
Walla Walla--Oregon	---	F	---	---	---	---	A,B	---	---	---
Washington	---	F	---	---	---	---	A,B,C,D	---	---	---
Hood--Hood River	A,C	A,B,C,D	---	B,C,D	---	A,B,C,D	B,C,D	---	---	---
Fifteen Mile Crk	---	---	---	---	---	A	---	---	---	---
Umatilla	F	F	---	---	---	---	C,D	---	---	---
John Day	A,B	A	---	---	---	---	A	---	---	---
Deschutes	B	C,D	(F)	---	---	---	C,D	---	A,B	B,F
MID-COLUMBIA										
Methow	---	C,D	B,C,D	---	---	---	C,D	---	---	---
Okanogan	---	---	B	---	---	---	D,E	---	B	---
Wenatchee	B	B,C,D	A	---	---	---	C,D	---	A,B	---
Entiat	---	C,D	B	---	---	---	C,D	---	---	---
Mainstem	C,D	D,E	C,D	D,E	---	---	C,D	---	---	---
Yakima	B,C,D	B,C,D	F	C,D,E	---	---	C,D	---	F	---
SNAKE RIVER										
Tucannon	---	A,B,C,D	---	---	---	---	C,D	---	---	---
Imnaha	---	C,D	---	---	---	---	C,D	---	---	---
Grand Ronde--OR/WA	---	B/C,D	---	---	---	---	B/C,D	---	---	---
Mainstem	C,D	B/C,D	---	---	---	---	C,D	---	---	---
Salmon	---	A,C,D	A,B,C,D	---	---	---	A,C,D	---	B,F	---
Clearwater	---	A,B,C,D	B,C,D	---	---	---	A,B,C,D	---	---	---

A = Retain native wild stock　C = Sustain natural w/ hatchery　E = Increase hatchery stock productivity
B = Facilitate natural stock productivity　D = Improve hatchery effectivness for natural　F = Select/test new stock

considerations in husbandry, taking advantage of the natural strengths of the stocks released.

Production must also be coordinated with harvest regulations, so that increased production of a stock does not increase harvest pressure on other, weaker stocks.

Overall, action should reflect a **systemwide framework** for investment and implementation. Activities intended to protect or to benefit salmon and steelhead have been undertaken piecemeal.[33] Yet anadromous fish migrate through one of the world's largest ecosystems; without an understanding of how the parts of the anadromous life cycle fit together, efforts to benefit fish work at cross-purposes or are simply futile.

It is fundamental to the Council's systemwide approach that scientific knowledge is imperfect. Thus, each intervention into the natural system, from the operation of a hatchery to the seasonal closure of a fishery, is an occasion for learning more about the biological response of fish stocks to the combined effects of natural and human action. By treating human interventions as experiments, resource managers can learn over time how to protect and to enhance more effectively.[34]

In sum, what systemwide planning and genetics offer is a scientifically informed perspective on how to improve and sustain the *quality* of the fish being produced.

But we have a very large mitigation responsibility, and harvest managers face continued pressure to reopen the fishery. Can we afford to think about quality in the Columbia Basin? When are we being short-sighted to ignore the quality embodied in wild and natural fish? That is, when might enhancement conflict with protection?

When the Northwest Power Act was passed five years ago, such a question would have seemed ludicrous. Columbia Basin stocks were severely depressed; the question was whether they could be rebuilt at all, and no one dreamed that salmon and steelhead could be rebuilt too hastily. Yet as we look at the 1985 salmon treaty with Canada, the progress made by strictly controlling coastal harvests, and the ripening agreement in *U.S.* v. *Oregon*, the possibility that a rush to rebuild the fishery will do unintended biological damage is worth keeping in mind.

What is most important is to learn from experience as we move forward with restoration. Learning is easy to endorse in principle, difficult to attain in practice. Sorting out the quiet sound of human successes and failures from the deafening background noise of natural fluctuations will require

[33] Wilkinson and Conner, *Op. Cit.*, p. 104.

[34] See K.N. Lee and J. Lawrence, "Adaptive Management: learning from the Columbia River Basin Fish and Wildlife Program," *Environmental Law*, forthcoming.

careful *systemwide* evaluation, so that efforts in one geographic area can be assessed against the experiences of projects and control areas elsewhere in the Columbia system.[35]

The tribes and fish agencies face difficult choices in balancing short-run gains against long-term risks. The Power Council must invest prudently. It is in forging that difficult balance, and in maintaining a prudent course, that we need the participation, support and criticism of the broader interested public. Both the fish and the ratepayers need you.

Although Kai Lee represents the state of Washington on the Power Planning Council, he stresses that views expressed in this paper are not necessarily positions of the Council.

[35] C. Walters, T. Webb, and J. Collie, "Experimental Designs for Estimating Transient Responses to Production Enhancement Measures in Columbia River Streams," Environmental and Social Systems Analysts, Ltd., Vancouver, B.C., May 1986. Unpublished.

Restoration of Anadromous Fish —Not As Simple As It Sounds

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Introduction

Restoration implies the recovery or rebuilding of something lost or destroyed. Once lost, genetically unique stocks of wild fish can never be recovered. To discuss restoration in a manner pertinent to management of wild salmon and steelhead, one must review the causes of habitat loss and destruction, because these must be reversed or their effects mitigated before reestablishment of fish runs becomes feasible.

Some events causing loss of habitat were the result of ignorance and carelessness, but most were a consequence of debate and thoughtful decisions. Those decisions were considered wise at the time. This suggests that restoration must involve not only physical change or recovery of habitat, but also changes in the procedures and criteria for decision-making.

Our frame of reference is the Columbia River Basin and the anadromous stocks of trout and salmon affected by hydropower development. This drainage is one of the most intensively developed of the large basins in the Western Hemisphere. As the United States emerged from the Great Depression of the 1930s, hydropower development on the mainstem Columbia River was seen as the means of revitalizing the Northwest economy. World War II convinced planners of the the wisdom of building Grand Coulee and Bonneville dams. Most of the other locations of the present federal dams were by then identified, and non-federal interests hurried to stake out their claims on remaining preferred sites in the basin.

Grand Coulee Dam on the Columbia, Hells Canyon Dam on the Snake, and other unladdered dams on the Deschutes, Willamette, Cowlitz and Lewis rivers eliminated one-third to one-half of the salmon and steelhead production areas in the Columbia River Basin (PFMC, 1979). Below these insurmountable dams, 13 mainstem run-of-the-river projects have transformed about two-thirds of the remaining 792 miles of the Columbia and the Snake from free-flowing rivers to a series of slack-water impoundments. These projects resulted in a significant loss of spawning and rearing habitat. They also contribute to the continuing annual loss of juvenile outmigrant salmon and steelhead through mortality in the turbines or in the reservoirs (Evans, 1985).

Much of the decline in run sizes occurred during the war years, apparently because of overfishing; but with only Bonneville and Rock Island dams to contend with, stocks from the upper basin were recovering by the early 1950s. Completion of McNary Dam in 1957 marked the beginning of a period of rapid hydropower development, with five more projects completed on the mainstem by 1965 and another five by 1975. The failure of these stocks to continue to recover in the face of project construction was partially obscured by harvests of hatchery fish released in the lower river. The decline of upriver stocks was recognized to some extent, but that had little effect on the decision makers. Fishery interests were a disparate lot, poorly organized, and almost totally lacking in political clout at the time.

These were not the only factors, however, that delayed the realization that anadromous fish in much of the Columbia Basin might become curiosities, relics of a different time and a different way of life. The full potential of mainstem hydro projects to kill juvenile migrants was demonstrated in 1973 and 1977 when almost the entire upriver run perished because of record low-water conditions. Turbine mortality took much of the run. Few of the turbine intakes were equipped with screen and bypass facilities (Fig. 1), and the low flows left no water for spills that might have provided an alternative to passage through the powerhouses.

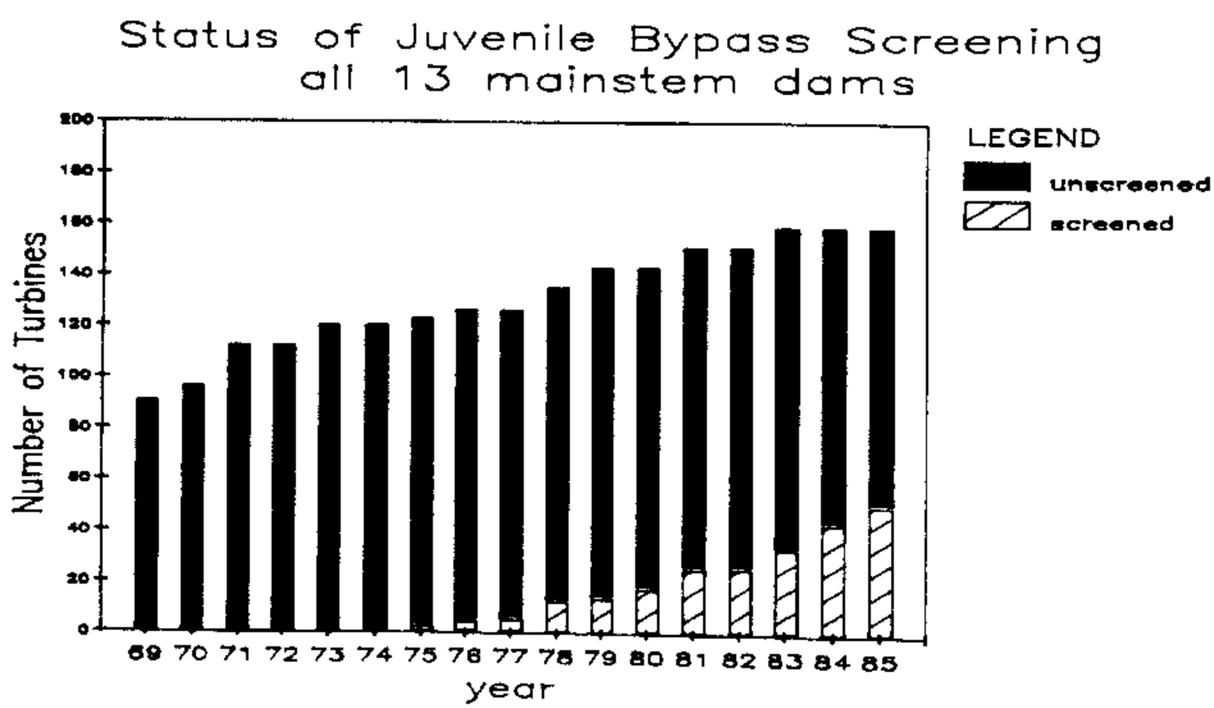
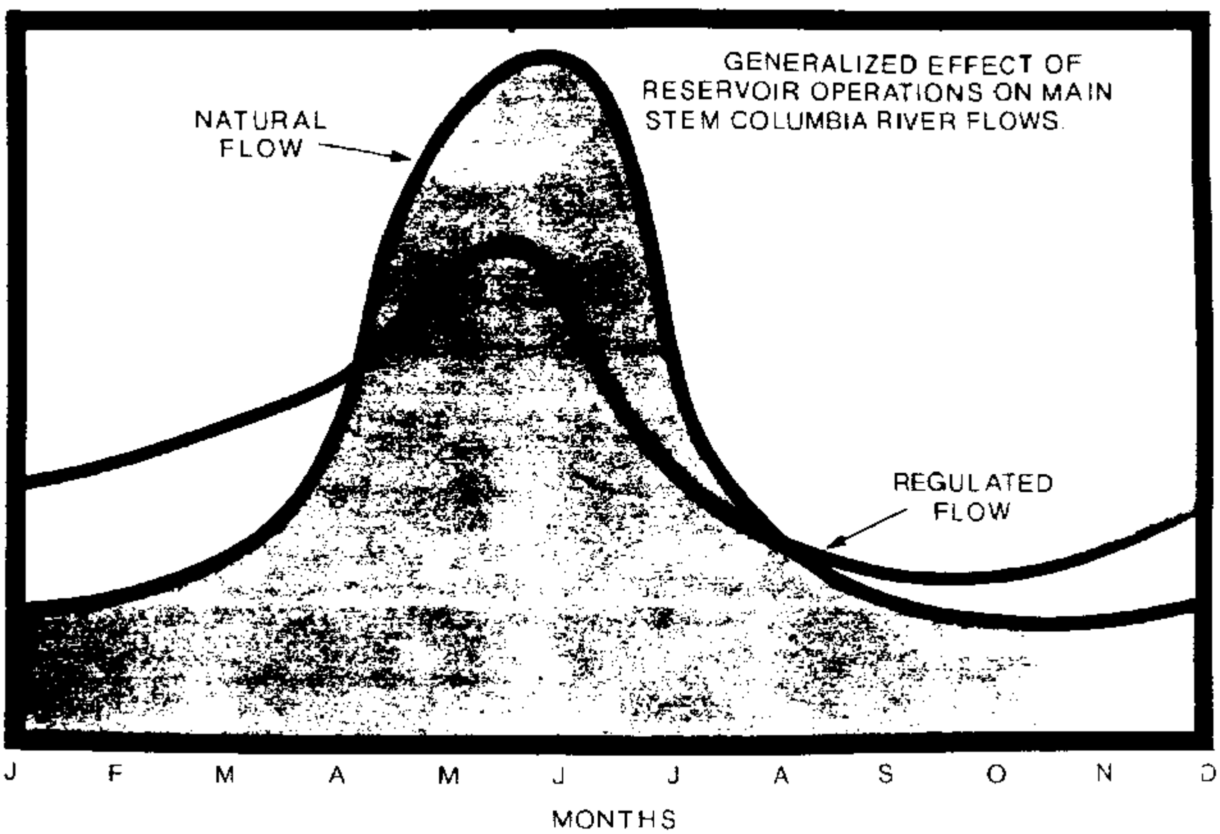


FIGURE 1

Also, construction of headwater projects in Canada during the 1960s had nearly doubled the storage capacity in the basin so that the little runoff of those years was held back in reservoirs. The capability of the Federal Columbia River Power System to manipulate reservoir storage and river flow then became apparent (Fig. 2). This elimination of the spring freshet delayed passage through reservoirs, in turn causing greater losses because of increased exposure to predation, disease and adverse environmental conditions.

FIGURE 2



Negotiations during this period with the Corps of Engineers (COE) and Bonneville Power Administration (BPA) to improve flow and spill conditions for fish followed a pattern: they went well until there was a conflict with power generation. Then, fishery agencies were told, there was little flexibility to alter project operations for fish protection because of the power sales contracts that were in place. Operational flexibility was further limited because fisheries were not a project purpose in the congressional authorizations. The means to correct this imbalance in the use of water became available in the fish and wildlife provisions of P.L. 96-501, the Pacific Northwest Electric Power Planning and Conservation Act of 1980—popularly called the Northwest Power Act or simply the Act.

Legislation for Restoration

Among the purposes of the Northwest Power Act are protection, mitigation and enhancement of fish and wildlife in the Columbia Basin. Achievement of these purposes is pursued through the Columbia River Basin Fish and Wildlife Program (the Program) adopted by the Northwest Power Planning Council (the Power Council). The standards of the Act specify that measures to be included in the Program should complement the activities of the fishery agencies and tribes, be supported by the best available information, use the least cost alternative for each sound biological objective, and be consistent with tribal legal rights. The only substantive requirement for these measures is that, in the case of anadromous fish, they must:

1. Improve survival and hydroelectric facilities; and,
2. Provide sufficient flows to improve survival between such facilities.

The objectives of improved survival at and between dams were not new under the Act. They had been recognized for several years by the fishery agencies and tribes as the key to restoration of upriver wild salmon and steelhead stocks, and as a necessary step toward realization of the benefits of new hatchery production being planned under the Lower Snake River Fish and Wildlife Compensation Plan. Under the Act, however, these objectives were for the first time explicitly included as a purpose coequal with all other purposes for which federal and non-federal hydroelectric facilities on the Columbia and its tributaries are to be managed.

Survival of migrating fish *between projects* is improved by increasing spring flows to move fish through the system in a biologically timely manner. This can be accomplished by adjusting the rule curves for reservoir operations so that stored waters are released to simulate an artificial freshet when high spring runoff should occur, or by allowing more of the natural freshet to pass (Fig. 2).

Survival *at projects* is improved by directing juvenile migrants away from turbine intakes. This is accomplished by screening intakes to divert fish into bypass channels that return them to the river below the dam, or by collecting the migrants upriver and transporting them via truck or barge to a release point downriver. Also, at projects without bypasses, passage can be provided by spilling water (and fish) over the dam.

The Power Council has estimated that the annual loss of salmon and steelhead in the Columbia River Basin due to all causes is in the range of 7 to 14 million adults (0.4 to 1.1 million of them steelhead). The loss of 5 to 11 million of these fish is attributed to hydroelectic projects (NPPC, 1986). At present, production of Columbia salmon and steelhead is only about 2.5 million adults, and most of these fish come from hatcheries.

The fishery agencies and tribes are committed to making full use of all available natural spawning and rearing habitat, but it seems clear that much of the hydropower debt of 5 to 11 million fish will have to come from hatcheries. Further, it seems likely that reestablishment of wild, naturally spawning runs to obtain optimum use of that habitat will depend to some extent on hatchery outplanting of juvenile fish. At this point, one cannot say how the objectives of habitat utilization, allocation of harvest, wild fish management and collection of the hydropower debt will be reconciled. It is clear, however, that the enhanced productivity and viability of salmon and steelhead populations in the upper river depend upon substantial improvements in the survival of mainstem juveniles.

Restoration of wild anadromous fish runs has a good chance of succeeding under provisions of the Northwest Power Act because of two factors that have been missing from previous plans. These are the authority for the fishery agencies and tribes to affect project operations, and an assured source of funding. A review of progress made since passage of the legislation in 1980, however, will show that federal project operators and regulators have not moved aggressively to develop internal policies fully responsive to the intent of the Act.

The National Marine Fisheries Service recently reviewed the success of the Program and other initiatives to improve juvenile fish survival on the mainstem Columbia and Snake rivers through flow enhancement, bypass facility development and interim spill (NMFS, 1986). Progress in each area was reviewed for the period immediately prior to and since passage of the Northwest Power Act. Mechanisms for fishery agency and tribal participation in decision-making also were reviewed.

In general, the review concludes that there has been no substantive improvement in flows for fish migration or in the role of the fishery agencies and tribes. There has been some progress in developing bypass facilities and allowing spill for fish passage, most notably in response to orders issued by the Federal Energy Regulatory Commission (FERC) at the mid-Columbia public utility district (PUD) projects, and in the completion of previously planned COE projects. There has also been some backsliding. Each area is summarized below.

Role of the Fishery Agencies and Tribes

The Committee on Fishery Operations (COFO) has been replaced by the Fish Passage Center as the fishery agencies' and tribes' representative at federal power system decisions. The COFO was an ad hoc group that included the project operating agencies, the fishery agencies, members of the Northwest Power Pool and other interested parties. COFO was formed in 1975 in response to an appeal by fishery agencies that every effort be made to improve the survival of migrating adult and juvenile salmon and steelhead in the Columbia and Snake rivers (COFO, 1981). The process was entirely voluntary, and there was no formal membership, written charter or clearly defined status. Annual fishery plans developed by the COFO were limited by constraints imposed by dam operators; and except where the plans followed a FERC order, their implementation relied on the voluntary cooperation of those operators.

The Fish Passage Center (formerly the Water Budget Center) represents the fishery agencies and tribes and coordinates their input in pre-season planning, in-season operational requests, and post-season reports on flow and spill programs as well as fish facility inspections (FPC, 1986; Water Budget Center, 1985). In 1985, after the Fish Passage Center had performed these duties for two years, BPA administrators attempted to use their contracting authority over the Center to prevent it from participating in decisions involving spills. The Power Council supported the fishery agencies' and tribes' view in that dispute and clarified the Program by identifying the Water Budget managers specifically as the primary points of contact between fishery and power interests on matters concerning both the Water Budget and spill at COE projects. Coordination of facility inspections was not included. Funding for this activity is now provided to the Fish Passage Center by the fishery agencies.

The Fish Passage Center has served as an effective coordinator among the fishery agencies and tribes but its input into hydropower operations remains minimal. Meanwhile, the Power Council, COE, and most notably the BPA have expanded their fish and wildlife staffs and are becoming increasingly involved in such fishery management decisions as whether, when, and for which stocks protective flow and spill measures are needed.

Flows to Improve Juvenile Survival

A major component of the Power Council's Fish and Wildlife Program is the Water Budget. This is a volume of water set aside in reservoir system planning and available for use by the agencies and tribes to improve flows needed by juvenile migrating salmonids (NPPC, 1984). With the establishment of the Water Budget, the objective of the project operating agencies for provision of flows changed from meeting the fishery agencies' and tribes' recommended minimum or optimum flow levels to providing the Water Budget flow regime set out in the Program. This is particularly significant given that in recent BPA actions the Water Budget has been interpreted as setting a cap on the flow available for fishery purposes—regardless of the volume actually available.

Since the size of the Water Budget was determined based on what could be provided in a critical low-flow year, this BPA interpretation means that spring flows for anadromous fish are limited in *all* years to what could be provided under drought conditions. In years of greater runoff more water goes to fish only if it is not claimed by other interests (e.g., natural runoff that can not be stored or managed to produce power is available for spill).

There are additional problems upriver. The Water Budget was based in part on the fishery agencies' and tribes' recommended flow levels, yet it provides less than minimum levels in the Snake River because of concerns about the impact on reservoir refill. Also, Water Budget flows specified in the Fish and Wildlife Program for both the Columbia and Snake rivers are maintained for a shorter period than was recommended.

So far the fishery agencies and tribes have worked within this compromise because of the participatory role in water management decisions promised by the Fish Passage Center's charter. In particular, management by the fishery agencies and tribes, and water budget priority above reservoir refill and non-firm power, were viewed as significant improvements. It was expected that the agencies and tribes would be able to manage the Water Budget to provide the baseline protection needed in low-flow years, and would be allotted better-than-minimum protection under more favorable conditions. The Water Budget measures still hold that promise. It has not, however, been fulfilled to date.

The Snake River component of the Water Budget has been diminished by the COE's position regarding Dworshak Reservoir and by the position of Idaho Power Company regarding Brownlee Reservoir. The principal problem is the top priority the COE and Idaho Power assign to refill at both reservoirs. This is in direct opposition to the priorities established in the Program. Meanwhile in the Columbia River, while a considerable volume of water has been provided from

Grand Coulee, the opportunity for fishery agencies and tribes to shape flows to maximize juvenile fish survival—as specified in the Program—has been preempted by secondary power production. Unfortunately, the Power Council appears unwilling to provide the leadership needed to resolve these problems and ensure compliance with the Program.

Figures 3 and 4 depict flows at Priest Rapids and Lower Granite dams from 1975 to 1985. They present the total flow at each project from April 15 to June 15 as it relates to the average minimum flow recommendations of the fishery agencies and tribes for the same period. It is clear from these figures that in most years there was more than enough water to meet minimum flows shaped to the needs of migrating fish. In other words, except during a drought year like 1977 (the worst in a 50-year record), the question is not whether sufficient water exists to meet recommended flows, but how that water is to be managed.

Thus compared with conditions before enactment of the Northwest Power Act, there has been little improvement in flows provided for fish. Instead there have been significant problems implementing the modest provisions of the Water Budget, most acutely in the Snake River. If this is the case now, what will happen when a dry year puts the Water Budget to a true test?

Interim Bypass Protection Using Spill

The annual spill program at mid-Columbia PUD dams has been carried out under an order of the Federal Energy Regulatory Commission (FERC), or under a negotiated agreement accepted by the FERC, since 1979. These orders or agreements have always included a specified volume or proportion of water to be spilled for fish protection, plus a specified spill period. A further requirement was that the spills be effective, which required monitoring programs and subsequent modifications to the spill program.

Since 1979 there has been substantial progress in protecting spring runs through spills at Priest Rapids, Wanapum and Wells dams. There has been no change in passage protection at Rocky Reach Dam, where spill is of little value; but hastened development of a bypass facility will remedy this. On the negative side, there has been significant backsliding at Rock Island Dam, and no summer spill programs exist at the PUD projects.

The interim juvenile fish protection program at federal projects has suffered because the COE has retained total discretion to determine objectives and acceptable impacts. Rather than specific volumes, the COE spill plan relies on specified spill to some percentage of instantaneous or daily average flow when significant numbers of fish are present. In practice, this has resulted in substantially less water being allotted to fish protection than would have been provided with the fixed volume or proportion required at the PUD projects.

In 1984 the Power Council adopted a 90 percent survival objective for federal projects, but its basis and application remain unclear. At some projects the 90 percent objective has been used to justify reduced spill for fish passage. The spill program at federal projects also has suffered from a lack of consistent, comprehensive monitoring and spill-effectiveness data.

FIGURE 3

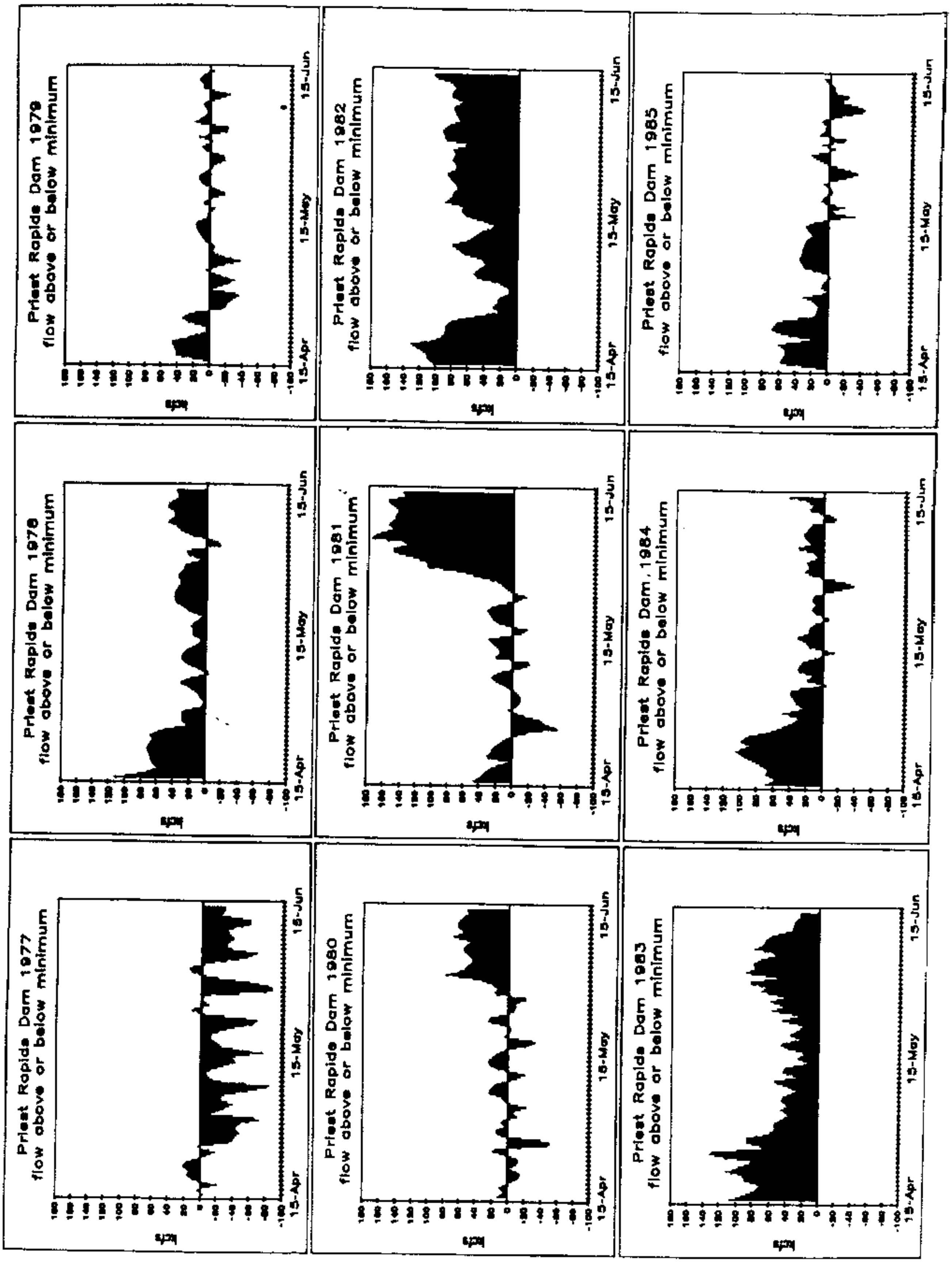
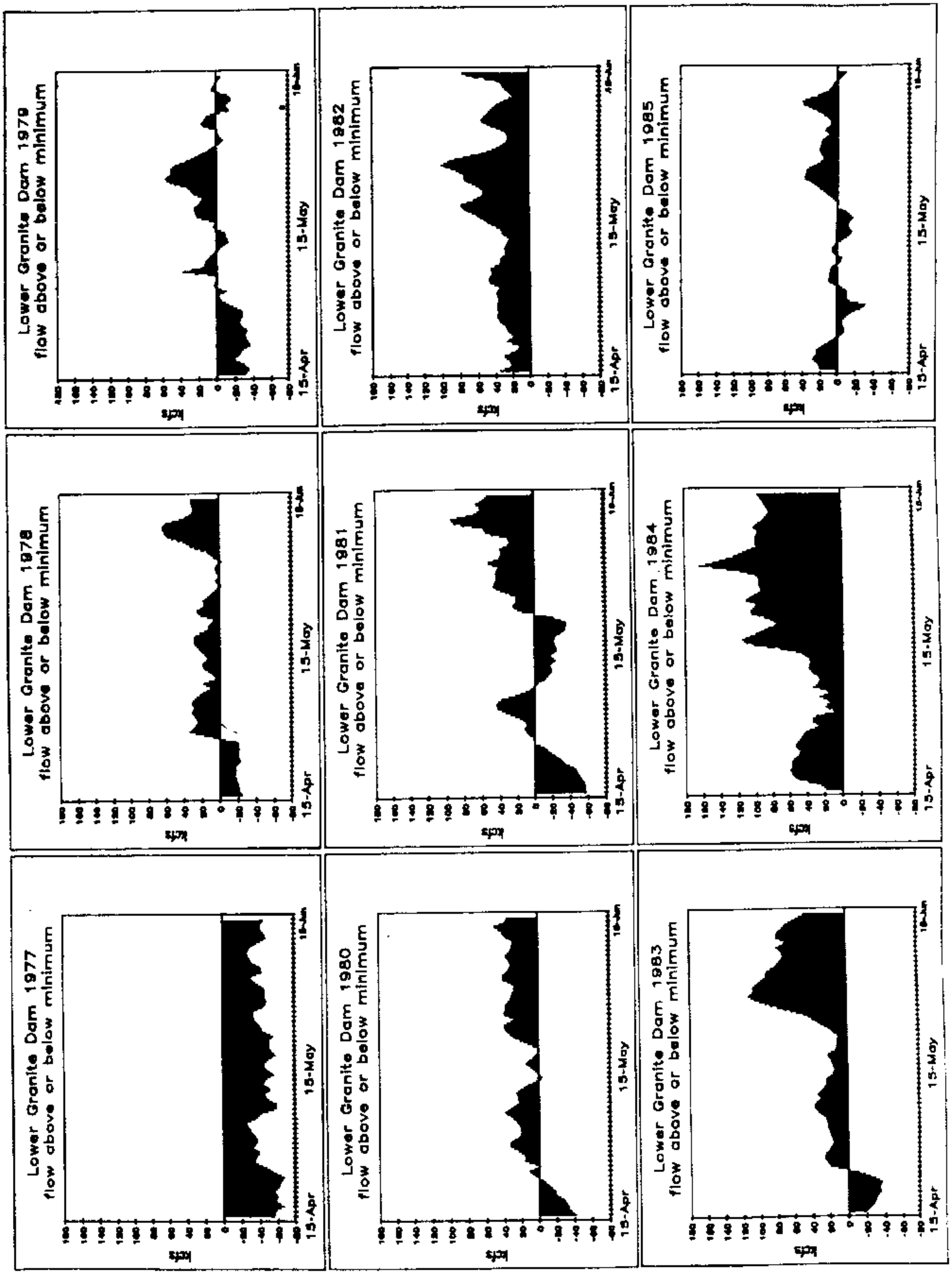

Priest Rapids Dam 1979
flow above or below minimum
Priest Rapids Dam 1982
flow above or below minimum
Priest Rapids Dam 1985
flow above or below minimum
Priest Rapids Dam 1978
flow above or below minimum
Priest Rapids Dam 1981
flow above or below minimum
Priest Rapids Dam 1984
flow above or below minimum
Priest Rapids Dam 1977
flow above or below minimum
Priest Rapids Dam 1980
flow above or below minimum
Priest Rapids Dam 1983
flow above or below minimum
kcfs
15-Apr
15-May
15-Jun

FIGURE 4


Lower Granite Dam 1977
flow above or below minimum
Lower Granite Dam 1978
flow above or below minimum
Lower Granite Dam 1979
flow above or below minimum
Lower Granite Dam 1980
flow above or below minimum
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Lower Granite Dam 1984
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Lower Granite Dam 1985
flow above or below minimum
kcfs
15-Apr
15-May
15-Jun

There were some improvements in the spill program at COE projects that seemed to parallel the directives of the Power Council's Fish and Wildlife Program. For example, beginning in 1983, following initial adoption of the Fish and Wildlife Program, the COE increased the amount of spill provided at John Day Dam. Then in 1985, following amendment to the Fish and Wildlife Program to include the 90 percent survival objective, the COE reinstituted spill that had been discontinued at Ice Harbor Dam and planned for fish passage spill at The Dalles Dam for the first time. Planned spill levels for fish at both projects in 1985 exceeded what the COE determined was necessary to meet the 90 percent survival objective.

In February of 1986, however, the Power Council again amended the spill provisions of the Fish and Wildlife Program. The 90 percent survival objective was retained but the Council clarified that it should be met in spring and summer regardless of water conditions, even if that impacted firm power. The COE has agreed to meet this minimal level of spill but has withdrawn commitments to meet the higher survival objective (COE, 1986). As a result, planned spring spill has been eliminated at Ice Harbor Dam and much reduced at The Dalles Dam. On the positive side, summer spill should be provided at these and other projects.

Concerns about the adequacy of the spill objectives now in the Program parallel concerns regarding the Water Budget. Like the Water Budget, the spill levels included in the Program were based on what would be a reasonable spill volume during critical low-flow conditions, always keeping in mind the Power Act's intent to achieve an equitable balance between fisheries and power. In 1986, however, in spite of the fact that projected flow conditions were well above critical water, the COE spill plan included only the minimum required by the Program. According to that plan, spill above these minimum levels may be provided at the discretion of the COE (COE, 1986).

In comments on the COE 1986 Juvenile Fish Passage Plan, the Power Council made it clear that the 90 percent survival objective "only established the minimum level of spill," and that additional spill should be considered. The fishery agencies and tribes informed the COE that they would request spills above these minimal levels consistent with the agencies' and tribes' Detailed Fishery Operating Plan when there was a surplus of federal firm power or when federal non-firm power exists (an indication that conditions exceed critical water levels).

Serious disagreement persisted throughout the 1986 planning process for spills. As in past years, the COE interpreted the language of the Program as giving it authority over management of fish passage. In practice the COE implemented their own plan regardless of recommendations from the agencies and tribes. The COE was able to use the Power Council and the Program as a buffer against agency and tribal recommendations by citing consistency with the minimal standards. At the same time, however, the COE plan was inconsistent with the Program directives calling for deference to tribal and agency recommendations to improve project survival. The Power Council ignored this inconsistency with Program measures; it took no action, offered no comment, and did not support the agencies' and tribes' recommendations to improve project survival. The entire 1986 spring migration occurred without any action by the Power Council. Fortunately, Mother Nature and the Mideast oil cartel teamed up to produce conditions of high flow and low demand for surplus Northwest hydropower, so much of the 1986 spring migration benefited from relatively good spill conditions.

Juvenile Fish Bypass Facilities

Juvenile fish bypass facilities were in place at two projects in 1980—at Lower Granite and Little Goose dams on the Snake River. Bypass facilities were installed at McNary Dam in 1981, at Bonneville's first powerhouse in 1984, and a partial system was added at John Day Dam in 1985. Completion of the John Day bypass is expected in 1987. Bonneville's second powerhouse was completed in 1983 but the efficiency of its bypass system is so poor that it has yet to be approved.

These facilities were planned, under construction, or in operation when the Act was passed in 1980. After passage of the Act, and in some cases after an initial delay, the Power Council adopted fishery agency and tribal recommendations for bypass facility development at the other three federal projects and at the five PUD projects. It has since reversed itself in the case of Rock Island Dam. Thus the number of unscreened turbines has not substantially decreased (Fig. 5).

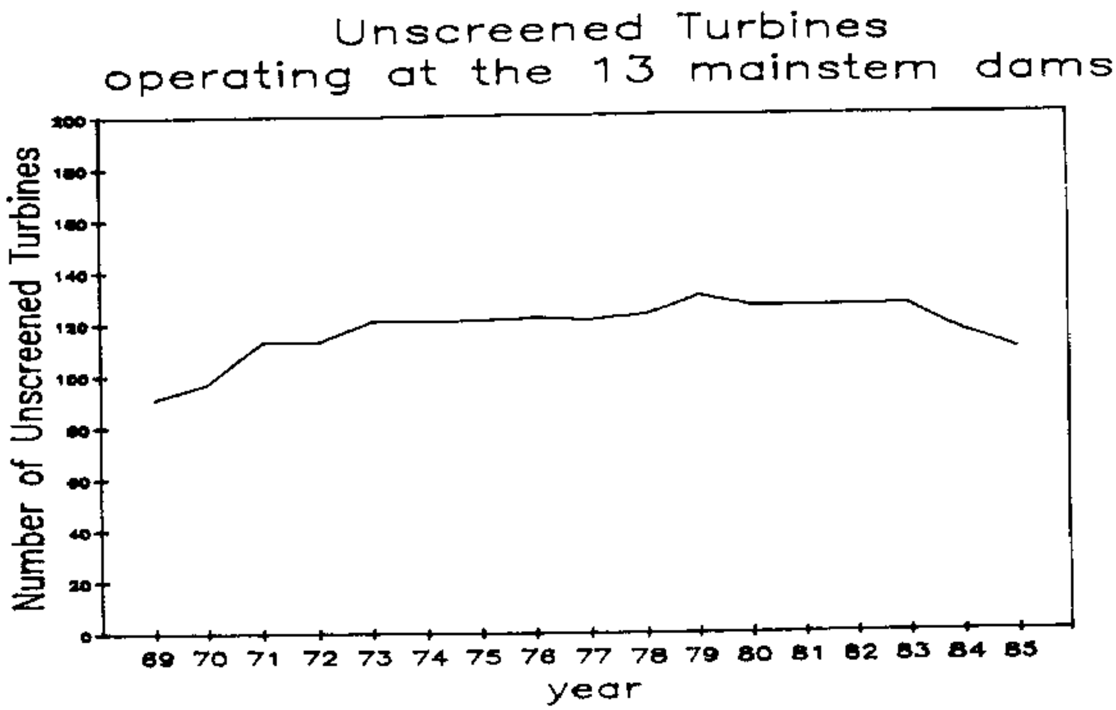

FIGURE 5

Progress on design studies for bypass facilities at the PUD projects generally has followed a schedule agreed to by the fishery agencies, tribes and project operators. Based on that schedule, it is possible that permanent facilities could be in place as early as 1988-1990 at all PUD projects except Rock Island Dam.

There has been less progress at three federal projects without complete juvenile bypass facilities—The Dalles, Ice Harbor and Lower Monumental dams. Although the Program requires the completion of facilities at all these dams by 1989, the COE has not yet committed to this schedule. However, prototype studies were conducted at The Dalles Dam in 1985 and 1986, were initiated at Lower Monumental in 1986, and are scheduled to begin at Ice Harbor Dam in 1987. The COE indicated in the 1984 amendment process that five years are required between initiation of studies and bypass completion, hence the 1989 completion date specified in the Program.

Using the COE's present schedule, the earliest possible on-line dates for the facilities at The Dalles, Ice Harbor and Lower Monumental dams are 1989, 1991 and 1990. The fishery agencies and tribes believe that this schedule is overly conservative and that the Program requirement for completion by 1989 could still be met. The COE, however, recommended Program amendments that would result in even further setbacks of these dates, to 1992, 1992 and 1991 respectively. In response to criticisms from the fishery agencies and tribes, as well as from the Power Council and other power interests concerned about the increasing costs of spill for fish passage, the COE has agreed to investigate the feasibility of accelerating these schedules.

Figures 1 and 5 illustrate how far we have come in providing juvenile fish bypass facilities at the 13 mainstem dams, and how far we have to go. It should be noted that all of the progress reflected in these figures has been at COE's projects. More than half of the Corps' turbine units have been screened during the last 10 years.

Summary

Restoration of runs of anadromous fish, particularly wild fish, involves consideration of harvest management, production, and habitat management. Programs to restore runs of wild salmon and steelhead in the Columbia River Basin to productive, harvestable levels must be adapted to the management and procedural requirements of the Federal Columbia River Power System which regulates the critical environmental conditions for fish migrating to and from their spawning and rearing areas. At this point in the implementation of restoration programs for Columbia Basin anadromous fish, it is important to keep the relationship of these factors in mind.

The factor presently dominating the restoration equation is the relationship between production and migrant survival. Massive releases of hatchery fish might overwhelm the high mortality suffered by upriver juvenile migrants at mainstem dams. However, rebuilding populations of wild fish is not amenable to that solution, and it is wasteful of hatchery fish. By the same token, even very substantial investments in habitat enhancement in tributary streams will not provide positive results without an increase in spawning adults, which requires improved juvenile survival. There are few areas in the upper basin where spawning and rearing habitat are the primary factors limiting production. Wild fish, even more than hatchery stocks or populations augmented by hatchery outplanting, depend upon improved survival at and between projects on the Columbia and Snake rivers.

Restoration of wild anadromous fish runs in the Columbia River Basin is not simple, but it can be done, and it offers enormous rewards, not only to the economy of the region, but to the social and cultural needs of its citizens.

LITERATURE CITED

COE, 1986. Juvenile fish passage plan for 1986 for Corps of Engineers projects. NPDEN-WM. U.S. Army Corps of Engineers, Portland, Oregon. April 1986.

COFO, 1981. Committee on fishery operations 1980 annual report. U.S. Army Corps of Engineers, Portland, Oregon.

Evans, Dale R. 1985. Environmental factors affecting abundance. *In* Richard H. Stroud (ed.), Recreational uses, production and management of anadromous Pacific salmonids. Marine Recreational Fisheries Symposium, Seattle, Washington. April 26-27, 1985. National Coalition for Marine Conservation, Inc., Savannah, Georgia.

FPC, 1986. 1985 spill planning and management for juvenile fish passage: a supplement to the 1985 water budget managers annual report. Fish Passage Center, Portland, Oregon. January 1986.

NMFS, 1986. Mainstem passage programs for juvenile fish before and after enactment of the Northwest Power Act: a progress report. National Marine Fisheries Service, Portland, Oregon. May 1986.

NPPC, 1984. Columbia River Basin fish and wildlife program. Amended October 10, 1984. Northwest Power Planning Council, Portland, Oregon.

NPPC, 1986. Hydropower responsibility for salmon and steelhead losses in the Columbia River Basin: staff issue paper. Northwest Power Planning Council, Portland, Oregon. April 1986.

PFMC, 1979. Freshwater habitat, salmon produced, and escapement for natural spawning along the Pacific coast of the U.S. A report prepared by the anadromous salmonid task force. Pacific Fishery Management Council, Portland, Oregon.

Water Budget Center, 1985. Annual report from the water budget managers, 1985. Bonneville Power Administration, Portland, Oregon.

CASE HISTORIES
OF
WILD SALMONID POPULATIONS

There is much to be said for failure. It is more interesting than success.

—Max Beerbohm

Human history becomes more and more a race between education and catastrophe.

—H.G. Wells

Between two evils, I always like to take the one I've never tried before.

—Mae West

It's a bad plan that can't be changed.

—Publilius Syrus

There's a kind of a wild and glad elation in the natural way of insemination.

—Opus

How Fish Management Can Affect Wild Populations: A Case Study of the Clackamas River

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Physical Features and History

The Clackamas River is 83 miles long and drains 937 square miles on the west slope of the Cascade Range. It includes about 840 miles of class I, II and III streams. The Clackamas joins the Willamette River near Oregon City 10 miles south of Portland. The flow at its mouth averages 3,700 cfs, ranging from 700 cfs in August to 4,600 cfs in December. Above river mile 32 it is in the Mount Hood National Forest, where summer water temperatures rarely exceed 62° F. Temperatures exceeding 70° F are common at the mouth, however, especially during low flows.

There are three dams on the Clackamas mainstem, at river miles 23, 28 and 31. There are also two fish hatcheries in the Clackamas subbasin: a federal hatchery on Eagle Creek, and a state-operated hatchery at McIver Park near river mile 22.

The stocks of native game fish as we know them today include spring chinook, coho, winter steelhead, rainbow, and sea-run and resident cutthroat. Introduced stocks consist of fall chinook, spring chinook, early run coho, early run winter steelhead, summer steelhead, brook trout and brown trout.

The native fish populations of most Oregon rivers have been significantly altered by human activities. On the Clackamas those activities included commercial fishing, dams and hatchery practices.

Because of its proximity to Portland and easy access, the Clackamas was an early favorite for commercial fishermen. Fishwheels and drift nets caused serious depletion in the spring chinook run as early as 1876. One fishwheel at the mouth of the river reportedly blocked all upstream passage, and in 1893, 140 tons of chinook were taken at a single location.

A combination of early dams and hatcheries probably accounted for the greatest fish mortalities as well as for the major changes in run characteristics. The first dam on the Clackamas was built near the mouth in 1891. Seven feet high and used to run a grist mill, it blocked most of the runs until being laddered in 1895.

Next came Cazadero and River Mill dams in 1905 and 1911. Both were equipped with fish ladders, but each ladder was racked and fish passage stopped so chinook eggs could be collected for hatchery operations. The first fish eggs from the ladders were taken in 1907; in addition there were at least two other egg-taking stations on the river. All these stations collected eggs for two hatcheries. Chinook eggs from at least four other river systems, including some from California, had been brought to the Clackamas by 1904. The practice at that time was to hatch the eggs and release the fish in the winter as unbottoned fry. Such releases are regarded now as ineffective, and they probably provided very few adult returns in the early years. Still, even if this practice—which went on for some 30 years—didn't seriously change Clackamas runs, the fact that the Cazadero fish ladder washed out in 1917 and wasn't rebuilt until 1939, undoubtedly did.

The proximity of the Clackamas to Oregon's major metropolitan area has also subjected the river to tremendous sport-fishing pressures. In 1984 the estimated sport catch of salmon and steelhead in the Clackamas system was 6,491 chinook, 1,430 coho and 18,779 steelhead. Above river mile 23 there is excellent bank access because of roads that follow the river on public land. Although the lower river has more restricted access, numerous boat ramps now serve jet sleds as well as drift boats. Most of the trout fishing occurs above North Fork Dam, while most of the salmon and steelhead fishing, with the exception of summer steelhead, takes place in the lower 23 miles.

Fisheries Management

Four agencies regulate or otherwise significantly affect Clackamas River fisheries. Chief among them is the Oregon Department of Fish and Wildlife (ODFW). Its role includes recommending bag limits and seasons, carrying out stocking programs, and assuring habitat protection. ODFW also runs the Clackamas Hatchery which releases spring chinook. The U.S. Fish and Wildlife Service is involved through its Eagle Creek Hatchery, a Mitchall Act hatchery which releases coho, winter steelhead and spring chinook. The U.S. Forest Service is responsible for timber harvest, habitat enhancement, and other land management activities on the national forest that makes up most of the Clackamas drainage. The National Marine Fisheries Service is charged with supporting commercially important fish; thus on the Clackamas it is involved with habitat protection and fish-passage issues, and shares in the operation and maintenance costs for the Clackamas Hatchery.

The main commercial/industrial concerns that affect fisheries management on the Clackamas are the hydro projects owned by Portland General Electric (PGE). Other commercial interests exist, such as irrigation and municipal water supplies, but their impact on fisheries is negligible. PGE owns and operates a three-dam hydroelectric complex on the mainstem. It is responsible for maintaining fish ladders, trapping and hauling adult fish, and counting downstream migrants. PGE also participates in enhancement projects and shares in operation and maintenance costs for the Clackamas Hatchery.

Small local businesses also have a strong influence on Clackamas River fisheries. These businesses—ranging from fishing guides and tackle shops directly dependent on the fisheries, to gas stations and restaurants that profit indirectly—exert political pressure to protect their economic stake in the fisheries.

The impact of commercial fisheries on all salmon stocks of the Clackamas occurs outside the basin, hence will not be considered.

Last come recreational fishermen, who probably exert the most influence on Clackamas River fisheries. Their ability to harvest fish (if not by expertise, then by sheer numbers) directly affects population numbers. And it is their desires, expressed through economic and political pressures, that mold the responses of all the aforementioned groups. Since they have so much influence and their desires are so diverse, wild fish management often gets lost in the shuffle.

Now, what does all of this means to the wild fish stocks of the Clackamas River?

Status of Wild Fish

There are three main issues or conflicts, as I prefer to call them, continually shaping Clackamas fisheries: hatchery stocks versus wild stocks, introduced stocks versus native stocks, and anadromous fish versus resident fish. (Some clarification may be needed on the first two conflicts, which are closely related. Hatchery stocks are spawned and hatched in a hatchery, whereas wild fish reproduce on their own. Introduced stocks originated from another river system, perhaps several generations earlier, whereas native stocks evolved in their system. Wild fish may hail from introduced or native stocks, or even from hatchery stocks that succeeded in reproducing at large.)

In the past wild fish did not receive the attention they do today. There seemed to be plenty of wild stocks; managing for wild fish wouldn't have allowed for high harvest rates; and the effects of using hatchery fish were not well understood. The first hatchery in Oregon was built on the Clackamas River in 1877 by the Oregon and Washington Fish Propagating Company to ensure continued salmon runs for the salteries and, eventually, the canneries. In time, hatcheries started producing fish to help restore or supplement wild populations for sport fishing. At some point the role of hatcheries changed from supplementing fisheries to providing new fisheries, and from providing a supply for a demand to creating a demand.

The use of hatchery fish or introduced stocks can affect native wild stocks in a number of ways. On the Clackamas those include: high harvest rates, competition among stocks, changes in run characteristics, and loss of native runs.

As already noted, the Clackamas has wild and hatchery components to almost all of the salmonid stocks. In many cases the conflict between hatchery and wild fish is how to harvest the hatchery without overharvesting the wild component. In 1977, ODFW conducted a creel survey during the first month of the trout season. Fishermen took 28,400 hatchery rainbows and 700 wild trout *in that one month*. Obviously the wild trout population could not be maintained under such pressure.

When introduced stocks are able to spawn successfully in the wild, they may compete with native stocks at all life stages. More often than not, the stocks of fish available for stocking are not indigenous to the stream where they are released. The native Clackamas River coho is one of the latest-returning coho in the state (Fig. 1). Prior to release of early run Big Creek stock coho in 1967, adults passed North Fork Dam from October to mid-March. As seen in Figure 1, the return period has shifted and now begins earlier, in August. This is not the result of hatchery practices, but of the introduction of a stock with a different run-timing. The run size has remained the same, around 1,600 adults, which indicates there has been a decrease in the natives. Since the two segments of the run return and spawn at different times, fishing pressure on the early run doesn't affect late-run fish, and there is less chance for genetic crossing. In this case the decrease in the native segment apparently is due to competition between juveniles.

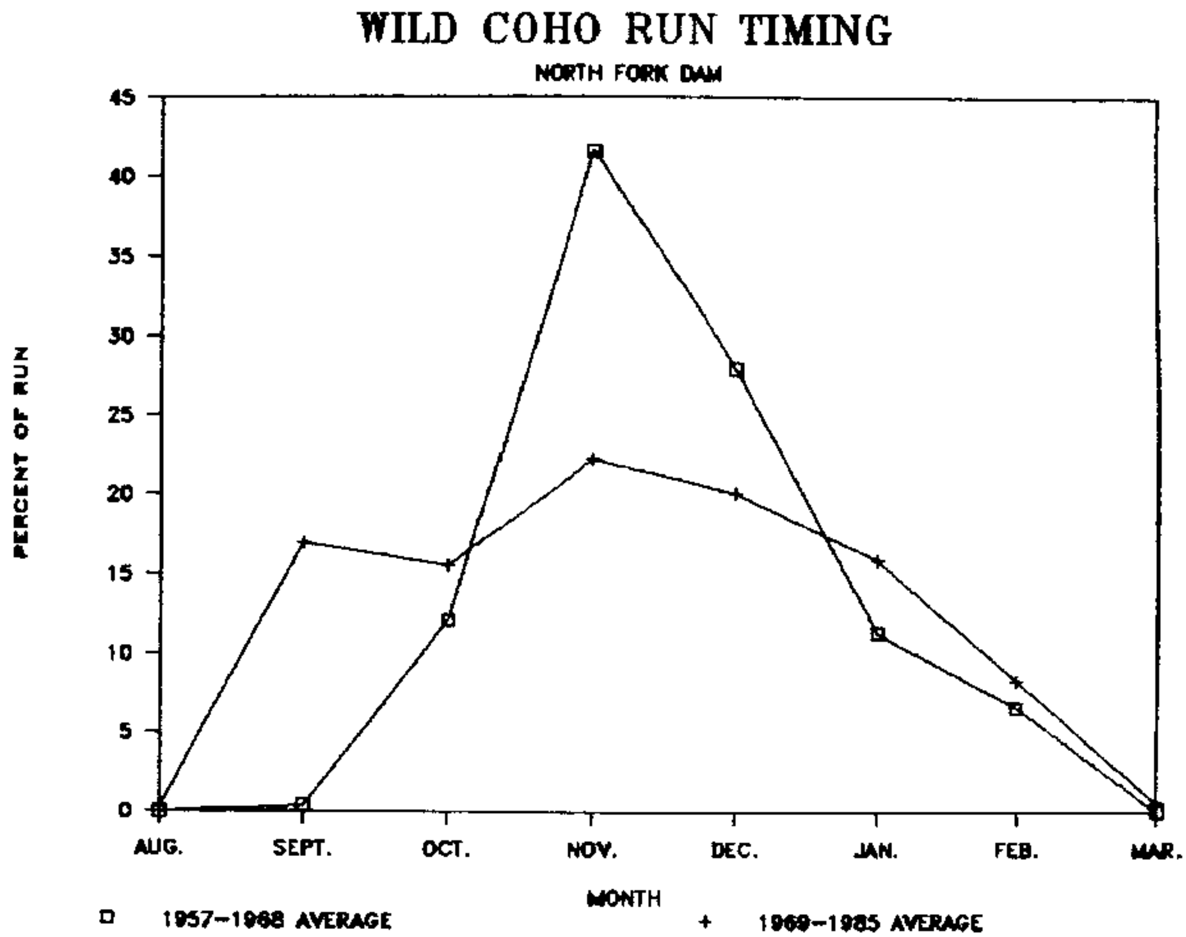

Figure 1. Average percent of run by month for coho salmon over North Fork Dam on the Clackamas River, showing changes in run timing after introduction of an early run stock into the system in 1969.

Steelhead provide another example of potential competition between native and introduced stocks. Summer steelhead were first introduced into the Clackamas River in 1970, with the first adult returns in 1972. Although fisheries management agencies hoped that summer steelhead would not spawn successfully, the downstream counts of wild steelhead smolts began to increase in 1977 (Fig. 2). The wild smolt count went from an annual average of 24,200 between 1962 and 1976 to 44,100 between 1977 and 1986. The adult escapement for winter steelhead from 1979 to the present, however, has been below average.

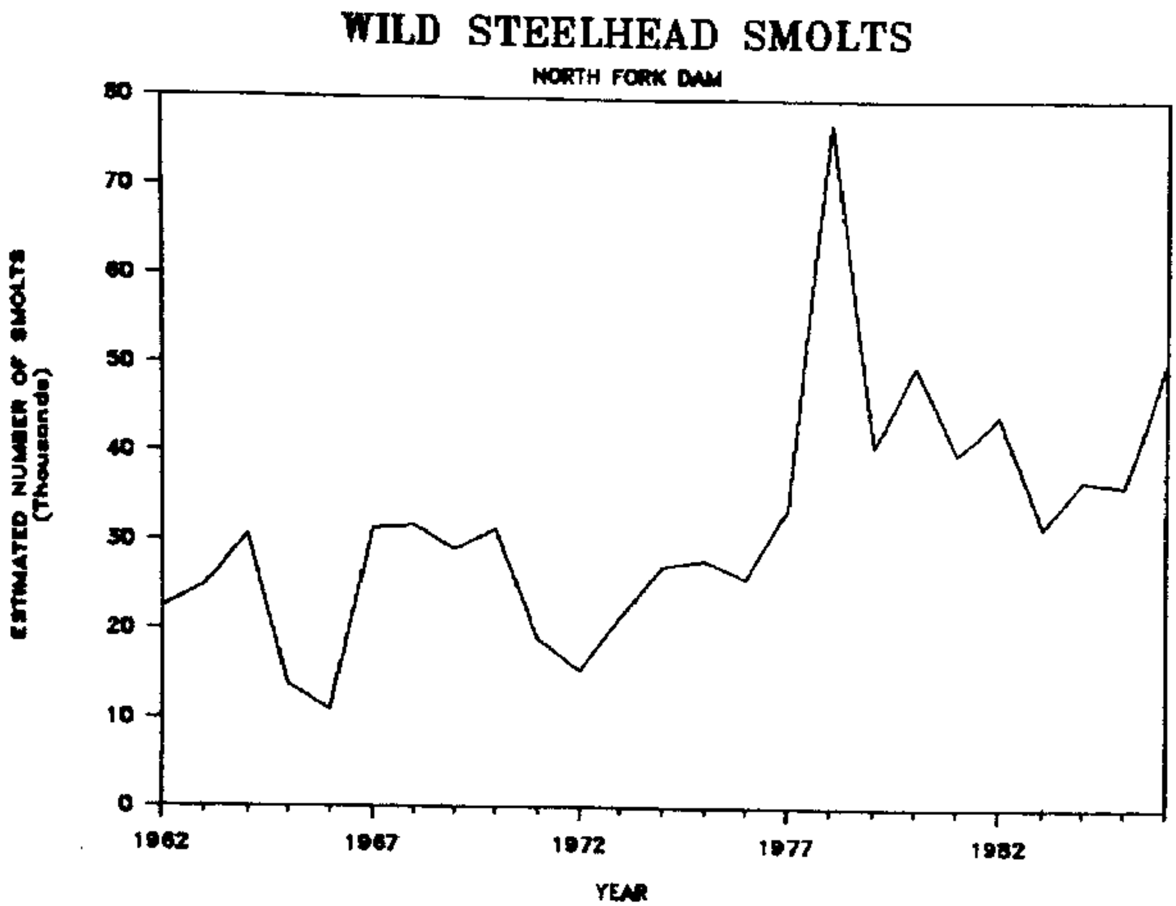

Figure 2. Counts of wild steelhead smolts made at North Fork Dam on the Clackamas River.

If we graph the return rate for winter steelhead, expressed as adults per smolt (Fig. 3), we see a downward trend. Several factors could have caused this trend, but if we assume that ocean survival has not decreased, and that the sport catch has remained about the same, it would indicate the increased smolt production is from the summer fish.

Many sportsmen got excited when they learned there might be wild summer steelhead in the Clackamas. Different groups encouraged people to release their wild fish. Personally, I would encourage fishermen to keep all of their summer steelhead to reduce competition with Clackamas native stocks.

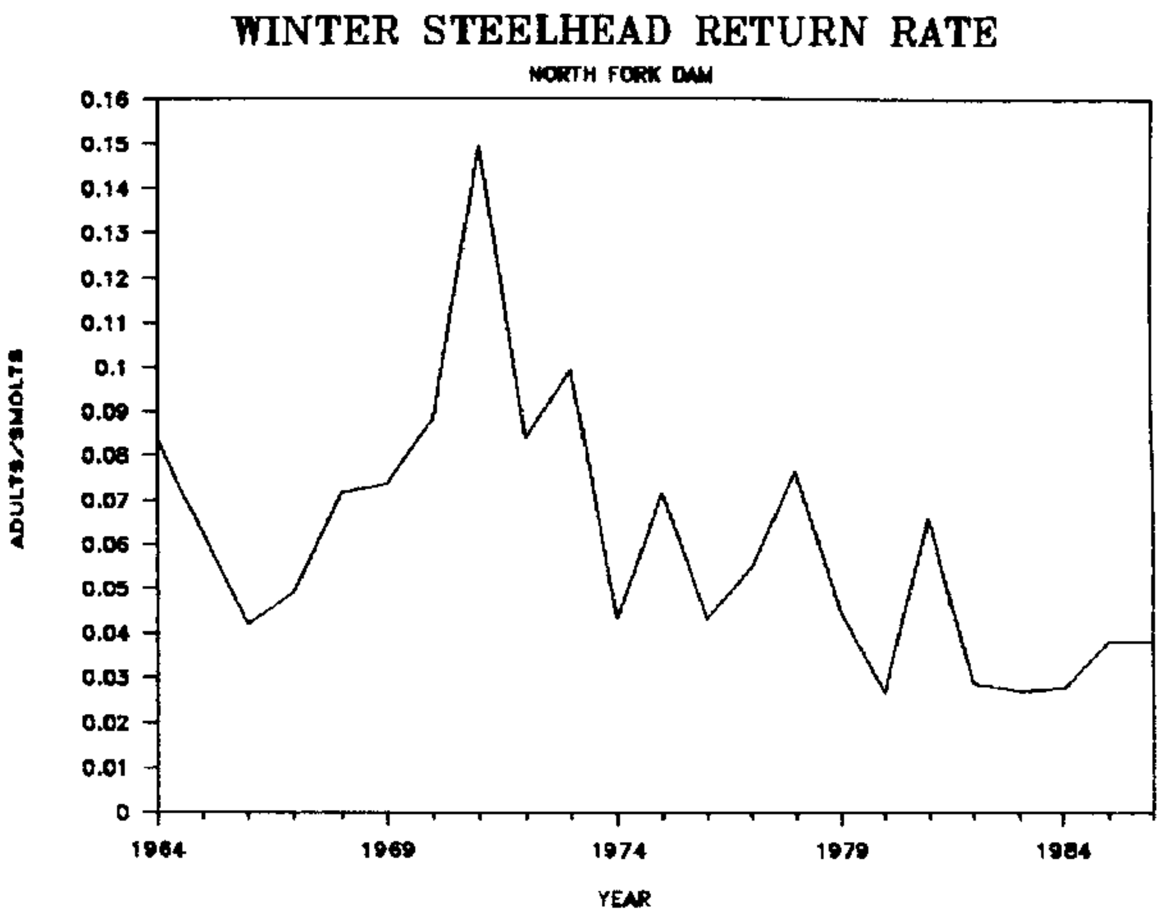

Figure 3. Changes in the number of adult winter steelhead returns per wild smolt that migrated out two years earlier, using counts from North Fork Dam on the Clackamas River.

An example of an introduced stock that has provided a fishery with minimal impact on native stocks is the early run of Big Creek winter steelhead. This introduced steelhead enters the river from October through January, while the native winter steelhead enter the river from February through May. ODFW limits the stocking of early run fish to below River Mill Dam, to minimize any effects on the native run that spawns above River Mill. Still, there has been some straying of early run fish over North Fork Dam since their first returns in 1968 (Fig. 4). About 12 percent of the present winter steelhead escapement over North Fork consists of early run fish.

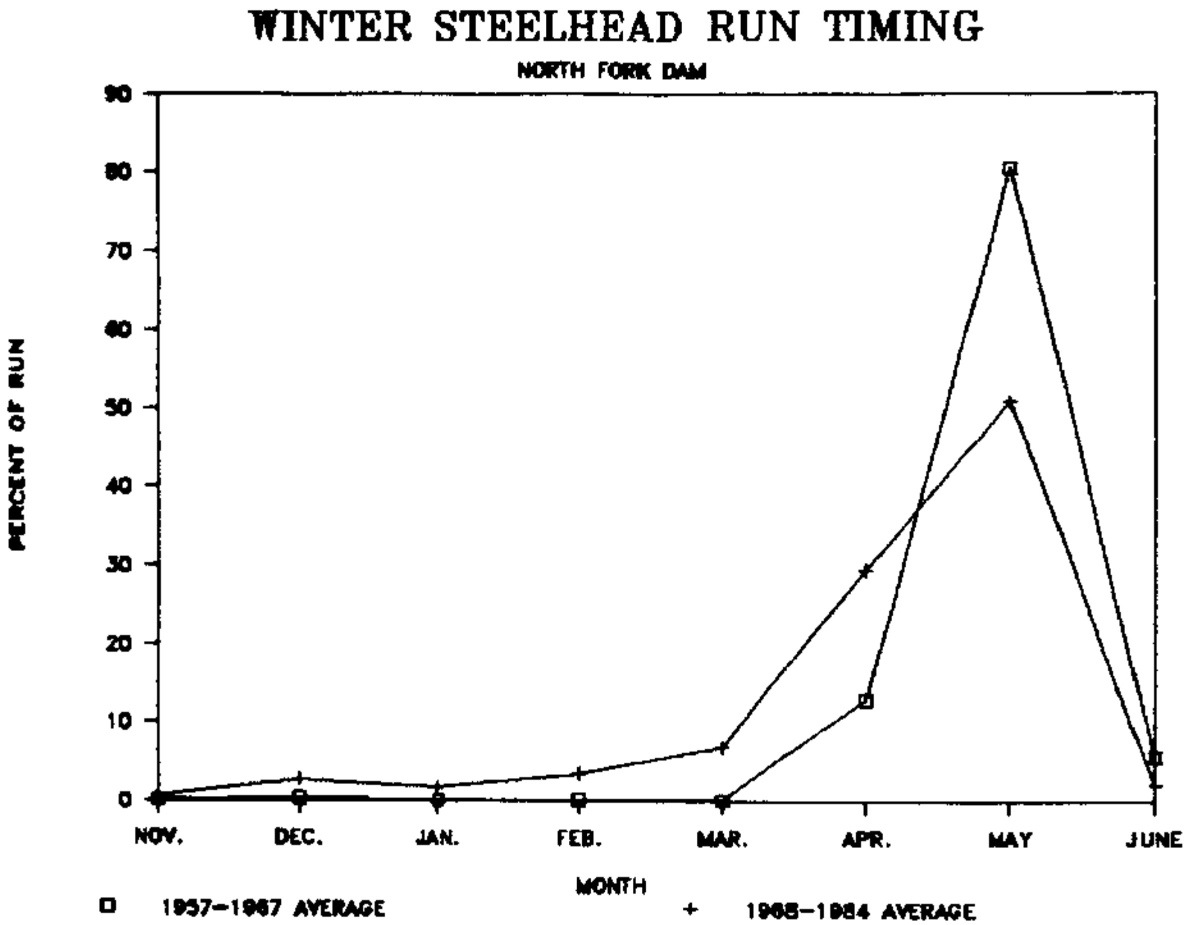

Figure 4. Average percent of run by month for winter steelhead over North Fork Dam on the Clackamas River, showing changes in run timing after introduction of an early run stock into the system in 1968.

In the 1970s a decision was made to build a spring chinook hatchery on the Clackamas River at McIver Park. Although a self-sustaining spring chinook run averaging about 500 fish a year was available from the Clackamas, the decision was to use Willamette stock. Even though the hatchery is located below the dams, more than 50 percent of the escaping adults pass over the dams and spawn naturally. The catch of spring chinook in the river went from an average of 16 percent of the run before the first Clackamas hatchery returns in 1980, to an average of 36 percent of the run since 1980. Figure 5 shows how the adult returns over North Fork Dam and the in-river sport catch have changed.

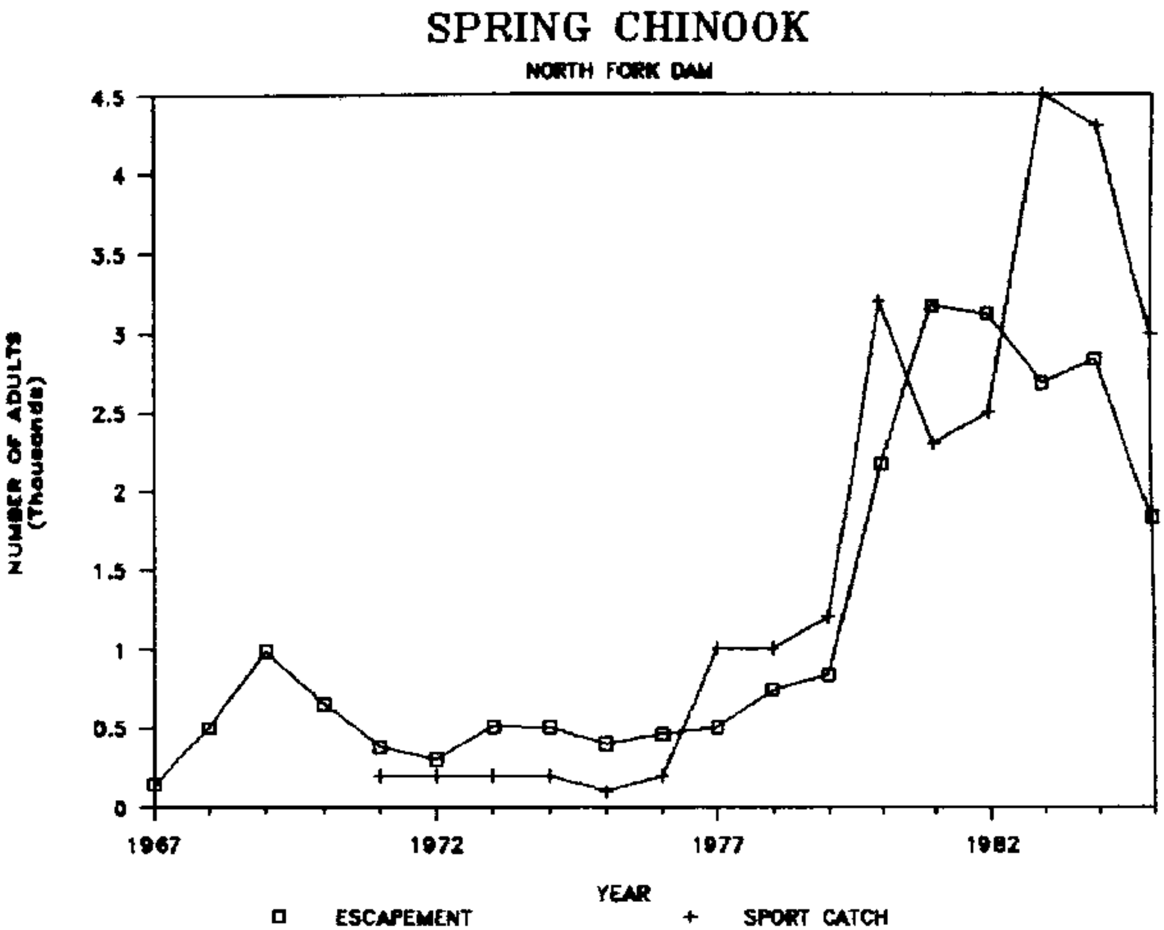

Figure 5. Escapement at North Fork Dam and estimated in-river sport catch of spring chinook on the Clackamas River.

I feel that the main reason behind the decision to use Willamette stock was simply the time element. Willamette stock smolts were available for release in 1978, so adults could be returning when the hatchery was completed in 1980. A decision to use Clackamas brood stock would have delayed the process three years. Some biologists suspected that Clackamas chinooks were really strays from the Willamette, but no effort was made to verify that. Unfortunately, with the increased fishing pressure and the dilution of the spawning stock, if there was a native Clackamas stock, it has now been lost.

So much for the interactions of wild, hatchery, native and introduced stocks. Now onto the conflict between anadromous and resident fish.

Native cutthroat, native rainbow and hatchery rainbow are the populations of concern among resident trout. Other trout and char exist in the system but their numbers are inconsequential. The main cutthroat populations are in the smaller tributaries, while rainbows dominate the larger tributaries and the mainstem. Hatchery rainbows are stocked as catchables in the larger tributaries, the mainstem and the reservoirs.

Many streams in the Clackamas system have natural barriers impassable to anadromous fish. All of the streams that I know of, that are large enough, have resident trout above those barriers. Because increased anadromous production usually shows a high economic benefit, a common practice is to make the barriers passable, or to release juvenile salmon and steelhead above them to rear, in an effort to increase anadromous production. The literature indicates, however, that the introduction of anadromous species leads to substantial reductions in resident populations. This means that whenever a barrier is removed, we are likely to see a reduction in a wild native trout fishery.

Another tradeoff, with even greater consequences, is seen in the incidental harvest of juvenile salmon and steelhead in the trout fishery. Let's take a closer look at the 1977 creel survey I mentioned earlier (Table 1). On the Clackamas the first month of the trout season, which opens near the end of April, coincides with the peak of the outmigration of salmon and steelhead. The catch of 4,600 wild steelhead smolts accounted for 12 percent of the wild steelhead smolt production in 1977. The number of smolts in the bag represents only part of the smolt catch, since only 60 percent of the wild steelhead smolts and 0.5 percent of the wild coho smolts are large enough to keep. Potentially, the 78 coho smolts could represent a catch of over 15,000 fish.

Table 1. Creel data for the first month of the trout season, beginning April 23, 1977, above North Fork Dam on the Clackamas River.

	Number Caught	Percent of Catch
Hatchery Rainbow Trout	28,400	42.4
Wild Trout	700	1.1
Hatchery Steelhead Smolts	31,900	47.6
Wild Steelhead Smolts	4,600	6.9
Wild Steelhead Parr	1,300	1.9
Wild Coho Smolts	78	0.1

A number of changes have occurred since 1977—some mitigating, others exacerbating the problem. A reduction in the stream bag limit from 10 to 5 fish and a partial closure of North Fork Reservoir has helped reduce the smolt catch. But increased chinook production and the closing of most other streams in the area during that first month of the season, causing anglers to concentrate on the Clackamas, has acted to increase that catch. Efforts to protect smolts by delaying the opening of trout season have met stiff opposition from local communities that claim they would suffer severe economic hardship.

Are Wild Fish Overvalued?

I have briefly presented several examples showing how certain managment activities appear to have affected wild fish in the Clackamas. In reality the cause-and-effect relationships are not so clear as they seem, given the many interactions in the system.

Also, although my examples emphasize the negative effects to wild populations, there is another side to the story. In that one month of the trout season in 1977, over 94,000 angler-hours were tallied. That level of recreation is hard to replace. Overall fishing opportunities on the Clackamas have increased. There is probably more effort expended to catch summer steelhead—an introduced fish—than any other species, and angling effort for spring chinook increases every year.

At a wild trout management symposium in 1975, Ralph Abele of the Pennsylvania Fish Commission said: "Wild trout have a certain public image to which lip service is paid in an era when 'environment' is in vogue—they're in the category of patriotism and puppy dogs; no decent American will speak out against them. Perhaps the problem or the subject is better defined in terms of the politics of stocked trout. Social or political pressures are not exerted against wild trout; they are exerted for stocked trout."

On the Clackamas there have been several recent successes in bringing more fish to the river. This has raised the expectation of the average angler. To keep pace with the increased demand caused by these higher expectations, more pressure will be exerted for stocked fish. If wild fish populations are to be maintained, they will need a high priority in the Clackamas Management Plan now being developed. Brood stocks used in hatcheries should be of native stocks whenever possible. Ways to reduce competition between introduced and native stocks should be identified, and wild juveniles need more protection.

Finally, we need to educate the anglers, to make them aware of the long-term tradeoffs. Maybe we need to adjust their fishing ethic so we can all have wild fish into the 21st century.

LITERATURE CITED

Abele, R.W. 1975. Wild trout—the political area. In Proceedings of the Wild Trout Managment Symposium at Yellowstone National Park. W. King, ed. Trout Unlimited, Inc. Pp. 74-76.

Benett, D.E. 1985. 1984 Willamette River spring chinook salmon run. Oregon Department of Fish and Wildlife. Portland, Oregon.

Eden, M. and D. Swartz. 1986. Oregon salmon and steelhead sport catch statistics, 1975-84. Oregon Department of Fish and Wildlife. Portland, Oregon.

Eicher, G.J. 1977. Clackamas dams and anadromous fish. Portland General Electric Company. Portland, Oregon.

Glova, G.J. 1984. Management implications of the distribution of sympatric populations of juvenile coho salmon and coastal cutthroat trout in British Columbia, Canada. Progress in Fish Culture 46(4):269-277.

Miscellaneous documents and unpublished reports regarding history of Clackamas River fish runs. On file with Doug Cramer, Portland General Electric, Portland, Oregon.

Whitt, C.R. 1978. An evaluation of existing andpotential fishery resources in the Clackamas River Land Planning Unit. U.S. Forest Service. Mt. Hood National Forest. Gresham, Oregon.

Wild Fish in a Tame River: The Yakima's Story

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History of a Declining Resource

The Yakima River Basin is located in south-central Washington between the crest of the Cascade Mountains and the Columbia River. Originating near Snoqualmie Pass on Interstate 90, the Yakima flows southeast more than 200 miles to join the Columbia at Richland. In its drainage of 6,200 square miles are found habitats ranging from alpine meadows and barren ridge tops, to fir- and pine-covered hills and valleys, to semiarid steppe. The extremes in elevation and precipitation are responsible for a wealth of plant and animal communities.

The Yakima Basin produced salmon and steelhead in wondrous abundance prior to the European immigration. Its complex of waters—including a large river, major tributaries, small streams and lakes—provided spawning and rearing habitats for spring, summer and fall chinook, as well as coho, sockeye and steelhead. This basin welcomed total annual runs of over 500,000 fish, according to modern estimates. And I can't help but point out that there wasn't one hatchery fish in the lot.

Such productivity can be explained not only by the variety of habitats but by their accessibility. The entire Yakima system was open to migrating fish, with minor exceptions in the headwaters. Sustaining this ecosystem was a dependable source of cold, high-quality water from the deep snowpack that accumulated annually in the western portion of the basin. All in all, the Yakima Basin was nearly perfect for producing anadromous fish.

In 1855 the federal government signed a treaty with the Confederated Tribes and Bands of the Yakima Indian Nation which opened much of the basin to non-Indian settlement. Soon, things began to change. During the 1880s, extensive irrigation development began. To provide water for irrigation, diversion dams and delivery canals were constructed—without fish passage facilities. Suddenly, migrating salmon and steelhead faced major obstacles, and many of the adults and juveniles perished in their attempts to run what had become a gauntlet.

By 1902 the summer flow of the Yakima River was overappropriated to irrigate some 250,000 acres. In addition to diversion dams and canals, migrating fish encountered stretches of dry riverbed, high temperatures, and diminished spawning and rearing habitat. Near the mouth of mountain lakes, storage reservoirs were built to hold water for summer irrigation. These reservoirs marked the demise of the sockeye run.

The impact of all this development on anadromous fish runs was predictable—if people had been concerned enough to review the situation. But apparently they weren't concerned. By 1920, the runs of 500,000 had been reduced to 10,000.

Finally, in the late 1920s, the depleted state of salmon and steelhead received official recognition, and ladders and screens were installed at the major dams and canals during the next 10 years. Although imperfect, they were better than no facilities. Meanwhile the problems posed by low summer flows and poor water quality went unattended. If anything, they got worse.

Spring chinook and steelhead runs slowly increased over the next 20 years, while summer chinook and coho runs continued their slide to oblivion. About 20,000 chinook and steelhead returned to the basin in 1960. That proved to be the peak of their resurgence, however. By 1980, only 2,000 chinook and steelhead returned to the river.

The plight of Yakima Basin salmon and steelhead did not go unnoticed between 1950 and 1980. The Bureau of Reclamation proposed in 1956 to enlarge Bumping Lake to provide water for in-stream flows and to build improved fish passageways. Between 1960 and 1980, public meetings were held and legislation was introduced; but success, seemingly always in reach, always slipped away. The last of those attempts to rescue fish runs died in committee at the end of the Congressional Session in late 1980.

The Yakima Indian Nation has been heavily impacted by the destruction of abundant runs because, historically, fish met most of their dietary requirements and were central to their religious and cultural activities. For many years the Tribe supported the plans to enlarge Bumping Lake and improve fish passage facilities. But as time passed and the remnant runs grew still thinner, even promises made in good faith ended up sounding hollow.

The Elements of Restoration

Fortunately, there were other stirrings in the 1970s. After witnessing decades of inaction by state and federal agencies, the Tribe realized that Yakima Basin runs were approaching the point of no return. In 1976, a Tribal fisheries management program was created and given the tall order of restoring salmon and steelhead runs in the basin. An important element in the Tribe's directive was that restoration was to be based on natural production if at all possible.

So how do you go about restoring salmon and steelhead runs in a basin with only remnant runs plagued by low flows, poor water quality, poor passage facilities and little basic data?

You do it by addressing some of the very subjects discussed during this wild fish symposium. You protect and restore habitat; rectify water quality and instream flow problems; build appropriate fish passageways; implement reasonable harvest management; and, when necessary, you use appropriate propagation techniques to replace runs that have been eliminated totally.

Two things happened in 1980 that continue to have an enormous impact on salmon and steelhead runs in the Yakima Basin. After several years of effort and debate, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act with its now well-known Section 4(h). And the Tribe, in an effort to protect spring chinook redds in the upper Yakima from low flows caused by operation of the reservoir system, successfully sought relief in the Federal District Court for the Eastern District of Washington.

Because of the court decision, reservoir operations have been modified to protect redds in the Yakima Basin. The decision has also led to closer cooperation between the Tribe and the Bureau of Reclamation regarding other fisheries issues in the basin. This has been accomplished, it must be noted, *without* adversely affecting the irrigation water supply.

The Tribe also is addressing other habitat issues, such as forest practices, road construction and general instream activities. It is not easy to reverse decades of habitat degradation, but we are embarked on that course.

In the area of harvest management, since 1980 the Tribe has severely restricted its subsistence harvest of spring chinook in the Yakima River. To fully appreciate this action, you need to understand how controversial such a regulation is. The Fish and Wildlife Committee has been subjected to considerable political pressure to suspend these harvest regulations. Despite this, the Committee and the full Tribal Council have declined to alter them, and they remain committed to restoring the natural spring chinook runs in the Yakima Basin.

In a related development, the Washington Department of Game implemented a wild fish release policy for the Yakima River steelhead fishery in January of 1986. This change in the state's harvest regulations should substantially assist the restoration of wild steelhead in the basin.

In contrast to the progress made with the above is the persisting problem of low instream flows. The Bureau of Reclamation and the Washington Department of Ecology have been pursuing the Yakima River Basin Water Enhancement Project since 1981. One of the four main goals of this project is to provide more instream water. As was the case in the 1960s and 1970s, potential solutions appear on the horizon. But this time there is greater urgency to do someting, given the other activities to restore fish runs. Maybe something will be done, this time. . . .

When you set out to rebuild a salmon or steelhead run without using artificial production, it is of course essential that you have at least some returning adults of that stock to work with. What do we do if a particular run is extinct or present in impossibly low numbers? In these cases we are compelled to make judicious use of artificial production.

In the Yakima Basin, if we are to restore natural summer chinook, coho, or sockeye production, we must begin with some type of hatchery supplementation. But this will not be done without due regard for our ultimate goal, without careful consideration of disease and genetic factors, nor without close monitoring and review of the success, or failure, of such supplementation.

We are in considerably better shape with respect to the spring chinook run. From a low of less than 1,000 in 1979, the run has improved to approximately 9,300 in 1986. The magnitude and breadth of artificial supplementation of spring chinook in the basin have not yet been determined. Numerous tributaries in the basin are without spring chinook and could potentially benefit from outplantings. In these cases we will have the advantage of recourse to local stocks.

Hatchery-produced steelhead have been released into the basin by the Washington Game Department for many years without contributing much to adult returns. The releases might have been more successful except for their reliance on stock from outside the Yakima Basin.

Will smolts from local stock result in a higher percentage of returning adults? By 1989 we can begin to answer that question, because the Tribe and the Washington Game Department initiated a cooperative hatchery steelhead program in 1985 using Yakima River brood stock. At present there are over 220,000 juvenile steelhead at the Game Department hatchery in Yakima. These fish will be released as smolts in the Yakima River in 1987 and return as adults during the 1988-1989 migration.

The issues attending hatchery production and its role in restoring natural runs are receiving close scrutiny during the development of the Master Plan for the Yakima Basin Central Outplanting Facility. Development of this facility is included in the Northwest Power Planning Council's Fish and Wildlife Program. It will not be just another hatchery. Instead, its innovations in techniques and procedures will set the standard for hatchery supplementation of depleted stocks throughout the Columbia Basin.

I have saved a crucial and common concern for last. The various programs presented at this symposium all deal with vital aspects of wild fish management. Spawning and rearing habitat protection, harvest management, riparian zone management, water quality and instream flows, and different strategies for restoring or enhancing depleted runs: all are parts of the Columbia Basin anadromous fish puzzle. But putting these parts in place will be futile if we do not provide for the safe, efficient passage of upstream and downstream migrants. Unfortunately, safe passage across dams and past irrigation diversions is proving more difficult technically and far more expensive than fisheries biologists and engineers predicted a half-century ago.

I would like to remind you of the magnitude of these passage problems. The concrete monoliths in the mainstem Columbia and Snake rivers, and the difficulties they present to migrants, are known to most of us. But are you aware of the dozens of smaller dams on tributaries in Washington, Oregon and Idaho? And are you aware of the hundreds of diversion canals and ditches in the same region? Each of these poses a threat to migrating salmon and steelhead, whether they are wild or hatchery-produced.

In the Yakima Basin the problems of inadequate or nonexistent fish passage has been recognized for almost 40 years. The Bureau of Reclamation's proposal to enlarge Bumping Lake also included the construction of new fish ladders and screens. But as I have already noted, this proposal was never authorized.

It was not until the Northwest Power Planning Council began to draft its Fish and Wildlife Program in 1981 that progress occurred in this area. The program, as adopted in November 1982, included Section 900, which calls for construction of new fish ladders and screens at some 20 locations in the Yakima Basin. Their construction is now well under way.

A Model for Success

Although I may be somewhat partial, I believe we in the Yakima Basin are compiling a record others will look to as they implement fisheries restoration in other basins. If nothing else, the institutional cooperation seen in the Yakima story is instructional. Where else can you find an Indian Tribe, the Bonneville Power Administration, the Northwest Power Planning Council, the Bureau of Reclamation, the National Marine Fisheries Service, the Washington Departments of Fisheries and Ecology, and various irrigation districts all engaged in a fish-restoration program?

I am convinced that the methods we used to pull this diverse group together are transferable to other basins in the Northwest, and perhaps in other parts of the country. For example, the mix of problems and entities are very similar in the Umatilla Basin. Indeed, during an on-site tour with a number of Oregon colleagues, already we have shared our experiences and the technology of our new passage facilities.

In summary, at least five basic elements have contributed to recent successes in the Yakima Basin:

1. **The presence of an Indian Tribe with Treaty Rights**. In the past, membership in a tribe has been considered a detriment by many people, but I think our record in reversing the decline of salmon and steelhead runs clearly documents the importance of Treaty Rights, without which there would be no protection for spring chinook redds in the upper Yakima, nor any real pressure to solve instream flow problems in the basin. I believe that without Treaty Rights there would be no Section 900 in the Power Council's Fish and Wildlife Program, and I suspect that effective language in Section 4(h) of the Power Act also would be missing.

2. **Defined goals and guidelines**. When the Power Council began drafting its Fish and Wildlife Program, we had a plan with the problems identified and solutions enumerated. In short, we knew what we wanted and where we wanted it. Vague concepts, no matter how good the intentions, don't lead to funded projects in today's world.

3. **Congressional support**. We had, and still have, strong backing from our Congressional delegation. We do our political homework. While I realize that fisheries biologists and managers traditionally have shied away from the political arena, I am convinced that this has been a resounding mistake. If we are to be successful in our efforts to restore fisheries resources, we absolutely must understand the political process and become adept at participating in it.

4. **Cooperation among resource users**. Although, as I noted earlier, there was one instance of litigation over protection of fisheries habitat, by and large the cooperation among many diverse groups in the Yakima Basin has been extraordinary.

5. **Dedication.** There are many dedicated people working with Yakima Basin issues who are committed to restoring its salmon and steelhead runs. This group numbers not only residents of the basin, but people located in Olympia, Portland and Washington, D.C.

The Future

I don't want to leave you with the impression that hard times for Yakima Basin salmon and steelhead are behind us. Many problems still need solving. We have taken only the first steps in reversing a century of neglect and degradation. In closing, let me envision where I hope we will be 10 years from today. Then:

- **All the diversion canals and ditches will be properly screened** (some 200-300 small diversions are unscreened at present)
- **The Central Outplanting Facility will be in operation**, seeding the basin with summer chinook, coho, and sockeye, and supplementing production of fall chinook, spring chinook, and steelhead
- **A reservoir will be completed and ready for filling**, with its stored water used subsequently to maintain instream flows
- And I would like to see a **firm program for habitat protection and restoration in place**

In 1980, I set a goal of having 10,000 spring chinook returning to the Yakima Basin by 1990. Many people said that we would be fortunate to have *any* spring chinook return in 1990. Well, we missed it by less than 700 fish this year, and barring a disaster, we will top 10,000 in 1989. Today, I would like to propose a new goal: 100,000 returning salmon and steelhead in the Yakima Basin by the year 2000. Yes, I know that sounds unreachable, but so did 10,000 spring chinook. Given the same cooperation and dedication of the last six years, we will reach that goal.

Cultured and Wild Salmon Populations in the Noatak River, Alaska

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Introduction

In 1982 the state of Alaska constructed a salmon hatchery on the Noatak River just outside the Noatak National Preserve (Fig. 1). Managed by the U.S. National Park Service, the Preserve is a 6.57-million acre federal withdrawal encompassing the largest mountain-ringed river basin in America, a basin virtually unaffected by human activities (National Park Service, 1985). In addition to its scenery, wilderness values and abundant wildlife, the Preserve has been designated a "Biosphere Reserve" in the United Nations' "Man and the Biosphere" program. The program has urged preservation of this arctic area in its undisturbed state in order to maintain pools of wild genetic materials, both plant and animal, for future study and against which other impacted areas can be compared.

The National Park Service is concerned about potential interactions between the cultured salmon returning to the hatchery and the wild populations of salmon that inhabit the Noatak National Preserve. Returning hatchery fish could compete with wild fish on the Noatak River spawning grounds, and could also interbreed with them, possibly altering the genetic integrity of the wild chum stocks.

Commercial salmon harvests in Alaska reached near historic lows of 20 to 25 million fish in the mid-1970s, compared with very high salmon harvests of 100 to 126 million fish in the 1930s (Fig. 2). To supplement the low harvests the state embarked on an ambitious salmon enhancement program. As part of the Alaska Department of Fish and Game, the Fisheries Rehabilitation, Enhancement and Development Division was formed in 1970 to coordinate fish enhancement activities. Today, the division has 20 hatcheries operating throughout Alaska (Fig. 3), annually producing more than 300 million juvenile salmon. In 1984, 2.3 million salmon from these hatcheries were harvested commercially (Fig. 4). In 1985, over 517 million eggs were taken from trout, sheefish, grayling and salmon for incubation. Preliminary data indicate that more than 9 million hatchery-bred adult salmon returned to state hatcheries in 1985; of those, an estimated 8 million were harvested in the commercial fishery (Hansen, 1986).

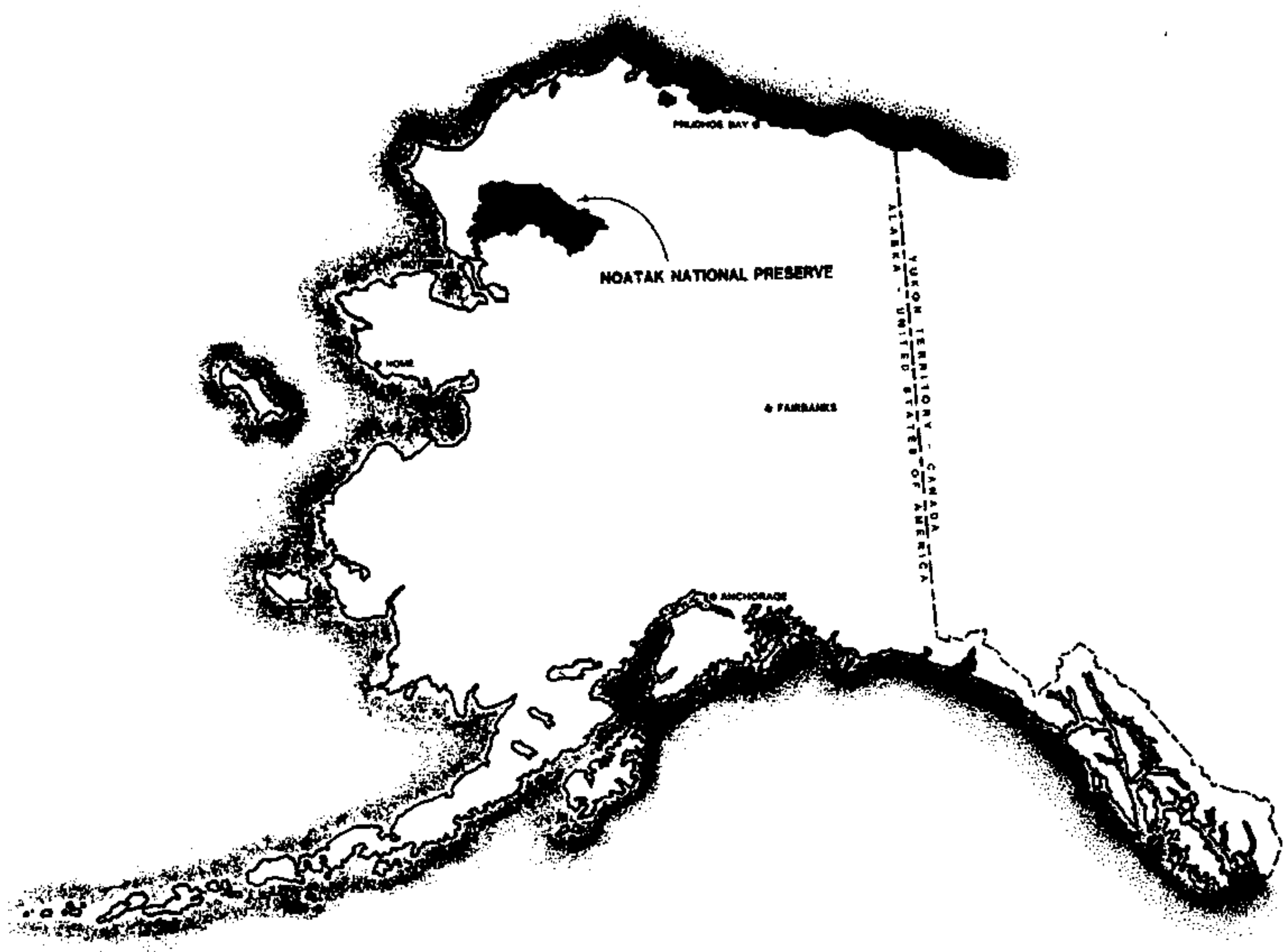

Figure 1. Location of Noatak National Preserve in northwest Alaska.

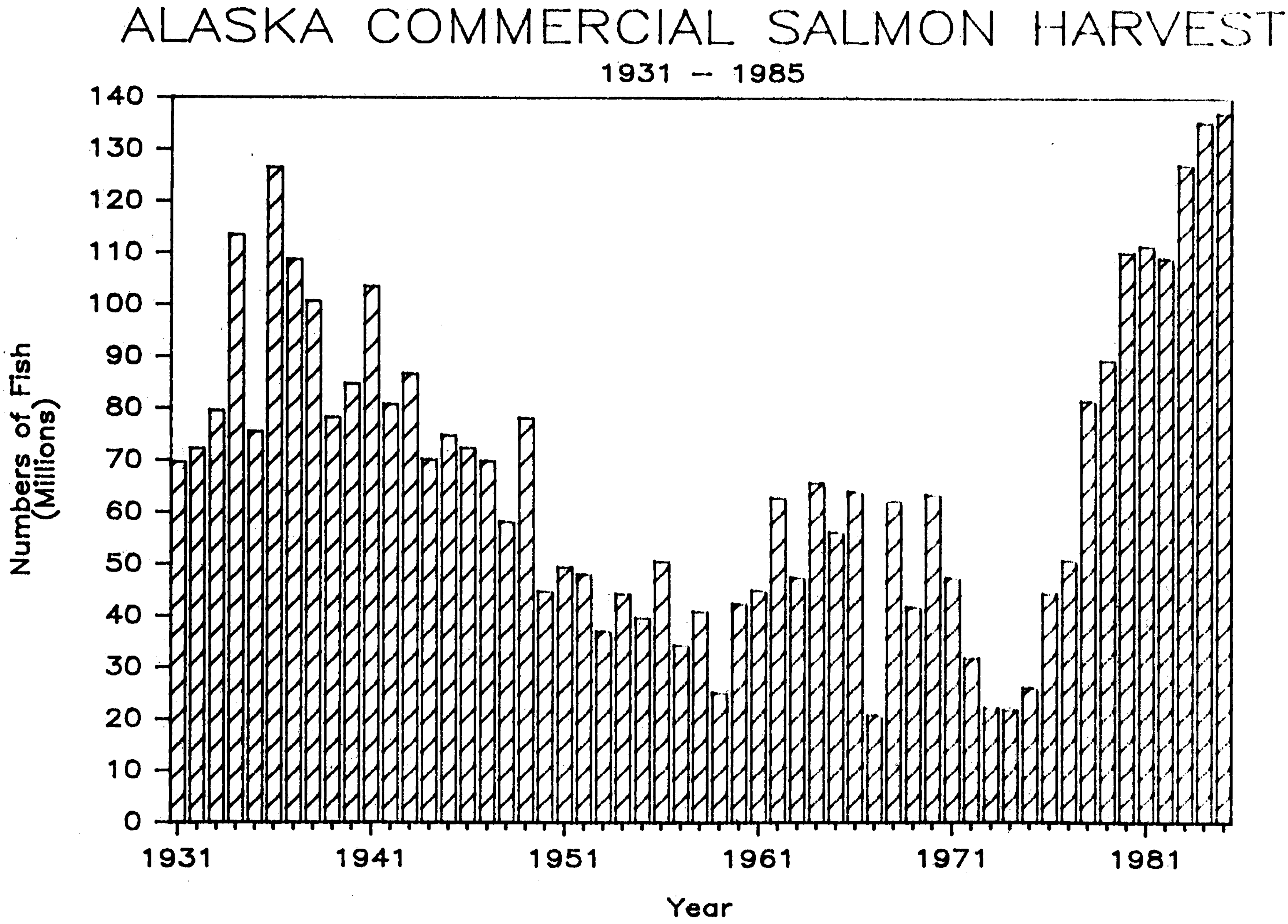

Figure 2. Commercial harvest of salmon in Alaska, 1931-1985.

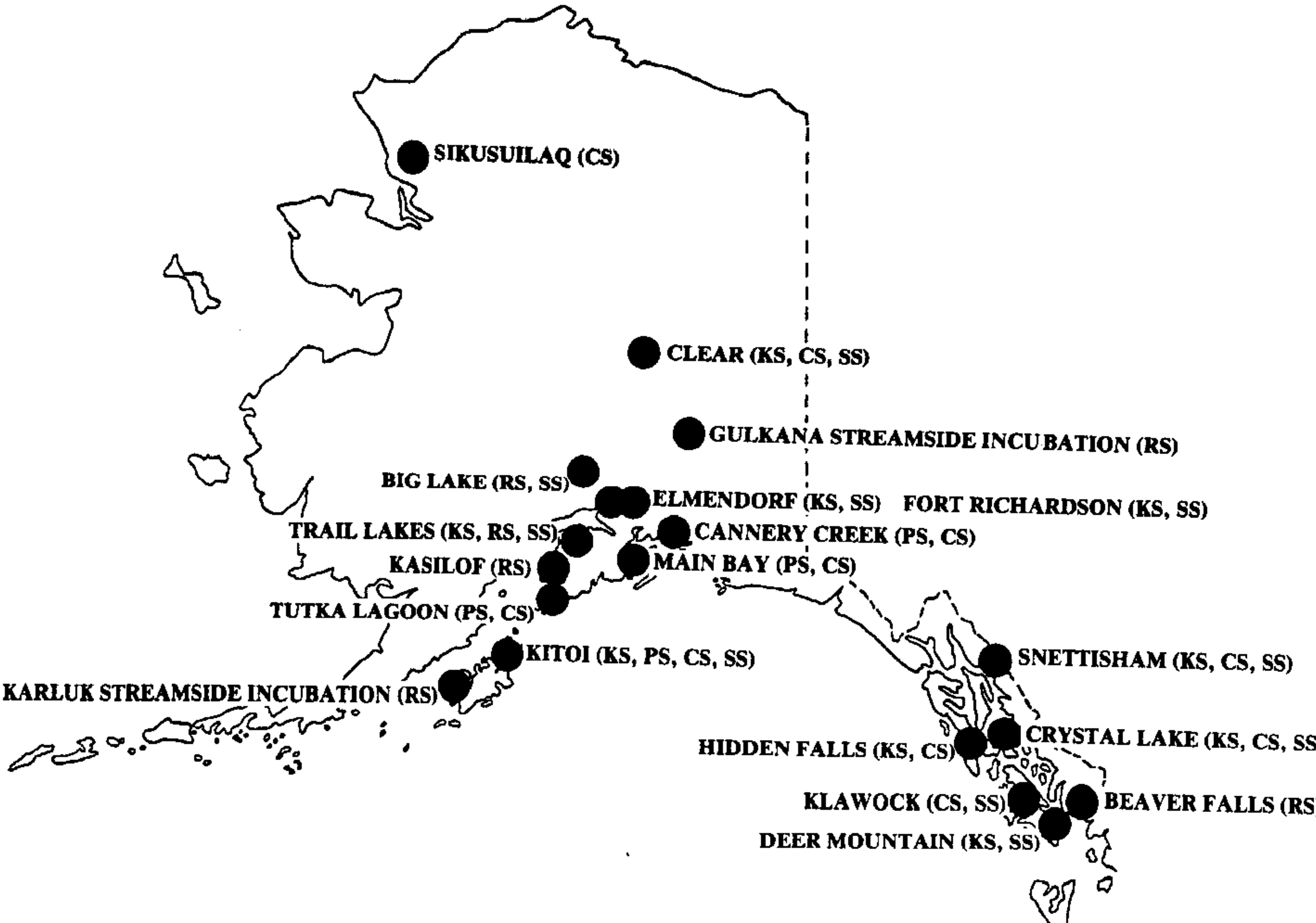

Figure 3. State salmon hatcheries in Alaska administered by the Alaska Department of Fish and Game (species cultured: CS = chum salmon, PS = pink salmon, KS = chinook salmon, RS = sockeye salmon, SS = coho salmon).

Figure 4. Statewide Alaska salmon harvest in 1984.

Statewide Salmon Harvest (number of fish X 1000)

Species	Sport Harvest	Subsistence Harvest	Commercial						TOTAL
			Wild Stocks	Hatchery Stocks			Total		
				State	PNP[1]	Total			
Chinook	85	132	663	2	2	4		667	884
Coho	239	178	5,257	35	94	129		5,386	5,803
Sockeye	124	298	37,937	255	0	255		38,192	38,614
Chum	24	505	11,589	676	505	1,241		12,829	13,358
Pink	154	56	73,837	1,365	3,055	4,419		78,256	78,466
Total	626	1,169	129,282	2,332	3,715	6,047		135,330	137,125

[1]Private, non-profit hatcheries

To further supplement salmon production, in 1976 the Alaska legislature authorized a program to permit private, nonprofit salmon hatcheries. Twenty-two permits have been issued to date, and of those 15 private hatcheries are in operation with a combined return of 3.7 million salmon in 1984 (Fig. 4), and approximately 8 million salmon in 1985 (Hansen, 1986). In total, the state and private hatcheries contributed 6 million salmon in 1984 and about 15 million salmon to the state's commercial fishery in 1985. The largest portion of the hatchery production consists of pink salmon from private facilities (Fig. 5).

To further supplement Alaska's salmon runs, the state's voters approved a bonding issue in 1978 which provided for the construction of additional salmon hatcheries. Included in the 1978 public bond proposition was nearly 5 million dollars for construction of a salmon hatchery in northwest Alaska where local residents were pressuring for improvement of the regional economy. Area residents are primarily Eskimo peoples inhabiting small villages and one central hub community, Kotzebue. Personal incomes are low, and people depend heavily on a subsistence lifestyle.

After a year-long site-selection study, the Alaska Department of Fish & Game chose a location on the Noatak River for a hatchery. The Sikusuilaq Springs hatchery, named after the Inupiat Eskimo name for the perennial springs that provide its water, is 30 miles up the Noatak River and about 40 miles north of Kotzebue (Fig. 6). The facility was completed in 1982 in time for a fall egg-take that resulted in the release of 480,000 briefly reared chum fry in 1983. Over 2 million eggs were collected in 1984, resulting in the release of about 1.6 million fry. The 1985 egg take was similar to 1984 (Fig. 7).

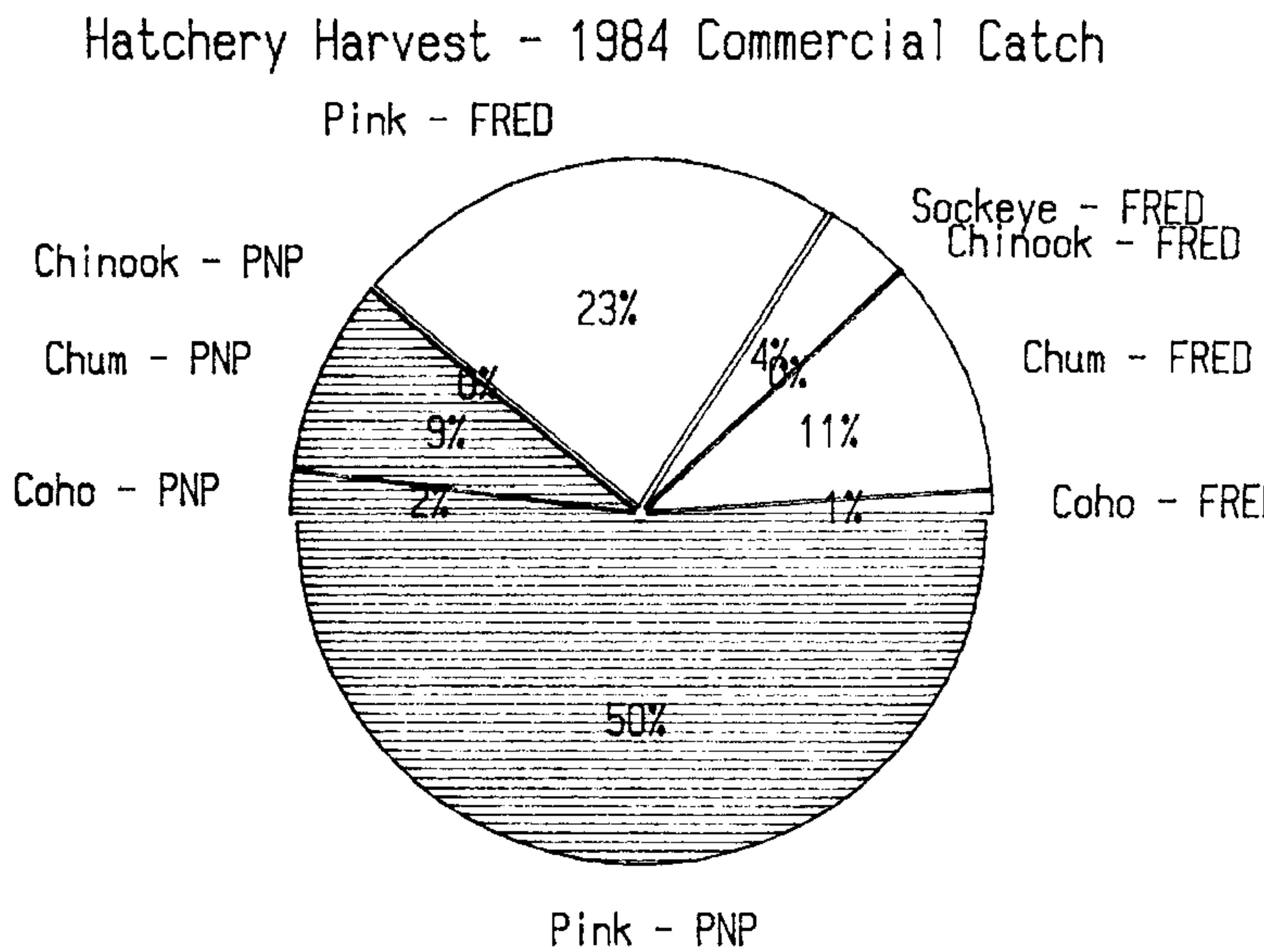

Figure 5. Percent contributions to the 1984 Alaska commercial salmon harvest made by the Alaska Department of Fish and Game (FRED) and private nonprofit (PNP) hatcheries, by species.

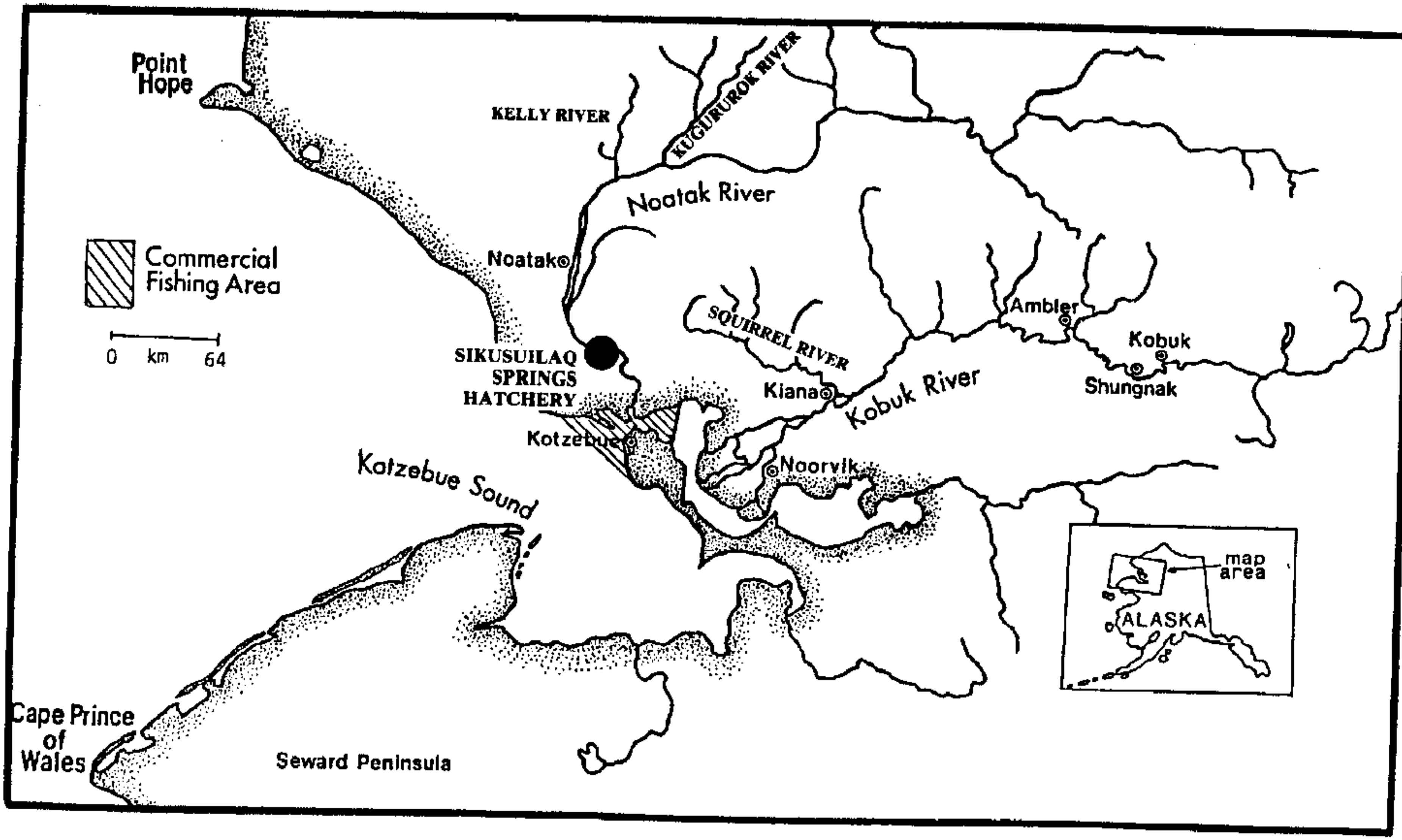

Figure 6. Location of Sikusuilaq Springs hatchery and the Kotzebue commercial fishing district in northwest Alaska.

Initially, Sikusuilaq Springs was to be an experimental 2-million egg facility for testing the feasibility of culturing salmon in an arctic environment. If judged practicable, the facility would be expanded to a full-production hatchery. Now, the state's intent is to proceed with expansion to create a 40- to 60-million egg facility by the 1990s.

Figure 7. Sikusuilaq Springs hatchery chum salmon production, 1982-1985.

Brood Year	Egg Take (x 1000)	Fry Released	
		Number (x 1000)	Survival (%)[1]
1982	750	480.5	64.1
1983	2210	1347.0	61.0
1984	2580	1693.0	65.6
1985	2500	1600.0[2]	64.0[2]

[1] Green eggs to released fry
[2] Estimate

The principal argument for the Sikusuilaq Springs hatchery is to produce fish to fill the valleys in the natural salmon return cycles (Fig. 8), ensuring that the commercial fishery in Kotzebue Sound is more reliable from year to year. Because of the processing facilities that would be built in Kotzebue to handle a significantly increased chum salmon return, local residents support expansion of the hatchery. The extra chum might also considerably increase personal subsistence usage by villages on both the Noatak and Kobuk rivers.

The Kotzebue Sound Salmon Fishery

The commercial fishery in Kotzebue Sound depends almost entirely on chum salmon, although some other species, including large char (Dolly Varden), are taken incidental to salmon (Alaska Department of Fish & Game, 1984). This may be the northernmost commercial chum fishery in the world. Commercial fishing in the Kotzebue fishing district (Fig. 6) relies on gill nets up to 150 fathoms in length, set from small open skiffs powered by outboard motors. In recent years, 180 to 200 boats participated in this fishery (Bird, 1982).

Commercial salmon harvests have fluctuated from a low of 29,400 in 1967 to a record catch of 677,239 in 1981 (Fig. 9). The ex-vessel value of the 1981 harvest totaled 3.2 million dollars, the highest on record (Bigler and Burwen, 1984). Fish are brought to Kotzebue, sold to fish buyers, iced, placed in containers, and transported by aircraft to processing facilities in other cities in Alaska. Many of the fish are exported to the Tokyo Central Wholesale Market for auction as "Kotzebue chums," favored by Japanese because of their high oil content.

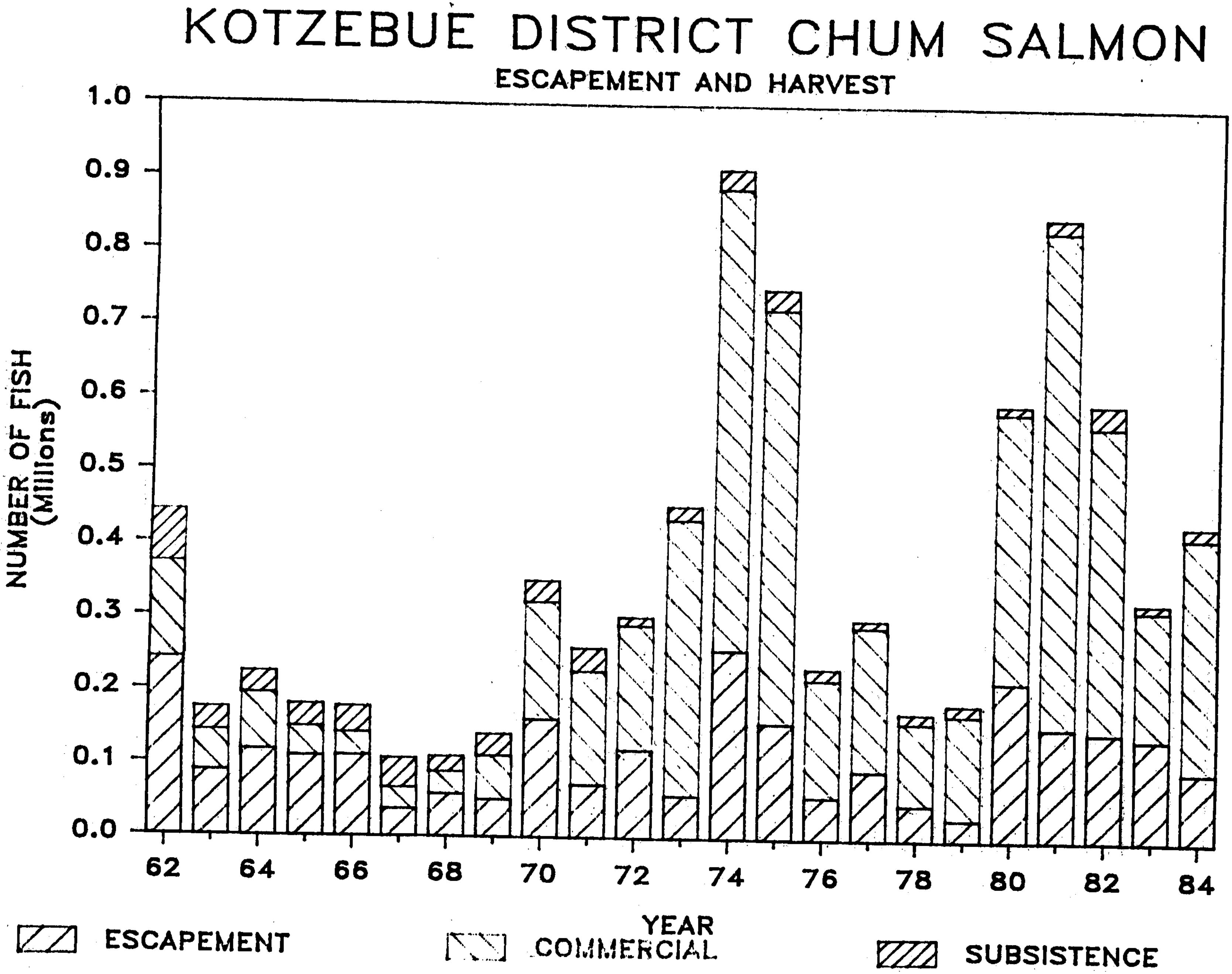

Figure 8. Total run of chum salmon to the Kotzebue District, 1962-1984, shown as both commercial and subsistence harvest and escapement.

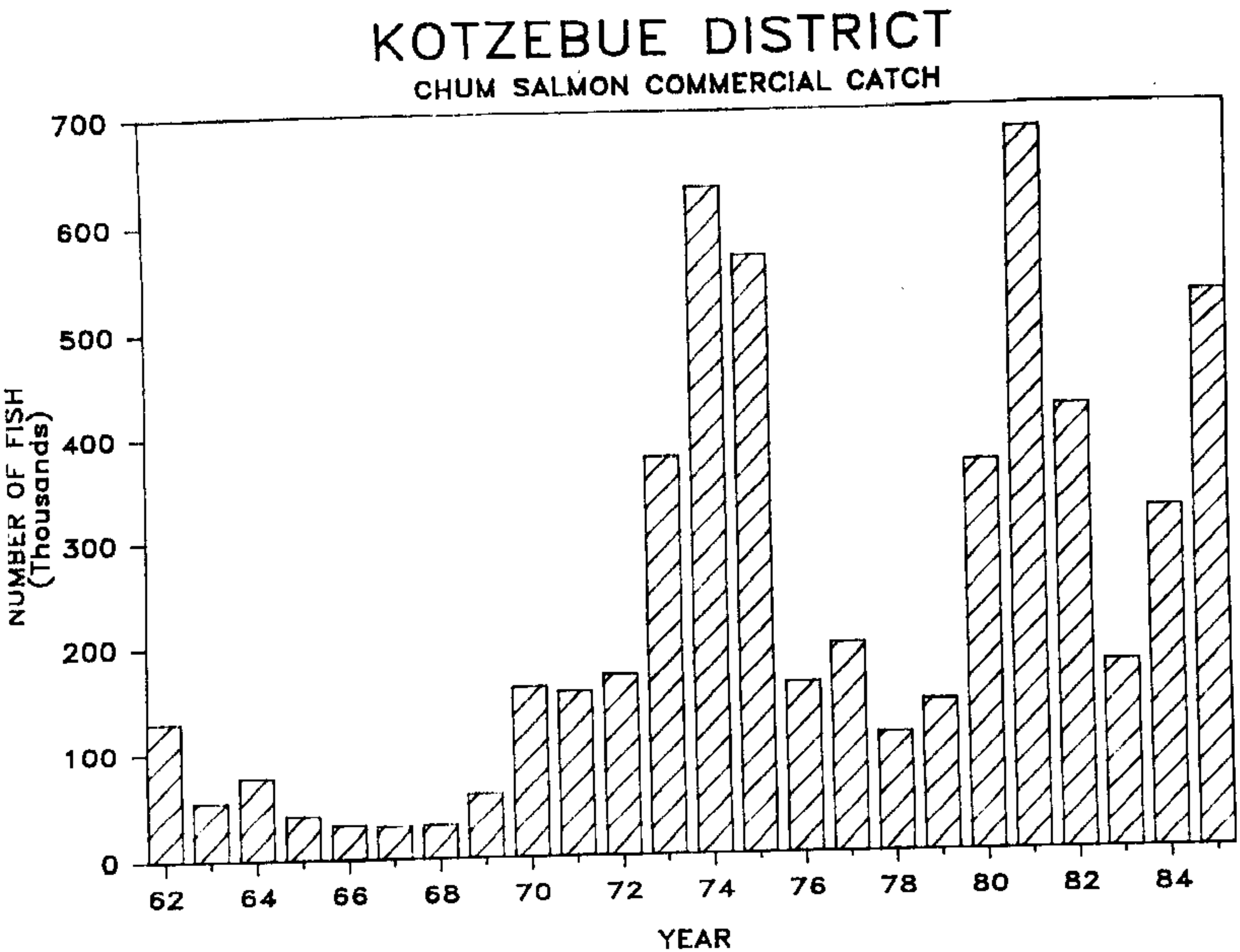

Figure 9. Levels of commercial harvest of chum salmon in the Kotzebue District, 1962-1985.

The harvest centers on chums bound for the Kobuk and Noatak rivers. Kobuk chum have been identified by tagging studies as arriving first in the commercial fishery, peaking in mid- to late July. The more abundant Noatak chums peak in the commercial fishery in early to mid-August. The fishery is regulated to allow adequate escapement (around 30,000 fish) of the lesser Kobuk stocks (Fig. 10). The Alaska Department of Fish & Game allows approximately 86,000 chums to escape into the Noatak River annually, the majority of which spawn in the lower river (Fig. 11).

A subsistence fishery for chum salmon also occurs in the Kotzebue Sound region. Residents from Noatak on the Noatak River and from five villages on the Kobuk River gill-net chum salmon in both rivers during the summer They also fish under the ice in early fall for late-run chum and char. Chum salmon subsistence harvests in the district have averaged 24,800 fish annually from 1962 to 1984 (Fig. 12). Chum stocks returning to the Kobuk River are less abundant but sustain a larger share of the subsistence harvest than do those of Noatak River, because there are more villages on the Kobuk and the residents prefer chum. The 10-year (1974-1984) average subsistence chum salmon catch for the Noatak River was about 3,900 fish, whereas for the Kobuk it approached 13,000 fish. There is also a subsistence fishery for Noatak char, both in late summer through early fall and during the winter beneath river ice. The salmon and char are used for human consumption or as feed for dog teams (Alaska Department of Fish & Game, 1984).

In addition, the Noatak River supports a minor sport fishery on big char averaging 7 pounds. They are taken by fly-in fishermen and by people floating the Notak, a wilderness river recognized internationally for its floating opportunities.

Issues of Concern

The Sikusuilaq Springs hatchery has raised several issues that relate to the question: Can hatchery fish and wild salmon coexist in the Noatak River basin without compromising the wild stocks over time?

Of immediate concern is whether state fishery managers can implement a management scheme for a mixed stock fishery while ensuring sufficient wild stock escapement. Although salmon abundance is cyclic, an average of 350,000 wild chum return to the Kotzebue Sound fishery annually, of which around 230,000 are commercially harvested. At full production, the Alaska Department of Fish & Game estimates 500,000-600,000 hatchery fish will be added to the fishery, thus potentially tripling the size of the harvest. Since hatchery stocks can be harvested at higher rates than wild stocks, and department policy requires management to ensure escapement of wild stocks, it's likely there will be surplus hatchery fish. But pressure to permit commercial harvest of any surplus hatchery fish is expected to be high.

This situation could lead to management of all stocks contributing to the Kotzebue Fishery as a single unit. In this case, the Noatak and Kobuk river stocks, along with the hatchery stocks, would be considered one unit stock, and would be managed as a single population. This could lead to overharvest of smaller components of runs to both rivers, particularly the upriver run of

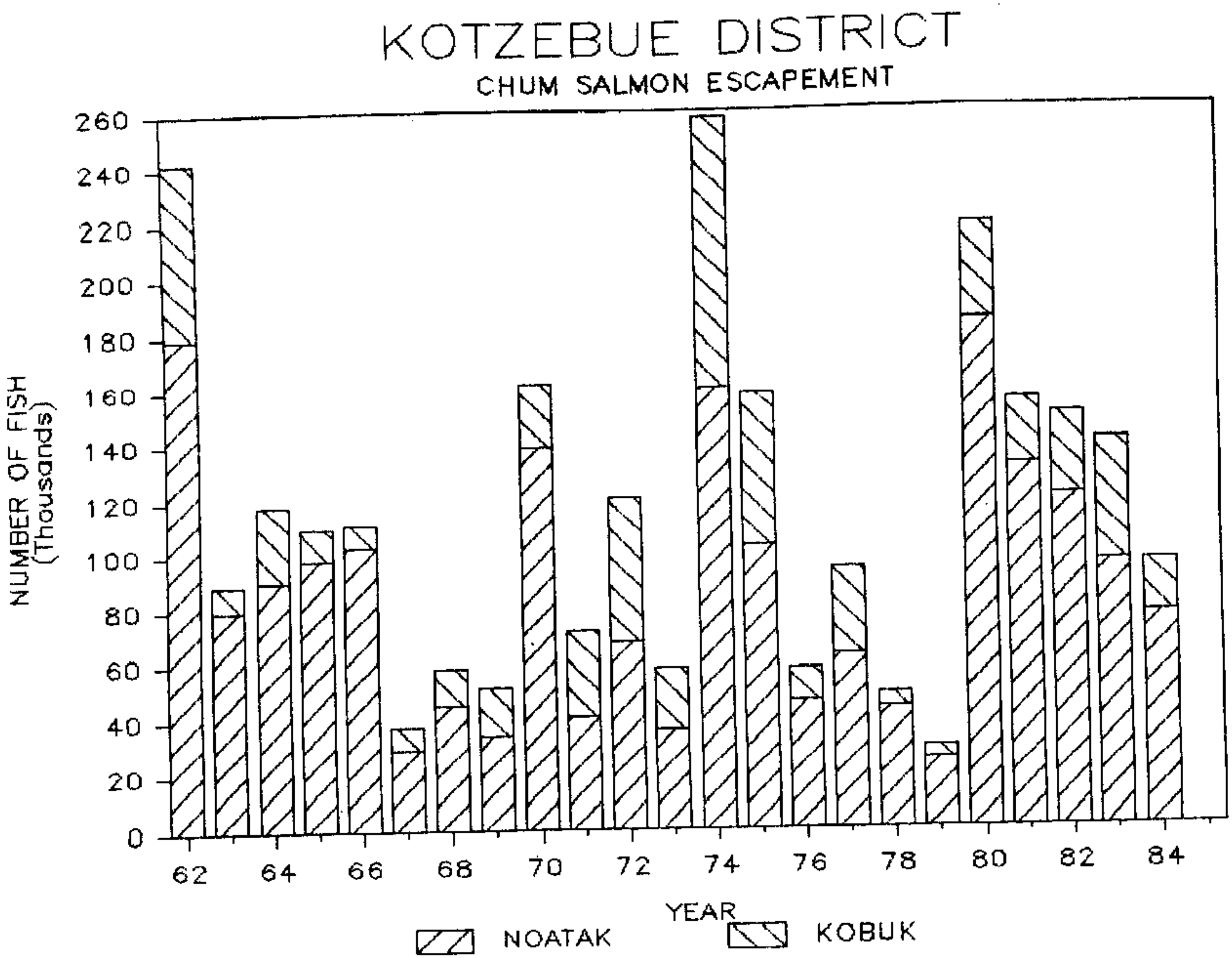

Figure 10. Chum salmon escapement levels for the Kobuk and Noatak rivers, 1962-1984.

NOATAK RIVER— CHUM SALMON ESCAPEMENT

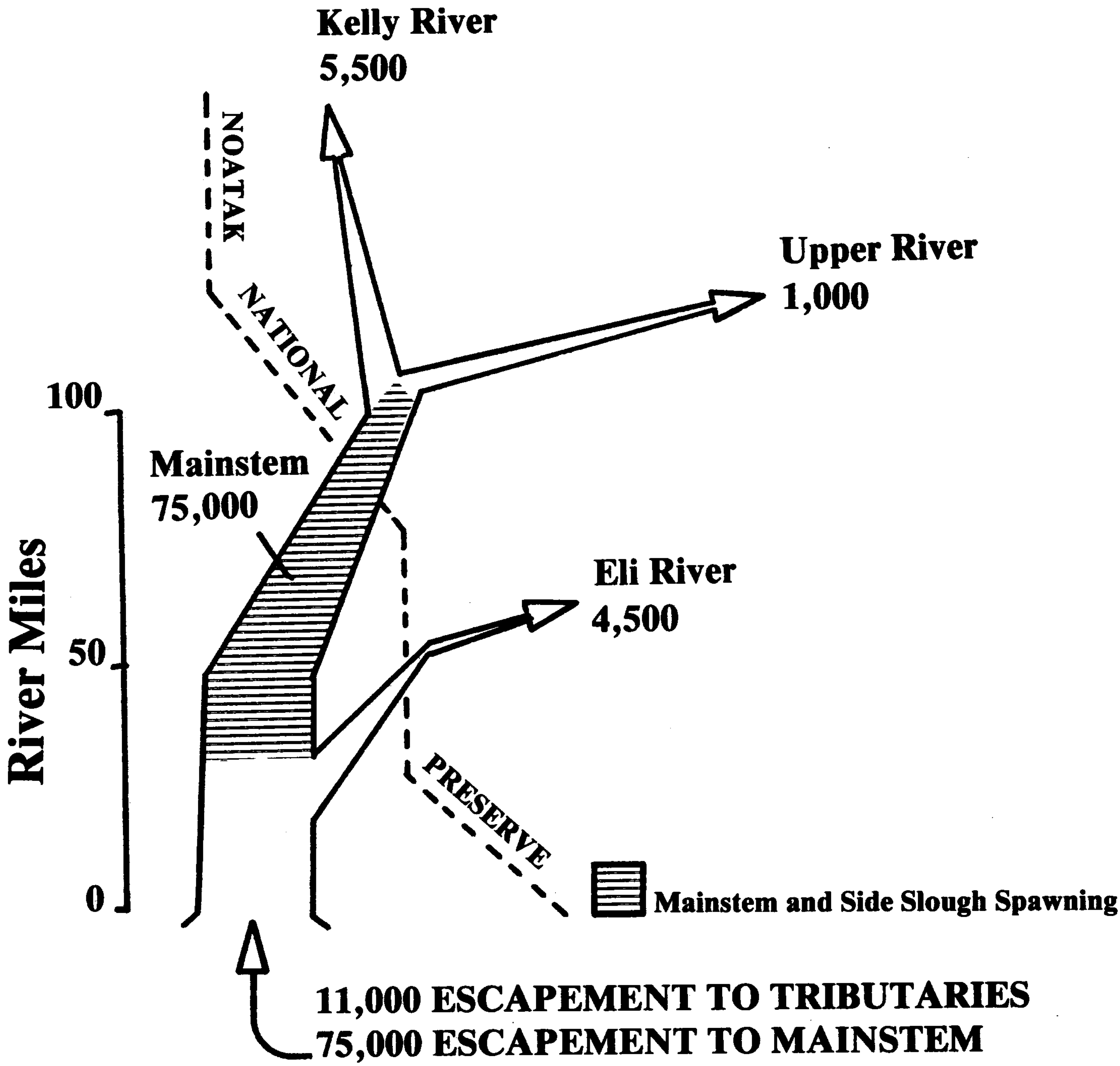

Figure 11. Schematic illustration of the average annual size of chum salmon escapement (number of fish) to tributaries and to the lower river mainstem of the Noatak River.

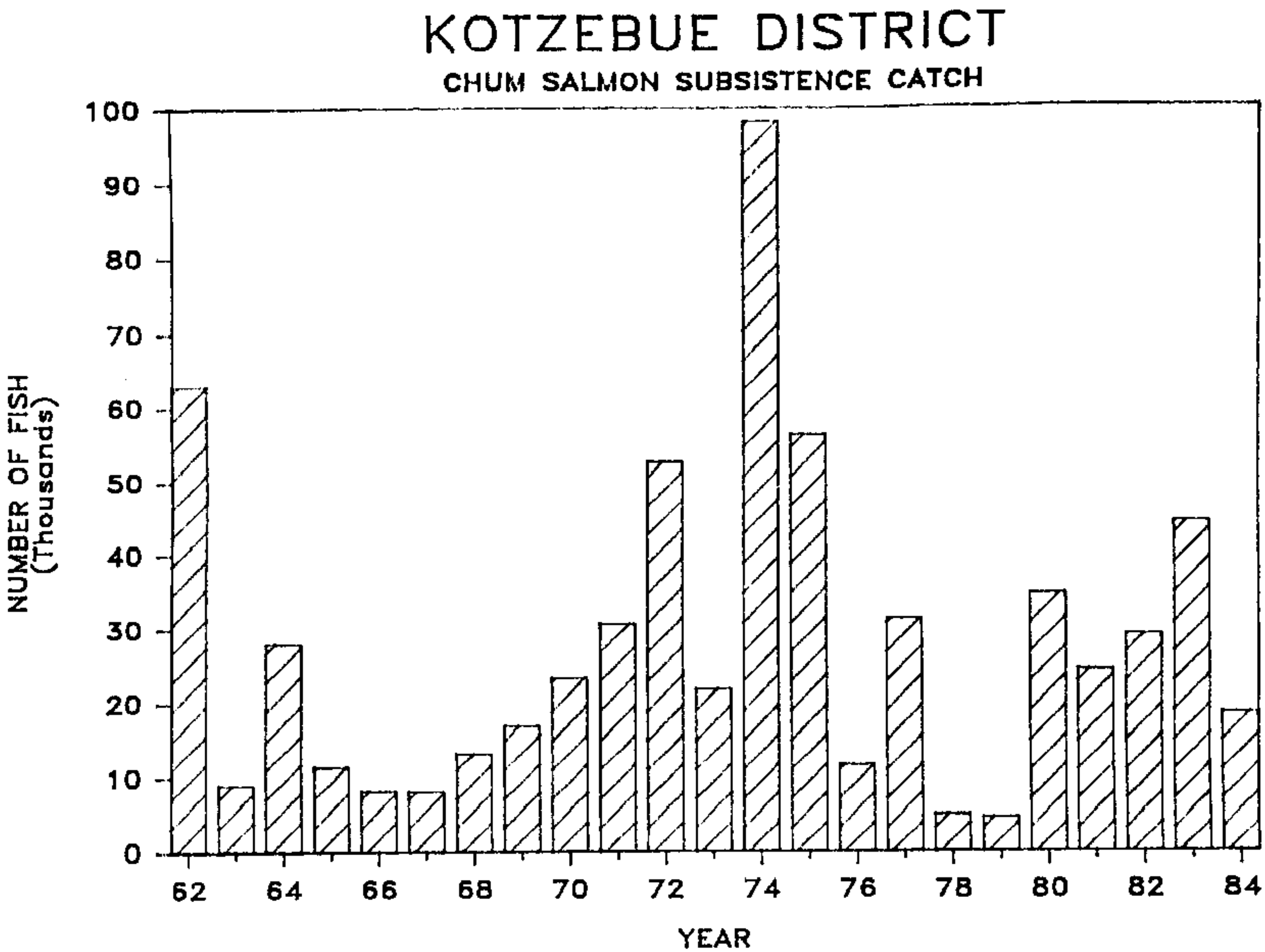

Figure 12. Levels of subsistence harvest of chum salmon in the Kotzebue District, 1962-1985.

chum in the Kobuk. Since this run is very important to the residents' subsistence fishery, there would be a sociocultural impact on local people.

One management scheme to avoid overharvest of any chum salmon or char populations relies on temporal separation of hatchery stock from other stocks (Madden, 1985). This would entail development through breeding practices of a late-returning hatchery stock which would pass through the commercial fishery one to two weeks after the fishery for wild chum. The major constraint to this alternative is that the late run would extend into September, when fishermen may be reluctant to participate. The lifestyles of subsistence fishermen would have to change, since September traditionally is given over to hunting and other forms of food gathering. Also, the Alaska Department of Fish & Game believes that a later fishery might impact char more heavily because the strength of the char run increases then.

A second technique suggested would separate wild and hatchery stocks in space, possibly by developing a remote release site for chum fry produced by the hatchery (Madden, 1985). In subsequent years, adults would return to this site, which would be geographically separate from the fishery on the wild stocks. However, no site has been identified to date and preliminary field studies indicate that potential sites near the established fishery are unsuitable. Local fishermen might balk at traveling long distances from Kotzebue in their small open skiffs, both because of hazardous seas and because stored chum soon degenerate.

A terminal in-river fishery has also been suggested, but this raises questions over the quality of fish harvested 30 miles upriver and their marketability compared with the bright, premium fish harvested in the salt water of Kotzebue Sound.

Another concern expressed by the National Park Service is the potential loss of genetic integrity of the wild chum salmon population in the Noatak National Preserve because of mixing with hatchery stocks. The Kobuk and Noatak rivers support separate stocks of chum according to contemporary definitions (Helle, 1981); but it is inconclusive whether either or both river systems support more than one salmon stock. Limited electrophoretic genetic screening by the Alaska Department of Fish & Game indicates some evidence of homogeneity between the systems. Slight genetic differences were observed, however, between chum populations using the lower mainstem and those in tributaries of the Noatak River (Davis and Olito, 1985). These fish also are thought to be different stocks because of their use of different habitats and, possibly, differences in their spawning times—tributary fish appear to spawn earlier. The fish and game department believes the Sikusuilaq Springs hatchery might be enhancing a specific late-spawning stock in the Noatak River. If so, this would reduce National Park Service concerns about genetic degration to the upriver tributary spawners. Still, chum salmon are known to stray, and there is no guarantee that hatchery chums won't mix with wild upriver stocks.

Another issue is potential competition between wild and hatchery-produced fry during their early sea-going stages in waters of Kotzebue Sound. Will hatchery-released fry outcompete wild fry for available food? Or will the carrying capacity of Kotzebue Sound accommodate both populations?

Discussion

Many questions regarding the interactions between hatchery and wild stocks in the Noatak and Kobuk rivers in northwest Alaska remain. What stocks of chum salmon are present in the region? What are the implications of a large run of hatchery-produced chum salmon on the long-term genetic integrity of wild chum in these rivers? Can the hatchery return be managed to protect smaller populations of wild chum returning to various segments of these river drainages?

Based on a preliminary literature review and consultation with several fish geneticists and managers in the Northwest, a detailed stock assessment is needed for chum salmon populations in this region. Evidence indicates there are several stocks in both river systems, at least in the Noatak River where limited electrophoretic screening suggests that gene flow has been restricted between the tributary spawners and the lower river slough and side-channel spawning stock (Davis and Olito, 1985). Additional stock separation studies are required to ascertain this, including not only electrophoresis but also detailed life history, behavioral and morphometric studies. Electrophoresis can identify genetic dissimilarity, but absence of detectable differences in gene frequencies does not mean stocks are genetically identical.

If genetically discrete breeding units can be verified in the Noatak and Kobuk rivers, it could be argued that the hatchery is enhancing a separate stock of lower Noatak River chum salmon. Impacts on upriver wild chum salmon stocks might then be minimized because of their separation in time of spawning and location from the lower river group. Certainly, hatchery fish will interbreed with lower river wild fish over time, possibly resulting in more homogeneity among the lower river population; but it is fairly unlikely that interbreeding would occur between upper river wild fish in the Noatak National Preserve and lower river hatchery-influenced stocks.

The Sikusuilaq Springs hatchery can be operated in various ways depending on the desired genetic characteristics of fish produced. Matings can be made to mimic as close as possible what occurs in the wild, including use of multiple males with each female as observed for chum salmon by Helle (1981) in Olson Creek, Alaska. Selection pressures from controlled water flows, temperatures, and food rations can be minimized by reducing the length of time fry are reared before release (Helle, 1982). Wild fish can be used in breeding schemes to infuse wild genetic materials into the hatchery population in order to maximize the wild nature of the hatchery stock, thereby maintaining stock diversity and fitness, and improving survival. These practices are recommended by the state genetics policy (Alaska Department of Fish & Game, 1985) and by the American Institute of Fishery Research Biologists (1975) to maximize genetic variability in hatchery stock. However, if differently timed runs for hatchery and wild stocks were desired, intentional genetic mixing would be folly.

One option to alleviate concerns over the mixed stock fishery would keep the hatchery small and produce an adult population no larger than the wild population, thereby minimizing the possibility of hatchery stocks overwhelming wild stocks when harvested in the commercial fishery. All fry produced from the hatchery could be marked to assure complete monitoring of the return to the fishery in Kotzebue Sound. A portion of the adult hatchery return could be tagged and its upriver migration monitored to determine the degree to which wild and hatchery fish mingle on spawning grounds, and to observe if hatchery fish show a high degree of fidelity to the hatchery or migrate into upriver tributaries. A small production hatchery, however, may not be economically acceptable to the public.

Many of these suggestions involve monitoring, stock separation work, or after-the-fact hatchery practices. To date no assurances have been made that wild stocks in the Noatak and Kobuk rivers will not, over the long term, be overharvested because of high hatchery production. Also, genetic mixing of wild and hatchery populations in the Noatak River cannot be completely avoided. However, whether interbreeding between wild and hatchery stocks will affect the viability of wild stocks is uncertain—insufficient work has been done to go beyond speculation.

Careful evaluation of the regional socioeconomic needs, in light of the biological concerns, should be made to determine the future of this hatchery. The relative priorities of local economies and genetic concerns should be discussed and resolved publicly, with the realization that the genetic needs of a population of fish may contradict the socioeconomic needs of the area.

At issue also are the policies of a major landholder in the region, the National Park Service. Its stringent mandate to manage the Noatak National Preserve in as natural a state as possible argues against fish enhancement on the Noatak River. Much of the Preserve is wilderness (5.8 million acres), and the preserve is internationally recognized for the pool of wild genetic materials in its indigenous animal and plant populations. The National Park Service is likely to oppose the hatchery on these grounds. However, the hatchery site is on land outside the Preserve, and the National Park Service is but one voice. Resolution of the hatchery's future must be based on federal, state and local decisions regarding the costs and other consequences of artificial supplementation of salmonid fisheries in the area.

LITERATURE CITED

American Institute of Fishery Research Biologists, Alaska District. 1975. Genetic considerations in artificial propagation of salmon. Alaska Seas and Coasts 3(2):8-10.

Alaska Department of Fish & Game. 1984. Norton Sound, Port Clarence, and Kotzebue annual management report. Division of Commercial Fisheries, Anchorage. 155 pp.

_____. 1985. Genetic policy. Genetic Policy Review Team, Juneau. 25 pp.

Allendorf, F.W. and S.R. Phelps. 1980. Loss of genetic variation in a hatchery stock of cutthroat trout. Trans. Am. Fish. Soc. 109: 537-543.

Bigler, B., and D. Burwen. 1984. Migratory timing and spatial entry patterns of chum salmon in Kotzebue Sound. Alaska Dept. of Fish & Game. Informational Leaflet 238. 23 pp.

Bird, F. 1982 Preliminary forecast model for Kotzebue Sound, Alaska chum salmon (*Oncorhynchus keta*). Alaska Dept. of Fish & Game. Information Leaflet 203. 27 pp.

Davis, R.H. and C. Olito. 1985. Preliminary investigations of genetic structure of chum salmon (*Oncorhynchus keta*) in the Noatak and Kobuk River drainage of northwestern Alaska. Alaska Dept. of Fish & Game, Div. of Fisheries Rehabilitation, Enhancement and Development, Juneau. Unpub. MS. 24 pp.

DeCicco, A. 1983. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Annual report. Pages 1-33 *in* Div. of Sport Fish, Alaska Dept. of Fish & Game. Federal Aid in Fish Restoration and Anadromous Fish Studies. Vol. 24 F. Inventory and cataloging. Study G-I-P-A.

_____. 1984. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Annual report. Pages 47-69 *in* Div. of Sport Fish, Alaska Dept. of Fish & Game. Federal Aid in Fish Restoration and Anadromous Fish Studies. Vol. 25 E. Inventory and cataloging. Study G-I-P-A.

Eggers, D.M. 1986. Preliminary forecasts and projections for the 1986 Alaska salmon fishery. Alaska Dept. of Fish & Game Informational Leaflet No. 253. 55 pp.

Hansen, J.A. 1986. FRED 1985 annual report to Alaska State Legislature. Div. of Fisheries Rehabilitation, Enhancement and Development, Alaska Dept. of Fish & Game. 91 pp.

Helle, J.H. 1981. Significance of the stock concept in artificial propagation of salmonids in Alaska. Can. J. Fish. Aquat. Sci., 38:1665-1671.

_____. 1982. Genetic considerations in management of wild and hatchery stocks of salmonids, pp. 25-29. *In* California Trout, Inc. and American Fisheries Society, California-Nevada Chapter, Proceedings of a Symposium on the role of hatcheries in the management of wild salmonids. Reno, Nevada.

Ihssen, P.E., H.E. Booke, J.M. Casselman, J.M. McGlade, N.R. Payne, and F.M. Utter. 1981. Stock identification: materials and methods. Can. J. Fish Aquat. Sci., 38:1838-1855.

Madden, J. 1985. The Sikusuilaq Springs hatchery operations/management plan, 1980-2000. Draft report (May 2, 1985). Alaska Dept. of Fish & Game, Juneau. 1 vol.

National Park Service. 1985. Noatak National Preserve, Alaska, draft general management plan and environmental assessment. Alaska Regional Office, Anchorage.

Raymond, J. 1985. Status report, Sikusuilaq Hatchery. Alaska Dept. of Fish & Game, Div. of Fisheries Rehabilitation, Enhancement and Development, Fairbanks. Unpub. MS. 4 pp.

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations, pp. 19-160. *In* R.C. Simon and P.A. Larkin [ed.] The stock concept in Pacific salmon. H.R. MacMillan Lectures on Fisheries. Univ. British Columbia, Vancouver, B.C.

Wright, S. 1981. Contemporary Pacific salmon fisheries management. N. Am. J. Fish. Management 1:29-40.

Evaluation of Redband Trout in the Blitzen River

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Introduction

Redband trout (*Salmo* sp.) thrive in streams of the harsh, arid environment of southeast Oregon, where in prehistoric times they inhabited inland lakes that provided an abundance of aquatic invertebrates and chubs for food.

The Blitzen River has provided excellent angling for native redband trout and is recognized by anglers as one of Oregon's finest "wild trout" streams. Each spring the Oregon Department of Fish and Wildlife (ODFW) releases yearling hatchery rainbow into the mainstem Blitzen between river mile 40 and 45. ODFW believes the gene pool for the population of wild redbands in the upper Blitzen River is still relatively unaltered because the upstream migration of hatchery fish is blocked by a dam at river mile 46, and because hatchery trout have not been released above this point since the 1940s.

In recent years, however, fishermen seeking quality angling for wild trout have been concerned about the decline in the number of large trout (16 to 20 inches) in the population. Surveys of the Blitzen in 1972 indicated trout were being overharvested in parts of the river accessible to anglers, while in the inaccessible areas trout were small. The surveyors also concluded that the basin was being degraded by livestock overuse.

ODFW attempted a tagging study in 1975 to obtain information on movements, size and growth of redband trout in the Blitzen River. Fish were caught by hook and line because the Blitzen resists conventional sampling methods. The Portland Anglers Club assisted in this program. The inventory produced little biological data, but the educational value and the working relationship that developed between the Department and the Anglers Club were valuable.

An expanded inventory of the basin was conducted in 1981 and 1982. Its goal was to collect information needed to manage wild redband trout in the Blitzen River. Specific objectives were to:

1. Determine species composition of the total fish population;

2. Determine size and age composition of the redband trout population;

3. Calculate population estimates of redband trout at selected sites; and,

4. Define movement of redband trout from tributaries into the mainstem Blitzen.

This paper presents the findings and conclusions of that study.

Historical Perspective

The life cycle of prehistoric redband probably was similar to that of anadromous salmonids. Mature fish migrated into tributary streams in the spring to spawn. Many young trout remained there for one to two years, then migrated downstream to feed in the rich lake environment. Others lived their entire lives in the stream.

Historical information indicates that the Blitzen River system and Malheur Lake held large numbers of big redband trout. The first recorded observation in Malheur Lake comes from the diary of Captain Charles Bendire, an amateur naturalist with the U.S. Cavalry. In 1875, Bendire was stationed at Fort Harney about 15 miles east of present-day Burns. He states he was the first person to fish in Malheur Lake, where he observed trout that averaged 5 pounds. He also observed "redside suckers" (probably bridgelip suckers) and pelicans feeding on perch-like fish, undoubtedly roach (Bendire, 1875).

Marcus Haines, a member of the Harney County Historical Society, grew up in the Blitzen Valley and has provided considerable information on redbands. He recalls that in 1914 and 1915, he watched trout 20 to 30 inches long being trapped at the Grain Camp Dam near Frenchglen, where he was working on a cattle ranch. Haines also remembers seeing trout up to 24 inches long below Dunn Dam, a rock structure on the Blitzen about 4 miles south of the Malheur Refuge headquarters. This dam blocked fish migration during certain flows, and ranchers would dynamite the trout and pick up the ones they wanted. In 1945, Haines and a friend saw large numbers of big trout below the dam on the McCoy diversion ditch, which is 200 yards up the ditch from its junction with the Blitzen at river mile 26 (Marcus Haines, personal communication).

According to John Scharff, manager of the Malheur National Wildlife Refuge from 1935 to 1971, Malheur Lake went dry and many fish died in 1931 and again in 1934. However, during 1940 and 1942, trout populations in the lake were extremely high; and each spring he saw many fish trying to negotiate various irrigation dams in the Blitzen Valley. During these years he recalled seeing numerous large trout (20 to 28 inches) trying to ascend the crude fish ladder at Sodhouse Dam near the Refuge Headquarters (John Scharff, personal communication).

Both Haines and Scharff stated that trout numbers were at their highest in the Blitzen Valley during the early 1940s. By the late 1940s and early 1950s, the carp population in Malheur Lake had ballooned, and both men mentioned that this was the cause of the demise of big trout in the Blitzen system. Few trout were seen below the irrigation dams during the 1950s.

The first irrigation ditches in the Blitzen Valley were built in the late 1800s. The irrigation system was further developed by the Civilian Conservation Corps (CCC) between 1935 and 1941 when irrigation ditches were enlarged and extended to obtain better water control throughout the valley. The CCC also replaced many of the old rock dams with permanent concrete structures. The present Page Dam at river mile 46 was rebuilt in 1935-36.

Carp were first introduced into waters of the Harney Basin as a food fish in the late 1800s. They appeared in the Silvies River in the early 1920s and in Malheur Lake in the late 1930s and early 1940s. Reproduction of carp in Malheur Lake apparently did not occur until the late 1940s and early 1950s (McLaury, 1968). Extremely high runoff from the Silvies River in April of 1952 apparently flushed large numbers of adult carp into the marsh, for a definite increase in their numbers was observed by Refuge personnel at this time (Marshall, 1957). Refuge personel also noted that increased activity of carp was followed by reduced numbers of waterfowl on the lake.

The first carp control program began in the fall of 1955 when Malheur Lake, Bocal Lake, the Silvies River and the Blitzen River downstream from the mouth of Fish Creek were chemically treated to remove carp. This and subsequent treatment projects on the Refuge were failures.

The Study Area

The Blitzen River originates on the west side of Steens Mountain in southern Harney County and flows north into Malheur Lake. The drainage basin contains approximately 760 square miles of surface area and 279 linear miles of trout-producing stream. Discharge from the lower Blitzen averages 120 cfs and ranges from 25 to 43,000 cfs. High, murky water occurs in May and June because of snow melt and runoff. Periodic severe summer thunderstorms increase the discharge dramatically. Water temperatures in the lower Blitzen range from 32 degrees in the winter to 75 degrees Fahrenheit in the summer.

The upper portion of the Blitzen System is primarily summer rangeland dominated by alpine meadows and aspen thickets. The gradient ranges from steep to fairly flat with a good pool-riffle ratio. The South Fork Blitzen and its tributaries flow through wide juniper-sage valleys for the most part grazed extensively by livestock. The upper drainages have large areas of poor trout habitat, primarily because heavy grazing has disturbed the vegetation on a thin, poor mantle of soil. In some areas beaver have contributed to removal of woody vegetation from the stream corridor. Silt and sediment cover much of the food-producing and spawning area.

The river flows through a narrow, rocky canyon from Blitzen Crossing downstream to the mouth of Fish Creek. Livestock access to this area is limited. Below Fish Creek the canyon widens and this area has been severely overgrazed and its riparian habitat degraded. In 1980 the Bureau of Land Management (BLM) built a fence along the river from two miles above Fish Creek down to Page Springs to exclude livestock, and riparian vegetation has since sprung up. Below Page Springs the Blitzen enters the wide Blitzen Valley where the river has been channelized and diverted into numerous canals that distribute water on the Malheur National Wildlife Refuge. Little trout habitat remains in this area because of slackwater pools, diversions, siltation and concentrations of rough fish.

Despite the areas with poor trout habitat, the Blitzen River System as a whole contains an excellent population of wild redband trout. Angling pressure generally is light because of the remote location, few access sites, rough terrain and private land ownership.

Materials and Methods

Sampling sections were chosen to represent habitat types, stream sizes and angler access. The locations sampled were in three areas: the mainstem Blitzen River within the Malheur Refuge; the mainstem Blitzen upstream from the Refuge; and tributaries of the main stem. Fifteen sites ranging in length from 200 yards to 2.5 miles were sampled.

Fish were collected with electrofishing gear consisting of backpack, raft-mounted and drift boat-mounted units. The type of unit varied with the depth and flow at the sampling site. The study also included capture of fish with barbless hooks by volunteer anglers.

Captured fish were anesthetized and measured to the nearest half inch (fork length). Scale samples taken at each site were used to determine ages.

Population estimates relied on two mark-and-recapture projects at sample sites 3 (mainstem Blitzen) and 4 (South Fork Blitzen) using procedures developed by Robson and Regier (1968). Members of the Portland Anglers Club, using barbless flies, captured trout for marking. Electrofishing gear was used several days later to make the first recapture. All fish captured on this pass were given an identifying mark and released. Electrofishing gear was again used for the final recapture. Standard assumptions about mortality and movement were made.

In 1981 all fish were removed from sample sites 5 (South Fork Blitzen) and 9 (Big Indian Creek) to document movement of redbands back into a fishless reach. The same areas were resampled in 1982, using the same gear and methods, to determine the movement of redband back into them.

Findings and Discussion

Fish species collected in the Blitzen River system above Page Springs Dam were redband trout (*Salmo* sp.), mountain whitefish (*Prosopium williamsoni*), longnose dace (*Rhinichthys cataractae dulcis*) and mottled sculpin (*Cottus bairdi semiscaber*). In addition to these species, hatchery rainbow (*Salmo gairdneri*), redside shiner (*Richardsonius balteatus*), bridgelip sucker (*Catostomus columbianus*) and carp (*Cyprinus carpio*) were collected during sampling in the Refuge. Roach (*Gilia bicolor*) are known to be present in the Refuge but were not collected.

The redband was the most common species found in the Blitzen system. Percent composition ranged from 13.2 in waters of the Refuge to 86.7 in the upper tributaries.

Whitefish accounted for zero to 8.1 percent of the total population but made up a higher percentage of biomass, especially in the mainstem Blitzen.

Low numbers of longnose dace and mottled sculpin were recovered in the upper tributaries compared to the number captured in other areas. Previous work in southeast Oregon indicates these fish are found only where water quality is good. Bridgelip suckers, carp and redside shiners were captured only in the Malheur Refuge, an area of poor water quality and degraded habitat.

The size, structure and relative population of redband trout in the portion of the mainstem within the Refuge were of interest to the researchers. The area just below Page Springs Campground, where about 5,000 legal-sized trout are stocked annually, receives heavy angling pressure. Researchers wanted to determine how native redbands responded to this heavy angling pressure and to the presence of hatchery fish, and how many hatchery fish were present. The three sample sites in the Refuge have been heavily impacted by human activities that include channelization, irrigation withdrawal and return, and bank protection work, and researchers wanted to know how these activities influenced the trout population.

Because of the low numbers of fish recovered at all three sample sites in the Refuge, catches were combined and a length-frequency distribution for all redbands captured was plotted. The redbands averaged 8.6 inches in length. This large size is probably the result of high nutrients, large stream size and decreased competition with whitefish.

The bulk of the angling pressure in the system occurs in the mainstem above the Malheur Refuge, where we were very interested in the size of the redbands. Redbands were largest in the section just below the mouth of Fish Creek, which is the most heavily fished section we sampled with the exception of the "P" Ranch site on the Refuge. This large size (average 7.1 inches) probably is the result of better productivity and habitat. The average size of redbands from the other two sample sites on the mainstem Blitzen varied from 6.4 to 6.9 inches.

The low number of fish observed over 12 inches in length has also been noted in inventories conducted in the past. The low percentage of large fish and the combined mainstem average length of less than 7 inches is a true reflection of the actual size distribution of the redband population. The mainstem Blitzen above the Refuge is fairly productive, but it is not conducive to rapid growth and large trout because of various environmental conditions including siltation, low summer flows and lack of riffles.

The average size of redbands captured in tributaries of the Blitzen River decreased as the streams became smaller. Few redbands over 12 inches in length were recovered in the tributaries. A greater proportion of fish under 4 inches in length occurred in the upper tributaries where the streams are small, habitat degraded, and living conditions impaired. These conditions result in a crowded, stunted population with the fish maturing at an average length of only 4.5 inches.

Analysis of scale samples collected at sample sites in the Refuge showed no fish older than age 3, considerable overlap between age groups, and no positive spawning checks.

The length frequency of five age classes sampled in the main stem were compared. Considerable overlap occurred between age classes, especially ages 2 and 3. This could be expected in the Blitzen where growth is variable because of differing habitat and growing conditions within the system. Redbands age 3 and younger made up 97 percent of the sample even though all larger fish were sampled. This is consistent with aging work done from otoliths by Konopacky and Wallace (1980) for redbands in eight southwest Idaho streams.

The length frequency of the three age classes sampled in the tributaries were compared. There was considerable overlap between age groups, and few fish exceeded 12 inches in length. No fish older than age 3 were sampled even though scales were taken from all large fish. The upper length limit of each age class was from 1 inch to 2 inches less in the tributaries compared to the main stem. We feel this difference in size is a reflection of the slower growth rate experienced in the less than optimum habitat of the tributaries.

Redband population estimates were made at sample site 3 on the mainstem Blitzen and sample site 4 on the South Fork Blitzen. Two estimates were made at each location. The first estimate involved the recapture of fish caught and marked by anglers. The second estimate was the recapture of fish originally captured by electrofishing equipment. We were disappointed with the accuracy of the population estimate obtained by recapturing angler-marked fish. Because of the low number of these fish in the population, the 95 percent confidence interval was high. The most accurate population estimate was obtained using the raft-mounted electrofishing gear to capture fish for marking, then recapturing them with the same gear.

We believe the population estimate made on the mainstem Blitzen of 325 redbands (95.6 percent CI ± 4.6) over 4.75 inches in length is very accurate. We also believe this section has the lowest population of any of the mainstem sites sampled.

The population estimate made on the South Fork Blitzen of 273 redbands was of little value because of the wide confidence interval. This 0.5-mile section was heavily fished by anglers and we believe many of the marked fish were removed between the time they were marked and the recapture effort. Although we must assume the marked and unmarked fish were removed from the population at the same rate, the apparent removal of large numbers of marked fish reduced the number of at-large marked fish to such a low level that an accurate population estimate was impossible.

In 1981 all redband trout were removed from sample site 5 (South Fork) and sample site 9 (Big Indian Creek) by electrofishing. Redbands removed numbered 168 and 164. This work was repeated in 1982 to determine the movement of redbands into the barren area and to examine the size of the fish present. The South Fork site yielded 50 redbands, about one third of the 1981 total. This section showed signs of having been heavily fished just prior to our sampling, and we assume that this influenced the samples. There was no significant difference between the 1981 and 1982 average size. One hundred and sixty-one redbands were captured in the Big Indian site in 1982, nearly the same number as the previous year. However, the average size of these fish was significantly smaller than in 1981. The elimination sites showed there was a rapid repopulation of barren habitat by redbands. These areas were repopulated primarily by age-1 and age-2 downstream migrants.

Conclusions

Information gathered on redband trout in the Blitzen River in 1981 and 1982 showed that most of these fish spawn at age 3; that most, if not all, apparently die after spawning; and that habitat and environmental conditions dictate growth rate and size at maturity. Work conducted at Parsnip Lake (ODFW, unpublished data), a small reservoir south of Jordan Valley, produced similar data.

Carp appear to be the greatest single factor in the loss of large redband trout in the Blitzen System. Other factors such as irrigation diversion dams and degradation of streamside habitat also have contributed to the loss.

Several things could be done within the Blitzen drainage to improve redband trout populations. Fish ladders could be placed on irrigation dams within the Refuge to insure better passage for the few large redband trout that now try to ascend the Blitzen during their spawning migration. Great care must be taken to ensure that carp, suckers and roach can not negotiate these ladders and gain access to the Blitzen above the "P" Ranch. If rough fish were allowed to invade the upper Blitzen system, they would destroy the current valuable trout fishery. Better watershed protection on the upper South Fork Blitzen and tributaries would promote better soil stabilization and improve habitat in that area and water quality downstream.

LITERATURE CITED

Bendire, C.E. Personal diary. 1875. Smithsonian Institute.

Haines, Marcus. Hines, Oregon. Personal communication with Bill Hosford, 12 April 1982 and 23 November 1982.

Konopacky, R.C., and R.L. Wallace. Age and growth of native trout populations of Owyee County, Idaho. Boise, Idaho: Bureau of Land Management, Annual Progress Report, Contract ID-010-CT0-0002, 1980.

Marshall. 1957. n.p. Cited in Malheur National Wildlife Refuge unpublished material.

Robson, D.S., and H.A. Regier. Estimation of population number and mortality rates. In Methods for Assessment of Fish Production in Fresh Waters. International Biological Program. Handbook No. 3. Second Edition. Ed. W.E. Ricker. Oxford and Edinburgh, Scotland: Blackwell Scientific Publications, 1968, pp. 124-158.