An ABSTRACT OF THE THESIS OF

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Approximately $1 billion a year is spent on salmon in the Pacific Northwest. Spending has escalated, yet the number of wild runs placed under the protection of the Endangered Species Act has increased, creating social and political controversy. For more than 100 years, salmon management in the Pacific Northwest has evolved around a fundamental concept, that hatcheries could replace the numbers of salmon lost as the region underwent industrialization. Spending on hatcheries makes up approximately 40 percent of expenditures on Northwest salmon issues. Four new studies have identified hatcheries as one of the reasons for the decline of some wild salmon stocks. Yet hatcheries are also considered one of the most important tools for saving wild runs. This thesis examines some of the national and international forces that shaped the modern hatchery program in the Pacific Northwest. After World War II, scientists and policy makers worldwide were motivated by idealistic dreams of using science and technology to end world hunger. With the creation of

factory processing ships, and the discovery of such strategically important minerals such as manganese, there was growing political pressure to protect national resources through the creation of 200-mile limits. As part of this worldwide interest in increasing the marine harvest, hatchery programs for salmon were expanded in Japan, the U.S.S.R., Canada and the United States. At the same time, human activities, including logging, mining, agriculture and urbanization, contributed to the decline of salmon in the Northwest. This thesis examines some of the national and international forces that contributed to the expansion of the hatchery system in the Pacific Northwest.

Fish Tales:

Salmon Stories, 1945-1980.

by

Carmel Finley

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes Redacted for privacy on request.

Carmel Finley, Author

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# DEDICATION

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Fish Tales: Salmon Stories
1945-1980

Introduction

The seven races of Pacific salmon are unique in their biology and their integration into the equally unique landscape of the Pacific Northwest, with its winter rains and summer droughts. From California to Alaska, salmon were the backbone of the aboriginal economy. With the arrival of white settlers and the industrialization of the region, the runs have dwindled yet the fish retain their hold on the human imagination. Catching a big silver fish, according to historian Richard White, is the "quintessential Northwest experience," endlessly evoked in art and literature, to the point where the fish have come to symbolize nature itself.[1]

But while salmon is an icon, it is also a commodity.[2] Just twenty-file years ago, it was the most important commercial fishery in the region and thousands of people from Cordova to San Diego depended on them for a living. Thousands still depend on fishing for salmon in the state of Alaska, but in British Columbia, Washington, and Oregon, human activities have drastically reduced the once great runs. Mining, agriculture, irrigation, navigation, fishing, and urbanization have all taken their toll on the fish. The habitat they depend on is fragmented at best and much of it has been dramatically altered, impairing its ecological functions. Each year, additional runs of salmon qualify for protection under the federal Endangered Species Act. Spending on salmon tops $1 billion a year but so far has failed to arrest the decline.[3] How much money should be spent and how it should be allocated will continue to be contentious issues.

Two recent books have discussed the decline of Northwest salmon. In *Making Salmon: An Environmental History of the Northwest Fisheries Crisis,* historian Joseph E. Taylor III argues that policies developed out of a genuine concern for the fish "unintentionally channeled fishery management and salmon evolution onto paths that contributed significantly to the mounting disaster."[4] Biologist Jim Lichatowich, in *Salmon Without Rivers: A History of the Pacific Salmon Crisis,* says people must find a new balance between the natural economy of salmon, with its connections to the landscape, and the industrial economy, that has dominated Northwest development for most of the last 200 years.[5]

Both of these books examine events in Oregon and Washington, starting with the aboriginal fishery, the arrival of white settlers, the development of an industrial fishery, and the building of the hydroelectric system on the Columbia River. But national and international forces have also played a role in the decline of salmon, just as they have in the collapse of other fish stocks around the world. The same forces that contributed to the collapse of Pacific salmon also played a role in the overfishing of northern cod (*Gadus morhua*) off New England and Canada. The pressures that propelled the expansion of the salmon fishery during the 1950s and 1970s built the West Coast trawl fisheries, an industry now facing severe cutbacks. Globally, biologists believe that so many stocks are overfished that the harvest does not cover the costs of fishing, creating a worldwide deficit of $46 million. To eliminate the deficit, scientists recommend a combination of reducing fishing costs, increasing the price of fish and reducing the size of the world fishing fleet by between 25 and 53 percent.[6]

This thesis will examine some of the national and international forces that contributed to the decline of Northwest salmon runs. After World War II, which had severely disrupted food production in much of the world, there was an urgent need to increase the food supply. Nations such as Japan and the Union of Soviet Socialist Republics had to rebuild their fishing fleets. Fisheries in countries like Canada and the United States expanded, incorporating the new technology which had emerged from wartime development.

One common factor in the collapse of most fisheries has been the rapid explosion of technology that has been steadily applied to increasing the world fish catch. During World War II scientists developed radar and sonar, sharply improving the ability of fishermen to find fish. Sophisticated nets and sensors caught more fish. During the 1950s, dozens of nations built factory processing ships that spend months at sea catching and freezing fish. Marine commerce has also steadily increased. Between 1950 and 1970, the world's merchant fleet doubled in size and quadrupled in tonnage. The discoveries of oil and gas deposits offshore stimulated increased research into new fields of knowledge such as oceanography, underseas mining, and aquaculture.[7]

For centuries, freedom of the seas meant unimpeded passage and the right to fish anywhere in the ocean. New mineral and oil discoveries, along with the desire to catch fish as quickly as possible, contributed to the political pressures to extend national jurisdictions during the 1970s. The adoption of the 200-mile limit in many countries contributed to a "largely uncontrolled increase in the world fleet size."[8] Additional legislation also created government programs to encourage ship building and investment in exploration of new fisheries and fishing techniques.

Changes in science and technology also played an important role in efforts to create more salmon. While hatchery technology had been around since the 1870s, it grew rapidly after World War II because of advances in diet, disease control, and improved hatchery practices. As part of postwar recovery efforts, the Japanese introduced hatchery-based enhancement programs for chum (*O. keta*), pink (*O. gorbuscha*) and cherry (*O. masu*) salmon in 1951.[9] The output from hatcheries in the Soviet Union reached 320 million eggs by 1958, and the total doubled by 1970.[10] The Asian programs expanded so quickly that by 1970, Japan was second only to the USSR in the production of pink and chum salmon.[11] The spectacular releases of pink and chum salmon in Asia were goals that Canadian and American fishery biologists sought to emulate.

Spending on new hatcheries accelerated in the decades after World War II. Canada, the U.S., Japan, and the USSR all invested heavily in expanding hatchery facilities for salmon. Faith in technology and its ability to circumvent natural barriers contributed to optimism about how much fish could be harvested from the sea without negative ecological consequences.

There was enormous pressure in the Pacific Northwest to produce more salmon. A series of legal decisions beginning in 1969 culminated in the ruling that treaty Indian tribes should have the right to catch half the returning salmon to state waters in western Washington and on the Columbia River System.[12] Both Canada and the U.S. were rapidly undergoing an industrial expansion, one that scientists and policy makers could see was harming the salmon runs. Hatcheries were viewed as a way to have salmon and to continue industrial growth.

For more than 100 years, stories about salmon have been deeply interwoven with a number of assumptions about hatcheries. The most basic assumption has been that hatcheries have the ability to tame wild salmon and to remake them into fish that are more useful to humans. These assumptions have animated salmon policy in the region for 130 years. They have formed our science, our social goals,[13] how much money we spend and how it will be spent. But the core assumptions about the salmon/hatchery relationship have only recently been examined.

The Northwest Indian tribes tell stores about salmon and people in which there is an interdependent relationship between humans and nature. Humans live a world with many equivalent beings: trees, rocks, animals, and fish. The tribes believed that salmon were a race of supernatural beings who lived in five great houses under the sea.

Each year, the salmon king directed his people to don silver skins and present themselves to the people on the land, as a gift. The tribes treated the first salmon with an elaborate ceremony, intended to convey gratitude and respect to the salmon king for the gift.[14] The stories of native tribes have much in common with stories told by the native Ainu in Japan. Salmon was an important means of subsistence to both groups and they evolved similar fishing techniques, as well as religious ceremonies that returned portions of ceremonial meal to the river, contributing to the nutrient cycle.[15]

The early settlers who moved to the Northwest also saw salmon as a gift, but to them it was a source of potential wealth, along with sea otters, beavers, and trees. Early Americans saw nature as a force that had to be subdued and tamed, brought under human control and transformed from wilderness into a garden. They believed in progress and that technological superiority conveyed moral worth, "justifying the extension of European power on a world-wide scale."[16] As a result of these assumptions, modern historians such as Donald Worster conclude the settlers saw nature as a storehouse of commodities; they believed the function of the social structure was to facilitate the transformation of the raw materials into wealth.[17] If there were social conflicts, technology also offered solutions.[18]

A critical component of taming and improving nature was to make it more efficient. The enormous strides taken by science during World War II helped create a  booming economy and an era of supreme self-confidence. As historian William G. Robbins says, the post-war era in the United States was marked by "a belief that landscapes could be perfected, that scientific and technical expertise could be employed to improve the material and social conditions of humankind, and that the natural world could be endlessly manipulated to achieve that end."[19] A core assumption was that habitat alternation was an unfortunate but inevitable consequence of civilization.[20] The links between fish and their environment were not thought to be important and policies sought to maximize the harvest, while paying little attention to the underlying ecological principles.

These ideas were reinforced by a series of developments during the 1960s. Technology helped unlock the key to salmon nutrition and a new diet was fed to hatchery fish as the runs rebounded from a coastwide slump. Economic studies based on cost/benefit ratios showed that the Columbia River hatcheries generated greater revenues than their costs, proving the worth of the hatchery system. As more dams were built throughout the region, hatcheries became a way to replace the wild fish with other fish that would be more resilient in the polluted and warmer waters of the region. The increasing numbers of hatchery fish helped create a large sport and commercial fishery in the ocean, replacing the aboriginal fishery in the rivers.

As Richard White has pointed out, each step that created the Northwest salmon crisis was logical. "One thing followed quite understandably from another until both a kind of environmental insanity and a bitter social conflict were achieved."[21] The current stories about salmon are all about conflict, between types of fishermen, between Indians and whites, among the states, and among the scientists who try to advise policy makers. But we tend to lose sight of the fact that people in the Northwest have been fighting over fish as far back as the 1880s, when the invention of the canning industry created an unlimited global market for Pacific salmon. Overlaying the decades of conflicts is a new layer of complexity that comes from the emergence of the new science of ecosystem management which seeks to re-establish the ties between wild salmon and the watersheds in which they live. To do so will require systematic government reorganization that is sure to generate more conflict.[22]

This thesis will look at some of the actions since 1945 that have had an influence on the current salmon situation. The study will primarily deal with events in Oregon, Washington, and British

Columbia. The development of commercial fisheries was different in California, a story that has been told by Arthur McEvoy in *The Fisherman's Problem.* And the habitat problems that have caused such havoc for the salmon runs in Oregon, Washington, and British Columbia, are largely absent in much of Alaska.

The first chapter will look briefly at the biology of the seven races of salmon that inhabit the Pacific Northwest. It will also discuss the native people and the interdependence of their economy with salmon, a relationship that was disrupted by the arrival of white settlers. The development of early hatcheries in the U.S., Canada, the Soviet Union and Japan will be discussed. Scientists in all four countries were well aware of what others were doing and exchanged information about biology, ocean conditions, hatchery rearing practices, and fishing technology.

The second chapter will discuss events after World War II, including the formation of the Food and Agriculture Organization of the United Nations in 1945 and its adoption of Maximum Sustained Yield as the international goal of fishery development. Fueled by new technologies discovered during the war, world fishing fleets expanded rapidly, culminating in the building of factory-freezer ships capable of fishing anywhere in the world. There was enormous interest in increasing the harvest from the sea and all four countries made substantial investments in aquaculture facilities, including hatcheries to expand salmon production.

Chapter Three deals with the growth of the hatchery system in Washington and Oregon and the expansion of the hydroelectric system on the Columbia River. Technological developments such as the Oregon Moist Pellet and improvements in hatchery rearing techniques led to increased survival, especially for coho salmon. As the number of sports and commercial ocean fishermen increased, fewer and fewer salmon were returning to the tribal fishing grounds. The tribes responded with a series of lawsuits that, in time, generated increased pressure for more fish.

Events in Canada are discussed in Chapter Four, including government policies to expand fisheries as a way of balancing governmental trade policies. Based on the increased survival of the Columbia River hatcheries, Canada embarked on a $400 million Salmon Enhancement Program in 1974, aimed at doubling the salmon runs. The growing presence of factory trawlers off the East and West coasts of North America generated pressures to expand territorial limits out of 200 miles, actions which took place in the late 1970s. The American government expanded its support for oceanographic investigations and fishery development with a series of bills, including the creation of the National Sea-Grant College Program in 1966. Some of the Sea-Grant funded research at Oregon included the establishment of a hatchery at Whiskey Creek on the Oregon coast, which became a source of eggs for the newly created ocean-ranching industry.

Chapter Six details the growth and increased efficiency of the ocean fishery. The improved survival of hatchery fish, coupled with an increase in salmon prices, attracted corporate money which established a number of private salmon ranches in Oregon. A new record for salmon harvests was established in 1976 when ocean fishermen caught 5.2 million coho off Washington, Oregon, and California. The same year, the U.S. expanded its territorial sea to 200 miles and created a system of regional management councils. But as the number of salmon smolts released by Columbia River hatcheries increased, the number of adult fish returning continued to decline. By 1983, as ocean conditions changed and salmon numbers plummeted, scientists realized that growing salmon was not as simple as it had always seemed.

References


1.Richard White, The Organic Machine: The Remaking of the Columbia River. New York: Hill and Wang 1995. 90-91.

2.Joseph Taylor III. Making Salmon: An Environmental History of the Northwest Fisheries Crisis. Seattle: University of Washington Press, 1999. 28.

3.Ross Anderson, "Where does the money flow?" Seattle Times. Nov. 30, 1997.

4.Taylor, 10.

5.Jim Lichatowich, Salmon Without Rivers: A History of the Pacific Northwest Salmon Crisis. Washington, D.C.: Island Press, 1999. 226.

6. S. Garcia and C. Newton. "Current situation, trends, and prospects in world capture fisheries." Global Trends: Fisheries Management, E.L. Pikitch, D.D. Huppert, and M.P. Sissenwine, editors. Bethesda, Ma: American Fisheries Society Symposium 20, 1997.3-27. 23.

7.Ann L. Hollick, U.S. Foreign Policy and the Law of the Sea. Princeton: Princeton University Press, 1981.9.

8.Garcia and Newton, 17.

9.Y .Nasaka, "Salmonid programs and public policy in Japan." Salmon Production, Management and Allocation. William J. McNeil, ed. Corvallis: Oregon State University Press, 1988, 25-31.25.

10.S.M. Konovalov. "USSR: Salmon Ranching in the Pacific." Salmon Ranching. J.E. Thorpe, ed. London: Harcourt Brace Jananovich, 1980. 63-89. 76 (Table VI).

11.James A. Anderson, "The Growth of Salmon Aquaculture and the Emerging New World Order of the Salmon Industry." E.L. Pikitch, D.D. Huppert, and M.P. Sissenwine, editors. Global Trends: Fisheries Management. Bethseda, Ma.:American Fisheries Society Symposium, 1997, 175-184. 175.

12.Fay G. Cohen. Treaties on Trial: The Continuing Controversy over Northwest Indian Fishing Rights. Seattle: University of Washington Press, 1986. 11.

13. Sheila Jasanoff, The Fifth Branch. Cambridge: Harvard University Press, 1990. 13.

14.Lichatowich, 28.

15.Shannon A. Docherty, "Parallels Between the Bear and Salmon Tales of the Ainu of Japan and the Native Americans of the Northwest Coast: An Analysis from a Cultural-Prehistoric Perspective." Thesis, Interdisciplinary Studies Program, University of Oregon. June 1986. 32.

16. Bowler, Peter J. The Environmental Sciences. New York: W. W. Norton & Co. 1992. 380.

17.Donald Worster, Dust Bowl: The Southern Plains in the 1930s. New York: Oxford University Press, 1979. 6.

18.Taylor, 23.

19.William G. Robbins, Landscapes of Promise: The Oregon Story, 1800-1940. Seattle: University of Washington Press, 1997. 298.

20.Arthur McEvoy, The Fisherman's Problem: Ecology and Law in the California Fisheries,1850-1980. Cambridge: Cambridge University Press, 1986. 213.

21.White, 49.

22.Jeanne Nienaber Clarke and Daniel C. McCool. Staking out the Terrain: Power and Performance Among Natural Resource Agencies. 2nd ed. Albany: State University of New York Press. 1996. 213.

# Chapter 1

## Pacific Salmon and Hatcheries

Seven species of salmon live in the waters of the North Pacific Ocean, along the edges of North America and Asia. Nobody knows how many runs of salmon there used to be, or how many are left as we move into the twenty-first century; a 1972 estimate suggested there were 10,000 stocks of salmon on both sides of the Pacific Ocean.[1] That estimate was considered conservative.

Salmon belong to a technical biological classification called *Oncorhynchus*, from the Russian term for "hooknose," which refers to the way the upper jaw in male salmon develop a hook during mating.[2] Five species live in North America: pink *(O. gorbuscha),* chum (*O. keta),* sockeye (*O. nerka),* coho (*O. kisutch*), and chinook *(O. tshawytscha*). Two live only in Asia: masu (*O. masou)* and amago (*O. rhodurus).* Not all species of salmon are found in all watersheds. The freshwater spawning grounds for salmon extend from California northward to Alaska, around the North American Arctic coast to the Mackenzie River and along the Aleutian chain. On the Asian coast they extend from the Arctic Ocean to the Amur River, Sakhalin Island, and the northern parts of Japan.[3]

On the Pacific Northwestern coast, the most abundant salmon is the sockeye. The largest populations are found in the streams entering Bristol Bay in Alaska and the Skeena and Fraser Rivers in British Columbia. Sockeye used to travel as far inland as Red Fish Lake in Idaho, some 900 miles from the Pacific Ocean. There are sockeye on the Asian side as well, most of them in the Kamchatka peninsula, with a few populations on the northern coast of the Okhotsk Sea on the northern coast of the Bering Sea.[4]

The most abundant salmon on the Asian side are pinks, which make up 60 percent of all salmon caught in the North Pacific and adjacent waters. They are the smallest salmon as adults and they have the simplest life cycle. When they hatch and emerge from their gravel nests, they go directly to sea. They live in the ocean for two years and return to their natal streams to spawn in a particular pattern of odd and even years. Pinks are more than three times as abundant on the Asian coast as in North America, with the greatest concentration on the west coast of Kamchatka. They also spawn in the short, shallow rivers of Sakhalin Island, the Kuriles, and the large valley rivers of western Kamchatka. The most important North American area for pinks is in southeastern Alaska, although populations used to be found as far south as Monterey Bay in California.[5]

Chum salmon are also more abundant in Asia than in North America. Like pink salmon, the chum fry migrate directly to the sea after they emerge from the gravel. They mature at between three and six years. Their range is from northern Korea to the Arctic coast of Siberia, and from the Mackenzie on the Canadian coast south to Tillamook Bay in Oregon. The largest Asian runs are on the west coast of Kamchatka, the north coast of the Okhotsk Sea and the Amur river.[6]

Coho are more abundant on the North American side. They are widely distributed throughout their natural range, from the Soviet Far East around the Bering Sea, to Alaska, and south along the North American coast to California. They live for up to a year in streams before migrating to the ocean where they rear for eighteen months before returning to their natal streams to spawn.[7]

The largest salmon are the chinook, which are also more abundant on the North American coast. But while chinook are the largest of the Pacific salmon, they are the smallest in terms of total population. There are estimated to be well more than 1,000 spawning populations in North America, but each population tends to be relatively small, usually fewer than 1,000 fish. Chinook are found from central California to Kotzebue Sound in Alaska, although there are reports of chinook in rivers in the Canadian Arctic. On the Asian side, they are found from northern Hokkaido to the Anadyr River on Kamchatka. Chinooks show a wide range of life history characteristics; they can spend from less than a year in the ocean to seven years at sea. Spawning can take place from near tidewater to more than 3,200 kilometers upstream in the headwaters of the Yukon River. It is this enormous versatility and ability to survive across a wide range of habitats that spreads the risk of mortality during poor environmental or climatic conditions.[8]

Two additional species are found only on the Asian side of the Pacific, the masu and amago. Until recently, steelhead, rainbow and cutthroat trout were classified as *Salmo*. They were recently changed to the genus *Oncorhynchus*, but they will not be considered here.[9]

The differences among salmonid species are remarkable and the variety bewildering. Pinks grow to four pounds whereas chinook can exceed 100 pounds. Some sockeye go to sea as fry shortly after emerging from the egg; some spend several years in lakes. While there are enormous differences among the species, they share one common trait, an ability to return to the stream where they spawned. Salmon are anadromous, which means they spawn in fresh water, move to the ocean for a few months to a few years, and then return to their home stream to spawn. Unlike Atlantic salmon (*Salmo salar)* and steelhead, which can return to the ocean and spawn again, Pacific salmon die after they spawn.

Each species lives in a highly specialized niche. Each salmon has local breeding populations called demes that are reproductively isolated and adapted to each individual environment.[10] Each salmon represents the accumulated history of its species, "a textbook containing thousands of years of evolutionary experience–lessons on how to survive in a harsh, changing world."[11]

We have been slow to understand just how diverse salmon life histories can be and why this is important. This complexity, added to social goals which have changed over the decades, makes the management of salmon the most expensive fishery in the world. Fish in general are enormously difficult to study. While salmon return to the rivers to spawn and thus are more visible, getting accurate counts of how many fish actually spawn is time consuming and expensive. During the time they spend in the ocean they look so identical that managers for many years believed one fish was just like any other.[12] It was not until the late 1920s that studies by biologist Willis Rich showed that the appropriate unit for studying salmon was the watershed.[13] The home stream theory, that salmon return and spawn in the waters where they were hatched was not widely accepted in the United States until the late 1930s.[14] During the early decades of this century, there was a general belief that salmon were genetically uniform,[15] a fundamental assumption that continues to have a profound impact on the salmon themselves and how populations are managed.

Salmon are rife with paradox; perhaps the most fundamental is that they can look so uniform, yet have such enormous genetic and life history diversity. The genetic variability of salmon, and their ability to survive under a wide range of conditions, helped make salmon the cornerstone of the economy for Northwest Indian tribes.[16] Biologist Jim Lichatowich writes of the long, slow co-evolutionary dance between salmon and the native people of the Northwest:

> At first, the dance was probably clumsy and out of step. There's little doubt that native Americans made mistakes and learned hard lessons through starvation. Over thousands of years, the dance improved as humans adapted their economies to the changing landscape and resources.[17]

The archaeological records in the Pacific Northwest show evidence of fishing as early at 9,000 B.P. in the vicinity of the Columbia River.[18] As historian Joseph Taylor III puts it, the tribes "developed a culture and economy that meshed well with nature. Respect, propitiation, utility, and territoriality reinforced a coherent strategy of modern exploitation."[19] Biologists in 1940 estimated that the Columbia River tribes harvested as much as 18 million pounds of salmon a year prior to settlement by whites.[20] Modern estimates place the harvest at between 4.5 to 6.3 million fish, which compares to what the industrial fishery harvested between 1883-1919.[21] The Indian Claims Commission in its study of the Nez Perce tribe concluded that the economic cycle was ten months of salmon fishing, followed by two months of berry picking, with hunting almost year-round.[22]

The tribes utilized salmon heavily, but they made no assumptions that salmon would return each year.[23] The fall salmon fishing at Celilo Falls was at the center of Northwest tribal culture. Each year thousands of people, many of them from interior tribes, traveled great distances to trade. Salmon were not sold, but traded for other food, suggesting "an ongoing relationship rather than a single act in which a person sought advantage."[24]

The Native people had an integrated view of themselves and the world they inhabited. The believed all life forms possessed active spirits; these spirits could be much like people themselves, they could be helpful or dangerous. An important component of this was the spiritual exchange that took place between the hunter and his prey, as well as the fisherman and the salmon. "Animals gave themselves up to the catch when a hunter-fisher showed proper respect and followed ritualistic ceremonial practices."[25] The first salmon ceremony called for the fish to be cut and eaten completely, so the fish spirit was not offended and would continue to return to the river. "This was a society of dense networks of relations, and the salmon fisheries formed a basic node where the lines of human relationships intersected," writes Richard White.[26] The Indians imbued salmon with spiritual values and saw them as potent symbols of renewal. "They were at once food, currency, and icon."[27]

Tribal society was severely disrupted, first by the arrival of explorers and fur traders, then by growing numbers of settlers. The population of Oregon country Indians had declined 95 percent by 1900, mainly because of successive waves of diseases like smallpox, malaria, measles, and influenza. As the tribal people dwindled, the non-Indian population grew from less than 800 in 1840 to 1.1 million by 1900.[28] The thousands of settlers who moved to the Oregon Territory in the last half of the nineteenth century found what appeared to them to be a mostly empty country-- fertile, beautiful, with what seemed like limitless resources. The abundance was interpreted as a demonstration of God's power and care, a blessing bestowed on his chosen people. This was a regional manifestation of the larger belief in which Americans saw their presence in North America. Human beings were God's highest creation, a benign presence on the earth. Early Americans celebrated nature, but they believed it was in need of transformation through human labor.[29]

While North American Indians saw humans and nature as part of the same landscape, European Americans saw a radical division between the human and natural world. Early settlers wanted to get the economy rolling; they had plenty of natural resources, but they lacked capital and manpower. Their solution lay in technology, the tools and machines that allowed them to turn raw natural resources into material wealth. Such thinking was an outgrowth of the Enlightenment, the diverse body of literature which includes the writings of John Locke, Rene Descartes, and Immanuel Kant. A key tenet of Enlightenment thought is the belief that science and technology are the basis for material advancement and freedom.[30] As far as fisheries went, the philosophy was laissez-faire, which held that regulation by the state was both unnecessary and impractical.[31] American fishery agencies proceeded on the assumption that "resource depletion was a necessary complement to economic progress, and no less inevitable than the passing of the buffalo or the Indians."[32]

The discovery of gold in California in 1848 created an instant market in Oregon for all the timber and foodstuffs that Oregonians could supply. The mining boom spread to southwestern Oregon, and as logging increased, salmon habitat was reduced, especially in the riparian zones along streams, where the water made it easier for the logs to be moved to market. But it was not just logging that degraded salmon habitat. Trappers, farmers, miners, irrigators, and developers embarked on a host of actions that resulted in warmer, dirtier, and obstructed waterways.[33]

Just as there is no one solution today to the problem of reduced salmon runs, there was no single cause of the decline. But an important component was the discovery that salmon could be canned. The first cannery on the Columbia River was started by R. D. Hume in 1866 at Eagle Cliff, Washington, about 40 miles from the mouth of the river.[34] Within eight years, the industry had grown to 13 canneries supplied by 300 boats and 600 workers. The number of canneries on the Columbia River peaked at 39 in 1883 and declined steadily afterwards.[35] With the increase in the number of canneries and the growing national and international markets for their products came the decline of number of the salmon. The peak catch was 42 million pounds in 1883, which could be all chinook, since the canners did not even use other species until 1889, when the catch dropped to 18 million pounds.[36] All of the salmon fisheries south of British Columbia peaked by 1915.[37]

Canning meant that the market for salmon extended from the West Coast to the rest of the world, creating a limitless demand for cheap protein. Technology continued to make the processing of salmon more efficient, lowering production and labor costs. Inventions such as the "iron chink," which cut the fish and packed them into cans, greatly accelerated the amount of fish that canneries could handle, while decreasing the numbers of Chinese laborers required. As the great runs on the Columbia River dwindled, the canning industry petitioned Congress for legislation to restrict the harvest and to provide artificial propagation. The first hatchery in Oregon was built on the Columbia River in 1866; the program increased rapidly after 1888 and maintained high levels of production through the end of the 1930s.[38]

It is a relatively simple thing to hatch fish eggs into tiny, wiggling alevins. It turns out to be vastly more complicated to raise a Pacific salmon in a hatchery and have it survive once it is released into the wild. It is obvious that some sort of protection from the elements will mean that more of the tiny alevins will survive–or appear to. It is not surprising that many people believe that if the salmon eggs could be protected from nature while they are hatching, more of them would survive, contributing to an ultimately larger harvest. The attitude is best expressed by Livingston Stone, the first professional West Coast salmon culturist, writing about the Columbia River in 1884:

> Nature...produces great quantities of seed that nature does not utilize or need. It looks like a vast store that has been provided for nature, to hold in reserve against the time when the increased population of the earth should need it and the sagacity of man should utilize it. At all events nature has never utilized this reserve and man finds it already here to meet his wants.[39]

Stone's writing reflects his belief that history unfolds in a linear fashion, that events have a purpose, and that resources were put on earth for humans to use. These views illustrate what historian Donald Worster calls a vision of nature as a warehouse of commodities, existing only for the benefit of man.[40]

Hatcheries also provided a convenient way to get around the pollution, habitat degradation, and overfishing that was depleting fish species on both the East and West coasts. A common theme that would resonate throughout the development of fish culture would be the taming of wild animals to serve as domestic animals, an outgrowth of the utilitarian theme that the inherent order of the earth was evidence that it was designed for human use and improvement. The goal of fish culturists was to improve fish by accentuating the qualities most valued by fish culturists, anglers and consumers.[41] Another important component of this world view, which would continue to resonate throughout the twentieth century, was that water could be farmed, just as the land was–but that somehow at a much more productive level. The inherently inefficient and wasteful natural processes, which allowed so many eggs to die before they hatched, would be "improved" by modern management techniques which circumvented mortalities.

## 1.1 Fish Hatcheries in Other Countries

It was not only Americans who experimented with fish hatcheries in the late nineteenth century. The Canadians, the Japanese, and the Russian all began experimental salmon facilities at roughly the same time. The goals were very similar.

The Canadians began their involvement in fish culture in 1857 in Quebec City with speckled trout. A decade later, fish culturists from New Hampshire hoped to use Atlantic salmon from the Miramichi River in New Brunswick to repopulate New England streams. A salmon breeding establishment was set up on the Miramichi River, under the direction of Livingston Stone. Stone would later transfer his efforts to the West Coast, to the McCloud River (a tributary of the Sacramento

River) in 1872, and then on the Columbia. There was such an outcry about Stone's New Brunswick breeding station by local residents that it was abandoned and the first publically-owned salmon hatchery in the U.S. was built in Maine in 1870.[42].

The first Japanese salmon hatchery was built in 1876. The state-run Chitoe Central Hatchery was built twelve years later, on a tributary of the Ishikari River in Hokkaido. It was modeled after the Bucksport Salmon Hatchery in Maine and was established by Ichiryu Ito, a government official who studied salmon culture in America.[43] The hatchery incubated six million chum eggs in 1889. Within the next twenty years, there were fifty salmon hatcheries in Hokkaido, most of them privately run.[44]

Salmon form only a very small part of fish-raising efforts in Japan. The Japanese had been breeding goldfish since the 1700s, and carp since the 1800s.[45] Between 1950 and 1978, the output of cultured marine fish, mussels, mollusks, and seaweeds expanded from 48,000 metric tons to 917,000 metric tons, a staggering 1,810 percent increase. During the 1970s, with the adoption of 200-mile limits by countries around the world, which curtailed Japanese fishing, there was a renewed emphasis on stimulating marine and freshwater culture of fishes.[46] Cultivation efforts center on trout *(Salmo gairdneri)*, Japanese eel (*Anguilla japonicus*), Common carp (*Cyprinus carpio*), Crucian carp (*Carassius carassius*), and Ayu or sweetfish (*Plecoglossus altivelis*). The number of chum salmon released by Japanese hatcheries climbed rapidly and impressively during the 1950s: releases reached 400-500 million juveniles in the 1960s; increased to about one billion by 1977 and two billion by 1983.[47]

In Russia, the Tsarist Government constructed the first experimental salmon hatchery in 1909 near the Amur estuary. It was built in response to the serious decline of salmon, due to urbanization, industrialism, and overfishing. Three species of salmon are native in the Amur River, pinks, chums, and masu. Pink salmon are the most numerous, followed by chum and smaller quantities of masu.[48] The Russians expanded their hatchery system, starting in 1928, in the Amur and Kamchatka basins. After World War II, when the Japanese were forced to cede Sakhalin Island to the Soviets, they left twelve operating hatcheries with a capacity for 130 million eggs. Although most of the hatcheries were in poor repair, five were restored between 1951 and 1955. By 1958, total output from Russian hatcheries reached 320 million eggs, a number that doubled to 600 million by 1970.[49]

While the Japanese have concentrated on chum salmon, the Soviet production is divided between pink and chum salmon. By the 1980s, the Soviet development plan called for increasing hatchery production to some 3 billion fry released from hatcheries on Sakhalin by the year 2000. The same plans call for an additional 1 billion fish to be released from hatcheries in other regions of the Far East.[50] West Coast hatchery production pales by comparison. To use the terminology of the day, Oregon "liberated" 61 million fingerling steelhead and salmon in 1962.[51] Two years later, Washington's hatchery program released 91 million salmon.[52] A strict numerical accounting is misleading, since chinook, coho and steelhead are all reared for much longer periods in hatcheries than are pinks and chum, with a corresponding increase in costs. Nevertheless, the impressive numbers of fish released by the Asian hatcheries were well-known in both Canada and the U.S. During the late 1950s and the 1960s, North American scientists focused on expanding the production of pink and chum salmon.

Asian hatchery efforts have concentrated on pink and chum salmon and after World War II they were especially successful. Under the direction of General MacArthur and his American staff, the Japanese government in 1951 passed the Aquatic Resources

Conservation Act. The act stimulated the modern Japanese hatchery program for chum, pink and cherry salmon, by providing subsidies to private salmon hatcheries. All returning mature fish became the property of the national government until they were legally harvested. The Fisheries Agency of Japan prepared two five-year programs to expand the salmon fisheries. The hatcheries released between 400-500 million juveniles in the 1960s, but the numbers increased to one billion by 1977 and to two billion by 1983, mainly chum salmon.[53]

Part of the reason for Japan's success was because the fish were fed before they were released, an experiment which was tried in 1962 and expanded in the spring of 1967.[54] Seattle fisheries consultant Clinton E. Atkinson attributes part of the increase to the number of Japanese salmon culturists who visited hatcheries in the Soviet Union and the U.S., and to the organization of symposia for the exchange of knowledge and ideas.[55] A more important factor was the rapid increase after 1970 in Japanese sardines *(Sardinops melanostictus)*, a food fish for salmon. The increase is correlated with changes in the Kuroshio Current, which corresponded to a high egg abundance and good distribution of food plankton.[56] Such a shift in ocean currents is called a regime shift. It is estimated to have increased the carrying capacity of the area by a staggering seventy-five times.[57]

1.2 The Transfer of Scientific Information

The success of the Japanese and Russian hatchery programs was not lost on American biologists and politicians. Hatcheries had a very mixed success rate on the West Coast. The Canadians closed their hatcheries in 1935 after a series of studies showed the science had not yet advanced to the point where it was worth the expenditure. Hatcheries were also closed in Alaska.[58] But American fishery managers persisted with their hatchery efforts, especially after World War II, when much research centered on creating a diet that would allow the fish to be held for longer periods of time, giving them a greater chance for survival.[59]

There was ample transfer of information about the success of the Japanese and Russian salmon programs to the West Coast. Information about fisheries was just part of the transfer of information among scientists, a process that steadily increased during the twentieth century as international relationships were formalized.[60] The Japanese had always been interested in publishing the success of their science in the West, and they had never been shy about taking Western technology and applying it at home. The father of the Japanese fishing industry, Kosuke Kunishi, worked on trawlers in 1907 in England and Germany. He brought trawl techniques back to

Japan and is credited with creating the first Japanese trawl boats powered by diesel engines. He began the Japanese fish meal industry and encouraged boats to pioneer new fishing grounds, including whaling in the polar regions.[61] Formal contact between east and west scientists was furthered in 1920, when four Japanese scientists traveled to Honolulu for the First Pan-Pacific Science Conference. The Pacific Science Association was created in 1926, when the scientists met in Tokyo.[62] The National Research Council of Japan began publishing *Records of Oceanographic Works in Japan,* a scholarly journal, in 1928.[63] A second journal, *The Ocean Oceanographic Magazine,* began publication in 1949 under the auspices of the Center Meteorological Observatory of Japan.[64]

The Americans were increasingly interested in what the Japanese had learned about oceanographic processes and fish, especially migratory tunas. Ocean research lagged in the United States until World War II, when military advances such as submarine navigation provided new techniques for studying the seabed. Congress passed the Pacific Oceanic Fishery Investigations Act in 1947, providing funds to build three oceangoing research ships and a research lab in Honolulu. The act also funded the translation of Japanese scientific literature on Pacific tuna and other fisheries, including salmon.[65] Full-scale research programs on marine biology and fishing technology in tropical waters were started, laying the foundation for an American claim to the large migratory tuna of the western tropical Pacific Ocean.[66]

There was also considerable effort to translate Soviet scientific literature. Starting in 1955, the Mifal Tirgume Ha Mada Ha Yisreeli, or the Israel Program for Scientific Translations, based in Jerusalem, began publishing Soviet scientific literature in English.[67] W. E. Ricker, a Canadian biologist, published a brief dictionary of Russian-English fishery terms in 1962. The version was "surprisingly in demand," and it was expanded and reissued in 1973, "made desirable by the increasing volume of fishery publications from the USSR and by the extension of their fishing and research activities to all the oceans of the world."[68] The American Bureau of Commercial Fisheries established a translation program in 1963, to disseminate information about Russian scientific literature and to act as a clearing house for translations from all languages. The program's bibliographic file began in 1959 and contained records of nearly 5,000 completed translations. Articles were available at no charge.

When the International North Pacific Fisheries Commission was established in 1955, it led to joint fisheries investigations by Canada, Japan, and the U.S. Members met two years later, in 1960, to pool their research findings on pink salmon. The symposium was hosted by the Institute of Fisheries at the University of British Columbia. Two Japanese papers were presented and Soviet scientists had been invited but were unable to attend.[69] Teruo Ishida of the Hokkaido Regional Fisheries Research Laboratory told participants that scientists had been collecting data since 1952 from the Japanese high-seas fishing fleet. Russia had been collecting data since 1955.[70]

The transfer of scientific and biological information was an important backdrop to other high-level international negotiations which were also going on. Who was catching high-value American and Canadian salmon was an important question. Japanese fishermen had ventured as far as Alaska's Bristol Bay in 1936, where they launched a three-year investigation of the salmon resource, an act that aroused intense indignation and suspicion in Alaskan fishermen and politicians.[71] The fishing tensions were engulfed in other issues between Japan and the U.S., leading to the 1941 declaration of war between the two countries. When the war ended, American experts began assisting the Japanese in rebuilding their economy, including the fishing industry, which had been almost totally destroyed.

There were still tensions over Japanese intentions towards West Coast salmon. The U.S. government issued the Truman Proclamation in 1945, asserting U.S. jurisdiction and control over the natural resources of the continental shelf contiguous to the U.S. The proclamation also declared a U.S. right to establish conservation zones for the protection of fisheries in certain areas of the high seas, where they had been substantial fishing activity by U.S. nationals. Fishers from other countries could be excluded from specific fisheries, although the conservation zones were still considered the high seas and navigation would not be impeded.[72]

The proclamation was followed in 1951 by the International Convention for the High Seas Fisheries of the North Pacific Ocean. Signed by the U.S., Canada, and Japan, the convention created what was called the "abstention line," at 175 degrees west longitude. Japan would not be allowed to fish for salmon, halibut or herring off the North American coast east of the line. The line was arbitrarily drawn, in hopes that it would protect Bristol Bay salmon from Japanese fishing.[73] But by 1957, when Bristol Bay salmon stocks suffered a sharp drop, Japanese fishing was blamed.

References

1. W. E. Ricker. "Hereditary and Environmental Factors Affecting Certain Salmonid Populations." The Stock Concept of Pacific Salmon. Papers presented at the Stock Identification Workshop, Montlake Biological Laboratory, Seattle, April 8, 1970. Peter Larkin, ed. H.R. MacMillan Lectures in Fisheries. Vancouver: University of British Columbia Press, 1970: 19-160. 32.

2.Jim Lichatowich. Salmon Without Rivers: A History of the Pacific Salmon Crisis. Washington, D.C.: Island Press, 1999. 9.

3.Peter A. Larkin. "Pacific Salmon," in Fish Population Dynamics. J.A. Gulland, ed. London: John Wiley & Sons, 1977. 156-186. 156.

4.R. L. Burgner, "Life History of Sockeye Salmon". Pacific Salmon Life Histories. C. Groot and L. Margolis, editors. Vancouver: University of British Columbia Press, 1991. 3-117. 3.

6.S.M. Konovalov. "U.S.S.R.:Salmon Ranching in the Pacific". Salmon Ranching. J. E. Thorpe, ed. London: Harcourt Brace Jovanovich. 1980. 63-89. 69.

7.E. O. Salo. "Life History of Chum Salmon". Pacific Salmon Life Histories. C. Groot, and L. Margolis. Vancouver: University of British Columbia Press, 1991. 233-309. 234.

8.F.K. Sandercock. "Life History of Coho Salmon". Pacific Salmon Life Histories. C. Groot, and L. Margolis. Vancouver: University of British Columbia Press, 1991. 397-445.397.

9.M. C. Healey. "Life History of Chinook Salmon". Pacific Salmon Life Histories. C. Groot and L. Margolis, editors. Vancouver, University of British Columbia Press. 1991 313-393. 313.

10.C. Groot and L. Margolis. Pacific Salmon Life Histories. Vancouver: University of British Columbia Press. 1991. x.

11.National Research Council. Upstream: Salmon and Society in the Pacific Northwest. Washington, D.C.:National Academy Press. 1997.8.

12.Lichatowich, 10.

13.Gary S. Morishima and Kenneth A. Henry. "The History and Status of Pacific Northwest Chinook and Coho Salmon Ocean Fisheries and Prospects for Sustainability." Sustainable Fisheries Management: Pacific Salmon. E. Eric Knudsen, Cleveland R. Steward, Donald D. MacDonald, Jack E. Williams, and Dudley W. Reiser, editors. Boca Raton: Lewis Publishers, 2000. 219-235. 220.

14.Jim Lichatowich, L.E. Mobrand, R.J. Costello, and T.S. Vogel. A History of Frameworks Used in the Management of Columbia River Chinook Salmon: Report Submitted to Bonneville Power Administration, 1996. Portland, Or.#DE-AM79-92BP25105. 25.

15.Frameworks, 26.

16.Ricker, 27.

17.Upstream, 18.

18.Lichatowich, 28.

19.E. S.Hunn. Nch'i-Wana "The Big River" Mid-Columbia Indians and Their Land. Seattle: University of Washington Press, 1990. 20.

20.Joseph Taylor III. Making Salmon: An Environmental History of the Northwest Fisheries Crisis. Seattle: University of Washington Press. 1999. 28.

21.J. A. Craig, J.A. and R.L. Hacker. "The History and Development of the Fisheries of the Columbia River". Bulletin of the Bureau of Fisheries 49(32):133-216. 1940. 138.

22.Taylor, 23.

23. D. L. Pinkham. Salmon and his People: Fish & Fishing in Nez Perce Culture. Lewiston, Idaho: Confluence Press,1999. 92.

24.Richard White. The Organic Machine: The Remaking of the Columbia River. New York: Hill and Wang. 1995. 18.

25. White, 23.

26. Frederick Bunting. The Pacific Raincoast: Environment and Culture in an American Eden, 1778-1900. Lawrence, Kansas: University of Kansas Press, 1997.19.

27.White, 21.

28.Taylor,28.

29.Taylor, 39.

30.Bunting, 44.

31.Brooke Hindle and Steven Lubar. Engines of Change: The American Industrial Revolution, 1790-1860. Washington, D.C.: Smithsonian Institution Press, 1986. 31.

32.Larry A. Nielsen. "The Evolution of Fisheries Management Philosophy." Marine Fisheries Review. Vol. 38, No. 12. December 1976. 15-22. 16.

33.Arthur A. McEvoy. "An Interactive Theory of Nature and Culture." The Ends of the Earth: Perspectives on Modern Environmental History. Donald Worster, ed. Cambridge, Cambridge University Press, 1988. 211-229. 217-218.

34.Taylor, 59.

35.Lichatowich, 86.

36.Craig and Hacker, 138.

37.Frameworks,13.

38.Frameworks, 30.

39.Frameworks,15.

40.Livingston Stone. "The Artificial Propagation of Salmon in the Columbia River Basin." Transactions of the American Fish-Culture Association, Thirteenth Annual Meeting, May 13-14, Washington, D.C. 21-31. 22.

41.Donald Worster, Donald. Dust Bowl: The Southern Plains in the 1930s. New York: Oxford University Press, 1979. 8.

42.Daniel L. Bottom. "To Till the Water–A History of Ideas in Fisheries Conservation." Pacific Salmon & Their Ecosystems: Status and Future Options. Deanna J. Stouder, Peter A. Bisson, Robert J. Naiman, editors. New York: Chapman & Hill, 1997. 569-597. 576.

43.Hugh MacCrimmon. "The Beginning of Salmon Culture in Canada." Canadian Geographical Journal 71:3; 96-103. 101.

44.The Japan Times and Mail. Japan's Fisheries Industry 1939. Tokyo, 1939. 148.

45.Yoshio Nasaka. "Salmonid Programs and Public Policy in Japan." Salmon Production, Management, and Allocation. William J. McNeil, ed. Corvallis, Or.: Oregon State University Press. 1988. 25-31. 26.

46.Japan Times and Mail, 118.

47.Evan E. Brown and S. Nishimura. World Fish Farming: Cultivation Economics. Westport, Conn.: Avi Publishing Co. Ltd., 1983. 323.

48.Nasaka, 27.

49.S. M. Konovalov. "USSR: Salmon Ranching in the Pacific." Salmon Ranching. J. E. Thorpe, ed. London: Harcourt Brace Jovanovich. 1980. 63-89. 68.

50.Konovalov, 76.

51.Clinton E. Atkinson. "Salmon Aquaculture in Japan, the Koreas and the USSR." Proceedings of the Conference on Salmon Aquaculture and the Alaska Fishing Community, Cordova, Alaska, Jan. 9-11, 1978. University of Alaska, Sea Grant Report 76-2. 79-154. 87.

52.Fish Commission of Oregon, Biennial Report. 1962. 16.

53.Washington Department of Fisheries, 1964 Annual Report. 104.

54.Nasaka, 27.

55.T. Kobayashi. "Salmon Propagation in Japan." Salmon Ranching. J.E. Thorpe, ed. London: Harcourt Brace Jovanovich, 1980. 91-107. 101.

56.Atkinson, 87.

57. Keiichi Kondo. "The Recovery of the Japanese Sardine-The Biological Basis of Stock-Size Fluctuations." Rapp. P.-V.Reun. Cons. Int. Explor., Mer, 177:332-354. 1980. 344.

58.Tokio Wada and Larry D. Jacobson. "Regimes and stock-recruitment relationships in Japanese sardine *(Sardinops melanostictus)* 1951-1995." Canadian Journal of Fisheries and Aquatic Sciences. 55:2455-2463. 1998. 2455.

59.Peter A. Larkin. "Management of Pacific Salmon in North America," A Century of Fisheries in North America. Norman G. Benson, ed. Washington, D.C.: American Fisheries Society. 1970. 223-236. 225.

60.Oregon Fish Commission, Eighth Progress Report on Salmon Diet Experiments. May 1963. 52-56.

61.Peter J. Bowler. The Environmental Sciences. New York: W.W. Norton & Co., 1992. 389.

62.Japan Times and Mail, 101.

63.Philip F. Rehbock. "Organizing Pacific Science: Local and International Origins of the Pacific Science Association." Nature in Its Greatest Extent: Western Science in the Pacific. Ray MacLeod and Philip F. Rehbock, editors. Honolulu: University of Hawaii Press, 1988. 195-221. 195.

64.Records of Oceanographic Works in Japan. The Committee on Oceanography of the National Research Council of Japan. Vol. 1, 1928.

65.The Oceanographical Magazine. Central Meteorological Observatory of Japan. Vol. 1, 1949.

66.Harry N. Scheiber. "Wilbert Chapman and the Revolution in U.S. Pacific Ocean Science and Policy, 1945-1951."Nature in Its Greatest Extent: Western Science in the Pacific. Ray MacLeod and Philip F. Rehbock, editors. Honolulu: University of Hawaii Press, 1988. 223-245. 230.

67.Arthur F. McEvoy. The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850-1980. Cambridge: Cambridge University Press, 1986. 193.

68.P.A. Moiseev. The Living Resources of the World Oceans. (Biologicheskie resursy Mirovogo okeana). Jerusalem: Israel Program for Scientific Translation, 1971.

69.W.E. Ricker. Russian-English Dictionary for Students of Fisheries and Aquatic Biology. Ottawa: Fisheries Research Board of Canada. 1973. ix.

70.Norman Wilimovsky. Symposium on Pink Salmon: Conference held at the University of British Columbia, Oct. 13-15, 1960. Norman Wilimovksy, ed. Vancouver: University of British Columbia, 1960. Preface.

71. Teruo Ishida. "Aspects of Marine Biology of Asiatic Pink Salmon." Symposium on Pink Salmon. Conference held at the University of British Columbia, Oct. 13-15, 1960. Norman Wilimovsky, ed. Vancouver: University of British Columbia, 1960. 135-139. 135.

72. Ann L.Hollick. U.S. Foreign Policy and the Law of the Sea. Princeton: Princeton University Press, 1981. 23.

73. Hollick, 18.

74. Hollick, 100.

# Chapter 2:

## Maximum Sustained Yield

It is difficult today to imagine the devastation left in the wake of World War II. There was enormous destruction all across Europe, the Union of Soviet Socialist Republics, (USSR) and especially Japan. Ocean warfare had totally disrupted marine commerce, including the transport of food from North America. Countries such as Great Britain and Japan, which had thriving fishing industries before the war, were left with sunken fleets and a shortage of fuel, fishing gear, and shipping materials. Hunger was an enormous problem, especially in Germany, Eastern Europe, and the Soviet Union. In Japan, the Allied policy of economic strangulation had resulted in the destruction of most of the fishing fleet, the navy, and the merchant marine, choking off supplies of basic foodstuffs from Korea, Formosa, and China.[1] In many countries, the war was followed by drought and famine. In the wake of the devastation, countries set about rebuilding food production processes as quickly as possible.

The focus for the policy makers was on increasing the global food supply. An obvious target was to rebuild the world's fishing fleets and to increase the supply of cheap protein harvested from the sea. Representatives from twenty-three nations attended a meeting at Quebec City in 1945 and created the Food and Agricultural Organization of the United Nations. Its mission was "to contribute to the expanding world economy by raising levels of nutrition and standards of living, improving the production and distribution of food and agricultural products, and bettering the conditions of rural populations." [2] A French biologist, Prof. A. Meyer, described the FAO mission in grand terms: "An extraordinary adventure has begun, one of the most splendid and astounding that men have ever embarked upon. Men have decided jointly to take in hand their own destiny in order to try and improve their condition."[3] Central to that destiny would be beliefs in Western science, technology, and attitudes about nature. Man had "forged tools out of his technical discovering which have allowed him to increase his control over nature and to produce goods as never before," wrote P. Lamartine Yates in 1955.[4] Much attention would focus on the systematic development of the ocean's resources.

There was enormous interest in the oceans. Books about the ocean became bestsellers. Rachel Carson published *The Sea Around Us* in 1950, and *The Silent World*, by Captain J.Y. Cousteau and Frederic Dumas, appeared in 1953. California had begun pumping oil from offshore deposits before 1900, but very little was produced up until 1940, when exploration increased considerably. As early as 1952, oceanographer John Mero, working with the University of California and Scripps Institution of Oceanography, was trying to figure out how to economically mine manganese nodules from the ocean floor.[5]

Just as scientists during the nineteenth century thought the oceans would be capable of generating more protein than the land, scientists in the twentieth century believed the seas would be the source not only of food, but also of great wealth. The oceans were seen as limitless; the problem was how to harvest the resources economically. The authors of *The Inexhaustible Sea*, published in 1954, write of the huge quantities of plankton, "one of the great potential food products of the sea–a product which, in itself alone, may offer supplies of food sufficient to lessen the possibility of an increasingly undernourished world."[6] The seas were inexhaustible because sea water was so rich in nutrients, they could never be harvested, and the "ceaseless currents will always bring in new water."[7] A cubic mile of seawater was estimated to contain, in solution, up to twenty five tons each of gold and silver, and a host of other minerals and chemicals.[8] Writing in 1962, another author says that only the top few inches of soil are used in agriculture. But the oceans could be cultivated to a much greater depth, thus "a given region in the sea could yield many times more than a surface of equal dimensions on land."[9]

Beliefs in the productive capacity of the seas prompted a series of actions. The first was the rapid construction in several countries of what would become a worldwide fishing fleet, using technologies developed during the war, such as radar, echo sounding equipment, and synthetic fibers, to vastly increase the world fish catch.[10] Many believed that technology offered the ability to plant, fertilize, and harvest the ocean, as if it was land. Bays and estuaries would be enclosed to create fish farms, where fish would be raised like cattle. At the same time, high-value fish like salmon would be redistributed from the northern to the southern hemisphere. Many scientists believed that producing food from the ocean would follow the same pattern of progress that humans had followed on land with agriculture. "Ashore, the production of food from the land evolved slowly from mere collection, to active hunting, to herding and finally to a true agriculture . . . The extraction of food from the sea is still at this (fishing) stage of development."[11] Norman Wilimovsky of the Institute of Fisheries at the University of British

Columbia wrote in 1968 that "every effort should be made to shift from the hunter philosophy to harvesting the sea on some ranching system."[12]

A year earlier, at the Second Fishing Gear Congress, a meeting sponsored by the FAO in 1967, Wilimovsky and Lee Alverson of the University of Washington delivered a paper on prospective developments in harvesting marine fish. The two biologists predicted that a network of unmanned buoys would soon cover the seas, able to determine movements of schools of fish. The location of the fish would be transmitted via a satellite to a shore-based data collection center, then relayed to the fishing fleet. The fleet would either move directly to the fish or the fish would be guided to the boats. Planes would drop chemical pellets into the sea to guide the fish by odor, or remote-controlled underwater vehicles which would produce electrical fields or sonic waves which would guide the fish to the boats.[13] Wilimovsky and Alverson might almost have been parroting the work of scientist and novelist Arthur C. Clarke. In his 1957 novel, *The Deep Range,* the character Don Burley is a deep-sea game warden.

> He was holding at bay the specter of famine which had confronted all earlier ages, but which would never threaten the world again while the great plankton farms harvested their millions of tons of protein, and the whale herds obeyed their new masters. Man had come back to the sea, his ancient home, after aeons of exile, and until the oceans freeze, he would never be hungry again.[14]

The American National Research Council's Committee on Oceanography decided in 1966 that malnutrition was the most serious health threat in the world, "a basic barrier to social and economic development in more than half the world."[15] But the scientists were optimistic. The report went on to say that in the future there would be large nuclear reactors situated off the coast that would use their waste heat to generate upwelling, increasing the fish catch.[16]

## 2.1 The Development of MSY

The scientific emphasis was on maximizing harvest, as quickly as possible. When the FAO met in Rome in 1955, members adopted Maximum Sustained Yield, or MSY, as the goal of worldwide fisheries management. British biologist R.J. Beverton, who was among the scientists at the Rome meeting, believed the decision was essentially political.[17]

There are various definitions of MSY. In the FAO report, maximum sustained productivity was defined as:

> The immediate aim of conservation of living marine resources is to conduct fishing activities so as to increase, or at least to maintain, the average sustainable yield of products in desirable form. At the same time, wherever possible, scientifically sound, positive measures should be taken to improve the resources.
> The principle objective of conservation of the living resources of the sea is to obtain the optimum sustainable yield so as to secure a maximum supply of food and other marine products. When formulating conservation programs, account should be taken of the special interests of the coastal state in maintaining the productivity of the resources of the high seas near its coast.[18]

More recently, MSY was defined as "an equilibrium point determined by stock productivity, natural mortality, and exploitation rate, and is an estimate of the maximum average harvest of a given stock or group of stocks that can be sustained indefinitely."[19] The definition is focused on production, not on ecological interactions. But when so much of the world was recovering from the devastation of World War II, MSY focused on the humanitarian goal of eradicating world hunger. Other goals, social, economic, and political, would also play their part. So did the scientific thinking of the time, which was focused on using new tools like statistics, population dynamics, and computers, to calculate how many fish swam in the sea.

The new tools were used to create complex mathematical models to estimate fish populations. Once the population estimate and the rate of growth were established, biologists believed they could estimate how many fish could be caught without depleting the number of fish needed to maintain populations at sustainable levels. The models were built slowly as scientists worked to formulate theories about the dynamics of fish populations in the oceans and the impact of harvest. Three important theories of fisheries management were published in 1954. The surplus production theory estimated the maximum total harvest of fish each year. The spawner and recruit theory sought to estimate the maximum number of spawners (or parents) from each year class. And the yield per recruit theory dealt with estimating the maximizing yield that could be obtained from whatever young fish appeared in a year class.[20] A key component of the models was the idea that fish which were surplus to the number needed to maintain the spawning population could be harvested, with no negative ecological impact.

The theory of MSY was also influential in the management of game animals, timber, and other living resources. The U.S. Congress adopted the Sustained Yield Forest Management Act in 1944, providing the intellectual foundation for a policy of manipulating forest growth to provide maximum yields.[21] As far as fisheries were concerned, MSY was an improvement over the idea that the seas were inexhaustible. But the mathematical models existed in isolation from the environment; they did not include any variables about the environment in which the fish were living. Fish live in a complex and constantly changing world. Arthur McEvoy, author of *The Fisherman's Problem,* concludes that predicting the yield from a fishery is more like predicting the weather or the results of an election, rather than the "sustainable yield of guppies from a well-maintained aquarium."[22] Biologist W.F. Thompson, who headed the International Pacific Salmon Fisheries Commission from 1937 until 1943, wrote in 1965 that scientists could not measure how many fish to take in a good year, let alone a crisis year. "Nor do we know what years are crisis years because we do not know what conditions vary to make them crises."[23]

One of the big questions of the age was how much food would be needed by the burgeoning world population and how much of it could be supplied by the oceans. Scientists like C. O. Idyll expected that the oceans could produce more food than the sea and made elaborate calculations on how much sunlight entered the oceans and how much of the energy was used by fish and plant species. Idyll hoped that mankind could turn "vast tracks of sea bottom into marine equivalents of Iowa cornfields and herding fishes and whales with submarine-mounted cowboys."[24] With the worldwide catch of fish increasing by an average rate of 6.8 percent annually during the 1950s, [25] some scientists questioned if the escalating catch rates could be sustained. Others thought the catch could continue to increase. Dr. A.W. H. Needler, Canada's deputy minister of fisheries, told a 1967 conference at McGill University that the world's current catch of 50 million metric tons (mt.) of fish could be quadrupled "if we can overcome the economic problems it will be technically possible . . . to harvest two billion metric tons, including all animals down to the smallest level."[26]

The golden age of MSY was the decade following World War II, according to Canadian biologist Peter Larkin in 1978. He equated the belief in mathematical models to a religious movement that had a negative effect on limnology, the study of fish life and its interactions in ponds and rivers. The traditional study of evolution, biodiversity, and eco-integrity had little to offer fishery managers who wanted to harvest a "relatively undifferentiated mass" of fish.[27] The mathematical models, wrote Larkin, assumed that as individual fish increased in size, their numbers decreased. At some critical stage, the fish attain a maximum biomass, which could be cropped "like radishes," giving the maximum yield. Larkin irreverently summed up MSY:

> Briefly, the dogma was that: any species each year produced a harvestable surplus, and if you take that much, and no more, you can go on getting it forever and ever (Amen). You only need to have as much effort as if necessary to catch this magic number, so to use more is wasteful for effort; to use less is wasteful of food.[28]

## 2.2 The Growth of Fishing

The speed with which the world's fishing fleets would reach–and exceed- the goals of MSY for various species would be nothing short of breathtaking. The most astounding growth came in Japan, fueled by American capital directed by the Supreme Commander of the Allied Powers (or SCAP as the American occupation forces were called). The war between the U.S. and Japan lasted four years; the American occupation of Japan would last six. The re-creation of the fleet was so rapid and the increases in harvest so great that by 1966, the American President's Science Advisory Committee report on oceanography included a chart showing Japan's fishing and aquaculture successes. The Japanese harvest had more than quadruped from 1951 levels to 857 million pounds of food a year by 1963.[29]

The Japanese harvests increased substantially after the War, despite the loss of productive fishing grounds that had historically been fished by the Japanese. The Japanese had pioneered high-seas fishing off Korea, Taiwan, South Sakhalin and the Kurile Islands. They also lost long-established historical rights to fish in Kamchatka and other Far Eastern areas of the Soviet Union.[30] Faced with the demand for protein, the Japanese turned their attention to exploiting fish stocks in other parts of the oceans. The Japanese fishing industry was rebuilt with incredible rapidity. There had been about 60,000 boats in 1939; by 1946, the number was almost 300,000, and about 475,000 in 1950.[31] A series of five-year plans funded the construction of ships and fish processing facilities and a wide-range of aquaculture activities. The propagation of salmon in Hokkaido was incorporated into a national development program in 1952.[32]

Japan was not the only country rebuilding its fishing fleet. Soviet fishing fleets had been destroyed during World War I and the Soviet Revolution in 1917. The Pacific Fisheries Research Station began operations in Vladivostok in 1925, and the State Hydrological Institute opened in 1926, making yearly voyages to the Japan Sea and later the Bering Sea and Sea of Chukotsk. With the expulsion of the Japanese fishing boats after World War II, major research efforts were focused on the Amur River area  and exploratory voyages to Sakhalin and Kurile Islands.[33] The expansion of the Soviet fleet began in the late 1940s.[34] The systematic investigation of the Barents, Black and Baltic seas was begun in the 1940s and expanded to the Sea of Japan and the Okhotsk Sea; the studies revealed a large biomass of fish which had not been exploited.[35] The USSR announced a five-year plan in 1946 for development of the fishing industry, designed to increase harvests beyond the prewar level. "By 1950, the catch must be 56%

greater than before the war," the ministry announced, adding that fishing would be intensified in the sea basins of the North and Far East. The number of fishing boats would double. The plan also called for fish breeding of salmon and sturgeon. Implementing the plan involved 1,700 fishery specialists and 7,000 technicians. The Moscow and Astrakhan Institutes were enlarged and a new fishery institute was to be built in the Far East. The plan was thorough: the Ministry of Railroads was to increase the number of refrigerator cars, the Ministry of Trade was to provide warehouse and refrigeration facilities, and the Ministry of Paper Industries was to build factories to manufacture cardboard packing cases.[36]

Technology was about to revolutionize the way that fish were caught. As Mark Kurlansky points out in *Cod: The Biography of the Fish that Changed the World,* the methods of fishing in Northern Europe had not changed in four centuries. The size of the nets was limited by the ability of the crew to pull them in; there was little machinery to help them. Boats were powered by the wind and the influence of the schooner ships lingered until 1963, when the *Theresa E. Connor* could not find a crew willing to sail for codfish off the Grand Banks of Newfoundland.[37] The steam trawler had been developed by the British between 1880 and 1897. The arrival of engines changed fishing forever. "Fish could now be pursued," wrote Kurlansky. "And since a bigger, more powerful engine could always be developed, the scale of the fishing could increase almost limitlessly."[38]

By the end of World War II, new high-seas trawlers would be built with high-powered engines that could drag increasingly large nets through the water and with machinery that could freeze fish at sea. All three elements would come together in the modern factory ship. The British built the prototype in 1954: the world's first factory-freezer, the *Fairtry* was almost 400 feet long, cost $4 million and could fish in a force ten gale (winds of up to 63 miles an hour).[39] Within two years, the Soviet Union had twenty-four trawlers of a similar design. The Japanese, the East Germans, France, and Spain were all building new fishing boats. The first foreign factory trawler freezer arrived on the Grant Banks of Newfoundland in 1956, searching for cod.[40] Soviet fishing boats arrived off the coast of New England in 1960 and off California four years later.[41] By 1965, the factory ships had appeared off Oregon.[42]

The American fishing fleet was growing as well. Fishing did not develop as quickly on the West Coast as it did on the East. Packing sardines (*Sardinops pilchardus*) began experimentally off California in 1902.[43] Albacore tuna (*Thunnus alalunga*) was also abundant at the turn of the century, when the techniques of chumming, or using live bait, were brought to California by Kondo Masaharu, a professor at the Japanese Imperial Fisheries Institute. Some 125 boats delivered albacore to canneries at San Diego and San Pedro by 1914. Production never exceeded 300,000 metric tons in the years before the war; however annual production increased rapidly through the 1940s and exceeded a million tons by the mid-1960s. Skipjack (*Katsuwonus pelamis*) made up 36 percent of the world harvest, followed by tropical yellowfin (*Thunnus albacares*) (26 percent) and albacore (14 percent).[44] After the collapse of the California sardine fishery in the 1940's, American fishermen turned their attention to the high seas.

One of the first things the American advisors to the Japanese government did during the occupation of Japan was translate fishery documents into English. One of the first publications was a pamphlet about the Japanese salmon industry, published in the Commercial Fisheries Review in 1946.[45] Military authorities assigned a small group of marine biologists to survey and develop fishery resources in the South Pacific areas which came under U.S. military control as the Japanese were pushed toward their home islands.[46]

The Pacific Oceanic Fishery Investigations of the U.S. Fish and Wildlife Service was set up in 1949 to explore and develop the high-seas fishery resources of the various territories and possessions of the United States in the tropical and subtropical Pacific Ocean. A report on the live-bait fishery for tuna was published in 1953,[47] and information on the tuna longline fishery and its Japanese fishing grounds in 1954.[48] The U.S. was especially eager to expand its own high-seas fleet which targeted the migratory stocks of tuna that lived in the world's oceans. There was a huge international market for cheap protein and canned tuna fish filled the demand. An American tuna fleet was built and headquartered in San Diego. American canners like Van Camp had facilities around the world. American boats also targeted shrimp in the waters off Mexico, Panama and Chile.[49]

The search was on for new sources of fish and the West Coast of South America had vast potential. With the invention of nylon seine nets, developed by the Japanese, the Peruvian anchoveta fishery began in 1956. Harvests reached eight million mt. by 1964; the catch was 12 million mt., or about one-fifth of the total world harvest by 1970. Two years later the fishery collapsed.[50] While there had been much rhetoric about increasing the amount of protein for the poor in underdeveloped countries, most of the catch was made into fish meal and fed to industrialized pig and poultry farms in the developed nations.[51]

There were numerous other efforts at finding new stocks of fish. The U.S. government has played a direct role in developing the fisheries in the Pacific Ocean. The federal research ship the *John N. Cobb* began surveying for tuna between California and Alaska in 1949. The research included oceanographic and biological observations, as well as the testing of various gear. The *John N. Cobb* would be used to explore shrimp stocks off the West Coast in 1960.[52]

There was a boom in shipbuilding and global fish catches were climbing by 6.8 percent a year during the 1950s.[53] The new technology was increasing the catch and the new management techniques were seen as based on the most up-to-date science. The harvests were increasing but the fish stocks were also being preserved. "If we go on husbanding our stocks with wisdom and care, I see no reason why this expansion should not continue," H.J. Robichaud, the Canadian Minister of Fisheries, said in 1965.[54] American biologist Wilbur Chapman wrote in 1966 that "fishing can ordinarily be permitted to expand without serious damage to the resource."[55]

If the science was reassuring, so were the economics. Exploiting a resource as vast as earth's oceans was extremely good for domestic and global business. If the goal is economic development, fishing is an extremely good activity because it requires ongoing purchases of gear, nets, motors, mechanical parts, and electronics, all of which requires a substantial infrastructure. To read the pages of the *Commercial Fisheries Review*, published by the U.S. Fish and Wildlife Service, during the 1950s is to read a story of the globalization of the fisheries resource. The boom in fishing stimulated enormous economic development in all corners of the globe. Developing nations started to exploit their own fishing resources, moving from primitive small boats to engines and electronics. As political scientist Eugene Skolnikoff argues, new technology and its systematic application were important vehicles for the intensified integration of national economies.[56] New financial arrangements facilitated the building of boats and new processing plants.

Most of the increased catch was not of the traditional fish like tuna or cod. They were clupeids, schooling fish like herring, achoveta, sardines, and sprat. Fishermen were moving down the ocean food chain. "The dominant process was a progression from depleted stocks to new stocks, as the range of fishing fleets, the technology of fishing, catching and storing fish, and the techniques of processing them all improved," wrote Canadian economist Peter Pearse.[57]

## 2.3 The Growth of Aquaculture

There was enormous interest in aquaculture, involving many species of fish and shellfish in controlled environments. Both Canada and the U.S. wanted to raise more salmon, especially pinks and chums, as the Soviets and Japanese were doing so cheaply and so successfully. Both species are ready to enter salt-water shortly after the eggs emerge from the gravel. That means they are held for a short time in hatcheries, making them the most cost-effective salmon to raise in captivity. There was substantial research during the 1960s in both Washington and Oregon on the acclimatization of salmon to sea water. The more salinity-tolerate pink and chum salmon were crossed with chinook, as scientists attempted to find a salmon which would rapidly adapt to sea water, shortening the expensive and gradual acclimatization process in the hatcheries.[58]

The Soviet Union was also engaged in large-scale aquaculture efforts. Between 1933 and 1939, they planted more than nine million chum fry from rivers in Sakhalin and Kamchatka in the White and Barents Seas. Some adult chum were caught in 1937 and 1938 but the experiment was a failure. Another  large salmon planting, this time of pinks, was undertaken in 1957, and adults began showing up in Barents and White Seas in 1960. Adults were caught or seen spawning in Norway, Iceland, Spitsbergen, and even Aberdeen in Scotland. "The strength of the Pink invasion was not that of an army, but rather of its vanguard," wrote the Norwegian correspondent for the Seattle-based Pacific Fisherman in November of 1960.[59] The same story reports that the Soviets "substantially enlarged" hatchery plans in the Murmansk region, where 21.6 million eggs had been transported in 1959. Additional plantings were made but there were almost no survivors from the 1960 spawn of migrants and few from the 1961 groups.[60] But Dr. D.B. Finn, the Director of Fisheries for the FAO, declared the project a success during a 1963 speech to the Board of Trade in St. John's, Newfoundland. He also reported on the success of a hatchery to rear plaice, an important North Atlantic whitefish. The plans called for a hatchery to rear the tiny fish during their first critical eight weeks, then the fish would be transferred to an inlet, which would be fertilized to increase growth. Finn told the group that scientists believed the program could quadruple the yield of the fishery.[61]

The Soviets were not the only people planting salmon. The Canadians moved pinks from British Columbia to Newfoundland. The Alaskans moved them as far south as Oregon, and to Japan. Much of the research with pinks and sockeye lay in trying to resolve the economic problem the fish created with their life cycles. Pink salmon live two years; the run is much heavier in one of the two years of the life cycle. The heavier run is called the dominant one. With sockeye, the life cycle is four years, with one dominant year. This biological fact created economic chaos. In boom years, canneries could not process the huge quantities of fish. In low-run years, fishermen couldn't make any money. "There was intense interest in being able to predict the size of the next run, and in the possibility of doing something to make every year a big run."[62]

This was especially true in the Pacific Northwest. Fisheries world-wide were booming and millions of salmon were being produced in Japan and the Soviet Union. But in the Northwest, where salmon was traditionally the most lucrative catch, the runs were in trouble.

References

1.John W. Dower. Embracing Defeat: Japan in the Wake of World War II. New York: W.W. Norton & Company, 1999. 91.

2.A.A. Anderson. "The FAO Conference at Copenhagen." Commercial Fisheries Review Vol. 8, No. 11: 1946: 1-2.

3.A. Mayer. Nutrition and Society. Rome: Food and Agriculture Organization of the United Nations, 1956. 28.

4.L.P. Yates. So Bold an Aim. Rome: Food and Agricultural Organization of the United Nations, 1955. 6.

5.John Mero. The Mineral Resources of the Sea. Amsterdam: Elsevier Publishing Company, 1965. 277.

6.D.Hawthorne and F. Minor. The Inexhaustible Sea. New York: Dodd, Mead & Company, 1954. 74.

7.Hawthorne, 12.

8.M.B. Spangler. New Technology and Marine Resource Development: A study in government-business cooperation. New York: Praeger Publishers, 1970. 109.

9.C.C. Troubst. Conquest of the Sea. New York: Harper & Row, 1962.124. Translated by Brian C. Price and Elsbeth Price.

10.H. Kristjonsson. Modern Fishing Gear of the World. Surrey: Fishing News (Books) Ltd., 1973.xxv.

11.Hawthorne, 3.

12.Norman J. Wilimovsky. "The Present and the Future." Canadian Fisherman, July 1968. 18-23.

13.Dayton L. Alverson and Norman J. Wilimovsky. "Prospective developments in the harvesting of Marine Fishes." Modern Fishing Gear of the World 2. Fishing News (Books) Ltd.. 1967: London. 583-590. 583.

14. Arthur Clarke. The Deep Range. New York: Harcourt, Brace and World, Inc. 1957. 11-12.

15.National Academy of Sciences. Oceanography 1966: Achievements and Opportunities. Washington, D.C.: National Academy of Sciences, 1967. 68.

16. National Academy, 91.

17.R. J.H. Beverton. "The State of Fisheries Science." The State of the World's Fisheries Resources: Proceedings of the World Fisheries Congress, Plenary Sessions. Clyde Voitlander, ed. Lebanon, N.H.: International Science Publishers, 1994. 25-54. 46.

18.Richard Van Cleve and Ralph W. Johnson. Management of the High Seas Fisheries of the Northeastern Pacific. Seattle: University of Washington Press, 1963. 41.

19. Snake River Salmon Recovery Team: Final Recommendations to the National Marine Fisheries Service. May, 1994. Donald Bevan, John Harville, Peter Bergman, Theodore Bjornn, James Crutchfield, Peter Klingeman and James Litchfield. Glossary, 10.

20.Tim D. Smith. Scaling Fisheries: The science of measuring the effects of fishing, 1855-1955. Cambridge: Cambridge University Press, 1994. 324.

21.Paul W. Hirt. A Conspiracy of Optimism: Management of the National Forests since World War II. Lincoln and London: University of Nebraska Press, 1994. 40.

22.Arthur F. McEvoy. The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850-1980. Cambridge: Cambridge University Press, 1986. 7.

23.W.F. Thompson. "Fishing Treaties and Salmon in the North Pacific." Science. Dec. 31, 1965. 1786-1789. 1787.

24.C.P. Idyll. The Sea Against Hunger: Harvesting the Oceans to Feed a Hungry World. New York: Thomas Y. Crewel Company, 1978. 28.

25.S. Garcia and C. Newton. "Current situation, trends, and prospects in world capture fisheries." Global Trends: Fisheries Management. E.L. Pikitch, D.D. Huppert, and M.P. Sissenwine, eds. Bethesda: American Fisheries Society Symposium 20, 1997.3-27. 4.

26."Millions more will starve unless action taken NOW!" Canadian Fisherman. August, 1967. 10.

27.Henry A. Regier. "Old Traditions that Led to Abuses of Salmon and Their Ecosystems." Pacific Salmon and Their Ecosystems: Status and Future Options. New York: Chapman & Hall, 1997. 17-28. 25.

28.Peter A. Larkin. "An epitaph for the Concept of Maximum Sustained Yield." Transactions of the American Fisheries Society. 106:1-11. 1.

29.National Academy of Sciences. Oceanography 1966: Achievements and Opportunities. Washington, D.C., 1967. 12.

30.Hirochi Kasahara and William Burke. "North Pacific Fisheries Management." The Program of International Studies of Fishery Arrangements. Washington, D.C.:Resources for the Future, Inc. 1973. 14.

31.Supreme Commander for the Allied Powers. Mission and Accomplishments of the Supreme Commander for the Allied Powers in the Economic, Scientific, and Natural Resources Fields. Tokyo, April 28, 1952.

32.T. Kobayashi. "Salmon Propagation in Japan." Ocean Ranching. J.E. Thorpe, ed. London: Harcourt Brace Jovanovich, 1970. 91-107. 98.

33.Robert H. Randolph and John E. Bardach. "Soviet Science in the Pacific: The Case of Marine Biology." Nature in its Greatest Extent: Western Science in the Pacific. Ray MacLeod and Philip H. Rehbock, eds. Honolulu: University of Hawaii Press, 1988. 245-274. 248.

34.Kasahara and Burke, 19.

35.P.A. Moiseev. The Living Resources of the World Ocean (Biologicheskie resursy Mirovogo okeana) Jerusalem: Israeli Program for Scientific Translations, 1971. 272.

36.Commercial Fisheries Review. Vol, 8, No. 11, November 1946. 46-47.

37.Mark Kurlansky. Cod: The Biography of the Fish that Changed the World. New York: Walker and Company, 1997. 129.

38.Kurlansky, 132.

39.Michael Harris. Lament for an Ocean: The Collapse of the Atlantic Cod Fishery: A True Crime Story. Toronto: McClelland & Stewart Inc. 1998. 53.

40.Harris, 56.

41.McEvoy, 210.

42."Magnuson suggests boycott of Japanese-made Products." Pacific Fisherman, May 1965. 12.

43.McEvoy, 131.

44.James Joseph and Joseph W. Grennough. International Management of Tuna, Porpoise, and Billfish: Biological, Legal, and Political Aspects. Seattle: University of Washington Press, 1979. 8.

45. "The Japanese Salmon Industry." Commercial Fisheries Review. Vol. 8, No. 7, July 1946, 8-19.

46.Harry N. Scheiber. "Wilbert Chapman and the Revolution in U.S. Pacific Ocean Science and Policy, 1945-1951." Nature in its Greatest Extent: Western Science in the Pacific. Ray MacLeod and Philip H. Rehbock, eds. Honolulu: University of Hawaii Press, 1988. 223-245. 225.

47.Isaac I. Ikehara. "Live-Bait Fishing for Tuna in the Central Pacific." Special Scientific Report: Fisheries No. 107. Pacific Oceanic Fishery Investigations, U.S. Fish and Wildlife Service. July 1953.

48.Hiroshi Nakamura. "Tuna Longline Fishery and Fishery Grounds." Special Scientific Report: Fisheries 112. Pacific Oceanic Fishery Investigations, U.S. Fish and Wildlife Service. January 1954. Translated by W.G. Van Campen.

49.McEvoy, 209.

50.McEvoy, 229.

51.Georg Borgstrom. The Hungry Planet: The Modern World at the Edge of Famine. New York: The MacMillan Company, 1965. 281.

52.Lael L. Bonholt and Austin R. Mcgill. "Biological Observations and Results of the 1960 John N. Cobb Exploratory Shrimp Cruise off the Central Oregon Coast." Oregon Fish Commission, Progress Report, 1961. 31-52.

53.Newton and Garcia, 4.

54.H.J. Robichaud. "Current expansion expected to continue." Canadian Fisherman, June, 1965. 56-58.

55.McEvoy, 190.

56.Eugene B. Skolnikoff. The Elusive Transformation: Science, Technology, and the Evolution of International Politics. Princeton: Princeton University Press, 1993. 141.

57.Peter H. Pearse."Fishing Rights and Fishing Policy: The Development of Property Rights as Instruments of Fisheries Management." The State of the World's Fisheries Resources: Proceedings of the World Fisheries Congress, Plenary Sessions. Clyde Voigtlander, ed. Lebanon, N.H.: International Science Publisher, 1994. 76-91. 79.

58.John E. Bardach, John H. Ryther, and William O. McLarney. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. New York: Wiley Interscience, 1972. 478.

59."Pacific Pinks on Norway Coast to Bergen Region." Pacific Fisherman. November, 1960. 15.

60.Anthony Netboy. The Salmon: Their Fight for Survival. Boston: Houghton Mifflin Company, 1974. 345.

61. “Forecast on World Fisheries Trends.” Canadian Fisherman. May,1963. 28-29.

62.Smith, 20.

# Chapter 3

## Biological Alchemy

Within months of becoming director of the Washington Department of Fisheries in1957, Milo Moore announced an ambitious new plan to revitalize the state's ailing salmon runs. The department was releasing some 60 million salmon fry annually, but Moore, fresh from a decade of exploring aquaculture programs around the world as a fishery consultant, had a ten-year plan that would boost that number to 500 million fry a year.[1] His fish farming program was designed to augment the existing hatchery system. Smolts would be raised in the state hatcheries, then transferred to lakes, ponds, and marine estuaries that would be fertilized to provide optimum growing conditions. The ponds would also be treated with poisons to control predators. Hatcheries would continue to do the important work of propagating and hybridizing desirable salmon stocks and producing eggs, but ponds would replace the most expensive portion of the hatchery process by having the young fish forge for themselves in controlled, fertilized environments before they were released into the ocean. The plan offered many benefits; the fish could be controlled, the stocks would be improved, and there was the potential of being able to multiply the effectiveness of the existing hatchery system. Moore's plan was firmly rooted in seeing salmon as a crop that could be produced more cheaply and efficiently:

> As man makes ready the soil for the growing of better crops, so may he improve the water for the growing of fish. The steps to be taken in the harvest of seed, the surplus crops, the preparation of land or water follows the same fundamental procedures.[2]

The program quickly moved into what Moore called high gear. Seventeen million fry were planted in 1958 in 1,200 acres of fresh and salt water and "and without exception the fish reared in these predator-free food-rich areas were larger than wild fish of the same age."[3] Two major predators were identified, mergansers, a fish-eating bird, and spiny dogfish sharks *(Squalus_acanthias).* The State of Washington had recently persuaded the United States Congress to pass Public Law 85-887, requiring the secretary of the interior to fund a four-year investigation into dogsharks. The goal was to come up with "a vigorous program for the elimination and eradication or development of economic uses of dogfish shark populations."[4]

Moore visited Japan in 1958. He and Albert M. Day, director of the Oregon Fish Commission, were advisors to the North Pacific Fisheries Commission in Tokyo. Their visit included a trip to Hokkaido, where they toured hatchery installations and met with scientific staff.[5] The two were impressed; the Japanese did not feed their chum fry before the fish were released, but returns averaged between one and two percent, similar to returns in the Northwest.[6] In his annual report to the Washington legislature in 1958, Moore said that the "on-the-spot investigation of Japanese salmon hatchery operations . . . verified previous reports of outstanding success in the rearing the chum salmon and has encouraged the use of simplified methods in the incubation and rearing of other species of salmon."[7]

It was Milo Moore's second stint as director of the Department of Fisheries. He had resigned in 1949 and become a fisheries' consultant for an agency called the Economic Cooperation Administration, making fisheries surveys in Greece, Turkey, and Italy. Between 1955 and 1957, he was a consultant to the U.S. Senate Committee on Interstate and Foreign Commerce. During his travels, he began "collecting materials pertaining to the science of fish farming."[8] When he returned to the department as director in 1957, Moore outlined his fisheries philosophy. He contended the time was ripe for man to "assist nature in producing greater numbers of fish in environmentally controlled water areas."[9]

Moore was solidly in the forefront of what he doubtless thought were new ideas in fisheries management: expanding the harvest by controlling predators and fertilizing the crop. Fishery managers had sought to accomplish these goals for almost 100 years. And there was also no doubt that salmon in the Pacific Northwest needed help. The runs were not doing well. So few coho salmon returned in 1960 that the run set a new low record for harvest. "Not since the outstandingly poor year of 1921...had there been such a scarcity of all species of salmon," wrote one British Columbia author.[10] From Alaska to Puget Sound, Moore gloomily observed, all indicators point "to depressed runs in need of complete protection to secure escapements for spawning purposes."[11] Chinook harvests were also down, and the chum catch was the lowest in history, despite the fact that Washington had doubled its production of hatchery chums. Two new hatcheries had recently been completed and two more were in the planning stages. The fish farming project had continued to expand, but Moore had to urge that fishing be curtailed so enough fish would spawn in the wild to carry on the runs.

### 3.1 Failure on the Columbia River

Washington's hatcheries were not the only ones that had failed to produce more fish; the program on the Columbia River, established by Congress in 1948, was also struggling. With the record-low returns in 1960s, Congress declared that no more money would be spent unless the existing hatcheries were evaluated and showed a positive economic contribution to the region.[12] The declines were so serious that the governor of Alaska called for a conference and invited the governors of Washington, Oregon, and California. The politicians and their scientists met in Juneau of February of 1961. The scientists reviewed current research programs and management techniques, while the politicians decided that hope lay in a coastwide management program where research results would be shared. It was not the first time that social goals had been established for salmon management. Jim Lichatowich points out that a similar conference took place in 1925 in Seattle; it brought representatives from Canada and the U.S. to a two-day conference where they focused on solutions to the salmon decline. They wanted to facilitate the transfer of eggs from one region to another, eliminate salmon predators, control the growing ocean fishery, and secure salmon passage at high dams.[13]

Thirty-seven years later, at the follow-up conference which was also in Seattle, managers and biologists adopted two goals: the maximum development of the U.S. fisheries in the Pacific, and the management of fisheries to obtain "maximum sustained yield on both biological and economic bases.[14] Managers acknowledged that hatcheries and artificial propagation, which had seemed to offer so much, had been a disappointment. But they were confident that the scope of their research activities, now efficiently coordinated coastwide for the first time in history and grounded in the most up-to-date scientific principles, would soon solve the problems. “Fish culture must be made to be the valuable management tool which it has so long held promise of being,” the scientists concluded.[15] The research priority was to provide information for regulations that would allow de maximum sustained yield to be achieved on salmon.

Scientists knew they needed more information to fine-tune their mathematical models that tended not to account for troublesome factors like predator-prey relationships and species interactions.[16] But they were also interested in making the hatchery system more efficient. Lauren Donaldson of the University of Washington offered a practical suggestion, selecting chinook and coho that both spawn late in the season for hatchery brood stocks. That way ponds and raceways could be fully utilized to increase the production of both species. Donaldson summed up his goal, “to build a better brood stock of salmon or steelhead trout.”[17]

There were other pressing problems for the scientists and politicians meeting in Seattle. Foreign fishermen were now regularly appearing off both the East and West coasts, fishing international waters that were inconveniently close to shore and preempting the catches of smaller boats. The domestic fleet had to become more efficient, to compete with the factory ships. William F. Royce, director of the Fisheries Research Institute at the University of Washington, told participants that policy makers must adopt policies to make fishermen more efficient, "to let them acquire rights in fishing, to let them build the boats and obtain the equipment that they must have to compete on the high seas, and not to hamstring them with petty restrictions."[18] Royce laid out four principal objectives to conserving salmon: (1) to regulate for conservation; (2) to maintain the runs even though water is used for other purposes; (3) to increase the efficiency of the salmon's reproduction and (4) to catch salmon more efficiently.

The governors' conference established several committees, including the Committee on Supplements and Substitutes for Natural Reproduction. The committee acknowledged the inadequacies of fish culture that had resulted in the closing of some hatcheries. It admitted that success "is still far from being achieved." But with the rapid urbanization of the West, the destruction of habitat, as well as the continued expansion of dam building, "there has come about a deep-seated conviction that the fish-cultural problems must be resolved. Fish culture must be made to be the valuable management tool which it has so long held promise of being."[19]

### 3.2 The Oregon Moist Pellet

In fact, success– or what looked like success–was just around the corner, thanks to a new fish diet fed to the 1958 brood at hatcheries operated by the Oregon Fish Commission. The coho were given the latest version of what would be called the Oregon Moist Pellet. In development for more than a decade at several university laboratories,[20] the pellet was a mixture of fish meal and frozen turbot, with yellowfin tuna liver. Fish fed the new diet did not develop the high levels of tuberculosis that most salmon did in the crowded hatchery ponds of the time. When the coho returned to the hatchery in 1961, they would return in good numbers.[21] "Good ocean conditions, coupled with vastly improved physical condition of fingerlings released from the hatcheries, appear to have played an important role in making returns among the highest since the 1930's," reported the 1960-62 biennial report by the Oregon Fish Commission.[22] The diet was being fed to spring and fall chinook, "and there is considerable optimism that returns . . . will be better than the average of recent years."[23] The new diet also cut hatchery costs, from 46 cents per pound of fish produced to 28 cents, the Fifty-First Biennial Report estimated in 1960.

Early salmon hatcheries were crude affairs. The ponds were usually just dug into the ground and the fish were fed whatever was easily at hand, provided it was cheap. According to a 1937 Fish Commission of Oregon report, smolts were fed waste from the salmon canneries, as well as smelt and salmon carcasses. The mixture was kept in a deep freeze and run through a food grinder.[24] Crowded hatchery ponds produced diseases like tuberculosis, probably from the fish being fed diseased offal. Mortality rates were high and the longer the fish were held in the hatchery, the more the tuberculosis spread.[25] There was no treatment and the diseased fish were released into the wild.

The Fish Commission of Oregon adopted its first salmon research program in 1928. Forty years later, new goals were developed. The Commission wanted to build fishways over barriers, remove log jams, control the discharge of industrial wastes, and to restock streams with hatchery-rearing fingerlings. The decline would be arrested and the resource would be rebuilt.[26] One focus of the research would be fish nutrition, and what to feed young salmon to improve their survival in the hatcheries. It looked like a broadly focused package of options, but the major emphasis would be on improving hatchery fish, not helping wild runs.

It was a similar story on the Columbia River. Congress had passed the Mitchell Act in 1938, instructing the Bureau of Reclamation and the Corps of Engineers to work with fishery agencies to save salmon. While the dam builders continued to obstruct the river and its tributaries, the agencies concentrated on fishways, irrigation screens and hatcheries to mitigate for the damage.[27] A decade later, when Congress passed what was initially called the Lower Columbia River Development Program, its goals were similar to those of the Oregon Fish Commission. The program had six parts: (1) clean up obstructions to salmon mitigation in the tributaries of the lower Columbia; (2) clean up pollution in the major tributaries like the Willamette; (3) screen water diversions to prevent the loss of juveniles in irrigation ditches and construct fishways over barriers; (4) to transplant salmon stocks from above McNary Dam to the lower river; (5) expand the hatchery program and (6) create salmon refuges by setting aside tributaries below McNary Dam for salmon and steelhead runs.[28]

Oregon and Washington joined the federal government in a cooperative biological program in 1948 to study the causes of salmon decline. They would look at the "maximum and most efficient type of hatchery management which will serve as a supply of young fish. . . The culmination of successful biological studies will provide the basis for a coordinated fishery management program to obtain the largest possible sustained annual yield from the Columbia River fisheries.[29]"

3.3 Salmon and Dams

The Pacific Northwest had three million people in 1930 and 70 percent of them did not have electricity.[30] Marc Reisner, author of *Cadillac Desert*, calls the 1930s "the Go-Go Years," when federal dams were being built at a breakneck pace across the west. In 1936, the four largest dams ever built were under construction: Bonneville, Grand Coulee, Shasta and Hoover. Congress had voted 110 separate authorizations for the Bureau of Reclamation by 1956, some involving a dozen or more irrigation projects and dams. Three-quarters of the authorizations were built, along with hundreds of other projects by the Army Corps of Engineers.[31]

The boosters of dams in the Northwest spun a potent story that involved "a dream of liberation from labor, an end to social conflict and environmental degradation through the harnessing of nature's power to human purposes."[32] The power generated by the Columbia River dams would fuel the economic development of the region, freeing it from dependence on eastern money and letting the region process its own natural resources, rather than shipping them elsewhere. The debate was not over if the dams would be built, but in what order they would be built, and who would pay–the federal government, private or public utilities. "Dams were development. Development was progress. Progress was good."[33]

The dams and the social goals of what could be accomplished with cheap electricity were enormously popular. One dramatic example of the need for control of the Columbia River came in 1948, when a disastrous flood wiped out Vanport, a World War II city on the banks of the Columbia River adjacent to Portland. The second-largest city in Oregon, Vanport's 20,000 people were housed on the flood plain at the mouth of the Willamette River across the Columbia from Vancouver. Within hours after the Columbia River crested, the city was destroyed.[34] The Army Corps of Engineers was already updating its comprehensive plan for the region and dam supporters could now add flood-control to their arguments. The engineers concluded that a system of storage dams was needed throughout the region to avert similar disasters. Adding to the pressure during the 1950s were the Cold War and the Korean War. The military escalation used massive amounts of power to produce aluminum and plutonium.[35]

Congress had authorized the Army Corps of Engineers in 1945 to construct the Lower Snake River Project, which would build four dams and create the Port of Lewiston in Idaho, some 600 miles from the Pacific Ocean.[36] The Corps recommended building two more dams, The Dalles and John Day, to help control flooding on the Columbia. No new dams would be built below Bonneville Dam and the lower Columbia River tributaries would become fish sanctuaries. The report also outlined a $20 million plan of fish ladders, irrigation screens, and hatchery construction on the Lower Columbia, "developing the salmon runs in the lower tributaries to the highest levels of productivity."[37] Much of the research would focus on identifying the characteristics that allowed salmon to survive in hatchery settings.[38]

The federal efforts on the Columbia River came under the Lower Columbia River Fisheries Development Program, created in 1948. It brought fish management agencies from Washington, Oregon, Idaho, and the federal government together under the Columbia Fisheries Program Office, based in Portland and administered by what is now the National Marine Fisheries Service.[39] The program's main thrust was to "improve the runs of salmon and steelhead by protecting and improving stream environment and by production of fish in hatcheries."[40] Hatcheries were only one component of the plan, but they soon became the dominant portion. There were twelve hatcheries on Oregon rivers and sixteen on Washington rivers.[41] The program was spending 49 percent of its budget on hatcheries and five percent on habitat by 1951. And while the program was initially designed to last ten years, "it can be considered the grandfather of the current efforts to mitigate for the effects of the hydropower system."[42]

The "Lower" river designation was dropped in 1957 and the program came to be known as the Columbia River Fisheries Development Program. The focus expanded when Idaho entered the program in 1959. The scope of work was laid out in a 1957 inter-agency committee report that contained 100 pages of typewritten research plans. The emphasis was on finding ways around barriers that limited production of salmon. Dam passage would be studied and the effect of irrigation diversions on fish. But the report also focused on studies to transplant upper Columbia salmon and trout into the lower Columbia. "Undesirable fish populations" would be eradicated, which would "bring about a tremendous economic savings to fishery agencies and will also increase sport and commercial species production."[43] The 1957 wish list proposed that $225,000 to be spent on fishery genetics. Pointing out that most of what was known about fish genetics came from work on goldfish, the authors wanted research on developing new strains of fish that would survive in hatcheries and be resistant to diseases and pollution.

There were enormous hopes that the success of the Oregon Moist Pellet could be duplicated in other areas. Salmon were coming back to the Northwest's hatcheries at such a rate that Washington was able to abandon Milo Moore's fish farming plan. An economic analysis in 1965 found a benefit-cost ratio of only 0.13: 1, a return of 13 cents for every dollar spent, casting doubt on the feasibility of the program.[44] The analysis conceded that the application of fertilizer and adjustment of water levels might have increased the survivability of the fish, but those actions often conflicted with other uses of the bodies of water. The economic analysis recommended that twelve of the programs be discontinued, leading to a revaluation of the entire program.[45]

The new tool for fishery managers was the cost-benefit analysis. When Congress cut off funds to the Columbia River hatchery program in 1960 because of poor returns, the fishery agencies swung into the most ambitious fish tagging program ever seen on the West Coast. A percentage of the hatchery fish would be tagged and workers in every port from Alaska to California would check the sport and commercial catches, looking for the marked fish. The tagging data created a picture of where the Columbia fish were caught. When the value of the caught fish was compared to the costs of the hatchery program, the success of the hatchery program would be established once and for all. Through the late 1960s, as each fall brought returning salmon, the results began to coalesce. Managers knew the new diet was working, producing coho that "were characteristically large and healthy with a high survival potential."[46]

The tagging studies established the importance of the international dimension of salmon management. Scientists had known that most salmon headed north, to spend at least part of their lifetime feeding in the rich Arctic waters. The tagging studies established that five percent of the chinook from the Lyons Ferry Hatchery on the Columbia River was caught by Alaskans, while about 22 percent was taken by Canadians. The ocean harvest off Washington, Oregon, and California accounted for another 12 percent. The gillnet and sport fishers in the Columbia took about a third. But the hydro system itself was also identified as one of the largest source of mortality: interdam loss was estimated at 17.3 percent, with another 6.6 percent were lost at the Ice Harbor Trap.[47]

3.4 The Decline of the Tribal Fisheries

The increased ocean catch came at great cost to the tribal fishermen, in both Puget Sound and the Columbia River. As the ocean catch grew, the tribal catch steadily declined. The canning industry at the mouth of the rivers had severely disrupted Indian fishing in the 1880s. Fish wheels and horse seining ensured that fewer fish would reach the tribal fishers. Managers enforced restrictions on Indian fishers, saying all the remaining fish were needed to spawn.[48] With the completion of each dam on the Columbia River, the number of fish caught by the tribes was shrinking. In 1957 the construction of The Dalles Dam flooded the historic fishing grounds of Celilo Falls, one of the longest-standing gathering and trading places for tribes in North America.[49] The tribes would lose more of their historic fishing sites when John Day Dam was completed in the next decade. The new dam created two lakes, backing up the river for seventy-five miles, from The Dalles to near Umatilla.[50]

With the dams came promises. When Bonneville Dam was built in the 1930s, it flooded more than two dozen traditional fishing sites. The Army Corps of Engineers in 1939 promised to replace six of the sites with 400 acres of land. By 1999, five of the sites totaling more than 40 acres, one-tenth of the promised area, had been built.[51] Managers wanted to provide more salmon, but not to tribal fishermen. Just as the Army Corps of Engineers surveyed the Northwest rivers for potential dam sites, biologists raced to find sites to build more hatcheries. Oregon began a Hatchery Site Evaluation Study in 1967, looking for potential sites on the coast.[52] There was no federal money to build hatcheries that would return fish to the tribal fishing grounds and the tribes had no money. As the ocean catch increased, managers were concerned that not enough wild fish were reaching the spawning grounds. They responded by curtailing the tribal harvest.

"There is serious concern that if the present trend (of tribal fishing) continued, the management program and possibly some of the runs could be jeopardized," the Fish Commission of Oregon warned in its 1962-64 Biennial Report.[53] Herbert Lundy, the editorial page editor at The Oregonian, spoke for many when he summed up the situation at fisheries meeting in Seattle during 1965.

> It is ridiculous to say, in my opinion, as a lot of people do, that nothing can be done about the Indians' gillnetting in the closed area . . . The 1855 Treaty was abrogated by Congress itself when it authorized and appropriated the money to build The Dalles Dam which flooded out the Celilo Falls dip net fishery. The Indians with Treaty interests there were paid for their losses, around 25 million dollars, but they could not prevent the loss of their fishing grounds. Now they are on the river in annually increasing numbers with gill nets claiming the same Treaty rights they were paid to give up.[54]

Harvesting the fish in the ocean generated the most income, especially when the fish were taken by sport anglers, who generated economic development by paying for trips on charterboat, and stays in coastal motels. An analysis in 1975 showed that out of 1,000 fish caught, 606 would be taken in the ocean by trollers, while ocean sportsmen would take 264 fish. White gillnetters in the lower Columbia River would take 100 fish and freshwater sportsmen would also harvest some of the catch. It left five fish for the tribal fishermen to share.[55]

The tribes were preempted from participating in the political process. After Washington achieved statehood in 1898, it frequently passed laws to curtail Indian fishing in the name of conservation. "Designations of 'salmon preserves' restricted tribal fishing in western Washington rivers, while largely ignoring ocean and Puget Sound salmon fishing by whites. Thus, the late nineteenth century, technological and political developments had displaced much of the traditional Indian harvest.[56]

The Indian fishery was hurt in other ways. A major factor was placing all of the so-called "mitigation hatcheries," funded by the 1938 Mitchell Act, downriver from the traditional tribal fisheries. Another decision to focus production on fall chinook, known as tules. Unlike the spring chinook, which return to the river in the spring, carrying enough fat to sustain life as they wait for the fall rains to trigger spawning, tule fall chinook put on little fat in the ocean. They will spawn shortly after reaching the river, so the flesh is dark and does not keep well, reducing its value. But managers liked to raise tule fall chinook for a number of reasons. About 80 percent of the tules were caught as immature fish in the ocean.[57] Fall chinook is the salmon that will be the most "compatible with civilization" because it spawns in the lower section of streams. To translate the language of the day, fall chinook spend less time in the streams after hatching, and occupy the lower stretches of streams, so they will not be as effected by log jams and poorly placed culverts.[58] Before the Columbia River was developed, 77 percent of the salmon, an estimated 11 million fish, returned to the tributaries on the upper river. The total salmon population was reduced to less than 3 million fish by 1996, but the upper river share had dropped to 42 percent.[59]

Spring chinook, which return to the river systems as early as February, require an adequate supply of cold, clean water until they spawn the following fall. The fish do not eat while they are in freshwater, living off the fat reserves they have accumulated during their years in the ocean pasture. But with increased development, pollution, and water withdrawals, it was harder to maintain the conditions needed to allow spring chinook to spawn. Fall chinook, returning much later in the year, were seen as a more practical species for the industrial Pacific Northwest. Instead of bright chinook with a high fat content and good keeping qualities, the tribal fishermen were left with poorer-quality fish that did not keep as well, nor were they worth as much.

The tribal frustration over the restrictions and the lack of fish resulted in a series of lawsuits filed in the late 1960s. David Sohappy, a member of Wanapum Band, and his nephew, Richard Sohappy, a decorated soldier on leave to recuperate from wounds received in the Vietnam War, were arrested for fishing illegally.[60] Federal District Court Judge Robert Belloni made a decision in the Sohappy case in 1969, determining that the treaties signed by the federal government guaranteed the tribes a fair share of the fishery harvests. His ruling was expanded by Federal District Judge George Boldt, who ruled in a Puget Sound decision in 1974 that a fair share meant 50 percent of the harvestable salmon must be caught the Northwestern treaty tribes.

The decision ignited what would be called a fish war in the state of Washington.[61] The result was still more pressure to produce more salmon.

References

1.State of Washington, Department of Fisheries, 1957 Annual Report, 4.

2.State of Washington, Department of Fisheries, 1958 Annual Report, 7.

3.WDF 1958, 7.

4.WDF 1958, 141.

5.Albert M. Day and Milo Moore. A Review of the Japanese Salmon Fishery. Portland: Oregon Fish Commission, 1959. 1.

6.Day, 21.

7.WDF 1958, 3.

8.Ken McLeod. Fisheries: Fish Farming and Fisheries Management. Olympia: Washington State Printer, 1958. Vol 1. 2.

9.McLeod, 1.

10.Cicely Lyons. Salmon: Our Heritage. Vancouver: Mitchell Press Ltd., 1969. 544.

11.Washington Department of Fisheries, Annual Report, 1960. 10.

12.R.T. Pressey. Appraisal of hatcheries. One hundred Thirty-first meeting of the Columbia Basin Inter-Agency Committee, U.S. Bureau of Commercial Fisheries Laboratory, Seattle, Oct. 6, 1965. 39-40.

13.Jim Lichatowich. Salmon Without Rivers: A History of the Pacific Salmon Crisis. Washington, D.C.: Island Press, 1999. 152.

14.R.S. Crocker and Don Reed. The First Governors' Salmon Conference Recommendations and Results. Report of Second Governors' Conference on Pacific Salmon, Seattle, Jan. 7-10, 1963. State Printing Plant, Olympia, 1963, 14.

15.Crocker and Reed, 14.

16.M.W. Klingle. "Plying Atomic Waters: Lauren Donaldson and the "Fern Lake Concept" of Fisheries Management." Journal of the History of Biology. 31(1): 1-32. 23.

17.Crocker and Reed, 104.

18.Crocker and Reed, 17.

19.Crocker and Reed, 31.

20.G.L. Rumsey. "History of Early Diet Development in Fish Culture, 1000 B.C. to A.D. 1955." The Progressive Fish-Culturist. 56(1): 1-6.

21.W.F. Hublou, J. Wallis, Thomas B. McKee, Duncan K. Law, Russell O. Sinnuber, T.C. Yu. Development of the Oregon Pellet Diet. Portland: Fish Commission of Oregon Research Briefs. Vol. 7, No. 1.28-56. 40.

22.Fish Commission of Oregon, Biennial Report to the Governor and Fifty-Second Legislative Assembly, 1960-62. 19.

23. Fish Commission, 19.

24.H.C. Mitchell. Artificial propagation of salmon in the State of Oregon. Oregon Fish Commission, Research Briefs, 1937. 1-7.

25.James W. Wood and Erling J. Ordal. "Tuberculosis in Pacific Salmon and Steelhead Trout." Fish Commission of Oregon, Contribution No. 25. Portland, December, 1958. 3-38. 9.

26.D.L. McKernan. The biological research program. Oregon Fish Commission, Research Briefs, Vol. 1, No. 1.5-12. 5.

27.Joseph Taylor III. Making Salmon: An Environmental History of the Northwest Fisheries Crisis. Seattle: University of Washington Press, 1999. 228.

28.Leo L. Laythe. The Fishery Development Program in the Lower Columbia River. Transactions of the American Fisheries Society 78th Annual Meeting, 1948. 42-55.

29.McKernan, 6.

30.Marc Reisner. Cadillac Desert. New York, Viking Press, 1986. 159.

31.Reisner, 172

32.Richard White. The Organic Machine: The Remaking of the Columbia River. New York: Hill and Wang, 1995. 48.

33.Roberta Ulrich. Empty Nets: Indians, Dams, and the Columbia River. Corvallis: Oregon State University Press, 1999. 55.

34.White, 74.

35.Ulrich, 59.

36.Keith C. Petersen. River of Life, Channel of Death: Fish and Dams on the Lower Snake. Lewiston, Idaho: Confluence Press, 1995. 2.

37.Michael C. Blumm and F. L. Bodi. "Commentary." The Northwest Salmon Crisis: A Documentary History. Joseph Cone and Sandra Riddlington, eds. Corvallis: Oregon State University Press, 1996. 120.

38.Joe Wallis. Recommended time, size, and age for release of hatchery reared salmon and steelhead trout. Oregon Fish Commission, 1968. 1-61.

39.Iola I. Berg. History of the Washington Department of Fisheries, 1890-1967. Washington Department of Fisheries, 1968. 12.

40.Roy J. Wahle, Robert R. Vreeland, Robert, H. Lander. "Bioeconomic contribution of Columbia River hatchery coho salmon, 1965 and 1966 broods, to the Pacific Salmon fisheries." Fishery Bulletin, Vol. 72., No. 1. 139-168.

41.Laythe, 53.

42.Jim Lichatowich and Lars Mobrand. A History of Frameworks Used in the Management of Columbia River Chinook Salmon. Portland, Or. U.S. Department of Energy, Bonneville Power Administration, Environmental Fish and Wildlife. 1996. DE-AM79-92BP25105. 34.

43.Columbia Basin Interagency Committee. Columbia River Basin Fishery Program, Part 1, Comprehensive research Program for development of the fishery resources. Part 11, Inventory of streams and proposed improvements for development of the fishery resources. January, 1957.

44.Washington Department of Fisheries, Annual Report, 1965. 79.

45.J.E. Bardach and J. H. Ryther, et al. Aquaculture: The Farming and Husbanding of Freshwater and Marine Organisms. New York: Wiley-Interscience, 1972. 477.

46.Wahle, 140.

47.Frameworks, 56.

48.Blumm and Bodi, 180.

49.Jay LaPlante. "Ceililo Falls: Flooded 40 Years ago but not Forgotten." Wana Chinook Tymoo, Columbia River Inter-Tribal Fish Commission. 1997, Issue 2.8-11.

50.Ulrich, 123.

51.Ulrich, 1.

52.Fish Commission of Oregon. Studies on Increasing the Production of Anadromous Salmonids in Oregon Coastal Lakes and Streams. 1968. 6.

53.Fish Commission of Oregon. Biennial Report to the Governor and the Fifty-third Legislative Assembly. 1962-64.7.

54.Herbert Lundy. One Hundred Thirty-first meeting Columbia Basin Inter-Agency Committee, U.S. Bureau of Commercial Fisheries Laboratory, Seattle. Oct. 6, 1965. 85.

55.Merritt E. Tuttle, Jack A. Richards and Roy Wahle. Partial Net Economic values for salmon and steelhead for the Columbia River System. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1975.

56.Blumm and Bodi, 180.

57.Columbia River Fisheries Council. Comprehensive plan for production and management of Columbia River Basin anadromous fish, Phase 1-Strategic Plan. March 23, 1978.

58.Oregon Game Commission. The Salmon and Steelhead Program of the Oregon Game Commission. 1962.

59.Kai N. Lee. Compass and Gyroscope: Integrating Science and Politics for the Environment. Washington, D.C.: Island Press, 1993. 26.

60.Ulrich, 130.

61.Fay G. Cohen. Treaties on Trial: The Continuing Controversy over Northwest Indian Fishing Rights. Seattle: University of Washington Press, 1986. 3.

# Chapter 4

## The National Forces

The Americans were not the only people facing pressure to create more salmon in the years following World War II. There were substantial pressures in Canada as well. The Canadians had closed their salmon hatcheries in the 1930s, after a series of experiments showed a few more fish, but not enough to justify the costs.[1] As the results of the tagging studies on the Columbia River fish emerged during the late 1960s, there was a great deal of interest in British Columbia--but more importantly there was interest in Ottawa. The federal government had the responsibility for setting the national fishing policy since it passed the Fisheries Act in 1868.[2]

After World War II, Ottawa wanted to expand fishing and processing to meet the growing American demand for fresh and frozen fish products. Fish products were an important component in Canada's balance of trade, especially with the Americans. There was an international shortage of protein and countries like Canada, with ample natural resources, had an obligation to produce as much food as possible. Fisheries also offered a way to increase employment in areas of the country where job opportunities were limited. The government established a small-boat insurance program in 1953 and the Fisheries Improvement Loans Act was set up in 1955 to provide loans to purchase or repair fishing boats and equipment.[3] A Royal Commission on Canada's Economic Prospects issued a report on fisheries in 1956, pointing out that fishing employment on both coasts was in decline. The Commission saw a solution: if there was an investment in technology, production could be maintained but fewer people would be required.[4]

The Canadian government made fishermen eligible for a special fishermen's unemployment insurance program in 1957, designed to pay benefits to seasonal workers.[5] Every subsequent policy review of the unemployment insurance system would condemn the fisherman's portion of the program and call for it to be revoked. The economic and political implications, especially in Newfoundland, the Maritime provinces, and British Columbia, "have ensured that once in place, the system could not be dismantled."[6]

The federal government underwrote $3.5 million in loans to build twenty-two fishing boats in 1962. The *Canadian Fisherman* reported in April 1963 that subsidies under the loan program had produced "vessels of all kinds" valued at $80 million, and that more than a quarter of a billion dollars in shipbuilding "has been induced during the last two years."[7] The first Canadian trawler was built in

1962, and new vessels were planned for the Atlantic tuna fishery. Much of the boat building activity was in the Maritime provinces. Boats were built and plants modernized to freeze fish instead of salting them. Money was also being spent on the West Coast, where new tuna seiners were equipped with a brine spray freezing system developed by the Department of Fisheries and the Fisheries Research Board. The Canadian government sent a Fisheries Reconnaissance Mission to Japan in 1964, to study "the phenomenal growth of the Japanese fishing industry."[8]

The Canadian fish catch increased by about nine percent a year between 1958 and 1962, providing important employment in two areas of the country where good paying jobs were scarce. But the increasing number of foreign fishing boats, especially on the cod grounds off the Grand Banks of Newfoundland, threatened the expansion. The Grand Banks, one of the richest fishing areas in the world, were part of the high seas and anybody could navigate or fish on the high seas. But the Canadians viewed the fish as Canadian.

A particularly ominous development occurred in 1963, when the French government announced plans for a multi-million dollar redevelopment of the old port area on Saint-Pierre-et-Miquelon, its island about fifteen miles off the southwest corner of Newfoundland's

Burin Peninsula. The island is the last remnant of French North America and had been ceded to France in 1783 by the Treaty of Versailles.[9] It would now become a staging area for European fishing interests. Plans called for two new seawalls to protect the harbor, dredging to deepen the channel, construction of a breakwater and wharves, a freezing plant and cold storage warehouses, as well as fish processing and a fish meal plant. Total investment was projected at $8 million.[10] By 1965, *Canadian Fisherman* magazine reported that ten countries were using the port facilities, including ships from Poland, Spain, Japan, Denmark, Portugal, France and Venezuela .[11]

The Canadian government responded by making substantial investments in its fisheries. On Christmas Eve, 1965, Newfoundland Premier Joey Smallwood unveiled a $100 million fisheries program for the province. The timing of the announcement was appropriate since the money would be coming from Ottawa. It marked the Canadian government's most ambitious social experiment connected with fishing, calling for provincial assistance for families that agreed voluntarily to leave small communities and move to more urban areas. Smallwood said the relocation program was needed because there were so many small fishing communities in Newfoundland, some 800 in all, and "there is just not enough money in Ottawa to get modern equipment into all of them."[12] The package also included money for aquaculture to raise oysters, trout, and to rehabilitate Atlantic salmon runs. There was also money to expand a 1959 effort to transport Pacific salmon from British Columbia to Newfoundland.[13]

Although the 1956 Royal Commission had worried that too many fishermen were leaving the industry, a decade later a study in British Columbia found that the major problem in the industry was too many fishermen.[14] The report pointed out an important consideration: fishing accounted for about 7 percent of the province's labor force overall. But it was particularly important in remote coastal such as Prince Rupert and Vancouver Island. More than 40 percent of the processing plant workers in Prince Rupert were estimated to be native peoples. The Canadian government responded to the over-capacity problem in 1968 by imposing a moratorium in the number of salmon licenses it would issue. There were 8,000 boats, but the fleet would be cut to 6,000 by canceling licenses of all boats that did not make landings during a certain period. The ultimate aim was to reduce the number of fishers, so that each would earn more money.[15] Conservation of the salmon resource was a secondary goal, but the real intent of the program was socioeconomic rationalization, to promote "a strong and economically viable fishery...to ensure that its exploiters and its ultimate owners...obtain maximum benefit from it."[16]

At the same time that the federal government was cutting the number of salmon licenses by getting rid of the older, inefficient boats, it was also trying to increase the fishing capacity of the rest of the fleet. The government created a fund to buy out old and inefficient boats and remove them from the market. The theory, as outlined in a speech by federal Minister of Fisheries Jack Davis in 1968, was that capital would be removed from the fishery as old boats were retired; however, the fleet would be upgraded. "Boat owners will have every incentive to improve their vessels, fishing methods and gear," Davis promised. "Fresh advances in technology will help and our commercial fishery will become more effective with every passing year."[17]

Three years later, in early 1971, Davis announced that five new hatcheries would be built around the Strait of Georgia. A few months later, *Western Fisheries* carried a two-part series based on a new federal investigation into the Columbia River hatchery program. With the apparent success of the American hatchery program, the report proposed a coho and chinook hatchery program for B.C. and that hatchery stock be transplanted into areas which were barren of fish.[18] It was the start of what would become a multi-million dollar enhancement program, unveiled by the Canadian government in 1975.

There was another federal fisheries minister at the helm by this time, Romeo Le Blanc. He announced a ten-year, $300 million program designed to increase salmon stocks to their pre-1960s levels. The resource had dropped to 145 million pounds, less than half of the previous historical high.[19] The enhancement program was expected to produce a commercial catch valued at $400 million (figures are in Canadian dollars). The program had significant social objectives: to increase employment, supply a recreational fishery that was growing by 6 percent a year, and to supply a growing tribal fishery with subsistence salmon. Other goals included stabilizing the supply of salmon at a higher level of abundance, strengthening the economic base of coastal communities, and improving the Canadian balance of payment.

"The rationale of the programme is to apply enhancement technology to create wealth," wrote J.R. MacLeod, an official with Environment Canada. "The programme, by doubling today's annual commercial catch value to $400 million, will produce a rich flow of public benefits." MacLeod went on to say that although authorities have been aware of the need for a program, "it is only recently that the certainty for success has been established." He noted a shift in management philosophy: in the past, managers were concerned only about biological issues; "the objective now is to achieve socioeconomic goals on a sustained basis through wise use of the resource."[20] The new Canadian fishery management philosophy would move from a "purely biological to a socioeconomic focus."[21]

The argument for the massive enhancement project was made by one of Canada's premier fisheries scientists, Peter A. Larkin. In a 1974 paper titled "Play it Again, Sam," Larkin did not assess the scientific basis for an enhancement project. "From a social point of view, salmon enhancement is a highly desirable activity," Larkin wrote. Salmon had to be saved for social reasons, because they were an important part of the natural inheritance of the West Coast. But he also argued that salmon fishing provided an outlet "for people who find it difficult to make a living in other ways. Many of these people would be a potential social problem and would perhaps become a source of social costs if there were no salmon fishing."[22] Larkin was confident that enhancement would show quick results. He summed up the thinking of the time, that hatchery technology had progressed to the point where scientists could improve salmon:

> It is to be underlined, emphasized, and repeated until it is realized, that salmon enhancement is a good biological bet, and a necessary biological bet. Nature can be improved upon, and now is a good time to get cracking.[23]

4.1 Pressures for Growth in the United States

The Canadians were not the only ones interested in expanding fishing opportunities. There was renewed interest in the U.S. as well, not just in fisheries but in the new science of oceanography. The first Committee on Oceanography of the National Academy of Sciences had been appointed in 1927, with private funds paying for the research. The oceanic information proved its value during World War II, leading the National Science Academy to appoint a second oceanography committee to review and make recommendations in 1952 on the support needed for ocean science.[24]

But while the U.S. was spending more money on fisheries and ocean science, the United States share of the world fish catch was declining. The U.S. slid in 1966 from the world's third leading producer to fifth, replaced by the Soviet Union, where the fishing and merchant fleets had grown by 150 percent since the end of the war.[25] The Soviet production of fish per man and per year tripled between 1960 and 1975. Soviet boats began fishing in the waters around Newfoundland in 1954, and started a herring fishery on the Georges

Bank off Maine in 1961. Their boats expanded into the South Atlantic and into the Indian Ocean, as well as into the Far East to the fishing grounds off both Alaska and Peru. They began fishing for Pacific ocean perch (*Sebastes alutus*) in the Gulf of Alaska in the mid-1960s.[26] As the perch catch declined, the Soviet fleet shifted to fishing for Pacific hake (*Merluccius productus*) off Oregon and Washington. As more boats joined the Soviet fleet, fishing expanded to California and British Columbia, and to other species of bottomfish. The Soviets began trawling the waters off Antarctic in 1969, fishing for finfish and mounting an experimental fishery on krill, the tiny planktonic crustaceans which are estimated to be the largest biomass in the ocean.[27]

Modern fishing boats were being built in France, Holland, Sweden, West Germany and Japan.[28] The Japanese had also substantially increased their world fishery. The Japanese government between 1956 and 1958 appropriated $440 million for overseas fishery development.[29] The program was spectacularly successful. The Japanese sent three boats to fish in the Bering Sea in 1952; there were 105 the following year. The boats canned king crab and salmon and they started a successful fishery for roe herring in 1962.

But the Japanese were also involved in substantial fishery developments in many other countries. Food scientist Georg Borgstrom concluded in 1964 the overseas investment program in fishery development made Japan one of the major fish sellers in the world. The expenditures were dwarfed by the economic benefits of the Japanese technical aid program, which involved shipbuilding, fish processing, and the sale of fishing gear and electronics. Borgstrom concluded that "the technical aid programme in scope and depth competes almost with FAO activities in this field and those of the entire Soviet bloc."[30]

American fisheries were growing but not as the same rate as fisheries in other countries. American boats were expanding their fisheries from southern California to the coast of Peru, another of the world's richest fishing areas. The cold waters of the Humboldt Current, moving along the South American coast from Antarctica, cause upwelling of nutrients and minerals, which stimulate the marine food chain. The anchovy fishery off Peru was built with American money. During 1963, boats landed 6.4 million tons of fish, but little of the catch would benefit Peru or any other Latin American country with malnutrition problems. The bulk of the catch would be turned into fish meal that would be fed to pigs and chickens in the U.S. and

Europe.[31] American boats were also fishing for shrimp in the Carribean and off Peru and Ecuador. They were also chasing migratory tuna and billfishes, among the fastest swimming fish in the ocean. The fish undertake extensive migrations that cross and re-cross the oceans. By the early 1950s, the worldwide tuna catch reached a half-million tons, doubling within a decade and growing to 1.7 million tons in 1974.[32] Because tuna occur off the coasts of most nations, forty countries participated in the 1974 harvest. But six nations took three-quarters of the catch, with the lion's share taken by Japan and the United States.

4.2 The 200-mile Limit

The increased international fishing was eroding the centuries old principle of the freedom of the sea. As more factory processing ship were deployed, more countries proposing legislation to protect the fish and mineral resources that lay off their coasts. During the early 1950s, Honduras, El Salvador, Peru, and Ecuador had claimed to offshore jurisdiction, a protest against the American boats fishing tuna and shrimp in their waters.[33] The first United Nations Conference on the Law of the Sea was in 1958, and the U.S. delegation wanted an international agreement on offshore limits for the territorial sea and a fishing zone. Complicating the picture was research into the mineral resources off the continental shelf, far beyond the limits of the territorial seas. Some scientists believed it would be possible to develop the technology to mine minerals, such as phosphate, nickel, copper, cobalt, and manganese from the ocean; they also thought the sea would soon be the only major source of molybdenum, vanadium, lead, zinc, titanium, aluminum, and zirconium.[34] Obviously such potentially valuable mineral resources would have to be safeguarded. Many of the mineral deposits were in the open ocean, where they theoretically could be minded by any country able to develop-and pay for-the technology.

The oceans were a hodgepodge of territorial claims by 1962; Japan, the United States, and Great Britain claimed a three mile territorial limit. India claimed six miles, Mexico claimed nine, while the USSR, Venezuela, Panama, and the United Arab Republics claimed twelve miles. Canada had recently announced it would move from claiming three miles to twelve. Off Central and South America, Chile, Ecuador, Peru, Costa Rica, and El Salvador claimed up to 200 miles of exclusive fishery jurisdictions. The claims were met with protest by other countries, especially the U.S., which had substantial investment in tuna and shrimp fisheries off these countries.[35]

With the U.S. and the Soviet Union locked in the cold war, the interest in fishing changed from the lofty altruistic goal of ensuring a world food supply to the domestic concern of increasing national security. Fish landings were static, but fish imports had tripled, creating concern about future supplies.[36] "Soviet Russia is winning the struggle for the oceans," Washington Senator Warren Magnuson said. "Scientists call it a wet war and say the outcome can determine the fate of nations and the human race. Without firing a missile, a rocket, or a gun, Soviet Russia has been winning in the Atlantic, the Pacific and the Antarctic."[37] The Interagency Committee on Oceanography of the Federal Council for Science and Technology announced in 1963 that the national goal in oceanography was to comprehend the world's ocean and to "exploit this comprehensively in the public interest, in enhancement of our security, our culture, international posture, and our economic growth."[38]

During the summer of 1965, Congress held hearings on nineteen bills submitted during the session to examine the world's oceans. The President's Science Advisory Committee in June of 1966 released a report that found "widespread and intense controversy existed concerning the adequacy of our national effort to explore, understand and develop the oceans."[39] The president's science panel expected a major breakdown in the world food economy "within perhaps 20 years," a crisis that could be avoided by increasing the harvest from the sea. "The strategic importance of food resources suggests a new focus for part of the national program," the group concluded. "In fact, the oceans are so huge and potential benefits so great that a cooperative, international effort to develop marine resources for the benefit of all humanity seemed both logical and appealing."[40] To ensure national security through the application of science and technology, Congress passed the Marine Resources and Engineering Development Act of 1966. The act recognized the need for America to remain a leader in marine science and resource development and it set up a marine science program to encourage "private investment enterprise in exploration, technological development, marine commerce and economic utilization of the resources."[41]

Congress also passed the National Sea-Grant College and Program Act of 1966 to mobilize the sciences for more rapid exploitation of marine resources.[42] There were four goals: first, to acquire the ability to predict and ultimately control phenomena affecting the safety and economy of seagoing activities; second to fully exploit the resources "represented by, in and under the sea," third to utilize the sea to enhance national security; and fourth to pursue scientific investigations to understand marine processes and resources.[43] Much of the research would focus on ways to catch fish more efficiently, increase survival of fish in hatcheries, and find ways to utilize the waste that came from fish plants. For the fishing industry, and for universities, both bills meant a rich flow of federal funds for a variety of oceanic projects.

4.3 Fishery Science at Oregon State University

One of the those schools was Oregon State University. The university is one of the land grant colleges created by the 1862 passage of the Morrill Act. The Act lays out the three mission of the colleges: first, to investigate and promote improvements in agriculture; second, to provide educational opportunities to the underclasses; and third, to provide professional training programs in the military and industrial arts. In her masters thesis, Linda Hahn argues that the close association between the land-grant colleges and the U.S. Department of Agriculture focused on breeding superior forms of domestic plants and animals with a higher potential economic return. The programs were based in the theories of Mendelian genetics and grounded in the belief that nature could be improved upon. "The craft of breeding became a science," Hahn writes. "That science found its first home within land grant colleges' agricultural programs and agricultural research stations."[44] Wildlife research in the U.S., according to historian Paul Hirt, funded research on game animals, which were viewed as a crop, research on the damaging effects of wildlife on other crops, and research on the impacts of logging on fish habitat.[45] The focus was economic, not ecological.

When the Fish and Game Management school at Oregon State was created in 1935, it was housed in the College of Agriculture under the division of Animal Industries. Between 1935 and 1949, classes included fur farming, fish and game management and a three-section class of "Economic Ichthyology," focused on the classification and distribution of fishes, with "special attention to those economic and recreational importance."[46] Hahn argues that under a Kuhnian analysis, hatcheries to improve salmon were a natural extension of the "normal" science of the time and helped to prevent biologists from following research that would benefit native fish.

Oregon State was one 12 campuses where oceanography laboratories were established in the 1950s. The Department of Oceanography was established in 1950 and within a decade it would be the fourth largest oceanography department in the country and the fifth largest in terms of annual operating budget, with much of the money coming from the federal government, the National Science Foundation, Atomic Energy Commission and U.S. Navy. There were many goals expected from oceanographic research off Oregon: improved fishery production, possible exploitation of minerals, reduced property loss due to erosion, increased coastal tourism, construction of recreational facilities such as marinas, improved weather forecasting, safe discharge of industrial pollutants into the ocean, better locations for atomic power plants and increased shipping for Oregon ports.[47]

With the post-war emphasis ocean development and the federal government eager to fund research, federal spending at the university grew rapidly. In 1967, when the National Sea Grant program was created, the university was one of eight included in the program. The first budget to the National Science Foundation asked for $701,200, to be spent on programs in marine fisheries, aquiculture, seafood processing, marine minerals, marine economics, ocean engineering, and oceanography. The total funding for the first year of the program would be $4.6 million.[48]

Federal money constructed an experimental research station in 1967 at Whiskey Creek on Netarts Bay, north of Pacific City on the

Oregon Coast. The station's initial research was on chum salmon because of the short time the fish spend in fresh water, which cuts rearing costs.[49] The first year, the site produced 75,000 chinook, 75,000 coho, 12,000 pinks and 6,000 chum fry.[50] The same year, Alaska sent pink salmon eggs to Oregon to raise at the Whiskey Creek site, part of an experiment to transfer Alaskan pink eggs in an attempt to produce an annual run.[51] Oregon coho eggs were also sent to South Korea.[52]

### 4.4 Improving Salmon

With the apparent success of the hatchery program, especially with coho salmon, there was a renewed emphasis on establishing the fish in other areas. West Coast coho were transported to Japan in the 1960s, after scientists began experimenting with the saltwater culture of rainbow trout (*Oncorhynchus mykiss*). A small commercial industry developed in Japan by 1967 and large rainbow trout were being produced at several farms by 1975. The Nichiro Company established a salmon culture division in 1970 and began a series of experiments with native and imported salmon, including coho, chinook and sockeye. Commercial production began in 1974, using salt pens. Production centered on coho by 1979, which had good resistence to disease, and good growth in the cages.[53]

Coho were also transplanted from Washington to France after a series of studies by the National Marine Fisheries Service showed that coho could be grown to a marketable size in less than eighteen months, with a final production level of 250 tons per surface acre of water. The Washington Department of Fisheries sent eyed eggs, which were fertilized and ready to hatch, to a private fish farm in Bretagne.[54]

There was continued interest in creating hybrid salmon. The Canadians had done extensive hybridization of all salmon species during the 1930s. One result was that hybridized coho turned out to be sterile. The best results came with pink salmon, but even the few fry which hatched were defective.[55] The experiments were repeated during the 1950s and 1960s in the Soviet Union, and the results were published in English in 1972, in a book translated by the Israel Program for Scientific Translations.

Hybridization was tempting; it seemed to offer the promise of rapid growth and larger fish. But the Soviet biologist who summarized the experiments, A.I. Smirnov, concluded that there were barriers such as the variations in ecological requirements of spawning times and nesting sites of different species and races. The attractive idea of creating new and superior fish "is hampered by increasingly disturbed morphogenesis in successive generations. For this reason natural spawning grounds should be protected from mass penetration of artificial hybrids."[56]

At the University of Washington, Lauren Donaldson had done extensive experiments with hybridization, creating the "Donaldson's rainbow trout," which was widely transplanted throughout the Northwest and in Japan. The fish had been designed for "rapid growth, greater weight, and a shorter cycle of spawning and egg production."[57] They seemed to be fish designed for the industrial Northwest with its goal of maximizing salmon production. The spawning time had been cut and egg production increased. The hatchery fish were substantially bigger and "deep-bodied, meaty, of fine color and the aquatic counterparts of Aberdeen Angus or Hereford cattle."[58]

Donaldson began experimenting with chinook in 1949. He selected large males and females, which would produce larger eggs, thus requiring fewer females to maintain a run so that harvest could be increased. He selected for time of return, "for the sake of convenience to hatchery workers, to spawn during a short period of time rather than dribbling in over a fairly long season."[59] He also selected fish with a tolerance to pollutants and resistence to diseases. Donaldson's chinook eggs were shipped to four states during 1970, including Oregon, and to the province of Nova Scotia as well as to Japan, which was trying to establish a run of chinook salmon.[60] Donaldson was not alone in seeking to improve salmon.

During the fall of 1961, the Washington Department of Fisheries began crossing male chum salmon with female pink salmon, creating the hybrid "chumpy."[61] An Oregon report in 1970 discusses the preliminary studies on crossing chinook males with pink and chum females, an experiment that produced smolts with good growth potential.[62] Produced at Oregon State University, the pink-chinook crosses were called "pinooks" and were subject to something biologists called bloat. "Within a few hours after eating, pinooks sometimes bloat and die from rupture. Depending on experimental conditions, bloat kills vary from zero to 100 percent in a tank of fish."[63]

Fish were viewed as interchangeable. According to a 1973 Washington Department of Fisheries report, biologists calculated the total number of eggs they needed to fill the hatchery space and the rearing capacity at the various hatcheries. If one station was short, another could increase its egg take "to fill the void."[64] The same document points to the delicate role the agency had to play: "The anadromous fishery resource is both perishable and renewable. . . while an over-harvest could imperil its renewability, an under-harvest . . . would result in an irreplaceable waste of the resource."[65] A key component of managing under MSY is that not to harvest fish is to waste them. The policies were in line with an industrial or mechanistic view of nature, which saw the individual pieces of salmon as interchangeable, having no relationship with the environment from which they were taken or subsequently placed. “Nature was thoroughly plastic and could be manipulated in the service of enterprise to the limit of human ingenuity and political will,”[66] wrote law professor Arthur McEvoy.

Since the late 1800s, thousands of fish and millions of eggs were transferred to rivers and streams in other states and countries, and the majority of the transfers failed. There was, however, one spectacular success. Between 1873 and 1934, more than six million chinook salmon had been stocked in the Great Lakes of the U.S. and Canada, with no indications that survivors successfully reproduced. But when coho salmon were stocked in the Great Lakes during the 1960s, they were extremely successful. The reason is a complex predator-prey interaction. When Lake Erie’s Welland Canal was built in 1932, it opened the four upper Great Lakes to several fish species, including the parasitic sea lamprey (*Petromyzon marinus).*

The lamprey eventually became so abundant that they eliminated the major native fishes in the lakes, allowing another non-native predator, the alewife, (*Alosa pseudoharengus*) to become the dominant species. Scientists estimated that by 1966, some 90 percent by weight of the total fish population was composed of alewives. Scientists were looking for a predator to control the alewife population, while allowing for the creation of a sport fishery. They rejected chum salmon because the plankton-feeding fish do not bite at lures, and settled on coho, which would provide better sport fishing opportunities.[67]

### 4.5 A Salmon for the Industrial Northwest

In the Northwest during the 1960s and 1970s, scientists were trying to determine the impact that industrialization was having on salmon runs. The pulp and paper industry was rapidly expanding as timber companies accelerated the rate of cut on their private lands. Many creeks and rivers were completely blocked by the debris from logging operations. Decades of operating splash dams had scoured rivers banks and river beds, increasing their velocity, scraping away gravel and reducing their complexity, all activities which hurt salmon runs. The United States Water Control and Pollution Authority released its first comprehensive study of the Willamette River in 1967. The report charged the pulp and paper mills along the river with causing pollution, and criticized the state for not acting more aggressively to clean up the river.[68] With the growth in hydroelectric facilities, there was interest in seeing if the heated waste water from thermal power stations could be used to accelerate fish growth.[69] Three Oregon utility companies funded a three-year study by Oregon State University in 1971 to examine using heated water for oyster and salmon farming.[70]

Scientists wanted a hatchery fish that would survive in a landscape that was increasingly hostile to fish. They hoped to use the emerging science of genetics to continue manipulating salmon to make them more useful. "Since fishermen prefer a larger fish, a program to increase the size of returning steelhead was started," biologist Jack Ayerst reported at a 1977 symposium sponsored by the American Fisheries Society. "We can develop in the future a strain of fish that is better suited to the rapidly changing environment of the Columbia River through intelligent genetic selection in our hatcheries."[71]

There was enormous interest in building hatcheries. The Oregon Legislature in 1961 adopted the chinook salmon as the official state fish. A fifty-four pounder returning to the Cascade Salmon Hatchery was mounted and presented to then Governor Mark Hatfield. In making the presentation, Fish Commission Chairman Herman P. Meierjurgen said it was only fitting that the fish "should be one that was reared and liberated as a young fish at a state hatchery and eventually returned as an outstanding product of the cooperative effort of man and nature."[72] With an economic boom across the Northwest and an accelerated program of dam building, utility companies like Tacoma City Light included a hatchery in their hydro development plans, to mitigate for the damage to the salmon runs. Tacoma City Light built a $10 million hatchery on the Cowlitz River, capable of rearing more than 25 million fingerlings.[73]

The Columbia River Fishery Development Program had built or remodeled twenty-one hatcheries. The Army Corps of Engineers completed two large stations on the Willamette River for the Oregon Fish Commission. The Corps built a large new hatchery at Dworshak Dam in Idaho, another at Foster Dam in Oregon, and enlarged two more hatcheries on the lower Columbia River. The Bureau of Sport Fisheries and Wildlife was building a new station at Kooskia, Idaho, while the state was expanding salmon rearing facilities on the Salmon River. Idaho Power Company was building a steelhead facility, Pacific Power and Light built a dam and hatchery on Washington's Lewis River, and Portland General Electric Company was working on the Deschutes River in Oregon.[74]

Washington Governor Dan Evans gave the keynote address to a 1977 salmon and steelhead symposium sponsored by the American Fisheries Society in Vancouver, Wash. Evans was optimistic about the resource. "I think it's pretty safe to say that the fish biologists and the scientists can produce almost any kind of anadromous fish," Evans told participants. "They can produce them in almost any amount, given the natural limitations of the streams and the food chain."[75]

References

1.Peter A. Larkin. "Management of Pacific Salmon of North America." A Fisheries in North America, Norman G. Benson, ed. American Fisheries Society, Washington, D.C. 1970. 223-236. 225.

2.L.S. Parsons and J. S. Beckett. "Fisheries Management in Canada: The Case of Atlantic Groundfish." Global Trends: Fisheries Management. E. L. Pikitch, D. D. Huppert, and M. P. Sissenwine, eds. American Fisheries Society Symposium 20, Bethesda, Maryland. 1997. 73-79. 73.

3.The Department of Fisheries Canada and the Fisheries Research Board. The Commercial Fisheries of Canada. Ottawa, 1956. 120.

4.Commercial Fisheries, 8.

5.Michael Harris. Lament for an Ocean: The Collapse of the Atlantic Cod Fishery: A True Crime Story. Toronto: McClelland & Stewart Ltd., 1998. 62.

6.William E. Schrank. "The failure of Canadian seasonal fishermen's unemployment insurance reform during the 1960s and 1970s." Marine Policy. 22(1)67-81. 1998. 67.

7.R.U. Mahaffy. "Fishing Industry Expands During 1962." Canadian Fisherman, April, 1963. 24-26.

8."Canadian Fisheries Mission to Japan." Canadian Fisherman. July, 1964. 54-55.

9.Commercial Fisheries, 2.

10."Saint-Pierre Site of Ambitious Plans." Canadian Fisherman. May, 1963. 22-24.

11.Jean P. Andrieux. "Ten fishing nations use port in 1965." Canadian Fisherman. December, 1965. 18-19.

12.Bren Walsh. "Smallwood announces $100 million program." Canadian Fisherman. March, 1965. 11.

13. "Nfld. Pink Salmon Trial Yields Only One Fish." Canadian Fisherman, March, 1962. 29.

14."Problems of the B.C. fish industry." Canadian Fisherman. May, 1964. 26-27.

15.Thomas A. Morehouse. "Limited entry in British Columbia salmon fisheries." Alaska Fisheries Policy. Arlon R. Tussing, Thomas A. Morehouse, and James. D. Babb Jr., editors. Fairbanks: University of Alaska, 1972. 385-418. 391.

16.Alex G. Fraser. "License limitation in the B.C. salmon fishery." R. Bruce Reddig and Jay C. Ginter, editors. Limited Entry as a Fisheries Management Tool. Seattle: University of Washington Press, 1980. 358-381. 385.

17.Jack Davis. "Why license limitation had to be imposed in B.C." Canadian Fisherman. November, 1968. 19-21. 20.

18."Hatcheries in British Columbia." Western Fisheries. April, 1971. 12-41. May, 1971. 72-78.

19.J.R. MacLeod. "Enhancement technology: A positive statement." Pacific Salmon: Management for People. Derek V. Ellis, ed. Victoria: University of Victoria Press, 1977. 137-147. 137.

20.MacLeod,139-140.

21.MacLeod, 138.

22.Peter A. Larkin. "Play it Again Sam–An Essay on Salmon Enhancement." Journal of the Fisheries Restoration Board of Canada. 31(8) 1974.1433-1456. 1438.

23.Larkin, 1446.

24.National Academy of Science. Oceanography 1966: Achievements and Opportunities. 1967. 2.

25.National Academy of Science, 3.

26.A.T. Pruter. "Soviet Fisheries for Bottomfish and Herring off the Pacific and Bering Sea Coasts of the United States. Marine Fisheries Review. 38(12). 1976.1-16. 9.

27.Dietrich Sahrhage and Johannes Lundbeck. A History of Fishing. Berlin: Springer-Verlag Berlin Heidelberg, 1992. 213.

28.Goerg Borgstrom. The Hungry Planet: The Modern World at the Edge of Famine. New York: The McMillan Company. 1965. 257.

29.Georg Borgstrom. Japan's World Success in Fishing." London: Fishing News (Books) Ltd. 1964. 130.

30.Borgstrom, Japan, 239.

31.Borgstrom, Hungry Planet, 280.

32.James Joseph and Joseph W. Grennough. International Management of Tuna, Porpoise, and Billfish: Biological, Legal, and Political aspects. Seattle: University of Washington Press, 1979. 369.

33.Ann L. Hollick. U.S. Foreign Policy and the Law of the Sea. Princeton: Princeton University Press, 1985. 120.

34.John L.Mero. The Mineral Resources of the Sea. Amsterdam, N.Y.: Elsevier Publishing Co., 1965. 275.

35.Hirochi Kasahara and William Burke. North Pacific Fisheries Management. Washington, D. C. : Resources for the Future, Inc. 1973. 5-6.

36.Kasahara and Burke, 22.

37.Cord-Christian Troubst. Conquest of the Sea. New York: Harper & Row, 1962. 11.

38.National Academy of Sciences. Oceanography 1966: Achievements and Opportunities. Washington, D.C.: National Academy of Sciences, 1967. 68.

39.Panel on Oceanography of the President's Science Advisory Committee. Effective Use of the Sea. President's Science Advisory Committee. June, 1966. Xi.

40. Panel, 3.

41.Miller B. Spangler. New Technology and Marine Resource Development: A study in government-business cooperation. New York: Praeger Publishers, 1970. Xxxi.

42.Spangler, 44.

43.Spangler, viii.

44.Hahn, Linda. In the Midst of a Revolution: Science, Fish Culture, and the Oregon Game Commission, 1935-1949. M.A. Thesis, Oregon State University, Corvallis, 2000. 77.

45. Paul W. Hirt. A Conspiracy of Optimism: Management of the National Forests since World War Two. Lincoln: University of Nebraska Press, 1994. 162.

46. Hahn, 173.

47.Oceanography in Oregon: A History of the Department of Oceanography, Oregon State University. Department of Oceanography, Oregon State University, October 1968. Reference 68-49. 5-6.

48. Sea Grant Institutional Program, Oregon State University. A proposal submitted to The National Science Foundation, September 1967. 1.

49.Fish Commission of Oregon. Studies on Increasing the Production of Anadromous Salmonids in Oregon Coastal Lakes and Streams. Annual Report, October, 1968.

50. Fish Commission of Oregon. Studies on Increasing the Production of Anadromous Salmonids in Oregon Coastal Lakes and Streams. Annual Report, September, 1969. 8.

51.Peter A. Larkin. "Pacific Salmon." Fish Population Dynamics. J.A. Gulland, ed. London: John Wiley & Sons, 1977. 156-186. 178.

52.Fish Commission of Oregon, Annual Report, 1969.

53.Conrad Mahnken. "Coho Salmon Farming in Japan." Culture of Salmonid Fishes. Robert R. Stickney, ed. Boca Ratan, La.: CRC Press, 1991. 131-149. 133.

54.Yves Harache and Anthony J. Novotny. "Coho Salmon Farming in France." Marine Fisheries Review. 38(8) 1976. 2-9. 2.

55.R.E. Foerster. "Interspecific Crossbreeding of Pacific Salmon." Transactions of the Royal Society of Canada. Meeting of May, 1935. Third Series, Vol. XXIX. Ottawa. 21-33

56.A.I. Smirnov. "Hybrids of Pacific Salmon of the Genus Oncorhynchus, Characteristics of Development and Prospects of Utilization." Genetics, Selection and Hybridization of Fish. Washington, D.C.: Israeli Program for Scientific Translations, National Marine Fisheries Service, 1972. 131-147. 145.

57.Neal O.Hines. Fish of Rare Breeding: Salmon and Trout of the Donaldson Strains. Washington, D.C.: Smithsonian Institution Press, 1976. 97.

58.Hines, 98.

59.J.E. Bardach and J.H. Ryther. Aquaculture: The Farming and Husbanding of Freshwater and Marine Organisms. New York: Wiley-Interscience, 1972. 497.

60.Hines, 82.

61.Washington Department of Fisheries, 1964 Annual Report, 109.

62.Fish Commission of Oregon. "Development and Improvements of Hatchery Techniques for Pacific Salmon and Steelhead Trout." Annual Report, September, 1970. 4.

63.Jim Kadera. "OSU scientists try to breed 'pinook' salmon." The Oregonian. Portland, Or. Jan. 11, 1971. F9.

64.Washington Department of Fisheries, U.S. Fish and Wildlife Service, Washington Department of Game. Joint Statement regarding the biology, status, management and harvest of the salmon and steelhead resources of the Puget Sound and Olympia Peninsula drainage areas of Western Washington. United States, et al vs. State of Washington, et al, United States District Court, Western District of Washington. May 14, 1973. 81.

65.WDF et al., 47.

66.Arthur F. McEvoy. The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850-1980. London: Cambridge University Press, 1986. 219.

67.Bardach, 49

68.Brent Walth. Fire at Eden's Gate: Tom McCall & the Oregon Story. Portland: Oregon Historical Society Press, 1994. 182.

69.Thomas A. Gaucher. "Thermal enrichment and Marine Aquaculture." Marine Aquiculture. William J. McNeil, ed. Corvallis: Oregon State University Press, 1970. 141-152. 142.

70."OSU receives $97, 535 for seafood study." The Oregonian. Portland, Or. Aug. 19, 1971. R13.

71.Jack D. Ayerst."The role of hatcheries in rebuilding steelhead runs of the Columbia River system." Columbia River Salmon and Steelhead Symposium, Vancouver, Wash., March 5-6, 1976. Ernest Schwiebert, ed. American Fisheries Society, Special Publication 10. Washington, D.C. 1977.84-88. 84.

72.Fish Commission of Oregon, Biennial Report, 1960-62. 7.

73."Hatcheries in British Columbia." Western Fisheries. April 1971. 12.

74.Leo Laythe. "The Fishery Development Program of the Lower Columbia River." Transactions of the American Fisheries Society 78th Annual Meeting, Sept. 13-14, 1948. 42-55.

75.Dan Evans. "Keynote address." Columbia River Salmon and Steelhead Symposium, Vancouver, Wash., March 5-6, 1976. Ernest Schwiebert, ed. American Fisheries Society, Special Publication 10. Washington, D.C. 13-19. 15.

# Chapter 5

## Not leaving any fish on the table

The golden age of the hatchery system in the Pacific Northwest was the 1960s. By the middle of the decade there were sixty-seven hatcheries in operation: thirty-two in Washington, twenty-two in Oregon, seven in California, four in Alaska, and two in Idaho. They were managed by a mix of nine state and federal agencies, and all were receiving state, federal, and private funds. Agencies had engineering divisions, which designed hatcheries. Hatchery construction and maintenance was the largest expenditure in the agency budgets. The focus of management was to allocate the available fish among growing numbers of sport, commercial, and tribal fishermen. The pressure to harvest as many fish as possible was relentless. Thanks to the technological breakthrough of the Oregon Moist Pellet, which led to better hatchery practices and increased survival, there seemed to be unlimited potential to create as many salmon as people wanted.[1] The pellet was now the industry standard for feeding hatchery fish and it produced coho that were big, healthy, and obviously capable of surviving.[2] Towards the end of the decade, the results of the tagging studies begun in 1960 on Columbia River hatcheries began to be known, and they were good, very good. The best of the lower river coho hatcheries provided $7 of benefit for every dollar spent producing fish.[3] Managers were not surprised by the success of their program. The Asian hatchery system had been successful for many years and it was just a matter of time until the North American hatcheries caught up. Years of research into such efficiencies as using warm water to cut the length of time it took to raise coho smolts was showing success.[4] The studies offered assurance that salmon could be manipulated to fit into an increasingly industrial Northwest economy, growing quickly in the warm waste water from pulp and paper plants and even Oregon's Trojan Nuclear Power Plant on the Columbia River.

Cost-benefit analyses were being done to quantify how much fishing was contributing to the state and provincial economy. More people than ever were catching fish, either commercially or for sport, creating more tourism activity. The link between fishing and tourism had been recognized early; Astoria held its first fishing derby in 1936. Steelhead had been considered a game fish in Washington since the early 1920s, a restriction that Oregon anglers sought to duplicate.[5] The increasing catch proved how successful the hatchery program was becoming. The sport coho catch had increased almost 300 percent, from 34,600 in 1960 to 247,000 by 1965. Ocean troll landings and Columbia River gillnet landings set 30-year records in 1965.[6] When

Oregon and Washington managers met in Seattle at an annual meeting in 1969, they heard good news. The ocean sport catch off the mouth of the Columbia River "is unequaled anywhere in the world," Henry O. Wendler of Washington Department of Fisheries told attendees.[7] Sports fishing had grown so rapidly in the last decade that the Army Corps of Engineers had enlarged the docks at the tiny Washington coastal towns of Ilwaco and Chinook. The Washington charter boat industry had expanded up to ninety boats in 1964, from a mere ten a decade earlier. Sports fishing techniques had changed from trolling with artificial lures to using live bait like herring, which "permitted more efficient angling." A decade earlier sportsmen used outboard motors. New boats with more powerful inboard motors were becoming common. It was all because of coho salmon, Wendler said. He estimated that 100,000 mature salmon within the Columbia River were less valuable from an economic standpoint than 100,000 smaller coho taken in the ocean by sportsmen. More fishing time was involved, more angler trips, more economic benefit. Wendler concluded his remarks on a triumphant note:

> It must be recognized that for a single river, the Columbia now provides the greatest salmon sport fishery that has ever existed and under wise water resource management, could reach even greater proportions.[8]

Managers believed that hatcheries would be able to break the roller-coaster ride in fish landings. The pattern with salmon harvests over the last century  had been one of a series increasingly good years, a peak, then a slow decline followed by a slow return to better landings. Hatcheries offered the potential of turning the naturally-fluctuating resource into steady-state production, with enormous economic benefits. Anybody could buy a sport or commercial salmon license, although there was talk about declaring a moratorium on issuing new permits. It was well known that there were too many salmon fishermen.  Canada began a license reduction program in 1968, designed to cut the fleet to 6,000 boats.[9]  There was discussion in both Oregon and Washington about putting a limit on the number of licenses. Salmon prices began a dramatic rise in 1971; prices for all species would triple in the next two years.[10]  The big catches, high prices, and talk of tightening the number of licenses brought still more people into the fishery.  Agencies did elaborate mathematical calculations, trying to figure out how many fish would be needed in the future. There was no consideration of allowing the status of the fish runs to dictate how many could safely be caught; the agency biologists believed they could expand the resource to meet all the demands. Not to harvest all the available fish was wasteful. Fishermen were unable to harvest all of the fish being produced by 1970, and large numbers began returning to the hatcheries. There was an outcry from both fishermen and the public that harvestable salmon were going to waste and managers should allow them to be caught.[11]

Managers recognized that good ocean conditions played a role in the increased salmon returns. But they also attributed the success to the "vastly improved physical condition of fingerlings released from the hatcheries."[12] The improved returns were "not unplanned nor unexpected. For a number of years the Commission has directed much effort toward modernization of fish cultural practices soundly based on research and practical experience," explained the 1964 Oregon Biennial Report.[13] The 1966 Biennial Report described the "spectacular upward trend" that was the result of the hatchery modernization program.[14] The proper fish diet allowed hatchery mangers to hold smolts longer to reach an optimum size when the maximum number of adults would return. Salmon numbers began to increase, especially for coho.[15] The rearing principle was developed, raising fish to the size where they would have an optimum chance to survive after release. Chinook had once been released at a very small size, where it took about 1,000 fish to equal a pound. But under the rearing principle, they were held for about three months, and released at 100 to the pound. Coho, which had been released as fry at 1,500 to the pound, were reared for fourteen months, until they reached seventeen fish to the pound. The Oregon Smolt Program, begun in 1960, would show amazing results over the next fifteen years. Production would more than triple, to twenty-four million fish by 1982 and runs increased substantially, even on streams that continued to lose habitat.[16]

Scientists believed they were remaking salmon to improve their value and efficiency. Judgements were simple: "good fish" had commodity value and "trash fish" were predators which competed with man and cut into profits. Hatchery fish were not the only populations that were heavily managed. Exotic fish, transplanted into Pacific Northwest waters for the past 100 years, had been so successful that managers now wanted to get rid of them. Their preferred weapons were toxicants such as rotenone. Approximately 45,000 pesticide products had been registered by the Pesticides Regulation Division of the U.S. Department of Agriculture by 1947. Thirty-five of the "chemical tools" had been registered for water use.[17]

"Fish husbandry and fishery management are essential for meeting the growing recreational needs of the increasing population of sportsmen," Charles R. Walker of the Bureau of Sport Fisheries and

Wildlife told a 1969 American Fisheries Society conference. "The use of chemical tools is required for attaining maximum yields by necessary manipulation of certain biological features of the aquatic ecosystem."[18] The Oregon State Game Commission began a series of "Habitat Improvement Projects" in 1962. Many of the projects were "rehabilitation" programs designed to remove "trash fish" such as black crappies, suckers and redsided shiners, whitefish, lamprey, and even rainbow trout. A compilation of the first fifteen reports, covering 1962 to 1964, showed that eleven of the projects were "rehabilitation" involving chemical toxicants.[19]

Not to harvest all the available fish was considered wasteful. Large numbers of fish were coming back to the hatcheries, providing far more eggs than managers needed to fill their ponds. There was pressure to utilize hatching facilities as fully as possible. To make sure the ponds were filled hatchery managers generally took eggs from the first portion of the returning run of fish, the early spawners. One of the consequences would be that soon the bulk of the hatchery fish, especially coho, returned far earlier than the wild runs. This gave a competitive advantage to hatchery fish which strayed into the wild and spawned. Their eggs would hatch earlier than those of wild fish and their progeny would have a head start in colonizing increasingly scarce winter rearing habitat. Hatchery workers continued the program of taking surplus hatchery fish and "liberating" them, (to use the language of the day) in waters that "were accessible but supported no natural runs or only remnant runs."[20] Other fish were planted above impassable falls or obstructions. In these situations, adults would not be able to return to the areas to spawn, but they would provide fishing opportunities for sportsmen. The program was not evaluated and it was assumed that the results were positive. "The success of this program has never been completely measured, but spot checks at each of the streams have usually indicated the liberations result in good populations of juveniles the succeeding summer," a 1968 report concluded.[21] The impact on native fish was not considered.

The economics of hatchery production continued to improve. The Oregon Biennial Report for 1966 concluded that although fish food prices had increased, a better conversion rate kept costs the same as they had been during the previous biennium. The average conversion for all species was 1.9 pounds of food per pound of fish between 1964 and 1966, compared with 2.1 pounds per pounds of fish during the previous bienium.[22]

The success attracted more fishermen. Technology was helping fulfill the policy goal of making American fishermen more efficient so they could compete with foreign competitors. Trollers coastwide had evolved from small boats fishing close to shore and returning to port at night to larger boats that were more seaworthy and had a greater range. They carried ice and could stay out longer. Gear evolved from hand-pulled operations to power gurdies that allowed a fisherman to operate six lines or more. The power gear and the introduction of the automatic pilot allowed many boats to shift from needing two people to handle the gear to a single operator. Other developments included direction finders, radiotelephone, echo sounders, loran station navigation, and radar that allowed boats to stay in one area to fish in poor-visibility conditions. The switch from cotton lines to steel allowed fishing at greater depths. Lures and other hardware increased in sophistication.[23]

The increased numbers of hatchery fish attracted more fishermen. There was virtually no regulation of the ocean fishery until 1977 and the number of boats fishing off both Washington and British Columbia increased rapidly.[24] Washington and Oregon trollers fished off British Columbia and Canadian trollers fished off the United States. The sockeye runs on the Fraser River were managed by the International Pacific Salmon Commission, but more fish were being caught outside the convention waters. When fishermen of one country catch fish originating in another the action is called an interception, and it was a growing problem for the world's fisheries. Canadians and Americans tolerated catching each other's fish, but they did not want the Japanese or the Soviets to take fish, especially the high-value salmon.

The number of high-seas factory trawlers with their awesome efficiency was drawing concern around the world. There was a growing body of research in law and economics which drew attention to the problems of exploiting unowned resources such as fish. Such resources were typically subjected to fierce competition and the fish themselves were ecologically volatile, vulnerable to a range of human and natural forces.[25]

## 5.1 The Tragedy of the Commons

Science magazine published Garrett Hardin's classic essay "Tragedy of the Commons" in 1968. The article linked fears about nuclear war, the arms race, the military-industrial complex, doubts about technology, and unpleasant truths about human nature. The classic example of the tragedy is the mismanagement of the world's fisheries, which had been known for decades. Hardin's essay discussed optimum populations, something biologists were preoccupied with estimating. "The optimum population is, then, less than the maximum," wrote Hardin. "The difficulty of defining the optimum is enormous; so far as I know, no one has seriously tackled this problem."[26] Hardin went on to argue that when a resource is managed under a commons situation, voluntary controls will not work because each individual acts to maximize his own utility, at the expense of the collective good. As long as there is profit to be made, capital will enter the fishery, causing profits to decline. The following year two economists, James A. Crutchfield and Guilio Pontecorvo, published a book about the situation, called *The Pacific Salmon Fisheries: A Study in Irrational Conservation.*[27]

The growth of the international fisheries had slowed by 1972. The average rate of increase dropped to about 1 percent from 6.5 percent each year. Boats caught 10.5 million tons of anchovies in the Peruvian fishery in 1972; the next year, the catch was 4.7 million tons.[28] Complicating the picture was a worldwide economic crisis driven by increased costs for energy and capital, adding to the constraints facing the fishing industry.[29] But while there were ominous signs that the world's oceans were being fished too heavily, there were other indications that stocks were healthy. Sardine stocks in the offshore waters around Japan showed a spectacular increase in

1972 and the salmon returns really took off. Favorable ocean conditions due to a shift in the Kuroshio current, combined with a dominant 1972 sardine year class, resulted in an increased survival rate.[30] When Japanese sardine stocks are high, they support one of the world's largest fisheries; the productivity of the area increased by about seventy-five times.[31] The productivity helped increase the Japanese chum catch from about 3 million fish in 1970, to about 62 million by 1990.[32]

### 5.2 Private Salmon Hatcheries

The excellent survival rates of hatchery fish, combined with higher prices for all species of salmon, attracted attention. The American states had always prohibited private salmon hatcheries. That ended in 1971 when California passed legislation legalizing private hatcheries. Oregon followed in 1971, allowing private companies to raise chum salmon. The law was amended in 1973 to include coho and chinook. The 1971 Washington legislature passed a law allowing salmon farmers to grow pan-sized salmon in feedlots.[33] The change in the laws was driven by the results of experiments begun in 1969 by the National Marine Fisheries Service, raising coho in Puget Sound in floating net pens. The federal biologists produced a mature fish in 10 to 12 months, a third of the time that nature took.[34]

Like the rest of the coastal states, the Alaskan constitution originally prohibited an exclusive right or special privilege of fishing in the "natural" waters of the state. The legislation was changed in 1972, allowing the development of aquaculture and to establish a limit on the number of salmon licenses the state would issue. Alaskan fish runs did poorly during the 1960s. When Alaska was made a state in 1959, the salmon harvest was only 25 million fish, the lowest since 1900.[35] There was a great deal of interest in duplicating the success of the Japanese program. The Fisheries Rehabilitation, Enhancement and Development division was created within the Alaska Department of Fish and Game and in 1974 the Alaskan legislature passed the Hatchery Act and the Fisheries Enhancement Loan Fund, which provided low-interest loans to regional aquaculture organizations.[36] The following year, the Alaska Department of Fish and Game sent biologists to Japan to study the salmon hatchery program, which was releasing more than 800 million chum salmon from Hokkaido Island alone. The return rates ranged from 2 to 4 percent.[37] The Alaskan legislature in 1976 authorized a $29 million bond measure for a series of non-profit corporations to raise pink and chum salmon.[38] The hatcheries were modeled on the Japanese system and the goal was to increase the harvest of salmon in Alaskan waters to one million fish a year by 2000.[39]

The state of Washington also wanted to emulate the Japanese program. In the wake of the 1974 Boldt Decision that mandated tribal fisherman had the right to catch half the returning fish, the state wanted to increase salmon numbers as quickly as possible. More fish was seen as the easiest way to resolve the growing tension and animosity between tribal and non-tribal fishermen.[40] Chum salmon, which could be raised in four years, seemed like the best hope. The natural chum runs had fallen to a very low ebb throughout the state because of habitat alteration. Flood runoff and land clearing had increased siltation in the streams. The market value of chum salmon had increased sharply, making it also as economically important as coho. There was an additional plus to increasing the chum population: the fish would not migrate northward into the Canadian troll, net, and sport fisheries, where increasing numbers of Washington fish were being caught, much to the irritation of state managers.

Washington Sea Grant sent two University of Washington biologists to Japan in 1975 to study the Hokkaido program. The

Hokkaido hatcheries were experiencing substantially higher survival rates than Washington hatcheries. "It is quite probable that if we can duplicate Japan's three most apparent keys to success...we can have an equally successful hatchery chum program," the biologists concluded.[41]

At the urging of Washington Senator Warren Magnuson , President Carter in 1977 announced the formation of a federal task force to develop solutions to Washington's fish problems. The result was a 348-page report, produced by a team of federal officials headed by John C. Merkel, a federal attorney. The task force's goal was to increase "the number of fish available for harvest and establish reasonable harvest opportunities for treaty and non-treaty fishermen."[42] Washington's commercial and sport fishermen were harvesting an average of 7.5 million salmon a year. The task force concluded that increasing natural and artificial production could double, and maybe even triple, salmon landings to between 15 million to 20 million fish a year.[43] The task force recommendations were never implemented; too many groups disliked elements of the plan.

But Washington did adopt a hatchery expansion plan, designed to add an additional seven million salmon a year to the state harvest. The expansion plan, written by Seattle consultants Kramer, Chin &

Mayo, detailed the commitments being made to enhancement elsewhere in the Pacific Ocean: the $29 million Alaskan bond measure; the Japanese were harvesting thirty million salmon a year, while the Soviets were harvesting nineteen million and had plans to expand their hatchery system to produce an additional nine million fish. British Columbia expected to double its harvest of twenty-five million fish. "With all of the proposals now being considered seriously, a doubling of the salmon production seems likely," the report concluded.[44]

The high price of salmon and the apparent hatchery successes were drawing private money into the salmon business. The Scandinavian countries and the British Isles had companies raising rainbow trout and Atlantic salmon in pens, aiming to produce pan-sized fish for the restaurant trade. The British opened an experimental hatchery on the West Coast of Scotland where plaice and Dover sole were raised in the warm water from the Hunterston nuclear power station.[45] Companies such as Weyerhaeuser Corporation, the timber giant, were looking for opportunities to expand and diversify and aquaculture seemed like a lucrative opportunity. Weyerhaeuser was one of four companies that began raising pan-sized salmon in Puget Sound during 1974. The timber company also diversified into a prawn project in Malaysia and freshwater shrimp in Florida.[46] Union Carbide owned 60 percent of a second company, Pacific Ocean Farms. When the company was sold in 1972, Union Carbide took over the salmon farming subsidiary and created a new company called Domsea Farms.[47]

The initial efforts made by private hatcheries in Oregon were concentrated on chum salmon. The first permit was issued in 1971 in Tillamook County to Keta Corporation. The company was allowed to use wild chum as brood stock and to buy eggs from the Oregon State University experimental hatchery at nearby Whiskey Creek.[48] Faculty member John Donaldson, the son of Lauren Donaldson of the University of Washington, left Oregon State University in 1972 and formed a private company called Oregon Aqua-Foods. The company wanted to rear salmon and trout to pan-size in ponds. It also wanted to release chum salmon at Wright Creek on Yaquina Bay at Newport. As the company gained additional financing, permits were acquired to release coho and chinook.[49] A major development came in 1975, when the company was sold to Weyerhaeuser Corporation. The pan-sized trout operation was closed and the company began buying surplus eggs from the Oregon Department of Fish and Wildlife. Weyerhaeuser expected to ultimately release 80 million juvenile salmon at Yaquina and Coos Bay on the Oregon coast. They also built a $6 million hatchery at Springfield on the Willamette River where the company also had a paperboard mill. The company planned to use the warm waste water from the mill to accelerate the growth of coho salmon, raising the fish in six months instead of the twelve to eighteen months in the state hatcheries and in the wild. The fish would be trucked to Newport and Coos Bay for release into the ocean.[50]

Weyerhaeuser was not the only corporation interested in raising salmon. Crown Zellerbach applied in 1978 for permits to raise salmon on Tillamook Bay. The Oregon Fish and Wildlife Commission issued the permit and the decision was appealed by a coalition of fishers and environmentalists. Domsea Farms, a subsidiary of Campbell Soup, set up a hatchery at Florence in 1977. Anadromous, Inc. received permits to release coho and chinook at Coos Bay in 1976. Stockholders included Charter Oil and Menasha Corporation; the Charter Oil stock was later sold to British Petroleum.[51]

With the entry of private companies, a new term–ocean ranching-- entered into common usage. The concept is the same as for state-run hatcheries: using aquaculture methods to raise fish to the optimum size for release, then turning them loose to feed on the ocean pasture. When the fish return to spawn, they are harvested. The objective is same as for hatcheries: to reduce the high natural mortality of spawning and in the early life stages, in hopes of increasing overall populations.[52] The ocean ranching operations were supposed to use eggs from the existing hatchery system, but as the number of companies increased, there was a shortage of eggs. "The availability of chum stocks continue to be a problem," the Oregon Department of Fish and Wildlife wrote in a 1969 report. "Imports appear to be the only rapid way to improve production at this time."[53] Ore-Aqua released coho eggs from Puget Sound at Yaquina Bay in 1977. Two years later, the firm released twenty million chum salmon from the Sakhalin Island in the USSR into Coos Bay.[54] Oregon issued permits by 1979 authorizing companies to release thirty-eight million coho, forty-two million chinook and 100 million chum. There were additional permits pending for another fifty million fish.[55]

### 5.3 Record salmon harvests

There was no reason to doubt that the companies would be successful. By 1976, it looked as if hatcheries had fulfilled their promise. Between 1964 and 1975 troll landings in Oregon increased by a staggering 350 percent, to an average catch of 1.5 million coho a year. The following year, in 1976, the coho catch would hit a record 5.2 million fish off Washington, Oregon, and California. The catch was worth $100 million to the Oregon coastal economy alone.

It was not only investments in salmon production that were paying off. There was increased national interest in protecting fish and mineral resources in the ocean. When the nations of the world gathered in Caracas for the first session of the third Law of the Sea Conference in 1974, there was a widespread demand by the coastal states to extend their jurisdiction over fisheries.[56] Foreign vessels were taking nearly 70 percent of the commercial catch off the American coast and as Washington Senate Warren Magnuson put it, "the foreigners have been virtually vacuuming the seas of precious life and economic value."[57]

Canada was the first Pacific Rim country to declare a 200-mile limit. The Order in Council took effect on Jan. 1, 1977. The Canadian action was followed by the passage of the Magnuson Fishery Conservation and Management Act, which took effect on March 1, 1977. The Soviet Union's Supreme Soviet Decree was passed Dec. 10, 1976, and took effect the following March. Japan extended its fishing jurisdictions up to 200 miles on July 1, 1977. A month later, North

Korea created its own exclusive economic zone.[58] In both Canada and the United States, the legislation included subsidies to expand fisheries.

5.4 The Fisheries Conservation and Management Act

The two broad purposes of the Magnuson Act were to extend the jurisdiction of the United States for the purpose of regulating and marine fisheries in the new 200-mile limit zone and imposing a management regime within the zone through the establishment of eight regional fishery management councils which would be overseen by the Department of Commerce.[59] The legislation was a compromise, hammered out between the distant water shrimp and tuna fleets that fished the high seas and domestic fishermen who saw 70 percent of the catch in American waters taken by foreign fishing boats. There was also strong objection to the legislation from the secretaries of State and Defense, concerned that the unilateral claims undercut United States efforts to negotiate international obligations by coastal states in managing offshore areas.[60] Fishing interests were also unhappy about the extent to which environmentalists influenced the legislation. In the past, federal policy had been aimed at expanding the industry through research, exploration, and development. "The new law brought the national government broadly and squarely into the business of policing fisheries use for the first time."[61] The emphasis would be on expanding opportunities for American fishermen, but there was also language about protecting stocks from over-fishing.

Maximum Sustained Yield was at the heart of the new legislation. It continued to be the central goal for fisheries management. The law said "conservation and management measures shall prevent overfishing while achieving on a continuous basis the optimum yield from each fishery." Although the term "optimum yield" was defined, it was extremely vague.

> The term 'optimum' with respect to the yield from a fishery means the amount of fish (A) which will provide the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunities; and
> (B) which is prescribed as such on the basis of the maximum sustainable yield from each fishery, as modified by any relevant economic, social or ecological factor.[62]

The language was drafted by an attorney, Christopher M. Weld. Weld was executive director of the National Coalition for Marine Conservation. His bill, H.R. 8265, was introduced into the House of Representatives on June 26, 1975. Four years later, Weld wrote an article on the experience for Fisheries, the American Fisheries Society bulletin, on the results of the legislation. On the subject of MSY, Weld wrote:

> It is highly doubtful that either Congressional staff personnel responsible for drafting the definition or the Committee members who approved it has more than a tenuous grasp of the concept. More than once in Committee session the sentiment was expressed, "Well, you've got to start somewhere," as if MSY were a fixed reference point. Unfortunately, it is not. MSY is a theoretical ration based on a hypothetical ratio. In other words, as a reference point, MSY is very slippery. Probably if the non-biologists responsible for the incorporation of MSY into the Act thought about it at all, they envisioned MSY has the maximum number of fish that could be harvested from a fishery on a continuum basis without doing harm to the fishery–if the fish stocks were at optimum levels.[63]

The new act mandated that social and economic factors had to be considered in establishing management objectives. Any shift away from MSY for economic, social or ecological reasons had to be substantiated by the using the best scientific information available.[64]

Fish stocks were at anything but optimal levels. Scientists identified sixteen species off the U.S. that were overfished when the act was passed. There were active efforts on the West Coast to reduce the size of the salmon fleet. British Columbia began to reduce its salmon fleet in 1968. Alaska began limiting the number of salmon permits in 1973, after the number of boats had more than doubled and the catch was in decline.[65] Washington tried to reduce the amount of salmon fishing gear and put a cap on the number of salmon licenses in 1974. But because of the Boldt Decision, there was pressure to expand fishing opportunities for tribal fishermen.[66] And the forces of expansion were strong, especially after 1976. In addition to the Fishery Conservation and Management Act, Congress passed additional legislation included the Capital Construction Fund, Fishing Vessel Obligation Guarantee Program and several Buyback Programs, including one for salmon boats in the Northwest.[67] Officials were trying to freeze the size of the salmon fleet, but more money was pouring into the fishing industry overall. The new government programs were aimed at building larger boats to target species of groundfish. But with multi-million salmon enhancement programs in place from Alaska to Oregon, there were expectations that salmon catches would continue to increase.

The Washington, Oregon, and California coho catch peaked in 1976 at 5.2 million fish, an all time record. But just a year later, coho landings had plummeted by two thirds, making the lowest commercial landings since 1961 and the worst ocean sport fishery on record.[68] There appeared to be limits on how many salmon would survive in the ocean.[69] Agency officials in Oregon and Washington and on the Columbia were confronted with a troubling problem: the more smolts the hatcheries released, the fewer adult fish came back. And there were disquieting indications that all was not well with the wild fish. As Oregon biologist Paul Reed wrote in 1975, peak counts in Oregon coastal streams had been at or below average for the past nine years and were especially low for the last three years. It was a similar story on the Columbia tributaries, where the number of returning adult fish during 1973 and 1974 were record lows. "No increase in ocean fishing pressure on Oregon coho is justifiable considering the present status of our wild stocks."[70] But until the passage of the Magnuson Act in 1976, and the creation of the Pacific Fishery Management Council the following year, there was no mechanism to slow the ocean catch. The states only controlled fishing out to three miles; beyond that, it was international waters and Canadian and American troll boats fished heavily on each other's stocks.

There were other pressing problems as well. The Northwest region was locked in a battle about how much electricity would be needed in the future. Additional dams were being built and many of the ones on the mainstem Columbia River did not have systems to pass juvenile salmon. The mortality on the outgoing fish was estimated at 15 percent for each dam the fish had to pass through.[71] At the same time, the region's utility companies were predicting that more power plants were necessary to provide for the future growth of the Northwest. The projections were controversial. Many citizens questioned the assumptions and suggested that energy conservation should be the focus in the future, not expanding of the hydroelectric system by building more dams. The Columbia River Indian tribes sought support for repairing the damage to the region's salmon runs. "Rather than choosing among these partially conflicting claims, Congress sought to accommodate them all," wrote Washington political scientist Kai N. Lee in 1993. "The result was an increasingly complex piece of legislation, whose implementation has taken turns unanticipated by those who fashioned the compromises."[72]

Congress passed the Northwest Power Act at the end of 1980. Its goals were to prepare a plan for regional electric power development and to bring back the salmon. The council's fish and wildlife plan was designed to double the runs returning to the Columbia River to five million fish from the current 2.5 million, and the council looked to hatcheries to do it. The runs in the preindustrial era were estimated to be between 10 million and 16 million fish.[73] There was broad public support for a plan that would "rebuild the salmon populations so that there would once again be enough for all to take "in common" without battling one another for the right to kill off the stocks forever." [74]

But there was a great deal of conflict about how to rebuild the salmon runs. Hydropower, irrigation, navigation, and urbanization all placed demands on the Columbia and its water. The new council had two members each from four states, Washington, Oregon, Idaho, and Montana. Each state had different interests in both the power issues and the salmon issues. The council also had limited authority, which made "coordination of the rehabilitation effort indirect at best."[75] Increasing the salmon population meant allocating more water to the fish and away from the utilities, irrigators, barging interests, manufacturers, and farmers. "The easiest solution was to focus on technological fixes to the salmon dilemma rather than on natural means of restoring endangered salmon populations."[76] The council turned to hatcheries and a program called supplementation. The idea was to release hatchery-bred juvenile fish into streams that no longer had major populations of salmon, in hopes of creating more fish for harvest while at the same time increasing the natural spawning population. Supplementation is thought to combine the advantages of hatcheries, especially the high survival rate of young fish before they are releases, with the strength that comes the natural selection process.[77] As Kai Lee pointed out, there was skepticism that supplementation would work:

> Supplementation thus promises effective use of existing and new hatchery capacity, together with the hope of rebuilding wild stocks in their native streams and at populations levels that will permit harvest. Supplementation may not work. It has never been tried on as large a scale as is being proposed in the Columbia basin.[78]

As the Northwest Power Planning Council legislation was moving through Congress, Canadian biologist Peter Larkin wrote another essay, questioning the prevailing optimism about salmon enhancement. Larkin, who had been so optimistic about the possibilities of salmon enhancement just five years earlier, was no longer so positive. He called the essay "Maybe you can't get there from here: a foreshortened history of research in relation to management in Pacific salmon." Larkin said the "standard religion" on salmon had been that research, regulation, protection and enhancement were the components of successful salmon management. But he was no longer sure the standard religion worked.

> It is the thesis of this essay that these perceptions will not be sufficient for the future: that the current prospect for natural populations of salmon is a long, slow decline in abundance; and that only a major change in attitude will make it otherwise.[79]

The change in perspective had taken just a decade. The fish and wildlife agencies had gone into the 1970s confident that they had created a technologically-generated niche where salmon could be maintained despite the habitat alteration as the Northwest economy boomed, creating more jobs and attracting more population. Scientists believed that improved hatchery technology, along with increasingly specialized diets, would allow them to produce as many salmon as society wanted. Both the Canadians and American governments were involved in multi-million efforts to expand the number of salmon. Negotiations for a new salmon treaty began in the early 1970s but the stakes increased dramatically because of the new enhancement programs. Each nation wanted to make sure its fishermen harvested their share of the increased catch.

More people were involved in fishing. Thousands bought licenses, both sport and commercial. As managers talked restrictions, trollers, gillnetters, purse seiners, and sportsmen hired economists to calculate the value of their catch and its economic impact on their communities. Salmon prices increased, drawing interest from multi-national companies that wanted to share in the potential profits. The catches climbed until 1976, when fishermen caught 5.2 million coho off Washington, Oregon, and California. The following year the catch dropped by 75 percent; chinook catches also began to drop. By 1983, a new term, "El Nino" entered the picture. The ocean warming event decimated stocks of salmon, especially the hatchery runs of coho and fall chinook. The golden age of the hatchery system, when it seemed that unlimited numbers of salmon were within easy reach, was over.

References

1.Jim Lichatowich and J. D. McIntyre. "Use of Hatcheries in the Management of Pacific Anadromous Salmonids." American Fisheries Society Symposium 1: 1978. 131-136. 133.

2.Roy J. Wahle, Robert R. Vreeland and Robert H. Lander. "Bioeconomic contribution of Columbia River hatchery coho salmon, 1965 and 1966 broods, to the Pacific Salmon fisheries." Fishery Bulletin. 72(1) 139-168.

3.R.N. Williams, L.D. Calvin, C.C. Coutant, M.W. Erho, J.A. Lichatowich, W.J. Liss, W.E. McConnaha, P.R. Mundy, J.A. Stanford and R.R. Whitney. Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem. Northwest Power Planning Council, NPPC 96-6. 1996. 358.

4.T.A. Gaucher, T. A. "Thermal Enrichment and Marine Aquaculture. Conference on Marine Aquiculture, May 23-24, 1968, Oregon State University. Marine Aquiculture. W. J. McNeil, ed. Corvallis: Oregon University Press, 1970. 141-152. 142.

5.Lisa Mighetto. "Sport Fishing on the Columbia River." Pacific Northwest Quarterly. Winter, 1995/96. 5-15.

6.Fish Commission of Oregon. Biennial Report, 1964-66. 11.

7.Henry O. Wendler. Status of fisheries and stocks–sport fishing aspects. One Hundred Thirty-first meeting, Columbia Basin Inter-Agency Committee, U.S. Bureau of Commercial Fisheries Laboratory, Seattle. Oct. 6, 1965. 2-4.

8.Wendler, 4.

9. Jack Davis. "Why license limitation had to be imposed in BC." Canadian Fisherman. November, 1968. 19-21. 20.

10.Kramer, Chin & Mayo, Inc. Washington Salmon Study: A study which develops and defines a program for the period 1977 to 1981, for the enhancement of the salmon fishery in the State of Washington. Washington Department of Fisheries, 1976. 35.

11.Fish Commission of Oregon, Biennial Report. 1970-72. 23.

12.Biennial Report, 1970-72, 19.

13.Fish Commission of Oregon, Biennial Report. 1962-1964. 16-19.

14.Fish Commission of Oregon, Biennial Report. 1964-1966. 5.

15.Lichatowich and McIntyre, 132.

16.Joseph E. Taylor III. Making Salmon: An environmental history of the Northwest Fisheries Crisis. Seattle: University of Washington Press, 1999. 235.

17.H.W. Hays. "Uses, regulations and registration of chemicals used in fish culture and management." Fish & Chemicals: A symposium on registration and clearance of chemicals for fish culture and fishery management. Sept. 12, 1969, New Orleans. U.S. Bureau of Sport Fisheries and Wildlife, Sept. 12, 1969.3-4. 3.

18.Charles R. Walker. "Problems in clearance and registration of chemical tools used to fish culturists and fishery biologists." Fish & Chemicals: A symposium on registration and clearance of chemicals for fish culture and fishery management. Sept. 12, 1969, New Orleans. U.S. Bureau of Sport Fisheries and Wildlife. 1-54. 2.

19.Oregon Game Commission. Habitat Improvement Project, 1962-1964. Portland. Reports 1-15.

20.Fish Commission of Oregon. Biennial Report. 1964-1966. 12.

21.Fish Commission of Oregon. Studies on Increasing the Production of Anadromous Salmonids in Oregon Coastal Lakes and Streams. Annual Report, 1968. 46.

22.Fish Commission of Oregon. Biennial Report. 1964-1966. 13.

23.Samuel G. Wright. "An Examination of Washington's Troll Salmon Fleet in 1967." Washington Department of Fisheries, 1970. 5-18.

24.Gary S. Morishima and Kenneth A. Henry. "The History and Status of Pacific Northwest Chinook and Coho Salmon Ocean Fisheries and Prospects for Sustainability." Sustainable Fisheries Management: Pacific Salmon. E. E. Knudsen, C. R. Steward, D. D. MacDonald, J. E. Williams and D. W. Reiser, editors. Boca Raton: Lewis Publishers. 219-235. 224.

25.Arthur F. McEvoy. The Fisherman's Problem: Ecology and Law in the California Fisheries. Cambridge: Cambridge University Press, 1986. 215.

26.Garrett Hardin. "The Tragedy of the Commons." Science. 162. 1243- 248. 1243.

27.James A. Crutchfield and G. Pontecorvo. The Pacific Salmon Fisheries: A Study in Irrational Conservation. Baltimore: John Hopkins Press, 1969.

28.McEvoy,208.

29.J.P. Troadec. "The Mutation of World Fisheries: Its Effects on Management Priorities and Practices." Management of World Fisheries: Implications of Extended Coastal State Jurisdiction." E. L. Miles, ed. Seattle: University of Washington Press, 1989. 1-18. 2.

30.K. Kondo."The Recovery of the Japanese Sardine–The Biological Basis of Stock-Size Fluctuations." Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 177: 332-354. 1980. 344.

31.T. Wada and L. D. Jacobson. "Regimes and stock-recruitment relationships in Japanese sardine (*Sardinops melanostictus*), 1951-1995." Canadian Journal of Fisheries and Aquatic Sciences. 55: 1998. 2455-2463. 2455.

32.M. Ogura and S. Ito. "Change in the Known Ocean Distribution of Japanese Chum Salmon, *Oncorhynchus keta,* in relation to the progress of Stock Enhancement." Canadian Journal of Fisheries and Aquatic Sciences. 51:1994. 501-505. 501.

33.William McNeil and Jack Bailey. Salmon Rancher's Manuel. Northwest Fisheries Center Auke Bay Fisheries Laboratory, National Marine Fisheries Service. July 1975. 73.

34."Status Report: Commercial Salmon Culture in Puget Sound. The Commercial Fish Farmer. Sept/Oct 1975 Vol. 2, No. 1. 8.

35.A.C. Wertheimer. "Status of Alaska Salmon." Pacific Salmon and Their Ecosystems: Status and Future Options. D. J. Stouder, P. A. Bisson and R. J. Naiman, eds. New York: Chapman & Hall, 1997. 179-197. 181.

36.Ray Hilborn and D. Eggers. "A Review of the Hatchery Program for Pink Salmon in Prince William Sound and Kodiak Island, Alaska." Transactions of the American Fisheries Society. 129:2000. 333-350. 333.

37.S.A. Moberly and Robert Lium. Japan's Salmon Hatchery Review. Alaska Department of Fish and Game, 1977. 6.

38.Kramer, Chin & Mayo. 11.

39.Kramer, Chin & Mayo. 14.

40.John C. Merkel, Dayton L. Alverson and John Hough. Settlement for Washington State Salmon and Steelhead Fisheries. The Regional Team of the Federal Task Force on Washington State Fisheries. June, 1978.

41.Steven B. Matthews and H. G. Senn. Chum Salmon Hatchery Rearing in Japan. Washington Sea Grant. 1975. 1-24. 16

42.Merkel, xii.

43.Merkel,43.

44.Kramer, Chin & Mayo, 14.

45.Clifford Hampden. "Fish Farming: The Answer to Over-Fishing." Commercial Fish Farmer. March/April, 1974. 1(4).10-11.

46.Jim Kadera. "Weyerhaeuser buys salmon ranch." The Oregonian. Aug. 21, 1975. C5.

47."Company sold." Commercial Fish Farmer. September/October, 1975. 2(1). 18.

48.T.E. Cummings. Private Salmon Hatcheries in Oregon. Oregon Department of Fish and Wildlife, 1979. 7.

49.Cummings, 8.

50.Jim Kadera. "Fish beginning to return to private salmon hatchery." The Oregonian. Oct. 12, 1977. E3.

51.T.E. Cummings. Private Salmon Hatcheries in Oregon 1986. Oregon Department of Fish and Wildlife. 14.

52.Brian E. Riddell. "Salmonid enhancement: Lessons from the past and a role for the future." Salmon in the Sea and New Enhancement Strategies. D. Mills, ed. Oxford: Blackwell Scientific Press, 1993. 338-355. 346.

53.Cummings, 1986. 8.

54.Cummings, 1986. 12.

55.Cummings, 1986. 9.

56.Troedec, 2.

57.Warren G. Magnuson. "The Fishery Conservation and Management Act of 1976: First Step Toward Improved Management of Marine Fisheries." Washington Law Review. 52(3): 427-450. 432.

58.C Park. "Implications of Extended Coastal Jurisdiction for the Management and Development of World Fisheries: The Northwest Pacific Region." Management of World Fisheries: Implications of Extended Coastal State Jurisdiction." E. L. Miles, ed. Seattle: University of Washington Press, 1989. 174-184. 175

59.Magnuson, 434.

60.Ann L. Hollick. U.S. Foreign Policy and The Law of the Sea. Princeton: Princeton University Press, 1981. 353.

61.McEvoy, 242.

62.Christopher M.Weld. "The First Year of Federal Management of coastal fisheries: An outsider's view." Fisheries. 4(2) 13. 1979. 12-15.

63.Weld,13-14.

64.Dayton L. Alverson. "The role of Conservation and Fishery Science Under the Fishery Conservation and Management Act of 1976." Washington Law Review. 52(3): 723-741. 1977. 728.

65.J. Hanrahan and P. Gruenstein. Lost Frontier: The Marketing of Alaska. New York: W. W. Norton & Company, 1977. 293.

66.Gary Benson and Robert Longman. "The Washington Experience with Limited Entry." Limited Entry as a Fishery Management Tool: Proceedings of a National Conference to Consider Limited Entry as a Tool in Fishery Management, July 17-19, 1978. Denver, Colo. R.Bruce Reddig and Jay Ginter, editors. Seattle: University of Washington Press, 1978. 333-352. 333.

67.John H. Dunnigan. Federal Fisheries Investment Task Force, Report to Congress. July 1999. Xviii.

68.Robert T. Gunsolus. The status of Oregon coho and recommendations for managing the production, harvest, and escapement of wild and hatchery-reared stocks. Oregon Department of Fish and Wildlife, 1978. 2.

69.Carl Walters. "Management Under Uncertainty." Pacific Salmon Management for People. Derek V. Ellis, ed. Victoria: University of Victoria Press, 1977. 261-297.266.

70.Paul Reed. Status of Oregon coho salmon stocks with respect to current troll fishery regulations. Oregon Department of Fish and Wildlife, Newport. 1975.1-10. 8-9.

71.Columbia River Fisheries Council. Draft public review, Comprehensive Plan for Production and Management of Columbia River Basin Anadromous Salmon and Steelhead. Columbia River Fisheries Council, Portland. 1980. 203

72.Lee, 31.

73.Lee, 23.

74.Lee, 21.

75.Michael V. McGinnis. "On the Verge of Collapse: The Columbia River System, Wild Salmon and the Northwest Power Planning Council." Natural Resources Journal. 35 (Winter) 1995. 63-92. 72.

76.Riddell, 346.

77.Lee, 21.

78.Peter A. Larkin. "Maybe you can't get there from here: A foreshortened history of research in relation to management of Pacific salmon." Canadian Fisheries Research Board. 36(1) 98-106.

## Conclusions

Oregon State University held a conference on coastal estuaries in the spring of 1971 at Corvallis. Oregon's senior senator, Mark O. Hatfield, urged scientists to come up with a grand design for the "preservation and development of the Northwest's estuaries." The Republican senator and former governor suggested that the small coastal fishing community of Newport had the potential to become a center for international shipping. Perhaps an offshore island could be constructed to handle supertankers that would be too large for the existing ports on the West Coast. Federal money would be available "if we could show that we have the manpower, the leadership and involvement to carry out a model estuary," Hatfield was quoted as saying in the Portland *Oregonian.* The story was accompanied by a shorter account about a "vibrant " new fish farming industry that would be possible for Oregon "if social, political and legal hurdles can be crossed."[1]

There was no mention of biological barriers. In the post-World War II optimism about the future, when all things seemed possible, there was no apparent contradiction between preserving the "fragile beauty" of a small, coastal community and proposing that it be transformed into an international supertanker port. The difficulties of creating a new natural resource-based industry were seen as social and political, not biological.

This thesis contends that the rapid development of technology has played a significant role in the global expansion of fisheries and aquaculture during the twentieth century. Michael Harris, a Canadian journalist who documented the collapse of the Atlantic cod fishery in *Lament for an Ocean,* writes that the deep-sea fishery "is the closest thing to a gold rush that the ocean has to offer."[2] The exploitation of the world's fisheries after World War II was indeed a gold rush, with government policies aimed at facilitating the extraction of resources as quickly as possible.

In *The Elusive Transformation: Science, Technology, and the Evolution of International Politics,* political scientist Eugene Skolnikoff argues that national governments after World War II increased their investments in research and development, resulting in the development of a systematic process to apply technology to various problems. He also argues that the dissemination of technical information, mainly through government agencies and resources, played a role in the intensified integration of national economies. The transfer of technology and the invention of new techniques contributed to the creation of new international financing arrangements.[3] All of these forces played roles in the decline of salmon and groundfish stocks off the West Coast.

This thesis makes four findings: (1) government-funded research aided the rapid transfer of technical information among Canada, the United States, Japan, and the Soviet Union; (2) that fisheries were vehicles that helped establish the current global economic infrastructure; (3) that science was vastly too optimistic in its assessment of how much food could be wrung from the ocean on a sustainable basis; and (4) that salmon policy tended to be grounded in political, social, economic considerations, not what was known about the biology of the fish.

In *Dust Bowl: The Southern Plains in the 1930s,* historian Donald Worster says the ecological collapse of the Southern Plains during the 1930s was the result of capitalism and culture. The destruction of the land "came about because the culture was operating in precisely the way it was supposed to. Americans blazed their way across a richly endowed continent with a ruthless, devastating efficiency unmatched by any people anywhere."[4] That same "ruthless, devastating efficiency" would be unleashed in the Pacific Ocean after World War II.

A key economic policy for all four countries after the war was to invest heavily in the extraction of natural resources, especially those in the ocean. All four countries allocated funds to expanding fishing opportunities, through loans to build fishing boats and processing facilities. All governments used their university systems and government laboratories to undertake research on more efficient fishing techniques and how to process species which could not be readily marketed, such as the soft-fleshed Pacific whiting. All four countries greatly expanded the scope of their fisheries, and Japan, the Soviet Union, and the U.S. became global fishing powers. The countries also vastly expanded aquaculture facilities for a number of fish species, as well as their hatchery systems for raising salmon.

There is ample information about the rapid transfer of fish culture technology, especially with regard to salmon, traditionally one of the most high-value commercial fisheries in the world. Efforts at increasing the salmon supply date to the 1800s; the Bucksport Salmon Hatchery opened in 1976 in Maine, hoping to reverse the decline of Atlantic salmon. The first Japanese hatchery, Chitoe Central Hatchery, was built in 1888 and modeled after the Maine facility. There was an exchange of information and personnel between fish-culture operations in Canada and the eastern U.S. The Soviet Union's involvement in aquaculture came somewhat later, starting in 1919. Hatchery construction proceeded rapidly, especially after 1928. The program was boosted after World War II when the Japanese were forced to cede Sakhalin Island to the Soviets. The Japanese left twelve operating hatcheries with a capacity for 130 million eggs; five of the hatcheries were restored by 1955. It is beyond the scope of this paper, but there is a substantial body of work examining relations between Japan the Soviet Union, as both nations wrestled to control the rich fishing resources of the Northeast Pacific Ocean.

A formal mechanism for scientists to exchange information was established with the creation of the Pan-Pacific Science Conference in 1920. Four Japanese scientists attended the first meeting of the group and the 1926 meeting of the newly-formed Pacific Science Association was in Tokyo. Further research is warranted into the agendas for these meetings, to document exactly what kind of information was exchanged. The Japanese published their research in English in at least four journals during the 1920s, including works on botany and mathematics, as well as the Records of Oceanographic Works in Japan, published by the Committee on Pacific Oceanography of the National Research Council of Japan in 1928. It would be interesting to study the volumes in the series to see what information was included about fishing techniques and exploration for fish stocks.

The Americans created the Pacific Fishery Investigations of the U.S. Fish and Wildlife Service in 1949, to translate Japanese fishing and oceanographic data into English. The agency also translated information on Japanese hatchery practices. The U.S. Bureau of Commercial Fisheries established a translation program in 1963 to disseminate information about Russian scientific literature and to act as a clearing house for translations from all languages. More than 5,000 completed translations were available at no charge. Further research into how many of the documents discussed fishing techniques, fish processing, oceanographic exploration, and aquaculture would be of interest.

All countries were involved in rapidly expanding ocean fisheries after World War II. With the development of the modern factory trawlers, capable of staying at sea at months at a time and fishing in all weather, new fisheries abounded. The Japanese pioneered the canning of king crab and salmon in the Bering Sea, started a successful fishery for roe herring, a purse-seine fishery for tuna, and whaling in Antarctica. They also pioneered joint venture operations, to either build boats or fish processing plants, in almost every country around the globe. The scope of the Japanese fishing is worthy of much greater study. Food scientist Georg Borgstom pointed out in 1964 that the Japanese technical aid program "competes with FAO activities in this field and those of the entire Soviet bloc."[5] I suggest that where fisheries are concerned, the role of the Japanese in the creation of the global fishing fleet deserves special attention.

The Soviets also made a substantial commitment to building a deep-sea fishing fleet. By the time the British launched the first factory freezer ship, the *Fairtry,* in 1954, the Soviets had ordered 24 trawlers of the same design. Between 1954 and 1956, the Soviets built twenty-four factory-freezers at Kiel, West Germany. Shipbuilding was also expanded in the satellite countries of Communist Poland and East Germany. Soviet boats appeared off North America in 1954, then expanded into the South Atlantic and the Indian oceans, as well as the far east fishing grounds off both Alaska and Peru. They mounted an experimental fishery for krill in the waters off Antarctica in 1969. The transfer of shipbuilding and fishery technology and products contributed to the globalization of international trade. The expansion of the Soviet fishing fleet, especially to the waters off the U.S., contributed to Cold War fears about the security of the nation's food supply and supremacy in oceanographic technology. The pressures led to federal policies that expanded loans for ship building and new processing facilities.

Canada did not expand its global fishing presence. But the federal government actively supported the expansion of domestic fishing opportunities, especially in the Maritime provinces, with programs of low-interest loans to build boats and new processing facilities. Fisheries were an important component in helping to balance trade with the U.S. and other countries. Canadian concern about foreign trawlers fishing off its coasts pushed the federal government into adopting a 200-mile limit in 1977. The creation of the Salmon Enhancement Program, with its $400 million price tag, escalated Canadian concern about protecting its fishery's investment in the Pacific Ocean.

The U.S. government funded exploration for new fish stocks, such as anchoveta off Peru and pink shrimp off Oregon. Two key pieces of legislation were passed in 1966, the Marine Resources and Engineering Development Act and the National Sea-Grant Program. More research is needed on what projects were funded under this legislation. Federal funds were instrumental in two experiments with enormous impact for salmon. The National Marine Fisheries Service during the 1970s funded critical research on using warm water to accelerate the development of coho salmon. The apparent success of the program led directly to private companies such as Weyerhaeuser Corporation and Union Carbide becoming involved in private salmon hatcheries. The initial vehicle for the expansion of private hatcheries in Oregon was using the Oregon State University experimental hatchery at Netarts Bay, the only source of chum eggs. When the hatchery could not produce enough eggs, political pressure led to legislative changes that allowed the introduction of eggs from Puget Sound and the Soviet Union. Ocean ranching efforts in Oregon were a failure and the ecological consequences contributed to the status of Oregon coastal coho today. The stocks are listed as threatened under the Endangered Species Act.

There can be no question that scientists and policy makers were too optimistic about what technology could and could not do when it came to taking protein from the ocean. "This optimism at times leads to the view that there are few constraints on technological possibilities, that technologies can be designed to solve all problems or reach all goals, if only enough financial and human resources are allocated," Skolnikoff writes.[6] Despite the infusion of enormous amounts of capital, many of the things predicted by scientists during the 1960s have not come about. There are no underwater nuclear power plants using their waste heat to generate upwelling and stimulate fisheries production. Many of the dreams of the Cold War period, such as using nuclear bombs to reconfigure the continents, now seem like science fiction.[7] While humanity's knowledge of the sea has greatly expanded, the oceans have by no means been conquered. The sea cannot be harvested in the same way as the land. It is possible to enclose an area, fertilize a species of fish and control predators, producing great quantities of protein. But while such techniques work with some fish species, the record with wild Pacific salmon is decidedly mixed.

The modern fishing methods pioneered since World War II are extremely efficient at catching fish, but enormous quantities are wasted because they are "bycatch," discarded for a variety of market and regulatory reasons. Bycatch varies by type of fishery and region, but it is estimated at 27 million metric tons globally, with a range of 17.9 to 39.5 million. The highest discard rate is in the fisheries of the Northwest Pacific.[8]

The one common goal in the research I have studied was to achieve Maximum Sustained Yield. While MSY was an improvement over the idea that the resources of the ocean were limitless, it also has substantial drawbacks. It is essentially an economic equation, not an ecological one. One result as far as fisheries are concerned is that some substocks of herring, cod, ocean perch, salmon, and lake trout have been eliminated.[9] As Hanna J. Cortner and Margaret A. Moote have observed, the focus on MSY has too often been harvesting the maximum available amount, with little regard for the impact on other systems:

> Intuitively, sustained yield is a logical and laudable goal: no more is taken than can be replenished. As it has come to be implemented, however, the concept of sustained yield has been modified to mean taking the maximum supply a system can withstand (i.e., the furthest point to which production can be pushed without impairment of the resource's ability to reproduce.[10]

As far as salmon are concerned, much of the research during the last few decades has been on finding a way to fit a hybridized and improved salmon into an increasingly industrialized Pacific Northwest. Science promised that hatcheries had the potential to mitigate for fish lost to a variety of industrial uses, from irrigation to hydroelectricity. At the same time, hatcheries offered the potential for important economic development in coastal areas where employment opportunities were limited. Hatcheries were seen in the positive light of other post-world war technological successes. There was no systematic evaluation of the hatchery program until 1960 and there was a widespread expectation that hatcheries would be successful. "Salmon hatcheries gained and maintained their popularity because they appeared to resolve problems within economic development," historian Joseph Taylor writes. "Making salmon has been a political success story but a fiscal and ecological disaster."[11]

It is beyond the scope of this study to detail the interactions between hatcheries and wild fish. Much of what is known about the migration patterns, distribution, abundance, survival, and recovery of salmon and steelhead stocks throughout their range comes from hatchery technology developed during the 1970s through the use of coded wire tags. Before that, the only information scientists had were trends in spawning escapement and catches, not enough information to base a scientific or legal argument to justify harvest reductions. As the coded wire tag technology evolved, it showed that many stocks were being systematically overharvested throughout an extensive geographic range. The emergence of the personal computer gave managers a way to process large quantities of data into computer models, that provided information on the distribution of fish and fishing mortality.[12]

The focus of hatcheries for most of the last century has been to make stocks homogeneous, to produce easily manipulated stocks with advantages such as "short run timing, relative simplicity of harvest management, smaller size for easy of handling, and docile behavior which may have resulted improved within-facility survival."[13] The work of Dr. Lauren Donaldson at the University of Washington focused on increasing the rates of growth of the salmon to produce cost and space efficiencies. One unintended result is that fewer numbers of individuals within the population reach the maximum potential adult size, thereby reducing the quantity and quality of eggs produced.[14]

The hatchery expansion between 1945 and 1980 fueled the growth of ocean fisheries, adding to management complexity and cost. The Washington hatchery program directly led to the growth of the West Coast Vancouver Island troll fishery, which harvested up to 90 percent of some runs of Washington coho and Washington and Oregon chinook stocks. There were enormous political and legal difficulties before the Pacific Salmon Treaty could be signed between Canada and the U.S. in 1985. The treaty involved a balance among four American states, twenty-four treaty tribes, one province, and one territory. There were six distinct fisheries involved, all with complex biological, political, and social interactions.

The ocean salmon fishery is what is known as a mixed stock fishery, meaning that trollers and ocean sportsmen will catch both hatchery and wild fish, chinook and coho. A handful of hatchery fish will supply all the eggs needed to fill the trays at a modern hatchery, meaning that the rest of the surviving population can be harvested. But wild stocks, even at optimum populations, can only sustain a harvest rate of about 50 percent, so the overall catch must be lower or the wild runs will be systematically over-harvested. Overall harvest rates on coho in the ocean fishery reached 88 percent during the 1970s, contributing to the decline of the coastal coho stocks a decade later. Trolling takes its toll of immature fish, especially chinook, which are harvested at multiple age classes. The selective fishery in the ocean has resulted in the decline of large and fast-growing individual fish. Adult salmon today are substantially smaller than in the past, and population fecundity has been decreased because small females produce fewer eggs.[15]

This thesis has not looked at the substantial role the ocean has played in the worldwide expansion of salmon hatcheries. During the 1960s and 1970s many biologists believed the ocean was a relatively stable environment for fish. While they knew that a percentage of the fish died in the ocean, they assumed it was a constant percentage, within a certain range. The fish that died in the ocean could be replaced by increasing the number of hatchery smolts that went into the ocean. Since the ocean was a constant environment, a relatively narrow range of biological diversity was required. The focus was on increasing the number and survival of the juvenile fish entering the ocean, rather than on preserving biological diversity. "Hatcheries, hydroelectric operations and harvest are managed to provide a standard 'product,' with limited impact on other uses of the river," explained a Northwest Power Planning Council document on ocean conditions. "Numbers of fish available for harvest or returning to the river can be increased by augmenting the number of juveniles released from hatcheries."[16] Between 1960 and 1980, the number and average size of coho released from the Columbia River hatcheries increased, which should have resulted in increased number of adult fish. In fact, the runs declined; some studies found that up to 75 percent of the fish perished in the river before getting to the ocean.[17]

While there have been some successes, hatchery programs have been "partly or entirely responsible for detrimental effects on some wild runs of salmon," the National Research Council concluded in 1996.[18] The Council said that hatcheries had not favored conservation of biological diversity and that programs lacked proper monitoring and evaluation.

In one of the most thoughtful essays written about the Northwest salmon problems, biologist Dennis Scarnecchia says that fishery management "has been based more often on an accumulation, not a selective integration, of different vaguely defined value systems."[19] Implementing these conflicting values has resulted in management actions that are contradictory and conflicting, both within agencies and among agencies. "Management of the common property salmon fisheries has created a management commons, where shards of all value systems are expressed, but none are expressed completely," Scarnecchia goes on to say. He adds that Northwest salmon plans "are themeless collages–surrealistic aggregations of incongruent management goals, objectives, and actions suggestive of many value systems but truly indicative of none."[20]

Looking back on the last half-century of fisheries management, there were indeed "incongruent management goals, objectives, and actions." Just as Senator Hatfield was able to talk about the "fragile beauty" of the Yaquina estuary, he saw no contradiction in urging development of a supertanker port. According to biologist Daniel Pauly, when it comes to fisheries, management goals often "simultaneously include increasing total sustained harvest, increasing exports, increasing employment, improving distribution of benefits among the fisheries and improving the economic efficiency of the industry."[21] But as the goals were established after World War II, they did not seem contradictory or impossible. The goal of increasing the world food supply was fueled by a desire to end hunger and to raise the global standard of living. Technology has been an important tool to accomplish those goals. What was not realized was how quickly technology could increase the harvest of fish. What was left out of the MSY equations was the ecological impact of such a human-centered policy. Still to be discovered was how long-lived some West Coast groundfish stocks were and how slowly they would rebuild after being fished below MSY levels.

The focus of salmon hatcheries during the last fifty years has resulted in the simplification of the complex interactions between fish and their environment. Wild salmon are far more complex than we imagined and their role in the ecology of the Northwest more important than we ever thought. Restoring the bonds between salmon and the landscape, amid the political, social, legal, and economic, constraints of salmon management, is a major challenge for the Northwest as we move into the 21st century.

# References

1.Larry Shaw. "Hatfield calls Yaquina Bay ideal site for model estuary," and "Fish farming future outlined for scientists." The Oregonian. March 16, 1971. 25.

2.Michael Harris. Lament for an Ocean: The Collapse of the Atlantic Cod Fishery: A True Crime Story. McClelland & Stewart Inc. 1998.56.

3.Eugene B. Skolnikoff. The Elusive Transformation: Science, Technology, and the Evolution of International Politics. Princeton: Princeton University Press, 1993. 26-27.

4.Donald Worster. Dust Bowl: The Southern Plains in the 1930s. New York: Oxford University Press, 1979. 4.

5.Georg Borgstrom. Japan's World Success in Fishing. London: Fishing News (Books) Ltd. 1964. 130.

6.Skolnikoff, 32.

7.Dan O'Neill. The Firecracker Boys. New York: St. Martin's Press, 1994.

8.Dayton Lee Alverson. "Global Assessment of Fisheries Bycatch and Discards: A summary Overview." Global Trends: Fisheries Management. E.L. Pikitch, D.D. Huppert, and M.P. Sissenwine, editors. American Fisheries Society Symposium 20, Bethesda, Maryland, 1997. 115-125.116.

9.Donald Ludwig, Ray Hilborn, and Carl Walters. "Uncertainty, Resource Exploitation, and Conservation: Lessons from History." Science. 260:17-36. 17.

10.Hanna J. Cortner and Margaret A. Moote. The Politics of Ecosystem Management. Washington, D.C.: Island Press, 1999. 17.

# Bibliography

## Government Documents, Reports, and Publications

Berg, Iola I. History of the Washington Department of Fisheries, 1890-1967. Washington Department of Fisheries, 1968.

Bonholt, Lael L., and Austin R. Magill. "Biological Observations and Results of the 1960 John N. Cobb Exploratory Shrimp Cruise off the Central Oregon Coast." Progress Report, Portland: Oregon Fish Commission, 1961. 31-52.

Columbia Basin Fisheries Council. Comprehensive plan for production and management of Columbia River Basin anadromous fish, Phase 1 Strategic Plan. March 23, 1978.

Columbia Basin Interagency Committee. Columbia River Basin Fishery Program, Part 1, Comprehensive research program for development of the fishery resources. Part II, Inventory of streams and proposed improvements for development of the fishery resource. January, 1957.

Columbia River Fisheries Council. Draft public review. Comprehensive Plan for Production and Management of Columbia River Basin Anadromous Salmon and Steelhead. Columbia River Fisheries Council, Portland, 1980.

Craig , J.A., and R.L. Hacker. "The History and Development of the Fisheries of the Columbia River." Bulletin of the Bureau of Fisheries, Portland. 49(32) 133-216. 1940.

Crocker, R.S., and Don Reed. The First Governor's Salmon Conference Recommendations and Results. Report of Second Governor's Conference on Pacific Salmon, Seattle, Jan. 7-10, 1963. Olympia: State Printing Plant.

Cummings, T.E. Private Salmon Hatcheries in Oregon, 1986. Oregon Department of Fish and Wildlife.

Day, Albert M., and Milo Moore. A Review of the Japanese Salmon Fishery. Oregon Fish Commission, Portland, 1959.

Department of Fisheries Canada and the Fisheries Research Baord. The Commercial Fisheries of Canada. Ottawa, 1956.

Dunnigan, John H. Federal Fisheries Investment Task Force, Report to Congress, July, 1999.

Gonsolus, Robert T. The status of Oregon coho and recommendations for managing the production, harvest, and escapement of wild and hatchery-reared stocks." Oregon Department of Fish and Wildlife, 1978.

Houblou, W.F., J. Wallis, Thomas B. McKee, Duncan K. Law, Russell O. Sinnuber, T.C. Yu. "Development of the Oregon Moist Pellet Diet." Fish Commission of Oregon Research Briefs, Portland. 7(1) 28-56.

Ikehara, Isaac I. "Live-Bait Fishing for Tuna in the Central Pacific." Special Scientific Report: Fisheries No. 107. Pacific Oceanic Fishery Investigations, U.S. Fish and Wildlife Service. January 1954. Translated by W. G. Van Campen.

Kramer, Chin & Mayo, Inc. Washington Salmon Study: A study which develops and refines a program for the period 1977 to 1981, for the enhancement of the salmon fishery in the State of Washington. Washington Department of Fisheries, 1976.

Mayer, Andre. Nutrition and Society. Rome: Food and Agriculture Organization of the United Nations, 1956.

McKee, Thomas B., et al. "Eighth Progress Report on Salmon Diet Experiments." Portland: Oregon Fish Commission, 1963.

McKernan, D.L. "The biological research program." Oregon Fish Commission Research Briefs, 1(1). 5-12.

McLeod, Ken. Fisheries: Fish Farming and Fisheries Management. Olympia: Washington State Printer, 1958.

Mitchell, H.C. "Artificial Propagation of salmon in the State of Oregon." Oregon Fish Commission Research Briefs, 1937. 1-7.

Nakamura, Hiroshi. "Tuna Longline Fishery and Fishery Grounds." Special Scientific Report: Fisheries 112. Pacific Oceanic Fishery Investigations, U.S. Fish and Wildlife Service. January 1954. Translated by W.G. Van Campen.

National Academy of Sciences. Oceanography 1966: Achievements and Opportunities. Washington, D.C.: National Academy of Sciences, 1967.

National Research Council. Upstream: Salmon and Society in the Pacific Northwest. Washington, D.C.: National Academy Press, 1997.

Oregon Fish Commission, Biennial Reports, 1960-1972.

______.Eighth Progress Report on Salmon Diet Experiments. May 1963.

______.Studies on increasing the production of anadromous salmonids in Oregon coastal lakes and streams. 1968.

______.Development and Improvement of Hatchery Techniques for Pacific Salmon and Steelhead Trout. Annual Report, September, 1970.

Oregon Game Commission. "The Salmon and Steelhead Program of the Oregon State Game Commission. 1962.

______.Habitat Improvement Projects, 1962-1964. Reports 1-15.

Oregon State University, Department of Oceanography. Oceanography in Oregon: A History of the Department of Oceanography, Oregon State University. October 1968. Reference 68-49.

Pacific Council News, Pacific Fishery Management Council. Summer 2000, V24 (2).

President's Science Advisory Committee, Panel on Oceanography. Effective Use of the Sea. Washington, D.C. June, 1967.

Pressey, R.T. Appraisal of Hatcheries. One hundred Thirty-first meeting of the Columbia Basin Inter-Agency Committee, U.S. Bureau of Commercial Fisheries Laboratory, Seattle, Oct. 6, 1965.

Records of Oceanographic Works in Japan. The Committee on Oceanography of the National Research Council of Japan. Vol 1, 1928.

Reed, Paul. Status of Oregon coho salmon stocks with respect to current troll fishery regulations. Oregon Department of Fish and Wildlife, Newport, 1975.

Sea Grant Institutional Program, Oregon State University. A proposal submitted to The National Science Foundation, September, 1967.

Snake River Recovery Team: Final Recommendations to the National Marine Fisheries Service. May, 1994.

The Oceanographic Magazine, Central Meteorological Observatory of Japan. Vol. 1, 1949.

Translation Program, Bureau of Commercial Fisheries. "Fishery and Oceanography Translations." (1963).

Tuttle, Merritt E., Jack A. Richards and Roy Wahle. "Partial Net Economic values for salmon and steelhead for the Columbia River System." U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1975.

Wallis, Joe. "Recommended time, size, and age for release of hatchery reared salmon and steelhead trout." Fish Commission of Oregon, 1968. 1-61.

Washington Department of Fisheries, Annual Reports, 1957-1972.

Washington Department of Fisheries, U.S. Fish and Wildlife Service, Washington Department of Game. Joint statement regarding the biology, status, management, and harvest of the salmon and steelhead resources of the Puget Sound and Olympia Peninsula drainage areas of Western Washington. United States District Court, Western District of Washington. May 14, 1973.

Wendler, Henry O. Status of fisheries and stocks–sports fishing aspects. One Hundred Thirty-first meeting, Columbia Basin Interagency Committee, U.S. Bureau of Commercial Fisheries Laboratory, Seattle, Oct. 6, 1965. 2-4.

Wright, Samuel G. "An Examination of Washington's Troll Salmon Fleet in 1967." Washington Department of Fisheries, 1970. 5-18.

Wood, James. W., and Erling J. Ordal. "Tuberculosis in Pacific Salmon and Steelhead Trout." Fish Commission of Oregon, Contribution No. 25. Portland, December, 1958. 3-38.

Yates, Lamartine P. So Bold an Aim. Rome: Food and Agricultural Organization of the United Nations, 1965.

Articles and Chapters

Alverson, Dayton L. and Norman J. Wilimovsky. "Prospective developments in the harvesting of Marine Fishes." Hilmar Kristjonsson, ed. Modern Fishing Gear of the World. Surrey: Fishing News (Books) Ltd., 1973.

Alverson, Dayton L. "The role of Conservation and Fishery Science under the Fishery Conservation and Management Act of 1976." Washington Law Review. 52(3): 723-741.

______. "Global Assessment of Fisheries Bycatch and Discards: A Summary Overview." Global Trends, Fisheries Management. E.K. Pikitch, Daniel D. Huppert and Michael P. Sissenwine, editors. Bethesda, Ma: American Fisheries Society, 1994. 115-135.

Anderson, A.A. "The FAO Conference at Copenhagen." Commercial Fisheries Review. 8(11) 1946. 1-2.

Anderson, James L. "The Growth of the Salmon Aquaculture and the Emerging New World Order of the Salmon Industry." Global Trends: Fisheries management. E.L. Pikitch, D.D. Huppert, M.P. Sissenwine, editors Bethesda: American Fisheries Society, 1997. 175-184.

Anderson, Ross. "Where does the money flow?" The Seattle Times Nov. 30, 1997.

Atkinson, Clinton E. "Salmon Aquaculture in Japan, the Koreas and the USSR." Proc. of Conference on Salmon Aquaculture and the Alaska Fishing Community, Cordova, Alaska, Jan. 9-11, 1978. University of Alaska, Sea Grant Report 76-2.

Ayerst, Jack D. "The role of hatcheries in rebuilding steelhead runs of the Columbia River system." Columbia River Salmon and Steelhead Symposium. Vancouver, Wash., March 5-6, 1976. Ernest Schwiebert, ed. American Fisheries Society, Special Publication 10. Washington, D.C. 1977. 84-88.

Bardach, John E., John H. Ryther, and William O. McLarney. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. New York: Wiley Interscience, 1972.

Benson, Gary and Robert Longman. "The Washington Experience with Limited Entry." Limited Entry as a Fishery Management Tool: Proceedings of a National conference to consider Limited Entry as a Tool in Fishery Management, July 17-19, 1978. Denver, Colo. R. Bruce Rettig and Jay Ginter, editors. Seattle: University of Washington Press, 1978. 333-352.

Beverton, R.J.H. "The State of Fisheries Science." The State of the World's Fisheries Resources: Proceedings of the World Fisheries Congress, Plenary Sessions. Clyde W. Voigtlander, ed. Lebanon, N.H.: International Science Publisher, 1994.

Blumm, Michael C., and F. Lorraine Bodi. "Commentary."The Northwest Salmon Crisis: A Documentary History. Joseph Cone and Sandy Ridlington, editors. Corvallis: Oregon State University Press, 1996.

Borgstrom, Georg. Japan's World Success at Fishing. London: Fishing News (Books) Ltd., 1964.

______. The Hungry Planet: The Modern World at the Edge of Famine. New York: The MacMillan Company, 1965.

Bottom, Daniel L. "To Till the Water: A history of ideas in fisheries conservation." Pacific Salmon and their Ecosystems: Status and future options. Deanna J. Stouder, Peter A. Bisson, Robert J. Naiman, editors. New York: Chapman & Hall, 1997. 569-597

Bowler, Peter J. The Environmental Sciences. New York: W.W. Norton & Co., 1992.

Brown, E. Evan and S. Nishimura. World Fish Farming: Cultivation and Economics. Westport, Conn.: Avi Publishing Company, Inc., 1983.

Bunting, Robert. The Pacific Raincoast: Environment and Culture in An American Eden, 1778-1900. Lawrence, Kansas: University of Kansas Press, 1997.

Burgner, Robert L. "Life History of Sockeye Salmon." Pacific Salmon Life Histories. C. and L. Margolis Groot, editors. Vancouver: UBC Press, 1991. 3-117.

Central Meteorological Observatory of Japan. "The Oceanographical Magazine." The Oceanographical Magazine 1 (1949).

Clarke, Arthur. The Deep Range. New York: Harcourt, Brace and World, Inc. 1957.

Clarke, Jeanne Nienaber and Daniel C. McCool. Staking Out the Terrain: Power and Performance among Natural Resource Agencies. Second ed. Albany: State University of New York Press, 1996.

Cohen, Fay G. Treaties on Trial: The Continuing Controversy over Northwest Indian Fishing Rights. Seattle: University of Washington Press, 1986.

Committee on Pacific Oceanography of the National Research Council of Japan. Records of Oceanographic Works in Japan 1 (1928).

Crocker, Richard S., and Don Reed. The First Governors' Conference Recommendations and Results. Seattle: State Printing Plant, Olympia. 1963.

Craig, J. A., and R. L. Hacker. "The History and Development of the Fisheries of the Columbia River." Portland: Bulletin of the Bureau of Fisheries, 1940. 133-216.

Crutchfield, James A., and G. Pontecorvo. The Pacific Salmon Fisheries: A Study in Irrational Conservation. Baltimore: John Hopkins Press, 1969.

Dower, John W. Embracing Defeat: Japan in the Wake of World War II. New York: W.W. Norton & Company, 1999.

Ellis, Derek V. Pacific Salmon: Management for People. Victoria: University of Victoria Press, 1977.

Evans, Dan. "Keynote address." Columbia River Salmon and Steelhead Symposium. Vancouver, Wash., March 5-6, 1976. Ernest Schwiebert, ed. American Fisheries Society, Special Publication 10. 1977. 84-88.

Foerster, R.E. "Interspecific Crossbreeding of Pacific Salmon." Transactions of the Royal Society of Canada. V(29). 21-33.

Fraser, Alex G. "License limitation in the B.C. salmon fishery." Limited Entry as a Fisheries Management Tool. R. Bruce Reddig and Jay C. Ginter, editors. Seattle: University of Washington Press, 1980. 358-381.

Garcia, S.M., and C. Newton. "Current Situation, Trends, and Prospects in World Capture Fisheries." Global Trends, Fisheries Management. E.K. Pikitch, Daniel D. Huppert and Michael P. Sissenwine, editors. Bethesda, Ma: American Fisheries Society, 1994. 3-27.

Gaucher, Thomas A. "Thermal enrichment and Marine Aquaculture." Marine Aquaculture. William McNeil, ed. Corvallis: Oregon State University Press, 1970. 141-152.

Groot, C., and L. Margolis. Pacific Salmon Life Histories. Vancouver: University of British Columbia Press, 1991.

Hanrahan, J. and P. Gruenstein. Lost Frontier: The Marketing of Alaska. New York: W.W. Norton & Company, 1977.

Harache, Yves, and Anthony J. Novotny. "Coho Salmon Farming in France." Marine Fisheries Review. 38(8) 1976. 2-9.

Hardin, Garrett. "The Tragedy of the Common." Science. 162. 1243-1248.

Harris, Michael. Lament for an Ocean: The Collapse of the Atlantic Cod Fishery: A True Crime Story. Toronto: McClelland & Stewart Inc., 1998.

Hawthorne, Daniel, and Francis Minor. The Inexhaustible Sea. New York: Dodd, Mead & Company, 1954.

Hays, H.W. "Uses, regulations and registration of chemicals used in fish culture and management." Fish & Chemicals: A symposium on registration and clearance of chemicals for fish culture and fishery management. Sept. 12, 1969, New Orleans. U.S. Bureau of Sport Fisheries and Wildlife. 1-54.

Healey, M.C. "Life History of Chinook Salmon." Pacific Salmon Life Histories. C. Groot and L. Margolis, editors. Vancouver: University of British Columbia Press, 1991. 313-393.

Heard, William R. "Life History of Pink Salmon." Pacific Salmon Life Histories. C. Groot, and L. Margolis, editors. Vancouver: University of British Columbia Press, 1991. 121-230.

Hilborn, Ray, and D. Eggers. "A review of the Hatchery Program for Pink Salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society. 129:2000. 333-350.

Hindle, Brooke, and Steven Lubar. Engines of Change: The American Industrial Revolution 1790-1860. Washington, D.C.: Smithsonian Institution Press, 1986.

Hines, Neal O. Fish of Rare Breeding: Salmon and Trout of the Donaldson Strains. Washington, D.C.: Smithsonian Institution Press, 1976.

Hirt, Paul. A Conspiracy of Optimism: Management of the National Forests since World War II. Lincoln and London: University of Nebraska Press, 1994.

Hollick, Ann L. U.S. Foreign Policy and the Law of the Sea. Princeton: Princeton University Press, 1981.

Hunn, Eugene S. Nch'i-Wana "The Big River" Mid-Columbia Indians and Their Land: University of Washington Press, 1990.

Idyll, C.P. The Sea Against Hunger: Harvesting the Oceans to Feed a Hungry World. New York: Thomas Y. Crewel Company, 1978.

Ishida, Teruo. Aspects of the Marine Biology of Asiatic Pink Salmon. N.J. Wilimovsky, ed. Vancouver: University of British Columbia, 1960. 135-139.

Japan Times and Mail. Japan's Fisheries Industry 1939. Tokyo, 1939.

Jasanoff, Sheila. The Fifth Branch. Cambridge: Harvard University Press, 1990.

Joseph, James, and Joseph W. Grennough. International Management of Tuna, Porpoise, and Billfish: Biological, Legal, and Political Aspects. Seattle: University of Washington Press, 1979.

Kadera, Jim. “OSU scientists try to breed ‘pinook’ salmon.” The Oregonian. Portland, Or., Jan. 11, 1971. F9.

______. “Weyerhaeuser buys salmon ranch.” The Oregonian. Aug. 21, 1975. C5.

______. “Fish beginning to return to private salmon hatchery.” The Oregonian. Oct. 12, 1977. E3.

Kasahara, Hirochi and William Burke. "North Pacific Fisheries Management." The Program of International Studies of Fishery Arrangements. Washington, D.C.: Resources for the Future, Inc., 1973.

Klingle, Matthew W. "Plying Atomic Waters: Lauren Donaldson and the "Fern Lake Concept" of Fisheries Management." Journal of the History of Biology. 31.1 (1998)

Kobayashi, T. "Salmon Propagation in Japan." J.E. Thorpe, ed. Salmon Ranching. London: Harcourt Brace Jovanovich, 1980. 91-107.

Kristjonsson, Hilmar. Modern Fishing Gear of the World. Surrey: Fishing News (Books) Ltd., 1973.

Kondo, Keiichi. "The Recovery of the Japanese Sardine-The Biological Basis of Stock-Size Fluctuations." Rapp. P.-V. Reun. Cons. Int. Explor. Mer 177 (1980): 332-354.

Konovalov, S.M. "U.S.S.R.:Salmon Ranching in the Pacific." Salmon Ranching. J.E. Thorpe, ed. London: Harcourt Brace Jovanovich, 1980. 63-89.

Kurlansky, Mark. Cod: A Biography of the Fish that Changed the World. New York: Walker and Company, 1997.

Laplante, Jay. "Celilo Falls: Flooded 40 Years ago but not Forgotten." Wana Chinook Tymoo, Columbia River Inter-Tribal Fish Commission. 1997.

Laythe, Leo. L. The Fishery Development Program in the Lower Columbia River. 1948. Transactions of the American Fisheries Society 78th Annual Meeting, 1948. 42-55.

Larkin, Peter A. "Play it Again Sam--an Essay on Salmon Enhancement." Journal of the Fish. Res. Board of Canada 81.8 (1974): 1434-1456.

______. "Pacific Salmon." Fish Population Dynamics. Ed. J.A. Gulland. London: John Wiley and Sons, 1977. 156-186.

______. "Management of Pacific Salmon in North America." Ed. Norman G. Benson. A Century of Fisheries in North America. Washington, D.C.: American Fisheries Society, 1970. 223-236.

______. "An epitaph for the Concept of Maximum Sustained Yield." Transactions of the American Fisheries Society, 106: 1-11.

______. "Maybe you can't get there from here: A foreshortened history of research in relation to management of Pacific Salmon." Canadian Fisheries Research Board. 36(1) 98-106.

Lee, Kai N. Compass and Gyroscope: Integrating Science and Politics for the Environment. Washington, D.C.: Island Press, 1993.

Lichatowich, Jim. Salmon Without Rivers: A History of the Pacific Salmon Crisis. Washington, D.C.: Island Press, 1999.

______. and J.D. McIntyre. "Use of Hatcheries in the Management of Pacific Anadromous Salmonids." American Fisheries Society Symposium 1: 1978. 131-136.

Lichatowich, James A., et al. "A History of Frameworks Used in the Management of Columbia River Chinook Salmon." Portland, Or: U.S. Department of Energy, Bonneville Power Administration, Environmental Fish and Wildlife, 1996.

Lyons, Cicely. Salmon: Our Heritage. Vancouver: Mitchell Press Ltd., 1969.

MacCrimmon, Hugh. "The Beginning of Salmon Culture in Canada." Canadian Geographical Journal 71.3 (1965): 96-103.

MacLeod, J.R. "Enhancement technology: A positive statement." Pacific Salmon: Management for People. Derek V. Ellis, ed. Victoria: University of Victoria Press, 1977. 137-147.

McEvoy, Arthur F. The Fisherman's Problem: Ecology and Law in the California Fisheries. Cambridge: Cambridge University Press, 1986.

______. "An Interactive Theory of Nature and Culture." The Ends of the Earth: Perspectives on Modern Enviromental History. Donald Worster, ed. Cambridge: Cambridge University Press, 1988. 211-229.

Magnuson, Warren G. "The Fishery Conservation and Management Act of 1976: First Step Towards Improved Management of Marine Fisheries." Washington Law Review. 52(3): 427-450.

Mahnken, Conrad. "Coho Salmon Farming in Japan." Culture of Salmonid Fishes. Robert R. Stickeny, ed. Boca Ratan, La.: CRC Press, 1991. 131-149.

Matthews, Stephen B. and H.G. Senn. Chum Salmon Hatchery Rearing in Japan. Washington Sea Grant, 1975. 1-24.

McGinnis, Michael V. "On the Verge of Collapse: The Columbia River System, Wild Salmon and Northwest Power Planning Council." Natural Resources Journal. 35(Winter) 1995. 63-92.

McNeil, William, and Jack Bailey. Salmon Rancher's Manuel. Northwest Fisheries Center Auke Bay Fisheries Laboratory, National Marine Fisheries Service. July 1975.

Merkel, John C., Dayton L. Alverson and John Hough. Settlement for Washington State Salmon and Steelhead Fisheries. The Regional Team of the Federal Task Force on Washington State Fisheries. June, 1978.

Mero, John L. The Mineral Resources of the Sea. Amsterdam, New York: Elsevier Publishing Company, 1965.

Mighetto, Lisa. "Sport Fishing on the Columbia River." Pacific Northwest Quarterly. Winter, 1995/96. 5-15.

Moberly, Stan A., and Robert Lium. Japan's Salmon Hatchery Review. Alaska Department of Fish and Game, 1977.

Morehouse, Thomas. A. "Limited Entry in British Columbia salmon fisheries." Alaska Fisheries Policy. Arlon R. Tussing, Thomas A. Morehouse, and James D. Babb Jr., editors. Fairbanks: University of Alaska Press, 1972. 385-418.

Moiseev, P.A. The Living Resources of the World's Oceans. Trans. Israel Program for Scientific Translations. Jerusalem, 1971.

Morishima, Gary S., and Kenneth A. Henry. "The History and Status of Pacific Northwest Chinook and Coho Salmon Ocean Fisheries and Prospects for Sustainability." Sustainable Fisheries Management: Pacific Salmon. E. Eric Knudsen, et al.,editors. Boca Raton: Lewis Publishers, 2000. 219-235.

Netboy, Anthony. The Salmon: Their fight for Survival. Boston: Houghton Mifflin Company, 1974.

Nasaka, Yoshio. "Salmonid Programs and Public Policy in Japan." Salmon Production, Management, and Allocation. William J. McNeil, ed. Corvallis: Oregon State University Press, 1988. 25-31.

Nielsen, Larry A. "The Evolution of Fisheries Management Philosophy." Marine Fisheries Review 38.12 (1976).

Ogura, M., and S. Ito. "Change in the Known Ocean Distribution of Japanese Chum Salmon, *Oncorhynchus keta,* in relation to the progress of Stock Enhancement." Canadian Journal of Fisheries and Aquatic Sciences. 51: 1994. 501-505.

O'Neill, Dan. The Firecracker Boys. New York: St. Martin's Press, 1994.

Park, C. "Implications of Extended Coastal Jurisdiction for the Management and Development of World Fisheries: The Northwest Pacific Region." Management of World Fisheries: Implications of Extended Coastal State Jurisdiction. E.L. Miles, ed. Seattle: University of Washington Press, 1989. 174-184.

Parsons, L.S., and J.S. Beckett. "Fisheries Management in Canada: The Case of Atlantic Groundfish." Global Trends: Fisheries Management. E.L. Pikitch, D.D. Huppert, and M.P. Sissenwine, editors. American Fisheries Society Symposium 20, Bethesda, Maryland, 1997. 73-79.

Pearse, Peter H. "Fishing Rights and Fishing Policy: The Development of Property Rights as Instruments of Fisheries Management." Clyde Voigtlander, ed. The State of the World's Fisheries Resources: Proceedings of the World Fisheries Congress, Plenary Sessions. Lebanon, N.H.: International Science Publisher, 1994. 76-91.

Petersen, Keith C. River of Life, Channel of Death: Fish and Dams on the Lower Snake. Lewiston, Id.: Confluence Press, 1995.

Pinkham, D.L. Salmon and his People: Fish & Fishing in Nez Perce Culture. Lewiston, Idaho: Confluence Press, 1999.

Pruter, A.T. Soviet Fisheries for Bottomfish and Herring of the Pacific and Bering Sea Coasts of the United States. Marine Fisheries Review. 38(12) 1976. 1-16.

Randolph, Robert H. and John E. Bardach. "Soviet Science in the Pacific: The Case for Marine Biology." Roy MacLeod and Philip F. Rehbock, editors. Honolulu: University of Hawaii, 1988. 245-274.

Regier, Henry A. "Old Traditions that Led to Abuses of Salmon and Their Ecosystems." Pacific Salmon and Their Ecosystems: Status and Future Options. Denna J. Stouder, Peter A. Bisson and Robert J. Naiman, editors. New York: Chapman & Hall, 1997. 17-28.

Rehbock, Philip F. "Organizing Pacific Science: Local and International Origins of the Pacific Science Association." Nature in Its Greatest Extent: Western Science in the Pacific. Roy MacLeod and Philip F. Rehbock, editors. Honolulu: University of Hawaii Press, 1988. 195-221.

Reisner, Marc. Cadillac Desert. New York: Viking, 1986.

Ricker, W.E. Russian-English Dictionary for Students of Fisheries and Aquatic Biology. Ottawa: Fisheries Research Board of Canada, 1973.

______. Hereditary and Environmental Factors Affecting Certain Salmonid Populations. Peter A. Larkin, ed. Seattle: University of British Columbia, 1970. 19-160.

Riddell, Brian E. "Salmonid enhancement: Lessons from the past and a role for the future." Salmon in the Sea and New Enhancement Strategies. D. Mills, ed. Oxford: Blackwell Scientific Press, 1993. 338-355.

Robbins, William. Landscapes of Promise: The Oregon Story, 1800-1940. Seattle and London: University of Washington Press, 1997.

Robichaud, H.J. "Current expansion expected to continue." Canadian Fisherman. 1965.

Rumsey, Gary L. "History of Early Diet Development in Fish Culture, 1000 B.C. to A.D. 1955." The Progressive Fish-Culturist. 56.1 (1994), 1-6.

Sahrhage, Dietrich, and Johannes Lundbeck. A History of Fishing. Berlin: Springer-Verlag Berlin Heidelberg, 1992.

Salo, E.O. "Life History of Chum Salmon." Pacific Salmon Life Histories. C. Groot, and L. Margolis, editors. Vancouver: University of British Columbia Press, 1991. 233-309.

Sandercock, F.K. "Life History of Coho Salmon." Pacific Salmon Life History. C. Groot, and L. Margolis, editors. Vancouver: University of British Columbia Press, 1991. 397-445.

Scheiber, Harry N. "Wilbert Chapman and the Revolution in U.S. Pacific Ocean Science and Policy, 1945-1951." Roy MacLeod and Philip N. Rehboch, edtiors. Nature in Its Greatest Extent: Western Science in the Pacific. Honolulu: University of Hawaii, 1988. 223-245.

Schrank, William E. "The failure of the Canadian seasonal fishermen's unemployment insurance reform during the 1960s and 1970s." Marine Policy. 22(1)67-81.

Skolnikoff, Eugene. The Elusive Transformation: Science, Technology, and the Evolution of International Politics. Princeton: Princeton University Press, 1993.

Smirnov, A.I. "Hybrids of Pacific Salmon of the Genus Oncorhynchus, Characteristics of Development and Prospects of Utilization." Genetics, Selection and Hybridization of Fish. Washington, D.C.: Israeli Program for Scientific Translations, National Marine Fisheries Service, 1972. 131-147.

Smith, Tim. Scaling Fisheries: The Science of Measuring the Effects of Fishing, 1855-1955. Cambridge: Cambridge University Press, 1994.

Spangler, Miller B. New Technology and Marine Resource Development: A study in government-business cooperation. New York: Praeger Publishers, 1980.

Stone, Livingston. "The artificial propagation of salmon in the Columbia River basin." Transactions of the American Fish-Cultural Association, 13th annual meeting, May 13-14, 1884, New York, NY. (1884).

Taylor, Joseph E. III. Making Salmon: An Environmental History of the Northwest Fisheries Crisis. Seattle: University of Washington, 1999.

Thompson, W.F. "Fishing Treaties and Salmon of the North Pacific." Science. 150. Dec. 31, 1965: 1786-1789.

Troadec, J.P. "The Mutation of World Fisheries: Its Effects on Management Priorities and Practices." Management of World Fisheries: Implications of Extended Coastal State Jurisdiction. E.L. Miles, ed. Seattle: University of Washington Press, 1989. 1-18.

Troubst, Cord-Christian. Conquest of the Sea. New York: Dodd, Mead & Company, 1954.

Ulrich, Roberta. Empty Nets: Indians, Dams, and the Columbia River. Corvallis: Oregon State University Press, 1999.

Van Cleve, Richard, and Ralph W. Johnson. Management of the High Seas Fisheries of the Northeastern Pacific. Seattle: University of Washington Press, 1963.

Wada, Tokio, and Larry D. Jacobson. "Regimes and stock-recruitment relationships in Japanese sardine *(Sardinops melanostictus)*, 1951-1995." Canadian Journal of Fisheries and Aquatic Sciences 55 (1998): 2455-2463.

Wahle, Roy J., Robert R. Vreeland and Robert H. Lander. "Bioeconomic contribution of Columbia River hatchery coho salmon, 1965 and 1966 broods, to the Pacific Salmon fisheries." Fishery Bulletin. 72(1) 139-168.

Walker, Charles R. "Problems in clearance and registration of chemical tools used by fish culturists and fishery biologists." Fish & Chemicals: A symposium on registration and clearance of chemicals for fish culture and fishery management. Sept. 12, 1969, New Orleans. U.S. Bureau of Sport Fisheries and Wildlife. 1-54.

Walters, Carl. "Management Under Uncertainty." Pacific Salmon: Management for People. Derek V. Ellis, ed. Victoria: University of Victoria Press, 1977. 261-266.

Walth, Brent. Fire at Eden's Gate: Tom McCall & the Oregon Story. Portland: Oregon Historical Society Press, 1994.

Weart, Spencer R. Nuclear Fear: A History of Images. Cambridge: Harvard University Press, 1988.

Weld, Christopher M. "The First Year of Federal Management of Coastal Fisheries: An Outsider's View." Fisheries. 4(2) 13. 12-15.

Wendler, Henry O. Status of fisheries and stocks-sport fishing aspects. One Hundred Thirty-first meeting, Columbia Basin Inter-Agency Committee, U.S. Bureau of Commercial Fisheries Laboratory, Seattle, Oct. 6, 1965. 2-4.

Wertheimer, A.C. "Status of Alaska Salmon." Pacific Salmon and Their Ecosystems: Status and Future Options. D.J. Stouder, P.A. Bisson and R.J. Naiman, editors. New York: Chapman & Hall, 1997. 179-197.

White, Richard. The Organic Machine: The remaking of the Columbia River. New York: Hill and Wang, 1995.

Wilimovsky, Norman. Symposium on Pink Salmon. Norman Wilimovsky, ed. Vancouver, B.C.: University of British Columbia, 1960. Preface.

Williams, R.N., L.D. Calvin, C.C. Coutant, M.W. Erho, J.A., Lichatowich, W.J. Liss, W.E. McConnaha, P.R. Mundy, J.A. Stanford and R.R. Whitney. Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem. Northwest Power Planning Council, NPPC 96-6. 1996.

Wright, Samuel G. "An Examination of Washington's Troll Salmon Fleet in 1967." Washington Department of Fisheries, 1970. 5-18.

Worster, Donald. Dust Bowl: The Southern Plains in the 1930s. New York: Oxford University Press, 1979.

Yates, Lamartine P. So Bold an Aim. Rome: Food and Agricultural Organization of the United Nations, 1955.

## Periodicals and Newspapers

Canadian Fisherman, 1962-1980.

Commercial Fisheries Review, 1945-1980.

Commercial Fish Farmer, 1975.

The Oregonian, 1968-1980.

Pacific Fisherman, 1960-1975.

Western Fisheries, 1971-1972

## Theses, Dissertations, and Manuscripts

Docherty, Shannon A. "Parallels Between the Bear and Salmon Tales of the Ainu of Japan and Native Americans of the Northwest Coast: An Analysis from a Cultural-Prehistoric Perspective." M.A. thesis, University of Oregon, 1986.

Hahn, Linda. "In the Midst of a Revolution: Science, Fish Culture, and the Oregon Game Commission, 1935-1949. M.A. thesis, Oregon State University, 2000.