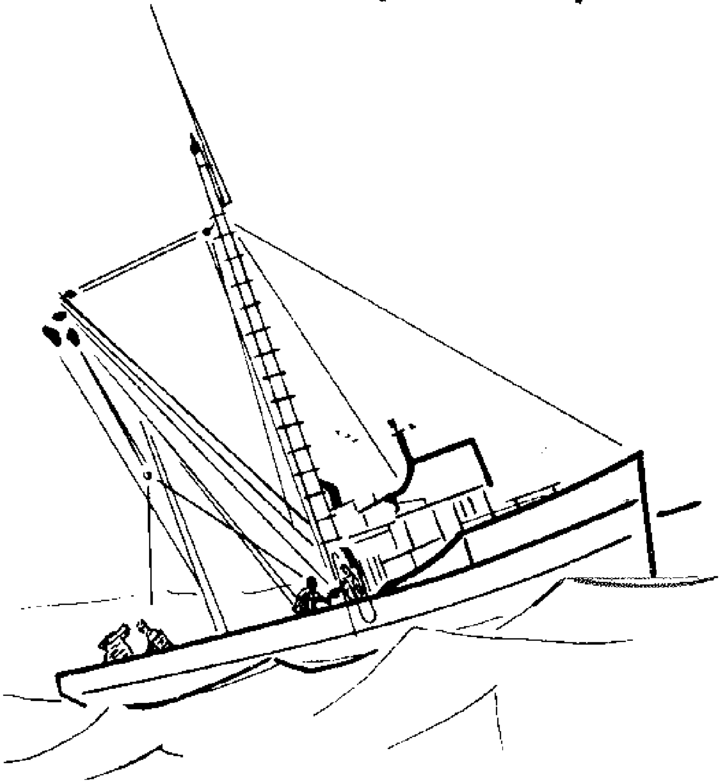
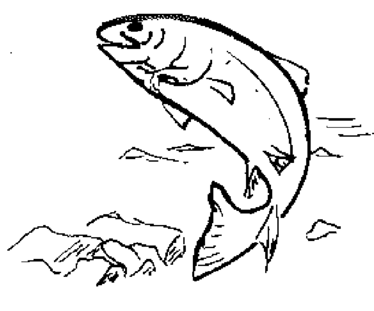


Proceedings of the Conference on

Salmon Aquaculture and the Alaskan Fishing Community

January 9, 10 and 11, 1976
CORDOVA, ALASKA



Sea Grant Report 76-2
February 1976

ALASKA
SEA GRANT PROGRAM

PRINCE WILLIAM SOUND
AQUACULTURE CORPORATION

PROCEEDINGS OF THE CONFERENCE ON SALMON AQUACULTURE AND THE ALASKAN FISHING COMMUNITY

January 9, 10 and 11, 1976

Cordova, Alaska

Sponsored by

Prince William Sound Aquaculture Corporation

National Endowment for the Humanities

Alaska Humanities Forum

University of Alaska Sea Grant Program

Sea Grant Report 76-2
February 1976

Donald H. Rosenberg
Editor

TABLE OF CONTENTS

	Page
About the Publication	iv
Acknowledgements	v
The Historic Role of Fisheries Management from The Fishermen's Point of View — by Charles Simpler	1
The Alaskan Fishing Community and the Socio-Economic History of the Alaska Salmon Fishery — by George W. Rogers	7
Potential for Salmon Aquaculture in Alaska — by William J. McNeil	25
Salmon Enhancement in British Columbia — by J. R. MacLeod	69
Salmon Aquaculture in Japan, the Koreas and the USSR — by Clinton E. Atkinson	79
Overview of F.R.E.D. Activities — by Robert S. Roys	155
First Year Activities of the Prince William Sound Aquaculture Corporation — by Armin Koernig and Wallace Noerenberg	163
Genetic Considerations for Salmonid Aquaculture: Biological Uncertainties — by John H. Helle	171

Page

Reflections on Salmon Enhancement

by Robert A. Bams 191

Hatcheries and Occupancy of National Forest Lands

by James A. Calvin 197

The High-Seas Distribution of North American Salmon and Their Vulnerability to Foreign Exploitation Under Various High-Seas Treaty Arrangements

by Richard L. Major 201

Some Common Property Implications with Private Nonprofit Salmon Hatcheries

by John Wiese 239

The Economic Implications of Alternative Forms of Business Organization for Alaska Salmon Ranching Ventures

by Franklin L. Orth 249

Costs and Benefits of Public Aquaculture Programs

by Howard Ness 257

A Partnership Proposal for Salmon Management

by James W. Brooks 263

The Market for Salmon Aquaculture Products: Some Demand Considerations

by Richard S. Johnston 269

Aquaculture and the Alaskan Fisherman

by Philip A. Daniel 277

	Page
Salmon Aquaculture in Oregon	
by John R. Donaldson	281
Closing Statement and Conference Assessment	
by Ernest O. Salo	289
Conference Attendees	293

ABOUT THE PUBLICATION

In 1974, the Alaska State Legislature passed an Act (AS 16.10.400-470) authorizing the operation of private non-profit salmon hatcheries. The intent of the act is to authorize the private ownership of salmon hatcheries by qualified nonprofit corporations for the purpose of contributing, by artificial means, to the rehabilitation of the state's depleted and depressed salmon fishery.

The result of this legislation was to stir interest among many different groups and individuals within the state. One such group, Prince William Sound Aquaculture Corporation, recognized the need of bringing together those persons with an interest in salmon aquaculture development. The purpose of such a gathering was to discuss the opportunities, define possible problems, and identify possible courses of action. Prince William Sound Aquaculture Corporation took the initiative and leadership in putting together such a conference. It was held in Cordova, Alaska on January 9, 10, and 11, 1976.

This publication resulted from that conference. Presented herein are the papers which were presented orally at the conference. It was our original intent to include the discussion which followed each paper but found that the questions could not be heard on the recording of the conference.

Donald H. Rosenberg
Director
Alaska Sea Grant Program

ACKNOWLEDGMENTS

Support for the conference was provided by Prince William Sound Aquaculture Corporation, the National Endowment for the Humanities, the Alaska Humanities Forum, the University of Alaska Sea Grant Program, and the people of the City of Cordova.

We wish to acknowledge the support and efforts of all those who attended and participated in the conference. Thanks are offered to the following individuals who assisted in the planning and running of the conference:

Bob Maxwell
Bill Kilby
Gary Raymond
Jim Tutt
Doug Bechtel
Dave Butler
Ken Simpson
Dick Groff
Jay Bynum
Kathy Andersen
Mark Hutton.

A special thanks goes to Mr. Bill Hall, Conference Coordinator, who carried the major burden of organizing and running the conference.

The preparation and printing of this publication is sponsored by the Alaska Sea Grant Program, cooperatively supported by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 04-6-158-44039 and by the University of Alaska with funds appropriated by the State of Alaska.

THE HISTORIC ROLE OF FISHERIES MANAGEMENT

FROM THE FISHERMEN'S POINT OF VIEW

Charles Simpler
Commercial Fisherman
P. O. Box 159
Cordova, Alaska 99574

My name is Charles Simpler. I was born in Lewes, Delaware, May 18, 1911. I was raised on a farm until I was eighteen, then went to sea as a merchant seaman. I worked my way up to holding a chief-mate unlimited license of oceans. I quit the shipping game in the spring of 1940 and came to Cordova, as I had purchased an interest in a small clam cannery, and have lived here since that time. I am married and have raised four children, two boys and two girls, and all are still living in Alaska. I started fishing this area in 1940 and have fished here continuously. There are two completely different fisheries for salmon in this area. We drift gill net in the spring for a limited number of kings, and red (sockeyes), and in the fall for silver or coho salmon on the Copper River flats. Pinks and chum, which are purse seined, are the main runs in the Prince William Sound area. There are gill net fisheries in the Coghill and Eshamy districts.

I will dwell on the Copper River district first. In the early forties the runs were up and down, but seemed to be consistent. In the late forties, the runs seemed to decrease. During this time, there was practically no enforcement of the fishing regulations; and we were using two hundred fathoms of linen gear, slow boats and a few skiffs on the flats that were powered with no more than nine-horsepower motors. I would say fishing effort per string of gear, at that time, consisted of not more than five sets a day, as every fisherman pulled by hand and there were no power rollers or reels at all. Each fisherman had a picking skiff and stayed on their gear all the time that they were fishing trying to get to the fish that hit the gear before the seals got them. In the late forties, the fishermen became worried about the fishing and instituted the mid-week closure, as there were more fishermen entering the fishery and the outboard motors increased in size, and gear length was decreased to one hundred fifty fathoms. During this time, the federal bureau of fisheries didn't do anything to try to enhance the fishery except to agree with the fishermen and send biologists up here to see if seals ate salmon. They decided they didn't as the only seals they could kill were the ones up the river feeding on hooligan at that time.

The first nylon gear was introduced in this area in 1950. I would say that within the next two years every fisherman had nylon gear, as it fished much more efficiently and lasted much longer than linen gear.

In 1951 the fishermen, with the help of the legislature and packers, initiated a seal dynamite program to control the herds; in three years there were, by actual count, in excess of fifty thousand seals destroyed on the Copper River flats.

There were record packs on the Copper River in 1952 and 1954. I believe this was a direct result of the seal control program. The Copper River red run has stayed consistent since then, with some seasons better than others. The seasons were good throughout the sixties and until 1973. Now the outlook of the Copper River fishery, in my opinion, is very dismal because the federal government has protected the hair seals, and they are returning by leaps and bounds. I estimate there were in excess of ten thousand seals last spring, and there will probably be over fifteen thousand this year.

Also, for some reason, since the earthquake the sea lions have started to prey upon the Copper River Salmon. Before the earthquake, we didn't see many - maybe two or three a season. Now there are herds of them, and they tear the nets and eat the fish that are in the gear.

Another example of lack of foresight and concern for the Copper River commercial fishery is the ADF&G's lack of adequate control of the growth of the subsistence fisheries in the upper Copper River. This is due in part to the political influence that voters have on the department. In 1972, there were enough permits issued to take more red salmon out of the upper Copper River than were harvested on the Copper River flats in the commercial fishery. I don't know how much it has grown since that time as I have hesitated to ask for the statistics.

In view of all the pressure on the red salmon from predators, subsistence fishing, the increased efficiency of the fishermen with power reels and faster boats that can fish in almost any weather, I can't foresee any future to the Copper River fisheries. The coho or silver salmon were a vital part of our fishery but were apparently seriously damaged by the earthquake. There is no reason to believe that it is going to get any better since the fall silver fishery has steadily declined since 1964 - ten years.

I will now go to the Prince William Sound area and talk about purse seining, pink and chum salmon, and traps. When I started seining in 1940, most of the seines in Prince William Sound were ninety fathoms in length and one hundred fifty meshes deep with a half purse. The major portion of the fish was caught by traps. The fishermen were put on a limit as soon as the traps started to fish. We were getting four cents for pinks and five cents for chums. Most of the fish that the fishermen caught were close to the creeks, as there wasn't any enforcement to speak of.

The fishing stayed very good through 1947 and then decreased rapidly to a complete closure in 1954. During the early years up to 1946, the season opened on July 5th and closed on August 5th. The weekly closure from Saturday at 6:00 A. M. to 6:00 A. M. Monday was in effect, and there were no emergency openings, closures, or extension of fishing times. There was very little protection.

I believe we had our first extension past August 5th in 1946. This has continued since then whenever there are a few fish available. The 1950's were disastrous years: 1954, 1955, and 1959 were completely closed. I remember one hearing I attended here in Cordova conducted by Mr. Donald McKernan. One old fisherman took the stand and stated his name and said, "I am a professional creek robber." Mr. McKernan asked what he meant. He stated that he made his living fishing in the creeks. Mr. McKernan stated, "I'd like to catch you." The answer was, "You are not smart enough." Then the fisherman stated that the bureau was doing such a poor job of enforcement that everyone was fishing in the creeks and that a professional creek robber couldn't make a living fishing in the creeks. The bureau just passed it off as a joke and didn't try to do anything about it.

I remember one year I was sport fishing for trout in the stream at Makarka Point. The stream was full of pink salmon so we thought we would get some fresh eggs for bait. Upon close observance of the fish in the stream, it turned out that there were five males to each female. We thoroughly checked this stream and the same ratio prevailed. I have often wondered if this has happened in other streams, especially since so many of the stream surveys are done with airplanes. Also, have the biologists surveying on foot observed the ratio of males to females?

The first season on the Sound without fish traps was 1960. Even at that, the season was a disaster. 1961 was a closed season for seining; however, a large run occurred at the latter part of July and an opening was announced. There was only one cannery open here and the net result wasn't good - there were a lot of fish wasted. We managed to salvage a good season for there were several large tenders that came here and took fish to other areas.

With this, even the fishermen became optimistic. Without fish traps, with state-controlled fisheries, and with some local autonomy, we thought we were going to have a bonanza; however, this didn't happen. The Board of Fish and Game turned out to be a political arm of the governor. I have attended personally several board meetings on commercial fisheries, and the only way you can accomplish any necessary regulatory changes is by lobbying. This is difficult because everyone that attends the meetings has his/her own little desires.

The salmon runs in this area haven't held up to any consistency at all. It appears that harvesting on the premise of a maximum sustained yield has proven unsatisfactory. The emergency openings and closures of areas, left to the direction of a few people, seem very debatable.

There is little or no protection of closed areas. In fact, when the last governor took the protection away from the Alaska Department of Fish and Game and put it in the Public Safety Department, it proved to be a fiasco for this area. The Cordova office manages the fishery. The protection is divided up between Seward, Valdez, and Cordova. As a result, the protection department doesn't know what management is doing and vice versa. As the end result, the only way the ADF&G can control the fishery is by closing the season. It has proved this many times in the past. The only time we have a good run is after having an early or complete closure. There is a good forecast for the 1976 season, but you will see that it is a result of two complete closures of this cycle.

It has been my opinion in the past 36 years of fishing that an early closure is necessary to obtain a good return. After the extensions past August 5th beginning in 1946, we have never obtained a good return unless we have had an ideal winter, which we do not have very often.

To my knowledge, the processors or packers have never recommended any closures or in any other way suggested a means to increase the production of fish. I believe they would pack the last fish every season, if it were possible.

In closing, I would stress that the fishermen and the newly formed Aquaculture Corporation must get the management and protection of the commercial fisheries out of the political arena. From 1900 to 1960, the Federal Fish and Wildlife

Service controlled our fisheries; from statehood on, the Alaska Department of Fish and Game has had the upper hand. After these many decades of bureaucratic control (I won't say bungling), the only realistic answer, and perhaps the only hope of salvaging our commercial fisheries, is to have a great deal more local input and local control. This can be accomplished only through a cooperative effort between our Alaskan fishermen's organizations, the aquaculture corporations being formed under the new law, and a stable group of biologists in a non-political Department of Fish and Game. We hope that an intelligent and farsighted approach will save our fisheries. Man can destroy anything and has often done so in the name of progress. Let us hope that the Alaskan salmon do not follow the fate of the buffalo.

THE ALASKAN FISHING COMMUNITY AND THE SOCIO-ECONOMIC HISTORY OF THE ALASKA SALMON FISHERY

George W. Rogers
Institute for Social, Economic and Government Research
University of Alaska
Juneau, Alaska 99801

Our concepts of "community" generally stand for many things. In ecological terms, "community" is simply a gathering of plants or animals - rabbits, businessmen, etc. - in a given territory or place. We also speak of a "community of interest" or an "occupational community." In some religious denominations, a congregation is thought of as a "community of saints"; and there was a time, alas no more, when units of our educational system were described as "communities of scholars." The concept of community implied by the agenda of this conference and the characteristics of its local sponsor, the Prince William Sound Aquaculture Corporation, however, is what MacIver defined fifty years ago as a "true community, a concept which goes beyond these partial concepts, which he labels 'associations'."

> "A community is a focus of social life, the common living of social beings; an organization of social life, definitely established for the pursuit of one or more common interests. An association is partial, a community is integral.... Within a community there may exist not only numerous associations but also antagonistic associations."[1]

The topic assigned to me under the general panel title of "The History and Description of the Alaskan Fishing Community" specified a kind of community as a social organization around the interdependent economic activities of managing, harvesting and processing Alaska salmon. To specify the type and purpose of a community is not to say that the result is static. The community must change over time with changes in the physical environment and the larger social, political, and economic systems of which it is a local unit and, within the limited range of economic activities which are its foundation, change in technology. Communities must adapt (adjust is not strong enough) to change if they are to survive.

In my presentation, I will consider economic history of the salmon fishery as the force of change and social history as the record of attempts of the communities to adjust. Only generalized treatment is possible, and this will be done in terms of four stages of evolution - the aboriginal period, the initial period of highly exploitive colonial commercial harvest, the transition period between World War II and Alaska Statehood, and the fifteen years of Alaska Statehood. Within each period, a brief analysis will be made of the changes in the organization of the economic activities, their purpose, and the human values to be served.

THE TOTAL FISHING COMMUNITY - THE ABORIGINAL PERIOD

Estimates of Alaska's population, at the time of the first European contacts (circa 1740-1780), put 11,800 Tlingit and Haida in southeast Alaska, 10,800 Pacific Athapascan and Eskimo in southcentral Alaska, 12,000 Aleuts along the Peninsula and Chain, and another 18,000 Eskimo scattered along the Bering Sea coast and on into the coast of the Arctic Ocean (only 4,800 Athapascan were estimated as living in interior Alaska). For most of the communities within these population groups, availability of salmon determined their size and location. In fact, original population estimates by Kroeber were in turn based upon estimates by fisheries biologists of the distribution and probable size of the pre-commercial period salmon runs.

There was some variation in the degree to which salmon provided the community base. The Tlingit and Haida and their "cousins" further south in the Pacific Northwest were characterized by one anthropologist as "the richest people in North America...they did not need to plant. They had more berries and roots than they could use, simply by going to the places where Nature had spread them. Most of them did not even hunt, unless they felt like a change in diet. Every year, they had only to wait until the salmon came swarming up the streams.... In three or four months, a family could get enough food to last a year. The rest of the time they could give to art and war, to ceremonies and feasting. And so they did."[2] The Eskimo and Aleut lived in a less salubrius climate, but salmon were available as well as a variety of sea mammals - seal, sealion, and whale.

Rather than attempt an inadequate summary of the rich cultural life of the Tingit and Haida or a discussion of varieties of communities among the other Native groups, I will turn further south to a simpler but related society, that of the Yurok Indians on the Klamath River as described by Erik H. Erikson.[3]

> "The Yurok lived in a narrow, mountainous, densely forested river valley and along the coast of its inlet into the Pacific. Moreover, they limited themselves within the arbitrary borders of a circumscribed universe. They considered a disc of about 150 miles in diameter, cut in half by the course of their Klamath River, to include all there was to this world.... They prayed to their horizons, which they thought contained the supernatural 'homes' from which generous spirits sent the staff of life to them: the (actually non-existent) lake upriver whence the Klamath flows; the land across the ocean which is the salmon's home; the region of the sky which sends the deer; and the place up the coast where the shell money comes from. There was no centrifugal east and west, south and north. There was an 'upstream' and a 'downstream', a 'toward the river', and an 'away from the river', and then, at the borders of the world (i.e., where the next tribes lived), an elliptical 'in back and around' as centripetal a world as could be designed.[4]
>
> In the Yurok world, the Klamath River may be likened to a nutritional canal, and its estuary to a mouth and throat forever opened toward the horizon from whence the salmon came.... All through the year the prayers of the Yurok world go out in that direction, protesting humility and denying any wish to hurt. Once a year, however, the Yurok tearfully lure their God back into this world just long enough to assure his good will - and to snare his salmon.... The Yurok world dramatizes all it stands for during those exalted days when, with utmost communal effort and organization, it builds the fish dam; gradually closing, as if they were gigantic jaws, the two parts extended from the opposite shores of the river. The jaws close and the prey is trapped. The creator once more rejuvenates the world by grudgingly bequeathing it parts of himself, only to be banished for another year.... During the rejuvenation festivals - that is when their prayer was reinforced by technological teeth - the Yurok were not permitted to cry, for anyone who cried would not be alive in a year. Instead, 'the end of the dam building is a period of freedom. Jokes, ridicule, and abuse run riot; sentiment forbids offense; and as night comes, lovers' passions are inflamed' (Kroeber). This one time, then, the Yurok behaved as licentiously as his phallic creator, proud that by an ingenious mixture

> of engineering and atonement had again accomplished the feat of his world: to catch his salmon - and have it next year, too...."[5]

The daily life of the Yurok was influenced and shaped by the salmon and the river in ritual and behavior compounded of magic and economics. The highest value was "clean" living, which consisted of "continuous avoidance of impure contacts and contaminations, and of constant purification from possible contaminations."[6] As noted above, only during the salmon run and the communal dam building were these avoidances set aside.

> "To be properly avoidant and yet properly avid, the individual Yurok must be clean; i.e., he must pray with humility, cry with faith, and hallucinate with conviction, as far as the Supernatural Providers are concerned; he must learn to make good nets, to locate them well, and to collaborate in the fish dam, as his technology requires; he must trade and haggle with stamina and persistence when engaged in business with his fellow men; and he must learn to master his body's entrances, exits, and interior tubeways in such a manner that nature's fluid-ways and supply routes (which are not accessible to scientific understanding and technical influence) will find themselves magically coerced. In the Yurok world, then, homogeneity rests on an integration of economic ethics and magic morality with geographic and physiological configurations."[7]

In the aboriginal period "community" was defined by The People (my kin); and territory, in turn, was defined by the salmon run and the salmon stream drainage. The Yurok "people" and territory were narrowly circumscribed, but the Tlingit, through division of labor and trade, had expanded both the concept of The People and the territory over a much larger geographic area. Among the Aleut and Eskimo, physical and geographic features again narrowed the concept of community to something close to family units. The objective of the community was survival and something more, if possible. The economic activities of management and harvest of the resource also involved the total ethos of the The People and was carried out in a context of belief in the unity of all living things within a defined universe. In terms of integration through common traditions and shared social life, the aboriginal Alaska fishing community was the archetype of the anthropologist's and sociologist's model of a community.

UNBRIDLED COMMERCIAL EXPLOITATION - THE COLONIAL PERIOD, 1878 - 1939

The Russian period in Alaska can be ignored as far as the history of salmon fisheries is concerned. They were interested almost solely in furs, in particular sea otter; and as regards numbers of "colonists" these probably did not greatly exceed the number of pseudo-Cossaks in Alaska during the "Golden Samovar" period of Alaska Airlines' recent show-biz phase. Annual company and government census for the period 1799-1867 report the average population of Russians and Siberians in all of Russian America (including California) as 536 (with a peak of 823 in 1839 followed immediately by 699 in 1840 and 469 by 1849).[8] Some salmon and other fish were dried and salted as a kind of K-ration for hunting parties, but as an 1862 government report critically stated, "Fishing has been done on a scale which barely meets the needs of the colonies themselves, in spite of the extraordinary abundance of various good stocks of fish in the lakes and rivers of the colonies."[9]

Economic development during the American period commenced with the appearance of the first salmon canneries at Klawock and Sitka in 1878 and spread northward and westward into central and western Alaska, coming to a halt in Bristol Bay in 1884. From an initial pack of 8,159 cases of 48 one-pound cans, the output of the industry rose to about two and a half million cases per year by the turn of the century and averaged 4.8 million cases during the 1920's. The total annual average catch of salmon rose from 31.7 million fish for the period 1904-1914 to an annual average of 98.8 million fish for the period 1935-1939. Although the Gold Stampedes and a brief but intense period of copper production stole the limelight for part of the period, salmon fishing and canning dominated the Alaska economy until the advent of World War II. Average annual value of Alaska exports for 1931-1940, for example, were accounted for by 55.1% canned salmon and 6.4% other fish products, the remaining 38.5% consisting of the value of gold, copper, furs, junk (i.e., damaged cannery machinery being shipped out for repairs) and miscellaneous.[10]

This industrial invasion originated from California's Sacramento River migrating northward after exhausting the runs there, and still had its headquarters in San Francisco although this was later to shift to Seattle. It was based upon the factory system and a processing technology in advance of its time. The initial harvest in southeast Alaska was an adaptation of the Indian's dam or barricade but without ethnical or religious controls. The canneries were, after all, highly portable and could be dismantled and erected elsewhere when a stream had been mined out completely. When the initial "prospecting" period ended about 1894 with the stabilization of the number of firms in the industry and the emergence of the "giants." The worst of these harvesting abuses had been abandoned and the task accomplished by several varieties of mobile gear and, where the natural conditions permitted, highly efficient fixed traps. For the period 1904-1914, fish traps accounted for 37.8% of the total salmon catch. The take of this form of gear rose to 54.1% of the salmon catch in 1925-1934, declining slightly to 48.3% for 1935-1939 due to the loss of runs at some sites and more stringent conservation regulations eliminating other traps deemed located too close to stream mouths.[11]

Although Native labor was used both in fishing and processing, particularly in the southeastern region, seasonally imported non-resident workers made up the bulk of the labor force. Initially, the canneries found an abundant and cheap labor force in the California Chinese "coolies" now redundant to the needs of the railroads who had originally imported them. These sources were supplemented and later replaced by other Oriental immigrants, notably Filipinos from California and Italian and Scandinavian fishermen from San Francisco and Puget Sound.

The course of the industry and fishery development can be traced in the annual reports of the government agencies charged with resource management and economic regulation. The most complete social and economic picture was provided, at the very end of this period, by a special investigation of labor conditions and characteristics in 1939. Table 1 summarizes the salmon catch in thousands of fish and by the three major management regions, resident and non-resident ownership of traps, fisherman, and the disposal of the catch to processors. Canning took all but an insignificant amount of the catch in all regions. Approximately two-thirds to three-quarters of the catch were taken by traps and non-resident fishermen. Table 2 summarizes the number of persons engaged in all phases of the salmon-canning industry by residence, race, and region for 1939. Residents accounted for 59.2% and 47.5% of the labor force employed in the southeast and central regions respectively, but only 22.9% of the western (Bristol Bay -Alaska Peninsula) region.

One or more salmon canneries were located at almost every coastal Native village from Ketchikan to the Nushagak River, at one time or another, during the first three decades of the twentieth century. The seasonal rhythm and tempo of life echoed that of the aboriginal period, but the new technology and commercial motivation of the non-resident oriented activity destroyed the former whole fabric of village community life with the exception of the first decade of the century when Nome was the largest city in Alaska (12,488 at the 1900 census and 2,600 at the 1909 census), the center of gravity of non-native population was in southeastern Alaska and its urban centers at Juneau, Ketchikan and Sitka. Each of these new cities had taken over the site and population of former Native communities and become the trade and service centers for the surrounding area and smaller communities and places. Juneau was the location of the largest hard-rock gold mining operation in Alaska and the territorial capital, but like the other two centers, the landing and processing of salmon was an important element of the basic economy. Ketchikan was truly the "salmon canning capital of the world." Intermediate non-Native population centers appeared at Wrangell (a former Native village site), Petersburg, Haines, Cordova, Seward, Seldovia, Kenai, and Dillingham with salmon harvesting and processing as their economic base. (Although a small Eyak village and a cannery was located near the site of Cordova before the non-native town was established as the rail head and port for the Kennecott copper developments, it was not until after the shut-down of the mine at McCarthy that the present diversified fishing community fully emerged).

The factors which might contribute to the creation of true fishing communities at these new population centers, however, were diluted by the non-resident element in the labor force and the non-resident ownership of almost all of the harvesting and processing capital. More importantly, the objectives of this economic development were the exploitation of Alaska resources at the lowest cost to the exploiters and for the benefit of distant markets - a classical colonial objective. The technologically specialized nature of the activities further fragmented the integration of the population and inhibited community development. The usurpation of the resource, coupled with this specialization, was destructive of the Native community. A 1937 look at Alaska generalized that, "The labor situation in the Territory is influenced by the fact that the population consists almost entirely of adult males, engaged for the most part in occupations requiring considerable physical activity and mobility, and living, to a very considerable extent, in rather scattered and often more or less temporary communities. This type of employment tends to discourage the building of normal family and communal life."[12]

There was a sense of industrial "community" among the territory-wide non-resident population centered in Seattle and embracing all elements of the Alaska Canned Salmon Industry (the name of the principal lobbyist organization of Alaska's territorial period). There must have been a sense of occupational community even among the wretched Chinese laborers of the initial period of development and expansion. But local community, in the whole or "true" sense as defined by

MacIver, was only beginning to emerge from the wreck of the previous aboriginal communities. One clear exception was the colony of Tsimshian Indians, who migrated eight hundred strong to Alaska under the leadership of William ("Father") Duncan from British Columbia and established the community of Metlakatla in 1887. In 1891, Congress created the Annette Island Reservation which provided an exclusive salmon resource base which was, and still is, harvested by a rational combination of fixed traps and mobile gear. This was to become a model community for Native and non-Native Alaskans, with integration through adherence to a mid-Victorian ideal of Christian utopianism and advanced technology.

TRANSITION, WORLD WAR II TO STATEHOOD - 1940 - 1959

The 1939 census reported only 524 members of the armed forces in Alaska, but by July 1940, this rose to 1,000 and a year later to 152,000 members. The men in uniform were accompanied by a corresponding increase in construction employment as a defense complex was thrown together and then revamped in accordance with shifts in international politics (i.e., war) and the technology of warfare. For the next two decades, Alaska was primarily the key defense bastion of the North American continent as the "Cold War" followed the "hot war."

From a total of 72,524 persons in the 1939 census, Alaska's total population rose to 128,643 in 1950 and 226,167 in 1960. Most of this increase was concentrated in the military-urban centers of Anchorage and Fairbanks; and by the end of the period, Alaska appeared to be well on the way to becoming a one- (or at most two-) city territory. This population was largely a wholesale transplant from outside Alaska tied directly to the defense establishment, but it had important implications for the Alaska fisheries community. For one thing, the age-sex patterns of non-Native populations became more "normal." These new Alaskans joined forces with elements among the old Alaskans to launch the Statehood movement, a search for self-determination, which culminated in the passage of the Alaska Statehood Act in 1959.

Resident fishing interests joined with the urban Alaskans in seeking local control of resource management and in anticipation of this eventuality, the Alaska Department of Fish and Game was established by the 1949 legislature. Funds were limited, but by strategic selection of pilot projects, it prodded the Federal managers into programs of expanded research and management. As Crutchfield and Pontecorvo stated in 1969, "there was no significant degree of conservation in the Alaska salmon industry until the 1950's."[13] There was cause for concern. The Statehood movement provided a rallying point for resident fishermen seeking the outlawing of the non-resident controlled fish trap and further localization of management; and this, in turn, created an awareness of a community of interest in the centers of population devoted primarily to fishing.

But, as Charlie Simpler's review of his life as a Cordova fisherman makes clear, there was little "sense of community" during this period. The Alaska fisherman emerges from his account as an essentially lonely figure, struggling heroically and with indifferent success against the hazards and niggardliness of Nature, in competition for a share of a dwindling salmon resource against other gear and other predators, and being harried and frustrated by a confused and divided Federal and Territorial attempt at resource management. It is difficult to find any trace of integration or unity in this picture, the centrifical forces of specialization, competition and increasing scarcity having driven the whole into fragments and chaos.

THE FIRST FIFTEEN YEARS OF STATEHOOD - 1959 - 1974

Statehood was a basic rearrangement of political and administrative institutions with transfer of administration and management functions and land and resource ownership and control from Washington, D. C. to Alaska with expansion of state and local government. In short, a shift of objectives and control from the non-resident. The basic philosophy of the Alaska Statehood Movement increased local self-determination and sharing in the benefits of economic development. They reappeared in modified form in the Alaska Native political movement of the 1960's, culminating in the Alaska Native Claims Act of 1971. This program launched further land ownership transfers and introduced new political-economic institutions in the form of the Native regional and village corporations.

More directly affecting salmon, in 1972 the voters approved a constitutional amendment allowing the state to limit entry into Alaska fisheries; and in 1973 the legislature passed an act launching such a program. High-seas fishing activities of foreign fishermen, particularly Japan, appear to pose a growing threat to survival of the salmon fisheries. On the other hand, Japanese purchases of fish through the A-Y-K Native fishermen cooperative provided financial assistance; and, in 1975, foreign investment (mostly Japanese) in Alaska fish processing plants totaled $17 million.

Alaska continued to grow. Between the April 1960 and 1970 census dates, population increased by 33.8% or an average annual rate of growth of 2.9%. All principal economic indicators recorded steady growth in the economy - between 1961-1972 state gross product increased annually at an average of 9.8% (or 5.7% in constant dollars); per capita personal income received by Alaskans by 6.2% (or 3.7% in constant dollars); and civilian employment by 3.3%.[14] Within the commodity-producing sector of the economy, oil and gas production and forest products were the main sources of growth while fisheries showed little or no change.

The salmon fishery continued to decline - from an annual average catch of 34.5 million fish in the five year period 1955-1959 to 30.0 million for 1971-1975 (the annual catches for this five year period were 47.5 million, 32.0 million, 22.3 million, 21.9 million, and 25.5 million preliminary for 1975). Prior to the limited entry program of 1973, the number of commercial fishermen licenses issued rose from 11,919 in 1960 to 22,088 in 1970. Use of licenses issued as a proxy for actual employment, however, is somewhat misleading during this period. The elimination of fish traps, which accounted for approximately half the catch from 1915-1944 and a third of it thereafter required a shift to more labor-intensive forms of gear just to maintain catch levels (e.g., licenses increased from 11,919 in 1960 to 14,010 in 1961) and this period also witnessed an increase in "sports-commercial" fishermen, particularly in the southeast and Cook Inlet regions.

An estimate of the number of persons actually engaged in fishing (using data on weekly catch landings from fish tickets) for 1970 at 10,826 fishermen as compared with 22,088 licenses issued. Taking into account the effects of trap elimination, this figure does not represent an undue increase over the 1930 employment of 7,736 (Table 2).[15]

The spectrum of types of fishermen was extended and embraced greater variety than in the previous historical periods. At one end of the spectrum were the surviving subsistence fishermen, and at the other extreme were the sports fishermen interested only in the recreational aspects of the activity. The range of commercial fishermen in between subsistence and sport divided into non-resident and resident and the last into subsistence-commercial, full-time commercial (those fishermen dependent primarily upon fishing for their livelihood), part-time commercial (moon-lighting teachers and others who supplemented their basic income with summer work), and sports-commercial (pleasure craft owners who secured commercial licenses to provide cash for operating costs and/or tax write-offs). All were competing for a share of the dwindling resource and their different motivations presented managers with complications of dealing with these conflicting interest groups and setting priorities of some sort.

In the broader context of political and economic change and the salmon fisheries context of continued decline in catch accompanied by increased fragmentation of the harvesting labor force, the continuation of the Alaska salmon community appeared threatened. In southeastern Alaska many resident fishermen faced with ever-shortening open seasons found it expedient to become non-residents wintering in the Puget Sound area and coming up for the brief summer season. At the other end of the geographic line, the resident Bristol Bay fishermen did not have this alternative escape and were increasingly dependent upon special emergency and welfare programs to make ends meet. But the 1970 census reports revealed a survival of all places which might be identified as "salmon communities" and in a number of cases registered population increases.

My study of fisheries employment for 1965-1970 suggests that this evidence of survival did not rest solely on tenacity or welfare subsidization but on a continuing basis for making a living at fishing. New employment in natural resources production and government dominated the total state employment, but in the fisheries regions of the state fisheries and fish processing employment continued to constitute an important position of the total employed civilian workforce (Table 3).

In Bristol Bay, this constituted virtually the total civilian employment available (military personnel are excluded). In Prince William Sound and the Southwestern region (Kodiak, the Peninsula, and Aleutians) these employments accounted 40% to more than half the peak employment and between 18% and 38% of the twelve month average employment. The expansion of oil and gas and petrochemical industries in the Cook Inlet region and logging, timber and pulp production, and government employment in southeastern region (coupled with absolute declines in fisheries) reduced the relative importance of fishery and related employment; but for the period these sources were still significant. Isolating the center of oil and gas, timber and pulp, and the state capital, the remaining places within these two regions still depended upon salmon and other fisheries for their survival.

THE FUTURE OF THE ALASKA FISHING COMMUNITY

Today we are in the process of further changes in Alaska, the nation and the world which both threaten the survival of the small community and increase its value to the future of mankind. A recent collection of studies of community points up this dichotomy in the destruction within a space of two hundred years of the agricultural village, an innovation of the Neolithic age, which survived more than ten thousand years as the home of mankind, by the superior energy and power of urban technology. "Uncontrolled technological development and economic exploitation were the engines, large-scale and largely urban societies the destination. And now the very liberalism that allowed this world to be created is in a process of decay; the massive interdependence simply cannot persist without a greater degree of order than the classical economists prescribed. In this new crisis there is promise of community, and there is threat ... our communications ... our educational systems ... make possible a kind of integration ... never before known. They also make possible a kind of coercion, indoctrination, and control over the behavior of others not possible before. While we may learn from the historical instances available to us, we cannot simply extrapolate from them; we shall have to invent new styles of community."[16]

The Alaska fishing community viewed in the socio-economic history of the Alaska salmon fishery is a model of this longer and larger story of the course of history and future fate of mankind. The wholly integrated aboriginal village, which probably evolved over a period of hundreds or thousands of years, was likewise destroyed with the swift expansion of the salmon cannery industry between 1878 and 1884. The broader course of Alaska's history has likewise been toward increased urbanization and larger scale community - at times, the destination almost appears to be the creation of a one- (or at most two-) city state as functions and population become increasingly centralized. The present overwhelming wave of oil and gas exploitation, driven by the international energy crisis, poses real physical and economic threats to the survival of any fishing community.

To paraphrase the quotation with which this section opened, we will have to invent a new style of fishing community, not a copy of the aboriginal community but one embodying its forces of integration and unity. The very threat of Valdez tanker traffic and offshore oil and gas leasing have forced upon the highly individualistic Alaskan fisherman an awareness of community of occupation and interest. Looking at the sponsors of this conference and the members of the

Prince William Sound Aquaculture Corporation, there is further evidence that others with interests in salmon are here aware of a broader community of associations, to refer back to MacIver's definition. During the course of this conference, we may be discovering this needed "new style of fishing community," one in which shared fate will take the place of the ancient basis of shared tradition, and a philosophy of giving as well as taking, the recent one of taking only. In this, we may be seeing on a small scale, prescription for the salvation of Alaska as a place to live and make a home, as well as a living. Like the rest of you, I am here to listen and learn.

FOOTNOTES

1 R. M. MacIver, Community, Macmillan, London, 1924; p. 24. For further discussion see essays in Peter H. Fricke, editor, Seafarer and Community, Croom Helm, London, 1973.

2 Ruth Underhill quoted in Y. A. Cohen, Man in Adaptation-The Cultural Present, Aldine Publishing Co., Chicago, 1969, pp. 94-95.

3 Based upon the earlier work of Kroeber in searching out and studying "wild Indians" (i.e., non-reservation Indians living in hiding from the white man) and his own more recent field work. Erik H. Erikson, Childhood and Society, Second Edition, W. W. Norton & Co., New York, "Fishermen Along a Salmon River," (first edition, 1950), pp. 166-187.

4 Ibid, pp. 166-167.

5 Ibid, pp. 181-182.

6 Ibid, p. 168.

7 Ibid, p. 182.

8 Sveltana G. Fedorova, The Russian Population in Alaska and California, The Limestone Press, Kingston, 1973, pp. 175-280.

9 Quoted from "Report of the Minister of State Property" in S. B. Okun, The Russian-American Company, Harvard University Press, Cambridge, 1951, p. 235.

10 Joseph L. Fisher, External Trade of Alaska 1931-1940, Natural Resources Planning Board, Portland, Oregon, 1943, pp. 6-11.

11 For a fuller discussion see: R. A. Cooley, Politics and Conservation, The Decline of the Alaska Salmon, Harper & Row, New York, 1963, pp. 23-68.

12 National Resources Committee, Alaska-Its Resource and Development, USGPO, Washington, 1938, p. 40.

13 J. A. Crutchfield and G. Pontecorvo, The Pacific Salmon Fisheries, The Johns Hopkins Press, Baltimore, 1969, p. 61.

14 David T. Kresge, "Alaska Economic Growth, 1961-1972", Alaska Review of Business and Economic Conditions, University of Alaska, ISEGR, August 1974.

[15] G. W. Rogers, R. F. Lisotwski, A Study of the Socio-Economic Impact of Changes in the Harvesting Labor Force in the Alaska Salmon Fishery, NMFS, College Park, Md., December 1972; Vol. 1, p. 29.

[16] D. W. Minar, S. Greer, The Concept of Community, Aldine Publishing Co., Chicago, 1969, p. xi.

TABLE 1

PRINCIPAL CHARACTERISTICS OF THE ALASKA SALMON CATCH - 1939 - BY REGION

	Southeast		Central		Western	
	(thousands of fish)	%	(thousands of fish)	%	(thousands of fish)	%
Total Salmon Catch	31,372	100.0	32,252	100.0	15,596	100.0
Trap Caught	20,307	64.7	16,208	50.3	---	---
Resident	5,339	17.0	1,543	4.8	---	---
Non-resident	14,968	49.7	14,665	45.5	---	---
Fisherman Caught	11,065	35.3	16,044	49.7	15,596	100.0
Resident	10,213	32.6	11,472	35.6	4,117	26.4
Non-resident	852	2.7	4,573	14.2	11,479	73.6
Traps and Non-resident Fishermen	21,159	67.4	20,781	64.4	11,479	73.6
Disposal of Catch						
Canneries	29,577	94.3	31,895	98.9	15,187	97.4
Other Processors	1,795	5.7	357	1.1	409	2.6

SOURCE: Ward T. Bower, Alaska Fishery and Fur-Seal Industries in 1939, Admin. Report No. 40, U.S.D.I., Bureau of Fisheries, pp. 131-132, 145.

TABLE 2

PERSONS ENGAGED IN ALASKA SALMON CANNING INDUSTRY, 1939 - BY RESIDENCE, RACE AND REGION

	Resident			Non-Resident	Unallocated	
	Native	Non-Native	Total			Total
SOUTHEAST						
Fishermen	1,026	508	1,534	502	622	2,658
Shoresmen	1,804	2,123	3,927	2,126	195	6,248
Transporters	31	282	313	422	106	841
Total	2,861	2,913	5,774	3,050	923	9,747
%	29.4	29.9	59.2	31.3	9.5	100.0
CENTRAL						
Fishermen	687	845	1,532	578	158	2,268
Shoresmen	680	925	1,605	2,104	212	3,921
Transporters	52	110	162	543	53	758
Total	1,419	1,880	3,299	3,225	423	6,947
%	20.4	27.1	47.5	46.4	6.1	100.0
WESTERN						
Fishermen	378	907	1,285	1,431	94	2,810
Shoresmen	117	447	564	4,274	41	4,879
Transporters	1	33	34	504	---	538
Total	496	1,387	1,883	6,209	135	8,227
%	6.0	16.9	22.9	75.5	1.6	100.0

SOURCE: Ward T. Bower, Alaska Fishery and Fur-Seal Industries in 1939, Admin. Report No. 40, U.S.D.I., Bureau of Fisheries, pp. 143-145.

TABLE 3

PERSONS ENGAGED IN ALL COMMERCIAL FISHERIES AND PROCESSING AS PERCENTAGE OF EMPLOYED CIVILIAN* LABOR FORCE - 1965 -- 1970

FISHERIES REGION (ADFG Management region or area)	1965 Peak Month	1965 12 Month Average	1970 Peak Month	1970 12 Month Average
	(Percent total civilian employment)			
SOUTHEASTERN				
Commercial fishing	16.6	5.5	13.7	5.1
Processing	7.6	3.8	7.2	3.8
Total	24.2	9.3	20.9	8.9
PRINCE WILLIAM SOUND (Copper-Bering Rivers, Prince William Sound)				
Comercial fishing	30.0	10.4	25.1	11.7
Processing	8.7	7.5	16.9	9.8
Total	38.7	17.9	42.0	21.5
COOK INLET (Cook Inlet, Resurrection Bay)				
Commercial fishing	23.5	5.6	20.3	5.1
Processing	10.6	9.0	10.3	6.9
Total	34.1	14.6	30.6	12.0
SOUTHWESTERN (Kodiak, Chignik, South and North Peninsula, Aleutian Islands)				
Commercial fishing	25.5	15.1	30.5	17.7
Processing	21.1	17.6	25.8	20.7
Total	46.6	32.7	56.3	38.4
BRISTOL BAY				
Commercial fishing	46.9	26.8	40.4	25.3
Processing	44.8	37.8	45.1	37.4
Total	91.7	64.6	85.5	62.7
ARCTIC-YUKON-KUSKOKWIM				
Commercial fishing	17.6	2.6	16.2	4.4
Processing	4.0	3.3	11.7	6.4
Total	21.6	5.9	27.9	10.8

* Excludes uniformed military personnel, but includes civilian employees of the Department of Defense.

SOURCE: G. W. Rogers, R. F. Listowski, A Study of the Socio-Economic Impact of Changes in the Harvesting Labor Force in the Alaska Salmon Fishery, Volume I, NMFS, College Park, Md., December 1972.

POTENTIAL FOR SALMON AQUACULTURE IN ALASKA

Willaim J. McNeil
National Marine Fisheries Service
Northwest Fisheries Center
Auke Bay Fisheries Laboratory
Auke Bay, Alaska 99821

This conference on salmon aquaculture and the Alaskan fishing community will address a broad spectrum of technical and social issues which relate to artificial recruitment of salmon and ocean ranching. My contribution considers two specific questions: (1) How many spawners are required for natural recruitment to restore the Alaska salmon harvest to previous high levels? (2) What will be the egg requirements of incubation systems to restore Alaska salmon harvests to previous high levels?

The first question needs to be answered so that we can understand the nature of our task should we continue to rely solely on natural recruitment for the restoration of Alaska salmon fisheries. The second question needs to be answered so that we can appreciate the size of a hatchery program that might be required to restore Alaska salmon fisheries. This is also a first step in estimating the cost of salmon enhancement, a question which will need to be addressed in the near future.

My estimates in this report for spawner escapements for natural recruitment and for egg capacity of incubation systems for artificial recruitment presented in this report should be treated as first approximations. It is my hope that these approximations will stimulate other observers to refine my estimates through more rigorous statements of assumptions and more refined techniques of analysis.

My analysis proceeds in three parts: (1) an assessment of declines in commercial catches in order to define goals for restoration of Alaska salmon fisheries, (2) an assessment of the number of spawners required for natural recruitment to have produced the previous high catches of salmon in Alaska, and (3) an assessment of the number of eggs required for artificial recruitment to rebuild the harvest to previous high levels.

DECLINES IN COMMERCIAL CATCHES

The total catch of salmon in Alaska peaked in the 1930's, declined rapidly in the 1940's and 1950's, recovered moderately in the 1960's, and recently entered another period of decline. Similar declines in salmon catches have not been observed in British Columbia or the Pacific Northwest (Figure 1). Although catches have declined for all species in Alaska, pink salmon have suffered the greatest reduction (Table 1).

To assess the trends of Alaska salmon catches in greater detail, I have divided Alaska into 13 fishing districts for which catch statistics are available (Figure 2). The decline in commercial catches is assessed for each district by subtracting the average number of fish caught in the last 10 consecutive years (1966-75) from the largest average catch on record for any 10 consecutive years. Catch statistics were compiled from various documents prepared by the International North Pacific Fisheries Commission Secretariat, the Alaska Department of Fish and Game, and Informal Committee on Chinook and Coho Salmon, and from information printed in the Pacific Fisherman Yearbooks and the Fisherman's News. The catch statistics used to calculate declines in commercial catches date back to 1893.[1] Table 2 summarizes the decline in average commercial catches in 13 fishing districts. The combined southern and northern districts of southeastern Alaska account for 47% of the total decline of commercial catches of all species of salmon in Alaska, and Bristol Bay accounts for 16% of the decline of all species.

Pink salmon represent about 59% of the total decline in numbers of salmon on a statewide basis and sockeye about 28%. The two districts of southeastern Alaska account for 62% of the statewide decline of pink salmon, and Bristol Bay accounts for 54% of the statewide decline of sockeye salmon.

NATURAL RECRUITMENT

A basic problem in managing Pacific salmon is that each fishery usually operates concurrently on a mixture of spawning populations, while the managers strive for an optimum escapement for each population. Healthy spawning populations usually provide a surplus of maturing fish, but the size of this surplus is highly variable from year to year and is not the same for the many spawning populations

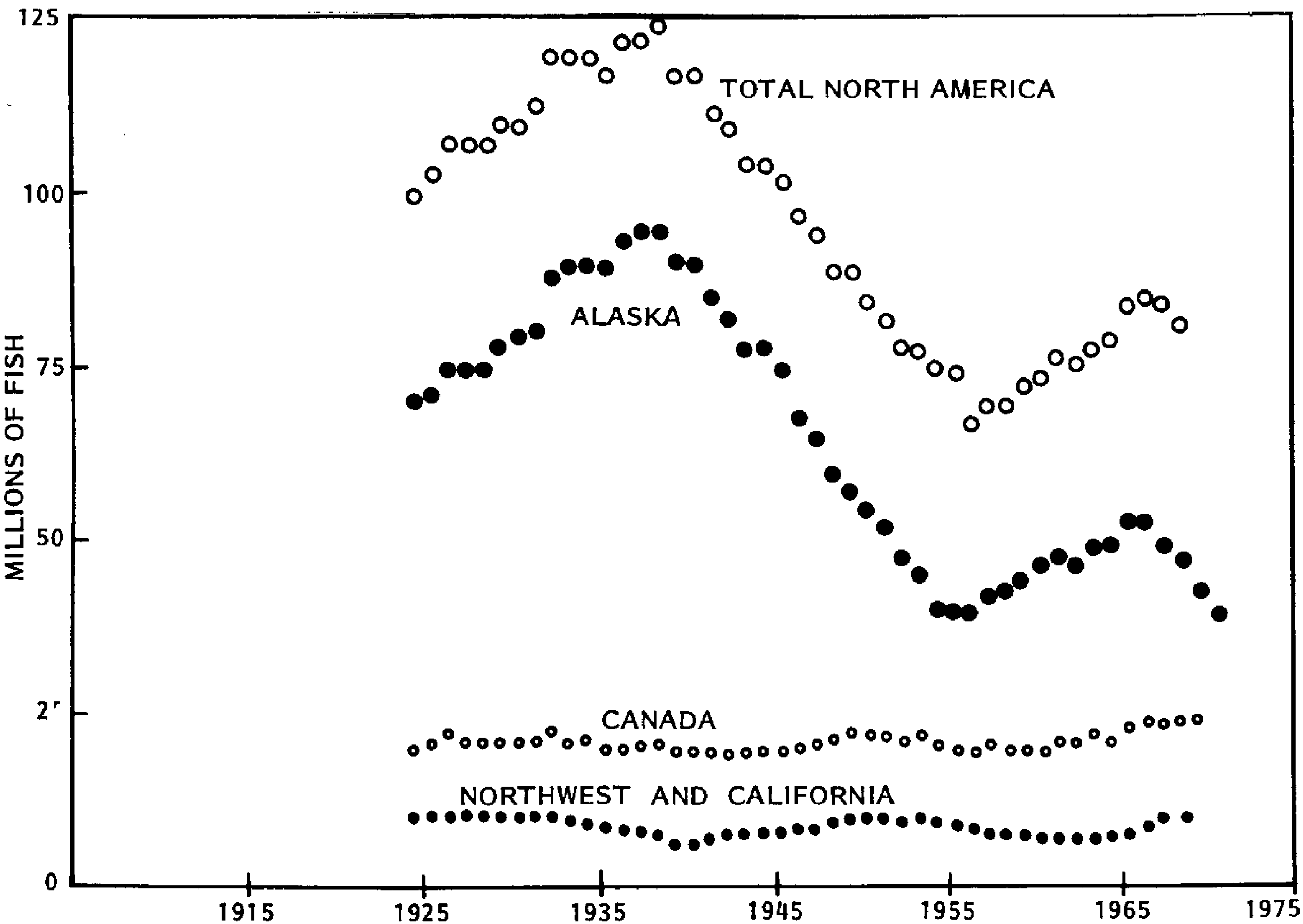


Figure 1. Ten-year moving average of catch of Pacific salmon in North America.

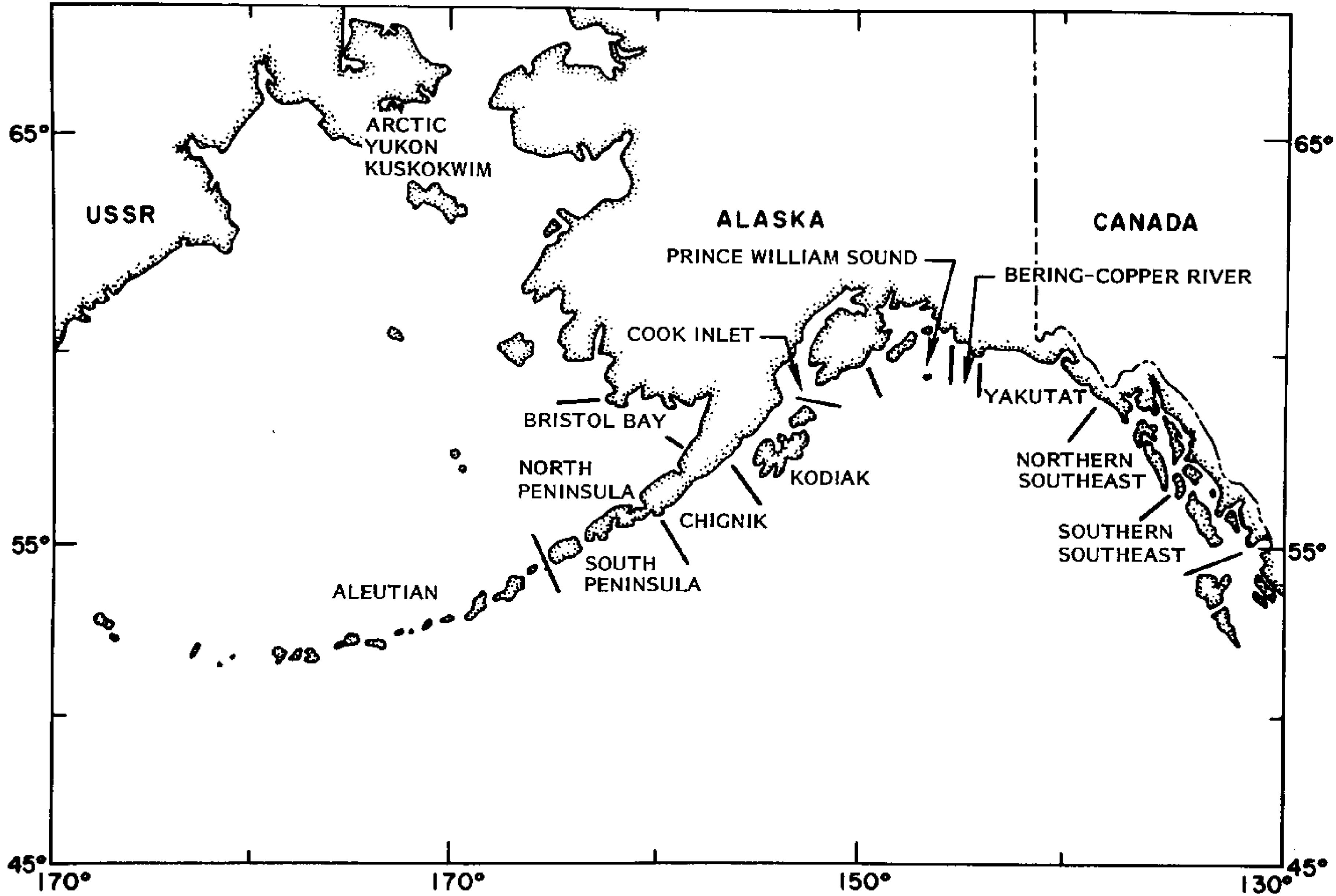


Figure 2. Alaska salmon fishing districts.

passing through any given fishing ground. Furthermore, the rate of exploitation varies unpredictably for each spawning population. It is extremely difficult, if not impossible in many cases, to manage fisheries on mixed spawning populations without overharvesting some and underharvesting others. Fishing on mixed populations is often regulated on the stronger components, and over a succession of years the weaker components are likely to be reduced below optimum levels.

Restoration of commercial salmon fisheries in Alaska means restoration of pink, sockeye, and chum salmon because these species account for 96% of the decline. The three species are primarily of interest to the commercial fishing industry because relatively few are caught in recreational fisheries.

Escapement Goals

If restoration of Alaska salmon fisheries is to be achieved through natural recruitment, escapement goals can be approximated by applying simple relationships between catch and escapement. Use of these relationships rests on the assumption that imbalances in the distribution of spawners in time and/or space do not become serious.

We let:

C = number of fish in the catch,

E = number of spawners in the escapement,

R = number of fish in the returning run, and

k = average number of fish returning per spawner.

The following relationships are obtained:

$$C+E = R,$$

$$R = kE,$$

$$C+E = kE, \text{ and}$$

$$E = C/(k-1).$$

We can use the equation $E = C/(k-1)$ to calculate the number of spawners (E) required for natural recruitment to provide any defined average catch (C) provided we have an estimate of the average number of fish returning per spawner (k). Estimates of return per spawner for natural stocks of pink, chum, and sockeye salmon are given in Table 3.

The size of fish runs used in calculating return per spawner are the sum of catches and escapements. The catches are observed catches, but escapements are derived mathematically, are estimated from visual counts of fish on spawning grounds, or are determined by counting fish passing weirs. It is impractical to assess bias and precision of individual estimates or return per spawner. It is encouraging to note, however, that mean values for individual areas and species are not highly variable (range 1.8 to 4.2 fish returning per spawner) and that the pooled mean value of k = 2.8 fish per spawner is based on a large sample of 366 observations.

The value k = 2.8 will be used to calculate escapement goals with the equation $E = C/(k-1)$. Thus, the average allowable rate of exploitation is assumed to be 64% to achieve a replacement level of spawners.

Even though the value k = 2.8 was determined from observations on pink, chum, and sockeye salmon, I will also apply it to coho and chinook salmon in the absence of more definitive information on return per spawner for these species. The average return per spawner is likely to differ somewhat among species and fishing districts and will change in relationship to the size of the spawning stock. For an unexploited stock utilizing natural spawning and/or nursery grounds to their fullest, return per spawner will trend toward unity. Where spawning stocks are moderately depressed, return per spawner will increase to allow recovery, and the goal of a fishery manager is to maintain the escapement of spawners at a level that will generate the maximum return of fish to the fishery.

Using the equation $E = C/(k-1)$, where k = 2.8, I will now calculate spawner escapements required to sustain catches at their highest previous levels through natural recruitment. The calculated values for each of the 13 districts are summarized in Table 4. It is estimated that an escapement of 64.5 million spawners (all species and districts combined) for natural recruitment can potentially sustain commercial catches of salmon at highest previous levels.

Restriction of Exploitation

Catches in Alaska have averaged 39.8 million salmon in the last 10 years, which gives a calculated average total return (catch plus escapement) of 61.9 million fish in the last 10 years where k = 2.8. It appears, therefore, that certain depressed fisheries might still be restored through natural recruitment by restricting exploitation for at least one cycle of reproduction (2 to 6 years, depending on species).

A more detailed assessment of possibilities for restoration of salmon fisheries through natural recruitment emerges if the calculated escapement goals and the average returning runs in the last 10 years are compared (Tables 5, 6, 7, 8, and 9). Table 10 suggests that the rates of exploitation which would be required for at least one cycle of reproduction to provide a basis for restoration of commercial fisheries through natural recruitment. These rates are based on the assumption that possible imbalances in distribution of spawners would impart a relatively minor decrease in k as escapements increase to 64.5 million spawners.

ARTIFICIAL RECRUITMENT

Hatcheries in Japan and the USSR produce about 75% of the approximately 2 billion juvenile Pacific salmon recruited artificially each year into the North Pacific Ocean and contiguous seas. The remaining 25% come primarily from hatcheries in the Pacific Northwest and spawning channels in Canada. Perhaps 60% or more of the juveniles recruited artifically are chum salmon, mostly from hatcheries in Japan and USSR.

The Japanese coastal fishery for chum salmon is one of the best examples of artificial recruitment supporting an important salmon industry. The Japanese embarked on a planned modernization and enlargement of chum salmon hatcheries on Hokkaido Island after the second world war, and it appears that they are reaching or exceeding an annual harvest of 10 million adult chum salmon (Okamoto, 1975) (Figure 3).

The equation used to calculate escapement of spawners for natural recruitment, --$E + C/(k-1)$-- can also be used to assess artificial recruitment. Because artificial recruitment holds the promise of increasing the efficiency of reproduction over natural recruitment, the value of k will be larger for artificial than for natural recruitment.

With artificial incubation it is possible to achieve about a tenfold gain in efficiency of reproduction over natural incubation. For example, egg-to-fry survival averages 79% in Japanese chum hatcheries (Japanese Fisheries Resource Conservation Association, 1966), whereas, the average is about 8% in natural spawning beds (Table 11). Extending the period of husbandry into feedlots where juveniles are fed artificial diets in a protected environment has the potential of providing even higher gains in survival, but costs will also increase.

Using statistics on egg-to-fry survival, we can calculate expected return per spawner where unfed fry are recruited

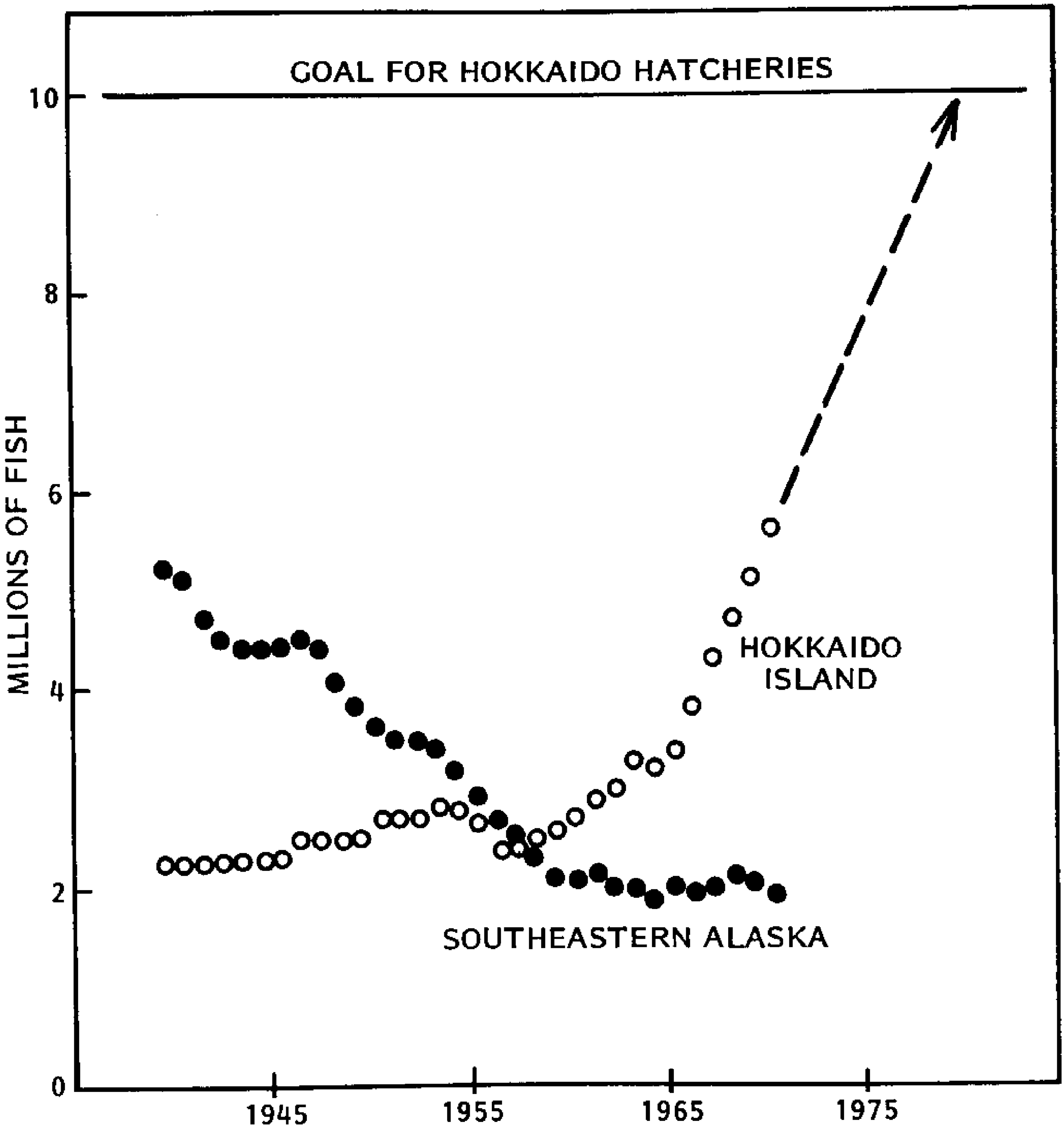


Figure 3. Ten-year moving average of catch of chum salmon, southeastern Alaska and Hokkaido Island. (Hokkaido Island data from Okamoti, 1975.)

artificially into natural nursery waters. We will assume egg-to-fry survival averages 0.790 in a hatchery and 0.083 in a natural spawning bed. If hatchery fry and wild fry have the same ocean survival, the average return per spawner will be 9.5 times higher for hatchery spawned fish than for naturally spawned fish. When k = 2.8 for natural recruitment, our expected return per spawner for artificial recruitment becomes k = 2.8 x 9.5 = 26.6 fish.

It is not uncommon for return per spawner to be less than 26.6 fish with artificial recruitment, but there are cases where higher returns have been observed. On Hokkaido Island, Japan, for example, Mathews and Senn (1975) estimated that marine survival of chum salmon released unfed from hatcheries averaged 0.012, whereas, short-term rearing boosted marine survival to 0.016. Assuming an equal number of males and females, an average content of 2,600 eggs per female (Japanese Fisheries Resource Association, 1966), and an average egg-to-fry survival of 0.790 in the hatchery, return per spawner can easily be calculated for Hokkaido hatcheries by multiplying freshwater survival times marine survival times average egg content per spawner, i.e.:

$$k \text{ (fed fry)} = 0.790 \times 0.012 \times \frac{2{,}600}{2} = 12.3$$

$$k \text{ (fed fry)} = 0.790 \times 0.016 \times \frac{2{,}600}{2} = 16.4$$

It is informative to compare estimates of return per spawner for various locations where artificial recruitment has been tried (Table 12).

I conclude that technology for artificial recruitment is now capable of producing 15 returning fish per spawner where fry are released unfed into natural nursery waters, and that 25 fish returning per spawner may produce with further improvements in technology. Both values (i.e., k = 15 and k = 25) will be used in this report to calculate first approximations of the number of eggs required for artificial incubation to restore Alaska salmon fisheries to previous high levels.

I will proceed with my calculation of incubation capacity on the assumption that existing wild stocks will continue to be managed to achieve harvest levels comparable to the average of the last 10 years in each fishing district. Thus, the total statewide harvest of salmon produced by natural recruitment is assumed to remain at an average of 39.8 million annually (Table 1).

My next step is to take the estimated decline in average annual catch, which is summarized for each species and each fishing district in Table 2, and calculate the number of spawners required for artificial recruitment to equal the decline. I will again make use of the equation $E = C/(k-1)$, with $k = 15$, for the necessary calculations. The results are summarized in Tables 13 through 25 for each of the fishing districts.

My final step is to multiply the number of spawners by average egg content. For this I have assumed that the numbers of males and females are approximately equal and that the average numbers of eggs per spawner for the five species of Pacific salmon are: pink 900; chum 1,200; sockeye 1,600; coho 1,500; and chinook 2,500.

The estimated egg capacities of incubation systems required to restore the salmon fisheries are summarized in Table 26 for $k = 15$ and in Table 27 for $k = 25$. Requirements for pink, chum, and sockeye salmon represent 95% of the total estimated required capacity for all species combined.

Improvements in technology providing a shift in k-value from 15 to 25 would result in a 2.6 billion egg reduction (all species combined) in the required artificial incubation. Such a saving would be a very substantial improvement in the economics of artificial recruitment. The prospect of such an improvement should be strong motivation for an effective research and development program.

DISCUSSION AND CONCLUSIONS

First approximations of the added number of spawners required to rebuild Alaska salmon fisheries to previous high levels can be developed from statistics given in this report. The approximations are:

1. Natural recruitment ($k = 2.8$).

Number of spawners required to maintain previous high levels	≈64.5 million fish.
Number of spawners to maintain present run naturally	≈22.1 million fish.
Number of additional spawners required	42.4 million fish.

2. Artificial recruitment ($k = 15$).

Number of spawners required to maintain previous high levels	≈27.5 million fish.
Number of spawners to maintain present run naturally	≈22.1 million fish.
Number of additional spawners required	5.4 million fish.

3. Artificial recruitment (k = 25).

Number of spawners required to maintain previous high levels	≈25.3 million fish.
Number of spawners to maintain present run naturally	≈22.1 million fish.
Number of additional spawners required	3.2 million fish.

The added escapement required for restoration of fisheries with natural recruitment is very substantial, and major reductions in fishing effort would be required for at least one cycle of reproduction to achieve escapement goals. Any plan to impose further drastic reductions on rates of exploitation should, however, be viewed with skepticism because there is little or no assurance that increased escapements will result in a fixed ratio of increased returns. There is a possibility that the number of fish returning per spawner might decline significantly if escapements increase because of imbalances in the distribution of spawners which might produce overescapement in some spawning populations and continued underescapement in others. Deterioration in the quality of spawning or nursery grounds may also contribute to declining trends in the number of fish returning per spawner.

Although similar arguments can be used against artificial recruitment, it does, nevertheless, afford a genuine possibility for substantial increases in the supply of salmon without undue curtailment of fishing on natural stocks. A number of years would be required to implement fully a statewide program of artificial incubation, and brood fish for stocking hatcheries would exert a relatively minor impact on catch and escapement of wild donor stocks.

Artificial recruitment raises questions vital to conservation of wild stocks, especially where naturally and artificially recruited fish intermingle in a common property fishery. Naturally recruited fish can withstand up to a 64% rate of exploitation where k = 2.8. Artificially recruited fish, on the other hand, can withstand a 93% rate of exploitation where k = 15 and 96% rate where k = 25. Thus, the fishery manager faces a serious dilemma! If, on the one hand, the manager permits the common property fishery to remove hatchery fish surplus to the needs of reproduction, any intermingled naturally recruited stocks will be overfished and rapidly depleted. If, on the other hand, the manager holds down exploitation to conserve naturally recruited stocks, substantial numbers of surplus fish will return to hatcheries and possibly create marketing problems. These difficulites can possibly be minimized through careful location of hatcheries and perhaps the creation of new institutions for their operation.

To achieve a return per spawner between k = 15 and k = 25 with artificial recruitment, it is essential that the following guidelines be followed:

1. Transplantation of brood fish must be avoided if at all possible. The most successful applications of artificial recruitment have resulted where brood stock was native to the hatchery stream.

2. Incubation methods simulating the natural spawning habitat of salmon should be used. This becomes especially important for larval (alevin) stages. Spawning channels, incubation channels, and substrate incubation devices are recommended over conventional hatchery incubators.

3. Juvenile fish must be released at the right time of year, normally from about mid-April to mid-June.

4. Juvenile fish must be released into nursery waters where competition for food and space are not seriously limiting factors. This becomes an especially important consideration for species like sockeye, coho, and chinook salmon, which are released into lakes and streams.

Continued success of a hatchery stock will probably depend to a high degree upon adaptive genetic variability within the stock. It becomes important, therefore, to maintain genetic diversity in artificial stocks and to avoid artificial selection. This is opposite to mating procedures used commonly in animal husbandry, but keep in mind that our purpose is to produce fish through artificial recruitment which will continue to compete effectively within complex natural ecosystems.

FOOTNOTE

1 McNeil, William J. 1976.
Tables of commercial catch statistics for Alaska salmon fisheries. Unpublished manuscript, Northwest Fisheries Center Auke Bay Fisheries Laboratory, National Marine Fisheries Service, NOAA, P. O. Box 155, Auke Bay, Alaska 99821.

REFERENCES

Bams, R. A. 1972. A quantitative evaluation of survival to the adult stage and other characteristics of pink salmon (Onchorhynchus gorbuscha) produced by a revised hatchery method which simulates optimal natural conditions. J. Fish. Res. Bd. Canada, 29:1151-1167.

________ 1974. Gravel incubators: a second evaluation on pink salmon, Oncorhynchus gorbuscha, including adult returns. J. Fish. Res. Bd. Canada, 31:1279-1385.

________ In press. Method and results of a pink salmon transplant using males native to the recipient stream. J. Fish. Res. Bd. Canada.

Drucker, B. 1970 Red salmon studies at Karluk Lake, 1968, Northwest Fisheries Auke Bay Center Laboratory, National Marine Fish. Servic. Fisheries, NOAA, MRF-70, 55 p. (processed).

Ellis, R. J. 1969. Return and behavior of adults of the first filial generation of transplanted pink salmon, and survival of their progeny, Sashin Creek, Baranof Island, Alaska. U. S. Fish and Wildl. Serv., Spec. Sci. Rpt. - Fisheries 589:13 p.

Ellis, R. J. and W. J. McNeil In press. Possible management procedures for maximum production of sockeye salmon in the Naknek River system, Katmai National Monument, Alaska. Proceedings of symposium on research in National Parks, Annual AIBS Meeting, Corvallis, Ore., 1975.

Friden, R. A., S. Pennoyer, K. R. Middleton, R. R. Roys, S. C. Smedley, and A. S. Davis 1974. Information on recent changes in the salmon fisheries of Alaska and the condition of the stocks. Inter. No. Pacific Fish. Com., Bul. 29:37-142.

________ 1962b. Supplementary information on salmon stocks of the United States: return-escapement relationships: Salmon. Inter. No. Pacific Fish. Com., Bul. 10:67-72.

__________ 1974a. Comments on INPFC document 1350 (Japan, 1970). Inter. No. Pacific Fish. Com., Bl. 29:170-175.

__________ 1974b. Annual report of the International Pacific Salmon Fisheries Commission, 1973, 54 p.

__________ 1975. Annual report of the International Pacific Salmon Fisheries Commission, 1974, 47 p.

Anon. 1966. Propagation of the chum salmon in Japan. Japan Fisheries Resource Cons. Assoc., Tokyo:55 p.

Koski, K V. 1975. The survival and fitness of two stocks of chum salmon (*Oncorhynchus keta*) from egg deposition to emergence *in a* controlled-stream environment at Big Beef Creek. Ph.D. Thesis, Univ. Wash., Seattle, 212 p.

Lister, D. B. and C. E. Walker 1966. The effect of flow control on freshwater survival of chum, coho, and chinook salmon in the Big Qualicum River. Canadian Fish-Cult. 37:3-26.

Mathews, S. B. and H. G. Senn 1975. Chum salmon hatchery rearing in Japan, in Washington. Wash. Sea Grant Info. Rpt. 75-3, 24 p.

Okamoto, Y. J. 1975. A preliminary study of the chum salmon stock rehabilitation program, Hokkaido, Japan. Pacific Rim Development Research Assoc., Anchorage, AK, 43 p. (Processed).

Olson, J. M. and W. J. McNeil 1967. Research on pink salmon at Little Port Walter, Alaska. 1934-64. U. S. Fish and Wildl. Serv., Data Rpt. 17, 301 p.

Paine, J. 1974. The Big Qualicum River artificial spawning channel for chum salmon. *In* D. R. Harding (Ed), Proceedings of *the* 1974 northeast Pacific pink and chum salmon workshop, 72-78. Canada Dept. of Environment, Fisheries Service, Vancouver, B. C.

Parker, R. R. 1962. A concept of the dynamics of pink salmon populations. In N. J. Wilimovsky (Ed), Symposium on pink salmon, P. 203-211. H. R. MacMillan Lectures in Fisheries, Univ. of British Columbia, Vancouver.

Pritchard, A. L. 1948. Efficiency of natural propagation of the pink salmon (*O. gorbuscha* in McClinton Creek, Masset Inlet, B.C., J. Fish. Res. Bd. Canada, 7:223-236.

Ricker, W. E. and J. I Manzer 1974. Recent information on salmon stocks in British Columbia. Inter. No. Pacific Fish. Com., Bul. 29:1-24.

Taylor, S. G. 1975. Production of pink salmon fry in a hatchery with gravel incubators at Auke Creek, Alaska, and evaluation of the adult return from the 1973 brood. Pink salmon aquaculture studies, Anadramous Fishes Investigations, Prog. Rpt., Northwest Fisheries Center Auke Bay Fisheries Lab., National Marine Fish. Serv., NOAA, 30 p. (Processed).

Wickett, W. P. 1952. Production of chum and pink salmon in a controlled stream. Fish. Res. Bd. Canada, Prog. Rpt. Pacific Coast Sta., 93:7-9.

Wright, A. T. 1964. A study of the carrying capacity of pink and chum salmon spawning areas in Alaska. In Studies to determine optimum escapement of pink and chum salmon in Alaska. Part 9. Alaska Dept. of Fish and Game. Final Summary Rpt. for Contract No. 14-17-0007-22 (U. S. Fish & Wildl. Serv.).

Table 1.--Species composition of Alaska salmon catch.

Species	Largest average catch for 10 consecutive years (1934-43)		Average catch for last 10 consecutive years (1966-75)	
	Millions of fish	%	Millions of fish	%
Pink	60.8	64	21.9	55
Sockeye	22.4	23	10.2	26
Chum	8.4	9	5.5	14
Coho	2.7	3	1.6	4
Chinook	0.7	1	0.6	1

Table 2.--Decline in average annual commercial catches of salmon in Alaska.

District	Millions of fish					
	Pink	Chum	Sockeye	Coho	Chinook	Total
Southern southeast	18.0	2.6	0.6	1.0	0.2	22.4
Northern southeast	9.5	1.9	1.2	0.3	0.2	13.1
Yakutat	0.1	*	0.4	0.1	*	0.6
Bering-Copper R.	*	*	0.3	0.1	*	0.4
Prince William Sound	5.1	0.5	0.5	0.1	*	6.2
Cook Inlet	0.7	0.1	0.9	0.2	0.1	2.0
Kodiak	3.9	0.2	2.7	0.2	*	7.0
Chignik	0.6	*	1.2	*	*	1.8
South Peninsula	6.1	1.2	1.1	0.2	*	8.6
Aleutian	0.2	*	*	*	*	0.2
North Peninsula	*	0.2	1.0	*	*	1.2
Bristol Bay	0.1	0.1	11.4	0.1	*	11.7
Arctic-Yukon-Kuskokwim	*	*	*	*	*	--
Total	44.3	6.8	21.3	2.3	0.5	75.2

* Indicates 50,000 or less.

Table 3.--Return per spawner for natural stocks of pink, chum, and sockeye salmon.

Species	Location	No. of observa-tions	Mean return/ spawner	Escapement estimated by	Refer-ence
Pink	Alaska Peninsula	23	2.4	derived mathematically	1
Pink	Kodiak Island	22	2.3	derived mathematically	1
Pink	Northern southeast	30	3.4	derived mathematically	1
Pink	Southern southeast	30	2.8	derived mathematically	1
Pink	Prince William Sound	23	4.2	spawning surveys	2
Pink	Cook Inlet	10	3.0	spawning surveys	3
Pink	Northern southeast	10	3.5	spawning surveys	3
Pink	Southern southeast	10	3.6	spawning surveys	3
Chum	British Columbia	14	1.8	spawning surveys	4
Chum	Prince William Sound	16	3.7	spawning surveys	3
Sockeye	Bristol Bay	45	2.8	spawning surveys	2
Sockeye	Kodiak Island (Karluk L.)	62	2.5	weir counts	5
Sockeye	Chignik	17	2.3	weir counts	3
Sockeye	British Columbia (Skeena R.)	54	2.6	weir counts	4
Mean of pooled observations		366	2.8		

[1]International North Pacific Fisheries Commission, 1962a.
[2]International North Pacific Fisheries Commission, 1974a.
[3]Fredin et al., 1974.
[4]Ricker and Manzer, 1974.
[5]International North Pacific Fisheries Commission, 1962b.

Table 4.--Average annual escapement of spawners for natural recruitment to sustain catches at previous highest levels (k = 2.8).

District	Escapement goal (millions of spawners)					
	Pink	Chum	Sockeye	Coho	Chinook	Total
Southern southeast	13.6	1.8	0.5	0.8	0.2	16.9
Northern southeast	7.2	1.8	0.8	0.4	0.2	10.4
Yakutat	0.1	*	0.3	0.1	*	0.5
Copper-Bering R.	*	*	0.6	0.2	*	0.8
Prince William Sound	4.4	0.4	0.3	0.1	*	5.2
Cook Inlet	1.0	0.4	1.1	0.2	0.1	2.8
Kodiak	5.4	0.5	1.8	0.1	*	7.8
Chignik	0.7	0.1	1.0	*	*	1.8
South Peninsula	3.8	0.9	1.0	0.1	*	5.8
Aleutian	0.2	*	*	*	*	0.2
North Peninsula	*	0.2	0.7	*	*	0.9
Bristol Bay	0.4	0.3	9.8	0.1	0.1	10.7
Arctic-Yukon-Kuskokwim	0.1	0.4	*	0.1	0.1	0.7
Total	36.9	6.8	17.9	2.2	0.7	64.5

* Indicates 50,000 or less.

Table 5.--Comparison of escapement goals and average returns in the last 10 years calculated for pink salmon ($k = 2.8$).

District	Millions of fish		
	Escapement goal[1]	Calculated average catch plus escapement last 10 years	Shortage (-) or Surplus (+)
Southern southeast	13.6	10.1	-3.5
Northern southeast	7.2	5.5	-1.7
Yakutat	0.1	0.1	0
Copper-Bering R.	*	*	*
Prince William Sound	4.4	4.4	0
Cook Inlet	1.0	1.7	+0.7
Kodiak	5.4	9.0	+3.6
Chignik	0.7	0.9	+0.2
South Peninsula	3.8	1.1	-2.7
Aleutian	0.2	0.3	+0.1
North Peninsula	*	*	*
Bristol Bay	0.4	0.9	+0.5
Arctic-Yukon-Kuskokwim	0.1	0.2	+0.1
Total	36.9	34.2	

[1] From Table 4.

* Indicates 50,000 or less.

Table 6.--Comparison of escapement goals and average returns in the last 10 years calculated for chum salmon (k = 2.8).

District	Millions of fish		
	Escapement goal[1]	Calculated average catch plus escapement last 10 years	Shortage (-) or surplus (+)
Southern southeast	1.8	1.1	-0.7
Northern southeast	1.8	2.0	+0.2
Yakutat	*	*	*
Copper-Bering R.	*	*	*
Prince William Sound	0.4	0.5	+0.1
Cook Inlet	0.4	1.1	+0.7
Kodiak	0.5	1.1	+0.6
Chignik	0.1	0.3	+0.2
South Peninsula	0.9	0.8	-0.1
Aleutian	*	*	*
North Peninsula	0.2	0.2	0
Bristol Bay	0.3	0.8	+0.5
Arctic-Yukon-Kuskokwim	0.4	1.2	+0.8
Total	6.8	9.1	

[1] From Table 4.

* Indicates 50,000 or less.

Table 7.--Comparison of escapement goals and average returns in the last 10 years calculated for sockeye salmon (k = 2.8).

District	Millions of fish		
	Escapement goal[1]	Calculated average catch plus escapement last 10 years	Shortage (-) or surplus (+)
Southern southeast	0.5	0.5	0
Northern southeast	0.8	0.5	-0.3
Yakutat	0.3	0.2	-0.1
Copper-Bering R.	0.6	1.1	+0.5
Prince William Sound	0.3	0.2	-0.1
Cook Inlet	1.1	1.6	+0.5
Kodiak	1.8	0.8	-1.0
Chignik	1.0	0.9	-0.1
South Peninsula	1.0	1.1	+0.1
Aleutian	*	*	*
North Peninsula	0.7	0.3	-0.4
Bristol Bay	9.8	9.7	-0.1
Arctic-Yukon-Kuskokwim	*	*	*
Total	17.9	16.9	

[1] From Table 4.

* Indicates 50,000 or less.

Table 8.--Comparison of escapement goals and average returns in the last 10 years calculated for coho salmon (k = 2.8).

District	Millions of fish		
	Escapement goal[1]	Calculated average catch plus escapement last 10 years	Shortage (-) or surplus (+)
Southern southeast	0.8	0.6	-0.2
Northern southeast	0.4	0.8	+0.4
Yakutat	0.1	0.2	+0.1
Copper-Bering R.	0.2	0.3	+0.1
Prince William Sound	0.1	*	*
Cook Inlet	0.2	0.3	+0.1
Kodiak	0.1	*	*
Chignik	*	*	*
South Peninsula	0.1	*	*
Aleutian	*	*	*
North Peninsula	*	*	*
Bristol Bay	0.1	*	*
Arctic-Yukon-Kuskokwim	0.1	0.2	+0.1
Total	2.2	2.4	

[1] From Table 4.

* Indicates 50,000 or less.

Table 9.--Comparison of escapement goals and average returns in the last 10 years calculated for chinook salmon (k = 2.8).

	Millions of fish		
District	Escapement goal[1]	Calculated average catch plus escapement last 10 years	Shortage (-) or surplus (+)
Southern southeast	0.2	0.2	0
Northern southeast	0.2	0.3	+0.1
Yakutat	*	*	*
Copper-Bering R.	*	*	*
Prince William Sound	*	*	*
Cook Inlet	0.1	*	*
Kodiak	*	*	*
Chignik	*	*	*
South Peninsula	*	*	*
Aleutian	*	*	*
North Peninsula	*	*	*
Bristol Bay	0.1	0.2	+0.1
Arctic-Yukon-Kuskokwim	0.1	0.2	+0.1
Total	0.7	0.9	

[1] From Table 4.

* Indicates 50,000 or less.

Table 10.--Suggested rates of exploitation for at least one complete cycle[1] of natural recruitment for restoration of salmon fisheries where k = 2.8.

District	Rate of exploitation for				
	Pink	Chum	Sockeye	Coho	Chinook
	%	%	%	%	%
Southern southeast	0	0	0	0	0
Northern southeast	0	10	0	50	33
Yakutat	0	*	0	50	*
Copper-Bering R.	*	*	45	33	*
Prince William Sound	0	20	0	*	*
Cook Inlet	41	64	31	33	*
Kodiak	40	55	0	*	*
Chignik	22	67	0	*	*
South Peninsula	0	0	9	*	*
Aleutian	33	*	*	*	*
North Peninsula	*	0	0	*	*
Bristol Bay	56	62	0	*	50
Arctic-Yukon-Kuskokwim	50	67	*	50	50

1 Two years for pink; 5 years for chum; 6 years for sockeye; 4 years for coho; 6 years for chinook.

Table 11.--Egg to fry survival for natural recruitment.

Species	Location	No. of observations	Mean survival %	Reference
Pink	Sashin Creek, Alaska	18	9.3	Ellis (1969)
Pink	Hooknose Creek, B. C.	14	7.3	Parker (1962)
Pink	McClinton Creek, B. C.	6	14.5	Pritchard (1948)
Pink	Pleasant Bay & Whale Pass, Alaska	3	19.6	Wright (1964)
Pink	Auke Creek, Alaska	4	8.6	Taylor (1975)
Chum	Sashin Creek, Alaska	14	4.1	Olson & McNeil (1967)
Chum	Big Qualicum River, B. C.	4	11.2	Lister & Walker (1966)
Chum	Nile Creek, B. C.	4	1.5	Wickett (1952)
Chum	Hooknose Creek, B. C.	14	8.5	Parker (1962)
Chum	Disappearance Creek, Alaska	4	13.5	Wright (1964)
Sockeye	Naknek Lake, Alaska	10	8.8	Ellis & McNeil (In Press)
Sockeye	Karluk Lake, Alaska	8	4.7	Drucker (1970)
	Mean of pooled observations	(103)	8.3	

Table 12.--Return per spawner for artificial recruitment.

Species	Location	Age at release	No. of obser-vations	Average return/ spawner	Remarks	Reference
Chum	Hokkaido I., Japan	Unfed	12	12	Catch & escapement	Mathews & Senn (1975)
Chum	Hokkaido I., Japan	3 mo.	8	16	Catch & escapement	Mathews & Senn (1975)
Chum	Qualicum R., B.C.	Unfed	3	6	Catch & escapement	Paine (1974)
Chum	Big Beef Cr., Wn.	Unfed	4	10	Catch & escapement	Koski (1975)
Pink	Tsolum R., B.C.	Unfed	3	[1] 15	Catch & escapement	Bams (1972, 1974, In press)
Pink	Auke Creek, AK	Unfed	3	[1] 8	Escapement only	Unpublished data[2]
Pink	Sashin Creek, AK	3 mo.	1	16	Escapement only	Unpublished data[2]
Pink	Seton Cr., B.C.	Unfed	6	14	Catch & escapement	Int. North Pac. Comm. (1974b)
Sockeye	Weaver Cr., B.C.	Unfed	5	17	Catch & escapement	Int. North Pac. Comm. (1975)
Sockeye	Pitt River, B.C.	Unfed	7	30	Catch & escapement	Int. North Pac. Comm. (1975)
		Weighted mean (52 observations) = 17 fish returning per spawner				

[1] Based on estimated survival of unmarked hatchery fish.

[2] Unpublished data are from various progress reports prepared by the Northwest Fisheries Center Auke Bay Fisheries Laboratory, NMFS, NOAA. True return per spawner is higher than reported because no estimate is made of catch.

Table 13.--Spawners required for artificial recruitment to compensate for decline in average annual catches in southern southeastern district.

	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	18.0	1.286	0.750
Chum	2.6	0.186	0.108
Sockeye	0.6	0.043	0.025
Coho	1.0	0.071	0.042
Chinook	0.2	0.014	0.008

[1] From Table 2.

Table 14.--Spawners required for artificial recruitment to compensate for decline in average annual catches in northern southeastern district.

Species	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
		k = 15	k = 25
Pink	9.5	0.679	0.396
Chum	1.9	0.136	0.079
Sockeye	1.2	0.086	0.050
Coho	0.3	0.021	0.012
Chinook	0.2	0.014	0.008

1 From Table 2.

Table 15.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Yakutat district.

Species	[1]Decline in average annual catch	Spawners to compensate for decline (Millions of fish) K = 15	k = 25
Pink	0.1	0.007	0.004
Chum	*	--	--
Sockeye	0.4	0.029	0.017
Coho	0.1	0.007	0.004
Chinook	*	--	--

[1] From Table 2.

* Indicates 50,000 or less.

Table 16.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Copper-Bering River district.

Species	[1]Decline in average annual catch	Millions of fish: Spawners to compensate for decline, k = 15	k = 25
Pink	*	--	--
Chum	*	--	--
Sockeye	0.3	0.021	0.012
Coho	0.1	0.007	0.004
Chinook	*	--	--

[1] From Table 2.

* Indicates 50,000 or less.

Table 17.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Prince William Sound district.

	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	5.1	0.364	0.212
Chum	0.5	0.036	0.021
Sockeye	0.5	0.036	0.021
Coho	0.1	0.007	0.004
Chinook	*	--	--

1 From Table 2.

* Indicates 50,000 or less.

Table 18.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Cook Inlet district.

	Millions of fish		
	[1]Decline in average	Spawners to compensate for decline	
Species	annual catch	k = 15	k = 25
Pink	0.7	0.050	0.029
Chum	0.1	0.007	0.004
Sockeye	0.9	0.064	0.038
Coho	0.2	0.014	0.008
Chinook	0.1	0.007	0.004

[1] From Table 2.

* Indicates 50,000 or less.

Table 19.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Kodiak district.

	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	3.9	0.279	0.162
Chum	0.2	0.014	0.008
Sockeye	2.7	0.193	0.112
Coho	0.2	0.014	0.008
Chinook	*	--	--

1 From Table 2.

* Indicates 50,000 or less.

Table 20.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Chignik district.

Species	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
		k = 15	k = 25
Pink	0.6	0.043	0.025
Chum	*	--	--
Sockeye	1.2	0.086	0.050
Coho	*	--	--
Chinook	*	--	--

1 From Table 2.

* Indicates 50,000 or less.

Table 21.--Spawners required for artificial recruitment to compensate for decline in average annual catches in south Peninsula district.

	Millions of fish		
	Decline in average annual catch[1]	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	6.1	0.436	0.254
Chum	1.2	0.086	0.050
Sockeye	1.1	0.079	0.046
Coho	0.2	0.014	0.008
Chinook	*	--	--

1 From Table 2.

* Indicates 50,000 or less.

Table 22.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Aleutian district.

	Millions of fish		
	[1] Decline in average annual catch	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	0.2	0.014	0.008
Chum	*	--	--
Sockeye	*	--	--
Coho	*	--	--
Chinook	*	--	--

[1] From Table 2.

* Indicates 50,000 or less.

Table 23.--Spawners required for artificial recruitment to compensate for decline in average annual catches in north Peninsula district.

Species	[1]Decline in average annual catch	Millions of fish Spawners to compensate for decline k = 15	k = 25
Pink	*	--	--
Chum	0.2	0.014	0.008
Sockeye	1.0	0.071	0.042
Coho	*	--	--
Chinook	*	--	--

1 From Table 2.

* Indicates 50,000 or less.

Table 24.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Bristol Bay district.

	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	0.1	0.007	0.004
Chum	0.1	0.007	0.004
Sockeye	11.4	0.814	0.475
Coho	0.1	0.007	0.004
Chinook	*	--	--

1 From Table 2.

* Indicates 50,000 or less.

Table 25.--Spawners required for artificial recruitment to compensate for decline in average annual catches in Arctic-Yukon-Kuskokwim district.

	Millions of fish		
	[1]Decline in average annual catch	Spawners to compensate for decline	
Species		k = 15	k = 25
Pink	*	--	--
Chum	*	--	--
Sockeye	*	--	--
Coho	*	--	--
Chinook	*	--	--

[1] From Table 2.

* Indicates 50,000 or less.

Table 26.--Egg capacity of incubation systems required to restore salmon fisheries through artificial recruitment where k = 15.

District	Millions of eggs					
	Pink	Chum	Sockeye	Coho	Chinook	Total
Southern southeast	1,157	223	69	106	35	1,590
Northern southeast	611	163	138	32	35	979
Yakutat	6	0	46	10	0	62
Copper-Bering R.	0	0	34	10	0	44
Prince William Sound	328	43	58	10	0	439
Cook Inlet	45	8	102	21	18	194
Kodiak	251	17	309	21	0	598
Chignik	39	0	138	0	0	177
South Peninsula	392	103	126	21	0	642
Aleutian	13	0	0	0	0	13
North Peninsula	0	17	114	0	0	131
Bristol Bay	6	8	1,302	10	0	1,326
Arctic-Yukon-Kuskokwim	0	0	0	0	0	0
Total	2,848	582	2,436	241	88	6,195

Table 27.--Egg capacity of incubation systems for restoration of salmon fisheries through artificial recruitment where k = 25.

District	Millions of eggs					
	Pink	Chum	Sockeye	Coho	Chinook	Total
Southern southeast	675	130	40	63	20	928
Northern southeast	356	95	80	18	20	569
Yakutat	4	0	27	6	0	37
Copper-Bering R.	0	0	19	6	0	25
Prince William Sound	191	25	34	6	0	256
Cook Inlet	26	5	61	12	10	114
Kodiak	146	10	179	12	0	347
Chignik	22	0	80	0	0	102
South Peninsula	229	60	74	12	0	375
Aleutian	7	0	0	0	0	7
North Peninsula	0	10	67	0	0	77
Bristol Bay	4	5	760	6	0	775
Arctic-Yukon-Kuskokwim	0	0	0	0	0	0
Total	1,660	340	1,421	141	50	3,612

SALMON ENHANCEMENT IN BRITISH COLUMBIA

J. R. MacLeod
Environment Canada
Fisheries and Marine
Vancouver, British Columbia
Canada

I want first to thank your organization for extending the invitation to attend this conference. My colleague, Al Wood, and I appreciate the opportunity to be here.

Al Wood is senior biologist with my office. We look forward to the chance to meet with you during the course of these proceedings and to discuss informally this fascinating and exciting subject of salmonid enhancement. Robbie Bams, a research scientist from our Research and Development Branch is also here; Robbie will speak in more detail than I will about the technical aspects of our enhancement program.

Let me begin by briefly outlining our salmonid enhancement program. The jargon used to describe activities such as artificial propagation of fish and improvement of fish habitat is confusing: among the terms most frequently and loosely used are aquaculture, fish culture, enhancement, rehabilitation, restoration. Although we refer to our program locally as 'Enhancement,' our national advisory board on fisheries research refers to it as 'Rehabilitation.' I will use the term 'Enhancement' and, to be more specific, salmonid enhancement, since we include steelhead and other coastal trout, as well as sockeye, coho, pinks, chums, and chinooks among the stocks to be increased through the application of enhancement techniques.

We are entering the second and final year of a planning phase for salmonid enhancement. We are required by March, 1977, to submit to the Cabinet of the government of Canada, a comprehensive program proposal. We are currently operating under approval-in-principle of the Cabinet, with instructions to develop a proposal which, if implemented, would double production of salmon in British Columbia and would substantially increase production of steelhead and other coastal trout.

At this stage, we estimate that a 10-year program to achieve these production levels would cost in the area of 250 to 300 million dollars. The job could probably be done on a direct cost recovery basis if such is the desire of government. Doubling production of salmon would add about 150 million pounds or approximately 25 million pieces to the annual catch by commercial fisheries. This would raise production to historic levels, or at least within the potential of those stocks existing at the beginning of this century. Wholesale value of this production would reach about $400 million annually. This production would not be expected to come fully on line until 1990 at the earliest.

The program would also make very substantial contributions to sport fishing, which is growing in use at a rate of slightly more than 6% annually. We anticipate an annual usage of about 3 million user days by 1990, a target we think could be met without significant negative impact on quality of experience.

Indians in British Columbia have an aboriginal right to take fish for food. The Indian population is growing quite rapidly. We anticipate that production from the enhancement program could meet the need for food fish with minimal disadvantages for other users.

We also want to create and to diversify opportunities for the public to enjoy outdoor recreation, such as fish watching, for example, or hiking in an attractive stream-side setting. There is a great deal of interest in British Columbia in these kinds of activities - in a two week period, over 140,000 people went to watch the Adams River sockeye spawning ritual.

There is tremendous public interest in visiting fish facilities. In 1975, for example, over 400,000 people visited one hatchery (the Capilano hatchery). We intend to take advantage of this public interest. We intend to stimulate active public participation in enhancement activities. A comprehensive information-education-participation program will be an essential element of our enhancement proposal. We believe that an involved, concerned, and understanding public is the best assurance, in the long term, that the salmonid resource and its environment will be protected and preserved.

We are spending about $1-3/4 million in the current fiscal year (1975/76) on conceptual and feasibility planning. This includes biological and engineering feasibility surveys and economic assessment studies. We are also doing some enhancing: we are testing ideas and concepts under field conditions in a number of pilot projects as well as restoring threatened stocks and habitats.

We anticipate a budget of $4 million for the next fiscal year (1976/77). Our Minister of Fisheries has given us a guarantee of sorts: he is prepared, he says, to sell his office furniture, if necessary, in order to provide funds. We are assuming that the federal Cabinet will approve our proposal in March, 1977, and that we will commence implementation in fiscal year 1977/78 with a budget of $10 million. We will, therefore, in addition to feasibility surveys and economic assessment studies, be undertaking some facility design activities in 1976/77 in preparation for a capital construction program of about $5 million in 1977/78.

Conceptual and feasibility planning will continue at a substantial level through the first 3 to 5 years, with a budget of about $5 million annually. By 1979/80, we expect to be spending at a rate of about $25 to $35 million a year, of which a progressively increasing percentage will go to facility operation and project evaluation.

Before I go on to discuss 'What we are going to do,' 'How we are going to do it,' and 'Why we are going to do it,' I want to divert briefly to describe the setting within which our program is developing:

Canada is a federal nation, composed of 10 Provinces, 2 Territories, and the federal state. Our constitution gives the federal government jurisdiction over 'Seacoast and Inland Fisheries.' The federal government makes <u>all</u> regulations governing fisheries. But, in some cases the federal government has delegated to Provinces responsibility for administration of these regulations. Under this kind of arrangement, British Columbia administers gamefish in freshwater; this delegation includes steelhead and other coastal trout. The federal government retains control of all tidal water fisheries, including salmon.

Our constitution assigns jurisdiction over freshwater and land use rights largely, but not exclusively, to the Provinces.

Both levels of government share goals for regional economic development. These goals aim at reduction of regional disparities through development of natural resources, with emphasis on distribution of benefits to the people who live in the rural areas.

For these reasons, that is, common interests, it has been concluded that the federal salmon enhancement program should be expanded into a salmonid enhancement program, a program which will be developed by the federal government in co-operation with the Province of British Columbia. A formal federal-provincial agreement will be developed to incorporate this intent.

The Province of British Columbia will not be expected to make direct financial contributions. Provincial technical staff will, however, participate jointly with federal staff in the design and implementation of feasibility surveys and in the design of facilities.

Canada has been augmenting natural production of fish for well over one hundred years, primarily through the use of hatcheries. This hatchery phase of enhancement terminated in British Columbia in 1937, at which time hatcheries were criticized as expensive short-term palliatives that were diverting attention from the need for better regulation of fisheries and better protection of fish habitats.

Subsequently, between 1945 and 1975, Canada invested about $31 million on fifty enhancement facilities, such as spawning channels, fishways, flow control systems, and, yes, even hatcheries. Our newest facility is a $5.5 million coho-chinook hatchery on the east coast of Vancouver Island, completed in 1974. During this period, the federal government also invested many millions of dollars in related scientific research.

We have deduced from our practical experience with these various kinds of facilities that the science is now available and can be successfully applied in a concerted and sustained effort to restore and improve fisheries.

What is it that we intend to do?

For convenience of discussion, I would roughly group our technical implementation of the program as follows:

1. Habitat improvement, such as flow control systems, fishways, habitat engineering, airlifts, and lake fertilization, for example.

2. Creation of artificial habitat - hatcheries, spawning channels, upwelling incubation boxes, rearing ponds, artificial streams.

3. Inducing behavioral changes through imprinting or by other forms of manipulation to affect migration habits, particularly timing and distribution.

4. Genetic manipulation to affect qualitative changes in the animal through, for example, selective breeding, transplants, manipulation of sex ratio and age of return.

The objective on some occasions may be to compensate for some harmful effects resulting from over-fishing or pollution or a dam, or to utilize more fully natural potential. In other instances, the objective may be an attempt to improve on nature or to provide a stable substitute for highly unstable natural environment. At one extreme these activities grade into aquaculture (artificial rearing to market size) and, at the other extreme, can be almost synonomous with preservation of natural stocks and natural habitat.

How do we intend to do it?

Project plans for technical implementation of the program will be carefully evaluated. Project proposals will be tested against a complex matrix of selection criteria. Again, for convenience of discussion, these are grouped:

1. <u>Desirability</u>.

   This grouping is concerned with social and economic considerations. For example, will the project help to spread fishing effort? Will the project help to extend fishing periods or fishing seasons? will the project create employment in high unemployment (rural) areas? The aim here is to increase general employment and to improve earnings and return on capital invested in the primary, processing, and support service industries; and high priority will be assigned to projects which contribute significantly to this aim. Projects must also provide satisfactory social and economic benefit/cost ratios, must contribute to meeting needs of rural coastal areas, and must not close future options.

2. <u>Enhanceability</u>.

   This grouping is concerned with fish health, water quality and quantity, site suitability, energy, and technology needed to operate the facility, degree technology needed to operate the facility, degree of disruption of other resources in the area. With regard to fish health, there are persistent problems of disease which require the development of more efficient diagnostic and prescription services than are now available.

3. <u>Manageability</u>

   This grouping is concerned with discreteness of harvesting and with the capability of the freshwater and estuarine environments to support the proposed level of production with minimal effects on other stocks.

Enchanced stocks must be manageable in the fishery. If a fishery on mixed stocks is based on the average productive capacity of all the stocks, then the low production stocks will be fished to extinction.

The implications for enhancement are enormous. It is necessary not only to raise fish that are healthy and vigorous but also to raise a particular race of fish for placing in a particular locality or set of localities. With these considerations in mind, large scale factory-type enhancement operations will not be the major thrust of our program, at least in the early years. There are high risks of disease, of catastrophic human error, of over-exploitation of intermingled natural stocks, and of the fishes, not being suited to the waters in which they are placed.

The main effort in the initial stages will go to small geographically dispersed projects which use natural stocks, preferably with minimal intervention in the natural life history. Small-scale spawning channels, incubation boxes, fishways, habitat engineering, fertilization, airlifts, and the like are considered to be preferable techniques for building up the myriad of small stocks, which in the aggregate are the backbone of the fisheries. There is also much that can be done to restore and improve habitat.

In summary, our strategy for technical implementation will take into account the following considerations:

- maintenance of the natural balance, diversity and distribution of species;
- enhancement of only those stocks which demonstrate manageability;
- emphasis on enhancement projects which tend to emulate nature;
- placing a priority on stock and habitat rehabilitation;
- minimizing capital investment in a single species, site, or technology;
- maintain as many biological options as possible;
- enhance a diversity of sites and species with diverse techniques.

This is not to suggest that we won't build hatcheries, because we certainly will. It does suggest, however, that we intend to minimize risk and consequences of failure. We will try pilot operations to work out the manageability of the target stock, among other things.

Stock enhancement, after all, is only a tool of stock management and not the master; certainly, most certainly, it is not independent of stock management. Stock enhancement must, in our opinion, be developed within the context of stock management criteria.

Why are we going to enhance salmonids? There are many reasons. Here are three:

There is certainly an urgent need. Many of the stocks are in a depressed state - our commercial production is about half of its former potential. Some stocks have been overexploited or adversely affected by natural changes in habitat or competition. Other stocks have been reduced or eliminated through pollution, construction of dams or shoreline restructuring. Removal of forest cover has rendered streams unstable. Agricultural practices have increased erosion and silt loading. Some stocks are threatened by diversion of water systems to other uses and most of these will not be protected unless they are made fully productive of fish.

Secondly, we have the technical know-how to do the job, and we still have a good stock base on which to build. There has been a considerable investment of public funds in development of the technology and in preserving the stock base; we should not risk wasting this investment by letting this resource disappear. There is a happy conjunction of talent, time, technique, and stock potential.

The major reason for investment of public funds on the scale contemplated, however, must be to generate public benefits. The program is an economic development program aimed substantially, but not exclusively, at achieving economic and social objectives of government. Some of these objectives have been referred to earlier, but there is one particular aspect that should be touched on briefly at this point. One of the important objectives of the enhancement program will be to create opportunities for Indian employment. Much of the program will be carried out along the rural coastal zone where many Indians prefer to live. For the most part, these are high unemployment areas. Indians respond positively to the enhancement program. It is obviously an excellent vehicle for responding to the needs of Indian communities.

I mentioned earlier the potential for recovery of costs by government. The commercial salmon fishery in British Columbia is a limited entry fishery, from which government now extracts about $1 million annually through licensing fees. The resource rent potential in the commercial salmon fishery is considerably greater and licensing fees could be increased several fold. Sport fishing by residents in tidal waters is not presently licensed, but this will change in the very near future with the imposition of a licensing system designed to yield a net of $1 million annually. If cost recovery is wanted, the yield from these two sources could be increased in phase with increased fish production.

However, bearing in mind the social and economic goals of government in this program, the decision may be that government satisfy itself with recovery of the cost of operating and maintaining fish facilities. In this case, government would direct and control distribution of benefits to achieve optimal results in respect of attainment of regional economic development goals.

The options relating to cost recovery and distribution of benefits will be subjected to rigorous analysis over the next two or three years.

In winding down this overview of our program, it might be interesting to glance very, very briefly into the future.

What happens when the energies and creative talents of a diverse group of dedicated scientists are directed in a concentrated and sustained effort to apply the technology as efficiently and effectively as possible?

Very rapidly this technology will grow and expand into unforeseen areas. New knowledge will burst forth. A dynamic and creative process will be set in motion.

We might even hope that some old problems will be resolved. Perhaps over the next 15 years there will be breakthroughs in disease control, nutrition and genetics. Salmon fishing might evolve from its present fish-ranching state to one that is a combination of fish-ranching and fish-farming so that eventually the salmonid resource could become an important contributor to the world's supply of protein food as well as a stable producer of wealth directed in part to maintaining the viability of fishing communities.

In conclusion, we consider our enhancement program to be a major lever of change: it will change federal-provincial relations; it will change behaviour within our organization; it will change our relations with our clients and with the owners of the resource - the people of Canada; it will change fish harvesting patterns and the mode and character of fisheries. For one of the few times in the history of our management of the fisheries resource, we will be concerned with how to share an increment of wealth rather than how to share a fixed or diminishing stock among more and more demands. This consideration alone will force organizations such as ours to change from a passive, reactive posture to one that is dynamic, active, and creative.

We are setting off on a voyage to the unknown, and we all feel a bit uneasy. You, too, are setting forth on a complex voyage. I wish you well in your venture.

SALMON AQUACULTURE IN JAPAN, THE KOREAS AND THE USSR

Clinton E. Atkinson
Fisheries Consultant and Advisor
8000 Crest Drive, N.E.
Seattle, Washington 98101

After World War II the production of many of the hatcheries in Japan and the Soviet Far East was marginal, the methods obsolete and the basic, scientific information needed to understand the behaviour and survival of salmon was lacking. In Japan the salmon hatcheries, as well as the fishing industry as a whole, were in almost complete disrepair, and the program had little financial support and no encouragement to continue from the occupation forces. Similarly, after the war the USSR "inherited" a number of former Japanese salmon hatcheries in southern Sakhalin and the Kurile Islands that were also in disrepair, and there was an almost immediate need for additional technical expertise and a comprehensive plan for future operations.

In the ensuing 35 years the salmon hatchery programs of both Japan and the Soviet Union developed rapidly. During the 1960's new hatchery programs were adopted, which included the modernization or rebuilding of most of the hatcheries and the initiation of studies to improve the efficiency of hatchery operation. This growth in the hatchery programs is especially apparent in a comparison of the numbers of pink and chum salmon fry released: In Japan the numbers increased from less than 200 million in 1950-1953 to 940 million in 1974; in the USSR the numbers increased from about 200 million at the end of the war to some 800 million in 1974.

The high rate of return of adults that is being obtained from the number of fry released is of particular significance. In Japan, for example, the rate of return now regularly exceeds the 2 percent level. The number of hatchery salmon taken in the Japanese coastal catch in 1975 was truly phenomenal - the total catch for Hokkaido and northern Honshu totaled about 17 million fish, or equivalent to the entire Japanese high-seas salmon catch (45,000 metric tons) in 1975.

At this time, when so much interest is being focussed on salmon aquaculture in Alaska and when we consider the success of the Asian salmon hatchery programs and the similarities of climate and species, a review of the experiences of the Japanese and Russians in the development and operation of their respective salmon programs is of particular value. I hope that this report will serve that purpose.

Attention is drawn to the description of the salmon hatchery program for the Republic of Korea, which has been taken almost verbatum from a previous report - "A Report of the Salmon Hatcheries of the Republic of Korea." The author is deeply indebted to members of the Korean Study Team for the use of this material.[1]

The author wishes to thank the following people for their help in the preparation of this report: Mr. Yoshihiro Aoki (Japan Salmon Resources Preservation Association) for cost information on the operation of Japanese hatcheries and for other material; Mr. Osamu Kuwata (Hokkaido Fisheries Department) for detailed information on the national and provincial salmon hatchery programs; Mr. Paul Macy (Seattle Biological Laboratory, National Marine Fisheries Service) for his assistance and advice in the search of Russian literature; Mr. William J. McNeil (Auke Bay Biological Laboratory, National Marine Fisheries Service) for recent material on the magnitude of salmon production in the USSR; Dr. Tsuneo Nishiyama (Fisheries-Oceanographer of the University of Alaska) for identifying the names and location of a number of hatcheries in Japan, and translation of some of the material; and most of all, Mr. Yoshio Nasaka, (Office of the Fisheries Attache, American Embassy Tokyo) for the needed contacts and liaison in Japan.

JAPAN

Salmon propagation in Japan has a long history. In 1716, for example, a samurai by the name of Buheji Aoto placed mature salmon in a fenced area of a stream to protect them while spawning and their eggs from natural enemies and adverse stream conditions - a primitive artificial spawning channel. From all accounts, the salmon runs increased through his efforts and the program continued for more than 200 years. In another stream, the Gekko River, the adult salmon were caught in the lower reaches of the stream and transported by bamboo basket to the headwaters where conditions were more favorable for spawning and survival of the young. At the same time (about 1800), a local administration prohibited the taking of young salmon in the Naka River (flowing into the Pacific Ocean) in order to conserve the stock. There are a number of similar examples in the Japanese literature.

Shortly after the beginning of the Meiji period in 1868 and at the invitation of the Hokkaido government, a team of 45 agriculture experts was sent from the United States to assist in the development and modernization of farming methods in northern Japan. One member of the delegation, Mr. U. S. Treat, was familiar with the early salmon propagation methods being used in the United States. Mr. Treat, with the assistance of local help, actually attempted to rear salmon in a crude hatchery in Sapporo in 1877 but without success - the eggs died due to cold weather and drifting snow.

Similarly, the federal government in Tokyo established a hatchery in Shinjuku (a suburb of Tokyo) in the previous year (1876) but, according to reports, the eggs were eaten by rats or destroyed by fungus so that few, if any, hatched. Because of the numerous difficulties in these early attempts to rear salmon and the lack of public interest and administrative support, this initial salmon hatchery program was short-lived and finally abandoned in 1880.[2]

It was not until 1889 that the first permanent hatchery was built at Chitose, Hokkaido, following closely the design and related information obtained by Kazutaka Ito after several months of study at the U. S. Federal Hatchery at Bucksport, Maine, and subsequent visits to the Columbia and Fraser Rivers. During the ensuing 85 years, the Japanese government has rapidly expanded the program of salmon propagation in order to support the intense fishery for salmon, to counter the effects of industrial development and pollution, and to protect the spawning stocks from rampant poaching.

At the present time the national government operates a total of 41 hatcheries, 76 collecting stations and 94 areas for the release of fry in Hokkaido. The Hokkaido Fisheries Department operates two salmon hatcheries but depends upon 40 to 50 "private hatcheries" of local fishery cooperatives and associations to rear the fry before release.

In Honshu, there are between 80 and 100 prefectural and private hatcheries located in the eight northern prefectures.

These hatcheries basically support the domestic coastal fisheries for chum salmon, the dominant species of salmon in Japan. Although the over-all program and technology have been the subject of criticism from time to time, the results speak for themselves: an average of 1.8 percent of the fry released would equal the record of many of the hatcheries in the United States and could be accomplished at a very low cost of less than 30 cents per adult return.[3]

Histories of the number of chum salmon fry released by Japanese hatcheries and of the catch are shown in Figures 1 and 2.

Hokkaido

For administrative purposes, the Hokkaido salmon program is divided into two regions and/or five districts. The eastern region, where salmon resources are abundant and the hatcheries numerous, is for the most part under the jurisdiction of the national government. The western region especially along the Japan Sea coast has only limited salmon runs. The Hokkaido government is studying this area intensively with the objective of rebuilding the salmon runs and providing a better balanced salmon production program for the island as a whole.

At the present time almost four-fifths of the salmon production in Hokkaido is found in the eastern region and one-fifth in the western region. Budgetwise, the national appropriation for the hatchery program amounts to about 800 million yen or 2.6 million dollars (1974), and the appropriation for the Hokkaido government is about 170 million yen or 570 thousand dollars.

The results from the existing hatcheries are of interest. The best returns have come from hatcheries located along the Okhotsk Sea in northeastern Hokkaido (4%), the poorest are from releases along the Japan Sea coast of Hokkaido (less than 1%). This information is illustrated in Figure 3.

The cause for the poor returns of salmon to the streams flowing into the Japan Sea is believed to be related to the extreme range of temperatures found in the coastal waters off western Hokkaido. A branch of the warm Kuroshio current flows along the west coast of Japan with summer temperatures as high as 24^{o} to $26^{o}C$, and complicated by the southward shift of the cold Liman current in winter with temperatures as low as 2^{o} to $3^{o}C$.

Salmon are reared in hatcheries at temperatures of about $8^{o}C$ - higher than those found in the natural environment. Accordingly, the young salmon hatch out and emerge from the gravel early in the spring and, if allowed to enter the river and the sea immediately, the water would still be too cold and the food too limited for good survival. All hatcheries now try to hold their fish for one or two months, or until the temperature conditions are more favorable for migration and survival.

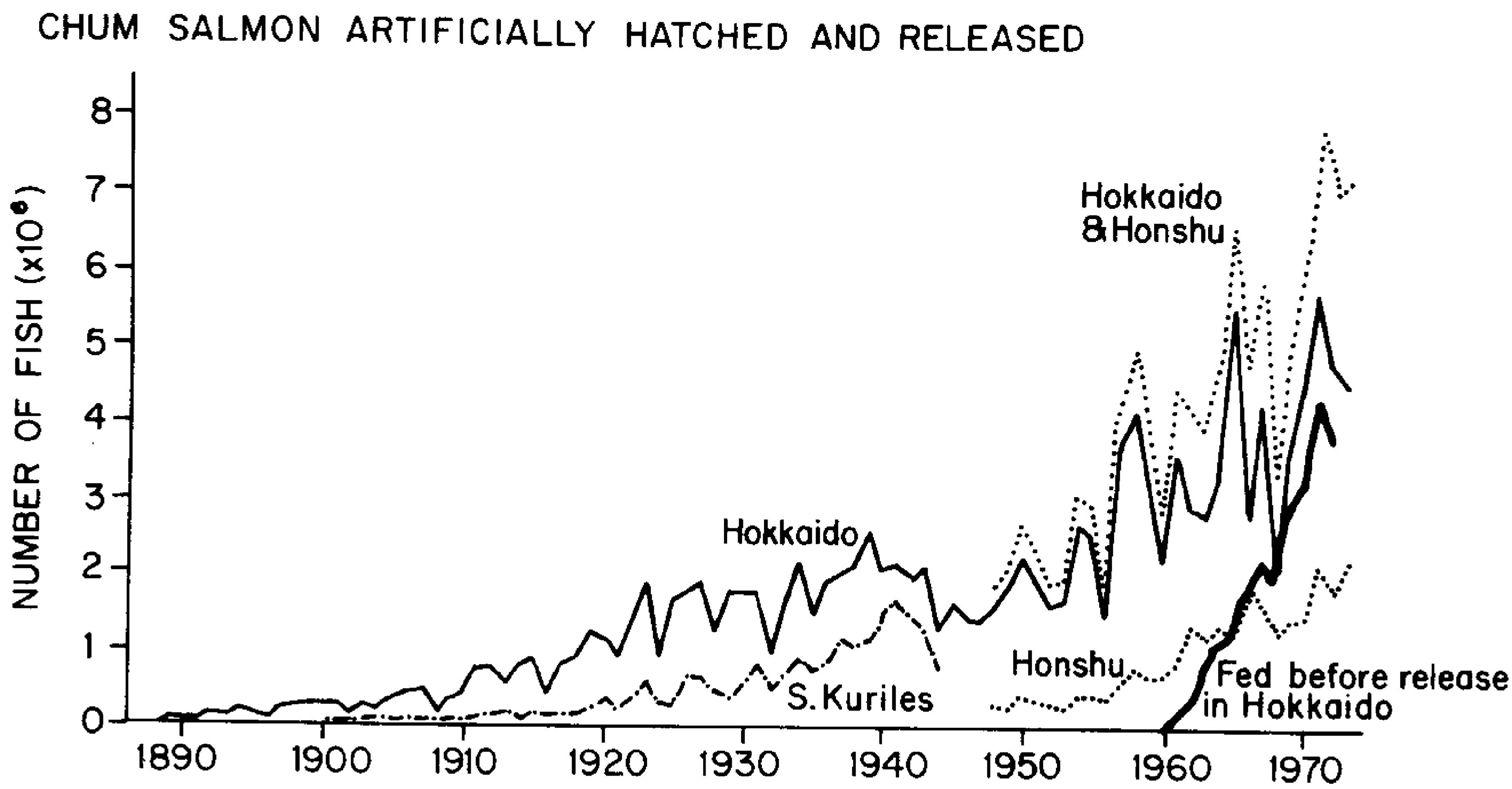


Figure 1. Number of Chum Salmon Fry Released from Hatcheries in Japan (from Fish Farming in Japan, Japan Fisheries Association).

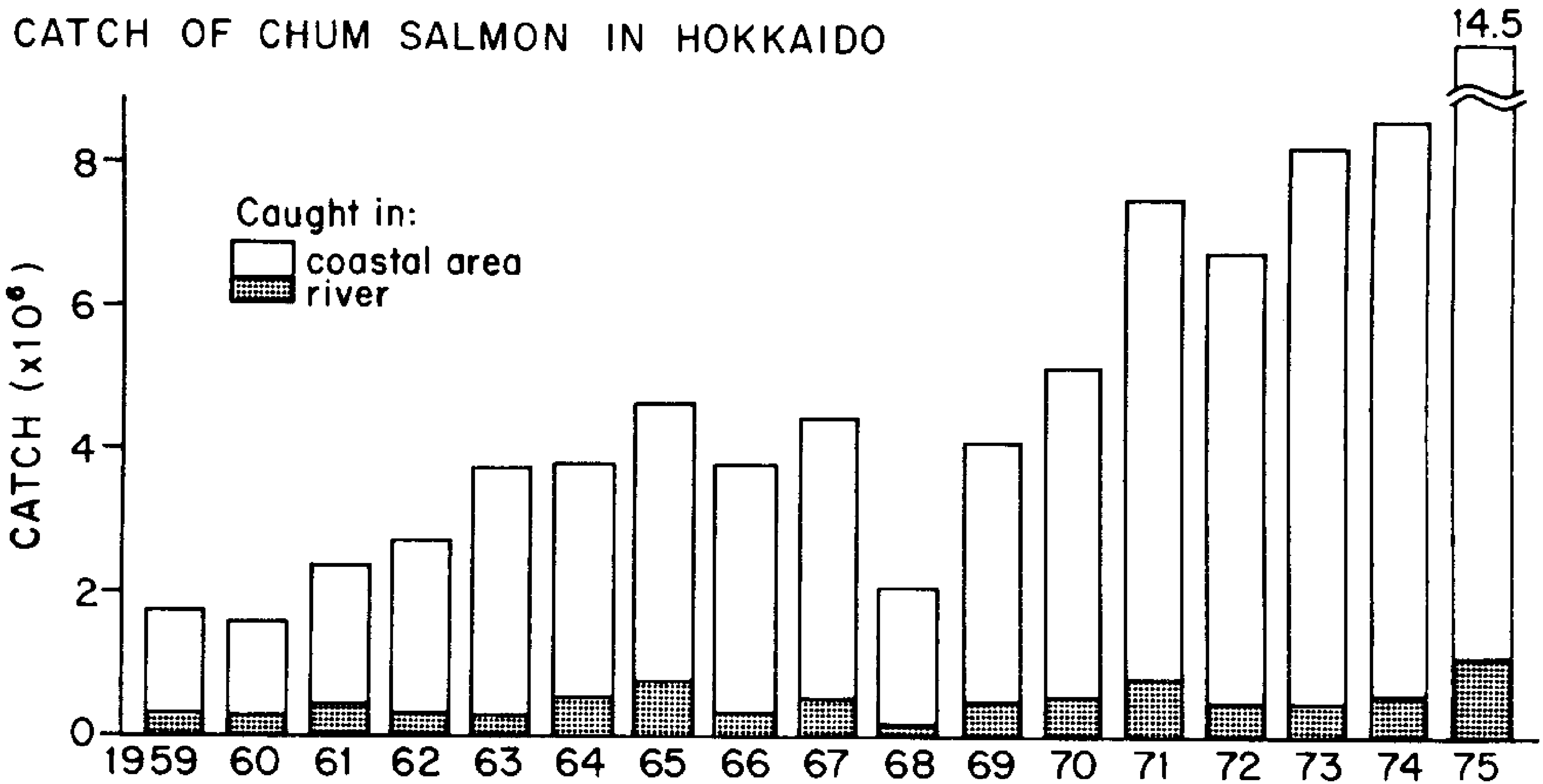


Figure 2. Millions of Chum Salmon Taken in the Coastal and River Fisheries (from Fish Farming in Japan, Japan Fisheries Association).

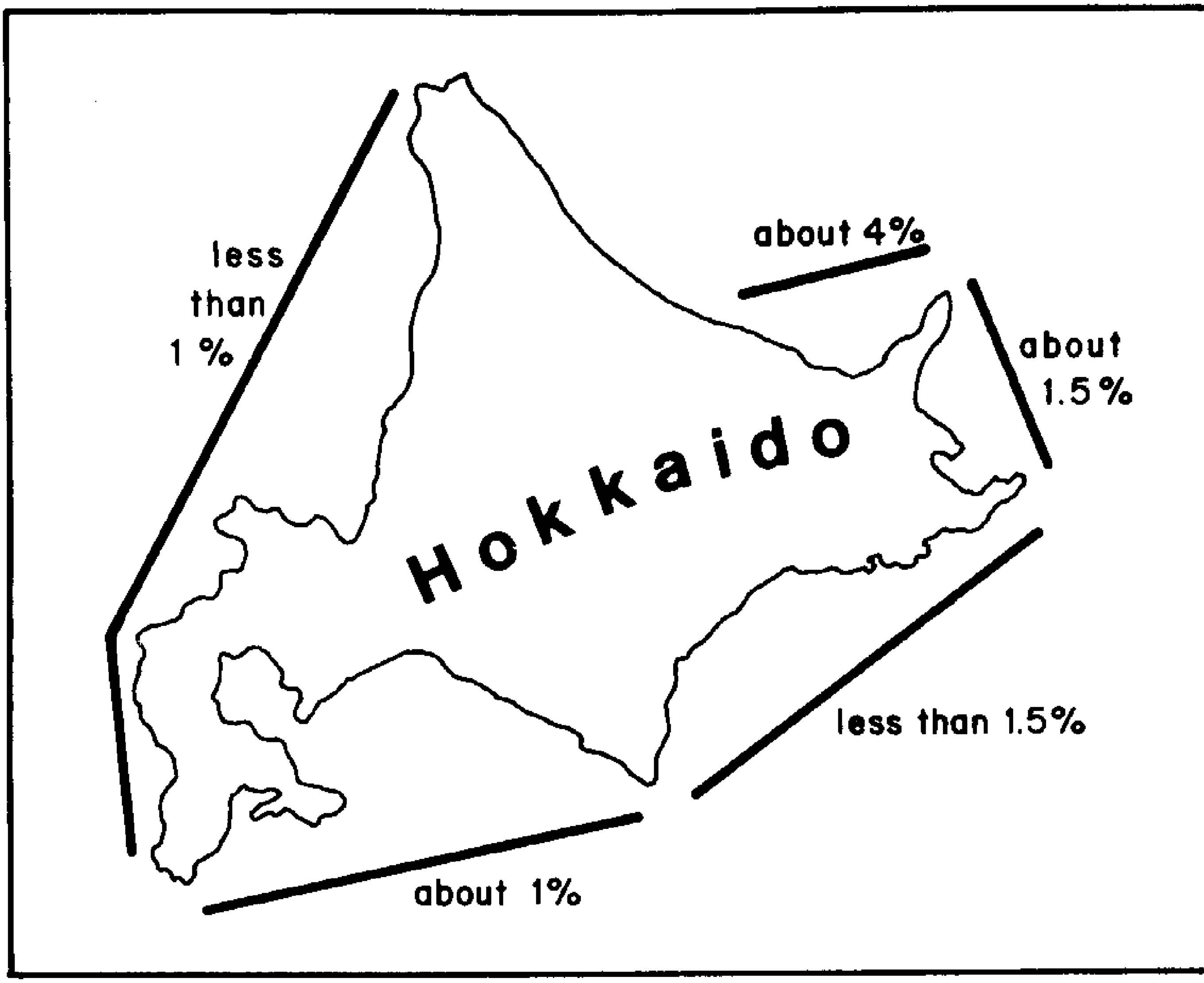


Figure 3. Average Percent Returns for Chum Salmon under the Hokkaido Hatchery Program.

The Hokkaido government has conducted experiments on the effect of temperature on the success of return. A first group of fry was released shortly after hatching and a second group fed for two months until river and sea conditions were more favorable. The returns from the second group were eight times those from the first group.

Japanese hatchery biologists also believe that the high returns from northeastern Hokkaido are related to the available food supply. They point out that along the northeastern coast of Hokkaido, the ice goes out in March, the cloud cover is low, the water temperatures increase rapidly, and the amount of food available to the young salmon is very high. Along the southeastern coast of Hokkaido, the area is usually covered with fog in the spring, the light intensity is low, the water temperatures increase slowly, and the production of food is poor.

As will be pointed out later, the Soviet scientists have shown that the percent return of adults from fry released is related to the size of the fish at time of release. Of course, the size of fish, temperature of water, amount of food and other factors are all interrelated and, so far as is known, no one has been able to assess the contribution of each factor to ultimate survival.

At the present time the disease problem for salmon is critical in Japan. The virus IPN is prevalent in salmon and trout and the disease is causing numerous mortalities in many of the hatcheries. Most seriously infected are the native stocks of Kokanee (land-locked sockeye salmon) and Yamabe (land-locked masu or cherry salmon).

Significantly, over the years there has been a rather thorough mixing of eggs and fry between the streams of Hokkaido and Honshu with little regard for the genetic purity of the individual stocks. Yet, in recent years the percent returns from the Japanese hatcheries have been high - quite contrary to the results of studies and the concern expressed by the United States and Canadian scientists. It is possible that the Japanese hatchery program has developed an overall, general strain to fit conditions in Hokkaido and northern Honshu as a whole, and similar to that described by Simon (1972) for the fall chinook salmon runs to the lower Columbia River. In any case, the genetics associated with salmon hatchery practice is critical to any aquaculture program and deserves a great deal more attention than it has received to date. A careful genetic study by Japanese scientists of the experience of the Hokkaido salmon program would be a most valuable contribution at this time.

The distribution of the salmon hatcheries and related facilities is shown in Figure 4, with an accompanying legend of names in Table 1.

National Salmon Hatchery Program

No attempt will be made at this time to review the long histories of the various hatcheries operated by the national government. A summary of the number of fry released and the returns by brood year is given in Table 2 and in Figure 5.

For years these hatcheries have followed methods and procedures developed by Atkins and others in the early years of salmon propagation. Even in the 15 years or so after World War II these same methods continued to be used with little attempt to improve - a surprise to many foreign fish culturists familiar with the rapid strides made by the Japanese experts in the culture of other fish and shellfish. Changes that have occurred in the past eight years, however, have doubled the rate of return for hatchery salmon and can be attributed, at least in part, to the opportunity for a number of Japanese salmon culturists to visit hatcheries in the Soviet Union and the United States, and the organization of symposia and other media for the exchange of ideas and experiences of others. Significant is the high rate of return of 2.14 percent reflected in the four most recent years of complete returns (1966 to 1970); returns for the previous 16 years averaged about 1 percent.

The advances that have been made in the past few years are apparent in the modern hatchery facilities constructed at Chitose and placed in operation in 1972. The hatchery building is about 20,000 sq. ft. in size with about two-thirds of the space (12,800 sq. ft.) occupied with troughs and other incubation facilities. The remaining space is used for 24 raceway-type ponds (81.25 ft. by 5.8 ft.). The raceways are used for the rearing of fry: a layer of gravel is spread over the bottom of the ponds and two perforated pipes (2 mm holes spaced at intervals of 20 cm) are imbedded in the concrete to provide for proper circulation of water through the gravel. The eight additional ponds (17.55 ft. by 48.75 ft.) just outside the hatchery building are used to hold and feed the fingerlings until ready for release (at a size of 4-5 cm in length or about 5 gr in weight). The whole system is so designed that the fry can be flushed from the troughs into the gravel raceways, and then, when free-swimming, into the outside rearing ponds and finally into the river - all without handling.

The young fish are fed a standard trout dry-pellet food, described in detail by Mathews and Senn (1975). The amount fed per fish per day is related to water temperature and the

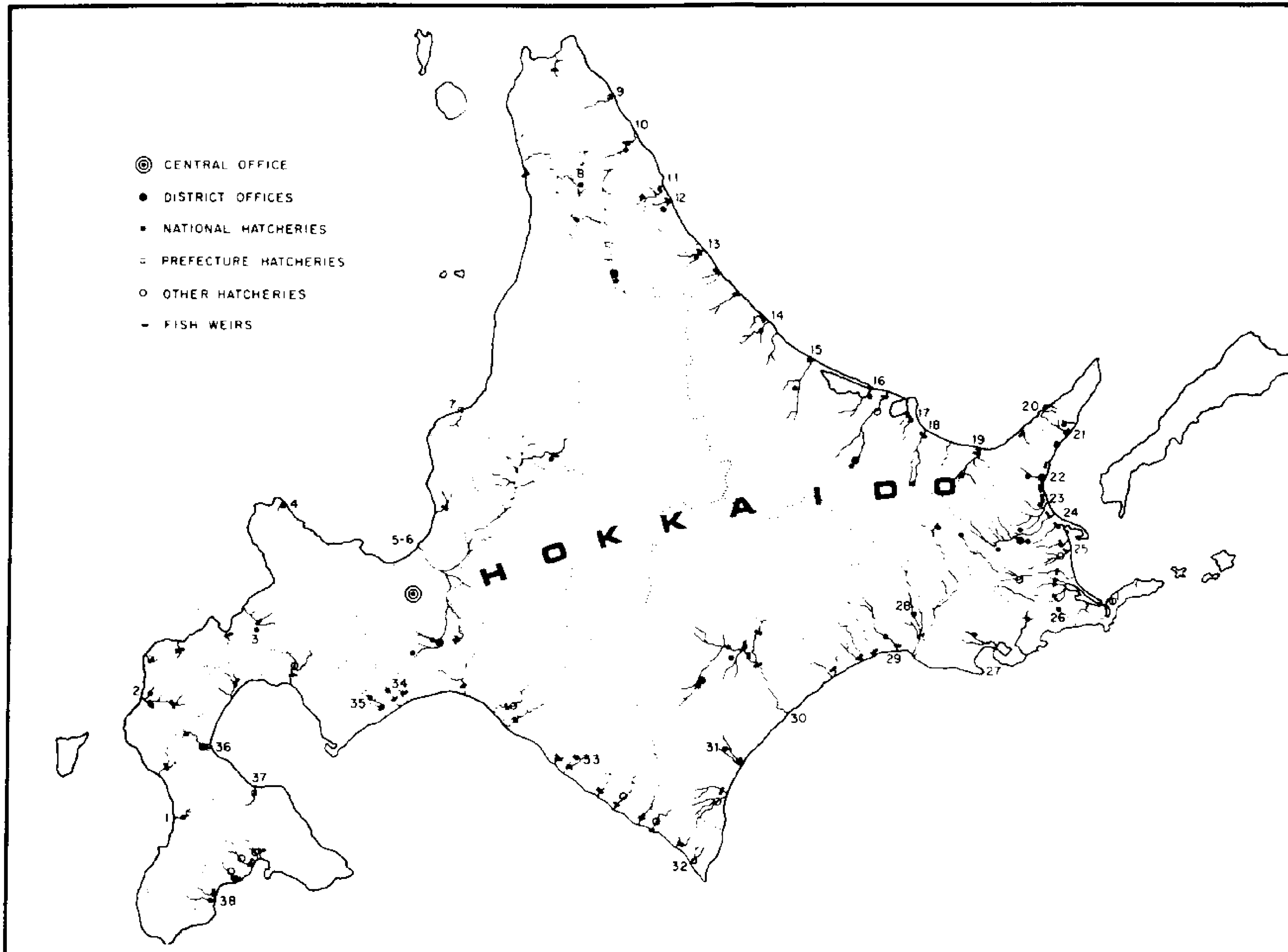


Figure 4. Salmon Hatcheries and Related Activities in Hokkaido (See Table 1).

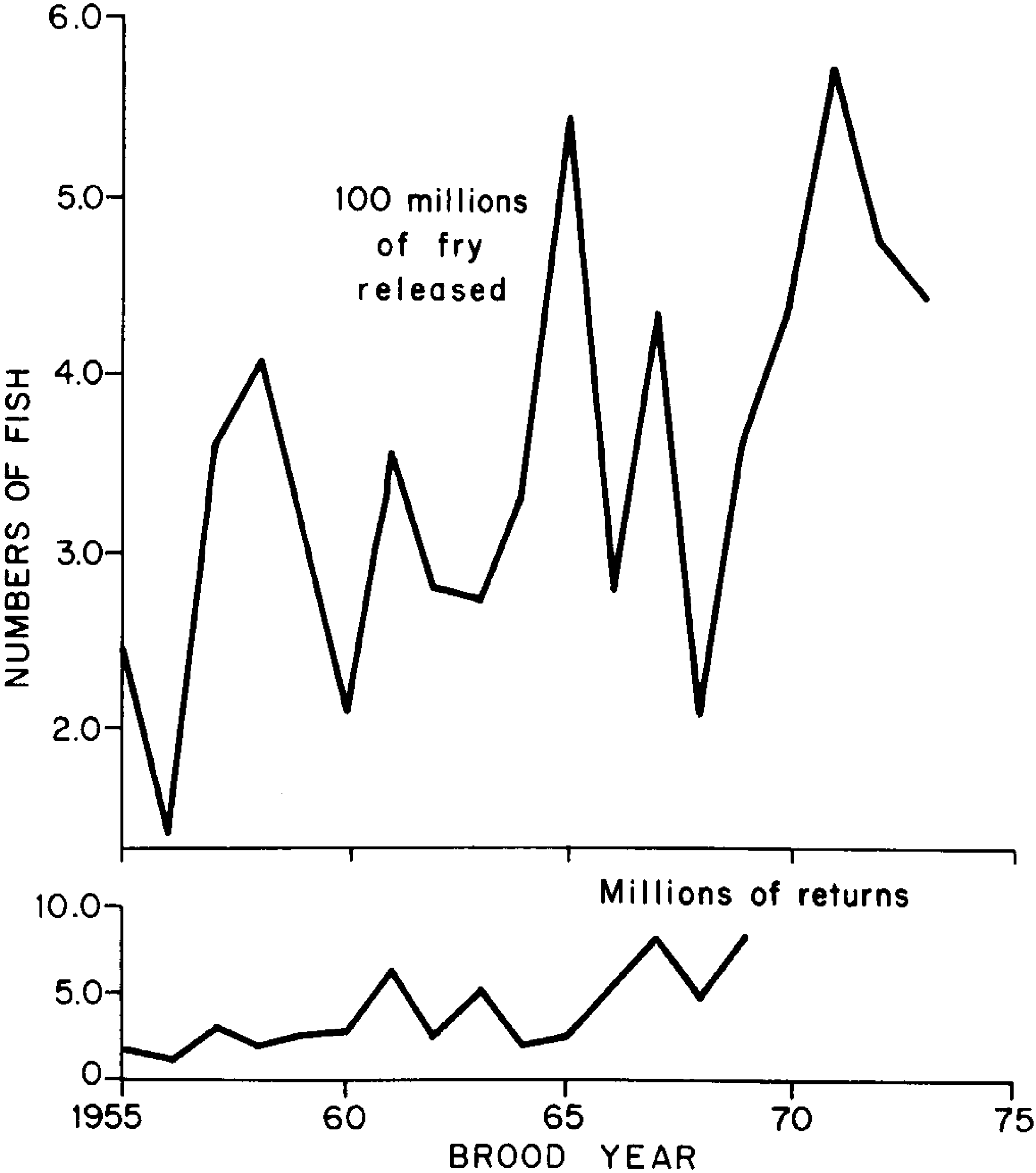


Figure 5. Numbers of Fry Released and Returns by Brood Year for Chum Salmon Reared at National Salmon Hatcheries in Hokkaido

size of fish. This amount is worked out by the biologists and the feed manufacturer and is available to the culturist in a convenient tabular form.

In 1972, the Chitose hatchery handled some 18.5 million chum salmon fry (from 24 million eggs), releasing the young in three rivers tributary to the Japan Sea and five rivers flowing into the Pacific Ocean. In addition, the hatchery released 280,000 masu (cherry salmon) fingerlings (from 380,000 eggs).

Hokkaido Provincial Salmon Hatchery Program[4]

Until very recently, salmon propagation in Hokkaido was the sole responsibility of the national government. However, the decrease in supply and the increase in demand for salmon, and the growing restrictions on high seas salmon fishing imposed by the Japan-Soviet and the Japan-Canada-United States fisheries commissions, generated considerable local pressure to expand the work beyond the scope and means of the national program. Accordingly, in 1967 the Fisheries Department of the Hokkaido provincial government, in close cooperation with the national government, began to propagate salmon at the freshwater fish hatchery at Mori (near Hakodate), and subsequently embarked on an impressive salmon propagation program that will eventually involve the operation of the five hatcheries given below:

Name of Hatchery	First Year of Operation
Mori	1967
Mashike	1973
Erimo (Utabetsu river)	1975
Yoichi	1976
Soya	1978

The Mori hatchery has a capacity of 20 million eggs and rearing ponds of about 10,600 sq. ft. The recently completed Mashike hatchery has a capacity of 30 million eggs and rearing ponds of 8,400 sq. ft. (including 2,730 sq. ft. designated for research purposes).

In addition to the general supervision of the overall salmon/freshwater fisheries program, the Hokkaido Department of Fisheries will (1) collect and hatch salmon eggs at the five hatcheries noted above, (2) establish two experimental hatcheries (Mashike and Mori), (3) distribute young salmon to various cooperatives and associations for rearing and release, and (4) provide expertise in nutrition, disease and other hatchery technology to the cooperatives and culturists.

The key to the Hokkaido provincial hatchery program is the subsidy provided local cooperatives and associations by the Hokkaido government for the construction and operation of salmon rearing facilities. At the present time, there are about 40 or 50 "private" (cooperative-run) hatcheries in Hokkaido. In the future, the province expects that there will be about 100 of these "private" hatcheries - all relatively small and widely distributed throughout Hokkaido. The amount of support provided by the government is not fixed but varies according to the ability of the local group to pay and the need for increased salmon production in a specific locale. Subsidies totaling 30 to 40 million yen a year (100 to 130 thousand dollars) are provided by the Hokkaido government for this purpose.

Following is a record of the numbers of fry distributed by the Hokkaido government during the first four years of operation of the salmon program:

Year	Number of Fry Distributed
1969	6,302,000
1970	9,400,000
1971	16,098,000
1972	6,950,000

Most of these fish were reared at Mori and the young placed in small rearing ponds operated by cooperatives and associations at Matsumae, Fukushima, Shiriuchi, Kikonai, Hakodate, Shirikishinai and Shikabe.

A good example of the degree of modernization of the present Japanese hatchery system is illustrated by the new Mashike hatchery, located on the Shokanbetsu River about midway along the Japan Sea coast of Hokkaido. Construction of the hatchery began in 1972 and was completed and in operation in the following year. The present staff total five - one chief, two scientists (nutrition and disease), and three hatchery technicians. The basic specifications for the hatchery are summarized:

Total land area		269,041 sq. ft.
Building		
Hatchery	2100 sq. ft.	

Inside ponds (30 million eggs)	1470 sq. ft.	
Office/laboratory (10 million fry)	2730 sq. ft.	
Total		6,300 sq. ft.
Outside ponds (5 million fingerlings)		4,200 sq. ft.
Garage/generating room		425 sq. ft.
Pumps		
River (one operating, two spare)		264 gal./min.
Hatchery and ponds (two operating)		792 gal./min.
Heating equipment (water and space)		992,000 K cal./hr.

Mashike is unique in two ways: (1) it is the first hatchery in Japan to recirculate and heat the water for incubation and rearing of salmon, and (2) it uses tray-type incubators to handle all eggs and fry. The total cost of the hatchery was 92.6 million yen or 308.6 thousand dollars.

To heat the water, the hatchery uses an oil-fired boiler with two heat exchangers - one to raise the temperature of the river water from 1^{o} to 8^{o}C (340,000 K cal./hr.), and a second to heat the recycled water from 3^{o} to 8^{o}C (180,000 K cal./hr.). A schematic drawing of the water recirculating system and the actual river and hatchery water temperatures are given in Figures 6 and 7.

Although tray incubators are commonly used in the United States, their use to date in some of the hatcheries in Japan (Abashiri, Chitose, etc.) has been on a small scale, almost experimental. Mashike hatchery, however, will depend entirely on tray incubators to handle their projected 30 million eggs a year. The incubators were designed by the staff of the Hokkaido Fisheries Department and manufactured in Japan. The units are made of aluminum, consisting of 10 horizontally-stacked trays, and with a capacity of 150,000 eggs or 120,000 fry per unit of 10 trays.

At present, Mashike hatchery obtains its supply of chum salmon eggs from the Nishibetsu and Raosu Rivers of northeastern Hokkaido. The young are released in 11 rivers flowing into

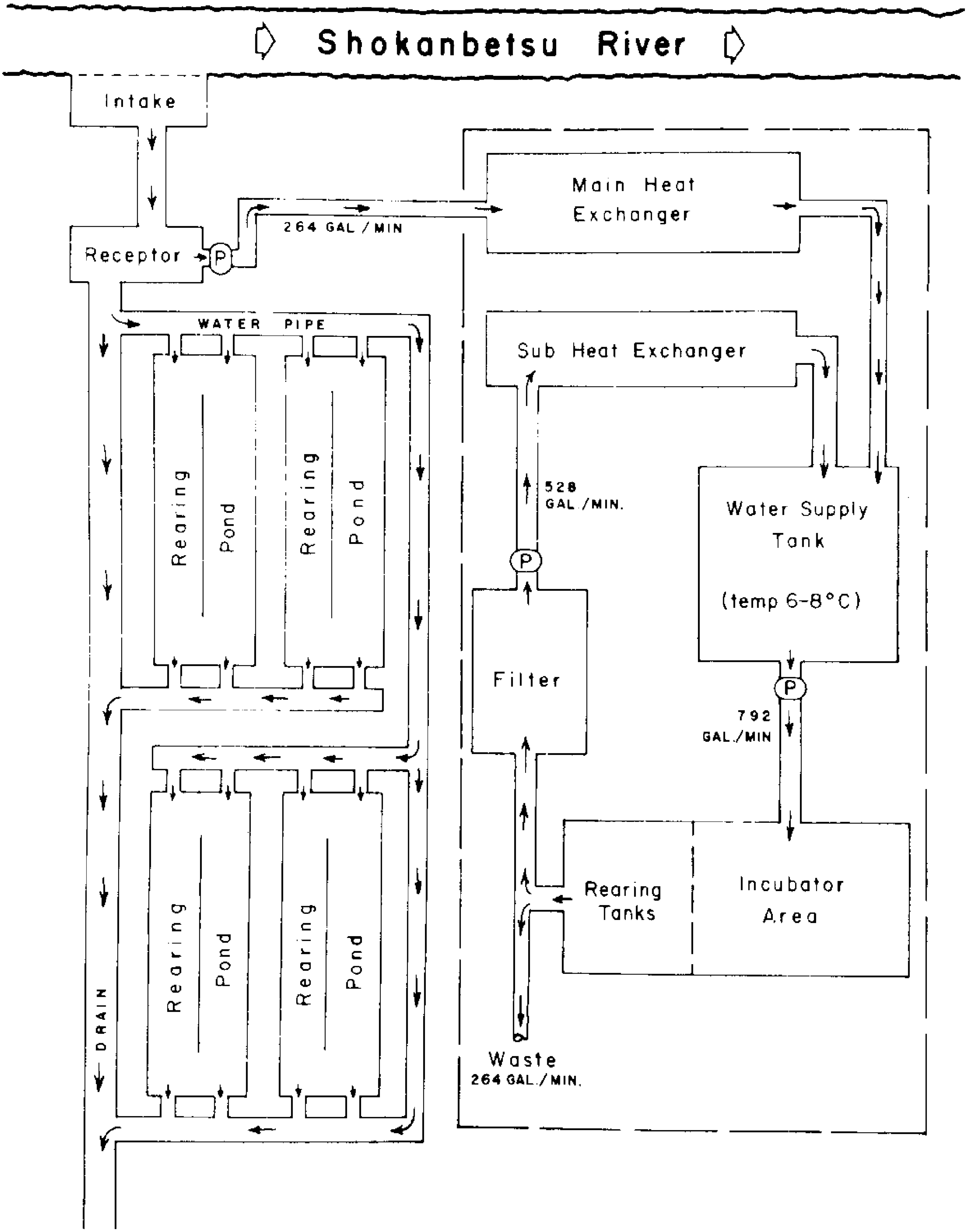


Figure 6. Schematic Drawing of the Water Recirculating System at Mashike Hatchery.

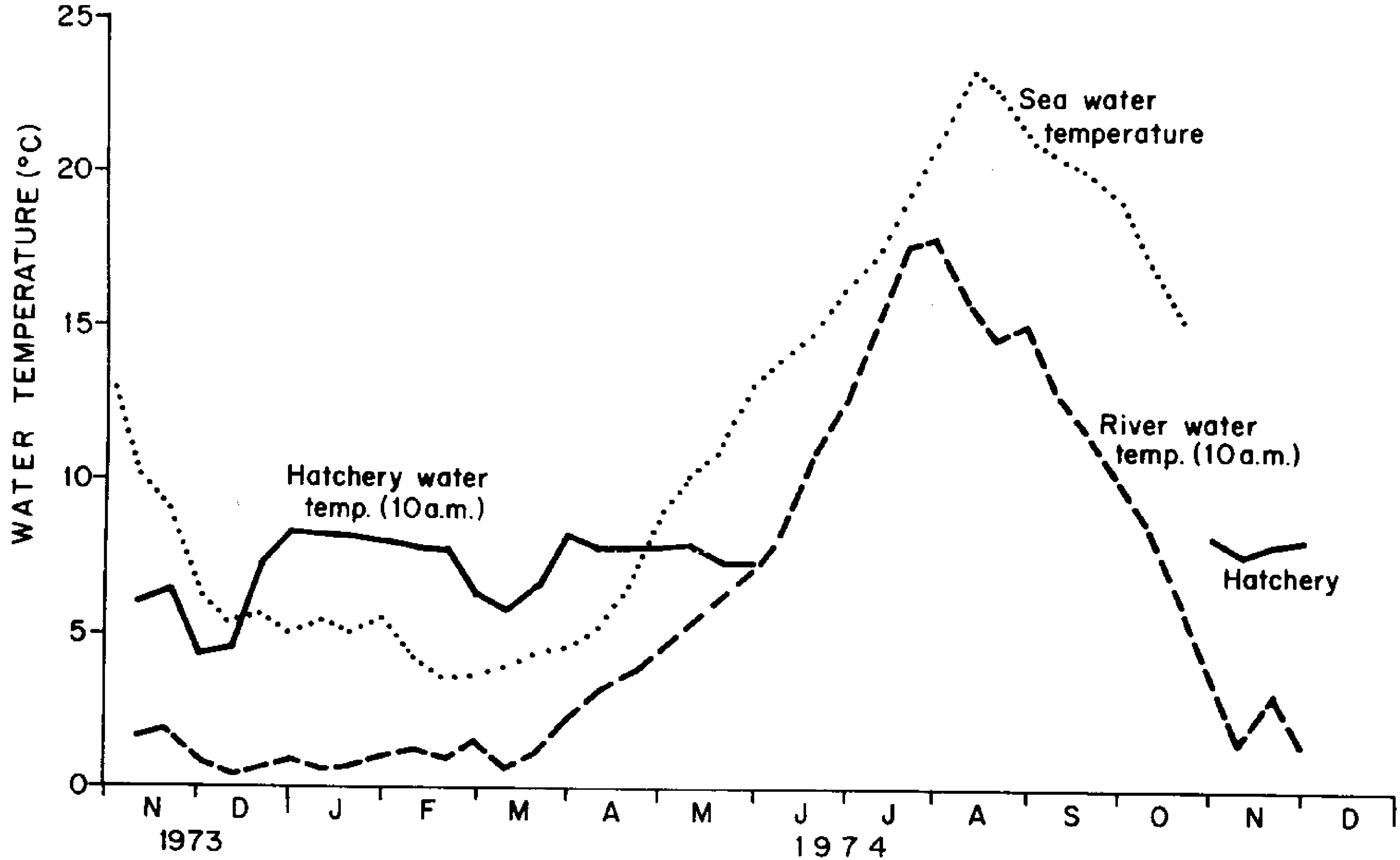


Figure 7. Comparison of Sea and River Temperatures with Heated Water Supply, Mashike Hatchery.

the Japan Sea in the Rumoi and Ishikari Districts. About 10 percent of the young fish are marked before release by the removal of one pectoral fin in order to study their distribution in the sea and the proportion taken by the fishery.

A "Private" Hokkaido Salmon Hatchery

The Yoichi hatchery, located about four miles from the mouth of the Yoichi River, is a good example of a "private" hatchery operated by a fishery cooperative with government subsidy. The hatchery is small, having a capacity of 8 million eggs and using troughs and trays for handling the eggs and fry. When free-swimming, the fry are transferred to outdoor ponds where they are held for approximately one month before release. The young fish are fed the standard trout dry-pellet food generally used in all Hokkaido salmon hatcheries.

The hatchery obtains a small amount of water from a nearby spring (about 190 gallons/minute). Although the constant temperature of the spring water is nearly ideal for rearing salmon ($8^{o}C$), the amount is only adequate to incubate the eggs, not for use in the rearing ponds. Preliminary studies show that equipment to cool the water during the critical summer months would be too expensive to consider at this time.

In 1974/75, the hatchery handled about 5 million chum salmon eggs, 3 million pink salmon eggs from Okoppe and Shari Rivers of northeastern Hokkaido, and 200,000 chinook salmon eggs from the University of Washington. The costs of operation of the Yoichi hatchery are almost entirely financed by the cooperative - 25 million yen (83.3 thousand dollars) by the cooperative and 5 million yen (16.6 thousand dollars) from the Hokkaido government. The staff consists of one professional hatchery man, two full-time hatchery workers and seasonal help as required.

The chum salmon returns for the Yoichi hatchery are comparatively good for the Japan Sea area, averaging about 1 percent.

Honshu

Although the reasons are not completely clear, the salmon hatchery program for the nine prefectures of northern Honshu has remained under the direct supervision of the prefectural governments. The program has had a tendency to become fragmented and the results have depended to a large extent upon the expertise and financial support of each "private" group and have not attained the scale of production found in the Hokkaido hatcheries. The emphasis is reflected in a gross way by a comparison of the total fry released in 1974 - 230 million for northern Honshu, or about one-fourth the total of 900 million for all of Japan.

The salmon propagation program of Iwate prefecture is an exception. Here the prefecture has taken a lead in developing an effective program, operating two or three hatcheries and working very closely with the various "private" hatcheries in order to assure good returns. The interest is shown in a recent communication from the fisheries section of the Iwate prefecture government: "We had lots of chum salmon this year (more than 1.2 million, including sea and river). This is due to our propagation efforts, I think. We're going to propagate salmon more and more." (Sato, 1976)

It is also at Yamada Bay (Iwate prefecture) that chum salmon have been experimentally reared in salt water for about four months or more before release. Although there are still two more year-classes to return, the rate thus far has already exceeded the 1 percent level (Anonymous, 1975b; Anonymous, 1976a).

There are a number of different kinds of organizations that are involved in the salmon hatchery program of northern Honshu. Most of the effort comes from special Fish Culture Associations, and as shown in Table 3, accounts for about 70 percent of the total; Fishery Cooperatives make up only about 2.5 percent of the total. The pattern of membership of the Fish Culture Associations (i.e., local fishermen, fish dealers, local businessmen, and other interested local people) is similar in many ways to the membership of the private, nonprofit aquaculture associations now being formed in Alaska.

Detailed production records for chum salmon released in the nine northern Honshu prefectures between 1962 and 1967 are given in Table 4, and summarized in Table 5. More recent data for all salmon (i.e., chum, pinks and masu) are given in Table 6 for the years 1965 to 1974. Many of the variables, of course, are due to the cyclic nature of the salmon returns, making comparisons over short periods of time difficult. At the same time, however, we cannot ignore the very sharp increase in numbers of fry released between 1965 and 1974, as shown in Figure 8, and an indication of the degree of success of the Japanese salmon propagation program.[5]

The operation of the "private" hatcheries of northern Honshu is dependent upon the receipt of a subsidy from the national and prefecture governments. The system of payment apparently has varied from year to year. For example, one reference states that the amount of subsidy provided in 1964 amounted to 0.30 yen per fry released (Anonymous, 1969). Another source notes that the subsidy paid would be one-half the cost of rearing and distributing the young salmon (Anonymous, 1965).

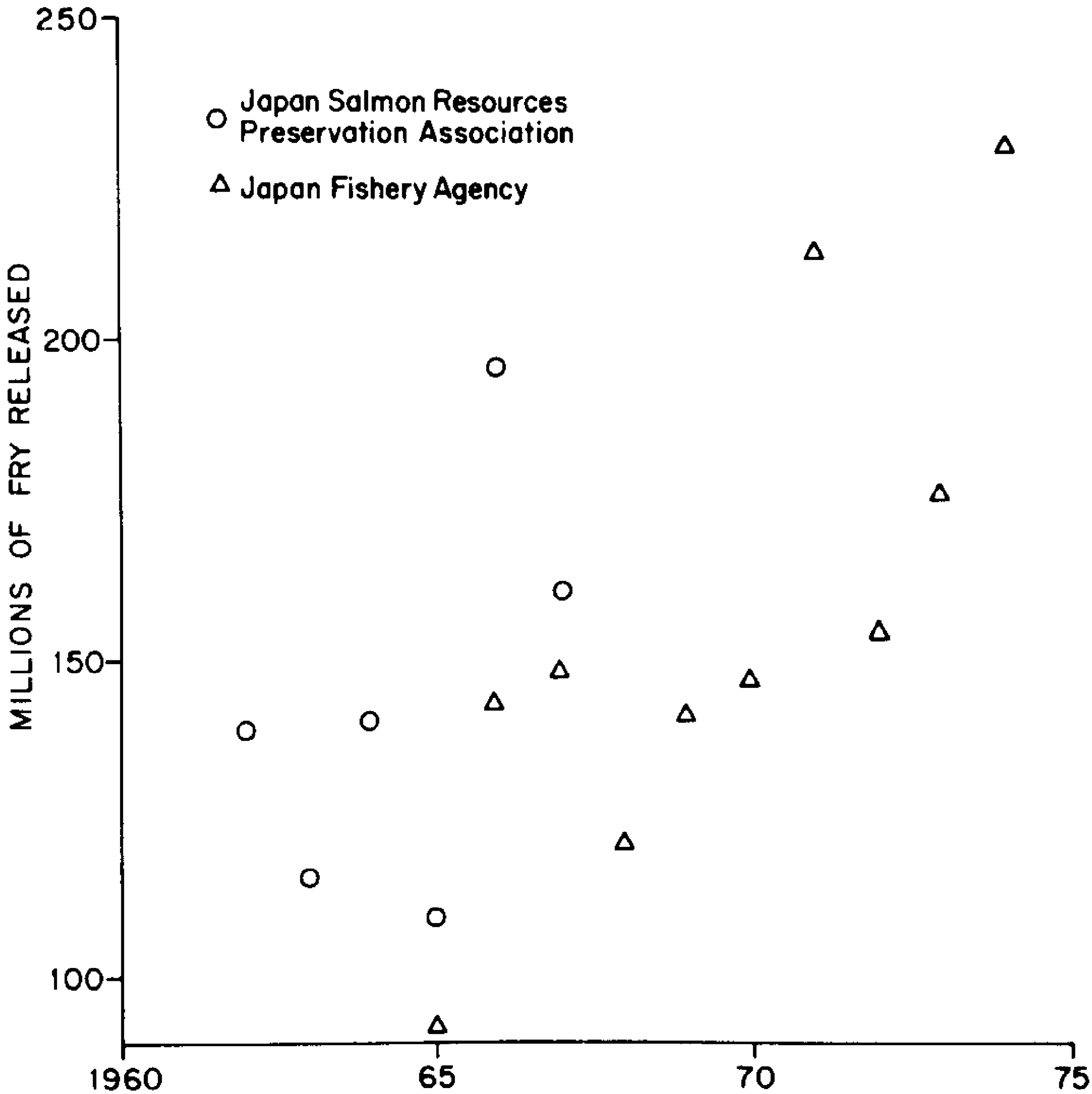


Figure 8. Number of Chum Salmon Fry Released from Northern Honshu Salmon Hatcheries.

The distribution of salmon hatcheries in Honshu is shown in Figure 9, with an accompanying legend of names in Table 7.

It should be pointed out that much of the success of the prefecture programs has been due to the coordinating role of the Japan Salmon Resources Preservation Association. This association is supported by funds received from government and industry and serves a vital role in providing assistance to the various groups when needed, especially in the design of hatcheries, the introduction of new technology, the arrangements for foreign transplants and the distribution of appropriate reports and other literature.

For example, for some time the association has pressed for the adoption of better feeding practices for the young salmon fry before release from the hatcheries. A recent letter states: "As you well know, the return of chum last year was unprecedentedly high. I regard this...(as) increasing evidence that the large number of fry of the 1971 year-class, reared with artificial feed before release, contributed greatly. I think that in evaluating the return of last year, we must pay due regard to the fact that quite a number of salmon fry were released in 1967 and that the year 1971 was a year after which the practice of feeding before release was fully adopted in our hatcheries" (Aoki, 1976).

Economics of Japan's Salmon Hatcheries

For the past 50 years or more, the salmon hatcheries along the Pacific coast of the United States have been operated by public funds, in the form of subsidy to the salmon fishermen and the industry, and with little attention to the actual cost of production. During the 1920-1930's, the economic feasibility of salmon hatcheries was questioned by a number of investigators and, in fact, many hatcheries were closed when it became quite obvious that for one reason or another, the production record was too low to maintain the runs or the costs too high to justify continued operation. This attitude was reflected even in recommendations made by SCAP[6] in their review of the Japanese salmon hatchery program immediately following World War II (Anonymous, 1966).

Beginning with the construction of Bonneville Dam and continuing for about 30 years, the development of water-use projects on the Columbia and other rivers created an immediate need for economic studies of the salmon resources, for the development of new concepts in fish passage, and for an increasing reliance on hatcheries and other culture methods as the only way to maintain the salmon runs. The results of studies made during this period revolutionized many of the old, inefficient methods used for many years in the salmon hatcheries.

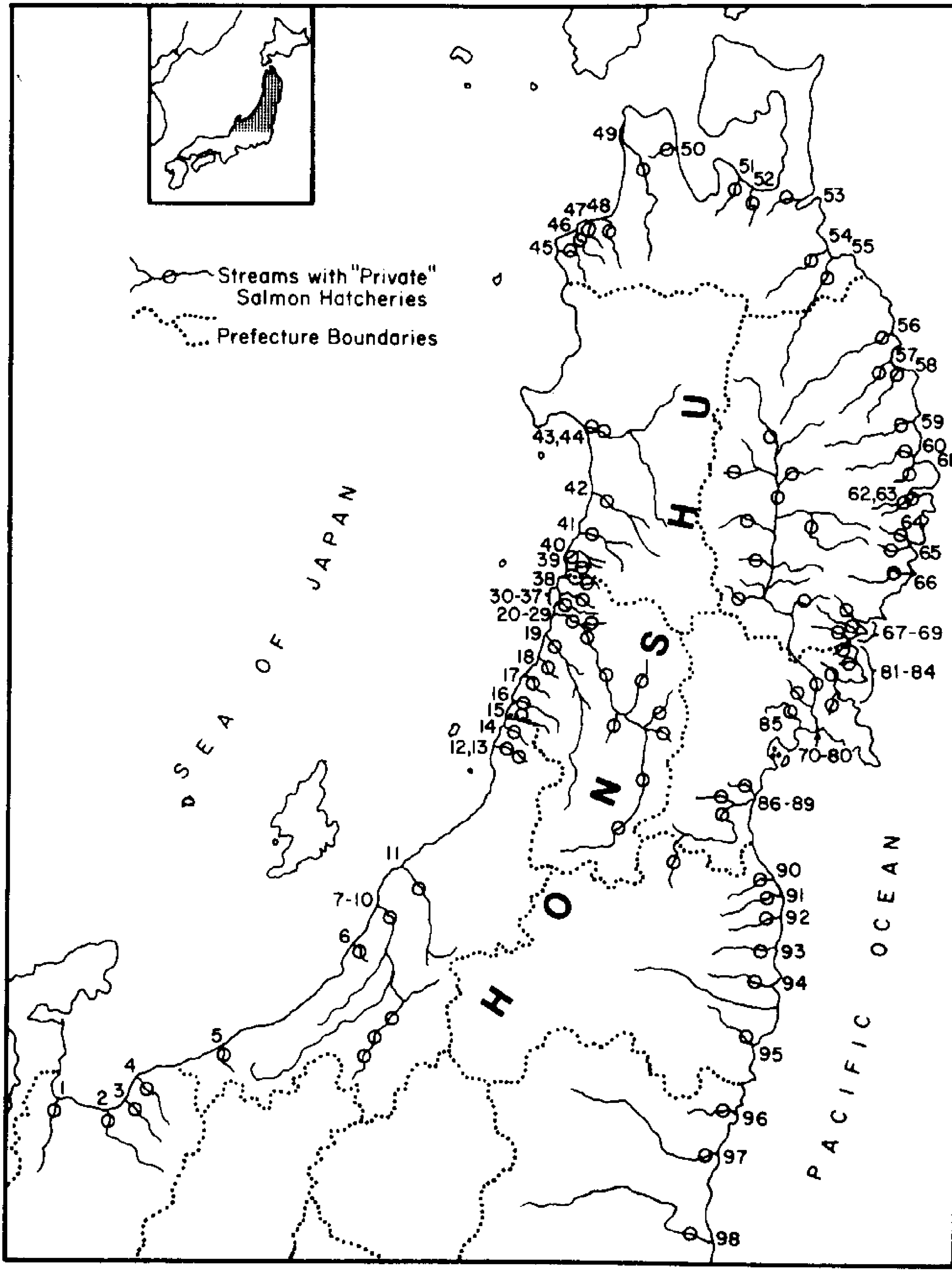


Figure 9. Streams of Northern Honshu with Salmon Hatcheries or Hatchery Activity (See Table 7).

Recent successes of public-funded salmon hatcheries, especially for silver salmon, have stimulated the formation of several commercial salmon aquaculture companies in Washington and Oregon and, more recently, of private nonprofit organizations in Alaska. Since economics is of primary concern to these private ventures, the cost-production records for the Japanese salmon hatcheries become all the more important.

Estimates of the total costs of operations are available in two forms: (1) net expenditures for the National Hatchery Program in Hokkaido for 1953 to 1965, and (2) as net expenditures for chum salmon production for Hokkaido and Honshu, 1962 to 1975. The cost of hatchery operations include new facilities, repairs, operation expenses, etc., but do not include depreciation per se which, in the Japanese system, is taken as a part of the cost of new facilities (Anonymous, 1966). These costs are summarized in Tables 8 and 9.

Unfortunately, information on the distribution of costs in the available literature is limited to detail presented during the three year hatchery expansion program of 1962 to 1964 (Anonymous, 1969), and diagrammed in Figure 10. Ten years ago, facilities and operational expenses each accounted for 29 percent of the total, and salaries and wages for 14 percent. It is known that salaries and wages have increased rapidly during the past several years as well as other costs, but the effect on the overall distribution of expenditures is not known.

Information on the cost of fry production (i.e., the net expenditures/number of fry released) is given in Tables 10 and 11. As pointed out by previous authors, the production costs per fry decreased as the number of fry increased (Anonymous, 1966), as shown in Figure 11. Although the three cost levels are loosely associated with three corresponding phases of growth and inflation in the Japanese economy[7], the costs also are related to modernization of the hatchery facilities between 1962 and 1964 and the more recently adopted practice of feeding the fry before release, coupled with the very rapid rise in costs from 1967 to the present: the effect of recent inflation in Japan has been sufficient to reverse the cost trend of fry production. At the present time, the cost of fry production ranges from 0.5 to 0.7 cents with an average of 0.6 cents per fish released.

The cost per adult return is summarized in Table 12. Here the values of the completed returns for brood years 1962 to 1970 vary between 20 and 67 cents or an average of 29 cents per adult return.

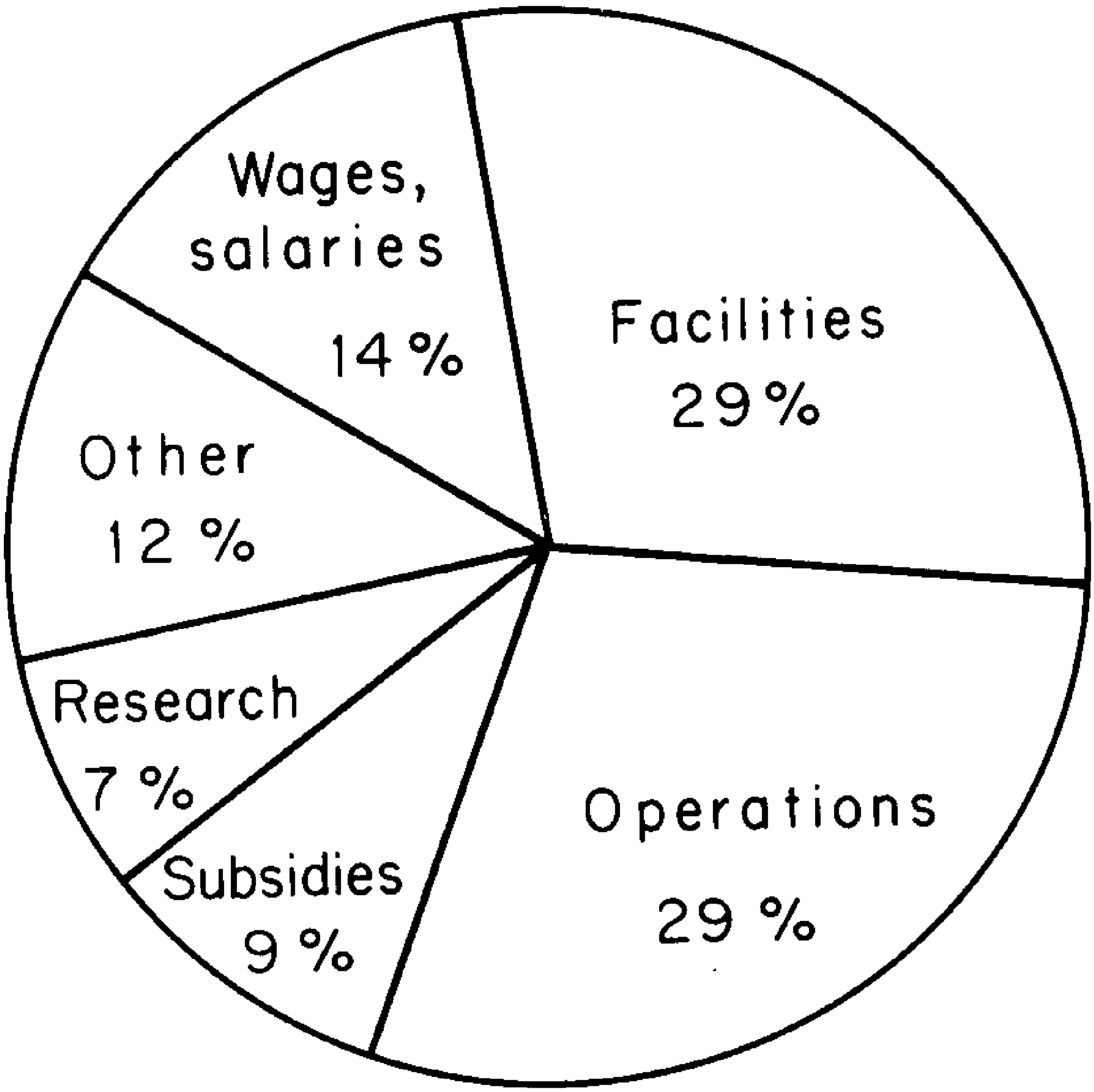


Figure 10. Distribution of Hatchery Expenditures, 1962 to 1964.

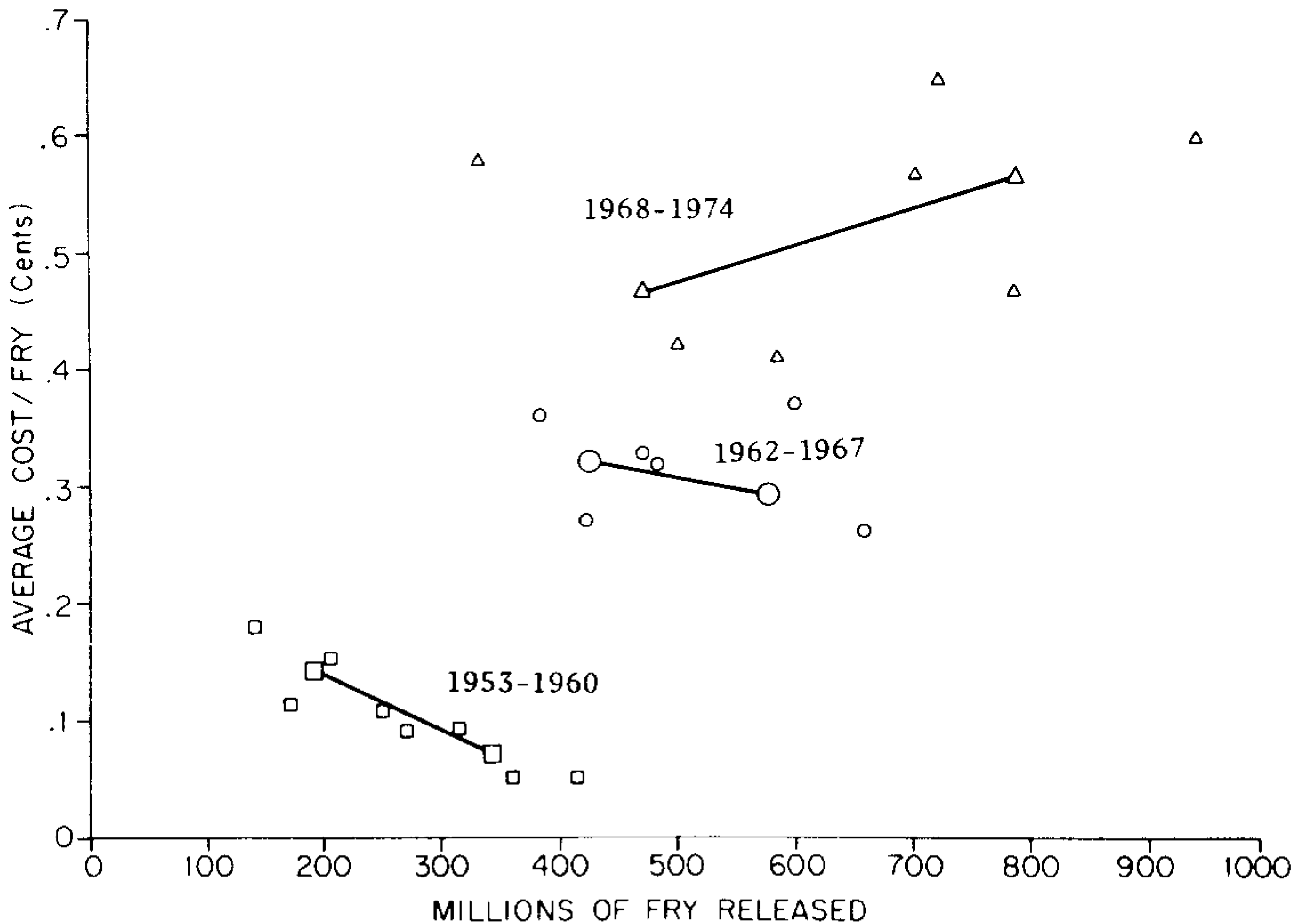


Figure 11. The Relationship between the Number of Fry Released and Average Cost per Fry.

A second cost estimate has been provided by the Japan Salmon Resource Preservation Association, using the propagation costs and the value of the coastal catch to obtain an estimate of the cost per fish taken in the coastal catch. As can be seen in Table 13, the costs vary between 24 and 73 cents per adult for Hokkaido and 17 to 47 cents for Honshu - an average of 34 and 31 cents respectively.

REPUBLIC OF KOREA[8]

In June 1967 a team of seven fishery experts from the Republic of Korea and the United States conducted a joint survey of the streams along the east and southeast coasts of the Republic of Korea in order to determine the range and magnitude of the native salmon runs and the feasibility of increasing the production of salmon in these streams by hatcheries or other means. Although few in number, runs of both chum and masu salmon were found in 15 of the 26 streams examined. The total catch in 1966 was 6,400 fish but previously (in 1933), a catch of 8,000 salmon was reported for only one of the streams, Oship Chun (Kanggu), where past records are available (see Table 14). Further, an economic feasibility study showed favorable cost benefit ratios for four hatchery sites - Milyang Kan, Oship Chun (Samchok), Oship Chun (Kanggu) and Namdae Chun.

Based on these findings two fishery engineering consultants from the United States were sent to Korea in October 1967. Engineering studies made at three of the four sites proposed by the survey team showed that, from an engineering point of view, construction of hatcheries at Milyang and Oship Chun (Samchok) was completely feasible and fully supported the previous findings.

It is important to note here that the engineering study recognized the high summer water temperatures at all sites and gave high priority to exploratory drilling for a suitable supply of cool water "essential to provide incubation and rearing water temperatures and to provide for occasional deficient river flows" (Mack, John V., and Edward K. Newbauer, 1967). Although some test drilling has been made, test drills have failed to indicate flows that satisfy the requirements of these or other hatcheries; a possible exception is in the spring area near the hatchery at Oship Chun (Samchok).

Following approval of the design and specifications in the latter part of 1967, one of the hatcheries was built and in operation by 1968, the other two by 1969. The locations of these hatcheries are shown in Figure 12; the construction schedule and tabular description of the hatcheries are given in Table 15.

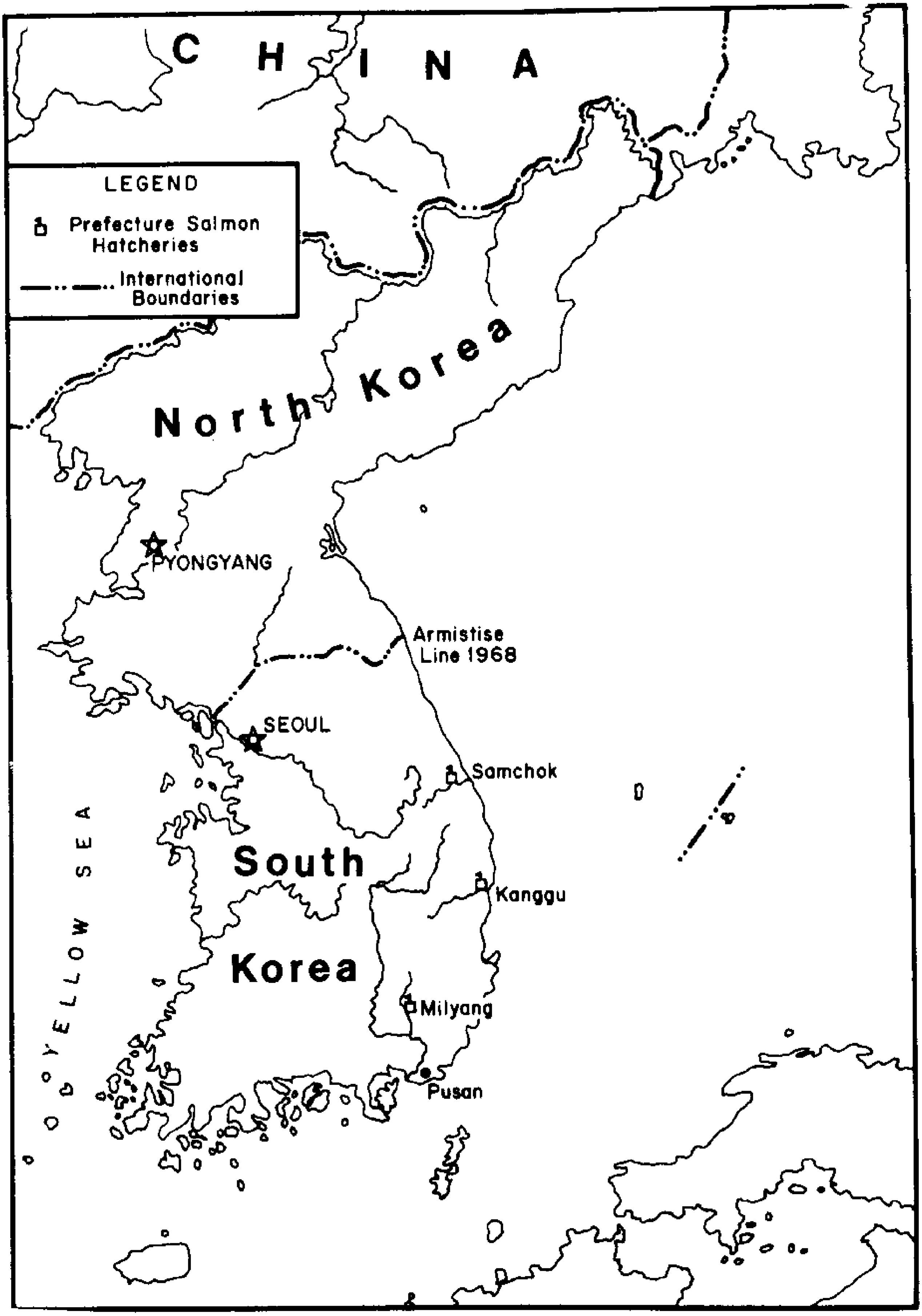


Figure 12. The Salmon Hatcheries of the Republic of Korea.

The three hatcheries were built at a total cost of $430,000. Detailed costs are found in Appendix A of the original report (Atkinson, et al., 1973).

Following completion of the two hatcheries at Milyang and Oship Chun (Samchok) and in order to place the hatcheries in production, the Office of Fisheries of the Republic of Korea requested a total of one million salmon eggs from the United States in 1969.

Unfortunately, only about 100,000 chum salmon eggs could be provided by the United States in 1968 supplemented by 500,000 coho eggs due to the limited supply. At that time, Pressey (1968) recommended that "the coho be reared to yearlings at the Oship Chun (Samchok) since coho would not be compatible to the year round water temperatures experienced at Milyang." The same substitution of coho eggs for chum salmon eggs continued for the following five years resulting in shipments from the United States totaling 560 thousand chum salmon eggs and 6 million coho eggs between 1969 and 1974. The United States will provide an additional 1.5 million chum salmon eggs and 1.0 million coho eggs in 1975/76. In addition to the above shipments of eggs, a total of 200,000 chum salmon eggs were made available to the Republic of Korea in 1973/74 through the Japan Fishery Agency and an additional 200,000 chum salmon eggs will be sent by the State of Alaska to Korea in the fall of 1976.

In addition to the eggs provided by the United States approximately 737,450 eggs were collected from the native chum salmon runs in Korea. A summary of the hatchery operations is given in Table 16.

The native chum salmon runs have been able to maintain themselves in the Korean streams - possibly supplemented by a few returns from eggs provided by the United States. Coho, however, which require a period of stream residence before migrating to sea, would be difficult to handle because of the very high summer stream temperatures (over 16°C from April through September). One possibility would be to provide heated water in winter and force feed to allow release of the fingerlings before mid-April. Another possibility however would be to rear the young in deep reservoirs where they could avoid the high water temperatures. For example, some coho have escaped into a deep reservoir below the hatchery at Samchok, have survived and are now taken in limited numbers by local sportsmen.

In addition to the problem of "hot water", the low recovery rates (0.04% in 1973/74) are attributed to the lack of proper food and release of fry at inappropriate times. At the present time, the Office of Fisheries of the Republic of

Korea is making every attempt to correct these deficiencies. If the effort is successful there is no reason why these hatcheries cannot produce chum and coho salmon at a high level of return.

PEOPLES DEMOCRATIC REPUBLIC OF KOREA

At the present time reliable information on the fisheries of the Peoples Democratic Republic of Korea is almost non-existant in the western world. It is known from past studies that chum and masu occur in streams all along the eastern coast of Korea and that pink salmon are found as far south as the Wonsan area. Further, it is believed that the Japanese operated salmon hatcheries on some of the streams, similar to the ones built and operated in Sakhalin, the Kuriles and in the Republic of Korea, further south (see Table 14).

Reference has been made in the literature to a modern fish hatchery for the culture of grass carp, crucian carp (goldfish), true carp, and rainbow trout, but there is no reference to salmon. The hatchery is located in an isolated area on the Songchon Gang (near Sinhung, Hamgyong Namdo) and consists of 160 hatching ponds (1 to 2 meters wide and 5 to 6 meters long, covered with a tile roof), and 73 outside rearing ponds. A total of 1,130,000 fry/fingerlings of all species were released over "the past few years" (Anonymous, 1971).

Because of the emphasis that the government is placing on the development of its fisheries at the present time and because of the probable remnants of hatcheries built by the Japanese before World War II, it is almost certain that the Peoples Democratic Republic of Korea have salmon hatcheries in operation but there is no way to confirm at this time.

THE UNION OF SOVIET SOCIALISTIC REPUBLICS

Although several earlier investigators had expressed concern for the future of the salmon runs to the Amur River, I. I. Kuznetsov was the first to take active steps to protect the natural spawning runs of salmon and to propose artificial propagation, "...which, when there is an excess of spawners on the grounds, can provide a real addition to natural reproduction." Mainly, as a result of his efforts to maintain the salmon runs in the Far East, measures were taken in 1924 to establish catch quotas, protect spawning grounds, regulate fishing seasons, and undertake artificial propagation of salmon. Thus, in 1927/28, the first salmon hatcheries were built at Teplovka Lake (tributary to the Amur River) and at Ushki Lake (tributary to the Kamchatka River). Later, a third hatchery was built on the Bidzhan River, tributary to the Amur River and about 55 miles above the hatchery at Teplovka Lake (Atkinson, 1960).

It is interesting to note the growth in the production record for chum salmon at Teplovka Lake. There has been an increase of two to three times between the pre-war (1928-1937) and post-war (1938-1952) periods, or from an average of 12.5 to 23.2 million eggs and 8.1 to 20.4 million fry released. At the same time, however, the neighboring Bidzhan hatchery began to experience difficulty in obtaining sufficient eggs to operate. This was blamed specifically on local development and poaching.

The hatchery at Ushki Lake produced mostly sockeye, coho, and a few chum salmon. A production level of 20 to 26 million eggs was maintained before World War II; but afterwards, the run suffered a catastrophic decline, dropping from 16 million eggs in 1947 to only 3.9 million in 1952. The criticism at the time was directed toward failure to maintain the facilities in proper operating condition; but whatever the cause, the hatchery has now been rebuilt and is in full operation.

The Japanese also built a number of salmon hatcheries in the southern part of Sakhalin and the Kurile Islands during the latter part of the 1920's. By the beginning of World War II a total of at least 12 hatcheries were in operation with a total capacity of 170 million eggs. The average annual take by the Japanese hatcheries, however, was only about 73 million eggs (Chernyavaskaya, 1964).

Between 1946 and 1960, the 12 existing Japanese hatcheries were improved and an additional 12 new hatcheries were built between 1955 and 1960, together providing a total capacity of 265 million eggs for Sakhalin and 100 million eggs for the Kurile Islands. By 1963, there was a total of 25 hatcheries in operation in Sakhalin and the Kuriles - 20 in Sakhalin and five on Iturup Island (Kuriles).

The relative size of the hatcheries was described by Chernyavskaya (1964) as follows:

Number of Hatcheries	Hatchery Capacity
7	Less than 10 million eggs
12	10-20 million eggs
6	Over 20 million eggs

In 1959, all hatcheries, except for three on Iturup Island, had rearing ponds. In 1958, the young were fed for two or three months at ten of the hatcheries before release. The food was ground, frozen fish waste (pollock, cod, etc.), supplemented at times with fish meal; no meat products were used. There is no information on the type of food now being used in the Soviet salmon hatcheries.

Although the list of hatcheries is still incomplete, the locations of known hatcheries are shown in Figures 13 and 14, and are keyed to the summary given in Table 17.

Both Tables 18 and 19 show the rapid growth in production by the USSR hatcheries since 1962. In Sakhalin, for example, the numbers of pink and chum salmon fry released almost doubled in the ten year period - 257 million fry released in 1962 to 468 million in 1971 (See Figure 15) (Rukhlov, 1973a). Further, according to Doroshev, the total number of salmon fry released by the hatcheries in the Soviet Far East increased from some 642 million in 1970 to 808 million in 1974.

Note that the salmon hatchery production of the USSR and Japan are of about the same magnitude. The real difference is that the Japanese effort is almost exclusively on chum salmon while that of the Soviets is almost equally divided between pink and chum salmon. Further, the combined hatchery production for the Soviet Union and Japan could well approach 2.5 or even 3 billion fry for release in the next two or three years.

The Soviet scientists have made a number of studies of the rate of adult return from fry released, both by extensive marking programs and by simple comparison of the numbers of fry released to actual count of the numbers of adult returns to the hatchery. Although the most recent comprehensive program by Kanid'yev, et al., (1970), gives a coefficient of return for the 1956 to 1963 brood years of 0.21 to 0.62 percent, these are returns to the hatchery and do not include the high seas catch of the Japanese or the more distant Japanese and Soviet coastal fisheries. It would appear that the estimate of 1.3 percent for autumn chum salmon at Teplovka hatchery (Levanidov, 1954), or the estimate of 1 to 3 percent (rarely 5 percent) for Sakhalin pink and chum salmon (Chernyavskaya, 1964) would still be a more accurate estimate to use at this time. Such a rate of return would be quite comparable to the results being obtained from salmon hatcheries in Japan and the United States.

Based upon hatchery costs given by Kanid'yev, et al., (1970), some attempt has been made to estimate Soviet costs of salmon hatchery production. For example, if we take the cost of 197,800 rubles to produce 131,900,000 fry for release in 1959-1963, a return of 1 to 3 percent, and the present exchange rate of U.S.$ 0.29 = 1 ruble, then the average cost per adult return would be from 1 to 4 cents per fish. The cost return ratio for 1968 (i.e., 1 million fry for release at a cost of 1,506 rubles) gives an even more favorable production cost. There are problems here, however, in trying to compare costs between the two economic systems and until more information is available on just what is included in the hatchery costs, these figures should be used with caution.

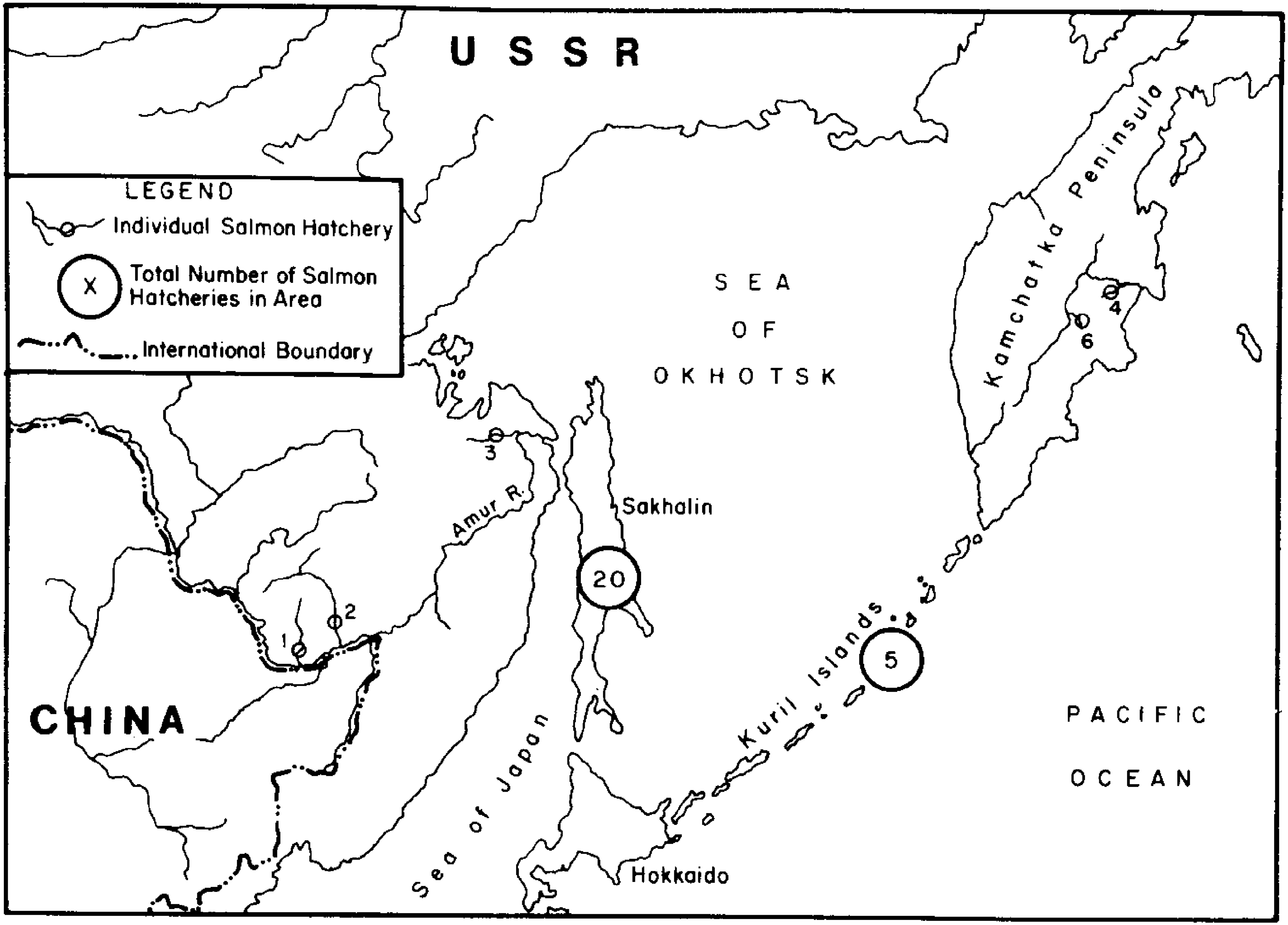


Figure 13. The Salmon Hatcheries of the Soviet Far East (See Table 17).

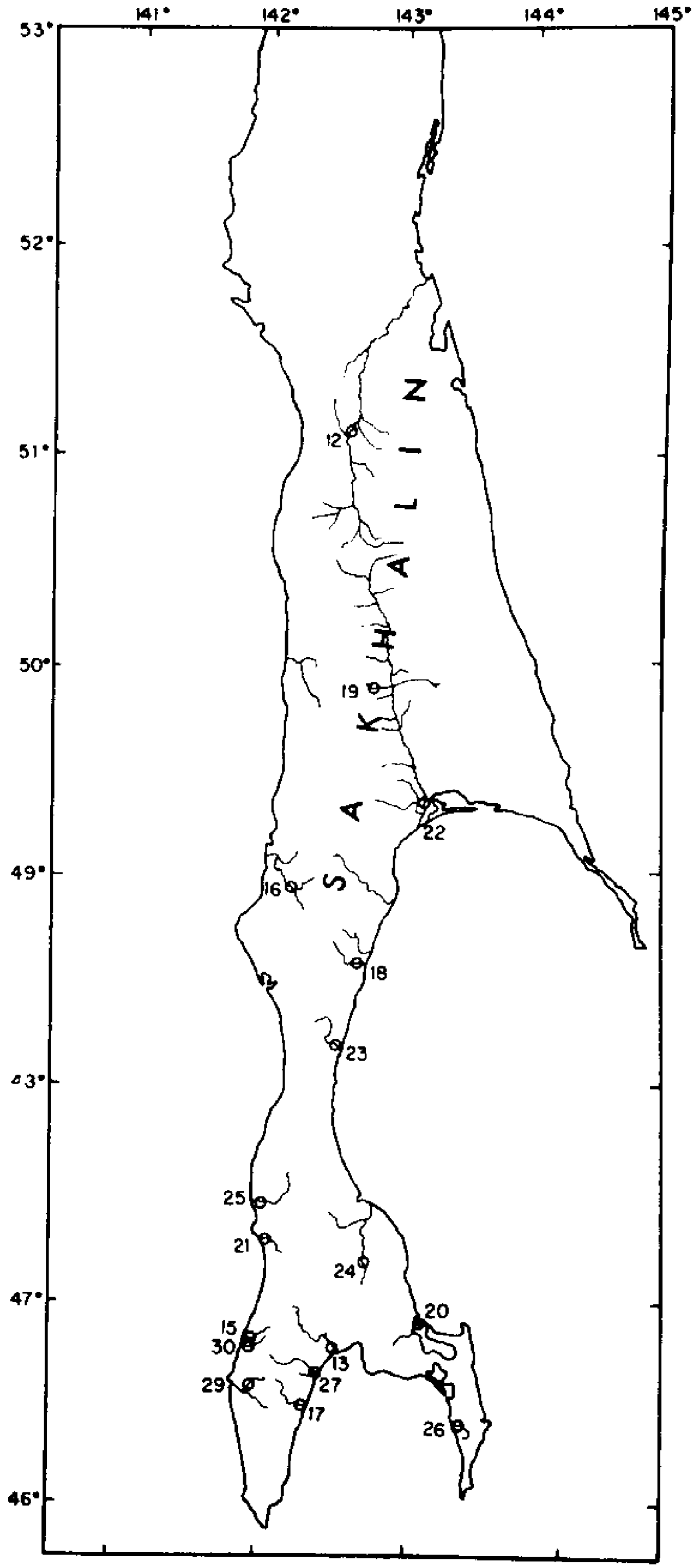


Figure 14. Map of Sakhalin showing Rivers with Known Salmon Hatcheries (See Table 17).

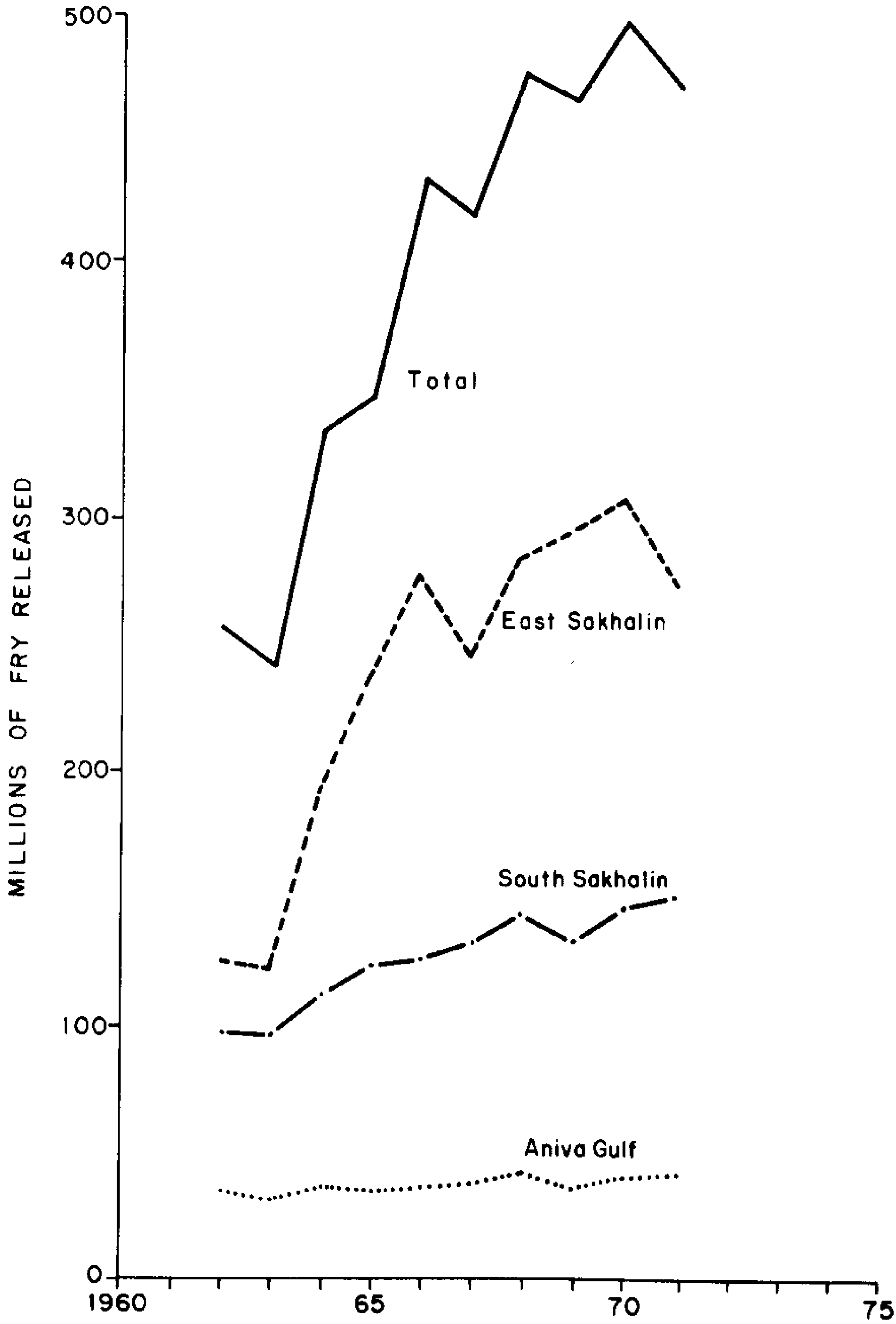


Figure 15. Number of Salmon Fry Released from Sakhalin Hatcheries, 1962-1971.

Kanid'yev, et al., (1970), also gives the results of an interesting study by V. Ya. Levanidov on the relationship between the size of young chum salmon and the survival from char predation. In his work, he has been able to show that the larger the young chum salmon, the better the chance of survival (Figure 16). Levanidov has also been able to demonstrate a similar relationship between the survival of young chum salmon and fish-eating birds.

Although somewhat out-of-date, the following notes obtained during a visit to the Soviet Far East in 1959 may be of help in understanding some of the operational detail of the salmon hatchery program of the USSR.

Khabarovsk Region (Amur River)

There are apparently three hatcheries now operating on streams tributary to the Amur River: Teplovka Lake (Bira River), Bidzhan, and Udinsk (built in 1959-60 on the Amgun River). In 1959, the Teplovka hatchery had, in some years, handled between 40 and 55 million eggs and the Bidzhan hatchery about 12 million eggs. The new hatchery at Udinsk was being designed with a capacity of 25 million eggs.

The hatchery at Teplovka Lake is located about 450 feet above the outlet. The area of the lake is 1.3 acres, with a maximum depth of about 12 feet and an average depth of five feet. The water supply for the hatchery comes from springs with an average monthly temperature of 3.2°C in winter and 6.8°C in summer (Vasil'ev, 1954a).

The outlet stream is about three miles in length, flowing into the Bira River and then into the Amur. The young fish migrating out of the lake are counted by a trap placed in the outlet stream.

The collection of eggs usually begins in October at the Teplovka hatchery. The adult salmon, after removal of the eggs or sperm, are sold for human food - similar to the practice followed in Japan.

The eggs are incubated in trays placed in troughs. By February the eggs hatch and the young are held in the hatchery until free-swimming. The young fish are then released into the lake where they feed upon chironomids and other natural food.

The Teplovka hatchery was the first hatchery established in the Soviet Far East and over the years has probably been the most successful. The average return from fry released has been about 1.3 percent, more than six times the 0.2 percent from natural spawning.

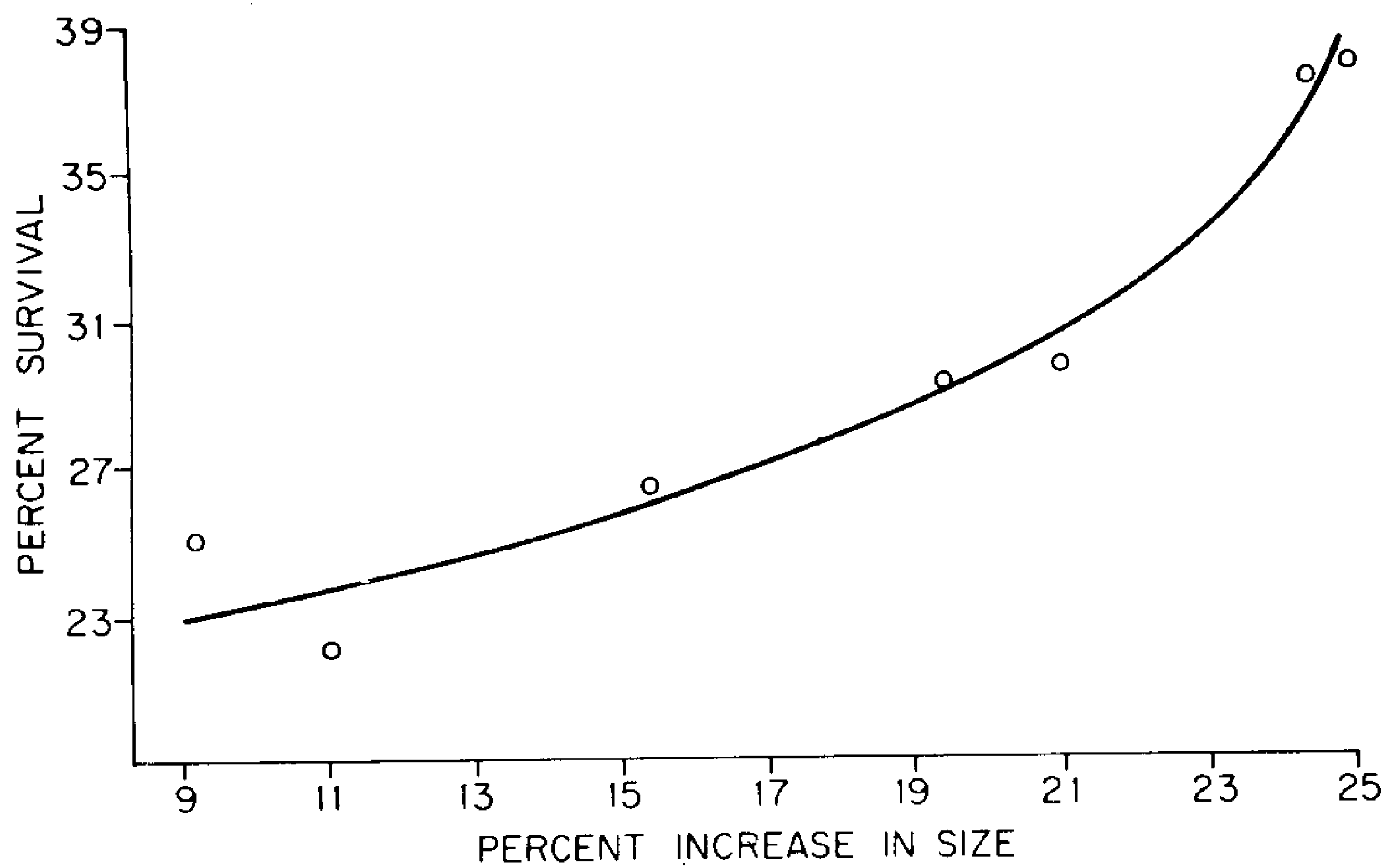


Figure 16. The Relationship between Size of Young Chum Salmon (34 to 55 mm) and Survival, from Studies by V. Ya. Levanidov (Kanid'yev, et al., 1970).

Sakhalin Region

The hatchery at Kalinin (southwest Sakhalin) was built in 1925 and was operated by the Japanese until 1939. After World War II, the fishing industry, including hatcheries, was placed under the jurisdiction of the Sakhalin Fishing Authority (SAKHALIN-RYBPROMA) and under their direction the water supply and ponds at Kalinin were rebuilt in 1951, new houses and a garage added in 1952-1954, and a new hatchery building in 1959 and 1960. The hatchery at Kalinin has probably been one of the most successful hatcheries of the Sakhalin group and is a favorite site for tests and scientific studies.

In 1959, the hatchery was operating on an annual budget of 300,000 to 400,000 rubles a year. The supervisor was a trained economist and the hatchery technicians were all university graduates trained in fish culture. The results of the hatchery operations are not usually published but reported only to the Sakhalin Fishing Authority.

The Kalinin hatchery handles both chum and pink salmon. In the first year of operation after the war (1951), the hatchery took 5 million eggs. In 1958, the quota was set at 21 million eggs; the hatchery took 28 million eggs. The new hatchery building increased the capacity of the hatchery to 33 million eggs in 1959 and from the number of eggs shown in Table 17, the capacity must have been further increased in the latter part of the 1960's. For example, in 1967 a total of 48.6 million fry were released from Kalinin and in 1968, 55.8 million.

The water supply for the Kalinin hatchery comes from a spring, is filtered through sand and gravel, and is carried into the hatchery through a covered flume. The water temperature is about 4°C in the winter and 9°C in the early fall. The water supply does not freeze in winter.

The salmon are trapped at a weir located a short distance above salt water. Chum salmon are taken from August until the beginning of October, and pink salmon slightly earlier (i.e., from early August until the latter part of September). The fish are spawned at the weir, the eggs washed and taken to the hatchery for the eggs to water harden.

The eggs are picked after one or two days and placed on standard hatchery trays (about a foot square and 3/8's of an inch deep). About 1,500 chum eggs or 2,000 pink eggs on each tray and ten trays are stached together. The stacks of trays are placed in concrete troughs, built into the floor of the hatchery, but similar in design to those used in Japan and the United States. The Soviet technologists reported an average of 1.5 percent egg mortality at time of "pick-off."

After the eggs are eyed and just before hatching, the stacks of trays are transferred to raceways (about 10 meters long, 1.34 meters wide and a water depth of 25 centimeters). The bottom of the raceways are covered with about 2 inches of gravel (1-1/2 to 3 inch size). When the young hatch, they drop through the screens on the bottom of the trays and enter the gravel.

Several weeks before transferring the eggs to the raceways, the gravel is washed and sterilized with calcium chloride at the rate of 10 kg./sq. meter.

At the time of the visit in 1959, the young fish were fed ground fish waste (pollock, cod, etc.) by placing the food on shallow trays suspended about 5 centimeters from the bottom. The trays were made of wood, perhaps 15 inches wide and 24 inches long, and the food placed on the tray about 1-1/2 to 2 centimeters deep. About 1-1/2 to 2 kilograms of food were placed on each tray twice a day, or at a rate of 5 milligrams per fish at the beginning of feeding to about 20 milligrams per fish at the end. Some fish meal is used to supplement the ground fish diet.

Although unconfirmed, it is believed that the Soviet hatchery technologists have now developed a more efficient way of feeding the young fish and a better formulated food. (Frolenko, 1964; Kanid'yev, et al., 1970)

COOPERATIVE PROGRAMS

In considering the hatchery programs of Japan, the Koreas and the USSR, some mention should be made of the number of international cooperative salmon aquaculture programs that have developed during the past ten or fifteen years. These programs, which will be briefly described below, have played an important role in the success of the present hatcheries by arranging for meetings and visits between hatchery scientists and technologists of the various countries, the transplant of eggs, the conduct of joint studies and surveys, and the exchange of data and other hatchery information.

Japan and the Soviet Union

Because of the decline in the salmon runs and the growing restrictions on the salmon fisheries adopted by the Japan-USSR Northwest Pacific Fisheries Commission, Japan proposed, in 1962, to establish in the Soviet Far East a series of salmon hatcheries operated jointly by the two countries. Finally, on June 8, 1975, the two governments agreed to establish such a station on an appropriate river in southern Sakhalin. Subsequently, there has been a series of meetings between Japanese and Soviet hatchery experts, and they now have agreed to construct a joint salmon hatchery on the Pioner River (southwest Sakhalin).

Although a number of details must still be worked out, tentative plans call for the construction of a hatchery in 1977 and for completion and operation in 1978. The hatchery will have a capacity of 30 million eggs (25 million chum, 3 million pinks, 1 million silver, and 1 million other). The estimated cost of about 6 million dollars will be shared equally by the two countries.

Also, in December 1972, the first Japan-USSR Joint Symposium on Aquaculture of the Pacific Ocean was held in Tokyo, and subsequently annual symposia have been held alternately in Japan and the USSR. These symposia have been organized by Tokai University (Shimizu) and VNIRO[9] (Moscow). Although the papers cover a broad field of subjects related to fish culture and ocean farming, many are either directly or indirectly related to salmon aquaculture. For example, it is in these seminars that problems of disease and genetics have been discussed. (Shikama, 1973; Altukhov, 1973)

Finally, there have been continuing exchanges of experts, data and other materials related to salmon propagation between the countries. Kanid'ev, et al. (1970) refers to such an exchange.

Japan and the United States

Since the occupation days of SCAP[6], there have been a number of visits between scientists of the two countries, a free exchange of information on hatcheries and salmon culture, and at least one extensive transplant effort to reestablish a chinook salmon run on the Japan Sea coast of Hokkaido.

The chinook salmon program has not been a success. A total of 3.0 million chinook salmon fingerlings from University of Washington brood stock have been released in the Yoichi River between 1968 and 1974, as shown below:

Year	Place of Rearing	Number Released
1969	Chitose	600,000
1970	Mori	550,000
1971	Mori	700,000
1972	Yoichi	330,000
1973	Yoichi	300,000

In addition to the above, chinook salmon fingerlings have been reared over a period of 11 years at various national hatcheries, as shown below:

Year	Number Released	Place of Release
1959	62,000	Tokachi River
1960	12,000	Tokachi River
1961	59,400	Tokachi River
1962	59,400	Tokachi River
1963	72,400	Tokachi River
1967	410,000	Teshio River
1968	675,000	Teshio River
1969	407,700	Teshio River
1970	300,900 383,400	Kushiro River Shari River

A number of chinook salmon has been taken from time to time by the fisheries along the Japan sea coast of Hokkaido. For example, 33 chinook salmon were taken between May and July 1972; of the 17 specimens examined, one was three years of age, 11 were five years of age, and five were six years of age. About 30 chinook salmon were taken between March and October 1974; one specimen taken on March 26 weighed nine pounds and was six years of age.

The reason why there has been no return of chinook salmon is of serious concern to the staffs of the Hokkaido Prefectural Department of Fisheries and the national salmon hatcheries and may well be related to the high river and sea temperatures during the summer months. Usually, the fingerlings are released in mid-June, after attaining a size of 2.5 to 5 grams in weight and before the sea temperatures exceed 15°C.

Chinook salmon, however, have a different life pattern than have pink or chum salmon; the young usually remain in the river for the first summer before migrating to the sea. At Yoichi, the temperatures reach 23° or 24°C in the summer months - too warm for the young chinook salmon to stay in the river or to survive in the coastal waters of the Japan Sea along the coast of Hokkaido. This may well be a source of heavy mortality and the reason for no return to the Yoichi or other rivers in western Hokkaido.

There have been other attempts to establish new runs of salmon in Japan. For example, the State of Alaska has provided sockeye salmon eggs on several occasions for rearing in Hokkaido. The eggs were handled at the Nishibetsu hatchery in eastern Hokkaido with good returns, but an outbreak of a virus disease that caused particularly heavy mortalities to kokanee and red salmon resulted in a discontinuation of these experiments. At the present time (1974-75) small lots of silver salmon eggs from the United States are being hatched and released in northern Honshu and Hokkaido to determine the adaptability of this species to Japanese stream and ocean conditions.

Finally, the United States and Japan signed a bilateral agreement in 1967 establishing the United States - Japan Conference on Natural Resource Development (UJNR). In the United States, this program is administered through the Department of Interior, in Japan through the Science and Technology Agency. The organization is simple with a coordinator from each country and the formation of some 15 panels dealing with very specialized subjects, such as, desalinization, national parks, energy, air and water pollution, toxic micro-organisms, marine engineering, etc. Each panel meets once a year, alternating between countries, and providing for the presentation of formal papers, visits to areas of mutual interest, and an exchange program of scientists and experts. One of the panels is on aquaculture and subjects related to salmon propagation and farming have been discussed at these meetings from to time.

In addition, there has been a growing number of informal exhanges and visits between salmon aquaculturists of the two countries - a trend that should be further encouraged by the various agencies.

<u>The People's Democratic Republic of Korea and the Soviet Union</u>

No definitive information is available regarding specific cooperative salmon programs between the Soviet Union and the People's Democratic Republic of Korea. It is known, however, that "Fisheries Assistance Agreements" have been signed between the two countries.

Further, a four-power Treaty for the Scientific Studies of Fisheries of the Western Pacific was signed by China, North Vietnam, North Korea and the USSR on June 3, 1956. The treaty provided for annual meetings between delegates from the four countries, the exchange of information, and the initiation of joint studies. In all likelihood, problems of the salmon fisheries and aquaculture, which are of mutual interest to China, North Korea and the USSR, have been the subject of discussion under this convention.

<u>The Republic of Korea and the United States</u>

After about four years of negotiation, the Republic of Korea and the United States signed a bilateral agreement on December 12, 1972. The agreement provides for cooperation and assistance in the conservation and development of the fishery resources of the two countries. As a part of the agreement, a working group, composed of experts from both countries, meets each year to review the program and to recommend areas in need of further study and cooperation.

The present salmon hatchery program of the Republic of Korea, initiated in 1967, has become a part of this agreement; and each year the working group reviews the progress of the program and recommends the number of eggs, technical assistance, etc., required to make the program a success. A detailed account of the status of the program is found in the section on the Republic of Korea.

FOOTNOTES

1 Members of the team were Seung Kwan Chun, Suck Cho Chyung, Bobby J. Combs, Lauren R. Donaldson, Jong Du Kim, Richard T. Pressey, Chung Duk Yang, and Clinton E. Atkinson.

2 The historical material is taken from the "Propagation of Chum Salmon", published by the Japan Fisheries Resource Conservation Association, August 1966. (See Anonymous, 1966)

3 The production figures for the hatcheries are probably of the right magnitude but should be considered only as "best estimates." Lacking are reliable estimates of the numbers of hatchery fish taken by the Japanese offshore and high seas fisheries and the number of salmon of Soviet origin that might be taken in the Hokkaido coastal fisheries.

4 The term "province" is used here to denote the broader form of government associated with Hokkai-do or Tokyo-to, and in contrast with the prefectures (or ken) of Honshu, Shikoku and Kyushu.

5 Discrepancies are noted between the data given in Tables 5 and 6; it is impossible to reconcile these differences without access to the original records.

6 The Supreme Command of the Allied Powers.

7 (1) development of domestic industry (1952-1958),
(2) liberalization of trade and exchange (1958-1968), and
(3) economic affluency, inflation and crises (1968 to the present). (Anonymous, 1975).

8 Much of the material presented in this section is taken directly from two basic reports: Atkinson, et al., (1967) and Atkinson, et al., (1973).

9 All-Union Scientific Research Institute of Marine Fisheries and Oceanography (Moscow).

REFERENCES

Anonymous 1966 - 1974 — The Annual Report of Trends in the Fisheries (Gyogyo no Doko nado ni Kansuru Nenji Hokoku). Prepared for the Regular Sessions of the Diet (various years).

Anonymous 1966 — Propagation of the Chum Salmon in Japan. Japan Fisheries Resource Conservation Association (August 1966, Tokyo). 55 pp.

Anonymous 1969 — A Review (or The Course) of Salmon Propagation (Sake Masu Zoskhoku no Ayumi). Hoshimi Publishing Company (January 1969 Tokyo). 455 pp.

Anonymous 197? — Fish Farming in Japan. Japan Fisheries Association (no publication date given). 41 pp.

Anonymous 1975a — The Catch is 45,000 Metric Tons: Half the Amount Allowed by the Japan-Soviet Treaty (in Japanese, original text being reproduced). Suisan Keizai Number 6910 (November 18, 1975). p. 1.

Anonymous 1975b — Rearing Salmon in the Sea is Possible: Proof from Chum Salmon at Yamada Bay (in Japanese, original text being reproduced). Suisan Keizai, Number 6927 (December 23, 1975). p. 1.

Anonymous 1975c — Japan's Foreign Trade - History of Postwar Structural Change and Future Strategy. The Business Community Quarterly of Japan, Number 8 (Autumn 1975). pp. 10-36.

Anonymous 1976a — Unexpected Progress in Ocean Rearing: Salmon Propagation Studies (Kaichu Shi-iku no Kojo; Sake Masu Zoshoku Ken [kyu]). Suisan Keizai, Number 6957 (February 12, 1976). p. 3.

Anonymous 1976b — Postpone until March 10 or Thereafter: Japan-Soviet Salmon Propagation Meeting - Will Also Take Another Look at the Overall Plans (Sangatsu Toka Iko ni Enki: Keikaku Zenpan no Minaoshi mo). Suisan Keizai, Number 6960 (February 17, 1976). p. 1.

Anonymous 1976c — Fifteen Million Adult Fish Return (Raiyu Ryo Sen-go-hyaku-mon-biki ni). Suisan Keizai, Number 6937 (January 13, 1976). p. 1.

Altukhov, Yu. P.
1973 Rational Management of Marine Biological Resources in the Light of Population Genetics, In Propagation of Marine Resources of the Pacific Ocean. First Japan-USSR Joint Symposium of Aquaculture of the Pacific Ocean (Tokai University and VNIRO), September 1973 Tokyo. pp. 31-40.

Andreeva, M. A.
1954 Fish Culture and Fish Preservation Methods Relating to the Conservation and Utilization of Salmon in Kamchatkan Waters (Rybovodnyye i Rybookhrannyye Meropriyatiya po Sokhaneniyu i Vosproizvodstvu Lososevykh Ryb v Vodoyemakh Kamchatki), in Trudy Lososevogo Khozyaystva Dal'nego Vostoka). SSSR NAUK 1954 (USSR Academy of Science 1954). pp. 70-77.

Aoki, Yoshihiro
1974 Letter, Aoki to Atkinson. January 29, 1976. 2 pp.

Atkinson, Clinton E.
1960 Fisheries Research: Its Organization and Program within the USSR. Biological Laboratory (Seattle), U. S. Bureau of Fisheries. 43 pp.

Atkinson, Clinton E.
1974 The Salmon Fisheries of the Soviet Far East. University of Washington, Thesis (M.Sc.). 137 pp.

Atkinson, Clinton E., Seung Kwan Chun, Suck Cho Chyung, Bobby J. Combs, Lauren Donaldson, Jong Du Kim, Richard T. Pressey, Chung Duk Yang.
1973 A Review of the Salmon Hatcheries of the Republic of Korea. U. S. Department of State (AID) and the ROK Office of Fisheries. 141 pp.

Atkinson, Clinton E., Seung Kwan Chun, Earnest R. Jeffries, Jong Du Kim, Ki Young Kim, Kyun Hyun Kim, Richard T. Pressey.
1967 A Survey of the Salmon and Trout Resources of the Republic of Korea. U. S. Department of State (AID) and the ROK Office of Fisheries. 103 pp.

Bogdonova, E. A.
1964 Diseases of Young Salmon and Means of Control in the Fish Hatcheries of Sakhalin and the Amur (Zablevaniya Molodi Lososevikh i Mery Bor'by c Nimi na Rybovodakh Sakhalina i Amura, in Lososevogo Khozyaystvo Dal'nego Vostoka). NAUK SSSR (USSR Academy of Science 1964). pp. 186-188.

Chernyavskaya, I. K.
1964 The State of Artificial Rearing of Salmon in the Sakhalin Region (Sostoyaniye Iskysstvenogo Razvedeniya Lososey v Sakhalinskoy Oblasti, in Lososevoye Khozyaystov Dal'nego Vostoka). NAUK SSSR 1964 (USSR Academy of Science 1964). pp. 175-178.

Disler, N. N.
1954 The Development of Amur River Fall Chum Salmon (Razvitiye Osenney Ketiy R. Amur, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). NAUK SSSR 1954 (USSR Academy of Science 1954). pp. 129-143.

Dvinin, P. A.
1954 A Survey of the Salmon Fisheries of Sakhalin and an Analysis of the Work of the Fish Hatcheries of the Sakhalin Fisheries Authority (Obzor Lososevog Khozyaystva Sakhaline i Analiz Deyatel'nosti Rybovodnykh Zavodov Sakhalinrybvoda, in Trudy Sovenshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). NAUK SSSR 1954 (USSR Academy of Science 1954). 78-86.

Frolenko, L. A.
1964 The Rearing of Young Chum and Pink Salmon in Sakhalin Hatcheries with Artificial Food (Vyrashchivaniye Molodi Kety i Gorbushi na Sakhalinskikh Rybovodnikh Zavodakh c Primeneniyem Iskusstvennykh Kormov, in Lososevoye Khozyaystbo Dal'nego Vostoka). NAUK SSSR 1964 (USSR Academy of Science 1964). pp. 184-185.

Kanid'yev, A. N., G. M. Kostyunin and S. A. Salmin
1970 Hatchery Propagation of the Pink and Chum Salmons As a Means of Increasing the Salmon Stocks of Sakhalin. Journal of Ichthyology, Volume 10 (1970). pp. 249-259.

Kokhmenko, L. V.
1972 The Food of the Mykiss (Salmo mykiss [Walb.]) in Kamchatka. Journal of Ichthyology, Volume 12, Number 2 (1972). pp. 282-291.

Kokhmenko, L. V.
1962 Food Organisms for Fall Chum Salmon and Freshwater Salmonids in the Nursery Waters of Teplovka Hatchery (Pushchevyye Svyazi Mal'kov Osenny Kety i Presnovodnikh Lososevykh v Vyrastnykh Vodemakh Tepkovskogo Rybovodnogo). Izvestiya, TINRO, Volume 48 (1962). pp. 67-84.

Koposova, A. F.
1964 Some Questions on the Effectiveness and the Economics of Artificial Propagation of Salmon in Sakhalin (Nekotoryye Voprosy Effektivnosti i Ekonomiki Isyusstvennogo Razvedeniya Lososey na Sakhalinye, in Lososevogo Khozyaystvo Dal'nego Vostoka). Izdatel'stvo NAUKA 1964 (Publication of the Academy of Science 1964). pp. 179-183.

Krykhtin, M. L.
1962 Material on the Early Life History of Masu (Materialy o Reshom Periodye Zhizni Simy). Izvestiya, TINRO, Volume 48 (1962). pp. 84-132.

Kudryavtsev, V.V.
1954 Discussion of the Conference Papers (Preniya po Dokladam, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka) Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 174-175.

Landyshevskaya, A. E.
1965 Increasing the Effectiveness of the Work of the Sakhalin Fish Hatcheries (O Povyshenii Effektivnosti Raboty Rybovodnykh Zavodov Sakhalina [V Poryadkye Obsyzhdeniya]). Rybnoye Khozyaystvo, Year of Publication 41 (1965), Number 10. pp. 9-10.

Lazerev, M. S.
1954 On the Work of the Sokolovo Fish Hatchery (O Rabotye Sokolovskogo Rybovodogo Zavoda, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 87-93.

Levanidov, V. Ya.
1954 The Way to Increase the Reproduction of the Chum Salmon of the Amur (Puti Usileniya Vosproizvodstva Kety Amura, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 120-128.

Levanidov, V. Ya. and I. M. Levanidova
1962 The Spawning-Rearing Waters of Teplovka Hatchery and Its Biological Productivity (Nerestovo-vyrastnye Vodoemy Teplovskogo Rybovodnogo). Izvestiya, TINRO, Volume 48 (1962). pp. 3-66.

Mack, John V. and Edward K. Newbauer
1967 Engineering Instructions for Milyang, Oship (Samchok), and Namdae (Yang Yang) Chum Salmon Hatcheries. (See Appendix B, Atkinson, et al., 1973).

Mathews, Stephen B. and Harry G. Senn
1975 Chum Salmon Hatchery Rearing in Japan, in Washington. Division of Marine Resources, University of Washington (National Sea Grant Program), WSG-TA 75-3, 24 pp.

McNeil, William J.
1976 Letter, McNeil to Atkinson. January 28, 1976. 1 p.

Oshima, Hiroshi
1969 Suisan Yoshoku Handobuku (Fish Culture Handbook). Suisansha (Tokyo). 535 pp.

Ostroyumov, A. G.
1964 Dynamics of the Numbers of Salmon in the Kamchatka Rivers (Dinamkia Chislennosti Lososey Reki Kamchatki, in Lososevogo Khozyaystvo Dal'nego Vostoka). Izdatel'stvo NAUKA 1964 (Publication of the Academy of Science 1964). pp. 69-72.

Pressey, Richard T.
1968 Shipment of Chum Salmon Eggs from the United States to Korea. (See Appendix C, Atkinson, et al., 1973).

Rukhlov, F. N.
1973a A contribution to the Question of the Method of Artificial Reproduction of the Pacific Salmon (K Voprosu o Putyakh Iskusstvennogo Voproizvodstva Tikhookeankikh Lososey no Sakhalinye). Izvestiya, TINRO, Volume 91 (1973). pp. 11-17.

Rukhlov, F. N.
1973b The Freshwater Period of Life of the Spawning Fall Chum and Pink Salmon of Sakhlin (O Rechnom Periodye Zhizni Nerestovoy Osenney Kety i Gorbushi Sakhalina). Izvestiya, TINRO, Volume 91 (1973). pp. 25-30.

Rukhlov, F. N.
1973c Peculiarities of the Downstream Migrants of Artificially-Reared Pink Salmon (Osovennosti Skata Molodi Gorbushi Iskyssvennogo Razvedeniya). Izvestiya, TINRO, Volume 91 (1973). pp. 31-36.

Sato, Mitsugi
1976 Letter, Sato to Atkinson, January 15, 1976. p. 1.

Shidlovskiy, A. L.
1954 Discussion of the Conference Papers (Preniya po Dokladam, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 154-185.

Shikama, Yasumasa
1973 Pathological Study of Fish Diseases, in Propagation of Marine Resources of the Pacific Ocean. First Japan-USSR Joint Symposium of Aquaculture of the Pacific Ocean (Tokai University and VNIRO), September 1973 Tokyo. pp. 41-50.

Simon, Ray
1972 Gene Frequency and the Stock Problem, in The Stock Concept in Pacific Salmon (edited by Ray Simon and P. A. Larkin). MacMillan Lectures in Fisheries, University of British Columbia (Canada). p. 161.

Smirnov, A. I.
1954a Rationalization of the Biotechnology of the Culture of Salmon in Sakhalin (Voprosy Ratsionalizatsii Biotekhniki Razvedeniya Lososey na Sakhalinye, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954.). pp. 94-110.

Smirnov, A. I.
1954b Discussion of the Conference Papers (Preniya po Dokladam, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 195-196.

Smirnov, A. I.
1960 Salmon Culture in the Far East (Lososevodstvo Dal'nego Vostoka). Rybnoye Khozyaystvo, Year of Publication 36, Number 10 (1960). pp. 30-37.

Vasil'ev, I. M.
1954a Experiences of the Work at the Teplovka Fish Hatchery of the Amur Fishing Authority (Opyt Raboty Teplovskogo Rybovodnogo Zavoda Amurribvoda, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). 11-119.

Vasil'ev, I. M
1954b Discussion of the Conference Papers (Preniya po Dokladam, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 187-189.

Vanyaev, N. A.
1954 Discussion of the Conference Papers (Preniya po Dokladam, in Trudy Soveshchaniya po Voprosam Lososevogo Khozyaystva Dal'nego Vostoka). Izdatel'stvo NAUK SSSR 1954 (Publication of the Academy of Science USSR 1954). pp. 173-174.

Zhuykova, L. I.
1973 The Effect of the Degree of Ripeness of the Eggs on the Embryological Development of Fall Chum Salmon (Vliyaniye Stepeni Zrelostu Ikry na Embrional'oye Razvitiye Ocenney Kety). Izvestiya, TINRO, Volume 91 (1973). pp. 18-24.

Table 1. Names of Hokkaido Rivers with Salmon Hatcheries

Map Reference Number	Name of River (gawa)
1	Asabu
2	Toshibetsu
3	Shiribetsu
4	Yoichi
5	Ishikari
6	Chitose
7	Shokanbetsu (Mashike)
8	Teshio
9	Soya
10	Tombetsu
11	Horobetsu
12	Tokushibetsu
13	Horonai
14	Shokotsu
15	Yubetsu
16	Tokoro
17	Abashira
18	Mokoto
19	Shari
20	Iwaobetsu
21	Raosu
22	Kumbetsu
23	Ichinibetsu
24	Shibetsu
25	Nishibetsu
26	Tokabetsu
27	Furen
28	Kushiro
29	Akan
30	Tokachi
31	Rekifune
32	Utabetsu
33	Shizunai
34	Shiraoi
35	Shikui
36	Urappu
37	(Mori)
38	Shiriuchi

Table 2. Numbers of Fry Released and Returns by Brood Year for Chum Salmon

Reared at National Salmon Hatcheries in Hokkaido.

Year of Birth	Number of fry released (1,000)	Returns (Number) of the same year stock of salmon by age: Age 2	3	4	5	6	Total	Ratio of return of mature fish to released fry (%)	Ratio of return of 3 year old fish to released fry (%)
1950	222,422	38,259	764,518	2,059,699	258,246	7,790	3,128,412	1.41	0.34
51	189,157	26,227	1,034,141	1,453,421	239,624	12,958	2,766,371	1.46	0.55
52	159,557	35,934	583,602	931,848	201,165	1,586	1,754,135	1.15	0.37
53	170,606	32,067	659,822	1,135,948	161,845	1,387	1,991,069	1.17	0.39
54	269,338	44,833	1,233,913	1,900,420	133,897	85	3,313,148	1.23	0.45
55	247,922	34,413	850,864	1,043,730	77,834	2,098	2,008,939	0.81	0.34
56	140,454	45,106	570,733	992,391	286,442	12,064	1,906,736	1.36	0.41
57	361,608	30,733	637,481	1,829,481	554,823	15,011	3,067,529	0.85	0.18
58	417,238	22,093	765,864	1,279,517	160,022	371	2,227,867	0.53	0.18
59	313,549	57,997	895,430	1,846,287	379,085	1,033	3,179,832	1.01	0.29
1960	203,413	17,799	1,601,827	1,581,909	195,217	1,978	3,398,730	1.67	0.78
61	359,489	144,715	1,836,311	3,515,067	538,822	3,600	6,038,515	1.68	0.51
62	280,743	14,282	996,975	1,506,289	405,500	800	2,923,846	1.04	0.36
63	272,106	40,980	1,658,230	3,103,200	230,000	200	5,032,610	1.85	0.61
64	334,463	98,865	971,800	913,900	75,500	--	2,060,065	0.61	0.29
65	549,278	15,800	816,900	1,707,600	131,000	--	2,671,300	0.49	0.15
66	272,036	175,900	2,310,100	3,260,800	237,200	--	5,984,000	2.20	0.85
67	434,729	79,400	1,830,100	5,501,800	820,900	--	8,232,200	1.89	0.42
68	207,438	66,000	1,737,000	2,706,300	324,900		4,834,200	(2.33) 1/	0.83
69	361,571	176,000	3,353,300	4,664,600			8,193,900 3/	(2.27) 2/	0.93
1970	442,101	78,600	3,221,300	4,707,000					0.73
71	575,986	109,800							
72	475,805								
73	445,510								

1/ 6 year old fish not returned as yet
2/ 5 and 6 year old fish not returned as yet
3/ Through 4 year old fish

Table 3. Kinds of Organizations Involved in Salmon Culture in Northern Honshu (Japan)

1968 - 1969

Prefecture	Cities, Towns, Villages	Fishery Cooperatives	Fishery Culture Associations	Other Associations	Voluntary Groups	Joint Operation	Number
Aomori			7				7
Iwate	1		20		2		23
Miyagi			8	1	1		10
Fukushima			6		1		7
Ibariki			2		1		3
Akita	1		1	2	2		6
Yamagata			6	8		2	16
Niigata		1	5				6
Toyama		1	3				4
Total	2	2	58	11	7	2	82

Table 4. Number of Cooperative Hatcheries and Production of Chum Salmon by Prefectures of Northern Honshu (Japan)

Year	Number Hatcheries	Fish Taken	Number Females	Number Eggs Taken	Total Eggs in Hatchery	Percent Survival	Number Fry Released
Prefecture Aomori							
1962	10	14,165	5,844	17,472,000	17,472,000	92.7	15,432,000
1963	9	17,378	7,298	21,894,000	21,894,000	67.0	13,332,000
1964	9	14,882	5,413	15,977,000	15,144,000	89.2	12,753,000
1965	6	14,114	5,612	16,836,000	17,649,000	88.7	14,782,000
1966	6	20,746	6,923	20,670,000	20,453,000	81.4	16,365,000
1967	7	13,171	6,438	19,298,000	19,598,500	93.0	17,553,000
Prefecture Iwate							
1962	20	118,733	29,196	79,028,000	78,728,000	91.5	70,608,000
1963	23	65,110	20,020	49,029,000	49,029,000	95.6	45,882,000
1964	22	61,228	20,129	49,877,000	50,320,000	94.4	46,531,000
1965	24	36,561	12,698	32,514,000	35,854,000	94.5	33,194,000
1966	15	54,623	21,296	56,492,000	59,418,000	97.8	57,435,000
1967	23	46,226	18,544	52,002,000	34,635,000	95.0	51,918,000
Prefecture Miyagi							
1962	11	10,197	3,561	6,890,000	6,452,000	95.0	6,004,000
1963	11	8,436	2,622	5,611,000	5,392,000	93.3	4,876,000
1964	11	7,466	3,028	6,719,000	6,539,000	95.2	5,636,000
1965	11	9,404	3,874	7,604,000	7,246,000	94.9	6,770,000
1966	10	8,996	3,651	7,362,000	7,054,000	94.0	6,500,000
1967	10	7,496	2,688	6,475,000	6,343,000	96.4	5,976,000

Table 4. Number of Cooperative Hatcheries and Production of Chum Salmon (cont.)

Year	Number Hatcheries	Fish Taken	Number Females	Number Eggs Taken	Total Eggs in Hatchery	Percent Survival	Number Fry Released
Prefecture Fukushima							
1962	7	8,750	3,128	5,636,000	5,346,000	98.0	5,085,000
1963	7	8,527	2,927	6,795,500	6,113,500	97.7	5,857,600
1964	7	6,830	2,135	4,858,000	4,178,000	97.7	4,081,000
1965	7	4,235	1,564	3,500,000	4,861,000	91.8	4,329,000
1966	7	8,267	2,057	5,017,000	4,884,000	93.7	4,423,000
1967	7	7,573	2,622	6,523,200	6,455,600	91.6	5,796,000
Prefecture Ibariki							
1962	3	10,635	2,770	6,653,000	6,653,000	84.3	5,010,000
1963	3	10,895	2,916	7,386,700	7,386,700	86.0	5,599,500
1964	3	8,141	2,718	6,834,000	6,834,000	88.4	5,831,000
1965	3	8,613	3,092	7,620,000	8,620,000	88.3	7,335,000
1966	3	9,174	3,577	8,947,000	8,947,000	93.6	8,039,000
1967	3	14,044	6,372	12,823,000	12,823,000	79.9	9,000,000
Prefecture Akita							
1962	6	7,396	3,202	6,635,000	6,635,000	92.3	6,080,000
1963	6	5,788	2,110	6,009,470	6,169,470	90.5	5,570,920
1964	6	5,188	2,469	6,964,000	6,964,000	92.8	6,368,000
1965	7	7,135	2,936	7,724,000	9,251,000	96.6	8,460,000
1966	6	16,760	5,755	15,076,500	15,073,500	96.7	13,896,000
1967	6	9,583	4,860	14,074,000	14,891,000	86.1	12,308,500

Table 4. Number of Cooperative Hatcheries and Production of Chum Salmon (cont.)

Year	Number Hatcheries	Fish Taken	Number Females	Number Eggs Taken	Total Eggs in Hatchery	Percent Survival	Number Fry Released
Prefecture Yamagata							
1962	23	16,355	8,608	25,241,200	25,154,350	99.1	24,870,580
1963	18	22,801	10,092	30,137,500	30,089,600	98.1	29,494,000
1964	20	30,454	18,368	55,425,000	55,264,000	91.7	48,818,000
1965	20	20,440	9,494	28,188,000	29,199,000	98.0	28,442,000
1966	21	53,717	28,717	85,400,000	82,805,000	98.7	81,709,000
1967	16	30,239	17,721	52,682,000	50,927,000	98.8	48,345,000
Prefecture Niigata							
1962	8	14,819	1,946	5,642,000	5,642,000	94.9	
1963	8	27,194	2,132	6,386,000	6,386,000	95.1	5,864,000
1964	10	11,958	3,860	11,187,000	11,187,000	89.9	9,557,000
1965	10	5,907	1,566	4,443,000	6,143,000	89.9	5,243,000
1966	9	12,112	2,122	5,765,000	7,265,000	90.4	6,229,000
1967	6	9,226	2,566	7,430,000	8,030,000	93.5	7,147,000
Prefecture Toyama							
1962	0						
1963	0						
1964	0						
1965	4	1,347	562	1,503,000	1,503,000	88.3	1,281,000
1966	4	2,134	847	2,410,000	3,910,000	91.7	3,515,000
1967	4	4,090	1,160	2,874,000	3,274,000	97.7	3,194,000

Source: Sake-Masu Zoshoku no Ayumi, Japan Salmon Resources Association (1969)

Table 5. Total Number of Hatcheries and Production of Chum Salmon by All Prefectures of Northern Honshu (Japan)

Year	Number Hatcheries	Fish Taken	Number Females	Number Eggs Taken	Total Eggs in Hatchery[1]	Percent Survival	Number Fry Released
1962	88	200,963	58,255	153,177,200	152,082,350	93.1	138,266,580
1963	85	166,129	50,117	133,249,170	133,266,670	90.1	116,476,020
1964	88	146,147	58,120	157,841,000	156,430,000	92.4	139,575,000
1965	92	107,756	41,398	109,132,000	120,326,000	93.8	109,836,000
1966	81	186,529	74,945	207,136,000	209,277,000	95.7	196,469,000
1967	82	141,971	62,971	174,181,700	176,977,100	93.9	161,237,000

[1] Includes eggs brought in from outside sources

Table 6. Summary of the Production of Subsidized Private Hatcheries in Northern Honshu.[1]

Year	Number of Hatcheries[2]	Number of Watersheds	Number of Fry Released (in millions)
1965	83	55	91.0
1966	89	61	143.0
1967	89	59	148.0
1968	92	60	121.0
1969	93	65	141.6
1970	88	63	147.2
1971	88	63	213.4
1972	101	72	154.9
1973	101	84	175.4[3]
1974			230.0 (est.)

[1]As given by the Japanese Government's White Paper (Gyogyo no doko ni kansuru nenji hokoku) for various years

[2]Number of hatcheries operated by cooperatives and associations

[3]175.4 million fry were released by hatcheries operated by cooperatives or associations of a total of 221.9 million - the difference is attributed to releases from Prefecture Government operated hatcheries

Table 7. Northern Honshu Rivers where Private Organizations have Reared and/or Released Salmon, 1962-67

Map Ref. Number	Prefecture and River
	Toyama
1	Sho
2	Jintsu
3	Fuse
4	Kurobe
	Niigata
5	Arakawa
6	Igarashi
7	Shinano
8-10	Uono
11	Agano
12-13	Miomote
14	Okawa
	Yamagata
15	Nezugaseki
16	Oguni
17	Iso or Goju
18	Nurumi
19	Aka
20-29	Mogami
30	(Hinata)
	Ushiwatari
31	Funadori
32	Mambedori
33-34	Gekko
35	Takase
36	Araizawa
37	Takibuchi
	Akita
38	(Kawabukoro)
39	Naso
40	Akashi
41	Shirayuki
42	Koyoshi
43-44	Omono
	Amori
45	Oirase
46	Araida
47	Oibe
48	Akaichi
49	Iwaki
50	Kanida
51	Kominato
52	Noheji
53	Ogawara
54	Oirase
55	Mabechi

Map Ref. Number	Prefecture and River
	Iwate
56	Kuji
57	Yasuke
58	Fudai
59	Komoto
60	Hei-i
61	Tsugaruishi
62	Sekiya
63	Origasa
64	Otsuchi
65	(Uzumii)
66	Katagishi
67	Sakari
68	Kesen
69	(Arike)
	Iwate-Miyagi
70	Kitakami
71	Naruse
72	Kizuku
73	Takina
74	(Hinuki)
75	Sarugaishi
76	Toyosawa
77	Tanzawa
78	(Kinu)
79	Satetsu
	Miyagi
80	Ookawa
81	Koizuma
82	Minajiri
83	Minatobe
84	Yoshida
85	Natori
86-87	Abukuma
88	Shiraishi
	Fukushima
89	Mano
90	Niido
91	Uketo
92	Kuma
93	Kido
94	Same
	Ibaragi
95	Kuji
96	Naka
97	Tone

Table 8. Income and Expenditures for the Hokkaido Hatchery System, 1953 to 1965[1]

(in thousands of dollars)

Year	Expenditures				Income			Net
	Government	Industry	Other	Total	Government	Industry	Total	Expenditures
1953	236.1	167.9		404.0	23.3	162.0	185.3	218.7
1954	255.7	202.4		458.1	42.1	185.0	227.1	231.0
1955	282.2	185.8		468.0	21.4	224.9	246.3	221.7
1956	281.4	146.3		427.7	26.0	145.8	171.8	255.9
1957	304.8	168.9		473.7	82.8	214.1	296.9	176.8
1958	313.4	165.7		479.1	84.8	199.7	284.5	194.6
1959	334.0	153.2		487.2	61.5	152.7	214.2	273.0
1960	371.3	157.6		528.9	34.9	185.7	220.6	308.3
1961	412.8	183.3		596.1	69.7	206.1	275.8	320.3
1962[2]	624.9	251.7	64.6	941.2	60.4	269.3	329.7	611.5
1963	734.1	348.0	135.5	1217.6	50.8	359.2	410.0	807.6
1964	828.6	439.1	70.7	1338.4	82.6	559.5	642.1	696.3
1965	852.2	348.7	49.8	1250.7	123.3	770.6	893.9	356.8

1 Taken directly from Table 14A, Propagation of the Chum Salmon in Japan, Japan Fisheries Resource Conservation Association, August, 1966, Tokyo

2 Beginning of the first three-year plan for modernization of Japanese hatchery system, 1962 to 1964

Table 9. Total Funds for Chum Salmon Hatchery Program

1962 to 1975[1]

(in thousands of dollars)

Year	Salmon Resource Preservation Ass.	Hokkaido (all sources)	Honshu (all sources)	Total
1962[2]	19.4	1040.2	92.4	1152.0
1963	35.9	1212.6	132.1	1380.6
1964	25.5	1381.9	153.4	1560.8
1965	26.7	1511.7	164.4	1702.8
1966	20.2	1321.8	196.0	1538.0
1967	22.2	1615.3	225.0	1862.5
1968	29.0	1675.5	217.8	1922.3
1969	32.3	1861.0	226.0	2119.3
1970	39.5	2130.4	262.8	2432.7
1971[3]	53.1	3306.7	311.7	3671.5
1972	54.6	3645.8	323.9	4024.3
1973	73.2	4205.6	289.1	4567.9
1974	76.5	4754.2	792.0	5622.7
1975	107.2	5709.4	968.6	6785.2

1 From data provided by the Japan Salmon Resources Preservation Association

2 US$ 1.00 = 360 yen for period 1962 to 1970

3 US$ 1.00 = 300 yen for period 1971 to 1975

Table 10. Average Cost Per Fry Released, 1952-1960

Year	Total Cost[1] (thousands)	Total Fry Released[2] (millions)	Average Cost/Fry (cents)
1953	218.7	170.0	0.13
1954	231.0	269.0	0.09
1955	260.8	248.0	0.11
1956	256.0	140.0	0.18
1957	176.9	362.0	0.05
1958	194.6	417.0	0.05
1959	273.0	314.0	0.09
1960	308.3	203.0	0.15

1 From Table 8

2 From Propagation of the Chum Salmon in Japan, Japan Fisheries Resource Conservation Association, August 1966, Tokyo

Table 11. Average Cost per Fry Released, 1962-1974

Year	Total Cost[1] (thousands)	Total Fry Released[2] (thousands)	Average Cost/Fry (cents)
1962	1,152.0	419,009.0	0.27
1963	1,380.6	388,582.0	0.36
1964	1,560.8	474,038.0	0.32
1965	1,702.8	660,556.0	0.26
1966	1,538.0	468,505.0	0.33
1967	1,862.5	595,960.0	0.31
1968	1,922.3	328,630.0	0.58
1969	2,119.3	501,107.0	0.42
1970	2,432.7	586,770.0	0.41
1971	3,671.5	788,450.0	0.47
1972	4,024.3	700,748.0	0.57
1973	4,667.9	721,733.0	0.65
1974	5,622.7	940.000.0	0.60
1975	6,785.2	-	-

1 From Table 9

2 From data provided by the Japan Salmon Resources Preservation Association

Table 12. Cost per Adult Return from Hokkaido Salmon Hatcheries, 1962-1969

Year	Total Cost[1] (thousands)	Total Adult Return[2] (thousands)	Average Cost/Adult (cents)
1962	1040.2	2923.8	35.6
1963	1212.6	5032.6	24.1
1964	1381.9	2060.1	67.1
1965	1511.7	2671.3	56.6
1966	1321.8	5984.0	22.1
1967	1615.3	8232.2	19.6
1968	1675.5	4834.2	34.7
1969	1861.0	8193.9	22.7

[1] From Table 9

[2] From Table 2

Table 13. Cost per Adult Hatchery Chum Salmon Taken in Coastal Catch, 1962-1970[1]

Brood	Hokkaido			Honshu		
Year	Total Cost (thousands)	Value in Catch (thousands)	Cost/Adult Return (cents)	Total Cost (thousands)	Value in Catch (thousands)	Cost/Adult Return (cents)
1962	1,040.2	13,253.3	30.5	92.4	2,143.6	16.7
1963	1,212.6	16,287.5	31.0	132.1	1,760.8	31.2
1964	1,381.9	8,453.3	72.6	153.4	1,453.6	46.9
1965	1,511.7	16,976.4	42.0	164.4	1,848.5	42.0
1966	1,321.8	23,255.0	28.4	196.0	2,471.1	39.6
1967	1,615.3	34,035.0	23.7	225.0	4,515.6	24.5
1968	1,675.5	33,476.9	26.4	217.8	3,857.6	29.8
1969	1,861.0	43,055.6	24.0	226.0	4,233.0	29.7
1970	2,130.4	49,788.9	23.8	262.8	6,983.3	20.9

1 From tabular material provided by Japan Salmon Resources Preservation Association: Total Cost and Value in Catch converted to US dollars (US$ 2.00 = 360 yen)

Table 14. Record of Hatchery Operations for Chum Salmon on the Oship Chun (Kanggu)[1]

Year	Catch	Spawners	Total	Egg Take	Release	Remarks
1923	4,000	2,500	6,500			
1924	3,500	2,000	5,500			
1925	3,000	3,000	6,000			
1926	5,000	3,500	8,500			
1927	4,000	4,000	8,000			
1928	4,500	3,000	7,500			
1929	6,000	2,500	8,500			
1930	5,000	4,500	9,500			
1931	5,500	4,200	9,700			
1932	4,000	3,500	7,500			
1933	8,000	4,000	12,000	600,000	400,000	Established hatchery
1934	7,000	3,500	10,500	500,000	400,000	
1935	4,000	3,000	7,000	400,000	200,000	
1936	5,000	3,500	8,500	600,000	500,000	
1937	6,000	3,000	9,000	500,000	400,000	
1938	4,500	2,500	7,000	500,000	450,000	
1939	5,000	4,000	9,000	400,000	300,000	
1940	5,000	3,000	8,000	400,000	350,000	
1941	4,000	2,000	6,000	300.000	200,000	
1942	4,000	2,500	6,500	300,000	200,000	
1943	4,000	3,000	7,000	400,000	320,000	
1944	3,000	2,000	5,000	300,000	200,000	
1945	3,000	1,500	4,500	200,000	150,000	Facility partly
1946	2,000	1,000	3,000	300,000	200,000	Destroyed by flood
1947	2,000	1,500	3,500	200,000	150,000	
1948	1,500	1,000	2,500	200,000	100,000	
1949	1,500	800	2,300	200,000	150,000	
1950	1,000	500	1,500	200,000	100,000	
1951	1,500	600	2,100	200,000	100,000	
1952	1,000	500	1,500	200,000	150,000	
1953	700	300	1,000	100,000	50,000	
1954	500	200	700	100,000	50,000	
1955	1,000	500	1,500	200,000	100,000	
1956	600	300	900	200,000	100,000	
1957	600	400	1,000	100,000	50,000	
1958	200	100	300	no eggs		
1959	400	200	600	no eggs		
1960						Destroyed by typhoon
1966			2,000			
	121,500	78,100	201,600	7,600,000	5,370,000	

1 Data from Kanggu Fishery Cooperative

Table 15. Specifications and Schedule of Construction of the Salmon Hatcheries, Republic of Korea

Hatchery	Construction		Area	Rearing Ponds		Hatchery
	Begun	Completed	(sq. ft.)	Number	sq. ft.	Capacity
Milyang	6/5/68	11/-/68	6,563	15	1,032	150 million eggs
Oship Chun (Samchok)						
First Phase	9/7/68	11/30/69	6,000	10	540	150 million eggs
Second Phase	9/25/69	12/25/69				
Oship Chun (Kanggu)						
First Phase	10/12/69	12/25/69	5,458	10	707	150 million eggs
Second Phase	7/12/70	10/29/70				
Total			18,021	35	2,279	450 million eggs

Table 16. Production Record of the Three Salmon Hatcheries Republic of Korea

		Chum Salmon						Coho Salmon		
		Native Stock			Introduced Stock			Introduced Stock		
Hatchery	Year	Eggs	Hatch	Released	Eggs	Hatch	Released	Eggs	Hatch	Released
Milyang	1969				100,000	99,385	70,520	200,000	200,000	173,005
	1970	70,000	56,000	54,911	100,000	95,146	94,902	250,000	248,200	247,047
	1971	31,500	30,255	30,140				400,000	394,850	384,460
	1972	57,000	54,800	52,800	360,000	360,000	345,200			
	1973	22,500	20,000	18,400				900,000	873,000	740,000
Total		181,000	161,055	156,251	560,000	543,023	510,622	1,750,000	1,716,050	1,544,512
Oship Chun (Samchok)	1969							300,000	270,340	100,000
	1970							200,000	184,000	120,000
	1971	110,000	88,000	79,000				400,000	364,000	351,000
	1972	207,500	178,175	178,000				500,000	495,000	484,000
	1973	83,000	71,120	57,000				1,200,000	1,098,000	885,000
Total		400,500	337,295	314,000				2,600,000	2,411,340	1,940,000
Oship Chun (Kanggu)	1969									
	1970							50,000	49,000	47,000
	1971	32,250	29,560	27,866				200,000	299,350	198,549
	1972	74,400	70,680	68,117				500,000	490,000	481,707
	1973	50,300	48,000	46,370				900,000	873,000	860,000
Total		156,950	148,240	142,353				1,650,000	1,711,350	1,587,256
Annual Totals	1969				100,000	99,385	70,520	500,000	470,340	273,005
	1970	70,000	56,000	54,911	100,000	95,146	94,902	500,000	481,200	414,047
	1971	173,750	147,815	137,006				1,000,000	1,058,200	934,009
	1972	338,900	303,655	298,917	360,000	348,492	345,200	1,000,000	985,000	965,707
	1973	155,800	139,120	121,770				3,000,000	2,844,000	2,485,000
Grand Total		738,450	646,590	612,604	560,000	543,023	510,622	6,000,000	5,838,740	5,071,768

Table 17. A Summary of Salmon Hatchery Operations in the Soviet Far East [1]

Map No. Ref.	Area and River	Hatchery	Year Built	Species	Egg Capacity (millions)	Annual Record (millions)				Information Source
						Year	Eggs	Hatch	Released	
	Khabarovsk									
	Amur River									
1.	Bidzhan	Bidzhan		Chum	12	1942-52	9/a.			Atkinson, 1960
					12.6	1959				Kanid'yev, et al., 1970
										Kudryavtsev, 1954
										Vasil'ev, 1954b
2.	Bira	Teplovka	1928	Chum	30	1928-37	12.5/a.	8.6/a.	8.1/a.	Atkinson, 1960
						1938-52	23.2/a.	20.5/a.	20.4/a.	Vanyaev, 1954
					40-45	1959				Bogdonova, 1964
										Disler, 1954
										Kokhmenko, 1972
										Krykhtin, 1962
										Kudryavtsev, 1954
										Levanidov, et al., 1962
										Shidlovskiy, 1954
										Smirnov, 1954a
										Smirnov, 1954b
										Smirnov, 1960
										Vasil'ev, 1954a
										Vasil'ev, 1954b
3.	Amgun	Udinsk	1959-60	Chum	25					Atkinson, 1960
	Kamchatka									
	Kamchatka River									
4.		Azabach'ye	*	Sockeye						Andreyeva, 1954
										Ostroumov, 1964

[1] The information given in this table should be considered to be tentative only. Although many papers have been reviewed, there is no assurance that the hatcheries are still operating or that new ones have not been built

* proposed

Table 17 (cont.)

Map No. Ref.	Area and River	Hatchery	Year Built	Species	Egg Capacity (millions)	Annual Record (millions) Year	Eggs	Hatch	Released	Information Source
5.		Ponorskiy	*	Sockeye						Andreyeva, 1954
6.		Ushki	1927	Sockeye, coho, chum	20	1927-46	20-26			Andreyeva, 1954
						1947	16			Kokhmenko, 1962
						1948	10			
						1949	under 4			
						1950	under 4			
						1951	4			
						1952	3.9	3.8	3.8	
	Sakhalin-Kuriles									
7.	Kurile Is.	Urozhay								Bagdonova, 1964; Landyshevskaya, 1965; Chernyavaskaya, 1964
8.		Unyebetsu								Dvinin, 1954
9.		(not known)								Rykhlov, 1973c
10.		(not known)								Rykhlov, 1973c
11.		(not known)								Rykhlov, 1973c
		Total Kuriles			100					Chernyavskaya, 1964
	Sakhalin Is.									
12.	Tym'	Adotym'	Chum							Chernyavskaya, 1964; Kanid'yev, et al., 1970; Smirnov, 1960
13.	Lyutoga	Aniva		Pinks & Chum						Dvinin, 1954; Kanid'yev, et al., 1970; Rukhlov, 1973a

* proposed

Table 17 (cont.)

Map No. Ref.	Area and River	Hatchery	Year Built	Species	Egg Capacity (millions)	Annual Record (millions) Year	Eggs	Hatch	Released	Information Source
14.	Nayba	Berezhyakovo		Pinks & Chum	15	to 1952	quota			Dvinin, 1954
						1952	7.2			Kanid'yev, et al., 1970
										Lazerev, 1954
										Landyshevskaya, 1965
										Smirnov, 1954a
15.		Kalinin	1925	Chum		1951	5			Atkinson, 1960
						1958	28			Chernyavskaya, 1964
			1959		33	1959	33			Dvinin, 1954
						1960	27			Frolenko, 1964
										Koposov, 1964
										Smirnov, 1960
16.	Pokosnaya	Krasnopol'ye	1938	Pinks,	2	1948-52	0.4/a.			Bogdonova, 1964
			1942	Chum &	3					Chernyavskaya, 1965
			1952	Masu	5					Dvinin, 1954
										Kanid'yev, et al., 1970
										Krykhtin, 1962
										Landyshevskaya, 1965
17.	Kvostovka	Kirillovo		Pinks & Chum						Chernyavskaya, 1964
										Kanid'yev, et al., 1970
										Landyshevskaya, 1965
18.	Lesnaya	Lesnaya		Pinks & Chum						Kanid'yev, et al., 1970
										Landyshevskaya, 1965
										Rykhlov, 1973a
										Rykhlov, 1973b
										Rykhlov, 1973c

Table 17 (cont.)

Map No. Ref.	Area and River	Hatchery	Year Built	Species	Egg Capacity (millions)	Annual Record (millions) Year	Eggs	Hatch	Released	Information Source
19.		Muyka								Kanid'yev, et al., 1970
20.		Okhotsk		Chum						Chernyavskaya, 1964 Dvinin, 1954 Kanid'yev, et al., 1970 Landyskevskaya, 1965
21.	Khabomay	Pioner	1938 1942	Chum	2 3					Dvinin, 1954 Frolenko, 1964 Kanid'yev, et al., 1970
22.	Poronay	Poronay		Chum						Bagdonova, 1964 Chernyavskaya, 1964 Dvinin, 1954 Kanid'yev, et al., 1970 Landyshevskaya, 1965 Smirnov, 1954a
23.	Pugachevka	Pugachevka		Pinks & Chum	15	1948-52	4.4/a.			Bagdonova, 1964 Chernyavskaya, 1954 Dvinin, 1954 Rykhlov, 1973a Rykhlov, 1973b Smirnov, 1954a

Table 17 (cont.)

Map No. Ref.	Area and River	Hatchery	Year Built	Species	Egg Capacity (millions)	Annual Record (millions) Year	Eggs	Hatch	Released	Information Source
24.	Nayba	Sokolova	1939	Pinks & Chum	14	1939 1946 1947 1948-51 1952	14 quota flood quota 14.3			Bogdonova, 1964 Dvinin, 1954 Frolenko, 1964 Kanid'yev, et al., 1970 Landyshevskaya, 1965 Lazarev, 1954 Smirnov, 1960 Zhukova, 1973
25.	Beloy	Sokol'nikovkso								Bogdonova, 1964 Kanid'yev, et al., 1970 Landyskevskaya, 1965 Koposov, 1964 Smirnov, 1960
26.		Spochnaya								Landyshevskaya, 1965
27.	Taranay	Taranay		Chum						Bogdonova, 1964 Chernyavskaya, 1964 Dvinin, 1954 Krytkhin, 1962 Landyshevskaya, 1965
28.	Nayba	Tokoy		Chum						Bogdonova, 1964 Dvinin, 1954 Kanid'yev, et al., 1970 Koposev, 1964 Smirnov, 1960
29.		Vatutino								Kanid'yev, et al., 1970

Table 17 (cont.)

Map No. Ref.	Area and River	Hatchery	Year Built	Species	Egg Capacity (millions)	Annual Record (millions) Year	Eggs	Hatch	Released	Information Source
30.		Yasnomorskiy								Dvinin, 1954 Kanid'yev, et al., 1970
31.		Zavelinkye		Chum		1959 1960	40 20			Chernyavskaya, 1964
		Total Sakhalin			170	1926-52 1926-52	73/a. 9.5/a.			Chernyavskaya, 1964 Dvinin, 1954

Table 18. The Numbers of Young Salmon Released from Sakhalin Hatcheries, 1962-1971 [1]

Species	Region	Year of Release (in millions)									
		1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Pink Salmon	East Sakhalin	44.7	15.7	81.1	38.4	88.1	78.3	191.1	108.2	191.1	87.3
	Southwest Sakhalin	23.5	11.4	43.3	10.2	32.6	30.1	47.9	18.8	48.7	7.5
	Gulf of Aniva	29.2	17.3	36.7	31.6	17.6	36.0	42.9	16.7	40.5	17.2
	Total	97.4	44.4	161.1	80.2	138.3	144.4	281.9	143.7	280.3	112.0
Chum Salmon	East Sakhalin	80.0	108.1	105.1	201.3	185.5	169.9	93.3	186.9	116.9	188.3
	Southwest Sakhalin	75.2	78.3	69.5	112.6	93.9	102.6	97.7	115.3	100.3	143.3
	Gulf of Aniva	4.5	12.7	0.2	4.4	18.6	3.1	--	20.0	1.2	24.7
	Total	159.7	199.1	174.8	318.3	298.0	275.6	191.0	322.2	218.4	356.3
Total, Pink and Chum Salmon		257.1	243.5	335.9	398.5	436.3	420.0	472.9	465.9	498.7	468.3
Percent Chum Salmon of Total		62	82	52	80	68	65	40	60	44	76

[1] From Rukhlov (1973a); minor discrepancies noted in chum salmon totals for 1963 and 1964

Table 19. Total Number of Salmon Released from Hatcheries in the Soviet Far East, 1970-1974 [1]

Species	Year of Release (in Millions)				
	1970	1971	1972	1973	1974
Pink Salmon	423.1	206.3	398.8	269.4	457.1
Chum Salmon	218.4	446.6	351.6	413.7	336.8
Sockeye Salmon	--	--	9.3	--	9.1
Coho	--	--	3.2	10.3	4.8
Total	641.5	652.9	762.9	693.4	807.8

[1] McNeil (1976) - Personal communication from Dr. S. I. Doroshev, Head, Laboratory of Acclimatization and Aquaculture, VNIRO, Moscow

OVERVIEW OF F.R.E.D. ACTIVITIES

Robert S. Roys
Alaska Department of Fish and Game
Divison of Fisheries Rehabilitation
Enhancement and Development
Juneau, Alaska 99811

Who would have thought five years ago when I left Cordova that I would be returning to come back here and give a speech at a meeting that I consider rather historic? Historic because that is what the fishermen called it, not a group of professional biologists. My remarks this morning are directed mainly to the fishermen.

Prior to 1971, the salmon fisheries research and management programs of the Department of Fish and Game were primarily directed toward obtaining and applying knowledge that, when converted to regulations by the Department of Fish and Game, would allow commercial sport and subsistence harvest of the resource without jeopardizing future production. Reduced to its simpliest form, this program attempted to secure annual optimum escapement in each management area and for most salmon species by relaxing or restricting harvest levels by a variety of regulatory methods. Since Alaska has vast natural spawning and rearing areas, management based upon optimum escapement will yield, when controlling environmental factors are favorable, major catches of salmon that may meet the needs of the user groups. However, when controlling environmental factors are unfavorable, as they have been somewhat in the past several years, poor catches are evidenced and the user groups are dissatisfied for economic, sport or subsistence reasons.

A management strategy based solely upon achieving optimum escapement is considered by many fisheries professionals to be an extremely simplistic form of agriculture. In lay terms, plant the seeds in the ground and pray for a rewarding harvest.

Early farmers witnessed the ravishes of insects, floods, birds, predators, etc., and over a period of time modern agriculture evolved. Farmers today strive to control as many factors as possible in order to bring in a crop. Even so, production can be severely limited by (a) natural environmental factors that remain beyond control, and (b) perhaps one of the most important, new techniques that are used before the full impact of the technique is understood, such as DDT, the evolution of more virulent strains of disease, and the degrading of environmental fitness of the organism. Generally, optimum escapement management strategy attempts to plant an optimum number of eggs in the spawning ground and then hopes for favorable survival conditions. The salmon catches in many areas of the state (and we have seen several graphs since yesterday) in the past 40 years have demonstrated the fallacy of such a simplistic approach to a problem that is far more complex than just the number of eggs in the gravel or the probable carrying capacity of a natural nursery area. To continue this approach would be to assume the following:

1. Basic demands for salmon will not exceed the supply produced by the natural environment in a given year or over a period of years.

2. The genetic fitness of stocks and their ability to reproduce will not be, or has not been, altered by harvest regulations.

3. High levels of organic materials, primarily catches of red salmon, may be removed from natural fresh-water rearing systems without eventually altering the carrying capacity of those rearing systems.

4. User groups would be satisfied with wildly fluctuating harvests (and I can guarantee you that we have had input from the user groups on what they think of wildly fluctuating harvests).

5. Effects of predators and competitors always contribute in a positive and insignificant or an acceptable manner on the production of salmon.

6. Restoration of previously disseminated stocks is strictly a problem of increasing escapements.

7. It is not an economically sound investment to develop unutilized spawning or rearing areas.

8. Securing optimum escapements is the most cost effective program, even when total closures are required. What is the cost to the community when this happens? I sometimes wonder whether natural escapements are the most cost effective program.

9. The citizens of the state did not want the development and application of salmon husbandry techniques to take place in the state by state agencies, private profit, private nonprofit, or a combination of these.

It seems apparent that because all of these assumptions could not be satisfied, the 1971 legislature created the Division of Fisheries Rehabilitation, Enhancement, and Development (FRED).

The Division of FRED was charged with the following statutory obligations:

A. Develop and continually maintain a comprehensive, coordinated state plan for the orderly present and long-range rehabilitation, enhancement, and development of all aspects of the state's fisheries for the perpetual use, benefit, and enjoyment of all citizens and revise and update this plan annually. One comment: when you develop a plan, you first have to know what the technology is and have a pretty good idea of what the people want.

B. Encourage investment by private enterprise in the technological development and economic utilization of the fisheries resources.

C. Through rehabilitation, enhancement, and development programs, do all things necessary to insure perpetual and increasing production and use of the food resources of Alaska waters and continental shelf areas.

D. Make a comprehensive annual report to the legislature containing detailed information regarding its accomplishments under this section and proposals, plans and activities for the next fiscal year not later than 20 days after the convening of each regular session.

The 1971 Legislature also charged the Division with specific responsibility of developing and testing the feasibility of salmon substrate incubation and estuarine-saltwater rearing technology in the state. Careful examination of FRED legislation and subsequent legislation dealing with private nonprofit hatcheries demonstrates clearly that in a very short time period (1971 to 1974) the department was forced out of a relatively simple management policy of manipulation of natural stocks, which was controlled to a large extent by budget, into a policy that would be extremely broad in scope and based upon development and application of more advanced fishery methods as well as the possibility of different institutional arrangements to apply those methods.

There are three basic aquaculture systems, which I will describe briefly. The first is the natural system, which has great potential in this state. The natural system may be wasteful because little control is exercised over major causes of mortality. However, there are ways of increasing production in the natural environment; fish ladders, predator-competitor control programs, and fertilization of rearing areas are examples. The natural system is a publicly owned resource in Alaska.

The second aquaculture system is what I call the semi-artificial system, in which attempts are made to increase production by controlling one phase or several phases of the life history of the animal with an artificial environment. The use of substrate salmon incubators for increasing the survival of eggs is one example of the semi-artificial system. Some environmental factors may not be controlled. Salmon fry (fingerlings) may be planted in a lake or may be released directly into the estuary. Control exercised is obviously more than in the natural environment.

The third system is totally artificial. All, or an extremely high percentage, of environmental factors may be controlled. Maximum control is exercised over the animal. Feedlot rearing of salmon is a good example.

In general, the natural system is simple and costs least to manage, but production will fluctuate wildly. Maintenance of markets and profits, therefore, would be difficult under that kind of a system, though I hasten to add I am not an economist. Disciplines required to maintain such a system may be fewest in number. The semi-artificial system, on the other hand, should tend to stablize production more than the natural. However, the costs will be higher because construction of facilities may be required. Benefit costs become extremely critical, more disciplines are required, a higher level of knowledge is needed. Fundamental knowledge that is required in the semi-artificial system, such as timing of release of fry, nutrition, or disease can be overlooked in a natural system. The artificial system, of course, may be the most expensive of all, and we are seeing attempts of this for salmon. There are some totally artificial systems in the world. Oyster aquaculture and mussel development in Spain are examples.

We do carry out a fairly extensive program on the natural system, fish ladders, stream improvement, etc. However, our major thrust at this time in the FRED Division centers around the semi-artificial system. What are some of the prerequisite disciplines for implementing the semi-artificial aquaculture system?

1. Pathology - Absolutely. The minute you start rearing animals in dense rearing situations (for cost effectiveness), you will be confronted by diseases.

2. Genetics - closely related to pathology. Breeding programs must be implemented that maintain the fitness of the organism.

3. Engineering - proper design of facilities for cost effective operation and satisfying the biological requirements of the animal.

4. Biology - yes, and of course fish culture.

All of these disciplines plus a few others must be integrated for maximum results. When this occurred in the agriculture industry, success was evidenced. Until integration of disciplines occurred, agriculture was a hit-or-miss proposition.

What are some of the projects we are working on in the semi-artificial type of aquaculture system? I'll break them down into three major categories:

The first is developing and testing salmon technology relative to utilization of our freshwater rearing areas. We have a great deal of lake nursery area in the state of Alaska that could produce salmon. For example, we find it very, very foolish to think in terms of increasing sockeye production in the state by rearing sockeye to the smolt stage. The longer you rear an animal, obviously the higher the cost not only for facility construction but also operations. Therefore, our technology is aimed at stocking high quality fry in lake systems where a potential for subsequent natural rearing exists. Six projects are under development along those lines. Lake Nunavaugaluk is a sockeye substrate incubation hatchery in Bristol Bay of 15 million fry capacity. That facility when constructed will be adjacent to a lake that is about 89 square kilometers of nursery area. Presently Lake Nunavaugaluk produces only 10 or 15 thousand sockeye. Big Lake is another sockeye substrate incubation facility recently constructed in the Matanuska Valley with about a 10 million fry capacity. Over the years the department has not been able to secure adequate escapements in Big Lake; and, as a result, high levels of production have been lost. We feel that installing an incubation system will result in a lesser level of escapement for restoring production and maintaining it.

At this point I would like to say that I do not recommend development of sockeye hatcheries to anyone in the private nonprofit business because of the many unsolved problems in technology and disease. The technology and disease factors relative to sockeye are complicated, but we are confident that these problems will be solved. At this time IHN virus is a serious disease problem, but professional groups are developing an effective vaccine.

At Little Port Walter, located on the south end of Baranof Island, the technology of stocking coho fry or fingerlings in lakes is being developed through a cooperative agreement with the National Marine Fisheries Service. The same type of research and development is underway on the Kenai Peninsula, Bear Lake near Seward, and in the Mendenhall ponds near Juneau.

The second category of semi-artificial systems under study and development is the concept of estuarine-saltwater rearing of salmon as directed by the legislature. This approach may be valuable, as demonstrated by Bill Heard at Little Port Walter (N.M.F.S.) in 1975. About 15 thousand adult cohos returned from a release of 173 thousand smolts produced from an estuarine pen rearing facility. This type of facility does not use concrete raceways or heat, but uses floating pens and freshwater lenses. We are testing several facilities similar to Little Port Walter but slightly different in design: one at Starrigavan near Sitka, one at Fish Creek in Juneau (which is a pre-smolt/post-smolt type of rearing), and at Halibut Lagoon in Cook Inlet. As far as I know, Halibut Lagoon is the farthest north saltwater rearing system in the world. Some very interesting problems are cropping up at these facilities, but returns are occurring.

The third major program that FRED is conducting is the development and application of pink and chum salmon technology. This development is based upon the work of Bams and Bailey and centers around upwelling gravel incubators. A prototype production unit is in operation at Kitoi Bay and has a capacity of about 4 million pink salmon eggs. Adult returns of pink salmon have averaged about 1-1/2% ocean survival. Some of you may have visited the pink salmon substrate incubator at Auke Creek near Juneau, which has about a million fry capacity. Several years of adult returns have occurred with an ocean survival of about 1%. Auke Creek is another cooperative project with the National Marine Fisheries Service.

At George Inlet near Ketchikan we are testing out various substrates - Astroturf and other types of plastic. George Inlet was put into production last year, and about a million chum fry were released.

The Tutka Lagoon (near Homer) pink salmon substrate incubation system was just completed and will be in full operation in 1976. With the exception of Auke Creek and George Inlet, our pink-chum salmon incubation systems are located in areas where they may be expanded for major production. Other facilities are on the drawing boards, and detailed site investigations are underway.

Now quickly, since time is of the essence, I want to make some general comments for your consideration, particularly for those people who are becoming involved in the private nonprofit aquaculture business:

1. There is a tremendous difference in the environmental conditions in this state.

2. Construction cost will vary considerably depending upon the area and site.

3. The size of the fish and survival characteristics will vary, thus making brood stock selection extremely important in terms of cost effectiveness.

4. The location of the hatchery will, because of the influence of the estuary, influence tremendously the survival rate of released fish. In the past, some hatcheries have been located based strictly on the quality and quantity of freshwater with little attention paid to the estuary.

5. Value of fish varies considerably from area to area. What chum salmon are worth in Bristol Bay is different from their worth in Southeastern. Cost variances must be considered during site investigations.

6. Extremely broad ranges of air temperature in the state requires design modifications. For example, at Crooked Creek we initially operated that facility unhoused in temperatures of 40 below. I would not recommend an unhoused facility under those conditions.

7. There is a lack of reliable water resource information in the state. Stream gages are few and far between, and in many cases we've been forced to use existing data and extrapolate for other sites. If you are considering investing from 200 thousand to 5 million dollars, this extrapolation game becomes very serious indeed.

In summary, I believe we in FRED are ready for major application of chum and pink salmon enhancement technology in those areas of the state pending the development of a plan based upon needs. As I mentioned earlier, we are at the beginning of the development of sockeye technology. Our view on coho is to produce them in high demand areas as cheaply as possible, although in some instances conventional hatcheries may be necessary. Intensive surveys of lakes are commencing to determine what species are best suited for stocking. We do not have much detailed information on potential lake rearing areas. All we know in many instances is that suitable freshwater nursery areas are probably very abundant.

In conclusion, the road we are traveling is complicated, but I believe, after hearing discussions the last couple of days, that a definite cross roads has been reached. The question is will the state conduct the enhancement program, will it be private nonprofit, or will the program be a combination of both? Presently, FRED is in the middle of the deliberations as reflected by divisional statutory obligations. The issues are far greater than biological. Most of the discussions the past few days, with few exceptions, have been directed toward the biological; but the issues encompass social, economic, and cultural aspects. After a thorough review of the multitude of facts and alternatives, it will be up to the people to decide the direction, and it is of paramount importance that all issues be clearly defined.

FIRST YEAR ACTIVITIES OF THE PRINCE WILLIAM SOUND AQUACULTURE CORPORATION

Armin Koernig and Wallace Noerenberg
Prince William Sound Aquaculture Corporation
P. O. Box 1110
Cordova, Alaska 99574

The President of our corporation, Armin Koernig, a fisherman, has worked jointly with me as the other administrative officer for the past year and is going to give a talk tomorrow morning. I will, therefore, not cover in this report details on the corporation organizational structure and the slide presentation on actual hatchery construction in 1975.

We had a very intensive year of activity. What happened here in Cordova concerning the amount of time spent by a large number of fishermen, several processing firms, and two or three professional people working very closely together to develop private sector aquaculture was very unusual in the State of Alaska. I will briefly review the various phases of our activities.

A little background on the local situation is necessary to understand our actions. Salmon stocks in Prince William Sound - Copper River area have been harvested since the beginning of the twenthieth century. The first canneries were built on the Copper River delta, and the emphasis was primarily on Copper River red salmon. The principal salmon resource in Prince William Sound is an entirely different species complex from that of the Copper River delta area. In Prince William Sound, pinks and chums dominate the situation representing almost 90% of the stock strength, the other three species being either absent or very minimal. The heavy fishery on this pink and chum resource goes back actually into the 1920's when the traps were developed, and seine fisheries and a great number of canneries were built almost simultaneously around Prince William Sound.

Production from the wild stocks based upon this industrial development in the 1920's remained high for 25 years, except that there was an environmental disaster in the odd-year cycle of pink salmon in the 1930's which caused a decline for a short time. Basically the production levels of the wild stock were quite high for about 25 years (1920 to 1945). Suddenly after 1945, odd-numbered-year pinks, even-year pinks, and to a lesser extent, chum salmon plunged to quite low levels of production. It led to total closure of fisheries for five different years in the last 25 years. This was the first major fishing district of Alaska that suffered total fishing closures for entire fishing years; in 1954-1955 we had two closures back to back. In 1959, 1972 and 1974 we had similar closures of the main seine salmon fishery of Prince William Sound.

The reason we have a corporation and are trying to do something in the private sector is related to this economic background of our fisheries. Prince William Sound ranks fourth or fifth among Alaskan salmon production units. I do not mean to downgrade the Sound as a production unit, but it has had a critical history, especially in the 1950's, of economic disaster for the industry. When I came here in 1952, we had major canneries all over the Sound; only one of those eight major canneries is still in existence. They are all gone except for the New England plant at Orca. They have been replaced to some extent by other plants here on the Cordova waterfront. We have had some real economic problems, leading to some real interest among the fishermen in what we might do in the Sound to counteract this.

The development of accurate forecasts of Prince William Sound runs, back in the early 1960's, assisted the management agency in improved management of the runs. In fact, we were quite encouraged through the 1960's in the rising trend of production; but it is now clear that environmental factors, specifically adverse winter conditions in the streams which devastate eggs and alevins in the stream gravel at times of certain weather sequences, will continue to cancel much of this improved management. Many other things have to be done besides forecasting to improve management of the stocks. Management efforts to get a decent escapement, the right kind of escapement, the right timing, etc., only to have the benefits die through freezing or some other in-stream factor during the winter is discouraging. This occurred in the early 1970's and led to very depressed conditions after a lot of hopeful periods in the 1960's. I think the crashing of these stocks in the 1970's has had more to do with the formation of our corporation than anything else.

Finally, the fishermen realized that artificial propagation probably is the key to doing something about stabilization of fishable stocks and that all the good management in the world may never accomplish this by itself in Prince William Sound. So, with this rationale behind us, and with a group of fishermen who have been a very stable group, many of them residents for 25, 30 or 40 years, there was a strong basis for self-help in fish enhancement. Stabilization of the volume of catch by annual production of 200 million fry was fairly quickly put together as a program target in the first meetings of fishermen interested in private aquaculture. In the first year we tried to decide through engineering, research and planning, the necessary elements of a private hatchery system with sufficient buildings and other structures to produce over 200 million pink and chum fry a year. With this fry production, we think that use of techniques developed from government pilot hatcheries at Auke Bay, Kitoi Bay and other places, will enable us to produce 3 to 4 million adult salmon per year in the common property fishery. This will build a stable base underneath the wild stocks which vary a great deal (up to 6 or 7 million catches at a time but also down to zero to 1 million catches in other years). With this wild stock fluctuation problem, causing unfishable seasons at certain times, we propose with our actions to build a guaranteed run every year of 4 to 5 million adult salmon including contributions from state hatcheries. Our corporation activity goals are to raise this catch up to 3 million hatchery fish; the rest will be from state and other private aquaculture activities.

One reason that the Prince William Sound Aquaculture Corporation proposed to do such a great part, or about 60% of the program, was our belief that Prince William Sound will continue to receive a very low rate of state appropriation. The Sound, with a minimum of population, has been almost wiped out as far as legislative representation is concerned. The district not only includes all of Prince William Sound, Valdez, and Cordova, but also takes in part of Kenai Peninsula; and, as a matter of fact, our one house seat is held by a man who lives on the Kenai Peninsula. The only Senate seat is held by a man who lives in Palmer, in the Matanuska Valley. The Sound will not get a lot of sympathy from the tax payers in Alaska and the legislature for doing much for Prince William Sound since there are so few voters here; it is as simple as that. This point of view is the reason our corporation took upon itself the goal of doing about 60% of this rehabilitation program. Whether or not we will get it accomplished is something else, but this is our goal.

The Prince William Sound Aquaculture Corporation is composed of a lot more than just the fishermen of this area. It is composed of the processors, four Native corporations, the city governments of Valdez and Cordova, and hopefully, shortly, Seward and Whittier as well, and some general interest people, biologists, such as myself and Dr. Nevé.

There is also a seat on the board for sport fishing interests. We believe development of this regional corporation is a very significant thing. We hope that it will be a productive type of corporation because of its broad areas of interest.

I will now summarize some of the high points of activities of the corporation in 1975. First was development of long-range and short-range action plans. Whereas, we could have justified a long period of planning, engineering, etc., there was another overrriding factor: namely, we had a lot of enthusiasm in Cordova which we felt would not last if we set up a bureaucracy in our own private sector. We, therefore, attempted to do two or three years work in one year. Our plan was to have by the end of the very first summer an operating salmon hatchery. The way it worked out, we were not able to accomplish this goal; but through hard work by a large number of people, we came very close to reaching it. We greatly simplified the matter of reaching full operating status during the summer of 1976.

Another reason for speeding our construction schedule was to insure achievement of a self-sustaining economic status at the first hatchery at an early date. In other words, access to surplus fish sales to offset operating expenses at an early date (by 1977) was part of our plan.

Having runs returning as early as 1977 seemed a little bit far fetched in view of the delay of the start of permanent hatchery construction until August, 1975. It involved building a complete temporary hatchery with 10-million-egg capacity and operating the same during the construction phase. As it turned out, we were able to accomplish this by proceeding with egg takes totaling over 6 million pink eggs. From this effort, something like 60 thousand fish are expected to come back into the fishery and, to some extent, back as escapement in 1977. Eyed eggs from this operation were planted in the stream bed at the hatchery site when it became apparent that the permanent hatchery could not be finished in November. If nothing else, we expect sufficient brood stock in 1977 to fully stock our completed hatchery complex.

In our early discussions of our corporation goals, we recognized we were equally interested in the Copper and Bering River fisheries from the standpoint of possible enhancement through hatcheries. The declines in these fisheries have not been quite the same as in the pink and the chum salmon fisheries of the Sound; nevertheless, we do think there is productive hatchery-oriented work to be done on the Copper and Bering Rivers. In the early years, however, we defined our emphasis as Prince William Sound, even though this is really only half of our fishing area and half of our problem area.

Another major thing the corporation accomplished was the search for hatchery sites. My 15 years of detailed stream foot and aerial surveys with the Fish and Game Department and the University of Washington expedited this operation. In February, 1975, we surveyed with vessels and aircraft to document winter water conditions. Our main concern was what existed in mid-winter in Prince William Sound for water from the point of view of running a hatchery. We concluded from these surveys that there were some sites that had 5 to 15 cubic feet per second in winter or sufficient water on which to operate major hatcheries. Gravity water flows from lakes were particularly sought since they would eliminate expensive water pumping and provide hydro-electric generation to reduce operating costs.

As a private corporation, we, like Fish and Game who have done similar surveys, were not looking at streams that contain major salmon runs. The Private Hatchery Act and Department policies had pretty well restricted us from looking at those; we, therefore, were looking at non-productive streams with good winter water flows. One of the major functions of the corporation in 1975 was investigating new incubation box designs. We concluded that a deep matrix system utilizing Astroturf was the most promising. Examples of our box design are on display at this conference. Note that the same box can be used in a number of different ways: i.e., loaded with trays, loaded with Astroturf, with either upwelling or down-draft water delivery systems. It can also be used as a fry-rearing tank. The original idea for this box was from a private corporation in Oregon. However, their low-cost box has been modified greatly in a number of areas so that it is, we believe, far more versatile and will have a longer life.

Probably the most critical area of corporate activity was the collection of sufficient money to carry on a relatively large program. We looked at many sources. The attainment of fishermen assessments for the period 1975 - 1979 via the CAMA organization was the least time consuming due to the high interest of fishermen in this project. This assessment generated $121,000 for us in 1975.

The next source of money was procured from fish processors, on terms of matching of their fishermen's assessments. This took somewhat more convincing than was the case of the fishermen, but eventually all major processors agreed to participate. About $113,000 was realized from this source in 1975.

Our other two principal sources of money to meet budgetary needs this year were a $100,000 loan from the state government, utilizing an amendment to the Fishermen's Revolving Loan Fund. Finally, the major source of money for hatchery construction was the Federal Economic Development Administration. Contacts were made at the local committee level as well as with EDA proper in Anchorage and Seattle. It was finally established that EDA did have an interest in this community development project and did give us a lot of cooperation. We received, via Washington, D. C., approval of $440,800, which was the major portion of our construction budget. The sum of all grants and loans was $785,000. It is almost unbelievable that such could be generated out of almost nothing less than a year ago here in Cordova.

The preliminary hatchery site study I mentioned earlier determined we had a real land acquisition problem including necessity for environmental impact statements, etc. Prince William Sound is mostly National Forest lands. Delays of one to two years in building anything are necessary on Forest Service lands. We, therefore, decided to build the first hatchery at Port San Juan, an abandoned cannery owned by New England Fish Company, where the land is patented. Fairly early in the game it was determined that New England would talk to us, at least, about renting this site for use as a hatchery. It finally developed that a small portion of their holdings could be used as a hatchery; and we negotiated a 22-year lease for a site which includes the stream mouth, hatchery building, housing, the pipeline corridor and access to dock and warehousing.

Procurement of necessary permits was also a time consuming item. One of the key things, of course, is the hatchery-site permit from the Department of Fish and Game. Water-use and water-discharge permits were also necessary from two separate agencies.

Engineering design of the complete hatchery system was an expensive and time consuming operation, in view of our tight time schedule. Much efficiency was lost at Port San Juan because the engineering firm could not keep pace with the rate of construction. It is a tribute to a lot of people that fully 70% of the construction was completed under difficult circumstances last fall. This means that in 1976 we can complete construction and be in operation within a fairly easy time schedule.

Volunteer labor and boat-charter donations were critical to what success we had. Somehow, with 30 or 40 free boat charters from the fishermen of Cordova, plus help from the Alaska Ferry System and Sea-Land, all materials were laid down at the site in relatively short time periods.

The other key activity in 1975 was the temporary hatchery operation. We were working with a brand new incubation-box design tested for only one year in Oregon. The box design was modified from a down-draft flow to upwelling as a safety factor in case we lost our water. Within our temporary water system we had air entrapment, siltation from a flood, and finally a fungus problem. The result was loss of about 30% of the eggs to the eyed stage. Technical assistance from NMFS, Auke Bay Laboratory, the Hatchery Section (Fire Lake) and the FRED Division of ADF&G was extremely helpful in solving our key problems. We want to thank these agencies for all their help.

In summary, we could not quite finish construction in 1975 because of lost materials and an unusual October freeze. We decided, through permission of the Commissioner, rather than lose the eyed eggs, to plant them in Larsen Creek at Port San Juan. This turned out to be a very favorable project. We are going to have about 3 million fry migrating seaward in 1976 from the 3.5 million eggs planted. I think this will provide us the brood stock we need in 1977 as well as perhaps some surplus funds to help start paying for this project. This project of planting eyed eggs in the inaccessible portions of the hatchery stream has convinced me to recommend to our Board that this be a regular project every year. The process conceivably will produce a significant addition to our hatchery production in the area of 25% annual addition of adult returns. This inaccessible stream bed can be a natural hatchery of high quality, it turns out.

GENETIC CONSIDERATIONS FOR SALMONID AQUACULTURE: BIOLOGICAL UNCERTAINTIES

John H. Helle
Northwest Fisheries Center Auke Bay Fisheries Laboratory
National Marine Fisheries Service, NOAA
Post Office Box 155
Auke Bay, Alaska 99821

INTRODUCTION

Returns of salmon have been discouragingly low to most areas of Alaska for the past several seasons. The prospect for a quick recovery also has some discouraging environmental aspects. Many climatological scientists studying long-term trends in world weather patterns are predicting that the northern latitudes will experience cooler and longer winters with shorter growing seasons and lowered productivity, e.g., Johnsen, Dansgaard, and Clausen (1970), Kukla and Kukla (1974), and Bryson (1975). If these predicted trends materialize, our salmon populations would experience lower freshwater and marine survival potentials. This disturbing possibility makes it imperative that man's demands on this resource and its environment do not further deteriorate an already unstable situation and make the decline of the salmon irreversible. If we are indeed entering a period of rapid climatic change, the importance of genetic diversity to permit biological adaptation will be great.

Impatience with the recent low levels of salmon production and recent advancements in the methods of artificial propagation of salmonids have led to increased demands for application of this technology. Responding to these demands, the 1974 Alaska legislature created Alaska Statute 16.10.400, which authorizes the operation of private, nonprofit hatcheries for salmon. Lack of genetic considerations in this statute prompted the Alaska District of the American Institute of Fishery Research Biologists to issue a position paper on the subject (American Institue of Fishery Research Biologists, 1975).

Lack of genetic considerations in the implementation of artificial propagation facilities for salmon could result in additional stresses on our already stressed salmon populations. Many of the people becoming involved in hatcheries in Alaska are unaware of some of these problems. Some of these problems were discussed by Miller (1957) and Vincent (1960). More knowledge on stock adaptations has accumulated since these papers were published, but incorporation of genetic concepts into artificial propagation technology is slow. The following remarks may stimulate planning so that we can integrate a biologically complete and sound hatchery program into our fishery management without endangering the future reproductive potential of our salmon.

ADAPTATION AND THE STOCK CONCEPT

The stock concept has been basic in recent strategies for managing Pacific salmon fisheries. The term stock refers to the "fish spawning in a particular lake or stream (or portion of it) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season" (Ricker, 1972). Therefore, a group of salmon of the same species returning to a river system or a stream to spawn could comprise a number of different stocks. When a group of stocks have similar migration times, they are called a run, e.g., early run of pink salmon, fall run of chum salmon, etc.

The management of pink and chum salmon fisheries consists of harvesting the surplus of each stock and letting exactly the right number of fish spawn so that the carrying capacity of the spawning grounds is not exceeded. Management of stocks of other species of salmon require, in addition, attention to the capacity of freshwater rearing areas. Ideally, the gene pool of the escapement should represent the gene pool of the returning spawners for each stock. These management goals are very difficult to attain because most of the fisheries in Alaska harvest a mixture of stocks.

The existence of stocks of salmon is made possible by "homing"--salmon tend to return to their natal stream to spawn. The ability of all species of salmon to home is well documented. A few examples are Davidson (1934), Scheer (1939), Pritchard (1939), Hartman and Raleigh (1964), Parker (1964), Hasler (1966), Bams (1972), and Ricker (1972).

The progeny of each stock of salmon, after many generations of natural selection, become uniquely adapted to their particular series of life history experiences. This local adaptation is the the result of interaction between the various phenotypes and their environment. Gene combinations best suited for survivial prevail.

The concept of local populations of salmon was stated in 1939 when Rich (p. 47) said, "To summarize: Diverse evidence points so clearly to the existence of local, self-perpetuating populations in the Pacific salmon that any hypotheses that do not conform must be subject to considerable doubt."

Examples of stocks of salmon (and trout) that demonstrate adaptation to specific environments abound in the literature. Perhaps the most extensive documentation is in a paper by Richer (1972).

Some specific examples illustrate the complexities of adaptations to local environments. Northcote, Williscroft, and Tsuyki (1970) found differences in meristic characters and biochemical genetic diversity between rainbow trout (*Salmo gairdneri*) that resided in a stream above and below a waterfall. Time of spawning of stocks is a characteristic that demonstrates genetic adaptation to specific environments (see Ricker, 1972; Rupp and Redmond, 1966; Calaprice, 1969). Pink salmon (*Oncorhynchus gorbuscha*) spawners in a small coastal stream (Olsen Creek) in Prince William Sound, Alaska, consistently return in a predictable pattern based on season and specific areas of the stream (Helle, Williamson, and Bailey, 1964; Helle, 1970; Thorsteinson, Helle, and Birkholz, 1971). Returns of marked pink salmon to Auke Creek (near Juneau, Alaska) clearly demonstrated that progeny of the early and late spawners return to spawn at the same time of season that their parents returned to spawn (S. G. Taylor and J. E. Bailey, Northwest Fisheries Center Auke Bay Fisheries Laboratory, Personal Communication). These consistent behavioral patterns argue strongly in favor of a heritable response.

Some behavior, for example the direction of first migration of sockeye salmon fry (*Oncorhynchus nerka*) in a water current, have been shown to be adaptations to local environments, and these responses in turn have been shown to be largely under genetic control (Raleigh, 1967; Brannon, 1967 and 1972). Thus, in sockeye salmon, the progeny of fish spawning in lake outlets migrate upstream to the lake, while the progeny of fish spawning in tributaries simply migrate downstream to the lake. If the progeny of outlet spawners migrated downstream in a single lake system, they would, of course, not survive because most sockeye salmon juveniles require a period of freshwater residence before they enter the ocean.

Brannon (1972) also evaluated the migratory responses of sockeye salmon fry in multiple-tributary-lake systems of the Fraser River in British Columbia, Canada. The fry in each of the six stocks he examined required distinctly different behavioral patterns to reach their nursery lakes. Through hybridization experiments, Brannon demonstrated that the migratory response in these stocks has a strong genetic basis.

Direction of migratory response in progeny of rainbow trout and cutthroat trout (*Salmo clarki*) that spawn in outlet and inlet streams of lakes has also been shown to be largely under genetic control and represents adaptation to local environments (Raleigh, 1971; Raleigh and Chapman, 1971; and Bowler, 1975).

There are many other examples of behavioral, physiological, and morphological adaptations to local environments in salmonids as well as in other animals (e.g., Bams, 1969; Koski, 1975). The intricacies of these adaptations can be highly complex in fish as well as in higher animals.

TRANSPLANTATION OF STOCKS

Man has transplanted animals (and plants) from one area to another for many years for many different reasons. This practice has some disturbing biological implications that are apparently now well known. A quotation from Mayr (1971, p. 196-197) concisely states the problem:

> "One conclusion emerged from these observations more strongly than any other: the phenotype of every local population is very precisely adjusted to the exacting requirements of the local environment. This adjustment is the result of a selection of genes producing an optimal phenotype. The discovery of this physiological adaptation of local populations is of considerable practical importance for instance in wildlife management. Populations that are well adapted in their native environments are often very vulnerable when transplanted into different environments. The literature on game animals records many instances in which stock died out rapidly after introduction into a different region. *If they survive long enough to breed, introgression of their inferior genes will contribute to the deterioration of the native stock*. (Emphasis added.)
>
> It is for this reason some countries now prohibit the import of game birds and mammals. Millions of dollars of taxpayers' money spent on raising and releasing ill-adapted game stocks could

> have been saved if those in charge had been aware of the physiological differences among local populations."

Even though Mayr was specifically referring to game animals, the genetic principles involved apply equally to fish. Records of transplanting stocks of salmon show no lack of imagination of the part of the transporters. Shipments of eggs or juveniles of chinook salmon (Oncorhynchus tshawytscha) during the period 1872-1930 were sent to 17 states east of the Mississippi River and to countries like Tasmania, Nicaragua, Italy, Mexico, Argentina, and Germany, (Davidson and Hutchinson, 1938). They also record where chinook salmon were transplanted unsuccessfully to Hawaii on several occasions.

From a biological point of view, salmonid transplants can be categorized in three ways:

1. Transplant of a species to an area where that species is not present.

2. Transplant of a species to a barren system in an area where the species exists in nearby systems.

3. Transplant to a system where the species is already present.

The first category presents more of an ecological problem than a genetic problem. The transplant of coho salmon (Oncorhynchus kisutch) to the Great Lakes is an example (Tody, 1966). There were no natural coho salmon populations in the Great Lakes, so interbreeding was not a problem.

Transplants of the type listed in categories 2 and 3 present the genetic problems. The homing of transplanted stocks of salmon has been highly variable (Ricker, 1972; Simon, 1972; Worlund, Wahle, and Zimmer, 1969). Recent experiments in Canada by R. Bams (described by him at this conference) again illustrate the imprecise homing behavior of transplanted pink salmon. The returns from his hybridization experiment, where he crossed the transplanted stocks with the indigenous stock, strongly support the hypothesis that homing ability is associated with genetic adaptation to specific environments.

Evidence exists that species-specific pheromones released in the stream water can influence homing behavior in Atlantic salmon (Salmo salar) and olfactory response in migrating chinook salmon (Solomon, 1973; Oshima, Hahn, and Gorbmam, 1969). Transplanted stocks that have an imprecise homing ability may be decoyed into the wrong stream by being attracted to pheromones released in the water by salmon of the same species. Regardless of the causes, this imprecise homing ability makes it likely that the transplanted stock, if it survives, will stray to other systems and interbreed with wild fish. The probable result of this interbreeding is clearly stated by Dobzhansky, 1951, p. 179-180:

> "The biological significance of the sexual process, of the interbreeding of carriers of distinct genotypes, lies in the proliferation of a multitude of gene combinations. Some of these combinations are the harmonious genotypic systems adapted to the different ecological nitches in the environment. But the interbreeding could be just as efficient in breaking down the harmonious gene combinations as it was in forming them. Unlimited interbreeding of distinct species would result in submergence of the existing genetic systems in a mass of recombinations. Among the recombinations some may be as harmonious, or in fact better, than the existing gene patterns, and thus by hybridization the species may 'discover' new evolutionary possibilities. But the chance of discovery is pitted against the fact that a majority, and probably a vast majority, of the new genetic patterns are discordant, unfit for any available environment, and represent a total loss to the species." (Emphasis added.)

Dobzhansky (1951, p. 196) further states:

> "We have seen that F^1 hybrids between species, and occasionally between races, may be poorly viable or lethal. This is evidence that combining in one genotype two gene complements each of which is harmonious by itself often results in an adaptively incompetent genetic system. This bears out the premise stated at the beginning of this chapter, that gene combinations of proven adaptive value may be endangered by hybridization." (Emphasis added.)

Damage to genetic adaptiveness of our native salmon and trout stocks by hybridization of stocks or races (intra-species) is difficult to assess because smaller than expected returns could be blamed on overfishing or adverse environmental conditions.

For certain there have been "successful" transplants, and these are readily located in the literature (e.g., Meehan, 1966; Ellis, 1969; Ricker, 1972). Not so readily located in the literature are descriptions of the enormous numbers of unsuccessful transplants.

Unsuccessful experiments have a negative connotation, and these data are often left in the files.

IMPORTANCE OF ADAPTIVE GENETIC VARIABILITY

Considerable adaptive genetic variability (or diversity) exists within a flourishing wild population of animals (Mayr, 1963). This variability allows the population to respond to environmental changes. There is evidence that the more diverse the environment, the more adaptively diverse are its inhabitants (Mayr, 1963). There is also evidence that "populations with greater genetic variability have larger population sizes" (Ayala, 1968). Lerner (1954) believes that certain levels of heterozygosity are necessary to ensure normal development. Abnormal development is definitely associated with the increased homozygosity observed in inbreeding degeneration (Strickberger, 1968). The importance of the adaptation of an animal to its particular environment and how changes may reduce fitness is stated by Strickberger (1968, p. 778-779).

> "In general, genetic homeostasis depends upon the array of gene frequencies built up by a population over the long period of its evolution in a particular environment. Since these established gene frequencies have been selected to confer a high degree of fitness upon a population, any rapid departure from these frequencies may be expected to reduce fitness."

Clearly, the greater the adaptive genetic variability present in a population, the greater are the chances that the population will be able to respond positively to environmental changes. In addition, the development of precise adaptations to local fluctuating environments would logically require that a population have a high degree of adaptive genetic diversity. Clarke (1975) gives a very clear account of some of the "mechanics" of genetic diversity.

In agricultural situations where man controls the breeding of animals and plants, selection for emphasis of certain characteristics is commonly practiced. Artificial selection reduces genetic variability. Recent examples in food crops illustrate the extent to which genetic uniformity from intense selection results in uniform susceptibility to natural disasters like new strains of disease organisms (Harlan, 1972; Wade, 1972). In plants the solution to these problems is clearer. First, the severity of the problem has to be acknowledged (Harlan, 1975). Next, seeds can be stored, so that wild types with a high degree of variability can be preserved in "gene banks." As we trend toward more use of "aquaculture" in our fishery resources, a similar loss of genetic diversity will occur, but the solution has to be quite different. Sperm from salmonid fishes may be cryo-preserved for a short time (Ott and Horton, 1971), but no similar technique has been developed for ova.

Loss of genetic diversity and development of genetically uniform strains of salmon and trout in our hatcheries have been recognized (Calaprice, 1969; Simon, 1972; McIntyre, 1975; Lannan, 1973 - see Chapter 4 - Bams, 1972; American Institute of Fishery Research Biologists, 1975); still, genetic implications of hatchery practices receive too little attention in most production facilities.

DIFFERENCES BETWEEN AGRICULTURAL GENETICS AND AQUACULTURAL GENETICS

Two basically different systems of aquaculture are currently used: (1) confined systems (intensive culture), and (2) unconfined systems (extensive culture). The genetic strategies needed are very different for each. If fish are to be confined in raceways, ponds, or closed systems during all of their life (category 1), then many of the breeding schemes developed in agricultural genetics will be useful. Selective breeding, development of inbred lines, and heterosis (hybrid vigor) are familiar methods and goals in agricultural genetics (Brewbaker, 1964). The application of these techniques and others in aquaculture ventures is discussed by Calaprice (1970), Simon (1970), and Purdom (1972). If, however, fish are released in streams, lakes, or oceans to survive natural environmental fluctuations and compete for space and food with wild populations, then genetic tools like selective breeding and inbreeding could introduce genetic handicaps instead of benefits. Remember that animals with a high degree of adaptive genetic variability have a distinct advantage when exposed to the fluctuating natural environment. Breeding schemes involving artificial selection or inbreeding reduce genetic diversity. Pleiotropic effects associated with artificial selection can further reduce genetic diversity (Dobzhansky, 1070). Obviously, breeding schemes that maintain or enhance adaptive genetic variability will be advantageous to a stock of salmon released to compete in the ocean.

How should matings be made in a salmon hatchery so that genetic variability can be maintained instead of reduced? How not to make the matings is more obvious. The milt from one mature male salmon is capable of fertilizing the eggs from hundreds of female salmon. Instances where the milt from a few male salmon have been used to fertilize the eggs from many females, even hundreds, have occurred too often. For general use the sex ratio of brood stock should be closer to one to one.

RELATION BETWEEN COURTSHIP, SPAWNING BEHAVIOR, AND MAINTENANCE OF GENETIC DIVERSITY

Perhaps the question of how to make matings in a salmon hatchery could be answered if we better understood how matings are accomplished naturally in wild populations. Some aspects of observations I made on courtship and spawning behavior of pink and chum salmon at Olsen Creek, in Prince William Sound, Alaska, between 1958 and 1975 may help describe the need for use of more males in breeding schemes for hatcheries. I made these observations under water using two techniques: (1) lying on the stream bottom dressed in a neoprene wetsuit with mask and snorkel (See National Geographic, August 1968, p. 218) and (2) sitting in the stream (wearing a wetsuit) and watching the activity of the fish through a 35-mm reflex camera with a telephoto lens and magnified waist-level viewfinder placed in a waterproof open-top case.

Courtship, or prespawning behavior, is complex. Briefly, the female pink or chum salmon selects the area and "digs" the redd by repeatedly turning on her side and with powerful body flexures "fanning" the gravel with her caudal fin. This action displaces rocks, sand, and silt and gradually a depression is created in the stream bottom. A female needs about 5 hours to complete a redd, but many factors can interrupt or prolong her activities: tides (if spawning in intertidal portion of stream), floods, bear and bird activity, interspecies and intraspecies interactions with other females, density of spawners, courtship activity of the males, etc.

Concomitant with the construction of the redd by the female, a hierarchial order of one dominant and one to five or more subordinate males develops around the female. The rank is determined by fighting. Fights among equal size chum salmon males are especially vicious. A pair of males, the body of one locked in the jaws of the other, can often tumble and thrash 20 feet or more downstream before they come apart and swim back to the redd. Their elongated jaws with large "canine-like" teeth can inflict gaping wounds on each other.

The dominant male performs most of the courtship displays with the female. Moving back and forth over her caudal peduncle is one such display. This activity also keeps the subordinate males to the rear of the redd where they interact with each other for rank. Another display performed often by the dominant male is "quivering." Here he swims up next to the female and quivers for about 2 to 3 seconds.

When the female is close to being ready to spawn, her interactions with other females change. She stops initiating attacks on nearby females and responds very passively to attacks by other females of her own or another species. At the same time, the subordinate males become more active and the dominant male has trouble keeping them at the downstream edge of the redd. When the female is ready to spawn, she lies in the redd with her head facing upstream and her vent in the deepest portion of the excavation. She starts to gape her mouth and immediately the dominant male takes a position beside her. The other males swim into the redd and one takes a position beside the female on the opposite side and the other males take up positions beside the dominant male on one side of her and beside each other on the opposite side. With their mouths agape, the female releases the eggs and the males release the milt simultaneously. The water in the redd turns cloudy from the white milt and several seconds go by before the milt starts to spill over the rear lip of the redd.

The simultaneous orgasm lasts about 10 seconds. Then the female starts her fanning flexures in rapid sequence just ahead of the upstream lip of the redd. After she finishes a series of flexures, she quickly circles back and starts another series. This action fans out gravel which settles in the redd and covers the eggs. At the same time, the female is starting the excavation of a new redd. Her rate of fanning gradually decreases to a slower pace.

Meanwhile, the group of males she has spawned with usually desert her and may try to enter the hierarchy of males around other nearby females. By the time the female is ready to spawn again, she may have a completely new hierarchy of males around her although some of the original males may remain.

The number of times a female spawns certainly must vary in relation to may factors, e.g., floods and density of spawners. Considering that at Olsen Creek, the average stream life of a female is about 11 days and the fecundity of pink and chum salmon females is about 2,000 and 3,000 eggs respectively, it seems likely that each female could spawn three to five times or more.[1] Regardless, the important point here is that the eggs of each female are fertilized by several males, each with different genetic composition.

This type of spawning behavior in pink and chum salmon prevents inbreeding and ensures that future generations maintain a high degree of adaptive genetic variability. This would be an especially advantageous strategy for pink salmon because they invariably mature at 2 years old. All the spawners are, therefore, the same age rather than of several age groups as in the other species of salmon, where in one spawning season the adaptive genetic diversity from several brood years are combined.

EFFECTS OF ARTIFICIAL PROPAGATION ON GENETIC COMPOSITION OF STOCKS

Wild populations of salmon maintain adaptive genetic diversity through natural selection and their spawning behavior. Any form of artificial propagation that increases survival by reduction of natural mortality at any life history stage will change the genetic composition of the original stock.

Genetic change (change in gene frequency) can be introduced into a stock by artificially mixing eggs and sperm. Selection of gametes from only large fish or early maturing individuals will, of course, reduce genetic diversity, but artifical matings made at random may also introduce change. Assortative matings made by naturally spawning salmon are variable, but partners are not determined randomly. Natural matings involve complex courtship behavior and establishment of hierarchies. This system of mating must have adaptive significance for the wild stock, and by artificially mixing eggs and sperm, we will probably introduce genetic changes in the stock. Nevertheless, until we understand the genetic significance of natural spawning behavior, our only hope for maintaining genetic diversity in the hatchery situation is by use of the eggs and milt from randomly picked individuals representing the total stock.

The most obvious situation for introducing genetic change in a stock is in salmon hatcheries where young are raised to the smolt stage. Here we release fish that have undergone no natural selection for fitness in the wild freshwater environment. Certainly the progeny of these fish will eventually be genetically different from "wild" individuals of the same stock. If the hatchery-produced smolts experience good marine survival and return to the hatchery as adults, one would expect rapid selection to occur for an optimal "hatchery type" fish.

Based on the above considerations, different methods of artificial propagation can be evaluated for their likelihood to introduce genetic change or to maintain genetic diversity. Artificial spawning channels would introduce the least genetic change and could retain a high degree of genetic diversity because the fish make their own matings and usually no artificial rearing is involved. Incubation channels and hatcheries for pink and chum salmon would be next because they require little or no rearing of fish beyond the fry stage. Hatcheries in which fish must be raised for a long period beyond the fry stage, mainly those for chinook and coho salmon and steelhead trout, create the greatest potential for genetic change and loss of genetic diversity. The smolts released from these hatcheries have undergone no natural selection in the stream environment; therefore, rapid selection favoring an optimal "hatchery-type" fish should occur.

CAN HATCHERY AND WILD STOCKS COEXIST?

The potential genetic effects of superimposing hatchery fish on wild stocks of the same species depend on the species, the method of artificial propagation, and the situation. Pink salmon are restricted to a 2-year life cycle, so deleterious effects of interbreeding cannot be exchanged with the opposite year line. All of the other salmon have multiple age classes, so genetic change occurring in one brood year will eventually affect all brood years. Non-adaptive genes introduced into the gene pool by interbreeding could be perpetuated for many generations as recessives (Mayr, 1971).

As a hypothetical example, say a hatchery were built on a small pink salmon stream and the indigenous stock was used in the hatchery and also allowed to spawn naturally in the stream. Because of the higher survival in the hatchery, the run would probably eventually be dominated by the returns from the hatchery releases. If the stream were situated so that the returns could be harvested separately from other stocks, it could be a manageable system. If the returns were harvested while mixed with other stocks and the hatchery fish could not be identified in the catch, then it would probably be an unmanageable situation. If an outside stock were brought into the hatchery in place of or in addition to the indigenous stock, the genetic patterns of the locally adapted indigenous stock would be altered by interbreeding, and fitness of both the wild and hatchery stocks could suffer. Additionally, the homing ability might be altered and if the survivors strayed to nearby systems the gene pool of the locally adapted stocks in these systems could be altered by introgression.

If the hatchery were built on a barren system, a transplanted stock would have to be brought in, then imprecise homing could become the major problem. Are we willing to jeopardize other stocks of fish in the area?

Another consideration would be the complexity of the stock composition in a system. If the system had many stocks present, our problems would be compounded. Even if we enhanced one stock in such a system, could we harvest the returns without overfishing the other stocks? Timing and identification of the runs is of obvious importance in this situation.

What if we had built a hatchery for a species such as coho, chinook, or steelhead trout instead of for pink salmon. Here the wild stock would eventually have been lost, not only because of differences in exploitation rates that would have disadvantaged the wild stock, but also because the hatchery stock would have undergone no natural selection for rearing adaptations in the stream, and we would eventually have been committed totally to the hatchery for our desired production levels. This type of hatchery has its place, but some difficult and permanent decisions have to be made in the early planning stages.

Another hypothetical hatchery situation could be one in which we planned to use the hatchery stock as a source of eggs or smolts to develop other hatcheries or enhancement programs. Development of a hatchery of this type for planting fish in a "closed" system or for a "put-and-take" fishery in a closed system is sometimes desirable. For general use in projects involving anadromous fish in Alaska, this situation would be biologically dangerous. We would endanger our already depleted stocks of salmon with the hazards of transplantation and loss of genetic diversity on a large scale. The wide dissemination of a generalized stock would constitute a genetic impediment that would reduce fitness of a great many stocks. We should not consider this type of hatchery operation.

More hypothetical situations could be developed, but perhaps my point is already made - programs for enhancement or rehabilitation of salmonid stocks should be based on biological knowledge and each situation has its own unique problems.

Can artificially propagated stocks and wild stocks of the same species coexist? Probably not in the same stream, but location of the artificial production facilities will be a key factor in determining the success of maintaining both types in one general area. Returns to artificial propagation facilities have to be separable in time and/or space from local wild stocks, or the system will be unmanageable. Our record for successful management of mixed stock fisheries is not very good. To superimpose another stock with a different exploitation rate in an existing mixed stock fishery would result in a chaotic management problem, and the wild stocks would suffer. Artificial propagation technology is still in the formative years, and our wild stocks can and should be the basis for our salmonid fisheries if we hope to have any fisheries at all in the future.

Planning, especially biological planning, is the important missing ingredient in our enhancement and rehabilitation efforts. Hatcheries have been promoted without adequate consideration of the problems. Rhetoric about the benefits of hatcheries should not make us complacent about our natural streams and river systems. These diverse environments provide us with diverse stocks of salmonids.

Our natural watersheds are our "gene banks" for salmonid fishes. Hatcheries are not a panacea (Narver, 1973).

Have spawning channels been adequately considered as an enhancement tool in Alaska? Spawning channels have been notably successful in Canada, and they reduce potential genetic problems by allowing fish to make their own matings.

Rejuvenation of our salmon resources into thriving manageable fisheries could be accomplished through a combination of basic and applied research, stream and estuary protection, stream rehabilitation, and artificial propagation techniques. Hatcheries alone will not solve our problems. In fact, improperly conceived and managed artificial propagation facilities could further deplete our salmon resources.

FOOTNOTE

1 For more detailed information on courtship behavior of chum salmon in an artificial spawning channel, see Schroder (1973).

REFERENCES

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

Ayala, F. J. 1968. Genotype, environment, and population numbers. Science 162:1453-1459.

Bams, R. A. 1969. Adaptations of sockeye salmon associated with incubation in stream gravels. In T. G. Northcote (editor), Symposium on salmon and trout in streams, p. 71-87, H. R. MacMillan Lect. Fish., University of British Columbia, Vancouver.

_________. 1972. A quantitative evaluation of survival to the adult stage and other characteristics of pink salmon (*Oncorhynchus gorbuscha*) produced by a revised hatchery method which simulates optimal natural conditions. J. Fish. Res. Board Can. 29:1151-1167.

Bowler, B. 1975. Factors influencing genetic control in lakeward migrations of cutthroat trout fry. Trans. Am. Fish. Soc. 104:474-482.

Brannon, E. L. 1967. Genetic control of migrating behavior of newly emerged sockeye salmon fry. Int. Pac. Salmon Fish. Comm., Progr. Rep. 16, 31 p.

_________. 1972. Mechanisms controlling migration of sockeye salmon fry. Int. Pac. Salmon Fish. Comm., Bull. 21, 86 p.

Brewbaker, J. L. 1964. Agricultural genetics. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 156 p.

Bryson, R. A. 1975. The lessons of climatic history. Environ. Conserv. 2:163-170.

Calaprice, J. R. 1969. Production and genetic factors in managed salmonid populations. In T. G. Northcote (editor) Symposium on salmon and trout in streams, p. 377-388, H. R. MacMillan Lect. Fish., University of British Columbia, Vancouver.

_________. 1970. Genetics and mariculture. Fish. Res. Board Can., Tech. Rep. 222, 10 p.

Clarke, B. 1975. The causes of biological diversity. Sci. Am. 223 (Aug.):50-60.

Davidson, F. A. 1934. The homing instinct and age at maturity of pink salmon (Oncorhynchus gorbuscha). Bull. U.S. Bur. Fish. 48:27-39.

Davidson, F. A., and S. J. Hutchinson. 1938. The geographic distribution and environmental limitations of the Pacific salmon (genus Oncorhynchus). Bull. U.S. Bur. Fish. 48:667-692.

Dobzhansky, T. 1951. Genetics and the origin of species. 3d ed. Columbia Univ. press, N. Y., 364 p.

Ellis, R. J. 1969. Return and behavior of adults of the first filial generation of transplanted pink salmon, and survival of their progeny, Sashin Creek, Baranof Island, Alaska. U.S. Wildl. Serv., Spec. Sci. Rept. - Fish. 589, 13 p.

Harlan, J. R. 1972. Genetic conservation of plants that feed the world. Environ. J. (Oct.):15-17.

________. 1975. Our vanishing genetic resources. Science 188:618-621.

Hartman, W. L., and R. F. Raleigh. 1964. Tributary homing of sockeye salmon at Brooks and Karluk lakes, Alaska. J. Fish. Res. Board Can. 21:485-504.

Hasler, A. D. 1966. Underwater guideposts, homing of salmon. Univ. Wis. Press, Madison, 155 p.

Helle, J. H. 1970. Biological characteristics of intertidal and freshwater spawning pink salmon at Olsen Creek, Prince William Sound, Alaska, 1962-63. U.S. Fish Wildl., Serv. Spec. Sci. Rep. - Fish. 602, 19 p.

Helle, J. H., R. S. Williamson, and J. E. Bailey. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. U.S. Fish Wildl. Serv., Spec. Sci. Rep - Fish. 483, 26 p.

Johnsen, S. J., W. Dansgaard, and H. B. Clausen. 1970. Climatic oscillations 1200-2000 AD. Nature 227:482-483.

Koski, K V. 1975. The survival and fitness of two stocks of chum salmon (Oncorhynchus keta) from egg deposition to emergence in a controlled-stream environment at Big Beef Creek. Ph. D. Thesis, Univ. Washington, Seattle, 212 p.

Kukla, G. J. and H. J. Kukla. 1974. Increased surface albedo in the northern hemisphere. Science 183:713.

Lannan, J. E., Jr. 1973. Genetics of the Pacific oyster: Biological and economic implications. Ph. D. Thesis, Oreg. State Univ., Corvallis, 104 p.

Lerner, I. M. 1954. Genetic homeostasis. John Wiley, N. Y.

Mayr, E. 1963. Animal species and evolution. Belknap Press, Harvard Univ. Press, Camb., Mass., 795 p.

___________. 1971. Populations, species and evolution. Belknap Press, Harvard Univ. Press, Camb., Mass. 453 p.

McIntyre, J. 1975. Steelhead and their genes, or - what makes a steelhead? Salmon-Trout-Steelhead (April):38-39.

Meehan, W. R. 1966. Growth and survival of sockeye salmon introduced into Ruth Lake after removal of resident fish populations. U.S. Fish Wildl. Serv., Spec. Sci. Rep. - Fish. 532, 18 p.

Miller, R. B. 1957. Have the genetic patterns of fishes been altered by introductions or by selective fishing? J. Fish. Res. Board Can. 14:797-806.

Narver, D. W. 1973. Hatcheries, channels are not panaceas. West. Fish. (April):38-46.

Northcote, T. G., S. N. Williscroft, and H. Tsuyuki. 1970. Meristic and lactate dehydrogenase genotype differences in stream populations of rainbow trout below and above a waterfall. J. Fish. Res. Board Can. 27:2987-1995.

Oshima, K., W. E. Hahn, and A. Gorbman. 1969. Olfactory discrimination of natural waters by salmon. J. Fish. Res. Board Can. 26:211-2121.

Ott, A. G., and H. F. Horton. 1971. Fertilization of chinook and coho salmon eggs with cryo-preserved sperm. J. Fish, Res. Board Can. 28:745-748.

Parker, R. R. 1964. Estimation of sea mortality rates for the 1960 brood-year pink salmon of Hook Nose Creek, British Columbia. J. Fish. Res. Board Can. 21:1019-1034.

Pritchard, A. L. 1939. Homing tendency and age at maturity of pink salmon (*Oncorhynchus gorbuscha*) in British Columbia. Res. Board Can. 4:233-251.

Purdom, C. E. 1972. Genetics and Fish Farming. Fish. Lab., Lowestoff, Suffolk, Minist. Agric., Fish. Food, (U.K.), Lab. Leafl. 25, 17 p.

Raleigh, R. F. 1967. Genetic control in the lakeward migrations of sockeye salmon (Oncorhynchus nerka) fry. J. Fish Res. Board Can. 24:2613-2622.

__________. 1971. Innate control of migrations of salmon and trout fry from natal gravels to rearing areas. Ecology 52:291-297.

Raleigh, R. F., and D. W. Chapman. 1971. Genetic control in lakeward migrations of cutthroat trout fry. Trans. Am. Fish. Soc. 100:33-40.

Rich, W. H. 1939. Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska. Am. Assoc. Adv. Sci., Publ. 8:45-50.

Ricker, W. E. 1972. Hereditary and environmental factors affecting certain salmonid populations. In R. C. Simon and P. A. Larkin (editors), The stock concept in Pacific salmon, p. 19-160, H. R. MacMillan Lect. Fish., University of British Columbia, Vancouver.

Scheer, T. T. 1939. Homing instinct in salmon. Quart. Rev. Biol. 14:408-430.

Schroder, S. E. 1973. Effects of density on the spawning success of chum salmon (Oncorhynchus keta) in an artificial spawning channel. M.S. Thesis, University of Washington, Seattle, 78 p.

Simon, R. C. 1970. Genetics and marine aquiculture. In W. J. McNeil (editor), Marine aquiculture, p. 53-63, Oregon State University Press, Corvallis.

__________. 1972. Gene frequency and the stock problems. In R. C. Simon and P. A. Larkin (editors), The stock concept in Pacific salmon, p. 161-169, H. R. MacMillan Lect. Fish., University of British Columbia, Vancouver.

Solomon, D. J. 1973. Evidence for pheromone-influenced homing by migrating Atlantic salmon (Salmo salar L.) Nature 244:231-232.

Strickberger, M. W. 1968. Genetics. MacMillan Co., N.Y., 868 p.

Thorsteinson, F. V., J. H. Helle, and D. G. Birkholz. 1971. Salmon survival in intertidal zones of Prince William Sound streams in uplifted and subsided areas. In The great Alaska Earthquake, of 1964, Biology, p. 194-219, Committee on the Alaska Earthquake, Division of Earth Sciences, Natl. Res. Counc., Natl. Acad. Sci.

Tody, W. H. 1966. Great Lakes victory. Mich. Conserv. 35;2-8.

Vincent, R. E. 1960. Some influences of domestication upon three stocks of brook trout (*Salvelinus fontinalis* Mitchill) Trans. Am. Fish. Soc. 89:35-52.

Wade, N. 1972. A message from corn blight: the dangers of uniformity. Science 177:678-679.

Worlund, D. D., R. J. Wahle, and P. D. Zimmer. 1969. Contributions of Columbia River hatcheries to harvest of all chinook salmon (*Oncorhynchus tshawytscha*). U.S. Fish Wildl. Serv., Fish. Bull. 67:361-391.

REFLECTIONS ON SALMON ENHANCEMENT

Robert A. Bams
Department of the Environment
Fisheries and Marine Service
Pacific Biological Station
Nanaimo, B. C.
Canada

Having been exposed to the first half of the conference, Jack Helle and I decided to change the emphasis of our contributions somewhat; and I intend to be somewhat of a devil's advocate. In response to the general atmosphere, as I experience it, I feel a responsibility to dull the stars that appear to be blinding some eyes a bit. Hence, I am going to stress some of the negative aspects that could accompany hurried implementation of not-fully-thought-out programs and of insufficient planning and consideration of alternatives. This is not intended to stop your hatchery programs, but it aims at possibly preventing mistakes or omissions you would regret, or which could cost you dearly, later.

My orientation toward development of a working hatchery method for unfed salmon fry has been from the point of view of a research scientist interested in understanding the essential requirements of successful incubation of Pacific salmon. A novel incubation method was, indeed, developed by me; but the purpose was to test completeness of my understanding and to test the assumption basic to all enhancement work, viz., the non-selectiveness of most egg and alevin mortality in the stream environment. A positive outcome of such a test would establish once and for all that one could indeed propagate artifically and get paid off in the end and put to rest the old "delayed mortality" notion. My intent, therefore, was to devise an optimum sort of hatchery system whereas the emphasis now is on practical systems that are cheaper, easier, and, perhaps of necessity, some distance removed from the biological optima in favour of economic and engineering considerations. Where we simply don't know enough biology to predict what will happen as we move increasingly further away from the established optima, this searching for alternatives will have to be done ever so carefully and with continuing evaluation of the effects of each step that we take away from what we know is right.

What constitutes a good incubational environment? The main requirements are basically simple and few:

1. Favourable (high) combination of flow rate and O-content (velox concept).

2. Low concentrations of metabolic waste products, e.g., CO_2 and NH_3.

3. Proper substrate to satisfy the alevins' righting response and to separate individuals. This requirement led to gravel and then to Astro-Turf incubators.

4. Satisfactory medium (gravel) hygiene, e.g., water filtration.

5. Heat budget control to coincide with natural system for optimized time of release.

We devised an incubation system satisfying these requirements and ran three consecutive tests on a single gene pool of pinks. Results of the first two tests are in the literature; those of the third test will follow soon. Survivals to the fry stage gradually increased to well over 90%, which has brought the standard gross gain[1] to well over 10 times. However, this gain was not fully retained to the adult stage. Differences in survival to the adult stage were 1.5, 2.5 and 9.1% in favour of the wild fry in the three successive generations. The cause for this difference is unknown; but the observed trend may reflect a genetic cumulative treatment effect or, simply, be associated with increasing survivals as obtained to the fry stage, which were, respectively 68.3, 74.9, and 93.6%. If the latter notion were correct, "delayed mortality" effects would appear to become noticeable when less than 25% of the available brood dies during the incubational period. Presumably, at these high levels of survival inherently inferior fry are sufficiently pampered to reach the fry stage, but they succumb when introduced into nature. Such fish may still contribute to the mean survival of the total group by attracting predation pressure and thus protecting the others. In any event, virtually linear gains appear feasible up to about 10 times standard which should be ample to "pay" for rather sophisticated enhancement propositions. In practice, I suppose, many managers will be willing to settle for less sophisticated and cheaper designs that may realize perhaps only half the available potential. Only time and experimentation will tell whether or not such economies are "false."

Additionally, we have used the new hatchery method to advantage to test a hypothesis concerning increasing local adaptiveness of a transplanted salmon stock by infusing "local" genes into the total gene complement originating from a possibly very limited number of males. We raised the progeny of a pink salmon egg transfer, half of which was fertilized by donor males, the other half by local males, in the hatchery and marked and released fry of both treatments upon emergence. Evaluation of adults returning to the coast (in the fishery) and to the river showed that fish of both treatments had survived equally well to the adult stage, but that propensity for homing, although present, was greatly inferior in the pure donor stock. Estimated returns to the river system favoured the "crosses" at least 3 to 1 over the "pure" stock, while return to the tributary stream on which the hatchery was located showed a 10 to 1 ratio. Evidently, accuracy of return within the coastal zone and also within the river system is under genetic control and "locally adapted" genes are of great importance to stock survival and, by virtue of "straying" and introducing genetic load, to survival and fitness of other stocks.

Both these experiments are now completed from the research point of view, but the implications and obviously considerable spin-off for the applied field are not. Much is left to be desired in completeness of design and knowledge of limits of virtually all parameters of concern to supplying an adequate "artificial" incubational environment. A great problem exists here regarding who is going to fill this hiatus: as a researcher I don't want to spend my precious time on seemingly endless applied engineering problems requiring biological evaluation. Similarly, management-associated biologists are, as a rule, not trained to design and evaluate properly this kind of experimentation; and they would be wasting time and resources too.

This brings me to the first of a group of observations I want to leave with you:

1. Without having a solution for the problem, I want to point out to you this real area of difficulty: in a continuing enhancement program, in addition to a continuing input from the primary research people, you need to cover this gray area between pure and applied science. Someone must work out and evaluate the many details left open after a breakthrough is made. In the

same vein, someone must continually analyse, adapt and optimize existing techniques and methodology and evaluate adequately any and all changes (usually called "improvements") that need be, or simply are being, instigated.

2. My second observation concerns organization and responsibility of those in charge of an enhancement project. In all my naivete as a protected researcher, I believe that your independent corporation concept has much going for it. It is probably a mistake to get the entire process locked into a single organization, particularly a large one such as your ADF&G or our Fisheries Operations, which is likely to be too monolithic, with its implied inertia and rigidity, and to have insufficient internal control. Intense personal commitment, community involvement and, in general, a cooperative type approach to a common problem and, yes, a certain singlemindedness of purpose, can do things no bureaucratic giant can touch! If I have an immediate concern, it would be that a number of small corporations may tend to leave the larger, statewide problems untouched. As has already been suggested, the addition of a different type of organization could fill this gap. Alternatively, provisions could perhaps be made to restore contributions made to common-property fisheries by means of a users-tax or similar vehicle.

3. Your prospectus suggests a possible trap that should be avoided at all costs. When the scope of artificial propagation programs exceeds rehabilitation and becomes enhancement, a proper ecological approach becomes mandatory. Single species, or ecotype, propagation should, in general, yield to a systems approach in which <u>all</u> participants in a mutually interacting ecosystem (which includes man as a predator) require attention. Keep as many options open as possible and avoid lopsided monoculture.

4. In the natural progression of new projects, avoid confounding different treatments. Go a step at a time and evaluate before taking the next one. Each project will have site-specific problems requiring adaptations; and, until our knowledge of biology and requirements increases drastically, each new application should be considered an experiment. For illustration, in the first project proposed in the prospectus, there are five mutually confounding factors which could make evaluation of results virtually impossible. These are the use of a single unproven incubation technique, addition of a donor stock, application of selection to

females, reduction in genetic variability of males, and simultaneous use of a spawning channel on the same stock. If you start this all at once, you will never know what your successes and your failures were. You also greatly increase the chance of failure.

5. In association with the previous observations and knowing something about tendencies of operators, I suggest extensive monitoring and recording of all possibly relevant information throughout operations. Get people in with expertise in areas related to your programs to observe and evaluate procedures and techniques. Good leads to what caused unexpected events may thus be available in retrospect and critical observers help keep, or put, routine operations on the straight and narrow.

6. Project-related research <u>must</u> be insured and should probably not be in-house. Funding should not depend on unreliable "excess" income, but a continuing research element, which may have to be front weighted, should be firmly committed for adequate time and money minima.

7. I think there would be merit in starting a number of initially smaller operations rather than putting all the eggs in the proverbial single basket. As results come in, operations would expand in steps, and you approach your limiting asymptote gradually and naturally. A single large failure might be disastrous, but 2 out of 10 in smaller scale projects is good news!

8. I very much like your present "openness" to exchange ideas with a very wide field of people and organizations. If you can continue this attitude, you won't become rigid and inbred. In general, with Alaska, British Columbia, Oregon, and Washington all getting increasingly into salmon enhancement, such an open attitude and a free trade of expertise and experience by all would be of tremendous potential benefit, especially in these times of limited funding from which we all suffer.

9. All that remains now is for you to go out there and do it, and with unblinded eyes wide open! Good luck!

FOOTNOTE

1 Based on a fixed stream survival at 7.3%, see Bams 1974.

HATCHERIES AND OCCUPANCY OF NATIONAL FOREST LANDS

James A. Calvin
Chief, Division of Lands and Minerals
U. S. Forest Service
Juneau, Alaska 99801

Congress directed the Forest Service to manage that part of the reserved public domain known as National Forest according to the principles of multiple use as described in the Multiple Use - Sustained Yield Act of 1960. These principles provide for management and utilization of resources but require recognition and protection of other related resources. What has this got to do with nonprofit fish hatcheries authorized by the Alaska Legislature in 1974? It means that hatcheries that have been in the past and can be in the future, an additional, renewed dimension to the multiple use management of the National Forest. It means that hatcheries are a legitimate use of the National Forest. It means that when an Environmental Analysis Report and/or Environmental Impact Statement indicates that a hatchery is a compatible use of an area and the applicant is qualified and able to perform, occupancy can be authorized.

I do wish to caution you, however, that if this seems a simple process, it most certainly is not. The management of the National Forest has not escaped the complications of life that we all must live with today. Not many years ago, the processing of a Forest Service special use permit was relatively simple. A proponent submitted his application and plans. The ranger and his staff called upon their experience and that of other available experts to analyze the impacts of the project, and the proponent could expect action within a week or ten days. Such is not the case today. The National Environmental Policy Act of 1969 requires that every major federal action affecting the environment be preceded by an Environmental Impact Statement (EIS). Therefore, every project, large or small, must first be evaluated by an Environmental Analysis Report (EAR) to determine whether the project is a major one as defined in the Act. If it is "major" or is in any way controversial, a full EIS is required. While the EAR is still a comparatively simple process taking some four to six weeks to prepare, it often leads to an environmental statement that involves many interests and agencies and requires a minimum of six months to prepare and process. These six months represent the ideal situation with the preparation, publication, public comments and approval of the final EIS by the Environmental Protection Agency all falling into place like clockwork. To date, we have not been able to achieve this ideal: EIS's are all taking from eight months to over a year to process.

Further complications developed in 1971 following the roadless area review of all the National Forests in the country. This review was to identify areas of the National Forests with wilderness characteristics. Six wilderness study areas, totaling about 2.6 million acres, were identified here in Alaska during that process. Following that review, the Sierra Club filed suit against the Forest Service contending that the review of roadless areas was inadequate and that all possible wilderness areas were not considered. In an attempt to resolve an apparent stalemate, the Chief of the Forest Service agreed with the Sierra Club to prepare an EIS on all projects on the inventoried roadless areas within the National Forest. The court agreed, and all activities on inventoried roadless areas since have been preceded by an EIS. Of the 20 million acres of National Forest in Alaska, 18 million are considered roadless for the purposes of this out-of-court settlement.

This means that virtually all hatchery proposals located on National Forest land will affect an inventoried roadless and undeveloped area and must have an EIS. This EIS will address the question of compatibility; identify conflicts and impacts, mitigation and enhancement opportunities, if any; and measure compliance with the land-use plans. When, and if, this process indicates that a hatchery is a compatible use, then, and only then, can we talk in terms of issuing an occupancy permit. The EIS could identify conflicts that would preclude the issuing of a permit. The point is that we do not know whether a permit can be issued or not until the EIS process is complete.

Please bear in mind that the EIS process applies to all projects in roadless areas on the National Forest including navigation sites, electronic sites, timber sales, mineral developments, power lines, fish ladders, as well as proposed hatcheries.

If the EIS clears the way for a Forest Service special use permit and the state has issued a hatchery permit, the occupancy would be authorized under the Alaska Term Permit Act of 1948. This law has a statutory limitation of 80 acres and 30 years. This is the only instrument available that assures tenure and protects the permittee and his investment. Under this authorization, the government is required to reimburse the permittee should, for reasons of higher public need, the permit be terminated.

There will be a fee based on a percentage of land value. This value will be determined by a comparison of sales on comparable land within or adjacent to the National Forest.

After making an application to the appropriate forest supervisor, the applicant cannot rest on his laurels. He must be involved in the EAR and EIS process. The applicant must provide all basic data on which the EAR or EIS will be based. Before impacts can be analyzed, specific project plans must be completed. An economic analysis of project feasibility is required. Although not part of the EIS, a clear, concise financial statement is necessary. These are items that only the proponent can provide.

If some of these things seem unreasonable to you, please remember that the demands for use of the National Forest and their resources are tremendous; and we must commit our personnel and resources to the best sites and the most qualified applicants. To do otherwise would work to the disadvantage of the hatchery program and unnecessarily delay the availability of the resources to be provided by this new program.

It should be clear by now that obtaining authorization to occupy the National Forest is a rather complicated, time-consuming process. It is also clear to us that there remain procedural problems between the agencies involved which require prompt resolution. This can only be accomplished through cooperative efforts of not only state and federal agencies but the hatchery interests as well.

THE HIGH-SEAS DISTRIBUTION OF NORTH AMERICAN SALMON AND THEIR VULNERABILITY TO FOREIGN EXPLOITATION UNDER VARIOUS HIGH-SEAS TREATY ARRANGEMENTS

Richard L. Major
Fishery Research Biologist
National Oceanographic and Atmospheric Administration
National Marine Fisheries Service
Seattle, Washington 98101

The organizers of this conference, very likely reflecting a general concern of salmon aquaculturists, have asked for information about the oceanic distribution of various North American salmon stocks and their vulnerability to foreign fisheries under various multinational or international treaty arrangements. Or, stated in another way: What protection from foreign exploitation will be afforded by the International North Pacific Fisheries Commission's (INPFC) abstention line? By the 200-mile limit (with continued abstention by Japan)? By the 200-mile limit without abstention?

These questions are best answered by examining charts of summarized tagging data prepared by French, Bakkala and Sutherland (1975). The charts show, for each species of salmon, the locations on the high-seas where fish were tagged, released, and later returned to North American streams.

To the charts originally prepared by French et al., (1975), I have added the INPFC abstention line (which prohibits Japan and <u>only Japan</u> from fishing for salmon eastward of 175°W), and the 200-mile limit, beyond which salmon could be harvested unless they were afforded special protection. Vulnerability to foreign exploitation is expressed under three situations: (1) INPFC abstention line with the present 12-mile limit; (2) 200-mile limit with continued abstention but no other special protective measures for salmon; and (3) 200-mile limit without special protective measures for salmon and without continued abstention. An important possible adjunct to situations (2) and (3) is a negotiated prohibition on salmon fishing beyond 200 miles in return for other concessions -- e.g., access to groundfish stocks within the 200-mile zone.

SOCKEYE SALMON (FIGURES 1-17)

1. With abstention and a 12-mile limit (the current situation):

   By and large, only western Alaskan salmon are exposed to the Japanese fisheries; the remaining stocks are given almost total protection by the abstention line. Other nations, which could conceivably fish for salmon to within 12-miles of the North American coast where virtually all U.S. salmon would be available, are either prevented from doing so by bilateral agreement or have voluntarily abstained.

2. 200-mile limit with continued abstention:

   Japan's opportunity to harvest sockeye salmon of North American origin, especially the above-mentioned western Alaskan sockeye, would be sharply reduced under this arrangement. All major stocks would be highly vulnerable beyond the 200-mile limit in the central Gulf of Alaska to other would-be harvesters (nations other than Japan).

3. 200-mile limit without abstention:

   All major stocks would be highly vulnerable to all nations beyond 200 miles in the Gulf of Alaska.

CHUM SALMON (FIGURES 18-31)

1. With abstention and a 12-mile limit:

   As was the case with sockeye salmon, western Alaskan chums are the only North American stocks vulnerable to the Japanese fisheries west of the abstention line. Although all but one of the tagged chums that have returned to western Alaska from this area have been from the North Pacific Ocean (south of the Aleutian Islands), it seems highly probable that heavy Japanese catches of chum salmon in the central and northern Bering Sea contain significant numbers of western Alaskan fish as well. Tagging has been inadequate to indicate the relative abundance of western Alaskan chums in the Bering Sea west of 175°W.

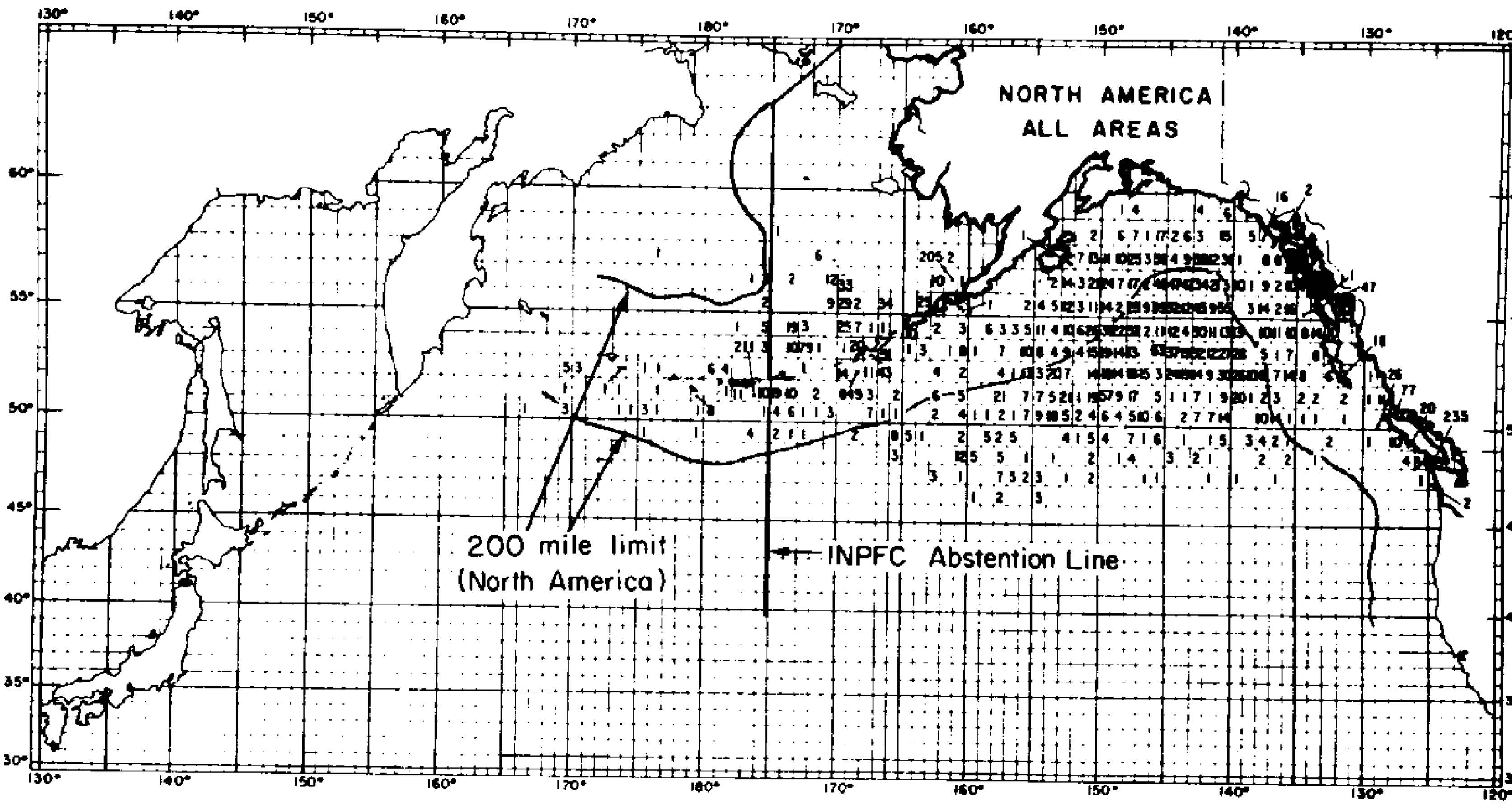


Figure 1 —Tagging locations of maturing sockeye salmon recovered in North America.

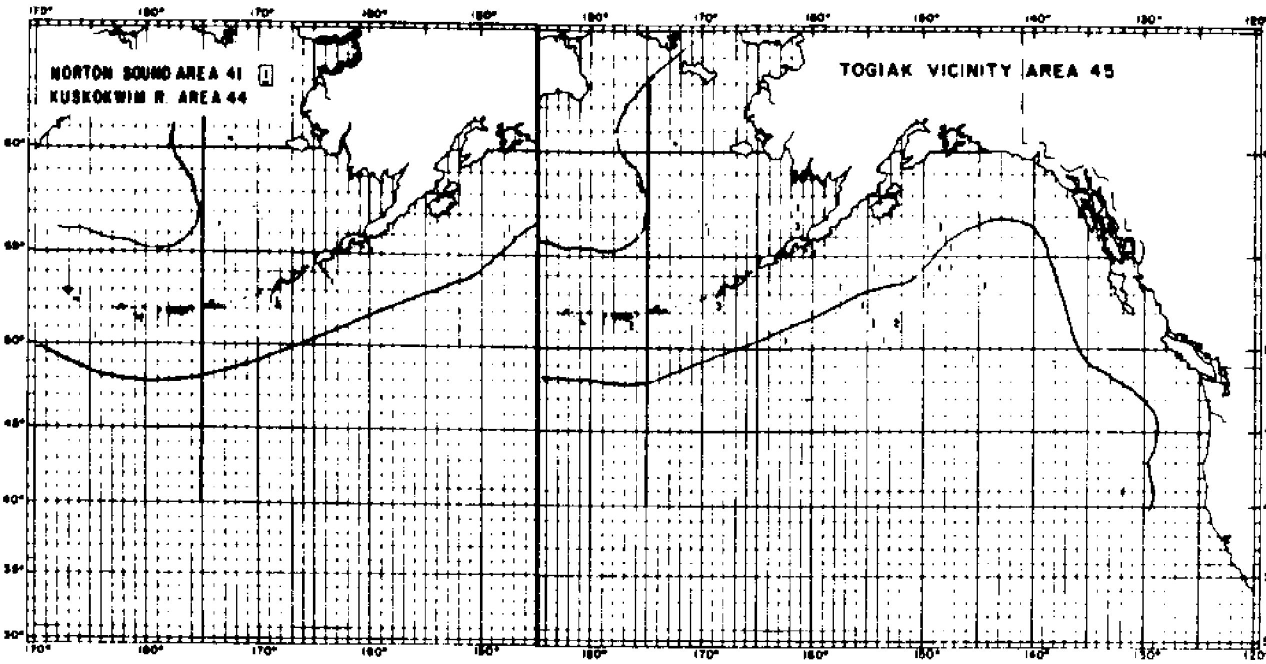


Figure 2.--Tagging locations of maturing sockeye salmon recovered in Norton Sound and Kuskokwim River and in Togiak vicinity.

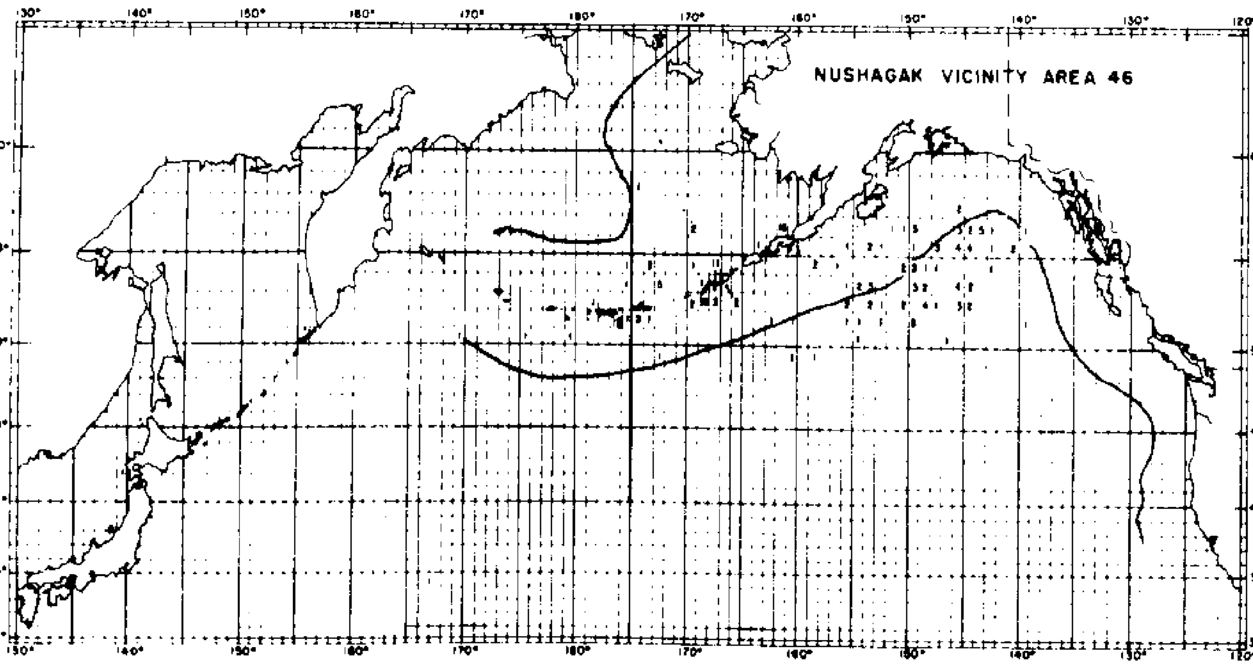


Figure 3.—Tagging locations of maturing sockeye salmon recovered in the Nushagak vicinity.

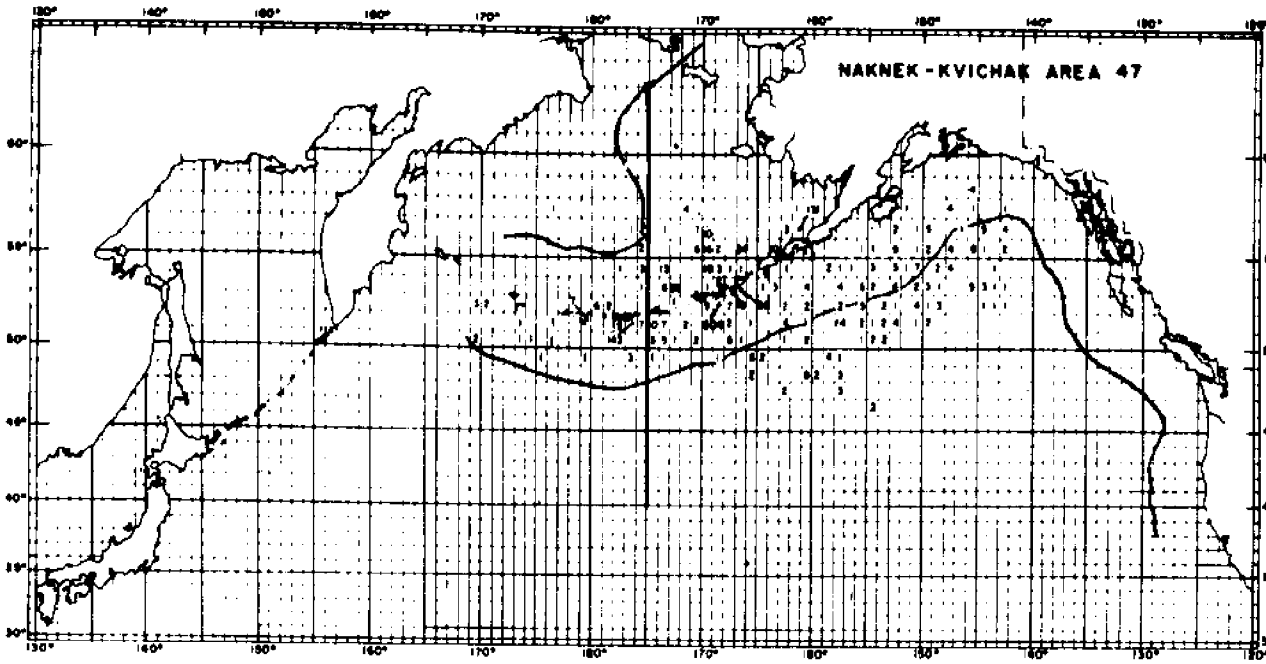


Figure 4.—Tagging locations of maturing sockeye salmon recovered in Naknek-Kvichak.

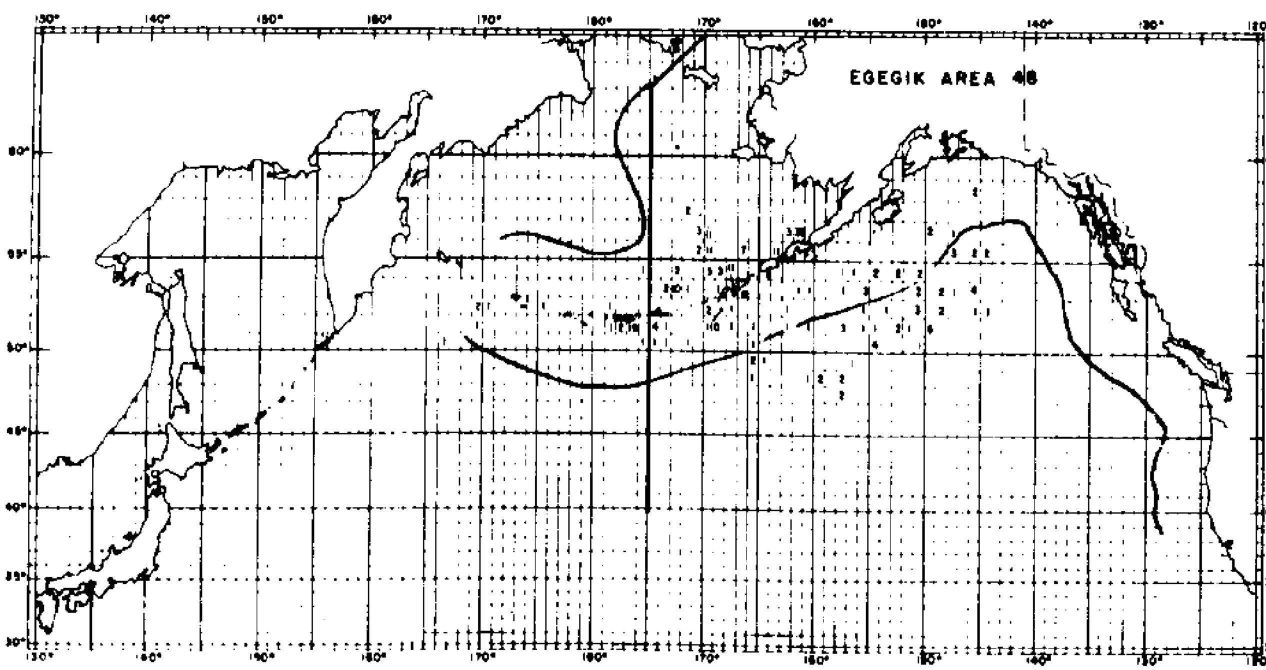


Figure 5.—Tagging locations of maturing sockeye salmon recovered in Egegik.

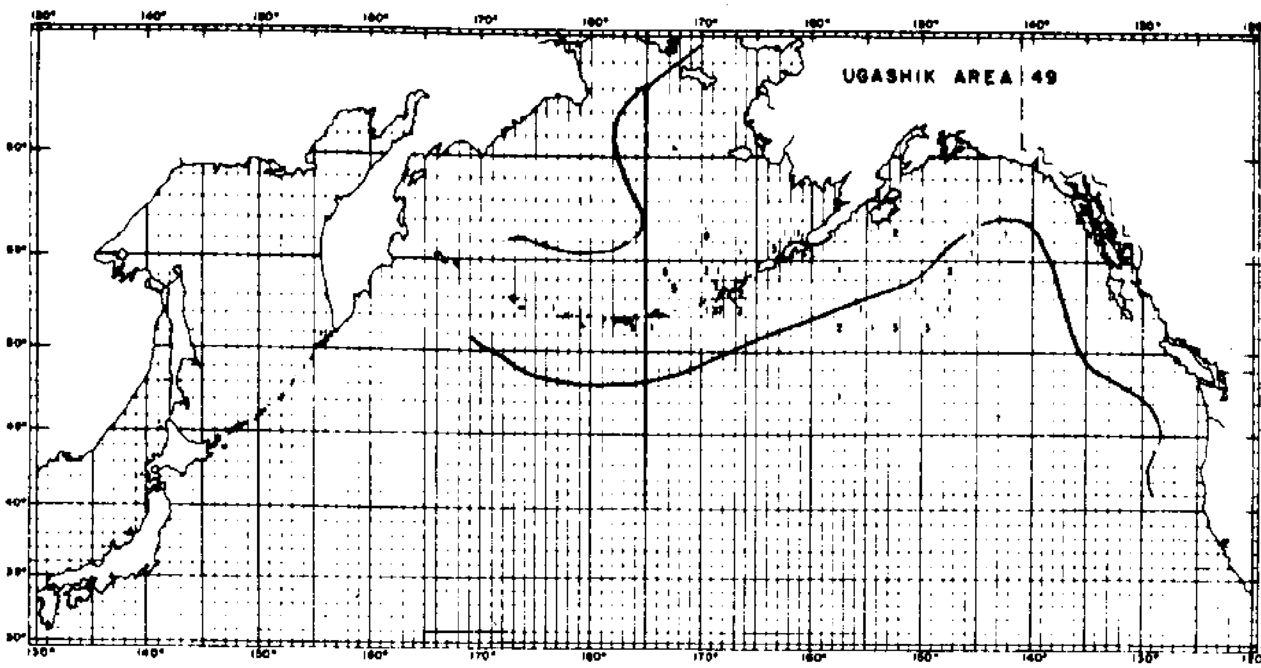


Figure 6 —Tagging locations of maturing sockeye salmon recovered in Ugashik.

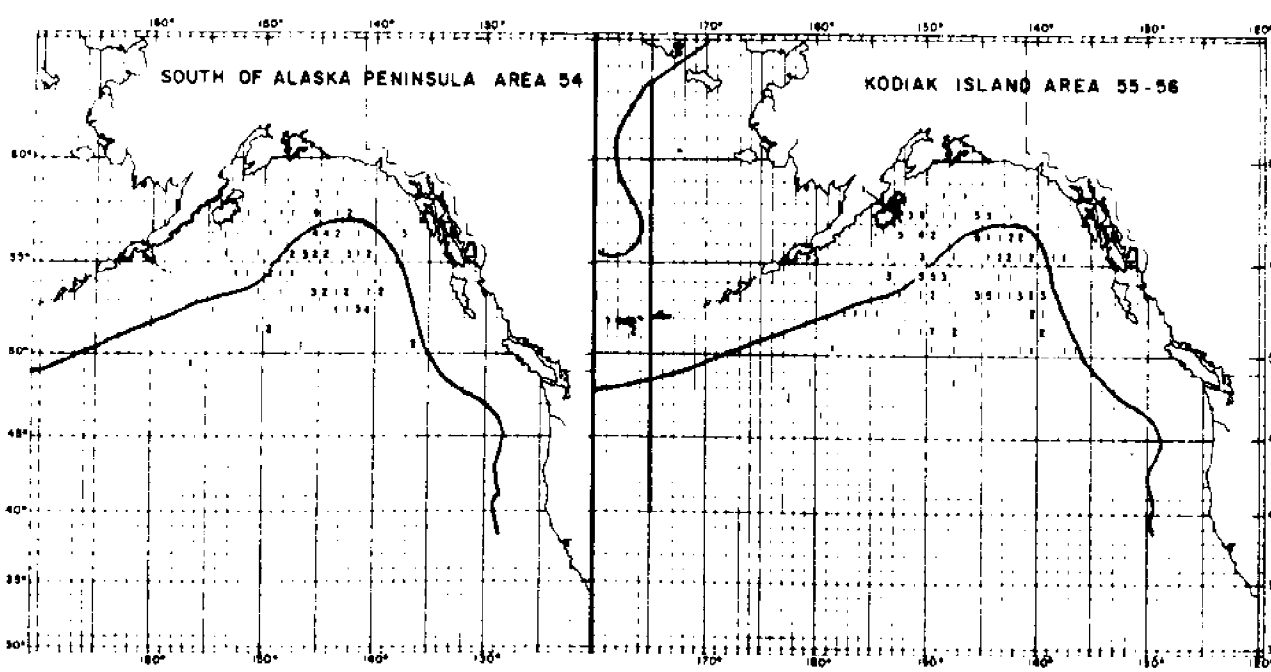


Figure 7.—Tagging locations of maturing sockeye salmon recovered from south of the Alaska Peninsula and Kodiak Island areas.

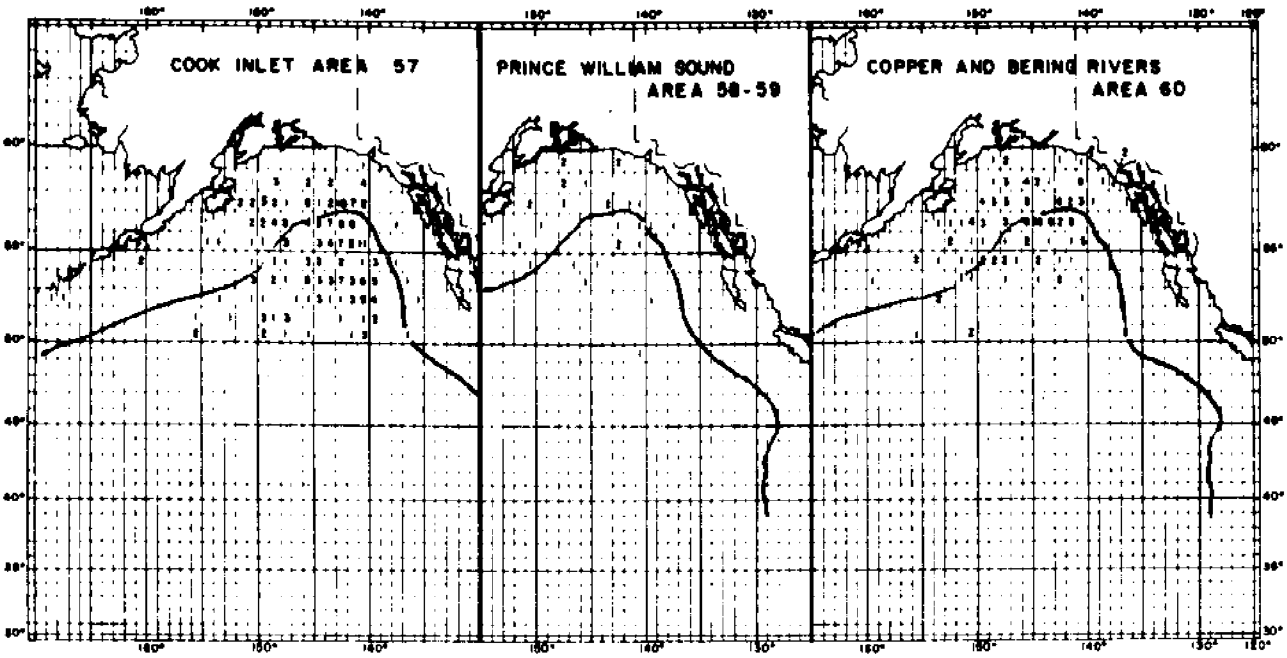


Figure 8 —Tagging locations of maturing sockeye salmon recovered in Cook Inlet, Prince William Sound, and Copper and Bering rivers areas.

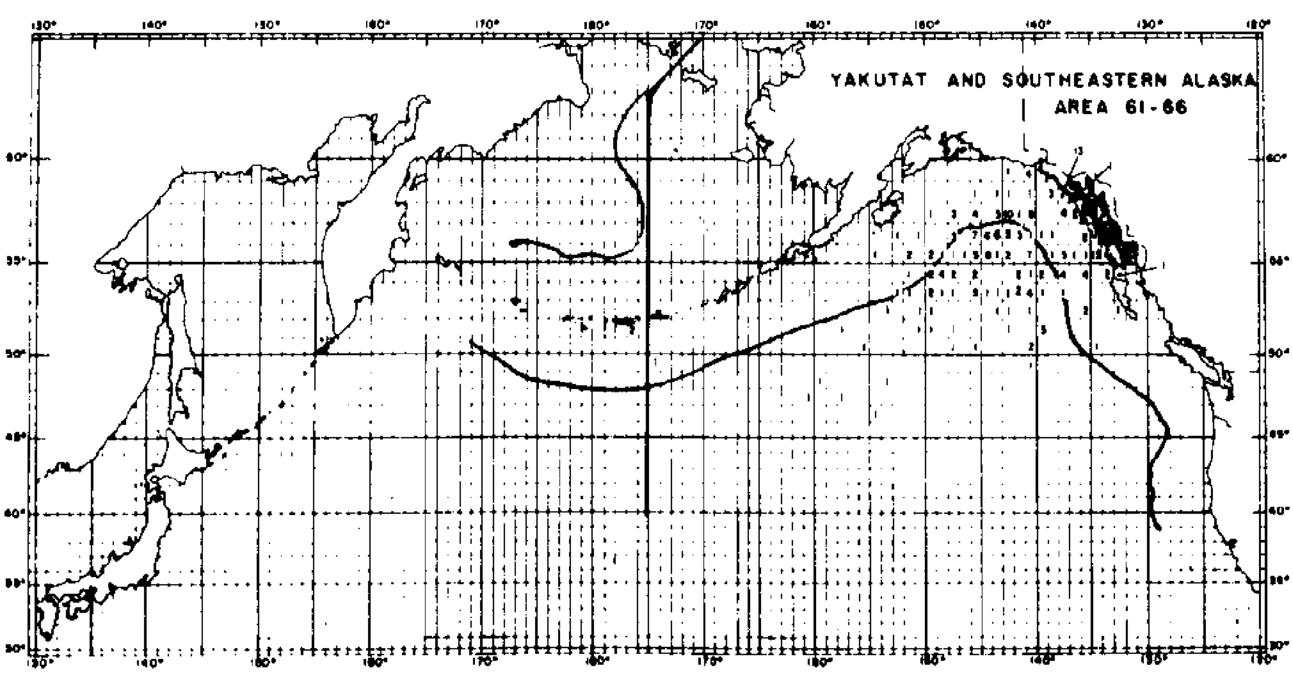


Figure 9 —Tagging locations of maturing sockeye salmon recovered from Yakutat to southeastern Alaska.

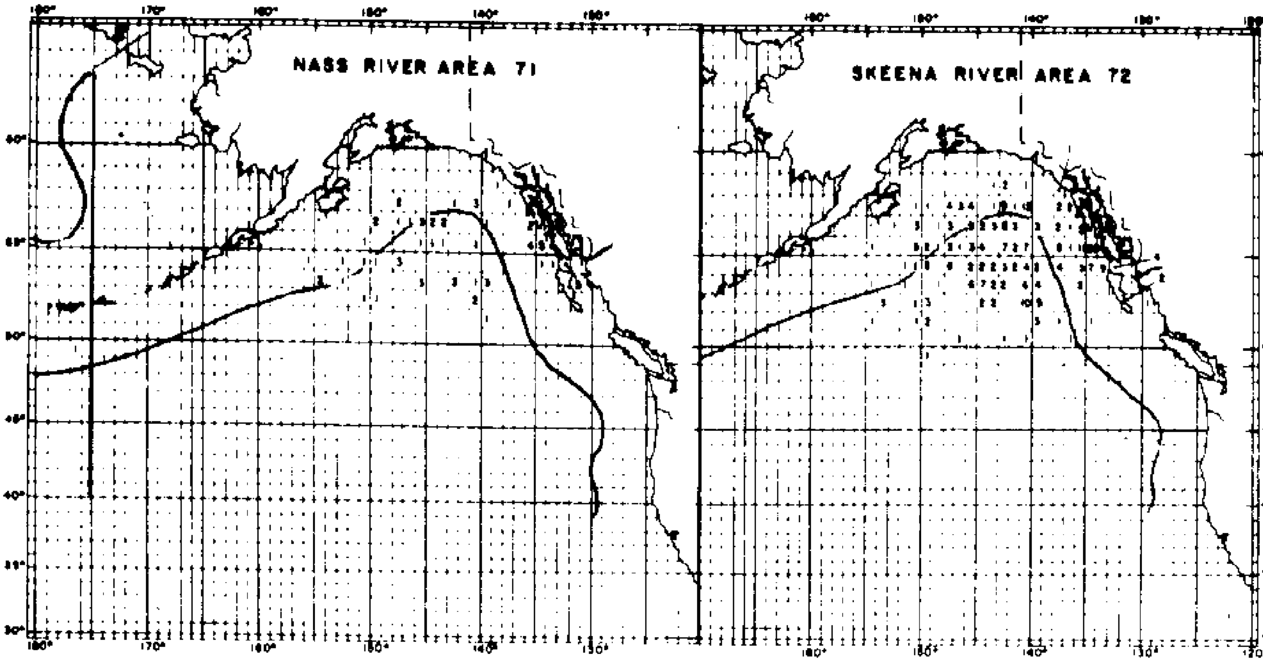


Figure 10 —Tagging locations of maturing sockeye salmon recovered in Nass and Skeena rivers.

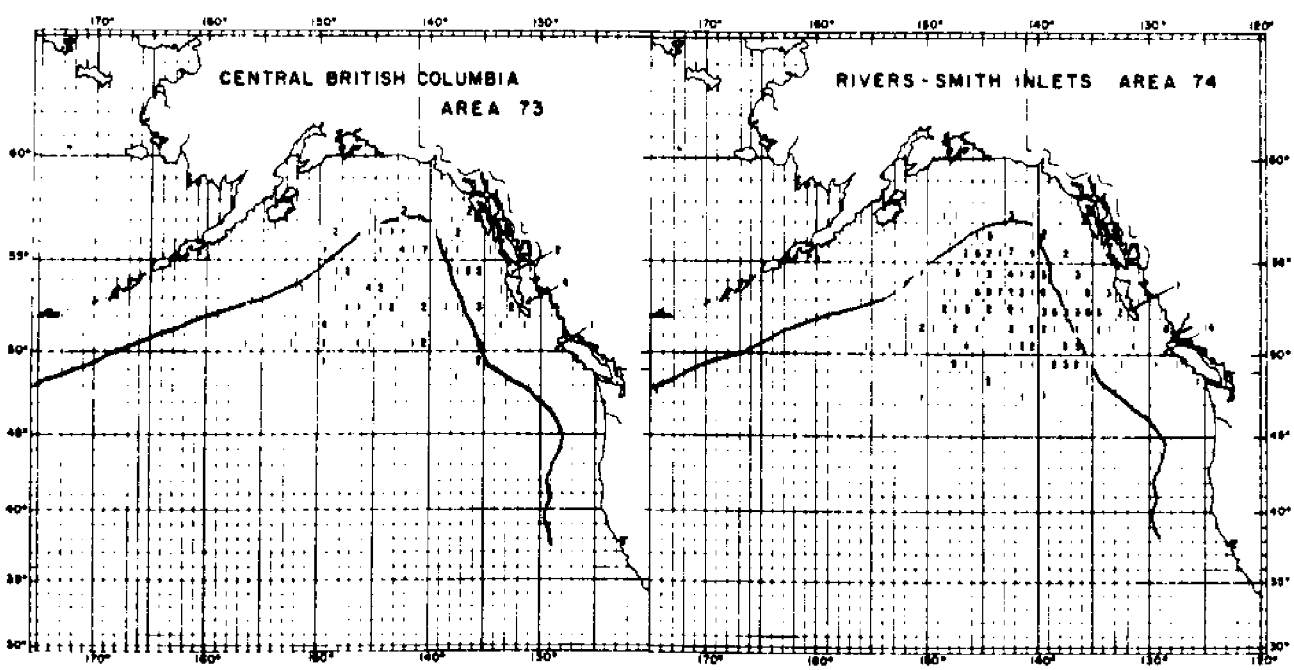


Figure 11 —Tagging locations of maturing sockeye salmon recovered in central British Columbia and River-Smith inlets.

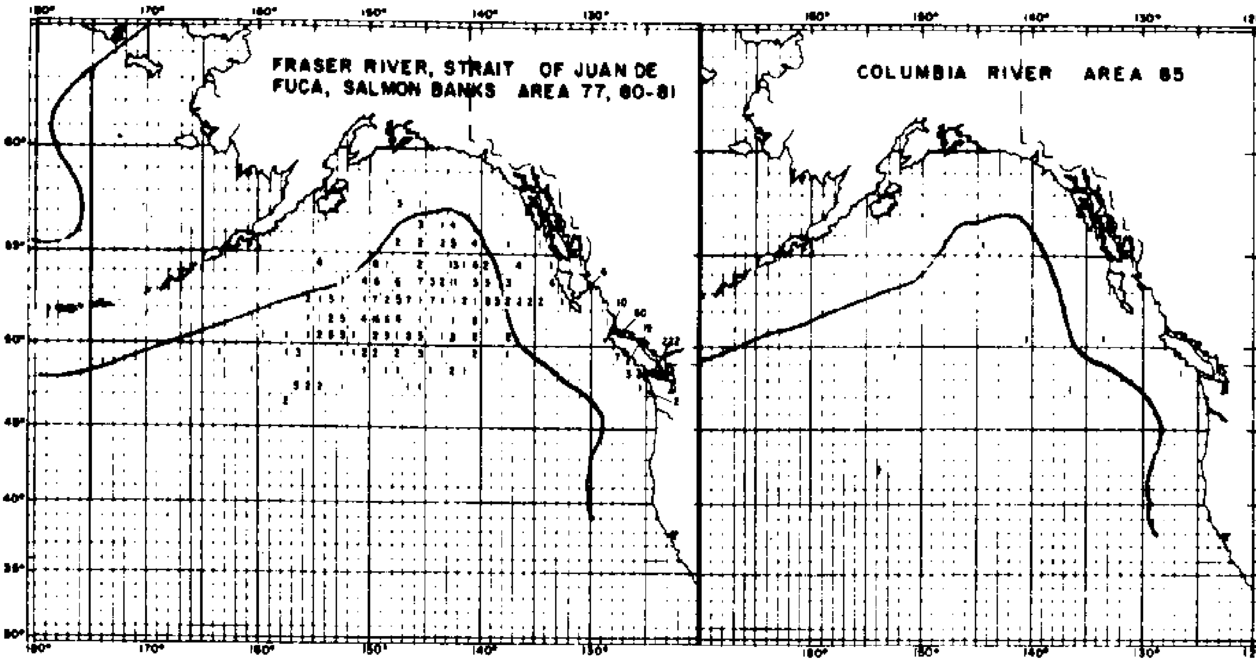


Figure 12 –Tagging locations of maturing sockeye salmon recovered in Fraser River, Strait of Juan de Fuca, and Salmon Banks and in the Columbia River.

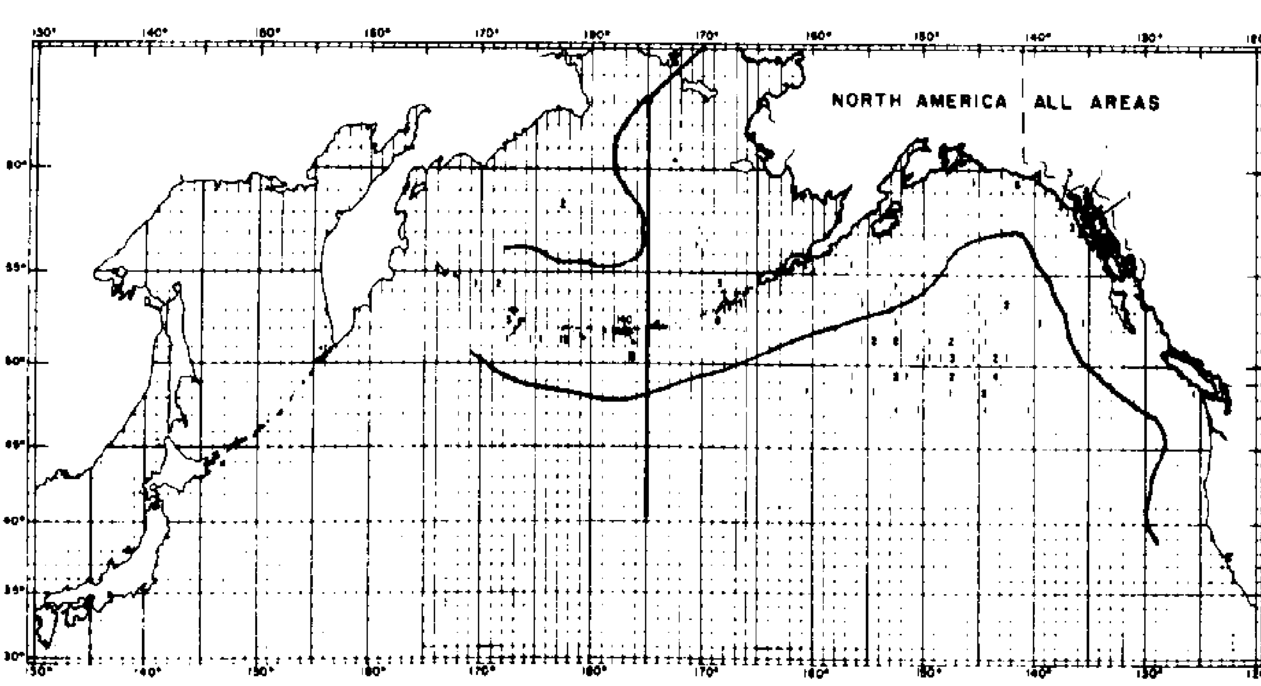


Figure 13 –Tagging locations of sockeye salmon recovered subsequent to year of tagging in North America.

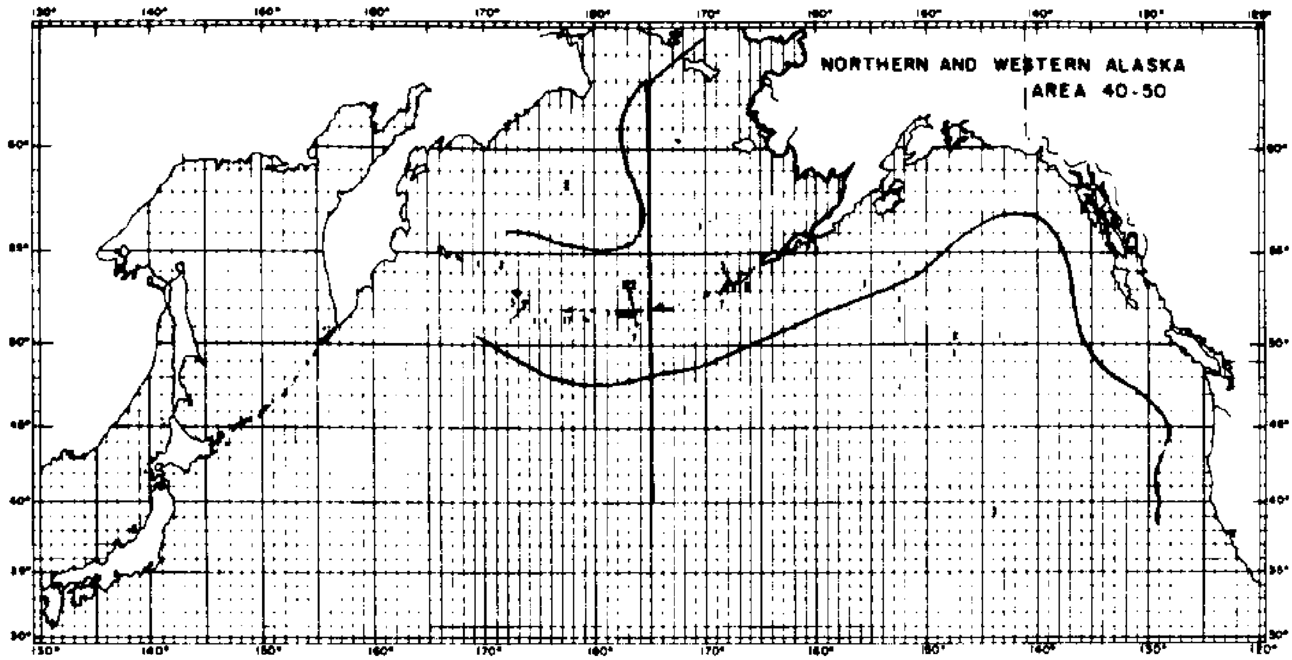


Figure 14 -Tagging locations of sockeye salmon recovered subsequent to year of tagging in northern and western Alaska.

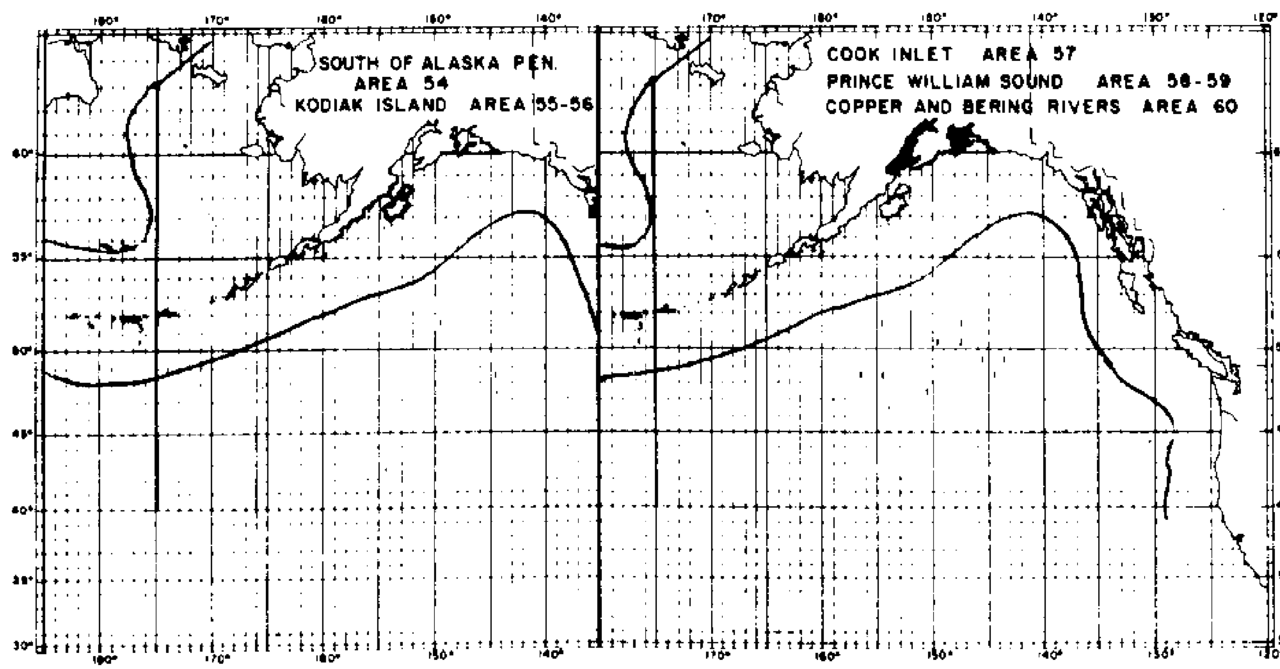


Figure 15 -Tagging locations of sockeye salmon recovered subsequent to year of tagging in south of Alaska Peninsula and Kodiak Island and in Cook Inlet, Prince William Sound, and Copper and Bering rivers areas.

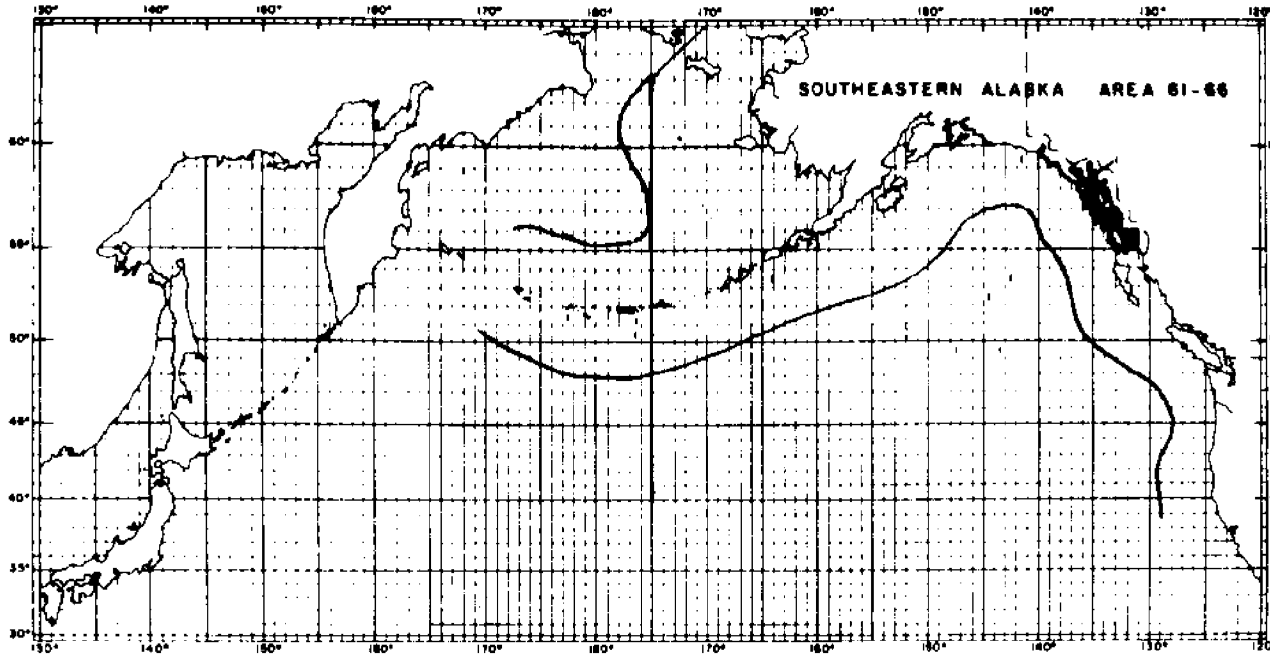


Figure 16 -Tagging locations of sockeye salmon recovered subsequent to year of tagging in southeastern Alaska.

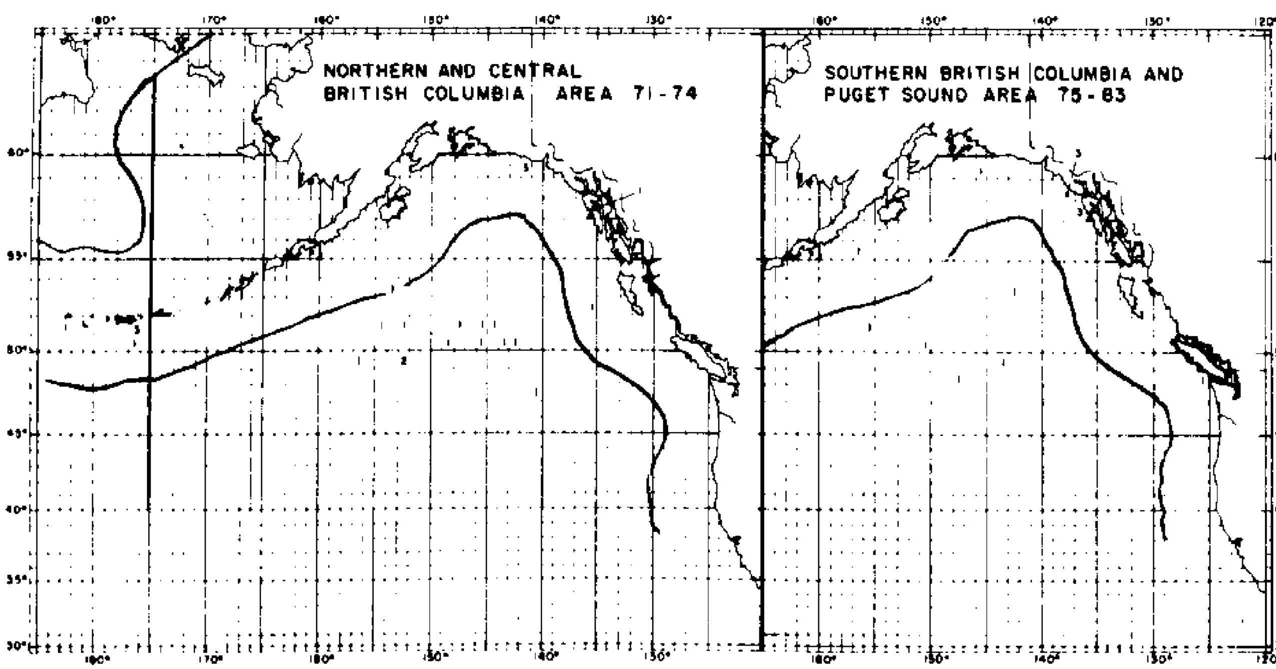


Figure 17 -Tagging locations of sockeye salmon recovered subsequent to year of tagging in northern and central British Columbia and in southern British Columbia and Puget Sound areas.

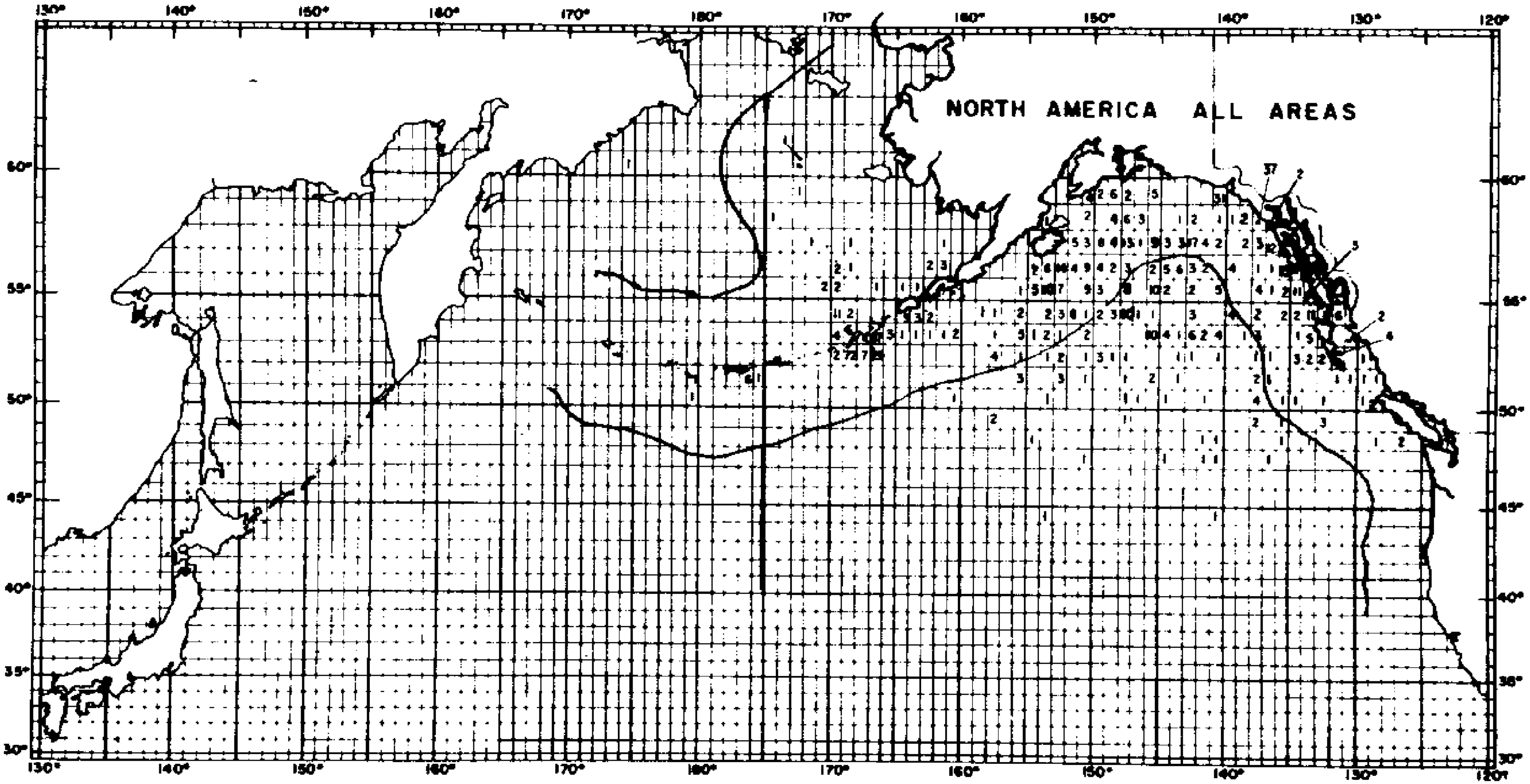


Figure 18 -Tagging locations of maturing chum salmon recovered in North America.

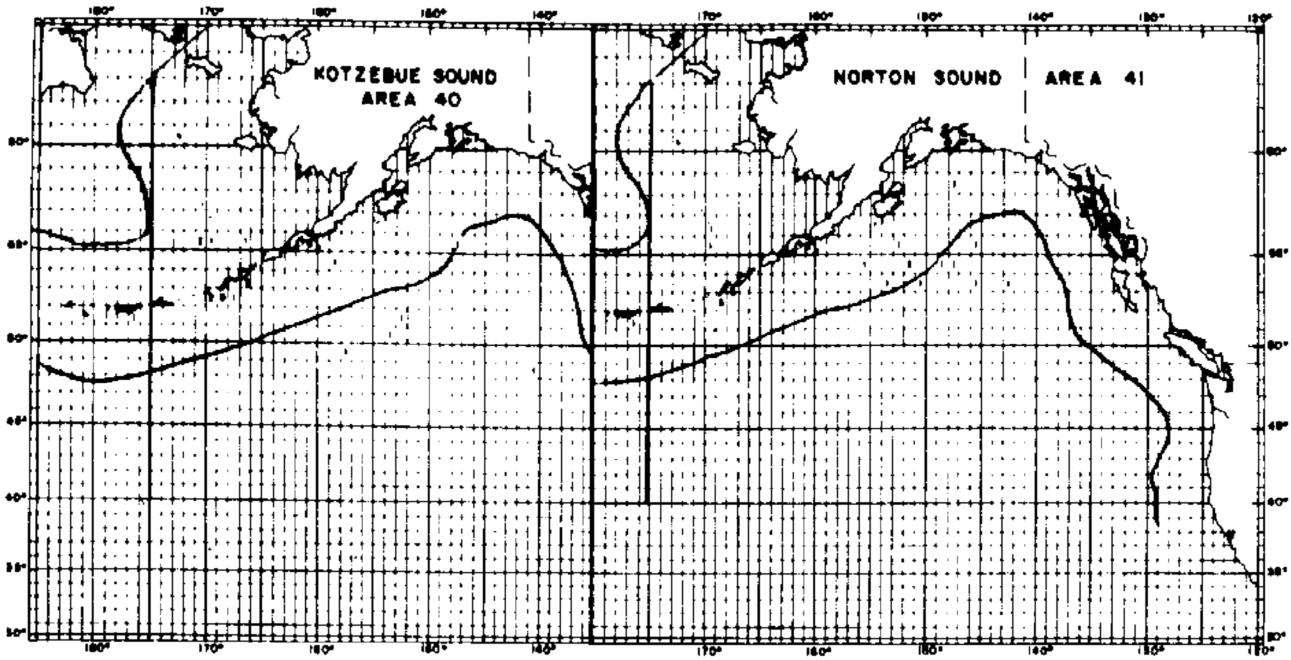


Figure 19 Tagging locations of maturing chum salmon recovered in Kotzebue and Norton sounds.

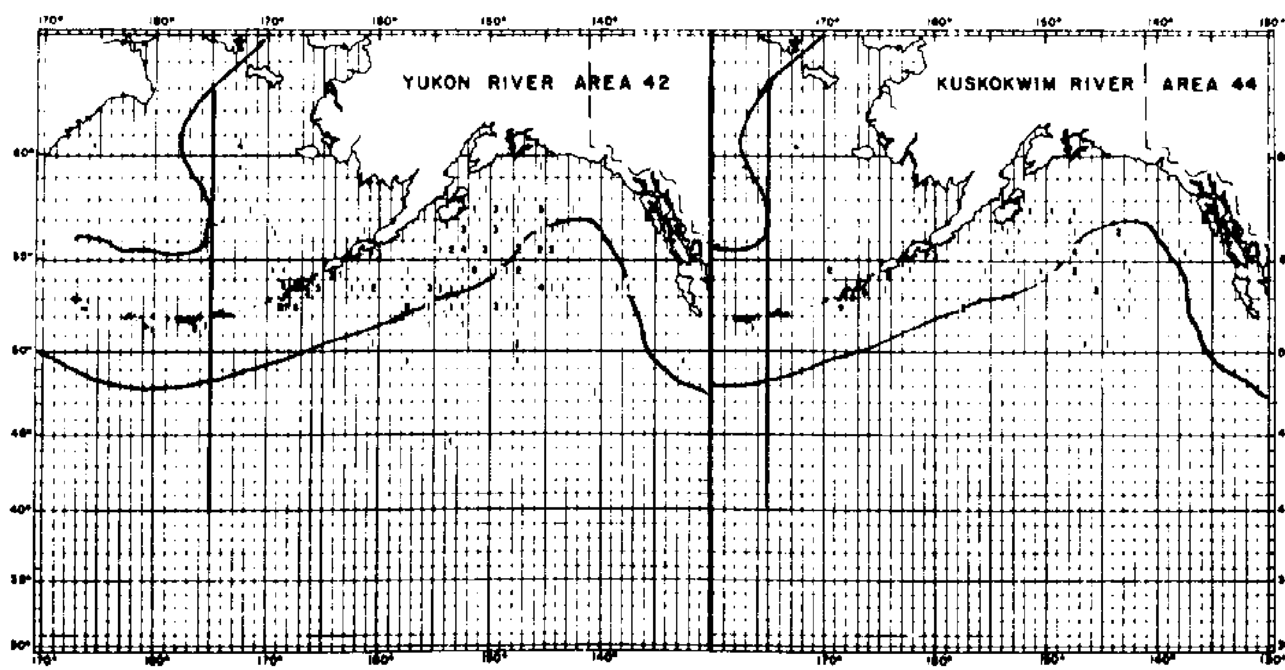


Figure 20 Tagging locations of maturing chum salmon recovered in Yukon and Kuskokwim rivers.

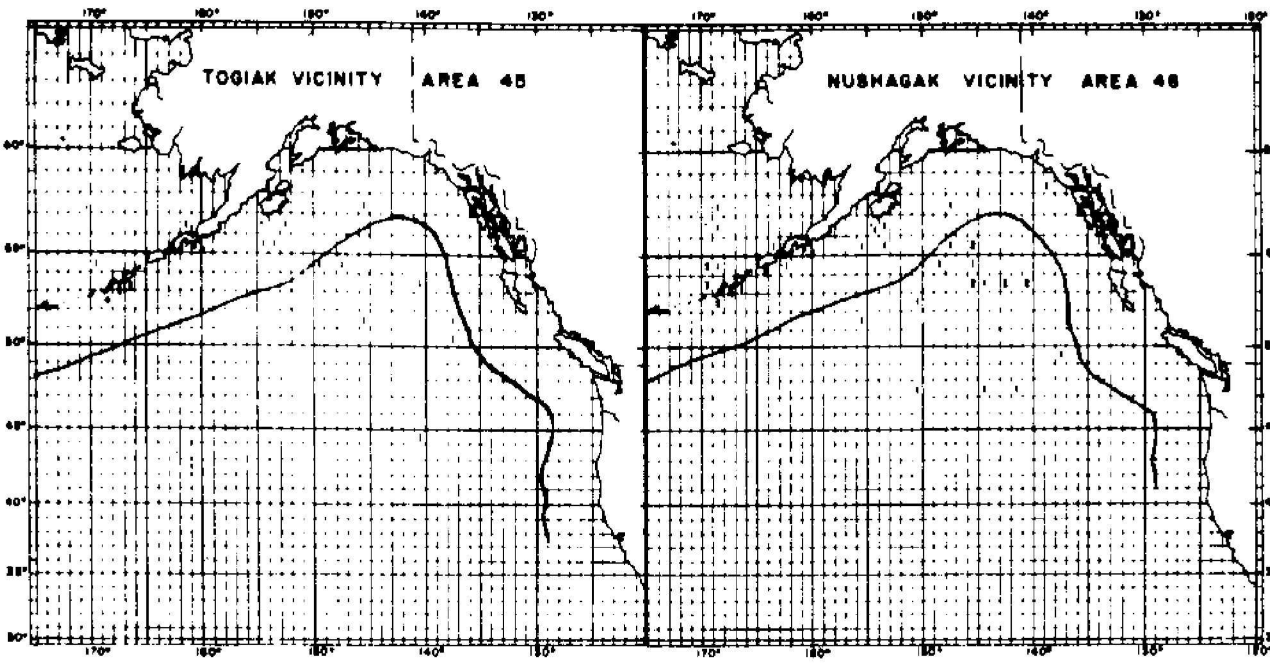


Figure 21 -Tagging locations of maturing chum salmon recovered in Togiak and Nushagak vicinities.

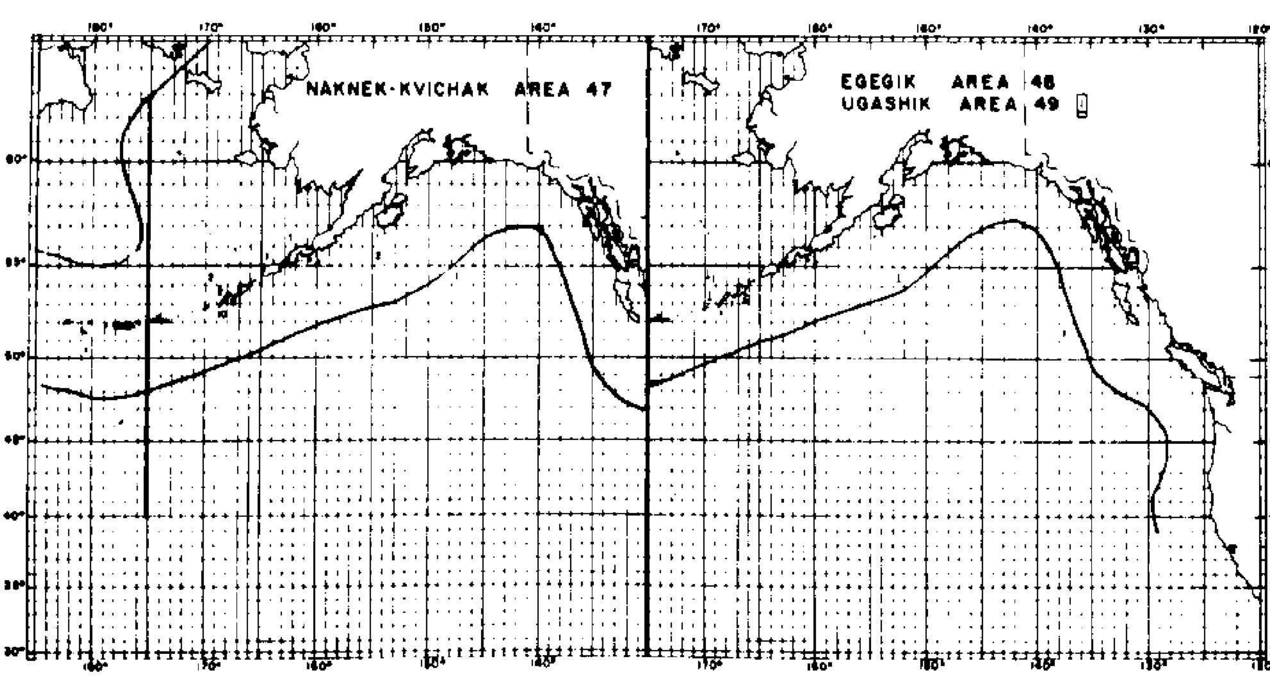


Figure 22 -Tagging locations of maturing chum salmon recovered in Naknek-Kvichak and in Egegik and Ugashik areas.

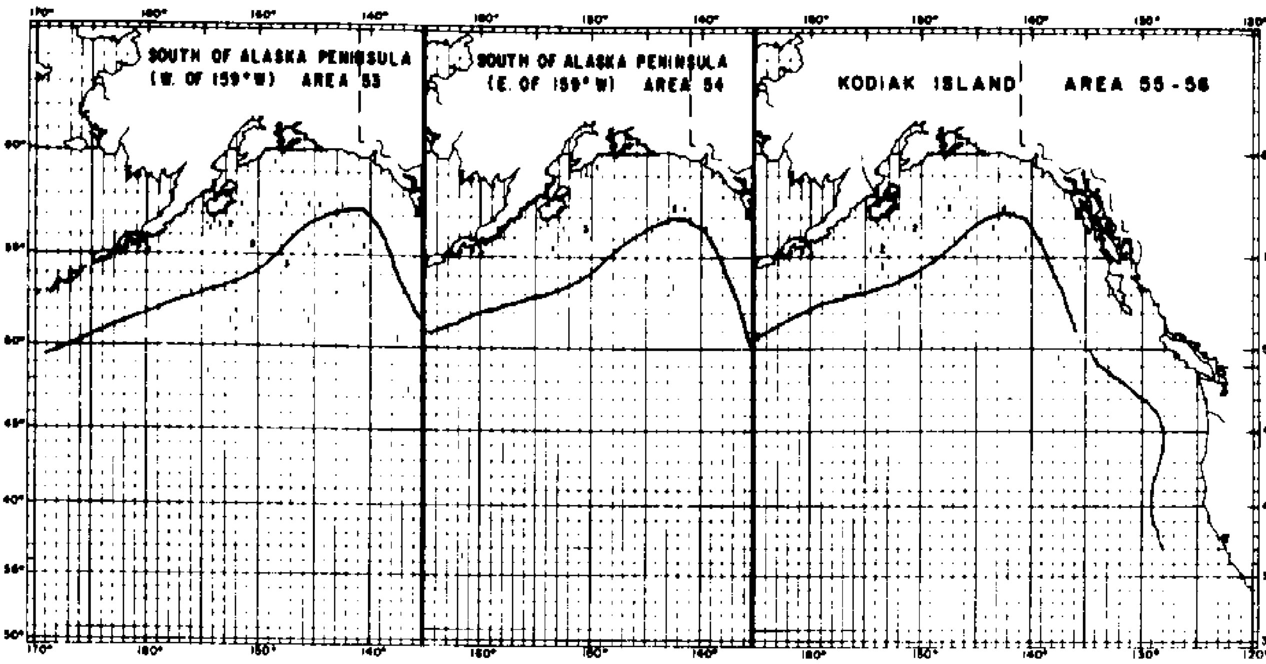


Figure 23 -Tagging locations of maturing chum salmon recovered south of the Alaskan Peninsula and in Kodiak Island.

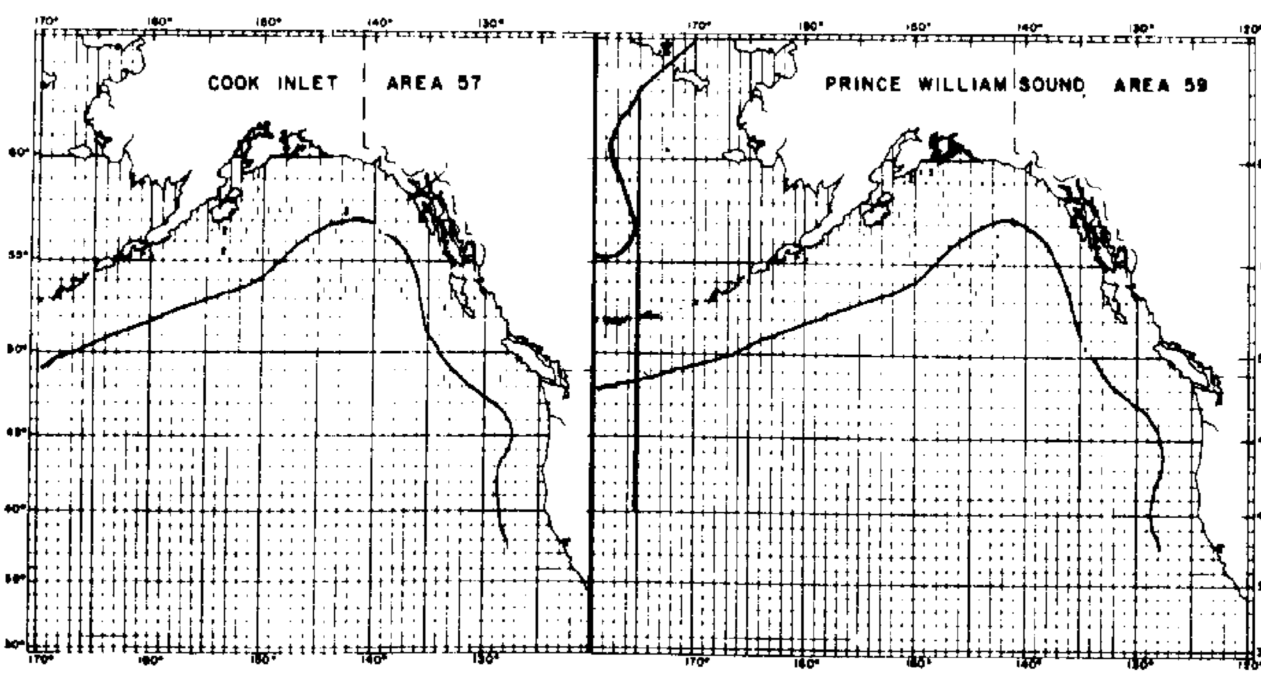


Figure 24 –Tagging locations of maturing chum salmon recovered in Cook Inlet and Prince William Sound.

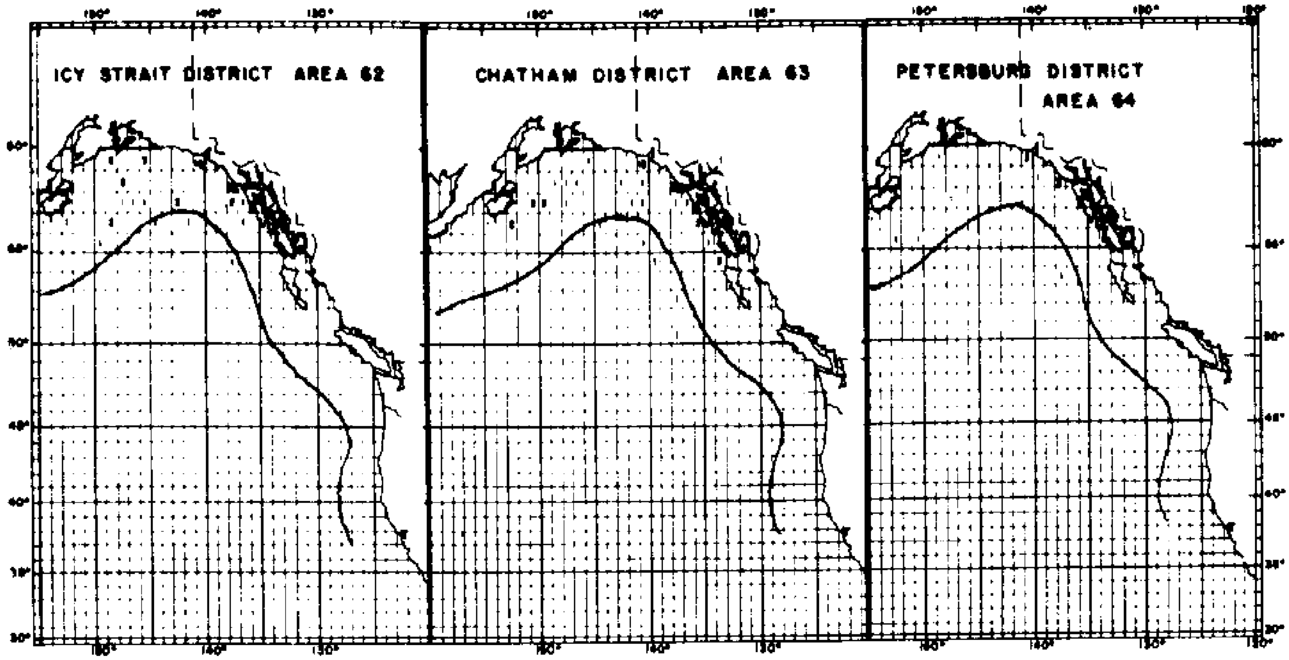


Figure 25 -Tagging locations of maturing chum salmon recovered in Icy Strait, Chatham, and Petersburg districts.

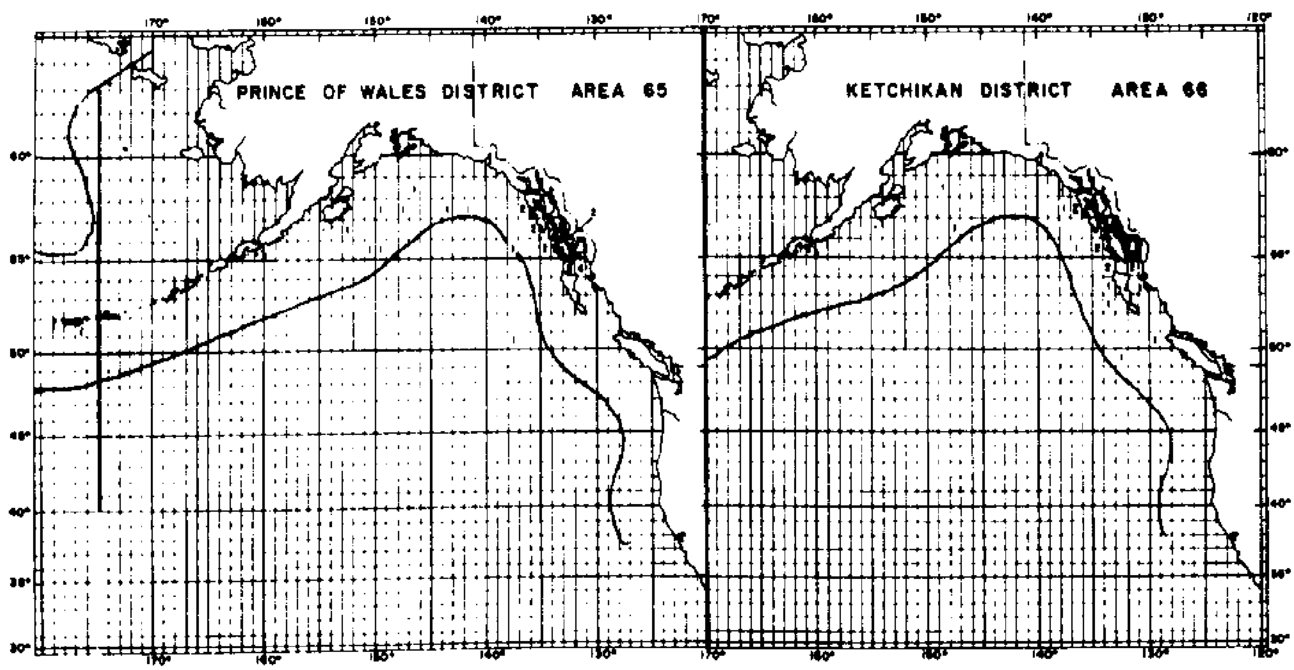


Figure 26 -Tagging locations of maturing chum salmon recovered in Prince of Wales and Ketchikan districts.

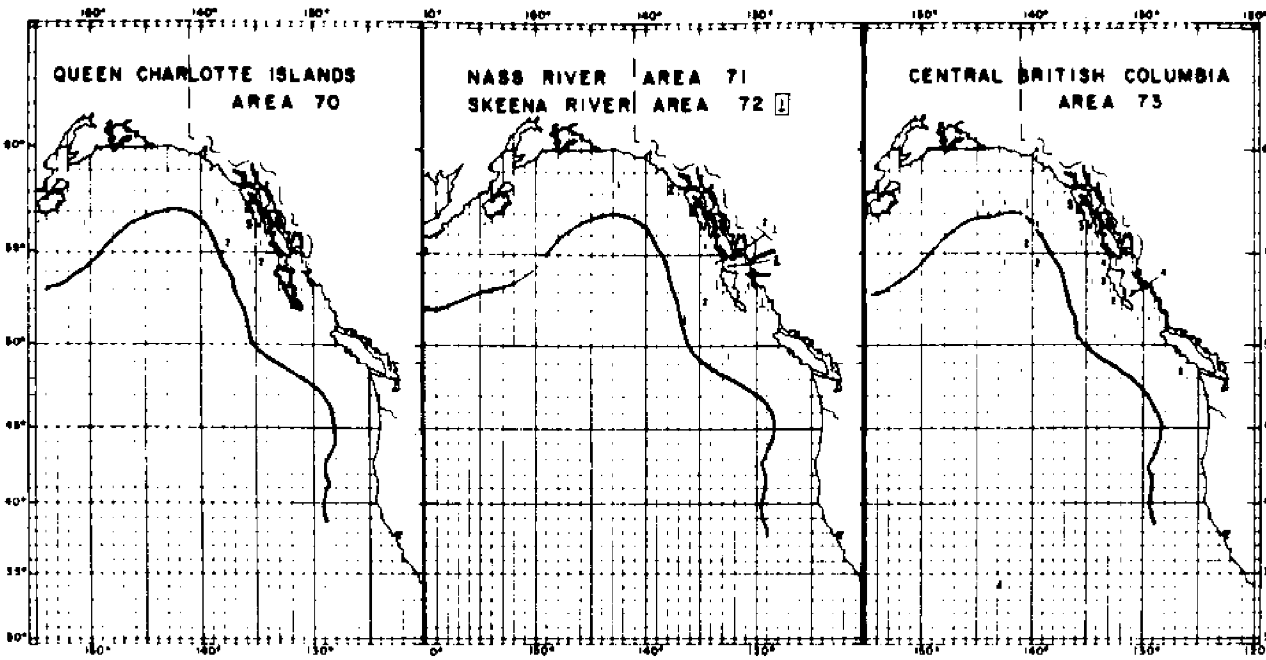


Figure 27 –Tagging locations of maturing chum salmon recovered in Queen Charlotte Islands, Nass and Skeena rivers, and central British Columbia areas.

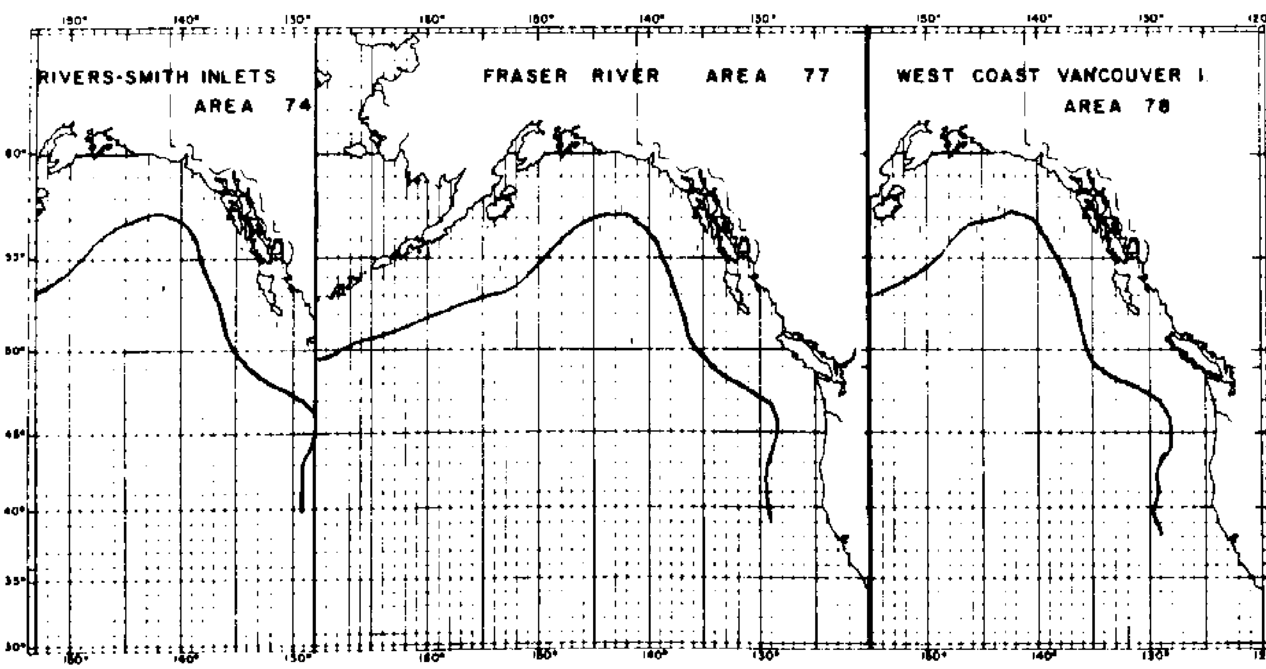


Figure 28 -Tagging locations of maturing chum salmon recovered in Rivers-Smith inlets, Fraser River, and west coast of Vancouver Island.

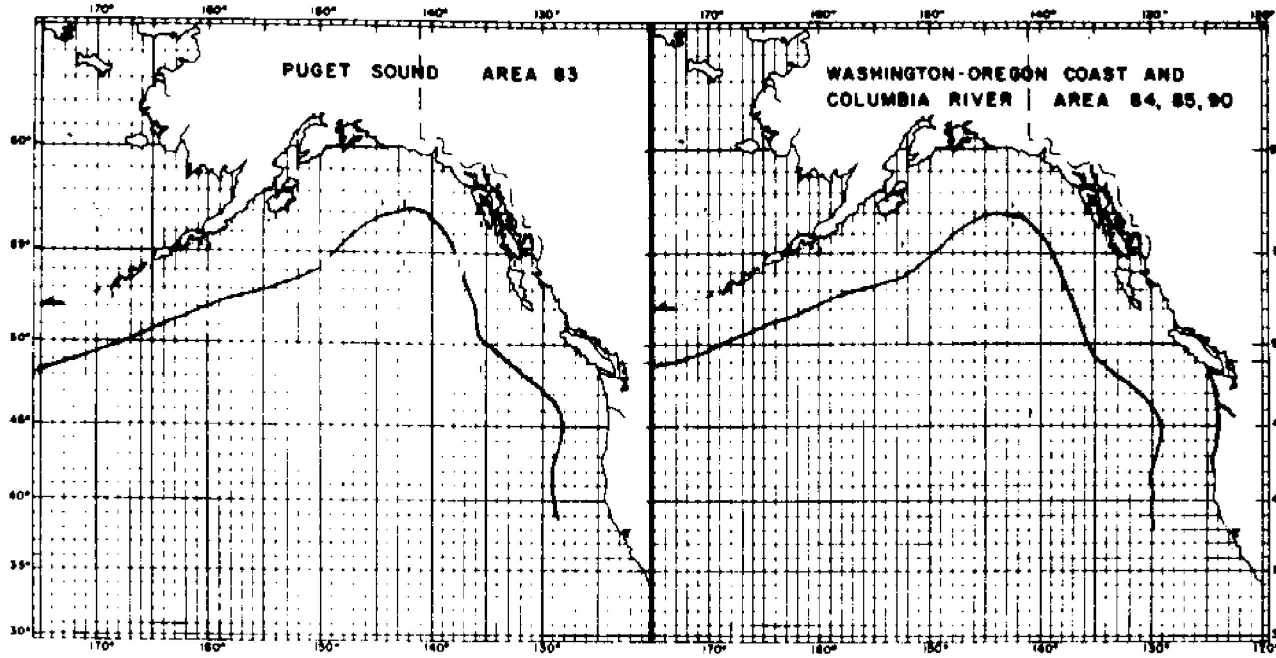


Figure 29 —Tagging locations of maturing chum salmon recovered in Puget Sound and on the Washington-Oregon coast and Columbia River.

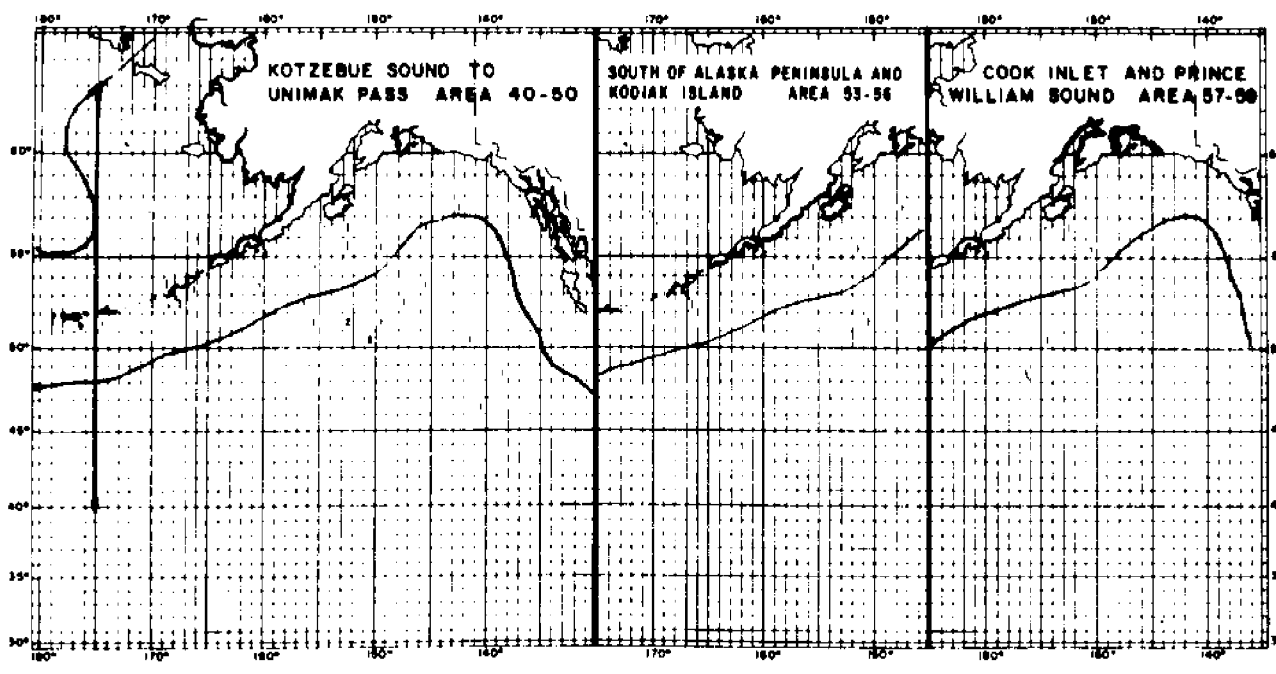


Figure 30 -Tagging locations of chum salmon recovered subsequent to year of tagging from Kotzebue Sound to Unimak Pass, south of Alaska Peninsula and Kodiak Island, and Cook Inlet and Prince William Sound areas.

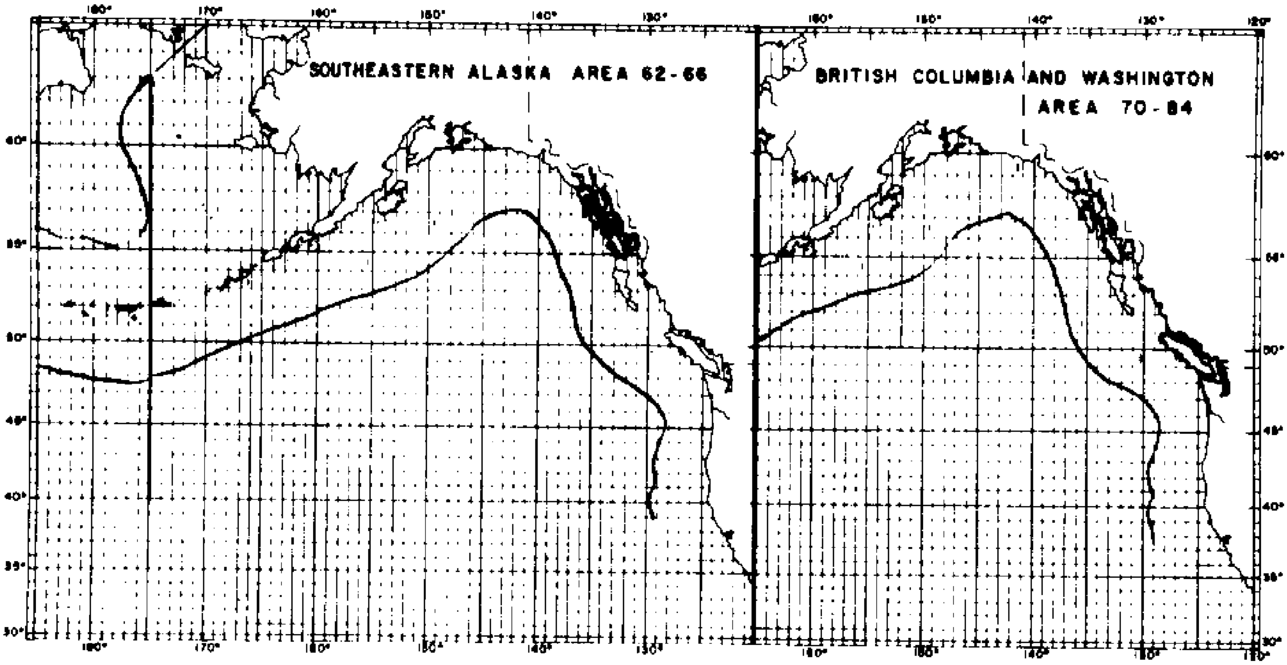


Figure 31 –Tagging locations of chum salmon recovered subsequent to year of tagging in southeastern Alaska and in British Columbia and Washington areas.

Chums from all regions would be vulnerable to foreign fishing (other than Japanese) outside the 12-mile limit.

2. 200-mile limit with continued abstention:

   Chum salmon north and south of the Aleutians would gain added protection under this arrangement; but western Alaskan chums in the central and northern Bering Sea, although somewhat less available to Japanese fishermen, would still be vulnerable beyond North America's 200-mile limit unless the USSR claimed similar jurisdiction and banned high-seas salmon fishing. Those from most North American areas, particularly those from western Alaska to Prince William Sound, would be vulnerable to nations other than Japan beyond the 200-mile limit in the central Gulf of Alaska. Chum stocks east and south of Prince William Sound would be less vulnerable.

3. 200-mile limit without continued abstention:

   Most western and central Alaskan stocks would be vulnerable to Japanese (and possibly other) fisheries beyond 200 miles in the central Gulf of Alaska.

PINK SALMON (FIGURES 32-41)

1. With abstention and a 12-mile limit:

   Only western Alaskan pink salmon are currently exposed to the Japanese fisheries west of the abstention line. Pink salmon, like all other species, are vulnerable beyond the 12-mile limit to nations other than Japan who could have, but have not yet, opted to fish for them.

2. 200-mile limit with continued abstention:

   Japan's opportunity to harvest North American pink salmon would all but be eliminated. Pinks from the Kodiak area southward to, but apparently not including, Puget Sound could be exploited by other foreign fisheries beyond 200-miles in the central Gulf of Alaska.

3. 200-mile limit without abstention:

   Japan would join the list of eligible harvesters in the central Gulf of Alaska (see 2 above).

COHO SALMON (FIGURES 42-51)

1. With abstention and a 12-mile limit:

   The Japanese mothership fishery takes most of its coho in the North Pacific Ocean south of the western Aleutians.

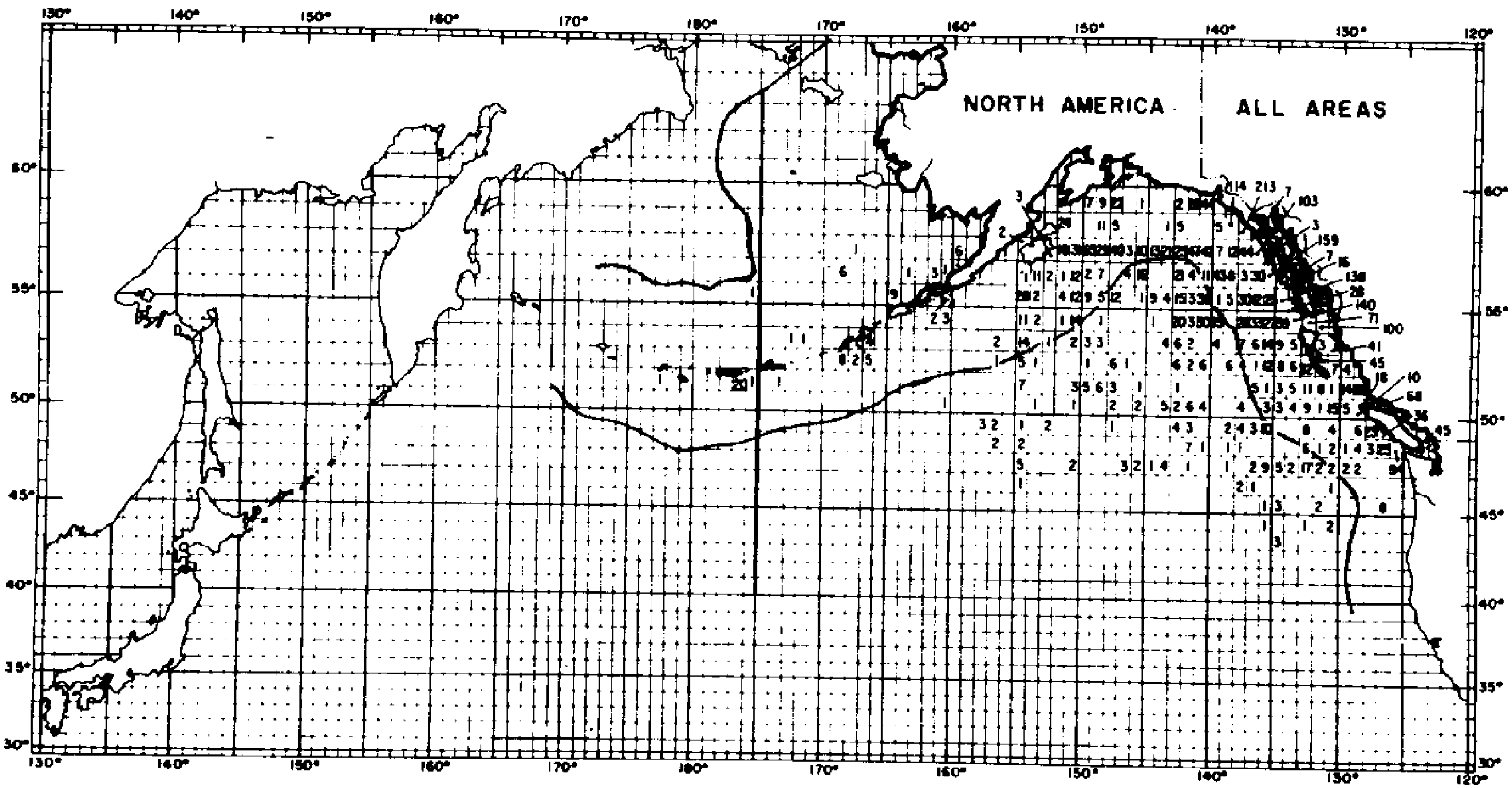


Figure 32 -Tagging locations of maturing pink salmon recovered in North America.

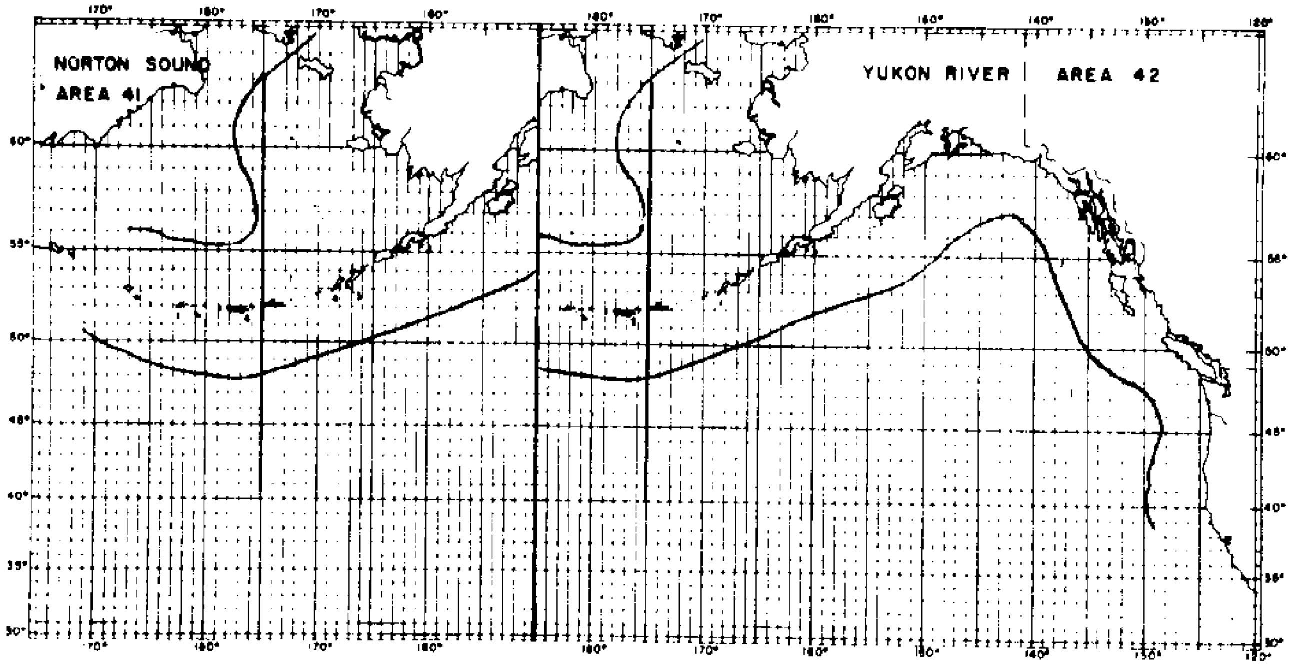


Figure 33 -Tagging locations of maturing pink salmon recovered in Norton Sound and Yukon River.

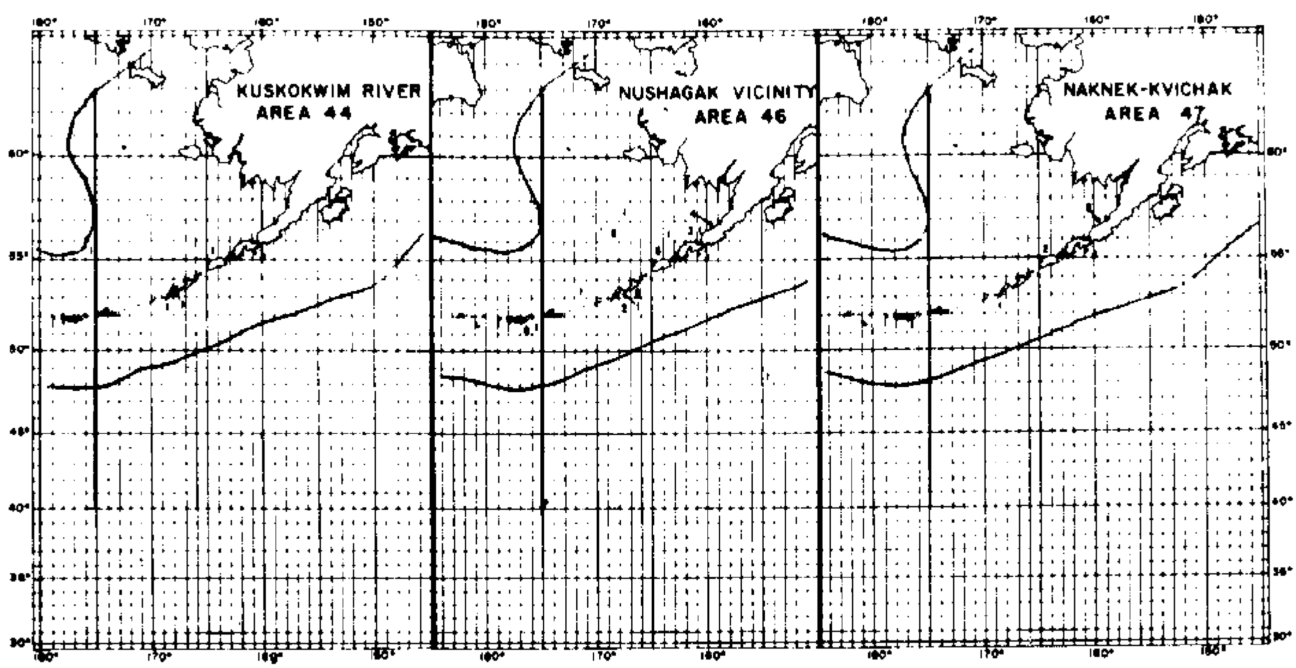


Figure 34 -Tagging locations of maturing pink salmon recovered in the Kuskokwim River, Nushagak vicinity, and Naknek-Kvichak.

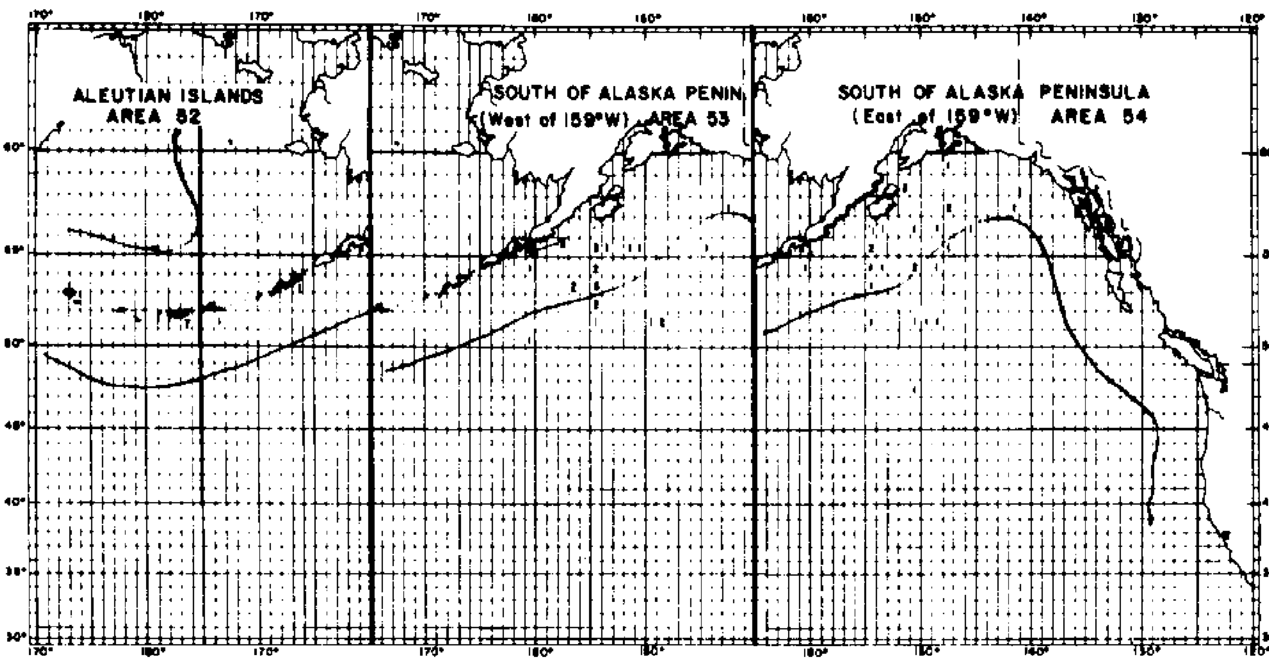


Figure 35 -Tagging locations of maturing pink salmon recovered in the Aleutian Islands and south of the Alaska Peninsula.

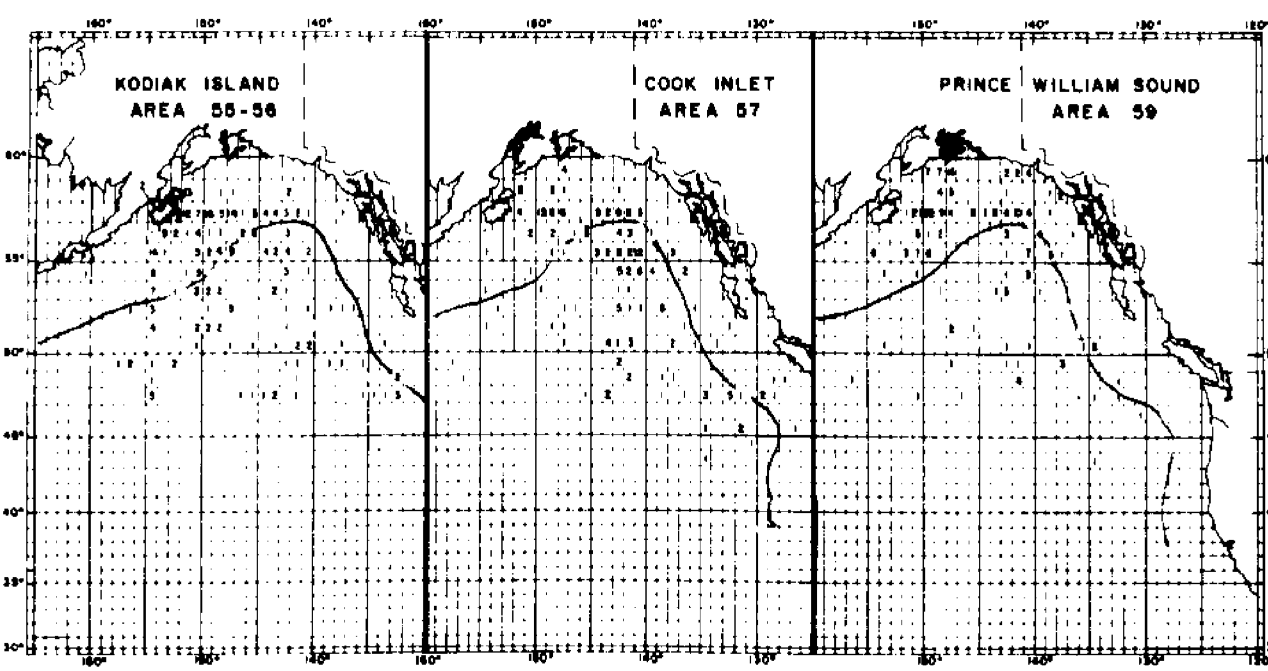


Figure 36 -Tagging locations of maturing pink salmon recovered in Kodiak Island, Cook Inlet, and Prince William Sound areas.

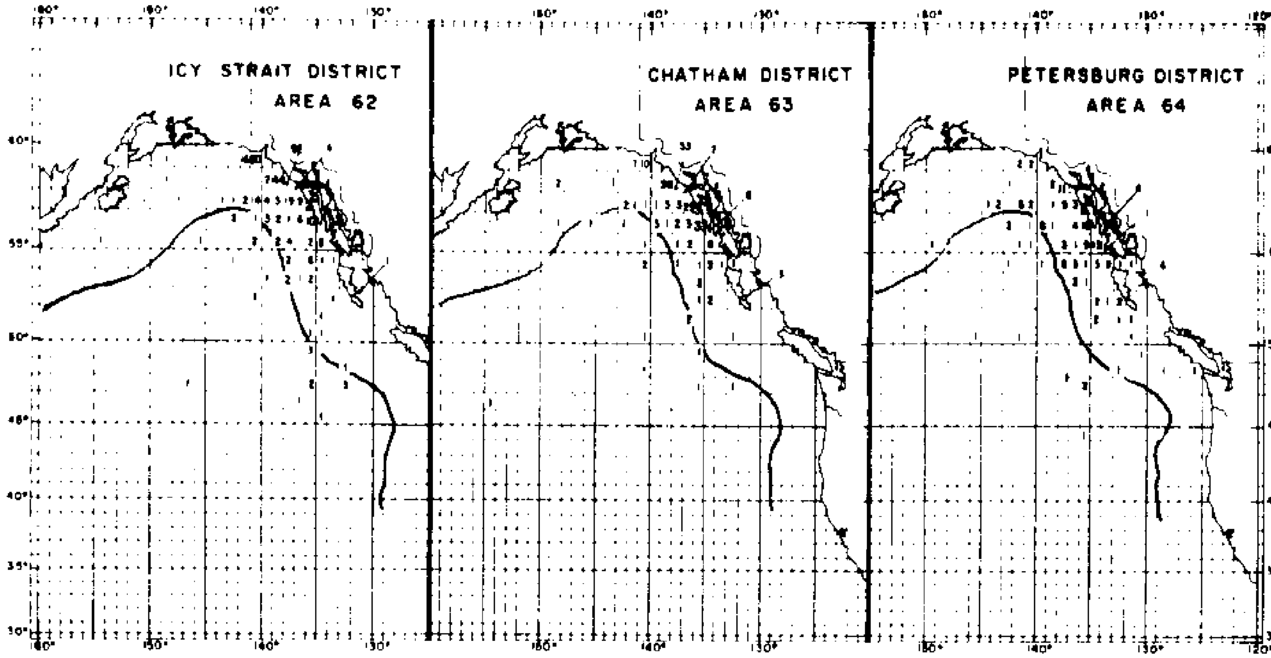


Figure 37.–Tagging locations of maturing pink salmon recovered in Icy Strait, Chatham, and Petersburg districts.

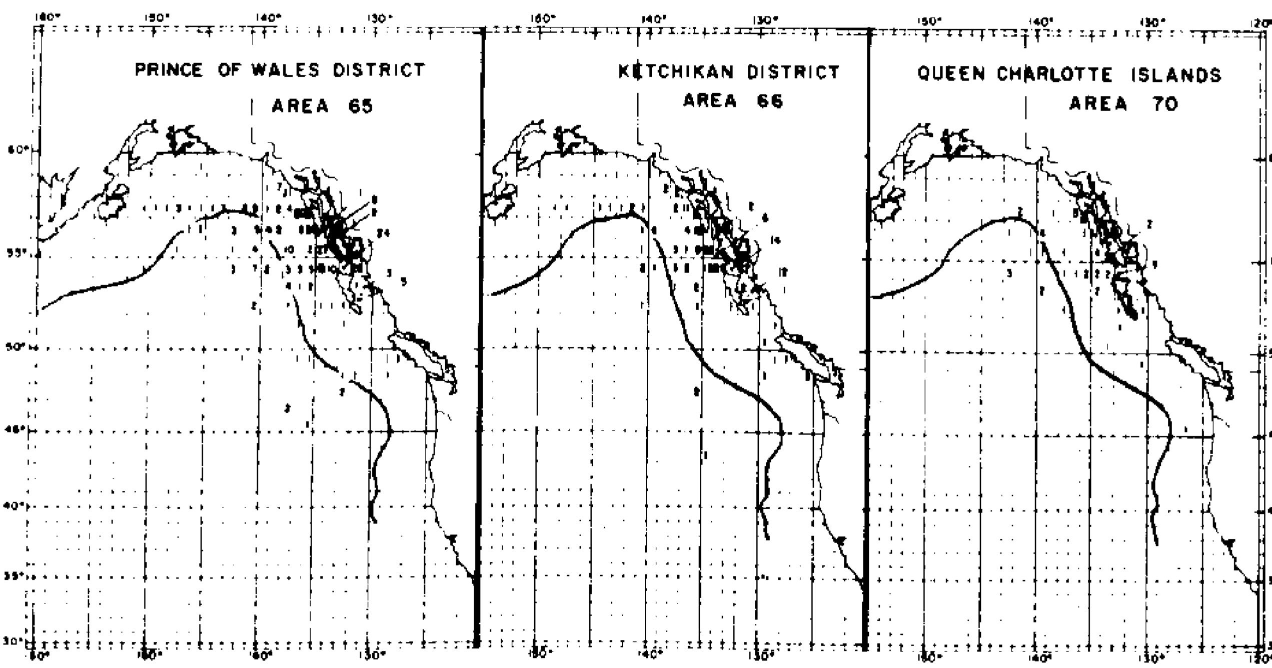


Figure 38.–Tagging locations of maturing pink salmon recovered in Prince of Wales district, Ketchikan district, and Queen Charlotte Islands.

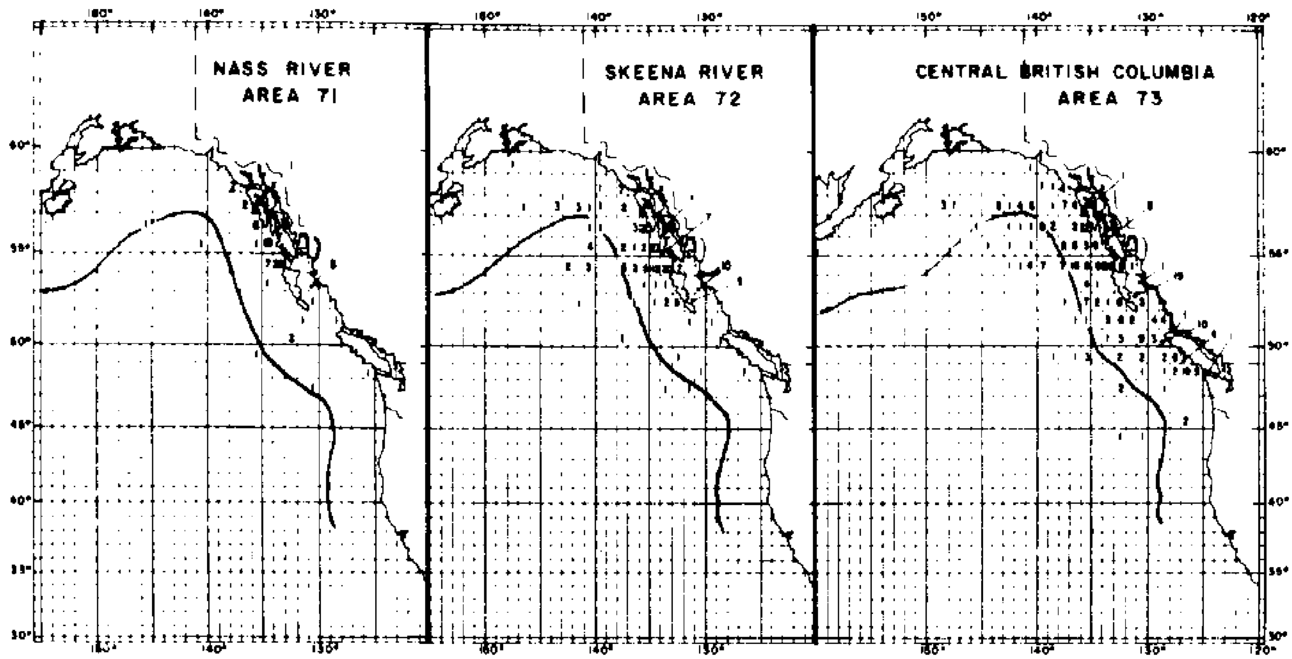


Figure 39 —Tagging locations of maturing pink salmon recovered in the Nass River, Skeena River, and central British Columbia.

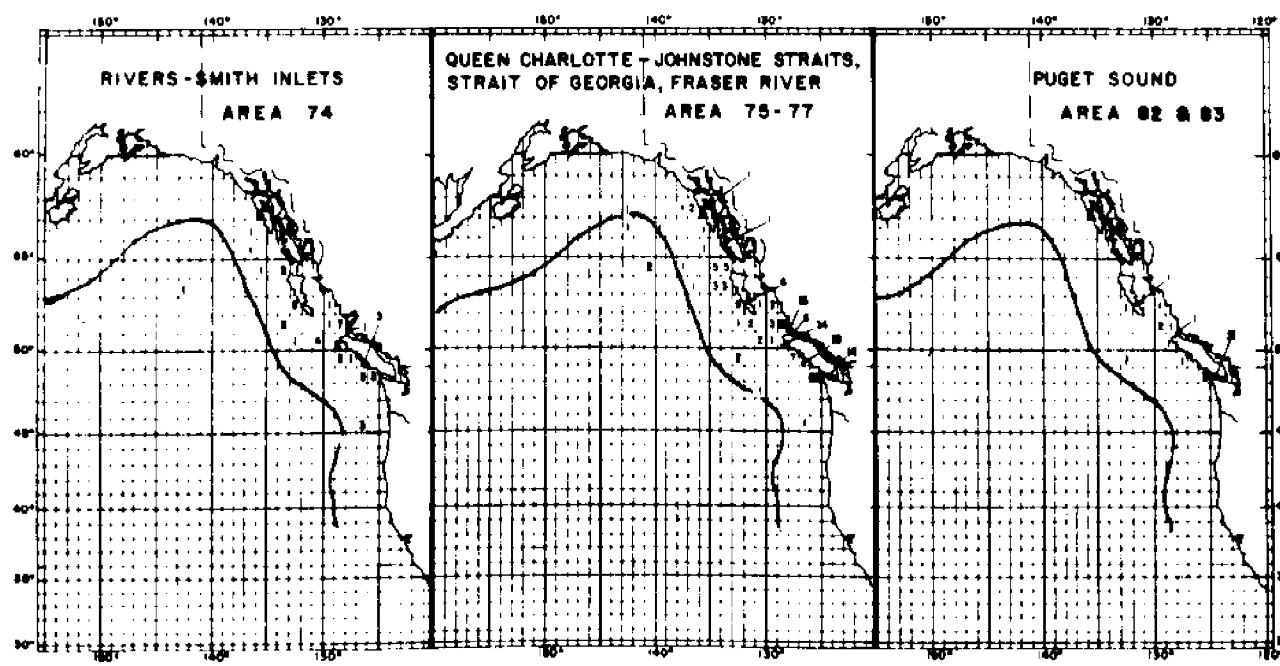


Figure 40 —Tagging locations of maturing pink salmon recovered in Rivers-Smith inlets, Queen Charlotte-Johnstone straits to Fraser River, and Puget Sound.

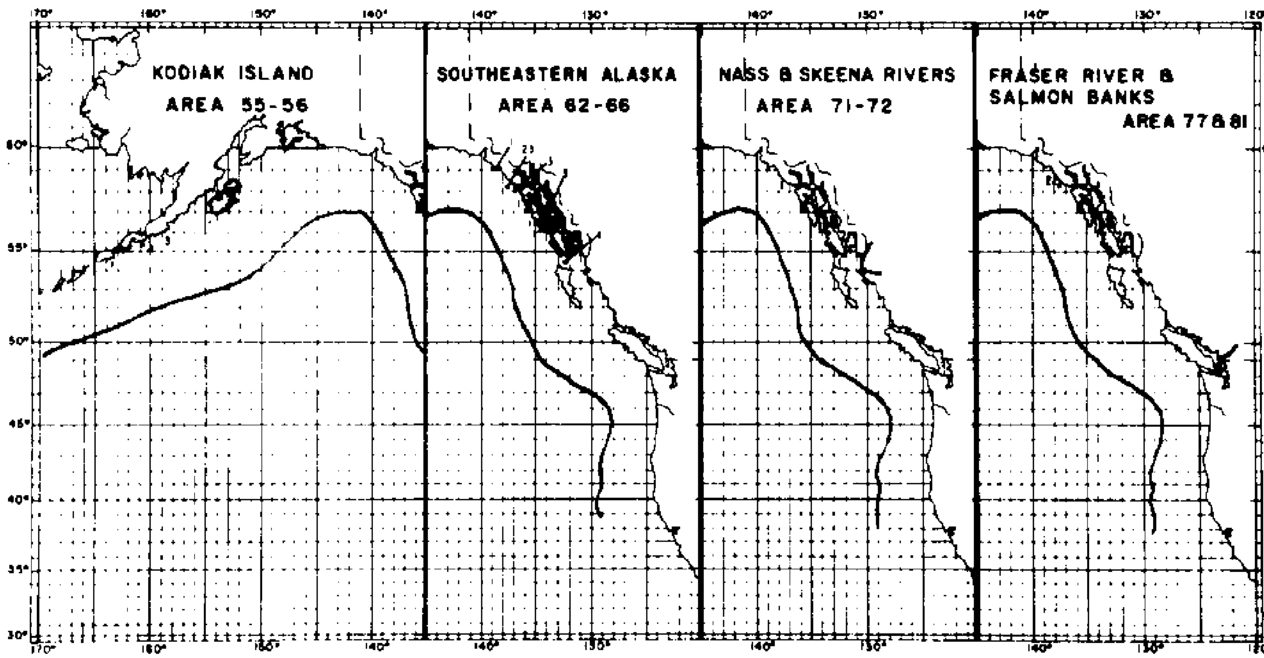


Figure 41 –Tagging locations of pink salmon recovered subsequent to year of tagging in Kodiak Island, southeastern Alaska, Nass and Skeena rivers, and the Fraser River and Salmon Banks.

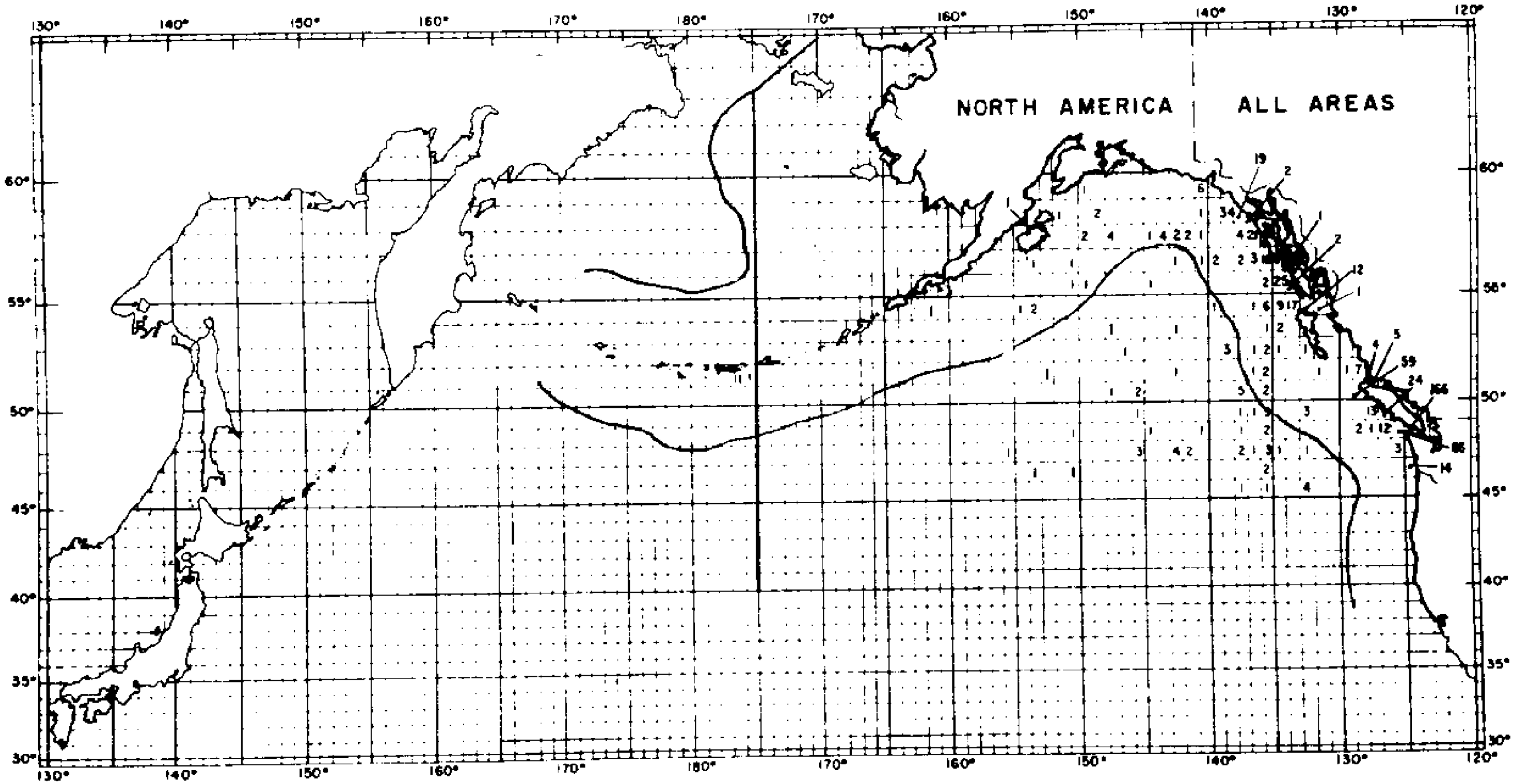


Figure 42 -Tagging locations of maturing coho salmon recovered in North America.

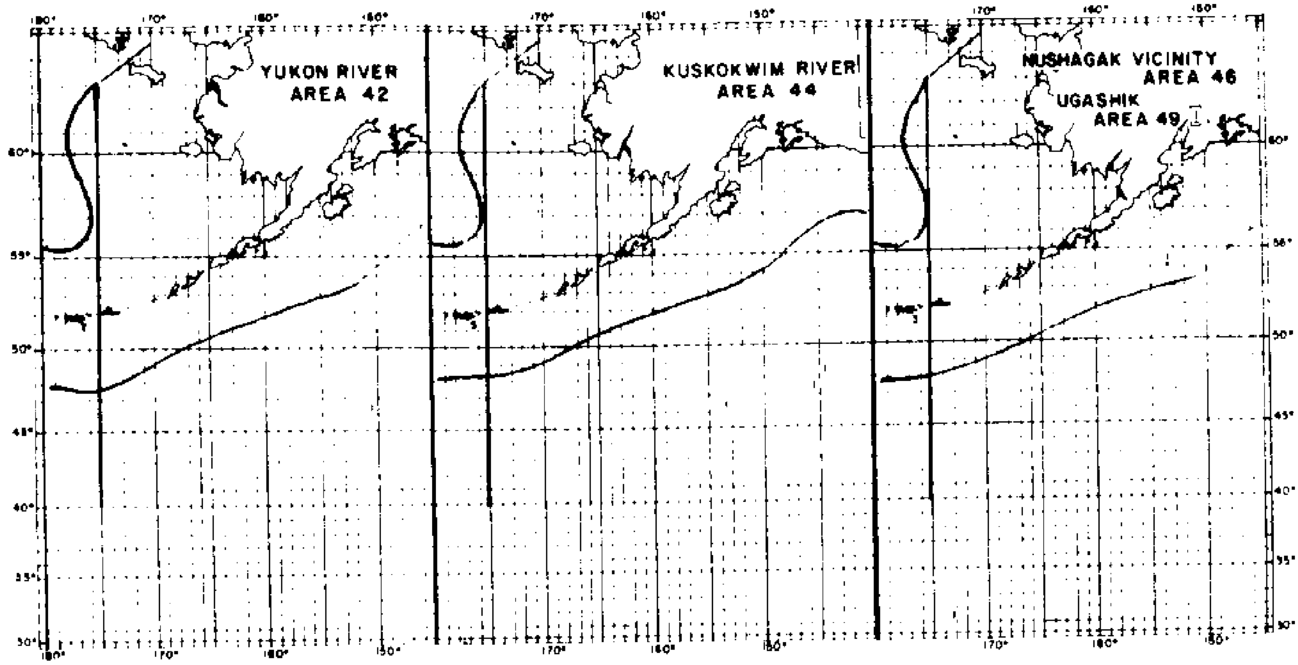


Figure 43 -Tagging locations of maturing coho salmon recovered in the Yukon River, the Kuskokwim River, and the Nushagak vicinity and Ugashik.

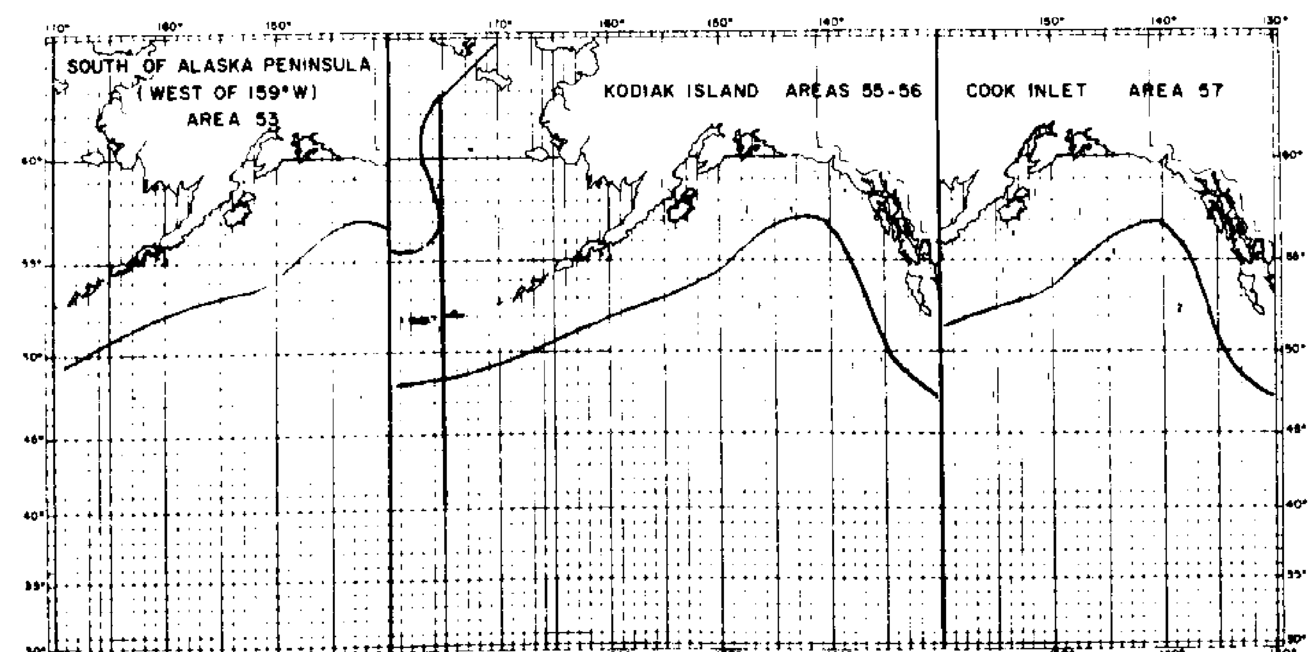


Figure 44 -Tagging locations of maturing coho salmon recovered from south of the Alaska Peninsula, Kodiak Island, and Cook Inlet.

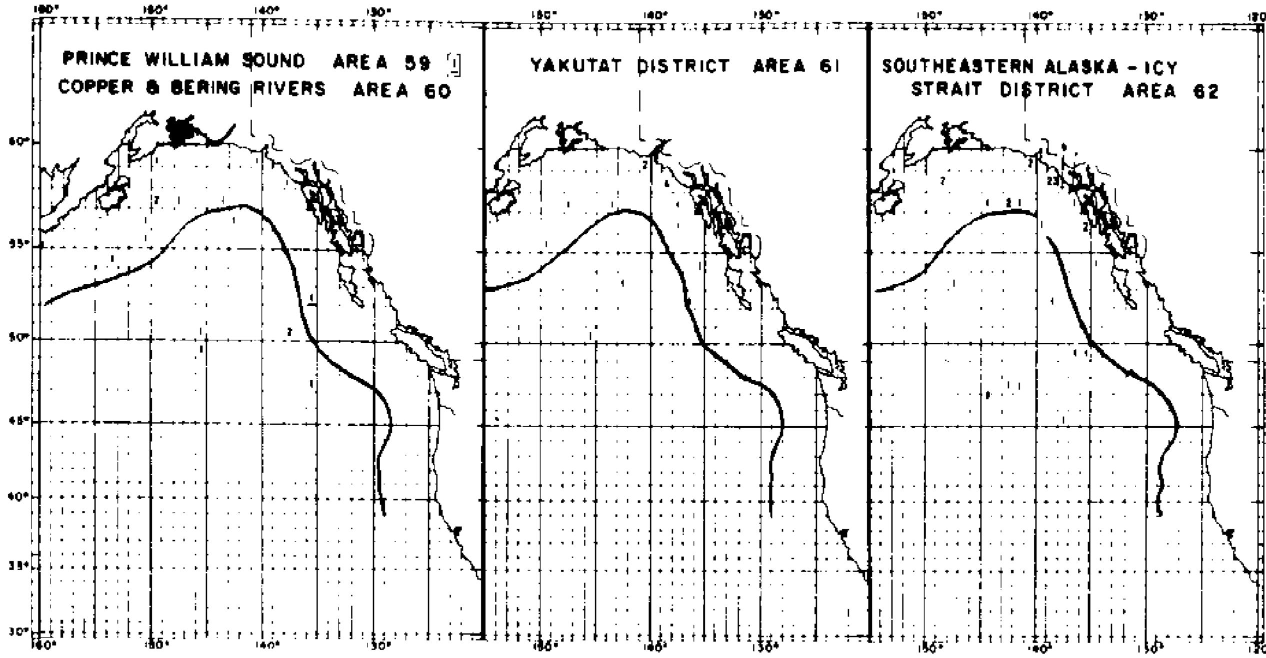


Figure 45 -Tagging locations of maturing coho salmon recovered in Prince William Sound and Copper and Bering rivers; Yakutat district; and southeastern Alaska-Icy Strait district.

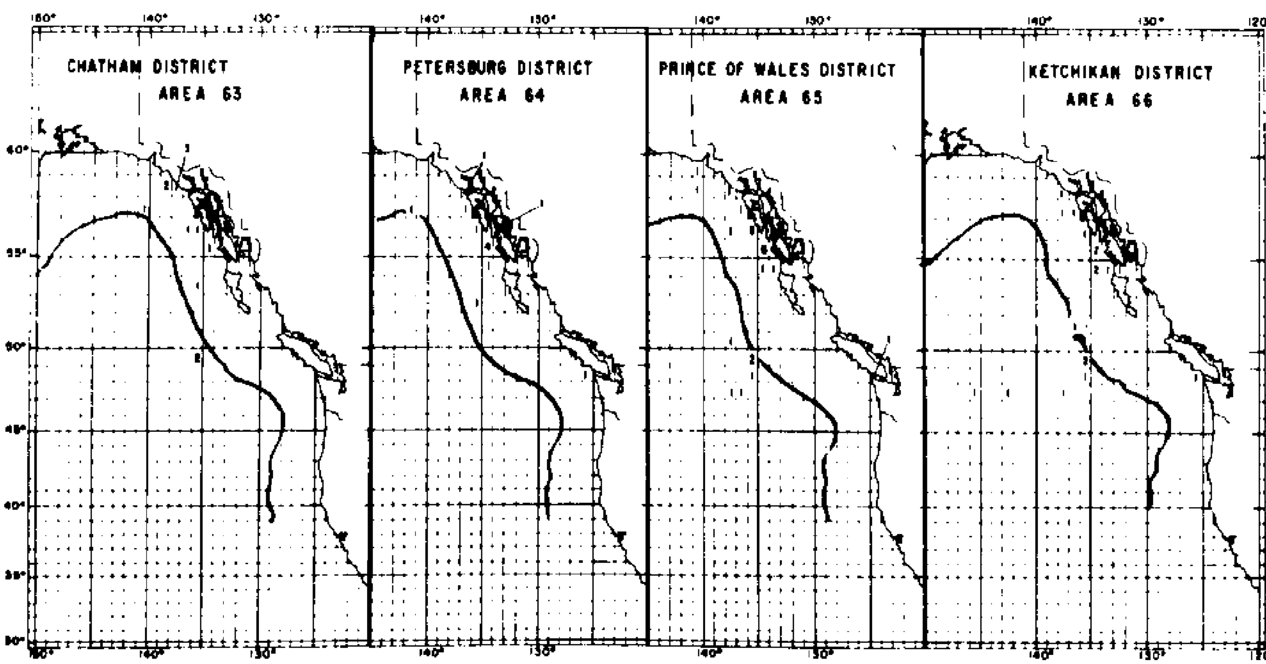


Figure 46 -Tagging locations of maturing coho salmon recovered in the Chatham, Petersburg, Prince of Wales, and Ketchikan districts.

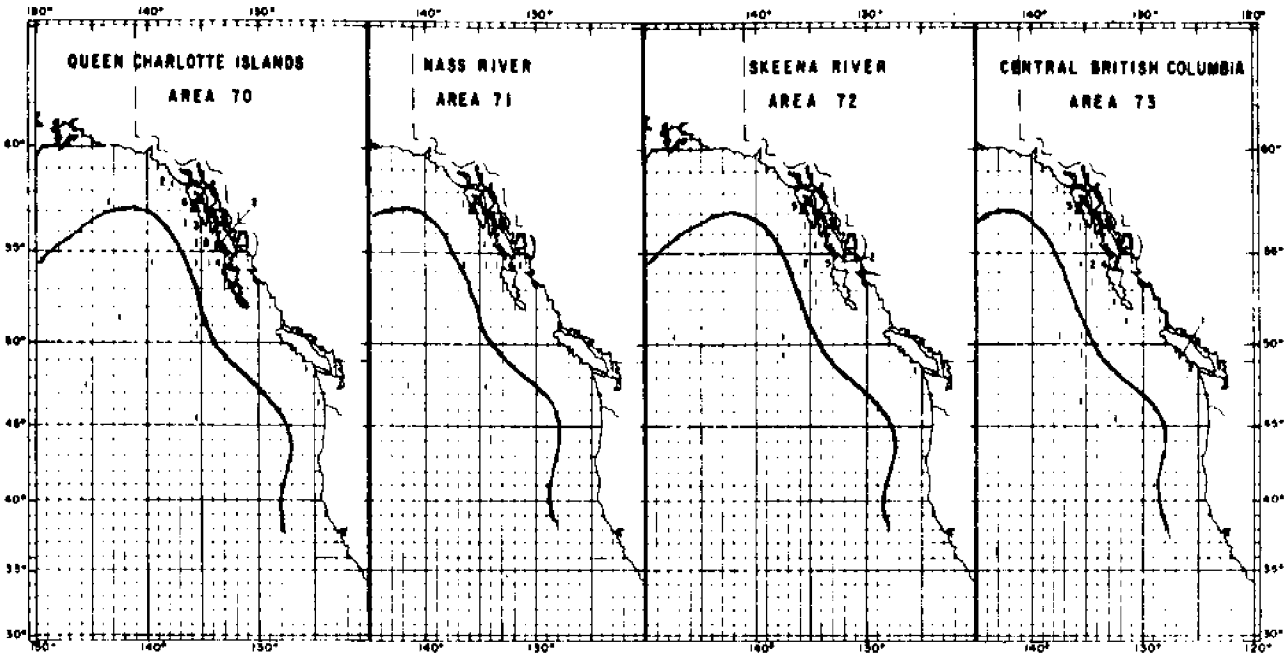


Figure 47 -Tagging locations of maturing coho salmon recovered in the Queen Charlotte Islands, Nass River, Skeena River, and central British Columbia areas.

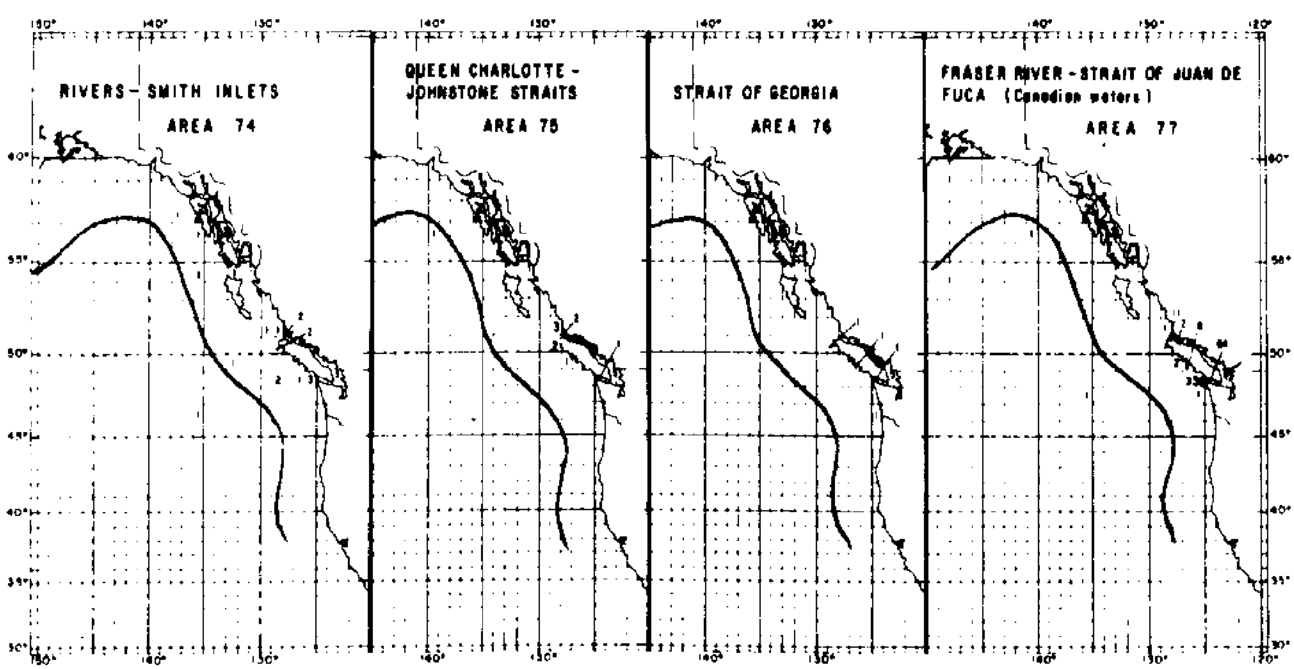


Figure 48 -Tagging locations of maturing coho salmon recovered in Rivers-Smith inlets, Queen Charlotte-Johnstone Straits, Strait of Georgia, and Fraser River-Strait of Juan de Fuca (Canadian waters).

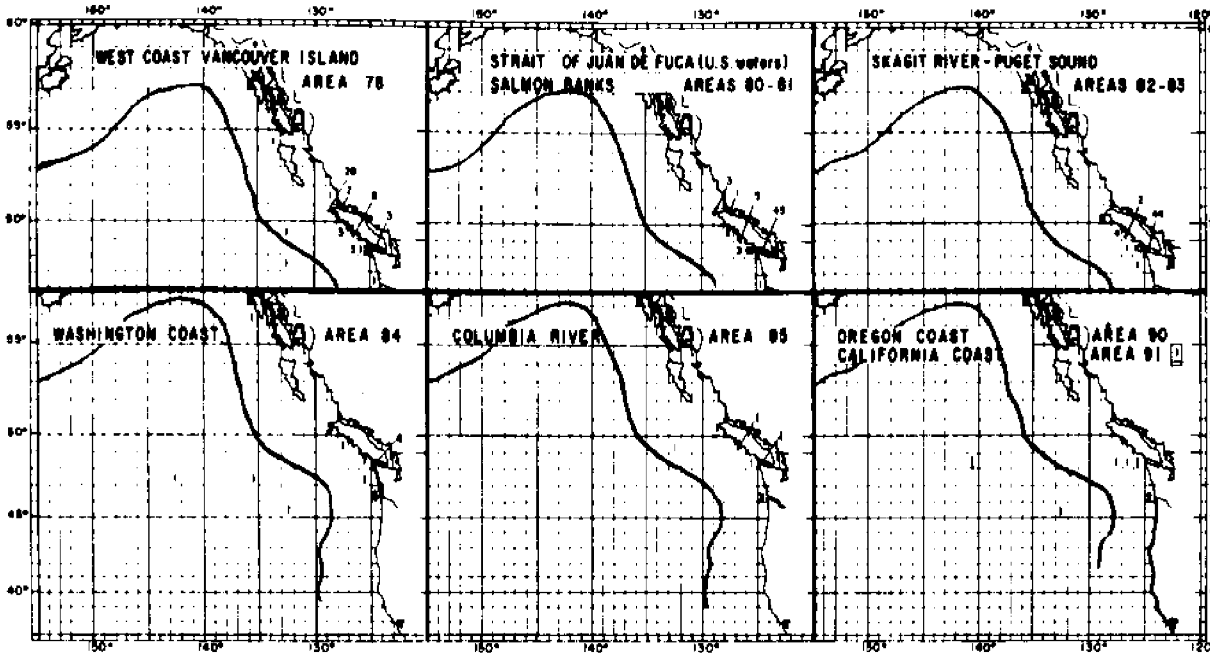


Figure 49 –Tagging locations of maturing coho salmon recovered in the west coast of Vancouver Island, Strait of Juan de Fuca (U.S. waters) and Salmon Banks, Skagit River-Puget Sound, Washington coast, Columbia River, and Oregon and California coast areas.

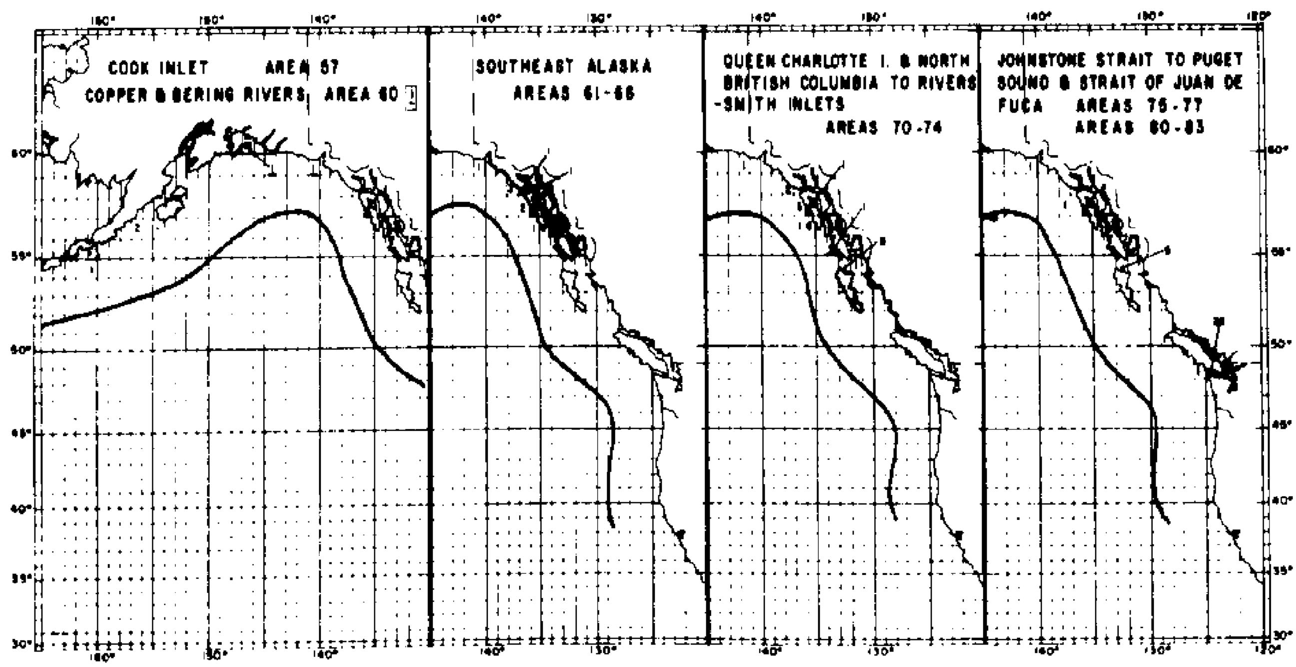


Figure 50 –Tagging locations of coho salmon recovered subsequent to year of tagging in Cook Inlet and Copper and Bering rivers; southeastern Alaska; Queen Charlotte Islands and northern British Columbia to Rivers-Smith inlets; and Johnstone Strait to Puget Sound and Strait of Juan de Fuca areas.

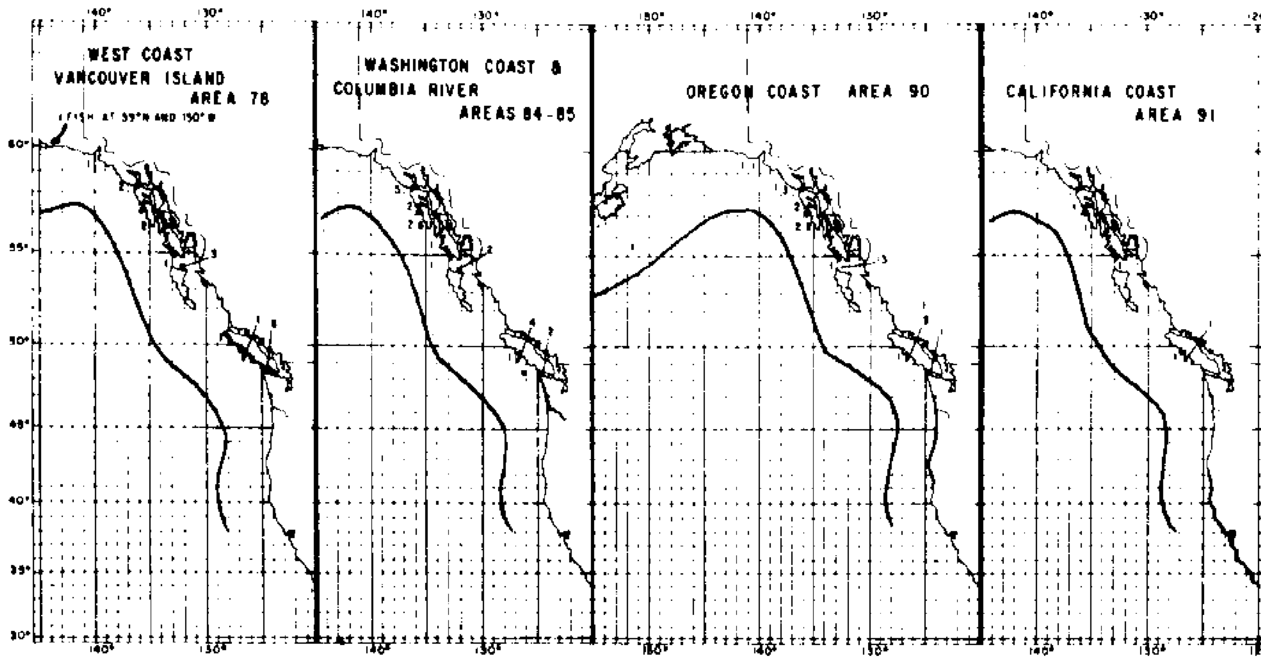


Figure 51 –Tagging locations of coho salmon recovered subsequent to year of tagging in the west coast of Vancouver Island, Washington coast and Columbia River, Oregon coast, and California coast areas.

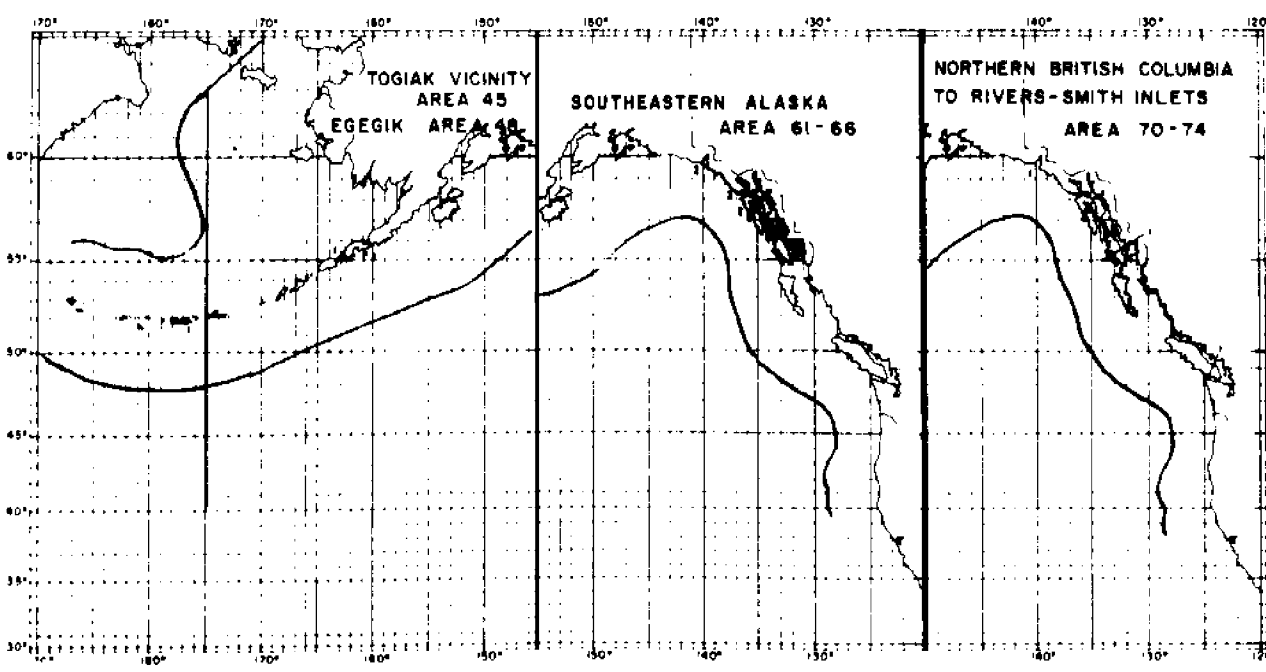


Figure 52 –Tagging locations of maturing chinook salmon recovered in Togiak vicinity and Egegik; southeastern Alaska; and northern British Columbia to Rivers-Smith inlets.

The only area in that vicinity where significant numbers of tagged fish have been released and subsequently recovered is that just south of Adak, from which Asian recoveries outstrip North American recoveries about 2:1. All North American recoveries, incidentally, except one from Kodiak Island, came from western Alaska. This indicates that these are the only two North American coho stocks being intercepted by Japan; other stocks appear to be well protected by the abstention line. Nations other than Japan, however, could have access to coho from many areas should they commence fishing for salmon to within 12 miles of the North American coast.

2. 200-mile limit with continued abstention:

   Japan's access to coho south of the Aleutians would be sharply reduced. Coho from a wide range of coastal areas would remain vulnerable in the central Gulf of Alaska, but much less so than sockeye, chums, and pinks.

3. 200-mile limit without abstention:

   Same as 2 (above), adding Japan as a potential harvester in the central Gulf.

CHINOOK SALMON (FIGURES 52-55)

1. With abstention and a 12-mile limit:

   On the basis of stock identification studies other than tagging, Chinook salmon (particularly immatures) from western Alaska, are extremely vulnerable to the Japanese mothership fishery west of 175°W in the Bering Sea and in the North Pacific Ocean. There have not been enough tag recoveries to comment on the vulnerability of chinook salmon to other would-be exploiters beyond the current 12-mile limit in the eastern Pacific area.

2. 200-mile limit with continued abstention, and

3. 200-mile limit without abstention:

   Chinook, particularly that segment of immature fish from streams flowing into the Bering Sea in western Alaska, occur seaward from North America's 200-mile limit and could still be harvested in the central Bering Sea. Other regional stocks would appear to be protected by the 200-mile limit with or without abstention.

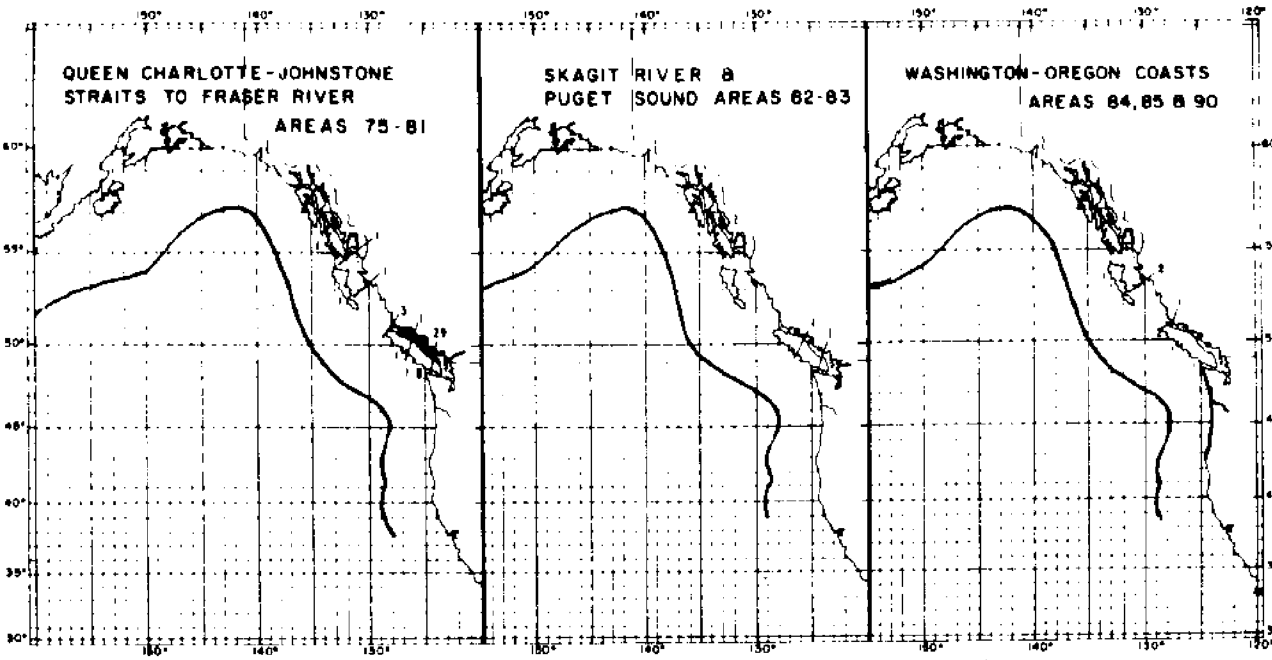


Figure 53 –Tagging locations of maturing chinook salmon recovered from Queen Charlotte-Johnstone Straits to the Fraser River; Skagit River and Puget Sound; and Washington-Oregon coasts.

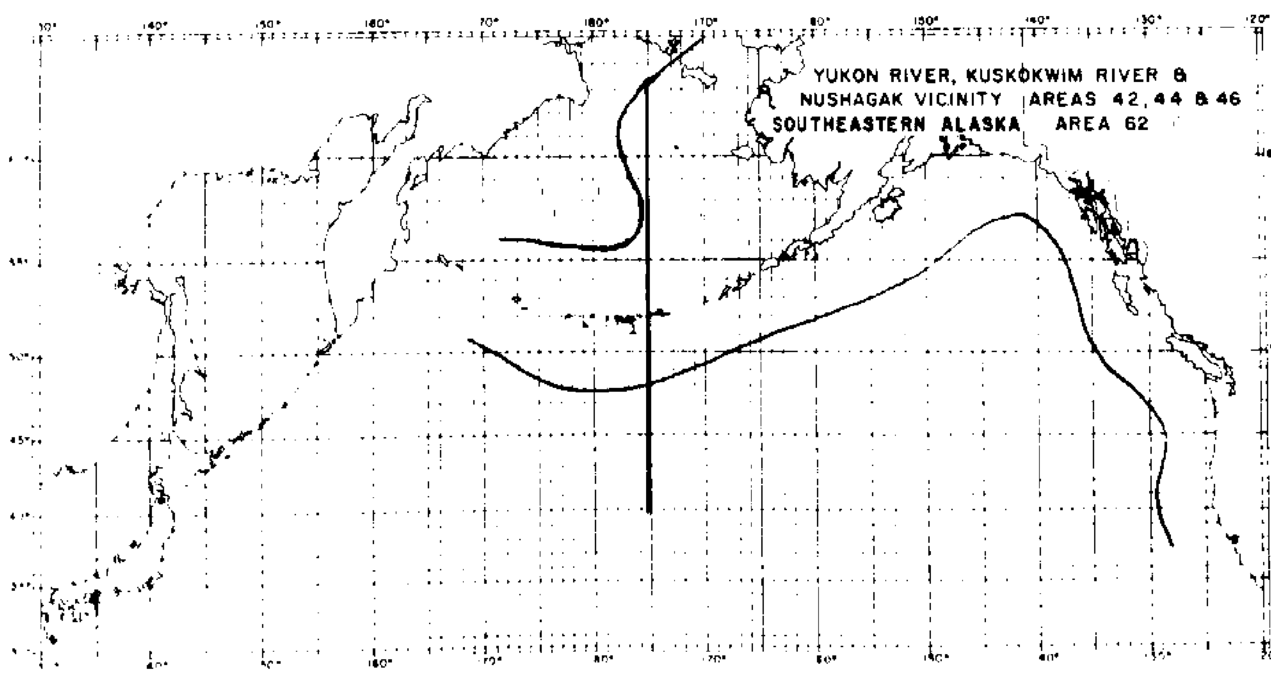


Figure 54 –Tagging locations of chinook salmon recovered subsequent to year of tagging in the Yukon River, Kuskokwim River, Nushagak vicinity, and southeastern Alaska.

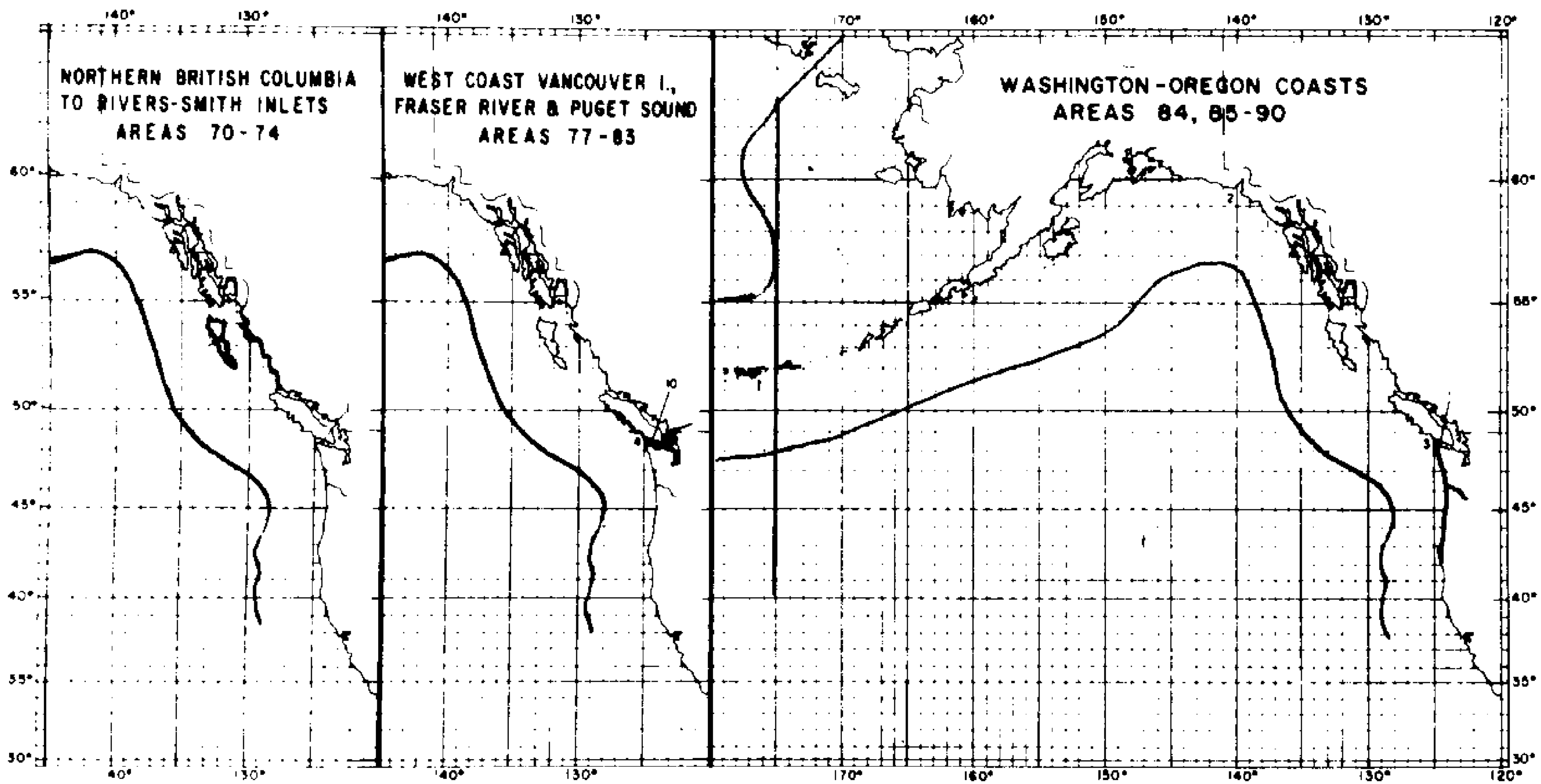


Figure 55 –Tagging locations of chinook salmon recovered subsequent to year of tagging from northern British Columbia to Rivers-Smith inlets; west coast Vancouver Island, Fraser River, and Puget Sound; and Washington-Oregon coasts.

In summary, and considering Japan to be the major threat to North American salmon, 200-mile fishing jurisdiction, coupled with the current abstention provision, would significantly reduce foreign interceptions of Alaskan salmon. Two hundred-mile jurisdiction without continued abstention would make more North American salmon, from virtually all regions, available to foreign fishing in the central Gulf of Alaska.

REFERENCE

French, R.R., R. G. Bakkala, and D. F. Sutherland, 1975.

Ocean distribution of stocks of Pacific salmon, Oncorhynchus spp., and steelhead trout, Salmo gairdneri, as shown by tagging experiments. Charts of tag recoveries by Canada, Japan and the United States, 1956-1969. Tech. Rep. NMFS-SSRF-689 National Oceanic and Atmospheric Administration.

SOME COMMON PROPERTY IMPLICATIONS WITH PRIVATE NONPROFIT SALMON HATCHERIES

John Wiese
Journalist
2104 Sunrise Drive
Anchorage, Alaska 99504

There should be no question about the appropriateness of programs that seek to supplement the natural and wild reproduction of salmon stocks.

In the face of the tragic diminishments of natural salmon stocks, it is, in fact, especially appropriate that such programs be undertaken.

It has been primarily as a result of the various "civilized" operations of contemporary man that diminishments have set in. These misadventures - inconsiderate developments as well as overharvesting - materially added to damages to salmon stocks that came from nature's roster of cyclic disturbances; and it is fully in order that man's governing agencies rectify at least that portion for which his culture is responsible.

It seems especially appropriate that steps be taken in this state - Alaska - to keep its unique marine resource in existence as closely as possible to the levels of abundance with which nature provided the region.

At the same time, it is also appropriate that this be accomplished with a minimum of disturbances for institutional arrangements that are valued by modern society. It would hardly be appropriate to substitute one set of ailments for another - that is, to make the cure more devastating than the illness.

The "private nonprofit hatchery" program was a result of frustration politically expressed. This frustration developed among fish-users - primarily commercial fishermen - following realization that salmon resources in Alaska had diminished to dangerously low levels and that government in the state had not moved effectively to provide remedies.

They literally lost faith in bureaucratic and other political processes and, in their frustration, looked for other media to work at restoration of stocks that provide their livelihoods. Even establishment of a "Fish Rehabilitation and Enhancement Division" didn't appease the frustration.

"Get it out of politics!" was one cry often heard with this. (It is still common.)

Political engineers, prompted by elaborate and often exaggerated reports of allegedly successful private operations elsewhere, hatched out the state's enabling bill for private hatcheries embellished by promises of public funding, of course.

The matter offered here for examination with this presentation concentrates on circumstances that obviously are developing around and in the State of Alaska's authorization in the 1974 legislation for establishment and operation of what are termed "private nonprofit hatcheries," the most notable application of which is the Port San Juan endeavor of the Prince William Sound Aquaculture Corporation, the host for this symposium.

Perhaps the easiest way to introduce this issue for examination is to pose some questions, such as:

- In the light of the "common property" concept of ownership of the fish and wildlife stocks in Alaska, is it fully realistic to expect the state's private nonprofit hatchery program to be a success without revising either the program or the "common property" tradition?

This question is intensified by the fact that the "private" nonprofit efforts are functional only with the input of major volumes of public financing in one form or another.

Another question is

- Are there alternatives to the private nonprofit features of the Alaska program as instituted - alternatives other than leaving the whole salmon rehabilitation chore to the state (or federal) agencies that are charged with fisheries management?

(It should be noted that what is being discussed here is the program that seeks to supplement wild stocks of fish and not the "fish farming" venture in which the stocks are propogated, nurtured and matured totally in a captive environment entirely distinct from the public marine domain - that is, undertakings like trout farming or catfish farming in privately controlled ponds and the raising of sedentary species like oysters in marine areas that are tidal-washed. Such are not the concern here. This presentation is concerned exclusively with stocks like salmon that may be hatched in a man-controlled environment, nurtured by man-devised means to a point at which they can survive in marine waters like wild stocks, and then be released to travel to marine areas where they will pasture in the public domain like (and together with) the natural wild stocks to attain maturity and 90% or more of their size and usefulness.)

A companion question akin to the foregoing is also in order:

- How valid is an effort for enhancement and utilization (as a social/economic measure) that confines itself to one stock or species - salmon - without reference or relationship to other natural resource stocks?

The goal of enhancement is, first of all, to assure an availability of the resources so they may serve and be utilized. "Achieve a public benefit" is the phrase used here yesterday by Director Ron MacLeod. These programs are not authorized or supported to be idle exercises for frivolous diversion or entertainment.

This companion question is put here to suggest that with salmon enhancement through private nonprofit aquaculture simultaneous attention should also be given to the use of the diversity of other stocks available for public benefit.

It is really doubtful that an exclusively "salmon culture" type of primitive society is desired these days - like the primitive situation that Dr. George Rogers told in his anecdote about aboriginal Klamath Falls people and their "fishing and fornicating" situation.

It has been traditional that fishes occurring in nature - the wild stocks - are "common property." That is, they are owned publicly (or "by the people") in their natural state and not by individuals, persons or otherwise. There has long been a great deal of controversy over what constitutes "the public" or "the people," admittedly.

In very recent years there has been a distinct tendency toward instituting changes in this common property tradition and in some of the mandates that were established as law from this tradition.

The Alaska constitution contains specific citations on the point of such mandates with passages such as:

"The Legislature shall provide for utilization, development and conservation of all resources....for the maximum benefit of its people."

"...fish......are reserved to the people for common use."

"No exclusive right or special privilege of fishery shall be created or authorized..." which has been amended with provisos for limiting entry and for aquaculture, but without explicit permission to obliterate the common use requirements for such stocks.

The first two passages here recited mandated the common property characteristic of fish resources. The third one mandated that this common property is not to be privately appropriated or assigned. The amendment referred to clarified this to permit temporary assignment, but not permanent assignment.

The tendency to seek changes from the common property concept toward defacto appropriation for effective permanent assignment into a permanent private property status is not unique with the situation of fish stocks in Alaska. Neither is it unique with salmon.

- An element of this tendency exists as a distinct characteristic in actually functioning programs for restricting participation in fisheries like in Alaska's and British Columbia's "limited entry" regimes governing salmon harvesting, as well as in other similar projected but unimplemented programs in other states.

- To a substantial extent, at least, a part of the pressure for U. S. unilateral extension of fisheries controls out to "the 200-mile line" is generated by this tendency that seeks a switch from traditional common property doctrine in favor of something closer to a private-property status for marine-fishery resources, especially for the more valued and utilized species.

This matter was discussed recently in an article by U. S. Sen. Ernest Hollings (from South Carolina), who is the chairman of the prestigious Senate Ocean Policy Study Group. He noted (in Oceanus) under the heading "Marine Fisheries Management" that the currently envisioned 200-mile jurisdictional expansion would include "limited access into fisheries (that) would also result in the creation of some form of quasi-property rights" in fishery resources. The goal of this change toward private property status was given as "increased efficiency and lower consumer prices."

One of the earlier advocates seeking changes from traditional common-property concepts for fish stocks is William Harrington, who began a lengthy career in governmental fisheries management as a biologist associated with the late Dr. W. F. Thompson when the latter led efforts toward a North Pacific halibut conservation regime during and after World War I. Harrington subsequently served the U. S. State Department as its fisheries ambassador and, on retirement from government service, joined the staff of the University of Rhode Island's Law of the Sea Institute.

A frequently repeated conviction of Harrington's observed, "The fisheries of the United States will never experience genuine stability from either an economic or a conservation standpoint until the industry is able to operate, like our agriculture industry, from a base of resources that are privately owned and managed with the same kind of rational efficiency that has made American agriculture such a landmark success."

- It would seem that a piece of national legislation that could be as vital to public policy as the current Magnuson bill designed to institute a federal fisheries management system (including unilateral 200-mile jurisdiction) would state a position treating on the "common property" doctrine. But it doesn't do so!

This measure (S.961) meanders through other policy areas, but not even by implication does it recognize any feature of a common property characteristic of the resources it seeks to govern.

Could it not be that this means that it is really another thrust to alter the traditional doctrine? What then does this do to the Alaskan constitutional prescriptions on the issue? (Or to the all-most-sacred "abstention" doctrine's basic philosophy?)

To get back to the specifics in the situation of private nonprofit hatcheries in Alaska:

At least some of the element anticipating (or, maybe, hoping for) changes in Alaska salmon stocks from common property into effective private domain has been evident recently. Some such indications have surfaced here in the discussions in this symposium and in questions asked here.

This subject deserves some earnest attention. It is too important to pass by.

The Prince William Sound Aquaculture Corporation's hatchery effort is, of course, not the only venture being undertaken currently. Others - over 50, according to State Fish & Game Department information - elsewhere in the state are projected or are in a process of being promoted.

A published report dealing with one such venture this past fall noted that "some states....now permit private profit hatcheries.... and Alaska (may) soon follow" this policy. The author of the comment also advanced the observation (as it was reported) that the thing to do is to start now with the so-called "private nonprofit" venture because "thus far this is all there is," implying, "get in on the ground floor and cash in later on!"

This is not to imply that the Prince William Sound leadership has this tactic in view. Quite the contrary is doubtless true, although if scuttle-butt is a reasonably accurate indicator, there are elements even here (in Cordova) who see golden opportunities.

"Think of this," one local conversation discoursed, "suppose the aquaculture deal operates successfully and they come out with earnings for themselves, plus producing some good big 10-to-12 million pink runs that can be caught before they get back to the hatchery stream.

"And, in the meantime, the 'buy-back' part of the limited entry scheme has been operating so that there are only 60 or 70 of us with seine permits sharing in those runs. You think we won't have a real big thing?"

Probably this isn't typical. But the point is that the opportunity-sensing is at work, and it distinctly smells an end to salmon's being "common property."

Another item in a somewhat different vein:

How proper is it, actually, to term a program "private" when the funds putting it into being are from public coffers, for the most part, adding to the publicly-owned character of the resource involved, especially if the prospects for its continuation may well require substantial continuing public funding?

Public funding for salmon restoration is certainly in order, but should it actually accommodate an abandonment of or encroachment into the public ownership of natural resources traditionally dedicated "for common use?"

Questions put to Commercial Fisheries Division Director Carl Rosier yesterday, as well as certain other comments here in this symposium, gave some pretty distinct implications that at least some serious bending of the applications of the common property concept regulations do exist.

It was asked, for example, whether the state authorities would accommodate private efforts by, in effect, restraining common-property fishing operations for private-hatchery financial benefits as well as by regulating fishing to provide them with brood stocks.

Also, could not salmon streams already stocked with natural fish runs be assigned to private hatcheries (now restricted to essentially barren streams)?

Are not these instances definite indications that a desire exists or is building toward invasions of the common property doctrine?

It is to be expected, of course, that this contention calling attention to violations of the common-property concept will be contested and denied. Also, there will be efforts exerted to side-track the issue by, for example, insisting that it is a matter that ought to be decided or adjudicated in processes before courts - by legal machinations, that is. Such a contention is, however, strictly an evasion of actual responsibilities.

This matter is not, in the first instance, a "legal" issue. It is distinctly a social and moral problem at its root. And to obtain any degree of remedial effect requires political processing.

Another way of saying this might be to state that, before this issue can be regarded as a "legal" (or "judicial") problem for which legal processing can be used rightfully, it is a political issue and must be politically processed for meaningful rectification.

It is also important to pursue the question noted earlier in this discourse:

Since even a cursory examination of circumstances relating to the Alaskan "private nonprofit" hatchery program, as instituted, confirms that it has problems requiring attention - that is, social and political problems and not only the technological variety - are there alternatives in part or in the whole? What are they? Are they practical as well as popularly palatable?

The answer should be "yes" as to the possibility for alternatives.

As to practicability and palatability, some will respond with "could be," some "maybe, depending on current imponderables" and some "no way!"

It should be feasible, for example, to change the structure of the "private" feature of the present hatchery program to some form of a public corporation.

In some regions the hatchery facilities could be owned by borough municipalities for basic policy-promulgation and for accountability under state-legislated guidelines (as in Kodiak or Cook Inlet). Or maybe combinations of municipalities could be authorized (legislatively) to form a sort of "port authority" entity. To these could be inserted provisions for certain administrative or management participation by private sector elements associated with fisheries industries. Since public-sector agencies can have taxing and similar funding capabilities superior to private potentials, financing problems would be simplified. "Voluntary" assessments could be replaced with improved and stablized procedures, and receipts from "surplus" fish sold at hatchery locations could be accounted for with appropriate public accountability.

An alternative (to the present "private" operation) might be the formation of public corporations directly under state charter with appropriate ownership, fiscal controls, and accountability thus under public scrutiny.

It should be remembered that the Alaska "private nonprofit" hatchery program was devised hardly more than a year ago as a political response to dissatisfaction with state functions in fish stock management, especially in the salmon-resource management.

The dissidents, whose concerns led to this new program, generally shared anxieties about governmental efforts in the application of technologies to try to rescue salmon resources from their depleted condition. But they seldom held mutual analyses about the nature or magnitude of the malaise in a social sense.

Devising a model for a more adequate operating authority for these hatcheries ought to be participated in very broadly - ideally as broadly as the diversity of the identities that make up the ownership of the state's natural fish resources. And the ultimate implementation for it must, of course, be legislated.

The crux of the issue at hand is: it is timely and appropriate now to take a good critical look at this new program - the sooner the better - to seek out and to make the adjustments necessary so that it can perform a genuine service, and to guard effectively against what could prove to be a regrettable exercise violating a socially valuable doctrine - popular ownership of natural resources like salmon and other fish.

THE ECONOMIC IMPLICATIONS OF ALTERNATIVE FORMS OF BUSINESS ORGANIZATION FOR ALASKA SALMON RANCHING VENTURES

Franklin L. Orth
School of Management
University of Alaska
Fairbanks, Alaska 99701

INTRODUCTION

The purpose of this paper is to explore the importance of institutional arrangements for the development of salmon hatcheries in Alaska. By institutional arrangements, I mean in particular the organizational form of the hatchery firm. The central theme is that, because economic feasibility of hatchery firms will be dependent upon variables that may be highly volatile over time, (e.g., price, costs, productivity, and public management policies), institutional arrangements, rather than being of little significance, can be a crucial element in making hatchery development work as intended for Alaska's salmon fisheries. The policy implication which will follow from my remarks is that a very restrictive policy toward hatchery-firm organization, one which forecloses all but the nonprofit form of organization, may retard hatchery development and that a more liberal policy designed to encourage profit as well as nonprofit firms (and perhaps hybrids of these forms of organization) would be more conducive to private-sector hatchery development. This view does not deny that there may be historical, cultural, or philosophical bases for restricting hatchery firms to the nonprofit form, but it does contend that it is important for society to be aware of, and weigh, the economic implications of exercising its values through restrictive policies.

I approach this topic with some misgiving because I know that many people here and elsewhere already have strongly held opinions and because, as a result, it appears that the State of Alaska may have prematurely committed itself to a particular institutional approach. Nevertheless, it is important for both sides of the institutional issue to be examined.

WHY STUDY ECONOMIC FEASIBILITY?

Before I go on to a discussion of those aspects of the economic and physical environment which make institutional arrangements an important consideration for hatchery development, I would like to digress for a moment to discuss what I consider to be the primary uses of economic-feasibility analysis. The least important initial use of feasibility analysis, as it applies to salmon-hatchery development in Alaska, is to provide a precise statement of whether or not a particular hatchery investment is feasible. This rather startling conclusion follows from the fact that a precise cut-off point for or against feasibility is a mirage founded on the assumptions that the determinants of economic feasibility are measurable without error and that they are unvarying through time (or at least that they are predictable without significant error). At best, a statement about feasibility is really only an estimate, applicable to the particular hatchery studied, for the current period and under the assumptions made.

What initial studies of feasibility do provide are (1) an explicit statement of the factors upon which feasibility depends, (2) estimates as to the relative importance of these factors under present or anticipated conditions, (3) a model through which impacts of changes in determinants of feasibility can be evaluated, and (4) a model through which management can evaluate the effects of alternative strategies, particularly with respect to site selection, species selection, hatchery capacity, and the type of technology.

Only after the parameters of feasibility and their relative importance are well understood can feasibility analysis become a relatively mechanical procedure for making "accept" or "reject" decisions within the hatchery firm. In the early stages of development of the salmon-hatchery industry, I believe that the educational, analytical and policy-evaluation roles for feasibility analysis are paramount. Only after we become knowledgeable about the "relevant range" of some of the important variables affecting feasibility does the mechanical intra-firm decision-making role of feasibility analysis become the dominant application.

THE NATURE OF A HATCHERY FIRM AND ITS INTERACTION WITH THE ECONOMY

Now, in order to evaluate the relevance of the organizational form of the hatchery firm, it is useful to view the hatchery in the context of the economic environment in which it will function. Figure 1 is intended to facilitate this exercise. The primary economic interactions can be summarized as follows: (1) the hatchery firm incurs costs to produce, after a lag, returning adult salmon, (2) the returning adult salmon are captured by the offshore fishermen, creating external benefits, and by the hatchery firm, creating internal benefits, (3) from the viewpoint of the hatchery firm there is considerable uncertainty about the percentage of released fry that will return as adults to the region and, once there, what percentage will become the property of the hatchery (that is, the division of total benefits between internal and external benefits), (4) the sales revenues (internal benefits) of the hatchery may or may not be sufficient to cover all costs of resources required to produce the salmon, (5) if sales revenue do not cover costs, some part of the external benefits created in the common-property fishery could, on economic grounds, justifiably be transferred to the hatchery to assist it in covering costs, and (6) in the latter case some mechanism is needed for organizing a voluntary transfer to the hatchery of some of the benefits received by parties external to the hatchery firm. Examples of this type of transfer are fishermen and processor self-assessments paid to Prince William Sound Aquaculture Corporation.

INSTITUTIONAL ARRANGEMENTS AND ECONOMIC FEASIBILITY

These are the primary attributes of the economic environment facing hatcheries, and their listing leads us directly to the question of the organizational form of the hatchery firm and its relationship to the potential for economic feasibility. The primary organizational alternatives are (1) public hatcheries, (2) private nonprofit hatcheries, and (3) private profit-seeking hatcheries. Presumably, in the private sector, corporation, partnership and proprietorship forms are possible; and the form actually adopted in an unrestricted environment would be that which most suited the preferences of the entrepreneurs involved; and these preferences would reflect, at least to some extent, the economic realities peculiar to each case.

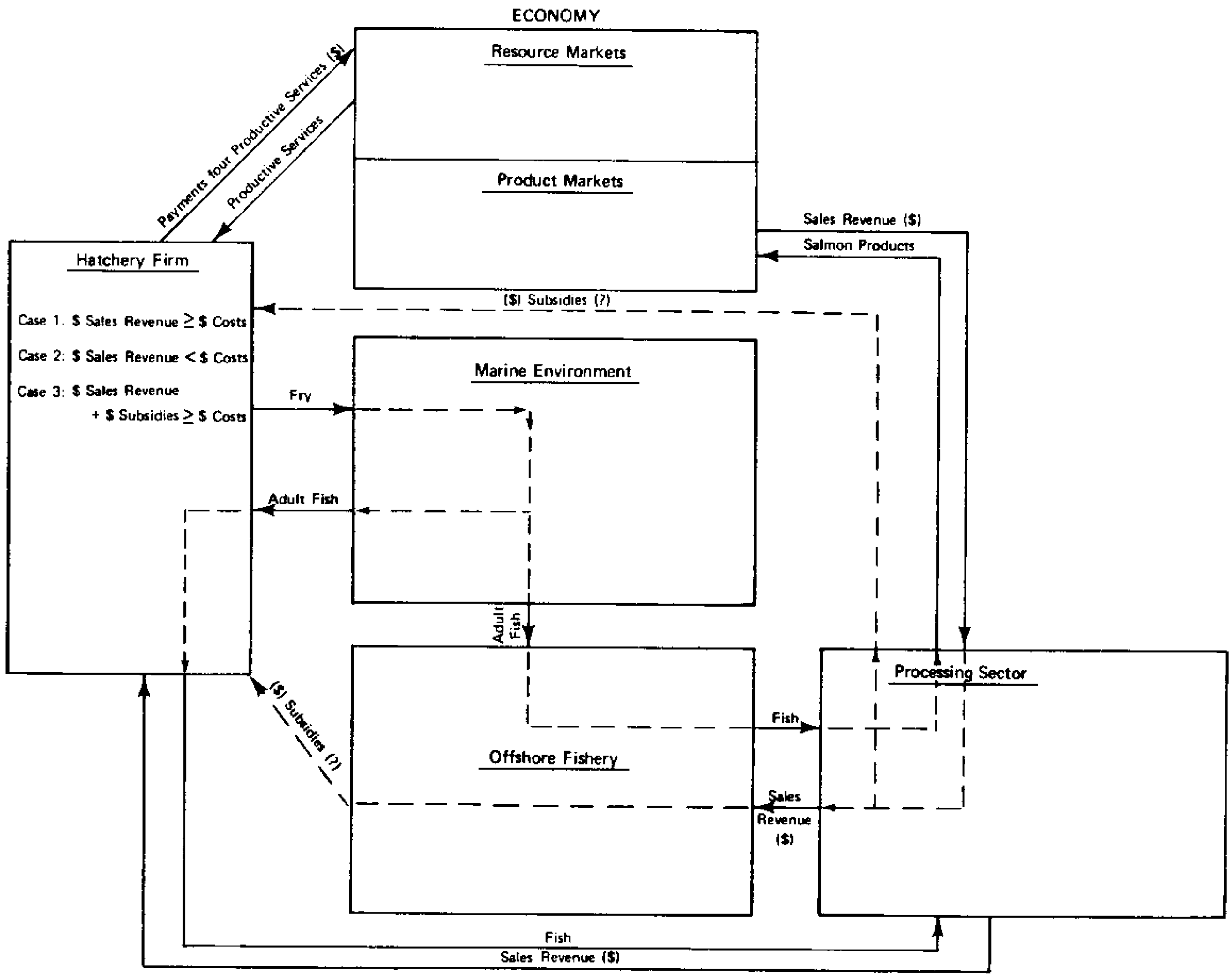


Figure 1. Benefit and Cost Flows Associated with Salmon Hatcheries.

Dealing first with the public hatchery alternative, the significant external benefits associated with salmon hatcheries is a point in their favor. In fact, public hatcheries may be required if the private sector proves to be unable to channel some of the external benefits into private hatchery firms, should such transfers be necessary for their survival. Points against public hatcheries as the primary mechanism for accomplishing hatchery development in Alaska are: (1) the demonstrated relative inefficiency of the public sector in conducting activities having attributes found primarily in the private-business sector of the economy; and (2) the marketing conflicts that are sure to develop between the private, offshore fishery and the state when harvests at state hatcheries are absolutely or relatively large. Weighing the pros and cons of public hatchery development leads me to favor private-sector hatchery development as the primary mechanism for enhancement, if it proves to be an economically and biologically feasible approach.

I have developed the economic case for private nonprofit hatcheries elsewhere so I will only summarize the arguments in their favor here.[1] First, private nonprofit salmon firms have the potential for representing broad groups of people, in particular the people who will be receiving the external benefits from a hatchery. If such representation materializes in general (as it has in the Prince William Sound Aquaculture Corporation) the hatchery firm is in a good position to arrange for the voluntary transfer to the hatchery of some of the external benefits (in the form of dollar transfers) as the need arises.[2] Such transfers would augment the sales revenues of the hatchery to help cover costs incurred by the firm and would thus overcome what may prove to be the major economic deterrent to private hatchery development, namely, the generation of sufficient sales revenues to cover costs. The second point in favor of private nonprofit hatcheries also derives from their potential for broad representation - this point is that the potential for marketing conflict between the nonprofit hatchery firm and the offshore fishery would be minimized when large (absolute or relative) hatchery returns are realized. If hatcheries eventually contribute a significant part of the total harvest each year, this would be no small advantage.

A point against the nonprofit form of organization might be the absense of intense internal pressure to be efficient. Efficiency is a matter of degree and is difficult to generalize about, primarily because it has both static and dynamic dimensions. Nevertheless, I feel reasonably safe in stating that the internal pressure for efficiency in a nonprofit firm would in general be less intense than in a profit-seeking firm.

Finally, with respect to the private, profit-seeking form of organization, there is a disadvantage, the seriousness of which will only become evident with experience: a hatchery firm organized for profit will find it difficult to obtain financial support from external parties who benefit from its operations. That is, the voluntary transfers discussed above would not be forthcoming. The realized division of hatchery fish between the offshore fishery and the hatchery, and the implications of that division for the profitability of the hatchery will determine the dependency of a hatchery on outside support. If outside support is required, the nonprofit form of organization will result in more rapid hatchery development than the profit-seeking form. The advantages of the profit-seeking form of organization are the tendency toward efficiency, ingenuity, and resourcefulness found in the reasonably competitive, profit-seeking sectors of our economy, and the greater flexibility inherent in this form of organization. By flexibility, I mean that there would be more potential sources of resources - particularly capital and managerial ability - available to hatchery development if profit-seeking firms were allowed. Investments might be forthcoming from large corporations, from established Alaska businesses, and from small entrepreneurships. Every conceivable type of firm would be a potential investor in hatcheries. In those cases in which private hatcheries prove to be economically feasible without support from external beneficiaries, then it seems clear that profit-seeking hatchery development is desirable. There are two possible objections: one objection would derive from the distributional question, that is, who should benefit (make profits) from hatchery development in Alaska. I personally am convinced that this objection, if subject to rigorous analysis, even under the assumption of complete outside ownership, would turn out to have little substantive merit. I believe this to be the case because profit-seeking hatchery firms would generate substantial external benefits, because scarce capital and management resources would flow into the hatchery industry, and because the classification of benefit recipients into "Alaskan" and "non-Alaskan" is difficult, if not impossible. A second objection might be that there is a potential for conflict between profit-oriented hatchery firms and the common-property fishery. It is likely that such conflicts would not be as great as they would be with public hatcheries, however.

POLICY IMPLICATIONS

I would like to conclude by suggesting what I think public policy should be with respect to the institutional arrangement for hatchery development. First, policy should be non-committal with respect to the organizational form of private hatchery firms, there should be an explicit statement favoring private hatchery development, but there should be no general statement with respect to the form of organization. In some situations, particularly in regions having an established offshore fishery and where the expectation is that a relatively large proportion of hatchery fish will be taken by parties external to the hatchery firm, the nonprofit form would have an advantage and presumably would be the form to appear. In situations where the opposite conditions prevail (no established offshore fishery) the profit-seeking form would have an advantage and would presumably be the form to appear. The point is that the public sector should make it as easy as possible for the private sector to adopt the organizational form which can best take advantage of the incentive characteristics exhibited by each potential hatchery site. If this is correct, then the present policy of restricting hatchery firms solely to the nonprofit form of organization should be reviewed.

A second policy direction would be desirable - public policy should encourage hybrid forms of organization which seek to utilize the superior incentive characteristics of a profit-seeking organization along with the superior representation attributes of a nonprofit organization. The encouragement by the public sector could, for example, come in the form of favoring applications by profit-seeking firms which exhibit broad representation from groups favorably affected by hatchery development. By encouraging such hybrids, the distributional problems that some associate with the profit-seeking form of organization can be partially overcome.

FOOTNOTES

1 Orth, Frank. Economic Feasibility of Private Nonprofit Salmon Hatcheries: An Introduction. Aquaculture Notes, 1975, Sea Grant Report 75-13.

2 Successful representation of fishermen by a hatchery firm is probably dependent upon limited entry. In the absence of limited entry, regional cohesiveness would be absent and the "free-rider" problem would make agreement on a transfer system unlikely. Where there is some other basis for communality, e.g., Alaska Native Corporations, this problem would not be as limiting.

COSTS AND BENEFITS OF PUBLIC AQUACULTURE PROGRAMS

Howard Ness
Economist
National Marine Fisheries Service
Juneau, Alaska 99801

Traditionally in the United States it has been difficult to assign monetary benefits to fish and wildlife resources. There has been opposition to assessing dollar benefits to living resources because of their aesthetic and intrinsic qualities, particularly in recreational fisheries. This unnecessary dichotomy between economics and biology does not exist concerning the Pacific salmon. We, in the Pacific northwest and Alaska, have long realized the value of, and economic dependency on the commercial and recreational salmon fishing industry. We have yet, however, to fully understand the costs of constructing and managing fish production facilities. Efficient cost factor allocations of hatchery facilities are difficult to determine because cost accounting documentation is often incomplete or difficult to find.

Recent changes in the Federal government's Office of Management and Budget policy have directed fishery administrators' attention toward production costs and the monetary and social benefits that will accrue from increased production or rehabilitation. Scientists and farm managers who have been analyzing traditional agriculture practices for many years can now assess the unit costs of a fertilizer additive or of a new farm implement and acquaint that cost with a marginal production unit. Because large production scale aquaculture is in its infancy in the United States, the industry has not yet had time to fully assess the economics of full-scale production models. There are two major exceptions. One is the catfish industry in the southeastern portion of the U. S., which consists of thousands of acres of privately-held catfish production. This industry has experienced a steady growth rate over the last few years, and economic analysis of the success and failures of this industry by NMFS economists is extremely helpful. The other exception is the trout hatchery production industry concentrated in the Rocky Mountain states. This $25 million-dollar-a-year industry is well established, and production economics are generally understood.

The aquaculture of anadromous fishes has been traditionally accomplished by the public sector. The most well-known of these systems is the Columbia River fishery development program initiated in 1949. This system has produced millions of dollars of monetary benefits to the commercial and recreational salmon fisheries in the northwest. The benefits of these hatchery systems has been questioned; and, in order to determine whether increased financing by the Federal government was justified, benefit-cost-ratio analysis was conducted by the program's staff. Benefits of over $7 return for each $1 invested were indicated for 1965 and 1966 coho broods and $2 - $4 for 1962 and 1963 fall chinook.

However, in each of the reports containing this analysis, a lump sum total cost figure or gross expenditure breakdown was offered to the reader, making it impossible to perform any indepth cost analysis showing how a more efficient allocation of costs could decrease expenditures. Under NMFS contract, Oregon State University researchers recently analyzed the costs of two major Columbia River production systems and found that salmon smolt production could be increased significantly with only a small increase in food costs. This conclusion required some rather sophisticated linear programming, and only meticulously kept production cost records enabled the analysts to accomplish this.

Production cost data is virtually non-existent for incubator hatchery systems. Recent cost returns analysis by the Japanese government-sponsored Hokkaido chum hatchery systems revealed fantastically high benefit cost ratios, some as high as 14:1, meaning that, if the analysts underestimated the cost by 100%, the benefit cost ratio would still be a favorable 7:1. The total production costs were estimated to be 2.3¢/pound of returning adult fish. This compares to a 79¢/pound cost of trout in some of our most efficient public hatcheries in the U. S., and approximately 20¢/pound per returning coho adult produced in the Columbia River system.

University of Alaska Sea Grant economic analysts will monitor the costs of the Cordova hatchery operation. We hope that this will become public information and will benefit both the public and private sectors in determining efficient production methods. Almost all of the existing cost-benefit and return analysis is predictive and utilizes information that is purely speculative and not based upon actual production models.

All of the economic forecasting of salmon incubator hatchery system production that this author has reviewed concludes that the greatest benefit and profit-determinant factors are the biological considerations, and production cost projections can have a wide variance.

A final cost consideration is that events caused by widespread artifical propagation clearly have the potential to decrease our wild stocks. This could occur by over harvesting wild stocks if total quotas are designed to harvest hatchery-propagated stocks and if undesirable traits occur due to genetic degradation between wild and artifically propagated salmon stocks. This trade off could have the net effect of lowering the benefit-cost ratio.

Adequate escapement, assuring good natural propagation, is the most efficient production method of all, and artificial propagation should never be thought of as a low-cost substitute for natural production until all of the opportunity costs of wild-stock maintenance are examined. It should be thought of primarily as a supplementive and rehabilitative tool in fishery management until it is shown to be a satisfactory replacement for wild stock production.

A Memorandum of Agreement between Oregon State University, University of Alaska, and the National Marine Fisheries Service in Juneau regarding salmon aquaculture economic research was initiated last summer. Among its provisions are economic analysis of fish hatchery and rearing costs and benefits as the industry and the State of Alaska develop salmon aquaculture systems.

We hope that economic analysis will be used to develop foresight rationale in the form of reliable predictive models and be based upon current cost-benefit data rather than attempting to reconstruct past mistakes by using incomplete economic information.

BIBLIOGRAPHY

Arp, Arthur H., Joe H. Rose, and Steven K. Olhausen (1970). Contribution of Columbia River Hatcheries to Harvest of 1963 Brood Fall Chinook Salmon (oncorhynchus tshawytscha), Economic Feasibility Report No. 1, Columbia Fisheries Program Office, NMFS, NOAA, U. S. Department of Commerce, Portland, Oregon (December), 33 pages.

Brown, William G., and Ahmed Hussen (1974). A Production Economic Analysis of the Little White Salmon and Willard National Fish Hatcheries, Special Report No. 428, Agricultural Experiment Station, Oregon State University, Corvallis, Oregon (December, 15 pages).

Handy, Paul (1976). Personal communication. Fish and Wildlife Service, Department of the Interior, Portland, Oregon.

Okamoto, Yutaka Jake (1975). A Preliminary Study of the Chum Salmon Stock Rehabilitation Program, or, as it is Called "Salmon and Trout Hatchery and Release Project," of the Hokkaido Salmon and Trout Hatchery System of Sapporo, Hokkaido, Japan, Pacific-Rim Development Research Associates, Anchorage, Alaska (April), 43 pages.

Richards, Jack A., Conrad V. W. Mahnken, and George K. Tanonaka. Evaluation of the Commercial Feasibility of Salmon Aquaculture in Puget Sound, Northwest Fisheries Center, NMFS, NOAA, U. S. Department of Commerce, Seattle, Washington, 19 pages.

Robinson, Clay. "The Commercial Trout Industry - How it All Began," Fish Farming Industries, Vol. 5, No. 4. August-September 1974, pp. 10-13.

Rose, Joe H., and Arthur H. Arp (1970). Contribution of Columbia River Hatcheries to Harvest of 1962 Brood Fall Chinook Salmon (oncorhynchus tshawytscha), Bureau of Commercial Fisheries, Columbia Fisheries Program Office, Portland, Oregon (April), 27 pages.

Wahle, Roy J., Robert R. Vreeland, and Robert H. Lander (1972). Contribution of Columbia River Hatcheries to Harvest of 1964 Brood Fall Chinook Salmon (oncorhynchus tshawytscha), Economic Feasibility Report No. 2, Columbis Fisheries Program Office, NMFS, NOAA, U. S. Department of Commerce, Portland, Oregon (February), 31 pages.

Wahle, Roy J., Robert R. Vreeland, and Robert H. Lander (1974). "Bioeconomic Contribution of Columbia River Hatchery Coho Salmon, 1965 and 1966 Broods to the Pacific Salmon Fisheries," Fishery Bulletin, Vol. 72, No. 1, pp. 139-169.

Worlund, Donald D., Roy J. Wahle, and Paul D. Zimmer (1969), "Contribution of Columbia River Hatcheries to Harvest of Fall Chinook Salmon (oncorhynchus tshawytscha)," Fishery Bulletin, Vol. 67, No. 2, pp. 361-391.

A PARTNERSHIP PROPOSAL FOR SALMON MANAGEMENT

James W. Brooks
Commissioner
Alaska Department of Fish and Game
Subport Building
Juneau, Alaska 99811

In witness of the worldwide assault on the rapid depletion of the ocean's renewable resources, only the most foolhardy optimists still believe that our commercial fisheries can stabilize and prosper without introduction of fundamental changes. The compelling need for transition is the inevitable product of a free enterprise industry remaining dependent on naturally occurring living resources existing in their wild state. History clearly shows that the most rigid regulation is rarely successful in perpetuating commercial enterprises that depend on utilization of such undomesticated resources. Early prosperity in the developmental stages inexorably leads to excessive competition, overcapitalization, diminution of the resource base, and failure of the industry. Where this pattern is disrupted, as it fortunately has been in most of the world's major food industries except fisheries, either domestication and culture of the resource or else total control of competition in harmony with proper management has been the vital and responsible cause. When viewed in the context of other industrial experiences, the problems of our salmon fisheries are more easily understood if not actually seen as inevitable. Similarly viewed, promising solutions to the problems suggest themselves.

Recognizing that our salmon fisheries have parallels in other resource industries with similar evolutionary histories, it is evident that the biologic and economic distress that besets us today can rightfully be attributed to three familiar basic causes: first, deficiencies in the regulatory or management functions; second, high unrestrained competition in the harvest of a common property resource; and third, natural environmental stresses or events that reduce the abundance of the resource. Each of these factors is complex and a challenge in itself. Nevertheless, much progress has already been made in rectifying various troubles, while the essential elements crucial to resolving all three major problems are within our means.

The managerial and regulatory role of government has been played out since the very beginning of our commercial salmon fisheries without adequate policies, plans, or the complement of knowledge and tools necessary to long-term success. The need for fundamental change here is imperative, and changes are indeed at hand. As you know, within the past year, we have circulated for public review a salmon fishery policy document that has generally been accorded high marks for soundness, if not for prose. Furthermore, the administration will shortly offer for review by the newly constituted Alaskan Fisheries Council the first comprehensive plan ever developed for Alaska's salmon fisheries. The plan's goal is to stimulate and direct the actions necessary to restore the salmon fisheries to acceptably high levels of production in the shortest time possible. A major objective of the plan is to overcome past deficiencies in the state's managerial function, and I am confident that the knowledge and technological advances vital to achieving this objective are close at hand.

The second major problem identified earlier was competition, which really means sharing a limited annual crop of mature salmon among a larger number of fishermen while still reserving adequate spawning stock. The commercial fisheries entry program shows promise for halting the increase in the numbers of people directly involved in harvesting salmon. The progress made in implementing this program for our salmon fisheries and the generally good acceptance of this program by the fishermen themselves indicate that competition will no longer be an unmanageable factor that would threaten the economic viability of our fisheries. Thus, it appears that we have effected a fundamental change which should contribute to overcoming one of the most important causes of resource industry failures.

The third and last factor contributing importantly to our salmon production problems is the natural occurrence of environmental extremes that impose rather violent fluctuations on salmon survival rates. While our ability to predict the effects of environmental variations on salmon will no doubt improve, there is no reason to expect that we can control them on a widespread basis. We can, however, control environmental conditions within hatcheries and rearing facilities; and the potential benefits of doing so appear enormous. Thus, it is within our means to introduce a measure of stability in our fisheries by producing a substantial increment of fish that are immune during early critical life-history stages to the inimical extremes and stresses common to the natural environment. We may thus realize the rewards associated with domestication of other wild populations.

I feel comfortable and confident now in addressing the future of our salmon fisheries in a positive vein. The management problems of the past seem certain to yield to the determined efforts and investments of the state. Natural stocks will be rehabilitated, barring ecological catastrophies, by a combination of regulatory and nonregulatory actions. Unrestrained competition has already been harnessed by our limited entry program, and the enhancement of our salmon stocks through hatchery operations can, if approached and developed properly, contribute to the economic wellbeing of the fishing industry while introducing a large measure of stability to at least some of our salmon-producing areas.

Before discussing salmon enhancement, however, I would like to refer to three state laws that laid the foundation for such activities: (1) the 1971 amendment to Title 16 that created the Division of Fisheries Rehabilitation, Enhancement and Development within Alaska Department of Fish and Game; (2) the 1973 enactment of the statute that permits limiting entry to our fisheries; and (3) the 1974 enactment of the statute authorizing private nonprofit salmon hatcheries. Great credit must be given to those individuals, all with roots in the fishing community, who perceived the need for and who furnished the leadership and determination necessary to see these concepts translated into law.

All three laws were clearly intended to benefit an identical constituency composed of persons who participate in and are dependent on our salmon fisheries. I remind you of this consideration because it has influenced departmental policies guiding the administration of both the state-enhancement program and the private nonprofit hatchery program.

It is the contention of this administration that public and private enhancement programs which have the same goals, which utilize the same waters, and which serve the same people should not be allowed to develop in competitive ways. In harmony with this belief is the statutory mandate that the department encourage and assist private hatcheries. So our challenge, on the one hand, is to arrange orderly and constructive participation by the private sector in the state's enhancement programs and, on the other hand, to deliver the assistance and services of the state to private enhancement operations. With the desire on both sides and under the right situations, joint state-private enhancement operations might even be the most efficient and beneficial.

Considering the need for the public to participate in, or at least to influence, the state's enhancement efforts, it is essential that the private sector unify and organize itself so that its representatives reflect the major interests of an area or region. Such organizing has largely been accomplished in Prince William Sound through the formation of the Prince William Sound Aquaculture Corporation. This corporation, with its broad based membership, its excellent plan and objectives, and its competent leadership is truly revolutionary and offers an outstanding pattern for people in other areas to emulate. Given this kind of group to work with, it is altogether proper and possible to coordinate the state's enhancement efforts and plans with those of the private sector. There should be no difficulty in reaching a concensus on the location of state hatcheries, the species to be produced, the size of the facilities, the management and harvest procedures, and even cooperative planning and operational activities. If, however, in a given area private enhancement interests represent competitive investors, some involved with the common property fisheries and some not, it is unlikely that joint state-private cooperation could be developed to the same degree. The Alaskan Fisheries Council may also function to recommend both policy and specific actions that will promote constructive cooperation between public and private enhancement programs.

As mentioned earlier, the department has been mandated the function of encouraging and assisting private hatcheries. So, while a certain level of services must be delivered to all private hatchery operators, the state may be able to go further in supporting some operations than others. This situation stems from the varied nature of private hatchery initiatives. Without doubt, the private nonprofit hatchery act has attracted the attention of profit motivated entrepreneurs who have no present connection with the salmon fisheries and who will design and manage their operations to yield maximum returns at the hatchery site. At the other extreme, we have the Prince William Sound Aquaculture Corporation.

At this point, you may be interested in knowing that 59 private hatchery inquiries have reached my office, 19 of these have now submitted applications, and of these, only three are visibly founded on an existing base of organized fishermen. It should be noted that the department's published policy dealing with private nonprofit hatcheries is intended to minimize risks to the private investor and to avoid waste of the salmon resource, rather than to curtail options and innovative approaches or to justify the rejection of applications. It is my hope that the fishing community will seriously consider the merits of each application when it is proposed for public hearing and express its views through testimony at these hearings. In the four hearings that have been conducted to date, not a single negative comment has been heard. I am afraid that some people are reluctant to speak critically out of fear that it might result in the premature development of restrictive standards that could impede approval of subsequent applications of importance to them.

As to the range of assistance that the state may legally render to the private nonprofit hatchery operator, there is nothing that should be arbitrarily ruled out in advance. With common goals, purposes, and constituencies, state and private salmon enhancement efforts must develop in harmony, even to the point of joint enterprises where there is mutual benefit and agreement. These statements reflect the administration's policy, certainly another fundamental change from the traditional role of government in our fisheries, and I hope they contribute to a new era of progress and cooperation.

THE MARKET FOR SALMON AQUACULTURE PRODUCTS:
SOME DEMAND CONSIDERATIONS[1]

Richard S. Johnston
Department of Aquaculture and Resources Economy
Oregon State University
Corvallis, Oregon 97330

To an economist, the term demand has a special meaning. When an economist speaks of the consumer demand for salmon, he or she is speaking not of the sales of salmon during some particular time period but, rather, of the relationship between the quantities of salmon which a given population of consumers would be willing to purchase during that time period and salmon prices, consumer incomes, prices of substitutes for salmon (such as beef), and other variables (for example, age distribution, racial mix) which may affect consumer decisions. By way of illustration, suppose we were interested in the demand for canned red (sockeye) salmon by U. S. consumers for some particular year. I recognize that the current interest is in pink and chum salmon aquaculture, but I have chosen this example because of some fairly recent research in this market. The principles to be discussed are as appropriate for pinks as they are for reds. Figure 1 depicts a hypothetical relationship between prices and annual quantities demanded under the assumption that, irrespective of the price of canned red salmon, the values of other variables, including the prices of substitute goods, do not change.

The graph in Figure 1 is to be interpreted as follows: if the price of salmon were $2.00 per one-pound tin,[2] consumers would purchase, at most, 50 million pounds per year. If, on the other hand, the price were $2.50 per pound, consumers would purchase a maximum of 30 million pounds per year. Similarly, different quantities would correspond to other prices.

There is an alternative interpretation of this relationship, namely, that it shows the maximum price consumers would be willing to pay for each of the quantities depicted on the horizontal axis. Thus, if 30 million pounds (625,000 standard cases) were placed on the market, and if they were sold at a single price, $2.50 is the highest such price at which all of the fish could be sold. Alternatively, the highest price at which 50 million pounds (just over one million standard cases) would clear the market is $2.00 per can.

A useful concept related to demand is the price-elasticity of demand. This refers to the percentage change in quantities consumers would be willing to purchase associated with a given percentage change in price. It is a measure of how sensitive consumers are to price changes. An important determinant of price-elasticity is the degree of availability of close substitutes. Some commodities, such as margarine, beef, and Fords, have quite close substitutes. Butter is a substitute for margarine; other meat (e.g., pork) and seafood products substitute for beef; other makes of cars substitute for Fords. A change in the price of margarine or of beef or of Fords, the prices of the substitutes remaining constant, can be expected to cause quite substantial substitution: a fall in price would probably lead consumers to buy more of the commodity in question while a rise in price would probably lead consumers to buy more of the substitute. The demand for these commodities is probably relatively price-elastic. Other commodities, such as salt, have few, if any, close substitutes; and a rise in their prices would no doubt be associated with a smaller fall in quantity demanded than would be the case if close substitutes were available. The demand for these commodities is likely to be price-inelastic.

SALMON AQUACULTURE AND CONSUMER DEMAND

Let us consider these concepts in the context of salmon aquaculture. Suppose that, in the absence of salmon enhancement efforts (either public or private), the total annual quantity of sockeye salmon sold at retail were 30 million pounds. For given levels of consumer incomes, population, and prices of substitute goods, Figure 1 indicates that total consumer expenditures on canned sockeye salmon would be 30 Mil x $2.50 = $75.0 Million. Now suppose that, through a salmon aquaculture program, the total pack of canned reds were increased and that, instead of 30 million pounds being sold, 50 million pounds were sold. Under these circumstances, consumer expenditures on canned sockeye salmon would be 50 Mil x $2.00 = $100 Mil. Notice that, in this case, while the total poundage of sockeye salmon sold increased and while retail prices fell, total consumer expenditures on sockeye salmon rose. The reason is that the percentage increase in sockeye salmon sales was higher than the percentage decrease in sockeye salmon prices - a situation of price-elastic demand in this price range.

Suppose, now, that the demand curve for sockeye salmon does not look like that pictured in Figure 1 but, rather, more closely resembles that drawn in Figure 2. Again, starting from the initial assumptions of an industry output of 30 million pounds and a retail price of $2.50 per pound, an increase of industry output to 50 million pounds would reduce price to $1.40 per pound. Consumer expenditures on canned red salmon would, under these circumstances, be $70 million. In this case, with the same increase in canned sockeye volume, total consumer expenditures on canned sockeye salmon is shown to decrease. The reason is that the percentage increase in red salmon sales was lower then the percentage decline in red salmon prices (a case of price-inelastic demand). Whether salmon aquaculture will generate additional revenue to the industry, (and here I'm speaking of gross, not net, revenue), will depend, at least in part, on the price-elasticity of demand.

But this analysis is partial at best. If the quantity of sockeye salmon being marketed increases, is it reasonable to assume that the prices of substitute goods will remain unchanged? Probably not. As the price of canned sockeye salmon falls, consumers can be expected to reduce their purchases of canned pink salmon, canned tuna, etc. This will have an effect on the prices of those commodities which, in turn, will affect purchases of red salmon. Thus, an understanding of the relationship between the demand for pink salmon and red salmon would be necessary to predict the impact of salmon aquaculture on prices and consumer expenditures on pink and sockeye salmon.

Furthermore, what about the effect of a change in other variables on the demand for canned sockeye salmon? Suppose the price of canned tuna were to fall, thereby reducing the demand for canned salmon. As implied by the discussion to this point, such a drop in tuna prices could not only reduce the quantity of red salmon purchased at current prices but could reduce the quantity demanded at all prices. This is illustrated in Figure 3.

The magnitude of such a shift and the nature of such a shift (lower tuna prices may affect the salmon demand only in the lower range of salmon prices) will depend upon the relationship between the demand for tuna and the demand for salmon. It seems to me that understanding the impact of a salmon aquaculture program on salmon prices and consumer expenditures will depend on understanding such relationships.

Another important consideration here is the role of changes in consumer incomes. If real consumer incomes rise, one would expect the demand for sockeye salmon to increase as well. Our research, however, suggests that consumer demand may not only not be sensitive to changes in consumer income but may be inversely related to consumer incomes. That is, as consumer incomes rise, the demand for canned red salmon may actually fall. This may not be true for all regions of this country or for other countries (although recent evidence suggests that it may be the case in Canada and in the United Kingdom). Whatever the case, an understanding of this relationship would be vital to predicting the impact of salmon aquaculture on prices and expenditures.

Many other factors could be considered here. They would include regional differences in tastes and the availability of competitive products, seasonal patterns in demand, the nature of the demand for alternative market forms and for "by-products," such as eggs, promotional activities, the role of imports, to name a few. The point is that, as you are well aware, many factors affect consumer demand. Simply looking at what has happened to prices and quantities sold over time obscures the underlying relationships and may lead to miscalculations about causes and effects. With current statistical techniques, however, the separate influences of the various factors can often be sorted out. An economic analysis which uses these techniques should be helpful in predicting the impacts - and, perhaps, the viability - of salmon aquaculture.

So far, discussion has focused upon demand at the final consumer level. Between the fisherman and the final consumer, however, are many individuals who deal in salmon: processors, wholesalers, brokers, retailers, and other distributors. At each of these levels at which an exchange takes place and a price is struck, there are separate "demand" and "supply" relationships, all of which are highly interconnected. For the State of Alaska, the demand facing the processors of salmon and the demand for salmon facing commercial fishermen and fish ranchers may be of most interest. Let me discuss each of these briefly. Again, I shall focus on sockeye salmon because of our recent work there, recognizing that your interest is in pink and chum salmon. The underlying principles are the same, however.

THE DEMAND FOR SOCKEYE SALMON FACING WHOLESALERS AND PROCESSORS

For discussion purposes I shall lump wholesalers and processors together in this section. The quantity of sockeye salmon which retailers and other distributors are willing to purchase from wholesalers-processors will depend upon the prices retailers expect to receive for sockeye salmon (that is, the consumer prices just discussed), the prices which they pay for red salmon, the buying and selling prices of other goods which they sell (for example, pink salmon, tuna), and what we might call marketing costs (including labor costs, storage costs, transportation costs, etc.). Purchases by retailers from any particular group of wholesalers-processors will depend also upon what prices are being charged by other wholesalers-processors (for example, foreign suppliers.)

Let's consider the demand facing a particular group of wholesalers-processors, perhaps even a single firm. Figure 4 depicts the demand relationship facing this particular group under the assumptions that the retail price of sockeye salmon (and pink salmon and tuna) is constant, that prices charged by other wholesalers-processors are constant, and that marketing costs per case processed and sold are also constant. As drawn, the curve states that the lower the price charged by this group of wholesalers-processors, the larger the quantity of sockeye salmon retailers would purchase from this group of wholesalers-processors. It also says that the larger the quantity these sellers seek to place on the market as a result, say, of aquaculture programs, the lower the price retailers would be willing to pay. If this group were selling 60,000 cases at $80.00 per case, it could gross $4.8 million. By lowering its price to $70.00 per case, the group would be able to sell 90,000 cases and could gross $6.3 million. However, if lowering the price is advantageous for this group of wholesalers-processors, it is probably advantageous (or, at least, perceived to be advantageous) for all processors. And, as all processors expand the quantities they sell, this will depress the consumer price (see Figure 1). The result of this will be to reduce the demand for sockeye facing our group. As depicted in Figure 5, an attempt by this group to expand from 60,000 to 90,000 cases will reduce price not just to $70.00 but to $40.00. Instead of increasing its total receipts to $6.3 million, the group experiences a decline in its total receipts to $3.6 million. This is, of course, an hypothetical example. Actually, our research results suggest that a ten-percent increase in the total red pack for the industry would be associated with a four-percent reduction in the wholesale price. (In passing, I should note that we are in the process of revising our model to better predict the impact on market prices of such phenomena as increased Japanese purchases in 1973.)

The expected influence of the other factors identified earlier could be traced through here. Changes in the variables in the consumer demand function, such as the price of beef, income levels, etc. will shift the demand for salmon facing wholesalers-processors. Changes in marketing costs (e.g., storage charges) may also shift the demand. The point, once again, is that understanding the impact of salmon aquaculture on prices and industry revenues will depend on the nature of these various relationships. I hope that, in this section, I have also demonstrated how the actions of firms and groups of firms, even though acting independently of one another, can influence each other. Thus, an understanding of the structure of the salmon market may also be crucial to predicting the impacts of salmon aquaculture.

THE DEMAND FOR SALMON FACING FISHERMEN AND FISH RANCHERS

The type of reasoning just discussed can be carried through to examine the demand facing salmon fishermen and salmon ranchers. Our results, to date, indicate that the demand for sockeye salmon and the demand for pink salmon, at the fisherman's level, are both highly price-elastic. This suggests that increasing the catch of sockeye salmon will increase gross returns to sockeye fishermen and that increasing the catch of pink salmon will increase gross returns to pink salmon fishermen. However, the impact of an increased catch of pink salmon on the sockeye fishery (and vice versa) has not been adequately explored. Nor has the distribution of this income among fishermen been examined. Finally, it must be remembered that gross returns and net returns are not identical. The costs of increasing this harvest have not been considered.

Here again, however, the point is that conditions in the wholesale and retail markets are important in determining the nature of the demand at the fisherman's level. Indeed, there exist strong relationships among the demands at the various levels of the marketing channel. Only when these relationships have been considered can one predict with confidence the impact of salmon ranching on prices and total revenues accruing to the fishery. While such relationships may be somewhat complex, techniques are available to estimate their nature and magnitude. Public and private decisions regarding salmon aquaculture made in the presence of an understanding of these relationships may be different than those made in the absence of such an understanding. In fact, it seems to me that understanding these relationships is almost crucial to being able to predict with confidence the economic survivor ability of salmon aquaculture.

Let me close with a request that you assist us in our efforts to estimate these relationships. Your cooperation will be greatly appreciated and should have high returns.

FOOTNOTES

1 I wish to acknowledge the critical comments of Walter Jones, NMFS, on this manuscript.

2 Here I'm assuming that all sales have been converted to one pound-tall equivalents.

AQUACULTURE AND THE ALASKAN FISHERMAN

Philip A. Daniel
Executive Secretary
United Fishermen of Alaska
P. O. Box 1352
Juneau, Alaska 99801

I would like to say at the outset that I am very impressed with this meeting and with what the fishermen have put together here in Prince William Sound. I think it is exciting; and from talking with other fishermen across the state, it appears that they share that point of view. For many years our salmon stocks have been declining; we all know the sad story. Alaska has continuously taken what has to be considered as negative steps in an effort to stay the decline. We have cut gear, fishing time; and, ultimately, we have initiated the painful process of limited entry.

Perhaps this is the first time we have taken what can be called a positive step. The UFS thinks it is a step in the right direction. One of the most optimistic overtones about developments in the Sound has been based on the fact that for the first time the various user groups, groups who have traditionally been rivals, are cooperating in an effort to produce salmon. When one considers the rivalries in the Alaska fishery, (and I have not been here as long as some of you) it seems to me that every conflict has been based on the fact that there simply were not enough fish to go around. For the first time we are seeing the various interest groups in a fishery trying to resolve the traditional conflicts not by doing in the opposition but by producing more fish.

The scope of the Prince William Sound project is in itself impressive. One thing I would not fault the Cordova fisherman on is the ability to think in large numbers; a 300 million-fish-capacity project is a project of magnitude. The fact that you are 90 percent complete on your first hatchery site is also praiseworthy.

It is curious to see fishermen involved in a hatchery program. The question was raised yesterday as to why fishermen became involved. It think there are many reasons. One of the reasons, of course, is based on the fact that Alaska's salmon stocks are in trouble. You may recall yesterday's graph showing the historic rise and fall of the Alaskan salmon stocks. Some of us are worried that the line may continue to decline and eventually disappear in the lower right hand corner of the graph, that the line may be headed toward extinction. To put it in another term, two-thirds of our salmon stocks are gone. This fact more than anything else has provided the primary impetus.

The Limited Entry Program also provides a reason. It seems to me rather difficult to conceive of fishermen becoming heavily involved in putting money into the production of fish if they would only be providing for additional boats to enter the fishery. We have always had the problem of the fleets growing more rapidly than the stocks. With Limited Entry on the books, it makes sense for fishermen to help rehabilitate the fishery; without Limited Entry, it is not likely that fishermen will be willing to foot the bill for rehabilitation.

The UFA helped pass the nonprofit private hatchery bill. A couple of years ago someone called it an "Edsel-style" concept. I must say I always had a little bit of predilection for the Edsel. Another gentleman referred to the bill's being put together by political engineers. Actually, nothing very sinister went on when the bill was put together. It was patterned after the Oregon law with the exception that we put in the nonprofit stipulation. I have been intrigued by the fact that in the first day's presentations, and perhaps over the duration of this meeting, very few people seem to give credence to the idea that this is a nonprofit bill. I would like to talk about what went into putting the bill together and perhaps allay some of the fears that we are really talking about a "profit" motivated approach. Were we to have tried, in the UFA board meetings, to put together a profit approach, I think we would have been unsuccessful. The simple fact is that fishermen fear the possibility that a large company, processor, or someone else might come in, put their own hatchery in and essentially not need fishermen.

When I was in Hokkaido two years ago, I went through several hatcheries there. One of the sites had two weirs across a stream and a fishway built along side the stream. The fishway ran about 150 yards and then doglegged through the floor of the catching station. While I was eating with my Japanese host, who was in charge of the catching station, several chum salmon swam up to my feet. Had you rigged it right, those fish would have jumped right on to the iron chink. It would not have been necessary to touch them with human hands. At any rate, the prospect of a straight private type bill being put on the books and fishermen being circumvented is viewed with considerable apprehension by the fishing community. I will admit that perhaps it is not the most enlightened view point, but it is the prevailing one.

There are probably some people who would like to see a straight private bill. As long as the fishermen have anything to say in state government that is not likely to happen. Also, it seems clear that in order for our present nonprofit bill to have any teeth, it must be enforced; and we believe it will be enforced by the state. As you may recall, in the bill it is stated very clearly that money derived from the sale of fish beyond covering the cost of the hatchery operation and reasonable expenditures, remains under the control of the nonprofit private hatchery group which owns the hatchery; and it can be spent only for matters of general interest in the fishery. The private-profit concept is not in the bill.

I understand apprehensions of this kind and also understand the genetic problems brought up yesterday. Anytime you take a step of dramatic departure, such as we are taking now in talking about private nonprofit hatcheries, certainly there are hazards. What I do not want to do, of course, is simply allow someone, myself or anyone else, to manufacture problems when many of these problems can be avoided. The points which have been made on genetics are very pertinent. My reaction is simply that we would expect that the biologists involved in this development will be familiar with the literature. There may be regulatory safeguards which have to be instituted; the bill itself may have to be revised, as well as departmental policy. We do believe that most of the biological problems can be dealt with, with proper planning.

Going on to other matters, I think in the future aquaculture is likely to play a major role in Alaska. I am very encouraged with statements the Commissioner of Fish and Game and Bob Roys of the FRED Division have made recently. I am also encouraged by the attitude in the Governor's Office. The state is definitely and intensely interested in the development of aquaculture in Alaska. The Governor has recently appointed the Alaska Fisheries Council.

My understanding of the primary role of the council will be to review the various plans that have been prepared for rehabilitating the salmon fisheries and make recommendations on the implementation of a program to the Governor. Legislation is going to be required, as well as the active support of some good minds exercising what I sincerely hope will be good judgment. I think that what a lot of us have waited for a long, long time is on the verge of happening. We are in the "flood" stage of aquaculture development in Alaska. To me, it is a bright moment, something the fishermen of the state have long anticipated.

I wish, at this time, I could speak in more detail about what is happening in the Governor's Office and elsewhere in the administration. I am not at liberty to do so. The Governor is carrying the ball in this situation, and he should be the one to make the announcements. As I see it, future hatchery development in the state will be undertaken by both the public and private sector. I have put a lot of thought into what the differences are between nonprofit private hatcheries, such as the one in Cordova, and state hatchery projects. There are very few dissimilarities. One dissimilarity lies in the fact that in a regional nonprofit hatchery there is an interest in getting fish back to the hatchery so you can pay off some of your indebtedness. We might want to do essentially the same thing with state-owned hatcheries. It would be much easier to go to the legislature for money if a state-owned hatchery, for example, had the ability to pay its own way.

The UFA may become involved in the effort to organize regional hatcheries in other areas of the state. The UFA would be involved as a catalytic agent getting out information on how a regional hatchery like the one here could work in other areas. I do not know whether a regional hatchery like this one is possible in Southeastern, Cook Inlet, Kodiak, or any other area; but the germinal seed around which the regional hatchery can be built is the assessment agreement. The UFA may play a role in helping other areas organize. Additionally, I should say that there will probably be legislation this session that will be tailored toward the regional hatchery. I would add that the nonprofit private hatchery is likely to play a very significant role in future aquaculture developments in the state.

SALMON AQUACULTURE IN OREGON

John R. Donaldson
Oregon Aqua-Foods, Inc.
Newport, Oregon

INTRODUCTION

What is all the fuss and excitement about? There is absolutely nothing new about the concept of farming water. It is at least several thousand years old. The Chinese raised carp and the Romans fattened oysters before Christ was born. Many people of the world today depend primarily on water-cultured stocks of plants and animals for their nutrition, as they have for centuries. The art of fish farming, or to use the more erudite title of aquaculture, is well established for such things as carp, oysters, shrimp, trout and salmon as well as numerous species less well known to us here in the Pacific Northwest.

Science has bolstered the art of aquatic husbandry in this century with the result that more pounds of product of higher quality can now be produced in a given unit of water. By far the greatest portion of these advancements in the areas of nutrition, disease, genetics, and facility design have come from federal, state, and academic institutions. Public money has carried the load almost exclusively. The latest change in this country, and I must add a most healthy one, is the increased involvement of the private sector in fish farming. When free enterprise is allowed to function responsibly within a renewable resource, not just as harvesters of present stocks but by being directly involved in seeing that the stocks increase, exciting results are possible. This is the tradition in agriculture and of late in forestry. It is high time that we started with salmon. It is this free enterprise involvement in aquaculture to which I want to draw particular attention.

Until very recently in the Pacific Northwest commercial fish farming has been applied to only two groups of animals - trout and oysters. Trout farms in Oregon, though they number about 26, are entirely small family affairs involved with "you catch-um" ponds or selling fish for stocking farm ponds. The economic impact of this industry is miniscule. Only in Idaho is trout rearing a significant commercial enterprise. Oyster rearing in Oregon is the only established aquaculture we have and our production falls far behind Washington, California, and other oyster centers in the United States. However, the new comer, private salmon aquaculture, is now on the scene. Some very progressive legislation by the 1971 and 1973 Oregon Legislature has opened the way.

Legally it has always been a simple process to obtain permission to get a stock of trout and go into business. To raise salmon similarly in containment presents no new legal problems. This is the pan-sized salmon business. This contained or intensive culture is true fish farming. However, to use the ocean as a pasture for salmon is another story. This has become known as ocean ranching and is why we are all here.

Again, there is nothing new about ranching the sea for salmon. It has been going on in the northwest in the public sector for over 100 years. The Japanese have been busy on Hokkaido Island with chum salmon, both public and private, for many years.

In the 1971 Oregon Legislature, Dr. William McNeil and an assembly of interested persons introduced a bill to allow the private sector to rear, release, and recapture anadromous fish. This was quickly attacked by other user groups, especially the sportsman, and was reduced to chum salmon only. Because nets have been illegal for many years along the Oregon coast and because neither commercial trollers nor sportsmen could hook them, there was little concern for the nearly extinct stocks of chum. Under these conditions sea ranching has established a toe hold in Oregon.

During the 1973 Legislature, I was able to interest Senator Stan Ouderkirk of Newport, Oregon into introducing a bill that expanded the chum permit system to include coho and chinook. It passed the Senate unanimously and had only two votes against it in the House. Oregon thus became the first state to establish a permit system for the private ocean ranching of salmon.

To date, there are eight permits issued for chum salmon release sites, two for coho and two for chinook. There are permits pending for all species. The newly combined Oregon Commission for Fish and Wildlife is presently taking a "go slow" approach to the issuing of new private salmon aquaculture permits until the existing operators have demonstrated the value of the system through operating experience.

THE ORE-AQUA STORY

To some, the idea of fish farming is an exciting dream; to others, it may be a casual whim; but neither of these approaches can be successful unless the attitude of a serious challenge is included. There are all too many examples of failure in aquaculture by those who relied only on dreams. For me it began 47 years ago when I was born at the site of a fish hatchery and I have never been away from them since. Throughout the many years of my professional training and experience, I have been involved almost exclusively in the public sector. I have spent time working in the agency systems of both Washington and Oregon as well as the academic systems of both states. During this time, I occasionally became frustrated by the slowness of the system and its frequent inability to respond to new ideas and change. Therefore, in 1972 I made the decision to step out into what is sometimes euphemistically called the "real world" or the "cold world" and attempted to put together a full scale aquaculture business. I had already designed on paper what I refer to as a completely integrated system. The system would produce fish, molluscs, and crustaceans in fresh and saltwater with the complete control of broodstock, food supply, production, processing, and marketing. I am convinced that this involvement in all facets of the business is necessary in order to assure the quantity and quality of the items produced. The operational theme of Ore-Aqua has become "from egg to market."

Since it was not feasible to proceed into production with all the possible species simultaneously, it was necessary to choose one, or several, that would give earliest and best possible cash returns. Thus began the first of many pro forma statements. These became the paper fish farm. Great care must be taken with these feasibility studies. Total honesty is the only way to proceed. In the selection of the costs involved, always use the highest one and when they are finally summed up, add at least 20 percent for good measure. When you select market prices, always pick the lowest ones. If you do this and the projections are favorable, you have avoided kidding yourself and you may even come out a big winner.

Our early efforts in feasibility analyses told us that salmonids reared in saltwater to pan-size gave by far the best return on dollars invested. Oysters would bring a profit, but not as great as salmon and trout. Crustaceans were not ready for substantial capital investment in production. This order of profitability should be obvious as being directly related to technological advances. Considerable agency and institutional money, mostly tax-based, has been spent on salmonid research and thus there is a wealth of technology available. Marketability differences also enter into the cost figures. The site we selected had to meet the life-cycle needs of the salmonid.

The development of the early pro formas and the selection of the sites were the fun part of the game. When these were completed, putting them into operation got sticky beyond belief.

The Permit Parade

A person, like myself, who has been trained and steeped in the agency system, has no comprehension of the many regulatory hurdles, restrictions, and, at times, the almost total impasses which can be confronted by a new business; especially if you are considering the use of any portion of the natural environment, no matter how prudent the design. Without a doubt, developing a fish farm on an estuary, especially in Oregon, has to be the most closely viewed, scrutinized, investigated, debated, and downright spied upon operation imaginable. The following is a list of some of the general major permit areas with accompanying comments, most of which are appropriate to Oregon, but I am certain they are similar to those in other areas.

Fish Use

Most fish resources in their natural habitat are the property of some unit of government. If it is at all legal to possess them privately, one of several permits are needed. In Oregon it requires two formal permits and three letters of approval to obtain eggs and rear salmon or trout. Disease-free certifications are also involved.

Recent legislation has greatly liberalized the laws regarding the possession of salmon stocks by private enterprise in Oregon. The new permit system is well designed to protect the state's salmon resources, yet give the entrepreneur the opportunity to proceed with broodstock development and obtain his production stock from the excess eggs.

Land and Water Use

Getting permission to use land and water is by far the most difficult part of becoming a fish farmer. Long gone are the days when you could just help yourself, and rightfully so.

However, there needs to be some sanity put into the process. Every level of government, and several agencies on each level, have their say in whether or not you can do business. On occasion, they will be at cross purposes and the applicant is caught in the middle. Have you ever tried to pour a concrete floor in a food processing building? FDA says make it smooth so it can be cleaned. The safety people say make it rough so the workers will not fall down.

My last agency count was two city departments, four county groups, eight state agencies and four federal entities, each with the power to allow or disallow what you have in mind to do. This is 16 unanimous yes votes. It is very much like being voted into a secret fraternity, one blackball and you are out. Paranoia toward agencies is a common ailment in business today and nowhere is it greater than for an aspiring or operating fish farmer.

An added frustration to the imposing list of needed permits is the frequent lack of assistance from the regulatory agency in helping with your problems. They set rigid rules, or in some cases sliding rules that you cannot get hold of, and then serve as judge and jury. Frequently there is no place to go for counseling in the system. You are on your own to sink or to swim. The newcomer is hopelessly lost.

The Source of Money

Here is an area that will curl your hair; particularly if you are a very recent convert from academia to business. How do you pay for your ideas? I am firmly convinced, based on innumerable pro forma exercises, that there is a critical mass necessary in order to make a go at fish farming. Ma and Pa operations will always be just that, and the corner grocery store is testimony to that approach. There are those who have gone to the other extreme and set up grand stock promotion ventures. The money game always received more attention than the fish and they were in trouble from the beginning.

My experience tells me that between one and two million dollars are necessary in the first several years to get an operation underway if it is going to have a chance for success. At this level of front money, you should be able to see some return after three to four years, first from the farm program and then from the sea ranch returns.

Believe me, you cannot walk into a bank and ask for that kind of money to start an aquaculture operation. They will be genuinely interested in your ideas; most everyone is as there is great public interest in aquaculture today, but unless you have money backers who will sign personal guarantees, you are just having a nice visit. Bankers take zero risks. Even federally supported loans are difficult. I have played that game with the Small Business Administration and was led down the primrose path for months to the bitter end that huge personal guarantees were again necessary. Even, as in our case with people on the Board of Directors who have healthy financial statements, personal guarantees were hard to get. It makes you wonder who personally guarantees the foreign aid money our government gives away by the bushel baskets full.

The solution is to interest large corporations in your venture. These people are quick to see your scheme and size up its potential and they will act unbelievably fast in their decisions. The business mind is an exciting thing to watch. It is a head full of steel springs that makes things happen now, not six to twelve months later. Realize, however, that for their money they want control, which means at least 51 percent. So you lose your nice little company for which you had such great dreams planned of personal success and wealth. Your dreams, however, were just that without sufficient financial backing. It is certainly better to have 49 percent of something than 100 percent of nothing.

Large corporations have been showing interest in aquaculture. Union Carbide is heavily invested in a sea framing program in Puget Sound. Weyerhaeuser Company, after several years of intensive investigation into aquaculture, have made the decision to get involved and have purchased a shrimp farm in Florida and in August 1975 purchased all of the stock in Oregon Aqua-Foods, Inc. It is exciting to be working with a group like Weyerhaeuser as they know about managing a renewable natural resource for a profit. They have the management and technological skills along with the financial commitment to make aquaculture work.

Management -- Not Things

I am firmly convinced, based on viewing numerous state, federal and private fish culture operations over a number of years, that success is not based solely on technological advances. The primary control is in the management. People, not gadgets or canned programs make an operation work. This is even more true in the private sector where a profit has to be made or it's all over. Tax supported facilities can have costs get out of hand for sometime before anyone notices or cares. The regular profit and loss statement makes considerable difference in how the management functions.

In Ore-Aqua, we have a crew of young professionals who have been given the challenge of making a fish farm work. Professional pride motivates each of us. Professional doubters and objectors have made themselves known by using the wet blanket of disease, nutrition, genetics, mechanical failures, and costs. Sportsmen cry that you will ruin the natural runs and that Californiation of Oregon will follow private involvement with salmon runs. Commercial fishermen fear competition.

Summing up the problems of aquaculture development, it is not technology, but the social-legal impediments that are of concern. How do you get resource agencies, the planning commission, the sportsmen, environmentalists, and commercial fishermen to believe in and possibly support your ideas? How do you get state or federal discharge permits? Add to this the financial worries and you have the problems that really concern a potential or actual fish farmer. I have found no one to step forward with guidance, let alone answers.

Where Does Help Come From

Technology

Agencies and institutions in the past have provided the basic hard facts of life and death in the husbandry of both land and aquatic species. They are still the mechanism through which such efforts can continue. We do have unsolved problems. From my vantage point, these are disease control, sources of food, effluent control, marketing, etc. The rest of the problems are less important, but none of the completely unsolved technical problems should hold back a serious fish farmer. Many species can now be reared.

Socio-legal

Whether you are allowed to farm or not is the question. Who is talking sense within the environmental concern spectrum? Certainly not the regulatory agencies, that is too much to expect. Industry's voice will most always be suspect as self-serving, which is the only way it can be.

We need an agency or institution to assume the role of peace-maker. How many in state or local administration or research know the rules and regulations of EPA, FDA, SBA, OSEA or whatever other agencies in the "alphabet soup" there might be? It is with these problems that help is needed.

People Who Can Do Things

Another crying need of the fish farmer is for people who can do things. A thinking man or woman who can build or mend a functioning system is rare. If you find one, pay him well so he will not be hired away. Presently, the community college program has by far the best offerings. Our Oregon State Superintendent of Instruction recently expressed his concern over our information-rich but experience-poor society of today which has replaced the information-poor but experience-rich society of 50 years ago. It must be possible to stike a balance.

The Challenge

Aquaculture must no longer be mauled and pawed over in the laboratories and test facilities of our institutions. Other areas of the world stopped this long ago, if they ever began. The challenge for the aquaculturist is to get involved with your local politician, bureaucrat, and environmentalist and solve the socio-legal problems that impede progress.

When we can freely and pridefully use the word "farmer" or "rancher" to mean one who produces a crop from water, then we are philosophically and physically on our way to economic reality as our land-based counterparts have been for so long.

CLOSING STATEMENT AND CONFERENCE ASSESSMENT

Ernest O. Salo
Fisheries Research Institute
College of Fisheries
University of Washington
Seattle, Washington 98195

Now comes the time for the visiting preacher to give the benediction to the revival meeting. Before the benediction is given, let us see what faiths we have revived:

First - Faith in hatcheries of any and all kinds? Not quite.

Second - Faith in totally effective management by public agencies? Not quite.

Third - Faith in private profit-seeking enterprises? The faith is not absolute.

Fourth - Faith in not-for-profit organizations? The faith is not unanimous, as I sense it.

Did we really expect unanimity in faith in any or all of these? No. Then, why did we gather here at this wonderful community known as Alaska's Best-Kept Secret? (Incidentally, if you want to gather a crowd, just send out a few invitations.) But it is obvious that at this conference no secrets were intended. The purpose, as defined by Bill Hall, was to discuss and determine possible courses of action for aquaculture in Alaska. I think we discussed it fairly thoroughly under the necessary limitations of time and the more severe limitations of knowledge of the state of the art. Bill wanted us to discuss why aquaculture, and aquaculture for whom--and not so much how. But the uncertainties of "how" kept interfering with the "why" and the "for whom."

Why? The "why" seems to have come about from a sense of extreme frustration caused by the declining stocks of salmon resulting from a multiplicity of factors which include overfishing and over-reliance upon simplistic models of maximum sustained yield based upon the numbers games called Spawners and Recruits--models that did not include biological principles and phenomena that we do not understand.

For whom? Theoretically, it is for any Alaskan who wants to become a part of a salmon fishing community, a community that perhaps is ideally exemplified by the Prince William Sound complex. The frustrations mentioned above have caused a lack of security which has been removed in part by the intense desire to come together with the common enterprise of producing more fish for the common fishery. We hope that this community, which, of course, cannot be compared directly to the Yurok Community on the Klamath described by Dr. Rogers, will be held together before it is fractured and divided by factors and interests more diverse and of more immediate economic attractiveness than fishing.

The present frustrations, as well as some of the past mores associated with fishing, were expressed by Charles Simpler and others. By some, analogies - which are always too simple - were drawn between hunters and farmers, farmers and ranchers, fences and pastures, and agriculture and aquaculture.

The question remains - can we go back voluntarily to the community type of life? We may be forced to go back because of the present energy crisis when the available energy forces us to have a more equitable expenditure of calories vested versus calories produced.

Carl Rosier introduced the complications of offshore limits, limited entry, enhancement by public agencies and reviewed the decline of the harvestable salmon resources from approximately 100 million fish down to about 25 million. Also, he emphasized that no matter who contributes to the rehabilitation and enhancement, no guarantees can be made to allow for the uncertainties of nature.

Bill McNeil compared the returns of 2.8 adults per natural spawner to 13-to-15 adult returns for each adult spawned artificially. Incidentally, these figures are almost exactly those derived for the Upper Columbia River. This emphasizes two things, the comparison between artificial and natural propagation and too, the hazards of fishing mixed stocks of wild fish and hatchery fish in the same system. Building modern, efficient, concrete and steel hatcheries on a river is a certain kiss of death to the wild stock. Alternatives, I do not know. According to McNeil, to produce, by means of hatchery systems, 40 million salmon, some 200 hatcheries are needed. This assumes a capacity of 20 million eggs per hatchery. Completely independently, based upon the system in the State of Washington of more than 30 hatcheries, I came up with the figure of 260 hatcheries needed to produce the 40 million fish. It could be that Bill and I are using the same sources of data and they are erroneous, or it could be that our sources are independent and that we got into the same ball park coincidentally. Bill and others suggested that fewer hatcheries with larger capacities might be employed. On the other hand, recommendations were made that consideration be given to greater numbers of small stations...that is, "keep them small." Perhaps this pertains only to the period of pilot operations.

At this point, Mr. MacLeod introduced caution and the desirability of progress in the form of intensive research without haste. Mr. MacLeod emphasized the need of leaving room for future biological options, the building up of some small stocks, maintaining natural balance, enhancing only stocks that can be managed, and starting out with pilot operations.

Without subsidy, starting out small is not consistent with profits, whether private or not-so-private.

Mr. Clinton Atkinson showed us that the Japanese can do it. And Jack Donaldson showed us an impressive combination of a farm and a ranch, one that is already producing, be it at the present time small.

Rightfully, Robert Roys pointed out the must of a many-pronged approach. FRED means rehabilitation and enhancement by the many common-sense approaches. The State of Alaska has made substantial progress in many of these.

Wally Noerenberg and Armin Koernig, reviewing the PWS program, zeroed in on a first target of 200 million fry and demonstrated how a community can put their boots on and immediately jump into deep water. They have gotten their feet wet, have wrung out their socks, and are in a program that cannot be classified as small.

It is amazing how long man has been taking salmon eggs and how understandable it is that each group has to learn how to solve its own site-specific problems. I am sure the Prince William Sound group felt that the approach they took was the only one to take.

Robert Bams' and Jack Helle's warnings on straying, genetic manipulations, and other uncertainties are real, based on fact, and must be heeded regardless of which approach we use in management. Some of their cautions appear to be infinite, without tangible boundaries, and at this time appear to be in the category of wrestling an amoeba. As research topics, however, they are of top priority.

Mr. John Wiese's soul-searching concerns, which may be vital to the maintenance of the principle of common property, include the fear of trespass upon, or the abrogation of, the responsibility of the state government. We cannot allow the state and local governments to shirk this responsibility. Until this is resolved, disturb nature and the natural stocks as little as possible.

Mr. Calvin told us how not to go about getting a permit in a hurry, and Dick Majors told us, in impressive detail, where the salmon may go at sea and the hazards they may encounter.

Throughout the conference, we had a sprinkling of economists. Now, I am not capable of summarizing anything economists say, but it has something to do with the broad base that public enterprises have, the narrower base of the nonprofit organizations, and the even narrower private-for-profit base, and their respective capabilities to absorb shock of cost and the diversity available to distribute gains. But, along with this varying base, there is a variance in incentives.

Thank you Dr. Orth, Mr. Ness, and Dr. Johnston. There appears to be no end to the elasticity of economists - and biologists.

Finally, I have no vested authority to bless this operation and I do not intend to, nor need I, for I believe Commissioner Brooks did that well. In summary:

1. We all admit we have a problem.

2. We have attempted to define the problem.

3. We are applying the old adage that a problem well-stated is half-solved.

4. This open dialogue is welcome and essential.

Thus, we must consider this conference a success thanks to the Prince William Sound Aquaculture Corporation.

CONFERENCE ATTENDEES

Ray Alexander
(address unknown)

George Allen
Box 358
Cordova, Alaska 99574

Les Anderson
Koniag Associates
Box 746
Kodiak, Alaska 99615

Rose Arvidson
Box 258
Cordova, Alaska 99574

Clinton Atkinson
Fisheries Consultant and Advisor
8000 Crest Drive, N.E.
Seattle, Washington 98101

George Ballum
Box 98
Cordova, Alaska 99574

Robert Bams
Pacific Biological Station
Box 100
Nanaimo, British Columbia
Canada

Jim Barry
U. S. Fish & Wildlife
Federal Bldg.,
Ketchikan, Alaska 99901

Louie Barton
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

Ray Baxter
Alaska Dept. of Fish and Game
Box 96
Bethel, Alaska 99559

Clay Beal
U. S. Forest Service
121 W. Fireweed
Anchorage, Alaska 99501

Dave Benson
KRFF Engineering
SRA Box 30 R
Anchorage, Alaska 99501

Sam Bertoni
Alaska Dept. of Fish and Game
Box 901
Ketchikan, Alaska 99901

Dick Bishop
Commercial Fishermens Association of Ketchikan
Kiard Cove, Alaska

Bill Bledsoe
Star Rt. A
Box 61
Homer, Alaska 99603

Art Bloom
U. S. Forest Service
Box 909
Juneau, Alaska 99801

Floyd Blossom
Box 3
Ninilchik, Alaska 99639

John Borodkin
Prince William Sound Aquaculture Corporation
Box 423
Cordova, Alaska 99574

Jim Brooks
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, Alaska 99801

Tim Brown
Alaska Dept. of Fish and Game
Box 283
Cordova, Alaska 99574

Jim Calvin
U. S. Forest Service
Box 526
Douglas, Alaska 99824

Hugh Carr
NEFCO
Pier 89
Seattle, Washington 98101

Paula Carroll
Box 722
Cordova, Alaska 99574

Virgil Carroll
Prince William Sound Aquaculture
Corporation
Box 281
Cordova, Alaska 99574

Thomas Casey
United Fishermen of Alaska
Box 1035
Kodiak, Alaska 99615

J. E. Caldwell
Alaska Aquaculture Foundation
P. O. Box 10338, Klatt Station
Anchorage, Alaska 99501

John Clark
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, Alaska 99801

Robert C. Clasby
Institute of Marine Science
University of Alaska
Box 617
Seward, Alaska 99664

Garri Constantine
Wingham Bay Big Pink Ranch
Box 711
Port Alexander, Alaska 99834

Dave Coopee
Prince William Sound Aquaculture
Corporation
Box 1110
Cordova, Alaska 99574

Clyde Courtenage
Economic Development
Administration
632 6th Avenue, Rm. 455
Anchorage, Alaska 99501

Thomas Craig
Alaska Aquaculture Foundation
P. O. Box 10338, Klatt Station
Anchorage, Alaska 99501

Ed Crateau
U. S. Fish and Wildlife
Box 493
Kenai, Alaska 99611

James Dangel
Alaska Dept. of Fish and Game
210 Ferry Way
Juneau, Alaska 99801

Phil Daniels
United Fishermen of Alaska
Box 1352
Juneau, Alaska 99801

J. and D. Danielsen
6 1/2 Mile Glacier Highway
Gruening Park, Apt. 42
Juneau, Alaska 99801

Jeff David
Tlingit-Haida
Box 174
Haines, Alaska 99827

Jack Deville
Box 178
Cordova, Alaska 99574

John Donaldson
Oregon Aquaculture Foods
P. O. Box 1218
Newport, Oregon 97365

John Doyle
Marine Advisory Program
University of Alaska
3211 Providence Drive
Anchorage, Alaska 99504

Bruce Eagle
Wrangell Fishermens Association
Box 641
Wrangell, Alaska 99929

Lotti Edelman
Kenai Peninsula Co-op.
Box 752, Rt. 2
Soldotna, Alaska 99669

Dick Eide
Petersburg Vessel Owners
Association
Box 15
Petersburg, Alaska 99833

Terry Ellison
Prince William Sound Aquaculture
Corporation
Box 1027
Cordova, Alaska 99574

Hank Every
Commercial Fisherman of
Cook Inlet
Rt. 1, Box 970
Kenai, Alaska 99611

Nancy Freeman
Kodiak Mirror &
National Fishermen
Box 2859
Kodiak, Alaska 99615

Pete Fridgen
Alaska Dept. of Fish and Game
Box 401
Cordova, Alaska 99574

Nancy Friese
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

Dave Gaither
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

Tony Gasbarro
(address unknown)

Tony Guggenbickler
Wrangell Fishermens Association
Box 641
Wrangell, Alaska 99929

Gilbert Gunderson
Tlinget-Haida
130 So. Seward
Juneau, Alaska 99801

John Gunderson
(address unknown)

Martin Gunderson
Penn. Marketing Association
of Sand Point
Box 45
Sand Point, Alaska 99661

Gary Gunstrom
Alaska Dept. of Fish and Game
210 Ferry Way
Juneau, Alaska 99801

Bud Guthrie
Prince William Sound Aquaculture
Corporation
7800 DeBarr Road, Space 93
Anchorage, Alaska 99501

Bill Hall
Prince William Sound Aquaculture
Corporation
Box 458
Cordova, Alaska 99574

Ed Halverson
Tlingit-Haida
130 So. Seward
Juneau, Alaska 99801

Bill Heard
Auke Bay Fisheries Lab.
National Marine Fisheries Service
Box 155
Auke Bay, Alaska 99821

Jack Helle
Auke Bay Fisheries Lab.
National Marine Fisheries Service
Box 155
Auke Bay, Alaska 99821

Larry Hollinshead
Box 1055
Homer, Alaska 99603

Roger Holmberg
Sand-Point Aquaculture Corp.
Box 124
Sand Point, Alaska 99661

Bob Honkola
Box 124
Cordova, Alaska 99574

Ken Honkola
Box 124
Cordova, Alaska 99574

Don Hood
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Martha Hoover
Prince William Sound Aquaculture Corporation
Box 1153
Cordova, Alaska 99574

Bill Hoppes
El Paso Natural Gas Co.
Box 1492
El Paso, Texas 79910

Ralph Horn
Nunam Kitzutsisti
Box 214
Bethel, Alaska 99559

Norm House
U. S. Forest Service
121 W. Fireweed
Anchorage, Alaska 99501

William Hunt
Dept. of History
University of Alaska
Fairbanks, Alaska 99701

Floyd Hutchens
Offshore, Inc.
1204 S.W. 168th
Seattle, Washington 98101

Mark Hutton
Marine Advisory Program
University of Alaska
3211 Providence Drive
Anchorage, Alaska 99501

Charles Imig
Aleutian Planning Commission, Commercial Development Assoc.
650 W 20th
Anchorage, Alaska 99501

Clarence Jackson
Tlingit-Haida
(address unknown)

Ginger Jacobsen
Cook Inlet Fishermens Assoc.
(address unknown)

Dick Janson
Chugach Natives, Inc
540 No. Bliss
Anchorage, Alaska 99501

Joe Jarvis
Prince William Sound Aquaculture Corporation
Box 1146
Cordova, Alaska 99574

Barbara Jensen
Prince William Sound Aquaculture Corporation
Box 294
Cordova, Alaska 99574

Herb Johnson
Dawn Tide Fisheries
Box 10338, Klatt Station
Anchorage, Alaska 99501

LaVern Johnson
A.P.A.
Box 425
Cordova, Alaska 99574

Richard Johnston
Dept. of Agriculture & Resource Economy
Oregon State University
Corvallis, Oregon 97330

Tod Jones
Alaska Aquaculture Foundation
Box 1288
Wrangell, Alaska 99929

Walt Jones
National Marine Fisheries Service
Box 1668
Juneau, Alaska 99801

Andrew Kelly
Native Liaison
Box 3267
Bethel, Alaska 99559

Bernie Kepshire
Alaska Dept. of Fish and Game
FRED Division
Anchorage, Alaska 99501

Bill Kilby
Prince William Sound Aquaculture Corporation
Box 484
Cordova, Alaska 99574

Herman Kitka
Shee-Atika
Box 578
Mt. Edgecumbe, Alaska 99835

Armin Koernig
Prince William Sound Aquaculture Corporation
Box 1110
Cordova, Alaska 99574

Pete Kompkoff, Jr.
Prince William Sound Aquaculture Corporation
Box 725
Cordova, Alaska 99574

K. Koski
Auke Bay Fisheries Lab.
National Marine Fisheries Service
Auke Bay, Alaska 99821

John Kostoe
Dawn Tide Fishery
Box 10338, Klatt Station
Anchorage, Alaska 99501

Paul Krasnowski
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

Pete Kust
Penn. Marketing Assoc.
Nelson Lagoon
via Port Heiden, Alaska 99695

Jim Landis
Rural Cap.
Box 2364
Anchorage, Alaska 99501

Richard Lee
Marine Advisory Program
University of Alaska
3211 Providence Drive
Anchorage, Alaska 99504

Loren Leman
310 "K" Street, Suite 602
Anchorage, Alaska 99501

Ken Leon
Alaska Dept. of Fish and Game
210 Ferry Way
Juneau, Alaska 99801

Ernest Lewis
Anadromous, Inc.
107 W. John Street
Seattle, Washington 98101

Jon Lindberg
Domsea Farms
6720 Old Belfair Highway
Bremerton, Washington 98310

Sandra Linstrom
Alaska Dept. of Fish and Game
Subport Bldg
Juneau, Alaska 99801

John & Charlene Listenbee
Prince William Sound Aquaculture Corporation
Port San Juan
Prince William Sound, Alaska 99695

Richard Listowski
United Fishermen of Alaska
Box 1352
Juneau, Alaska 99801

Gary Love
U. S. Fish & Wildlife
Box 2800
Kenai, Alaska 99611

Dennis Lund
Sheldon-Jackson College
Box 479
Sitka, Alaska 99835

Ladd Macaulay
Douglas Pink & Chum Salmon Corp.
R. R. 4, Box 4754
Juneau, Alaska 99801

Ron MacLeod
Canadian Fed. Salmon
Enhancement Program
263 Newdale Ct.
N. Vancouver, British Columbia
Canada

Dick Major
National Marine Fisheries
Service
2725 Montlake Blvd., E.
Seattle, Washington 98101

Chet Mattson
National Marine Fisheries
Serivce
P. O. Box 314
Douglas, Alaska 99824

Richard Mattson
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, Alaska 99801

Douglas McConnel
Alaska Humanities
429 "D" Street
Anchorage, Alaska 99501

Mike McCurdy
Alaska Dept. of Fish and Game
Box 897
Cordova, Alaska 99574

John McLean
Box 1468
Anchorage, Alaska 99501

John McMullen
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

William McNeil
National Marine Fisheries
Serivce
P. O. Box 1054
Auke Bay, Alaska 99821
Stan Moberly

Stan Moberly
Alaska Dept. of Fish and Game
210 Ferry Way
Juneau, Alaska 99801

Nancy Munro
Alaska Seas & Coasts
University of Alaska
707 "A" street
Anchorage, Alaska 99501

Tom Namtvedt
Alaska Dept. of Fish and Game
Box 235
Homer, Alaska 99603

Don Nekeroffer
Box 2395
Kodiak, Alaska 99615

Beaver Nelson
Box 1113
Homer, Alaska 99603

Howard Ness
National Marine Fisheries Service
R. R. 4, 4180-60
Juneau, Alaska 99801

Richard Nevė
Institute of Marine Science
University of Alaska
Box 617
Seward, Alaska 99644

Richard Nickerson
Alaska Dept. of Fish and Game
Box 751
Cordova, Alaska 99574

Tsuneo Nishiyama
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Wallace Noerenberg
Prince William Sound Aquaculture
Corporation
P. O.. Box 1110
Cordova, Alaska 99574

Jim Novy
Alaska Dept. of Fish and Game
FRED Division
Anchorage, Alaska 99501

Al O'Leary
NEFCO
Pier 89
Seattle, Washington 98101

ORCA
Box 120
Cordova, Alaska 99574

Frank Orth
School of Management
University of Alaska
Fairbanks, Alaska 99701

Dave Osterback
Dept. of Education
640 W. 20th
Anchorage, Alaska 99501

Al Otness
Petersburg Fishery
(address unknown)

Alvin G. Ott
Woodward-Clyde Consultant
4791 Business Park, Suite 1
Anchorage, Alaska 99501

Bob Ouellet
Chenega Corp
924 Tyowek Street
Anchorage, Alaska 99501

Jim Owers
P. O. Box 173
Juneau, Alaska 99801

Dean Paddock
Alaska Dept. of Fish and Game
Box 312
Juneau, Alaska 99801

John Palmer
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, Alaska 99801

John Palms
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, Alaska 99801

Peggy Parker
Cordova Times
Box 200
Cordova, Alaska 99574

A. J. Paul
Institute of Marine Science
University of Alaska
Box 617
Seward, Alaska 99664

Judy Paul
Institute of Marine Science
University of Alaska
Box 617
Seward, Alaska 99664

Bob Paulus
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

Paul Pedersen
Alaska Dept. of Fish and Game
Box 686
Kodiak, Alaska 99615

Ralph Pirtle
Alaska Dept. of Fish and Game
Box 699
Cordova, Alaska 99574

Larry Putnam
Box 518
Cordova, Alaska 99574

Ken Quinn
3100 Coolidge Drive
Bellingham, Washington 98225

Richard Randall
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99501

Michael Rasmussen
Box 2213
Kodiak, Alaska 99615

Jim Rearden
Alaska Magazine
Box 313
Homer, Alaska 99603

Ron Reiland
R & M Consultant
P. O. Box 6087
Anchorage, Alaska 99501

Dick Reynolds
Dept. of Commerce
Pouch E
Juneau, Alaska 99801

Randy Riddell
(address unknown)

Ken Roberson
Alaska Dept. of Fish and Game
Box 375
Glennallen, Alaska 99588

Debbie Roberts
Box 507
Cordova, Alaska 99574

Bill Robertson
KPFF Engineering
SRA Box 30 R
Anchorage, Alaska 99501

George Rogers
University of Alaska
1790 Evergreen Avenue
Juneau, Alaska 99801

Carl Roiser
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, Alaska 99801

Patricia Roppel
435 Washington
Ketchikan, Alaska 99901

Donald Rosenberg
Alaska Sea Grant Program
University of Alaska
Fairbanks, Alaska 99701

Rick Rosenthal
Dames & Moore
Box 818
Cordova, Alaska 99574

Tom Rosenthal
426 San Remo
San Diego, California 92101

Jon Rowley
Ketchikan Alaska Trollers Assoc.
Box 825
Ketchikan, Alaska 99901

Robert Roys
Alaska Dept. of Fish and Game
306 7th Street
Juneau, Alaska 99801

Ernest Salo
University of Washington
6273 20th Avenue, N.E.
Seattle, Washington 98101

Dick Saunders
NEFCO
Pier 89
Seattle, Washington 98101

Tom Schroeder
Alaska Dept. of Fish and Game
Box 235
Homer, Alaska 99603

Mel Seifert
Sheldon Jackson College
Box 479
Sitka, Alaska 99835

Brad Sele
Alaska Dept. of Fish and Game
Box 1728
Sitka, Alaska 99835

Jack Shaw
Prince William Sound Aquaculture Corporation
Box 891
Cordova, Alaska 99574

Bill Sheridan
U. S. Forest Service
Box 368
Juneau, Alaska 99801

Bill Shiels
Kramer, Chin & Mayo
1917 1st Avenue
Seattle, Washington 98101

Bruce Short
Alaska Dept. of Fish and Game
Box 4
Kodiak, Alaska 99615

Charles Simpler
Box 159
Cordova, Alaska 99574

Bob Simpson
National Marine Fisheries Service
R. R. 5, Box 5792
Juneau, Alaska 99801

William Smoker
National Marine Fisheries Service
526 E. 5th Street
Juneau, Alaska 99801

Harold Sparck
Nunam Kitzutsisti
Box 267
Bethel, Alaska 99559

Jack Sprague
Cook-Inlet Fishermens Assoc.
(address unknown)

Ray Staska
Alaska Dept. of Fish and Game
210 Ferry Way
Juneau, Alaska 99801

Alan Stein
Point Baker Association
Point Baker, Alaska 99927

Steve Streitz
S. E. Seiner Association
Box 2486
Ketchikan, Alaska 99901

Ken Shul
Nunam Kitzutsisti
Box 267
Bethel, Alaska 99559

Bob Summers
Whitney-Fidalgo Seafoods
731 Thomas Road
Bow, Washington 98232

Joe Terrell
Box 1912
Charlotte, North Carolina 28202

Chip Thoma
Windham Bay Big Pink Ranch
Box 61
Douglas, Alaska 99824

Don Thomson
Kodiak Community College
University of Alaska
Box 946
Kodiak, Alaska 99615

Jeff Tobolski
14295 35th N.E.
Seattle, Washington 98101

Bob Tracy
U. S. Forest Service
Box 162
Juneau, Alaska 99801

Jim Tutt
Prince William Sound Aquaculture Corporation
Box 471
Cordova, Alaska 99574

Jack van Hyning
Nerka Aquaculture
Box 80165
College, Alaska 99701

Louise Champagne Veselka
United Fishermen of Alaska
540 Calhoun, Apt. 8
Juneau, Alaska 99801

Bill Webber
Prince William Sound Aquaculture Corporation
Box 876
Cordova, Alaska 99574

John Weise
Industry Magazine
2140 Sunrise Drive
Anchorage, Alaska 99501

Harry Wilde
Nunam Kitzutsisti
Box 3267
Bethel, Alaska 99559

Andy Williams
Anchorage News
821 West 5th,
Box 1660
Anchorage, Alaska 99501

Bill Wilson
Arctic Environment Information
and Data Center
University of Alaska
707 "A" Street
Anchorage, Alaska 99501

F. E. A. Wood
Canadian Salmon Enhancement
Program
5327 Ranger Avenue
N. Vancouver, British Columbia
Canada

Rich Zahniser
2410 S. E. 6th Avenue
Portland, Oregon 97208