THESIS

A STUDY OF THE RED SALMON, _ONCORHYNCHUS NERKA_ (WALBAUM) OF BRISTOL BAY WITH PARTICULAR REFERENCE TO TEACHING ITS CONSERVATION

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A STUDY OF THE RED SALMON, *Oncorhynchus nerka* (WALBAUM), OF BRISTOL BAY WITH PARTICULAR REFERENCE TO TEACHING ITS CONSERVATION

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By

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BIOGRAPHY

Robert Christopher Kallenberg was born in New York City, May 26, 1903. He attended the public schools of Bloomfield, New Jersey, graduating from Bloomfield High School in 1920, entering Iowa State College in 1921, and receiving the degree of Bachelor of Science in June, 1925.

The greater part of the next twenty-six years was spent in the Bristol Bay region of Alaska where he was engaged in commercial fishing, trapping and prospecting. During this time the writer taught school on three occasions for a total of four years to meet teacher shortages. Having decided to enter the teaching profession permanently, and feeling the need of additional preparation, he entered the Graduate School of Cornell University in the fall of 1951.

PREFACE

The purpose of this paper is to furnish the teachers in Bristol Bay with material that may be used in teaching conservation of the salmon fisheries in schools of the area. A history of the establishment of the canneries and development of the fishing industry is given. The biology and ecology of the salmon is considered along with scientific investigations in Bristol Bay and other areas that bear on the involved conservation problems. Suggestions are given as to how this material may be integrated with the present curriculum in developing an understanding of the conservation problems connected with maintaining a run of salmon large enough to support a commercial fisheries.

The economy of the towns in Bristol Bay rests squarely on the salmon fishing industry. It is imperative that the people realize that many complicated problems are involved, and that no easy and permanent solution can be reasonably expected. The children in the schools must be given the facts and aided in developing the proper concepts in order that they may adjust themselves satisfactorily to their environment.

ACKNOWLEDGMENTS

I wish to express my gratitude to Dr. Theodore E. Eckert and Dr. Dwight A. Webster for their help and encouragement throughout this study, and especially for their valuable advice and critical interest during the preparation of this manuscript.

A paper of this type owes more than usual to the writings of others. I wish to acknowledge this indebtedness to the many biologists who have contributed their efforts to furthering the knowledge of fisheries and the related fields.

I wish to thank Mr. Theodore S. Johnson for his cooperation in furnishing information regarding the Waterfront Course offered at the Portland High School, Portland, Maine.

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PART I

DEVELOPMENT OF THE BRISTOL BAY FISHERY

Introduction

Bristol Bay is the home of one of the largest runs of red salmon to be found anywhere. Red salmon, Oncorhynchus nerka (Walbaum), make up about eighty-five percent of the run, although all five species of Pacific salmon are represented. The conservation problems involved in these fisheries are unique and very complex because the Pacific salmon spawn only once and then die.

The red salmon are known as lake spawners because of their preference to spawn along the lake shores or in streams running into a lake. The mature fish enter the rivers during the latter part of June and the run continues until the end of July, and sometimes as late as the second week in August. After entering the rivers the red salmon proceed to the spawning grounds, the late run fish with considerably more haste than the earlier arrivals. The spawning period extends from the latter part of July to the end of September. The eggs hatch during the early spring of the following year and the fry hatched in the streams make their way to the lake. The parr spend one or two years in the lake, attaining a length of four or five inches before going out to sea as smolt. The migrators, or smolt, spend two or three years in the ocean, making rapid growth, and return as mature fish either four, five or six years after the year they were spawned. The returning fish make their way to the spawning grounds and thus complete their life cycle.

Red salmon are not caught in any of the ocean fisheries. Little is known of their life from the time they make their way down the streams as migrators until they appear in schools along the coast on their way to spawn. Rich (1939) related two instances of red salmon being located at sea. The first was that of a single mature red salmon being taken seven or eight hundred miles off-shore during experiments in the halibut work of the International Fisheries Commission. The second was the report of a former fisheries worker of having seen, while sailing to the Orient, a school of red salmon several hundred miles offshore. Commercial fishing of red salmon is done after the fish have approached the coast in schools and are on their way to spawn.

Because each generation spawns only once the species is made especially vulnerable to any adverse environmental conditions or to over exploitation. Each river or district has runs of fish in which a single age class predominates. This characteristic leads to a cyclic effect and the rivers are referred to as four-year rivers or five-year rivers, depending upon whether the majority of fish return four years or five years after having been spawned. Bristol Bay is considered to be on a five year cycle.

The early designation of Bristol Bay included all of Bering Sea lying east of a line drawn from the northwest cape of Unimak Island to the Kuskokwim River. Moser, in his report of 1900 (Moser 1902), used a western boundary line from Port Moller to Cape Newenham. The present designation of Bristol Bay includes all the waters east of a line from Cape Menchikof to Cape Newenham.

In a northeasterly direction from Cape Menchikof the four commercial fishing districts are in order of location: Ugashik, Egegik, Naknek-Kvichak, and Nushagak, each with its system of rivers and lakes comprising the spawning ground of the area. Kulukak and Togiak rivers are between Nushagak and Cape Newenham. These two smaller rivers support a limited run of salmon that is not commercially exploited.

Twenty-four major lakes are drained by the four large river systems. Iliamna, the largest lake, is about 80 miles long and 25 miles wide. Becharof, drained by the Egegik river, is over 40 miles long and no less than 16 miles at the widest part. One of the smaller, Lake Ualik in the Nushagak drainage, is about 8 miles long and 2 miles wide.

Establishment of Canneries

Earliest Record of Commercial Fishing

A history of the salmon fishing, and canning operations in Bristol Bay will greatly aid in understanding the problems involved in maintaining and improving the runs in that area. We are indeed fortunate in having first hand accounts of several competent observers and will lean heavily on their reports in reconstructing the establishment and development of commercial fishing in Bristol Bay.

Moser (1902), in recording the history of the salmon fisheries of Bristol Bay for commercial purposes, states:

> The earliest record in the history is the salting of salmon on the Nushagak by the schooner

Neptune in 1883, and the erection of cannery buildings that year for the Arctic Packing Company, which made a trial pack of 400 cases the year following (1884). It is noticed, however, that Petroff, in the census report of 1880, states:

"The salmon family, the great feeder of the Alaskan people, frequents in astonishing numbers the Nushagak and other streams emptying into Bristol Bay. The facilities for building traps and weirs are also extraordinary, and American fishermen have for some years been engaged here every season in reaping a rich harvest and shipping the fish, salted in barrels, to market. Hundreds of barrels have been filled with a single clean up of a trap. The only drawback to this business is the short period over which the run extends, necessitating the employment of a very large number of hands while it lasts. .... Exports from this section have thus far been limited to from 800 to 1,200 barrels of salted salmon per annum from the Nushagak River."

It is probable that this later reference was to the salting done by traders on a limited scale. The Alaska Commercial Company, or their agents, salted salmon at various stations prior to 1880, and as they had an important station at Fort Alexander on the Nushagak, it is probable that some salting was done there.

The establishment of the canneries on the Nushagak was followed by exploration and establishment of canneries in the other districts. The general pattern was to send a salting expedition to the various rivers to prospect for fish and to establish canneries after having determined that a considerable supply of salmon was available.

Moser gives the following account of the Bristol Bay canneries as he found them in 1900 and 1901:

Establishment of Canneries on the Nushagak River

Artic Packing Company. In 1883 the schooner Neptune was sent by Mr. Rohlfs to prospect for fish on the Nushagak, and a large number of redfish salted. The same year cannery buildings were erected for the above named company, and in 1884 an experimental pack of 400 cases was made. This is the first cannery that operated in Bering Sea. It has made a pack every year to date, excepting 1892, when it joined the pool of the Alaska Packing Association and was closed; in 1893 it became a member of the Alaska Packers Association. The cannery is located on the eastern shore 1 3/4 miles above Fort Alexander, at a place called Kanulik, and known as the Mission. The Moravian mission and the village are situated on the bluff overlooking the cannery. The Nushagak post-office is also located at this point. The capacity of the cannery was increased this year and now has a daily output of 2,400 cases.

Alaska Packing Company. This company was organized at Astoria, and in the spring of 1886 sent a cannery outfit on the schooner Sadie F. Caller and the brig Courteney Foard to the Nushagak, where a cannery was built at the head of the bay on the western side, at the village of Kanakanek (also called Chogiung) about 1½ miles below the junction of the Wood and Nushagak rivers. It made a pack that year and every year since to date. It entered the pool of the Alaska Packing Association in 1892, and became a member of the Alaska Packers Association in 1893. The capacity was increased this year, and it now has a daily output of 2,400 cases.

Bristol Bay Canning Company was organized in San Francisco and built a cannery in 1886 on the western shore of Nushagak Bay, in a bend about 2 miles below the cannery of the Alaska Packing Company. It made a pack that year and every year to date. In 1892 it entered the pool of the Alaska Packing Association, and in 1893 became a member of the Alaska Packers Association. The capacity was increased in 1900, and it now has a daily output of 2,400 cases.

Nushagak Canning Company built a cannery on the eastern shore of Nushagak Bay in 1888, at a place called Stagarok (also known as Clark Point), 5½ miles below Fort Alexander and 3 miles above Ekuk. It was operated in 1888, 1889, 1890, and 1891, but has not since been used. In 1892 it joined the pool of the Alaska Packing Association, and became a member of the Alaska Packers Association in 1893. This cannery is held in reserve and at present is used as a fishing station.

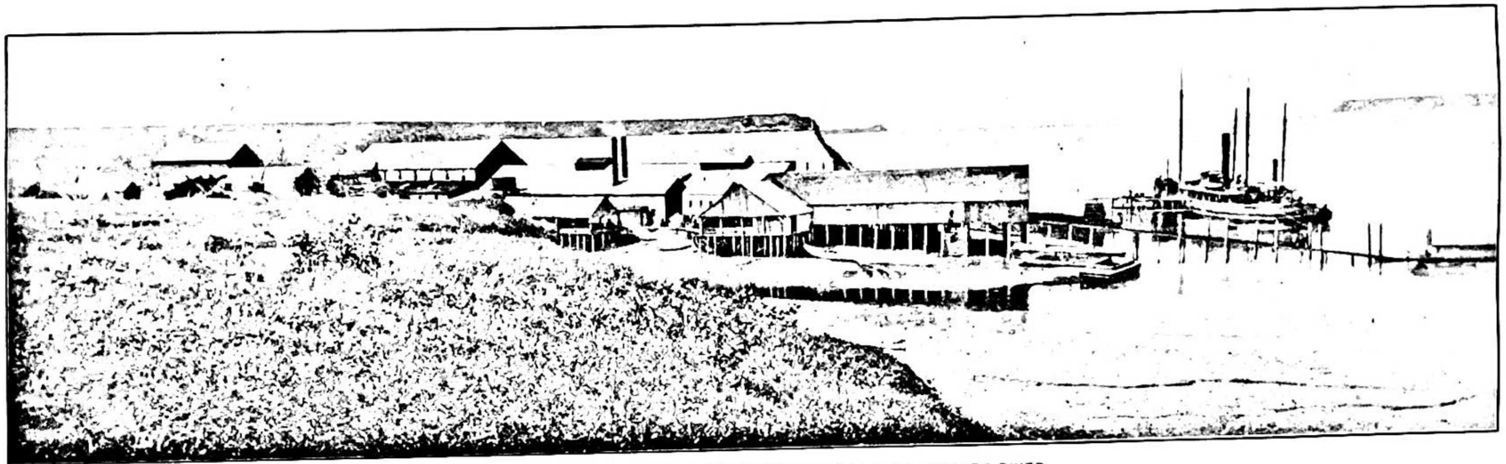
The Nushagak Cannery, of the Pacific Steam Whaling Company, is located on the eastern shore of Nushagak Bay at Fort Alexander, which is also known as Nushagak Village. The cannery outfit was transported by vessels of the company and arrived on the Nushagak April 12, 1899. The erection of the buildings was commenced at once and the cannery was ready for work June 8. A pack was made in 1899 and in 1900. It is a modern cannery, well built and equipped, has good light and is clean and airy. The capacity is 1,600 cases per day. . . .

The Alaska Fishermen's Packing Company, of Astoria, built a cannery immediately below that of the Pacific Steam Whaling Company in the spring of 1899. The canning outfit arrived May 27, and the plant was ready for operation June 25. They made a pack in 1899 and in 1900. The cannery has a daily capacity of 1,600 cases, ...

Saltery of C. E. Whitney & Co. This saltery was built and operated by the Bristol Bay Canning Company, on the Egashak (Snake) River in 1886: three years later three fishermen acquired each a one-quarter interest and moved the outfit to the mouth of the Nushagak. Upon the formation of the Alaska Packers Association, Messrs. C. E. Whitney & Co. purchased the one-quarter interest of the Bristol Bay Canning Company, and also that of one of the fishermen, and in 1895 purchased another quarter. In 1899 the firm became the owner of the saltery by purchasing the remaining quarter. The saltery was moved to its present site about 1892. It is the largest in Alaska and is located on the eastern shore of the Nushagak Bay, 4½ miles above Fort Alexander, at a point where the bluff recedes and the long, broad low point commences to make out to form the head of the bay.

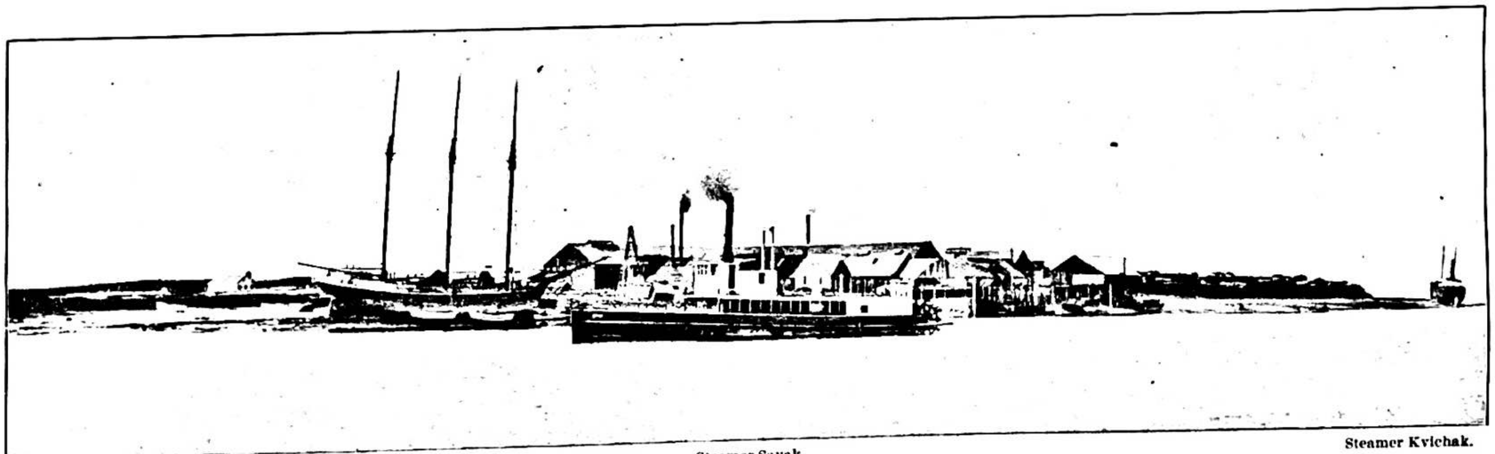
Establishment of Canneries on the Kvichak River

Point Roberts Packing Company. The Prosper Fishing and Trading Company established a saltery at Koggiung in 1894 and salted that year and in 1895. In 1896 it was sold to the Alaska Packers Association under the name of the Point Roberts Packing Company. The Alaska Packers Association established a saltery at Koggiung in 1894, near that of the Prosper Fishing and Trading Company, and after the purchase of the latter in 1896 consolidated the two. This saltery has been operated every year except 1899.



CANNING PLANT OF ARCTIC PACKING COMPANY (A. P. A.), NAKNEK RIVER.

General view from bluff to eastward, showing headlands at entrance.



Schooner Prosper. Steamer Sayak. Steamer Kvichak.

CANNING PLANT OF POINT ROBERTS PACKING COMPANY (A. P. A.), KOGGIUNG, KVICHAK BAY.

View from stream to northeast.

Figure 1. Canneries of 1900,(after Moser).

In 1895, under the same name (Point Roberts Packing Company), the Alaska Packers Association built a cannery at Koggiung, utilizing the available machinery from the cannery of the Central Alaska Company at Thin Point. It was a two-filler cannery two lines of canning machinery of 1,500 cases capacity per day. It made the first pack in 1896 and a pack every year since to date. In 1897 it was enlarged to three fillers, and in 1898 a second three-filler cannery was built close to and connected with the first, so that the plant now practically consists of a six-filler cannery and a saltery. . . .

<u>The Kvichak Packing Company</u>. Under this name the Alaska Packers Association built a cannery in the spring of 1900, on the eastern shore of Kvichak Bay, about 6 miles below the cannery of the Point Roberts Packing Company, and on the northern point of entrance to Bear Slough. It is a three-filler cannery with a daily capacity of 2,400 cases, and has substantial warehouses and quarters. It is well lighted, roomy, and well ventilated, and contains the latest machinery and cannery improvements. It was ready and commenced packing June 29.

<u>North Alaska Salmon Company.</u> This company, organized from the Sacramento River Packers' Association and incorporated under the laws of California, sent a large cannery plant to Bristol Bay in the spring of 1900 and buit two canneries on the left bank of the Kvichak River, near the mouth, about 6 miles above Koggiung. The plant was placed in two canneries, 1,000 feet apart, for the purpose of obtaining fire protection. They will be operated, however, under one management during the season of 1901, when the first pack is expected. Each cannery will have 4 retorts, 2 fillers, 2 toppers, 2 solderers, 1 cutter, and 1 set of can-makers. As the cannery will employ 50 hands to the filler, a daily capacity is expected of 1,800 cases, or 3,600 cases for the two canneries; a conservative rating, however, would be 3,200 cases.

<u>Establishment of Canneries on the Naknek River</u>

<u>Artic Packing Company</u>. In 1890 this company built and operated a saltery on the Naknek, at a point indicated in the preceding paragraph. This saltery was sold to the Alaska Packers Association

in 1893. In 1894 the association built a cannery at the same point, utilizing in its construction the available machinery of the cannery of the Thin Point Packing Company, at Thin Point, and made the first pack in 1895. A pack has been made every year since to date. The saltery has been operated every year except 1897. The original plant was a two-filler cannery, but in the spring of 1900 an additional machine was installed, and it now has a daily capacity of 2,400 cases. A pack of 55,000 cases is expected during a good average season.

Naknek Packing Company. In 1890 Mr. L. A. Pedersen established and operated a small saltery on the right bank of the Naknek about 3 miles above the mouth. In 1894 a company under the above title, incorporated under the laws of the State of California, absorbed the saltery and erected a cannery near it. The first pack was made in 1895, and a pack has been made every year to date. The saltery has also been operated every year, and in 1897 an additional one was built and operated on the shore of Kvichak Bay, about 2 miles above the mouth of the Naknek. The latter was abandoned in 1900, During the present season (1900) the cannery plant was enlarged by the addition of a small cannery building, warehouse, bunk houses, etc., and it is expected to have three fillers ready for operation in 1901 and the cannery equipped for a pack of at least 40,000 cases.

Establishment of Canneries on the Egegik River

Egagak (Egegik) Fishing Station. Under this name the Alaska Packers Association, in 1895, established and operated a saltery on the right bank of the Egagak about 5 miles from the entrance, and salted every year until 1900, when the apparatus was moved to the new cannery site, though the buildings were left standing.

Egegak (Egegik) Packing Company. In 1899 the Alaska Packers Association, under this title, commenced building a cannery on the left bank of the Egegak, opposite and a little above the salting station, utilizing the available machinery of the cannery of the Baranoff Packing Company, of Redfish Bay, Southeast Alaska. This plant had been purchased during the winter of 1898 and 1899, when that locality was abandoned. The new cannery was completed in 1900, and the first pack commenced July 1. It has substantial buildings, and is clean and well arranged. The cannery machinery consists of 5 retorts, 2 fillers, 2 toppers, 2 solderers, and 1 cutter; can-makers will be installed. This year all cans were brought from San Francisco, 100-pound tin plate being used for bodies and 95-pound plate for tops; all domestic.

Establishment of Canneries on the Ugashik River.

Johnson Saltery. Mr. C. A. Johnson salted salmon on the Ugashik from 1889 to 1898, both inclusive. He was the pioneer in this business on the river and built and operated a saltery in 1889, on the left bank, about 23 miles above Smoky Point and 2 miles below the trading post of the Alaska Commercial Company. This saltery was merged in the cannery of the Bering Sea Packing Company. In 1894 Mr. Johnson established and operated another saltery on the right bank of the river, about 1½ miles above the pilot station, which he sold in 1899 to the Alaska Packers Association, who absorbed it in their cannery plant.

Bering Sea Packing Company. In 1890 this company, a branch of the Alaska Improvement Company, though a separate corporation, purchased the machinery of the Western Alaska Packing Company at Ozernoy, and commenced building a cannery on the left bank of the Ugashik, near the first Johnson saltery. In transporting the machinery on the schooner Premier, that vessel went ashore in Stepovak Bay and the machinery did not all reach the Ugashik until 1891, when it was installed and a small pack made that year. As the site appeared unsuitable, the cannery remained closed in 1892 and 1893 and in 1894 it was moved to a point on the left bank, about 15 miles above Smoky Point, where it was operated in 1894, 1895, and 1896. In 1897 it was sold to the Alaska Packers Association, with other property of the Alaska Improvement Company, and the machinery and equipment were utilized in the Alaska Packers Association cannery. Nothing remains but the dwelling of the superintendent, now used as a fishing camp by the Alaska Packers Association.

Nelson Saltery. In 1893 Mr. Charles Nelson established a saltery on the left bank of the Ugashik, immediately above the last site of the Bering Sea Packing Company. After operating it in 1893 and 1894 it was sold to the Alaska Packers Association and closed.

Alaska Packers Association Saltery. In 1893 the Alaska Packers Association built a saltery on the left bank of the Ugashik, about a mile below the last site of the Bering Sea Packing Company. It was operated in 1893, 1894, and 1895, and then merged in with the Alaska Packers Association cannery, built the latter year near the pilot station.

Ugashik Fishing Station. In 1895 the Alaska Packers Association built a cannery on the right bank of the Ugashik immediately above the pilot station, where the river is about 3 miles wide, utilizing in its construction the available machinery of the Russian-American Packing Company's cannery at Afognak. It made the first pack in 1896, and has packed every year since to date. Originally it was a two-filler cannery, but in 1900 another filler was installed, and it now has a capacity of 2,400 cases per day.

Bristol Packing Company. This company, organized largely by the stockholders of the Naknek Packing Company, sent a cannery outfit to the Ugashik early in the spring of 1900 and located on the left bank of that river about 25 miles from Smoky Point, near the site of the old trading post of the Alaska Commercial Company. The cannery was ready for packing July 9. It was not fully equipped but had at the time of our visit 2 retorts, 1 fruit topper, 1 solderer, and 1 cutter. The work was done largely by hand, but it was estimated that 500 cases could be packed per day. All the cans were brought from San Francisco; they were made of 100-pound imported tin plate. It is said that in 1901 the cannery will be equipped with 3 fillers and the corresponding machinery, and it is anticipated that a pack of 40,000 cases will be made during the season.

New Canneries, Western Alaska, 1901

From Cross Sound to Bering Sea there were no additions to the canneries, but the latter district received six new ones and enlargements to several old plants.

The Portland-Alaska Packers' Association built a cannery at Snag Point, on the Upper Nushagak Bay. The location is in front of the village, a short distance above the A. P. A. cannery known as the Alaska Packing Company, or the Johnson plant.

The Columbia River Packers' Association constructed a cannery at the mouth of Clark Creek, above the Nushagak Canning Company's reserve plant (A. P. A.).

The Alaska Salmon Company erected a canning plant on the right bank of Wood River, about 2 miles from the mouth, and abreast of the lower point of the first island in the river.

The Red Salmon Packing Company built and operated a cannery on the Ugashik River, about half a mile above the site of the old Bering Sea Packing Company.

The Alaska Packers' Association built an additional three-filler cannery on the Ugashik, on the site of the old Bering Sea Packing Company, and have retained the latter name for the new cannery.

Under the name of the Guardian Packing Company the A. P. A. built a four-filler cannery on the Naknek, about 2 miles below their old cannery, which is operated under the name of the Arctic Packing Company.

The Alaska Packers' Association has also laid the foundation for a large addition to their plant below Koggiung, which was constructed and operated in 1900. In my last report this was called the Kvichak Packing Company, but since then the name has been changed to the Horseshoe Fishing and Mining Company. This addition is to have four fillers and to be ready for operation during the season of 1902.

Operating Canneries during Recent Years

The number of canneries increased until twenty-five were operated in 1920, eight on the Nushagak, six on the Kvichak, seven on Naknek, two on Egegik and two on Ugashik. The number of operating canneries has varied from year to year depending upon fluctuations in the demand for canned salmon and on the owners premonitions as to whether or not there would be a plentiful supply of fish. The increased efficiency of canning machinery during the past 15 years has resulted in consolidation of operations; the more favorable cannery sites being used and the poorer locations being abandoned.

Floating canneries made their first appearance at Ugashik and Kvichak in 1922 and since then have operated off and on in the various districts. Reefer ships joined the floating operations following the close of the last war, and must now be considered along with the canneries in estimating the fishing pressure on the run of red salmon.

Methods of Fishing

Gill Nets

Gill nets and traps were used in taking salmon for the early canning and salting operations in Bristol Bay. Both methods are well adapted to the local conditions. The strong currents, narrow channels, and soft muddy beaches do not favor seining but the extremely muddy water permits the efficient use of gill nets.

Alexander (1890) reported that the gill nets used on the Nushagak were of two sizes, one for king salmon and one for red and silver salmon. The king salmon nets were 100 fathoms long, 30 meshes deep, the meshes measured 9½ inches stretched. The red salmon nets were 75 fathoms long, 24 meshes deep, and meshes of 6½ inches stretched measurement. He states, "The nets seldom survive a season's fishing for they are continually in the water except when undergoing repairs."

Moser, in 1900, found the gill nets used in fishing red salmon varying in length from 70 fathoms to 85 fathoms, from 20 to 24 meshes in depth and mesh sizes of either 6 1/8 or 6 1/4 inches stretched measurement between knots.

The length of net and size of mesh varied from year to year according to the will of the cannery operators until the executive order dated December 16, 1922 provided that:

> King-salmon nets shall have a mesh not less than 8½ inches knot measure, and red-salmon nets, after the season of 1923, a mesh not less than 5 3/4 inches stretched measure between knots. For the season of 1923 only, red-salmon nets will be permitted with mesh as small as 5½ inches, measured as above. Each fishing boat may be provided with gill nets not to exceed in length 200 fathoms hung measure.

On December 2, 1924, the regulations were revised to permit after the season of 1925, the use of red-salmon nets with a minimum mesh of 5½ inches and not over 28 meshes deep.

Set nets were limited to length of 75 fathoms in the 1926 regulations.

The 1928 regulations provided that the total aggregate length of gill nets per boat was not to exceed 150 fathoms, but set nets remained at the 75 fathom length.

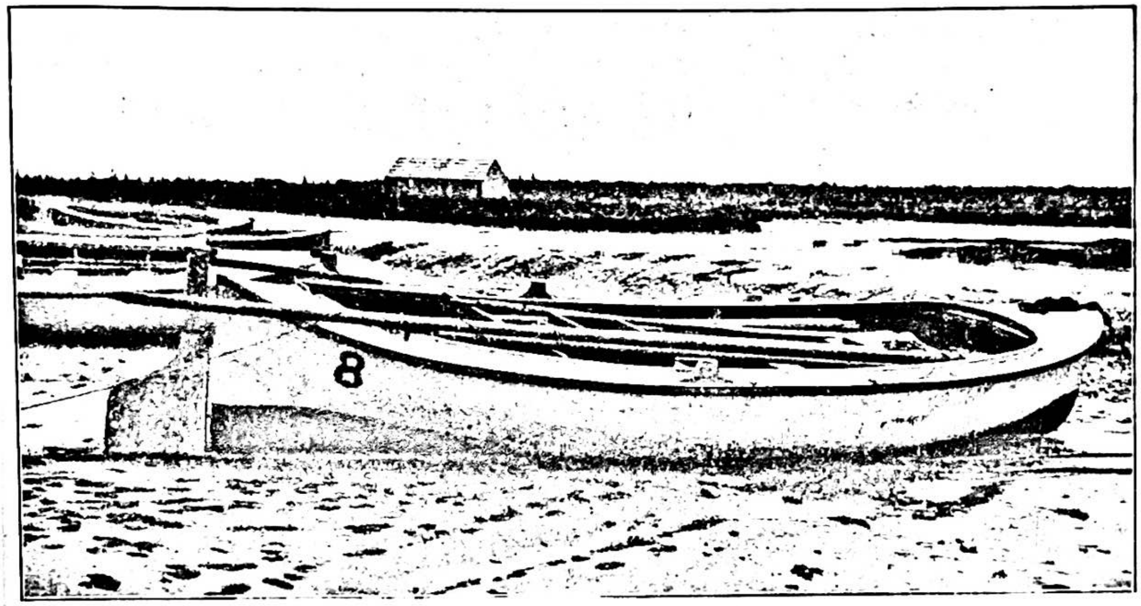
Set nets were reduced to a maximum length of 50 fathoms in 1935.

Types of Fishing Boats

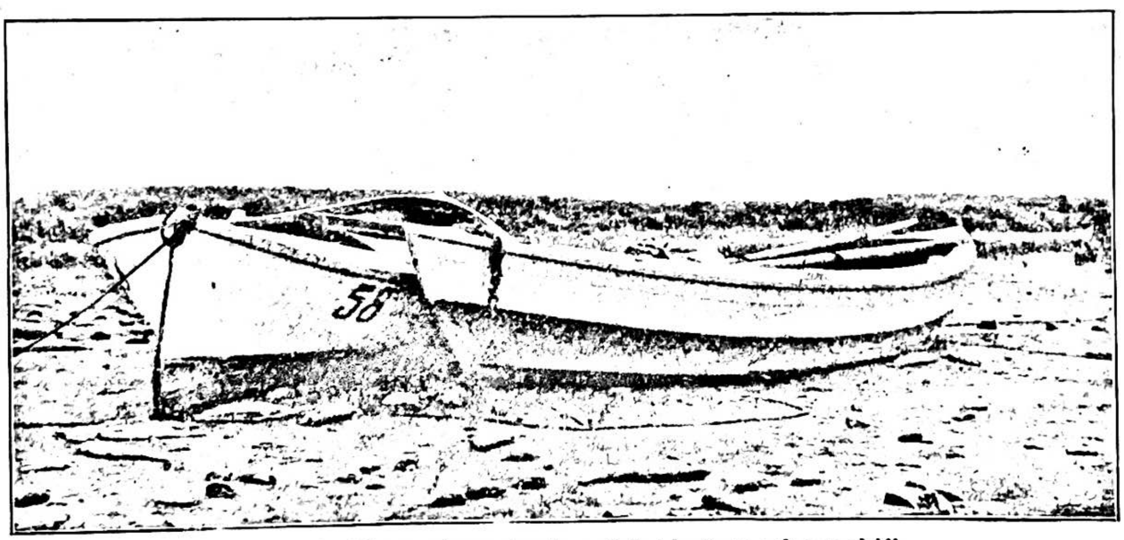
The gill-net boats in 1900, as described by Moser, were regular Columbia River boats with the usual dimensions of length, 25 feet 1 inch; beam, 7 feet 8 inches; depth, 2 feet 6 inches; capacity, 300 cubic feet. They had a centerboard and spritsail, and carried, as an extreme, 1,400 redfish. This type of boat was used in the Nushagak and Ugashik Rivers while the boats used on the Kvichak, Naknek and Egegik Rivers were flat-bottomed doublenders, about a foot longer than the Columbia River boats but had the same rig and the same capacity. Two men formed the gill-net crew -- a netter and a boat-puller.

The flat-bottom doublenders were gradually replaced by Columbia River type boats. The design of the boats was improved and in recent years they reached an over all length of 29 or 30 feet with a capacity of 420 cubic feet and have carried extreme loads of 3000 red salmon. Figure 2 is reproduced from Moser's report (Moser, 1902) showing the boats in use at that time.

The Carlisle Packing Company moved its operations from the Yukon River to the Kvichak River in 1922, and brought powered gill-net boats into Bristol Bay for the



Columbia River salmon boat.



Columbia River salmon boats and flat bottom salmon skiff.

Figure 2. Types of Fishing Boats, (after Moser).

first time. Purse seiners also made their appearance for the first time and made excellent catches about 25 miles offshore from Egegik. (Winn, 1923)

Regulations issued by the Secretary of Commerce on December 16, 1922 prohibited any further use of purse seiners in the area and forbid the use of power boats after the season of 1923. The regulations forbidding any power, other than sail and oars, remained in effect until the season of 1951 when the regulations permitted powered gill-net boats not to exceed 32 feet in length.

Number of Boats

Moser records the number of gill-net boats used in Bristol Bay as 146 in 1898, 195 in 1899, and 290 in 1900. The boats in 1900 were distributed in the various rivers as follows: Nushagak 22, Kvichak 50, Naknek 62, Egegik 19 and Ugashik 37.

In 1923 the number of boats operating in Bristol Bay were limited by executive order, and proportioned to the various canneries on the basis of ten gill-net boats per line of machinery operated in preceeding seasons. A total of 1,254 boats fished in Bristol Bay with 352 on the Nushagak, 410 on the Kvichak, 354 on the Naknek, 72 on the Egegik, and 66 on the Ugashik River. (Bower, 1925)

An act of Congress approved June 6, 1924 gave broad authority to the Secretary of Commerce for conserving the fisheries of Alaska, but provided that regulations must be general and that exclusive rights to fish must not be granted. Under these provisions the Bureau of Fisheries, and of later years, the Fish and Wildlife Service, has made recommendations as to the number of boats to be used in each fishing district. Any boats over the recommended allotment fishing in a district has been compensated by additional closed time each week in the district concerned. The total number of boats in the recommendations for Bristol Bay has varied from year to year, but has been about 1000.

Traps

Traps were used in the first commercial fishing as noted in Petroff's report of 1880. The early canneries in Alaska used barricades on the streams as a means of obtaining a supply of salmon. An act of Congress, approved March 2, 1889 prohibited the erection of such dams or barricades in any of the rivers of Alaska.

Early in April, 1890, information reached the Commissioner of Fisheries that four cannery firms located on the Nushagak River had determined to construct a trap on Wood River in such a manner as to be in violation of the act. The Commissioner of Fisheries transmitted the information to the Secretary of the Treasury with the suggestion that the necessary steps be taken by some of the Treasury officials in that region. The matter was then referred to the chief of the Revenue-Marine division with the recommendation that if possible, the captain of one of the Revenue-Marine steamers cruising in Alaskan waters make the investigation, and if necessary, remove the obstruction and arrest the guilty parties.

The chief of the Revenue-Marine division informed the Commissioner of Fisheries that the commanding officers of the Revenue-Marine steamers cruising in Alaskan waters would be instructed to enforce the law for the protection of the fisheries as far as circumstances would permit. He suggested that the commanding officer of the Fish Commission steamer Albatross be instructed to investigate the complaint and enforce the law if found necessary. The Commissioner of Fisheries did not have authority to give directions for the enforcement of the law, and therefore wrote to the chief of the Revenue-Marine division that if the Secretary desired to confer the necessary authority upon the commanding officer of the Albatross, Lieutenant Commander Z. L. Tanner, U. S. Navy, that he would take pleasure in forwarding same. The acting Secretary of the Treasury, Hon. George S. Batcheller forwarded to the Commissioner of Fisheries an order giving the commander of the Albatross the necessary authority to act in the matter and inclosed copies of Treasury circular of March 16, 1889 in relation to the matter.

The following exchange of communications not only tells of the conditions found on Wood River but illustrates the difficulties of law enforcement at this time. (McDonald 1894)

Treasury Department,
Office of the Secretary
Washington, D.C. April 18,1890

Sir: You are hereby clothed with full power and authority to enforce the provisions of law contained in act of Congress approved March 2, 1889, providing for the protection of the salmon fisheries of Alaska, which prohibits the erection of dams, barricades, or other obstructions in any of the rivers of Alaska, with the purpose or result of preventing or impeding the ascent of salmon or other anadromous species to their spawning grounds.

Respectfully yours,

Geo. S. Batcheller
Acting Secretary

Lieut. Commander Z. L. Tanner
Commanding U. S. Fish Commission Steamer Albatross
San Francisco, Cal.

Treasury Department,
Office of the Secretary,
Washington, D. C. March 16,1889

TO COLLECTORS AND OTHER OFFICERS OF THE CUSTOMS:

The following provision of the act approved March 2, 1889, entitled "An Act to provide for the protection of the salmon fisheries of Alaska" is hereby published for the information and guidance of all concerned:

"That the erection of dams, barricades, or other obstructions in any of the rivers of Alaska, with the purpose or result of preventing or impeding the ascent of salmon or other anadromous species to their spawning-grounds, is hereby declared to be unlawful, and the Secretary of the Treasury is hereby authorized to insure that this prohibition is strictly enforced and to otherwise protect the salmon fisheries of Alaska; and every person who shall be found guilty of a violation of the provisions of this section shall be fined not less than $250 for each day of the continuance of such obstruction."

Collectors and other officers of the customs, and officers under the jurisdiction of this Department who may be assigned to duty in Alaska, will see that the requirements of said section are strictly observed, and that no dams, barricades, or other obstructions are placed in any of the rivers of Alaska with the purpose or result of preventing or impeding the ascent of salmon or other anadromous species to their spawning-grounds; and should any such dams, barricades, or other obstructions be discovered, to warn the persons who erected the same to immediately remove them and thereafter report the persons (with statement of facts) to the United States attorney of Alaska for prosecution under the said section, and also to forward duplicate reports to this Department for its information.

Officers of the Revenue-Marine Service on duty in Alaskan waters are hereby required, so far as practicable, to assist officers of the customs in Alaska in seeing that the requirements of the statute are strictly enforced.

Hugh S. Thompson
Acting Secretary

On April 23 a letter of instructions was forwarded to Lieut. Commander Tanner, calling his attention to the existence of a trap or dam on Wood River, as also to the order of the Secretary of the Treasury directing the Revenue-Marine steamers to enforce the law as far as circumstances would permit, and to the request that the steamer Albatross make an investigation and carry out the provisions of the law in case of its violation. Lieut. Commander Tanner was directed to make this one of the first objects of his cruise in Bering Sea, and to comply with the instructions of the Secretary of the Treasury as fully as possible. His report, after making the investigation, was as follows:

Unalaska, Alaska Territory
June 15, 1890

Hon. Marshall McDonald,
U. S. Commissioner of Fish and Fisheries,
Washington, D. C.:

Dear Sir: I have the honor to inform you that the Albatross anchored in the Nushagak River on June 3. I visited the four canneries located on that stream the following day. They use gill nets almost exclusively in taking salmon, although three of them have a small trap in the immediate vicinity of their establishments. They are all dry at low tide, and when fish are found in them men go in and pick them up from the ground.

The fourth cannery had a trap formerly, but did not find it profitable. Nothing that can be called an obstacle to the free passage of salmon exists in the Nushagak River.

I learned from Mr. J. W. Clark, one of the projectors, and others, that a union trap was in process of construction in Wood River, and in order to ascertain the character and present condition of the work I took Mr. P. H. Johnson, who has charge of the enterprise, and Mr. Clark, in one of the ship's boats, and steamed to the point indicated, which I found to be about 20 miles above its mouth.

Wood River at that point is a stream of pure cold water between 700 and 800 feet in width and 10 feet deep at low tide; rise, 3 to 4 feet.

The work of trap-building was in progress, a group of ten piles having been driven about 300 feet from shore, and lying on the bank were a portion of the nets required to mount the finished structure. Operations were not sufficiently advanced to enable me to judge their intention, and I can only give the plan as detailed to me by the builders. Mr. Clark stated that the plans contemplated two 40-foot square traps, with wings extending to the shore on either side, an open channel of 100 feet being left in mid-stream for the passage of the salmon; that he had joined the enterprise with the stipulation that this passage should be left unobstructed at all times.

In reply to a question, he said that he had lived in the country many years as a fur-dealer, and the thickly populated region on Wood River contained many of his best customers; hence he would have no hand in anything that would injure them. An obstruction in the river preventing the run of salmon would result in actual starvation to the majority of the natives.

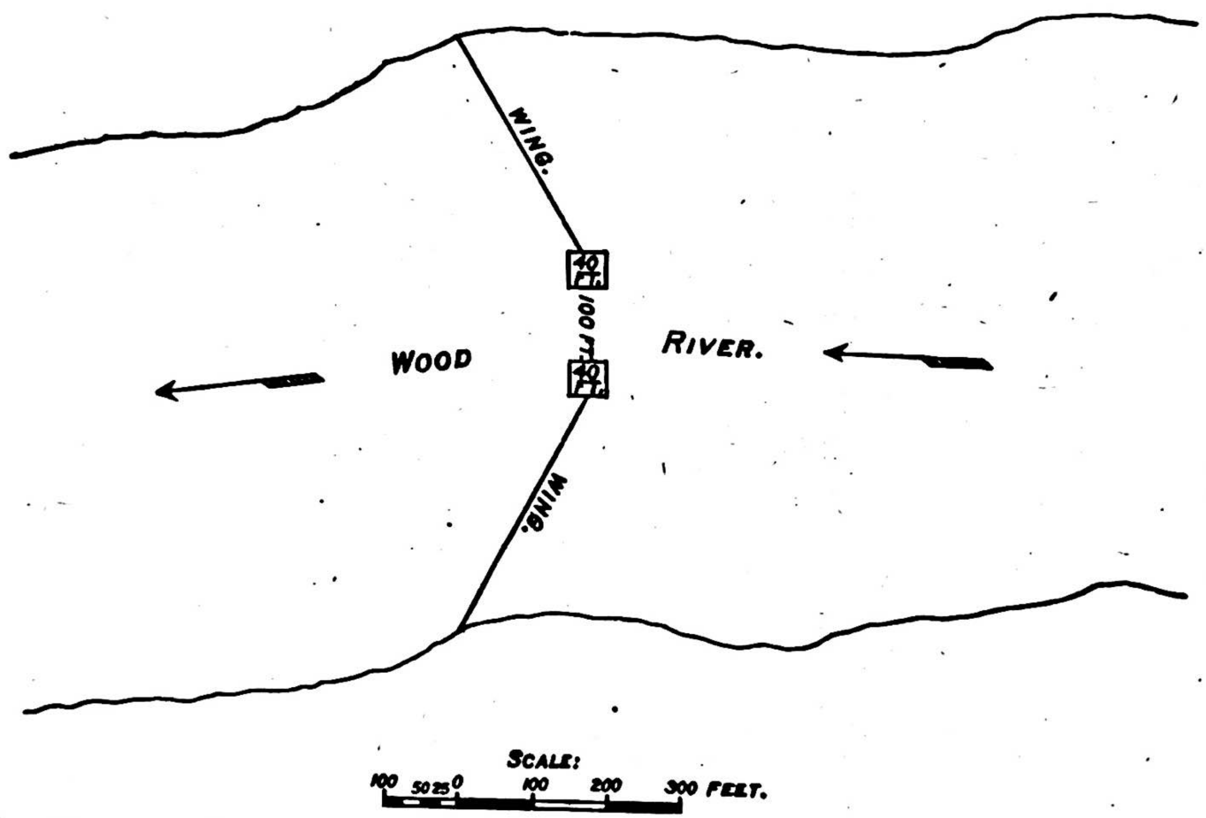
Mr. P. H. Johnson, the prime mover in the affair, described the plans precisely as Mr. Clark had done. He considered the traps as an experiment involving too much money to be expended by either of the canneries singly; hence, he had endeavored to interest all four, and finally succeeded, Mr. Clark having joined them with the provision that a free passage of at least 100 feet should be left in the middle of the river. He said this stipulation was agreed to willingly, as they never had an idea of barricading the stream. The inclosed sketch shows the plan as given to me by the genelemen mentioned, and the blue prints (not reproduced) give an accurate idea of the present state of the structure. It will be observed that, while a 100-foot channel will serve for the ascent of salmon, complete barricade of the stream can be accomplished with a net of that length, 12 to 15 feet in depth. Whether this simple appliance will be used depends, in the absence of a Government inspector, upon the canneries themselves.

Very respectfully,

Z. L. Tanner
Lieutenant Commander, U. S. Navy
Commanding

Figure 3 is a reproduction of the sketch referred to above.

Z. L. TANNER,
Lieutenant Commander, U. S. Navy, Commanding.



NOTE.—The river is at this point about 750 feet wide; depth at mean low water, 10 feet; rise, 3 to 4 feet.

Figure 3. Proposed Wood River Trap, 1890, (after Tanner).

Unalaska, Alaska Territory,
June 18, 1890

Hon. Marshall McDonald,
U. S. Commissioner of Fish and Fisheries

Dear Sir: In looking over my letter regarding the construction of traps in Wood River it occurs to me that I may not have explained my action very definitely. It is generally understood here that the act of March 2, 1889, does not prohibit the ordinary use of the trap, and that when a practicable channel is left for the passage of salmon they may lawfully be used. As I did not feel fully competent to argue the point I advised them to keep within the law, as the Government intended to enforce it strictly and would exact the full penalties for its infraction.

If it is the intention of the act to prohibit the use of traps, I would respectfully suggest that it be so stated in a Treasury circular. It would simplify matters very much if the Treasury Department would state definitely what the canners may or may not do under the act of March 2, 1889.

Very respectfully

Z. L. Tanner
Lieut. Commander, U. S. Navy
Commanding

This correspondence was referred to the ichthyologist of the Commission, who made the following report:

U. S. Commission of Fish and Fisheries,
Washington, D. C., July 24, 1890

Col. Marshall McDonald
U. S. Commissioner of Fish and Fisheries:

Sir: After having considered the letters of Lieut. Commander Z. L. Tanner, U. S. Navy, dated June 15 and 18, 1890, referring to the construction of a trap in Wood River, Alaska, I respectfully offer my opinion that such a contrivance for the capture of salmon is of the nature of an obstruction which would impede and in all probability, prevent the ascent of salmon to their spawning grounds. It is, therefore, clearly a violation of the act approved March 2, 1889, a portion of which is quoted herewith:

(PUBLIC No. 158--- An act to provide for the protection of the salmon fisheries of Alaska)

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the erection of dams, barricades, or other obstructions in any of the rivers of Alaska, with the purpose or result of preventing or impeding the ascent of salmon or other anadromous species to their spawning-grounds, is hereby declared to be unlawful, and the Secretary of the Treasury is hereby authorized and directed to establish such regulations and surveillance as may be necessary to insure that this prohibition is strictly enforced and to otherwise protect the salmon fisheries of Alaska; and every person who shall be found guilty of a violation of the provisions of this section shall be fined not less than $250 for each day of the continuance of such obstruction."

It has been demonstrated that traps in salmon rivers will speedily exterminate the salmon. Newfoundland furnished a satisfactory illustration of this fact. So well is this matter understood that British Columbia forbids altogether the capture of salmon in narrow reaches of streams, and the rivers are guarded to see that the close time and other regulations are observed; the length of nets and their size of mesh are fixed by law; even the offal from canneries is not allowed to lie in the way of ascending fish.

The Alaska salmon firms are in the territory to get fish. They prefer to get them without injury to the future of the business if possible, but get them they must or be overcome by financial disaster. In their efforts to win success they have often stretched nets across the mouths of small streams and prevented the salmon from going up until a sufficient number had collected to make a good seine haul possible. They have erected traps in rivers in such a way as to stop every salmon from ascending and, in some cases, actually built impassable barricades to prevent the ascent of fish entirely until the demands of the canneries were satisfied. Even when fishing regulations were adopted by mutual agreement among the firms interested, individual infractions of the rule were only too frequent.

The trap men on Wood River are building upon the well-known habit of the quinnat (or King salmon) of following along the shores in shallow water to escaped from enemies. All the conditions, both natural and invented, will favor the entrance of salmon into the great inclosure at the end of the leader of netting. In all probability few salmon will swim in midchannel and reach the upper waters and lake sources of the river, and it will always be possible to cut off this remnant in the manner suggested by Lieut. Commander Tanner and actually practiced by fishermen on occasions, that of stretching a seine across the open water. If the Government should interpret its act so as to allow the use of traps, in spite of the unfortunate outcome of such appliances in neighboring countries, it should then prescribe regulations for the conduct of the fishery and appoint agents to see that the laws are enforced. If these matters are left solely to the discretion of the individuals having a financial interest in the fishery, there will soon be no salmon to protect.

Very respectfully,

T. H. Bean
Ichthyologist
U. S. Fish Commission

The papers relating to the obstruction of Wood River were transmitted to the Secretary of the Treasury by the Commissioner of Fish and Fisheries, with the following letter:

Washington, D. C., July 31, 1890

To the Secretary of the Treasury,
Washington, D. C.:

Sir: Referring to your communication of April 18 last, forwarding to Lieut. Commander Z. L. Tanner, U. S. Navy, commanding the Fish Commission steamer Albatross on the Pacific coast, a letter clothing him with full power to enforce the provisions of the Alaskan salmon law, with special reference to obstructions which it was reported were to be constructed in the Nushagak and Wood rivers, I have the honor to transmit herewith for your consideration several documents bearing upon that subject, namely:

Copies of two letters from Lieut. Commander Z. L. Tanner, with their inclosures, dated Unalaska, Alaska, June 15 and 18, and a copy of a letter from Dr. T. H. Bean, ichthyologist of the U. S. Fish Commission, dated July 24.

Lieut. Commander Tanner reports having visited the Nushagak and Wood rivers on June 3. He found no obstructions in the former river, but in the Wood River two traps were in process of construction, with wings leading the shore and leaving a passageway in the middle of the river 100 feet wide. Not feeling competent to judge if these traps formed an obstruction to the ascent of salmon within the meaning of the law, Lieut. Commander Tanner did not feel justified in carrying out the provisions of the law without further instructions from Washington.

Dr. T. H. Bean, whose letter is inclosed, may be considered as one of the foremost authorities in this country respecting the habits of the Alaskan salmon. He paid special attention to that subject during two official visits to Alaska, the last visit having been made a year ago, in obedience to instructions from Congress contained in the act of which the law now referred to forms a part. In his opinion the building of the traps in Wood River according to the plan submitted by Lieut. Commander Tanner should be regarded as an infringement of the law, and in that opinion I fully concur.

Should you desire to have further instructions respecting this matter sent to Lieut. Commander Tanner, I shall be pleased to transmit the same without delay, although, on account of the imperfect mail arrangements with Unalaska, I fear they may not reach him before the close of the season.

Very respectfully,

M. McDonald
Commissioner

To the foregoing communication the Acting Secretary of the Treasury made the following reply:

Treasury Department,
Office of the Secretary
Washington, D.C., August 13, 1890

Hon. Marshall McDonald
U. S. Commissioner of Fish and Fisheries,
Washington, D. C.:

Sir: I respectfully acknowledge the receipt of your letter dated July 31, 1890 with the following inclosures:

Copies of two letters from Lieut. Commander Z. L. Tanner, U. S. Navy; one sketch and two blue prints of Wood River, Alaska, and one letter from Dr. T. H. Bean, ichthyologist, U. S. Fish Commission.

The correspondence above mentioned has been carefully reviewed, and you are informed that it is the decision of this Department that the erection of traps as described by Capt. Tanner, or any other permanent fences, dams, or barricades in any of the rivers of Alaska, whether they extend wholly or only in part across said stream, is an impediment to the ascent of salmon or other anadromous species to their spawning-grounds, and is clearly a violation of the act of March 2, 1889.

The Department will be pleased if you will inform Lieut. Commander Tanner of its decision in this case and instruct him to warn the parties who erected said traps, or any others of like nature that may come to his notice, to immediately remove the same and thereafter to report the persons, with statement of facts, to the United States attorney of Alaska for prosecution under act March 2, 1889, and also to forward a duplicate of his report to this Department for its information.

Respectfully yours,

O. F. Spaulding,
Acting Secretary

The following communication was therefore transmitted to Lieut. Commander Tanner, advising him of the ruling of the Treasury Department.

Washington D. C., August 15, 1890

Lieut. Commander Z. L. Tanner,
Commanding Fish Commission Steamer Albatross,
Unalaska, Alaska

Dear Sir: Your letters of June 15 (179) and 18 (182), relative to your visit to the Nushagak and Wood rivers in respect to reported obstruction to the ascent of salmon, came duly to hand and were referred to the Secretary of the Treasury for his information. In connection with them, I also transmitted to the Secretary of the Treasury a report by Dr. Bean, based upon your letters and describing the inevitable effect of the construction of such traps as those now being constructed in the Wood River. A copy of Dr. Bean's report is herewith inclosed, and also a copy of a letter just received from the Acting Secretary of the Treasury, in which a decision is rendered that the Wood River traps are a violation of the act of March 2, 1889.

Should this communication reach you in time you will proceed to carry out the request of the Treasury Department as stated in the letter of the Acting Secretary.

Very respectfully,

M. McDonald
Commissioner

Moser's observation of traps throughout Alaska, as well as in Bristol Bay, prompted him to make the following comments which are not only of historical interest but should be considered in light of the influence that these traps may have had in relation to our present problem.

> Traps, used extensively in the Bristol Bay district, are a subject for criticism throughout Alaska. They are expensive to build and maintain, but have many advantages to the canner. The great benefit of a trap is not only that it fishes day and night, but, if the run is heavy for a few days and the cannery fully supplied by the gill-netters, the fish in the traps can be held for a time until the catch of the gill-netters is slack. These advantages have frequently led the trapmen beyond the limits of the law, and the time has come when the use of traps must be regulated and the law enforced, or else they must be abolished. Having in mind now the whole of Alaska, it is my opinion that if this be not done they will work a great injury to the fisheries.
>
> Traps catch not only the salmon wanted, but all other species of salmon and other fish not wanted. Practically all fish taken in the traps, except redfish, are waste, and until one sees the tons of this waste product, one can not realize the magnitude of this giant octopus that grasps everything in its tentacles.
>
> Fish were very plentiful this year, and the gill-netters were able to supply most of the fish used. It was said on this account that traps took more fish than were wanted, and that they were frequently opened to let the impounded fish escape. This statement may be true, but there never was a cat that held a mouse with more tenacity than a canneryman holds a salmon, and it is doubted if a salmon of choice species is ever allowed to escape as long as it is fit to be put inside a tin can.

I have said here that practically all fish taken in the traps, except redfish, are waste. This should be slightly modified, though practically it is true; yet, in justice to the cannerymen, it may be said that the records of the past few years show that, besides redfish, on the average less than 8,000 cases of king and 8,000 cases of all other species were packed per year in the whole Bristol Bay district, and some of these no doubt were taken in traps.

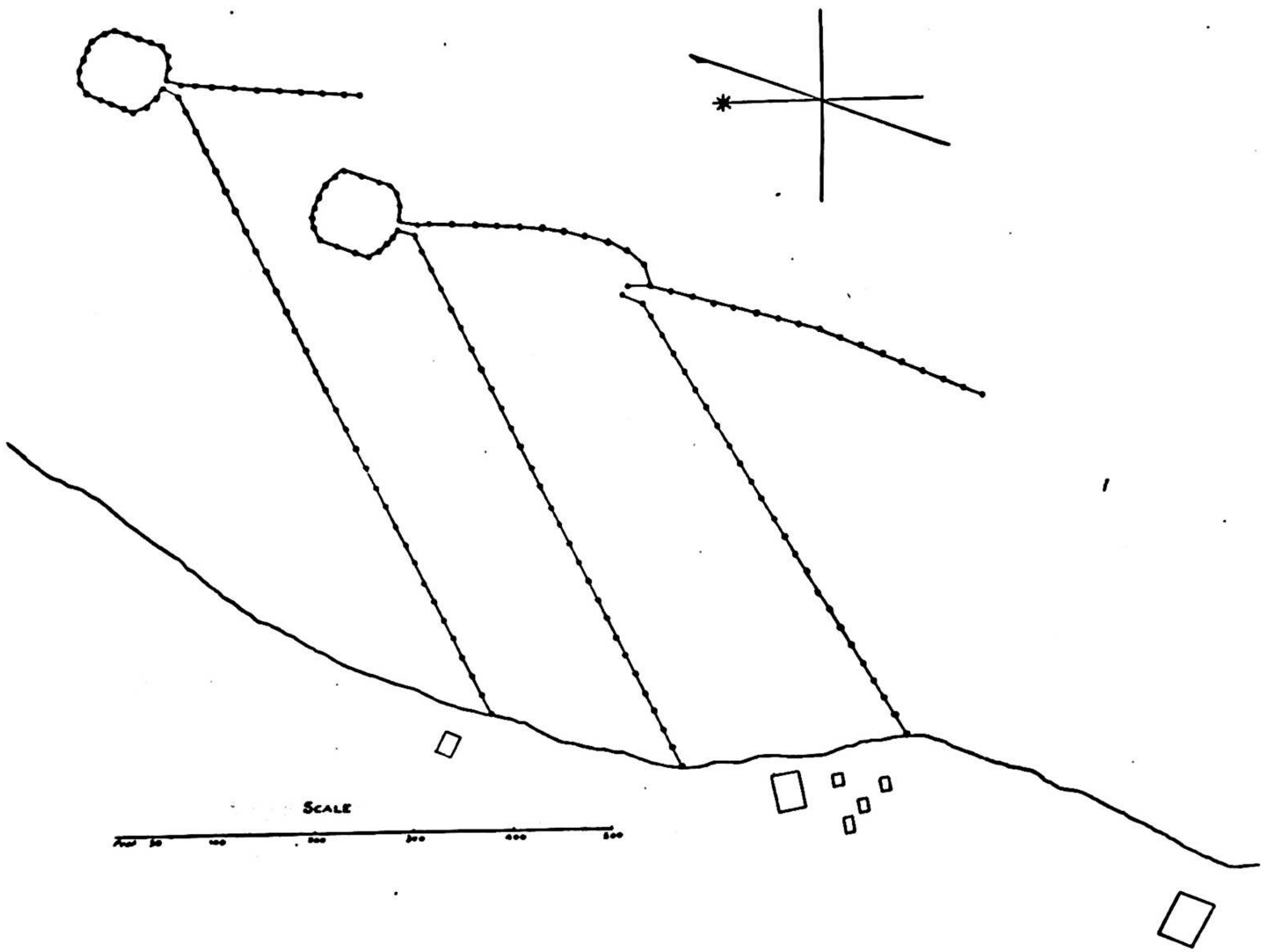
There is question arising in my mind which now can only be stated and left for the future to decide, as follows: Traps take all fish of all sizes; gill nets take only the large fish; will gill-net fishing result in decreasing the size of the fish?

In one locality trap men informed me that trap fish are more expensive than gill-net fish. In another place it was said that this year two gill-net boats secured more fish than one trap, but when asked why the traps were maintained the reply was that the fish were held in the traps until wanted.

One canneryman, whose resources seemed limited and who did not feel able to maintain traps, frankly said that traps should be abolished; but, when asked if he believed that traps were injurious to the fisheries, he was equally frank in saying "No." The motive is evident.

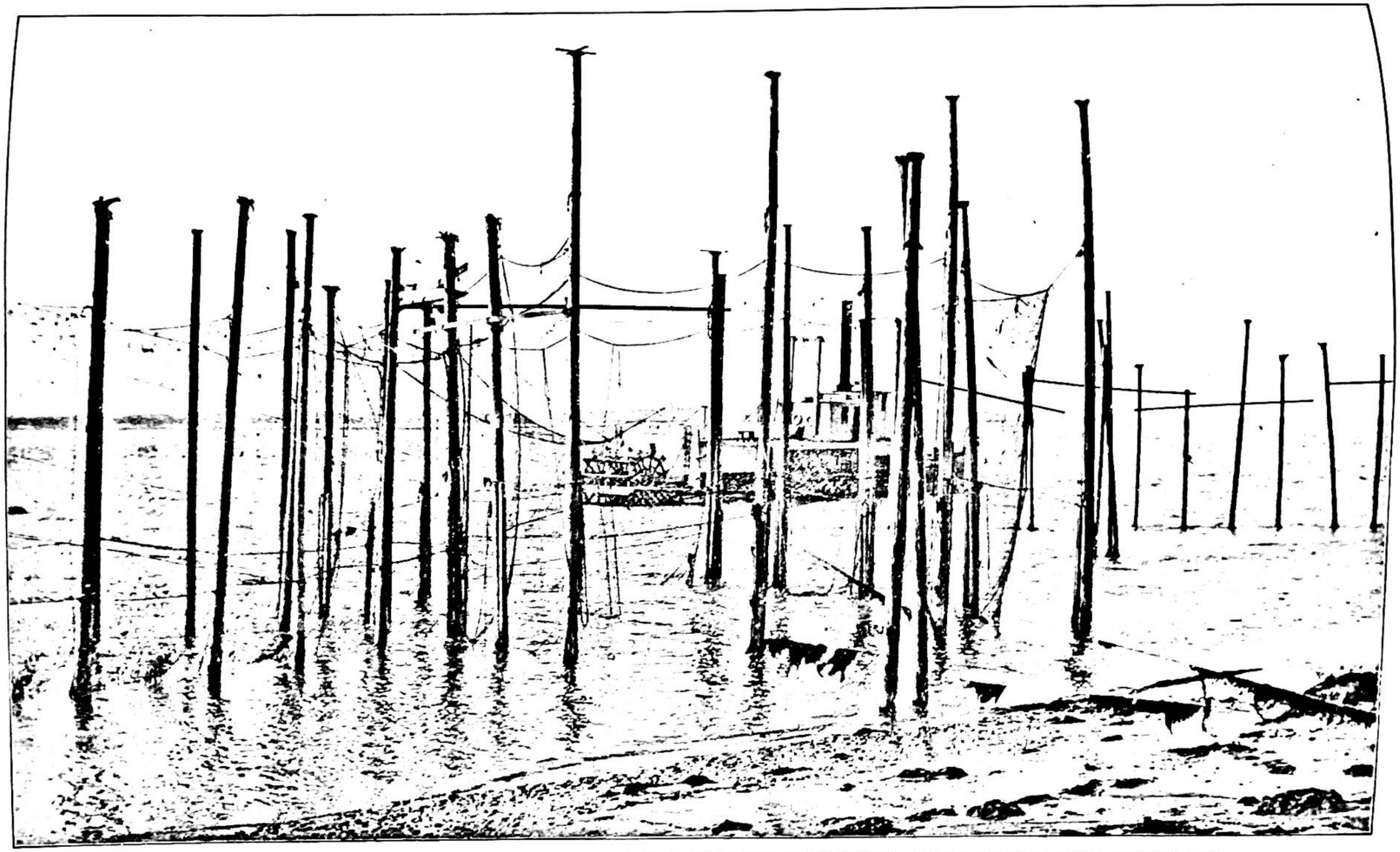
The traps used are of the general type illustrated in my report of 1897, page 170. They consist of the usual shore and channel leads, with hearts and pots, but there are all kinds of variations to meet local conditions or the fancy of the "trap boss". Some have two pots and some have additional appendages in the shape of corrals.

Not only is the first cost of a trap in this country large, but its maintenance forms a big item of expense. All piling must be imported, and the strong currents frequently damage both piles and web. The piles are pulled up when fishing ceases on account of the ice, and are redriven in the spring as soon as the ice is out of the river and before the fish begin to run. The largest trap seen in the Bristol Bay district had about 2,700 feet of leads laid out in a rather complex way, with two pots, 75 feet by 75 feet, and a large corral.



Fish trap in Wood River, about 15 miles above mouth.

Figure 4. Wood River Trap, 1900, (after Moser).



NORTHERN AND INSHORE POT OF SALMON TRAP, BELONGING TO ALASKA PACKERS ASSOCIATION, NEAR GRAVEYARD POINT, KVICHAK BAY.

View from beach at low tide, showing tunnel down; steamer Sayak at anchor beyond.

Figure 5. Salmon Trap, Kvichak Bay, 1900, (after Moser).

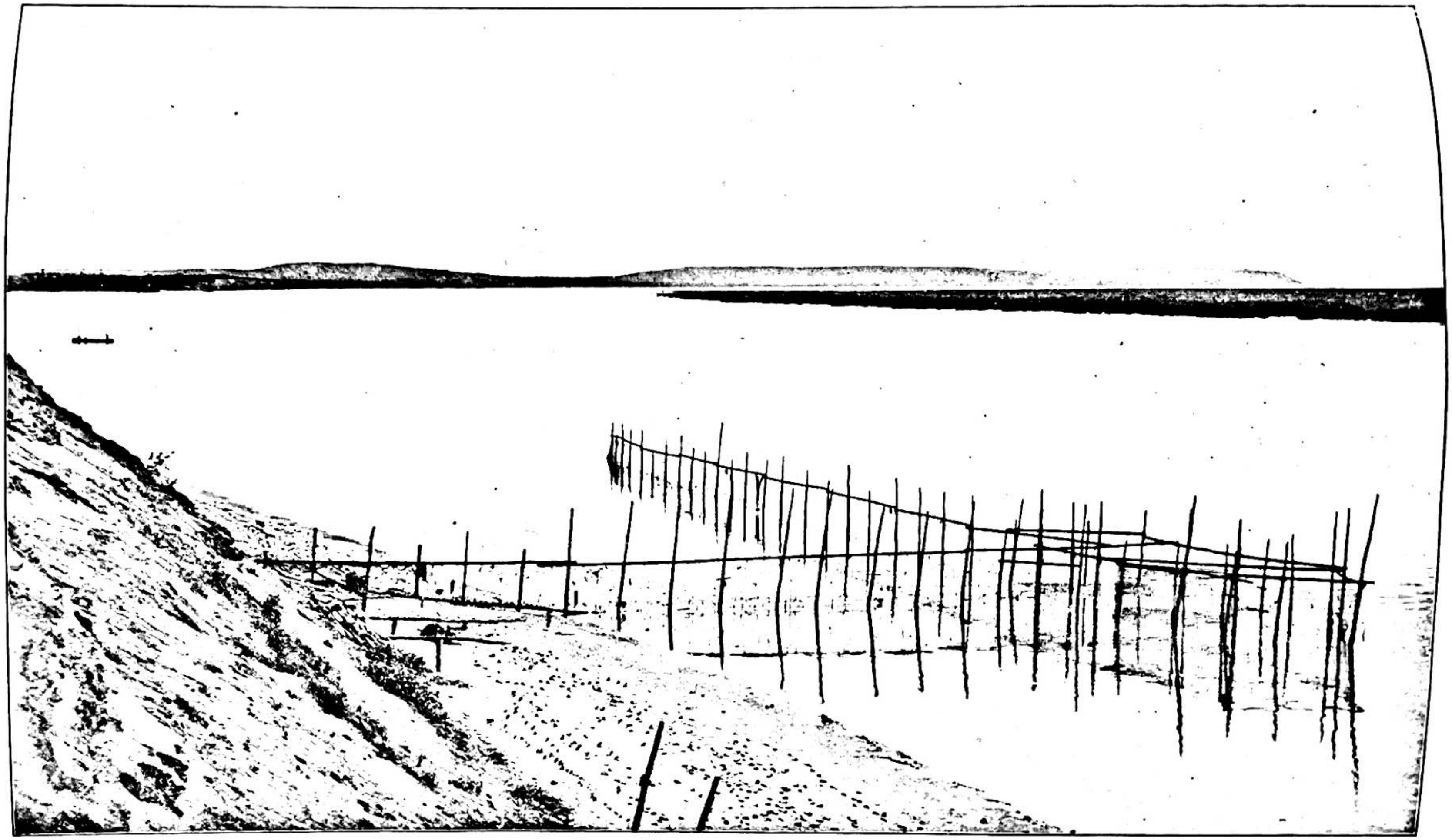

SALMON TRAP BELONGING TO C. E. WHITNEY & CO., NEAR THEIR SALTING STATION ON NUSHAGAK BAY.

Figure 6. Salmon Trap, Nushagak Bay, 1900,(after Moser).

The above mentioned trap was located on Wood River about 15 miles from its mouth. The accompanying sketch, Figure 4, was included in the report. (Moser 1902) The Wood River trap continued to operate until an order of the Secretary of Commerce and Labor, dated December 19, 1907, closed to all commercial fishing Wood River and the area within 500 yards of its mouth.

In 1900 there were four traps in operation on the Nushagak River, one on the Kvichak River, two on the Naknek River and three on the Ugashik River. Figure 5 and Figure 6, showing two traps in operation in 1900, one on Kvichak Bay and one on Nushagak Bay, are reproduced from Moser's report. (Moser 1902). The number of traps in Bristol Bay increased until 1906 when a total of 17 were operated. The number declined to eight in 1914, all of which were located on the Nushagak. Only three, all on the Nushagak, were in operation in 1920 and did not again exceed that number. It would appear that the special regulations for Bristol Bay contained in Department of Commerce Circular No. 251, ninth edition, January 9, 1923, restricting fishing to gill nets except that traps operated in 1922 may be operated in 1923, worked no particular hardship on the canneries.

Fishing Regulations

Early Regulations

The Wood River incident of 1890 serves to illustrate the difficulties of enforcing such regulations as existed at that time. Conditions improved very little, if any, during the next thirty years. Rich (1928) in speaking of Bristol Bay, sums up the situation by saying, "Up to 1922, then, it is safe to say that the catch of salmon had not been affected materially by legal restrictions."

Dr. Gilbert, following his survey of Bristol Bay in 1919, (Gilbert & O'Malley, 1921) had emphasized the need of regulations, but his warning was not heeded by Congress.

> As a last resort and as more or less of a temporary measure pending the passage of adequate laws by Congress the President, under date of November 3, 1922, signed an Executive order creating the Southwestern Alaska Fisheries Reservation, including the waters of Bristol Bay, Cook Inlet, and the Kodiak-Afognak region. (Bower 1923)

The area was administered by the Secretary of Commerce under this order until Congress by Act of June 6, 1924, gave the Secretary of Commerce broad authority for conserving the fisheries of Alaska. Under provisions of the President's Reorganization plan, made effective June 30, 1940, the Bureau of Fisheries and the Bureau of Biological Survey in the

Department of the Interior, with their respective functions, were consolidated into one agency in the Department of the Interior to be known as the Fish and Wildlife Service.

Summary of Fishing Regulations

The following is a summary of the Federal fishery laws and regulations affecting the salmon fisheries in Bristol Bay:

Act of March 2, 1889.

Section 1. Prohibits erection of dams or other obstructions in salmon streams.

Section 2. Directs Commissioner of Fisheries to investigate salmon and salmon fisheries of Alaska.

Act of June 9, 1896, amended and reenacted by act of March 3, 1899, Treasury Department Circular No.8, 1902, division of special agents.

Section 179. Prohibits erection of dams, barricades, fish wheels, etc., in salmon streams.

Section 180. Prohibits fishing above tidewater in streams less than 500 feet in width, except with rod or spear; setting gear across tidewaters of streams for more than one third the width or within 100 yards of another net or seine in such streams or channels; fishing from midnight Friday to 6 a.m. Sunday, except in Cook Inlet, Prince William Sound, and Bering Sea; fishing between 6 p.m. and 6 a.m. except by rod or spear, in streams less than 100 yards in width.

Section 181. Authorizes setting aside streams for spawning grounds, close seasons, and limitation of fishing season, but only after giving a hearing to interested parties.

Section 182. Provides penalties.

Act of February 12, 1903, Department of Commerce and Labor Circular No. 42, May 10, 1904.
Repeats act of March 3, 1899, changing authority to Department of Commerce and Labor.

Act of June 14, 1906, Department of Commerce and Labor Circular No. 136.
Prohibits aliens from fishing in the waters of Alaska.

Act of June 26, 1906, Department of Commerce and Labor, Circular No. 136, supersedes act of March 3, 1899.
Section 5. Prohibits fishing between 6 p.m. Saturday and 6 a.m. Monday except in Cook Inlet, Copper River Delta, and Bering Sea, and between 6 p.m. and 6 a.m. in any streams less than 100 yards in width. Provides for closing of trap and opening of heart walls of traps during weekly closed season.
Section 6. Authorizes reservations for spawning and limitation or restriction of fishing after giving hearing and in case those engaged in catching do not maintain adequate hatcheries.

Order of Secretary of Commerce and Labor, December 19, 1907
Closed to all commercial fishing Wood River and the area within 500 yards of its mouth.

Notice to Packers by Commissioner of Fisheries, April 18, 1908.
Prohibits use of salmon bellies only without utilizing remaining edible portions of fish.

Department of Commerce and Labor Circular No. 192, April 24 , 1909
Regulations of Bureau of Fisheries, Alaska Fisheries Service Circular No. 2, March 10, 1911. Provides for numbering of fixed fishing appliances.

Department of Commerce Circular No. 251, August 19, 1913.
Repeats acts of June 14 and June 26, 1906, changing authority to Department of Commerce.

<u>Announcement, Department of Agriculture, Bureau of Biological Survey</u>, April 13, 1914.
Permits to fish required in Aleutian Island Reservation.

<u>Department of Commerce Circular No. 251</u>, second edition, May 4, 1915.
Gives acts of June 14 and 26, 1906; general regulations providing for (1) inspection, (2) numbering of fixed appliances, (3) filing of labels, and (4) waste of backs. Regulations in Afognak Reservation. Regulations in Aleutian Island Reservation.
Closing orders:
1. Promulgated December 19, 1907. Closes fishing in Wood and Nushagak Rivers and within 500 yards of the mouth of Wood River.

<u>Department of Commerce Circular No. 251</u>, sixth edition, January 2, 1920
Revised as to closing orders which are as follows:
3. Southeastern Alaska and between Capes Spencer and Newenham (all of Alaska south of Cape Newenham), December 23, 1919. This combines the orders for (1) Wood and Nushagak, (2) Cook Inlet, Eyak Lake, Anan, and Naha, (3) Barnes Lake, Hetta, and Sockeye Creek, (4) Karluk, and (5) Bering River and Southeastern Alaska, making general provisions as follows:
(2) West of Cape Spencer. Prohibits fishing within 500 yards of stream mouths except --
(d) Ugashik River. Fishing permitted below a line 500 yards below mouth of King Salmon River.

<u>Department of Commerce Circular No. 251</u>, ninth edition, January 9, 1923
Alaska Peninsula Reservation regulations include limitation of gear and fishing operations; otherwise essentially the same as for 1922.

Southwestern Alaska Fisheries Reservation established by Executive order, November 3, 1922; regulations therefore promulgated on December 16, 1922.

Districts and zones defined; permits to operate required; pack, gear, and operations to be limited; taking of salmon for fox food permitted; purse seines prohibited; transportation of salmon between districts or zones outside the reservation prohibited; transfer of salmon from one plant to another prohibited in Cook Inlet and Kodiak districts.

Buying from natives permitted, but salmon so bought come under pack limitations; fishing prohibited in Chinik Inlet; special regulations for Bristol Bay:

1. Transportation between Nushagak and Kvichak-Naknek-Egegik district prohibited.
2. Fishing restricted to gill nets except that traps operated in 1922 may be used in 1923.
3. Limits size of nets and mesh.
4. Use of motor boats used in 1922 permitted in 1923, after which they are prohibited.
5. Fishing season for reds, June 26 to July 25.
6. Fishing for king salmon may begin before June 26.

<u>Act of June 6, 1924</u>. Department of Commerce Circular No. 251, tenth edition, June 21, 1924.

Section 1. Gives broad authority to Secretary of Commerce for conserving fisheries of Alaska; authority given to establish areas in which fishing may be prohibited or limited by (a) limitation of size and character of gear, (b) limitation of catch, and (c) limitation of time, means, methods, and extent of fishing. Such regulations must be of general application and exclusive rights to fish shall not be granted; act does not affect specified closed areas; prohibits importation of salmon taken during closed periods.

Section 2. Not less than 50 per cent escapement required in streams where counting weirs are maintained.

Section 3. Amends section 3 of the act of June 26, 1906; prohibits erection of dams, traps, etc., in waters less than 1,000 feet in width or within 500 yards of salmon stream mouths except at Karluk and Ugashik; prohibits setting of gear within 100 yards of other gear or to drive a trap within 600 yards laterally or 100 yards endwise of another trap.

Section 4. Amends section 4 of the act of June 26, 1906; prohibits commercial fishing in streams or within 500 yards of stream mouths, except at Karluk and Ugashik.

Section 5. Amends section 5 of the act of June 26, 1906; provides for a weekly closed season from 6 p.m. Saturday to 6 a.m. Monday and for the proper closing of traps during closed seasons.

Section 6. Provides penalties for violations of regulations.

Section 7. Repeals sections 6 and 13 of the act of June 26, 1906, authorizing reservations and providing penalties

Executive Orders Nos. 4020 and 4021, June 7, 1924

Revoke orders establishing Alaska Peninsula and Southwestern Alaska Fishery Reservation.

Regulations for 1926,

Limits length of set nets to 75 fathoms.

Regulations for 1928,

Limits boats to total of 150 fathoms of gill-nets.

Regulations of 1935,

Limits length of set nets to 50 fathoms.

Act of April 7, 1938,

Required two years residence on the Bristol Bay watershed in order to fish by means of a set net.

Act of June 25, 1938,

Entitled "An Act to Prevent Aliens from Fishing in the Waters of Alaska" became effective June 25, 1941.

Presidential Proclamation of September 28, 1945, entitled Policy of the United States with Respect to Coastal Fisheries in Certain Areas of the High Seas.

Provides for the establishment of conservation zones in certain areas of the high seas contiguous to the coasts of the United States wherein fishing activities have been or in the future may be developed and maintained on a substantial scale by its nationals alone. The conservation zones will be explicitly bounded zones in which fishing will be subject to regulation and control of the United States.

Establishment and Growth of Bristol Bay Communities

The population of Bristol Bay was almost entirely composed of native Eskimos and Aleuts when the canneries first came to Bristol Bay. The companies brought the necessary help needed to catch and process the fish. Some Natives were employed by the canneries as noted by Moser.

> The canneries gladly employ every native who is willing to work; nay, more, they seek for this labor in the villages and offer every inducement for them to work, and would employ many more if they could be obtained and were reliable. This is not done for charity's sake--the canneries are not in the field for that purpose, though they are far from being uncharitable--but because the labor is needed, particularly when the rush is on, and for which profitable provision can not otherwise be made.

When shore installations were built it became necessary to leave some one in charge of the property.

The winter watchmen were recruited from those among the crew who had developed a liking for the country and were willing to spend the winter in more or less isolation. Two men were generally retained as watchmen, and this has been the practice to date. From year to year others of the crew decided to remain for the winter. Following the gold strikes of Nome and Fairbanks a few prospectors made their way into the region, and some of these men stayed to fish during the summer and to spend their winters trapping and prospecting in the headwaters of the various rivers. In this way small settlements sprang up around the canneries. All depended on the canneries for their needed supplies, and the cannery vessels brought in supplies for the traders as well.

During the season of 1923 a total of 89 permits were issued to residents of Bristol Bay, of whom 58 fished independently and sold their catch to the canneries. Of the remaining permittees 20 worked on company boats, two worked in a cannery, and nine others did fish. (Bower 1925). In addition a few residents fished on company permits and a few more were employed in capacities other than fishermen.

The establishment of radio communication and the development of airplane transportation aided in making the area a more attractive place in which to live. During the 1930's many of the cannery employees remained to make the various villages their homes. A few families moved in from the States. Many of the natives sought work at canneries both as fishermen and cannery workers. Slowly but steadily the communities of Bristol Bay grew. The manpower shortage during the war years made the canneries more dependent upon local labor. By 1945 the residents furnished about half the fishermen and a substantial number of the cannery workers employed in the Bristol Bay fisheries. These people, permanent residents, depend almost entirely on the salmon fishing for their livelihood. Of recent years the policy of the government has been to develop a resident population in Alaska in the interest of national defense. The conservation problems connected with perpetuating the salmon runs in Bristol Bay have become more pressing than ever before. A great natural resource, a way of life for many people, and a vital link in the defense of the country are all tied in together, making the solutions of the conservation problems imperative.

PART II

BIOLOGY AND ECOLOGY

Ability of the Run to Sustain Itself

All competent observers visiting Bristol Bay down through the years have expressed concern over the ability of the salmon run to sustain itself. Although Moser (1902) saw no evidence of depletion at the time of his visit, he foresaw the expansion of the fishery and predicted that in the absence of proper laws with enforcement these streams would in time be depleted.

Gilbert and O'Malley (1921) in their survey of 1919 warned that retrenchment in any stream is called for when the crests of the pack grow lower and the troughs deeper. They believed that the maximum red-salmon pack in Bristol Bay had been reached, and was in danger of decline if the scale of operations continued unchanged. They urged that the usual precautions should be taken to provide a larger spawning escapement, pointing out that in this district unlimited fishing was permitted, without seasonal or weekly closed seasons, or protected areas. Their recommendations for Bristol Bay were as follows:

> 1. That the Bureau of Fisheries seek to have the present law amended in such way that no Alaska districts will be relieved from the requirement of a weekly close season of 36 hours, during which no fishing is permitted. Bristol Bay is now one of several specifically exempted regions. No valid reason aside from the desires of the salmon packers can be assigned in any of these cases. All are in need of the protection that would be afforded by this regulation.
>
> 2. That all the Bristol Bay rivers be closed to commercial fishing at all points above their mouths, and that the mouths of these streams be determined by the Secretary of Commerce in his discretion, and that suitable marks be erected.
>
> 3. That a further attempt be made to enforce the provision that fish should be canned or otherwise preserved within 48 hours after their capture. One of the worst and most wasteful features of the Bristol Bay fisheries is the custom, during heavy runs, of permitting the daily capture of fish far in excess of the capacity of the cannery, with resulting daily accumulation of stale fish. This is done in anticipation of a slackening of the run, which will permit the cannery to catch up with its hoard of fish. But the run sometimes continues for an unexpected period, and the weather may turn exceptionally warm. Then the stalest fish of the accumulated lot must be canned each day, or one or more days' catch must be thrown away. The regulations should be so enforced that not more than one day's surplus shall be on hand at any time. This would remove all dangers from the Bristol Bay pack and would at the same time be a powerful aid to conservation of the fisheries.

Rich and Ball (1928) believed that an increase in the size of fluctuations might be an indication that the fishery had been developed to the danger point or that depletion had occurred already, and found that:

> The amplitude of the fluctuations in all districts of Bristol Bay has been increasing with considerable regularity, thus corroborating the evidence given by the trends of general depletion throughout Bristol Bay.

The annual report for 1940 (Bower 1942) describes the conditions in that year as follows:

> A survey of the spawning grounds, partly by airplane, showed that the only places adequately seeded were those where spawning occurred early.

The report for 1941 (Bower 1943) states,

> The red salmon run in Bristol Bay was one of the poorest from every standpoint, for which any record exists. The failure came as a complete surprise for all indications pointed to runs of at least normal volume. With one or two exceptions, all streams in the district were poorly seeded.

Success or failure of the runs in Bristol Bay have been measured by an estimation of the escapement and the catch per unit of gear engaged in the fishing operations of that particular year. The experiences of the 1941 season illustrate that this procedure is not necessarily a measure of the well being of the fishery.

Development of an Index to the Success of the Return

Need for an Index

Thompson (1945) in the studies of salmon runs of the Frazier River developed an index based on catch records. The reasons for using catch records, and the uses of the index are best explained in the language of the bulletin.

> There is some reason to believe that the total catch will vary more widely than the escapement and form a more sensitive index to the changes in numbers of adults. The salmon pass through a series of fishing grounds, in each of which they may remain for varying periods of time. Each fishing area is like a reservoir, in which the abundance, as the fisherman sees it, is the accumulation due to delay in passage as well as to the magnitude of the stock of fish. Delay may vary with the season or the race. Upon the residue of the accumulation, after the catch is taken, or upon its size at the moment of upstream movement, must depend the escapement. Fishing operations tend to reduce this residue to where the profit becomes insufficient. In a year with big runs there are many men fishing full seasons, reducing the accumulation. In a year of poor runs there are few fishermen, easily discouraged. The accumulation and therefore the escapement remains correspondingly higher, perhaps proportionately equal to that in a big year. The resultant effect may be a regulatory one tending toward, but not attaining, a constant escapement, and shifting to the catch many of the major natural variations in the runs. If so, an index based on the catch should be more sensitive to the fluctuations we are studying, than would be the total run.

On page 22:

It is convenient to express the return of any given spawning as the catch four years hence. Thus if the catch in 1900 were 400,000 cases, a return four years later of 400,000 cases, or 100 per cent, would indicate that the catch was being maintained. If the catch were 50 per cent of the parent year, that would indicate a decline, or a partial failure of the catch--whatever the cause. Such a value constituted an index to the success of the return. This method of stating the success or failure of a catch is in common use, but it has not been used consistently in studying the history of the fishery, and its validity for that purpose has not been examined.

The index values as given hereafter are actually percentages unless otherwise stated. Thus the ratio of the catch in the year of return to that of the parent year is given as 100 and not 1.00. If C_o is the catch of the parent year and C_4 that of the return the index is $\frac{C_4}{C_o}$.

Interpreting the Index

He cautions that the graphs prepared from percentage index of success of return should be interpreted with care.

As already noted, it expresses only the degree to which the catches of the individual years of the four-year cycle are reproduce, at whatever level of abundance the races concerned may be at that time. Once the catch has risen or fallen to a new level the index merely shows whether or not that level is maintained. This is a necessary characteristic of such an index.

Moreover, the value of the index rises and falls accordingly as the catch of the return year represents a larger or smaller fraction of the total run for the year than does the catch of the parent year. A correction is given for this . . .

This correction is included under a study of the effect of amount of fishing on the index.

The falling line that the index takes in a new fishery that is using an increasing portion of the run, expresses the period between its beginning and its maturity.

> The change shown should be characteristic of all fisheries during first development and is a useful expression of the approach to full utilization.

As the catch of the parent year approaches the catch of the return year the index will approach 100. Periods in which the returns from the fishery are below that of the parent years will have an index value of less than 100, and are to be considered periods of decline.

Two types of statistics were available for the Frazier River work, one the number of cases packed and the other the number of fish caught. The number of fish taken per year was calculated from the number of fish required to pack a 48-pound case of salmon. The index was calculated from both types of statistics and the result was the same for the purpose of showing periods of depletion.

Thompson then goes on to say,

> Before using the index freely it must be examined with care. The possible alternative of a direct measure of the total run in the form of a measurement of relative abundance, such as return by a unit of gear or effort, must be considered. And two sources of possible error in the index deserve special attention. The first is the existence of other than four-year-olds in the return runs. The second is the direct effect of the amount of fishing on the proportion of the total run taken as catch.

<u>Catch per Unit of Effort</u>

Catch per unit of effort, and its use in connection with a salmon fishery is commented on in this manner:

> If a measurement of abundance reflects the changes in the total run, then it can be used as another basis for calculation of the index which was derived above directly from the catch. There is available for use thus the "index of abundance" given by Rounsfell and Kelez (p. 772).
>
> These authors made an exhaustive examination of available data and they indicate the possibilities in such a measurement. This was designed to discount changes in amount of fishing effort and is essentially a calculated catch per unit to reflect the year by year changes in the total runs. Their measurement of "abundance" in the parent year has been compared here with that in the year of return. This gives an index derived from an index, a rather unsatisfactory procedure from the standpoint of compounded errors.
>
> The changes shown by this "index of abundance" for years prior to 1926, hence during the two main periods of depletion, are roughly the same as the index from the pack. It is plain that corrections available to Rounsfell and Kelez have not destroyed the evidence of depletion in the two periods.

Objections to Use of Catch per Unit of Effort

However, this "index of abundance" cannot logically be used in this way. In various other fisheries, such as halibut, the catch per unit is regarded as reflecting the size of the accumulated stock present at the time the catch was made. But in the salmon the case is entirely different. The catch per unit cannot reflect the magnitude of the year's run in any simple direct way. When the catch approaches 80 or 90 per cent of the whole run, as is deemed probable in these salmon rivers, there is not much scope left for the increasing number of boats, fishermen, or traps to enlarge the catch. So doubling or trebling their number simply divides the catch accordingly. To do so gives an average catch per boat or per man or per trap reduced nearly to a half or third, even though the total run is as large. Hence the average catch per unit correspondingly fails to represent the "abundance". That latter term must in the last analysis be defined as the size of the run (catch plus escapement) if it has any biological significance at all. Yet there is only one moment during a run when the catch per unit would indicate this size of run for any school of migrating salmon, and that is when the catch begins. By the very nature of the fishery this moment cannot be defined by any means now at our command. There are too many schools and too many moments of beginning for the several races or stocks. The average catch per unit for a season therefore cannot give any fair measure of "abundance", except as the fisherman sees it from an economic standpoint. Perhaps the catches of the last fisherman to sample the run might give a relative measure of escapement, but here again the moment at which this happens cannot be determined.

But the catch per unit of gear, neglecting competition between gear, does give the theoretical limit to the relative abundance in case the escapement is very large in proportion to the catch, and it is used below in this way.

Effect of Age Class on Index

The Frazier River run is made up of one dominant year class, those returning in the fourth year after being spawned, and of some third-year fish and some fifth-year fish. An index based on the distribution of ages was compared with an index based on the assumption that there were four-year-olds only. Thompson concluded that:

> There is no substantial difference between the general pictures given by the two methods. The most obvious is that the periods of depletion are visable a year earlier in the case of distributed age classes. For instance, the age correction indicates that decline in returns began in 1910, whereas by the simple four-year cycle index, 1911 was the first year.

Effect of Amount of Fishing on Index

Explanation of the effect of amount of fishing on the index is as follows:

> The index is subject to correction for the varying amount of fishing in the parent and return years. An increase or decrease in return may be due in part to an altered fishery, which may take a larger or smaller part of the total run in the year of return than was the case in the parent year. The correction for this gives a definite limit within which the index values must lie. It can be made in two ways, depending upon whether the gear is competitive or not.
>
> If the numbers of fish in the runs were without limit so that the units of gear would not interfere with one another, and the escapement would be very large, the catch should increase or decrease in proportion to the amount of fishing.

In comparing the catch of the year of return, C_4 with that of the parent year, C_o, the change in the amounts of fishing f_4 and f_o would then have to be discounted to arrive at the true values of the total runs, t_4 and t_o.

If the catch of a unit of gear is C then $f_o c_o = C_o$ and $f_4 c_4 = C_4$. It can be assumed that the catch of a unit of gear will vary with the total run of fish available to it. Then if gear is not competitive

$$\frac{T_4}{T_o} = \frac{c_4 f_4}{c_o f_o} \cdot \frac{f_o}{f_4} \quad \text{or} \quad \frac{T_4}{T_o} = \frac{C_4}{C_o} \cdot \frac{f_o}{f_4}$$

This correction is the maximum which can be suggested to account for changes in amount of fishing.

A more acceptable correction which is consistently less can be made by recognizing that the gear fished competes for the catch. The size of the run, including catch and escapement, provides a limit to the increase of the catch and the gear used becomes competitive. Each unit of gear, when not interfered with, has its own rate of fishing. But due to interference the combined rates of all gear do not equal the sum of these rates. Rather, the appropriate relationship between the total run (T) and the escapement (E), the units of gear or effort (f) and the average fishing rate (r) is given by the equation $Te^{-fr} = E$, then $T(1 - e^{-fr}) = C$.

The corrected index of success of return is given by the percentage which T_4 forms of T_o. This can be determined from the ratio

$$\frac{T_4(1 - e^{-f_4 r})}{T_o(1 - e^{-f_o r})} = \frac{C_4}{C_o}$$

then

$$\frac{T_4}{T_o} = \frac{C_4}{C_o} \cdot \frac{1 - e^{-f_o r}}{1 - e^{f_4 r}}$$

The ratio $\frac{1 - e^{-f_o r}}{1 - e^{f_4 r}}$ should be compared to that of $\frac{f_o}{f_4}$ given above.

The use of these corrections in a precise manner would require knowledge as to the degree to which gear is competitive, and as to the amount of fishing determined by a correction for varying efficiency. For the use of the second method (competitive gear) there must also be known the intensity of fishing, (r), per unit of effort of gear and r can be determined if the escapement is known for any one year.

In other fisheries, such indices as the catch per unit of gear are affected in a cumulative way by the mortalities natural and otherwise. Factors such as intensive fishing alter the accumulated stock upon which the catch per unit depends. In the salmon, however, each value of the index depends upon the fish present in a pair of years, and reflects directly the conditions for reproduction in the parent year. This renders adjacent values of the index independent of each other, and of peculiar value in reflecting variations of conditions in these adjacent years. Where the amount of fishing varies widely from year to year, or the effect of an obstruction fluctuates similarly, the range of variation in the resultant mortalities should give a better basis for determining the amount which the species can endure. In that way the index should be of greatest value.

Application of the Index to Bristol Bay

Age of Bristol Bay Red Salmon

Bristol Bay red salmon have been considered five-year fish for many years. Rich and Bell (1928) found:

> A strong tendency toward a repetition of conditions at intervals of four or five years. . . . While the exact significance of an association between catches at four or five year intervals can not be stated definitely, it seems more than probable that it is indicative of the prevailing age groups in the run in question. In the case of Karluk River we know definitely that a large percentage of the fish are in their fifth year when they return to spawn. This is reflected in the relatively high coefficient of correlation between catches ar five-year intervals--over seven times its probable error--and statisticians generally agree that a coefficient that is three times its probable error is significant of some degree of association. It is possible, of course, that some factors other than a predominance of five-year fish has caused this high correlation between catches at five-year intervals, but we have no suggestions to make as to what these factors might be.

A high correlation between the size of catches at four-year intervals was found in the Nushagak district; no significant correlation at five-year intervals and a negative correlation at six-year intervals. From 1911 to 1927 the Nushagak catch averaged 23.8 per cent of the total for Bristol Bay (Rich and Ball, 1928).

Index Values for Years 1893 - 1922

An index of the success of return has been prepared for Bristol Bay on the basis of a five-year cycle.

From the Frezier River work we may assume that the four-year fish of the Nushagak would not alter the general picture, and that a separation of year classes would move evidences of depletion to a period one year earlier. Data contained in Table 1, covering the years 1893 to 1927 inclusive, are taken from tables reported by Rich and Ball, (1928).

Table 1. Red salmon caught in Bristol Bay, 1893 to 1927. From Rich and Ball, (1928).

Year	Number of Red Salmon
1893	94,000
1894	1,235,400
1895	1,472,137
1896	2,099,740
1897	3,317,523
1898	4,927,840
1899	5,112,737
1900	8,547,335
1901	10,220,577
1902	12,808,518
1903	16,320,092
1904	11,903,352
1905	14,833,989
1906	10,823,431
1907	10,193,403
1908	16,233,902
1909	15,497,883
1910	11,593,609
1911	8,815,114
1912	19,696,343
1913	20,581,826
1914	20,195,107
1915	14,787,678
1916	17,521,921
1917	24,513,532
1918	23,090,665
1919	7,161,375
1920	8,897,915
1921	15,680,076
1922	23,632,077
1923	18,181,964
1924	10,302,066
1925	7,909,508
1926	19,414,094
1927	11,071,828

The index is not corrected for the amount of fishing from 1893 to 1927 because Rich and Ball state:

> The records of gill nets in Bristol Bay seems especially unsatisfactory, as the records indicate a decided change in the average length of gill net during the history of the fishery. For several

> years the standard length has been 200 fathoms, but in former years the standard length was only about 100 fathoms. Again, in most instances the number of gill nets recorded in the statements submitted by the companies is apparently a record of the total number of gill nets on hand for the season and does not state the number of nets actually fished. No doubt the number of gill nets on hand bears a fairly definite and constant ratio to the number fished, but this is certainly a possible source of serious error. . . .

The index values for 1893 to 1922 are illustrated in figure 7.

<u>Index Values for Years 1923 - 1942</u>

The index values and amount of fishing effort for the years 1923 to 1942 and the data used in computing these values are given in table 2. The numbers of cases of red salmon packed, boats, fathoms of gill net, and fishing days were compiled from information contained in the annual report entitled <u>Alaska Fishing and Fur-Seal Industry</u> for the years 1923 to 1947 inclusive.

The catch is reported as one total for Bristol Bay and Yukon River in numbers of cases packed, without any seperation by districts. The entire pack has been converted to cases containing 48 one-pound cans each. The number of fathoms of gill nets, and the number of gill-net boats are reported for Western Alaska which is comprised of the Bristol Bay and Yukon River district, and the Port Moller and Herendeen Bay district. Practically all of the gill net used in Western Alaska is

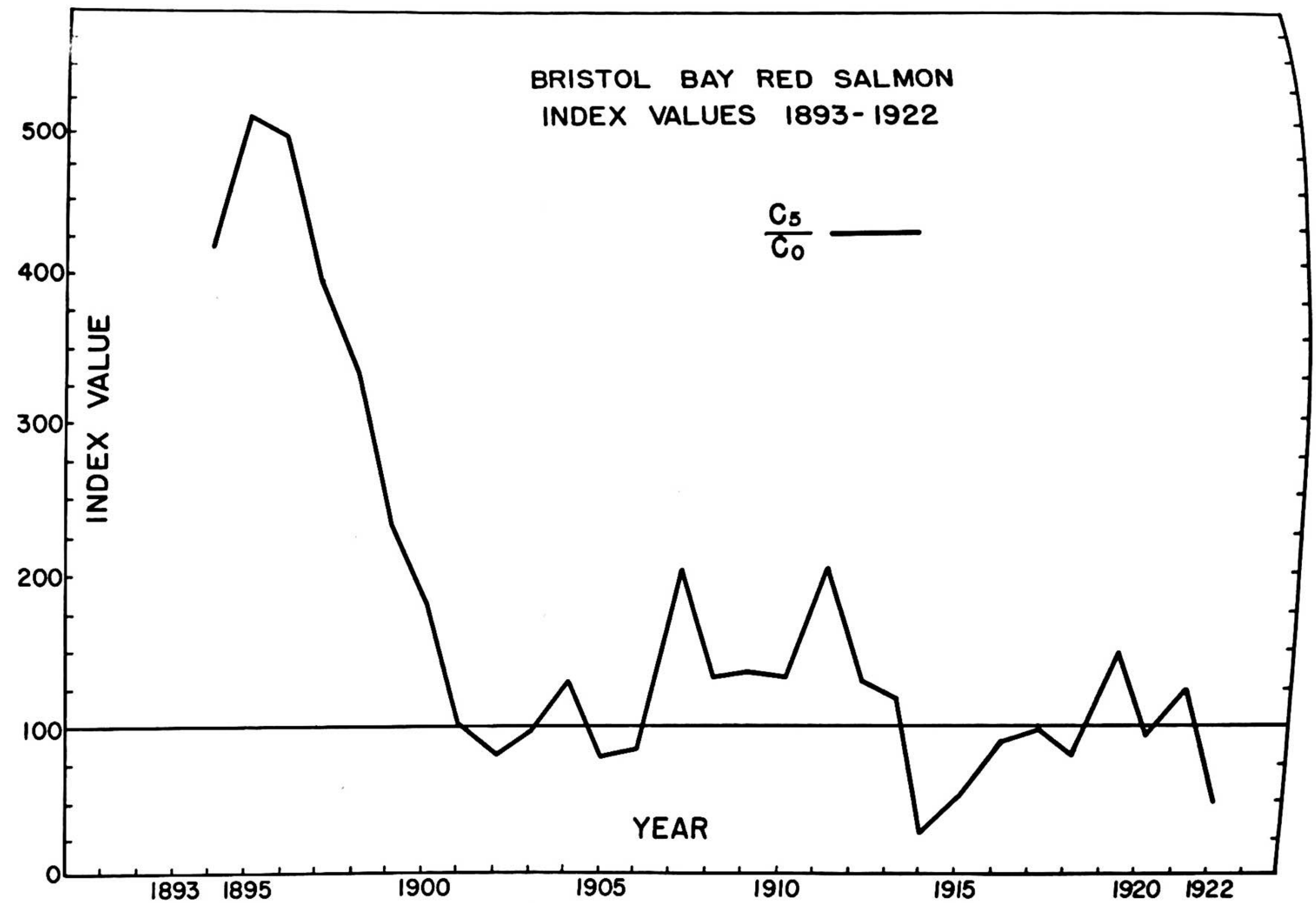


Figure 7. Index for Bristol Bay Red Salmon from 1893 to 1922.

Table 2. Index values for red salmon of Bristol Bay, 1923-1943. Numbers of cases packed, boats, fathoms of gill net, and fishing days were compiled from Alaska Fishery and Fur-Seal Industries 1923-1947.

Year	Number of cases of red salmon packed in Bristol Bay	Number of gill-net boats in Western Alaska	Fathoms of gill net used in Western Alaska	Number of fishing days in Bristol Bay	Fishing effort (f)	$\frac{C_5}{C_o}$	$\frac{C_5}{C_o} \cdot \frac{f_o}{f_5}$
1923	1,193,526	1,216	255,160	30	76.54	109.7	182.1
1924	764,663	1,187	231,240	24	55.49	130.3	239.7
1925	524,395	1,252	264,600	24	63.50	66.5	223.5
1926	1,300,752	1,116	206,100	24	49.46	80.6	144.3
1927	867,303	1,096	207,500	15	31.12	141.3	204.9
1928	1,393,001	1,053	190,700	24	45.76	113.9	202.7
1929	995,628	1,062	157,625	19	29.94	173.4	197.7
1930	348,762	854	118,450	16	18.95	66.2	253.5
1931	1,048,917	1,039	145,270	19	27.60	132.4	115.1
1932	1,225,618	1,001	112,750	19	21.42	115.9	78.8
1933	1,598,008	1,027	142,967	18	25.73	111.6	99.4
1934	1,726,769	1,027	146,360	18	26.34	61.3	52.1
1935	231,014	215	32,958	15	4.94	174.2	66.2
1936	1,388,776	1,100	176,335	18	31.74	41.5	49.4
1937	1,421,369	1,086	164,820	19	31.31	30.8	103.1
1938	1,772,885	943	150,435	19	28.58	71.9	74.7
1939	1,059,181	1,219	181,010	17	30.77	90.1	149.5
1940	402,553	474	81,180	19	15.42	143.1	198.9
1941	577,024	846	138,927	19	26.39	108.8	115.3
1942	438,053	227	36,930	26	9.60	304.8	112.8
1943	1,275,212	581	104,725	26	27.22		
1944	954,694	836	97,320	19	18.49		
1945	576,318	455	57,575	19	10.93		
1946	628,240	963	131,200	19	24.92		
1947	1,335,031	1,189	148,412	18	26.71		

is used in the Bristol Bay area. The greatest fluctuation in amounts of gill net and the number of gill-net boats used in Western Alaska would be largely due to the differences in fishing intensity in Bristol Bay. It is assumed that the errors introduced by using the figures for Western Alaska will have a negligible effect upon the index. Fishing intensity was computed in three ways; by the amount of gill nets in operation; by the number of gill-net boats in use; and by multiplying the amount of gill net by the number of fishing days in the season. The use of gill nets alone does not consider the time involved or the number of commercial set nets. The graph was therefore prepared with the correction for amount of fishing by using fathoms of gill nets multiplied by days in the season. Again some compromise was necessary because the closed time in all Bristol Bay districts was not always the same. It is assumed that any errors due to the differences in closed time will not materially change the index to the point of rendering it useless.

The limits of the index are set by $\frac{C_5}{C_o}$ and $\frac{C_5}{C_o} \cdot \frac{f_o}{f_5}$ and any further correction or refinements that may be made will fall between these limits.

As an example the parent year 1930 and the year of return 1935 will be considered. The number of cases of red salmon packed in Bristol Bay in 1930 was 348,762 and in 1935, 231,014 cases were packed. $\frac{C_5}{C_o}$ would therefore be $\frac{231,014}{348,762}$ giving the index figure 66.2. This, however, is not corrected for amount of fishing. During the season of 1930 there were 118,450 fathoms of gill net in operation in Western Alaska, and the Bristol Bay season was 16 fishing days. In 1935 there were 32,958 fathoms of gill net operated for a total of 15 fishing days. By multiplying the fathoms of gill net and the number of fishing days the correction factors f_o (1930) and f_5 (1935) were found to be 1,895,200 and 494,370 respectively. Thus $\frac{C_5}{C_o} \cdot \frac{f_o}{f_5}$ would be 66.2 • 3.83 or 253.5. This figure does not tell how many fish were available in either 1930 or 1935, but it does indicate that the run of 1930 was successful in perpetuating itself at the level of abundance at that time.

Interpretation of the Index for Bristol Bay

The index as illustrated in figure 7 shows a falling line from 1893 to 1901. This indicates that an increasing proportion of the run was being utilized by the developing fishery.

The first depletion occurred in 1902, followed by 1905 and 1906. Whether the depletion was due to over fishing, or to unfavorable natural conditions, or to a combination of these can not be stated with assurance. Serious depletion is shown in 1914, followed by four more years of unfavorable values of the index. Also, 1920 and 1922 are marked by an inability of the run to maintain itself.

Figure 8 illustrates the index calculated on the pack only, and when the amount of fishing is considered. The run apparently maintained itself from 1923 to 1931 when this correction is used. However, even with this correction there is evidence of depletion again in the years 1932 through 1938 with the one exception of 1937.

The over-all picture given by the index leaves no room for doubt as to the existence of a conservation problem. The information at hand is not sufficient to draw any conclusions as to the exact causes of the periods of depletion. However, we might very profitably consider what the influences of both nature and man might have on the fishery, and in particular on the red salmon runs. Some experimental work in connection with salmon in other areas will be reviewed in the hopes that

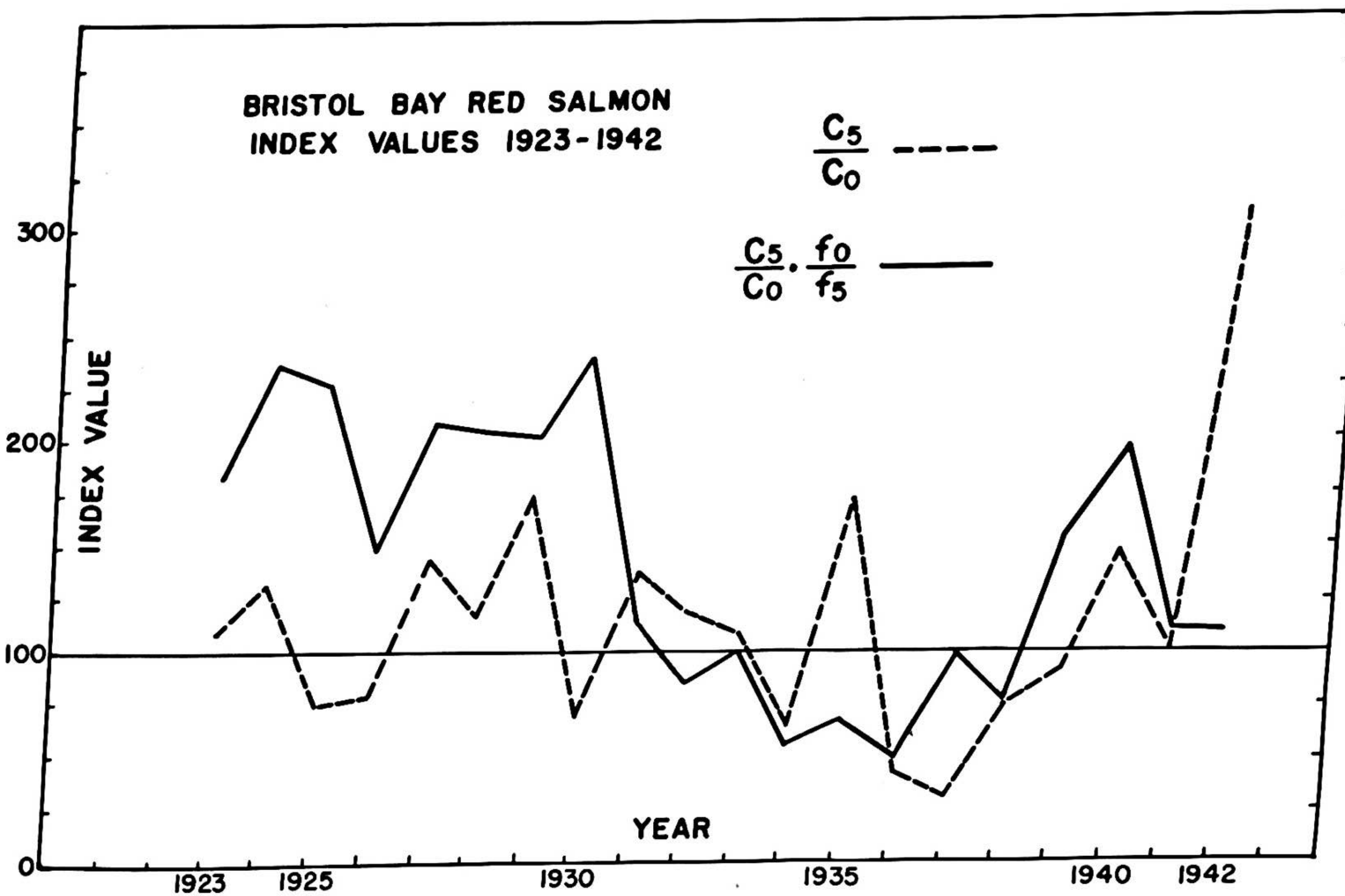


Figure 8. Index for Bristol Bay Red Salmon from 1923 to 1942.

some of these findings may aid in the solution of the problems in Bristol Bay.

Conservation Problems Relative to the Bristol Bay Run of Salmon

Escapement

Escapement is probably the first thing to come to mind when the conservation problems connected with Pacific salmon are being considered. And rightly so. Without escapement there will be no return run. A part, at least, of each generation must make its way to the spawning beds in order to perpetuate that year class, because the Pacific salmon spawn only once in their life cycle.

No doubt it will be a surprise to many people interested in the salmon runs to learn that to date no positive relationship has been demonstrated between the size of the escapement and the size of the return run resulting from that escapement. Barnaby (1944) in studying the fluctuations in abundance of red salmon of the Karluk River found a negative correlation exists between the escapement and ~~return.~~ surplus. He is not willing to accept the indication that most escapements in the study have been too large, but attributes the negative correlation to adverse factors influencing the survival value.

Hunter(1951) in working with pink salmon of British Columbia states:

> The results indicate that a large escapement of pink salmon does not necessarily mean a large return for the cycle year. . . . Adequate adult escapement, though essential, is no guarantee of future production.

Hunter attributes many of these fluctuations to the natural variations of weather and climate.

Jackson (1937) in reviewing the work at Karluk up to 1935, makes this observation:

> Records for eight generations are now available showing wide variation in production, varying 1 to 5.6 to 1. There seems to be little possibility of regulating spawning escapement so as to produce consistently a large population. Hence, efforts are being directed to the determining of factors which determine survival in order to control natural forces and to regulate the fishery in the interest of conservation.

Barnaby (1944) has most certainly summed up the problem of escapement in saying that,

> The most important point in considering escapement is to determine what escapement will produce the greatest surplus, return minus escapement that may be utilized by the fishery.

What constitutes the optimum escapement in any given area, and for any particular stream in Bristol Bay still awaits determination. The optimum escapement will without question depend upon how much control can be exercised over natural forces.

The mortality of the Pacific salmon may be divided into fishing mortality and natural mortality. Natural mortality may be subdivided into fresh water mortality and ocean mortality. All Pacific salmon that survive to return to the spawning grounds suffer total mortality. Very little is known about the ocean life of the salmon. We cannot hope to exercise any control over the natural causes of ocean mortality at the present. However, it may be possible to reduce the losses occurring previous to the migration of the fingerlings to the sea.

Losses during Egg Stage

The eggs are deposited in fresh water and most of the young fish spend one or two years in fresh water. Work at Karluk River (Barnaby, 1944) shows a fresh water mortality of over 99 per cent of all the eggs deposited to the time of seaward migration of the fingerlings. Less than one per cent of the possible progeny from the deposited eggs managed to make their way to the ocean. Cultus Lake experiments (Foerster,1936) found that the losses in fresh water were in the neighborhood of 97.5 per cent of the total egg deposition. The losses in fresh water are tremendous under the most favorable of natural conditions and during the time that man might be able to exert some influence.

The losses during the egg stage could be due to lack of fertilization, silt deposits that would smother the eggs during incubation, floods, superimposition of redds, egg predators, fungus, actual freezing of gravel where eggs have been deposited. There are no figures available regarding any of these losses in Bristol Bay. Losses due to superimposition of redds is thought to be serious in years of tremendous escapements when there are more spawning fish than the areas suitable for spawning can accommodate, and redds of early spawners are dug up by late arrivals in the process of building their nests.

It might appear that all of the above losses could be easily eliminated by incubating the eggs in hatcheries and liberating the free swimming fry in the lake waters. This was tried at Cultus Lake (Foerster, 1941). The tests included the planting of eyed eggs, and the liberation of free swimming fry. Both methods were compared to natural propagation.

Foerster states:

> The conclusion was reached that in an area such as Cultus Lake, where a natural run of sockeye occurred with a reasonable expectancy of successful spawning, artificial propagation, as commonly practiced, provided no advantage over natural spawning,

as a means of maintaining the run. Similar results would undoubtedly be obtained if the tests were repeated in Bristol Bay.

Predation

Other losses during the fresh water life would include those due to disease, parasites, lack of food, and predation. Little is known about disease and parasites of red salmon and no estimation as to losses due to them has been made. The food and food supply will be considered along with the other limnological aspects of the lakes. The ravages of predators have long been recognized by observers, and considerable work in this regard has been carried on by investigators in various localities including Bristol Bay. The following specific accounts of predators are taken from the reports of reliable investigators, and serve to illustrate common and widespread conditions.

Bean (1894) in writing of his visit to Karluk, records the enemies of the salmon as being numerous, describing sculpins swarming in the nests eating large quantities of eggs, trout devouring great numbers of eggs and young salmon, and gulls, terns, loons and other birds gorging themselves with tender fry. Bears are credited with consuming large quantities of the breeding fish.

Jones (1915) vividly describes bears slapping the fish out of the water with their huge paws, and later perhaps eating a portion of them. He states:

> I should like to cite a few instances of actual conditions as I saw them, concerning the destruction of salmon where they had not yet spawned.
>
> At Union Bay, Cleveland Peninsula, I spent over a day in and around the region of Black Bear Creek. I walked the middle of the stream, also examining both banks for as much as 3 miles. I found the greater part of the shore, sometimes for 100 to 150 feet back from the stream, trodden like a pasture in well-defined paths that looked as if made by cattle. Over all this area, frequented by bears during the salmon runs, I saw hundreds upon hundreds of humpbacks, silvers, and chums that had been thrown out of the water by these animals. In the majority of cases the fish were not mutilated, only bruised by the mark of the bear's paw on their backs, showing their characteristic way of tossing the fish out of the water. The bear is very fastidious and prefers the cheek of the salmon to any other part. In most cases the remaining portion of the fish is left untouched. One can readily realize that a large, healthy bear would require a great many salmon cheeks to satisfy his ravenous appetite. The stench along this stream was most unpleasant, and besides the fish in varying stages of decomposition there were many bones that gave indication of the large number of salmon destroyed annually by the bears.
>
> I found a similar condition on Prince of Wales Island below Silver Salmon Falls, where thousands of fish, unable to ascend this natural barrier, had fallen back tired and worn out, only to be cast ashore by bears. If the bear would take out of the water only what he actually eats, this condition would not be nearly so bad; but the destruction of so many fish from pure maliciousness, or playfulness, makes it a serious matter.

He tells of flushing an enormous horde of gulls, numbering at least 10,000, that were among the salmon making their way up a shallow stream. On going closer he found salmon everywhere with their eyes gone and otherwise mutilated from the picking and clawing of these birds. He estimated that on this creek alone there were within sight 5,000 fish, either dead or dying, that had never spawned.

He observed terns diving for salmon eggs, and found, upon killing them, that their crops were filled with eggs.

The report for 1920 by Field Superintendent Dennis Winn (1921) has this to say about predators in Aleknagik Lake, a part of the Nushagak drainage:

> Set and drift gill nets, in connection with seine and troll lines, were used and the early work centered at the lake outlet, where a considerable number of Dolly Vardens were taken, weighing from two to seven pounds each. The stomachs of these fish were well filled with migrating salmon, Nos. 2½ and 3 in size, 25 or more young salmon being counted in a stomach. The habits of the trout were observed closely. It was noticed that they met the salmon schools at the inlet and outlet of the lake, where the bar drops off into deep water, a certain number of trout accompanying and feeding on the salmon.
>
> In connection with the Dolly Vardens working on the young salmon in deep water, the terns are almost equally severe at the surface. The salmon migrate in enormous schools, making them easy prey for trout, and the work of the latter forces the young salmon to the surface, where the terns take their toll. Large flocks of from 500 to 1,000 were noticed actively feeding whenever a school passed certain points. After several days opera-

tions at the lake outlet the catch of trout became almost negligible, and it was noticed that while the terns were present in large numbers and would become excited and active on sighting a school of young salmon, their success in catching was materially lessened, the fish not coming close enough to the surface. No trout other than Dolly Vardens were taken in this section, and very few under 2 pounds were captured. All averaged 3 and 4 pounds, and specimens weighing 7 pounds were common. . . . When the trout became scarce at the lake outlet the camp was moved to the upper end of the lake where the scow was placed in the mouth of the river connecting with Nerka Lake. At this point good results were secured, and it was here that the bulk of the trout was taken. It is estimated that from 35,000 to 40,000 pounds of trout were destroyed. Many were diseased, wormy and emaciated, but always ready to feed.

The migrating season of salmon in this district extends over a period of about three months, and figuring an average of 15 to 20 migrating salmon for each trout per day--which represents but one feed for the average trout taken--the number of trout destroyed would mean a saving of more yearling salmon than could be handled in any of our hatcheries during a season not to mention the expense of feeding, etc., and this without taking into consideration the serious depredations of the terns.

. . . It was impossible to use gill nets without injury to the salmon, and the trout operating in deep water made it necessary to devise some other means of capture. Mr. Savage devised a mold in the shape of a fish, and this was poured full of lead over the stem of a large, long-shanked fishhook, which was used as a troll and fished among the migrating salmon. With this crude device two men succeeded in taking 1½ tons of trout in one day. As fishing continued the numbers taken gradually decreased several hundred pounds each day to the time of our departure when the best capture possible was from 300 to 1,000 pounds per day.

In the summary of the report he says,

We are thoroughly convinced that the predatory fishes, together with the terns mentioned heretofore,

> constitute one of the most serious menaces facing the salmon industry. In small years such as 1919 and 1920, they will practically eliminate the cycle runs by their depredations, first on the eggs on the spawning beds, next on the young fish in the first year or two spent in the lakes, and last but not least, on the migrating fish descending to the ocean. The only hope of curtailing this loss is by waging a constant, aggressive, and extensive campaign against these maurauders. . . .

The report for 1923 (Bower, 1925) tells of taking Dolly Varden trout specimens having in their stomachs young feeding sockeyes just out of the gravel. One Dolly Varden's stomach contained approximately 200 young salmon, the count being considered as conservative because many of the young fish were partly digested.

The work of predator control was carried on for several years by employees of the Bureau of Fisheries. After two years the numbers of trout decreased, judging from the numbers caught and the ease of catching them, and the average length and weight decreased, indicating that some measure of control had been accomplished.

The report for 1928 (Bower, 1929) states that no work of consequence had been accomplished in the destruction of predatory enemies of salmon for the past two years. Investigations had given convincing evidence that Dolly Vardens had returned in alarming numbers, and were nearly as numerous and active as in former years. The water in certain places in Naknek River appeared to be boiling with trout feeding on the migrators.

A bounty on Dolly Varden trout was established by 1930 and was in effect for the next ten years. No attempts of control have been made since then, and Dolly Varden trout in great numbers are again reported on the spawning grounds.

Foerster and Ricker (1941) in studying the effect of reduction of predaceous fish on survival of young salmon at Cultus Lake found an average increase of survival rate from 3.13 to 9.95 per cent after predator control had been started. More than three sockeyes lived to go to sea, where only one survived formerly. The survival rate, from eggs of females naturally spawning to migrators, increased from 1.78 per cent to 7.81 per cent.

Prior to predator control the relation between size of the year-old migrants was inversely correlated with their abundance. Two large migrations occurred after control was begun and in neither case was dwarfing noticeable. The authors give the following explanation:

> With the greater survival rate now prevailing, it takes only about a third of as many newly-hatched fry to produce a given number of migrants, with the result that competition for food in summer (the principal growing season) is now much less acute than in former years, comparing migrants of the same size.

> It can be claimed therefore as a further very important advantage of the destruction of predaceous fish, that it will permit a much greater maximum population of sockeye to inhabit the lake than has been the case heretofore. . . .

No experiments have been conducted in Bristol Bay that measure the amount of damage by predaceous fish, and one can only ask what would be the state of the fisheries today if Dennis Winn had not put a control program into effect when he did.

Observations and experiments concerning the effect of predator birds on the runs of Atlantic salmon have been made in Canada. White (1937) concluded that the American merganser on the Northeast Morgaree River was responsible for a considerable depletion of young salmon and trout in the upper reaches of the stream. Young salmon and trout were very scarce in sections of the stream away from human habitations and well traveled highways, while they were abundant near the areas occupied by man. These later sections were considered to be typical sections of the stream and the abundance of fish in these areas was due to the fact that most of the fish-eating birds had been frightened away.

Huntsman (1941) found that:

> Experimental elimination of the birds from a stream more than doubled the number of salmon smolts descending subsequently. Analysis of the

attendant circumstances eliminates extent of spawning and height of water as causitive factors for the increase.

In the year of return following the bird control the catch of salmon at sea was greater than had been expected from the dryness of the season of control. Detailed analysis of the catch shows that the catch was proportionally highest from the river along which the birds had been reduced. Huntsman states,

> It is concluded that control of birds may remedy periodical scarcity.

Huntsman said that the control of predator birds was allowing the trout to increase as well as the salmon and cautioned that the experiment would have to continue over a period of years before the total effect could be measured.

The important observation made is that man's presence favored the young salmon by driving or frightening away fish-eating birds. Destruction of the birds is not necessary. Frightening or driving away the fish-eating birds accomplished the beneficial results.

Reed and Dymond (1951) report that the first two runs to be benefited by this protection their entire lives numbered 20,000 and 13,000 in the springs of 1949 and 1950 respectively, as compared to a smolt production of about 4,000 prior to the removal of the birds. Other species in the stream increased along with the smolt production but apparently reached an equilibrium without destroying the favorable effects on salmon. The authors consider control of predatory birds as a promising method of increasing salmon production, but state that as yet this conclusion cannot be applied to waters differing widely from the Petitcodiac or the Morgaree.

Barnaby (1944) found in the work at Karluk, that less than one per cent of the possible number of progeny survived to the migration stage, and only 21 per cent of these migrators survived to return as mature fish. Therefore, about 0.2 per cent of the possible number of progeny live to return as mature fish. The average egg count per female in Karluk has been found to be from 3,700 (Gilbert and Rich, 1929) to 3,500 (Holmes, 1933). The most optimum ratio of return would then be less than 1 to 4.

Cultus Lake data (Foerster, 1936) indicate a fresh water mortality of 97.5 per cent and further ocean losses with a most probable value of 90.1 per cent. The total mortality throughout the life history amounts to a most probable value of 99.75 per cent of eggs deposited. The most probable ratio of return obtained at Cultus Lake is given as 1 to 5.5.

Any measure that will result in decreasing the tremendous fresh water mortality of the salmon should be given serious consideration, and predator control offers this possibility. Predator control does not mean extermination of the predators. Some program of holding their numbers within reasonable limits would seem justified. Trout control along the methods first used by Dennis Winn with the fishing under close supervision, is to be recommended. A reduction of the tremendous losses during the fresh water life of the salmon would result in greater use of this great natural resource. The experimental evidence shows that this can be accomplished in some measure by predator control.

Migratory Routes and the Home Stream Theory

While it is true that little is known regarding the ocean life of the salmon, we do have in the case of Bristol Bay salmon, considerable information about the migratory route taken after the fish at first become vulnerable to the fishery. Extensive tagging operations were carried on by Gilbert and Rich during the 1922 and 1923 seasons. (Gilbert and Rich, 1927). The results obtained in the 1922 experiments demonstrated that an extensive migration of mature red salmon past the shores of Shumagin Islands and along the shores of the Alaska peninsula as far as False Pass was the subject of an intense fishery centered at Unga Island, King Cove, Ikatan, and False Pass. A total of 3,311,911 red salmon were taken in this district in 1922. The pack produced by these fish was 225,888 cases of 48 one-pound cans.

The fish were fresh from the feeding grounds and still feeding, making this fishery unusual in that it uses fish in the midst of their migration. The fact that the fish are feeding indicates that the fish were a considerable distance from their spawning ground, because salmon on approaching their spawning grounds cease feeding and maintain the fast to their ultimate end. The authors assume that the mature fish had recently separated themselves from the immature fish that would make up the runs of the coming seasons.

A very few of the migrants tagged at the Shumagin Islands made their way to the east and were recaptured as far away as Cook's Inlet. However, the total number taking the easterly course were so few that runs to Chignik, Karluk and Cook Inlet would not be endangered by the fishing in the Shumagin district.

Only a few of the Shumagin fish entered the small spawning streams of Unga and Popof Islands. The vast majority continued to the westward to Morzhovi and

and Ikatan Bays; an important number along with other Morzhovoi and Ikatan fish distributed themselves to all the red-salmon streams of the Bering Sea shores of the Alaska Peninsula and Bristol Bay. This wide distribution was one of the most important discoveries of the 1922 season.

The salmon tagged in Morzhovoi and Ikatan did not move to the east but moved back and forth between these two bays for a period of two or three weeks. A very few entered local streams, but many were reported from Bristol Bay and along the Bering Seas side of the peninsula.

There was an exceptionally heavy run of fish to Bristol Bay in 1922 and it was thought that the salmon might not enter the same areas in years of less abundance. The experiment was repeated in 1923 in order to determine if the 1922 season was exceptional or if the banks on the south side of the peninsula were constant feeding grounds for Bering Sea salmon. The findings in 1923 completely verified the results of 1922.

In 1923 the salmon were taken from three traps on Unga Island, from four in Morzhovoi Bay, from three in Ikatan Bay and from one in East Anchor Cove. The fish were tagged and released outside the trap. Approximately

10,000 adult salmon were tagged. Salmon were tagged in each of the localities near the beginning, the middle and the end of the run. The places of tagging and recapture with the assumed migratory routes are given on the accompanying charts.

Salmon from the same trap in Unga Island were recovered in more than 20 different streams, ranging from Cook Inlet on the south side of the peninsula to the mouth of the Yukon in the north. The question arises as to whether these salmon are returning to the stream of their origin or if they are scattering themselves aimlessly in search of a spawning stream.

In the words of the authors,

> If the homing instinct prevails, we are compelled to accept at the other end of the salmon's life an extremely wide dispersal of the young to feeding grounds hundreds of miles distant from the mouths of the streams in which they were reared; and at the close of their period of growth and development, at the beginning of the season in which their eggs and milt will ripen, we must figure them for leaving the feeding grounds and independently retracing the hundreds of miles which may separate each of them from its natal stream.

The tags were all numbered and the recovery at a later date shows that fish released from the same starting point at the same time followed different routes to destinations hundreds of miles away. The report points out that the physical and chemical conditions of the water assuredly were the same for all fish released from a single trap at a given time. Under favorable conditions the rate of tagging was 300 fish per hour, and this would make the use of the term "same time" or "given time" justified. That the fish pursued their course in no haphazard fashion is demonstrated by their strict conformity to time schedules constructed on a basis of recapture.

The "homing instinct" theory is further strengthened by earlier findings that each colony is stamped by certain distinctive physical characteristics that is best explained by assuming that each group is isolated and self-perpetuating with the constant habit of home-coming at maturity. Admitting that strays do exist, their presence is in too small a proportion to prevent the colony from maintaining its racial peculiarities. This experiment was the first to trace the salmon as they were about to leave their feeding grounds in the sea and disperse to a number of widely separated spawning grounds.

Scale samples were taken as the fish were tagged and when the distribution of returned tags was studied it was found that the fish had returned to the river supporting colonies having the same characteristics as they had. Previous studies had revealed that a large percentage of Nushagak salmon have a one year fresh water life, while Naknek-Kvichak fish have a two or three year fresh water life. In the Nushagak recaptures, 58 per cent had a fresh water history of one year and 42 per cent had stayed in the lake two years before going to the sea. Only four per cent of the Kvichak fish had remained in the lake one year, eight per cent of the Ugashik, one per cent of the Egegik and six per cent of the Naknek. This segregation on a basis of early life history is deemed to have but one significance. In certain of the streams this had been verified by studying the scales of migrators and finding adult fish returning to the same stream having scales that show the same fresh water history as the fingerlings do.

The authors conclude that each stream is an independent unit, and the perpetuation of each run depends upon salmon being permitted to spawn within its own watershed.

Some writers (Ward, 1939) take exception to the "home stream theory" on the grounds that there are too many marked or tagged fish unaccounted for in the experiments, and prefer to think that migratory movements are dependent upon ocean currents and temperatures.

Other investigators (Powers, 1939) explain the return to the spawning grounds as a physiological reaction to a carbon dioxide tension gradient, or to a fresh-salt water gradient. During the process of maturing sexually a physiological change takes place that causes the salmon to seek water having a relatively low carbon dioxide tension. The offshore water during the spring and summer probably have a lower carbon dioxide tension than the ocean water due to photosynthesis of a more intense population of phytoplankton on the continental shelf. The streams entering along the coast are well aerated and have low carbon dioxide tension. The returning salmon are responding to an environment more suitable to them. The seaward migration is assumed to be a drift with the ocean currents and the salmon stay within the influence of these fresh-salt water gradients. In returning to the spawning grounds the salmon move against the ocean currents.

Hasler and Wisby (1951) are of the opinion that the sense of smell may play a large part in the ability of fish to return to their parent streams. The acuity of the sense of smell in fishes is thought to be similar in sensitivity to that of dogs and insects where but a few molecules will stimulate the end organ. The authors point out that salmon return to their parent stream in spite of pollution, floods, and changes in weather. Chemical and physical characteristics of a stream are thought not to be sufficient, by themselves, to act as a guide to the home stream. They state:

> The nature of the guiding odor must be such that it have meaning only for those salmon conditioned to it during their fresh-water sojourn. Any substance which has merely a general attractant could not guide salmon to their "home" tributary.

Hasler and Wisby worked with minnows under laboratory controlled conditions and found that, "the fish reacted to the distillate, but not the residue, of water fractionated by vacuum distillation at 25° C., a strong indication that the stimulate is a volatile, aromatic substance."

The nature of the attractant must remain constant over a long period of time, at least while the salmon are at sea. One suggestion, or possibility offered is that a distinctive aromatic odor is derived from the soils and vegetation of the watershed, and that this odor is the guide or attractant enabling the salmon to select its home stream.

Rich and Ball (1928) have found the Pearsonian coefficient of correlation for the number of fish caught in the Ikatan-Morzhovoi district and in the Bristol Bay district to be $+.792 \pm .070$. This high correlation is additional evidence that red salmon of the Ikatan district are composed, in a large part, of Bristol Bay fish.

The numerous tagging experiments have demonstrated that sufficient numbers of salmon do return to the parent stream as to require conservation measures to be based on this assumption.

The rate of travel from the Ikatan district to Bristol Bay is reported (Gilbert and Rich, 1927) in median number of days and varies from 12 to 20 days from Ikatan and 15 to 20 days from Unga Island. The rate of travel is faster for fish having a longer distance to go and the rate also increases as the season progresses. Apparently the degree of maturity of the sex products and the distance from the spawning grounds have a direct influence on the rate of travel.

Tagging experiments were again made in the Shumagin Island and Ikatan-Morzhovoi Bay area in 1939, (Higgins, 1940). A higher return in the Shumagin Island area was obtained in 1939 than in 1923, 22.6 per cent of the fish being caught locally as compared to 2.6 per cent in 1923. Lower recoveries were made in Ikatan and Bristol Bay in 1939, 3.0 and 1.2 per cent as compared to 11.1 and 9.2 per cent, respectively, in 1923.

Part of the lower recoveries in Bristol Bay is attributed to the fishery on the south side of Unimak Island which recaptured 10.8 per cent of the fish tagged. This fishery did not exist in 1923.

The tagging operations in 1939 indicate that a large number of the Bristol Bay red salmon enter the Bering Sea by way of Unimak Pass rather than False Pass. Gilbert and Rich (1927) stated the possibility of fish entering Bering Sea through the westward passes but they had no tag recoveries on which to base their assumptions. The greater locally recaptured fish in the Shumagin Islands might very well be interpreted as indicating a more efficient, if not more intense, fishery having developed since 1923. The Unimak Pass fishery was added pressure on a run of fish already being fished to the danger point in 1923.

Japanese Fishing Operations in Bering Sea.

The Bristol Bay run in 1937 was intercepted by offshore fishing operations of Japanese floating canneries and the failure of the fish to return to the Bristol Bay fisheries is shown in the drop of the index for 1932, the parent year of the 1937 run. Japanese fishing vessels began fishing crabs along the Alaska Peninsula and in Bristol Bay in 1930. From one to four floating canneries were operated during the following years. In addition to the crab canneries there were also the following vessels in Bering Sea in 1936: The Japanese floating salmon cannery *Chichibu Maru*, accompanied by six fishing tenders, was observed fishing about two miles of gill nets about 100 miles southeast of the Pribilof Islands,

The training ship *Hakuyo Maru* of the imperial Fisheries Institute made its usual annual cruise to Bering Sea with students of pelagic fishing methods. Experimental canning of salmon as well as crab meat was carried on in 1936,

The trawler type vessel *Tenyo Maru* of 657 tons accompanied by one auxiliary motor vessel of 61 tons and working under an appropriation of the Japanese Government made studies of the migration routes and availability of salmon in the extra-territorial waters of Bering Sea.

During the summer of 1937 (Bower, 1938) three Japanese floating canneries were operated in Bering Sea. The *Taihohu Maru* was accompanied by 12 bottom trawlers varying from 75 to 150 feet. The *Toten Maru* by eight launches and one crab-trap planter; and the *Taiyo Maru* by three auxiliary vessels. The *Taiyo Maru* was about 20 miles west of Ugashik Bay and its three auxiliary vessels each operated gill nets about two miles long. The training ship *Hakuyo Maru*, with its students in deep-sea fishing, navigation, and seamanship, was also in Bering Sea. This vessel was equipped for experimental canning of salmon and crab.

Fishermen and packers in Bristol Bay were much alarmed over the Japanese activities, and protested vigorously against the interception of the salmon runs.

Extensive hearings were held on bills introduced in Congress to protect the American interests in the fisheries. The Secretary of State announced in March 1938 that the Japanese Government stated that their official survey of salmon fishing in the waters of Bristol Bay and the issuance of licenses to Japanese vessels to fish in these waters would be suspended.

In order to prevent a similar situation in the future the United States, by Presidential Proclamation on September 28, 1945, has declared the establishment of conservation zones on certain areas of the high seas contiguous to the coasts of the United States wherein fishing activities have been or in the future may be developed and maintained. This will apply where the fisheries are of substantial size and have been developed and maintained by its (United States) nationals alone. The conservation zones will be explicitly bounded areas in which fishing will be subject to regulation and control of the United States.

The proclamation also provides for treaties covering waters fished and maintained jointly by our nationals and those of other countries, and also concerns reciprocal agreements regarding fishing with other nations. This in no way interferes with the normal navigation of offshore waters.

Effect of Exploiting a Mixed Population

If the home stream theory is accepted, and if each spawning area is deemed to have its own particular population and is to be treated as a unit, then the exploitation of the fisheries must be in such a manner that each unit can be protected as the need may be. Confining the fishing to the estuaries of the streams would lend itself to far better control than permitting a heterogenous population to be exploited hundreds of miles away and two or more weeks travel time from the spawning grounds.

All tagging experiments to date have demonstrated that the Bristol Bay red salmon on the south side of the peninsula are a mixed population, containing individuals destined for all the different spawning grounds in Bering Sea. No determination has yet been made as to where the fish for the various rivers leave the main body of fish, and form their own school to make their way independently to their own particular spawning ground. At the present time the different units are not known to be segregated previous to their entry into the different estuaries, and some fishermen are of the opinion that salmon may enter a river or bay a few miles and then go out again.

Frequently during recent years it has been necessary to shorten the fishing season in Bristol Bay because of poor escapement. There is no way to judge escapement before the fish are due to arrive on the spawning ground. When the fishing is being conducted adjacent to the spawning ground this measure is effective in securing additional escapement. It will avail little to close a fishery conducted at a distance requiring two or more weeks travel time for the salmon to reach the spawning grounds because the damage to the run will be done long before it is realized and there will be very few if any fish to be saved.

The detrimental effect of intercepting the Bristol Bay run by the offshore fishing operations of the Japanese was fully realized and caused wide spread alarm. It is well within the realm of possibilities that many of the conservation problems connected with Bristol Bay red salmon are primarily due to the run being intercepted at a considerable distance from the spawning ground. It is most difficult, if not impossible, to satisfactorily regulate a fishery at a distance in light of present knowledge of the salmon.

Potential Ability of Area to Sustain Run

In the last analysis the size of the Bristol Bay runs will depend upon how many young salmon the 24 major lakes in the area can produce. The fabulous runs to Bristol Bay prior to the establishment of the canneries attest to the potential of these lakes. To date the situation in Bristol Bay is fortunate in that the lake shores and adjacent terrain are practically the same as one hundred years ago. There are no cultivated fields or logged off hillsides to change the character or amount of runoff into the lakes. So far no power projects have added complications and there are no problems of pollution due to industrialization.

There is a possible question as to whether or not conditions in the lakes are the same as they were fifty years ago, and if the changes would be a benefit or a detriment to the young salmon. Man is directly responsible for having decreased the number of spawning salmon going into the lakes and in this way decreased the number of fry and fingerlings inhabiting the lakes. At first thought it might seem that the reduced population of young fish would have more space and more food and should thrive better under the new conditions. This might be the case, but there is also the possibility that some other species has gained in numbers in using the excess food either directly or indirectly. There are no records of the past by which the present may be judged, but a study of present conditions might indicate whether or not the salmon's former place in the life of the lake is now occupied by another species. Increased escapement in itself may not be enough to bring the area back to its former population of salmon. It may be necessary for man to aid the salmon in regaining their place in the life of the lakes.

The ability of any body of water to support life depends upon the various nutrient materials and chemicals that are brought to it by the runoff from the adjacent terrain. Slowly but surely these materials are carried to the sea. The Pacific salmon are unique in that they make their greatest growth during their ocean life and then return to die in the streams and lakes of their origin. In so doing the salmon bring back material from the sea and deposit it where it is again available to life in the lakes. The reduction of the number of mature fish returning to the spawning grounds has reduced the total amount of nutrients being returned.

Barnaby (1944) in the experiments at Karluk states:

The yearly increment of soluable phosphorus is dependent, very largely, upon the number of spawning fish which enter the lake each year. There was from $1\frac{1}{2}$ to 10 times the concentration of phosphorus in the water at the mouths of the streams as in the water of the same streams, on the same dates, above the area where spawning and spawned-out salmon were found. Furthermore, a part of the salmon spawn along the beaches and eventually die, and the carcasses, together with the carcasses which drift downstream into the lake from the tributaries, decompose and the phosphorus contained therein becomes available to the phytoplankton. A shortage of phosphorus in the lake water would inhibit the growth of all forms of phytoplankton.

It is apparent from a study of the chemical analysis of the lake water and of the stream waters that both phosphorus and silicon are being absorbed, during the summer months, by the phytoplankton as fast as they become available, for otherwise the concentration of these chemicals in the lake water would approach that found in the streams. Since the concentration of these chemicals in the lake water during the summer months was less than a measurable amount, it is evident that they must be limiting factors in the production of the phytoplankton and may possibly be effecting indirectly the growth and survival of the red salmon fingerlings of Karluk Lake.

It has been the practice of the processors of salmon to dump the unused portions of the fish into the rivers and bays at their places of operation. Many of the canneries, of recent years, have installed disintegrators in order that these waste products may be more readily carried away by the tide. It would be possible to run the waste products from the disintegrator through a centrifuge and reduce the bulk to an amount that would not be too difficult to transport to the spawning grounds. This could be done in a limited way until experimental evidence was gathered as to whether or not such a practice would be justified.

Application of various forms of fertilizers might be used to furnish an additional amount of phosphorus. Fertilizers would have an advantage in being less bulky and therefore easier to transport to the more inaccessible lakes. The phosphorus cycle has not as yet been worked out; neither is the precise connection between zooplankton and phytoplankton thoroughly understood. Something other than phosphorus might be the limiting factor. The utilization of what is now waste would be closer to nature's arrangement and might prove in the end to be the most feasible.

Foerster (1925) in an analysis of the contents of the digestive tracts of sockeye fry and fingerlings in Cultus Lake found _Cyclops_, _Daphnia_, _Bosmina_, and _Epischura_ in the order named with _Cyclops_ forming the major part, and very few _Epischura_. Nauplii, rotifers and Protozoa were entirely absent.

Fingerlings from the Stuart Lake District had taken principally insects, especially chironomid larvae. A lack of plankton collections in this area prevented a determination as to whether a lack of Crustacea forced the fry to take insects.

Sockeye fry were placed in cages in Cultus Lake at varying depths and Bosmina obtusirostris was found to be the most abundant constituent, with Cyclops bicuspidatus and Daphnia pulex forming the other two organisms. Rotifera were found only in those fry held in water at the two-foot depth.

Ricker (1937) found pelagic plankton crustaceans to be practically the only food of sockeye fingerlings and the most important food of the older fish. The amount of food taken increases during the summer reaching a height in August, declining through the winter and increasing again during the spring. The fingerlings consume Cyclops and Bosmina when very small and in later summer mostly Daphnia. Cyclops is the chief food during fall and winter, and Epischura is uncommon at all times.

Observations of fingerlings in cages suggest that fingerling sockeyes feed mostly at depths ranging from 5 to 15 meters. In Cultus Lake this area will normally include the whole of the thermocline and a narrow strip of the epilimnion and hypolimnion. The upward range is probably limited by temperature and the lower by the ability to see.

Extremely large populations of fingerlings show a smaller average size and this is thought to be due to intraspecific competition for food.

Seaward migration occurs at the same time that available food is increasing and the migration is probably not an effect of malnutrition.

The findings in the above two experiments are in good agreement. In general the fry apparently fed on whatever Crustacea were the most abundant.

Clarke (1939) points out that a failure in a more or less remote link in the food chain may result in rather poor production of an economically important animal. He reports widely different theories advanced by investigators in attempting to determine more precisely the relation between copepods and diatoms. The traditional impression of copepod production has been that it is dependent upon the growth of diatoms, however, some workers have found copepods spawning successfully at a time when diatoms of the region were at a rather low ebb. Young copepods are at times found in patches of diatoms while the majority of older copepods are outside the diatom zones. The longer time required for the development of diatoms is offered as an explanation of the increased number of copepods appearing after a period of phytoplankton bloom.

"Grazing" of herbivorous plankton animals such as copepods may act as regulators of the plant population. Early experiments at Wood's Hole (Clarke and Gillis, 1935) suggested that microorganisms might play an important role in the nutritive requirements of Calanus. Later work (Fuller and Clarke, 1936) ruled out bacteria as a possible food but left the question open for other types of nonplankton. Further laboratory experiments and observations under natural conditions are necessary before the exact relation between diatom population and success or failure of the copepod crop will be known.

This serves to illustrate the complexity of the food chain and to point out that the problems relating to the availability of food for young salmon depend upon further investigations. There is pressing need for limnological research in Bristol Bay in order that this knowledge can be brought to bear on the conservation problems.

PART III

USE OF THE MATERIAL

Need For Conservation Education

Adult Education

The conservation problems are twofold. First facts must be gathered and ascertained, and secondly, the public, and particularly those intimately associated with the fisheries, must be informed of these facts. The regulations necessary for the protection of the fisheries must be grounded on facts and the public must be acquainted with the facts. In dealing with the public it is important that scientists always bear in mind that many of the people they are dealing with have not had the benefits of scientific training. The explanations and discussions must be in terms that are understandable to the fishermen and other interested persons.

If the need for particular regulations is thoroughly understood by those effected, then the enforcement problem is largely solved. It is not reasonable to expect fishermen of a given area to accept restrictions and curtailment if they believe that the fish destined for that area are being intercepted and exploited at some other point. Whether or not the fish are being intercepted is a matter to be determined by investigation. The important consideration is that the fishermen concerned believe this to be so, and they must have the facts of the matter before their willing cooperation can be expected.

Gilbert and O'Malley (1919) in their report state:

> The trend of events, at least, should be ascertained and an opportunity given wisely to safeguard paramount interests before irretrievable harm has been done. To this end it is essential that wherever possible stream statistics be prepared and that they be made public year by year. It will then be possible to learn how well the public trust is being administered. Should such statistics prove a progressive depletion of the salmon supply in any or all districts, it is to be hoped public sentiment will be aroused and would find expression, demanding adequate protective legislation.

Public school teachers can do much to aid the adults in the community to understand the issues involved by explaining and interpreting the reports of scientific investigations of fishery problems. It is desirable that the people have a part in the formation and adoption of sound conservation programs. This phase of conservation education will in all probability be carried on outside formal classes. The teacher possessing definite information on fishery problems will be able to contribute to public and private discussions of these problems.

In the School

If we are to hold any hope for the future then certainly it is necessary to teach conservation in our schools. This is best accomplished in most cases by integrating conservation with the existing curriculum. Conservation of the fisheries, and the related problems, lend themselves admirably in this respect in the schools of Alaska.

If, in our teaching, we are to proceed from what the children know and are familiar with, to that which is new and unknown, then we could not find a better starting place than fish and especially salmon. All children of Alaska, and especially of the coast towns are interested in fish and fishing.

Concepts To Be Developed

Photosynthesis

The study of photosynthesis in general science and biology classes can, or rather should, be used to teach that all life in fresh and salt water as well as on land depends directly or indirectly on the ability of green plants to convert the energy of the sun into energy that can be used by organisms not possessing chlorophyll.

Light must penetrate the water before it can be used by the green plants. Logged off hillsides and poorly managed farms will result in faster run-off resulting in increased turbidity of the water. Turbidity effects the light penetration in the streams and lakes and this reduces photosynthesis and less phytoplankton is produced. The fisherman is concerned, knowingly or not, with soil conservation and conservation of the forests. In starting with fish as an introduction, it is possible to arrive at other conservation problems.

Water Cycle

Extreme high and low water levels in the streams and lakes do not provide a favorable environment for salmon. The importance of ground water should be stressed. A constant supply of water is needed for suitable conditions on the spawning grounds. The students should appreciate the necessity of vegetation on the watershed to aid in maintaining an optimum water level as well as in checking erosion.

Evaporation is not only the elevator in the water cycle but its cooling effects aid in keeping the lake and stream temperatures within the range that can be tolerated by salmon.

Erosion and Deposition

Erosion and deposition are dynamic forces continuously at work. A combination of the work of glaciers and moving water has given the streams and lakes the clean gravel necessary for salmon spawning grounds. Studies of the role of erosion and deposition will also serve as an introduction to the study of wind, wave and current action in the formation of beaches, bays,and spits.

Density and Viscosity of Water

Water has the unique property of having its maximum density at 4° C (39.2° F) instead of just prior to becoming ice, and this results in lakes freezing at the surface. Ice having less density than water, floats, and the winter conditions are such that the colder water is at the surface and the warmer water at the bottom of the lake. If it were not for this phenomenon lakes would freeze from the bottom, and be uninhabitable for most, if not all forms of acquatic life, including salmon.

Physics classes might consider the variations in viscosity of water at different temperatures. It is these variations in connection with varying density and the mixing action of wind which produce thermal stratification and the spring and fall overturn are closely related to the fresh water life of the salmon. Whether we approach the lake life of the salmon from the standpoint of a physics teacher, or approach the physical phenomena occurring in the lakes from the standpoint of a biology teacher makes no difference. In either case the students are helped to better understand their environment.

Productivity of Streams and Lakes

Pure water will not support life of any kind. All lakes and streams depend upon the surrounding land to furnish a large part of the chemicals necessary to maintain life. The geology of the area is directly connected with its ability to support the run of salmon. A knowledge of the local geology will further the understanding of some of the problems of maintaining the run.

Relation of Living Things to Their Environment

A study of living things in their various habitats will reveal that they are well suited to their environment. This is especially true of animals living in fast flowing streams. The bodies of these animals have rounded contours, are flattened and offer little resistance to strong currents. Some of these animals have special forms of attachment that enable them to cling to supporting objects, while others have well-developed burrowing ability. Studies of these animals should be made on field trips if at all possible.

Animals inhabiting wave swept shores are able to bury themselves in the hard packed sand when needing protection.

Fishes, such as the well proportioned and trim built salmon, have long been studied by men seeking to build ships that would pass through the water easily.

Living things are particularly suited to live in the environments in which we find them. Any great change in environment will drastically effect the normal populations, and if the change is great enough it will make that area uninhabitable for many of the forms in this population. Dams, barricades, pollution and excessive silt loads in streams have in the past adversely affected the fisheries. Students should be made well aware of the possible damage to the fisheries by industrialization, power development, or logging operations in order to competently judge the real value of these programs if they are to be made at the expense of the fishery involved.

Interdependence of Living Things

The oxygen and carbon dioxide exchange in an aquarium as usually taught in high school classes may be readily applied to salmon and their oxygen requirements.

Consideration of food chains, or perhaps more correctly the food web involving salmon, will afford an opportunity to study the effect of commercial fishing. Man is but one of the many forms of animals utilizing salmon, in one stage of its life or another, as food. In former years man's take of the salmon run was comparatively small, but was markedly increased with the development of commercial fishing and canning industries. If man is to continue taking an increased share, then it may well be necessary to relieve the pressure on the salmon by some of its other enemies. In the last analysis the conservation problems concerning the Bristol Bay red salmon are the problems of maintaining a scheme of things in which man will take a larger share than he formerly did. These food relations are extremely complex and dynamic. No permanent solution to the problem can be reasonably hoped for. Continual adjustments and compensations will have to be made, and this is an entirely natural state of affairs. The fishing pressure that the run will stand will depend upon man's ingenuity in meeting the ever new situations as they arise. Additional knowledge and understanding arising from research and careful observations will weigh heavily in man's favor to meet the situations as they present themselves in the future.

Exploratory Value of Conservation Studies

A study of the conservation problems relative to the red salmon of Bristol Bay will afford an opportunity to explore many areas of science. The student will be able to make inquiries into the fields of botany, zoology, physics, chemistry, and mathematics in direct connection with the studies. The need for language and grammer can be shown in order that the results of research may be expressed in terms unmistakably clear to interested persons, and persons who are not highly trained in science. The social sciences have their implications in the situation as it affects the social and economic status of the residents of the district.

A tremendous amount of work remains to be done. The high school student may select his life's work within any of these areas, and be confident that his contribution to society will be valuable and worthwhile.

Use of Conservation Material in Various Subjects

Science

Suggestions for the use of the materials in science classes have been given above in a general way. The extent of the study will no doubt be determined by the interest and ability of the class.

English

Salmon and salmon fishing, picnic trips to the lakes, and observations of the canning operations are abundant sources for materials to be used in oral and written work in English. Interviews with old timers in the community, whose memories reach back fifty years or more will furnish interesting material for reports, compositions, and articles for the school paper.

History

The history of Bristol Bay communities is largely the history of the development of the fisheries. Past practices employed in the fisheries have a direct bearing on the conservation problems of today. The Japanese fishing operations in the Bering Sea during the 1930's are, at one and the same time, a problem in conservation and a problem in international relations. The Presidential Proclamation of September 28, 1945 was made primarily to prevent the recurrence of a similar situation. Certainly all persons residing in Bristol Bay should be familiar with the provisions of this proclamation. (See pp. 39 and 84 of this paper).

Mathematics

The nature of the experimental design of any biological experiments concerning red salmon will involve mathematics more advanced than that of the secondary level. A working knowledge of mathematical formulas and equations as acquired in algebra will greatly aid in understanding population studies. A "need" to study algebra might be developed from this approach.

An arithmetic class can use data on the yearly packs of canned salmon, the dollar value of the pack, and the number of fish caught in construction of graphs and in problems of percentage. The average number of cases packed over a ten year period, and the percentage of the various species caught has real meaning to children living in fishing communities.

Geography

A lot of geography can be taught by studying the migratory routes of the salmon. The salmon passes by the Bristol Bay villages on its seaward migration as well as when homeward bound to the spawning ground. The story of a can of salmon would include practically all of the inhabited parts of the world.

Handbook Needed

These are but a few specific instances of the ways that salmon and the need for conserving the resource may be used. The versatile teacher will find many more. Many competent teachers may not be too well acquainted with the fisheries and related problems. High school text books dispense with salmon in a line or two, or a paragraph at the most. The needed information is in numerous government and scientific publications, and the busy teacher can hardly be expected to literally dig the material out of these sources. A compilation, or a hand book containing the necessary information and detailed teaching suggestions and techniques at different grade levels would aid greatly in implementing a program such as the one suggested.

Fisheries as a Course of Study

Portland, Maine

Some of the larger communities might desire to add a course in fisheries to the curriculum. The Portland Maine High School offers a vocational course entitled, "Ocean, Harbor and Waterfront." The course is concerned with the details of the fishing industry types of fishing, gear, handling the catch, selling the catch, and methods of merchandising the processed product.

The aim of the course is to place in the hands of the student such knowledge and skills as will help him to earn a living from the sea or from waterfront activities resulting therefrom. The course is popular with the students and well received by the community. Waterfront business concerns have given assistance by furnishing speakers, literature and various samples that they possess. The Maine State Department of Sea and Shore Fisheries has given enthusiastic and generous cooperation, sending experts and wardens to speak to the class and furnishing the results of state research.

Schools of Alaska

A suggested course suited to the needs of Alaska would be primarily concerned with the life history and the problems of conservation of salmon. The course would also teach the mending and care of nets and other forms of fishing gear used in the area; splicing, care and handling of lines; maintenance and repair of boats; use of charts and aids to navigation; and problems of marketing and price fluctuations. This knowledge would be useful to those intending to enter commercial fishing, and would help others to understand some of the problems of any community, the economy of which rests squarely on the resources of the fisheries.

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