STATISTICAL REVIEW OF THE ALASKA SALMON FISHERIES. PART I: BRISTOL BAY AND THE ALASKA PENINSULA

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INTRODUCTION

The exploitation of the Alaska salmon fishery resources may be said to have begun in 1878, 11 years after the purchase of the Territory from Russia, when the first cannery was established at Klawak, on Prince of Wales Island. Previously there had been some salting of salmon by both Americans and Russians and, of course, the salmon had formed one of the important food supplies for the natives from prehistoric times. Previous to the spectacular development of the canning industry, however, the inroads made on this natural resource must have been inconsequential. For the first few years after the establishment of the first cannery there was no great production of canned salmon, but about 1885 or 1886 the development started, which, with minor fluctuations, increased steadily, culminating in 1918 with a total pack of 6,605,835 cases, valued at $51,041,949. Few of the world's fishery resources exceed this one in productivity and value, and none has shown such remarkable growth in little more than 30 years. With 1918, however, the general upward trend ceased, and production dropped over 2,000,000 cases in 1919 and again in 1921. In the latter year the total pack was only a little over 2,500,000 cases, the lowest since 1910. It rose gradually again to a new peak of 6,652,882 cases, valued at $46,080,004, in 1926, only to fall disastrously once more in 1927. This brief history of the Alaska salmon fishery is shown graphically in Figure 2.

The development of the industry was marked by the gradual opening of new fishing grounds and by the extension of operations to include species formerly unused. The sharp rise that came between 1899 and 1902 was due largely to rapid development in the red-salmon fishery in Bristol Bay. Following this, for nine years the general level did not change materially, but then, between 1910 and 1918, the pack more than doubled, due mainly to the development of the fishery for pinks and

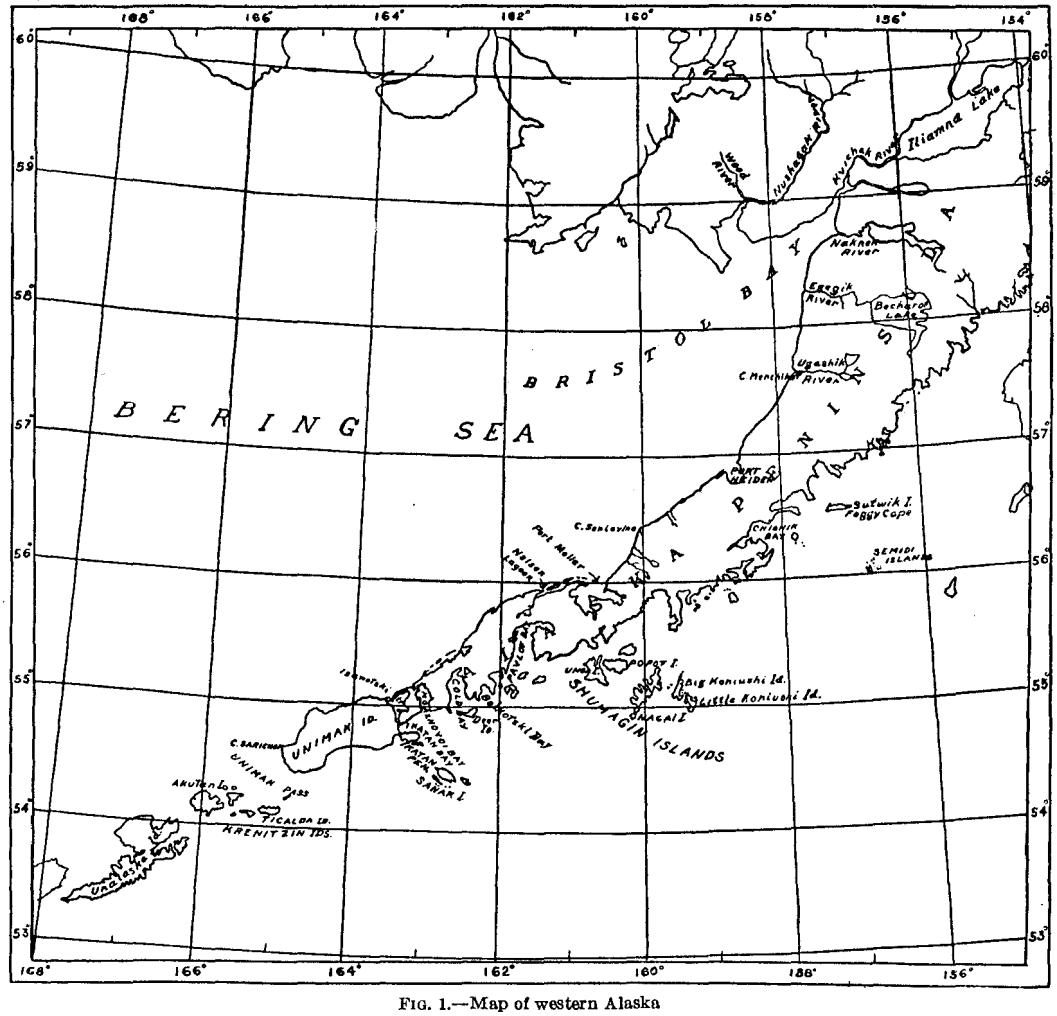

FIG. 1.—Map of western Alaska

chums in southeastern Alaska. The sudden drop in 1919 from over 6,500,000 cases to only a few over 4,500,000 was due to some extent to the postwar economic conditions; but it can not be ascribed entirely to that cause, as the red-salmon pack of western Alaska was poor in spite of intensive fishing, as indicated by the presence there of more gear than in any other year save one and a corresponding drop in the catch per unit of gear. Furthermore, a distinct drop in the pack of pinks took place in southeastern Alaska, while at the same time the pack of chum salmon maintained itself fairly well.

The striking drop in 1921 was an entirely different matter, however. The market was glutted with the cheaper grades held over from the previous two or three years, and in consequence no serious effort was made to pack pinks and chums in southeastern Alaska; the small total pack of 1921 was due almost entirely to this cause. In the following year the market recovered and operations were resumed in southeastern Alaska. For four years the pack fluctuated slightly around 4,500,000 and 5,000,000, rising sharply to a new maximum in 1926, followed by the remarkable drop in 1927. This rise and fall were shown, in general, by all species and in all districts; there was no marked change in the intensity of fishing, and the conclusion seems warranted that these fluctuations were caused primarily by biological factors.

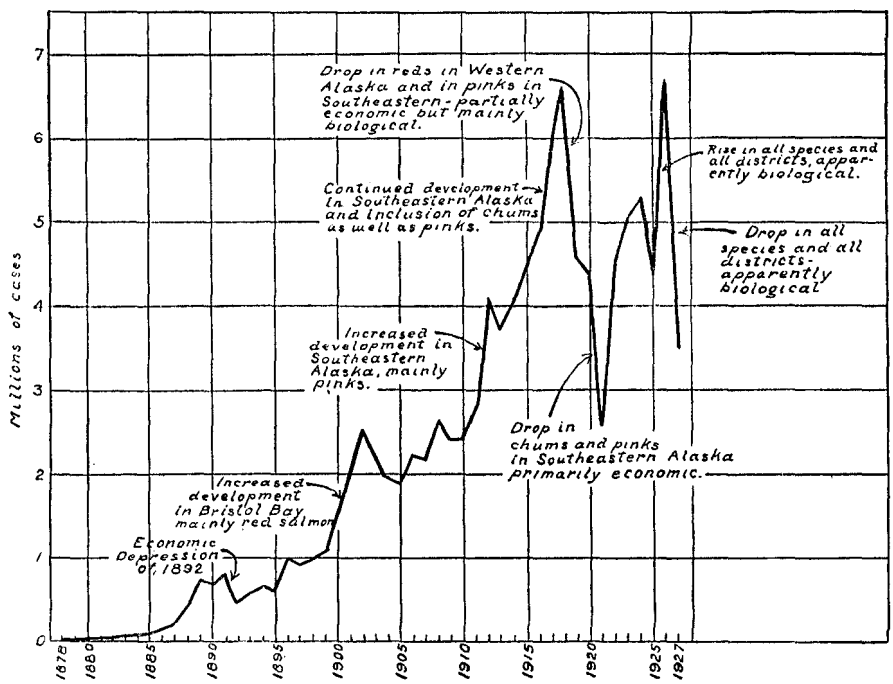

FIG. 2.—Total pack of canned salmon in Alaska

Our knowledge of these factors is too meager at present to warrant speculation as to their nature, but it seems safe to say that the wide fluctuations that have taken place since 1918 (although in part economic) are associated with the onset of depletion, or at least with the development of the fishery to the point of maximum productivity. This hypothetical point of maximum productivity may be defined as the number of fish that may be taken from the resource without impairing it. It will vary from year to year and can never be defined sharply, although it seems probable that ultimately we may be able to define it rather broadly. Any development of the fishery beyond the point of maximum productivity must lead inevitably to depletion and must be guarded against carefully. The conclusion that such wide fluctuations indicate that the fishery has reached its limit seems warranted from the following considerations: Under natural conditions, unaffected by exploitation, the abundance of fish in any fishery resource is certain to fluctuate rather widely, due to varying

natural conditions. The maximum productivity also will fluctuate widely, though not necessarily in proportion to the actual abundance of fish, as it would seem probable that a larger percentage could be taken in times of relative abundance than in times of relative scarcity. This available surplus, which can be taken for commercial use, will, then, on a percentage basis, fluctuate even more widely than will the general abundance. In the early stages of the development of a fishery the number of fish taken remains so far below the available supply that it is affected less seriously by the fluctuations in abundance. In times of scarcity the fishing effort may be adjusted readily, so that the annual catches will not show nearly as violent fluctuations as those of real abundance. When, however, the fishery has developed to the point where the actual take of fish exceeds the available surplus and approaches the total supply, it will be impossible to adjust the fishing effort so that in times of scarcity the annual catch may be maintained and wider fluctuations in productivity will appear. If, for instance, the annual catch of a fishery over a period of time is only one-tenth of the total supply, the great preponderance of the total supply will act as a buffer, so to speak, between the fluctuations in total abundance and the actual catch, and adjustments of the fishing effort will serve to maintain the catch at a fairly constant level. However, as the annual catch approaches closer and closer to the total abundance, until, for example, 75 per cent of the total supply is taken annually, it will become increasingly difficult to maintain the catch at a constant level and it will reflect more and more the inequalities in abundance. When this stage of development has been reached, therefore, it is logical to expect that the fluctuations in annual catches will become more violent, and we may assume that a fishery that shows such violent fluctuations has at least reached a point where more intensive exploitation will cut into the reserve necessary for the maintenance of the resource.

The Alaska salmon fisheries apparently had reached this stage at least by 1918, when the relatively smooth curve of development was replaced by the wide fluctuations of the succeeding years. The general level for the past 10 or 12 years has been around 4,500,000 or 5,000,000 cases, but if the hypothesis given above is correct it would seem that this is more than the resource can stand without injury. Perhaps the general level should be maintained at 3,500,000 or 4,000,000, but any such statement in reference to the total pack is necessarily very indefinite, as the total pack includes five species of salmon and an indefinitely large number of races taken throughout the vast extent of the Territory. In the more detailed analyses of separate species and localities, which follow, we shall attempt to show the fluctuations in the numerous components that together make up the total pack.

The studies of Alaska salmon statistics upon which this report is based were begun in 1925. The passage of the act of June 6, 1924, had placed full responsibility for the care and preservation of the Alaska fisheries upon the Department of Commerce. To fulfill this responsibility adequately, a knowledge of the trends and fluctuations in the fishery was imperative, and this report is the result of an effort to collect and analyze the available data on the salmon fisheries of Alaska. Fortunately, the bureau possessed detailed yearly statistics in the form of sworn annual reports submitted since 1904 by each firm or individual packing salmon in the Territory. These reports give, among other things, the number of salmon of each species caught, the locality where the capture was made, and the kind and amount of gear

used. Similar data bearing on the yield have been compiled and published in various publications of the Bureau of Fisheries, but the only segregation has been as to species and into three general districts—southeastern, central, and western Alaska. Although this arrangement has some value and is of long standing, having been originated when the collection of data pertaining to the Alaska fisheries was conducted by the Treasury Department, it masks the details of the fluctuations quite effectually, so that critical analysis is impossible. It has been necessary, therefore, to go to the original records for most of the data presented in this report, and this has been an arduous and time-consuming task. Certain data have been secured from published reports; those for the years previous to 1904 were taken mainly from the various reports of special agents of the Treasury Department and various others from the annual reports on the Alaska fisheries and fur industries published by the Bureau of Fisheries. It has not seemed desirable, in such a report as this, to give citations of the sources of data in any but certain special cases. Data of the sort presented in this report are subject to some inexactness, of course, but it is felt that they are as accurate as such data can well be and certainly are as accurate as is necessary for any practical purposes to which they may be put.

In the treatment of these data we have attempted to segregate them into the smallest possible geographical units. The ideal thing to have would be separate data for each stream, but this has been possible only in a few cases. As a rule, it has been necessary to combine the data for several streams or for an entire bay, inlet, channel, or larger geographical district. It has happened frequently that some companies gave detailed information as to the localities where the fish were captured, while others, operating in the same district, would assign the fish only to a general region; as, for instance, Prince William Sound, Bristol Bay, or southeastern Alaska. In such cases we have attempted first to complete the records for at least the larger items by correspondence with the companies that submitted the incomplete records. With the fullest available data at hand, it has then been necessary to decide whether to retain the smaller units (and if so, which ones) or to give the data for the larger unit only. Our procedure in such cases has not been uniform, as it was felt that each case presented a separate problem that must be decided on its own merits. In some instances the unapportioned fish formed so small a percentage of the whole that they could not possibly affect the general results, in which case they were merely included in the total for the district. For example, 194,045 red salmon and a few kings and chums were taken in Bristol Bay in 1922 and were unapportioned between the four districts. These are included in the table giving the totals for Bristol Bay but are not to be found in the tables for either of the four districts, so that, as given in these tables, the total catch for Bristol Bay for 1922 is greater than the sum of the catches in the four districts. Such discrepancies are more conspicuous in some of the other tables.

In other cases we found that the data for some of the minor localities within a larger unit were reliable and significant while many were not. In such cases it has seemed best to give the detailed data in so far as they were reliable, even though they aggregated but a small percentage of the catch in the larger district. As an instance of this, in the Shumagin Island district we have given separate data for Acheredin Bay, Orzinski Bay, Ivanof Bay, and Red Cove and have combined all the other

data into a single table for the remainder of the Shumagin Island district, finally giving a table of totals for the entire district.

Still other cases were even more confusing, and our decision to present separate data for a given locality or to include them with those of the next larger including unit has had to rest upon a consideration of such matters as the relative importance of the catches under consideration, the nature of the data supplied, and to a very considerable extent upon our personal local knowledge of the geography and fishing.

A study of this sort is primarily a study of abundance. We are concerned to know what changes in the abundance of salmon have taken place, and, so far as they may be discovered, the causes of these changes. We must decide immediately, therefore, what we are to use as a measure of abundance. The best measure undoubtedly would be one based on the yield per unit of fishing effort, but the introduction of new forms of gear, the enlargement and improvement of old forms, the replacement of sailing boats by motor boats, the impossibility of separating in our available data the catch made by different forms of gear, and other similar factors have made it impossible to define a sensible unit of fishing effort. We are forced, therefore, to use the total yield as our chief measure of abundance, although we recognize the unsatisfactory features of this procedure. Wherever possible we have given data showing the amount of gear as given in the available records, but we consider the records of gear to be only moderately reliable. The number of traps recorded in many instances includes "dummy" traps, which are driven primarily for the purpose of preempting a trap location and are never really fished. The gill-net records frequently include all the gill nets on hand during the season and so give no accurate idea of the actual number fished; and the aggregate length of the gill nets reported by a single company are given only in certain years.

In any carefully considered plan for the conservation of a fishery the most important thing is to determine, as accurately as may be, the condition of the resource. At any time we may wish to know the present condition of the fishery and the prospects for the future, and knowledge of this sort is dependent upon a knowledge of the changes the fishery has undergone in past years. Without a knowledge of the past and present conditions it is impossible to determine whether depletion has occurred or is imminent or what effect regulatory measures that may have been imposed have had. This last is an especially important function of such data, as it is necessary adequately to protect the resources and yet in the interest of true conservation the regulations must not be made so stringent as to reduce the commercial yield below what the resource can provide safely. And, if we can look into the future far enough so that the industry can be advised as to the prospects for the next season, a measure of efficiency and stability can be given which will make for the saving of millions of dollars now wasted in outfitting for runs that fail to materialize. Any appreciation of the present situation or any prophecy for a future year must be based upon consideration of the general trend of the fishery, the cyclic fluctuations about that trend (if present), the spawning escapements in preceding years, the conditions on the spawning grounds and in the streams and lakes that may have affected the mortality of the broods during their life in fresh water, and such information as may be available on the relative abundance in the preceding year or years of fish of younger age groups derived from the same brood years.

While other matters are involved, it is quite apparent that any knowledge of the state of a fishery will depend primarily upon the statistical records that are available. The importance of accurate, reliable, and adequate statistical data can not be stressed too strongly. They are, without doubt, the foundation stones of scientific fishery conservation. The better the statistical records the more accurate our knowledge will be and the better we can adjust our control to the requirements of rational conservation. It is especially important that the continuity of the statistical data be preserved, as we will want perpetually, as long as we have any interest whatsoever in maintaining our fishery resources, to know their immediate condition and future possibilities.

We have pointed out above various weaknesses in the available data on the Alaska salmon fisheries, and it is our belief that a more adequate system should be devised and adopted at the earliest possible moment. The past records, which form the basis of this report, are extremely valuable, but at best can answer our many problems in a general way only. The proper care of these fisheries, for which the Secretary of Commerce is now responsible, will depend in no small measure upon such knowledge as statistics alone can supply, and these should be made adequate at once to the demands of the future.

It is pertinent to inquire what effect legal restrictions may have had throughout the history of the fishery in modifying the catch, and we give herewith a brief chronological summary of the laws and regulations up to and including the act of June 6, 1924.

FEDERAL FISHERY LAWS AND REGULATIONS AFFECTING THE SALMON FISHERIES IN ALASKA

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.

Presidential proclamation, December 24, 1892.

Establishes Afognak Reservation.

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.

Regulations promulgated May 2, 1900, under authority of act of March 3, 1899. Treasury Department Circular No. 57, 1900, division of special agents. Repeated in Circular No. 8, 1902.

Paragraph 2. Prohibits movable traps, etc.

Paragraph 3. Prohibits nets, etc., within 100 yards of stream mouths.

Paragraph 4. Prohibits wanton destruction.

Paragraph 5. Requires reports of operations.

Paragraph 6. Requires information to be given as required.

Paragraph 7. Requires establishment of hatcheries.

Regulations promulgated January 5, 1903. Treasury Department Circular No. 3, 1903.

Prohibits fishing until after June 30 in southeastern Alaska.

Act of February 14, 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.

Department of Commerce and Labor. Department Circular No. 34, April 18, 1904.

Rescinds regulation promulgated January 5, 1903, prohibiting fishing in southeastern Alaska until after June 30.

Executive order, February 1, 1906.

Establishes Yes Bay hatchery reservation and limits fishing therein.

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 1. Provides license taxes as follows: Canned salmon, 4 cents per case; pickled, 10 cents per barrel; salt salmon, 5 cents per 100 pounds; fish oil, 10 cents per barrel; fertilizer, 20 cents per ton.

Section 2. Provides tax rebates on account of hatcheries at rate of 10 cases of salmon to every 1,000 red or king salmon fry liberated; provides for inspection and approval of hatcheries, submission of reports, and certification of reports.

Section 3. Prohibits maintenance of dams and other obstructions to passage of salmon in any waters where the distance from shore to shore is less than 500 feet, or within 500 yards of the mouth of any red-salmon stream less than 500 feet in width.

Section 4. Prohibits setting gear across or above the tidewater of any stream, estuary, or lagoon for more than one-third its width, or within 100 yards outside the mouth of any red-salmon stream less than 500 feet in width, or within 100 yards of another fishing appliance, or to construct a trap or other fixed appliance within 600 yards laterally or within 100 yards endwise of another trap.

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 stream 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.

Section 7. Prohibits canning or salting for sale for food any salmon more than 48 hours after it has been killed.

Section 8. Prohibits wanton waste.

Section 9. Prohibits misrepresentation on labels.

Section 10. Requires reports of operations.

Section 11. Authorizes regulations consistent with this act by Secretary of Commerce and Labor.

Section 12. Authorizes expenditures to enforce.

Section 13. Provides penalties.

Section 14. Method of enforcing act.

Section 15. Inconsistent acts repealed.

Section 16. Act effective June 26, 1906.

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 and Labor Circular No. 238, March 21, 1912.

Regulates fishing in Afognak Reservation; restricts fishing rights to natives; gear and seasons subject to restrictions. (Presidential proclamation of December 24, 1892.)

Order of Secretary of Commerce and Labor, November 18, 1912.

Closes to all commercial fishing for salmon, streams flowing into Cook Inlet; Eyak Lake and its tributaries; Anan or Humpback Creek, its lagoon, lakes, and tributaries, and the region within 500 yards of its mouth; Naha stream and its tributary waters above a line from Loring Point to House Point.

Department of Commerce and Labor notice, February 6, 1913.

Extends privileges of fishing in Afognak Reservation to certain other natives and white men married to native women.

Department of Commerce Circular No. 251, August 19, 1913.

Repeats acts of June 14 and June 26, 1906, and regulations of April 24, 1909, changing authority to Department of Commerce.

Announcement, Department of Agriculture, Bureau of Biological Survey, April 13, 1914.

Permits to fish required in Aleutian Islands Reservation.

Department of Commerce Circular No. 251, 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 Islands 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.
2. Promulgated November 18, 1912. Closes fishing in (1) all streams of Cook Inlet, (2) Eyak Lake, (3) Anan Creek and for 500 yards outside, and (4) Naha River above Loring Point and House Point.

Order of Secretary of Commerce, October 25, 1915.

Closes to all fishing for salmon all waters tributary to Barnes Lake; Hetta Creek, its tributary waters, and the region within 500 yards of its mouth; and Sockeye Creek, its tributary Boca de Quadra waters, and the region within 500 yards of its mouth.

Department of Commerce Circular No. 251, third edition, March 20, 1916.

Includes, in addition to contents of second edition:

1. Executive order of February 1, 1906, establishing Yes Bay Reservation.
2. Closing order promulgated October 25, 1915, closing fishing in Barnes Lake, Hetta Creek and for 500 yards outside, and Sockeye Creek (Boca de Quadra) and for 500 yards outside.

Department of Commerce Circular No. 251, fourth edition, March 12, 1918.

Includes, in addition to contents of third edition:

1. Proclamation of April 28, 1916, establishing Annette Island Fishery Reserve.
2. Closing order promulgated November 30, 1917, closing Karluk River and Lagoon.
3. Closing order promulgated November 30, 1917, closing Bering River.
4. Closing order promulgated December 29, 1917, restricting fishing in Copper River, as follows:
   (1) Copper River Delta closed between January 1 and June 1 each year and at Miles Lake and Abercrombie Canyon between January 1 and June 5.
   (2) Weekly closed season.

(3) Gear in delta limited to gill nets excepting four traps at Cape Whitshed; no net over 1,000 feet in length, only one net to a location, no offshore nets, lateral distance between nets not less than 1,800 feet.
(4) Fishing prohibited between delta and Miles Lake.
(5) Fishing in Miles Lake only by stake and set nets not over 600 feet in length and only one net to a location, lateral distance between not less than 600 feet.
(6) Fishing in canyon by dip nets only, not greater than 16 inches in diameter and at least 300 feet between nets.
(7) Prohibits fishing above canyon.
(8) Set nets to be in straight line.
(9 to 12) Defines areas and certain forms of gear.

Department of Commerce Circular No. 251, fifth edition, January 14, 1919.

Includes, in addition to contents of fourth edition:

1. Closing order promulgated December 14, 1918, restricting fishing in Yukon River, as follows:
   (1) Pack restricted to not over 30,000 cases, 1,000 barrels, and 200 tierces. Pack to be apportioned among established plants. Weekly reports of pack required.
   (2) No packing for shipment out of Alaska above mouth of the Clear River near Andreafski.
   (3) Commercial fishing in the delta only in Kwikluak Pass.
   (4) Traps and pound nets prohibited.
   (5) Length of gill nets not to exceed 700 feet.
   (6) No fishing after August 31, except for local requirements.
2. Closing order promulgated December 20, 1918, restricting fishing in Copper River; revises closing order of December 29, 1917, as follows:
   (1) Closed season extended to June 10 (instead of June 1) in the delta and to June 15 (instead of June 5) in Miles Lake and Abercrombie Canyon.
   (2) Omits weekly closed season as required by section 2 of order of December 29, 1917; excludes all traps and limits length of gill nets to 800 feet (instead of 1,000 feet); lateral distance between set nets to be not over 600 feet (instead of 1,800 feet).
   (4) Excludes stake nets from Miles Lake. No set net to exceed 800 feet in length (instead of 600 feet); shore of lake to be considered throughout season as it was on June 15; fishing prohibited along west and north shores of Miles Lake and along islands between the bridge and head of lake.
   (5) No fishing permitted on east side of canyon.
   (8 to 11) Define areas more clearly and certain forms of gear; essentially the same as sections 9 to 12 in the order of December 29, 1917.

Department of Commerce Circular No. 251, sixth edition, January 2, 1920.

Revised as to closing orders, which are as follows:

1. Yukon River, December 14, 1918.
2. Copper River, December 20, 1918.
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:
   (1) East of Cape Spencer—
      (*a*) Prohibits all fishing in salmon streams, their tributaries and lakes.
      (*b*) Prohibits all fishing except by gill nets and purse seines within 500 yards of the mouths of streams.
      (*c*) Prohibits fishing by gill nets and purse seines within 200 yards of the mouths of all salmon streams; all appliances prohibited within 500 yards of the mouths of the Chilkat, Chilkoot, Anan, Hetta, Sockeye, and Naha streams.

(2) West of Cape Spencer. Prohibits fishing within 500 yards of stream mouths except—
   (*a*) Bering River. Fishing permitted below a point 800 feet northwest of the mouth of Gandil River.
   (*b*) Copper River. Same as in order promulgated December 29, 1917.
   (*c*) Karluk River. Fishing permitted up to within 100 yards of the mouth.
   (*d*) Ugashik River. Fishing permitted below a line 500 yards below mouth of King Salmon River.
(3) Prohibits driving salmon downstream or outside the protected areas.
(4) Permits taking salmon with rod, hand line, or spear for family use.
(5) Afognak Reservation regulations remain as before (presidential proclamation of December 24, 1892).
(6) Previous orders by Secretary of Commerce over waters herein are suspended.
(7) Order effective January 1, 1920.

Announcement, Department of Agriculture, Bureau of Biological Survey, June 25, 1921.

Renews requirements for permits in Aleutian Islands Reservation.

Department of Commerce Circular No. 251, seventh edition, January 4, 1921.

Closing orders revised.
Fishing in Bering River prohibited.
Fishing in Copper River prohibited after September 1, 1921.
Fishing in Kuskokwim River prohibited after September 1, 1921.

Department of Commerce Circular No. 251, eighth edition, April 22, 1922.

Alaska Peninsula Fisheries Reservation established by Executive order February 17, 1922. Regulations therefor issued on April 18, 1922:

Districts defined.
Permits to operate required; will be issued only to present operators; pack will be limited.
Transportation of fresh salmon from one district to another prohibited.
Taking of salmon for fox food permitted.
Closing orders simplified, as follows:
1, 2, and 3. Prohibit fishing in streams and within 500 yards of stream mouths except in Karluk and Ugashik Rivers, which remain as before.
4. Driving salmon downstream prohibited.
5. Permits taking salmon for local requirements.
6. Afognak reservation remains as covered by presidential proclamation of December 24, 1892.
7. Previous orders of Secretary of Commerce over waters herein specified are suspended.
8. Order effective January 1, 1922.

Department of Commerce Circular No. 251, 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 therefor 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.

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

Revoke orders establishing Alaska Peninsula and Southwestern Alaska Fishery Reservations.

Act of June 6, 1924. 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.

The acts of June 14, 1906 (prohibiting fishing by aliens), and section 2 (providing tax rebates for hatcheries operated), section 7 (prohibiting use of salmon after 48 hours), section 8 (prohibiting waste), section 9 (prohibiting false labeling), section 10 (requiring reports), section 11 (authorizing regulations), section 12 (authorizing expenditures to enforce), and sections 14, 15, and 16 (formal) of the act of June 26, 1906, are still in force.

The acts of June 14, 1906, and of June 6, 1924, and the given sections of the act of June 26, 1906, remain (February 14, 1928) unmodified, except for the act of June 18, 1926, which modifies section 1 of the act of June 6, 1924, and permits the taking of fish and shellfish for bait purposes at any time. Numerous regulations have been promulgated under the authority given by these acts, the details of which may be found in the various editions of circular No. 251 and in the various annual reports of the Alaska fishery and fur-seal industries. Most of the current regulations are in the fourteenth edition of this circular, issued December 12, 1927.

It is apparent from this summary that there were no drastic restrictions on the fishery up to the time of the establishment of the Alaska Peninsula and the Southwestern Alaska Fishery Reservations, and even such mild restrictions as were imposed by the two acts of 1906 were not really effective because of lack of funds for adequate enforcement. A few dozen stream guards and a few small patrol boats could do comparatively little along such an extended coast line as that of Alaska. Up to 1922, then, it is safe to say that the catch of salmon had not been affected materially by legal restrictions. It remains to be seen whether the restrictions imposed in the central and western districts under the authority of the reservations or those imposed so far under the authority of the act of 1924 are adequate to protect the salmon resources. If the theory we have expressed above is correct and the Alaska salmon fisheries have reached a point beyond the safe limit of exploitation, it is obvious that

effective conservation must result in a general lowering of the yield. It is but blinding our eyes to an obvious if unwelcome fact to expect a resource that is being conserved adequately and intelligently to yield as much as it would yield, *for a very limited period*, under conditions of unrestricted and intensive fishing. So far as the data for the entire pack serve to indicate, it does not appear that the present restrictions have reduced the strain on the resource materially. There was a gradual recovery after the depression of 1921, and the total pack of 1926 was the largest in the history of the industry. The drop in 1927 may have been due, in part, to an increased effectiveness in the regulations and their enforcement, but there was an unquestionable scarcity of fish in that year, so that the effect of the regulations would seem, at best, to have had a relatively small influence in reducing the catch. It may safely be predicted that effective conservation will mean, on the one hand, an increased stringency in the regulations and, on the other hand, a generally reduced level of the yield when compared with the general level that has been maintained for the past 10 years. This statement applies to the salmon resources of Alaska as a whole. The conditions as found in separate localities will be discussed below.

The analyses of data presented in this report have been limited by lack of time, but the data themselves are presented in full, so that it will be possible to make any additional analyses in the future that may seem desirable. A careful rechecking of the work has been impossible, and no doubt various errors have crept in. It is our hope, however, that none of these is great enough to affect our general conclusions seriously.

BRISTOL BAY

The available statistics for the early years of the salmon fishery in Bristol Bay are unsatisfactory in that they give records of the pack only, not of the catch, and in these all species are combined. Beginning with 1893, however, the reports of the special agents of the Treasury Department give the number of fish taken in the various localities. This was continued until 1904, when the collection of statistics by the Bureau of Fisheries began. Moser [1] gives the best available record of the pack during the years preceding 1893. Pracht [2] gives a record, substantially the same as that of Moser, of the pack for 1892, but does not allocate all of the pack to a definite district. Moser gives the pack for each cannery and the location of the cannery, so that it has been possible to rearrange his data for these early years into the form given in Table 1.

TABLE 1.—*Salmon pack in Bristol Bay, 1884 to 1892, by cases*

Year	Nushagak	Ugashik	Year	Nushagak	Ugashik
1884	400		1889	115,985	
1885	14,000		1890	118,390	
1886	48,822		1891	129,423	3,995
1887	72,700		1892	63,499	
1888	89,886				

[1] "Alaska salmon investigations in 1900 and 1901," by Jefferson F. Moser. Bulletin, United States Fish Commission, Vol. XXI, 1901 (1902), pp. 173-398. Washington.

[2] See report of special agent Max Pracht, dated Jan. 19, 1893, in Seal and Salmon Fisheries and General Resources of Alaska, Vol. II (1898), p. 385. Washington.

Table 2 gives, in detail, the catch of each species of salmon in each region of Bristol Bay and the total of each species for the whole of Bristol Bay. Four quite distinct districts are recognized in the Bristol Bay region, known by the name of the chief river in each district. The Nushagak district includes several important streams flowing into Nushagak Bay—the Nushagak, Igushik, Wood, and Snake Rivers. The Kvichak district includes, besides the Kvichak, the Naknek River and several smaller streams, which are virtually tributary to the Kvichak. The Egegik and Ugashik Rivers are distinct. The data for the years 1893 to 1903, taken from the reports of special agents of the Treasury Department, do not give the locality of capture but only the location of the cannery where the fish were packed. Although doubtless there is some danger of confusion in assuming that the fish canned in any one of the four districts of Bristol Bay were captured in that same district, we believe that the confusion is not likely to be serious and, therefore, have included the figures in our tables.

It is quite apparent, from a comparison of the catch figures with those for the pack, that in many cases the figures for the catch have been derived from those of the pack by multiplying the number of cases by a factor assumed to represent the number of fish per case. This is a source of some error, especially in the earlier data; but as most of the companies keep fairly reliable records of the number of fish per case the data are considered adequate for such analysis as we have made.

No records of the amount of gear used are available until 1904. Without doubt these records are much less satisfactory than are the records of the catch of fish and must be used with the greatest care. 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. Furthermore, there are two kinds of gill nets in common use—a large-meshed net used for king salmon and a small-meshed net used primarily for reds. Some of the companies show the number of nets of each kind, while others do not segregate them, although there is no reason to suppose that they have not operated the same sort of gear. In spite of these and other weaknesses we have thought best to include in these tables the number of nets and traps operated, although we have not given the number of fathoms of nets used, as in some of the later tables. These data will serve to give some measure, however roughly, of the gross changes in the intensity of fishing, and even a rough measure of this is better than none.

TABLE 2.—*Salmon caught and fishing appliances used in Bristol Bay, 1893 to 1927, by districts*

Year	Coho	Chum	Pink	King	Red	Gill nets	Traps
Nushagak:							
1893	74,000			44,000	640,000		
1894	47,000			10,500	860,000		
1895	28,050			18,473	938,946		
1896	117,530			14,777	1,262,690		
1897	150,000		35,348	18,134	1,240,080		
1898	55,744		59,786	16,736	1,890,092		
1899	100,396		16,758	37,011	2,517,436		
1900			7,803	55,146	4,234,533		
1901	2,893		218,188	86,431	5,401,051		
1902	193,838		447,433	98,216	4,725,715		
1903	60,073		238,804	81,640	6,319,189		
1904	123,661	34,570	340,139	85,787	5,345,659	760	10
1905	65,568	34,933	183,153	96,929	7,387,935	496	9
1906	207,257	169,541	1,545,585	105,058	5,427,512	518	13
1907	129,065	415,372	344,148	104,157	2,627,351	421	12
1908	103,013	415,369	392,797	69,175	6,092,031	495	10
1909	80,513	356,621	94,119	108,311	4,906,635	394	11
1910	139,200	206,220	430,369	86,433	4,469,755	431	8
1911	129,971	245,795	79,764	103,806	2,957,073	492	10
1912	195,083	341,059	1,516,039	87,489	3,993,428	758	8
1913	66,640	265,184	418,015	67,656	5,409,933	871	8
1914	81,434	541,690	390,776	88,693	6,457,815	977	8
1915	117,172	444,146		116,387	5,904,862	1,163	8
1916	293,210	1,173,914	638,607	81,921	3,744,551	1,078	8
1917	62,260	303,620		74,316	5,847,239	1,263,	7
1918	108,576	638,537	583,981	46,386	6,296,702	1,224	7
1919	46,687	170,501	13	93,778	1,477,336	1,096	7
1920	145,510	208,601	1,095,318	97,937	2,682,056	1,172	3
1921	84,564	235,763	15	71,048	3,717,284	1,057	
1922	159,783	425,572	222,100	60,924	3,408,358	952	3
1923	9,274	152,161		56,397	1,921,874	760	
1924	39,787	152,235	101,031	53,532	2,168,154	405	
1925	16,591	96,266	18	68,596	3,903,125	625	
1926	12,947	175,295	283,876	54,856	4,022,328	450	
1927	137	137,525	3	68,044	657,467	444	
Kvichak:							
1893					100,000		
1894					262,550		
1895				1,452	413,651		
1896	127,538			2,524	487,630		
1897				1,247	1,410,287		
1898				1,845	2,241,113		
1899				1,248	1,649,127		
1900				2,342	3,208,263		
1901	1,286		13,000	15,245	3,622,638		
1902			46,752	6,755	6,038,386		
1903				3,032	7,516,329		
1904	5,250	1,138	35,593	11,406	5,856,442	351	5
1905	7,000	4,946	32,200	17,470	6,773,275	317	5
1906		24,000	319,563	33,574	4,954,905	123	4
1907		45,458		28,495	6,782,072	307	3
1908		5,024	2,570	17,565	9,088,285	327	3
1909		1,872	28	17,084	9,533,337	357	4
1910		93,840	219,330	13,620	6,336,382	395	3
1911		89,688	12,000	7,951	4,587,344	525	4
1912	10	11,149	145,536	9,570	13,821,905	584	2
1913	2	5,830	4,524	5,648	13,691,550	655	2
1914	17,508	9,662	167,423	10,657	12,584,809	652	
1915	13,271	129,130	124,385	29,392	7,156,488	638	
1916	288	259,013	45,164	20,934	11,551,086	792	
1917	3	45,997	37,082	16,155	15,762,582	1,076	
1918		94,036	35,322	39,540	14,219,530	1,233	
1919		25,251	439	106,705	4,929,761	1,305	
1920	3,900	188,469	950,098	27,791	5,275,140	1,146	
1921		102,157	924	19,540	9,690,857	984	
1922	180	57,309	38,766	11,225	15,636,907	853	
1923		17,319	3	9,681	14,361,488	1,066	
1924	152	113,731	2,025	17,715	6,813,083	1,080	
1925	5	110,396		26,149	3,355,293	1,228	
1926	350	130,644	4,165	18,933	12,717,504	1,001	
1927	8	44,489		14,298	8,917,893	910	

TABLE 2.—*Salmon caught and fishing appliances used in Bristol Bay, 1893 to 1927, by districts*—Con.

Year	Coho	Chum	Pink	King	Red	Gill nets	Traps
Egegik:							
1893					54,321		
1894					20,400		
1895					257	203,458	
1896					537	247,842	
1897					284,650		
1898					41	307,574	
1899					616	427,886	
1900						403,444	
1901			2,700	264	781,038		
1902			2,691		136,759	45	
1903			49,000		140,000	15	
1904			14,000	400	238,000	15	
1905		20,925		1,410	481,578	41	
1906		29,197		1,213	781,131	44	
1907		8,917	7,132	2,891	840,674	47	
1908		3,002	2,430	801	619,001	50	
1909		3,416		460	1,158,176	67	
1910		2,419	4,900	202	1,455,247	57	
1911	165		2,954	254	902,728	56	
1912		1,064	6,717	405	897,767	52	
1913		1,591	10,413	510	1,217,252	62	
1914		7,500		365	1,578,862	71	
1915		5,726		143	1,856,600	89	
1916		6,663		427	1,818,217	82	
1917		2,627		198	607,688	109	
1918	264	5,503	21	441	498,949	67	
1919		8,634		566	1,136,670	103	
1920	21	27,631	28,929	936	2,529,129	115	
1921		7,169		394	1,116,057	100	
1922	440	6,042		126	874,019	94	
1923		9,321		833	212,987	98	
1924		1,017		331	1,522,721	72	
1925	1	5,413		735	1,285,059	84	
Ugashik:							
1893					200,000		
1894					112,850		
1895					65,219		
1896					229,020		
1897				259	463,698		
1898				142	548,793		
1899					661,524		
1900				778	796,965		
1901				3,755	769,002		
1902			8,080	4,118	1,640,973		
1903				1,570	1,703,536		
1904	558	1,600	19,723	760	564,492	105	
1905	5,733	19,105	26,662	2,456	532,779	75	
1906		60,000	22,797	4,162	203,014	57	
1907		26,972		3,615	302,402	26	
1908		10,309	3,890	2,056	272,355	46	
1909		10,728		2,203	218,237	27	1
1910		7,156		892	168,471	27	1
1911		8,967		946	112,521	47	
1912			14,167	467	425,763	48	
1913		13,704		691	577,615	79	
1914		14,531	82	1,209	254,716	65	
1915		18,212		1,739	509,076	70	
1916		49,196		1,904	647,422	60	
1917		879		531	1,047,111	66	
1918		6,588		695	756,206	64	
1919		6,095		1,273	146,590	52	
1920	3,630	31,765		1,181	441,770	86	
1921		8,777		828	1,135,265	62	
1922		4,883		623	1,863,638	84	
1923		8,253		541	782,545	130	
1924		13,455		290	446,810	77	
1925		15,825		1,870	438,103	118	
1926		19,062		484	1,151,541	81	
1927		8,376		769	211,409	78	

TABLE 2.—*Salmon caught and fishing appliances used in Bristol Bay, 1893 to 1927, by districts*—Con.

Year	Coho	Chum	Pink	King	Red	Gill nets	Traps
Total:							
1893	74,000			44,000	940,000		
1894	47,000			10,500	1,235,400		
1895	28,050			19,925	1,472,137		
1896	245,068			17,301	2,099,740		
1897	150,000		35,348	19,897	3,317,523		
1898	55,744		59,786	19,260	4,027,840		
1899	100,396		16,758	38,259	5,112,737		
1900			7,803	58,307	8,547,335		
1901	4,179		231,188	106,047	10,220,577		
1902	193,838		502,265	109,089	12,808,518		
1903	60,073		241,504	86,506	16,320,092		
1904	129,469	37,308	398,146	97,953	11,903,352	1,261	15
1905	78,301	58,984	291,015	116,855	14,833,989	903	14
1906	207,257	253,541	1,901,945	143,194	10,823,431	713	17
1907	129,065	508,727	344,148	137,677	10,193,403	795	15
1908	103,013	459,899	399,257	90,009	16,233,802	912	13
1909	80,513	378,138	101,279	130,489	15,497,883	825	16
1910	139,200	310,218	652,129	101,755	11,593,609	903	12
1911	129,971	347,866	91,764	113,163	8,815,114	1,131	14
1912	195,093	354,627	1,680,652	97,728	19,696,343	1,447	10
1913	66,807	284,718	425,493	74,249	20,581,826	1,661	10
1914	98,942	566,947	564,998	100,964	20,195,107	1,746	8
1915	130,443	593,079	134,798	148,028	14,787,678	1,933	8
1916	293,498	1,489,623	683,771	105,124	17,521,921	2,001	8
1917	62,263	356,222	37,082	91,145	24,513,532	2,494	7
1918	108,576	745,824	619,303	87,048	23,090,665	2,603	7
1919	46,687	204,474	452	201,954	7,161,375	2,562	7
1920	153,304	434,338	2,045,437	127,350	8,897,915	2,471	3
1921	84,564	355,331	939	91,982	15,680,076	2,206	
1922 [1]	159,984	515,915	289,795	74,020	23,632,077	2,004	3
1923	9,274	184,902	3	67,013	18,181,964	2,056	
1924	40,379	285,463	103,056	71,663	10,302,066	1,656	
1925	16,596	231,808	18	97,448	7,909,508	2,069	
1926	13,297	326,018	288,041	74,604	19,414,094	1,604	
1927	146	195,803	3	83,846	11,071,828	1,516	

[1] Includes 520 chums, 312 kings, and 194,045 reds not given above.

We may now examine these data in an attempt to answer several important and more or less interrelated questions: 1. Do the trends of the four districts vary independently or together? In other words, has the development of the fishery in the four districts been parallel? 2. Do the deviations from the trends, the yearly fluctuations in abundance, vary independently or together? 3. What is the present state of the fishery in each of the four districts? We shall consider the catches of the various species separately, and as the red salmon is by far the most important species in Bristol Bay we shall discuss it first.

RED SALMON

Figures 3 to 6 present graphically the data for red salmon given in Table 2 and in addition the trends of the catches. These trends are five-year moving averages and were calculated in the usual manner. The value of such a trend for any given year is determined as the average of the catch for that year, the two preceding years, and the two succeeding years.[3] The trends alone are shown in Figure 7 on a proportional (logarithmic) scale, so that the relative changes in the four districts may be more readily compared.

[3] Principles and Methods of Statistics. By R. E. Chaddock. Page 310 and following. Houghton Mifflin Co., 1925.

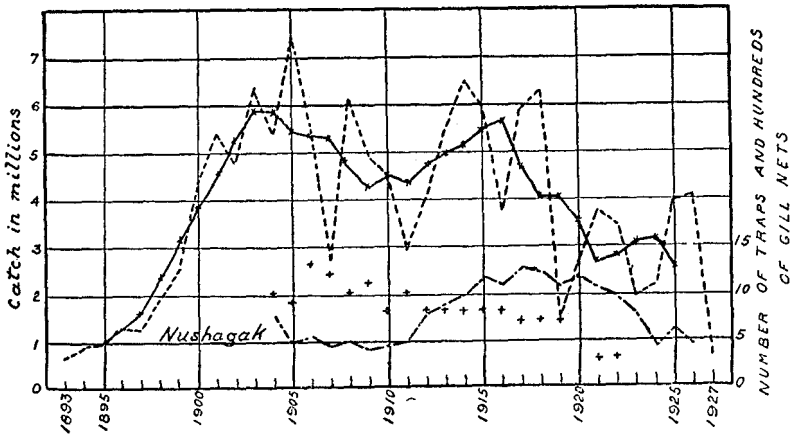

FIG. 3.—Catch of red salmon at Nushagak. Dotted line, catch; solid line, trend of catch; crosses, number of traps; dots and dashes, number of gill nets

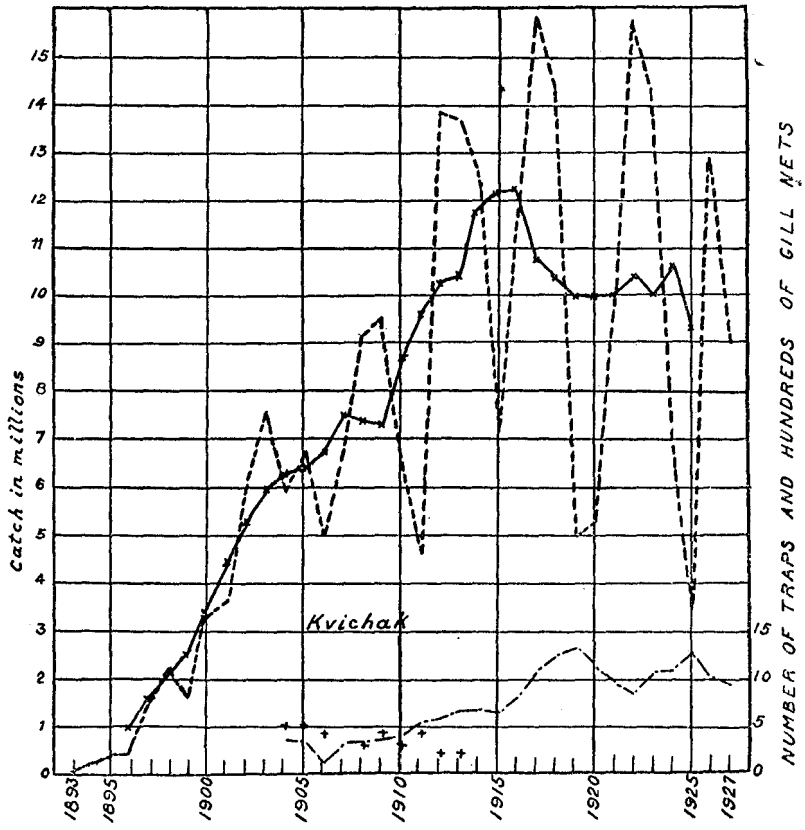

FIG. 4.—Catch of red salmon at Kvichak. Dotted line, catch; solid line, trend of catch; crosses, number of traps; dots and dashes, number of gill nets

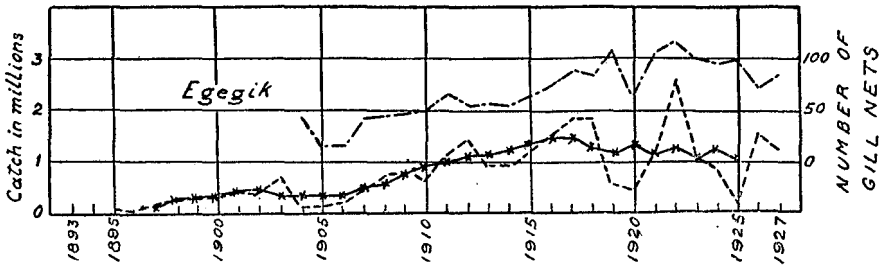

FIG. 5.—Catch of red salmon at Egegik. Dotted line, catch; solid line, trend of catch; crosses, number of traps; dots and dashes, number of gill nets

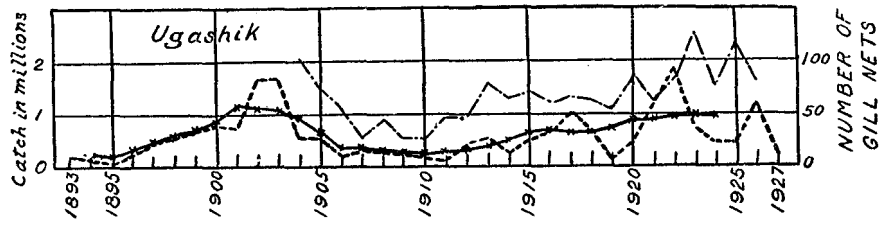

FIG. 6.—Catch of red salmon at Ugashik. Dotted line, catch; solid line, trend of catch; crosses, number of traps; dots and dashes, number of gill nets

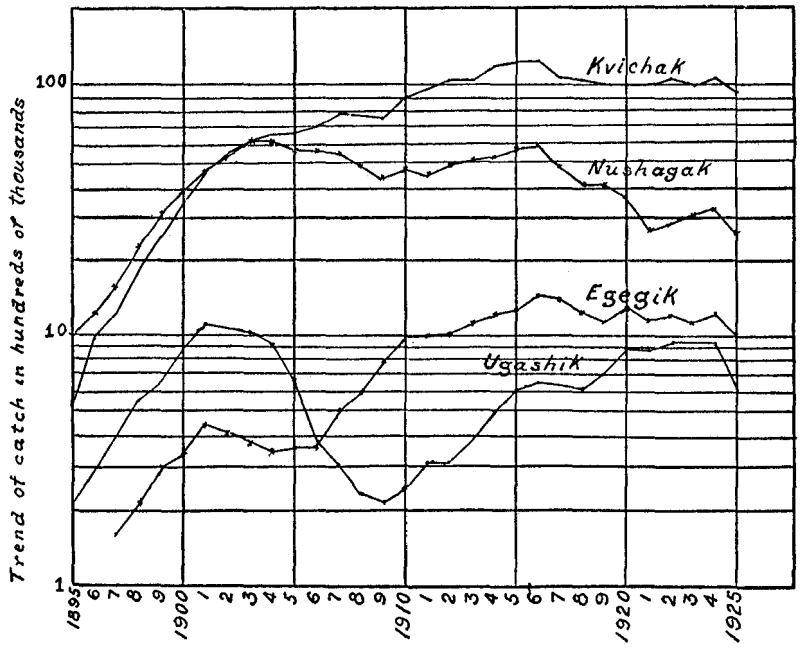

FIG. 7.—Trends of the catches of red salmon in the four districts of Bristol Bay on a logarithmic (proportional) scale

The trends in all four districts show a constant and fairly regular rise during the first 10 years or so (up to 1903 or 1904), which is indicative of the gradual development of the fishery during that period. In the Nushagak district the trend remained generally high (near the 5,000,000 level) for the next 15 years (1902 to 1916) then fell off sharply. Since 1920 it has remained at about the 3,000,000 level. This drop was even more sharply marked than shown by the trend, as may be seen by reference to Figure 3. This shows that the change to a lower level came very suddenly and without warning in 1919. In this case the process of smoothing, by which the trend was obtained, has obscured the very sharp drop in the general level. It is of the greatest importance to those interested in conservation to note the suddenness with which the catch sank to this lower level. It seems impossible to ascribe this phenomenon to any cause other than depletion—to overfishing in the 15 years or more that preceded the drop. This is exactly the sort of thing that biologists have warned could be expected, the logical explanation being that the catch was held up, in spite of real depletion, by an increased intensity in fishing, until finally the break came and severe depletion became apparent all at once. It is interesting to note, in accordance with the hypothesis advanced above that wide fluctuations are a mark of a too intensive fishery, the decade and more that preceded the year 1919 was marked by wide fluctuations in the total catch. The question immediately arises, is the present intensity of fishing on the Nushagak side too great for the lowered level of abundance that is now established? Unfortunately the problem is complicated by a number of factors, which it is impossible to evaluate with the available data. During the period of heavy catches (from 1902 to 1918) there was a considerable increase in the number of gill nets but a decrease in the number of traps, and to what extent one offset the effect of the other we can not know. Neither do we know how the intensity of fishing has been modified by changes in the length of gill nets and the length of time each gill net was actually in the water. It would appear that a reduction in gear from 8 traps and over 1,000 gill nets to no traps and about 500 gill nets was more of a change than that of a catch of approximately 5,000,000 to one of approximately 3,000,000, but this is by no means certain. Furthermore, the former intensity of fishing was unquestionably too great, but just how excessive it was we have no way of telling. With the greatly decreased abundance it may well be that the present intensity is still too great and that further depletion will result. The extremely poor catch of 1927 certainly would indicate that the intensity of fishing had not been reduced sufficiently in 1921, 1922, and 1923 to permit an adequate escapement, as the red salmon of Bristol Bay are largely 4, 5, and 6 years old; and even though the reduction in gear has been sufficient to permit the maintenance of the catch at the 3,000,000 level, should there not be a sufficient reduction in the catch to permit the runs to increase to something approaching their former abundance? Unquestionably the general tendency on the Nushagak has been downward, and if the depletion should continue at the present rate we may anticipate that within the next two or three decades the formerly magnificent runs here will be so reduced as to be worthless commercially.

None of the other districts of Bristol Bay show such sudden and serious depletion as does the Nushagak. While the Nushagak catch reached its maximum size about

1903, the Kvichak catch continued to increase, and the trend reached its peak in 1915 and 1916, since when there has been a material drop, although this is by no means as marked as in the case of the Nushagak catch. The trend at Egegik has been much the same as that in the Kvichak, with the exception of a drop in the years 1902 to 1906. The peak of the Egegik trend came in 1916, since which time the trend has slowly but unmistakably declined. The Ugashik trend is quite different, rising to its highest peak in 1901 and then falling gradually until 1909, since which time it showed a gradual but steady recovery, which was broken sharply in 1925. Without much doubt the early drops in the trends at Ugashik and Egegik were due to reduced intensity of fishing, as shown by corresponding decrease in the number of gill nets. For some reason the early development of the fishery in these two districts was arrested for a time but was resumed later.

It is apparent that there has been a certain amount of independence in the trend of the red salmon fisheries in the four districts. With the possible exception of the Ugashik, however, they all show a present tendency to drop. In the case of the Ugashik it would appear, from the raw data presented in Figure 6, that this stream, too, is entering a period of decreased productivity. While the depletion of the Nushagak is much more pronounced than in the other districts, it is quite evident that the red-salmon catch in the entire Bristol Bay region is distinctly on the decline.

We will now examine the short-time fluctuations, as distinguished from the long-time fluctuations, or "secular" changes indicated by the trends. We have discussed above the general importance of a knowledge of the character of these short-time fluctuations. To be more explicit, it is important that we know (1) whether or not there is any regularity in these short-time changes—whether they occur in cycles or not; (2) what the interval of the cycles is, if the changes are cyclic in character; (3) whether there are sudden or progressive changes in the nature of the fluctuations, and (4) whether there is any correlation in the fluctuations in different streams.

Our interpretation of the facts disclosed by an analysis of the fluctuations will depend, as in the case of any statistical analysis of such data, upon an understanding of the biological and economic factors that may affect them. We are concerned here chiefly with the discovery of the facts about the fluctuations in the catch of salmon and must leave the consideration of the true causative factors for future treatment.

The study of the short-time fluctuations has been based on the percentage deviation of the yearly catch from the trend or moving average by fives. In this method, adequately described by Chaddock (loc. cit.), the percentage deviation for any year is the algebraic value of the catch minus the trend, divided by the value of the trend. When the catch is greater than the trend, the deviations have a positive value and a negative value when less than the trend. Such treatment does two important things to our data—it removes the effect of the long-time, secular fluctuations, which might accentuate or destroy any correlation that might exist between two series of data, and it makes it possible to compare more fairly and more directly the fluctuations at very different levels of abundance, whether in different streams or in the same stream at different periods. For example, if the trend in one series of data was at 1,000,000 and in another series of data was at

10,000,000, a deviation of 100,000 in the first case would be just as significant as a deviation of 1,000,000 in the second case.

In our analysis of these fluctuations we have not made use of the data collected previous to 1904. The Bureau of Fisheries began the collection of statistics in that year and it seemed best to confine this analysis to data obtained by a single agency. Furthermore, as we pointed out above, the fishery apparently became fully developed about this time, and it is quite probable that the fluctuations during the period of rapid growth were largely obscured by great changes in the intensity of fishing.

The use of deviations from a moving average by fives has one disadvantage, in that two years are lost at each end of the series; thus, our series of data extends from 1904 to 1927, both inclusive, but our trend of moving averages extends only from 1906 to 1925. It would be possible, of course, to use some sort of a straight-line trend or to extend more or less arbitrarily the trend of moving averages so as to make use of the extreme values, but we have not thought it advisable to do either. The straight-line trend certainly does not fit some of the localities, and any extrapolation of the line of moving averages will introduce a personal element, which we have been anxious to avoid.

Figure 8 shows the deviations from the moving average for each of the four districts in Bristol Bay, and in Table 3 we present various coefficients of correlation (Pearsonian), which we have calculated and which measure the degree of association in the fluctuations at 4, 5, and 6 year intervals. We have made some estimates of the correlation between fluctuations at 3 and 7 year intervals, also, but these were invariably without significance, and we have therefore omitted them from consideration.

TABLE 3.—*Coefficients of correlation between catches of red salmon at intervals of 4, 5, and 6 years for the four districts in Bristol Bay and Karluk River*

Locality	Interval		
	4 years	5 years	6 years
Nushagak	+0.624±0.103	−0.090±0.159	−0.538±0.133
Kvichak	+.468± .131	+.786± .067	−.066± .172
Egegik	+.383± .143	+.466± .136	+.289± .165
Ugashik	+.466± .132	+.716± .085	−.290± .164
Karluk	+.297± .108	+.581± .080	+.028± .122

Examination of Figure 8 shows that in all of the districts of Bristol Bay there is a strong tendency toward a repetition of conditions at intervals of four or five years. The extent to which the catches are correlated with the catches of 4, 5, and 6 years earlier or later is shown in Table 3. For purposes of comparison we have added to this table a similar series of correlation coefficients for the run of red salmon in the Karluk River. 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 the 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 at 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 suggestion to make as to what these factors may be.

In the Nushagak district there is an undoubtedly significant correlation between the size of the catches at four-year intervals; the coefficient is over six times its probable error. It is apparent from the graph, however, and also from the work sheets made in the process of calculating the correlation coefficients, that the correlation between the catches at four-year intervals is due mainly to an exceptionally close association, which has been maintained in comparatively recent years since about 1914. Previous to this time there was much more of a tendency toward correlation in catches at five-year intervals, but the strong tendency toward correlation at four years, which has prevailed recently, has, in considering the entire series, entirely outweighed the earlier condition. The correlation between catches at five-year intervals in the Nushagak district is not significant, the coefficient being less than its probable error and, as would necessarily be the case with a strong correlation at the four-year interval, the correlation at the six-year interval is significantly negative. Such a negative coefficient of correlation means that in general a good catch in a

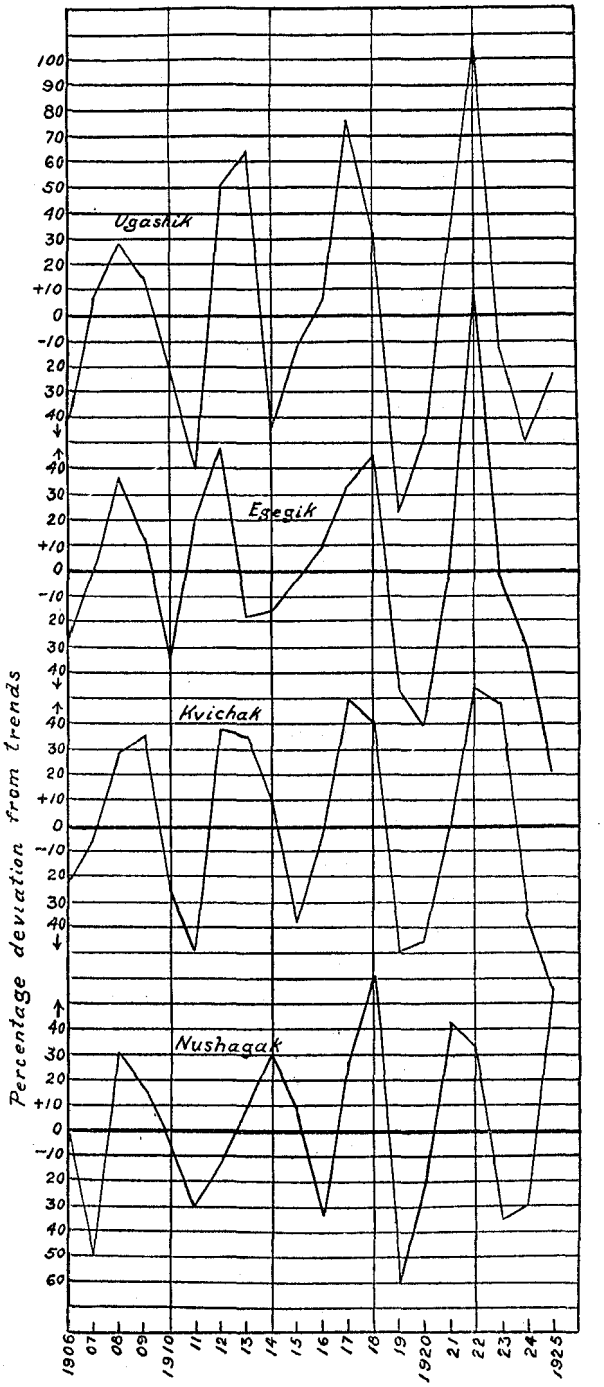

FIG. 8.—Percentage fluctuations from the trends of the catches of red salmon in the four districts of Bristol Bay

given year will be followed by a poor catch six years later, and vice versa. If, as we have indicated, there has actually been a change in the Nushagak district from an association between catches at five-year intervals to an association at four-year intervals it is most interesting, and certain possible explanations may be suggested. Most of the fishing in the entire Bristol Bay region has been carried on by gill nets, and it is generally supposed that this type of gear has a tendency to select the larger individuals in a run. With such a selective agency at work it is possible that a race or several races of predominantly large, five-year fish might be so reduced in numbers as to disappear almost entirely from the commercial catch. It may have been that this occurred in the Nushagak district quite suddenly in 1919, when the run at Nushagak was abnormally low. It is possible, though hardly probable, that the selection of the larger and older fish by the gill nets has operated to change the predominant ages of all the races that make up the Nushagak catch from five to four years. In any event it does not seem likely that this high degree of correlation between the catches at four-year intervals is due merely to the operation of chance fluctuations.

In the case of the other three districts in Bristol Bay the highest correlation occurs between catches at five-year intervals. In the Kvichak and Ugashik catches there is also a low but probably significant correlation at four-year intervals but there is no significant correlation at six-year intervals. In the discussion of the cycles at Nushagak we pointed out that a significant correlation between catches at any given interval of years was strong indication that the prevailing age of the fish was of the same number of years. If this be true, the data herewith presented would indicate that a considerable percentage of the Kvichak, Egegik, and Ugashik red salmon are in their fifth year. We find a similar degree of correlation between catches at five-year intervals at Karluk, where the fish are known to be chiefly 5 years old; and the maintenance for many years of a four-year cycle on the Frazer River, where the fish were predominantly 4 years old, is well known. We wish to emphasize again the fact that no correlation of this sort can be expected to be very high, not only on account of inaccuracies in the data but because of the presence of more than one age group in the catches, fluctuations in the relation of escapement to catch, possible fluctuations in the percentage of fish of different ages coming from different broods, fluctuations in the efficiency of spawning and the rate of mortality at different stages in the life history, and various other factors.

TABLE 4.—*Coefficients of correlation (r) between catches of red salmon in the four districts of Bristol Bay*

Localities	r	Localities	r
Nushagak and Kvichak	+0.305±0.137	Kvichak and Egegik	+0.738±0.069
Nushagak and Egegik	+.209± .144	Kvichak and Ugashik	+.822± .049
Nushagak and Ugashik	+.453± .120	Egegik and Ugashik	+.720± .073

Figure 8 shows clearly that there is a distinct tendency for the catches in the four districts to vary together, although at times, and especially in certain districts, the catches vary independently to a considerable degree. The extent of the correlation

between all possible pairs of districts is presented in Table 4. It is apparent from a consideration of these values that there is a high degree of association between the catches in the three districts on the eastern shore of Bristol Bay at Kvichak, Egegik, and Ugashik, but the correlation between any of these districts and Nushagak is distinctly lower; in fact, so low that the correlation of Nushagak with Kvichak and Egegik is without significance. The correlation between Nushagak and Ugashik is significant of some slight degree of association but is less than four times its probable error. On the whole, it appears that the fluctuations at Nushagak are independent of those on the eastern side of the bay. The correlation between the catches at Kvichak, Egegik, and Ugashik is so marked, however, as to indicate some causal relationship, and it seems more than probable that it is due to the catching in the Egegik and Ugashik districts of fish bound for the Kvichak district. This possibility was pointed out by Gilbert and O'Malley in their report on the salmon fishery in central and western Alaska.[4] It may also be due, in part at least, to fish being reported as taken in one district when actually they were caught in another and were brought into the district from which reported for canning; or it is possible that there is enough "straying" from the parent stream to cause the catch in near-by streams to fluctuate together. This last possibility does not seem likely, however, as one would suppose that any such straying might affect the correlation between the catches at Nushagak and the other streams as well as between the other three streams.

We have mentioned above that an increase in the size of the fluctuations may be an indication that the fishery has been developed to the danger point or that depletion has occurred already. This hypothesis has also been advanced by Gilbert and O'Malley (loc. cit.), who, in discussing the situation in the Kvichak region of Bristol Bay, say: "Other river basins have been watched during the progress of depletion. The sequence of events is always the same. Decreased production is [accompanied] by increase of gear. Fluctuations in the seasons become more pronounced. Good seasons still appear in which nearly maximum packs are made. But the poor seasons become more numerous. When poor seasons appear, no attempt is made to compensate by fishing less closely. On the contrary, efforts are redoubled to put up the full pack. The poorer years strike constantly lower levels, until it is apparent to all that serious depletion has occurred." Figure 8 shows, with great clearness, 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.

Such cyclic fluctuations in the abundance of salmon are extremely interesting biological phenomena, and a knowledge of them is of great practical importance to the industry and to an adequate conservation program. It may not be out of place here, therefore, to speculate briefly upon some of the characteristics of such fluctuations. It seems safe to assume that in a state of nature the abundance of any race of salmon would be constant from year to year, except as modified by environmental conditions, and that the level of abundance will be at the maximum capacity of the waters occupied by the race. If under these conditions unusually favorable circum-

[4] Special Investigation of Salmon Fishery in Central and Western Alaska. By C. H. Gilbert and Henry O'Malley. *In* Alaska Fisheries and Fur Industries in 1919, by Ward T. Bower. Appendix IX. Report, U. S. Commissioner of Fisheries for 1919 (1921). Bureau of Fisheries Document No. 891, pp. 143–160. Washington.

stances should operate to increase the survival (and therefore the spawning run) in any year, the effect of such an increased run would not necessarily be felt in future years, as the area occupied by the race will not, in general, accommodate a population greater than the normal maximum capacity. On the other hand, if the general level of abundance be reduced materially by fishing, this level will be below the potential capacity of the area, and then an increase in abundance in one year can have a very definite effect upon the future generations and would start a series of years marked by good runs separated by years of ordinary runs. The interval between the good years would be determined by the prevailing age at maturity of the race in question—more particularly, perhaps, by the prevailing age of the females. Somewhat similar results would follow the occurrence of a year in which survival was reduced. Under natural conditions the abundance of fish resulting from a poor year would be below the normal capacity of the area, and we may suppose that the race would react by an increased survival of the progeny of the reduced spawning run, so that the size of the resultant spawning runs would tend to approach the normal level. It seems possible that the effect of a very poor year might be felt for one or two generations while building up to the normal level, in contrast to the effect of an unusually good year, which, on account of the limitation imposed by the capacity of the occupied area, could not greatly affect the future runs. Under conditions of exploitation, however, a poor year will tend to be perpetuated, just as in the case of a good year, but for a different reason. The perpetuation of a good year is dependent upon what we may term the elasticity of the race—the tendency to approach the normal level of abundance; but the perpetuation of a poor year will depend mainly upon the continuous application of a fishing effort sufficient to keep the spawning escapement down to a low level. There is no doubt that fishing operations ordinarily operate so that the spawning escapement in good years is better in proportion than in poor years, which is just the reverse of what sensible conservation would call for. On the other hand, it seems probable that the lower the actual level of abundance the stronger the tendency of the race to resist further lowering and the greater the tendency to return toward the normal level of abundance. In other words, as the level of abundance drops there is a tendency toward an increased survival rate. This is well illustrated by the present situation on the Karluk River. It has been shown [5] that the present production from the spawning escapements is approximately 300 per cent; that is, for each spawning fish three adults may be expected to return in future years. Under natural conditions the production in general is 100 per cent, of course. This increased percentage of production is exactly what we would expect in the case of a depleted run such as that in the Karluk; but however strong this tendency toward an increased percentage productiveness at the lower levels of abundance may be, it is impotent in the face of intensive fishing. It may operate to retard the depletion of the poor years, but without some relief from intensive fishing it can not rebuild poor years into good ones or even average ones.

The chief contention in the above argument is to the effect that cyclic fluctuations are associated especially with the exploitation of a fishery, and that under natural conditions such fluctuations would not be so conspicuous. However, there

[5] Investigations Concerning the Red-Salmon Runs to the Karluk River, Alaska. By Charles H. Gilbert and Willis H. Rich. Bulletin, U. S. Bureau of Fisheries, Vol. XLIII, 1927, Part II, pp. 1-69, 34 figs. Washington, 1927.

is the possibility that cyclic fluctuations in the abundance of fish might follow cyclic changes in environmental conditions, such as those that have been shown to accompany the periodicity of sun spots;[6] but it does not seem likely that such a factor could cause such cycles as we observe in the salmon. We have also the remarkable four-year cycles of the Frazer River sockeyes, which existed for an unknown number of years before the white man came and recorded the phenomenon. In this case, as is well known, the tremendous runs that came every fourth year consisted of two races (or groups of races), one spawning in the lakes tributary to the lower course of the Frazer and the other in the higher lakes above the Frazer River Canyon. The first race entered the river yearly, but it was only every fourth year that the second and much more important race entered the river. The latter was a race in which 4-year fish (especially among the females) predominated to a remarkable extent.[7] The last "big" year was in 1913, and in that year a slide in the Frazer River Canyon prevented the ascent of the fish to the upper spawning grounds, the race died out, and the four-year cycle became virtually obliterated. One can hardly doubt that originally the runs of salmon in the Frazer were "big" every year; that every year saw the upper spawning grounds as well covered with spawning fish as they were in the "big" years that we have known. At some more or less remote prehistoric time, however, a slide probably blocked the river for a period of three years and destroyed the race that spawned in the upper lakes. In the fourth year the obstruction was removed and the fish were able to proceed as usual to the spawning grounds. On account of the great predominance of 4-year fish in this race this one year was perpetuated, perhaps for centuries, until the disaster of 1913. In this case the most remarkable cycle known developed under natural conditions, quite unaffected by exploitation, but we have a sufficient understanding of the circumstances so that an adequate explanation can be given. Under ordinary circumstances it seems probable that marked cycles occur most commonly under the conditions resulting from exploitation.

Cycles may become established by the occurrence of various unusual conditions, such as an expecially large or small spawning escapement or the effect of environmental conditions that make for a high or low rate of mortality during the life of a brood. Such conditions may be expected to occur only occasionally and at irregular intervals, and the effect will tend to be perpetuated more or less strongly in future generations by the dominance of certain age groups in the race in question. If a single age group is dominant the effect may last indefinitely, but if two or more age groups occur in fairly large percentages the effect will be spread out gradually and the cycles will lose their sharpness and become obscured, or they may be destroyed entirely or modified by the incidence of another set of unusual conditions, which in turn may give rise to an entirely different cycle. Overfishing, especially at critical times, may be an important determinant of such cycles, although undoubtedly they are frequently caused by natural conditions about which we know very little at present.

[6] Climatic Cycles and Tree Growth. By A. E. Douglass. Carnegie Institution of Washington, Publication No. 289. Washington.

[7] Contributions to the Life History of the Sockeye Salmon. Nos. 1 to 9. By Charles H. Gilbert. Reports of the Commissioner of Fisheries for British Columbia, 1912 to 1923.

In our Bristol Bay data we can see occasional evidence of sudden, unexplained fluctuations, which apparently have been reflected in later years. Perhaps the best example of this is the sudden drop of 1919, which affected all the districts. The fourth and fifth years before 1919 had been exceptionally good on the Nushagak. On the Kvichak the fourth preceding year had been below average but the fifth had been excellent, and we have shown above that the highest correlation between catches in this district is at five-year intervals. So far as the evidence of previous catches goes, therefore, there was no reason to anticipate a poor catch in 1919. Whatever the factors that caused this sudden fluctuation, the effect has been reflected in a poor catch on the Nushagak in 1923 and again in 1927 and on the Kvichak in 1924. It seems probable that we have witnessed here the operation of just such factors as we have been discussing, and that for some unknown reason one or more of the spawning runs that were the parents of the run of 1919 failed to produce the usual number of adult fish, and that this sudden fluctuation has tended toward the production of cycles. The situation is extremely complex, of course, and we have no way of telling how long these fluctuations (which appear to have been fixed by the poor run of 1919) will persist. They may be distinguishable for several cycles, or they may have been obliterated already by factors about which we know nothing and the effect of which we will not see until it becomes apparent in a modified run.

With the data at hand we do not feel that it is possible to make any reliable prophecy as to future runs. The probable errors of all our measures are large, and there is always the chance that unusual circumstances may intervene to upset any estimate that may be made. At present we know virtually nothing about these unusual circumstances in the Bristol Bay region. Apparently they have operated in former years to modify the runs very materially, and there is no reason to suppose that they may not operate again and just as unexpectedly as they have in the past. In spite of all this it seems desirable to review what evidence we have and to point out certain indications as to the future.

In the Nushagak region we have had a general decline in abundance, as indicated by the trend. It has been shown also that the short-time fluctuations here are at four-year intervals at present. The run of the coming season (that of 1928) should bear a general relationship to the run of 1924, therefore, which was one of the poorest in recent years. The run of 1923 on the Nushagak River was exceedingly poor also, so that we can expect no marked effect in 1928 due to five-year fish derived from that year. On the other hand, we have some evidence that in spite of a poor catch the spawning escapement of 1924 was better than usual. The report of observers on the spawning grounds in Wood River states that the escapement to that river was "the most satisfactory for the last several years." [8] Nothing is known, however, of the escapement to the other spawning regions in the Nushagak district. Except for this meager evidence of a good spawning escapement, then, all indications point toward an unfavorable year at Nushagak, possibly as bad as 1927. Knowing the present depleted condition of this district, it would seem to be the part of wisdom to reduce the intensity of fishing as far as possible. Even if a fairly good run should develop, it does not seem at all likely that it will approach the magnitude of the runs

[8] Alaska Fishery and Fur-Seal Industries in 1924. By Ward T. Bower. Appendix IV, Report, U. S. Commissioner of Fisheries for 1925 (1926), p. 99. Washington.

previous to 1919, and a distinctly larger spawning escapement certainly is called for if further depletion of this region is to be prevented.

On the eastern side of Bristol Bay the situation does not appear to be so serious. It seems useless to try to give separate consideration to the Kvichak, Egegik, and Ugashik districts on account of the high degree of correlation, which we have shown exists between the catches in these three localities. If the correlation in catches at five-year intervals holds for 1928, we would expect the run of the coming season to be correlated largely with that of 1923, which was a very good year in the Kvichak district and about average in both Egegik and Ugashik. The year 1922, from the runs of which the 6-year fish of 1928 will come, was also an excellent year, but 1924 was relatively poor. So far as this evidence goes, then, it would appear that the coming season on the eastern shore of Bristol Bay ought to be good. The trend of the catches here has been slightly downward, but it would not appear from this that a serious deficiency would occur in 1928. The escapment to the Kvichak in 1923, as indicated by observations on the spawning grounds, was exceptionally poor, however, in spite of the good commercial catches.[9] The escapement of 1922 was excellent, and if we had discovered a correlation between catches at six-year intervals it would seem a favorable indication. As it stands, the evidence for the Kvichak is conflicting, although on the whole it would appear to indicate a somewhat less favorable year than 1927.[10]

In this general connection there is one other matter that seems worthy of mention, and that is the remarkable association between climatic conditions and catches in 1926 and 1927. The winter of 1925–1926 was one of the warmest on record in Alaska, as was also the summer of 1926. The winter of 1926–1927, on the contrary, was exceptionally cold, and the summer of 1927 proved correspondingly cold and rainy. It seems not beyond the bounds of possibility that there was some causal connection between these conditions and the exceptionally heavy run of 1926 and the exceptionally light run of 1927. We know nothing of the factors, other than age and size, that affect the sexual maturing of salmon, and it may be that temperature or conditions associated with temperature during the winter months may affect materially the percentage of fish of a given age group that matures in a given year. A high temperature may result in the maturing of a larger than normal percentage of the fish in the ocean, while a low temperature may retard maturation. On some such basis as this we might explain the large run of 1926 as due in part to the maturing of a large number of fish that under normal conditions would not have matured for another year; and the poor run of 1927 as due in part to the reduction of the stock by the unusual maturing of fish in 1926 and in part to the retardation of maturation in a large number of fish that normally would have matured in 1927. If this were so, we might expect a rather better run than otherwise in 1928, due to the maturing of fish retarded in 1927. This seems to be a rather remote possibility, it being more likely that the fluctuations in salmon catch and weather conditions in 1926 and 1927 were

[9] Alaska Fishery and Fur-Seal Industries in 1923. By Ward T. Bower. Appendix III, Report, U. S. Commissioner of Fisheries for 1924 (1925), pp. 80 and 81. Washington.

[10] Since this report went to press, the 1928 salmon runs in Bristol Bay have proved to be of considerably greater proportions than our data indicated. We have discussed above some of the possible causes that may upset any prophecy based on such data. With such large probable errors as we have to deal with, close estimates of the size of salmon runs are impossible, but it is our belief that carefully considered estimates of this kind will, in the long run, be justified.—W. H. R., July 17, 1928.

merely chance coincidences. Certainly such considerations could not be made the basis for any prophecy, but they have seemed worthy of recording.

OTHER SPECIES

For several reasons we have not thought it desirable at this time to attempt a detailed analysis of the data pertaining to the catches of pinks, chums, cohos, and king salmon in Bristol Bay. These species are all of minor importance in this region, and we have some reason to suppose that the records are less reliable. We will confine ourselves, therefore, to the brief mention of a few interesting points that

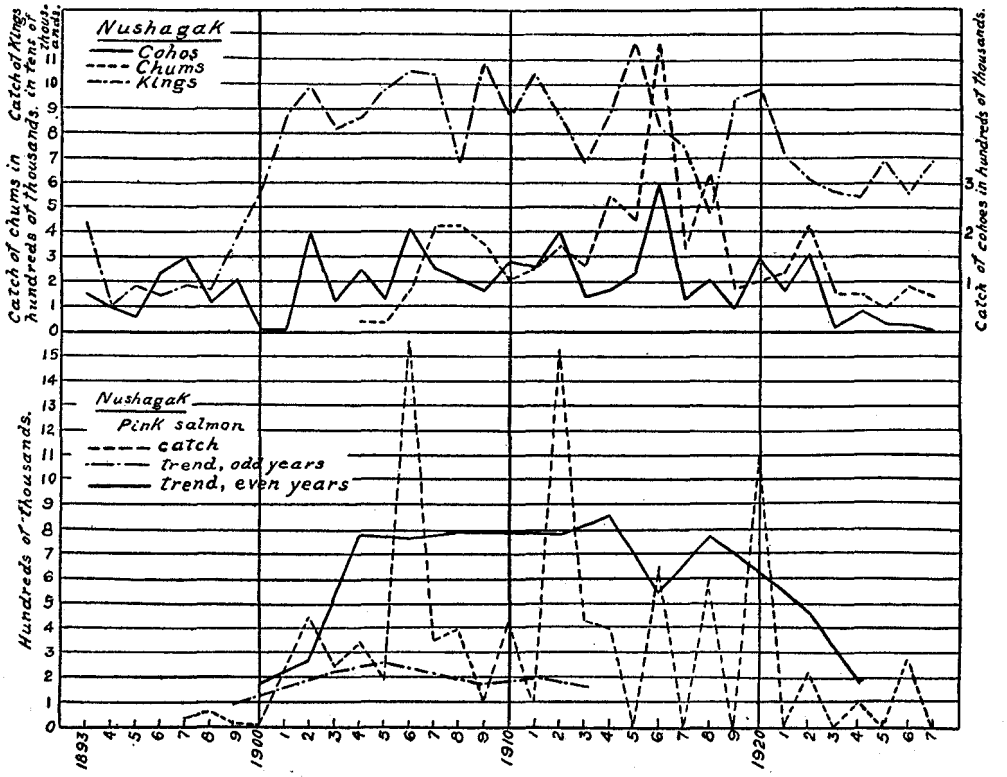

FIG. 9.—Catch of pinks, cohos, chums, and kings at Nushagak

have developed from the limited study we have made. The data for the Nushagak district are presented graphically in Figure 9 and for Kvichak in Figure 10. The catches of all these species at Egegik and Ugaskik and the catch of cohos at Kvichak have been so small and irregular that the data do not lend themselves to analysis, and therefore they have not been included.

Our procedure in the analysis of the catch of pink salmon has been affected by the fact that, to the best of our knowledge, these are always 2-year fish; that is to say, they always return to spawn at the end of their second year. On this account the fish running in the odd years are quite independent of those running in the even years, and vice versa. The two-year cycle in the pink salmon is so well known that this subject need not be enlarged upon here. We have calculated separate trends

for the series of odd and even years, therefore, and have shown these two distinct trends on the graphs. These trends represent a moving average of three years instead of five, as used in the case of the red salmon, as the use of a five-year average would have shortened our trend unduly.

In general, throughout western and central Alaska the pink salmon run much more heavily in the even years than in the odd. This is shown clearly in the graphs for both Nushagak and Kvichak by the conspicuous "peaks" that occur, with very few exceptions, in the even years. The size of the catches, especially in the even years, varies tremendously, as is exemplified particularly well by the catch of over

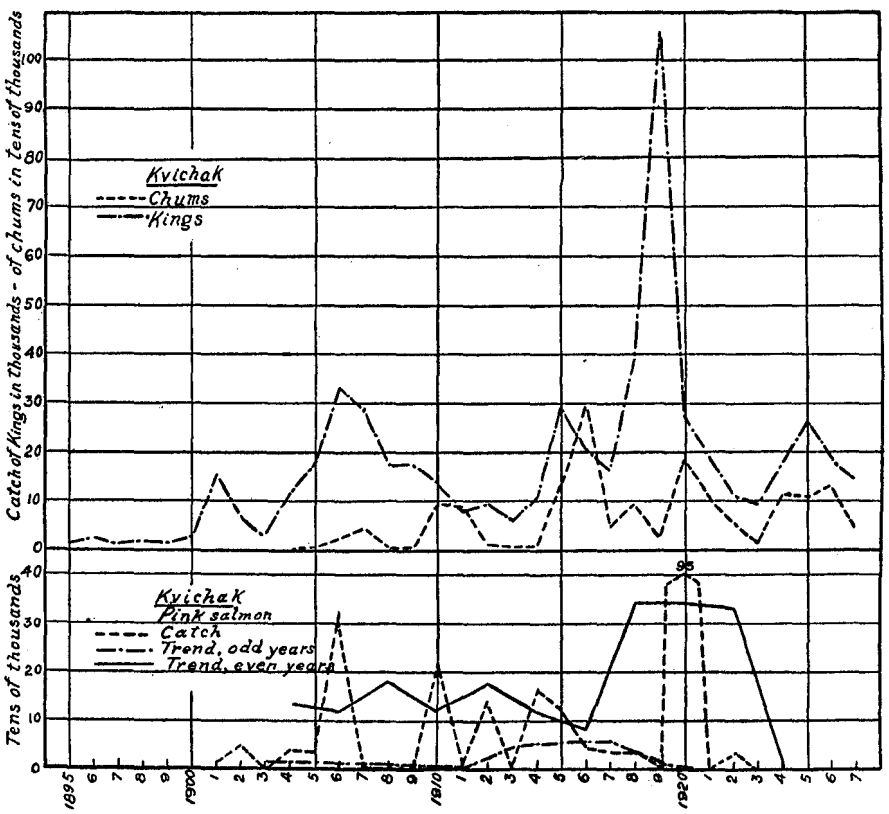

FIG. 10.—Catch of pinks, chums, and kings at Kvichak

950,000 pinks at Kvichak in 1920—approximately three times the next largest catch. The catch of pink salmon in Bristol Bay has been largely affected by the regulations that have been in effect since 1922. These regulations have closed the fishing season on July 25, and as the pink-salmon run occurs mainly after this date the catch of this species has been reduced materially.

The trends of the catches of pink salmon in the odd and even years show some interesting variations, both at Nushagak and Kvichak. In both localities the trend for the odd years is distinctly below that for the even years, as would be expected. The odd year trend at Nushagak rises gradually to a peak in 1905, then declines gradually to an abrupt termination in 1913. After that date no pink salmon have

been reported from this district in the odd years. Whether this is due to the complete failure of the run or whether there is some economic explanation we have no way of knowing. Inquiries have been made of some of the companies operating at Nushagak, but they have been unable to offer any acceptable explanation of the phenomenon. The trend of the even-year catches at Nushagak rose rapidly to the level of 800,000 in 1904, where it remained remarkably constant for over a decade. In this case, however, the level of the trend is determined very largely by the two exceptionally large catches of 1906 and 1912, and the method of determining the trend has so spread these large catches that the constancy of the level is especially marked. The catch during the even years from 1914 to 1920 remained fairly constant and at a level above that of the preceding years, with the exception of 1906 and 1912. The trend for these years (1914 to 1920) is somewhat lower, however, but this is due to the influence of the two exceptional catches. Since 1920 the even-year catches have been poor, but those for 1924 to 1926 were influenced by the regulations, as mentioned above, and that for 1922 possibly was influenced by the economic factors that operated to reduce the pack of 1921 throughout Alaska. It does not appear from these data that the pink-salmon run of the even years has been depleted. In this connection it should be noted that if the parent-stream theory holds as rigidly in the case of the pink salmon as in the case of the reds, the pinks would be expected to show the effects of over fishing very promptly.

The catch of pink salmon at Kvichak is much smaller than at Nushagak but shows similar extreme fluctuations and the same two-year cycle with good catches in the even years and poor catches in the odd. In only two of the odd years were any significant catches of pink salmon recorded—1915 and 1917. The general trend of the catches in the even years was approximately level until 1918; then came the remarkable catch of 1920, and since then the catch has been insignificant; but the catch of the years since 1922, as at Nushagak, has been affected by the regulations, and it seems possible that the catch of 1922 was reduced by economic causes. So here, again, we have no evidence of depletion in the pink-salmon run.

We have not calculated the trends for the other three species, believing that the graphs are sufficiently clear. The catch of cohos at Nushagak shows a gradual increase up to about 1916. Subsequently a somewhat lower level was maintained until 1922, since which year the catch has been lower than at any time since 1901. The cohos as well as the pinks run late in the season, and there is no doubt that the closing of the season on July 25 has been responsible for the reduced catch of cohos in the years following 1922. It is possible that some depletion is shown by the reduced catches in the years 1917 to 1922, inclusive, but this is by no means certain.

In the case of the king salmon there appears to have been a slight reduction in the catch at Nushagak since 1916, but the catch at Kvichak does not seem to have been affected similarly. The catch of kings has not been affected so much by the regulations, however, as provision is made for the use of king-salmon nets not less than 8½ inches stretched mesh previous to June 25, when the season begins in which red salmon may be taken.

The catch of chum salmon at Nushagak reached a maximum in the years from 1914 to 1918 and since then has maintained a decidedly lower level. On the Kvichak side no general change has occurred. The effect of the regulations is apparent again

in the Nushagak catch of chums by the very much reduced catches since 1922. It seems doubtful that any serious depletion is indicated by these data.

One very striking phenomenon for which we have no adequate explanation is apparent from the graphs. This is the distinct correlation between the catches of pink salmon and those of cohos and chums. This is especially well marked on the Nushagak side, where all these species show a distinct two-year cycle, the catches being higher in general in the even years than in the odd. This is what we expect of the pinks, of course, but there seems to be no reason why the cohos and chums should follow the same fluctuations. It seems probable that there is some association between the intensity of fishing for pinks and that for the other two species, but we have not been able to assure ourselves that this is the case. We are unable to suggest any reasonable biological explanation, and it seems more probable that the phenomenon is due to the operation of some economic factor at present unknown.

ALASKA PENINSULA

PORT HEIDEN

The salmon fishery at Port Heiden is of minor importance but is quite isolated from other districts, either north or south. A small commercial saltery has been maintained here at various times, and reports of operations are at hand for four years. Some fishing undoubtedly has been carried on here in other years but apparently mainly for local use, as no records have been submitted to the bureau. Cobb states [11] that a saltery was operated here in 1918, but of this we have no record. The available data are given in Table 5 but are obviously too few to permit of any analysis.

TABLE 5.—*Salmon caught and fishing appliances used at Port Heiden, 1912 to 1917*

Year	Coho	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
				Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
1912	11,029	20	7,280			1	175	2	200	1
1913	18,720		19,410			1	75	8	400	1
1914			10,450			1	75			
1917	6,800	108	13,140	2	150			9	450	

NOTE.—No catches reported in 1915 and 1916.

PORT MOLLER

The data for Port Moller are presented in Table 6, and graphically in Figure 11. It is well known that the red-salmon run in this district is seriously depleted, and this is distinctly shown by the trend (five-year moving average), which has been constantly downward since 1916. It is true there have been material reductions in the amount of gear used and the weekly closed season was extended (in 1924) from 36 to 84 hours; but this can not entirely account for the reduction in catch, although the low level maintained since 1921 probably is due in part to the regulations. The fishery at Port Moller was discussed in 1920 by Gilbert and O'Malley (loc. cit.), who concluded that the run already was showing depletion at that time. The fish

[11] Pacific Salmon Fisheries. Third edition. By John N. Cobb. Appendix I, Report, U. S. Commissioner of Fisheries for 1921 (1922). Bureau of Fisheries Document No. 902, 268 pp., 48 figs. Washington, 1921.

taken in the Port Moller fishery are produced mainly in two small rivers—the Bear and the Sandy, a few miles east of Port Moller proper. Gilbert and O'Malley gave cogent reasons for believing this to be the case, in spite of the opinion held by some that the Port Moller fishery drew upon the Bristol Bay runs to a greater or less extent. It was believed by some of the men in the industry that in certain years, if not in all, the salmon bound for Bristol Bay approached the coast in the region of Port Moller and thus were taken in the fishery at that point. The tagging experiments carried out in 1922 and 1925 [12] proved conclusively that this was not true, and that the red salmon taken in this region did not belong in any appreciable measure to the Bristol Bay runs. Additional evidence of the independence of the Port Moller runs is given by a comparison of the data presented in Table 6 with those for Bristol Bay. It is obvious from such a comparison that there is no significant correlation between the fluctuations in the catches in the two regions, as would be expected if they drew to any great extent upon the same body of fish. These additional lines of evidence, therefore, support the conclusion of Gilbert and O'Malley that the red-salmon fishery at Port Moller is dependent primarily upon the runs supported by the Bear and Sandy Rivers, and we can have no doubt that these are very seriously depleted. The very limited supply has been greatly overexploited, and it seems probable that the process of depletion is continuing even with the reduced intensity of fishing that now prevails. Even under present conditions the intensity of fishing is high, as is shown by the fact that, in the tagging experiments of 1925, 47.5 per cent of the tagged fish were recovered.

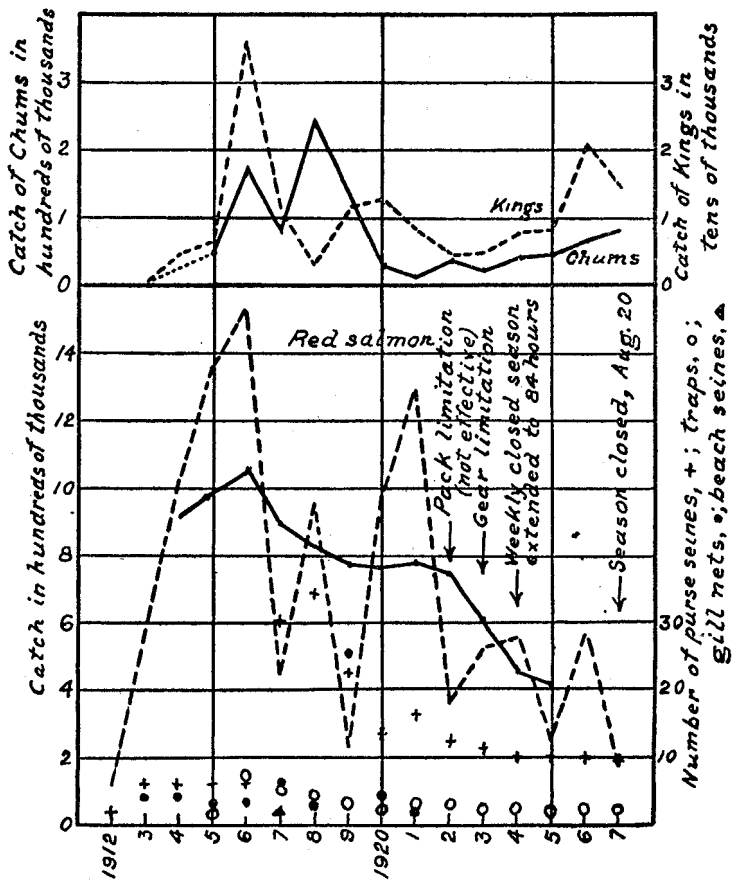

FIG. 11.—Catch of salmon at Port Moller

[12] Experiments in Tagging Adult Red Salmon, Alaska Peninsula Fisheries Reservation, summer of 1922. By Charles H. Gilbert. Bulletin, U. S. Bureau of Fisheries, Vol. XXXIX, 1923-24 (1924), pp. 39-50, Washington, 1923. Salmon-Tagging Experiments in Alaska, 1924 and 1925. By Willis H. Rich. Bulletin, U. S. Bureau of Fisheries, Vol. XLII, 1926 (1927), pp. 109-146, Washington, 1926.

TABLE 6.—*Salmon caught and fishing appliances used in the Port Moller district, 1912 to 1927*

Year	Coho	Chum	Pink	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
						Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
1912					101,606			2	440			
1913	17	1,964		258	571,713			6	1,440	4	600	
1914				4,655	1,012,713			6	960	4	600	
1915		50,701		6,361	1,349,030			6	1,500	3	450	2
1916		175,620	2,567	35,859	1,532,942			6	1,500	3	450	7
1917		82,604	560	11,164	436,450	2	120	30	8,120	6	375	5
1918		243,231	1,211	3,172	953,015	11	745	34	9,150	3	225	4
1919		138,905	12,041	11,578	221,738			22	5,800	25	1,780	3
1920		29,285		12,806	971,090			13	3,400	4	100	2
1921		11,444		8,452	1,314,069			16	4,630	2	150	3
1922		34,906		4,891	357,751			12	2,900			3
1923	61	21,542		5,043	523,933			11	2,675			2
1924		41,509		7,751	562,006			10	2,375			2
1925		49,373		8,598	247,934			10	2,500			2
1926		68,931		20,986	567,190			10	2,500			2
1927		81,781		14,109	172,934			9	2,175			2

NOTE.—According to Cobb (loc. cit.), a saltery was operated on the Bear River in the years 1902 to 1906, but we have no record of the catch or pack during those years.

The fluctuations in the catch of red salmon are somewhat peculiar in that the "peaks" and the "valleys" come at two and three year intervals. Without much doubt this is to be explained by the predominance of 5-year fish in the runs and the existence of two maxima and two minima in each cycle of five years. Thus, referring to Figure 11, the peak coming in 1916 probably is associated with the peak of 1921, and that again with the peak of 1926, while the peak of 1918 is associated with those of 1923 and 1924. On account of the few data available for study, we have not thought it worth while to calculate the correlation of catches at different intervals (as was done for Bristol Bay), but the fluctuations are sufficiently well marked to warrant such a tentative interpretation.

The catch of king salmon has fluctuated considerably, up to a maximum of over 35,000 fish. There was a slight reduction in the average annual catch during the interval from 1921 to 1925, inclusive, but the catches of 1926 and 1927 were among the best on record, being exceeded only by the catch of 1916. There seems to be no evidence here of depletion nor of any reduction in the catch due to the regulations.

The catch of chums dropped suddenly in 1920 from an average of over 100,000 to the relatively low level of less than 30,000. The catch has been increasing gradually since that time and by 1927 was over 80,000. The sudden drop may have been due to depletion, but it seems more likely that it was due to economic causes, inasmuch as the catch has increased during the past seven years in spite of the reduced intensity of fishing brought about by the decrease in gear and the extension of the weekly closed season.

NELSON LAGOON

Salmon fishing in Nelson Lagoon always has been a closely restricted one conducted almost entirely with traps and drawing solely upon the run of fish entering Nelson River to spawn. The catch of species other than red salmon never has been of great importance, but the catch of reds has been remarkably large considering the size of the stream. The data are presented in Table 7 and Figure 12.

The catch of red salmon shows a fairly steady rise from the early years of the fishery to a maximum in 1915 and 1916. The catch for the next three years was

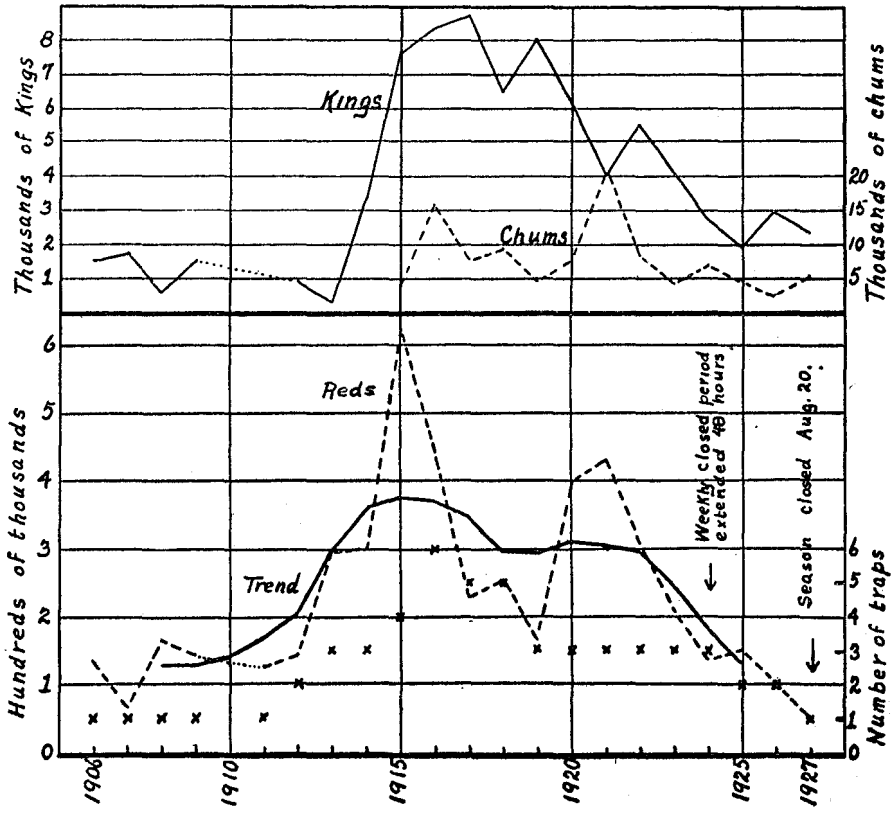

FIG. 12.—Catch of salmon at Nelson Lagoon

relatively poor, but it rose again in 1920 and 1921. Since that time the catch has dropped off consistently, that of 1927 being the poorest on record. These records of the total catch show quite clearly the usual story of excessive exploitation, accompanied by large catches and followed by wide fluctuations and an ultimate decrease due to depletion. In this case depletion appears to have been more rapid and more severe than in Bristol Bay, and in this respect the situation resembles that at Port Moller. A five-year cycle is indicated clearly by the peaks in 1915 and 1916 and 1920 and 1921, and the fact that no maximum appeared in 1925 and 1926 is further indication of the serious extent of the depletion. We have mentioned above the

disadvantages of using the total catch as a measure of abundance and have suggested that some measure of the yield per unit of gear or per unit of fishing effort would be more satisfactory. Such measures of abundance have been used with marked success in various recent fishery investigations, notably those conducted by W. F. Thompson and his associates for the California Fish and Game Commission and the International Fisheries Commission.

TABLE 7.—*Salmon caught and fishing appliances used in Nelson Lagoon, 1906 to 1927*

Year	Coho	Chum	Pink	King	Red	Gill nets		Pile traps
						Number	*Fathoms*	*Number*
1906				1,530	135,000	2		1
1907	3,150		1,500	1,725	66,500			1
1908				600	166,870			1
1909		1,000	15	1,500	143,000			1
1911					129,600			1
1912		2,448		920	143,860			2
1913				342	297,693			3
1914				3,435	301,918			3
1915		4,088		7,592	625,240			4
1916		15,784		8,385	441,776	2	120	6
1917		7,697		8,734	230,002	2	120	5
1918		9,056		6,507	255,530	1	120	5
1919		4,559		8,054	167,438			3
1920		7,669		6,195	400,849			3
1921		21,306		4,022	432,396			3
1922		8,006		5,540	310,139			3
1923		4,213		4,035	207,735			3
1924		6,880		2,742	139,706	2	140	3
1925		4,501		1,952	152,300			2
1926		2,602		2,939	105,670	3	225	2
1927	104	5,182		2,386	57,660			1

NOTE.—No catch reported in 1910. Cobb (loc. cit.) states that a saltery was operated also in 1902 and 1903 but of this we have no record.

As fishing in Nelson Lagoon has been conducted so largely with traps, it has been possible to analyze the data, and while the results are not entirely satisfactory they have proved suggestive enough to warrant inclusion in this report.

It is apparent from Figure 12 that the rise in the catch, which culminated in 1915 and 1916, was accompanied by an increase in gear from one to six traps, and similarly the later reduction in the catch accompanied a decrease in gear. Furthermore, the intensity of fishing has been affected by the increase in the weekly closed period, which has been in effect from 1924 to 1927, inclusive. This has reduced the weekly open period from 132 to 84 hours. In other words, the present time available for fishing is only seven-elevenths (63.6 per cent) of the time available previous to 1924. It is pertinent to inquire how much of the reduction in the total catch is due to the decreased intensity of fishing and how much to depletion.

In order to answer this question, it is essential to have some measure of the fishing effort maintained from year to year, and this is by no means simple, as there are various complicating factors. In the first place, we have to consider the fact that the multiplication of gear, beyond a certain point at least, will, even with a constant supply of fish, tend to reduce the catch per unit of gear solely as a result of what may be called competition between the units of gear. Thus, in the case of Nelson Lagoon an increase in the number of traps in all probability would tend to

reduce the catch per trap simply because of the competition between traps. Supposing that a single trap were operated and caught 25 per cent of the run, then if another trap were placed in an equally advantageous position, but beyond the first trap, so that the only fish to reach the second trap would have to pass the first trap, we would expect the second trap to catch less than the first. If the second trap were equal in efficiency to the first, it would catch 25 per cent of the fish that passed the first one—that is, 25 per cent of 75 per cent, or approximately 19 per cent of the run. In the same manner a third trap, equally efficient but located beyond the second, would catch only 25 per cent of the fish that evaded the second trap, or 14 per cent of the run. Undoubtedly there is some such competition between units of gear, and undoubtedly this will tend to reduce the catch per unit as the number of units is increased, regardless of any depletion due to overfishing. The situation is complicated further by the fact that the fish do not always pass directly through a given fishing area but move back and forth, often on the tides, and thus repeatedly run the gantlet of the fishing gear. In this way the effect of the competition between gear is reduced and under certain circumstances might be entirely nullified, so that any change in the amount of gear would cause a corresponding change in the size of the catch.

In the second place, it is quite possible that a given fishing effort will take a different percentage of a small run than of a large run. To make use again of the example given above it is possible that while a single trap would take 25 per cent of an average run it might take only 20 per cent of a large run but would take 30 per cent of a small run, or vice versa. So far as we know, there is no evidence that such is the case, but it is a possibility that should be kept in mind.

Again, it is very probable that a present-day trap is, in effect, entirely different from those used in 1906; that the two are by no means comparable units. The one trap fished in 1927 or the two fished in 1925 and 1926 were planned and driven in the light of all the experience gained in nearly two decades of fishing in these waters and undoubtedly were driven in the localities and in the manner which have proved most effective. Certainly, as the number of traps has been reduced since 1916 it was the less productive ones that were eliminated.

A fourth complicating factor is the reduction in the intensity of fishing due to the increase in the weekly closed period from 36 to 84 hours, which has been effective for the past four years. This undoubtedly has tended to reduce the annual catch per trap, and it may be assumed that the reduction in catch has been approximately in proportion to the reduction in the time during which fishing is permitted. Such an effect necessarily must be taken into account in any analysis of catch per unit of gear and an adjustment made therefor.

In spite of the difficulties in the way of getting an accurate measure of the catch per unit of effort, we have felt that it was worth while to make the attempt in the case of the Nelson Lagoon data, inasmuch as the conditions here for the analysis of the trap catches are about as ideal as they are likely to be anywhere in Alaska. The available data do not show the actual number of days or weeks fished per season, so that we could not calculate the number of fish caught per trap per day or per trap per week.

The best measure of the catch per unit of fishing effort that we have been able to devise is the catch per trap per days of fishing per week; that is to say, we have taken as our unit of fishing effort one trap fishing one day per week throughout the season, and to secure the catch per unit of effort have divided the total catch for the season by the product of the number of traps and the number of days of fishing per week. This makes the necessary adjustment for the effect of the decline in the number of days per week during which fishing is permitted but does not take into account any changes that may have occurred in the effectiveness of traps.

Figure 13 shows the changes this measure of the catch per unit of effort has undergone. Although there have been wide fluctuations the general trend has been downward, and there can be no doubt that the actual abundance of fish has decreased in much the same proportion. The present yield approximates two-thirds that obtained in the early years of this fishery. It will be noted that the greater number of traps employed between 1914 and 1919 is reflected in the smaller yield per unit of

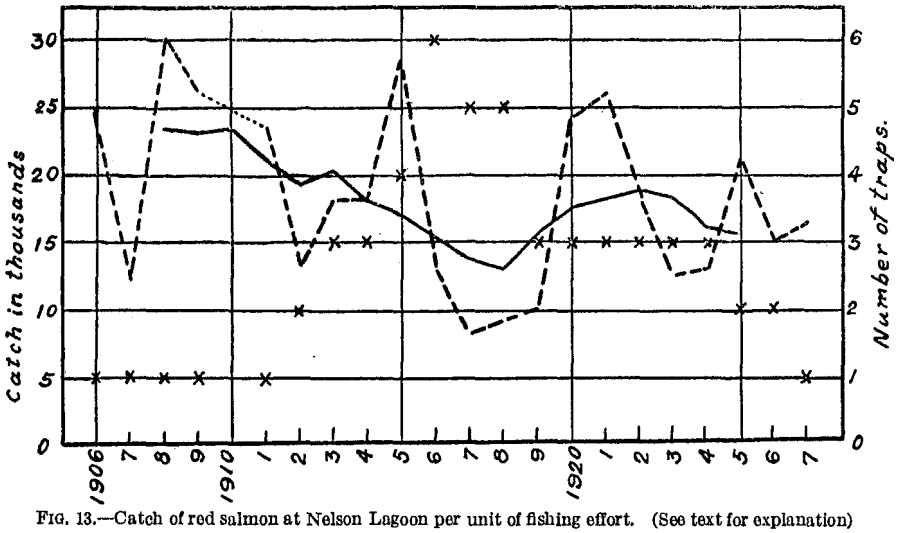

FIG. 13.—Catch of red salmon at Nelson Lagoon per unit of fishing effort. (See text for explanation)

fishing effort, an effect that may be ascribed (in part, at least) to competition between the units of gear. The decreased abundance indicated by the yield per unit of effort does not appear to be so marked as that indicated by the decline in total yield, although the two are of the same order of magnitude. Furthermore there is a general impression current that the fishery is even more seriously depleted than is indicated by either of these measures of abundance. It appears fairly clear that neither the total catch nor the catch on the basis of the unit of effort is entirely satisfactory as a measure of the actual abundance. However, both indicate serious depletion, and the future will show whether the present greatly reduced fishing effort will permit the recovery of the run into Nelson River to something like its original proportions.

ALEUTIAN ISLANDS

Table 8 presents the data on the salmon catch made in the numerous localities of the Aleutian Islands from which reports have been received. The data are so scattered that it is useless to try to determine whether the changes in catches have

been due to depletion, natural fluctuations, or shifts in the fishery. They are presented without any attempt at analysis.

TABLE 8.—*Salmon caught and fishing appliances used in the Aleutian Islands District, 1911 to 1927*

Year	Coho	Chum	Pink	King	Red	Beach seines		Gill nets	
						Number	*Fathoms*	*Number*	*Fathoms*
Akun Cove: 1918					3,250				
Beaver Inlet:									
1917	764	409	72		163				
1918	945								
Chernofski Harbor: 1917		100							
Kalekta Bay:									
1918	360				840				
1919					300				
Kashega Bay:									
1916	1		8,986	4	16,367				
1917					6,749				
1918					6,000				
1919	300								
1920					5,000				
1925					4,291				
Makushin Bay:									
1916	148	8	159,592		1,212				
1917	2,330		247		17,120				
1918	2,000		48,625		30,624				
1920					5,050				
1924		123	673,846		5,676				
1925			3,842		11,422				
1926		3,460	515,841		427				
1927	20		334,575		16,768				
Nikolski Creek:									
1917					17,343				
1922					14,000				
Swanson Lagoon:									
1924				8	19,200				
1925		9,136			2,501				
1926		4,337	5,883		908				
Unalaska Bay:									
1916			10,007						
1918	1,100		26,975		4,330				
1919	500		4,000						
1920	2,790								
Urilia Bay: 1927					491				
Volcano Bay:									
1916	1,025	129	1,679	43	58,915				
1917	675	22,636	293		27,125				
1918					10,200				
1919					3,600				
Winslow Bay:									
1911					9,252				
1917					1,934				
1925					420				
Total:									
1911					9,252	2	75		
1916	1,174	137	180,264	47	76,494	6	1,050		
1917	3,769	23,145	612		70,434	17	2,030		
1918	4,405		75,600		55,244	13	495	1	75
1919	800		4,000		3,900	7	300	1	75
1920	2,790				10,050	4	160		
1922					14,000	1	50		
1924		123	673,846	8	24,876	4	500		
1925		9,136	3,842		18,634	4	340		
1926		7,797	521,724		1,335	3	300		
1927	20		334,575		17,259	3	375		

NOTE.—No catches were reported in years not shown above.

IKATAN DISTRICT

This district includes the waters of Ikatan Bay, False Pass, and eastward as far as but not including the Shumagin Islands. There are a number of independent fisheries in this district that draw upon more or less local runs of salmon, and we have kept these separate so far as practicable. The following localities are not named on the map:

Arch Point, western shore of Pavlof Bay, north of Volcano Bay.

King Cove, mainland shore between Belkofski and Cold Bays.

Nicholaski Spit, western shore of Pavlof Bay, south of Volcano Bay.

Thin Point, western entrance to Cold Bay.

Volcano Bay, indentation on the western shore of Pavlof Bay just north of Belkofski Bay. Also known locally as Bear Bay.

Various regulations have been promulgated from time to time under the authority provided for the administration of the Alaska Peninsula Fisheries Reservation in 1922 and 1923 and that of the act of June 6, 1924. As the interpretation of our data for these years will depend to some extent upon the probable effect of the restrictions imposed, we shall review the regulations briefly.

The restrictions were intended to prevent undue expansion of the industry during the life of the reservation, and they had no material effect upon the then established intensity of fishing. Beginning with the season of 1924, however, effective restriction of the fishing intensity began. The regulations that presumably had the greatest effect upon the catch of salmon may be summarized as follows:

1. The weekly closed period was extended from 36 to 60 hours. In 1925 and subsequent years this order was modified and made effective only up to July 25, after which date the weekly closed period remained as before, 36 hours.

2. On August 20, 1927, the fishing season was closed for the remainder of the year.

3. The use of purse seines was prohibited in 1925 and subsequent years.

4. Beginning with 1926 all traps were prohibited in False Pass, and it was required that traps be spaced at least 1 mile apart in all waters.

5. In 1924 Thin Point Lagoon and the waters within 500 yards of the entrance were closed to fishing.

6. The east side of Morzhovoi Bay and all of Cold Bay were closed in 1925 and 1926, but in 1927 were opened to fishing after July 25.

The data for the various localities in the Ikatan district are given in Table 9.

TABLE 9.—*Salmon caught and fishing appliances used in the Ikatan district, 1908 to 1927*

Year	Coho	Chum	Pink	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
						Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
Arch Point: 1927	168	8,413	18,998		815							1
Belkofski Bay:												
1911	800	8,231										
1912		1,112										
1915		12,491	2,692									
1916		74,207	10,309									
1917	90	12,251	168		168							
1918		32,065	8,928									
1919		7,730										
1923	37	11,392	3,525		19							
1924	188	88,130	206,583		2,533							1
1925	4,293	124,881	34,503	6	8,758							1
1926	3,545	102,619	267,471		4,635							1
1927	1,554	104,313	97,529		24							1
Cold Bay:												
1911	3,500				33,167							
1912	2,200	5,976	3,856		20,525							
1914		15,710	1,187		3,316							
1915	336	38,690	20,852		17,605							1
1916	4,042	10,138	2,187		33,640							
1917	116	8,557	883		21,260							
1918		24,483	7,874		13,500							
1919	362	8,444	145		3,274							
1920	126	2,178	22,621		12,005							
1922		4,065	194		12,705							
1923	19	785	72		28,661							
1924		29,412	14,708		20,405							
1927	1,562	24,562	9,675		14,114							

TABLE 9.—*Salmon caught and fishing appliances used in the Ikatan district, 1908 to 1927*—Continued

Year	Coho	Chum	Pink	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
						Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
Deer Island:												
1916			51,088									
1918		18,084	96,232									
1925	6	9,720	19		48							
1927		4	50,841		1							
Ikatan Bay:												
1911					653							
1912		22,993	3,632		42,865							
1913		2,316		1,832	272,694							
1914		100,387	174,448	227	284,032							2
1915	3,005	107,715	44,352	1,873	109,378							4
1916	2,180	247,759	237,842	3,345	198,627							2
1917	722	149,218	42,224	3,047	670,680							14
1918	3,215	373,208	304,306	3,880	516,509							15
1919	15,018	524,501	60,954	7,384	422,344							22
1920	21,201	644,443	759,577	5,488	786,123							8
1921	1,457	81,712	44,685	678	783,246							6
1922	965	153,798	219,468	3,235	1,900,139							13
1923	16,416	184,247	52,953	3,574	1,084,797							12
1924	58,146	378,806	571,343	3,079	888,910							16
1925	33,037	254,745	73,183	6,930	309,305							12
1926	62,236	256,794	713,955	6,127	1,497,850							9
1927	44,588	420,322	266,093	7,213	430,989							10
King Cove:												
1914		10,312	1,988									
1915		41,450	6,130									
1916		27,227	5,568									
1917		4,041										
1918		12,235										
1919		3,622										
1920		8,965										
1922			3,014		1,442							
1923		2,499	127		5							
1925	3	28,192	892		9							
1927		22,938	5,799		3							
Morzhovoi Bay:												
1911	4,147	29,428			57,693							
1912	3,868	41,509	14,063		101,036							4
1913		4,634			141,648							3
1914	3,904	66,445	105,143	421	182,232							2
1915	8,859	48,217	45,014	2,880	141,773							4
1916	17,317	54,360	82,122	3,347	340,153							2
1917	3,184	101,591	26,702	2,377	651,603							14
1918	6,423	513,874	479,246	4,547	216,114							13
1919	11,477	119,693	10,494	1,039	122,588							14
1920	6,254	116,715	350,537	1,127	167,913							1
1921		2,915	2,635		47,420							5
1922	1,058	73,234	121,468	413	875,012							5
1923	2,988	28,091	6,141	61	255,017							4
1924	8,045	171,647	191,225		82,341							4
1925	7,878	58,533	9,182	120	47,745							4
1926	3,175	55,623	83,804	101	400,302							3
1927	2,234	114,816	33,920	27	24,490							3
Nicholaski Spit:												
1924	2,818	52,989	151,001		43,356							1
1925	4,763	62,711	12,778	42	17,214							1
1926	8,125	71,589	321,711	233	137,628							1
1927	1,318	57,314	77,002	101	20,955							1
Pavlof Bay:												
1912					4,425							
1916			162,188									
1917	130	11,675	130		1,650							
1918	494	91,829	854,219		30,590							2
1919	1,414	31,567	1,617	56	9,929							2
1920	6,943	49,891	319,017	14	4,484							2
1922		2,936	135,860	10	3,000							1
1923	1,103	21,988	2,075		1,074							2
1924	4,509	90,916	1,012,937		3,876							2
1925		30	60		315							2
1926	13,293	107,465	830,860		43,558							2
1927	22	61,155	30,319		356							6
Sanak Island:												
1911			25,232		40,067							
1912		1,854	10,700		23,592							
1914					46,004							
1915					30,677							
1917		3,147	319		22,626							

TABLE 9.—*Salmon caught and fishing appliances used in the Ikatan district, 1908 to 1927*—Continued

Year	Coho	Chum	Pink	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
						Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
Sanak Island—Contd.												
1920			132		8,283							
1922			99		19,857							
1923			2,209		10,012							
1924			1,854		5,427							
1927		44	18		736							
Thin Point:												
1908					46,942							
1909	7,200				92,075							
1910	5,500				45,000							
1911	4,000				78,200							
1912	20,914	24,360	8,158		58,309							
1913					43,028							
1914	342				68,265							
1915	4,037	2,938	1,095		44,383							
1916	10,406			70	77,482							
1917	106	722	344		37,349							
1918	1,579	5	639		134,563							
1919	18,535				21,553							
1920	9,156	44	6,563		90,410							
1922	50	133	284		76,310							
1923	1,449		175		82,463							
1924		27,127	54,031		34,703							
1925	9,997	16,060	2,595		45,456							
1926					20,000							
1927		13	52		19,363							
Volcano Bay:												
1911		31,755										
1912		97,213			556							
1914		28,211	28,211									
1915		81,640										
1916		95,029										
1917		98,674	300									
1918		324,217	90,275									2
1919	942	102,471	166		911							2
1920	142	66,675	115,624	526	182							2
1922	100	72,359	127,572	40	2,501							2
1923	2,840	132,165	4,607	46	7,286							2
1924	356	369,328	236,534		2,634							2
1925	762	178,696	15,182	45	5,453							2
1926	12,466	268,618	378,954	24	27,117							2
1927	1,051	129,201	83,460	8	8,140							4
Unallocated:												
1911		13,549			15,257							
1927	3	90	170		10							1
Total:												
1908					46,942	2	90	2	80			
1909	7,200				92,075	3	280					1
1910	5,500				45,000	2	75					
1911	12,447	82,963	25,232		234,632	7	400	2	400			
1912	26,982	195,017	40,409		251,308	6	600	4	800	1	150	4
1913		6,950		1,832	272,694	1	125	2	250			3
1914	4,246	221,065	310,977	648	583,849	4	350					4
1915	16,237	333,141	120,135	4,753	343,816	5	362					8
1916	33,945	508,720	551,304	6,762	640,902	8	980			1	40	4
1917	4,348	389,876	71,060	6,424	1,405,336	11	1,500					28
1918	11,711	1,390,000	1,841,719	8,427	911,276	12	1,550	4	875			32
1919	47,748	805,716	73,398	8,479	579,599	15	1,745	6	1,700			40
1920	43,822	888,911	1,578,421	7,155	1,069,400	15	1,745	6	1,700			17
1921	1,457	84,627	47,320	678	830,066							7
1922	2,173	296,936	603,691	3,698	2,890,966	5	510	2	600			21
1923	24,852	381,167	71,884	3,681	1,469,334	4	395	2	600			20
1924	74,062	1,208,365	2,440,216	3,079	1,084,185	3	375	6	1,055			26
1925	60,739	733,568	148,394	7,143	434,303	3	350					22
1926	102,840	862,708	2,596,755	6,485	2,131,135	5	550					18
1927	50,951	936,502	674,659	7,349	519,997	9	900					27

NOTE.—The years in which no catches were reported have been omitted. The catches at Volcano and Belkofski Bays in 1918 were not separated in the reports received from the packers for that year. They have been divided on the basis of the total production in both localities in 1917 and 1919, whereby 91 per cent was credited to Volcano Bay and 9 per cent to Belkofski Bay. In the same way an undivided catch taken at Deer Island and Cold Bay in 1918 was allocated 92 per cent to Deer Island and 8 per cent to Cold Bay. The number of traps has been determined in part from the company records, which show all traps driven, and in part from the records of the bureau's agents, which show the traps actually fished. Whenever possible the bureau's records have been used as providing a more accurate measure of the fishing effort.

The two most important localities, especially as regards the catch of red salmon, are Ikatan and Morzhovoi Bays. The tagging experiments of 1922 and 1923 [13] showed that the runs of red salmon in these two bays were intimately associated, not only with one another but with the runs of Bristol Bay. It was apparent that there was a considerable interchange of fish between Ikatan and Morzhovoi Bays, and that important percentages of the fish from both localities went ultimately to Bristol Bay. It was shown further that the traps located on the east side of Morzhovoi Bay caught a smaller percentage of Bristol Bay fish and a correspondingly larger percentage of red salmon derived from local spawning streams along the southern shore of the Alaska Peninsula than did the traps on the west side of the bay. On this account it would be desirable to separate the catches made on the east and west sides of this bay, but it has been impossible to do this with the data at hand. In view of the close association between the red-salmon runs in Ikatan and Morzhovoi Bays we have combined the catches for the purpose of analysis, and the data are presented graphically in Figure 14.

The trend of the total catch increased consistently up to 1922, but since that year has fluctuated rather widely, although the general tendency seems to be downward. We can not say whether this downward tendency is due to the restrictions imposed during the past four seasons or whether it is a reflection of the general downward trend that has been demonstrated in the Bristol Bay catches for the past few years. It seems probable that both factors may have had their effect.

It is quite clear from Figure 14 that the fluctuations in Morzhovoi Bay have been proportionally greater than those in Ikatan Bay, the poor years being relatively much poorer at Morzhovoi than at Ikatan. It has been suggested that in years marked by poor runs a smaller percentage of the fish enter Morzhovoi Bay. It is as though the mass of fish passing along the southern shore of the peninsula kept to the more direct routes for Ikatan Bay and False Pass in the poor years, while on the good years the relatively greater mass of fish tended to crowd large numbers off the direct route and into such side branches as Morzhovoi Bay. The available evidence lends some weight to such an hypothesis.

On account of the proved relationship between the red-salmon runs in Ikatan and Morzhovoi Bays and those of Bristol Bay we have been interested to learn to what extent the catches at Ikatan and Morzhovoi Bays are correlated with the catches in Bristol Bay. Figure 15 shows the percentage deviations of the red-salmon catches from the trend as compared with the similar data for Nushagak and Kvichak and for Bristol Bay as a whole. The Pearsonian coefficients of correlation for three combinations are as follows:

Ikatan–Morzhovoi and Nushagak	+0.163	±0.181
Ikatan–Morzhovoi and Kvichak	+.814	±.063
Ikatan–Morzhovoi and Bristol Bay	+.792	±.070

The high correlation between the Ikatan and Kvichak catches leaves little doubt that the Kvichak fish form by far the most important element in the catch at Ikatan. The lack of correlation with Nushagak is doubtless due to the dominating influence

[13] Gilbert, footnote 12, p. 74. Second Experiment in Tagging Salmon in the Alaska Peninsula Fisheries Reservation, Summer of 1923. By Charles H. Gilbert and Willis H. Rich. Bulletin, U. S. Bureau of Fisheries, Vol. XLII, 1926 (1927), pp. 27-75. Washington, 1925.

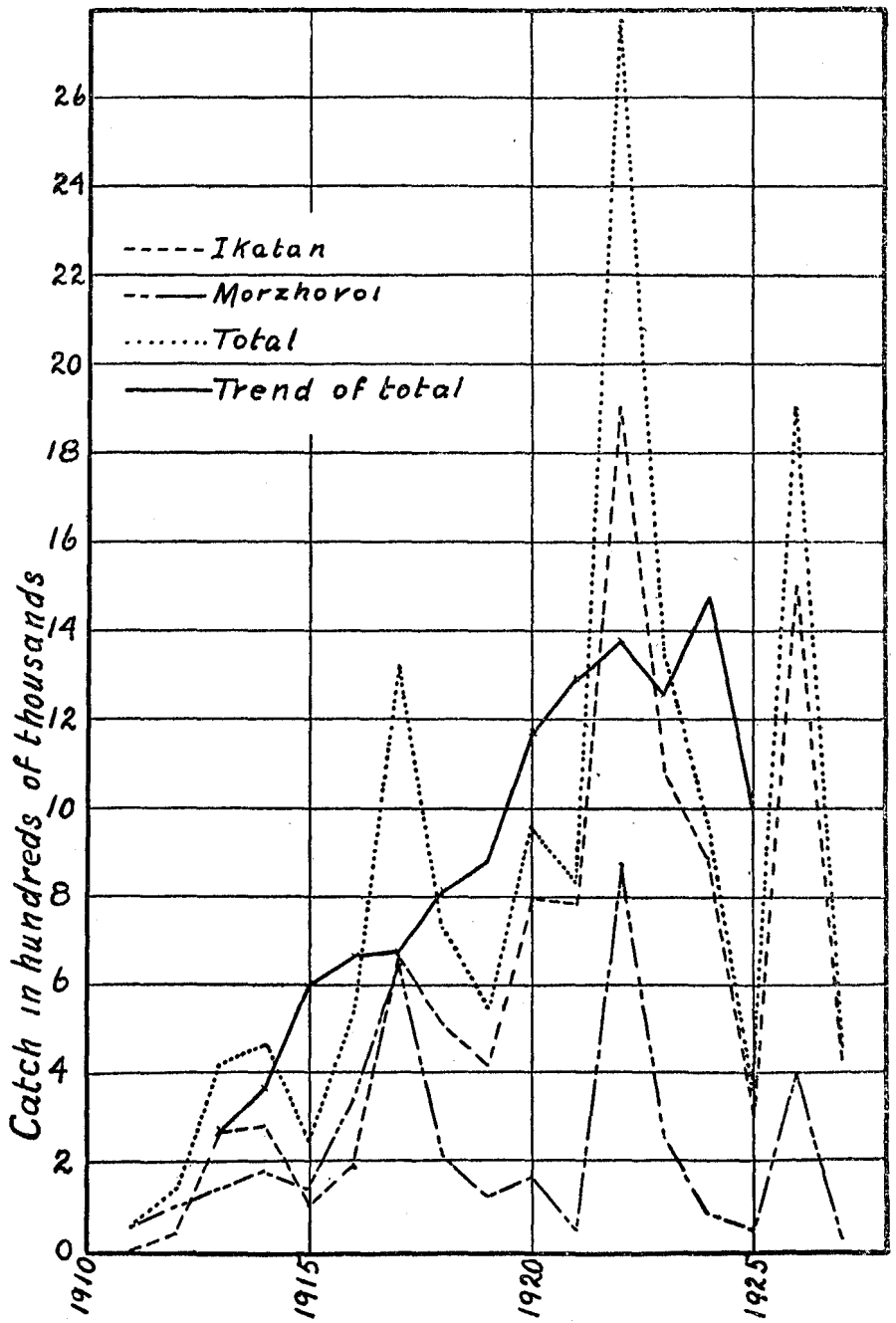

FIG. 14.—Catch of red salmon in Ikatan and Morzhovoi Bays

of the much larger run of Kvichak fish; in the period 1911 to 1927 the catch of salmon on the Nushagak side averaged only 23.8 per cent of the total for Bristol Bay. It does not appear probable that either the Kvichak or the Nushagak fish appear in the runs south of the peninsula in materially different proportions than in Bristol Bay. This is borne out by the results of the tagging experiments in 1923; 11.5 per cent of the tags recovered in Bristol Bay that year were taken on the Nushagak side, and the catch at Nushagak for the season was 10.5 per cent of the total for Bristol Bay. These facts indicate strongly that the red salmon of the Ikatan district are composed, in large part, of a mixture of Bristol Bay fish, in which each run is proportionally represented. One would anticipate, if this be true, that the correlation between Ikatan and Bristol Bay as a whole would be greater than the correlation between Ikatan and any one of the units. In fact, the correlation with Kvichak is slightly higher, but the difference is so small that it can have no possible significance.

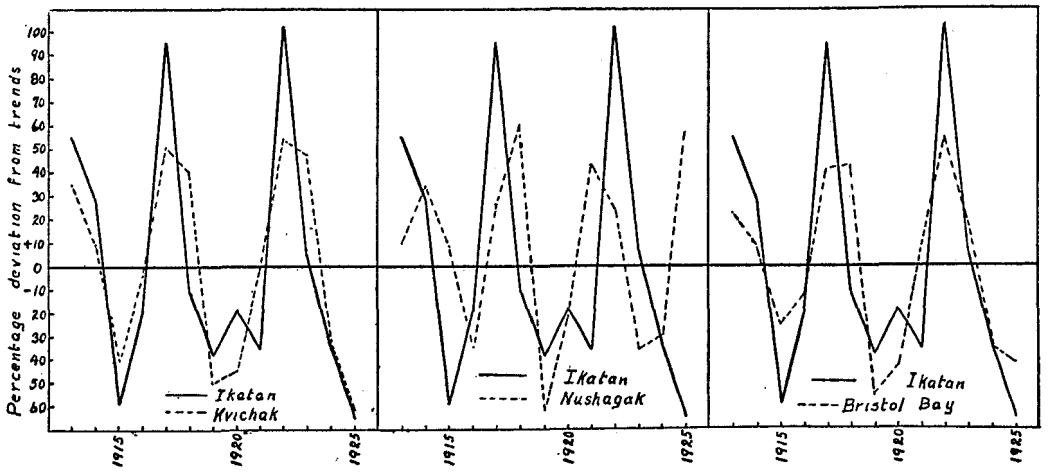

FIG. 15.—Percentage fluctuations in the catch of red salmon at Ikatan compared with those in Bristol Bay

An interesting possibility suggests itself as a result of this intimate correlation between the catches of red salmon at Ikatan and Bristol Bays and in view of the fact that the fish require about two weeks in which to make the journey between the two regions. It should be possible to determine from the run of fish at Ikatan what may be expected in Bristol Bay later in the season. To do this with any accuracy would involve a careful comparative study of the daily catches in both places, with particular reference to the reliability (as measured by the probable error) of determinations of the Bristol Bay run based on the accumulated totals of catches at Ikatan on various dates during the season. If such an analysis should prove accurate within reasonable limits, it might have some very interesting and practical applications.

Relative to the catches of other species of salmon, there does not seem to be any material correlation between the catches taken in Ikatan and Morzhovoi Bays except that due to the simultaneous development of the fisheries and other economic factors. Therefore, we shall consider them as separate units in the following discussions of the various localities in the Ikatan district.

ARCH POINT

This locality is at present of minor importance and was first fished in 1927, when a trap was driven. It seems probable that this locality will be included with the rest of Pavlof Bay ultimately, but on account of the possibility that the catch might prove to draw upon a different body of fish it was thought better to keep the data separate for the present.

BELKOFSKI BAY

The fishery here has been spasmodic and of little importance up to 1924, when a single trap was driven. Since then the catches of all species except kings have been much larger. Previous to the installation of the trap the catch had been chiefly of chums and pinks, but reds and cohos have appeared in noticeably larger numbers since 1924. The pinks, as usual in this region, are taken in much greater numbers in the even years. On account of the recent change in the character of the fishery no further analysis is possible.

COLD BAY

Beach seines were operated in Cold Bay in most years since 1911, and one trap was operated in 1915. The bay was closed to fishing in 1925 and 1926 but in 1927 was reopened to fishing after July 25. The most valuable element in the catch has been the red salmon. The catch of this species has been subject to wide fluctuations, which may have been caused by changes in the intensity of fishing. The data appear to indicate that some depletion occurred previous to 1925, but this is by no means certain on account of the irregularity in the fishery and the wide fluctuations in the catch that have prevailed from the beginning. Much the same thing may be said of the catch of pinks and chums. It is interesting to note, however, that the largest catch of pinks (over 38,000) was made in an odd year (1915), contrary to the usual rule in this region. As this was the year in which the one trap was operated, the large catch doubtless was due to this; but the fact that so large a catch could be made in an odd year would indicate the presence of a considerable run of this species.

DEER ISLAND

Catches have been reported from Deer Island in four years only and were confined virtually to pinks and chums. These fish are presumably though not certainly of local origin. The fishing has been carried on irregularly, and the data are too few to permit analysis.

IKATAN BAY

The red salmon of Ikatan Bay have been treated above. All four of the other species show a somewhat similar history. The catches in general increased up to 1920, then fell off sharply in 1921 due to the economic conditions that have been mentioned above frequently. Since 1921 all of these species have shown gradual recovery, until at present the level of the catches is approximately the same as it was in the years immediately preceding 1921, and in the case of cohos the level is noticeably higher. The data are shown graphically in Figure 16.

MORZHOVOI BAY

As in the case of Ikatan Bay the red-salmon catch of Morzhovoi Bay has been discussed above. The data relative to the other species are shown graphically in Figure 17. It will be apparent from a comparison of this figure with the similar one for Ikatan Bay that the recent history of the catches of pinks, chums, cohos, and kings has been somewhat different in the two localities. Up to 1921 the development in the two localities had been similar, but Morzhovoi Bay does not show the

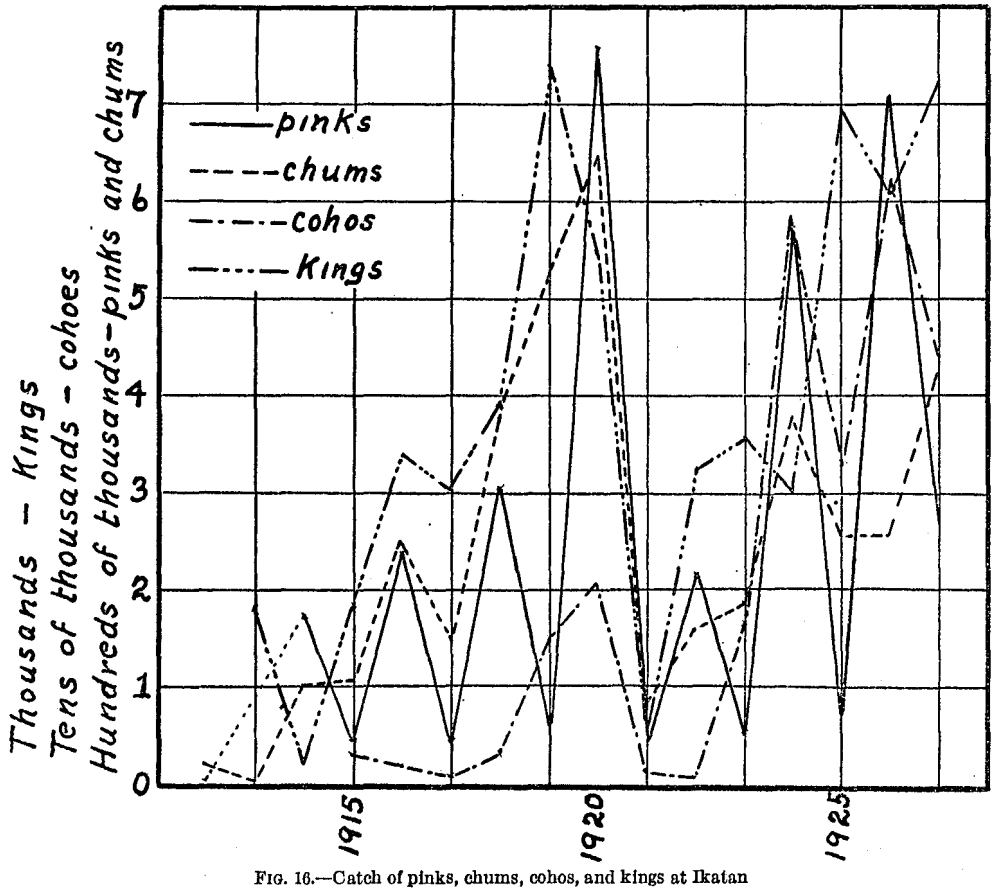

FIG. 16.—Catch of pinks, chums, cohos, and kings at Ikatan

same recovery from the depression of 1921 that is shown by Ikatan Bay. The tendency for the catches to return to the former level is evidenced by the pinks and chums, but neither the cohos nor kings have recovered to any marked degree. The cause of these differences is not apparent.

KING COVE

This small fishery, carried on chiefly in King Cove Lagoon, has produced chiefly chums and a few pinks. It has not been continuous, and the yield has been subject to wide fluctuations. No depletion is indicated by the available data.

NICHOLASKI SPIT

This particular locality has been fished only since 1924, when a trap was driven here. This trap has caught an unusually large number of red salmon, and Doctor Gilbert has stated, on the basis of scale studies, that these reds apparently were Bristol Bay fish (in part, at least) that were intercepted here as at Ikatan, Morzhovoi Bay, and Unga Island. A tagging experiment planned for the coming summer (1928) undoubtedly will settle this point, but it is interesting to note that our catch data lend considerable support to the theory even though only four years are available for study. If the catches of red salmon from 1924 to 1927 at Nicholaski be compared with the catches for the same years at Ikatan, it will be seen that, based on the size of the catch, the rank of each year is identical in the two localities. The largest catch was made in 1926, then came 1924, 1927, and 1925. While such a "rank" method of determining correlation is not especially reliable, particularly

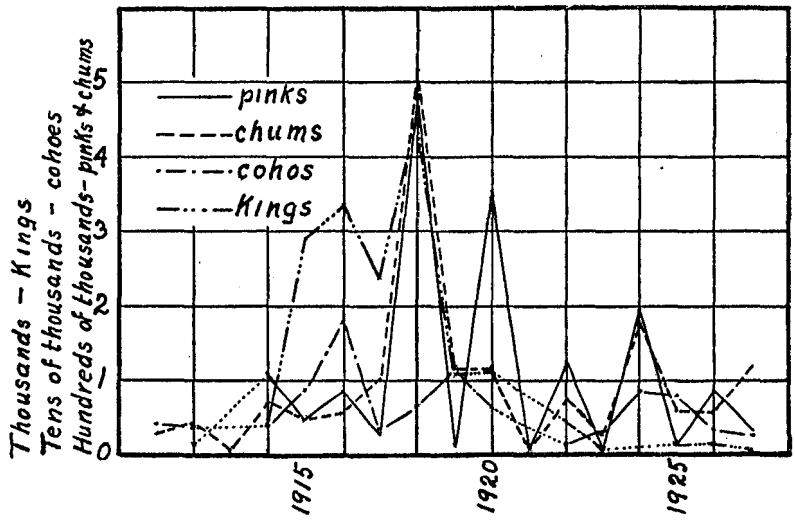

FIG. 17.—Catch of pinks, chums, cohos, and kings at Morzhovoi Bay

with so few data, in this case it is so marked as to lend considerable weight to the theory advanced by Doctor Gilbert. The data are too few to warrant any discussion of the other species.

PAVLOF BAY

The fishery in Pavlof Bay has been conducted with some intensity since 1918 (with the exception of 1921), when traps were first installed. The yield of red salmon has never been consistently large, although in 1918 the catch was over 30,000 and in 1926 exceeded 43,000. The catch of kings has been negligible and that of cohos has been very irregular and never large. The chief species taken in Pavlof Bay have been pinks and chums, and of these the catch of pinks has been by far the more important; but both species have shown such wide fluctuations that it is difficult to see any general trend. The pinks, of course, show the usual two-year cycle, abundant in the even years and scarce in the odd years; and the catch of both species shows the effect of the economic situation that prevailed in 1921. The poor catch of 1925 can

not be accounted for from the data at hand, but it appears reasonable to suppose that for some reason the traps were not actually fished. In general, the catches of all species appear to be as good now as they ever were.

VOLCANO BAY

In reality Volcano Bay is only an arm of Pavlof Bay and also was first fished intensively in 1918, when traps were driven. Previous to this time it had been fished regularly by seiners since 1911, except for 1913. Up to 1918 the yield had been almost exclusively chums, but after the traps were installed large catches of pinks were made and a few reds and cohos also were taken. As in Pavlof Bay, the catch of king salmon is negligible. The general trend of the catches of all four species is clearly upward. This rise is remarkably constant in the case of the even-year catches of pinks—each catch has been greater than the one preceding and the series does not even show the effect of the depression of 1921. As usual the catch of pinks in the odd years has been relatively small, although that, too, has been increasing, the catch of

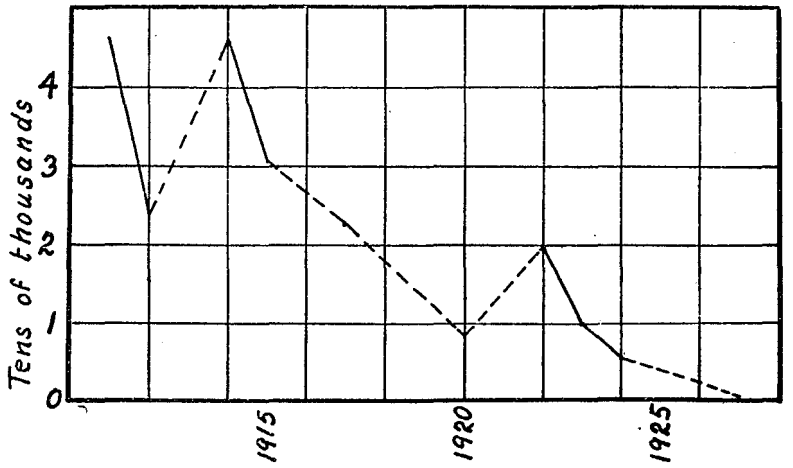

FIG. 18.—Catch of red salmon at Sanak

1927 being over 80,000. In the case of the chums the rise has been less regular, but the present level is distinctly higher than formerly. With the exception of 1918 there was no year previous to 1923 in which the catch equaled that of the poorest year since 1923; and the catches of both cohos and reds, while relatively small and subject to wide proportional fluctuations, show a constant tendency to increase. It is especially to be noted that the general tendency here is quite different from that shown by the fishery in Pavlof Bay. Our data are insufficient to show whether this is because the two localities draw upon fairly distinct stocks of salmon or because of fluctuation in the intensity of fishing. The general tendency for increased catches in Volcano Bay naturally would lead one to infer that the intensity of fishing has increased gradually, probably through improvements in the efficiency of the traps inasmuch as the number of traps remained constant until 1927.

SANAK ISLAND

The fishery at Sanak Island has always been a small one, conducted with beach seines, and has produced mainly red salmon. The data for the catch of reds are given graphically in Figure 18, and if our records of the total catch may be relied

upon to show abundance they tell a story of depletion to the point of practical extermination. The Sanak Islands are isolated and are visited rarely, and there can be little doubt that fishing has been mercilessly intense, with a result that might have been foreseen.

THIN POINT

The fishery at Thin Point is the oldest in the district, having been established in 1889, when a cannery was built and was operated for three seasons. A second cannery was built here in 1890 and was operated for two years only. In 1892 both canneries were closed, but salteries were operated during the period from 1892 to 1896, inclusive. Between the years 1896 and 1908, when our more detailed statistics begin, we have no record, and Cobb infers in his historical account of this fishery

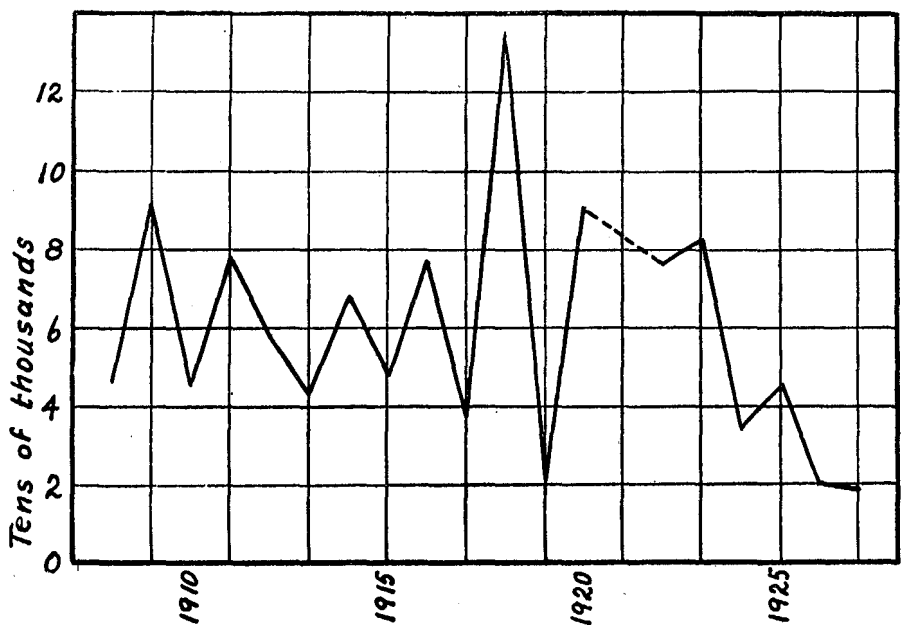

FIG. 19.—Catch of red salmon at Thin Point

that no commercial operations were carried on then at Thin Point. Most of the data we have for these early years has been taken from the reports of the special agents of the Treasury Department. For the three years in which the canneries were operated we have no record of the species canned, but it is fairly certain that they were all reds. The packs were as follows: 1889, 28,748 cases; 1890, 9,417 cases; and 1891, 11,000 cases. The pack of salted fish in 1892 amounted to 1,500 barrels. There is no record for this year of the species used nor of the number of fish caught, but it is probable that they were all red salmon and that approximately 75,000 fish were taken. The records for the years 1893 to 1896 state definitely that the fish were all red salmon, and the packs and catches were as follows: 1893, 1,232 barrels, 60,000 fish; 1894, 2,519 barrels, 125,950 fish; 1895, 375 barrels, 23,453 fish, and 1896, 611 barrels, 27,198 fish. The records for the recent years, beginning with 1908, are given in Table 9, and the catch of red salmon is shown graphically in Figure 19.

This fishery, like the one at Sanak Island, has been conducted solely with beach seines and has produced chiefly red salmon, although occasional good catches of pinks, chums, and cohos have been reported in recent years. It does not appear from our records that the catches of red salmon were, on the whole, greatly reduced previous to the closure of the lagoon to fishing in 1924. As a result of this closure the fishing has been restricted to the beach outside the entrance to the lagoon, and a marked reduction in the catch has resulted. This fishery has also been a very intense one, and it is rather surprising that the catches previous to 1924 did not show evidence of greater depletion.

SHUMAGIN DISTRICT

The following localities of the Shumagin district are not named on the map:

Acheridin Bay, southern shore of Unga Island.

Red Cove, southwest side of Popof Island.

Balboa Bay, Alaska Peninsula, directly north of Unga Island across Unga Strait.

Ivanof Bay, Alaska Peninsula, the first bay east of Kupreanof Point.

Stepovak Bay, Alaska Peninsula, the first bay west of Kupreanof Point.

Orzinski (Orzenoi) Bay, a small bay on the west side of Stepovak Bay.

The same general regulations have applied to the Shumagin district as were in force in the Ikatan district, and the following special regulations have been promulgated: Stepovak and Balboa Bays, with the exception of Orzinski Bay, were closed to fishing in 1925, and the catch at Orzinski was limited to 25,000 red salmon. In 1926 traps were prohibited on all islands except Unga, and beginning with 1928 the traps on Unga Island will be restricted to the east side (Popof Strait). Table 10 presents the data for this district.

TABLE 10.—*Salmon caught and fishing appliances used in the Shumagin Islands district, 1908 to 1927*

Year	Coho	Chum	Pink	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
						Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
Acheredin Bay:												
1912					30,925							
1922					11,227							
1923		11,989	2,766		293							
1924					5,316							
1925					6,285							
1926					6,500							
1927					4,498							
Balboa Bay:												
1918	66	85,967	121,046									
1919	100	36,100	750		192							
1920	620	21,130	129,498	5	4,600							
1922		10	50		40							
Ivanof Bay:												
1912		14,200										
1917		16,629			210							
1918		37,168	51,655									
1919		11,791										
1923		3,293	268									
1924			15,000									
Orzinski Bay:												
1908					22,500							
1909					16,362							
1910					1,324							
1911					3,593							
1912					45,000							
1913					27,000							
1914	5,650				25,800							
1915					20,400							
1916			5,600	30	20,000							

TABLE 10.—*Salmon caught and fishing appliances used in the Shumagin Islands district, 1908 to 1927*—Continued

Year	Coho	Chum	Pink	King	Red	Beach seines		Purse seines		Gill nets		Pile traps
						Number	*Fathoms*	*Number*	*Fathoms*	*Number*	*Fathoms*	*Number*
Orzinski Bay—Continued.												
1917					30,000							
1918		559	400		29,666							
1922					26,000							
1923					14,000							
1924					30,066							
1925			300		12,450							
1926					25,000							
1927	5,600		83,314		2,364							
Popof Strait:												
1916			9,000									
1917	300	23,400	1,000		14,339							
1918	4,557	24,511	172,851	255	33,687							
1919	6,239	39,118	5,462	1,147	31,650							6
1920	1,850	23,100	314,146	375	59,694							6
1922		52,358	153,000	3,241	513,890							3
1923	50,054	144,342	68,000	378	336,711							3
1924	53,250	122,370	1,491,092	839	226,494							3
1925	64,390	245,956	223,454	3,599	354,662							4
1926	83,735	202,244	986,294	2,711	483,426							2
1927	69,760	341,752	561,674	2,261	178,572							3
Red Cove:												
1911					2,597							
1917					19,161							
1918					10,506							
1922					24,688							
1923					6,097							
1924					5,931							
1925			10,000		12,780							
1926					1,261							
1927		190	190		5,598							
Stepovak Bay:												
1919	2,200	40,503	561		7,700							
1920	39	900	4,451	28	8,558							
Unallocated:												
1912					7,150							
1914					19,290							
1916	200	160	10,200		61,020							
1917		2,200			17,430							
1918			14,800		28,980							
1920	1,400		83,289									
1922					10,000							
1923	370	1,450	960		720							
1925	1,958	158										
1926	7,215	24,830	136,656	200	38,005							
1927	2,021	28,100	128,801		3,720							
Total:												
1908					22,500	1	40					
1909					16,362	1	40					
1910					1,324	1	40					
1911					6,192	2	100					
1912		14,200			83,075	7	550			2	100	
1913					27,000	1	100			2	200	
1914	5,650				45,090	1	100					
1915					24,072	4	265			6	125	
1916	200	160	24,800	30	81,020	3	305			3	125	
1917	300	42,229	1,000		80,930	10	680			3	125	
1918	4,623	148,205	360,752	255	102,839	5	575			3	220	
1919	8,339	127,512	6,773	1,147	39,542	4	205	2	210			6
1920	3,900	45,130	531,384	408	72,852	5	255	2	315			6
1922		52,368	153,050	3,241	485,846	2	135	4	475	2	100	3
1923	50,424	161,074	71,994	378	357,821	1	75	1	150			3
1924	53,250	122,370	1,506,092	859	267,807							3
1925	66,348	256,114	233,754	3,599	386,177	2	150	4	400	1	90	4
1926	90,950	317,074	1,122,950	3,001	940,369	5	395	1	100	4	200	3
1927	74,381	363,164	780,857	2,261	194,752	4	425	2	200	2	150	3

NOTE.—No catches were reported in the years not shown. The unallocated catches were taken wholly in the coastal waters of the Shumagin Islands, but the specific locality was not indicated in all cases. Among the places mentioned are the following: Barn Cove, Bay Point, Coal Harbor, Eagle Harbor, East Bight, Falmouth Harbor, Korovin Island, Little Harbor, Meno Creek, Nagai Island, Northeast Bight, Red Bluff, Sanborn Harbor, Unga Strait, and Wosnesenski Island.

ACHERIDIN BAY

So far as our records go, the fishery here has been very irregular. A catch of nearly 31,000 red salmon was made in 1912, but no other catch was recorded until 1922, although since then reports have been received yearly. It is very probable, however, that the fishery was fairly continuous between 1912 and 1922 and that for one reason or another records have not been submitted. The fishery is mainly for red salmon, but in 1923 a small catch of pinks and chums was made also. If our record be taken as it stands and the catch of 1912 be considered as a fair indication of the abundance at that time, it is clear that this locality has been seriously depleted. The available data are too few to warrant a definite conclusion to this effect, however.

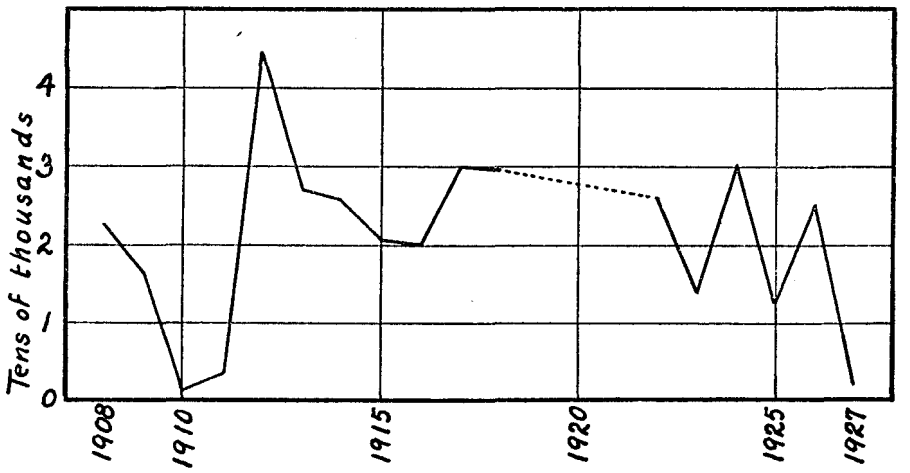

FIG. 20.—Catch of red salmon at Orzinski

BALBOA AND IVANOF BAYS

The fisheries in both these localities have been irregular so far as our reports show and no analysis is possible. They have produced chiefly pinks and chums caught by beach seines and presumably of local origin.

ORZINSKI BAY

This bay receives a small river that supports a run of red salmon that has formed the object of a fishery for many years. Cobb states that a cannery was started here in 1889 but operated only for two years. For these years we have no record of either the pack or the catch. Cobb states further that a saltery was established here about 1905, but the earliest records available to us begin with 1908. Very few fish other than red salmon had been taken here up to 1927, but in that year an unprecedented catch was made of over 83,000 pinks. It seems possible that this was due to some economic factor with which we are not acquainted. The catches of red salmon are shown graphically in Figure 20. It is not apparent that there has been much change in the yield, unless the poor catch recorded for 1927 is an indication of a fall. However, as this smaller yield of reds was accompanied by a greatly augmented yield of

pinks we are inclined to the opinion that there was some marked change in the conduct of the fishery. Leaving 1927 out of consideration, there would still appear to be some slight fall in the yield, which possibly may be referred to depletion. It is very interesting to note, however, that the discontinuance of the fishery during the years 1919 to 1921, inclusive (if, indeed, our records are reliable), had no appreciable effect in increasing the future runs.

POPOF STRAIT

The most important fishery in the Shumagin district is prosecuted in Popof Strait, where several extremely productive traps are situated. Our records show that traps were driven here first in 1919, but it was not until 1922 that the production increased markedly. Doubtless this was due to improvements made in the location and contruction of the traps. The tagging experiments of 1922 and 1923 showed that these traps caught large numbers of the fish bound for Ikatan and Morzhovoi Bays and thence for Bristol Bay. With this in mind we have investigated the correlation shown between the catches in Popof Strait and those at Ikatan and in Bristol Bay for the years 1922 to 1927, inclusive. For this purpose we have used Spearman's coefficient of correlation (ρ), which is recommended for cases in which the number of items is small. While this method is not as accurate as the better-known formula of Pearson (r) it is as reliable a method as is justified by the available data. The following values of ρ have been determined:

Popof Strait and Ikatan	$+0.657 \pm 0.164$
Popof Strait and Bristol Bay	$+.600 \pm .184$

A high degree of correlation is indicated, as would be expected from our knowledge of the routes of migration.

On account of the marked change in the effectiveness of the fishery, which took place in 1922, and the short series of years since that event we do not feel justified in making any additional analyses of the data.

RED COVE

This fishery has drawn chiefly upon a small run of red salmon that enters a stream flowing into Red Cove. As is the case in most such small fisheries, doubtless it has been prosecuted intensely, and our data, although not extensive, indicate a general decline in the yield, which may safely be ascribed to depletion.