OFFSHORE FISHING IN BRISTOL BAY AND BERING SEA

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 89

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

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Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating agencies and in processed form for economy and to avoid dealy in publication.

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United States Department of the Interior, Oscar L. Chapman, Secretary
Fish and Wildlife Service, Albert M. Day, Director

OFFSHORE FISHING IN BRISTOL BAY AND BERING SEA

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INTRODUCTION

Japanese interests, in 1930, extended their offshore fishing operations for bottom fish and shellfish to the eastern, or Alaskan, side of the Bering Sea where the extension of the continental shelf provides conditions suitable for the growth and development of large populations of crabs and bottom fish. The edge of the continental shelf extends northwesterly from Unimak Pass, in the Aleutian Islands, nearly to the Siberian coast (see figure I). All the waters east and north of this "line" are less than 100 fathoms in depth whereas those west and south of the line, except in the proximity of the islands of the Aleutian chain, the Komandorski Islands and the Siberian coast, are quite deep, ranging up to 2200 fathoms. Thus practically one-half of Bering Sea - comprising an area of one-quarter of a million square miles - is part of the continental shelf. The area extending from the Pribilof Islands eastward to and including Bristol Bay and from the Alaska Peninsula northward to Nunivak and St. Matthew Islands is especially productive of bottom life such as crabs, codfish, and flounders.

At first, Japanese interests confined their activities to the taking of crabs, with a small operation for bottom fish. However, it was apparent by 1937 that they intended to extend their activities to include the taking of salmon. Positive evidence was obtained by officials of the Fish and Wildlife Service and by members of the Bristol Bay salmon industry that Japanese vessels were engaged in salmon fishing. This discovery aroused such a storm of protest from the Pacific Northwest that the U. S. Department of State protested to the Japanese Government. In addition, funds were made available to conduct a series of investigations on the subject of offshore fishing in these waters.

These investigations covered a variety of related subjects such as the migration routes of salmon as determined by tagging experiments, type of food organisms utilized by salmon, the currents, temperature, and chemical composition of the waters of eastern Bering Sea, etc.

This paper deals with the life history of the salmon, the salmon fishery as carried on by United States nationals, the regulations imposed on the fisheries of Alaska by the United States Government, and the results of the experimental offshore fishing carried on by the Fish and Wildlife Service during the years 1939, 1940, and 1941.

LIFE HISTORY OF SALMON

There are five species of salmon on the Pacific Coast of North America, all belonging to the genus Oncorhynchus. In the order of their commercial value (in Alaska) they are as follows: red or sockeye, O. nerka; pink, O. gorbuscha; coho or silver, O. kisutch; chum, O. keta; and king or chinook, O. tschawytscha.

Fig. 1. Bering Sea and North Pacific Ocean. Stippled area is the continental shelf.

All of these salmon are anadromous. The eggs, which are deposited in the gravels of fresh water streams and lakes during the summer and fall, hatch during the winter and following spring and the young fish - after a varying period of time depending on the species and locality - migrate to the ocean. After they have attained their full growth, they return to fresh water to spawn.

It has been quite definitely demonstrated that the adult salmon return to spawn in the same stream from which they migrated as young fish. While there are some exceptions, there is no question of the fundamental fact that the majority of the salmon return to their "home stream". If a spawning area be depopulated -- whether by overfishing or other causes - that area will remain depopulated until it has been restocked by the planting of eggs, fry, or spawning fish, an expensive undertaking that would have no assurance of success.

ALASKA SALMON FISHERY

The salmon fishery of Alaska had its inception in 1878 when a small pack of canned salmon was produced at Klawock on the west coast of Prince of Wales Island. The fishery expanded rapidly to all areas of Alaska and since the beginning of the century has been the chief industry of the Territory. Most of the fish are canned although some are frozen, salted, pickled, or delivered fresh to the consumer. The annual packs of canned salmon and their wholesale values are presented in table 1. The wholesale values reflect only to a minor degree the intrinsic worth of the resource for canned salmon is an important source of highly nutritious, vitamin rich, protein in the nation's food economy.

Salmon are caught by means of gill nets, beach seines, purse seines, and traps. All of these forms of gear are operated close to shore, the "fixed" gill nets, beach seines and traps usually having one end of the gear anchored on the beach. "Drift" gill nets and purse seines usually are operated in the estuaries of rivers or in bays.

Regulations governing the fishery

Owing to the rapid expansion of the salmon fishery after its inception in 1878, fears were expressed by certain far-sighted individuals that unless the fishery were regulated, the populations of salmon would be decimated and the resource destroyed by overexploitation. As a result, legistation regulating the fishery was passed by the Congress in 1889 and subsequently numerous other acts regulating the fishery have been approved. In addition to specific regulations enacted by the Congress,

Table 1. Pack of Canned Salmon in Alaska from 1878 to 1943, by species*
(in cases of 48 one-pound cans)

Year	Reds	Kings	Cohos	Pinks	Chums	Total	
						Cases	Value
1878						8,159	
1879						12,630	
1880						6,539	
1881						8,977	
1882						21,745	
1883						48,337	
1884						64,886	
1885						83,415	
1886						142,065	
1887						206,677	
1888						412,115	
1889						719,196	
1890						682,519	
1891						801,400	
1892						474,717	
1893						643,654	
1894						686,440	
1895						626,530	
1896						966,707	
1897						909,078	
1898	782,941	12,862	54,711	109,399	5,184	965,097	
1899	864,254	23,400	39,402	149,159	1,931	1,078,146	
1900	1,197,406	37,715	50,984	232,022	30,012	1,548,139	
1901	1,319,335	43,069	65,509	541,427	47,464	2,016,804	
1902	1,685,546	59,104	82,723	549,602	159,849	2,536,824	
1903	1,687,244	47,609	120,506	355,799	35,052	2,246,210	
1904	1,505,548	41,956	85,741	299,333	21,178	1,953,756	
1905	1,574,428	42,125	67,394	168,597	41,972	1,894,516	$ 6,304,671
1906	1,475,961	30,834	109,141	348,297	254,812	2,219,044	7,896,392
1907	1,295,113	43,424	85,190	561,973	184,173	2,169,873	8,781,366
1908	1,651,770	23,730	68,827	644,133	218,513	2,606,973	10,185,783
1909	1,705,302	48,034	56,556	464,873	120,712	2,305,477	9,438,152
1910	1,450,267	40,221	114,028	554,322	254,218	2,413,054	11,086,322
1911	1,320,705	45,378	120,704	1,021,356	303,823	2,820,966	16,198,833
1912	1,904,268	52,594	170,384	1,303,365	638,528	4,060,129	16,890,229
1913	1,964,379	34,167	77,377	1,402,916	267,654	3,746,493	13,859,478
1914	2,201,574	48,165	157,792	997,823	662,478	4,067,832	19,719,942
1915	1,922,296	85,694	126,570	1,870,373	484,408	4,489,341	19,930,010
1916	2,119,442	66,179	265,184	1,753,546	715,238	4,919,589	23,823,428
1917	2,484,881	67,552	193,708	2,298,466	877,713	5,922,320	51,850,017
1918	2,618,559	57,367	216,572	2,418,212	**1,366,859	6,677,569	52,877,823
1919	1,265,543	90,533	230,229	1,657,434	1,348,462	4,592,201	45,552,714
1920	1,500,000	**110,003	192,085	1,593,120	1,033,517	4,395,937	37,050,212
1921	1,758,794	48,319	109,783	440,471	247,606	2,604,973	20,470,043
1922	2,075,397	31,604	174,312	1,857,556	562,496	4,501,428	31,006,027
1923	1,878,330	38,977	163,752	2,455,136	527,145	5,063,340	33,909,428
1924	1,449,724	33,741	182,207	2,613,068	1,027,183	5,305,923	34,581,689
1925	1,065,290	50,774	164,199	2,105,240	1,065,395	4,450,898	33,802,839
1926	2,157,087	52,476	202,527	3,338,349	902,443	6,652,882	46,080,004
1927	1,320,563	70,483	252,629	1,414,756	507,641	3,566,072	31,441,534
1928	1,944,061	51,195	297,886	2,785,464	991,504	6,070,110	45,624,968
1929	1,693,050	73,740	172,070	2,570,506	860,876	5,370,242	41,672,456
1930	848,787	63,560	329,988	3,150,652	596,000	4,988,987	29,884,813
1931	1,695,782	51,124	170,208	2,978,512	536,909	5,432,535	29,696,636
1932	2,104,727	68,709	149,351	2,116,573	821,128	5.260,488	20,449,405
1933	2,182,371	41,006	161,633	2,183,443	658,245	5,226,698	29,406,294
1934	**2,626,002	51,367	235,560	3,822,602	735,055	7,470,586	37,040,830
1935	823,175	36,475	188,918	3,254,528	852,730	5,155,826	26,009,934
1936	2,482,555	57,908	218,232	4,589,270	1,106,983	**8,454,948	44,078,213
1937	2,101,154	69,394	135,078	3,619,298	729,114	6,654,038	45,028,418
1938	2,523,123	42,726	216,732	3,222,104	786,859	6,791,544	36,547,250
1939	1,971,338	28,786	103,156	2,509,519	626,412	5,239,211	35,110,571
1940	953,381	22,303	284,130	2,908,025	860,539	5,028,378	31,828,451
1941	1,164,888	38,246	356,213	**4,636,649	710,507	6,906,503	57,466,702
1942	912,006	43,127	**372,537	2,818,650	942,789	5,089,109	48,677,509
1943	1,982,175	50,965	158,734	2,322,057	882,578	5,396,509	58,579,194

* Data from Pacific Fisherman Yearbook
** Year of largest pack

the Secretary of the Interior[1/] was authorized by an act passed in 1924, to promulgate such additional regulations as in his opinion might from time to time be necessary. Under this authority, numerous regulations have been imposed on the fishery to keep the populations of salmon at a high level of abundance with the ultimate objective of keeping the industry at its optimum level of production. The Federal Government, through the Fish and Wildlife Service, also carries on extensive scientific studies of the salmon populations of Alaska to obtain information on the life history of the species and to ascertain the causes of the fluctuations in abundance from year to year, and strictly enforces the regulations governing the fishery. All this has been done with the sole intent of permitting the fishery to take the greatest number of salmon each year that is consistent with the principles of sound conservation. The policy has met with some success as is evidenced by the fact that after some 50 years of intensive exploitation the populations, as a whole, are still at a high level of abundance. In fact, the commercial pack of salmon in the Bristol Bay area in 1938 was the greatest in the history of the fishery.

The present healthy state of the fishery is not due to the presence of an undiminishable number of salmon but to constant vigilance and generally wise management of the resource. Examples of sudden declines in abundance of certain populations as a result of localized overexploitation have occurred in the past and should serve as a stern warning that should adequate control of the fishery be lost, disaster - in the form of irreparable depletion - is bound to follow.

EXPERIMENTAL OFFSHORE FISHING

On July 1, 1938, funds were made available to the Fish and Wildlife Service to carry on investigations relating to the migration routes and availability of salmon in western Alaska and particularly the salmon of the Bristol Bay Region.

Through the cooperation of the U. S. Coast Guard, the U. S. S. Redwing was outfitted to carry on oceanographic and related studies in western Alaska (eastern Bering Sea) and investigations were conducted in 1938, 1939,

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1/ As used herein the term "Secretary of the Interior" refers to the Secretary of Commerce prior to July 1, 1939 and the Secretary of the Interior from that date. The Fish and Wildlife Service was originally established on February 9, 1871, as the Commission of Fish and Fisheries, an independent agency; it was redesignated the Bureau of Fisheries on July 1, 1903, when it was by law included in the newly created Department of Commerce and Labor. On July 1, 1939, the Bureau was transferred to the Department of the Interior, and on June 30, 1940, it was merged with the Bureau of Biological Survey and became the Fish and Wildlife Service.

and 1940 and for a very short period in 1941.

In the fall of 1938 and the spring of 1939, plans were made for a program of experimental fishing to study the availability of salmon in the offshore waters of Bristol Bay and the Alaska Peninsula.

When inaugurating the study of the availability of the Bristol Bay salmon in the offshore waters, numerous questions arose in connection with the first season's field work, the most vital being as follows: Where would be the most logical place to start operations? What type of gear could be used most effectively to catch the fish? What type of fishing vessels would be needed?

It was decided to start the fishing operations as far from the rivers in Bristol Bay as possible and yet intercept a portion of the salmon run. While no definite information was available as to where such a locality might be, it was finally decided to carry on operations between Cape Seniavin (a point on the northern shore of the Alaska Peninsula about thirty miles northeast of Port Moller) and Cape Newenham (a point on the nothern shore of Bristol Bay where the shore line turns abruptly northward). The distance between these two points is approximately 150 nautical miles and a line between these two points roughly represents the western boundary of Bristol Bay. The nearest Bristol Bay river to this section line is the Ugashik, which is some 100 miles distant, while the Kvichak,Naknek, and Nushagak rivers are some 150 miles distant (see figure 4).

Because fishing operations for salmon had never been carried on by American nationals so far from shore as was planned, no data were available as to the type of gear that would be most efficient and practical. It was considered that the gear should be of sufficient magnitude to insure the capture of salmon, if any were present, and capable of being taken aboard the fishing vessel in a relatively short time in case of a sudden storm.

Operations in 1939

Two purse seine vessels of the type used in the Pacific Coast pilchard fishery were employed in the fishing operations during 1939. These vessels the Anna A of 89 gross tons, 69.2 feet registered length, 20.4 feet breadth and 9.9 feet depth; and the Western Flyer (see figure 2)of 93 gross tons, 71.0 feet registered length, 19.3 feet breadth and 8.9 feet depth were of sturdy construction, very good sea boats, had a long cruising radius and were equipped with radio telephone.

One vessel was equipped to operate a large salmon purse seine. This seine was 300 fathoms long and approximately 19 fathoms deep.

The other vessel carried a combination lead and gill net. The lead was 900 fathoms long and 300 meshes deep - when in use, this net hung ap-

Fig. 2. M.S. Western Flyer. This vessel was used in experimental fishing by the U.S. Fish and Wildlife Service during 1939 and 1940.

Fig. 3. Dory with outboard motor (in well) running along gill net, eastern Bering Sea, 1940.

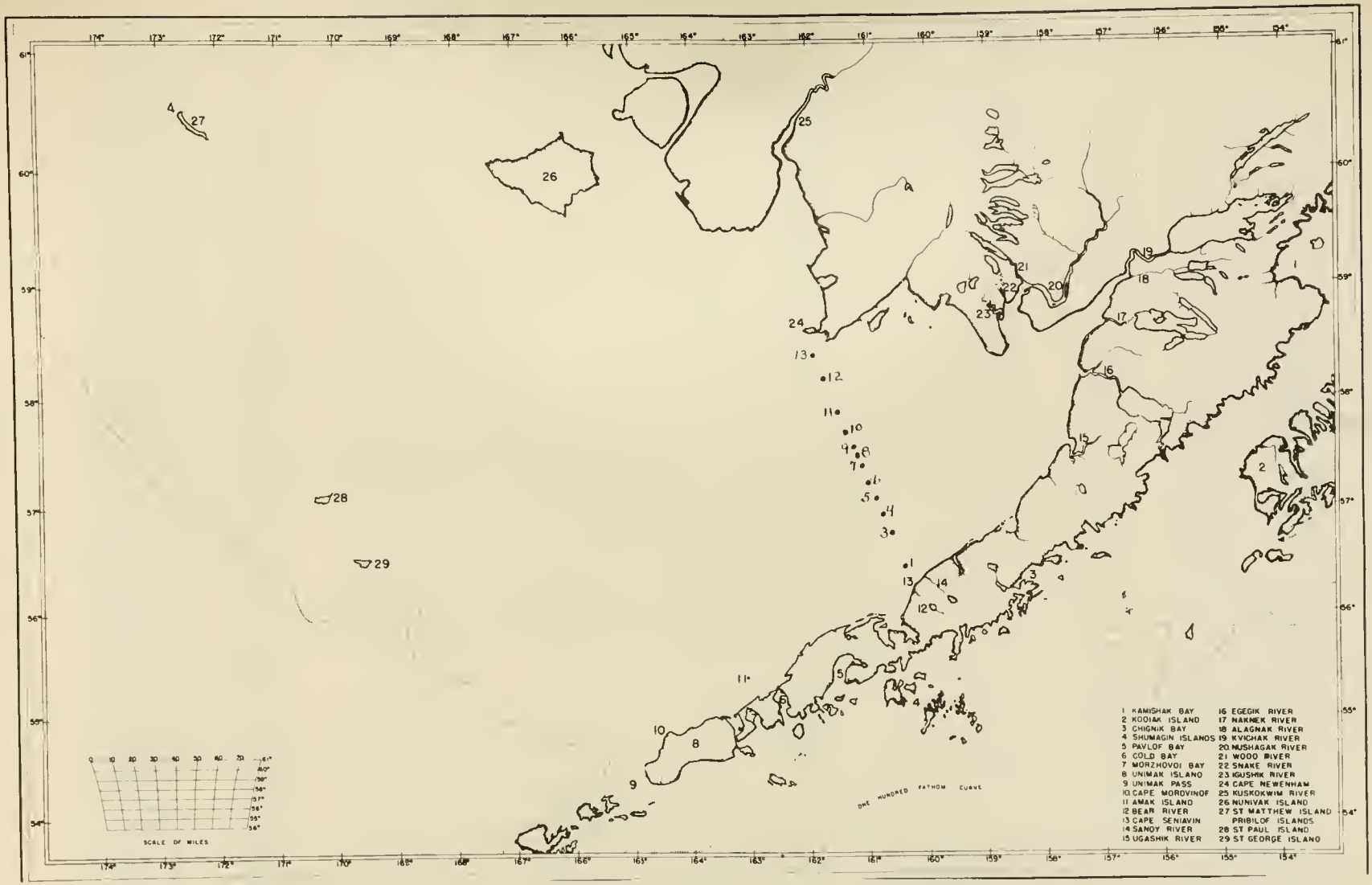

Fig. 4. Eastern Bering Sea and the Alaska Peninsula. Dots indicate localities fished during 1939. Figures beside dots are station numbers referred to in the text.

proximately 17 fathoms deep. The web was 5 inches stretched measure and was made of No. 15 cotton twine. During the season it was found to be unnecessarily deep and its depth was reduced to 100 meshes. The gill net was 130 fathoms long, 60 fathoms being 200 meshes deep and the balance being 50 meshes deep. It was made of linen thread of 5-1/2 inches stretched measure. These two pieces of gear were permanetly attached and were operated as a unit.

The lead was to act as a barrier to the normal migration of the salmon and to lead them either to the purse seine being operated at one end of the lead or to the gill net at the other end.

In table 2 are presented the data on the catch of salmon made by means of purse seine hauls in the section between Cape Seniavin and Cape Newenham (see figure 4). The data, grouped according to areas fished are presented in table 3.

Table 2. Purse seine hauls made between Cape Seniavin and Cape Newenham during 1939

Date	No. of hauls	Station number*	Miles from Cape Seniavin	Number of salmon caught					
				Reds	Chums	Kings	Pinks	Cohos	Total
June 27	1	1	10	107	24	-	-	-	131
28	2	3	30	172	35	-	3	-	210
30	3	5	50	38	104	-	-	-	142
July 2	3	8	75	11	56	-	-	-	67
7	2	13	135	4	1	-	-	-	5
10	3	12	120	4	2	-	-	1	7
11	4	11	100	3	5	-	-	-	8
12	3	9	80	7	25	-	-	-	32
13	3	6	60	196	17	-	-	-	213
14	3	4	40	94	9	2	-	-	105
16	2	1	10	29	-	5	1	-	35
17	2	1	10	27	2	-	-	-	29
20	2	3	30	23	1	-	1	-	25
20	2	5	50	176	18	-	2	-	196
21	1	7	70	5	1	-	-	-	6
23	2	10	90	8	7	-	-	1	16

*See appendix for latitude and longitude of stations.

It can be seen that the abundance of salmon, as judged by the average catch per haul which is shown in table 3, was the greatest in the southern half of the section line; however, it is significant that fish were taken in all areas fished. The salmon were apparently more abundant in the area 30 to 60 miles off shore than they were on either side of that region.

Table 3. Average catch per haul made by purse seine between Cape Seniavin and Cape Newenham during 1939

Miles from Cape Seniavin	No. of hauls	Average catch per haul					
		Reds	Chums	Kings	Pinks	Cohos	Total
0-20	5	32.6	5.2	1.0	.2	-	39.0
21-40	7	41.2	6.4	.3	.6	-	48.6
41-60	8	51.2	17.4	-	.2	-	68.9
61-80	7	3.2	11.7	-	-	-	15.0
81-100	6	1.8	2.0	-	-	.1	4.0
101-120	3	1.3	.7	-	-	.3	2.3
121-140	2	2.0	.5	-	-	-	2.5

While the catches made were small in comparison with the usual catches of commercial operations it must be remembered that all of the hauls were made "blind", i.e. the net was set out regardless of wind or tide or the apparent presence of fish. In commercial fishing the fishermen almost invariably "set" around a previously observed school of fish. At no time during the season's purse seining was a fish seen prior to setting out the gear. Salmon seldom jupm when in offshore waters and there is no means of determining whether or not fish are present prior to setting the gear for them.

In table 4 are presented the data on the catch of salmon in the gill net and lead. While the lead was intended primarily to direct the fish into the purse seine or gill net, it was found that it acted almost as efficiently in gilling the fish as did the gill net. Owing to stormy weather, it was not always possible to keep the catches made by the lead separate from those made by the gill net, consequently the data have been combined. In table 5 the data are presented according to areas fished.

It can be seen that these data are in agreement with those of the purse seine hauls insofar as they reflect the relative abundance of fish at various points along the section line between Cape Seniavin and Cape Newenham. Salmon were entering Bristol Bay at all points between the two mentioned capes; however they were most numerous in the southern half of the section line.

No hauls were made closer to the shore than ten miles, however two tagging experiments conducted in 1922[2/] in the vicinity of Cape Seniavin proved rather conclusively that the Bristol Bay salmon do not follow close

2/ Experiments in tagging adult red salmon, Alaska Peninsula Fisheries Reservation, summer of 1922, by Charles H. Gilbert, Bulletin of the Bureau of Fisheries, Vol. XXXIX, 1923-1924. Washington, D.C.

Table 4. Gill net and lead catches made between Cape Seniavin and Cape Newenham during 1939

Date	Station number	Miles from Cape Seniavin	Number of salmon caught			
			Reds	Chums	Kings	Total
June 27	1	10	24	11	13	48
28	3	30	99	2	-	101
30	5	50	22	5	-	27
July 2	8	75	56	60	-	116
3	11	100	3	7	-	10
7	13	135	7	6	1	14
10	12	120	22	25	-	47
11	11	100	28	8	-	36
12	9	80	129	111	-	240
13	6	60	220	20	-	240
14	4	40	165	39	-	204
17	1	10				177*
20	3	30	79	3	-	82
20	5	50	142	16	-	158
21	7	70	16	3	-	19
23	10	90	10	3	-	13

*Not segregated as to species due to stormy weather.

Table 5. Average catch per set made by gill net and lead between Cape Seniavin and Cape Newenham during 1939

Miles from Cape Seniavin	No. of sets	Average catch per set			
		Reds	Chums	Kings	Total
0-20	2	24.0*	11.0*	13.0*	112.5
21-40	3	114.3	14.7	-	129.0
41-60	3	128.0	13.7	-	141.7
61-80	3	67.0	58.0	-	125.0
81-100	3	13.7	6.0	-	19.7
101-120	1	7.3	8.3	-	15.7
121-140	1	2.3	2.0	.3	4.7

*Data for one haul only

along the shore in the vicinity of that cape. One experiment was conducted by tagging red salmon from a trap in Port Moller, and in the second experiment, red salmon that had been captured by a purse seine boat off the mouth of the Sandy River were tagged. All of the returns from these two experi-

ments were taken in the Bear-Sandy River fishing grounds. Quoting from the report (page 16) "The red salmon bound in 1922 for Bristol Bay assuredly did not school close inshore until after they had passed the Sandy River..."

As information was desired on the depth at which the salmon were traveling, the lead had been made three "strips",of 100 meshes each, deep, i.e. a total depth of 300 five-inch meshes. It was found that at least 95 percent of the fish were caught in the uppermost strip, many of the fish being caught in the top fathom of web. As extreme difficulty was encountered in taking the net aboard due to its great depth and as the lower two strips of the net were catching very few fish, the net was rehung during the season and made only one strip deep.

One fact of special interest in the gill net and lead catches was that over 90 percent of the fish gilled in this gear were traveling in an easterly direction regardless of the direction of the wind or tide and regardless of the distance offshore. While offhand this seems only natural in view of the fact that the majority, if not all, of the fish were enroute to Bristol Bay rivers, it does raise the interesting question as to how a fish in the upper region of twenty to thirty fathoms of water and as much as seventy-five miles from the nearest land can "know" in what direction it is traveling.

Summary of 1939 operations

1. During the course of the 1939 season's operations salmon could be caught at any point along the 150-mile section line between Cape Seniavin and Cape Newenham.

2. Salmon were more abundant in the southern half of the section line than they were in the northern half.

3. The Bristol Bay salmon populations do not follow close along shore in this area. They utilize the full extent of the Bay entrance but were most abundant in the southern 60 or 80 miles of the entrance.

4. The salmon were most abundant in the surface waters, practically all of them being in the upper six fathoms of water.

5. Salmon can be caught between Cape Seniavin and Cape Newenham by means of purse seines or gill nets despite the fact that the water is perfectly clear in this area. Fishing with gill nets would undoubtedly be far more efficient if carried on at night as is done by the fishermen around Bella Bella, British Columbia, and in certain other areas where drift gill nets are employed in clear water for the capture of salmon.

6. In the area under discussion, the salmon are not schooled, at least in large aggregations, hence purse seining is not a practical method of catching them.

Operations in 1940

In 1940, two vessels were used in offshore fishing: the Western Flyer, which had been operated in 1939, and the Adventure of 101 gross tons, 74.6 feet registered length, 20.4 feet breadth and 9.8 feet depth.

The gear used on each vessel was identical, being as follows: a center section of 350 fathoms of linen gill net, 5-1/2 inches stretched measure, 91 meshes deep; together with 450 fathoms of No. 15 thread cotton netting, 5 inches stretched measure, 100 meshes deep, on either end, making one net 1,250 fathoms long and 500 inches stretched measure deep. These nets were used as gill nets and were laid out in a stright line. The use of cotton webbing at either end of the linen webbing was of no particular merit other than to utilize webbing on hand. The nets undoubtedly would have been more efficient if made entirely of linen thread. Identical fishing gear was used on each vessel in order that the data obtained by each could be compared directly if the vessels operated in different localities.

Operations were carried on in four distinct areas, i.e., from the Islands of Four Mountains to the Pribilofs, from Cape Mordvinof to the Pribilofs, from the Pribilofs to Nunivak Island, and from Cape Seniavin to Cape Newenham (see figure 5). Four sets were made along the section from the Islands of Four Mountains to the Pribilof Islands, the data for which are presented in table 6.

Table 6. Gill net catches along the section line extending from the Islands of Four Mountains to the Pribilof Islands, during 1940.

Date	Station number	Miles from Islands of Four Mountains	Number of salmon caught		
			Reds	Chums	Total
June 28	14	20	12	101	113
29	15	75	19	39	58
30	16	130	22	11	33
July 1	17	185	19	28	47

It is probable that the higher catch of chum salmon in the first locality fished was due to the proximity to islands in the Aleutian chain where certain of the streams are populated by that species. All of the localities fished along this section line are in excess of 450 miles from the nearest Bristol Bay river and three of the four sets made were in waters beyond the edge of the continental shelf, in depths of from 900 to 1,600 fathoms. This is the first recorded instance of salmon having been captured beyond the edge of the continental shelf.

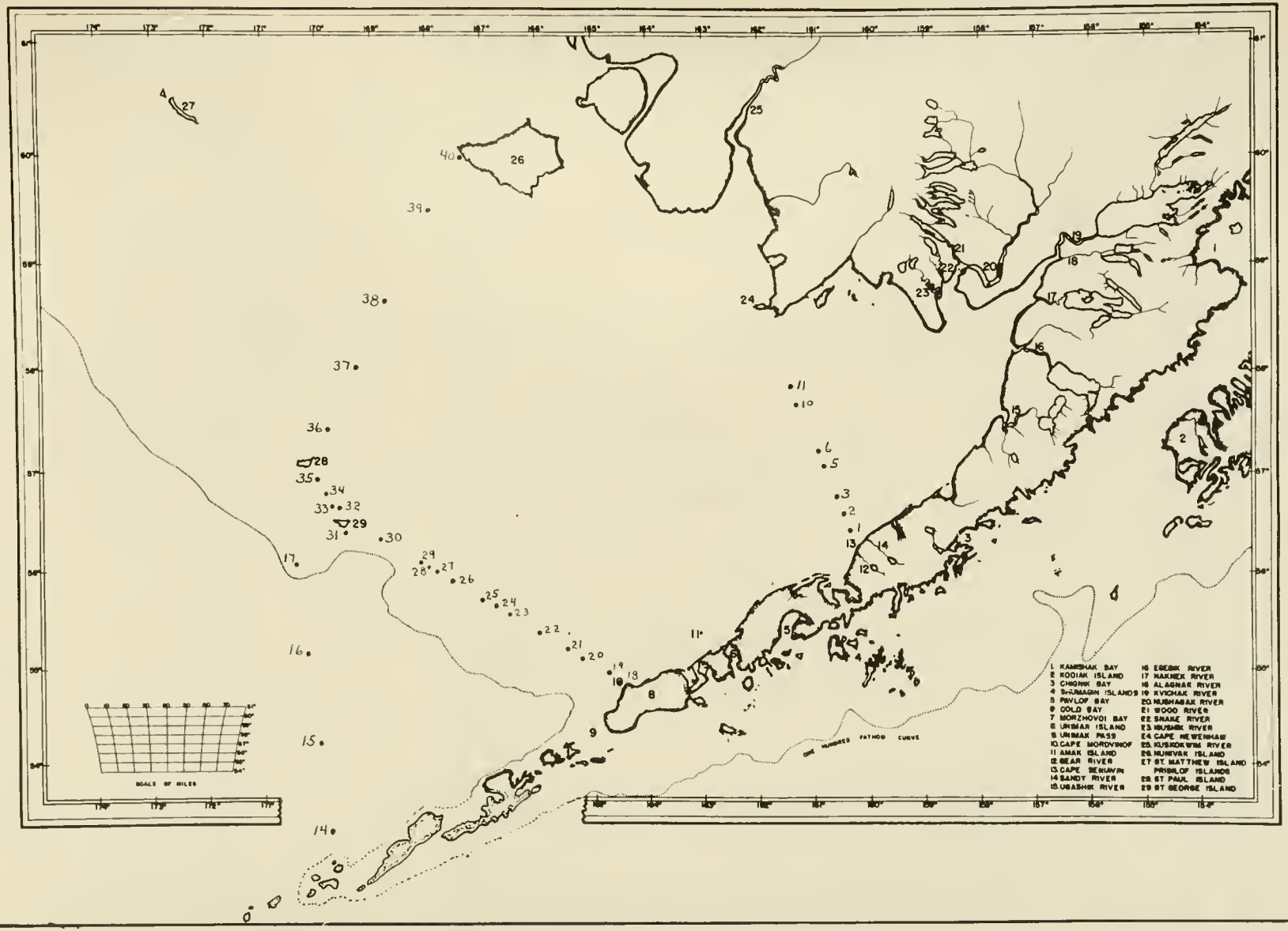

Fig. 5. Eastern Bering Sea and the Alaska Peninsula. Dots indicate localities fished during 1940. Figures beside dots are station numbers referred to in the text.

The data on the catches from Cape Mordvinof to the Pribilofs are presented in tables 7 and 8.

Table 7. Gill net catches made along the section line extending from Cape Mordvinof to the Pribilof Islands, during 1940.

Date	Station number	Miles from Cape Mordvinof	Number of salmon caught					
			Reds	Chums	Kings	Pinks	Cohos	Total
June 6	19	10						40*
6	18	1/2	11	4	1	-	-	16
7	20	30						80*
9	31	194	21	19	-	-	-	40
9	20	30						135*
10	28	135	46	88	-	-	-	134
16	35	225	15	117	-	-	-	132
16	32	205						328*
17	30	170	50	6	-	-	-	56
18	27	130	34	57	-	-	-	91
19	24	90	18	6	-	-	-	24
28	21	40	88	120	-	23	-	231
29	23	80	46	21	-	1	-	68
30	26	120	72	18	-	-	-	90
July 2	33	206	25	52	-	-	-	77
3	34	215	6	28	-	-	-	34
23	29	140	1	15	-	1	-	17
24	25	100	5	23	-	4	-	32
25	22	60	7	33	-	4	-	44
26	20	30	3	40	-	4	2	49

*Due to stormy weather these salmon were not segregated as to species.

Table 8. Average catch per set made by gill nets between Cape Mordvinof and the Pribilof Islands

Miles from Cape Mordvinof	No. of sets	Average catch per set					
		Reds	Chums	Kings	Pinks	Cohos	Total
0- 40	6	34.0*	54.7*	0.3*	9.0*	0.7*	91.9
41- 80	2	26.5	27.0	-	2.5	-	56.0
81-120	3	31.5	15.7	-	1.3	-	48.7
121-160	3	40.5	80.0	-	0.5	-	121.0
161-200	2	35.5	12.5	-	-	-	48.0
201-240	4	15.3*	65.7*	-	-	-	142.8

*Average of 3 sets only.

This section line passed by St. George Island, the southernmost island of the Pribilof group. and extended to Northeast Point on St. Paul Island; four of the stations along the section line, i.e. No. 32,33,34 and 35, being between these two islands. Salmon were taken at every station fished. It is of interest to note that the largest catch was made at station 32, one of the stations located between the islands. There are no salmon streams on any of the islands in the Pribilof group.

The data on the catches made between the Pribilof Islands and Nunivak Island, are presented in tables 9 and 10.

Table 9. Gill net catches made along the section line extending from the Pribilof Islands to Nunivak Island during 1940.

Date	Station number	Miles from Pribilof Islands	Number of salmon caught				
			Reds	Chums	Kings	Pinks	Total
June 17	36	17	168	24	-	1	193
18	37	57	144	10	1	-	155
19	38	97	21	138	-	1	160
21	40	190	15	286	-	20	321
July 13	39	157	1	113	-	-	114
14	38	97	2	14	-	1	17

Table 10. Average catch per set made by gill nets between the Pribilof Islands and Nunivak Island.

Miles from Pribilof Islands	No. of sets	Average catch per set				
		Reds	Chums	Kings	Pinks	Total
0- 40	1	168.0	24.0	-	1.0	193.0
41- 80	1	144.0	10.0	1.0	-	155.0
81-120	2	11.5	76.0	-	1.0	88.5
121-160	1	1.0	113.0	-	-	114.0
161-200	1	15.0	286.0	-	20.0	321.0

The catch of red salmon dropped off markedly north of station 37 whereas the catch of chum salmon increased. Most of the red salmon found here are undoubtedly enroute to Bristol Bay watersheds and those populations may not frequent these northern waters to any great extent during their migration. The chum salmon, however, probably are part of the populations enroute to the Kuskokwim and Yukon rivers as well as to some of the small streams on the mainland and on Nunivak Island.

On June 30, one of the vessels was detailed to operate between Cape Seniavin and Cape Newenham to repeat the operations made along that section line in 1939. The data for these catches are presented in tables 11 and 12 The first set was made on July 2, but stormy weather interrupted the program and no further sets could be made until July 14. Owing to unfavorable weather, there was not sufficient time for an adequate coverage of this section. While the data confirm, in a measure, the results obtained in 1939, it is unfortunate that only a small number of sets were made and that the northern third of the section could not be fished at all.

Table 11. Gill net catches made along the section line extending from Cape Seniavin to Cape Newenham during 1940.

Date	Station number	Miles from Cape Seniavin	Number of salmon caught					
			Reds	Chums	Kings	Pinks	Cohos	Total
July 2	1	10	448	51	7	2	-	508
14	2	20	27	20	-	16	-	63
17	10	90	15	42	1	43	3	104
18	5	50	34	15	1	36	-	86
19	2	20	74	35	-	12	3	124
22	2	20	27	3	-	4	-	34
23	6	60	9	23	1	12	3	48
24	11	100	10	12	2	6	37	67
25	6	60	7	8	-	15	3	33
26	3	30	16	3	-	4	4	27

Table 12. Average catch per set made by gill nets between Cape Seniavin and Cape Newenham during 1940.

Miles from Cape Seniavin	No. of sets	Average catch per set					
		Reds	Chums	Kings	Pinks	Cohos	Total
0- 20	4	144.0	27.2	1.8	8.5	0.7	182.2
21- 40	1	16.0	3.0	-	4.0	4.0	27.0
41- 60	3	16.7	15.3	0.7	21.0	2.0	55.7
61- 80	0	-	-	-	-	-	-
81-100	2	12.5	27.0	1.5	24.5	20.0	85.5

The Bristol Bay salmon run is of very short duration, 90 percent of the annual Bristol Bay commercial catch being made in a three-week interval. Consequently, direct comparisons, for the purpose of determining

relative abundance between the catches made along different section lines, are not justifiable unless the catches are made almost simultaneously. Since the great distances separating the sections precluded the possibility of simultaneous operations along all three sections, it is not considered advisable to draw other than general conclusions as to relative abundance. It is evident, however, that salmon are present in all the waters east of a line from the Islands of Four Mountains to Nunivak Island, via the Pribilofs, and it appears that salmon are more abundant in the waters on the continental shelf than they are in the waters beyond the edge of the shelf. It also appears that red salmon are as abundant, if not more so, around the Pribilof Islands as they are south of the Islands, but that their abundance decreases to the north of those islands.

When taking the salmon out of the gear a record was kept, insofar as was possible, of the side of the net that the fish had entered. As the gear was always set out in a north-south direction, it is possible to obtain some idea of the direction in which the fish were traveling when caught. The data, presented in table 13, are grouped according to the four section lines fished, i.e., from the Islands of Four Mountains to the Pribilof Islands, from Cape Mordvinof to the Pribilof Islands, from the Pribilof Islands to Nunivak Island, and from Cape Seniavin to Cape Newenham.

Table 13. Percentage of fish traveling in an easterly direction when caught during 1940.

Area	Reds		Chums		Pinks		Cohos	
	No. examined	Percent east	No. examined	Percent east	No. examined	Percent east	No. examined	Percent east
Four Mountains to Pribilofs	71	87.3	179	78.2	-	-	-	-
Cape Mordvinof to Pribilofs	201	83.6	296	69.3	-	-	-	-
Pribilofs to Nunivak Island	255	96.4	380	49.7	8	25.0	-	-
Cape Seniavin to Cape Newenham	315	97.4	253	85.0	112	93.7	51	98.0

It can be seen that in nearly every area and for nearly every species, a very high percentage of the fish were traveling in an easterly direction. The two exceptions were the pink salmon and the chum salmon taken between the Pribilof Islands and Nunivak Island. Very few pinks were examined and the percentage figure probably is of little significance. However, a fair sample of chum salmon was examined and it was found that about one-half the fish were traveling easterly and one-half westerly.

Stating the direction of travel as easterly or westerly does not imply that the fish were traveling due east or due west. A fish traveling in a direction slightly east of north or east of south, that entered the net from the west side, would be recorded as traveling easterly, whereas it should more properly be considered as traveling northerly or southerly. The same thing is true of a fish that entered the net from the east side; i.e., the fish would be recorded as traveling westerly, whereas it might have been traveling southwesterly, westerly or northwesterly.

Thus it is very probable that many of the chum salmon which were recorded as traveling westerly (and also to some extent those which were found to be traveling easterly) were actually traveling in a northerly direction enroute to the Yukon River or to other salmon streams to the northward. A part of the fish probably were not actively migrating and hence might have been moving at random in search of food. Despite the apparent random movements of some of the fish, it is apparent that the general movement of the red salmon, in the areas fished, was in an easterly direction regardless of how far offshore the fish were taken.

It has been commonly assumed that all of the Bristol Bay salmon migrate through Unimak Pass and spend the greater part of their ocean residence in the waters south of the Alaska Peninsula, and that on their spawning migrations they come in from the ocean to the spawning grounds via Unimak Pass. The catching of salmon between the Islands of Four Mountains and the Pribilofs indicates that some of the salmon undoubtedly enter Bering Sea through passes to the westward of Unimak. It likewise seems probable that many of the Bristol Bay salmon never leave Bering Sea at all but remain north of the Alaska Peninsula throughout their ocean residence.

Summary of 1940 operations

1. During the course of the 1940 operations salmon could be caught in all areas fished in Bering Sea.

2. The most westerly section line fished was between the Islands of Four Mountains and the Pribilof Islands, slightly over 450 miles from the nearest Bristol Bay river.

3. Three of the four localities fished between the Islands of Four Mountains and the Pribilofs were beyond the continental shelf, the depth of water ranging up to 1,600 fathoms. The salmon were caught, however, in

the upper six fathoms of water as the gear only fished to that depth.

4. A very high percentage of the salmon caught were traveling in an easterly direction, regardless of wind or tide or distance off shore.

5. Salmon were as abundant, if not more so, in the vicinity of the Pribilof Islands as in any other locality along the Cape Mordvinof-Pribilof Islands-Nunivak Island section line.

6. It seems probable that some of the Bristol Bay salmon never migrate south of the Aleutian Islands but remain in Bering Sea during their entire ocean residence.

7. While many of the salmon that have migrated south of the Aleutians pass by the Shumagin Islands and Ikatan Bay on their return migration and go through Unimak Pass enroute to Bristol Bay rivers and other rivers entering Bering Sea, it seems highly probable that many fish also enter Bering Sea through other passes to the westward such as Akatan, Umnak, Amukta,etc.

8. Most of the salmon caught in the offshore waters were actively feeding at the time of capture. (A report on the food habits of the salmon of this region has not yet been released, however the most common food found in the stomachs was euphasiids and small fish).

Operations in 1941

In 1941, only one vessel was engaged in experimental offshore fishing; the American Star of 98 gross tons, 70.7 feet registered length, 20.5 feet breadth and 9.2 feet depth (see figure 6).

The gear used on this vessel was as follows: 700 fathoms of linen gill net, 5 ply (2 green strans), 5-1/2 inches stretched measure, 91 meshes deep; 225 fathoms cotton gill net, 20/9 cable fine yarn, 4 inches stretched measure, 125 meshes deep; and 125 fathoms cotton gill net, 20/6 cable fine yarn, 2-1/2 inches stretched measure, 200 meshes deep, making one net 1175 fathoms long, 500 inches deep stretched measure. This net "hung" about six fathoms deep.

The reason for using three sizes of gill nets was to determine if immature fish could be taken in the waters fished. Cotton webbing was used in the smaller sizes of webbing owing to certain difficulties involved in obtaining linen webbing of those sizes. The cotton webbing was treated with a copper preservative to dye the webbing green and to prolong its useful life.

As fish had been caught in all areas fished in previous years it was decided to run a section as far west of Bristol Bay as fish could be caught. Consequently, starting at Unimak Pass fishing operations were carried on 300, 495, 650, 755 and 870 miles west of the Bristol Bay rivers.

Fig. 6. M.S. American Star. This vessel was used in experimental fishing by the U.S. Fish and Wildlife Service during 1941.

West of the Islands of Four Mountains, 495 miles from the Bristol Bay rivers, the catches dropped to virtually nothing though one or more fish one or more fish were taken at every locality fished. After fishing abeam of Semisopochnoi Island (Petrel Bank) - 870 miles from the Bristol Bay rivers - it was decided to return to more productive waters. Fishing operations were carried on during the return trip at four localities, the results of these operations being in agreement with those obtained on the trip westward. The data are presented in tables 14 and 15.

Table 14. Gill net catches along the section line from Unimak Pass to to Petrel Bank, during 1941

Date	Station number	Miles from Bristol Bay rivers	Number of salmon caught				
			Reds	Chums	Pinks	Cohos	Total
June 14	41	300	30	9	-	-	39
19	43	495	33	14	6	-	53
20	47	650	2	1	-	-	3
24	48	755	2	1	-	-	3
25	49	870	1	2	2	-	5
27	46	625	1	-	-	-	1
28	45	565	5	3	-	-	8
29	44	515	3	1	-	-	4
30	42	455	219	41	141	4	405

Table 15. Average catch per set made by gill nets between Unimak Pass and Petrel Bank, during 1941

Miles from Bristol Bay rivers	No. of sets	Average catch per set				
		Reds	Chums	Pinks	Cohos	Total
300 to 455	2	124.5	25.0	70.5	2.0	222.0
456 to 605	3	13.7	6.0	2.0	-	21.7
606 to 755	3	1.7	0.7	-	-	2.3
756 to 905	1	1.0	2.0	2.0	-	5.0

These data indicate that the concentration of salmon in the offshore waters drops off markedly to the westward of the Islands of Four Mountains but that salmon are present in small numbers in the entire area in which operations were carried on (see figures 7 and 8).

There is no reliable index of the ultimate destination of the fish in this vicinity as tagging experiments have not been carried on. It is known that small populations of all species of salmon spawn in certain rivers of

Fig. 7. Bering Sea and North Pacific Ocean. Dots indicate localities fished during 1941. Figures beside dots are station numbers referred to in the text.

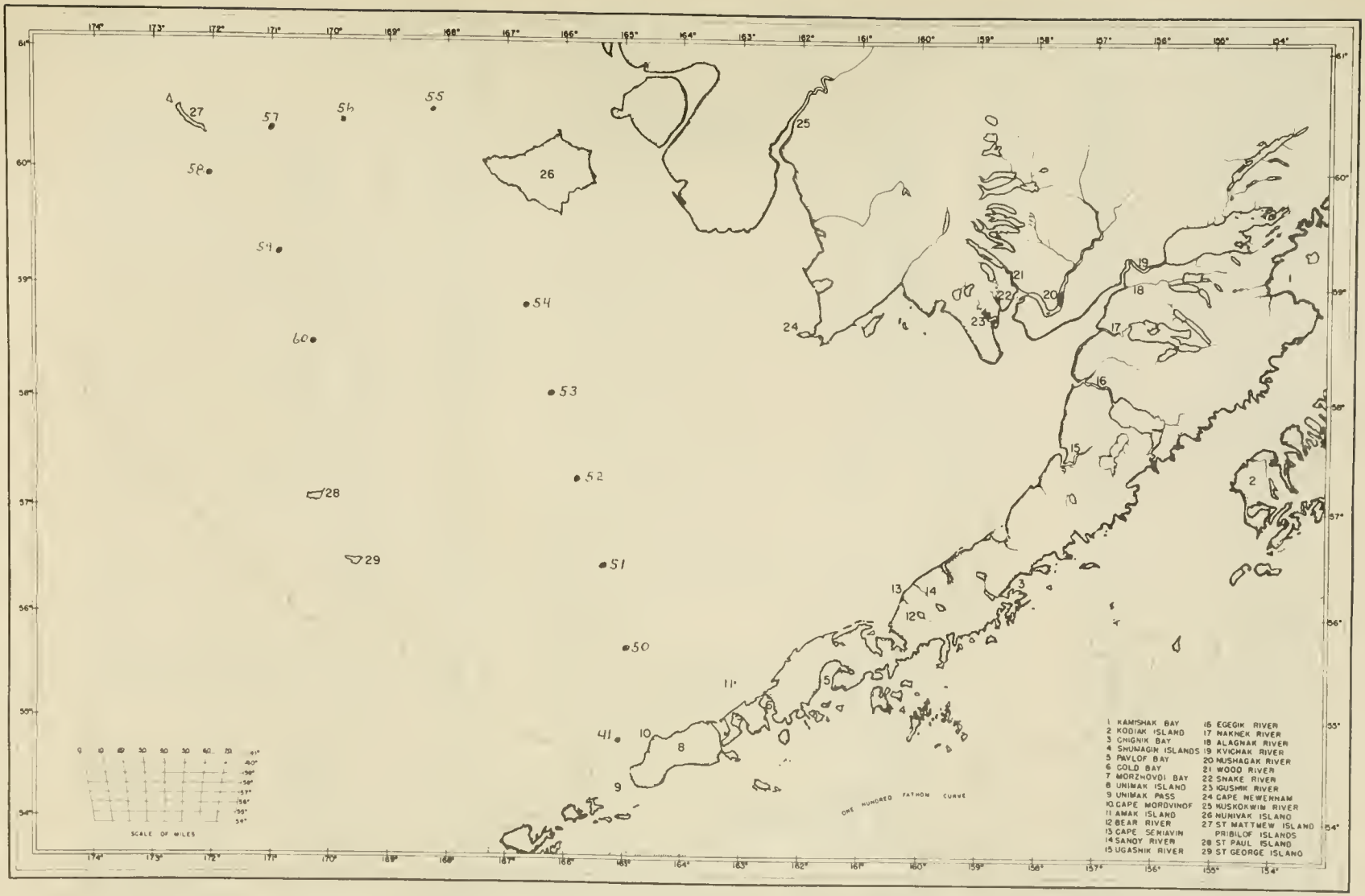

Fig. 8. Eastern Bering Sea and the Alaska Peninsula. Dots indicate localities on the continental shelf fished during 1941. Figures beside dots are station numbers referred to in the text.

the islands in the Aleutian chain, and certainly some of the fish in this region would eventually proceed to those streams. There are no very productive red salmon streams in the area however and it would seem that most of the fish of this species present in the waters between Unimak Pass and the Islands of Four Mountains must be bound for rivers in Bristol Bay and vicinity.

To obtain additional information on the distance offshore that salmon could be taken, a section line was run from Cape Mordvinof directly across to Univak Island, a distance of 330 miles. The data are presented in table 16.

Table 16. Gill net catches along the section line from Cape Mordvinof to Nunivak Island during 1941.

Date	Station number	Miles from Cape Mordvinof	Number of salmon caught				
			Reds	Chums	Pinks	Cohos	Total
July 7	50	50	9	1	2	-	12
8	51	100	174	12	1	1	188
9	52	150	31	4	-	-	35
10	53	200	120	33	6	-	159
11	54	250	14	14	3	1	32

These data are in agreement with the data obtained in previous years and verify the belief that salmon are present in - and utilize - all the waters of the entrance to Bristol Bay.

A section line was then fished from Nunivak Island to St. Matthew Island; the data for these operations are presented in table 17.

Table 17. Gill net catches along the section line from Nunivak Island to St. Matthew Island during 1941.

Date	Station number	Miles from Nunivak Island	Number of salmon caught				
			Reds	Chums	Kings	Pinks	Total
July 15	55	35	-	5	-	-	5
16	56	75	2	37	2	5	46
17	57	110	-	69	1	5	75

Only two red salmon were captured during the three days fishing operations were carried on, the majority of the fish being chum salmon. It is known that fairly large numbers of chum salmon enter the Yukon River to the north of this section line and that small runs of the other species of salmon are present in many of the rivers of northwestern Alaska. It is probable that most of the migrating adult salmon in the region along this section line are enroute northward.

From St. Matthew Island, fishing operations were carried on along a section line extending southward to the pribilof Islands. The data are presented in table 18.

Table 18. Gill net catches along the section line from St. Matthew Island to the Pribilof Islands.

Date	Station number	Miles from St.Matthew Island	Number of salmon caught			
			Reds	Chums	Pinks	Total
July 18	58	20	1	99	3	103
19	59	70	2	6	2	10
20	60	115	16	4	1	21

As will be noted from this table, salmon were taken at all points fished along this section line, chum salmon being more numerous in the northern part of the region and red salmon being more numerous in the southern part of the region; these results being in agreement with the data, presented in tables 8 and 9, obtained in 1940.

As mentioned, the purpose of using several sizes of meshes in the gill net was to obtain immature salmon as well as mature migrating fish. It proved difficult, however, to obtain data on the relative abundance of immature fish. The smaller, immature, salmon would not endeavor to pass through the meshes - which they must attempt to do if they are to be caught in this type of gear - and consequently the small mesh net acted more as a lead than a gill net. Furthermore, it was impossible to set up a valid criterion of immaturity based on the size of the fish or the size of the eggs. Five red salmon were taken on July 10, when fishing 200 miles north of Cape Mordvinof, that were unquestionably immature fish and throughout the season's operations a portion of the red salmon taken were considered to be immature. Of the chum salmon taken, a greater percentage of possibly immature fish was taken between Nunivak Island and St. Matthew Island than in other areas. On July 17, of 53 chum salmon examined, 17 were undoubtedly mature, 2 were questionable, and it was considered that 34 were immature. The two king salmon taken on that date were considered as being immature. All of the pink

salmon taken during the season were unquestionably mature. Owing to the doubt that exists concerning the state of maturity of the salmon examined, the data on maturity are not included herein. They do indicate, however, that a portion of the salmon caught was immature and consequently resident in the waters where they were taken. As noted in previous years, most of the fish taken were actively feeding at the time of capture and most of them were traveling in an easterly direction.

Summary of 1941 operations

1. During the course of the 1941 operations, salmon were taken in all areas fished in Bering Sea. The data obtained in 1941 together with those obtained in 1939 and 1940 justify the belief that during the summer months, at least, salmon can be taken anywhere in the waters on the continental shelf of eastern Bering Sea, an area exceeding 100,000 square miles.

2. Fishing operations were carried on as far west as Petrel Bank abeam of Semisopochnoi Island and as far north as Nunivak and St. Matthew Islands.

3. The abundance of salmon diminishes rapidly west of the Islands of Four Mountains.

4. In agreement with the data collected during previous years, most of the salmon taken were actively feeding at the time of capture.

5. Further evidence was obtained, in the catching of immature fish to justify the belief that some salmon never migrate south of the Alaska Peninsula but remain in Bering Sea throughout their ocean residence.

CONCLUSIONS

1. The salmon populations of Alaska are a self-perpetuating resource, and the present high level of baundance and productivity is the result of generally wise and sound conservation measures promulgated and enforced by the U. S. Government. These populations are being fished by American nationals as intensively as possible consistent with intelligent managerial procedure. The resource, however, is extremely vulnerable to overexploitation, and only through constant surveillance can the present level of productivity be maintained. Unrestrained exploitation would most certainly result in depletion of the resource and financial loss to the industry.

2. Experimental fishing operations conducted by the U. S. Fish and Wildlife Service have shown that salmon can be taken at any locality on the continental shelf in eastern Bering Sea. While the exploratory fishing was not designed for testing fullythe feasibility of commercial operations in these waters there is little doubt that such operations could be carried on, if not at every locality on the shelf at least in many and especially in the offshore waters of Bristol Bay proper. Experimental fishing opera-

tions were not carried on closer than a section line 100 miles from the nearest Bristol Bay river. However from that section line eastward the width of the Bay becomes progressively smaller, similarly the concentration of salmon would become progressively greater, and consequently the salmon would become progressively easier to capture.

3. In addition to the salmon populations residing in or passing through the waters of eastern Bering Sea, there are large populations of bottom fishes and shellfishes residing on the continental shelf in this region. While United States nationals have not intensively engaged in fishing operations for such species, except for cod, it is only a matter of time before these resources on our continental shelf will be prosecuted.

4. In addition to the problem of protecting the fishery resources of Alaska after the war, there will also be the problem of protecting the fur seals which breed on the Pribilof Islands. These seals were protected by a treaty between Russia, Canada, the United States and Japan, under the terms of which the nationals of these states were prohibited, with certain minor exceptions, from engaging in pelagic sealing. Japan abrogated this treaty effective October 1941.

Table 19. Latitude and Longitude of stations where experimental fishing was carried on during 1939, 1940 and 1941. (latitude north and longitude west, except as noted)

Station number	Latitude		Longitude		Station number	Latitude		Longitude		
1	56°	34'	160°	15'	31	56°	58'	169°	32'	
2	56	43	160	23	32	56	44	169	40	
3	56	52	160	31	33	56	42	169	43	
4	57	01	160	39	34	56	52	169	53	
5	57	10	160	47	35	56	59	170	04	
6	57	19	160	55	36	57	30	169	53	
7	57	28	161	03	37	58	06	169	20	
8	57	32	161	07	38	58	42	168	48	
9	57	37	161	11	39	59	36	168	00	
10	57	46	161	19	40	60	00	167	18	
11	57	55	161	27	41	54	43	165	10	
12	58	13	161	43	42	53	24	169	03	
13	58	26	161	55	43	53	16	170	02	
14	53	25	169	45	44	52	55	170	28	
15	54	20	170	00	45	52	45	171	56	
16	55	14	170	14	46	52	22	173	28	
17	56	10	170	30	47	52	26	174	11	
18	54	55	164	31	48	52	04	176	57	
19	55	00	165	16	49	52	09	179	53	East
20	55	11	165	16	50	55	44	164	54	
21	55	16	165	31	51	56	31	165	19	
22	55	26	166	01	52	57	20	165	46	
23	55	37	166	31	53	58	08	166	12	
24	55	42	166	46	54	58	55	166	40	
25	55	47	167	01	55	60	35	168	13	
26	55	57	167	31	56	60	29	169	53	
27	56	02	167	46	57	60	22	171	07	
28	56	05	167	54	58	59	58	172	03	
29	56	07	168	02	59	59	18	170	48	
30	56	23	168	48	60	58	34	170	20	