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EXPERIMENTAL FISHING TO DETERMINE DISTRIBUTION OF SALMON IN NORTH PACIFIC OCEAN AND BERING SEA, 1956

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SPECIAL NOTE

The International North Pacific Fisheries Commission, established in 1953 by the International Convention for the High Seas Fisheries of the North Pacific Ocean, coordinates the research of the member nations: Japan, Canada, and the United States. The resulting investigations provide data to the Commission for use in carrying out its duties in connection with fishery conservation problems in the North Pacific Ocean. Publication of this scientific report has been approved by the United States Section of the Commission.

United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service, Arnie J. Suomela, Commissioner

EXPERIMENTAL FISHING TO DETERMINE DISTRIBUTION OF SALMON IN THE NORTH PACIFIC OCEAN AND BERING SEA, 1956

by

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Contribution No. 10 to research conducted with the approval of the United States Section of the International North Pacific Fisheries Commission.

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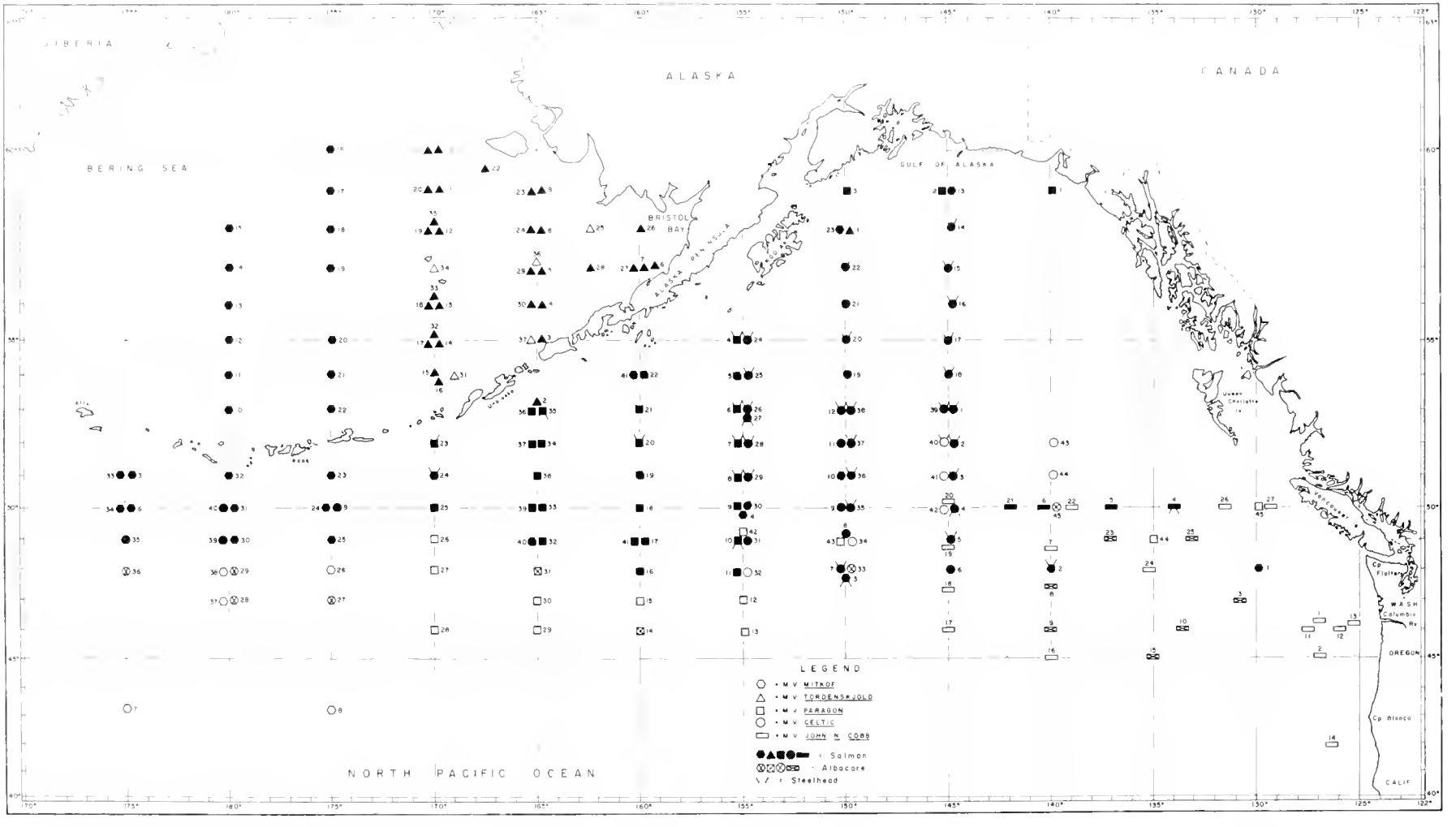

Figure 1.--Distribution of salmon, steelhead, and albacore during the period May to September 1956 as determined by the catches of the vessel Mitkof, Tordenskjold, Paragon, Celtic, and John N. Cobb. Numbers indicate serial order of sets.

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ABSTRACT

Five vessels were employed from May to October 1956 to study the distribution of Pacific salmons in the North Pacific Ocean and Bering Sea. The operation was designed to (1) provide samples of fish for racial identification, (2) provide evidence of seasonal movements and changes in the distribution of salmon and (3) study the ocean habitat and conditions that control the distribution, movement and survival of salmon.

The area of operation was approximately 2,000,000 square miles extending from the coast of Washington and Oregon to longitude 175° E. and from latitude 43° N. to 60° N. Within this area 195 gill net sets resulted in the capture of 7,963 salmon.

Salmon were measured aboard the vessels before freezing. Length frequencies are shown graphically by species and area and in relation to the mesh size in which the fish were capture.

INTRODUCTION

The United States Fish and Wildlife Service as a research agency of the International North Pacific Fisheries Commission, is engaged in a study to determine the extent of intermingling in the North Pacific Ocean and Bering Sea of Asian and North American salmons. In part this program requires (1) the collection of large samples of salmon from an extensive oceanic area and the preservation of these samples for racial analysis, (2) detection and measurement of seasonal movements and changes in the distribution of salmon and (3) the study of the ocean habitat and the conditions that control the distribution, movement and survival of salmon.

The report which follows describes the cruises and operations of five vessels engaged in this program during the 1956 season. They include four schooner-type vessels, the Tordenskjold, Mitkof, Paragon, and Celtic, chartered by the Branch of Fishery Biology [1], Fish and Wildlife Service, and the John N. Cobb, operated by the Exploratory Fishing and Gear Development Section [2] of the Service.

Figure 1 shows the pattern of this extensive fishing and oceanographic operation, the stations fished by the five vessels, and the distribution of salmon, steelhead and albacore during the period of the study, which extended from mid-May until the first week in October.

During this 4 1/2-month period there was 195 gill net sets in a sampling area of approximately 2,000,000 square miles. The total salmon catch was 7,963 or an average

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1/ Now Division of Biological Research, Bureau of Commercial Fisheries.

2/ Now Branch of Exploratory Fishing and Gear Research.

of 59 salmon per set for the 135 sets which captured salmon. Albacore were taken on 15 sets and 45 sets produced neither salmon nor albacore.

Oceanographic data were collected at each set and at intervals between fishing stations. A summary of these data was reported by Love (1957) and the data will appear in detail elsewhere.

Individual cruise reports describing these operations in detail were prepared by Richard Hajny, George Tanonaka, Douglas Weber, Richard Johnsen, Eugene Hill and Robert Ting, all of whom served as biologists aboard the vessel. The present report summarizes data presented to the Commission in these more detailed cruise reports.

DESCRIPTION OF VESSELS

Specifications for the four chartered schooner-type vessels were as follows:

Vessel	TORDENSKJOLD	MITKOF	PARAGON	CELTIC
Total length	70 feet	72 feet	90 feet	70 feet
Gross tonnage	57 tons	62 tons	88 tons	57 tons
Breadth	18 feet	18' 4"	19' 5"	17' 1"
Draft	9' 1"	9 feet	9 feet	8' 2"
Cruising speed	8.7 knots	9 knots	8.5 knots	8.5 knots
Maximum speed	9.0 knots	9.5 knots	9.0 knots	9.0 knots
Horse power	150	200	165	135
Number of bunks	8	12	13	12
Freezer capacity (0°F)	925 cu. ft.	440 cu. ft.	500 cu. ft.	450 cu. ft.

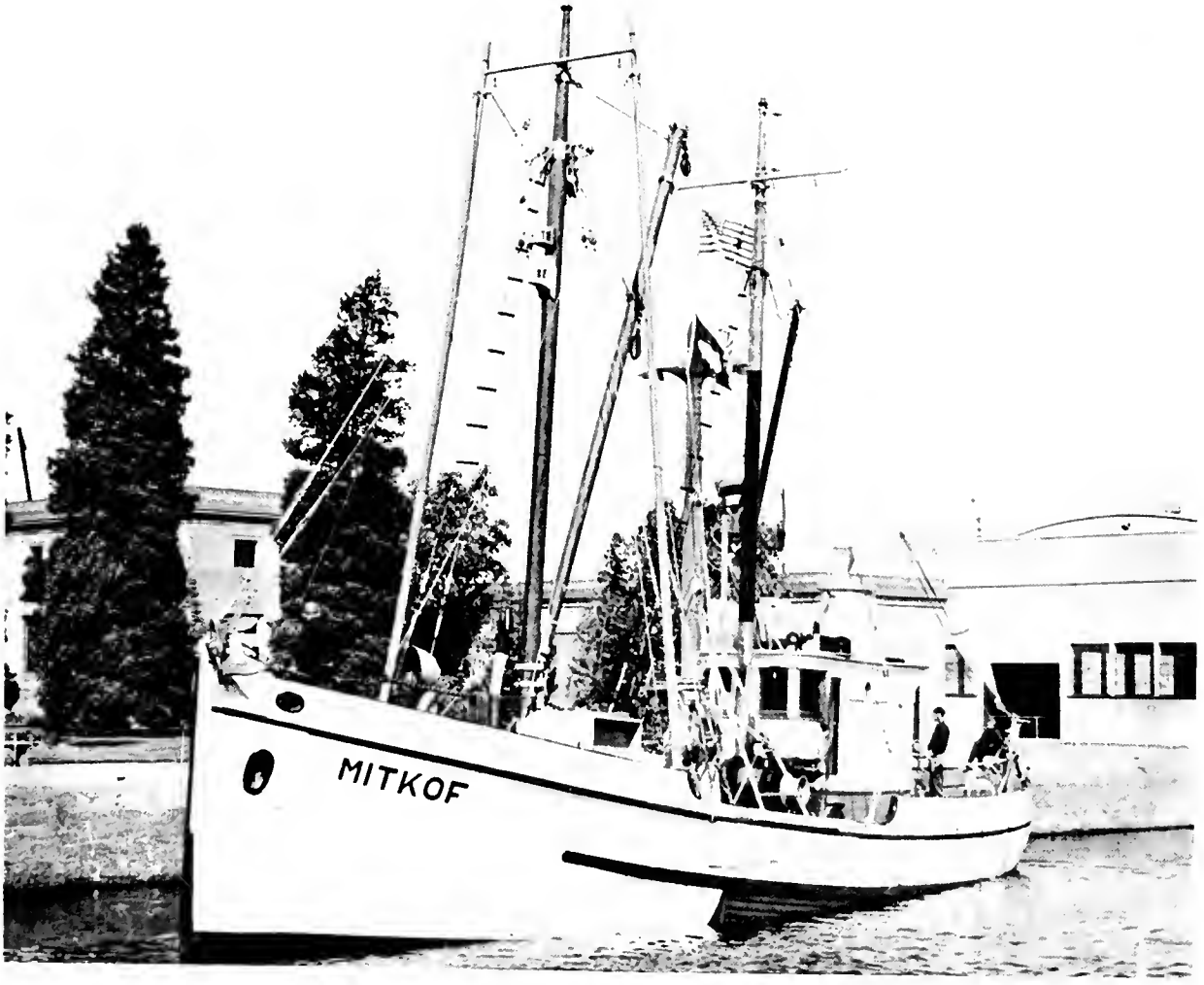

Figure 2.-- Salmon charter vessel M/V Mitkof.

The U. S. Fish and Wildlife Service Exploratory Vessel John N. Cobb is described by Powell and Peterson (1957).

Navigational equipment of the four charter vessels included the following: loran, radio direction finder, fathometer, radio telephone, automatic pilot, and radar (except for the M/V Celtic).

Each charter vessel had a complement of seven men: a master, four crewman, an oceanographer from the University of Washington, and a Fish and Wildlife Service biologist.

Figure 2 shows the charter vessel M/V Mitkof, which is similar in appearance to the other schooners described above.

GILL NET CONSTRUCTION

The standard gill net set consisted of 18 shackles (fig. 3). Each shackle of net was approximately 50 fathoms in length (300 feet) and 20 feet deep. Four mesh sizes were used in each set including 6 shackles of 5 1/4 inch, 6 shackles of 4 1/2 inch, 3 shackles of 3 1/4 inch, and 3 shackles of 2 1/2 inch stretched measure. Gill nets were of nylon constructed in the manner described by Powell and Peterson (1957) with the exception that "Spongex" floats were used in place of cedar in nets constructed for the 1956 season. Two to six fabricated seine floats (18" diameter) were placed along the string to supplement the wood and "Spongex" floats.

The 18 shackles were generally arranged in the following order: 5 1/4 inch, 4 1/2 inch, 3 1/4 inch, 5 1/4 inch, 4 1/2 inch, and 2 1/2 inch; the same sequence repeated three times for a total length of approximately 1.05 statute miles.

A 1/2-inch nylon drift cable was attached along the corkline at every 10 feet on the "shock" net and on the first six shackles to help reduce the strain on the corkline. This cable was attached to 200 fathoms of 3/4-inch nylon line, which in turn was secured to the bow of the vessel by a heavy sisal rope which served as a mooring line. The sisal rope and nylon drift line were submerged, acting as a spring line to take up the surge of the vessel.

The Tordenskjold used a 40-foot triangular section of 4-inch cotton trawl net attached at the head of the first shackle to take up the shock of wave action on the gill nets while the Mitkof, Paragon and Celtic used a 180-foot "shark" net for this purpose. Two flagpoles with lights were placed near each end of the string to mark the position of the net during hours of darkness. Figure 3 shows a typical gill net set.

OPERATIONS

Setting

The gill nets were set from the stern while the vessel traveled downwind at a speed of about 4 knots. As the last shackle

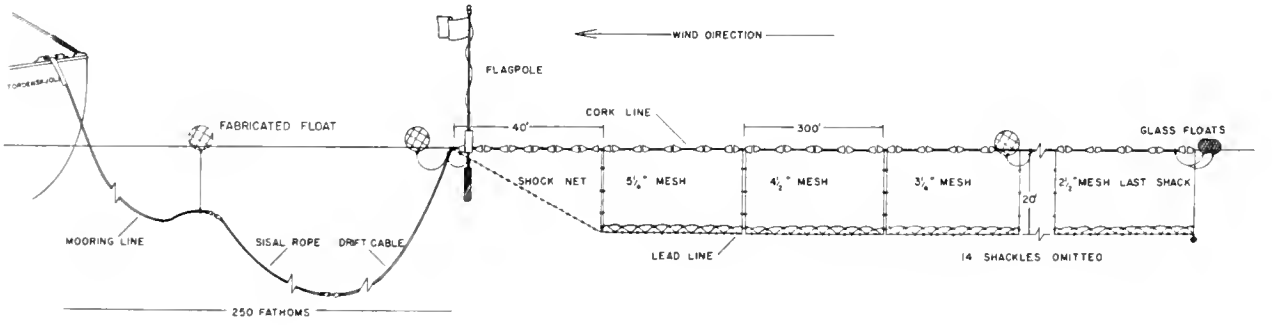

Figure 3.--Typical station set.

Figure 4.--Initial phase of hauling operations on the Mitkof. The nylon drift cable is brought in over the roller, around the gurdy and coiled on the deck.

Figure 5.--Gill net with salmon coming around the gurdy on the Mitkof.

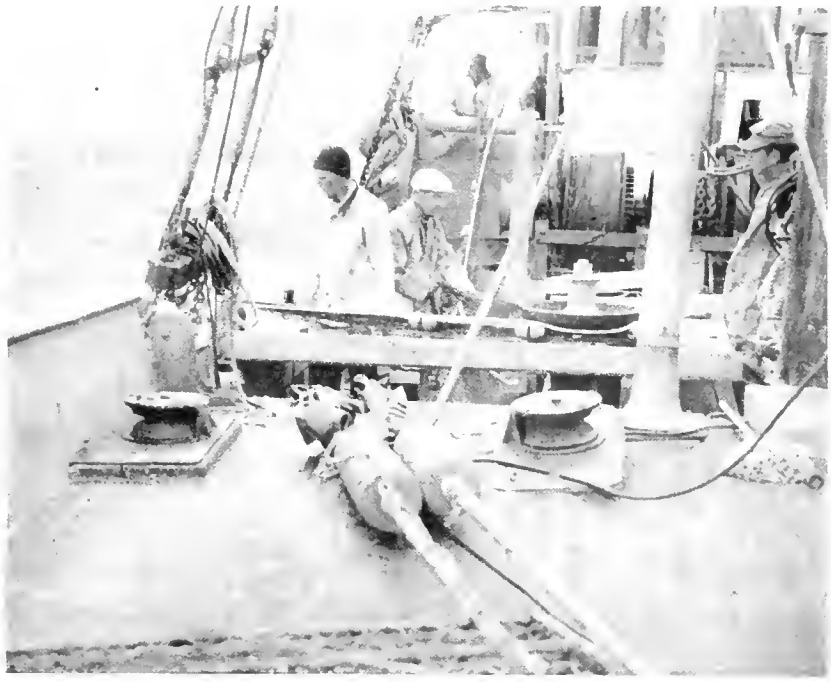

Figure 6.--Two crewmen in background repiling the gill nets beside the pilot house on the Mitkof.

passed over the stern, the boat executed a 180-degree turn, and the mooring line was attached to a cleat on the bow. The setting operation required 15 to 20 minutes.

With few exceptions the nets were fished at night from about five in the evening to six in the morning, a total period of approximately 13 hours.

Hauling

Nets were hauled in over a roller on the starboard side of the well deck. As the nets cleared the powered gurdy, or net-puller (figs. 4 and 5), two crewmen picked the salmon out of the net and cleared the web. The net was then passed to the stern and re-piled in readiness for the next set (fig. 6). Hauling required two to three hours, depending on the size of the catch and sea conditions.

Sampling and Preservation of Salmon

Salmon taken out of the nets during hauling were placed in deck bins in accordance with the mesh size from which they were removed. They were recorded as to species apparent direction of movement, and depth in the net. Upon completion of hauling, the salmon were tagged with a numbered, colored strap tag which was attached to the left gill cover to provide future identification. Fork length measurements were recorded from a measuring board and the fish were then placed in the freezer for shipment to the Seattle laboratory for detailed morphometric examination.

When possible, blood from live fish was frozen for serological studies. Blood samples were obtained by cutting through the caudal penduncle and allowing the blood to drop into a sterile jar.

CATCH DATA

Salmon catches by set, date, position of set, species, and mesh size for the five vessels are shown in tables 1 - 5. Included are numbers of hours nets were fished, sea conditions, surface temperatures, incidental fish catches, and observations of sea mammals.

Table 1 - Gill-net catch Data --- M.V. THORDENSKJOLD --- May 14 to October 8, 1956

Set No.	Date	Position of set Lat.N.	Long.W.	No. hours net soaked 1/	Sea condition	Surface temperature	Number of salmon caught: Red	Chum	Silver	King	Pink	Total	Salmon catch by mesh size: 5¼"	4½"	3½"	2½"	Incidental catch	Mammals 2/
1	5/24 - 5/25	58°00'	150°00'	11	Calm	40.5°F.	2	1				3	3					Fur seals, Sea lions
2	5/30 - 5/31	53°00'	165°00'	9½	Moderate	39.5°F.	39	34		2		75	58	15	2			Fur seals
3	6/6 - 6/7	55°00'	165°00'	11½	Moderate	37.5°F.	62	17				79	75	4				Fur seals
4	6/7 - 6/8	56°00'	165°00'	11½	Moderate	36.5°F.	2	14		1		17	13	4				Sea lion
5	6/8 - 6/9	57°00'	165°00'	12¼	Calm	34.4°F.	2	14				16	16				1 Yellowfin sole	Sea lions
6 1/	6/10	57°17'	159°15'	6½	Calm	32.9°F.		1				1	1				1 Herring	
7	6/10 - 6/11	57°00'	160°00'	12	Rough	36.8-32.2°F.	3	1		1		5	5				2 Herring	
8	6/12 - 6/13	58°00'	165°00'	11½	Moderate	36.0-35.2°F.	2	45			4	51	41	10			1 Herring, 1 Yellowfin sole	Sea lion
9	6/13 - 6/14	59°00'	165°00'	11½	Calm	35.5°F.	1	126		1	3	131	90	40	1		1 Dolly Varden, 2 Yellowfin sole	
10	6/15 - 6/16	60°00'	170°00'	9½	Calm	34.2°F.	1	19			2	22	17	5			1 Herring, 4 Yellowfin sole	Hair seal
11	6/16 - 6/17	59°00'	170°00'	11½	Calm	35.9°F.	1	57			5	63	45	12	6			
12	6/17 - 6/18	58°00'	170°00'	11½	Calm	38.7°F.	1	31		1	5	38	30	7	1			Fur seals, Sea lions
13	6/19 - 6/20	56°00'	170°00'	11½	Calm	42.3°F.	917	62		3	5	987	549	344	36	8		Fur seals
14	6/20 - 6/21	55°00'	170°00'	11½	Calm	44.6-43.7°F.	679	67		1	9	756	356	355	39	6	1 Mackerel shark	Fur seals, Sea lion
15	6/24 - 6/25	54°00'	170°00'	11½	Light	45.0°F.	83	19				102	74	24	4			Fur seals
16	7/28 - 7/29	54°00'	169°58'	12	Moderate	46.2°F.	1	2	1		1	5	4	1				
17	7/29 - 7/30	55°00'	170°02'	12¼	Moderate	46.8°F.	1					1	1					Fur seals
18	7/30 - 7/31	55°59'	170°02'	12	Calm	46.3°F.	1	9				10	7	2		1		Fur seals
19	8/1 - 8/2	58°00'	170°00'	12	Calm	43.8°F.	4	5				9	8	1				Fur seals
20	8/2 - 8/3	59°00'	170°00'	11½	Moderate	44.4°F.		31	1			32	24	8				
21	8/3 - 8/4	59°59'	170°01'	12	Calm	47.2-45.8°F.		6	1	1		8	3	5			1 Herring	Fur seals, Sea lion
22	8/4 - 8/5	59°36'	167°27'	11	Moderate	44.5°F.	2	11			1	14	13	1			2 Herring, 12 Dolly Varden	
23	8/5 - 8/6	58°56'	165°12'	11½	Moderate	44.3°F.		4				4	2	2			9 Dolly Varden	
24	8/6 - 8/7	57°57'	165°05'	12	Light	47.3°F.	1	11				12	7	5			5 Sea poachers, 1 Yellowfin sole	Fur seals
25	8/7 - 8/8	58°00'	162°32'	10½	Calm	47.1°F.											1 Herring, 1 Sea poacher	
26	8/8 - 8/9	58°00'	159°57'	11½	Calm	50.8-53.2°F.	1	1	6	8		16	8	5	3		1 Yellowfin sole, 4 Dolly Varden, 1 Mackerel shark	
27	8/10 - 8/11	56°57'	160°04'	11	Calm	52.7-47.8°F.	2		1	1		4	1	1	2		5 Dolly Varden, 1 Yellowfin sole, 1 Herring	
28	8/11 - 8/12	57°05'	162°22'	12¼	Light	51.6-50.5°F.		1				1	1				13 Herring	
29	8/12 - 8/13	57°04'	164°58'	11½	Calm	50.9°F.	1	3	1	2		7	3	2	1	1	3 Dolly Varden	Fur Seals
30	8/13 - 8/14	56°04'	164°56'	11½	Moderate	51.5°F.	11	6	3			20	13	6	1		1 Yellowfin sole, 2 Juvenile wolfeels	Fur seals
31	9/11 - 9/12	54°00'	169°00'	11	Moderate	43.5-44.4°F.												Fur seals
32	9/13 - 9/14	55°00'	170°00'	12	Rough	46.9°F.	1	12				13	11	2				Fur seals
33	9/14 - 9/15	55°58'	170°01'	12	Light	45.6°F.				1		1	1					
34	9/15 - 9/16	57°00'	170°00'	10½	Moderate	44.1°F.												Fur seals
35	9/16 - 9/17	58°01'	169°58'	12¼	Light	43.5°F.	1					1	1					Fur seals, Sea lion
36	9/18 - 9/19	57°00'	165°00'	11	Rough	40.3°F.											1 Herring	
37	9/20 - 9/21	55°01'	165°04'	12¼	Moderate	44.7°F.												Fur seals
	TOTALS					4/	1822	610	14	23	35	2504	1481	911	96	16		

1/ Does not include setting and hauling time.

2/ Mammals observed or snagged in nets during hauling operations.

3/ Daytime set.

4/ Two temperature readings - 1st reading at set, 2nd reading at haul.

Note: 900 fathoms of net fished on all sets.

Table 2 - Gill-net Catch Data --- M.V. MITKOF --- May 14 to September 28, 1956

Set No.	Date	Position of set Lat. N.	Long.	No. hours net soaked 1/	Fathoms of net	Sea condition	Surface temperature	Number of salmon caught						Salmon catch by mesh size				Incidental catch						Mammals 4/
								Red	Chum	Silver	King	Pink	Total	5½"	6"	7½"	8½"	Steelhd.	Albacore	Shark 2/	Pomfret	Other fish	Squid	
1	5/16 - 5/17	48°00'	129°59'W	15	600	Light	51.6°F.	1		1			2	1	1									
2	5/19 - 5/22	48°02'	140°03'W	64 3/	600	Rough	46.9°F.	9	7	1	1		18	4	10	3	1	2						Seals
3	5/24 - 5/25	47°58'	150°00'W	17	600	Rough	44.2°F.	9	5		2		16	6	6	1	3	2						
4	5/27 - 5/28	50°00'	155°04'W	18	600	Rough	41.5°F.	6					6		6									
5	6/14 - 6/15	51°00'	175°00'E	14½	900	Moderate	41.9°F.	16	45			9	70	26	30	13	1							
6	6/15 - 6/16	50°00'	175°00'E	15½	900	Moderate	41.2°F.	91	42	1		3	137	29	46	45	17			1-M				
7	6/16 - 6/19	43°12'	175°00'E	15½	600	Light	53.4°F.													1-M, 2-S	47	1 Squaretail		
8	6/21 - 6/22	43°11'	175°00'E	17½	600	Moderate	54.5°F.													1-S	1			
9	6/25 - 6/26	50°00'	175°05'W	16½	600	Calm	44.2°F.	12	3		1		16	2	11	1	2			1-M			Present	
10	7/5 - 7/6	53°00'	180°00'	16	600	Moderate	43.9°F.	8	9				17	5	7	4	1							
11	7/6 - 7/7	54°00'	180°00'	15	600	Moderate	44.4°F.	21	42			1	64	13	28	15	8			1-D		3 Atka mackerel		
12	7/7 - 7/8	55°00'	180°00'	15½	600	Calm	44.6°F.	13	128		1	1	143	5	24	55	59			1-D				
13	7/8 - 7/9	56°00'	180°00'	16½	600	Moderate	45.5°F.	7	88		7		102	7	9	16	70						Present	Seals
14	7/9 - 7/10	57°00'	180°00'	16½	600	Moderate	45.8°F.	6	21		2		29	6	5	6	12							Seals
15	7/10 - 7/11	58°00'	180°00'	17	600	Rough	44.8°F.	8	70				78	9	29	39	1					1 Dolly Varden		
16	7/12 - 7/13	60°00'	175°00'W	15½	900	Calm	46.2°F.	3	10				13	6	7									Seals Sea lion
17	7/13 - 7/14	59°00'	175°00'E	15	900	Calm	45.1°F.		8				8	7	1									Seals Sea lion
18	7/14 - 7/15	58°00'	175°00'W	15	900	Light	49.1°F.	14	85		3		102	22	23	36	21			1-S				Seals
19	7/15 - 7/17	57°00'	175°00'W	35½ 3/	900	Rough	47.3°F.	Heads, gills & parts of salmon only																Seals
20	8/2 - 8/3	54°59'	171°55'W	15½	900	Rough	48.4°F.	9	5				14	7	7									
21	8/3 - 8/4	53°59'	171°59'W	15	900	Moderate	49.1°F.	2	Headless fish															Seals
22	8/4 - 8/5	52°57'	171°59'W	15	900	Light	50.5°F.	2	36				38	11	20	5	2			1-M				
23	8/7 - 8/8	50°59'	171°57'W	16½	900	Light	52.7°F.	87	28		2		117	36	59	21	1				4	1 Anotopterus pharao	Present	
24	8/8 - 8/9	49°59'	171°58'W	17½	900	Light	54.3°F.	4	58		2		64	13	36	12	3				119		"	
25	8/9 - 8/10	49°00'	175°00'W	16½	900	Light	56.3°F.	1	10				11	4	5	2					151		"	Seals
26	8/10 - 8/11	48°00'	175°00'W	15½	900	Light	56.3°F.													1-S	13		"	
27	8/11 - 8/12	47°00'	175°00'E	16	900	Light	57.6°F.												26	12-B, 2-M	4		"	
28	8/13 - 8/14	47°00'	160°00'	16½	900	Moderate	62.8°F.												4	92-S	6		"	
29	8/14 - 8/15	48°40'	179°54'E	13	900	Moderate	59.2°F.												3	35-S	3		"	
30	8/15 - 8/16	49°00'	179°57'W	15½	900	Moderate	56.1°F.		4				4	4						1-M	11	2 Squaretail	"	
31	8/16 - 8/17	50°00'	180°00'	5½	900	Rough	56.8°F.		49				49	18	31									
32	8/22 - 8/23	51°00'	180°00'	14½	900	Rough	44.8°F.	162	27	1	6	1	197	34	86	72	5	2						
33	8/24 - 8/25	51°00'	175°00'E	14	900	Rough	49.5°F.	235	88				323	85	161	48	9					3 Anotopterus pharao	Present	
34	8/25 - 8/26	50°00'	175°00'E	15½	900	Rough	52.2°F.	13	27		5		45	20	21	3	1	3			10		"	
35	8/26 - 8/27	49°00'	175°00'E	15½	900	Rough	53.8°F.		21		1		22	6	16					2-S	6			
36	8/27 - 8/28	48°00'	175°00'E	15½	900	Moderate	56.7°F.												5	32-B, 5-M				
37	9/1 - 9/2	47°00'	180°00'	12	900	Rough	53.1°F.													4-S	28		Present	
38	9/2 - 9/3	48°00'	180°00'	15½	900	Rough	53.1°F.														21	1 Squaretail	"	
39	9/3 - 9/4	49°00'	180°00'	16	900	Rough	52.8°F.		8				8	6	2							1 Squaretail	"	
40	9/4 - 9/5	50°00'	180°00'	5/	900	Rough	51.1°F.		32				32	15	17									
41	9/15 - 9/16	54°00'	160°00'E	16½	900	Calm	51.1°F.	1	7				8	3	3	2								
TOTALS								738	963	4	33	15	1753	410	727	399	217	9	38	101-S, 13-M, 2-D	426			

1/ Does not include setting and hauling time.

2/ Letters S - blue shark, D - dogfish shark, M - mackerel shark.

3/ Unable to haul in nets earlier due to sea conditions.

4/ Mammals observed or snagged in nets during hauling operations. Seals - Fur seals.

5/ Last 600 fathoms of net parted from set. Retrieved after 8 hours of searching.

Table [1] - Gill net Catch Data --- M/V, FARALON --- July 1 to September 27, 1958

Set No.	Date	Position of set Lat. N.	Position of set Long. W.	No. hours net soaked 1/	Fathoms of net	Sea condition	Surface temperature	Number of salmon caught: Red	Chum	Silver	King	Pink	Total	Salmon catch by mesh size: 5½"	6"	7½"	8"	Incidental catch: Steelh.	Albacore	Shark 2/	Pomfret	Other fish	Squid	Mammals 3/
1	7/11 - 7/12	59°00'	144°00'	12	900	Light	52.0°F.	11	24			67	92	16	67	9				6-M		1 fable fish, 1 Snapper		
2 4/	7/13	59°00'	144°00'	14½	900	Calm	54.3°F.	12	137	2		20	171	63	61	47				7-M				
3	7/14 - 7/15	59°	150°00'	14½	900	Calm	53.6°F.	2				3	5		5					4-M		1 Herring		Porpoise, Sea lions
4	7/19 - 7/20	55°00'	155°00'	17	900	Light	50.7°F.	45	91	6		33	175	30	127	13	5	10						
5	7/20 - 7/21	54°00'	155°00'	15	900	Moderate	50.9°F.	41	44	4		8	100	58	52	10		4						Fur seals
6	7/21 - 7/22	53°00'	155°00'	15½	900	Calm	50.9°F.	13	8	1	1		23	5	16	2		2						
7	7/22 - 7/23	52°00'	155°00'	16½	900	Light	49.3°F.	26	19	1		5	51	13	30	7	1	1						
8	7/23 - 7/24	51°00'	155°00'	15½	900	Light	48.9°F.	37	10	4		1	52	11	22	14	5	2						
9	7/24 - 7/25	50°00'	155°00'	15	900	Light	49.2°F.	3	29	6	1	1	40	13	18	9						1 Giant skilfish		
10	7/25 - 7/26	49°00'	155°00'	16½	900	Light	49.5°F.	2	33	1			36	4	12	19	1	1			68	1 Giant skilfish		
11	7/26 - 7/27	48°01'	154°53'	15½	900	Calm	52.2°F.	2	1				3			3					4		Present	
12	7/27 - 7/28	46°54'	155°00'	15	900	Calm	54.3°F.													1-B	12	1 Squaretail		
13	7/28 - 7/29	45°51'	154°53'	15½	900	Calm	54.7°F.															1 Giant skilfish	Present	
14	7/30 - 7/31	45°59'	160°03'	19½	900	Light	57.7°F.												8			6 Giant skilfish, 1 Boarfish, 1 Tarsetis sp., 3 Squaretail		
15	7/31 - 8/1	47°00'	160°00'	13½	900	Light	54.1°F.														108	1 Giant skilfish, 32 Squaretail	Present	
16	8/1 - 8/2	48°00'	160°00'	17	900	Moderate	53.1°F.		5				5	3	2						63	3 Giant skilfish	Present	
17	8/2 - 8/3	48°58'	160°00'	16½	900	Moderate	52.2°F.	2	27	3	1		33	10	20	3					33		Present	Porpoise
18	8/3 - 8/4	50°00'	160°00'	14½	600	Moderate	50.7°F.	10	28				38	7	31								"	
19	8/4 - 8/5	51°00'	160°10'	14½	600	Light	50.5°F.	6	32	1			39	7	24	8					2	1 Giant skilfish	"	Fur seals
20	8/5 - 8/6	51°57'	160°00'	17	900	Moderate	50.5°F.	14	33				47	9	35	3		2				1 Giant skilfish		
21	8/6 - 8/7	53°02'	160°00'	13½	600	Moderate	50.7°F.	23	10		1		34	7	24	2	1							
22	8/7 - 8/8	54°00'	160°00'	17½	900	Light	53.8°F.	21	80			3	104	31	65	7	1							
23	8/18 - 8/19	52°00'	170°00'	14½	900	Light	49.8°F.	26	5				31	1	5	13	12	2			1			
24	8/19 - 8/20	51°00'	170°00'	13	600	Light	50.7°F.	23	21				44	7	29	6	2	2						
25	8/20 - 8/21	50°00'	170°00'	15	600	Light	51.4°F.	11	40		1		52	13	30	9					11		Present	
26	8/21 - 8/22	49°00'	170°00'	14	600	Light	53.6°F.														4		"	
27 4/	8/22	48°00'	170°00'	5	600	Light	53.6°F.														3			
28 4/	8/25	46°00'	170°00'	5	850	Moderate	53.6°F.													6-B				
29	8/26 - 8/27	46°00'	165°00'	12½	600	Rough	53.9°F.														49			
30	8/26	47°00'	165°00'	8½	600	Light	53.6°F.														225	1 Giant skilfish	Present	
31	8/28 - 8/29	48°00'	165°00'	8½	600	Light	51.8°F.												1	1-B	52			
32	8/29 - 8/30	49°00'	165°00'	12½	600	Light	50.5°F.		7				7	1	6					1-M	3	1 Giant skilfish	Present	
33	8/30 - 8/31	50°00'	165°00'	12½	850	Light	49.4°F.	4	51				55	11	41	3				1-D			"	
34	9/1 - 9/2	52°00'	165°00'	9½	850	Light	49.3°F.	24	31				55	8	33	14								
35	9/2 - 9/3	53°00'	165°00'	11½	850	Light	48.7°F.	14	17	2	1	2	36	13	16	4	3	7				1 Amotopterus pharao		
36	9/7	53°00'	165°00'	7½	850	Light	50.4°F.	2	4				6	1	5					1-Mud				
37	9/7 - 9/8	52°00'	165°00'	8½	850	Rough	49.5°F.	4					4	1	3									
38	9/9 - 9/10	51°00'	165°00'	11½	800	Rough	50.7°F.	5	16				21	1	18	1	1							
39	9/10 - 9/11	50°00'	165°00'	7½	800	Rough	50.5°F.	1	10				11	2	9									
40	9/11 - 9/12	49°00'	165°00'	8½	800	Moderate	51.8°F.		20				20	8	12					1-B	4	1 Giant skilfish, 1 Amotopterus pharao		
41	9/13 - 9/14	49°00'	160°00'	15½	800	Light	52.0°F.		4				4		4						2		Present	
42 4/	9/15	49°00'	155°00'	11½	800	Light	53.8°F.													1-M		2 Boar fish		
43	9/16 - 9/17	49°00'	150°00'	12	800	Light	55.9°F.													4-B		1 Giant skilfish, 1 Boarfish	Present	
44	9/21 - 9/22	49°00'	135°00'	12½	850	Light	57.6°F.													20-B		40 jack mackerel	"	
45	9/23 - 9/24	50°00'	130°00'	15½	650	Light	59.6°F.																	
TOTALS								387	837	31	6	133	1394	334	822	206	32	32	9	33-B, 1-D, 19-M, 1-Md	644			

1/ Does not include setting and hauling time.

2/ Letters B - blue shark, D - dogfish shark, M - mackerel shark, Md - mud shark.

3/ Mammals observed or entangled in nets during hauling operations.

4/ Daytime set.

Table 4 - Gill-net Catch Data — M.V. CELTIC — July 5 to September 24, 1956

Set No.	Date	Position of set Lat.N.	Long.W.	No. hours net soaked 1/	Fathoms of net	Sea condition	Surface temperature	Number of salmon caught: Red	Chum	Silver	King	Pink	Total	Salmon catch by each size: 5½"	4½"	3½"	2½"	Incidental catch: Steelhd.	Albacore	Shark 2/	Pomfret	Other fish	Squid	Mammals 3/
1	7/12 - 7/13	53°00'	145°00'	13	900	Light	50.0°F.	13	101	2		12	128	7	96	23	2	2						
2	7/13 - 7/14	52°00'	144°58'	11¼	900	Light	51.0°F.	9	42		1	3	55	5	33	16	1	3		1-D				
3	7/14 - 7/16	51°00'	145°00'	33 4/	900	Rough	51.0°F.	6	33			3	42	7	31	4		3				1 Giant skilfish		
4	7/16 - 7/17	50°00'	145°00'	12½	900	Moderate	51.8°F.	8	99	14	1	2	124	22	34	58	10	1						
5	7/17 - 7/18	49°00'	145°00'	12½	900	Light	52.2°F.	1	26				27	1	19	6	1	1		1-M				
6	7/18 - 7/19	48°00'	145°00'	13½	900	Calm	54.1°F.		4				4		2	1	1				14		Present	
7	7/20 - 7/21	48°00'	150°00'	20½	900	Moderate	52.1-51.2°F.	1	34	4			39	6	18	14	1	1			13	3 Giant skilfish	*	Fur seals, Porpoise
8	7/21 - 7/22	49°00'	150°00'	12½	900	Moderate	50.7°F.	7	67	3	1		78	8	27	43					4	4 Giant skilfish	*	
9	7/22 - 7/23	50°00'	150°00'	12	900	Calm	50.5°F.	5	80	3		1	89	11	36	40	2	3			2	1 John Dories	*	Fur seals
10	7/23 - 7/24	51°00'	150°00'	13½	900	Light	51.2-50.3°F.	22	57	3	1	3	86	6	29	49	2	3				1 Giant skilfish	*	Fur seals
11	7/24 - 7/25	52°00'	150°00'	13½	900	Light	50.3°F.	9	32	5		3	49	4	36	9		1						
12	7/25 - 7/26	53°00'	150°00'	12½	900	Light	51.0-50.2°F.	17	27	3		10	57	12	41	2	2	1						
13	7/30 - 7/31	59°00'	145°00'	11	900	Moderate	57.5°F.	5	44	4		53	106	22	46	38								
14	7/31 - 8/1	58°10'	144°55'	12½	900	Moderate	55.5°F.	6	25	7		48	86	30	50	6		2		1-D	1	25 Three-spined stickleb acks		Fur seals
15	8/1 - 8/2	57°00'	145°00'	12½	900	Moderate	54.0-55.0°F.	4	48	1		46	97	10	42	43	2	4						
16	8/2 - 8/3	56°00'	144°50'	13	900	Moderate	54.0-55.0°F.		51	4		15	70	12	50	8		2			12	1 Giant skilfish		Porpoise
17	8/3 - 8/4	54°57'	145°00'	14	900	Light	53.0°F.	3	27	2		1	33	2	26	5		5			27	1 Giant skilfish		
18	8/4 - 8/5	54°00'	145°00'	15	850	Moderate	52.0°F.	15	27		2		44	3	40	1		1			6			
19	8/6 - 8/7	54°00'	150°00'	20½	900	Moderate	52.5°F.	31	64			1	96	10	68	17	1	2				1 Anotopterus pharao	Present	Porpoise
20	8/7 - 8/8	55°00'	150°00'	12½	900	Calm	54.0°F.	13	27			6	46	8	30	8		3						Fur seal
21	8/8 - 8/9	56°00'	150°04'	14½	900	Calm	55.0°F.	10	9	1		12	32	8	16	7	1	3			1			
22	8/9 - 8/10	57°00'	150°00'	14½	900	Calm	55.5°F.	7	19			10	36	9	16	10	1	1						Fur seal
23	8/10 - 8/11	58°00'	150°00'	15½	900	Calm	50.1°F.	9	10	7	3	74	103	47	40	5	3							
24	8/16 - 8/17	55°00'	155°00'	11½	900	Rough	54.0°F.	2	82				84	23	41	15	2	6		1-M	1	8 Atka mackerel		
25	8/17 - 8/18	54°00'	155°00'	14	900	Light	55.0-54.0°F.	58	35	1			94	13	54	27				1-M				
26	8/18 - 8/19	53°00'	155°00'	13½	900	Rough	55.0-54.0°F.	110	40				150	20	87	37	6	3			132			
27	8/19 - 8/20	52°50'	155°00'	17½	900	Moderate	54.0-53.0°F.	45	3				48	15	28	3	2	4			14			
28	8/20 - 8/21	52°00'	155°00'	14½	900	Light	53.0-52.0°F.	34	12		1		47	13	32	1	1	2			18		Present	
29	8/21 - 8/22	51°00'	155°00'	14	900	Moderate	53.0-52.0°F.	36	39		1		76	10	31	34	1	2			13	1 Giant skilfish, 3 Jack mackerel	*	Fur seal
30	8/22 - 8/23	50°00'	155°00'	14	900	Calm	52.0°F.	18	33				51	2	21	26	2				26	1 Giant skilfish, 9 Jack mackerel	*	
31	8/25 - 8/26	49°00'	155°00'	62 4/	900	Rough	52.0-51.0°F.	1	18				19			14	5			2-M	18	2 Giant skilfish	*	
32	8/27 - 8/28	48°00'	155°00'	14½	900	Rough	53.0°F.													1-M, 1-D		1 Giant skilfish	*	
33	8/29 - 8/30	48°00'	150°00'	20½	850	Light	55.0-54.0°F.												2	1-M, 4-D		4 Jack mackerel	*	
34	8/30 - 8/31	49°00'	150°00'	11	850	Light	53.0°F.													4-D	14		*	
35	8/31 - 9/1	50°00'	150°00'	13½	850	Light	52.8°F.		6				6	1	4	1				2-D	33	2 Jack mackerel, 1 Handsaw-fish	*	
36	9/1 - 9/2	51°00'	150°00'	12	850	Calm	52.0°F.	3	30				33		11	22					19	1 Giant skilfish, 3 Jack mackerel, 1 Boar fish	*	
37	9/2 - 9/3	52°00'	150°00'	14	850	Light	52.3°F.	16	51				67	5	29	33					22	1 Giant skilfish	*	
38	9/3 - 9/4	53°00'	150°00'	13½	850	Light	52.3°F.	44	45				89	22	54	13		3			55	1 Jack mackerel		
39	9/11 - 9/12	53°00'	145°00'	15½	900	Light	54.5°F.	2	12				14	5	5	4		1		3-D	38	14 Jack mackerel	Present	
40	9/12 - 9/13	52°00'	145°00'	12½	900	Calm	55.6°F.											1		1-D	25	1 Giant skilfish, 6 Jack mackerel	*	
41	9/13 - 9/14	51°00'	145°00'	13½	900	Moderate	56.5°F.													5-D	22		*	
42	9/14 - 9/15	50°00'	145°00'	13½	900	Light	57.2°F.													4-D, 1-M	8	1 Giant skilfish, 8 Jack mackerel	*	
43	9/16 - 9/17	52°00'	140°00'	16½	900	Light	57.7°F.													1-M	2	32 Jack mackerel	*	
44	9/17 - 9/18	51°00'	140°00'	12½	900	Rough	57.7°F.													10-D		3 Jack mackerel		
45	9/18 - 9/19	50°00'	140°00'	12½	850	Rough	57.6°F.												3	13-D	2		*	Porpoise
TOTALS							5/	570	1357	64	11	503	2505	379	1248	634	44	64	5	47-D, 3-D 9-M	542			

1/ Does not include setting and hauling time.

2/ Letters D - blue shark, D - dogfish shark, M - seckeral shark.

3/ Mammals observed or snagged in nets during hauling operations.

4/ Unable to haul in nets earlier due to sea conditions.

5/ Two temperature readings - 1st reading at set, 2nd reading at haul.

Table 5 - Gill-net Catch Data --- M.V. John N. Cobb --- Cruise 28 --- July 16 to August 30, 1956 **

Station No.	Date 1/	Position of set Latitude N.	Longitude W.	Surface temperature	Wind direction and force 2/	Fathoms of net	No. hours net soaked 3/	Number salmon caught Red	Silver	Total	Number albacore caught	Number incidental catch Blue shark	Jack mackerel	Pomfret	Squid	Other
1	7/17 - 7/18	46°17'	126°58'	60.5°F.	NW-4	900	6¼	0	0	0	0	2	9	2	1	1 brown ragfish
2	7/18 - 7/19	45°05'	126°54'	62.1°F.	NW-5-7	900	8	0	0	0	0	3	0	0	0	----
3	7/20 - 7/21	46°45'	130°47'	59.0°F.	SE-4 - SW-7	900	8½	0	0	0	2	11	17	5	0	----
4	7/22 - 7/23	50°01'	133°58'	56.0°F.	SSE-4	900	9	2	0	2	0	2	0	33	0	1 steelhead trout
5	7/23 - 7/24	50°00'	137°00'	55.0°F.	SW-3	900	8	2	1	3	0	0	2	41	3	----
6	7/24 - 7/25	50°00'	140°00'	54.0°F.	W-4	900	8¼	1	0	1	0	0	3	206	2	----
7	7/25 - 7/26	48°40'	140°00'	54.0°F.	W-5	900	8½	0	0	0	0	1	5	27	0	----
8	7/26 - 7/27	47°20'	140°00'	55.5°F.	NW-4	900	9¼	0	0	0	7	3	2	13	2	----
9	7/27 - 7/28	46°00'	140°00'	58.0°F.	NE-2	900	8	0	0	0	2	6	0	0	97	----
10	7/29 - 7/30	46°00'	133°30'	58.0°F.	WSW-4	900	8½	0	0	0	9	8	8	44	10	----
11	7/31 - 8/1	46°00'	127°28'	61.0°F.	NW-4-5	900	8	0	0	0	0	9	0	1	0	----
12	8/1 - 8/2	45°58'	125°49'	61.0°F.	WNW-5	900	7¾	0	0	0	0	11	1	0	0	----
13	8/6 - 8/7	46°12'	125°13'	62.5°F.	NW-4	900	8¼	0	0	0	0	14	2	0	0	1 mackerel shark, 2 sablefish
14	8/8 - 8/9	41°50'	126°24'	61.0°F.	NNW-6-7	400	8½	0	0	0	0	4	0	0	0	----
15	8/14 - 8/15	45°00'	135°00'	63.0°F.	ESE-4	900	10¼	0	0	0	3	8	98	47	4	----
16	8/16 - 8/17	45°00'	140°00'	62.2°F.	SSW-4-7	900	10½	0	0	0	0	19	0	7	7	----
17	8/18 - 8/19	46°00'	145°00'	59.0°F.	SW-8	400	12¾	0	0	0	0	7	0	0	0	----
18	8/19 - 8/20	47°20'	145°00'	57.3°F.	SW-6	900	10¼	0	0	0	0	31	0	1	5	----
19	8/20 - 8/21	48°40'	145°00'	56.5°F.	SSW-6	900	11½	0	0	0	0	27	5	9	1	----
20	8/21 - 8/22	50°00'	145°00'	56.5°F.	SSW-4	900	10½	0	0	0	0	3	0	59	0	----
21	8/22 - 8/23	49°59'	141°48'	58.2°F.	NW-3	900	10	0	1	1	0	4	52	58	13	1 giant skilfish, 1 mackerel shark
22	8/23 - 8/24	49°58'	139°00'	58.3°F.	W-5	900	11¼	0	0	0	0	3	76	62	43	1 giant skilfish
23	8/24 - 8/25	49°00'	137°07'	59.0°F.	SSE-4	900	9¾	0	0	0	1	9	38	5	5	----
24	8/25 - 8/26	48°06'	135°10'	61.5°F.	SSW-5	900	9¾	0	0	0	0	15	148	22	6	----
25	8/26 - 8/27	49°06'	133°11'	61.0°F.	WSW-5	900	10¼	0	0	0	1	12	31	25	0	----
26	8/27 - 8/28	50°01'	131°31'	61.7°F.	SSW-3	900	10½	0	0	0	0	11	0	0	0	----
27	8/28 - 8/29	50°00'	129°30'	61.5°F.	WSW-5 - WNW-6	900	10¾	0	0	0	0	2	0	0	0	----
TOTALS						23,300	253	5	2	7	25	225	497	667	199	

1/ All gill-net sets were made at night

2/ Wind force is according to Beaufort scale

3/ Does not include setting and hauling time

** Prepared by Exploratory Fishing and Gear Development Section, Fish and Wildlife Service, Seattle.

Table 6.--Summary of catch statistics.
(Numbers of fish)

		V E S S E L S						
		TORDENSKJOLD	MITKOF	PARAGON	CELTIC	COBB	Totals	Percent of total catch
Species of salmon	Red	1822	738	387	570	5	3522	44.2
	Chum	610	963	837	1357	0	3767	47.3
	Pink	35	15	133	303	0	486	6.2
	Silver	14	4	31	64	2	115	1.4
	King	23	33	6	11	0	73	0.9
	Total	2504	1753	1394	2305	7	7963	100.0
Catch by mesh size	5 1/4 inches	1481	410	334	379	5	2609	32.7
	4 1/2 "	911	727	822	1248	2	3710	46.6
	3 1/4 "	96	399	206	634	0	1335	16.8
	2 1/2 "	16	217	32	44	0	309	3.9
	Total	2504	1753	1394	2305	7	7963	100.0
Types of set	Night	36	41	41	45	27	190	
	Day	1	0	4	0	0	5	
	Total	37	41	45	45	27	195	
Sets with fish catch	Salmon	32	32	31	36	4	135	
	Albacore	0	4	2	2	7	15	
	None	5	5	12	7	16	45	
	Total	37	41	45	45	27	195	
Fishing time	Average number hours net fished	12½	15½	13½	14½	10½	13¼	
Catch of salmon per salmon set		78.4	54.8	45.0	64.2	1.7	59.0	

Table 7.--Catch per shackle of salmon by species and mesh size.

M/V TORDENSKJOLD

[Including only the 32 sets which captured salmon]

Species	Catch	Percent of total	5½-inch mesh 192 shackles		4½-inch mesh 192 shackles		3¼-inch mesh 96 shackles		2½-inch mesh 96 shackles		All mesh 576 shackles
			No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	Catch per shackle
Red	1822	72.8	975	5.08	746	3.88	86	.90	15	.16	3.16
Chum	610	24.4	477	2.48	131	.68	2	.02	0	0	1.05
Pink	35	1.4	9	.04	24	.12	2	.02	0	0	.06
Silver	14	0.6	8	.04	6	.03	0	0	0	0	.02
King	23	0.9	12	.06	4	.02	6	.06	1	.01	.03
Total	2504	100.1	1481	7.71	911	4.74	96	1.00	16	.17	4.35

Table 8.--Catch per shackle of salmon by species and mesh size.

M/V MITKOF

[Including only the 30 sets which captured salmon]

Species	Catch	Percent of total	5½-inch mesh 152 shackles		4½-inch mesh 152 shackles		3¼-inch mesh 76 shackles		2½-inch mesh 76 shackles		All mesh 456 shackles
			No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	Catch per shackle
Red	738	42.1	157	1.03	368	2.42	167	2.20	46	.61	1.62
Chum	963	55.0	234	1.54	335	2.30	227	2.99	167	2.20	2.11
Pink	15	0.9	1	.01	10	.07	4	.05	0	0	.03
Silver	4	0.2	1	.01	3	.02	0	0	0	0	.01
King	33	1.8	17	.11	11	.07	1	.01	4	.05	.07
Total	1753	100.0	410	2.70	727	4.88	399	5.25	217	2.86	3.84

Table 9.--Catch per shackle of salmon by species and mesh size.

M/V PARAGON

[Including only the 31 sets which captured salmon]

Species	Catch	Percent of total	5¼-inch mesh 118 shackles		4½-inch mesh 201 shackles		3¼-inch mesh 103 shackles		2½-inch mesh 87 shackles		All mesh 509 shackles
			No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	Catch per shackle
Red	387	27.0	76	.64	195	.97	86	.84	30	.35	.76
Chum	837	60.0	212	1.80	525	2.61	98	.95	2	.02	1.64
Pink	133	9.5	18	.15	94	.47	21	.20	0	0	.26
Silver	31	2.2	24	.20	6	.03	1	.01	0	0	.06
King	6	0.3	4	.03	2	.02	0	0	0	0	.01
Total	1394	100.0	334	2.82	822	4.10	206	2.00	32	.37	2.74

Table 10.--Catch per shackle of salmon by species and mesh size.

M/V CELTIC

[Including only the 36 sets which captured salmon]

Species	Catch	Percent of total	5¼-inch mesh 215 shackles		4½-inch mesh 216 shackles		3¼-inch mesh 108 shackles		2½-inch mesh 104 shackles		All mesh 643 shackles
			No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	No. fish	Catch per shackle	Catch per shackle
Red	570	24.7	116	.53	304	1.40	129	1.19	21	.21	.88
Chum	1357	58.9	140	.65	705	3.26	493	4.56	19	.18	2.11
Pink	303	13.1	81	.37	215	.99	7	.06	0	0	.47
Silver	64	2.8	39	.18	17	.07	5	.04	3	.02	.10
King	11	0.5	3	.01	7	.03	0	0	1	.01	.02
Total	2305	100.0	379	1.76	1248	5.75	634	5.85	44	.42	3.58

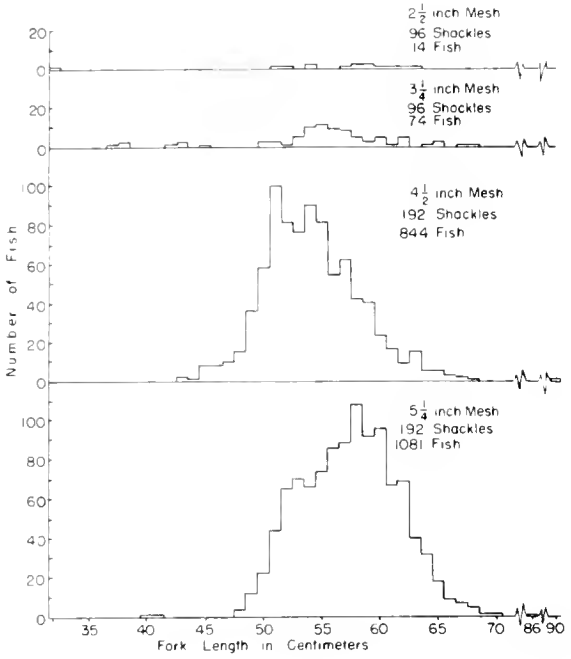

Figure 7.--Catch by Tordenskjold of all species of salmon. Length frequency of 2,013 salmon in relation to mesh size.

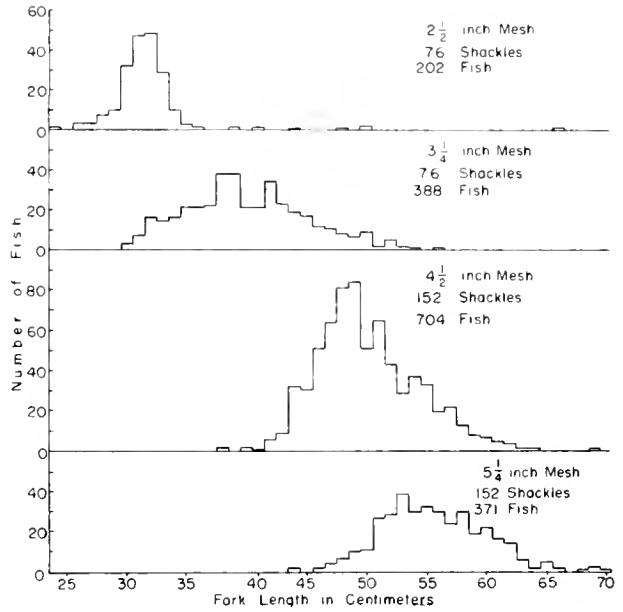

Figure 8.--Catch by Mitkof of all species of salmon. Length frequency of 1,665 salmon in relation to mesh size.

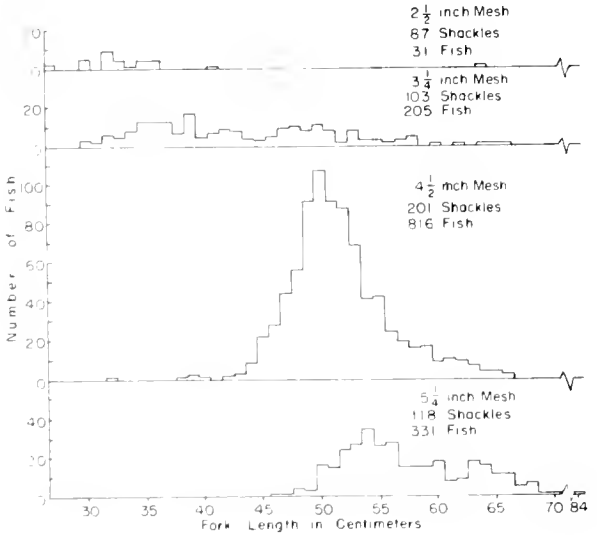

Figure 9.--Catch by Paragon of all species of salmon. Length frequency of 1,383 salmon in relation to mesh size.

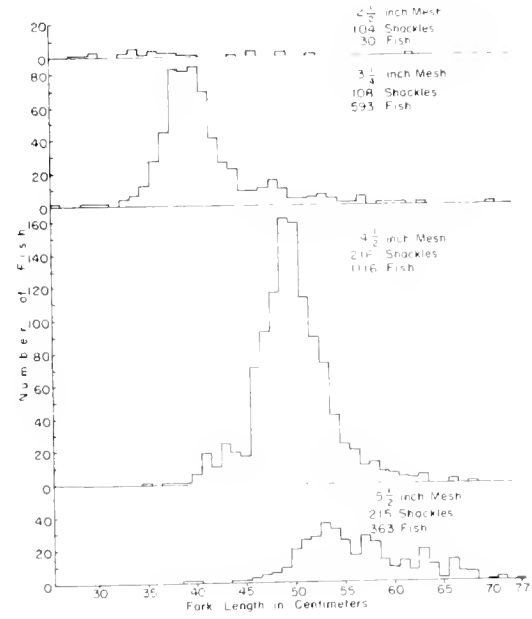

Figure 10.--Catch by Celtic of all species of salmon. Length frequency of 2,102 salmon in relation to mesh size.

Table 6 (page 11) is a summary by vessels of the total salmon catch by species and mesh size, total number and types of gill net sets, the average number of hours nets were fished, and the catch of salmon per set.

The Tordenskjold operated in the eastern Bering Sea and Bristol Bay (fig. 1) from May 24 to September 21 with two periods (June 26 to July 23 and August 15 to September 10) spent in king crab studies in the eastern Bering Sea. A total of 36 night and 1 day set was made by the Tordenskjold with salmon catches ranging from 1 to 987 fish.

The Mitkof operated in central Bering Sea and in the North Pacific Ocean, south of the western Aleutians (fig. 1). Fishing extended from May 16 to September 16. A total of 41 night sets were made with salmon catches ranging from 2 to 323 fish.

The Paragon operated in the area south of the Alaska Peninsula and the eastern Aleutians (fig. 1) and fished from July 11 to September 24; a total of 41 night sets and 4 day sets were made within this period. Salmon catches ranged from 3 to 175 fish per set.

The Celtic's area of operation was in and south of the Gulf of Alaska on longitude 140°, 145°, 150°, and 155° W. (fig. 1). Fishing extended from July 12 to September 19 and catches ranged from 4 to 150 salmon per set.

The Fish and Wildlife Service's John N. Cobb operated in the area off Washington and Vancouver Island between latitude 45° and 50° N. westward to longitude 145° W. (fig. 1). The primary purpose of this cruise was to locate areas of albacore abundance. Of the 27 gill net sets made during the period July 17 to August 29, four caught salmon. Catches ranged from 1 to 3 fish.

Catch per-unit-effort data for the four charter vessels are shown in tables 7 - 10 (pages 12 and 13). Effort data for the John N. Cobb are not included because of the small number (7) of salmon taken.

In eastern Bering Sea, where the Tordenskjold encountered mature reds migrating to Bristol Bay, the 5 1/4-inch mesh proved most efficient, accounting for more than half the total catch. The area occupied by the Mitkof, central Bering Sea and south of the Aleutians, produced smaller fish and a greater proportion of juvenile reds and chums. Significant numbers of juveniles were taken in the 2 1/2-inch mesh, most of them in central Bering Sea. The 3 1/4-inch mesh proved most efficient for the Mitkof. The Paragon, fishing south of the Aleutians and the Alaska Peninsula, took few juveniles. The 4 1/2-inch mesh proved most efficient in this area. Further to the east, south of Kodiak and the Gulf of Alaska, the Celtic's catch was largely immature-adult chums. Adjusting catch to number of shackles fished shows that 4 1/2-inch and 3 1/4-inch meshes were equally effective in this area.

Combined catches from all areas show that the 4 1/2-inch mesh was most effective, with a catch of 4.87 fish per shackle; 5 1/4-inch mesh was second with 3.85 fish per shackle; followed by 3 1/4-inch mesh with 3.49 fish per shackle; and 2 1/2-inch mesh with 0.85 fish per shackle.

LENGTH FREQUENCIES

Catch by Mesh Size

Figures 7 - 10 and Appendix table 1 show the fork lengths of salmon caught in the 5 1/4-, 4 1/2-, 3 1/4-, and 2 1/2-inch mesh nets. These are listed by vessel or area since the vessels fished separate areas.[3/] The mean fork length of salmon taken in the 5 1/4-inch mesh nets by the Tordenskjold (fig. 7) was 57.4 centimeters, in the 4 1/2-inch mesh the mean length was 54.2 centimeters, in the 3 1/4-inch mesh - 55.2 centimeters, and in the 3 1/4-inch mesh - 55.8 centimeters. The 5 1/4-inch and 4 1/2-inch meshes, which took over 95 percent of the total catch, showed selectivity for size of fish. Apparently very few small fish were available for capture in eastern Bering Sea as few were taken in the smaller mesh nets. Predominantly the fish taken in this area were mature red salmon.

The fork lengths of salmon caught by the Mitkof (fig. 8) show a more pronounced mesh-size selectivity, indicating that the stocks fished in the Mitkof's area of

3/ John N. Cobb's length frequency data omitted in figures.

operation were composed of individuals with a wide range in size. The mean fork length of salmon caught in the 5 1/4-inch mesh was 55.6 centimeters; 4 1/2-inch mesh - 50.1 centimeters; 3 1/4-inch mesh - 40.1 centimeters; and 2 1/2-inch mesh - 31.8 centimeters. The bulk of the catch in the 2 1/2-inch mesh were juvenile chum salmon taken in the central Bering Sea.

Mesh-size selectivity is also evident in catches of the Paragon and Celtic (figs. 9 and 10). This again indicates that the stocks fished by these two vessels in their respective areas of operation were composed of individuals with a wide range in size. The mean fork length of salmon caught in the 5 1/4-inch mesh by the Paragon was 57.2 centimeters; 4 1/2-inch mesh - 51.5 centimeters; 3 1/4-inch mesh - 43.2 centimeters; and 2 1/2-inch mesh - 33.8 centimeters. For the Celtic, the mean fork length for the 5 1/4-inch mesh was 56.1 centimeters; 4 1/2-inch mesh - 49.7 centimeters; 3 1/4-inch mesh - 40.9 centimeters; and 2 1/2-inch mesh - 38.3 centimeters.

Figure 11 shows the two extreme sizes of red salmon taken in one set by the Mitkof.

Catch by Species

Figures 12 - 14 and Appendix table 2

Figure 11.--Maximum and minimum sizes of red salmon taken in one set by the Mitkof. The smaller is a one-winter-in-ocean fish while the larger may have spent either two or three winters at sea.

show the fork length frequencies of red, chum, pink, silver and king salmon captured by the four vessels.

Red salmon.--The red salmon length distributions (fig. 12) show two or more modes indicating the presence of different age groups within the areas fished by the Celtic, Paragon and Mitkof. In the Celtic's catch the mode falling between 29 and 42 centimeters is composed of 1-year-in-ocean reds and the mode in the 43- to 60-centimeter interval of 2-year-in-ocean reds. Red salmon of 61 centimeters and above are largely 3-year-in-ocean fish with an increasing degree of overlapping lengths in the older age groups.

The Paragon's catch shows a similar pattern; the 27- to 43-centimeter interval is composed of 1-year-in-ocean reds and the 44- to 60-centimeter interval mode of 2-year-in-ocean reds. Fish 61 centimeters and above are largely 3-year-in-ocean reds.

The Mitkof's 1-year-in-ocean reds fall in the 26- to 40-centimeter interval and the

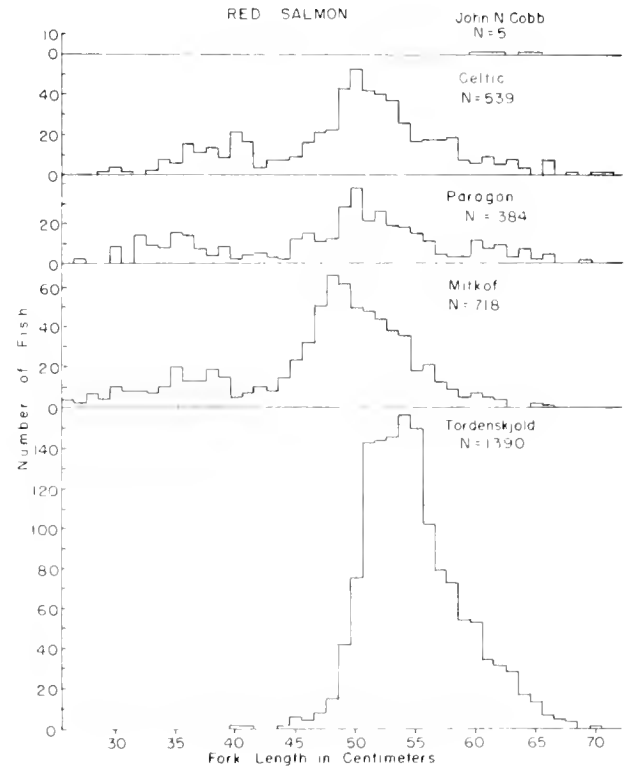

Figure 12.--Length frequency distributions of red salmon taken by five vessels.

2-year-in-ocean reds in the 41- to 62-centimeter interval. The bulk of the Mitkof's reds were taken in the North Pacific, south of the western Aleutians.

The Tordenskjold's red salmon catch exhibits a definite unimodal curve. Of the 1,390 red salmon measurements, approximately 76 percent were those caught on the two stations south of the Pribilof Islands on June 20 and 21. These were in the majority 2-year-in-ocean reds. The absence of small reds during the period from May to September and the capture of large numbers of migrating adult fish at two stations suggest that the eastern Bering Sea and the Bristol Bay area are a migratory path rather than a major feeding ground for red salmon.

The John N. Cobb's red salmon catch included five fish ranging from 60 to 65 centimeters in fork length.

Chum salmon.--There are several modes in the length frequencies of chum salmon captured by the Celtic, Paragon and Mitkof, indicating the presence of different age groups within their areas of operation.

Age analysis indicates that the Celtic's pronounced bimodal curve is made up of 2nd-year chums in the 33- to 45-centimeter interval and 3rd-year chums in the 46- to 61-centimeter interval, with a very small number of 4th-year fish overlapping the latter in length.

Chums caught by the Paragon operating south of the Alaska Peninsula and eastern Aleutians, during the same period as the Celtic (mid-July to mid-September), exhibit a pronounced mode in the 43- to 70-centimeter length interval. This mode includes 63 percent 3rd-year chums and 37 percent 4th-year chums. The 2nd-year chums fall in the 31- to 42-centimeter interval.

A distinct group of 2nd-year chums is found in the 28- to 35-centimeter interval of the Mitkof's catch. These fish, with the exception of one, were caught in the central Bering Sea from July 6 to 15. The remaining group, in the 36- to 71-centimeter interval, is composed of 2nd-, 3rd- and 4th-year chums with a great degree of overlap in length.

The unimodal curve of the Tordenskjold's catch is composed largely of mature 4th-year chums. The absence of small chums from May

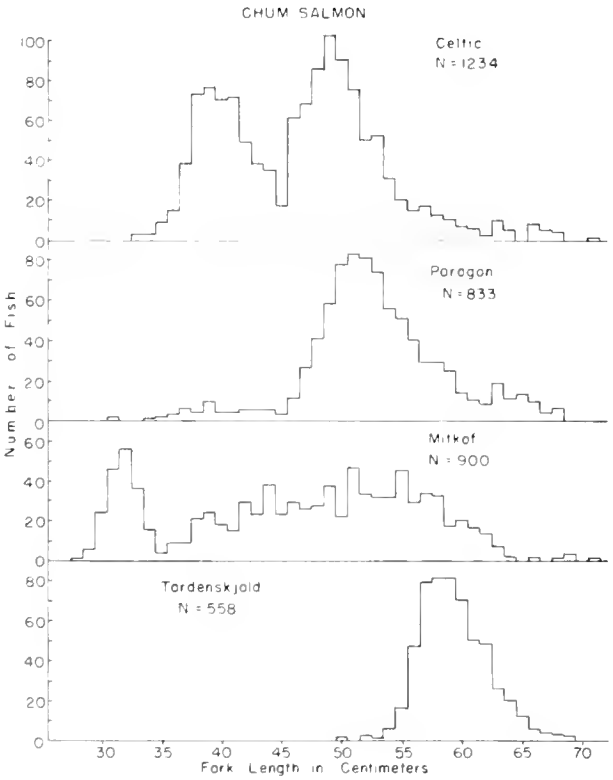

Figure 13.--Length frequency distributions of chum salmon taken by four vessels.

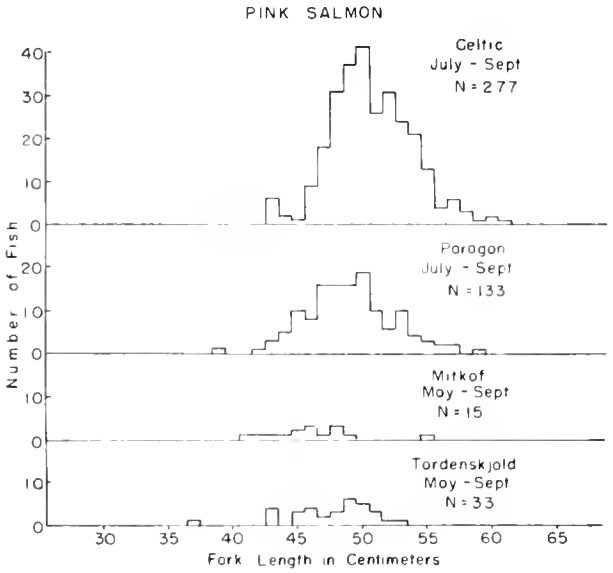

Figure 14.--Length frequency distributions of pink salmon taken by four vessels.

to September in the eastern Bering Sea and Bristol Bay is as marked as the absence of small reds, lending further evidence that eastern Bering Sea is not a feeding area for immature salmon.

Pink salmon.--The greater part of a small catch of pink salmon was taken in the Gulf of Alaska and the general vicinity of Kodiak Island in late July and early August; more than half of the total by the Celtic (fig. 14). Small numbers were taken in mid-June by the Mitkof in the central Aleutians and by the Tordenskjold in eastern Bering Sea.

Silver and king salmon.--As shown in tables 1 - 6 (pages 6 - 11), silver and king salmon were taken in small numbers and were widely distributed. Six juvenile silvers, 26 to 34 centimeters in length, were taken near Kodiak Island. Most of the silvers captured were in the 50- to 70-centimeter length range.

King salmon ranged from 27 to 90 centimeters in length with no clearly dominant size evident in the small numbers captured. The Mitkof operating in the westernmost areas made the largest catch, 33. A few small kings, 27 to 38 centimeters in length, were taken by the Mitkof and the Tordenskjold, all of them in Bering Sea.

VERTICAL DISTRIBUTION OF SALMON CATCH

It has been observed that most gillnetted salmon are taken near the surface. The Tordenskjold, with a predominance of maturing red salmon in the catch, captured 1,366 or 55 percent in the upper 1/3, 699 or 28 percent in the middle 1/3, and 408 or 17 percent in the lower 1/3 of nets which are approximately 20 feet in depth. This vertical distribution is in conformity with the observations of Barnaby in 1939 (Barnaby, 1952) who reported that with a net some 90 feet in depth at least 95 percent of the catch was taken within 30 feet of the surface and "many of the fish were caught in the top fathom". His catches were made at the entrance to Bristol Bay on a line from Cape Seniavin to Cape Newenham, and consisted of maturing red and chum salmon. Barnaby's sets were made during the day while the Tordenskjold's were made at night.

Total season's catch of the Mitkof in 1956 shows 47 percent (523) in the top, 40 percent (447) in the middle, and 13 percent (144) in the bottom third of the nets; the Paragon, 42 percent (586), 44 percent (614), and 14 percent (195); and the Celtic, 51 percent (1,045), 26 percent (523), and 23 percent (462). Cursory inspection of the record sheets indicates that catches tend to be greater near the surface in clam or moderate seas, increase in the lower portion of the nets during periods of rougher weather.

An evaluation of vertical distribution of salmon on the basis of this evidence might, however, be misleading. While errors of observation and record should be minor and compensatory, there is little doubt that a bias does exist in the nets themselves resulting from the fact that fish can swim under but not over them. This tends to increase the efficiency of the upper portion of the net in relation to the deeper portion.

The evidence does suggest, however, a surface tendency on the part of the salmon which may be most pronounced in migrating mature fish and may be influenced in some degree by the condition of the sea. Fukuhara (1953) notes that it is the experience of the extensive Japanese high seas gillnet fishery that 85 to 90 percent of the salmon are taken in the upper 10 feet of net, and Powell and Peterson (1957) observe that 53 percent of the salmon taken by the John N. Cobb in 1955 were gilled in the upper third of the nets.

SURFACE WATER TEMPERATURES AND SALMON CATCH

Surface water temperatures in the region in which salmon were captured ranged from 32.9° to 58.2° F. Variations relating to both area and season contribute to this temperature range of 25.3°. Lower temperatures were encountered in eastern Bering Sea and warmer temperatures near the southern boundary of salmon distribution in the North Pacific. No juvenile red or chum salmon were captured in temperatures below 40° F. and, in Bering Sea, the largest catches of mature red salmon were associated with water temperatures of 42° and 44° F. In warmer waters south of the Aleutian

Islands the largest salmon catches were made in waters ranging from 49° to 55° F. with the largest total catch associated with a 50° F. surface temperature.

SPECIES OTHER THAN SALMON

Catches of species other than salmon, by vessels and by sets, are shown in tables 1 - 55 (pages 6 - 10). These data also are summarized in table 11, below.

The range of steelhead (Salmo gairdneri gairdneri) generally coincides with that of the salmon. However, most steelhead were taken in the Gulf of Alaska and none were taken in Bering Sea. In contrast, a small number of charrs (Salvelinus malma) were caught in Bering Sea, but none were taken in other areas.

Albacore (Thunnus alalunga) were taken near the juncture of sub-Arctic and central Pacific waters. The Mitkof recorded the largest catch, 26 albacore on set number 27 at 47° N., 175° W.

Next to salmon, the pomfrets (Brama raii) were the most numerous species taken. They were caught in large numbers in both salmon and albacore waters of the North Pacific Ocean with the apparent center of abundance near the southern limits of salmon distribution. None was taken in the Bering Sea.

Of the four species of sharks taken on the high seas, blue shark (Prionace glauca) were the most numerous, the greatest number occurring in the southern waters. The Mitkof caught 92 blue sharks on set number 28 at 47° N., 180°.

The capture of five boarfish (Pseudopentaceros richardsoni) by the Paragon and Celtic is the first reported occurrence of this species in the North Pacific Ocean, and is an extension of its known range by 5,000 miles (Welander et al., 1957).

One of the John Dories (Allocyttus verrucosus) captured by the Celtic is the first of this species recorded from the northern hemisphere (Welander et al., 1957).

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Table 11.--Incidental catch.

Common name	Scientific name	V E S S E L S					Total
		TORDENSKJOLD	MITKOF	PARAGON	CELTIC	COBB	
Steelhead	Salmo gairdneri gairdneri		9	32	64	1	106
Albacore	Thunnus alalunga		38	o	5	25	77
Pomfret	Brama raii		426	644	542	667	2279
Jack mackerel	Trachurus symmetricus			40	85	497	622
Giant skilfish	Erilepis zonifer			19	20	2	41
Atka mackerel	Pleurogrammus monopterygius		ɔ		8		11
Three-spined sticklebacks	Gasterosteus sp.				25		25
Handsaw fish	Alepidosaurus aesculapius				1		1
Boarfish	Pseudopentaceros richardsoni			4	1		5
John Dory	Allocyttus verrucosus				1		1
Snapper	Sebastodes sp.			1			1
Squaretail	Tetragonurus cuvieri		5	36			41
Sablefish	Anoplopoma fimbria			1		2	3
Brown ragfish	Acrotus willoughbyi					1	1
---	Anotopterus pharao		4	2	1		7
---	Taractes princeps			1			1
Blue shark	Prionace glauca		181	33	47	225	486
Mackerel shark	Isurus nasus	2	13	19	9	2	45
Dogfish shark	Squalus acanthias		2	1	2		5
Mud shark	Hexanchus griseus			1			1
Herring.	Clupea pallasi	24		1			25
Yellowfin sole	Limanda aspera	12					12
Dolly Varden trout	Salvelinus malma	34	1				35
Juvenile wolf-eels	Anarrhichas orientalis	2					2
Sea poacher	Agonus acipenserinus	6					6

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Table 1. Fork Length Frequencies of Total Salmon Catches by Mesh Size

Vessel	TORDENSKJOLD					MITKOF					PARAGON					CELTIC					COBB			TOTALS			
Fork Length in Cms. \ Mesh Size	5¼	4½	3¾	2½	Total	5¼	4½	3¼	2⅜	Total	5¼	4½	3¼	2⅜	Total	5¼	4⅜	3¼	2½	Total	5¼	4½	Total	5¼	4½	3¼	2⅜
24									1	1																	1
25																											
26									3	3								1		1						1	3
27									3	3				2	2												5
28									7	7									1	1							8
29									10	10								1	1	2						1	11
30								3	32	35			3	5	8			1	3	4						7	40
31								7	47	54			2		2			1		1						10	47
32				1	1			16	49	65		1	6	9	16											1	22	59
33								14	29	43			5	4	9			4	2	6						23	35
34								16	10	26			8	1	9			6	5	11						30	16
35								21	3	24			13	4	17		1	12	1	14						1	46	8
36								21	1	22			13	4	17			27	3	30						61	8
37			1		1			22		22			13		13		1	45	2	48						1	81	2
38			2		2		2	38		40		1	7		8		1	83	2	86						4	130	2
39								38	1	39		2	17		19	1	1	82	1	85				1	3	137	2
40	1				1		2	21		23		1	5		6	1	6	84	1	92				2	9	110	1
41	1				1		1	21	1	23			7	1	8		19	69		88				1	20	97	2
42			1		1		6	34		40			9		11		11	41		52					19	84	
43		2	2		4		9	23		32		3	8		11		25	26		51					39	59	
44		1			1	2	32	19	1	54		8	4		12	1	20	22	1	44				3	61	45	2
45		8	1		9		31	17		48		22	3		25	1	17	9		27				1	78	30	
46		8			8	2	51	12		65	1	28	5		34	3	71	9	3	86				6	158	27	3
47		10			10	4	64	11		79	1	44	9		54	5	93	10		108				10	211	30	
48	4	15			19	7	81	8	1	97	4	56	10		70	6	117	15		138				21	269	33	1
49	12	36			48	10	84	6		100	3	91	8		102	9	162	10	2	183				34	373	24	2
50	22	58	2		82	11	51	9	2	73	16	107	11		134	20	139	4		183				69	375	26	2
51	44	100	2	1	147	27	65	2		94	15	91	8		114	26	113	4		143				112	369	16	1
52	65	81	1	1	148	29	43	5		77	24	87	2		113	27	89	5	1	122				145	300	13	2
53	70	76	4		150	39	29	2		70	27	68	8		103	36	73	6		115				172	246	20	
54	66	90	10	2	168	30	37	1		68	35	41	3		79	32	41	4		77				163	209	18	2
55	74	81	11		166	33	33			66	26	42	3		71	25	24	1		50				158	180	15	
56	86	54	9		149	30	20	1		51	28	24	2		54	16	20	1		37				160	118	15	
57	88	62	8	1	159	24	22			46	15	19	3		37	28	11	5		44		1	1	155	115	16	1
58	108	42	4	2	156	30	13			43	15	16	5		36	24	13			37				177	84	9	2
59	92	40	2	2	136	19	8			27	13	17			32	13	7	1		21		1	1	139	73	3	2
60	96	23	4	1	124	22	7			29	18	9	1		28	9	6	1		16	1		1	146	45	6	1
61	67	16	1	1	85	17	5			22	8	10			18	13	4	1		18	1		1	106	35	2	1
62	69	9	4	1	83	15	4			19	9	9	1		19	7	3		1	11				100	25	5	2
63	40	15		1	56	6	1			7	18	7			25	20	5	1		26	1		1	85	28	1	
64	32	5	1		38	2	1			3	16	4	1	1	22	10				10	1		1	61	10	2	2
65	18	5	2		25	5				5	11	4	1		16	2				2				36	9	3	
66	9	3			12	2			1	3	11	2	1		14	13	2			15				35	7	1	1
67	7	2	1		10						5				5	6				6	1		1	19	2	1	
68	5	1	1		7	1				1	7				7	5	1			6				18	2	1	
69	2				2	3	1			4	1				1									6	1		
70	2				2	1				1	1				1	1		1		2				5		1	
71							1			1						2				2				2	1		
72																											
73																											
74																											
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85																											
86	1				1																			1			
87																											
88																											
89																											
90		1			1																				1		
Total	1081	844	74	14	2013	371	704	388	202	1665	331	816	205	31	1383	365	1116	593	30	2102	5	2	7	2151	3482	1260	277

Table 2. Fork Length Frequencies of Total Salmon Catches by Species

Vessel / Species 1/ / Fork Length in Cms.	TORDENSKJOLD						"LITSOF						PARAGON						CELTIC						JOBE			TOTALS				
	R	C	P	S	K	Total	R	C	P		K	Total	R	C	P		K	Total	R	C	P		K	Total	R	S	Total	R	C	P	S	K
24							1					1																1				
25																																
26							3					3									1			1				3			1	
27							2				1	3	2					2										4				1
28							6	1				7									1			1				6	1		1	
29							4	6				10							1		1							5	6		1	
30							10	24			1	35	8					8	3		1			4				21	24		1	1
31							8	46				54		2				2	1					1				9	48			
32					1	1	8	56			1	65	14	2				16										22	58			2
33							7	36				43	9					9	2	3		1		6				18	39		1	
34							10	15			1	26	8	1				9	7	3		1		11				25	19		1	1
35							20	4				24	15	2				17	5	9				14				40	15			
36							13	9				22	14	3				17	15	15				30				42	27			
37			1			1	13	9				22	7	6				13	10	38				48				30	53	1		
38					2	2	19	21				40	4	4				8	13	73				86				36	98			2
39							15	24				39	8	10	1			19	8	77				85				31	111	1		
40	1					1	5	18				23	2	4				6	21	70			1	92				29	92			1
41	1					1	7	15	1			23	4	4				8	16	71			1	88				28	90	1		1
42	1					1	10	29	1			40	5	5	1			11	3	49				52				19	83	2		
43			4			4	8	23	1			32	3	5	3			11	7	38	6			51				18	66	14		
44	1					1	15	38	1			54	2	5	5			12	7	35	2			44				25	78	8		
45	5		3		1	9	23	23	2			48	12	3	10			25	9	17	1			27				49	43	16		1
46	4		4			8	32	29	3		1	65	15	11	8			34	16	61	9			86				67	101	24		1
47	8		2			10	51	26	1		1	79	11	27	16			54	21	68	18	1		108				91	121	37	1	1
48	15		3		1	19	66	27	3		1	97	12	41	16		1	70	22	85	31			138				115	153	53		3
49	42		6			48	62	37	1			100	28	58	16			102	43	102	37	1		183				175	197	60	1	
50	75	2	5			82	50	22			1	73	37	78	19			134	50	90	41			183				214	192	65		1
51	143		3		1	147	48	46				94	21	83	10			114	41	75	26	1		143				253	204	39	1	1
52	144	3	1			148	44	33				77	26	81	6			113	40	50	31		1	122				254	167	38		1
53	146	1	1		2	150	38	31			1	70	19	74	10			103	37	52	24	1	1	115				240	158	35	1	4
54	157	6		2	3	168	36	31			1	68	18	56	4		1	79	25	31	21			77				236	124	25	2	5
55	150	16				166	18	45	1	1	1	66	15	51	3	2		71	16	20	13		1	50				199	132	17	3	2
56	101	47		1		149	21	29		1		51	11	40	2	1		54	17	15	4	1		37				150	131	6	4	
57	79	79		1		159	12	33			1	46	4	29	2	2		37	17	17	6	4		44		1	1	112	158	8	8	1
58	73	81		1	1	156	9	31		1	1	43	3	29		3	1	36	18	12	3	4		37				103	154	3	9	3
59	54	81			1	136	5	17			5	27	3	25	1	3		32	7	10	1	2	1	21	1		1	70	133	2	5	7
60	53	70		1		124	7	20			2	29	11	14		3		28	5	7	2	2		16	1		1	77	111	2	6	2
61	34	50		1		85	5	16			1	22	7	10		1		18	9	6	1	2		18	1		1	56	82	1	4	1
62	31	49		2	1	83	4	13			2	19	9	8		2		19	5	2		4		11				49	72		8	3
63	28	26		1	1	56		7				7	3	19		1	2	25	7	10		8	1	26	1		1	39	62		10	4
64	17	20		1		38		2			1	3	7	11		4		22	3	5		2		10	1		1	28	38		7	1
65	13	12				25	2				3	5	2	13		1		16				1	1	2				17	25		2	4
66	6	6				12	1	2				3	4	9		1		14	7	8				15				18	25		1	
67	4	4		2		10								4		1		5		5		1		6		1	1	4	13		5	
68	3	3		1		7		1				1		6		1		7	1	4		1		6				4	14		3	
69		2				2		3			1	4	1					1										1	5			1
70	1				1	2					1	1				1		1	1			1		2				2			2	2
71								1				1							1	1				2				1	2			
72																																
73																																
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77																							1	1								1
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84																	1	1														1
85																																
86					1	1																										1
87																																
88																																
89																																
90					1	1																										1
Total	1390	558	33	14	18	2013	718	900	15	3	29	1665	384	633	133	27	6	1383	539	1234	277	43	9	2102	5	2	7	3036	3525	458	89	62

1/ Letters R - Red, C - Chum, P - Pink, S - Silver, K - King indicate the species of salmon.