

# DIRECTION OF MOVEMENT OF SALMON IN THE NORTH PACIFIC OCEAN AND BERING SEA AS INDICATED BY SURFACE GILLNET CATCHES, 1959-1960

By Richard C. Johnsen

Fishery Research Biologist, Biological Laboratory, Bureau of Commercial Fisheries,  
Seattle, Washington, September 1962

## ABSTRACT

High seas movements of sockeye, chum and pink salmon in the Aleutian area of the North Pacific Ocean and the Bering Sea are described for the period May through August. Included is a brief comparison of movement indicated by gillnet catches with that indicated by purse seine catches from this area.

Gillnet catches showed a similar direction of movement for each species where taken together in the North Pacific; this direction of movement was predominantly westward. Dominant sockeye salmon movements in the Bering Sea were eastward and northward, whereas the movements of chum and pink salmon were westward and northward.

Direction of movement indicated by gillnet catches in 1959 and 1960 compared with movement indicated by purse seine catches in 1956, 1957 and 1958 shows a general similarity in most of the Aleutian area, particularly in the North Pacific.

## CONTENTS

Introduction . . . . .	33
Procedures . . . . .	33
Data collection . . . . .	33
Criteria for comparable catches . . . . .	34
Determining direction . . . . .	35
Results . . . . .	35
Catch . . . . .	35
Maturity . . . . .	35
Sockeye salmon . . . . .	35
Chum salmon . . . . .	37
Pink salmon . . . . .	39
Direction of movement . . . . .	40
Sockeye salmon, 1959 . . . . .	40
Sockeye salmon, 1960 . . . . .	40
Sockeye salmon, 1959 and 1960 . . . . .	41
Chum salmon, 1959 . . . . .	42
Chum salmon, 1960 . . . . .	42
Chum salmon, 1959 and 1960 . . . . .	44
Pink salmon, 1959 . . . . .	44
Pink salmon, 1960 . . . . .	45
Pink salmon, 1959 and 1960 . . . . .	46
Discussion . . . . .	46

Comparison between species . . . . .	46
May-June . . . . .	46
July-August . . . . .	47
Comparison between gillnet and purse seine catches . . . . .	47
Conclusions . . . . .	47
Literature cited . . . . .	48

## INTRODUCTION

Salmon (*Oncorhynchus* spp.) have been gillnetted in offshore waters of the North Pacific Ocean and Bering Sea by the U.S. Bureau of Commercial Fisheries for the International North Pacific Fisheries Commission (INPFC) each year since 1955. Among objectives of this sampling program is that of determining the distribution in time and space of sockeye, chum and pink salmon. Information on the direction of movement of salmon captured in the gillnets is pertinent to the study of their distribution and should contribute to the determination of migration routes in the Aleutian waters.

This report deals with the direction of movement of sockeye (*O. nerka*), chum (*O. keta*) and pink salmon (*O. gorbuscha*) during the 1959 and 1960 seasons in the Aleutian area of the North Pacific Ocean and Bering Sea as indicated by offshore surface gillnet catches and includes a brief comparison with purse seine catches of 1956, 1957 and 1958 from this same general area.

## PROCEDURES

Direction data were obtained in conjunction with other catch data obtained at each gillnet set, but, because direction data are greatly affected by certain variables, particularly weather, only comparable catches could be utilized. Criteria used for determining comparable (usable) catches are given along with certain assumptions which were made in determining direction of movement.

## DATA COLLECTION

In the Aleutian area, the fishing was from May 20 until August 12 in 1959 and from May 18 until

August 26 in 1960. Surface gillnets were fished from chartered halibut schooners, the MV *Pioneer* and MV *Tordenskjold* in 1959, and the MV *Paragon* and MV *Pioneer* in 1960.

Nets were fished in a string which consisted of four standard (INPFC) mesh sizes fished in the following ratio: twenty-four  $4\frac{1}{2}$ -inch nets and four each of the  $5\frac{1}{4}$ -inch,  $3\frac{1}{4}$ -inch and  $2\frac{1}{2}$ -inch sizes. Twenty-four nets were arranged in a  $4\frac{1}{2}$ -inch,  $5\frac{1}{4}$ -inch,  $4\frac{1}{2}$ -inch,  $3\frac{1}{4}$ -inch,  $4\frac{1}{2}$ -inch,  $2\frac{1}{2}$ -inch sequence repeated four times with 12 additional  $4\frac{1}{2}$ -inch nets attached at the end of the string. Each net was 50 fathoms in length and approximately 25 feet deep. Thirty-six nets were fished in 70 of 76 sets during 1959 and in 78 of 82 sets during 1960. Twenty-four nets were fished in each of the other sets.

The nets were constructed entirely of nylon materials with the exception that some cotton lead lines were used; color ranged from medium to dark grey-green. Additional details of gear, set and haul procedures and the usual catch data collections are given by Hanavan and Tanonaka (1959).

Each time the nets were fished the direction of net lay was recorded (1) when the net string was set out in the evening, and (2) when hauled aboard in the morning. Direction of net lay is defined as the two compass points, e.g., N-S, fixing the line formed by the string of nets when fishing. It was necessary while hauling to obtain the definite lay of each shackle of net, since often the far end of the string could not be seen from the vessel, and the nets frequently were lying in an irregular pattern as the result of wind and ocean currents. During the net hauling operations, as fish were picked from the nets, their entry direction was recorded and later corrected to the compass bearing at a 90 degree angle to the direction of the lay of the net.

Maturity determinations of sockeye and chum salmon were made of all or a sample of each catch in 1959 and of all the catches in 1960 with the exception of (1) catches in excess of 300 fish from which representative samples of at least 300 fish were taken, and (2) mutilated fish from which gonads were not available. Maturity of the 1959 catches was determined in the laboratory, but maturity of a portion of most 1960 catches was determined aboard ship and the remainder in the laboratory. In either case, maturity determinations were based upon the method of Ishida and Miyaguchi (1958), i.e., for fish taken in May and after, testes weight of two grams or more or ovary weight of 20 grams or more (both ovaries) indicates fish maturing in the year caught. In the laboratory

actual gonad weights were taken; however, aboard ship maturity determinations were made primarily by visual examination of the gonads after the observer first had gained experience at recognition of the size of "mature" and "immature" gonads. Actual shipboard classification as to maturity was made only when the observer was certain of the gonad development. This may have resulted in a slightly higher percentage of immatures, particularly chums, since those of borderline size may have been from fish which would have matured later in the year.

#### CRITERIA FOR COMPARABLE CATCHES

Ocean currents and wind changes at times swung the nets and vessel to such an extent it was impossible to determine even a general direction of fish movement from a particular set. Also, weather conditions at the time the nets were retrieved influenced to some extent the accuracy of observations and the recording of these observations. Since currents, wind and weather could not be controlled, nor their influence on the accuracy of observations assessed, only comparable sets under the following criteria were considered: (1) Single night sets; (2) Sets in which swing of the entire string did not exceed 90 degrees and the position of the individual shackles within the string did not vary by more than 90 degrees; (3) Catches of at least 20 fish of a single species. To reduce congestion in the illustrations which indicate direction of movement, smaller catches were not used. Examination of catches of five to 19 fish showed that the direction of movement in most of these catches was similar to larger catches made nearby.

Dominance of the catch from one side of the nets or the other requires mention even though it is not one of the above criteria. Experience suggests that under certain conditions, such as severe weather or large catches, direction error approaches 10 percent as a result of human error in observation and recording. Catches which show a dominance of 60 percent or more from one side of the nets are therefore considered to be more reliable indicators of direction of movement than those showing a more nearly equal percentage from each side. On the other hand, accurately recorded catches which show nearly equal numbers of fish entering from each side of the net may indicate a movement parallel to the net lay or a random movement in the immediate area where the nets are set. Since the nature of these records does not permit a precise determination of direction, catches of less than 60 percent dominance in direction are not employed in ascertaining the probable movement of salmon caught. Usable catches having at least a 60 percent dominance in direction included

78 percent of all catches in 1959, 85 percent of all catches in 1960 and 81 percent of all catches for the combined years.

#### DETERMINING DIRECTION

In determining the direction of fish movement of each catch from net lay at set and haul, the "average" net lay was used. Average net lay was considered to be the midpoint of swing of the net string with the vessel as the pivot. From this average net lay, the nearest of the eight main compass points (i.e., North, Northeast, East, Southeast, South, Southwest, West and Northwest) was chosen.

A compass point perpendicular to the average net lay was assumed to represent the general direction a majority of the fish were moving in a particular catch. This assumption was made because of the large angle, perhaps nearly 180°, from which fish can enter the net from either side.

Most salmon in Aleutian waters spawn in streams of either Asia or North America exclusive of the Aleutian Islands. Therefore, migration of maturing fish from these waters ultimately must be more or less westward or eastward toward the major continental spawning areas. North-south sets for this reason were believed to be the most effective in determining and clarifying the major movements. In practice this was not always possible because the string of nets had to be set approximately downwind to hold the vessel free while drifting overnight. These sets made in other than a north-south direction thus provided some information on various directions of movement for immature as well as maturing salmon.

The direction in which the nets were set influenced the interpretation of direction data. For example, a catch of fish moving northwest would be interpreted as moving west when caught in a string of nets set north-south or interpreted as moving north in a string of nets set east-west. Several sets in the same proximity were therefore necessary to provide a more reliable indication of the direction of movement than a single set could provide in the large ocean areas. Since sets were usually made in a north-south direction, the interpretation of these data therefore was somewhat biased toward either a westward or an eastward direction of movement.

Direction of movement data from gillnets, while not so precise as direct observation of live fish, does provide considerable information on the general movements of salmon.

## RESULTS

### CATCH

Seventy-six gillnet sets during the 1959 season produced catches of salmon (sockeye, chum and pink only) ranging from two to 1,431, and totaling 21,092 fish, as compared to 83 sets in 1960 with catches ranging from four to 1,334, but totaling only 16,179 fish (INPFC, 1960, 1961). The main difference in total catch was the marked reduction in the number of pink salmon in 1960. The area covered in 1959 was roughly bounded by latitudes 60°N. and 47°N. and longitudes 171°E. and 160°W. Coverage in 1960 shifted slightly southward, but was approximately the same as in 1959. The patterns of the total number of gillnet sets in 1959 and 1960 are shown in the annual reports of the International North Pacific Fisheries Commission for those years. There were 49 sockeye, 53 chum and 33 pink salmon catches in 1959 and 48 sockeye, 50 chum and 16 pink salmon catches in 1960 which provided usable direction data.

Usable data in Tables 1 to 4 were plotted separately for May-June and July-August catches. Figures 1 to 4, 7 to 10 and 13 to 16 show these plots with the percentage of dominant direction of movement indicated. Catches of 50 or more fish are represented by a heavy arrow and those of from 20 to 49 fish by a light arrow and are referred to as "large" and "small" catches, respectively. Similarly, Figures 5 and 6, 11 and 12, and 17 and 18 show the dominant direction of movement with 1959 and 1960 plotted together but with percentage figures omitted for clarity.

### MATURITY

#### Sockeye Salmon.

A seasonal change in the maturity composition of the sockeye salmon catch in the Aleutian area was quite evident in both 1959 and 1960 (Table 5). The total catch was composed mostly of mature fish during May and June (1959, 93 percent; 1960, 90 percent) and mostly of immature fish during July and August (1959, 84 percent; 1960, 86 percent). (Mature, here, refers to those fish which would have spawned during the year caught.) That portion of the total catch providing usable direction data shows a similar maturity composition, within plus or minus five percent, compared to the total catch. Individual catches, too, show a dominance of matures in May and June and immatures in July and August. Some exceptions were noted each year, usually in late

TABLE 1. Direction of movement of salmon as indicated by gillnet catches of the MV *Pioneer*, 1959.

Set no.	Date	Position of set		Direction by species <sup>1</sup>						
				Sockeye		Chum		Pink		
				Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>	
1	4/23-4/24	56°01'	152°59'W	1N		1S				
2	4/24-4/27	55°00'	153°00'W	16?		7?				
3	5/19-5/20	51°29'	175°03'E	11N-14S	56S	143N-39S	79N			
4	5/21-5/22	51°00'	175°00'E	15S-26N	64N	165S-253N	61N			
5	5/22-5/23	50°00'	175°00'E	11N-6S		35N-7S	85N			
6	5/23-5/24	49°00'	175°00'E	18N-10S	64N	125N-52S	73N			
7	5/24-5/25	48°00'	175°00'E	28N-7S	80N	326N-162S	67N	86N-16S	85N	
8	5/26-5/27	49°38'	171°44'E	17N-10S	63N	12N-25S	68S			
9	5/27-5/28	50°25'	171°20'E	12NE-10SW	54NE	3NE-16SW				
10	6/2-6/3	52°00'	171°00'E	13N-2S		10N-1S				
11	6/3-6/4	52°47'	171°00'E	12N-4S		12N-8S	60N	3N-1S		
12	6/4-6/5	53°30'	171°00'E	31N-5S	86N	18N-7S	72N			
13	6/5-6/6	54°20'	171°00'E	49NE-6SW	89NE	8NE-7SW				
14	6/6-6/8	55°00'	171°00'E	21W-42E	<sup>a</sup>	12W-6E		1E		
15	6/12-6/13	53°30'	180°	61NW-7SE	90NW	47NW-9SE	84NW	41NW-3SE	93NW	
16	6/21-6/22	52°38'	178°47'W	25SE-27NW	54NW	3SE-13NW		19SE-50NW	72NW	
17	6/22-6/23	52°59'	179°55'E	5SE-78NW	94NW	10SE-114NW	92NW	58SE-557NW	91NW	
18	6/23-6/24	54°00'	180°	15E-5W	75E	1E-22W	96W	33E-256W	89W	
19	6/24-6/25	55°00'	180°	43E-14W	75E	6E-9W		24E-186W	89W	
20	6/25-6/26	56°00'	180°	159N-6S	96N	23N-16S	59N	11N-25S	69S	
21	6/26-6/27	57°00'	180°	127NE-11SW	92NE	63NE-40SW	61NE	33NE-42SW	56SW	
22	6/27-6/28	58°00'	180°	32N-12S	73N	90N-15S	86N	1045N-237S	81N	
23	6/29-6/30	60°00'	180°	32N	100N	119N-1S	99N	390N-3S	99N	
24	7/4-7/5	58°00'	175°00'E	60N-8S	88N	146N-4S	97N	755N-9S	99N	
25	7/14-7/15	55°00'	175°00'E	19N		15S-83N	85N	74S-490N	87N	
26	7/15-7/16	54°00'	175°00'E	6SW-4NE		17SW-17NE	50NE	10SW-14NE	58NE	
27	7/18-7/19	51°54'	174°06'E	16N-8S	67N	15N-5S	75N	10N-1S		
28	7/21-7/22	51°30'	175°00'E	32SW-26NE	<sup>a</sup>	4SW-2NE		3SW		
29	7/22-7/23	50°30'	175°00'E	42W-15E	74W	8W-3E		3W		
30	7/26-7/27	51°31'	176°42'W	387SW-88NE	<sup>a</sup>	136SW-28NE	<sup>a</sup>	33SW-4NE	<sup>a</sup>	
31	7/27-7/28	51°31'	176°40'W	101W-73E	58W	42W-24E	64W	2W-3E		
32	7/28-7/29	51°29'	176°38'W	168NE-339SW	67SW	53NE-144SW	73SW	22NE-17SW	56NE	
33	8/4-8/5	51°00'	175°00'W	47N-320S	87S	2N-12S				
34	8/5-8/6	50°00'	175°00'W	157NW-201SE	56SE	62NW-53SE	54NW	1NW-2SE		
35	8/6-8/7	49°00'	175°00'W	17SW-11NE	61SW	44SW-34NE	56SW			
36	8/8-8/9	48°00'	175°00'W	1NE		11SW-18NE	62NE			
37	8/11-8/12	49°05'	170°10'W	1W		5E-22W	82W	1E		

<sup>1</sup> Heading direction of salmon. (Net lay direction of usable catches was approximately perpendicular to the heading direction shown.)

<sup>2</sup> Percentage of dominant direction—usable catches only.

<sup>3</sup> Net turned during set—direction estimated.

June or early July, although in May 1960 fish caught south of 48°N. were immature.

In view of the rather sharp separation of mature and immature sockeye salmon catches in 1959 and 1960, it is evident that the direction of movement presented here is essentially that of matures through May and June and that of immatures through July

and August. In the few catches where both matures and immatures were taken in number (20 or more), four catches (Table 6) do provide some evidence that direction of movement differed with maturity at a certain location and time. However, this difference in movement was only apparent in 1960 and only from a relatively small area, roughly 4,000 square miles, south of the east-central Aleutians.

TABLE 2. Direction of movement of salmon as indicated by gillnet catches of the MV *Tordenskjold*, 1959.

Set no.	Date	Position of set		Direction by species <sup>1</sup>					
				Sockeye		Chum		Pink	
				Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>
1	5/24–5/25	53°17'	165°35'W	2NE–6SW		5NE–53SW	91SW	2NE–4SW	
2	5/25–5/26	52°40'	167°37'W	1SW		1NE–35SW	97SW		
3	5/26–5/27	51°56'	169°39'W	7NE–48SW	87SW	3NE–8SW		4NE–5SW	
4	5/27–5/28	51°41'	171°57'W	61S–17N	<sup>3</sup>	24N–7S	<sup>3</sup>	10S–5N	
5	6/1–6/2	51°00'	180°	99W–9E	92W	117W–34E	78W	9W–1E	
6	6/2–6/3	49°59'	179°57'W	15W–8E	65W	77W–17E	82W	7W–3E	
7	6/3–6/4	49°03'	179°56'W	9E–10W		37E–73W	66W	36E–109W	75W
8	6/6–6/7	49°01'	175°04'W	7S–15N	68N	12S–34N	74N	28S–63N	69N
9	6/11–6/12	51°32'	176°31'W	106E–144W	58W	10E–45W	82W	24E–42W	64W
10	6/13–6/14	51°32'	176°34'W	20N–33S	62S	9N–6S		13N–9S	59N
11	6/14–6/15	51°31'	176°25'W	132E–159W	54W	36E–81W	69W	36E–106W	75W
12	6/20–6/21	52°59'	175°00'W	32W–6E	84W	26W–13E	69W	170W–55E	76W
13	6/21–6/22	54°00'	176°00'W	29W–80E	<sup>3</sup>	17W–28E	<sup>3</sup>	154W–28E	<sup>3</sup>
14	6/22–6/23	55°00'	176°00'W	17W–79E	82E	33W–5E	87W	760W–96E	89W
15	6/23–6/24	56°00'	176°00'W	41W–64E	<sup>3</sup>	22W–6E	<sup>3</sup>	130W–27E	<sup>3</sup>
16	6/24–6/25	57°00'	175°00'W	22S–97W	82N	5S–5N		18S–11N	62S
17	6/26–6/27	59°00'	170°00'W	55E–4W	93E	42E–5W	89E	67E–23W	74E
18	6/27–6/28	58°00'	170°00'W	7W–62E	90E	1W–10E		1W–3E	
19	6/28–6/29	56°56'	170°06'W	3W–2E					
20	6/29–6/30	55°59'	170°00'W	21W–181E	<sup>3</sup>	35W–28E	<sup>3</sup>	62W–17E	<sup>3</sup>
21	6/30–7/1	55°01'	170°03'W	4W–13E		7W–11E		8W–4E	
22	7/1–7/2	53°58'	170°01'W	10W–11E	52E	25W–7E	78W	60W–10E	86W
23	7/2–7/3	53°18'	170°00'W	2W–13E		29W–24E	55W	115W–45E	72W
24	7/3–7/4	52°00'	169°53'W	201SW–38NE	84SW	77SW–11NE	87SW	86SW–35NE	71SW
25	7/4–7/5	51°00'	169°56'W	67W–11E	86W	48W–11E	81W	159W–30E	84W
26	7/10–7/11	53°30'	165°00'W	386W–74E	84W	423W–108E	80W	38W–26E	59W
27	7/11–7/12	52°58'	164°56'W	283W–30E	90W	26W–3E	90W	12W–11E	52W
28	7/12–7/13	52°00'	165°00'W	171SW–28NE	86SW	33SW–15NE	69SW	8SW–5NE	
29	7/14–7/15	50°02'	165°00'W	8SE–30NW	<sup>3</sup>	90SE–334NW	<sup>3</sup>	3SE	
30	7/15–7/16	49°02'	165°00'W	4W–1E		147W–21E	88W		
31	7/16–7/17	48°01'	165°05'W	3W–3E		41W–7E	85W		
32	7/18–7/19	47°01'	160°02'W	1E		13E–53W	80W	1E	
33	7/19–7/20	48°02'	160°00'W	5E		18E–28W	61W	1W	
34	7/20–7/21	49°02'	160°00'W	6E–14W	70W	31E–35W	53W		
35	7/21–7/22	49°55'	160°05'W	15S–47N	76N	110S–72N	60S	6S–6N	
36	7/22–7/23	50°57'	159°55'W	51S–86N	62N	37S–96N	72N	7S–25N	78N
37	7/23–7/24	51°57'	159°58'W	167SE–127NW	57SE	26SE–32NW	55NW	8SE–15NW	65NW
38	7/24–7/25	53°00'	160°00'W	22E–44W	67W	101E–215W	68W	45E–72W	65W
39	7/25–7/26	53°55'	159°40'W	29E–40W	58W	21E–39W	65W	44E–37W	54E

<sup>1</sup> Heading direction of salmon. (Net lay direction of usable catches was approximately perpendicular to the heading direction shown.)

<sup>2</sup> Percentage of dominant direction—usable catches only.

<sup>3</sup> Net turned during set—direction estimated.

#### Chum Salmon.

Cursory examination of maturity data from 1960 high seas catches of chum salmon indicates a maturity composition similar to that of sockeye salmon catches by season (i.e., catches were mostly mature fish in May and June and mostly immatures in July and August). The proportion of immature chum in

July–August catches appears to be generally lower than for sockeye salmon in the same catch. However, observers did note distinct difficulty in visually determining the maturity of gonads of many of the large chum (over 50 cm.) taken during the July–August period. Small, definitely immature, fish usually dominated the July–August catches, however. Examination of unpublished maturity data and per-

TABLE 3. Direction of movement of salmon as indicated by gillnet catches of the MV *Paragon*, 1960.

Set no.	Date	Position of set		Direction by species <sup>1</sup>					
				Sockeye		Chum		Pink	
				Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>
1	5/17-5/18	52°50'	167°00'W	4W-2E		7W-9E		1W-1E	
2	5/18-5/19	52°25'	168°31'W	1W		35W-9E		1W-1E	
3	5/21-5/22	52°00'	169°59'W	2NW-3SE		36NW-9SE	80NW		
4	5/22-5/23	51°04'	170°49'W	147N-88S	<sup>3</sup>	52N-11S	<sup>3</sup>	19N-4S	<sup>3</sup>
5	5/23-5/24	50°06'	171°40'W	50NW-44SE	53NW	20NW-2SE	91NW	11NW-9SE	55NW
6	5/26-5/27	47°03'	174°10'W	4NW		68NW-18SE	79NW	32NW-9SE	78NW
7	5/27-5/28	46°00'	174°59'W	10W-4E		15W-1E		18W-3E	86W
8	5/28-5/29	45°00'	175°00'W	55W-5E	92W	4W		5W-1E	
9	5/30-5/31	47°00'	177°11'W	2E-2W		18E-55W	75W	3E-18W	86W
10	5/31-6/1	47°44'	177°46'W	1W-14E		27W-16E	63W	6W-3E	
11	6/3-6/4	49°01'	180°	4W-2E		24W-43E	64E	2W-6E	
12	6/4-6/5	50°02'	179°59'E	35W-16E	<sup>3</sup>	77W-17E	<sup>3</sup>	8W-1E	
13	6/5-6/6	51°00'	179°59'E	82E-264W	76W	21E-157W	88W	2E-25W	93W
14	6/6-6/7	51°04'	178°30'W	31E-143W	82W	6E-20W	77W	3E-2W	
15	6/14-6/15	53°00'	176°10'W	127W-151E	54E	7W-8E		24W-11E	69W
16	6/15-6/16	54°01'	175°38'W	50NW-232SE	82SE	12NW-8SE	60NW	7NW-2SE	
17	6/16-6/17	55°00'	175°01'W	6NW-2SE		8NW-1SE		13NW-1SE	
18	6/17-6/18	56°01'	175°00'W	15W-52E	78E	10W-8E		13W-2E	
19	6/18-6/19	57°01'	174°59'W	18SE-53NW	75NW	1SE-64NW	98NW	13SE-68NW	84NW
20	6/19-6/20	56°42'	173°27'W	232E-48W	<sup>3</sup>	32E-39W	<sup>3</sup>	5E-7W	
21	6/20-6/21	56°21'	171°41'W	99E-70W	59E	11E-47W	81W	1E-1W	
22	6/21-6/22	55°58'	169°59'W	52W-207E	<sup>3</sup>	4W-9E			
23	6/22-6/23	55°00'	170°01'W	21W-80E	79E	4W-7E		2W	
24	6/23-6/24	54°00'	169°59'W	26SE-170NW	<sup>3</sup>	36SE-162NW	<sup>3</sup>	3SE-11NW	
25	6/24-6/25	53°20'	169°59'W	143NW-52SE	<sup>3</sup>	71NW-23SE	<sup>3</sup>	4NW-1SE	
26	6/25-6/26	52°15'	169°57'W	41NW-57SE	58SE	95NW-70SE	58NW	6NW-6SE	
27	6/26-6/27	51°18'	170°37'W	34NE-49SW	59SW	14NE-42SW	75SW	1NE-1SW	
28	6/27-6/28	50°07'	171°43'W	60W-41E	59W	57W-32E	64W	9W	
29	6/28-6/29	49°05'	172°31'W	15SW-4NE		65SW-39NE	62SW	1SW	
30	7/6-7/7	53°44'	173°00'W	22W-37E	63E	15W-27E	63E	2W-1E	
31	7/7-7/8	53°26'	173°01'W	10W-16E	62E	16W-4E	80W	1E	
32	7/8-7/9	53°06'	173°01'W	1W-1E		2W			
33	7/10-7/11	51°29'	173°04'W	111W-72E	61W	11W-6E		3E	
34	7/11-7/12	51°09'	173°01'W	83W-31E	73W	8W-3E		1W-2E	
35	7/12-7/13	50°50'	172°59'W	52W-20E	72W	43W-8E	84W	10W-1E	
36	7/14-7/15	50°29'	173°00'W	21W-12E	64W	49W-8E	86W	15W-3E	
37	7/16-7/17	50°29'	170°00'W	32E-38W	54W	10E-43W	81W	15E-10W	60E
38	7/17-7/18	50°54'	170°02'W	122E-110W	<sup>3</sup>	34E-85W	<sup>3</sup>	11E-19W	<sup>3</sup>
39	7/18-7/19	51°13'	170°02'W	93W-39E	<sup>3</sup>	39W-24E	<sup>3</sup>	14W-9E	<sup>3</sup>
40	7/19-7/20	51°32'	170°01'W	65NW-73SE	53SE	33NW-39SE	54SE	11NW-4SE	
41	7/20-7/21	51°51'	169°59'W	204W-102E	67W	448W-161E	74W	58W-20E	74W
42	7/22-7/23	52°15'	170°00'W	60W-29E	67W	412W-129E	76W	45W-18E	71W
43	7/24-7/25	53°05'	166°05'W	24W-19E	56W	1050W-165E	87W	43W-33E	56W

<sup>1</sup> Heading direction of salmon. (Net lay direction of usable catches was approximately perpendicular to the heading direction shown.)

<sup>2</sup> Percentage of dominant direction—usable catches only.

<sup>3</sup> Net turned during set—direction estimated.

TABLE 4. Direction of movement of salmon as indicated by gillnet catches of the MV *Pioneer*, 1960.

Set no.	Date	Position of set		Direction by species <sup>1</sup>					
				Sockeye		Chum		Pink	
				Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>	Number	Percent <sup>2</sup>
1	5/27–5/28	50°07'	170°04'E	24E–36W	60W	4E–17W	81W	1W	
2	5/28–5/29	51°00'	170°00'E	6SE–6NW		3SE–11NW		31NW	100NW
3	5/29–5/30	52°00'	170°00'E	7SE–29NW		6SE–90NW		1SE–22NW	96NW
4	5/30–5/31	53°02'	170°00'E	4SW–27NE	81NW	2SW–19NE	94NW	90NE	1SW–5NE
5	6/4–6/5	54°03'	171°04'E	7SE–4NW		3SE–44NW	94NW	3SE–7NW	
6	6/5–6/6	53°58'	172°46'E	5E–6W		4E–10W		2E–3W	
7	6/6–6/7	53°48'	174°13'E	7E–1W		4E		1E–10W	
8	6/7–6/8	53°37'	175°54'E	37NE–4SW	90NE	67NE–3SW	96NE	33NE–4SW	89NE
9	6/8–6/9	53°14'	178°08'E	4SE–1NW		3SE–14NW		4SE–11NW	
10	6/9–6/10	52°52'	179°51'W	2SE–6NW		3SE–6NW		1SE–3NW	
11	6/10–6/11	52°24'	178°00'W	28?		18?			
12	6/17–6/18	53°00'	176°58'W	8SW–116NE	*	12NE		4SW–7NE	
13	6/18–6/19	54°03'	177°05'W	198E–9W	96E	15E–15W	50W	1E	
14	6/19–6/20	55°01'	176°58'W	130E–6W	94E	29E–8W	78E	2E	
15	6/20–6/21	55°00'	178°52'W	14NW–10SE	58NW	74NW–15SE	83NW	58NW–7SE	89NW
16	6/22–6/23	54°57'	179°23'E	3SW–39NE	93NE	4SW–1NE		5SW	
17	6/24–6/25	54°59'	174°57'E	7N–2S		24N–6S	80N	26N–8S	77N
18	6/26–6/27	53°00'	175°00'E	11NW–1SE		171NW–53SE	76NW	18NW–1SE	
19	6/28–6/29	50°59'	174°55'E	71NW–20SE	78NW	45NW–13SE	78NW	4NW–1SE	
20	6/29–6/30	50°01'	175°03'E	76NW–32SE	70NW	15NW		4NW–1SE	
21	7/1–7/2	49°01'	179°56'W	19N–3S	86N	19N–3S	86N		
22	7/2–7/3	50°02'	178°36'W	41W–13E	76W	28W–3E	90W	2W	
23	7/3–7/4	51°20'	176°45'W	61SW–34NE	64SW	29SW–36NE	55NE	2SW–1NE	
24	7/13–7/14	53°18'	173°12'E	26N–4S	87N	32N–18S	64N		
25	7/15–7/16	52°22'	172°50'E	180W–37E	83W	76W–19E	80W	1W–1E	
26	7/16–7/17	52°00'	173°00'E	79W–16E	83W	55W–22E	71W	2W	
27	7/17–7/18	51°39'	173°02'E	116NW–23SE	83NW	100NW–12SE	89NW	2NW	
28	7/18–7/19	51°20'	173°00'E	61NW–12SE	84NW	13NW–1SE			
29	7/26–7/27	51°20'	178°00'E	90N–62S	59N	50N–24S	68N	12N–1S	
30	7/27–7/28	51°00'	178°00'E	84N–254S	70S	13N–14S	52S	3N–1S	
31	7/28–7/29	50°39'	178°02'E	86NE–158SW	66SW	8NE–25SW	76SW	1SW	
32	7/29–8/1	50°20'	178°00'E	149NW–76SE	*	23NW–8SE	*	1SE	
33	8/13–8/14	51°28'	176°30'W	67NW–351SE	84SE	52NW–33SE	61NW	4SE	
34	8/16–8/17	51°00'	176°30'W	76N–186S	71S	28N–70S	71S		
35	8/17–8/18	50°40'	176°30'W	41NW–212SE	84SE	16NW–77SE	83SE		
36	8/18–8/20	50°20'	176°30'W	147S–88N	*	28S–8N	*	1N	
37	8/23–8/24	52°43'	159°58'W	2W		18W–21E	54E		
38	8/24–8/25	53°15'	160°00'W	3W–3E		12W–15E	56E	1E	
39	8/25–8/26	54°17'	160°00'W	4SE		1NW–5SE		1NW–2SE	

<sup>1</sup> Heading direction of salmon. (Net lay direction of usable catches was approximately perpendicular to the heading direction shown.)

<sup>2</sup> Percentage of dominant direction—usable catches only.

<sup>3</sup> Net turned during set—direction estimated.

sonal observation of gillnet catches during the 1956 to 1959 seasons corroborate this impression that maturity of chum catches was generally similar to that of sockeye catches at the same time and location.

Although it is not now possible to cite specific maturity data with regard to direction of movement,

it can be stated that the direction of movement presented for chum salmon is essentially that of mature fish in May and June and of immatures in July and August.

Pink Salmon.

All pink salmon caught were mature.

TABLE 5. Maturity of the total sockeye salmon catch compared with that portion providing usable direction data, by season, 1959 and 1960.

Season	Year	Total catch				Direction catch			
		Catch	Number examined	Mature		Catch	Number examined	Mature	
				Number	Percent			Number	Percent
May-June	1959	2768	2178	2031	93	2127	1672	1538	92
July-August	1959	4198	2013	313	16	3542	1654	242	15
Total	—	6966	4191	2344	—	5669	3326	1780	—
May-June	1960	4236	3992	3575	90	2880	2541	2197	86
July-August	1960	4363	3844	526	14	3462	3105	466	15
Total	—	8599	7836	4101	—	6342	5646	2663	—

TABLE 6. Contrast in direction of movement of mature sockeye salmon compared to immatures in the same catch.

Set no. <sup>1</sup>	Mature		Immature	
	No. of fish by direction	Dominant direction (percent)	No. of fish by direction	Dominant direction (percent)
27	25NE-18SW	58NE	9NE-23SW	72SW
33	20W-32E	62E	66W-32E	67W
40	30NW-21SE	59NW	28NW-40SE	59SE
41	15W-28E	67E	162W-55E	75W

<sup>1</sup> MV *Paragon*, 1960 (see Table 3 for locations).

#### DIRECTION OF MOVEMENT

##### Sockeye Salmon, 1959.

*May-June.* North Pacific catches during May and June (Fig. 1) show that the predominant movement of sockeye salmon was northward with some indication of westward movement. Catches west of 180° indicated a northward direction of movement, whereas the movement on 180° was westward and variable elsewhere. A single catch near Adak Island indicated a southward movement.

In the Bering Sea during May and June, the majority of catches show either a northward or an eastward directional movement component; most catches were between 175° W. and 180° longitude. Three catches nearest the central Aleutians show westward and northwestward movement in contrast to the dominant directions of movement.

*July-August.* Catches during July and August (Fig. 2), due to a concentration of fishing effort, were almost entirely from the North Pacific and show a dominant southwestward to westward movement by 71 percent of the catches. Somewhat in contrast, a catch on 175° W. indicated southward and two catches on 160° W. indicated northward movement.

A single catch in the Bering Sea (175°E.) indicated northward movement.

##### Sockeye Salmon, 1960.

*May-June.* Catches in the May-June period from the North Pacific (Fig. 3) show the main movement as westward to northwestward. One of these catches was nearly 500 miles south of the Aleutian Chain.

Bering Sea catches of sockeye salmon in May and June show the dominance of a general eastward movement; seven of eight catches indicated north-eastward, eastward or southeastward movement. A contrasting northwestward movement was shown by a single catch. Most catches were located near or between 175° W. and 180° longitude.

*July-August.* North Pacific catches of sockeye salmon during July and August (Fig. 4) showed westward or northwestward movement east of 175° W. and west of 175° E. in each of 10 catches; these closely spaced catches, most at 20 mile intervals, pointed out the apparent similarity of movement near shore and offshore at some points along the Aleutian Chain. Between 175° W. and 175° E. eight catches indicated five different directions of movement, although catches nearest the Aleutians did show a general southward movement ranging between south-eastward and southwestward.

Turbulent hydrographic conditions encountered immediately south of the central Aleutians (175° W.-180°) and the resulting difficulty in determining direction of net lay no doubt contributed to the apparent variation in movement shown in this area, particularly in July and August 1960. To what extent turbulent hydrographic conditions, such as tidal currents and eddies, affected movement of fish is unknown, but some effects on the gillnet string were observed, namely, irregular net lay and at times tangled nets.



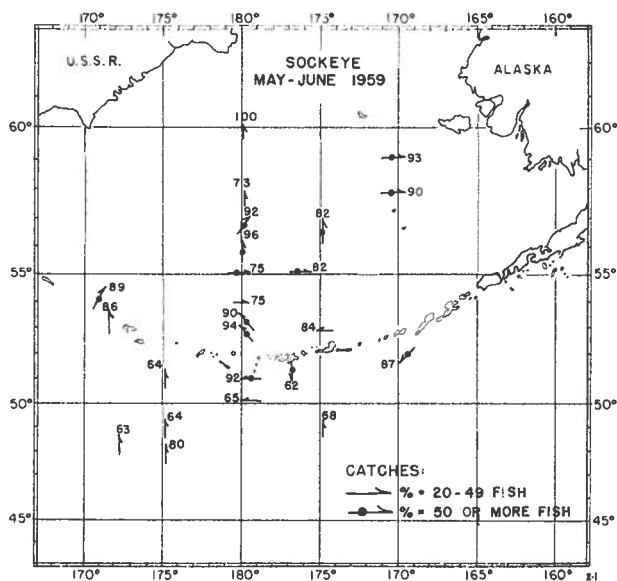


FIGURE 1. Dominant direction of movement of sockeye salmon indicated from gillnet catches of the *Pioneer* and *Tordenskjold* during May and June 1959. Numbers are percentage of catch. Catches were composed mostly of mature fish.

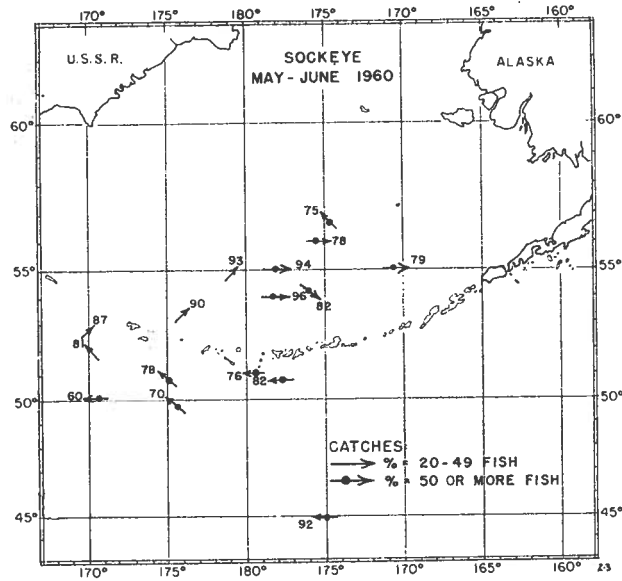


FIGURE 3. Dominant direction of movement of sockeye salmon indicated from gillnet catches of the *Paragon* and *Pioneer* during May and June 1960. Numbers are percentage of catch. Catches were composed mostly of mature fish.

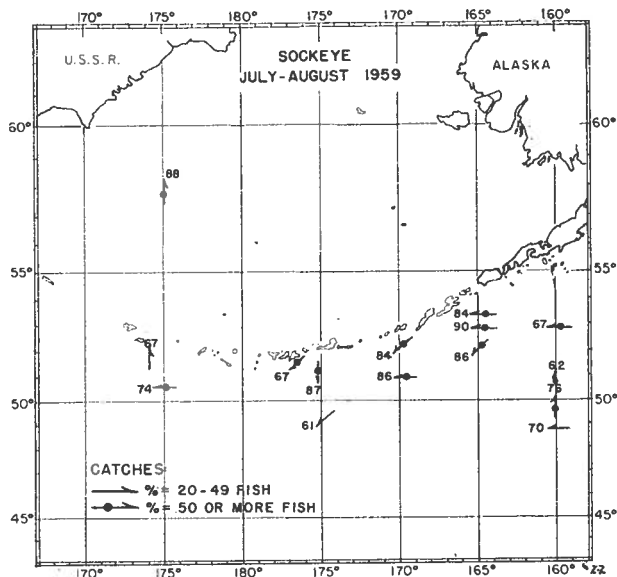


FIGURE 2. Dominant direction of movement of sockeye salmon indicated from gillnet catches of the *Pioneer* and *Tordenskjold* during July and August 1959. Numbers are percentage of catch. Catches were composed mostly of immature fish.

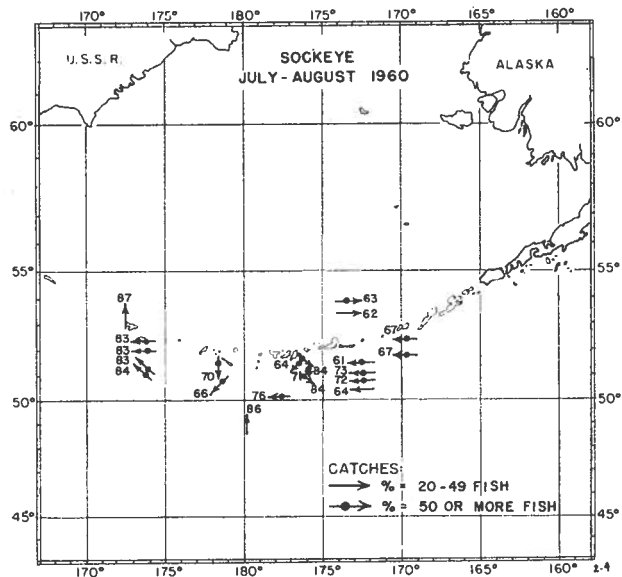


FIGURE 4. Dominant direction of movement of sockeye salmon indicated from gillnet catches of the *Paragon* and *Pioneer* during July and August 1960. Numbers are percentage of catch. Catches were composed mostly of immature fish.

The two catches in the eastern Bering Sea during July and August indicated an eastward movement; these were adjacent catches on 173° W, near the Aleutian Chain. A third catch immediately north of Attu Island showed northward movement.

#### Sockeye Salmon, 1959 and 1960.

*May-June.* Dominant movement direction during May and June (Fig. 5) was westward along the central Aleutians changing to a dominance of northward

movement south of the western Aleutians with indications of northward and eastward movement in the Bering Sea. The eastward movement in the Bering Sea was most pronounced in the 1960 season.

*July-August.* July and August catches (Fig. 6) show movement that was generally westward; nearly all fishing effort was concentrated in the North Pacific Ocean in both years. Fishing effort shifted from the eastern and central Aleutians in 1959 to the central and western Aleutians in 1960, and in 1960 adjacent catches near the central Aleutians area, particularly between 175° W. and 178° E., showed considerable variation in direction of movement. This may have been an area of variable movement, but apparent variation was likely due to inaccuracy in determining direction of net lay caused by turbulent hydrographic conditions. Actual movement may well have been westward as indicated by Hartt (1962).

#### Chum Salmon, 1959.

*May-June.* The direction of movement of chum salmon in the North Pacific during May and June (Fig. 7) was predominantly westward or northward. Movement shown by most catches in the eastern and central Aleutians, both near shore and offshore, paralleled the general contour of the Aleutian Chain, but in the western Aleutians a northward movement was evident.

Bering Sea catches in May and June indicated a westward and northwestward movement near the Aleutian Chain to 55° N., but northward and northeastward movement to 60° N. Most catches were located along 180° longitude.

*July-August.* Catches of chum salmon from the North Pacific during July and August (Fig. 8) were concentrated south of the western Alaska Peninsula to the central Aleutians. Seventy-eight percent of all catches showed either a southwestward, westward or northwestward direction of movement. These included near shore and offshore catches; a third of all catches were more than 200 miles south of the Aleutians. Two adjacent catches on 160° W. indicated opposite directions, one northward, the other southward and both somewhat contrasting the general westward movement.

In the Bering Sea during July and August, two catches indicated northward movement and both were located on 175° E.; a third catch near the eastern Aleutians on 170° W. showed westward movement.

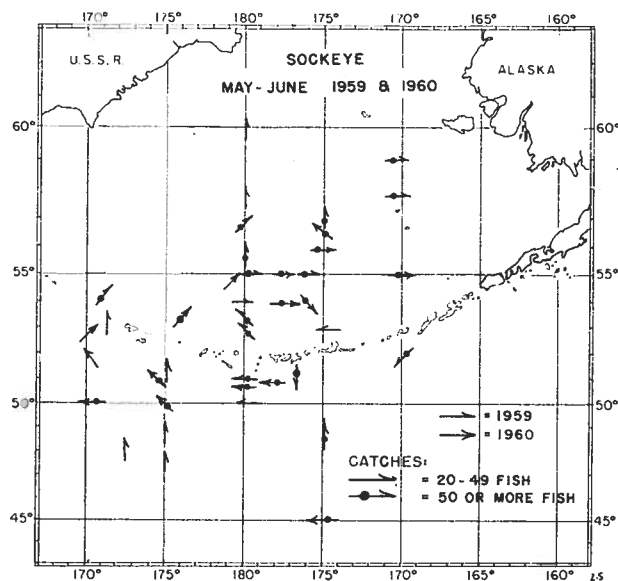


FIGURE 5. Dominant direction of movement of sockeye salmon indicated from gillnet catches during May and June, 1959 and 1960. Catches were composed mostly of mature fish.

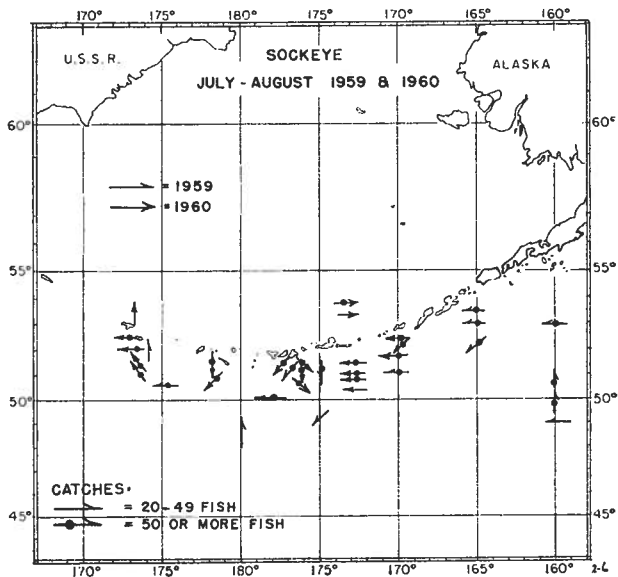


FIGURE 6. Dominant direction of movement of sockeye salmon indicated from gillnet catches during July and August, 1959 and 1960. Catches were composed mostly of immature fish.

#### Chum Salmon, 1960.

*May-June.* The direction of movement of chum salmon in the North Pacific during May and June (Fig. 9) was predominantly southwestward, westward, or northwestward as indicated by 13 of 15 catches ranging to 300 miles from the Aleutians. One catch (on 180°) contrasted the general westward movement,

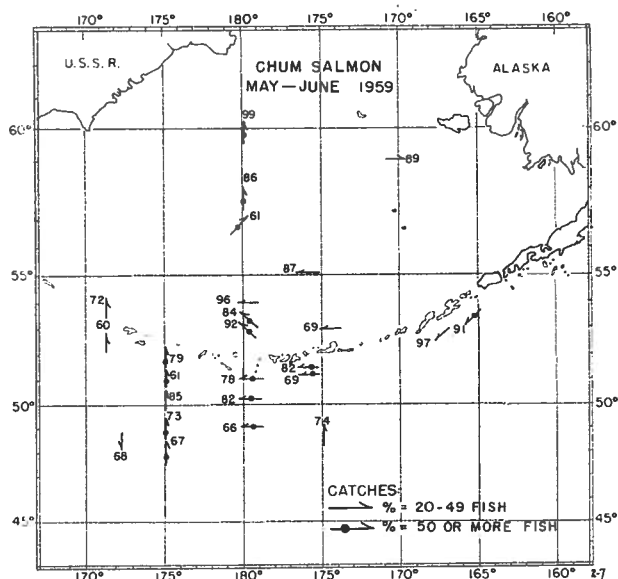


FIGURE 7. Dominant direction of movement of chum salmon indicated from gillnet catches of the *Pioneer* and *Tordenskjold* during May and June 1959. Numbers are percentage of catch. Catches were composed mostly of mature fish.

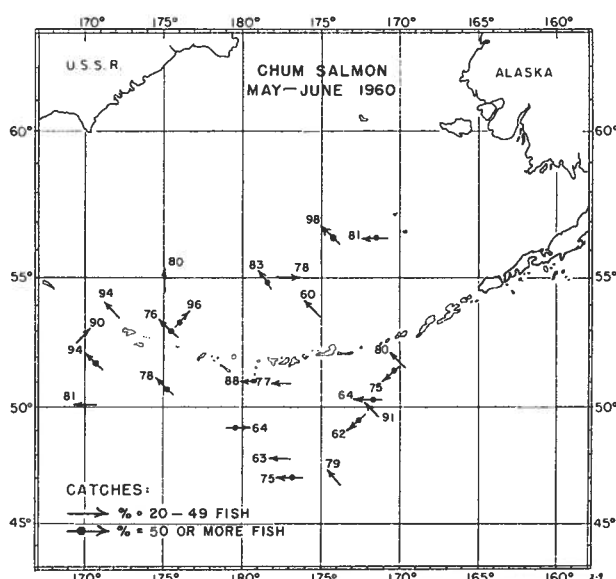


FIGURE 9. Dominant direction of movement of chum salmon indicated from gillnet catches of the *Paragon* and *Pioneer* during May and June 1960. Numbers are percentage of catch. Catches were composed mostly of mature fish.

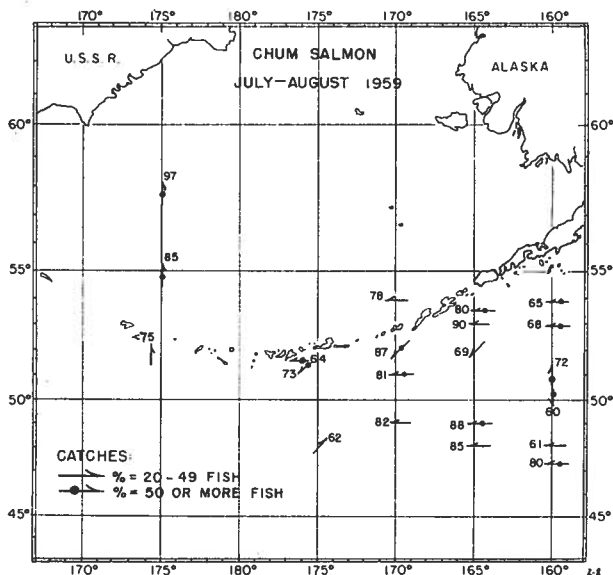


FIGURE 8. Dominant direction of movement of chum salmon indicated from gillnet catches of the *Pioneer* and *Tordenskjold* during July and August 1959. Numbers are percentage of catch. Catches were composed mostly of immature fish.

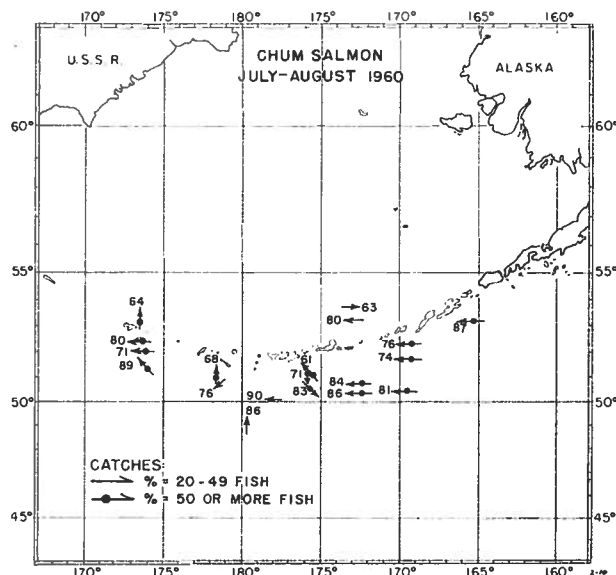


FIGURE 10. Dominant direction of movement of chum salmon indicated from gillnet catches of the *Paragon* and *Pioneer* during July and August 1960. Numbers are percentage of catch. Catches were composed mostly of immature fish.

indicating an eastward direction, and a catch near the western Aleutians showed a northeastward movement.

Six of the nine catches from the Bering Sea in May and June indicated westward or northwestward direc-

tion of movement. Single catches indicated northward, northeastward and eastward movement.

*July-August.* The majority of the catches (12 of 16) from the North Pacific during July and August (Fig. 10) indicated a southwestward, westward or north-

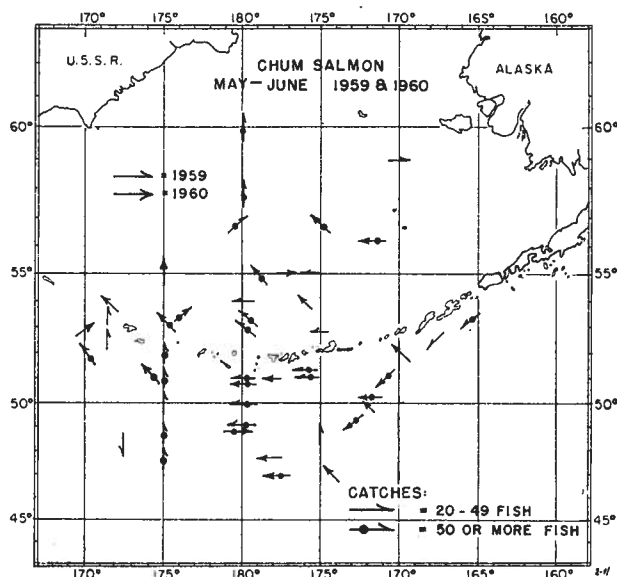


FIGURE 11. Dominant direction of movement of chum salmon indicated from gillnet catches during May and June, 1959 and 1960. Catches were composed mostly of mature fish.

westward direction of movement. Of three adjacent catches south of Attu Island, two indicated a westward movement and the third northwestward. Catches in the eastern Aleutians were consistent in showing a westward movement; however, those in the central Aleutians indicated a wide variation in direction of movement. This variation in movement was particularly evident south of Adak Island where four large catches in a relatively small area indicated four different directions of movement; hydrographic conditions may have influenced interpretation of these data, as mentioned.

Bering Sea catches during July and August consisted of one catch near the western Aleutians (173°E.) showing northward movement and two adjacent catches near the east-central Aleutians (173° W.) which indicated opposite directions of movement, one eastward and the other westward.

#### Chum Salmon, 1959 and 1960.

*May-June.* Catches of chum salmon during May and June (Fig. 11) in both 1959 and 1960 showed a general westward movement on the south side of the eastern Aleutians and both south and north of the central Aleutians to about 54° N. Northwestward and northward movement was evident in the western Aleutians. Movement indicated from the scattered catches in the north-central Bering Sea was generally northward but ranged from westward to eastward.

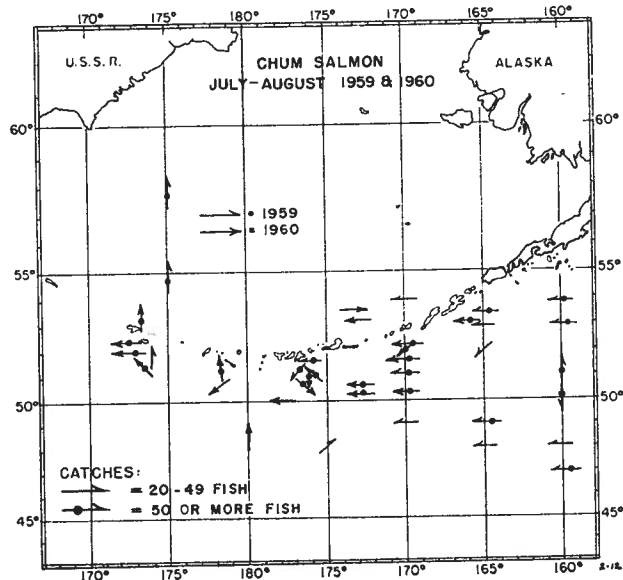


FIGURE 12. Dominant direction of movement of chum salmon indicated from gillnet catches during July and August, 1959 and 1960. Catches were composed mostly of immature fish.

*July-August.* A westward movement was indicated from July and August catches (Fig. 12) in both years south of the eastern Aleutians, but movement near the central Aleutians (175° W.-180°) in 1960 was variable. The fishing effort, farther westward in 1960, provided some evidence of westward and northward movement in the western Aleutians. Few catches in either year were made north of the Aleutian Chain.

#### Pink Salmon, 1959.

*May-June.* Pink salmon catches during May-June (Fig. 13) indicated a dominance (82 percent) of westward, northwestward and northward direction of movement in both the North Pacific Ocean and the Bering Sea. Most catches were from the Bering Sea between 175° W. and 180° longitude. Two of the three small catches in the Bering Sea were distinct in that they were the only catches indicating a southward direction of movement. Two catches nearest the Chain on the south side and all those on the north side through 55° N. indicated a westward or northwestward direction of movement. One catch north of the Pribilof Islands (170° W.) was unique, being the only catch of pink salmon showing an eastward direction of movement.

*July-August.* A general westward movement of pink salmon (southwestward to northwestward) was indicated by six of seven catches concentrated around

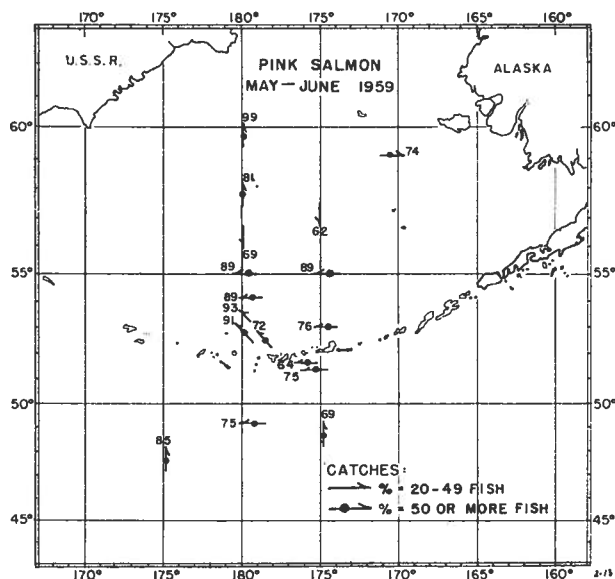


FIGURE 13. Dominant direction of movement of pink salmon indicated from gillnet catches of the *Pioneer* and *Tordenskjold* during May and June 1959. Numbers are percentage of catch. Catches were composed of mature fish.

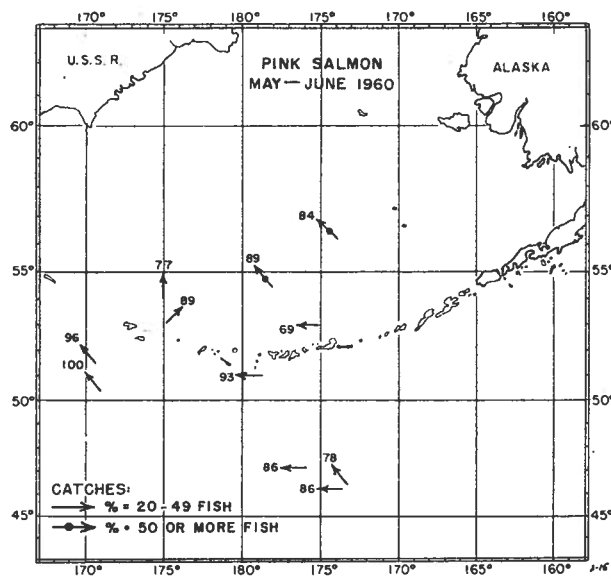


FIGURE 15. Dominant direction of movement of pink salmon indicated from gillnet catches of the *Paragon* and *Pioneer* during May and June 1960. Numbers are percentage of catch. Catches were composed of mature fish.

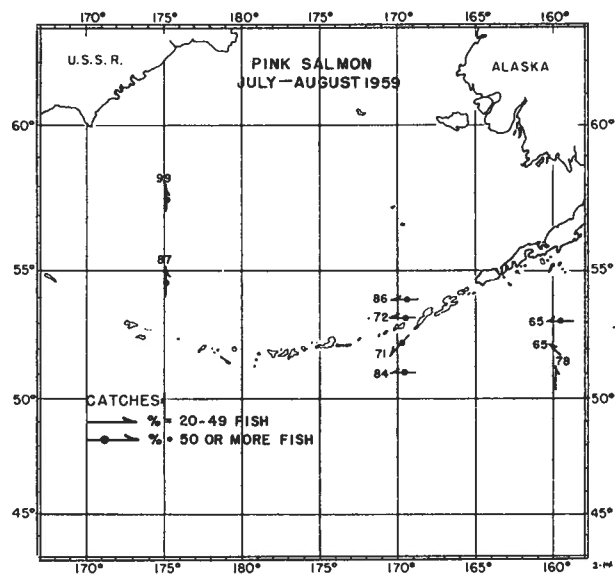


FIGURE 14. Dominant direction of movement of pink salmon indicated from gillnet catches of the *Pioneer* and *Tordenskjold* during July and August 1959. Numbers are percentage of catch. Catches were composed of mature fish.

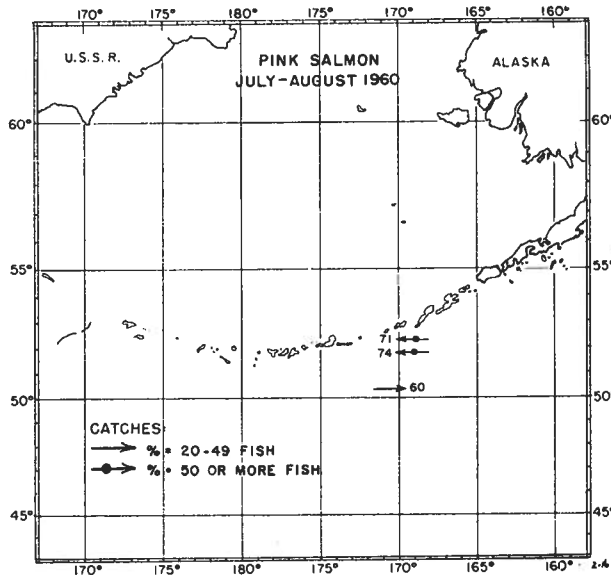


FIGURE 16. Dominant direction of movement of pink salmon indicated from gillnet catches of the *Paragon* and *Pioneer* during July and August 1960. Numbers are percentage of catch. Catches were composed of mature fish.

the eastern Aleutians during July and August (Fig. 14). Two of these were in the Bering Sea and five in the North Pacific; all were on 160°W. or 170°W. Two catches north of the western Aleutians (175°E.) indicated northward movement.

#### Pink Salmon, 1960.

*May-June.* Pink salmon catches in May and June (Fig. 15), although small, few and widespread, showed a general westward movement as much as

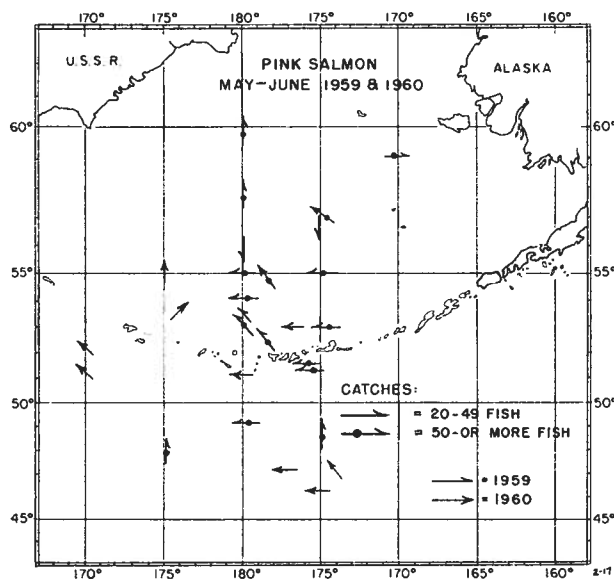


FIGURE 17. Dominant direction of movement of pink salmon indicated from gillnet catches during May and June, 1959 and 1960. Catches were composed of mature fish.

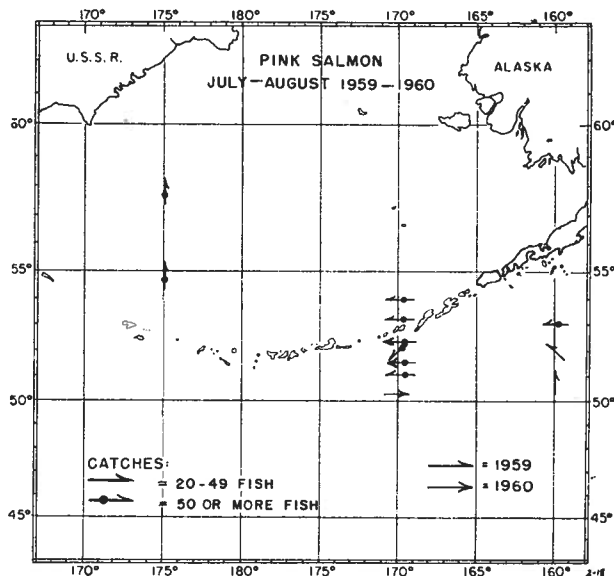


FIGURE 18. Dominant direction of movement of pink salmon indicated from gillnet catches during July and August, 1959 and 1960. Catches were composed of mature fish.

300 miles from the Aleutians in the Bering Sea and the North Pacific Ocean. Nine of 11 catches indicated either a westward or northwestward direction of movement; six of 11 were from the North Pacific.

*July-August.* The three catches of pink salmon in July and August (Fig. 16) were located in a relatively small area immediately south of the Aleutians on

170° W. Two catches indicated a westward direction of movement but the third and farthest offshore catch indicated eastward movement.

Pink Salmon, 1959 and 1960.

*May-June.* Catches of pink salmon in May and June 1959 were large, numerous and located mostly in the central Bering Sea, whereas those in 1960 were small, few and about equally divided between the North Pacific Ocean and the Bering Sea (Fig. 17). The movement indicated by the majority (68 percent) in both years was westward or northwestward, with some indication (18 percent) of northward movement.

*July-August.* July-August catches (Fig. 18) were few in each year and were located mainly in the eastern Aleutians with about two-thirds indicating a general westward movement.

## DISCUSSION

### COMPARISON BETWEEN SPECIES

Movement direction of sockeye, chum and pink salmon during the 1959 and 1960 sampling seasons was similar, particularly in the summer sampling period in the North Pacific. Some variation between species was nevertheless apparent, most noticeably north of the central Aleutians when comparing sockeye with pink salmon and to a somewhat lesser extent when comparing sockeye with chum salmon.

### May-June.

The direction of movement of each species in the North Pacific was predominantly westward south of the eastern and central Aleutians and northwestward to northward south of the western Aleutians during May and June (Figs. 5, 11 and 17). Few pink salmon were caught in the western Aleutians.

Catches of each species in the Bering Sea near the Aleutian Chain and north from 56°N. indicated generally similar movement; however, in the area roughly bounded by latitudes 54°N. to 55°N. and longitudes 175°W. to 179°E., the predominant direction indicated by sockeye salmon catches was eastward as opposed to westward and northwestward by chum and pink. The majority of fish in catches of the May-June period was mature; to spawn, these mature fish travel to streams of the Asian or North American continent. Thus, the difference in direction of movement between sockeye and both chum and pink salmon, particularly pink, implies their ultimate destinations were eastward and westward respectively from this portion of the Aleutian "feeding grounds"

(54° N–55° N.). (An exception would be fish destined for Aleutian Island streams southward from the area referred to.)

#### July-August.

In July and August sockeye and chum catches (Figs. 6 and 12) in the North Pacific showed a marked westward direction of movement. Catches of both sockeye and chum showed an area of variable movement south of the central Aleutians. The few catches of pink salmon (Fig. 18) indicated a direction of movement generally similar to sockeye and chum catches at the same locations although the comparison essentially was that of mature pink with immature sockeye and chum salmon.

Catches in the Bering Sea during July and August were few. Some contrast was noted near the Aleutians between 170° W. and 175° W. where an eastward movement was shown by sockeye salmon catches, whereas chum and pink salmon catches showed predominantly westward movement.

#### COMPARISON BETWEEN GILLNET AND PURSE SEINE

A rough comparison of direction of movement indicated by gillnet catches with that indicated by purse seine catches from 1956–1958 (Hartt, 1962) shows a definite similarity in most Aleutian areas; similarity is apparent for catches of a comparable time and area especially in the North Pacific. Generally the gillnets were fished offshore and purse seines near shore. Maturity composition of the catches from both types of gear was similar.

In the North Pacific, sockeye, chum and odd-year pink salmon catches from both types of gear strongly indicated that the westward direction of movement was predominant. (In the Aleutian waters large numbers of pink salmon have been caught only in odd-numbered years, thus for pink salmon it is 1957 purse seine catches and 1959 gillnet catches which are compared.) This westward movement appears to be generally consistent in both the spring and summer periods in near shore and offshore waters and most evident in the area between 165° W. and 175° W. Purse seine catches indicated a continued westward movement beyond 180° at least to 170° E., particularly for chum and pink, with also some indication of northward movement though the major Aleutian passes. On the other hand, gillnet catches west of 180° to 171° E. showed northward movement as dominant in May and June and westward movement as dominant in July and August for sockeye and chum salmon; few pink salmon were caught in this area.

In the Bering Sea, the direction of movement indicated by purse seine and gillnet catches was clearly westward for pink salmon north of the central Aleutians to 55° N. during May and June, the only period for which data are comparable; with the exception of eastward movement shown for sockeye salmon in the Pribilof Islands area, catches in the Bering Sea of both sockeye and chum salmon were not comparable.

In the North Pacific, the similarity in movement indicated by gillnet and purse seine catches suggests that from May to August between 165° W. and 175° W. and from 48° N. to the Aleutians this was an area of definite westward migration for mature sockeye, chum and pink salmon and immature sockeye and chum salmon; during May and June the westward migration extends to 180° longitude.

In the Bering Sea, similar movement shown by catches from these two types of gear is evident for pink salmon during May and June from the Aleutians north to 55° N.; here, too, a definite westward migration is suggested. Similarity in movement direction of sockeye salmon shown by catches near the Pribilof Islands provides evidence of an eastward migration in that area during May and June.

#### CONCLUSIONS

1. Gillnet catches of sockeye salmon in May and June indicated predominantly mature fish moving westward along the central Aleutians, northward through the western Aleutians and eastward in the Bering Sea between 54° N. and 55° N. and 180° and 175° W. as well as near the Pribilof Islands (160° W.). Dominant movement in the central Bering Sea was northward. July and August catches, mostly of immatures, showed a general westward movement in the North Pacific from 160° W. to 175° W., variable movement between 175° W. and 175° E. and westward to 173° E., the westernmost fishing location.

2. Chum salmon catches in May and June showed a dominance of mature fish moving westward in both the North Pacific and the Bering Sea except northward through the western Aleutians and the west-central Bering Sea. North Pacific catches in July and August were largely immatures moving westward in all areas except the central Aleutians, where variable movement was evident.

3. General westward movement from May through August was shown by all pink salmon catches except those from the central Bering Sea.

4. Similar movement was shown by all species in the North Pacific.

5. A comparison of movement in the Aleutian area indicated by gillnet catches in 1959 and 1960 with that indicated by purse seine catches from 1956–1958 shows general agreement in the North Pacific Ocean, and for sockeye salmon in the Pribilof Islands area of the eastern Bering Sea, as well as for pink salmon throughout the comparable Bering Sea area. Similarity in movement shown by these two types of gear was most evident south of the Aleutians between 165° W. and 180° longitude in May and June and between 165° W. and 175° W. during July and August.

#### LITERATURE CITED

HANAVAN, MITCHELL G., and GEORGE K. TANONAKA. 1959.

Experimental fishing to determine the distribution of salmon in the North Pacific Ocean and Bering Sea, 1956. *U.S. Fish and Wildlife Service, Special Scientific Report—Fisheries*, No. 302, 22 pp.

HARTT, ALLAN C. 1962. Movement of salmon in the North Pacific Ocean and Bering Sea as determined by tagging, 1956–1958. *Int. North Pac. Fish. Comm., Bulletin*, No. 6, 157 pp.

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION. 1960, 1961. *Annual report 1959 and 1960*. Various pagination.

ISHIDA, TERUO, and KIICHI MIYAGUCHI. 1958. On the maturity of Pacific salmon (*Oncorhynchus nerka*, *O. keta* and *O. gorbuscha*) in offshore waters, with reference to the seasonal variation in gonad weight. *Bulletin Hokkaido Reg. Fish. Res. Lab.* (Yoshi, Japan), No. 18, pp. 11–22. In Japanese, with English summary. (Translated by Fisheries Research Board of Canada, Nanaimo, B.C., Translation Series, No. 190.)