DIRECTION OF MOVEMENT OF SALMON IN THE NORTH PACIFIC OCEAN, BERING SEA AND GULF OF ALASKA AS INDICATED BY SURFACE GILLNET CATCHES, 1961

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ABSTRACT

Direction of movement of sockeye, chum and pink salmon on the high seas is described for the spring and summer months of 1961. Individual direction estimates are obtained from surface gillnet catches by applying the side of the net in which the fish were gilled to the average direction of the lay of the net string.

The results indicate, for sockeye salmon, eastward movement in the eastern Bering Sea, westward movement in the western Bering Sea and western Gulf of Alaska during the spring. In the summer, sockeye salmon move northward in the North Pacific Ocean and westward along the Aleutian Chain. Chum salmon move westward in the Bering Sea and western Gulf of Alaska during the spring months and follow the sockeye salmon pattern in the summer. The few usable pink salmon results indicate a northward movement in the north-central North Pacific Ocean and westward movement in the Bering Sea and western Gulf of Alaska.

In areas of comparable sampling, these direction estimates are similar to those obtained from 1961 purse seine catches and as described by Johnsen (1964) for 1959 and 1960 gillnet catches and Hartt (1962) for 1956 to 1958 purse seine catches.

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INTRODUCTION

As the research agency of the United States Section of the International North Pacific Fisheries Commission, one phase of the work of the Bureau of Commercial Fisheries has been to conduct gillnet salmon sampling on the high seas of the North Pacific Ocean, Bering Sea and Gulf of Alaska from 1955 through 1961. Our sampling program is designed to collect salmon for racial analysis, to obtain data for distribution and abundance studies and to study the oceanographic conditions related to salmon distribution and abundance.

Important in the study of salmon distribution and abundance is the direction of travel of the fish encountered on the high seas. By observing this direction at successive intervals in space and time, an indication of migration routes may be obtained.

The application of accurate direction data extends to the problems of determining precise migration routes and continent of origin of high seas caught salmon, and properly interpreting gillnet catches for relative abundance studies.

This report will discuss the analysis of the direction of travel of sockeye (*Oncorhynchus nerka*), chum (*O. keta*) and pink salmon (*O. gorbuscha*) in 1961 as indicated by surface gillnet catches.

PROCEDURES

In 1961, as in past years, the high seas sampling was carried out on chartered fishing vessels. The season began in mid-April with the departure from Seattle of the MV *Marine View*, a 75-foot herring seiner, and MV *Paragon*, an 81-foot halibut schooner, for the central and western Aleutian area. In late May, the 72-foot herring seiner MV *Windward* departed for the western Gulf of Alaska, and in early August a converted Navy AKL (light cargo vessel), the 176-foot MV *Bertha Ann*, left for the central and northern Gulf of Alaska.

Paragon fished in the Bering Sea and western North Pacific until early July, *Marine View* worked the central North Pacific and Bering Sea until late August, *Windward* covered the area south of Kodiak until early September and *Bertha Ann* fished the northern and central Gulf of Alaska until early

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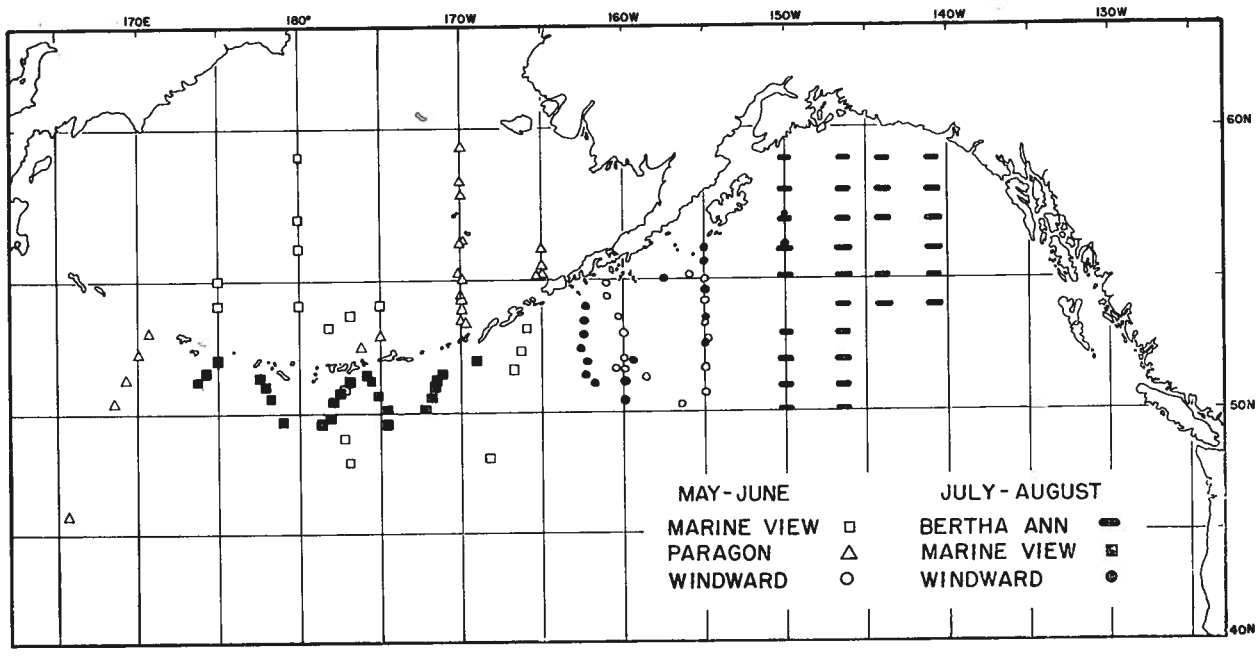

FIGURE 1. Fishing stations of United States research vessels in 1961.

October. Figure 1 shows the stations fished by the four research vessels.

Each vessel was equipped with a 2,000 fathom string of gillnets consisting of 40 shackles of varying mesh sizes and appropriate spare nets for repairs. The only change in the gear from 1959 and 1960 was the addition of four shackles of 3 7/8-inch mesh nets, making a string of four 2½-inch mesh nets, four 3¼-inch mesh nets, four 3 7/8-inch mesh nets, twenty-four 4½-inch mesh nets, and four 5¼-inch mesh nets. At various times through the season this proportion was temporarily changed due to net loss or damage. For complete gear description and make-up see Johnsen (1964) and Hanavan and Tanonaka (1959).

The normal fishing routine consisted of setting the nets at dusk, letting them fish through the night, and hauling an hour or so after dawn. As the nets came aboard, the fish were removed from the nets, and the side of the net from which the fish were gilled, left or right looking from the vessel, was recorded on a tally board. Each fish was marked by clipping either the left or right pelvic fin to retain direction identity throughout processing and placed in bins on deck corresponding to mesh size. The nets were then repiled on the afterdeck in readiness for the next evening's set. When the haul was completed the fish were measured, scale samples taken and the fish frozen for further study in the laboratory.

To determine the direction of travel of the individual fish, the magnetic heading of each shackle was recorded as the nets were hauled. These individual headings were then averaged to give the mean string direction during hauling. This information, when combined with the side of the net from which the fish were gilled, gave an indication of direction of travel by adding 90° to the string direction for left fish and subtracting 90° from the string direction for right fish. For the purposes of this study the direction of movement assigned to the fish is perpendicular to that of the net string although the possible angle of entry into a gillnet approaches 180°. The resulting direction of travel, in degrees, was then corrected for variation to express direction in true degrees.

To minimize handling and classification errors (estimated by Johnsen to be in the order of 10%), and variations in net direction, the following five criteria were applied to each set: (1) length of set: between 8 and 14 hours; (2) net swing: maximum of 90°; (3) individual net variation (within the string): maximum of 90°; (4) 60 percent or more dominance of direction; (5) 20 or more fish of a particular species. Only those sets which met all five criteria were accepted for direction analysis.

Judging from our experience in past seasons and according to Cleaver (MS), the May and June catches

of sockeye salmon are primarily of mature fish and the July, August and September catches are of immature fish in the Bering Sea and Aleutian Islands area. Available maturity data for 1961 show that this maturity separation does not hold for the North Pacific Ocean south of 50°N. or the Gulf of Alaska or for chum salmon.

The maturity study of 1961 catches had not been completed at the time of writing so a presentation of direction of travel for mature and immature salmon separately was not possible. Where maturity is known for a particular area, the fact is mentioned in the results section.

Because of the wide possible angle of entry into the nets and the fact that the direction of set influences the assignment of direction (nets that are set to the south or to the north may have only east or west directions assigned), the individual direction assignments must be regarded as estimates with the possibility of a 90° error to either side of the assignment. Regardless of the limitations of the method we can at least be positive that the majority of the fish was not moving in a direction opposite to the assigned direction. For example, a direction assignment of east would indicate that the fish could be moving north-northeast or south-southeast but not west.

RESULTS

The four research vessels spent a total of 12 vessel-months at sea and fished 126 stations. Elimination of sets that did not qualify under the five criteria for

TABLE 1. Assignment of direction of movement to sockeye salmon caught in gillnets, 1961.

Vessel	Set number	Haul date	Location		Number left	Number right	Total	Percent direction	Haul direction	Individual net variation	Net swing	Predominant direction of travel
			Latitude	Longitude								
Paragon	7	6/10	53°N	175°W	2	20	22	91R	126°	70°	64°	036°
	8	6/12	53.5°N	170°W	60	5	65	92L	022°	60°	10°	112°
	11	6/16	56°N	170°W	17	52	69	75R	233°	25°	31°	143°
	12	6/17	58°N	170°W	0	139	139	100R	218°	85°	25°	128°
	13	6/18	59°N	170°W	2	14	16	88R	204°	65°	34°	114°
	14	6/19	58.5°N	170°W	3	47	50	94R	202°	55°	9°	112°
	19	6/25	53.5°N	170°W	59	12	71	83L	237°	30°	22°	327°
	22	6/29	56°N	165°W	7	147	154	95R	233°	60°	38°	143°
Marine View	10	6/18	53.5°N	176.5°W	11	65	76	86R	225°	30°	13°	135°
	11	6/19	53.5°N	178°W	8	68	76	89R	158°	80°	32°	068°
	13	6/21	56°N	180°	47	7	54	87L	034°	10°	27°	124°
	14	6/23	57°N	180°	21	11	32	66L	240°	35°	8°	330°
	15	6/25	59°N	180°	32	12	44	73L	220°	40°	11°	310°
	16	6/27	55°N	175°E	25	13	38	66L	191°	30°	8°	281°
	20	7/12	50.5°N	177.5°W	6	14	20	70R	059°	90°	6°	329°
	24	7/24	50.5°N	178.5°W	46	8	54	85L	269°	60°	7°	359°
	25	7/25	51°N	178°E	134	19	153	88L	174°	40°	12°	264°
	28	7/29	51.5°N	174.5°E	84	27	107	79L	212°	60°	28°	302°
	29	7/30	51°N	174°E	220	58	278	79L	201°	30°	17°	291°
	32	8/6	50.5°N	175°W	32	13	45	71L	245°	20°	10°	335°
	33	8/7	50°N	175°W	60	27	87	69L	305°	70°	48°	035°
	35	8/10	50°N	172°W	11	18	29	62R	090°	30°	34°	000
	40	8/17	51°N	168.5°W	6	38	44	86R	299°	20°	29°	209°
Windward	2	6/8	53.5°N	160.5°W	3	967	970	100R	356°	10°	40°	266°
	5	6/15	55°N	156°W	11	72	83	87R	342°	75°	17°	252°
	6	6/16	54.5°N	155°W	7	20	27	74R	334°	25°	15°	244°
	10	6/20	51.5°N	155°W	112	11	123	91L	205°	40°	40°	295°
	18	7/10	53.5°N	163°W	0	33	33	100R	349°	40°	21°	259°
	20	7/12	52.5°N	162.5°W	29	58	87	67R	347°	70°	52°	257°
	24	7/25	50.5°N	160°W	47	14	61	77L	231°	40°	81°	321°
	25	7/26	51.5°N	160°W	48	18	66	73L	188°	35°	42°	278°
	26	7/27	52°N	160°W	20	2	22	91L	205°	20°	5°	295°
Bertha Ann	6	8/21	53°N	150°W	20	4	24	83L	233°	30°	30°	323°
	7	8/22	52°N	150°W	32	11	43	74L	232°	20°	15°	322°

TABLE 2. Assignment of direction of movement to chum salmon caught in gillnets, 1961.

Vessel	Set number	Haul date	Location		Number left	Number right	Total	Percent direction	Haul direction	Individual net variation	Net swing	Predominant direction of travel
			Latitude	Longitude								
Paragon	2	5/29	53.5°N	171°E	3	20	23	87R	349°	25°	11°	259°
	13	6/18	59°N	170°W	16	10	26	62L	204°	65°	34°	294°
	19	6/25	53.5°N	170°W	57	9	66	86L	237°	30°	22°	327°
Marine View	5	5/21	48°N	168°W	40	11	51	78L	183°	40°	35°	273°
	10	6/18	53.5°N	176.5°W	22	5	27	81L	225°	30°	13°	315°
	17	6/28	54°N	175°E	43	21	64	67L	197°	10°	13°	287°
	19	7/11	51°N	177.5°W	5	41	46	89R	113°	20°	60°	023°
	21	7/13	50°N	178°W	8	16	24	67R	072°	10°	19°	342°
	24	7/24	50.5°N	178.5°E	42	17	59	71L	269°	60°	7°	359°
	25	7/25	51°N	178°E	46	16	62	74L	174°	40°	12°	264°
	27	7/27	52°N	175°E	14	67	81	83R	067°	75°	19°	337°
	28	7/29	51.5°N	174.5°E	18	9	27	67L	212°	60°	28°	302°
	29	7/30	51°N	174°E	42	19	61	69L	201°	30°	17°	291°
	32	8/6	50.5°N	175°W	47	16	63	75L	245°	20°	10°	335°
	33	8/7	50°N	175°W	135	19	154	88L	305°	70°	48°	035°
	34	8/8	49.5°N	174.5°W	18	41	59	69R	302°	70°	23°	212°
	35	8/10	50°N	172°W	12	39	51	76R	090°	30°	34°	000
Windward	2	6/8	53.5°N	160.5°W	1	231	232	100R	356°	10°	40°	266°
	5	6/15	55°N	156°W	1	34	35	97R	343°	75°	17°	252°
	6	6/16	54.5°N	155°W	12	33	45	73R	334°	25°	15°	244°
	7	6/17	53.5°N	155°W	5	67	72	93R	349°	0°	0°	259°
	8	6/18	53°N	155°W	2	65	67	97R	293°	65°	41°	203°
	10	6/20	51.5°N	155°W	74	1	75	99L	205°	40°	40°	295°
	12	6/22	50°N	156.5°W	0	37	37	100R	090°	0°	15°	000
	13	6/25	51.5°N	158°W	6	17	23	74R	301°	20°	11°	211°
	14	6/27	53°N	158°W	124	17	141	88L	266°	25°	2°	356°
	16	6/29	54.5°N	158°W	5	27	32	84R	285°	10°	40°	195°
	18	7/10	53.5°N	163°W	2	61	63	97R	349°	40°	21°	259°
	22	7/14	51.5°N	162.5°W	13	20	33	61R	109°	10°	39°	019°
	24	7/25	50.5°N	160°W	62	13	75	83L	231°	40°	81°	321°
	25	7/26	51.5°N	160°W	27	4	31	87L	188°	35°	42°	278°
	26	7/27	52°N	160°W	19	4	23	83L	205°	20°	5°	295°
	29	8/17	55.5°N	155°W	5	23	28	82R	175°	30°	20°	085°
	30	8/21	54.5°N	155°W	25	4	29	86L	204°	75°	24°	294°
	31	8/22	53.5°N	155°W	20	5	25	80L	261°	50°	66°	351°
	32	8/23	52.5°N	155°W	124	7	131	95L	272°	5°	7°	002°
Bertha Ann	2	8/13	59°N	150°W	17	5	22	77L	005°	90°	40°	095°
	4	8/18	56°N	150°W	49	193	242	80R	212°	0°	10°	122°
	7	8/22	52°N	150°W	20	9	29	69L	232°	20°	15°	322°
	12	8/27	52°N	147°W	25	8	33	76L	243°	0°	40°	333°
	13	8/29	53°N	147°W	15	8	23	65L	204°	60°	1°	294°
	14	8/30	54.5°N	147°W	6	22	28	79R	220°	50°	39°	130°
	15	8/31	55°N	147°W	209	56	265	79L	224°	70°	20°	314°
	16	9/1	56°N	147°W	31	12	43	72L	269°	50°	19°	359°
	21	9/14	58°N	144°W	12	29	41	71R	350°	80°	37°	260°

TABLE 3. Assignment of direction of movement to pink salmon caught in gillnets, 1961.

Vessel	Set number	Haul date	Location		Number left	Number right	Total	Percent direction	Haul direction	Individual net variation	Net swing	Predominant direction of travel
			Latitude	Longitude								
Marine View	10	6/18	53.5°N	173.5°W	49	13	62	79L	225°	30°	13°	315°
	13	6/21	56°N	180°	4	36	40	90R	034°	10°	27°	304°
	14	6/23	57°N	180°	80	9	89	90L	240°	35°	8°	330°
	15	6/25	59°N	180°	95	13	108	88L	220°	40°	11°	310°
	16	6/27	55°N	175°E	101	8	109	93L	191°	30°	8°	281°
	17	6/28	54°N	175°E	146	35	181	81L	197°	10°	13°	287°
	19	7/11	51°N	177.5°W	7	15	22	68R	113°	20°	60°	023°
	20	7/12	50.5°N	177.5°W	4	31	35	89R	059°	90°	6°	329°
Windward	8	6/18	53°N	155°W	3	21	24	87R	293°	65°	41°	203°
	10	6/20	51.5°N	155°W	106	3	109	97L	205°	40°	40°	295°
	12	6/22	50°N	156.5°W	4	58	62	94R	090°	0°	15°	000
	14	6/27	53°N	158°W	85	2	87	98L	266°	25°	2°	356°
	19	7/11	53°N	162.5°W	55	21	76	72L	252°	15°	48°	342°
	20	7/12	52.5°N	162.5°W	54	29	83	65L	347°	70°	52°	077°
	26	7/27	52°N	160°W	34	0	34	100L	205°	20°	5°	295°

usable sets[1] provided us with data from 34 sets for sockeye salmon, 45 sets for chum salmon and 15 sets for pink salmon which were acceptable. These sets are itemized in Tables 1–3. Generally, the summer season proved the most successful for the collection of direction data, due mainly to better weather in the study area. Late in the summer catches fell off in the Gulf of Alaska and resulted in otherwise usable sets being rejected for lack of an adequate sample. The offshore stations were the most productive in terms of direction data as they were free of the net tangling currents found near the mainland and island chain.

Data from the usable sets are portrayed for species and season (spring—May and June, summer—July, August and September) in Tables 1 through 3 and in Figures 2 through 6 where the larger catches are shown with heavy, full arrows and the smaller catches with light, half arrows. Results of pink salmon analyses are grouped for both seasons because the catch contained only maturing fish.

SOCKEYE SALMON

Spring. As shown in Figure 2, a general westward movement of primarily mature fish was suggested in the western Gulf of Alaska, south of the Alaska Peninsula to about 200 miles offshore. One catch of immature sockeye farther south at 51°30′N., 155°W. indicates a northwesterly movement. In the eastern Bering Sea, a very definite eastward movement is shown, again mature and very likely Bristol Bay fish. Three of four sets in the central and western Bering Sea indicate a westward movement, the fourth set in this area shows a southeasterly movement.

Summer. In Figure 3, the two sets in the central Gulf of Alaska show a northwesterly movement of sockeye salmon. A westward movement of primarily immature sockeye is shown along the south side of the eastern and western Aleutian Chain and a northerly movement south of the center of the Chain. It appears that, during summer, the immature sockeye move up from the south until they encounter the

[1] Elimination of sets due to :

	Criteria 1, 2, 3, 5	Criterion 4
Sockeye	81	11
Chum	75	6
Pink	111	0

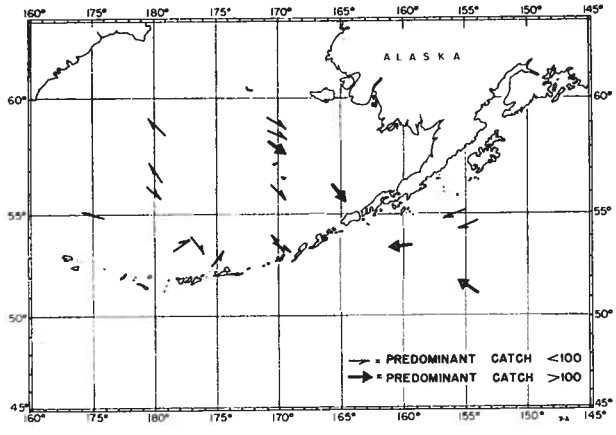

FIGURE 2. Predominant direction of travel of sockeye salmon as indicated by surface gillnet catches, May and June 1961.

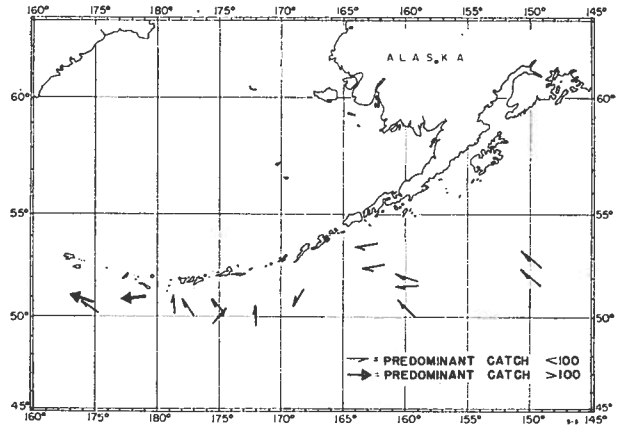

FIGURE 3. Predominant direction of travel of sockeye salmon as indicated by surface gillnet catches, July, August and September 1961.

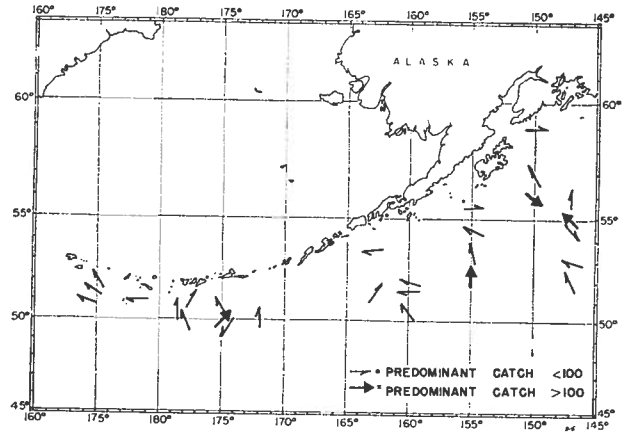

FIGURE 5. Predominant direction of travel of chum salmon as indicated by surface gillnet catches, July, August and September 1961.

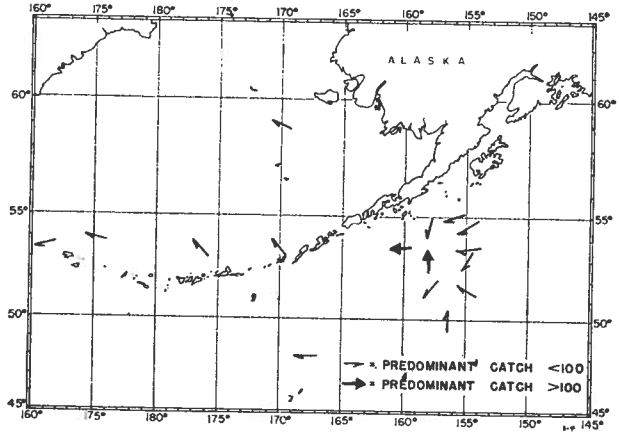

FIGURE 4. Predominant direction of travel of chum salmon as indicated by surface gillnet catches, May and June 1961.

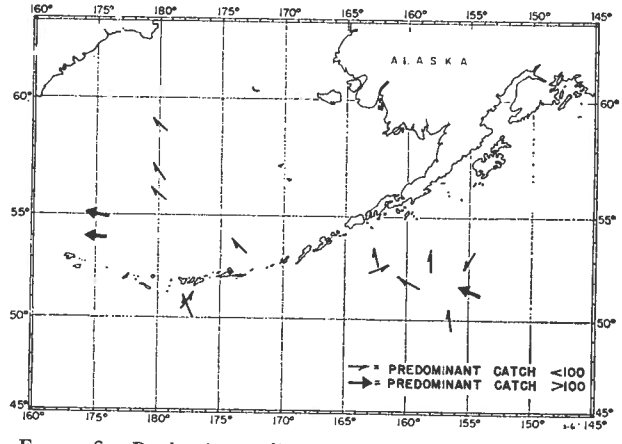

FIGURE 6. Predominant direction of travel of pink salmon as indicated by surface gillnet catches, May, June and July 1961.

Aleutian shelf and then turn westward to follow the Chain. There was no sampling in the Bering Sea during the summer season.

CHUM SALMON

Spring. Except for the western Gulf of Alaska, there are few usable sets during this period for chum salmon, but a northwestward movement is indicated in the eastern Bering Sea (Fig. 4). In the western half of the Bering Sea, two sets show a westward movement. In the western Gulf of Alaska, seven of ten sets show a general westerly movement, as does the single set in the eastern North Pacific Ocean.

Summer. There appears to be a northward movement in the North Pacific up to the central Aleutian Chain and a westward movement along the Chain farther to the west (Fig. 5), similar to the sockeye salmon pattern for this season. The western Gulf of Alaska shows a northerly and westerly direction of travel; movement in the central Gulf area is confusing with northerly, easterly, westerly and southerly directions in adjacent sets. However, the southernmost sets in the Gulf show a northerly movement as noted in the central Aleutian area.

PINK SALMON

Pink salmon direction results are not portrayed for separate seasons as the fish which are taken by the sampling gear are all mature, one-winter-in-ocean fish and few are caught after July.

Data from the central and western Bering Sea indicate a primarily westward movement of pink salmon (Fig. 6). Two sets south of the central Aleutians show northerly travel. In the western Gulf of

Alaska, the direction is basically north and west, but one set shows a southerly movement and another an easterly movement.

Comparison Between Gillnet and Purse Seine Catches

The Fisheries Research Institute of the University of Washington, under contract to the Bureau of Commercial Fisheries, has conducted a salmon tagging study in the Aleutian and Gulf of Alaska areas during the period covered by this report. Hartt (1962) has a complete description of methods and equipment. Four vessels, using salmon purse seines to collect samples for tagging, fished during the spring and summer months. F.R.I. records (unpublished data) show the direction the seine was held open, i.e., the direction from which fish could enter the net, for each set along with the catch for the particular set. When two or more sets were made in the same location on the same day and held open in different directions, an indication of direction of travel of the salmon is shown by comparing the catches. If a set open east takes twice as many fish as one open west in the same area and time, then we assume the majority of the fish caught are moving in a westerly direction.

In interpreting the purse seine catches, the following criteria were applied to single out usable series of sets: (1) two or more sets in the same day; (2) sets in one day within ten miles of each other; (3) at least one of the sets in a day open in a different direction from the others; (4) at least 20 fish of a species in the combined sets of one day; and (5) consistency, in terms of largest or smallest number of fish, in the catches of sets open in the same direction. Of the 347 purse seine sets made during 1961 the majority were at times or in areas removed from the gillnet operations and will not be included here.

Table 4. Assignment of sockeye salmon direction of travel from purse seine catches, 1961.

Vessel	Set number	Date	Location		Direction open	Catch	Predominant direction of travel	Season
			Latitude	Longitude				
Commander	17	6/17	52°52′N	168°32′W	East	99		
	18				West	0	West	Spring
	19				East	380		
Commander	55	7/26	51°23′N	176°50′W	East	68		
	56				West	0	West	Summer
	57				East	51		
Commander	60	8/7	51°30′N	177°30′E	Southeast	127		
	61				Northeast	9	Northwest	Summer
	62				Southeast	119		
Commander	64	8/16	51°30′N	177°30′E	East	40		
	65				West	27	Northwest	Summer
	66				Southeast	105		

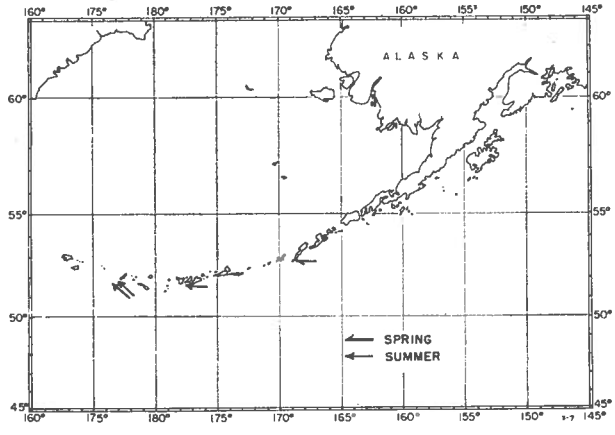

Figure 7. Predominant direction of travel of sockeye salmon as indicated by purse seine catches, 1961.

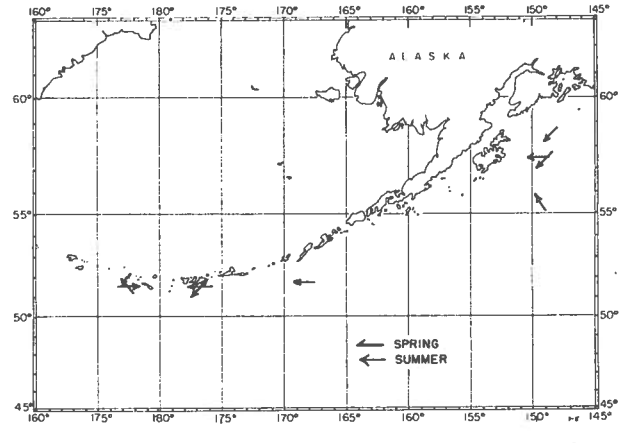

Figure 8. Predominant direction of travel of chum salmon as indicated by purse seine catches, 1961.

TABLE 5. Assignment of chum salmon direction of travel from purse seine catches, 1961.

Vessel	Set number	Date	Location		Direction open	Catch	Predominant direction of travel	Season
			Latitude	Longitude				
Storm	50	7/13	57°30′N	149°30′W	West	4		
	51				East	29	West	Summer
Renown	30	7/17	51°36′N	176°30′W	Northeast	12		
	31				Northeast	20	Northeast	Summer
	32				Southwest	52		
	36	7/21	51°46′N	168°38′W	East	81		
	37				West	4	West	
Storm	57	7/22	57°20′N	149°00′W	Northwest	5		
	58				East	30	Southwest	Summer
	50				Northeast	50		
	60	7/23	58°40′N	148°20′W	East	108		
	61				Northeast	144	Southwest	Summer
	62				West	20		
	67	7/26	55°26′N	149°42′W	Northeast	13		
	68				Northeast	17		
	69				Southeast	25	Northwest	Summer
	70				West	4		
Commander	55	7/26	51°23′N	176°50′W	East	81	West	
	56				West	0		Summer
	57				East	27		
	60	8/7	51°30′N	177°30′E	Southeast	9		
	61				Northeast	3	Northwest	Summer
	62				Southeast	16		
	64	8/16	51°30′N	177°30′E	East	12		
	65				West	44	East	Summer
	66				Southeast	5		
Renown	48	8/22	51°20′N	176°25′W	Northeast	30	Southwest	Summer
	49				West	0		
	50				Southeast	1		

TABLE 6. Assignment of direction of travel to pink salmon caught by purse seine, 1961.

Vessel	Set number	Date	Location		Direction open	Catch	Predominant direction of travel
			Latitude	Longitude			
Commander	17	6/17	52°52′N	168°32′W	East	15	West
	18				West	0	
	19				East	61	
Storm	50	7/13	57°30′N	149°30′W	West	10	
	51				East	28	West
	67	7/26	55°26′N	149°42′W	Northeast	3	
	68				Northeast	4	
	69				Southeast	23	Northwest
	70				West	2	

In accordance with the above limitations, four acceptable purse seine direction assignments fall within the areas in which we have sockeye salmon gillnet data (Table 4). This gives a very limited overlap, but the three summer observations in the western Aleutians are in agreement with the direction indicated by our gillnet catches—westward movement of immatures along the Aleutian Chain (Fig. 7). The single spring direction assignment in the eastern North Pacific Ocean also shows a westward movement.

Usable direction data for chum salmon in the high seas areas are from 10 days (Table 5) and may be

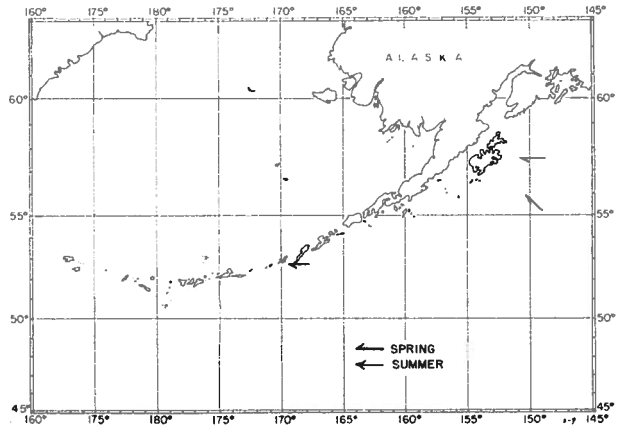

FIGURE 9. Predominant direction of travel of pink salmon as indicated by purse seine catches, 1961.

used to supplement the gillnet data, although considerable variation in the results is noted. In the summer, westward movement along the south side of the Aleutian Chain is evident in three series of sets (Fig. 8), as is true with the gillnet samples, but three other series depart from the pattern established by the gillnet data, showing easterly, northeasterly and southwesterly directions in this area. These three observations may have resulted from a local variation in migration caused by feeding conditions, currents, or perhaps, the capture of chum salmon from different stocks. In the western Gulf of Alaska, generally westward travel of mature chums is shown; gillnet results in this region were extremely variable for chum salmon.

Only three usable series of purse seine sets for pink salmon are in the area of high seas gillnet sampling; one in the eastern Aleutian Islands and two in the western Gulf of Alaska (Table 6). The lone sample in the Aleutian area (Fig. 9) shows a westward movement corresponding to the gillnet data in the Bering Sea. There were no gillnet samples of pink salmon in the Gulf of Alaska for comparison.

In summary then, there is no large contradiction between the available direction information from high seas purse seine and gillnet catches in the relatively small areas where there are comparable data.

COMPARISON WITH PAST YEARS

In comparison with the earlier work on salmon direction, there are some local differences that are readily apparent. For sockeye salmon, Johnsen (1964) shows a slight west and northwest trend in the south-central Bering Sea in the spring of 1959 and 1960 which was not noticed in 1961. During the summers of 1959 and 1960 he also found a considerable variation in the chum salmon directions south of the central Aleutians, with south, southwest, west, northwest, north and southeast movements in contrast to the predominant assignment of northerly directions in 1961.

Hartt (1962), reporting the direction of movement of salmon as measured by purse seine catches for 1956 through 1958, found much the same direction pattern in the Aleutian area as our gillnet samples have shown and further describes in detail the movements inshore and through the island passes not accessible to gillnet sampling.

In general, with relatively minor variations, the 1961 gillnet direction results are similar to the direction results of gillnetting and purse seining during the period 1956 through 1960.

CONCLUSIONS

During the spring, surface gillnet catches suggest that most of the sockeye salmon are eastbound in the eastern half of the Bering Sea (east of 180°) and westbound in the central Bering Sea; westbound sockeye predominate in the western Gulf of Alaska. In summer, the catches suggest that sockeye salmon move northward in the North Pacific Ocean until they near the Aleutian Chain, where a general westward movement occurs.

Chum salmon in the spring are quite variable in their movements, but a general westward trend is seen in the Bering Sea data and western Gulf of Alaska. During the summer season, the chum movement is similar to that of the sockeye salmon in the North Pacific—northward to the Aleutian Chain, then westward. In the Gulf of Alaska, there is a northward movement below 53°N., and east and west movements further to the north.

There are few usable pink salmon data, but these show a northward movement south of the central Aleutians and a general westward movement in the Bering Sea; assigned directions in the western Gulf of Alaska are variable but indicate a general westward movement.

The similarity of results shown for 1956 through 1958 (Hartt, 1962), 1959 and 1960 (Johnsen, 1964) and for 1961 in this report suggests that the general pattern of spring and summer high seas salmon migration in the Aleutian area has been as described above.

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