COMPARISON OF CATCHES OF PACIFIC SALMON BY GILL NETS, PURSE SEINES, AND LONGLINES

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ABSTRACT

Catches of salmon (*Oncorhynchus* spp.) on the high seas in 1963 by gill nets of different mesh size, purse seines, and longlines were compared. The species and size composition differed among the three types of gear. The purse seines generally took higher proportions of small sockeye salmon (*O. nerka*) and chum salmon (*O. keta*) than did the gill nets or longlines. Longlines took proportionately more of the larger salmon than did the gill nets or purse seines. Longlines did not always sample the small sockeye salmon caught by the other two types of gear. Gill nets caught fish of the widest range in lengths. Because they took salmon of sizes not caught by purse seines or longlines, gill nets probably best represent the size composition of salmon in the ocean.

CONTENTS

INTRODUCTION

Canada, Japan, and the United States have conducted joint research for the International North Pacific Fisheries Commission (INPFC) since 1955, during which have they attempted to answer questions raised by the Protocol to the Convention (International North Pacific Fisheries Commission, 1954). Stocks of Pacific salmon (*Oncorhynchus* spp.) have been sampled and tagged to investigate racial origin, distribution, abundance, and migration.

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During the first few years, the United States used two types of gear for sampling Pacific salmon. The Bureau of Commercial Fisheries Biological Laboratory, Seattle, Washington, fished with gill nets to obtain samples to study racial origins, distribution, and abundance. The Fisheries Research Institute of the University of Washington, Seattle, used purse seines to capture salmon for tagging (Hartt, 1962) and to obtain indices of abundance useful in forecasting the size of the runs of sockeye salmon (*O. nerka*) to Bristol Bay. Japan successfully pioneered the use of longlines for sampling and obtaining salmon for tagging. Sampling by the three types of gear is continuing.

Experience has shown that purse seines and longlines provide salmon in much better condition for tagging on the high seas than do gill nets. Because returns from tagging experiments on salmon caught in gill nets were poor, this practice was discontinued. The question arises, however, whether the three types of gear sample the available salmon stocks in a similar manner. The information could have an important bearing on conclusions reached on the distribution of salmon from high seas sampling and from tagging experiments.

The United States and Japan fished jointly in 1959 with gill nets, purse seines, and longlines to compare catches; the experiments were restricted to short periods in mid and late June and in July (Kondo, *et al.*, 1965). These authors compared the length composition by species, including the proportions of small and large sockeye salmon and chum salmon (*O. keta*). The Seattle Biological Laboratory and the Fisheries Research Institute fished jointly with gill nets and purse seines off the central Aleutians during 1963 to compare, over an extended period, catch per unit of effort and catch composition by length, age, and species. Both types of gear were fished to obtain indices of abundance of immature sockeye salmon, which are required to forecast runs of the species. Therefore results obtained from fishing by each type of gear were compared.

Sampling and tagging of high seas salmon have been mainly on fish of at least age .1;[1] some juvenile salmon of age .0 have been taken late in the summer by purse seines and gill nets. (In 1964 the Fisheries Research Institute began sampling and tagging

juvenile salmon in coastal waters with a modified purse seine that contained smaller mesh than used to capture older salmon.) The age groups of the various species of salmon generally available to the three types of gear were ages .1, .2, .3, and .4 for sockeye salmon ; ages .1, .2, .3, .4, .5, and .6 for chum salmon ; age .1 for pink salmon (*O. gorbuscha*) and coho salmon (*O. kisutch*) ; and ages .1, .2, .3, and .4 for chinook salmon (*O. tshawytscha*). Because sampling might be affected by the age composition of available stocks, we expected less variation in size among the catches by the three types of gear for pink and coho salmon than for the other species.

The purpose of this report is to compare quantitatively and qualitatively the catches of salmon by gill nets, purse seines, and longlines, and to assess these results in relation to sampling on the high seas. Results of comparative fishing in 1963 with gill nets and purse seines are presented first. Results of comparative fishing in 1959 with gill nets, purse seines, and longlines given by Kondo *et al.* (1965) are re-examined and results presented after adjustment of gill net catches to give equal weight to each mesh size fished.

EXPERIMENTAL PROCEDURES

Gill nets were set in the evening, allowed to drift during the night, and hauled after 12 hours. Purse seines were set one to three times daily during daylight and were held open 30 minutes before pursing. Longlines were set at dawn and retrieved after 2 to 3 hours of fishing.

The three types of gear were fished simultaneously during the same 24-hour periods except for two sets, 24 to 36 hours apart. All sets in 1959 were within 15 nautical miles of each other ; most sets in 1963 were within five miles of each other and all were within 16 miles of each other. Drift of the gear and vessels often caused further separation by the time the gear was retrieved. Because comparative fishing was typically conducted as close as practicable to the same locations and times, it was assumed that the level of abundance of the different species of salmon available to the various types of gear was the same. Larkins and French (1964) reported that paired gill net sets with two, four, and eight miles between net strings failed to show significant differences in catches of sockeye and chum salmon.

Gill nets and longlines float passively with the current ; fish are caught by swimming into a net or striking a baited hook. Purse seines also float with the current, but enclose a relatively small volume of water and capture all fish too large to escape the $2\frac{1}{2}$-inch mesh. Various factors influenced the sampling efficiency of the three types of gear (Table 1).

The theory of mesh selection was developed to relate the gill net catches to the size and abundance of fish. Regier and Robson (1966) summarized the existing methods for correcting for mesh selection and introduced new ones for lake whitefish (*Coregonus clupeaformis*). Manzer *et al.* (1965) developed gill net selectivity curves for sockeye, chum, and pink salmon which they applied to research vessel catches in the North Pacific Ocean. These authors concluded that the four mesh sizes used by INPFC research vessels in May, June, July, and August ($2\frac{1}{2}$-, $3\frac{1}{4}$-, $4\frac{1}{2}$-, and $5\frac{1}{4}$-inch, stretched measure) adequately covered the size range of salmon available when equal weight was given to each mesh size. The fork lengths considered were 24–70 cm for sockeye salmon, 24–71 cm for chum salmon, and 33–66 cm for pink salmon. The authors further reported that no adjustment for the effects of selectivity appeared necessary. In the present paper, therefore, equal weight was given to each mesh size, and catches were adjusted accordingly. In addition, for certain comparisons corrections for mesh selectivity from curves developed by Peterson (1966) were applied to the length-frequency composition of the gill net catches.

1963 Experiments

United States gill net (*George B. Kelez*) and purse seine (*Commander*) fishing in 1963 took place south of Adak Island, in central Aleutian waters.

The gill net string fished by the *George B. Kelez* consisted of the INPFC standard unit of 24 shackles (each 50 fm long and 4 fm deep). The standard unit is constructed of different mesh sizes in the following order : $4\frac{1}{2}$-, $5\frac{1}{4}$-, $4\frac{1}{2}$-, $3\frac{1}{4}$-, $4\frac{1}{2}$-, and $2\frac{1}{2}$-inch (stretched measure) repeated four times. Two each of $4\frac{1}{2}$- and $3\frac{1}{4}$-inch mesh nets were added to the end of the string to increase sample sizes. Thus, the basic string consisted of 28 shackles of multifilament gill nets. Four shackles of monofilament gill nets were fished experimentally but catches in these nets are not included in this report. In two sets the net strings were reduced—to 12 and 18 shackles.

Gill nets were set in a north-south direction to intercept the salmon, which moved predominantly westward in this area. Purse seines were held open

[1] Age designations in this report follow the system of Koo (1962) in which the number of ocean annuli on the scale is preceded by a demical point (age .1—one winter at sea, etc.), and the number of freshwater annuli (not used in this report) precedes the demical point. Total age is the sum of the two numbers plus 1 year for the time the eggs were in gravel. For example, a 1.2 fish has 1 freshwater annulus, 2 winters in the ocean, and is in its fourth year ; this age corresponds to age 4_2 in the system of Gilbert and Rich (1927).

TABLE 1. Known or presumed factors that influence catches in gill nets, longlines, and purse seines.

Factor	Gear		
	Gill nets	Purse seines	Longlines
1. Time of fishing	8 p.m.–8 a.m.	Daylight	Dawn
2. Number of hours fished	12–14	0.5	2–3
3. Depth of fishing	0–4 fm	0–20 fm	0–0.5 fm
4. Distance on water surface fished	1.6–2.0 miles (28–36 shackles)	0–0.25 mile	1.4 miles (20 skates)
5. Direction gear set relative to movement of fish	Some effect, depending on whether nets are set perpendicular or parallel to fish movement	Major cause of bias in abundance—nets must be open to main direction of fish movement	Possibly some effect similar to that for gill nets
6. Rate of fish movement	Possibly some effect of faster fish being caught more readily than slower fish; fish must come in contact with stationary gear	Larger, faster fish may escape more readily than smaller, slower fish	Some effect; fish must come into contact with stationary gear
7. Physiology of salmon	Probably some effect of time since feeding (modification of girth) and of maturity stage; also affected by preferred depths	No effect except for preference of some fish for depths below 20 fm	Influenced by hunger, feeding habits, aggressiveness, maturity
8. Mesh or hook size	Definite effect of mesh size	No effect on fish of at least age .1	Probably affected by hook and bait size
9. Gear saturation	Possibly some effect—important only in exceptionally large catches	No effect	Definite upper limit to catch
10. Leading of salmon	Possibly some effect of large fish leading along small mesh sizes	No effect	Probably no effect, though fish may be attracted or repelled by those already on hooks
11. Loss or escape from gear	Some effect; some fish drop out	Probably some effect—fish escape before seine is closed	Probably some effect—hooks tear out of mouth
12. Weather, currents, tides	Probably some effect—fishable in moderately rough seas	Definite effect; fishing limited to fairly calm seas	Probably some effect—fishable in moderately rough seas
13. Predators	Some effect	Some effect	Some effect

in an easterly direction in most sets for the same reason. Occasionally the purse seine was held open in other directions to confirm the direction of fish movement. On eight occasions, gill nets and purse seines were fished at about the same location.

1959 EXPERIMENTS

As reported by Kondo *et al.* (1965) Japan and the United States fished together with gill nets, purse seines, and longlines south of Adak Island during the summer of 1959. Three fishing sets with gill nets (United States vessel *Tordenskjold*) and longlines (Japanese vessel *Tenyo Maru*) were made on June 12, 14, and 15; unsuitable weather prevented fishing with purse seines. Longlines (*Tenyo Maru*) and purse seines (United States vessel *Windward*) were fished together on June 19–23; gill nets were not fished. Vessels of the two countries fished together again on July 27–29; the *Pioneer* (U.S.) fished gill nets, the *Commander* (U.S.) fished purse seines, and the *Tenyo Maru* (Japan) fished longlines.

The gill net string fished in 1959 consisted, as in 1963, of the INPFC standard unit of 24 shackles, but 12 shackles of 4½-inch mesh nets were added on the end of the string to increase sample sizes. The purse seine and the method of fishing it were described by Hartt (1962); longline gear and fishing methods were described by Kondo *et al.* (1965).

COMPARISON OF CATCHES IN GILL NETS AND PURSE SEINES—1963

Sockeye and chum salmon are the predominant

TABLE 2. Salmon catches by purse seines (*Commander*) and gill nets (*George B. Kelez*) fished at approximately the same time south of Adak Island in 1963.

Gear	Date of set	Set position		Set no.	Direction of set	Catch by species							
						Sockeye		Chum					
		Lat. (°N)	Long. (°W)			Age .1	Age .2 and .3	Age .1	Age .2 and older	Pink	Coho	Chinook	Total
Purse seines	July 8	51-24	176-20	36	S	8	6	100	2	2	0	0	118
		51-24	176-20	37	E	3	6	4	1	0	0	0	14
		51-23	176-20	38	SE	4	0	78	4	4	0	0	90
Gill nets	July 8-9	51-25	176-23	15	NW	5	33	48	21	90	8	0	205
Purse seines	July 9	51-32	176-24	39	NE	1	0	0	3	1	0	1	6
		51-32	176-24	40	S	2	0	2	1	10	0	1	16
		51-35	176-38	41	NE	0	0	0	0	0	0	0	0
Gill nets	July 9-10	51-32	176-19	16	NNW	4	6	45	9	9	2	1	76
Purse seines	July 10	51-20	176-19	42	S	3	1	41	1	2	1	0	49
		51-20	176-19	43	E	63	1	24	5	3	4	1	101
		51-20	176-19	44	E	44	12	10	2	2	0	0	70
Gill nets	July 10-11	51-20	176-15	17	NW	10	28	0	2	9	4	0	53
Purse seines	July 17	51-30	176-22	45	E	25	2	8	4	5	3	0	47
		51-23	176-20	46	SE	17	6	0	0	1	10	0	34
		51-18	176-21	47	SE	83	30	3	2	1	6	0	125
Gill nets	July 16-17	51-14	176-17	19	SE	27	101	6	23	9	43	0	209
Purse seines	July 19	51-33	176-25	48	E	40	14	11	7	3	0	1	76
Gill nets	July 17-18	51-22	176-24	20	NW	56	223	17	27	5	93	0	421
Purse seines	July 27	51-38	176-22	49	E	5	1	0	6	0	0	0	12
		51-38	176-22	50	W	0	0	0	0	0	1	0	1
		51-26	176-25	51	E	286	42	11	37	0	1	1	378
Gill nets	July 25-26	51-29	176-22	24	N	465	254	5	29	4	10	0	767
Purse seines	July 28	51-35	176-22	52	E	39	14	2	12	0	0	1	68
		51-30	176-22	53	E	11	3	2	4	1	5	0	26
		51-38	176-20	54	E	66	12	2	3	0	1	1	85
Gill nets	July 28-29	51-35	176-22	25	NW	39	33	2	19	3	5	0	101
Purse seines	Aug. 4	51-37	176-25	55	E	244	1	43	42	0	0	0	330
Gill nets	Aug. 4-5	51-35	176-22	31	SW	266	28	58	18	1	11	1	383
Total	(20 seine sets)					944	151	341	136	35	32	7	1,646
Total	(8 gill net sets, 198 shackles)					872	706	181	148	130	176	2	2,215

species near the central Aleutian Islands during summer; most pink salmon of the sizes available to the fishing gear have left this area by then for spawning streams. Coho and chinook salmon are less abundant on the high seas than the other three species.

Total catches (Table 2) depended on the amount of effective fishing effort and on the availability of salmon. Many other factors (Table 1) undoubtedly influenced the numbers caught. The species composition of the catches depended upon the type of gear (Table 3). Gill nets and longlines sampled available age groups of sockeye salmon differently, but there was no evidence of this difference for chum salmon (Table 3). Catch data in Table 3 have been adjusted to give equal weight to each mesh size. The data suggested that purse seines took a larger proportion of age .1 (smaller) sockeye salmon than did gill nets. Gill nets took more mature sockeye salmon

TABLE 3. Comparison of age and species composition of salmon catches by gill nets and purse seines fished at approximately the same time south of Adak Island in 1963; gill net data shown in Table 2 have been adjusted to catch per four shackles of each mesh size.

a. Sockeye and chum salmon

Gear	Sockeye			Chum		
	Total	Age .1	Age .2 and .3	Total	Age .1	Age .2 and older
Gill nets	1,154	839 (72.7%)	315 (27.3%)	269	191 (71.0%)	78 (29.0%)
Purse seines	1,095	944 (86.2%)	151 (13.8%)	477	341 (71.5%)	136 (28.5%)
	Chi-square = 61.58 ($P < 0.001$)			Chi-square = 0.008 ($P < 0.90$)		

b. Sockeye and chum (age .2 and older), and pink and coho salmon

Gear	Total	Sockeye	Chum	Pink	Coho
		Age .2 and .3	Age .2 and older		
Gill nets	546	315 (57.7%)	78 (14.3%)	51 (9.3%)	102 (18.7%)
Purse seines	354	151 (42.7%)	136 (38.4%)	35 (9.9%)	32 (9.0%)
	Chi-square = 73.46 ($P < 0.001$)				

than did purse seines. Of the 315 sockeye salmon (age .2 and .3) taken by gill nets, 59 (19%) were maturing. In contrast, of 151 sockeye salmon of the same ages taken by purse seines, only six (4%) were maturing.

Hartt (1966) reported that the direction a purse seine was held open influenced the numbers of mature sockeye salmon caught near Adak Island during the summer. The direction the gear is set relative to movement of salmon was indicated earlier (Table 1) to be a major cause of bias in purse seine catches. During July and August, when immature salmon predominate in the samples, mature sockeye salmon tended to move easterly or northeasterly in contrast to the westerly movement of immature fish. Although 4 of 20 purse seine sets (Table 2) were held open to the south or southwest, catches were too small to indicate the influence of direction of set on a comparison of the relative abundance of mature sockeye salmon in purse seines and gill nets.

Sockeye salmon (age .2 and .3 only) and coho salmon were caught in comparatively larger numbers in gill nets than in purse seines. Pink salmon catches were about the same for each gear; gill nets took a smaller proportion of chum salmon (age .2 and older) than did purse seines.

Under the conditions of the joint fishing experiments in 1963, we concluded that the age and species composition of salmon catches was dependent upon the gear used, but in most instances the differences were not exceptionally large.

SOCKEYE SALMON

Frequency distributions of the fork lengths of sockeye salmon (Figure 1) taken by gill nets and purse seines differed significantly at the 5% level (Kolmogorov-Smirov two-sample test; Siegel, 1956). The smallest fish (26 cm) were caught in both gears, but fish longer than 59 cm were taken only in gill nets.

Although gill net catches were adjusted to give equal weight to each mesh size, it was pertinent to examine the data for possible bias due to mesh selectivity as well. Mesh selection curves derived by Peterson (1966) from high seas samples, and as constructed and applied from the average of yearly values

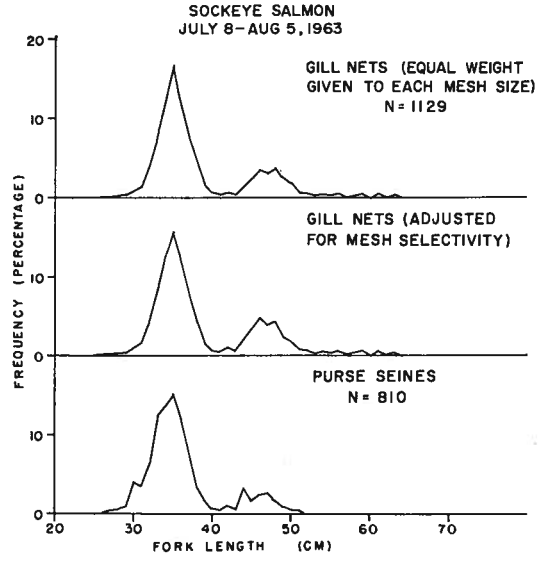

FIGURE 1. Comparison of length frequencies of sockeye salmon taken by gill nets and purse seines, 1963.

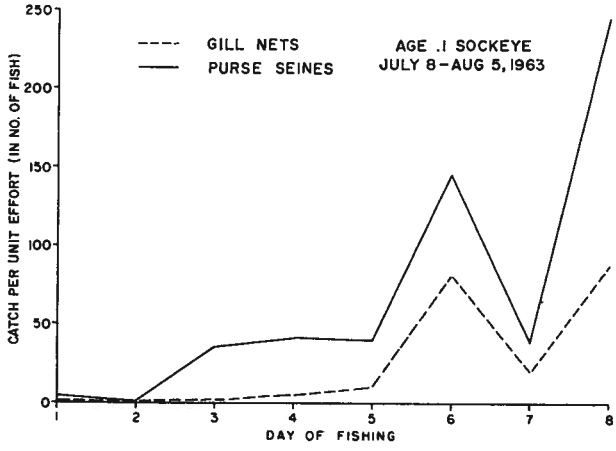

FIGURE 2. Comparison of indices of abundance of age .1 sockeye salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

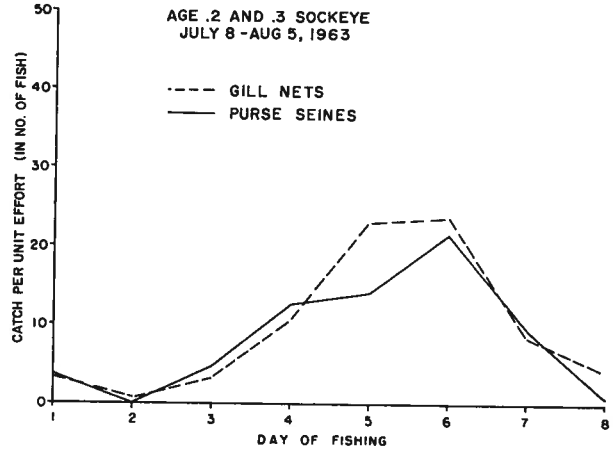

FIGURE 3. Comparison of indices of abundance of age .2 and .3 sockeye salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

(Lander and Tanonaka, 1964), were used to adjust the length observed from gill net catches for the effects of mesh selectivity. The resultant distribution was compared first with length data in which equal weight was given to each mesh size, and secondly to the purse seine data. No significant differences were found between the two curves constructed from gill net data, but the length-frequency distribution of the gill net catches differed significantly from that of the purse seine catches (Figure 1). These comparisons indicated that purse seines caught relatively more small sockeye salmon than did gill nets. The differences, although significant, were not large.

A comparison of indices of abundance of sockeye salmon as indicated by catches in gill nets and purse

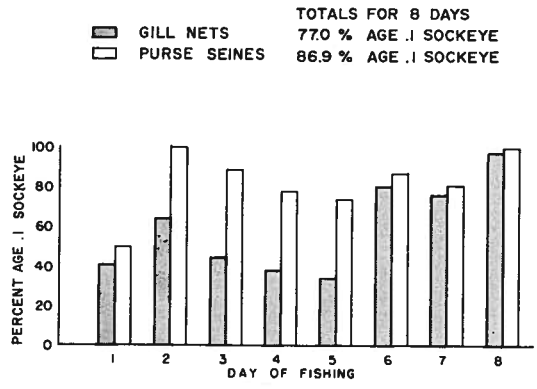

FIGURE 4. Percentages of age .1 sockeye salmon from daily catches of all immature sockeye salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

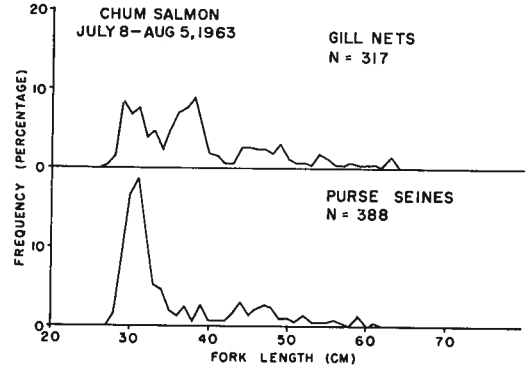

FIGURE 5. Comparison of length frequencies of chum salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

seines is shown in Figures 2 and 3. Abundance indices were computed from the catch per shackle of gear (equal weight given to each mesh size) for gill nets and from the average catch per haul for purse seines. Similar trends in abundance were indicated by catches in the two gears.

Catches of immature sockeye salmon by age group indicated that purse seines took a higher proportion of age .1 fish than did gill nets (Figure 4). Agreement between the two forms of gear in percentage of age .1 fish was typically closest on days of highest total catches.

CHUM SALMON

Comparison of the length-frequency distribution of chum salmon indicated that gill nets and purse seines sampled the available size groups differently (Figure 5). Age .1 chum salmon (35 to 42 cm) formed only a minor part of purse seine catches, but made up a substantial proportion of catches by gill nets—primarily in the $3\frac{1}{4}$-inch mesh nets.

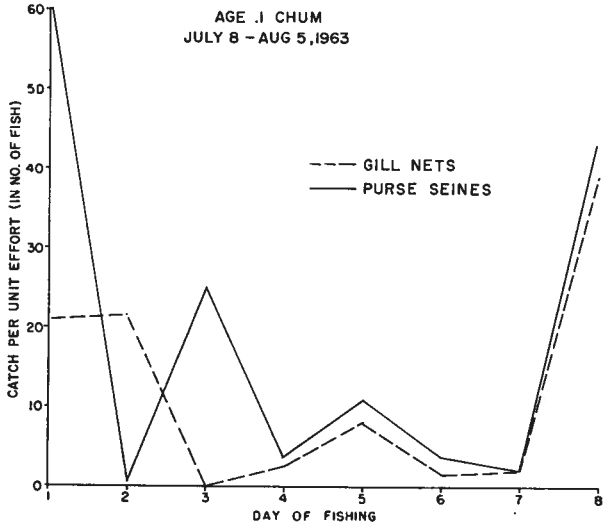

FIGURE 6. Comparison of indices of abundance of age .1 chum salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

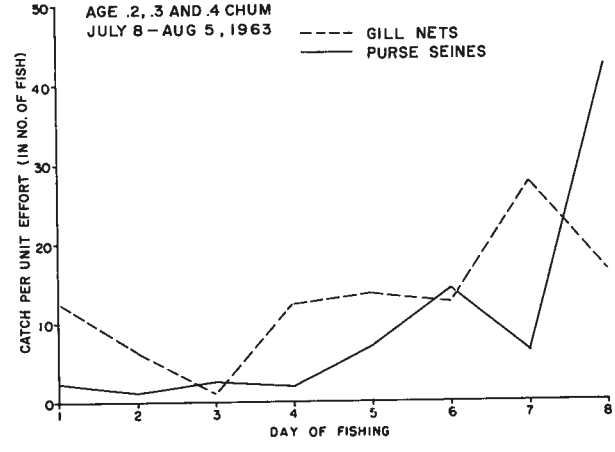

FIGURE 7. Comparison of indices of abundance of age .2, .3, and .4 chum salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

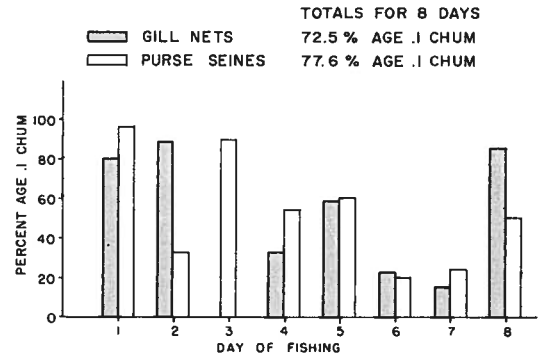

FIGURE 8. Percentages of age .1 chum salmon from total daily catches taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

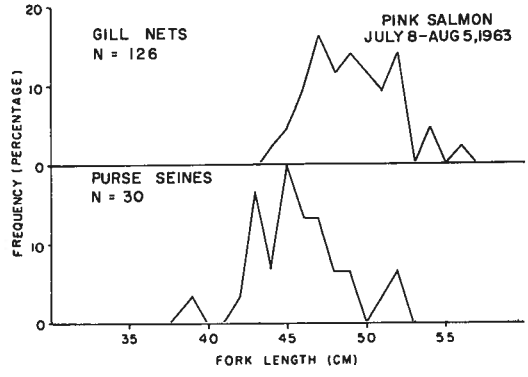

FIGURE 9. Comparison of length frequencies of pink salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

To determine if the gill nets were unduly selective for age .1 fish (35 to 42 cm), catches of chum salmon were corrected for mesh selectivity as described previously for sockeye salmon. The length distribution obtained by applying mesh selection curves was not significantly different from that obtained by giving equal weight to the catch of each mesh size. Thus, the second mode in gill net catches (Figure 5) was not due to mesh selectivity.

Eight-two percent of the age .1 chum salmon less than 35 cm taken by purse seines and 80% of those taken by gill nets (catch adjusted to give equal weight to each mesh size) were taken in the first three days (July 8, 9, 10) of comparative fishing. For chum salmon 35 to 42 cm caught in purse seines, about 38% were taken on the last day of joint fishing (August 4); for those caught in gill nets, 75% came during the last set. The reasons for the much smaller catch of fish of this size group by purse seines is unknown. Possibly fish of this size range were available to gill nets during the night fishing but not to purse seines the previous day.

Indices of abundance for the two main size groups of chum salmon are given in Figures 6 and 7. For age .1 chum salmon, the trends were similar for the last five days of joint fishing but dissimilar for the first three days. The trends in abundance were generally dissimilar for chum salmon of age .2 to age .4; both types of gear, however, reflected an increase in relative abundance during the last five days.

The percentages of age .1 fish in the 8-day total catches of chum salmon by gill nets and purse seines were similar (Figure 8). There were day-to-day dis-

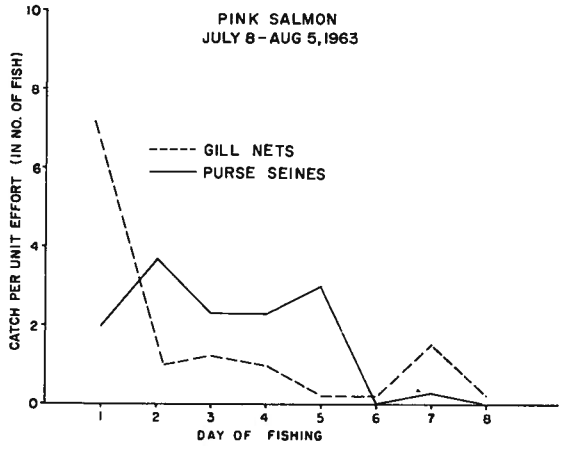

FIGURE 10. Comparison of indices of abundance of pink salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

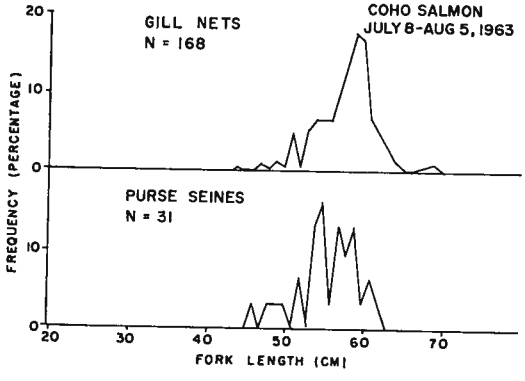

FIGURE 11. Comparison of length frequencies of coho salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

crepancies, however, in the age composition.

PINK SALMON

Length composition of pink salmon taken by gill nets and purse seines (Figure 9) indicated that gill nets took larger fish than did purse seines. The largest sizes caught in gill nets did not appear in the purse seines, nor did the smallest sizes caught in purse seines appear in gill nets. The length distribution of gill net catches, adjusted to give equal weight to each mesh size, differed significantly from the length distribution of purse seine catches; this relationship remained unchanged after the length distribution of gill net catches was corrected for mesh selectivity. Apparently, gill nets selected proportionately more large pink salmon than small ones, whereas the opposite occurred for purse seines.

Trends in the indices of abundance derived for gill nets and purse seines (Figure 10) showed little similarity for the small samples compared.

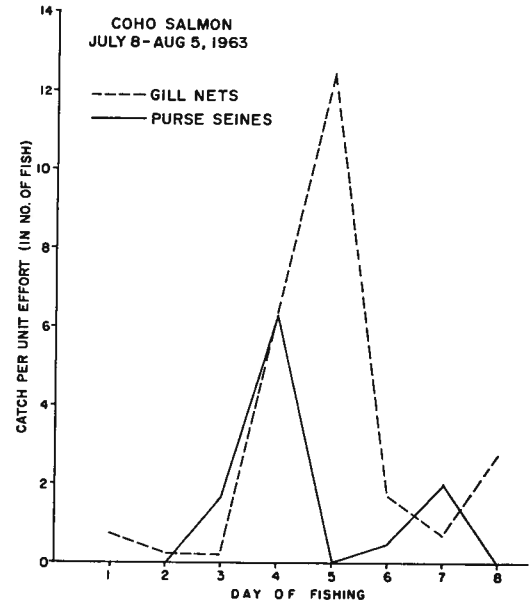

FIGURE 12. Comparison of indices of abundance of coho salmon taken by gill nets and purse seines, 1963. (Gill net data adjusted to give equal weight to each mesh size.)

COHO SALMON

Gill nets and purse seines took coho salmon of similar length (Figure 11), although (as observed for other species) the largest fish were caught in gill nets. The length distributions did not differ significantly between the two types of gear.

Indices of abundance obtained from the two types of gear were dissimilar (Figure 12); those based on purse seine catches were usually lower. On July 19 (day 5), when gill nets made their largest catch of coho salmon, one purse seine haul took none.

COMPARISON OF CATCHES IN GILL NETS, PURSE SEINES, AND LONGLINES—1959

The comparative fishing by Japan and the United States in 1959 permitted comparisons of length, species, and age composition between catches by the three types of gear. Catch data (Table 4) indicated that gill nets took more salmon than either longlines or purse seines during normal fishing operations with the respective amounts of each gear used. Longlines took more salmon than did purse seines when these two types of gear were fished together in late June.

Percentages of the salmon species in catches of the three types of gear (Table 5) indicated that gill nets, purse seines, and longlines fished the stocks differently. Chi-square tests revealed that the age and species

TABLE 4. Salmon catches by gill nets, purse seines, and longlines during comparative fishing south of Adak Island, 1959.

Period, gear and vessel	Date of set	Set position		No. of skates (longlines)	No. of shackles (gill nets)	Direction of set	Catch by species							
							Sockeye		Chum					
		Lat. (°N)	Long. (°W)				Age .1	Age .2 and .3	Age .1	Age .2 and older	Pink	Coho	Chinook	Total
MID-JUNE	6/12	51–31	176–27	50	—	—	0	22	0	20	4	0	0	46
Longlines	6/14	51–23	176–34	21	—	—	0	75	0	15	66	0	1	157
(*Tenyo Maru*)	6/15	51–23	176–34	48	—	—	0	16	0	28	19	0	0	63
		Total		119			0	113	0	63	89	0	1	266
Gill nets	6/12	51–32	176–31	—	36	NW	9	240	0	56	66	0	0	371
(*Tordenskjold*)	6/14	51–32	176–34	—	36	NW	0	53	0	15	22	0	0	90
	6/15	51–31	176–25	—	36	N	2	289	0	117	143	0	0	551
		Total			108		11	582	0	188	231	0	0	1,012
Purse seines (*Windward*)—Weather unfishable for purse seines														
LATE JUNE	6/19	51–29	176–27	50	—	—	0	49	0	61	139	0	0	249
Longlines	6/20	51–18	176–45	20	—	—	0	26	0	35	79	0	2	142
(*Tenyo Maru*)	6/22	51–31	176–26	40	—	—	0	65	0	33	66	2	12	178
	6/23	51–30	176–33	40	—	—	0	99	0	22	87	1	8	217
		Total		150			0	239	0	151	371	3	22	786
Purse seines	6/19	51–30	176–30	—	—	ENE	0	7	0	0	3	0	0	10
(*Windward*)	6/20	51–30	176–30	—	—	WSW	0	4	0	2	2	0	0	8
		51–30	176–30	—	—	ENE	0	17	0	18	53	0	0	88
	6/22	51–30	176–30	—	—	ENE	3	3	0	0	8	0	0	14
		51–30	176–30	—	—	W	0	12	0	3	1	0	0	16
		51–30	176–30	—	—	ESE	0	16	0	3	13	0	0	32
	6/23	51–30	176–30	—	—	ESE	1	15	0	25	71	0	0	112
		51–30	176–30	—	—	ESE	0	3	0	8	33	0	0	44
		Total					4	77	0	59	184	0	0	324
Gill nets—No gill net fishing on June 19–23														
JULY	7/27	50–30	176–37	50	—	—	63	49	3	56	8	36	4	219
Longlines	7/28	51–32	176–39	50	—	—	21	14	0	95	7	43	2	182
(*Tenyo Maru*)	7/29	51–30	176–50	50	—	—	67	24	10	75	5	19	2	202
		Total		150			151	87	13	226	20	98	8	603
Gill nets	7/27	51–31	176–42	—	36	NW	328	143	26	143	37	46	0	723
(*Pioneer*)	7/28	51–31	176–40	—	36	N	135	38	8	59	5	10	1	256
	7/29	51–29	176–38	—	36	SE	332	165	6	196	38	44	2	783
		Total			108		795	346	40	398	80	100	3	1,762
Purse seines	7/27	51–27	176–45	—	—	W	0	0	0	0	0	0	0	0
(*Commander*)		51–26	176–50	—	—	ENE	255	8	7	10	0	2	0	282
		51–30	176–50	—	—	WSW	3	0	0	0	0	0	0	3
	7/28	51–30	176–43	—	—	ENE	48	2	4	40	1	1	1	97
		51–30	176–42	—	—	WSW	2	0	0	0	1	4	0	7
	7/29	51–30	176–41	—	—	ENE	113	2	8	18	0	0	1	142
		51–29	176–43	—	—	WSW	0	0	2	0	2	4	0	8
		51–28	176–45	—	—	ENE	346	23	33	20	0	3	0	425
		Total					767	35	54	88	4	14	2	964

TABLE 5. Species and age composition of salmon taken by gill nets, purse seines, and longlines during comparative fishing, 1959; gill net catches have been adjusted to give equal weight to each mesh size.

Gear and vesssel	Total catch (no. of fish)	Catch by species (in percentages)						
		Sockeye		Chum		Pink	Coho	Chinook
		Age .1	Age .3 .2 and	Age .1	Age .2 and older			
		June 12–15						
Gill nets (*Tordenskjold*)	265	4.2	60.8	0	17.0	18.1	0	0
Longlines (*Tenyo Maru*)	266	0	42.5	0	23.7	33.5	0	0.4
		June 19–23						
Longlines (*Tenyo Maru*)	786	0	30.4	0	19.2	47.2	0.4	2.8
Purse seines (*Windward*)	324	1.2	23.8	0	18.2	56.8	0	0
		July 27–29						
Gill nets (*Pioneer*)	1,034	75.7	7.6	3.9	10.1	1.3	1.4	0.1
Longlines (*Tenyo Maru*)	603	25.0	14.4	2.5	37.1	3.3	16.3	1.3
Purse seines (*Commander*)	964	79.6	3.6	5.6	9.1	0.4	1.5	0.2

composition of catches were dependent upon the gear (June 12–15: $P<0.001$; June 19–23: $P<0.05$; July 27–29: $P<0.001$). Gill nets took relatively more sockeye salmon than did longlines in mid June, but longlines took relatively more chum and pink salmon. In late June longlines took relatively more sockeye salmon than did purse seines, but purse seines took relatively more pink salmon. In late July longlines took relatively more chum salmon (ages .2, .3, and .4) and coho salmon than did the other types of gear. Gill nets and purse seines fished the various species similarly.

SOCKEYE SALMON

Length frequencies of sockeye salmon caught in mid June by gill nets and longlines (Figure 13) were similar except for catches of small fish made by gill nets. Longlines took none of the small (age .1) sockeye salmon that gill net catches showed were in the area.

Longlines took relatively more large sockeye salmon in late June (Figure 14) than did purse seines. This undoubtedly occurred because purse seines fished primarily for immature sockeye salmon, whereas longlines may have been equally effective for mature and immature fish. In six of the eight sets, the purse seine was opened to the east—the direction from which immature sockeye salmon migrate during summer. Mature fish migrated from the west during this period (Hartt, 1966) and were not as available to purse seine gear as they were to longlines.

The length-frequency distribution of catches by the three types of gear in July (Figure 15) indicated that longlines took relatively more sockeye salmon over 42 cm than did the other types of gear. The frequency distributions were similar for sockeye salmon caught in gill nets and purse seines, but the distribution for fish

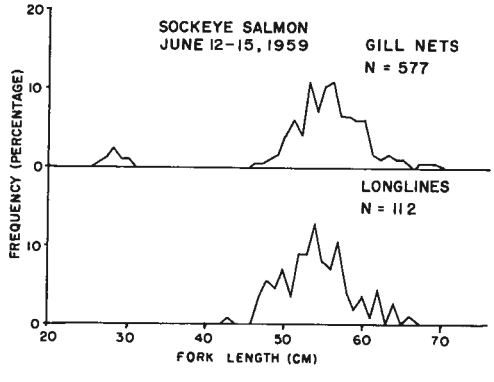

FIGURE 13. Comparison of length frequencies of sockeye salmon taken by gill nets and longlines, June 12–15, 1959. (Gill net data adjusted to give equal weight to each mesh size.)

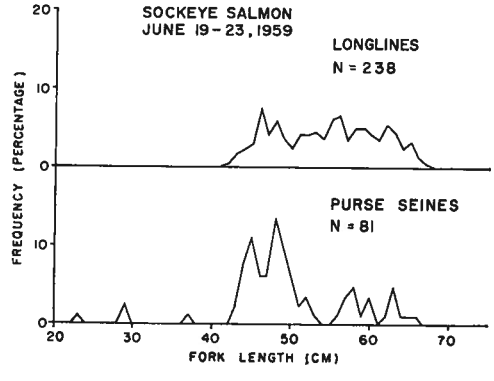

FIGURE 14. Comparison of length frequencies of sockeye salmon taken by longlines and purse seines, June 19–23, 1959.

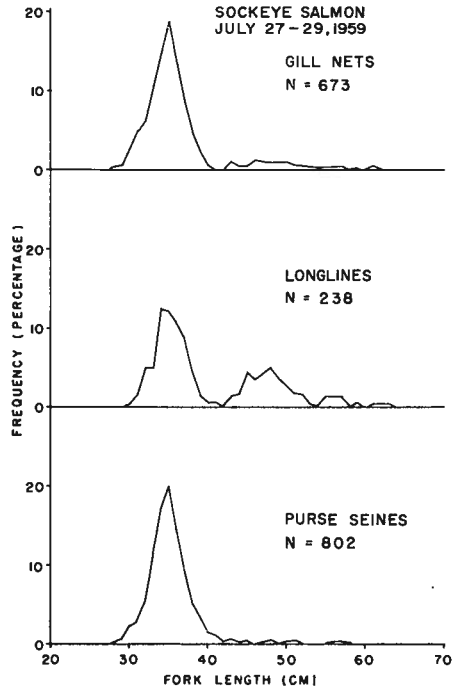

FIGURE 15. Comparison of length frequencies of sockeye salmon taken by gill nets, longlines, and purse seines, July 27–29, 1959. (Gill net data adjusted to give equal weight to each mesh size.)

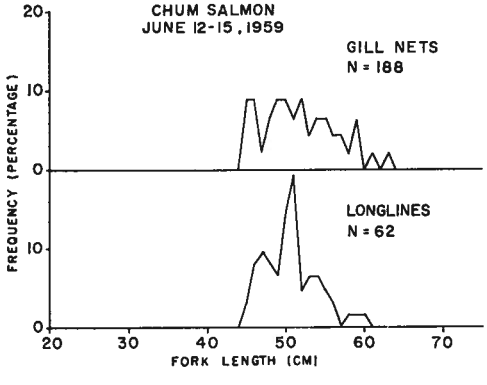

FIGURE 16. Comparison of length frequencies of chum salmon taken by gill nets and longlines, June 12–15, 1959. (Gill net data adjusted to give equal weight to each mesh size.)

caught on longlines was significantly different from that for each of the other types of gear. Longlines evidently selected the larger sockeye salmon.

On the basis of the same July 1959 catch data, Kondo *et al.* (1965) concluded that the proportions of large and small sockeye salmon (the two size groups of Figure 15) in gill net and longlines catches were similar, but differed from those in purse seine catches. This relationship appeared to hold for the particular

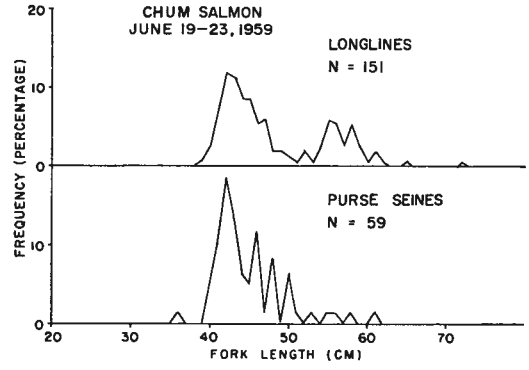

FIGURE 17. Comparison of length frequencies of chum salmon taken by longlines and purse seines, late June 19–23, 1959.

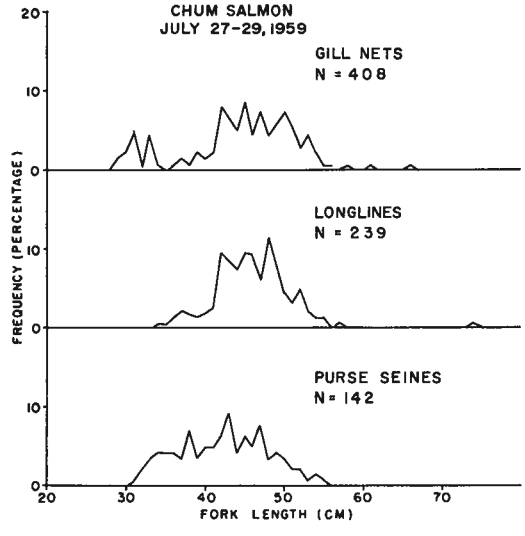

FIGURE 18. Comparison of length frequencies of chum salmon taken by gill nets, longlines, and purse seines, July 27–29, 1959. (Gill net data adjusted to give equal weight to each mesh size.)

combination of mesh sizes fished in the gill net string in 1959, but did not hold when equal weight was given to the catches in each mesh size (as was done in Figure 15).

CHUM SALMON

The length distributions of chum salmon caught in mid June by gill nets and longlines (Figure 16) were similar. Although sample sizes were small, the two frequency distributions were not significantly different. Longlines and purse seines caught chum salmon of significantly different lengths in late June (Figure 17). In the small catches of this period, purse seines took fewer large chum salmon than did longlines.

Length compositions of chum salmon taken by the

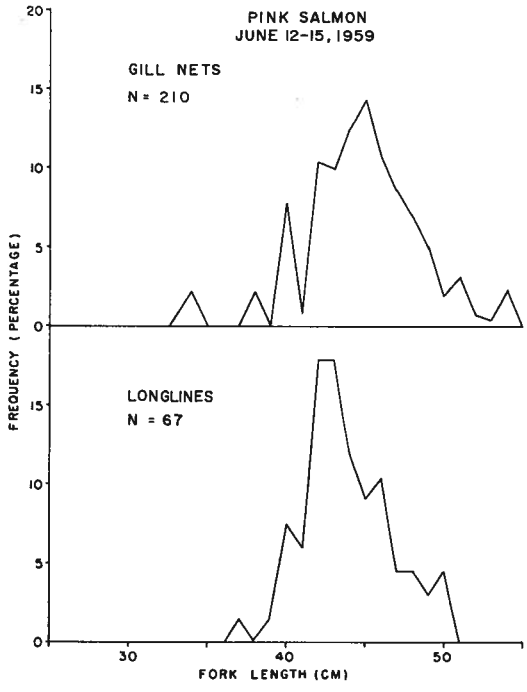

FIGURE 19. Comparison of length frequencies of pink salmon taken by gill nets and longlines, June 12–15, 1959. (Gill net data adjusted to give equal weight to each mesh size.)

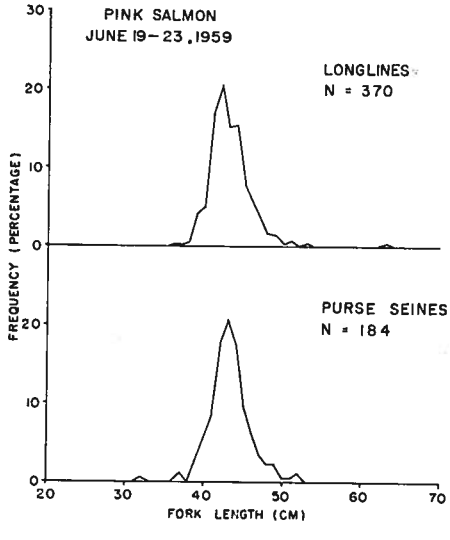

FIGURE 20. Comparison of length frequencies of pink salmon taken by longlines and purse seines, June 19–23, 1959.

three types of gear in July (Figure 18) were dissimilar. Gill nets took a wider range of lengths than did the other types of gear (except for one large chum salmon taken by longlines). Significance tests of cumulative frequency distribution indicated length differences

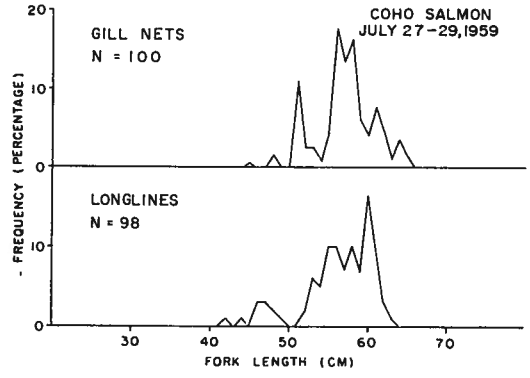

FIGURE 21. Comparison of length frequencies of coho salmon taken by gill nets and longlines, July 27–29, 1959. (Gill net data adjusted to give equal weight to each mesh size.)

among the catches of the three types of gear.

Percentages of age .1 chum salmon in the catches were: gill nets, 26.6%; purse seines, 38.0%; and longlines, 6.3%. As was noted for sockeye salmon, longlines selected relatively more of the large chum salmon than did the other types of gear. Gill nets and purse seines fished the two size groups somewhat similarly; purse seines selected slightly more of the small fish.

PINK SALMON

Relatively few pink salmon were taken in June. The length frequencies (Figure 19) of those taken by gill nets and longlines did not differ significantly. The same conclusion was reached for pink salmon taken during late June by longlines and purse seines (Figure 20). Catches in July were too small for meaningful comparison.

COHO SALMON

No significant differences were found in the length composition of coho salmon taken by gill nets and longlines (Figure 21).

SUMMARY AND CONCLUSIONS

Comparisons of catch data from gill nets, longlines, and purse seines fished on the high seas south of Adak Island showed that the species and size composition of salmon generally differed among the three types of gear. Several factors associated with a particular type of gear undoubtedly affected its selectivity and efficiency.

In the 1963 experiments, purse seines took proportionately more age .1 sockeye salmon than did gill nets, whereas gill nets took more of the older sockeye salmon. The ratio of small to large chum salmon was about the same for the two types of gear. Gill nets

took proportionately more large sockeye salmon (including maturing specimens) and more maturing coho salmon than did purse seines ; the larger chum salmon and maturing pink salmon were about equally represented in the two types of gear. Differences in species and age composition were not large.

The length distributions of salmon taken in purse seines and gill nets differed for sockeye, chum, and pink salmon, but were uniform for coho salmon. The largest sizes of fish caught by gill nets did not appear in purse seine catches.

In the 1959 experiments, the comparisons were between gill nets, purse seines, and longlines. In mid June gill nets took proportionately more sockeye salmon than did longlines, but longlines took more of the large chum and pink salmon. Longlines did not take age .1 sockeye salmon, although they were present in gill net catches and known to be in the area. The length-frequency distributions of sockeye salmon (age .2 and .3) taken by gill nets and longlines were not significantly different.

Comparisons of catches by longlines and purse seines in late June showed that longlines took proportionately more older sockeye, pink, and chinook salmon than did purse seines ; purse seines took age .1 sockeye salmon but longlines did not. Catches of chum salmon were about equal for the two types of gear. Significantly more large sockeye and chum salmon were taken on longlines than in purse seines. Differences in length frequencies of pink salmon taken by the two types of gear were not statistically significant.

The three types of gear were fished together in July. Gill nets and purse seines took proportionately more age .1 sockeye salmon than did longlines (purse seines also took more than gill nets) ; longlines took more of the older (large) sockeye salmon. The same catch pattern held for chum salmon. Longlines took proportionately more pink, coho, and chinook salmon than did the other gears ; gill nets took slightly greater proportions of pink salmon than did purse seines, but about the same proportions of coho and chinook salmon. Length frequencies of sockeye salmon were similar for gill nets and purse seines, but differed between gill nets and longlines and between purse seines and longlines ; longlines caught relatively more large fish. The length distributions of chum salmon were different among the three types of gear ; the size range was generally widest in gill nets. Too few pink salmon were caught in July for meaningful length comparisons. Length distributions of coho salmon were similar between gill nets and longlines ; too few were taken by purse seines for comparisons.

The direction toward which purse seines were held open influenced the catch of various age groups and maturity stages of salmon. This factor undoubtedly limited purse seine catches of large maturing sockeye salmon, since the seine was held open to the east during most sets.

Gill nets selected salmon by mesh size ; an adequate series gave a reasonably accurate representation of the size composition.

Comparisons of catches by the different types of gear showed that longlines definitely selected larger salmon and that purse seines tended to select smaller salmon. As hypothesized, variation in size of pink and coho salmon was less than for the other species. Why purse seines tended to catch relatively more small fish than did gill nets is not clear. Possibly the smaller fish schooled more readily than the larger fish and were more susceptible to capture. Also, the relatively small number of large salmon taken in purse seines (as compared to gill nets) may have been because the larger fish were more aggressive and escaped before the purse seines were completely closed. The dominance of large salmon in longline catches was undoubtedly due to feeding habits ; the young salmon most likely did not feed as readily on the salted anchovies typically used for bait. When particular sizes or age groups of salmon are fished, the various types of gear may not be unduly selective. For example, longlines may reflect the relative abundance of maturing salmon and purse seines may well reflect the relative abundance of age .1 sockeye salmon if these gears are fished under similar conditions each year.

In summary, there is little difference between the age and species composition of salmon caught by gill nets and purse seines, but longlines are selective for older sockeye and chum salmon. Because gill nets took larger sizes of salmon of all species than did purse seines, gill net catches probably best represent the size composition of salmon in the ocean. Gill nets do not provide viable specimens for tagging ; purse seines and longlines provide excellent specimens, although allowances must be made for selectivity.

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