DIFFERENTIAL SELECTIVITY OF THREE GEAR ARRAYS USED IN COMMERCIAL TROLLING FOR COHO AND CHINOOK SALMON

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23 October 1990

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ABSTRACT

Management of the commercial ocean troll salmon fishery in Oregon often requires regulations prohibiting the landing of coho salmon (*Oncorhynchus kisutch*) during time periods when chinook (*O. tshawytscha*) fishing is open. Hooking mortality in these "all-except-coho" fisheries has been estimated to be up to 16 per cent of the total allowable troll fishery-related mortalities south of Cape Falcon, Oregon in recent years. A reduction in the overall number of coho hooked and released (coho encounters) during periods closed for coho would reduce mortalities and increase the number of coho available for harvest.

This experiment was designed as a field test of the idea that trolling for chinook with fewer spreads (hooks) per line would reduce coho encounter rates without seriously affecting the chinook catch rate. Coho are generally found higher in the water column than chinook. With more spreads per line, more gear would be near the surface, with higher coho encounter rates on the upper spreads. Three chartered vessels trolled for chinook with four, seven, or ten spreads per line for 24 days (72 vessel days total) during May and June, 1990. Observers recorded coho and chinook encounters for each spread and gear type.

Fewer coho per day were caught on four spreads per line ($\bar{x}=9.3$) than on seven ($\bar{x}=19.9$) or ten ($\bar{x}=19.9$) spreads over the course of the study. Chinook catch rates were similar on all gear arrays ($\bar{x}=7.6$). Coho were distributed higher on the gear than chinook. This vertical separation was more pronounced later in the study when upwelling lowered sea surface temperatures. Through interviews with fishermen it was determined that commercial trollers typically were using from four to eight spreads during the study period. Data from this experiment could be used by fishery managers to estimate the savings in coho mortality which would result from a four spread regulation.

Local fishermen observe that coho are frequently found higher in the water column than chinook. Similar differences in depth are also referred to by Miller (1982), Milne (1955), and Van Hyning (1951). The present study was designed to test the idea that, due to the distribution of fish in the water column, shallower spreads contribute to a higher coho encounter rate. By limiting boats to fewer spreads, shallower spreads would be eliminated. Coho encounter rates should be lowered and coho hooking mortality reduced without seriously affecting chinook catch. Should such a gear restriction be adopted as a management tool, this study would provide quantitative data for use in adjusting coho mortality rates.

METHODS

The hypotheses tested were (1) the mean number of coho encountered per day is lower with fewer spreads per wire (one-tailed), (2) the mean number of coho encountered per day differs among boats fishing the same gear (two-tailed), and (3) the mean number of chinook encountered per day is not different when fewer spreads per wire are used (two-tailed). To relate the results of this study to current fleet practices, a profile of gear types used by the fleet in the 1990 May-June all-except-coho fishery was obtained through fisherman interviews.

Experimental Design

Experimental fishing was conducted in the Coos Bay and Newport catch areas (ODFW catch areas 4 and 5, Figure 1) from 26 May to 27 June 1990, during the period of all-except-coho fisheries. Three chartered vessels fished together with three gear arrays (4, 7, or 10 spreads per wire). Each boat was assigned a single gear array each day, and fished that gear for a full day. Gear arrays were rotated among the boats, so at the end of the experiment each boat had fished each gear array approximately the same number of days.

The gear was "run" by reeling in or "pulling" each line, removing hooked fish as they were brought up to the boat, then resetting the line. As the gear was run, observers recorded a result for each spread as it came out of the water. Recorded results included; 1) coho in good condition (minor injury, little or no bleeding, hooked in snout, maxillary, corner of mouth, or cheek), 2) coho in fair condition (serious condition, severe bleeding, hooked in or near gills or eyes), 3) dead coho, 4) legal chinook (at least 26 inches total length), 5) sublegal chinook (< 26 in.), 6) other species, 7) fouled gear, 8) missing gear. From these data, daily catches by category were tabulated for each boat and gear type. In addition, encounter rates for each spread in each gear array were calculated by species. These data were used to examine the differential effectiveness of spreads from top to bottom of the gear arrays, gave an idea of the distribution of the fish in the water column, and provided data to support observed differences in catch rates among the gear arrays.

Boats fished comparable gear; six lines, three per side, were run when weather permitted. Otherwise, four lines were fished. With minor exceptions, spreads were spaced at 4 fathom intervals. Because boats were specifically fishing for chinook, gear was run deep, with bottom spreads near the bottom. Typically the cannonball was 2 fm off the bottom, with the deepest spread 2 fm above the cannonball.

Terminal gear was standardized; alternate spreads of spoons and spreads of flashers and hoochies. This was the combination that Boydstun (1972) found caught the "most legal salmon per unit effort." He also emphasized that the entire line of gear in this configuration is considered to fish as a unit. Skippers determined the best gear for a particular day (i.e., hootchie color, spoon type, etc.). Leader length was standardized at four fm. Top leaders on the 10 spread gear type were occasionally shortened to allow a two fm spacing between spreads when fishing in marginal depths. Boats attempted to fish in areas where both coho and chinook were encountered. This was not always the area of highest chinook catch rates.

Data on ocean environmental conditions were obtained from the Hatfield Marine Science Center (P. Henchman, pers. com.) and the National Marine Fisheries Service (NMFC/FNOC, Monterey, California).

Statistical Design

The experiment was designed so data could be analyzed in a two-factor analysis of variance (ANOVA) with replication. The dependent variables, tested in separate analyses, were "coho encountered per boat per day" and "chinook encountered per boat per day." The two independent factors being simultaneously tested were gear array and boat. Gear x boat interactions were also tested. The factor of primary interest was gear array. Since there are three levels in the gear factor and three levels in the boat factor this experimental design is termed a 3 X 3 (or 3^2) factorial (Sokal and Rohlf, 1981). The design target was 5 to 8 replicate determinations for each of the 3 X 3 = 9 combinations of the two factors (15 to 24 days of fishing). This design was used for both coho and chinook catch rates. If day to day variability is greater than treatment effects, paired comparisons may be more sensitive to real differences. Since all three gear types were fished each day, paired T-tests (Zar, 1974) could be performed between similar gear types (eg.; 4 vs. 7 or 7 vs. 10 spreads). Data were compiled and analyzed using SAS® statistical analysis software (SAS Institute, Cary, N.C.).

Coho/day and chinook/day distributions were skewed to the right, with the variance always much greater than the mean, typical of random sampling from a patchy or clumped population. The square root transform (Sokal and Rohlf 1981) is most appropriate for Poisson distributions, with the variance equal to the mean. These data are more skewed than a Poisson distribution. However, after transformation, experimental distributions were not significantly different from normal ($p > 0.05$). Square-root-transformed variables were used in all ANOVAs.

RESULTS

Three boats fished a total of 24 days each for 72 days of fishing (Table 1). In total, 1105 coho and 822 chinook (569 legal and 253 sublegal) were encountered. Due to gear problems the 10-spread boat made only one pull on 8 June. On 13 June the 4-spread boat was "on fish" for several hours while the other two boats were in transit. Therefore, these two days were dropped from the catch rate analysis. All data were used in analyzing the distribution of fish on the gear.

Outside of the experimental design, ocean conditions (Figure 2) changed over the course of the study. Early in the study, winds were southerly, water temperatures were warm, and fish were near the bottom. Later in the study, winds were northerly, water temperatures were cooler, and fish were distributed throughout the water column. Distribution of fish in the water column affected distribution of fish caught on the gear and relative selectivity of the three gear arrays. Based on observations of skippers and ODFW observers, on examination of patterns in catch per day (Table 1), and on trends in environmental conditions (Figure 2), the study was divided, for analysis, into an early period from 26 May to 16 June, and a late period from 17 June to 27 June.

General Trends in Catch/Day

For coho over the entire study (Figure 3) and for the early and late periods separately (Figure 4), coho/day for the 4 spread gear appears lower than coho/day with either 7 or 10 spreads. There does not seem to be a difference between 7 and 10 spreads. Chinook per day showed no trend in central tendency with number of spreads over the entire study (Figure 5) or in either early or late periods (Figure 6). Day to day variability and maximum catch rates of chinook may have been lower with the larger gear arrays. These plots also show that coho catch rates tended to be higher in the late period, while chinook catch rates were higher early.

These general observations are also evident in the means of catch/day for each species (Table 1). Standard deviations of the untransformed means were generally equal to or greater than the means early in the study, but lower than the means in the late period. This reflects more consistent ocean conditions, fish availability, and fishing technique in the late period.

Analysis of Variance

The planned ANOVA showed no significant differences for gear arrays or boats, and no interactions between gear array and boats for either coho or chinook over the course of the study (Table 2A, B). An *a posteriori* Scheffé test showed both coho and chinook catch per day to be different between the two periods ($p < 0.05$). Therefore, the factorial ANOVA was repeated for the two time periods separately.

Results of the ANOVA for the late period with gear and boat as factors are presented in Tables 2C and 2D. A significant difference in coho per day was found in the late period, with 4 spreads having a lower mean than 7 or 10 spreads, which were not different (Tukey's LSD). There were no boat effects and no boat x gear interactions. ANOVA did not detect significant differences in coho catch rates among gear arrays in the early period. Chinook showed no differences in either early or late periods.

Paired T-test

Based on exploratory data analysis and patterns in the mean catch rates I pursued the apparent difference in coho/day for 4 vs. 7 or 10 spreads during the early period. I felt that high day to day variability in catch could be masking a real effect. A paired T-test comparing daily catch rates with 4 vs 7 spreads showed a significant difference in the early period ($T=1.8011$, $p=0.048$, 1-tailed). This is not a strong conclusion, but does provide a quantitative indication of real differences in coho encounter rates in the early period.

Vertical Distribution of Fish on the Gear

An independent measure of the relative performance of the three gear arrays is the distribution of fish on the gear, expressed as the probability of encountering coho and chinook on each spread. For this analysis no data were excluded. During the study 23,321 hooks were examined. Of these, 1105 had coho, 569 had legal chinook, 352 had sublegal chinook, 272 had other fish species, and 303 were fouled or missing. Sample sizes of legal chinook were low, so frequency distributions of legal and sublegal chinook were compared on each of the three gear arrays. In no case was there a significant difference (X^2, $p > 0.17$) so legal and sublegal chinook were pooled for analysis.

Figures 7, 8, and 9 portray the distribution of fish/hook by spread on each gear type for the entire study (Figure 7) and for early and late periods by species (Figures 8 and 9). Figure 7 illustrates that over the course of the study coho were caught higher on the gear than chinook. This was true for all three gear arrays. From Figure 8 it can be seen that coho were encountered at a higher rate in the late period. This figure supports the field observation that coho were distributed higher in the water column later in the study. In the early period the highest coho encounter rate on the ten spread gear array was on spread seven (spreads were numbered from 1 to 10, with 10 being the deepest spread: the four spread gear had only spreads 7 through 10). In the late period the highest encounter rate moved up to spread three. This change in distribution was significant on the seven and ten spread arrays (X^2, $p<0.01$) and the four spread array (x^2, $p=0.053$).

Figure 8 shows that chinook were encountered at higher rates early in the study. On the 10 spread gear array no chinook were caught above spread 5 early in the study. Later, chinook were encountered as high as spread 2 (never on spread 1). This also indicates a shift up in distribution. Differences in distribution of chinook between the early and late periods were significant (X^2, $p<0.01$).

Fleet Gear Profile

To compare results from the field experiment with characteristics of the fishing fleet a profile of gear use in Newport and Charleston during the May-June all-except-coho fishery was compiled. Each fisherman was asked how many lines he fished that day and how many spreads per line were used. In Charleston, 30 skippers were interviewed on 25 May and 11 June. In Newport, 41 skippers were polled between 11 and 25 June. Some fishermen reported using different numbers of spreads on different lines. For example, one skipper reported that he ran two lines with six spreads and two lines with eight spreads. Therefore, data were tabulated as frequency of lines by number of spreads.

Figure 10 illustrates the fleet gear profiles for Newport and Charleston in June 1990. Reported spreads per line ranged from a low of 2 to a high of fifteen. Newport boats typically ran four to six spreads per line, while Charleston skippers favored six to eight spreads.

DISCUSSION

In this study, boats fishing with four spreads encountered fewer coho per day than boats with seven or ten spreads. For chinook, mean encounter rates were apparently unaffected, or potentially higher on the four spread gear array. Coho were distributed higher on the gear than chinook.

Catch per day is a function of the effectiveness of the gear (fish per hook, Figs. 7, 8, 9) and the frequency with which the gear is run (pulls, Table 1). In the early period, with heavy weather, the ten-spread rigs were run less frequently than the seven or four spread rigs because of the difficulty of handling large amounts of gear in rough conditions. In the late period all rigs were run with about the same frequency.

Mechanisms of Selectivity

The suggestion that four spreads might be more effective at catching chinook than seven or ten spreads is, at first, counter intuitive. Examination of the distribution of chinook on the gear shows why this may, in fact, be so. Over the course of the study, chinook per hook (Figure 7) on the bottom four spreads was greater on the four spread gear array than on either seven or ten spreads. This higher catch rate compensated for the chinook which were taken on higher spreads with the seven and ten spread arrays. The difference is apparent in both the early and late periods (Figure 8), suggesting that the effect was consistent, and not merely an artifact of small sample sizes or ocean conditions. In addition to the higher catch rates with four spreads, the gear can be run more frequently and the boat is "flying" less gear. This reduces the cost of the operation and the risk and cost of losing gear.

Reduction in coho encounters with fewer spreads appeared to be a more straight-forward effect. As with chinook, coho per hook (Figure 7) on the bottom four spreads was higher with four spreads than seven or ten. However, with the seven and ten spread rigs the higher spreads caught coho at a higher rate than the lower spreads, thus contributing to higher overall catch per day. This difference was especially apparent in the late period (Figure 9). A curious observation in the late period is that the top spread of the four and seven spread arrays caught coho at a higher rate than would be expected either from the ten spread catch rates or the rates on lower spreads of the arrays. Two ideas have been proposed to explain this phenomenon. Perhaps the top spread attracts fish from above it in the water column, thereby catching fish that would otherwise have been taken on higher spreads. Alternatively, coho are said to "go up the gear," biting on the top lure (M. Maahs, pers. com.). Either explanation suggests a strategy for reducing coho catch rates on a four spread gear array; fish a fifth, "dummy" spread with a lure but no hook. Coho attacking this lure would escape unharmed.

The lack of difference in coho encounter rates between seven and ten spreads may reflect conditions during the study. Due, perhaps, to the relatively warm water temperatures, coho were found in shallower areas, closer to shore than usual. Ten spreads at four fathom intervals nominally need 36 fm of water. In fact, the need is slightly less because the gear trails back at an angle. There may have been a tendency for the boat with seven spreads to fish shallower than the ten spread rig, effectively putting the top spreads of both gear arrays near the surface. Alternatively, the effectiveness of the ten spread array may have been reduced in shallow waters. In either case, ten spreads did not catch more fish than seven in this study. This is consistent with data from the fleet gear profile: few of the skippers interviewed used more than eight spreads.

Choice of Gear

The fleet gear profiles obtained in Newport and Charleston are probably typical of the most experienced professional fishermen in those two ports. Fishermen in Newport tended to favor fewer spreads than their Charleston counterparts. Reasons for this difference are open to speculation. From Charleston there is access to deeper water close to port, while Newport-based trollers find relatively shallow depths close in. Within each port there was evidence that less experienced skippers used more spreads, but there is no indication that this explains the difference between ports.

In some years a large number of inexperienced, part-time fishermen fish from small boats on the weekends. These "weekend warriors" are reputed to use more spreads, as a rule, than the full-time fishermen. Chinook catch rates were low in 1990 making commercial fishing a marginal venture. Part time fishermen had little incentive to participate in the fishery. In years of high chinook abundance the gear profiles could be markedly different from those observed in 1990.

Based on results from this study, fishing with four spreads for chinook in May and June could have several advantages to the fishermen. Foremost, four spreads appears to be more efficient at catching chinook. Less gear is in the water, reducing the cost of rigging and the amount of gear vulnerable to loss at any time. Boats use less fuel and are easier to handle with smaller gear arrays, and less time may be spent with fouled gear. The reduced coho encounter rate means less time is spent handling unmarketable fish, and coho hooking rates are reduced. Frequent running of the gear probably also reduces mortality from "drop-off" of coho hooked and escaping without being brought to the boat. Reduced pre-season mortality would mean bigger ocean populations when the season opens, larger quotas, and higher initial catch rates.

Potential Reductions in Coho Encounter Rates

If gear arrays were limited to four spreads in the May-June all-except-coho fishery off Oregon, whether by regulation or by voluntary effort of the fishermen, managers would be obligated to estimate the reduction in shaker mortality relative to estimates for traditional fishing patterns. Perhaps the simplest approach would be to assume a proportional reduction based on the ratio between four and seven spread catch rates. This calculation could be based on data from this study showing that catch rates using seven or more spreads per line are constant. For that portion of the fleet reducing from six or five lines to four, the savings are more difficult to estimate, but a proportional rate of reduction would be a reasonable assumption.

A variety of fishing conditions was encountered during this study. The degree of gear selectivity differed between the early and late study periods. Data from this study are best applied to fisheries with similar conditions. Chinook abundance was much lower than in recent years, but stock sizes were near long-term averages. Coho abundance was also near average. The extended period of southerly winds in late May and early June was highly unusual for this time of year. In most years the northerly winds are established by late May although there may be brief periods of southerly winds at any time. Sea water temperatures were warmer than usual, as they were in 1989. It is not clear if this is a short term trend or part of a longer term shift in weather patterns and sea conditions. The late period of this study was probably more typical of May-June conditions off the Oregon coast. In addition, the higher coho catch rates in the late period of study provide better sample sizes for estimating savings.

Need for Additional Study

Additional all-except-coho fisheries occur in Oregon after the coho quota is taken, usually in August and September. Fish behavior may be different at that time of year as the coho are preparing to enter freshwater and chinook are either maturing or embarking on another year in the ocean. Therefore, results from this study may not be applicable to August fisheries. Miller (1982) reports that the two species were stratified in the late season. Experimental data are needed to determine the relative performance of several gear arrays in that time period. At the same time, the effectiveness of a "dummy lure" on the top spread could be evaluated and we could attempt to confirm patterns observed in 1990.

CONCLUSION

The most valuable aspect of this study was the cooperation between fishermen and managers. The original idea of limiting the number of spreads was suggested by fishermen, and the study design was developed in consultation with members of the fishing industry. This increased interaction between fishermen and managers could be of benefit to all involved. Managers need a quantitative basis for management decisions. Fishermen are dependent on their own individual experiences to arrive at effective fishing techniques. In the highly variable marine environment, advantageous fishing strategies may not be obvious even to veteran fishermen. Cooperative experiments such as this can provide both fishermen and managers the kind of information they need to make efficient and economical use of the resource, improve the accuracy of management, and increase fishermen's time on the water. Continued cooperation and experimentation could lead to a simpler, more efficient, more economical salmon troll fishery.

ACKNOWLEDGEMENTS

I wish to thank the skippers, J. Feldner, P. Stannard, and T. Shafer. Their interest in the study and long fishing experience helped in determining appropriate fishing strategies within the confines of the experimental design. J. Feldner, especially, assisted with the study design, as did T. Robinson, R. Hannah, and J. Geibel. T. Robinson of the Oregon Salmon Commission, J. Johnson of the Independent Troll Fishermen of Oregon, and D. Pruden assisted with the fleet gear profile. Many ODFW personnel participated in the study as observers and organizers. This study would not have happened without the organizing skills of R. Kaiser. Funds were provided by the Restoration and Enhancement Program of the Oregon Department of Fish and Wildlife, and the State of Oregon.

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Table 1. Daily catches of chinook (chin) and coho and number of lines examined (pulls) with three gear arrays for 24 days of experimental fishing. Data are summarized for early (excluding two days) and late periods separately, early and late periods combined, and totaled for all days.

	Gear Array (number of spreads)											
	4			7			10			DAILY TOTALS		
Date	pulls	chin	coho	pulls	chin	coho	pulls	chin	coho	pulls	chin	coho
26 May	30	1	0	19	3	2	19	0	0	68	4	2
29 May	49	5	2	44	1	0	22	5	0	115	11	2
30 May	24	1	1	29	1	5	37	1	7	90	3	13
04 June	45	5	21	60	3	53	41	2	43	146	10	117
05 June	43	5	27	47	3	48	38	6	28	128	14	103
06 June	81	13	20	65	12	16	66	20	24	212	45	60
07 June	38	4	2	32	10	10	26	7	4	96	21	16
08 June[1]	56	22	0	52	4	6	1	0	1	109	26	7
09 June	62	13	4	45	14	3	49	1	2	156	28	9
11 June	104	28	5	84	36	16	49	30	14	237	94	35
12 June	87	38	6	77	21	8	68	20	3	232	79	17
13 June[1]	73	13	8	62	22	3	73	9	8	208	44	19
14 June	69	20	1	43	12	2	43	16	0	155	48	3
16 June	22	4	1	36	4	1	29	5	3	87	13	5
Early Total[2]	654	137	90	581	120	164	487	113	128	1722	370	382
Mean[2]	54.50	11.42	7.50	48.42	10.00	13.67	40.58	9.42	10.67	143.50	30.83	31.83
(s.d.)[2]	25.14	11.22	9.05	18.75	9.86	17.30	15.06	9.28	13.31	55.25	28.63	38.51
17 June	80	16	23	61	9	43	74	4	42	215	29	108
18 June	76	11	24	75	4	74	52	5	74	203	20	172
19 June	39	4	9	57	9	41	39	7	29	135	20	79
20 June	29	3	12	21	3	15	25	6	18	75	12	45
22 June	33	1	15	31	1	35	28	2	32	92	4	82
23 June	43	9	13	56	2	13	44	5	32	143	16	58
24 June	50	5	6	59	2	16	67	2	28	176	9	50
25 June	42	1	5	33	7	7	27	2	12	102	10	24
26 June	21	0	4	41	1	15	29	3	30	91	4	49
27 June	31	2	4	32	3	14	41	0	12	104	5	30
Late Total	444	52	115	466	41	273	426	36	309	1336	129	697
Mean	44.40	5.20	11.50	46.60	4.10	27.30	42.60	3.60	30.90	133.60	12.90	69.70
(s. d.)	18.52	4.94	7.03	16.41	2.95	19.74	16.24	2.06	16.96	47.10	7.84	41.71
Total[2]	1098	189	205	1047	161	437	913	149	437	3058	499	1079
Mean[2]	49.91	8.59	9.32	47.59	7.32	19.86	41.50	6.77	19.86	139.00	22.68	49.05
(s.d.)[2]	22.93	9.45	8.43	17.75	8.10	19.66	15.64	7.57	18.14	51.94	23.55	44.22
Grand Total	1227	224	213	1161	187	446	987	158	446	3357	569	1105

[1] Excluded from catch rate analysis.
[2] Excluding 8 and 13 June.

Table 2. ANOVA Tables for the main and interaction effects of gear array and boat on coho and chinook catch per day for the entire study and for the late period (17-27 June) only.

	Species	Period	Source	df	SS	F	P
A.	Coho	All	Gear	2	19.5791	2.08	0.1339
			Boat	2	0.8219	0.09	0.9164
			G x B	4	2.8943	0.15	0.9604
			Error	57	267.8164		
			Total	65	291.1117		
B.	Chinook	All	Gear	2	0.9931	0.24	0.7913
			Boat	2	2.3209	0.55	0.5804
			G x B	4	1.5938	0.19	0.9434
			Error	57	120.4292		
			Total	65	125.3370		
C.	Coho	Late	Gear	2	24.6375	4.73	0.0201
			Boat	2	1.0207	0.20	0.8234
			G x B	4	4.5600	0.44	0.7796
			Error	21	54.6436		
			Total	29	84.8616		
D.	Chinook	Late	Gear	2	0.2105	0.15	0.8610
			Boat	2	0.4332	0.54	0.5895
			G x B	4	0.1012	0.13	0.9711
			Error	21	16.7838		
			Total	29	18.2959		

Figure 1. Salmon management areas off the Oregon coast. This study took place in catch areas 4 and 5, between Orford Reef Red Buoy and Cascade Head.

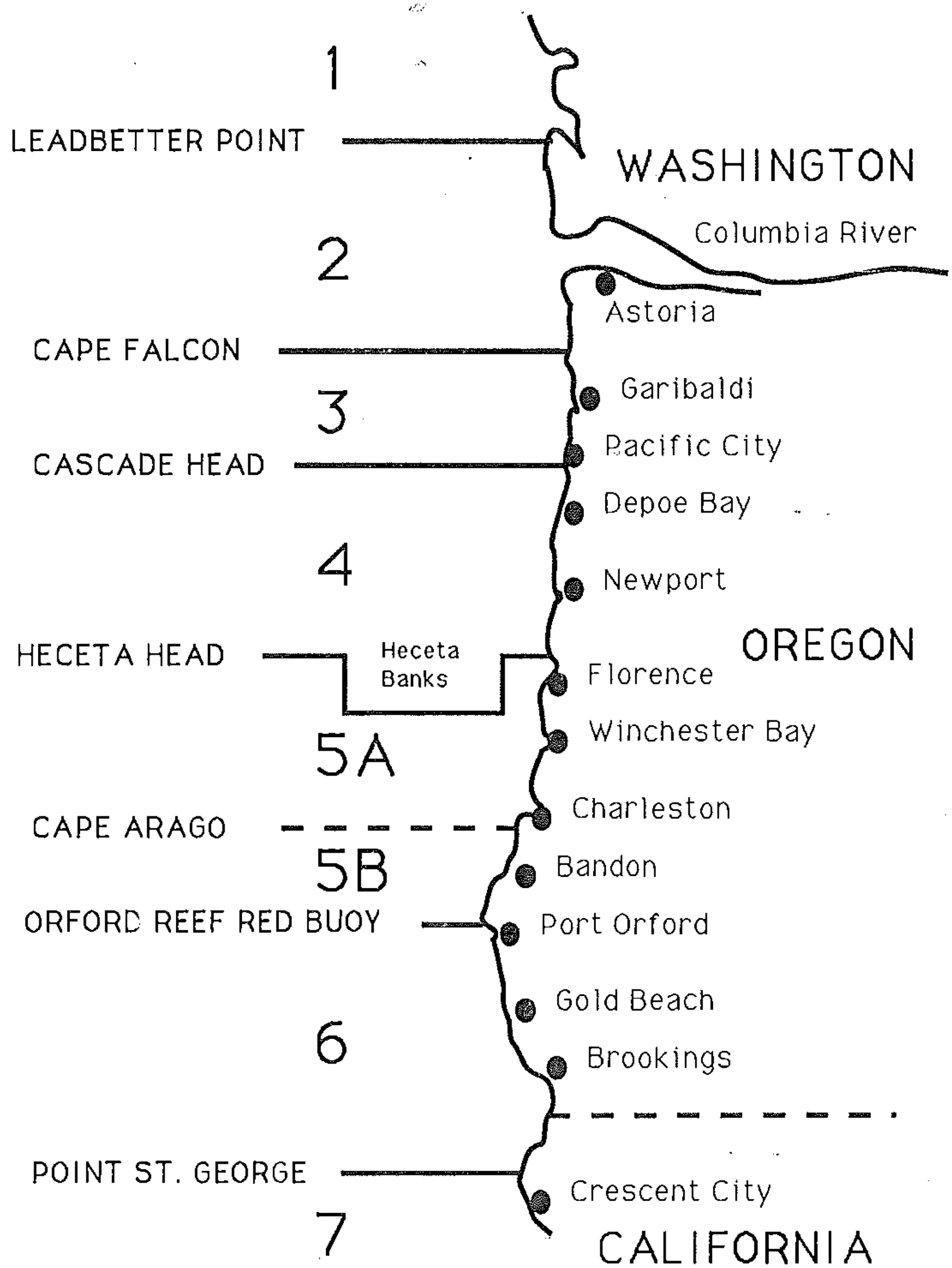
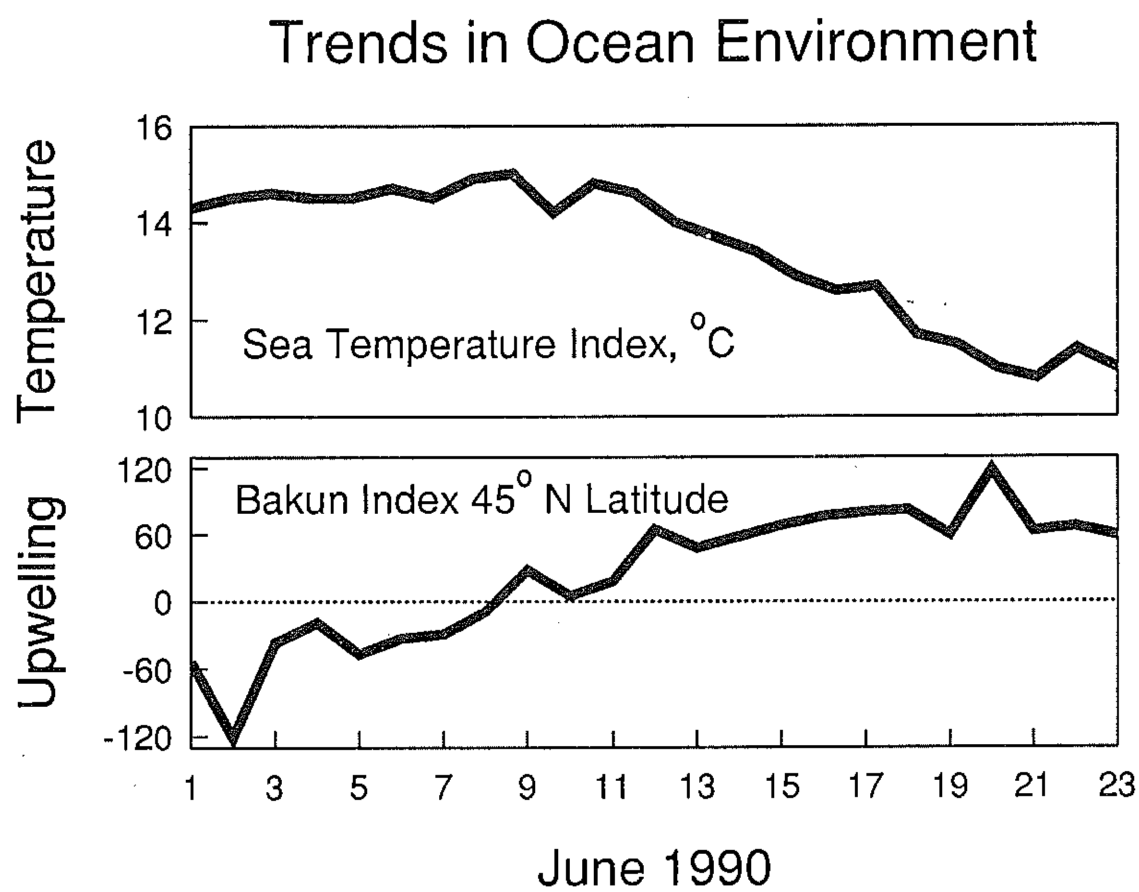

1
LEADBETTER POINT
WASHINGTON
Columbia River
2
Astoria
CAPE FALCON
Garibaldi
3
Pacific City
CASCADE HEAD
Depoe Bay
4
Newport
HECETA HEAD
Heceta
Banks
OREGON
Florence
Winchester Bay
5A
CAPE ARAGO
Charleston
5B
Bandon
ORFORD REEF RED BUOY
Port Orford
Gold Beach
6
Brookings
POINT ST. GEORGE
Crescent City
7
CALIFORNIA

Figure 2. Trends in ocean environment during the period of experimental fishing. Sea temperature index is the 24 hr. minimum temperature of the seawater in the Hatfield Marine Science Center, C°. Upwelling is the daily Bakun index at 45° N. latitude.



Trends in Ocean Environment
Temperature
16
14
12
10
Sea Temperature Index, °C
Upwelling
120
60
0
-60
-120
Bakun Index 45° N Latitude
1
3
5
7
9
11
13
15
17
19
21
23
June 1990

Figure 3. Box and whisker plots of coho/day with three gear arrays for the entire study. In these plots the circles mark the extremes of the range of data, the lines (whiskers) include the 5th to the 95th percentiles, the boxes enclose the 25th to the 75th percentiles, the solid line within each box marks the median, and the dotted line marks the arithmetic mean.

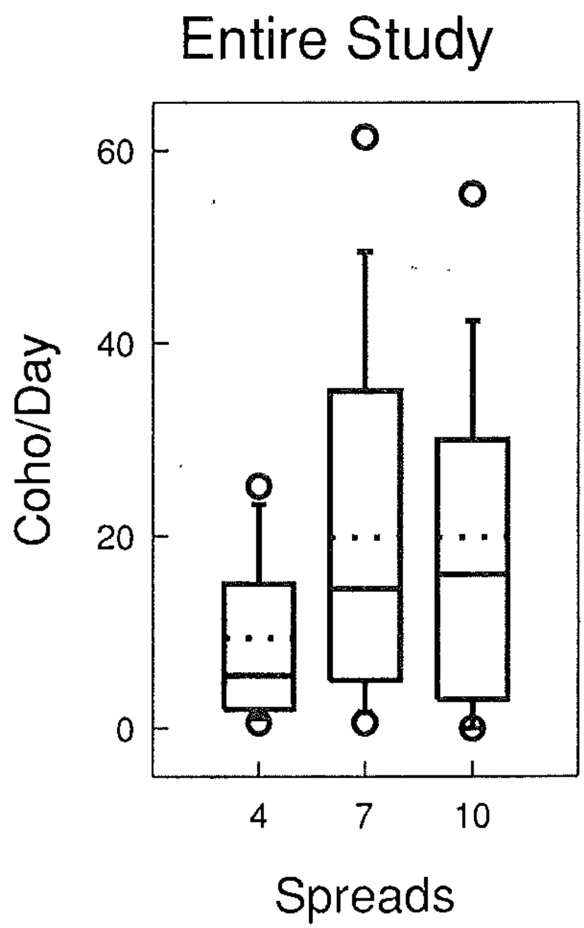
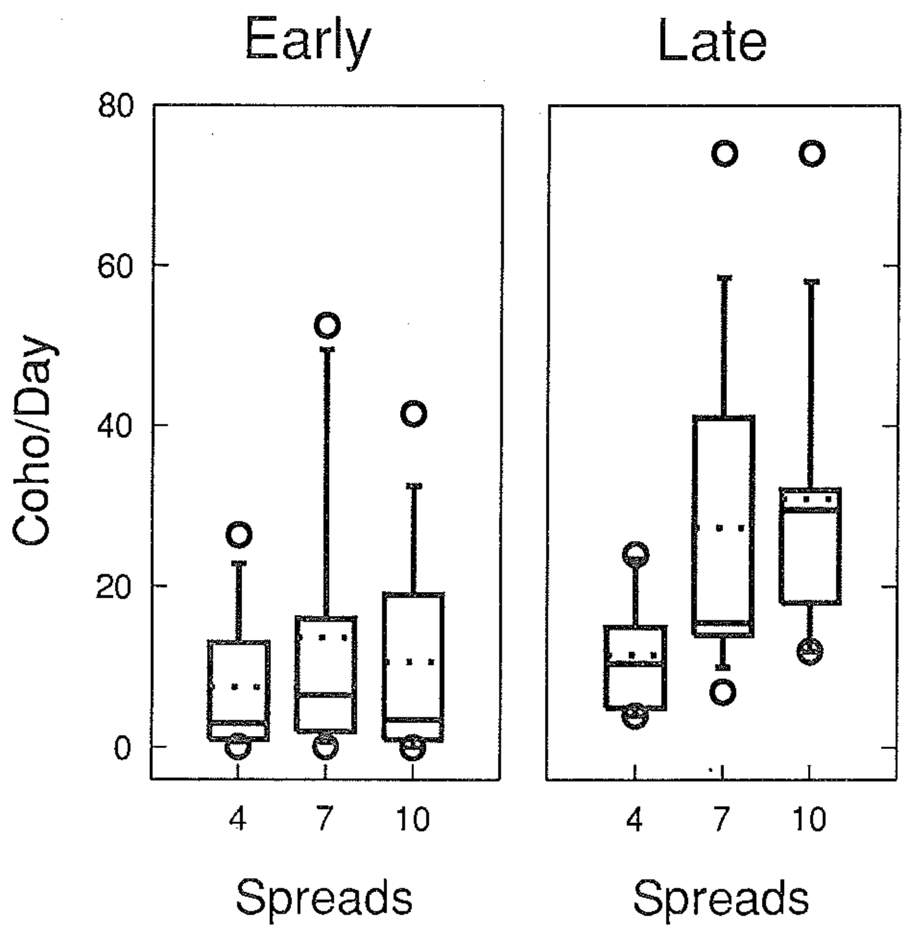
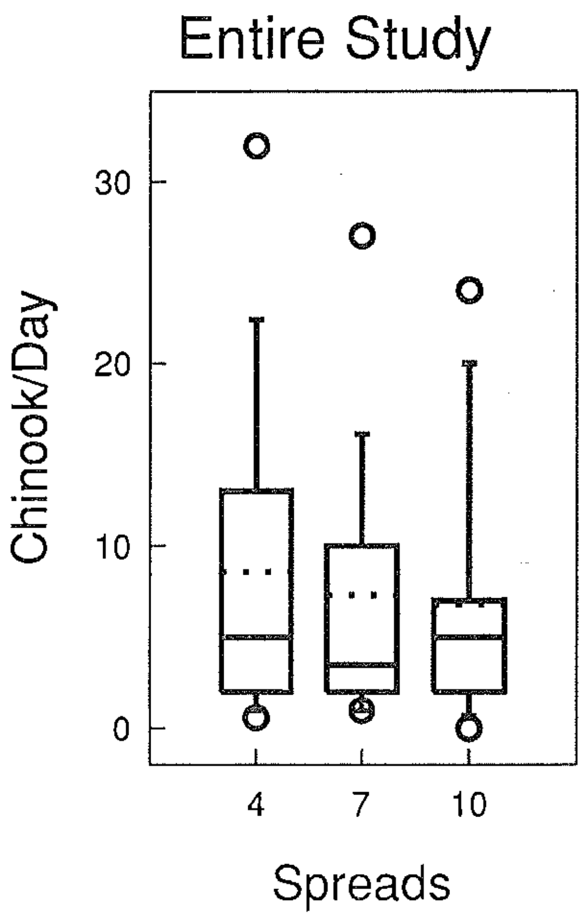

Entire Study
Coho/Day
60
40
20
0
4
7
10
Spreads

Figure 4. Box and whisker plots of coho/day with three gear arrays in early (26 May-16 June) and late (17-27 June) study periods.



Early
Late
80
60
40
20
0
Coho/Day
4
7
10
Spreads
4
7
10
Spreads

Figure 5. Box and whisker plots of chinook/day with three gear arrays for the entire study.



Entire Study
Chinook/Day
0
10
20
30
4
7
10
Spreads

Figure 6. Box and whisker plots of chinook/day with three gear arrays in early (26 May-16 June) and late (17-27 June) study periods.

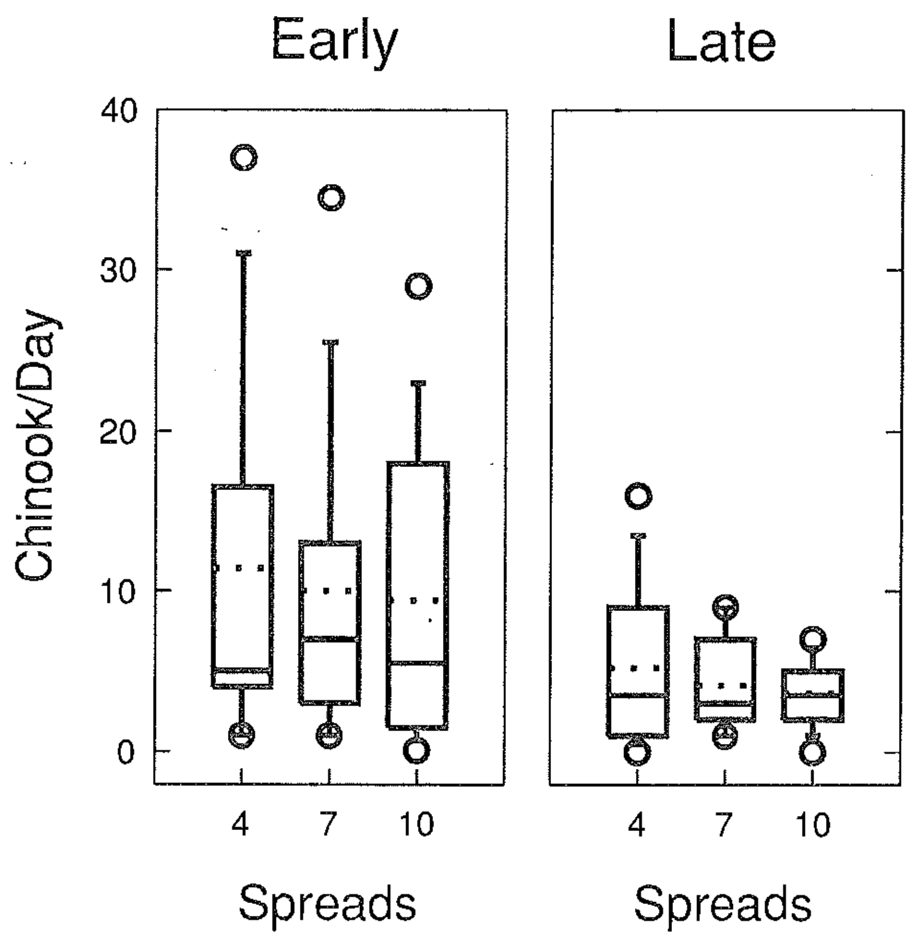
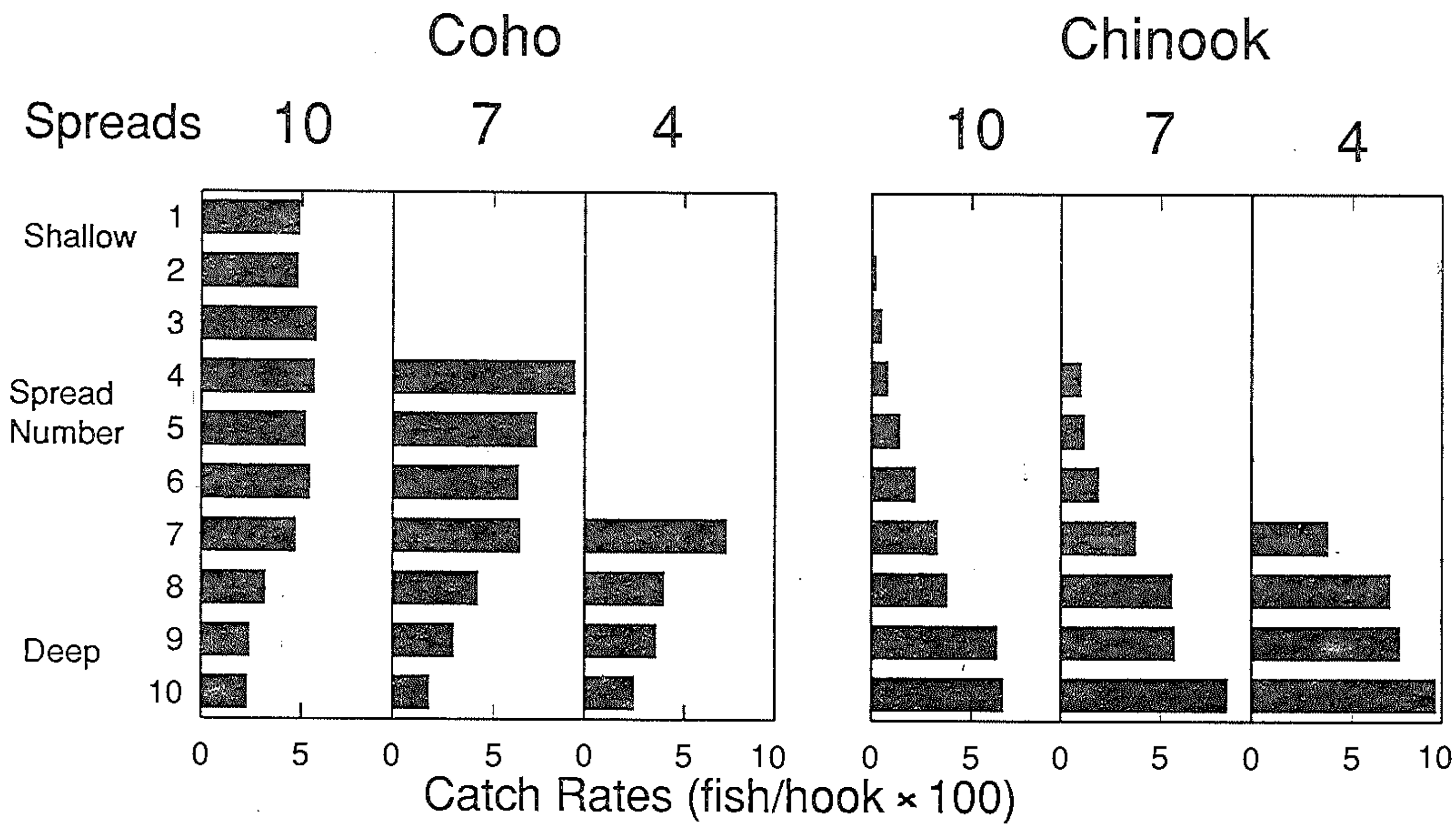
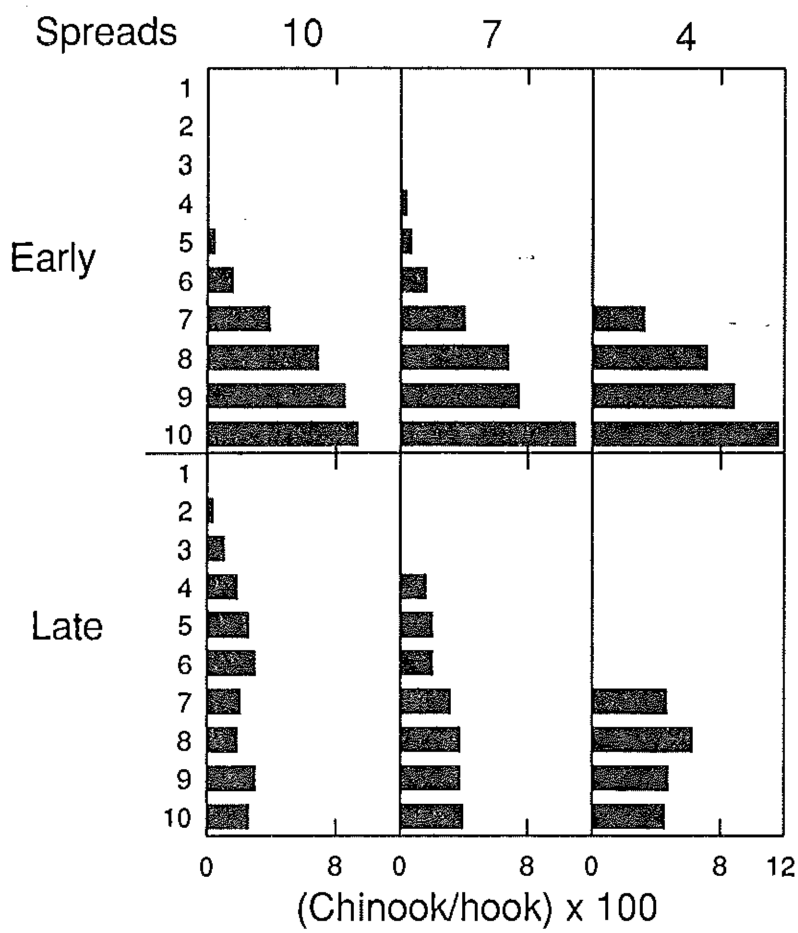

Early
Late
40
30
20
10
0
Chinook/Day
4
7
10
4
7
10
Spreads
Spreads

Figure 7. Distribution of coho and chinook encounters by spread on three gear arrays for the entire study. Spread 1 was always near the bottom and at similar depths for all three arrays.



Coho
Chinook
Spreads
10
7
4
10
7
4
Shallow
Spread
Number
Deep
1
2
3
4
5
6
7
8
9
10
0
5
0
5
0
5
10
0
5
0
5
0
5
10
Catch Rates (fish/hook × 100)

Figure 8. Distribution of chinook encounters by spread on three gear arrays for early (26 May-16 June) and late (17-27 June) study periods.



Spreads
10
7
4
Early
Late
1
2
3
4
5
6
7
8
9
10
0
8
12
(Chinook/hook) x 100

Figure 9. Distribution of coho encounters by spread on three gear arrays for early (26 May-16 June) and late (17-27 June) study periods.

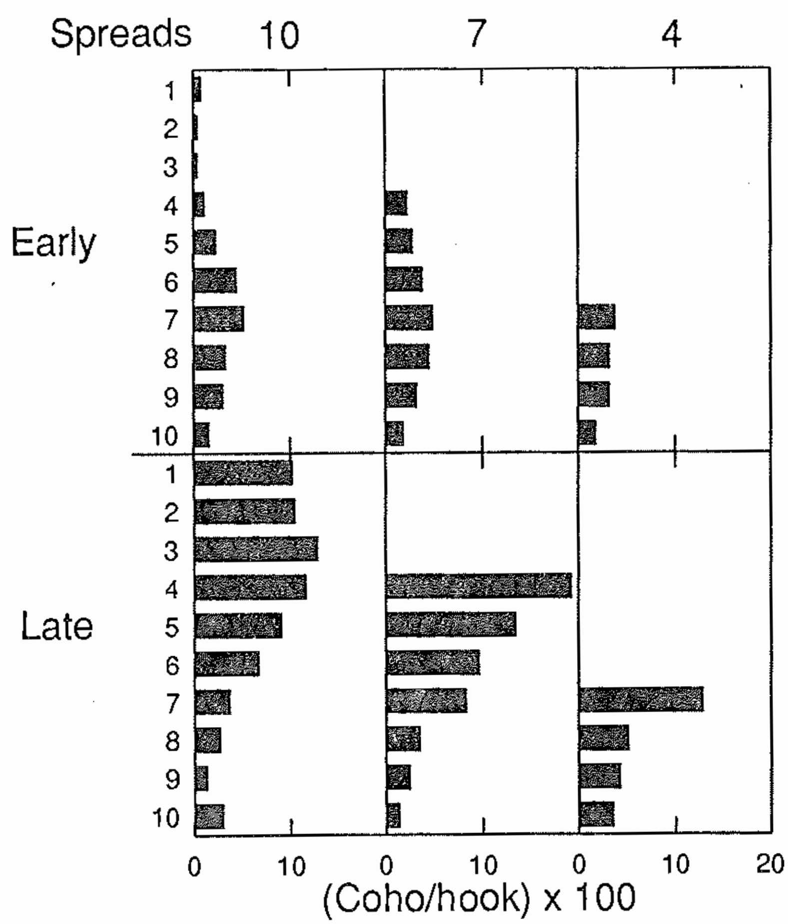
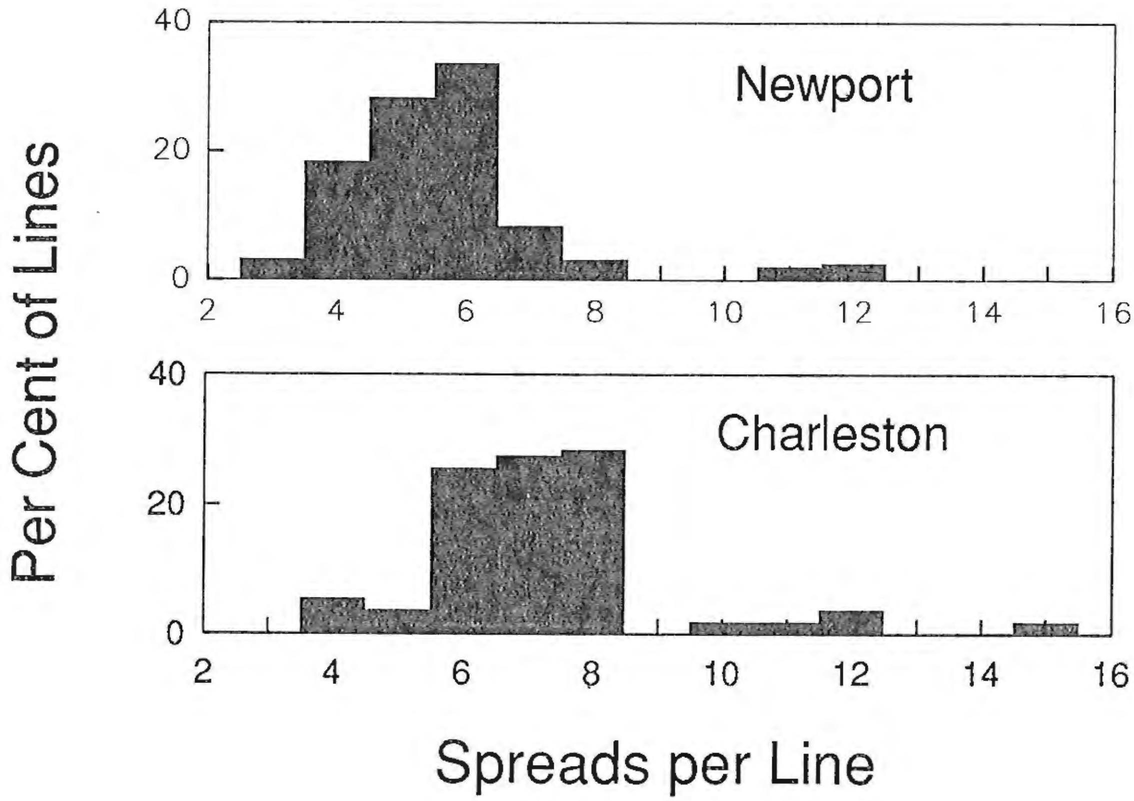

Spreads
10
7
4
Early
Late
1
2
3
4
5
6
7
8
9
10
0
10
20
(Coho/hook) x 100

Figure 10. Profile of gear use in Newport and Charleston during the May-June all-except-coho fishery in 1990. Bars represent per cent of lines reported for each number of spreads. Sample sizes: Newport, 41 boats, 196 lines; Charleston, 30 boats, 116 lines.


Newport
Charleston
Per Cent of Lines
Spreads per Line
40
20
0
2
4
6
8
10
12
14
16