GILLNET GEAR EVALUATION STUDY
IN SOUTHEAST ALASKA, 1987

By

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ABSTRACT

Four test fisheries were conducted in Southeast Alaska in 1987. The objective was to compare the efficiencies of four different mesh types including multifilament, mono-twist with center core, six-strand monofilament and single-strand monofilament. The experiments were conducted in two districts, glacial and clear water, and in two time periods, summer for sockeye and pink salmon and fall for coho and chum salmon. The results showed a general increase in efficiency with six- and single-strand mesh. Analysis of variance tests shows that single-strand was significantly more efficient in catching pink salmon in both districts, and that six- and single-strand were significantly more efficient for coho and chum salmon in the clear water district. No significant differences were found for sockeye salmon.

KEYWORDS: Salmon, Southeast Alaska, gillnet mesh efficiency.

INTRODUCTION

The most important factors associated with gillnet selectivity are: mesh size, elastic stretching of the net, inelastic stretching of the net (including stretching of the knots), hanging ratio of the net, strength and flexibility of the twine, and visibility of the twine (Clark, 1960). Other than mesh size, the most important characteristics of a gillnet are its visibility, stretchability of mesh, and tangling capacity (Hamley, 1975). Differences between gear types in the construction of the mesh may translate into differences in efficiency.

Prior to 1960, Alaska did not have any gillnet mesh regulations and all types of gear were legal. After statehood, monofilament nets became illegal. From 1960 to 1978 monofilament gear was not allowed, and was defined as any net which had any single filament of more than 50 denier (50 grams/900 meters of filament). Legal nets were those which had mesh comprised of many small fibers or strands. In 1978, the Alaska Board of Fisheries redefined a legal net as one whose "gillnet must contain no less than 30 strands." The new regulation eliminated any reference specifying individual fiber diameter. Consequently gear was developed which contain 30 strands, but of unequal sizes. The most common of this new type of gear was "mono-twist with center core", which had a core strand comprised of 24 very fine filaments around which a minimum of 6 heavier strands were wrapped. This gear was very similar to the traditional multistrand monofilament nets used in other areas of the country, but cost substantially more. Recognizing the physical similarities between "mono-twist with center core" gillnet mesh and the less expensive six-strand monofilament gillnet, the Alaska Board of Fisheries legalized six-strand monofilament gillnet gear in several areas of the state, including Southeast Alaska, beginning in 1988. The new regulation stated legal gillnet web must contain at least 30 filaments of equal diameter, or the web must contain at least 6 filaments each of which must be at least .20 millimeter in diameter.

Southeast Alaska has 4 distinct drift gillnet salmon fisheries located in regulation districts 101, 106 and 108, 111, and 115 (Figure 1). Gillnet catch-per-unit-of-effort (CPUE) is used by the Department of Fish and Game as a major indictor of the strength of the salmon returns and is used to manage these fisheries. Inseason CPUE is compared to historical averages to decide weekly gillnet fishing time and areas opened to gillnet fishing. In addition, gillnet coho salmon CPUE is monitored by the Department as an indication of coho salmon abundance in the inside waters of Southeast Alaska, and is used as a data base to manage the outside troll coho salmon fishery.

As a result of the recent gear changes in the Southeast Alaska gillnet fisheries, it is unknown to what extent salmon CPUE patterns during the past few years are reflective of changes in gillnet gear efficiency and therefore not reflective of run strength. In order to standardize inseason and historical CPUE to more accurately manage the Southeast Alaska's gillnet fisheries and outside coho salmon troll fishery, the Alaska Department of Fish and Game conducted a gillnet gear evaluation study during 1987.

The purpose of this study was to examine the effects of four different gillnet web materials upon catch rates, size selectivity and sex composition of sockeye and coho salmon, utilizing the gillnet mesh sizes commercially used to harvest each species. In order to determine the effect of water clarity and visibility on the catch rates of the gear types, the study was carried out in glacial and clear water sites and over 24-hour fishing periods in each of the four weeks of the study.

The center-core and six-strand meshes were assumed to be more efficient compared to the older commercially used multifilament gear, and a factor of relative efficiency was therefore assumed to be needed to adjust historical CPUE databases. Single strand monofilament was included as the fourth mesh type. Although it is commonly used in other states it is not a legal gear type in Alaska.

METHODS

The study was conducted in two separate gillnet fishing districts in Southeast Alaska. Gillnet districts 111 (Taku/Snettisham) and 106 (Sumner Straits) were selected to represent glacial and clear water conditions respectively (Figure 2). Two test boats were chartered for a full 24-hour period each week for four weeks in District 111 and 106 during the peak of each district's sockeye and pink salmon returns and for another four weeks during each district's coho and fall chum salmon return. Four individual experiments were conducted, where one experiment comprised four weeks of test fishing in one district. Thus two experiments, summer and fall, were conducted in each of two districts.

Sampling Methods

Each vessel fished a 200 fathom net comprised of four different 50 fathom panels of gillnet web with hanging ratios of web to corkline of 2.2 to 1. Gillnet mesh size used during the sockeye and pink salmon fishery was 5 1/4", while that for the coho and fall chum salmon was 6 1/4". Mesh size was based on net manufacturers stretch measurement made with dry web material. Mesh color and thread size matched that which is currently used in each area as suggested by local net distributors. The 5 1/4 " nets fished in Districts 111 and 106 used 85 lbs and 95 lbs of leadline, respectively, per 100 fathoms of net. Cork spacing on the corkline was 42" center to center. The 6 1/4" nets used 120 and 110 pounds of leadline per 100 fathoms of net, with cork spacing every 36".

The panels in each net were comprised of the following types of gillnet mesh:

1. Multifilament nylon with 30 strands (Uroko "2000"), referred to as multifilament in this report.
2. Mono-twist with center core (Uroko "Diamond"), referred to as center-core.
3. Six-strand monofilament (Uroko), referred to as six-strand.
4. Single strand monofilament (Uroko), referred to as single-strand.

Within each net, panels were separated by five fathom spaces to avoid panels leading fish to adjacent panels. Panels were ordered randomly at the beginning of each 24 hour fishing period, and re-ordered randomly approximately half-way through the 24 hour fishing period. When setting the nets, the end panels were alternated in relationship to the beach in an attempt to reduce any catch bias caused by fish leading the shore.

Species, sex, length and weight were recorded for each fish caught by panel type for each set. The time when the net was set, the time each panel started to come into the boat, and the time each panel was completely onboard were recorded. Fishing time was defined as that period from when the first float left the vessel to when the last float was reeled back on the boat, and was calculated as:

$$T = (tin1 - tout) + 0.5(tin2 - tin1)$$

where,

T = fishing time in hours

tout = time first float of net leaves the boat

tin1 = time panel starts coming into boat

tin2 = time panel totally on the boat.

The method by which each fish was caught in the web, and those which dropped out, was recorded. The method of entanglement was divided in the following categories:

1. Drop outs
2. Those fish caught only by mouth or maxillary = tangled.
3. Those fish caught past their gills or gill plates = gilled.
4. Those fish caught past the head = wedged.

Analysis Methods

All data were entered on micro-computers using LOTUS 1-2-3 (LOTUS 1985) software; statistical analyses was conducted on a VAX mini-computer using SAS statistical software (SAS 1985a,b). The experimental design was a randomized complete block design with two- and three-way factor analysis. Analyses were carried out for each species and for males and females separately and combined. Two and three-way analyses of variance (ANOVA) were used to examine the effect of gear type on three dependent variables (Table 1), which were:

1. Length (mm)
2. Sex-ratios
3. Catch rates.

The data were blocked by sets within boats, as the catch rate was highly variable between sets. The analysis for catch rates and sex-ratios were conducted as 3-way analysis for the summer experiments, with week, period and mesh type as the three factors (Table 1). In the fall fisheries, period was not included as a factor as few or no night sets were taken, and the analysis became a 2-way study. Boats and sets within boats were considered random effects, as were weeks, while period and mesh type were fixed. The analysis of length included week, mesh type and entanglement mode as factors in a 3-way study, and entanglement mode was treated as a fixed effect in the model. The F-ratios used (Table 1) for testing the hypothesis were determined for this mixed model using procedures outlined in Zar (1984). Multiple comparisons of mesh types were made using the Tukey-Kramer test (Neter and

Wasserman 1974, SAS 1985b p. 470-476), and the maximum experimentwise error rate was controlled to 5% (= 0.05).

Chi-square tests were used to determine whether there was any effect of mesh type on the mode of fish entanglement. The number of fish caught by each entanglement method was compared for each mesh type to the average distribution for all mesh types combined. The significance probabilities (p) are reported for all of these tests in the results. For the purposes of this report significant probabilities of less than 0.05 were considered statistically significant.

Relative Gear Efficiency

The estimation of relative gear efficiency was an important objective of the study. Collins (1987) in a similar study derived a net efficiency factor as a ratio of catch rates such that,

$$R = r \times F(M, q_2, E, r),$$

where,

R = ratio of catch rates
r = "true" efficiency factor
M = natural mortality
q_2 = catchability of mesh type 2
E = effort,

and $F(M, q_2, E, r)$ is a function of r, mortality, catchability and effort.

When effort is small then,

$$R \simeq r$$

The ratio R is calculated as a ratio of CPUE for the mesh types being compared,

$$R = C_1 / C_2,$$

where,

C_1 = catch per hour fished for mesh type 1
C_2 = catch per hour fished for mesh type 2.

The mean ratio R was calculated for center-core (C_1), six-strand (C_1) and single-strand (C_1) compared to multifilament (C_2), and also for six-strand (C_1) compared to center-core (C_2) using CPUE values summed for each boat and week. The average ratios (R) were calculated,

$$R = 1/n \ S \ R_{ij}$$

where,

R_{ij} = ratio of CPUE values for 2 mesh types for week i and boat j.
n = the number of weeks x boats.

with variance,

$$Var(R) = s^2 / n$$

where

s^2 = variance of R_{ij}.

These ratios and their 95% confidence intervals were calculated. A ratio of one would indicate that there was no difference between the two mesh types being compared. Therefore, the results of the ANOVA tests comparing mesh types were first examined and the ratios calculated only for those mesh types which were found to be significantly different.

RESULTS

The 1987 test fishery was conducted in Taku Inlet and Sumner Strait during the weeks from July 9 to July 31 (Summer fishery), and during the weeks from August 27 to September 18 (Fall fishery). In Sumner Strait the summer fishery occurred from July 8 to July 30 and the fall fishery from August 20 to September 2. Sockeye and pink salmon were the major species caught during the summer test fishery; coho and chum salmon were dominant during the fall test fishery (Table 2).

A total of 1,476 sockeye salmon were taken during the summer fishery in Taku Inlet in 74 sets, and 874 sockeye were caught in Sumner Strait in 97 sets. An additional 4,933 pink salmon were taken in Taku Inlet and 1,676 pink salmon in Sumner Strait. In the fall 466 coho salmon were taken in Taku Inlet in 66 sets, and 478 coho salmon in Sumner Straits in 96 sets, with 1,094 chum salmon taken in Taku Inlet and 293 in Sumner Strait.

In Taku Inlet the catch of sockeye and pink salmon peaked in the second week (July 16), but in the first week in Sumner Strait (July 2). In the fall, coho and chum salmon were most numerous during the last week of the test fishery in Taku Inlet (September 17), and coho salmon were most numerous in the second week in Sumner Strait (August 26). Chum salmon were not caught in great numbers in any week in Sumner Strait (Table 2). The results presented here are for sockeye and pink salmon caught in the summer fishery, and for coho and chum salmon taken in the fall fishery.

Sex Ratios

The comparison of percent males in the catch did not show any significant differences between mesh types (Table 3). However, in Sumner Strait the F-statistic for the boat-effect was significant for all species; there was a significant difference in the male to female sex-ratios between the two boats fishing. Although the sample sizes were small, the number of fish per set averaged 3 to 18 fish in Sumner Strait (Table 4). This difference in sex-ratios may have been due to incorrect sexing of the salmon on-board, hence the data for Sumner Strait were combined for comparison of the catch rates of salmon. In addition, some samples of pink salmon in Taku Inlet were not separated by sex and these were also combined for analyses.

Length and Method of Entanglement

The average length for sockeye salmon ranged between 580 and 598 mm in the experiments (Table 5) and did not differ between Taku Inlet and Sumner Strait (Figure 3). Pink salmon were, on the average, larger in Sumner Strait (520 mm) compared to Taku Inlet (490 mm). In the fall fishery coho salmon and chum were larger in Taku Inlet compared to Sumner Strait. Coho Salmon averaged 660 mm in Taku Inlet and chum salmon averaged 650 mm, while in

Sumner Strait coho salmon averaged 640 mm and chum salmon 640 mm (Table 5). No significant differences were found comparing the average size of salmon caught by the four mesh types in each experiment (Table 6).

Comparison between weeks fished indicated that in four cases, pink salmon in Taku Inlet, female pink salmon in Sumner Strait, male coho salmon in Sumner Strait and female chum salmon in Taku Inlet, the mean size was significantly different between the weeks fished (Table 6). Ninety-five percent confidence intervals were calculated for these cases (Table 7). These indicated that for pink salmon in District 111 the average size was larger in the first week compared to the later weeks, and that there was an apparent increase in size for male coho in District 111 and female chum salmon in District 106 over the weeks. These differences could be due to several factors, including:

1. the increase in fish size due to growth over the weeks,
2. changes in body configuration as the males develop spawning characteristics in the later weeks, such as an increase in the girth to length ratio and kype development, and
3. size differences due to changes in stock composition over the four week period of the study.

In all cases the average size of fish was significantly larger for tangled and gilled fish compared to wedged fish (Figure 4). The dominant mode of entanglement differed between species and location (Table 8). Sockeye salmon were gilled more frequently in both locations, with a higher percentage of females wedged compared to the males. Pink salmon were wedged over 80% of the time in both areas. The 5 1/4" mesh used during the summer was "sockeye gear"; that is, it targeted sockeye salmon. Sockeye salmon length frequencies averaged around 590 mm in this gear (Table 5). Pink salmon are much smaller (Table 4), and so would be expected to wedge more easily. In the fall, coho and chum salmon were gilled most frequently in Taku Inlet, but were wedged more frequently in the nets in Sumner Strait (Table 8). Again, this was probably a function of size as Sumner Strait coho and chum salmon were smaller than Taku Inlet coho and chum salmon (Figure 3).

The number of drop-outs was included in the data collected for each mesh type. However, very few drop-outs were actually recorded during the fisheries and this "entanglement mode" was not included in the analysis.

Comparison of the number of fish caught by each entanglement method were significant for sockeye salmon in both locations and pink salmon in Taku Inlet (Table 9). In all cases, these significant tests appeared to be due to the fact that the single strand gear had a higher percentage of fish wedged in the net.

Catch Rates

Examination of the observed distribution of catch per hour fished indicated that it tended to be skewed to the right. A log-transformation was used to normalize the data prior to the analysis, and the mean CPUE and 95% confidence intervals were calculated using log-transformed data and the mean and confidence interval transformed back to the original variable (Table 10 and 11, Figure 5). Although there seemed to be a general trend in CPUE with multifilament being the least efficient and single strand the most efficient (Figure 5), the results of the statistical analyses comparing the CPUE between mesh types differed depending on the species and areas fished (Table 12).

Sockeye Salmon

Total mean CPUE for sockeye salmon ranged from 1.7 to 2.6 fish per hour in Taku Inlet (Figure 5), with peaks of 5.2 to 11.3 fish per hour in the second week (Table 10). In Sumner Strait the mean CPUE ranged from 1.3 to 1.6; the peak catches occurred in the first week, ranging from 4.1 to 10.6 fish per hour fished. The results from the ANOVA showed no significant differences in CPUE between mesh types for sockeye salmon (Table 12).

Pink Salmon

The CPUE for pink salmon (Figure 5) was found to differ significantly between mesh types in Taku Inlet (Table 12). The CPUE ranged from 5.8 to 11.1 fish per hour in Taku Inlet and 1.3 to 4.0 fish in Sumner Strait (Table 10). The single strand gear was the most efficient type of mesh for catching pink salmon in both areas and was significantly different from multifilament and center-core gear in Taku Inlet (Table 13).

The relative efficiencies of these mesh types for pink salmon ranged from 1.3 to 2.2 in Taku Inlet and 1.0 to 3.0 in Sumner Strait (Table 14). The single strand gear was twice as efficient as multifilament gear in Taku Inlet (Table 14) and three times as efficient as multifilament in Sumner Straits (Figure 6).

Coho Salmon

The CPUE values were relatively low in all weeks for coho salmon (Table 11), with the means ranging from 0.8 to 1.1 in Taku Inlet and 0.5 to 1.2 in Sumner Strait (Figure 5). The results of the ANOVA tests for coho salmon differed between Taku Inlet and Sumner Strait (Table 12). In Taku Inlet, a glacial environment, no significant differences were found in CPUE between the mesh types (Table 12). In the clear water area, Sumner Strait, a significant difference in CPUE was found for coho salmon (Table 12), where single strand gear was significantly more efficient than multifilament, but no other comparison was significant (Table 13).

The relative efficiencies of mesh types ranged from 1.3 to 1.8 in Taku Inlet and from 1.2 to 2.6 in Sumner Strait (Table 14). In Sumner Strait the single strand was almost three times more efficient than the multifilament (Figure 6).

Chum Salmon

The mean CPUE ranged from 1.5 to 2.1 for chum salmon in Taku Inlet and from 0.3 to 0.8 in Sumner Strait (Figure 5). In Taku Inlet a high catch occurred in the fourth week (3.4 to 5.6 fish per hour), but no similar peak occurred in Sumner Strait where catches remained low for the duration of the test fishery (Table 11). In Taku Inlet there was a significant difference in CPUE between mesh types for female chum salmon (Table 2), but none of the pairwise comparisons were significant (Table 13). In Sumner Strait the ANOVA tests were significant and the pairwise comparisons showed that single strand was significantly more efficient than multifilament.

The relative efficiencies for chum salmon in Sumner Strait indicate that single strand gear is over three times as efficient as multifilament (Figure 6); however, the CPUE values were very low for chum salmon in all weeks in Sumner Strait.

DISCUSSION

There was a trend towards increasing efficiency across the gear types included in this study, with multifilament mesh the least efficient and single-strand the most efficient. Generally, CPUE and gear efficiency increased as the number of strands decreased in the web (Figure 6). Water clarity, time of day, the species and the sex of the fish, and behavioral and morphological differences were all variables which effected the efficiency of each mesh type. The results of these studies seem to agree with Ali (1984) that the greatest factor influencing the efficiency of gear types is water clarity. Gear efficiency also increases as the number of strands decrease, and the transparency of gillnet gear is closely correlated to the number of strands which comprise the gear twine.

The results of this study are also similar to those found for sockeye salmon in a gillnet study conducted in Bristol Bay in 1984 (Bue 1986). Bue compared multifilament nylon to center-core gear and found that center-core caught significantly more sockeye salmon in clear water compared to the multifilament gear. Although the sockeye salmon results did not follow the same pattern in Southeast Alaska, the coho and chum salmon results did. The trends for these two species showed larger differences between gear types in Sumner Strait, which has clearer water than Taku Inlet (Figures 5 and 6).

The largest amount of variation in all of these studies occurred among the individual sets themselves. This variability, which is inherent in any field study of this kind, must complicate the task of measuring differences in efficiency between gear types and estimating the relative efficiencies of different mesh types. It is even more difficult to apply the results to the fisheries, as the variation among the fishermen will be greater than the variation measured between sets or boats in a controlled test fishery.

Catch rates for sockeye salmon were not significantly different between the gear types compared in this study, neither in the clear water areas nor in the glacial fishing areas (Table 13). The single strand monofilament gear caught more pink salmon independent of water clarity. The mesh size used was not an optimum size for harvesting pink salmon; most of the fish were wedged in the nets (Table 8). The results might be different with smaller mesh sizes in a directed pink salmon fishery. Coho and chum salmon were caught more efficiently in single-strand gear in clear water conditions, but not in glacial conditions (Figure 6). No difference was found between the recently legalized six-strand monofilament nylon gear and the mono-twist with center-core used commercially for the past several years (Figure 6). The six-strand gear did appear to be twice as efficient as the multifilament in clear water (as represented by the Sumner Strait results Figure 6), but our results were inconclusive, probably due to low catch rates and small sample sizes.

The implication for management of these results are important. In all cases where significant differences were found, single strand was more efficient than the other gear types. This gear is not legal in Southeast Alaska. If it were to become legal for use in the region's gillnet fisheries extensive adjustments would be needed to standardize the catch and effort data bases.

Gillnet fisheries in Southeast Alaska are, in some locations and for some species, U.S./Canada Treaty fisheries. In the case of coho salmon the gillnet CPUE is used as an indicator of abundance and it is important that the historical data base be comparable to inseason CPUE. The results indicate that the six-strand gear may be more efficient than the older multifilament gear for coho salmon in clear water fisheries. In order to address this problem additional study is planned in Sumner Strait, which will focus on the two gear types, multifilament and six-strand, to hopefully provide a more precise estimate of relative efficiency by increasing the samples sizes.

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Table 1. Model used for Analysis of Variance in 1987 Test Fishery (Zar, 1984).

Model.

$$Y_{ijklm} = \mu + A_i + B_{j(i)} + C_k + D_l + E_m + (CD)_{kl} + (CE)_{km} + (DE)_{lm} + (CDE)_{klm} + e_{(ijklm)}$$

Source of Variation	Model	Effect	F-ratio
Boats	A_i	Random (Block)	MS_A/MS_B
Sets	$B_{j(i)}$	Nested in boats	MS_B/MS_e
Weeks	C_k	Random	MS_C/MS_e
Period[a]/Entanglement[b]	D_l	Fixed	MS_D/MS_{CD}
Mesh Type	E_m	Fixed	MS_E/MS_{CE}
C x D			MS_{CD}/MS_e
C x E			MS_{CE}/MS_e
D x E			MS_{DE}/MS_{CDE}
C x D x E			MS_{CDE}/MS_e
Error	$e_{(ijklm)}$		

a) Period: 1=day, 2=night
This factor is included in analysis of catch rates and sex ratios in summer experiments. In fall experiments analysis of catch rates and sex ratios this factor (D) is eliminated and the analysis is a two-way study, with the effects CD, DE and CDE also eliminated.

b) Entanglement mode: 1=tangled, 2=gilled, 3=wedged.

c) Mesh type: 1=multifilament nylon, 2=monotwist center core, 3=six-strand monofilament, 4=single strandmonofilament.

Table 2. Number of Sets and Catch in Test Fishery 1987.

	Number of Sets	Chinook Salmon	Sockeye Salmon	Coho Salmon	Pink Salmon	Chum Salmon
Taku Inlet						
Summer - Week 1	22	18	167	4	1265	72
2	8	1	563	24	1158	171
3	23	4	404	8	1603	166
4	21	1	344	36	907	74
Total	74	24	1476	72	4933	483
Fall - Week 1	17	4	6	36	2	173
2	17	0	4	171	0	192
3	19	0	2	105	0	246
4	13	0	2	154	0	483
Total	66	4	14	466	2	1094
Sumner Strait						
Summer - Week 1	19	0	193	19	635	8
2	25	1	206	39	344	49
3	23	0	261	26	325	43
4	25	0	214	27	372	74
Total	92	1	874	111	1676	174
Fall - Week 1	24	0	20	122	11	77
2	48	0	5	264	15	139
3	24	0	0	92	3	77
Total	96	0	25	478	29	293

Table 3. Results of ANOVA Comparing Percent Males Between Mesh Types in 1987 Test Fishery.[a]

	Taku Inlet	Sumner Strait
Sockeye Salmon		
Boat	p = .54	p = .07
Week	p = .49	p = .13
Day	p = .50	p = .70
Mesh Type	p = .42	p = .60
Pink Salmon		
Boat	p = .28	p < .001
Week	p = .70	p = .02
Day	p = .38	p = .54
Mesh Type	p = .11	p = .30
Coho Salmon		
Boat	p = .55	p = .04
Week	p < .001	p = .22
Mesh Type	p = .73	p = .34
Chum Salmon		
Boat	p = .34	p = .004
Week	p = .94	p = .10
Mesh Type	p = .34	p = .79

[a] P is the significance probability. Significance probabilities of less than 0.05 were considered significant.

Table 4. Number of Sets and Average Fish Per Set in 1987 Test Fishery.

	Taku Inlet		Sumner Strait	
	Summer	Fall	Summer	Fall
Sets	74	66	92	96
Sockeye Salmon				
Total	1471	3	874	25
Fish/Set	20	<1	9	<1
Pink Salmon				
Total	3935	13	1672	29
Fish/Set	53	<1	18	<1
Coho Salmon				
Total	72	462	111	478
Fish/Set	1	7	1	5
Chum Salmon				
Total	483	1107	174	293
Fish/Set	6	17	2	3

Table 5. Mean Length (L), Standard Deviation (S) and Sample Size (N)[a] for Salmon Caught in Test Fishery 1987.

	Multifilament			Center-Core			Six-Strand			Single-Strand		
	N	L	S	N	L	S	N	L	S	N	L	S
Taku Inlet												
Sockeye Salmon												
Male	154	594	41.9	183	594	39.2	201	598	40.0	209	594	40.5
Female	141	589	21.5	163	586	22.5	72	588	23.9	196	589	22.8
Pink Salmon												
Male	421	485	27.6	577	486	27.3	624	483	27.2	871	480	44.0
Female	278	492	18.7	304	494	19.3	328	491	22.7	532	490	20.1
Coho Salmon												
Male	56	664	40.5	65	669	44.3	71	660	36.1	83	656	46.7
Female	42	646	35.0	39	647	35.1	45	648	33.6	61	646	26.5
Chum Salmon												
Male	135	656	37.9	116	655	38.6	145	655	39.0	158	654	35.6
Female	107	646	27.7	98	647	27.3	155	648	33.3	173	646	28.9
Sumner Strait												
Sockeye Salmon												
Male	84	592	43.2	110	587	40.4	93	589	44.2	98	595	37.6
Female	97	591	24.4	116	585	30.1	128	591	22.7	148	587	30.3
Pink Salmon												
Male	125	521	31.9	244	525	28.1	187	518	30.5	36.7	517	28.6
Female	110	524	23.5	163	525	25.2	150	522	21.6	326	519	20.2
Coho Salmon												
Male	39	637	39.9	66	630	37.0	54	633	39.5	99	634	38.9
Female	31	639	34.3	45	634	32.0	69	636	24.9	75	636	33.5
Chum Salmon												
Male	18	646	28.0	36	637	38.4	28	647	34.5	51	642	28.3
Female	20	642	35.4	37	630	31.6	47	625	30.4	56	631	29.7

[a] Sample size (N) is not equal to total catch of pink salmon.

Table 6. Comparison of Mean Length (mm) of Salmon in 1987 Test Fishery.[a)]

	Taku Inlet		Sumner Strait	
	Male	Female	Male	Female
Sockeye Salmon				
Week	p = .146	p = .215	p = .405	p = .437
Panel	p = .163	p = .417	p = .773	p = .759
Entanglement	p < .001	p = .002	p = .002	p < .001
Pink Salmon[b]				
Week	p < .001	p = .015	p = .308	p = .003
Panel	p = .067	p = .145	p = .264	p = .598
Coho Salmon				
Week	p = .421	p = .095	p < .001	p = .711
Panel	p = .640	p = .263	p = .481	p = .546
Entanglement	p = .002	p = .010	p = .051	p = .018
Chum Salmon				
Week	p = .807	p = .115	p = .506	p = .015
Panel	p = .996	p = .970	p = .449	p = .216
Entanglement	p < .001	p < .001	p = .021	p = .082

a P is the significant probability. P-values of less than 0.05 were considered significant.

b 80-90% of pink salmon were wedged in nets. Analysis of mean length included only wedged fish as very small numbers were tangled or gilled.

Table 7. 95% Confidence Interval of Mean Lengths by Week.

	Taku Inlet Male Pink Salmon	Sumner Strait Female Pink
Week 1	483.1 - 486.7	523.5 - 528.7
2	476.8 - 480.6	516.7 - 523.9
3	480.8 - 485.6	518.7 - 525.5
4	477.9 - 484.5	513.9 - 520.9
Mean	481.9 - 484.1	520.2 - 523.4

	Sumner Strait Male Coho	Taku Inlet Chum Female
Week 1	614.3 - 631.9	627.8 - 642.2
2	626.9 - 640.1	638.7 - 651.7
3	637.0 - 657.8	647.9 - 657.7
4		644.2 - 651.6
Mean	628.5 - 648.1	644.1 - 649.3

Table 8. Percent Caught by Each Entanglement Mode by Species and Sex in Test Fishery 1987.

	Taku Inlet			Sumner Strait		
	Tangled	Gilled	Wedged	Tangled	Gilled	Wedged
Sockeye Salmon						
Male	14.1	63.3	22.6	3.6	63.4	33.0
Female	3.4	53.6	43.0	1.6	48.9	49.5
Pink Salmon						
Male	4.6	8.8	86.6	1.4	16.4	82.2
Female	1.3	2.2	96.5	0.5	6.3	93.2
Coho Salmon						
Male	31.6	45.4	22.9	5.4	37.6	57.0
Female	15.0	43.3	41.7	1.4	29.1	69.5
Chum Salmon						
Male	24.4	53.8	21.8	2.3	54.1	43.6
Female	1.7	25.9	72.4	0	30.6	69.4

Table 9. Comparison of Mode of Entanglement Between Mesh Types in Test Fishery 1987.[a]

	Taku Inlet	Sumner Strait
Sockeye Salmon		
Males	$p = .162$	$p = .062$
Females	$p = .033$	$p < .0001$
Pink Salmon		
Males	$p = .036$	$p = .905$
Females	$p = .062$	$p = .074$
Coho Salmon		
Males	$p = .740$	$p = .290$
Females	$p = .150$	$p = .190$
Chum Salmon		
Males	$p = .460$	$p = .250$
Females	$p = .130$	$p = .009$

a) P is the significance probability and a value of less than 0.05 is considered significant.

Table 10. Mean Catch Per Hour Fished (CPUE) for Summer Test Fishery 1987.

	Number	Multi-filament		Center-Core		Six-Strand		Single-Strand	
	Sets	Sockeye	Pinks	Sockeye	Pinks	Sockeye	Pinks	Sockeye	Pinks
Taku Inlet									
Week 1									
Day	19	1.16	6.95	1.10	8.92	0.85	9.13	1.43	13.09
Night	3	0.34	2.10	0.23	2.31	0.48	2.79	0	3.73
Week 2									
Day	5	8.69	9.30	9.65	10.72	11.34	15.19	8.50	26.55
Night	3	6.16	2.67	10.46	3.62	5.31	16.70	6.02	23.14
Week 3									
Day	19	2.33	6.80	2.34	8.22	3.98	11.03	3.37	16.52
Night	4	0.49	2.30	0.56	3.52	0.92	2.47	0.87	3.64
Week 4									
Day	20	1.50	5.49	2.11	3.25	3.50	5.80	1.44	7.11
Night	1	0	0	0	0	0	3.03	0	2.5
Total	74	1.70	5.78	1.89	6.00	2.57	8.00	2.04	11.14
Sumner Strait									
Week 1									
Day	18	0.88	3.11	1.62	5.55	1.70	3.50	2.42	7.49
Night	1	4.13	11.57	10.64	42.81	0	10.13	2.02	30.30
Week 2									
Day	16	0.80	1.41	2.01	2.06	1.66	2.82	2.10	2.13
Night	9	0.87	1.05	1.07	1.30	1.70	1.76	0.77	2.68
Week 3									
Day	20	2.54	1.46	2.26	1.84	2.08	3.06	1.82	4.43
Night	3	1.84	3.46	4.26	0.93	1.57	1.19	1.53	1.06
Week 4									
Day	14	1.93	1.54	1.26	3.65	2.02	3.60	3.36	10.79
Night	11	0.40	0.61	0.79	0.72	0.86	1.10	0.40	0.82
Total	92	1.26	1.64	1.67	2.43	1.66	2.49	1.60	4.05

Table 11. Mean Catch Per Hour Fished for Fall Test Fishery 1987.

	Number Sets	Multifilament		Center-Core		Six-Strand		Single Strand	
		Coho	Chum	Coho	Chum	Coho	Chum	Coho	Chum
Taku Inlet									
Week 1	17	0.26	1.00	0.27	1.18	0.26	1.42	0.27	1.02
2	17	1.02	1.10	1.08	0.85	1.61	1.11	1.76	1.39
3	19	1.06	1.61	0.73	1.77	0.90	2.36	1.09	2.72
4	13	1.18	5.53	1.51	3.36	1.65	5.46	1.77	5.65
Total	66	0.81	1.77	0.79	1.54	0.97	2.08	1.08	2.13
Sumner Strait									
Week 1	24	0.66	0.35	0.95	0.58	1.07	0.59	1.41	1.14
2	48	0.43	0.37	0.99	0.48	0.83	0.52	1.28	0.63
3	24	0.47	0.16	0.67	0.67	0.97	0.36	0.91	0.81
Total	96	0.48	0.30	0.87	0.53	0.89	0.48	1.21	0.76

Table 12. Significance of Tests Comparing CPUE Between Mesh Types for 1987 Test Fishery.[a]

	Taku Inlet			Sumner Strait
	Male	Female	All	All[b]
Sockeye Salmon				
Week	$p < .001$	$p < .001$	$p < .001$	$p = .007$
Period	$p = .002$	$p = .035$	$p = .006$	$p = .742$
Mesh Type	$p = .233$	$p = .126$	$p = .076$	$p = .365$
Pink Salmon[c]				
Week			$p = .009$	$p = .003$
Period			$p = .223$	$p = .699$
Mesh Type			$p = .002$	$p = .090$
Coho Salmon				
Week	$p < .001$	$p < .001$	$p < .001$	$p = .715$
Mesh Type	$p = .070$	$p = .394$	$p = .105$	$p = .005$
Chum Salmon				
Week	$p < .001$	$p < .001$	$p < .001$	$p = .788$
Mesh Type	$p = .189$	$p = .039$	$p = .099$	$p = .018$

[a] P is the significance probability where a p-value of less than 0.05 was considered significant.

[b] Sexes were combined for Sumner Strait data.

[c] Pink salmon were not all sexed, and cannot be separated.

Table 13. Pairwise Comparisons of Mesh Types for Experiments With Significant ANOVA Results.

Location	Species	ANOVA p-value	Significant Panel Comparisons
Taku Inlet	Pink Salmon	.002	Single-Strand vs. Outer Core " vs. Multifilament
	Chum Female	.039	None
Sumner Strait	Coho Salmon	.005	Single-Strand vs. Multifilament
	Chum Salmon	.018	Single-Strand vs. Multifilament

Table 14. Relative Efficiency of Mesh Types as Estimated by Ratios of CPUE for Test Fisheries 1987.[a]

	Center Core/ Multifilament			Six-Strand/ Multifilament			Single-Strand Multifilament			Six-Strand Center Core		
	Mn	St. Err	CV	Mn	St. Err	CV	Mn	St. Err	CV	Mn	St. Err	CV
Summer												
Taku Inlet												
Sockeye	1.01	.09	25.3	1.42	.25	50.7	1.18	.13	31.1	1.39	.15	29.7
Pinks	1.26	.24	54.4	1.58	.20	35.7	2.19	.47	60.0	1.36	.12	25.0
Sumner Strait												
Sockeye	1.63	.33	57.9	1.78	.46	72.3	1.65	.33	56.6	1.08	.12	30.7
Pinks	1.83	.28	43.5	1.61	.21	36.8	2.96	.50	48.1	1.02	.21	56.8
Fall												
Taku Inlet												
Coho	1.33	.30	63.0	1.52	.37	68.6	1.78	.52	82.1	1.34	.36	75.2
Chum	0.98	.14	38.9	1.33	.24	50.4	1.50	.36	67.9	1.34	.07	15.4
Sumner Strait												
Coho	1.73	.35	49.8	1.92	.23	29.3	2.61	.56	52.7	1.21	.15	29.9
Chum	3.07	1.30	103.6	2.43	.60	60.0	3.76	.84	54.9	.99	.14	34.0

a Mn = Mean Ratio = $\frac{\text{CPUE Mesh Type 1}}{\text{CPUE Mesh Type 2}}$

St. Err = Standard error of mean ratio.

CV = Coefficient of variation = (standard deviation/mean)*100.

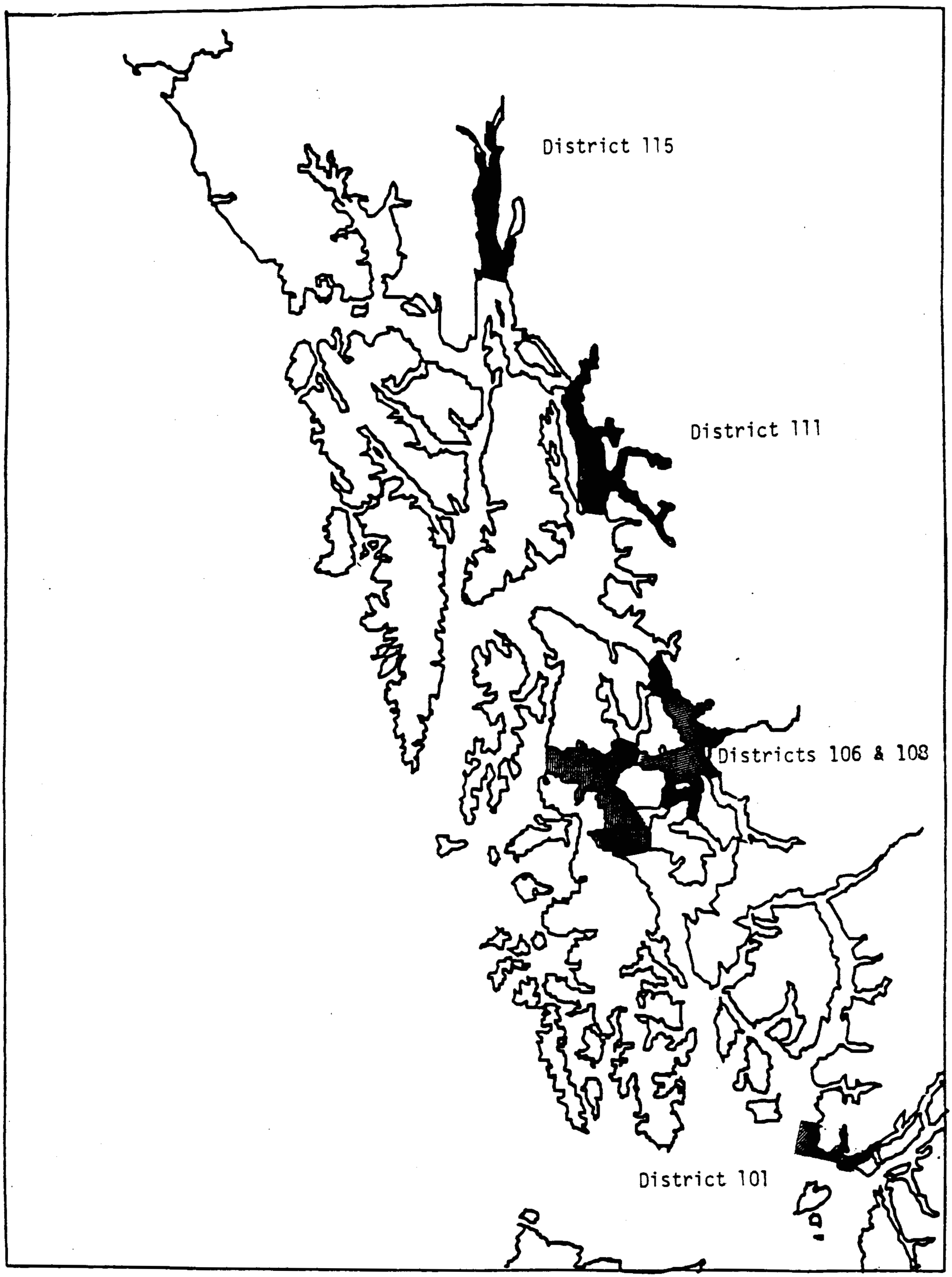


Figure 1. Southeast Alaska Drift Gillnet Fishing Areas.

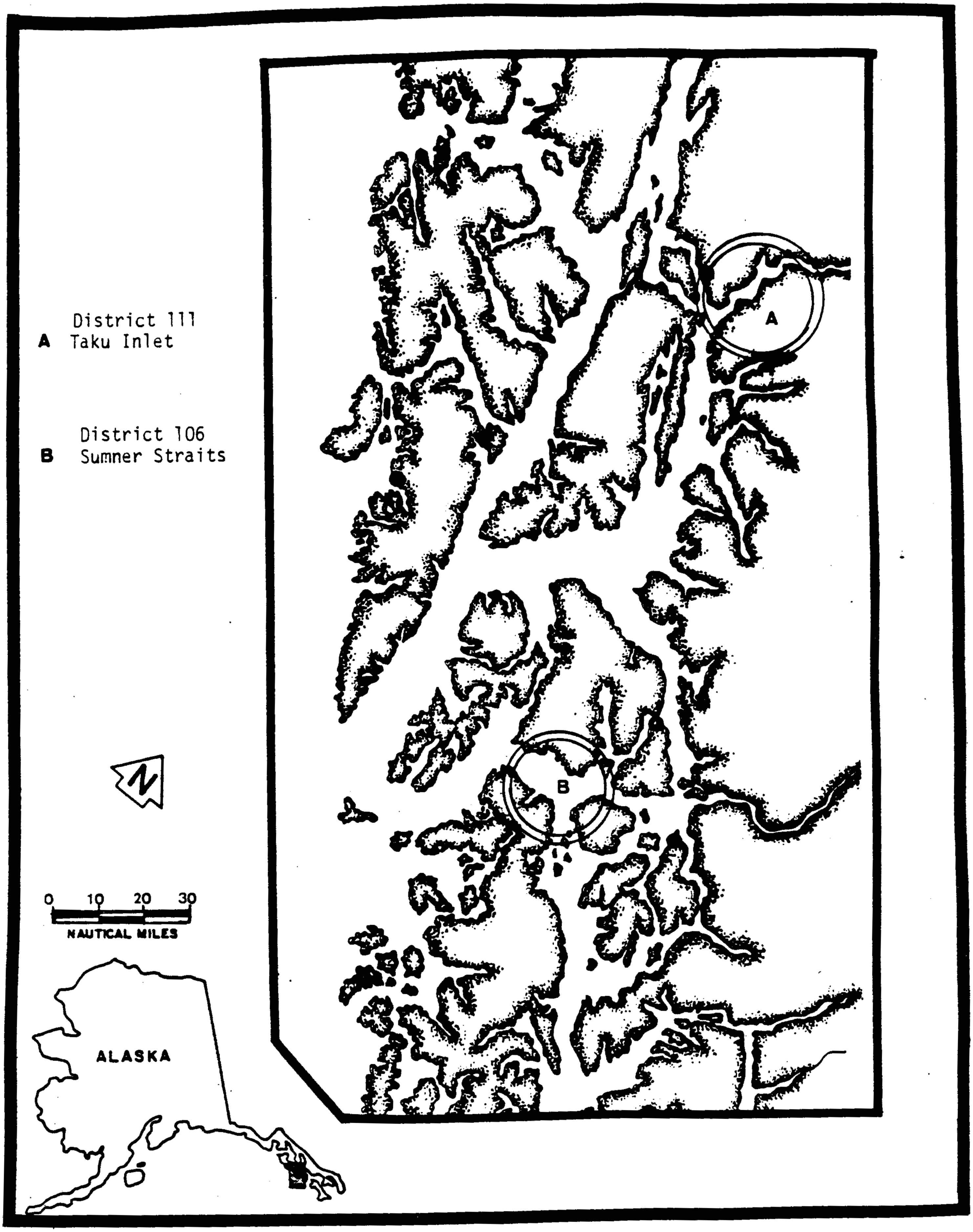


Figure 2. Gillnet Gear Evaluation Study Areas.

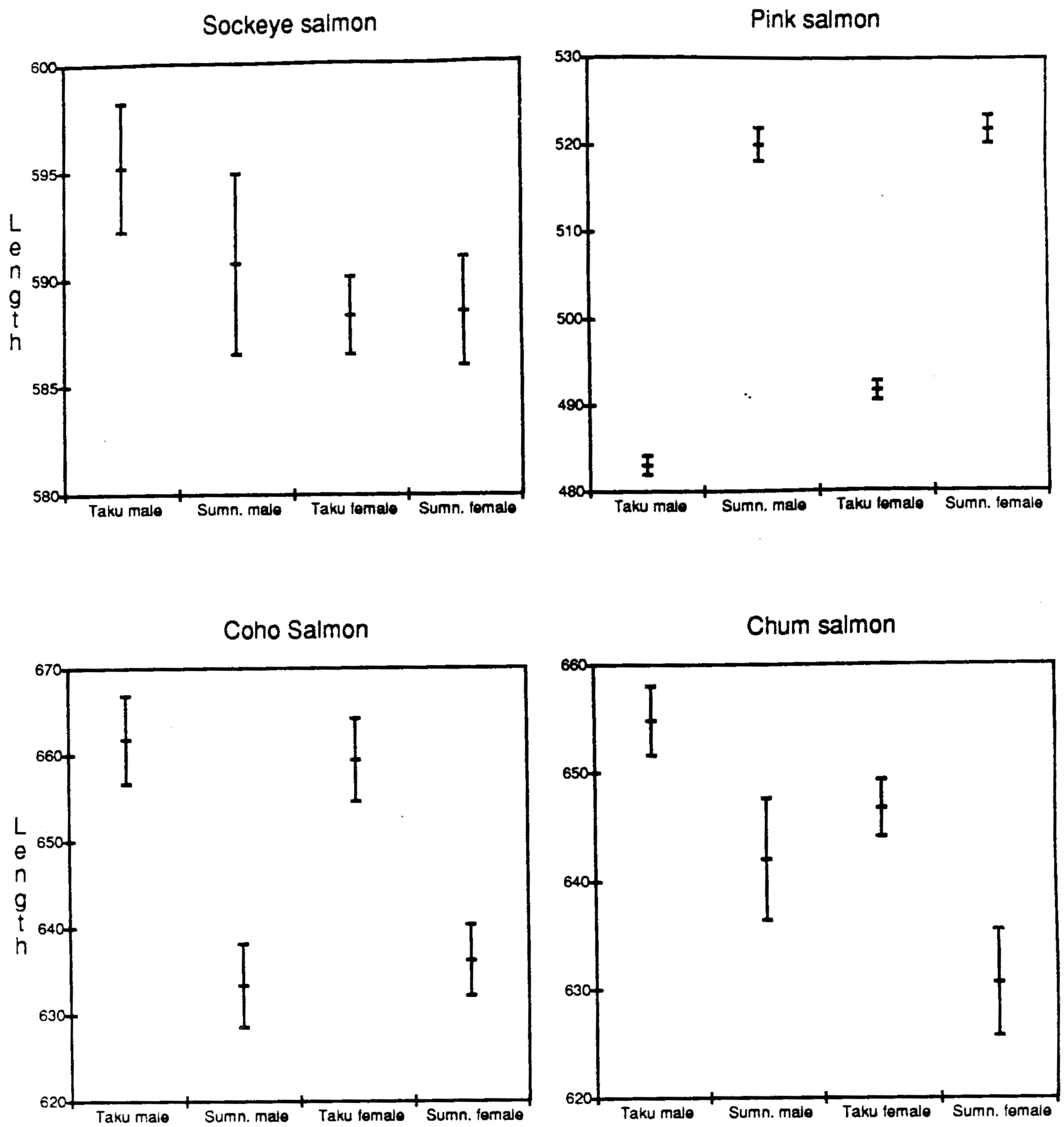


Figure 3. Average length (mm) and 95% confidence interval of salmon in 1987 test fisheries.

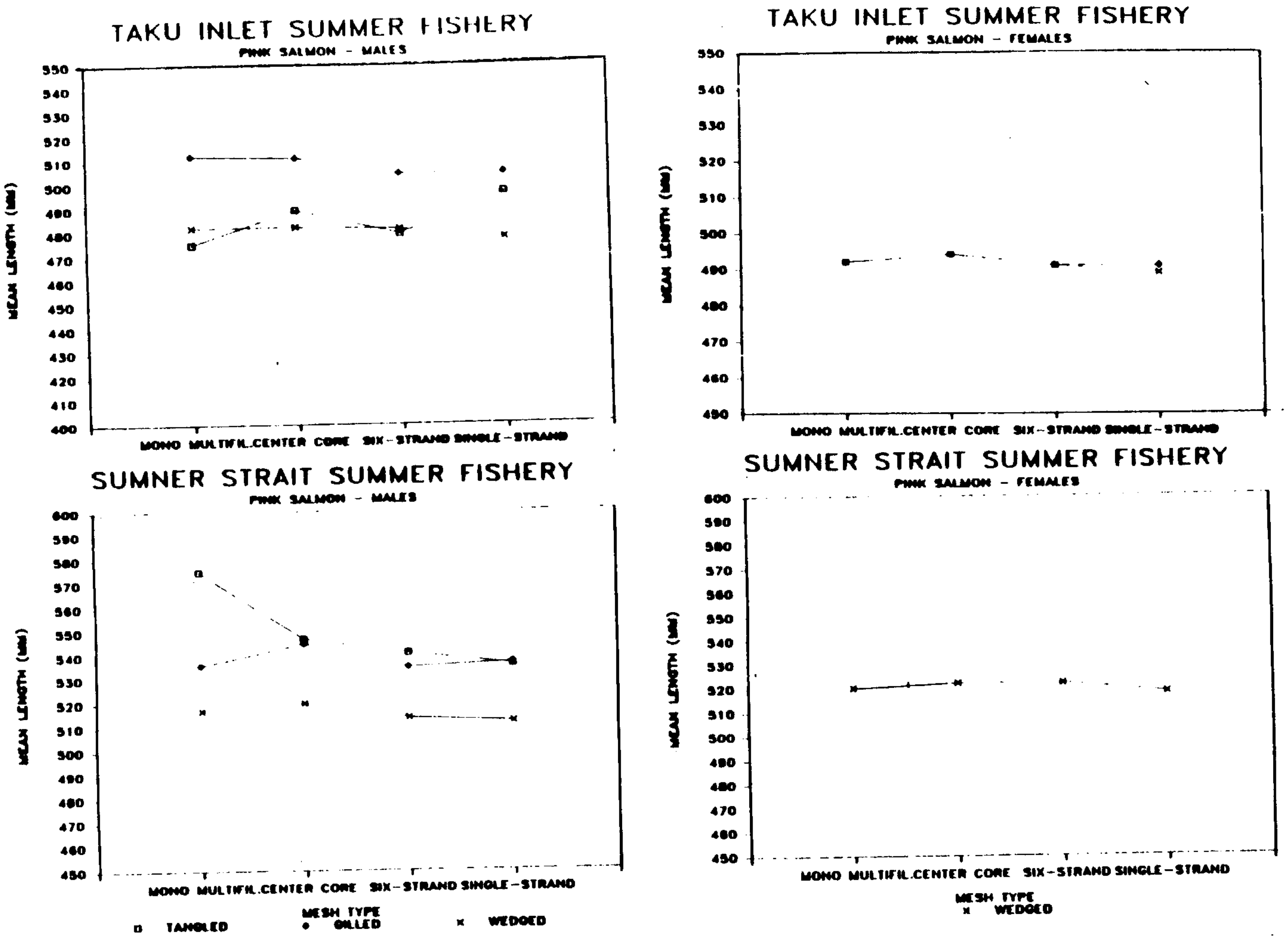


Figure 4. Average length (mm) by mesh type and entanglement mode for 1987 test fisheries.

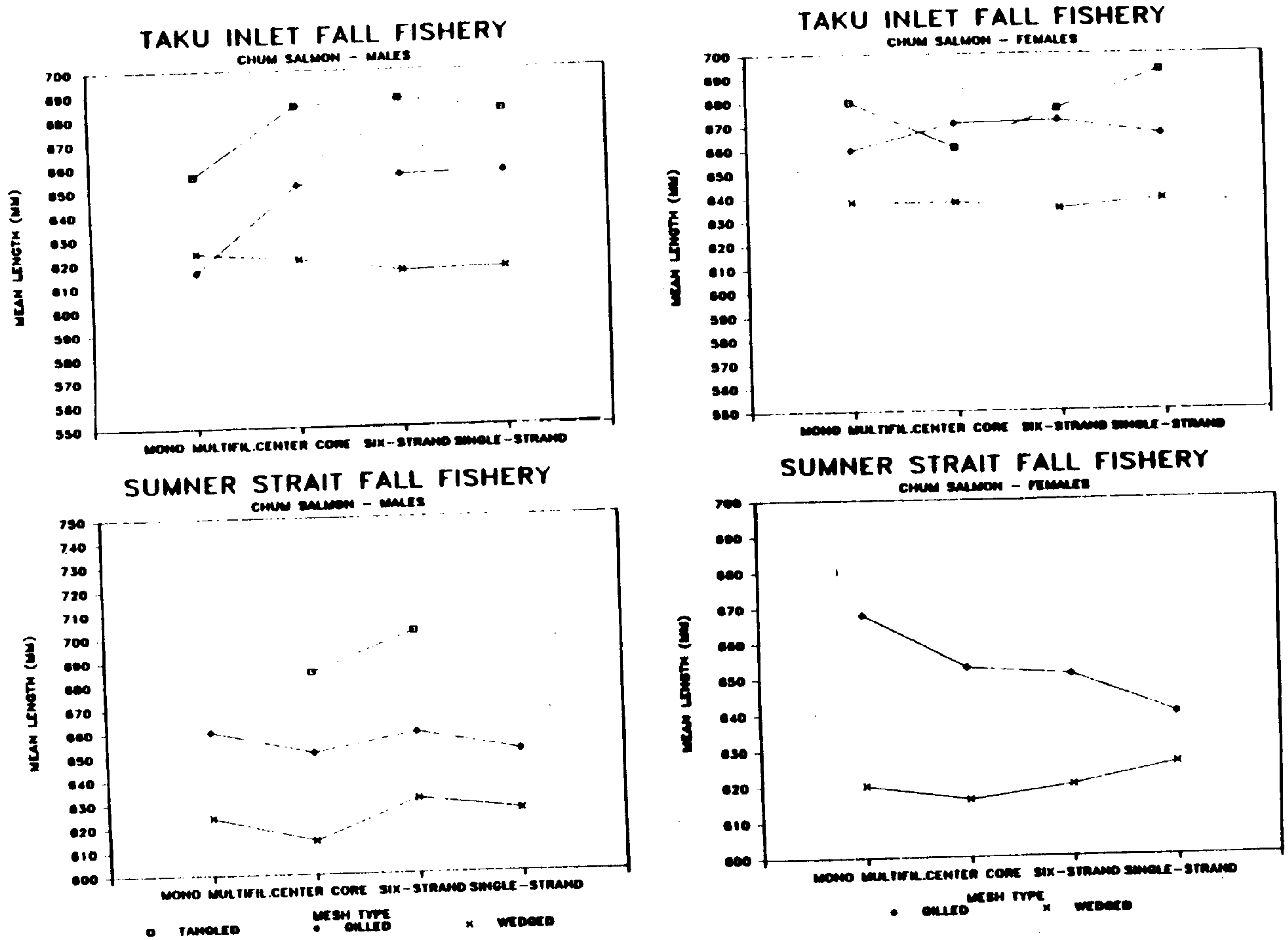
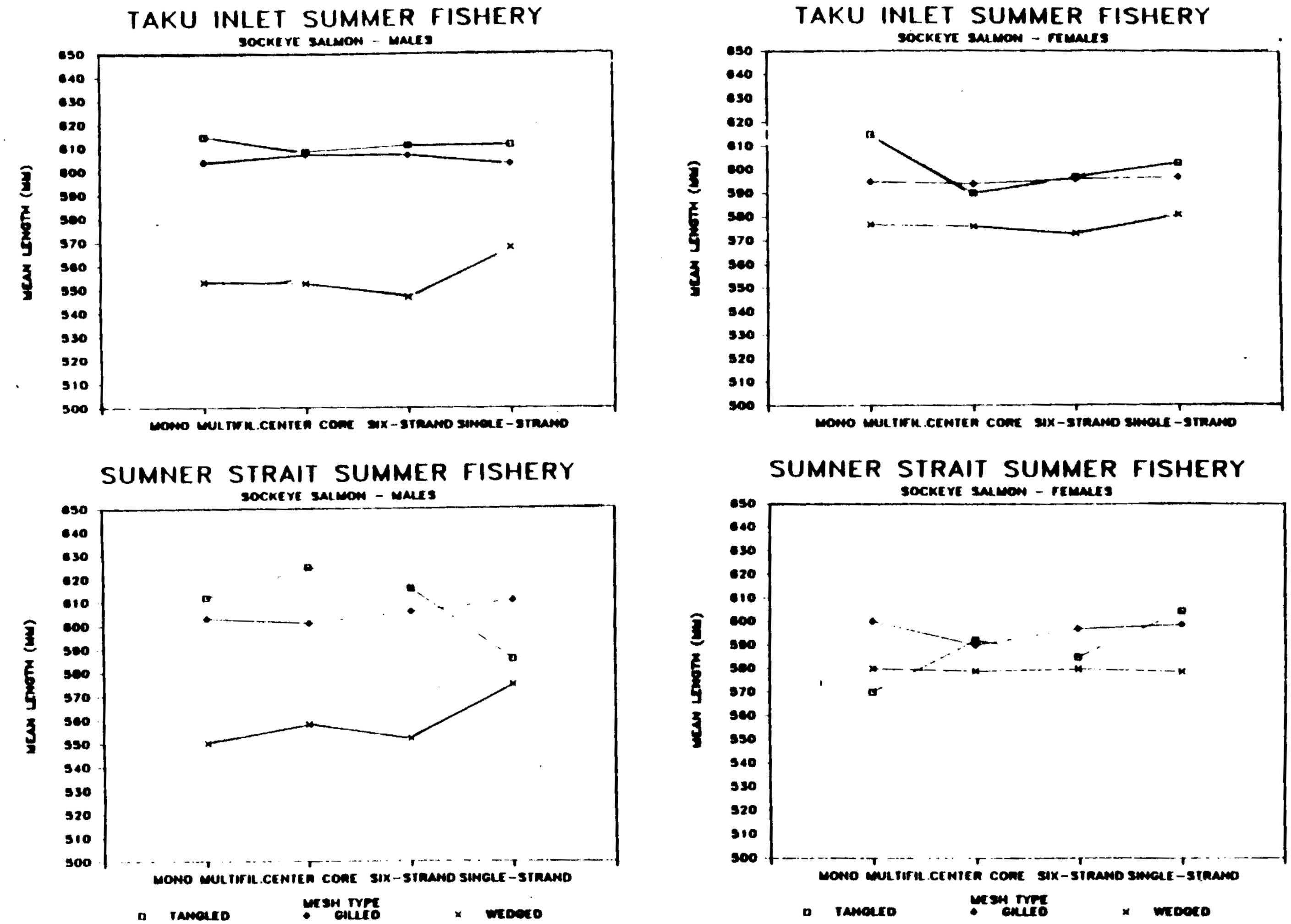


Figure 4. (page 2 of 4)



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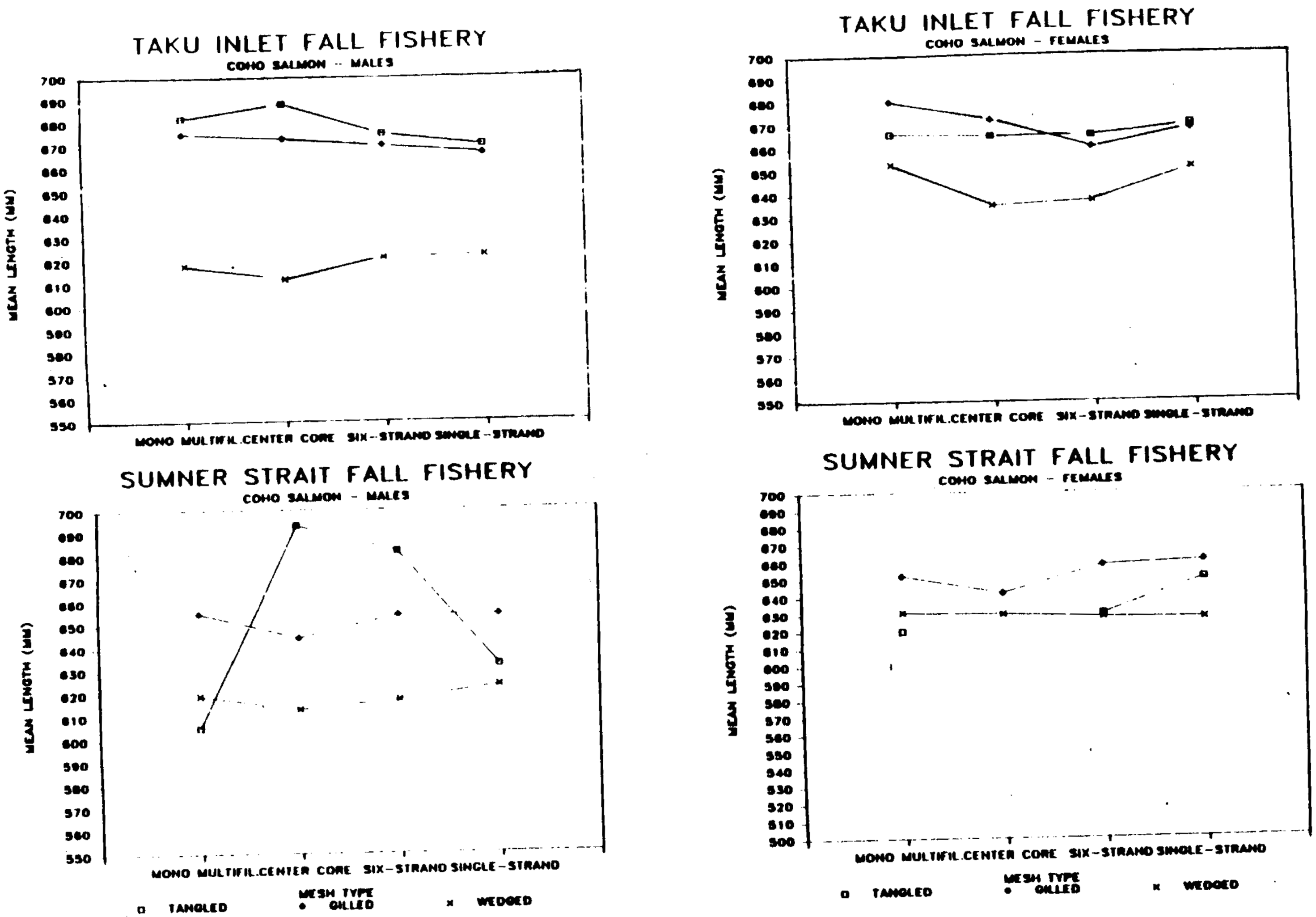

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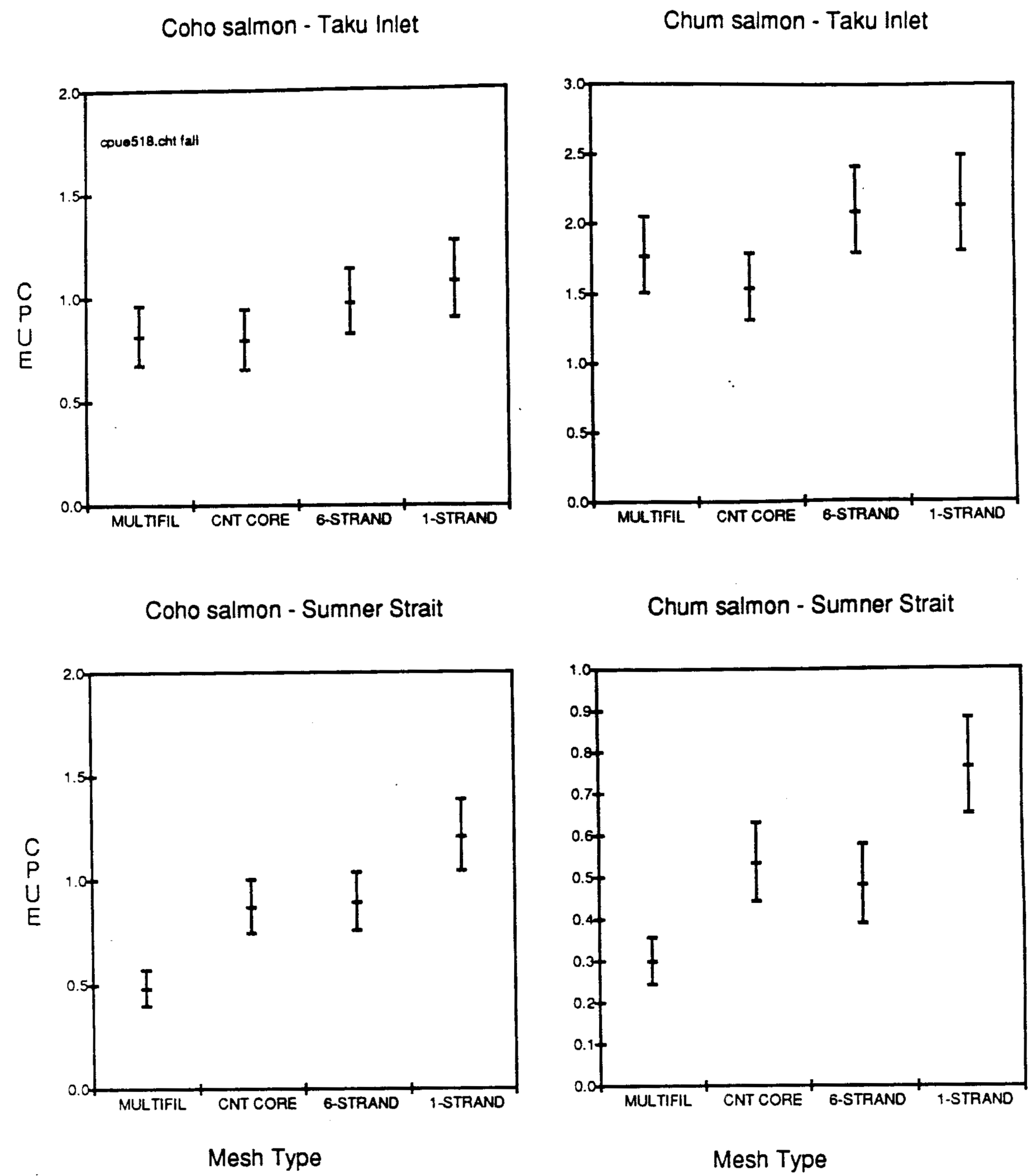
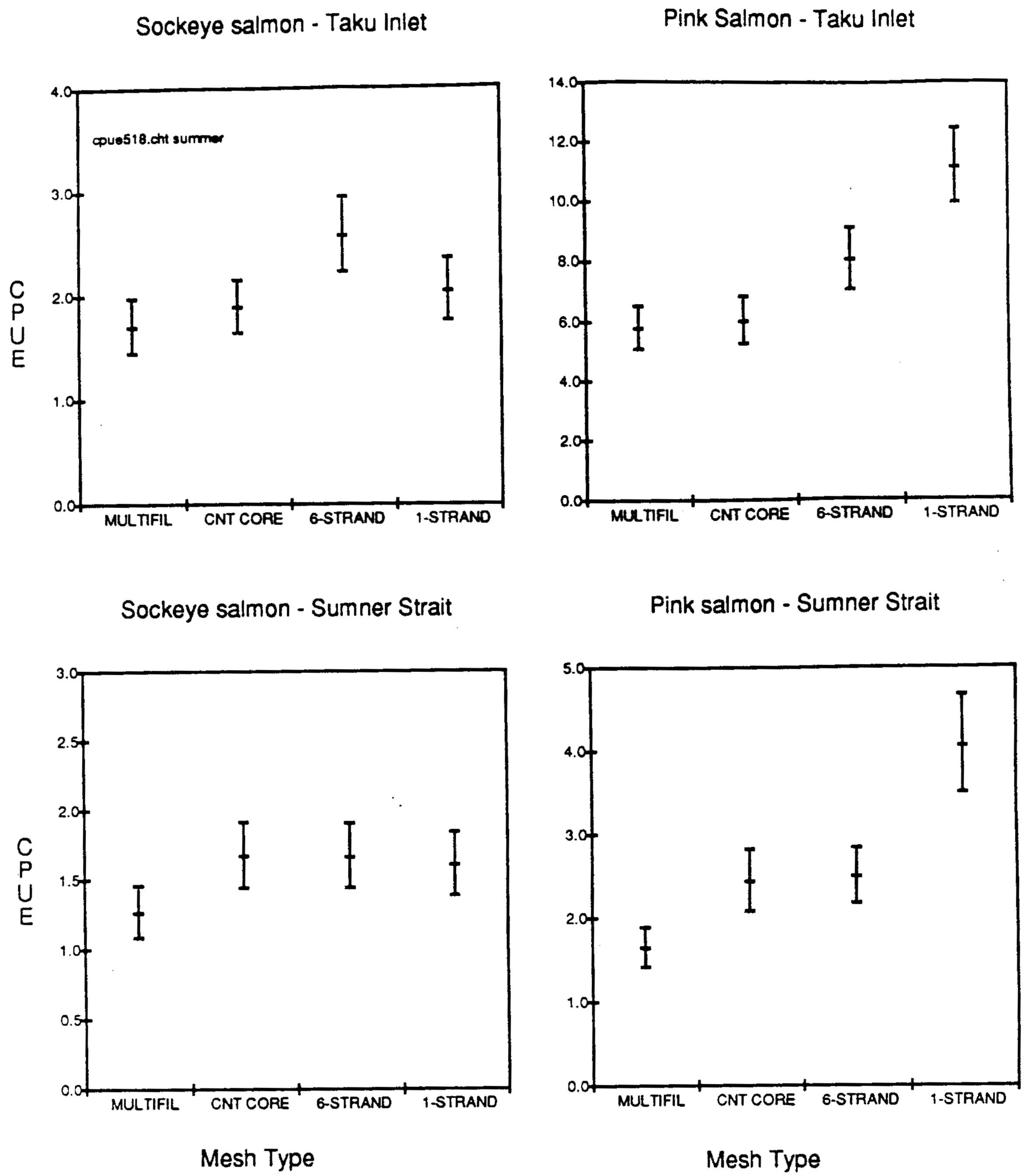


Figure 5. Catch-per-hour-fished (CPUE) and 95% confidence interval by mesh type and species in the 1987 test fisheries.



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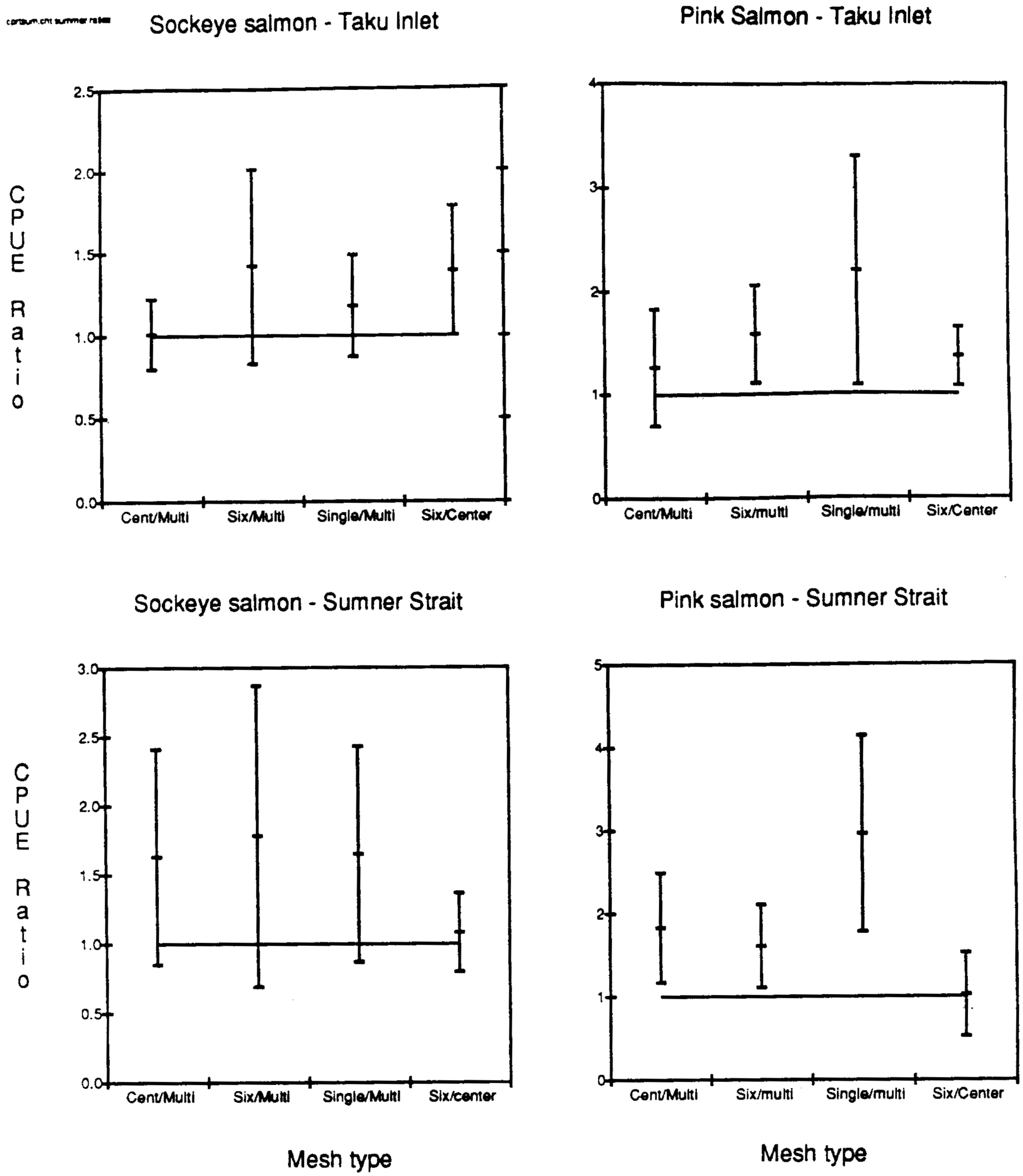

Figure 6. Ratio of CPUE and 95% confidence interval standardizing mesh types to multifilament in 1987 test fisheries.

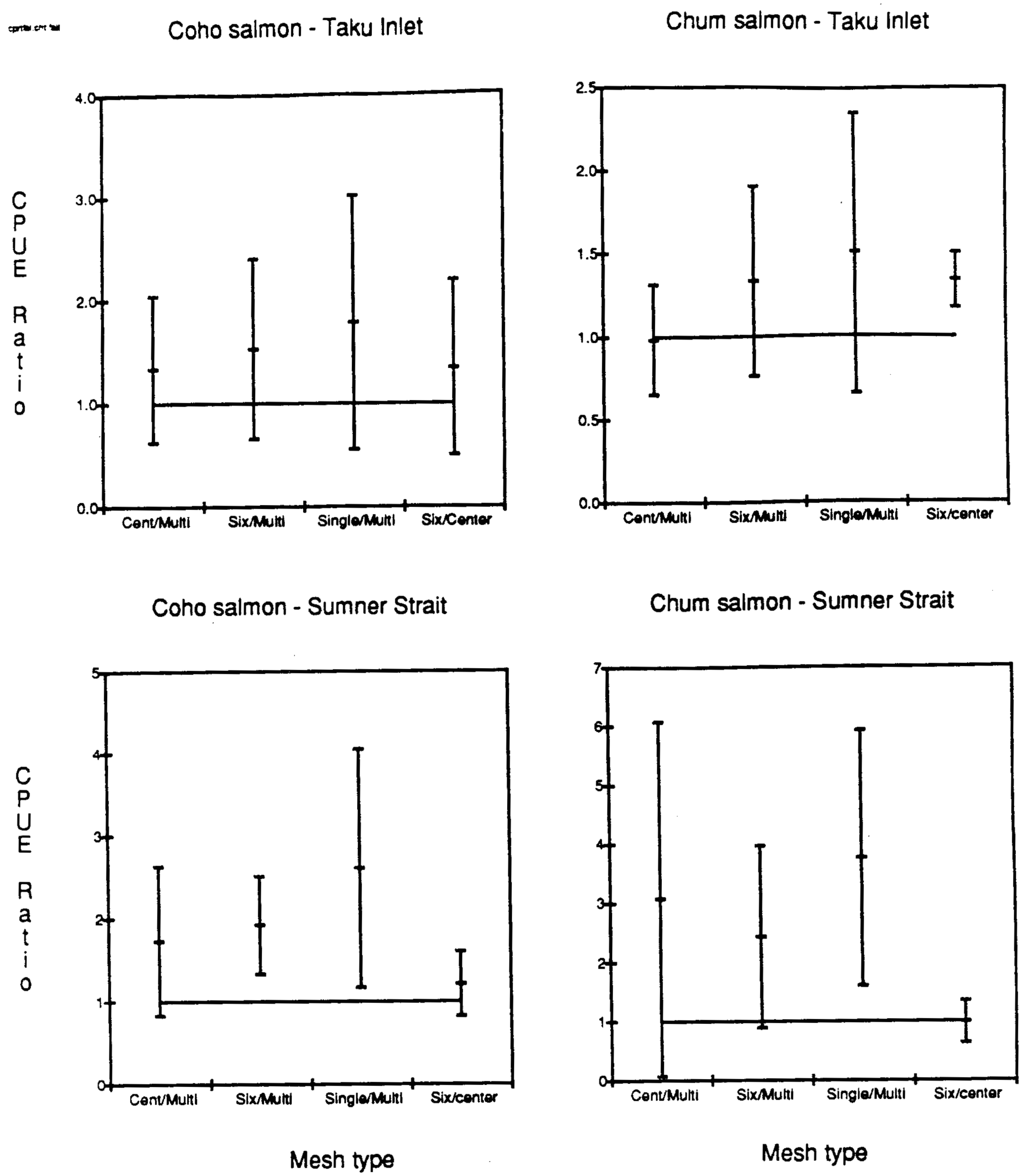

Figure 6. (page 2 of 2)