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THE CONTINENT OF ORIGIN OF COHO SALMON IN THE JAPANESE LANDBASED DRIFTNET FISHERY AREA IN 1981

by

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THE CONTINENT OF ORIGIN OF COHO SALMON IN THE JAPANESE LANDBASED DRIFTNET FISHERY AREA IN 1981

INTRODUCTION

This document is a report on an investigation of the continent of origin of coho salmon (Oncorhynchus kisutch) in and near the pre-1978 Japanese landbased driftnet (LBDN) fishery area (south of 46°N and west of 175°W, Fig. 1). Scale pattern analysis was used to determine Asian or North American origin of age 2.1 coho salmon collected in and near the LBDN area by Japanese research and mothership vessels in 1981. The research was conducted in response to provisions of the revised (1978) Protocol amending the International Convention for the High Seas Fisheries of the North Pacific Ocean, that called for a coordinated research endeavor by member nations to determine the continent of origin of salmonids in the LBDN area.

REVIEW OF PREVIOUS WORK

Coastal recoveries of coho salmon tagged in or near the LBDN area (Fig. 2) suggest that most fish are of Asian origin. However, tagging experiments have been insufficient to determine with any resolution either distributions of major regional stocks or mixing proportions in areas of intermingling.

In 1980, a preliminary analysis of the feasibility of using scale pattern analysis to determine coho origins was made, which employed scales of age 2.1 coho of known origin ("standards") collected in 1979

(Harris et al. 1980). Analysis of the 1979 scales was extended in 1981, and an overall classification accuracy of 66.5% was obtained (Myers et al. 1981). Classification of scales of fish sampled on the high seas ("unknowns") indicated a predominance of Asian over North American coho in most combinations of ten-day period and International North Pacific Fisheries Commission (INPFC) area in the LBDN area. Percentage estimates of North American fish decreased over the sample period, and no statistically significant estimates were obtained for coho from southeast Alaska stocks.

In 1982, an analysis was made of scales of age 2.1 coho collected in 1980 (Walker and Harris 1982). Overall classificatory accuracy in that study was 65.4%. Mixing proportion estimates of coho from Alaskan and Asian regions were roughly equivalent for most combinations of ten-day period and INPFC area in and near the LBDN area throughout the sample period, and there was no clear pattern of predominance of one region over another. No estimates were obtained for British Columbia stocks, strengthening the indication that southeast Alaska and British Columbia fish are not present in detectable numbers in the LBDN area.

METHODS

The methods used in the scale pattern analysis of 1981 coho salmon were essentially the same as those reported by Myers et al. (1981) in the analysis of 1979 coho scales. Differences from those methods are outlined below.

Construction of Regional Standards

Our analysis was again limited to age 2.1 coho, as scale samples of age 1.1 fish from Asia and western Alaska were too small (n = 83 and 94, respectively) to provide sufficiently precise mixing proportion estimates. In addition, age 1.1 fish were only a small proportion (9.0%) of coho sampled in and near the LBDN fishery area.

The stocks represented in our samples were grouped according to four major geographical regions (Kamchatka, western Alaska, central Alaska, and southeast Alaska/British Columbia), and standard samples composed of up to 200 scales were constructed for each area. The Alaska Department of Fish and Game (ADF&G) provided scales from Alaskan streams, while those from British Columbia streams were provided by the Department of Fisheries and Oceans Canada (DFO). Southeast Alaska and British Columbia were combined into a single standard, as the two areas are geographically similar. Requested scales from four areas of the U.S.S.R. were sent by the Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO) for this analysis, but they were never received by the Fisheries Research Institute (FRI). The Asian standard was therefore constructed from samples from two major coho-producing rivers of Kamchatka (Kamchatka and Bolshaya rivers), provided through the Japan Fisheries Agency (JFA).

The stock composition and construction of the regional standards are shown in Table 1. The criteria described by Myers et al. (1981) were used in allocating proportions of the desired regional sample

(n = 200) to major stocks within the region. Rough estimates of run sizes were used in apportioning the western Alaska stock. Escapement estimates were employed for southeast Alaska and British Columbia stocks. Representation in the central Alaskan standard was on the basis of commercial catch statistics.

Scales from Kamchatka Peninsula coho were markedly smaller than those from North American fish. As these scales were measured, they were placed in one of three size categories: normal, small, or very small. Normal scales were defined as those having a distance of at least six inches along the measurement axis from the focus to the outer edge of the ocean annulus of scales projected at a magnification of 100X. (Six inches was toward the lower range of this measurement in scales used for North American standards.) Small scales included those with the measurement between five and six inches on the projected image, and very small scales measured less than five inches. Very small scales were not used in the analyses.

Two different standards were constructed to represent Asian stocks. The first included normal and small scales from the Kamchatka and Bolshaya rivers. The two rivers were represented in proportion to unofficial catch statistics. (There were insufficient scales from the Kamchatka River to bring this standard to 200 fish.) This standard was used in a four-way analysis and in subsequent three- and two-way analyses. Because the results of these analyses may have been biased due to the inclusion of small scales in the standard, another analysis was performed using only larger (normal-sized) scales in the Asian standard,

although the number of these scales was inadequate to weight the stocks in proportion to catch indices of run sizes. The majority of these scales come from the Bolshaya River, the runs of which are perhaps a third the size of those of the Kamchatka River. This standard was used only in a four-way analysis.

Abundance estimates used in weighting stocks for inclusion in standards may be inaccurate. Commercial catches may not reflect actual run size, and escapement estimates are often extrapolations. Weighting factors used for construction of standards, while possibly inaccurate, are based on the best information available.

Sample Composition and Age Determination of Coho Unknowns

Two collections of scales of 1981 coho unknowns were used in the analysis. The first was a sample of scales (n = 6089) collected from coho caught in or near the LBDN area in 1981 by Japanese research vessels, and provided to us by JFA. The second was a sample of scales (n = 716) collected by JFA inspectors aboard Japanese motherships operating just north of the LBDN in 1981. Scales were provided from sites south of 51°N and east of 160°E. Therefore, in this paper analyses for INPFC areas north of 50°N (E6550, E7050, E7550, and W8050) only include scales from the southern half of the area, between 50°N and 51°N. (This observation applies to Myers et al. 1981 and Walker and Harris 1982, although it was not mentioned by those authors).

Ages of all scales in both collections were determined by JFA biologists. Due to differences in age determination of 1979 coho unknowns

(discussed in Myers et al. 1981), both collections were re-aged by FRI biologists to maintain consistency with age determinations in the standards. As was found with 1980 coho of unknown origin (Walker and Harris 1982), there was substantially better agreement between JFA and FRI determined ages than for the 1979 fish. Biologists of the JFA designated 4075 out of 4792 readable scales as age 2.1 coho (85.0%), while FRI biologists counted 3955 out of 4548 readable scales as age 2.1 (87.0%).

Scale Measurement

Measurement of coho scales was as described in Myers et al. (1981) and Harris et al. (1980). One fish scale technician made all measurements of standard, mothership, and a portion of research vessel unknown scales. A second technician read the remaining research vessel scales.

Character Selection

Scale characters were chosen from the set of 60 listed in Table 2, using the method of Cook and Lord (1978). As noted above and in a previous report (Walker and Harris 1982), scales from Kamchatka coho tended to be smaller than those of other regions, in particular having a smaller first ocean zone with fewer circuli. Because of the distinctiveness of this trait, several related characters also ranked high as discriminators between regions. In general, the use of highly dependent characters was avoided.

In the four-class analysis using the catch-weighted Asian standard, six scale characters were selected to separate the four regional standards and to classify high seas samples: characters 3, the size of the first ocean zone (zone 3); 10, the number of circuli from the focus to the end of the ocean annulus (zones 1 + 2 + 3); 14, the number of circuli in the first ocean zone (Zone 3); 15, the number of circuli in the freshwater and intermediate growth[1] zones (zones 1 + 2); 26, the distance between circulus 13 and circulus 15 in zone 3 divided by the size of zone 3; and 43, the distance between circulus 19 and circulus 21 in zone 3.

For areas where either the central Alaska or southeast Alaska/British Columbia stock-group was not detected, the analysis was repeated using the remaining three regions. A new character set was chosen for each combination of regions analyzed. For the three-class analysis between Kamchatka, western Alaska, and central Alaska, six scale characters were chosen: 3, 10, 15, and 43 as above; and characters 2, size of intermediate growth zone (zone 2) and 11, average spacing of circuli through the end of the ocean annulus (size of zones 1 + 2 + 3 divided by number of circuli in the zones). For the three-class analysis between Kamchatka, western Alaska, and southeast Alaska/British Columbia, a different set of six characters was used: 3, 10, 26, and 43 as above; and character 35, the distance between circulus 16 and circulus 18 in the intermediate and ocean zones combined (zones 2 + 3) divided by the size of the combined zones.

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[1]The intermediate growth zone, zone 2, was defined as the region from the last circulus of the second freshwater annulus through the last circulus before true ocean-growth circuli; it contained freshwater plus-growth and/or estuarine growth.

The analysis was again repeated between Kamchatka and western Alaska when either central Alaska or southeast Alaska/British Columbia was not detected in a three-class analysis. The six characters used were 3, 10, 26, and 43 as above, and characters 19, average spacing of circuli in the first ocean zone (size of zone 3 divided by number of circuli in the zone) and 42, the distance between circulus 16 and circulus 18 in zone 3.

In the four-class analysis using only normal-sized scales in the Asian standard, six characters were chosen: 10, 14, 15, and 26 as in the other four-class analysis, and characters 17, the average spacing of circuli in the freshwater zone (size of zone 1 divided by number of circuli in the zone) and 27, the distance between circulus 16 and circulus 18 in zone 3 divided by the size of zone 3.

The regional means, standard deviations, and frequency distributions of the fourteen scale characters are shown in Appendix Figures 1 to 6.

Classification and Point and Variance Estimation Procedures

Patterns of selected scale characters in the regional standards were used to determine the most probable origin of individual fish in the unknown samples. The methods of classification and point estimation are described by Cook et al. (1980) and those of variance estimation are described by Cook et al. (1981). A new technique, described by Cook (in press), constrains point estimates to values between zero and one, so that when a stock is not detected (i.e., its point estimate is zero or

negative), estimates for the remaining stocks can be obtained without repeating the analysis. Values obtained in this manner have been shown by extensive simulation experiments to be in good agreement with those obtained by collapsing and repeating the analysis with the non-detected stocks deleted. However, one possible advantage of a repeated analysis over the constrained estimator is that different scale characters, specifically chosen to maximize separation of the remaining stocks, may be selected.

Point estimates and 90% confidence intervals were obtained for each combination of 10-day period by INPFC statistical area, month by INPFC area, and month by quadrat (Fig. 1) for samples of 25 or more fish. The term "positive estimate" refers to any point estimate greater than zero obtained for a regional stock. The term (statistically) "significant estimate" refers to a point estimate for which the 90% confidence interval does not include zero.

In the four-class analysis using the catch-weighted Asian standard, the central Alaska stock was not detected in 22 time-area combinations and the southeast Alaska/British Columbia stock was not detected in 18 combinations. For these cases the analysis was repeated using the other three regions. For 46 time-area combinations neither the central Alaska nor the southeast Alaska/British Columbia stocks were detected, and a two-class Kamchatka-western Alaska analysis was done. In five cases in which the Kamchatka stock was not detected, point estimates from the constrained estimator procedure were used.

In the analysis using only normal-sized scales in the Asian standard, constrained estimates were used for all cases in which a stock was not detected.

RESULTS

Analyses Using Catch-weighted Asian Standard

The results of classifying the various combinations of regional standards, including the catch-weighted Asian standard, are shown in Appendix Table 1. Overall classificatory accuracy for the 4-class analysis was 64.1%. The percentages of fish correctly classified as western Alaska, central Alaska, southeast Alaska/British Columbia, and Kamchatka, were 60.4, 51.0, 66.3, and 78.7%, respectively. In the 3-class analyses, overall accuracies were 73.5% and 78.1% for the western Alaska-central Alaska-Kamchatka and the western Alaska-southeast Alaska/British Columbia-Kamchatka groupings, respectively. An accuracy of 85.3% was obtained in the two-class analysis between western Alaska and Kamchatka fish. As in the study of 1979 and 1980 fish, misclassification errors for North American coho were greatest among the three North American regions, and least with Kamchatka. Misclassification errors between Kamchatka and a North American region were largest between Kamchatka and central Alaska, and least between Kamchatka and southeast Alaska/British Columbia.

Mixing proportion estimates and 90% confidence intervals calculated for North American and Kamchatka stocks using the catch-weighted Asian

standard are presented in Appendix Table 2. Sample sizes of 25 or more fish within a combination of 10-day period and INPFC area were available from 46 strata sampled in 1981, 28 of which were in the LBDN area. The LBDN area strata were from 12 INPFC areas: E6044, E6046, E6540, E6542, E6544, E6546, E7042, E7044, E7542, E7544, W8042, and W8044. Adequate samples within a 10-day period were also available for 18 strata from 10 INPFC areas north of the LBDN area.

Statistically significant estimates were obtained for western Alaska coho in all 28 10-day period/INPFC area strata (in the LBDN area) analyzed. Estimates ranged from 55.3% to 100%, and tended to be higher in the western and southern portions of the LBDN area.

Only one significant estimate was obtained for central Alaska in the LBDN area, an estimate of 21.8% in area W8044 in late June. (Four positive but statistically nonsignificant estimates were obtained for other period-area combinations in the LBDN area.)

No significant estimates were obtained for southeast Alaska/British Columbia stocks for any combination of 10-day period and INPFC area. (Six positive but nonsignificant estimates for period-area combinations in the LBDN area were primarily grouped in the western half of the area in late June and early July.)

Statistically significant estimates were obtained for Kamchatka coho in nine out of 28 period-area combinations in the LBDN area. These estimates ranged from 13.1% to 27.5% and were primarily east of 175°E.

(Fifteen additional estimates for period-area combinations in the LBDN area were positive but nonsignificant.)

In waters outside of the LBDN area (north of 46°N), significant estimates were obtained for western Alaska coho for all period-area combinations except for two. Only three estimates for central Alaska were significant in these waters, and there were no significant estimates for southeast Alaska/British Columbia coho. Thirteen of the eighteen period-area combinations yielded significant estimates for Kamchatka coho.

Analysis Using Only Normal-sized Scales in the Asian Standard

Most scales from Kamchatka stocks appeared to be noticeably smaller than those from North American stocks or from the unknown samples, as noted earlier. Since this might bias the classification of unknowns toward North American stocks, a followup analysis was performed using only the larger scales available from Kamchatka stocks. This had the advantage of comparing more like-sized scales in the standards, although Asian scales generally remained smaller. One disadvantage was that in order to construct an adequate Asian standard sample, scales had to be taken disproportionately from the Bolshaya River, in violation of one of the assumptions of the pattern recognition technique (Cook 1982).

Overall classificatory accuracy was 61.2% for a four-class analysis, with 55.9%, 57.0%, 58.8%, and 73.2% of the fish classifying correctly to western Alaska, central Alaska, southeast Alaska/British Columbia, and Kamchatka, respectively (Appendix Table 3). As expected,

mixing proportion estimates shifted toward Kamchatka stocks, although North American (in particular western Alaskan) stocks remained predominant. Figures 3 to 8 present a comparison of the analyses using the catch-weighted Asian standard with the analysis using an Asian standard with normal-sized scales. The Kamchatka estimate for each period-area combination is juxtaposed with the sum of the North American stock estimates for each set of analyses. (Because of the combination of North American estimates, no confidence intervals are presented.) The two sets of estimates are not strictly comparable because of two factors in addition to the partial change of scales composing the Asian standard: 1) two scale characters were changed, and 2) the estimates from the second analysis come only from the constrained estimator technique, with no repetition of analysis when stocks dropped out. (Constrained estimates are generally in good agreement with estimates from reanalysis.)

The number of statistically significant estimates for western Alaska coho in the LBDN dropped slightly from 28 to 25, and the magnitudes of the estimates were generally lower. The reverse was true for estimates of Kamchatka coho: significant estimates in the LBDN doubled, from 9 to 19, and the magnitudes were generally larger. There were no significant estimates for either central Alaska or southeast Alaska/ British Columbia. The number of positive but nonsignificant estimates dropped slightly for central Alaska stocks and rose slightly for stocks from southeast Alaska/British Columbia. The trends of these changes are shown in Appendix Table 4.

DISCUSSION

Mixing proportion estimates for western Alaskan coho strongly dominated those from all other regions for most combinations of 10-day period and INPFC area in and near the LBDN area. Estimates for western Alaskan coho were more than four times the size of estimates for the second largest stock, Kamchatka, in the analyses using a catch-weighted Asian standard. The western Alaskan estimates were over one and a half times as large as those for Kamchatka using only normal-sized scales in the Asian standard. Percentages of western Alaskan fish were highest in the western and southern portions of the area, while percentages of Kamchatka fish were highest in the north and east, although still secondary to western Alaskan estimates. Estimates for central Alaska and southeast Alaska/British Columbia stocks were nearly all small and nonsignificant.

These results are markedly different from studies on 1979 and 1980 coho scales (Myers et al. 1981, Walker and Harris 1982). Analysis of 1979 samples indicated a predominance of Kamchatka fish over those of North America. The analysis of 1980 samples showed no clear pattern of predominance, as Kamchatka, western Alaska, and central Alaska estimates were in rough equivalence. In both years estimates for central Alaska were as large as or slightly larger than those from western Alaska. One point of agreement with past studies is the continuing lack of significant and positive estimates for the southeast Alaska/British Columbia region. This further supports our belief that age 2.1 coho from these

regions are not present in detectable numbers in waters as far west as the LBDN area.

The results of this year's analysis of 1981 scales are also in contrast to the pattern of tag returns (Fig. 2), which suggests that the majority of coho in the LBDN area are of Asian origin. However, there are three western Alaska recoveries of fish tagged in the area of study (south of 50°N, 160°E-165°W), including one from the pre-1978 LBDN area, and one-third (14 out of 41) of the returns of fish tagged in area W8050, just north of the study area, have come from western Alaska. In addition, coho fishery exploitation rates leading to tag recoveries may have been lower in western and central Alaska in early years. Catches of coho salmon have more than doubled in western and central Alaska since 1978, and all tag recoveries (from releases south of 50°N) from western Alaska have been in recent years (1977 and 1982). Nevertheless, tag returns indicate a preponderance of Asian fish in the LBDN area.

There are two possible factors that singly or together may explain the discrepancy between analysis of 1981 coho scales and results of previous scale analysis and tagging experiments. A dramatic shift in the relative magnitudes of Asian and Alaskan coho runs might be indicated. For example, the analysis of 1980 coho scales showed a shift from dominance by Asian stocks (indicated by the 1979 study) to near equivalence of Asian and Alaskan stocks. Subsequently available catch statistics lent some support to this finding, showing 1980 USSR catches of coho at half of their 1979 level, while Alaskan catches had

remained high. However, 1981 catch information indicates that the relative abundanced of Asian coho increased in 1981.

A more probable explanation is that results of the analysis of 1981 scales are to some degree biased by the type of scales available for the Asian standard. In 1979 TINRO biologists collected scales for the Asian standard using materials provided by FRI. Diagrams and explicit instructions demonstrated the body area preferred for scale collection. The 1980 Asian standard was composed of scales selected by FRI biologists from smear samples provided by TINRO. The 1981 Asian standard was constructed from acetate scale impressions provided by JFA, presumably from scales selected by JFA biologists from TINRO smear samples. Following the observations of FRI biologists on board a TINRO tagging cruise in the summer of 1983, it is now believed that TINRO biologists take scale samples from their own preferred body zone just below the dorsal fin, an area anterior and considerably dorsal to the INPFC preferred area. Smear samples provided in 1980 and 1981 probably came mostly from this region. Scales selected by FRI biologists from the 1980 sample were chosen for size and shape most closely resembling scales from the preferred area, while those selected by JFA biologists from 1981 samples may have been chosen primarily for aging purposes, without consideration of use in stock separation by scale pattern analysis. Therefore, the 1980 standard may have been more suitable for scale pattern analysis than that of 1981. The decline in percentage estimates of Kamchatka coho from 1979 to 1981 may be associated in part with use of scales farther and farther from the INPFC-preferred area.

Sato (1961) found that scales of age 2.1 coho of Asian origin had smaller first ocean zones with fewer circuli than fish of North American origin. Thus Kamchatka scales might be expected to be smaller. However, the extremely small scales found in this year's study are likely to have come from a nonpreferred body zone. Variation in scale characters with body zone has been noted before for coho salmon (Hayashi and Kitahara 1959, Scarnecchia 1979), and further studies are underway at FRI to examine the effect that area of collection may have on scale patterns.

In conclusion, three somewhat obvious points remain:

1. Kamchatkan, western Alaskan, and central Alaskan fish all seem to be present in the LBDN areas to some degree, although with the variation between analyses it is difficult to quantify the proportions.

2. Coho of southeast Alaskan and British Columbian origin are either absent from the LBDN area or are present in very low numbers that are difficult to detect.

3. For accurate analysis and reliable estimation of mixing proportions, it is necessary that all standard and unknown-origin scales be collected from the INPFC-preferred area of the body.

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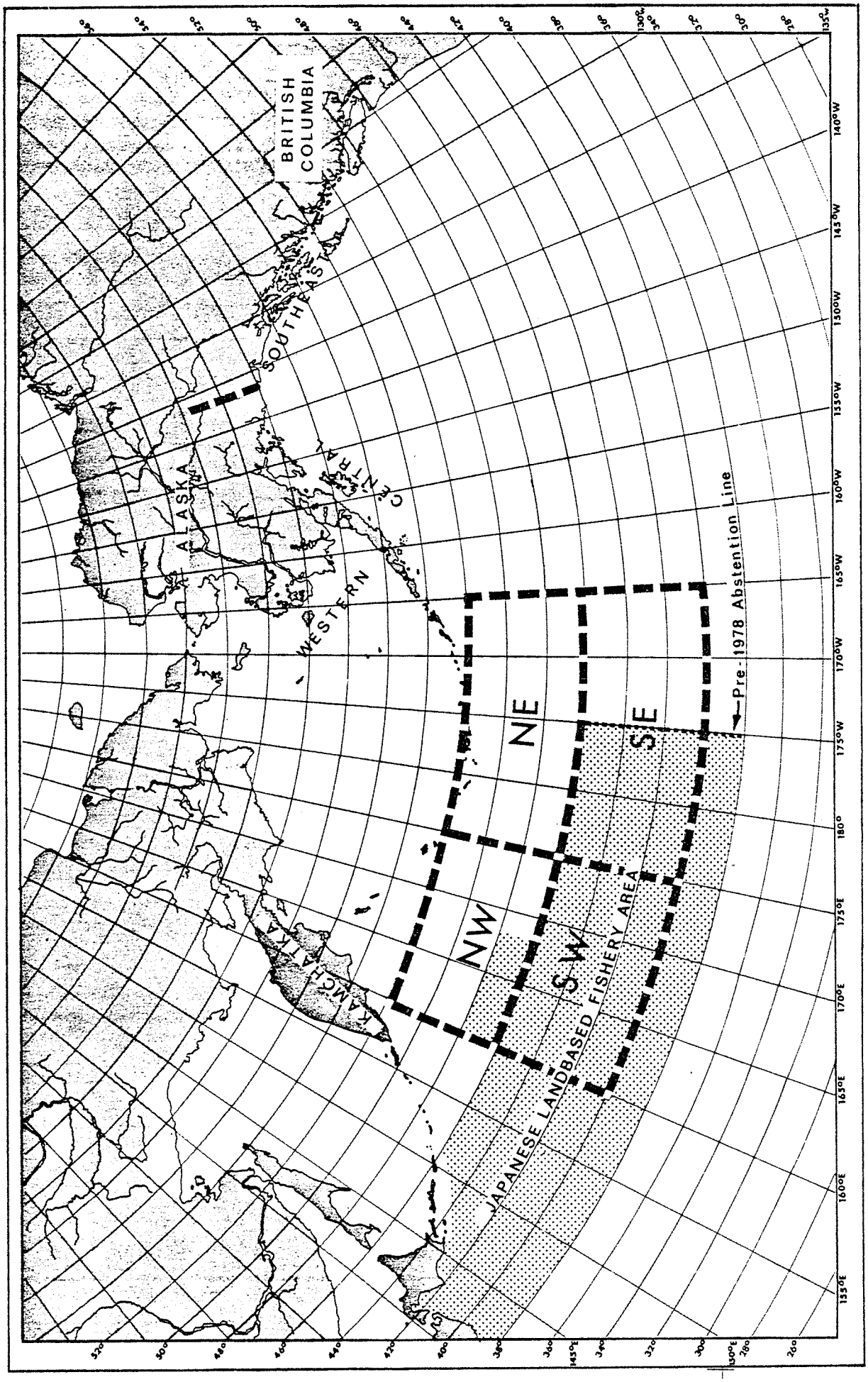

Fig. 1. Study area, broken into four quadrats. Stippling defines the pre-1977 landbased driftnet fishery area.

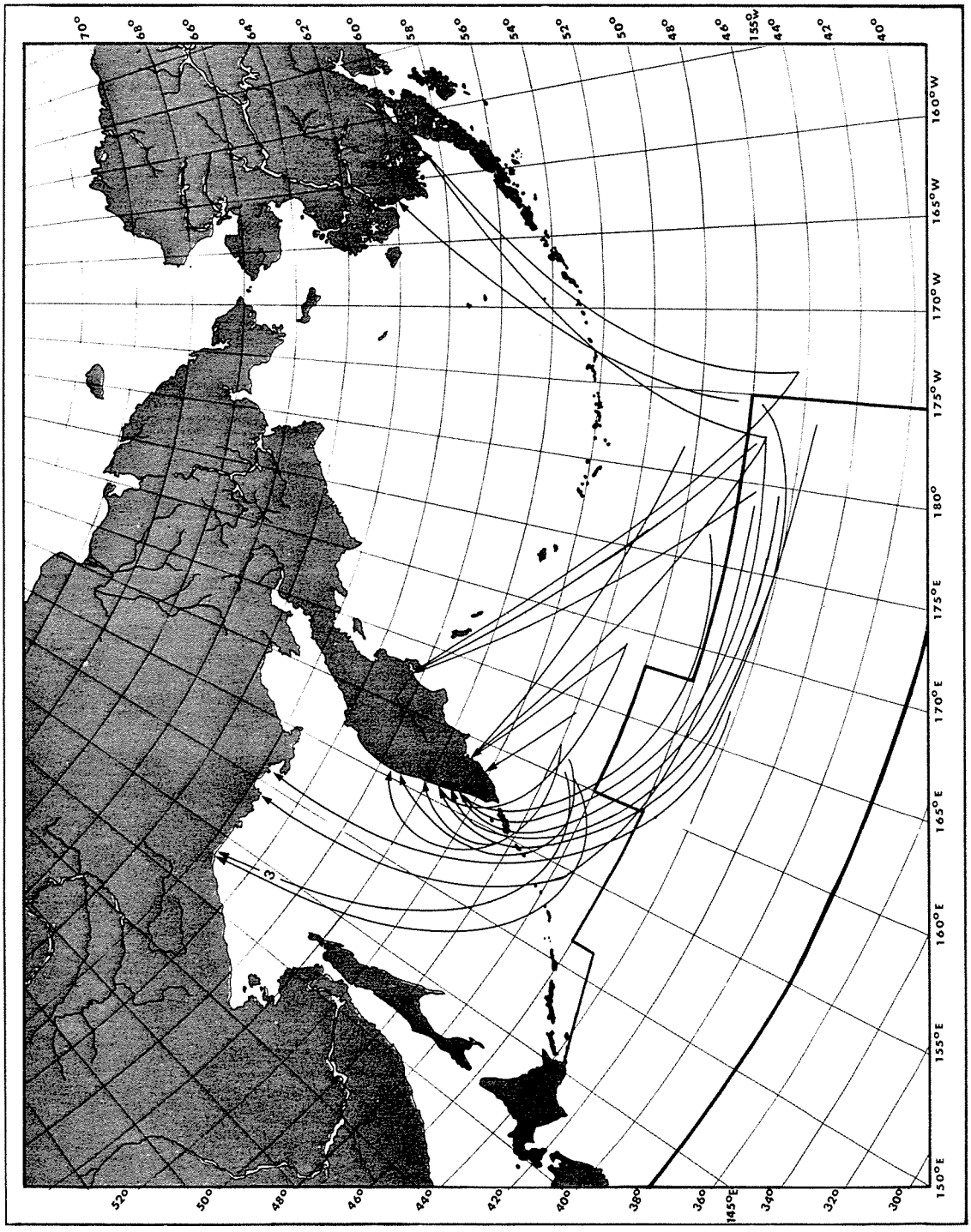

Fig. 2. Release and recovery locations for coho salmon (Oncorhynchus kisutch) tagged south of 50°N and west of 170°W, 1956-1983. (Recoveries reported by JFA after March 1983 not included.)

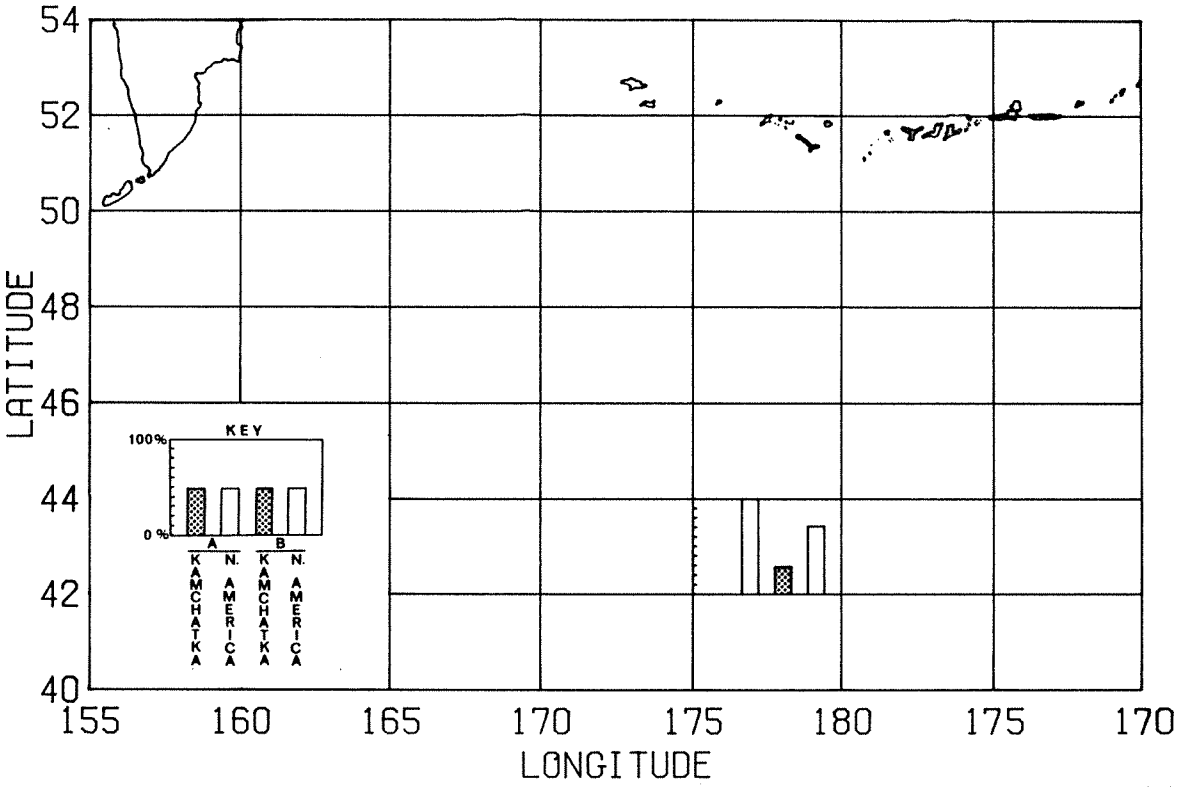

Fig. 3. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North America by INPFC area, May 11-20, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

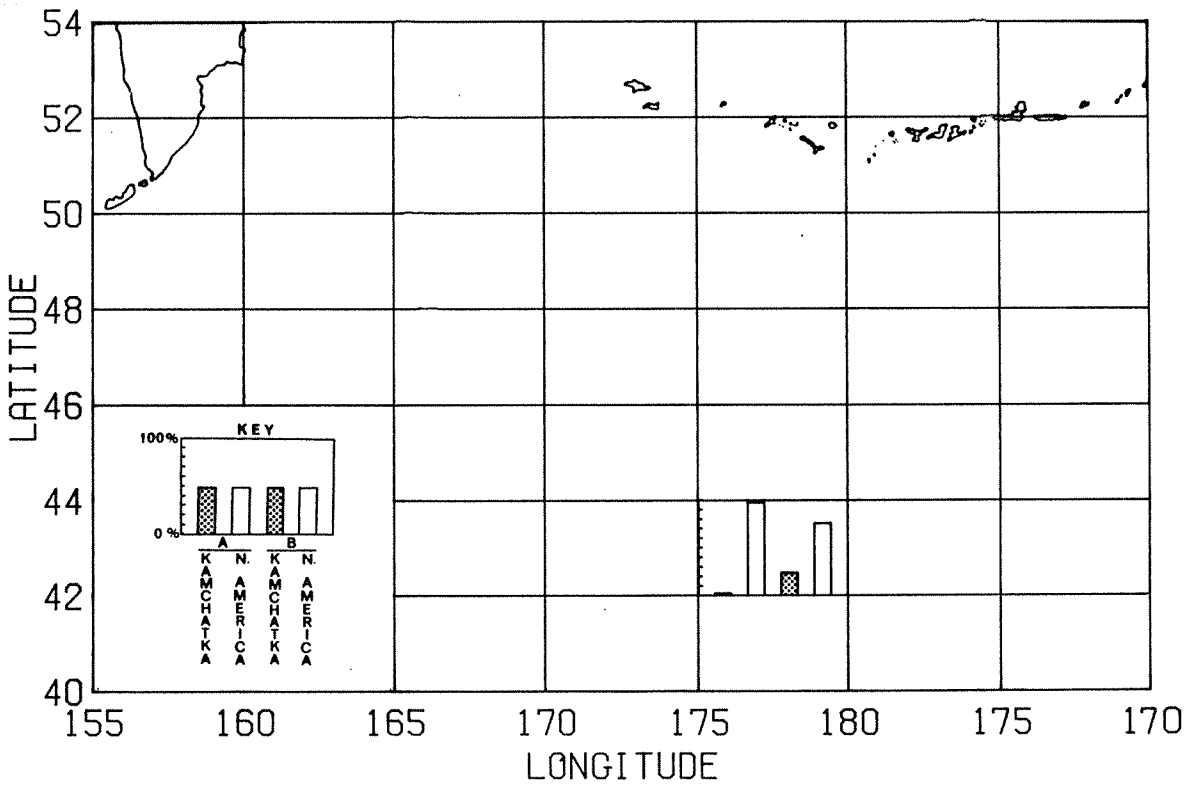

Fig. 4. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North American by INPFC area, May 21-31, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

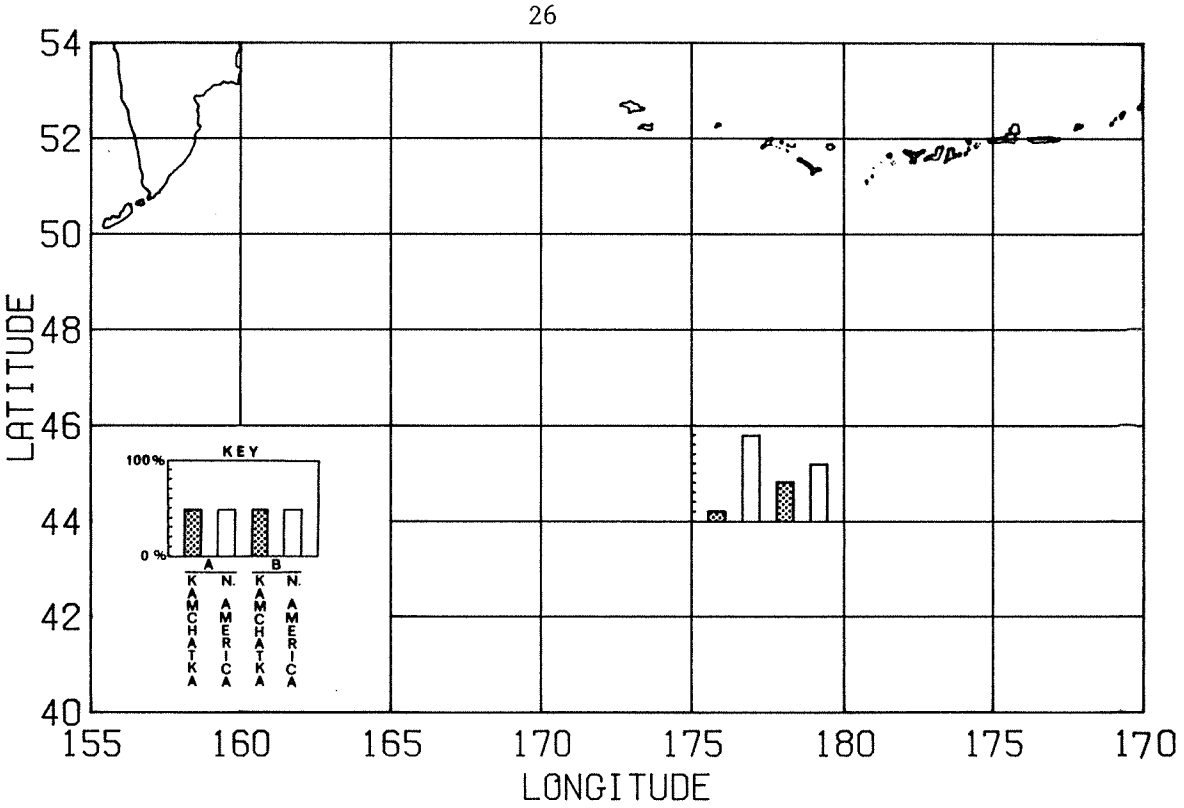

Fig. 5. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North America by INPFC area, June 11-20, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

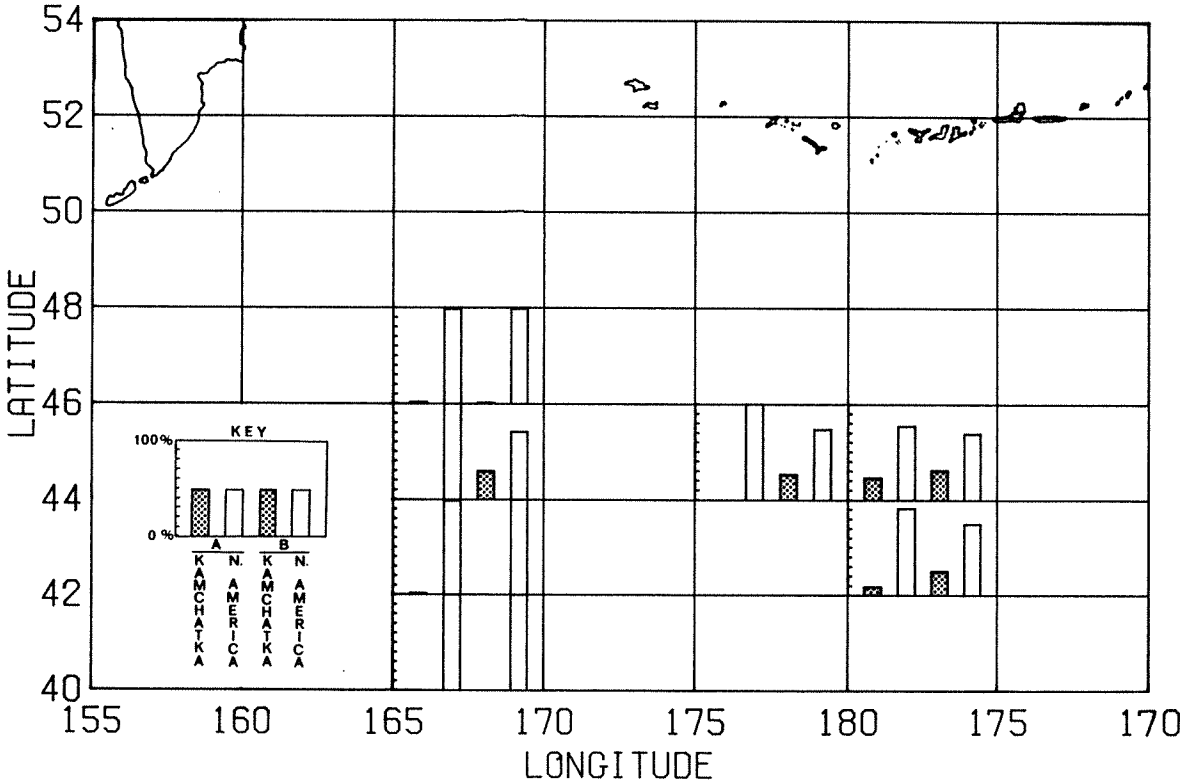

Fig. 6. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North America by INPFC area, June 21-30, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

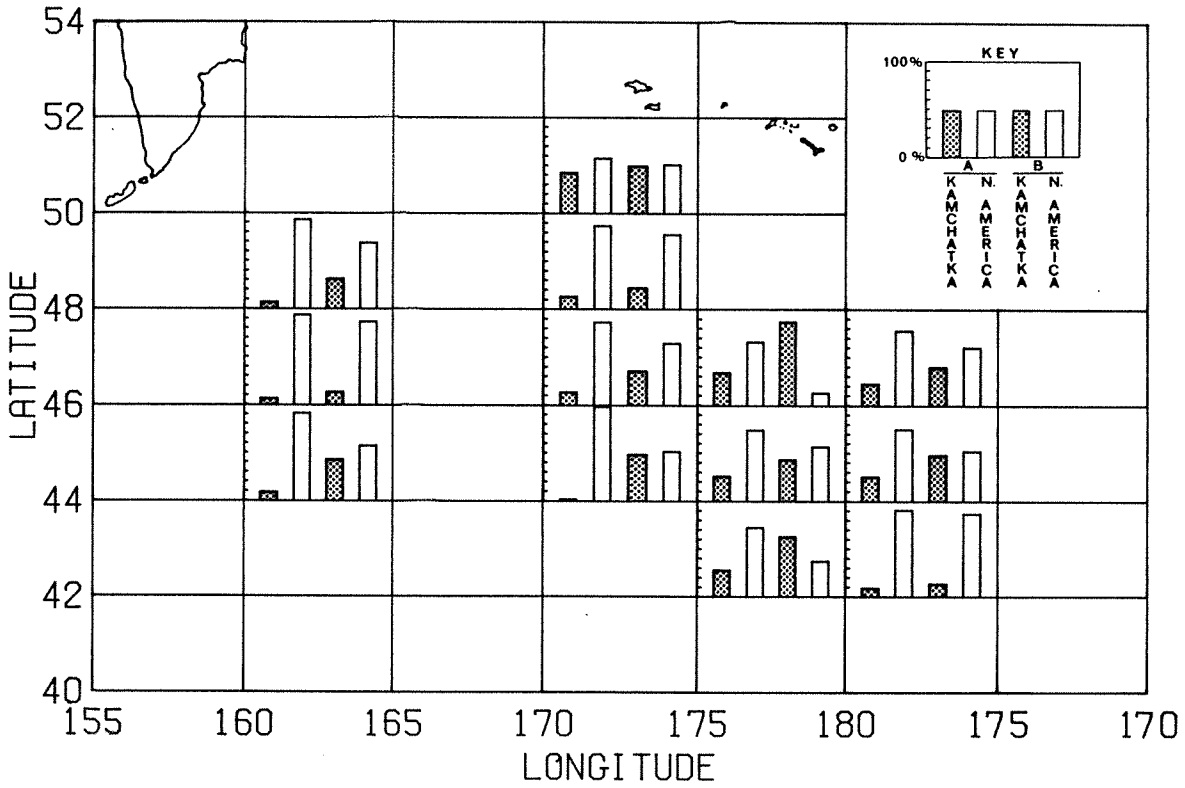

Fig. 7. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North America by INPFC area, July 1-10, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

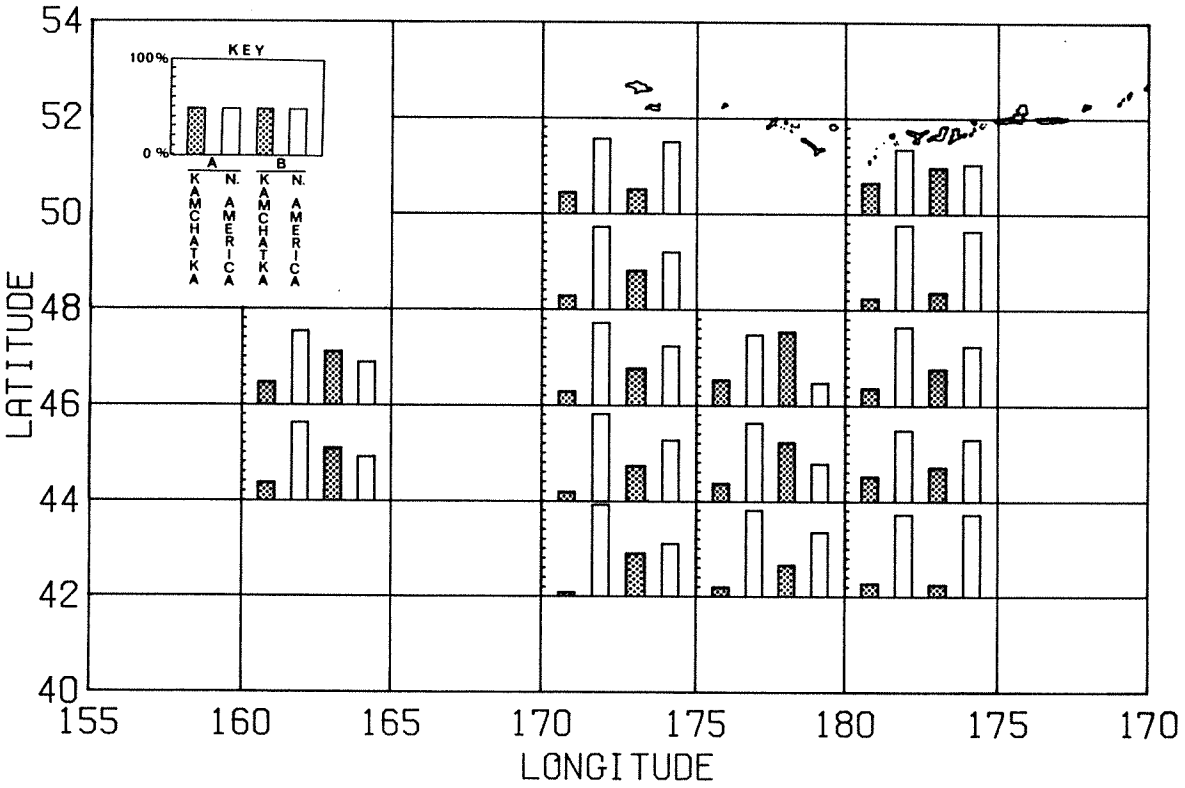

Fig. 8. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North America by INPFC area, July 11-20, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

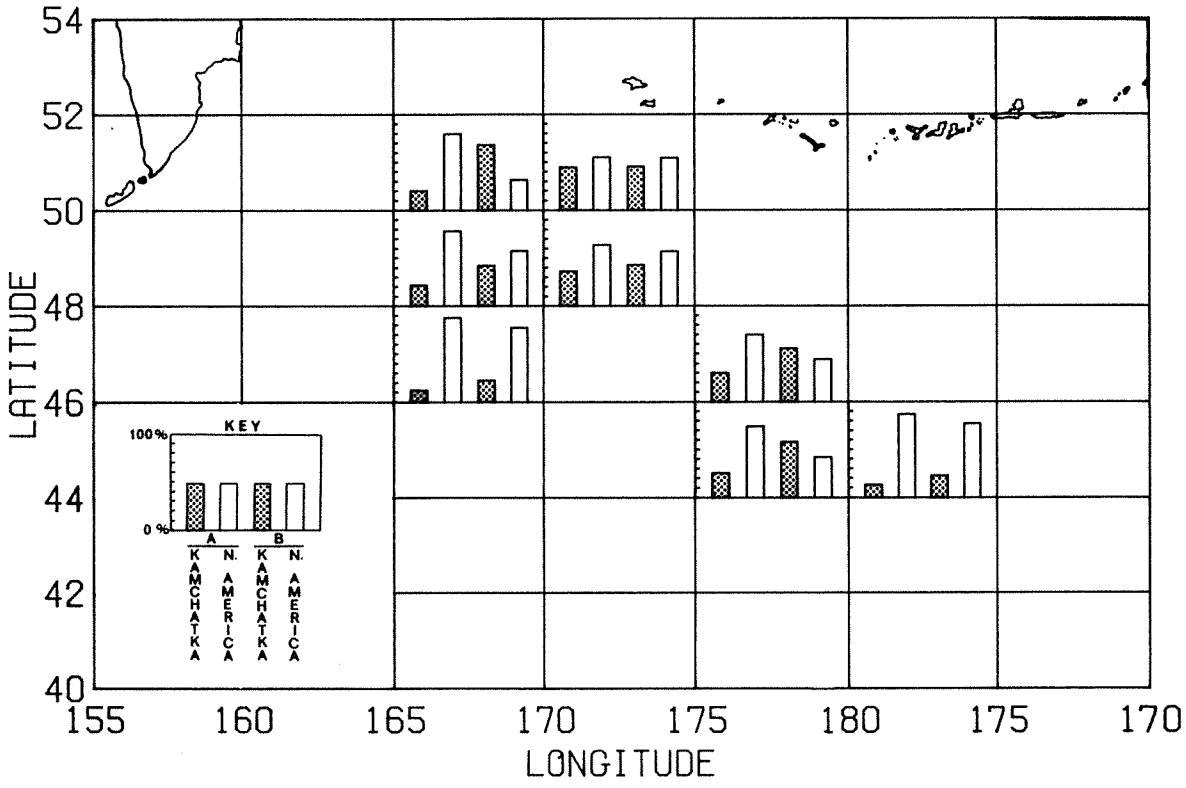

Fig. 9. Mixing proportion estimates (%) of age 2.1 coho salmon (Oncorhynchus kisutch) from the Kamchatka Peninsula and North America by INPFC area, July 21-31, 1981, using A) catch-weighted Asian standard and B) only normal-sized scales in Asian standard.

Table 1. The stock composition and construction of regional standards used to determine the continent of origin of age 2.1 coho salmon (Oncorhynchus kisutch) in and near the Japanese landbased fishery area in 1981.

Region	Stock	Number readable scales	Age 2.1 scales No.	Age 2.1 scales %	Stock abundance[a]	Age 2.1 abundance	% age 2.1 abundance	Scales needed (200 total)	Scales measured[b]
Kamchatka	Bolshaya	149	106	71.1	167,300[c]	118,950	13.1	26	26;64[p]
	Kamchatka	176	128	72.7	1,085,800[c]	789,377	86.9	174	96;59[p]
Total		325	234		1,253,100	908,327	100.0	200	122;123[p]
Western Alaska	Unalakleet	75	63	84.0	59,400[d]	49,896	4.3	9	9
	Yukon	250	204	81.6	113,600[e]	92,698	8.1	16	16
	Kuskokwim	311	295	94.9	387,000[d]	367,263	31.9	64	64
	Quinhagak	280	265	94.6	60,500[d]	57,233	5.0	10	10
	Goodnews	4	4	100.0	43,500[d]	43,500	3.8	7	4
	Nushagak	137	127	92.7	450,000[f]	417,150	36.2	73	73
	Nelson Lagoon	142	108	76.1	162,000[g]	123,282	10.7	21	21
Total		1,199	1,066		1,276,000	1,151,022	100.0	200	197
Central Alaska	Chignik	119	73	61.4	77,100[h]	47,339	7.6	15	15
	Susitna	212	118	55.7	133,100[h]	74,137	11.9	24	24
	Kenai	331	255	77.0	361,000[h]	277,970	44.8	89	89
	Copper	93	53	57.0	303,800[h]	173,166	27.9	56	51
	Bering	33	21	63.7	76,200[h]	48,539	7.8	16	16
	Tsiu	27	13	48.1	-	-	-	-	5[i]
Total		815	533		915,200	621,151	100.0	200	200

Table 1. The stock composition and construction of regional standards used to determine the continent of origin of age 2.1 coho salmon (Oncorhynchus kisutch) in and near the Japanese landbased fishery area in 1981 - cont'd.

Region	Stock	Number readable scales	Age 2.1 scales No.	Age 2.1 scales %	Stock abundance[a]	Age 2.1 abundance	% age 2.1 abundance	Scales needed (200 total)	Scales measured[b]
Southeast Alaska/ British Columbia	Chilkoot	219	137	62.6	2,050[j]	1,283	4.1	8	23[n]
	Chilkat	21	16	76.2	2,750[j]	2,096	6.7	14	16[n]
	Auke	178	96	53.9	678[j]	365	1.2	2	4[n]
	Speel Lake	393	247	62.8	1,942[j]	1,220	3.9	8	14[n]
	Barnes Lake (Stikine)	121	10	8.3	4,500[j]	374	1.2	2	4[n]
	Taku (B.C.)	85	60	70.6	6,000[k]	4,236	13.6	27	48[n]
	Stikine (B.C.)	111	50	45.0	1,700[k]	765	2.5	5	9[n]
	Skeena	69	46	66.7	26,556[l]	17,704	57.0	114	46[n]
	Kakweiken	113	50	43.6	7,000[m]	3,052	9.8	20	35[n,o]
Total		1,310	712		53,176	31,095	100.0	200	199

[a]Stock abundance is run size estimate, commercial catch, or escapement, as indicated.

[b]Some scales for which age was determined were not measured because of deformities or other abberations along the meaurement axis.

[c]Unofficial 1981 commercial catch statistics.

[d]1981 run size estimate from (commercial + subsistence catch) = .6 (total run) (W.D. Arvey, ADF&G, pers. comm., April 11, 1983).

[e]1981 run size estimate from (commercial + subsistence catch) = .4 (total run) (W. D. Arvey, ADF&G, pers. comm., April 11, 1983).

[f]1981 run size estimate from commercial catch = escapement = .5 (total run) (ADF&G, 1982a, p.48).

[g]1981 commercial catch (T. Gilmer, ADF&G, pers. comm., November 12, 1981).

[h]1981 commercial catch of coho salmon reported by fishing area (ADF&G, 1982b, p. 7).

[i]Scales not available from Copper River replaced by scales from nearby Tsiu River.

[j]1981 escapement estimate (L. Shaul, ADF&G, pers. comm., November 25, 1981).

[k]1981 escapement estimate (P. Etherton, Dept. Fisheries and Oceans, pers. comm., June 6, 1983).

[l]1981 escapement estimate (L. Jantz, Dept. Fisheries and Oceans, pers. comm., June 6, 1983).

[m]1981 escapement estimate (P. Starr, Dept. Fisheries and Oceans, pers. comm., July 15, 1983).

[n]Scales not available from Skeena River were apportioned to other rivers in regional standard.

[o]Scale with outlying value from Kakweiken River dropped from regional standard.

[p]Numbers of scales measured for catch-weighted and normal-sized scale standards, respectively.

Table 2. Scale characters examined for use in the discriminant analyses of 1981 age 2.1 coho salmon (Oncorhynchus kisutch) scale samples.

Character No.	Description[a]
1	Size zone 1
2	Size zone 2
3	Size zone 3
4	Size zone 1 + zone 2
5	Size zone 2 + zone 3
6	Size zone 1 + zone 2 + zone 3
7	Size zone 1/(Size zone 1 + zone 2 + zone 3)
8	Size zone 2/(size zone 1 + zone 2 + zone 3)
9	Size zone 3/(size zone 1 + zone 2 + zone 3)
10	No. circuli zone 1 + zone 2 + zone 3
11	(Size zone 1 + zone 2 + zone 3)/(no. circuli zone 1 + zone 2 + zone 3)
12	No. circuli zone 1
13	No. circuli zone 2
14	No. circuli zone 3
15	No. circuli zone 1 + zone 2
16	No. circuli zone 2 + zone 3
17	Size zone 1/no. circuli zone 1
18	Size zone 2/no. circuli zone 2
19	Size zone 3/no. circuli zone 3
20	(Size zone 1 + zone 2)/(no. circuli zone 1 + zone 2)
21	(Size zone 2 + zone 3)/(no. circuli zone 2 + zone 3)
22	Distance C1 to C3 in zone 3/size zone 3
23	Distance C4 to C6 in zone 3/size zone 3
24	Distance C7 to C9 in zone 3/size zone 3
25	Distance C10 to C12 in zone 3/size zone 3
26	Distance C13 to C15 in zone 3/size zone 3
27	Distance C16 to C18 in zone 3/size zone 3
28	Distance C19 to C21 in zone 3/size zone 3
29	Distance C22 to C24 in zone 3/size zone 3
30	Distance C25 to C27 in zone 3/size zone 3
31	Distance C28 to C30 in zone 3/size zone 3
32	Distance C31 to C33 in zone 3/size zone 3
33	Distance C34 to C36 in zone 3/size zone 3
34	Distance C1 to C9 in zone 3
35	Distance C10 to C18 in zone 3
36	Distance C19 to C27 in zone 3
37	Distance C1 to C3 in zone 3
38	Distance C4 to C6 in zone 3
39	Distance C7 to C9 in zone 3
40	Distance C10 to C12 in zone 3
41	Distance C13 to C15 in zone 3
42	Distance C16 to C18 in zone 3

Table 2. Scale characters examined for use in the discriminant analyses of 1981 age 2.1 coho salmon (Oncorhynchus kisutch) scale samples - cont'd.

Character No.	Description[a]
43	Distance C19 to C21 in zone 3
44	Distance C22 to C24 in zone 3
45	Distance C25 to C27 in zone 3
46	Distance C28 to C30 in zone 3
47	Distance C31 to C33 in zone 3
48	Distance C34 to C36 in zone 3
49	(Distance C1 to C3 in zone 2 + zone 3)/(size zone 2 + zone 3)
50	(Distance C4 to C6 in zone 2 + zone 3)/(size zone 2 + zone 3)
51	(Distance C7 to C9 in zone 2 + zone 3)/(size zone 2 + zone 3)
52	(Distance C10 to C12 in zone 2 + zone 3)/(size zone 2 + zone 3)
53	(Distance C13 to C15 in zone 2 + zone 3)/(size zone 2 + zone 3)
54	(Distance C16 to C18 in zone 2 + zone 3)/(size zone 2 + zone 3)
55	(Distance C19 to C21 in zone 2 + zone 3)/(size zone 2 + zone 3)
56	Distance C1 to C3 in zone 2 + zone 3
57	Distance C4 to C6 in zone 2 + zone 3
58	Distance C7 to C9 in zone 2 + zone 3
59	No. circuli in ocean annulus
60	Size of ocean annulus

[a]Zone 1: The area of the scale from the center of the focus to the outer edge of the last circulus in the second freshwater annulus.

Zone 2: The area of the scale from the outer edge of the last circulus in the second freshwater annulus to the outer edge of the last intermediate growth circulus (i.e., freshwater plus-growth and/or estuarine growth), if present.

Zone 3: The area of the scale from the outer edge of the last intermediate growth circulus if present (outer edge of last circulus in second freshwater annulus otherwise) to the outer edge of the last circulus in the ocean annulus.

C = circulus

APPENDIX TABLES AND FIGURES

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Appendix Table 1. Decision arrays for mature age 2.1 coho salmon of Western Alaska vs. Central Alaska vs. Southeast Alaska/British Columbia vs. Kamchatka Peninsula origin in 1981 calculated for a) 4-class, b) 3-class, and c) 2-class situations, using catch-weighted Asian (Kamchatka) standard. The overall classificatory accuracies were calculated as the unweighted means of the accuracies on the diagonals of the decision arrays.

a) 4-class: Overall accuracy: 64.1%
Western vs. Central vs. Southeast/B.C. vs. Kamchatka
Scale characters used: 3,10,14,15,26,43[a]

Calculated decision	Correct decision (%)			
	Western	Central	Southeast/ B.C.	Kamchatka
Western	119(60.4)	35(17.5)	30(15.1)	8(6.6)
Central	37(18.8)	102(51.0)	33(16.6)	17(13.9)
Southeast/B.C.	26(13.2)	40(20.0)	132(66.3)	1(0.8)
Kamchatka	15(7.6)	23(11.5)	4(2.0)	96(78.7)
Total	197	200	199	122

b) 3-class: Overall accuracy: 73.5%
Western vs. Central vs. Kamchatka
Scale characters used: 2,3,10,11,15,43[a]

Calculated decision	Correct decision (%)		
	Western	Central	Kamchatka
Western	143(72.6)	37(18.5)	11(9.0)
Central	33(16.7)	140(70.0)	16(13.1)
Kamchatka	21(10.7)	23(11.5)	95(77.9)
Total	197	200	122

Overall accuracy: 78.1%
Western vs. Southeast/B.C. vs. Kamchatka
Scale characters used: 3,10,26,35,43,54[a]

Calculated decision	Correct decision (%)		
	Western	Southeast/ B.C.	Kamchatka
Western	137(69.5)	39(19.6)	14(11.5)
Southeast/B.C.	40(20.3)	155(77.9)	2(1.6)
Kamchatka	20(10.2)	5(2.5)	106(86.9)
Total	197	199	122

Appendix Table 1. Decision arrays for mature age 2.1 coho salmon of Western Alaska vs. Central Alaska vs. Southeast Alaska/British Columbia vs. Kamchatka Peninsula origin in 1981 calculated for a) 4-class, b) 3-class, and c) 2-class situations, using catch-weighted Asian (Kamchatka) standard. The overall classificatory accuracies were calculated as the unweighted means of the accuracies on the diagonals of the decision arrays - cont'd.

c) 2-class — Overall accuracy: 85.3%
Western vs. Kamchatka
Scale characters used: 3,10,19,26,42,43[a]

Calcuated decision	Correct decision (%)	
	Western	Kamchatka
Western	168(85.3)	18(14.8)
Kamchatka	29(14.7)	104(85.2)
Total	197	122

[a]See Table 2 for descriptions of scale characters used in analyses.

Appendix Table 2. Estimates of the mixing proportion of maturing age 2.1 Alaskan and Asian coho salmon (Oncorhynchus kisutch) in and near the Japanese landbased fishery area in 1981 calculated for a) samples pooled over 10-day periods within International North Pacific Fisheries Commission (INPFC) areas, b) samples pooled over months within INPFC areas, and c) samples pooled over months within quadrats. Estimates derived from analyses using catch-weighted Asian standard. Northeast quadrat (NE) = 46°N to 52°N x 175°E to 165°W; Northwest quadrat (NW) = 46°N to 52°N x 160°E to 175°E; Southeast quadrat (SE) = 40°N to 46°N x 175°E to 165°W; Southwest quadrat (SW) = 40°N to 46°N x 160°E to 175°E. * = INPFC areas within landbased fishery area.

a) Samples pooled over 10-day periods within INPFC areas:

10-day period	INPFC area	Sample size	Mixing proportion estimates (%) with 90% confidence intervals: Western Alaska	Central Alaska	Southeast Alaska/B.C.	Kamchatka Peninsula
May 11-20	*E7542	25	100 (82.5-100)	0	0	0
May 21-31	*E7542	122	90.8(69.2-100)	0	6.8(0-24.4)	2.4(0-12.3)
June 11-20	*E7544	41	89.7(73.8-100)	0	0	10.3(0-26.2)
June 21-30	*E6540	32	84.1(31.9-100)	0	15.9(0-55.9)	0
	*E6542	73	75.5(39.3-100)	6.8(0-45.6)	15.9(0-42.5)	1.7(0-14.8)
	*E6544	76	100 (89.5-100)	0	0	0
	*E6546	28	89.7(50.5-100)	0	8.7(0-41.1)	1.6(0-19.0)
	*E7544	101	100 (89.9-100)	0	0	0
	*W8042	86	91.2(79.7-100)	0	0	8.8(0-20.3)
	*W8044	80	55.3(33.3-77.3)	21.8(0.8-42.7)	0	22.9(6.3-39.5)
July 1-10	*E6044	49	84.8(54.2-100)	0	6.5(0-30.7)	8.7(0-24.5)
	*E6046	56	83.4(54.3-100)	0	10.2(0-33.8)	6.4(0-20.6)
	E6048	51	93.1(79.0-100)	0	0	6.9(0-21.0)
	*E7044	38	98.5(85.6-100)	0	0	1.5(0-16.4)
	E7046	91	86.6(74.9-98.2)	0	0	13.4(1.8-25.1)
	E7048	56	60.5(34.1-87.0)	26.5(0.9-52.0)	0	13.0(0-30.8)
	E7050	27	31.6(0-77.9)	6.9(0-62.7)	19.0(0-56.4)	42.5(8.2-76.9)
	*E7542	44	72.5(55.3-89.8)	0	0	27.5(10.2-44.7)
	*E7544	64	74.3(59.9-88.8)	0	0	25.7(11.2-40.1)
	E7546	39	63.8(30.7-96.9)	0	2.4(0-24.7)	33.8(11.6-55.9)
	*W8042	33	90.8(73.4-100)	0	0	9.2(0-26.6)
	*W8044	123	69.4(50.8-88.0)	5.4(0-21.4)	0	25.2(11.0-39.4)
	W8046	35	59.5(27.2-91.8)	18.3(0-48.5)	0	22.2(0-46.4)

Appendix Table 2. Estimates of the mixing proportion of maturing age 2.1 Alaskan and Asian coho salmon (Oncorhynchus kisutch) in and near the Japanese landbased fishery area in 1981 calculated for a) samples pooled over 10-day periods within International North Pacific Fisheries Commission (INPFC) areas, b) samples pooled over months within INPFC areas, and c) samples pooled over months within quadrats. Estimates derived from analyses using catch-weighted Asian standard. Northeast quadrat (NE) = 46°N to 52°N x 175°E to 165°W; Northwest quadrat (NW) = 46°N to 52°N x 160°E to 175°E; Southeast quadrat (SE) = 40°N to 46°N x 175°E to 165°W; Southwest quadrat (SW) = 40°N to 46°N x 160°E to 175°E. * = INPFC areas within landbased fishery area - cont'd.

a) Samples pooled over 10-day periods within INPFC areas - cont'd.

10-day period	INPFC area	Sample size	Mixing proportion estimates (%) with 90% confidence intervals: Western Alaska	Central Alaska	Southeast Alaska/B.C.	Kamchatka Peninsula
July 11-20	*E6044	43	72.3(42.9-100)	9.1(0-35.0)	0	18.6(0-40.0)
	*E6046	144	76.6(66.4-86.8)	0	0	23.4(13.2-33.6)
	*E7042	51	95.9(82.2-100)	0	0	4.1(0-17.8)
	*E7044	85	90.8(79.2-100)	0	0	9.2(0-20.8)
	E7046	178	85.8(76.7-94.9)	0	0	14.2(5.1-23.3)
	E7048	93	45.8(25.1-66.5)	40.2(19.0-61.4)	0	14.0(0-28.3)
	E7050	43	57.5(15.0-100)	10.7(0-58.4)	9.6(0-39.2)	22.2(0-46.3)
	*E7542	51	90.3(75.9-100)	0	0	9.7(0-24.1)
	*E7544	112	81.6(70.6-92.6)	0	0	18.4(7.4-29.4)
	E7546	57	73.6(58.3-88.9)	0	0	26.4(11.1-41.7)
	*W8042	60	79.2(53.8-100)	7.0(0-29.3)	0	13.8(0-31.4)
	*W8044	88	74.1(61.6-86.7)	0	0	25.9(13.3-38.4)
	W8046	254	81.8(73.6-90.0)	0	0	18.2(10.0-26.4)
	W8048	96	52.6(31.8-73.3)	35.8(15.1-56.6)	0	11.6(2.1-25.2)
	W8050	86	57.5(36.4-78.6)	10.1(0-28.9)	0	32.4(15.3-49.6)
July 21-31	*E6546	43	87.9(72.0-100)	0	0	12.1(0-28.0)
	E6548	90	78.3(66.1-90.6)	0	0	21.7(9.4-33.9)
	E6550	53	56.6(29.9-83.3)	23.1(0-48.6)	0	20.3(0.7-40.0)
	E7048	136	52.4(27.5-77.4)	11.1(0-40.1)	0.2(0-15.1)	36.3(20.0-52.6)
	E7050	80	26.4(0-53.5)	22.6(0-59.4)	6.2(0-26.2)	44.8(23.3-66.3)
	*E7544	58	74.4(59.3-89.5)	0	0	25.6(10.5-40.7)
	E7546	64	69.9(55.2-84.6)	0	0	30.1(15.4-44.8)
	*W8044	96	86.9(75.5-98.3)	0	0	13.1(1.7-24.5)

Appendix Table 2. Estimates of the mixing proportion of maturing age 2.1 Alaskan and Asian coho salmon (Oncorhynchus kisutch) in and near the Japanese landbased fishery area in 1981 calculated for a) samples pooled over 10-day periods within International North Pacific Fisheries Commission (INPFC) areas, b) samples pooled over months within INPFC areas, and c) samples pooled over months within quadrats. Estimates derived from analyses using catch-weighted Asian standard. Northeast quadrat (NE) = 46°N to 52°N x 175°E to 165°W; Northwest quadrat (NW) = 46°N to 52°N x 160°E to 175°E; Southeast quadrat (SE) = 40°N to 46°N x 175°E to 165°W; Southwest quadrat (SW) = 40°N to 46°N x 160°E to 175°E. * = INPFC areas within landbased fishery area - cont'd.

b) Samples pooled over months within INPFC areas:

Month	INPFC area	Sample size	Mixing proportion estimates (%) with 90% confidence intervals: Western Alaska	Central Alaska	Southeast Alaska/B.C.	Kamchatka Peninsula
May	*E7542	147	95.7(75.2-100)	0	3.9(0-20.6)	0.4(0-9.7)
	*W8042	35	91.6(56.1-100)	0	8.4(0-38.2)	0
June	*E6540	32	84.1(31.9-100)	0	15.9(0-55.9)	0
	*E6542	79	76.1(41.1-100)	2.4(0-39.1)	18.4(0-44.3)	3.1(0-16.1)
	*E6544	76	100 (89.6-100)	0	0	0
	*E6546	28	89.7(50.5-100)	0	8.7(0-41.1)	1.6(0-19.0)
	*E7544	142	98.9(89.8-100)	0	0	1.1(0-10.2)
	*W8042	102	91.7(80.9-100)	0	0	8.3(0-19.1)
	*W8044	80	55.3(33.3-77.3)	21.8(0.8-42.8)	0	22.9(6.3-39.5)
July	*E6042	29	84.2(28.9-100)	15.8(0-80.9)	0	0
	*E6044	92	96.2(85.4-100)	0	0	3.8(0-14.6)
	*E6046	200	84.0(75.2-92.8)	0	0	16.0(7.2-24.8)
	E6048	51	93.1(79.0-100)	0	0	6.9(0-21.0)
	*E6546	43	87.9(72.0-100)	0	0	12.1(0-28.0)
	E6548	90	78.3(66.1-90.6)	0	0	21.7(9.4-33.9)
	E6550	55	53.6(27.5-79.8)	24.7(0-49.9)	0	21.7(2.2-41.2)
	*E7042	51	95.9(82.2-100)	0	0	4.1(0-17.8)
	*E7044	123	93.2(83.2-100)	0	0	6.8(0-16.8)
	E7046	273	86.6(78.6-94.5)	0	0	13.4(5.5-21.4)
	E7048	285	44.4(31.6-57.2)	32.7(19.7-45.7)	0	22.9(13.2-32.6)
	E7050	150	36.2(14.3-58.2)	16.4(0-43.9)	9.5(0-25.4)	37.9(22.4-53.5)
	*E7542	95	82.1(70.3-93.8)	0	0	17.9(6.2-29.7)
	*E7544	234	77.9(69.3-86.4)	0	0	22.1(13.6-30.7)
	E7546	160	67.7(57.7-77.7)	0	0	32.3(22.3-42.3)
	*W8042	93	78.8(57.5-100)	11.6(0-30.9)	0	9.6(0-23.4)

Appendix Table 2. Estimates of the mixing proportion of maturing age 2.1 Alaskan and Asian coho salmon (Oncorhynchus kisutch) in and near the Japanese landbased fishery area in 1981 calculated for a) samples pooled over 10-day periods within International North Pacific Fisheries Commission (INPFC) areas, b) samples pooled over months within INPFC areas, and c) samples pooled over months within quadrats. Estimates derived from analyses using catch-weighted Asian standard. Northeast quadrat (NE) = 46°N to 52°N x 175°E to 165°W; Northwest quadrat (NW) = 46°N to 52°N x 160°E to 175°E; Southeast quadrat (SE) = 40°N to 46°N x 175°E to 165°W; Southwest quadrat (SW) = 40°N to 46°N x 160°E to 175°E. * = INPFC areas within landbased fishery area - cont'd.

b) Samples pooled over months within INPFC areas - cont'd.

Month	INPFC area	Sample size	Mixing proportion estimates (%) with 90% confidence intervals: Western Alaska	Central Alaska	Southeast Alaska/B.C.	Kamchatka Peninsula
July (cont'd.)	*E8044	307	76.5(68.7-84.4)	0	0	23.5(15.6-31.3)
	E8046	289	82.1(74.2-90.0)	0	0	17.9(10.0-25.8)
	W8048	96	52.6(31.8-73.3)	35.8(15.1-56.6)	0	11.6(0-25.2)
	W8050	94	55.6(35.3-75.9)	14.5(0-33.2)	0	29.9(13.6-46.1)

c) Samples pooled over months within quadrats

Month	Quadrat	Sample size	Mixing proportion estimates (%) with 90% confidence intervals: Western Alaska	Central Alaska	Southeast Alaska/B.C.	Kamchatka Peninsula
May	SE	184	93.5(74.4-100)	0	6.3(0-22.0)	0.2(0-8.6)
June	NW	41	90.9(57.7-100)	0	9.1(0-37.2)	0
	NE	63	54.3(29.6-78.9)	26.5(2.5-50.5)	0	19.2(1.3-37.1)
	SW	187	90.2(71.3-100)	0	9.8(0-25.5)	0
	SE	355	90.5(83.1-97.9)	0	0	9.5(2.1-16.9)
July	NW	439	83.7(76.7-90.8)	0	0	16.3(9.2-23.3)
	NE	1373	59.6(50.4-68.7)	17.8(9.2-26.4)	0	22.6(16.2-29.0)
	SW	145	97.4(88.2-100)	0	0	2.6(0-11.8)
	SE	903	82.2(76.2-88.3)	0	0	17.8(11.7-23.8)

Appendix Table 3. Decision array for mature age 2.1 coho salmon of Western Alaska vs. Central Alaska vs. Southeast Alaska/British Columbia vs. Kamchatka Peninsula origin in 1981 calculated for the 4-class situation, using only normal-sized scales in the Asian (Kamchatka) standard. The overall classificatory accuracy was calculated as the unweighted mean of the accuracies on the diagonal of the decision array.

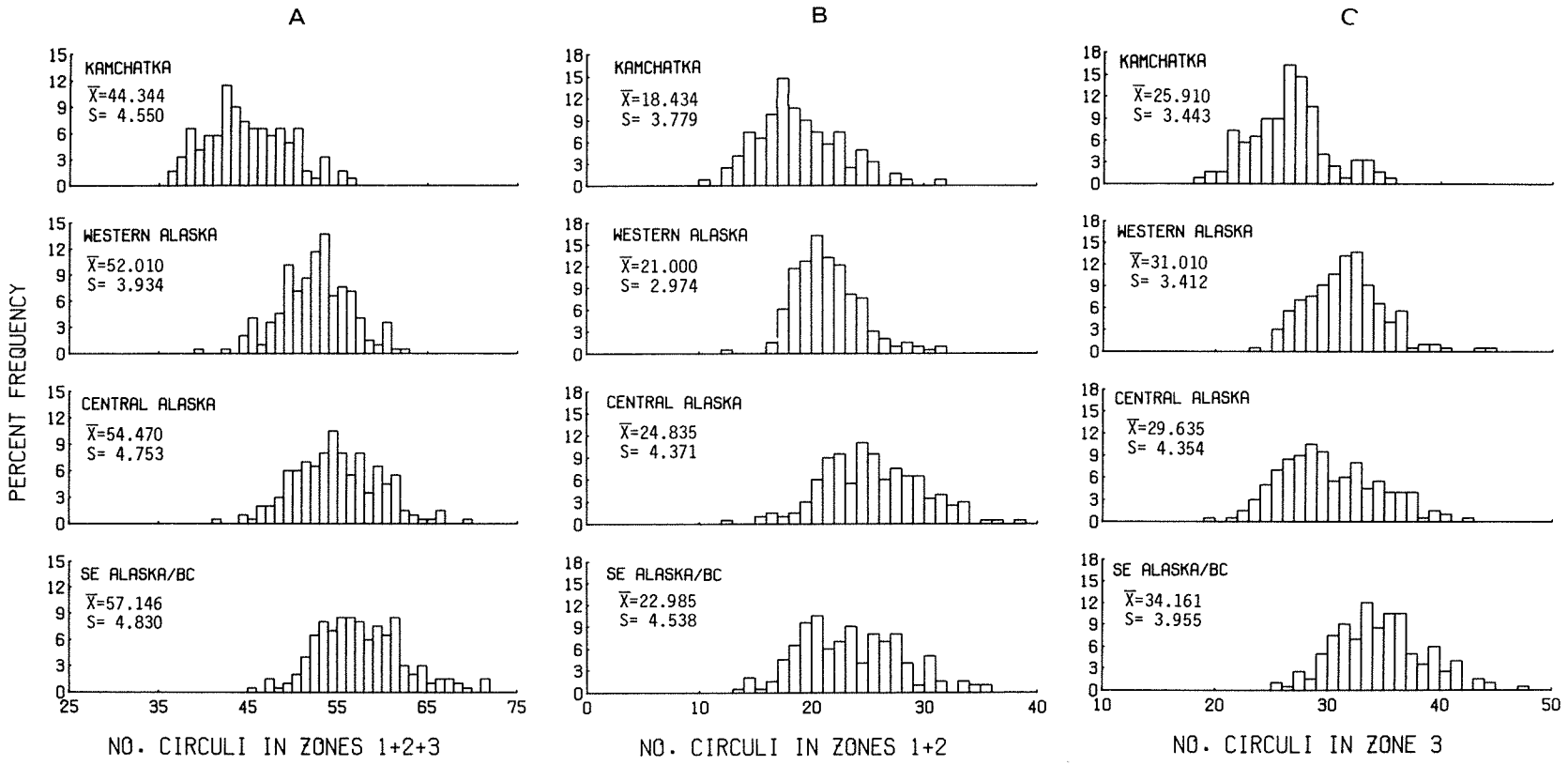
Scale characters used: 10,14,15,17,26,27[a] Overall accuracy: 61.2%

Calculated decision	Correct decision (%)			
	Western	Central	Southeast/ B.C.	Kamchatka
Western	110(55.9)	27(13.5)	41(20.6)	14(11.4)
Central	29(14.7)	114(57.0)	33(16.6)	15(12.2)
Southeast/B.C.	31(15.7)	43(21.5)	117(58.8)	4(3.2)
Kamchatka	27(13.7)	16(8.0)	6(3.0)	90(73.2)
Total	197	200	199	123

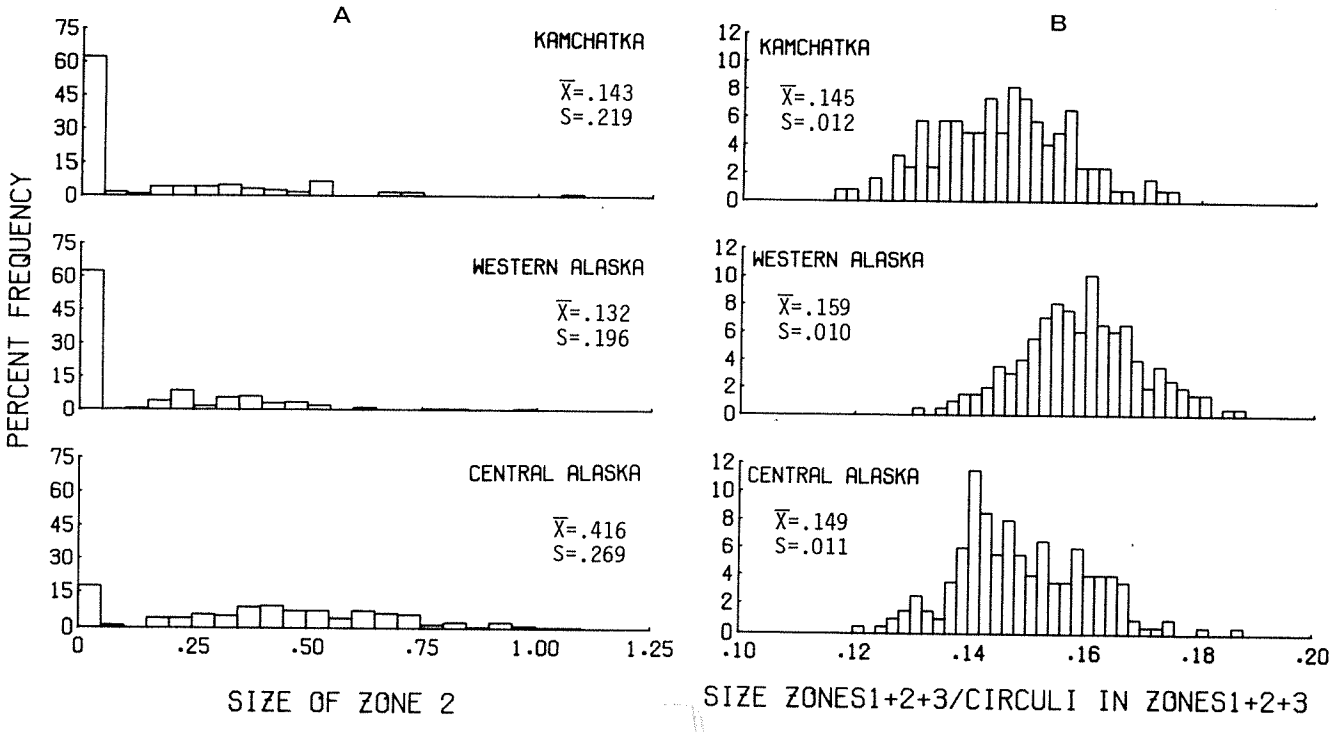
[a]See Table 2 for descriptions of scale characters used in the analysis.

Appendix Table 4. Numbers of statistically significant (sig), positive (pos), and zero mixing proportion estimates for age 2.1 Alaskan and Asian coho salmon in and near the Japanese landbased fishery area for four-way analyses using a) catch-weighted Asian standard and b) only normal-sized scales in the Asian standard.

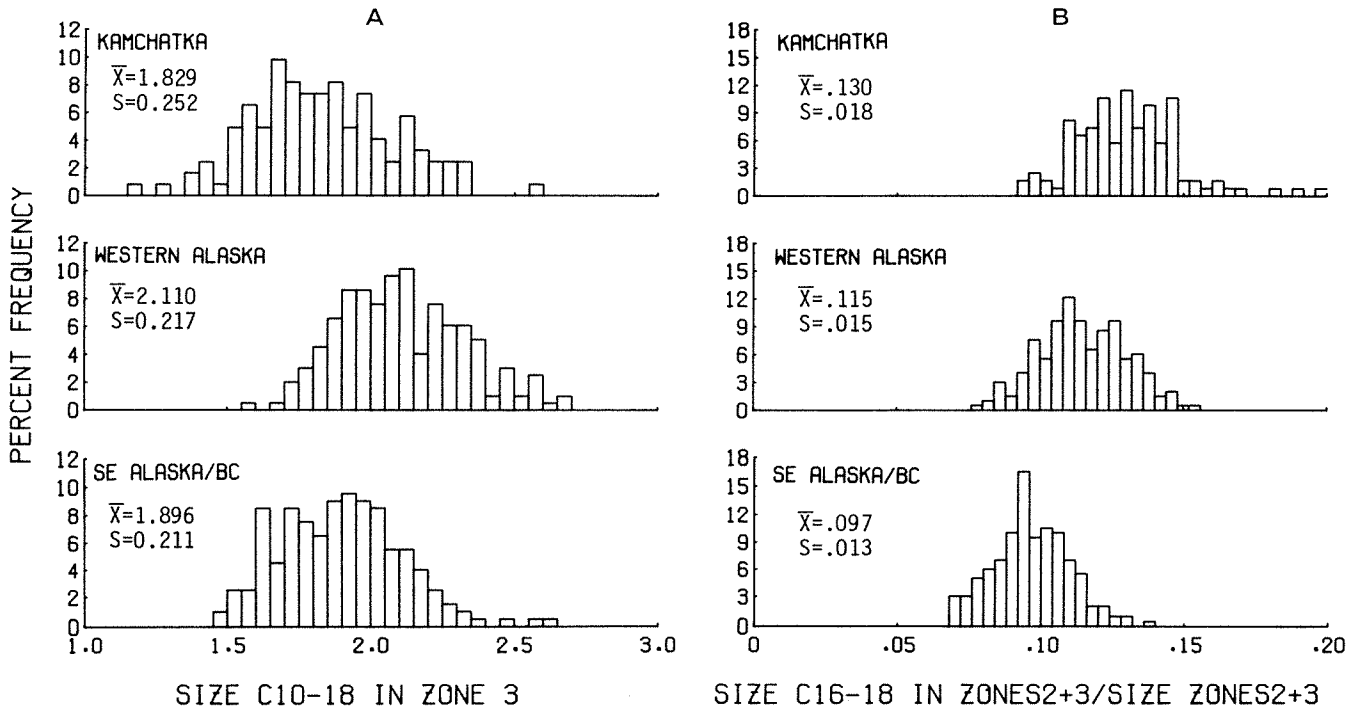
Stratum	Western Alaska			Central Alaska			Southeast Alaska/ British Columbia			Kamchatka Peninsula		
	Sig	Pos	Zero	Sig	Pos	Zero	Sig	Pos	Zero	Sig	Pos	Zero
a) Four-way analysis using catch-weighted Asian standard												
10-day period/ INPFC area	44	2	0	4	11	31	0	11	35	22	20	4
Month/INPFC area	29	0	0	3	6	20	0	6	23	13	12	4
Month/quadrat	9	0	0	2	0	7	0	3	6	5	2	2
Total	82	2	0	9	17	58	0	20	64	40	34	10
b) Four-way analysis using only normal-sized scales in the Asian standard												
10-day period/ INPFC area	38	8	0	0	12	34	0	14	32	33	11	2
Month/INPFC area	28	1	0	0	7	22	0	9	20	20	6	3
Month/quadrat	9	0	0	0	2	7	0	4	5	7	2	0
Total	75	9	0	0	21	63	0	27	57	60	19	5



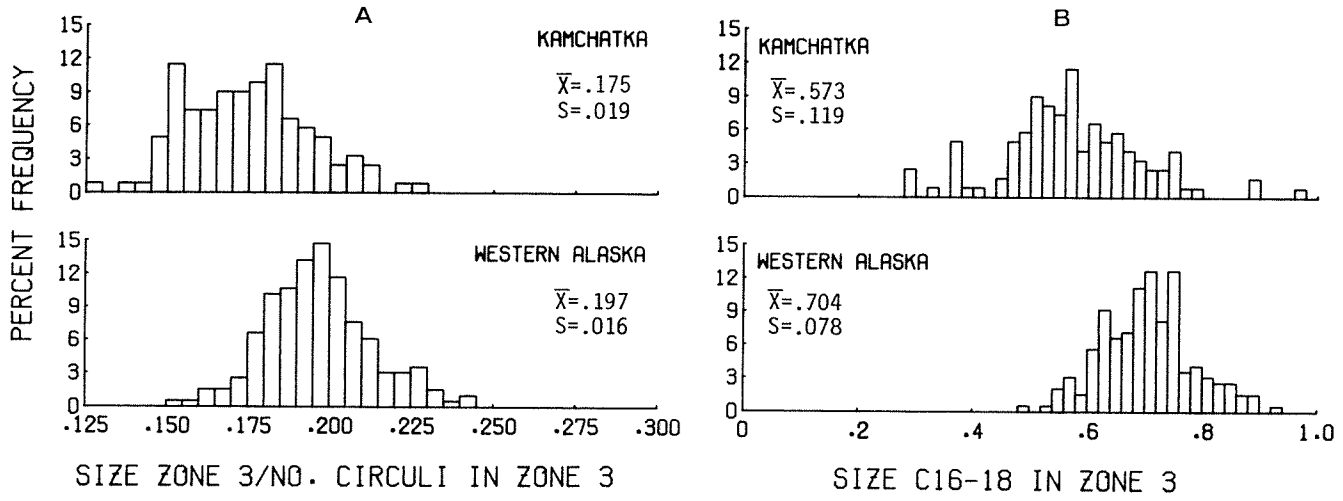
Appendix Fig. 1. Regional means ($\bar{X}$), standard deviations (S), and frequency distributions of scale characters used in the 4-way analysis (using the catch-weighted Asian standard) of scales of mature age 2.1 coho salmon from the Kamchatka Peninsula, western and central Alaska, and southeast Alaska/British Columbia in 1981. Characters are (A) the number of circuli through the end of the ocean annulus, (B) the number of circuli through the end of the intermediate-growth zone, and (C) the number of circuli from the end of the intermediate-growth zone through the end of the ocean annulus.



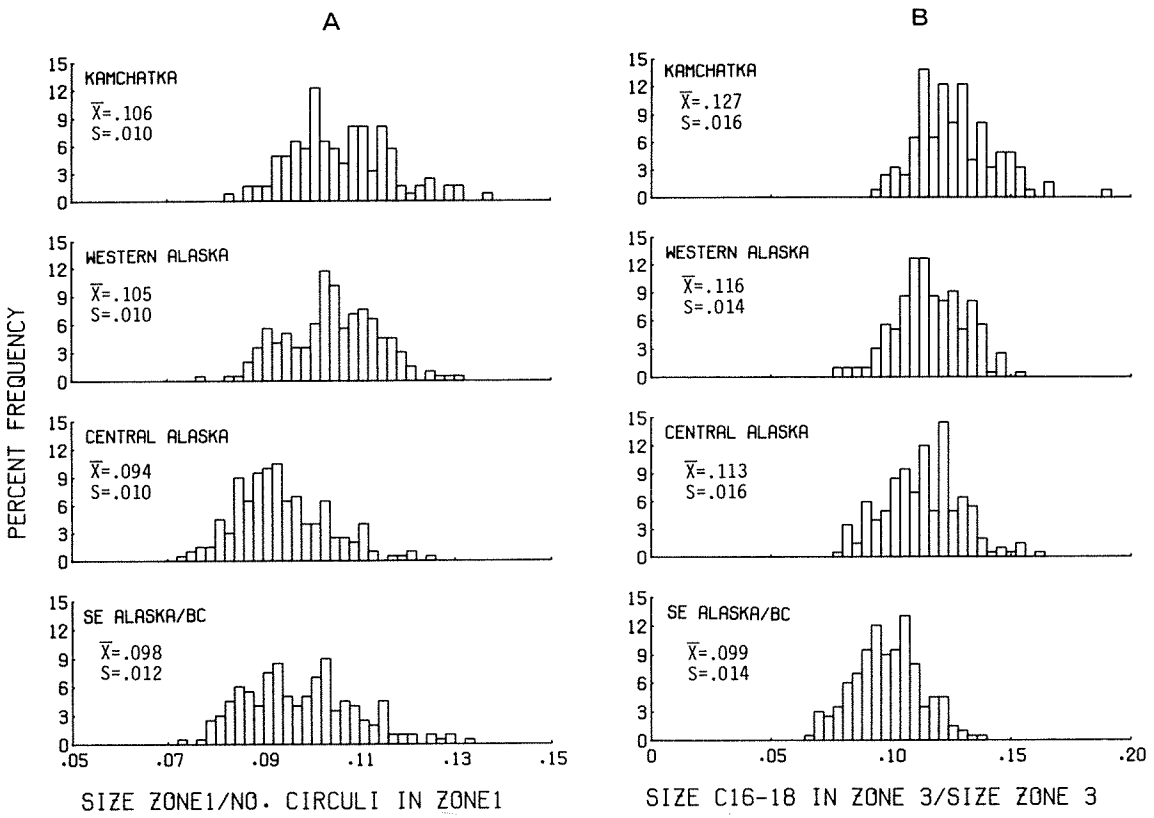
Appendix Fig. 3. Regional means ($\bar{X}$), standard deviations (S), and frequency distributions of scale characters used in the 3-way analysis (using catch-weighted Asian standard) of scales of mature age 2.1 coho salmon from the Kamchatka Peninsula, and western and central Alaska in 1981. Characters are (A) size of the intermediate growth zone and (B) distance to the outer edge of the ocean annulus divided by the number of circuli through the outer edge of the ocean annulus. Distributions of other characters used in this 3-way analysis are shown in Appendix Figures 1(A), 1(B), 2(A), and 2(C). All measurements are in inches at 100X.



Appendix Fig. 4. Regional means ($\bar{X}$), standard deviations (S), and frequency distributions of scale characters used in the 3-way analysis (using catch-weighted Asian standard) of scales of mature age 2.1 coho salmon from the Kamchatka Peninsula, western Alaska, and southeast Alaska/British Columbia in 1981. Characters are (A) the distance between circuli 10 and 18 in the first ocean zone and (B) the distance between circuli 16 and 18 in the intermediate-growth and first ocean zones combined divided by the combined size of the intermediate-growth and first ocean zones. Distributions of other characters used in this 3-way analysis are shown in Appendix Figures 1(A), 2(A), 2(B), and 2(C). All measurements are in inches at 100X.



Appendix Fig. 5. Regional means ($\bar{X}$), standard deviations (S), and frequency distributions of scale characters used in the 2-way analysis (using catch- weighted Asian standard) of scales of mature age 2.1 coho salmon from the Kamchatka Peninsula and western Alaska in 1981. Characters are (A) the size of the first ocean zone divided by the number of circuli in the first ocean zone and (B) the distance between circuli 16 and 18 in the first ocean zone. Distributions of other characters used in the 2-way analysis are shown in Appendix Figures 1(A), 2(A), 2(B), and 2(C). All measurements are in inches at 100X.



Appendix Fig. 6. Regional means ($\bar{X}$), standard deviations (S), and frequency distributions of scale characters used in the 4-way analysis (using only normal-sized scales in the Asian standard) of scales of mature age 2.1 coho salmon from the Kamchatka Peninsula, western and central Alaska, and southeast Alaska/British Columbia in 1981. Characters are (A) size of the freshwater zone through the end of the second freshwater annulus divided by the number of circuli through the end of the second freshwater annulus and (B) the distance between circuli 16 and 18 in the first ocean zone divided by the size of the first ocean zone. Distributions of other characters used in this analysis are shown in Appendix Figures 1(A), 1(B), 1(C), and 2(B). All measurements are in inches at 100X.