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ORIGINS OF CHINOOK SALMON IN THE AREA OF THE JAPANESE MOTHERSHIP AND LANDBASED DRIFTNET SALMON FISHERIES IN 1985 AND 1986

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ORIGINS OF CHINOOK SALMON IN THE AREA OF THE JAPANESE MOTHERSHIP AND LANDBASED DRIFTNET SALMON FISHERIES IN 1985 AND 1986

ABSTRACT

Scale pattern analysis was used to determine the continent of origin of immature age 1.2 chinook salmon caught on the high seas in 1985 (brood-year 1981) and 1986 (brood-year 1982). Regional brood-year standards were formed by grouping samples from major Pacific Rim stocks on the basis of similarity in their scale patterns, and diagnostic tests were performed to determine the accuracy of the models. A maximum likelihood estimator was used to allocate the high seas unknowns to region of origin. Maximum likelihood estimates from brood-year 1981 analyses were applied to reported catches by the landbased fishery to estimate interceptions of North American chinook in recent years. The 1985 high seas samples were allocated to four groups (western Kamchatka, eastern Kamchatka, western Alaska, and central Alaska). Because of similarity in the scale patterns of brood-year 1982 Kamchatka R. (Asia) and Yukon R. (North America) fish, the two stocks had to be combined into one group. The 1986 samples were allocated to four groups (western Kamchatka, Kamchatka -Yukon, Kuskokwim-Bristol Bay, and central Alaska). Results indicated that in 1985, the majority of fish in the Bering Sea between 175°E and 175°W was predominantly of western Alaskan origin. In the North Pacific Ocean north of 46° N, central Alaska was most often the predominant regional stock (35% to 64%), and western Kamchatka was an important secondary stock (10% to 52%). Few chinook salmon scale samples were available from the vicinity of the Japanese landbased driftnet fishery in the North Pacific (south of 46° N). The sample size was sufficient to meet the required 100 fish per stratum only in 1986, even when samples were pooled over four subareas and two months. Results from both 1985 and 1986 indicated that western Kamchatkan fish predominated in the landbased fishery area (43% in 1985; 81% in 1986). Application of the 1985 estimate (34% Alaskan fish) to catch of the entire landbased fishery in recent years indicated that catches of Alaskan chinook have decreased from 34,000 in 1985 to 17,000 fish in 1989. The results presented in this document are partially supported by information from previous tagging, parasite, and scale pattern studies, but the estimates of interception are provisional because new information on high seas distributions of chinook and verification of the accuracy of catch statistics may require that estimates be revised. Recommendations for future research include studies to determine if analyses can be performed without creating brood-year standards and to determine if the allocate-sum procedure can be validly applied to problems of high seas stock separation. Continued efforts to procure high quality scale samples from the U.S.S.R. and to increase the number of chinook salmon scales collected from the landbased area by sampling scales from the commercial fishery were also recommended.

INTRODUCTION

The 1978 renegotiation of the North Pacific Treaty and further revisions in 1986 included a mandate for research to investigate the stock origins of salmon in the landbased fishery area south of 46° N latitude. This study is a response to that mandate, and addresses itself specifically to the origins of chinook salmon in the area south of 46° N, but also in the mothership area of the North Pacific Ocean and Bering Sea, using methodologies of scale pattern analyses previously agreed upon by the Sub-Committee on

Salmon. The objectives of this study were (1) to briefly review information on stock origins of chinook salmon on the high seas from other studies including tagging, parasite studies, and previous scale pattern analyses; (2) to develop reliable statistical models from which to calculate stock mixing proportion estimates; and (3) to estimate the recent interceptions of North American chinook salmon in the landbased fishery area.

Information From Tagging

Although salmon tagging operations have been performed on the high seas for 37 years, there have been only 16 recoveries of chinook salmon tagged west of 155° W (Myers et al. 1990). One of these recoveries was released near the Japanese coast and recovered in Japan. Eleven of the remaining 15 recoveries were released in the central and western Bering Sea and recovered in western Alaska (Yukon River, Kuskokwim River, and Bristol Bay). Four other recoveries were from fish released just south of the central Aleutian Islands (48°-52°N latitude, 180°-170°W longitude) and recovered in eastern Kamchatka, western Alaska, the Yakutat area of southeast Alaska, and the upper Columbia River. The recovery from the Yakutat area was caught in a troll fishery and the recovered fish may not have originated in that area. In spite of monitoring of salmon research vessel, mothership fishery, and landbased driftnet fishery catches for fish missing adipose fins, no chinook has yet been found to have a coded-wire tag (Dahlberg et al. 1989; Fisheries Agency of Japan 1988, 1989). There is no tag recovery information on stock origins of chinook in the landbased area. In summary, the meager information available from tagging experiments suggests that chinook in the Bering Sea may be predominantly of western Alaska origin and that chinook in the North Pacific Ocean may be a mixture of North American and Asian stocks.

Information From Parasites

Geographical distribution of infection rates by myxosporean brain parasites of chinook salmon is being investigated to determine if these parasites may be used as biological tags (Nagasawa and Urawa 1987; Urawa and Nagasawa 1988, 1989; Urawa et al. 1990). Urawa and Nagasawa (1989) suggested that *Myxobolus arcticus* is an indicator of chinook originating in Asia and *M. neurobius* is an indicator of chinook originating in the Columbia River. Rates of infection of *M. arcticus* in chinook caught on the high seas indicate that more than 50% of the catches southwest of 50° N, 170°W originate in Asia (Urawa and Nagasawa 1989; Urawa et al. 1990). The absence of chinook carrying this parasite in the Bering Sea indicates that in this area fish may be primarily of North American origin (Urawa and Nagasawa 1989). Examination of infection rates in major Asian and North American stocks of chinook continues in an effort to test the suitability of this parasite as a biological tag (Urawa et al. 1990).

Information From Scale Pattern Studies

In the last 15 years there have been several scale pattern studies to determine the origins of chinook in offshore waters. The first studies were those of Major et al. (1975, 1977a, b). These studies used two standard groups, a western Alaska standard (including Yukon, Kuskokwim, Kanektok, and Bristol Bay stocks) and an Asian standard (composed of maturing fish collected by Japanese research vessels and motherships west of 170° E in June and July). Their results showed that western Alaskan fish predominated in the Bering Sea and that the proportion of western Alaskan fish increased to the east. Results for the central North Pacific Ocean (northeast of 46°N, 175°E) indicated that western Alaskan fish predominated and that west of 175°E Asian fish predominated.

Myers et al. (1984) analyzed stock origins of immature age 1.2 and 1.3 chinook caught in the mothership and landbased fishery area in 1975-1981 by classifying fish to four regional standards (Asia, western Alaska, central Alaska, and southeast Alaska-British Columbia). The brood-year standards were constructed by weighting the component stocks by the relative sizes of their runs. The Asian standard was composed of scales from two major Soviet stocks, the Bolshaya and Kamchatka. Western Alaska was determined to be the predominant stock in the Bering Sea, and an important secondary stock in both the North Pacific mothership fishery area and the area of the landbased driftnet fishery south of 46°N. Estimates for Asia indicated that it was a significant secondary stock in all three areas. It had previously been assumed that the catch in the landbased area was of predominantly Asian fish, but this study gave the rather unexpected result that central Alaskan fish predominated, not only in the North Pacific mothership fishery area, but also in the landbased fishery area in most years. This provided impetus for studies addressing the methodology of construction of standards and the representativeness of standards.

Ito et al. (1985) questioned whether the Asian standard used by Myers et al. (1984) adequately represented Asian stocks, and created an Asian standard by combining the scales from Bolshaya and Kamchatka fish with scales from maturing fish caught by Japanese research vessels west of 165°E (May through July). These scales were added to the Asian standard in order to make the standard more representative of the fish from all Asian stocks. The North American standards included stocks from western Alaska, central Alaska, and southeast Alaska-British Columbia. No weighting by coastal catches, CPUEs or age composition was employed. Their results for 1974 high seas samples were similar to those of Myers et al. (1984) for 1975-1981 high seas samples in that western Alaskan fish predominated in the Bering Sea in June and July. Both studies also showed small estimates for southeast Alaska-British Columbia stocks in all areas. However, results of the two studies differed in estimates for central Alaska. In the North Pacific mothership and landbased driftnet areas, Myers et al. (1984) found that central Alaskan fish predominated in most years, but Ito et al. (1985) found that Asian fish predominated in 1974.

Ito et al. (1986) tested the effect on Asian mixing proportion estimates of apportioning high seas unknowns using Asian standards constructed by three different methods. In case 1, they combined Kamchatka and Bolshaya River scales in numbers weighted by the relative sizes of their inshore runs. In case 2, samples of maturing fish collected by Japanese research vessels west of 170°E in the North Pacific Ocean and Okhotsk Sea were combined with no internal weightings. In case 3, the Okhotsk Sea scales were removed and only scales collected from the Pacific side were used. Resulting mixing proportion estimates in all three cases indicated that western Alaskan fish predominated in the Bering Sea and that southeast Alaskan and British Columbian fish were in low proportion in all areas. However, in case 1, western Alaskan and central Alaskan fish predominated in the North Pacific mothership and the landbased driftnet areas, but in cases 2 and 3 Asian fish predominated in these areas. Test classification of scales from the Okhotsk Sea using the Asian standard in case 1 resulted in a higher proportion of western Alaskan fish than Asian fish. Ito et al. (1986) concluded that the mixing proportion estimates resulted more from the manner in which the Asian standard was constructed than from the true nature of the mixed stock samples.

Myers (1985) and Ishida et al. (1987) both investigated similarities of scale characters among the component stocks composing the standards that had been used in the study of Myers et al. (1984) . Myers's (1985) results indicated that statistically significant differences between the means of scale characters were most frequent between the Bolshaya and Kamchatka Rivers. Ishida et al. (1987) obtained similar results with clustering and concluded that although the freshwater scale characters of Bolshaya and Kamchatka fish were similar to one another, the ocean scale characters were very dissimilar and for this reason these two stocks should be treated as different regional standards in future analyses.

METHODS

The standardized methodology agreed to by the Sub-Committee on Salmon included the estimation of stock compositions using either maximum likelihood or classification (with matrix correction), continued efforts to procure scale samples from the U.S.S.R., construction of regional standards on the basis of similarity in scale patterns, and estimation of stock composition based on unknown-origin sample sizes of 100 or more scales. This study has employed most of these recommendations. Standards were grouped on the basis of the similarity in their scale patterns rather that solely on their geographical proximity. As a result the Bolshaya and Kamchatka Rivers were separated into two regional standards. To test the representativeness of the resultant standards, they were tested against scales of known origin. These standards were then used to calculate mixing proportion estimates of immature age 1.2 chinook salmon caught on the high seas in 1985 and 1986. The mixing proportion estimates for 1985 were applied to the landbased fishery catches to give provisional interception estimates of North American and Asian chinook salmon.

DATA COLLECTION AND SCREENING FOR OUTLIERS

Scale pattern data were collected using the Optical Pattern Recognition System (OPRS; BioSonics, Seattle, USA) equipped with a CCD video camera (Walker 1987). To establish a consistent measurement axis, circuli in the first ocean annulus along the boundary between the sculptured and unsculptured fields were placed on a baseline. The measurement axis was located perpendicular to the baseline, from the center of the focus to the last circulus in the first ocean annulus. The OPRS automatically measured the incremental distances between circuli along the axis, and the accuracy for each scale was checked by hand to insure that the correct number of circuli was measured. Raw data were reformatted into ten scale characters that have been found to be useful in stock separation of high seas chinook in previous analyses (Myers et al. 1984, Davis 1987; Table 1).

Data were measured from many stocks in regions of North America and Asia (Fig.1). For each stock descriptive statistics of the ten scale variables were calculated. If a particular scale had a value for a variable that was equal to or greater than 4.0 standard deviations from the mean then that scale was deleted. This was a rare occurrence and resulted in deletion of only six scales from the standards. Data from the high seas unknowns were grouped by month and 5°-longitude subarea (Fig. 2).

The numbers of scales measured from the high seas unknowns are listed by subarea and month in Table 2. Immature age 1.2 chinook were selected for this investigation because this age-maturity group is the largest group found in research vessel catches (70% in 1985 and 61% in 1986). Most scale samples were from subareas 8 and 10 in the Bering Sea and subareas 3 and 5 in the former mothership fishery area of the North Pacific Ocean. Only 5% of the scales measured in the 1985 samples and 7% of the scales in the 1986 samples were collected in the landbased fishery area (subareas 11 through 15). Descriptive statistics were calculated for each month-subarea strata, and scales with a variable having a value greater than or equal to 4.0 standard deviations from the mean were inspected to insure that the value was not a measurement error. If required, scales were remeasured, but, unlike the standards, scales with variables more than 4.0 standard deviations away from the mean that were not measurement errors were retained in the analyses.

CONSTRUCTION OF BROOD-YEAR STANDARDS

In order to characterize a stock (generally defined as fish returning to one river), scales from the terminal (river of origin) commercial fishery samples were used if these were available. The commercial samples used often contained a mixture of sub-stocks from within a river (e.g., Emmonak commercial samples include scales from upper, middle and lower Yukon River fish) or from major rivers in the vicinity of the fishery (e.g., samples from the north district of Cook Inlet, which include primarily Susitna River fish). Escapement samples were measured, especially from returns in 1986, but were generally not used in the brood-year standards because they might be heavily weighted toward one sub-stock. In addition, scales from the terminal fishery samples are generally much higher in quality (non-resorbed) and sample sizes are usually larger than in escapement samples. Often samples from several sources were measured for each stock (i.e., commercial samples, test fisheries, or escapement samples) so that later the similarity of their scale patterns could be examined or the accuracy of the standards could be tested.

In deciding if a particular sample could be used in a standard, one criterion was a minimum sample size of 30 scales. Two exceptions to this rule, however, were samples from the Vorovskaya and Kikhchik Rivers of the U.S.S.R., which each had only 20 scales that could be measured.

The standards developed to classify immature age 1.2 chinook caught on the high seas in 1985 (brood-year 1981) consisted of scales from age 1.3 fish that returned in 1986 and from age 1.4 fish that returned in 1987. The standards used to classify immature age 1.2 chinook caught on the high seas in 1986 (brood-year 1982) consisted of scales from age 1.3 fish that returned in 1987 and from 1.4 fish that returned in 1988. Stocks were combined on the basis of similarity in their scale patterns, and the standards were not constructed with any internal weighting of relative run size or age composition.

To examine the similarities of scale patterns among the stocks, a linear discriminant program (BMDP7M; Dixon 1988) that attempted to separate each of the individual stocks was used. This program plots the mean of each stock on axes of the first and second canonical variables; the plot gives an indication of the distances between groups. The linear discriminant function analysis (LDA) was employed rather than a clustering routine because it was thought that the LDA algorithm was closer than clustering algorithms to the actual method used to allocate the unknown samples. Walker (1990) developed a computer program that calculated the euclidean distance between each pair of stocks based on the canonical variables evaluated at each stock's centroid. This number is a measure of the similarity between each pair of stocks, a small distance indicating more similarity between a pair of stocks and a larger value indicating greater dissimilarity. Similarity between each pair of stocks was evaluated using both the plots and Walker's (1990) euclidean distance (as an example see Appendix Fig. 1 and Appendix Table 1).

Plots of the canonical variables and the euclidean distances indicated that stocks in relative geographic proximity were generally similar in their scale patterns. Scales collected from ages 1.3 and 1.4 fish from the Bolshaya River in the same brood year were very similar to one another, as were the scales collected from Kamchatka River fish in the same brood year. But the scale patterns of fish from the two rivers were very dissimilar from one another. Therefore, for brood-year 1981 I formed a western Kamchatka standard, which contained scales from the two age classes of Bolshaya River fish, and an eastern Kamchatka standard, which contained scales from the two age classes of Kamchatka River fish (Table 3).

For brood-year 1982, the two samples from western Kamchatka (i.e., the Vorovskaya and Kikhchik Rivers) clustered closely to the Bolshaya stocks and were combined into one standard. Similarity measures indicated that the Yukon scales, specifically the Emmonak samples, were more similar to the Kamchatka River scales than in the earlier brood year. Because the scale patterns of these two stocks were very similar, they were combined into one standard (Table 4). Combining stocks from different continents into one standard was unavoidable because in preliminary test classifications of the standards where the two stocks had been separated, misclassifications were so great that the results were meaningless.

Plots and the euclidean distances indicated a fairly distinct grouping among the brood-year 1981 western Alaskan stocks. Kuskokwim Bay, Unalakleet R., and Bristol Bay stocks grouped closely together. The Naknek R. sample measured closest to the Nelson Lagoon sample and the Yukon R. sample. All these stocks were combined to form a western Alaska standard. The results were slightly different for brood-year 1982. The Bristol Bay stocks plotted close to one another and formed a group. The Nelson Lagoon sample fell midway between the Yukon stocks (now grouped with Kamchatka River) and the central Alaskan stocks, so the Nelson Lagoon sample was not included in the standard, but used instead to test the accuracy of the model. The Nelson Lagoon stock is not a major stock, and preliminary classifications of the standards indicated that it misclassified heavily to western and central Alaska.

Plots and distance measures indicated that Cook Inlet stocks were similar to one another and formed a group. Copper River samples were more similar to the southeast Alaska-northern British Columbia stocks than to those in Cook Inlet. In preliminary analyses of the unknowns these southeast Alaska and British Columbia stocks contributed zero or negligible proportions to the high seas samples, so the southeast stocks and Copper River were not included in the standards, but were later tested by the model.

The stocks that were grouped together are listed in Tables 3 and 4 along with the number of scales used from each stock and the sample size of the standards. Descriptive statistics for the standards and unknown samples for the brood-year 1981 and brood-year 1982 are summarized in Appendix Tables 2 and 3.

Accuracy and Diagnostic Tests of the Standards

Jackknifed classification matrices calculated from an LDA describe the trends in misclassifications among the standards for brood-year 1981 and 1982 (Tables 5 and 6). The overall unweighted average percent correct was similar for both brood years (68.6 % and 67.1%).

Scales not used in the models were available for diagnostic tests. The purpose of these tests was to determine if scales of known origin were allocated to the correct standard or continent and to provide some insight into which may heavily misclassify. Many more samples were measured to test the brood-year 1981 standards than the following brood year; there were no extra scales from Asia to test the Asian standards because all acceptable Soviet scale samples were needed in the standards. The maximum likelihood estimator

(MLE) calculated by the FORTRAN program of Millar (1988) was used to allocate the stocks. The analysis option of Millar's program calculated the point estimate from the standard and unknown sample data. The bootstrap option recalculated the point estimate for 100 iterations. During each iteration, the standards are resampled to create a new standard sample, the unknown sample is resampled creating a different unknown mixture, and a new MLE is calculated. The standard deviation of the 100 MLE estimates contains an estimate of the variance in both the standard and unknown sample. The 90% confidence interval is calculated by multiplying the standard deviation by a z-value of 1.6449. A point estimate of zero indicates that the standard does not contribute anything to the mixture. A 90% confidence interval that includes zero is a non-significant estimate, and a confidence interval that ranges from zero to zero means that over the 100 bootstraps there was no variance in the point estimate; the MLE was the same value each time it was recalculated.

For brood-year 1981, age at return (age 1.3 or 1.4) did not affect the accuracy of the allocated stock (Table 7). Generally there was accurate allocation of the western Alaska stocks. The Yukon River samples from fish caught with 8.5 inch mesh gillnets (Yukon 8.5s) were more accurately allocated than the samples from fish caught with 5.5 inch mesh gillnets (Yukon 5.5s). The Yukon 5.5s were more often misallocated to eastern Kamchatka than to central Alaska and so the accuracy did not improve by allocating to continent. Most Kuskokwim Bay and Bristol Bay stocks were accurately allocated to the western Alaska standard, and all were correctly allocated to North America. Nelson Lagoon misallocated to all standards, but because it had some misallocation to central Alaska, the accuracy of allocation to continent was slightly higher. The Red River stock was the most inaccurately allocated stock tested against these standards. Ninety-three percent were incorrectly allocated to western Kamchatka (Table 7). The North District stocks of Cook Inlet misallocated to western Kamchatka by 19.5% to 26.7%, but only 5.7% of the Central District stock misallocated to western Kamchatka. The Copper River stocks and the stocks to the southeast of Copper River allocated to the correct continent, except for the Snettisham Hatchery (65.4%) and the Taku River (94.9%, Table 7).

For brood-year 1982, the Yukon River 5.5s had a low accuracy (49.3%) and misallocated heavily to central Alaska (Table 8). The Yukon River 8.5s classified more accurately (91.7%). Nelson Lagoon stock misallocated evenly between the Kamchatka R.-Yukon R. standard and the central Alaska standard. Chignik River allocated to three standards, but mostly heavily to Kamchatka R.-Yukon R. (61.1%). Similar to the previous brood year, Copper River stocks and most stocks to the southeast allocated to central Alaska with a few exceptions that allocated to western Kamchatka (Snettisham Hatchery, Taku River, and Stikine River, Table 8).

Calculation of Mixing Proportions of Unknowns

If the sample size of the unknown strata (subarea and month) was less than the recommended 100 scales, subareas and months were combined until the sample size reached a minimum of 70 scales. The MLE was used to allocate the unknowns. Bootstraps of 500 iterations were used to get accurate estimates of the variability of the point estimates of the unknown samples. A 90% confidence interval was calculated by multiplying the standard deviation by a z-value of 1.6449.

Interceptions of Regional Stocks in the Landbased Driftnet Area

Mixing proportions obtained from one stratum (June and July, subareas 11 through 15 in 1985; n=72) from the brood-year 1981 analyses were applied to reported catches in the landbased fishery to estimate interceptions of North American and Asian chinook salmon in recent years. Extrapolation of mixing proportion estimates to the commercial catch required that I make several assumptions. As samples were pooled over 5 subareas and two months to create the stratum, stratification of the interception estimates by individual subarea or month was not appropriate. Estimates calculated for one age-maturity group were applied to the whole catch with the assumption that mixing proportion estimates of immature age 1.2s, the largest age-maturity component, were the same as the proportions in all age-maturity groups. It was also assumed that the estimates applied to catches west of 160°E.

Multiplying the reported landbased catches for 1986 through 1989 by the mixing proportion estimates from the 1985 stratum also required making the assumption that stock proportion estimates were stable between years, and that estimates from this stratum were representative of catches in May. From 1985 through 1988 little or no catch was reported from May, but in 1989 over 16% of the catch was made in May. Assuming stability of these estimates between years, I applied the same mixing proportion estimates to the annual reported landbased catches from 1985 through 1989. Confidence limits were not calculated for the interception estimates because variance estimates for the 1985 immature age 1.2 stratum did not apply under the additional assumptions extending the mixing proportions estimates. Total annual interceptions of North American chinook were calculated by summing the estimated interception of western and central Alaskan stocks.

RESULTS

MAXIMUM LIKELIHOOD ESTIMATES OF MIXING PROPORTIONS

In 1985 in subareas 8 and 10 in July, western Alaskan fish predominated with estimates of 51.2% and 62.0% (Table 9). Eastern Kamchatka was an important secondary stock (21.3% and 37.4%). There were small but significant estimates for the western Kamchatka regional stock (10.3% and 10.8%), and the central Alaskan regional stock had small positive, but non-significant estimates. Results in subareas 3 and 5 in the mothership area of the North Pacific indicated a mixture of regional stocks, with large proportions of central Alaskan and western Kamchatkan stocks. In subarea 3 in June, western Alaska was the predominant stock (46.1%) and central Alaska was an important secondary stock (36.3%). Further to the east in subarea 5, central Alaska (35.6%) and western Kamchatka (31.6%) predominated. In July, central Alaska predominated in subareas 3 (64.3%) and 7+9 (43.6%) and western Kamchatkan fish predominated in subarea 5 (52.1%). In the North Pacific, significant estimates for eastern Kamchatka ranged from 4.2% to 16.9% . In this area in July, significant estimates for western Alaska ranged from 8.5% to 13.0%. In the landbased area, western Kamchatka was the predominant stock (43.1%) and eastern Kamchatka and western Alaska stocks were both important secondary stocks (both 23.3%).

In 1986, the Kamchatka R.-Yukon R. regional standard was the predominant stock in Bering Sea subareas 8 and 10 in June and July (66.1% to 72.2%; Table 10). Central Alaska was an important secondary stock (14.8% to 19.8%). The western Alaskan regional stock (Kuskokwim and Bristol Bay) was present in a slightly smaller proportion (10.1% to 12.5%). Western Kamchatka had small nonsignificant estimates. In the mothership area of the North Pacific in subarea 5 in June Kamchatka R.-Yukon R. was dominant (48.6%) but this standard was a secondary stock in this area in July (18.0%). Western Kamchatka was a secondary stock in June (36.0%) and predominant in July (69.4%). Central Alaska made a small contribution to the stocks in this area, and in July the estimate was not significant (12.6%-13.4%; Table 10). The western Alaska regional standard does not have significant estimates for either month in subarea 5. The results of the allocations of the unknowns sample in the landbased areas indicate the presence of only two regions. Western Kamchatkan fish were predominant (81.4%) and the Kamchatka R.-Yukon R. standard was a secondary stock (18.6%; Table 10).

INTERCEPTIONS OF REGIONAL STOCKS IN THE LANDBASED DRIFTNET AREA

The total reported chinook catch of the landbased driftnet fishery decreased by 50% between 1985 and 1989 (Table 11), and catches of North American fish are assumed to have declined by the same proportion (mixing proportion estimates were not stratified, so any shifts in fishing to areas of higher or lower North American abundance would not be detected). Provisional mixing proportion estimates for 1985 indicate western and central Alaskan chinook contribute an estimated 33.7% to the total landbased catch of chinook salmon (23.2% western and 10.5% central Alaskan; Table 9). Provisional estimates of the interceptions of western Alaskan chinook salmon have decreased from 23,000 fish in 1985 to 12,000 fish in 1989 and those of central Alaskan fish decreased from 11,000 to 5,000 fish during the same period (Table 12). The regional stock contributing the largest numbers to this fishery was western Kamchatka. The number of fish likely to have been intercepted decreased from 44,000 in 1985 to 22,000 in 1989, while eastern Kamchatkan fish decreased from 23,000 to 12,000 (Table 12). Interception estimates for 1985 are likely to be more accurate because all estimates are based on mixing proportions calculated from fish caught in 1985, which were also applied to subsequent years. These estimates are provisional; new knowledge of the high seas distributions of chinook and verification of the accuracy of catch statistics may require that these interception estimates be revised.

DISCUSSION

DIFFERENCES IN SCALE PATTERNS BETWEEN REGIONS

There are trends in the differences in scale pattern data between regions that extend from one brood-year to the next (Appendix Table 2 and 3). Western Kamchatkan fish have small ocean zones and a small number of circuli. Triplets 1 through 4 are widely spaced and there is no freshwater plus growth (growth in freshwater after the freshwater annulus). This pattern is characteristic of fish that move out of freshwater and estuaries into the ocean early in the spring.

Eastern Kamchatkan fish scales are quite unlike the western Kamchatkan scales (Appendix Tables 2 and 3). Triplets 1 through 4 are narrowly spaced, indicating that fish remain in freshwater or in an estuary and delay their migration to the ocean. However, triplets 5 and 6 have the widest spacing of all the groups.

Western Alaskan scales have a large ocean zone, a large number of ocean circuli, and widely spaced triplets 5 through 7 (Appendix Tables 2 and 3). Central Alaskan scales have the largest size for the first year spent in freshwater (FWSZ; Appendix Tables 2 and 3). The values for the remaining scale variables are intermediate to the other regions and this contributes to the frequent misclassification of central Alaskan scales.

Trends in the regional differences in scale patterns are similar to those described by Myers et al. (1984). If these regional scale characteristics have persisted since their study, which included brood-years 1970 to 1977, then perhaps the persistence of regional characteristics may allow the use of pooled-year standards.

General differences in regional scale patterns may persist through time, but the differences between some stocks may change from year to year. The Kamchatka River and Yukon River samples were combined to form one standard for brood-year 1982. The similarity between these two stocks was due to the relationship between the Kamchatka River age 1.4s and the two Emmonak samples. Euclidean distances between canonical variables of the Kamchatka River age 1.4 sample and the Emmonak samples were small. Ocean zone size and the number of circuli are important characters in discriminating between groups (OCSZ, Table 6), and the means for these variables shifted closer together in brood-year 1982 than they were in the previous year (Appendix Table 4). This slight change in these variables may have caused the increase in similarity between these two stocks. The change in the ocean zone size may have been due to changes in the proportions of upper, middle, or lower Yukon runs mixed in the Emmonak samples, or may be have been a result of changes in ocean conditions between years.

ADEQUACY OF THE STANDARDS

Major chinook production areas in North America and Asia were well represented among the stocks measured for this study. Because a large number of scales from North American stocks were available, tests of the accuracy of North American standards could be conducted. Asian samples were collected from the two major chinook-producing river systems (Bolshaya and Kamchatka Rivers) and available in the quality and quantity necessary to create standards of adequate size. Separation of the eastern and western Kamchatkan samples into two standards improved the model by not combining stocks with different scale patterns. Asian standards in this study benefited from the inclusion of new Asian stocks (Vorovskaya and Kikhchik Rivers) although the number of scales from these stocks was small. Many more scales will be required to assess the accuracy of Asian standards in the future.

ADEQUACY OF THE FISHERY SAMPLES

The distribution of unknown samples southwest of 46°N, 175°W in 1985 indicates that only 38% of the chinook scales were collected from the current fishery area (subareas 11 through 13; Table 2). If the assumption is made that between 175°W and 160°E the proportion of Asian fish increases further to the west, then application of the 1985 landbased area stratum, where more than half of the samples were caught east of the fishery, to the total fishery catch might underestimate the proportion of Asian fish. However, the small numbers of scales collected in the vicinity of the landbased fishery required that samples from the entire area (subareas 11 through 15) be combined.

Only three month-subarea strata in 1985 and two strata in 1986 in the North Pacific provided the 100 or more scales recommended by the Sub-Committee on Salmon (Table 2). Large numbers of samples were acquired from subareas 3 and 5 because they were sampled from the commercial fishery by Japanese and U. S. observers aboard salmon motherships. The landbased fishery area, which has been the area of greatest concern in recent years, did not have one subarea sample that satisfied the minimum size requirement. By combining subareas 11 through 15 in June and July, the sample size was increased enough to reach the recommended minimum in 1986 (n=108) but was slightly smaller in 1985 (n=72; Table 2). Calculation of mixing proportion estimates from small sample sizes and expansion of these estimates to interceptions in commercial fishery catches can be misleading if the sample does not adequately represent the fish caught in the fishery.

There are not enough chinook salmon in research vessel catches to meet the minimum sample size criterion for strata by subarea and month. Since 1978 total research vessel catches of chinook have been below 400 fish (Table 11), and because of regeneration and presence of several age-maturity groups, not all scales can be used in an analysis. Abundance of chinook salmon in the landbased area is too low to enable the research vessels to collect the required number of scales by longlining, but scale collection from the commercial landbased fishery could provide scales in the quantity required. If interception estimates are to improve, then obtaining larger samples directly from the landbased fishery is necessary.

MIXING PROPORTION ESTIMATES

Mixing proportion estimates from scale pattern analyses have consistently indicated that western Alaska is the predominant regional stock grouping and Asian stocks are an important secondary component in the Bering Sea (Major et al. 1975, 1977a,b; Myers et al. 1984; Ito et al. 1985; this study). Results from analyses of scale samples from the North Pacific Ocean have shown less agreement among the four studies. Major et al. (1975, 1977a, b) found that Asian fish predominated west of 175°E, and Ito et al. (1985) found that Asian fish predominated west of 175°W except in subarea 5 where western Alaska was predominant. Myers et al. (1984) and the present study found that central Alaskan fish predominated. All studies agreed that western Alaska is an important secondary stock in the mothership area. In the landbased fishery area, results of Myers et al. (1984) indicated central Alaskan fish predominated in most years, but their estimates indicated Asian fish predominated in 1981 (May and June). The results of Ito et al. (1985) for 1974 and the present study both indicated that Asian fish, specifically western Kamchatka fish, predominated in the landbased fishery area and that western Alaska was an important secondary stock. Differences in estimates for the landbased fishery area may be attributable to several sources: changes in abundance or patterns of migrations of these regional stocks over time may cause shifts in which stocks predominate in the area; the small number of unknown scales on which these estimates are based may produce variable estimates; and western Kamchatkan stocks may be dominant in the landbased area, but Myers et al.'s (1984) study underweighted these scales by combining small numbers with eastern Kamchatkan scales in their analyses and thereby underestimated their proportion in the fishery area.

Results of scale pattern analyses are difficult to compare with tag return data because there is so little information available from tag returns. The best information from tag returns in all high seas areas is the preponderance of tags recovered in western Alaska from tagging experiments in the Bering Sea (Myers et al. 1990), which supports the conclusion of this study that western Alaskan stocks predominate in the Bering Sea. Results of the present study also indicate a mixture of stocks in the North Pacific Ocean, with predominantly North American fish in the mothership area (central and western Alaska) and predominantly Asian fish in the the landbased fishery area (western and eastern Kamchatka). Four tags recovered from just south of the central Aleutian Islands indicate a mixture of North American and Asian stocks (Myers et al. 1990), but the number of high seas recoveries from the North Pacific Ocean west of 155°W is too scanty to confirm or contradict the scale pattern estimates.

Urawa et al. (1990) have concluded that most chinook caught southwest of 50°N, 170°W were Asian fish and that fish caught southwest of 50° N, 165°E were western

Kamchatkan fish based on the distribution of two chinook brain parasites, *M. arcticus* (a parasite indicating Asian origin) and *M. neurobius* (a parasite indicating Columbia River origin). In two subareas in July the combined estimates from scale pattern analysis for western and eastern Kamchatkan fish approximated the value Urawa et al. (1990) obtained for infection rates of *M. arcticus* (subarea 3 Asian scale pattern estimates=23%, infection rate=29%; subarea 5 Asian scale pattern estimates =56%, infection rate=52%; Table 9). Estimates from scale pattern analysis do not support their general conclusion that Asian fish predominate in the entire area southwest of 50°N, 170° W. Scale pattern estimates for Asian fish indicate they predominate in the mothership area of the North Pacific only in July in area 5 (56%, Table 9). However, in subareas 11-15, the rate of infection Urawa et al. (1990) found was 48% and the combined Asian scale pattern estimate in this study was 66%, which agrees with their conclusion that Asian chinook stocks predominate in the landbased fishery area.

Interceptions of Regional Stocks in the Landbased Driftnet Area

This study was the first to calculate provisional estimates of interceptions based on analysis of scales collected from the landbased fishery area. Myers et al. (1984) applied average stock compositions from the mothership areas of the North Pacific Ocean to catches in the landbased fishery to estimate interceptions. Because their estimates are based on samples from outside the fishery area they are not comparable to the results of this study.

Provisional estimates of interceptions by the landbased fleet relative to inshore commercial catches indicate that the Asian stocks, primarily those of western Kamchatka, are being intercepted at significant levels (Tables 12 and 13). Estimated interceptions of western Kamchatkan fish by the landbased fishery may be as large as 1.5 to 3.2 times the reported inshore catch; interceptions of eastern Kamchatkan fish may be 9% to 14% of the inshore commercial catch. The estimated interceptions of North American stocks are generally smaller: central Alaskan fish may be intercepted in the landbased fishery at levels from 5% to 13% of the reported inshore commercial catch, and western Alaskan fish may be intercepted at levels from 5% to 7% of the inshore catch.

RECOMMENDATIONS

The feasibility of conducting scale pattern analyses without creating brood-year standards should be investigated. If regional differences in scale patterns reliably persist between brood-years, then it may be possible to construct a stable standard model (perhaps of pooled brood-years) to estimate the stock origins of unknown samples from any year. This would eliminate the need to measure a new set of standards for each year of high seas unknown samples analyzed, and avoid the lag time between capture of immature fish at sea and return of adults to natal streams.

The validity of applying the allocate-sum procedure (Wood et al. 1987) to problems of high seas stock separation should be explored. If separate allocations were calculated for each individual stock and then summed by geographical area, that would eliminate the need to combine stocks into composite standards before calculating the mixing proportion estimates. The allocate-sum procedure might have been particularly helpful in these analyses where the similarity in scale patterns of two stocks (Kamchatka R. and Yukon R.) required that they be combined into one standard, making it impossible to estimate stock contributions by continent.

I recommend that efforts be continued to procure high quality scale samples from the U.S.S.R. These samples should include not only the Bolshaya and Kamchatka Rivers, but also other stocks not available before for scale pattern analyses. Increased numbers of stocks and sample sizes will improve the ability to statistically describe Asian chinook salmon scales and will provide additional data to test the accuracy of Asian standards.

I recommend that the number of chinook salmon scales collected from the landbased area be increased. Abundance of chinook salmon in this area is low; collection of scales in the numbers suggested for scale pattern analyses will require a program which samples scales from fish caught by the commercial landbased fishery.

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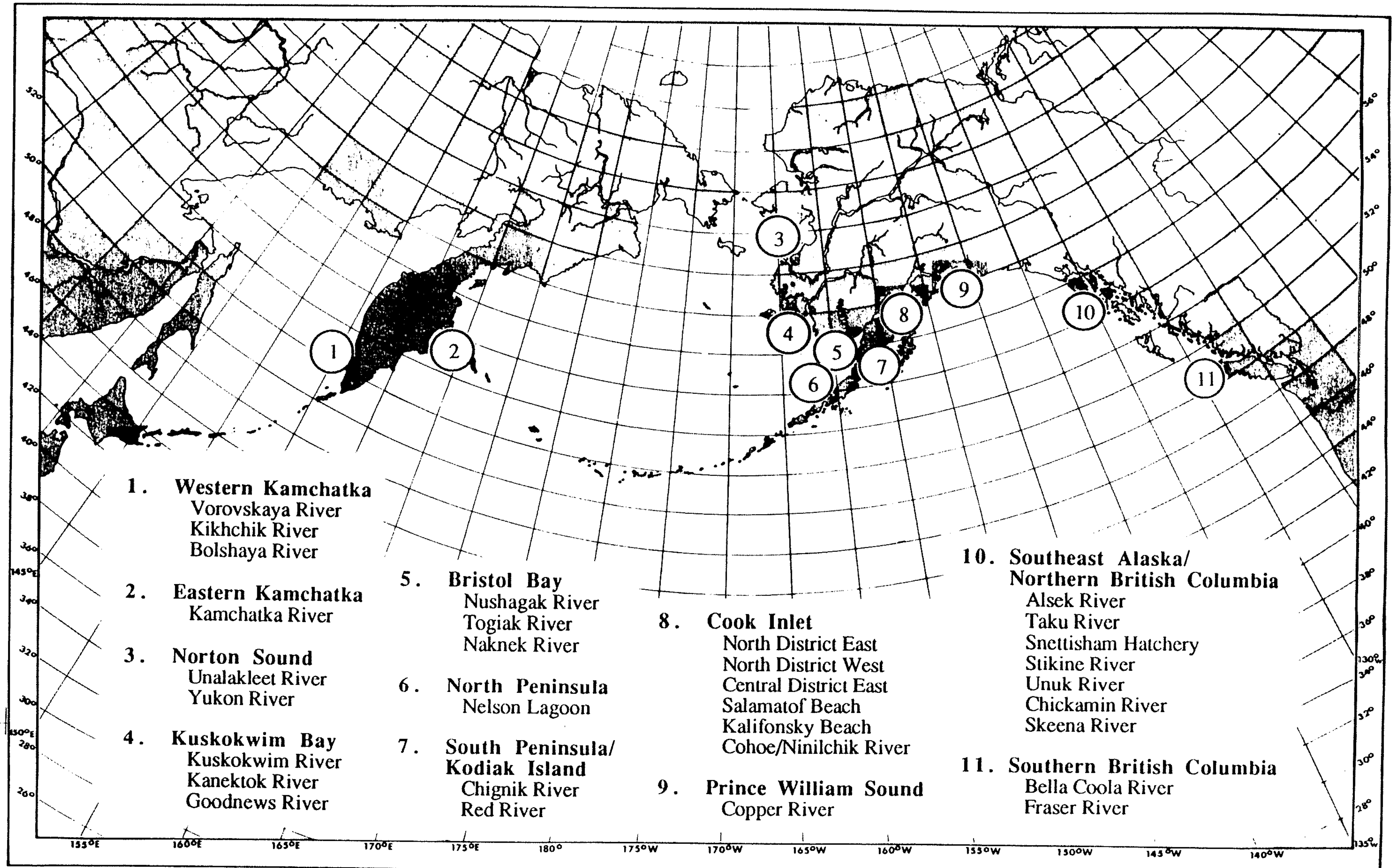


Figure 1. Geographical location of stocks used to construct regional standards or to test the accuracy of the regional standards.

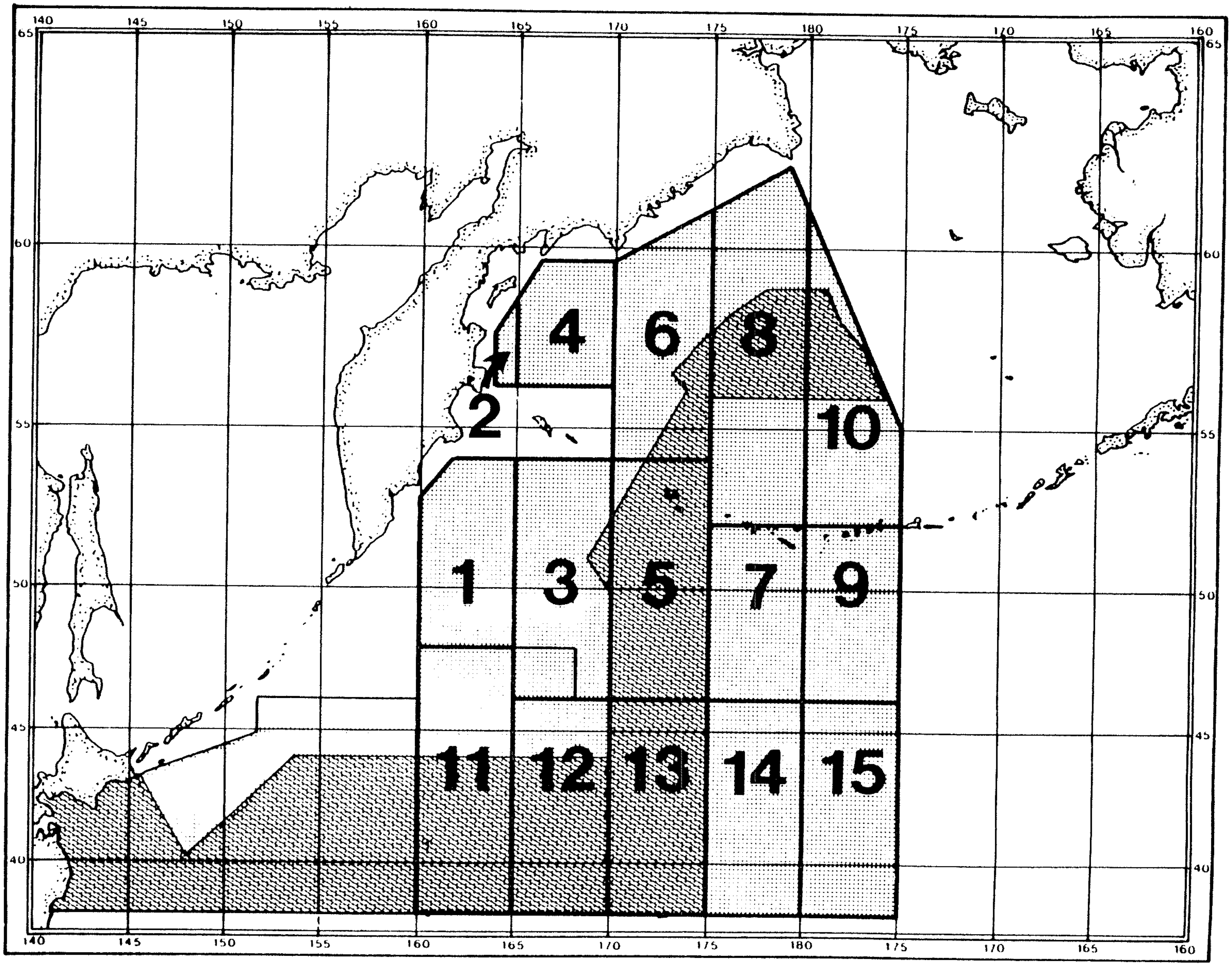


Figure 2. Statistical subareas used to stratify high seas fishery samples. Area of the Japanese high seas fishery 1977-1986 is crosshatched. Subareas 1 through 10 are the mothership fishery area and 11 through 15 are the landbased fishery area.

Table 1. Ten chinook scale characters used in the scale pattern analyses.

Scale Character Name	Description
FWSZ	Size of the freshwater zone measured from the center of the focus to the last circulus in the freshwater annulus.
OCSZ	Size of the ocean zone measured from the last circulus in the freshwater annulus to the last circulus in the first ocean annulus.
OCIRCC	Number of circuli in the first ocean zone.
TR1	Size of triplet 1 is the distance from the last circulus in the freshwater annulus to the third circulus in the first ocean zone.
TR2	Size of triplet 2 is the distance between the third and the sixth circulus in the first ocean zone.
TR3	Size of triplet 3 is the distance between the sixth and ninth circulus in the first ocean zone.
TR4	Size of triplet 4 is the distance between the ninth and twelfth circulus in the first ocean zone.
TR5	Size of triplet 5 is the distance between the twelfth and fifteenth circulus in the first ocean zone.
TR6	Size of triplet 6 is the distance between the fifteenth and eighteenth circulus in the first ocean zone.
TR7	Size of triplet 7 is the distance between the eighteenth and twenty-first circulus in the first ocean zone.

Table 2. Number of chinook salmon by subarea and month measured for this study. Scales were collected from aboard Japanese research vessels and salmon motherships.

A. Immature age 1.2 chinook caught in 1985 (brood year 1981).

	Subareas															
	Bering Sea					North Pacific					Landbased Driftnet Area					
Month	2	4	6	8	10	1	3	5	7	9	11	12	13	14	15	Total
June	0	0	2	4	0	0	92	428	0	24	4	7	4	4	24	593
July	0	0	19	79	81	22	156	510	48	33	5	0	7	5	12	977
															Total	1570

B. Immature age 1.2 chinook caught in 1986 (brood year 1982).

	Subareas															
	Bering Sea					North Pacific					Landbased Driftnet Area					
Month	2	4	6	8	10	1	3	5	7	9	11	12	13	14	15	Total
June	0	0	0	20	2	0	55	505	17	10	1	39	8	8	13	678
July	0	0	0	38	84	6	64	520	19	4	27	0	11	0	1	774
															Total	1452

Table 3. Regional standards and component stocks used to allocate immature age 1.2 chinook caught on the high seas in 1985 (brood-year 1981).

Regional Standard	Stock	Age	Year of Return	Number of scales
Western Kamchatka				
	Bolshaya R.	1.3	1986	94
	Bolshaya R.	1.4	1987	76
Total				170
Eastern Kamchatka				
	Kamchatka R.	1.3	1986	150
	Kamchatka R.	1.4	1987	81
Total				231
Western Alaska				
	Unalakleet R.[1]	1.3	1986	60
	Yukon R.			
	Emmonak 5.5[1]	1.3	1986	30
	Emmonak 8.5[1]	1.3	1986	30
	Kuskokwim R.			
	Bethel[1]	1.3	1986	54
	Kanektok			
	Quinhagak[1]	1.3	1986	60
	Goodnews R.[1]	1.3	1986	59
	Nushagak R.[2]	1.3	1986	60
	Togiak R.[1]	1.3	1986	60
	Naknek R.[3]	1.3	1986	60
	Nelson Lagoon[1]	1.3	1986	60
Total				533
Central Alaska				
	North District West[1]	1.3	1986	60
	Salamatof Beach Seine	1.3	1986	57
	Kalifonsky Beach Seine	1.3	1986	60
	Cohoe-Ninilchik	1.3	1986	60
Total				237
Grand Total				1171

[1] Commercial fishery sample
[2] Subsistence fishery sample
[3] Escapement sample

Table 4. Regional standards and component stocks used to allocate immature age 1.2 chinook caught on the high seas in 1986 (brood-year 1982).

Regional Standard	Stock	Age	Year of Return	Number of scales
Western Kamchatka				
	Bolshaya R.	1.3	1987	119
	Bolshaya R.	1.4	1988	146
	Vorovskaya R.	1.3	1987	20
	Kikhchik R.	1.3	1988	20
Total				305
Kamchatka R.-Yukon R.				
	Kamchatka R.	1.3	1987	140
	Kamchatka R.	1.4	1988	110
	Yukon R.			
	Emmonak 5.5[1]	1.3	1987	30
	Emmonak 8.5[1]	1.3	1987	30
Total				310
Western Alaska				
	Kuskokwim R.			
	Bethel[1]	1.3	1987	45
	Kanektok			
	Quinhagak[1]	1.3	1987	51
	Goodnews R.[1]	1.3	1987	41
	Nushagak R.[2]	1.3	1987	60
	Togiak R.[1]	1.3	1987	60
Total				257
Central Alaska				
	North District East[1]	1.3	1987	60
	North District West[1]	1.3	1987	60
	Central District East[1]	1.3	1987	119
Total				239
Grand Total				1111

[1] Commercial fishery sample
[2] Subsistence fishery sample

Table 5. Jackknifed classification matrix that describes the accuracy of the scale data in the brood year 1981 standards. Scale variables entered the LDF in the following order: OCSZ, TR3, OCIRCC, TR2, FWSZ, TR1, TR5, TR7, TR6, and TR4.

Regional Standard	N	Percent Correct	Western Kamchatka	Eastern Kamchatka	Western Alaska	Central Alaska
Western Kamchatka	170	77.1	131 (77.1)	9 (5.3)	4 (2.3)	26 (15.3)
Eastern Kamchatka	231	75.3	13 (5.6)	174 (75.3)	30 (13.0)	14 (6.1)
Western Alaska	533	62.7	23 (4.3)	84 (15.7)	334 (62.7)	92 (17.3)
Central Alaska	237	59.5	37 (15.6)	18 (7.6)	41 (17.3)	141 (59.5)
Unweighted overall average		68.6				

Table 6. Jackknifed classification matrix used to describe the accuracy of the scale data in the brood year 1982 standards. Scale variables entered the LDF in the following order: OCSZ, TR3, TR6, TR5, TR7, OCIRCC, TR1, TR4, TR2, FWSZ.

Regional Standard	N	Percent Correct	Western Kamchatka	Kamchatka R.-Yukon R.	Western Alaska	Central Alaska
Western Kamchatka	305	79.3	242 (79.3)	20 (6.6)	0 (0)	43 (14.1)
Kamchatka R.-Yukon R.	310	73.6	19 (6.1)	228 (73.6)	31 (10.0)	32 (10.3)
Western Alaska	257	61.9	9 (3.5)	41 (15.9)	159 (61.9)	48 (18.7)
Central Alaska	239	53.5	42 (17.6)	25 (10.5)	44 (18.4)	128 (53.5)
Unweighted overall average		67.1				

Table 7. Diagnostic test of regional standards used to allocate brood year 1981. Scales from known stocks were allocated as if the origin of these stocks was unknown. None of the scales tested were included in the standards used to allocate them. Maximum likelihood mixing proportion estimates (%) by sample and age of return. Confidence intervals (90%) are calculated by multiplying the standard deviation of 100 bootstraps by a z-value of 1.6449.

Stock	Age	Year of Return	N	Percent Correct to Standard	Percent Correct to Continent	Western Kamchatka		Eastern Kamchatka		Western Alaska		Central Alaska	
Unalakleet River	1.4	1987	59	96.7	100.0	0.0	(0-0)	0.0	(0-8.6)	96.7	(82.6-100)	3.3	(0-15.9)
Yukon 5.5[1]	1.3	1986	30	88.9	88.9	0.0	(0-0)	11.1	(0-28.0)	88.9	(72.0-100)	0.0	(0-0)
Yukon 5.5[1]	1.4	1987	61	94.0	94.0	0.0	(0-5.4)	6.0	(0-14.3)	94.0	(83.9-100)	0.0	(0-4.1)
Yukon 8.5[2]	1.3	1986	30	100.0	100.0	0.0	(0-0)	0.0	(0-12.3)	100.0	(87.7-100)	0.0	(0-0)
Yukon 8.5[2]	1.4	1987	60	100.0	100.0	0.0	(0-4.1)	0.0	(0-4.1)	100.0	(92.5-100)	0.0	(0-3.8)
Yukon TF 5.5[3]	1.3	1986	60	69.1	69.1	3.1	(0-10.3)	27.8	(13.8-41.8)	69.1	(53.3-84.9)	0.0	(0-0.4)
Yukon TF 8.5[4]	1.3	1986	20	96.5	96.5	0.0	(0-8.2)	3.5	(0-36.4)	96.5	(61.6-100)	0.0	(0-0)
Yukon TF 5.5[5]	1.3	1986	50	90.7	90.7	0.0	(0-0)	9.3	(0-23.6)	90.7	(75.4-100)	0.0	(0-7.3)
Yukon TF 8.5[6]	1.3	1986	61	100.0	100.0	0.0	(0-0)	0.0	(0-5.6)	100.0	(94.4-100)	0.0	(0-0)
Kuskokwim River[7]	1.4	1987	60	60.3	100.0	0.0	(0-0)	0.0	(0-0.4)	60.3	(41.4-79.3)	39.7	(20.8-58.6)
Kuskokwim Weir[8]	1.3	1987	60	69.1	100.0	0.0	(0-0)	0.0	(0-0)	69.1	(48.1-90.1)	30.9	(9.9-51.9)
Goodnews River[9]	1.4	1987	60	74.5	100.0	0.0	(0-0)	0.0	(0-1.5)	74.5	(54.7-94.3)	25.5	(5.7-45.3)
Kanektok River[10]	1.4	1987	60	75.0	100.0	0.0	(0-0)	0.0	(0-2.3)	75.0	(54.9-95.1)	25.0	(5.5-44.6)
Bristol Bay[11]	1.3	1986	25	100.0	100.0	0.0	(0-3.4)	0.0	(0-5.0)	100.0	(89.7-100)	0.0	(0-9.0)
Nushagak River[12]	1.4	1987	60	93.9	100.0	0.0	(0-0)	0.0	(0-0)	93.9	(77.8-100)	6.1	(0-22.2)
Togiak[9]	1.4	1987	59	67.2	100.0	0.0	(0-0)	0.0	(0-0.3)	67.2	(47.1-87.2)	32.8	(12.9-52.8)
Nelson Lagoon	1.3	1986	63	55.4	66.9	2.4	(0-8.8)	30.7	(5.9-55.5)	55.4	(25.6-85.2)	11.5	(0-28.1)
Nelson Lagoon	1.4	1987	60	87.1	92.6	7.4	(0-15.0)	0.0	(0-6.8)	87.1	(69.6-100)	5.5	(0-21.9)
Chignik River	1.4	1987	34	44.1	100.0	0.0	(0-0.3)	0.0	(0-8.3)	55.9	(23.5-88.2))	44.1	(12.4-75.9)
Red River	1.4	1987	53	4.7	7.0	93.0	(84.7-100)	0.0	(0-3.6)	2.3	(0-0.7)	4.7	(0-13.3)
North Dist. East[9]	1.4	1987	49	78.9	80.5	19.5	(1.9-37.1)	0.0	(0-2.4)	1.6	(0-6.6)	78.9	(60.4-97.4)
North Dist. West[9]	1.4	1987	60	71.7	71.7	26.7	(7.3-46.0)	1.6	(0-5.5)	0.0	(0-0.7)	71.7	(52.7-90.8)
Central Dist. East[9]	1.4	1987	120	94.3	94.3	5.7	(0-13.2)	0.0	(0-1.2)	0.0	(0-0.3)	94.3	(86.8-100)
Copper River	1.3	1986	198	100.0	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Copper River	1.4	1987	60	100.0	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)

Table 7. Continued.

Stock	Age	Year of Return	N	Percent Correct to Standard	Percent Correct to Continent	Western Kamchatka		Eastern Kamchatka		Western Alaska		Central Alaska	
Chickamin River	1.3	1986	43	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Chickamin River	1.4	1987	28	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Unuk River	1.3	1986	151	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Unuk River	1.4	1987	72	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Snettisham[14]	1.4	1987	60	N/A	65.4	34.6	(12.4-56.9)	0.0	(0-0)	0.0	(0-0)	65.4	(43.1-87.6)
Taku River	1.3	1986	43	N/A	100.0	0.0	(0-2.5)	0.0	(0-0)	0.0	(0-0)	100.0	(97.5-100)
Taku River	1.4	1987	20	N/A	94.9	5.1	(0-17.2)	0.0	(0-1.0)	0.0	(0-0)	94.9	(82.8-100)
Alsek River	1.3	1986	51	N/A	100.0	0.0	(0-3.9)	0.0	(0-0)	0.0	(0-0.1)	100.0	(95.0-100)
Alsek River	1.4	1987	60	N/A	100.0	0.0	(0-0)	0.0	(0-0.9)	0.0	(0-2.2)	100.0	(99.1-100)
Stikine River	1.4	1987	60	N/A	100.0	0.0	(0-2.7)	0.0	(0-3.1)	0.0	(0-0)	100.0	(96.0-100)
Skeena River	1.3	1986	60	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Skeena River	1.4	1987	60	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)
Bella Coola River	1.3	1986	60	N/A	100.0	0.0	(0-0)	0.0	(0-0.3)	0.0	(0-0)	100.0	(99.7-100)
Fraser River	1.3	1986	155	N/A	100.0	0.0	(0-0)	0.0	(0-0)	0.0	(0-0)	100.0	(100-100)

1 Emmonak commercial fishery 5.5 inch mesh size
2 Emmonak commercial fishery 8.5 inch mesh size
3 Middle Mouth test fishery 5.5 inch mesh size
4 Middle Mouth test fishery 8.5 inch mesh size
5 Big Eddy test fishery 5.5 inch mesh size
6 Big Eddy test fishery 8.5 inch mesh size
7 Bethel commercial fishery
8 Kogrukluk weir escapement
9 Commercial fishery
10 Quinhagak commercial fishery
11 Mixture of Nushagak R. (subsistence), Togiak R. (commercial), and Naknek R. (escapement).
12 Subsistence fishery
13 Escapement
14 Hatchery

Table 8. Diagnostic test of regional standards used to allocate brood year 1982. Scales from known stocks were allocated as if the origin of these stocks was unknown. None of the scales tested were included in the standards used to allocate them. Maximum likelihood mixing proportion estimates (%) by sample and age at return. Confidence intervals (90%) are calculated by multiplying the standard deviation of 100 bootstraps by a z-value of 1.6449.

Stock	Age	Year of Return	N	Percent Correct to Standard	Percent Correct to Continent	Western Kamchatka		Kamchatka R.-Yukon R.		Western Alaska		Central Alaska	
Yukon 5.5 River[1]	1.3	1987	21	49.3	N/A	9.0	(0-23.9)	49.3	(23.5-75.0)	0.0	(0-15.0)	41.7	(11.5-72.0)
Yukon 8.5 River[2]	1.3	1987	27	91.7	N/A	0.0	(0-0)	91.7	(80.0-100)	8.3	(0-20.3)	0.0	(0-3.9)
Nelson Lagoon	1.3	1987	60	0.0	50.5	0.6	(0-7.0)	48.9	(25.7-72.0)	0.0	(0-10.6)	50.5	(26.7-74.4)
Chignik River	1.3	1987	42	28.2	38.8	0.0	(0-0)	61.1	(40.3-82.0)	10.7	(0-27.5)	28.2	(5.9-50.6)
Copper River	1.3	1987	60	100.0	100.0	0.0	(0-4.0)	0.0	(0-0)	0.0	(0-0)	100.0	(96.0-100)
Chickamin River	1.3	1987	44	N/A	100.0	0.0	(0-22.7)	0.0	(0-0)	0.0	(0-0)	100.0	(77.3-100)
Unuk River	1.3	1987	64	N/A	87.0	13.0	(0-33.8)	0.0	(0-0)	0.0	(0-0)	87.0	(65.9-100)
Snettisham[3]	1.3	1987	60	N/A	0.0	99.6	(91.9-100)	0.4	(0-3.4)	0.0	(0-3.5)	0.0	(0-6.8)
Taku River	1.3	1987	30	N/A	25.2	74.8	(51.0-98.5)	0.0	(0-0)	0.0	(0-0.2)	25.2	(1.5-49.0)
Alsek River	1.3	1987	60	N/A	100.0	0.0	(0-6.1)	0.0	(0-0)	0.0	(0-0)	100.0	(93.9-100)
Stikine River	1.3	1987	60	N/A	73.6	26.4	(8.1-44.8)	0.0	(0-0)	0.0	(0-0)	73.6	(55.2-91.9)
Skeena River	1.3	1987	60	N/A	97.7	2.3	(0-15.3)	0.0	(0-0)	0.0	(0-0)	97.7	(84.7-100)

1 Emmonak commercial fishery 5.5 inch mesh size
2 Emmonak commercial fishery 8.5 inch mesh size
3 Hatchery

Table 9. Provisional maximum likelihood mixing proportion estimates (%) by subarea and month for immature age 1.2 chinook caught in 1985 (brood year 1981). Confidence intervals (90%) are calculated by multiplying the standard deviation from 500 bootstraps by a z-value of 1.6449.

Area	Month	N	Western Kamchatka		Eastern Kamchatka		Western Alaska		Central Alaska	
Bering Sea										
8	July	79	10.3	(0.5-20.0)	37.4	(17.6-57.3)	51.2	(29.1-73.2)	1.1	(0-12.8)
10	July	81	10.8	(2.8-18.7)	21.3	(7.6-35.0)	62.0	(43.6-80.4)	5.9	(0-21.0)
8+10	July	160	10.6	(4.0-17.2)	28.4	(15.5-41.4)	57.9	(41.8-73.9)	3.1	(0-13.8)
North Pacific Ocean										
3	June	92	10.1	(0.3-19.9)	7.5	(0-17.9)	46.1	(27.5-64.7)	36.3	(18.3-54.2)
5	June	428	31.6	(23.9-39.4)	11.3	(5.8-16.7)	21.5	(12.9-30.0)	35.6	(25.1-46.2)
3	July	156	20.1	(7.2-32.9)	2.6	(0-6.6)	13.0	(2.5-23.5)	64.3	(48.0-80.7)
5	July	510	52.1	(41.0-63.1)	4.2	(1.1-7.3)	8.5	(1.3-15.8)	35.2	(21.5-48.9)
7+9	July	81	31.8	(12.6-51.0)	16.9	(5.5-28.3)	7.7	(0-21.6)	43.6	(20.4-66.8)
Landbased Driftnet Area										
11-15	June+July	72	43.1	(28.6-57.5)	23.2	(10.2-36.3)	23.2	(7.2-39.2)	10.5	(0-25.8)

Table 10. Provisional maximum likelihood mixing proportion estimates (%) by subarea and month for immature age 1.2 chinook caught in 1986 (brood year 1982). Confidence intervals (90%) are calculated by multiplying the standard deviation from 500 bootstraps by a z-value of 1.6449.

Area	Month	N	Western Kamchatka		Kamchatka R.-Yukon R.		Western Alaska		Central Alaska	
<u>Bering Sea</u>										
10	July	84	1.6	(0-4.6)	66.1	(54.1-78.0)	12.5	(2.0-23.0)	19.8	(8.0-31.5)
8+10	July	122	1.3	(0-3.6)	72.2	(62.5-82.0)	11.7	(2.9-20.5)	14.8	(6.0-23.6)
8+10	June+July	144	1.3	(0-3.9)	71.8	(62.1-81.5)	10.1	(2.1-18.1)	16.8	(7.5-26.0)
<u>North Pacific Ocean</u>										
5	June	505	36.0	(28.7-43.3)	48.6	(41.8-55.3)	2.0	(0-5.1)	13.4	(3.9-23.0)
5	July	520	69.4	(58.4-80.3)	18.0	(12.8-23.3)	0.0	(0-0.7)	12.6	(0-25.2)
<u>Landbased Driftnet Area</u>										
11-15	June+July	108	81.4	(71.0-91.8)	18.6	(9.3-27.9)	0.0	(0-0)	0.0	(0-6.8)

Table 11. Reported chinook salmon catch in the (large-vessel) Japanese salmon landbased driftnet fishery in comparison to the number caught in Japanese research vessel operations between 146°E and 175°W longitude and south of 46°N latitude (thousands of fish).

Year	Reported Landbased Fishery Catch	Research Vessel Operation Catch
1978	210	.377
1979	162	.204
1980	160	.238
1981	190	.200
1982	165	.114
1983	178	.158
1984	92	.137
1985	101	.205
1986	77	.221
1987	74	.166
1988	47	.264
1989	51	.180

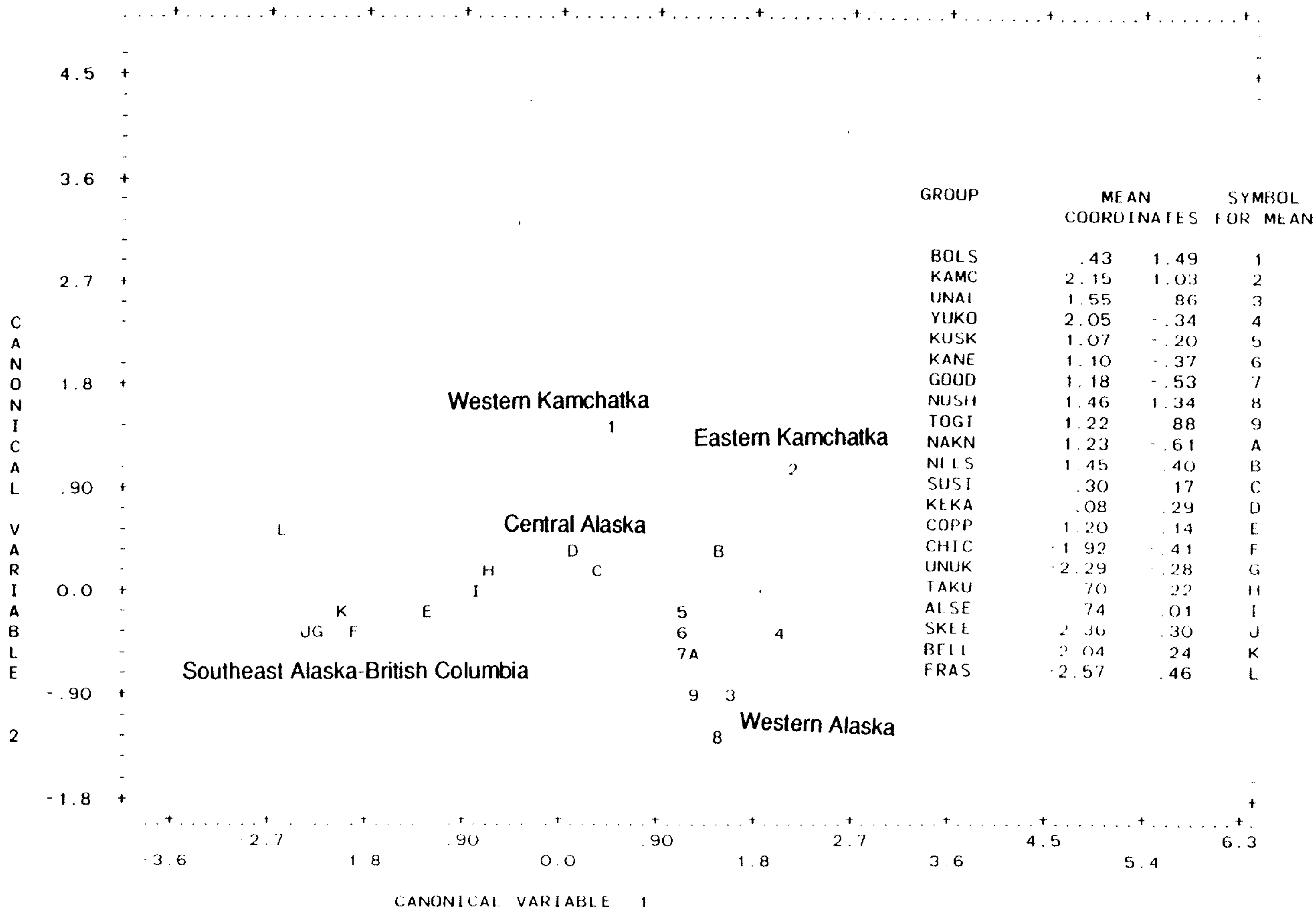
Table 12. Provisional estimates of the (large-vessel) Japanese salmon landbased driftnet fishery catches of chinook salmon (in thousands of fish) by region of origin.

Year	Western Kamchatka	Eastern Kamchatka	Western Alaska	Central Alaska
1985	44	23	23	11
1986	33	18	18	8
1987	32	17	17	8
1988	20	11	11	5
1989	22	12	12	5

Table 13. Reported and estimated inshore commercial catches of chinook salmon in thousands of fish.

Year	Western Kamchatka	Eastern Kamchatka	Western Alaska	Central Alaska	Southeastern Alaska	British Columbia
1978[a]	12	302	400	100	400	1400
1979[a]	32	247	400	<100	400	1300
1980[a]	9	117	300	<100	300	1200
1981[a]	17	140	500	<100	300	1100
1982[a]	21	116	500	100	300	1300
1983[a]	21	160	400	100	300	1000
1984[a]	16	154	300	100	300	1000
1985[b,c]	20	167	381	82	258	870
1986[b,c]	23	203	257	94	246	813
1987[b,d,e]	10	159	297	99	261	768
1988[d,e]			240	103	265	725
1989[d]			225	70	288	

[a] 1952-1984 (Harris 1989).
[b] 1985-1987 western and eastern Kamchatka (Kazarnovskii 1989).
[c] 1985-1986 North America (INPFC 1988, 1989)
[d] 1987-1989 Alaska stocks (Eggers and Dean 1988; Geiger and Savikko 1989, 1990)
[e] 1987-1988 British Columbia (DFO 1989).



GROUP	MEAN COORDINATES		SYMBOL FOR MEAN
BOLS	.43	1.49	1
KAMC	2.15	1.03	2
UNAL	1.55	86	3
YUKO	2.05	-.34	4
KUSK	1.07	-.20	5
KANE	1.10	-.37	6
GOOD	1.18	-.53	7
NUSH	1.46	1.34	8
TOGI	1.22	88	9
NAKN	1.23	-.61	A
NELS	1.45	.40	B
SUSI	.30	17	C
KEKA	.08	.29	D
COPP	1.20	.14	E
CHIC	-1.92	-.41	F
UNUK	-2.29	.28	G
TAKU	70	22	H
ALSE	74	.01	I
SKEE	2.36	.30	J
BELL	2.04	24	K
FRAS	-2.57	.46	L

Appendix. Figure 1. Plot of stock centroids evaluated at the first and second canonical variable. These stocks were used in analyses of immature age 1.2 chinook caught on the high seas in 1985 (brood-year 1981). Abbreviation of stock names include the following: BOLS=Bolshaya River, KAMC=Kamchatka River, UNAL=Unalakleet River, YUKO=Yukon River, KUSK=Kuskokwim River, KANE=Kanektok River, GOOD=Goodnews River, NUSH=Nushagak River, TOGI=Togiak River, NAKN=Naknek River, NELS=Nelson Lagoon, SUSI=Susitna River, KEKA=Kenai Peninsula, COPP=Copper River, CHIC=Chickamin River, UNUK=Unuk River, TAKU=Taku River, ALSE=Alsek River, SKEE=Skeena River, BELL=Bella Coola River, FRAS=Fraser River.

Appendix Table 1. Euclidean distances calculated from canonical variables evaluated at the centroid for 21 stocks from Asia and North America. These stocks were used in analyses of immature age 1.2 chinook caught on the high seas in 1985 (brood-year 1981). Abbreviation of stock names include the following: BOLS=Bolshaya River, KAMC=Kamchatka River, UNAL=Unalakleet River, YUKO=Yukon River, KUSK=Kuskokwim River, KANE=Kanektok River, GOOD=Goodnews River, NUSH=Nushagak River, TOGI=Togiak River, NAKN=Naknek River, NELS=Nelson Lagoon, SUSI=Susitna River, KEKA=Kenai Peninsula, COPP=Copper River, CHIC=Chickamin River, UNUK=Unuk River, TAKU=Taku River, ALSE=Alsek River, SKEE=Skeena River, BELL=Bella Coola River, FRAS=Fraser River.

	BOLS	KAMC	UNAL	YUKO	KUSK	KANE	GOOD	NUSH	TOGI	NAKN	NELS	SUSI	KEKA	COPP	CHIC
BOLS	.0000														
KAMC	3.0391	.0000													
UNAL	3.3074	2.6772	.0000												
YUKO	2.9091	2.0229	2.0026	.0000											
KUSK	2.6530	1.9868	2.1740	1.5016	.0000										
KANE	2.6952	1.9438	1.8188	1.4510	.8554	.0000									
GOOD	2.7579	2.1136	1.1970	1.3668	1.0953	.9322	.0000								
NUSH	3.4068	2.7128	1.9431	1.6116	1.4813	1.3286	1.2883	.0000							
TOGI	2.9068	2.6454	1.4633	1.6176	1.7216	1.5101	.9700	1.1386	.0000						
NAKN	2.6042	2.3801	1.8871	1.3620	1.3083	1.1883	1.0367	.9259	.7259	.0000					
NELS	2.8707	1.7341	2.7469	1.9056	1.8577	1.7890	1.9197	2.1674	1.8921	1.6358	.0000				
SUSI	1.8528	2.4606	2.2640	2.0312	1.3384	1.2099	1.4781	2.1218	1.9342	1.6105	2.2710	.0000			
KEKA	1.9196	2.5521	2.1615	2.3354	1.5592	1.6030	1.4347	2.3246	1.7907	1.7119	2.1713	.9471	.0000		
COPP	2.8167	3.7144	3.1547	3.4832	2.5836	2.4884	2.5221	2.9930	2.6020	2.5655	2.9799	1.8446	1.4952	.0000	
CHIC	3.5438	4.4218	4.0294	4.0617	3.1045	3.0661	3.2876	3.6029	3.5164	3.3496	3.8086	2.4184	2.4626	1.3931	.0000
UNUK	3.5943	4.7752	4.3420	4.4371	3.4748	3.4471	3.6316	3.9514	3.7819	3.6365	4.0823	2.7324	2.6804	1.4684	.6044
TAKU	2.3928	3.2077	3.0345	2.9218	2.1622	2.1566	2.2501	2.8503	2.5909	2.3678	2.8583	1.2464	1.3492	1.3249	1.5743
ALSE	2.4446	3.6110	3.5398	3.0110	2.1160	2.3814	2.5812	2.8275	2.7917	2.4032	3.0096	1.5814	1.7927	1.7489	1.6973
SKEE	3.8271	4.8126	4.1608	4.5647	3.6103	3.5703	3.6287	4.0928	3.7818	3.7885	4.1295	2.8991	2.6141	1.3557	1.2715
BELL	3.8131	4.4979	4.3534	4.2570	3.3741	3.3236	3.5541	3.8282	3.6858	3.5264	3.6873	2.7877	2.7326	1.5692	.8609
FRAS	3.8124	4.8767	4.4978	4.8571	3.9480	3.9837	3.9276	4.5827	4.1186	4.1337	4.2851	3.2174	2.7720	1.7405	1.7827

	UNUK	TAKU	ALSE	SKEE	BELL	FRAS
UNUK	.0000					
TAKU	1.9064	.0000				
ALSE	1.9183	1.2442	.0000			
SKEE	1.1760	2.1546	2.4271	.0000		
BELL	1.0147	1.8992	2.0517	1.4208	.0000	
FRAS	1.6011	2.2593	2.7193	1.1620	1.7312	.0000

Appendix Table 2. Descriptive statistics for scale data from the brood year 1981 analyses.

Scale Variables	Western Kamchatka	Eastern Kamchatka	Western Alaska	Central Alaska	High Seas sample Age 1.2 1985
Freshwater zone size					
mean	293.0	272.9	310.5	316.8	319.0
std. dev.	48.0	42.9	54.7	53.2	52.8
min. value	195.0	166.0	176.0	180.0	157.0
max. value	456.0	404.0	465.0	494.0	494.0
Ocean circuli count					
mean	28.5	31.8	34.5	33.3	31.4
std. dev.	2.8	3.3	3.0	3.8	3.2
min. value	22.0	25.0	25.0	22.0	22.0
max. value	36.0	43.0	44.0	44.0	46.0
Ocean zone size					
mean	1157.1	1290.9	1480.4	1329.3	1343.5
std. dev.	146.8	171.5	151.0	164.1	152.9
min. value	826.0	836.0	1040.0	722.0	836.0
max. value	1538.0	1799.0	1923.0	1761.0	1942.0
Size of Triplet 1					
mean	89.7	75.9	80.2	82.0	89.5
std. dev.	15.1	13.5	14.2	13.8	17.2
min. value	52.0	47.0	52.0	52.0	47.0
max. value	138.0	109.0	123.0	128.0	161.0
Size of Triplet 2					
mean	105.5	77.1	92.5	95.3	100.1
std. dev.	16.9	14.8	18.6	18.4	19.7
min. value	62.0	47.0	52.0	62.0	52.0
max. value	147.0	128.0	176.0	147.0	171.0
Size of Triplet 3					
mean	122.4	89.3	108.5	112.9	119.1
std. dev.	19.1	18.0	20.7	20.2	22.5
min. value	71.0	57.0	57.0	66.0	57.0
max. value	176.0	152.0	176.0	180.0	204.0
Size of Triplet 4					
mean	134.3	118.6	125.0	125.3	136.1
std. dev.	19.0	22.6	18.8	17.3	22.7
min. value	90.0	62.0	66.0	71.0	66.0
max. value	190.0	176.0	190.0	171.0	209.0
Size of Triplet 5					
mean	134.8	139.4	135.6	131.2	145.1
std. dev.	19.1	23.4	20.9	19.5	22.1
min. value	95.0	81.0	62.0	90.0	85.0
max. value	204.0	214.0	209.0	180.0	223.0
Size of Triplet 6					
mean	139.7	150.9	148.3	136.2	151.6
std. dev.	21.7	24.2	23.5	19.1	22.6
min. value	90.0	100.0	85.0	90.0	90.0
max. value	190.0	233.0	237.0	204.0	237.0
Size of Triplet 7					
mean	128.7	152.2	157.9	136.6	148.2
std. dev.	22.1	25.4	22.5	19.1	23.6
min. value	90.0	90.0	104.0	76.0	66.0
max. value	195.0	218.0	233.0	190.0	233.0
Sample size	170.0	231.0	533.0	237.0	1499.0

Appendix Table 3. Descriptive statistics for scale variables used in the brood year 1982 analyses.

Scale Variables	Western Kamchatka	Kamchatka R./ Yukon R.	Western Alaska	Central Alaska	High Seas Sample Age 1.2 1986
Freshwater zone size					
mean	282.2	282.7	304.3	288.3	324.2
std. dev.	43.4	42.9	44.9	53.0	49.8
min. value	190.0	185.0	166.0	171.0	180.0
max. value	413.0	399.0	465.0	442.0	503.0
Ocean circuli count					
mean	29.8	32.2	36.6	34.9	31.3
std. dev.	3.0	2.9	4.0	3.7	3.1
min. value	22.0	24.0	24.0	23.0	21.0
max. value	39.0	41.0	53.0	43.0	46.0
Ocean zone size					
mean	1159.0	1329.1	1505.7	1387.4	1330.7
std. dev.	144.2	154.1	163.4	169.7	152.8
min. value	793.0	945.0	1078.0	845.0	826.0
max. value	1614.0	1837.0	2132.0	1809.0	1771.0
Size of Triplet 1					
mean	86.5	77.4	78.4	81.4	87.1
std. dev.	13.4	12.1	12.6	14.4	15.7
min. value	52.0	52.0	52.0	52.0	52.0
max. value	128.0	114.0	114.0	138.0	142.0
Size of Triplet 2					
mean	100.9	82.4	83.6	88.4	101.3
std. dev.	18.4	15.2	15.6	18.6	21.3
min. value	62.0	52.0	57.0	57.0	52.0
max. value	166.0	133.0	138.0	157.0	209.0
Size of Triplet 3					
mean	121.5	95.5	99.3	107.5	121.8
std. dev.	20.6	21.5	19.2	21.9	27.5
min. value	66.0	52.0	62.0	62.0	62.0
max. value	190.0	161.0	166.0	171.0	199.0
Size of Triplet 4					
mean	131.4	121.7	114.6	124.3	137.8
std. dev.	20.6	22.9	19.0	18.9	23.8
min. value	81.0	66.0	66.0	66.0	62.0
max. value	190.0	228.0	185.0	190.0	228.0
Size of Triplet 5					
mean	130.5	142.7	125.1	130.0	146.9
std. dev.	20.4	23.0	21.9	17.1	22.8
min. value	76.0	81.0	66.0	90.0	76.0
max. value	209.0	223.0	209.0	185.0	228.0
Size of Triplet 6					
mean	131.5	155.3	137.5	136.3	153.7
std. dev.	12.1	25.9	22.0	19.6	23.0
min. value	81.0	104.0	85.0	90.0	66.0
max. value	199.0	247.0	195.0	195.0	247.0
Size of Triplet 7					
mean	122.2	153.7	148.1	139.9	146.9
std. dev.	21.4	23.5	21.1	19.3	26.4
min. value	71.0	95.0	85.0	90.0	81.0
max. value	195.0	228.0	204.0	190.0	242.0
Sample size	305.0	310.0	257.0	239.0	1277.0

Appendix Table 4. Comparison of scale variable statistics for the Kamchatka and Yukon Rivers used in the analyses of brood year 1981 and 1982.

Scale Variables	Brood Year 1981				Brood Year 1982			
	Kamchatka Age 1.3	Kamchatka Age 1.4	Emmonak 5.5 Mesh	Emmonak 8.5 Mesh	Kamchatka Age 1.3	Kamchatka Age 1.4	Emmonak 5.5 Mesh	Emmonak 8.5 Mesh
Freshwater zone size								
mean	278.0	263.4	283.0	289.1	275.0	278.7	311.9	311.8
std. dev.	45.2	36.9	52.4	47.1	43.9	38.4	40.4	40.6
min. value	185.0	166.0	176.0	223.0	185.0	209.0	209.0	256.0
max. value	404.0	385.0	375.0	394.0	399.0	389.0	399.0	389.0
Ocean circuli count								
mean	31.8	31.9	32.6	34.2	31.7	32.6	32.9	32.6
std. dev.	3.4	3.1	2.9	2.6	3.1	2.5	3.3	2.4
min. value	25.0	25.0	29.0	29.0	24.0	27.0	29.0	29.0
max. value	43.0	40.0	41.0	39.0	41.0	39.0	41.0	40.0
Ocean zone size								
mean	1304.4	1265.7	1411.6	1517.0	1272.8	1335.1	1447.2	1455.5
std. dev.	181.5	148.9	153.0	104.4	144.6	133.3	140.5	136.4
min. value	836.0	888.0	1140.0	1325.0	945.0	983.0	1135.0	1097.0
max. value	1799.0	1657.0	1695.0	1705.0	1837.0	1643.0	1733.0	1828.0
Size of Triplet 1								
mean	76.4	74.9	74.0	76.9	76.1	77.8	79.1	82.2
std. dev.	13.8	13.0	14.4	14.4	11.4	12.7	11.4	13.4
min. value	47.0	47.0	52.0	52.0	52.0	52.0	62.0	57.0
max. value	109.0	109.0	114.0	114.0	114.0	114.0	104.0	114.0
Size of Triplet 2								
mean	76.7	77.9	85.9	88.8	79.3	81.7	93.6	90.1
std. dev.	14.8	14.9	17.2	20.4	12.8	14.2	19.8	19.1
min. value	47.0	52.0	52.0	62.0	57.0	57.0	62.0	52.0
mex. value	128.0	123.0	128.0	147.0	133.0	128.0	133.0	133.0
Size of Triplet 3								
mean	87.6	92.5	110.1	111.1	91.3	90.7	119.7	111.3
std. dev.	17.2	19.3	18.8	27.4	20.3	17.4	17.4	23.4
min. value	66.0	57.0	81.0	57.0	52.0	66.0	95.0	76.0
max. value	152.0	142.0	161.0	161.0	157.0	152.0	161.0	161.0
Size of Triplet 4								
mean	118.5	118.7	124.0	124.0	119.7	118.8	132.7	134.1
std. dev.	23.3	21.5	19.4	20.5	22.3	22.9	19.7	27.6
min. value	62.0	71.0	81.0	66.0	66.0	71.0	95.0	81.0
max. value	166.0	176.0	180.0	171.0	209.0	190.0	180.0	228.0
Size of Triplet 5								
mean	142.4	133.8	136.2	136.6	140.9	139.1	154.2	155.2
std. dev.	24.4	20.2	23.1	18.2	24.4	19.3	23.2	23.3
min. value	81.0	85.0	90.0	109.0	81.0	100.0	114.0	104.0
max. value	214.0	190.0	185.0	195.0	209.0	190.0	204.0	223.0
Size of Triplet 6								
mean	153.5	146.2	149.5	155.8	150.2	150.0	172.5	183.8
std. dev.	24.8	22.4	25.3	28.2	23.9	21.0	22.0	30.9
min. value	100.0	100.0	109.0	123.0	104.0	109.0	138.0	128.0
max. value	233.0	223.0	204.0	223.0	214.0	209.0	218.0	247.0
Size of Triplet 7								
mean	156.0	145.2	161.0	175.1	149.1	152.0	166.9	169.0
std. dev.	26.3	22.2	26.9	25.2	21.5	23.2	21.0	24.9
min. value	95.0	90.0	114.0	133.0	95.0	104.0	114.0	104.0
max. value	218.0	199.0	228.0	228.0	209.0	223.0	214.0	228.0
Sample size	150.0	81.0	30.0	30.0	142.0	110.0	30.0	30.0