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DETERMINATION OF STOCK ORIGINS OF CHINOOK SALMON
INCIDENTALLY CAUGHT IN FOREIGN TRAWLS IN THE ALASKA FCZ:

Part II

by

Katherine W. Myers

and

Donald E. Rogers

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PREFACE

Stock separation of salmon (Oncorhynchus spp.) by scale pattern analysis is based on the assumption that fish from a particular region or stock grow in a characteristic manner. This characteristic growth is reflected in the number and spacing of circuli (concentric bony ridges) on the scales, and these patterns can be used to identify fish in a mixed stock population. Since 1978 biologists at the University of Washington's Fisheries Research Institute (FRI) have been involved in the development and application of scale pattern recognition techniques and stock proportion estimation procedures, primarily for International North Pacific Fisheries Commission (INPFC)-related research on stock origins of salmon in the area of the pre-1978 Japanese landbased drift-net (LBDN) fishery (south of 46°N and west of 175°W in the North Pacific Ocean). In 1979, a microcomputer-based fish scale digitizing system developed at FRI for INPFC-related research greatly enhanced the ability of FRI biologists to make rapid and accurate measurements of the large number of scales usually required for racial analysis.

In 1981, biologists at FRI began a two-year scale pattern study funded by the North Pacific Fishery Management Council (NPFMC) to determine stock origins of chinook salmon in incidental catches by the foreign groundfish fishery in the U.S. Fishery Conservation Zone (FCZ) of Alaska. The results of this study demonstrated that scale pattern analysis is a feasible technique for region-of-origin stock identification of age 1. chinook salmon in mixed stock fisheries (Myers and Rogers 1982). Stock proportion estimates for 1979 and 1981 indicated that western Alaska was often the predominant regional stock in Bering Sea catches by the groundfish fishery, and significant estimates were also obtained for several non-western Alaskan stocks (Asia, central Alaska, Southeast Alaska/British Columbia) (Myers and Rogers 1983).

Recommendations from this study (Myers and Rogers 1983) for additional research were reviewed by the North Pacific Council's Scientific and Statistical Committee (SSC) in September 1983, and the SSC recommended a one-year continuation of this research in three specific areas: 1) 1982 foreign trawl fishery samples should be allocated via regional stock models (similar to what was done with 1979 and 1981 samples), 2) numerical estimates by stock for 1979, 1981 and 1982 catches should be developed and analyzed to determine critical time/area blocks for stock conservation, and 3) the feasibility of scale pattern analysis techniques for region-of-origin stock identification of age 0. chinook salmon should be determined. Funding for this research was received by FRI in July 1984, and the results are presented in the following final report.

EXECUTIVE SUMMARY

This is the final report for contract 84-3, Determination of Stock Origins of Chinook Salmon Incidentally Caught in Foreign Trawls in the Alaska FCZ: Part II. In 1984 the University of Washington was contracted by the North Pacific Fishery Management Council for a one-year project to continue research on stock origins of chinook salmon in incidental catches by the foreign groundfish fishery in the Alaska Fishery Conservation Zone (FCZ). The objectives, methods, and materials as stated in contract 84-3 were as follows:

Objectives

- (1) Determine if scale samples collected from incidentally caught salmon by U.S. observers on foreign trawlers in the FCZ in 1982 are adequate for stock separation analyses, and, if feasible, allocate the 1982 fishery samples via regional stock models, similarly to what was done with 1978, 1979, and 1981 samples.
- (2) Develop numerical estimates by stock for 1979, 1981, and if appropriate, 1982 incidental chinook catches, and evaluate the results to determine if there are critical time/area blocks that could be used in the future to conserve important domestic chinook stocks and yet allow continuation of groundfish fisheries in the FCZ.
- (3) Determine if freshwater-marine growth patterns on the scales of selected major coastal stocks allow region-of-origin separation of freshwater age 0. chinook salmon.

Methods and Materials

- (1) Aging and Classification of 1982 Chinook Scale Samples. The analysis of chinook scale samples collected by U.S. observers in the Alaska FCZ in 1982 will provide needed additional information on the age and stock composition of chinook incidentally caught by the foreign groundfish fishery in the Bering Sea and Gulf of Alaska. The methods used to determine adequacy of the 1982 samples will be similar to methods used by Myers and Rogers (1982). The 1982 chinook scale samples will be provided by the National Marine Fisheries Service (NMFS). All chinook scale samples collected in the Alaska FCZ in 1982 will be mounted on gummed cards, and acetate impressions of the scales will be aged.

However, only scales collected from the preferred area (A, shown in Figure 1) will be considered adequate for scale pattern analysis. It has been found that scales collected from areas adjacent to the preferred area (B, shown in Figure 1) are not valid for use in scale pattern analyses. Because of the low incidental catch of chinook by the foreign groundfish fishery in 1982, there may not be a sufficient quantity of scales for a scale pattern analysis. However, any samples having 25 or more preferred area scales when

stratified by age class, INPFC statistical area (Figure 2), and month will be classified to region of origin by the same techniques described by Myers and Rogers (1983). These analyses will require the use of 1983 inshore chinook scale samples and stock abundance estimates. Agencies involved in managing chinook stocks will be relied upon to provide these samples and estimates. Because of the time and cost involved in preparing scale samples and abundance estimates, there may be a considerable delay between the date the request is made to the agencies and the date that samples and estimates can be provided. Milestones in the contract have been adjusted to reflect a reasonable time frame within which to accomplish the objectives.

- (2) Interception Estimates. Interception estimates will be calculated using a technique similar to that described by Meyer and Harris (1983). Mixing proportion and age composition estimates calculated for 1979 and 1981 incidental catches of chinook by the foreign groundfish fishery in the Alaska FCZ (Myers and Rogers 1983) will be used in combination with U.S. observer incidental chinook catch estimates to provide estimates of the number of fish of each regional or western Alaskan stock in the fishery catches. If mixing proportion estimates can be calculated for 1982 observer samples, then interception estimates will also be calculated for 1982. U.S. observers' estimates of chinook catch will be provided by NMFS. Interception estimates will be calculated for only those age classes, years, areas, and time periods for which mixing proportion, age composition, and U.S. observer incidental chinook catch estimates are available. Interception estimates will be evaluated to identify time/area blocks where catches of Alaskan chinook stocks are highest. Those blocks over the years for which data are available will be examined to determine if there are critical times or areas that could be used in the future to conserve important domestic chinook stocks, and yet allow continuation of groundfish fisheries in the FCZ. However, because of the considerable year-to-year variability in the fishery, and the lack of information on stock composition for 1977, 1978, and 1980, it is anticipated that this evaluation will be of a provisional nature.
- (3) Scale Pattern Studies of Age 0. Chinook. Although the results of earlier analyses of freshwater age 1. chinook in the foreign trawl fishery were encouraging, it was suggested that analyses of freshwater age 0. chinook were needed to determine the applicability of scale pattern recognition techniques to Southeast Alaskan troll fishery samples. It will be determined if freshwater-marine growth patterns on the scales of selected major coastal chinook stocks allow region-of-origin separation of age 0. chinook. Standards will be constructed for two different brood years (probably 1976 and 1977, for which inshore scale samples are already available at Fisheries Research Institute) by the same methods described for age 1. chinook in Myers and Rogers (1983). However, regional standards will be adjusted to reflect the areas where age 0. chinook stocks

are most abundant. Because of the paucity of age 0. chinook in Asian and Alaskan inshore scale samples (Myers and Rogers 1983), this analysis will probably include regional standards for British Columbia, Washington, Oregon, and California only. A direct density leaving-one-out classification technique (Cook 1982) will be used to determine the levels of accuracy that may be obtained when classifying age 0. chinook salmon of unknown origin in the Southeast Alaskan troll fishery.

The following is a summary of the methods and results in terms of the contract requirements.

Objective No. 1, Methods and Materials No. 1: Aging and Classification of 1982 Chinook Scale Samples

Methods used to determine adequacy of the 1982 samples were similar to methods used by Myers and Rogers (1982). Scales from a total of 2,627 'chinook' salmon sampled by U.S. observers in 1982 were mounted on gummed cards and aged. Among these samples, there were 25 scale packets with no samples, 40 species misidentifications, 61 chinook samples with no body area of scale collection indicated, 1,001 chinook samples coded as non-preferred scales, and 1,500 samples coded as preferred scales. Among the samples coded by observers as preferred scales, 622 (41.5%) were identified from their appearance as non-preferred scales. There were only six strata (age class/U.S. statistical area/month) with adequate sample sizes (25 or more fish) in the Bering Sea statistical areas. There were no adequate sample sizes for freshwater age 1. chinook in the Gulf of Alaska statistical areas.

The methods used to classify the 1982 samples to region-of-origin were similar to Myers and Rogers (1983). However, because of an unresolved error discovered in the method used to calculate the smoothing parameter for Cook's (1982) technique, the 1982 samples were classified with a linear discriminant model (BMDP7M, Brown et al. 1983). Unlike previous years examined, the predominant ocean age class in statistical area Bering II catches in 1982 was .3. Western Alaska was the predominant regional stock of age 1.3 (brood year 1977) chinook in all time/area strata. All estimates of age 1.3 chinook were non-significant for the central Alaska and Southeast Alaska/British Columbia regions, and there was only one statistically significant estimate for the Asian region (32.5% in Bering II in November). Stock proportion estimates were obtained in only one stratum (Bering I, October) for age 1.2 chinook in 1982. The only statistically significant estimate was for the Southeast Alaska/British Columbia region. The results indicate that low incidental catches of chinook by the groundfish fishery in the Bering Sea in 1982 may, in part, reflect low abundances of brood year 1978 (age 1.2) western Alaska chinook.

Objective No. 2., Methods and Materials No. 2: Interception Estimates

Interception estimates for 1979, 1981, and 1982 incidental chinook catches were calculated using a technique similar to that described by

Meyer and Harris (1983). The estimates were summarized by statistical area and month to determine if there are critical time/area blocks that could be used for conservation of Alaskan chinook stocks. Because of limitations in the data, methodology, and estimates used for the calculations, the interception estimates presented in this report are provisional.

Over the three years examined, the foreign directed groundfish fishery in the Bering Sea caught an estimated 148,000 chinook salmon. Estimated chinook catches were highest in 1979 (99,000 fish), decreased to 34,000 fish in 1981, and were lowest in 1982 (15,000 fish). During all three years, estimated chinook catches were highest in statistical area Bering II (80.8% of the catch in 1979, 63.3% in 1981, and 65.6% in 1982), and statistical area Bering I accounted for most of the remaining catch (18.9% of the catch in 1979, 34.6% in 1981, and 32.0% in 1982). The entire Bering Sea chinook catch during the study period was estimated to be approximately 50% (74,000) western Alaskan, 26% (38,000) central Alaskan, 12% (18,000) Southeast Alaskan/British Columbian, 10% (15,000) Asian, and 2% (3,000) non-Alaskan (North American, freshwater age 0.). The largest catches of western Alaskan (43,000 chinook), central Alaskan (24,000 chinook), and southeast Alaskan/British Columbian (8,000 chinook) stocks occurred in statistical area Bering II in 1979. Catches of western (22,000 chinook) and central (15,000 chinook) Alaskan stocks in this statistical area in February 1979 exceeded the estimated total annual catch of these stocks in 1981 and 1982. Because Alaskan chinook stocks constituted the majority of the incidental catches of salmon in the Bering Sea in 1979, 1981, and 1982, spatial and temporal trends in salmon incidence estimates calculated by NMFS and the chinook interception estimates for Alaskan stocks reported herein are similar, and the same general conclusions can be drawn from either set of estimates. That is, the highest rates of salmon incidence and the largest interceptions of Alaskan chinook stocks occur during the first, early portion of the second, and fourth quarter of the year in statistical areas Bering I and II. Reduction of groundfish fisheries in those time/area strata would decrease incidental catches of Alaskan chinook salmon, but would also result in a substantial reduction in groundfish catches.

Objective No. 3, Methods and Materials No. 3: Scale Pattern Studies of Age 0. Chinook

Although the methodology in our contract called for construction of standards for two brood years, the FRI scale collection contained samples for only one age class and brood year (age 0.3, brood year 1978) with numbers sufficient (approximately 200 scales) to construct a regional standard for British Columbia. For the reasons stated above, a linear discriminant method (BMDP7M, Brown et al. 1983) was used instead of Cook's (1982) classification technique.

A total of 1,219 scales from 36 different stocks or terminal area fishery samples of age 0.3 chinook in 1982 were measured. Samples or subsamples of these stocks were grouped into 6 regional categories

(British Columbia, Washington inland, Washington coastal, Columbia River, Oregon, and California), and linear discriminant models were constructed to determine levels of accuracy that may be obtained when classifying age 0. chinook salmon of unknown origin. Overall classification accuracies for six-, five-, and four-region models were 51.5%, 55.3%, and 59.9%, respectively. These classification accuracies are below acceptable levels for six- (58.3%), five- (60.0%), and 4- (62.5%) category models. The results suggest that low classification accuracies for age 0. models may be related to close geographic proximity of the regional standards. In addition, the regional stock categories used in our analysis may be inappropriate. Examination of misclassifications by stock suggested that accuracies might be improved by regrouping the stocks into different categories. Our models included samples from many stocks (e.g., Rogue River, Klamath Spring, Klamath Falls) that would not be present in the Southeast Alaska troll fishery area, and samples of many other stocks that would be present in the fishery area were not available at FRI. Although classification accuracies of the regional models were low, reasonably high accuracies for some of the standards and individual stock categories indicate that the technique may be feasible. Clearly, a considerable amount of additional research in this area is needed.

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LIST OF ABBREVIATIONS AND SYMBOLS

A	INPFC preferred body area for scale collection.
\hat{C}	Estimated foreign directed groundfish fishery catch of chinook in numbers of fish
Ck	Creek
CWT	Coded wire tag
\hat{F}	Estimate proportional age composition
FCZ	Fishery Conservation Zone
FRI	Fisheries Research Institute
i	Age group
j	Month
K	Year
LBDN	Landbased driftnet
mt	Metric ton
\hat{N}	Estimated interception of a regional stock in numbers of fish
N or N.	North
n	Sample size
No.	Number
NMFS	National Marine Fisheries Service
NPFMC	North Pacific Fisheries Management Council
p	Estimated regional stock proportion
R.	River
S.E.	Southeast
SSC	Scientific and Statistical Committee
USFWS	United States Fish and Wildlife Service
W	West

- WDF Washington Department of Fisheries
- > Greater than
- \leq Less than or equal to
- < Less than
- σ 'sigma' - smoothing parameter used in Cook's (1982) classification model.

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INTRODUCTION

Estimated incidental catches of chinook salmon (Oncorhynchus tshawytscha) by foreign groundfish fisheries in the U.S. Fishery Conservation Zone (FCZ) in the Bering Sea (1977-1983) have ranged from approximately 113,000 fish in 1980 to 10,000 fish in 1983 (Table 1). Incidental catches as high as those in 1980 may have a significant impact on U.S. commercial, subsistence, and sport chinook fisheries, and escapement, yet stock origins of chinook caught by the foreign groundfish fisheries are not well known.

Myers and Rogers (1983) employed scale pattern recognition techniques to estimate proportions of regional chinook stocks in 1979 and 1981 incidental catches by the foreign fishery in the Bering Sea/Aleutian Islands region of the Alaska FCZ. Results of this study indicated that western Alaskan chinook were often the predominant regional stock in Bering Sea catches, and significant estimates were also obtained for three other regional stocks (Asia, central Alaska, southeast Alaska/British Columbia).

As a result of this study, several areas for additional research were recommended (Myers and Rogers 1983). These suggestions were reviewed by the Scientific and Statistical Committee (SSC) of the North Pacific Fishery Management Council (NPFMC) at their September 1983 meeting, and the SSC recommended NPFMC support of a one-year continuation of research in three suggested areas. The project was funded by NPFMC for the period 1 July 1984 to 30 June 1985. This is the final report on this research.

The objectives of the study were to:

- (1) determine if scale samples collected by U.S. observers in 1982 are adequate for scale pattern analysis, and, if feasible, develop regional stock proportion estimates for 1982;
- (2) develop interception (numerical) estimates by stock for 1979, 1981, and, if appropriate, 1982 incidental chinook catches, and evaluate the results to determine if there are critical time/area strata that could be used to conserve domestic chinook stocks, yet allow continuation of groundfish fisheries in the FCZ; and
- (3) determine whether scale pattern analysis techniques allow region-of-origin separation of freshwater age 0. chinook salmon.

(1) 1982 STOCK PROPORTION ESTIMATES

METHODS

Methods used to determine adequacy of the 1982 samples were similar to methods used by Myers and Rogers (1982). The 1982 chinook scale samples and accompanying biological and fishery data were provided by the National Marine Fisheries Service (NMFS). All chinook scale samples collected in the Alaska FCZ in 1982 were mounted on gummed cards, and acetate impressions of the scales were aged. Only samples having 25 or more International North Pacific Fisheries Commission (INPFC) preferred body area scales (Area A, Fig. 1) when stratified by age class, U.S. statistical area (Fig. 2), and month were considered adequate for scale pattern analysis.

As in previous analyses, a large number of the scales in the 1982 samples coded as body area 'A' by observers did not appear to be preferred area scales. For scales coded 'A' by observers, a standard set of criteria (Table 2), developed by examining scales collected from known body areas, were used to identify preferred area area scales. Although scales meeting all of these criteria may still be non-preferred, there is a reasonable certainty that scales not meeting these criteria were collected from outside of the INPFC preferred body area.

Methods of scale ageing, measurement, data reformatting, and standard sample construction are described in detail by Myers and Rogers (1983). The only notable difference in technique was that the classification models used in the present analysis did not include a standard sample for Washington/Oregon/California. No statistically significant estimates were obtained for this regional stock group by Myers and Rogers (1983), and the elimination of this category should improve the accuracies of the classification models.

Myers and Rogers' (1983) scale pattern analysis employed a non-parametric discriminant technique developed by Cook (1982). However, we have recently discovered the presence of an error in the method used to calculate the smoothing parameter (σ) employed in this technique, and, as yet, we have not been able to identify the problem. Cook (1982) suggested that for standardized data a smoothing parameter value of 1.0 can be assumed, but this was apparently based on simulation models with erroneous values for the smoothing parameter. The use of two different assumed values for the smoothing parameter ($\sigma = 0.25$ and $\sigma = 1.0$) with the same test data (brood year 1977), scale characters (character No.s 36, 28, 7, 3, 14, 56, Table 4), and a priori probabilities (0.25) yielded classification matrices with column vectors that were different (Table 3). Therefore, the assumption of a particular value for the smoothing parameter did not appear to be appropriate. Because the resolution of this problem was beyond the scope of the present study, we chose to use linear discriminant analysis (BMDP7M, Brown et al. 1983) as the classification technique.

The scale characters used in calculating the linear classification functions were chosen in a stepwise manner by the BMDP7M program. At each step the character that added the most to the separation of the regional stocks was entered into the function ($F\text{-to-enter} = 4.0$), and group classifications were evaluated and presented in a jackknifed classification matrix. The jackknife-validation procedure reduces the bias in group classifications by classifying each scale in the regional standards with a discriminant function calculated from the remaining ($n-1$) scales. For classification of the unknowns, we selected the character set that resulted in the highest overall classification accuracy (percentage of fish in the standards assigned to the correct regional standard).

The methods used to estimate stock proportions were the same as Myers and Rogers (1983). Nearly unbiased estimates of the proportions of the regional stocks in the trawl fishery samples were determined by the classification matrix correction procedure (Cook and Lord 1978). When negative values were obtained for the stock proportion estimates, Cook's constrained estimator (1983) was employed. The resulting estimates were used with Pella and Robertson's (1979) variance formulae to obtain 90% confidence intervals.

Regional (Asia, western Alaska, central Alaska, southeast Alaska/British Columbia) stock proportion estimates were calculated only for freshwater age 1. fish in trawl samples greater than or equal to 25 scales when stratified by ocean age class, month, and U.S. statistical area (Fig. 2).

RESULTS AND DISCUSSION

Scales from a total 2,627 'chinook' salmon sampled by U.S. observers in 1982 were mounted on gummed cards and aged. Among these samples, there were 40 species misidentifications by U.S. observers. Two of these were identified from their scale patterns as sockeye salmon, and 38 were chum salmon. Of the 2,587 chinook samples, 1,500 (57.9%) were coded by observers as having been collected from body area 'A' (Fig. 1), 1,001 (38.7%) were coded as having been collected from other body areas, 61 (2.4%) samples had no body area indicated, and 25 (1.0%) scale packets contained no scale samples. Among the samples coded by observers as 'A', 622 (41.5%) were identified by our criteria (Table 2) as non-preferred area scales.

The number of preferred body area scales stratified by U.S. statistical area (Fig. 2), month, and age class is shown in Table 5. The number of strata with adequate sample sizes (25 or more fish) was disappointingly small. There were no adequate sample sizes for freshwater age 1. chinook in the Gulf of Alaska statistical areas. Although there were only six strata with 25 or more fish in the Bering Sea statistical areas (Table 5), scales in these few strata were classified to region of origin.

Two different classification models were used to analyze the 1982 trawl unknowns. Age 1.3 chinook in the trawl samples were classified with mature brood year 1977 (ages 1.3 in 1982 and 1.4 in 1983) chinook scale patterns, and age 1.2 chinook in the trawl samples were classified with mature brood year 1978 (age 1.3 in 1983) chinook scale patterns. The scale characters used as variables and the decision arrays calculated for these models are presented in Table 6. Means and standard deviations of the scale characters used in the classification models are shown in Table 7. The average spacing of circuli on the measured portion of the scale (character no. 9, Table 4) and the size of the scale in the first portion of the second year of growth (character no. 34, Table 4) were among the top three characters selected in both models (Table 6). Overall accuracies for brood year 1977 and 1978 models (80.0% and 76.6%, respectively) were well above the acceptable level of accuracy for 4-way classification models (62.5%).

The estimates of regional stock proportions for ages 1.2 and 1.3 chinook salmon caught by the 1982 groundfish fishery in the Bering Sea FCZ are presented in Table 8. Western Alaska was the predominant regional stock of age 1.3 (brood year 1977) chinook in all time/area strata. All estimates for this age class and brood year were non-significant for the central Alaska and southeast Alaska/British Columbia regions, and there was only one statistically significant estimate for the Asian region (32.5% in Bering II in November). Western Alaska was also the predominant stock of brood year 1977 (age 1.2) chinook caught in the Bering Sea FCZ in 1981 (Myers and Rogers 1983). The results of both studies indicate that the predominant regional stock of age 1.3 chinook salmon in incidental catches in the Bering Sea FCZ, regardless of brood year, is western Alaska.

For age 1.2 chinook in 1982, stock proportion estimates were obtained for only one stratum (Bering I, October 1982). The only statistically significant estimate was for southeast Alaska/British Columbia chinook (28.2%). It is interesting to note that the only significant estimate for brood year 1978 chinook caught as age 1.1 fish in incidental catches in the Bering Sea in November 1981 was also for the Southeast Alaska/British Columbia region (Myers and Rogers 1983). The point estimates for brood year 1978 western Alaskan chinook in these strata were very low (0.0% in 1981 and 18.3% in 1982). Unlike previous years examined, the predominant ocean age class in statistical area Bering II catches in 1982 was .3 (Table 5). The predominant ocean age class in incidental catches from this statistical area in 1978, 1979, and 1981 was .2 (Myers and Rogers 1983). The proportion of age 1.3 (brood year 1978) chinook in 1983 western Alaskan commercial catches (Rogers et al. 1984) was the lowest since 1978-79. These results indicate that low incidental catches of chinook by the groundfish fishery in the Bering Sea in 1982 (Table 1) may, in part, reflect low abundances of brood year 1978 western Alaskan chinook.

(2) INTERCEPTION ESTIMATES

METHODS

Estimates of the interception of regional chinook stocks by the foreign directed groundfish fishery in the Alaska FCZ in 1979, 1981, and 1982 were calculated with a technique similar to that described by Meyer and Harris (1983). Interception estimates were calculated according to the formula:

$$\hat{N}_{ijkl} = \hat{C}_{jkl} \times \hat{F}_{ijkl} \times \hat{P}_{ijkl}$$

where \hat{N} is the estimated interception of a regional stock in numbers of fish, \hat{C} is the estimated foreign directed groundfish fishery catch of chinook in numbers of fish, \hat{F} is the estimated proportional age composition of the population exploited by the fishery, and \hat{P} is the estimated regional stock proportion for age group i , month j , year k , and statistical area l .

Interception estimates were calculated only for Bering Sea statistical areas, as quality and quantity of U.S. observer scale samples in 1979, 1981, and 1982 were, in most cases, insufficient for calculation of stock proportion estimates for Gulf of Alaska statistical areas.

Estimation of Foreign Directed Groundfish Fishery Chinook Catch (\hat{C})

Estimates of the catch of salmon by the foreign directed groundfish fishery in the Alaska FCZ in 1979, 1981, and 1982, and salmon species composition estimates for 1981 and 1982 catches were obtained from NMFS (Northwest and Alaska Fisheries Center). Species composition estimates for 1979 were not available, but NMFS was able to provide data on the number of salmon of each species measured for length frequency determinations in 1979. All estimates and data provided by NMFS were stratified by nation / vessel class, statistical area (Bering I-IV, Fig. 2), and month.

For 1979, monthly species composition estimates were calculated for each statistical area from the length frequency data. The proportion of salmon of each species was determined for all nation/vessel class, statistical area, and month strata in which length frequency data were collected. The product of these species composition estimates and the catch of salmon in the same stratum was summed over all nation/vessel class strata for each month and statistical area, and the monthly proportion of chinook salmon in the total sampled catch was determined. The monthly catch (\hat{C}) of chinook salmon for each statistical area was calculated as the product of the monthly proportion of chinook and the monthly catch of salmon for each statistical area, determined by summing the estimates provided by NMFS over nation/vessel class strata.

For 1981 and 1982, \hat{C} was calculated by the product of NMFS salmon catch and the proportion of chinook in each area/month stratum, summed over nation/vessel class strata. For strata in which there were no NMFS

species composition estimates, the annual average proportion of chinook for a nation/vessel class/area stratum was used. If there were no NMFS species composition estimates for particular nation/vessel class strata, then the annual average for a different nation and the same vessel class/area was used.

Estimation of Age Composition (\hat{F})

Age composition estimates were calculated from FRI age determinations of U.S. observer scale samples collected in 1979, 1981, and 1982. Only age determinations from readable, non-regenerated scales collected from INPFC preferred or adjacent-to-preferred sample areas on the body of the fish were used. Estimates were calculated for area/month strata from samples pooled over nation/vessel class. If there was no age composition estimate for a particular area/month stratum, the average of monthly age composition estimates from the same quarter of the year and statistical area was used. If quarterly estimates were not available for a particular statistical area, the average of quarterly age composition estimates for the other Bering Sea statistical areas in the same year was used.

Estimation of Regional Stock Proportions (\hat{P})

Regional stock proportion estimates for 1979 and 1981 were calculated by Myers and Rogers (1983), and the calculation of stock proportion estimates for 1982 was described earlier in this report. Because foreign directed groundfish fishery catches were made in many strata for which there are no direct stock proportion estimates, the following assumptions and procedures were used to derive an estimate:

1. All freshwater age 0. chinook salmon were assumed to be of North American, non-Alaskan origin.
2. All age 1.0 chinook salmon caught in the Bering Sea in November and December were assumed to be of western Alaskan origin.
3. There was only one estimate available for age 1.1 chinook salmon, and this estimate was used for all ocean age .1 strata.
4. There were no estimates for freshwater age 2. chinook salmon. Therefore, estimates for freshwater age 1. fish of the same ocean age class were used.
5. There were no estimates for ocean age .5 chinook salmon. Therefore, estimates for ocean age .4 fish were used.
6. For ages 1.2, 1.3, and 1.4 chinook salmon, averaged or substituted estimates were selected from those of fish of the same age class according to the following order of preference:
 - a. same area/same year/same quarter,

- b. same area/different year or average of other two years/same month,
 - c. same area/different year or average of other two years/same quarter,
 - d. different area/same year/same month,
 - e. different area/same year/same quarter,
 - f. different area/different year or average of other two years/same month,
 - g. different area/different year or average of other two years/same quarter,
 - h. same area/same year/adjacent quarter.
7. There were no stock proportion estimates for statistical areas Bering III and IV. Therefore, estimates from statistical areas Bering I and II corresponding to the same area/time strata were used. When monthly or quarterly estimates were available for both statistical areas, unweighted average estimates were used.
 8. Stock proportion estimates calculated by Myers and Rogers (1983) for three strata included statistically non-significant estimates for the Washington/Oregon/California region. These were added to the estimates for the Southeast Alaska/British Columbia region.

RESULTS AND DISCUSSION

The estimated number of salmon, number of chinook salmon (\hat{C}_{jkl}), percent age composition (\hat{F}_{ijkl}), and number of chinook salmon of each age class ($\hat{C}_{jkl} \times \hat{F}_{ijkl}$) caught by the foreign directed groundfish fishery in 1979, 1981, and 1982 are presented by statistical area and year in Tables 9 to 18. Estimated regional stock proportion estimates (\hat{P}_{ijkl}) used to calculate the interception estimates are listed by number in Table 19. The estimated interceptions of regional chinook stocks (\hat{N}_{ijkl}) are presented by age class and month for each statistical area and year in Tables 20 to 29. The estimated interceptions of regional chinook salmon stocks in 1979, 1981, and 1982 are summarized by statistical area and month in Table 30 to 32.

The primary objective of this analysis was to determine if there are critical time/area blocks that could be used in the future to conserve Alaskan chinook stocks. However, before the results are discussed in terms of this objective, limitations of the data, methodology, and estimates must be considered.

Most of the limitations discussed by Harris and Meyer (1982) for interception estimates of North American sockeye also apply to the present analysis. The results of the present analysis are based on numerous biological and statistical assumptions which may or may not be appropriate. Inadequate quality and quantity of scale samples and biological data created many problems with scale aging, measurement, standard sample construction, etc., and necessitated the use of substituted and/or averaged estimates for species, age, and stock composition in many time/area strata. In view of known underlogging of groundfish catches by foreign trawlers in the Alaska FCZ in 1981 and 1982, estimates of incidental salmon catches may be inaccurate. Perhaps the most serious limitation is that there is presently no method for calculating the variance of interception estimates. Therefore, there is no statistical method for evaluating the validity of the estimates. Because of these major limitations, the interception estimates presented in this report are provisional. The following evaluation of interception estimates to identify time/area blocks where catches of Alaskan chinook stocks are highest should be viewed with these limitations in mind.

Over the three years examined, the foreign directed groundfish fishery in the Bering Sea caught an estimated 147,876 chinook salmon. Estimated chinook catches were highest in 1979 (99,182 fish) decreased to 34,079 fish in 1981, and were lowest in 1982 (14,615 fish) (Tables 30 to 32). During all three years, estimated chinook catches were highest in statistical area Bering II (80.8% of the catch in 1979, 63.3% in 1981, and 65.6% in 1982), and statistical area Bering I accounted for most of the remaining catch (18.9% of the catch in 1979, 34.6% in 1981, and 32.0% in 1982). Interceptions of chinook in statistical areas Bering III and IV represent a minor portion of the total catch in all three years (Tables 30 to 32). The entire Bering Sea chinook catch during the study period was estimated to be approximately 50% western Alaskan, 26% central Alaskan, 12% Southeast Alaskan/British Columbian, 10% Asian, and 2% non-Alaskan (North American, freshwater age 0.).

The largest catches of western Alaskan (43,125 chinook), central Alaskan (24,462 chinook), and Southeast Alaskan/British Columbian (8,092 chinook) stocks occurred in statistical area Bering II in 1979 (Table 30). Catches of western (21,960 chinook) and central (15,320 chinook) Alaskan stocks in this statistical area in February 1979 exceeded the estimated total annual catch of these stocks in 1981 and 1982 (Tables 30 to 32). The large catches in area Bering II in February 1979 can be attributed to high incidence rates [number of salmon caught per metric ton (mt) of groundfish catch] on Japanese small stern trawlers (0.655 salmon/mt), Japanese large surimi trawlers (0.552 salmon/mt), and Korean large freezer trawlers (1.238 salmon/mt) fishing along the 200 m contour (Nelson et al. 1980). Incidence rates for these nations and vessel classes were considerably lower (≤ 0.098 salmon/mt) in area Bering II in February 1981 and 1982 (Nelson et al. 1982, 1983).

In statistical area Bering II, relatively large interceptions (>2,000 chinook/month) also occurred for western Alaskan stocks in January, March, and April of 1979 and 1981, and in December of 1979 and

1982, central Alaskan stocks in January 1979, and Southeast Alaskan/British Columbian stocks in December 1979. During the period May through September, catches in area Bering II in all three years were low (<1,000 chinook/month), and from June through August interceptions of Alaskan chinook stocks never exceeded 100 fish/month.

In statistical area Bering I, the largest catches of Alaskan stocks occurred in October and November 1979, and during this period catches of central Alaskan chinook (5,724 fish) exceeded those of western Alaskan (3,590 fish) stocks (Table 30). Catches of Southeast Alaskan/British Columbian stocks (1,476 fish) also exceeded those of western Alaskan stocks (1,125 fish) in November 1979, and catches for both stocks were similar in October and December 1981. However, except for the last quarter of the year (October-December) estimates interceptions of western Alaskan chinook exceeded those of other Alaskan chinook stocks in area Bering I, and catches were largest in March 1979 (1,553 fish) and January 1981 (1,651 fish) and 1982 (1,247 fish) (Tables 30 to 32). During the period April through September, catches of Alaskan chinook stocks in area Bering I never exceeded 1,000 fish/month, and catches from June through August, though often higher than catches in Bering II, never exceeded 400 fish/month.

Because Alaskan chinook stocks constitute the majority of the incidental catch of salmon by the foreign groundfish fishery in the Bering Sea in 1979, 1981, and 1982, spatial and temporal trends in the magnitude of salmon incidence estimates reported by Nelson et al. (1980, 1982, 1983) parallel those of the provisional Alaskan chinook interception estimates presented here, and the same general conclusions can be drawn from either set of estimates. That is, the highest rates of salmon incidence and the largest interceptions of Alaskan chinook stocks occur during the first, early portion of the second, and fourth quarter of the year in statistical areas Bering I and II. Reduction of groundfish fisheries in these time/area strata would decrease incidental catches of Alaskan chinook salmon, but would also result in a substantial reduction in groundfish catches.

(3) SCALE PATTERN STUDIES OF FRESHWATER AGE 0. CHINOOK SALMON

The feasibility of scale pattern recognition techniques for regional stock identification of freshwater age 1. chinook salmon in samples from mixed stock fisheries is well established (Major et al. 1977; Myers and Rogers 1983; Rogers et al. 1984). However, scale pattern studies of freshwater age 0. chinook salmon are needed to determine the applicability of this technique to the southeast Alaska troll fishery and other fisheries with large proportions of age 0. chinook salmon in the catch.

METHODS

Because funding did not provide for collection of age 0. chinook scales, the samples used in this analysis were selected from a collection of chinook scale samples already on file at the Fisheries Research Institute (FRI). Although the original intention was to analyze samples from two different brood years, the FRI collection contained samples for only one age class and brood year (age 0.3, brood year 1978) with numbers sufficient (approximately 200 scales) to construct a regional standard for British Columbia.

The FRI scale collection contained samples of brood year 1978 (age 0.3) chinook from 36 different stocks or terminal area fisheries in 1982 (Table 33). The following description of these samples is included to aid the reader in interpretation of results.

All of the British Columbia samples were from collections provided to FRI by the Canadian Department of Fisheries and Oceans. There were samples from only three British Columbia stocks, and, among these, the Shuswap (a sub-stock within the Fraser system) was poorly represented. The Fraser River samples (12 July-3 October) are from the Albion test gillnet fishery near the mouth of the river, and a large component of the sample is thought to be Harrison River fall chinook. The Harrison stock migrates to estuarine areas as emergent fry (Fraser et al. 1982), and so the scale patterns do not include any freshwater circuli. The 'Robertson Creek' samples (13 August-12 September) are from commercial gillnet fisheries in Alberni Inlet on the west coast of Vancouver Island, and are thought to be composed primarily of Robertson Creek Hatchery (Somass River) chinook.

Except for the Samish and University of Washington samples, the Washington inland and Willapa and Grays Harbor samples were collected by the Washington Department of Fisheries (WDF). These are, primarily, samples (July-September) of saltwater catches by indian and non-indian commercial gillnet fisheries on maturing fall chinook. In these samples, stock was identified by catch area, and so the probability of some mixing of stocks within these samples is high. The Samish and University of Washington samples were collected by FRI personnel from the carcasses of spawners at the Samish and School of Fisheries hatcheries in October.

The remainder of the Washington coastal samples were collected by Quinault Indian Nation and Quileute Fisheries personnel. These are in-river samples (April–November) from tribal gillnet fisheries on maturing spring and fall chinook salmon. Data on coded wire tagged (CWT) fish within these samples indicated some mixing of stocks. For example, the Quinault samples contained some Quinault Lake chinook that had been released as juveniles into the Queets River, the Queets sample contained some Quinault Lake chinook that were released from Quinault Lake, and the Chehalis sample contained a chinook that was released from the Trinity Hatchery into the Trinity River, California.

All of the Columbia River samples (except for a small sample from the Cowlitz Hatchery collected by FRI personnel in October) were collected by WDF. The 'Columbia River Fall' samples (September–October) were from the commercial gillnet fishery near the mouth of the river. These samples are thought to include a mixture of lower river fall chinook stocks [e.g., Willamette Falls (Oregon), Cowlitz Hatchery (Washington), and Lewis River (Washington)]. The 'Columbia River Spring' samples (February–March) are from commercial and test fisheries in the lower river, and are thought to be composed primarily of Willamette River (Oregon) stocks and some Washington stocks (Cowlitz, Kalama, and Lewis). The remainder of the Columbia River stocks were from samples of tagged or marked fish collected in the fall at hatcheries or on the spawning grounds. Priest Rapids was the only sample of upriver Columbia fall chinook, and Grays Hatchery, Sea Resources Hatchery, Cowlitz, Kalama, and Lewis are all Washington stocks from the lower Columbia River. The CWT data for Columbia River chinook collected at hatcheries or on the spawning grounds in 1982 indicates some mixing of stocks within these samples. For example, CWT fall chinook recovered on the Kalama River included fish released from Washougal, Abernathy Creek, Spring Creek, and Toutle hatcheries on the Columbia system, and a sample from the North Fork of the Lewis River included one fish from Priest Rapids (upper Columbia River) and one from Trinity River, California.

Most of the Oregon samples were collected by Oregon Department of Fish and Wildlife personnel sampling on the spawning grounds in the fall (October–December). The scales were often extremely resorbed, so that ocean age determinations may be inaccurate.

The California samples were collected by the U.S. Fish and Wildlife Service (USFWS). The 'Klamath Fall' samples were collected by beach seine in the river in the summer and fall (July–September), and the 'Klamath Spring' samples were from USFWS net harvest monitoring (April–August).

The entire sample or a stratified (over time) random subsample of scales from each stock or fishery sample was selected, and the incremental distance from the center of the focus to the outer edge of each successive circulus through the last circulus in the second ocean annulus was digitized at 104X along a standard measurement axis (Fig. 3). The measurements were grouped into two life history zones (Fig. 3), and

35 different scale characters were calculated from the raw data for each scale (Table 34).

For each stock, descriptive statistics were calculated for four basic scale characters (Character No.s 1, 2, 4, and 5, Table 34), and the mean values of these scale characters were analyzed with cluster analysis of cases (BMDP2M, Brown et al. 1983) to explore whether the stocks group into geographical regions. In this procedure, the stocks and/or clusters of stocks are joined in a stepwise process until all stocks are combined into one cluster. The single linkage algorithm was used for amalgamating stocks, and the Euclidean distance (the square root of the sum of squares of the differences between the values of the variables for two stocks) was used as the distance measure. The data were standardized (to Z-scores) before the computation of the distance.

To determine probable levels of classificatory accuracy attainable by scale pattern analysis, the stocks were grouped into six regional categories [British Columbia, Washington inland, Washington coastal, Columbia River, Oregon, and California (Table 33)], and the scale patterns were classified by the linear discriminant technique (Brown et al. 1983) described earlier in this report. For this procedure, stocks with sample sizes of less than 10 scales were eliminated [Shuswap, Grays Hatchery, Sea Resources Hatchery, and Yaquina Bay (Table 33)], and samples of Columbia River spring and University of Washington fall chinook were also excluded. The Columbia River spring sample contained many possible ageing errors (0. vs. 1.), and, probably because of a combination of genetic selection and unusual rearing regimes, the scale patterns of University of Washington fall chinook are so distinct as to be considered unrepresentative of stocks from Washington's inland waters. Within the samples of stocks to be included, scales with values outside of three standard deviations on either side of the mean for four basic scale characters (character No.s 1, 2, 4, and 5 in Table 34) were re-examined, and were excluded if possible ageing or measurement errors were found.

When more than one stock is included in a regional category, the usual procedure is to weight the sample sizes of component stocks on the basis of relative abundance. However, estimates of relative abundance were not available for many of the stocks. Therefore, when sample sizes permitted, approximately equal numbers of scales for each stock or fishery sample (based on a total standard sample size of 200) were included in a regional standard. Although standard samples constructed in this manner would not be appropriate for classification of unknowns in a fishery sample, they are adequate for determining probable levels of classificatory accuracy attainable by scale pattern analysis.

RESULTS AND DISCUSSION

A total of 1,219 scales from the 36 different stocks or terminal area fishery samples was measured (Table 33). Means and standard deviations of four basic scale characters [size and number of circuli in

zones 1 and 2 (Fig. 3) for the 36 stocks or fishery samples are presented in Table 35]. A dendrogram representing the results of a cluster analysis employing these variables is shown in Figure 4. Although some stocks from within the same geographical region are closely linked [Coquille and Tillamook (Oregon), Kalama and Cowlitz (Columbia), Willapa and Humptulips (Washington coastal), and Duwamish, Stillaguamish/Snohomish, Samish, and Nooksack (Washington inland)], the dendrogram also shows close linkages between stocks from different geographical regions (South Sound and Sea Resources, Quinault River and Klamath Spring, Columbia Fall and Skagit, Cowlitz and Quileute, Siuslaw and Grays Harbor).

Stock composition and sample sizes of regional standards used for classification models in the linear discriminant analysis are shown in Table 36. Variables selected for inclusion in the models and jack-knifed decision arrays for six-, five-, and four-region models are presented in Table 37. Means and standard deviations of the scale characters used in the models are listed in Table 38.

The average incremental distance in the third quintuplet in the first year of growth (Character No. 17, Table 34) was among the top three characters selected in all three models (Table 37). This portion of the scale includes freshwater or estuarine growth in some stocks and ocean growth in others. Because increments formed in freshwater are usually smallest, estuarine increments intermediate, and ocean increments largest, incremental distance in this portion of the scale is quite variable depending on how long a fish has reared in freshwater or estuarine environments. In addition, checks or closer spacing of circuli caused by changes in growth due to smoltification, ocean emigration, or hatchery release may occur in this portion of the scale. British Columbia had the largest value for this character followed in decreasing order by Washington inland, California, Oregon, Columbia River, and Washington coastal (Table 38). The values of average increments for preceding and following quintuplets (character No.s 16 and 18, Table 38) show an increasing trend in circulus spacing for three stocks (British Columbia, Washington inland, and California), and are larger on either side (indicating check formation) for the other three stocks (Washington coastal, Columbia, and Oregon).

Other top characters in the six-region model included the proportion of size and number of circuli in zone 1 to total size and number of circuli in both zones (character no.s 9 and 10, Table 34). The size of zone 1 and the proportion of the second quintuplet in zone 2 to the size of zone 2 (character no.s 1 and 23, Table 34) were among the top three characters in both five- and four-region models.

Overall classification accuracies for the six-, five-, and four-region analyses were 51.5%, 55.3%, and 59.9%, respectively (Table 38). These classification accuracies are below acceptable levels (halfway between random and 100%) for 6- (58.3%), 5- (60.0%), and 4- (62.5%) way models. The overall accuracy for the 4-region model was considerably less than that obtained for a 4-region model of brood year 1978 fresh-

water age 1. chinook salmon (Table 6). However, the accuracy obtained in the age 0. model for the Washington coastal standard (71.2%) was higher than the accuracy for the Central Alaska standard (69.1%) in the age 1. model.

Classification accuracies for the regional standards in the age 0. model were similar to accuracies obtained in linear discriminant models of age 1. western Alaskan chinook stocks (Yukon, Kuskokwim, and Bristol Bay) (Rogers et al. 1984). Classification accuracies reported by Wilcock (1984) for linear discriminant models of age 1. lower, middle, and upper Yukon River chinook were also sometimes below acceptable levels for 3- (66.7%) and 2- (75.0%) category models. These results suggest that low classification accuracies for age 0. models may be related, in part, to the close geographic proximity of the regional standards.

However, another reason for low classification accuracies may be that the regional stock categories are inappropriate. Examination of misclassifications by stock in the 4-region analysis (Table 39) leads to the conclusion that classification accuracies might be improved by grouping the stocks into different categories. For example, Robertson Creek and Fraser might better be separated into two different standards (perhaps representing hatchery and wild components of British Columbia chinook stocks). Quileute and Grays Harbor, which misclassify heavily to Columbia River could be separated from other Washington coastal stocks. Northern Washington inland stocks (Nooksack, Samish, Skagit, and Stillaguamish/Snohomish), which misclassify most heavily to British Columbia, and southern stocks (Duwamish, Puyallup, South Sound, and Skokomish), which misclassify towards Columbia River, could be separated into two standards. Columbia River standards might be regrouped into lower and upper river components. In addition, the removal of fishery samples that might include mixed regional stocks (e.g., Grays Harbor) would improve classification accuracies.

The purpose of this analysis was to determine whether scale pattern analysis techniques allow region-of-origin separation of freshwater age 0. chinook salmon in mixed stock fisheries such as the S.E. Alaska troll fishery. However, the quality and quantity of the scale samples at FRI were, basically, inadequate for this purpose. Our models included samples from many stocks (e.g., Rogue River, Klamath Spring, Klamath Falls) that would not be present in the S.E. Alaska troll fishery area, and samples of many other stocks that would be present in the fishery area were not available at FRI. Although classification accuracies of the regional models presented here are not adequate for region-of-origin separation of age 0. chinook, reasonably high classification accuracies obtained for some of the standards and individual stock categories (Table 39) indicate that the technique may be feasible. Clearly, a considerable amount of additional research in this area is needed.

SUMMARY AND CONCLUSIONS

1. Unlike previous years (1978, 1979, 1981), .3 (instead of .2) was the predominant ocean age class in statistical area Bering II incidental chinook salmon catches in 1982 (Tables 10, 13, 16).
2. In the 1982 samples, western Alaska (including Canadian Yukon) was the predominant regional stock of age 1.3 (brood year 1977) chinook salmon in all Bering Sea time/area strata for which stock proportion estimates were calculated (Table 8).
3. All Bering Sea estimates for age 1.3 chinook caught in 1982 were non-significant for the central Alaska and southeast Alaska/British Columbia regions, and there was only one statistically significant estimate for the Asian region (32.5% in Bering II in November) (Table 8).
4. In the 1982 samples, there was only one stratum (Bering I, October) with a sufficient sample size to calculate stock proportion estimates for age 1.2 (brood year 1978) chinook salmon (Table 5). In this sample, the only statistically significant estimate was for the Southeast Alaska/British Columbia region (Table 8).
5. The results indicate that low incidental catches of chinook by the groundfish fishery in the Bering Sea in 1982 may, in part, reflect low abundances of brood year 1978 (age 1.2) western Alaska chinook salmon.
6. Because of limitations in the data, methodology, and estimates used for the calculations, the interception estimates presented in this report are provisional.
7. In the three years examined (1979, 1981, and 1982), the foreign directed groundfish fishery in the Bering Sea caught an estimated 148,000 chinook salmon (Tables 30-32). Catches were highest in 1979 (99,000 fish) decreased to 34,000 fish in 1981, and were lowest in 1982 (15,000 fish). Chinook salmon catches were highest in statistical area Bering II (80.8% of the 1979 catch, 63.3% of the 1981 catch, and 65.6% of the 1982 catch), and statistical area Bering I accounted for most of the remaining catch (18.9% of the 1979 catch, 34.6% of the 1981 catch, and 32.0% of the 1982 catch).
8. During the study period (1979, 1981, 1982), the regional stock composition of the entire Bering Sea chinook catch by the foreign directed groundfish fishery was estimated to be approximately 50% (74,000) western Alaskan, 26% (38,000) central Alaskan, 12% (18,000) Southeast Alaskan/British Columbian, 10% (15,000) Asian, and 2% (3,000) non-Alaskan (North American, freshwater age 0.). Estimates for western Alaska include Canadian Yukon chinook.
9. During this period, the largest catches of western Alaskan (43,000 chinook), central Alaskan (24,000 chinook), and Southeast Alaskan/

British Columbian (8,000 chinook) stocks occurred in statistical area Bering II in 1979 (Table 30). Catches of western (22,000 chinook) and central (15,000) Alaskan stocks in this statistical area in February 1979 exceeded the estimated total annual catch of these stocks in 1981 and 1982 (Tables 31 and 32).

10. Spatial and temporal trends in salmon incidence estimates calculated by NMFS (Nelson et al. 1980, 1982, 1983) and the chinook interception estimates for Alaskan stocks in 1979, 1981, and 1982 (Tables 30-32) are similar. For both, the largest estimates are for the first, early portion of the second, and fourth quarters of the year in statistical areas Bering I and II. Reduction of groundfish fisheries in these time/area strata would decrease incidental catches of Alaskan chinook salmon, but would also result in substantial reductions in groundfish catches.
11. Overall classification accuracies for six-, five-, and four-region (British Columbia vs. Washington inland vs. Washington coastal vs. Columbia River vs. Oregon vs. California) linear discriminant models of the scale patterns of age 0.3 chinook salmon in 1982 were low (51.5%, 55.3%, and 59.9%, respectively) (Table 37).
12. Low classification accuracies in the models of freshwater age 0. chinook salmon may be related to close geographic proximity of the regional standards or inappropriate regional stock categories. Reasonably high accuracies (>70%) for some of the regional standards and individual stock categories (Table 39) indicate that scale pattern analysis techniques may be feasible for stock identification of freshwater age 0. chinook salmon in mixed stock fisheries, but additional research in this area is needed.

RECOMMENDATIONS

In view of the results of this study, we recommend the following additional areas for research:

1. Interception estimates for joint-venture fisheries in the Gulf of Alaska FCZ

In recent years, incidental chinook catches by the foreign directed groundfish fisheries in the Alaska FCZ have decreased, but incidental chinook catches by the joint-venture groundfish fisheries have increased (Berger et al. 1984). In addition, incidental chinook catches by the joint-venture groundfish fishery in the Gulf of Alaska are larger than catches by this fishery in the Bering Sea (Berger et al. 1984). Because of this major change in the fishery, we recommend that, if adequate scale samples can be obtained, scale pattern stock identification studies be extended to include interception estimates for chinook catches by the joint-venture fishery in the Gulf of Alaska. This would also provide needed information on proportions of regional chinook stocks in the Gulf of Alaska FCZ. To date, U.S. observer scale samples from the foreign directed fishery in the Gulf of Alaska FCZ have been inadequate for this purpose (Myers and Rogers 1983).

2. Scale pattern studies of freshwater age 0. chinook

Because a relatively large proportion of chinook salmon in incidental catches in the Gulf of Alaska are age 0. fish (Myers and Rogers 1983), we also recommend continuation of scale pattern studies of age 0. chinook salmon. If accurate scale pattern models for regional stocks of freshwater age 0. chinook can be developed, they could also be used for estimating regional stock proportions of age 0. chinook caught by the S.E. Alaska troll fishery.

ABSTRACT

This is the final report of a one-year study funded by the North Pacific Fishery Management Council in July 1984 to: 1) determine by scale pattern analysis the regional stock composition of the 1982 foreign directed groundfish fishery incidental chinook salmon catch in the Alaska Fishery Conservation Zone (FCZ), 2) calculate numerical (interception) estimates by region-of-origin for 1979, 1981, and 1982 incidental chinook catches by the foreign groundfish fishery in the Alaska FCZ, and 3) determine if scale pattern analysis is a feasible technique for region-of-origin stock identification of freshwater age 0. chinook salmon in mixed stock fisheries.

Regional stock proportion estimates for 1982 incidental catches in the Bering Sea FCZ indicate that western Alaska (including Canadian Yukon) was the predominant regional stock of age 1.3 chinook. Unlike previous years (1978, 1979, 1981), .3 (instead of .2) was the predominant ocean age class in statistical area Bering II catches in 1982. Only one statistically significant estimate (Southeast Alaska/British Columbia) was obtained for age 1.2 chinook in 1982. Low incidental catches of chinook by the groundfish fishery in the Bering Sea in 1982 may reflect low abundances of brood year 1978 (age 1.2) western Alaskan chinook salmon.

During 1979, 1981, and 1982, the foreign directed groundfish fishery in the Bering Sea caught an estimated 148,000 chinook salmon. During the study period (1979, 1981, 1982), the regional stock composition of the entire Bering Sea chinook catch by the fishery was provisionally estimated to be 50% (74,000) western Alaskan, 26% (38,000) central Alaskan, 12% (18,000) Southeast Alaskan/British Columbian, 10% (15,000) Asian, and 2% (3,000) non-Alaskan (North American, freshwater age 0.). The largest catches of western Alaskan (43,000 chinook), central Alaskan (24,000 chinook), and Southeast Alaskan/British Columbian (8,000 chinook) stocks occurred in statistical area Bering II in 1979. Catches of western (22,000 chinook) and central (15,000) Alaskan stocks in this statistical area in February 1979 exceeded the estimated total annual catch of these stocks in 1981 and 1982. Reduction of groundfish fisheries in statistical areas Bering I and II during the first, early portion of the second, and fourth quarters of the year would decrease incidental chinook catches, but would also result in substantial reductions in groundfish catches.

Overall classification accuracies for six-, five-, and four-region linear discriminant models based on the scale patterns of freshwater age 0. chinook were low (51.5%, 55.3%, and 59.9%, respectively). Low accuracies in these models may be related to close geographic proximity of the regional standards or inappropriate regional stock categories. Reasonably high accuracies (>70%) for some of the regional standards or stock categories indicate that scale pattern analysis may be a feasible technique for stock identification of freshwater age 0. chinook salmon in mixed stock fisheries, but additional research is needed.

KEY WORDS

Chinook salmon (Oncorhynchus tshawytscha)

Scale pattern analysis

Stock identification

Foreign groundfish fishery

Alaska Fishery Conservation Zone

Bering Sea

Interception estimates

Age composition estimates

Regional stock proportion estimates

Incidental chinook catch estimates

REFERENCES

- Berger, J., J. Wall, and R. Nelson, Jr. 1984. Summary of U.S. observer sampling of foreign and joint-venture fisheries in the northeast Pacific Ocean and eastern Bering Sea, 1983. [Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Vancouver, B.C., Canada, October 1984.] Northwest and Alaska Fisheries Center, National Marine Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.
- Brown, M. B., L. Engelman, J. W. Frane, M. A. Hill, R. I. Jennrich, and J. D. Toporek. 1983. BMDP statistical software, University California Press, Berkeley. 733 pp.
- Cook, R. C. 1982. Stock identification of sockeye salmon (Oncorhynchus nerka) with scale pattern recognition. *Can. J. Fish. Aquat. Sci.* 39:611-617.
- Cook, R. C. 1983. Simulation and application of stock composition estimators. *Can. J. Fish. Aquat. Sci.* 40(12):2113-2118.
- Cook, R. C., and G. E. Lord. 1978. Identification of stocks of Bristol Bay sockeye salmon, Oncorhynchus nerka, by evaluating scale patterns with a polynomial discriminant method. *Fish. Bull.* 76:415-423.
- Fraser, F. J., P. J. Starr, and A. Y. Fedorenko. 1982. A review of the chinook and coho salmon of the Fraser River. *Can. Tech. Rep. Fish. and Aquat. Sci.*, 1126. 130 pp.
- Harris, C. K., and W. G. Meyer. 1982. Interceptions of North American sockeye salmon by the Japanese landbased driftnet fishery, 1972-1981. 49 pp. (Document submitted to 1982 Annual Meeting of the International North Pacific Fisheries Commission, November 1982, Tokyo, Japan.) Fisheries Research Institute, University of Washington, Seattle.
- Major, R. L., S. Murai, and J. Lyons. 1977. Scale studies to identify Asian and Western Alaskan chinook salmon. *Int. N. Pac. Fish. Comm., Annual Rep.* 1975. 68-71 pp.
- Meyer, W. G., and C. K. Harris. 1983. Interceptions of North American and Bristol Bay sockeye salmon by the Japanese landbased driftnet fishery, 1972-1981. 58 pp. (Document submitted to 1983 Annual Meeting of the International North Pacific Fisheries Commission, November 1983, Anchorage, U.S.A.) University of Washington, Fisheries Research Institute, FRI-UW-8316. Seattle.
- Myers, K. W., and D. E. Rogers. 1982. Determination of stock origins of chinook salmon incidentally caught in foreign trawls in the Alaska FCZ. Annual Report, Oct. 1981-Sept. 1982, Contr. No. 81-5,

- North Pacific Fishery Management Council. 64 pp. Univ. Washington, Fish. Res. Inst., FRI-UW-8215, Seattle, WA 98195.
- Myers, K. W., and D. E. Rogers. 1983. Determination of stock origins of chinook salmon incidentally caught in foreign trawls in the Alaska FCZ. Final Report, Sept. 1983, Contr. No. 81-5, North Pacific Fishery Management Council. 131 pp. Univ. Washington, Fish. Res. Inst. FRI-UW-8318, Seattle, WA 98194.
- Nelson, R., Jr., R. French, and J. Wall. 1980. Summary of U.S. observer sampling on foreign fishing vessels in Bering Sea/Aleutian Islands region, 1979. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska. October 1980.) 85 pp. Northwest and Alaska Fisheries Center, Nat. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.
- Nelson, R., Jr., R. French, and J. Wall. 1981a. Sampling by U.S. observers on foreign fishing vessels in the eastern Bering Sea and Aleutian Island region, 1977-78. Mar. Fish. Rev. 43(5):1-19.
- Nelson, R., Jr., R. French, and J. Wall. 1981b. Summary of U.S. observer sampling on foreign fishing vessels in the Bering Sea/Aleutian Islands region, 1980. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Vancouver, B.C., Canada, September 1981.) 69 pp. Northwest and Alaska Fish. Center, Nat. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.
- Nelson, R., Jr., J. Wall, and J. Berger. 1982. Summary of U.S. observer sampling of foreign and joint venture fisheries in the Bering Sea/Aleutian Islands region, 1981. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Tokyo, Japan, October 1982.) Northwest and Alaska Fisheries Center, Nat. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.
- Nelson, R., Jr., J. Wall, and J. Berger. 1983. Summary of U.S. observer sampling of foreign and joint-venture fisheries in the Northeast Pacific Ocean and Eastern Bering Sea, 1982. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska, October 1983.) Northwest and Alaska Fisheries Center, Nat. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.
- Pella, J. J., and T. L. Robertson. 1979. Assessment of composition of stock mixtures. Fish. Bull. 77(2):387-398.
- Wall, J., R. French, and R. Nelson, Jr. 1980. Observations of foreign fishing fleets in the Gulf of Alaska, 1979. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska, September 1980.) 78 pp. Northwest

and Alaska Fish. Center, Nat. Mar. Fish. Serv., NOAA, 2725
Mointlake Blvd. E., Seattle, WA 98112.

Wall, J., R. French, and R. Nelson, Jr. 1981a. Foreign fisheries in
the Gulf of Alaska, 1977-78. Mar. Fish. Rev. 43(5):20-35.

Wall, J., R. French, and R. Nelson, Jr. 1981b. Observations of foreign
fishing fleets in the Gulf of Alaska, 1980. (Document submitted to
the Annual Meeting of the International North Pacific Fisheries
Commission, Vancouver, B.C., Canada, September 1981.) 60 pp.
Northwest and Alaska Fisheries Center, Nat. Mar. Fish. Serv., NOAA,
2725 Montlake Blvd. E., Seattle, WA 98112.

Wall, J., R. Nelson, Jr., and J. Berger. 1982. Observations of foreign
fishing fleets in the Gulf of Alaska, 1981. (Document submitted to
the Annual Meeting of the International North Pacific Fisheries
Commission, Vancouver, B.C., Canada, October 1982.) Northwest and
Alaska Fisheries Center, Nat. Mar. Fish. Serv., NOAA, 2725 Montlake
Blvd. E., Seattle, WA 98112.

Wilcock, J. A. 1984. Origins of chinook salmon (Oncorhynchus
tschawytscha Walbaum) in the Yukon River fisheries, 1983. Alaska
Dept. Fish. and Game, Info. Leaf. 243. 30 pp.

FIGURES AND TABLES

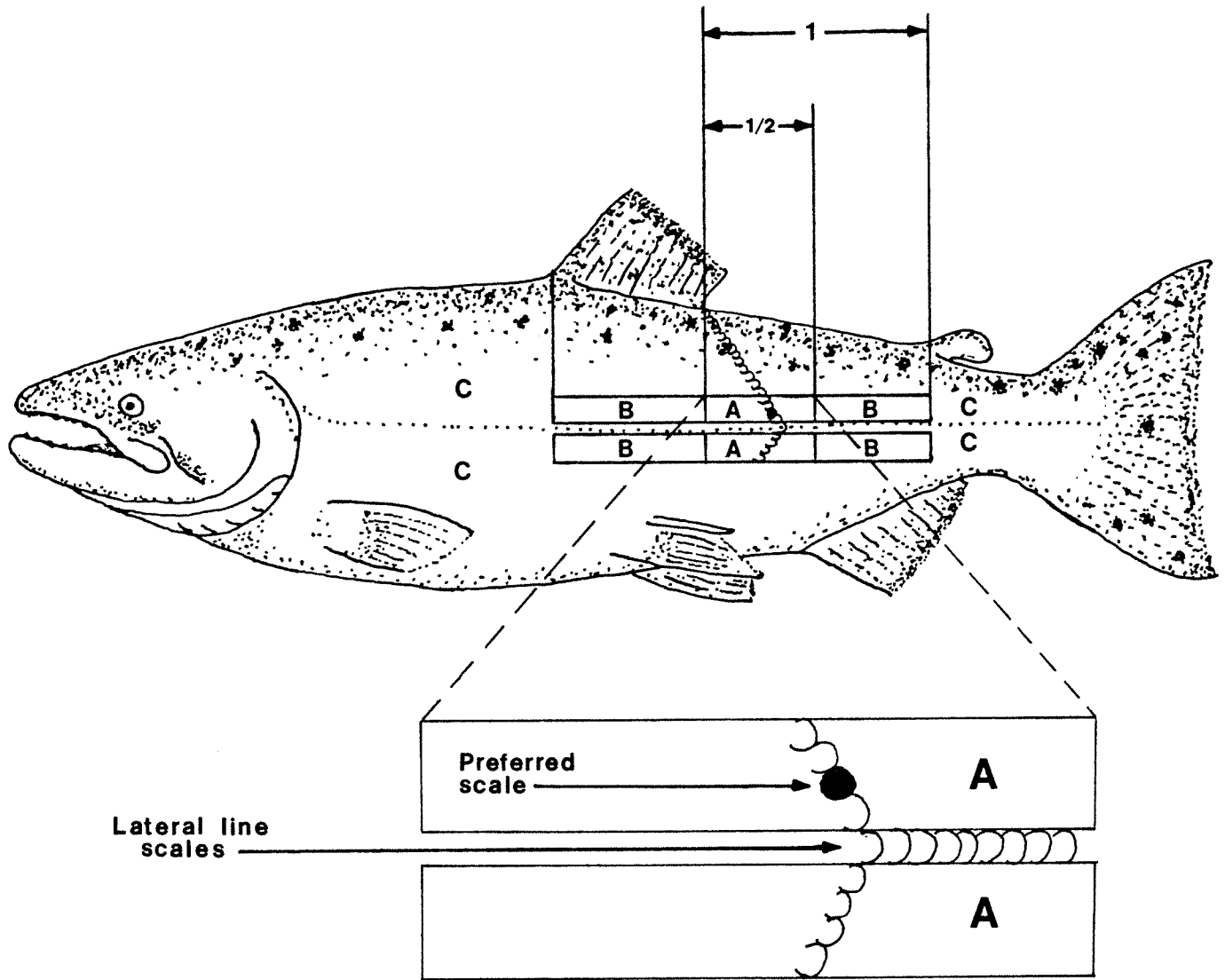
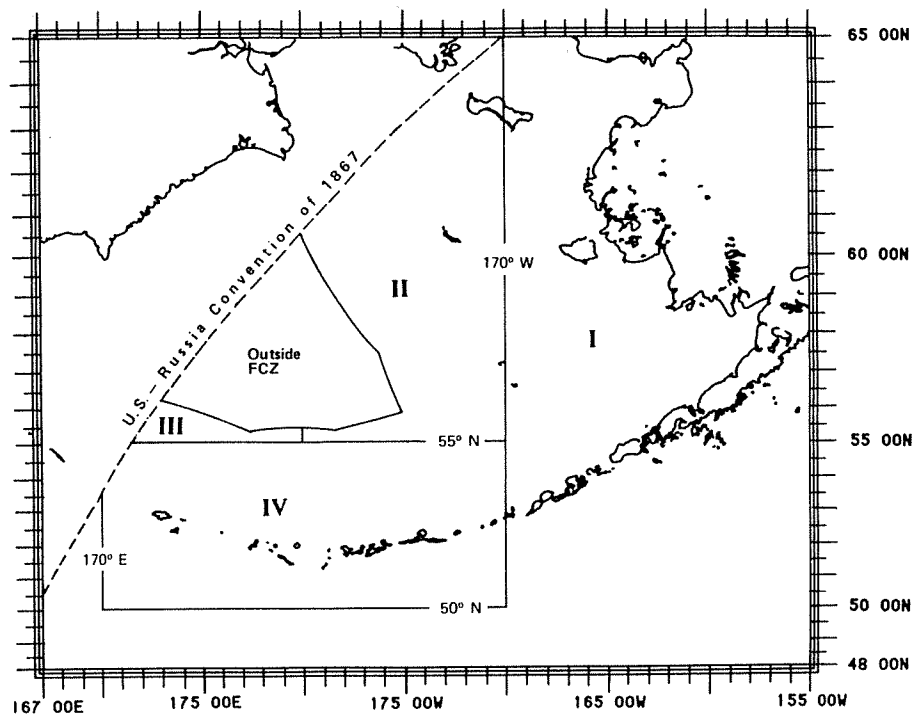


Figure 1. Area of the salmonid's body designated as "preferred" (Area A) by the International North Pacific Fisheries Commission. Note the location of the "preferred" scale along the diagonal scale line running from the posterior edge of the dorsal fin to the second scale row above the lateral line. Whenever possible, scales should be taken from Area A.

A. Bering Sea Region



B. Gulf of Alaska Region

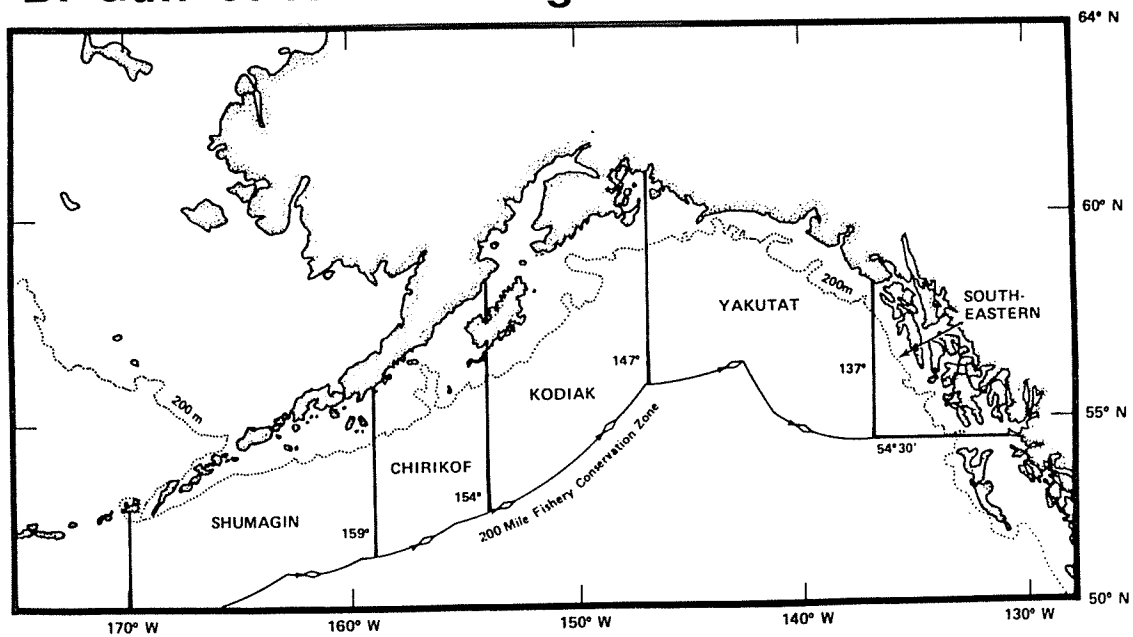


Fig. 2. U.S. statistical areas in the A) Bering Sea region and B) Gulf of Alaska region (from Berger et al. 1984).

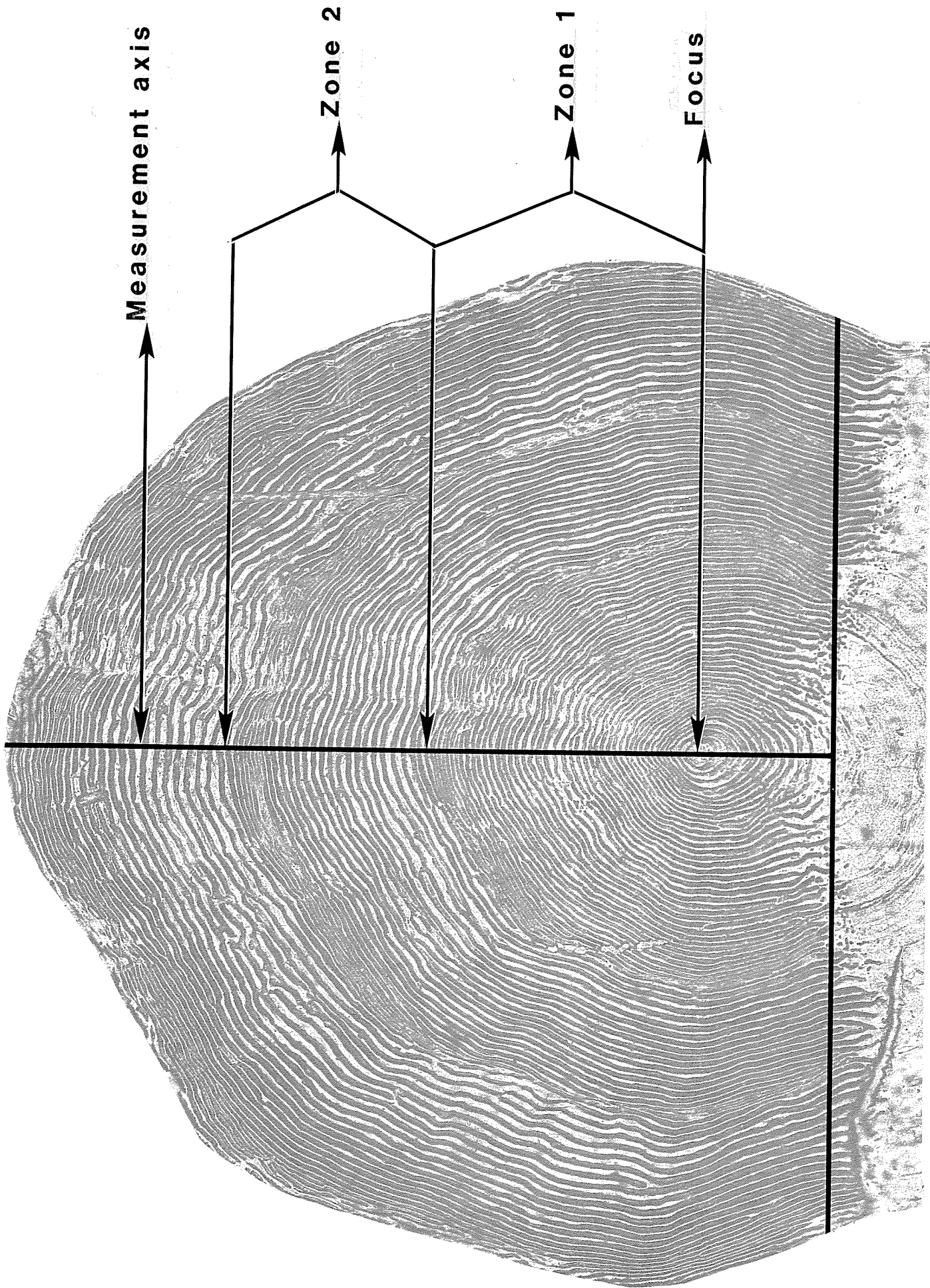


Fig. 3. Measurement axis and life history zones measured for scale pattern analyses of freshwater age 0 chinook salmon.

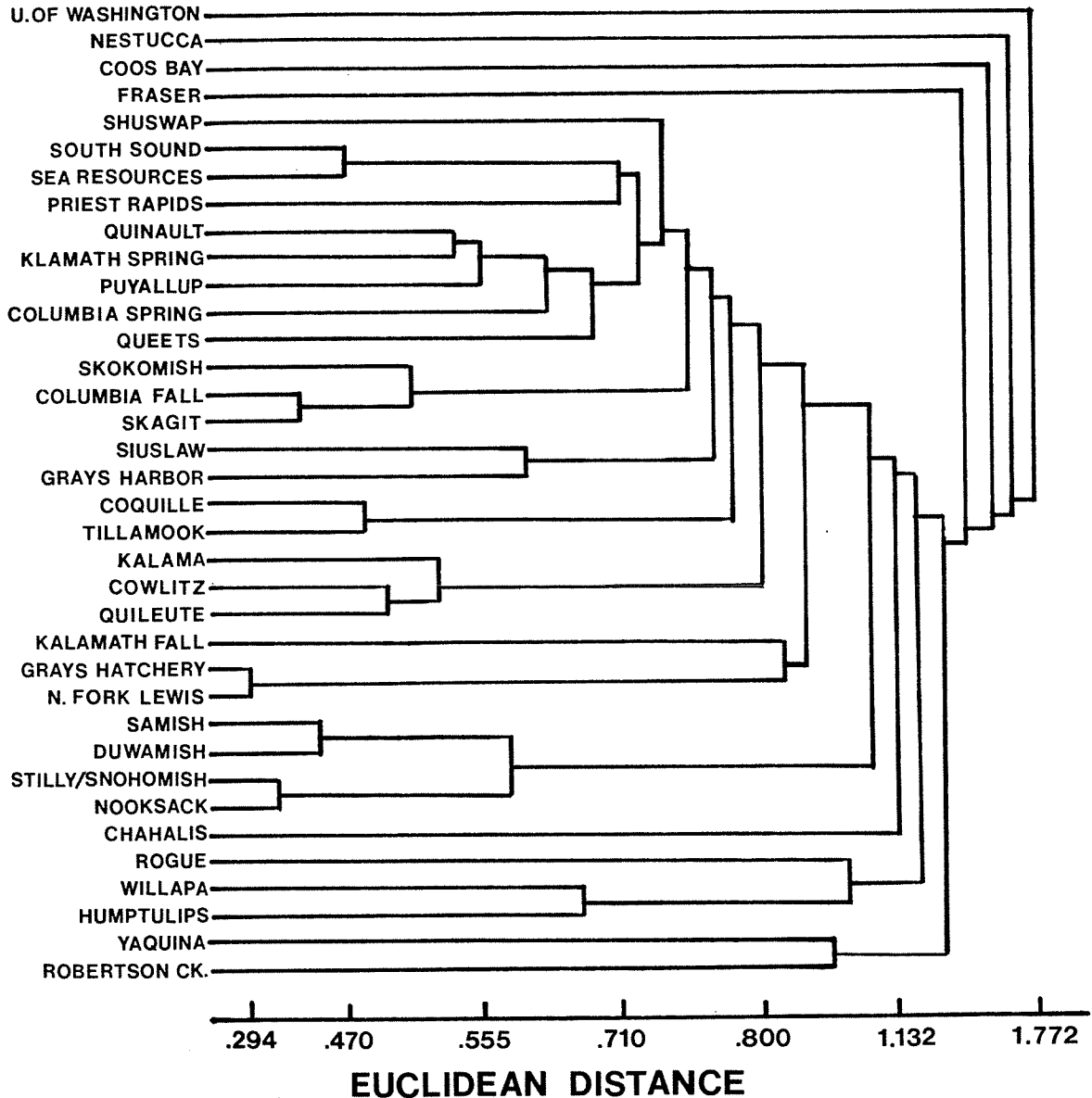


Fig. 4. Tree diagram describing the sequence of cluster formation for a single linkage cluster analysis of four basic scale characters from 36 different stocks or scale samples of age 0.3 chinook salmon in 1982.

Table 1. Estimated total incidental catch of Pacific salmon (*Oncorhynchus* sp.), species composition of total catch, and catch of chinook salmon (*O. tshawytscha*) in the foreign groundfish fishery in the Bering Sea/Aleutian Islands and Gulf of Alaska regions, 1977-83.

Region	Year	Total catch ¹		Species composition (%) ²						Chinook catch	
		No.	Metric tons	Chinook	Chum	Sockeye	Pink	Coho	No.	Metric tons	
Bering Sea/ Aleutian Islands	1977	47,840	198	91.0	9.0	0.0	0.0	0.0	0.0	43,534	180
	1978	44,548	137	87.8	10.0	-	-	-	-	39,113	120
	1979	107,706	340	93.2	5.7	-	-	-	-	100,382	317
	1980	120,104	381	94.2	5.6	-	-	-	-	113,138	359
	1981	42,337	137	84.8	13.7	0.6	0.2	0.8	-	35,902	116
	1982	21,241	85	65.7	33.5	-	-	-	-	13,955	56
	1983	18,173	66	54.0	45.1	0.1	0.1	0.7	-	9,813	36
	Gulf of Alaska	1977	5,272	19	91.0	9.0	0.0	0.0	0.0	0.0	4,798
	1978	45,603	131	93.1	2.1	2.2	1.0	1.6	1.6	42,456	122
	1979	20,410	69	82.7	14.1	0.2	0.3	2.7	2.7	16,879	57
	1980	35,901	107	87.9	11.6	0.0	0.1	0.4	0.4	31,557	94
	1981	30,860	96	92.6	6.4	0.0	0.1	1.0	1.0	28,576	89
	1982	5,556	19	84.9	12.8	0.1	0.1	2.2	2.2	4,717	16
	1983	9,621	32	61.8	37.1	0.2	0.1	0.8	0.8	5,946	20

¹Source of estimated total catches for the Bering Sea/Aleutians and the Gulf of Alaska (1977-83): Berger et al. (1984).

²Source of estimated species composition for the Bering Sea/Aleutians for 1977-78: Nelson et al. (1981a, 1979); Nelson et al. (1980); 1980: Nelson et al. (1981b); 1981: Nelson et al. (1982); 1982: Nelson et al. (1983), and 1983: Berger et al. (1984). Estimated species composition for the Gulf of Alaska for 1977-78: Wall et al. (1981a); 1979: Wall et al. (1980); 1980: Wall et al. (1981b); 1981: Wall et al. (1982); 1982: Nelson et al. (1983); and 1983: Berger et al. (1984).

Table 2. Criteria for identifying INPFC preferred body area chinook salmon scales.

-
1. Size: Preferred scales are often larger in size than non-preferred scales from the same fish or fish of equivalent size.
 2. Shape of scale: Preferred scales are fairly symmetrical and rounded in shape.
 3. Appearance of anterior and posterior portions of the scale: The upper surface of the anterior portion of preferred area scales is sculptured with bony ridges (circuli) and grooves (interspaces) and the posterior portion is unsculptured.
 4. Appearance of the boundary between the sculptured and unsculptured portions of the scale: Preferred scales have a relatively straight boundary ($140-170^\circ$) between sculptured and unsculptured portions of the scale, and ocean circuli near the outer edge of the scale do not extend into the posterior field.
 5. Size of unsculptured field: Typically, the unsculptured field is $1/4$ to $1/3$ the total size of a preferred scale that has not undergone resorption.
 6. Shape of the focus: Preferred scales have a circular or nearly circular focus.
 7. Number of complete circuli around the focus: Preferred scales have fewer complete and/or broken circuli around the focus than non-preferred scales. (A general guideline for chinook is approximately 12 or fewer complete and/or 12 or fewer broken circuli around the focus.)
-

Table 3. Classification matrices calculated using Cook's (1982) direct density method and two different values of the smoothing parameter (σ). The same test data, scale characters, and a priori probabilities were used for both analyses.

a) $\sigma = 0.25$				
Overall classificatory accuracy = 72.8%				
Calculated decision	Correct decision			
	Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.
Asia	169	9	10	3
Western AK	13	157	40	7
Central AK	17	23	116	50
Southeast AK/ British Col.	1	10	33	138
Total	200	199	199	198

b) $\sigma = 1.0$				
Overall classificatory accuracy = 71.7%				
Calculated decision	Correct decision			
	Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.
Asia	182	7	21	6
Western AK	11	156	33	8
Central AK	7	27	106	57
Southeast AK/ British Col.	0	9	39	127
Total	200	199	199	198

Table 4. Sixty scale characters calculated for use in the scale pattern analyses.

Character No.	Description ^a
1	Size Zone 1
2	Size Zone 2
3	Size Zone 3
4	Size Zone 1 + size Zone 2
5	Size Zone 2 + size Zone 3
6	Size Zone 1 + size Zone 2 + size Zone 3
7	No. circuli Zone 1 + no. circuli Zone 2 + no. circuli Zone 3
8	Size zone 2/(size Zone 1 + size Zone 2 + size Zone 3)
9	(Size Zone 1 + size Zone 2 + size Zone 3)/(no. circuli Zone 1 + no. circuli Zone 2 + no. circuli Zone 3)
10	(Size Zone 1 + size Zone 2)/(size Zone 1 + size Zone 2 + size Zone 3)
11	(Size Zone 2 + size Zone 3)/(size Zone 1 + size Zone 2 + size Zone 3)
12	No. circuli Zone 1
13	No. circuli Zone 2
14	No. circuli Zone 3
15	No. circuli Zone 1 + no. circuli Zone 2
16	No. circuli Zone 2 + no. circuli 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 + size Zone 2)/(no. circuli Zone 1 + no. circuli Zone 2)
21	(Size Zone 2 + size Zone 3)/(no. circuli Zone 2 + no. circuli Zone 3)
22	Distance C1 to C3 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
23	Distance C4 to C6 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
24	Distance C7 to C9 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
25	Distance C10 to C12 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
26	Distance C13 to C15 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
27	Distance C16 to C18 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
28	Distance C19 to C21 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
29	Distance C22 to C24 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
30	Distance C25 to C27 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
31	Distance C28 to C30 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
32	Distance C31 to C33 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
33	Distance C34 to C36 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
34	Distance C1 to C9 in Zones 2+3 (= character Nos. 49 + 50 + 51)
35	Distance C10 to C18 in Zones 2+3 (= character Nos. 52 + 53 + 54)
36	Distance C19 to C27 in Zones 2+3 (= character Nos. 55 + 56 + 57)
37	Distance C28 to C36 in Zones 2+3 (= character Nos. 58 + 59 + 60)
38	Radius of focus
39	Distance C2 - C4 in Zone 1
40	Distance C5 - C7 in Zone 1

Table 4. Sixty scale characters calculated for use in the scale pattern analyses - continued.

Character No.	Description ^a
41	Distance C8 - C10 in Zone 1
42	Distance C11 - C13 in Zone 1
43	Distance C14 - C16 in Zone 1
44	Distance C2 - C4 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
45	Distance C5 - C7 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
46	Distance C8 - C10 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
47	Distance C11 - C13 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
48	Distance C14 - C16 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
49	Distance C1 to C3 in Zones 2+3
50	Distance C4 to C6 in Zones 2+3
51	Distance C7 to C9 in Zones 2+3
52	Distance C10 to C12 in Zones 2+3
53	Distance C13 to C15 in Zones 2+3
54	Distance C16 to C18 in Zones 2+3
55	Distance C19 to C21 in Zones 2+3
56	Distance C22 to C24 in Zones 2+3
57	Distance C25 to C27 in Zones 2+3
58	Distance C28 to C30 in Zones 2+3
59	Distance C31 to C33 in Zones 2+3
60	Distance C34 to C36 in Zones 2+3

^aZone 1: The area of the scale from the center of the focus to the outer edge of the last circulus in the freshwater annulus.

Zone 2: The area of the scale from the outer edge of the last circulus in the freshwater annulus to the outer edge of the last freshwater circulus.

Zone 3: The area of the scale from the outer edge of the last freshwater circulus to the outer edge of the last circulus in the first ocean annulus.

Cn: The nth circulus from the beginning of the indicated zone.

Table 5. The number of preferred body area scales by U.S. statistical area, month, and age class in samples collected by U.S. observers in 1982. A "T" after the decimal point represents the total count of fish of a particular freshwater age class. The letter "R" represents scales that are regenerated or otherwise unusable for scale pattern analyses - cont'd.

Stat. Area	Month	0.1	0.2	0.3	0.4	0.5	1.1	1.2	1.3	1.4	1.5	Total			R	Total
												1.T	2.T	usable		
CHIRIKOF	JAN	2			2			4	1		5			2		2
	FEB	5	2		7			4	2		6		12			12
	MAR	2			2			4	2		6		8		3	11
	APR	6			6			2			2		8			8
	MAY	1			1			1			1		2			2
	JUN	2	2	2	5				1		1		6		1	7
	JUL	3	2	2	6								6		1	7
	AUG							1			1		1			1
	SEP	2	2	2	4	5	4	4	4		13		17		1	18
	OCT	1	3	4	8	8	12	9	1		30	2	40		9	49
	NOV	9	26	7	42	19	9	1			29		71		6	77
KODIAK	APR	1			1									1		1
	JUN	1			1			1		1		2			1	3
	AUG	2		1	3			1	3		4		7			7
	SEP	1		1	1			1	1		2		3		5	8
	OCT	2	3	3	6	3	5	4	4		12		18		7	25
	NOV	1	4	3	9	3	6	0			9		18		4	22
YAKUTAT	JUL			1	1									1		1
TOTAL		13	96	39	5	153	65	220	280	60	6	631	3	187	91	878

Table 6. Decision arrays for a) mature brood year 1977 chinook salmon (ages 1.3 in 1982 and 1.4 in 1983) used to classify age 1.3 chinook in 1982 samples from the foreign groundfish fishery, and b) mature brood year 1978 chinook salmon (age 1.3 in 1983) used to classify age 1.2 chinook in 1982 samples from the foreign groundfish fishery. The overall classification accuracy was calculated as the unweighted mean of the accuracies on the diagonal of the decision array.

a) Brood year 1977				
Variables = 27, 9, 34, 17, 58, 16, 31, 35, 28, 44, 42, 21, 36, 47, 25, 26 (Table 4)				
Overall accuracy = 80.0%				
Calculated decision	Correct decision (%)			
	Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.
Asia	174(87.0)	10(5.0)	11(5.5)	1(0.5)
Western Alaska	15(7.5)	146(73.4)	22(11.1)	7(3.5)
Central Alaska	10(5.0)	34(17.1)	147(73.9)	20(10.1)
Southeast Alaska/ British Columbia	1(0.5)	9(4.5)	19(9.5)	170(85.9)
Total	200	199	199	198
b) Brood year 1978				
Variables = 9, 7, 34, 16, 6, 36, 31, 42, 30 (Table 4)				
Overall accuracy = 76.6%				
Calculated decision	Correct decision (%)			
	Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.
Asia	161(80.9)	15(7.8)	27(16.4)	2(1.3)
Western Alaska	18(9.0)	147(76.2)	13(7.9)	2(1.3)
Central Alaska	18(9.0)	30(15.5)	114(69.1)	27(17.3)
Southeast Alaska/ British Columbia	2(1.0)	1(0.5)	11(6.7)	125(80.1)
Total	199	193	165	156

Table 7. Means and standard deviations of scale characters used as variables in a) brood year 1977 and b) brood year 1978 models used to classify 1982 incidental chinook catches to region of origin. Measurements are in units of inches at 104X.

Character No. ^{1/} sample size (n)	Mean (standard deviation)			
	Asia	Western Alaska	Central Alaska	Southeast Alaska/ British Columbia
a) Brood year 1977				
27	0.115(0.016)	0.082(0.013)	0.084(0.014)	0.074(0.012)
9	151.172(14.530)	158.456(12.141)	149.877(11.403)	136.036(11.748)
34	1080.705(194.412)	1161.558(164.845)	1181.869(165.825)	1270.379(195.486)
17	114.730(17.161)	115.816(13.709)	125.901(17.527)	101.600(14.029)
58	71.405(172.912)	515.271(174.318)	388.965(197.400)	369.207(122.441)
16	26.795(2.574)	34.864(3.907)	32.834(4.283)	35.732(4.414)
31	0.012(0.029)	0.070(0.023)	0.058(0.029)	0.056(0.019)
35	1713.100(241.355)	1612.452(219.489)	1570.020(164.712)	1485.763(164.530)
28	0.114(0.018)	0.084(0.012)	0.082(0.013)	0.072(0.013)
44	0.065(0.012)	0.057(0.009)	0.063(0.011)	0.057(0.010)
42	19.140(63.690)	42.588(90.535)	37.563(89.454)	118.611(107.240)
21	164.805(18.310)	172.546(14.545)	158.219(12.424)	149.008(13.214)
36	1359.270(472.333)	1791.492(220.495)	1434.171(282.769)	1320.126(165.224)
47	0.003(0.010)	0.006(0.013)	0.006(0.013)	0.018(0.016)
25	0.094(0.017)	0.067(0.012)	0.076(0.015)	0.076(0.013)
26	0.106(0.015)	0.074(0.015)	0.083(0.014)	0.076(0.012)
n	200	199	199	198
b) Brood year 1978				
9	149.801(12.711)	165.997(12.597)	152.046(9.631)	134.322(11.947)
7	36.412(3.809)	42.140(3.715)	42.491(4.898)	47.192(4.294)
34	1061.935(186.555)	1217.275(209.385)	1261.673(158.807)	1267.744(173.415)
16	27.231(3.302)	31.088(3.473)	32.097(4.579)	33.987(3.211)
6	5450.101(694.438)	6982.922(696.986)	6459.861(832.981)	633.333(751.882)
36	1359.412(473.487)	1839.155(355.918)	1427.485(292.474)	1360.904(194.671)
31	0.019(0.035)	0.056(0.035)	0.052(0.033)	0.059(0.018)
42	22.317(69.368)	41.860(92.210)	44.588(98.161)	113.917(107.361)
30	0.053(0.046)	0.075(0.031)	0.063(0.028)	0.067(0.011)
n	199	193	165	156

^{1/}Scale characters are listed by number and described in Table 4.

Table 8. Estimates of regional stock proportions of a) brood year 1977 (age 1.3) and b) brood year 1978 (age 1.2) chinook salmon caught in 1982 by the foreign groundfish fishery in the Bering Sea FCZ.

Age Class	Area	Month	Sample size	Stock proportion estimates (90% confidence intervals)				
				Asia	Western Alaska	Central Alaska	Southeast Alaska/ British Columbia	
a) Brood year 1977								
1.3	Bering I	APR	32	6.0(0.0-22.0)	69.5(34.3-100.0)	11.3(0.0-43.3)	13.2(0.0-33.6)	
"	Bering II	JAN	28	20.4(0.0-44.2)	64.7(27.2-100.0)	6.7(0.0-38.0)	8.2(0.0-26.6)	
"	"	FEB	38	12.2(0.0-30.7)	79.1(46.4-100.0)	8.7(0.0-38.3)	0.0(0.0-9.1)	
"	"	MAR	51	12.1(0.0-28.0)	60.8(32.0-89.6)	27.1(0.0-55.6)	0.0(0.0-9.4)	
"	"	NOV	25	32.5(3.7-61.3)	41.6(3.5-79.7)	25.9(0.0-63.1)	0.0(0.0-12.8)	
b) Brood year 1978								
1.2	Bering I	OCT	32	22.4(0.0-50.2)	18.3(0.0-43.4)	31.1(0.0-68.7)	28.2(2.5-53.9)	

Table 9. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1979 foreign groundfish fishery in Bering Sea statistical area I. n = size of scale sample used for age composition estimates.

Month	No.		% Age composition (no. in catch)										n
	salmon	chinook	0.2	0.3	1.0	1.1	1.2	1.3	1.4	2.2			
Jan.	127	100.0	127				50.0 (64)	50.0 (63)				0A	
Feb.	178	100.0	178					100.0 (178)				2	
Mar.	2,636	100.0	2,636				100.0 (2,636)					1	
Apr.	41	74.9C	31	5.0 (2)			20.0 (6)	47.5 (15)	27.5 (8)			0B	
May	150	75.0	112					75.0 (84)	25.0 (28)			4	
June	242	74.8	181	10.0 (18)			40.0 (73)	20.0 (36)	30.0 (54)			10	
July	193	72.1	139	10.5 (15)			57.9 (80)	31.6 (44)				19	
Aug.	554	92.6	513	5.9 (30)	17.6 (90)		67.7 (348)	5.9 (30)				34	
Sept.	1,488	94.9	1,412	11.1 (157)	7.9 (111)	0.0 (0)	66.7 (942)	11.1 (157)	0.0 (0)			63	
Oct.	9,316	89.6	8,347	4.0 (334)	1.3 (109)	0.0 (0)	74.5 (6,219)	8.1 (676)	0.7 (58)			149	
Nov.	4,989	98.8	4,929				33.3 (1,641)	66.7 (3,288)				3	
Dec.	114	96.0	109			11.8 (13)	29.4 (64)					17	
Total	20,028	93.5	18,714	2.8 (521)	1.8 (345)	0.1 (13)	14.0 (2,626)	73.3 (13,720)	6.9 (1,283)	0.8 (148)		0.3 (58)	

A Average of quarterly (JAN-MAR) age composition estimates was used.

B Average of quarterly (APR-JUN) age composition estimates was used.

C Average of quarterly (APR-JUN) estimates, as no length frequency data were collected.

Table 10. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1979 foreign groundfish fishery in Bering Sea statistical area II. n = size of scale sample used for age composition estimates.

Month	No. salmon	% chinook	No. chinook	% Age composition (no. in catch)												n		
				0.2	0.3	0.4	1.0	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2		2.3	2.4
Jan.	14,327	100.0	14,327	0.7 (100)	61.8 (8,854)	32.5 (4,656)	3.8 (545)	0.6 (86)							0.6 (86)			157
Feb.	42,269	99.4	42,015	0.3 (126)	70.8 (29,747)	22.3 (9,369)	3.3 (1,387)	0.4 (168)	1.5 (630)						0.7 (294)	0.4 (168)		1,141
Mar.	5,666	97.9	5,547	0.7 (39)	57.2 (3,173)	32.4 (1,797)	5.5 (305)	1.4 (78)	1.4 (78)						0.7 (39)			145
Apr.	3,314	95.9	3,178	1.9 (60)	60.9 (1,935)	26.6 (845)	6.8 (216)	1.4 (45)	1.0 (32)									207
May	553	89.3	494	3.2 (16)	71.4 (352)	12.7 (63)	4.8 (24)	1.6 (8)	6.3 (31)									63
June	108	50.0	54		100.0 (54)													1
July	25	0.0 ^A	0															0
Aug.	788	0.0 ^A	0															0
Sept.	835	0.0	0															0
Oct.	3,462	35.5	1,229	5.9 (72)	82.3 (1,012)	11.8 (145)												17
Nov.	5,176	60.7	3,142		3.2 (101)	24.2 (760)	4.2 (132)											95
Dec.	10,666	95.4	10,175		2.9 (295)	25.0 (600)	5.9 (600)								2.9 (295)			68
Total	87,189	91.9	80,161	0.1 (76)	5.1 (396)	67.0 (53,686)	22.0 (17,607)	3.1 (2,477)	0.5 (385)	0.1 (42)	0.1 (42)	0.1 (42)	0.1 (42)	0.1 (42)	0.9 (714)	0.2 (168)	0.2 (42)	0.1 (42)

^AAverage of quarterly (JUL-SEP) estimate, as no length frequency data were collected.

Table 11. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1979 foreign groundfish fishery in Bering Sea statistical area IV. Age composition estimates are the average of quarterly estimates for statistical areas Bering I and II in 1979.

Month	No. salmon	% chinook	No. chinook	% Age composition (no. in catch)										
				0.2	0.3	1.0	1.1	1.2	1.3	1.4	1.5	1.6	2.2	
Jan.	1	100.0 ^A	1		0.3			0.5	56.6	39.6	2.1	0.4	0.1	0.4
					(0)		(0)	(0)	(1)	(0)	(0)	(0)	(0)	(0)
Feb.	2	100.0 ^A	2		0.3			0.5	56.6	39.6	2.1	0.4	0.1	0.4
					(0)		(0)	(0)	(1)	(1)	(0)	(0)	(0)	(0)
Mar.	11	100.0	11		0.3			0.5	56.6	39.6	2.1	0.4	0.1	0.4
					(0)		(0)	(0)	(6)	(4)	(1)	(0)	(0)	(0)
Apr.	13	50.0 ^A	6	0.2	3.4		1.2	48.7	30.3	30.3	15.7	0.5		
				(0)	(0)		(0)	(3)	(2)	(2)	(1)	(0)		
May	71	50.0	36	0.2	3.4		1.2	48.7	30.3	30.3	15.7	0.5		
				(0)	(1)		(0)	(18)	(11)	(6)	(6)	(0)		
June	14	50.0 ^A	7	0.2	3.4		1.2	48.7	30.3	30.3	15.7	0.5		
				(0)	(0)		(0)	(4)	(2)	(2)	(1)	(0)		
July	8	43.3 ^B	4	5.7	12.0		2.0	64.1	16.2	16.2	0.1			
				(0)	(0)		(0)	(3)	(1)	(1)	(0)			
Aug.	22	43.3 ^B	10	5.7	12.0		2.0	64.1	16.2	16.2	0.1			
				(1)	(1)		(0)	(6)	(2)	(2)	(0)			
Sept.	14	43.3 ^B	6	5.7	12.0		2.0	64.1	16.2	16.2	0.1			
				(0)	(1)		(0)	(4)	(1)	(1)	(0)			
Oct.	109	0.0	0											
Nov.	61	100.0	61	0.8	1.2	3.0	20.4	68.9	5.0	5.0	0.1			0.6
				(1)	(1)	(2)	(12)	(42)	(3)	(3)	(0)			(0)
Total	489	62.8	307	0.9	2.0	2.3	14.7	65.2	11.4	11.4	3.2	0.0	0.0	0.3
				(3)	(6)	(7)	(45)	(200)	(35)	(35)	(10)	(0)	(0)	(1)

^AAverage of quarterly estimates, as no length frequency data were collected.

^BAverage of quarterly estimates for statistical areas Bering I and II in 1979.

Table 12. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1981 foreign groundfish fishery in Bering Sea statistical area I. n = size of scale sample used for age composition estimates.

Month	No. salmon	% chinook	No. chinook	% Age composition (no. in catch)										n							
				0.0	0.1	0.2	0.3	0.4	1.1	1.2	1.3	1.4	1.5		2.1	2.2	2.3				
Jan.	5,460	70.1	3,829			3.6 (138)	3.6 (138)					75.0 (2,872)	17.8 (681)								28
Feb.	743	75.4	560				1.7 (10)	1.7 (10)				38.3 (214)	43.3 (242)	13.3 (74)						1.7 (10)	60
Mar.	1,492	88.9	1,327				1.4 (19)	1.4 (19)		2.8 (37)		38.0 (504)	42.3 (560)	11.3 (150)	1.4 (19)					1.4 (19)	71
Apr.	769	99.2	763				3.1 (24)	3.1 (24)		3.1 (24)		65.6 (500)	21.9 (167)	6.3 (48)							32
May	137	82.5	113			12.5 (14)	8.3 (9)	8.3 (9)				12.5 (14)	50.0 (58)	8.3 (9)							24
June	128	31.2	40			22.2 (9)	22.2 (9)					33.3 (14)	22.2 (9)	11.1 (4)							9
July	303	65.4	198				33.3 (66)	33.3 (66)				16.7 (33)	50.0 (99)	16.7 (33)							6
Aug.	376	67.8	255			25.0 (64)	25.0 (64)					50.0 (127)	25.0 (64)	25.0 (64)							4
Sept.	631	72.7	459				6.7 (31)	6.7 (31)				20.0 (92)	46.7 (214)	6.7 (31)							15
Oct.	1,014	93.5	948				1.7 (16)	1.7 (16)				11.7 (111)	10.0 (95)	11.7 (95)							60
Nov.	3,111	84.1	2,615				3.3 (86)	3.3 (86)				18.4 (481)	61.6 (1,612)	7.8 (204)	0.4 (10)				0.4 (10)	2.4 (63)	245
Dec.	955	73.0	697									23.1 (161)	69.2 (482)	23.1 (161)						7.7 (54)	13
Total	15,119	78.1	11,804			3.4 (402)	4.3 (503)	0.2 (29)	7.8 (915)	60.5 (7,138)	18.7 (2,210)	2.4 (285)	0.2 (19)	0.1 (10)	1.2 (146)	0.0 (4)					

Table 13. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1981 foreign groundfish fishery in Bering Sea statistical area II. n = size of scale sample used for age composition estimates.

Month	No.		% Age composition (no. in catch)													n
	salmon	chinook	0.0	0.2	0.3	1.0	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	
Jan.	8,641	71.8	6,205	1.0 (62)	2.6 (161)			45.4 (2,817)	34.5 (2,141)	16.0 (993)			0.5 (31)			194
Feb.	4,776	79.5	3,797	2.7 (103)	1.8 (69)		0.9 (34)	42.8 (1,625)	33.9 (1,287)	16.1 (611)			0.9 (34)	0.9 (34)		112
Mar.	4,609	99.6	4,589	0.8 (37)			3.4 (156)	55.5 (2,547)	25.2 (1,156)	10.9 (500)	1.7 (78)		0.8 (37)		1.7 (78)	119
Apr.	4,247	99.4	4,223	0.6 (26)	0.6 (26)		0.3 (13)	67.7 (2,859)	20.3 (857)	7.1 (300)	0.6 (26)		1.5 (64)	0.6 (26)		325
May	848	97.1	823					21.3 (175)	31.9 (263)	42.6 (351)			2.1 (17)		2.1 (17)	10
June	7	85.7	6	0.3 (0)	0.3 (0)		0.2 (0)	44.5 (3)	26.1 (2)	24.8 (1)	0.3 (0)		1.8 (0)	0.3 (0)	1.4 (0)	0 ^A
July	75	85.3	64	10.0 (6)				80.0 (52)	10.0 (6)							0 ^B
Aug.	8	0.0	0													0
Sep.	258	43.0	111	10.0 (11)				80.0 (89)	10.0 (11)							10
Oct.	217	59.4	129					72.7 (93)	9.1 (12)	9.1 (12)				9.1 (12)		11
Nov.	200	46.5	93					100.0 (93)								5
Dec.	1,737	88.6	1,539	4.4 (68)	1.1 (17)		4.3 (66)	58.7 (903)	9.8 (151)	2.1 (32)			1.1 (17)			92
Total	25,623	84.2	21,579	0.3 (68)	1.2 (262)	1.2 (256)	0.3 (66)	52.2 (11,256)	27.3 (5,886)	12.9 (2,800)	0.5 (104)	0.1 (17)	0.9 (200)	0.3 (72)	0.6 (121)	

^AAverage of quarterly (APR-JUN) age composition estimates was used.

^BAverage of quarterly (JUL-SEP) age composition estimates was used.

Table 14. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1981 foreign groundfish fishery in Bering Sea statistical area IV. n = size of scale sample used for age composition estimates.

Month	No.		No. chinook	%	% Age composition (no. in catch)							n	
	salmon	chinook			0.1	0.2	0.3	1.1	1.2	1.3	2.2		
Jan.	21	0.0	0									0	
Feb.	134	17.2	23								100.0 (23)	0 ^A	
Mar.	32	6.3	2								100.0 (2)	2	
Apr.	489	100.0	489				9.1 (44)	9.1 (44)	63.6 (313)		9.1 (44)	9.1 (44)	11
May	0	0.0	0									0	
June	0	0.0	0									0	
July	8	37.5	3		1.1 (0)	11.4 (0)	15.0 (0)	3.3 (0)	50.6 (2)		18.6 (1)	0 ^B	
Aug.	70	0.0	0									0	
Sept.	26	7.7	2		1.1 (0)	11.4 (0)	15.0 (0)	3.3 (0)	50.6 (1)		18.6 (1)	0 ^B	
Oct.	309	16.8	52						40.0 (21)		60.0 (31)	5	
Nov.	113	4.4	5						75.0 (4)		25.0 (1)	4	
Dec.	393	30.5	120					100.0 (120)				1	
Total	1,595	43.6	696				6.3 (44)	23.5 (164)	49.0 (341)		14.8 (103)	6.3 (44)	

^AAverage of quarterly (JAN-MAR) age composition estimates was used.

^BAverage of quarterly (JUL-SEP) age composition estimates for statistical areas Bering I and II in 1981 was used.

Table 15. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1982 foreign groundfish fishery in Bering Sea statistical area I. n = size of scale sample used for age composition estimates.

Month	No.		% Age composition (no. in catch)										n
	salmon	chinook	% chinook	No. chinook	0.2	0.3	0.4	1.1	1.2	1.3	1.4	1.5	
Jan.	4,011	48.0	1,927							100.0 (1,927)			1
Feb.	238	100.0	238							100.0 (238)			0A
Mar.	888	48.1	427							100.0 (427)			0A
Apr.	702	100.0	702	8.2 (58)	4.9 (34)			29.5 (207)		52.5 (369)	1.6 (11)	3.3 (23)	67
May	79	88.6	70	17.2 (12)	3.4 (2)	3.4 (2)		34.5 (24)		27.6 (20)	13.8 (10)		29
June	20	80.0	16	33.3 (5)				58.3 (9)		8.3 (2)			12
July	151	7.3	11							100.0 (11)			1
Aug.	605	2.0	12	33.3 (4)				33.3 (4)		33.3 (4)			3
Sept.	458	12.0	55					37.5 (21)		62.5 (34)			8
Oct.	613	70.6	433	5.7 (25)	1.9 (8)		1.9 (8)	60.4 (262)		26.4 (114)	3.8 (16)		53
Nov.	735	94.8	697	3.9 (27)		2.0 (14)	19.6 (137)	41.2 (287)		33.3 (232)			51
Dec.	93	100.0	93				50.0 (46)			50.0 (47)			2
Total	8,593	54.5	4,681	2.8 (131)	0.9 (44)	0.3 (14)	4.1 (193)	17.4 (814)		73.2 (3,425)	0.8 (37)	0.5 (23)	

Average of quarterly (JAN-MAR) age composition estimates was used.

Table 16. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1982 foreign groundfish fishery in Bering Sea statistical area II. n = size of scale sample used for age composition estimates.

Month	No. salmon	% chinook	No. chinook	% Age composition (no. in catch)										n
				0.3	1.1	1.2	1.3	1.4	1.5	2.4				
Jan.	1,252	100.0	1,252	11.6 (145)	65.1 (815)	23.3 (292)							43	
Feb.	1,400	100.0	1,400	4.0 (56)	50.0 (700)	25.0 (350)	2.6 (36)	1.3 (18)					76	
Mar.	1,352	99.6	1,346	1.1 (15)	59.1 (795)	14.8 (199)	2.3 (31)						88	
Apr.	507	97.8	496	13.6 (67)	45.5 (226)	18.2 (90)							22	
May	80	76.2	61			100.0 (61)							2	
June	2	50.0	1	6.8 (0)	22.7 (0)	59.1 (1)							0 ^A	
July	34	64.7	22		100.0 (22)								0 ^B	
Aug.	2	0.0	0										0	
Sept.	108	5.6	6		100.0 (6)								1	
Oct.	742	6.7	50	50.0 (25)	50.0 (25)								2	
Nov.	2,029	37.0	750	2.4 (18)	61.0 (458)								41	
Dec.	4,709	89.2	4,200	41.2 (1,730)	47.0 (1,974)	11.8 (496)							21	
Total	12,217	78.4	9,584	0.3 (33)	2.1 (202)	28.7 (2,754)	52.4 (5,021)	15.5 (1,489)	0.7 (67)				0.2 (18)	

^AAverage of quarterly (APR-JUN) age composition estimates was used.

^BAverage of quarterly (JUL-SEP) age composition estimates was used.

Table 17. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1982 foreign groundfish fishery in Bering Sea statistical area III. n = size of scale sample used for age composition estimates.

Month	No.		% Age composition (no. in catch)										n
	salmon	chinook	0.2	0.3	0.4	1.1	1.2	1.3	1.4	1.5	2.4		
Jan.	2	50.0	1	0.1 (0)	0.9 (0)	38.7 (0)	52.7 (1)	7.0 (0)	0.5 (0)	0.1 (0)	0 ^A		
Feb.	2	50.0	1	0.1 (0)	0.9 (0)	38.7 (0)	52.7 (1)	7.0 (0)	0.5 (0)	0.1 (0)	0 ^A		
Mar.	<1	0.0	0										
Apr.	-												
May	-												
June	-												
July	-												
Aug.	-												
Sept.	-												
Oct.	-												
Nov.	-												
Dec.	25	64.0	16	1.6 (0)	0.5 (0)	0.2 (0)	8.4 (1)	30.2 (5)	55.3 (9)	3.7 (1)	0.1 (0)	0 ^B	
Total	29	62.1	18	0.0 (0)	0.0 (0)	5.6 (0)	27.8 (1)	61.1 (5)	5.6 (11)	0.0 (1)	0.0 (0)		

^AAverage of quarterly (JAN-MAR) age composition estimates for statistical areas Bering I, II, and IV in 1982 was used.

^BAverage of quarterly (OCT-DEC) age composition estimates for statistical areas Bering I, II, and IV in 1982 was used.

Table 18. Estimated number of salmon, number of chinook, and percent age composition and number of chinook of each age class caught by the 1982 foreign groundfish fishery in Bering Sea statistical area IV. n = size of scale sample used for age composition estimates.

Month	No. salmon	% chinook	No. chinook	% Age composition (no. in catch)										n	
				0.2	0.3	1.1	1.2	1.3	1.4	1.5					
Jan.	4	50.0	2			100.0 (2)									1
Feb.	2	100.0	2			100.0 (2)									0 ^A
Mar.	<1	0.0	0												
Apr.	<1	0.0	0												
May	1	100.0	1	9.8 (0)	1.4 (0)	3.9 (0)	26.1 (0)	26.1 (0)	26.1 (0)	26.1 (0)	32.1 (1)	32.1 (1)	0.6 (0)	0.6 (0)	0 ^B
June	192	93.2	179	9.8 (17)	1.4 (2)	3.9 (7)	26.1 (47)	26.1 (47)	26.1 (47)	26.1 (47)	32.1 (58)	32.1 (58)	0.6 (1)	0.6 (1)	0 ^B
July	3	0.0	0												
Aug.	30	73.3	22							100.0 (22)					0 ^C
Sept.	40	95.0	38							100.0 (38)					1
Oct.	43	60.5	26				50.0 (13)	50.0 (13)	50.0 (13)	50.0 (13)	50.0 (13)	50.0 (13)	50.0 (13)	50.0 (13)	2
Nov.	9	55.6	5				25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	0 ^D
Dec.	80	71.2	57							100.0 (57)					1
Total	404	82.2	332	5.1 (17)	0.6 (2)	2.1 (7)	19.6 (65)	19.6 (65)	19.6 (65)	54.5 (181)	54.5 (181)	17.8 (59)	17.8 (59)	0.3 (1)	

^AAverage of quarterly (JAN-MAR) age composition estimates was used.

^BAverage of quarterly (APR-JUN) age composition estimates for statistical areas Bering I and II in 1982 were used.

^CAverage of quarterly (JUL-SEP) age composition estimates was used.

^DAverage of quarterly (OCT-DEC) age composition estimates was used.

Table 19. Estimates of the regional stock composition of incidental catches of chinook salmon by the foreign groundfish fishery in the Bering Sea used to calculate interception estimates. Estimates for 1979 and 1981 are from Myers and Rogers (1983). n = number of estimates used to calculate averages.

Estimate no.	Age class	Area(s)	Month(s)	Year(s)	n	Stock of origin (%)			
						Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.
1	1.1	Bering I	Nov	1981		17.1	0.0	18.2	64.7
2	1.2	Bering I	Sep	1979		0.0	60.6	9.3	30.1A
3	"	"	Oct	1979		0.0	34.2	53.2	12.6
4	"	"	Oct	1981		11.2	45.1	4.3	39.5B
5	"	"	Oct	1982		22.4	18.3	31.1	28.2
6	"	"	Nov	1981		27.4	53.0	0.0	19.6
7	"	"	Oct-Dec	1981	2	19.3	49.1	2.1	29.5
8	1.2	Bering II	Jan	1979		0.0	68.7	31.3	0.0
9	"	"	Jan	1981		26.4	51.7	10.5	11.3
10	"	"	Jan	All	2	13.2	60.2	20.9	5.7
11	"	"	Feb	1979		0.0	49.1	45.0	5.9
12	"	"	Feb	1981		13.0	64.7	2.0	20.3
13	"	"	Feb	All	2	6.5	56.9	23.5	13.1
14	"	"	Mar	1981		5.3	84.0	0.0	10.6
15	"	"	Jan-Mar	1979	2	0.0	58.9	38.1	3.0
16	"	"	Apr	1981		7.1	74.7	0.0	18.3
17	1.2	Bering II	Nov	1979		13.8	7.9	78.2	0.0
18	"	"	Dec	1979		0.0	75.6	7.0	17.4
19	"	"	Dec	1981		23.1	46.1	12.4	18.5
20	"	"	Dec	All	2	11.6	60.8	9.7	17.9
21	"	"	Oct-Dec	1979	2	6.9	41.8	42.6	8.7
22	"	"	Oct-Dec	All	3	12.3	43.2	32.5	12.0
23	1.3	Bering I	Apr	1982		6.0	69.5	11.3	13.2
24	1.3	Bering II	Jan	1979		16.4	55.3	22.7	5.5C
25	"	"	Jan	1981		43.9	24.2	31.9	0.0
26	"	"	Jan	1982		20.4	64.7	6.7	8.2
27	"	"	Feb	1979		11.2	65.0	17.6	6.2
28	"	"	Feb	1982		12.2	79.1	8.7	0.0
29	"	"	Mar	1982		12.1	60.8	27.1	0.0
30	"	"	Jan-Mar	1979	2	13.8	60.1	20.2	5.9
31	"	"	Apr	1981		6.7	47.8	31.4	14.1

Table 19. Estimates of the regional stock composition of incidental catches of chinook salmon by the foreign groundfish fishery in the Bering Sea used to calculate interception estimates. Estimates for 1979 and 1981 are from Myers and Rogers (1983). n = number of estimates used to calculate averages - cont'd.

Estimate no.	Age class	Area(s)	Month(s)	Year(s)	n	Stock of origin (%)			
						Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.
32	"	"	Nov	1982		32.5	41.6	25.9	0.0
33	"	All	Apr	All	2	6.4	58.6	21.4	13.6
34	1.4	Bering II	Jan	1981		20.5	34.0	31.4	14.1
35	"	"	Feb	1979		9.9	63.2	0.0	26.9
36	"	"	Jan-Mar	All	2	15.2	48.6	15.7	20.5

A This includes an estimate of 18.6% for Washington/Oregon/California.

B This includes an estimate of 0.4% for Washington/Oregon/California.

C This includes an estimate of 2.2% for Washington/Oregon/California.

Table 20. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area I in 1979 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non- Alaskan		
0.T ^B	Apr					2	2	
"	June					18	18	
"	July					15	15	
"	Aug					120	120	
"	Sep					268	268	
"	Oct					443	443	
"	Total					866	866	
1.0	Dec	0	13	0	0		13	
1.1	Aug	2	0	3	10		15	1
"	Sep	8	0	8	29		45	1
"	Oct	153	0	162	578		893	1
"	Nov	280	0	299	1,062		1,641	1
"	Dec	5	0	6	21		32	1
"	Total	448	0	478	1,700		2,626	
1.2	Jan	0	44	20	0		64	8
"	Mar	0	1,553	1,004	79		2,636	15
"	Apr	0	5	0	1		6	16
"	June	5	55	0	13		73	16
"	July	0	49	7	24		80	2
"	Aug	0	211	32	105		348	2
"	Sep	0	571	88	283		942	2
"	Oct	0	2,127	3,308	784		6,219	3
"	Nov	0	1,125	1,749	414		3,288	3
"	Dec	0	22	34	8		64	3
"	Total	5	5,762	6,242	1,711		13,720	
1.3	Jan	10	35	14	4		63	24
"	Feb	20	116	31	11		178	27
"	Apr	1	10	2	2		15	23
"	May	5	58	10	11		84	23
"	June	2	25	4	5		36	23
"	July	3	30	5	6		44	23
"	Aug	2	21	3	4		30	23
"	Sep	9	109	18	21		157	23
"	Oct	220	281	175	0		676	32
"	Total	272	685	262	64		1,283	

Table 20. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area I in 1979 by age class, month, and stock of origin - cont'd.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
1.4	Apr	1	5	0	2		8	35
"	May	3	18	0	7		28	35
"	June	5	34	0	15		54	35
"	Oct	6	37	0	15		58	35
"	Total	15	94	0	39		148	
2.2	Oct	0	20	31	7		58	3

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 21. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area II in 1979 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A no.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non- Alaskan		
0.T ^B	Jan					100	100	
"	Feb					168	168	
"	Mar					39	39	
"	Apr					105	105	
"	May					16	16	
"	Oct					72	72	
"	Nov					31	31	
"	Total					531	531	
1.0	Nov	0	101	0	0		101	
"	Dec	0	295	0	0		295	
"	Total	0	396	0	0		396	
1.1	Feb	108	0	115	407		630	1
	Mar	13	0	14	51		78	1
	Apr	5	0	6	21		32	1
	May	5	0	6	20		31	1
	Nov	130	0	138	492		760	1
	Dec	435	0	463	1,646		2,544	1
	Total	696	0	742	2,637		4,075	
1.2	Jan	0	6,083	2,771	0		8,854	8
"	Feb	0	14,606	13,386	1,755		29,747	11
"	Mar	0	1,869	1,209	95		3,173	15
"	Apr	137	1,445	0	353		1,935	16
"	May	25	263	0	64		352	16
"	June	4	40	0	10		54	16
"	Oct	70	423	431	88		1,012	21
"	Nov	293	168	1,657	0		2,118	17
"	Dec	0	4,869	451	1,121		6,441	18
"	Total	529	29,766	19,905	3,486		53,686	
1.3	Jan	765	2,576	1,058	257		4,656	24
"	Feb	1,049	6,090	1,649	581		9,369	27
"	Mar	248	1,080	363	106		1,797	30
"	Apr	57	404	265	119		845	31
"	May	4	30	20	9		63	31
"	Oct	47	60	38	0		145	32
"	Nov	43	55	34	0		132	32
"	Dec	195	250	155	0		600	32
"	Total	2,408	10,545	3,582	1,072		17,607	

Table 21. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area II in 1979 by age class, month, and stock of origin - cont'd.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
1.4	Jan	54	344	0	147		545	35
"	Feb	137	877	0	373		1,387	35
"	Mar	30	193	0	82		305	35
"	Apr	21	137	0	58		216	35
"	May	2	15	0	7		24	35
"	Total	244	1,566	0	667		2,477	
1.5	Jan	9	54	0	23		86	35
"	Feb	17	106	0	45		168	35
"	Mar	8	49	0	21		78	35
"	Apr	5	28	0	12		45	35
"	May	1	5	0	2		8	35
"	Total	40	242	0	103		385	
1.6	Mar	4	24	0	10		38	35
2.1	Feb	7	0	8	27		42	1
2.2	Jan	0	59	27	0		86	8
"	Feb	0	145	132	17		294	11
"	Mar	0	23	15	1		39	15
"	Dec	0	223	21	51		295	18
"	Total	0	450	195	69		714	
2.3	Feb	19	109	30	10		168	27
2.4	Feb	4	27	0	11		42	35

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 22. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area IV in 1979 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
0.T ^B	May					1	1	
"	Aug					2	2	
"	Sep					1	1	
"	Nov					2	2	
"	Dec					3	3	
"	Total					9	9	
1.0	Nov	0	2	0	0		2	
"	Dec	0	5	0	0		5	
"	Total		7				7	
1.1	Nov	2	0	2	8		12	1
"	Dec	6	0	6	21		33	1
"	Total	8	0	8	29		45	
1.2	Jan	0	1	0	0		1	8
"	Feb	0	1	0	0		1	11
"	Mar	0	4	2	0		6	15
"	Apr	0	2	0	1		3	16
"	May	1	14	0	3		18	16
"	Jun	0	3	0	1		4	16
"	Jul	0	2	0	1		3	2
"	Aug	0	4	0	2		6	2
"	Sep	0	3	0	1		4	2
"	Nov	6	3	33	0		42	17
"	Dec	0	85	8	19		112	18
"	Total	7	122	43	28		200	
1.3	Feb	0	1	0	0		1	27
"	Mar	1	2	1	0		4	30
"	Apr	0	1	1	0		2	33
"	May	1	6	2	2		11	33
"	June	0	1	1	0		2	33
"	July	0	1	0	0		1	33
"	Aug	0	1	1	0		2	33
"	Sep	0	1	0	0		1	33
"	Nov	1	1	1	0		3	32
"	Dec	3	3	2	0		8	32
"	Total	6	18	9	2		35	

Table 22. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area IV in 1979 by age class, month, and stock of origin - cont'd.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non- Alaskan		
1.4	Mar	0	1	0	0		1	35
"	Apr	0	1	0	0		1	35
"	May	0	4	0	2		6	35
"	Jun	0	1	0	0		1	35
"	Dec	0	1	0	0		1	35
"	Total	0	8	0	2		10	
2.2	Dec	0	1	0	0		1	18

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 23. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area I in 1981 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
0.T ^B	Jan					276	276	
"	Jan					20	20	
"	Feb					38	38	
"	Apr					24	24	
"	May					23	23	
"	June					9	9	
"	July					66	66	
"	Aug					191	191	
"	Sept					122	122	
"	Oct					63	63	
"	Nov					245	245	
"	Total					1,077	1,077	
1.1	Mar	6	0	7	24		37	1
"	Apr	4	0	4	16		24	1
"	May	1	0	2	6		9	1
"	Sep	16	0	17	59		92	1
"	Oct	19	0	20	72		111	1
"	Nov	82	0	88	311		481	1
"	Dec	28	0	29	104		161	1
"	Total	156	0	167	592		915	
1.2	Jan	759	1,486	302	325		2,872	9
"	Feb	28	139	4	43		214	12
"	Mar	27	423	0	54		504	14
"	Apr	35	373	0	92		500	16
"	May	1	10	0	3		14	16
"	June	1	10	0	3		14	16
"	July	0	20	3	10		33	2
"	Sept	0	130	20	64		214	2
"	Oct	76	306	29	268		679	4
"	Nov	442	854	0	316		1,612	6
"	Dec	93	237	10	142		482	7
"	Total	1,462	3,988	368	1,320		7,138	

Table 23. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area I in 1981 by age class, month, and stock of origin - cont'd.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
1.3	Jan	299	165	217	0		681	25
"	Feb	106	59	77	0		242	25
"	Mar	246	135	179	0		560	25
"	Apr	10	116	19	22		167	23
"	May	3	40	7	8		58	23
"	June	1	6	1	1		9	23
"	July	6	69	11	13		99	23
"	Aug	4	45	7	8		64	23
"	Sept	2	22	3	4		31	23
"	Oct	31	39	25	0		95	32
"	Nov	66	85	53	0		204	32
"	Total	774	781	599	56		2,210	
1.4	Feb	15	25	23	11		74	34
"	Mar	31	51	47	21		150	34
"	Apr	10	16	15	7		48	34
"	May	2	3	3	1		9	34
"	June	1	1	1	1		4	34
"	Total	59	96	89	41		285	
1.5	Mar	4	6	6	3		19	34
2.1	Nov	2	0	2	6		10	1
2.2	Feb	1	7	0	2		10	12
"	Mar	1	16	0	2		19	14
"	Nov	17	34	0	12		63	6
"	Dec	10	27	1	16		54	7
"	Total	29	84	1	32		146	
2.3	Jun	0	3	0	1		4	23

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 24. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area II in 1981 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non- Alaskan		
0.T ^B	Jan					223	223	
"	Feb					172	172	
"	Mar					37	37	
"	Apr					52	52	
"	July					6	6	
"	Sept					11	11	
"	Dec					85	85	
"	Total					586	586	
1.0	Dec	0	66	0	0		66	
1.1	Feb	6	0	6	22		34	1
"	Mar	27	0	28	101		156	1
"	Apr	2	0	2	9		13	1
"	Dec	46	0	49	173		268	1
"	Total	81	0	85	305		471	
1.2	Jan	745	1,457	296	319		2,817	9
"	Feb	211	1,051	33	330		1,625	12
"	Mar	136	2,140	0	271		2,547	14
"	Apr	202	2,135	0	522		2,859	16
"	May	12	131	0	32		175	16
"	June	0	2	0	1		3	16
"	July	0	31	5	16		52	2
"	Sept	0	54	8	27		89	2
"	Oct	21	43	12	17		93	19
"	Nov	21	43	12	17		93	19
"	Dec	208	416	112	167		903	19
"	Total	1,556	7,503	478	1,719		11,256	
1.3	Jan	940	518	683	0		2,141	25
"	Feb	565	311	411	0		1,287	25
"	Mar	507	280	369	0		1,156	25
"	Apr	57	410	269	121		857	31
"	May	18	126	82	37		263	31
"	June	0	1	1	0		2	31
"	July	0	3	2	1		6	31
"	Sept	1	5	3	2		11	31
"	Oct	4	5	3	0		12	32
"	Dec	49	63	39	0		151	32
"	Total	2,141	1,722	1,862	161		5,886	

Table 24. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area II in 1981 by age class, month, and stock of origin - cont'd.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
1.4	Jan	203	338	312	140		993	34
"	Feb	125	208	192	86		611	34
"	Mar	102	170	157	71		500	34
"	Apr	62	102	94	42		300	34
"	May	72	119	110	50		351	34
"	June	0	1	0	0		1	34
"	Oct	2	4	4	2		12	34
"	Dec	7	11	10	4		32	34
"	Total	573	953	879	395		2,800	
1.5	Mar	16	27	24	11		78	34
"	Apr	5	9	8	4		26	34
"	Total	21	36	32	15		104	
2.1	Dec	3	0	3	11		17	1
2.2	Jan	8	16	3	4		31	9
"	Feb	4	22	1	7		34	12
"	Mar	2	31	0	4		37	14
"	Apr	4	48	0	12		64	16
"	May	1	13	0	3		17	16
"	Dec	4	8	2	3		17	19
"	Total	23	138	6	33		200	
2.3	Feb	15	8	11	0		34	25
"	Apr	2	12	8	4		26	31
"	Oct	4	5	3	0		12	32
"	Total	21	25	22	4		72	
2.4	Mar	16	27	24	11		78	34
"	Apr	5	9	8	4		26	34
"	May	4	6	5	2		17	34
"	Total	25	42	37	17		121	

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 25. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area IV in 1981 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
0.T ^B	Apr					44	44	
1.1	Apr	8	0	8	28		44	1
"	Dec	20	0	22	78		120	1
"	Total	28	0	30	106		164	
1.2	Apr	22	234	0	57		313	16
"	Jul	0	1	0	1		2	2
"	Sep	0	1	0	0		1	2
"	Oct	2	10	1	8		21	4
"	Nov	1	2	0	1		4	6
"	Total	25	248	1	67		341	
1.3	Feb	10	6	7	0		23	25
"	Mar	1	0	1	0		2	25
"	Apr	3	21	14	6		44	31
"	July	0	1	0	0		1	31
"	Sep	0	1	0	0		1	31
"	Oct	10	13	8	0		31	32
"	Nov	0	1	0	0		1	32
"	Total	24	43	30	6		103	
2.2	Apr	3	33	0	8		44	16

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 26. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area I in 1982 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
0.T ^B	Apr					92	92	
"	May					14	14	
"	June					5	5	
"	Aug					4	4	
"	Oct					33	33	
"	Nov					41	41	
"	Total					189	189	
1.1	May	0	0	0	2		2	1
"	Oct	1	0	1	6		8	1
"	Nov	23	0	25	89		137	1
"	Dec	8	0	8	30		46	1
"	Total	32	0	34	127		193	
1.2	Apr	15	154	0	38		207	16
"	May	2	18	0	4		24	16
"	June	0	7	0	2		9	16
"	Aug	0	3	0	1		4	2
"	Sept	0	13	2	6		21	2
"	Oct	59	48	81	74		262	5
"	Nov	64	53	89	81		287	5
"	Total	140	296	172	206		814	
1.3	Jan	393	1,247	129	158		1,927	26
"	Feb	29	188	21	0		238	28
"	Mar	52	259	116	0		427	29
"	Apr	22	256	42	49		369	23
"	May	1	14	2	3		20	23
"	June	0	2	0	0		2	23
"	July	1	8	1	1		11	23
"	Aug	0	3	0	1		4	23
"	Sept	2	24	4	4		34	23
"	Oct	37	47	30	0		114	32
"	Nov	75	97	60	0		232	32
"	Dec	15	20	12	0		47	32
"	Total	627	2,165	417	216		3,425	
1.4	Apr	2	5	2	2		11	36
"	May	2	5	1	2		10	36
"	Oct	2	8	3	3		16	36
"	Total	6	18	6	7		37	
1.5	Apr	3	11	4	5		23	36

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 27. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area II in 1982 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)				Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.		
0.T ^B	Mar					15	15
"	Nov					18	18
"	Total					33	33
1.1	Feb	10	0	10	36	56	1
"	Mar	10	0	11	40	61	1
"	Apr	12	0	12	43	67	1
"	Nov	3	0	3	12	18	1
"	Total	35	0	36	131	202	
1.2	Jan	19	87	31	8	145	10
"	Feb	16	137	56	31	240	13
"	Mar	13	206	0	26	245	14
"	Apr	8	84	0	21	113	16
"	Oct	3	11	8	3	25	22
"	Nov	36	20	200	0	256	17
"	Dec	201	1,052	168	309	1,730	20
"	Total	296	1,597	463	398	2,754	
1.3	Jan	166	527	55	67	815	26
"	Feb	85	554	61	0	700	28
"	Mar	96	483	216	0	795	29
"	Apr	15	108	71	32	226	31
"	July	2	10	7	3	22	31
"	Sept	0	3	2	1	6	31
"	Oct	8	10	7	0	25	32
"	Nov	149	190	119	0	458	32
"	Dec	642	821	511	0	1,974	32
"	Total	1,163	2,706	1,049	103	5,021	
1.4	Jan	44	142	46	60	292	36
"	Feb	53	170	55	72	350	36
"	Mar	30	97	31	41	199	36
"	Apr	14	44	14	18	90	36
"	May	9	30	10	12	61	36
"	June	0	1	0	0	1	36
"	Dec	75	241	78	102	496	36
"	Total	225	725	234	305	1,489	

Table 27. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area II in 1982 by age class, month, and stock of origin - cont'd.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
1.5	Feb	5	18	6	7		36	36
"	Mar	5	15	5	6		31	36
"	Total	10	33	11	13		67	
2.4	Feb	3	9	3	3		18	36

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 28. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area III in 1982 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
1.1	Dec	0	0	0	1		1	1
1.2	Dec	1	1	2	1		5	5
1.3	Jan	0	1	0	0		1	26
"	Feb	0	1	0	0		1	28
"	Dec	3	4	2	0		9	32
"	Total	3	6	2	0		11	
1.4	Dec	0	1	0	0		1	36

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

Table 29. Provisional estimates of the foreign groundfish fishery interceptions of chinook salmon in Bering Sea statistical area IV in 1982 by age class, month, and stock of origin.

Age class	Month	Stock of origin (no. of fish)					Total	Est. ^A No.
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan		
0.T ^B	June					19	19	
1.1	June	1	0	1	5		7	1
1.2	Jan	0	2	0	0		2	10
"	Feb	0	1	1	0		2	13
"	June	3	35	0	9		47	
"	Oct	3	2	4	4		13	
"	Nov	0	0	1	0		1	
"	Total	6	40	6	13		65	
1.3	June	3	33	5	6		47	23
"	Aug	1	15	3	3		22	23
"	Sept	2	27	4	5		38	23
"	Oct	4	5	4	0		13	32
"	Nov	1	2	1	0		4	32
"	Dec	18	24	15	0		57	32
"	Total	29	106	32	14		181	
1.4	May	0	1	0	0		1	36
"	June	9	28	9	12		58	36
"	Total	9	29	9	12		59	
1.5	June	0	1	0	0		1	36

^AStock composition estimates used to calculate interception estimates are listed by number in Table 19.

^BEstimates include all ocean age classes of freshwater age 0. chinook salmon.

Table 30. Provisional estimated interceptions of regional chinook salmon stocks by the foreign groundfish fishery in the Alaska FCZ in the Bering Sea in 1979 by statistical area and month.

Area	Month	Stock of origin (no. of fish)				Total	
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.		Non-Alaskan ¹
Bering I	Jan	10	79	34	4	127	
	Feb	20	116	31	11	178	
	Mar	0	1,553	1,004	79	2,636	
	Apr	2	20	2	5	31	
	May	8	76	10	18	112	
	June	12	114	4	33	181	
	July	3	79	12	30	139	
	Aug	4	232	38	119	513	
	Sept	17	680	114	333	1,412	
	Oct	379	2,465	3,676	1,384	8,347	
	Nov	280	1,125	2,048	1,476	4,929	
	Dec	5	35	40	29	109	
Total	740	6,574	7,013	3,521	866	18,714	
Bering II	Jan	828	9,116	3,856	427	100	14,327
	Feb	1,341	21,960	15,320	3,226	168	42,015
	Mar	303	3,238	1,601	366	39	5,547
	Apr	225	2,014	271	563	105	3,178
	May	37	313	26	102	16	494
	June	4	40	0	10		54
	Oct	117	483	469	88	72	1,229
	Nov	466	324	1,829	492	31	3,142
	Dec	630	5,637	1,090	2,818		10,175
	Total	3,951	43,125	24,462	8,092	531	80,161
Bering IV	Jan	0	1	0	0		1
	Feb	0	2	0	0		2
	Mar	1	7	3	0		11
	Apr	0	4	1	1		6
	May	2	24	2	7	1	36
	June	0	5	1	1		7
	July	0	3	0	1		4
	Aug	0	5	1	2	2	10
	Sept	0	4	0	1	1	6
	Nov	9	6	36	8	2	61
	Dec	9	95	16	40	3	163
	Total	21	156	60	61	9	307
All	Total	4,712	49,855	31,535	11,674	1,406	99,182

¹This category includes all freshwater age 0. chinook salmon.

Table 31. Provisional estimated interceptions of regional chinook salmon stocks by the foreign groundfish fishery in the Alaska FCZ in the Bering Sea in 1981 by statistical area and month.

Area	Month	Stock of origin (no. of fish)					Total
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan ¹	
Bering I	Jan	1,058	1,651	519	325	276	3,829
	Feb	150	230	104	56	20	560
	Mar	315	631	239	104	38	1,327
	Apr	59	505	38	137	24	763
	May	7	53	12	18	23	113
	June	3	20	2	6	9	40
	July	6	89	14	23	66	198
	Aug	4	45	7	8	191	255
	Sept	18	152	40	127	122	459
	Oct	126	345	74	340	63	948
	Nov	609	973	143	645	245	2,615
	Dec	131	264	40	262		697
Total		2,468	4,958	1,232	2,051	1,077	11,804
Bering II	Jan	1,896	2,329	1,294	463	223	6,205
	Feb	926	1,600	654	445	172	3,797
	Mar	806	2,675	602	469	37	4,589
	Apr	339	2,725	389	718	52	4,223
	May	107	395	197	124		823
	June	0	4	1	1		6
	July	0	34	7	17	6	64
	Sept	1	59	11	29	11	111
	Oct	31	57	22	19		129
	Nov	21	43	12	17		93
	Dec	317	564	215	358	85	1,539
	Total		4,444	10,485	3,404	2,660	586
Bering IV	Feb	10	6	7	0		23
	Mar	1	0	1	0		2
	Apr	36	288	22	99	44	489
	July	0	2	0	1		3
	Sept	0	2	0	0		2
	Oct	12	23	9	8		52
	Nov	1	3	0	1		5
	Dec	20	0	22	78		120
Total		80	324	61	187	44	696
All	Total	7,010	15,767	4,697	4,898	1,707	34,079

¹This category includes all freshwater age 0. chinook salmon.

Table 32. Provisional estimated interceptions of regional chinook salmon stocks by the foreign groundfish fishery in the Alaska FCZ in the Bering Sea in 1982 by statistical area and month.

Area	Month	Stock of origin (no. of fish)					Total	
		Asia	Western Alaska	Central Alaska	Southeast AK/ British Col.	Non-Alaskan ¹		
Bering I	Jan	393	1,247	129	158		1,927	
	Feb	29	188	21	0		238	
	Mar	52	259	116	0		427	
	Apr	42	426	48	94	92	702	
	May	5	37	3	11	14	70	
	June	0	9	0	2	5	16	
	July	1	8	1	1		11	
	Aug	0	6	0	2	4	12	
	Sept	2	37	6	10		55	
	Oct	99	103	115	83	33	433	
	Nov	162	150	174	170	41	697	
	Dec	23	20	20	30		93	
	Total		808	2,490	633	561	189	4,681
Bering II	Jan	229	756	132	135		1,252	
	Feb	172	888	191	149		1,400	
	Mar	154	801	263	113	15	1,346	
	Apr	49	236	97	114		496	
	May	9	30	10	12		61	
	June	0	1	0	0		1	
	July	2	10	7	3		22	
	Sept	0	3	2	1		6	
	Oct	11	21	15	3		50	
	Nov	188	210	322	12	18	750	
	Dec	918	2,114	757	411		4,200	
	Total		1,732	5,070	1,796	953	33	9,584
	Bering III	Jan	0	1	0	0		1
Feb		0	1	0	0		1	
Dec		4	6	4	2		16	
Total		4	8	4	2		18	
Bering IV	Jan	0	2	0	0		2	
	Feb	0	1	1	0		2	
	May	0	1	0	0		1	
	June	16	97	15	32	19	179	
	Aug	1	15	3	3		22	
	Sept	2	27	4	5		38	
	Oct	7	7	8	4		26	
	Nov	1	2	2	0		5	
	Dec	18	24	15	0		57	
	Total	45	176	48	44	19	332	
All	Total	2,589	7,744	2,481	1,560	241	14,615	

¹This category includes all freshwater age 0. chinook salmon.

Table 33. Region and stock of origin and number of scales measured (n) for brood year 1978 (age 0.3 in 1982) chinook salmon.

Number	Region	Stock	n
1	British Columbia	Fraser (Albion Test Fishery)	110
2	"	Shuswap	8
3	"	Robertson Creek	110
4	Washington Inland Waters	Nooksak	30
5	"	Samish	30
6	"	Skagit	30
7	"	Stillaguamish/Snohomish	25
8	"	University of Washington	30
9	"	Duwamish	30
10	"	Puyallup	11
11	"	South Sound (Minter Ck/Deschutes)	15
12	"	Skokomish (Hood Canal)	30
13	Washington Coastal	Quileute	50
14	"	Queets	50
15	"	Quinalt	50
16	"	Grays Harbor	20
17	"	Chehalis	20
18	"	Humptulips	18
19	"	Willapa Bay	45
20	Columbia River	Col. R. Fall (Commercial Catch)	55
21	"	Col. R. Spring (Commercial Catch) and test fishery)	22
22	"	Grays Hatchery	7
23	"	Sea Resources Hatchery	7
24	"	Cowlitz	46
25	"	Kalama	20
26	"	Lewis	35
27	"	Priest Rapids	45
28	Oregon	Tillamook Bay	29
29	"	Nestucca	10
30	"	Yaquina Bay	6
31	"	Siuslaw	33
32	"	Coos Bay	14
33	"	Coquille	27
34	"	Roque	91
35	Klamath Fall	Klamath Fall	30
36	Klamath Spring	Klamath Spring	30
Total			1,219

Table 34. Thirty-five scale characters calculated for scale pattern studies of freshwater age 0. chinook.

Character No.	Description ^a
1	Size Zone 1
2	Size Zone 2
3	Size Zone 1 + 2
4	No. circuli Zone 1
5	No. circuli Zone 2
6	No. circuli Zones 1 + 2
7	Size Zone 1/No. circuli Zone 1
8	Size Zone 2/No. circuli Zone 2
9	Size Zone 1/Size Zones 1 + 2
10	No. circuli Zone 1/No. circuli Zones 1 + 2
11	C ₂₋₆ in Zone 1/Size Zone 1
12	C ₇₋₁₁ in Zone 1/Size Zone 1
13	C ₁₂₋₁₆ in Zone 1/Size Zone 1
14	C ₁₇₋₂₁ in Zone 1/Size Zone 1
15	C ₂₋₆ in Zone 1/5
16	C ₇₋₁₁ in Zone 1/5
17	C ₁₂₋₁₆ in Zone 1/5
18	C ₁₇₋₂₁ in Zone 1/5
19	C ₂₋₁₁ in Zone 1/Size Zone 1
20	C ₂₋₁₆ in Zone 1/Size Zone 1
21	C ₂₋₂₁ in Zone 1/Size Zone 1
22	C ₁₋₅ in Zone 2/Size Zone 2
23	C ₆₋₁₀ in Zone 2/Size Zone 2
24	C ₁₁₋₁₅ in Zone 2/Size Zone 2
25	C ₁₋₅ in Zone 2/5
26	C ₆₋₁₀ in Zone 2/5
27	C ₁₁₋₁₅ in Zone 2/5
28	C ₁₋₁₀ in Zone 2/Size Zone 2
29	C ₁₋₁₅ in Zone 2/Size Zone 2
30	Radius of focus
31	C ₂₋₁₁ in Zone 1/10
32	C ₂₋₁₆ in Zone 1/15
33	C ₂₋₂₁ in Zone 1/20
34	C ₁₋₁₀ in Zone 2/10
35	C ₁₋₁₅ in Zone 2/15

^aZone 1: The area of the scale from the center of the focus to the outer edge of the last circulus in the first ocean annulus.

Zone 2: The area of the scale from the outer edge of the last circulus in the first ocean annulus to the outer edge of the last circulus in the second ocean annulus.

C_n: The nth circulus from the beginning of the indicated zone.

Table 35. Means and standard deviations of four basic scale characters calculated for 36 stocks of age 0.3 chinook in 1982.

Stock ²	Scale characters ¹ - mean (Standard deviation)			
	No. circuli		Size	
	Zone 1	Zone 2	Zone 1	Zone 2
Fraser	41.93(5.72)	27.20(4.45)	5687.92(1275.50)	5203.26(882.34)
Shuswap	34.12(3.56)	30.25(5.06)	3872.12(297.47)	5660.25(1067.73)
Robertson Creek	41.61(4.66)	29.81(4.12)	5066.56(842.77)	5277.00(752.06)
Nooksack	37.50(4.46)	28.17(4.04)	4786.23(785.32)	5000.67(841.24)
Samish	36.87(3.54)	29.57(4.56)	4562.60(622.81)	5073.37(860.07)
Skagit	37.90(4.46)	30.50(4.26)	4781.23(898.70)	5565.63(803.88)
Stillaguamish/ Snohomish	37.08(6.26)	28.36(4.44)	4806.44(953.44)	5136.12(809.23)
U. of Washington	44.17(4.68)	25.30(4.40)	6133.03(965.75)	4513.53(899.26)
Duwamish	37.70(4.84)	29.40(4.99)	4434.70(777.93)	5160.40(939.26)
Puyallup	35.64(5.63)	32.64(4.03)	4294.45(781.27)	5875.18(916.43)
South Sound	37.13(4.42)	31.67(5.75)	4433.00(805.32)	5598.93(1288.98)
Skokomish	39.00(4.75)	30.90(4.89)	5149.97(801.45)	5593.80(802.48)
Quileute	36.20(4.84)	30.64(4.52)	3987.68(676.67)	5144.84(906.85)
Queets	37.72(3.64)	33.86(4.09)	4226.08(455.26)	5836.18(767.94)
Quinault	36.42(4.54)	35.36(4.00)	4041.84(557.89)	6019.88(902.70)
Grays Harbor	38.15(6.00)	35.45(6.26)	3994.00(845.33)	6119.80(1256.71)
Chehalis	37.15(4.96)	38.25(2.92)	3809.00(525.39)	6833.30(775.68)
Humtulsips	33.83(4.97)	36.78(5.79)	3554.06(774.33)	6427.39(860.98)
Willapa Bay	34.89(3.52)	37.73(5.17)	3502.60(459.16)	6199.44(865.16)
Col. R. Fall	38.80(4.33)	30.64(5.04)	4836.56(790.43)	5565.80(925.80)
Col. R. Spring	34.36(4.18)	33.18(4.32)	3932.36(746.99)	5937.59(749.61)
Grays Hatchery	34.00(5.80)	33.43(7.34)	3383.57(635.88)	5590.43(964.68)
Sea Resources	36.29(10.06)	32.29(3.64)	4273.57(1836.16)	5513.57(626.13)
Cowlitz	34.89(6.84)	31.13(5.27)	3916.83(1039.17)	5171.73(1007.72)
Kalama	36.95(5.50)	29.95(4.99)	3830.75(846.93)	4979.75(907.23)
Lewis	34.34(6.68)	33.71(5.23)	3528.66(1036.30)	5539.49(1001.45)
Priest Rapids	34.87(3.84)	32.27(4.17)	3978.07(555.94)	5558.69(740.81)
Tillamook Bay	38.69(4.45)	37.62(5.27)	4323.10(749.50)	6569.83(882.11)
Nestucca	40.80(5.92)	34.10(8.28)	4717.50(1025.99)	5772.20(1107.77)

Table 35. Means and standard deviations of four basic scale characters calculated for 36 stocks of age 0.3 chinook in 1982 - continued.

Stock ²	Scale characters ¹ - mean (Standard deviation)			
	No. circuli		Size	
	Zone 1	Zone 2	Zone 1	Zone 2
Yaquina Bay	41.00(7.13)	28.33(4.59)	4609.33(880.28)	5105.00(665.08)
Siuslaw	38.18(4.67)	36.00(5.20)	4298.97(899.98)	6254.15(880.48)
Coos Bay	42.36(3.71)	31.50(5.13)	5261.29(640.04)	5894.93(1070.39)
Coquille	39.11(4.55)	37.52(4.92)	4528.93(628.83)	6744.15(960.56)
Rogue	34.80(4.54)	37.32(5.18)	4095.81(740.45)	6528.42(1028.08)
Klamath Fall	32.00(4.51)	33.33(5.01)	3613.93(569.28)	5484.13(678.79)
Klamath Spring	35.47(3.69)	34.07(5.45)	4102.27(601.73)	5803.90(1099.23)

¹Zone 1: the area of the scale from the center of the focus to the outer edge of the last circulus in the first ocean annulus.

Zone 2: the area of the scale from the outer edge of the last circulus in the first ocean annulus to the outer edge of the last circulus in the second ocean annulus.

Sizes are the linear distances in inches at 104x.

²Sample sizes are presented in Table 33.

Table 36. Stock composition of regional standards constructed for scale pattern analysis of age 0.3 chinook in 1982.

Region	Stock	Sample size
British Columbia	Fraser	100
"	Robertston Creek	100
"	Total	200
Washington Coastal	Quileute	40
"	Queets	40
"	Quinault	40
"	Grays Harbor	13
"	Humptulips	13
"	Chehalis	13
"	Willapa Bay	39
	Total	198
Washington Inland	Nooksack	30
"	Samish	30
"	Skagit	30
"	Stillaguamish/Snohomish	25
"	Duwamish	30
"	Puyallup	11
"	South Sound	14
"	Skokomish	29
	Total	199
Columbia River	Col. R. Fall	54
"	Cowlitz R.	46
"	Kalama R.	20
"	N. Fork Lewis	34
"	Priest Rapids	45
	Total	199
Oregon	Tillamook Bay	28
"	Nestucca	10
"	Siuslaw	33
"	Coos Bay	14
"	Coquille	27
"	Rogue	88
	Total	200
California	Klamath Fall	30
"	Klamath Spring	29
	Total	59

Table 37. Decision arrays for a) 6-region, b) 5-region, and c) 4-region scale pattern analyses of age 0.3 chinook salmon in 1982. The overall classification accuracy was calculated as the unweighted mean of the accuracies on the diagonal of the decision array.

Calculated decision		Correct decision (%)					
		British Columbia	Washington Coastal	Washington Inland	Columbia River	Oregon	California
a) 6-region							
Variables = 9, 17, 10, 12, 2, 26, 1, 14, 24, 33, 8, 30, 13, 16, 11, 35 (Table 34).							
Overall accuracy = 51.5%							
British Columbia	109(54.5)	3(1.5)	26(13.1)	5(2.5)	13(6.5)	1(1.7)	
Washington Coastal	23(11.5)	95(48.0)	9(4.5)	48(24.1)	28(14.0)	1(1.7)	
Washington Inland	33(16.5)	18(9.1)	114(57.3)	27(13.6)	7(3.5)	8(13.6)	
Columbia River	14(7.0)	33(16.7)	26(13.1)	80(40.2)	29(14.5)	5(8.5)	
Oregon	8(4.0)	28(14.1)	10(5.0)	20(10.1)	106(53.0)	11(18.6)	
California	13(6.5)	21(10.6)	14(7.0)	19.(9.5)	17(8.5)	33(55.9)	
Total	200	198	199	199	200	59	
b) 5-region							
Variables = 23, 1, 17, 7, 12, 33, 6, 18, 30, 10, 24, 14, 13, 29, 8 (Table 34).							
Overall accuracy = 55.3%							
Calculated decision		British Columbia	Washington Coastal	Washington Inland	Columbia River	Oregon	
British Columbia	118(59.0)	6(3.0)	34(17.1)	8(4.0)	16(8.0)		
Washington Coastal	23(11.5)	95(48.0)	8(4.0)	34(17.1)	25(12.5)		
Washington Inland	33(16.5)	18(9.1)	117(58.8)	36(18.1)	3(1.5)		
Columbia River	15(7.5)	35(17.7)	28(14.1)	97(48.7)	32(16.0)		
Oregon	11(5.5)	44(22.2)	12(6.0)	24(12.1)	124(62.0)		
Total	200	198	199	199	200		
c) 4-region							
Variables = 1, 17, 23, 7, 6, 12, 33, 14, 13, 24 (Table 34).							
Overall accuracy = 59.9%							
Calculated decision		British Columbia	Washington Coastal	Washington Inland	Columbia River	Oregon	
British Columbia	117(58.5)	6(3.0)	34(17.1)	13(6.5)			
Washington Coastal	27(13.5)	141(71.2)	17(8.5)	60(30.2)			
Washington Inland	35(19.0)	19(9.6)	122(61.3)	29(14.6)			
Columbia River	18(9.0)	32(16.2)	26(13.1)	97(48.7)			
Total	200	198	199	199			

Table 38. Means and standard deviations of scale characters selected for use in regional classification models of age 0.3 chinook in 1982. Measurements are in units of inches at 104x.

Character No. ^{1/} Sample size (n)	Mean (Standard deviation) - regional stock					
	British Columbia	Washington Coastal	Washington Inland	Columbia River	Oregon	California
1	5375.350(1119.683)	3884.510(600.613)	4694.206(812.042)	4077.302(938.293)	4297.130(786.857)	3845.814(628.917)
2	5228.295(827.669)	5888.106(905.450)	5300.271(883.816)	5421.900(932.444)	6438.125(1009.967)	5631.915(923.005)
6	70.250(5.409)	70.657(5.966)	67.236(5.875)	67.593(6.315)	73.845(5.741)	67.153(6.416)
7	127.905(16.902)	107.442(10.570)	125.161(13.201)	112.806(14.891)	115.374(11.478)	114.538(10.024)
8	184.526(19.216)	171.008(15.087)	178.297(15.567)	171.596(15.943)	176.104(16.066)	167.940(14.924)
9	0.505(0.071)	0.399(0.056)	0.470(0.061)	0.428(0.071)	0.401(0.064)	0.407(0.054)
10	0.595(0.057)	0.512(0.051)	0.558(0.053)	0.531(0.063)	0.504(0.061)	0.500(0.053)
11	0.110(0.028)	0.147(0.027)	0.134(0.027)	0.143(0.034)	0.133(0.029)	0.143(0.035)
12	0.097(0.017)	0.124(0.023)	0.107(0.023)	0.122(0.030)	0.114(0.024)	0.112(0.021)
13	0.111(0.020)	0.118(0.022)	0.122(0.021)	0.11790(0.029)	0.113(0.025)	0.135(0.034)
14	0.128(0.020)	0.132(0.032)	0.139(0.025)	0.132(0.031)	0.133(0.031)	0.164(0.031)
16	102.043(16.598)	95.084(16.905)	98.263(16.275)	95.547(17.875)	95.237(14.993)	85.081(14.235)
17	117.788(24.772)	90.583(15.287)	112.986(19.086)	91.538(17.005)	94.102(14.765)	101.447(19.423)
18	135.502(26.610)	100.711(20.356)	129.541(25.495)	105.454(28.084)	112.244(24.741)	124.349(22.941)
23	0.189(0.041)	0.147(0.034)	0.192(0.038)	0.171(0.036)	0.132(0.033)	0.153(0.040)
24	0.195(0.033)	0.154(0.032)	0.189(0.032)	0.178(0.035)	0.143(0.034)	0.169(0.035)
26	192.950(29.798)	168.505(22.714)	198.254(24.001)	180.293(25.332)	164.969(25.287)	166.749(27.176)
29	1859.675(269.150)	1625.522(192.299)	1874.420(205.889)	1735.645(209.194)	1588.963(212.100)	1614.644(236.873)
30	265.090(38.922)	258.556(39.781)	268.910(39.533)	252.849(33.008)	248.930(33.337)	248.424(36.404)
33	1703.301(232.431)	1519.627(207.115)	1702.636(202.163)	1519.037(202.929)	1530.186(184.518)	1497.036(184.247)
35	1926.231(273.374)	1684.289(195.752)	1939.569(207.737)	1798.259(213.540)	1648.590(218.102)	1676.316(240.630)
n	200	198	199	199	200	59

^{1/}Scale characters are listed by number and described in Table 34.

Table 39. Classification by stock in 4-region analysis of age 0.3 chinook in 1982.
n = sample size.

Correct decision Region	Stock	n	Calculated decision (%)			
			British Columbia	Washington Coastal	Washington Inland	Columbia River
British Columbia	Fraser	100	70(70.0)	8(8.0)	12(12.0)	10(10.0)
	Robertson Creek	100	47(47.0)	19(19.0)	26(26.0)	8(8.0)
	Total	200	117	27	38	18
Washington Coastal	Quileute	40	3(7.5)	19(47.5)	6(15.0)	12(30.0)
	Queets	40	2(5.0)	28(70.0)	4(10.0)	6(15.0)
	Quinalt	40	0(0.0)	28(70.0)	6(15.0)	6(15.0)
	Grays Harbor	13	1(7.7)	7(53.8)	1(7.7)	4(30.8)
	Humtulpis	13	0(0.0)	12(92.3)	1(7.7)	0(0.0)
	Chehalis	13	0(0.0)	13(100.0)	0(0.0)	0(0.0)
	Willapa Bay	39	0(0.0)	34(87.2)	1(2.5)	4(10.3)
Total	198	6	141	19	32	
Washington Inland	Nooksack	30	7(23.3)	0(0.0)	21(70.0)	2(6.7)
	Samish	30	7(23.3)	0(0.0)	23(76.7)	0(0.0)
	Skagit	30	8(26.7)	2(6.7)	17(56.7)	3(10.0)
	Stillaguamish/ Snohomish	25	5(20.0)	0(0.0)	19(76.0)	1(4.0)
	Duwamish	30	3(10.0)	4(13.3)	16(53.3)	7(23.3)
	Puyallup	11	1(9.1)	5(45.4)	2(18.2)	3(27.3)
	South Sound	14	1(7.1)	4(28.6)	4(28.6)	5(35.7)
	Skokomish	29	2(6.9)	2(6.9)	20(69.0)	5(17.2)
	Total	199	34	17	122	26
	Columbia River	Col. R. Fall	54	7(13.0)	8(14.8)	18(33.3)
Cowlitz R.		46	0(0.0)	12(26.1)	4(8.7)	30(65.2)
Kalama R.		20	3(15.0)	5(25.0)	1(5.0)	11(55.0)
N. Fork Lewis		34	1(2.9)	16(47.1)	2(5.9)	15(44.1)
Priest Rapids		45	2(4.4)	19(42.2)	4(8.9)	20(44.4)
Total	199	13	60	29	97	