FRI-UW-8215
September, 1982

FISHERIES RESEARCH INSTITUTE
School of Fisheries
University of Washington
Seattle, Washington 98195

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

by

Katherine W. Myers and Donald E. Rogers

ANNUAL REPORT
Contract No. 81-5
October 1, 1981 to September 30, 1982
North Pacific Fishery Management Council

Approved

Submitted September 3, 1982

R. L. Burgner
Director
by S. Smith

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

Appendix Figure

Page

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

Annual Report for October 1, 1981 to September 30, 1982

INTRODUCTION

This is a report on the first year of a two-year project to determine stock origins of incidental catches of chinook salmon (Oncorhynchus tshawytscha) in foreign groundfish fisheries of the U.S. Fishery Conservation Zone (FCZ) of Alaska. Our purpose during this first year was to determine the feasibility of using scale pattern recognition techniques to determine region or stream origins of chinook in samples collected by U. S. observers in 1978, 1979, and 1981.

Chinook salmon is the least abundant species of Pacific salmon in Alaska (Major et al. 1978). However, since the enactment of the Magnuson Fishery Conservation and Management Act of 1976, observers placed aboard foreign groundfish vessels operating in the Alaska FCZ have found that chinook often account for over 90% of the incidental salmon catch in the Bering Sea/Aleutian Islands and Gulf of Alaska regions (Table 1). Estimated incidental catches of over 100,000 salmon in foreign groundfish fisheries in the Bering Sea/Aleutian Islands region in 1979 and 1980 (Table 2) amounted to more than 1/3 the average annual commercial harvest of 261,000 chinook salmon in Western Alaska since 1963 (Meacham 1980). Incidental catches of this magnitude are likely to have a significant impact on commercial, subsistence, and sport chinook fisheries (Fig. 1), as well as on escapement of mature adults to the spawning grounds (Table 3).

Tagging, scale, maturity, and distribution studies summarized by Major et al. (1978) indicate that the probable area of origin of chinook salmon stocks in the eastern Bering Sea is Western Alaska. Meacham (1980) reported that over 90% of the chinook salmon produced in Western Alaska probably originate in the Nushagak, Kuskokwim, and Yukon rivers.

Much less is known about the origins of chinook salmon in the Gulf of Alaska, but they are thought to represent a mixture of stocks originating along the North American coast from California to Central Alaska (Major et al. 1978). The relative contributions of individual streams or areas within this large geographical area to chinook populations in the Gulf of Alaska have not been well defined.

Scale pattern analysis has been used for many years to identify stocks of Pacific salmon (Major et al. 1972). However, early attempts at separating stocks of chinook salmon using univariate statistical techniques were, largely, unsuccessful (Rowland 1969; Bohn and Jensen 1971). More recently, discriminant function analyses of scale characters have resulted in reasonably high classification accuracies for determining origins of chinook in mixed stock fisheries (Major et al. 1978; McBride 1981).

Our objectives were 1) to determine if freshwater age patterns and freshwater-marine growth patterns on the scales of selected major coastal chinook stocks allow area or stream-of-origin separation, and 2) to determine if chinook scale samples collected by U. S. observers on foreign groundfish vessels in the Alaska FCZ in 1978, 1979, and 1981 are

adequate for stock separation analyses. If stock separation by scale pattern analysis proves feasible, chinook unknowns in the 1978, 1979, and 1981 foreign trawl catches in the Alaska FCZ will be classified to region or stream-of-origin.

METHODS

Inshore Scale Samples

Information on chinook stocks, particularly those in the Gulf of Alaska, is limited (Major et al. 1978). Therefore, initial analyses should include all major hatchery and wild chinook stocks from California to the Yukon River and Asia. Because our funding does not provide for such an extensive amount of scale collecting, collection of inshore chinook scale samples is being conducted, primarily, by personnel on a Fisheries Research Institute (FRI) project funded by the Alaska Department of Fish and Game (ADF&G) to determine origins of chinook salmon caught by the Japanese mothership fishery (1975-1981). Samples collected to date are listed in Rogers et al. (1982), and include 1975-1981 scales of North American stocks from the Sacramento River in California to the Yukon River in Western Alaska, and 1975-1980 scales of Asian stocks from the Bolshaya and Kamchatka rivers. However, the inshore sample collection is not yet complete and several notable gaps occur. In particular, very few samples for Central and Southeast Alaskan stocks have been collected.

For our feasibility study we decided to select inshore samples from one year during the period of interest (1978-1981) that had the best regional coverage. Although none of the yearly inshore samples for this period are complete, we decided to use the 1980 sample. This sample included a recently received collection of Kamchatka River and Bolshaya River chinook scales provided by the U.S.S.R.'s Pacific Scientific Institute of Fisheries and Oceanography (TINRO). In addition, 1980 was the only year for which we had obtained scale samples from the Columbia River, the major producer of chinook salmon in the Oregon-Washington region.

Trawl Scale Samples

The trawl scale samples were collected by U.S. observers aboard foreign groundfish vessels in the Alaska FCZ in 1978, 1979, and 1981. The scales, data forms, and sample and biological data stored on magnetic tape were provided by the National Marine Fisheries Services (NMFS, Northwest and Alaska Fisheries Center).

The scale samples consisted of a scraping of scales taken from each fish and smeared on the inside of a small Manila envelope. The outside of the envelope was marked with some identification, usually a scale number, haul/set number, date, species, and scale zone.

The scale zone refers to the area of the fish where the scale sample was taken. Observers are provided by NMFS with a diagram showing the location of preferred scale sampling (Fig. 2). When observers did not collect scales from Zones A or B (Fig. 2), they usually wrote on the scale

envelope the area of the fish from which scales were collected. This information is of particular importance to our study. Because the inshore scale samples that we will use to classify the trawl unknowns are taken from the preferred area of the fish (Fig. 2), a valid scale pattern analysis will require the use of only those trawl scale samples taken from or near this area.

Preparation, Aging, and Measurement

Laboratory preparation and visual aging of chinook salmon scales was done using techniques similar to those described by Koo (1962) and Clutter and Whitesel (1956). Because chinook salmon are known to have a large number of regenerated scales, non-regenerated scales, identified by their small, regularly shaped nucleus, were selected under a binocular microscope for trawl and unprocessed inshore scale samples. One scale was selected per fish, and if all of the scales in a sample were regenerated, a scale showing the least amount of regeneration was selected.

Aging and measurement of 1980 inshore samples and 1978, 1979, and 1981 trawl samples was done by one experienced fish scale technician to maintain consistency in interpretation throughout the analysis. Inshore scale samples provided by resource agencies were re-aged using a standard set of criteria established by aging chinook of unknown origin in the trawl samples. Briefly, annuli were identified by a decrease in circuli spacing and thickness, and by breakage and inter-braiding of circuli. Thickness and spacing of freshwater circuli was less than thickness and spacing of ocean circuli.

Measurements and counts of freshwater and marine scale characters were made on 1980 inshore scale samples using a micro-computer based digitizing system developed by FRI in 1979 for INPFC-related research (Harris et al. 1980). Acetate impressions of the scales were rear-projected onto the digitizing surface at 100 power, and counts and measurements were made along a radius approximately 17.5 degrees dorsad or ventrad from the anterior-posterior axis of the scale. The distance to the outer edge of every circulus in the freshwater and first ocean zone was measured and recorded on floppy disc. A subset of up to 100 scales for each major age class was measured for each stock in the 1980 samples.

Character Selection

Thirty-six scale characters were generated from the raw scale data (Table 4). From these a subset of six characters were chosen using the method of Cook and Lord (1978). Briefly, a Kruskal-Wallis H-statistic (Kruskal and Wallis 1952) and the difference between the average sum of ranks for each pairwise class combination were calculated. Characters having the largest H-statistic, the greatest pairwise differences, and the least dependence on each other were chosen.

Construction and Classification of Training Samples

The major chinook producers in Western Alaska are the Yukon, Kuskokwim, and Nushagak rivers (Meacham 1980), and the major producers in Asia are thought to be the Kamchatka and Bolshaya rivers on the Kamchatka Peninsula. Because chinook of Asian and Western Alaskan

origin are likely to be the major stocks present in the Bering Sea trawl samples (Major et al. 1978), we conducted an analysis in which four major stocks from Asia and Western Alaska in 1980 were classified: 1) the Kamchatka River; 2) the Bolshaya River; 3) the Yukon River; and 4) the Nushagak River. There were too few scales to construct a training sample for 1980 Kuskokwim River chinook.

Much less is known about the origin and composition of chinook stocks in the Gulf of Alaska. Therefore, Gulf of Alaska stocks will probably only be separable on the basis of large geographic areas. A second analysis was performed in which stocks were grouped according to four major geographical regions: 1) Asia; 2) Western Alaska; 3) British Columbia; and 4) Oregon-Washington. The 1980 inshore samples did not contain enough scales of Central or Southeast Alaskan chinook to construct standards for these regions. However, the British Columbia sample includes stocks returning to the major chinook producing streams in Southeastern Alaska.

Training samples or standards of selected scale characters for each region or stream to be classified were constructed from the digitized scale samples. Because there is no information on population sizes of Asian and most Western Alaskan stocks, sample sizes of stocks within the training samples were not proportionalized to reflect abundance. Initially, enough scales (up to 100) of each major age class and stock were digitized to insure an adequate sample size when training sample construction was determined. This sample size is large enough to keep the variance of mixing proportion estimates low (Cook, unpublished manu-

script), yet small enough to maintain reasonable computer costs. When digitized samples were greater than 200 scales, a random sample of up to 200 scales for each region or stock was selected. Within each region or stock samples were pooled over ocean age class. Only freshwater age 1. chinook were used in these analyses, as this is known to be the predominant age class in Asian and Western Alaskan stocks (Vronskiy 1972; McBride and Wilcock, unpublished manuscript).

Training samples were classified using a direct density, leaving-one-out approach (Cook 1982) to establish the level of accuracy that would be obtained in classifying chinook in the trawl samples.

Adequacy of Trawl Samples

The adequacy of the trawl scale samples collected in 1978, 1979, and 1981 was examined in terms of quality and quantity. In terms of quality, scale samples were examined to determine if they were regenerated, and regeneration rates were calculated. In addition, the body zone of each scale sample was coded and tallied. In terms of quantity, we determined if sample sizes were "area-significant," i.e., if enough fish had been sampled from each area to make a classification to region or stock meaningful. The number of non-regenerated scales taken from in or near the preferred area was tallied by month within NMFS statistical areas (Fig. 3) for predominant age classes in the trawl samples. Sample sizes greater than or equal to 25 fish were considered to be area-significant. These will be the largest time-area strata and smallest sample sizes used to make point estimations of mixing proportions of chinook salmon stocks in the Alaska FCZ.

RESULTS

Age Composition of 1980 Inshore Samples

The age composition of the inshore scale samples by stock and region is shown in Table 5. Age 1. was the predominant freshwater age class in both the Asian and Western Alaskan samples. Only a small percentage of freshwater age 0. fish were present in western Alaskan and Asian samples. Freshwater age 0. chinook were more prevalent to the south, and comprise a large percentage of the 1980 Fraser River sample.

The age composition of the 1980 Columbia River sample (Table 5) does not accurately reflect the true proportions of freshwater age 0. and 1. chinook in this river. This sample was collected in spring chinook test fisheries during April, and consists primarily of age 1. hatchery chinook. The 1980 Columbia River spring chinook test fishery samples were specifically requested from the Oregon Department of Fisheries and Wildlife when it became apparent that our analyses would involve only freshwater age 1. chinook.

The predominant ocean age classes in the 1980 samples were .2's, .3's, and .4's (Table 5). Age .4 chinook were predominant in the Kamchatka, Bolshaya, and Yukon rivers, and age .3's were predominant in the remaining Western Alaska, British Columbia, and Oregon-Washington samples. The percentage of age .2 chinook was highest in the Washington-Oregon region; however, the proportions of age .2 chinook, particularly in the Western Alaskan samples, are affected by the proportions of the

catch made with chinook (about 8 1/2" mesh) and sockeye (about 5 3/8" mesh) gillnet gear.

Regeneration rates for the 1980 inshore scale samples are also shown in Table 5. Regeneration rates were very high (51.4%) for Western Alaska samples where only one scale per fish was mounted, and lowest for the Asian samples (8.8%) which were selected under a binocular microscope. As we re-aged the Western Alaskan samples, we found that many of the regenerated scales had been assigned a freshwater age of 1. by ADF&G scale readers.

Stock Separation Analyses

The total number of 1980 chinook salmon scales digitized and the sample sizes used in the four-way region and river stock separation analyses are shown by region, stock, and age in Table 6. The number of stocks available in our 1980 British Columbia scale collection was quite large, and because of time limitations we chose to use scales only from the Fraser River, the major producer of chinook salmon in British Columbia, and from the Taku, Stikine, and Alsek rivers, as these are the major chinook producers in Southeastern Alaska. The number of stocks available in our 1980 Washington scale collection was also quite large, but the percentage of age 1. chinook in these samples was very low. Therefore, we chose to use only the scale samples from the Columbia River, the major producer of age 1. chinook in the Oregon-Washington region.

The difference between the average ranks of categories and the Kruskal-Wallis H-statistic for each scale character for pooled age 1.2, 1.3, and 1.4 chinook used in the four-region and four-river analyses are shown in Tables 7 and 8, respectively. The numbered scale characters listed in Tables 7 and 8 are described in Table 4. The six scale characters chosen for each analysis are marked with asterisks (Tables 7 and 8). The means, standard deviations, and frequency distributions of the scale characters chosen for the four-region and four-river analyses, respectively, are shown in Appendix Figures 1 and 2. For the regional analysis, the best characters for separating Oregon-Washington from the other three regions were in the freshwater zone, and the best characters for separating Asia, Western Alaska, and British Columbia were in the first ocean zone. In general, means of circuli counts and measurements in the first ocean zone were considerably lower for Asian than for North American chinook. However, mean values of characters in the freshwater zones of Kamchatka and Yukon chinook were similar, and could lead to misclassification errors.

The results of classifying the four regional standards are shown in Table 9. The percentages of fish correctly classified as Asia, Western Alaska, British Columbia, and Oregon-Washington were 80.0, 84.0, 75.0, and 89.9%, respectively. The overall accuracy was 82.2%. Misclassification errors were greatest between British Columbia and Asia.

The results of classifying the four river standards are shown in Table 10. The percentages of fish correctly classified as Kamchatka River, Bolshaya River, Yukon River, and Nushagak River were 66.4, 82.7,

63.0, and 71.5%, respectively. The overall accuracy was 70.9%. Misclassification errors were greatest between rivers within the same regions.

Adequacy of Trawl Scale Samples

A summary of NMFS data on the numbers of chinook sampled for scales by U.S. observers on foreign trawlers in the Alaska FCZ by area and month, 1977-1981, is shown in Table 11. The 1977 and 1980 samples were collected, primarily, for species identification, and will not be used for stock separation analyses. These original sample sizes include the scales of chum salmon (*O. keta*) mistakenly identified as chinook salmon by U.S. observers in 1978 (n=16), 1979 (n=8), and 1981 (n=29), and scale samples from two cruises in 1978 (n=57), one cruise in 1979 (n=23), and one cruise in 1981 (n=14) that were lost at the NMFS lab (Northwest and Alaska Fisheries Center).

Regeneration rates calculated for the 1978, 1979, and 1981 samples by NMFS statistical areas and ocean age classes are shown in Table 12. Compared to regeneration rates in some of the regional standards (Table 5), regeneration rates in the observer samples were low. Within a particular year, regeneration rates appear to be similar for all ocean age classes. Total regeneration rates decrease over the period from 1978 through 1981; and this is probably related to increased skill of scale technicians or observers in selection of non-regenerated scales.

The body zone composition of the 1978, 1979, 1981 trawl scale samples is shown in Table 13. Zones A and B are shown in Fig. 2, and

Zone C represents a scale that could have been taken from any area of the body, except Zones A or B. By convention, scale samples collected from both Zone A and B were coded as Zone B scales. When observers were more specific than coding Zone C, these areas (usually near body fins) were tallied if more than one sample was collected from a particular body area. The category "other" in Table 13 represents samples taken from unique body areas or samples in which scales were taken from more than one body area. In general, Table 13 shows that scale samples collected by U.S. observers were taken from many different areas of the fish. In 1978 over 40% of the samples had no zone indicated on the scale packets, this percentage decreased to less than 0.5% in the 1981 samples, indicating an improvement in observer sampling techniques. With the exception of the 1978 Bering Sea samples, percentages of scales taken from the preferred (Zone A) or adjacent (Zone B) areas was usually high (> 75%).

Sample sizes of 1978, 1979, and 1981 trawl chinook samples usable in stock separation analyses by month, age class, and NMFS statistical areas are shown in Table 14. Only readable, non-regenerated scales taken from the preferred area of the fish (Zone A) or areas directly adjacent to the preferred area (Zone B) were included in these sample sizes. Observer samples for which a zone was not indicated were not included in the sample sizes since we have no established criteria for identifying preferred area scales. The largest area-time strata considered to be acceptable for a stock separation analysis were NMFS statistical areas by month. Samples were considered to be "area-significant" if they contained 25 or more fish. No samples for Bering

4, Yakutat, and Southeast (Fig. 3) were area-significant. Only four samples of freshwater age 0. fish pooled over ocean age classes were area-significant. All four of these samples were in Gulf of Alaska statistical areas (Shumagin, Nov. 1978; Kodiak, May 1979; and Chirikof, Oct. and Nov. 1980), and none were area-significant without pooling over ocean age classes. Twenty-nine samples of freshwater age 1. chinook pooled over ocean age classes were area-significant. Within these samples there were 4 area-significant samples for 1.1's, 20 for 1.2's, 10 for 1.3's, and 2 for 1.4's. The majority of the area-significant samples are in NMFS statistical areas: Bering 1 and Bering 2 (Fig. 3) during winter months (November-April). Several samples, particularly Bering 2 in February 1979 (n=1122), are large enough to divide into smaller area-time strata for a finer-grained analysis.

DISCUSSION

Use of Freshwater Age Patterns for Stock Separation

Chinook in the 1978, 1979, and 1981 trawl samples spent from zero to two winters in freshwater (Table 14). Age 2. fish accounted for less than 2% of readable scales in the trawl samples. Age 0. fish were more prevalent, but only accounted for about 11% of the total sample size. Approximately 75% of the age 0. chinook were collected in Gulf of Alaska statistical areas (Table 14). The predominant freshwater age class was 1., comprising approximately 87% of the total sample of readable scales. The greatest number of readable scales in the trawl samples were collected in the eastern Bering Sea statistical areas (Table 14); and the

probable area of origin of eastern Bering Sea chinook stocks is Western Alaska (Major et al. 1978). The majority of chinook in our 1980 inshore samples from Western Alaska were also freshwater age 1. (Table 5), and, therefore, freshwater age appears to be of little use in determining detailed stock origins of chinook in the trawl samples.

One possible use of freshwater age patterns would be for a regional (Alaskan vs non-Alaskan) stock separation based on the assumption that all age 0. chinook are of non-Alaskan origin. Stock separations based on this assumption have been conducted on chinook caught in mixed stock fisheries in Southeastern Alaska (Kissner 1975). Although age composition of chinook stocks from the Yukon River to the Columbia River and from the Bolshaya and Kamchatka rivers in Asia were determined for only one year, the 1980 Western Alaska and British Columbia samples (Table 5) exhibit the well known geographical trend of increasing percentages of age 0. chinook in stocks from more southern regions. A recent compilation of age statistics on Alaskan chinook salmon (1961-1980) by the Alaska Departmernt of Fish and Game (McBride and Wilcock, unpublished manuscript) finds that "virtually all Alaskan chinook stocks are of the 'spring' type exhibiting one winter's growth in the freshwater zone." However, our re-aged chinook scale data from 1980 western Alaskan stocks show a small percentage of age 0. fish, as well as other (primarily age 2.) age classes in Western Alaskan stocks (Table 5). We have already noted the tendency we found in our 1980 samples of Western Alaska stocks for agency scale readers to assign a freshwater age of 1., regardless of the appearance of the scale. The age 0. scales in our 1980 Nushagak

samples may be age 1. fish in which the annulus did not form in freshwater or was masked by rapid estuarine growth. Chinook scales of this type have been reported by Tutty and Yole (1978). However, the presence of age 0. chinook in 1980 British Columbia samples (Table 5) suggests that age 0. chinook may also be present in southeastern Alaska sections of streams originating in British Columbia, especially since chinook originating in spawning groups near the ocean have a greater tendency to migrate to the ocean during their first year than fish originating farther upstream (Major et al. 1978). Therefore, until we have examined more inshore (particularly Southeastern Alaska) scale samples, we are reluctant to assume that all age 0. chinook are of non-Alaskan origin.

Use of Freshwater-Marine Scale Growth Patterns for Stock Separation

Overall classification accuracies of 82.2% were obtained for a four region analysis (Table 9) and overall accuracies of 70.9% were obtained for a four river analysis (Table 10) of 1980 chinook stocks. These accuracies are well above the lowest acceptable overall accuracy (60.0%) for a four-way classification using the techniques of Cook (1982), and demonstrate the feasibility of using scale pattern recognition techniques to determine region- or stream-of-origin of mixed stocks of chinook.

A major premise of previous high seas salmon stock separations using scale pattern recognition techniques has been that the most accurate classification is based on training samples constructed from scale characters of maturing fish of the same cohort (Harris et al. 1981). However, because the age of maturity of chinook caught incidentally in

the foreign groundfish fisheries is not known, a different strategy for training sample construction will have to be developed. We think the best classification results will be obtained by classifying chinook in the unknowns with chinook of the same freshwater age and brood year in the inshore samples. These fish will have resided in freshwater and entered the ocean at the same approximate time, and therefore, should have similar scale growth patterns in the freshwater and first ocean zone.

Because most of the inshore scale samples were collected well into 1982, we only had time to age and measure inshore samples from one year. For our analysis, we pooled all freshwater age 1. fish over ocean age class (Table 6). This same technique was used by Major et al. (1970) to construct training samples for classifying chinook caught in the mothership fishery. These classifications represent a "worst-case" analysis in that fish were pooled over brood year. We expect that even higher accuracies, particularly in stream-of-origin analyses, may be obtained with training samples constructed from fish of the same freshwater age and brood year.

Adequacy of Trawl Scale Samples

The scales of chinook salmon are highly deciduous, and this results in high regeneration rates in chinook scale samples. By selecting scales from the trawl samples under a binocular microscope we were able to obtain a regeneration rate of 8.6% for the entire sample (Table 12). This is relatively low when compared to regeneration rates as high as

51.4% in some of the 1980 inshore samples (Table 5). This rate is similar to that obtained for 1980 scales from the Kamchatka and Bolshaya rivers (8.8%; Table 5) that were processed using the same techniques, and is probably about the best rate that can be obtained from scrape samples of chinook scales taken from only one side of the body.

Chinook caught in the cod end of a trawl net with a large catch of groundfish may arrive on board completely scaled or with scales attached only to body areas protected by fins. In these cases, observers have sampled scales from any part of the body where scales are still present. With the exception of the Bering Sea samples in 1978 (Table 13), observers usually noted the area of the body from which scales were sampled. The majority of the trawl scale samples were taken either from Zone A or Zone B (Fig. 2; Table 13).

Several studies have shown that counts and measurements of circuli on the scales of salmon vary with sample location on the body (Clutter and Whitesel 1956; Hayashi and Kitahara 1959; Kondo and Kitahara 1962; Lalanne 1963; Anas 1963, 1964; and Scarnecchia 1979). Therefore, one of the requirements for a valid scale pattern analysis is that all of the scales should be taken from approximately the same area on the fish. In a statistical comparison of scale characters, Scarnecchia (1979) found that counts and measurements on the scales of coho salmon taken from the preferred area (Zone A; Fig. 2) and areas adjacent to the preferred area (Zone B; Fig. 2) were not significantly different; scales taken from other areas of the body (Zone C) were significantly different than preferred scales. Therefore, we think that a valid scale pattern analysis

of the trawl samples requires that we use only those scales taken from Zones A and B on the fish.

The largest area-time strata considered to be acceptable for a stock separation analysis were NMFS statistical areas (Fig. 3) by month; and samples were considered to be "area-significant" if they contained 25 or more fish. Using these criteria, a tally of non-regenerated scales taken from body Zones A and B found 33 area-significant samples for chinook of the same freshwater age pooled over ocean age in the 1978, 1979, and 1981 samples (Table 14). Most of these were age 1. fish caught in NMFS statistical areas in the eastern Bering Sea during winter months. Within these samples there were 36 area-significant samples for individual ocean age classes of freshwater age 1. fish; and several of these are large enough to divide into smaller area-time strata for a finer grained analysis. We think that this quantity of samples is adequate for a provisional classification of chinook stocks caught in foreign groundfish fisheries in the Alaska FCZ.

Recommendations to NMFS

In order to improve the quality and quantity of salmon scale samples collected by U. S. observers for future stock separation analyses, we have provided the NMFS with the following recommendations:

1. Always write the body area or zone from which the scale sample was collected on the scale envelope. If the scale sample was not collected from Zone A or B, the specific area, e.g., "underneath the pectoral fin," should be written on the scale envelope. Many observers,

particularly in 1978, did not write the scale zone on the envelope (Table 13).

2. Collect scales only from the preferred area (Zone A) whenever possible. We realize that in many cases there are no scales present in Zone A due to scaling in the net. However, some observers were so consistent in collecting all of their scales from Zone B or another particular body area, we suspect they may not be aware that Zone A is the preferred area on salmon.

3. Collect a sample from both sides of the fish in Zone A to reduce the probability of samples in which all of the scales are regenerated. There were many samples in which most or all of the scales were regenerated in the freshwater portion of the scale. Grossly regenerated scales in which most of the circuli pattern is regenerated can be detected by holding them up to the light, and should be rejected before placing them into the sample envelopes.

4. Collect scale samples from only one zone on the body of the fish. Many of the observers have collected scales from two or more different body zones on the same fish. This may be because they think they have to collect a large sample of scales from each fish.

5. No more than 20 scales should be collected from each fish. For example, a sample of 20 scales, 10 from each side of the body in Zone A would be more than adequate. Many of the scale packets contained very large samples (up to 150 scales per fish). These samples may be so large because they are being collected as scrape samples with a knife.

6. Collect only scales that are still attached to the fish. Many of the scale packets contained the scales of non-salmonid species, indicating contamination from previously collected samples or from other fish whose scales were rubbed off onto the fish being sampled.

7. Clean the scales before placing them in the scale envelopes. Scales can easily be cleaned by rubbing them between the thumb and forefinger or on a cloth before placing them in the scale envelopes. Many of the scales in the '78 and '79 samples were so covered by slime and dirt that they had partially decomposed in the packets.

8. Use forceps instead of a knife to collect scale samples. This would enable the collection of a smaller sample of scales from a more precise area on the body, and would also aid in avoiding contamination from previously collected samples or unattached scales. In addition, individual scales collected with forceps could be cleaned and examined more easily than a scrape sample.

9. Collect scale samples from all fish that are weighed or measured for length. If the fish is already being handled to take a length measurement, it should only take a few more seconds to collect a scale sample. The collection of a scale sample from all of the fish for which length measurements were taken in 1978 and 1979 would have greatly improved our sample sizes, particularly, for Bering I and Bering II in 1979, Shumagin and Kodiak in 1978 and 1979, and Chirikof in 1978 (Table 15).

10. Improve the instruction sheet for observers showing the location of the preferred scale sampling zones. The preferred area on the body of the salmon is the area between the insertion of the dorsal fin and origin of the anal fin, but not more than four scale rows above or below the lateral line. Although the drawing of the salmon shows four scale rows in Zone B beneath the origin of the dorsal fin (Fig. 2), this is not adequately explained in the caption under the drawing. The sizes of the boxes enclosing A and B give the impression of including an area much larger than four scale rows above and below the lateral line, i.e., they reach over half-way to the dorsal fin (chinook salmon usually have about 27 scale rows between the base of the dorsal fin and the lateral line). Because the scales in many samples taken from individual fish and coded as Zone A or B contained a wide variety of shapes and sizes, and because the scale samples were often large (50-150 scales per fish), we suspect that some samples collected by observers and coded as Zone A or B were actually taken from a much larger vertical area. In addition, several observers coded scales as Zone "D". Although there is not a Zone "D" on the salmon drawing, there is one on the drawing of the herring at the bottom of the page (Fig. 2). Observers may be confusing the drawing of the herring with a salmon.

SUMMARY

A study was conducted from October 1, 1981 through September 30, 1982 to determine the feasibility of using scale pattern recognition techniques to determine region or stream origins of chinook in samples collected by U.S. observers on foreign groundfish vessels in the Alaska

FCZ in 1978, 1979, and 1981. Because the predominant freshwater age class in both the trawl samples and the 1980 inshore samples from Asia and Western Alaska was 1., freshwater age patterns will be of little use in determining detailed stock origins of chinook in the Alaska FCZ. High classification accuracies obtained for a four-region (82.2%) and four-river (70.9%) scale pattern analysis of selected major coastal chinook stocks in 1980 demonstrate the feasibility of using freshwater marine scale growth patterns to separate Asian and North American chinook stocks, as well as major Western Alaskan or Asian stocks, from each other. Out of 6,917 scales collected by U.S. observers in 1978, 1979, and 1981, a total of 4,895 or approximately 71.0% were non-regenerated scales taken from the preferred area or areas adjacent to the preferred area. Of these, 3,921 or approximately 80.0% were from "area-significant" ($n \geqslant 25$ fish when samples were stratified by month and NMFS statistical areas) samples. Although quality and quantity of U.S. observer samples could be improved, samples collected in 1978, 1979, and 1981 appear to be adequate for a provisional classification of chinook stocks caught by foreign groundfish fisheries in the Alaska FCZ.

REFERENCES CITED

Anas, R. E. 1963. Red salmon scale studies. Pages 114-116 in Int. N. Pac. Fish. Comm., Annu. Rep. 1961.

Anas, R. E. 1964. Sockeye salmon scale studies. Pages 158-162 in Int. N. Pac. Fish. Comm., Annu. Rep. 1963.

Bohn, B. R., and H. E. Jensen. 1971. Investigations of scale patterns as a means of identifying races of spring chinook salmon in the Columbia River. Fish. Comm. Oregon, Res. Rep. 3:28-36.

Clutter, R. I., and L. E. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Int. Pac. Salmon Fish. Comm., Bull. 9. 159 pp.

Cook, R. C. 1980. Estimating subpopulation mixing proportions with the results of classifying individuals. Univ. Washington, Fish. Res. Inst., Seattle. (Unpublished manuscript.)

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., 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.

Fredin, R. A. 1980. Trends in North Pacific salmon fisheries. Pages 59-119 in W. J. McNeil and D. C. Himsworth (eds.). Salmonid Ecosystems of the North Pacific. Oregon State Univ. Press, Corvallis, OR.

Harris, C. K., R. C. Cook, S. L. Marshall, R. H. Conrad, R. L. Burgner, and J. P. Graybill. 1980. High seas salmon studies. Pages 8-10 in D. D. Beall (ed.). 1979 Research in Fisheries, Annual Report of the College of Fisheries. Contrib. 515. Univ. Washington, Seattle, WA 98195.

Harris, C. K., R. H. Conrad, R. C. Cook, K. W. Myers, R. W. Tyler, and R. L. Burgner. 1981. Monitoring migrations and abundance of salmon at sea - 1980. Pages 71-90 in Int. N. Pac. Fish. Comm., Annu. Rep. 1980.

Hayashi, S. and M. Kitahara. 1959. A note on scales of the coho salmon. Tokai Reg. Fish. Res. Lab., Bull. 26:7-20.

International North Pacific Fisheries Commission. 1979. Historical catch statistics for salmon of the North Pacific Ocean. Int. N. Pac. Fish. Comm., Bull. 39. 166 pp.

Kissner, P. 1975. A study of chinook salmon in Southeast Alaska. Alaska Dep. Fish Game, Div. Sport Fish., Anadromous Fish Studies, July 1, 1974 to June 30, 1975. AFS-41-3. 30 pp.

Kondo, K., and M. Kitahara. 1962. A note on scales of the chum salmon and allied species. Tokai Reg. Fish. Res. Lab., Bull. 33:1-10.

Koo, T. S. Y. 1962. Age and growth studies of red salmon scales by graphical means. Univ. Wash., Publ. Fish., New Ser. 1:51-121.

Kruskal, W. H., and W. A. Wallis. 1952. Use of ranks in one-criterion variable analysis. J. Am. Stat. Assoc. 47:583-621.

Lalanne, J. 1963. Chum salmon studies. Pages 119-124 in Int. N. Pac. Fish. Comm., Annu. Rep. 1961. 127 pp.

Major, R. L., K. H. Mosher, and J. E. Mason. 1972. Identification of stocks of Pacific salmon by means of scale features. Pages 209-231 in R. C. Simon and P. A. Larkin (eds.). The stock concept in Pacific salmon. H. R. MacMillan Lectures in Fisheries, Univ. B.C., Inst. Fish., Vancouver, B.C.

Major, R. L., J. Ito, S. Ito, and H. Godfrey. 1978. Distribution and origin of chinook salmon (Oncorhynchus tsahwytscha) in offshore waters of the North Pacific Ocean. Int. N. Pac. Fish. Comm., Bull. 38. 54 pp.

McBride, D. 1981. Yukon River chinook salmon stock separation studies, legislative report. Alaska Dep. Fish Game, Div. Comm. Fish. 9 pp. (Processed report.)

McBride, D. N., and J. A. Wilcock. 1982. A compilation of catch, escapement, age, size, and sex data of Alaskan chinook salmon (Oncorhynchus tshawytscha Walbaum), 1961-1980. Alaska Dep. Fish Game, Div. Comm. Fish., Anchorage, AK 99502. (Unpublished manuscript.)

Meacham, C. P. 1980. Summary of western Alaska chinook salmon catch and escapement data. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska, October 1980.) 20 pp. Alaska Dep. Fish Game, Comm. Fish. Div., 333 Raspberry Rd., Anchorage, AK 99502.

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, Anchorage, Alaska, September 1981.) 69 pp. Northwest and Alaska Fish. Center, Nat. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Rogers, D. E., K. J. Bruya, K. W. Myers, and T. Nishida. 1982. Origins of chinook salmon in the area of the Japanese mothership salmon fishery. Annual Rep. Oct. 1981-June 1982, Cont. No. 82-0421, Alaska Dep. Fish Game, Comm. Fish. Div. 107 pp. Univ. Washington, Fish. Res. Inst. FRI-UW-8209, Seattle, WA 98195.

Rowland, R. G. 1969. Relation of scale characteristics to river of origin in four stocks of chinook salmon (Oncorhynchus tshawytscha) in Alaska. U.S. Bur. Comm. Fish., Spec. Sci. Rep., Fish. 577. 5 pp.

Scarnecchia, D. L. 1979. Variation of scale characteristics of coho salmon with sampling location on the body. Prog. Fish Cult. 41:132-135.

Tutty, B. D., and F. Y. E. Yole. 1978. Overwintering chinook salmon in the upper Fraser River system. Canadian Dep. Fish. and Environ., Fish. Mar. Serv., MS Rep. 1460. 24 pp.

Vronskiy, B. B. 1972. Reproductive biology of the Kamchatka River chinook salmon [Oncorhynchus tshawytscha (Walbaum)]. Vop. Ikhtiol. 12:293-308. In Russian. (Transl. in J. Ichthyol., 1972, 12:259-273).

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 Montlake 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, National Marine Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Table 1. The species composition (%) of Pacific salmon (Oncorhynchus spp.) in the Alaska FCZ foreign groundfish fishery, 1977-1980.

Area	Year	Chinook	Chum	Sockeye	Pink	Coho	Source
Bering Sea/ Aleutians	1977	91.0	9.0	0.0	0.0	0.0	(Nelson et al. 1981a)
	1978	87.8	10.8	NA	NA	NA	(Nelson et al. 1981a)
	1979	93.2	5.7	NA	NA	NA	(Nelson et al. 1980)
	1980	94.2	5.6	NA	NA	NA	(Nelson et al. 1981b)
Gulf of Alaska	1977	91.0	9.0	0.0	0.0	0.0	(Wall et al. 1981a)
	1978	93.1	2.1	2.2	1.0	1.6	(Wall et al. 1981a)
	1979	82.7	14.1	0.2	0.3	2.7	(Wall et al. 1980)
	1980	87.9	11.6	0.0	0.1	0.4	(Wall et al. 1981b)

Table 2. The estimated incidental catch (numbers and metric tons) of Pacific salmon (Oncorhynchus spp.) in the Alaska FCZ foreign groundfish fishery, 1977-1981.

Area	Year	No.	Metric Tons	Source
Bering Sea/ Aleutian	1977	47,840	197.9	(Nelson et al. 1981a)
	1978	44,548	137.0	(Nelson et al. 1981a)
	1979	107,706	340.1	(Nelson et al. 1980)
	1980	120,104	381.0	(Nelson et al. 1981b)
	1981	43,126	140.0	(NMFS, Northwest and Alaska Fisheries Center)
Gulf of Alaska	1977	5,272	19.3	(Wall et al. 1981a)
	1978	45,603	131.3	(Wall et al. 1981a)
	1979	20,410	68.7	(Wall et al. 1980)
	1980	35,901	106.9	(Wall et al. 1981b)
	1981	34,304	105.0	(NMFS, Northwest and Alaska Fisheries Center)

Table 3. Estimates[1] of chinook salmon escapements (wild and hatchery), 1976-1980 (fish in thousands.)

Year	California	Oregon-Washington	British Columbia	Southeast Alaska	Total
1976	258*	593	164	18	1,033
1977	258*	660	224	30	1,172
1978	290	702	196	20	1,208
1979	269	581	177	25	1,052
1980	216	643	190*	39	1,088
Average 1976-80	258	636	190	26	1,111
Average catch (all gear)	671	1,361	1,719**	339	4,090

*Estimate from average of other years.
**1976-1978 average only.

[1]Data sources: Fredin (1980), INPFC (1979), Major et al. (1978), INPFC Statistical Yearbooks, PFMC proposed management plan for 1981, and personal communication with fisheries agencies (1978-1980 data).

Table 4. Scale characters examined for use in the discriminant function analyses of 1980 Age 1. chinook salmon (Oncorhynchus tshawytscha) scale samples.

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	Ocean age
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 zone 3/size zone 3
23	Distance C4 to C6 in zone 3/size zone 3
24	Distance C7 to C9 in zone 3/size zone 3
25	Distance C10 to C12 in zone 3/size zone 3
26	Distance C13 to C15 in zone 3/size zone 3
27	Distance C16 to C18 in zone 3/size zone 3
28	Distance C19 to C21 in zone 3/size zone 3
29	Distance C22 to C24 in zone 3/size zone 3
30	Distance C25 to C27 in zone 3/size zone 3
31	Distance C28 to C30 in zone 3/size zone 3
32	Distance C31 to C33 in zone 3/size zone 3
33	Distance C34 to C36 in zone 3/size zone 3
34	Distance C1 to C9 in zone 3
35	Distance C10 to C18 in zone 3
36	Distance C19 to C27 in zone 3

[a]Zone 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.

C = circulus

Table 5. Age composition of 1980 chinook salmon (Oncorhynchus tshawytscha) scale samples by stock and region.

Region	Stock	Age 1.2	1.3	1.4	0.2	0.3	0.4	Other	Regenerated[1]	Total
Asia	Kamchatka R.	33	60	72	0	3	2	15	13	198
	Bolshaya R.	17	25	122	1	0	5	8	22	200
Total		50	85	194	1	3	7	23	35	398
% Total		12.6	21.4	48.7	0.2	0.7	1.8	5.8	8.8	100.0
Western Alaska	Yukon R.	47	392	320	0	0	0	32	776	1567
	Kuskokwim R.	7	43	13	0	0	0	5	72	140
	Nushagak R.	6	231	75	1	3	5	34	435	790
	Togiak R.	4	10	5	0	0	0	2	23	44
Total		64	676	413	1	3	5	73	1306	2541
% Total		2.5	26.6	16.2	0.1	0.1	0.2	2.9	51.4	100.0
British Columbia	Fraser R.	36	164	10	24	74	32	6	76	422
	Klukshu R. (Alsek R.)	4	16	32	0	0	1	0	32	85
	Stikine R.	27	55	49	0	3	1	8	44	187
	Taku R.	9	14	6	0	0	0	2	7	38
Total		76	249	97	24	77	34	16	159	732
% Total		10.4	34.0	13.3	3.3	10.5	4.6	2.2	21.7	
Oregon-Washington	Columbia R.	62	106	0	2	6	6	0	131	313
% Total		19.8	33.9	0.0	0.6	1.9	1.9	0	41.9	100.0

[1]This column includes scales that are regenerated, damaged, missing or otherwise unreadable.

Table 6. Total number of 1980 chinook salmon scales digitized by region, stock, and age; and sample sizes used in the four-way region and river stock separation analyses by region, stock, and age.

Region	Stock	Age class 1.2 Total digitized	1.2 Sample size Region	1.2 Sample size River	1.3 Total digitized	1.3 Sample size Region	1.3 Sample size River	1.4 Total digitized	1.4 Sample size Region	1.4 Sample size River	Total Total digitized	Total Sample size Region	Total Sample size River
Asia	Bolshaya R.	17	10	17	22	16	22	100	69	100	139	95	139
	Kamchatka R.	30	23	30	59	35	59	69	47	69	158	105	158
Region Total		47	33		81	51		169	116		297	200	
Western Alaska	Yukon R.	46	16	38	100	44	79	100	39	83	246	99	200
	Nushagak R.	6	1	6	100	44	100	66	24	66	172	69	172
	Togiak R.	4	1		10	2		4	4		18	7	
	Kuskokwim R.	8	4		38	16		13	5		59	25	
Region Total		64	22		248	106		183	72		495	200	
British Columbia	Fraser R.	31	18		100	63		9	6		140	87	
	Stikine R.	25	12		53	33		44	29		122	74	
	Taku R.	10	6		13	8		6	1		29	15	
	Klukshu R. (Alsek R.)	3	3		11	5		28	16		42	24	
Region Total		69	39		177	109		87	52		333	200	
Washington-Oregon	Columbia R.	55	55		93	93		0	0				

Table 7. The differences between the average rank of categories and the Kruskal-Wallis H-statistic for each scale character for pooled 1980 age 1.2, 1.3, and 1.4 chinook salmon (Oncorhynchus tshawytscha) scales used in the four region analysis. Asterisks indicate scale characters selected for use in the discriminant analysis. (Numbered scale characters are described in Table 4)

Category Combination[1]	Scale Character No.											
	1*	2	3	4	5	6	7	8	9	10	11*	12
WA,OR-ASIA	433.4	68.3	316.6	333.4	344.6	426.7	507.4	-35.2	-226.2	97.3	-209.3	424.1
WA,OR-AK	291.5	126.9	-68.1	285.7	-28.9	91.2	272.6	95.9	-174.3	312.4	-382.5	334.8
WA,OR-BC	319.9	269.8	93.7	385.5	178.6	265.7	246.9	212.3	-122.7	316.6	-250.7	301.4
BC-AK	-25.4	-142.8	-161.8	-99.8	-207.6	-174.5	25.7	-116.4	-51.5	-4.2	-131.8	33.4
BC-ASIA	116.4	-201.4	222.9	-52.1	166.0	161.1	260.5	-247.5	-103.5	-219.3	41.4	122.7
AK-ASIA	141.8	-58.6	384.7	47.6	373.6	335.5	234.8	-131.1	-51.9	-215.1	173.2	89.2
H-Statistic	355.7	153.5	352.8	306.5	369.1	414.7	475.2	152.8	118.2	283.8	270.6	355.6

Category Combination[1]	Scale Character No.											
	13	14*	15*	16	17	18	19*	20	21	22	23	24
WA,OR-ASIA	90.8	346.9	344.1	430.4	-131.8	-54.7	-26.5	-137.7	-32.9	-194.6	-188.7	-289.0
WA,OR-AK	144.3	69.7	334.4	156.8	-228.5	-33.6	-217.6	-222.8	-262.8	105.5	120.5	38.2
WA,OR-BC	275.7	-8.5	378.2	145.2	-94.7	93.2	153.0	-93.3	81.2	64.2	85.9	-8.7
BC-AK	-131.4	78.2	-43.8	11.6	-133.8	-126.8	-370.6	-129.5	-344.1	41.3	34.6	46.9
BC-ASIA	-184.9	355.4	-34.1	285.2	-37.1	-147.8	-179.6	-44.4	-114.2	-258.8	-274.6	-280.3
AK-ASIA	-53.5	277.2	9.7	273.6	96.8	-21.1	191.0	85.1	229.9	-300.1	-309.2	-327.2
H-Statistic	153.7	346.8	321.4	376.0	99.4	54.9	296.6	95.3	276.2	226.8	246.0	287.2

Category Combination[1]	Scale Character No.											
	25	26	27	28	29	30	31	32	33	34	35	36*
WA,OR-ASIA	-296.9	-320.8	-242.1	-24.9	145.4	258.5	205.8	128.5	50.7	26.3	26.8	287.1
WA,OR-AK	27.2	-67.1	-147.2	-175.9	-179.2	-50.4	8.7	34.6	33.4	62.8	-168.8	-124.9
WA,OR-BC	-5.3	-59.4	-58.7	-41.1	-41.6	26.9	-12.1	-3.2	-6.7	180.9	65.5	61.8
BC-AK	32.5	-7.6	-88.5	-134.8	-137.6	-77.3	20.8	37.8	40.0	-118.2	-234.2	-186.7
BC-ASIA	-291.7	-261.3	-183.3	16.2	187.0	231.7	217.9	131.7	57.4	-154.7	-38.7	225.3
AK-ASIA	-324.2	-253.7	-94.8	151.0	324.6	308.9	197.1	93.9	17.4	-36.5	195.5	411.9
H-Statistic	294.5	246.0	128.7	75.6	232.2	249.3	163.4	82.3	38.7	76.6	136.8	379.5

[1]WA,OR = Washington and Oregon; AK = Alaska; BC = British Columbia.

Table 8. The difference between the average ranks of categories and the Kruskal-Wallis H-statistic for each scale character for pooled 1980 age 1.2, 1.3, and 1.4 chinook salmon (Oncorhynchus tshawytscha) scales used in the four river analysis. Asterisks indicate scale characters selected for use in the discriminant analysis. (Numbered scale characters are described in Table 4)

Category Combination[1]	Scale Character No. 1	2	3	4	5	6*	7	8	9	10	11	12
NUS-KAM	103.8	-209.1	311.5	-124.5	284.2	275.8	251.7	-243.0	11.9	-310.8	199.4	21.8
NUS-BOL	216.4	-62.4	391.6	79.3	393.4	385.3	386.2	-136.4	-81.7	-250.9	247.7	148.7
NUS-YUK	-29.8	-147.2	78.8	-151.4	52.4	42.6	66.5	-127.8	18.2	-143.2	65.7	-60.7
YUK-BOL	246.2	84.8	312.8	230.8	340.9	342.7	319.7	-8.6	-99.9	-107.8	182.0	209.4
YUK-KAM	133.6	-61.9	232.6	26.9	231.8	233.2	185.2	-115.2	-6.3	-167.6	133.7	82.4
BOL-KAM	-112.6	-146.7	-80.1	-203.8	-109.2	-109.5	-134.5	-106.6	93.6	-59.9	-48.3	-126.9
H-Statistic	158.9	112.9	443.7	151.1	447.4	437.3	391.6	131.5	31.1	245.1	169.4	100.6

Category Combination[1]	Scale Character No. 13	14	15*	16*	17	18	19	20	21	22	23	24
NUS-KAM	-217.3	336.5	-197.2	282.9	123.3	-39.0	52.1	141.0	153.7	-297.1	-321.5	-339.2
NUS-BOL	-41.0	366.2	49.8	399.6	99.0	-62.9	213.3	53.6	240.0	-387.1	-372.2	-377.1
NUS-YUK	-126.8	130.3	-154.1	95.9	47.2	-109.6	-90.2	18.1	-50.9	-156.6	-165.0	-160.1
YUK-BOL	85.8	235.9	203.9	303.7	51.8	46.7	303.6	35.6	290.9	-230.5	-207.1	-217.1
YUK-KAM	-90.5	206.2	-43.2	187.1	76.1	70.6	142.3	122.9	204.6	-140.5	-156.4	-179.1
BOL-KAM	-176.3	-29.7	-247.1	-116.6	24.3	23.9	-161.2	87.4	-86.4	89.9	50.7	37.9
H-Statistic	122.9	392.2	181.4	412.7	39.8	31.2	208.7	52.1	238.0	364.3	363.3	390.7

Category Combination[1]	Scale Character No. 25*	26	27	28	29	30	31*	32	33	34*	35	36
NUS-KAM	-362.6	-332.6	-171.5	93.6	239.8	288.8	245.4	165.0	60.2	-190.1	-13.4	341.2
NUS-BOL	-365.8	-285.4	-145.7	104.8	277.1	309.3	256.6	169.1	62.4	-136.0	153.2	374.3
NUS-YUK	-157.2	-129.2	-103.9	-17.9	51.6	137.7	160.4	137.1	59.1	-246.0	-149.3	112.6
YUK-BOL	-208.6	-156.2	-41.8	122.8	225.4	171.6	96.3	31.9	3.2	110.0	302.4	261.7
YUK-KAM	-205.3	-203.4	-67.6	111.6	188.2	151.2	85.1	27.9	1.1	55.9	135.9	228.6
BOL-KAM	3.2	-47.2	-25.8	-11.2	-37.3	-20.4	-11.2	-4.1	-2.2	-54.1	-166.6	-33.1
H-Statistic	406.7	302.6	75.5	53.5	254.4	319.3	279.9	200.9	83.9	160.3	202.8	424.9

[1]NUS = Nushagak River; KAM = Kamchatka River; BOL = Bolshaya River; YUK = Yukon River.

Table 9. Decision array for four-way regional classification of pooled mature age 1.2, 1.3, and 1.4 chinook salmon (Oncorhynchus tshawytscha) of Asia vs. Western Alaska vs. British Columbia vs. Oregon-Washington origin in 1980. The overall classificatory accuracy was calculated as the unweighted mean of the accuracies on the diagonal of the classification array.

				Overall accuracy 82.2%
	Correct decision (%)			
Calculated decision	Asia	Western Alaska	British Columbia	Oregon-Washington
Asia	160(80.0)	19(9.5)	19(9.5)	1(0.7)
Western Alaska	16(8.0)	168(84.0)	15(7.5)	0(0.0)
British Columbia	21(10.5)	13(6.5)	150(75.0)	14(9.4)
Washington-Oregon	3(1.5)	0(0.0)	16(8.0)	133(89.9)
Total	200	200	200	148

Table 10. Decision array for four-way river classification of pooled mature age 1.2, 1.3, and 1.4 chinook salmon (Onchorynchus tshawytscha) of Kamchatka R. vs. Bolshaya R. vs. Yukon R. vs. Nushagak R. origin in 1980. The overall classificatory accuracy was calculated as the unweighted mean of the accuracies on the diagonal of the classification array.

				Overall accuracy 70.9%
Calculated decision	Correct decision (%)			
	Kamchatka R.	Bolshaya R.	Yukon R.	Nushagak R.
Kamchatka R.	105(66.4)	21(15.1)	25(12.5)	8(4.6)
Bolshaya R.	27(17.1)	115(82.7)	0(0.0)	1(0.6)
Yukon R.	20(12.7)	3(2.2)	126(63.0)	40(23.3)
Nushagak R.	6(3.8)	0(0.0)	49(24.5)	123(71.5)
Total	158	139	200	172

Table 11. Summary of National Marine Fisheries Service data on the number of chinook salmon (Oncorhynchus tshawytscha) sampled for scales by U.S. observers on foreign trawlers in the Alaska FCZ by area and month, 1977-1981.

Area	Year	Month												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Bering 1	1977	0	0	0	0	0	0	0	0	3	42	127	18	190
	1978	0	0	0	1	2	18	4	12	9	21	15	1	83
	1979	0	2	1	0	5	16	20	44	71	166	5	21	351
	1980	1	9	6	9	8	0	0	7	10	21	119	17	207
	1981	30	68	101	66	34	10	7	6	14	85	319	15	755
Bering 2	1977	0	26	9	2	0	0	1	2	2	58	7	13	120
	1978	239	20	22	13	9	0	0	0	2	11	96	10	422
	1979	228	1706	257	220	87	2	0	0	0	20	139	114	2773
	1980	27	40	6	22	2	0	0	0	0	0	76	44	217
	1981	240	133	178	459	64	0	0	0	11	12	6	109	1212
Bering 4	1977	0	0	0	0	0	0	0	0	0	0	0	0	0
	1978	0	0	0	0	0	0	1	0	0	1	0	0	2
	1979	0	0	0	0	1	0	0	0	0	0	0	1	2
	1980	0	1	0	0	0	0	0	0	0	0	0	0	1
	1981	0	0	2	15	0	0	0	0	0	6	5	1	29
Shumagin	1977	0	0	0	1	0	3	0	0	0	0	0	0	4
	1978	0	0	0	0	29	0	5	0	5	59	75	0	173
	1979	0	0	0	0	0	15	4	10	66	19	21	44	179
	1980	5	0	0	0	4	2	3	0	3	16	2	0	35
	1981	8	41	0	0	0	3	4	10	10	90	43	0	209
Chirikof	1977	0	0	0	0	0	0	0	2	2	0	1	0	5
	1978	0	0	0	12	46	1	1	0	0	0	5	0	65
	1979	0	0	0	0	0	8	4	2	0	0	0	0	14
	1980	0	0	0	5	0	0	0	0	0	1	13	0	19
	1981	21	0	0	0	0	3	36	37	5	126	232	18	478

Table 11. Summary of National Marine Fisheries Service data on the number of chinook salmon (Oncorhynchus tshawytscha) sampled for scales by U.S. observers on foreign trawlers in the Alaska FCZ by area and month, 1977-1981 - continued.

Area	Year	Month												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Kodiak	1977	0	0	0	0	0	3	45	25	6	6	7	0	92
	1978	0	0	0	0	0	23	2	1	5	5	34	0	70
	1979	0	0	0	0	49	34	13	19	5	32	16	0	168
	1980	0	0	0	0	0	13	1	2	4	50	2	0	72
	1981	0	0	0	0	0	0	2	0	1	6	15	0	24
Yakutat	1977	0	23	0	0	0	2	0	0	0	0	1	0	26
	1978	0	0	0	1	2	0	0	0	0	0	0	0	3
	1979	0	0	0	0	4	0	1	0	1	2	1	0	9
	1980	0	0	0	0	0	1	0	0	2	3	0	0	6
	1981	0	0	0	0	0	0	0	0	0	26	0	0	26
Southeast	1977	0	7	0	0	2	0	0	0	0	0	0	0	9
	1978	0	0	0	0	4	0	0	0	0	0	0	0	4
	1979	0	0	0	0	0	2	0	0	0	8	0	0	10
	1980	0	0	0	0	0	0	0	0	0	0	0	0	0
	1981	0	0	0	0	0	0	0	0	0	1	0	0	1

Table 12. Regeneration rates calculated for chinook salmon scales sampled by U.S. observers on foreign trawlers in the Alaska FCZ in 1978, 1979, and 1981, by National Marine Fisheries Service statistical areas and ocean age class.

Year	Stat. Area	Ocean age[a] X.0	T.0	X.1	T.1	X.2	T.2	X.3	T.3	X.4	T.4	X.5	T.5	X.X	Total reg	Total sample size
1978	Bering 1	0	0	0	4	6	33	3	26	1	4	0	0	4	14	71
	Bering 2	0	0	3	43	9	168	9	129	5	58	0	2	12	38	412
	Bering 4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
	Shumagin	0	0	2	24	4	75	0	16	0	1	0	0	9	15	125
	Chirikof	0	0	0	0	6	42	2	19	0	1	0	0	3	11	65
	Kodiak	0	0	3	21	1	32	1	9	0	2	0	0	5	10	69
	Yakutat	0	0	0	0	0	0	0	1	0	1	0	0	1	1	3
	Southeast	0	0	0	1	1	1	0	2	0	0	0	0	0	1	4
Total 1978		0	0	8	93	27	353	15	202	6	67	0	2	34	90	751
% Total 1978[b]		0.0		8.6		7.6		7.4		9.0		0.0		4.5	12.0	
1979	Bering 1	0	3	2	30	23	250	1	54	0	7	0	0	5	31	349
	Bering 2	1	24	13	120	168	1920	41	542	9	89	0	12	36	268	2743[c]
	Bering 4	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2
	Shumagin	0	0	2	38	13	122	1	14	0	3	0	0	1	17	178
	Chirikof	0	0	0	0	0	8	1	3	0	2	0	0	1	2	14
	Kodiak	0	0	3	26	12	110	0	27	0	3	0	1	1	16	168
	Yakutat	0	0	0	1	0	3	0	2	0	3	0	0	0	0	9
	Southeast	0	0	0	0	0	3	1	5	0	2	0	0	0	1	10
Total 1979		1	27	20	215	216	2417	45	648	9	109	0	13	44	335	3473
% Total 1979[b]		3.7		9.3		8.9		6.9		8.3		0.0		1.3	9.6	

Table 12. Regeneration rates calculated for chinook salmon scales sampled by U.S. observers on foreign trawlers in the Alaska FCZ in 1978, 1979, and 1981, by National Marine Fisheries Service statistical areas and ocean age class - continued.

Year	Stat. Area	Ocean age[a] X.0	T.0	X.1	T.1	X.2	T.2	X.3	T.3	X.4	T.4	X.5	T.5	X.X	Total reg.	Total sample size
1981	Bering 1	0	1	3	106	11	425	8	153	2	26	0	1	21	45	733
	Bering 2	0	9	1	29	36	683	16	306	6	141	0	5	36	95	1209
	Bering 4	0	0	0	2	0	18	0	9	0	0	0	0	0	0	29
	Shumagin	0	0	2	76	1	65	3	47	0	12	0	4	3	9	207
	Chirikof	0	0	5	172	5	214	1	62	1	9	0	0	7	19	464
	Kodiak	0	0	0	6	0	8	1	6	0	0	0	0	2	3	22
	Yakutat	0	0	0	0	0	11	0	12	0	3	0	0	0	0	26
	Southeast	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Total 1981		0	10	11	391	53	1424	29	596	9	191	0	10	69	171	2691
% Total 1981[b]		0.0		2.8		3.7		4.9		4.7		0.0		2.6	6.4	
Grand Total 1978,1979,1981		1	37	39	699	296	4194	89	1446	24	367	0	25	147	596	6915
% Grand Total 1978,1979,1981		2.7		5.6		7.1		6.2		6.5		0		2.1	8.6	

[a]An "X" before the decimal point represents scales that are regenerated or otherwise unredable in the freshwater zone. An "X" after the decimal point represents scales that regenerated or otherwise unredable in the ocean zone. A "T" represents the total count of fish of a particular ocean age.

[b]Total (%) regenerated scales for each ocean age class, the percentage of the total sample regenerated in both the freshwater and ocean zones (x.x), and the percentage of the total sample that was regenerated.

[c]One age 1.6 scale was not included in the total.

Table 13. Body zone composition of chinook salmon (Oncorhynchus tshawytscha) scale samples collected by U.S. observers on foreign trawlers in the Bering Sea and Gulf of Alaska in 1978, 1979, and 1981.

Body zone	Area and year											
	1978				1979				1981			
	Bering (%)	Sample size	Gulf (%)	Sample size	Bering (%)	Sample size	Gulf (%)	Sample size	Bering (%)	Sample size	Gulf (%)	Sample size
ZONE A*	21.6	105	57.5	153	50.8	1573	46.1	175	56.8	1119	46.3	333
ZONE B*	13.6	66	22.9	61	27.2	842	41.1	156	25.5	502	38.1	274
ZONE C*	0.0	0	0.0	0	1.6	50	2.1	8	4.7	93	1.4	10
Pectoral fin	3.1	15	0.4	1	7.6	236	3.4	13	7.2	142	7.2	52
Behind head	0.0	0	0.0	0	0.0	0	0.0	0	0.5	10	0.1	1
Dorsal fin	1.9	9	0.0	0	2.1	65	2.4	9	2.5	50	1.5	11
Lateral line	0.0	0	1.9	5	0.0	1	0.3	1	0	0	0	0
Operculum	2.3	11	0.0	0	1.8	56	0.3	1	0.1	2	0.1	1
Pelvic fin	0.0	0	0.0	0	0.9	27	0.0	0				
Anal fin	0.0	0	0.0	0	2.9	90	0.0	0				
Other	0.6	3	0.0	0	1.4	42	1.1	4	1.5	30	3.6	26
No zone indicated	56.7	275	15.0	40	3.2	100	3.2	12	0.7	14	1.3	9
No scale in packet	0.2	1	2.3	6	0.5	14	0.0	0	0.5	9	0.4	3
Total	100.0	485	100.0	266	100.0	3096	100.0	379	100.0	1971	100.0	720

*Zones A, B, and C are International North Pacific Fisheries Commission body zone.

Table 14. Sample sizes of 1978, 1979, and 1981 foreign trawl chinook salmon (Oncorhynchus tshawytscha) scale samples usable in stock separation analyses by month, age class, and National Marine Fisheries Service statistical areas. Only readable, non-regenerated scales taken from the preferred area of the fish or areas directly adjacent to the preferred area are included in these sample sizes.

Year	Stat. Area	Month	Age class[1]															
			0.0	0.1	0.2	0.3	0.4	0.5	0.T	1.0	1.1	1.2	1.3	1.4	1.5	1.T	2.T	Total
1978	Bering 1	Apr											1			1		1
		May				1			1				1			1		2
		Jun			5	2			7			3	4			7		14
		Aug				1	1		2			3	4			7		9
		Sep										2	1			3		3
		Oct			1	2			3		1	6	1	1		9		12
		Nov				2			2			6	2	1		9		11
	Bering 2	Apr			1				1		1	5	1			7		8
		May											4	2		6		6
		Sep											2			2		2
		Oct			1				1			4	1			5		6
		Nov									17	42	6	1		66	1	67
		Dec									5	2				7		7
	Bering 4	Jul										1				1		1
		Oct										1				1		1
	Shumagin	May			12	3	1		16			5	4			9		25
		Jul			3				3			1				1		4
		Sep			2				2		1					1		3
		Oct		1	7				8			6	2			8		16
		Nov		4	18	6			28		10	15				25		53

Table 14. Sample sizes of 1978, 1979, and 1981 foreign trawl chinook salmon (Oncorhynchus tshawytscha) scale samples usable in stock separation analyses by month, age class, and National Marine Fisheries Service statistical areas. Only readable, non-regenerated scales taken from the preferred area of the fish or areas directly adjacent to the preferred area are included in these sample sizes - continued.

Year	Stat. Area	Month	Age class[1] 0.0	0.1	0.2	0.3	0.4	0.5	0.T	1.0	1.1	1.2	1.3	1.4	1.5	1.T	2.T	Total
1978	Chirikof	Apr			2	2			4									4
		May			5	6	1		12			2	1			3		15
		Jun			1				1									1
		Jul			1				1									1
		Nov			2	1			3			1				1		4
	Kodiak	Jun			12	4			16			3	1			4		20
		Jul			2				2									2
		Sep		1					1		1	1		1		3		4
		Oct		2	2				4									4
		Nov		7	10	1			18		6		2			8	1	27
	Yakutat	Apr												1		1		1
		May				1			1									1
	Southeast	May				2			2		1					1		3
Total	1978			15	87	34	3		139		43	109	38	7		197	2	338
1979	Bering 1	Feb											2			2		2
		Mar										1				1		1
		May											3	1		4		4
		Jun				1			1			4	2	3		9		10
		Jul				2			2			11	6			17		19
		Aug			2	6			8		1	23	2			26		35
		Sep			7	5			12		2	42	7			51		63

Table 14. Sample sizes of 1978, 1979, and 1981 foreign trawl chinook salmon (Oncorhynchus tshawytscha) scale samples usable in stock separation analyses by month, age class, and National Marine Fisheries Service statistical areas. Only readable, non-regenerated scales taken from the preferred area of the fish or areas directly adjacent to the preferred area are included in these sample sizes - continued.

Year	Stat. Area	Month	Age class[1] 0.0	0.1	0.2	0.3	0.4	0.5	0.T	1.0	1.1	1.2	1.3	1.4	1.5	1.T	2.T	Total
1979 (cont'd.)	Bering 1	Oct			6	2			8		16	111	12	1		140	1	149
		Nov									1	2				3		3
		Dec								2	5	10				17		17
	Bering 2	Jan				1			1			97	51	6	1	155	1	157
		Feb				3	1		4		17	808	254	38	5	1122	15	1141
		Mar				1			1		2	83	47	8	2	142	1	144
		Apr			3	4			7		2	126	55	14	3	200		207
		May				2			2		4	45	8	3	1	61		63
		Jun										1				1		1
		Oct				1			1			14	2			16		17
		Nov			1				1	3	23	64	4			94		95
		Dec								2	17	43	4			66	2	68
	Bering 4	Dec										1				1		1
	Shumagin	Jun			7	2	3		12			2				2		14
		Jul			1				1									1
		Aug				1			1			5	2			7		8
		Sep			13	4			17		2	29	3			34		51
		Oct			1				1			16				16		17
		Nov			2				2		3	13				16		18
		Dec		7	5				12		23	5				28		40
	Chirikof	Jun					1		1			5	1			6		7
		Jul					1		1			2				2	1	3
		Aug											1			1		1

Table 14. Sample sizes of 1978, 1979, and 1981 foreign trawl chinook salmon (Oncorhynchus tshawytscha) scale samples usable in stock separation analyses by month, age class, and National Marine Fisheries Service statistical areas. Only readable, non-regenerated scales taken from the preferred area of the fish or areas directly adjacent to the preferred area are included in these sample sizes - continued.

Year	Stat. Area	Month	Age class[1] 0.0	0.1	0.2	0.3	0.4	0.5	0.T	1.0	1.1	1.2	1.3	1.4	1.5	1.T	2.T	Total
1979	Kodiak	May			23	6			29			11		1		12		41
		Jun			16	5		1	22			4	1			5		27
		Jul				1			1			3	3			6		7
		Aug		2	2		1		5		3	3				6		11
		Sep			2				2		1					1		3
		Oct		3	6	4			13		8	5	2			15		28
		Nov		1	1				2		3	2	1			6		8
Yakutat		May			1		1		2			1				1		3
		Jul												1		1		1
		Sep											1			1		1
	Southeast	Jun				2			2									2
		Oct				1	2		3			2				2		5
Total	1979			13	99	54	10	1	177	7	133	1594	474	76	12	2296	21	2494
1981	Bering 1	Jan			1	1			2			21	5			26		28
		Feb				1	1		2			23	26	8		57	1	60
		Mar				1	1		2		2	27	30	8	1	68	1	71
		Apr				1			1		1	21	7	2		31		32
		May			3	2			5		2	3	12	2		19		24
		Jun			2				2			3	2	1		6	1	9
		Jul				2			2			1	3			4		6
		Aug			1	2			3				1			1		4
		Sep		1	2	1			4		3	7	1			11		15
		Oct		1	2	1			4		7	43	6			56		60

Table 14. Sample sizes of 1978, 1979, and 1981 foreign trawl chinook salmon (Oncorhynchus tshawytscha) scale samples usable in stock separation analyses by month, age class, and National Marine Fisheries Service statistical areas. Only readable, non-regenerated scales taken from the preferred area of the fish or areas directly adjacent to the preferred area are included in these sample sizes - continued.

Year	Stat. Area	Month	Age class[1] 0.0	0.1	0.2	0.3	0.4	0.5	0.T	1.0	1.1	1.2	1.3	1.4	1.5	1.T	2.T	Total
1981 (cont'd.)	Bering 1	Nov	1	8	8	6			23		45	151	19			215	7	245
		Dec									3	9				12	1	13
	Bering 2	Jan			2	5			7			88	67	31		186	1	194
		Feb			3	2			5		1	48	38	18		105	2	112
		Mar			1				1		4	66	30	13	2	115	3	119
		Apr			2	2			4		1	220	66	23	2	312	9	325
		May										10	15	20		45	2	47
		Sep			1				1			8	1			9		10
		Oct										8	1	1		10	1	11
		Nov										5				5		5
		Dec	4		1				5	4	16	54	9	2		85	2	92
	Bering 4	Mar											2			2		2
		Apr				1			1		1	7	1			9	1	11
		Oct										2	3			5		5
		Nov										3	1			4		4
		Dec									1					1		1
	Shumagin	Jan					1		1			1	1	1	1	4	3	8
		Feb			1	9	6	1	17			11	10	2		23	1	41
		Jun			1	1			2			1				1		3
		Jul										3				3		3
		Aug									1	6	2			9		9
		Sep				1			1		1	4	2			7		8
		Oct		11	3	6			20		27	18	6			51		71
		Nov		1	5	3		1	10		14	7	1			22		32

Table 14. Sample sizes of 1978, 1979, and 1981 foreign trawl chinook salmon (Oncorhynchus tshawytscha) scale samples usable in stock separation analyses by month, age class, and National Marine Fisheries Service statistical areas. Only readable, non-regenerated scales taken from the preferred area of the fish or areas directly adjacent to the preferred area are included in these sample sizes - continued.

Year	Stat. Area	Month	Age class[1] 0.0	0.1	0.2	0.3	0.4	0.5	0.T	1.0	1.1	1.2	1.3	1.4	1.5	1.T	2.T	Total
1981	Chirikof	Jan			12	1	1		14				1			1		15
		Jul				3	1		4				4			4		8
		Aug											2			2		2
		Sep											1			1		1
		Oct		4	24	5	1		34		41	33	1			75		109
		Nov		6	17	15	3		41		76	63	13			152		193
		Dec		2		3			5		4	7	2			13		18
	Kodiak	Jul											1			1		1
		Oct			1	1			2		2		1			3		5
		Nov		1	4	2			7		3	3				6		13
	Yakutat	Oct			3	3	3		9			5	3			8		17
	Southeast	Oct				1			1									1
Total	1981		5	35	100	82	18	2	242	4	256	990	397	132	6	1785	36	2063

[1]Age is designated by the European formula where the number preceeding the decimal point is the number of winters the fish spent in freshwater, and the number following the decimal point is the number of winters the fish spent in the ocean. A "T" after the decimal point represents the total count of fish of a particular freshwater age.

Table 15. Comparison of the number of chinook sampled for scales to the number of chinook whose lengths were measured by U.S. observers on foreign trawlers in the Alaska FCZ, 1978-1979.

Area	Year	No. chinook scale samples	No. chinook length measurements
Bering I	1978	83	101
	1979	351	2,124
Bering II	1978	422	551
	1979	2,773	5,736
Bering IV	1978	2	2
	1979	2	7
Shumagin	1978	173	434
	1979	179	396
Chirikof	1978	65	204
	1979	14	18
Kodiak	1978	70	161
	1979	168	281
Yakutat	1978	3	8
	1979	9	6
Southeastern	1978	4	4
	1979	10	9

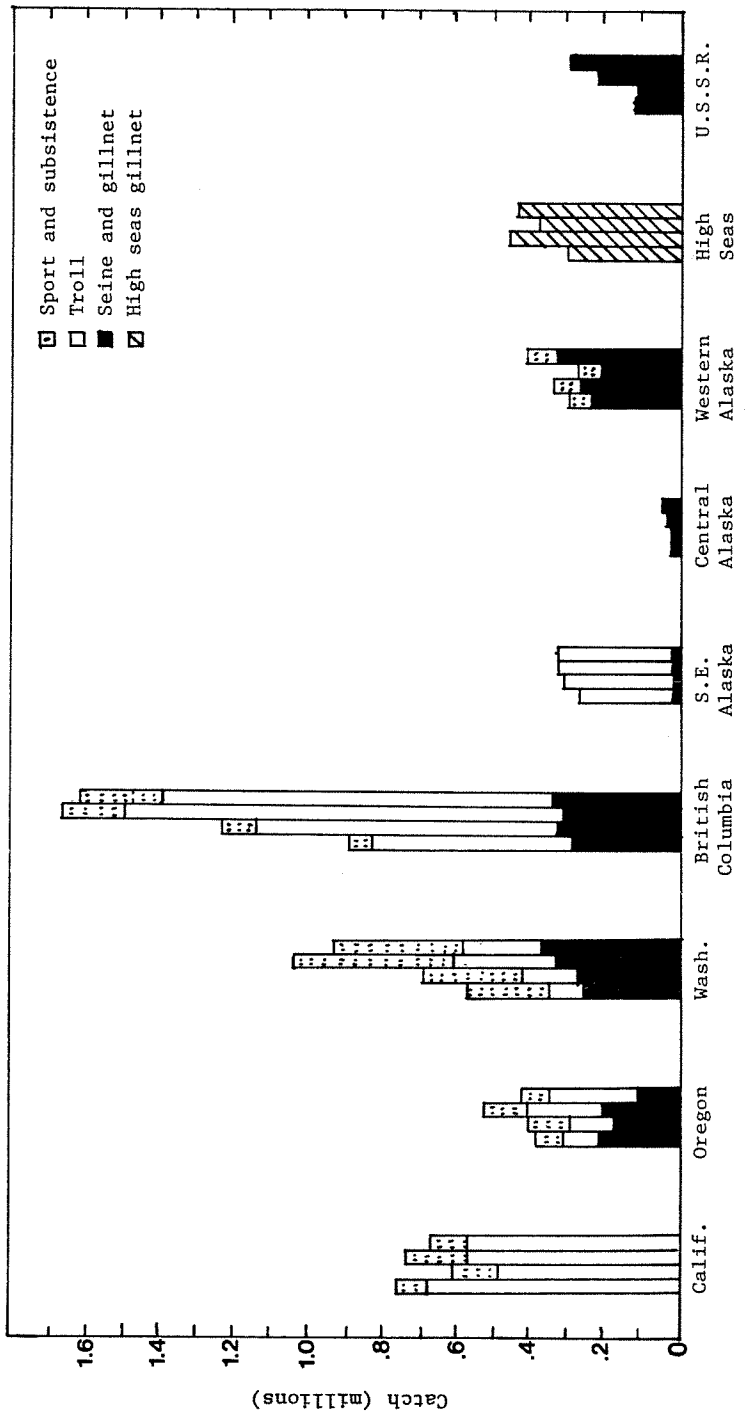


Fig. 1. Catches of chinook salmon by 5-year periods beginning 1961-1965 and ending 1976-1980. (U.S.S.R. fishery is seine and trap.)

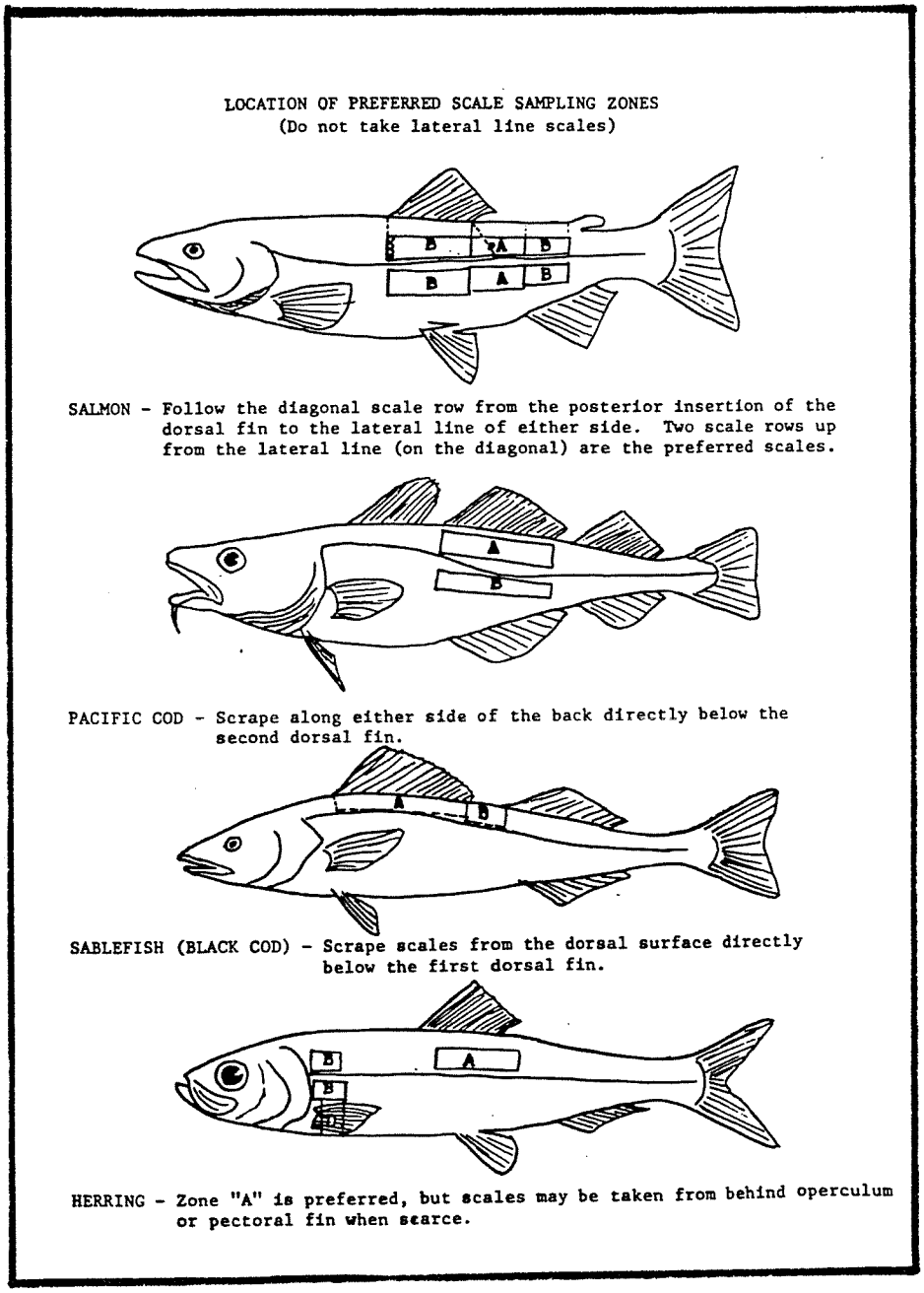


Fig. 2. National Marine Fisheries Service instructions to U.S. observers on location of preferred scale sampling zones.

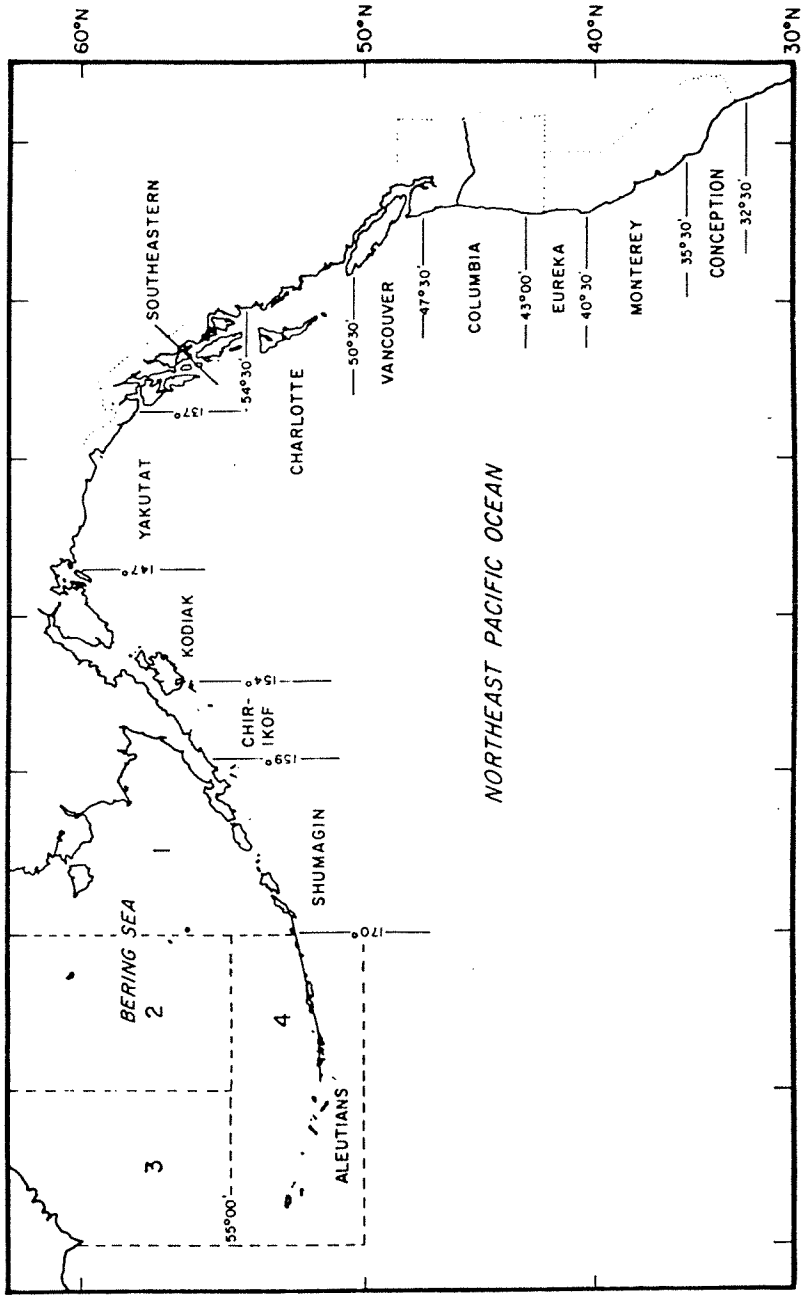
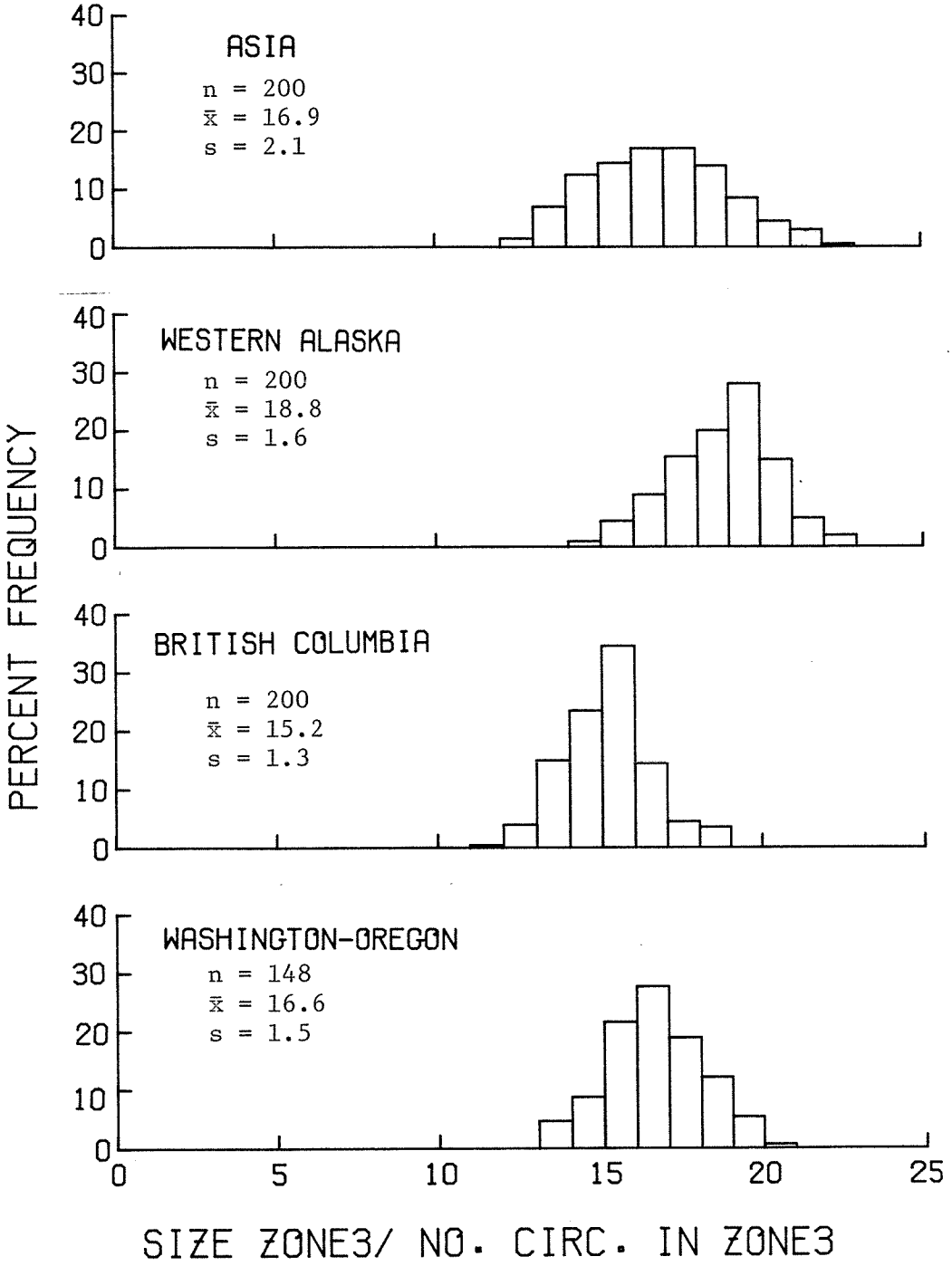


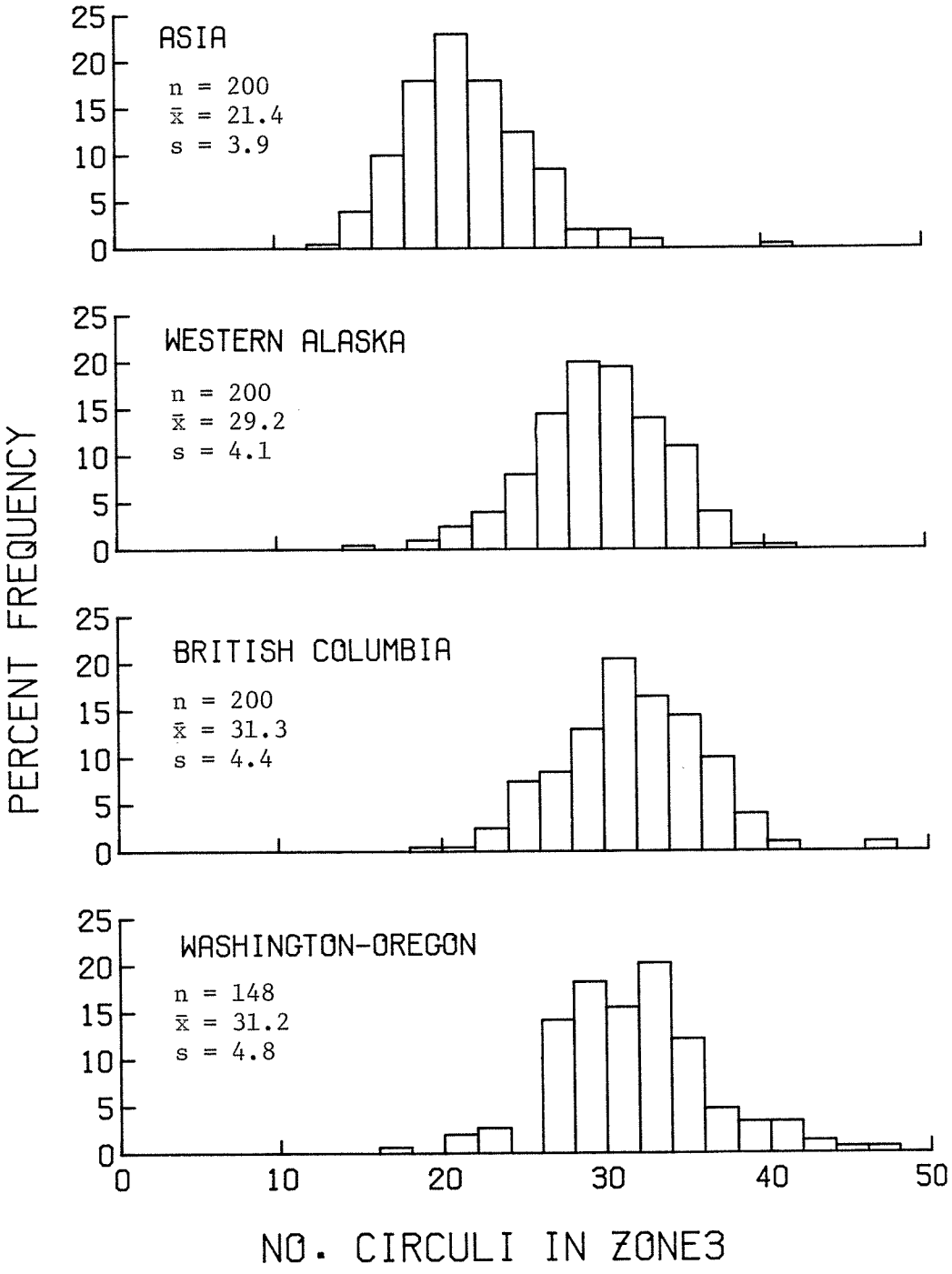
Fig. 3. Map showing National Marine Fisheries Service statistical areas.

APPENDIX



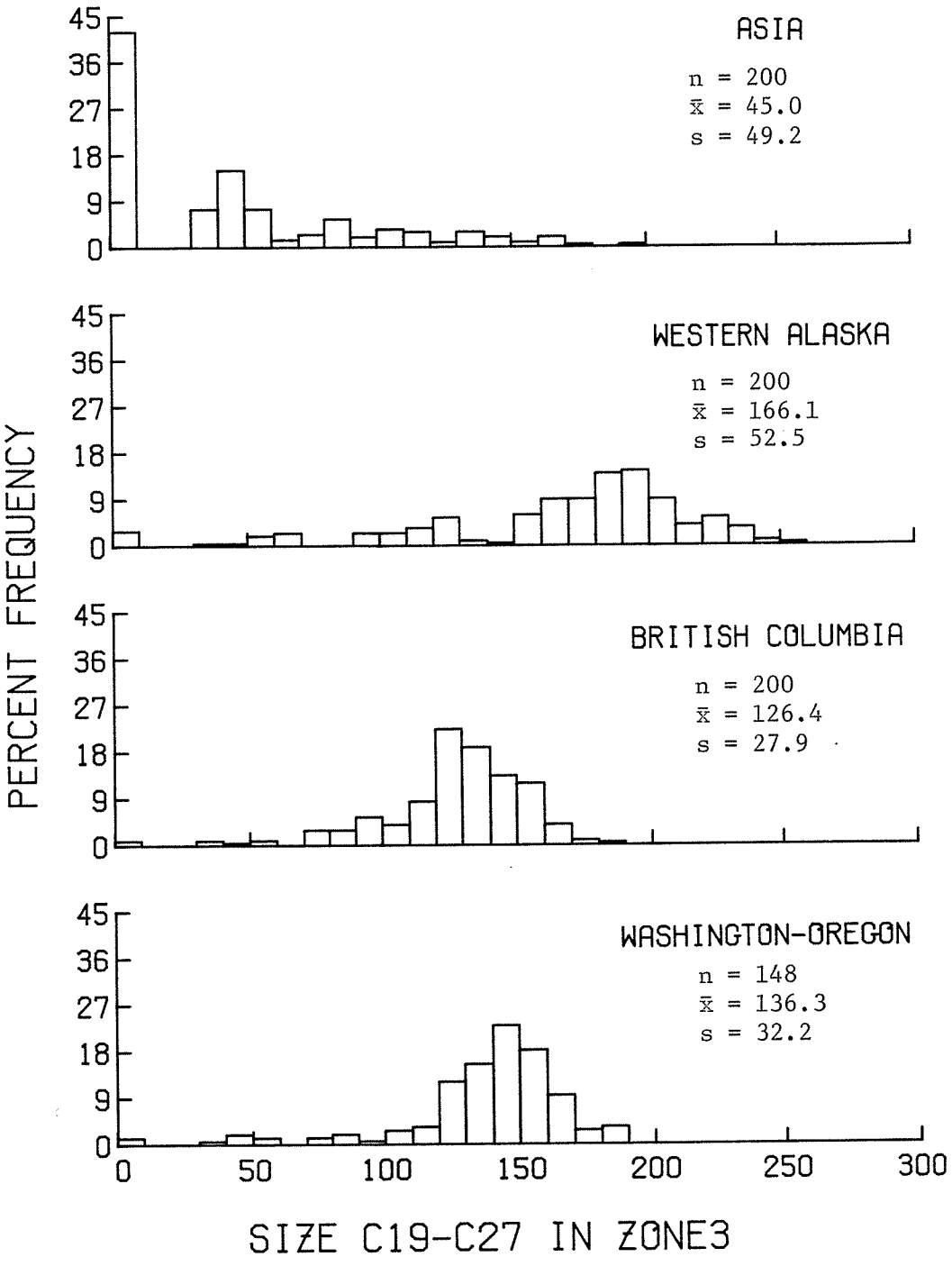
Appendix Fig. 1. The means ($\bar{x}$), standard deviations (s), and frequency distributions of the six scale characters used in a four region stock separation analysis of 1980 inshore chinook salmon (Oncorhynchus tshawytscha) stocks from Asia, Western Alaska, British Columbia, and Oregon-Washington. All measurements are .01 inches at 100 power. n = sample size.

A. The mean spacing of circuli in the first ocean year (zone 3).



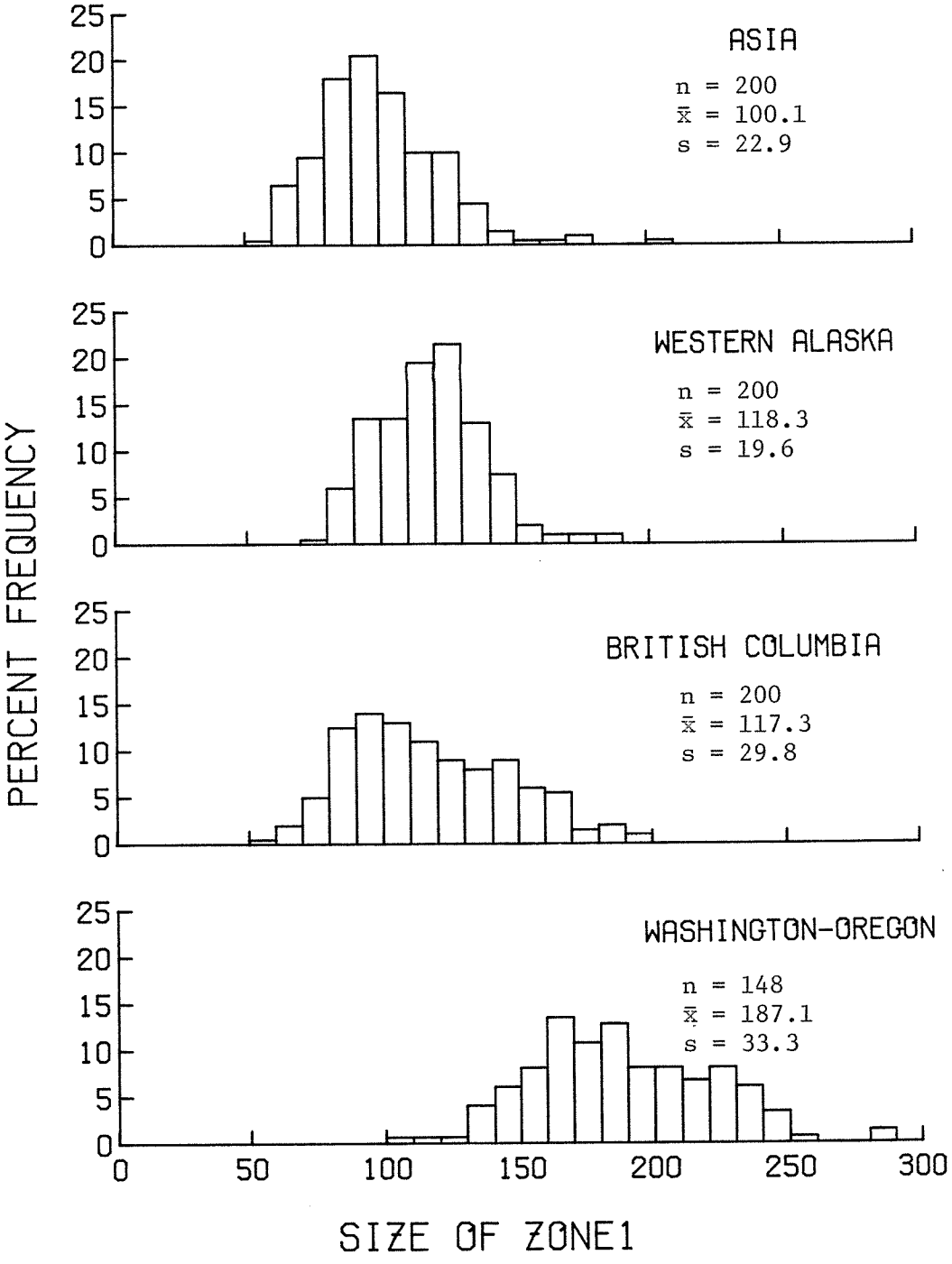
Appendix Fig. 1 - continued.

B. The number of circuli in the first ocean year (zone 3).



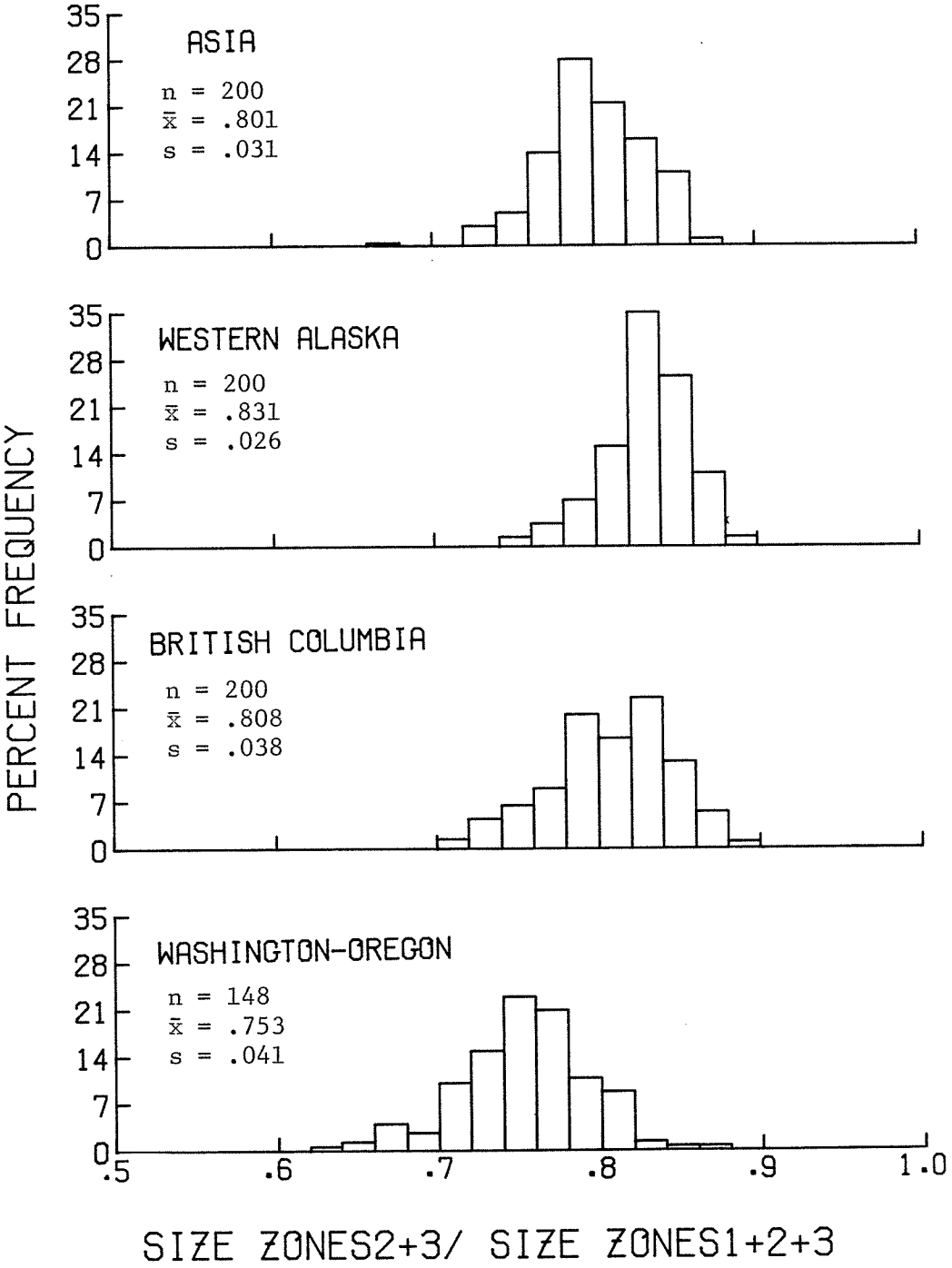
Appendix Fig. 1 - continued.

C. The distance between the nineteenth (C19) and twenty-seventh (C27) circulus in the first ocean year (zone 3).



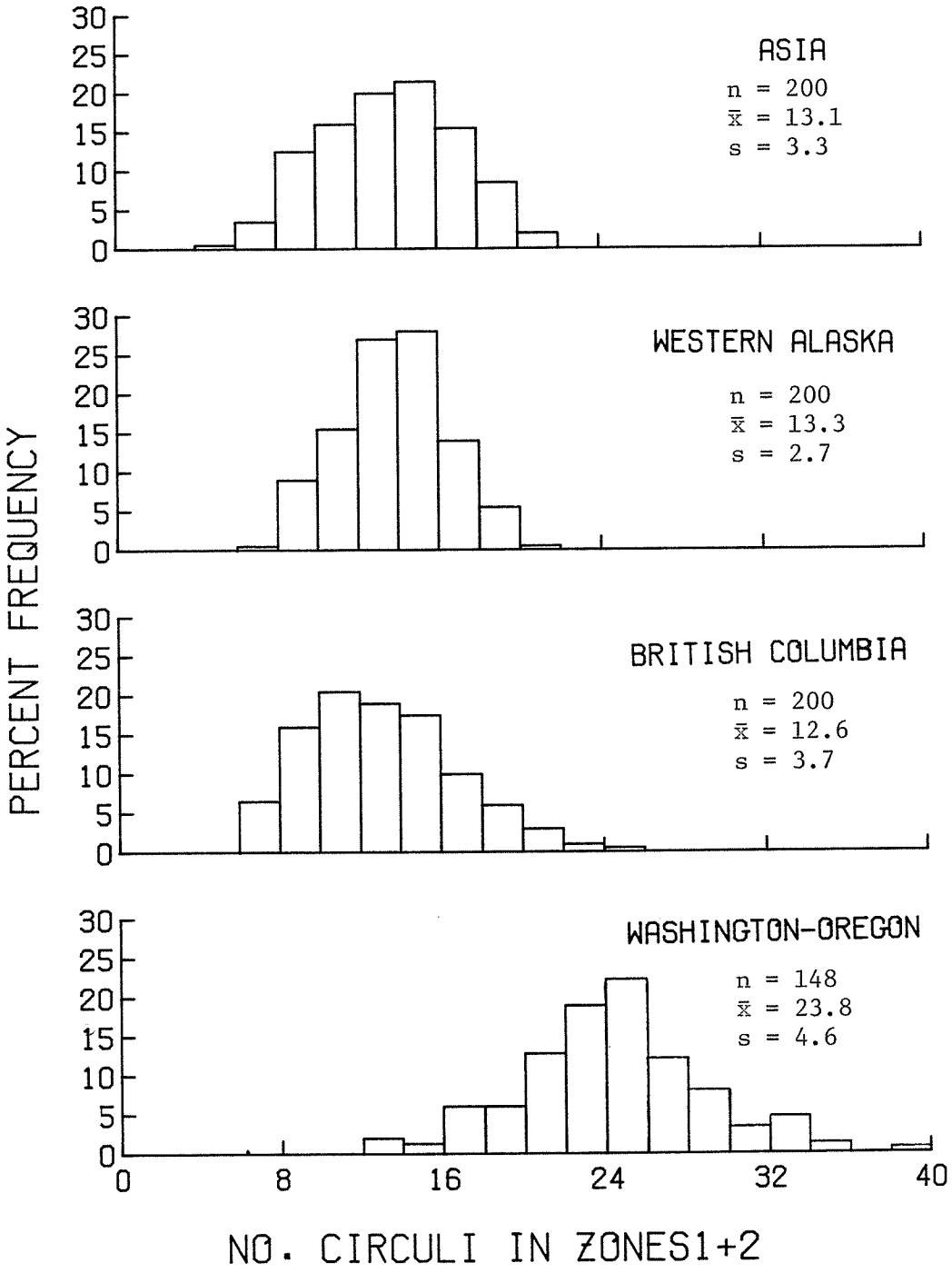
Appendix Fig. 1 - continued.

D. The size of the freshwater zone from the center of the focus to the outer edge of the last circulus in the freshwater annulus (zone 1).



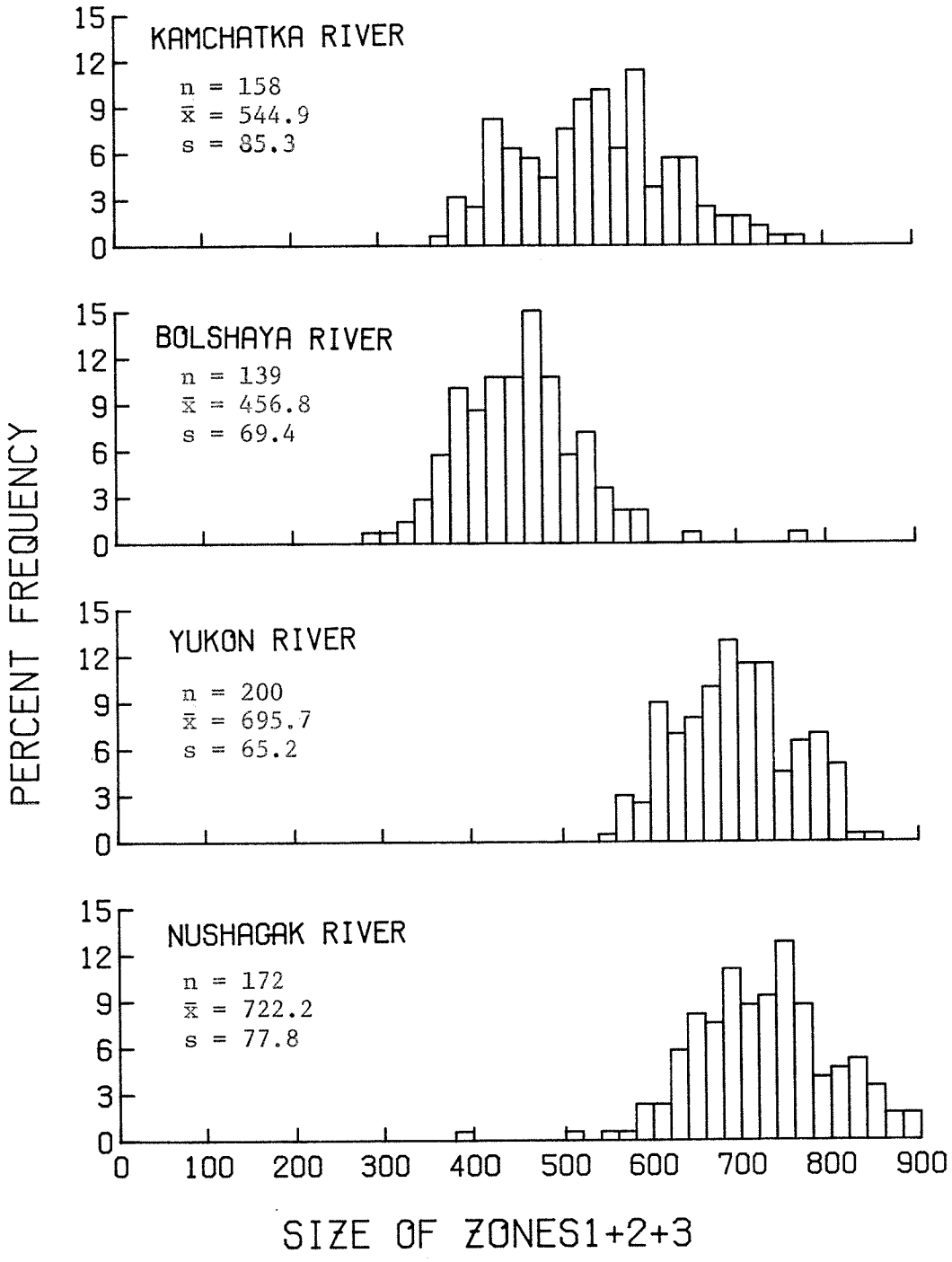
Appendix Fig. 1 - continued.

E. The size of the second year of growth (zone 2 and zone 3) divided by the size of the scale from the center of the focus to the outer edge of the last circulus in the first ocean year (zone 1 + zone 2 + zone 3).



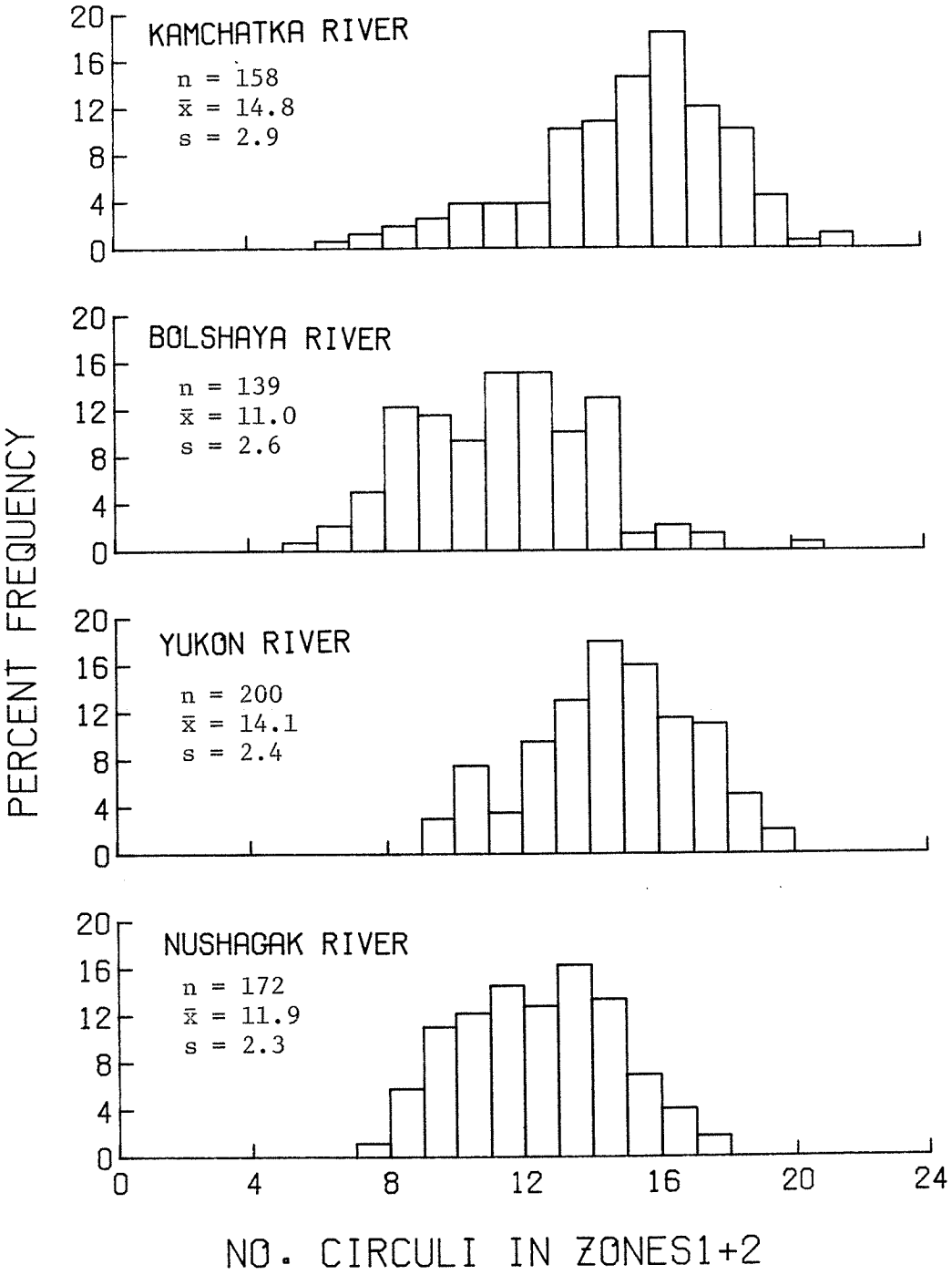
Appendix Fig. 1 - continued.

F. The number of circuli in the freshwater zone (zone 1 and zone 2).



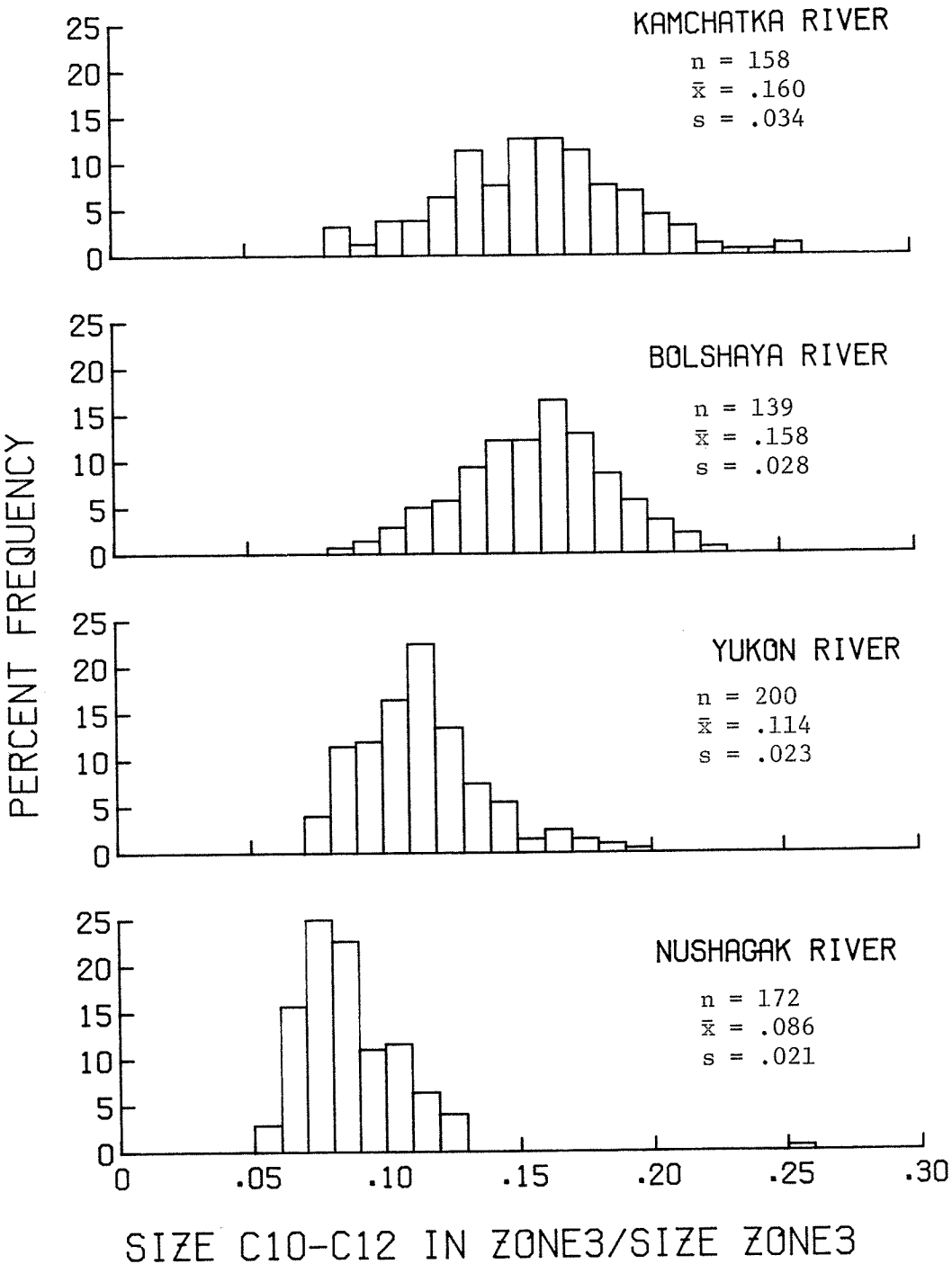
Appendix Fig. 2. The means ($\bar{x}$), standard deviations (s), and frequency distributions of the six scale characters used in a four river stock separation analysis of 1980 inshore chinook salmon (Oncorhynchus tshawytscha) stocks from the Kamchatka River, the Bolshaya River, the Yukon River and the Nushagak River. All measurements are .01 inches at 100 power. n = sample size.

A. The size of the scale from the center of the focus to the outer edge of the last circulus in the first ocean year (zone 1 + zone 2 + zone 3).



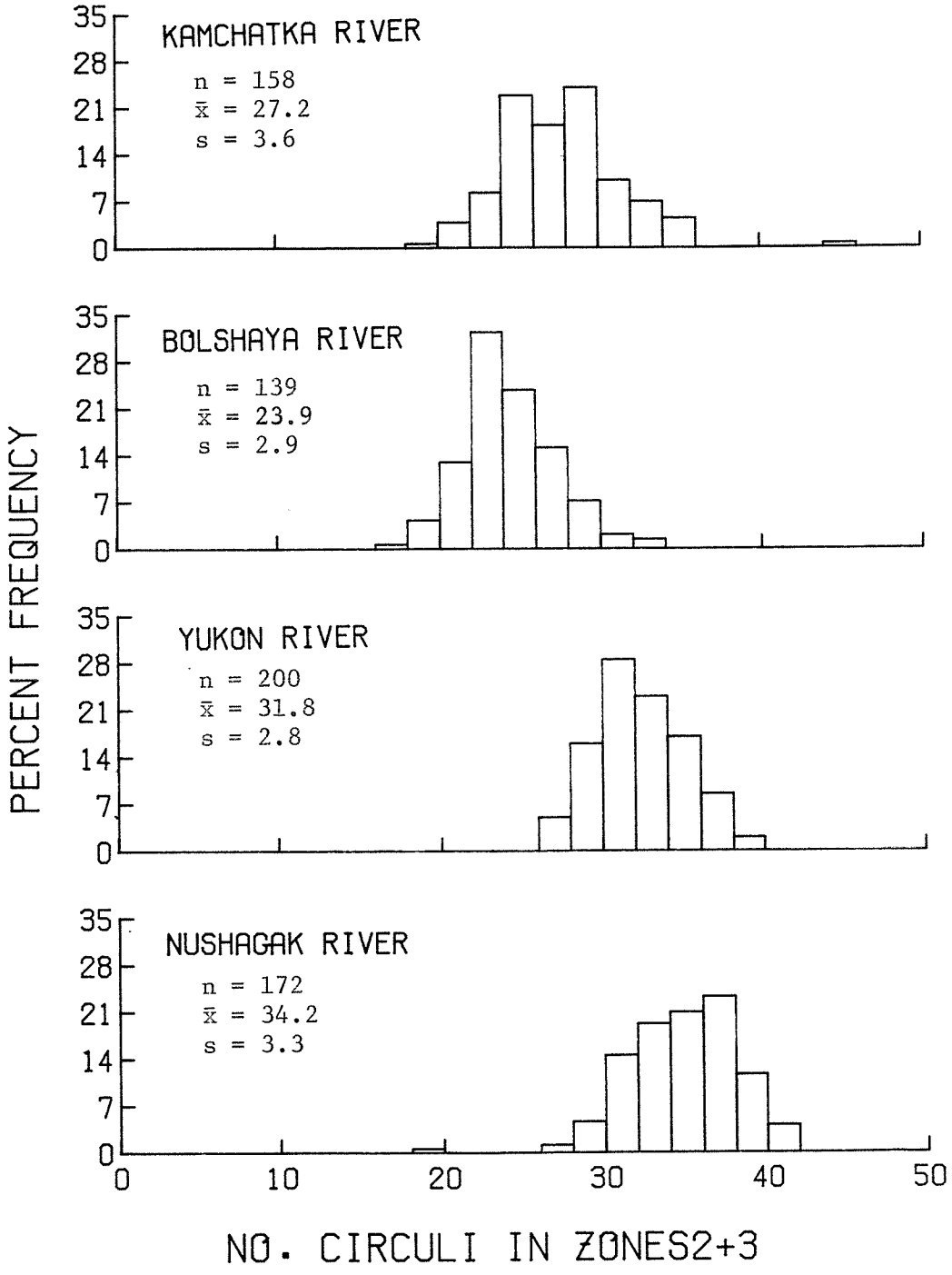
Appendix Fig. 2 - continued.

B. The number of circuli in the freshwater zone (zone 2 and zone 3).



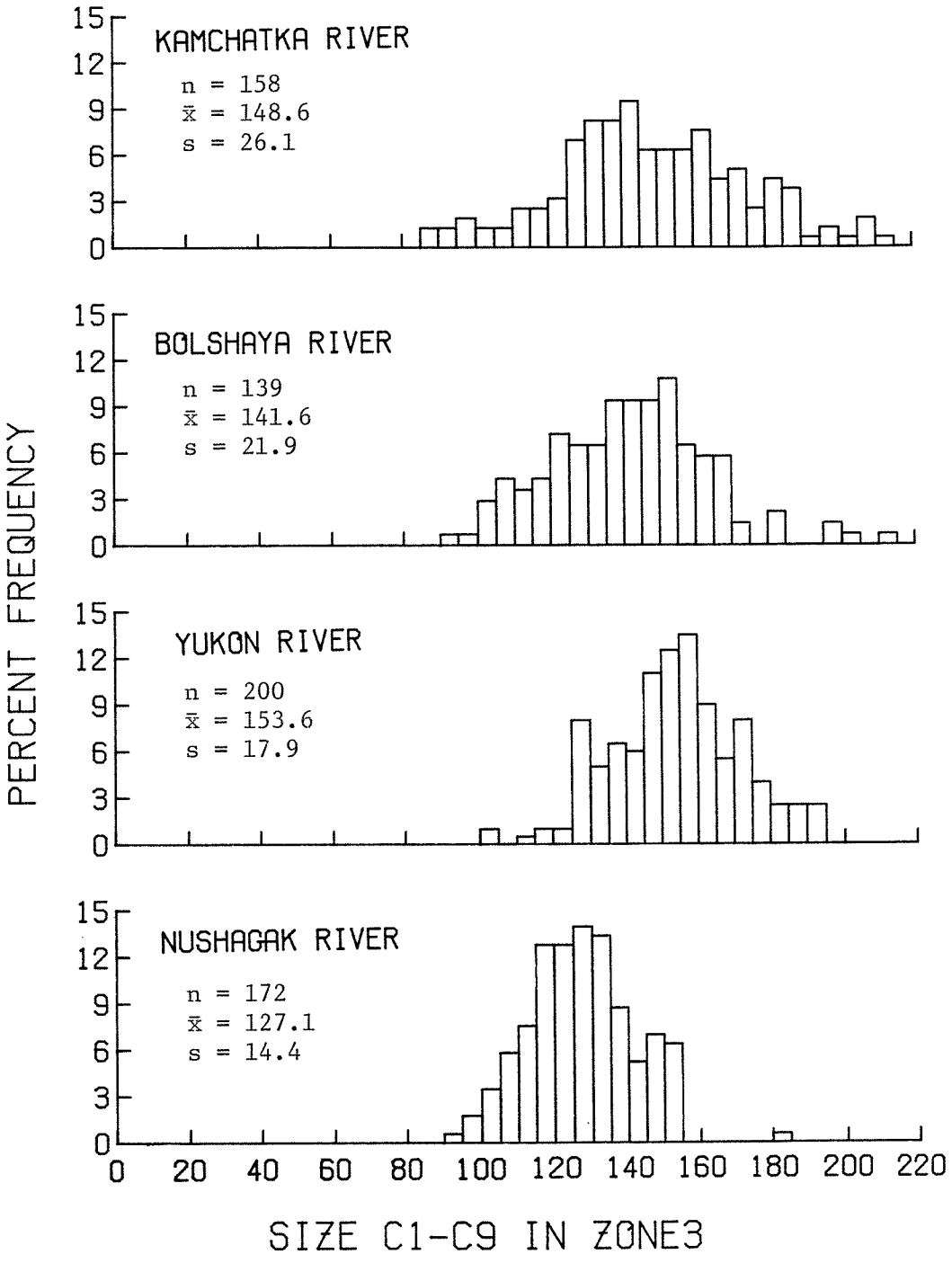
Appendix Fig. 2 - continued.

C. The distance between the tenth (C10) and twelth (C12) circuli in the first ocean year (zone 3) divided by the size of the first ocean year.



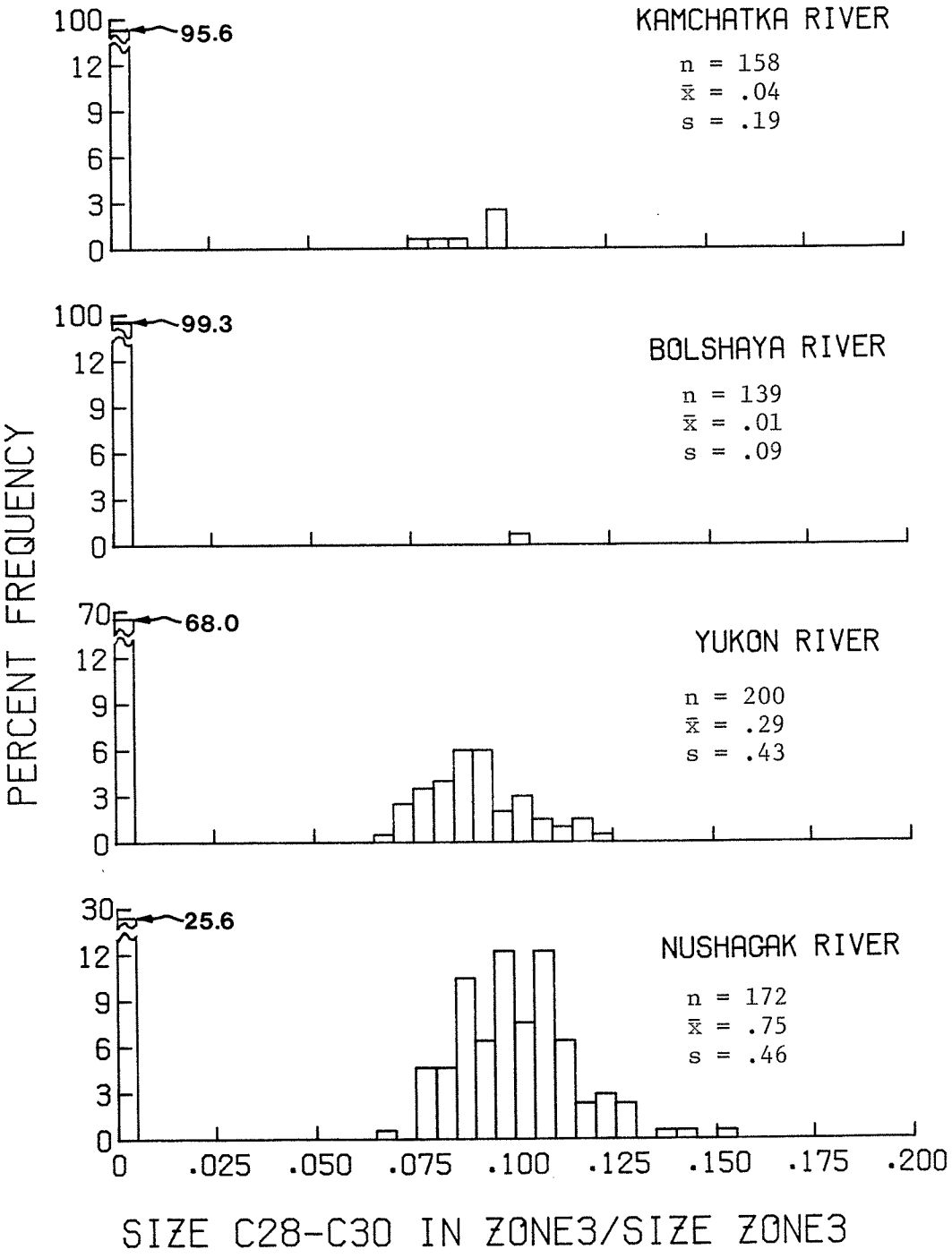
Appendix Fig. 2 - continued.

D. The number of circuli in the second year of growth (zone 2 and zone 3).



Appendix Fig. 2 - continued.

E. The distance between the first (C1) and the ninth (C9) circuli in the first ocean year (zone 3).



Appendix Fig. 2 - continued.

F. The distance between the twenty-eighth (C28) and thirtieth (C30) circuli in the first ocean zone (zone 3) divided by the size of zone 3.