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Chinook Salmon Stock Separation
Report # 4

CHINOOK SALMON SCALE PATTERN STUDIES

by

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INTRODUCTION

There has been considerable recent discussion in the International North Pacific Fisheries Commission regarding the distribution and origins of chinook salmon (Oncorhynchus tshawytscha) in the North Pacific Ocean and Bering Sea. This discussion was prompted largely by the INPFC treaty mandate to study origins of anadromous salmonids in waters south of 46°N, by the record 1980 catch of 703,798 chinook by the Japanese mothership salmon fishery, and by incidental catches of about 114,516 chinook (1978-1980 mean, from information in Tables 1 and 2) by foreign groundfish fisheries in the Bering Sea/Aleutian Island and Gulf of Alaska areas. These foreign catches compare to 1978-1980 inshore commercial harvests averaging 367,982 chinook in western Alaska (Meacham 1980) and 41,569 chinook in central Alaska (south side of Alaska Peninsula to Prince William Sound, from data tables in McBride and Wilcock 1982). Foreign catches of this relative magnitude may have a significant impact on commercial, subsistence, and sport chinook fisheries (Fig. 1), as well as on escapements (Table 3).

Interest in origins of chinook salmon on the high seas is not new. Major, Murai and Lyons (1975, 1977a, b) attempted to determine origins of chinook in the pre-1978 mothership fishery area by linear discriminant function analysis of scale patterns, and concluded that the majority of chinook in the eastern portion of the mothership area (primarily east of 175°E where major catches have occurred) is of

western Alaska origin. However, these investigators cautioned that their conclusions were provisional because of certain inadequacies in the analysis (e.g., lack of standard samples representing North American areas other than western Alaska, use of high seas samples from the western Pacific Ocean to represent Asian runs, use of standards from one year to classify unknowns collected in 1966-1972, etc.). Because of the provisional nature of these earlier studies and because of the different time/area pattern of mothership fishing after 1977, there is need to update information on origins of chinook in the past and present mothership fishery area.

The Fisheries Research Institute (FRI) has undertaken three related studies to determine origins of chinook in various areas of the North Pacific Ocean and Bering Sea. One study, funded by the National Marine Fisheries Service (NMFS), is aimed at determining chinook origins in the area of the pre-1978 Japanese landbased driftnet fishery (i.e., south of 46°N). Another, funded by the Alaska Department of Fish and Game, concerns the origins of chinook in the area of the past and present mothership fishery, and is essentially an updating of the earlier study by Major, Murai and Lyons (1975, 1977a, b). A third study, supported by the North Pacific Fishery Management Council (NPFMC), will provide estimates of stock composition of chinook caught incidentally by foreign trawl fisheries in the U.S. Fishery Conservation Zone (FCZ) off Alaska (primarily in the Bering Sea/ Aleutian region). These studies are related in that they all involve compilation of catch, escapement, and age composition information for major world chinook stocks, development

of chinook scale reading methodology, collection and analysis of regional standard samples, and application of the same basic statistical methods in the analysis of unknown samples. Our efforts to date have included compilation of background information on major chinook stocks, collection of standard samples representing major stocks from Kamchatka to California, development of scale reading methods, and preliminary determination of separability of certain regional stock-complexes and major river systems. Some of this work has been reported by Rogers et al. (1982).

The specific objectives of the work reported herein 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. The remainder of this document was extracted with little modification from an annual progress report recently prepared for the NPFMC. While it deals specifically with the study of chinook caught incidentally by foreign trawl fisheries, much of the information summarized is equally pertinent to the other studies mentioned.

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 manuscript), 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 per-

centage 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 micro-

scope. 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, 1980 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.

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 Westen 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-reigon (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 Wetern 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 nonregenerated 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" ($n \geq 25$ 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.

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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

Check these data

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.

		Age class											
		1.2			1.3			1.4			Total		
		Total	Sample size		Total	Sample size		Total	Sample size		Total	Sample size	
Region	Stock	digitized	Region	River	digitized	Region	River	digitized	Region	River	digitized	Region	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,UR-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,UR-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,UR-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,UR-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,UR-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,UR-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,UR-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,UR-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,UR-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,UR = 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-BUL	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-BUL	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
BUL-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-BUL	-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-BUL	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
BUL-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-BUL	-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-BUL	-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
BUL-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; BUL = 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

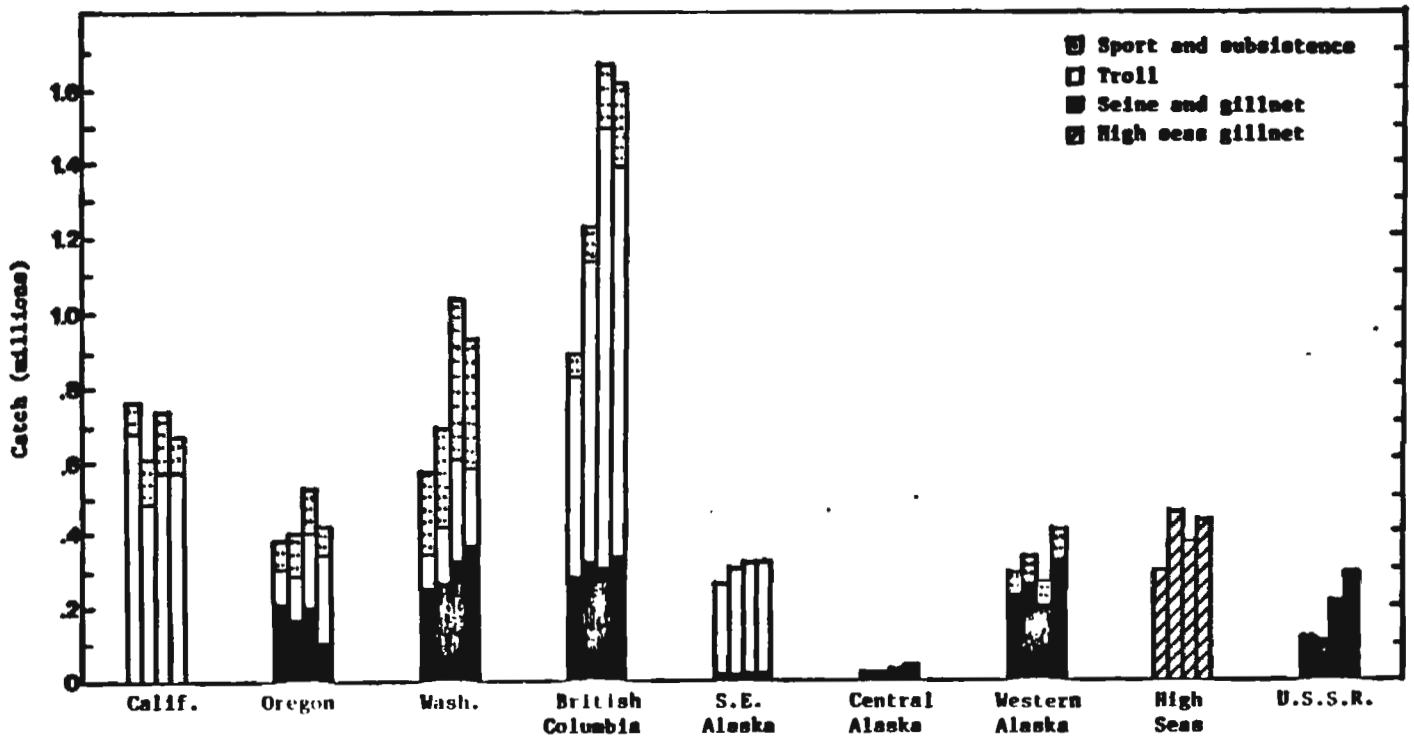


Fig. 1. Catches of chinook salmon by 5-year periods beginning 1961-1965 and ending 1976-1980. (U.S.S.R. fishery is seine and trap.)

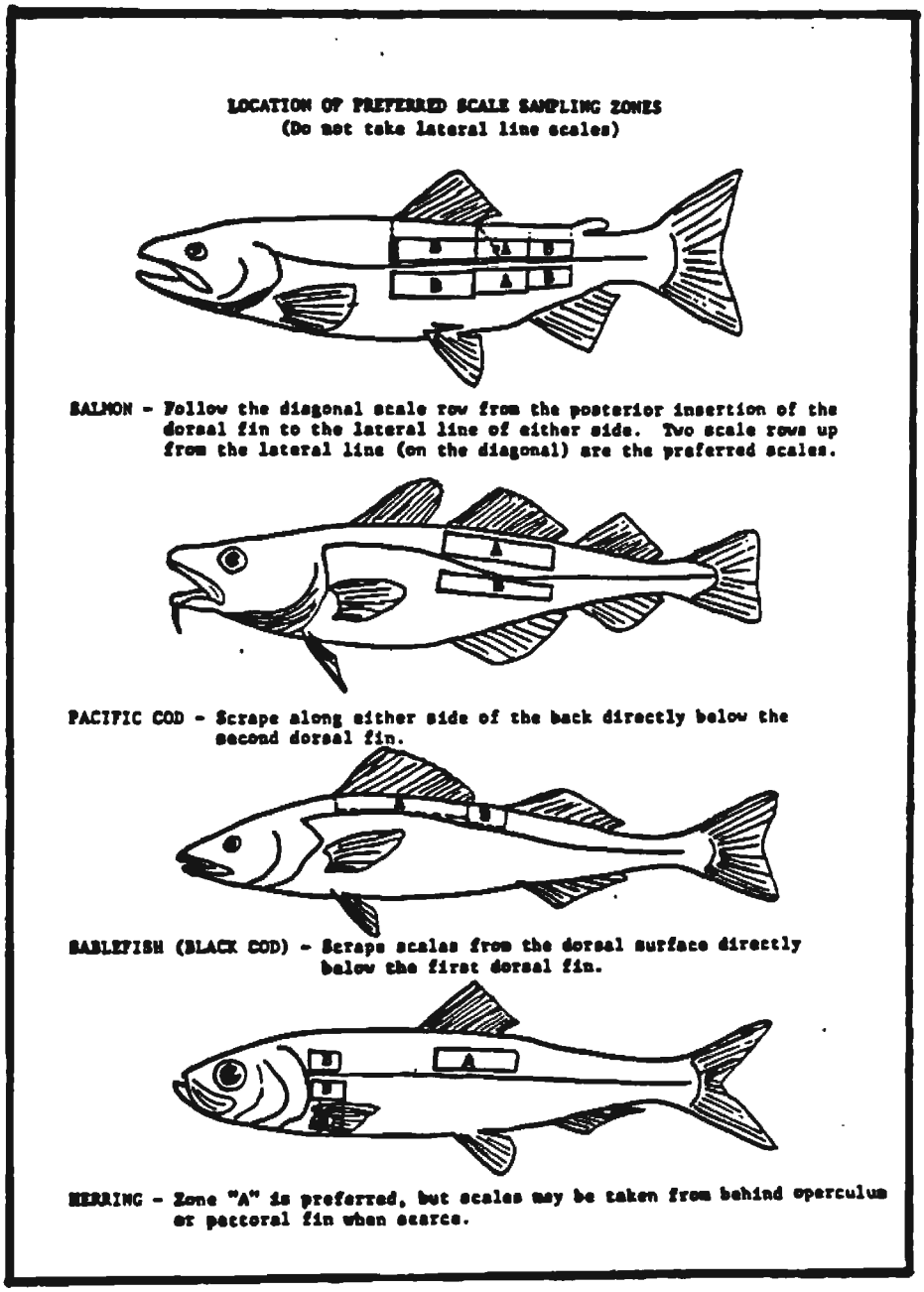


Fig. 2. National Marine Fisheries Service instructions to U.S. observers on location of preferred scale sampling zones.

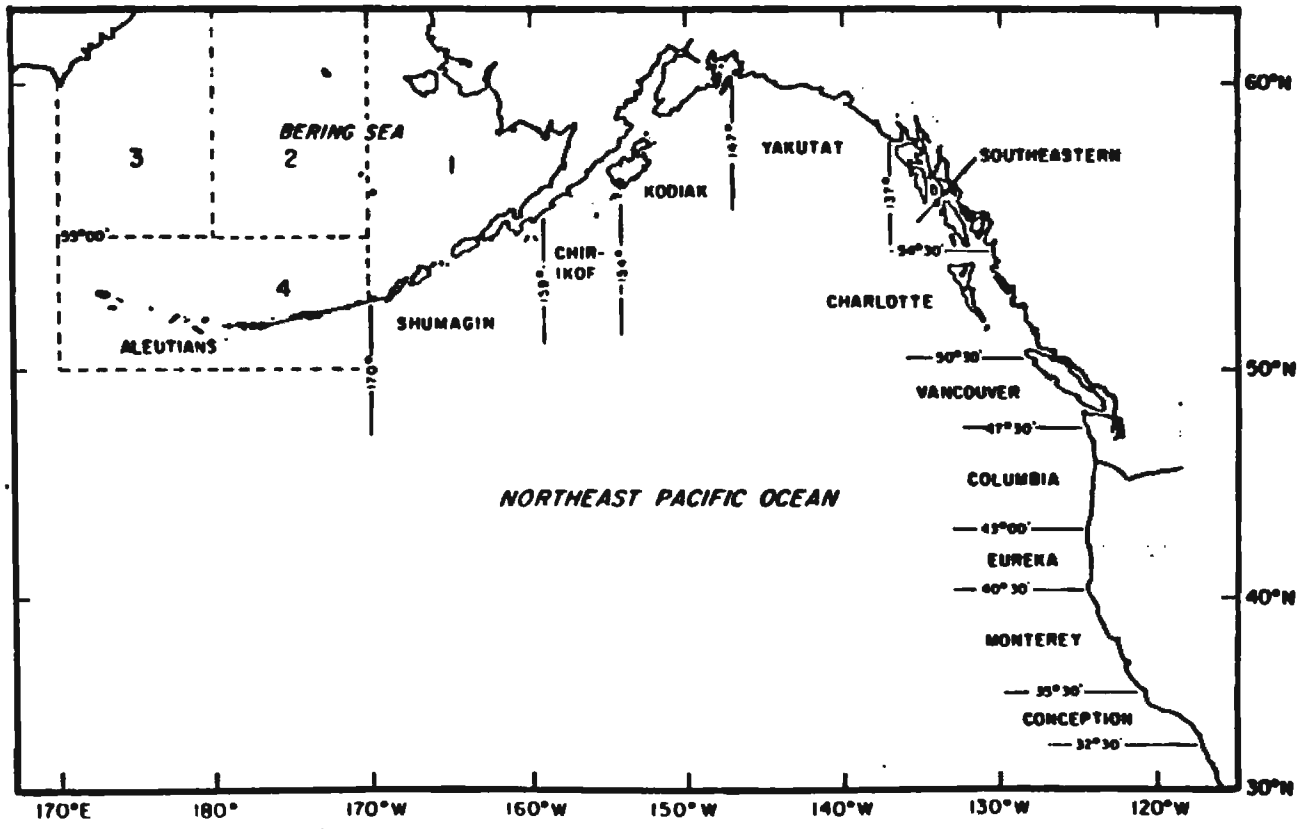
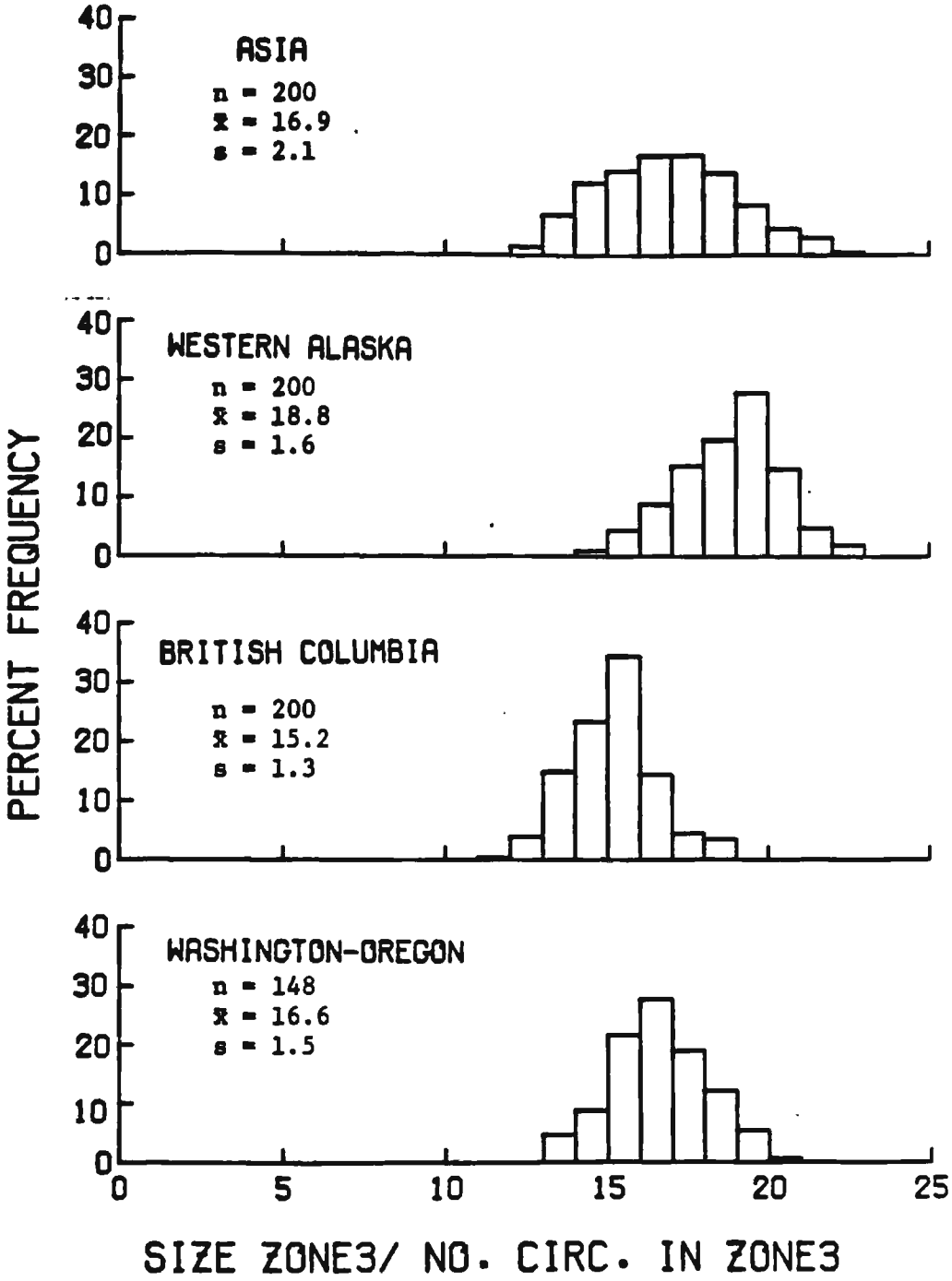


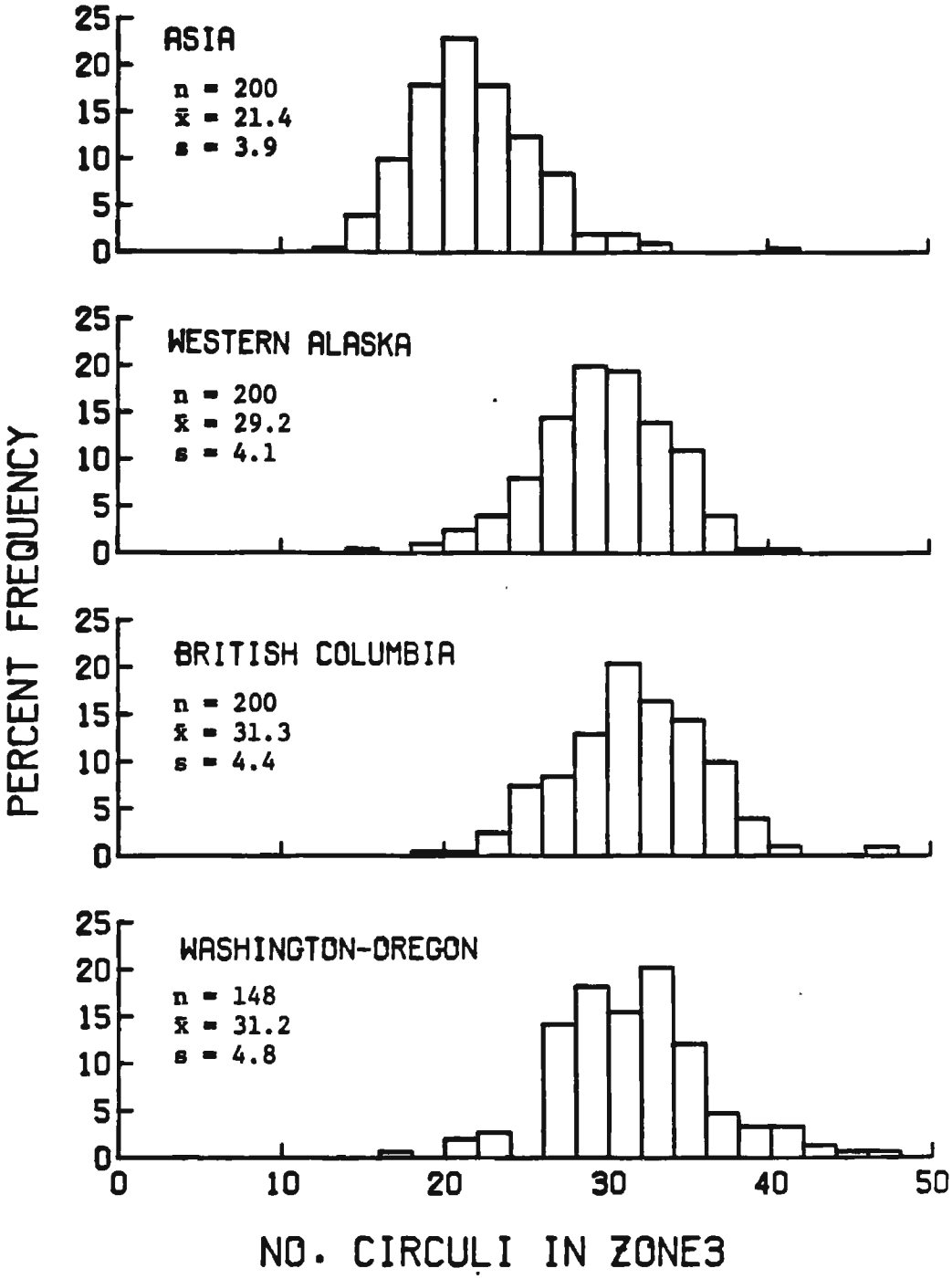
Fig. 3. Map showing National Marine Fisheries Service statistical areas.

APPENDIX



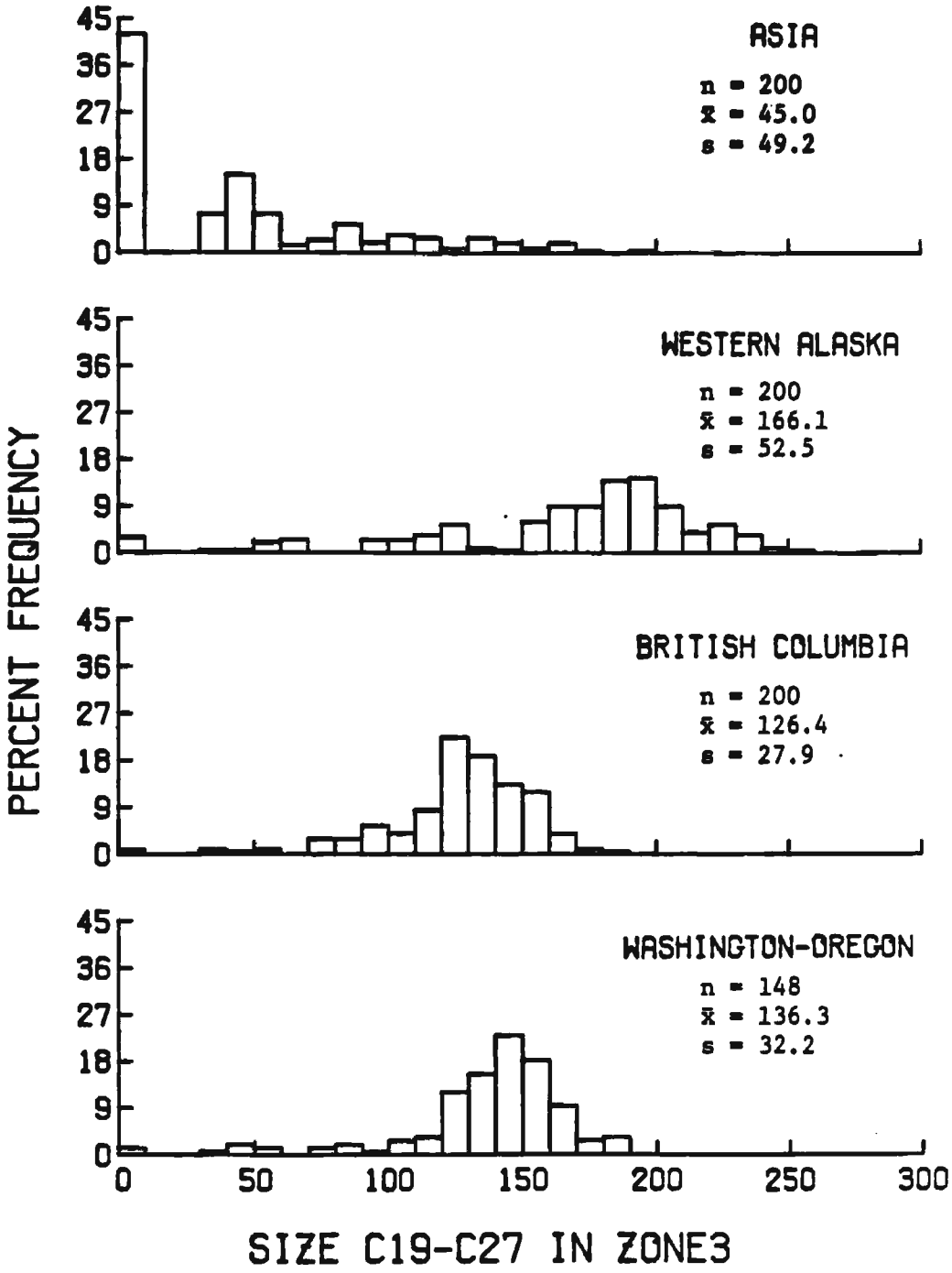
Appendix Fig. 1. The means ($\bar{x}$), standard deviations (s), and frequency distributions of the six scale characters used in a four region stock separation analysis of 1980 inshore chinook salmon (Oncorhynchus tshawytscha) stocks from Asia, Western Alaska, British Columbia, and Oregon-Washington.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

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



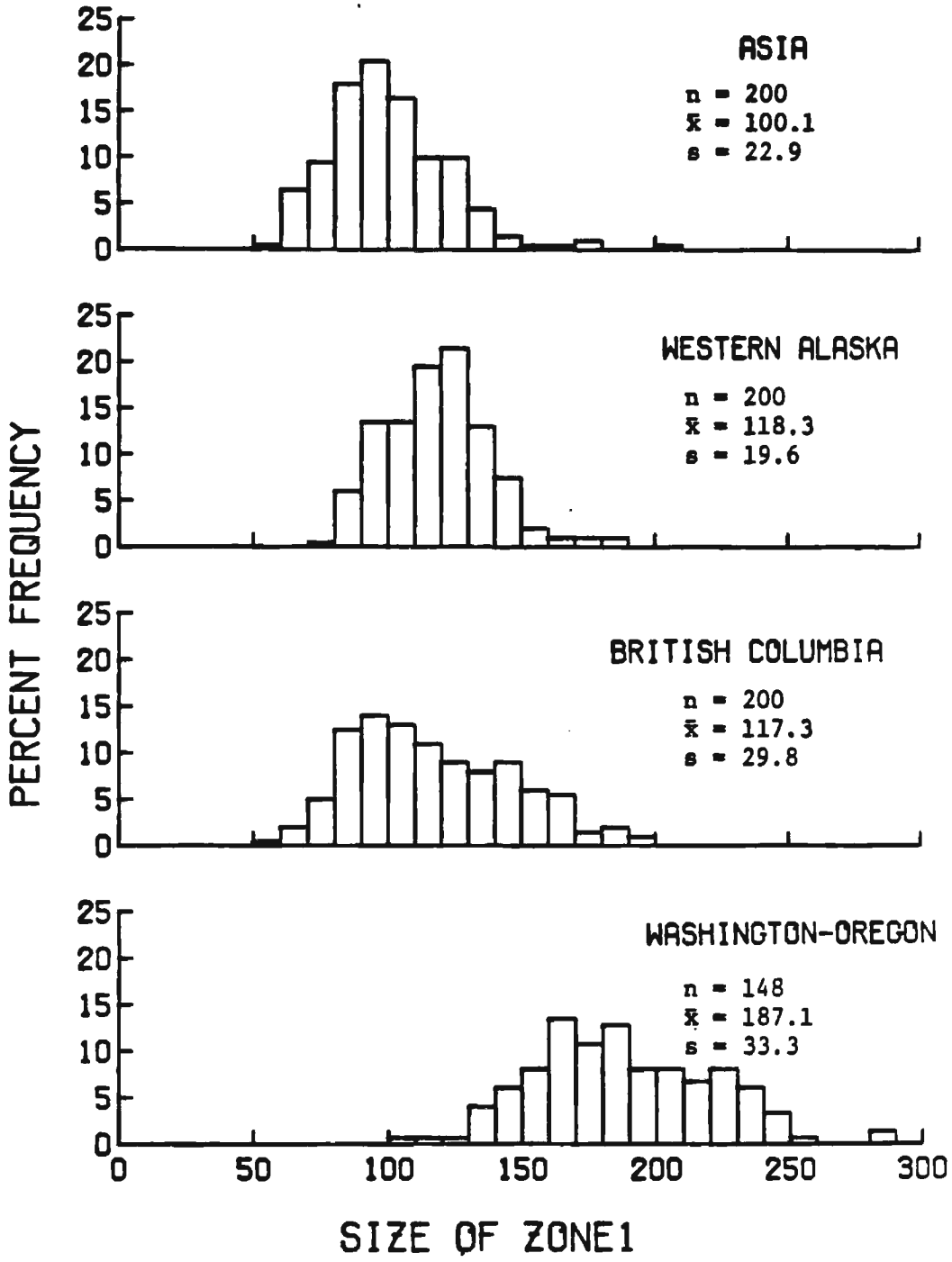
Appendix Fig. 1 - continued.

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



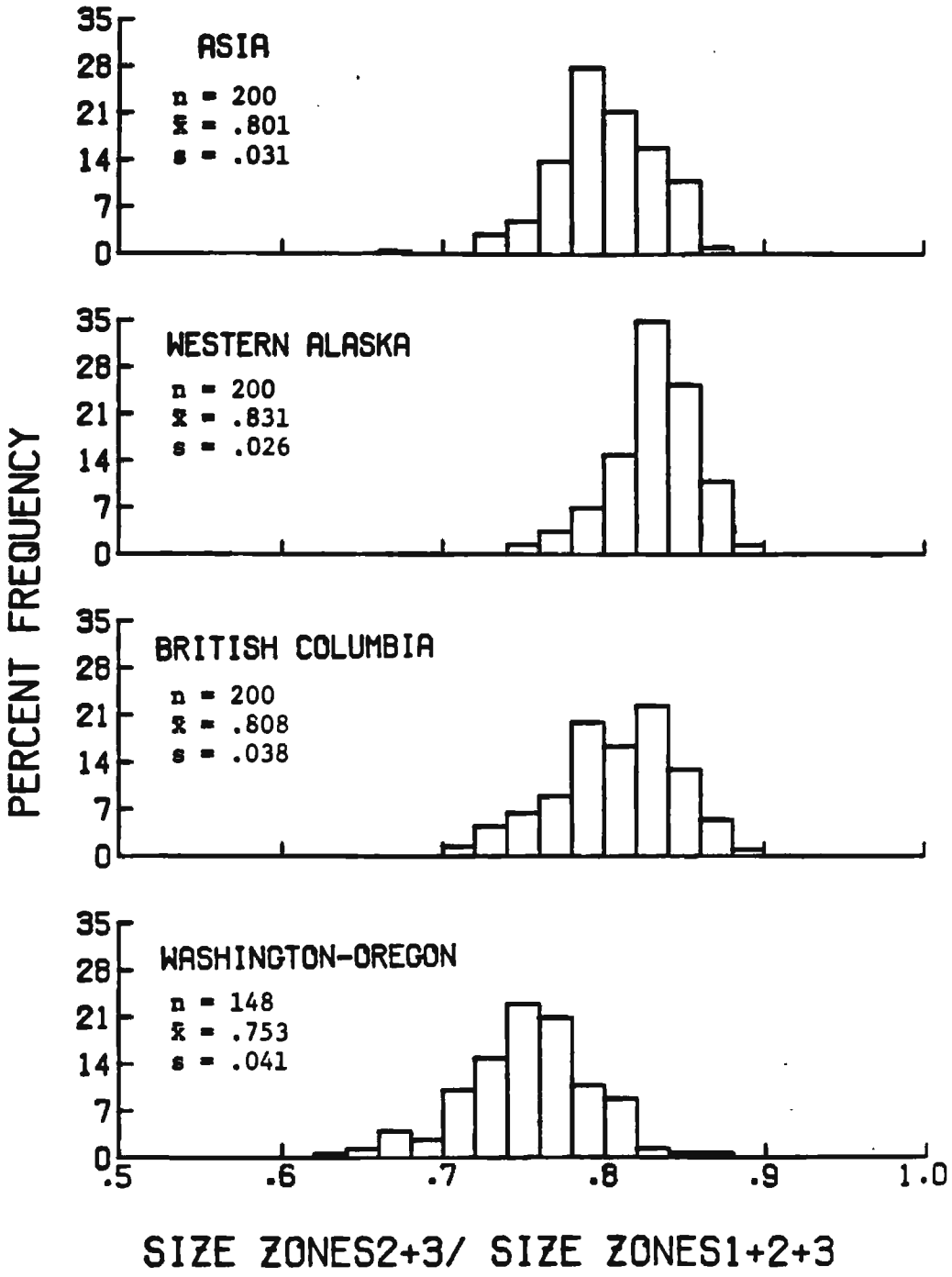
Appendix Fig. 1 - continued.

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



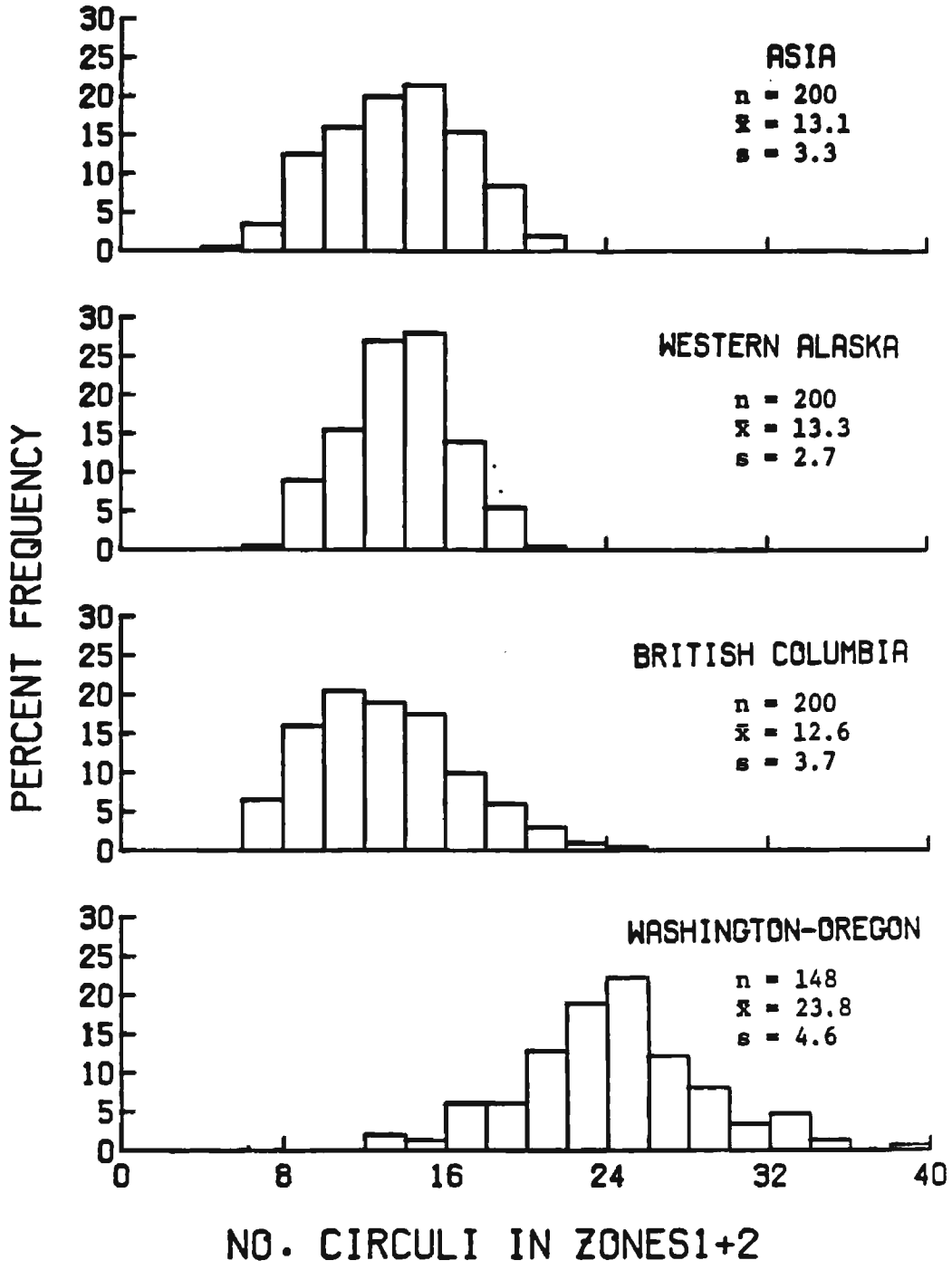
Appendix Fig. 1 - continued.

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).



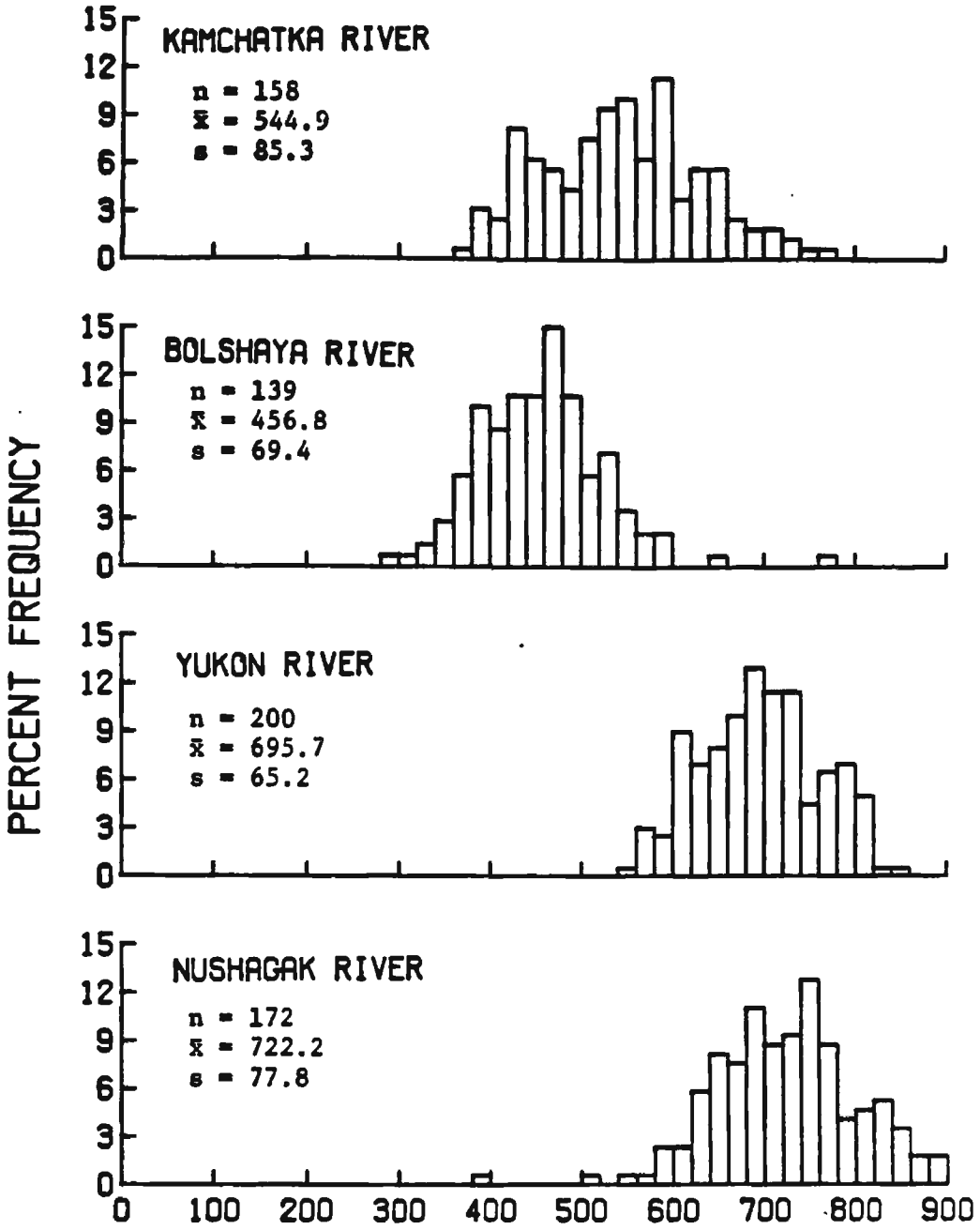
Appendix Fig. 1 - continued.

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).



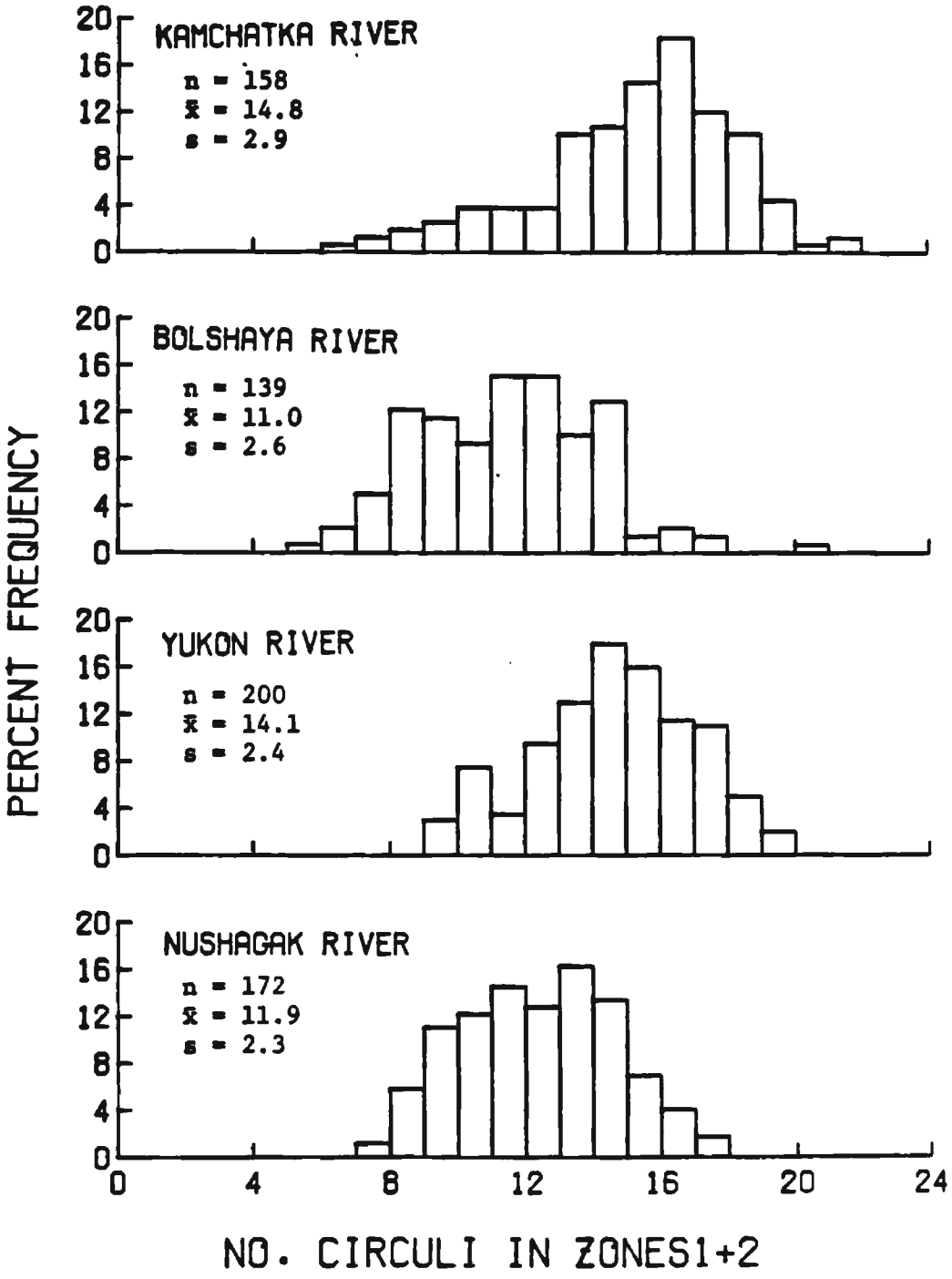
Appendix Fig. 1 - continued.

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



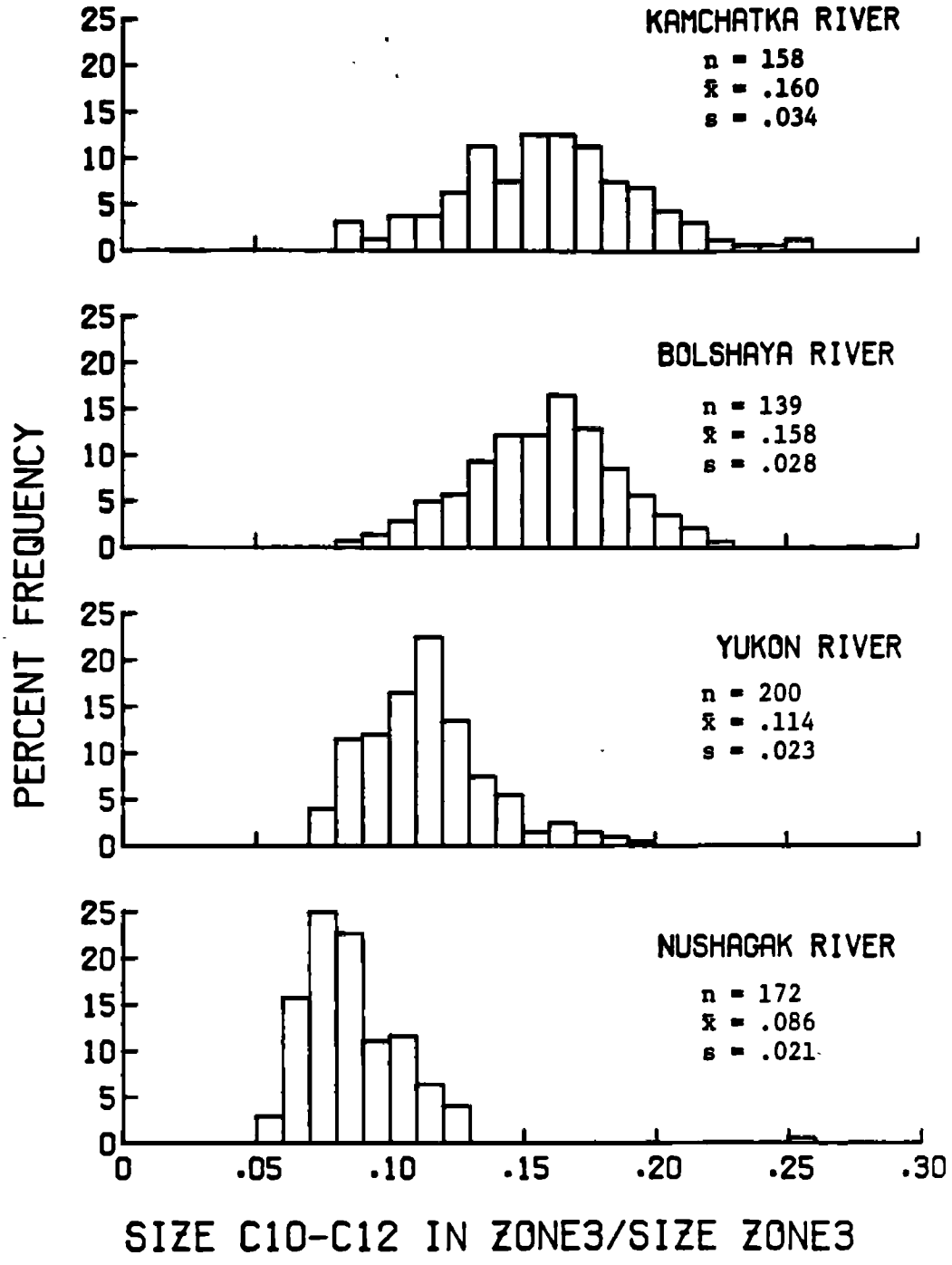
Appendix Fig. 2. The means ($\bar{x}$), standard deviations (s), and frequency distributions of the six scale characters used in a four river stock separation analysis of 1980 inshore chinook salmon (Oncorhynchus tshawytscha) stocks from the Kamchatka River, the Bolshaya River, the Yukon River and the 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).



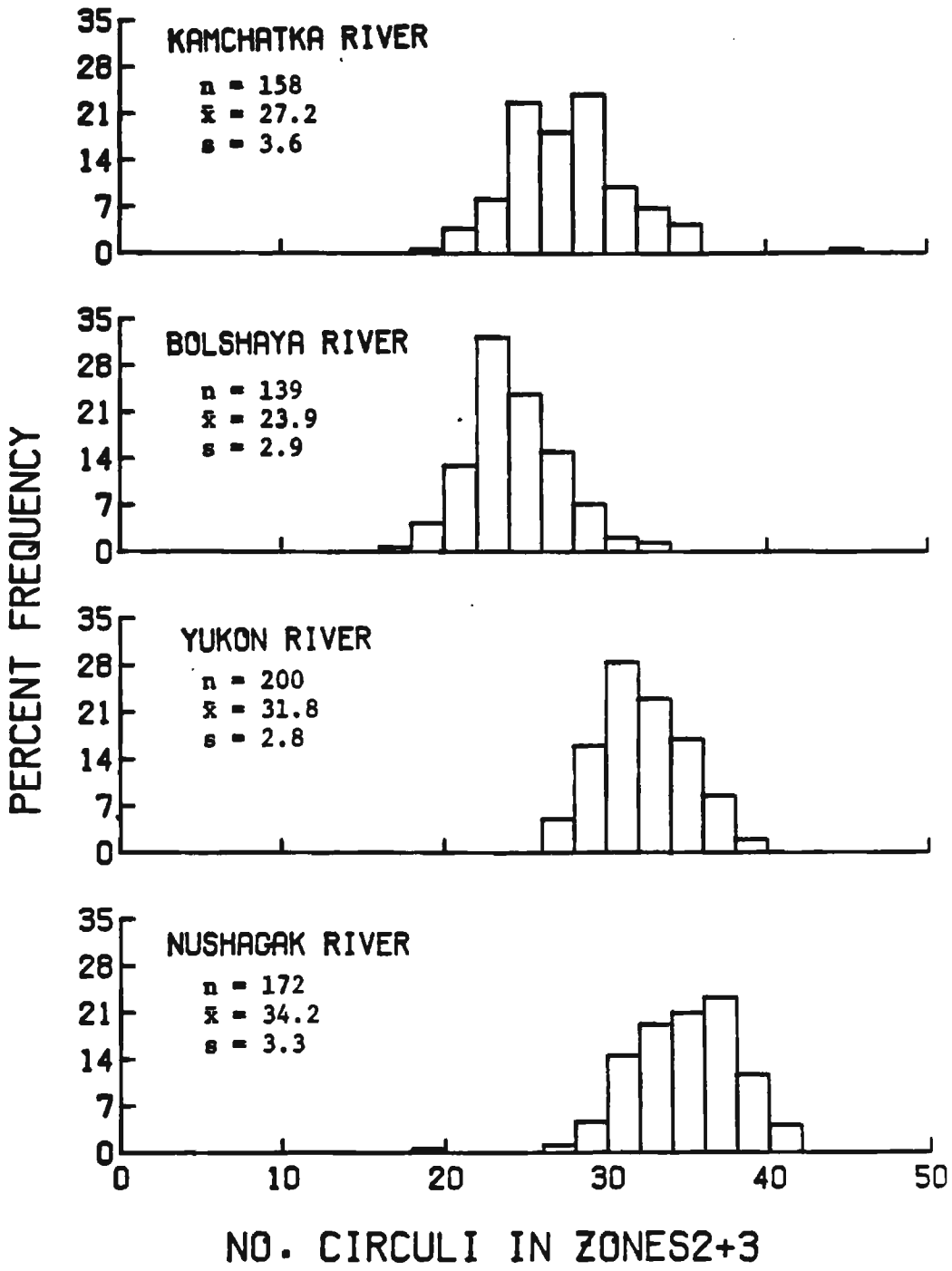
Appendix Fig. 2 - continued.

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



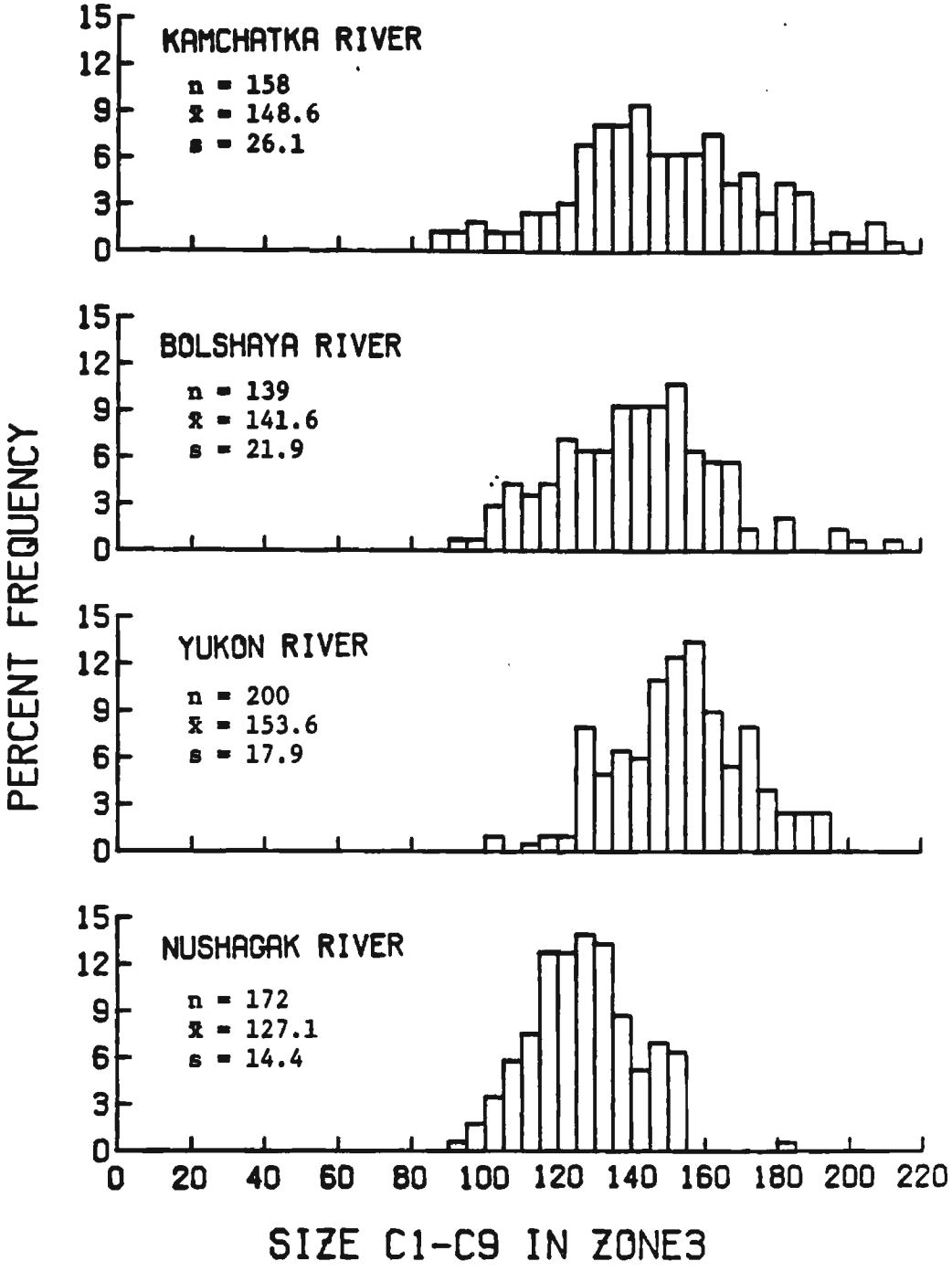
Appendix Fig. 2 - continued.

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.



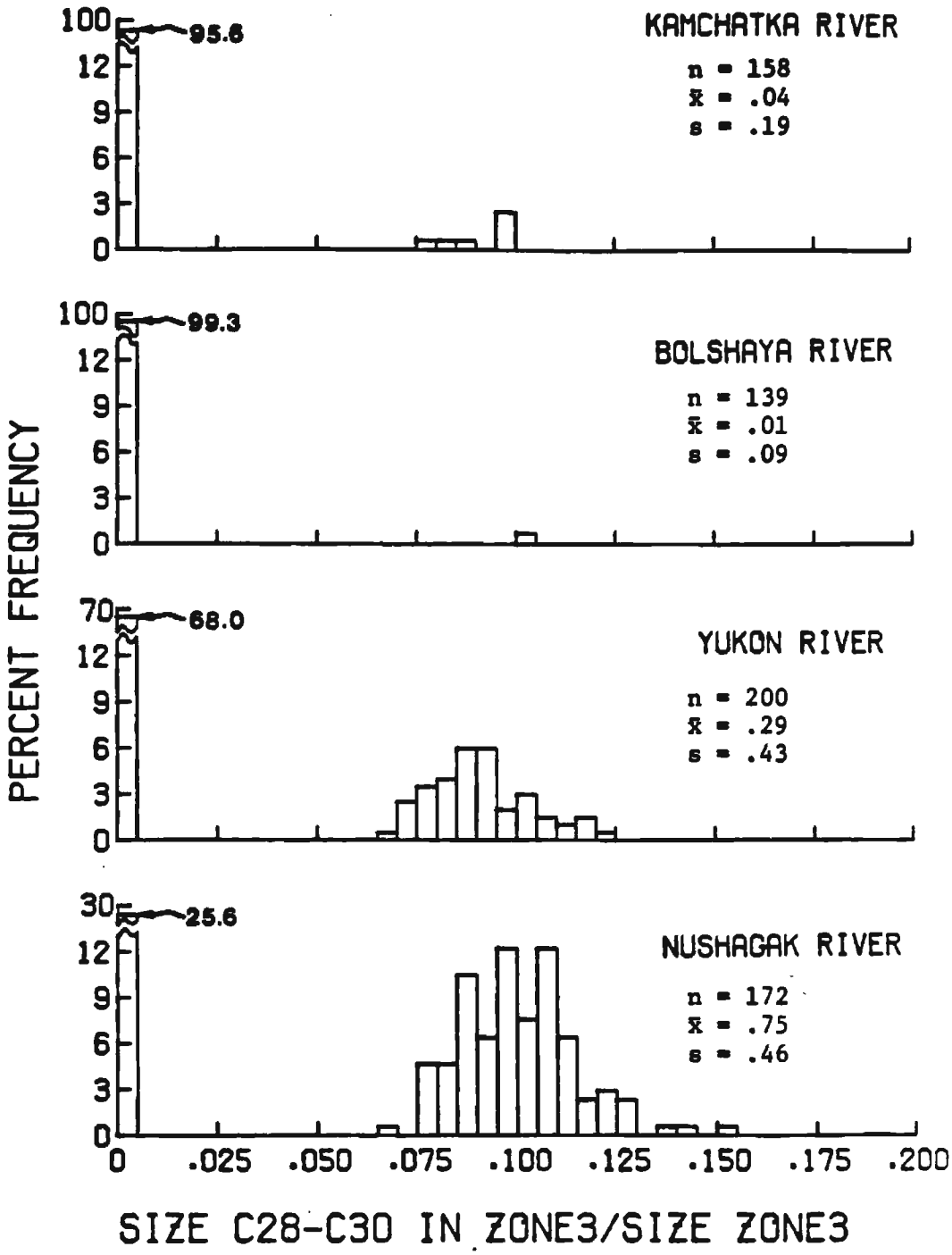
Appendix Fig. 2 - continued.

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.