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**ORIGINS OF COHO SALMON IN THE AREA OF THE  
JAPANESE LANDBASED DRIFTNET FISHERY IN 1986 AND 1987**

by

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# ORIGINS OF COHO SALMON IN THE AREA OF THE JAPANESE LANDBASED DRIFTNET FISHERY IN 1986 AND 1987

## ABSTRACT

The continent of origin of coho salmon caught on the high seas in 1986 and 1987 in and around the Japanese landbased driftnet fishery area (southwest of 46°N, 175° W) was determined by scale pattern analysis. Coverage of Asian and North American production areas was improved over earlier studies, and a new method based on similarity was utilized to construct composite standards. For 1986 age 2.1 fish four standard groupings were constructed: western Kamchatka Peninsula (Bolshaya R.); eastern Kamchatka and North Okhotsk Sea coast (Kamchatka R. and Kukhtui R.); western Alaska (Norton Sound to Bristol Bay); and North Alaska Peninsula. Sample sizes of scales from high seas areas in 1986 were sufficient to approach or exceed the recommended level of 100 scales for seven subarea-month strata. A maximum likelihood method was employed to calculate mixing proportion estimates of age 2.1 Asian and North American fish, and samples were bootstrapped to derive estimates of variance. In 1986 Asian fish appeared to predominate in six of the strata and were more abundant toward the western part of the fishery area. Proportions of North American fish increased toward the east. Estimates of age 2.1 North American fish in four strata in the fishery area ranged from 17% in subarea 11 (between 160°E and 165°E) in July to 47% in subarea 13 (170°E to 175°E) in July. The estimates obtained were in general agreement with those of previous scale pattern studies, but are higher than the proportion of North American fish in recoveries of tags from the study area. Application of estimates of age 2.1 fish to all ages and to all strata east of 160°E yielded a provisional catch estimate of 87,000 North American-origin coho in the landbased fishery in 1986, 18% of the total catch. Sample sizes were insufficient to analyze age 1.1 scales from 1986. Statistical difficulties and poor Kamchatka R. samples made results from analysis of age 2.1 scales from 1987 questionable.

## INTRODUCTION

The research reported here is an effort to determine the origins of coho salmon in the landbased driftnet fishery area as part of U.S. obligations as a member of the International North Pacific Fisheries Commission (INPFC). The 1978 revision of the International Convention for the High Seas Fisheries of the North Pacific Ocean (North Pacific Treaty) calls for coordinated research to determine continental origins of salmonids in the landbased driftnet fishery area. In 1986 the member nations of INPFC agreed on additional measures to reduce high seas interceptions of U.S.-origin salmonids, including a 1°-longitude westward shift of the eastern boundary of the landbased fishery area to 174°E. One product of this agreement was a Memorandum of Understanding on salmon research which stipulated initiation of a three- to five-year program of coordinated research to determine origins of salmonids migrating in the area of the landbased fishery "so that the eastern limit of that fishery shall be negotiated no later than the beginning of the 1991 season." The objective of this study is to provide information of use to the Commission in this negotiation from scale pattern analysis estimates of stock origins of coho salmon caught on the high seas in 1986 and 1987.

## PREVIOUS STUDIES

The identification of the origins of coho salmon in and near the landbased driftnet fishery area by scale pattern analysis has been addressed in three studies by the Fisheries Research Institute (FRI) at the University of Washington (Myers et al. 1981, Walker and Harris 1982, Walker and Davis 1983) and by four studies by the Fisheries Agency of Japan (FAJ) (Kato and Ishida 1985, 1986, 1988, 1989). In general all the studies estimated that Asian coho predominate in the area, but that North American fish are present to some extent. FRI studies encountered difficulties with small, poor samples from Asian stocks and incomplete coverage of Asian production areas. FAJ studies have had incomplete coverage of North American production areas and used samples of unknown origin collected in marine areas to represent Asian stocks. FAJ scientists have criticized the results of all seven studies on the basis that scale pattern estimates did not closely match tag recovery data, while FRI researchers have pointed out that tag recoveries of coho are too few to determine the distributions of major stocks in this area and that exploitation and recovery rates may differ markedly between the U.S.S.R. and Alaska.

Earlier summaries of oceanic distribution of coho summarized tagging data (Godfrey 1965, Godfrey et al. 1975), but there was very little data from the landbased fishery area. The scale pattern studies mentioned above have usually reported updated tag recovery data. The majority of the few recoveries of fish tagged in and near the landbased fishery area have come from the U.S.S.R., although some recoveries have been reported from western Alaska. No studies of genetic stock identification, parasites, or morphometrics have been done on coho from this area.

## METHODS

### SCALE SAMPLES

All scale samples measured were in the form of acetate impressions. Impressions for Alaska stocks were provided by the Alaska Department of Fish and Game (ADF&G), and those from British Columbia were provided by the Canadian Department of Fisheries and Oceans (CDFO). The Fisheries Agency of Japan provided impressions of scales from salmon caught in and near high seas salmon fishery areas and also impressions of scales from the Kamchatka and Bolshaya Rivers. The U.S.S.R.'s Pacific Research Institute of Fisheries and Oceanography (TINRO) provided FRI with original scale samples of adult returns to the Kukhtui River in 1986 and 1987 and to the Taui River in 1987. Under a binocular microscope a scale close in appearance to INPFC-preferred area scales was selected for each fish, and acetate impressions were made for measuring.

### AGE DETERMINATION

Ages were determined by the number of checks (decrease in spacing and thickness of circuli, and breakage, interbraiding, and cutting over of circuli) which were considered annuli. Age designation was by the European method (Koo 1962). Since there were no samples of known-age coho from Alaskan or Asian streams to validate ages, any strong checks in the freshwater zone were considered annuli. Emphasis was placed less on the 'correctness' of the age than on consistency, that is, that fish from Asia, North America, and high seas samples having similar patterns of checks would be considered as the same age and would be analyzed together. Age determination was made as scales were measured, in part guided by ages determined by the agency that provided the scales.

Age determination was in general agreement with ages listed on data sheets by ADF&G, but there was less agreement with ages of fishery samples provided by FAJ. FAJ scientists tended not to regard all freshwater checks as annuli, leading to a higher estimated proportion of age 1.1 fish. This is a similar circumstance to that encountered in analysis of coho scales from 1979 (Myers et al. 1981). It is not considered a problem in this analysis, as all scales in both the standards and fishery samples were aged by one person and all scales with similar patterns of freshwater checks were analyzed together. Age proportions of 1986 high seas samples are listed by subarea-month stratum in Table 1. No age composition is presented for 1987 samples as age 1.1 scales were not measured and ages were not determined for all scales.

#### SCALE MEASUREMENT

Scales were measured using an image analysis system, the Optical Pattern Recognition System (OPRS, BioSonics, Inc., Seattle, WA; Walker 1987). A reference line was chosen which connected the posterior ends of the ocean annulus, and measurements were made on an axis 90° to this line. Distances were measured from the center of the focus of the scale. Because of resolution difficulties, measurements were not made of most freshwater circuli. The first measurement was at the outer edge of the last circulus in the last freshwater annulus, and subsequent measurements were made at the outer edge of each circulus thereafter, including circuli of freshwater plus growth if present, to the outer edge of the ocean annulus. On scales from 1987 a marker consisting of two very closely placed measurements (one OPRS sampling unit apart) was made to denote the beginning of the ocean annulus and separate the summer and winter growth of the first ocean year.

#### SAMPLE SIZES

In order to explore similarities and differences between individual stocks to determine the best grouping methods for forming composite standards, a relatively large number of scales was measured from each stock sample collected in 1986 (Table 2; Fig. 1). For most stocks as many scales of each age class as possible were measured, up to a total of 60 scales. For Asian stocks and important Alaskan stocks larger numbers of scales were measured. Because of the large number of samples available from Kodiak and southeastern Alaska, only 40 scales were measured for most stocks. For 1987 scales, only 40 scales per sample were measured, except for larger numbers from Asian stocks and large western Alaska stocks (Table 2). Due to decisions made after preliminary analysis of 1986 scales, no age 1.1 scales and no scales from southeastern Alaska or British Columbia were measured from 1987.

In construction of standards, only samples from fisheries near the river mouth were used, as they were more likely to be representative of the production of the entire river, compared to escapement samples collected only at a specific location in the river. In the course of analyzing data from age 2.1 fish in 1986, larger samples were reduced by random sampling to create roughly equal numbers per stock, and in order that the western Alaska standard not be substantially larger than other standards. The unused scales and escapement samples were used later to test the model.

All measurable scales of age 2.1 (n= 1,746) and 1.1 (n= 299) fish in high seas samples from the landbased fishery area in 1986 were measured. From 1987 samples only age 2.1 fish were measured (n= 1,752). In order to achieve sample sizes in accord with recommendations of the INPFC Sub-Committee on Salmon (n=100 or more), samples were pooled and stratified by month and 5°-longitude subarea (see Fig. 2 for location of subareas).

## SCALE CHARACTERS

Measurement data was exported from OPRS internal files as ASCII files which were in turn reformatted by a FORTRAN program. Reformatted data included biological and collection information on each scale and 18 (1986) or 20 (1987) measurement variables. All reformatted measurements are expressed in microns. For 1986 data, distance along the measurement axis and circulus count of the first ocean year were used as variables, while for 1987 distance and circulus count of the first ocean summer were used instead (Table 3). There was wide variability in width of ocean annuli in both years, and it was sometimes difficult to determine the end of the annulus. Because of this, separate variable sets containing the distance and circulus count of the first ocean summer and of the first ocean year were tested from 1987 data. Linear discriminant analysis of all Asian and western Alaska stocks and of standards constructed of these stocks showed very little difference when using the two variable sets. Because determination of the start of the ocean annulus subjectively seemed to have been more consistent, it was decided to use first ocean summer values with 1987 data, although in practice this probably made little difference. As no marker was placed at the beginning of the ocean annulus in 1986, distance and circulus count for the first ocean year were used.

Individual circulus measurements were grouped in threes (triplets) up to a maximum of 45 circuli (15 triplets). As most scales did not contain this many circuli in the first ocean year, only those triplets for which all scales had a value were used. Under this criterion only the first through the seventh triplets were used for both the 1986 and 1987 data (Table 3). Distance along the measurement axis of the freshwater zone through the end of the last freshwater annulus was also used for both years. Basic statistics for all variables were calculated for each stock or fishery sample; outliers were identified and those greater than four standard deviations from the mean were removed.

## CONSTRUCTION OF STANDARDS

In line with recommendations from the INPFC Scale Pattern Analysis Workshop (INPFC 1987) groupings based on similarity were attempted in forming standard samples composed of several stocks. The linear discriminant function analysis (LDA) program, 7M, of BMDP (Dixon 1988) was used to evaluate the similarity of individual stocks. LDA was used rather than a clustering approach because it was felt that the LDA algorithm was closer than clustering algorithms to the actual method used in allocating scales. Although the use of a large number of groups in LDA is not a valid approach when actually classifying groups, the method was used because it tries to discriminate or separate groups. Those samples that are difficult to separate can be considered as a natural grouping. An indication of the distance between groups can be seen in a two-dimensional plot of the first two canonical variables (which usually account for over 70% of the dispersion) evaluated at the mean of each group. This plot is provided in output from BMDP 7M. BMDP 7M output also provides a table of the values of all canonical variables evaluated at group means. These values can be used as coordinates in a space of dimension  $n$ , where  $n$  is the number of canonical variables. Euclidean distances can be calculated between the groups using these coordinate values. A table of these distances can then be examined for stocks or groupings of stocks which are relatively closer together or further apart, and composite standards can be decided on. Canonical variable plots and tables of distance measures from the analysis of 1986 age 2.1 coho are provided as an example of the method (Appendix Figs. 1-2; Appendix Tables 1-2).

Age 2.1 in 1986. When all individual stocks were considered together, there was some confusion between Asian and south central Alaska stocks. Values of canonical variables from western Kamchatka Peninsula (Bolshaya R.) scales were in the center of the distribution and were

close to those of Kodiak Is. and southeastern Alaska (Appendix Fig. 1; Appendix Table 1). Values from the North Okhotsk Sea coast (Kukhtui R.) and from eastern Kamchatka (Kamchatka R.) were similar to each other but were also intermixed with those from Kodiak and Cook Inlet. Yukon River and Norton Sound samples formed a tight cluster and were close to another cluster formed by Kuskokwim area (Kuskokwim R., Quinhagak, and Goodnews) and Bristol Bay (Nushagak and Togiak) stocks. Together these two clusters composed a western Alaska standard. Values from two stocks along the northern coast of the Alaska Peninsula (Nelson and Ilnik) were not close to other western Alaska stocks and were treated as a separate grouping. Kodiak and Cook Inlet stocks formed a loose group that extended into the center of the distribution and overlapped with Asian stocks. Cordova area stocks (Copper and Bering rivers) were between central Alaska and a separate grouping of southeastern Alaska/British Columbia stocks.

From 40 samples from 37 stocks, six standard groupings could be constructed (Bolshaya, Kamchatka/Kukhtui, western Alaska, North Peninsula, central Alaska including Cordova, and southeastern Alaska/British Columbia), although the Asian and central Alaska standards were not distinct from each other. Means and standard deviations for scale variables from these standards are presented in Appendix Table 3. When a classification model was tested using these six standards, there was confusion between central Alaska and all other standards, particularly Kamchatka/Kukhtui. Kamchatka/Kukhtui also misclassified to most of the other standards, especially central Alaska. Because of the high similarity to Asian stocks and because virtually all tag returns (43 of 44; Myers et al. 1990) from coho stocks in central Alaska have come from fish tagged in the Gulf of Alaska, east of 161°W, it was decided to remove these fish from the analysis. Southeastern Alaska/British Columbia stocks were also removed as stocks unlikely to be present in the high seas fishery area. All tag recoveries from these areas have come from east of 155°W (567 external tags, 22 coded-wire tags; Myers et al. 1990).

When only Asian and western Alaska stocks were considered, values from Bolshaya fish were distinctive from other stocks (Appendix Fig. 2; Appendix Table 2). A grouping of Kukhtui and Kamchatka stocks was well-separated from others, and western Alaska and North Peninsula stocks again formed well-defined groupings. In summary four standard groupings from 12 stocks were used for the 1986 age 2.1 fish: Bolshaya R; Kamchatka/Kukhtui rivers; western Alaska (Norton Sound, Yukon, Kuskokwim, Bristol Bay); and North Peninsula.

To see how scales from central Alaska and southeastern Alaska/British Columbia stocks would be allocated in the four standard model if they were actually present, the data that were removed from the analysis were used as unknowns in the maximum likelihood estimator program. The largest proportion of all groups of these stocks was estimated to have come from Kamchatka/Kukhtui (Table 4). Secondary to Kamchatka/Kukhtui, Chignik and Kodiak scales were allocated to western Alaska and the North Peninsula; Cook Inlet scales to Bolshaya and North Peninsula; Cordova (Copper and Bering) scales to Bolshaya; and southeastern Alaska/British Columbia scales to Bolshaya and North Peninsula. Thus if fish from one of the deleted stocks are present in the fishery area, the contribution of the standards indicated above, particularly Kamchatka/Kukhtui, will be overestimated.

Age 2.1 in 1987. For age 2.1 fish in 1987 no scales were measured from southeastern Alaska/British Columbia. When scales from 23 other samples were considered together, Bolshaya, Kamchatka, and Cordova (Copper and Bering) values formed three distinct groups. However, all other stocks (North Okhotsk, western Alaska, North Peninsula, Kodiak, and Cook Inlet) were inextricably mixed. It was again decided to delete the central Alaska stocks from the analysis.

When only Asian and western Alaska stocks were considered, Bolshaya, Kamchatka, and North Peninsula stocks were each distinctive from others and were considered as three standards. Kamchatka River scales probably were distinctive in part because of the poor quality of the samples; FAJ biologists were often only able to find one or two scales per fish to mount from Soviet samples, instead of five per fish as for Bolshaya scales. Many of the mounted scales were not measured because they were obviously non-preferred, and means for most scale variables were substantially smaller in 1987 than in 1986. The two North Okhotsk stocks, Kukhtui and Taiui, were close to one another, but were also close to the Kuskokwim-Bristol Bay edge of the cluster of western Alaska stocks. Because of the importance of distinguishing between Asian and North American fish, it was decided to split this larger group into two standards, North Okhotsk and western Alaska, despite the similarity between them. Thus five standards were used for the analysis of 1987 age 2.1 fish: Bolshaya, Kamchatka, North Okhotsk, western Alaska, and North Peninsula. Means and standard deviations for these groupings as well for central Alaska are contained in Appendix Table 4.

To see how scales from central Alaska stocks would be allocated in the five standard model if they were actually present, the data that were removed from the analysis were used as unknowns in the maximum likelihood estimator program. North Okhotsk was estimated to be the largest contributor to the Chignik sample and North Peninsula was secondary (Table 5). Kodiak scales were estimated to have come primarily from the North Peninsula. The majority of Cook Inlet scales were allocated to North Peninsula and secondarily to Bolshaya and western Alaska. Cordova (Copper and Bering) scales were estimated to have come almost equally from Bolshaya, North Okhotsk, and western Alaska. Thus if fish from one of the deleted stocks are present in the fishery area, the contribution of the standards indicated above will be overestimated.

Age 1.1 in 1986. Samples from central Alaska and southeastern Alaska/British Columbia were removed from the analysis of age 1.1 fish in 1986 to reduce confusion between stocks and because tag returns from these regions are virtually all from the Gulf of Alaska. Distances derived from canonical variable values and plots from BMDP 7M indicated five natural groupings of age 1.1 fish from Asia and western Alaska: Bolshaya (n=11), Kamchatka/Kukhtui (n=66), Yukon/Norton Sound (n=72), Kuskokwim/Bristol Bay (n=59), and North Peninsula (n=66). Means and standard deviations for these groups as well as for central and southeastern Alaska and British Columbia are contained in Appendix Table 3. As reflected in the small sample sizes, freshwater age 1. fish are not common in these areas, nor are they common in the high seas samples. The small sizes of the standards preclude their use in a stable and acceptable analysis.

#### TESTS OF THE MODELS

There are no accepted methods for estimating the accuracy of maximum likelihood models. However, the maximum likelihood estimator uses the same likelihood values that are used by classification models. The jackknifed classification matrices from BMDP 7M are presented here (Table 6) merely as crude indicators of the probable general accuracy of the maximum likelihood models, and to indicate directions of misclassification among the standards. The matrices are not intended to represent the true accuracy of the models. The overall unweighted accuracy of the 1986 age 2.1 four standard model was 75.7%; that of the 1986 1.1 four standard model (without the very small Bolshaya standard) was 59.0%; and that of the 1987 age 2.1 five standard model was 65.2%. In the 1987 model note that the accuracies of classifying the North Okhotsk and western Alaska stocks were 51.4% and 56.5%, respectively, with large misclassifications between the two groups.

The four standard model for age 2.1 coho in 1986 was tested with scales from western Alaska samples which were not used in construction of the model. These samples consisted of remainder scales left after random sampling of five stocks to reduce sample sizes, and scales from three escapement samples which were not used in construction of the model. The samples were treated as unknowns and allocated by the maximum likelihood method. Remainder scales from the five groups used in the model were allocated to the correct standard (western Alaska) to an overwhelming degree (98.6% to 100%; Table 7). Scales from three escapement samples not used in the model were only slightly less successfully allocated (91.0% to 100%; Table 7). Because of the accuracy of the estimates, no bootstrap runs were made to estimate variances. These results give a high degree of confidence in the ability of the model to correctly identify scales of western Alaska coho. There were no additional scales to test the accuracies of the other three standards in the 1986 2.1 model, nor were there scales to test the 1986 1.1 and 1987 2.1 models.

#### CALCULATION OF MIXING PROPORTIONS OF UNKNOWNNS

Estimates of proportions of fish from each of the standard groupings present in the mixed fishery samples (unknowns) were obtained by a maximum likelihood method (Millar 1987, 1990a) using a FORTRAN program written by R. Millar (Millar 1988, 1990b). Ten variables were used in both the 1986 and 1987 analyses; there was no selection of variables, following Davis's (1987) finding that inclusion of nondiscriminating variables had only a slight effect on classification accuracy. Variance estimates were derived from bootstrap runs (500 iterations) of the same program. Confidence intervals (90%) were calculated as the estimate plus or minus 1.6449 times the standard deviation.

#### COMPARISON WITH TAG RECOVERIES

Tag return data were also analyzed and compared with scale pattern estimates. Tag data were taken from the INPFC tag recovery database maintained at FRI (see also Myers et al. 1990) and new data reported by FAJ (Ogura 1990).

#### INTERCEPTION ESTIMATES

Catch estimates were calculated by applying proportions estimated for subarea-month strata in the landbased and mothership fishery areas in 1986 to reported catches stratified in the same manner. Proportions for the two North American standards were pooled, as were those from the two Asian standards. Pooled variances were also calculated, and were used to calculate 90% confidence intervals for the catch estimates.

## RESULTS

#### MIXING PROPORTION ESTIMATES OF UNKNOWN (FISHERY AREA) SAMPLES

Statistical estimation of mixing proportions is an indirect method and as such depends on a number of assumptions. Portions of this analysis that have some bearing on these assumptions include questions on consistency of body area from which all scale samples were collected; lack of samples from some small Asian stocks from which tag recoveries have been reported; misallocations of scales between stocks; and discrepancies between tagging and scale pattern data. Because new information or samples could lead to changes in the analysis, all estimates presented here are considered provisional.

Age 2.1 in 1986. Sample sizes are above or close to the recommended level of 100 for seven strata (subarea-month combination) in the present or former landbased driftnet fishery area in June and July of 1986 (Table 8). In the current fishery area four out of a possible six strata have adequate sample sizes. Provisional maximum likelihood estimates of the proportion of fish from stocks of each of the four standards are presented in Table 8. Asian fish predominate in all strata except for subarea 15 in July. In general the proportion of Asian fish is higher in the west and declines toward the east, while North American fish show the opposite trend. These estimates indicate an average of 28% of the fish in the current landbased fishery area are of Alaskan origin, while 49% of the fish in the former fishing area between 175°E and 175°W are of Alaskan origin.

Fish from the Kamchatka and Kukhtui systems were more abundant than fish from the Bolshaya in four of the seven strata. Estimates of fish from western Alaska were generally higher than those from the North Peninsula, but North Peninsula estimates were higher in two of the seven strata.

Age 2.1 in 1987. Sample sizes for all five subareas in the current and former landbased fishery area were above recommended levels for the month of June in 1987; for July, samples for subareas 13 and 14 were adequate, and scales from subareas 11 and 12 were combined to give an adequate sample (Table 9). Provisional maximum likelihood estimates indicate that the overwhelming majority of fish in all strata are of North Okhotsk origin (Table 9). Bolshaya fish are second in abundance. Fish from the Kamchatka River, western Alaska, and the North Peninsula are estimated to be in low abundance or absent. Estimates for Alaskan fish are higher in the east in June, but are higher toward the west in July. Because of the confusion between North Okhotsk and western Alaska scales and because of the poor quality of Kamchatka River scales (see Construction of Standards, above), this analysis is considered questionable. The estimates from high seas samples, which are generally zero for Kamchatka R. (a major Asian production system) and small for western Alaska fish, also bring the analysis into question.

Age 1.1 in 1986. Adequate sample sizes for three high seas strata could be obtained only by broadly pooling across wide areas: subareas 12-15 in June (n=143) and subareas 11, 13, and 15 in July (n=78). Because the sizes for the standard groupings were too small (average n= 66) to perform an acceptable analysis, no estimation of composition of unknown strata is reported here. That age 1.1 fish are uncommon (11-19%; Table 3) in the high seas fishery area indicates that fish from more southerly regions where this age class is more common (central Alaska and especially southeastern Alaska and British Columbia) are not likely present in substantial numbers.

#### COMPARISON WITH TAG RECOVERIES

The majority (54 of 59) of tag recoveries in and near the landbased fishery area (southwest of 48°N, 170°W) have come from streams in the U.S.S.R. (Table 10). Of the five North American recoveries, only two have come from releases southwest of 175°W, 46°N and none from west of 175°E. However, there are two difficulties in using these data to infer that the vast majority of fish in the landbased area are of Asian origin: the total number of recoveries is very low, and there is potential bias in recovery and reporting rates between U.S.S.R. and Alaskan fisheries.

In spite of intensive tagging in recent years, the number of tag recoveries and the recovery rate southwest of 175°W, 46°N remains very low. After 34 years of tagging, there are only five recoveries from inside the boundaries of the current landbased fishery area, and a total of 49 from southwest of 175°W, 46°N. These numbers are not large enough to make reliable estimates of origins of coho in the landbased fishery. The recovery rate from 5,965 releases of coho southwest

of 175°W, 46°N is 0.8%, compared with 2.9% (3,463 releases) between 155°E and 175°W north of 46°N and south of the Aleutians and 26.2% (3,439 releases) east of 160°W. The lower recovery rates indicate either that tagged fish in this area suffer a greater mortality, which is unlikely, or that they return to areas where exploitation or reporting rates are much lower.

#### INTERCEPTION ESTIMATES

All interception estimates are considered provisional and may be revised based on new information on the distribution of stocks in the landbased fishery area and on confirmation of the accuracy of landbased catch data.

Provisional estimates of catches and 90% confidence intervals of age 2.1 North American- and Asian-origin coho salmon in sampled strata of the landbased fishery in 1986 are presented in Table 11. Catches of North American age 2.1 fish in the four landbased strata for which estimates are available total 58,016, or 24% of the 242,167 age 2.1 fish in those strata. An estimate for the entire landbased fishery catch can be calculated based on the following assumptions:

- age 1.1 and 3.1 fish are from the same stocks in the same proportions as the age 2.1 fish;
- the July proportions for subarea 11 (0.174) are applied to June for that subarea;
- the June proportions for subarea 12 (0.185) are applied to July for that subarea; and
- all coho west of 160°E are of Asian origin.

The total catch of North American coho by the landbased fishery in 1986 would then be 87,014, or 18% of the total coho catch of 477,483 (Table 12).

The 1986 age and proportion data can be used to make crude estimates for 1987-1989 catches by making the same assumptions as above and the additional assumptions that age and mixing proportions are generally the same in the subsequent years and that for 1988 and 1989 the June (for subareas 12 and 13) and July (for subarea 11) proportions can be extended to May catches in these subareas. While these gross assumptions undoubtedly do not strictly hold, application of the 1986 proportions to stratified 1987-1989 landbased catches can give a very rough idea of what more recent catches might be. These calculations show interceptions of North American coho declining as the fishery declines. Provisional rough estimates of catches of North American coho decrease from 84,277 in 1987 (18% of the total) to 62,843 in 1988 (21% of the total) to 49,581 in 1989 (24% of the total) (Table 13). Increases in proportions of North American fish in the catch are due to a greater proportion of the catch coming from the eastern part of the fishery area, where Alaskan coho are in higher relative abundance.

#### DISCUSSION

Results of this study in general confirm the findings of earlier work. U.S.S.R. streams are the predominant producers of fish caught in the landbased fishery area, although North American fish are present in low to moderate numbers. In earlier studies, FRI researchers (Myers et al. 1981, Walker and Harris 1982, Walker and Davis 1983) found increasing proportions of North American coho present in the landbased fishery area from 1979 (about 40%) to 1980 (60%) to 1981 (over 90%). However, North American proportions rose as the estimated quality of Kamchatka R. samples declined between years. The analyses also did not include samples from North Okhotsk coast stocks and used small samples from the Bolshaya R. which were combined with those from the Kamchatka R.

The studies of FAJ researchers (Kato and Ishida 1985, 1986, 1988, 1989) have generally found lower proportions of North American fish than the FRI studies, with estimates usually in the range of 15 to 30%. These estimates are very much in line with those of the present study. Some deficiencies of the FAJ work include use of unknown origin mixed fishery samples to represent Asian standards, poor coverage of and small samples from North American production areas in some years, and small sample sizes for many of the fishery strata.

Although FAJ estimates of North American fish in the landbased area are generally low, FAJ scientists have disputed their results on the grounds that they do not agree closely with tag return estimates, which indicate very few North American fish southwest of 46°N, 175°W. Though few, North American recoveries do constitute 4.1% of the 49 tags in that area, and 8.5% of the 59 tags southwest of 48°N, 170°W. While there is no doubt of the value of tag returns in proving definitively the presence of a stock in an area, the question arises of how reliable tag return data are for deriving precise estimates of proportions of stocks in an area. Not only are the number of recoveries of coho from the fishery area very low, but using the data for estimation of proportions requires assuming that the chances of a tag being recovered and reported are roughly the same in all recovery regions. This may be a valid assumption for sockeye salmon, where major stocks are relatively few and intensively fished on both continents. However, exploitation of coho stocks may differ significantly between fisheries.

It is difficult to estimate and compare exploitation rates in the U.S.S.R. and western Alaska coho fisheries. The total commercial catches in the two regions are roughly similar (Appendix Table 5), although the current level of exploitation of coho in western Alaska is a recent phenomenon, as demonstrated by the increase in catches between 1973 and 1982. Soviet catches have fluctuated around a relatively constant level since 1925. Estimates of escapement, and hence total run size, are much more difficult to obtain. Alaskan fishery biologists caution that "escapement" data that they tabulate is usually only an index, below the actual escapement. Escapement is usually estimated from aerial surveys, and in autumn when coho return, weather for flying is poor. Spawning areas are remote and difficult to census. Soviet escapement and exploitation estimates are also difficult to obtain, and are subject to the same difficulties as Alaskan estimates.

An example of the difficulties in interpreting tag data can be seen in examining U.S.S.R. catch and tag recovery data. Catch statistics indicate that eastern Kamchatka Peninsula (primarily Kamchatka River) stocks are largest, followed by western Kamchatka (primarily Bolshaya River) stocks (Appendix Table 5). North Okhotsk catches are generally minor; in 21 years for which there are reports, North Okhotsk catches average 1.5% of the total of the Kamchatka catches. However, a much higher proportion (17 of 135, or 13%) of Soviet tag returns are from the North Okhotsk coast, seven of them from southwest of 175°W, 46°N. Does this indicate that the exploitation rate (or the reporting rate) from these fisheries is higher than from the eastern and western Kamchatka fisheries? Or does it indicate that North Okhotsk stocks are more likely to be encountered in the area where tagging was conducted? In any case, the discrepancy between North Okhotsk catch sizes and their contribution to Asian tag recoveries, combined with uncertainty over high seas distribution, is an indication of the problems inherent in using the small amount of tag data to infer proportions of coho stocks in the landbased fishery area.

In the absence of better quantitative data from tagging, genetics, or any other source, scale pattern analysis remains our best means of estimating mixing proportions of Asian and North American coho stocks in the area of the landbased driftnet fishery. Although this study shares some of the deficiencies of other work (coastal and high seas samples too small to analyze age 1.1

scales; poor Kamchatka River scale samples in 1987; high overlap in distribution of variables of important Asian and Alaskan production areas in 1987), it has a number of improvements over previous scale pattern studies. Samples from the U.S.S.R. are generally markedly improved in quantity, quality, and coverage of production areas. There is better coverage of North American production areas as well. High seas samples are large enough to meet recommended levels for estimating mixing proportions in most month-subarea strata in the area of the landbased fishery and give relatively small confidence intervals on the estimates. A new approach to composing standard groupings based more on similarity and less on geography has allowed good discrimination between Asian and North American standard groups for age 2.1 fish in 1986. These improvements allow confidence in the estimates from this model.

Provisional interception estimates based on the proportions from the 1986 age 2.1 model are not large, but are not insignificant either. Expansion of the age 2.1 proportions to all ages in all strata yields a total North American interception estimate of 87,000 fish, 18% of the total landbased catch in 1986 and less than 8% of the combined western Alaska commercial catch of 1,130,000. However, total catches by the landbased fishery are declining steeply as the fishery is reduced, and current catches of North American coho are probably below 50,000 fish.

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## LITERATURE CITED

- Davis, N.D. 1987. Variable selection and performance of variable subsets in scale pattern analysis. (INPFC Doc.) FRI-UW-8713. Fish. Res. Inst., Univ. Washington, Seattle. 47 pp.
- Dixon, W.J. (ed.) 1988. BMDP statistical software manual. Univ. California Press, Berkeley. 2 vol., 1234 pp.
- Godfrey, H. 1965. Coho, chinook and masu salmon in offshore waters. 1. Coho salmon. Int. N. Pac. Fish. Comm., Bull. 16: 1-39.
- Godfrey, H., K.A. Henry, and S. Machidori. 1975. Distribution and abundance of coho salmon in offshore waters of the North Pacific Ocean. Int. N. Pac. Fish. Comm., Bull. 31. 80 pp.
- Harris, C.K. 1989. The effects of international treaty changes on Japan's high seas salmon fisheries, with emphasis on their catches of North American sockeye salmon, 1972-1984. Ph.D. Dissertation, Univ. Washington, Seattle. 231 pp.
- Int. N. Pac. Fish. Comm. 1979. Historical catch statistics for salmon of the North Pacific Ocean. Int. N. Pac. Fish. Comm., Bull. 39. 166 pp.
- Int. N. Pac. Fish. Comm. 1987. Report of scale pattern analysis workshop. (INPFC Doc.) Int. N. Pac. Fish. Comm., Vancouver. 7 pp.
- Kato, M. and Y. Ishida. 1985. Scale pattern analysis of coho salmon in the northwest North Pacific Ocean by materials obtained in 1975. (INPFC Doc.) Fisheries Agency of Japan, Shimizu. 18 pp.
- Kato, M. and Y. Ishida. 1986. Scale pattern analysis of coho salmon in the northwest North Pacific Ocean using materials obtained by salmon research vessels in 1976. (INPFC Doc.) Fisheries Agency of Japan, Shimizu. 17 pp.
- Kato, M. and Y. Ishida. 1988. Scale pattern analysis of 1975 coho salmon by maximum likelihood method. (INPFC Doc.) Fisheries Agency of Japan, Shimizu. 10 pp.
- Kato, M. and Y. Ishida. 1989. Stock identification of 1985 offshore coho salmon by scale pattern analysis. (INPFC Doc.) Fisheries Agency of Japan, Shimizu. 11 pp.
- Kazarnovskii, M.Ya. 1989. [U.S.S.R. commercial catch of Pacific Salmon in the northwestern Pacific Ocean.] All-Union Research Institute of Fisheries and Oceanography, Moscow. 71 pp. [in Russian]
- Koo, T.S.Y. 1962. Age designation in salmon. Univ. of Washington, Publ. Fish., New Ser. 1:41:48.
- Millar, R.M. 1987. Maximum likelihood estimation of mixed stock fishery composition. Can. J. Fish. Aquat. Sci. 44: 583-590.
- Millar, R.M. 1988. Statistical methodology for estimating composition of high seas salmonid mixtures using scale analysis. (INPFC Doc.) FRI-UW-8806. Fish. Res. Inst., Univ. Washington, Seattle. 57 pp.
- Millar, R.M. 1990a. Comparison of methods for estimating mixed stock fishery composition. Can. J. Fish. Aquat. Sci. 47: (pages to be assigned).
- Millar, R.M. 1990b. A versatile computer program for mixed stock fishery composition estimates. Can. Tech. Rep. Fish. Aquat. Sci. (In press)
- Myers, K.W., R.V. Walker, S. Fowler, and M.L. Dahlberg. 1990. Known ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1989. (INPFC Doc.) FRI-UW-9009. Fish. Res. Inst., Univ. Washington, Seattle. 57 pp.

- Myers, K.W., R.C. Cook, R.V. Walker, and C.K. Harris. 1981. The continent of origin of coho salmon in the Japanese landbased driftnet fishery area in 1979. (INPFC Doc.) Fish. Res. Inst., Univ. Washington, Seattle. 34 pp.
- Ogura, M. 1990. Release data for Japanese salmon tagging experiments in 1990 and recovery data up to August, 1990. (INPFC Doc.) Natl. Res. Inst. of Far Seas Fish., Fisheries Agency of Japan, Shimizu. 11 pp.
- Walker, R.V. 1987. Examination of an image analysis system for collection of scale pattern data. (INPFC Doc.) FRI-UW-8711. Fish. Res. Inst., Univ. Washington, Seattle. 22 pp.
- Walker, R.V. and N.D. Davis. 1983. The continent of origin of coho salmon in the Japanese landbased driftnet fishery area in 1981. (INPFC Doc.) FRI-UW-8314. Fish. Res. Inst., Univ. Washington, Seattle. 48 pp.
- Walker, R.V. and C.K. Harris. 1982. The continent of origin of coho salmon in the Japanese landbased driftnet fishery area in 1980. (INPFC Doc.) Fish. Res. Inst., Univ. Washington, Seattle. 26 pp.

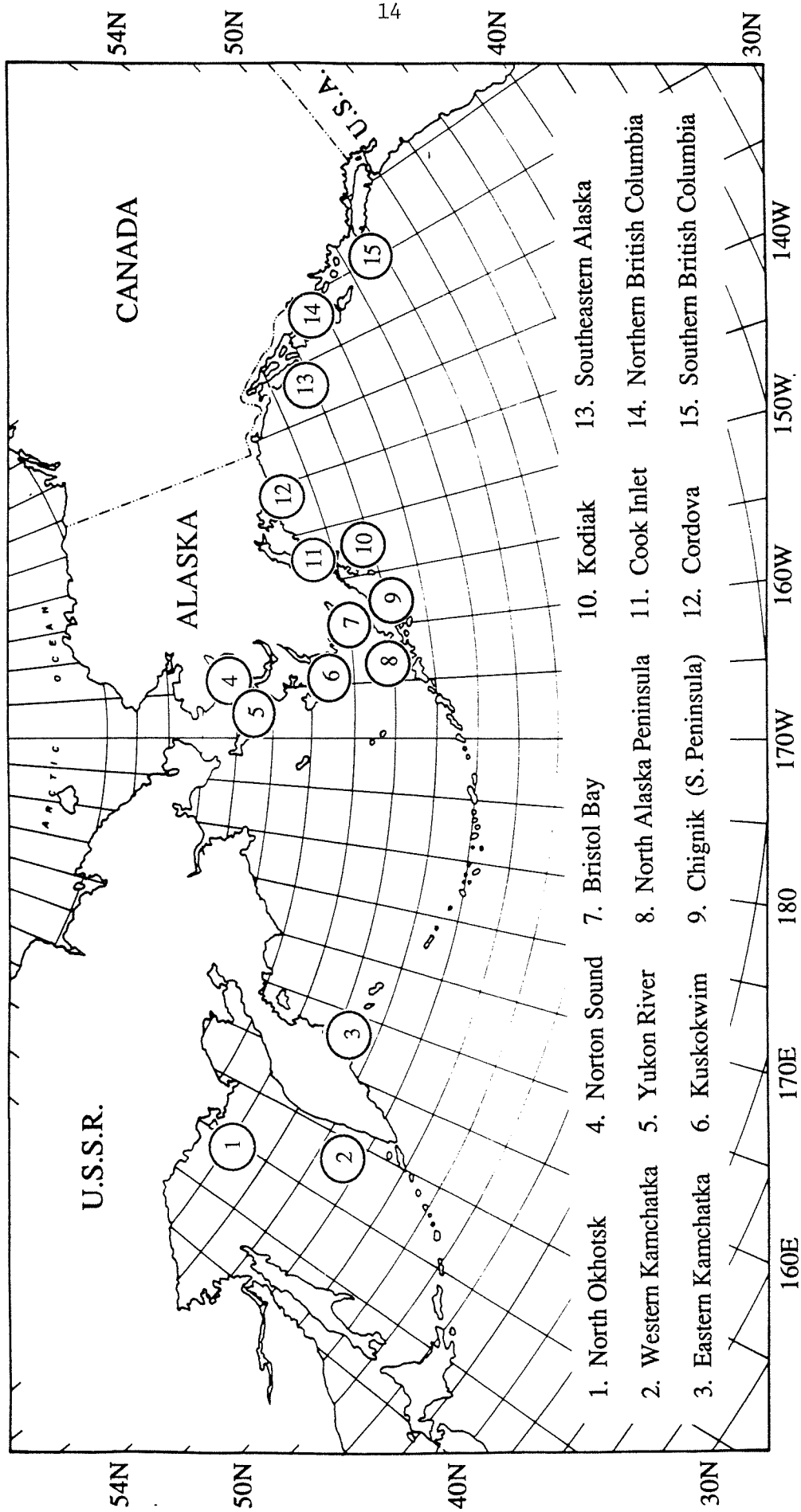


Figure 1. Geographic regions from which scale samples were used in 1986 and 1987 coho analyses. For individual stocks or samples in each region, see Table 1.

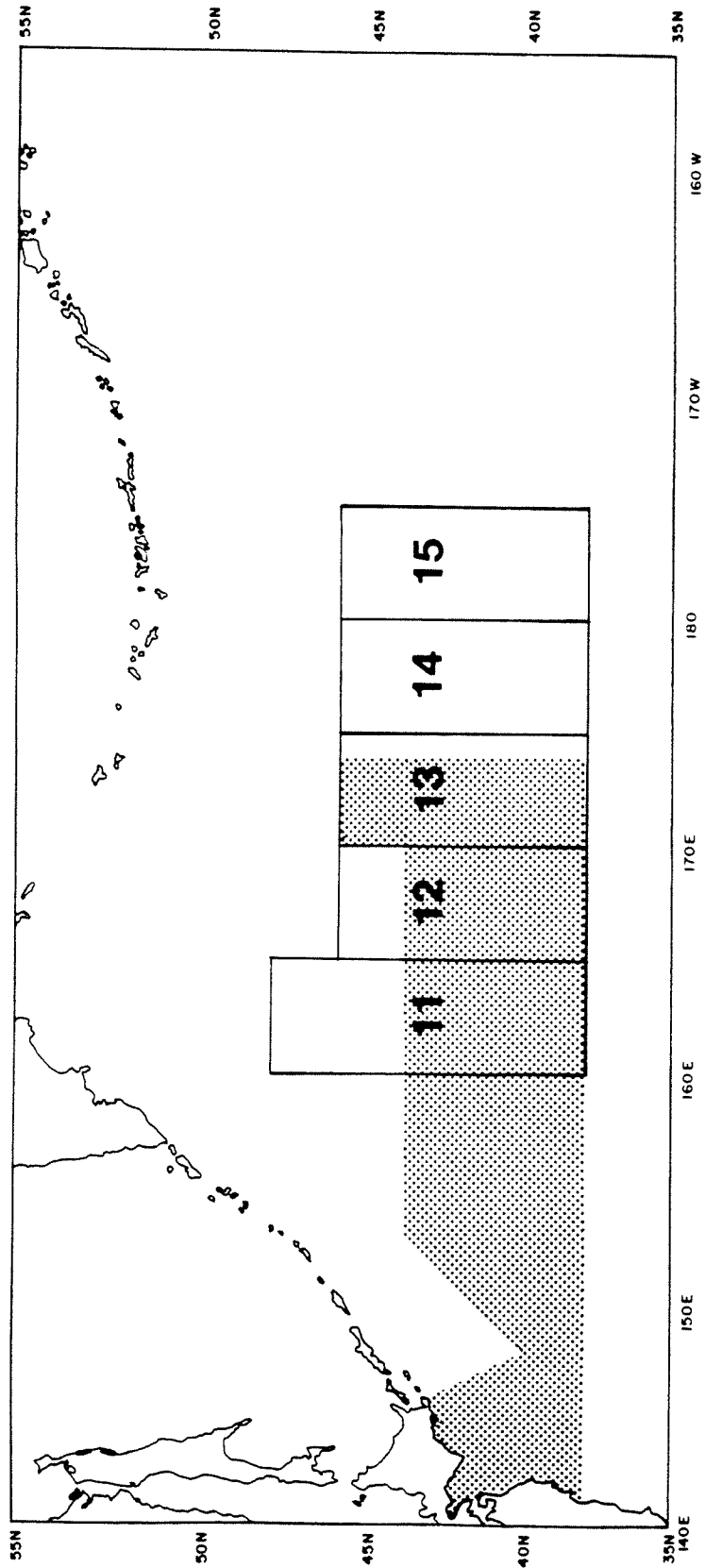


Figure 2. Location of subareas used for stratification of high seas samples of coho salmon scales in and around the landbased driftnet fishery area. Shading indicates fishery area since 1986.

Table 1. Estimated age composition of coho salmon in and near the landbased driftnet fishery area in 1986. Sample sizes of age 1.1 and 2.1 fish are numbers of scales measured in each stratum.

Month	Sub-Area	N	Age		
			1.1	2.1	3.1
June	12	213	24 (.113)	187 (.878)	2 (.009)
	13	371	57 (.154)	308 (.830)	6 (.016)
	14	430	64 (.149)	357 (.830)	9 (.021)
	15	460	58 (.126)	396 (.861)	6 (.013)
July	11	252	31 (.123)	217 (.861)	4 (.016)
	13	248	48 (.194)	195 (.786)	5 (.020)
	15	96	16 (.167)	78 (.812)	2 (.021)

Table 2. Number of scales measured from samples used in 1986 and 1987 coho analyses.

Region	Stock or Sample	1986				1987
		Age 2.1		Age 1.1		Age 2.1
		measured	used	measured	used	
North Okhotsk	Kukhtui R.	161	161	34	34	120
	Tauai R.					135
Western Kamchatka	Bolshaya R.	64	64	11	11	160
Eastern Kamchatka	Kamchatka R.	184	184	32	32	131
Western Alaska	Unalakleet:					
	Commercial fishery	60	31	2	2	40
	Test fishery	60	29	0	0	40
	Yukon:					
	Middlemouth test	34	12	5	5	40
	Emmonak comml.	60	19	18	18	
	Ruby S. bank test	60	29	47	47	
	Big Eddy					40
	Kuskokwim:					
	Bethel commercial	149	60	34	34	40
	Kogrukluuk esc.	55	0	6	0	
	Quinhagak comml.	60	60	5	5	40
	Goodnews comml.	60	60	8	8	40
	Nushagak:					
Nushagak comml.	107	60	3	3	56	
Portage Cr. esc.	60	0	0	0		
Togiak comml.	108	60	9	9		
North Peninsula	Nelson Lagoon	60	60	60	60	60
	Ilnik Lagoon	60	60	6	6	60
South Peninsula	Chignik Lagoon	60	60	22	22	41
Kodiak	Karluk R.	60	60	3	0	29
	Dog Salmon (Frazer R.)	36	36	15	15	30
	Upper Station	40	40	20	20	29
	Saltery R.	40	40	40	40	30
	Discoverer Bay	40	40	29	29	
	Zachar Bay	41	40	41	41	
	Swikshak	40	40	40	40	
Cook Inlet	Central Dist. comml.	120	120	28	28	60
	Yentna (Susitna R.)	76	76	6	6	
	Fish Cr. esc.	60	60	10	10	40
	Kenai R. esc.	4	0			

Table 2. - continued.

Region	Stock or Sample	1986				1987
		Age 2.1		Age 1.1		Age 2.1
		measured	used	measured	used	
Cordova	Pr. Wm. Sound	30	0	25	0	12
	Copper R.	164	164	150	150	60
	Bering R.	60	60	60	60	60
Southeast Alaska	Berners R.	60	60	51	51	
	Chilkat Lake	60	60	40	40	
	Redoubt Lake	59	59	21	21	
	Ford Arm Lake	39	39	35	35	
	Auke Cr.	40	40	9	0	
	Snettisham Hatchery	22	22	40	40	
	Taku R.:					
	Yehring Cr.	40	40	40	40	
	Canyon Is.	60	60	60	60	
	Black Bear Cr.	5	0	9	0	
	Crystal Lake Hatchery	4	0	60	60	
	Salmon Bay Lake	52	52	34	34	
	Salmon Bay Tributary	9	0	10	0	
	Klawock R.	12	0	8	0	
	Karta R.	55	55	27	27	
Hugh Smith L.	60	60	28	28		
Northern British Columbia	Taku R.:					
	Taku R.	43	43	43	43	
	Hackett R.	46	46	40	40	
	Skeena R.:					
	Test fishery	12	0	26	26	
	Kitwanga	0	0	6	0	
	Babine	0	0	34	34	
Kitimat R.	3	0	40	40		
Southern British Columbia	Quinsam Hatchery	0	0	8	0	
	Fraser R.:					
Salmon R.	0	0	40	40		

Table 3. Scale characters used in 1986 and 1987 coho analyses. All distances measured along an axis 90° to a reference line connecting the posterior ends of the ocean annulus.

Name of Scale Character	Description	Used in analyses:		
		<u>1986</u>	<u>1987</u>	<u>1987</u>
		2.1	1.1	2.1
Freshwater size	Distance in the freshwater zone from the center of the focus to the outer edge of the last circulus in the last freshwater annulus	X	X	X
Ocean size	Distance in the first year of ocean growth from the edge of the last freshwater annulus to the edge of the last circulus in the ocean annulus; may include freshwater plus-growth after the last freshwater annulus	X	X	
Ocean circulus	Number of circuli in the first year of ocean growth; may include circuli of freshwater plus-growth	X	X	
Ocean summer size	Distance in the first year of ocean growth from the edge of the last freshwater annulus to the edge of the first circulus in the ocean annulus; may include freshwater plus-growth after the last freshwater annulus			X
Ocean summer circulus count	Number of circuli in the first summer of ocean growth; may include circuli of freshwater plus-growth			X
Triplet 1	Distance from the edge of the last circulus in the last freshwater annulus to the edge of the third circulus in the first year of ocean growth; may include plus-growth	X	X	X
Triplet 2	Distance from the third to the sixth circulus in the first year of ocean growth	X	X	X
Triplet 3	Distance from the sixth to the ninth circulus in the first year of ocean growth	X	X	X
Triplet 4	Distance from the ninth to the twelfth circulus in the first year of ocean growth	X	X	X
Triplet 5	Distance from the twelfth to the fifteenth circulus in the first year of ocean growth	X	X	X
Triplet 6	Distance from the fifteenth to the eighteenth circulus in the first year of ocean growth	X	X	X
Triplet 7	Distance from the eighteenth to the twenty-first circulus in the first year of ocean growth	X	X	X

Table 4. Test of samples from excluded regions (central Alaska, southeastern Alaska, and British Columbia) against the four standard model used for 1986 age 2.1 coho, to demonstrate where scales would be allocated if fish from these areas were present in the fishery.

Region: Stock group	N	Bolshaya	Kamchatka/ Kukhtui	Western Alaska	North Peninsula
Central Alaska:					
Chignik	60	4.0	54.1	15.0	26.9
Kodiak	297	6.3	53.9	20.4	19.4
Cook Inlet	256	25.4	46.9	2.7	25.0
Cordova	224	16.9	82.4	0.7	0.0
S.E. Alaska/ British Columbia	360	21.4	61.8	15.6	1.2

Table 5. Test of excluded central Alaska stocks against the five standard model used for 1987 age 2.1 coho, to demonstrate where scales would be allocated if fish from these areas were present in the fishery.

Region: Stock group	N	Bolshaya	North Okhotsk	Kamchatka	Western Alaska	North Peninsula
Central Alaska:						
Chignik	41	11.6	64.0	0.0	0.0	24.4
Kodiak	118	0.0	0.0	0.2	13.5	86.3
Cook Inlet	100	22.9	5.4	0.0	21.1	50.6
Cordova	119	29.4	34.0	0.0	36.6	0.0

Table 6. Jackknifed classification matrices for coho models from BMDP 7M. Information provided as crude index of accuracy of the maximum likelihood models and is not intended to represent the true accuracy of the models.

a) 1986 age 2.1  
Overall accuracy: 75.7%

Correct Decision	N	Calculated Decision			
		Bolshaya	Kamchatka/ Kukhtui	Western Alaska	North Peninsula
Bolshaya	64	55 (85.9)	3	5	1
Kamchatka/Kukhtui	345	31	245 (71.0)	42	27
Western Alaska	420	21	47	308 (73.3)	44
North Peninsula	120	6	12	15	87 (72.5)

b) 1986 age 1.1  
Overall accuracy: 59.0%

Correct Decision	N	Calculated Decision			
		Kamchatka/ Kukhtui	Yukon/ Norton	Kuskokwim Bristol Bay	North Peninsula
Kamchatka/Kukhtui	66	41 (62.1)	9	8	8
Yukon	72	6	50 (69.4)	16	0
Kuskokwim/B. Bay	59	4	10	36 (61.0)	9
North Peninsula	66	12	3	8	43 (65.2)

c) 1987 age 2.1  
Overall accuracy: 65.2%

Correct Decision	N	Calculated Decision				
		Bolshaya	North Okhotsk	Kamchatka	Western Alaska	North Peninsula
Bolshaya	160	123 (76.9)	7	14	15	1
North Okhotsk	255	12	131 (51.4)	24	46	42
Kamchatka	131	6	10	99 (75.6)	7	9
Western Alaska	336	31	62	25	190 (56.5)	28
North Peninsula	119	3	21	2	15	78 (65.5)

Table 7. Test of four standard model for 1986 age 2.1 coho. Allocation by maximum likelihood method of western Alaska scales not used in model.

Sample	N	Bolshaya	Kamchatka/ Kukhtui	Western Alaska	North Peninsula
Remainders <sup>1</sup> :					
Norton Sound	60	0.0	0.0	98.6	1.4
Yukon	94	0.0	0.9	99.1	0.0
Kuskokwim	89	0.0	0.0	100.0	0.0
Nushagak	47	0.0	0.0	100.0	0.0
Togiak	48	0.0	0.0	100.0	0.0
Escapement <sup>2</sup> :					
Kogrukluk weir (Kuskokwim R.)	55	0.0	0.0	100.0	0.0
Kisarlik R. (Kuskokwim R.)	30	3.2	5.7	91.1	0.0
Portage Cr. (Nushagak R.)	60	0.0	6.3	93.7	0.0

<sup>1</sup>Scales left after random sampling of the indicated stocks; not used in model

<sup>2</sup>Escapement scales from rivers indicated in parentheses; not used in model

Table 8. Provisional maximum likelihood mixing proportion estimates by subarea and month for 1986 age 2.1 coho. Estimates utilize Millar's (1988) method with confidence intervals calculated from standard deviations derived from bootstrapping (500 runs) times a Z-statistic of 1.64.

Month	Sub-Area	N	Bolshaya		Kamchatka/Kukhtui		Western Alaska		N. Peninsula	
			Est.	90% CI	Est.	90% CI	Est.	90% CI	Est.	90% CI
June	12	187	.100	(.034-.166)	.715	(.616-.814)	.082	(.005-.159)	.103	(.014-.192)
	13	308	.212	(.110-.314)	.478	(.363-.593)	.221	(.111-.331)	.090	(.014-.166)
	14	357	.317	(.225-.409)	.205	(.128-.282)	.291	(.168-.414)	.187	(.072-.302)
	15	396	.190	(.126-.254)	.389	(.294-.484)	.309	(.214-.404)	.112	(.033-.191)
	July	217	.082	(.018-.146)	.744	(.645-.843)	.074	(.013-.135)	.100	(.014-.185)
	13	195	.349	(.249-.449)	.180	(.076-.284)	.287	(.169-.405)	.184	(.070-.298)
	15	78	.213	(.104-.322)	.213	(.080-.346)	.308	(.142-.474)	.266	(.103-.429)

Table 9. Provisional maximum likelihood mixing proportion estimates by subarea and month for 1987 age 2.1 coho. Estimates utilize Millar's (1988) method with confidence intervals calculated from standard deviations derived from bootstrapping (500 runs) times a Z-statistic of 1.64.

Month	Sub-Area	N	Bolshaya		N. Okhotsk		Kamchatka		W. Alaska		N. Peninsula	
			Est.	90% CI	Est.	90% CI	Est.	90% CI	Est.	90% CI	Est.	90% CI
June	11	160	5.6	(10.6-11.1)	93.7	(86.5-100)	0.0	(0-0.8)	0.0	(0-2.0)	0.6	(0-4.6)
	12	120	16.6	(8.8-24.4)	83.4	(74.2-92.6)	0.0	(0-0.4)	0.0	(0-4.9)	0.0	(0-3.1)
	13	285	15.8	(8.8-22.7)	78.4	(67.3-89.6)	0.1	(0-1.1)	0.1	(0-10.0)	5.6	(1.1-10.2)
	14	449	25.4	(18.7-32.0)	59.4	(48.2-70.6)	0.0	(0-0.9)	7.6	(0-18.9)	7.6	(3.6-11.7)
	15	355	28.7	(21.0-36.4)	55.4	(43.4-67.4)	2.6	(0-5.8)	12.5	(0-25.4)	0.8	(0-2.5)
July	11+12	126	15.6	(5.5-25.7)	66.6	(47.2-86.0)	0.0	(0-0.7)	17.8	(0-40.0)	0.0	(0-3.2)
	13	135	37.1	(24.5-49.7)	45.8	(30.4-61.2)	0.3	(0-2.2)	16.8	(0-35.0)	0.0	(0-5.7)
	14	122	41.9	(31.1-52.7)	53.6	(40.8-66.3)	3.0	(0-7.1)	0.0	(0-3.5)	1.5	(0-5.6)

Table 10. Recoveries of coho tagged southwest of 48°N, 170°W reported to INPFC from 1955 to 1990, by recovery region. North American recoveries are marked with an asterisk (\*).

Latitude	Recovery Region	Longitude						
		155°-160°E	160°-165°E	165°-170°E	170°-175°E	175°E-180°	180°-175°W	175°-170°W
46°-48°N	N. Okhotsk	1			1			
	W. Kamchatka		1			1		
	E. Kamchatka		1					
	U.S.S.R. unknown Kuskokwim		1					2*
44°-46°N	N. Okhotsk		1	1		2		1
	W. Kamchatka				2	11		2
	E. Kamchatka					5		4
	Bristol Bay					1*	1*	1*
42°-44°N	N. Okhotsk			1				1
	W. Kamchatka					3		1
	E. Kamchatka				1	2		3
	Kuril Is.							1
	Sakhalin U.S.S.R. unknown				1	1		
40°-42°N	W. Kamchatka							1
	Kuril Is.					1		

Table 11. Provisional estimated catch of age 2.1 coho of western Alaska (including North Peninsula) origin in various strata in the landbased driftnet fishery areas in 1986. Strata are those for which adequate sample sizes exist. Confidence intervals calculated using pooled variances from bootstrap-derived individual variances for two Alaskan standard groupings.

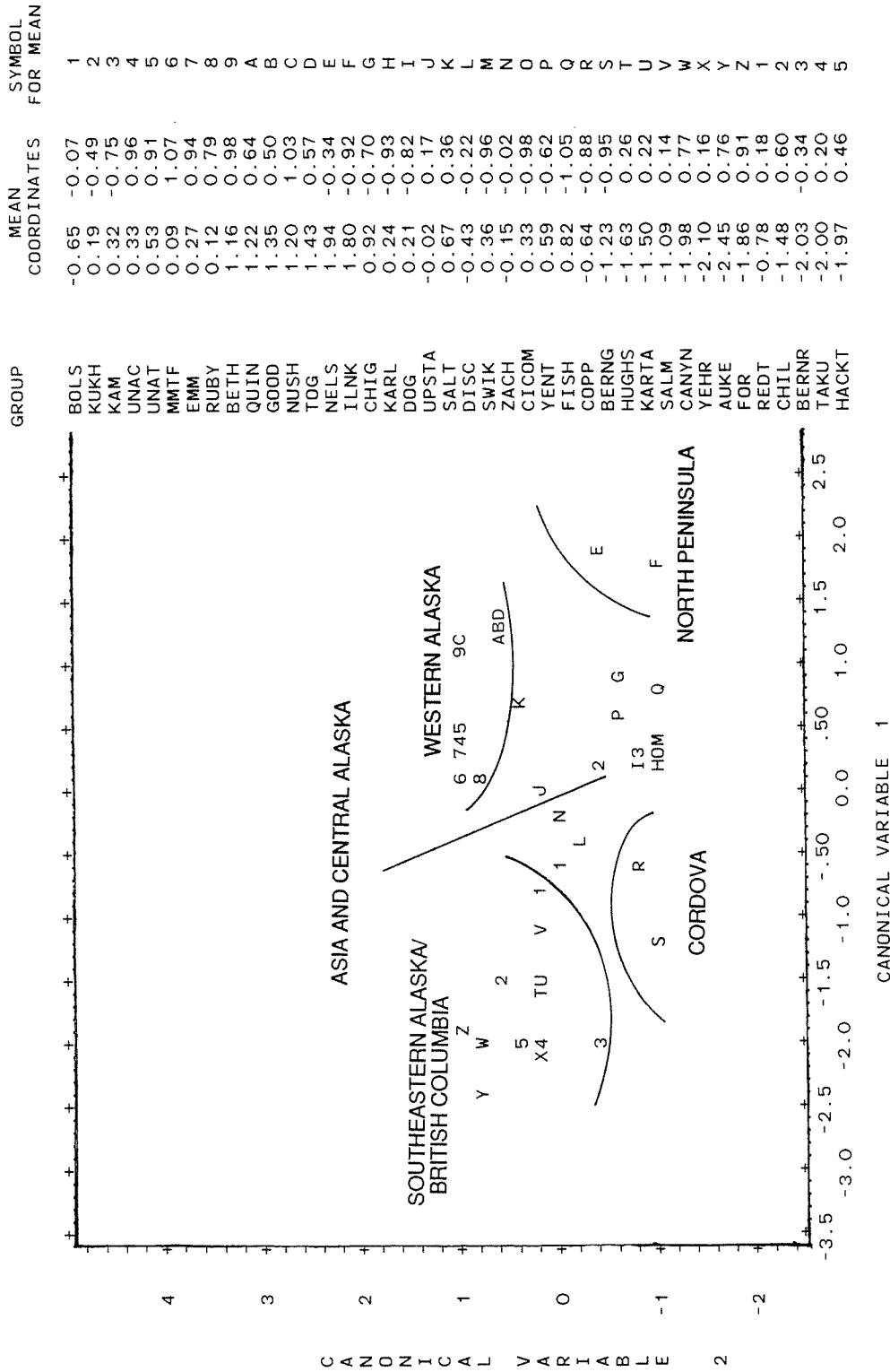
Month	Sub-Area	Stratum Size	Catch	Age 2.1		Western Alaska origin 2.1		
				Prop.	Catch	Prop.	Catch	90% CI
June	12	187	140,034	.878	122,950	.185	22,746	(11,668-33,824)
	13	308	123,994	.830	102,915	.311	32,007	(21,160-42,854)
July	11	217	17,268	.861	14,868	.174	2,587	( 1,241-3,933 )
	13	195	1,825	.786	1,434	.471	676	( 498-854 )
Total			283,121		242,167		58,016	

Table 12. Provisional estimated catch of coho of western Alaska (including North Peninsula) origin in the landbased driftnet fishery in 1986. Estimates made by extending estimated proportions of western Alaska age 2.1 fish in various strata to all ages and strata. See text for details.

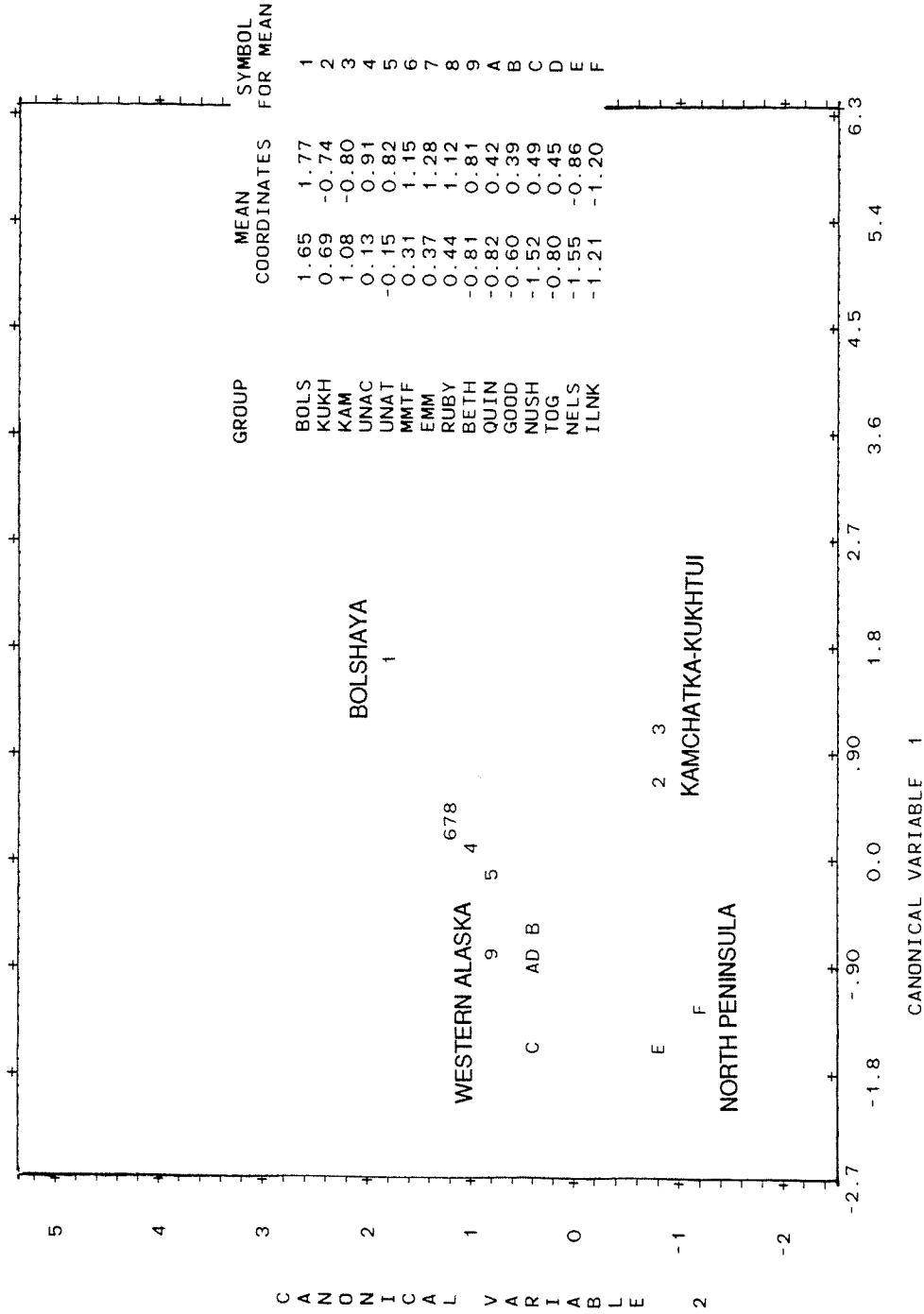
Month	Sub-Area	Catch	Western Alaska origin	
			Prop.	Catch
June	11	92,361	.174	16,070
	12	140,034	.185	25,906
	13	123,994	.311	38,562
July	11	17,268	.174	3,004
	12	14,115	.185	2,612
	13	1,825	.471	860
W. of 160°E		87,986	.0	0
Total		477,583		87,014

Table 13. Provisional rough estimates of catch of coho of western Alaska (including North Peninsula) origin in the landbased driftnet fishery for 1987-89. Estimates made by extending estimated proportions of western Alaska age 2.1 fish in various strata in 1986 to all ages and strata in succeeding years. See text for details.

Year	Month	Sub-Area	Catch	Western Alaska origin		
				Prop.	Catch	
1987	June	11	131,845	.174	22,941	
		12	160,981	.185	29,781	
		13	74,268	.311	23,097	
	July	11	11,030	.174	1,919	
		12	14,486	.185	2,680	
		13	8,193	.471	3,859	
		W. of 160°E		58,348	.0	0
	1987	Total		459,151		84,277
	1988	May	11	30	.174	5
12			1,635	.185	302	
13			776	.311	241	
June		11	61,270	.174	10,661	
		12	91,236	.185	16,879	
		13	111,751	.311	34,755	
		W. of 160°E		25,930	.0	0
1988		Total		292,628		62,843
1988		May	11	10,335	.174	1,798
	12		16,542	.185	3,060	
	13		7,542	.311	2,346	
	June	11	21,928	.174	3,815	
		12	55,343	.185	10,238	
		13	91,074	.311	28,324	
		W. of 160°E		5,215	.0	0
	1988	Total		207,979		49,581



Appendix Figure 1. Plot of first two canonical variables from BMDP 7M linear discriminant function analyzed at the mean of each of 40 samples used in preliminary analysis of 1986 age 2.1 coho scales. Note poor separation between Asian and central Alaska samples in center of plot. See Table 1 for names of samples.



Appendix Figure 2. Plot of first two canonical variables from BMDP 7M linear discriminant function analyzed at the mean of each of 15 samples from Asia and western Alaska used in construction of four composite standards for analysis of 1986 age 2.1 coho scales. Note relatively good separation between four groupings. See Table 1 for names of samples.

Appendix Table 1. Euclidean distances calculated from values of canonical variables analyzed at the mean of each of 40 samples from Asia and western Alaska used in preliminary analysis of 1986 age 2.1 coho scales. Note generally poor separation (small distances) between Kukhtui and Kamchatka and central Alaska stocks. See Table 1 for names of samples.

	BOLS	KUKH	KAM	UNAC	UNAT	MMTF	EMM	RUBY	BETH	QUIN	GOOD	NUSH	TOG	NELS	ILNK
BOLS	0.0000														
KUKH	3.3148	0.0000													
KAM	3.2324	1.3637	0.0000												
UNAC	2.6441	2.0354	1.9421	0.0000											
UNAT	2.8702	1.9999	1.9736	0.5390	0.0000										
MMTF	2.6491	2.2206	2.2405	0.6736	0.7881	0.0000									
EMM	2.5234	2.0825	2.0272	0.3270	0.6916	0.7238	0.0000								
RUBY	2.4490	2.0105	2.0684	0.6407	0.7319	0.6488	0.5037	0.0000							
BETH	3.1566	2.0381	2.4544	1.3480	1.1629	1.5737	1.4038	1.5294	0.0000						
QUIN	3.2769	1.7724	2.3253	1.5757	1.3032	1.7696	1.6521	1.6387	0.5973	0.0000					
GOOD	3.2111	1.7855	2.0319	1.4455	1.2287	1.7790	1.5482	1.5993	0.8596	0.6062	0.0000				
NUSH	3.5578	2.1935	2.5171	1.5441	1.1519	1.7172	1.7161	1.7096	0.9599	0.8237	1.0021	0.0000			
TOG	3.2921	2.0122	2.3286	1.6401	1.4206	1.8888	1.7302	1.6786	0.9599	0.7873	1.0021	0.0000	0.0000		
NELS	4.3007	2.5177	2.7501	2.8937	2.4706	3.0077	3.0094	2.9410	2.1610	1.8255	1.9522	2.2742	2.0913	0.0000	
ILNK	4.2376	2.5388	2.7243	3.1348	2.7373	3.2473	3.2080	3.0956	2.5310	2.1764	2.2742	2.2927	2.4016	0.6901	0.0000
CHIG	3.2041	1.2441	1.5688	2.1572	1.9290	2.3319	2.2352	2.1504	1.8096	1.4575	1.4210	1.8651	1.6878	1.5755	1.5556
KARL	2.9915	1.1099	1.4804	2.2606	2.0917	2.3591	2.3199	2.1478	2.2336	1.9067	1.8938	2.2440	2.1017	2.1177	1.9860
DGG	4.2014	2.2648	1.9094	2.8612	2.5708	2.8636	3.0130	2.8587	3.1155	2.8439	2.7429	1.7938	2.9424	2.4045	2.3841
UPSTA	3.5902	1.7368	1.8778	1.9227	1.5988	1.8744	2.0750	1.9063	2.1536	1.9704	2.0439	1.7928	2.2522	2.2087	2.3717
SALT	3.2148	1.6023	1.8267	1.6487	1.4900	1.8692	1.8425	1.8217	1.5552	1.3121	1.0990	1.4390	1.3262	2.2937	2.5999
DISC	2.5325	2.2734	2.7496	2.4510	2.2425	2.3041	2.4554	2.1447	2.4503	2.2668	2.5052	2.4027	2.5716	2.6874	2.6095
SWIK	2.9778	1.8427	2.4096	2.6864	2.4565	2.7608	2.6880	2.4412	2.4209	2.0541	2.2142	2.3841	2.2631	2.1312	1.8623
ZACH	2.6580	1.5031	2.2759	2.1541	2.2239	2.1733	2.2058	2.0807	2.1218	1.9337	1.9959	2.3996	2.0933	3.1248	3.2473
CICOM	2.3379	2.0580	2.2197	2.4151	2.2687	2.4232	2.3866	2.1537	2.4129	2.1917	2.2479	2.5119	2.3243	2.3815	2.1159
FISH	2.2176	1.9182	1.9772	1.9954	2.0307	2.0425	1.9890	1.9082	2.0817	1.9957	1.9811	2.3741	2.0867	2.5835	2.5071
FISH	2.8902	1.9548	1.9648	2.3738	2.2161	2.5177	2.3202	2.2057	2.2983	2.1247	2.1351	2.4622	2.2980	2.1180	1.7894
COPP	2.5969	1.4712	1.6796	2.2805	2.2376	2.3109	2.2562	1.9945	2.7024	2.4802	2.4555	2.7631	2.5952	3.0384	2.8656
BERNG	2.5966	1.9021	1.8736	2.5723	2.6688	2.6304	2.5752	2.3825	3.2363	3.0770	2.9880	3.2945	3.1315	3.7416	3.6023
HUGHS	3.4907	2.0562	2.7485	2.7294	2.8049	2.6612	2.7763	2.6450	3.1051	3.0319	3.1857	3.3637	3.3637	3.9800	4.0680
KARTA	2.9654	2.0642	2.3151	2.1709	2.2582	2.1636	2.1562	2.0142	2.8886	2.8901	2.9605	2.9437	3.1567	3.7875	3.7986
SALM	3.0566	1.9462	2.2506	2.1130	2.0654	1.9943	2.1172	1.9739	2.5825	2.5996	2.7681	2.6495	3.0220	3.2299	3.4336
YEHY	2.9866	2.9656	3.1963	2.6372	2.6802	2.4240	2.6842	2.4655	3.3387	3.3454	3.4544	3.2437	3.5548	4.2401	4.3298
YEHY	3.2551	2.5403	3.0551	3.0219	2.8910	2.8910	2.9246	2.7642	3.4607	3.4224	3.5755	3.5041	3.7225	4.3143	4.3093
AUKE	3.0441	3.2113	3.7811	3.1596	3.3160	2.9662	3.0684	2.8856	3.6756	3.7466	3.9066	4.0662	4.0662	4.8994	4.9226
FOR	3.7418	3.0727	3.4641	2.9622	2.8918	2.6896	3.0275	2.8609	3.3719	3.4123	3.6633	3.8424	3.8424	4.0259	4.1530
REDT	2.4649	1.6291	2.0241	1.7031	1.7931	1.7467	1.6653	1.6084	2.1362	2.2085	2.3368	2.4215	2.6100	3.1858	3.2172
CHIL	4.1454	3.3062	3.4088	3.1079	2.8673	2.8611	3.1638	2.9140	3.5937	3.5416	3.7072	3.8437	3.8437	3.7973	3.9773
BERNR	3.0199	2.4349	2.9576	2.9913	3.1167	2.8453	2.9409	2.6778	3.5905	3.4823	3.6062	3.6916	3.6681	4.3893	4.3060
TAKU	2.6103	2.7449	2.9813	2.6713	2.7507	2.4855	2.6693	2.4184	3.3780	3.3476	3.4365	3.3832	3.5363	4.2225	4.2163
HACKT	3.1122	2.8351	3.0379	2.6692	2.6971	2.5186	2.7160	2.5031	3.3918	3.3739	3.4911	3.2469	3.6010	4.1227	4.1570

Appendix Table 1. - continued.

	CHIG	KARL	DOG	UPSTA	SALT	DISC	SWIK	ZACH	CICOM	YENT	FISH	COPP	BERNG	HUGHS	KARTA
CHIG	0.0000														
KARL	0.7345	0.0000													
DOG	1.9753	1.7976	0.0000												
UPSTA	1.6985	1.5586	1.3233	0.0000											
SALT	1.4124	1.6085	2.2385	1.6118	0.0000										
DISC	1.9684	1.6257	2.6507	1.9099	2.3010	0.0000									
SWIK	1.3463	1.1381	2.5665	2.1524	2.2515	0.0000	0.0000								
ZACH	1.8336	1.6556	2.9915	2.2954	1.5195	2.0453	2.1235	0.0000							
CICOM	1.4783	1.2820	2.6238	2.2755	2.3574	1.3404	0.9776	2.1871	0.0000						
YENT	1.5930	1.6187	2.9296	2.4755	2.2219	2.0343	1.7860	1.9782	1.1308	0.0000					
FISH	1.4295	1.5037	2.6350	2.3538	2.0751	1.5947	1.5688	1.7997	1.0250	1.2964	0.0000				
COPP	1.7238	1.0881	2.1758	1.8202	2.1163	1.5947	2.2736	2.0131	1.5193	1.9379	0.8846	0.0000			
BERNG	2.3665	1.7282	2.5555	2.2883	2.4794	2.1493	2.2736	2.9152	2.1485	2.3464	0.0333	0.0000	0.0000		
HUGHS	2.8702	2.4175	3.0515	2.2367	2.5567	2.4505	2.9152	1.9360	3.1178	3.1489	3.4421	2.0333	1.9021	0.0000	0.0000
KARTA	2.7243	2.2621	2.7861	1.9386	2.5574	2.1675	2.6736	2.3059	2.6840	2.8035	2.8806	1.5926	1.5048	1.2649	0.9350
SALM	3.3338	2.8697	3.2022	2.3394	2.4425	1.7901	2.3750	2.3110	2.3444	2.5149	2.4938	1.6094	1.8532	1.5427	1.3875
CANYN	3.2513	2.7243	3.4154	2.5891	3.0957	2.3824	2.9419	2.5046	3.0980	3.2755	3.4464	2.0787	1.8331	1.0840	1.0011
YEHR	3.8517	3.3979	4.2402	3.2743	3.6269	2.6896	3.4924	2.7980	3.4802	3.5797	3.9092	2.6887	2.5551	1.7740	1.7125
AUKE	3.4057	3.0265	3.1328	2.1916	3.1437	2.3293	3.2966	2.9791	3.3584	3.5655	3.7325	2.7162	2.7696	1.7644	1.7279
FOR	2.0853	1.7786	2.7588	1.8093	2.1263	1.7381	2.1549	1.7939	2.0667	2.0459	2.2230	1.4637	1.6823	1.5752	1.0411
REDT	3.4068	3.0491	2.5653	1.9236	3.2856	2.4577	3.2672	3.5806	3.3385	3.8006	3.5900	2.7212	2.9624	2.6540	2.1241
CHIL	3.1936	2.5968	3.4359	2.7758	3.2042	2.3757	2.8219	2.3342	2.8266	2.9581	3.2412	1.7752	1.5203	1.4696	1.3982
BERNR	3.1489	2.5986	3.1749	2.4325	2.8971	1.9644	2.8448	2.3719	2.7390	2.9786	3.3109	1.8468	1.6025	1.5982	1.2199
TAKU	3.2553	2.7541	3.0564	2.2333	2.9753	2.1317	2.9757	2.7369	2.9658	3.1955	3.4042	2.1448	1.9584	1.6727	1.1449
HACKT															
SALM	0.0000														
CANYN	1.6826	0.0000													
YEHR	1.5498	1.4073	0.0000												
AUKE	2.0875	1.6469	1.3169	0.0000											
FOR	1.4428	1.2933	1.7315	2.0036	0.0000										
REDT	0.8823	1.8813	1.5978	2.0036	2.0104	0.0000									
CHIL	1.8047	1.9499	2.5212	2.9700	1.5165	2.5490	0.0000								
BERNR	1.8488	1.8092	1.1503	1.4895	2.3202	1.8325	2.8959	0.0000							
TAKU	1.5898	0.7096	1.1997	1.4538	1.6651	1.6760	2.2302	1.2914	0.0000						
HACKT	1.4629	0.6830	1.1395	1.7517	1.2885	1.7674	1.8007	1.6399	0.8275	0.0000					

Appendix Table 2. Euclidean distances calculated from values of canonical variables analyzed at the mean of each of 15 samples from Asia and western Alaska used in construction of four composite standards for analysis of 1986 age 2.1 coho scales. In this example, samples closer together than two measurement units were generally grouped together. See Table 1 for names of samples.

	BOLS	KUKH	KAM	UNAC	UNAT	MMTF	EMM	RUBY	BETH	QUIN	GOOD	NUSH	TOG	NELS	ILNK
BOLS	0.0000														
KUKH	3.1910	0.0000													
KAM	3.1049	1.3748	0.0000												
UNAC	2.7318	2.1952	2.0627	0.0000											
UNAT	2.7937	2.2460	2.1395	0.5111	0.0000										
MMTF	2.7697	2.5109	2.5020	1.1775	1.4984	0.0000									
EMM	2.5210	2.4724	2.3279	0.5504	0.8411	1.0601	0.0000								
RUBY	2.1908	2.2106	2.1558	0.7849	1.0151	1.1195	0.6658	0.0000							
BETH	3.1921	2.2963	2.7078	1.4849	1.4550	1.8000	1.8402	1.7065	0.0000						
QUIN	3.2004	1.9722	2.4265	1.5113	1.3440	2.0668	1.8870	1.7248	0.7295	0.0000					
GOOD	3.1183	1.9969	2.1675	1.3800	1.2483	2.1206	1.7808	1.6489	1.0666	0.6009	0.0000				
NUSH	3.8837	2.7493	3.0038	1.8471	1.6021	2.2673	2.1601	2.2334	1.3633	1.1600	1.3671	0.0000			
TOG	3.2542	2.2263	2.4915	1.7449	1.5648	2.4247	2.0515	1.8940	1.3513	0.7975	0.5883	1.5203	0.0000		
NELS	4.2261	2.6369	2.7850	2.7845	2.4981	3.1761	3.1775	2.9740	2.2207	1.8322	1.9619	1.7929	2.0342	0.0000	
ILNK	4.1669	2.5879	2.7213	3.0682	2.7611	3.4803	3.4246	3.1515	2.6713	2.2198	2.3322	2.3821	2.3590	0.7706	0.0000

Appendix Table 3. Means and standard deviations of scale variables used in 1986 age 2.1 coho analyses, by standard grouping. All measurements are expressed in microns.

Age and Standard	N	Freshwater Size	Ocean Circuli	Ocean Size	Triplet 1	Triplet 2	Triplet 3	Triplet 4	Triplet 5	Triplet 6	Triplet 7	
<b>2.1:</b>												
Bolshaya	64	404.1 (68.1)	27.3 (3.9)	1273.5 (208.8)	106.3 (20.2)	152.4 (27.1)	168.8 (19.8)	170.5 (19.1)	162.2 (23.5)	144.6 (26.2)	123.4 (20.5)	
Kamchatka/ Kukhtui	345	449.5 (76.6)	36.8 (5.4)	1735.2 (298.1)	93.4 (17.7)	107.0 (26.8)	139.9 (28.9)	164.5 (26.7)	174.5 (24.0)	176.9 (23.8)	165.9 (25.9)	
Western Alaska	420	463.3 (74.0)	32.9 (3.6)	1571.2 (190.6)	107.6 (20.8)	137.6 (25.3)	155.1 (22.5)	167.9 (21.7)	174.0 (23.4)	179.6 (21.8)	172.6 (22.4)	
N. Peninsula	120	585.2 (101.7)	32.6 (4.1)	1689.5 (212.6)	105.4 (21.0)	132.8 (33.6)	172.2 (35.0)	195.6 (28.8)	207.2 (24.9)	200.4 (22.4)	180.9 (29.8)	
Central Alaska	837	491.8 (92.6)	33.8 (4.5)	1681.1 (245.2)	101.8 (19.9)	131.8 (32.9)	165.4 (30.9)	181.6 (25.7)	182.5 (23.7)	172.6 (23.0)	159.5 (23.3)	
S.E. Alaska/ Br. Columbia	360	490.6 (108.8)	38.2 (4.6)	1836.3 (260.4)	112.9 (24.4)	153.6 (28.6)	171.6 (25.2)	168.8 (23.8)	160.7 (23.5)	153.2 (23.5)	143.6 (21.6)	
<b>1.1:</b>												
Bolshaya	11	285.3 (43.0)	33.1 (3.3)	1488.9 (246.6)	96.1 (14.0)	103.1 (31.8)	135.3 (25.5)	174.6 (17.6)	170.1 (11.8)	167.5 (11.4)	140.0 (25.0)	
Kamchatka/ Kukhtui	66	363.5 (68.4)	38.1 (5.3)	1764.4 (315.6)	93.0 (15.3)	92.1 (14.7)	117.4 (29.1)	144.0 (31.2)	163.6 (26.4)	177.3 (20.1)	179.9 (29.2)	
Yukon/ Norton	72	344.0 (64.8)	36.6 (3.9)	1569.6 (166.8)	89.4 (13.7)	103.1 (24.3)	129.7 (25.1)	146.3 (19.4)	150.3 (17.5)	151.2 (16.7)	156.6 (18.3)	
Kuskokwim/ Bristol Bay	59	368.5 (56.3)	34.5 (3.3)	1575.4 (179.8)	98.0 (15.4)	113.9 (22.5)	133.7 (21.0)	143.4 (21.6)	159.7 (23.0)	176.0 (23.0)	178.1 (19.0)	
N. Peninsula	66	381.2 (67.8)	35.2 (4.1)	1731.7 (188.4)	99.6 (14.2)	109.7 (17.4)	128.8 (33.8)	157.3 (33.7)	183.5 (33.9)	199.7 (28.7)	198.9 (22.6)	
Central Alaska	250	356.0 (74.6)	36.0 (4.6)	1770.3 (250.5)	100.6 (17.6)	111.9 (25.5)	137.1 (31.4)	162.1 (30.9)	180.1 (24.3)	181.5 (23.6)	176.4 (25.8)	
S.E. Alaska/ N. Br. Col.	789	372.5 (73.5)	39.9 (5.1)	1854.1 (288.7)	98.1 (17.8)	121.3 (27.9)	146.0 (28.4)	155.7 (25.9)	155.0 (23.7)	152.5 (23.1)	149.9 (24.2)	
S. Br. Col.	80	427.0 (115.7)	43.8 (4.6)	1809.5 (335.2)	96.5 (16.8)	106.2 (23.9)	122.0 (28.1)	136.2 (28.2)	144.4 (28.9)	143.5 (26.7)	142.0 (21.4)	

Appendix Table 4. Means and standard deviations of scale variables used in 1987 age 2.1 coho analysis, by standard grouping. All measurements are expressed in microns.

Standard	N	Size of Freshwater	Ocean Summer Circuli	Size of Ocean Summer	Triplet 1	Triplet 2	Triplet 3	Triplet 4	Triplet 5	Triplet 6	Triplet 7
Bolshaya	160	425.8 (60.1)	24.9 (2.5)	1270.5 (158.4)	116.4 (25.3)	158.2 (28.1)	174.7 (18.9)	171.6 (22.6)	160.6 (25.0)	150.8 (25.2)	150.0 (21.0)
North Okhotsk	255	500.4 (67.7)	27.2 (2.4)	1453.7 (160.5)	104.7 (17.6)	126.3 (28.4)	161.9 (24.1)	178.9 (23.0)	187.9 (21.7)	187.5 (21.2)	179.4 (21.0)
Kamchatka	131	441.3 (92.4)	24.6 (3.5)	1109.1 (178.9)	98.7 (16.5)	114.3 (25.9)	133.9 (26.7)	147.2 (26.4)	154.6 (21.0)	155.2 (21.5)	143.3 (24.5)
Western Alaska	336	479.4 (70.2)	26.5 (2.7)	1410.5 (141.9)	112.7 (21.8)	142.5 (26.4)	160.4 (22.2)	172.2 (21.6)	181.5 (20.9)	185.3 (19.8)	175.5 (20.0)
N. Peninsula	119	608.7 (101.2)	25.4 (2.9)	1438.1 (144.3)	111.0 (24.7)	145.5 (35.6)	181.4 (35.2)	195.3 (26.7)	201.2 (23.7)	195.9 (19.7)	182.2 (22.7)
Central Alaska	378	555.4 (108.0)	26.9 (3.5)	1416.5 (165.8)	111.0 (22.9)	144.7 (31.9)	173.9 (29.3)	184.9 (23.6)	182.2 (22.6)	174.5 (21.2)	161.9 (21.1)

Appendix Table 5. Commercial catches of coho salmon (in thousands of fish) from areas for which scales were measured for analysis of 1986 and 1987 fish.<sup>1</sup>

Year	Kamchatka		Western Alaska				North		Central Alaska			S.E.		British Columbia	
	Okhotsk	West	Norton	Yukon	Kusk	BBay	Peninsula	Kodiak/SPen	Cook	Cordova	Alaska	Alaska	Columbia		
1952		654	753	11		5	54	100	234	229	1,744		2,746		
1953		1,219	753			5	26	91	228	67	1,164		2,894		
1954		1,368	909			24	35	116	337	250	1,771		2,445		
1955		1,219	690			21	6	79	180	229	1,338		2,968		
1956		505	659			63	8	120	207	197	917		3,050		
1957		803	784			69	18	90	127	107	1,218		3,137		
1958		268	596			136	57	92	242	125	955		2,990		
1959	26	762	390			17	59	28	113	192	1,024		2,897		
1960		181	401			5	44	65	314	239	721		2,030		
1961	14	627	737			5	25	42	119	196	889		3,297		
1962	21	653	624			13	40	72	358	262	1,222		3,626		
1963	21	1,466	747			16	41	83	204	340	1,275		3,421		
1964	19	76	237			29	37	51	462	352	1,588		4,148		
1965	25	490	519			12	34	70	154	168	1,548		4,443		
1966	17	130	755			23	37	89	295	190	1,227		5,412		
1967	9	369	665			54	47	22	180	247	866		3,302		
1968	<0.5	162	815			93	65	90	475	310	1,543		5,257		
1969	1	421	592			110	49	78	102	94	596		2,414		
1970	11	187	1,426			62	26	114	280	253	759		3,945		
1971	5	345	923			10	8	64	105	328	914		4,788		
1972	6	175	330			24	10	44	83	125	1,509		3,359		
1973	1	160	544			152	27	32	107	199	836		3,531		
1974	6	199	959			179	18	35	207	76	1,278		3,724		
1975	7	105	1,195			46	28	77	234	84	427		2,332		
1976		101	981			112	26	59	212	160	824		3,698		
1977		104	891			264	34	47	194	179	945		3,341		
1978	11	114	609			247	63	130	225	313	1,714		3,350		
1979	18	195	1,135			304	113	597	284	316	1,284		3,648		
1980	40	44	533			328	128	533	286	337	1,137		3,341		
1981	14	167	1,086			314	155	362	494	397	1,407		2,822		
1982		101	1,054			620	238	904	840	630	2,138		3,187		
1983		217	859			128	75	347	527	366	1,985		4,132		
1984		143	1,198			830	200	651	466	583	1,918		3,601		
1985	18	711	1,079			163	176	648	655	1,025	2,599		2,951		
1986		589	909			147	164	521	753	426	3,402		4,905		
1987		196	875			70	171	570	466	175	1,590		3,359		
1988						187	221	1,153	567	478	1,043		2,745		
1989						240	228	513	279	425	2,133				
1990						74	165	286	496	398	1,937				

Appendix Table 5. - continued.

- <sup>1</sup> Alaska and British Columbia values for 1952-1976, and U.S.S.R. values for 1952-1977 and 1978-1981 are from INPFC (1979).  
Alaska and British Columbia values for 1977-1986 are from INPFC Statistical Yearbooks.  
Alaska values for 1987-1989 are from ADF&G Regional Information Reports No. 5J88-1, 5J89-01, and 5J90-03.  
Alaska values for 1990 are from preliminary ADF&G statistics presented to the U.S. National Section of INPFC, September 1990.  
British Columbia values for 1987-1988 are from CDFO Annual Summary of British Columbia commercial catch statistics 1988.  
U.S.S.R. values for 1976-1977 and 1982-1987 are from Kazamovskii (1989).  
U.S.S.R. values for 1978-1981 are from Harris (1989).  
U.S.S.R. values for 1952-1961, 1976-1977, and 1982-1987 were obtained by converting catches reported in weight to numbers by applying mean fish weights calculated from the 1962-1975 and 1978-1981 statistics.