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SCALE PATTERN ESTIMATES OF ORIGIN OF COHO SALMON TAKEN IN THE JAPANESE TRADITIONAL LANDBASED DRIFTNET SALMON FISHERY IN 1990

by

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ABSTRACT

Collection of salmon scales by the Fisheries Agency of Japan from the catch of the Japanese traditional landbased driftnet fishery in 1990 provided the first opportunity to estimate origins of fish directly from the catch. The continent of origin of coho salmon caught in the fishery was determined by scale pattern analysis. Four standard groupings were constructed: Bolshaya R. (western Kamchatka Peninsula); Kamchatka R. (eastern Kamchatka); northern western Alaska (Norton Sound to central Bristol Bay); and southern western Alaska (southern Bristol Bay and north coast of the Alaska Peninsula). 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 1990 western Alaska fish appeared to predominate in the fishery. Estimates of age 2.1 North American fish in the fishery were 66% overall. The estimates obtained were higher than those of most previous scale pattern studies, and 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 yielded a provisional catch estimate of 127,000 North American-origin coho in the landbased fishery in 1990, 66% of the total catch of 193,500.

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. This agreement led to 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. The objective of this study is to provide information of use to the Commission from scale pattern analysis estimates of stock origins of coho salmon caught on the high seas in 1990. This study was made possible by the opportunity to examine the first scales ever collected directly from landings of the traditional landbased driftnet salmon fishery.

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 four studies by the Fisheries Research Institute (FRI) at the University of Washington (Myers et al. 1981, Walker and Harris 1982, Walker and Davis 1983, Walker 1990) 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. The studies usually have also 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

Methodology and standard samples employed in this analysis are identical to those in Walker (1991). For further details on methods and samples, see that study.

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). The Fisheries Agency of Japan provided impressions of scales sampled from traditional landbased fishery landings at Hanasaki and Kushiro ports (FAJ 1990). Both FAJ and the U.S.S.R.'s Pacific Research Institute of Fisheries and Oceanography (TINRO) provided FRI with impressions of scales from the Kamchatka and Bolshaya Rivers.

Age Determination

Ages were determined by the number of checks that were considered annuli. Age designation was by the European method (Koo 1962). Age determination of standard samples was made as scales were measured, in part guided by ages determined by the agency that provided the scales. Scales from the port samples were aged earlier, as part of a separate study (Myers and Campbell 1991).

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 (Myers and Campbell 1991). This is a similar circumstance to that encountered in earlier analyses of coho scales (Myers et al. 1981, Walker 1990). 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.

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. 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. 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

For most western Alaska stocks 60 scales of age 2.1 fish were measured. (For names and sizes of individual Alaskan stocks, see Walker 1991.) As many age 2.1 scales as possible were measured from both Asian stocks (Bolshaya: n=84; Kamchatka: n=141). All measurable scales of age 2.1 fish from port sampling at Hanasaki (n=192) and Kushiro (n=119) were measured. Sample sizes from both ports are above the level recommended by the INPFC Sub-Committee on Salmon (n=100). As no information is available on date or location of the fishery samples, no stratification by area or time is possible.

SCALE CHARACTERS

Measurement data were reformatted to 20 variables for each scale. Individual circulus measurements were grouped in threes (triplets). All reformatted measurements were expressed in microns. Of the 20 variables, ten were used in the analysis: distance along the measurement axis of the freshwater zone through the end of the last freshwater annulus, distance and circulus count of the first ocean summer, and the first through the seventh triplets. Basic statistics for all variables were calculated for each stock; outliers were identified and those greater than four standard deviations from the mean were removed.

CONSTRUCTION OF STANDARDS

Groupings of stocks to form standards were determined by a method based on similarity as indicated by canonical variable values from linear discriminant function analysis. This method has been described elsewhere (Walker 1990, 1991). Four natural groupings were apparent: Bolshaya River, Kamchatka River, northern Western Alaska (from Norton Sound to central Bristol Bay) stocks, and southern Western Alaska (southern Bristol Bay and north coast of Alaska Peninsula) stocks. Means and standard deviations for variables used in this analysis for each standard grouping are presented in Table 1.

TEST OF THE MODEL

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 matrix from the linear discriminant function analysis program, 7M, of BMDP (Dixon 1988) is presented (Table 2) as a crude indicator of the probable general accuracy of the maximum likelihood model, and to indicate directions of misclassification among the standards. The overall unweighted accuracy of the four standard model was 78.1%. When misclassifications within continental groups are taken into account, overall North American accuracy was 91.3% and overall Asian accuracy was 85.3%.

CALCULATION OF MIXING PROPORTIONS OF FISHERY SAMPLES

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, 1990) using a FORTRAN program written by R. Millar (Millar 1988). Ten variables were used in the analysis; there was no selection of variables, following Davis's (1987) finding that inclusion of nondiscriminating variables had only a slight effect on classification accuracy. Estimates were made for each port separately and for the two ports combined. Confidence intervals were derived from two methods based on a bootstrap run (500 iterations) of the same program. One method simply took from the 500 iterations values which bracketed 95% of the estimates. This method would avoid any problems of asymmetrical distributions of values near the boundary conditions (0% and 100%). The other method used variance estimates derived from the bootstrap run. Confidence intervals (95%) were calculated as the estimate plus or minus 1.96 times the standard deviation. Results of the two methods were nearly all within 2% of each other.

INTERCEPTION ESTIMATES

Catch estimates were calculated by applying proportions estimated for the two Asian and the two North American standards in the combined port samples to the total reported catches of the traditional landbased fishery in 1990. Although the two port samples were of different size, no weighting factor was used in combining the samples. All vessels were sampled in each port, and the 81 vessels sampled represented 70% of the entire fleet (FAJ 1990). It was felt the combined sample was most representative of the fishery as a whole. Estimated proportions for the two standards in each continental grouping were pooled. Pooled variances were also calculated, and were used to calculate 95% confidence intervals for the catch estimates.

RESULTS

MIXING PROPORTION ESTIMATES OF FISHERY SAMPLES

Maximum likelihood estimates of the proportion of fish from stocks of each of the four standards are presented in Table 3. Estimates from the two port samples are generally similar, with Alaskan coho predominating. Kushiro estimates show a higher proportion of Asian (mainly Kamchatkan) fish and a lower porportion of Alaskan (especially southern western Alaskan) fish. The combined port samples indicate approximately two-thirds of the fish in the traditional landbased fishery in 1990 were of Alaskan (primarily northern western Alaskan) origin. Between Asian stocks, fish from the Kamchatka River were more abundant than fish from the Bolshaya.

INTERCEPTION ESTIMATES

Provisional estimates of catches and 95% confidence intervals of age 2.1 North American- and Asian-origin coho salmon in the landbased fishery in 1990 are presented in Table 4. Catches of North American age 2.1 fish total 96,724, or 66% of the 147,445 age 2.1 fish. An estimate for the entire landbased fishery catch can be calculated by assuming that age 1.1 and 3.1 fish are from the same stocks in the same proportions as the age 2.1 fish. The total catch of North American coho by the landbased fishery in 1990 would then be 126,935, or 66% of the total coho catch of 193,498 (Table 5).

DISCUSSION

Estimates of proportions of Alaskan coho in the landbased fishery catch in this study are in general higher than those in earlier work. Most previous studies indicated that U.S.S.R. streams were the predominant producers of fish caught in the landbased fishery area, although North American fish were present in low to moderate numbers. FRI researchers (Myers et al. 1981, Walker and Harris 1982, Walker and Davis 1983) did find increasing proportions of North American coho in the landbased fishery area from 1979 (about 40%) to 1980 (60%) to 1981 (over 90%), but North American proportions rose as the perceived quality of Kamchatka R. samples declined between years. FAJ researchers (Kato and Ishida 1985,1986,1988,1989) generally found lower porportions of North American fish, with estimates in the range of 15 to 30%. Walker (1990) also obtained estimates in this range.

There are several possible reasons for the discrepancy with previous studies. Previous studies used samples collected by Japanese research vessels to represent the fishery catch. The research vessels operated in a systematic grid throughout the traditional landbased fishery area, and their sampling may not have been representative of the actual areas where commercial vessels fished for coho. The fishery vessels in the port sampling program may have been fishing in areas of concentration of North American fish or fishing outside of the traditional landbased fishery area. In 1990 the abundance of North American coho may have been higher than that of Asian coho, or relative distribution of coho from the two continents may have shifted. The scale patterns of western Alaska fish in 1990 may have resembled those of some Asian stocks, such as North Okhotsk coast stocks, which were not in the model. The scales from Kamchatka River fish may not have been collected from the preferred body area and were of slightly poorer quality than other standards. Although North American estimates in the present analysis may seem high, the estimates confirm indications of prior studies that Alaskan fish are probably present in significant numbers in the fishery.

FAJ scientists have criticized the results of all previous 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. After 35 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 origin of coho in the traditional landbased fishery. 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. The difficulties of using tag return data to estimate coho origins were more thoroughly discussed in Walker (1990).

Because estimates of proportions of North American fish in the catch are higher than in an earlier study (Walker 1990), the estimate of catch of North American coho in 1990 is higher than previous estimates of catch (Table 6). Provisional interception estimates based on the proportions from the 1990 age 2.1 model are not insignificant. Expansion of the age 2.1 proportions to all ages yields a total North American interception estimate of 127,000 fish, one-sixth (16%) as large as the combined western Alaska commercial catch of 777,000 (Geiger and Savikko 1991).

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Table 1. Means and standard deviations of scale variables used in 1990 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	84	376.4 (58.5)	24.1 (2.7)	1105.2 (172.2)	110.5 (18.4)	140.5 (24.8)	161.2 (19.1)	161.1 (26.6)	138.9 (28.7)	124.8 (21.5)	129.4 (19.2)
Kamchatka	141	497.3 (92.9)	26.7 (5.1)	1182.1 (264.9)	96.0 (19.4)	109.5 (25.2)	132.0 (23.9)	146.1 (23.1)	150.0 (23.3)	149.6 (23.6)	141.8 (23.7)
N. Western Alaska	390	497.8 (82.5)	26.9 (2.6)	1396.6 (136.1)	111.6 (21.3)	138.4 (26.5)	161.2 (23.3)	170.9 (21.2)	176.4 (22.0)	177.3 (19.4)	171.8 (19.5)
S. Western Alaska	300	605.2 (104.1)	26.3 (2.6)	1424.0 (126.1)	105.6 (17.9)	124.7 (30.0)	157.7 (33.0)	181.2 (29.3)	192.0 (26.8)	191.8 (22.6)	186.9 (19.5)

Table 2. Jackknifed classification matrix for coho model from BMDP 7M. Information provided as crude index of accuracy of the maximum likelihood model and is not intended to represent the true accuracy of the model.

Overall accuracy: 78.1%

		Calculated Decision			
Correct Decision	N	Bolshaya	Kamchatka	N. Western Alaska	S. Western Alaska
Bolshaya	84	75 (89.3)	2	7	0
Kamchatka	141	11	104 (73.8)	12	14
N. Western Alaska	390	11	34	286 (73.3)	59
S. Western Alaska	300	0	15	57	228 (76.0)

Table 3. Provisional maximum likelihood mixing proportion estimates for 1990 age 2.1 coho. Estimates utilize Millar's (1988) method with confidence intervals derived from bootstrapping (500 runs; method B) and calculated from standard deviations derived from bootstrapping (500 runs) times a Z-statistic of 1.96 (method Z).

		Bolshaya		Kamchatka		N. Western Alaska		S. Western Alaska		
Port	N	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Method
Hanasaki	192	.016	(0 -.044)	.243	(.142-.350)	.539	(.376-.680)	.202	(.106-.316)	B
			(0 -.040)		(.140-.346)		(.394-.684)		(.093-.310)	Z
Kushiro	119	.098	(.000-.212)	.387	(.237-.516)	.507	(.363-.647)	.008	(0 -.097)	B
			(0 -.203)		(.242-.532)		(.367-.647)		(0 -.063)	Z
All	311	.037	(.002-.088)	.307	(.205-.399)	.527	(.410-.634)	.129	(.055-.223)	B
			(0 -.079)		(.211-.404)		(.410-.645)		(.046-.212)	Z

Table 4. Provisional estimated catch of age 2.1 coho of Asian and western Alaska origin in the landbased driftnet fishery areas in 1990. Confidence intervals calculated using pooled variances from bootstrap-derived individual variances for two Asian (Bolshaya and Kamchatka) and two Alaskan standard groupings (northern and southern western Alaska).

Total	Age 2.1		Asian origin 2.1			Western Alaska origin 2.1		
Catch	Prop.	Catch	Prop.	Catch	95% CI	Prop.	Catch	95% CI
193,498	.762	147,445	.344	50,721	(37,543-63,899)	.656	96,724	(83,559-109,889)

Table 5. Provisional estimated catch of coho of western Alaska origin in the landbased driftnet fishery in 1990. Estimates made by extending estimated proportions of western Alaska age 2.1 fish to all ages.

		Western Alaska origin	
	Catch	Prop.	Catch
Total	193,498	.656	126,935

Table 6. Provisional estimates of catch of coho of western Alaska origin in the landbased driftnet fishery for 1986-89 from Walker (1990). Estimates made by extending estimated proportions of western Alaska age 2.1 fish in various strata in 1986 to all ages and strata in 1986 and succeeding years.

Year	Total Catch	Estimated catch of Western Alaska origin
1986	477,583	87,014
1987	459,151	84,277
1988	292,628	62,843
1989	207,979	49,581