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ESTIMATES OF ORIGIN OF COHO SALMON CAUGHT IN ASIAN HIGH SEAS SQUID DRIFTNET FISHERIES IN 1991 AND IN AN ILLEGAL TAIWANESE SALMON DRIFTNET CATCH IN 1989

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ESTIMATES OF ORIGIN OF COHO SALMON CAUGHT IN ASIAN HIGH SEAS SQUID DRIFTNET FISHERIES IN 1991 AND IN AN ILLEGAL TAIWANESE SALMON DRIFTNET CATCH IN 1989

ABSTRACT

The continent of origin of coho salmon caught in Asian high seas squid driftnet fisheries in 1991 and in an illegal Taiwanese salmon driftnet fishery in 1989 was estimated by scale pattern analysis. The samples were compared to models composed of Kamchatka River and western Alaskan coho scales from 1991, and Russian and western Alaskan coho scales from 1980, 1986, 1990, and combinations of these three years. The Asian standard (Kamchatka River only, n=39) from 1991 was not adequate for the analysis. The pooled 1980-1986-1990 models were not accurate, but the 1980 and 1990 models performed reasonably well when tested with samples from 1981, 1987, and 1991. These two models and the 1991 model all estimated western Alaska contributed about 70 to 80% of the 1991 coho bycatch of the Asian squid driftnet fisheries . All three models estimated that western Alaskan coho made up the great bulk (67 to 95%) of the illegal Taiwanese catch seized in 1989. More work remains to be done in testing historical baseline models for classifying coho fishery mixtures by scale pattern analysis.

INTRODUCTION

Although high seas driftnet fisheries are scheduled to cease at the end of 1992, it is of interest to know the origin of salmon taken in these fisheries, not only to determine the impacts of the fisheries on Asian and North American salmon stocks, but also to ascertain the distribution of stocks from various regions, the effect that oceanographic conditions in specific ocean areas may have on stocks in those areas, and the overlap and potential competition between stocks of different regions. This study is an attempt to estimate regions of origin, using scale pattern analysis, of coho salmon from two driftnet fishery samples, Asian squid driftnet fisheries in 1991 and an illegal Taiwanese salmon driftnet catch in 1989.

Because no baseline reference scales, or standards, had been measured from 1989 and because there were very few Asian coho scales available from 1991, a preliminary exploration was also made of using standard samples from other years and from pooling standards from other years to classify these 1989 and 1991 fishery samples. Canadian scientists have classified chum salmon scales using baseline data from non-brood years (Bilton and McKinnell 1990a,1990b; McKinnell 1990,1991), and a U.S. scientist has used this approach for chinook salmon scales (Davis 1991).

METHODS

SCALE SAMPLES

All scale samples were measured in the form of acetate impressions. Impressions from Alaskan stocks were provided by the Alaska Department of Fish and Game (ADF&G). Scale impressions from the Kamchatka River were provided by the Fisheries Agency of Japan (FAJ). Japanese, Korean, and Taiwanese high seas squid driftnet fisheries were sampled by Canadian, Japanese, Korean, Taiwanese, and U.S. observers (Int. N. Pac. Fish. Comm. 1992). Samples from U.S. squid fishery observers were provided by the U.S. observer program and were processed at the Fisheries Research Institute (FRI), School of Fisheries, University of Washington. Acetate impressions of Canadian and Asian squid fishery observer samples were provided to FRI by the U.S. National Marine Fisheries Service (NMFS). Samples from the illegal Taiwanese catch were taken from the salmon catch of the Sung Ching No. 1 (total salmon catch 137.6 tons) and the Ta Feng No.

11 (19.3 tons) in Kaohsiung, Taiwan, by a team of NMFS and FRI scientists in September, 1989 (Waples et al. 1989). The samples were processed at FRI.

The great majority (approximately 80%) of both samples of coho salmon were age 2.1 fish (Table 1), so only this age class was analyzed. This age class is also predominant in Asian and western Alaskan coho stocks. It is much less common from southeastern Alaska southward.

For samples from the six Alaskan rivers used in the 1991 standards, up to 60 scales of age 2.1 fish were measured (Table 2). For the Kamchatka River, the only Asian stock for which 1991 samples were available, as many usable age 2.1 scales as possible (n=39) were measured. Many scales in the Kamchatka sample (total number of age 2.1 scales: 65) subjectively appeared to be from body areas other than the International North Pacific Fisheries Commission (INPFC) preferred area; these scales were not used. All samples came from commercial or test fisheries near river mouths.

All usable scales of age 2.1 fish (n=251) from squid fishery observer samples were measured. Samples were collected from June through September, with the majority collected in July (197). The area where usable age 2.1 coho scales were collected was from 169°E to 157°W, and from 38°N to 46°N, with the majority (194) collected between 170°E and 180° and between 38°N and 42°N (Fig. 1).

All usable scales of age 2.1 fish (n=378) from the illegal catch samples were measured. Precise information on the locations and dates of the Taiwanese catches is not available, but the captain of the Sung Ching No. 1 claimed that he was fishing in the following areas, starting 29 June 1989: within 25 nm of 161°22'E, 39°22'N; within 10 nm of 162°10'E, 39°10'N; within 10 nm of 162°12'E, 39°32'N; and within 20 nm of 163°20'E, 39°23'N (unclassified, unpublished U.S. Coast Guard boarding report 1989). The vessels were encountered at 171°E, 39°N on 18 July 1989.

Information on sources and samples in the standard samples from 1980, 1986, and 1990 used in the non-brood year standards analyses (see below) can be found in Walker and Harris (1982) and Walker (1990, 1991a). Information on sources and stocks in the samples from 1981 and 1987 used to test the non-brood year standards analyses (see below) can be found in Walker and Davis (1983) and Walker (1990).

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 that connected the posterior ends of the ocean annulus, and measurements were made on an axis 90° to this line. Distances were measured from the focus of the scale to the outer edge of the last freshwater annulus and to the outer edge of each circulus thereafter, including circuli of freshwater plus growth, to the outer edge of the ocean annulus. A marker was placed at the beginning of the ocean annulus to separate summer and winter growth of the first ocean year. Measurements from 1980 and 1981 samples were collected on a microcomputer-based digitizing system. Data from this system and the OPRS are compatible (Walker 1987).

Measurements from OPRS data were reformatted to 20 variables, where measurements were expressed in microns. 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 (Table 3). Distance along the measurement axis of the freshwater zone through the end of the last freshwater annulus and of the first ocean summer growth were also used, as was the circulus count of the first ocean summer. For 1986 and pooled-year analyses, distance and circulus count through the end of the first ocean year were used instead of first ocean summer variables. Basic statistics for these ten variables were calculated for each stock; outliers were identified, and those greater than four standard deviations from the mean were removed.

CONSTRUCTION OF 1991 STANDARDS

Groupings based on similarity of scale patterns were used in forming standard samples composed of several stocks, in accordance with recommendations from the INPFC Scale Pattern Workshop (Int. N. Pac. Fish. Comm. 1987) . Relative distances between the seven stocks measured for 1991 standards were calculated from values of canonical variables evaluated at group means. The canonical variable values were taken from output of the linear disriminant function analysis (LDA) program of BMDP (Dixon 1988). When all individual stocks were considered together, the values of canonical variables from Kamchatka River scales were distinctive from other stocks (Table 4). Values of four western Alaskan stocks from Norton Sound, Yukon and Kuskokwim rivers, and Bristol Bay formed a cluster, and two stocks from the northern coast of the Alaska Peninsula formed another cluster. These three groupings (Kamchatka R., northern western Alaska, and North Peninsula) were used as standards in the analysis. Means and standard deviations for variables used in this analysis for each standard grouping are presented in Table 5. Coho stocks from south central Alaska to California were not included in the analysis, as they were considered less likely to be in the areas of the fisheries samples.

CONSTRUCTION OF NON-BROOD YEAR STANDARDS

Because there were only 39 scales available to represent age 2.1 Asian coho in the 1991 standards, the fishery samples were also classified by standard samples from previous years: 1980, 1986, and 1990, and two sets of standards composed of these three years combined. These years were chosen because coverage of the range of coho in Asia and western Alaska was relatively good, scales were of good or acceptable quality, and data could be made compatible with that collected from 1991 samples. Similarities of individual stocks for each year and for pooled years were evaluated in the manner described above, and clusters similar to those in the 1991 model emerged. Groupings used include the Kamchatka River, Bolshaya River (western Kamchatka Peninsula), northern western Alaska (from Naknek River in Bristol Bay northward) and southern western Alaska (from Egegik River in southern Bristol Bay southwestward along the Alaska Peninsula). In 1986 scales from the Kukhtui River, a northern Okhotsk Sea stock, were available and clustered with Kamchatka River. When the three years were pooled, the 1986 Kukhtui sample was kept as a separate standard in a five-standard model, but because of its confusion with Alaskan stocks and because it represents an area of low production of coho, it was dropped from a four-standard pooled model of the same years and stocks. The 1980 standards include no scales from southern western Alaska, and neither 1980 nor 1990 includes samples from the northern Okhotsk coast.

TESTS OF THE MODELS

There are no standard methods for estimating the accuracy of the maximum likelihood model. However, the maximum likelihood estimator uses the same likelihood values that are used by classification models. Jackknifed classification matrices from BMDP 7M LDA models for 1991 and non-brood year models are presented as crude indicators 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 three standard 1991 model was 85.8%. The accuracies of the non-brood year models ranged from 65.5 to 91.2% (Table 6).

The non-brood year models were also tested by known-origin samples from 1981, 1987, and 1991. Information on the 1981 and 1987 samples can be found in Walker and Davis (1983) and Walker (1990); compositions of the test samples are given in Table 7. The 1991 samples are those used in 1991 standards in this report.

When all correct allocations (allocated to the same stock region, or to a neighboring stock region when the tested stock was not in the model) were averaged, the 1980 and 1990 models had the best performances (75.0 and 75.3%), followed by the 1986 model (62.3%)

(Table 8a,b,c). These are slightly lower than the jackknifed accuracies estimated by LDA for same-brood year scales. The pooled-year models were least accurate (46.1 and 46.6%, substantially lower than the LDA jackknifed estimates for same-brood year scales).

In the two best models, 1980 and 1990, the majority (60.8 to 100%) of the Bolshaya, Kamchatka, northern western Alaska and southern western Alaska samples from all three test years were correctly allocated (Table 8a,b,c). Both models incorrectly placed most of the 1987 northern Okhotsk scales in northern western Alaska. The other three models were in general less successful, particularly with Bolshaya and Kamchatka scales.

CALCULATION OF MIXING PROPORTION OF UNKNOWNS

The two fisheries samples were allocated by the 1991 standards and by the 1980 and 1990 non-brood year models. As time-area strata from the 1991 squid fishery sample were smaller than the recommended level of 100 (Int. N. Pac. Fish. Comm. 1987), all fish were pooled and treated as a single mixture of 251. There were no precise date and location data associated with the 1989 Taiwanese samples, and those samples were also pooled in a single mixture of 378. Estimates of proportions of fish from each of the standard groupings present in the fisheries samples (unknowns) were obtained by a maximum likelihood method (Millar 1987, 1990) using a FORTRAN program written by Millar (1988). Ten variables were used; there was no selection of variables, following Davis (1987), who found that inclusion of nondiscriminating variables had only a slight effect on classification accuracy. Confidence intervals were derived from ranked results of bootstrap runs (500 iterations) of the same program.

Because the 1991 Asian standard was inadequate and because of uncertainty over the use of non-brood year models, no estimates were made of interceptions by the 1991 Asian squid driftnet fisheries.

RESULTS

The 1991 Asian squid driftnet fisheries samples were allocated primarily (73.1%) to northern western Alaska and secondarily to the Kamchatka River (18.8%) by the 1991 standards (Table 9). Very similar allocations were obtained from the 1980 and 1990 standards, the non-brood year models which performed the best. Southern western Alaska (8.1 and 4.9%) and the Bolshaya River (5.5 and 4.0 %) were estimated to be minor contributors (Table 9).

The samples from the illegal Taiwanese salmon catch in 1989 were estimated by all models to be overwhelmingly of western Alaskan origin. The 1991 model allocated 94.8% to western Alaska, evenly split between the northern and southern stock groups (Table 9). The 1980 and 1990 standards estimated the northern western Alaskan contribution to be 66.7% and 88.0%, respectively. The estimates of contribution of Kamchatka River coho ranged from 0.8 to 9.7%, and those of Bolshaya River were 23.6 and 7.3% in the 1980 and 1990 models (Table 9).

DISCUSSION

The small sample size of the Kamchatka River standard, the poor quality of some of the other scales from that sample, and the lack of samples from other Asian stocks of coho all cause some reservations in confidence in the estimates from the model using 1991 standards. This is just the most recent illustration of a continuing problem of obtaining good-quality, widely representative scale samples of coho stocks in the Russian Far East. The problem is partially due to the life history of coho, which return to spawn when weather is deteriorating, many fisheries may have closed, and most researchers experienced in collection of scales have left the field.

One way to circumvent this problem would be if historical scale baseline data (meaurements collected from scales of other spawning years) could be used in classifying fishery mixtures from any given year. In this study, the samples from 1980 and 1990 seem to offer some reliability in correctly allocating scales from other years for most of the regions tested. The 1986 model seemed less accurate, and the pooled 1980-1986-1990 models had poor accuracies.

The estimates for the 1991 Asian squid driftnet fishery catch are generally in line with a previous estimate of 74% western Alaskan origin of coho in the 1990 bycatch of that fishery (Walker 1991a). These estimates are higher than most previous Japanese and U.S. estimates of Alaskan fish in the coho catch of the Japanese traditional landbased salmon driftnet fishery, but that fishery operates farther to the west. Other factors that may contribute to differences in estimates from the two fisheries were also discussed in an earlier document (Walker 1991a). While the nature of the standard samples used does not allow complete confidence in a single point estimate, the indication is that a large percentage of the coho in the squid fishery bycatch may be of Alaskan origin, but Asian fish are also present as a substantial fraction. These results are congruent with a similar study of chum salmon in the 1990 bycatch, where Alaskan chum and Russian chum were the major contributors in allocations estimated from several historical baselines (McKinnell 1991).

The predominance of Alaskan fish in the estimates from the seized 1989 Taiwanese catch is more puzzling in light of the purported fishing area. It seems unlikely that Alaskan coho would strongly predominate at 162°E, 39°N, where the master of one of the vessels claimed he was fishing, or even at 171°E, 39°N, where the U.S. Coast Guard encountered the vessels. However, it also seems unlikely that a vessel could catch 137 tons of salmon fishing at 39°N in July. Catches per tan by research vessels fishing at 39°N have been zero for all species of salmon in June and July, except for a CPUE of 0.0103 for coho in June west of 170°W (Walker 1991b). Observed salmon CPUE values on squid driftnet vessels fishing at 39°N were also very low in 1989 (0 salmon per tan), 1990 (0 to 0.096), and 1991 (0 to 0.090; Int. N. Pac. Fish. Comm. 1990, 1991, 1992). It seems probable that the area fished was misrepresented by the captain.

An analysis of scale patterns of chum salmon from the same Taiwanese vessels, using historical baseline data, found Russian fish to be the major contributors to the catch, followed by Japanese chum (Bilton and McKinnell 1990a). The discrepancies between the chum and coho estimates, and between the coho estimates and purported fishing location, cannot easily be resolved and indicate either that the vessels may have been fishing at other locations where Alaskan coho would be more abundant, or that the other-year models may not be appropriate for analysis of this catch.

Although use of historical baseline data appears to be of some use in analyzing fishery mixtures from other years, more work needs to be done to discover the limitations of its applicability.

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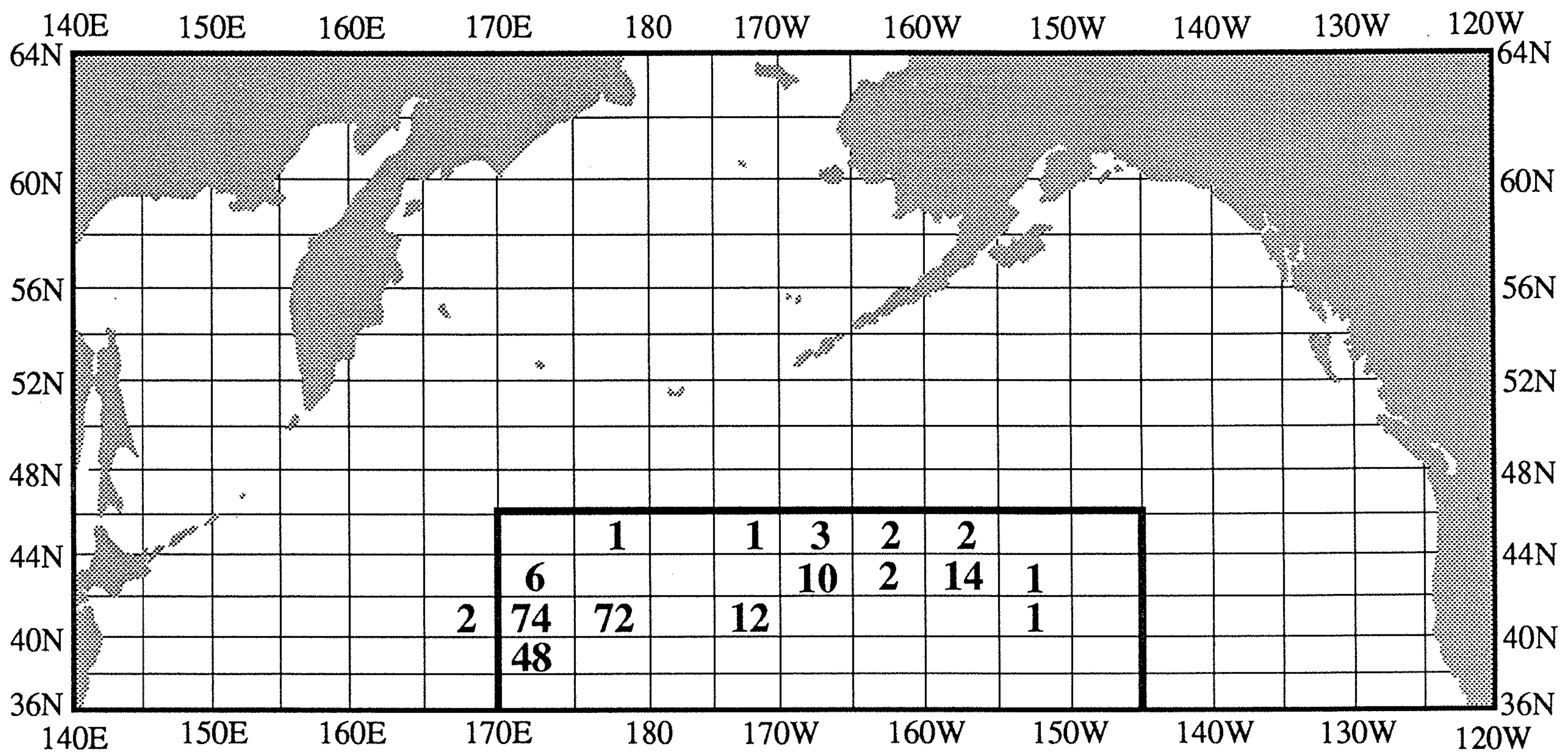

Figure 1. Location of collection and numbers of usable age 2.1 coho scale samples collected by observers on vessels of the Japanese, Korean, and Taiwanese high seas squid driftnet fisheries in 1991. Heavy line indicates boundary of Japanese squid fishery area in September.

Table 1. Estimated age compositions of coho from 1991 Asian squid fishery observer samples and from a scientific sample of a seized 1989 Taiwanese catch .

Fishery	N	Age 2.0	1.1	2.1	3.1
1991 squid fishery	314	1 (.003)	40 (.127)	258 (.822)	15 (.048)
1989 Taiwanese catch	489		97 (.198)	387 (.792)	5 (.010)

Table 2. Sample sources and number of scales used in standard samples in 1991, 1980, 1986, and 1990 models.

Region	Stock or Sample	Return Year 1991	1980	1986	1990
North Okhotsk	Kukhtui R.			161	
Western Kamchatka	Bolshaya R.		100	64	84
Eastern Kamchatka	Kamchatka R.	39	100	184	141
N. Western Alaska	Unalakleet				
	comml. fishery	60	8	31	60
	test fishery			29	
	Yukon:				
	Middlemouth			12	30
	Emmonak	59	2	19	30
	Ruby			29	
	Big Eddy				30
	Kuskokwim	60	73	60	60
	Quinhagak		18	60	
	Goodnews		14	60	
	Bristol Bay:				
	Nushagak	60	50	60	60
	Togiak		35	60	60
	Naknek/Kvichak				60
S. Western Alaska	Bristol Bay:				
	Egegik				60
	Ugashik				60
	N. Peninsula:				
	Nelson Lagoon	60		60	60
	Ilnik Lagoon			60	60
	Bear R.	60			60
Total		398	400	949	915

Table 3. Scale characters used in analyses of age 2.1 coho from 1991 Asian squid driftnet fisheries and 1989 illegal Taiwanese coho catch. All distances measured along an axis 90° to a reference line connecting the posterior ends of the ocean annulus.

Name of Scale Character	Description
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
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
Ocean summer circulus count	Number of circuli in the first summer of ocean growth; may include circuli of freshwater plus-growth
First 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
First ocean circulus count	Number of circuli in the first year of ocean growth; may include circuli of freshwater plus-growth
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
Triplet 2	Distance from the third to the sixth circulus in the first year of ocean growth
Triplet 3	Distance from the sixth to the ninth circulus in the first year of ocean growth
Triplet 4	Distance from the ninth to the twelfth circulus in the first year of ocean growth
Triplet 5	Distance from the twelfth to the fifteenth circulus in the first year of ocean growth
Triplet 6	Distance from the fifteenth to the eighteenth circulus in the first year of ocean growth
Triplet 7	Distance from the eighteenth to the twenty-first circulus in the first year of ocean growth

Table 4. Euclidean distances calculated from values of canonical variables analyzed at the mean of each of seven samples from Kamchatka River and western Alaska used in construction of three composite standards of 1991 age 2.1 coho scales. Samples as close together as approximately two sampling units or less were generally grouped together.

Stock	Kamchatka	Unalakleet	Yukon	Kuskokwim	Nushagak	Nelson L.	Bear R.
Kamchatka	0.0000						
Unalakleet	3.7049	0.0000					
Yukon	3.4795	0.5574	0.0000				
Kuskokwim	2.7328	2.0891	2.0728	0.0000			
Nushagak	3.3724	1.2604	1.3216	1.2769	0.0000		
Nelson L.	3.4354	3.4048	3.4869	2.0614	2.7117	0.0000	
Bear R.	3.5631	3.4272	3.5142	1.7639	2.6811	1.0783	0.0000

Table 5. Means and standard deviations of scale variables used in 1991 age 2.1 coho model, by standard grouping. All measurements are 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
Kamchatka	39	464.5 (83.2)	23.9 (3.0)	1030.8 (140.1)	89.9 (16.9)	99.5 (16.3)	122.8 (15.5)	139.5 (19.3)	151.6 (19.3)	156.6 (22.1)	143.5 (25.1)
N. Western Alaska	239	463.0 (66.5)	28.6 (2.7)	1395.4 (132.2)	107.3 (21.1)	127.1 (24.1)	147.8 (22.4)	160.3 (18.6)	161.8 (19.8)	161.9 (20.3)	161.0 (22.6)
North Peninsula	120	568.2 (124.2)	26.3 (2.9)	1438.8 (162.8)	101.3 (21.0)	121.5 (35.4)	155.1 (35.7)	184.8 (30.2)	198.5 (23.3)	195.4 (19.1)	187.5 (25.3)

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

a) 1991 model
Overall accuracy: 85.8%

Correct Decision	N	Calculated Decision: Kamchatka	Western Alaska	North Peninsula
Kamchatka	39	35 (89.7)	3	1
N. Western Alaska	239	14	198 (82.8)	27
North Peninsula	120	7	11	102 (85.0)

b) 1980 model
Overall accuracy: 91.2%

Correct Decision	N	Calculated Decision: Bolshaya	Kamchatka	N Western Alaska
Bolshaya	100	90 (90.0)	6	4
Kamchatka	100	8	88 (88.0)	4
N. Western Alaska	200	2	7	191 (95.5)

c) 1986 model
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)

d) 1990 model
Overall accuracy: 78.1%

Correct Decision	N	Calculated Decision: 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 6. (cont.)

e) 1980-1986-1990 5-standard pooled-year model
Overall accuracy: 65.5%

Correct Decision	N	Calculated Decision: Bolshaya	Kukhtui	Kamchatka	N. Western Alaska	S. Western Alaska
Bolshaya	248	218 (87.9)	7	5	17	1
Kukhtui	161	15	91 (56.5)	25	19	11
Kamchatka	425	43	65	244 (57.4)	28	45
N. Western Alaska	1,010	38	195	103	563 (55.7)	111
S. Western Alaska	420	2	27	32	64	295 (70.2)

f) 1980-1986-1990 4-standard pooled-year model
Overall accuracy: 74.1%

Correct Decision	N	Calculated Decision: Bolshaya	Kamchatka	N. Western Alaska	S. Western Alaska
Bolshaya	248	223 (89.9)	7	17	1
Kamchatka	425	44	266(62.6)	64	51
N. Western Alaska	1.010	40	138	712 (70.5)	120
S. Western Alaska	420	4	34	74	308 (73.3)

Table 7. Sample sources and number of scales used in tests of different models.

Region	Stock or Sample	Return Year 1981	1987	1991
North Okhotsk	Kukhtui R.		120	
	Taui R.		135	
Western Kamchatka	Bolshaya R.	64	160	
Eastern Kamchatka	Kamchatka R.	59	131	39
N. Western Alaska	Unalakleet			
	comml. fishery	9	40	60
	test fishery		40	
	Yukon:			
	Middlemouth		40	
	Emmonak	16		59
	Big Eddy		40	
	Kuskokwim	64	40	60
	Quinhagak	10	40	
	Goodnews	4	40	
	Bristol Bay:			
	Nushagak	73	56	60
S. Western Alaska	N. Peninsula:			
	Nelson Lagoon	21	60	60
	Ilnik Lagoon		60	
	Bear R.			60
Total		320	1,002	398

Table 8. Tests of 1980, 1986, 1990, and pooled 5- and 4-standard models of age 2.1 coho using known-origin scales. See Table 2 for composition of model standards. The Kamchatka standard in the 1986 model also includes Kukhtui samples.

a. Allocation percentages from 1981 known-origin scales.

		Standards				
1981 Groups	Models	Bolshaya	Kukhtui	Kamchatka	N. Western Alaska	S. Western Alaska
Bolshaya (n=64)	1980	87.2	-	12.8	0	0
	1986	59.9	-	0	40.1	0
	1990	67.3	-	0	32.7	0
	Pooled-5	68.2	0	0	31.8	0
	Pooled-4	69.6	-	0	30.4	0
Kamchatka (n=59)	1980	12.9	-	87.1	0	-
	1986	36.6	-	20.0	26.7	16.7
	1990	10.2	-	79.4	0	10.4
	Pooled-5	94.4	0	0	0	5.6
	Pooled-4	93.5	-	0	0	6.5
N. Western Alaska (n=176)	1980	5.8	-	24.0	70.2	-
	1986	2.0	-	16.7	81.1	0.2
	1990	0.4	-	14.4	84.6	0.6
	Pooled-5	6.0	14.3	0	79.7	0
	Pooled-4	0	-	23.4	76.6	0
N. Peninsula (n=21)	1980	5.6	-	70.8	23.6	-
	1986	0	-	23.4	0	76.6
	1990	0	-	5.6	34.2	60.8
	Pooled-5	84.8	0	0	15.2	0
	Pooled-4	84.4	-	0	15.6	0

Table 8. (cont.)

b. Allocation percentages from 1987 known-origin scales.

1987 Groups	Models	Standards: Bolshaya	Kukhtui	Kamchatka	N. Western Alaska	S. Western Alaska
Bolshaya	1980	70.2	-	0	29.8	-
(n=160)	1986	45.0	-	0	55.0	0
	1990	63.6	-	0	36.4	0
	Pooled-5	2.4	2.1	0	95.5	0
	Pooled-4	2.3	-	0	97.7	0
N. Okhotsk	1980	1.0	-	7.6	91.4	-
(n=255)	1986	0	-	54.9	27.0	18.1
	1990	0	-	0.8	86.1	13.1
	Pooled-5	0	0	33.9	46.4	19.6
	Pooled-4	0	-	9.0	83.2	7.8
Kamchatka	1980	21.2	-	65.1	13.6	-
(n=131)	1986	20.3	-	31.7	47.5	0.5
	1990	8.5	-	80.5	10.9	0
	Pooled-5	68.2	0	8.5	19.8	3.5
	Pooled-4	62.5	-	27.0	8.8	1.8
N. Western Alaska	1980	3.5	-	2.2	94.2	-
(n=336)	1986	0	-	9.0	91.0	0
	1990	0	-	0	100.0	0
	Pooled-5	0	0	0	100.0	0
	Pooled-4	0	-	0	100.0	0
N. Peninsula	1980	1.1	-	4.2	94.7	-
(n=120)	1986	0.6	-	2.8	3.7	93.0
	1990	0	-	0	31.8	68.2
	Pooled-5	0	0	0	0	100.0
	Pooled-4	0	-	0	0	100.0

Table 8. (cont.)

c. Allocation percentages from 1991 known-origin scales.

1991 Groups	Models	Standards: Bolshaya	Kukhtui	Kamchatka	N. Western Alaska	S. Western Alaska
Kamchatka (n=39)	1980	0	-	98.4	1.6	-
	1986	2.6	-	42.2	51.7	3.5
	1990	0	-	97.8	0	2.2
	Pooled-5	93.4	0	0	0	6.6
	Pooled-4	93.8	-	0	0	6.7
N. Western Alaska (n=239)	1980	0.4	-	5.2	94.4	-
	1986	0	-	28.2	71.8	0
	1990	0	-	19.7	80.3	0
	Pooled-5	0	3.7	9.5	86.8	0
	Pooled-4	0	-	25.6	74.4	0
N. Peninsula (n=120)	1980	1.7	-	17.7	80.6	-
	1986	0.8	-	8.0	12.3	78.9
	1990	0	-	0.9	15.6	83.5
	Pooled-5	0.8	0	7.1	1.7	90.4
	Pooled-4	2.4	-	0	5.2	92.4

Table 9. Provisional maximum likelihood mixing proportion estimates for 1991 Asian squid driftnet fisheries and for a 1989 illegal Taiwanese coho catch. Estimates utilize Millar's (1988) method with confidence intervals derived from bootstrapping runs.

Fishery Sample	Model	Bolshaya Est.	Bolshaya 95% CI	Kamchatka Est.	Kamchatka 95% CI	N. Western Alaska Est.	N. Western Alaska 95% CI	S. Western Alaska Est.	S. Western Alaska 95% CI
1991 Squid (n=251)	1991	-		.188	(.115-.248)	.731	(.623-.816)	.081	(.019-.186)
	1980	.055	(.015-.105)	.239	(.163-.308)	.706	(.629-.781)	-	
	1990	.040	(.006-088)	.220	(.143-.294)	.691	(.587-.783)	.049	(.00*-.131)
1989 Taiwan (n=378)	1991	-	-	.052	(.012-.091)	.463	(.279-.654)	.485	(.297-.672)
	1980	.236	(.132-.355)	.097	(.046-.162)	.667	(.525-.789)	-	
	1990	.073	(.040-.110)	.008	(0 -.031)	.880	(.809-.923)	.038	(.001-.089)

.00* denotes small values less than .001 but greater than zero.