ORIGINS OF IMMATURE SOCKEYE SALMON IN AND AROUND THE AREA OF THE JAPANESE LANDBASED DRIFTNET FISHERY IN 1974 AND 1975 AS DETERMINED BY EVALUATION OF SCALE PATTERNS WITH A DISCRIMINANT FUNCTION

by

Scott L. Marshall, Rodney C. Cook, Colin K. Harris and
Robert H. Conrad

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Fisheries Research Institute
College of Fisheries
University of Washington
Seattle, Washington 98195

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INTRODUCTION

Investigations on the continent of origin of sockeye salmon in the area of the Japanese landbased driftnet fishery (Fig. 1) were undertaken because under P.L. 94-265 the United States assumed management authority of her stocks of Pacific salmon throughout their migratory range, and because the origins of sockeye salmon, particularly in the eastern portion of this fishery, were unclear (Hartt 1975[1]; French, et al., 1976; Marshall, et al., 1978). In addition, the work has become a part of the United States' research commitment to the International North Pacific Fisheries Commission as outlined in the Protocol Amending the International Convention for the High Seas Fisheries of the North Pacific Ocean.

This report summarizes results of investigations conducted during the 1978-79 fiscal year and should not be viewed as a comprehensive treatment of the subject matter; rather, it is intended to inform the member nations of the INPFC of progress to date.

MATERIALS AND METHODS

Scales of sockeye salmon record their growth and Mosher (1968) summarized typical patterns. One to three freshwater growth zones and one to four oceanic growth zones are common, each zone representing a year's growth (Fig. 2). In addition, a zone of plus or intermediate growth may be present between the freshwater and oceanic zones on some scales. This zone corresponds to growth realized in the season of seaward migration and forms during freshwater and/or estuarine residence. The use of scales for

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[1] Hartt, A.C. 1975. Continent of origin of sockeye salmon in the area of the Japanese landbased gillnet fishery. Univ. Washington, Fish. Res. Inst., 18 pp. (unpublished manuscript).

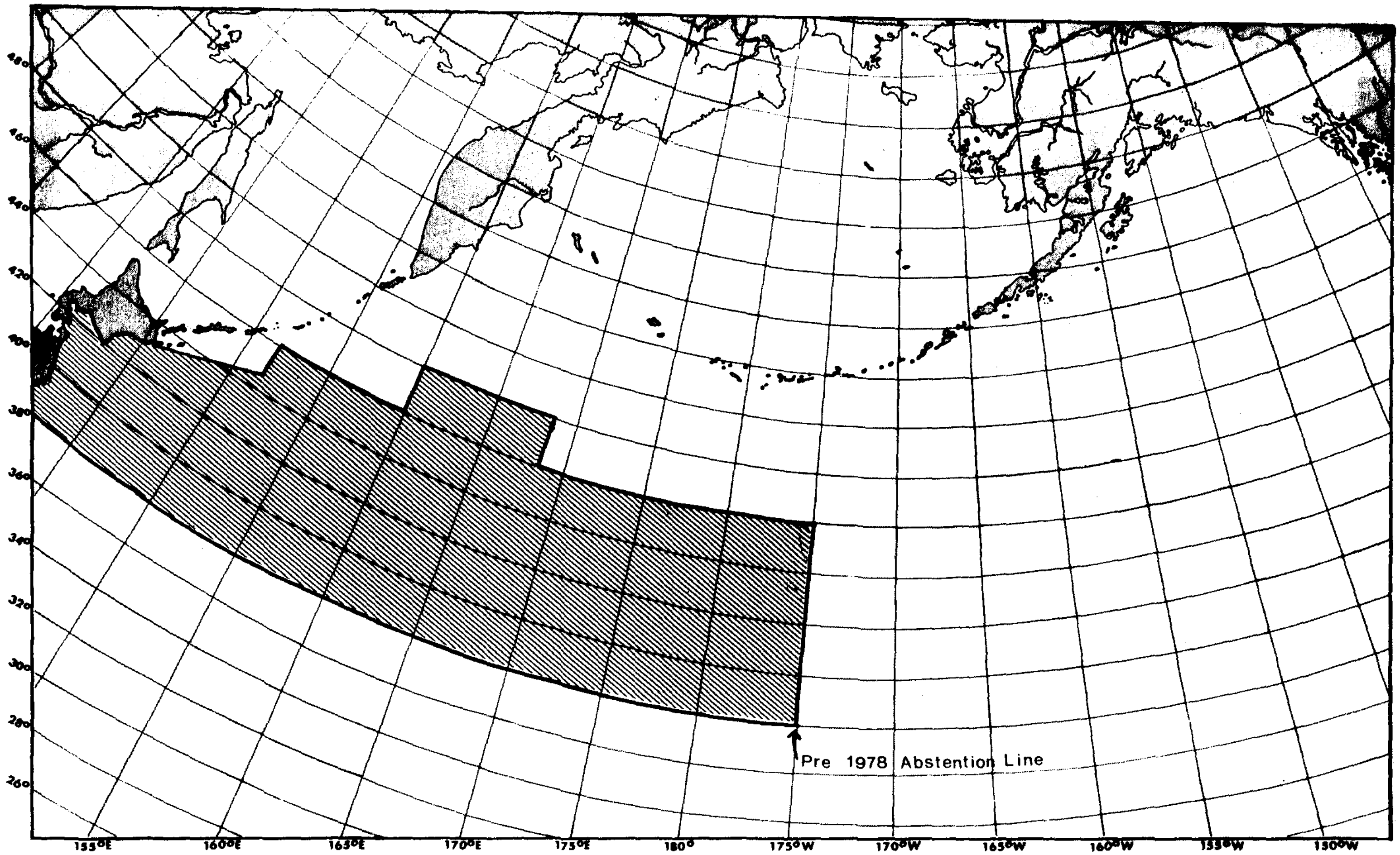

Fig. 1. Map of the North Pacific Ocean showing the area of the Japanese landbased driftnet fishery. The Eastern boundary line was moved to 175°E in 1978.

Fig. 2. Photograph of a scale from an age 1.3 sockeye salmon. Line perpendicular to sculptured field indicates radius along which measurements and counts were made.

identifying the racial origins of sockeye salmon is made possible by the genetic similarity of a local (or regional) stock of fish acting in conjunction with local (or regional) environmental conditions to produce differences in scale patterns on a local (or regional) basis. Generally, multivariate statistical analyses are used to identify these patterns.

Analytical Procedures

The goal in our racial analyses of sockeye salmon is to estimate accurately the proportions of subpopulations in areas of intermingling. Cook (1979) has shown that the most important consideration in reducing the variance of these estimates is classification accuracy. Thus, the classification methodology used should provide the best separation.

Various discriminant analyses have been used for stock identification of Pacific salmon. Linear discriminant functions (Fukuhara, et al., 1962; Amos, et al., 1963; Dark and Landrum 1964; Anas 1964; Mason 1966; Krasnowski and Bethe 1978; and others), quadratic discriminant functions (Anas and Murai 1969), and polynomial discriminant functions (Cook and Lord 1978; Marshall, et al., 1978) have all been used.

The form of the underlying (parent) distribution is an important consideration when choosing a classification methodology. The assumption of Fisher's (1936) linear discriminant function (LDF) is that the parent distributions are multivariate normal with a common variance-covariance matrix. Quadratic discriminant functions (QDF) assume only that the parent distributions are multivariate normal (Smith 1947). Specht's (1966) polynomial discriminant function (PDF) is appropriate for continuous non-Gaussian distributions.

LDFs appear to be fairly robust against deviations from the underlying assumptions. Gilbert (1969) found that the behavior of the LDF was satisfactory if variance-covariance matrices are not too different. She also found the LDF satisfactory when used on a vector of Bernoulli variates (Gilbert 1968). Large sample sizes appear to make the LDF robust to the assumption of a common variance-covariance matrix (Isaacson 1954; Anas and Murai 1969). Revo (1970, cited by Lachenbruch and Kupper 1973) found that the LDF worked very well on univariate and bivariate Poisson and negative binomial variates. Thus, the LDF appears robust to violations of the normality assumption for discrete distributions. However, Lachenbruch, et al. (1973), have shown that the LDF is not robust for continuous non-Gaussian parent distributions. They also found that the QDF may actually provide worse results than the LDF for some types of non-normality. For small sample sizes, Specht (1966) found that his PDF performed better than the QDF when the parent distributions were Gaussian.

The multivariate distributions of scale characters of sockeye salmon are poorly understood. The data may or may not be Gaussian; some variates are discrete (e.g., circuli counts) while others are continuous (e.g., measurements). We are evaluating the use of linear, quadratic, and polynomial discriminant functions with sockeye salmon scale data. Until that analysis is complete we have provisionally chosen to use the exponential form of Specht's (1966) polynomial discriminant function. We chose this approach because no assumptions about the underlying parent distributions need be made. The exponential form was chosen because Lachenbruch's (1967) leaving-one-out approach may then be adapted to estimate elements of the classification matrix. We refer to this as the direct density approach. This approach allows us to combine available learning and test samples into one larger training sample. Because the variance of the proportional estimates decreases as test sample size increases, we more efficiently utilize the available samples. Also, the direct density approach bypasses truncation of the polynomial and allows a different smoothing parameter to be used for each class.

A detailed report of the approach has been prepared for publication (Cook, in prep.). The method is briefly outlined below. The decision rule from which discriminant functions may be derived is given by:

Choose $d(\underline{X}) = \Theta a$ such that

$h_a f_a(\underline{X}) \geq h_b f_b(\underline{X})$ for all $a \neq b$

where $\underline{X}$ is vector of scale measurement data from a salmon to be classified

$d(\underline{X})$ = the decision on an $\underline{X}$

Θ_k = the classes (subpopulations)

$f_k(\underline{X})$ = the value of the estimated density function for class Θ_k at point $\underline{X}$

h_k = the a priori probabilities

The density function is:

$$f_b{}^j(\underline{X}_{aj}) = \frac{1}{\sigma_b{}^p(2\pi)^{p/2} n_b} \sum_{i=1}^{n_b} \exp\left[- \frac{(\underline{X}_{bi}-\underline{X}_{aj})' \ (\underline{X}_{bi}-\underline{X}_{aj})}{2\sigma_b{}^2}\right] \qquad (1)$$

where i = observation (fish) number

$\underline{X}_{bi}$ = ith observation from class Θ_b

n_b = training sample size for class Θ_b

$\underline{X}_{aj}$ = the observation to be classified

p = the dimension of $\underline{X}$ (number of variables)

σ_k = the smoothing parameters

The density function employing the leaving-one-out approach is:

$$f_a^{\,j}(\underline{X}_{aj}) = \frac{1}{\sigma_a^{\,p}\,(2\pi)^{p/2}\,(n_a-1)} \sum_{\substack{i=1\\ i\neq j}}^{n_a} \exp\left[-\frac{(\underline{X}_{ai}-\underline{X}_{aj})'\,(\underline{X}_{ai}-\underline{X}_{aj})}{2\sigma_a^{\,2}}\right] \quad (2)$$

Equation (1) is used to calculate the value of the estimated density function for Θ_b at $\underline{X}_{aj}$, and equation (2) is used to calculate the value of the estimated density function for Θ_a at $\underline{X}_{aj}$. Subsequent classification of the fish composing the unknown sample(s) utilizes equation (1) and the training sample for each of the established classes.

Estimation of the smoothing parameter is done with a leaving-one-out modification of the maximum likelihood method (Habbema, et al., 1974):

Choose the value $\hat{\sigma}_a$ such that

$$g(\hat{\sigma}_a) = \max_{\sigma_a>0} \prod_{j=1}^{n_a} f_a^{\,j}\,(\underline{X}_{aj})$$

Definition of Continental Standards

Marshall, et al. (1978), have shown that almost all commercially caught immature sockeye within the area of the landbased fishery are 2-ocean age fish, and we therefore considered only this group in the current analysis. We desired to form standards for each major freshwater age group, i.e., 1. and 2. We did not analyze origins of age group 1.2 in 1975 because few scales to serve as unknownswere available for this group.

In development of continental standards we wished to strike a balance between achieving good classificatory accuracy by factoring out as many sources of variability as possible, and keeping the number of standards that must be developed manageable. On one extreme, age classes from each brood year by stock could be treated separately; on the other extreme, two classes (Asia vs. North America) could be formed by pooling across age classes and brood years. The former extreme would produce an unmanageable experimental design, and the latter would cause serious loss of important biological information. We decided to group stocks within regions and to treat age classes within brood years separately. One Asian and two North American standard regions were defined. The two North American regions correspond to the major water masses into which the parent streams terminate; Bristol Bay, and the south coast of Alaska from about 160°W to 145°W (hereafter called the Gulf of Alaska Standard).

The classification of immature fish sampled on the high seas requires that standards be developed from maturing fish of the same cohort. For example, classification of age 1.2 immatures caught in 1974 requires standard samples from age 1.3 mature fish in 1975. We attempted to construct standards by age class within regions by subsampling from the major stocks within a region in proportion to the abundance of each age group. Table 1 summarizes the run size by stock and age class within each region of North America by year and the resulting sample sizes. Lacking run size and age composition information and sufficient coastal samples of known origin for the stocks returning to the Kamchatka Peninsula, we could not use this approach for the Asian standard. Instead we constructed the Asian standard with scale samples collected aboard Japanese research vessels operating off the Kamchatka coast. An attempt was made to allocate samples based on catch per tan (50 m of gill net) by age class by INPFC area and by month. A dearth of scales from some time and area cells required some divergence from this scheme. A limited number of escapement samples from the Kamchatka and Ozernaya rivers were available, and therefore included. Table 2 summarizes sample sizes used.

Table 1. Inshore run and sample sizes of the major stocks of sockeye salmon returning to the Bristol Bay and Gulf of Alaska regions for age classes 1.3 and 2.3 in 1975 and for 2.3's in 1976.

Region	Stock	1975 matures Run size (x10^3) 1.3	1975 matures Run size (x10^3) 2.3	1975 matures Sample size 1.3	1975 matures Sample size 2.3	1976 matures Run size (x10^3) 2.3	1976 matures Sample size 2.3
Bristol Bay	Alagnak	60.5	21.3	5	1	1.3	0
	Bear	3.1	158.8	0	11	213.4	26
	Egegik	75.5	968.7	7	66	152.7	19
	Goodnews	3.2	4.1	0	0	unknown	0
	Igushik	171.1	98.7	15	7	61.3	7
	Kvichak	10.6	505.4	1	34	568.2	70
	Naknek	269.9	1028.4	24	70	475.9	58
	Nushagak	80.5	3.4	7*	0	6.5	1
	Nuyakuk	622.5	4.5	55	0	11.6	1
	Sapsuk	<0.1	42.6	0	3	31.4	4
	Snake	8.7	1.6	1	0	.6	0
	Togiak	181.4	10.3	16	1	50.5	6
	Ugashik	1.9	21.9	0	1	24.3	3
	Wood	776.0	85.2	69	6	37.4	5
	Total	2,264.9	2,954.9	200	200	1,635.1	200
Gulf of Alaska	Akalura	3.0	0.4	1	0	no scales available	
	Bering	<0.1	1.2	0	0	1.7	1
	Chignik	220.9	540.8	41	137	600.1	145
	Coghill	144.8	10.5	27	3	5.2	1
	Cook Inlet	379.4	87.9	70	22	170.0	41
	Copper	301.5	93.3	56	24	25.4	6
	Eshamy	no scales available				<0.1	0
	Frazer	1.6	5.7	0	1	8.6	2
	Karluk	14.6	27.4	3	7	11.8	3
	Red	1.0	12.3	0	3	1.7	0
	Upper Station	9.8	11.6	2	3	2.7	1
	Total	1,076.6	791.1	200	200	827.2	200

*No scales available, Wood River samples were used.

Table 2. Catch per tan by year, age class, month and INPFC statistical area for mature sockeye salmon by Japanese research vessels operating off the coast of Kamchatka, and final sample sizes.

		1975 matures				1976 matures	
		1.3		2.3		2.3	
Month	Area	Catch/tan	Sample size	Catch/tan	Sample size	Catch/tan	Sample size
June	E5052	0.034	21	0.066	13	0.038	4
	E5050	0.066	38	0.104	21	0.045	4
	E5552	0.017	4*	0.014	23	0.025	3
	E5550	0.017	6*	0.072	15	0.017	2
July	E5052	0.057	62	0.027	31	0.017	2
	E5050	0	0	0.039	3*	0.065	7
	E5552	0.156	55*	0.052	17	0.149	15
	E5550	0.047	7*	0.133	19*	0.095	10
August	E5052	0	0	0.017	7	0.184	18
	E5050	0.011	1*	0.117	10*	0.021	2
	E5552	0.005	2*	0.042	22	0.201	19
	E5550	0.040	4*	0.199	19*	0.141	14
Sub-total			200		200		100
Kamchatka River Escapement			35		34		60
Ozernaya River Escapement			0		0		60
Total			235		234		220

*Indicates time x area cells in which insufficient samples were available, supplemental samples were therefore used from other time x area cells as close in time and space as possible.

Sample Collection, Preparation, and Viewing

Scale samples to serve as standards were provided by the Alaska Department of Fish and Game, the Japan Fishery Agency, and TINRO, USSR. Scale samples to serve as unknowns were obtained from the Japan Fishery Agency (JFA). Our request was for samples collected aboard research vessels and motherships operating in and just north of the landbased fishery area. Scale samples are not collected aboard commercial vessels within the landbased fishery area. Impressions of scales were made in cellulose acetate (Koo 1955). Personal communication with biologists from JFA and ADF&G indicated that nearly all scale samples were collected from body area A, as established by the International North Pacific Fisheries Commission (Anas 1963).

Scale images were projected at 100 power using a Bausch & Lomb micro-projector[1]. Measurement and count data were recorded directly onto a form from this image. A consistent radius along which measurements and counts were recorded was found by aligning the form so that the radius approximated a perpendicular angle to the sculpture field (Fig. 2) (Mosher 1968; Narver 1963). This axis was chosen over the longest axis because of the tendency for sockeye salmon scales from stocks returning to the south side of Alaska Peninsula, Cook Inlet, and some rivers of the Kamchatka Peninsula to show broken and irregular circuli along the longest axis (Mosher 1968).

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[1]Catalog No. 42-63-59.

Screening of Characters

Some characters selected for screening were identified from previous work. Anas and Murai (1969) reported that: (1) The number of circuli in the first half of the first ocean zone, (2) the measured distance between circuli 1 and 6 of the first ocean zone, and (3) the measured distance between circuli 13 and 18 of the first ocean zone, provided good separation of Asian from Bristol Bay sockeye salmon when used in either a linear or quadratic discriminant function. Mosher (1963) used the number of circuli in the freshwater zone and in the first ocean zone for sockeye of age groups 1.- and 2.- and the size of the same two zones for sockeye of age group 3.- in bivariate frequency tables to classify Asian and North American fish. We screened the following characters: Number of freshwater circuli, size of the freshwater zone, number of circuli in the first half of the first ocean zone, number of circuli in the second half of the first ocean zone, size of the first ocean zone, size of the second ocean zone, number of circuli in the second ocean zone. In addition, we measured the distance between the outer edges of every third circulus in the first ocean zone beginning with the outer edge of the last freshwater circulus. Some of these measurements were then summed to provide the distance between every sixth circulus.

Characters were selected from this group for use in classifying unknowns using the method of Cook and Lord (1978). Briefly, the Kruskal-Wallis "H" statistic (Kruskal and Wallis 1952) and the difference in average sum of ranks for each pairwise class combination is calculated for each characteristic. Characters were then ranked according to value of the H statistic and by the greatest difference in average sum of ranks. In two-category cases these procedures produce the same results.

In three or more category problems it is often necessary to make decisions as to whether or not to choose a variable with good overall discriminating power versus one which has a lower H value but which provides good separation for one group from the others. In circumstances where the choice is unclear it is a simple matter to compare classificatory accuracy using each variable in question.

RESULTS

Characters Selected and Classification Arrays

Characters selected for use in the analysis are summarized by year of maturity and age class in Table 3. Variability in discriminating power for a character between years and age classes resulted in some differences in those selected.

The ability of characters to identify fish to region of origin when used in a discriminant function analysis is summarized by calculating the percent correctly classified. Classificatory accuracies for 1974 age 1.3 and 2.3 and for 1975 age 2.3 training samples were 60.2, 59.6, and 70.7%, respectively. In Table 4 we present the classification arrays by year and age class.

Classification of Unknowns

Available unknown scale samples were stratified by year, age class, INPFC statistical area and 10-day period, and only strata with a sample size of 25 or more scales were analyzed. The proportional estimates obtained in the analyses are presented in Appendix Tables 1-3, and illustrated in Figures 3-5.

Table 3. Characters selected for use in the discriminant function analysis by year of maturity and age class (+ indicates use of the character).

Character	1975 matures 1.3	1975 matures 2.3	1976 matures 2.3
Number of freshwater circuli	+	+	+
Size of freshwater zone	+		+
Number of circuli in first half of first ocean zone	+	+	+
Size of first ocean zone	+	+	
Distance between circuli N_1 and N_2 of first ocean zone:			
N_1 N_2			
0* 3			+
3 6		+	+
6 12	+		
12 15	+	+	
12 18			+
18 21		+	

*Distance was measured from the outer edge of the last freshwater circulus.

Table 4. Classification arrays for sockeye salmon of Bristol Bay vs. Gulf of Alaska vs. Kamchatka Peninsula origin, by year of maturity and age class.

1975 Age 1.3

Calculated decision	Correct decision		
	Bristol Bay	Gulf of Alaska	Kamchatka
Bristol Bay	125 (0.625)	39 (0.195)	36 (0.153)
Gulf of Alaska	28 (0.140)	115 (0.575)	57 (0.242)
Kamchatka	47 (0.235)	46 (0.230)	143 (0.606)
Total	200	200	236

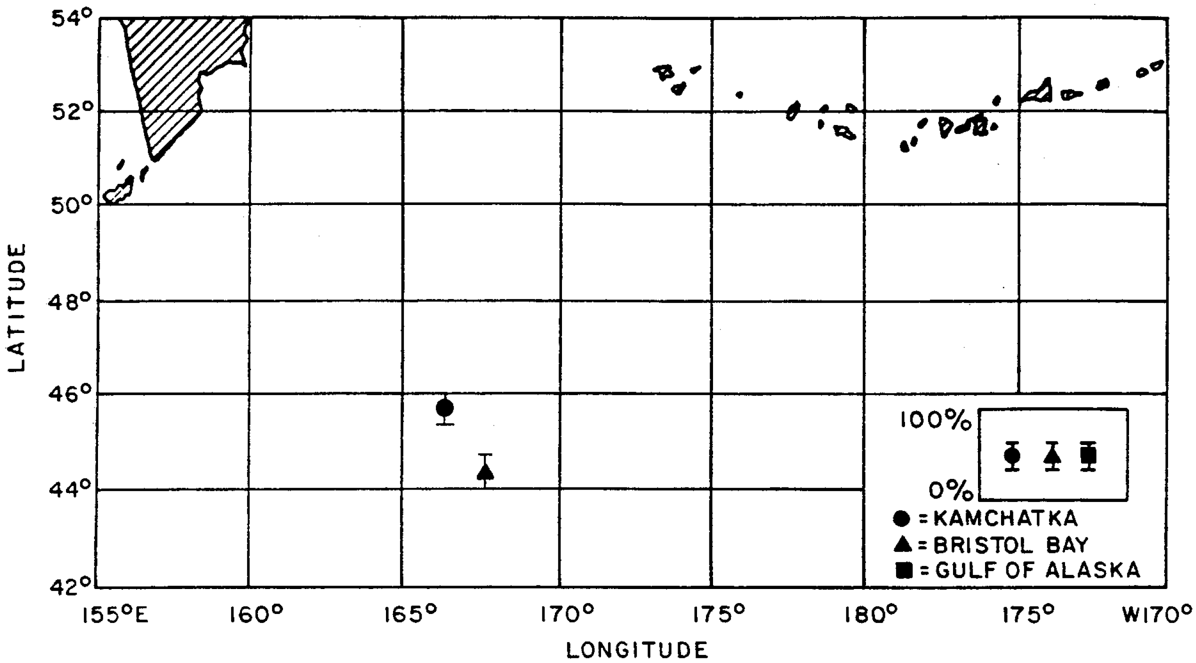
1975 Age 2.3

Calculated decision	Correct decision		
	Bristol Bay	Gulf of Alaska	Kamchatka
Bristol Bay	135 (0.675)	43 (0.215)	22 (0.094)
Gulf of Alaska	23 (0.115)	104 (0.520)	73 (0.312)
Kamchatka	42 (0.210)	53 (0.265)	139 (0.594)
Total	200	200	234

1976 Age 2.3

Calculated decision	Correct decision		
	Bristol Bay	Gulf of Alaska	Kamchatka
Bristol Bay	132 (0.660)	19 (0.090)	59 (0.268)
Gulf of Alaska	18 (0.090)	163 (0.776)	19 (0.086)
Kamchatka	50 (0.250)	28 (0.133)	142 (0.645)
Total	200	200	230

3a. May 1-10



3b. May 11-20

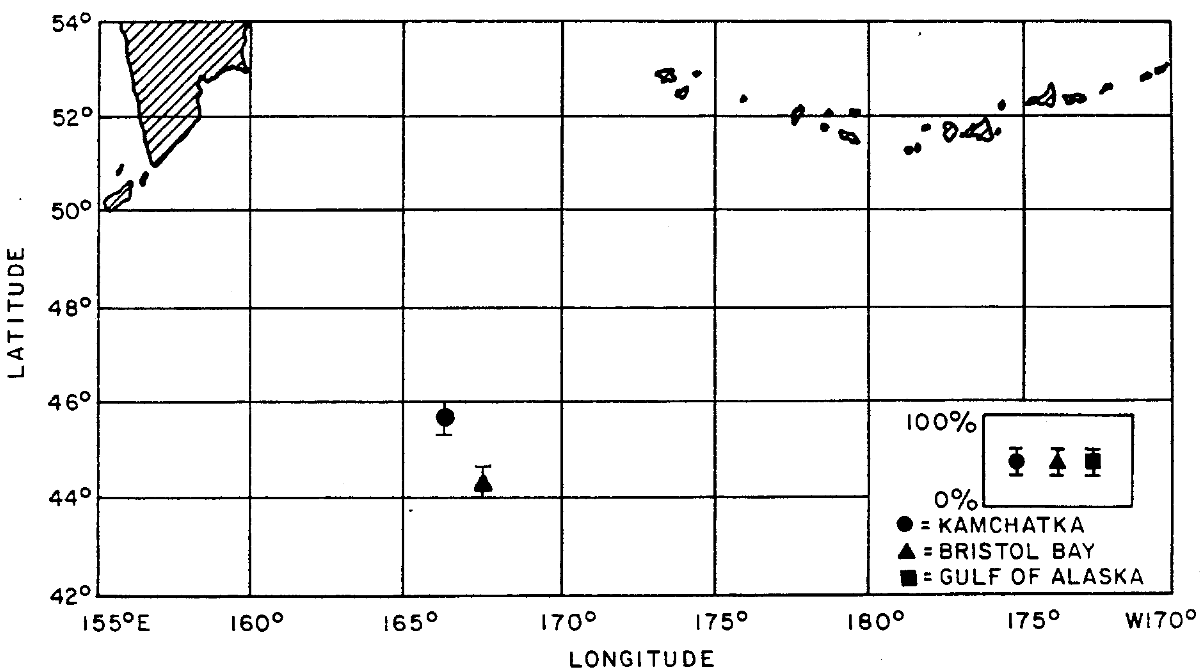
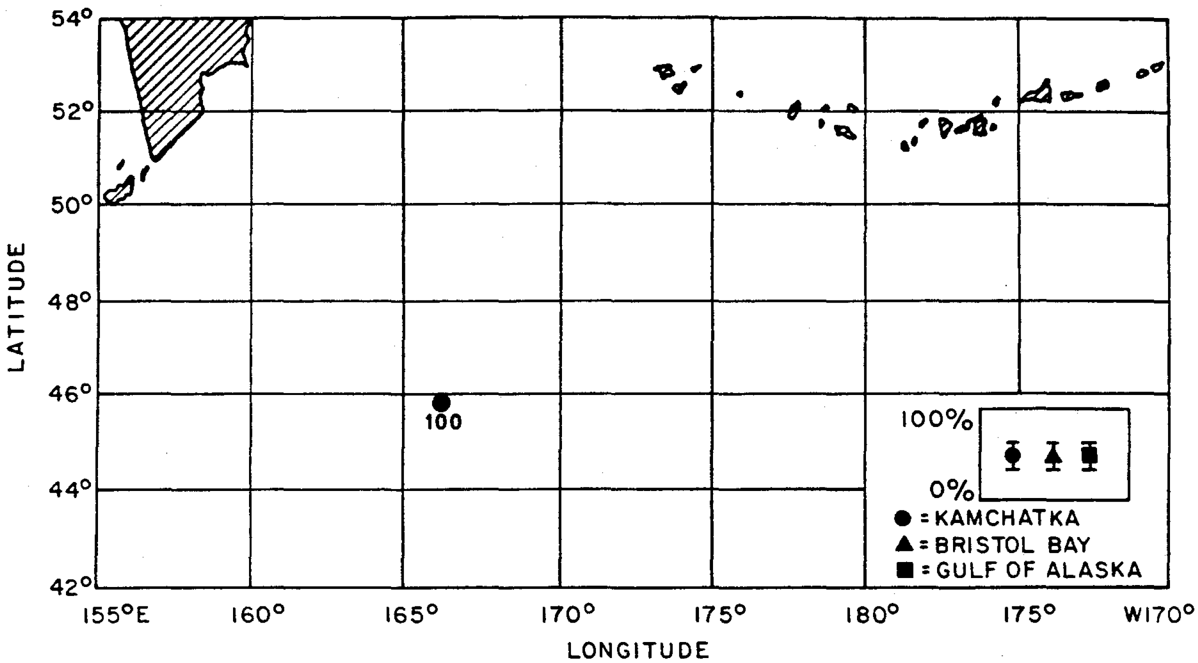


Fig. 3. Proportional estimates obtained by classifying scale samples collected from age 1.2 immature sockeye salmon in 1974 by period and INPFC statistical area. 95% confidence intervals are shown.

3c. May 21-31



3d. June 1-10

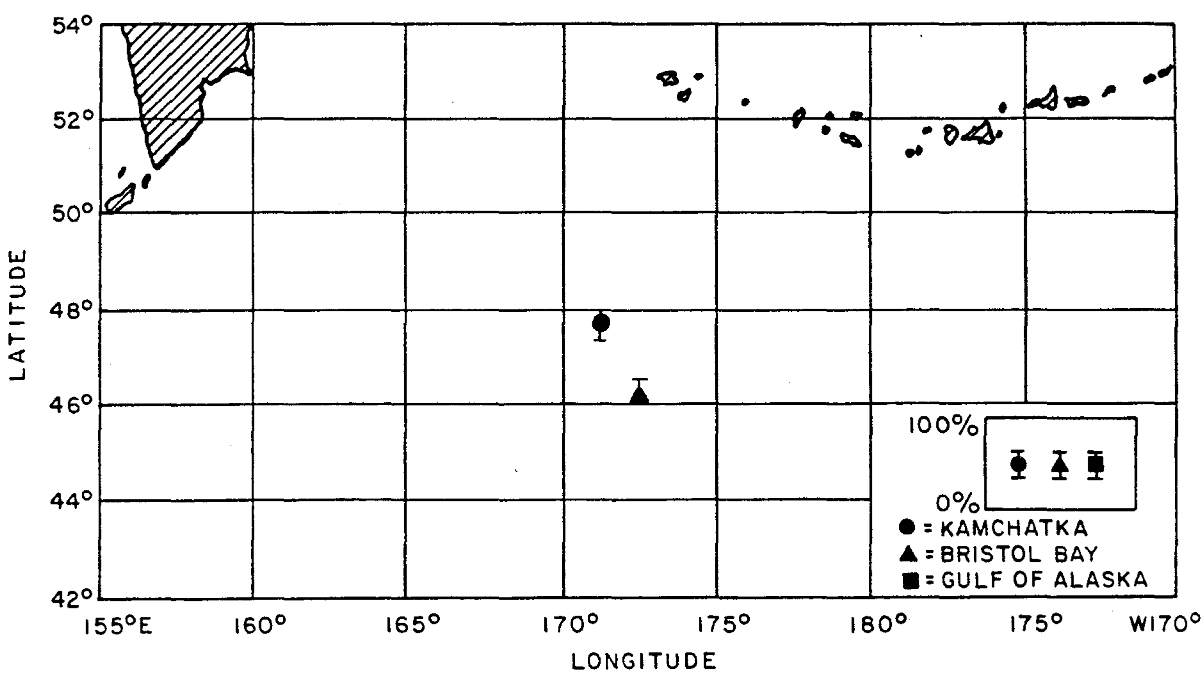


Fig. 3, cont'd

3e. June 11-20

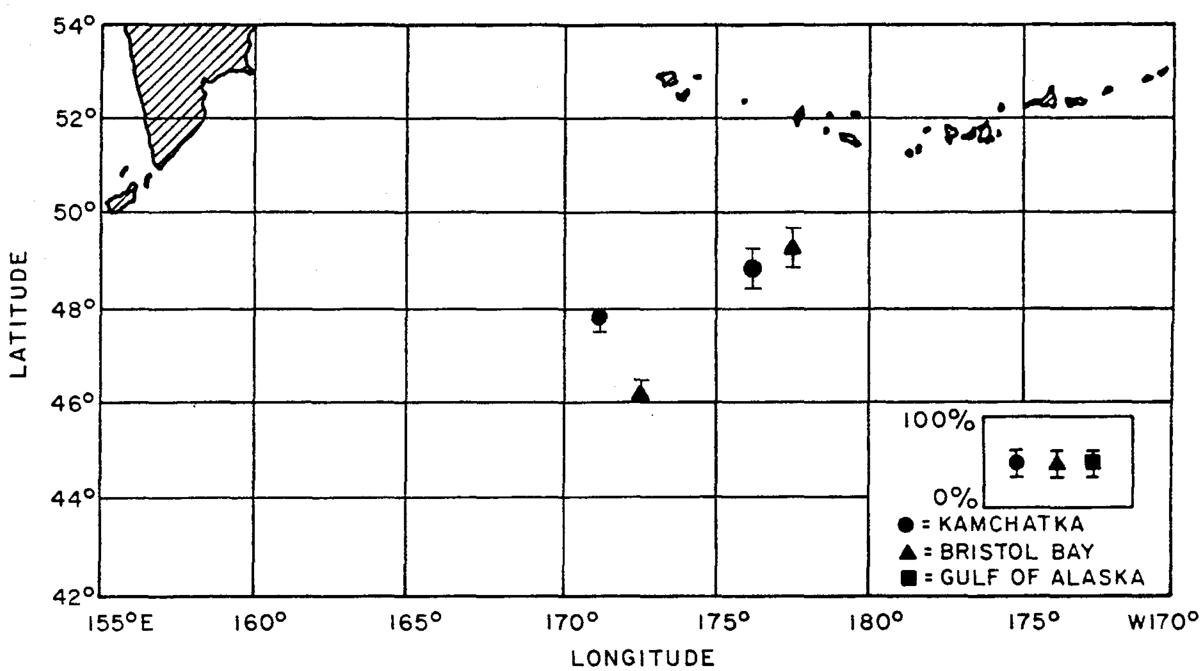
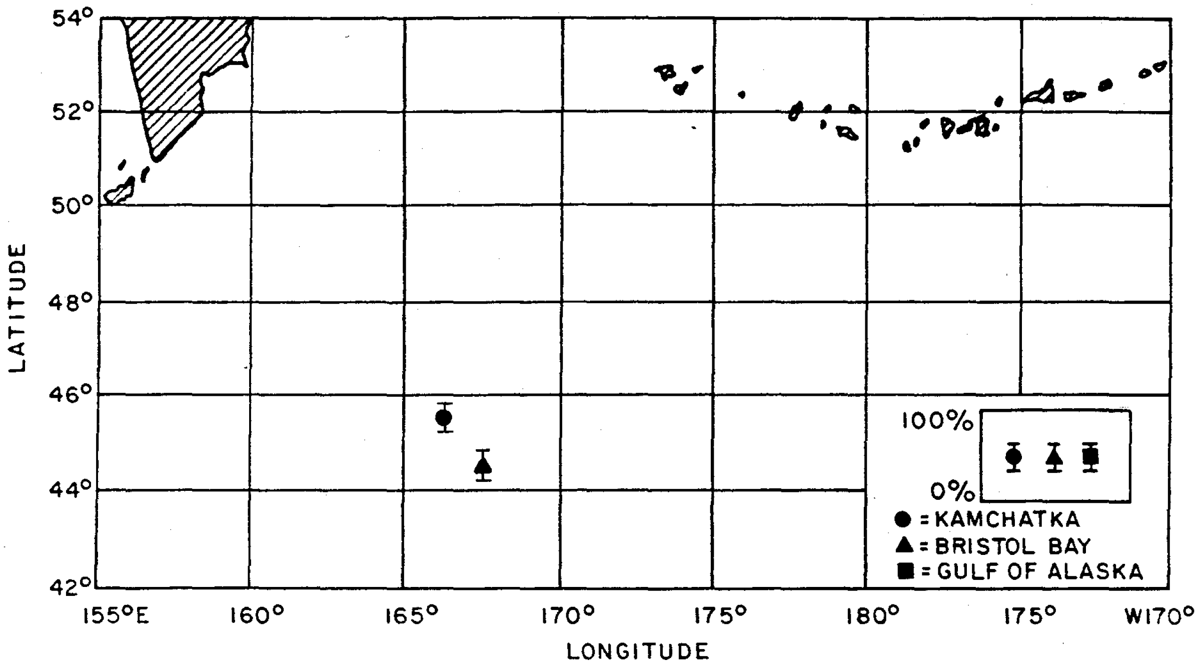


Fig. 3, cont'd

4a. May 1-10



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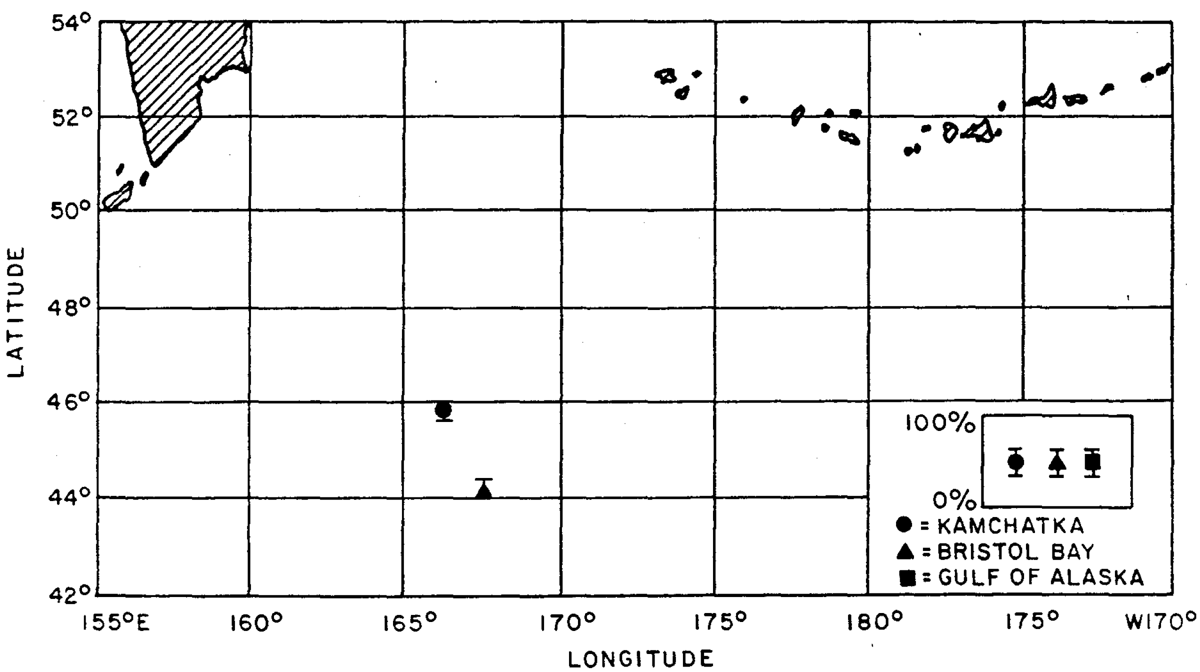
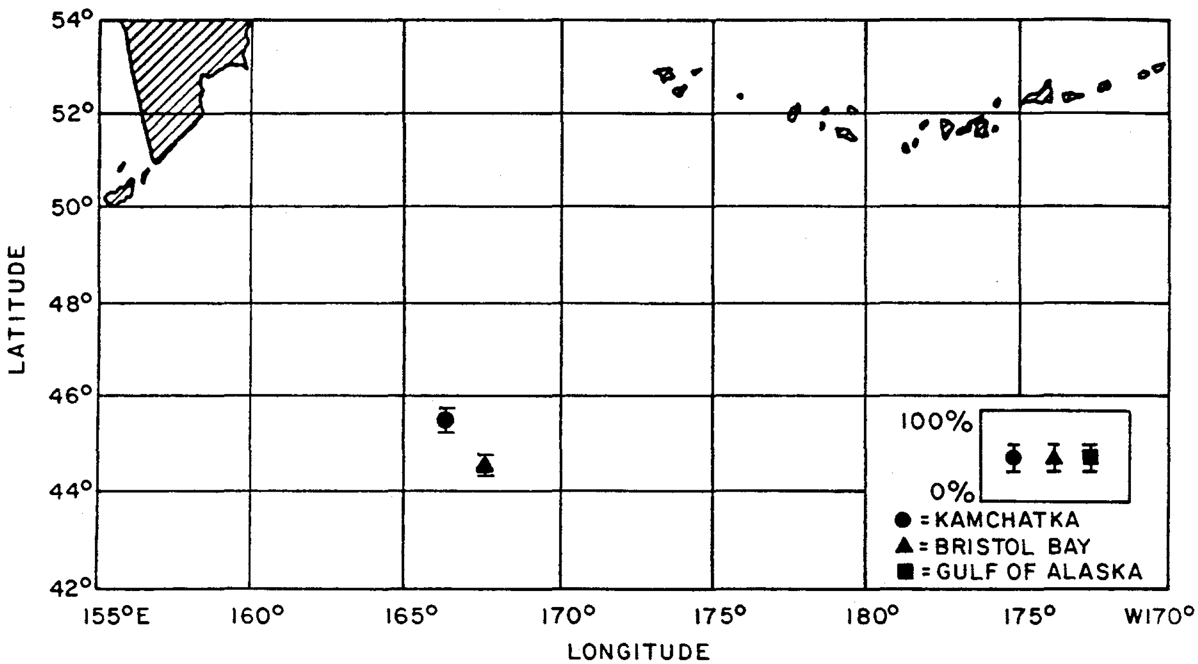


Fig. 4. Proportional estimates obtained by classifying scale samples collected from age 2.2 immature sockeye salmon in 1974 by period and INPFC statistical area. 95% confidence intervals are shown.

4c. May 21-31



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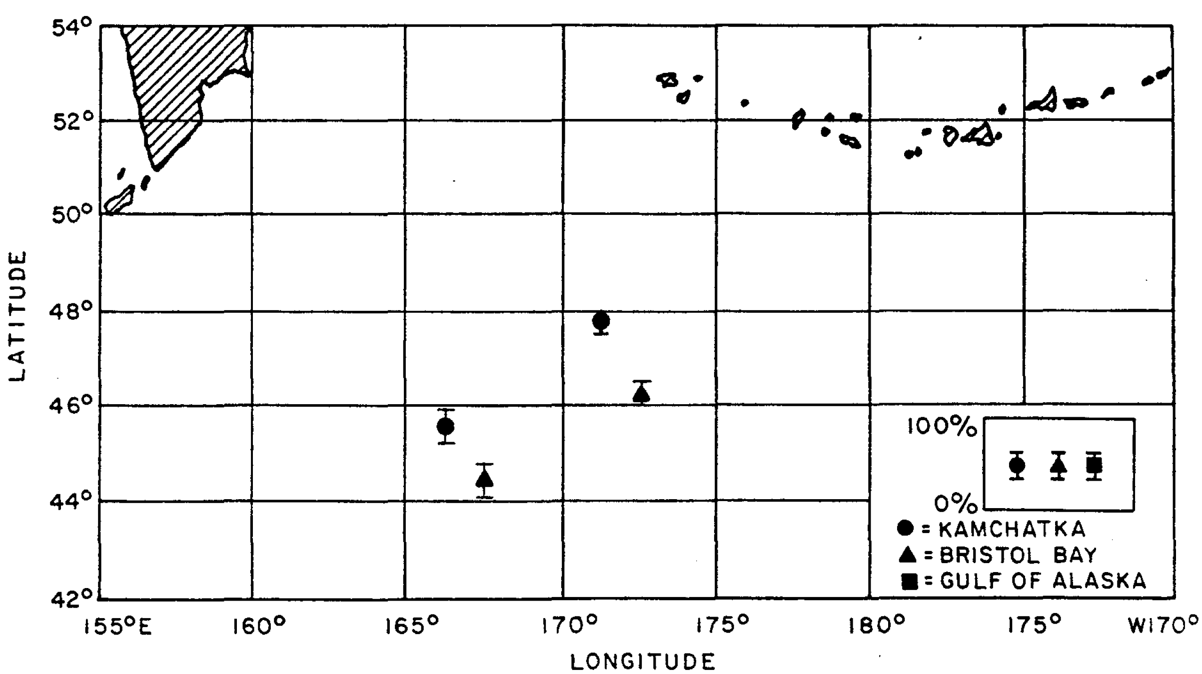
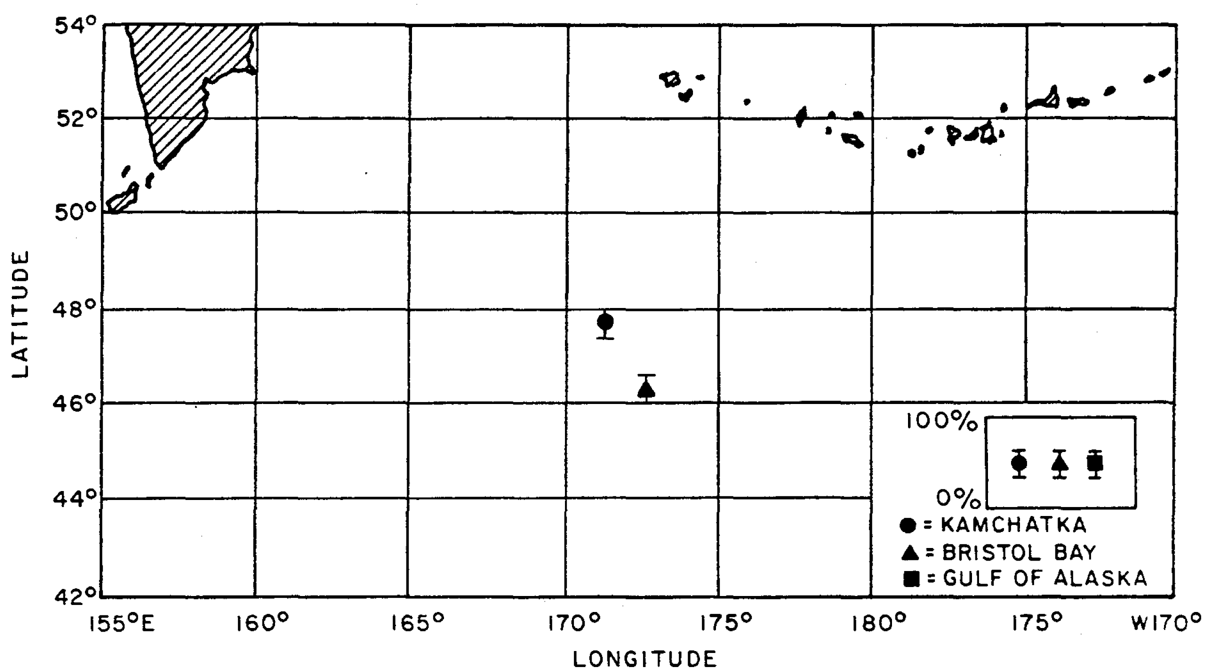


Fig. 4, cont'd

4e. June 11-20



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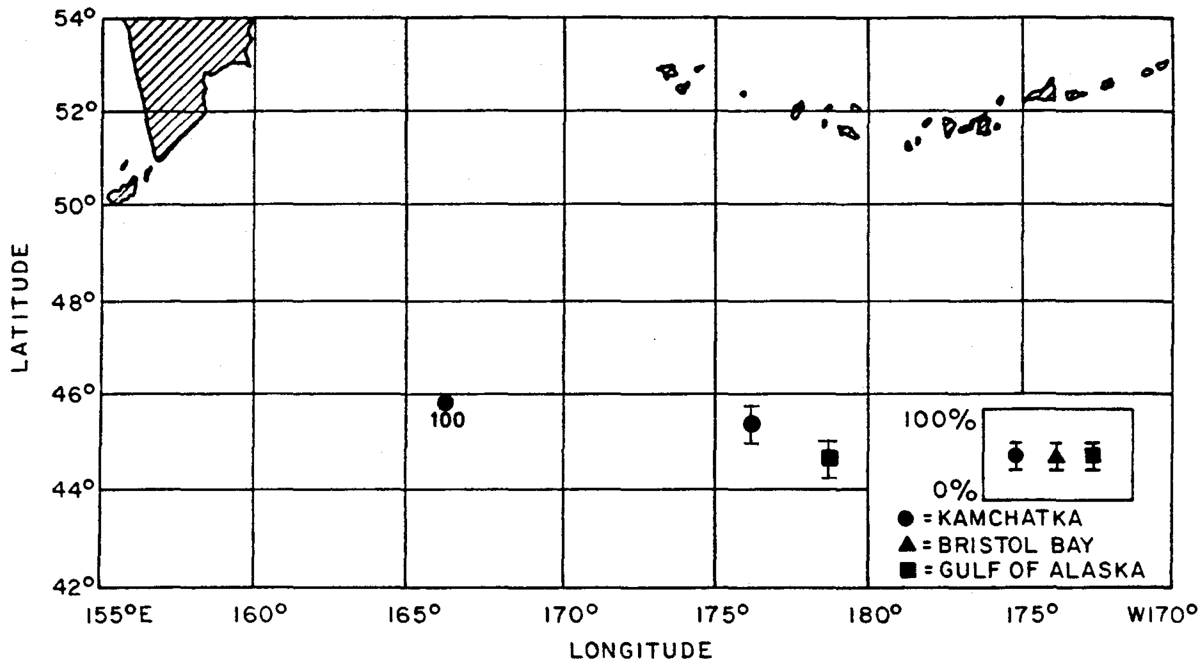
5a. May 1-10



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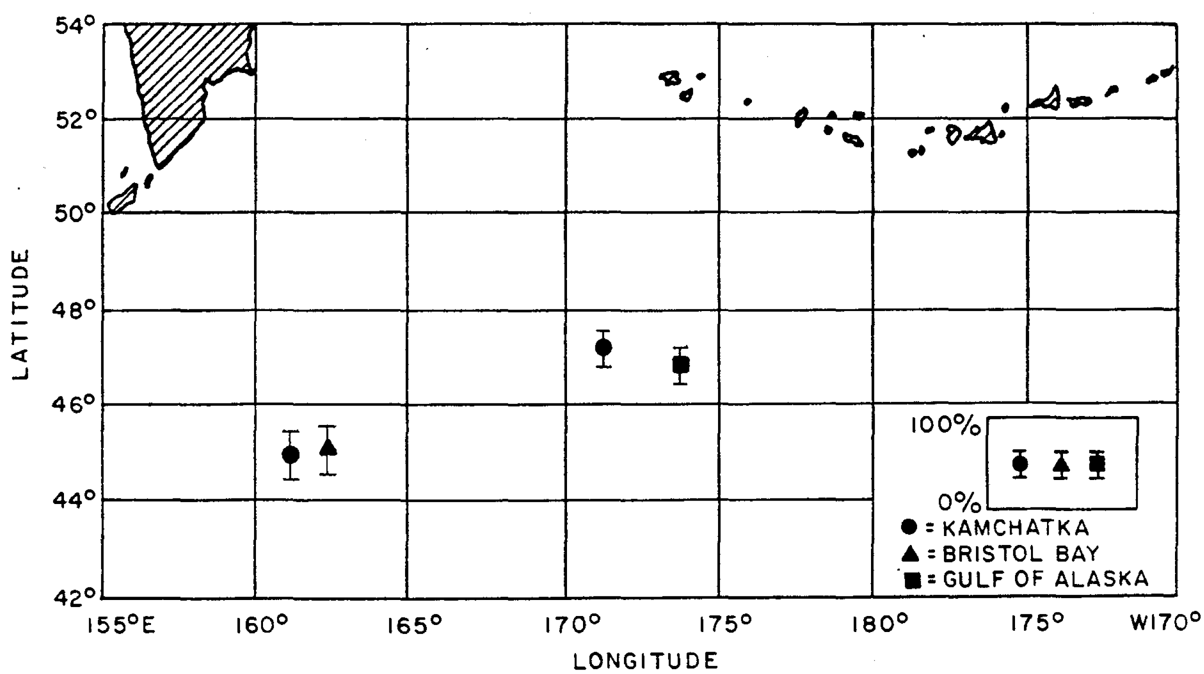

Fig. 5. Proportional estimates obtained by classifying scale samples collected from age 2.2 immature sockeye salmon in 1975 by period and INPFC statistical area. 95% confidence intervals are shown.

5c. June 1-10

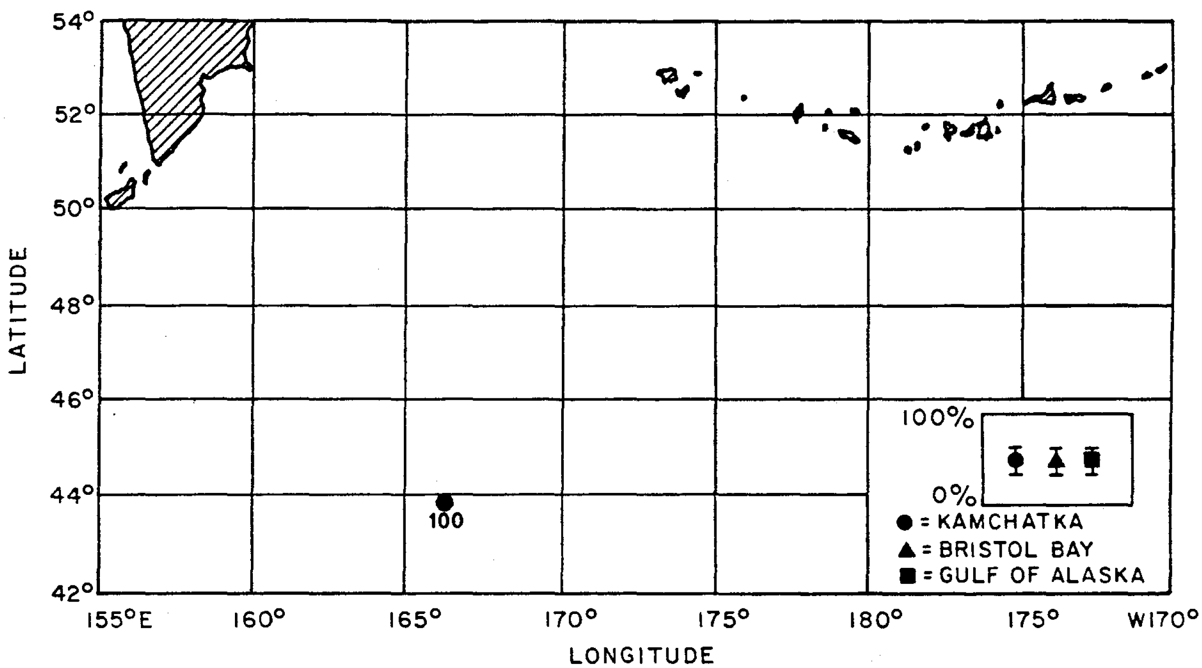

Fig. 5, cont'd

1974

Within the landbased fishery area, sufficient scale samples were available for age 1.2 immature sockeye salmon only in area E 6544. The three samples, one from each 10-day period in May (Fig. 3a,b,c), indicated a predominance of Kamchatka Peninsula fish during the first two periods, and Kamchatka Peninsula fish exclusively during the last period in May. The estimates of Bristol Bay fish in this area are not significantly different from zero. Analysis of two samples from the first two periods in June (Fig. 3d,e) in area E 7046, which is northeast of and contiguous to area E 6544, also indicated a predominance of Kamchatka Peninsula fish. The estimates for Bristol Bay fish were again not significantly different from zero. A majority of Bristol Bay fish was found in area E 7548 in the middle of June (Fig. 3e). Our results did not indicate the presence of age 1.2 fish from the Gulf of Alaska in the areas and periods examined.

Sufficient samples (i.e., $n \geq 25$) of age 2.2 immature sockeye were again available from only area E 6544 within the landbased fishery area. This series of four samples runs continuously from the first period in May through the first period in June (Fig. 4a-d), and each showed a predominance of Kamchatka Peninsula fish. However, all samples except for the second period in May indicated that almost one fourth of the fish were of Bristol Bay origin. During the first two periods in June in area E 7046 (Fig. 4d,e) Kamchatka Peninsula fish predominated and the incidence of Bristol Bay fish was not significantly different from zero. No presence of age 2.2 immature Gulf of Alaska sockeye salmon was detected.

1975

The majority of fish composing samples of age 2.2 immature sockeye salmon collected in 1975 were from the landbased fishery area. During the first period in May (Fig. 5a) only Kamchatka Peninsula fish were found to be in area E 6544, which is in the north-central portion of the area. Ten degrees east, in area E 7544, about one third of the population was estimated to be from the Gulf of Alaska. During the last period in May (Fig. 5b) in area E 6044 the incidences of Bristol Bay and Kamchatka Peninsula fish were approximately the same. In area E 7046, just north of the landbased area, the proportions of Gulf of Alaska and Kamchatka Peninsula fish were about equal. During the first period in June (Fig. 5c) in area E 6542, the entire population was estimated to be of Asian origin.

DISCUSSION

During 1978 we classified immature 2-ocean age sockeye salmon sampled in 1974 and 1975 by the Japan Fishery Agency over a broad region of the North Pacific Ocean between 160°E and 180°E and between 42°N and 48°N. We emphasized an analysis of this group because Marshall, et al. (1978), have shown that immature age .2 fish predominate in the commercial catches in the eastern area of the fishery, and this area, seemed most likely to contain North American stocks (French, et al., 1976).

We have shown that stocks of sockeye salmon from Bristol Bay, the Gulf of Alaska, and the Kamchatka Peninsula are separable by using scale pattern identification with a discriminant function, but that the best characters and resulting accuracy vary. This is consistent with the results of Anas and Murai (1969) and Marshall, et al. (1978).

The incidences of Asian sockeye reported herein are consistent with the migration model presented in French, et al. (1976).

The presence of age 2.2 immature Bristol Bay sockeye salmon in area E 6544 during May and June 1975 and in area E 6044 in late May 1975 indicates a slightly more southwesterly range for this group than reported by French, et al. (1976). Our results show that age 2.2 immature sockeye of Gulf of Alaska origin are present in areas E 7544 and E 7046 during early and late May, respectively, which entails a considerable southwestern extension of the range reported by French, et al. (1976).

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Appendix Table 1. Proportional estimates obtained by classifying scale samples collected from age 1.2 immature sockeye salmon in 1974. Data are percentages with 95% confidence intervals.

Period	Area	Sample size	Bristol Bay	Gulf of Alaska	Kamchatka Peninsula
May 1-10	E6544	29	15.7 ± 18.8	0	84.3 ± 18.8
May 11-20	E6544	40	13.6 ± 17.3	0	86.4 ± 17.3
May 21-31	E6544	56	0	0	100
June 1-10	E7046	58	5.2 ± 15.8	0	94.8 ± 15.8
June 11-20	E7548	36	59.9 ± 20.2	0	40.1 ± 20.2
	E7046	31	5.1 ± 16.7	0	94.9 ± 16.7

Appendix Table 2. Proportional estimates obtained by classifying scale samples collected from age 2.2 immature sockeye salmon in 1974. Data are percentages with 95% confidence intervals.

Period	Area	Sample size	Bristol Bay	Gulf of Alaska	Kamchatka Peninsula
May 1-10	E 6544	54	22.9 ± 14.3	0	77.1 ± 14.3
May 11-20	E 6544	80	0.6 ± 10.9	0	99.7 ± 10.9
May 21-31	E 6544	80	24.5 ± 12.9	0	75.5 ± 12.9
June 1-10	E 7046	44	5.3 ± 12.3	0	94.6 ± 12.3
	E 6544	25	23.7 ± 18.8	0	76.3 ± 18.8
June 11-20	E 7046	28	12.6 ± 15.6	0	87.4 ± 15.6

Appendix Table 3. Proportional estimates obtained by classifying scale samples collected from age 2.2 immature sockeye salmon in 1975. Data are percentages with 95% confidence intervals.

Period	Area	Sample size	Bristol Bay	Gulf of Alaska	Kamchatka Peninsula
May 1-10	E 7544	43	0	32.6 ± 14.9	67.4 ± 14.9
	E 6544	66	0	0	100
May 21-31	E 7046	25	0	42.6 ± 20.0	57.4 ± 20.0
	E 6044	26	53.7 ± 25.1	0	46.3 ± 25.1
June 1-10	E 6542	37	0	0	100

ADDENDUM

It should be noted that the area of the landbased fishery considered in this document (and shown in Fig. 1) is that which existed prior to 1977. There was a series of reductions of the landbased area beginning in 1977 other than the westward shift of the eastern fishery boundary.

ERRATA

1. On page 13, in the second paragraph of the RESULTS section, the sentence "Classificatory accuracies for 1974 age 1.3 and 2.3 and for 1975 age 2.3 training samples were 60.2, 59.6, and 70.7%, respectively. SHOULD READ "Classificatory accuracies for 1975 age 1.3 and 2.3 and for 1976 age 2.3 training sample were 60.1, 59.6 and 70.7%, respectively."

2. On page 15 (Table 4), in the first part of the three-part table, the column under "<u>Kamchatka</u>" SHOULD READ:

KAMCHATKA		KAMCHATKA
36 (0.153)		36 (0.153)
57 (0.243)	INSTEAD OF:	57 (0.242)
142 (0.604)		143 (0.606)
235		236

3. On page 15, in the third part of the three-part table, the column under "<u>Gulf of Alaska</u>" SHOULD READ:

Gulf of Alaska		Gulf of Alaska
9 (0.045)		19 (0.090)
163 (0.815)	INSTEAD OF:	163 (0.776)
28 (0.140)		28 (0.133)
200		200

Also, in the same part of the table, the column total under the "<u>Kamchatka</u>" column is erroneously shown as "230"; the correct value is "220".