STOCK COMPOSITIONS OF SOCKEYE SALMON CATCHES IN SOUTHEAST ALASKA'S DISTRICTS 106 & 108 AND IN THE STIKINE RIVER, 1989 ESTIMATED WITH SCALE PATTERN ANALYSIS

By

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ABSTRACT

Linear discriminant function analysis of scale patterns was used to estimate the 1989 sockeye salmon (*Onchorynchyus nerka*) stock compositions in the commercial gill net fisheries in Southeast Alaska's Districts 106 and 108. Contributions of the Alaska I, Alaska II, Canadian Nass/Skeena, Tahltan, and non-Tahltan Stikine stock groups to Alaska's District 106 and 108 fisheries were estimated to be 50,002, 77,781, 60,504, 1,452, and 13,078 sockeye salmon, respectively. The commercial fishery stock specific weekly CPUE is an indicator of migratory timing. The CPUE in District 106 was greatest in early to mid-July for the Alaska I, Alaska II, and Nass/Skeena stock groups. The catch of Tahltan and non-Tahltan Stikine stock groups was too small to estimate migratory timing.

INTRODUCTION

Sockeye salmon (*Oncorhynchus nerka*) are harvested in marine net fisheries throughout Southeast Alaska and northern British Columbia. Drift gill net fisheries in Alaska's commercial fishing Districts 106 and 108 harvest sockeye salmon of Alaskan origin, but also catch some sockeye salmon of transboundary Stikine River origin and some fish destined to spawn in the Nass and Skeena Rivers of Canada. Interception of salmon bound for one country's rivers as they migrate through the territorial waters of the other country has become a research and management concern in recent years with the implementation of the U.S./Canada Pacific Salmon Treaty. Cooperative international management of Stikine River sockeye salmon is mandated by this Treaty under Annex IV, Chapter 1. Knowledge and control of stock-specific harvest is, therefore, needed to fulfill requirements of and assess compliance with the harvest sharing guidelines outlined in the Treaty.

Objectives

The purpose of this study is to determine the contributions of major sockeye stock groups to gill net fisheries in Alaska's Subdistricts 106-41 and 106-30 and District 108. This study provides in-season information on the abundances of local sockeye stocks that is used by fishery managers in making harvest level decisions. It also provides postseasonally revised relative stock composition estimates which are used to finalize stock specific harvest estimates. An estimate of the total Stikine River sockeye return is derived from data provided by this study. Estimation of the interception rates and relative abundance of Stikine River sockeye salmon is of major importance in helping managers from the Alaska Department of Fish and Game (ADF&G) and the Canadian Department of Fisheries and Oceans (CDFO) implement Treaty guidelines.

Study Area

Sockeye salmon harvested in the Districts 106 and 108 commercial fisheries originate from lake systems and their tributaries throughout Southeast Alaska, from the sloughs and lakes of the transboundary Stikine River, and from the Canadian Nass and Skeena Rivers (Figure 1). Tagging studies have shown that few stocks from other than the above areas pass through District 106 (Steve Hoffman, Alaska Department of Fish and Game, personal communication). In these studies adult sockeye salmon were tagged in 1982 and 1983 in several Alaskan and Canadian fishing districts to determine migratory pathways and interception rates of various stocks. The majority of terminal area recoveries from fish tagged in District 106 occurred along the northeast coast of Prince of Wales Island and upper Behm Canal. Tags applied in this district were also recovered in Alaskan systems as far south as the U.S./Canada border, and in the Stikine, Nass, and Skeena Rivers. Tags applied in more southern districts were generally not recovered in either the northern Prince of Wales Island lake systems or the Stikine River.

Numerous sockeye salmon producing lakes are scattered throughout the archipelago and mainland of Southeast Alaska. They range in size from small lakes of a few hectares to large systems greater than 500 hectares (e.g., McDonald and Klawock Lakes) and include multi-lake systems like the Sarkar and Galea-Sweetwater complexes (Figure 2). Sockeye salmon production is limited by the quantity and quality of spawning areas, the available rearing area, and other environmental conditions as well as the number of spawners. Sockeye productivity varies greatly, even among systems of roughly equivalent size (McGregor 1983; McGregor et al. 1984; McGregor and McPherson 1985; McPherson and McGregor 1986; and McPherson et al. 1988a, 1988b). Typical small systems, such as Alecks and Kutlaku Lakes on Kuiu Island, produce runs estimated at a few thousand fish. While total run size is not known, escapements into two intermediate systems that had enumeration weirs, Karta Lake on eastern Prince of Wales Island and Salmon Bay Lake on northeast Prince of Wales Island, averaged 18,462 and 18,040 sockeye salmon, respectively (1982 to 1988, excluding 1984 when the weirs were not installed).

The Stikine River is a tranboundary river that originates in British Columbia, crosses the Alaskan panhandle, and flows into Frederick Sound north of Wrangell (Figure 3). Approximately 90% of the river system is inaccessible to anadromous fish due to natural barriers and velocity blocks. The majority of the accessible sockeye spawning habitat is located above the U.S./Canada border. The largest single contributor to the Stikine River sockeye run is the Tahltan Lake group, hereafter referred to as Tahltan. This system has a weir, and sockeye escapement counts have ranged from 1,800 fish in 1963 to 67,300 fish in 1985 and averaged 19,469 (1959 to 1989, excluding 1962 when the weir installation date was unspecified and 1965 when a large land slide hindered access into the lake) (TTC 1990). The remainder of the Stikine River sockeye stocks (the non-Tahltan Stikine stock group) spawn in small lakes, sloughs, and side channels of the mainstem river and its tributaries, most of which are glacially occluded. Non-Tahltan Stikine sockeye escapement estimates have ranged from 13,400 in 1979 to 63,000 in 1985 and averaged 37,400 (1979 to 1989). A Canadian subsistence fishery operating near Telegraph Creek has harvested a yearly average of 3,580 fish (1972 to 1989). Canadian commercial fisheries on the upper and lower river have harvested an average of 600 and 15,170 sockeye, respectively (1980 to 1989, excluding 1984 when both fisheries were closed).

The Nass and Skeena Rivers also contribute substantial numbers of sockeye salmon to the District 106 and 108 harvests in some years. The Nass River originates in British Columbia and drains into Portland Canal just south of the U.S./Canada border. Estimated sockeye escapements to this system have averaged 208,000 from 1980 to 1989. The Skeena River also originates in British Columbia and drains into the ocean about 50 km south of the Nass River. Estimated sockeye escapements have averaged 1,182,000 from 1980 to 1989 (CDFO 1986; NBTC 1990).

Stock Separation Studies

The United States and Canada initiated research programs in 1982 to assess the feasibility of various stock separation techniques applicable to sockeye salmon stocks harvested by both countries. Several methods of stock separation have been used, including: the incidence of the parasite *Myxobolus neurobius*, differences in genotypes, adult tagging studies, and scale pattern analysis. Of these, scale pattern analysis has been used most extensively to determine stock composition of the harvests in Alaskan mixed stock commercial fisheries (Oliver et al. 1984; Oliver and Walls 1985; Oliver and Jensen 1986; Jensen and Frank 1988; Jensen and Frank 1989; Jensen et al. 1989).

Scale pattern analysis has proven highly successful in determining the contribution rates of sockeye stocks to Southeast Alaska's commercial fisheries because of significant and persistent differences in the freshwater and early marine growth among stocks originating in various Alaskan and Canadian systems. The original stock groupings used by ADF&G were the Alaska group (comprised of samples taken from 22 to 28 Alaska escapements), Nass/Skeena group(comprised of samples taken from inriver test fisheries on the Nass and Skeena Rivers), and Stikine River group (comprised of scale samples collected from the Canadian inriver commercial fishery). The stock groupings were expanded in 1983 by creating separate standards for the Tahltan Lake escapement and for the non-Tahltan Stikine escapement (samples from mainstem river and side slough spawners and Chutine, Skud, and Iskut River spawners). Standards were further refined in 1986 to separate two distinct Alaska patterns (Alaska I, typified by Salmon Bay Lake and Hugh Smith Lake patterns and Alaska II, typified by the McDonald Lake pattern).

MATERIALS AND METHODS

Collection and Preparation of Scale Samples

One to three scales were taken from each of 350 sockeye salmon randomly sampled from the commercial catches in Alaska's Subdistricts 106-41 and 106-30 and District 108 during each week the fisheries were open. Stock group standards used in postseason analysis were developed from scales sampled from 1989 escapements and Stikine River inriver test and commercial fisheries. Standards were obtained for: (1) the Alaska I and II groups from approximately 600 scale samples collected from each of 13 lake systems throughout Southeast Alaska (Figure 2), (2) the Nass/Skeena group from 1,177 and 1,248 scales collected from the Nass and Skeena test fisheries, respectively (Figure 1), (3) the Tahltan Stikine group from 830 scales collected at the Tahltan Weir, and scales collected from fish caught in the Lower Stikine commercial and test fisheries (Figure 3) which had small diameter eggs and were not parasitized by the brain parasite *Myxobolus neurobius,* and (4) the non-Tahltan Stikine group from scales collected after 6 August at the lower river commercial fishery from females with large diameter eggs and parasitized by *Myxobolus neurobius.* A total of 3,770 scales were collected from the lower Stikine fisheries. The standards used in the in-season analysis were developed from scales collected in 1987 and 1988 in the same areas as above and also from escapements to tributaries and sloughs along the mainstem of the Stikine River.

Scales were taken from the left side of each fish approximately two rows above the lateral line along a diagonal line between the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). Scales of salmon fry develop first in this area, and thus, for purposes of aging and digitizing, it is the preferred area. Scales were mounted on gum cards and impressions made in cellulose acetate (Clutter and Whitesel 1956).

Age Determination and Measurement of the Scales

A sampling goal of scales from 700 fish per district per week was established for the age composition estimation. Individual fish ages were determined from scale images magnified 70X on a microfiche reader and were recorded in European notation. The sample size used for the scale pattern analysis varied on a weekly basis and was dependent on age composition. Generally, scales from 100 age-1.3 fish and as many scales as possible (up to 100) from each of the age- 1.2, -2.2, and -2.3 groups were analyzed for each district or subdistrict and week. Scale images magnified at 100X were projected onto a digitizing table using equipment similar to that described by Ryan and Christie (1976). Scale measurements were made and recorded with a microcomputer-controlled digitizing system with Fortran programs.

Previous studies have established that an axis approximately perpendicular to the anterior edge of the unsculptured posterior field is best for consistently measuring sockeye scales (Clutter and Whitesel 1956; Narver 1963). This axis is approximately 20° dorsal or ventral from the anterior-posterior axis, and all circuli counts and scale measurements in the lacustrine and first year marine zone were made along it. Marshall et al. (1984) established the separability of major stock groups by measurements in three (or four) zones: (1) the scale center to the last circulus of the first freshwater annulus, (2) when present, the first circuli of the second year of freshwater growth to the end of the second freshwater annulus, (3) the plus growth or scale growth after the last freshwater annulus and before the first marine circulus (Mosher 1968), and (4) the first year marine growth (i.e. the first marine circulus to the end of the first marine annulus) (Figure 4). A total of 74 variables, including circuli counts, incremental distances, and ratios and/or combinations of the measured variables, are calculated for samples with a single freshwater annular zone and 106 variables for samples with two freshwater annular zones.

Analytical Procedures

The ability to differentiate salmon stocks based on scale patterns depends upon the degree of difference in the scale characters among stocks (Marshall et al. 1987). Linear discriminant function (LDF) analysis of scale patterns has been used to estimate stock contributions to southern Southeast Alaska mixed stock sockeye salmon fisheries since 1982 (Oliver et al. 1984; Oliver and Walls 1985; Oliver and Jensen 1986; Jensen and Frank 1988; Jensen and Frank 1989; Jensen et al. 1989).

LDF is a multivariable technique that is used to develop classification rules used to assign a sockeye salmon sampled in a mixed stock fishery to a stock of origin. The variables calculated from the circuli counts and incremental distances on scales from fish of known origin provide a set of measurements used to define these rules. Scale variables are selected based on their ability to differentiate between stocks included in the analysis. Discriminant function analysis derives decision rules based on these variables that are used to determine the stock of an unknown origin fish according to its variable measures. The accuracy of classification of stocks represented by standards depends upon the precision with which the regions defining each stock or group are described and the inherent separation between them. The LDF is the linear combination of the variables which maximizes the between-group variance relative to the within-group variance (Fisher 1936).

Assuming that: (1) the groups being investigated are discrete and identifiable; (2) the parent distributions of the measured variables are multivariate normal; and (3) the variance-covariance matrices for all groups are equal, then LDI provides the best discriminant rule in the sense of minimizing the expected probability of misclassification. Gilbert (1969) found LDF satisfactory if the variance-covariance matrices were not too different from each other. Large sample sizes appear to make the LDF robust to the assumption of common variance-covariance matrices (Issacson 1954; Anas and Murai 1969). While the method is robust to violations of the normality assumption for discrete distributions, it is not robust for continuous non-Gaussian parent distributions (Lachenbruch et al. 1973; Krzanowski 1977).

The 2 to 10 scale variables used in the LDF analysis are selected from among 106 variables using a stepwise regression procedure (Enslein et al. 1977). In this process, variables are added until the partial F-statistic of each variable not yet entered into the model is less than 4.00 and the F- statistic of all variables included is greater than 4.00. An almost unbiased estimate of classification accuracy for each LDF was determined using a leaving-one-out procedure (Lachenbruch 1967). One sample is "left-out", the discriminant rule is estimated, and the "left-out" sample is classified using the discrimination rule and checked to see if it was classified correctly. This procedure is repeated for all samples. Thus, when an LDF is run using the leaving-one-out procedure, a classification matrix is developed which gives the proportion of correctly identified fish and the proportion of misclassification of each stock to each of the other stocks.

When more than two stock groups are being analyzed, the stepwise procedure does not always result in maximum classification accuracies or the most balanced classification matrix. Frequently, well-separated groups are separated even further, while poorly separated groups remain poorly separated (Habbema and Hermans 1977). Scale variables that provided the best discrimination between the groups (high F value) that most often misclassified as each other were occasionally added to, or substituted for, other variables used in the LDF to provide either a better balance to the classification matrix or an increase in the mean classification accuracy.

The estimates of stock composition proportions in the mixed stock harvests, referred to as initial estimates, were adjusted with a classification matrix correction procedure (Cook and Lord 1978). The fish in the mixed stock composition sample are classified with the LDF. The vector of estimates for each stock or stock group is multiplied by the inverse transpose of the classification matrix to give new estimates, referred to as adjusted estimates, for the true proportions of stocks and stock groups in the mixed stock fishery. In cases where adjusted estimated proportions for a stock group were less than zero, the entire catch sample was reclassified with a model excluding that stock group. This process was repeated until all adjusted estimated proportions were positive.

The variance and 90% confidence intervals of the adjusted estimates of stock proportions were computed according to Pella and Robertson (1979). Variance-covariance matrices for the misclassification matrix and the variances for the proportions of each stock are a function of: (1) the sampling variation in estimation of the probability of assignment of the known stock group and (2) the sampling variation in estimation of the assignment composition of the mixed stock group.

Developing Standards

The four major age groups (1.2, 1.3, 2.2, and 2.3) have generally contributed more than 98% of the catch in Districts 106 and 108. Standards were developed for each age class for the Alaska I, Alaska II, and Nass/Skeena groups and for age-1.2, -1.3, and -2.3 fish for the Tahltan group. Non-Tahltan Stikine standards were developed for age-1.2 and -1.3 fish only. Standards were not developed for age classes which contributed only a minor fraction of the escapement for a given stock or stock group since sample sizes were insufficient to build them. Age-specific models, where standards from age-1.3 fish were used to classify catches of age-1.3 fish, were used in the analysis to: (1) account for differences in age composition among stocks, (2) remove potential bias due to differences in migratory timing of different age fish, and (3) eliminate the effects of different environmental conditions on the scale patterns of different age fish.

Classification of Catches

Commercial catches are analyzed in-season with standards developed from the previous year's escapements. Stock contributions for the Subdistrict 106-41 and 106-30 and the District 108 commercial harvests were estimated and summaries provided to managers within 48 h of the fishery closures from mid-June through early August. Only the 1.3 age group was analyzed in-season due to time constraints. The three remaining age groups (1.2, 2.2, and 2.3) were digitized and analyzed postseasonally. Stock compositions of the Canadian commercial catches were not estimated by scale pattern analysis. The U.S. commercial catches were reclassified postseasonally with standards built from the 1989 escapements and catches from the Canadian Stikine commercial catches.

Stock contributions were estimated for each week to track temporal patterns; however, in some weeks catches were small and samples of the less common age groups were insufficient to classify unless pooled with the adjacent week's sample. The proportion of each stock in a week's catch sample was expanded to the week's catch by:

$$C_{ijt} = C_t * P_{it} * S_{ijt} \qquad (1)$$

where:

- C_{ijt} = Catch of fish of age i and group j in time period t,
- C_t = total catch in time period t,
- P_{it} = estimated proportion of fish of age i in the catch in time period t, and
- S_{ijt} = proportion of age i fish in the catch that belong to group j in time period t as estimated with LDF.

The stock apportionment of the minor age groups not classified with LDF assumes that the proportion of the minor ages belonging to any given stock is equal to the combined proportion of all LDF classified age classes:

$$C_{mjt} = C_t * P_{mt} * S_{jt} \qquad (2)$$

where:

- C_{mjt} = estimated catch of fish of minor age classes of group j in time period t,
- P_{mt} = estimated proportion of fish of minor age groups in the catch in time period t, and
- S_{jt} = proportion of fish of all classified age groups estimated with LDF to be in group j during time period t.

The variances (V) of the weekly (C_{ijt}) and seasonal (C_{ij}) stock composition estimates were approximated with the delta method (Seber 1982). The variance estimates are functions of: (1) the age-specific models used to classify the unknowns, (2) the sample size of each standard used to develop the age-specific models, (3) the proportions of each stock in the initial and in the adjusted stock composition estimates, (4) the age-specific stock composition sample sizes, (5) the age composition sample sizes, and (6) the catch size. However, it is a minimum estimate of variance since it does not include any variance associated with estimates for age classes not classified with LDF, any variance for stocks contributing no fish during a given week, nor any variance due to aging errors.

Variances of the proportions of stock contributions were calculated by

$$V(P_j) = P_j^2 * \left(\frac{V(C_j)}{C_j^2} + \frac{V(C.)}{C.^2}\right)$$

where:

P_j = Proportion of stock j or C_j/C

Comparison of In- and Postseason Estimates

Adjusted in-season and postseason weekly stock composition estimates for Subdistricts 106-41 and 106-30, and District 108 were compared to test whether the in-season estimates differed significantly from the postseason estimates for each fishery. The actual numbers of fish in the sample which were classified to each group in the in-season analysis were compared to those in the postseason analysis. Only the ages done in-season were compared; however, in some weeks time was insufficient to digitize a full sample in-season and, thus, the number of fish used in the postseason analysis was larger than that used in-season. Data were set up in a standard contingency table format and tested with the G statistic (log-likelihood ratio test) (Zar 1984).

RESULTS

Stock Composition of the Subdistrict 106-30 Catch

Stock composition by age-class was estimated for the Subdistrict 106-30 sockeye salmon harvest (Appendix A.1). Of the 84,848 sockeye harvested in the drift gill net fishery in 1989, 66.2% were of Alaska I and Alaska II origin, 32.2% were of Nass/Skeena origin, and 1.7% were of transboundary Stikine River origin. Maximum harvests occurred in mid to late-July (statistical weeks 29 and 30). The Alaska I stocks dominated the first two weeks of the fishery (statistical weeks 25 and 26) with 46% of the catch, while the Alaska II stocks dominated the catch from early July through mid-August with 50% of the catch. The Nass/Skeena group dominated the catch during one open period in early July (statistical week 28) and contributed 48% of the catch during mid-August through mid-September. The Tahltan and non-Tahltan Stikine groups contributed only 0.2% and 1.5% of the total catch. The Tahltan fish were not present after mid-July. Migratory timing based on CPUE for each stock is presented in Appendix A.2.

Stock Composition of the Subdistrict 106-41 Catch

Stock composition by age-class was estimated for the Subdistrict 106-41 sockeye salmon harvest (Appendix A.3). Of the 107,886 sockeye harvested in the drift gill net fishery in 1989, 65.3% were of Alaska I and Alaska II origin, 30.3% were of Nass/Skeena origin, and 4.5% were of transboundary Stikine River origin. Maximum harvests occurred in mid to late-July (statistical weeks 29 and 30). The Alaska I stocks dominated the second two weeks of the fishery (statistical weeks 26 and 27) with 33% of the catch, while the Alaska II stocks dominated the catch in early and late July and in mid-August with 45%, 57% and 52% of the catch, respectively. The Nass/Skeena group dominated the catch during one open period in early July (statistical week 27) at 32% and contributed 46% of the catch during mid-August through mid-September. The Tahltan fish were present only during the first two weeks of the fishery and contributed 0.2% of the total catch. The non-Tahltan Stikine groups contributed only 1.5% of the total catch but were present in low abundance throughout the fishery. Migratory timing based on CPUE for each stock is presented in Appendix A.4.

Stock Composition of the District 108 Catch

Stock composition by age-class was estimated for the District 108 sockeye salmon harvest (Appendix A.5). Of the 10,083 sockeye salmon harvested in the District 108 drift gill net fishery, 11.7% were of Alaska I and Alaska II origin, 5.4% were of Nass/Skeena origin, and 82.9% were of transboundary Stikine River origin. The non-Tahltan Stikine group was the most abundant group present throughout the fishery and contributed 79.5% of the total catch. Migratory timing based on CPUE for each stock is presented in Appendix A.6.

Comparison of In-season and Postseason Analysis

The in-season stock composition estimates were compared with the postseason estimates (Table 1; Appendix B). Only age-1.3 fish were analyzed in-season, due to time constraints, so the comparison is for this age class only.

The in-season stock composition estimates were significantly different from the postseason estimates (log-likelihood ratio analysis with $\alpha = 0.05$) in all weeks in Subdistricts 106-30, and 106-40, and District 108 (Table 1). In Subdistrict 106-30 the in-season analysis indicated a greater relative abundance of the Alaska I group and lower relative abundance of the Alaska II and Nass/Skeena groups than the postseason analysis for all weeks (Appendix B.1.). The in-season analysis also appeared to underestimate the abundance of the Stikine group during the two weeks (28 and 29) this group was detected in the analysis. The Tahltan group was not detected during any week in the in-season analysis and was detected only during week 28 in the postseason analysis.

In Subdistrict 106-41 the differences between the in-season and postseason stock composition analyses were similar to those for Subdistrict 106-30. As in Subdistrict 106-30, the in-season estimates of the Alaska I group were higher, and of the Alaska II group were lower than the postseason estimates (Appendix B.2.). The in-season relative abundance was lower than for the postseason analysis for the Tahltan group in weeks 25 to 27 and for the Stikine group in weeks 26 and 27, and was greater for the Stikine group in weeks 25 and 28.

In District 108, the in-season estimates were higher than the postseason estimates for Alaska I group in week 25 and combined weeks 30 to 36, and for the Alaska II group in all weeks (Appendix B.3.). The in-season estimates were lower than the postseason estimates for the Tahltan group in weeks 25 to 28 and combined weeks 30 to 36, for the Stikine group in all weeks.

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Table. 1. Log-likelihood (G) values for the comparison of weekly in-season and postseason stock composition estimates for sockeye salmon harvested in Alaska's Subdistricts 106-30 and 106-41 and District and 108 commercial gill net fisheries, 1989.

Stat. Week	Dates	G	P	Reject Ho[a]
106-30	Critical Value = 9.488			
25	6/18-6/24	65.415	P < 0.001	yes
26	6/25-7/01	91.216	P < 0.001	yes
27	7/02-7/08	93.257	P < 0.001	yes
28	7/09-7/15	70.601	P < 0.001	yes
29	7/16-7/22	199.761	P < 0.001	yes
30	7/23-7/29	83.558	P < 0.001	yes
Season Total		731.926	P < 0.001	yes
106-41	Critical Value = 9.488			
25	6/18-6/24	98.166	P < 0.001	yes
26	6/25-7/01	29.032	P < 0.001	yes
27	7/02-7/08	-66.559	P < 0.001	yes
28	7/09-7/15	117.073	P < 0.001	yes
29	7/16-7/22	24.666	P < 0.001	yes
30	7/23-7/29	73.366	P < 0.001	yes
Season Total		478.157	P < 0.001	yes
108	Critical Value = 9.488			
Season Total		134.059	P < 0.001	yes

[a]Ho: The stock composition estimates are independent of the type of analysis (i.e. in-season or postseason).

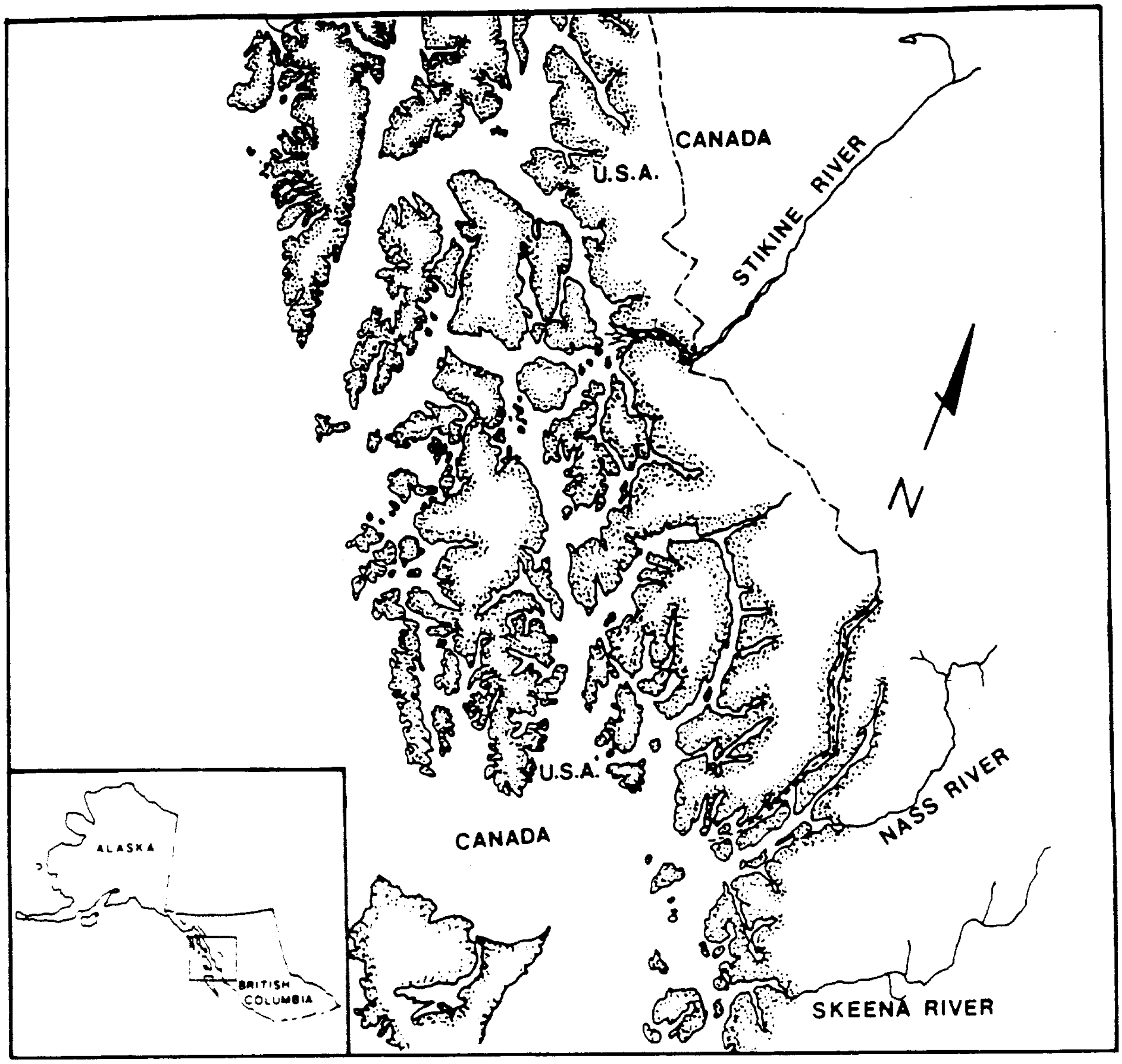

Figure 1. Southeast Alaska, northern British Columbia, and the transboundary Stikine River.

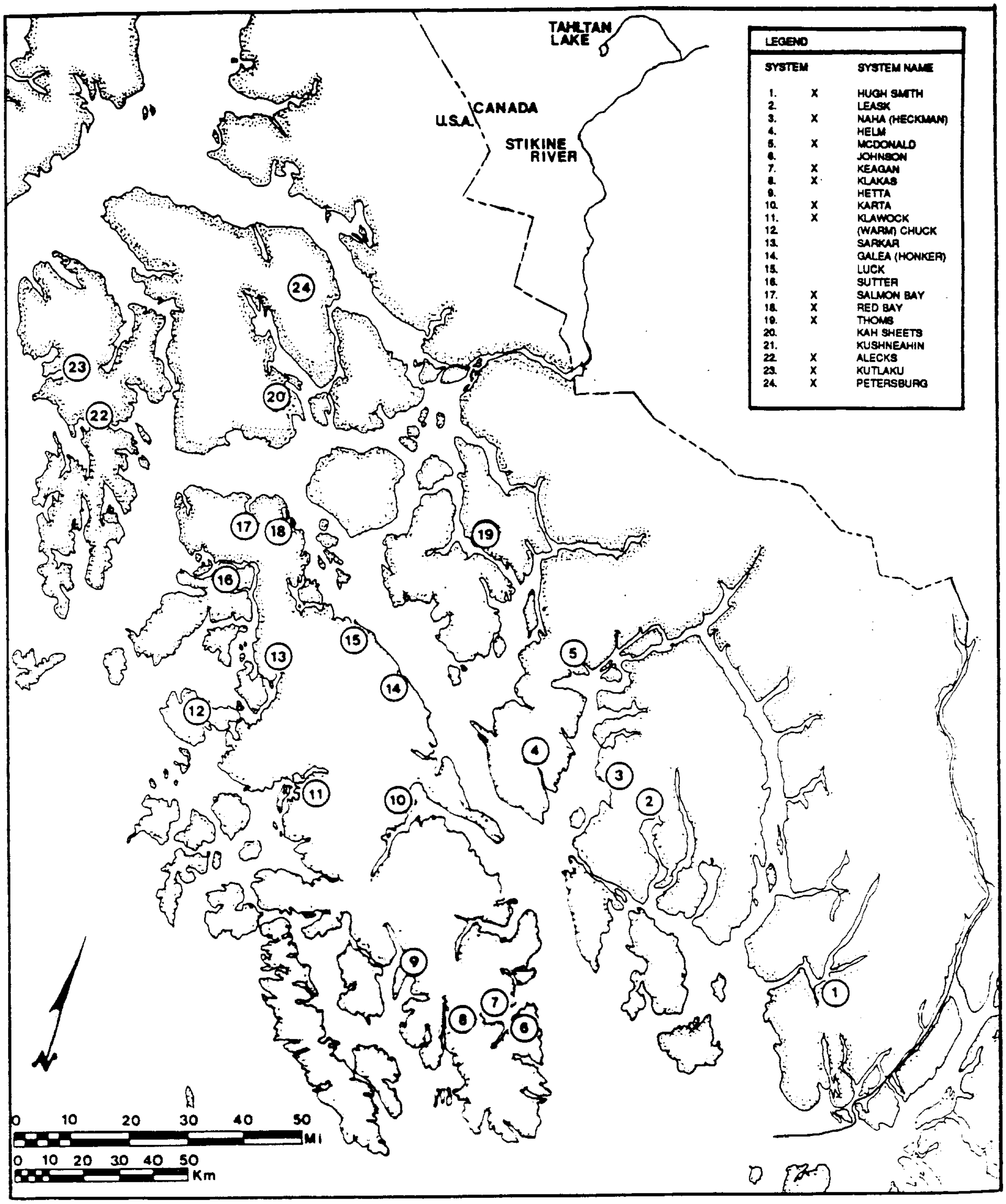

Figure 2. Major sockeye salmon systems of Southeast Alaska. Numbers identify major sockeye producing lakes where scale samples have been collected and x indicates systems where scales were collected in 1989.

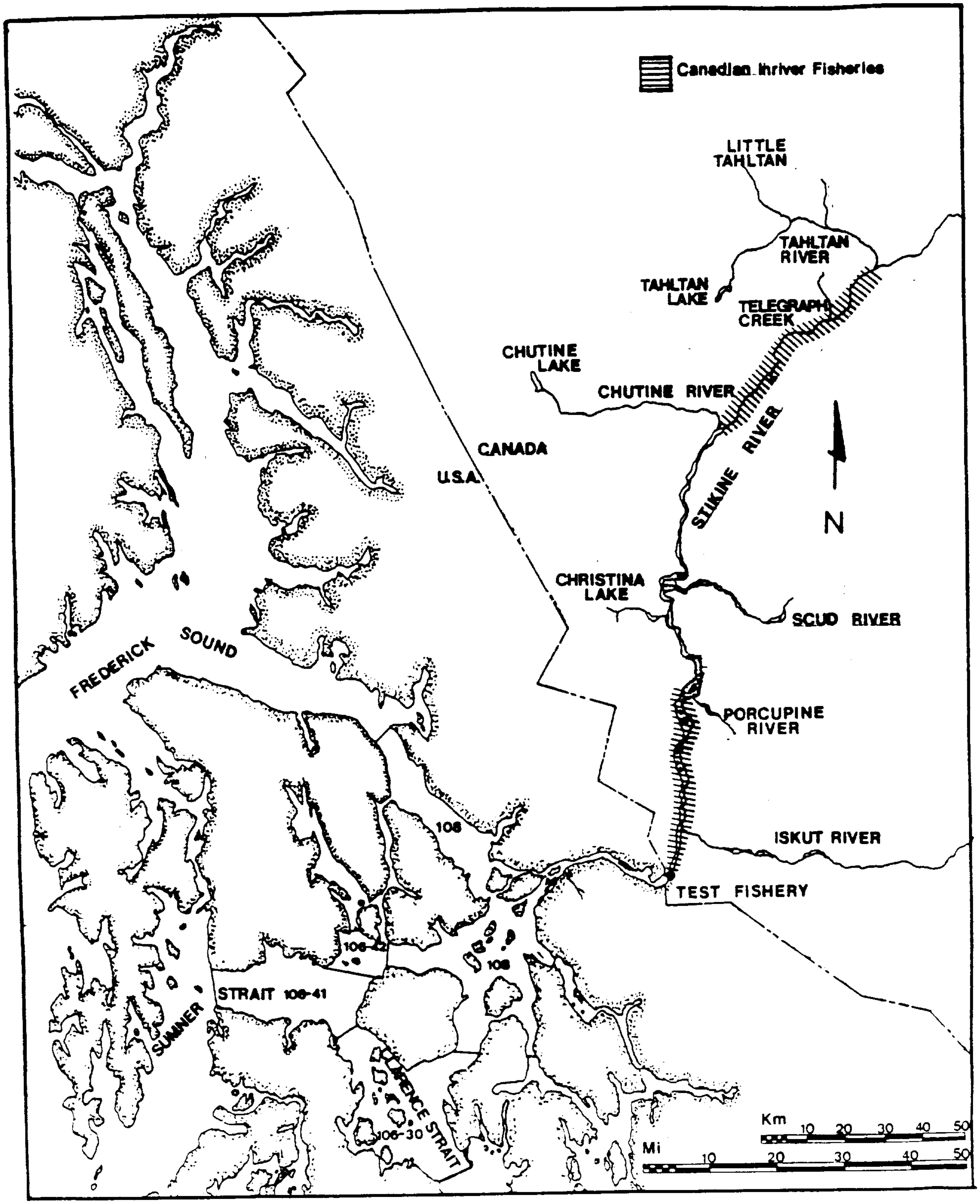

Figure 3. The transboundary Stikine River with its major tributaries and associated fishery areas.

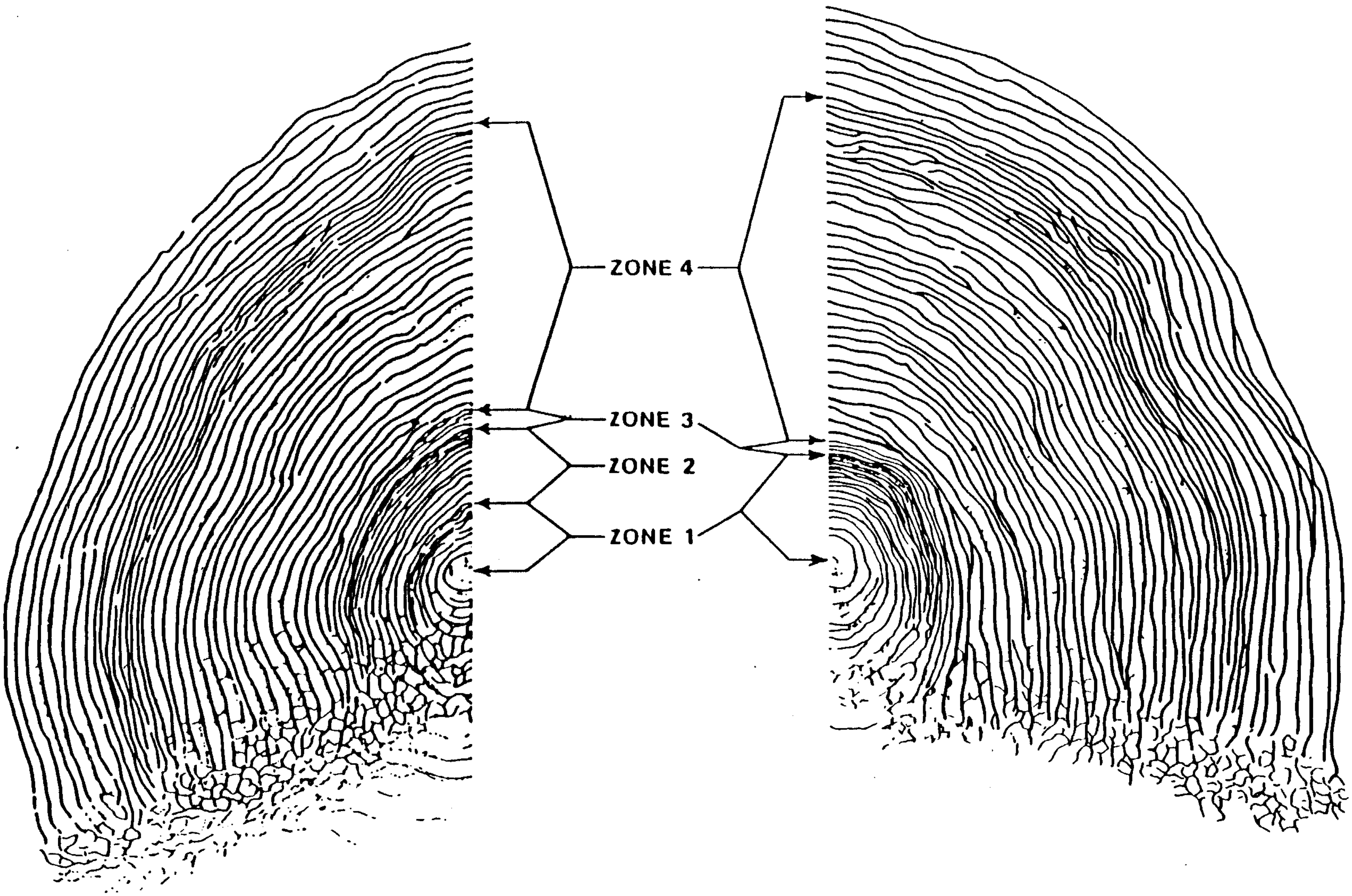

Figure 4. Typical scale for age 2. and 1. sockeye salmon with zones used for scale pattern analysis delineated.

APPENDICES

Appendix A.1. Estimated contributions of sockeye salmon stocks originating in Alaska and Canada to Alaska's Subdistrict 106-30 drift gill net fishery, 1989.

		Catch By Age Class								90% C.I.*	
Dates	Group	1.2	1.3	2.2	2.3	Other	Total	Percent	Standard Error*	Lower	Upper
6/18-6/24	Ak. I	38	392	47	102	24	603	50.8	136.3	379	827
Week 25	Ak. II	0	168	0	0	7	175	14.7	567.2	0	1,108
	Nas/Ske	9	167	88	66	14	344	29.0	67.9	0	456
	Tahltan	0	26	0	0	1	27	2.3	44.5	0	100
	Stikine	37	0	0	0	2	39	3.3	13.8	16	62
	Total	84	753	135	168	48	1,188				
6/25-7/01	Ak. I	87	487	46	122	13	755	42.6	192.4	439	1,071
Week 26	Ak. II	0	380	0	0	6	386	21.8	748.7	0	1,618
	Nas/Ske	21	313	124	78	10	546	30.8	92.0	0	697
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	86	0	0	0	1	87	4.9	40.7	0	154
	Total	194	1,180	170	200	30	1,774				
7/02-7/08	Ak. I	106	229	80	229	5	649	26.0	270.5	204	1,094
Week 27	Ak. II	0	908	0	0	7	915	36.6	756.2	0	2,159
	Nas/Ske	25	535	138	62	5	765	30.6	129.5	552	978
	Tahltan	0	0	0	13	0	13	0.5	26.5	0	57
	Stikine	104	0	0	53	1	158	6.3	45.8	83	233
	Total	235	1,672	218	357	18	2,500				
7/09-7/15	Ak. I	724	1,989	418	824	14	3,969	22.6	2128.4	468	7,470
Week 28	Ak. II	0	5,913	0	0	21	5,934	33.7	1557.9	3,371	8,497
	Nas/Ske	600	5,416	865	222	24	7,127	40.5	1323.8	4,949	9,305
	Tahltan	0	67	0	47	0	114	0.6	804.7	0	1,438
	Stikine	203	54	0	190	2	449	2.6	863.5	0	1,870
	Total	1,527	13,439	1,283	1,283	61	17,593				
7/16-7/22	Ak. I	465	0	297	1,675	0	2,437	12.2	612.9	1,429	3,445
Week 29	Ak. II	0	13,160	0	0	0	13,160	66.1	2478.0	9,084	17,236
	Nas/Ske	386	2,676	614	497	0	4,173	21.0	891.0	2,707	5,639
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	130	0	0	0	0	130	0.7	391.9	0	775
	Total	981	15,836	911	2,172	0	19,900				
7/23-7/29	Ak. I	501	1,713	420	1,109	11	3,754	20.0	2411.5	0	7,721
Week 30	Ak. II	0	9,260	0	0	28	9,288	49.5	1944.3	6,090	12,486
	Nas/Ske	565	3,796	853	329	16	5,559	29.6	1022.5	3,877	7,241
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	151	0	0	0	0	151	0.8	171.5	0	433
	Total	1,217	14,769	1,273	1,438	55	18,752				
7/30-8/05	Ak. I	414	0	361	867	0	1,642	15.0	396.9	989	2,295
Week 31	Ak. II	0	5,227	0	0	0	5,227	47.6	2112.0	1,753	8,701
	Nas/Ske	465	2,437	383	695	0	3,980	36.3	544.9	0	4,876
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	125	0	0	0	0	125	1.1	308.6	0	633
	Total	1,004	7,664	744	1,562	0	10,974				
8/06-8/12	Ak. I	258	0	190	480	13	941	14.3	301.7	445	1,437
Week 32	Ak. II	0	3,430	0	0	49	3,479	53.0	154.2	3,225	3,733
	Nas/Ske	515	697	471	386	29	2,098	31.9	357.2	1,510	2,686
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	48	0	0	0	1	49	0.7	82.8	0	185
	Total	821	4,127	661	866	92	6,567				
8/13-9/23	Ak. I	231	0	181	589	3	1,004	17.9	220.9	641	1,367
Wks 33-38	Ak. II	0	1,844	0	0	5	1,849	33.0	265.1	1,413	2,285
	Nas/Ske	462	1,420	395	419	8	2,704	48.3	305.1	2,202	3,206
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	43	0	0	0	0	43	0.8	156.5	0	300
	Total	736	3,264	576	1,008	16	5,600				
	Ak. I	2,824	4,810	2,040	5,997	83	15,754	18.6	3306.3	10,315	21,193
	Ak. II	0	40,290	0	0	123	40,413	47.6	4284.4	33,365	47,461
Season	Nas/Ske	3,048	17,457	3,931	2,754	106	27,296	32.2	1990.1	24,022	30,570
Totals	Tahltan	0	93	0	60	1	154	0.2	805.9	0	1,480
	Stikine	927	54	0	243	7	1,231	1.5	984.4	0	2,850
	Total	6,799	62,704	5,971	9,054	320	84,848				

* The standard errors are minimum estimates since no estimates of the variance for stocks contributing 0 fish during a given week or for the 'other' age class are available. The 90% confidence intervals are affected in a like manner.

Appendix A.2. Estimated CPUE and migratory timing of sockeye salmon stocks in Alaska's Subdistrict 106-30 drift gill net fishery, 1989.

CPUE

Stat Week	Days Open	Average Number Boats	Catch per Boat Day					
			Ak. I	Ak. II	Nas/Ske	Tahltan	Stikine	Total
25	2	20	15	4	9	1	1	30
26	2	28	13	7	10	0	2	32
27	2	25	13	18	15	0	3	50
28	3	37	36	53	64	1	4	158
29	3	43	19	102	32	0	1	154
30	3	86	15	36	22	0	1	73
31	3	63	9	28	21	0	1	58
32	3	55	6	21	13	0	0	40
33-38	3	42	8	15	21	0	0	44
Total			133	284	207	2	13	639

Migratory Timing

Stat Week	Proportion of Catch per Boat Day					
	Ak. I	Ak. II	Nas/Ske	Tahltan	Stikine	Total
25	0.11	0.02	0.04	0.34	0.08	0.05
26	0.10	0.02	0.05	0.00	0.12	0.05
27	0.10	0.06	0.07	0.13	0.25	0.08
28	0.27	0.19	0.31	0.52	0.32	0.25
29	0.14	0.36	0.16	0.00	0.08	0.24
30	0.11	0.13	0.10	0.00	0.05	0.11
31	0.07	0.10	0.10	0.00	0.05	0.09
32	0.04	0.07	0.06	0.00	0.02	0.06
33-38	0.06	0.05	0.10	0.00	0.03	0.07
Total	1.00	1.00	1.00	1.00	1.00	1.00

Appendix A.3. Estimated contributions of sockeye salmon stocks originating in Alaska and Canada to Alaska's Subdistrict 106-41,42 drift gill net fishery, 1989.

Dates	Group	Catch By Age Class 1.2	1.3	2.2	2.3	Other	Total	Percent	Standard Error*	90% C.I.* Lower	Upper
6/18-6/24 Week 25	Ak. I	211	428	29	245	12	925	18.3	560.0	4	1,846
	Ak. II	0	1,523	0	0	21	1,544	30.6	567.2	0	2,477
	Nas/Ske	138	1,482	374	91	29	2,114	41.9	365.9	0	2,716
	Tahltan	0	78	0	83	2	163	3.2	229.5	0	540
	Stikine	87	212	0	0	4	303	6.0	246.3	0	708
	Total	436	3,723	403	419	68	5,049				
6/25-7/01 Week 26	Ak. I	299	1,881	120	278	45	2,623	37.7	826.3	1,264	3,982
	Ak. II	0	927	0	0	16	943	13.6	748.7	0	2,175
	Nas/Ske	196	1,383	380	103	36	2,098	30.2	491.1	0	2,906
	Tahltan	0	487	0	95	10	592	8.5	352.9	11	1,173
	Stikine	124	561	0	0	12	697	10.0	366.2	95	1,299
	Total	619	5,239	500	476	119	6,953				
7/02-7/08 Week 27	Ak. I	360	1,142	144	478	35	2,159	29.2	833.4	788	3,530
	Ak. II	0	1,478	0	0	24	1,502	20.3	756.2	258	2,746
	Nas/Ske	236	1,444	457	176	39	2,352	31.8	386.2	1,717	2,987
	Tahltan	0	36	0	163	3	202	2.7	308.6	0	710
	Stikine	149	1,019	0	0	19	1,187	16.0	433.1	475	1,899
	Total	745	5,119	601	817	120	7,402				
7/09-7/15 Week 28	Ak. I	725	0	810	1,240	67	2,842	11.9	1604.6	202	5,482
	Ak. II	0	10,571	0	0	255	10,826	45.4	1557.9	8,263	13,389
	Nas/Ske	965	6,882	800	211	215	9,073	38.1	1241.3	7,031	11,115
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	0	899	0	159	26	1,084	4.5	1313.4	0	3,244
	Total	1,690	18,352	1,610	1,610	563	23,825				
7/16-7/22 Week 29	Ak. I	754	9,092	581	820	25	11,272	54.5	2856.5	6,573	15,971
	Ak. II	0	5,328	0	0	12	5,340	25.8	2478.0	1,264	9,416
	Nas/Ske	1,004	2,231	575	139	9	3,958	19.1	1151.2	2,064	5,852
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	0	0	0	105	0	105	0.5	357.5	0	693
	Total	1,758	16,651	1,156	1,064	46	20,675				
7/23-7/29 Week 30	Ak. I	288	1,022	610	1,425	0	3,345	21.1	2095.4	0	6,792
	Ak. II	0	9,052	0	0	0	9,052	57.2	1944.3	5,854	12,250
	Nas/Ske	588	2,241	163	369	0	3,361	21.2	720.7	2,175	4,547
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	0	0	0	61	0	61	0.4	173.9	0	347
	Total	876	12,315	773	1,855	0	15,819				
7/30-8/05 Week 31	Ak. I	642	6,324	747	1,411	29	9,153	51.0	2406.4	5,194	13,112
	Ak. II	0	2,998	0	0	9	3,007	16.8	2112.0	0	6,481
	Nas/Ske	1,308	3,616	200	366	17	5,507	30.7	1058.2	0	7,248
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	0	210	0	61	1	272	1.5	956.9	0	1,846
	Total	1,950	13,148	947	1,838	56	17,939				
8/06-8/12 Week 32	Ak. I	120	0	155	299	0	574	14.3	364.0	0	1,173
	Ak. II	0	2,073	0	0	0	2,073	51.6	353.3	1,492	2,654
	Nas/Ske	367	499	203	257	0	1,326	33.0	167.1	1,051	1,601
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	0	0	0	45	0	45	1.1	316.7	0	566
	Total	487	2,572	358	601	0	4,018				
8/13-9/23 Wks 33-38	Ak. I	205	118	169	510	5	1,007	16.2	911.8	0	2,507
	Ak. II	0	2,237	0	0	12	2,249	36.2	265.1	1,813	2,685
	Nas/Ske	624	1,577	220	438	15	2,874	46.3	326.9	2,336	3,412
	Tahltan	0	0	0	0	0	0	0.0			
	Stikine	0	0	0	76	0	76	1.2	128.3	0	287
	Total	829	3,932	389	1,024	32	6,206				
Season Totals	Ak. I	3,604	20,007	3,365	6,706	218	33,900	31.4	4814.2	25,981	41,819
	Ak. II	0	36,187	0	0	349	36,536	33.9	4284.4	29,488	43,584
	Nas/Ske	5,426	21,355	3,372	2,150	360	32,663	30.3	2223.1	29,006	36,320
	Tahltan	0	601	0	341	15	957	0.9	516.2	108	1,806
	Stikine	360	2,901	0	507	62	3,830	3.6	1762.1	0	6,729
	Total	9,390	81,051	6,737	9,704	1,004	107,886				

* The standard errors are minimum estimates since no estimates of the variance for stocks contributing 0 fish during a given week or for the 'other' age class are available. The 90% confidence intervals are affected in a like manner.

Appendix A.4. Estimated CPUE and migratory timing of sockeye salmon stocks in Alaska's Subdistrict 106-41,42 drift gill net fishery, 1989.

CPUE

Stat Week	Days Open	Average Number Boats	Catch per Boat Day Ak. I	Ak. II	Nas/Ske	Tahltan	Stikine	Total
25	2	55	8	14	19	1	3	0
26	2	68	19	7	15	4	5	51
27	2	57	19	13	21	2	10	65
28	3	55	17	66	55	0	7	144
29	3	64	59	28	21	0	1	108
30	3	60	19	50	19	0	0	88
31	3	65	47	15	28	0	1	92
32	3	37	5	19	12	0	0	36
33-38	3	37	9	20	26	0	1	56
34								
Total			202	232	216	8	28	640

Migratory Timing

Stat Week	Proportion of Catch per Boat Day Ak. I	Ak. II	Nas/Ske	Tahltan	Stikine	Total
25						
26	0.10	0.03	0.07	0.57	0.18	0.08
27	0.09	0.06	0.10	0.23	0.37	0.10
28	0.09	0.28	0.26	0.00	0.23	0.23
29	0.29	0.12	0.10	0.00	0.02	0.17
30	0.09	0.22	0.09	0.00	0.01	0.14
31	0.23	0.07	0.13	0.00	0.05	0.14
32	0.03	0.08	0.06	0.00	0.01	0.06
33-38	0.04	0.09	0.12	0.00	0.02	0.09
34						
Total	0.96	0.94	0.91	0.81	0.90	1.00

Appendix A.5. Estimated contributions of sockeye salmon stocks originating in Alaska and Canada to Alaska's District 108 drift gill net fishery, 1989.

Dates	Group	Catch By Age Class 1.2	1.3	2.2	2.3	0.+	Other	Total	Percent	Standard Error[a]	90% C.I.[a] Lower	Upper
6/18-7/01 Wks 25-26	Ak. I	9	22	9	5	0	0	45	10.1	29.5	0	93
	Ak. II	0	30	0	0	0	0	30	6.7	29.0	0	78
	Nas/Ske	4	71	14	8	0	0	97	21.7	28.5	0	144
	Tahltan	5	105	0	1	0	0	111	24.8	24.7	70	152
	Stikine	9	71	0	16	68	0	164	36.7	21.9	128	200
	Total	27	299	23	30	68	0	447				
7/02-7/08 Week 27	Ak. I	---------------------Fishery Closed-------------------										
	Ak. II											
	Nas/Ske											
	Tahltan											
	Stikine											
	Total											
7/09-7/15 Week 28	Ak. I	106	0	32	25	0	0	163	3.7	55.7	71	255
	Ak. II	0	395	0	0	0	0	395	9.0	222.9	28	762
	Nas/Ske	43	108	50	43	0	0	244	5.6	164.0	0	514
	Tahltan	50	119	0	8	0	0	177	4.0	137.5	0	403
	Stikine	99	2,140	0	86	1,069	0	3,394	77.6	266.5	2,956	3,832
	Total	298	2,762	82	162	1,069	0	4,373				
7/16-7/22 Week 29	Ak. I	63	0	15	12	0	0	90	2.5	76.4	0	216
	Ak. II	0	178	0	0	0	0	178	5.0	198.3	0	504
	Nas/Ske	26	36	23	20	0	0	105	3.0	126.1	0	312
	Tahltan	30	0	0	4	0	0	34	1.0	119.2	0	230
	Stikine	60	2,189	0	41	844	0	3,134	88.5	256.5	2,712	3,556
	Total	179	2,403	38	77	844	0	3,541				
7/23-7/29 Wks 30-38	Ak. I	26	0	18	6	0	0	50	2.9	86.5	0	192
	Ak. II	0	229	0	0	0	0	229	13.3	97.4	69	389
	Nas/Ske	11	49	28	11	0	0	99	5.7	102.3	0	267
	Tahltan	12	5	0	2	0	0	19	1.1	81.3	0	153
	Stikine	25	941	0	21	338	0	1,325	76.9	146.1	0	1,565
	Total	74	1,224	46	40	338	0	1,722				
Season Totals	Ak. I	204	22	74	48	0	0	348	3.5	96.6	189	507
	Ak. II	0	832	0	0	0	0	832	8.5	315.2	313	1,351
	Nas/Ske	84	264	115	82	0	0	545	5.4	216.6	189	901
	Tahltan	97	229	0	15	0	0	341	3.4	188.1	32	650
	Stikine	193	5,341	0	164	2,319	0	8,017	79.5	385.3	0	8,651
	Total	578	6,688	189	309	2,319	0	10,083				

[a] The standard errors are minimum estimates since no estimates of the variance for stocks contributing 0 fish during a given week or for the 'other' age class are available. The 90% confidence intervals are affected in a like manner.

Appendix A.6. Estimated CPUE and migratory timing of sockeye salmon stocks in Alaska's District 108 drift gill net fishery, 1989.

CPUE

Stat Week	Days Open	Average Number Boats	Catch per Boat Day					
			Ak. I	Ak. II	Nas/Ske	Tahltan	Stikine	Total
25								
25-26	2	9	3	2	5	6	9	25
27	FISHERY CLOSED							
28	3	7	8	19	12	8	162	208
29	3	12	3	5	3	1	87	98
30-36	3	8	2	10	4	1	55	72
Total			15	35	24	16	313	403

Migratory Timing

Stat Week	Proportion of Catch per Boat Day					
	Ak. I	Ak. II	Nas/Ske	Tahltan	Stikine	Total
25						
25-26	0.17	0.05	0.22	0.38	0.03	0.06
27	FISHERY CLOSED					
28	0.52	0.54	0.48	0.52	0.52	0.52
29	0.17	0.14	0.12	0.06	0.28	0.24
30-36	0.14	0.27	0.17	0.05	0.18	0.18
Total	1.00	1.00	1.00	1.00	1.00	1.00

Appendix B.1. Differences between in-season and postseason stock composition estimates for Alaska's Subdistrict 106-30 sockeye harvest, 1989.[a]

Stat. Week	Group	In-Season	Post Season	Change
6/18-6/24	Alaska I	100.0	52.0	-48.00
Week 25	Alaska II	0.0	22.3	22.30
	Nas/Ske	0.0	22.2	22.20
	Tahltan	0.0	3.5	3.50
	Stikine	0.0	0.0	0.00
6/25-7/01	Ak. I	100.0	41.3	-58.70
Week 26	Ak. II	0.0	32.2	32.20
	Nas/Ske	0.0	26.5	26.50
	Tahltan	0.0	0.0	0.00
	Stikine	0.0	0.0	0.00
7/02-7/08	Ak. I	75.9	13.7	-62.20
Week 27	Ak. II	24.1	54.3	30.20
	Nas/Ske	0.0	32.0	32.00
	Tahltan	0.0	0.0	0.00
	Stikine	0.0	0.0	0.00
7/09-7/15	Ak. I	67.9	14.8	-53.10
Week 28	Ak. II	15.2	44.0	28.80
	Nas/Ske	4.7	40.3	35.60
	Tahltan	0	0.5	0.50
	Stikine	12.2	0.4	-11.80
7/16-7/22	Ak. I	79.5	0.0	-79.50
Week 29	Ak. II	3.2	83.1	79.90
	Nas/Ske	0.0	16.9	16.90
	Tahltan	0.0	0.0	0.00
	Stikine	17.3	0.0	-17.30
7/23-7/29	Ak. I	70.0	11.6	-58.40
Week 30	Ak. II	30.0	62.7	32.70
	Nas/Ske	0.0	25.7	25.70
	Tahltan	0.0	0.0	0.00
	Stikine	0.0	0.0	0.00
	Ak. I	74.0	10.7	-63.29
Fishery	Ak. II	15.5	66.2	50.75
Total	Nas/Ske	1.3	22.7	21.41
	Tahltan	0.0	0.2	0.21
	Stikine	9.2	0.1	-9.07

[a] For age-1.3 fish only.

Appendix B.2. Differences between in-season and postseason stock composition estimates for Alaska's Subdistrict 106-41 sockeye harvest, 1989.[a]

Stat. week	Group	In-Season	Post Season	Change
6/18-6/24	Alaska I	81.0	11.5	-69.5
Week 25	Alaska II	8.3	40.8	32.5
	Nas/Ske	1.7	39.8	38.1
	Tahltan	0.0	2.2	2.2
	Stikine	9.0	5.7	-3.3
6/25-7/01	Ak. I	83.0	36.0	-47.0
Week 26	Ak. II	9.9	17.7	7.8
	Nas/Ske	2.0	26.4	24.4
	Tahltan	0.0	9.3	9.3
	Stikine	5.1	10.6	5.5
7/02-7/08	Ak. I	89.4	22.4	-67.0
Week 27	Ak. II	0.0	28.9	28.9
	Nas/Ske	0.0	28.2	28.2
	Tahltan	0.0	0.6	0.6
	Stikine	10.6	19.9	9.3
7/09-7/15	Ak. I	63.8	0.0	-63.8
Week 28	Ak. II	7.7	57.7	50.0
	Nas/Ske	5.0	37.5	32.5
	Tahltan	0.0	0.0	0.0
	Stikine	23.5	4.8	-18.7
7/16-7/22	Ak. I	85.7	54.6	-31.1
Week 29	Ak. II	14.3	32.0	17.7
	Nas/Ske	0.0	13.4	13.4
	Tahltan	0.0	0.0	0.0
	Stikine	0.0	0.0	0.0
7/23-7/29	Ak. I	74.3	8.3	-66.0
Week 30	Ak. II	25.7	73.5	47.8
	Nas/Ske	0.0	18.2	18.2
	Tahltan	0.0	0.0	0.0
	Stikine	0.0	0.0	0.0
	Ak. I	76.7	22.1	-54.6
Fishery	Ak. II	12.7	47.0	34.3
Total	Nas/Ske	1.8	25.5	23.7
	Tahltan	0.0	1.0	1.0
	Stikine	8.9	4.4	-4.5

[a] For age 1.3 fish only.

Appendix B.3. Differences between in- and postseason stock composition estimates for Alaska's Alaska's 108 sockeye harvest, 1989.[a]

Stat. Week	Group	In-Season	Post Season	Change
6/18-7/01	Alaska I	55.2	7.4	-47.80
Wks 25-26	Alaska II	14.3	10.2	-4.10
	Nass/Skeena	16.0	23.6	7.60
	Tahltan	0.0	35.0	35.00
	Stikine	14.5	23.8	9.30
7/09-7/15	Ak. I	9.6	14.3	4.70
Week 28	Ak. II	30.0	3.9	-26.10
	Nas/Ske	0.0	0.0	0.00
	Tahltan	0.0	4.3	4.30
	Stikine	60.4	77.5	17.10
7/16-7/22	Ak. I	0.0	0.0	0.00
Week 29	Ak. II	44.4	7.4	-37.00
	Nas/Ske	0.0	1.5	1.50
	Tahltan	0.0	0.0	0.00
	Stikine	55.6	91.1	35.50
7/23-7/29	Ak. I	9.3	0.0	-9.30
Weeks 30-38	Ak. II	42.4	18.7	-23.70
	Nas/Ske	0.0	4.0	4.00
	Tahltan	0.0	0.4	0.40
	Stikine	48.3	76.9	28.60
Fishery Total	Ak. I	8.1	0.3	-7.80
	Ak. II	36.7	12.4	-24.30
	Nas/Ske	0.7	4.0	3.23
	Tahltan	0.0	3.4	3.42
	Stikine	54.4	79.9	25.45

[a] For age-1.3 fish only.