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FEASIBILITY OF DETERMINING THE ORIGIN OF SOCKEYE SALMON (*Oncorhynchus nerka*) IN THE TAKU-SNETTISHAM GILLNET FISHERY USING SCALE PATTERN ANALYSIS, 1981-1982

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Division of Commercial Fisheries
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ABSTRACT

The feasibility of using scale pattern analysis to identify stocks of sockeye salmon *(Oncorhynchus nerka)* harvested in the District 111 gillnet fishery of Southeastern Alaska was examined by the Alaska Department of Fish and Game using data collected in 1981 and 1982. Nearest-neighbor analysis of age 1.3 sockeye salmon in a four-way model (Kuthai vs Little Trapper vs Crescent vs Speel Lake) yielded maximum overall classification accuracies of 58.5% and 67.7% for 1981 and 1982. Crescent and Speel Lakes classified with the lowest accuracies and were generally most often misclassified as each other. Two-way classification models between pooled Taku River systems and pooled Port Snettisham systems yielded much higher accuracies, 75.8% in 1981 and 85.4% in 1982. Large differences in the estimated age compositions of the escapements were evident with much higher proportions of age 1.1 and age 1.2 fish present in Crescent and Speel Lakes than in Little Trapper and Kuthai Lakes. Potential benefits of the application of scale pattern analysis to the management of the District 111 sockeye salmon fishery and recommendations for further study are discussed.

INTRODUCTION

The District 111 gillnet fishery operates in Southeastern Alaska in those waters of Stephens Passage north of a line from Pt. League to Pt. Hugh, and south and east of a line from a point at 58°12'20" N latitude, 134°10; W longitude, to Point Arden (Figure 1). Sockeye salmon are harvested from early June through late August. During the twenty-one year period 1962 through 1982 the harvests have ranged between 17,735 and 123,081 sockeye salmon, averaging 54,886. Sockeye salmon harvested in District 111 originate from the Taku, Speel, and Whiting River drainages (Figure 1). Little Trapper and Kuthai Lakes are the two principal sockeye salmon spawning sites in the Taku River drainage, and are located in Western British Columbia, Canada. Speel Lake and Crescent Lake are located in Southeastern Alaska in the Speel and Whiting River drainages.

The mixed stock nature of the District 111 harvest complicates effective management on an individual run basis and the contribution of stocks spawning in the Alaskan and Canadian drainages is a point of contention between the respective governments. This report examines the feasibility of using scale pattern analysis to determine the origin of sockeye salmon catches made in District 111 to system and country of origin. Nearest-neighbor analysis of scale patterns of age 1.3 fish was used to discriminate the stocks.

METHODS AND MATERIALS

Sample Collection and Processing

Scales were taken in 1981 and 1982 by the Alaska Department of Fish and Game (ADF&G) from escapements of sockeye salmon at Little Trapper, Kuthai, Speel, and Crescent Lakes. Scales were collected from the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (INPFC 1961). Scales were mounted on gum cards and impressions were made in cellulose acetate (Clutter and Whitesel 1956). Ages were recorded in European[1] notation.

Sockeye salmon ages were determined through visual examination of scale samples. Length frequency histograms and otoliths (when available) were used to aid in determination of ocean ages since resportion of scale margins in the escapement samples made age determination unreliable. Scale images were magnified to 100 power and projected onto a digitizing tablet using equipment similar to that described by Ryan and Christie (1976). Data was recorded onto computer diskettes from the digitizer tablet under control of a FORTRAN program executing on a microcomputer. Scale measurements were taken along a standardized axis approximately 20 degrees off the primary axis and perpendicular to the sculptured field. The distance between each circulus in each of three scale pattern zones were measured. The zones were: (1) focus to the outside edge of the freshwater annulus, (2) out-

[1] European formula: numerals preceding the decimal refer to the number of freshwater annuli; numerals following the decimal are the numbers of marine annuli. Total age is the sum of these two numbers plus 1.

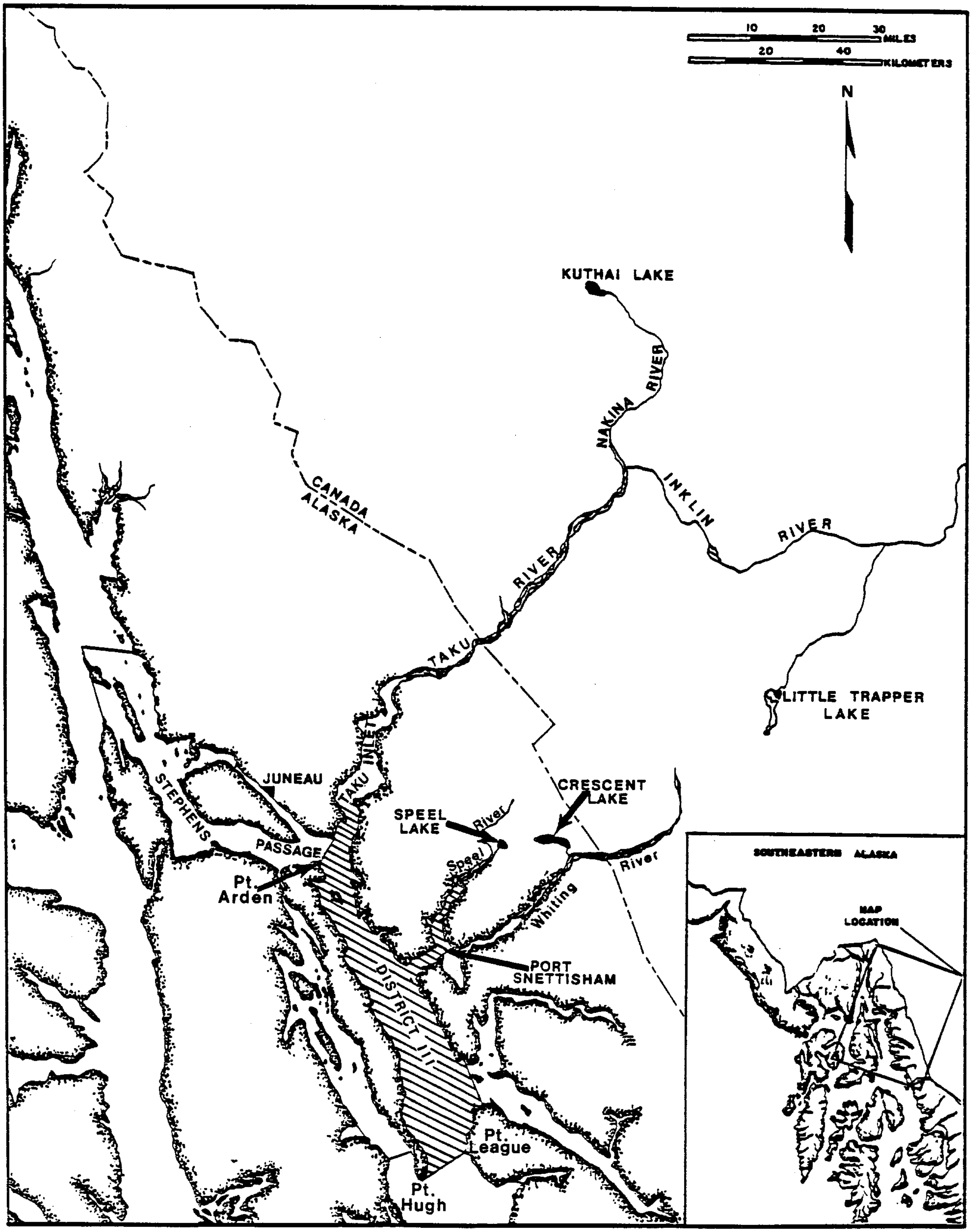

Figure 1. Map of District 111 and the Taku, Speel, and Whiting River drainages, with an inset of Southeastern Alaska.

side edge of the freshwater annulus to the last circulus of plus growth, and (3) the last circulus of the plus growth zone to the outer edge of the first ocean annulus. The three zones are shown in a photograph of a scale from an age 1.3 sockeye salmon (Figure 2). A set of 11 variables was then computed for each of these three zones (Table 1).

Stock Identification

Histograms of the distributions of each of the 33 variables revealed that most variables were not normally distributed. Nearest-neighbor analysis of scale pattern data was therefore chosen to discriminate stocks, since it is a nonparametric technique requiring no underlying assumptions of population parameters. Nearest neighbor analysis classifies each individual data case to the group membership of the K-nearest (measured in multivariate space) known data cases[2] (Clover and Hart 1967). The computational routines of the FORTRAN program ARTHUR (Duewer et al. 1975) were used for the nearest neighbor analysis.

Selection of scale variables for inclusion in the nearest-neighbor model was made using the "select" routine of the ARTHUR program. Variables were first normalized ($\overline{X} = 0$, $S = 1$) to prevent weighting by scale (Duewer, et al. 1975). Correlations between variables were removed, the discriminating ability of each variable was evaluated (by Fisher weighting), and variables were ranked in order of their usefulness. The top-ranked variables were then used to build the classification models. Development of a series of models, created using a stepwise procedure for selecting variables for inclusion, allowed comparison of the classification accuracies achieved when different numbers of variables were used. The ratio between the number of variables included in the model and number of samples from each escapement was kept less than 1:10.

1981 Analysis:

A four-way stock identification model was constructed from age 1.3 scale measurements representing the escapements to Kuthai, Little Trapper, Crescent, and Speel Lakes. The analysis was limited to 91 scale samples from each system because of the limited number of readable scales (N = 91) from Speel Lake and the requirement of equal sample sizes in the nearest-neighbor analysis. A two-way model that compared Canadian and Alaskan systems was built using pooled Taku River samples (Kuthai and Little Trapper Lakes) and pooled Port Snettisham samples (Crescent and Kuthai Lakes). The lack of accurate escapement estimates to those four lakes prevented any proportional weighting by stock abundance within the Canadian and Alaskan groups.

1982 Analysis:

Four-way and two-way stock identification models were built as in the 1981 analysis. The four-way model was limited to 79 scale samples from each system

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[2] K (group size) = 1,3,4,5,6,7,8,9,10. A data case is assigned to the category represented most often in the K-closest patterns to the pattern being classified. When two or more categories are equally represented, a case is classified to the category which has the nearest neighbor.

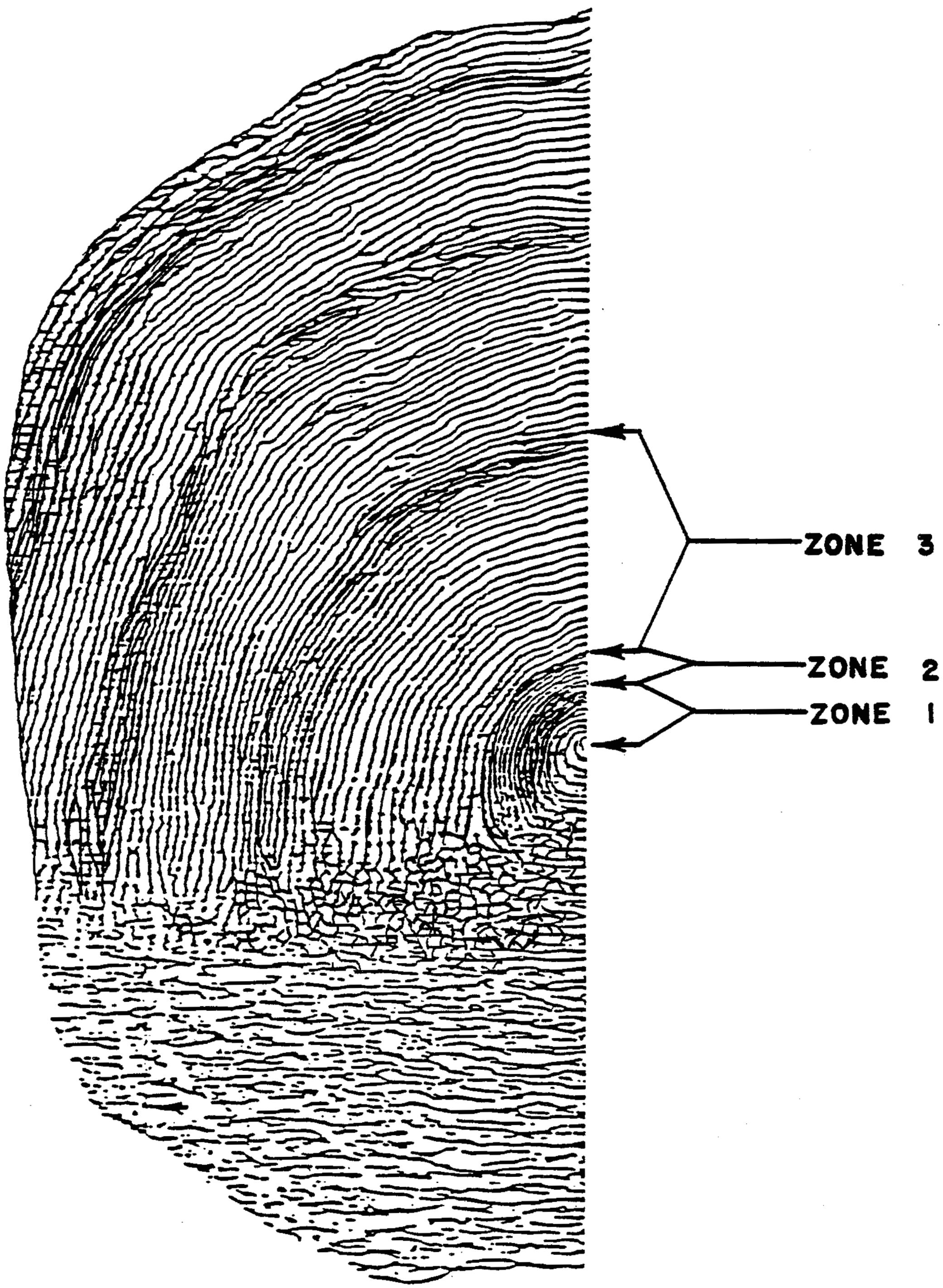

Figure 2. Photograph of a sockeye salmon scale showing the three zones measured.

Table 1. Variables computed from scale patterns for inclusion in the nearest-neighbor analysis.

Variable Name	Description
NC(i) [1]	Number of circuli in zone (i).
ID(i)	Measured size of zone (i).
TWO(i)	Distance from the beginning of zone (i) to the second circulus of zone (i).
FOUR(i)	Distance from the beginning of zone (i) to the fourth circulus of zone (i).
SIX(i)	Distance from the beginning of zone (i) to the sixth circulus of zone (i).
EIGHT(i)	Distance from the beginning of zone (i) to the eighth circulus of zone (i).
MIN(i)	The minimum distance between two contiguous circuli in zone (i).
MAX(i)	The maximum distance between two contiguous circuli in zone (i).
LMIN(i)	The distance from the beginning of zone (i) to the first circulus of variable MIN(i) in zone (i).
LMAX(i)	The distance from the beginning of zone (i) to the first circulus of variable MAX(i) in zone (i).
NCH(i)	The number of circuli in the first half of zone (i).

[1] Where i = 1,2,3.

again because of the limited number of readable scales from Speel Lake.

RESULTS

Age Composition

Large differences in the estimated age composition of the escapements existed both between systems within years and between years within systems (Tables 2 and 3). Age 1.3 fish dominated both year's samples from the Taku River systems (Kuthai and Little Trapper Lakes). In 1981, age 1.3 fish accounted for 86% of the escapement in each system. In 1982, between 73% and 75% of the escapement were age 1.3. In the Port Snettisham systems, the contribution of age 1.3 to the escapement was less than that of the Taku River systems in both years and more variable between Speel and Crescent Lakes.

Age 1.2 fish accounted for a consistently larger portion of the escapement to the Port Snettisham systems than to the Taku River systems in both years. In each year, Speel Lake had the highest incidence followed by Crescent, Kuthai, and Little Trapper Lakes.

Age 1.1 fish were extremely rare in the Taku River systems in both years and were found only in Little Trapper Lake. In the Port Snettisham systems, a significant incidence of age 1.1 fish was seen in both Speel Lake (25.7%) and Crescent Lake (13.5%) in 1981. In 1982 the incidences were much lower, 3.5 and 2.5%, for Speel and Crescent Lakes, respectively. Interestingly, the incidence of age 1.2 fish in 1982 to both Speel and Crescent Lakes were preceded in 1981 by significant returns of fish from the same brood, i.e., age 1.1 fish.

Fish which had spent two summers in freshwater (ages 2.2 and 2.3) were present in samples from each year and system but generally were of minor importance. Exceptions to this were the significant incidence of age 2.3 fish in Crescent Lake in 1981 (9.4%) and in Little Trapper Lake in 1982 (14.0%).

Comparison of Scale Patterns

In this section we summarize the statistics computed for individual scale pattern features and present the results of our nearest-neighbor analysis of these features as a method for identifying the fish taken in the District 111 fishery.

Summary Statistics for Scale Pattern Variables:

Summary statistics provided in this section are intended primarily to document the first level of data summary in the analysis. However, because the power of the nearest-neighbor analysis relates directly to the differences in growth history between the stocks of interest we compared the incremental size of each zone.

The growth realized in the first year in freshwater (ID1) was generally less in the Port Snettisham stocks in both 1981 and 1982 than in those from the Taku River (Tables 4 and 5). The one exception to this trend was the 1981 return to

Table 2. Age composition of sockeye salmon sampled in 1981 from Little Trapper, Kuthai, Speel, and Crescent Lakes.

Location		Age 1.1	1.2	1.3	2.2	2.3	Other	Total	Date Sampled
Little Trapper Lake	number	4	21	234	11	2	0	272	8/25
	percent	1.5	7.7	86.0	4.1	0.7	0.0		
Kuthai Lake	number	0	30	229	2	4	0	265	7/20-8/19
	percent	0.0	11.3	86.4	0.8	1.5	0.0		
Speel Lake	number	47	38	94	3	1	0	183	8/13-9/26
	percent	25.7	20.8	51.4	1.6	0.5	0.0		
Crescent Lake	number	62	70	278	3	43	2 [1]	458	9/01-9/19
	percent	13.5	15.3	60.7	0.7	9.4	0.4		

[1] Age 2.1

Table 3. Age composition of sockeye salmon sampled in 1982 from Little Trapper, Kuthai, Speel, and Crescent Lakes.

Location		Age 1.1	1.2	1.3	2.2	2.3	Other	Total	Date Sampled
Little Trapper Lake	number	2	51	462	11	86	1 [1]	613	8/29-8/30
	percent	0.3	8.3	75.4	1.8	14.0	0.2		
Kuthai Lake	number	0	47	160	0	12	0	219	8/28-8/29
	percent	0.0	21.5	73.0	0.0	5.5	0.0		
Speel Lake	number	11	180	118	0	3	1 [2]	313	9/22-10/02
	percent	3.5	57.5	37.7	0.0	1.0	0.3		
Crescent Lake	number	8	131	171	9	2	3 [3]	324	10/02-10/03
	percent	2.5	40.4	52.8	2.8	0.6	0.9		

[1] Age 0.3
[2] Age 1.4
[3] Age 2.1

Table 4. Group means and standard deviations for scale variables measured from age 1.3 sockeye salmon from Kuthai, Little Trapper, Crescent, and Speel Lakes, 1981.

	Kuthai		Little Trapper		Crescent		Speel	
Variable	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
TWO 1	40.3	5.1	37.7	5.6	40.0	6.1	39.9	5.9
FOUR 1	61.1	6.1	54.4	7.1	57.3	8.0	58.6	8.0
SIX 1	76.7	7.1	67.3	10.8	65.6	24.7	71.2	16.2
EIGHT 1	89.4	7.6	44.2	41.5	48.5	45.6	44.5	44.7
MAX 1	27.9	4.1	27.0	4.5	29.3	5.0	28.7	4.6
MIN 1	4.6	0.9	5.1	1.0	5.7	1.3	5.3	1.2
LMAX 1	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
LMIN 1	8.2	1.7	5.8	1.9	5.7	2.1	5.9	1.4
NC 1	11.0	1.2	7.9	1.5	7.8	1.9	7.7	1.3
ID 1	107.9	11.1	80.0	14.9	86.4	20.1	84.6	13.6
NCH 1	2.8	0.7	1.8	0.7	1.9	0.9	1.8	0.6
TWO 2	8.1	8.2	10.9	9.4	11.2	10.5	8.0	9.3
FOUR 2	2.1	7.9	3.5	11.3	2.8	10.2	1.6	7.6
SIX 2	0.0	0.0	0.5	5.1	0.6	6.2	0.0	0.0
EIGHT 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAX 2	8.9	2.6	10.1	2.2	10.0	2.8	9.7	2.4
MIN 2	7.4	2.7	8.6	2.1	8.4	2.3	8.7	2.3
LMAX 2	1.2	0.5	1.4	0.7	1.2	0.6	1.3	0.6
LMIN 2	1.4	0.7	1.4	0.7	1.5	0.8	1.2	0.5
NC 2	1.8	1.0	2.0	1.2	1.9	1.1	1.6	0.8
ID 2	14.3	7.8	18.8	11.3	18.3	11.6	14.7	8.2
NCH 2	0.4	0.6	0.6	0.7	0.4	0.6	0.3	0.5
TWO 3	27.1	4.5	27.8	4.8	27.1	4.4	26.6	4.7
FOUR 3	55.3	6.9	55.8	7.8	57.0	7.3	56.4	7.7
SIX 3	83.2	7.6	84.5	10.0	88.3	9.9	86.4	9.71
EIGHT 3	112.4	9.3	113.3	12.1	119.1	11.5	117.3	12.0
MAX 3	19.8	1.9	21.2	2.2	22.1	2.5	21.5	2.1
MIN 3	8.2	1.3	8.6	1.6	8.7	1.5	8.6	1.3
LMAX 3	9.9	6.2	14.0	7.0	13.6	6.6	13.5	7.5
LMIN 3	13.3	8.5	16.2	9.8	16.4	10.8	14.8	10.0
NC 3	25.8	2.2	30.3	3.0	31.4	2.5	29.5	2.7
ID 3	350.3	33.6	430.8	39.6	467.4	39.2	430.3	44.4
NCH 3	12.2	1.3	14.4	1.8	14.9	1.5	14.2	1.6
Sample Size	100		100		100		91	

Table 5. Group means and standard deviations for scale variables measured from age 1.3 sockeye salmon from Kuthai, Little Trapper, Crescent, and Speel Lakes, 1982.

Variable	Kuthai		Little Trapper		Crescent		Speel	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
TWO 1	40.4	7.4	37.1	6.1	31.8	6.2	36.5	6.3
FOUR 1	63.5	8.1	57.2	6.8	48.6	7.2	54.6	6.9
SIX 1	82.4	8.0	74.0	7.2	51.0	26.6	61.4	23.6
EIGHT 1	99.7	8.4	74.8	33.3	26.9	38.0	34.0	42.0
MAX 1	28.0	6.0	25.4	5.7	21.7	5.6	25.3	5.7
MIN 1	5.3	1.1	5.8	1.3	5.8	1.3	5.7	1.4
LMAX 1	1.1	0.7	1.0	0.2	1.0	0.0	1.0	0.0
LMIN 1	11.4	3.2	6.5	2.1	5.2	1.9	5.5	1.7
NC 1	14.4	2.4	8.7	1.3	6.9	1.7	7.2	1.5
ID 1	146.8	19.9	93.6	11.9	70.2	15.9	77.8	15.3
NCH 1	4.5	1.1	2.4	0.8	1.9	1.1	1.8	0.9
TWO 2	10.8	8.1	12.0	9.4	12.2	8.8	12.5	8.9
FOUR 2	8.4	14.4	2.7	10.2	5.1	12.5	7.3	14.9
SIX 2	6.2	16.2	0.5	5.0	1.6	9.3	2.2	10.9
EIGHT 2	1.5	10.3	0.6	6.3	0.0	0.0	0.0	0.0
MAX 2	9.2	2.8	10.8	2.7	10.4	2.6	10.5	3.0
MIN 2	7.1	2.5	8.7	2.6	8.2	2.4	8.3	2.8
LMAX 2	1.7	1.4	1.6	0.8	1.8	1.2	1.8	1.0
LMIN 2	1.8	1.5	1.3	0.7	1.4	0.7	1.5	0.8
NC 2	2.7	2.0	2.0	1.1	2.3	1.3	2.4	1.3
ID 2	21.9	16.1	19.2	10.2	21.4	12.6	22.2	12.8
NCH 2	0.9	1.0	0.6	0.6	0.7	0.8	0.7	0.8
TWO 3	27.1	5.0	25.9	4.6	25.6	5.2	25.3	5.1
FOUR 3	56.0	8.3	53.1	7.0	53.0	9.3	53.6	8.5
SIX 3	86.8	10.1	83.5	9.3	81.6	11.4	83.7	12.1
EIGHT 3	118.9	11.5	115.3	11.9	113.9	13.2	115.9	15.4
MAX 3	20.7	2.6	21.6	2.3	22.2	2.8	22.6	2.9
MIN 3	7.3	1.2	7.5	1.7	7.9	1.4	7.9	1.3
LMAX 3	8.2	4.3	11.5	4.7	12.0	5.5	10.8	4.9
LMIN 3	17.1	7.2	17.1	9.5	18.6	10.1	18.6	9.6
NC 3	23.9	2.6	27.1	3.3	29.3	3.0	28.0	2.4
ID 3	319.5	32.8	378.8	41.2	420.5	42.0	398.7	38.5
NCH 3	10.2	1.4	12.2	1.7	13.4	1.7	12.6	1.4
Sample Size	98		101		100		79	

Little Trapper Lake, which exhibited the smallest first growth zone of any stock (80.0). The Kuthai Lake stock had the largest first freshwater zone in each year, but the size of the zone varied considerably between years (107.9 and 146.8 for 1981 and 1982, respectively).

Growth realized in the spring of smolting prior to entry into saltwater or "plus growth" (ID2) was similar between stocks in the 1982 return (Table 5). In 1981, however, plus growth differed between stocks, with Little Trapper and Crescent Lake stocks exhibiting greater growth than fish from Kuthai and Speel Lakes (Table 4).

Growth in the first marine zone (ID3) exhibited fairly consistent trends between stocks, although growth was slightly greater in the 1981 return than in 1982. Taku River stocks generally grew less than Port Snettisham stocks in their first marine year. The Crescent Lake stock exhibited the largest third zone and the Kuthai Lake stock the smallest.

1981 Analysis:

Classification accuracy of the 1981 four-way model was the poorest. A series of models, created by utilizing the top two, the top three, up to the top six variables, yielded classification accuracies from 53.3% to 58.5% (Table 6). The peak accuracy was achieved with five variables. Classification accuracies tended to become better as the group size[3] and number of variables included in the model increased (Appendix Table 1). The Kuthai Lake stock was quite distinct; it classified correctly (90.1% to 94.5%) of the time. Little Trapper, Crescent, and Speel Lake stocks were less distinct, classifying correctly only (34.0% to 56.0%) of the time. Misclassification of each of these stocks was fairly evenly distributed between the three systems.

Classification accuracies of the two-way models between the Taku River and Port Snettisham systems yielded higher accuracies, ranging from 69.5% to 75.8% (Table 7), peaking with a model that included five variables. The highest classification accuracies were again achieved with large group sizes (K = 7,9,10; Appendix Table 2).

1982 Analysis:

Classification accuracies of the 1982 four-way models were much higher than in 1981, varying from 61.1% to 67.7% (Table 8). The peak accuracy was achieved when 6 variables were used. Group sizes that yielded maximum accuracies again tended to increase with the number of variables included in the model (Appendix Table 3). The Kuthai Lake stock again classified extremely well (89.9% to 96.2%). The Little Trapper Lake stock was much more distinct in the 1982 return than the previous year, classifying between 63.3% and 74.7% of the time. Port Snettisham stocks classified with lower accuracies and were most often misassigned as each other.

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[3] The number of nearest-neighbor data points represented in the group to which each case is classified.

Table 6. Classification matrices for nearest-neighbor analyses of age 1.3 sockeye salmon from Kuthai, Little Trapper, Crescent, and Speel Lakes, 1981.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3, NC1, K = 6)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	91	.901	.044	.022	.033
L. Trapper	91	.066	.340	.275	.319
Crescent	91	.044	.242	.560	.154
Speel	91	.044	.362	.362	.330
		Overall Classification Accuracy = .533			

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3, NC1, ID1, K = 7)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	91	.945	.022	.011	.022
L. Trapper	91	.055	.407	.242	.296
Crescent	91	.066	.209	.527	.198
Speel	91	.055	.308	.253	.384
		Overall Classification Accuracy = .566			

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3, NC1, ID1, 61, K = 9)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	91	.934	.033	.011	.022
L. Trapper	91	.044	.384	.264	.308
Crescent	91	.066	.242	.472	.220
Speel	91	.033	.252	.297	.417
		Overall Classification Accuracy = .552			

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3, NC1, ID1, 61, ID2, K = 9)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	91	.923	.0118	.022	.044
L. Trapper	91	.055	.407	.242	.296
Crescent	91	.055	.275	.505	.165
Speel	91	.022	.297	.176	.505
		Overall Classification Accuracy = .585			

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3, NC1, ID1,61, ID2, 41, K = 10)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	91	.923	.033	.011	.033
L. Trapper	91	.044	.429	.209	.318
Crescent	91	.066	.220	.472	.242
Speel	91	.044	.307	.220	.429
		Overall Classification Accuracy = .563			

Table 7. Classification matrices for nearest-neighbor analyses of age 1.3 sockeye salmon from the Taku and Snettisham systems, 1981.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3,NC1, K = 9)	
		Taku	Snettisham
Taku	182	.610	.390
Snettisham	182	.220	.780

Overall Classification Accuracy = .695

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3,NC1,ID1, K = 7)	
		Taku	Snettisham
Taku	182	.665	.335
Snettisham	182	.220	.780

Overall Classification Accuracy = .723

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3,NC1,ID1,61, K =10)	
		Taku	Snettisham
Taku	182	.681	.319
Snettisham	182	.225	.775

Overall Classification Accuracy = .728

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3,NC1,ID1,61,ID2, K = 9)	
		Taku	Snettisham
Taku	182	.720	.280
Snettisham	182	.203	.797

Overall Classification Accuracy = .758

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3,NC1,ID1,61,ID2,41, K = 9)	
		Taku	Snettisham
Taku	182	.725	.275
Snettisham	182	.247	.753

Overall Classification Accuracy = .739

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID3,NC1,ID1,61,ID2,41,MAX1, K = 9)	
		Taku	Snettisham
Taku	182	.725	.275
Snettisham	182	.220	.780

Overall Classification Accuracy = .753

Table 8. Classification matrices for nearest-neighbor analyses of age 1.3 sockeye salmon from Kuthai, Little Trapper, Crescent, and Speel Lakes, 1982.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, 61, 81, K = 10)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	79	.899	.088	.000	.013
L. Trapper	79	.038	.633	.089	.240
Crescent	79	.000	.190	.544	.266
Speel	79	.038	.279	.316	.367

Overall Classification Accuracy = .611

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, 61, 81, 41, K = 9)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	79	.923	.051	.013	.013
L. Trapper	79	.051	.633	.063	.253
Crescent	79	.000	.177	.570	.253
Speel	79	.051	.139	.278	.532

Overall Classification Accuracy = .665

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, 61, 81, 41, ID3, K = 7)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	79	.924	.076	.000	.000
L. Trapper	79	.038	.684	.063	.215
Crescent	79	.000	.126	.646	.228
Speel	79	.025	.241	.291	.433

Overall Classification Accuracy = .674

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, 61, 81, 41, ID3, NC2, K = 8)			
		Kuthai	L. Trapper	Crescent	Speel
Kuthai	79	.962	.038	.000	.000
L. Trapper	79	.025	.747	.076	.152
Crescent	79	.000	.177	.620	.203
Speel	79	.013	.279	.328	.380

Overall Classification Accuracy = .677

Accuracies of the 2-way models between Taku River and Port Snettisham systems were significantly higher in 1982 than in 1981, varying from 83.5% to 85.4% (Table 9). The highest accuracy was achieved with models utilizing only 2 or 3 variables and a group size of 5 (Appendix Table 4). Classification accuracies for both systems were almost identical.

DISCUSSION

Interpretation of Scale Pattern Data

Significant differences were found in the scale patterns of sockeye salmon originating from Kuthai, Little Trapper, Crescent, and Speel Lakes. The differences were more pronounced when data from these stocks were pooled to reflect fish originating from the Taku River and Port Snettisham drainages. A significant source of the variability which permits separation was in scale variable (ID1) in both years. Because the size of this zone is directly related to size of juveniles at the end of their first year in freshwater, we concluded that substantial differences exist in the biotic and abiotic factors regulating growth in the respective lakes. While essentially no data exists to compare limnological factors regulating growth of sockeye salmon in these lakes, we believe that the geography of the lakes may, in part, help us understand these differences.

Speel and Crescent Lakes are located within 20 miles of saltwater on the western slope of the coastal mountains which form the border between Southeastern Alaska and Canada. The maritime climate in this vicinity is characterized by cold, rainy summers, and mild winters. Kuthai and Little Trapper Lakes are located on the eastern slope of the coastal mountains. The interior climate of the Taku River drainage is characterized by dry relatively warm, and sunny summers with cold, clear winters. We believe these differences in climate establish the potential for differences in limnological factors in each lake which in part regulate growth. Elucidation of the mechanisms regulating growth awaits further study.

Management Applications

A critical and missing aspect of the sockeye salmon management program for the District 111 fishery has been the lack of ability to identify the origins of fish harvested. This has to some degree prevented development of stock-specific management and probably contributed to the decline in abundance of the Port Snettisham stocks.

In this study we have demonstrated that significant and most likely persistent differences exist in the scale patterns of the principal stocks which contribute to the fishery. While the ability to distinguish individual stocks may not exist in some years using this technique, the data suggests that identification to either the Taku or Port Snettisham groupings should persist each year. The differences in age composition between the systems also provides a method for allocating catches to stock of origin.

Demonstrating the feasibility of utilizing scale patterns to identify the origins of the sockeye salmon harvested in the District 111 fishery is but one aspect of

Table 9. Classification matrices for nearest-neighbor analyses of age 1.3 sockeye salmon from the Taku and Snettisham systems, 1982.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, ID3, K = 5)	
		Taku	Snettisham
Taku	158	.848	.152
Snettisham	158	.139	.861

Overall Classification Accuracy = .854

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, ID3, 81, K = 5)	
		Taku	Snettisham
Taku	158	.854	.146
Snettisham	158	.146	.854

Overall Classification Accuracy = .854

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, ID3, 81, 41, K = 7)	
		Taku	Snettisham
Taku	158	.835	.165
Snettisham	158	.165	.835

Overall Classification Accuracy = .835

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID1, ID3, 81, 41, LMAX3, K = 10)	
		Taku	Snettisham
Taku	158	.842	.158
Snettisham	158	.152	.848

Overall Classification Accuracy = .845

developing a complete stock-specific management program. The basic data required is the number of fish in both the catch and escapement each year. Accomplishment of this objective requires that we:

1) Implement an escapement enumeration program on the mainstem Taku River utilizing either sonar or mark-recapture techniques.

2) Collect basic biological data including sex, length, and scale samples from fish passing the enumeration site.

3) Urge the Canadians to reestablish their weir at Kuthai Lake and deploy a new weir at Little Trapper Lake.

4) Reinstitute our weir at Crescent Lake and deploy the weir operated by the Fisheries Rehabilitation, Enhancement, and Development Division of the ADF&G at Speel Lake sooner so that complete sockeye salmon counts can be made for both systems.

5) Collect basic biological data in conjunction with the weir operations at all sites.

6) Initiate a catch allocation program to estimate the contributions of Port Snettisham and Taku River sockeye salmon to the District 111 harvest. A scale sampling program of the District 111 catch is already in place. Additional sampling of site-specific catches could provide refined stock timing and distribution information useful in setting fishing period and area restrictions.

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APPENDICES

Appendix Table 1. Effect of the number of variables included and group size on the overall classification accuracy in the nearest-neighbor analysis of age 1.3 sockeye salmon from Kuthai, Little Trapper, Crescent, and Speel Lakes, 1981.

No. Variables Included in Model (Variables Names)	Overall Classification Accuracy: Group Size 1-NN	3-NN	4-NN	5-NN	6-NN	7-NN	8-NN	9-NN	10-NN
2 (ID3,NC1)	.484	.598	.497	.522	.533	.530	.519	.508	.497
3 (ID3,NC1,ID1)	.508	.511	.536	.536	.552	.566	.544	.566	.549
4 (ID3,NC1,ID1,61)	.500	.500	.522	.516	.547	.525	.547	.552	.547
5 (ID3,NC1,ID1,61,ID2)	.508	.525	.555	.555	.560	.577	.563	.585	.580
6 (ID3,NC1,ID1,61,ID2,41)	.519	.538	.541	.527	.530	.536	.549	.541	.563

Appendix Table 2. Effect of the number of variables included and group size on the overall classification accuracy in the nearest-neighbor analysis of age 1.3 sockeye salmon from the Taku and Snettisham systems, 1981.

No. Variables Included in Model (Variables Names)	Overall Classification Accuracy								
	Group Size								
	1-NN	3-NN	4-NN	5-NN	6-NN	7-NN	8-NN	9-NN	10-NN
2 (ID3,NC1)	.618	.687	.665	.662	.690	.684	.673	.695	.681
3 (ID3,NC1,ID1)	.673	.690	.681	.703	.703	.723	.706	.723	.717
4 (ID3,NC1,ID1,61)	.657	.698	.709	.690	.703	.695	.720	.717	.728
5 (ID3,NC1,ID1,61,ID2)	.679	.692	.701	.714	.703	.742	.739	.758	.753
6 (ID3,NC1,ID1,61,ID2,41)	.654	.706	.703	.731	.714	.728	.717	.739	.723
7 (ID3,NC1,ID1,61,ID2,41,MAX1)	.668	.734	.723	.736	.728	.745	.745	.753	.753

Appendix Table 3. Effect of the number of variables included and group size on the overall classification accuracy in the nearest-neighbor analysis of age 2.3 sockeye salmon from the Taku and Snettisham systems, 1982.

No. Variables Included in Model (Variables Names)	Overall Classification Accuracy								
	Group Size								
	1-NN	3-NN	4-NN	5-NN	6-NN	7-NN	8-NN	9-NN	10-NN
2 (ID1,ID3)	.788	.848	.848	.854	.848	.848	.845	.851	.848
3 (ID1,ID3,81)	.804	.839	.839	.854	.848	.851	.851	.851	.851
4 (ID1,ID3,81,41)	.778	.807	.797	.823	.820	.835	.823	.835	.829
5 (ID1,ID3,81,41,LMAX3)	.753	.832	.826	.832	.829	.835	.842	.842	.845

Appendix Table 4. Effect of the number of variables included and group size on the overall classification accuracy in the nearest neighbor analysis of age 1.3 sockeye salmon from Kuthai, Little Trapper, Crescent and Speel Lakes, 1982.

No. Variables Included in Model (Variables Names)	Overall Classification Accuracy — Group Size								
	1-NN	3-NN	4-NN	5-NN	6-NN	7-NN	8-NN	9-NN	10-NN
3 (ID1,61,81)	.513	.598	.595	.604	.604	.585	.604	.601	.611
4 (ID1,61,81,41)	.538	.579	.589	.627	.642	.642	.636	.665	.658
5 (ID1,61,81,41,ID3)	.576	.617	.611	.636	.649	.674	.674	.665	.668
6 (ID1,61,81,41,ID3,NC2)	.592	.623	.646	.652	.665	.661	.677	.658	.671