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SEPARATION OF THE 1981 CHIGNIK SOCKEYE SALMON STOCKS BY SCALE PATTERNS AND A LINEAR DISCRIMINANT FUNCTION

By:

Robert H. Conrad

July 1982

ALASKA DEPARTMENT OF FISH AND GAME
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Ronald O. Skoog
Commissioner

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SEPARATION OF THE 1981 CHIGNIK SOCKEYE SALMON STOCKS BY SCALE PATTERNS AND A LINEAR DISCRIMINANT FUNCTION

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PREFACE

This study was conducted by Robert Conrad of the Fisheries Research Institute, University of Washington under contract (No. 81-181) to the Alaska Department of Fish and Game, Division of Commercial Fisheries. This manuscript (report number FRI-UW-8203 of the Fisheries Research Institute) was provided to the Department of Fish and Game as a contract report in very limited quantities. Because of the contribution that this study has made to management of the sockeye salmon run to the Chignik Lakes and the limited circulation the original report received the Department of Fish and Game and the Fisheries Research Institute decided to publish it in this series.

ABSTRACT

The 1981 return of sockeye salmon *(Oncorhynchus nerka)* to Chignik, Alaska, was separated into its component stocks by linear discriminant function analysis of the scale patterns of the 1.3 and 2.3 age classes. The two stocks composing the Chignik sockeye salmon run were defined by the rearing area of fry from the different adult spawning areas, either Black Lake or Chignik Lake. Scale samples collected from the commercial catch in Chignik Lagoon were analyzed to estimate the proportion of each stock in the daily escapement and commercial catch. The estimated escapement and commercial catch totals for each stock were: For Black Lake, 444,558 escapement, 632,046 catch, total run 1,076,604; for Chignik Lake, 386,886 escapement, 1,478,847 catch, total run 1,865,733. In 1981 the total sockeye salmon return to Chignik was 2,942,337, which was the largest total return since 1947. The 1.3 and 2.3 age classes accounted for more than 90% of the total return. The discriminant function analysis indicated a significant difference in the time-of-entry of the 1.3 and 2.3 age classes which stresses the importance of an age-specific allocation method.

INTRODUCTION

The Chignik lakes watershed is located 274 km west of Kodiak Island on the south side of the Alaska Peninsula (Figure 1). The watershed is composed of two large connected lakes, Black Lake and Chignik Lake, and a single outlet river emptying into a nearly enclosed estuary, Chignik Lagoon. Narver (1966) summarized the physical characteristics of the watershed and provided a limnological description of each lake. A large run of sockeye salmon *(Oncorhynchus nerka)* returns annually to the Chignik system and has been the subject of numerous studies by the Fisheries Research Institute (FRI) since 1955. These studies have provided valuable information about the lacustrine life history of sockeye salmon fry in each lake and the relationship between abundance of adult spawners and the eventual adult return to the system.

Black Lake is a nursery area for fry from adult spawning in Alec River and its tributaries (Figure 1). Fry rearing in Black Lake normally experience rapid growth and most become smolts after spending one winter in the lake (Narver 1966). Chignik Lake receives fry from its beach spawning areas, Black River tributaries, and Clark River. These fry grow slower than those in Black Lake and a large portion of each year class remains in the lake for two winters before smolting (Narver 1966). Outmigrants from both lakes typically spend two or three winters in the ocean before returning as mature adults.

Research in the 1960's recognized that, because of the disparate lacustrine environments to which resident fry in each lake were exposed, Black Lake and Chignik Lake sockeye salmon populations should be considered separate stocks and managed accordingly. Extensive tagging during the years 1962-1968 revealed that the pattern of entry shown by returning adults defined two discrete peaks, one occurring in mid- to late June and another in mid-July. Early-returning adults were observed to spawn primarily in Black Lake tributaries and late-returning adults in Chignik Lake spawning areas. Dahlberg (1968) used these tagging studies to develop a model to determine each stock's time of entry into the fishery and estimate the proportions of Black Lake and Chignik Lake stocks in the catch and escapement during the period of transition from early to late run. An average time-of-entry (TOE) curve that uses Dahlberg's model and tagging data from the years 1962-1968 is currently used by the Alaska Department of Fish and Game (ADF&G) to separate the daily sockeye catch and escapement by spawning stocks.

Until recently, there has been no evaluation of the average TOE curve since its application began in 1970. It is assumed that returning Black Lake and Chignik Lake adults still exhibit approximately the same pattern of entry as that observed from 1962 to 1968. Marshall et al. (1980) developed a TOE curve using scale pattern recognition techniques to estimate the daily proportion of each stock in the catch and escapement. They found major differences between the total run apportionment by age class and stock given by the scale pattern recognition technique and the average TOE curve. They recommended that scale pattern recognition techniques be further evaluated as a method of separating the Chignik sockeye salmon run into its component stocks.

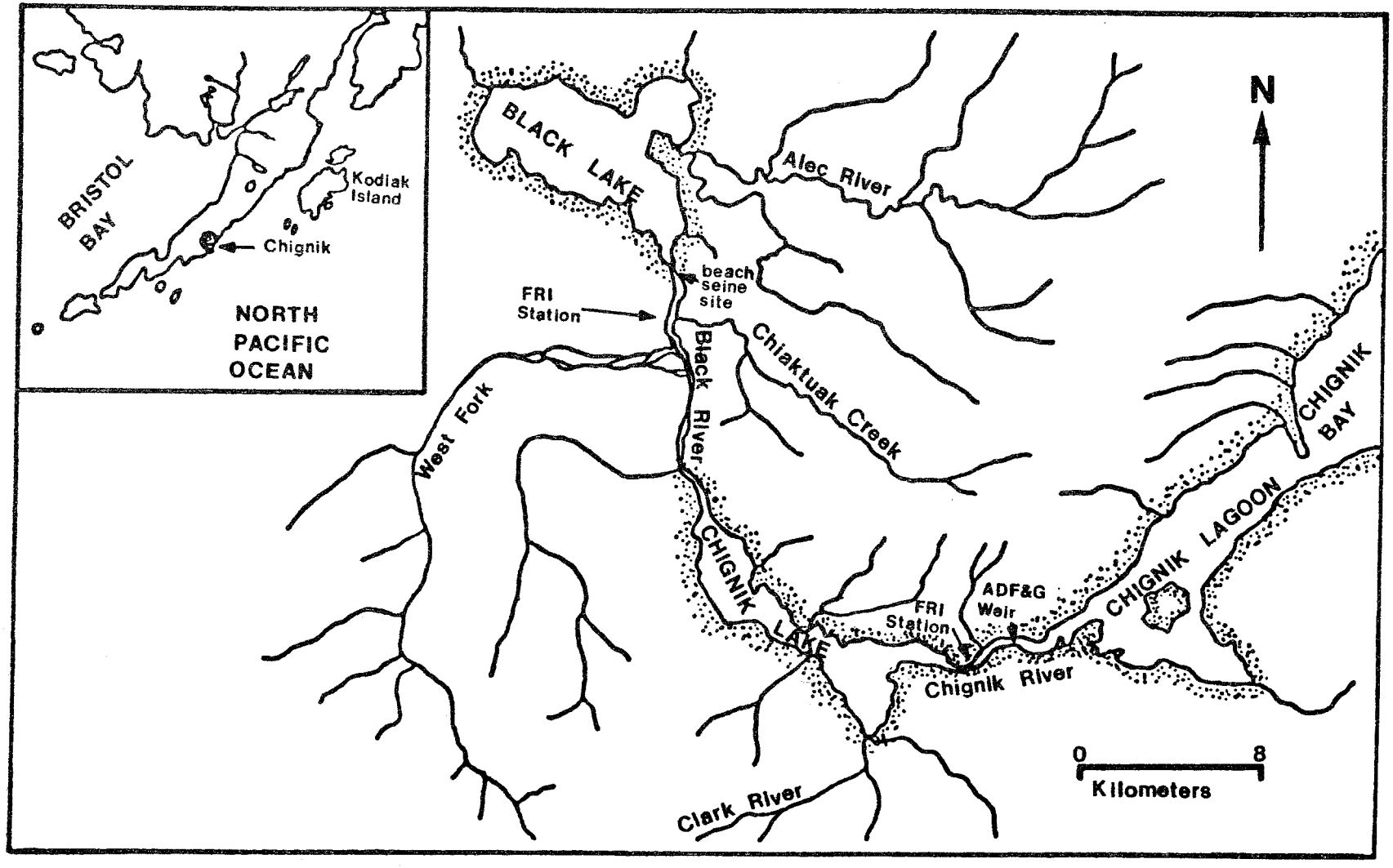

Figure 1. Map of the Chignik watershed with an inset of western Alaska.

This report continues that evaluation by using scale pattern analysis to apportion the 1981 sockeye salmon run to Chignik by its Black Lake and Chignik Lake spawning stocks, i.e., adults whose fry will rear in Black Lake or adults whose fry will rear in Chignik Lake.

MATERIALS AND METHODS

Estimation of Total Daily Abundance

To determine a total daily run abundance, the daily sockeye salmon escapement count at Chignik weir was combined with the daily commercial catch by fishing district (preliminary figures supplied by ADF&G). The fishing districts used were those defined by ADF&G with some modifications (Figure 2). The most important change was the division of the Central District into two areas, Hook Bay/Kujulik and Aniakchak. The escapement and the commercial catch outside Chignik Lagoon were adjusted to coincide with the daily catch in Chignik Lagoon. This adjustment was necessary because all scale samples for age and stock composition estimates were collected in the Lagoon.

Escapement counts at the weir were shifted 2 days earlier to account for travel time from Chignik Lagoon (Dahlberg 1968). All sockeye salmon caught in districts outside the Lagoon were assumed to be bound for Chignik Lagoon (Dahlberg 1968). The Cape Igvak catch of Chignik-bound sockeye was estimated as 80.0% of the total Cape Igvak catch (Nicholson, personal communication). These catches must be adjusted to account for the migration time to the Lagoon. Based on a summary of all sockeye salmon tagging conducted in the Chignik area prior to 1967 (Dahlberg 1968), the following migration times from each fishing area were used: Hook Bay/Kujulik, 1 day; Aniakchak, 2 days; Western, 2 days; Eastern, 3 days; Perryville, 3 days; Cape Igvak, 5 days. These are average migration times for an entire district and are realized to be gross approximations because of the size of some districts. This was not felt to be a major source of error because in 1981 only 22.7% of the commercial catch occurred in areas outside the combined Chignik Lagoon-Hook Bay/Kujulik area.

Scale Collection and Processing

Scale samples for age and stock composition estimates were periodically collected in Chignik Lagoon throughout June, July, and August. During the critical period of transition from a majority of Black Lake to Chignik spawners, samples were collected about every third day. When the commercial fishery was in progress samples were taken from catches delivered to commercial tenders. If the fishery was closed a test fishery was conducted by ADF&G to attain samples. Scale samples representing the Black Lake spawning population were collected by beach seining at Black Lake outlet (Figure 1) where large schools of adults congregate prior to migrating to Black Lake spawning grounds (Marshall and Burgner 1975).

The procedure for collecting samples was to remove one scale from the preferred area of each fish (Koo 1962; Clutter and Whitesel 1956), mount the cleaned scale on a gummed card, and record the sex and mideye-to-fork-of-tail

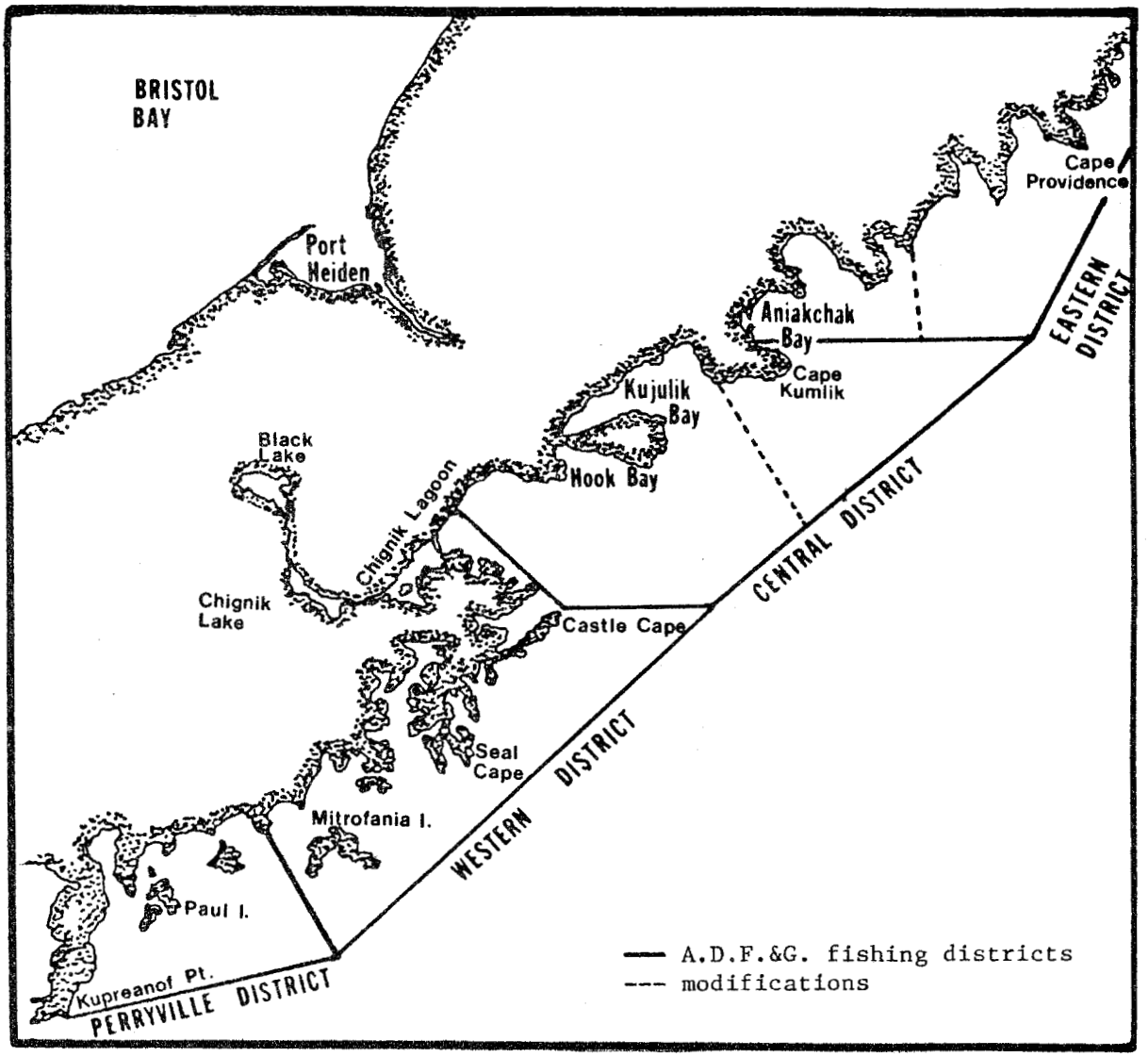

Figure 2. Map showing the modifications to the Alaska Department of Fish and Game fishing districts for the Chignik area.

length of the fish to the nearest millimeter. Scales taken outside the preferred area were noted on the age-length-weight form. For aging and measuring purposes impressions of each gummed card were made in cellulose acetate following the method of Koo (1962).

The scale impressions were projected at 82X on a standard microfiche reader for aging. All scales were aged by the same person to reduce variability in age interpretation. All ages were recorded in the European formula as defined by Koo (1962)[1].

Narver (1966) compared Black Lake and Chignik Lake adult scale patterns and found significant differences in the lacustrine scale growth between spawning groups in the two lakes. In this report all scale measurements made for the scale pattern analysis were in the lacustrine zone. Scales were projected at 210X and the distance to each circulus in an annular zone measured along the axis perpendicular to the sculptured field (Narver 1963) and recorded using a microcomputer-based digitizing system. Delineation of circuli and annular zones followed that of Narver (1963).

Analytical Procedures

Many studies have separated stocks of sockeye salmon by scale patterns and some form of discriminant function analysis (Fukuhara et al. 1962; Anas and Murai 1969; Cook 1979). The ADF&G has separated the commercial sockeye catch in Upper Cook Inlet by spawning stock using scale patterns and a linear discriminant function annually since 1977 (Bethe and Krasnowski 1979; Bethe et al. 1980; Cross et al. 1981). This report used a linear discriminant function and measurements made in the lacustrine zone of scales to estimate the proportions of Black Lake and Chignik Lake adult spawning stocks in the catch and escapement.

Discriminant function analysis requires a representative sample (termed a standard) of each group to be separated in the analysis. The Black Lake spawner standard consisted of scales randomly selected from those collected by beach seining at Black Lake outlet during June. The movement of Chignik Lake spawners onto the spawning grounds occurs so late in the season and the spawning area is so extensive that it precludes collecting a standard in a manner similar to Black Lake. Therefore, the Chignik Lake standard was composed of scales collected in the commercial fishery after 90.0% of the total run had passed through Chignik Lagoon, when it was assumed that all fish were Chignik Lake spawners. A minimum of 100 scales was required for each standard with the optimum standard size being 200 scales. Only the 1.3 and 2.3 age classes were present in sufficient numbers for stock composition analysis in 1981.

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[1] European formula - Number of freshwater annuli -decimal - number of saltwater annuli. Total age is the sum of these two numbers plus 1.

Scale samples collected in Chignik Lagoon during the period of transition (3 June to 21 July) were used to estimate the proportion of each spawning stock in the catch and escapement. Measurements for each age class were taken from a maximum of 100 scales of those available on a sample date. If less than 15 scales for an age class were available, that age class and sample date were omitted.

The scale characters evaluated for use in the discriminant analysis included those measured directly from each scale; size of each lacustrine annular zone, distance from the scale focus to each circulus in an annular zone, and distance from the focus to any lacustrine circuli past the last annulus; and combinations of these characters. Sixty-five scale characters in the first lacustrine annular zone, plus an additional 56 in the second lacustrine annular zone (if present), were screened for inclusion in the discriminant analysis (Appendix Table 1). Selection of scale characters to be used in the analysis was through a forward stepping technique with an F-to-enter of 4.0 (Dixon and Brown 1979). For the two-class problem this provides a good set of discriminant characters (Habbema and Hermans 1977).

After a character set for each age class had been selected a discriminant function was generated using program DSCRM2 (Conrad and Burgner 1981) and the Black Lake and Chignik Lake standards for an age class. This program generated a linear discriminant function following the procedure of Fisher (1936) and estimated the classification accuracy of the function using the leaving-one-out procedure of Lachenbruch and Mickey (1968). The age-specific discriminant functions were then used to classify samples of unknown spawning stock composition collected in Chignik Lagoon during the period of transition. The estimates of the proportions of Black Lake and Chignik Lake spawners in each unknown sample were adjusted by the classification correction procedure of Cook and Lord (1978) and a 90.0% confidence interval for the adjusted estimated proportions was determined (Pella and Robertson 1979).

RESULTS

Daily Abundance

The estimated total daily sockeye salmon abundance for the combined catch by area and escapement adjusted to Chignik Lagoon date is summarized in Appendix Table 2 and for the separate Black and Chignik Lakes in Appendix Tables 3 and 4, respectively. As in previous years there were two discrete peaks evident in the daily abundance by Lagoon date (Figure 3), one prior to 29 June and one after this date. The total estimated sockeye salmon return in 1981 was 2,942,337 composed of an estimated escapement of 831,444 and total catch of 2,110,893 fish. This was the largest total return to Chignik since 1947.

Age Composition

The age composition summary by sample date of the scale samples collected at Black Lake outlet is presented in Table 1. Ages were assigned to 87.8% of

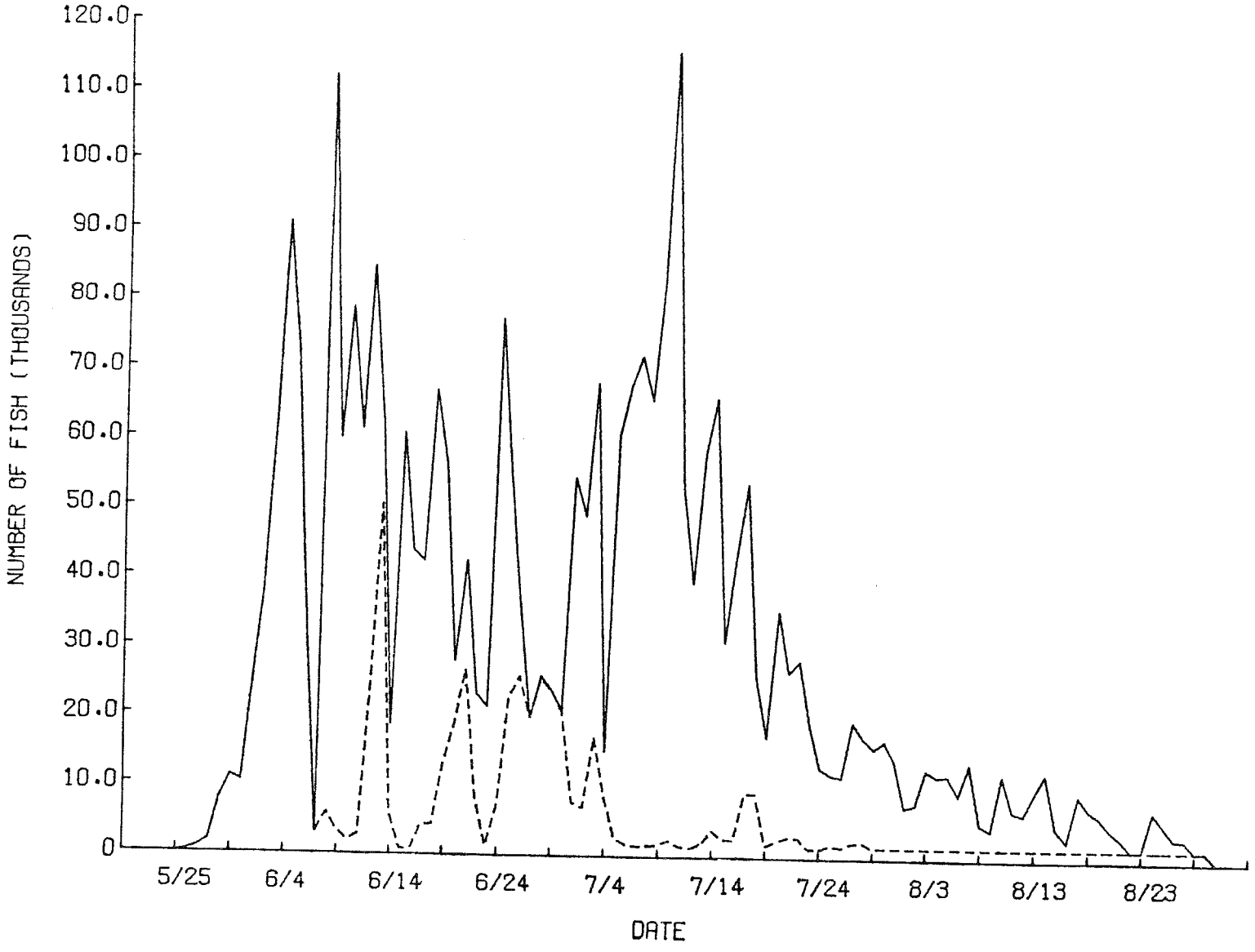

Figure 3. Daily abundance of the total Chignik sockeye salmon run (——) and the escapement (---) adjusted to Chignik Lagoon date, 1981.

Table 1. Age composition of sockeye salmon scale samples collected at Black Lake outlet during 1981, by percent of sample.

Sample Date	Sample Size	Age Class[1]										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/09	128	0.0	0.0	8.6	.8	0.0	78.1	10.9	0.0	0.0	0.0	1.6
6/10	222	0.0	0.0	16.2	1.8	0.0	71.6	9.0	0.0	0.0	0.0	1.4
6/12	193	0.0	0.0	6.7	2.6	0.0	74.1	15.6	0.0	0.0	0.0	1.0
6/13	181	0.0	0.0	13.3	.5	0.0	72.9	12.2	0.0	0.0	0.0	1.1
6/21	182	0.0	0.0	6.6	1.6	0.0	73.1	18.7	0.0	0.0	0.0	0.0
6/22	177	0.0	0.0	6.2	0.0	0.0	81.4	12.4	0.0	0.0	0.0	0.0
Mean		0.0	0.0	9.60	1.22	0.0	75.20	13.13	0.0	0.0	0.0	.85

[1] European formula - Number of freshwater annuli - decimal - number of saltwater annuli. Total age is the sum of these two numbers plus 1.

the 1,233 scales collected. The remaining scales were omitted from the analysis because of regeneration of the nuclear area or a bad impression in the acetate. As has historically been true, age 1.3 fish were the predominant age class in the Black Lake samples, with approximately 75% of the readable scales assigned to this class. Age classes 2.3 and 1.2 followed in importance. Together, these three age classes represented 97.9% of the readable scales collected at Black Lake.

Scale samples were collected in Chignik Lagoon on 20 separate occasions from 3 June to 27 August. Of the 5,829 scales collected, 4,977 (85.4%) were legible for aging purposes. Table 2 summarizes the age composition by sample date of scales collected in Chignik Lagoon during 1981. The abundance of the 1.3 age class declined steadily throughout June and early July before it stabilized between 10% and 20% after 9 July (Figure 4). The trend in the declining abundance of age 1.3 sockeye salmon is opposed by an increase in abundance of the 2.3 age class over the same period, which stabilized between 60% and 75% after 9 July. A similar trend was shown to a lesser degree by the 2-ocean age sockeye salmon. The 1.2 age class was more abundant throughout June than in July and August. In contrast, the abundance of age 2.2 sockeye salmon was low in June and early July but increased rapidly in late July and August.

The decline in abundance of 1-freshwater age adult spawners during the season, paralleled by an increase in abundance of 2-freshwater age adults, is consistent with past observations of the Chignik run. That is, the majority of the early segment of the run consists of Black Lake stock which produces primarily 1-freshwater age sockeye salmon, and the late segment of the run consists mostly of Chignik Lake stock which produces the majority of 2-freshwater fish.

Stock Composition

Six lacustrine scale characters for the age 1.3 analysis and 5 characters for the age 2.3 analysis were selected by the stepwise procedure. For age 1.3 sockeye salmon the following characters were selected, listed by order of entry:

1) distance between the scale focus and the fourth circulus in the lacustrine annular zone (DFOC4);

2) ratio of the size of the lacustrine annular zone to the size of the total lacustrine growth zone (RATIO1);

3) ratio of the distance between the third circulus before the end of the lacustrine annulus and the end of that annulus to the size of the lacustrine annular zone (RATIO2);

4) number of circuli in the lacustrine annular zone (NC1);

5) ratio of the distance between the first and fourth circuli in the lacustrine annular zone to the size of that zone (RATIO3); and

6) distance between the second and fourth circuli in the lacustrine annular zone (DIST1).

Table 2. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1981, by percent of sample.

Sample Date	Sample Size	Age Class										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/03	265	0.0	0.0	3.8	.4	0.0	88.3	7.1	0.0	0.0	0.0	.4
6/08	288	0.0	0.0	6.9	1.4	0.0	79.9	9.0	0.0	0.0	0.0	2.8
6/11	289	0.0	0.0	7.3	.7	.3	78.2	12.1	0.0	0.0	0.0	1.4
6/15	265	0.0	0.0	3.8	3.8	0.0	77.3	13.6	0.0	.4	0.0	1.1
6/17	257	.4	0.0	7.8	5.8	0.0	68.1	16.7	0.0	.4	0.0	.8
6/19	298	0.0	0.0	7.1	1.3	0.0	74.2	17.1	0.0	0.0	0.0	.3
6/22	258	0.0	0.0	8.1	.8	0.0	69.8	19.4	.4	.4	0.0	1.1
6/24	278	0.0	0.0	6.5	.7	0.0	63.7	28.0	.4	0.0	0.0	.7
6/28	254	0.0	0.0	2.8	.8	0.0	54.7	41.3	0.0	0.0	0.0	.4
7/01	239	0.0	0.0	3.8	1.3	.4	40.6	53.1	.4	.4	0.0	0.0
7/03	265	0.0	0.0	2.7	1.1	0.0	39.6	56.2	0.0	0.0	0.0	.4
7/06	253	0.0	0.0	.4	2.0	0.0	26.5	70.7	0.0	0.0	0.0	.4

-Continued-

Table 2. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1981, by percent of sample (continued).

Sample Date	Sample Size	Age Class										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
7/09	234	0.0	0.0	1.3	3.8	.4	18.4	74.8	1.3	0.0	0.0	0.0
7/12	254	0.0	.4	1.2	3.1	0.0	18.5	76.0	.4	0.0	.4	0.0
7/21	252	0.0	0.0	1.6	7.5	.4	14.7	73.4	2.0	0.0	.4	0.0
7/30	254	0.0	2.7	1.6	15.7	.8	14.2	64.2	.8	0.0	0.0	0.0
8/04	248	0.0	0.0	1.2	14.1	.8	8.9	75.0	0.0	0.0	0.0	0.0
8/13	273	0.0	.4	1.1	19.0	0.0	8.8	70.0	0.0	0.0	.7	0.0
8/25	128	.8	0.0	2.3	21.1	0.0	14.8	60.2	.8	0.0	0.0	0.0
8/27	125	0.0	0.0	1.6	17.6	.8	20.8	59.2	0.0	0.0	0.0	0.0

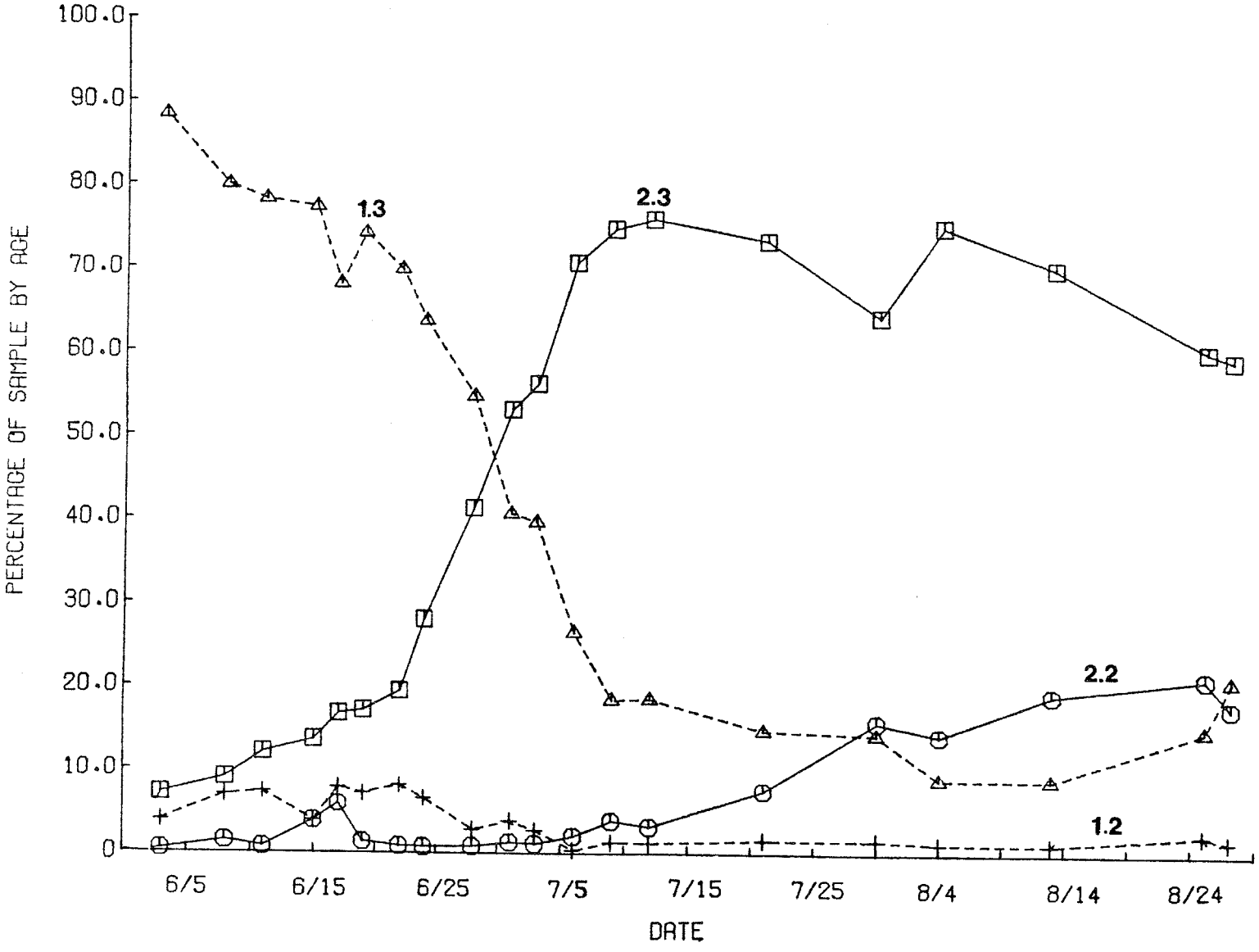

Figure 4. Age composition of scale samples collected in Chignik Lagoon during the 1981 sockeye salmon run, by sample date. Minor age groups are not shown.

For the 2.3 age fish the following characters were selected:

1) ratio of the size of the total lacustrine annular zone to size of the total lacustrine growth zone (RATIO1);

2) distance between the end of the first lacustrine annular zone and the second circulus in the second lacustrine annular zone (DIST1);

3) the distance between the scale focus and the first circulus in the first lacustrine annular zone (DFOC1);

4) ratio of the distance between the second and fourth circuli in the first lacustrine annular zone to the size of that zone (RATIO2); and

5) distance between the second circulus before the end of the second lacustrine annulus and the end of that annulus (DIST2).

The mean value and standard deviation for each scale character, by age class and spawning stock, are given in Table 3.

Classification accuracies for age 1.3 and 2.3 sockeye salmon were 74.05% and 79.75%, respectively. The classification arrays for each age class are presented in Table 4. These classification accuracies compare favorably with those of Marshall et al. (1980).

The adjusted stock composition estimates, their 90.0% confidence interval, and sample size for scale samples of age 1.3 and 2.3 sockeye salmon collected in Chignik Lagoon during the transition period and classified by each age-specific discriminant function, are presented in Table 5. Although the age-specific estimates show great variation, they display the trend of a progression from a majority of Black Lake spawners early in the season to a majority of Chignik Lake spawners later in the season. These estimates indicate that the change from a majority of Black Lake spawners to a majority of Chignik Lake spawners occurred much earlier than is normal which supports the decision by ADF&G to shift the average TOE curve forward 10 days.

Separation of the Catch and Escapement by Spawning Stock

The age-specific stock composition estimates can be applied to the daily catch and escapement in a number of different ways. Three possible alternatives are as follows: (1) apply the adjusted estimates as they are; (2) linearize the estimates and fit a regression line to them; or (3) smooth the estimates over a number of sample dates. The erratic behavior of the adjusted estimates, with large differences between stock estimates only 2 or 3 days apart, and the large confidence intervals associated with these estimates make their use difficult. Marshall et al. (1980) linearized their point estimates and fitted a regression line to the data. By converting the daily stock composition estimates given by the regression line they established a smooth curve, similar to the average TOE curve, to allocate the daily catch and escapement. This method assumed that the proportion of Chignik Lake spawners increased steadily (while the proportion of Black Lake spawners declined) during the season and deviations from this pattern were not recognized. The adjusted

Table 3. Mean value ($\bar{x}$) and standard deviation (s) of scale characters used in the stock composition analysis by age class and spawning stock (measurements in 0.01's inches were made at 210X).

Age 1.3	Scale character											
	DFOC4		RATIO1		RATIO2		NC1		RATIO3		DIST1	
Spawning stock	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Black Lake	130.15	15.17	0.89	0.07	0.23	0.05	8.43	1.35	0.35	0.05	46.69	8.45
Chignik Lake	114.46	14.17	0.82	0.13	0.29	0.08	7.47	1.88	0.37	0.07	39.75	7.51

Age 2.3	Scale character									
	RATIO1		DIST1		DFOC1		RATIO2		RATIO3	
Spawning stock	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Black Lake	0.99	0.04	36.03	6.29	57.67	7.38	0.25	0.04	15.57	3.50
Chignik Lake	0.95	0.04	41.08	5.86	54.63	5.46	0.27	0.03	14.00	3.20

Table 4. Classification arrays in numbers and percentage for age 1.3 and 2.3 sockeye salmon in the 1981 Chignik return.

Age 1.3		
Calculated decision	Correct decision	
	Black Lake	Chignik Lake
Black Lake	155 (0.775)	37 (0.294)
Chignik Lake	45 (0.225)	89 (0.706)
Total	200	126

Age 2.3		
Calculated decision	Correct decision	
	Black Lake	Chignik Lake
Black Lake	112 (0.800)	41 (0.205)
Chignik Lake	28 (0.200)	159 (0.795)
Total	140	200

Table 5. Age-specific stock composition estimates determined by scale pattern analysis, by sample date.

Sample Date	Spawning Stock	Stock composition estimate, 90.0% confidence interval, and sample size by age class 1.3		2.3	
6/3	Black Lake	.844±.180	(100)	1.056±.262	(18)
	Chignik Lake	.156±.180		-.056±.262	
6/8	Black Lake	.657±.186	(100)	.560±.278	(26)
	Chignik Lake	.343±.186		.440±.278	
6/11	Black Lake	.511±.191	(100)	.376±.239	(35)
	Chignik Lake	.489±.191		.624±.239	
6/15	Black Lake	.324±.197	(100)	.856±.226	(35)
	Chignik Lake	.676±.197		.144±.226	
6/17	Black Lake	.387±.195	(100)	.838±.209	(43)
	Chignik Lake	.613±.195		.172±.209	
6/19	Black Lake	.636±.186	(100)	.380±.201	(51)
	Chignik Lake	.364±.186		.620±.201	
6/22	Black Lake	.407±.194	(100)	.261±.199	(50)
	Chignik Lake	.593±.194		.739±.199	
6/24	Black Lake	.283±.199	(100)	.529±.169	(77)
	Chignik Lake	.717±.199		.471±.169	
6/28	Black Lake	.283±.199	(100)	.630±.152	(100)
	Chignik Lake	.717±.199		.370±.152	
7/1	Black Lake	.107±.216	(84)	.412±.150	(100)
	Chignik Lake	.893±.216		.588±.150	
7/3	Black Lake	.040±.208	(99)	.378±.149	(100)
	Chignik Lake	.960±.208		.622±.149	
7/6	Black Lake	.136±.238	(64)	.311±.148	(100)
	Chignik Lake	.864±.238		.689±.148	
7/9	Black Lake	.220±.287	(40)	.294±.148	(100)
	Chignik Lake	.780±.287		.706±.148	
7/12	Black Lake	.052±.268	(47)	.244±.146	(100)
	Chignik Lake	.948±.268		.756±.146	
7/21	Black Lake	.313±.301	(36)	.042±.139	(100)
	Chignik Lake	.687±.301		.958±.139	

estimates indicated that this assumption was not true in 1981 because there was a large influx of Chignik Lake spawners early in the season which was evident in both age classes.

For this report it was decided that the best approach was to weight the adjusted estimates equally and smooth them by a moving average of three sample dates. In order to include all sample dates in the analysis it was assumed that any sample prior to the first would be composed of 100% Black Lake spawners and any sample after the last composed of 100% Chignik Lake spawners. Negative stock composition estimates were set to 0.0 and estimates greater than one set to 1.0 before the estimates were smoothed. The average of the 1.3 and 2.3 estimates was used for the age classes for which there were no age-specific stock composition estimates (Figure 5).

Before the age-specific stock composition estimates could be applied, the total daily run had to be apportioned by age class. The age composition of the scale samples collected in Chignik Lagoon was used to determine a daily age composition. For the escapements prior to the first Lagoon sampling date the age composition of the first sample was used. The age composition of the subsequent samples was applied to the total sockeye salmon run on the day the sample was collected. For the days between two sample dates an age composition was calculated by linearly interpolating between the two samples. The age composition of the last Lagoon sample was applied to the total daily run on that day and the days following it.

After the total daily run had been apportioned by age class the age-specific stock composition estimates for ages 1.3 and 2.3 and the average estimates for the remaining ages were applied. The estimates used were those given by smoothing the adjusted stock composition estimates by a moving average of three sample dates. As with the age composition estimates, the stock composition estimates for a sample date were applied to that day and the stock composition for days between sample dates determined by linear interpolation. It was assumed that the first sockeye salmon counted at Chignik weir were entirely of Black Lake origin and that after the period of transition ending on 21 July all sockeye salmon were bound for Chignik Lake spawning areas.

The results of allocating the daily sockeye salmon catch and escapement using the age-specific stock composition estimates from the scale pattern analysis are summarized in Table 6 by age class and spawning stock. The total Black Lake run was 1,076,604 sockeye salmon which consisted of an escapement of 445,558 fish and a catch of 632,046 fish. Age 1.3 sockeye salmon were the predominant age class in the Black Lake run, with 61.7% of the total run belonging to that class. The total run to Chignik Lake was 1,865,733 sockeye salmon. The escapement to Chignik Lake spawning areas was 386,886 fish and there were 1,478,847 Chignik Lake fish caught in the commercial catch. Approximately 50% of the total Chignik Lake run was age 2.3 and 40% age 1.3. When both runs are combined, the 1.3 and 2.3 age classes account for more than 90% of the total Chignik sockeye salmon run.

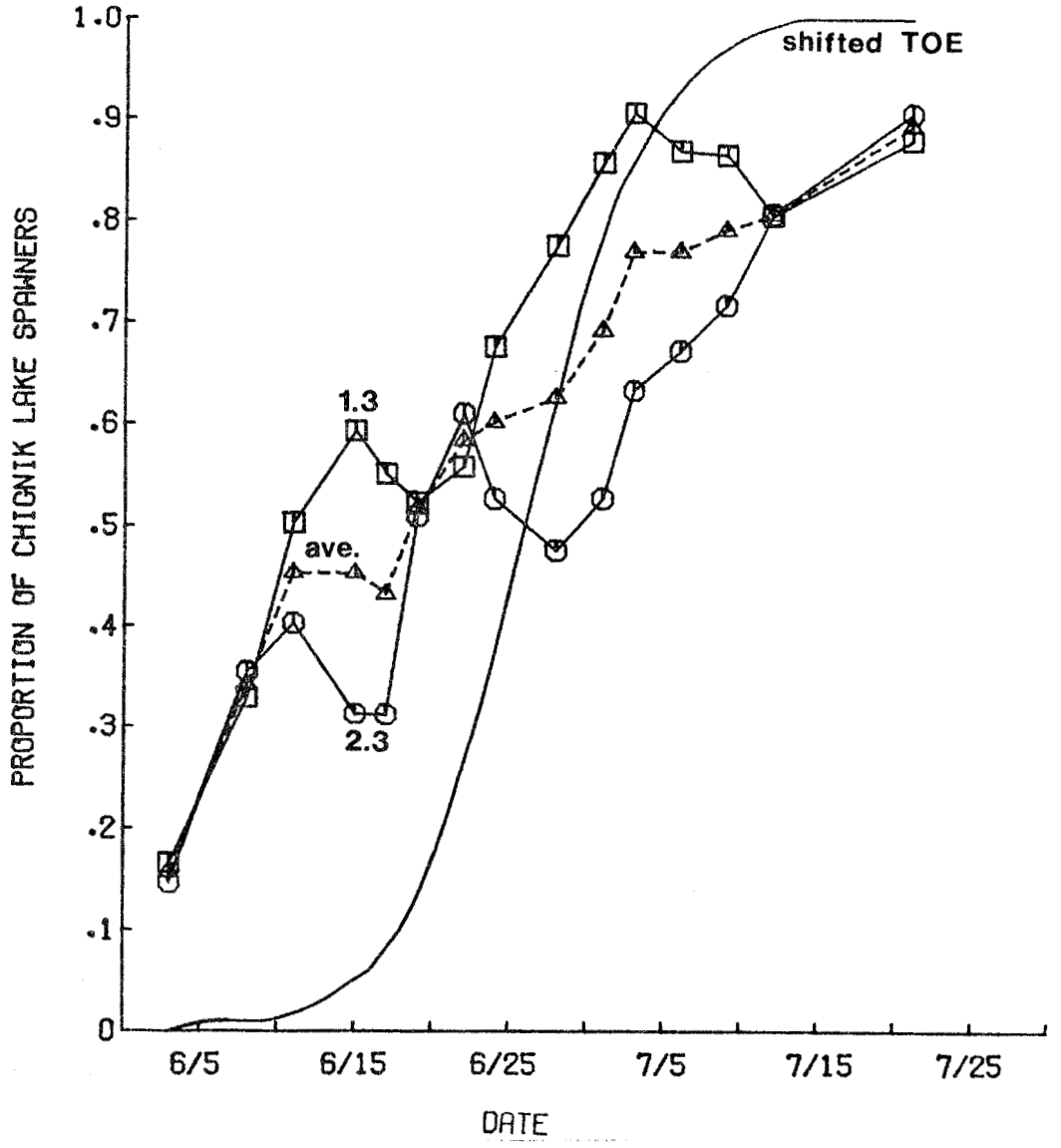

Figure 5. Daily stock composition during the period of transition as determined by the age-specific stock composition estimates smoothed by a moving average of three sample dates and by the average TOE curve shifted forward ten days.

Table 6. Summary of the escapement, commercial catch, and total return by age class and spawning stock for the 1981 Chignik sockeye salmon run as determined by the scale pattern analysis method.

	Age class											
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.3	Other	Total
Black Lake												
Escapement	16	12	21,128	4,244	139	334,680	80,159	254	197	24	3,705	444,558
%	T*	T	4.75	0.96	0.03	75.28	18.03	0.06	0.04	0.01	0.83	99.99
Catch	200	205	31,707	14,859	676	323,910	251,575	1,593	591	288	6,442	632,046
%	0.03	0.03	5.02	2.35	0.11	51.25	39.80	0.25	0.09	0.05	1.02	100.00
Total	216	217	52,835	19,103	815	658,590	331,734	1,847	788	213	10,147	1,076,604
%	0.02	0.02	4.91	1.78	0.08	61.17	30.81	0.17	0.07	0.03	0.94	100.00
Chignik Lake												
Escapement	83	467	14,651	17,057	521	217,051	133,439	1,078	241	287	2,011	386,886
%	0.02	0.12	3.79	4.41	0.14	56.10	34.49	0.28	0.06	0.07	0.52	100.00
Catch	299	3,592	40,414	81,708	3,180	536,848	795,988	8,647	645	2,114	5,412	1,478,847
%	0.02	0.24	2.73	5.53	0.22	36.30	53.83	0.58	0.04	0.14	0.37	100.00
Total	382	4,059	55,065	98,765	3,701	753,899	929,427	9,725	886	2,401	7,423	1,865,733
%	0.02	0.22	2.95	5.29	0.20	40.41	49.81	0.52	0.05	0.13	0.40	100.00

*Trace

DISCUSSION

The accuracy of any method of allocating the Chignik sockeye salmon catch and escapement by component spawning stocks can be evaluated by examining the actual escapement to each lake. Ideally, a tagging study to determine each stock's pattern of entry, similar to those conducted in the 1960's, followed by extensive spawning ground surveys, would provide the best standard for comparison. Such a study would require more money and man-hours than is currently practical. An alternative would be to survey the major Black Lake and Chignik Lake spawning areas to determine an average age composition for each spawning stock to compare with that estimated by the method of allocation. This presents problems because of the difficulty in obtaining representative samples because of the large area encompassed by each lake's spawning grounds. This is especially true of Chignik Lake where there are at least four important spawning areas. More importantly, spawning ground surveys must be conducted late in the season when it is impractical to use scales for aging purposes because of extensive absorption of the scale edges. Otoliths must be used to determine the ocean age and aging discrepancies between scales and otoliths can appear.

Using the available data, the best method of evaluating any allocation technique is to compare the age composition of the Black Lake escapement estimated by the allocation method to the age composition of the samples collected at Black Lake outlet. As stated previously, large schools of adults congregate at Black Lake outlet prior to moving to their spawning areas. If newly arriving fish behave similarly throughout the season, are available to sampling for equal periods of time, and are randomly sampled, then these samples should accurately represent the age composition of the Black Lake spawning stock.

When the mean age composition of the Black Lake outlet scale samples (Table 1) is compared to the age composition estimated for the Black Lake escapement by the scale pattern allocation method (Table 6), there is very good agreement for all age classes except for ages 1.2 and 2.3. The percentage of age 1.2 sockeye salmon observed at Black Lake outlet (9.60%) is more than twice the percentage estimated by the allocation using scale patterns (4.75%). The difference between the observed and estimated percentage of age 2.3 sockeye salmon (13.10% and 18.02%, respectively) is not nearly as severe with a 5% difference.

This difference between the observed and estimated percentage of age 2.3 sockeye salmon in the Black Lake escapement might be explained by examining the daily Black Lake escapement summary (Appendix Table 5). The last sample at Black Lake outlet was collected on 22 June, yet fish were being allocated to the Black Lake escapement until 21 July. Although only 16.2% of the Black Lake escapement occurred after 22 June, 61.9% of the sockeye salmon assigned to the Black Lake escapement during this period were age 2.3. If the scale pattern allocation method accurately estimates the Black Lake escapement, scale samples collected at Black Lake outlet in early or mid-July would show an increased abundance of age 2.3 sockeye salmon. Therefore, the difference between the observed and estimated percentage of age 2.3 sockeye salmon in the Black Lake escapement might be attributed to a failure to sample the late-arriving portion of the Black Lake escapement.

The difference between the observed and estimated percentage of age 1.2 sockeye salmon in the Black Lake escapement is difficult to explain. There is a peculiar anomaly in the observed percentage of the 1.2 age class for the samples collected at Black Lake outlet. There is little variation in the percentage of the 1.2 age class in four of the six samples, but the percentage in the samples collected on 10 June (16.2%) and 13 June (13.3%) is nearly twice the observed percentage of samples taken only 1 day earlier. Also, the observed percentage of the 1.2 age class in these two samples exceeds that seen in any of the samples collected in Chignik Lagoon by at least 5%.

There are two possible explanations for the difference between the observed and estimated percentage of age 1.2 sockeye salmon in the Black Lake escapement. If the samples collected on 10 and 13 June accurately reflect the abundance of the 1.2 age class in the Black Lake escapement, then that age class is not being representatively sampled in Chignik Lagoon. Because the age 1.2 sockeye salmon are much smaller than the 3-ocean fish which are predominant in the catch, they may not be sampled in proportion to their true abundance when scales are being collected. Another explanation is the samples collected at Black Lake on 10 and 13 June do not accurately reflect the abundance of the 1.2 age class in the escapement because of nonrandom distribution of fish on those days or to sampling bias.

SUMMARY

Allocating the run of Chignik sockeye salmon by its component spawning stocks using age-specific stock composition estimates determined by scale pattern analysis appears to be a viable alternative to the present use of the average TOE curve. In 1981, classification accuracies of 74.1% and 79.8% for ages 1.3 and 2.3, respectively, were given using a linear discriminant function. This indicates that the scale patterns of adults which reared as juveniles in Black Lake are significantly different than those which reared in Chignik Lake. A different time-of-entry pattern is evident for the two age classes analyzed in 1981 which stresses the importance of an age-specific allocation method.

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APPENDICES

Appendix Table 1. Scale characters evaluated for use in the linear discriminant function analysis.

First lacustrine annular zone	
1	number of circuli in the first lacustrine annular zone
2	size of the first lacustrine annular zone
3-10	distance from the scale focus to each of the first eight circuli in the first lacustrine annular zone
11-18	the ratio of characters 3-10 to the size of the first lacustrine annular zone
19-22	distance between the first, second, third, and fifth circuli before the end of the first lacustrine annulus and the end of that annulus
23-26	the ratio of characters 19-22 to the size of the first lacustrine annular zone
27	average interval between circuli in the first lacustrine annular zone
28	number of circuli in the first 3/4 of the first lacustrine annular zone
29-33	distance between every consecutive pair of circuli between the first and the sixth circuli in the first lacustrine annular zone
34-38	the ratio of characters 29-33 to the size of the first lacustrine annular zone
39-42	distance between every second circulus between the first and the sixth circuli in the first lacustrine annular zone
43-46	the ratio of characters 39-42 to the size of the first lacustrine annular zone
47-49	distance between every third circulus between the first and the sixth circuli in the first lacustrine annular zone
50-52	the ratio of characters 47-49 to the size of the first lacustrine annular zone
53	distance between the first and fifth circuli in the first lacustrine annular zone
54	distance between the first and sixth circuli in the first lacustrine annular zone
55-56	the ratio of characters 53-54 to the size of the first lacustrine annular zone

-Continued-

Appendix Table 1. Scale characters evaluated for use in the linear discriminant function analysis (continued).

57	the size of the widest pair of circuli in the first lacustrine annular zone
58	the ratio of character 57 to the size of the first lacustrine annular zone
59	the first circulus of the widest pair in the first lacustrine annular zone
Second lacustrine annular zone	
1	number of circuli in the second lacustrine annular zone
2	size of the second lacustrine annular zone
3-8	distance from the end of the first lacustrine annulus to each of the first six circuli in the second lacustrine annular zone
9-14	the ratio of characters 3-8 to the size of the second lacustrine annular zone
15-17	distance between the first, second, and fourth circuli before the end of the second lacustrine annulus and the end of that annulus
18-20	the ratio of characters 15-17 to the size of the second lacustrine annular zone
21	average interval between circuli in the second lacustrine annular zone
22	total number of annular circuli in the lacustrine zone
23	total size of the annular region to the lacustrine zone
24	ratio of the size of the first lacustrine annular zone to the size of the total lacustrine annular region
25	size of the widest pair of circuli in the second lacustrine annular zone
26	ratio of character 25 to the size of the second lacustrine annular zone
27	the first circulus of the widest pair in the second lacustrine annular zone
28-32	distance between every consecutive pair of circuli between the first and the sixth circuli in the second lacustrine annular zone

-Continued-

Appendix Table 1. Scale characters evaluated for use in the linear discriminant function analysis (continued).

33-37	the ratio of characters 28-32 to the size of the second lacustrine annular zone
38-41	distance between every second circulus between the first and the sixth circuli in the second lacustrine annular zone
42-45	the ratio of characters 38-41 to the size of the second lacustrine annular zone
46-48	distance between every third circulus between the first and the sixth circuli in the second lacustrine annular zone
49-51	the ratio of characters 46-48 to the size of the second lacustrine annular zone
52	distance between the first and fifth circuli in the second lacustrine annular zone
53	distance between the second and sixth circuli in the second lacustrine annular zone
54-55	the ratio of characters 52-53 to the size of the second lacustrine annular zone
56	the number of circuli in the first half of the second lacustrine annular zone
Lacustrine plus growth	
1	number of circuli of lacustrine plus growth
2	size of the region of lacustrine plus growth
3	total number of circuli in the lacustrine zone (including plus growth)
4	total size of the lacustrine zone (including plus growth)
5	ratio of the size of the first lacustrine annular zone to the size of the total lacustrine zone
6	ratio of character 4 to character 3

Appendix Table 2. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1981.

DATE	ESCAPEMENT	CHIGNIK LAGOON	HOOK BAY/ KUJULIK	ANIAKCHAK	EASTERN DISTRICT	CAPE IGVAK	WESTERN DISTRICT	PERRYVILLE DISTRICT	STEPOVAK	DAILY TOTAL
5/20	0	0	0	0	0	0	0	0	0	0
5/21	0	0	0	0	0	0	0	0	0	0
5/22	0	0	0	0	0	0	0	0	0	0
5/23	36	0	0	0	0	0	0	0	0	36
5/24	0	0	0	0	0	0	0	0	0	0
5/25	54	0	0	0	0	0	0	0	0	54
5/26	318	0	0	0	0	0	0	0	0	318
5/27	911	0	0	0	0	0	0	0	0	911
5/28	1,834	0	0	0	0	0	0	0	0	1,834
5/29	7,773	0	0	0	0	0	0	0	0	7,773
5/30	11,207	0	0	0	0	0	0	0	0	11,207
5/31	10,409	0	0	0	0	0	0	0	0	10,409
6/ 1	25,358	0	0	0	0	0	0	0	0	25,358
6/ 2	38,460	0	0	0	0	0	0	0	0	38,460
6/ 3	61,204	0	0	0	0	0	0	0	0	61,204
6/ 4	90,963	0	0	0	0	0	0	0	0	90,963
6/ 5	72,937	0	0	0	0	0	0	0	0	72,937
6/ 6	31,832	438	0	0	0	0	0	0	0	32,270
6/ 7	3,055	0	0	0	0	0	0	0	0	3,055
6/ 8	5,926	106,260	0	0	0	0	0	0	0	112,186
6/ 9	3,386	56,508	0	0	0	0	0	0	0	59,894
6/10	1,993	64,258	9,385	3,101	0	0	0	0	0	78,737
6/11	2,882	47,797	2,050	8,457	0	0	0	0	0	61,186
6/12	23,332	44,932	6,913	9,474	0	0	0	0	0	84,651
6/13	50,423	520	5,635	5,061	0	0	0	0	0	61,639
6/14	5,698	603	1,317	11,041	0	0	0	0	0	18,659
6/15	817	51,337	0	8,581	0	0	0	0	0	60,735
6/16	751	37,820	5,191	0	0	0	0	0	0	43,762
6/17	4,320	27,263	7,926	2,768	0	0	0	0	0	42,277
6/18	4,374	29,484	11,725	4,510	0	16,773	0	0	0	66,866
6/19	12,992	19,953	9,506	2,978	0	10,931	0	0	0	56,360
6/20	18,758	0	3,018	6,119	0	0	0	0	0	27,895
6/21	26,765	0	0	3,338	0	12,230	0	0	0	42,333
6/22	8,162	0	0	0	0	15,027	0	0	0	23,189
6/23	1,332	0	604	0	0	19,430	0	0	0	21,366
6/24	7,187	50,766	0	0	0	19,252	0	0	0	77,205
6/25	22,805	0	5,885	0	0	25,596	0	0	0	54,286

-Continued-

Appendix Table 2. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1981 (continued).

DATE	ESCAPEMENT	CHIGNIK LAGOON	HOOK BAY/ KUJULIK	ANIAKCHAK	EASTERN DISTRICT	CAPE IGVAK	WESTERN DISTRICT	PERRYVILLE DISTRICT	STEPOVAK	DAILY TOTAL
6/26	25,828	0	0	9,923	0	0	0	0	0	35,751
6/27	19,876	0	0	0	0	0	0	0	0	19,876
6/28	25,489	360	0	0	0	0	0	0	0	25,849
6/29	23,822	0	0	0	0	0	0	0	0	23,822
6/30	20,826	0	0	0	0	0	0	0	0	20,826
7/ 1	7,713	46,814	0	0	0	0	0	0	0	54,527
7/ 2	6,978	35,343	6,588	0	0	0	0	0	0	48,909
7/ 3	17,196	44,816	1,611	4,590	0	0	0	0	0	68,213
7/ 4	8,580	0	5,322	1,170	0	0	0	3	0	15,075
7/ 5	2,646	54,263	0	3,827	0	0	0	7	0	60,743
7/ 6	1,745	39,733	9,207	0	0	16,794	0	329	0	67,808
7/ 7	1,507	45,641	4,869	3,356	0	16,350	10	308	0	72,041
7/ 8	1,630	40,276	5,790	4,641	0	13,365	0	0	0	65,702
7/ 9	1,790	43,662	5,226	4,444	0	27,708	0	0	0	82,830
7/10	2,439	41,354	12,885	3,086	0	54,930	1,321	0	0	116,015
7/11	1,530	32,309	13,877	4,606	0	0	753	0	0	53,075
7/12	1,374	22,874	15,115	0	0	0	0	0	0	39,363
7/13	1,962	30,343	23,259	2,754	0	0	0	0	0	58,318
7/14	3,963	38,184	19,024	4,949	0	0	0	0	0	66,120
7/15	2,632	17,771	7,310	3,281	0	0	0	0	0	30,994
7/16	2,476	23,360	12,672	5,051	0	0	0	0	0	43,559
7/17	9,177	17,170	21,860	5,328	0	0	187	0	0	53,722
7/18	9,174	0	6,539	3,974	0	3,902	2,257	0	0	25,846
7/19	1,824	4,501	0	741	0	8,920	1,175	172	0	17,333
7/20	2,454	22,485	411	0	0	9,960	156	25	0	35,491
7/21	3,006	12,836	7,346	464	0	2,977	0	0	0	26,629
7/22	2,928	11,960	5,501	4,540	0	3,394	0	0	0	28,323
7/23	1,410	7,917	4,152	5,678	0	0	0	0	0	19,157
7/24	1,365	6,923	3,377	1,330	0	0	0	0	0	12,995
7/25	1,932	6,822	2,012	972	213	0	0	0	0	11,951
7/26	1,632	5,128	1,771	748	0	2,331	0	0	0	11,610
7/27	2,304	9,117	3,183	3,439	21	1,468	0	67	0	19,599
7/28	2,424	10,711	1,680	1,236	26	1,209	0	0	0	17,286
7/29	1,558	9,953	2,245	1,573	366	134	0	0	0	15,829
7/30	1,613	10,468	2,091	1,734	0	1,002	0	0	0	16,908
7/31	1,613	8,269	2,226	1,649	0	0	373	0	0	14,130

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Appendix Table 2. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1981 (continued).

DATE	ESCAPEMENT	CHIGNIK LAGOON	HOOK BAY/ KUJULIK	ANIAKCHAK	EASTERN DISTRICT	CAPE IGVAK	WESTERN DISTRICT	PERRYVILLE DISTRICT	STEPOVAK	DAILY TOTAL
8/ 1	1,613 *	0	1,055	3,324	0	0	1,188	228	0	7,408
8/ 2	1,613	0	0	3,357	0	0	2,233	625	0	7,828
8/ 3	1,613	10,285	0	0	0	0	0	967	0	12,865
8/ 4	1,613	9,046	1,177	0	0	0	0	0	0	11,836
8/ 5	1,613	6,852	622	2,967	0	0	0	0	0	12,054
8/ 6	1,613	6,813	286	26	0	0	454	0	0	9,192
8/ 7	1,613	6,489	424	2,191	64	0	2,844	162	0	13,787
8/ 8	1,613	0	500	1,562	137	0	654	675	0	5,141
8/ 9	1,613	0	0	1,173	702	0	423	323	0	4,234
8/10	1,613	10,250	0	0	27	0	80	208	0	12,178
8/11	1,613	5,140	285	0	0	0	0	0	0	7,038
8/12	1,613	3,565	84	1,243	0	0	2	0	0	6,507
8/13	1,613	6,550	1,169	0	14	0	176	158	0	9,680
8/14	1,613	8,307	1,166	1,108	25	0	105	191	0	12,515
8/15	1,613	0	1,636	734	6	0	127	626	0	4,742
8/16	1,613	0	0	347	35	0	174	579	0	2,748
8/17	1,613	7,070	0	0	0	0	59	667	0	9,409
8/18	1,613	4,745	1,022	0	0	0	0	0	0	7,380
8/19	1,613	4,072	384	138	0	0	0	97	0	6,304
8/20	1,613	1,440	1,356	122	0	0	0	0	0	4,531
8/21	1,613	1,628	4	63	0	0	0	0	0	3,308
8/22	1,613	0	0	0	0	0	0	0	0	1,613
8/23	1,613	0	0	0	0	0	0	0	0	1,613
8/24	1,613	5,598	0	0	0	0	0	0	0	7,211
8/25	1,613	3,251	385	0	0	0	0	0	0	5,249
8/26	1,613	1,704	0	0	0	0	0	0	0	3,317
8/27	1,613	1,573	0	0	0	0	0	0	0	3,186
8/28	1,613	0	0	0	0	0	0	0	0	1,613
8/29	1,610	0	0	0	0	0	0	0	0	1,610
8/30	0	0	0	0	0	0	0	0	0	0
8/31	0	0	0	0	0	0	0	0	0	0
TOTAL	831,444	1,343,680	287,859	172,867	1,636	283,683	14,751	6,417	0	2,942,337

* prorated for an estimated escapement of 50,000 in August

Appendix Table 3. Summary of daily and cumulative return of sockeye salmon to Black Lake, 1981 (adjusted to Chignik Lagoon date).

Date	Numbers of Fish				Cumulative Proportion
	Escapement	Catch	Daily Return	Cumulative Return	
Prior 5/28	1,249		1,249	1,249	.001
5/28	1,698		1,698	2,947	.003
5/29	7,075		7,075	10,022	.009
5/30	10,036		10,036	20,058	.019
5/31	9,163		9,163	29,221	.027
6/01	21,946		21,946	51,167	.048
6/02	32,709		32,709	83,876	.078
6/03	51,138		51,138	135,014	.125
6/04	72,969		72,969	207,983	.193
6/05	56,064		56,064	264,047	.245
6/06	23,395	322	23,717	287,764	.267
6/07	2,142		2,142	289,906	.269
6/08	3,953	70,873	74,826	364,732	.339
6/09	2,084	34,774	36,858	401,590	.373
6/10	1,126	43,322	44,448	446,038	.414
6/11	1,482	29,984	31,466	477,504	.444
6/12	11,661	30,648	42,309	519,813	.483
6/13	24,487	5,446	29,933	549,746	.511
6/14	2,688	6,113	8,801	558,547	.519
6/15	374	27,445	27,819	586,366	.545
6/16	363	20,783	21,146	607,512	.564
6/17	2,192	19,246	21,438	628,950	.584
6/18	2,151	30,725	32,876	661,826	.615
6/19	6,229	20,794	27,023	688,849	.640
6/20	8,689	4,233	12,922	701,771	.652
6/21	11,948	6,949	18,897	720,668	.669
6/22	3,502	6,449	9,951	730,619	.679
6/23	529	7,953	8,482	739,101	.687
6/24	2,675	26,063	28,738	767,839	.713
6/25	8,313	11,476	19,789	786,628	.731
6/26	9,270	3,562	12,832	800,460	.744
6/27	7,064		7,064	807,524	.750
6/28	9,022	127	9,149	816,673	.759
6/29	8,212		8,212	824,885	.766
6/30	7,004		7,004	831,889	.773
7/01	2,539	15,402	17,941	849,830	.789
7/02	2,034	12,221	14,255	864,085	.803
7/03	4,356	12,923	17,279	881,364	.819
7/04	2,250	1,704	3,954	885,318	.822
7/05	712	15,618	16,330	901,648	.837
7/06	477	18,041	18,518	920,166	.855
7/07	401	18,787	19,188	939,354	.873
7/08	421	16,594	17,015	956,369	.888
7/09	449	20,338	20,787	977,156	.908
7/10	566	26,355	26,921	1,004,077	.933
7/11	326	10,977	11,303	1,015,380	.943
7/12	266	7,360	7,626	1,023,006	.950
7/13	358	10,336	10,694	1,033,700	.960
7/14	686	10,758	11,444	1,045,144	.971
7/15	428	4,617	5,045	1,050,189	.975
7/16	379	6,262	6,641	1,056,830	.982
7/17	1,303	6,331	7,634	1,064,464	.989
7/18	1,210	2,198	3,408	1,067,872	.992
7/19	222	1,885	2,107	1,069,979	.994
7/20	271	3,672	3,943	1,073,922	.998
7/21	302	2,380	2,682	1,076,604	1.000
Total	444,558	632,046	1,076,604		

Appendix Table 4. Summary of daily and cumulative return of sockeye salmon to Chignik Lake, 1981 (adjusted to Chignik Lagoon date).

Date	Numbers of Fish				Cumulative Proportion
	Escapement	Catch	Daily Return	Cumulative Return	
Prior 6/01	3,321		3,321	3,321	.002
6/01	3,412		3,412	6,733	.004
6/02	5,751		5,751	12,484	.007
6/03	10,066		10,066	22,550	.012
6/04	17,994		17,994	40,544	.022
6/05	16,873		16,873	57,417	.031
6/06	8,437	116	8,553	65,970	.035
6/07	913		913	66,883	.036
6/08	1,973	35,387	37,360	104,243	.056
6/09	1,302	21,734	23,036	127,279	.068
6/10	867	33,422	34,289	161,568	.087
6/11	1,400	28,320	29,720	191,288	.103
6/12	11,671	30,671	42,342	233,630	.125
6/13	25,936	5,770	31,706	265,336	.142
6/14	3,010	6,848	9,858	275,194	.147
6/15	443	32,473	32,916	308,110	.165
6/16	388	22,228	22,616	330,726	.177
6/17	2,128	18,711	20,839	351,565	.188
6/18	2,223	31,767	33,990	385,555	.207
6/19	6,763	22,574	29,337	414,892	.222
6/20	10,069	4,904	14,973	429,865	.230
6/21	14,817	8,619	23,436	453,301	.243
6/22	4,660	8,578	13,238	466,539	.250
6/23	803	12,081	12,884	479,423	.257
6/24	4,512	43,955	48,467	527,890	.283
6/25	14,492	20,005	34,497	562,387	.301
6/26	16,558	6,361	22,919	585,306	.314
6/27	12,812		12,812	598,118	.321
6/28	16,467	233	16,700	614,818	.330
6/29	15,610		15,610	630,428	.338
6/30	13,822		13,822	644,250	.345
7/01	5,174	31,412	36,586	680,836	.365
7/02	4,944	29,710	34,654	715,490	.383
7/03	12,840	38,094	50,934	766,424	.411
7/04	6,330	4,791	11,121	777,545	.417
7/05	1,934	42,479	44,413	821,958	.441
7/06	1,268	48,022	49,290	871,248	.467
7/07	1,106	51,747	52,853	924,101	.495
7/08	1,209	47,478	48,687	972,788	.521
7/09	1,341	60,702	62,043	1,034,831	.555
7/10	1,873	87,221	89,094	1,123,925	.602
7/11	1,204	40,568	41,772	1,165,697	.625
7/12	1,108	30,629	31,737	1,197,434	.642
7/13	1,604	46,020	47,624	1,245,058	.667
7/14	3,277	51,399	54,676	1,299,734	.697
7/15	2,204	23,745	25,949	1,325,683	.711
7/16	2,097	34,821	36,918	1,362,601	.730
7/17	7,874	38,214	46,088	1,408,689	.755
7/18	7,964	14,474	22,438	1,431,127	.767
7/19	1,602	13,624	15,226	1,446,353	.775
7/20	2,183	29,365	31,548	1,477,901	.792
7/21	2,704	21,243	23,947	1,501,848	.805
7/22	2,928	25,395	28,323	1,530,171	.820
7/23	1,410	17,747	19,157	1,549,328	.830
7/24	1,365	11,630	12,995	1,562,323	.837
7/25	1,932	10,019	11,951	1,574,274	.844
7/26	1,632	9,978	11,610	1,585,884	.850
7/27	2,304	17,295	19,599	1,605,483	.861
7/28	2,424	14,862	17,286	1,622,769	.870
7/29	1,558	14,271	15,829	1,638,598	.878
7/30	1,613*	15,295	16,908	1,655,506	.887
7/31	1,613	12,517	14,130	1,669,636	.895
After 7/31	46,774*	149,323	196,097	1,865,733	1.000
Total	386,886	1,478,847	1,865,733		

* prorated for an estimated escapement of 50,000 in August

Appendix Table 5. Daily Black Lake sockeye salmon escapement, by age class, as estimated by the age-specific scale pattern analysis, 1981.

SAMPLE DATE	AGE CLASS											DAILY TOTAL
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	OTHER	
5/22	0	0	0	0	0	0	0	0	0	0	0	0
5/23	0	0	1	0	0	32	3	0	0	0	0	36
5/24	0	0	0	0	0	0	0	0	0	0	0	0
5/25	0	0	2	0	0	47	4	0	0	0	0	53
5/26	0	0	11	1	0	268	22	0	0	0	1	303
5/27	0	0	33	4	0	754	62	0	0	0	4	857
5/28	0	0	65	7	0	1,498	121	0	0	0	7	1,698
5/29	0	0	270	28	0	6,241	508	0	0	0	28	7,075
5/30	0	0	384	41	0	8,848	722	0	0	0	41	10,036
5/31	0	0	351	37	0	8,078	660	0	0	0	37	9,163
6/ 1	0	0	841	88	0	19,345	1,584	0	0	0	88	21,946
6/ 2	0	0	1,253	132	0	28,825	2,367	0	0	0	132	32,709
6/ 3	0	0	1,962	207	0	45,054	3,708	0	0	0	207	51,138
6/ 4	0	0	3,243	440	0	63,118	5,523	0	0	0	645	72,969
6/ 5	0	0	2,828	449	0	47,609	4,415	0	0	0	763	56,064
6/ 6	0	0	1,319	233	0	19,503	1,911	0	0	0	429	23,395
6/ 7	0	0	133	26	0	1,753	181	0	0	0	49	2,142
6/ 8	0	0	269	55	0	3,176	344	0	0	0	109	3,953
6/ 9	0	0	148	25	2	1,646	214	0	0	0	49	2,084
6/10	0	0	84	11	2	871	136	0	0	0	22	1,126
6/11	0	0	115	11	5	1,121	208	0	0	0	22	1,482
6/12	0	0	820	188	28	8,639	1,804	0	13	0	169	11,661
6/13	0	0	1,531	621	42	17,733	4,160	0	55	0	345	24,487
6/14	0	0	146	94	2	1,899	501	0	9	0	37	2,688
6/15	0	0	17	17	0	257	76	0	2	0	5	374
6/16	1	0	25	20	0	233	78	0	2	0	4	363
6/17	10	0	192	143	0	1,321	496	0	10	0	20	2,192
6/18	5	0	171	82	0	1,440	435	0	5	0	13	2,151
6/19	0	0	445	82	0	4,595	1,088	0	0	0	19	6,229
6/20	0	0	642	98	0	6,346	1,530	12	12	0	49	8,689
6/21	0	0	911	114	0	8,652	2,111	31	31	0	98	11,948
6/22	0	0	275	27	0	2,518	617	14	14	0	37	3,502
6/23	0	0	40	4	0	341	136	2	1	0	5	529
6/24	0	0	186	20	0	1,485	952	12	0	0	20	2,675
6/25	0	0	499	65	0	4,195	3,471	27	0	0	56	8,313

-Continued-

Appendix Table 5. Daily Black Lake sockeye salmon escapement, by age class, as estimated by the age-specific scale pattern analysis, 1981 (continued).

SAMPLE DATE	AGE CLASS											DAILY TOTAL
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	OTHER	
6/26	0	0	464	75	0	4,195	4,461	20	0	0	55	9,270
6/27	0	0	281	59	0	2,822	3,858	8	0	0	36	7,064
6/28	0	0	267	76	0	3,128	5,513	0	0	0	38	9,022
6/29	0	0	263	81	11	2,350	5,462	11	11	0	23	8,212
6/30	0	0	238	78	18	1,607	5,018	18	18	0	9	7,004
7/ 1	0	0	90	31	10	449	1,939	10	10	0	0	2,539
7/ 2	0	0	61	23	4	332	1,602	4	4	0	4	2,034
7/ 3	0	0	107	44	0	642	3,547	0	0	0	16	4,356
7/ 4	0	0	38	28	0	323	1,853	0	0	0	8	2,250
7/ 5	0	0	7	10	0	98	594	0	0	0	3	712
7/ 6	0	0	2	8	0	61	404	0	0	0	2	477
7/ 7	0	0	2	9	0	48	339	2	0	0	1	401
7/ 8	0	0	3	11	1	46	357	3	0	0	0	421
7/ 9	0	0	5	14	1	45	379	5	0	0	0	449
7/10	0	1	6	18	1	70	464	5	0	1	0	566
7/11	0	1	4	10	0	50	258	2	0	1	0	326
7/12	0	1	3	8	0	50	202	1	0	1	0	266
7/13	0	1	4	13	0	66	271	2	0	1	0	358
7/14	0	2	9	28	1	125	513	5	0	3	0	686
7/15	0	1	6	20	1	77	317	4	0	2	0	428
7/16	0	1	5	20	1	68	278	4	0	2	0	379
7/17	0	2	19	75	3	232	950	17	0	5	0	1,303
7/18	0	2	19	76	3	214	872	19	0	5	0	1,210
7/19	0	0	4	15	1	39	158	4	0	1	0	222
7/20	0	0	4	20	1	48	192	5	0	1	0	271
7/21	0	0	5	24	1	54	210	7	0	1	0	302
7/22	0	0	0	0	0	0	0	0	0	0	0	0
7/23	0	0	0	0	0	0	0	0	0	0	0	0
7/24	0	0	0	0	0	0	0	0	0	0	0	0
7/25	0	0	0	0	0	0	0	0	0	0	0	0
7/26	0	0	0	0	0	0	0	0	0	0	0	0
7/27	0	0	0	0	0	0	0	0	0	0	0	0
7/28	0	0	0	0	0	0	0	0	0	0	0	0
7/29	0	0	0	0	0	0	0	0	0	0	0	0
7/30	0	0	0	0	0	0	0	0	0	0	0	0
7/31	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	12	21,128	4,244	139	334,680	80,159	254	197	24	3,705	444,558

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