An Estimate of Spiridon Lake Sockeye Salmon Commercially Harvested Within the Southwest Afognak Section and Northwest Kodiak Management Area, 1996

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INTRODUCTION

Accurate assignment of salmon catches to stock or system of origin is necessary for evaluation of productivity trends, estimating smolt-to-adult survival, and preseason forecasting. For the purpose of estimating stock specific production within the Kodiak Management Area, a comprehensive salmon catch and escapement sampling program was initiated in 1985. This run reconstruction program initially focused on four major Kodiak sockeye salmon *Oncorhynchus nerka* stocks, including Karluk, Ayakulik, Upper Station, and Frazer (Barrett and Nelson 1995; Swanton 1992). During 1994, it was anticipated that an enhancement project at Spiridon Lake would be realizing it's first substantial sockeye return (>100,000 fish), which were expected to be harvested in traditional westside fishing areas. In order to maintain consistency in run reconstruction programs for wild stocks as well as quantify returns from the Spiridon Lake enhancement project, a novel stock identification program was implemented (Nelson and Barrett 1994).

Scale pattern analysis along with visual identification of freshwater growth patterns have been employed since 1994 to estimate the contribution of Spiridon Lake sockeye salmon to the Northwest, and Southwest Kodiak Districts' commercial catches. The objective of using scale pattern analysis (SPA) is to develop a statistical model that accurately identifies individual scales from known stocks within mixed stock fisheries or unknown samples. The freshwater scale pattern of Spiridon Lake sockeye salmon has remained consistent and easily distinguishable, lending itself to the application of this approach.

During 1994, a Spiridon stock contribution of 263,750 fish was estimated using visual freshwater scale pattern identification (Nelson and Barrett 1994). Scale pattern analysis incorporated in conjunction with visual scale pattern identification in 1995 resulted in a Spiridon sockeye salmon harvest estimate of 96,705 (Nelson and Swanton 1996a). Over 90% of these harvests occurred in the Northwest Kodiak District. Estimates were considered to be minimum values as this stock may have contributed to other Kodiak fisheries outside the Northwest Kodiak and Southwest Kodiak Districts, specifically the Southwest (SW) Afognak Section.

The migration and run timing of the Spiridon Lake stock appear to be very similar to that of the Upper Station late run brood stock source (Nelson and Swanton 1996a). Tagging experiments conducted in 1981 as well as catch estimates from 1994 and 1995 suggest that a majority of this run migrates from north to south along Kodiak Island's westside peaking in mid to late August (Nelson and Swanton 1996a, Nelson and Barrett 1994, Tyler et al. 1986).

Unlike the migration timing, the age composition of Spiridon Lake sockeye salmon does not appear to be consistent with the brood stock source. During both 1994 and 1995, age 1.2 was the dominant age class of sockeye salmon sampled in the Spiridon Lake Terminal Harvest Area (SLTHA) while the majority of Upper Station late run sockeye salmon were classified as age 2.2 fish.

This report serves as the third in a series of annual run reconstruction estimates of Spiridon Lake sockeye salmon (Nelson and Swanton 1996a, Nelson and Barrett 1994). The objectives of this report are threefold: first to estimate the number of Spiridon sockeye salmon harvested in the SW Afognak Section and Northwest (NW) Kodiak District; second, to monitor run timing based on commercial

harvest estimates; and finally, to compare and quantify annual freshwater growth of Spiridon sockeye salmon from scales collected during 1994, 1995, and 1996.

METHODS

Study Area

Spiridon Lake, located in the Central Section of the NW Kodiak District, is the third largest lake (9.6 km long, 1.6 km maximum width) on Kodiak Island (Figure 1). Prior to 1991, a series of barrier falls prevented access to the lake outlet and precluded the presence of anadromous fish (Kyle et al. 1990). Introduction of sockeye salmon fry to this system coupled with the construction of a smolt bypass system resulted in an artificial run. In 1993, the State Board of Fisheries (BOF) adopted the Spiridon Lake Sockeye Salmon Management Plan (5 AAC 18.366). In accordance with this plan, the Spiridon Lake sockeye run is intended to be harvested primarily in traditional commercial fishing areas of the NW Kodiak District during openings directed on local stocks (ADF&G 1996). The remainder is to be taken in an exclusive purse seine and beach seine terminal harvest area in Telrod Cove within Spiridon Bay (Figure 2).

The catch areas and time frame considered for this study (SW Afognak Section and NW Kodiak District; post-11 July) were based on spatial and temporal Spiridon harvest estimates from 1994 and 1995 (Nelson and Barrett 1994; Nelson and Swanton 1996a). The Southwest Kodiak District was not included in the 1996 study based on negligible estimates of Spiridon fish observed in this district during 1994 and 1995.

Stock Selection

Selection of the sockeye stocks to include in this analysis was based on historic run timing within the commercial catch areas of interest, and evaluation of the 1996 escapement age composition estimates post-14 July. All major Kodiak sockeye systems with a westside run potential of greater than 50,000 fish during July and August combined, and an age 1.2 escapement component of greater than 10% within any given week were considered (Barrett and Nelson 1994).

Escapement Sampling

Sockeye salmon escapements were sampled weekly for age (scales) at weir sites in the Kodiak Management Area (KMA; ADF&G 1995). These systems include Karluk, Ayakulik (Red Lake), Frazer, and Upper Station (Figure 1). Terminal catches were sampled weekly in the Spiridon Lake Terminal Harvest Area at Telrod Cove (statistical area 254-50; Figures 2 and 3) and were assumed to represent Spiridon escapement. The targeted sample size was 240 fish per system per week (Nelson and Swanton 1996b) .

Commercial Catch Sampling

During July and August, commercial sockeye salmon catches were sampled for age with a targeted sample size of 600 fish per week from the following areas:

Afognak District (Figure 1)
- Southwest Afognak Section (Statistical Areas 251-10 through 251-20);

Northwest Kodiak District (Figure 1)
- Central Section
  - Uyak Catch Area (Statistical Areas 254-10 through 254-40), and
  - Uganik Catch Area (Statistical Areas 253-11 through 253-35);

Age Designation of Catches and Escapements

Scales were collected from the preferred area following procedures outlined in INPFC (1963), mounted on gum cards, and impressions were made on cellulose acetate (Clutter and Whitesel 1956). Fish ages were assigned by examining scale impressions for annual growth increments using a microfiche reader fitted with a 48X lens following designation criteria established by Mosher (1968). Ages were recorded on sampling forms using European notation (Koo 1962). Age composition estimates of stock specific escapements and catches by area were assigned based on samples collected. Catch-at-age by area and day was estimated by multiplying the daily age composition of a particular sample by the daily catch from the corresponding catch area. Age composition of the catch from days not sampled was estimated using linear interpolation between sampling events (Blackburn 1993). Estimated age composition of escapements from major Kodiak systems followed similar procedures.

Scale Pattern Analysis and Stock Composition Estimation

Maximum sample sizes of 200 scales from the dominant age class per stock were selected for establishing standards (Cook 1982). The Spiridon Lake standard was constructed using terminal area catch samples collected from 29 July through 9 September. The Upper Station late run standard was constructed from weir escapement samples collected from 23 July to 30 August.

Mixed stock fishery samples ("unknowns") meeting the selection criteria had a minimum desired weekly sample size of 30 and a maximum of 100 scales by harvest area. Scale measures were obtained by starting with the first scale of the selected age class within the sample and continuing until all scales suitable for measurement had been exhausted or the sample size was met.

Scale measurement data were collected using the Biosonics[1] optical pattern recognition system (OPRS), which integrates a compound microscope, ocular lens, frame grabber, digitizing tablet, and microcomputer.

[1] Use of a company's name does not constitute endorsement.

Scale-data collection procedures consisted of:

(1) establishing a horizontal reference line below the scale focus through the reticulated region;
(2) identifying the center of the scale focus or measurement initiation point;
(3) measuring incremental distances from scale focus to each circuli within the first freshwater annular zone off an axis perpendicular to the reference line (Narver 1963);
(4) saving measured data to a unique computer file.

All scale measurements were specific to a single age class (age 1.2) utilizing 200X magnification. Scales with poorly defined images and those collected from a non-preferred region (Clutter and Whitesel 1956) were not measured.

Raw OPRS scale measures were transformed into individual variable format for both standard and unknown files using a BASIC program, REFORM1 (written by Larry Greer, ADF&G, Kodiak, AK). Variables constructed were circuli counts (C.C.) and incremental distances (I.D.) which start at the scale focus and end with the last circulus of the first freshwater annulus. These variables reflect the growth that occurred during the freshwater phase (lake residence) of each stock's life history. The maximum number of variables available for model development was constrained to the fewest number of circuli counted on any of the stocks included (e.g., if a stock had one scale with only 10 circuli, then the maximum number of potential variables describing the freshwater growth of that stock would be 11; one circuli count variable and 10 incremental distance variables).

A linear discriminate function (LDF; Fisher 1936) was employed for classifying unknown mixed stock fishery samples to stock of origin (Dillon and Golstein 1984). Assumptions associated with using both SPA and the LDF were (1) all probable stocks contributing to the commercial fishery samples were represented in the model; and (2) scale variables from each stock were multivariate normal; and (3) variance-covariance matrices between groups were equal. Evaluation of univariate normality was assessed using frequency histograms for all variables of each stock considered. All variables assumed normal in distribution were included in the discriminant model. Accuracy of a model in correctly classifying individuals to actual stock of origin was determined by the "leaving-one-out" approach of Lachenbruch (1967). Stock composition estimates for unknown samples (by area and time period) were corrected for misclassification error using the matrix correction approach of Cook and Lord (1978), with 90% confidence coefficients calculated using the variance formula of Pella and Robertson (1979). Confidence coefficients for the two stock model were generated assuming a chi-square distribution. All discriminant modeling was completed using PROC DISCRIM (SAS Institute 1987).

During weeks when stock contribution estimates were not available (no catch sample collected) we employed linear interpolation between adjacent weekly stock composition estimates. To derive stock composition estimates for a maximum of two weeks following the last sample obtained (e.g. sample obtained on 15 July with no sample on 21 July) then the prior weeks stock contribution estimate was assumed static and applied. The harvest by area and week was then apportioned based on these stock composition estimates.

Spiridon Catch Assignment

Sockeye salmon catch numbers by area were obtained from the Alaska Department of Fish and Game (ADF&G) fish ticket database on 28 January 1997. Apportionment of the age 1.2 component of the commercial catch by week within the aforementioned commercial fishing areas was accomplished by multiplying the estimated weekly age 1.2 component of the catch by the weekly stock composition estimate of Spiridon Lake sockeye salmon. The expansion of this estimate to include other age classes was based on the weekly ratio of age 1.2 fish to all other age classes in the Spiridon stock using the following formulae:

$$RS_i = \frac{E12_i}{Eo_i} \qquad (1)$$

$$\hat{C}so_{ij} = \frac{\hat{C}s12_{ij}}{RS_i} \qquad (2)$$

where:

i = sampling week

j = catch area

RS_i = the ratio of age 1.2 fish to fish of all other ages combined in the SLTHA area during week i

$E12_i$ = the number of age 1.2 fish in the SLTHA sample during week i

Eo_i = the number of fish sampled in the SLTHA classified to ages other than age 1.2 during week i

$\hat{C}so_{ij}$ = the estimated number of Spirdon fish in the catch of all other age classes combined during week i in catch area j

$\hat{C}s12_{ij}$ = the estimated number of Spiridon age 1.2 fish in the catch during week i in catch area j

Freshwater Growth Comparison

A single-factor ANOVA was computed (Microsoft Excel[2] 5.0, 1985-1994) to compare annual freshwater scale growth of age 1.2 Spiridon sockeye salmon between years (1994, 1995, 1996). A total of 200 age 1.2 scales (100 per year) were measured from samples collected from SLTHA during 1994 and 1995 while age 1.2 scales measured for the 1996 Spiridon standard were used to represent this years annual growth. Scale measures were obtained by starting with the first age 1.2 scale within the sample and continuing until 100 age 1.2 scales suitable for measurement had been met. All measurements were collected by a single reader and scale data collection followed procedures described previously. The studentized range test (T Method; Devore 1995) was used to identify significant differences in a multiple comparison analysis between yearly freshwater growth while maintaining an α value of 0.05. This test was performed only if the value of the computed F statistic in the ANOVA was significant.

[2] Use of a company's name does not constitute endorsement.

RESULTS

Stock Selection

Stocks meeting the run timing criteria included Karluk late run, Ayakulik, Upper Station late run, and Frazer. However, based on age composition estimates, Upper Station late run was the only stock included in this analysis (Appendix A1-4 , Figure 4). Although Karluk late run is a substantial contributor to westside Kodiak catches during July and August (Barrett and Nelson 1995), based on escapement age composition estimates, it was not contributing to the age 1.2 component of the catch (Appendix A1). Age composition estimates of Ayakulik (Red River) sockeye salmon escapement post-14 July consisted primarily of age 2.2, and 2.3 fish with an overall age 1.2 component of less than 1% (Appendix A2). The Upper Station post 14 July escapement consisted of three age classes (0.2, 1.2, and 2.2) representing 83% of the escapement (Appendix A3). Age 1.2 fish represented 10.0% (range 3.7 %-17.2 %) of the escapement post-14 July. The dominant age classes contributing to the Frazer Lake escapement were age 2.1, 2.2, and 2.3 (Appendix A4).

Age Composition Estimates of Selected Catches

Based on commercial catch sampling efforts, over 30% of the overall commercial harvest in each of the three catch areas were estimated to be age 1.2 fish (Appendix A5 - 8). A total of 1,157 sockeye salmon were sampled from the SW Afognak section post 14 July with 1.2 and 2.2 fish representing an estimated 74% of the catch (Appendix A5). Of the 3,201 scales collected from the Uganik area post-14 July, age 1.2 was the dominant age class (39.3%) and three age classes combined (age 1.2, 1.3, and 2.2) composed greater than 87% of the catch (Appendix A6). For the Uyak commercial catch area, 2,388 fish were sampled during the study period, and age 1.2 and 2.2 fish represented 77.5% of the commercial sockeye salmon catch post-14 July (Appendix A7). Harvests within the SLTHA were sampled from 26 July through 12 September. Age 1.2 fish contributed an estimated 79% of the catch followed by age 2.2 fish which represented an additional 14.3% (Appendix A8).

Stock Separation Model

All scale measurement variables were approximately univariate normal for each stock (Upper Station and Spiridon). The mean number of freshwater circuli for Spiridon was 18 (SE = 0.11), while the mean number of freshwater circuli for Upper Station was 12 (SE = 0.41; Appendix B).

A two stock (Upper Station and Spiridon) linear discriminant model which included variables 1 through 7 was developed with sample sizes of 243 age 1.2 scales measured from Spiridon and 78 scales from Upper Station late run. The overall mean classification accuracy was 93.1%, with individual classification accuracy's of 93.9% for the Spiridon stock and 91.1% for Upper Station Table 1).

Stock Composition Estimates

Spiridon stock composition estimates were generated for weeks 31, 33, and 34 for the SW Afognak Section (Table 2). In all cases, Spiridon contributed an estimated 100% to the age 1.2 component of the SW Afognak catch. The mean stock composition estimate from week 31 and week 33 was used to estimate the stock composition estimate for week 32 as samples were not available from the SW Afognak Section during week 32.

Stock composition estimates derived for the Uganik harvest area spanned the time period 12 July through 29 August (Table 2). The Spiridon stock composition estimates ranged from 69% during week 29 to 100% during weeks 30, and 32, 33, and 35. The mean stock composition estimate from week 33 and week 35 was used to estimate the stock composition estimate for week 34 and the stock composition estimate from week 35 was applied to catches from week 36 as scale samples were unavailable from weeks 34 and 36.

Uyak harvest area stock composition estimates closely mirrored those for Uganik (Table 2). The Spiridon stock composition estimate was 74% during week 29 and increased steadily reaching 100% by week 32. The stock composition estimate from week 33 was applied to week 34 and 35 catches as scale samples were unavailable from the Uyak harvest area post 15 August.

Estimated Spiridon Sockeye Salmon Catch and Run Timing

In 1996, an estimated total of 386,956 Spiridon sockeye salmon were harvested in the SW Afognak Section and NW Kodiak District combined (Table 3; Figure 5). The largest component of the catch (42%; 162,118 fish) occurred in the SLTHA in Telrod Cove followed by an additional 153,292 fish (40%) harvested in the Uganik harvest area (253-11 to 35). The majority of these fish (251,815; 80%) were assigned to Spiridon based on the age 1.2 stock composition estimates and an additional 63,596 fish (all other ages combined) were estimated based on the terminal harvest weekly ratio of age 1.2 fish to all other age classes (Table 2). An estimated 62,670 (48,109 age 1.2) Spiridon bound sockeye salmon were harvested in the Uyak Bay catch area (254-10 to 40) and 8,876 fish were caught within the SW Afognak Section (Table 3; Figure 6).

Peak run timing based on commercial catches varied by area, with peak catches occurring from 26 July to 1 August in the SW Afognak Section, 2-8 August in the Uganik harvest area, 16-22 August in Uyak, and 16-22 August in the SLTHA (Table 3; Figure 7). For the SW Afognak Section and NW Kodiak District combined, the largest catches of Spiridon sockeye salmon were attained during 2-8 August (Figure 8).

Freshwater Growth

The ANOVA analysis indicated that Spiridon sockeye freshwater scale growth measurements collected from 1994, 1995, and 1996 were significantly different among years ($p < 0.0001$). Further analysis (studentized range test) indicated that there was no significant difference in freshwater scale growth between 1994 and 1995. However, the multiple comparison procedure

results showed 1996 annual freshwater scale growth to be significantly less than that in 1994 and 1995 ($p < 0.05$).

DISCUSSION

The 1996 Spiridon Lake sockeye salmon harvest estimate (386,956) was about 1.5X larger than the 1994 estimate (263,750) and about 4X greater than the 1995 estimated Spiridon run (96,705; Figure 6). Sockeye harvests from the SW Afognak Section were included in the 1996 study because of findings from both 1994-95 that partially confirmed that the migration corridor followed by this stock was north to south. The estimated harvest of Spiridon bound sockeye salmon within the SW Afognak Section was minimal (2%, 8,876 fish) relative to the overall catch. In all years, nearly all of the Spiridon return was harvested in sections composing the NW Kodiak District. This is not surprising as a majority of Kodiak's wild stocks migrate along this corridor in route to natal spawning streams (Tyler et al. 1986). This is also the case for Frazer Lake sockeye which were introduced during the 1960's into previously barren Frazer Lake (Blackett 1979; Kyle et al. 1988).

Between 33% and 44% of the total Spiridon sockeye harvest in 1994, 1995, and 1996 occurred in the SLTHA. During 1996, 40% (158,400) of the Spiridon sockeye salmon run was harvested in the Uganik harvest area compared to 36% (1995) and 26% in 1994. The apparent shift in harvest between areas from 1994 to 1996 is confounded by several factors including the substantial size reduction in the SLTHA that occurred in 1995. Clearly, with only three years of data, any comparisons in harvest trends would be premature.

The methods employed to generate stock contribution estimates for the Spiridon Lake sockeye stock continue to evolve as this program matures. In 1994, the age 1.2 scale pattern was unique enough (mean number of freshwater circuli =19) and the relative number of age 1.2 fish within the SLTHA was large enough (99.5%) to obtain a reasonable estimate using only visual scale pattern identification. Estimates generated using scale pattern analysis in 1995 and 1996 showed little variability with the largest standard errors of weekly stock composition estimates being 20.7% and 7.8%, respectively (Nelson and Swanton 1996a). Since SPA has been used, classification accuracy's have ranged from 82.4%(1995) to 93.1% (1996). A portion of the difference between these years can be attributed to the use of a three stock model in 1995 versus a two stock model in 1996. Generally, classification accuracy decreases as the number of stocks included in a model increases(Swanton 1992).

Run timing of the Spiridon Lake stock appears to remain similar to the run timing of the Upper Station late run (Figure 8). During both 1994 and 1995, peak catches correspond to timing of the brood stock source. Harvest estimates during 1996 suggest a slight change in run timing which may be an artifact of shifts in commercial fishing patterns. Weekly catch estimates by area clearly suggest that a majority of this run migrates from north to south along Kodiak Islands westside. This is consistent with what Nelson and Barrett (1994) and Nelson and Swanton (1995) reported, as well as results from 1981 tagging experiments (Tyler et al. 1986). This is not surprising given that run timing is considered to be a conservative genetic trait central to the long term success of a salmon stock.

Based on returns to Spiridon in 1994, 1995, and 1996, the sibling relationship (age 1.2 to 1.3) does not appear to be consistent with the brood stock source. Various mechanisms have been associated with age at maturity including genetic inheritance, environmental influences, and maternal effects (Bradford and Peterman 1987). Enhanced freshwater environmental factors can positively affect size at smolting which in many stocks is inversely correlated with ocean age at maturity.

Although there are not enough data at present to determine a trend, the annual freshwater growth of Spiridon sockeye salmon may be decreasing. The fact that freshwater growth in 1996 as measured by incremental scale measures was statistically significant from previous years (1994 and 1995) points to potential biological changes which maybe occurring within the freshwater environment. Although additional data and analyses are required, this decrease in annual freshwater scale growth may be associated with fry stocking densities that have occurred within the lake. During the freshwater rearing years (1991 and 1992) which resulted in the adult returns from 1994-95, fry stocking levels were 3.5 and 2.2 million fall fry of which the freshwater growth between these two years was not different. However, the freshwater growth experienced by the 1996 returning adults (age 1.2) which were the result of a fry stocking level of 4.3 million fry during 1993, was significantly less than returning adults in 1994 and 1995. This decrease in annual freshwater growth as measured from scales may be associated with the increased fry loadings in the lake coupled with a possible reduction in the integrity of the forage base. Because of this potential concern, yearly nutrient inputs, zooplankton biomass, species composition and annual freshwater growth should continue to be monitored and rigorously analyzed

The estimated 386,956 fish harvest of Spiridon origin sockeye salmon is a minimum number. Possible sources of error in accounting for the total number of adult Spiridon sockeye salmon are: fish harvested in areas not considered as part of this study; fish harvested after 5 September within the Uganik harvest area and post 29 August within the Uyak harvest area; and non-local sockeye stocks that have a dominant age 1.2 component, similar run timing, and a migration route along the westside of Kodiak Island. However, it is our opinion that potential numbers associated with these errors are negligible relative to the estimated Spiridon run numbers presented in this report.

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Table 1. Classification accuracy, by stock, of the age 1.2 scale pattern analysis model.

Actual Stock of Origin		Sample Size	Classification by Stock	
			Spiridon	Upper Station
Spiridon	number	243	228	15
	percent		**93.9%**	6.2%
Upper Station	number	78	7	71
	percent		8.9%	**91.1%**

Mean Classification Accuracy =	93.1%

Table 2. Stock composition estimates and estimated harvest of Spiridon sockeye salmon by area and week, 1996

Catch Area		Catch		Sample		Stock Composition Estimates				
								age 1.2	other	
Week	Dates	Total	age 1.2	Date	Size	percent	90%cc	catch	catch	total
SW Afognak (251 - 10 - 20)										
29	7/12-7/18	6855	1516							
30	7/19-7/25	1897	533							
31	7/26-8/01	11763	4051	7/31	79	100%	0.056	4051	595	4646
32	8/02-8/08	2896	1247					1247	195	1442
33	8/09-8/15	1911	984	8/14	69	100%	0.050	984	238	1222
34	8/16-8/22	2460	1075	8/20	65	100%	0.032	1075	491	1566
35	8/23-8/29	587	251							
36	8/30-9/05	99	42							
Area Total		28468	9699		213			7357	1519	8876
Uganik (253 - 11 - 35)										
29	7/12-7/18	57683	6762	7/17	52	69%	0.129	4652	683	5335
30	7/19-7/25	25194	6167	7/22-7/23	75	100%	0.048	6167	906	7073
31	7/26-8/01	81883	24425	7/30	66	91%	0.086	22276	3271	25547
32	8/02-8/08	78106	51303	8/7	63	100%	0.032	51303	8025	59328
33	8/09-8/15	24732	13382	8/12-8/14	71	100%	0.032	13382	3230	16612
34	8/16-8/22	22168	10333					10333	4724	15057
35	8/23-8/29	23852	10225	8/23-8/24	68	100%	0.032	10225	4486	14711
36	8/30-9/05	12539	5354					5354	4275	9629
37	9/06-9/12	2067	883							
Area Total		328224	128834		395			123692	29601	153292
Uyak (254 - 10 - 40)										
29	7/12-7/18	12736	1756	7/15	53	74%	0.123	1298	191	1488
30	7/19-7/25	5841	1266	7/24	75	99%	0.063	1258	185	1443
31	7/26-8/01	37986	8083	7/29	73	94%	0.076	7622	1119	8742
32	8/02-8/08	21256	6724	8/6	74	100%	0.054	6724	1052	7776
33	8/09-8/15	23183	9546	8/12	79	100%	0.046	9546	2304	11850
34	8/16-8/22	27138	11174					11174	5108	16282
35	8/23-8/29	25469	10487					10487	4601	15088
36	8/30-9/05	20802	8566							
37	9/06-9/12	14104	5808							
Area Total		188515	63410		354			48109	14560	62670
Telrod Cove (254 - 50)										
31	7/26-8/01	27066	23589							27066
32	8/02-8/08	34309	29483							34309
33	8/09-8/15	42586	34513							42586
34	8/16-8/22	45242	32033							45242
35	8/23-8/29	9923	6791							9923
36	8/30-9/05	2648	1529							2648
37	9/06-9/12	344	185							344
Area Total		162118	128123							162118
Combined Total		707325	330066					179158		386956

Table 3. Estimated number of Spiridon Lake sockeye salmon harvested by area and week, 1996.

Catch week	Dates	Catch Area: SW Afognak (251-10-20) 1.2	other	total	Uganik (253-11-35) 1.2	other	total	Uyak (254-10-40) 1.2	other	total	Telrod Cove (254-50) 1.2	other	total	Total
29	7/12-7/18	0	0	0	4652	683	5335	1298	191	1488				6824
30	7/19-7/25	0	0	0	6167	906	7073	1258	185	1443				8516
31	7/26-8/01	4051	595	4646	22276	3271	25547	7622	1119	8742	23589	3477	27066	66000
32	8/02-8/08	1247	195	1442	51303	8025	59328	6724	1052	7776	29483	4826	34309	102855
33	8/09-8/15	984	238	1222	13382	3230	16612	9546	2304	11850	34513	8073	42586	72270
34	8/16-8/22	1075	491	1566	10333	4724	15057	11174	5108	16282	32033	13209	45242	78147
35	8/23-8/29	0	0	0	10225	4486	14711	10487	4601	15088	6791	3132	9923	39723
36	8/30-9/05	0	0	0	5354	4275	9629	0	0	0	1529	1119	2648	12277
37	9/06-9/12	0	0	0	0	0	0	0	0	0	185	159	344	344
Area Total		7357	1519	8876	123692	29601	153292	48109	14560	62670	128123	33995	162118	386956

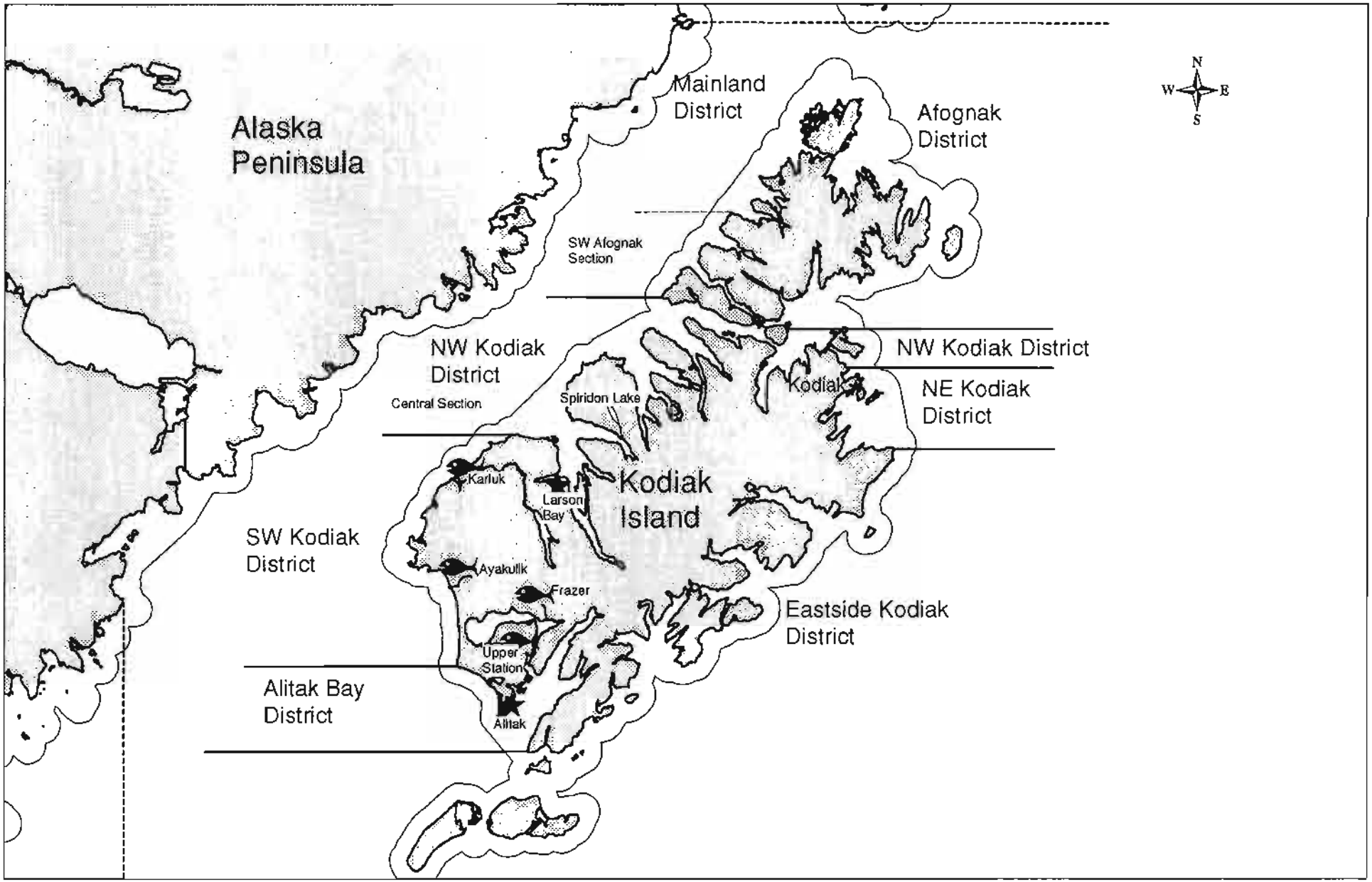


Figure 1. Map of the Kodiak Management Area showing fishing districts and major sockeye systems including Spiridon Lake.

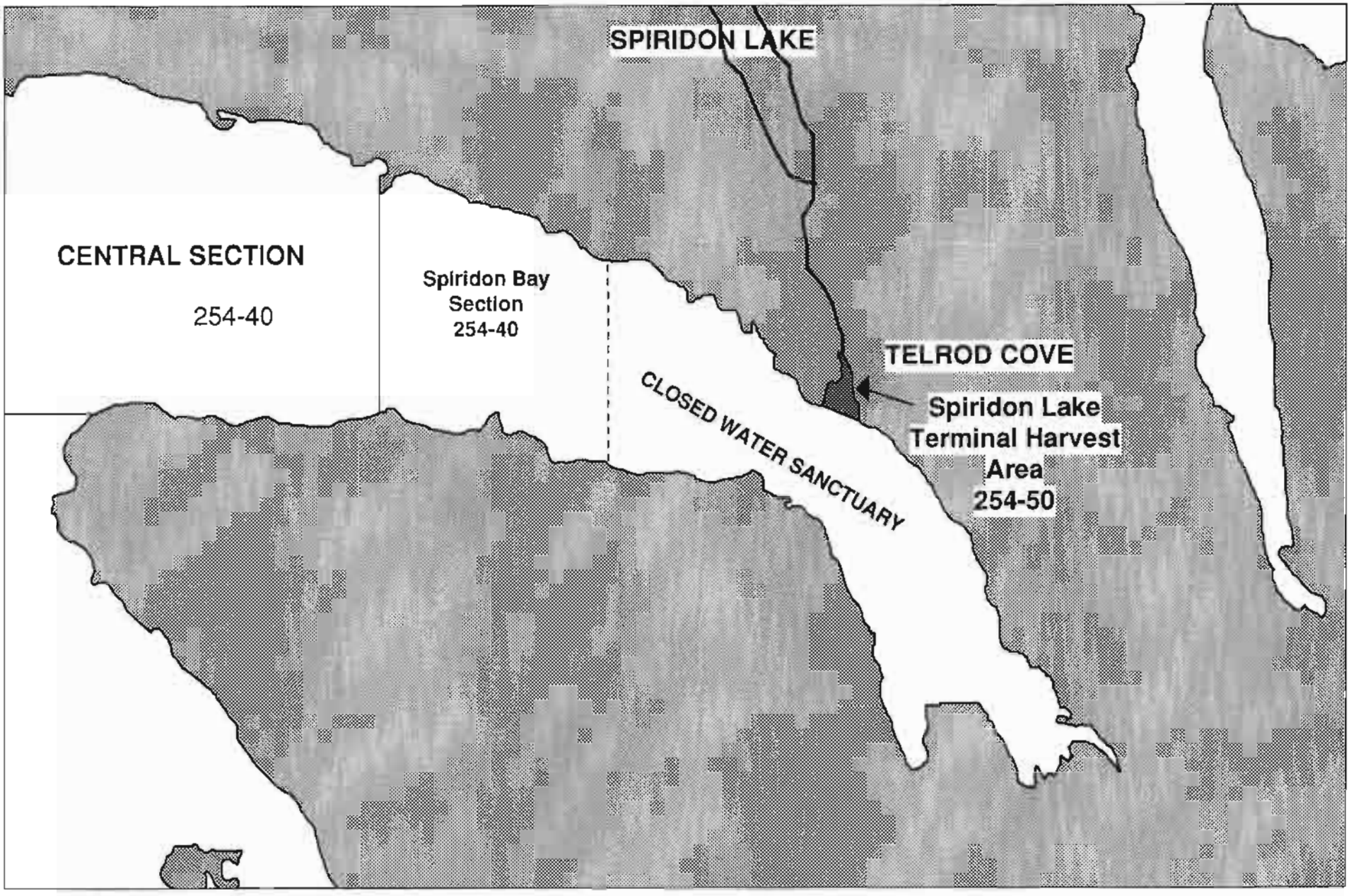
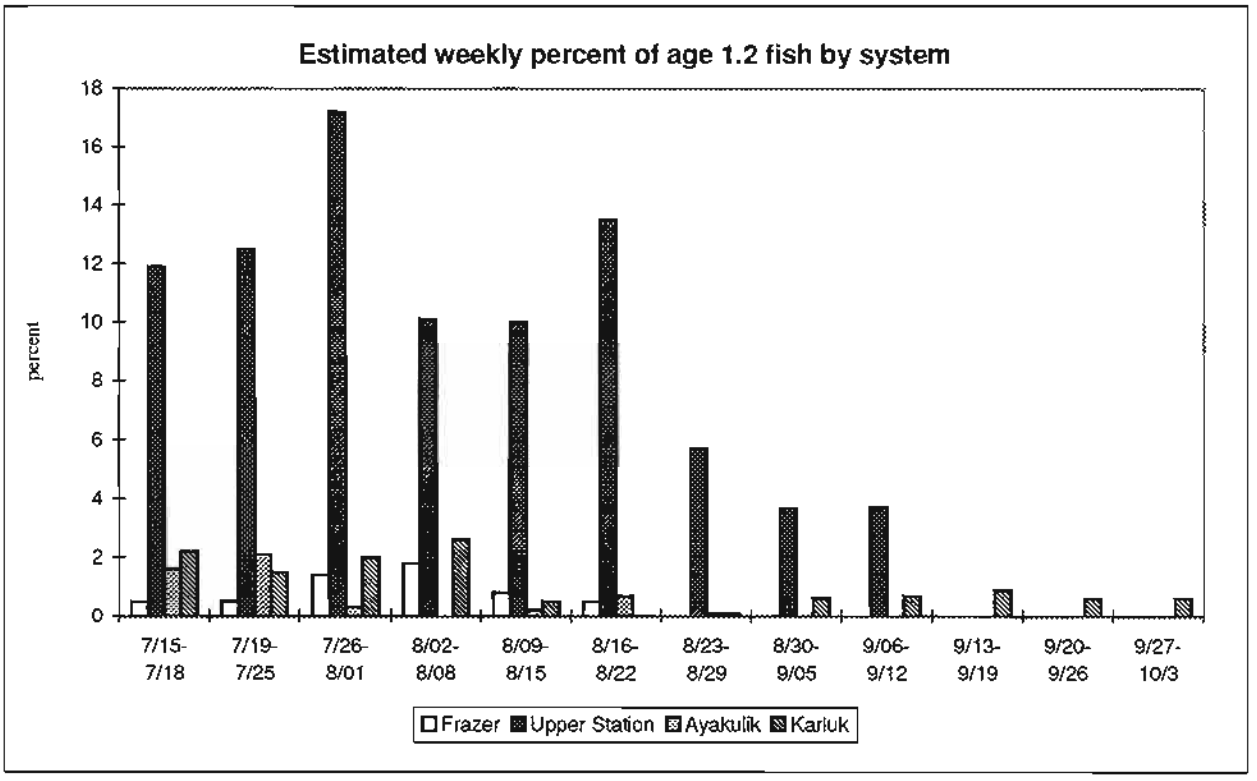


Figure 2. Map identifying the approximate boundaries of the Spiridon Lake Terminal Harvest Area in Telrod Cove.

Figure 3. Photograph of the Spiridon Lake Terminal Harvest Area at Telrod Cove, 1996.



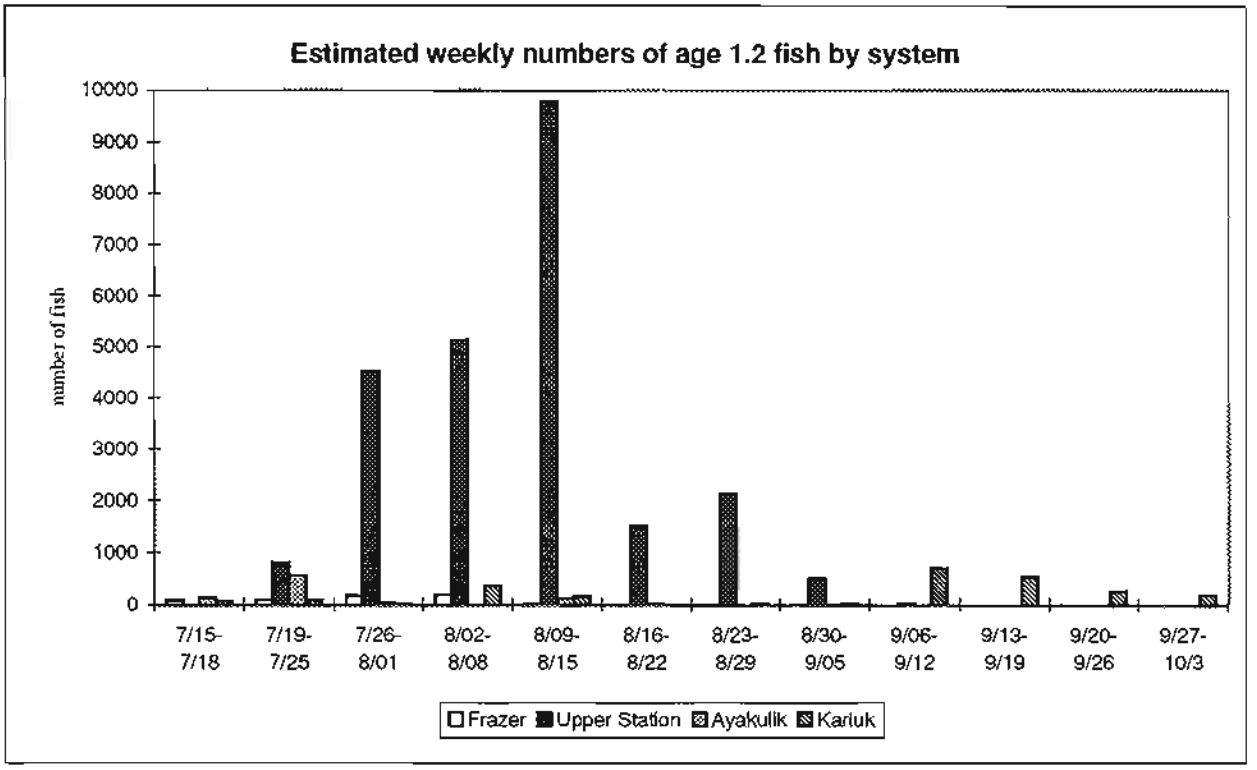
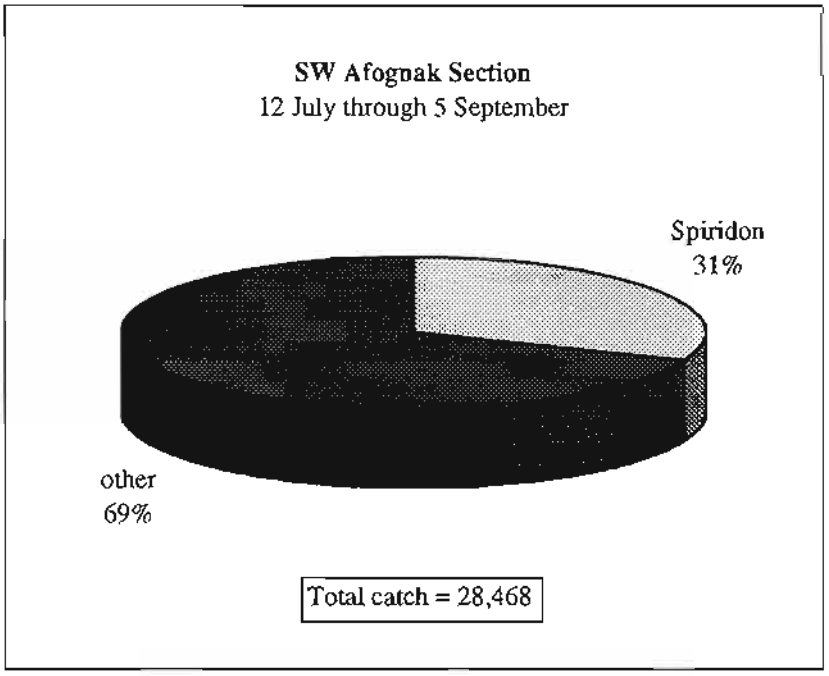


Figure 4. Estimated age 1.2 component of selected escapements by system and week, 1996.



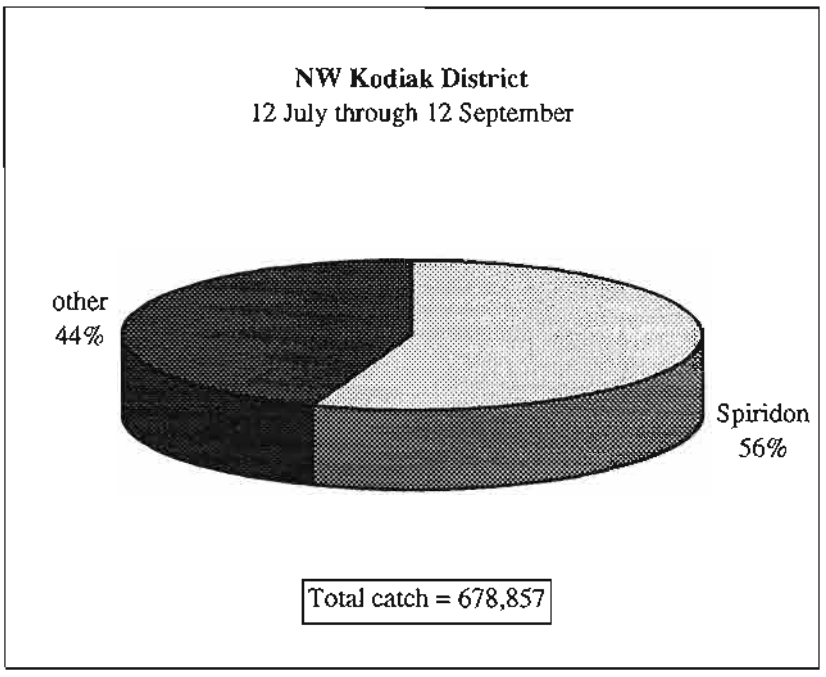
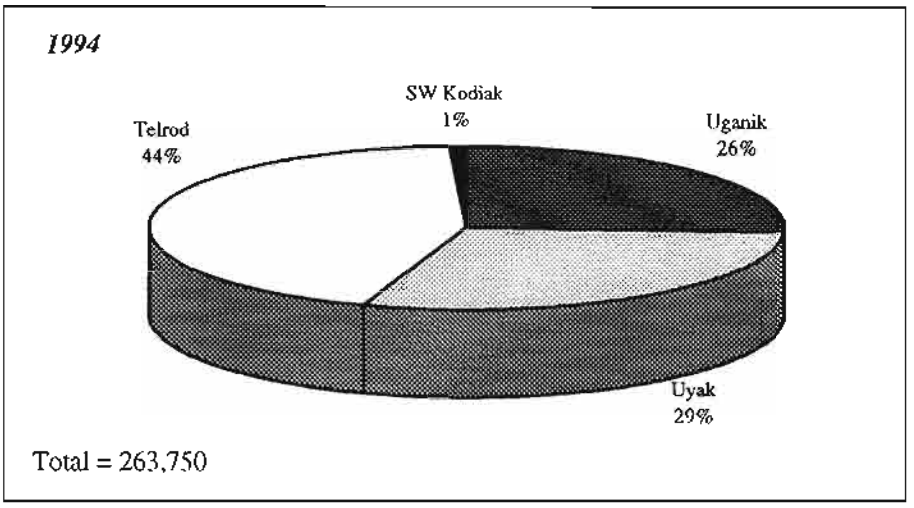
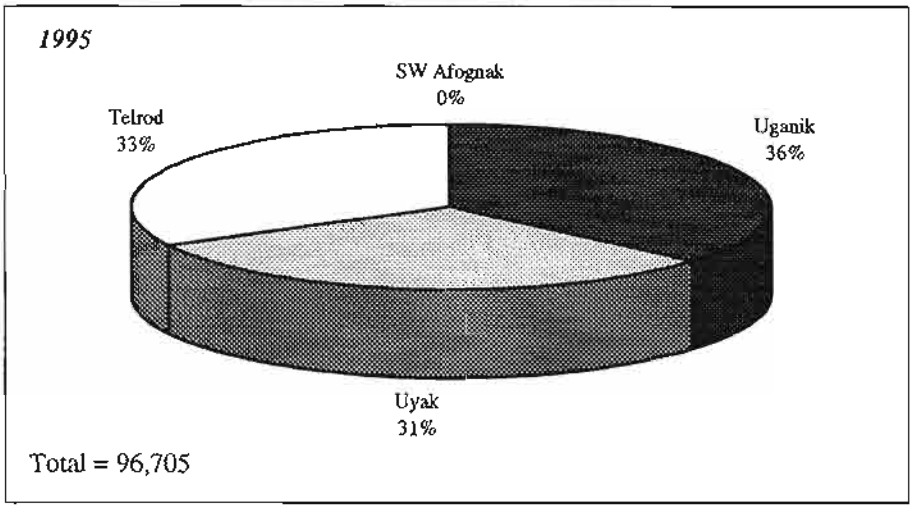


Figure 5. Estimated Spiridon sockeye salmon commercially harvested in the SW Afognak Section and NW Kodiak District, 1996.





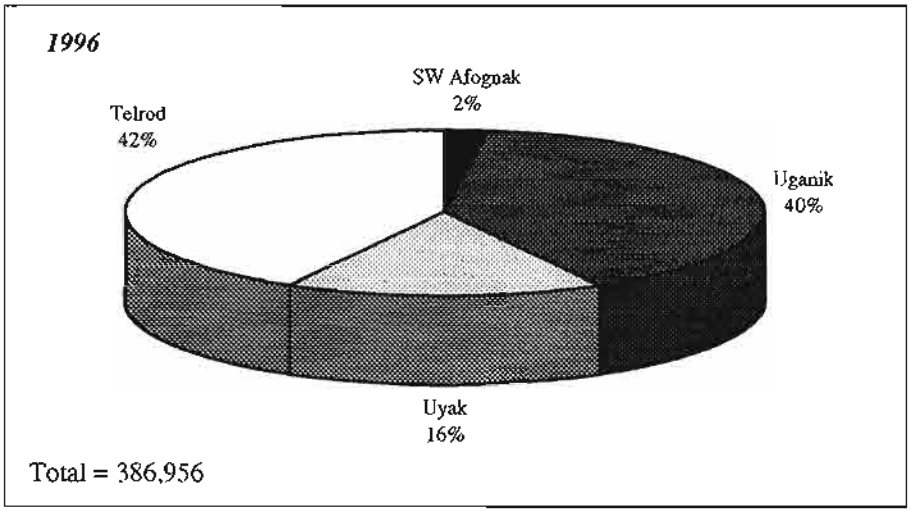


Figure 6. Estimated percentage of Spiridon Lake sockeye salmon harvested in the SW Afognak Section, and the NW Kodiak, and SW Kodiak Districts by catch area and year, 1994 - 1996.

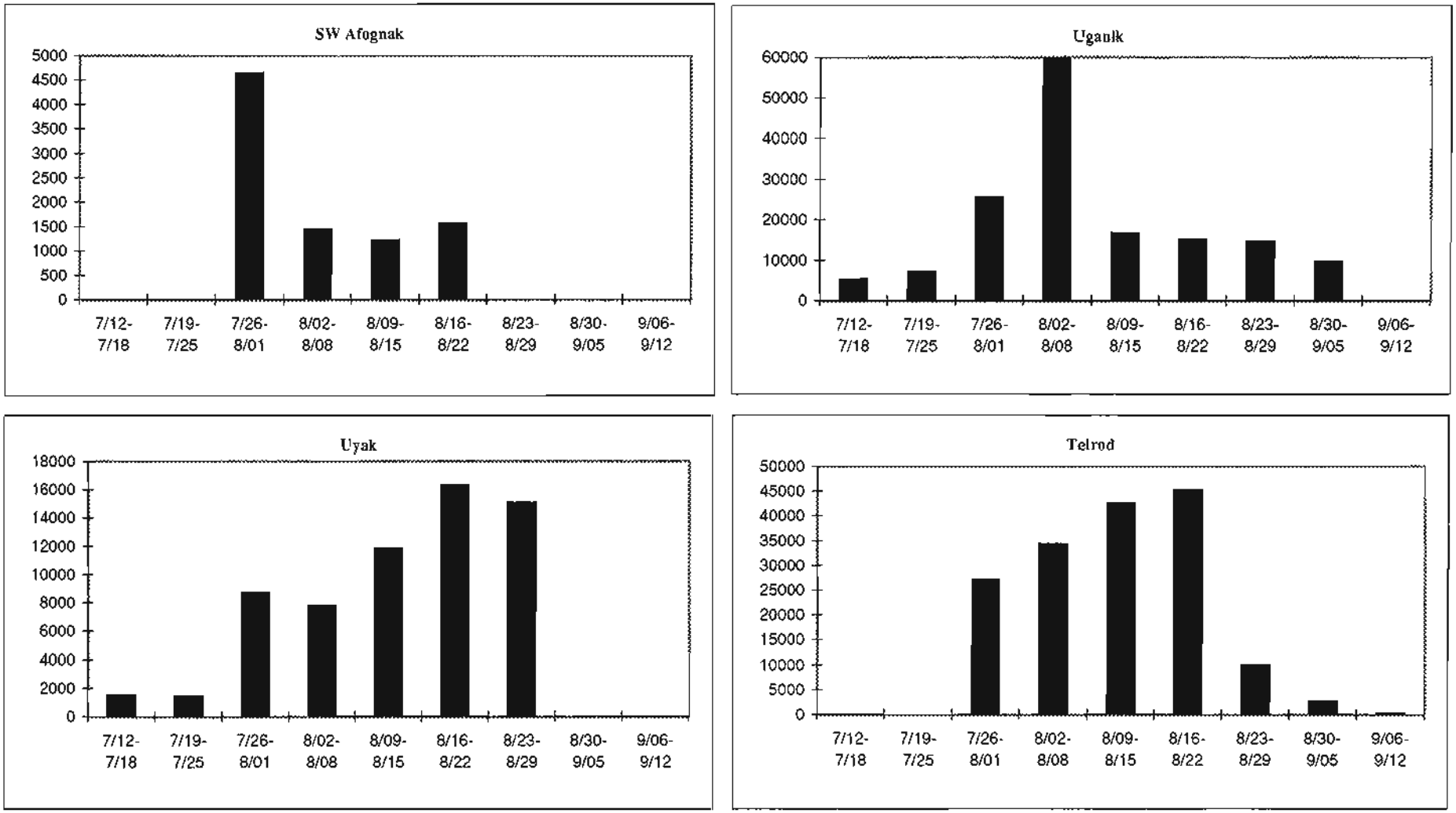


Figure 7. Estimated number of Spiridon sockeye salmon harvested by area and week, 1996.

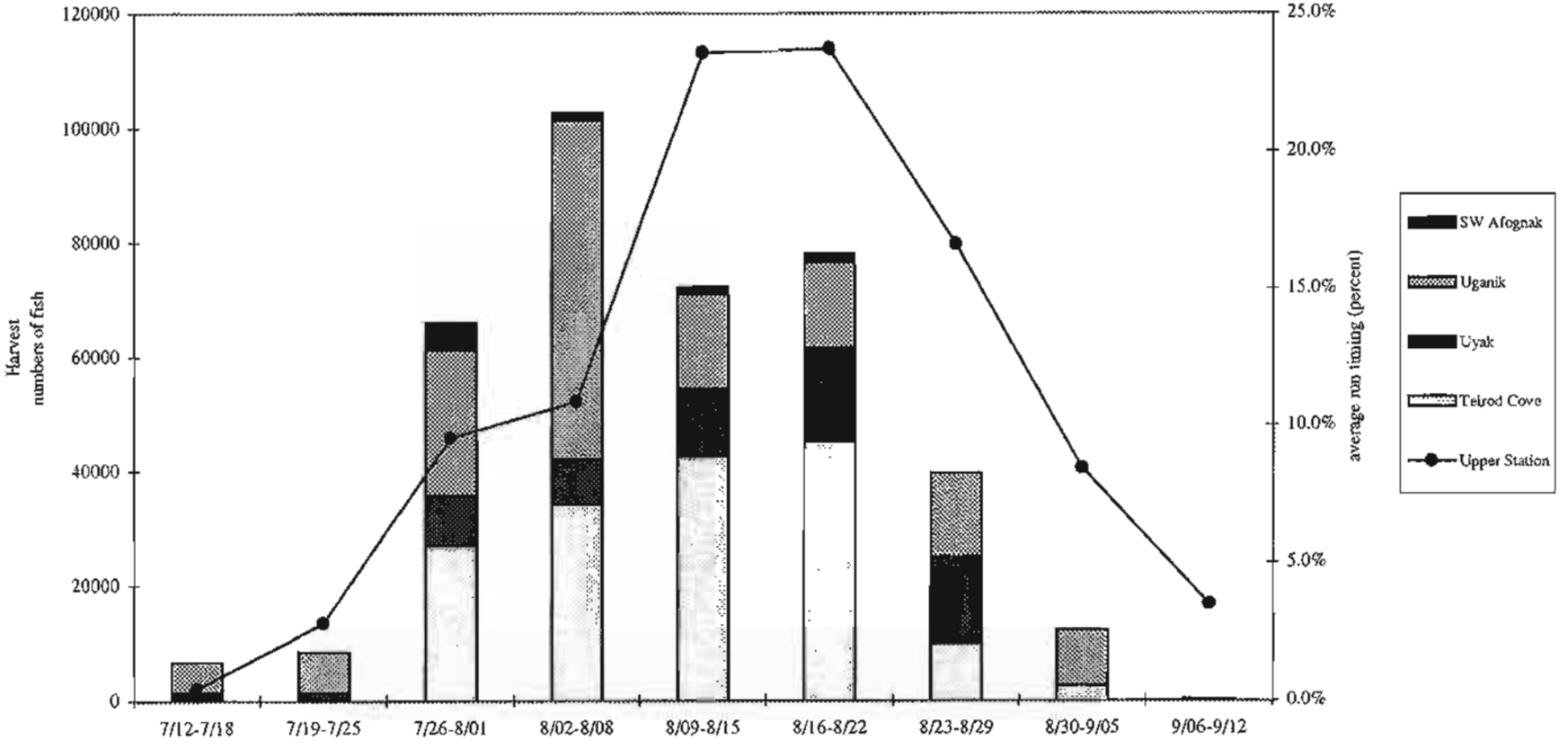


Figure 8. A comparison of the 1996 Spiridon run timing based on harvest estimates (in number of fish) and Upper Station late run escapement timing (1974-1996 average percent).

APPENDIX

Appendix A.1. Estimated age composition of Karluk sockeye salmon escapement by week, post 14 July 1996.

Week	Sample Size		Ages 1.1	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	3.3	4.2	4.3	Total
29	0	Percent	1.1	2.2	9.7	18.4	30.8	1.1	0	22.2	9.2	3.2	1.6	0.5	100
(7/15-7/18)		Numbers	40	79	357	674	1,129	40	0	812	337	119	59	20	3,665
30	185	Percent	1.3	1.5	7.2	15.2	32.9	0.6	0.2	22.4	12.7	4.5	1.2	0.3	100
(7/19-7/25)		Numbers	83	91	446	944	2,040	38	15	1,392	787	279	72	19	6,205
31	180	Percent	3.8	2	10.1	13.3	32.3	1.4	0.3	21.8	10.9	3.8	0.3	0	100
(7/26-8/01)		Numbers	32	16	83	110	267	12	3	180	91	31	3	0	828
32	177	Percent	4.4	2.6	12.1	12.3	38.1	2.1	0	20.6	5.8	2	0	0	100
(8/02-8/08)		Numbers	619	375	1,711	1,747	5,407	293	0	2,917	825	281	0	0	14,174
33	167	Percent	0.5	0.5	1.8	5.2	56.1	0	0	20	12.2	3.7	0	0	100
(8/09-8/15)		Numbers	165	165	594	1,687	18,123	0	0	6,444	3,926	1,191	0	0	32,296
34	143	Percent	0	0	2.1	1.1	64.8	0	0	14.6	16.3	1	0	0	100
(8/16-8/22)		Numbers	6	6	256	140	8,004	0	0	1,798	2,018	122	0	0	12,350
35	0	Percent	0	0.1	1.7	0.7	67.4	0	0	12.9	16.2	1.1	0	0	100
(8/23-8/29)		Numbers	0	28	369	151	14,645	0	0	2,797	3,513	235	0	0	21,738
36	148	Percent	0	0.6	0.2	0.6	73.7	0.2	0	8.5	13.6	2.5	0.1	0	100
(8/30-9/05)		Numbers	0	27	11	27	3,190	7	0	368	591	108	2	0	4,331
37	155	Percent	0	0.7	0.9	0.2	73.9	1.4	0	7.7	12.7	2.1	0.4	0	100
(9/06-9/12)		Numbers	0	702	897	173	75,313	1,465	0	7,862	12,948	2,159	448	0	101,967
38	170	Percent	0	0.9	0.6	0	74.1	1.9	0	6.7	13.7	1.8	0.3	0	100
(9/13-9/19)		Numbers	11	540	340	11	42,359	1,060	0	3,814	7,848	1,049	148	0	57,180
39	167	Percent	0.6	0.6	2.4	0.6	59.3	2.4	0	7.2	25.1	1.8	0	0	100
(9/20-9/26)		Numbers	263	263	1,052	263	26,028	1,052	0	3,155	11,042	789	0	0	43,905
40	0	Percent	0.6	0.6	2.4	0.6	59.3	2.4	0	7.2	25.1	1.8	0	0	100
(9/27-10/3)		Numbers	180	180	719	180	17,784	719	0	2,156	7,545	539	0	0	30,000
Total	1,492	Percent	0.4	0.8	2.1	1.9	65.2	1.4	0	10.3	15.7	2.1	0.2	0	100
		Numbers	1,399	2,472	6,835	6,107	214,289	4,686	18	33,695	51,471	6,902	732	39	328,639

Appendix A.2. Estimated age composition of Ayakulik sockeye salmon escapement by week, post 14 July 1996.

Week	Sample Size		Ages 1.1	1.2	2.1	1.3	2.2	2.3	3.2	3.3	Total
29	79	Percent	0	1.6	7	28.6	37.8	24.4	0	0.5	100
(7/15-7/18)		Numbers	0	135	577	2,343	3,092	2,000	0	37	8,184
30	193	Percent	0	2.1	5.3	21.5	48.7	21	0	1.4	100
(7/19-7/25)		Numbers	0	565	1,455	5,891	13,327	5,742	0	387	27,367
31	194	Percent	0	0.3	2.4	8.8	73.2	14.8	0	0.5	100
(7/26-8/01)		Numbers	0	35	292	1,068	8,923	1,803	0	66	12,187
32	195	Percent	0.1	0	1.2	4.1	82.3	12.2	0	0.1	100
(8/02-8/08)		Numbers	25	3	286	951	19,159	2,831	0	30	23,284
33	199	Percent	0.4	0.2	3	2.8	82.2	10.7	0.1	0.6	100
(8/09-8/15)		Numbers	199	119	1,516	1,435	41,968	5,461	60	319	51,077
34	191	Percent	0.3	0.7	1	2.4	85.9	8.4	0.4	1	100
(8/16-8/22)		Numbers	7	18	24	58	2,115	208	9	24	2,463
35	103	Percent	0.9	0.1	0.1	2.9	89.9	5.1	0	1	100
(8/23-8/29)		Numbers	5	0	0	15	459	26	0	5	510
Total	1,154	Percent	0.2	0.7	3.3	9.4	71.2	14.4	0.1	0.7	100
		Numbers	236	875	4,150	11,761	89,043	18,071	69	868	125,072

Appendix A.3. Estimated age composition of Upper Station sockeye salmon escapement by week, post 14 July 1996.

Week	Sample Size		Ages										Total
			0.1	0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	2.3	
29	0	Percent	0	6.2	0.5	5.7	11.9	2.6	25.8	46.9	0.5	0	100
(7/15-7/18)		Numbers	0	1	0	1	3	1	6	11	0	0	24
30	194	Percent	0	6.5	0.8	5.7	12.5	2.6	24.7	46.7	0.5	0	100
(7/19-7/25)		Numbers	0	422	49	370	817	171	1,618	3,056	31	3	6,538
31	196	Percent	0	8.3	3	3.9	17.2	3.2	11.8	52.3	0	0.3	100
(7/26-8/01)		Numbers	0	2,180	787	1,033	4,527	851	3,107	13,811	0	90	26,385
32	225	Percent	0.2	7.2	2	1.6	10.1	2.4	8.4	67.9	0	0.3	100
(8/02-8/08)		Numbers	114	3,655	999	839	5,144	1,198	4,274	34,514	0	129	50,866
33	203	Percent	0.7	12.9	2.5	2.8	10	4	5.6	60.7	0	0.8	100
(8/09-8/15)		Numbers	642	12,630	2,414	2,748	9,782	3,897	5,424	59,226	0	796	97,557
34	193	Percent	1.6	23.2	4.2	2.6	13.5	13.5	3	37.5	0	0.9	100
(8/16-8/22)		Numbers	180	2,594	467	291	1,513	1,509	335	4,189	0	106	11,185
35	199	Percent	1.2	11.2	2.4	0.7	5.7	8.1	2.4	68.3	0	0	100
(8/23-8/29)		Numbers	450	4,176	901	259	2,134	3,020	915	25,521	0	0	37,377
36	187	Percent	0.5	4.3	1.1	0.5	3.7	3.2	2.7	84	0	0	100
(8/30-9/05)		Numbers	72	576	144	72	504	432	360	11,295	0	0	13,453
37	0	Percent	0.5	4.3	1.1	0.5	3.7	3.2	2.7	84	0	0	100
(9/06-9/12)		Numbers	5	43	11	5	37	32	27	840	0	0	1,000
Total	1,397	Percent	0.6	10.8	2.4	2.3	10.0	4.5	6.6	62.4	0.0	0.5	100.0
		Numbers	1,463	26,277	5,772	5,618	24,461	11,111	16,066	152,463	31	1,124	244,385

Appendix A.4. Estimated age composition of Frazer sockeye salmon escapement by week, post 14 July 1996.

Week	Sample Size		Ages 1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	3.3	Total
29	0	Percent	2.5	0.5	51.5	0	20.1	0	16.2	2.9	6.4	100
(7/15-7/18)		Numbers	406	81	8,533	0	3,332	0	2,682	488	1,056	16,578
30	204	Percent	1.5	0.5	44.2	0.3	23.1	0.3	19.9	3	7.3	100
(7/19-7/25)		Numbers	310	104	9,111	52	4,772	52	4,099	622	1,504	20,625
31	194	Percent	0.3	1.4	34.5	0.3	25.5	0.3	24.7	2.6	10.5	100
(7/26-8/01)		Numbers	36	173	4,324	36	3,189	36	3,089	327	1,317	12,527
32	201	Percent	0	1.8	48.9	0	16.3	0	21	3.1	8.9	100
(8/02-8/08)		Numbers	0	189	5,215	0	1,739	0	2,236	330	952	10,661
33	207	Percent	0.2	0.8	73.6	0	7.6	0	11.9	3.2	2.7	100
(8/09-8/15)		Numbers	5	24	2,232	0	229	0	360	97	83	3,031
34	208	Percent	0.5	0.5	84.6	0	8.2	0	4.8	1	0.5	100
(8/16-8/22)		Numbers	6	6	1,095	0	106	0	62	12	6	1,294
Total	1,014	Percent	1.2	0.9	47.1	0.1	20.7	0.1	19.4	2.9	7.6	100
		Numbers	763	577	30,510	88	13,367	88	12,528	1,876	4,918	64,716

Appendix A.5. Estimated age composition of Southwest Afognak Section (251-10-20) sockeye salmon catch by week, post 14 July 1996.

Week	Sample Size		Ages 0.2	0.3	1.2	2.1	1.3	2.2	3.1	2.3	3.2	2.4	3.3	4.2	Total
29	0	Percent	1	0	34.5	1.3	17.6	36.8	0	4.9	2.3	0.7	1	0	100
(7/15-7/18)		Numbers	67	0	2,367	89	1,206	2,523	0	335	156	45	67	0	6,855
30	0	Percent	1	0	34.5	1.3	17.6	36.8	0	4.9	2.3	0.7	1	0	100
(7/19-7/25)		Numbers	19	0	655	25	334	698	0	93	43	12	19	0	1,897
31	307	Percent	1	0	34.9	1.3	17.3	36.8	0	4.8	2.3	0.6	1	0	100
(7/26-8/01)		Numbers	113	0	4,100	157	2,033	4,327	0	569	275	75	114	0	11,763
32	0	Percent	0.6	0	43	2.1	9.5	36.3	0.1	3.6	3.7	0.3	0.7	0	100
(8/02-8/08)		Numbers	18	0	1,247	61	276	1,050	3	104	107	10	20	0	2,896
33	499	Percent	0.2	0	51.5	3	1.5	35.7	0.2	2.3	5.2	0	0.4	0	100
(8/09-8/15)		Numbers	5	0	984	57	28	683	4	44	99	0	8	0	1,911
34	351	Percent	0.5	0.5	43.7	4.9	1.9	36.1	0	2	9	0	1.1	0.3	100
(8/16-8/22)		Numbers	13	13	1,075	121	46	889	0	50	221	0	26	6	2,460
35	0	Percent	0.6	0.6	42.7	5.1	2	36.2	0	2	9.4	0	1.1	0.3	100
(8/23-8/29)		Numbers	3	3	251	30	12	212	0	12	55	0	7	2	587
36	0	Percent	0.6	0.6	42.7	5.1	2	36.2	0	2	9.4	0	1.1	0.3	100
(8/30-9/05)		Numbers	1	1	42	5	2	36	0	2	9	0	1	0	99
Total	1,157	Percent	0.8	0.1	37.7	1.9	13.8	36.6	0	4.2	3.4	0.5	0.9	0	100
		Numbers	239	17	10,721	545	3,937	10,418	7	1,209	965	142	262	8	28,468

Appendix A.6. Estimated age composition of Uganik harvest area (253-11-35) sockeye salmon catch by week, post 14 July 1996.

Week	Sample Size		Ages 0.1	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	4.2	4.3	Total
29	606	Percent	0	0	0.2	1	12.2	0.2	61.6	10.3	0	13.9	0.7	0	0	0	0	100
(7/15-7/18)		Numbers	0	2	94	564	7,051	94	35,512	5,968	2	7,997	388	0	11	0	0	57,683
30	470	Percent	0	0.2	0	0.2	24.5	0	40.3	18.4	0.2	13.4	1.5	0	1.1	0	0	100
(7/19-7/25)		Numbers	0	50	5	61	6,167	11	10,155	4,645	61	3,371	383	5	280	0	0	25,194
31	773	Percent	0	0.2	0.2	0.4	29.8	0.3	35.7	21.4	0.4	9.6	1.6	0.1	0.3	0	0	100
(7/26-8/01)		Numbers	9	178	125	296	24,425	269	29,234	17,515	296	7,857	1,345	106	229	0	0	81,883
32	468	Percent	0.2	1.6	0.6	0	65.7	1.7	2.7	24.9	0	1	1.4	0.2	0	0	0	100
(8/02-8/08)		Numbers	151	1,221	477	7	51,303	1,298	2,083	19,460	18	781	1,117	164	26	0	0	78,106
33	521	Percent	0	0.2	0.3	0	54.1	1.6	0.3	33.8	0.2	2.4	6.4	0.2	0.4	0	0	100
(8/09-8/15)		Numbers	0	49	86	6	13,382	395	62	8,361	43	604	1,582	43	105	6	6	24,732
34	0	Percent	0	0.2	0.1	0.2	46.6	2	0.6	37.7	0.1	2.1	9.3	0.1	0.7	0.2	0.2	100
(8/16-8/22)		Numbers	0	55	26	42	10,333	442	139	8,348	13	467	2,051	13	153	42	42	22,168
35	363	Percent	0	0.3	0	0.3	42.9	2.2	0.8	39.6	0	1.9	10.7	0	0.8	0.3	0.3	100
(8/23-8/29)		Numbers	0	65	1	65	10,225	524	195	9,441	1	462	2,547	1	196	65	65	23,852
36	0	Percent	0	0.3	0	0.3	42.7	2.2	0.8	39.7	0	1.9	10.7	0	0.8	0.3	0.3	100
(8/30-9/05)		Numbers	0	35	0	35	5,354	276	104	4,974	0	242	1,347	0	104	35	35	12,539
37	0	Percent	0	0.3	0	0.3	42.7	2.2	0.8	39.7	0	1.9	10.7	0	0.8	0.3	0.3	100
(9/06-9/12)		Numbers	0	6	0	6	883	46	17	820	0	40	222	0	17	6	6	2,067
Total	3,201	Percent	0	0.5	0.2	0.3	39.3	1	23.6	24.2	0.1	6.6	3.3	0.1	0.3	0	0	100
		Numbers	160	1,661	814	1,082	129,123	3,355	77,501	79,532	434	21,821	10,982	332	1,121	154	154	328,224

Appendix A.7. Estimated age composition of Uyak harvest area (254-10-40) sockeye salmon catch by week, post 14 July 1996.

Week	Sample Size		Ages 0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	2.3	3.2	2.4	3.3	4.2	4.3	Total
29	480	Percent	0.5	0	1.6	13.8	0.2	30.7	24.3	0	19.3	3.3	0.2	6	0	0	100
(7/15-7/18)		Numbers	59	5	206	1,756	31	3,914	3,091	5	2,462	417	24	763	3	0	12,736
30	439	Percent	0.9	0.4	1.2	21.7	2.5	16.6	34.6	0.4	11.4	4.6	0	5.5	0.2	0	100
(7/19-7/25)		Numbers	50	24	69	1,266	145	970	2,021	24	664	271	1	322	12	0	5,841
31	468	Percent	0.1	0	1	21.3	0.1	14	34.1	0	14.5	9.5	0	5	0.2	0.4	100
(7/26-8/01)		Numbers	19	0	367	8,083	30	5,317	12,955	0	5,493	3,623	0	1,885	71	143	37,986
32	491	Percent	0.4	0	0.2	31.6	0.6	2.6	54.2	0	3.4	6.1	0	0.8	0	0	100
(8/02-8/08)		Numbers	87	0	47	6,724	119	558	11,528	0	722	1,302	0	163	2	3	21,256
33	510	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/09-8/15)		Numbers	182	0	0	9,546	0	227	11,091	0	273	1,773	0	91	0	0	23,183
34	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/16-8/22)		Numbers	213	0	0	11,174	0	266	12,984	0	319	2,075	0	106	0	0	27,138
35	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/23-8/29)		Numbers	200	0	0	10,487	0	250	12,185	0	300	1,948	0	100	0	0	25,469
36	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/30-9/05)		Numbers	163	0	0	8,566	0	204	9,952	0	245	1,591	0	82	0	0	20,802
37	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(9/06-9/12)		Numbers	111	0	0	5,808	0	138	6,748	0	166	1,079	0	55	0	0	14,104
38	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(9/13-9/19)		Numbers	11	0	0	574	0	14	667	0	16	107	0	5	0	0	1,394
Total	2,388	Percent	0.6	0	0.4	33.7	0.2	6.2	43.8	0	5.6	7.5	0	1.9	0	0.1	100
		Numbers	1,095	29	689	63,984	325	11,858	83,222	29	10,660	14,186	25	3,572	88	146	189,909

Appendix A.8. Estimated age composition of Telrod Cove (254-50) sockeye salmon catches by week, 1996.

Week	Sample Size		Ages 1.1	1.2	2.1	1.3	2.2	3.1	3.2	Total
31	328	Percent	0.6	87.2	0.5	0	11.5	0	0.3	100
(7/26-8/01)		Numbers	163	23,589	123	8	3,106	0	78	27,066
32	207	Percent	0.7	85.9	2.7	0.4	10.2	0	0	100
(8/02-8/08)		Numbers	232	29,483	936	141	3,506	0	11	34,309
33	360	Percent	1.9	81	3.8	0.3	12.9	0	0	100
(8/09-8/15)		Numbers	818	34,513	1,639	128	5,488	0	0	42,586
34	204	Percent	2.1	70.8	6.5	0	20.5	0	0	100
(8/16-8/22)		Numbers	945	32,033	2,953	23	9,280	9	0	45,242
35	423	Percent	4.2	68.4	12	0	14.9	0.5	0	100
(8/23-8/29)		Numbers	417	6,791	1,187	0	1,475	53	0	9,923
36	241	Percent	9	57.7	20.4	0	11	1.8	0	100
(8/30-9/05)		Numbers	240	1,529	541	0	290	48	0	2,648
37	112	Percent	9.1	53.9	20	0.7	13.6	0.3	2.2	100
(9/06-9/12)		Numbers	31	185	69	3	47	1	8	344
Total	1,875	Percent	1.8	79	4.6	0.2	14.3	0.1	0.1	100
		Numbers	2,846	128,123	7,448	303	23,192	111	97	162,118

Appendix B.1. Descriptive statistics for age 1.2 scale variables from Spiridon and Upper Station stocks, 1996.

Freshwater Variable[a]		Stock			
		Spiridon n = 243		Upper Station n = 78	
number	name	mean	SE	mean	SE
1	circuli counts	18.5	0.11	12.1	0.41
2	1st I.D.	37.8	0.45	58.3	1.03
3	2nd I.D.	55.6	0.56	87.6	1.34
4	3rd I.D.	74.4	0.70	113.4	1.58
5	4th I.D.	91.1	0.83	136.7	1.80
6	5th I.D.	106.7	0.97	157.8	1.92
7	6th I.D.	121.5	1.10	177.2	2.04

[a] Incremental distances (ID) for variables 2-7 were measured in .001mm at 200X magnification.

Appendix B.2. Scale pattern of age 1.2 sockeye salmon collected at Spiridon Lake Terminal Harvest Area (SLTHA), 4 August 1996.

Appendix B.3. Scale pattern of age 1.2 sockeye salmon collected at Upper Station weir, 30 July 1996.