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1981 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:
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April 1982

ALASKA DEPARTMENT OF FISH AND GAME
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Ronald O. Skoog
Commissioner

ADF&G TECHNICAL DATA REPORTS

This series of reports is designed to facilitate prompt reporting of data from studies conducted by the Alaska Department of Fish and Game, especially studies which may be of direct and immediate interest to scientists of other agencies.

The primary purpose of these reports is presentation of data. Description of programs and data collection methods is included only to the extent required for interpretation of the data. Analysis is generally limited to that necessary for clarification of data collection methods and interpretation of the basic data. No attempt is made in these reports to present analysis of the data relative to its ultimate or intended use.

Data presented in these reports is intended to be final, however, some revisions may occasionally be necessary. Minor revision will be made via errata sheets. Major revisions will be made in the form of revised reports.

1981 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

A summary of data collected from sockeye salmon *(Oncorhynchus nerka)* smolt programs in Bristol Bay, including Kvichak, Egegik, Wood, and Snake Rivers

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April 1982

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ABSTRACT

Sockeye salmon *(Oncorhynchus nerka)* smolt projects were conducted on four Bristol Bay rivers in 1981. Estimates of outmigrating sockeye salmon smolt were 183.6 million from the Kvichak, 97.5 million from the Wood, and 0.9 million from the Snake River system. No total outmigration estimate was generated from the Egegik River. Age composition was 89% Age I and 11% Age II smolt from the Kvichak, 48% Age I, 48% Age II, and 2% Age III from the Egegik, 66% Age I and 34% Age II from the Wood, and 99% Age I and 1% Age II from the Snake River.

INTRODUCTION

This Technical Data Report represents a continuation in the documentation of sockeye salmon *(Oncorhynchus nerka)* smolt data collected from various Bristol Bay river systems. In 1981 smolt projects were conducted on four systems, Kvichak, Wood, Egegik, and Snake. Sonar biomass counters were used to estimate smolt abundance on the Kvichak, Egegik, and Wood Rivers while an inclined plane trap sampling program was used on the Snake River. Length and weight data were collected from each age class of smolt on each of the four rivers sampled. Infection rate by the cestode parasite *(Triaenophorus crassus)* was documented for smolt emigrating down the Wood River. Climatological data are presented for each smolt site.

Smolt data is used to forecast returns of adults and to assist in establishing optimum escapement levels. These data are also used in assessing the effects of salmon rehabilitation and enhancement projects located in the Wood and Snake River systems.

As used in this report, Age I smolt are those smolt which have formed one scale annulus or "check", and are in their second year of freshwater residency at the time of outmigration. Age II or two-check smolt are those in their third year of freshwater residency possessing two scale annuli.

1981 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Data on age composition, size and numbers of Kvichak River sockeye salmon *(Oncorhynchus nerka)* smolt migrating to sea are used in forecasting the age composition and numbers of subsequent adult returns to the Naknek/Kvichak fishery and to evaluate escapement levels and smolt production. Total smolt outmigration estimates from sonar enumeration began in 1971, replacing outmigration indices estimated from fyke net catches which were initiated in 1955 (Russell 1972; Paulus and McCurdy 1972; Parker 1974a and 1974b). Collection of smolt age and size data as well as sonar enumeration of the Kvichak River smolt outmigration continued in 1981.

METHODS AND MATERIALS

Sonar Arrays

The sonar counting system consisted of three 3.2 m plastic ladder arrays, each holding 14 sonar transducers. Each array was independently anchored. The transducers were attached to the arrays and their cables gathered together into three separate bundles of 100 m in lenghth, which were connected to a single control unit housed in a tent on the river bank. Installation and operation of the sonar counting system was similar to that of 1976 with the few changes noted below (Randall 1977).

Initial placement of arrays began on 13 May. The counter became operational at 2300 hours with the inshore and offshore arrays. Due to problems in the anchor and cable, the center array was not operational until 1800 hours 15 May. Counts for the center array prior to 15 May were determined from the proportion of center to inshore and offshore counts during the remainder of the season.

Adjustment of Sonar Counts

The system was monitored 24 hours per day. Every 15 minutes counts were electronically totaled for each array and recorded on paper tape. To interpret the sonar counts as smolt, the following adjustments were required: subtract false counts, interpolate for missed time, adjust for river velocity, expand counts for river width, and multiply by 10.

False counts caused by wind, rain, ice, boats, etc., if recorded, were subtracted from the counts printed on the paper tape. False counts were avoided, however, by disabling the entire system when a known source of false counts appeared, e.g., boats, ice, etc. The control unit printed the number of seconds the system was disabled. Counts during missed time were estimated by linear interpolation. The control unit was temperature sensitive and there was approximately a 4% error in the disable time printed on the paper tape. The actual disable time was less than the disable time printed by the control unit. After 25 May this error was negligible, and no adjustment was made in the expanded outmigration counts. During the same time period a difference was also noticed between the printed counts and the number tallied on the control by the totalizers. This error was considered negligible, therefore, no adjustment was made in the outmigration estimate.

The counting rate of the control unit was dependent on water velocity. The control unit was initially set at 5.20 fps and reset to 4.98 fps on 21 May for the remainder of the project. Actual water velocities were measured with a Gurley meter four times during the project. 17 May, 25 May, 2 June, and 10 June average velocities over the inshore array were 4.79, 4.43, 5.54, and 4.49 fps, respectively. And offshore arrays were 5.20, 5.30, 5.28, and 5.26 fps, respectively. These water velocities were used to make linear adjustments in the sonar counts.

The counts from each array were expanded to estimate the number of smolt migrating in sections of the river not covered by the arrays. The sonar signal from each array was approximately 3.7 m wide. The surface width of the river was measured at 96.6 m. A side scanning sonar system was used to determine the limits of the lateral distribution of smolt in the river. Based on data obtained from the side scanning sonar, smolt did not utilize the first 13.4 m from the west bank nor the first 3.0 m from the east bank. Figure 1 illustrates the position of the arrays in the river and this season's lateral smolt distribution across the river. Daily counts were then expanded to estimate the total daily outmigration based on the daily lateral distribution of sonar counts over the three arrays. Mean expansion factors derived from the area under the lateral distribution curve were 5.59, 4.55, and 4.26 for the inshore, center, and offshore sectors respectively.

The sonar system functioned as a biomass counter and was designed one count for the biomass equivalent to 10 smolt passing over the sonar equipped arrays (Krasnowski 1975). Daily counts were therefore multiplied by 10 as the final adjustment in estimating the numbers of outmigrating smolt. A sample of a completed daily outmigration estimate with adjustments for disable time, water velocity, expansion for unsonified areas, and multiplication by 10 fish per count was presented by Randall (1977).

Age-Weight-Length Sampling

Samples from fyke net catches were used to determine mean lengths, weights, and age composition of the outmigrating smolt. A standard 1.5 m by 1.5 m fyke net was fished in about 1.4 m of water in approximately the same location as the index site of previous years. An effort was made to collect

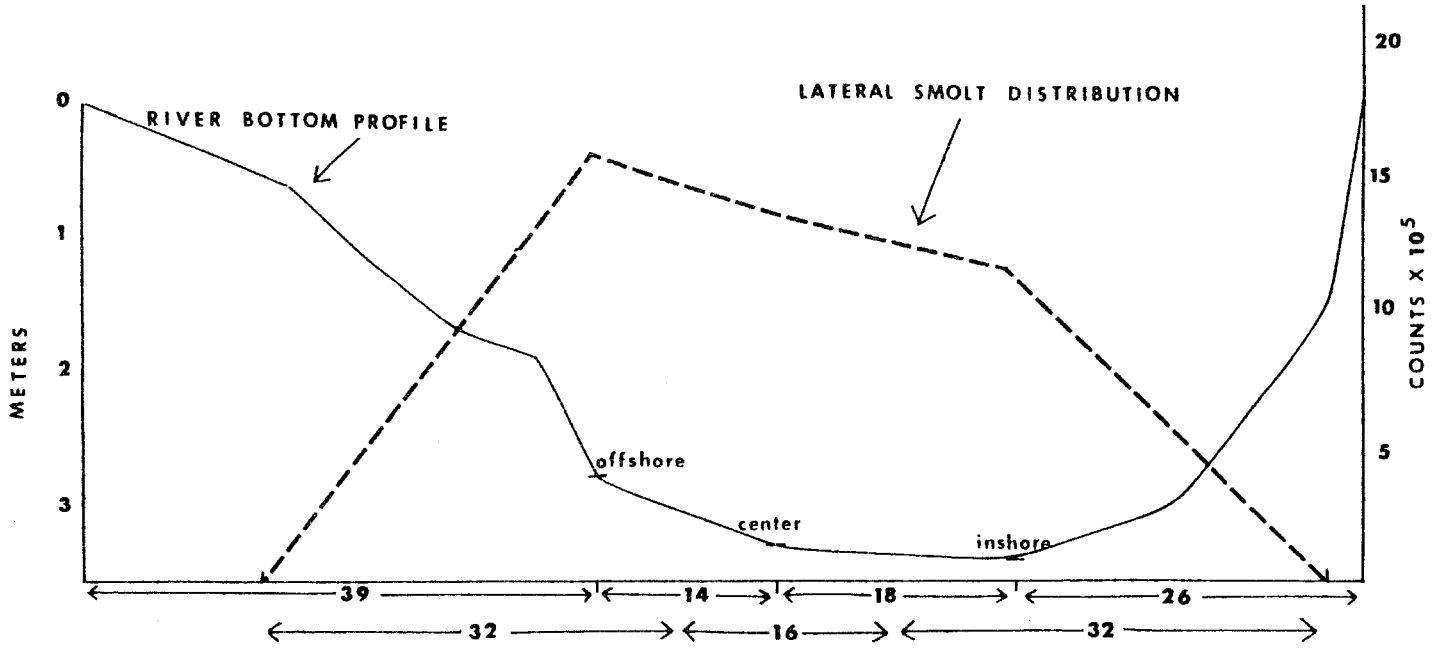

Figure 1. River bottom profile at sonar site, location of arrays, and estimated lateral smolt distribution, Kvichak River, 1981.

thirty smolt for age, length, and weight data at 0600, 1200, 1800, and 2400 hours daily. The estimated age proportion was 89% Age I and 11% Age II. Therefore, the smolt age samples were pooled into sample sizes of 165 fish or more which allowed detection of a 5% change in the age composition at the 95% confidence level (Snedecor and Cochran 1967). As a result there were 10 samples periods of 2 to 6 days each. Estimated age composition of the total outmigration was weighted by the outmigration estimate for each of the sample periods. The mean length and weight for the entire outmigration were estimated by summing the daily mean lengths and weights, weighted by the corresponding daily outmigration estimate.

RESULTS

Climatological and Hydrological Observations

Weather and river conditions were recorded at the sonar site from 15 May through 9 June (Table 1). The weather during the project was generally clear and warm with light breezes. Few corrections were necessary on the count data because of wind or rain over the duration of the project. The seasonal mean air and temperatures were 9.9 and 8.2° C, respectively. Water temperatures during the smolt studies in the past 19 years have averaged 5.3° C. Water temperature data from 1963 to 1981 are presented in Appendix Table 1. During the peak of the outmigration the mean water temperature was 7.6° C. The water level rose approximately 0.5 m during the course of the project.

Outmigration Estimate

A total of 3,946,207 sonar counts was tallied during the 1981 sonar enumeration project (Table 2). This led to an estimated outmigration of 183.6 million smolt (Table 3). The peak of the outmigration occurred between 23 May and 25 May and represented 43.3% of the total outmigration.

There were 163.0 million Age I smolt enumerated from the 1979 escapement of 11.2 million spawners (Table 4). The remaining 20.6 million smolt were Age II and were the progeny of 4.1 million adults spawning in 1978. The 20.6 million Age II smolt added to 162.5 million Age I smolt that emigrated in 1980 indicate a total production of 44.2 smolt per spawner from the 1978 brood year (Table 4). Smolt to adult marine survival has been calculated for Age I and Age II smolt from brood year 1968 through brood year 1976 (Table 5). Average marine survival for Age I smolt is 9.6% and for Age II smolt is 13.3%.

Age-Weight-Length

A total of 2,157 smolt was measured to determine mean weight, length, and age. Daily mean weights and lengths are presented in Table 6. The estimated age composition of the total outmigration was 89% Age I and 11% Age II. The estimated mean weights of the total outmigration were 5.45 g for Age I smolt and 10.2 g for Age II smolt. Mean lengths were 85.3 mm for Age I smolt and 108.3 mm for Age II smolt. Appendix Table 2 provides smolt age composition, weight, and length data for the years 1955 through 1981.

Table 1. Climatological and stream observations, Kvichak River, 15 May to 9 June 1981

Date	Sky[1] 0800	Sky[1] 2000	Wind (MPH) Direction 0800	Wind (MPH) Direction 2000	Air Temp C° min	Air Temp C° max	Water Temp C° 0800	Water Temp C° 2000	Precipitation (m) 24 hr	Water[2] Level (m) 0800	Turbidity[3] 0800
5/15	2	1					9.0	7.5	0	7.32	1
5/16	1	4	10SW	45W	2.8	8.0	6.7	8.0	0	7.35	1
5/17	4	3	2W	Calm	6.0	18.1	7.2	8.0	.33	7.30	1
5/18	3	4	8W	25NE	5.5	8.5	7.2	8.0	T	7.61	1
5/19	3	3	7E	7NE	-	-	7.2	7.0	.03	7.53	5
5/20	3	3	Calm	10E	11.0	23.0	6.8	7.0	.01	7.59	5
5/21	5	3	Calm	5W	4.8	22.3	6.6	7.5	.05	7.59	1
5/22	1	1	5E	10NE	3.6	15.3	7.1	7.5	0	7.57	5
5/23	2	3	8NE	5NE	5.0	15.0	6.6	8.0	0	7.52	1
5/24	4	2	Calm	2NE	5.5	12.0	7.6	8.0	0	7.53	1
5/25	1	1	Calm	Calm	0.3	15.3	7.3	8.3	0	7.53	1
5/26	1	1	3W	Calm	1.5	16.7	7.9	9.0	0	7.58	1
5/27	4	3	5NE	5NE	1.0	21.0	9.0	9.6	0	7.56	1
5/28	1	3	5NE	5NE	2.0	22.0	9.3	9.1	.05	7.56	1
5/29	4	4	12NE	10NE	2.0	15.0	8.8	8.7	T	7.56	5
5/30	2	2	10NE	-	-	-	8.9	-	-	7.68	5
5/31	2	4	10NE	12NE	-	-	8.5	8.8	0	7.67	5
6/01	3	4	15NE	15NE	-	-	8.0	7.5	0	7.68	5
6/02	4	3	12E	5NE	1.0	8.0	7.8	7.0	0	7.73	5
6/03	2	3	12N	10E	1.0	13.0	8.5	9.5	0	7.66	2
6/04	2	3	15NE	15E	6.0	18.5	8.1	8.7	0	7.74	2
6/05	2	2	Calm	Calm	6.0	18.0	8.8	9.2	0	7.73	2
6/06	4	2	2N	2NW	6.0	18.0	9.5	10.4	.06	7.71	2
6/07	4	4	25W	Calm	6.0	19.5	10.0	9.8	.06	7.71	3
6/08	2	4	Calm	35W	2.5	13.0	9.2	9.4	.06	7.76	2
6/09	4	-	5SW	-	8.0	15.0	8.9	-	.17	7.82	3
MEAN					9.9		8.2				

[1] Sky Codes:
1 Clear sky, clouds covering not more than 1/10 of sky
2 Cloud covering not more than 1/2 of sky
3 Cloud covering more than 1/2 of sky
4 Complete overcast
5 Fog

[2] Depth of inshore half of center array

[3] Turbidity Codes:
1 Clear
2 Light turbidity
5 Murky or glacial

Table 2. Kvichak River sockeye salmon smolt counts by array, less false counts, plus interpolation for missed time, 1981.

DATE	INSHORE	CENTER	OFFSHORE	TOTAL
5 13	202460	0	196210	398670
5 14	93610	0	29200	122810
5 15	90450	22000	59950	172400
5 16	231760	196360	132290	560410
5 17	177140	194120	518860	890120
5 18	142480	341650	457640	941770
5 19	98260	86850	153290	338400
5 20	35390	33570	125740	194700
5 21	99460	92220	124570	316250
5 22	133310	314400	507560	955270
5 23	2192850	2748360	2761370	7702580
5 24	1346230	2152570	2375620	5874420
5 25	1751210	1907040	1170020	4828270
5 26	1096630	860720	819420	2776770
5 27	588770	718020	1228130	2534920
5 28	553820	983140	872420	2409380
5 29	374950	443620	677360	1495930
5 30	431970	530530	862710	1825210
5 31	637910	314320	355090	1307320
6 1	140670	239950	544420	925040
6 2	366660	700280	645600	1712540
6 3	106540	157450	172160	436150
6 4	39940	57660	94640	192240
6 5	58670	61150	81470	201290
6 6	28950	56630	35230	120810
6 7	17540	58160	64670	140370
6 8	16790	29950	41290	88030
TOTAL	1105442	1330072	1510693	3946207
% OF TOTAL	0.2801	0.3371	0.3828	

Table 3. Daily smolt outmigration estimate by age class with percent age composition and accumulated totals, Kvichak River, 1981

DATE		AGE I	%	ACCUM	AGE II	%	ACCUM	TOTAL	ACCUM
5	13	2317515	0.79	2317515	616892	0.21	616892	2934408	2934408
5	14	875160	0.79	3192675	232956	0.21	849848	1108117	4042525
5	15	633606	0.79	3826281	168657	0.21	1018505	802263	4844788
5	16	2014258	0.79	5840539	536169	0.21	1554674	2550428	7395216
5	17	3017331	0.79	8857870	803174	0.21	2357848	3820506	11215722
5	18	3163619	0.79	12021489	842114	0.21	3199962	4005734	15221456
5	19	1299103	0.83	13320592	266482	0.17	3466444	1565585	16787041
5	20	736220	0.83	14056812	151019	0.17	3617463	887239	17674280
5	21	1217649	0.83	15274461	249774	0.17	3867237	1467423	19141703
5	22	3574118	0.83	18848579	733152	0.17	4600389	4307270	23448973
5	23	32854389	0.93	51702968	2663869	0.08	7264258	35518259	58967232
5	24	24831863	0.93	76534831	2013394	0.08	9277652	26845257	85812489
5	25	21860362	0.97	98395193	656749	0.03	9934401	22517111	108329600
5	26	12660488	0.97	111055681	380358	0.03	10314759	13040846	121370446
5	27	8880746	0.76	119936427	2732537	0.24	13047296	11613283	132983729
5	28	8412237	0.76	128348664	2588380	0.24	15635676	11000618	143984347
5	29	5485227	0.78	133833891	1517190	0.22	17152866	7002417	150986764
5	30	6674665	0.78	140508556	1846184	0.22	18999050	8520849	159507613
5	31	6074851	0.95	146583407	293084	0.05	19292134	6367935	165875548
6	1	4053214	0.95	150636621	195549	0.05	19487683	4248763	170124311
6	2	7155339	0.90	157791960	837326	0.10	20325009	7992666	178116977
6	3	1829388	0.90	159621348	214077	0.10	20539086	2043465	180160442
6	4	842044	0.94	160463392	51032	0.06	20590118	893077	181053519
6	5	890938	0.94	161354330	53996	0.06	20644114	944934	181998453
6	6	561559	0.99	161915889	3137	0.01	20647251	564696	182563149
6	7	638152	0.99	162554041	3565	0.01	20650816	641717	183204866
6	8	404080	0.99	162958121	2257	0.01	20653073	406337	183611203

Table 4. Kvichak River sockeye salmon escapement and smolt production by brood year, 1956-1979.[1]

BROOD YEAR	ESCAPEMENT	ESTIMATED SMOLT PRODUCTION AGE I	AGE II	AGE III	TOTAL	AGE PROPORTION AGE I	AGE II	AGE III	SMOLT PER SPAWNER
1956	9443318	3267274	2777960	0	6045234	0.54	0.46	0.	0.640
1957	2842810	85916	552603	0	638519	0.13	0.87	0.	0.225
1958	534785	61400	10126	0	71526	0.86	0.14	0.	0.134
1959	680000	26038	72180	0	98218	0.27	0.73	0.	0.144
1960	14630000	1130820	4116093	0	5246913	0.22	0.78	0.	0.359
1961	3705849	113338	1603464	0	1716802	0.07	0.93	0.	0.463
1962	2580884	458122	1748178	0	2206300	0.21	0.79	0.	0.855
1963	338760	64377	23377	0	87754	0.73	0.27	0.	0.259
1964	957120	252384	222528	0	474912	0.53	0.47	0.	0.496
1965	24325926	2866214	5475362	0	8341576	0.34	0.66	0.	0.343
1966	3775184	648321	541017	0	1189338	0.55	0.45	0.	0.315
1967	3216208	594327	298282	0	892609	0.67	0.33	0.	0.278
1968	2557440	185356	5959383	0	6144739	0.03	0.97	0.	2.403
1969	8394204	85723430	67004325	0	152727756	0.56	0.44	0.	18.194
1970	13935306	570750	189138158	4925610	194634518	0.00	0.97	0.03	13.967
1971	2337392	4987961	33767464	0	38755425	0.13	0.87	0.	16.233
1972	1009962	4021849	5784036	0	9805885	0.41	0.59	0.	9.709
1973	226554	9848495	2927804	0	12776299	0.77	0.23	0.	56.394
1974	4433844	99890123	132920297	0	232810420	0.43	0.57	0.	52.508
1976	1965282	31305140	25993357	0	57298497	0.55	0.45	0.	29.155
1977	1341144	26623136	10109539	0	36732675	0.72	0.28	0.	27.389
1978	4149288	162563957	20653073	0	183217030	0.89	0.11	0.	44.156
1979[2]	11218434	162958121	0	0	162958122	1.00	0.	0.	14.526

[1] Smolt production from 1956-1967 brood years and Age I smolt from 1968 brood year were estimated by a fyke net index program. All subsequent smolt production was estimated by sonar.

[2] Partial return.

Table 5. Kvichak River sockeye salmon escapement, smolt estimate, adult returns, and smolt survival by brood year, 1968-1978.[1]

		AGE I			AGE II		
BROOD YEAR	TOTAL ESCAPE	EST SMOLT	ADULT RETURN	ADULT/ SMOLT	EST SMOLT	ADULT RETURN	ADULT/ SMOLT
1968	2557440				5959383	256672	0.04
1969	8394204	85723430	436169	0.01	67004325	4730971	0.07
1970	13935306	570750	55160	0.10	189138158	15143864	0.08
1971	2387392	4987961	333077	0.07	33767464	2389975	0.07
1972	1009962	4021849	397355	0.10	5784036	1473645	0.26
1973	226554	9848495	1534979	0.16	2927804	806200	0.28
1974	4433844	99890123	8217366	0.08	132920297	17122358	0.13
1975	13140450	82097299	6744868	0.08	236523253	28802779	0.12
1976	1965282	31305140	5847324	0.19	25993357	3831856	0.15
1977	1341144	26623136	1832812	0.07	10109539		
1978	4149288	162563957			20653073		
mean				0.096			0.133

[1] 1977-1978, partial returns only.

Table 6. Mean length (mm), mean weight (g), standard error, and sample size (n) for sockeye salmon smolt by age class and sample date, Kvichak River, 1981.

	AGE I					AGE II				
DATE	MEAN LENGTH	S.E.	MEAN WEIGHT	S.E.	N	MEAN LENGTH	S.E,	MEAN WEIGHT	S.E.	N
5/14	79.150	1.456	4.910	0.210	20	0.	0.	0.	0.	0
5/15	65.000	0.	2.600	0.	1	0.	0.	0.	0.	0
5/16	84.026	0.913	5.450	0.187	10	112.090	1.355	12.420	0.430	21
5/17	89.592	0.778	6.284	0.175	31	106.500	4.445	10.320	1.285	4
5/18	90.061	0.469	6.735	0.104	77	110.940	2.266	11.588	0.711	12
5/19	85.670	1.530	5.730	0.475	4	115.000	5.416	12.470	1.793	5
5/20	83.060	1.427	5.772	0.323	23	112.667	1.836	12.622	0.479	13
5/21	85.819	0.527	5.618	0.100	88	114.490	2.325	12.462	0.800	5
5/22	88.281	0.484	6.164	0.110	41	108.035	1.833	10.300	0.481	9
5/23	87.734	0.304	5.777	0.070	103	107.778	2.055	9.823	0.629	17
5/24	85.976	0.285	5.587	0.060	119	115.000	0.	10.500	0.	1
5/25	84.890	0.305	5.253	0.059	115	107.067	0.558	9.820	0.262	5
5/26	83.217	0.334	5.015	0.064	118	106.046	0.	9.205	0.	2
5/27	82.898	0.527	4.875	0.099	89	114.466	1.025	12.466	0.349	29
5/28	82.454	0.507	5.007	0.108	93	97.080	1.142	8.748	0.297	27
5/29	85.368	0.642	5.657	0.140	89	109.067	0.847	10.618	0.335	26
5/30	85.805	0.433	5.594	0.088	93	107.065	1.339	10.324	0.693	27
5/31	82.282	0.453	5.133	0.086	116	109.965	0.997	9.263	1.450	4
6/ 1	83.829	0.405	5.220	0.074	112	110.983	4.772	10.367	1.858	8
6/ 2	84.008	0.341	5.265	0.068	89	108.000	0.	10.200	0.	1
6/ 3	83.171	0.427	5.056	0.092	99	105.803	1.131	9.998	0.259	21
6/ 4	82.830	0.410	5.105	0.085	84	110.336	1.864	11.460	0.848	6
6/ 5	85.305	0.326	5.331	0.065	114	110.146	1.887	11.430	0.371	6
6/ 6	85.509	0.410	5.509	0.084	60	0.	0.	0.	0.	0
6/ 7	85.288	0.277	5.325	0.057	89	99.000	0.	8.200	0.	1
6/ 8	84.970	0.546	5.280	0.124	30	0.	0.	0.	0.	0
MEAN	85.346		5.454			108.279		10.152		

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Appendix Table 1. Water temperatures (°C) during smolt studies, Kvichak River, 1963 to 1981.

Year	Start	End	Minimum	Maximum	Mean
1963	5/16	6/14	2.22	8.89	5.5
1964	5/18	6/14	0.00	5.6	2.6
1965	5/17	6/11	0.00	8.9	4.4
1966	5/16	6/26	0.00	11.1	4.7
1967	5/17	6/20	1.1	9.4	6.9
1968	5/12	6/12	3.3	8.3	5.4
1969	5/16	6/18	0.3	7.8	3.9
1970	5/13	6/07	2.8	11.1	6.8
1971	5/17	6/20	1.1	3.3	2.4
1972	5/18	6/18	0.6	5.0	2.9
1973	5/15	6/14	2.9	8.9	4.9
1974	5/13	6/09	3.0	8.0	6.2
1975	5/17	6/15	2.0	8.0	3.8
1976	5/18	6/19	2.0	9.5	3.9
1977	5/17	6/14	3.0	9.5	6.4
1978	5/19	6/09	5.0	11.0	7.6
1979	6/01	6/10	8.0	10.0	8.6
1980	5/16	6/18	1.5	9.0	5.5
1981	5/15	6/09	7.0	10.0	8.2
Mean					5.3

Appendix Table 2. Age, length, weight, and outmigration[1] estimate of sockeye salmon smolt.

YEAR OF SEAWARD MIGRATION	AGE I %	AGE I LENGTH (mm)	AGE I WT (g)	AGE II %	AGE II LENGTH (mm)	AGE II WT (g)	AGE III %	AGE III LENGTH (mm)	AGE III WT (g)	OUT MIGRATION ESTIMATE
1955	0.07	89.0	0.	0.93	0.	0.	0.	0.	0.	260068
1956	0.39	92.0	0.	0.61	116.0	0.	0.	0.	0.	77660
1957	0.72	96.0	7.3	0.28	120.0	14.4	0.	0.	0.	30907
1958	0.98	84.0	4.6	0.02	114.0	0.	0.	0.	0.	3333953
1959	0.03	80.0	0.	0.97	99.0	7.6	0.	0.	0.	2863876
1960	0.10	91.0	6.3	0.90	108.0	10.3	0.	0.	0.	2140033
1961	0.72	92.0	6.8	0.28	117.0	13.1	0.	0.	0.	36164
1962	0.94	82.0	4.3	0.06	110.0	9.9	0.	0.	0.	1203000
1963	0.03	83.0	4.8	0.97	98.0	7.5	0.	0.	0.	4229431
1964	0.22	87.0	5.2	0.78	108.0	9.8	0.	0.	0.	2061586
1965	0.04	90.0	6.8	0.96	109.0	11.3	0.	0.	0.	1812555
1966	0.92	94.0	7.4	0.08	114.0	12.6	0.	0.	0.	273761
1967	0.93	86.0	5.9	0.07	118.0	14.2	0.	0.	0.	3088742
1968	0.11	88.0	5.5	0.89	104.0	9.2	0.	0.	0.	6123683
1969	0.52	92.5	5.7	0.48	109.3	10.6	0.	0.	0.	1135344
1970	0.38	90.8	6.0	0.62	110.2	11.0	0.	0.	0.	483638
1971	0.94	89.9	5.8	0.07	111.0	11.1	0.	0.	0.	91682813
1972	0.01	80.0	4.2	0.99	106.0	10.0	0.	0.	0.	67575075
1973	0.03	85.6	5.1	0.97	97.1	8.3	0.	0.	0.	194126120
1974	0.09	95.5	8.3	0.79	111.0	13.1	0.12	123.5	17.5	42714923
1975	0.63	97.7	8.4	0.37	121.9	16.4	0.	0.	0.	15632531
1976	0.97	88.2	5.8	0.03	120.8	14.2	0.	0.	0.	103817927
1977	0.38	86.0	5.5	0.62	106.0	10.1	0.	0.	0.	215017596
1978	0.12	88.1	6.0	0.88	96.9	7.8	0.	0.	0.	269828392
1979	0.51	89.6	6.0	0.49	108.9	10.3	0.	0.	0.	52616493
1980	0.94	88.4	5.9	0.06	109.9	10.7	0.	0.	0.	172673496
1981	0.89	85.3	5.4	0.11	108.3	10.2	0.	0.	0.	183611194
mean	0.47	88.6	6.0	0.53	109.7	11.0				

[1] 1955-1970 outmigration estimates from fyke net index data only. 1971-1981 outmigration estimates based on sonar enumeration.

1981 EGEGIK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

A feasibility study was conducted in 1981 on the Egegik River to evaluate its potential as a sockeye salmon *(Oncorhynchus nerka)* smolt sonar project location. The Egegik River system is a major sockeye salmon producing system for which almost no historic smolt abundance data exists. This data is necessary to more accurately forecast returns of adults and to assist in establishing optimum escapement levels.

Specific objectives of the 1981 project were to collect data on outmigration abundance and timing, physical attributes of the smolt, and climatological and hydrological features. A water velocity model was also developed to correct for tidal influence.

METHODS AND MATERIALS

Site Location

The sonar site was located along a relatively narrow portion of the Egegik River, 4 km below the outlet of Becharof Lake and just upstream from the lagoon (Figure 1). It had a uniform bottom and was protected from entrained air caused by high winds and by the rapids at the outlet of the lake making it an ideal sonar site. Fyke netting was conducted 1 km downstream from Becharof Lake on the north side of the river.

Sonar Arrays

The smolt counter used in 1981 was a 1972 model, 2 array smolt counter originally designed for the Kvichak River smolt project. This system utilized two 3.2 m plastic ladder arrays. Each array housed seven upward facing transducers. The 1976 model #5117 transducers (10 smolt/count) were used rather than the original #5001 because of the improvements in accuracy incorporated in the #5117. Installation and operation of the sonar counting system was similar to that used on the Kvichak River (Randall 1977). On 14 May the arrays were placed in the water and tested. The slow current of the Egegik River greatly facilitated the placement and removal of the arrays. The inshore and offshore arrays were placed at 40 and 50 m from the west bank, respectively (Figure 2). The river velocity on the control was manually set at 2.5 fps and remained so throughout the duration of the project. Counting began at 1200 hours, 15 May.

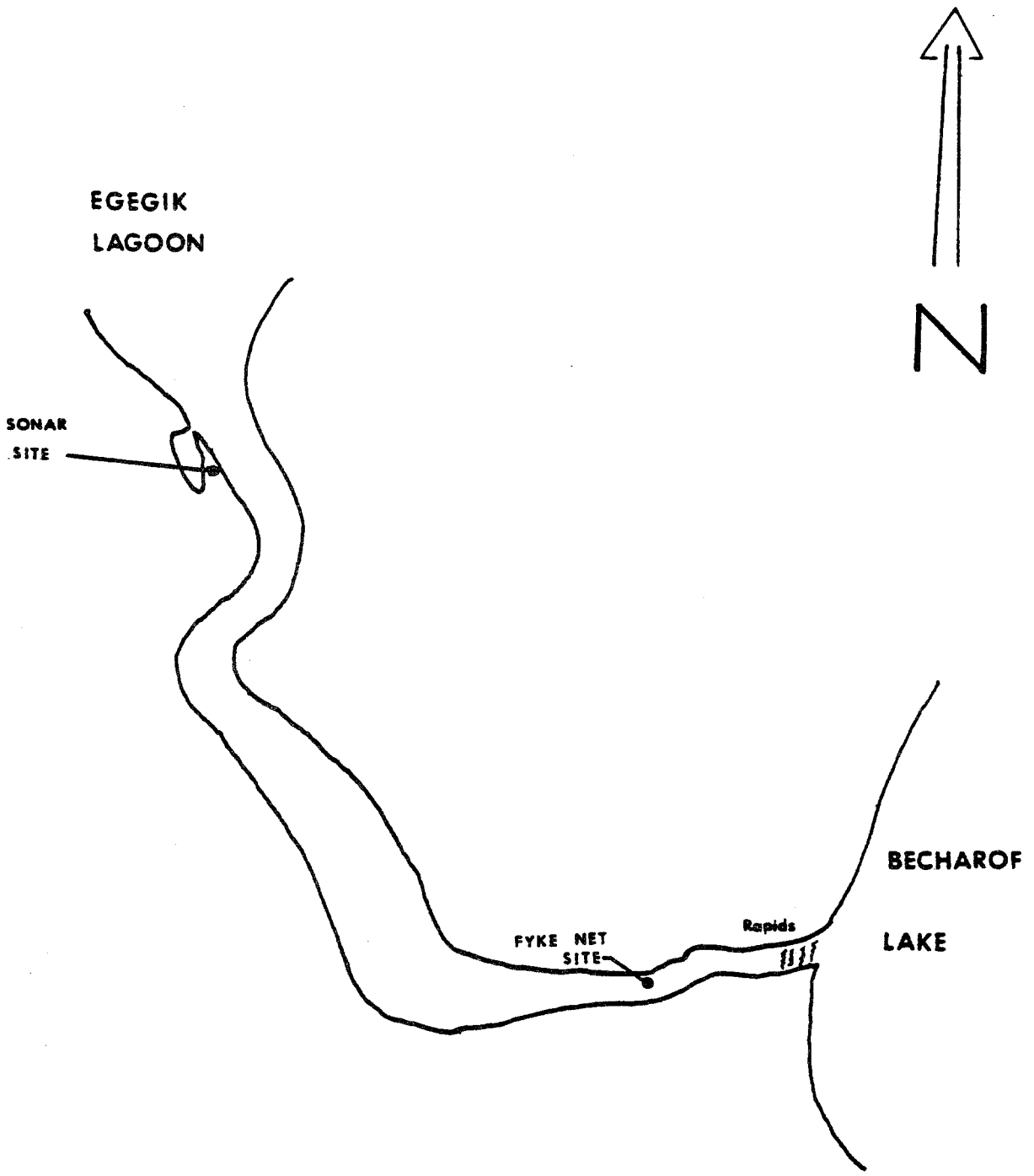

Figure 1. Egegik smolt sonar and fyke net sites, 1981.

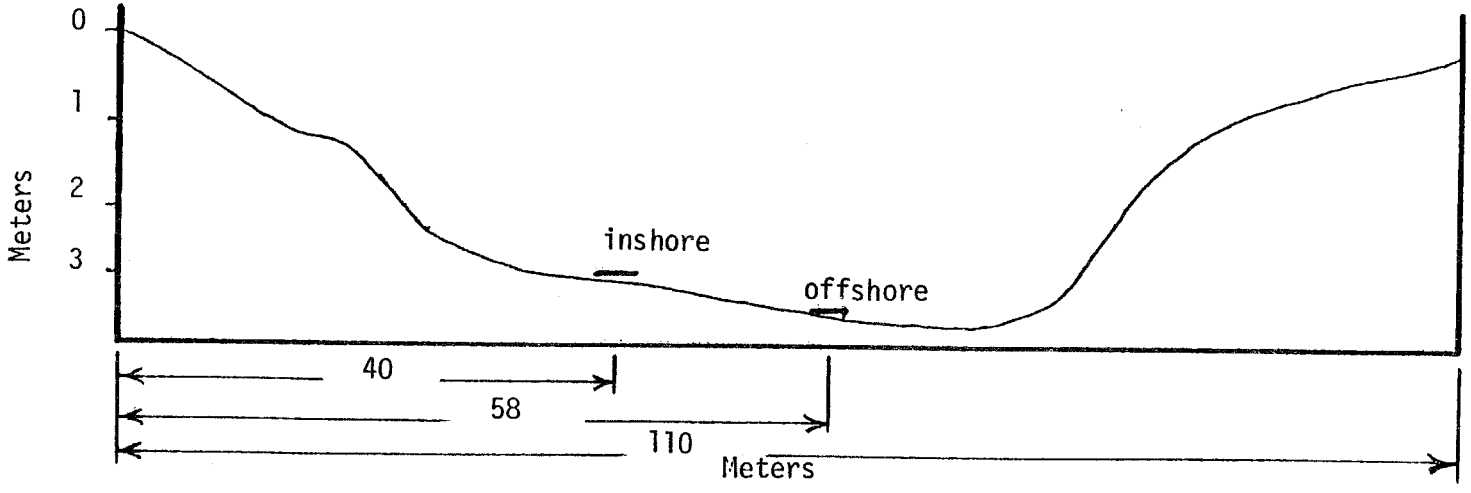

Figure 2. Egegik River bottom profile and array location, 1981.

River Velocity Observations

The Egegik River is subject to tidal influence at the sonar site causing the river velocity to fluctuate with the ebb and flood. A difference between actual river velocity and the velocity which is set on the counter causes erroneous counts in direct proportion to the ratio between the two velocities. In order to develop a statistical model to estimate hourly velocities for correcting hourly counts, river levels were recorded in front of the smolt tent. These river levels were then related to river velocity measurements taken during both the flood and ebb with a pygmy Gurley meter. River velocities were taken at the surface, and at 0.6 and 1.2 m below the surface. The mean of these three velocities was then related to the corresponding river level.

Age-Weight-Length Sampling

Samples from fyke net catches were used to determine mean lengths, weights, and age composition of the outmigrating smolt. A standard 1.2 x 2.1 m fyke net was fished in 1 m of water approximately 3 km upstream from the sonar site. An effort was made to collect 30 smolt daily at 2300 hours. Periodic attempts were made to collect smolt at other hours as time allowed.

RESULTS

Climatological and Hydrological Observations

Weather and river conditions were recorded at the sonar site from 15 May through 8 June (Table 1). There was no ice encountered in 1981 as Becharof Lake was ice-free when the crew arrived at the sonar site. Ice does not appear to be a major problem on the Egegik River largely because of the breaking action of the rapids and the geography of the river. The mean air and water temperatures were 13.4°C and 7.28°C, respectively. The mean water temperature during the peak outmigration period (19-23 May) was 5.6°C.

River Velocity Observations

During the course of the project, 56 water velocities were taken at different tide stages and water levels. The data were divided into a rising tide group and a falling tide group. Within each group water velocity was linearly regressed against water level (Table 2). The results indicated strong relationships between tide stage and velocity for both rising tide ($r^2 = 0.96$, $n = 22$) and falling tide ($r^2 = 0.89$, $n = 31$).

Water levels were recorded hourly as often as possible (Table 3). From the water level readings and the water velocity models, hourly water velocities could have been generated and subsequent correction of the sonar counts could have been made. These corrections were not actually implemented because of problems with the counter and incomplete water level data.

Sonar Counts

The counter was found to be undercounting until 2 June when it was adjusted.

Table 1. Climatological and stream observations, Egegik River, 15 May - 8 June 1981.

Date	Sky 0900	Sky 2100	Wind (MPH) Direction 0900	Wind (MPH) Direction 2100	Air Temp °C Max.	Air Temp °C Min.	Water Temp. °C 0900	Water Temp. °C 2100	Precipitation (cm) 24 hours	Turbidity 0900 hr.
5/15	1	3	5SE	5SE			6	7.5	0	1
5/16	3	2	10E	15W			7	7	0	1
5/17	2	3	5SE	25E			7	5	0	1
5/18	4	4	35E	40E			5	5	T	1
5/19	3	3	25E	15E			5	5	0	1
5/20	2	2	25E	10E	15	9	5	5.5	0	1
5/21	1	2	25E	10E	17	5	5.5	6	0	1
5/22	2	2	20E	5E	19	7	5	5	0	1
5/23	1	3	calm	calm	25	2	6	8	0	1
5/24	3	1	calm	calm	26	5	8	9	0	1
5/25	1	1	10E	5E	24	3	8	8	0	1
5/26	1	1	calm	calm	28	5	8	9	0	1
5/27	1	4	25E	10E	18	5	9	7	.50	1
5/28	3	4	calm	calm	18	7	7	7	T	1
5/29	2	4	calm	calm	18	8	8	8	.25	1
5/30	2	3	15E	10E	20	7	8	8	.10	1
5/31	4	4	calm	15NW	20	5	8	8	.05	1
6/1	3	4	5E	15E	19	8	8	8	.03	1
6/2	4	3	10E	5E	14	5	8	8	.25	1
6/3	4	3	10NW	calm	25	7	8	8	T	1
6/4	3	3	calm	calm	24	7	8	8	.15	1
6/5	3	3	calm	calm	28	8	8	8	0	1
6/6	3	3	calm	calm	18	7	8	8	.08	1
6/7	3	4	5E	calm	12	5	8	7	.43	1
6/8	4	4	calm	calm	15	8	7	8	.28	1

Sky codes: 1 - clear sky, cloud covering not more than 1/10 of sky.
2 - cloud covering not more than 1/2 of sky.
3 - cloud covering more than 1/2 of sky.
4 - completely overcast.
5 - fog.

Turbidity codes: 1-clear
2-light turbidity

Table 2. Water velocity observations, Egegik River, 1981

Rising Tide

Water level	River velocity
1.05	2.69
1.10	2.66
1.15	2.65
1.20	2.50
1.25	2.38
1.30	2.33
1.40	2.28
1.45	2.24
1.63	1.93
1.65	1.91
1.70	1.93
1.73	1.92
1.75	1.96
2.45	1.34
2.50	1.29
2.55	1.28
2.60	1.28
2.65	1.32
2.70	1.31
2.75	1.28
2.80	1.27
2.85	1.31

Linear Regression
$y = a + bx$
x = water level
y = river velocity
a = 3.40
b_2 = 0.80
r^2 = 0.96
n = 22

Falling Tide

Water level	River velocity
1.05	2.89
1.15	2.84
1.15	2.83
1.20	2.83
1.20	2.78
1.25	2.72
1.30	2.72
1.30	2.79
1.40	2.72
1.40	2.67
1.40	2.62
1.45	2.57
1.50	2.61
1.55	2.54
1.55	2.58
1.60	2.63
1.60	2.64
1.65	2.67
1.65	2.57
1.70	2.63
1.80	2.53
1.85	2.56
1.90	2.40
1.90	2.42
2.00	2.41
2.05	2.38
2.30	2.22
2.35	2.34
2.40	2.36
2.50	2.32

Linear Regression
$y = a + bx$
x = water level
y = river velocity
a = 3.27
b_2 = -0.41
r^2 = 0.89
n = 31

Table 3. Water levels by hour and day, Egegik River, 1981.

Hour	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	31/1	1/2	2/3	3/4	4/5	5/6	6/7
1200-1300	1.15	1.15	1.30	1.55	1.80	1.70	1.70	1.40	1.15	1.10	1.25	1.30	1.30	1.65	2.00	2.40	2.52	2.70
1300-1400		1.15	1.30	1.50	1.75	1.60	1.65	1.40	1.58	1.50		1.25	1.25	1.60	1.95	2.27	2.47	2.62
1400-1500	1.10	1.10	1.25	1.45	1.70	1.60	1.60	1.45	1.58	1.50	1.35	1.50	1.20	1.55	1.80	2.15	2.30	2.40
1500-1600	1.10	1.10	1.20	1.40		1.55	1.55	1.40	1.53	1.45	1.30	1.50	1.50	1.67	1.77	1.85	2.00	2.27
1600-1700	1.05	1.10	1.15	1.30		1.50		1.40	1.40		1.30	1.50	1.50	1.95	1.75	1.80		2.15
1700-1800		1.10	1.10	1.30		1.40		1.30	1.35	1.35		1.45	1.50	1.90	1.90	2.00		2.00
1800-1900		1.00			1.40	1.35	1.40	1.30	1.30	1.30	1.20	1.40	1.45		2.10	2.20		1.90
1900-2000	1.00	1.00			1.40	1.30	1.40	1.25	1.27	1.30	1.20	1.40	1.40		2.00	2.10	2.05	
2000-2100	1.00	1.05			1.35	1.30	1.35	1.20	1.25	1.25	1.20	1.35	1.40	1.85	1.90	2.00		
2100-2200	1.00	1.05	1.05	1.20	1.30	1.25	1.30	1.15	1.22	1.25	1.20	1.30	1.35		1.80	1.90	1.95	
2200-2300			1.00	1.15		1.20	1.25	1.15	1.20	1.15	1.15	1.25	1.30		1.65	1.85	1.90	2.00
2300-2400		1.00		1.10	1.20										1.60	1.77	1.80	1.90
0000-0100	.90	1.00	1.00	1.10	1.20		1.20	1.10	1.15	1.15	1.15		1.25	1.40	1.55		1.70	1.84
0100-0200	.95	1.00	1.00	1.10	1.20	1.10	1.15	1.10	1.15	1.15		1.20	1.20		1.50		1.60	1.70
0200-0300			1.00	1.10	1.15	1.25	1.15		1.20	1.35	1.10	1.15		1.35	1.42	1.55	1.52	
0300-0400										1.35				1.32				
0400-0500							1.10											
0500-0600															1.82			
0600-0700															2.42			
0700-0800														2.70			2.45	1.70
0800-0900									1.10			1.50	1.90		2.90	3.00	2.75	2.20
0900-1000	1.20			1.80	1.25	1.00	1.00	1.00	1.05	1.10	1.30	1.45	1.87		2.80	3.00	2.95	2.75
1000-1100	1.25	1.30	1.30	1.83		1.50	1.10	1.00	1.05	1.10	1.27	1.40	1.85	2.37		2.90	2.90	2.90
1100-1200	1.20	1.35	1.35	1.83	1.80	1.70	1.20	1.05	1.05	1.05	1.25	1.35	1.77	2.15	2.50	2.90	2.80	2.90

Due to surfacing difficulties, the data from the offshore array is questionable prior to 2 June, although the inshore array produced good index and timing data throughout the season. Table 4 shows the daily raw counts for the project. An estimation of the actual raw counts which would have been tallied on the inshore data was made by comparing the means of the raw counts 4 days on each side of the adjustment day. This indicated that the peak of the outmigration occurred between 19 and 23 May. Coho salmon *(O. kisutch)* smolt were observed in significant numbers in the sample on 30 May. From that point on, data regarding the coho to sockeye ratio were collected and the sockeye counts were adjusted. The estimated timing and magnitude of the sockeye smolt outmigration is shown in Figure 3.

Age-Weight-Length

In 1981, 549 sockeye smolt were sampled for age, weight, and length. Daily mean weights and lengths are presented in Table 5. The estimated age composition of the total outmigration was 48% Age I, 48% Age II, and 4% Age III. The estimated mean weights were 9.1 g Age I, 14.6 g Age II, and 19.1 g Age III. Mean lengths were 104.5 mm Age I, 121.5 mm Age II, and 128.3 mm Age III. Appendix Table 1 provides the historic smolt age composition, weight, and length data available since 1939.

Coho smolt began to appear in the samples in significant numbers on 30 May. These were also sampled (n = 18) and found to all be Age II with a mean weight and length of 27.1 g and 141.0 mm, respectively.

Table 4. Egegik River sockeye salmon smolt counts by array, 1981.

Date	Inshore Array	Offshore Array	Adjusted Inshore Array [1]
5/15	10	0	202
5/16	1	15	20
5.17	174	108	3514
5/18	217	169	4382
5/19	1752	128	35383
5/20	1021	235	20620
5/21	143	98	2888
5/22	205	28	4140
5/23	1241	21	25063
5/24	49	6	990
5/25	16	4	323
5/26	61	20	1232
5/27	39	193	788
5/28	19	85	384
5/29	30	10	606
5/30	55	23	972
5/31	9	2	144
6/1	8	9	147
6/2 [2]	868	2805	830
6/3	481	4124	437
6/4	336	794	336
6/5	375	558	375
6/6	181	225	181

[1] Adjusted by comparing the mean of the inshore counts for 4 days prior to adjustment to the mean of the inshore count 4 days after the adjustment and then subtracting the estimated coho counts.

[2] Adjustment day.

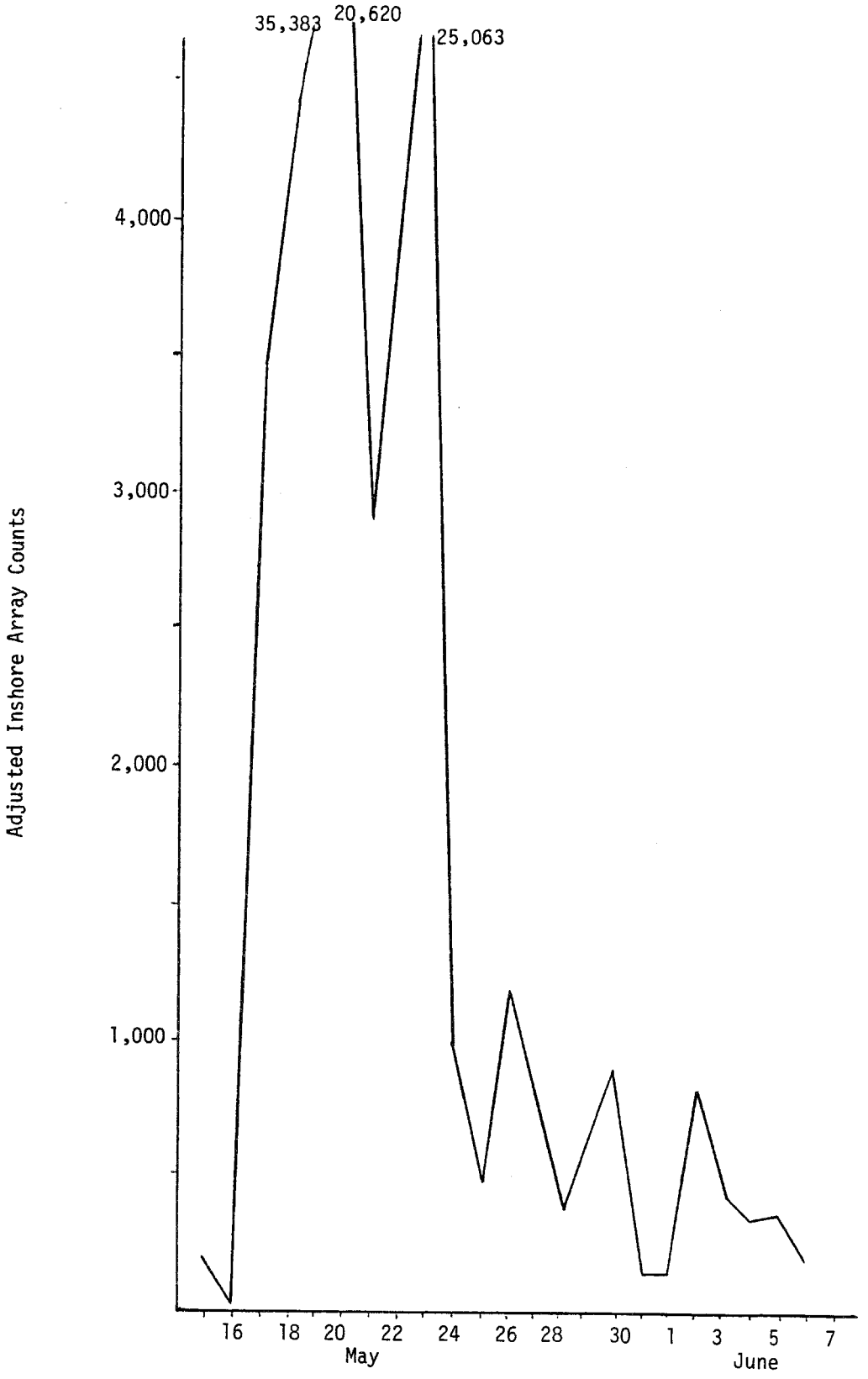

Figure 3. Adjusted inshore array counts by day, Egegik River, 1981.

Table 5. Mean length (mm), mean weight (g), standard deviation (s), and sample size (n) for sockeye salmon smolt by age class and sample date, Egegik River, 1981.

	AGE I					AGE II					AGE III				
Date	Mean Length	s	Mean Weight	s	n	Mean Length	s	Mean Weight	s	n	Mean Length	s	Mean Weight	s	n
5/15	97.00	14.1	9.15	4.31	2	126.41	3.28	18.47	1.98	21					
5/17						126.57	5.49	16.67	2.18	28					
5/19	103.67	1.15	9.17	0.38	3	125.48	6.03	15.03	3.18	25					
5/20	106.50	2.12	9.70	1.13	2	121.39	5.72	14.01	2.16	28					
5/21	103.67	4.98	8.80	1.39	6	122.43	7.42	14.35	3.48	23					
5/22	101.71	4.70	7.92	1.24	21	113.89	7.47	10.61	2.32	9					
5/23	102.06	4.82	8.53	1.09	16	109.29	3.99	10.48	0.95	14					
5/24	84.00	0.00	4.50	0.00	1	122.41	5.28	14.94	2.23	29					
5/25	108.80	6.22	9.06	1.26	5	125.12	4.91	15.97	1.91	24					
5/26	108.60	4.93	9.82	1.55	5	124.17	6.04	15.27	2.32	23	132	0.00	22.0	0.00	1
5/27	105.62	2.85	9.51	0.89	16	120.64	7.75	13.54	2.40	12					
5/28	112.29	7.20	11.56	2.53	7	124.19	5.02	15.60	1.64	21					
5/29	106.29	5.68	9.43	1.65	14	122.69	5.69	14.75	2.24	16					
5/30	107.92	7.05	9.78	1.46	13	118.69	4.22	12.91	1.81	16					
5/31	101.50	5.60	10.13	1.60	10	121.50	5.07	17.16	1.22	18	124	0.00	17.9	0.00	1
6/1	100.93	4.83	8.07	1.15	15	110.93	6.53	10.85	1.53	14	129	0.00	17.4	0.00	1
6/2	102.18	5.23	8.23	1.56	22	116.50	10.78	12.64	3.79	8					
6/3	106.95	4.09	10.00	1.32	19	112.36	9.05	12.01	3.25	11					
6/4	103.80	6.26	8.92	1.42	5	110.00	5.66	10.30	1.66	2					
6/5	105.41	3.37	9.45	1.07	17	111.00	0.00	11.30	0.00	1					
6/6	110.50	2.38	10.77	0.73	4										
Seasonal Mean	104.47		9.13			121.49		14.64			128.3		19.1		

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Appendix Table 1. Comparative age, length (mm), and weight (g) of sockeye salmon smolt from the Egegik River.

Year of Seaward Migration	Sample Dates	AGE I n	AGE I Mean Length	AGE I Mean Weight	AGE II n	AGE II Mean Length	AGE II Mean Weight	AGE III n	AGE III Mean Length	AGE III Mean Weight
1939 [1]	-	-	96.4	-	-	105.0	-	-	-	-
1956 [1]	-	14	101.0	-	249	116.0	-	123	123.0	-
1957 [1]	-	17	106.5	-	202	119.6	-	17	130.0	-
1959 [1]	-	80	99.0	-	190	116.0	-	11	123.0	-
1960 [1]	-	27	106.0	-	130	115.0	-	2	140.0	-
1969 [1]	-	21	99.0	-	44	119.0	-	2	115.0	-
1977 [2]	27-29 May	11	110.0	11.31	288	115.5	13.25			
1978 [3]	19-22 May	42	103.6	10.10	264	122.0	15.40	13	130.1	18.60
1981	15 May-6 June	203	104.5	9.13	343	121.5	14.64	3	128.3	19.10

[1] Paulus, 1972

[2] From interoffice memo dated 2 May 1978 from John H. Clark
Alaska Department of Fish and Game, Commercial Fisheries, Anchorage, Alaska

[3] Huttunen, 1980

1981 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Annual sockeye salmon *(Oncorhynchus nerka)* smolt migrations out of the Wood River Lakes system range between 20 and 100 million fish over about a 90-day period (approximately 1 June - 30 August) each summer. Reliable estimates of the number of smolts leaving the system are required for forecasting future adult returns and studying optimum escapement to the spawning grounds.

A program to enumerate smolt by sonar was initiated in 1975 because various index programs operated prior to that time proved to be of limited value in forecasting future runs. The sonar project has continued through 1981 with the major objectives being: (1) estimating numbers of outmigrating smolt, and (2) determining the qualitative aspects of the smolt run (age composition, mean length, weight, and incidence of the parasite *(Triaenophorus crassus)*.

METHODS AND MATERIALS

Sonar Arrays

The same four transducer arrays and electronic control unit used since 1976 (Krasnowski 1976, 1977) were used again in 1981. The system consists of 40 transducers mounted in four ladder-like arrays, each monitored separately on the river bottom. The 10 transducer cables from each array are taped together and the entire bundle is secured to the river bank with a safety line. The four cable bundles are connected to the electronic counting unit which is powered by a 12-volt battery. The counter is kept in a wall tent where technicians control and monitor the system. Placement of the gear has been in the same location in the river each year since 1975.

Installation and operation of the gear was similar to methods used in 1979 and 1980 (Bucher 1980, 1981). The arrays were positioned in the river so that distances from the north bank of Arrays I, II, III, and IV were: 20.7, 34.4, 53.9, and 72.5 m, respectively.

The arrays were installed in the river on 30 May and the counter was operated from 2100 until 0300 hours that night. The daily random counting schedule was begun on 1 June and continued through 0600 hours on 14 August. The sampling design and sonar data collection procedures were consistent

with those used in 1980 (Bucher 1981). The sonar gear was operated 75 hours (25 randomly selected 3-hour blocks) per 5-day sample period. Array I was designated as the index array and operated during all sampling hours. The other three arrays were operated in a random sequence of 15-minute intervals within each hour, and these 15-minute counts were expanded to yield hourly counts for each array.

Adjustment of Sonar Counts

Wood River is affected by tidal fluctuations throughout its entire length. As a result the river velocity fluctuates continually with the flood and ebb of the tide. Because counts registered on the sonar are a function of river velocity, compensation must be made for the tidal fluctuations. To compensate for changes in river velocity, a flowmeter was permanently installed in the river channel behind Array I. The flowmeter, equipped with a remote digital readout, allowed technicians to simultaneously monitor river velocity while operating the sonar counter. As changes in river velocity occurred, the technician changed the velocity setting on the counter. This technique eliminated the need to estimate velocities and correct the sonar counts after the season.

It was still necessary to determine the ratio of the river velocity behind each array to the velocity behind Array I. This array ratio factor (ARF) was derived by measuring river velocity behind Array II, III, and IV at a time not influenced by tides on or near the third day of each sample period. The actual ARF, computed once each sampling period, was the ratio of velocities behind a given array to the average velocity behind Array I, which was continuously measured by the flowmeter. Sonar counts for Arrays II, III, and IV were adjusted by the ARF to account for differences in velocity across the river.

During periods when the flowmeter was not properly functioning, the sonar counter was operated at one velocity setting. Periods of tidal influence were taken into account by applying velocity factors to the raw sonar counts to yield corrected counts (Bucher 1980). Appendix Table 1 provides a summary of velocity data used to adjust the counts throughout the season.

After the sonar counts were adjusted for the actual river velocity, they were expanded for the entire width of the river by expansion factors which were assigned to each array. The expansion factors were a function of distance between the individual arrays. These factors were as follows: Array I - 5.39, Array II - 4.96, Array III - 5.69, and Array IV - 5.66.

Because the sonar system was not monitored 24 hours per day, counts were estimated by linear interpolation for those time periods not sampled. After interpolation, counts were summed to yield a daily total expanded count. Since the sonar system is a biomass counter designed to register one count for the biomass equivalent of five smolt, the daily total expanded count was multiplied by five to estimate the actual daily smolt count.

Age-Weight-Length Sampling

Smolt samples were collected for age-weight-length analysis during each 5-day

sampling period. Samples were obtained by fyke net, which is the preferred method for collecting samples in the Wood River (Bucher 1980). Sampling goals were set at 300 smolt per 5-day period or 60 fish per day. A fork length measurement and scale samples were taken from each smolt. Weights were measured from at least 12 smolt per day and all smolt were externally examined for presence of the parasite *Triaenophorus crassus*.

RESULTS

Climatological and Hydrological Observations

Daily water temperatures and lake level measurements recorded at the sonar site during the smolt outmigration are presented in Table 1. Maximum and minimum seasonal water temperatures were 17.5°C (4 August) and 5.4°C (28 May), respectively. Mean lake depth recorded at the ADF&G camp was 0.545 m. A comparison of water temperatures and mean lake depth measurements for the years 1975-1981 is presented in Appendix Table 2.

Outmigration Estimates

The sonar counter was operated for 15 five-day periods for a total of 75 days. The daily raw and expanded sonar counts for 1981 can be found in Appendix Table 3. A total of 3,665,563 raw counts was enumerated. Of this total, 39% were recorded by Array I, 25% by Array II, 25% by Array III, and 11% by Array IV. This seasonal distribution of smolt across the river is shown relative to the past 6 years in Appendix Table 4. Expansion of the raw counts yielded an estimated total outmigration of 97,527,446 smolt. Table 2 lists the estimated smolt outmigration by age class and sample period. The estimated daily total outmigration is illustrated in Figure 1.

Age-Weight-Length

A total of 4,624 smolt was measured to determine mean length and age. Age composition estimates and mean lengths by sample period derived from fyke net sampling are given in Table 3. Seasonal mean lengths of Age I and Age II smolt were 88.0 mm and 96.3 mm, respectively. Age I smolt comprised 66% of the outmigration; Age II smolt comprised 34%, the majority of which emigrated during June and early July. A comparison of the mean length of smolt by year and age class for the years 1951-1981 is presented in Table 4. Mean weights for the 1981 season are also given by sample period in Table 3. Mean weight of Age I smolt was 6.3 g while that of Age II smolt was 8.4 g. Mean weight data by age class are available since 1977 and are presented in Appendix Table 5. Age composition and mean length and weight of the total outmigration was weighted by the outmigration estimate for each sample period.

Table 5 lists the estimated percentage of sockeye smolt infected by the cestode *Triaenophorus crassus*. Overall, 28.2% of the Age I smolt and 35.6% of the Age II smolt were estimated to be infected by the parasite.

Table 1. Water temperatures and lake depths recorded at ADF&G cabin, Wood River, 1981.

Date	Water Temp. (°C)	Lake Depth (m)	Date	Water Temp. (°C)	Lake Depth (m)
5/27	6.0	1.073	7/ 6	13.5	0.457
5/28	5.4	1.073	7/ 7	13.0	0.445
5/29	5.5	1.073	7/ 8	14.5	0.387
5/30	6.0	1.099	7/ 9	13.0	0.368
5/31	6.0	1.118	7/10	12.5	0.337
6/ 1	6.3	1.143	7/11	13.0	0.305[1]
6/ 2	6.5	1.156	7/12	12.0	0.279
6/ 3	6.5	1.168	7/13	10.0	0.254
6/ 4	7.0	1.181	7/14	9.5	0.254
6/ 5	7.0	1.187	7/15	11.0	0.248
6/ 6	7.5	1.187	7/16	13.5	0.241
6/ 7	7.5	1.187	7/17	12.0	0.229
6/ 8	7.5	-	7/18	11.0	0.229
6/ 9	6.5	1.207	7/19	11.5	0.216
6/10	8.0	1.143	7/20	14.0	0.216
6/11	6.5	1.124	7/21	13.5	0.203
6/12	7.0	1.079	7/22	13.5	0.178
6/13	8.0	1.067	7/23	14.0	0.159
6/14	8.5	1.033	7/24	13.5	0.178
6/15	8.5	0.978	7/25	13.0	0.178
6/16	9.0	0.946	7/26	12.0	0.159
6/17	9.5	0.946	7/27	13.0	0.152
6/18	11.5	0.902	7/28	14.0	0.152
6/19	11.5	0.870	7/29	13.5	0.146
6/20	13.0	0.838	7/30	14.0	0.140
6/21	12.5	0.806	7/31	13.0	0.127
6/22	12.7	0.762	8/ 1	14.0	0.146
6/23	13.0	0.762	8/ 2	15.5	0.127
6/24	13.0	0.749	8/ 3	14.5	0.127
6/25	12.7	0.686	8/ 4	17.5	0.121
6/26	11.8	0.654	8/ 5	15.0	0.121
6/27	11.5	0.635	8/ 6	15.0	0.057
6/28	14.0	0.597	8/ 7	15.5	0.034
6/29	12.5	0.546	8/ 8	13.5	0.044
6/30	14.0	0.546	8/ 9	13.0	0.038
7/ 1	13.0	0.546	8/10	12.5	0.064
7/ 2	12.0	0.521	8/11	12.0	0.089
7/ 3	14.0	0.502	8/12	14.0	0.114
7/ 4	14.5	0.489	8/13	11.0	0.121
7/ 5	15.0	0.483			
Mean	11.4	0.545			

[1] Below gauge used during prior years.

Table 2. Estimated smolt outmigration, by age class and sample period, Wood River, 1981.

Sample Period	Age I			Age II			Total
	n	No.	%	n	No.	%	
5/28-6/ 3	362	5,106,697	77.7	104	1,465,628	22.3	6,572,325
6/ 4-6/ 8	205	5,402,516	70.7	85	2,238,950	29.3	7,641,466
6/ 9-6/13	142	2,472,807	45.8	168	2,926,335	54.2	5,399,142
6/14-6/18	211	5,500,893	70.6	88	2,290,740	29.4	7,791,633
6/19-6/23	96	1,554,806	32.0	204	3,303,964	68.0	4,858,770
6/24-6/28	53	1,580,593	17.7	247	7,349,312	82.3	8,929,905
6/29-7/ 3	96	3,403,441	32.0	204	7,232,313	68.0	10,635,754
7/ 4-7/ 8	225	7,694,481	75.3	74	2,523,953	24.7	10,218,434
7/ 9-7/13	256	3,931,082	86.8	39	597,814	13.2	4,528,896
7/14-7/18	236	5,423,052	84.0	45	1,032,962	16.0	6,456,014
7/19-7/23	282	3,575,171	87.3	41	520,099	12.7	4,095,270
7/24-7/28	223	4,784,608	84.5	41	877,650	15.5	5,662,258
7/29-8/ 2	287	4,976,608	94.4	17	295,223	5.6	5,271,831
8/ 3-8/ 7	278	5,346,559	93.6	19	365,577	6.4	5,712,136
8/ 8-8/13	282	3,577,193	95.3	14	176,420	4.7	3,753,613
Total[1]	3,234	64,330,507	66.1	1,390	33,196,940	33.9	97,527,446

[1] Age composition of the total outmigration weighted by outmigration estimate for each sample period.

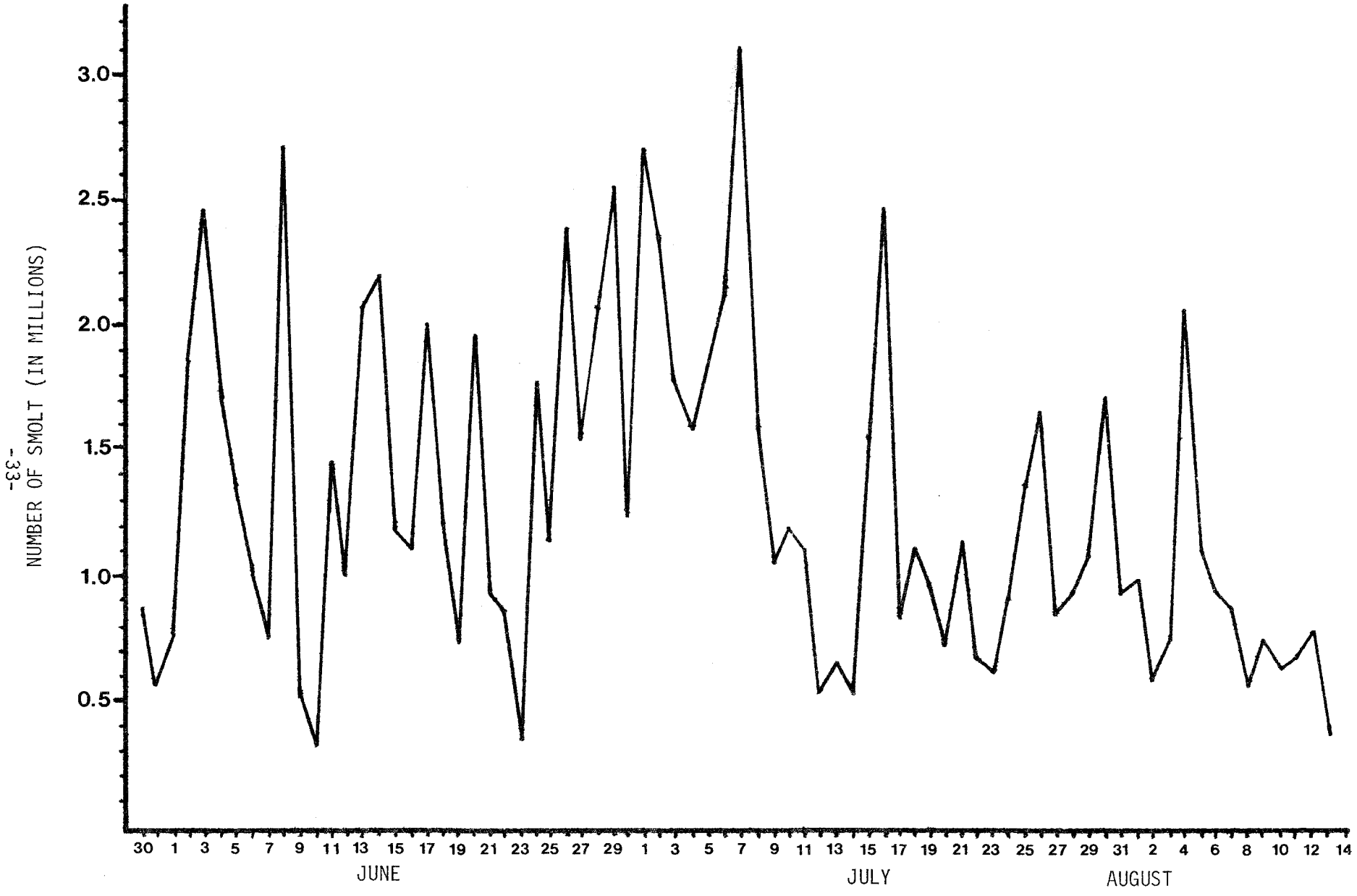

Figure 1. Estimated daily total outmigration of sockeye salmon smolt, Wood River 1981.

Table 3. Mean length (mm), mean weight (g), variance (s^2), and sample size (n) for sockeye salmon smolt by age class and sample period, Wood River, 1981.

		AGE I						AGE II					
	Sample Period	Mean Length	s^2	n	Mean Weight	s^2	n	Mean Length	s^2	n	Mean Weight	s^2	n
1	5/28-6/ 3	80.0	22.1	362	4.0	0.9	44	91.5	58.5	104	7.4	2.4	16
2	6/ 4-6/ 8	78.0	25.9	205	3.9	0.8	36	91.9	56.7	85	7.2	2.0	16
3	6/ 9-6/13	80.8	31.4	142	4.4	1.0	31	97.1	67.5	168	8.2	2.4	29
4	6/14-6/18	79.2	24.7	211	4.5	0.9	41	91.7	76.9	88	6.6	2.1	19
5	6/19-6/23	82.2	33.7	96	4.3	0.2	14	99.9	85.0	204	9.2	9.4	46
6	6/24-6/28	89.2	42.8	53	6.6	2.8	10	100.3	74.2	247	9.7	5.8	50
7	6/29-7/ 3	89.8	16.8	96	6.8	1.5	19	96.5	46.6	204	8.3	2.8	40
8	7/ 4-7/ 8	87.9	21.3	225	6.4	1.3	41	90.8	40.2	74	6.8	2.3	19
9	7/ 9-7/13	86.1	20.4	256	6.1	1.1	50	89.1	27.1	39	6.9	2.2	10
10	7/14-7/18	91.9	14.9	236	7.3	0.7	48	94.6	23.2	45	7.8	1.0	12
11	7/19-7/23	90.7	15.9	282	6.9	1.6	52	94.5	19.9	41	8.0	1.7	8
12	7/24-7/28	93.6	30.2	223	7.7	2.0	54	99.2	48.3	41	9.8	11.6	6
13	7/29-8/ 2	94.9	19.3	287	8.3	1.8	56	96.6	31.7	17	8.7	5.0	6
14	8/ 3-8/ 7	95.7	22.5	278	8.4	1.2	56	103.4	39.4	19	11.1	6.0	3
15	8/ 8-8/13	97.8	30.8	282	8.4	3.1	63	99.6	41.0	14	8.6	4.9	4
	5/28-8/13[1]	88.0		3,234	6.3		615	96.3		1,390	8.4		284

[1] Seasonal means were derived by weighting the mean for each sample period by the total outmigration estimate for that period (Table 2).

Table 4. Mean length of sockeye salmon smolt by year and age class, Wood River, 1951-1981 [1].

Year of Seaward Migration	Age I		Age II	
	Percent	Mean Length (mm)	Percent	Mean Length (mm)
1951	80.0	91	20.0	-
1952	99.0	87	1.0	-
1953	95.3	86	4.7	103
1954	95.8	87	4.2	107
1955	98.0	85	2.0	102
1956	78.4	82	21.6	95
1957	80.7	77	19.3	93
1958	65.0	82	35.0	102
1959	93.5	88	6.5	105
1960	99.4	88	0.6	114
1961	93.0	82	7.0	102
1962	86.0	80	14.0	98
1963	84.3	83	15.7	102
1964	98.8	84	1.2	104
1965	92.0	86	8.0	106
1966	94.3	77	5.7	101
1967-1974 [2]	-	-	-	-
1975	(86.0) [3]	83	(14.0) [3]	98
1976	95.5	84	4.5	95
1977	82.9	71	17.1	98
1978	84.7	79	15.3	90
1979	92.2	90	7.8	100
1980	96.0	78	4.0	95
1981	66.1	88	33.9	96
1951-81 Mean	88.6	83	11.4	100
1951-66 Mean	89.6	84	10.4	103
1975-81 Mean	86.2	82	13.8	96

[1] 1951-1974 Data Source: ADF&G Bristol Bay Annual Management Report, 1974. Age and length weighted by estimated outmigration for a given sample period based on a fyke net index program.

[2] Program not in operation or incomplete data.

[3] Percentage not weighted by estimated outmigration by period.

Table 5. Sample sizes and estimated infection by the cestode *Triaenophorus crassus* of Age I and Age II sockeye salmon smolt by sample period, Wood River, 1981.

Sample Period		AGE I		AGE II	
		n	% T.C.	n	% T.C.
1	5/28-6/ 3	362	37.3	104	70.2
2	6/ 4-6/ 8	205	41.0	85	62.4
3	6/ 9-6/13	142	34.5	168	46.4
4	6/14-6/18	211	32.7	88	35.3
5	6/19-6/23	96	33.3	204	28.4
6	6/24-6/28	53	13.2	247	30.0
7	6/29-7/ 3	96	28.1	204	25.5
8	7/ 4-7/ 8	225	28.9	74	36.5
9	7/ 9-7/13	256	37.9	39	48.7
10	7/14-7/18	236	28.4	45	35.6
11	7/19-7/23	282	22.3	41	41.5
12	7/24-7/28	223	30.5	41	29.3
13	7/29-8/ 2	287	14.6	17	17.7
14	8/ 3-8/ 7	278	13.7	19	21.1
15	8/ 8-8/13	282	19.9	14	35.7
	5/28-8/13[1]	3,234	28.2	1,390	35.6

[1] The overall percentage of smolt infected by the parasite *T. crassus* was derived by weighting the percentage of infection in each sample period by the total outmigration estimate for that period (Table 2). Infection was only determined by gross external observations.

DISCUSSION

Smolt Production

The 1981 Wood River smolt run was not average. The run began early with nearly a million smolt being enumerated the first day that the sonar gear was operated. A significant number may have outmigrated prior to that time. Individual smolts were healthy, robust fish with the Age I component averaging 88 mm in length, considerably longer than the 1975-1981 average of 82 mm (Table 4). The Age II smolt were not significantly longer than average, but certainly were more abundant, comprising nearly 34% of the outmigration.

The 1981 outmigration of 33.2 million Age II smolt was over 2.5 times the previous high (Table 6). Combined with the 1980 Age I outmigrants (46.3 million), a total of 9.5 million smolt were produced from an escapement of nearly 2.3 million sockeye into the Wood River system in 1978 (Table 7). While the total smolt outmigration from the 1978 escapement was the second largest recorded since the initiation of the sonar project, the estimated smolt production per spawner from that escapement was the lowest on record at 35.0.

Marine Survival

Survival of smolt outmigrating from Wood River was calculated completely for the 1973-1975 brood years, and partially for the 1976 and 1977 brood years. Table 8 shows the adult returns by brood year for Age I and Age II smolt that emigrated from the Wood River for the years that the sonar project has been in operation. Comparison of the percent survival of Age II smolt indicates a dramatic change between 1974 and 1975. The 6_3 adult return in 1981 was responsible for a large portion of the very high survival (12.52%) of Age II smolt from the 1975 brood year. This was a nearly three-fold increase from the 1974 survival rate of 3.74%. Survival of Age II smolt from the 1976 brood year was also high at 10.04%. Although not all Age II smolt from the 1976 brood year have returned, survival of one- and two-ocean sockeye has been extremely high.

Table 6. Summary of smolt outmigration by year and age class, Wood River, 1975-1981, in millions of smolt[1].

Year of Outmigration	Age I	Age II	Total
1975	27.95	5.90	33.85
1976	101.40	4.80	106.20
1977	60.75	12.55	73.30
1978	46.60	8.40	55.00
1979	60.84	5.13	65.97
1980	46.30	1.99	48.29
1981	64.33	33.20	97.53

[1] Totally expanded sonar counts, derived by expansion factor of (5) smolt per count.

Table 7. Summary of smolt outmigration by brood year escapements, by age class, in millions of smolt and smolt production per spawner, Wood River, 1972-1979.

Brood Year	Escapement	Age I	Age II	Total	Smolt Production Per Spawner
1972	0.43	-	5.90	-	-
1973	0.33	27.95	4.80	32.75	99.24
1974	1.71	101.40	12.55	113.95	66.64
1975	1.27	60.75	8.40	69.15	54.45
1976	0.82	46.60	5.13	51.73	63.09
1977	0.56	60.84	1.99	62.83	112.19
1978	2.27	46.30	33.20	79.50	35.02
1979	1.71	64.33	-	-	-

Table 8. Wood River sockeye salmon escapement, smolt production and adult returns (in millions of fish) and marine survival by brood year.

Brood Year	Escapement	Age I Smolt	2-freshwater Adult Return	Percent Survival	Age II Smolt	3-freshwater Adult Return	Percent Survival
1972[1]	0.43	-	1.352	-	5.90	.066	1.12
1973	0.33	27.95	1.342	4.80	4.80	.099	2.06
1974	1.71	101.40	4.514	4.45	12.55	.469	3.74
1975	1.27	60.75	3.486	5.74	8.40	1.052	12.52
1976	0.82	46.60	4.499	9.65	5.13	.515[2]	10.04[2]
1977	0.56	60.84	.966[3]	1.59[3]	1.99	-	-
1978	2.27	46.30	-	-	33.20	-	-
1979	1.71	64.33	-	-	-	-	-

[1] Incomplete data.

[2] 5_3 only.

[3] 3_2 and 4_2 only.

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Appendix Table 1. Standard velocity factors by sample period and array ratio factors by sample period and array, Wood River sonar site, Alaska, 1981.

Sample Period	Standard Velocity Factor (Index Array)	Array Ratio Factor		
	I	II	III	IV
1[1]	.78	.86	1.00	1.22
2	1.00	1.06	1.12	1.05
3	1.00	1.06	1.19	1.26
4	1.00	1.10	1.11	1.13
5	1.00	1.12	1.05	1.13
6	1.00	1.10	1.17	1.18
7	1.00	1.11	1.14	1.08
8	1.00	1.09	1.14	1.14
9	1.00	1.09	1.18	1.20
10[2]	.99	1.13	1.11	1.14
11	.96	1.13	1.17	1.16
12	1.27	1.30	1.30	1.19
13	1.09	1.24	1.35	1.31
14	1.32	1.36	1.48	1.31
15	1.12	1.27	1.36	1.39

[1] Array III was originally designated as the index array, but was changed to Array I on the 5th sample day of this period.

[2] A continuous river velocity reading taken at time of ARF measurements was used as the divisor from this period on.

Appendix Table 2. Mean water temperature and lake depth, Wood River sonar site, 1975-1981.

Year	Project Dates	Temperature (°C)			Depth (m)	
		Minimum	Maximum	Mean	Mean	Range
1975	5/29 - 7/19	2.0	9.5	5.0	0.368	.567 - (-) .238
1976	6/ 9 - 8/ 7	2.0	14.0	8.0	0.570	1.067 - .244
1977	6/ 9 - 8/ 8	4.5	15.5	9.0	1.521	-
1978	5/28 - 8/ 9	5.0	16.0	9.0	0.817	.976 - .366
1979	5/30 - 8/ 2	4.5	16.0	9.0	0.933	1.457 - .329
1980	5/30 - 8/15	4.5	18.0	9.0	1.067	1.646 - .335
1981	5/27 - 8/13	5.4	17.5	11.4	0.545	1.207 - .034

Appendix Table 3. Wood River sockeye salmon smolt outmigration estimate by day and array, 1981.

Mo.	Day	Daily Raw Counts Array 1	2	3	4	Daily Expanded Counts Array 1	2	3	4	Daily Expanded Total (Expanded Counts x 5)
5	30	14626	10097	5827	3025	78834	47353	33157	17119	882315
5	31	6146	5873	6597	3299	33127	27544	37537	18672	584403
6	1	13982	7973	4881	3166	75363	37393	27773	17920	792244
6	2	41912	12705	9049	5757	225906	59586	51489	32585	1847828
6	3	48842	19141	18234	6418	263258	89771	103751	36326	2465535
FIVE DAY TOTAL		125508	55789	44588	21665	676488	261649	253707	122621	6572325
UP TO DATE TOTAL		125508	55789	44588	21665	676488	261649	253707	122621	6572325
6	4	32165	12204	15262	4348	173369	57237	86841	24610	1710283
6	5	26184	13417	9364	3432	141132	62926	53281	19425	1383819
6	6	9735	9896	16972	3182	52472	46412	96571	18010	1067323
6	7	5570	6992	8477	7355	30022	32792	48234	41629	763391
6	8	27848	29540	39365	5424	150101	138543	223987	30700	2716650
FIVE DAY TOTAL		101502	72049	89440	23741	547096	337910	508914	134374	7641466
UP TO DATE TOTAL		227010	127838	134028	45406	1223584	599559	762620	256995	14213791
6	9	7362	4039	6162	1586	39681	18943	35062	8977	513313
6	10	4670	2582	3008	2688	25171	12110	17116	15214	348052
6	11	38708	8866	4203	2885	208635	41583	23913	16330	1452305
6	12	23950	7811	4715	1415	129093	36633	26830	8007	1002815
6	13	59218	11064	3548	4464	319186	51891	20190	25264	2082656
FIVE DAY TOTAL		133908	34362	21636	13037	721766	161160	123111	73792	5399142
UP TO DATE TOTAL		360918	162200	155665	58443	1945350	760718	885731	330787	19612933

-Continued-

Appendix Table 3. Wood River sockeye salmon smolt outmigration estimate by day and array, 1981 (continued).

Mo.	Day	Daily Raw Counts Array 1	2	3	4	Daily Expanded Counts Array 1	2	3	4	Daily Expanded Total (Expanded Counts x 5)
6	14	60140	13877	6400	2478	324154	65082	36419	14027	2198406
6	15	26128	12580	6153	1295	140832	59000	35010	7331	1210867
6	16	28513	7789	4607	1562	153686	36533	26214	8838	1126355
6	17	55695	8532	8089	3853	300196	40017	46024	21805	2040211
6	18	14895	12539	11800	6524	80286	58806	67139	36928	1215794
FIVE DAY TOTAL		185372	55317	37049	15712	999153	259437	210806	88929	7791633
UP TO DATE TOTAL		546290	217517	192713	74155	2944504	1020156	1096537	419716	27404566
6	19	12824	5598	5157	4769	69121	26255	29345	26995	758577
6	20	45554	11116	6525	10559	245538	52134	37129	59762	1972815
6	21	18933	8728	5405	1567	102050	40936	30753	8869	913040
6	22	10467	8666	8644	4241	56418	40642	49183	24006	851239
6	23	6198	2654	2723	1992	33405	12445	15495	11274	363100
FIVE DAY TOTAL		93976	36762	28454	23128	506532	172412	161905	130906	4858770
UP TO DATE TOTAL		640266	254279	221167	97283	3451035	1192568	1258442	550622	32263336
6	24	46854	11016	4478	4660	252546	51666	25478	26377	1780332
6	25	19299	14804	6831	2839	104019	69431	38867	16066	1141916
6	26	30413	30424	25351	4945	163928	142688	144246	27991	2394265
6	27	3898	11355	32895	8072	21012	53256	187175	45690	1535664
6	28	29880	21479	21225	5828	161053	100738	120771	32984	2077729
FIVE DAY TOTAL		130345	89079	90780	26344	702558	417779	516537	149107	8929905
UP TO DATE TOTAL		770611	343357	311947	123627	4153594	1610346	1774979	699730	41193241
6	29	77021	10450	4711	3427	415145	49010	26807	19394	2551782
6	30	23599	16296	6053	2121	127198	76430	34443	12004	1250376
7	1	72180	17539	8895	3265	389050	82260	50615	18479	2702018
7	2	56605	16864	12340	2678	305099	79094	70213	15160	2347833
7	3	33318	15594	13676	4632	179582	73136	77815	26216	1783744
FIVE DAY TOTAL		262722	76744	45675	16123	1416074	359930	259893	91254	10635754
UP TO DATE TOTAL		1033334	420102	357622	139750	5569668	1970277	2034872	790983	51828995

-Continued-

Appendix Table 3. Wood River sockeye salmon smolt outmigration estimate by day and array, 1981 (continued).

Mo.	Day	Daily Raw Counts Array 1	2	3	4	Daily Expanded Counts Array 1	2	3	4	Daily Expanded Total (Expanded Counts x 5)
7	4	31037	13590	10156	4920	167288	63735	57786	27845	1583270
7	5	23096	21179	17340	8512	124490	99329	98667	48176	1853309
7	6	17170	28833	25197	9595	92544	135227	143371	54309	2127252
7	7	49784	29592	25224	11508	268335	138786	143526	65135	3078911
7	8	16613	21855	12552	9129	89546	102498	71423	51671	1575692
FIVE DAY TOTAL		137700	115048	90470	43664	742202	539575	514774	247136	10218434
UP TO DATE TOTAL		1171033	535150	448092	183413	6311870	2509852	2549645	1038119	62047429
7	9	8224	10586	10616	9944	44329	49646	60406	56281	1053310
7	10	18364	12365	6471	8166	98982	57992	36820	46220	1200067
7	11	9292	11909	9690	10328	50084	55853	55136	58456	1097648
7	12	2593	3610	8085	5054	13976	16931	46004	28606	527582
7	13	2985	6757	5804	8702	16089	31690	33025	49253	650288
FIVE DAY TOTAL		41458	45227	40666	42194	223460	212113	231390	238816	4528896
UP TO DATE TOTAL		1212492	580376	488758	225607	6535330	2721964	2781035	1276935	66576325
7	14	4523	5920	5757	3865	24379	27765	32757	21876	533885
7	15	11644	17095	17816	10886	62761	80176	101373	61615	1529623
7	16	21080	37385	25500	10418	113621	175336	145095	58966	2465089
7	17	5536	8384	11678	5223	29839	39321	66448	29562	825850
7	18	4016	8522	15605	12351	21646	39968	88792	69907	1101568
FIVE DAY TOTAL		46799	77306	76356	42743	252247	362565	434466	241925	6456014
UP TO DATE TOTAL		1259291	657682	565114	268350	6787577	3084530	3215501	1518861	73032341
7	19	7489	7213	12856	7577	40366	33829	73151	42886	951156
7	20	4897	9440	9809	3045	26395	44274	55813	17235	718582
7	21	4582	7314	17525	11726	24697	34303	99717	66369	1125430
7	22	2474	5211	10559	6770	13335	24440	60081	38318	680867
7	23	5997	6786	8142	2362	32324	31826	46328	13369	619235
FIVE DAY TOTAL		25439	35964	58891	31480	137116	168671	335090	178177	4095270
UP TO DATE TOTAL		1284730	693646	624005	299830	6924693	3253201	3550591	1697038	77127611

-Continued-

Appendix Table 3. Wood River sockeye salmon smolt outmigration estimate by day and array, 1981 (continued).

Mo.	Day	Daily Raw Counts Array 1	2	3	4	Daily Expanded Counts Array 1	2	3	4	Daily Expanded Total (Expanded Counts x 5)
7	24	4509	8983	11194	8882	24304	42130	63694	50272	901999
7	25	6421	15969	17259	11147	34609	74895	98204	63092	1353998
7	26	10478	17430	25608	8010	56476	81747	145710	45337	1646346
7	27	7417	7799	11807	4506	39978	36577	67182	25504	846204
7	28	9330	10251	10090	4764	50289	48077	57412	26964	913711
FIVE DAY TOTAL		38155	60432	75958	37309	205655	283426	432201	211169	5662258
UP TO DATE TOTAL		1322885	754078	699963	337139	7130348	3536627	3982792	1908207	82789869
7	29	6399	8018	20606	4575	34491	37604	117248	25895	1076188
7	30	11560	22301	25334	5129	62308	104592	144150	29030	1700403
7	31	5859	7473	16545	4003	31580	35048	94141	22657	917132
8	1	7259	11431	14957	3490	39126	53611	85105	19753	987981
8	2	4111	6598	8371	3055	22158	30945	47631	17291	590126
FIVE DAY TOTAL		35188	55821	85813	20252	189663	261800	488276	114626	5271831
UP TO DATE TOTAL		1358073	809899	785776	357391	7320011	3798427	4471068	2022833	88061699
8	3	5310	9312	10899	3045	28621	43673	62015	17235	757721
8	4	21509	21231	26173	8066	115934	99573	148924	45654	2050424
8	5	11529	11457	9743	8449	62141	53733	55438	47821	1095668
8	6	9368	8631	11449	5459	50494	40479	65145	30898	935078
8	7	5392	7978	15122	3909	29063	37417	86044	22125	873244
FIVE DAY TOTAL		53108	58609	73386	28928	286252	274876	417566	163732	5712136
UP TO DATE TOTAL		1411181	868508	859162	386319	7606264	4073303	4888634	2186565	93773834
8	8	3401	5728	8624	2926	18331	26864	49071	16561	554137
8	9	5208	6166	11259	4513	28071	28919	64064	25544	732985
8	10	3965	6433	10055	2532	21371	30171	57213	14331	615431
8	11	4026	8296	8496	4718	21700	38908	48342	26704	678272
8	12	4727	8926	11308	4724	25479	41863	64343	26738	792109
FIVE DAY TOTAL		21327	35549	49742	19413	114953	166725	283032	109878	3372935
UP TO DATE TOTAL		1432508	904057	908904	405732	7721216	4240028	5171666	2296443	97146768
8	13	3700	4418	4372	1872	19943	20720	24877	10596	380678
FIVE DAY TOTAL		3700	4418	4372	1872	19943	20720	24877	10596	380678
UP TO DATE TOTAL		1436208	908475	913276	407604	7741159	4260749	5196543	2307038	97527446

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Appendix Table 4. Smolt distribution from raw sonar counts, by array and year, Wood River, 1975-1981.

Year	Percentage of Total Counts			
	Array I	Array II	Array III	Array IV
1975 [1]	68.6	31.4	-	-
1976	49.0	30.2	11.7	9.1
1977	36.0	24.4	20.8	18.8
1978	28.6	29.7	25.6	16.1
1979	17.0	27.1	33.1	22.8
1980	34.1	35.2	20.5	10.2
1981	39.2	24.8	24.9	11.1

[1] Only two arrays were used in 1975.

Appendix Table 5. Mean weight and sample size of Wood River smolt by age group, 1977-1981.

	Age I		Age II	
	Mean Wt. (g)	n	Mean wt. (g)	n
1977	3.5	2811	9.3	373
1978[1]	-	-	-	-
1979	7.6	953	10.1	121
1980	4.0	844	6.8	55
1981	6.3	615	8.4	284
Mean	5.4		8.7	

[1] No data

1981 SNAKE RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Lake Nunavaugaluk was chosen as the site for a sockeye salmon *(Oncorhynchus nerka)* fry production facility to supplement severely depressed natural production. Preliminary studies on the lake were initiated in 1974 to estimate the number of sockeye salmon juveniles that the lake was capable of supporting. While these studies identified the location and extent of important shallow water rearing areas, no estimate was made of how many fry the lake could support (Jaenicke, Mattson, and Hoffman 1978). The number and age of sockeye salmon smolts migrating from the lake was determined to evaluate freshwater survival and production of sockeye salmon juveniles. Unfortunately, estimates of the total number of smolts leaving the lake were not considered to be reliable since fyke net sampling could not be initiated until after the lake was ice-free. It was hypothesized that 50% of the total migration had occurred prior to this time (Thomason and Jaenicke 1979).

From 1979 until present, Fisheries Rehabilitation, Enhancement, and Development Division (F.R.E.D.) of the Alaska Department of Fish and Game has been continuing the efforts to provide accurate estimates of smolt migrating from Lake Nunavaugaluk. During 1981 specific objectives of F.R.E.D. Division field studies were: (1) to determine whether large numbers of smolt leave the lake prior to or during ice breakup, (2) to sample smolt migration to obtain information on total number leaving lake after ice breakup, (3) to estimate age and size composition of smolt leaving the lake, and (4) to develop and improve techniques for enumerating total smolt migration.

METHODS AND MATERIALS

Study Area

During ice breakup in 1981 smolt sampling was conducted at two sites near the outlet of Lake Nunavaugaluk. Outlet width was about 1000 m and water depth ranged from 1.4 m to 3.6 m. After ice breakup smolt sampling was conducted within Snake River, about 100 m below the outlet. River characteristics measured in 1981 were as follows: river width was approximately 47.5 m, depth ranged from 0.3 - 0.9 m, and current speed varied from 0.8 - 1.3 mps. This site was the same used in all previous Lake Nunavaugaluk smolt studies (Fried and Laner 1980; Thomason and Jaenicke 1979).

Outmigration Estimate

Before and during ice breakup smolt were captured using sinking variable square mesh (3.8, 3.2, 2.5, 1.9, and 1.3 cm) gill nets. Two gill nets were fished continuously from 2000 hours 27 April until 1930 hours 10 May. Sampling was discontinued between 11 May and 12 May because of heavy ice passage.

Outmigration estimation was conducted from 16 May until 25 June using three Incline Plane Traps (IPT). Traps were modified versions of those used by the Department of Fisheries of Canada (Todd 1966). The IPT's were 3.05 m in length with a mouth opening of 0.6 x 0.9 m. Each IPT was fished continuously at an assigned sampling site: one in mid-river and one near each bank. The IPT's were held in place by a cable stretched across the river.

Outmigration estimates were determined through mark and recapture techniques. Smolt to be marked were placed in a solution of Bismarck Brown Y and water (1.25 g/37.8 liters) for 45 minutes. Dyed smolt were then transferred to live boxes and released upstream of the sampling sites. Catches made between 16 May and 25 June were used to estimate actual number of migrating smolt. Catches made before 16 May were used as migration indices.

A sampling day consisted of a 24-hour period (2300-2259 hours). Upon completion of each IPT sampling period, all smolt were removed from the live boxes, transported to shore, counted (marked and unmarked), and placed in a holding pen.

Total smolt migration from 16 May until 25 June was estimated using the following formula:

$$N = n\,(D/d)\;\;[1 + D\text{-}d/Dd], \text{ where}$$

N = estimated total number of smolt leaving lake during sampling season,

D = number of dyed smolt released,

d = number of dyed fish recaptured,

n = number of fish caught in traps during period of interest.

The variance estimate about the outmigration estimate is adapted from Cochran (1978) and presented by Rawson (1981) as follows:

$$\text{var}\,(N) = n\,(n+d)\;D\;\;(D-d)/d^3$$

$$\text{s.d.}\;\;(N) = \sqrt{\text{var}\,(N)} \;\;= s$$

$$95\%\ CI = N - 1.96s,\ N + 1.96s$$

Age-Weight-Length

Toward the end of each sampling day a random sample of 20 smolt was taken from a holding pen, anesthetized with tricaine methanesulfonate (MS-222), measured for fork length, weighed (after blotting dry), and a scale smear taken. On days when the total catch was less than 20 smolt, all smolt in the pen were sampled. All smolt were returned to Snake River below the IPT fishing site prior to the start of each new sampling day.

Smolt scales were mounted on glass microscope slides in the field and later viewed under a microfiche reader. Scale patterns were interpreted using criteria developed by Thomason (1979) for Snake River sockeye salmon smolt. To estimate age composition, mean length, and mean weight for the total smolt migration, the sampling season was divided into eight periods of 5 days duration. Age composition by period was estimated from scale samples. These values were then multiplied by the total smolt migration estimates for corresponding periods to obtain the estimated number of each age class present by period. A seasonal total for each age class was obtained by adding all period totals. Mean length and weight for each age class by period were calculated in a similar manner, and weighted by period totals to provide a seasonal mean.

Coded Wire Tagging

Sockeye smolt were coded wire tagged (CWT) from 14 May until 5 June. Two 1.2 x 1.2 m fyke nets with attached live boxes were used to capture smolt for tagging. At the end of each sampling day fish were transported to shore from the live boxes and placed in holding pens. The following day the smolt were anesthetized with MS-222, adipose fin clipped and tagged with a full length CWT. Upon completion of each day's tagging all but 100+ fish were released downstream of the sampling site. The 100+ fish were retained for a 24-hour period, then anesthetized and passed through a quality control device to determine percent tag retention.

RESULTS

Climatological Observations

Daily water temperatures recorded from Snake River near the outlet of Lake Nunavaugaluk are presented in Table 1. Maximum and minimum seasonal water temperatures were 12.2°C and 3.5°C, respectively, with a seasonal mean of 7.2°C. All temperatures were recorded between 2400 and 0100 hours.

Outmigration Estimates

Fifty-nine Arctic char were captured in index gill nets during the period of 27 April - 10 May. Stomach analysis revealed a mean of 0.15 smolt per char stomach. No sockeye smolts were captured during the period of 27 April - 9 May. On 10 May three sockeye smolt were captured.

Small catches of smolt and the low mean number of smolt per char stomach suggests that only small numbers of smolt left the lake before 11 May. Due

Table 1. Surface water temperatures recorded from Snake River, near Lake Nunavaugaluk outlet, during Incline Plane Trap sampling for sockeye salmon smolts in 1981.

Date	Temp. (C)	Date	Temp. (C)
May 11	5.0	June 3	7.5
12	3.5	4	8.5
13	3.5	5	7.5
14	5.0	6	7.5
15	4.4	7	8.0
16	5.0	8	8.5
17	5.4	9	9.0
18	5.0	10	9.5
19	4.5	11	10.0
20	5.0	12	10.0
21	4.5	13	9.5
22	4.5	14	9.5
23	4.5	15	10.0
24	4.5	16	10.0
25	5.0	17	10.5
26	7.0	18	10.5
27	6.0	19	11.0
28	5.5	20	11.8
29	6.5	21	10.8
30	7.0	22	11.5
31	7.0	23	12.2
June 1	7.5	24	12.0
2	7.5	25	12.0
		MEAN	7.2

to heavy ice flows, no index sampling occurred during 12-13 May. Index fyke net sampling was initiated during the period of 14-15 May. Smolt age structure for 14-15 May were 88% Age I and 12% Age II.

IPT sampling to estimate total sockeye smolt outmigration began at 2300 hours 16 May and continued until 2300 hours 25 June. Releases of dyed fish occurred on 20 May and 26 May with 961 and 820 smolt released, respectively. Total number of marked fish recaptured was 23. An estimated 923,628 (95% CI: 526,535; 1,281,009) sockeye salmon smolt migrated seaward during this time period (Table 2). Peak migration occurred on 25 May and represented 11% of the total catch (Table 3). Approximately 85% of the total catch occurred between 16 May and 30 May (Figure 1). Water temperature during the peak of smolt migration ranged from 4.4°C to 7.0°C with a mean of 5.3°C.

Age-Weight-Length

A total of 756 smolt was sampled to determine mean weight, length, and age composition. Ninety-nine percent of the total estimated migration consisted of Age I smolt (Table 2). Peak migrations of both Age I and Age II smolt occurred between 21 May and 25 May.

Mean lengths were 103.6 mm for Age I smolt and 132.4 mm for Age II smolt. Mean weights of Age I and Age II smolt were 9.7 g and 20.3 g, respectively (Table 4). These compare to an 8-year mean of 95.5 mm and 7.8 g for Age I smolt, and 118.2 mm and 12.8 g for Age II smolt. Annual mean lengths and weights by age class from 1973 through 1981 are presented in Table 5.

Coded Wire Tagging

A total of 44,031 sockeye salmon smolt was tagged and released at Snake River. Daily tagging mortality rate ranged from 1-31% with a mean of 10.4%. Total tagging mortality accounted for 4,557 dead smolt. Mean tag retention was 94.2% (range: 88-100%).

DISCUSSION

Seasonal and diel timing of the sockeye salmon smolt migration from Lake Nunavaugaluk during 1981 was similar to patterns reported for this system in past years (Thomason and Jaenicke 1979). However, it did not appear that large numbers of smolt migrated prior to lake ice breakup or while ice was still drifting down Snake River, as was postulated by Thomason and Jaenicke (1979). Smolt leave the lake as soon as the south end is ice-free. Once migration begins it is rapid and of short duration, a typical pattern for smolt migration in single lake systems. This makes it imperative to have personnel available to remain on site during lake ice breakup so that sampling can begin as soon as conditions allow.

A summary of outmigrations by age class for 1979-1981 is given in Table 6. The 1981 smolt production per spawning adult was 105.9 Age I smolt and 1.7 Age II smolt (escapements of 8,439 in 1979 and 18,074 adults in 1978). These

Table 2. Sockeye salmon smolt migration estimates by age class grouped by sample periods from Snake River, 1981.

Date	Number Age I	Number Age II	Total number	Sample size	Percent Age I	Percent Age II
5/16-20	232,769	12,251	245,020	100	95	5
5/21-25	338,336	17,807	356,143	80	95	5
5/26-30	187,116	-	187,116	100	100	0
5/31-6/4	62,426	-	62,426	100	100	0
6/5-9	16,232	-	16,232	100	100	0
6/10-15	24,550	-	24,550	115	100	0
6/16-20	24,954	-	24,954	100	100	0
6/21-25	7,187	-	7,187	61	100	0
Totals	893,570	30,058	923,628	756	98.8	1.2

Table 3. Incline plane trap catches of sockeye salmon smolts, Snake River, 1981.

DATE	TRAP 1	TRAP 2	TRAP 3	TOTAL
May 16	76	110	730	916
17	104	436	228	768
18	8	6	2	16
19	279	386	192	857
20	139	135	63	337
TOTALS	606	1073	1215	2894
May 21	261	419	435	1115
22	125	200	334	659
23	24	60	230	314
24	178	154	753	1085
25	255	220	762	1237
TOTALS	843	1053	2514	4410
May 26	373	167	209	749
27	70	88	68	226
28	183	262	142	587
29	125	198	143	466
30	92	89	108	289
TOTALS	843	804	670	2317
May 31	63	60	55	178
June 1	67	36	29	132
2	89	74	73	236
3	42	45	43	130
4	25	37	35	97
TOTALS	286	252	235	773

-Continued-

Table 3. Incline plane trap catches of sockeye salmon smolts, Snake River, 1981 (continued).

DATE	TRAP 1	TRAP 2	TRAP 3	TOTAL
June 5	12	16	32	60
6	5	0	4	9
7	7	5	29	41
8	16	17	41	74
9	1	3	11	15
TOTALS	41	41	117	199
June 10	11	13	14	38
11	37	38	25	100
12	40	49	9	98
13	27	7	7	41
14*	--	--	--	--
15	22	0	5	27
TOTALS	137	107	60	304
June 16	11	0	4	15
17	48	30	56	134
18	15	5	11	31
19	30	23	10	63
20	32	8	26	66
TOTALS	136	66	107	309
June 21	14	3	4	21
22	5	4	3	12
23	6	6	4	16
24	7	3	3	13
25	19	7	1	27
TOTALS	51	23	15	89
GRAND TOTALS	2943	3419	4933	11295

* Traps not fished

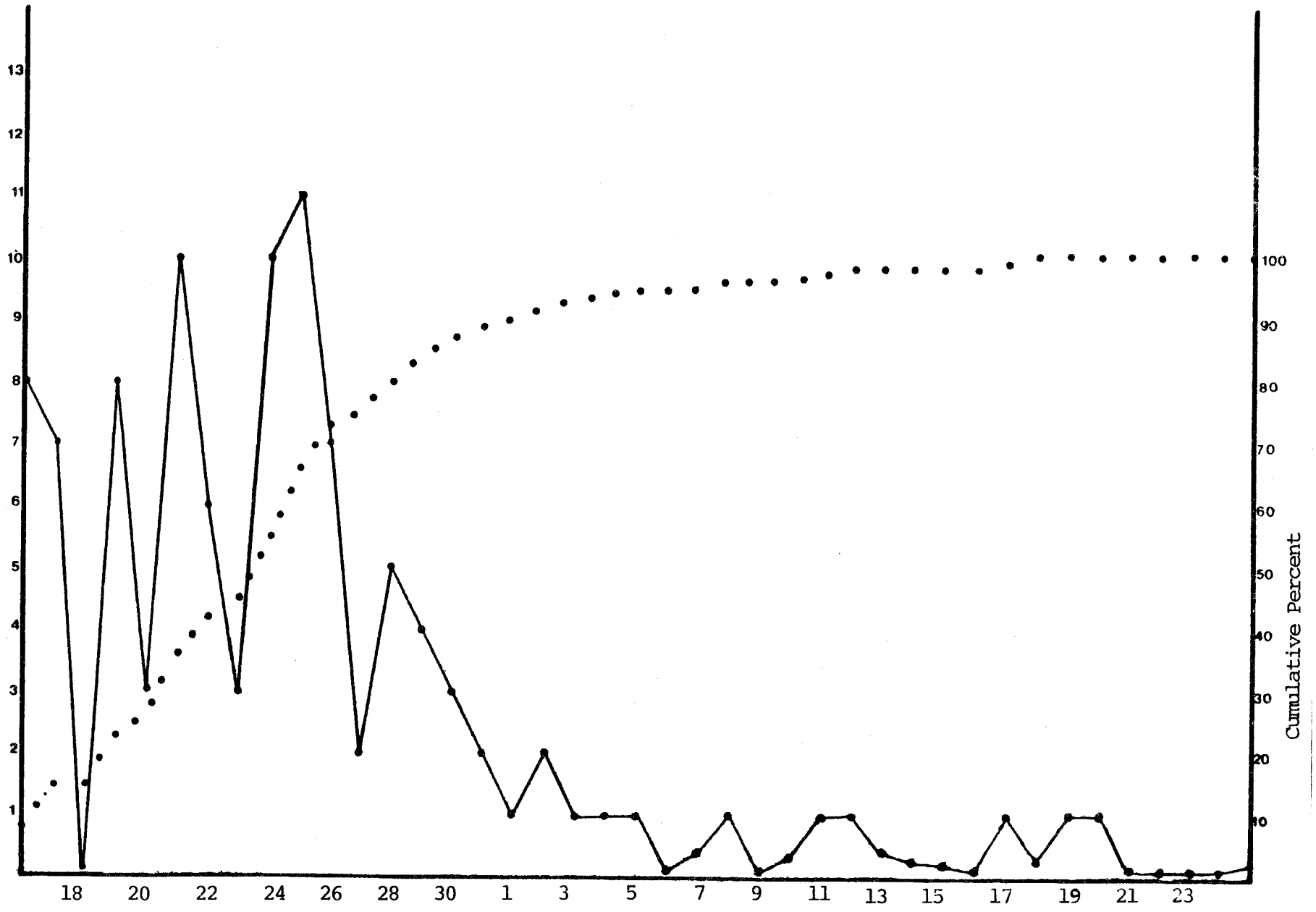

Figure 1. Daily and cumulative percent of total sockeye salmon migrating from Lake Nunavaugaluk between 16 May and 25 June 1981.

Table 4. Mean length, mean weight, standard deviation, variance and sample size for sockeye salmon smolts grouped by 5-day sample period and age class from Snake River, 1981.

DATE	MEAN LENGTH (mm)	s	s^2	MEAN WEIGHT (g)	s	s^2	n
AGE I							
5/16-20	106.23	5.95	35.02	10.43	1.88	3.38	95
5/21-25	105.45	10.27	24.19	10.17	1.51	2.26	76
5/26-30	102.33	6.19	37.90	9.18	1.69	2.82	100
5/31-6/4	97.45	7.03	48.87	8.03	1.75	3.04	100
6/5-9	95.88	7.09	49.85	7.58	1.63	2.62	100
6/10-15	95.04	6.61	43.26	7.46	1.63	2.64	115
6/16-20	94.10	6.12	37.09	7.44	1.45	2.08	100
6/21-25	95.51	3.53	12.25	7.92	.78	.60	61
Mean[1]	103.58			9.67			
AGE II							
5/16-20	134.6	2.70	5.84	20.96	1.14	1.04	5
5/21-25	130.8	3.59	9.69	19.90	.99	.73	4
Mean[1]	132.35			20.33			
Annual Mean	104.51			10.02			

[1] Weighted by estimated number of Age I and Age II smolts migrating during each sampling period.

Table 5. Mean lengths and weights of sockeye salmon smolt from Snake River, 1973-1981[1].

Year	AGE I		AGE II	
	Fork length (mm)	Weight (g)	Fork length (mm)	Weight (g)
1973	92	6.7	122	11.8
1974	92	7.3	-	-
1975	94	8.0	105	10.1
1976	91	6.3	-	-
1977	96	8.0	-	-
1978	93	6.8	104	9.4
1979	101	9.0	131	14.5
1980	105	10.1	129	18.0
1981	104	9.7	132	20.3

[1] Data for 1973-1980 from Fried and Laner (1981).

Table 6. Summary of smolt outmigration by year and age class in Snake River, 1979-1981.

Year of outmigration	Age I	Age II	Total
1979	1,182,977	97,594	1,280,571
1980	1,948,593	23,509	1,972,102
1981	893,570	30,058	923,628

figures represent a minimum smolt production of 109 smolt per spawner from the 1978 brood year escapement of 18,074 fish (Table 7). This indicates a freshwater survival of 7% (based on a potential egg deposition of 27,743,500, i.e., 9,037 female spawners of which 86% were 2-ocean and 14% were 3-ocean).

Lake Nunavaugaluk sockeye salmon smolts appear to be the largest produced by any system within Nushagak Bay (Thomason and Jaenicke 1979). Large smolt size, predominance of Age I smolts, and high smolt production all indicate that conditions with Lake Nunavaugaluk have been favorable for rearing juveniles resulting from adult escapements of about 10,000 sockeye salmon. However, optimum carrying capacity of the lake for sockeye salmon juveniles is not known. It will be important to continue to monitor size, age, and production of smolts migrating from the lake as efforts to increase adult escapement and introduce additional fry to the system from East Creek Hatchery continue. Large increases in the number of rearing sockeye salmon juveniles could result in decreased smolt size, increased lake residence time prior to the smoltification, and lowered smolt production.

Table 7. Summary of smolt outmigration by brood year escapements, by age class, and smolt production per spawner in Snake River from 1976 to 1981.

Brood year	Escapement	Age I	Age II	Total	Smolt production per spawner
1976	12,728	-	97,594	-	-
1977	9,304	1,182,977	23,509	1,206,486	130
1978	18,074	1,948,593	30,058	1,978,651	109
1979	8,439	893,570	-	-	-

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