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1985 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:
Brian G. Bue

September 1986

ALASKA DEPARTMENT OF FISH AND GAME
P.O. Box 3-2000, Juneau, Alaska 99802

Don W. Collinsworth
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.

1985 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

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

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ABSTRACT

Sockeye salmon (*Oncorhynchus nerka*) smolt studies were conducted on the Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk River systems within Bristol Bay, Alaska, during 1985. Estimates of numbers of smolt migrating to sea, based upon data obtained from sonar equipment, were 25,527,851 from Kvichak; 19,697,687 from Naknek; 66,073,528 from Egegik; 34,101,390 from Ugashik; 36,640,969 from Wood; and 23,366,044 from Nuyakuk. Fyke net samples indicated that age I smolt, from 1983 brood year spawning escapements, were the dominant age class in four out of the six river systems (percent of age I smolt: 92%, Kvichak; 83%, Egegik; 87%, Wood; 97%, Nuyakuk). Age II smolt, from 1982 escapements, were the dominant age class in the remaining two systems (percent of age II smolt: 68%, Naknek; 63%, Ugashik).

KEY WORDS: juvenile sockeye salmon, *Oncorhynchus nerka*, juvenile migration, sonar, Bristol Bay, Kvichak River, Naknek River, Egegik River, Ugashik River, Wood River, Nuyakuk River.

INTRODUCTION

This report is a continuation of a series of Alaska Department of Fish and Game Technical Data Reports documenting methods and results of projects conducted to estimate numbers and age composition of sockeye salmon (*Oncorhynchus nerka*) smolt migrating from Bristol Bay river and lake systems. Smolt data are used both to forecast adult returns and to estimate optimum spawning escapement for Bristol Bay freshwater systems. In 1985, sonar equipment was used to estimate the number of smolt migrating from the Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk River systems. Fyke nets were used to capture samples of smolt to obtain age, length, and weight data. Smolt which have remained within freshwater for one winter after hatching will have formed one annular mark on their scales and are referred to as age I smolt. Smolt which have spent two winters within freshwater after hatching will have formed two annual marks and are referred to as age II smolt.

1985 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

The number of seaward migrating sockeye salmon (*Oncorhynchus nerka*) smolt have been estimated by sonar for the Kvichak River system since 1971. Prior to 1971, fyke nets were used to calculate abundance indices (Kerns 1961; Russell 1972; Paulus and McCurdy 1972; Parker 1974a and 1974b). Abundance estimates and age composition data have been used to forecast adult returns and to estimate spawning escapement levels needed for optimum production.

Specific objectives of the 1985 smolt studies were: 1) to estimate the number of sockeye smolt migrating to sea, 2) to determine the age composition of the smolts, 3) to collect length and weight data for smolt, and 4) to record climatological and hydrological data which may influence smolt migratory patterns.

MATERIALS AND METHODS

In 1985 a sonar system developed by the Bendix Corporation was used to estimate the number of juvenile salmon migrating past the study site. The system consisted of a single control unit and three 3.3 m (11 ft) long plastic ladder-shaped arrays, each housing 14 transducers. The combined sonar beam produced by each array was 3.7 m (12.2 ft) wide. Arrays were anchored on the river bed, and their transducers were connected to the control unit with coaxial cables. The control unit was housed in a canvas wall tent on the river bank. The total number of sonar counts recorded by each array were printed by the control unit every 15 minutes. Sonar counts were converted to estimates of smolt numbers by: 1) subtracting false counts, 2) interpolating counts during missed time periods, 3) adjusting counts for differences in river velocity among arrays, 4) expanding counts to estimate numbers of smolt passing the transect site in areas not covered by the sonar beams, and 5) multiplying counts by the estimated number of smolt needed to generate a single sonar count.

A disabling switch was used to turn off the counting unit during times when ice, debris, boat traffic, etc. generated false counts. The time, in seconds, that the unit was disabled was automatically printed at the end of each counting interval. Estimates of valid (smolt) sonar counts during periods when the unit was disabled were calculated by linear interpolation. Any false counts noted during times when the unit was not disabled were subtracted from period totals.

Water current velocities were measured behind each array three times during the season so that sonar pulse rate could be adjusted. This minimized over and under counting errors, since residence time of smolt within the sonar beam decreased as water current speed increased.

Counts from each array were expanded to estimate numbers of smolt migrating in sections of the river not covered by the arrays. Expansion of counts was based on the lateral distribution of smolt across the counting site transect, which was estimated visually and from information gathered from a side scanning sonar unit.

The sonar system was designed to count biomass rather than individual smolt, and was calibrated at the factory to register one count for the biomass equivalent of 10 smolt weighing a total of 83 g (based on the weighted mean of all Kvichak smolt weight data available prior to 1971). In past studies, adjusted sonar counts were multiplied by 10 to obtain final estimates of smolt numbers. However, since mean smolt weight varied during the season as well as among years, more accurate final estimates of smolt numbers should be obtained using actual mean smolt weight data from daily fyke net catches. Therefore, daily adjusted smolt counts were multiplied by a correction factor (F):

$$F = 10 \times (8.3 / W), \text{ where}$$

W = daily mean weight of smolt from fyke net samples.

A 1.5 m by 1.5 m (5 ft by 5 ft) fyke net was fished downstream of the center and offshore sonar arrays. Captured smolt were identified according to species, weighed (g), measured (fork length, mm), and aged from scale samples. This data was used to apportion sonar counts according to age class and salmonid species.

Samples of at least 400 sockeye salmon smolt were used to estimate age class composition for each 24-hour sampling period. If this number of smolt was not captured during a 24-hour period, samples from subsequent period were combined until a total of at least 400 smolt was obtained. Samples of 400 smolt produced estimates of the actual proportion of age I or age II smolt which were within 0.05 of the estimated proportion (at the 0.05 significance level) for actual age class proportions ranging from 0.95 to 0.05 (Bill et al., in press). Samples of this size also produced estimates of the actual number of either age I or II smolt which were within 50% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.05 to 0.20, and which were within 15% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.30 to 0.95.

To obtain daily age data for 400 sockeye salmon smolt, it was necessary to decrease the time needed for sampling each smolt. Therefore, scale samples, weights, and lengths were obtained from about 150 smolt each day. An additional 250 smolt were measured for length data only. After the field season, smolt for which only length measurements had been obtained were assigned a weight and an age based upon analysis of available age, weight, and length data (Bill et al., in press).

RESULTS AND DISCUSSION

A total of 413,810 sonar counts were recorded during the season (Table 1). Seventy-five percent of the counts were recorded over the center array. Estimated total number of smolt was 25,527,851 (Table 2). There were intermittent ice problems from the beginning of the program until 7 June. No counts were made for three days (3 June through 5 June) due to continuous ice floes. Linear interpolations were made for these days using counts from 2 and 6 June. Peak days of migration was 9 June when over 6,000,000 smolt migrated seaward (24% of the total run). Age class composition of the total smolt population was estimated to be 92% age I (1983 brood year) and 8% age II (1982 brood year).

A total of 4,158 smolt were sampled to obtain data on age, length, and weight (Table 3). Mean lengths of age I and age II smolt were 85 mm and 102 mm, respectively. Mean weights of age I and age II smolt were 5.3 g and 9.2 g, respectively. Both age I and age II smolt were slightly smaller than the long term averages of 88 mm and 109 mm, respectively (Table 4). Average weights were also slightly smaller than the long term averages of 5.7 g and 10.8 g, respectively. These differences were reflected in the high number of smolt per count observed throughout the season (seasonal average of 15.5 smolt per count) (Table 5).

Total smolt production from the 1982 brood year spawning escapement of 1,134,840 sockeye salmon was 68.223 smolt per spawner (51,893,988 age I smolt migrated to sea in 1984; 25,527,851 age II smolt migrated to sea in 1985) (Table 6). This is the largest smolt per spawner relationship recorded. Average marine survival for smolt produced by the 1968-1980 brood years has been about 8.8% for age I smolt and about 12.8% for age II smolt (Table 7).

River and weather conditions were recorded at the sonar site from 23 May through 20 June (Table 8). Ice was a major problem in 1985. Mean water temperature during the project was 4.6°C (range 1.0-7.0°C). During the time of peak seaward migration (8 June - 11 June) the water temperature ranged from 4.3-6.0°C. This was the coldest mean water temperature since 1976 and nearly one degree below the long term mean of 5.5 degrees (Table 9).

Table 1. Sonar counts recorded from three 14 transducer arrays at the sockeye salmon smolt counting site on the Kvichak River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date a/	Inshore	Center	Offshore	Total
5 22	43	391	551	985
5 23	142	376	333	851
5 24	255	364	239	858
5 25	42	66	142	250
5 26	83	325	168	576
5 27	85	389	634	1,108
5 28	167	186	509	862
5 29	345	237	469	1,051
5 30	16	45	89	150
5 31	12	80	27	119
6 1	2	89	5	96
6 2	462	841	897	2,200
6 3	296	4,271	2,073	6,640
6 4	296	4,271	2,073	6,640
6 5	296	4,271	2,073	6,640
6 6	436	14,424	6,980	21,840
6 7	285	1,731	408	2,424
6 8	971	18,496	10,046	29,513
6 9	6,999	71,319	24,852	103,170
6 10	2,193	33,363	5,092	40,648
6 11	2,476	26,675	3,346	32,497
6 12	1,103	21,195	1,856	24,154
6 13	773	12,178	2,085	15,036
6 14	602	14,780	2,059	17,441
6 15	1,659	31,436	2,599	35,694
6 16	788	12,864	2,670	16,322
6 17	1,752	16,542	2,456	20,750
6 18	1,707	10,051	3,134	14,892
6 19	948	7,184	2,271	10,403
Total	25,234	308,440	80,136	413,810
Percent	6.10	74.54	19.37	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1985.

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 22	49,442	98.58	49,442	713	1.42	713	50,156	50,156
5 23	49,644	98.58	99,086	716	1.42	1,430	50,360	100,516
5 24	55,602	98.58	154,689	802	1.42	2,233	56,405	156,922
5 25	13,135	98.58	167,824	189	1.42	2,423	13,324	170,247
5 26	35,214	98.58	203,038	508	1.42	2,931	35,722	205,970
5 27	55,923	98.58	258,962	807	1.42	3,739	56,730	262,701
5 28	45,120	98.58	304,083	651	1.42	4,390	45,772	308,473
5 29	62,996	98.58	367,079	909	1.42	5,300	63,905	372,379
5 30	7,561	98.58	374,640	109	1.42	5,409	7,670	380,050
5 31	7,420	98.58	382,060	107	1.42	5,516	7,527	387,577
6 1	6,376	98.58	388,437	92	1.42	5,608	6,468	394,045
6 2	129,156	98.58	517,593	1,864	1.42	7,473	131,020	525,066
6 3	387,482	98.58	905,075	5,594	1.42	13,068	393,077	918,144
6 4	387,482	98.58	1,292,558	5,594	1.42	18,663	393,077	1,311,221
6 5	387,482	98.58	1,680,040	5,594	1.42	24,257	393,077	1,704,298
6 6	1,257,801	98.58	2,937,842	18,161	1.42	42,419	1,275,963	2,980,261
6 7	156,682	98.58	3,094,524	2,262	1.42	44,681	158,944	3,139,206
6 8	1,687,563	98.58	4,782,088	24,366	1.42	69,047	1,711,929	4,851,135
6 9	5,735,036	94.65	10,517,124	324,167	5.35	393,215	6,059,204	10,910,339
6 10	2,647,886	98.65	13,165,011	36,235	1.35	429,450	2,684,122	13,594,462
6 11	1,210,443	72.50	14,375,455	459,133	27.50	888,584	1,669,577	15,264,039
6 12	902,617	72.50	15,278,072	342,372	27.50	1,230,957	1,244,990	16,509,030
6 13	901,291	93.40	16,179,364	63,688	6.60	1,294,645	964,979	17,474,010
6 14	1,050,688	93.40	17,230,053	74,245	6.60	1,368,891	1,124,934	18,598,944

-Continued-

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
6 15	2,369,384	91.80	19,599,437	211,784	8.21	1,580,676	2,581,169	21,180,113
6 16	1,035,216	91.80	20,634,653	92,531	8.21	1,673,208	1,127,748	22,307,861
6 17	1,362,898	91.80	21,997,552	121,821	8.21	1,795,029	1,484,719	23,792,581
6 18	942,421	91.80	22,939,973	84,237	8.21	1,879,266	1,026,659	24,819,240
6 19	650,469	91.80	23,590,443	58,141	8.21	1,937,408	708,611	25,527,851
Total	23,590,443	92.41		1,937,408	7.59		25,527,851	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Kvichak River, Bristol Bay, Alaska, 1985. A dash (-) indicates data not available.

Date a/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
6 5	83	0.3	5.1	0.04	125	94		7.2		1
6 7	84	0.6	5.3	0.11	30					0
6 8	85	0.2	5.4	0.03	499	102	2.1	9.2	0.52	18
6 9	85	0.2	5.5	0.03	513	98	1.7	8.3	0.39	29
6 10	84	0.1	5.2	0.02	513	100	3.3	8.7	0.82	7
6 11	84	0.3	5.3	0.05	209	115	0.6	12.7	0.16	141
6 12	84	0.3	5.2	0.05	116	104	2.8	9.9	0.66	20
6 13	84	0.2	5.2	0.03	234	98	1.9	8.3	0.45	25
6 14	82	0.2	5.0	0.04	380	108	2.2	10.6	0.57	14
6 15	84	0.2	5.3	0.04	371	106	1.7	9.9	0.41	23
6 16	87	0.2	5.7	0.04	330	105	1.2	9.7	0.34	39
6 17	86	0.3	5.5	0.05	130					0
6 18	85	0.4	5.4	0.06	128	89	8.0	6.3	1.55	2
6 19	86	0.3	5.6	0.05	234	104	1.5	9.7	0.37	27
Totals					3,812					346
Means	85		5.3			102		9.2		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1985. A dash (-) indicates data not available.

Year of Migration	Age I			Age II			Age III			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1955 a/	7	89	-	93	-	-	0	-	-	260,068	Paulus and Parker (1974)
1956 a/	39	92	-	61	116	-	0	-	-	77,660	"
1957 a/	72	96	7.3	28	120	14.4	0	-	-	30,907	"
1958 a/	98	84	4.6	2	114	-	0	-	-	3,333,953	"
1959 a/	3	80	-	97	99	7.6	0	-	-	2,863,876	"
1960 a/	10	91	6.3	90	108	10.3	0	-	-	614,003	"
1961 a/	72	92	6.8	28	117	13.1	0	-	-	36,164	"
1962 a/	94	82	4.3	6	110	9.9	0	-	-	1,203,000	"
1963 a/	3	83	4.8	97	98	7.5	0	-	-	4,229,431	Marriott (1965)
1964 a/	22	87	5.2	78	108	9.8	0	-	-	2,061,586	Pennoyer and Seibel (1965)
1965 a/	4	90	6.8	96	109	11.3	0	-	-	1,812,555	Pennoyer (1966)
1966 a/	92	94	7.4	8	114	12.6	0	-	-	275,761	Pennoyer and Stewart (1967)
1967 a/	93	86	5.9	7	118	14.2	0	-	-	3,088,742	Pennoyer and Stewart (1969)
1968 a/	11	88	5.5	89	104	9.2	0	-	-	6,123,683	Paulus and McCurdy (1969)
1969 a/	52	92	5.7	48	109	10.6	0	-	-	1,135,344	McCurdy and Paulus (1972)
1970 a/	38	91	6.0	62	110	11.0	0	-	-	483,638	Paulus and McCurdy (1972)
1971 b/	93	90	5.8	7	111	11.1	0	-	-	91,682,813	Russell (1972)
1972 b/	1	80	4.2	99	106	10.0	0	-	-	54,623,559	Parker (1974a)
1973 b/	3	86	5.1	97	97	8.3	0	-	-	196,966,331	Parker (1974b)
1974 b/	9	96	8.3	79	111	13.1	12	124	17.5	27,082,626	Krasnowski (1975)
1975 b/	63	98	8.4	37	122	16.4	0	-	-	15,632,531	Randall (1976)
1976 b/	97	88	5.8	3	121	14.2	0	-	-	111,388,180	Randall (1977)
1977 b/	38	86	5.5	62	106	10.1	0	-	-	192,578,099	Randall (1978)
1978 b/	12	88	6.0	88	97	7.8	0	-	-	245,591,014	Yuen (1980a)

-Continued-

Table 4. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1985. A dash (-) indicates data not available (continued).

Year of Migration	Age I			Age II			Age III			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1979 b/	51	90	6.0	49	109	10.3	0	-	-	55,181,540	Yuen (1980b)
1980 b/	94	88	5.9	6	110	10.7	0	-	-	192,853,007	Yuen and Wise (1982)
1981 b/	89	85	5.4	11	108	10.2	0	-	-	252,222,769	Bergstrom and Yuen (1981)
1982 b/	58	84	5.1	39	103	9.1	0	-	-	239,721,729	Bill (1984)
1983 b/	8	80	4.9	92	98	8.5	0	-	-	82,793,899	Bill et al. (in press)
1984 b/	58	90	6.8	42	104	10.0	0	-	-	89,489,975	Bill (in press)
		---	---		---	---					
	Mean	88	5.7		109	10.8					
1985	92	85	5.3	8	102	9.2				25,527,851	

a/ Estimate of smolt numbers based on fyke net catches

b/ Estimate of smolt numbers based on sonar techniques

Table 5. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Kvichak River, Bristol Bay, Alaska, 1985.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 22	No Sample	15.6
5 23	No Sample	15.6
5 24	No Sample	15.6
5 25	No Sample	15.6
5 26	No Sample	15.6
5 27	No Sample	15.6
5 28	No Sample	15.6
5 29	No Sample	15.6
5 30	No Sample	15.6
5 31	No Sample	15.6
6 1	No Sample	15.6
6 2	No Sample	15.6
6 3	No Sample	15.6
6 4	No Sample	15.6
6 5	5.3	15.6
6 6	No Sample	15.6
6 7	5.3	15.6
6 8	5.3	15.6
6 9	5.6	14.8
6 10	5.3	15.7
6 11	6.9	12.0
6 12	6.9	12.0
6 13	5.4	15.4
6 14	5.4	15.4
6 15	4.9	16.8
6 16	4.9	16.8
6 17	4.9	16.8
6 18	4.9	16.8
6 19	4.9	16.8

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 6. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-1983 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
<u>Estimates of smolt numbers based upon fyke net catches</u>						
1956	9,443,318	3,267,274 (54)	2,777,960 (46)	0	6,045,234	0.640
1957	2,842,810	85,916 (13)	552,603 (87)	0	638,519	0.225
1958	534,785	61,400 (86)	10,126 (14)	0	71,526	0.134
1959	680,000	26,038 (27)	72,180 (73)	0	98,218	0.144
1960	14,630,000	1,130,820 (22)	4,116,093 (78)	0	5,246,913	0.359
1961	3,705,849	113,338 (7)	1,603,464 (93)	0	1,716,802	0.463
1962	2,580,884	458,122 (21)	1,748,178 (79)	0	2,206,300	0.855
1963	338,760	64,377 (73)	23,377 (27)	0	87,754	0.259
1964	957,120	252,384 (53)	222,528 (47)	0	474,912	0.496
1965	24,325,926	2,866,214 (34)	5,475,362 (66)	0	8,341,576	0.343
1966	3,775,184	648,321 (55)	541,017 (45)	0	1,189,338	0.315
1967	3,216,208	594,327 (67)	298,282 (33)	0	892,609	0.278
1968	2,557,440	185,356				
<u>Estimates of smolt numbers based upon sonar techniques</u>						
1968			5,959,383	0	-	-
1969	8,394,204	85,723,430 (61)	54,159,340 (39)	0	139,882,770	16.664
1970	13,935,306	464,219 (<1)	191,842,930 (98)	2,918,768 (1)	195,225,917	14.009
1971	2,387,392	5,123,400 (19)	21,423,246 (81)	0	26,546,646	11.120
1972	1,009,962	2,740,610	-	-	-	-
1973	226,554	-	3,031,287	0	-	-
1974	4,433,844	108,356,892 (49)	114,269,848 (51)	0	222,626,740	50.211

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Table 6. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-1983 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available (continued).

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
<u>Estimates of smolt numbers based upon sonar techniques</u>						
1975	13,140,450	78,308,251 (27)	213,364,470 (73)	0	291,672,721	22.197
1976	1,965,282	32,226,544 (55)	26,423,348 (45)	0	58,649,892	29.843
1977	1,341,144	28,758,191 (73)	10,410,467 (27)	0	39,168,658	29.205
1978	4,149,288	182,442,540 (85)	32,294,536 (15)	0	214,737,076	51.753
1979	11,218,434	219,928,232 (71)	89,300,703 (29)	0	309,228,935	27.564
1980	17,505,268	150,421,026 (62)	76,244,773 (38)	0	199,172,858	12.948
1981	1,754,358	6,549,125 (15)	37,595,987 (85)	0	44,145,112	25.163
1982	1,134,840	51,893,988 (96)	1,937,408 (4)	0	53,831,396	47.435
1983	3,569,982	23,590,443				

Table 7. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1983 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total a/ Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult a/ Returns	Adult Returns per Smolt	Number of Smolt	Adult a/ Returns	Adult Returns per Smolt
<u>Estimates of smolt numbers based upon fyke net catches</u>							
1952	-	-	17,442,177	-	241,870	3,568,683	14.75
1953	-	18,198	150,000	8.24	47,373	416,438	8.79
1954	-	30,287	108,062	3.57	8,654	638,807	73.82
1955	-	22,253	349,379	15.70	66,679	1,111,184	16.66
1956	9,443,318	3,267,274	31,072,719	9.51	2,777,960	7,669,165	2.76
1957	2,842,810	85,916	477,643	5.56	552,603	3,492,512	6.32
1958	534,785	61,400	121,131	1.97	10,126	157,830	15.59
1959	680,000	26,038	321,845	12.36	72,180	212,080	2.94
1960	14,630,000	1,130,820	1,841,471	1.63	4,116,093	52,434,234	12.74
1961	3,705,849	113,338	513,865	4.53	1,603,464	2,888,592	1.80
1962	2,580,884	458,122	249,330	0.54	1,748,178	4,951,714	2.83
1963	338,760	64,377	94,415	1.47	23,377	918,394	39.29
1964	957,120	252,384	2,447,045	9.70	222,528	2,918,799	13.12
1965	24,325,926	2,866,214	10,090,601	3.52	5,475,362	32,942,281	6.02
1966	3,775,184	648,321	1,534,238	2.37	541,017	4,488,399	8.30
1967	3,216,208	594,327	572,694	0.96	298,282	829,337	2.78
1968	2,557,440	185,356	300,402	1.62	-	-	-

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Table 7. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1983 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available (continued).

Brood Year	Total a/ Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult a/ Returns	Adult Returns per Smolt	Number of Smolt	Adult a/ Returns	Adult Returns per Smolt
<u>Estimates of smolt numbers based upon sonar techniques</u>							
1968	2,557,440	-			5,959,383	206,095	0.03
1969	8,394,204	85,723,430	442,515	0.01	54,159,340	4,787,896	0.09
1970	13,935,306	464,219	55,624	0.12	191,842,930	15,152,302	0.08
1971	2,387,392	5,123,400	332,822	0.06	21,423,246	2,412,403	0.11
1972	1,009,962	2,740,610	404,693	0.15	-	1,468,546	0.25
1973	226,554	-	1,566,472	0.16	3,031,287	802,035	0.26
1974	4,433,844	108,356,892	8,158,273	0.08	114,269,848	17,127,032	0.15
1975	13,140,450	78,308,251	6,735,383	0.09	213,364,470	28,823,894	0.14
1976	1,965,282	32,226,544	5,847,020	0.18	26,423,348	4,012,457	0.15
1977	1,341,144	28,758,191	2,451,387	0.09	10,410,467	281,173	0.03
1978	4,149,288	182,442,540	2,895,181	0.02	32,294,536	1,956,845	0.06
1979	11,218,434	219,928,232	18,460,313	0.08	89,300,703	17,699,284	0.20
1980	22,505,268	150,421,026	2,924,455	0.02 b/	76,244,773	7,975,551	0.10 b/
1981	1,754,358	6,549,125	961,803	0.15 b/	37,595,987		
1982	1,134,840	51,893,988			25,527,851		
1983 c/	3,569,982	23,590,443					

a/ Yuen et al. (1986)

b/ Future adult returns will increase these values.

c/ Yuen et al. (in preparation)

Table 8. Climatological and hydrological observations made at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1985. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)		Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr	Min	Max		
5 23	1	3	8 SW	8 NE	-2.2	14.4	3.8	clear
5 24	2	3	8 E	24 E	0.0	21.1	3.2	clear
5 25	2	4	16 E	calm	2.2	15.6	3.5	clear
5 26	4	2	8 SW	8 SW	3.3	13.3	4.0	clear
5 27	5	4	8 E	16 E	0.0	23.3	3.0	clear
5 28	4	4	8 NE	8 E	2.2	10.0	3.5	clear
5 29	4	2	16 SW	13 E	4.4	15.6	3.5	clear
5 30	4	4	32 E	8 E	3.3	13.3	2.8	clear
5 31	4	4	10 E	8 SW	3.9	13.3	3.0	clear
6 1	4	3	calm	16 NE	2.2	13.3	2.4	clear
6 2	4	3	24 NE	16 NE	4.4	8.9	2.0	clear
6 3	4	3	8 NE	24 NE	3.9	8.3	-	clear
6 4	3	4	8 NE	56 NE	6.1	8.9	-	clear
6 5	3	1	24 NE	16 NE	5.6	12.8	-	murky
6 6	1	1	16 NE	8 NE	-1.1	18.3	3.0	clear
6 7	4	4	32 S	24 S	4.4	11.1	3.0	clear
6 8	4	2	8 E	24 E	6.7	3.3	4.3	clear
6 9	3	2	8 NE	24 NE	0.0	20.0	5.8	clear
6 10	3	2	24 NE	24 NE	2.2	17.8	6.0	clear
6 11	4	3	calm	calm	1.1	20.0	6.0	clear
6 12	4	4	24 S	24 S	5.6	20.0	5.8	clear
6 13	4	3	8 S	8 NE	2.8	11.7	5.0	clear
6 14	2	3	3 S	8 S	0.0	14.4	5.8	clear

-Continued-

Table 8. Climatological and hydrological observations made at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1985. A dash (-) indicates missing data (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)		Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr	Min	Max		
6 15	-	4	16 S	8 S	4.4	21.7	5.8	brown
6 16	2	2	8 NW	8 NW	1.7	21.1	6.3	clear
6 17	1	3	8 SE	8 E	-2.2	22.2	6.5	clear
6 18	1	4	8 SE	8 NE	0.0	23.3	6.5	clear
6 19	4	4	8 NE	19 NE	5.6	17.8	7.0	clear
6 20	4	-	16 NE	- -	9.4	15.6	7.0	clear

- a/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Table 9. Water temperatures at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1963-1985.
Dash (-) indicates data not available.

Year	Sample Period	Water Temperature (C)			
		Minimum	Maximum	Mean	
1963	16 May-14 June	2.2	8.9	5.5	Marriott (1965)
1964	18 May-14 June	0.0	5.6	2.6	Pennoyer and Seibel (1965)
1965	17 May-11 June	0.0	8.9	4.4	Pennoyer (1966)
1966	16 May-26 June	0.0	11.1	4.7	Pennoyer and Stewart (1967)
1967	17 May-20 June	1.1	9.4	6.9	Pennoyer and Stewart (1969)
1968	12 May-12 June	3.3	8.3	5.4	Paulus and McCurdy (1969)
1969	16 May-18 June	0.3	7.8	3.9	McCurdy and Paulus (1972)
1970	13 May- 7 June	2.8	11.1	6.8	Paulus and McCurdy (1972)
1971	17 May-20 June	1.1	3.3	2.4	Russell (1972)
1972	18 May-18 June	0.6	5.0	2.9	Parker (1974a)
1973	15 May-14 June	2.9	8.9	4.9	Parker (1974b)
1974	13 May- 9 June	3.0	8.0	6.2	Krasnowski (1975)
1975	17 May-15 June	2.0	8.0	3.8	Randall (1976)
1976	18 May-19 June	2.0	9.5	3.9	Randall (1977)
1977	17 May-14 June	3.0	9.5	6.4	Randall (1978)
1978	19 May- 9 June	5.0	11.0	7.6	Yuen (1980a)
1979	1 June-10 June	8.0	10.0	8.6	Yuen (1980b)
1980	16 May-18 June	1.5	9.0	5.5	Bergstrom and Yuen (1981)
1981	15 May- 9 June	7.0	10.0	8.2	Yuen and Wise (1982)
1982	14 May-15 June	2.5	8.5	4.9	Bill (1984)
1983	19 May-14 June	5.2	10.5	7.9	Bill et al. (in press)
1984	19 May-11 June	5.5	10.0	7.9	Bill (in press)
	Mean	2.5	8.7	5.5	
1985	23 May-20 June	2.0	7.0	4.6	

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1985 NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Programs to sample and enumerate seaward migrating sockeye salmon (*Oncorhynchus nerka*) smolt provide data which are used to forecast adult returns and estimate optimal spawning escapement levels. Smolt sampling programs have been conducted on several of the rivers of Bristol Bay since the mid-1950's. Early studies used fyke nets to estimate smolt numbers [Kvichak River (1956-1974), Naknek River (1956-1977), and Ugashik River (1955-1965, 1967-1970, and 1972-1975)]. Fyke net fishing, however, proved to be inadequate due to net avoidance and high smolt mortality resulting from capture and handling methods. Therefore, smolt sonar was developed and tested by Bendix Corporation from 1970-1976 on the Kvichak River. This program was successful and has served as a template for further smolt sonar enumeration studies on other Bristol Bay systems.

Smolt sonar was also tested on the Ugashik River from 1973-1975 but was discontinued due to budgetary constraints; consequently, smolt studies on this and the Naknek and Egegik Rivers were limited to occasional fyke net sampling for age and size data from 1975 to 1982 (Huttunen 1980; Eggers 1984). An experimental two-array Kvichak system was tested on the Egegik River during the spring of 1981 (Bue 1982) and replaced with the present counter in 1982 (Bue 1984). Smolt sonar projects were established on the Naknek River in 1982 (Huttunen 1984) and the Ugashik River in 1983 (Fried and Yuen, in press).

Objectives of the 1985 Naknek, Egegik, and Ugashik River smolt studies were: 1) to estimate the number of seaward migrating sockeye salmon smolt, 2) to describe smolt migration patterns, 3) to collect age, weight, and length data for smolts, and 4) to record climatological and hydrological parameters which may affect migratory behavior.

A post-season analysis was conducted to determine if the number of hours spent monitoring the Egegik smolt sonar counter could be reduced without losing a significant amount of data. It has been shown that a large sample (approximately 400 smolt) from several replicates is needed to apportion biomass estimates into numbers of sockeye salmon smolt by age class at a predetermined level of precision (Bill et al., in press). This level of sampling combined with 24-hour monitoring of the smolt counter is a considerable work load for the present number of people stationed at the project. It is also believed that the majority of smolt migrate seaward during the evening hours. Consequently, it may be possible to reduce the

level of sonar monitoring during the mid-day hours without missing a significant number of smolt.

MATERIALS AND METHODS

Identical sonar counting systems were used to estimate biomass of seaward migrating smolt on the Naknek, Egegik, and Ugashik Rivers. The sonar systems consisted of 1) a control unit located in a canvas wall tent on the river's edge, and 2) either two or three 3.05 m (10 ft) long ladder-shaped arrays anchored to the river bottom and situated perpendicular to the river current at the counting site. Each array held 10 surface facing transducers enabling it to monitor approximately 3.35 m (11 ft) of river width.

The Naknek River sonar site is located 13 km (7.8 mi) below the outlet of Naknek Lake. Three arrays, the inshore, center, and offshore were anchored at 14, 28, and 51 m (46, 92, and 167 ft), respectively from the east bank of the river. A three-array system was also used at the Egegik River site located 4 km (2.4 mi) below the outlet of Becharof Lake. Inshore, center, and offshore arrays were located 40, 55, and 67 m (130, 180, and 220 ft), respectively from the west bank. Two arrays were used in the Ugashik River approximately 50 m from the outlet of Lower Ugashik Lake. The inshore and offshore arrays were placed at 16.5 and 24.5 (54 and 80 ft) from the north bank.

The sonar system was continuously monitored at each site by field personnel. Machine adjustments were made for changes in river velocity and depth. Counts were automatically tabulated and printed for each array at hourly intervals by the sonar counter. These totals were manually adjusted for false counts (counts due to causes other than smolt, e.g., ice, heavy rain, wind, boat traffic, etc.) and linear interpolation was used to estimate missed counts during periods when the counter was disabled (i.e., periods when the counter was manually disabled to avoid making false counts or when the counter was inoperative). Daily total counts were estimated for each array by summing the adjusted hourly counts.

Sonar signals pulse rate was manually set proportional to current speed, since current speed determines the time required for smolt to pass over the sonar array and through the transducer beam. Current speed was measured behind each array at the surface, 0.61 and 1.22 m depths (2 and 4 ft, respectively). The average of these three measurements was used for the array velocity. Velocity correction factors were derived for each array to account for the possible over and under counting due to lateral differences in river velocity, since the counter could only be set for a single pulse rate. Correction factors for the Naknek and Ugashik sites were obtained from the ratios of the individual array velocities to the inshore array velocity while corrections were estimated at the Egegik site as the ratios of the individual array velocities to the center array velocity. Tidal fluctuations have an influence on river speed and were noticeable at both the Naknek and Egegik sites. Consequently, river velocity was continuously monitored using a current meter suspended 0.61 m (2 ft) below the surface and behind the inshore and center arrays at the Naknek and Egegik sites, respectively. The

counter was adjusted at 15 to 30 minute intervals to account for changes in river velocity at these sites. River velocity was nearly constant during the study period at the outlet of Lower Ugashik Lakes, consequently, only weekly examinations of river speed were required to calibrate the Ugashik counter.

Estimates of total daily smolt migration past the counting sites were made by: 1) multiplying the daily total counts for each array by the corresponding river velocity correction factor, 2) linearly expanding counts to compensate for smolt which migrated past the site but were not counted (distances from the edges of lateral smolt distribution and distances between arrays were used along with daily totals adjusted for river velocity by array), and 3) the expanded count estimate was modified by a smolt per count correction factor to obtain estimated number of smolt. All three sonar systems were calibrated, at the factory, to register one count for the biomass equivalent of 41.49875 g. Therefore, pooled mean weight of all salmonid smolts from daily fyke net samples were used to estimate actual number of smolt equivalent to one sonar count (i.e., number per count = 41.4987 g / pooled mean weight).

Fyke nets were fished daily during periods of peak migration at each site. Attempts were made to capture four samples of approximately 100 fish during each day of the smolt migration. Age, weight, and length data were measured for 100 of these fish with the remaining smolt being measured for length only. This sampling procedure allowed for a larger sample size than time would allow if age, weight, and length data were collected from each specimen. Age and weight was estimated for the length samples after the season using age-weight and weight-length relationship derived from samples where all three parameters were measured.

Fyke net catches were also used to apportion daily smolt counts according to age class and salmonid species. Samples of approximately 400 sockeye salmon smolt were needed to produce estimates of the proportion (p) of either age I or age II smolt with an absolute error of 0.05 such that;

$$p = \hat{p} \pm 0.05, \text{ for } p \geq 0.05$$

where p = true proportion of either age I or age II sockeye salmon smolt. A sample size of 400 also resulted in an estimate of the least abundant of the two age classes with a relative error of 0.15 such that;

$$p = [(\hat{p} - p) / p] \pm 0.15, \text{ for } p \geq 0.20$$

A small weather station was maintained at each counting site. Observations on sky conditions, wind direction, wind velocity, daily precipitation, air temperature, and water temperature were recorded at 0800 and 2000 hours daily.

RESULTS AND DISCUSSION

Naknek River

A total of 981,268 sonar counts were tabulated during the 1985 season, 22 May through 2 July (Table 1). Twelve percent of these counts were registered over the inshore array, with 40 and 48% passing over the center and offshore arrays, respectively. Counts over the offshore array were adjusted to compensate for a malfunctioning transducer beginning on 25 May (actual offshore count was multiplied by 1.111 (10 transducers / 9 operational transducers)). The majority of smolt migration across the counting site transect occurred between the east bank and a point 80 m (262 ft) offshore.

Although river velocities varied widely, velocity correction factors remained the same throughout the project. The velocities over each array were standardized to the inshore array resulting in correction factors of 1.00, 1.09, and 0.89 for the inshore, center, and offshore arrays, respectively.

The final sockeye salmon smolt population estimate was 19,697,687 (Table 2). Age composition was 32.0% age I (1983 brood year), 67.9% age II (1982 brood year), and 0.1% age III (1981 brood year). Age II and III smolt migrated to sea earlier in the season than age I smolt. Consequently, numbers of smolt per sonar count increased as the season progressed (range, 3.2 to 5.6 smolt per count) (Tables 2 and 3). Total smolt production from the 1980 and 1981 brood years was 50.2 and 47.7 smolt per spawner, respectively (Table 4).

A total of 6,528 sockeye salmon smolt were sampled for age, weight, and/or length information (Table 5). Mean weights of age I, II, and III smolt were 8.7, 11.7, and 15.6 g, respectively. Mean lengths of age I, II, and III smolt were 97, 109, and 119 mm, respectively. Average size of all three age classes was smaller than historically observed (Table 6).

Weather and river conditions were recorded at the sonar site during 21 May through 3 July (Table 7). Mean air and water temperature during this period was 9.7°C (range 3.0 to 21.0) and 10.5°C (range 6.5 to 16.0), respectively. Mean water temperature was lower than observed during the 1984 smolt season but was close to the average temperature for the past 13 seasons (10.5 vs 11.0) (Table 8).

Egegik River

A total of 4,165,739 sonar counts were tabulated from 23 May through 11 June 1985 (Table 9). The counts were distributed at 48, 45, and 7% over the inshore, center, and offshore arrays, respectively. Side scan sonar was used to make subjective observations of lateral smolt distribution across the counting transect from the evening of 25 May through noon 1 June. During this period it was observed that the majority of smolt schools traveled between 12.2 and 85.3 meters from the west bank at the counting site. Several large schools were observed inshore of the inshore array and went undetected by the smolt enumeration sonar. Few schools were observed outside of the offshore array.

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date a/	Inshore	Center	Offshore	Total
5 22	2,455	2,608	1,294	6,357
5 23	3,026	1,878	2,003	6,907
5 24	138	184	446	768
5 25	0	324	202	526
5 26	399	1,621	190	2,210
5 27	10	840	83	933
5 28	297	527	788	1,612
5 29	246	113	843	1,202
5 30	181	1,285	1,340	2,806
5 31	603	2,541	1,956	5,100
6 1	1,029	7,672	7,219	15,920
6 2	5,035	13,905	10,906	29,846
6 3	6,132	13,334	34,467	53,933
6 4	3,327	21,765	36,133	61,225
6 5	9,089	40,070	55,147	104,306
6 6	5,209	23,740	26,874	55,823
6 7	3,015	9,735	45,697	58,447
6 8	16,317	48,229	28,221	92,767
6 9	3,131	11,932	14,082	29,145
6 10	4,344	26,218	22,849	53,411
6 11	2,630	13,779	29,052	45,461
6 12	3,593	13,084	42,302	58,979
6 13	6,166	18,321	16,624	41,111
6 14	2,781	10,531	9,637	22,949
6 15	4,774	21,376	9,441	35,591
6 16	936	2,868	2,633	6,437
6 17	1,968	4,984	4,027	10,979
6 18	2,706	10,391	8,285	21,382
6 19	4,299	16,249	15,995	36,543
6 20	5,645	19,103	14,780	39,528
6 21	2,631	12,028	7,353	22,012
6 22	1,163	2,506	935	4,604
6 23	882	1,683	2,043	4,608
6 24	2,971	7,926	2,735	13,632
6 25	685	3,668	1,991	6,344
6 26	231	1,596	826	2,653

-Continued-

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated (continued).

Sonar Counts				
Transducer Array				
Date a/	Inshore	Center	Offshore	Total
6 27	1,261	1,610	969	3,840
6 28	897	713	573	2,183
6 29	1,248	954	2,354	4,556
6 30	1,592	627	662	2,881
7 1	2,359	2,375	3,185	7,919
7 2	1,386	1,109	1,337	3,832
Total	116,787	396,002	468,479	981,268
Percent	11.90	40.36	47.74	100.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1985.

Date a/	Age I		Age II		Age III		Daily Total	Cumulative Total
	Number	Percent	Number	Percent	Number	Percent		
5 22	8,417	8.20	87,418	85.20	353	0.35	96,188	96,188
5 23	9,164	8.20	95,172	85.20	385	0.35	104,721	200,909
5 24	1,167	8.20	12,121	85.20	49	0.35	13,337	214,246
5 25	809	8.20	8,411	85.20	34	0.35	9,254	223,500
5 26	3,045	8.20	31,624	85.20	128	0.35	34,797	258,297
5 27	1,353	8.20	14,058	85.20	56	0.35	15,467	273,764
5 28	2,404	8.20	24,970	85.20	101	0.35	27,475	301,239
5 29	1,855	8.20	19,269	85.20	78	0.35	21,202	322,441
5 30	4,318	8.20	44,854	85.20	181	0.35	49,353	371,794
5 31	7,596	8.20	78,890	85.20	319	0.35	86,805	458,599
6 1	22,272	8.20	231,311	85.20	936	0.35	254,519	713,118
6 2	40,099	8.20	416,446	85.20	1,686	0.35	458,231	1,171,349
6 3	75,930	8.20	788,556	85.20	3,193	0.35	867,679	2,039,028
6 4	87,200	8.20	905,599	85.20	3,666	0.35	996,465	3,035,493
6 5	146,192	8.20	1,518,251	85.20	6,147	0.35	1,670,590	4,706,083
6 6	77,694	8.20	806,881	85.20	3,267	0.35	887,842	5,593,925
6 7	351,779	27.74	916,351	72.26	0		1,268,130	6,862,055
6 8	351,590	19.10	1,489,680	80.91	0		1,841,270	8,703,325
6 9	115,037	19.10	487,409	80.91	0		602,446	9,305,771
6 10	211,119	19.10	894,509	80.91	0		1,105,628	10,411,399
6 11	185,130	19.10	784,394	80.91	0		969,524	11,380,923
6 12	621,278	44.74	767,363	55.26	0		1,388,641	12,769,564
6 13	407,794	44.74	503,681	55.26	0		911,475	13,681,039
6 14	229,988	44.74	284,067	55.26	0		514,055	14,195,094
6 15	349,129	44.74	431,223	55.26	0		780,352	14,975,446
6 16	74,938	53.01	66,428	46.99	0		141,366	15,116,812

-Continued-

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I		Age II		Age III		All Ages	
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total
6 17	131,247	53.01	116,342	46.99	0		247,589	15,364,401
6 18	245,621	50.45	241,191	49.55	0		486,812	15,851,213
6 19	424,974	50.45	417,310	49.55	0		842,284	16,693,497
6 20	726,213	71.99	282,556	28.01	0		1,008,769	17,702,266
6 21	415,543	74.74	140,441	25.26	0		555,984	18,258,250
6 22	55,592	56.58	42,655	43.42	0		98,247	18,356,497
6 23	59,528	56.58	45,676	43.42	0		105,204	18,461,701
6 24	166,362	56.58	127,649	43.42	0		294,011	18,755,712
6 25	81,949	56.58	62,879	43.42	0		144,828	18,900,540
6 26	63,100	76.83	19,025	23.17	0		82,125	18,982,665
6 27	83,673	76.83	25,229	23.17	0		108,902	19,091,567
6 28	46,383	76.83	13,985	23.17	0		60,368	19,151,935
6 29	106,598	76.83	32,141	23.17	0		138,739	19,290,674
6 30	57,866	76.83	17,447	23.17	0		75,313	19,365,987
7 1	173,490	76.83	52,310	23.17	0		225,800	19,591,787
7 2	81,367	76.83	24,533	23.17	0		105,900	19,697,687
Total	6,306,803	32.02	13,370,305	67.88	20,579	0.10	19,697,687	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts Naknek River, Bristol Bay, Alaska, 1985.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 22	no sample	3.15
5 23	13.16	3.15
5 24	13.16	3.15
5 25	no sample	3.15
5 26	13.16	3.15
5 27	no sample	3.15
5 28	13.16	3.15
5 29	13.16	3.15
5 30	13.16	3.15
5 31	13.16	3.15
6 1	13.16	3.15
6 2	no sample	3.15
6 3	no sample	3.15
6 4	no sample	3.15
6 5	13.16	3.15
6 6	13.16	3.15
6 7	10.76	3.86
6 8	10.76	3.86
6 9	no sample	3.86
6 10	no sample	3.86
6 11	10.76	3.86
6 12	9.82	4.23
6 13	9.82	4.23
6 14	no sample	4.23
6 15	9.82	4.23
6 16	9.93	4.18
6 17	9.93	4.18
6 18	10.04	4.14
6 19	10.04	4.14
6 20	8.89	4.67
6 21	8.97	4.63
6 22	9.92	4.18
6 23	9.92	4.18
6 24	9.92	4.18
6 25	9.92	4.18
6 26	7.36	5.64
6 27	7.36	5.64
6 28	7.36	5.64
6 29	7.36	5.64
6 30	7.36	5.64
7 1	7.36	5.64
7 2	no sample	5.64

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1978-1983 brood years, Naknek River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1978	813,378	-	-	-	-	-
1979	925,362	-	12,898,936	23,256	-	-
1980	2,644,698	115,624,396 (88)	16,497,326 (12)	594,898	132,716,620	50.18
1981	1,796,220	36,798,239 (43)	48,825,473 (57)	20,579	85,644,291	47.68
1982	1,155,552	32,139,569	13,370,305			
1983	888,294	6,306,803				

Table 5. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1985. A dash (-) indicates data not available.

Date a/	Age I					Age II					Age III				
	Mean		Mean		Sample	Mean		Mean		Sample	Mean		Mean		Sample
	Length	Std. Error	Weight	Std. Error		Length	Std. Error	Weight	Std. Error		Length	Std. Error	Weight	Std. Error	
(mm)		(g)		(mm)		(g)		(mm)		(g)		(mm)		(g)	
5 23						119	3.5	15.3	1.4	4					
5 24						120	5.8	14.0	1.4	3					
5 26	112	1.5	13.6	0.5	2	122	2.8	15.7	1.1	7					
5 28						120	3.0	14.7		2					
5 29	115	2.8	13.1	0.5	4	116	1.3	13.0	0.4	24	119	0.0	15.6	0.0	1
5 30	125		16.7		1	114	2.0	11.8	0.6	13					
5 31	113	3.3	12.5	1.0	7	117	0.8	13.0	0.3	59					
6 1						117	0.4	13.8	0.1	226					
6 5	101	3.4	9.8	0.9	6	111	1.1	12.5	0.4	24					
6 6	95	0.7	8.6	0.2	57	110	0.3	12.0	0.1	355					
6 7	96	0.3	8.7	0.1	187	109	0.2	11.5	0.1	487					
6 8	97	1.3	8.5	0.4	19	107	0.8	10.8	0.2	70					
6 11	97	0.5	8.9	0.1	63	109	0.4	11.7	0.1	311					
6 12	91	2.4	7.5	0.5	14	106	1.7	11.0	0.5	17					
6 13	96	0.6	8.7	0.1	74	107	0.5	11.1	0.1	122					
6 15	95	0.5	8.3	0.1	99	108	0.7	11.4	0.2	94					
6 16	94	0.5	8.5	0.1	128	109	0.8	11.6	0.2	109					
6 17	94	0.2	8.3	0.1	337	109	0.4	11.8	0.1	311					
6 18	95	0.3	8.4	0.1	168	108	0.5	11.6	0.2	167					
6 19	95	0.4	8.4	0.1	134	109	0.5	11.7	0.2	130					
6 20	93	0.2	8.0	0.1	406	107	0.6	11.3	0.2	158					
6 21	93	0.2	8.1	0.1	580	107	0.5	11.4	0.1	196					
6 22	94	0.4	8.4	0.1	97	108	1.1	11.7	0.3	55					

-Continued-

Table 5. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1985. A dash (-) indicates data not available (continued).

Date a/	Age I					Age II					Age III				
	Mean		Mean		Sample	Mean		Mean		Sample	Mean		Mean		Sample
	Length	Std. Error	Weight	Std. Error		Length	Std. Error	Weight	Std. Error		Length	Std. Error	Weight	Std. Error	
6 23	93	0.8	8.1	0.2	21	109	2.2	11.6	0.6	11					
6 24	92	0.7	8.0	0.2	59	112	0.6	12.7	0.2	119					
6 25	94	0.4	8.6	0.1	116	110	0.9	12.4	0.3	66					
6 26	97	0.7	8.5	0.2	65	106	2.0	11.1	0.5	24					
6 27	95	0.3	8.7	0.1	214	109	0.9	12.0	0.2	78					
6 28	95	0.4	8.5	0.1	133	112	1.3	12.8	0.4	25					
6 29	95	0.4	8.5	0.1	86	107	1.7	11.4	0.5	22					
6 30	98	0.8	9.8	0.2	59	106	1.8	11.6	0.6	17					
7 1	96	0.4	8.7	0.1	66	110	1.8	12.1	0.5	19					
Totals					3,202					3,325					1
Means	97		8.7			109		11.7			119		15.6		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 6. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Naknek River, Bristol Bay, Alaska, 1957-1985. A dash (-) indicates data not available.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1957	-	-	111	13.1	112	13.1	-	-	USF&WS (unpublished)
1958	-	-	91	6.9	114	11.3	-	-	"
1959	-	-	97	8.2	106	10.1	-	-	"
1960	-	-	99	8.8	109	11.9	-	-	"
1961	-	-	103	10.8	113	13.8	-	-	"
1962	-	-	105	10.4	112	12.5	-	-	"
1963	-	-	98	8.1	114	12.8	-	-	"
1964	-	-	97	7.7	110	11.0	-	-	"
1965	-	-	99	8.4	114	13.0	-	-	"
1966	31 May-13 July	933	106	10.6	118	14.2	-	-	Robertson (1967)
1967	27 May- 9 July	855	113	13.1	119	14.7	-	-	Van Valin (1969a)
1968	23 May-12 August	1,380	99	8.4	108	11.1	-	-	Van Valin (1969b)
1969	30 May-27 June	1,079	100	7.5	112	12.1	-	-	Siedelman (1972)
1970	29 May- 5 July	932	100	9.0	114	12.1	-	-	Biwer (1972)
1971	6 June-7 July	-	102	8.8	120	13.5	-	-	McCurdy (1972a)
1972	8 June-6 July	689	98	9.1	110	11.9	-	-	McCurdy (1974a)
1973	28 May-26 June	745	106	10.7	114	12.9	122	15.2	McCurdy (1974b)
1974	22 May-27 June	827	104	10.3	118	14.5	109	11.3	Bill (1975)
1975	28 May- 9 July	1,037	98	8.3	111	12.1	109	11.5	Bill (1976)
1976	22 May-26 June	833	91	7.2	107	13.4	131	22.2	Bill (1977)
1977	20 May-23 June	1,178	92	7.2	113	11.9	-	-	Yuen (1978)
1978	1 June	239	96	8.3	105	11.0	-	-	Huttenun (1980)
1982	24 May-10 July	3,222	94	8.0	100	14.7	-	-	Huttenun (1984)
1983	17 May- 5 July	2,480	94	8.0	110	12.2	133	19.1	Fried and Yuen (in press)
1984	22 May- 5 July	3,011	97	8.8	108	11.4	124	16.7	Fried et al. (in press)
		Mean	100	8.3	112	12.6	121	16.0	
1985	23 May- 1 July	6,528	96	8.7	109	11.7	119	15.6	

Table 7. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1985.
A dash (-) indicates data not available.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation (mm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
5 21	-	1	-	16 SW	-	-	0.0	murky
5 22	1	1	11 NE	11 SW	8.0-13.5	6.5- 8.0	0.0	clear
5 23	1	3	calm	8 S	5.0-15.5	8.0- 8.0	0.0	clear
5 24	2	2	calm	6 NE	3.0-11.0	9.0- 9.5	0.0	clear
5 25	4	4	calm	5 N	6.5- 8.0	9.0- 9.5	3.0	clear
5 26	3	2	6 NW	8 E	6.5-13.0	10.0-10.5	0.0	clear
5 27	4	4	calm	calm	6.5-10.5	10.5-10.0	2.0	clear
5 28	2	3	16 S	10 SW	6.0-11.0	9.0-10.5	2.0	clear
5 29	4	3	calm	13 S	6.5-10.0	10.0-10.5	1.0	clear
5 30	3	4	11 S	10 SSW	8.0- 8.0	9.0-10.0	3.0	clear
5 31	4	3	calm	calm	5.5- 9.5	9.0-10.0	5.5	clear
6 1	4	2	5 S	5 S	4.5-10.5	10.0-10.5	3.5	clear
6 2	4	4	13 NE	11 WNW	6.0-10.0	10.0-10.0	0.0	murky
6 3	4	4	13 N	19 NW	7.0-10.0	10.0- -	0.0	murky
6 4	2	3	19 NE	19 W	10.0-10.0	- -12.5	0.0	murky
6 5	3	3	13 WNE	8 NE	10.0-11.0	8.0- 9.5	0.0	murky
6 6	3	2	calm	8 W	6.7-12.0	8.7-11.5	0.0	murky
6 7	5	4	21 SSW	8 WSW	4.0- 7.0	9.0- 7.5	3.0	murky
6 8	2	2	calm	16 S	7.2-11.0	8.0-10.0	3.0	murky
6 9	1	2	calm	16 ENE	8.3-11.0	9.0-10.0	0.0	murky
6 10	1	3	calm	11 ENE	7.2-13.0	9.0-10.5	0.0	murky
6 11	3	3	calm	8 NNW	6.7-14.0	10.0-11.5	0.0	murky
6 12	5	4	16 SSW	11 S	8.0- 6.0	10.0- 9.0	0.0	murky
6 13	4	3	8 SSW	5 SSW	4.2-10.0	9.0- 9.5	0.0	murky

-Continued-

Table 7. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1985.
A dash (-) indicates data not available (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation (mm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
6 14	4	4	calm	calm	6.7- 8.0	9.0-10.0	3.0	murky
6 15	4	3	calm	5 N	6.7-11.0	10.0-10.5	11.0	murky
6 16	3	3	calm	5 SW	8.0- 9.0	10.0-10.8	4.0	murky
6 12	5	4	16 SSW	11 S	8.0- 6.0	10.0- 9.0	0.0	murky
6 13	4	3	8 SSW	5 SSW	4.2-10.0	9.0- 9.5	0.0	murky
6 14	4	4	calm	calm	6.7- 8.0	9.0-10.0	3.0	murky
6 15	4	3	calm	5 N	6.7-11.0	10.0-10.5	11.0	murky
6 16	3	3	calm	5 SW	8.0- 9.0	10.0-10.8	4.0	murky
6 17	1	2	-	16 SW	- -13.3	- -12.0	-	murky
6 18	3	4	16 SW	5 SE	10.6-10.6	10.5-10.8	1.0	clear
6 19	4	4	8 NE	19 S	10.0-12.2	10.0-11.0	1.0	murky
6 20	4	3	calm	5 SE	7.7- 9.0	10.0-11.0	14.0	clear
6 21	4	3	5 SE	13 S	6.0-10.0	10.0-11.5	2.0	clear
6 22	5	3	6 S	15 N	6.0-12.0	10.0-11.0	0.0	clear
6 23	4	3	calm	11 NNW	7.7-11.0	11.0-11.5	3.0	clear
6 24	2	3	16 NNE	8 NW	6.7-14.5	10.5-11.0	1.0	clear
6 25	3	2	calm	21 SSW	10.0-13.0	11.5-12.0	1.0	clear
6 26	4	3	8 SW	calm	5.5-17.0	10.5-12.0	1.0	clear
6 27	2	3	calm	calm	3.3 19.0	11.5-13.0	0.0	clear
6 28	4	3	calm	10 NNW	12.8-19.0	13.0-14.0	0.0	clear
6 29	3	3	calm	11 SW	15.0-21.0	13.5-15.0	0.0	clear
6 30	5	3	calm	8 W	11.7-21.0	14.0-16.0	2.0	clear
7 1	4	3	calm	11 SSW	15.6-13.0	14.0-14.0	0.0	clear
7 2	4	4	calm	8 W	8.9- 9.0	13.0-12.0	5.0	clear
7 3	4	-	calm	-	10.0- -	12.0- -	-	clear

- a/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Table 8. Water temperatures at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1967-1985. A dash (-) indicates data not available.

Year	Sample Period	Water Temperature (C)			Reference
		Minimum	Maximum	Mean	
1967	27 May-11 July	10.6	15.0	13.0	Van Valin (1969a)
1968	21 May-14 July	7.2	16.7	12.9	Van Valin (1969b)
1969	27 May-16 July	6.7	13.9	11.0	Siedelman (1972)
1970	27 May-16 June	11.1	14.4	12.1	Biwer (1972)
1971	7 June- 7 July	4.4	10.0	7.2	McCurdy (1972a)
1972	8 June- 6 July	6.7	14.4	10.1	McCurdy (1974a)
1973	29 May-26 June	6.9	15.9	11.1	McCurdy (1974b)
1974	21 May-27 June	8.1	14.3	12.1	Bill (1975)
1975	28 May- 9 July	3.5	13.2	9.0	Bill (1976)
1976	22 May-26 June	4.6	12.8	9.5	Bill (1977)
1982	21 May-10 July	5.0	14.4	8.9	Huttenun (1984)
1983	20 May- 6 July	8.0	16.0	12.8	Fried and Yuen (in press)
1984	19 May- 6 July	7.5	16.0	13.0	Fried et al. (in press)
	Mean	6.9	14.4	11.0	
1985	21 May- 3 July	6.5	16.0	10.5	

Table 9. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Egegik River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date a/	Inshore	Center	Offshore	Total
5 23	131	103	6	240
5 24	87,842	256,017	34,765	378,624
5 25	15,539	22,916	11,021	49,476
5 26	3,348	8,094	373	11,815
5 27	897,248	523,564	15,856	1,436,668
5 28	29,017	60,714	6,976	96,707
5 29	151,889	264,610	6,566	423,065
5 30	662,833	464,939	97,066	1,224,838
5 31	10,820	39,035	39,682	89,537
6 1	12,597	38,902	34,121	85,620
6 2	24,371	28,034	3,798	56,203
6 3	26,425	36,495	2,988	65,908
6 4	17,755	31,391	5,130	54,276
6 5	25,210	44,032	7,275	76,517
6 6	3,653	11,151	10,393	25,197
6 7	925	546	617	2,088
6 8	3,668	278	117	4,063
6 9	15,718	63,034	1,645	80,397
6 10	2,430	614	253	3,297
6 11	841	145	217	1,203
Total	1,992,260	1,894,614	278,865	4,165,739
Percent	47.82	45.48	6.69	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Velocity correction factors remained constant throughout the season. The inshore, center, and offshore velocities on 19 May were 0.51, 0.59, and 0.61 meters per second, respectively (1.67, 1.93, and 2.00 ft/sec). The arrays were corrected to the center array, thus the velocity correction factors were 0.84, 1.00, and 1.04 for the inshore, center, and offshore arrays. The velocity correction factors remained the same until 6 June when the inshore velocity correction factor was adjusted to 0.97.

The final estimate of seaward migrating sockeye salmon smolt was 66,073,528 (Table 10). Estimated age composition was 82.6% age I (1983 brood year), 17.3% age II (1982 brood year), and 0.1% age III (1981 brood year). The percentage of age III smolt was highest during the early days of the project and slowly decreased as the project continued. The percentage of age I smolt showed a slight increase as the project progressed. Consequently, the estimated smolt per count increased only slightly between the beginning and end of counting (Table 11). Total smolt production from the 1980 and 1981 brood years was 62.4 and 49.7 smolt per spawner, respectively (Table 12).

A total of 5,427 sockeye salmon smolt were sampled for age, weight, and/or length information (Table 13). Seasonal mean weights were 10.4, 16.8, and 24.1 g for the age I, age II, and age III groups, respectively. Mean lengths were 106, 124, and 138 mm for the ages I, II, and III, respectively. Average size of Egegik smolt was larger than historically observed for all age classes (Table 14). No coho salmon smolts were observed in the samples.

Weather and river conditions were recorded at the sonar site during 17 May through 12 June (Table 15). Shore ice was present in the western shore of Lake Becharof and ice fragments were floating past the sonar site when observations were begun on 17 May. Ice was present until 22 May. Mean air and water temperature during this time was 5.9°C (range 1.0 to 12.8) and 4.2°C (range 2.5 to 7.5), respectively.

Ugashik River

A total of 3,696,047 counts were tabulated between 22 May and 17 June at the Ugashik site (Table 16). The counts were nearly equally divided between the two arrays (43% over the inshore and 57% over the offshore). No side scan sonar data was collected this season, but visual observations indicated that smolt lateral distribution across the sampling transect had shifted towards the north bank. A distinct eddie was still evident on the south bank this season, the interface of which was considered the edge of smolt lateral distribution. Side scan data collected during the 1983 and 1984 seasons indicated equal numbers of smolt passing at this current interface as migrating over the offshore array, consequently, the outmigration estimate was modified to take into account this observation. It was estimated that the majority of smolt passed between 7.6 and 30.5 meters of the north bank.

River velocity changed slightly during this project. The observed velocities on 22 May were 1.25 meters per second over the inshore array and 1.38 meters per second over the offshore array (4.10 and 4.53 ft/sec, respectively). The velocities were corrected to the inshore array, consequently, the velocity correction factors were 1.00 and 1.10 for the inshore and offshore arrays. The velocities recorded on 4 June were 1.50 and 1.33 meters per second (4.93 and 4.37 ft/sec) for the inshore and offshore arrays, respectively. The

Table 10. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Egegik River, Bristol Bay, Alaska, 1985.

Date a/	Age I		Age II		Age III		All Ages	
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 19	0		0		0		0	0
5 20	0		0		0		0	0
5 21	0		0		0		0	0
5 22	0		0		0		0	0
5 23	2,436	73.26	889	26.74	0		3,325	3,325
5 24	3,482,176	73.26	1,270,999	26.74	0		4,753,176	4,756,501
5 25	476,074	73.26	173,767	26.74	0		649,842	5,406,343
5 26	143,954	84.36	26,688	15.64	0		170,643	5,576,987
5 27	20,833,948	85.41	3,507,283	14.38	51,219	.21	24,392,451	29,969,439
5 28	791,769	67.85	373,483	32.01	1,633	.14	1,166,886	31,136,325
5 29	5,384,052	82.16	1,168,679	17.84	0		6,552,732	37,689,057
5 30	16,693,042	82.16	3,623,445	17.84	0		20,316,488	58,005,546
5 31	1,131,688	85.37	193,939	14.63	0		1,325,627	59,331,173
6 1	1,036,036	83.34	207,182	16.67	0		1,243,218	60,574,392
6 2	720,516	83.34	144,086	16.67	0		864,602	61,438,995
6 3	657,798	72.03	255,430	27.97	0		913,228	62,352,223
6 4	714,303	86.86	108,058	13.14	0		822,361	63,174,585
6 5	1,007,895	86.86	152,472	13.14	0		1,160,368	64,334,953
6 6	324,036	86.86	49,019	13.14	0		373,056	64,708,009
6 7	30,364	86.86	4,593	13.14	0		34,957	64,742,967
6 8	69,132	86.86	10,458	13.14	0		79,590	64,822,557
6 9	1,014,467	86.86	153,466	13.14	0		1,167,934	65,990,492
6 10	52,934	86.86	8,007	13.14	0		60,942	66,051,434
6 11	19,208	86.86	2,905	13.14	0		22,113	66,073,548
Total	54,585,828	82.61	11,434,848	17.31	52,852	0.08	66,073,528	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 11. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Egegik River, Bristol Bay, Alaska, 1985.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 23	No Sample	3.1
5 24	13.3	3.1
5 25	13.3	3.1
5 26	11.7	3.5
5 27	11.1	3.7
5 28	14.1	2.9
5 29	11.1	3.7
5 30	11.1	3.7
5 31	11.3	3.6
6 1	11.6	3.5
6 2	11.6	3.5
6 3	12.7	3.2
6 4	11.4	3.6
6 5	11.4	3.6
6 6	No Sample	3.6
6 7	No Sample	3.6
6 8	No Sample	3.6
6 9	No Sample	3.6
6 10	No Sample	3.6
6 11	No Sample	3.6

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 12. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1978-1983 brood years, Egegik River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1978	895,698	-	-	225,522	-	-
1979	1,032,042	-	14,287,075	0	-	-
1980	1,060,860	49,457,563 (74)	16,524,563 (25)	197,429	66,179,555	62.38
1981	694,680	2,242,326 (7)	32,235,734 (93)	52,852	34,530,912	49.71
1982	1,034,628	17,234,269	11,434,848			
1983	792,282	54,585,828				

Table 13. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Egegik River, Bristol Bay, Alaska, 1985.

Date a/	Age I					Age II					Age III				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 24	108	0.4	10.8	0.1	102	131	2.6	19.8	1.2	23					
5 25	107	0.3	10.8	0.1	235	133	1.0	20.7	0.5	127					
5 26	106	0.2	10.5	0.1	399	127	1.1	18.2	0.5	74					
5 27	106	0.2	10.4	0.1	410	120	1.3	15.4	0.5	69	138		23.8		1
5 28	105	0.2	10.4	0.1	494	135	0.8	22.1	0.4	233	145		29.0		1
5 29	106	0.4	10.3	0.1	85	113	3.5	12.5	1.1	15					
5 30	105	0.2	10.3	0.1	641	127	1.0	18.3	0.4	167					
5 31	105	0.2	10.4	0.1	356	124	1.6	17.1	0.7	61					
6 1	107	0.3	10.9	0.1	270	119	1.7	14.8	0.6	51					
6 2	106	0.2	10.6	0.1	336	125	1.6	16.9	0.6	71					
6 3	107	0.2	11.1	0.1	327	125	1.2	17.0	0.4	127					
6 4	105	0.2	10.4	0.1	357	130	1.9	19.0	0.7	54					
6 5	106	0.3	10.0	0.1	250	130	1.5	19.3	0.6	91					
Totals					4262					1163					2
Means	106		10.4			124		16.8			138		24.1		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 14. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Egegik River, Bristol Bay, Alaska, 1939-1985. A dash (-) indicates data not available.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1939	-	-	96	-	105	-	-	-	USF&WS (unpublished)
1956	-	386	101	-	116	-	123	-	"
1957	-	236	107	-	120	-	130	-	"
1959	-	281	99	-	116	-	123	-	"
1960	-	159	106	-	115	-	140	-	"
1969	-	67	99	-	119	-	115	-	Paulus (1972)
1977	27-29 May	299	110	11.3	116	13.3	-	-	ADF&G (unpublished)
1978	19-22 May	319	104	10.1	122	15.4	130	18.1	Huttunen (1980)
1981	15 May- 6 June	549	105	9.1	122	16.6	128	19.1	Bue (1982)
1982	27 May-15 June	881	104	9.2	130	17.1	145	23.5	Bue (1984)
1983	17 May- 9 June	2,631	101	9.3	116	13.6	-	-	Fried and Yuen (in press)
1984	10 May-10 June	3,602	106	10.1	112	12.2	134	20.2	Fried et al. (in press)
			—	—	—	—	—	—	
		Mean	103	9.9	117	14.7	130	20.2	
1985	24 May- 5 June	5,427	106	10.4	123	16.8	138	24.1	

Table 15. Climatological and hydrological observations made at sockeye salmon smolt counting site, Egegik River, Bristol Bay, Alaska, 1985.
A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Mean Water Temp. (C)	Precipitation (cm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
5 17	4	-	72 S	72 S	-	-	-	clear
5 18	4	4	24 WNW	32 WNW	3	4.0	trace	murky
5 19	4	2	40 NW	16 NW	2	2.5	0	murky
5 20	1	-	16 S	-	-	-	0	clear
5 21	1	-	8 S	-	2	3.5	0	clear
5 22	1	-	8 S	-	3	4.0	0	clear
5 23	1	1	8 S	16 S	1	3.0	0	clear
5 24	1	4	8 S	16 S	4	4.0	trace	clear
5 25	4	3	11 S	8 E	7	4.0	.13	clear
5 26	2	1	calm	24 SE	5	4.0	0	clear
5 27	4	4	56 S	56 S	4	4.0	.15	clear
5 28	2	3	32 SE	32 SE	6	4.0	0	clear
5 29	4	-	calm	-	4	4.0	0	clear
5 30	4	4	32 SE	16 SE	4	3.0	.33	clear
5 31	3	4	16 SE	8 SE	4	4.0	.33	clear
6 1	3	3	calm	32 E	4	4.0	0	clear
6 2	3	4	calm	calm	6	4.0	0	clear
6 3	4	3	8 NE	24 SE	7	4.0	.42	clear
6 4	3	4	calm	16 SE	7	4.0	.06	clear
6 5	3	2	8 SE	24 E	10	4.0	.09	clear
6 6	4	3	8 SE	8 NW	7	4.5	.39	clear
6 7	4	4	8 SW	8 SW	5	5.0	trace	clear
6 8	3	3	16-24 E	16-24 SE	6	4.5	trace	clear

-Continued-

Table 15. Climatological and hydrological observations made at sockeye salmon smolt counting site, Egegik River, Bristol Bay, Alaska, 1985.
A dash (-) indicates missing data (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Mean Water Temp. (C)	Precipitation (cm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
6 9	2	-	24-32 E	-	4	4.5	0	clear
6 10	2	3	16 NE	16-24 NE	9	4.5	0	clear
6 11	4	4	calm	16 NW	10	4.5	0	clear
6 12	4	-	24-32 S	-	4	5.0	trace	clear

a/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Table 16. Sonar counts recorded from two 10 transducer arrays at the sockeye salmon smolt counting site on the Ugashik River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts			
Transducer Array			
Date a/	Inshore	Center	Total
5 22	4,619	2,361	6,980
5 23	11,775	3,238	15,013
5 24	13,697	6,276	19,973
5 25	1,981	634	2,615
5 26	4,472	1,136	5,608
5 27	9,455	1,637	11,092
5 28	11,946	2,639	14,585
5 29	96,331	102,095	198,426
5 30	180,715	201,550	382,265
5 31	56,388	30,571	86,959
6 1	9,502	101,323	110,825
6 2	4,280	25,626	29,906
6 3	50,702	82,450	133,152
6 4	293,371	419,273	712,644
6 5	108,667	502,427	611,094
6 6	225,880	16,535	242,415
6 7	10,279	11,221	21,500
6 8	100,632	249,065	349,697
6 9	14,347	37,039	51,386
6 10	81,266	111,222	192,488
6 11	154,364	22,854	177,218
6 12	6,112	533	6,645
6 13	36,971	4,398	41,369
6 14	43,879	2,041	45,920
6 15	31,476	29,822	61,298
6 16	29,939	117,643	147,582
6 17	12,712	4,680	17,392
Total	1,605,758	2,090,289	3,696,047
Percent	43.45	56.55	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

correction factors of 1.00, and 0.89 were used for the remainder of the season.

The final estimate of seaward migrating sockeye salmon smolt was 34,101,390 (Table 17). Estimated age composition was 37.2% age I (1983 brood year) and 62.8% age II (1982 brood year). No age III smolt were observed this season. The percentage of age I smolt declined with time while the percent of age II increased as the season progressed. This was the opposite of what was observed on the other two systems. The estimated number of smolt per sonar count is summarized in Table 18. Total smolt production from the 1981 brood year was 85.9 smolt per spawner (Table 19).

A total of 3,473 sockeye salmon smolt were sampled for age, weight, and/or length information (Table 20). The mean weight of age I and age II smolts was estimated at 8.3 and 11.8 g, respectively. Mean length was estimated at 94 and 107 mm for the age I and age II smolts, respectively. Age I smolt were larger than historically observed while age II smolt were smaller (Table 21). No coho salmon were observed in the samples.

Climatological and hydrological observations were made at the sonar site from 17 May through 9 June (Table 22). More than half of Lower Ugashik Lake was covered with ice when observations began. Ice continued to flow past the sonar site through 21 May. Average air temperature for the time period was 5.0°C (range - 1.0 to 8.5) with an average water temperature of 4.3°C (range - 1.0 to 7.0).

Post-season Analysis

The 1982, 1984, and 1985 adjusted sonar counts by hour from the Egegik River were used in the study (1983 counts were found in the data library at the time of the analysis). The data were examined as counts (biomass) and standardized to percent of total counts for the time period examined in order to simplify the analysis. All of the accompanying figures were consistently designed; 1) the top plot is a time series of data from all three years, while 2) the bottom plot is an empirical curve, fit to the average of the three years.

Initially, counts were summed by hour for the time period 10 May through 15 June (Figure 1). These results indicated that counts were greatest between 2000 hours and 0700 hours although never low enough during the midday hours to justify not counting. The data were next examined for temporal changes as seaward migration progressed. The hourly counts were grouped by five-day periods and again plotted (10-14, 15-19, 20-24, 25-29 May, 30 May - 3 June, 4-8, and 9-13 June). Figures 2, 3, 4, and 7 show a diurnal pattern with peak migration occurring between 2000 and 0600 hours and periods of low passage during the midday hours. Figures 5 and 6 show an unpredictable seaward migration pattern.

Further insight was gained by examining total daily counts through time (Figure 8) and comparing this run timing to the daily timing of Figures 2-7. The diurnal migration pattern was most apparent during periods when daily migration was low, while the unpredictable patterns occur when seaward migration was greatest.

Table 17. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1985.

Date a/	Age I		Age II		All Ages	
	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 22	50,759	67.38	24,576	32.62	75,335	75,335
5 23	105,915	67.38	51,281	32.62	157,196	232,531
5 24	144,396	67.38	69,913	32.62	214,309	446,840
5 25	18,572	67.38	8,992	32.62	27,564	474,404
5 26	39,433	67.38	19,092	32.62	58,525	532,929
5 27	52,409	50.90	50,562	49.10	102,971	635,900
5 28	69,500	50.90	67,051	49.10	136,551	772,451
5 29	1,025,481	50.90	989,349	49.10	2,014,830	2,787,281
5 30	1,981,452	50.90	1,911,636	49.10	3,893,088	6,680,369
5 31	377,716	45.34	455,358	54.66	833,074	7,513,443
6 1	547,183	45.34	659,662	54.66	1,206,845	8,720,288
6 2	78,054	27.22	208,753	72.79	286,807	9,007,095
6 3	329,656	27.22	881,647	72.79	1,211,303	10,218,398
6 4	1,496,311	27.22	4,001,802	72.79	5,498,113	15,716,511
6 5	1,701,220	32.79	3,487,008	67.21	5,188,228	20,904,739
6 6	823,160	35.43	1,500,183	64.57	2,323,343	23,228,082
6 7	74,423	35.43	135,634	64.57	210,057	23,438,139
6 8	1,220,168	35.43	2,223,716	64.57	3,443,884	26,882,023
6 9	179,360	35.43	326,879	64.57	506,239	27,388,262
6 10	667,873	35.43	1,217,177	64.57	1,885,050	29,273,312
6 11	603,337	35.43	1,099,562	64.57	1,702,899	30,976,211
6 12	22,575	35.43	41,143	64.57	63,718	31,039,929
6 13	140,704	35.43	256,428	64.57	397,132	31,437,061
6 14	155,770	35.43	283,886	64.57	439,656	31,876,717

-Continued-

Table 17. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I		Age II		All Ages	
	Number	Percent	Number	Percent	Daily Total	Cumulative Total
6 15	211,872	35.43	386,129	64.57	598,001	32,474,718
6 16	516,765	35.43	941,788	64.57	1,458,553	33,933,271
6 17	59,564	35.43	108,555	64.57	168,119	34,101,390
Total	12,693,628	37.22	21,407,762	62.78	34,101,390	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 18. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Ugashik River, Bristol Bay, Alaska, 1985.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 22	No Sample	4.6
5 23	9.0	4.6
5 24	9.0	4.6
5 25	9.0	4.6
5 26	9.0	4.6
5 27	No Sample	4.1
5 28	10.0	4.1
5 29	10.0	4.1
5 30	10.0	4.1
5 31	10.2	4.1
6 1	10.2	4.1
6 2	11.5	3.6
6 3	No Sample	3.6
6 4	11.5	3.6
6 5	10.5	3.9
6 6	9.0	4.6
6 7	9.0	4.6
6 8	No Sample	4.6
6 9	9.0	4.6
6 10	No Sample	4.6
6 11	9.0	4.6
6 12	No Sample	4.6
6 13	No Sample	4.6
6 14	No Sample	4.6
6 15	No Sample	4.6
6 16	9.0	4.6
6 17	No Sample	4.6

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 19. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1979-1983 brood years, Ugashik River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1979	1,700,904	-	-	0	-	
1980	3,321,384	-	12,736,379	26,384	-	
1981	1,326,762	31,297,432 (27)	82,656,993 (73)	0	113,954,425	85.89
1982	1,157,526	75,491,249	21,407,762			
1983	1,000,614	12,693,628				

Table 20. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1985.

Date a/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std. Error	Sample Size
5 23	94	0.5	7.6	0.1	70	111	1.4	11.8	0.5	30
5 24	92	0.9	7.6	0.2	30	104	2.6	10.2	0.5	7
5 25	92	0.5	7.9	0.1	151	107	1.1	11.7	0.3	53
5 26	94	0.4	8.4	0.1	131	107	0.5	12.0	0.1	164
5 28	98	1.0	8.8	0.6	7	109	1.7	11.4	0.5	15
5 29	94	0.3	8.5	0.1	188	106	0.5	11.8	0.1	142
5 30	91	0.4	8.0	0.1	131	106	0.8	11.7	0.2	74
5 31	92	0.8	8.0	0.2	43	106	0.8	11.7	0.2	57
6 1	94	0.3	8.2	0.1	175	108	0.5	12.2	0.1	192
6 2	92	0.7	8.0	0.1	55	110	0.5	13.0	0.1	140
6 4	93	0.4	8.2	0.1	129	109	0.3	12.4	0.1	363
6 5	93	0.3	8.0	0.1	140	106	0.3	11.7	0.1	287
6 6	108	1.2	12.4	0.4	21	105	1.3	11.7	0.4	29
6 7	92	0.4	7.8	0.1	114	108	0.3	12.3	0.1	281
6 9	87	0.7	6.7	0.2	65	106	1.4	11.6	0.4	34
6 11	88	0.6	7.2	0.1	38	103	2.0	10.6	0.5	17
6 16	89	0.5	7.5	0.1	72	103	1.0	11.1	0.3	28
Totals					1,560					1,913
Means	94		8.3			107		11.8		

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a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 21. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Ugashik River, Bristol Bay, Alaska, 1958-1985. A dash (-) indicates data not available.

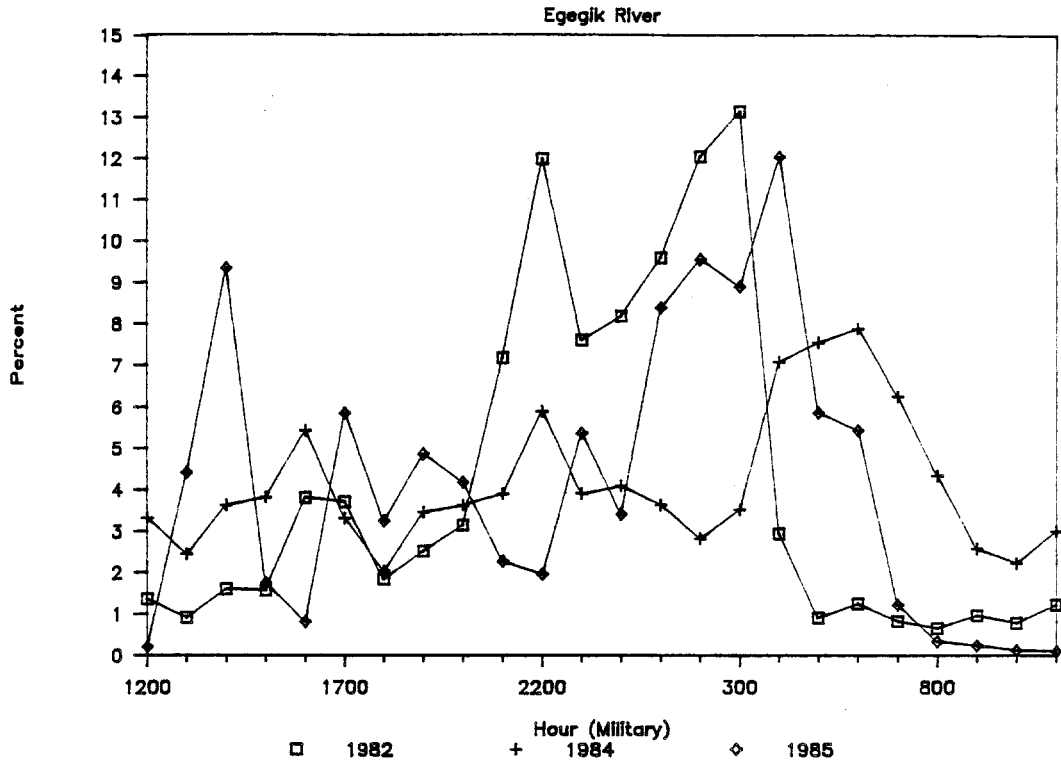
Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1958	-	-	93	6.4	112	11.7	-	-	USF&WS (unpublished)
1959	-	-	90	6.1	120	13.5	-	-	"
1960	-	-	90	6.6	104	11.0	-	-	"
1961	-	-	90	6.7	112	12.2	-	-	"
1962	12 May-28 June	1,070	88	6.1	112	12.3	-	-	Jaenicke (1963)
1963	5 May-26 June	921	90	6.1	104	9.6	-	-	Nelson and Jaenicke (1965)
1964	15 May-20 June	4,042	92	6.9	118	12.7	-	-	Nelson (1965)
1965	13 May-20 June	3,296	94	6.9	114	12.5	-	-	Nelson (1966)
1967	15 May-12 June	966	88	6.0	113	12.2	-	-	Nelson (1969)
1968	13 May-24 June	6,727	93	6.5	113	10.7	-	-	Siedelman (1969)
1969	23 May- 6 June	567	97	7.5	121	14.5	-	-	Schroeder (1972a)
1970	15 May-10 June	907	97	7.7	125	15.9	-	-	Schroeder (1972b)
1972	28 May-20 June	615	81	5.0	112	11.2	129	14.3	Schroeder (1974a)
1973	17 May-12 June	1,189	93	7.2	113	11.9	132	20.1	Schroeder (1974b)
1974	17 May-17 June	355	94	7.4	119	13.6	-	-	Schroeder (1975)
1975	3-13 June	-	96	7.2	116	13.0	125	16.7	Sanders (1976)
1982	6- 8 June	512	88	6.3	113	13.0	138	22.5	Eggers (1984)
1983	21 May-16 June	9,502	89	7.6	111	13.2	-	-	Fried and Yuen (in press)
1984	23 May-16 June	4,810	87	6.8	102	10.3	103	11.7	Fried et al. (in press)
			—	—	—	—	—	—	
		Mean	91	6.7	113	12.4	125	17.1	
1985	22 May-17 June	3,473	94	8.3	107	11.8	-	-	

Table 22. Climatological and hydrological observations made at sockeye salmon smolt counting site, Ugashik River, Bristol Bay, Alaska, 1985. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr			
5 17	4	3	56 SE	48 SSE	3.0- 5.0	1.5-1.0	clear
5 18	4	4	3 SE	24 WNW	2.0- 2.0	1.0-1.0	clear
5 19	4	2	24 W	3 W	-1.0- 0.0	2.0-2.0	clear
5 20	1	2	calm	32 SE	7.0- 6.0	2.0-3.5	clear
5 21	3	2	32 SE	32 SE	4.0- -	3.0- -	clear
5 22	1	1	32 ESE	8 E	- - 7.5	2.0-4.5	clear
5 23	1	2	calm	8 E	- - 7.0	3.0-4.0	clear
5 24	3	4	8 E	16 E	5.5- 5.0	4.5-4.5	clear
5 25	3	3	8 E	8 W	5.0- 7.0	4.5-5.0	clear
5 26	3	2	calm	8 SE	5.5- 5.0	4.0-4.0	clear
5 27	4	3	56 SE	56 SE	5.0- 7.0	4.5-5.0	clear
5 28	2	3	8 SE	8 S	6.0- 5.0	4.5-4.5	clear
5 29	3	-	8 SE	-	5.0- -	4.0- -	clear
5 30	3	4	13 SE	26 SE	8.5- 5.0	6.0-6.0	clear
5 31	4	3	8 SE	8 SE	4.0- 8.0	5.0-5.0	clear
6 1	4	4	3 SE	24 SE	3.0- 5.0	4.5-6.5	clear
6 2	4	4	24 E	24 E	5.0- 6.5	5.5-6.0	clear
6 3	4	4	8 N	24 E	6.0- 7.5	5.0-6.0	clear
6 4	4	4	16 N	16 E	6.0- 6.5	5.0-5.5	clear
6 5	4	4	16 E	16 E	6.0- 4.0	5.5-5.0	clear
6 6	4	4	8 E	16 NW	3.0- 6.0	4.5-5.0	clear
6 7	4	3	16 E	8 W	3.0- 4.5	4.5-4.5	clear
6 8	3	3	8 SE	32 E	5.0- -	4.0- -	clear
6 9	2	3	16 SE	8 SE	6.0- 5.0	6.0-7.0	clear

a/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Seasonal Average Sonar Counts by Hour



Average Sonar Counts by Hour

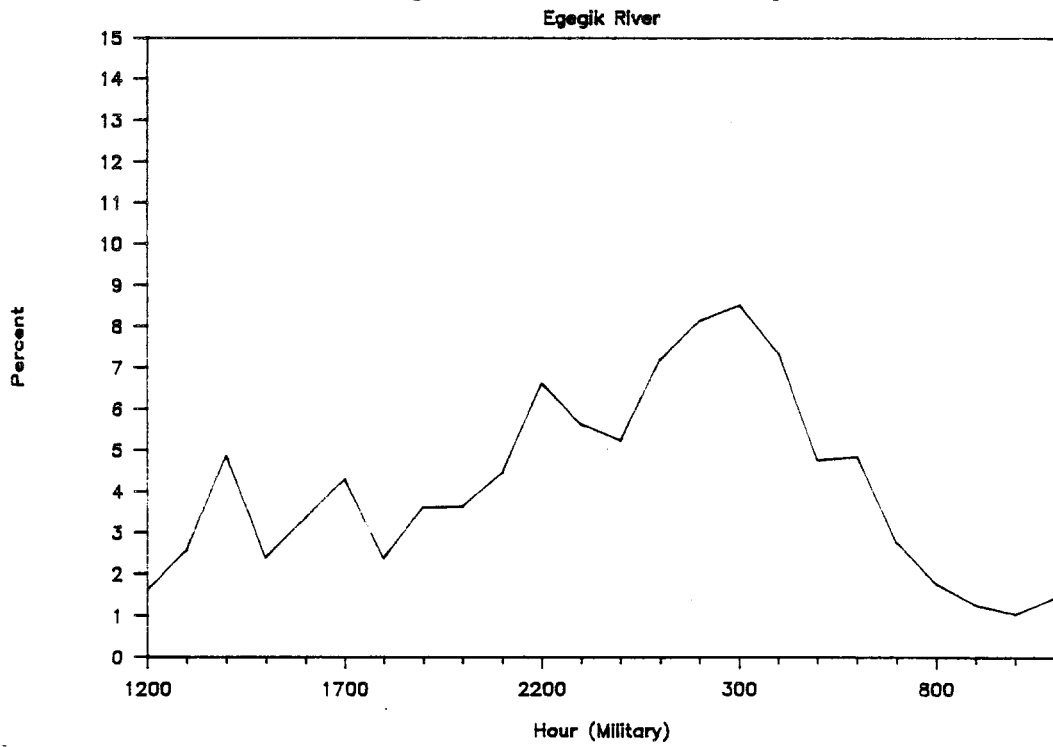
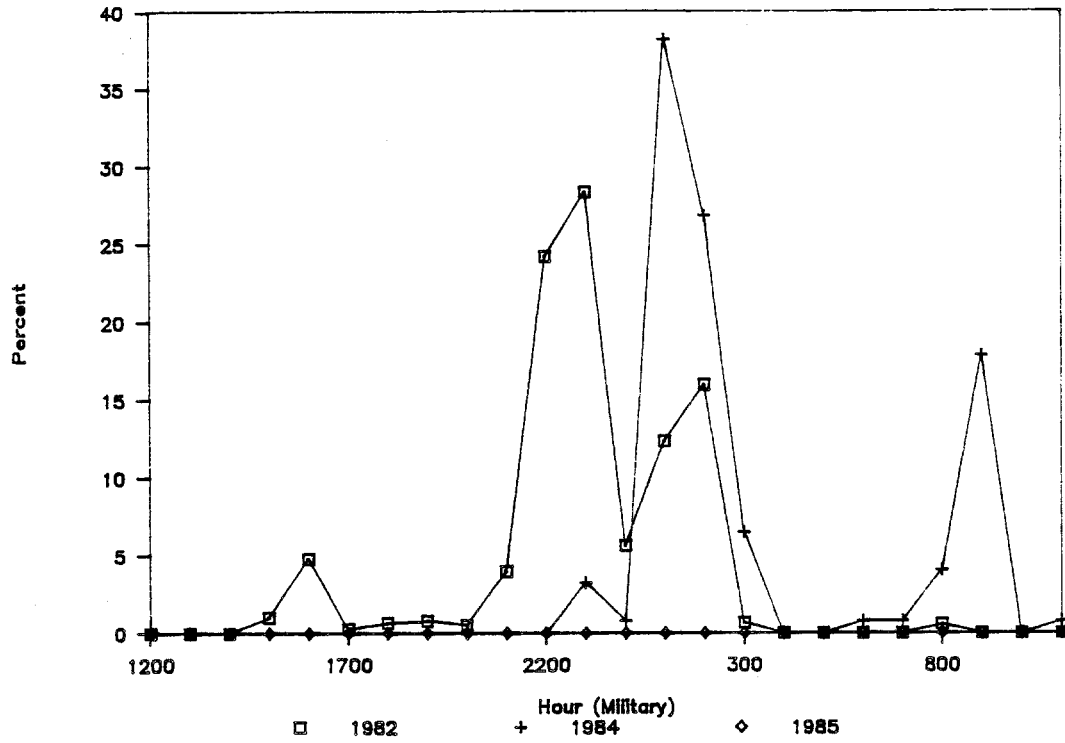


Figure 1. Seasonal average sonar counts by hour, Egegik River, 1982, 1984, and 1985.

Egegik Smolt May 15-19



Averaged Egegik Smolt May 15-19

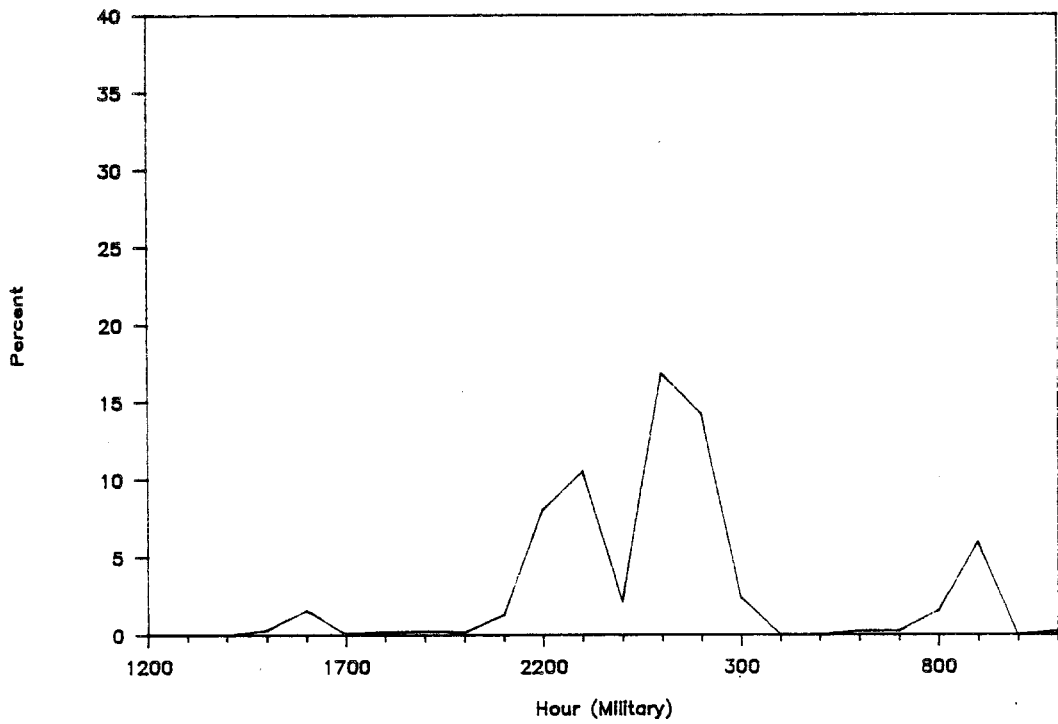
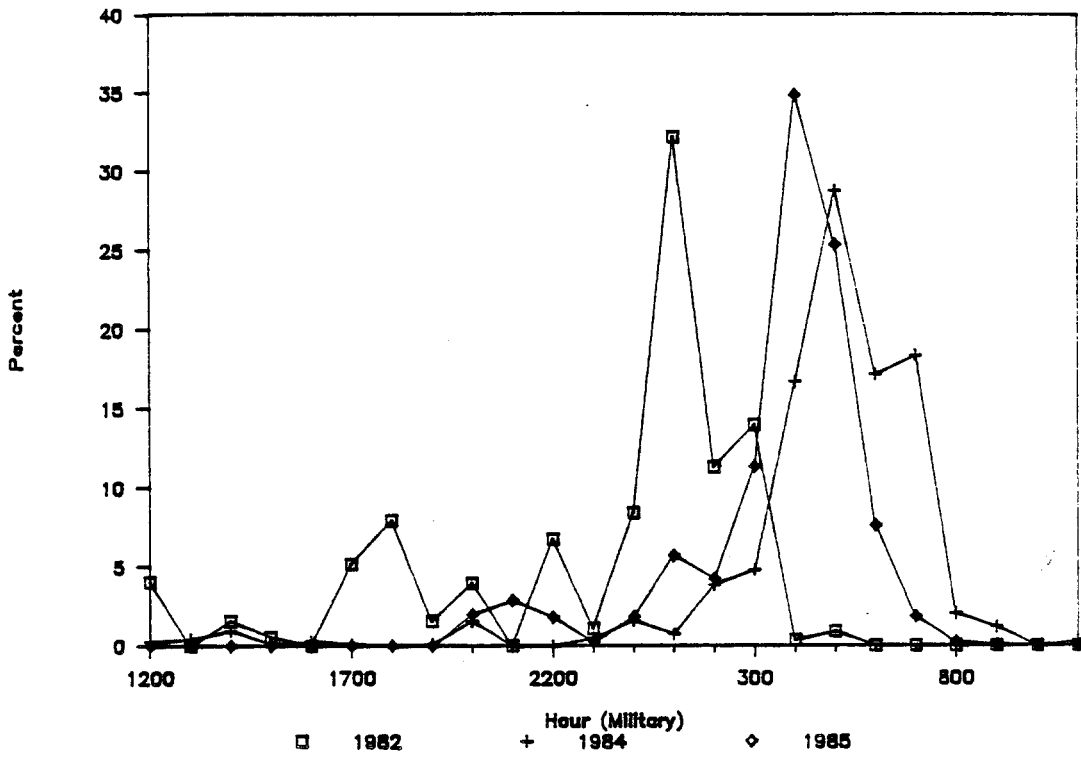


Figure 2. Smolt sonar counts by hour for 15 through 19 May, Egegik River, 1982, 1984, and 1985.

Egegik Smolt May 20-24



Averaged Egegik Smolt May 20-24

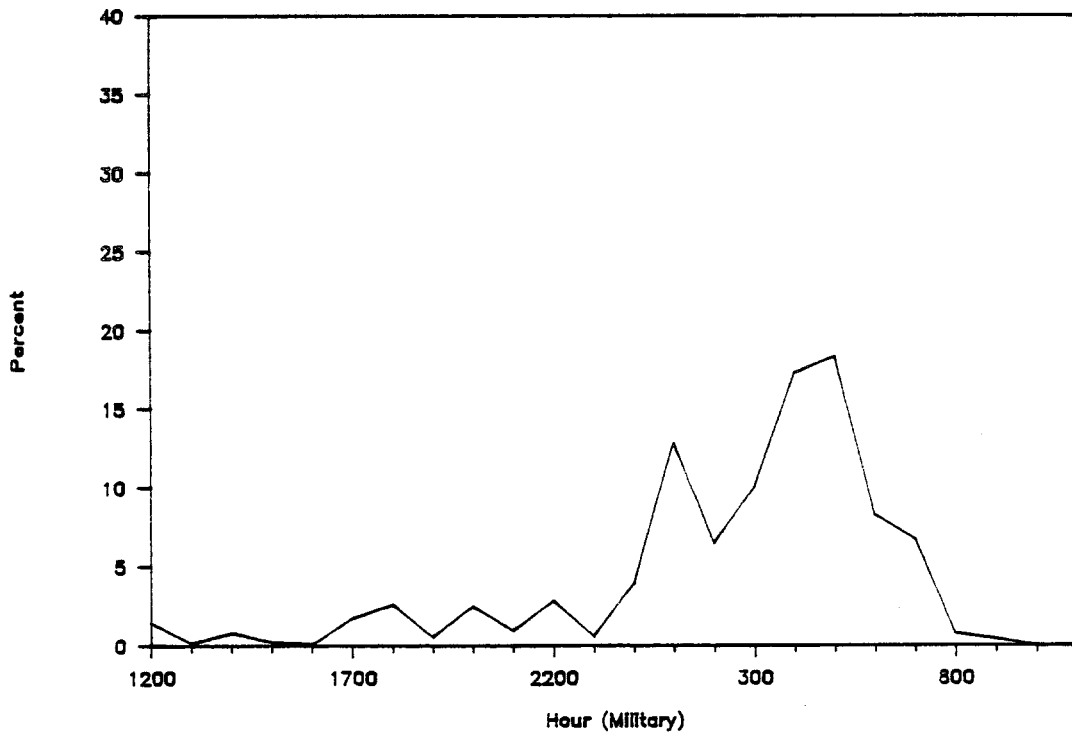
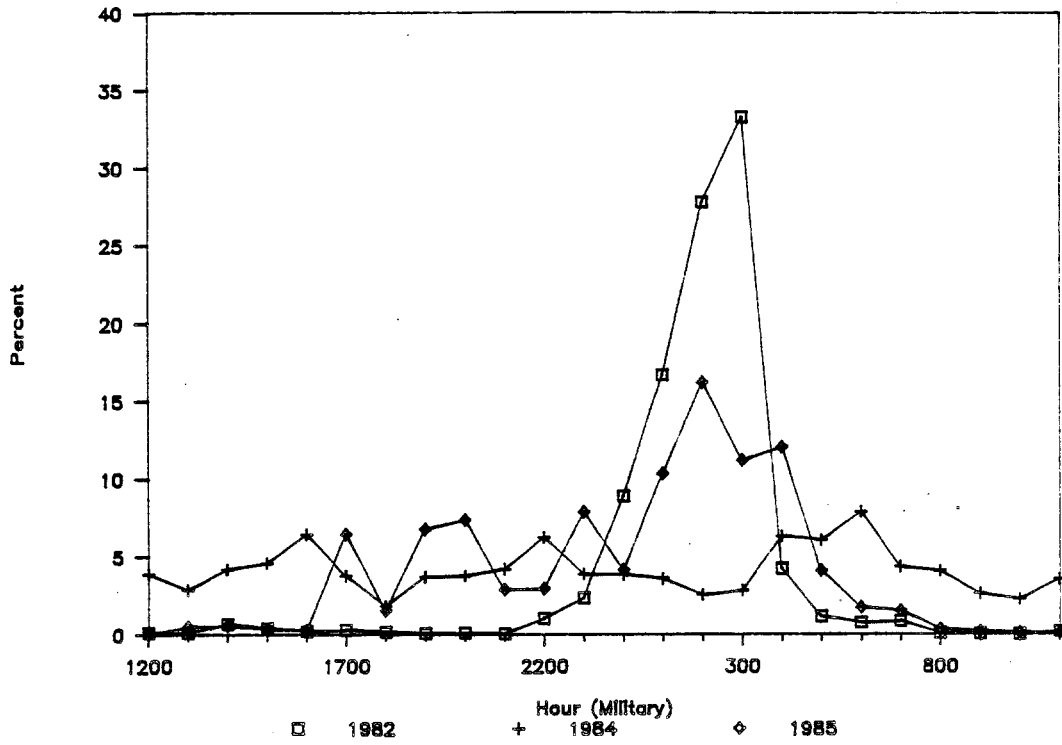


Figure 3. Smolt sonar counts by hour for 20 May through 24 May, Egegik River, 1982, 1984, and 1985.

Egegik Smolt May 25-29



Averaged Egegik Smolt May 25-29

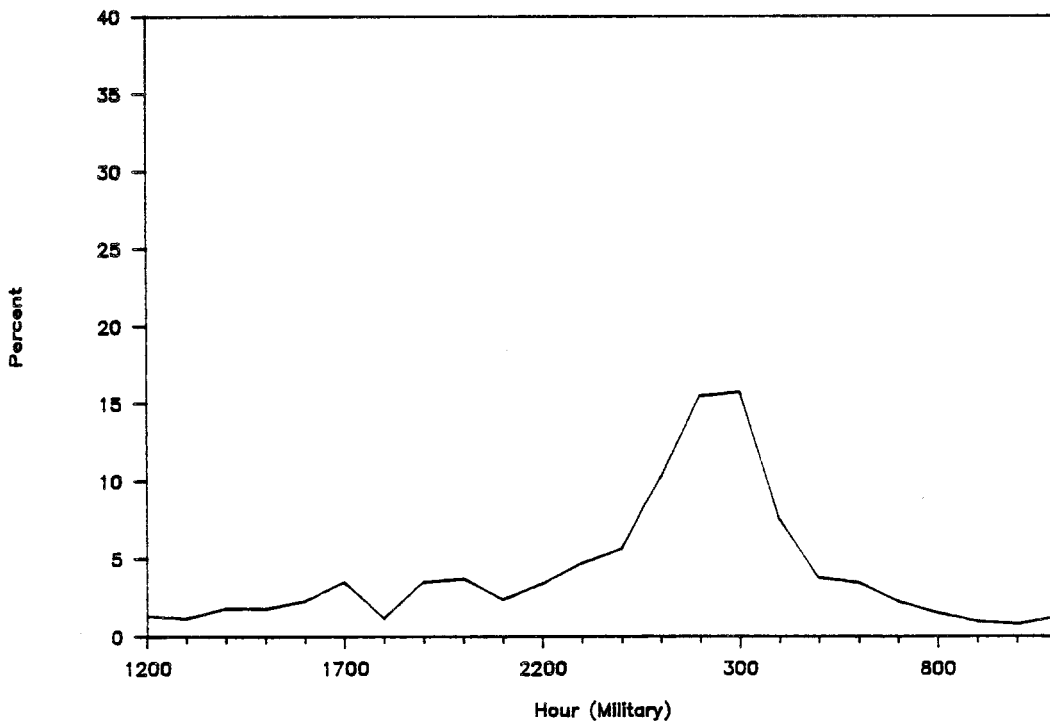
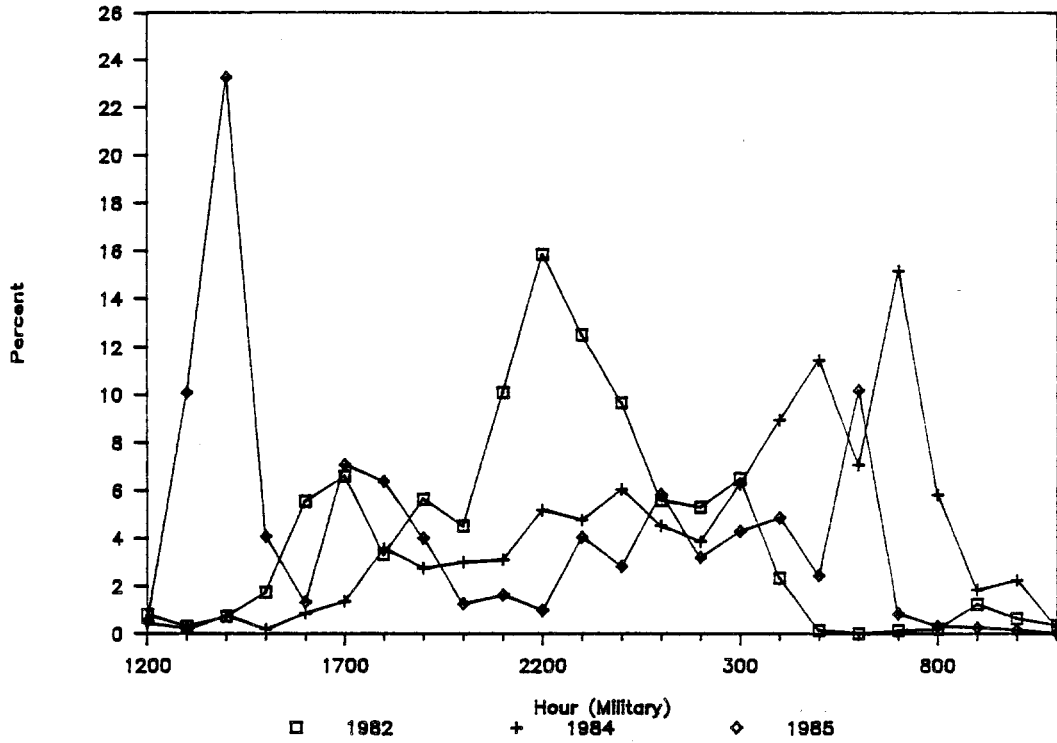


Figure 4. Smolt sonar counts by hour for 25 May through 29 May, Egegik River, 1982, 1984, and 1985.

Egegik Smolt May 30-June 3



Averaged Egegik Smolt May 30-June 3

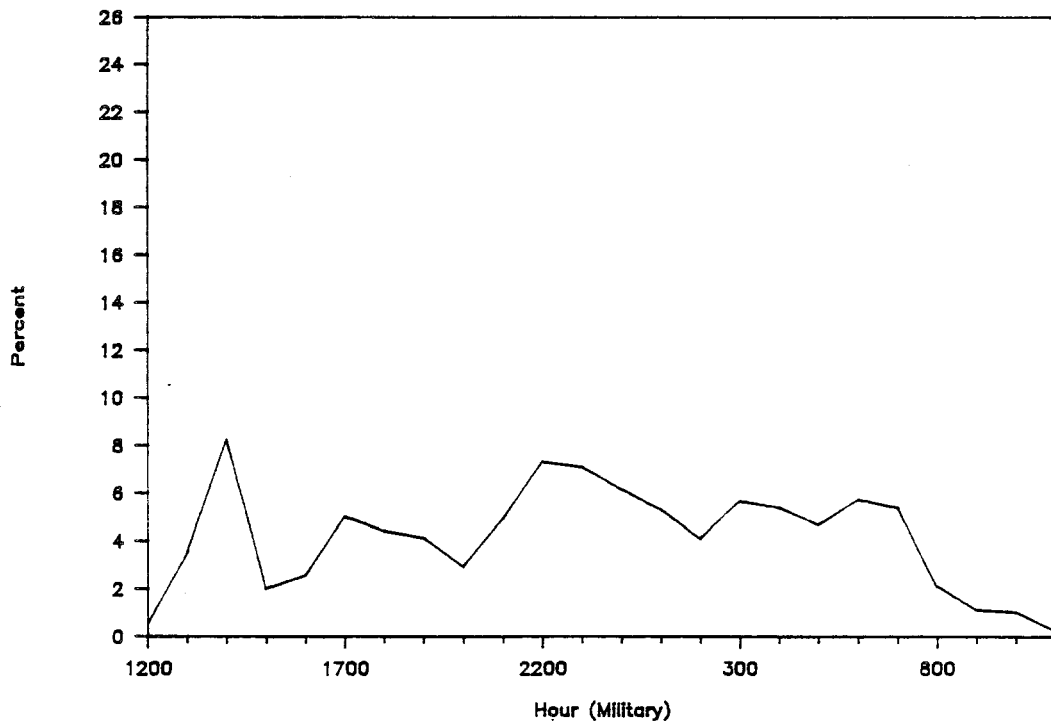
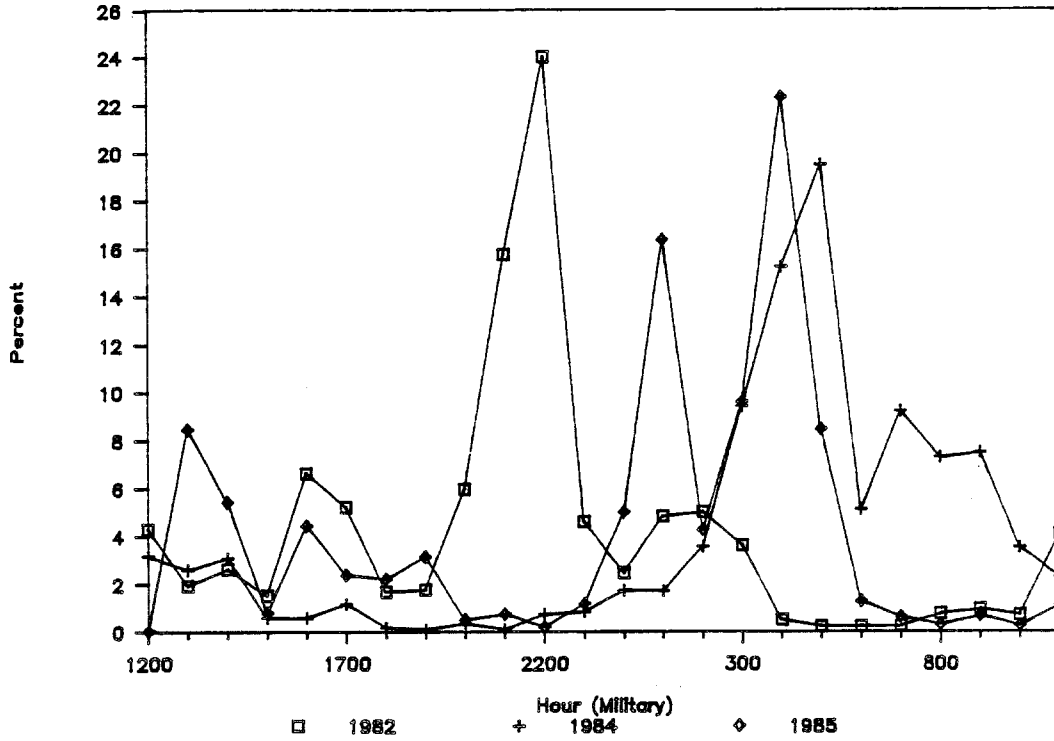


Figure 5. Smolt sonar counts by hour for 30 May through 3 June, Egegik River, 1982, 1984, and 1985.

Egegik Smolt June 4-8



Averaged Egegik Smolt June 4-8

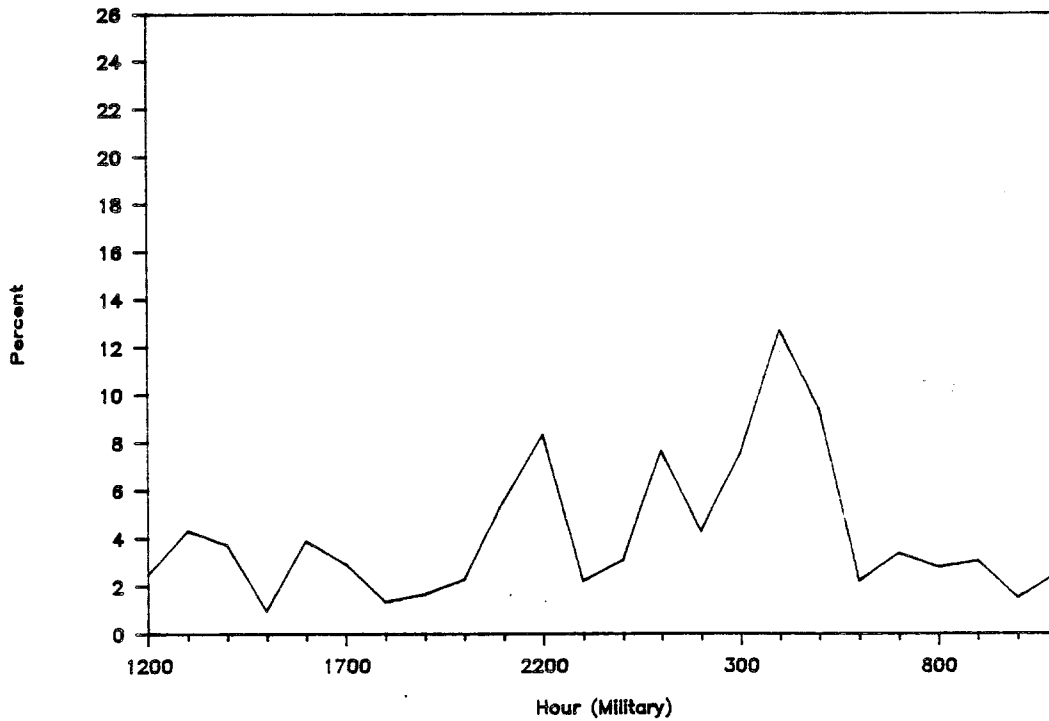
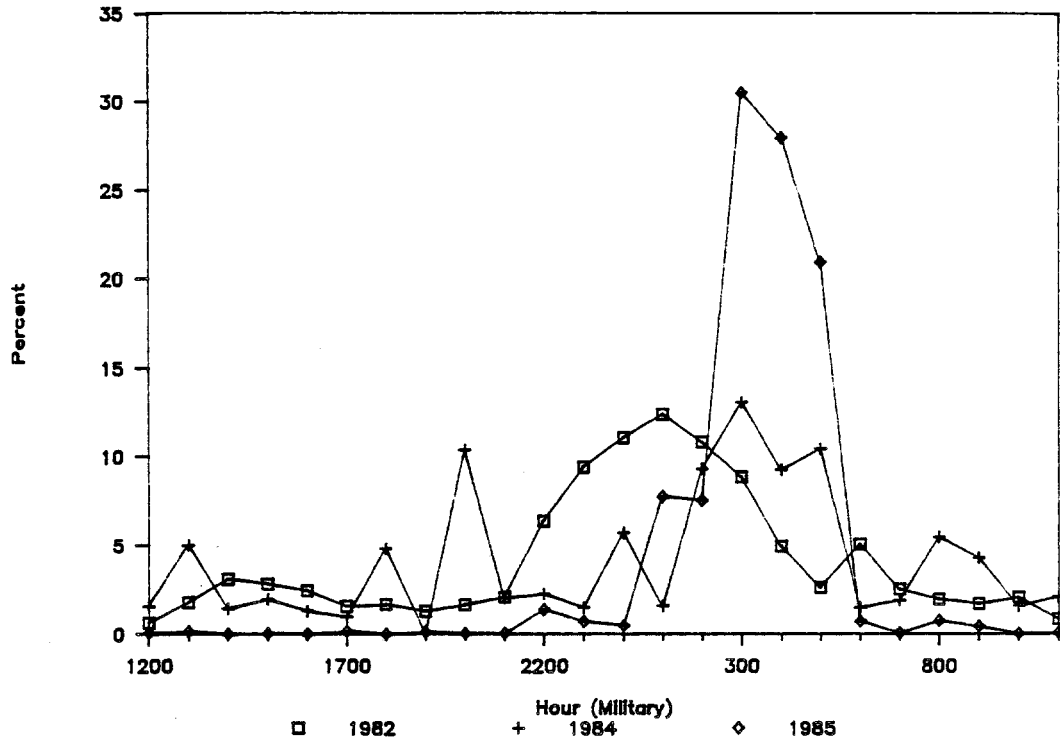


Figure 6. Smolt sonar counts by hour for 4 through 8 June, Egegik River, 1982, 1984, and 1985.

Egegik Smolt June 9-13



Averaged Egegik Smolt June 9-13

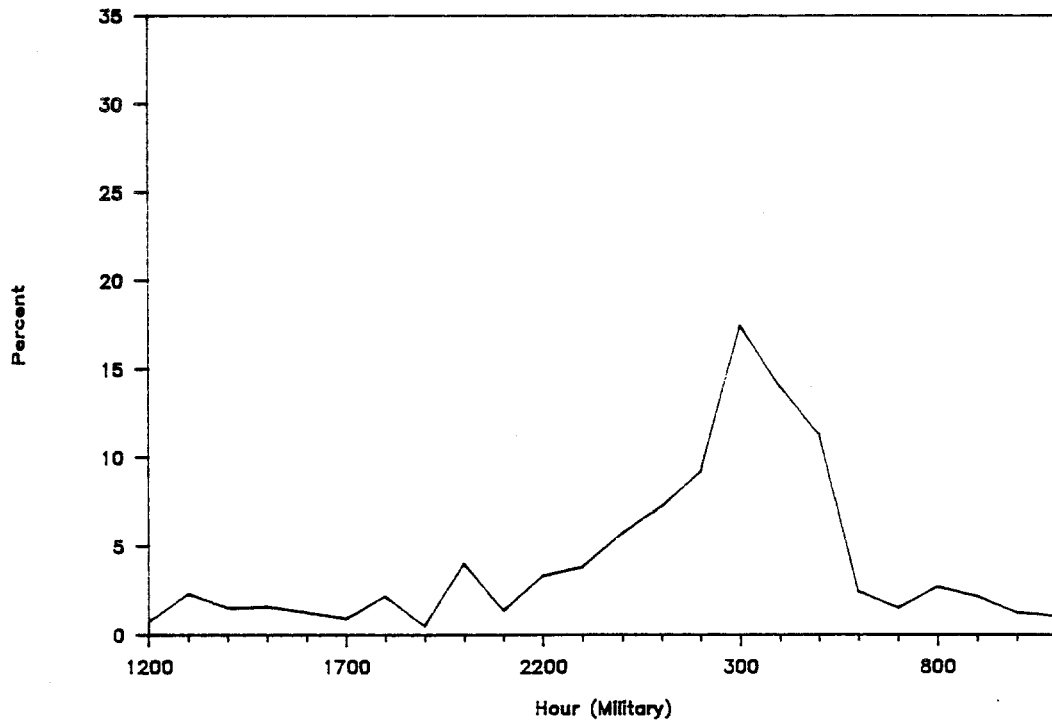
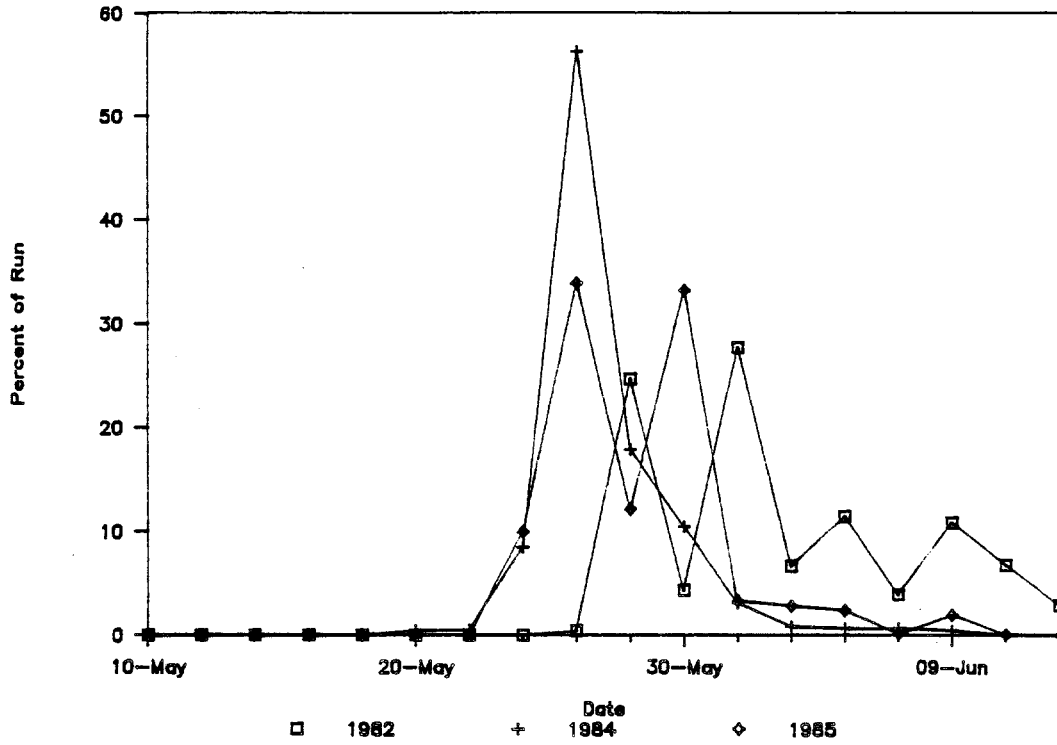


Figure 7. Smolt sonar counts by hour for 9 through 13 June, Egegik River, 1982, 1984, and 1985.

Egegik Smolt Run Timing



Average Egegik Smolt Run Timing

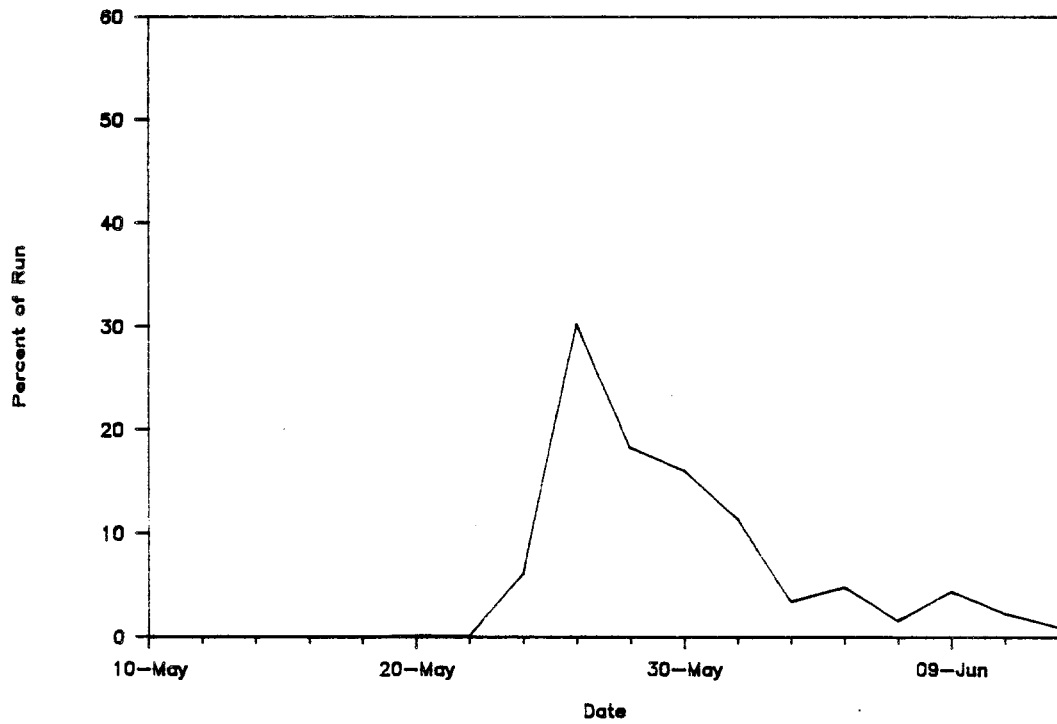


Figure 8. Smolt run timing, Egegik River, 1982, 1984, and 1985.

In summary, reducing the hours of sonar monitoring does not appear to be an appropriate way to relieve work load. Smolt migration patterns were most unpredictable when numbers of smolt were high, indicating that continuous monitoring of the sonar equipment was required. Likewise, an adequate sample is most important when large numbers of smolt are present and reducing the sampling load diminishes the precision of resulting smolt estimates.

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1985 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Annual numbers of sockeye salmon smolt migrating to sea from the Wood River Lakes system have ranged from about 30 million to 100 million smolt since the sonar program began in 1975 (Krasnowski 1976). Most smolt migration has occurred during the 90-day period between 1 June and 30 August. Estimates of smolt numbers are required for forecasting adult returns and determining optimum spawning escapement levels.

Specific objectives of the Wood River smolt project have been: 1) to estimate numbers of seaward migrating sockeye salmon smolt, 2) to describe smolt migration patterns, 3) to determine the age, length, and weight composition of the smolt population, 4) to record the incidence of the cestode parasite *Triaenophorus crassus*, and 5) to record climatological and hydrological parameters which might affect migratory behavior.

METHODS AND MATERIALS

The sonar system, described by Krasnowski (1976 and 1977), consisted of four ladder-like arrays anchored on the river bottom at the counting site and an electronic counting unit housed on shore in a canvas wall tent. Each array contained 10 upward facing transducers.

Installation and operation of the sonar gear has been described by Bucher (1980 and 1981). The same counting site has been used since 1975 (Krasnowski 1976). Actual placement of arrays I, II, III, and IV in 1985 were 22.6, 36.9, 48.8, and 65.6 m from the north bank of the river, respectively.

Sonar operation began at 2100 hours on 7 June and continued through 1000 hours on 7 August. Data collection procedures were the same as those used in past years (Bucher 1980). Smolt counting was conducted 24 hours per day. Array I was designated as the index array and operated continuously throughout the season. The other three arrays were operated in a random sequence of 15-minute intervals each hour. Hourly counts for arrays II, III, and IV were estimated by expanding 15-minute counts obtained for each array.

Counting rate of the sonar system was a function of water velocity, which fluctuated continually with the flood and ebb of the tide. Therefore, counting rate settings were adjusted as changes in water velocity occurred. To monitor water velocity, a current meter connected to a remote readout was

installed in the river channel behind array I. Flow measurements were also made behind each of the other arrays, once during each five-day sampling period when tidal influence was minimal. The ratio of water velocity over each array to that over array I was used to adjust counts obtained from arrays II, III, and IV.

Sonar counts were adjusted to account for smolt migrating through sections of the counting site transect not sonified. Expansion factors used for 1985 data analysis were 5.39, 4.10, 4.24, and 7.21 for arrays I, II, III, and IV, respectively. After these corrections were made, expanded array counts were summed to yield a total daily count.

Finally, the total daily count was adjusted for smolt size to produce an estimate of daily smolt passage. The Wood River sonar system was calibrated to register one count for the biomass equivalent of 26.85 g. Consequently, the daily mean weight of smolt from fyke net catches was used to estimate the number of smolt equivalent to one sonar count.

Smolt samples were obtained by fishing with a fyke net. About 60 smolt per sampling day were weighed (wet weight, g), measured (fork length, mm), and aged (from scale samples). Daily data were combined to obtain samples of about 400 smolt (usually obtained in seven sampling days) for estimating age class composition. This sample size was large enough to produce estimates of the actual proportion of age I or age II smolt which were within 0.05 of the estimated proportion (at the 0.05 significance level for actual age class proportions ranging from 0.05 to 0.95) (Bill et al., in press). This number of samples also produced estimates of the actual number of either age I or II smolt which were within 50% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.05 to 0.20, and which were within 15% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.30 to 0.95.

Smolt from daily samples were also externally examined for the presence of *T. crassus*. Percent infection of age I and II smolt by this parasite was calculated by five-day periods. Smolt population estimates for each five-day period were used as weighting factors for calculating percent infection.

RESULTS AND DISCUSSION

A total of 1,353,829 sonar counts were recorded during the season (Table 1). Counts generally decreased from the north bank to the south bank of the transect with most counts recorded over array II (about 36% of season total). This pattern was similar to that recorded for past years (Table 2).

Smolt numbers in 1985 showed moderate improvement from the past two years of very poor abundance. Estimated total number of smolt migrating seaward was 36,640,959 (Table 3). Age class composition was estimated to be 87% age I and 13% age II. The migration began on 7 June, slightly later than usual due to late ice breakup in Lake Aleknagik, and peaked on 29 June. The 1985 migration was similar to the 1982 run, with respect to total abundance and age composition.

Table 1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts					
Transducer Array					
Date a/	I	II	III	IV	Total
6 7	1,349	7,185	1,072	170	9,776
6 8	24	3,093	1,264	2,000	6,381
6 9	4,768	10,807	3,011	1,655	20,241
6 10	24,235	13,892	7,495	3,010	48,632
6 11	14,619	11,334	5,241	3,336	34,530
6 12	3,836	10,872	4,014	1,390	20,112
6 13	2,177	10,619	4,312	1,444	18,552
6 14	6,921	6,084	2,340	1,002	16,347
6 15	6,632	3,724	1,416	1,056	12,828
6 16	4,504	5,194	1,968	788	12,454
6 17	9,493	8,722	3,510	4,168	25,893
6 18	513	1,114	704	958	3,289
6 19	2,478	8,646	3,598	628	15,350
6 20	27,840	13,704	4,832	950	47,326
6 21	10,490	6,418	3,672	728	21,308
6 22	26,883	15,296	1,904	328	44,411
6 23	3,886	7,892	21,808	2,866	36,452
6 24	8,972	5,654	1,302	672	16,600
6 25	4,527	8,340	5,598	1,746	20,211
6 26	13,549	4,739	4,816	7,291	30,395
6 27	350	702	1,658	432	3,142
6 28	11,069	29,242	13,114	2,670	56,095
6 29	64,476	56,432	21,698	2,288	144,894
6 30	20,970	27,634	16,380	3,362	68,346
7 1	20,938	6,308	2,000	912	30,158
7 2	2,456	3,468	2,066	688	8,678
7 3	14,722	9,070	5,184	1,754	30,730
7 4	10,429	7,192	6,266	1,148	25,035
7 5	21,465	8,296	6,138	3,212	39,111
7 6	1,542	2,306	1,190	1,038	6,076
7 7	8,885	4,720	1,500	338	15,443
7 8	2,004	1,228	916	528	4,676
7 9	4,959	3,344	1,758	1,190	11,251
7 10	4,128	6,120	2,818	1,662	14,728
7 11	5,866	5,182	2,048	1,790	14,886
7 12	8,496	10,408	6,418	5,100	30,422

-Continued-

Table 1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated (continued).

Sonar Counts					
Transducer Array					
Date a/	I	II	III	IV	Total
7 13	3,839	3,642	2,358	2,142	11,981
7 14	7,398	9,848	2,742	1,354	21,342
7 15	14,396	21,896	3,602	3,222	43,116
7 16	1,763	9,536	7,700	5,628	24,627
7 17	2,390	6,544	5,710	7,688	22,332
7 18	2,156	3,954	7,652	5,748	19,510
7 19	3,148	6,412	3,256	2,874	15,690
7 20	3,793	4,216	2,356	4,486	14,851
7 21	5,223	20,916	5,718	5,082	36,939
7 22	463	4,686	4,326	13,228	22,703
7 23	6,041	7,212	5,376	4,558	23,187
7 24	3,605	8,452	2,910	1,144	16,111
7 25	1,424	3,072	2,030	1,642	8,168
7 26	3,140	2,830	1,464	1,700	9,134
7 27	4,093	2,649	1,210	3,034	10,986
7 28	2,325	3,954	1,638	1,870	9,787
7 29	3,077	4,022	2,104	4,220	13,423
7 30	948	1,908	1,534	3,956	8,346
7 31	2,288	2,496	472	1,304	6,560
8 1	1,258	2,308	1,001	878	5,445
8 2	751	1,148	1,426	812	4,137
8 3	871	1,738	734	1,800	5,143
8 4	1,122	2,298	1,202	1,540	6,162
8 5	3,523	6,126	3,360	2,214	15,223
8 6	1,297	1,932	2,880	1,948	8,057
8 7	1,912	1,926	1,134	1,138	6,110
Total	462,695	490,702	250,924	149,508	1,353,829
Percent	34.18	36.25	18.53	11.04	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Percentage of total unexpanded sonar counts recorded over each array, Wood River, Bristol Bay, Alaska, 1975-1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Percentage of Sonar Counts					
Transducer Array					
Year	I	II	III	IV	References
1975 a/	68.6	31.4	-	-	Krasnowski (1976)
1976	49.0	30.2	11.7	9.1	Krasnowski (1977)
1977	36.0	24.4	20.8	18.8	Newcome (1978)
1978	28.6	29.7	25.6	16.1	Clark and Robertson (1980)
1979	17.0	27.1	33.1	22.8	Bucher (1980)
1980	34.1	35.2	20.5	10.2	Bucher (1981)
1981	39.2	24.8	24.9	11.1	Bucher (1982)
1982	38.2	31.3	15.9	14.6	Bucher (1984)
1983	31.6	29.9	23.5	15.0	Bucher (in press)
1984	23.9	36.7	22.2	17.2	Bucher (in press)
Mean b/	34.2	29.1	22.0	14.7	
1985	34.2	36.3	18.5	11.0	

a/ Only two transducer arrays used.

b/ Data for 1975 omitted.

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1985.

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
6 7	166,387	92.39	166,387	13,707	7.61	13,707	180,095	180,095
6 8	149,060	92.39	315,448	12,280	7.61	25,988	161,340	341,436
6 9	464,126	92.39	779,574	38,237	7.61	64,225	502,363	843,800
6 10	1,119,827	92.39	1,899,402	92,256	7.61	156,482	1,212,084	2,055,884
6 11	826,190	92.39	2,725,593	68,065	7.61	224,547	894,255	2,950,140
6 12	462,500	92.39	3,188,093	38,103	7.61	262,650	500,603	3,450,744
6 13	455,269	92.39	3,643,363	37,507	7.61	300,158	492,777	3,943,521
6 14	379,934	92.39	4,023,297	31,300	7.61	331,459	411,234	4,354,756
6 15	354,910	92.39	4,378,207	29,239	7.61	360,698	384,149	4,738,906
6 16	290,976	90.48	4,669,183	30,630	9.52	391,329	321,606	5,060,513
6 17	786,320	90.48	5,455,504	82,775	9.52	474,104	869,095	5,929,608
6 18	111,116	90.48	5,566,620	11,697	9.52	485,801	122,813	6,052,422
6 19	378,588	90.48	5,945,209	39,853	9.52	525,655	418,442	6,470,864
6 20	1,007,167	90.48	6,952,377	106,023	9.52	631,678	1,113,191	7,584,056
6 21	479,977	90.48	7,432,354	50,526	9.52	682,205	530,504	8,114,560
6 22	1,234,784	90.48	8,667,138	129,984	9.52	812,189	1,364,768	9,479,328
6 23	849,360	81.24	9,516,499	196,167	18.76	1,008,356	1,045,527	10,524,856
6 24	377,819	81.24	9,894,318	87,260	18.76	1,095,617	465,080	10,989,936
6 25	477,297	81.24	10,371,616	110,235	18.76	1,205,853	587,533	11,577,470
6 26	910,148	81.24	11,281,764	210,206	18.76	1,416,060	1,120,355	12,697,825
6 27	67,905	81.24	11,349,670	15,683	18.76	1,431,743	83,589	12,781,414
6 28	1,202,977	81.24	12,552,648	277,838	18.76	1,709,581	1,480,815	14,262,229
6 29	3,351,587	81.24	15,904,235	774,077	18.76	2,483,659	4,125,665	18,387,895
6 30	1,502,558	81.24	17,406,793	347,028	18.76	2,830,688	1,849,586	20,237,481
7 1	838,570	87.43	18,245,364	120,563	12.57	2,951,251	959,133	21,196,615
7 2	207,350	87.43	18,452,715	29,811	12.57	2,981,062	237,162	21,433,778

-Continued-

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
7 3	751,599	87.43	19,204,314	108,059	12.57	3,089,121	859,658	22,293,436
7 4	654,134	87.43	19,858,449	94,046	12.57	3,183,168	748,181	23,041,617
7 5	929,377	87.43	20,787,826	133,618	12.57	3,316,786	1,062,995	24,104,613
7 6	204,654	87.43	20,992,481	29,423	12.57	3,346,210	234,078	24,338,692
7 7	469,719	87.43	21,462,201	67,532	12.57	3,413,743	537,252	24,875,944
7 8	128,749	84.42	21,590,950	23,758	15.58	3,437,501	152,508	25,028,452
7 9	319,920	84.42	21,910,871	59,036	15.58	3,496,537	378,956	25,407,409
7 10	357,035	84.42	22,267,907	65,885	15.58	3,562,422	422,920	25,830,330
7 11	403,986	84.42	22,671,894	74,549	15.58	3,636,971	478,535	26,308,866
7 12	712,491	84.42	23,384,385	131,478	15.58	3,768,450	843,969	27,152,836
7 13	257,110	84.42	23,641,495	47,445	15.58	3,815,895	304,555	27,457,391
7 14	425,117	84.42	24,066,613	78,448	15.58	3,894,344	503,566	27,960,957
7 15	926,177	89.76	24,992,791	105,627	10.24	3,999,971	1,031,804	28,992,762
7 16	550,291	89.76	25,543,082	62,758	10.24	4,062,730	613,050	29,605,812
7 17	613,058	89.76	26,156,141	69,917	10.24	4,132,647	682,976	30,288,789
7 18	549,093	89.76	26,705,235	62,622	10.24	4,195,269	611,715	30,900,504
7 19	381,497	89.76	27,086,733	43,508	10.24	4,238,778	425,006	31,325,511
7 20	350,037	89.76	27,436,770	39,920	10.24	4,278,698	389,958	31,715,469
7 21	694,850	89.76	28,131,620	79,245	10.24	4,357,944	774,095	32,489,564
7 22	641,000	90.92	28,772,621	63,982	9.08	4,421,926	704,982	33,194,547
7 23	479,059	90.92	29,251,680	47,817	9.08	4,469,744	526,876	33,721,424
7 24	322,723	90.92	29,574,404	32,213	9.08	4,501,957	354,936	34,076,361
7 25	180,288	90.92	29,754,692	17,995	9.08	4,519,952	198,284	34,274,645
7 26	198,214	90.92	29,952,906	19,784	9.08	4,539,737	217,998	34,492,644
7 27	241,949	90.92	30,194,856	24,150	9.08	4,563,888	266,100	34,758,745
7 28	185,545	90.92	30,380,402	18,520	9.08	4,582,408	204,066	34,962,811
7 29	300,999	93.14	30,681,401	22,152	6.86	4,604,560	323,151	35,285,962

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Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
7 30	192,460	93.14	30,873,862	14,164	6.86	4,618,725	206,625	35,492,587
7 31	129,069	93.14	31,002,932	9,498	6.86	4,628,223	138,568	35,631,155
8 1	99,260	93.14	31,102,192	7,305	6.86	4,635,528	106,565	35,737,721
8 2	76,728	93.14	31,178,920	5,646	6.86	4,641,175	82,375	35,820,096
8 3	109,553	93.14	31,288,474	8,062	6.86	4,649,238	117,616	35,937,713
8 4	114,555	93.14	31,403,029	8,430	6.86	4,657,669	122,985	36,060,698
8 5	236,368	93.14	31,639,398	17,395	6.86	4,675,064	253,764	36,314,462
8 6	156,995	94.55	31,796,393	9,049	5.45	4,684,114	166,044	36,480,507
8 7	151,716	94.55	31,948,110	8,745	5.45	4,692,859	160,461	36,640,969
Total	31,948,110	87.19		4,692,859	12.81		36,640,969	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

A total of 3,503 smolt were sampled to obtain data on length, weight, and age. Mean lengths of age I and age II smolt were 92 mm and 91 mm, respectively while mean weights of age I and II smolt were 7.2 g and 7.1 g, respectively (Table 4). Both mean length and weight of age I smolts exceeded that of age II smolts. This relationship has not previously been observed (Table 5). Sample mean weight increased as the season progressed. This resulted in a decrease in estimated smolt per sonar count with time (Table 6). Infection by *T. crassus* was greater for age II smolt (41.5%) than for age I smolt (35.7%) (Table 7). The 1985 population showed a relatively high incidence of *T. crassus* compared with the seven-year (1978-1984) mean, although the percentage of infected smolt was down for the two previous years (Table 8).

Smolt production per spawner increased in the 1981 and 1982 brood years after the low (12.28) observed in 1980 (Table 9). Survival of smolt emigrating from the Wood River has been calculated completely for the 1973-1979 brood years, and partially for the 1980 and 1981 brood years. Comparison of adult returns per smolt (survival) by brood year indicates stable production for all years except 1976, which showed significantly higher survival for both age I and age II smolts (0.10 and 0.16 adults per smolt, respectively) (Table 10).

Water temperature and lake depth measurements were recorded daily at Lake Aleknagik outlet from 5 June until 6 August (Table 11). Minimum and maximum daily water temperatures were recorded on 6 June (2.2°C) and 3-6 August (10.6°C), respectively. Minimum and maximum water depths were recorded on 6 August (0.43 m) and 16 June (1.40 m), respectively. Mean water temperature and depth for the season were 6.3°C and 0.99 m, respectively. The 1985 mean water temperature was 2.3° colder than the grand mean (1975-1984), while the 1985 mean water depth as 0.19 m higher than the grand mean (Table 12).

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1985.

Date a/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
6 9	90	0.9	6.8	0.2	22	90		7.3		1
6 10	88	0.5	6.8	0.1	72	87	0.5	6.5	0.2	6
6 11	91	0.4	6.6	0.1	71	92	2.4	7.0	0.6	9
6 12	87	0.5	6.5	0.1	55	87	0.8	6.5	0.3	5
6 13	88	0.5	6.0	0.1	54	90	1.0	6.4	0.2	6
6 14	91	0.6	6.6	0.1	58	89		6.5	0.5	2
6 15	88	0.5	6.0	0.1	55	88	2.1	6.1	0.5	5
6 16	90	0.5	6.6	0.1	56	99	3.9	8.5	0.9	4
6 17	88	0.4	5.8	0.1	55	86	0.7	5.4	0.3	5
6 18	88	0.5	5.8	0.1	54	87	2.4	5.8	0.5	6
6 19	86	0.4	6.0	0.1	55	88	2.4	6.3	0.7	5
6 20	95	0.4	7.8	0.1	53	96	0.5	7.9	0.3	7
6 21	94	0.5	7.4	0.1	54	97	3.4	7.9	0.8	6
6 22	87	0.8	6.0	0.2	53	85	0.6	5.5	0.2	7
6 23	89	0.7	6.6	0.2	48	88	1.9	6.3	0.3	12
6 24	90	0.6	6.7	0.1	49	89	1.5	6.4	0.4	11
6 25	87	0.9	6.2	0.2	48	88	2.1	6.5	0.5	12
6 26	87	0.5	5.9	0.1	50	87	1.5	5.8	0.4	10
6 27	91	0.7	7.1	0.2	46	93	1.8	7.5	0.5	14
6 28	91	0.8	6.6	0.2	42	89	3.4	6.1	0.9	8
6 29	89	1.0	6.1	0.2	20	89	2.0	6.0	0.3	3
6 30	90	0.6	6.5	0.1	85	92	1.4	6.7	0.3	25
7 1	86	0.6	5.8	0.2	55	88	1.4	5.9	0.2	5
7 2	90	0.8	6.7	0.2	51	88	1.9	6.3	0.5	9
7 3	90	0.5	6.7	0.2	52	88	1.7	5.8	0.4	8

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1985 (continued).

Date	a/	Age I					Age II				
		Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
7	4	87	0.6	6.1	0.2	49	86	1.7	5.7	0.3	11
7	5	94	0.7	7.5	0.2	56	94	2.8	7.0	0.8	4
7	6	85	0.7	5.5	0.1	55	84	1.9	5.2	0.4	5
7	7	86	0.8	5.5	0.2	41	86	1.0	5.6	0.2	9
7	8	89	0.5	6.5	0.1	59	85	1.2	5.7	0.3	11
7	9	88	0.6	6.1	0.1	50	86	1.2	5.7	0.2	10
7	10	89	0.6	6.5	0.1	53	88	1.8	6.2	0.3	7
7	11	87	0.8	6.0	0.2	49	86	1.9	5.9	0.5	11
7	12	92	1.0	7.3	0.2	51	90	2.2	6.7	0.4	9
7	13	95	0.5	8.0	0.1	50	94	1.7	8.0	0.4	10
7	14	93	0.7	7.6	0.2	51	92	2.4	7.7	0.6	9
7	15	93	0.7	8.0	0.2	49	92	0.9	7.6	0.3	11
7	16	97	0.5	8.8	0.2	56	94	1.8	7.3	0.3	4
7	17	94	0.6	8.0	0.2	52	93	1.2	7.3	0.4	8
7	18	91	0.6	7.3	0.2	52	96	2.1	8.6	0.6	8
7	19	93	0.7	7.8	0.2	56	94	0.9	8.4	0.3	4
7	20	96	0.6	8.8	0.2	57	93	0.6	8.7	0.5	3
7	21	97	0.7	9.1	0.3	55	101	4.0	10.4	1.4	5
7	22	97	0.8	9.1	0.2	55	95	2.0	8.6	0.7	5
7	23	97	0.7	9.3	0.2	51	94	1.5	8.8	0.5	7
7	24	96	0.9	8.4	0.2	30	96	0.8	8.1	0.2	7
7	25	95	0.5	8.6	0.2	80	97	2.6	9.4	0.7	5
7	26	97	0.6	8.9	0.2	55	100	1.1	9.6	0.2	5
7	27	100	0.5	9.7	0.1	57	100	2.6	10.3	0.7	3
7	28	100	0.7	10.1	0.2	57	104	2.6	10.8	1.3	3
7	29	98	0.6	9.9	0.2	55	98	1.2	9.3	0.3	5

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
7 30	101	0.6	10.5	0.2	57	102	2.0	10.3	0.5	3
7 31	100	0.6	9.9	0.2	55	99	1.7	9.5	0.7	5
8 1	100	0.6	10.1	0.2	55	102	1.6	10.6	0.8	5
8 2	101	0.4	10.4	0.2	56	104	2.4	11.0	1.0	4
8 3	103	0.9	10.3	0.3	23	102	1.5	10.7		2
8 4	103	0.5	11.4	0.2	51	100	1.2	10.5	1.4	3
8 5	105	0.5	12.4	0.2	62	107	1.8	12.2	0.4	3
8 6	104	0.6	11.1	0.2	52	107	2.4	11.3	1.6	3
Totals					3,105					392
Means	92		7.2			91		7.1		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Wood River, Bristol Bay, Alaska, 1951-1985. A dash (-) indicates data not available.

Year of Migration	Age I			Age II			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1951 a/	80.0	91	-	20.0	-	-	-	Univ. Washington (unpub.)
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	-	-	Church (1963)
1962	86.0	80	-	14.0	98	-	-	Church and Nelson (1963)
1963	84.3	83	-	15.7	102	-	-	Nelson (1964)
1964	98.8	84	-	1.2	104	-	-	Nelson (1965)
1965	92.0	86	-	8.0	106	-	-	Nelson (1966)
1966	94.3	77	-	5.7	101	-	-	Siedelman (1967)
1975 b/	86.0	83	-	14.0	98	-	33,850,000	Krasnowski (1976)
1976	95.5	84	-	4.5	95	-	106,200,000	Krasnowski (1977)
1977	82.9	71	3.5	17.1	98	9.3	73,300,000	Newcome (1978)
1978	84.7	79	-	15.3	90	-	55,000,000	Clark and Robertson (1980)
1979	92.2	90	7.6	7.8	100	10.1	65,970,000	Bucher (1980)
1980	96.0	78	4.0	4.0	95	6.8	48,300,000	Bucher (1981)
1981	66.1	88	6.3	33.9	96	8.4	97,530,000	Bucher (1982)

-Continued-

Table 5. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Wood River, Bristol Bay, Alaska, 1951-1985. A dash (-) indicates data not available (continued).

Year of Migration	Age I			Age II			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1982	87.3	79	4.7	12.7	98	8.4	37,060,000	Bucher (1984)
1983	82.6	86	6.5	17.4	98	9.2	23,730,000	Bucher (in press)
1984	94.2	92	7.8	5.8	97	8.7	23,710,947	Bucher (in press)
		—	—		—	—		
	Mean	80	5.4		96	8.7		
1985		92	7.2		91	7.1		

a/ Fyke net catches used to index abundance of smolt, 1951-1966.

b/ Sonar equipment used to estimate numbers of smolt, 1975-1985.

Table 6. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Wood River, Bristol Bay, Alaska, 1985.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
6 7	no sample	5.00
6 8	no sample	5.00
6 9	6.87	6.04
6 10	6.77	6.13
6 11	6.64	6.25
6 12	6.47	6.42
6 13	6.03	6.88
6 14	6.58	6.31
6 15	6.02	6.89
6 16	6.69	6.20
6 17	5.78	7.18
6 18	5.85	7.10
6 19	6.00	6.92
6 20	7.86	5.28
6 21	7.44	5.58
6 22	5.92	7.01
6 23	6.54	6.35
6 24	6.66	6.23
6 25	6.24	6.65
6 26	5.89	7.04
6 27	7.18	5.78
6 28	6.56	6.33
6 29	6.13	6.77
6 30	6.50	6.39
7 1	5.83	7.12
7 2	6.61	6.28
7 3	6.55	6.34
7 4	6.03	6.88
7 5	7.47	5.56
7 6	5.50	7.54
7 7	5.53	7.50
7 8	6.33	6.55
7 9	6.07	6.83
7 10	6.50	6.39
7 11	5.97	6.95
7 12	7.20	5.76
7 13	8.01	5.18
7 14	7.63	5.44
7 15	7.91	5.25
7 16	8.66	4.79
7 17	7.89	5.26
7 18	7.47	5.55

-Continued-

Table 6. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Wood River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Mean Weight of Smolt (g)	Smolt per Count
7 19	7.80	5.32
7 20	8.82	4.71
7 21	9.26	4.48
7 22	9.04	4.59
7 23	9.27	4.48
7 24	8.33	4.98
7 25	8.66	4.79
7 26	8.97	4.62
7 27	9.69	4.28
7 28	10.13	4.10
7 29	9.88	4.20
7 30	10.54	3.94
7 31	9.86	4.21
8 1	10.19	4.07
8 2	10.48	3.96
8 3	10.36	4.01
8 4	11.37	3.65
8 5	12.40	3.35
8 6	11.08	3.74
8 7	no sample	5.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 7. Infection of sockeye salmon smolts by the cestode Triaenophorus crassus, Wood River, Bristol Bay, Alaska, 1985.

Sample Period	Age I		Age II	
	Number Examined	Percent Infected	Number Examined	Percent Infected
6/ 9-6/13	274	35.8	27	14.8
6/14-6/18	278	37.8	22	50.0
6/19-6/23	263	32.3	37	45.9
6/24-6/28	235	36.2	55	34.5
6/29-7/ 3	263	50.6	50	54.0
7/ 4-7/ 8	260	63.1	40	65.0
7/ 9-7/13	253	32.8	47	38.3
7/14-7/18	260	29.2	40	30.0
7/19-7/23	274	7.3	24	4.2
7/24-7/28	279	13.3	23	13.0
7/29-8/ 2	278	16.5	22	9.1
8/ 3-8/ 7	285	10.9	16	12.5
Means		35.7		41.5

Table 8. Infection of sockeye salmon smolt by the cestode Triacnophorus crassus, Wood River, Bristol Bay, Alaska, 1978-1985.

Year	Percent Infected		References
	Age I	Age II	
1978	15.1	40.5	Clark and Robertson (1980)
1979	10.0	30.8	Bucher (1980)
1980	11.1	17.3	Bucher (1981)
1981	28.2	35.6	Bucher (1982)
1982	10.0	21.2	Bucher (1984)
1983	43.1	73.6	Bucher (in press)
1984	41.1	45.7	Bucher (in press)
Mean	19.6	36.5	
1985	35.7	41.5	

Table 9. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1972-1983 brood years, Wood River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced			
		Age I	Age II	Total	Per Spawner
1972	430,000	-	5,900,000	-	-
1973	330,000	27,950,000 (85)	4,800,000 (15)	32,750,000	99.24
1974	1,710,000	101,400,000 (89)	12,550,000 (11)	113,950,000	66.64
1975	1,270,000	60,750,000 (88)	8,400,000 (12)	69,150,000	54.45
1976	820,000	46,600,000 (90)	5,130,000 (10)	51,730,000	63.09
1977	560,000	60,840,000 (97)	1,930,000 (3)	62,770,000	112.19
1978	2,270,000	46,370,000 (58)	33,200,000 (42)	79,570,000	35.02
1979	1,710,000	64,330,000 (93)	4,710,000 (7)	69,040,000	40.37
1980	2,970,000	32,350,000 (89)	4,130,000 (11)	36,480,000	12.28
1981	1,230,000	19,590,000 (93)	1,380,000 (7)	20,970,000	17.05
1982	980,000	22,330,000 (83)	4,690,000 (17)	27,020,000	27.57
1983	1,360,000	31,950,000	-	-	-

Table 10. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1972-1983 brood years, Wood River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult Returns	Adult Returns per Smolt	Number of Smolt	Adult Returns	Adult Returns per Smolt
1972	430,000	-	1,411,551	-	5,900,000	55,771	0.01
1973	330,000	27,950,000	1,334,355	0.05	4,800,000	102,717	0.02
1974	1,710,000	101,400,000	4,574,242	0.05	12,550,000	478,861	0.04
1975	1,270,000	60,750,000	3,576,900	0.06	8,400,000	1,110,878	0.13
1976	820,000	46,600,000	4,744,923	0.10	5,130,000	826,181	0.16
1977	560,000	60,840,000	3,382,204	0.06	1,930,000	91,247	0.05
1978	2,270,000	46,370,000	2,485,803	0.05	33,200,000	741,426	0.02
1979	1,710,000	64,330,000	4,620,151	0.07	4,710,000	45,337	0.01
1980	2,970,000	32,350,000	1,512,165	0.05 a/	4,130,000	82,276	0.02 a/
1981	1,230,000	19,590,000	770,152	0.04 a/	1,380,000	-	-
1982	976,000	22,330,000	-	-	4,690,000	-	-
1983	1,360,000	31,950,000	-	-	-	-	-

a/ Future adult returns will increase these values.

Table 11. Water temperatures and depths, at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1985. A dash (-) indicates missing data.

		Mean Water Temp. (C)	Mean Water Depth (m)
6	5	3.3	0.87
6	6	2.2	-
6	7	3.3	1.04
6	8	3.9	-
6	9	3.3	1.22
6	10	3.3	1.22
6	11	3.9	1.28
6	12	3.9	1.31
6	13	3.3	1.34
6	14	3.9	1.37
6	15	3.9	1.37
6	16	3.9	1.40
6	17	4.2	1.37
6	18	4.4	1.36
6	19	4.2	1.37
6	20	4.4	1.37
6	21	4.4	1.37
6	22	4.4	1.37
6	23	4.4	1.37
6	24	4.7	1.34
6	25	5.3	1.33
6	26	5.8	1.33
6	27	5.3	1.31
6	28	5.8	1.28
6	29	5.8	1.26
6	30	6.1	-
7	1	6.1	-
7	2	6.1	-
7	3	6.1	-
7	4	7.2	-
7	5	5.5	-
7	6	6.0	-
7	7	6.0	-
7	8	6.0	-
7	9	6.5	-
7	10	7.5	-
7	11	8.0	-
7	12	8.0	-
7	13	8.0	-
7	14	6.0	0.88

-Continued-

Table 11. Water temperatures and depths, at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1985. A dash (-) indicates missing data (continued).

	Mean Water Temp. (C)	Mean Water Depth (m)
7 15	6.0	0.85
7 16	7.8	-
7 17	7.8	-
7 18	8.9	0.76
7 19	7.8	0.73
7 20	8.9	0.75
7 21	6.7	-
7 22	6.7	-
7 23	-	-
7 24	9.4	0.69
7 25	10.0	0.64
7 26	10.0	0.66
7 27	10.0	0.62
7 28	10.0	0.61
7 29	10.0	0.58
7 30	-	0.57
7 31	-	0.56
8 1	-	0.55
8 2	-	0.52
8 3	10.6	0.50
8 4	10.6	0.49
8 5	10.6	0.44
8 6	10.6	0.43
Mean	6.3	.99

Table 12. Water temperatures and depths at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1975-1985. A dash (-) indicates missing data.

Year	Sample Period	Water Temperature (C)			Water Depth (m)			References
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	
1975	29 May-19 July	2.0	9.5	5.0	-0.24	0.57	0.37	Krasnowski (1976)
1976	9 June- 7 August	2.0	14.0	8.0	0.24	1.07	0.57	Krasnowski (1977)
1977	9 June- 8 August	4.5	15.5	9.0	-	-	1.52	Newcome (1978)
1978	28 May- 9 August	5.0	16.0	9.0	0.37	0.98	0.82	Clark and Robertson (1980)
1979	30 May- 2 August	4.5	16.0	9.0	0.33	1.46	0.93	Bucher (1980)
1980	30 May-15 August	4.5	18.0	9.0	0.34	1.65	1.07	Bucher (1981)
1981	27 May-13 August	5.4	17.5	11.4	0.03	1.21	0.55	Bucher (1982)
1982	27 May-10 August	2.2	12.0	6.4	0.46	1.62	1.17	Bucher (1984)
1983	28 May-26 July	4.4	12.8	8.7	0.46	1.19	0.90	Bucher (in press)
1984	22 May-27 July	4.4	16.7	10.8	-0.21	0.23	0.01	Bucher (in press)
	Mean	3.8	14.6	8.4	0.25	1.22	0.88	
1985	6 June- 8 August	2.2	10.6	6.3	0.43	1.40	0.99	

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1985 NUYAKUK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

The Nuyakuk River accounts for approximately 83% of the sockeye salmon production from the Nushagak River system. A sonar biomass counter was first used on the Nuyakuk River in 1983 to estimate numbers of seaward migrating smolt. Fyke nets were fished to collect smolt samples for determination of age composition, length, weight, and incidence of parasitism by *Triaenophorus crassus*. Smolt data provides the basis for forecasting future returns of adult sockeye salmon to the Nuyakuk system and aids in evaluating spawning escapement goals.

Specific objectives of the 1985 Nuyakuk smolt study were: 1) to estimate the number of sockeye salmon smolt migrating to sea, 2) to determine the age composition of the smolt population, 3) to collect length and weight data for smolt, and 4) to record climatological and hydrological data which may influence smolt migratory patterns.

METHODS AND MATERIALS

Based on a 1982 site selection study (Minard 1984), the Nuyakuk smolt sonar site was selected approximately 3.5 km downstream from the outlet of Tikchik Lake. The river at this site is approximately 150 m wide and reaches a maximum depth of 6.0 m. River velocity is relatively constant throughout the smolting season, ranging between 0.45 and 1.15 m/sec.

The Nuyakuk River smolt counter was designed and built by Al Menin, Bendix Corporation, in 1982. It is composed of three, 3.05 m long ladder-type arrays, each housing ten upward-facing transducers. The transducers from each of the independently anchored arrays are connected to a single shorebound control unit which simultaneously processes signals from all thirty transducers.

The arrays were assembled and placed in the Nuyakuk River on 24 May. Measurements taken later indicated that the arrays were located 20 m, 44 m, and 70 m from the south bank, respectively. Counting operations commenced at 2000 hrs, 24 May, and continued without interruption until 1200 hrs, 29 June, when the gear was pulled.

The sonar system was monitored continuously throughout the project. All returned echoes were automatically tabulated and printed in hourly intervals. After reduction for obvious false counts (wind, rain, ice, etc.), raw counts were expanded for the time disabled, generating an adjusted count for each array.

The smolt counter pulse rate was set proportional to river velocity over the inshore array. A General Oceanics Model 2031 flowmeter was suspended directly behind the inshore array, approximately 0.5 meters below the surface. Continuous velocity data was transmitted to a shore-based readout allowing the smolt counter to be set to the correct velocity following each hourly print interval. Velocity ratios between arrays were measured weekly and counts were then expanded accordingly. River velocity at the center and offshore arrays averaged 1.171 and 1.001 times that of the inshore array.

Lateral expansion of adjusted counts for areas of the river not sampled by sonar was aided by a smolt side-scan counter built by Bendix Corporation in 1975. Measurements taken over the season identified the inshore and offshore limit of the smolt distribution to be 9.28 m and 126.94 m, respectively. Expansion of counts was then carried out through simple geometric analysis.

The smolt counter functions as a biomass counter and was designed to count once for the biomass equivalent of five, 8.29975 g smolt passing over the arrays (Menin 1983, personal communications). Deviation from this mean weight was accounted for in the final expansion. Because smolt weight changes over the course of the season estimates of total outmigration were made on the basis of 300 fish samples with the calculated average weight applied to expanded counts.

Samples collected from fyke net catches were used to apportion smolt into age classes. A standard 1.2 m by 2.1 m fyke net was fished in 1.5 m of water approximately 1 km upstream from the sonar site. Sixty fish per night were collected for sampling the following day. Catch per unit effort (CPUE) data were collected to correlate fyke net catches to sonar estimates.

A special study was designed to determine if mean length of sockeye salmon smolt remains constant over daily intervals. In addition to the regular sampling schedule, additional 100 fish samples were collected at regular intervals during two different sampling periods (1910 hrs 8 June through 1930 hrs 9 June and 1700 hrs 18 June through 0500 hrs 19 June). One way analysis of variance was used to detect differences in sample mean length both, by set within sampling periods, and between sampling periods.

Basic weather and river conditions were recorded at the sonar site. Subjective observations were made of sky conditions, wind velocity, and river turbidity while air and water temperature along with precipitation were measured daily at 0800 hrs and 2000 hrs.

RESULTS AND DISCUSSION

The Nuyakuk River sonar counter tabulated 337,163 raw counts from 24 May until 28 June 1985 (Table 1). Approximately 35% of the counts occurred over

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Nuyakuk River, Bristol Bay, Alaska, 1985. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Date a/	Transducer Array			Total
	Inshore	Center	Offshore	
5 24	44	46	549	639
5 25	133	637	793	1,563
5 26	199	531	244	974
5 27	17	72	119	208
5 28	359	103	606	1,068
5 29	124	131	345	600
5 30	108	241	1,179	1,528
5 31	455	311	736	1,502
6 1	2,039	1,161	900	4,100
6 2	2,595	3,834	1,950	8,379
6 3	6,349	2,800	1,789	10,938
6 4	14,162	4,890	2,004	21,056
6 5	2,088	5,320	2,962	10,370
6 6	4,847	13,197	8,100	26,144
6 7	6,908	14,742	12,367	34,017
6 8	5,036	6,103	3,701	14,840
6 9	4,076	2,347	6,169	12,592
6 10	5,851	6,922	11,184	23,957
6 11	10,768	12,994	11,337	35,099
6 12	2,923	3,744	5,233	11,900
6 13	1,617	2,489	3,657	7,763
6 14	2,068	2,057	3,320	7,445
6 15	1,636	1,664	3,146	6,446
6 16	2,607	3,007	2,753	8,367
6 17	2,571	3,472	3,737	9,780
6 18	2,778	2,279	1,873	6,930
6 19	1,163	1,176	1,218	3,557
6 20	2,661	3,366	3,290	9,317
6 21	5,183	4,717	3,302	13,202
6 22	5,154	3,468	4,036	12,658
6 23	1,883	2,106	2,576	6,565
6 24	3,211	3,575	2,586	9,372
6 25	1,408	1,548	1,270	4,226
6 26	1,420	1,524	1,370	4,314
6 27	637	1,147	944	2,728
6 28	794	1,126	1,099	3,019
Total	105,872	118,847	112,444	337,163
Percent	31.40	35.25	33.35	100.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

the center array and 31% and 33% over the inshore and offshore arrays, respectively. The final sockeye salmon smolt population estimate was 23,366,078 (Table 2). Age composition was 98% age I and 2% age II.

The 1985 smolt estimate of 23.4 million was 3.7 times that estimated in 1984 (6.4 million). Peak migration from the Nuyakuk Lake system occurred on 7 June with a second peak of approximately the same magnitude on 11 June. The sonar was in operation before the first large push of smolt, but was pulled earlier than desired because of fiscal restraints. Although daily estimates were less than 5% of the cumulative total at the termination of counting, communication with local sport fishing guides indicated that significant numbers of smolt migrated after counting was terminated.

In all, 1,479 smolt were sampled for standard length, weight, and age. Daily mean length, weight, and sample size by age class are presented in Table 3. The estimated seasonal mean length of age I and age II smolt was 85 and 94 mm, respectively. Mean weights were estimated at 5.5 g for age I and 7.1 g for age II smolt. Table 4 summarizes all available length and weight data by age class since 1978.

Incidental pink fry catches were recorded for the first time in 1985. A total of 7,187 fry were captured during 123.29 hours of fishing time. Daily catch per unit effort data are presented in Table 5. Several peaks in abundance were noted between 18 and 26 June.

Results of the sampling study are presented in Tables 6 and 7. Samples were taken from six different sets each of the two sampling periods. The analysis of variance results indicate significant differences in mean length between sets for each sampling period and a significant difference in mean length between sampling periods.

These differences in mean length could possibly be explained by changes in age and/or stock composition between samples, consequently, replicate sampling is needed to account for this variability.

The 1982 escapement of 538,000 spawners produced an estimated 6.3 million age I smolt and approximately 0.8 million age II smolt, or about 13.13 smolt per spawner (Table 8). This was 62% lower than observed for the 1981 brood year. In contrast, the 1983 brood year shows a preliminary production of 70.8 smolt per spawner.

Weather and river conditions were recorded at the sonar site from 25 May through 29 June (Table 9). Ice covered much of Nuyakuk Lake when the sonar was installed. Intermittent ice flows occurred during the first two weeks of operations. Mean air and water temperatures for the season were 9.2 and 5.5°C, respectively. Seasonal rainfall totaled 109 mm, an average of 3.11 mm daily.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1985.

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 24	65,108	92.92	65,108	4,958	7.08	4,958	70,066	70,066
5 25	155,113	92.92	220,221	11,811	7.08	16,769	166,924	236,990
5 26	87,619	92.92	307,840	6,672	7.08	23,441	94,291	331,281
5 27	20,739	92.92	328,579	1,579	7.08	25,020	22,318	353,599
5 28	87,802	92.92	416,381	6,686	7.08	31,706	94,488	448,087
5 29	46,278	92.92	462,659	3,524	7.08	35,230	49,802	497,889
5 30	279,632	92.92	742,291	21,294	7.08	56,524	300,926	798,815
5 31	123,710	92.92	866,001	9,420	7.08	65,944	133,130	931,945
6 1	278,360	92.92	1,144,361	21,197	7.08	87,141	299,557	1,231,502
6 2	1,070,427	92.92	2,214,788	81,513	7.08	168,654	1,151,940	2,383,442
6 3	853,342	92.92	3,068,130	64,982	7.08	233,636	918,324	3,301,766
6 4	923,492	92.92	3,991,622	70,324	7.08	303,960	993,816	4,295,582
6 5	612,924	92.92	4,604,546	46,674	7.08	350,634	659,598	4,955,180
6 6	1,773,436	92.92	6,377,982	135,048	7.08	485,682	1,908,484	6,863,664
6 7	2,039,582	92.92	8,417,564	155,315	7.08	640,997	2,194,897	9,058,561
6 8	869,783	99.58	9,287,347	3,655	0.42	644,652	873,438	9,931,999
6 9	832,553	99.58	10,119,900	3,499	0.42	648,151	836,052	10,768,051
6 10	1,502,085	99.58	11,621,985	6,313	0.42	654,464	1,508,398	12,276,449
6 11	2,058,238	99.58	13,680,223	8,651	0.42	663,115	2,066,889	14,343,338
6 12	748,951	99.58	14,429,174	3,148	0.42	666,263	752,099	15,095,437
6 13	530,427	99.58	14,959,601	2,229	0.42	668,492	532,656	15,628,093
6 14	471,685	99.58	15,431,286	1,982	0.42	670,474	473,667	16,101,760
6 15	503,103	98.04	15,934,389	10,057	1.96	680,531	513,160	16,614,920
6 16	584,740	98.04	16,519,129	11,690	1.96	692,221	596,430	17,211,350
6 17	740,474	98.04	17,259,603	14,803	1.96	707,024	755,277	17,966,627
6 18	466,844	98.04	17,726,447	9,333	1.96	716,357	476,177	18,442,804

-Continued-

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1985 (continued).

Date a/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
6 19	250,872	98.04	17,977,319	5,015	1.96	721,372	255,887	18,698,691
6 20	713,698	98.89	18,691,017	8,023	1.11	729,395	721,721	19,420,412
6 21	846,637	98.89	19,537,654	9,517	1.11	738,912	856,154	20,276,566
6 22	924,420	98.89	20,462,074	10,392	1.11	749,304	934,812	21,211,378
6 23	520,152	98.89	20,982,226	5,847	1.11	755,151	525,999	21,737,377
6 24	582,465	98.89	21,564,691	6,547	1.11	761,698	589,012	22,326,389
6 25	327,067	98.89	21,891,758	3,676	1.11	765,374	330,743	22,657,132
6 26	322,812	99.44	22,214,570	1,807	0.56	767,181	324,619	22,981,751
6 27	174,881	99.44	22,389,451	978	0.56	768,159	175,859	23,157,610
6 28	207,274	99.44	22,596,725	1,160	0.56	769,319	208,434	23,366,044
Total	22,596,725	96.71		769,319	3.29		23,366,044	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Nuyakuk River, Bristol Bay, Alaska, 1985.

Date a/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 29	73	0.0	3.1	0.0	1	106	14.5	9.2	1.1	2
5 30	73	1.2	3.4	0.3	3	-	-	-	-	0
5 31	91	1.2	6.2	0.3	52	86	-	5.3	0.4	2
6 2	69	4.1	2.8	0.4	3	-	-	-	-	0
6 3	76	3.8	3.8	0.5	4	-	-	-	-	0
6 5	86	0.5	6.4	0.1	119	89	-	6.7	-	1
6 6	90	0.6	5.6	0.1	84	-	-	-	-	0
6 7	88	0.6	6.5	0.1	90	-	-	-	-	0
6 8	85	0.8	6.4	0.2	70	-	-	-	-	0
6 9	89	0.6	6.4	0.1	107	-	-	-	-	0
6 13	86	0.6	5.7	0.1	70	-	-	-	-	0
6 14	87	0.7	6.0	0.2	59	86	-	7.2	-	1
6 15	82	0.6	4.9	0.1	70	-	-	-	-	0
6 16	84	0.9	5.0	0.1	67	101	-	8.0	-	1
6 17	81	0.8	5.2	0.1	60	-	-	-	-	0
6 18	84	0.8	5.2	0.1	57	87	1.5	6.0	0.5	3
6 19	85	0.8	5.3	0.1	58	92	1.5	6.7	0.5	2
6 20	83	0.6	5.1	0.1	60	-	-	-	-	0
6 21	87	0.6	5.4	0.1	57	98	6.2	7.5	1.4	3
6 22	84	0.7	4.9	0.1	59	97	-	7.3	-	1
6 23	84	0.8	5.0	0.1	54	-	-	-	-	0
6 24	86	0.6	5.3	0.1	60	-	-	-	-	0
6 25	78	1.0	4.3	0.1	60	-	-	-	-	0
6 26	81	0.8	4.5	0.1	60	-	-	-	-	0
6 27	84	1.5	5.5	0.3	19	-	-	-	-	0
6 28	82	0.8	5.1	0.1	59	93	-	7.2	-	1
Totals	—	—	—	—	1462	—	—	—	—	17
Means	85	—	5.5	—	—	94	—	7.1	—	—

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Nuyakuk River, Bristol Bay, Alaska, 1978, 1982-1985.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		References
			Mean Length (mm)	Mean Weight (g)	Mean Length (mm)	Mean Weight (g)	
1978	18-19 June	350	71	4.3	85	5.8	Huttunen (1980)
1982	15 June- 9 July	208	76	3.9	96	6.8	Minard (1984)
1983	27 May-30 June	1,847	75	4.3	91	6.6	Minard and Frederickson (in press)
1984	27 May-26 June	980	81	4.9	93	7.3	Minard and Frederickson (in press)
		Mean	76	4.4	91	6.6	
1985	24 May-28 June	1,479	85	5.5	89	6.6	

Table 5. Catch per unit effort by day for pink salmon smolt,
Nuyakuk River, Bristol Bay, Alaska, 1985.

Date	Time	Duration of Fishing (hours)	Catch	CPUE (hr)
6 3	2330-0900	9.50	300	31.58
6 4	2300-1000	11.00	623	66.64
6 5	1300-1015	21.25	569	26.78
6 6	2145-0145	4.00	139	34.75
6 7	1945-2130	1.75	50	28.57
6 9	1150-1930	7.67	40	5.22
6 13	1730-2110	3.67	5	1.36
6 14	1815-2200	2.40	5	2.08
6 15	2030-0045	4.25	309	72.71
6 16	2000-2245	2.75	130	47.27
6 17	2015-2350	3.60	92	25.56
6 18	1700-0100 0230-0500	10.67	1559	146.11
6 19	1650-0120	8.50	1084	127.53
6 20	2145-2430	2.75	496	180.36
6 21	1930-2240	3.20	74	23.13
6 22	1815-1930	1.25	52	41.60
6 23	1905-2220	3.25	64	19.69
6 24	1645-1830	1.75	230	131.43
6 25	1630-1950	3.33	113	33.93
6 26	1815-2245	4.50	810	180.00
6 27	1710-0140	8.50	387	45.53
6 28	2030-0015	3.75	56	14.93
Total		123.29	7187	58.29

Table 6. Mean length, variance, and sample size of sockeye salmon smolt captured during special sampling periods, Nuyakuk River, 1985.

Date	Time	Mean Length (mm)	Variance	Sample Size
6 8	1910-2310	88.5	26.13	100
6 8	2310-0130	89.8	28.01	100
6 9	0135-0515	86.8	31.31	100
6 9	0515-1000	85.0	42.80	6
6 9	1150-1445	89.7	34.66	99
6 9	1450-1930	89.5	37.83	100
6 18	1700-1900	86.3	28.49	100
6 18	1900-2100	86.8	32.55	100
6 18	2100-2300	87.1	26.94	100
6 18	2305-0110	84.8	38.33	100
6 19	0230-0330	82.2	43.56	34
6 19	0340-0500	82.0	32.29	8

Table 7. Analysis of variance results for average length of sockeye salmon smolt by set within sampling periods and between sampling periods, Nuyakuk River, 1985.

8-9 June

Source	df	MSE	F	p
set	5	145.26	4.58	0.0004
residual	499	31.70		
total	504			

18-19 June

Source	df	MSE	F	p
set	5	188.56	5.80	0.0000
residual	436	32.50		
total	441			

Between Sampling Periods

Source	df	MSE	F	p
period	1	2047.51	61.13	0.0000
residual	945	33.50		
total	946			

Table 8. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1980-1983 brood years, Nuyakuk River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced			
		Age I	Age II	Total	Per Spawner
1980	3,027,000	-	1,259,000	-	-
1981	834,000	28,875,000 (99)	90,000 (1)	28,965,000	34.73
1982	538,000	6,294,000 (89)	769,000 (11)	7,063,000	13.13
1983	319,000	22,597,000			

Table 9. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1985. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp (C)		Mean Water Temp. (C)	Water Clarity	Precipitation (mm)	Water b/ Gauge (m)
	0800 hr	2000 hr	0800 hr	2000 hr	0800 hr	2000 hr				
5 25	3	4	-	-	-	-	4.1	clear	0	-
5 26	3	2	-	-	-	9.4	4.0	clear	0	4.15
5 27	4	4	-	-	5.6	7.8	4.0	clear	2	4.22
5 28	4	3	-	calm	4.4	6.6	3.9	clear	2	4.26
5 29	4	3	-	5 SE	4.4	8.9	4.0	clear	0	4.29
5 30	4	4	5-10 SE	0-5 SE	4.4	5.5	4.9	clear	10	4.38
5 31	4	4	calm	calm	4.4	6.6	4.3	clear	12	4.44
6 1	4	4	0-5 SE	calm	3.3	-	-	clear	6	4.52
6 2	3	4	calm	calm	4.4	7.8	3.8	clear	2	4.58
6 3	4	3	0-5 N	20-30 SE	5.6	10.5	4.4	clear	7	4.66
6 4	3	4	calm	25-30 SE	4.4	5.6	4.1	clear	3	4.76
6 5	3	2	0-10 SE	calm	-	8.9	4.0	clear	0	4.85
6 6	4	2	calm	0-10 NW	4.4	11.6	4.7	clear	0	4.88
6 7	2	4	calm	calm	7.8	13.9	4.5	clear	1	4.94
6 8	4	3	0-5 SE	0-5 SE	11.0	8.3	4.3	light brown	10	5.03
6 9	4	1	0-5 SE	0-10 SE	6.7	10.0	4.4	light brown	0	5.09
6 10	1	2	calm	0-2 W	10.0	14.4	3.0	ice	0	5.16
6 11	3	3	calm	calm	11.1	13.3	1.9	ice	6	5.20
6 12	4	4	calm	0-5 SW	8.3	11.1	2.3	ice	2	5.27
6 13	4	4	calm	calm	5.6	6.7	3.9	clear	11	5.35
6 14	4	2	calm	calm	5.5	7.8	3.7	clear	0	5.41
6 15	4	2	calm	calm	6.1	-	4.0	clear	0	5.44
6 16	4	3	calm	calm	4.4	8.9	5.3	clear	10	5.46
6 17	1	2	calm	calm	8.3	13.2	6.0	clear	0	5.49
6 18	1	4	0-5 SE	0-5 SE	13.2	10.0	6.4	clear	trace	5.51

-Continued-

Table 9. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1985. A dash (-) indicates missing data (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp (C)		Mean	Water Clarity	Precipitation (mm)	Water b/ Gauge (m)
	0800 hr	2000 hr	0800 hr	2000 hr	0800 hr	2000 hr	Temp. (C)			
6 19	4	4	calm	0-5 SE	7.7	9.9	6.0	clear	3	5.56
6 20	4	3	calm	0-5 SE	5.5	11.1	6.3	clear	11	5.60
6 21	3	2	calm	calm	7.7	13.8	6.5	clear	2	5.62
6 22	1	2	calm	calm	8.9	15.4	7.5	clear	0	5.62
6 23	2	2	calm	calm	8.9	12.1	8.3	clear	2	5.61
6 24	2	3	calm	calm	8.9	14.3	8.7	clear	5	5.68
6 25	1	3	0-5 N	calm	8.9	15.4	8.8	clear	0	5.76
6 26	1	1	0-5 N	calm	8.9	16.5	9.5	clear	0	5.78
6 27	1	4	0-5 NE	calm	14.4	15.4	9.5	clear	2	5.79
6 28	3	4	0-5 NE	calm	13.2	18.3	10.3	clear	-	5.81
6 29	4	-	calm	-	14.3	-	10.0	clear	-	-

a/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

b/ Water Gauge = depth over inshore array

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