FRED Reports

The Development of the
Leisure Lake Sockeye Salmon:
Smolt and Adult Production Summary,
1977 to 1984

by
William R. Bechtol
Nicholas C. Dudiak
Number 83

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

The Development of the Leisure Lake Sockeye Salmon: Smolt and Adult Production Summary, 1977 to 1984

by
William R. Bechtol
Nicholas C. Dudiak

Number 83

Alaska Department of Fish and Game
Division of Fisheries Rehabilitation, Enhancement and Development

Don W. Collinsworth
Commissioner

Brian J. Allee, Ph.D.
Director

P. O. Box 3-2000
Juneau, Alaska 99802-2000

May 1988

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The Leisure Lake system, which drains into Kachemak Bay, has a set of falls below the outlet that prevents upstream migration of anadromous fish. Annual stocking of sockeye salmon, *Oncorhynchus nerka*, fry and their subsequent freshwater rearing takes advantage of the previously underutilized freshwater habitat. The impact of yearly increases in fry densities has been reflected in the condition of a number of emigrating smolts. In 1984 nearly 179,000 age-1. sockeye salmon smolts (54.3 mm and 1.14 g mean size) emigrated from a stocking of 2.1 million fry at a density of 20,130 fry/ha in 1983. The estimated survival rate of this partial emigration is 8.5%. Additionally, 50,244 age-2. smolts (76.4 mm and 3.59 g mean size) emigrated from the 1982 stocking of 1.5 million fry at 14,550 fry/ha. Freshwater survival for the 1981 brood year is estimated at 24.6%. The 1984 smolts are the smallest in the history of the Leisure Lake project and represent some of the smallest mean sizes ever documented for sockeye salmon smolts.

Over 117,360 adult sockeye salmon of Leisure Lake origin returned in 1984, with age-1.2 adults comprising over 91% of the harvest. This gives an estimated ocean survival of 34.3% for smolts from the 1981 fry stocking, based on partial returns. The remainder of the adult harvest was age-1.3 and age-2.2 fish from the 1980 fry stocking. Combining the return data for 4-year-old fish with that of the earlier 2- and 3-year-old fish return data provides a cumulative ocean survival estimated at 41.6% for the 1980 stocking. Thus, adult sockeye salmon returns resulting from the annual fry plants has provided a terminal-harvest fishery that has become important to the Kachemak Bay region.

KEY WORDS: Sockeye salmon, *Oncorhynchus nerka*, stocking density, smolt, freshwater survival, ocean survival, adult production, terminal harvest.

INTRODUCTION

Recently, Leisure Lake sockeye salmon (*Oncorhynchus nerka*) have developed into an important salmon fishery to the Kachemak Bay area where they return prior to attempting to enter Leisure Lake via China Poot Creek. Prior to the introduction of sockeye salmon juveniles into Leisure Lake, there was no sockeye salmon run in the area. Since the falls on China Poot Creek are impassable, the run is completely harvested and recruitment is currently supplied by annual fry plants. The present study documents the success of using Leisure Lake as a natural rearing system for hatchery-incubated sockeye salmon fry.

The goals of this study, as defined by Koenings and Burkett (1987), were to: (1) evaluate different fry and fingerling stocking densities by examining freshwater growth rates and survivals to smolt of specific stocking densities; (2) estimate ocean-survival (smolt to adult) and age-at-return differences for specific stocking groups; and (3) monitor changes in lake limnology.

The overall objective was to establish a direct relationship between changes in smolt size and ages, and the density of fry stocked in the lake the previous spring. Such experimental evidence could confirm mounting empirical observations that smolt populations not only serve as important precursors to adult production, but also indicate the balance between numbers of rearing juveniles and their forage supply. Most importantly, the stocking density returning the most adults would define the optimal fry-loading density for Leisure Lake and, potentially, for other sockeye salmon nursery lakes (Koenings and Burkett 1987).

Study Area Description

Leisure Lake, also called China Poot Lake, is located within Kachemak Bay State Park approximately 16 km across Kachemak Bay

from Homer, Alaska (Figure 1). From an elevation of 51 m above sea level, the outlet flows 2.0 km to China Poot Bay; the last 0.4 km includes a series of barrier falls. Leisure Lake has a surface area of 105 ha, 6.4 km of shoreline, and a shore-development index of 1.77. The littoral zone, defined by the area of the lake having depth less than the penetration depth of 1% of the subsurface light, represents 23% of the total lake area. The lake's total volume is 23.5 x 10^6 m^3, with a maximal depth of 68 m, and a mean depth of 22 m. Leisure Lake has two major inlets and a number of smaller ones (Figure 2). The lake outlet funnels into a channel 10 m across and has a mean depth of about 0.8 m; the total watershed area covers ~3,885 ha.

Since the lake outlet includes a set of impassable falls, no anadromous adults are able to return to the lake; however, Leisure Lake supports populations of coastrange sculpin, *Cuttus aleuticus*, threespine stickleback, *Gasterosteus aculeatus*, a relatively small (in terms of sockeye salmon predation) stock of rainbow trout, *Salmo gairdneri*, and annually introduced sockeye salmon fry.

MATERIALS AND METHODS

Smolt Emigration

Because of the potential for smolt emigration from Leisure Lake under the ice cover, China Poot Bay and Leisure Lake's outlet (China Poot Creek) were examined before break-up on 4 and 9 May 1984. Visual inspections were made of intertidal and eddy areas, and dip nets were passed through deep pools in an effort to locate and catch emigrating smolts.

A fyke-net system encompassing the entire 9.2-m width (0.8-m average depth) of the Leisure Lake outlet was deployed and fished continuously from 1600 h on 15 May until 0900 h on 26 June. The fyke tunnel tapered from a 1.2-m x 1.2-m mouth to a 15-cm hose

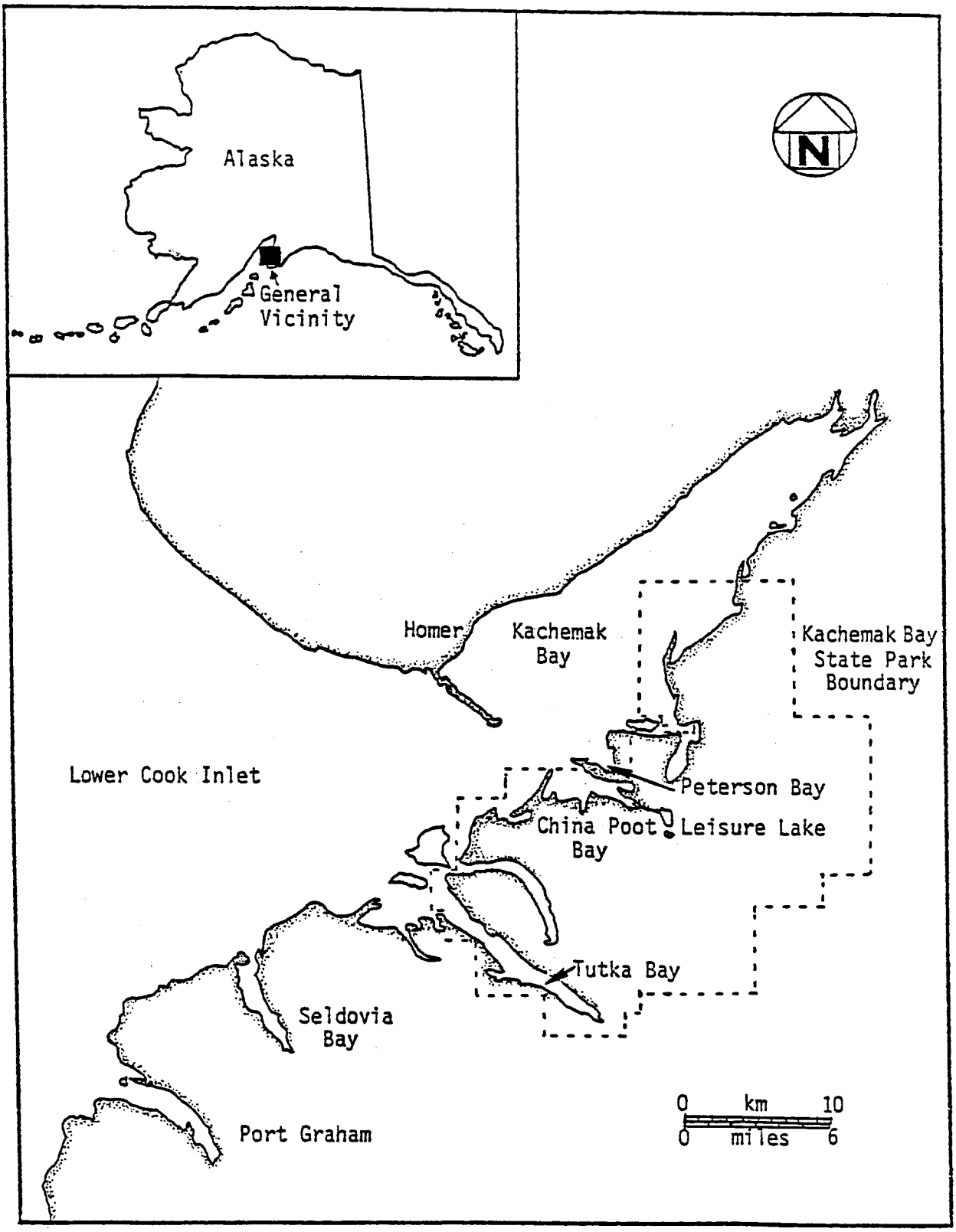

Figure 1. The general location of Leisure Lake within the State of Alaska and its specific location relative to the City of Homer and Kachemak Bay State Park.

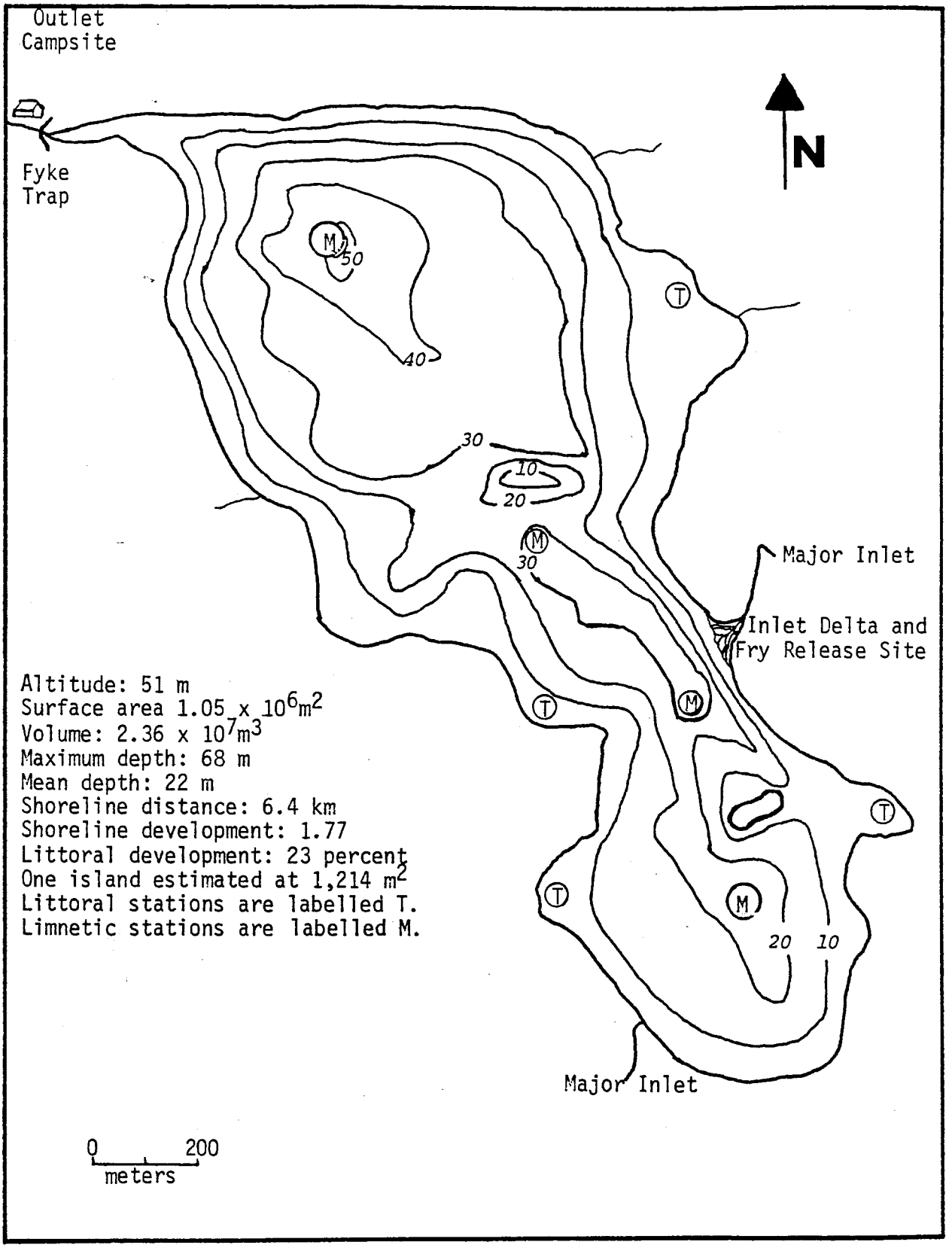

Figure 2. Bathymetric map of Leisure Lake (or China Poot Lake) showing field sites and limnology sampling stations.

connection to a collection box (Figure 3). The collection box was emptied every hour, or more frequently if necessary, to avoid stressing the smolts by overcrowding. Fish were counted individually or, as the rate of emigration increased, they were counted on a "biomass" basis. Counts were grouped into 6-hour collection periods with four periods per day (0001-0600 h, 0601-1200 h, 1201-1800 h, and 1801-2400 h). For biomass counts, three randomly selected, 454-g samples were counted out once during each 6-hour collection period. As mean fish size decreased through the season, thereby increasing the number of fish counted per sample, the biomass of samples were halved to 227 g. Age-class designation followed the European formula.

Population Estimates

The number of smolts (N_i) outmigrating in a given period (i) was estimated using the following (Kit Rawson, 3901 Totem Beach Road, Marysville, WA 98270):

$$N_i = W_i \ (n_1 + n_2 + n_3)/3$$

Where: W_i = total biomass (g) of smolts during period i
n_1, n_2, and n_3 = numbers of smolts counted in three 454-g subsamples during period i.

This calculation assumed a 100% efficiency of the traps; i.e., all fish are captured.

Estimation of the total run size (N) for the entire season was made from:

$$N = \sum_{i=1}^{K} N_i,$$

Where: K = the number of collection periods in the season.
N_i = the number of smolts estimated for each collection period.

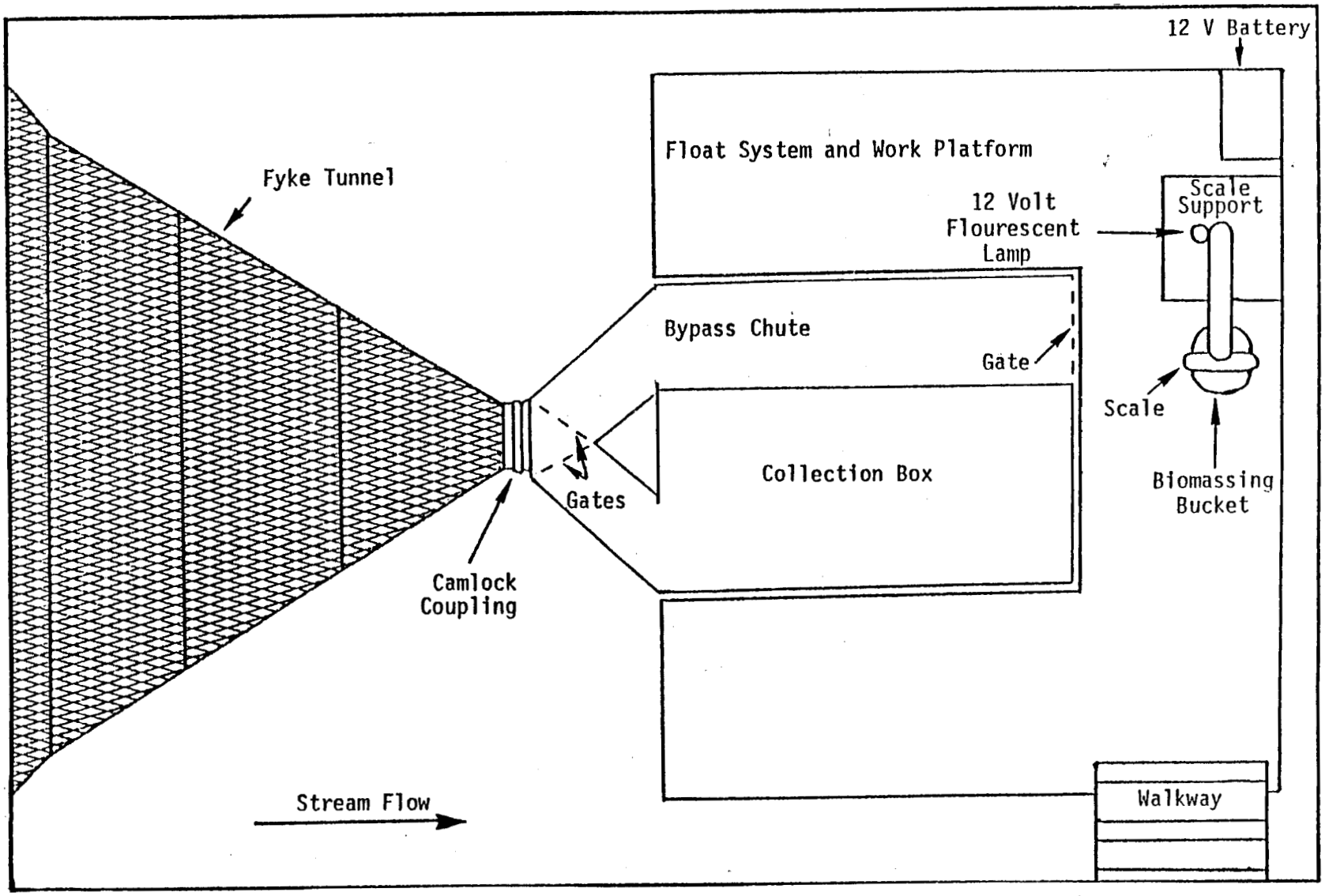

Figure 3. Overhead view of fyke-net tunnel, collection box, and float system work platform (not to scale) used to capture sockeye salmon smolts emigrating from Leisure Lake.

Age, Weight, and Length

Using 20 smolts (if available) from each age class, age, weight, and length (AWL) data were collected weekly or semiweekly. While in the field, it was possible to determine smolt age based on size distributions. Fish were randomly selected and anesthetized with methane tricain sulfonate (MS-222). Smolt weights (to the nearest 0.1 g) and fork-lengths (to the nearest mm) were measured. Ten scales collected from a representative number of fish from each age class (usually five) were mounted between two glass microscope slides and labeled in the field for later age verification. All fish were held in fresh water for a 15-minute recovery period prior to being released downstream from the fyke system.

For each age class, the mean weight and length, X_i with associated variances, var (X_i), were calculated for each AWL sampling. The mean weight and length for the season, X, and associated variances were then calculated by weighting with weekly or semiweekly migration counts as follows:

$$X = \sum_{i=1}^{W} N_i X_i / N$$

$$\text{var}(X_i) = S_i^2 / n_i$$

$$\text{var}(X) = \sum_{i=1}^{W} N_i^2 \, \text{var}(X_i) / N^2.$$

Where: W = total number of AWL samplings,

N_i = estimated number of smolts migrating from mid-date between AWL sampling periods i-1 and i through mid-date between periods i and i+1,

N = estimated total smolt emigration over the season,

S_i^2 = sample variance of AWL measurements (weight or length) from period i, and

n_i = sample size for period i.

Adult Returns

The return and harvest of adult sockeye salmon resulting from the stocking of Leisure Lake was monitored through commercial fisheries harvest reports and semiweekly visual observations of sport fishing and personal-use dip netting in China Poot Bay and China Poot Creek. Scales and weight and length data were collected semiweekly from a sample of fish (generally 80) out of the China Poot Bay harvest and other local harvest areas.

RESULTS

Rearing and Stocking

As part of an ongoing project of the FRED Division, Leisure Lake has been stocked annually since 1976 (excluding 1979) with juvenile sockeye salmon (Table 1). The sockeye salmon fry released into Leisure Lake in the spring of 1984 were obtained from fertilized eggs taken from the 1983 Bear Creek brood stock (Tustumena Lake, Alaska); the eggs and subsequent alevins were reared at the Crooked Creek Hatchery. Leisure Lake was stocked with 2.1 million sockeye salmon fry (0.14 g mean size) on 22 May 1984. Each of the three 45-minute helicopter transport trips averaged about 703,300 fry; the mean transport density was 104 g of fry per liter of water. All fry were released along the gravel delta of the major inlet stream (*See* Figure 2). The transport-tank temperatures were higher than the 6°C lake water by a half a degree in the morning and by two degrees later in the day. Stocking density into the lake was ~20,000 fry per ha.

Table 1. Leisure Lake juvenile sockeye salmon stocking summary, 1976-1984.

Brood Source		Hatchery	Date		Mean weight
Stock	Year	origin	stocked	Number	(grams)
		FINGERLING STOCKING[a/]			
Glacier Creek	1975	Crooked Cr.	Oct 1976	59,800	5.1
Glacier Creek	1976	Crooked Cr.	Sept 1977	92,300[b/]	5.9
Glacier Creek	1977	Tutka Lagoon	Oct 1978	77,100[b/]	2.5
		FRY STOCKING[c/]			
Glacier Creek	1979	Crooked Cr.	May 1980	532,700	0.15
Glacier Creek	1980	Crooked Cr.	May 1981	1,092,700	0.16
Bear Creek	1981	Crooked Cr.	May 1982	1,527,900	0.15
Bear Creek	1982	Crooked Cr.	June 1983	2,113,200	0.19
Bear Creek	1983	Crooked Cr.	May 1984	2,110,000	0.14

a/ Sockeye salmon fingerlings were transported by floatplane from Halibut Cove Lagoon saltwater rearing facility.

b/ 6,950 of the fingerlings released in 1976 were adipose clipped; 24,570 of the fingerlings released in 1977 were adipose clipped and coded-wire tagged. No other release groups were marked.

c/ Shortly after emergence, the sockeye salmon fry were transported in a tank carried below a helicopter.

Smolt Emigration

The field camp on Leisure Lake was established on 14 May 1984, but dead smolts had been observed in the China Poot Bay intertidal area beginning on 9 May 1984. Based upon the number of smolt mortalities found in the intertidal area, hydrological flow patterns, and predator and scavenger conditions, it was estimated that <700 smolts emigrated from under the lake ice prior to fyke-net operation.

The fyke-net system was operated continuously for total enumeration from 1600 h on 14 May until 0900 h on 26 June when all fish were either biomass-counted or hand-tallied; 221,522 ± 2,437 (95% C.I.) sockeye salmon smolts were estimated to have passed through the fyke system (Appendix A).

After field camp closure, some sockeye salmon smolts were found in the eddy areas of China Poot Creek and the intertidal areas of China Poot Bay throughout most of the month of July. The number of smolts found varied from a few individuals to schools of more than 200 fish. Based on these sightings, the nature of the water system and trends in the rate of emigration, it was estimated that an additional 7,000 smolts emigrated from Leisure Lake after the field camp was removed. As a result, over 229,200 sockeye salmon smolts were estimated to have emigrated from the Leisure Lake system during the spring of 1984.

Age, Weight, and Length

A total of 330 age-1. smolts, determined by size distributions and later confirmed by scale analysis, were sampled from 17 collection periods during the 1984 emigration season. In samples of age-1. smolts, the individual lengths ranged from 47 mm to 60 mm. The mean length of the seventeen sample groups ranged from 52.9 mm to 55.9 mm with a weighted average of 54.3 ± 0.5 mm (95% C.I.). Individual measurements of age-1. smolt weights ranged from 0.6 g to 2.8 g, while the mean weights for the 17

sample groups ranged from 1.00 g to 1.41 g and had a weighted average of 1.14 ± 0.03 g (95% C.I.) (Appendix C).

A total of 362 age-2. smolts (confirmed by scale analysis) were sampled from 18 collection periods during the 1984 emigration season. The individual lengths of age-2. smolt samples ranged from 66 mm to 103 mm, while the mean lengths of the 18 collection periods ranged from 73.1 mm to 90.4 mm and had a weighted average of 78.6 ± 0.7 mm (95% C.I.). Individual weights of the 18 collection periods ranged from 2.9 g to 6.5 g with a weighted average of 4.0 ± 0.1 g (95% C.I.) (Appendix B). An age-2. fish was measured and weighed at 65 mm and 1.8 g, respectively, on 20 May.

Age Composition

Age-composition analysis indicated that 174,658 ± 2,071 (95% C.I.) age-1. sockeye salmon smolts emigrated during field camp operations; an estimated 3,400 age-1. smolts emigrated before and after field camp operations, giving an estimated total of about 178,100 age-1. smolts leaving Leisure Lake during the 1984 season (Appendix C). These fish were from the June 1983 stocking of over 2,113,000 sockeye salmon fry at 0.19 g average size. From the stocking density of 20,130 fry/ha, these age-1. smolts constitute 8.4% of the original number stocked (Table 2).

An estimated 46,864 ± 1,285 age-2. sockeye salmon smolts emigrated from Leisure Lake during field camp operations. An additional 3,400 age-2. fish are estimated to have emigrated before and after camp operations, representing a total of over 50,300 age-2. smolts in 1984. Thus, of the estimated 1,527,900 fry stocked into Leisure Lake in May 1982, ~376,900 smolts have emigrated to date. These fish bring the cumulative fry-to-smolt survival to 24.7% for those fry that were planted at an average size of 0.15 g and a density of 14,550 fry/ha (Table 2).

Although numerous AWL samples were taken, no age-3. smolts were observed. Thus, based upon the age-1. and -2. emigrants of

Table 2. Summary of stocking rates of sockeye salmon fingerlings (1976-1978) and fry (1980-1983) into Leisure Lake; and numbers and population characteristics of resultant smolts, 1977-1984.

Lake Stocking				Smolt Emigration					
Date stocked	Number	Mean weight (g)	Density (fry/ha)	Year	Number	Survival (%)	Freshwater age	Fork length (mm)	Weight (g)
10/76	59,800	5.1	570	1977	31,300	52	1.	96.9	9.6
				1978	1,900	3	2.	109.4	11.1
				TOTAL	33,200	55			
09/77	92,300	5.9	880	1978[1]	56,500	61	1.	108.5	10.8
				1979	4,800	5	2.	152.1	29.1
				TOTAL	61,300	66			
10/78	77,100	2.5	730	1979	54,100	70	1.	96.6	8.2
				1980	3,900[1]	5	2.	--	--
				TOTAL	58,000[2]	75			
05/80	532,700	0.15	5,060	1981	240,700	45	1.	96.9	8.0
				1982	4,300	1	2.	117.0	13.2
				TOTAL	245,000	46			
05/81	1,092,700	0.16	10,380	1982	315,200	29	1.	79.1	4.0
				1983	90,300	8	2.	96.9	7.0
				TOTAL	405,500	37			
05/82	1,527,900	0.15	14,550	1983	326,600	21	1.	66.8	2.2
				1984	50,300	3	2.	76.4	3.6
				TOTAL	376,900	24			
06/83	2,113,200	0.19	20,130	1984	178,100	8	1.	53.9	1.1

[1] Counts derived from adult return data because of early smolt emigration in 1978 and limited funding in 1980.

[2] The project's sole verified age-3. smolt was a 246-mm, 137.1-g fish captured in 1981.

previous years, a total of 405,473 smolts emigrated from the May 1981 stocking of 1,092,700 fry; average size and density were 0.16 g and 10,380 fry/ha, respectively. The cumulative fry-to-smolt survival for those fish is 37.1%.

Commercial Harvest of Returning Adults

From June through August of 1984, adult sockeye salmon returning to China Poot Creek were commercially harvested from Port Graham to Peterson Bay by seine and set-net fishermen (*See* Figure 1). The seine fishermen directed some effort toward Tutka Bay and Peterson Bay, but their primary focus was on China Poot Bay. Up to 18 boats fished China Poot Bay during the two 48-hour fishing periods per week through the 25 June to 3 August seine season. Over 104,300 Leisure Lake sockeye salmon were commercially harvested in China Poot Bay in 1984, and this amount may increase as further catch analysis is completed (Table 3). A change in management strategy reduced commercial effort during the last openings as the commercial fishing boundary (initially placed at the head of China Poot Bay) was shifted toward the middle of the bay on 1 August (Figure 4). This boundary shift protected the natural run of pink salmon, *O. gorbuscha*, that spawns in the lower portion of China Poot Creek. The China Poot Bay commercial catch amounted to ~44% of the total sockeye salmon harvest for the entire lower Cook Inlet area in 1984.

Approximately 25 commercial set nets were fished from Port Graham to Tutka Bay during the summer of 1984. Leisure Lake sockeye salmon, mixed with other salmon stocks, were harvested primarily from 26 June through 3 August, although the nets continued to fish other stocks after that date. Over 10,000 fish of Leisure Lake origin are estimated to have been harvested by the set-net fishery, bringing the total commercial harvest of Leisure Lake sockeye salmon to nearly 114,400 fish (Table 3). Additional Leisure Lake returns were harvested in other interception fisheries, but insufficient information is available to enumerate Leisure Lake stocks in those fisheries.

Table 3. Leisure Lake adult sockeye salmon returns by harvest group for 1984.

Commercial Harvest:		
Seine		104,364
Set net		10,000[a]/
	Subtotal	114,360
Sport and Personal-Use Harvest:		
Personal-use dip net		2,000
Sport		500
	Subtotal	2,500
Remaining in Stream:		900
Preliminary Total Return		117,760[a]/

[a]/ This is considered a conservative estimate, as ADF&G, Division of Commercial Fisheries AWL analyses indicate that additional sockeye salmon to this estimate were intercepted in the set-net fisheries in the English Bay and Seldovia areas.

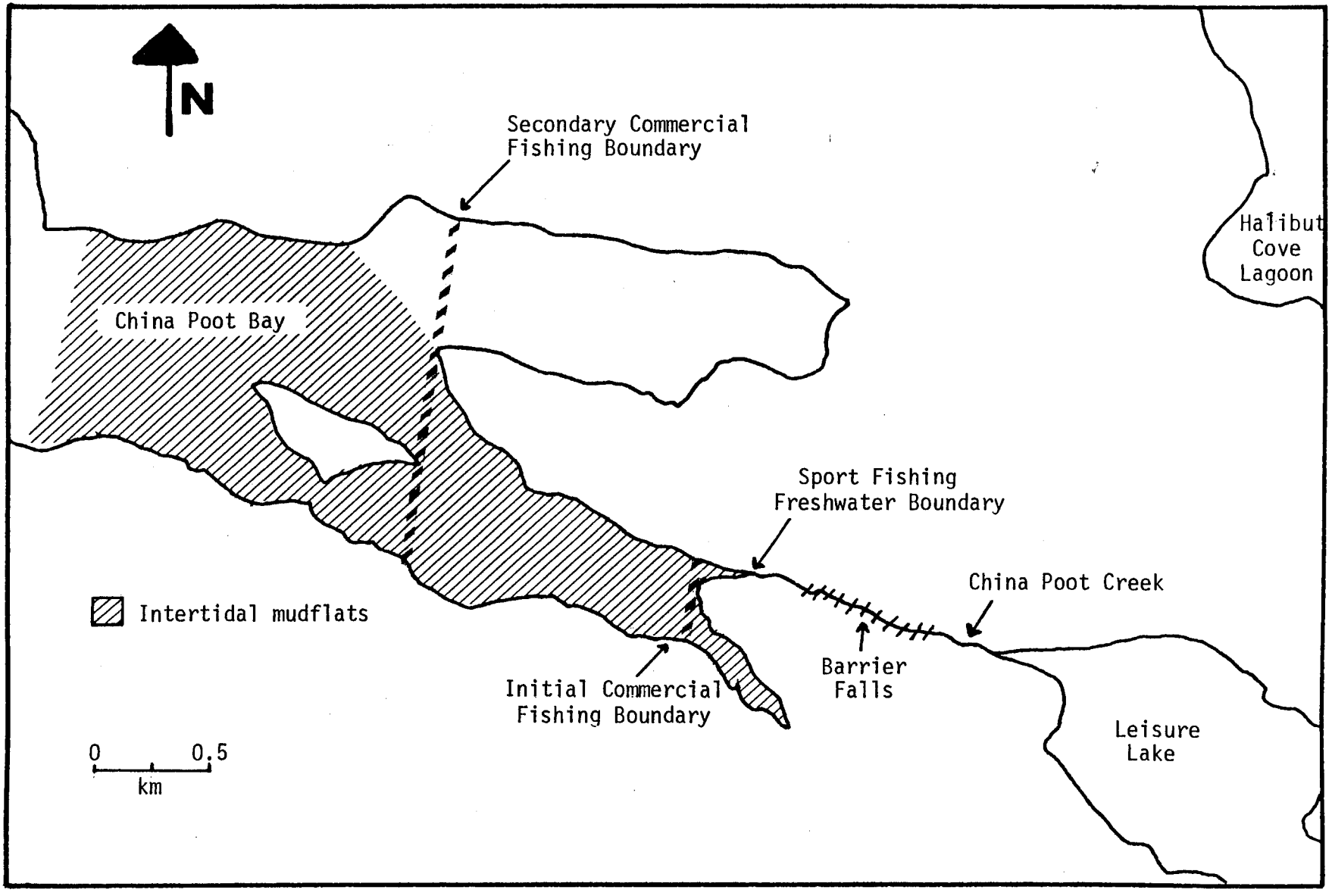

Figure 4. Terminal harvest area for Leisure Lake adult sockeye salmon in China Poot Bay showing the initial commercial fishing boundary that was moved to the secondary boundary to protect spawning pink salmon.

Sport and Personal-Use Harvest

Although adult sockeye salmon were returning to China Poot Creek from late June through early August 1984, most of the fishing effort by sport fishermen was applied in the latter half of July. A freshwater boundary was designated at the upper intertidal area of China Poot Bay (Figure 4) which separated the freshwater and saltwater regulation areas. In 1984, sport fishermen harvested an estimated 500 adult sockeye salmon with most fish taken in the intertidal area (Table 3).

Commencing in 1984, the Alaska Board of Fisheries designated China Poot Creek from the freshwater boundary to the barrier falls (Figure 4) open to personal-use, dip-net fishing from 1 to 31 July. Virtually all access was by boat from Homer; a total of 1,200 fishermen in 350 boats harvested ~2,500 sockeye salmon from China Poot Creek in 1984 (Table 3). Most of these fish were dipnetted during the last 2 weeks of July. However, the 1984 dip-net harvest was considerably less than the nearly 6,000 fish harvested in 1983. This was primarily attributed to the efficient commercial seining operations in China Poot Bay in 1984.

An estimated 500 adult sockeye salmon of Leisure Lake origin escaped harvest by commercial, sport, or personal-use fishermen (Table 3). The nonharvested and harvested (commercial, sport, and personal-use fisheries) adults bring the China Poot Bay 1984 return to over 117,360 adult sockeye salmon.

Adult Sockeye Salmon Age, Weight, and Length

Preliminary results of AWL data analysis are shown in Table 4. Depending upon where the commercial seiners fish in the China Poot Bay subdistrict, some sockeye salmon returning to other systems are intercepted in the harvest; however, the percentage of non-Leisure Lake fish is minimal (probably less than 1% of total).

Table 4. The population characteristics of the 1984 commercial catch of sockeye salmon in China Poot Bay by age group along with length (mm) and weight (kg)[a/].

	Age Group					
	1.2[b/]	1.3	2.2	1.4	2.3	TOTAL
Males	55,600	1,900	1,500	0	200	59,200
Percent	53.3	1.9	1.5	0	0.2	56.8
Avg Length	494	526	513	ND	565	495
Std Error	1.36	13.63	7.74	ND	0.00	1.36
Samp Size	258	9	7	0	1	275
Avg Weight	2.0	2.7	2.3	ND	2.9	2.1
Std Error	0.02	0.12	0.11	ND	0.00	0.02
Samp Size	178	8	7	0	1	194
Females	40,100	600	4,100	200	0	45,000
Percent	38.4	0.6	3.9	0.2	0	43.2
Avg Length	494	549	501	511	ND	495
Std Error	1.62	9.41	6.0	0.00	ND	1.55
Samp Size	186	3	19	1	0	209
Avg Weight	1.9	2.8	2.0	2.5	ND	1.9
Std Error	0.03	0.15	0.09	0.00	ND	0.02
Samp Size	118	3	14	1	0	136
Both Sex	95,700	2,500	5,600	200	200	104,200
Percent	91.7	2.5	5.4	0.2	0.2	100.0
Avg Length	494	532	504	511	565	495
Std Error	1.04	10.49	4.85	0.00	0.00	1.02
Samp Size	444	12	26	1	1	484
Avg Weight	2.0	2.7	2.1	2.5	2.9	2.0
Std Error	0.02	0.10	0.07	0.00	0.00	0.02
Samp Size	296	11	21	1	1	330

a/ Preliminary ADF&G Commercial Fishery catch data.

b/ Age "1.2" means the fish spent 1 year in fresh water and 2 years in the ocean for a total of 3 winters since emerging as fry from the gravel in which eggs were deposited.

Over 91% of the 1984 China Poot Bay harvest was age-1.2 fish from the 1981 planting of 1,092,700 sockeye salmon fry and subsequent 1982 emigration of 315,200 age-1. smolts. Thus, smolt-to-adult ocean survival was estimated at 34.3% (not including fish returning in subsequent years). The average length and weight at harvest was 494 mm and 2.0 kg, respectively. Almost 60% of the sampled fish were males (Table 4).

The remainder of the China Poot Bay harvest of Leisure Lake sockeye salmon was from the 1980 stocking of 532,700 fry. From that stocking, 240,700 age-1. smolts emigrated from the lake in 1981; 3,200 returned as age-1.3 adults in 1984. These age-1.3 adults had an average size of 532 mm and 2.7 kg, and over 70% of the fish sampled were males. Also represented from the 1980 stocking were the age-2. smolts that emigrated in 1982; 4,326 smolts were counted through the fyke-trap system, but the subsequent return in 1984 of 6,220 age-2.2 adults suggests that as many as 25,000 smolts may have emigrated in 1982. The age-2.2 adults were 504 mm and 2.1 kg in size, and about 30% of the fish sampled were males. This results in a cumulative ocean-survival rate of 42% for fish stocked in 1980 (Table 5).

DISCUSSION

Freshwater Growth and Survival

Increases in stocking density have led to decreases in the freshwater growth and survival of juvenile sockeye salmon (Figure 5). As a result of annually increasing the fry-stocking densities since 1980, the weight of smolts has decreased by ~50% in each successive year. Additionally, the survival rate for fry to age-1. smolts for this same period has decreased from 45% to only 8% (Koenings and Burkett 1987). These results suggest that in Leisure Lake, sockeye salmon juveniles rear in a density-dependent fashion and that the lake has reached its "carrying

Table 5. Summary of the Leisure Lake adult sockeye salmon production showing fry stocking densities, numbers and ages of resultant smolts, and adult returns by age class.

Year (no. stocked) (x10)	Smolt Emigrations: Year smolted	Smolt age	Number	Adult Returns: Return year	Age	Number	Percent survival
			FINGERLING STOCKING				
1976 (59.8)	1977	1.0	31,300	1978	1.1	20	<1
				1979	1.2	650	2
				1980	1.3	700	2
	1978	2.0	1,900	1980	2.2	175	1
	TOTAL		33,200	TOTAL		1,545	5
1977 (92.3)	1978	1.0	56,500	1979	1.1	20	<1
				1980	1.2	13,130	23
				1981	1.3	590	1
	1979	2.0	4,800	1981	2.2	150	3
	TOTAL		61,300	TOTAL		13,890	23
1978 (77.1)	1979	1.0	54,100	1980	1.1	20	<1
				1981	1.2	19,300	36
				1982	1.3	490	1
	1980	2.0	3,900	1982	2.2	870	22
	TOTAL		58,000	TOTAL		20,680	36
			FRY STOCKING				
1980 (500.0)	1981	1.0	240,700	1982	1.1	2,040	1
				1983	1.2	90,320	37
				1984	1.3	3,210	1
	1982	2.0	4,300[a/]	1984	2.2	6,220	[a/]
	TOTAL		245,000	TOTAL		101,790	41
1981 (1,100.0)	1982	1.0	315,200	1983	1.1	100	<1
				1984	1.2	107,970	34
				1985	-	-	-
	1983	2.0	90,300	1985	-	-	-
	TOTAL		405,500	PRETOTAL[b/]		108,070	34
1982 (1,500.0)	1983	1.0	326,600	1984	1.1	100	<1
				1985	-	-	-

a/ Error may be caused by early emigration of smolts (under the ice) before fyke trap was installed.

b/ Additional returns pending.

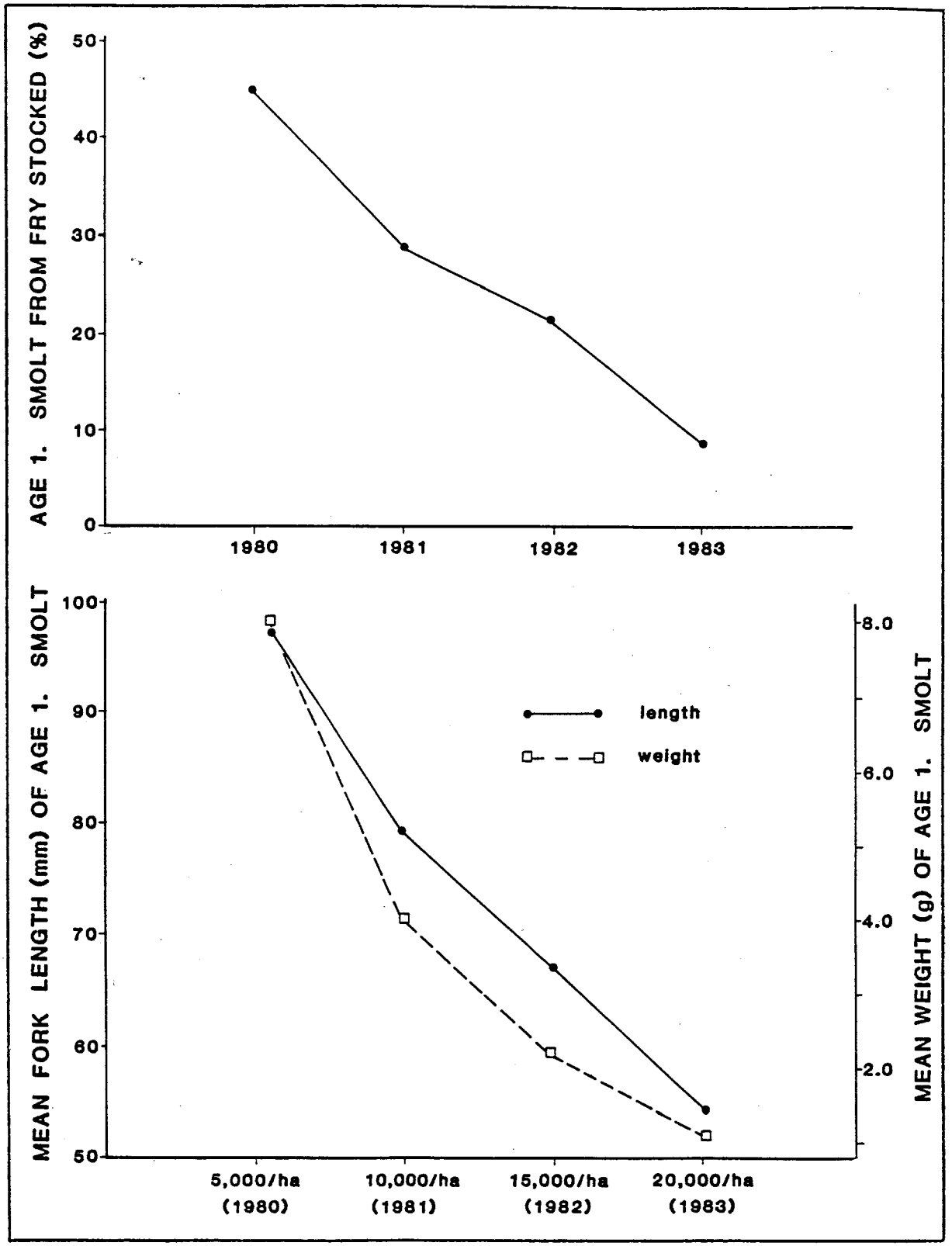

Figure 5. Changes to age-1. smolt characteristics resulting from increased densities of fry stocked into Leisure Lake.

capacity" in terms of the stocking of sockeye salmon fry into a natural system (Koenings and Burkett 1987).

The resident rainbow trout population in Leisure Lake appeared to increase slightly in 1984, relative to previous years. This was indicated by the total number of trout and the number of large-sized trout (>25 cm) that passed through the fyke system during the trout spawning migration, which coincided in timing with the latter portion of the smolt emigration. However, despite these increases, we believe that regulation of the juvenile sockeye salmon population by predators (primarily trout) is minimal. This is supported by the low numbers of rainbow trout relative to the number of juvenile sockeye salmon in the system and by the decreasing size of sockeye salmon smolts, suggesting that food limitations are more important. Based on data from limnological sampling and smolt characteristics during 1984 and previous years, sockeye salmon presently appear to be food limited. To increase the potential food supply available to juvenile sockeye salmon, lake fertilization was initiated during the summer of 1984, and it will probably continue for a number of years to determine if the rearing potential of Leisure Lake can be increased.

The mean length of the age-1. sockeye salmon in 1984 was 54.3 mm, which is slightly below the suggested threshold size of 60 mm for sockeye salmon smolts (Koenings and Burkett 1987). There has also been a substantial increase in the proportion of age-2. fish, as compared to previous years. Based upon seine catches of juvenile sockeye salmon made in the limnetic and littoral regions of Leisure Lake during the summer of 1984, the proportion of the smolt emigration composed of age-2. fish may increase in 1985.

Smolt Emigration Patterns

During smolt emigration seasons prior to 1984, the majority of smolts emigrated from Leisure Lake during 1801-2400 h, followed by 0001-0600 h (Table 6). However, during the 1984 season, the majority of the smolts emigrated from the lake during

Table 6. Comparison, by sample period, of the emigration timing of Leisure Lake sockeye salmon smolts, 1981-1984.

Year	Time Period			
	0001-0600	0601-1200	1201-1800	1801-2400
1981	17.7	5.8	14.9	61.6
1982	35.2	0.5	2.8	61.5
1983	31.4	3.0	9.3	56.3
1984	36.5	13.7	15.4	34.4

0001-0600 h. Thus, the proportion of smolts emigrating during the daylight periods (e.g., 0601-1200 h and 1201-1800 h) increased relative to previous years. This shift in relative numbers of emigrants per time period may be the result of larger numbers of older individuals, the influence of smaller mean smolt size impacting behavioral trends, or other factors. AWL sampling prior to 1984 suggested that smolts emigrating during daylight hours (e.g., 0601-1200 h) were slightly larger than those emigrating under cover of darkness or low light (unpublished data). An explanation might be that, for a given population or range of sizes, larger individuals are more capable of avoiding predation than smaller individuals because of better stamina, swimming speed, and problems they might present as larger prey to potential predators (Pyke et al. 1977; personal observation). Since vertical migration is not available as a predator-avoidance mechanism (Iwasa 1982), smaller-sized smolts might be expected to emigrate under the protective cover of low light levels. In the 1984 season, however, differences by time period within age classes became less pronounced, while differences between age classes increased. This became most noticeable during the latter part of the season when age-2. smolts tended to emigrate during the day and age-1. smolts at night. We would expect the above patterns to be evident only in clear-water systems. If the water is glacial or chronically muddy during the smolt outmigration season, it should provide effective cover, greatly reducing predation (Kyle 1983).

Instances of net avoidance, including cases where smolts enter the fyke tunnel only to reappear and move back toward the lake, were less prevalent in 1984 than in previous seasons. Such behavior became noticeable during the last week of smolt camp operation when schools of 100 to 200 fish (primarily age 2.) approached the net and then turned back toward the lake. The implications of this type of behavior are unknown, but the 'searching pattern' exhibited as the net is approached serves to reinforce the need for full-stream coverage.

Post-Lake Survival

While different sources of mortality act upon juvenile sockeye salmon during their freshwater existence, the transition from fresh water to salt water is perhaps the most traumatic event. For Leisure Lake smolts, this transition involves a 51-m descent from rearing area to salt water, including a 7-m barrier fall; this descent causes some mortality in the smolt populations. Based on observations on China Poot Creek between the barrier falls and the intertidal area, ~10% of the fish holding in stream eddies showed signs of bruising from their descent during early June. However, the fish in these areas tended to be low in numbers (e.g., two to three fish per eddy) and only a fraction of the potential eddy areas were occupied. In contrast, the intertidal area had several schools of 150 to 300 fish holding in the "slow water" along the shoreline. These fish reflected the age composition of smolts emigrating from the lake at that time; virtually all were age 1.. In addition, they actively shied away when approached and maintained cohesive schools, a characteristic of healthy and alert schooling fish, which moved toward the stream mouth as the tide came in, suggesting that osmoregulation had not yet been completed. Along the intertidal shore, counts made of fresh mortalities that had been hidden from potential scavengers (e.g., trapped under rocks or debris) revealed close to a 1:1 ratio between age classes (e.g., 19 age 1. and 16 age 2.). Considering that ~95% of the smolts emigrating from Leisure Lake were age 1., these counts may indicate a differential mortality operating on the two age classes. Autopsies were not performed, but the two most probable causes of mortality were osmoregulatory dysfunction and/or physical damage from the descent to salt water. However, it would seem that an age-2. fish that emigrates from Leisure Lake is doing so actively and should be physically capable of saltwater adaptation; although the possibility of passive emigration by following the school does exist. Regarding physical damage from the falls, age-1. smolts might be carried and buffered by the water more than the much larger age-2. fish. While this could imply a trade-off between size and survival from physical damage, it is recognized

that the larger smolt size with its greater ability to avoid predators (and possible greater endurance) would be more beneficial for longer seaward migrations in salt water.

Ocean Survival and Adult Harvest

The growth and survival of sockeye salmon in the marine environment is the last phase determining success of a salmon enhancement project. The Leisure Lake program has continued to have impressive ocean survivals, ranging from 20% to 40% (*See* Table 5). However, with the increase in stocking densities and the associated decrease in size at smoltification over the past 4 years, the effect upon ocean survival remains to be seen.

The impact of increasing numbers of returning adult sockeye salmon to the commercial harvests has been substantial. Prior to 1983, virtually all of the Kachemak Bay seine fleet fished in Tutka Bay; a predominately pink salmon fishery (*See* Figure 1). However, by 1983 ~75% of the seine fleet had moved to China Poot Bay. This was motivated by cannery prices that were higher for sockeye salmon than for pink salmon. Also, there have been relatively poor returns of pink salmon to Tutka Bay in recent years. If ocean survivals for Leisure Lake sockeye salmon remain even moderately high and annual fry stocking is continued, the China Poot Bay returns should continue to maintain the significantly restructured fishery.

We view the estimates of the harvest of returning adult sockeye salmon as conservative because of: (1) the unknown numbers of adults harvested in the interception fishery that occurs on the west side of the Kenai Peninsula south of Kachemak Bay (*See* Figure 1); (2) it may prove impossible to calculate the number of Leisure Lake sockeye salmon intercepted along the southern portion of the Kenai Peninsula because there is much stock intermixing in that region; (3) it is probable that the interception fishery alters the age composition of the China Poot Bay harvest from that of the true population (T. Schroeder, 3298 Douglas Street, Homer, Alaska 99603); and (4) the southern set-

net fishery tends to harvest larger sockeye salmon more efficiently than smaller ones, thereby exaggerating the proportion of smaller adults in the China Poot Bay return.

Besides the difficulty in estimating harvest rates, poor estimates of outmigrating smolt numbers could have resulted when smolts either emigrated under the ice, before the camp was set up, or after the camp was vacated. The unexpectedly large numbers of 1984 age-2.2 adults (6,220) indicate that the 4,300 smolts (*See* Table 4) estimated to have emigrated in 1982 were probably underestimated. Using historical smolt-to-adult survival data, it is more likely that about 25,000 smolts emigrated. Because age-1. and -2. smolts did not overlap in size, we are relatively confident that, of the smolts sampled, most all were aged correctly. However, we have found that some sockeye salmon smolts emigrate from Leisure Lake while the lake is still under cover of ice. Therefore, low smolt estimates may result from either very early or late unmonitored emigration in those particular years.

Another explanation for the discrepancy between the number of harvested sockeye salmon adults having scales showing 2 years of freshwater growth and the estimated number of age-2. smolts that emigrated in 1982 might be that fish migrating to other river systems on the eastern side of Cook Inlet are intercepted off the mouth of China Poot Bay. However, scale analysis, combined with local hydrographic patterns, suggests that the China Poot Bay fishery is highly specific for fish of Leisure Lake origin. Within Kachemak Bay, there is no major sockeye salmon rearing system other than the Leisure Lake system. Additionally, limited tagging studies conducted recently off river mouths in Cook Inlet north of Kachemak Bay have indicated that a substantial number of the adult sockeye salmon returning to the Leisure Lake system may be "staging" in areas north of Kachemak Bay prior to their arrival at China Poot Bay (unpublished data). This subjects a portion of the returning population to other fisheries, which would reduce the size of the China Poot Bay return. The fisheries north of Kachemak Bay, combined with the interception

fisheries that select for larger-sized adult sockeye salmon (i.e., age-2.2 and -1.3 fish) migrating along the southern Kenai Peninsula, would tend to reduce the proportion of older fish sampled in the terminal-harvest area. This suggests that the actual number of age-2. smolts could have been even higher than the "up to 20,000 'missed' smolts." As additional data on age-2. smolts are collected and analyzed, we may be able to make better estimates of the number of age-2. emigrants during 1982 and other years.

CONCLUSIONS

The barrier falls that separate the study lake from salt water has created a research area that is as close as possible to a large-scale, controlled, laboratory study in the field. For most years, many of the relevant parameters of the system have been monitored and are fairly well known: (1) the number of fry stocked; (2) the number, size, and age composition of emigrating smolts; and (3) the number, size, and age composition of the adult sockeye salmon returning to the terminal harvest area in China Poot Bay and other localities in the Kachemak Bay region. The information generated on juvenile sockeye salmon growth, survival, and age/size relationships at smoltification, in relation to stocking densities and food resources, has application toward the successful and efficient rearing of sockeye salmon and other salmonids in Alaska and other West Coast systems. The success of the Leisure Lake program is indicated by the results from the freshwater phase, the smolt-to-adult salmon ocean survivals, and the impact the adult returns have had upon the fisheries of lower Cook Inlet.

However, additional information is needed on the differences between emigration times for the two age classes of sockeye salmon smolts. One strategy for achieving a better understanding of the freshwater ecology and the degree of stock interception occurring in the fisheries would be to initiate a tagging study

using coded-wire tags (CWTs). Either fry could be tagged at the hatchery using half-length CWTs or smolts could be tagged at the lake outlet using full-sized tags.

Finally, from 1980 through 1983 the density of sockeye salmon stocked into Leisure Lake was increased by 0.5 million fry annually. The relatively small size and low number of age-1. smolts emigrating in 1984, and the decreases in fry-to-smolt growth and survival from 1981-1984 suggest that it was no longer feasible to continue challenging natural forage production without the addition of 'compensatory' nutrients. This is especially germane because the migration barrier precluded the cycling of nutrients from salmon carcasses back into the lake system (Koenings and Burkett 1987). The initiation of a fertilization program would represent a new approach at producing sockeye salmon smolts and adults through increasing the food supply for rearing juveniles. Thus, under enhanced nutrient levels, Leisure Lake should develop a stable and increased rearing capacity for juvenile sockeye salmon.

ACKNOWLEDGMENTS

Appreciation is given to the FRED Division Limnology Program for partial funding and to J. P. Koenings and R. D. Burkett for project design and editorial review. Thanks are given to L. Boyle, A. Quimby, B. Shafford; and to R. Och and his staff for their dedicated work during various phases of this project. Appreciation is also extended to K. Rawson for statistical analysis, and T. Schroeder for smolt-scale analysis.

REFERENCES

Fleiss, J. L. 1981. Statistical methods for rates and proportions. Second edition. John Wiley and Sons, New York. 321 p.

Koenings, J. P. and R. D. Burkett. 1987. Population characteristics of sockeye salmon (*Oncorhynchus nerka*) smolts relative to temperature regimes, euphotic volume, fry density and forage base with Alaskan lakes. p. 216-234. In: H. D. Smith, L. Margolis, and C. C. Wood [ed.]. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96:486 p.

Kyle, G. B. 1983. Crescent Lake sockeye salmon smolt enumeration and sampling, 1982. Alaska Department of Fish and Game, FRED Division Report Series 17:24 p.

Mood, A. M., F. A. Graybill and D. C. Boes. 1974. Introduction to the theory of statistics, 3rd ed. McGraw-Hill, New York.

Pyke, G. H., H. R. Pulliam and E. L. Charnov. 1977. Optimal foraging: a selective review of theory and tests. Quart. Rev. Biol. 52:137-154.

APPENDICES

APPENDIX A

Appendix A. 1984 Leisure Lake smolt emigration by period.

Date	Time Period 0000-0600	0600-1200	1200-1800	1800-2400	Daily Total	Cumulative Total[a]
5/14	...	...	0[b]	0	0	0
5/15	17	2	0	3	22	22
5/16	14	0	2	0	16	38
5/17	554	0	0	1	555	593
5/18	43	0	4	0	47	640
5/19	80	0	186	131	397	1,037
5/20	305	590	452	60	1,407	2,444
5/21	714	21	23	105	863	3,307
5/22	526	2,546	159	100	3,331	6,638
5/23	887	179	736	0	1,802	8,440
5/24	784	990	569	517	2,860	11,300
5/25	4,744	766	940	7,966	14,416	25,716
5/26	3,886	282	2,291	2,100	8,559	34,275
5/27	2,413	1,785	614	2,814	7,626	41,901
5/28	5,293	2,163	7,353	15,563	30,372	72,273
5/29	5,903	1,864	907	2,992	11,666	83,939
5/30	3,626	1,734	1,840	6,716	13,916	97,855
5/31	2,700	3,600	2,271	3,144	11,715	109,570
6/1	5,460	1,432	1,707	4,581	13,180	122,750
6/2	4,784	897	2,256	5,546	13,483	136,233
6/3	4,479	1,844	2,372	6,918	15,613	151,846
6/4	4,729	2,895	3,145	4,298	15,067	166,913
6/5	6,258	1,887	1,820	1,595	11,560	178,473
6/6	4,716	1,540	1,281	2,265	9,802	188,275
6/7	1,168	973	401	2,479	5,021	193,296
6/8	4,462	241	133	2,450	7,286	200,582
6/9	3,383	677	435	1,537	6,032	206,614
6/10	1,623	153	74	339	2,189	208,803
6/11	1,355	61	279	299	1,994	210,797
6/12	1,358	168	114	370	2,010	212,807
6/13	1,228	88	96	171	1,583	214,390
6/14	1,159	57	123	126	1,465	215,855
6/15	241	16	75	65	397	216,252
6/16	404	17[c]	49[c]	43	513	216,765
6/17	136	...[c]	...[c]	99	235	217,000
6/18	232	201	219	94	746	217,746
6/19	184	70	318	64	636	218,382
6/20	232	50	128	85	495	218,877
6/21	116	121	22	123	382	219,259
6/22	44	83	240	84	451	219,710
6/23	112	55	102	63	332	220,042
6/24	...[c]	178	25	50	253	220,295
6/25	182	125	371	129	807	221,102
6/26	388	32[b]	...	...	420	221,522
TOTALS	80,922	30,383	34,132	76,085	221,522	

[a] Does not include pre- and post-camp emigration estimates.
[b] Fyke assembled 14 May at 1600 h and disassembled 26 June at 0900 h.
[c] Catch not sampled during period but is represented as a cumulative count in the following period.

APPENDIX B

Appendix B. Weight and length summary of 1984 Leisure Lake age 1. sockeye salmon smolts.

Date	Sample period	Sample size	Mean length (mm)	Range	Sample variance	Mean weight (g)	Range	Sample variance ($x10^{-2}$)
5/17	0000-0600	17	53.4	50-57	3.38	1.10	0.8-1.4	2.7
5/20	0000-0600	15	56.9	52-63	12.98	1.38	1.0-2.0	9.3
5/23	0000-0600	18	55.6	50-61	7.43	1.41	1.0-2.1	10.4
5/25	0600-1200	20	55.9	50-62	11.08	1.27	0.9-1.8	6.1
5/25	1200-1800	20	54.6	51-59	5.31	1.16	0.8-1.6	3.4
5/26	0000-0600	20	54.7	50-61	8.35	1.18	0.9-1.9	6.7
5/26	1800-2400	20	54.7	51-60	6.33	1.15	0.9-1.7	6.3
6/1	0000-0600	20	53.1	50-58	7.40	1.05	0.8-1.4	2.6
6/1	0600-1200	20	54.6	50-61	10.99	1.15	0.8-1.7	6.0
6/1	1200-1800	20	53.7	50-58	4.87	1.08	0.8-1.4	2.6
6/1	1800-2400	20	54.3	50-58	3.80	1.11	0.9-1.4	1.9
6/6	0000-0600	20	53.1	47-58	9.08	1.03	0.6-1.4	5.2
6/6	1200-1800	20	54.7	52-58	3.69	1.13	0.9-1.5	2.4
6/7	0600-1200	20	54.5	49-61	9.32	1.14	0.8-1.7	6.0
6/7	1800-2400	20	53.0	48-58	9.26	1.00	0.7-1.5	3.4
6/12	0000-0600	20	52.9	48-66	26.62	1.03	0.6-2.4	22.0
6/12	0600-1800	20	54.3	48-64	13.91	1.08	0.5-2.8	23.2
Weighted Average		330	54.3	47-66	0.04	1.14	0.6-2.8	0.02

Appendix B (continued). Weight and length summary of 1984 Leisure Lake age 2. sockeye salmon smolts.

Date	Sample period	Sample size	Mean length (mm)	Range	Sample variance	Mean weight (g)	Range	Sample variance ($x10^{-2}$)
5/17	0000-0600	20	75.7	67-80	13.50	3.29	2.2-4.6	37.8
5/19	1200-1800	20	81.0	70-88	30.21	4.33	2.9-5.6	69.5
5/19	1800-2400	20	75.1	68-85	22.05	3.29	2.2-4.6	54.3
5/23	0000-0600	22	75.7	66-85	35.75	3.58	2.1-5.8	112.0
5/25	0600-1200	20	76.3	69-90	27.61	3.57	2.4-6.6	97.6
5/25	1200-1800	20	75.6	67-85	24.57	3.47	2.0-4.8	57.1
5/26	0000-0600	20	73.5	68-79	10.26	3.09	2.2-4.2	35.3
5/26	1800-2400	20	73.1	68-81	14.24	2.93	2.1-4.2	33.8
6/1	0000-0600	20	77.1	70-86	22.20	3.64	2.2-5.4	92.3
6/1	0600-1200	20	77.3	66-93	35.92	3.76	2.1-6.7	114.3
6/1	1200-1800	20	80.1	73-88	23.08	4.40	3.0-6.3	107.6
6/1	1800-2400	20	77.3	70-83	14.24	3.94	3.0-6.1	62.3
6/6	0000-0600	20	79.7	72-88	21.82	4.25	3.0-5.8	61.8
6/6	1200-1800	20	81.6	72-92	22.04	4.55	2.6-7.0	99.2
6/7	0600-1200	20	80.8	70-94	26.38	4.55	2.7-6.8	99.7
6/7	1800-2400	20	79.0	70-92	26.58	4.21	3.0-7.2	120.8
6/12	0000-0600	20	90.4	74-103	54.15	6.55	3.1-10.7	293.6
6/12	0600-1800	20	85.7	77-99	40.84	5.48	3.6-8.7	212.9
Weighted Average		362	78.6	66-103[a/]		4.05	2.0-10.7[a/]	0.327

[a/] One nonrandomly selected Age 2.0 fish captured on 20 May 1984 measured 65 mm and 1.8 g.

APPENDIX C

Appendix C. 1984 Leisure Lake sockeye salmon smolt emigration as apportioned by age class.

Date	Age 1. Daily	% Daily	Season	% Season	Age 2. Daily	Season	% Season	Daily total
Pre-camp[a/]	20	2.9	20	0.0	680	680	1.3	700
5/14	0	0.0	20	0.0	0	680	0.0	0
5/15	3	13.6	23	0.0	19	699	0.0	22
5/16	0	0.0	23	0.0	16	715	0.0	16
5/17	17	3.1	40	0.0	538	1,253	1.0	555
5/18	5	10.6	45	0.0	42	1,295	0.1	47
5/19	5	1.3	50	0.0	392	1,687	0.8	397
5/20	18	1.3	68	0.0	1,389	3,076	2.7	1,407
5/21	33	3.8	101	0.0	830	3,906	1.6	863
5/22	65	2.0	166	0.0	3,266	7,172	6.3	3,331
5/23	214	11.9	380	0.1	1,588	8,760	3.1	1,802
5/24	848	29.7	1,228	0.5	2,012	10,772	3.9	2,860
5/25	5,178	35.9	6,406	2.9	9,238	20,010	17.9	14,416
5/26	3,916	45.8	10,322	2.2	4,643	24,653	9.0	8,559
5/27	3,629	47.6	13,951	2.0	3,997	28,650	7.8	7,626
5/28	20,478	67.4	34,429	11.5	9,894	38,544	19.2	30,372
5/29	10,280	88.1	44,709	5.8	1,386	39,930	2.7	11,666
5/30	13,418	96.4	58,127	7.6	498	40,428	1.0	13,916
5/31	11,122	94.9	69,249	6.3	593	41,021	1.2	11,715
6/1	12,305	93.4	81,554	6.9	875	41,896	1.7	13,180
6/2	13,134	97.4	94,688	7.4	349	42,425	0.7	13,483
6/3	14,934	95.7	109,622	8.4	679	42,924	1.3	15,613
6/4	14,800	98.2	124,422	8.3	267	43,191	0.5	15,067
6/5	11,278	97.6	135,700	6.3	282	43,473	0.5	11,560
6/6	9,446	94.6	145,146	5.3	356	43,829	0.7	9,802
6/7	4,892	97.4	150,038	2.8	129	43,958	0.3	5,021
6/8	7,164	98.3	157,202	4.0	122	44,080	0.2	7,286
6/9	5,900	97.8	163,102	3.3	132	44,212	0.3	6,032
6/10	2,077	94.9	165,179	1.2	112	44,324	0.2	2,189
6/11	1,884	94.5	167,063	1.1	110	44,434	0.2	1,994
6/12	1,905	94.8	168,968	1.1	105	44,539	0.2	2,010
6/13	1,432	90.5	170,400	0.8	151	44,690	0.3	1,583
6/14	1,317	89.9	171,717	0.7	148	44,838	0.3	1,465
6/15	304	76.6	172,021	0.2	93	44,931	0.2	397
6/16	407	79.3	172,428	0.2	106	45,037	0.2	513
6/17	175	74.5	172,603	0.1	60	45,097	0.1	235
6/18	252	33.8	172,855	0.1	494	45,591	1.0	746
6/19	212	33.3	173,067	0.1	424	46,015	0.8	636
6/20	127	25.7	173,194	0.1	368	46,383	0.7	495
6/21	227	59.4	173,421	0.1	155	46,538	0.3	382
6/22	138	30.6	173,559	0.1	313	46,851	0.6	451
6/23	151	45.5	173,710	0.1	181	47,032	0.4	332
6/24	221	87.4	173,931	0.1	32	47,064	0.1	253
6/25	435	53.9	174,366	0.2	372	47,436	0.7	807
6/26	312	74.3	174,678	0.2	108	47,544	0.2	420
Post-camp[a/]	4,300	61.4	178,978	0.2	2,700	50,244	5.4	7,000

[a/] Pre- and post-camp estimates based on entire applicable period rather than daily summaries.