PROGRESS REPORT - FRAZER LAKE SOCKEYE AND CHINOOK SALMON ENHANCEMENT, 1978 and 1979

by
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ABSTRACT

Introduced runs of sockeye salmon (Oncorhynchus nerka) and chinook salmon (O. tshawytscha) were maintained at Frazer Lake in 1978 and 1979 by operation of a fishpass at a 10-m high falls. A total of 142,147 salmon ascended the fishpass in 1978. In 1979, 137,033 salmon used the fishpass to reach spawning areas. Entry rate into the fishpass averaged 98 salmon during 15-minute timed counts. Highest daily passage was 9,798 salmon in 1978. Salmon exit rate for two additional runs of fishpass constructed in 1978 was only 35% of the fish exiting the total fishpass structure. Dominant sockeye age groups were 1.2, 2.2, and 2.3 in 1978 and 1.2, 1.3, and 2.2 in 1979. Major chinook age groups were 1.3 and 1.4. Sockeye return per spawner has averaged 2.90 for eight parent years (1966 - 1973). Sockeye smolts migrated downstream from early June to mid-July. A trend of decreasing smolt size is apparent and may be due to increasing densities of young sockeye competing for zooplankton (98.7% copepods and rotifers in 1978) while rearing in the lake. The East Fork of Pinnell Creek and lakeshore support the highest concentrations of sockeye spawners. Chinook spawning has been observed in Frazer River. The most recent extension of sockeye spawning in the Frazer River outlet was observed in 1978 and 1979. FRED Division has a major responsibility at Frazer Lake to assure operation of the fishpass. A comprehensive evaluation and monitoring effort needs to be established to document long-term success or failure of salmon introductions, to test theoretical escapement goals, and to optimize salmon production.

Key words

Frazer Lake, sockeye, chinook, fishpass, salmon introduction, evaluation.

INTRODUCTION

The establishment of sockeye (Oncorhynchus nerka) and chinook (O. tshawytscha) salmon runs at Frazer Lake, Kodiak Island, Alaska has been documented by Blackett (1979). This long-term project has been highly successful in establishing a major run of sockeye in a lake system previously blocked to anadromous fish by a 10-m high falls.

Salmon runs at Frazer Lake are maintained by operation of four 64-m long runs of fishpass at the falls. Salmon introductions are evaluated by counting and sampling adult fish returns and by monitoring spawning area utilization. Emigrating outmigrating smolts are sampled for age-weight-length composition. Although sockeye and chinook salmon have been established, the sockeye returns have been less than half of the potential that the system can theoretically support. The ultimate success of this project will be determined by the capability of the stocks to maintain themselves at maximal levels of production.

The purpose of this report is to document project results not previously reported for 1978 and 1979 and to generally discuss the role of FRED Division in the development of the Frazer salmon runs to their full potential.

METHODS AND MATERIALS

Salmon Passage and Sampling

All salmon entering the fishpass at Frazer falls are counted at the exit tank and recorded by species. Optimal water flow in the fishpass is maintained throughout the migration by a stoplog water control diversion weir located at the top of the falls. A 23-cm wide vertical slot entrance orifice has a water attraction velocity of 2.1 to 2.5 m per second.

Salmon entrance and passage rates are evaluated by conducting 15-minute timed counts of the number of salmon entering the vertical slot entrance and exiting the fishpass during four time periods: morning, mid-day, afternoon, and evening; each day that passage is 1,000 or more salmon.

Adult sockeye and chinook salmon are sampled at the fishpass exit trap for determination of age, weight, length, and sex. In 1978, 25 sockeye were sampled on a daily basis (5 days per week) throughout the migration. The sampling scheme was changed in 1979 to 0.65% of the previous day's cumulative count on days when 1,000 or more sockeye were counted. All chinook captured in the trap are sampled at a maximal rate of 15 a day until a sampling limit of 150 fish has been reached.

Fish to be sampled are transferred by dip net from the trap to an anaesthetic tank containing a fresh MS 222 solution. Each anesthetized fish is examined externally for sex, measured with calipers from mid-eye to tail-fork to the nearest millimeter, weighed to the nearest tenth of a kilogram; and two scales are taken for age determination. The fish is then released in the exit channel to recover and to continue up-stream migration.

Sockeye smolts migrating downstream are captured by seining below the falls every other morning. Smolts caught per seine haul are either counted or estimated to provide a relative indication of timing and magnitude. Smolts are collected from the seine by crowding, and then 40 smolts are dip-netted for age, weight, and length measurements. Smolts are anesthetized in a MS 222 solution; length is recorded to the nearest millimeter and weight to the nearest 0.1 gram. A smear of six to eight scales is placed on a microscope slide for age determination.

Spawning Area Surveys

During the spawning period (15 July - 31 August), foot, boat, and aerial surveys of the lakeshore and tributaries are conducted as often as practical to determine sockeye utilization of spawning areas and spawner

distribution. Two observers independently count the number of sockeye per estimated tenth mile section and record an average count per section on the survey form. The number of lakeshore spawners, number of paired and unpaired sockeye, and intensity of spawning activity are recorded on a shoreline map. During the peak spawning period, an aerial survey of the entire lake system is conducted to estimate the number of live and dead sockeye in each spawning area.

Lake Studies

Plankton sampling, lake temperature profiles, and water chemistry analyses are done every even year to provide an index of composition and density and to monitor lake conditions for salmon production. Plankton are sampled at four stations (marked by buoys) within the lake, once a week from May through August. A vertical haul is made from a predetermined depth (normally 30 m) with a 0.5-m, 0.006-mesh plankton net. Net contents are washed into a sample bottle containing 10% formalin. Samples are read in Kodiak using a Sedgewick-Rafter counting cell and 0.05-ml test cell volumes (n=5).

Lake temperature profiles and water chemistry are taken at one of the plankton stations using an electronic thermometer with probe and a Hach AL 36 field kit.

Water temperature of the Frazer River, maximal and minimal air temperatures, water level (staff gauge measurement), and weather conditions are recorded at the fishpass facility daily.

RESULTS AND DISCUSSION

Adult Salmon Return

Sockeye salmon passage at the fishpass began 31 May in 1978 and 3 June in 1979. Passage was 50% completed by 2 July in 1978 and 27 June in 1979. Total salmon passage is shown in Table 1.

Table 1. Summary of salmon passage at the Frazer fishpass.

Year	Sockeye	Chinook	Pink	Chum	Total
1978	141,981	131	2	33	142,147
1979	126,742	53	10,178	60	137,033

The fishpass was closed at the end of the run on 19 August in 1978 and 8 August in 1969. For 1978 and 1979, the estimated commercial catches of Frazer sockeye are 50,000 and 26,000, respectively. The total Frazer sockeye returns in 1978 and 1979 are estimated at 192,000 and 163,000, respectively.

Fishpass Operation and Evaluation

In 1978, two new runs of steeppass and entrances were constructed, the exit tank was lengthened, and a water control diversion was installed at the top of the falls. Timed fish passage counts to evaluate fishpass performance were conducted in 1979 but not during construction in 1978.

Each fishpass has an independent vertical slot entrance of identical design. The new fishpass has a single resting tank that is 25 m from the entrance and exit. The original fishpass has three resting tanks, which are spaced at 15- and 12-m intervals between the entrance and exit.

Entry and exit rates of sockeye were compared between the new fishpass and old fishpass. Gross (total fish entering one or more times) entry rate (Table 2) into the entrance structures was higher for the new fishpass ($\bar{x}$ = 90.5 fish/15 min) than for the old fishpass ($\bar{x}$ = 64.6 fish/15 min). However, the number of fish dropping out of the new entrance structure was 37.7% compared to 34.5% for the old entrance. Net (fish left after dropouts) fish entry averaged 42.3 (-29 to 198) for the old entrance and 56.3 (-23 to 208) for the new entrance. The entrances are located side-by-side, but the new entrance is closest to the fish diversion weir where the majority of fish initially congregate. The combined net entry rate for the facility averaged 98 fish per 15-minute count with a range of -29 to 208 fish.

The rate at which fish exited the steeppasses into the exit tank at the top of the falls was considerably greater (Table 3) for the old fishpass ($\bar{x}$ = 49.6 fish/count) compared to the new fishpass ($\bar{x}$ to 26.3 fish/count). A higher percent (117%) of fish exited than entered the old fishpass, while only 46.8% of the fish entering the new fishpass exited during the

Table 2. Evaluation of sockeye entry into the Frazer fishpass entrance structure, 1979.

Fishpass	Number of 15 minute observations	Fish Entering			Fish Dropout			Dropout %	Net Fish Entry		
		Number	$\bar{x}$	Range	Number	$\bar{x}$	Range		Number	$\bar{x}$	Range
Old	133	8,593	64.6	0 - 252	2,962	22.3	0 - 92	34.5	5,631	42.3	-29 - 198
New	132	11,941	90.5	0 - 246	4,507	34.1	0 - 111	37.7	7,434	56.3	-23 - 208

Table 3. Evaluation of sockeye passage relative to fish entry, Frazer fishpass, 1979.

Fishpass	Number of 15-minute observations	Fish Entry			Fish Exiting			% of Fish Entry
		Number	$\bar{x}$	Range	Number	$\bar{x}$	Range	
Old	133	5,631	42.3	-29 - 198	6,601	49.6	0 - 158	117.2
New	132	7,434	56.3	-23 - 208	3,477	26.3	0 - 88	46.8

15-minute counts. Timed entrance and exit counts do not represent actual passage rates through the fishpass; therefore, it is possible to have higher counts of fish entering than exiting. Because fewer fish exit the new fishpass, a higher drop-out rate and lower entry rate are expected. The accumulation of fish in three tanks in the old fishpass compared to a single tank in the new fishpass could contribute to greater numbers of fish exiting the old fishpass during the timed counts.

Highest daily passage of sockeye was 9,798 in 1978, when only the old fishpass was operational. The highest daily count was 8,889 sockeye in 1979 with both fishpasses in operation. Peak passage of sockeye occurred between 26 June and 4 July both years (42.9% of the sockeye return in 1978 and 39.7% of the return in 1979).

Age, Size, and Sex Composition of Sockeye and Chinook

A total of 807 sockeye was sampled from each of the 1978 and 1979 returns to determine age, size, and sex composition (Tables 4 and 5). In 1978, 21.0% of the scales were unreadable for fresh- and salt-water age. Unreadable scales accounted for 18.9% of the sample in 1979. Eight and seven age groups were represented in the 1978 and 1979 samples, respectively. The predominant age groups were 2.3 (41.3%), 1.2 (31.1%), and 2.2 (18.4%) in 1978 and 2.2 (48.9%), 1.3 (18.7%), 1.2 (14.7%), and 2.3 (10.4%) in 1979.

The strong return of age 1.2 sockeye in 1978 and age 1.3 in 1979 represents a change from the previous five years when age 2.2 and 2.3 fish composed the majority of fish in the returns (Table 6).

Sex ratio of sockeye sampled was 42.7% males to 57.3% females in 1978 and 48.6% males to 51.4% females in 1979. Projections of the sample sex ratio to the escapement by weekly period are 53.1% females to 46.9% males in 1978 and 46.4% females to 53.6% males in 1979 (Appendix Tables 1 and 2).

Table 4. Age, weight, and length composition of 634 sockeye sampled from the Frazer fishpass, 1978 escapement.

Parameter	Age Group								Total or Average
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	
Number of Fish	4	197	18	34	117	262	1	1	634
Percent of Sample	0.6	31.1	2.8	5.4	18.4	41.3	0.2	0.2	100.0
Males									
Number Sampled	4	61	4	32	37	132	1	0	271
Percent of Sample	1.5	22.5	1.5	11.8	13.6	48.7	0.4	-	42.7
Mean Length (Mid-eye mm)	353	530	592	407	542	583	405		536
Standard Deviation	21.3	18.1	32.9	32.3	30.4	20.7	-		25.9
Mean Weight (kg)	0.7	2.2	3.1	1.0	2.3	3.0	1.0		2.4
Standard Deviation	0.1	0.3	0.6	0.2	0.4	0.4	-		0.3
Females									
Number Sampled	0	136	14	2	80	130	0	1	363
Percent of Sample	-	37.5	3.9	0.5	22.0	35.8	-	0.3	57.3
Mean Length (Mid-eye mm)		524	557	397	525	580		548	547
Standard Deviation		19.7	30.6	18.4	21.5	18.8		-	21.8
Mean Weight (kg)		2.0	2.4	1.0	2.0	2.8		2.4	2.3
Standard Deviation		0.3	0.5	0.1	0.3	0.3		-	0.3

Table 5. Age, weight, and length composition of 654 sockeye sampled from the Frazer Lake 1979 escapement.

Parameter	Age Group							Total or Average
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	
Number of Fish	9	96	122	38	320	68	1	654
Percent of Sample	1.4	14.7	18.7	5.8	48	10.4	0.1	100.0
				Males				
Number Sampled	9	35	67	38	126	42	1	318
Percent of Sample	2.8	11.0	21.1	11.9	39.6	13.2	0.3	48.6
Mean Fork Length (mm)[1]	379	506	574	391	520	575	350	517
Standard Deviation	15.8	29.5	23.5	27.2	25.9	30.1	-	25.3
Mean Weight (kg)	0.8	2.2	3.0	0.9	2.2	3.0	0.5	2.3
Standard Deviation	0.1	0.3	0.5	0.2	0.3	0.5	-	0.3
				Females				
Number Sampled	0	61	55	0	194	26	0	336
Percent of Sample	-	18.1	16.4	-	57.7	7.8	-	51.4
Mean Fork Length (mm)	-	505	563	-	513	562	-	524
Standard Deviation	-	17.6	15.9	-	21.2	24.5	-	19.8
Mean Weight (kg)	-	2.0	2.7	-	2.0	2.7	-	2.2
Standard Deviation	-	0.3	0.3	-	0.3	0.4	-	0.3
				Differences Between Male and Female Means				
Fork Length (mm)	-	1	11	-	7	13	-	
Weight (kg)	-	0.2	0.3	-	0.2	0.3	-	

[1] Measured from mid-eye to tailfork.

Table 6. Age composition of Frazer Lake adult sockeye, 1965 - 1979.

Sample Year	Age group (% composition)[1]												
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.1	3.3	3.4	Size
1965	0	0.9	1.7	0	6.5	78.0	9.0	0	0.2	3.5	0.2	0	463
1966	0.6	15.7	7.2	0.2	1.3	57.1	12.0	0.1	0.4	5.1	0.3	0	1,577
1967	0.3	6.5	6.6	0.7	1.6	42.0	29.6	1.9	0.5	6.5	3.6	0.2	1,380
1968	<1.0	4.0	3.0	0	4.0	66.0	22.0	0	<1.0	<1.0	0	0	774
1969	0	0	0	0	5.7	71.5	17.7	0	0.9	2.6	1.7	0	424
1970	4.0	41.9	1.7	0	6.2	44.5	1.0	0	0	0	0	0	420
1971	0.7	58.6	11.5	0	0.6	24.5	3.9	0	0	0.1	0.1	0	1,386
1972	0.2	22.5	55.4	0	1.3	16.7	3.8	0	0	0	0	0	599
1973	3.9	25.5	26.5	0	9.1	26.1	8.9	0	0	0	0	0	517
1974	0.6	20.7	10.9	0	19.9	35.3	12.6	0	0	0	0	0	493
1975	1.1	2.1	2.5	0	9.4	75.9	8.9	0	0	0	0	0	629
1976	0.2	8.5	0.6	0	8.5	71.8	7.2	0	0	2.4	0.4	0	540
1977	7.7	1.9	5.7	0	4.0	65.2	14.3	0	0	0	1.2	0	401
1978	0.6	31.1	2.8	0	5.4	18.4	41.3	0	0.2	0.2	0	0	634
1979	1.4	14.7	18.7	0	5.8	48.9	10.4	0	0.1	0	0	0	654

[1] Age expressed by the European Formula - number of freshwater annuli, decimal, number of saltwater annuli; i.e., a 2.2 age is a 5-year-old fish.

Average size of sockeye in 1978 was larger for nearly all age groups than in 1979. Mean size for females (combined age groups) was 547 mm and 2.3 kg in 1978 and 524 mm and 2.2 kg in 1979. Males averaged 536 mm and 2.4 kg in 1978 compared to 517 mm and 2.3 kg in 1979. The largest fish were those spending 3 or more years in the ocean and the smallest were the jack males (1 year in the ocean).

Chinook samples taken at the fishpass consisted of 98 fish in 1978 and 41 fish in 1979. Unreadable scales reduced the samples for age composition by 15.3% for 1978 and 19.5% in 1979. During both years, the majority of fish were ages 1.4 and 1.3 (68.7% and 25.3%, respectively, in 1978 and 57.6% and 39.4% in 1979). Age 1.2 was represented by five fish in 1978 and age 1.5 represented by a single fish in 1979 (Tables 7 and 8).

Sex ratios of chinook in the samples were 53.7% males and 46.3% females in 1978 and 54.5% males and 45.5% females in 1979. Since many chinook spawned in the lower river below the fishpass, the samples may not represent the ratios in the total return.

Average size of 83 chinook sampled in 1978 was 821 mm and 10.1 kg for males and 831 mm and 10.0 kg for females. In 1979, 18 male chinook average 832 mm and 9.8 kg and 15 females averaged 832 mm and 10.1 kg. The largest chinook in 2 years of sampling was a 958-mm male that weighed 16.3 kg.

Sockeye Return in Relation to Parent Year

The 1978 sockeye return to the Frazer fishpasses was composed of 55,254 fish of age 2.3 and 3.2 (1972 parent year), 33,838 fish of age 1.3, 2.2, and 3.1 (1973 parent year), 52,696 age 1.2 and 2.1 fish (1974 parent year), and 193 age 1.1 sockeye produced from parent year 1975. The sockeye return in 1979 consisted of 13,183 age 2.3 fish (1973 parent year), 85,818 age 1.3, 2.2, and 3.1 fish from parent year 1974, 25,986 age 1.2 and 2.1 fish (1975 parent year), and 1,775 age 1.1 fish from the 1976 parent year.

Table 7. Age, weight, and length composition of 83 chinook salmon sampled at the Frazer fishpass in 1978.

Parameter	Age Group			Total or Average
	1.2	1.3	1.4	
Number of Fish	5	21	57[1]	83
Percent of Sample	6.0	25.3	68.7	100.0
		Males		
Number Sampled	3	17	24	44
Percent of Sample	3.7	20.7	29.3	53.7
Mean Fork Length (mm)	575	796	870	821
Standard Deviation	42.9	51.0	44.2	89.2
Mean Weight (kg)	3.8	9.0	11.7	10.1
Standard Deviation	0.7	1.6	2.3	2.9
		Females		
Number Sampled	2	4	32	38
Percent of Sample	2.4	4.9	39.0	46.3
Mean Fork Length (mm)	617	753	856[2]	831
Standard Deviation	4.9	53.0	39.7	74.0
Mean Weight (kg)	4.3	7.9	10.7[2]	10.0
Standard Deviation	0.1	1.4	1.7	2.4
	Differences Between Male and Female Means			
Fork Length (mm)	42.8	43.1	14.5	
Weight (kg)	0.5	1.1	1.0	

[1] Includes one fish without sex recorded.

[2] Excludes three females without weight recorded.

Table 8. Age, weight, and length composition of 33 chinook sampled form the 1979 Frazer Lake escapement.

Parameter	Age Group			Total or Average
	1.3	1.4	1.5	
Number of Fish	13	19	1	33
Percent of Sample	39.4	57.6	3.0	100.0
		Males		
Number Sampled	7	11	0	18
Percent of Sample	38.9	61.1	-	54.5
Mean Fork Length (mm)	766	860	-	821
Standard Deviation	38.7	53.9	-	66.8
Mean Weight (kg)	7.7	11.3	-	9.8
Standard Deviation	1.0	1.8	-	2.3
	Differences between Male and Female Means			
Fork Length (mm)	17	2	-	11
Weight (kg)	0.8	0.5	-	0.3

Parent year escapement of sockeye to Frazer lake, potential egg deposition, return produced, and the return per spawner have been recorded (Table 9) for the eight parent years (1966 - 1973) in which returns have been completed for major age classes. The return per spawner for this period has averaged 2.90. The highest return per spawner was 4.85 for parent year 1969 and the lowest return 0.98 for the 1973 parent year. The return of age 2.3 sockeye in 1980 will probably significantly increase the 1.81 return per spawner for parent year 1974. All return data are collected at the fishpass and exclude fish taken in the commercial fishery.

Potential egg deposition increased substantially in the 1970's as the sockeye run developed. In 1978, the return of 141,981 fish was projected to have 75,405 females with a potential of 243.8 million eggs. The lower return of age 2.3 fish in 1979 decreased the 1979 potential egg deposition to 156.8.

Sockeye Smolts

Seining below the Frazer River falls for sockeye smolts began 30 May in 1978. The first smolts were captured on 1 June. Peak catches of an estimated 400 to 500 smolts per seine haul occurred between 5 June and 17 June. High water prevented effective seining for the remainder of the month. Smolts were not observed or seined in July. In 1979, two seine hauls below the falls on 2 June failed to capture any smolts. On 6 June, 650 smolts were caught in one seine haul. Peak smolt catches of 2,000 to 15,000 per seine haul occurred between 8 and 30 June. A decreasing number of smolts were caught in early July; by mid-July the smolt migration was finished.

Smolt seining provides a relative index of migration timing and magnitude. Seine catches indicate that the number of smolts leaving Frazer Lake in 1979 was considerably greater than in 1978, and the duration of migration was about 2 weeks longer. However, an unknown number of smolts could have migrated during the high water period in 1978 when seining was not conducted.

Table 9. Adult sockeye return in relation to parent year escapement and potential egg deposition at Frazer Lake.

Parent year	Escapement[1]	Female spawners	Supplemental[2] production($x10^6$)	Total Potential egg deposition ($x10^6$)	Return produced	Return/ spawner
1964	9,966	4,983	0	15.2	-	-
1965	9,074	4,628	0.8	14.3	-	-
1966	16,456	8,052	1.1	24.8	33,669[3]	2.05
1967	21,834	11,135	1.2	35.5	86,476	3.96
1968	16,738	9,104	3.7	32.5	59,800	3.57
1969	14,041	7,300	2.6	24.8	68,073	4.85
1970	24,039	11,173	1.0	32.5	73,605	3.06
1971	55,366	28,952	0.5	79.3	123,310	2.23
1972	66,419	30,404	0	87.2	167,599	2.52
1973	56,255	28,953	0	83.2	55,254[4]	0.98
1974	82,609	35,185	0	105.9	149,259[5]	1.81
1975	64,199	40,276	0	124.7	-	-
1976	119,300	66,320	0	209.8	-	-
1977	139,548	67,300	0	220.4	-	-
1978	141,981	75,405	0	243.8	-	-
1979	126,762	58,824	0	156.8	-	-

1 Includes transplanted fish through 1969.

2 Eyed-egg and fry plants.

3 Adult return data for age class 1.1 (1969) not included.

4 Adult return data for age class 3.3 not included.

5 Adult return data for age class 2.3, 3.2 and 3.3 not included.

In 1978, 330 emigrating sockeye smolts were sampled for age, length, and weight. In 1979, 831 smolts were sampled. Age 3.0 smolts were not represented in the sample either year. In 1978, 67.6% of the smolts sampled were age 2.0. In 1979, age 1.0 smolts composed 55.4% of the sample. Smolts were smaller both years (Table 10) than previous years. Age 1.0 smolts in 1979 had a mean length of only 112.9 mm and weight of 11.9 g. The age 2.0 smolts in 1979 were 179.2 mm and 54.1 g in mean length and weight, respectively. In comparison, Frazer smolts averaged 151.8 mm and 30.9 g for age 1.0 and 179.2 mm and 54.1 g for age 2.0 for 5 years between 1965 and 1970. The condition factor (robustness) of smolts also decreased. The decrease in smolt size and condition is believed to be related to higher densities of rearing fish and greater competition for food in the lake.

Sockeye and Chinook Spawning Surveys

Sockeye spawning at Frazer Lake usually begins about mid-July, peaks in early August, and is completed by the end of August. Several surveys of spawning areas are conducted during this period to determine density and distribution of sockeye. As in past years, the east fork of Pinnell Creek supported the majority of sockeye spawners in 1978 and 1979 (Table 11). Pinnell Creek has a potential capacity for approximately 163,000 spawners (Blackett 1979). Lake shore was the second most important area for spawning in 1978 and 1979. Lateral tributary streams to the lake were used the least. Frazer River outlet between the lake and fishpass was used by 267 sockeye in 1978 and 213 sockeye in 1979. The outlet stream is the most recent extension of sockeye spawning distribution in the system.

Chinook spawned in the Frazer (Dog Salmon) River below the fishpass and between the falls and lake in 1978 and 1979. Chinook have never been observed spawning in any other area at Frazer Lake. The donor stock for Frazer came from the Karluk River where they spawn downstream from the lake. Therefore, it is unlikely that chinook will extend spawning into any other area than Frazer River unless transplanted as eyed eggs or fry to new spawning areas. Returns of chinook adults have been site specific to the areas of fry release in Frazer River.

Table 10. Mean smolt length, weight, and condition factor by age group, Frazer Lake, 1965 - 1979.

Year	Mean length (mm)	Standard deviation	Sample size for length	Mean weight (g)	Standard deviation	Sample size for weight	Condition[1] factor
			Age 1.0				
1965	146.0	10.8	698	27.2	1.2	238	0.91
1966	163.0	6.5	542	31.0	4.9	205	0.93
1967	147.0	6.0	1,196	28.8	5.5	269	0.90
1968	154.0	9.2	1,517	36.3	7.3	379	0.92
1969[2]	-	-	-	-	-	-	-
1970	149.0	9.0	1,878	30.9	6.1	669	0.93
1971	129.9	6.6	130	20.5	3.7	62	0.93
1972	120.2	4.8	450	15.8	2.1	451	0.91
1973	125.5	13.4	46	18.2	4.6	46	0.91
1974	123.5	9.1	227	18.0	4.1	184	0.95
1975	132.0	5.2	328	22.4	2.6	362	0.97
1976	130.0	5.0	79	19.3	2.0	79	0.88
1977	130.0	5.9	385	20.7	2.7	385	0.95
1978	125.6	6.2	107	17.2	2.4	107	0.87
1979	112.9	6.1	460	11.9	1.8	460	0.83

[1] Condition factor: $K = \frac{w \times 10^5}{L^3}$ where w = weight (g) and L = length (mm).

[2] The smolt weir was inoperable in 1969 and sample data collected is insufficient for inclusion.

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Table 10.
Continued.

Year	Mean length (mm)	Standard deviation	Sample size for length	Mean weight (g)	Standard deviation	Sample size for weight	Condition[1] factor
			Age 2.0				
1965	174.0	17.5	346	48.0	5.0	65	0.89
1966	180.0	11.1	1,358	53.1	12.1	488	0.91
1967	177.0	13.2	680	53.2	11.2	279	0.97
1968	185.0	11.5	264	62.0	7.6	176	0.94
1969[2]	-	-	-	-	-	-	-
1970	180.0	12.4	649	54.0	10.1	566	0.93
1971	173.1	10.1	334	44.5	10.8	97	0.86
1972	151.3	11.9	22	31.7	8.1	22	0.92
1973	142.3	7.1	74	25.6	3.9	74	0.88
1974	150.5	8.8	573	29.9	5.0	531	0.89
1975	149.0	7.9	972	29.5	4.3	931	0.89
1976	157.0	8.8	418	34.0	5.3	390	0.87
1977	154.0	7.2	403	32.0	4.7	403	0.88
1978	144.5	10.9	223	26.0	5.7	223	0.86
1979	143.2	6.5	371	23.4	3.0	371	0.80

[1] Condition factor: $K = \frac{w \times 10^5}{L^3}$ where w = weight (g) and L = length (mm).

[2] The smolt weir was inoperable in 1969 and sample data collected is insufficient for inclusion.

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Table 10. Continued.

Year	Mean length (mm)	Standard deviation	Sample size for length	Mean weight (g)	Standard deviation	Sample size for weight	Condition[1] factor
			Age 3.0				
1965	193.0	-	13	-	-	-	-
1966	193.0	-	16	-	-	-	-
1967	201.0	13.0	62	76.4	11.2	48	0.94
1965	193.0	-	13	-	-	-	-
1966	193.0	-	16	-	-	-	-
1967	201.0	13.0	62	76.4	11.2	48	0.94
1968	200.0	-	8	-	-	-	-
1969[2]	-	-	-	-	-	-	-
1970	193.0	-	10	-	-	-	-
1971	191.3	20.1	6	72.9	20.8	3	1.04
1972	-	-	0	-	-	0	-
1973	-	-	0	-	-	0	-
1974	172.3	7.5	75	43.5	5.7	74	0.85
1975	150.5	18.6	4	30.1	11.6	4	0.88
1976	166.2	6.7	27	33.9	4.2	26	0.74
1977	-	-	0	-	-	0	-
1978	-	-	0	-	-	0	-
1979	-	-	0	-	-	0	-

[1] Condition factor: $K = \frac{w \times 10^5}{L^3}$ where w = weight (g) and L = length (mm).

[2] The smolt weir was inoperable in 1969 and sample data collected is insufficient for inclusion.

Table 11. Peak survey counts of sockeye spawners at Frazer Lake.

Spawning Area	1978 Date	1978 No.	1979 Date	1979 No.
Terminal Streams:				
Pinnel	7/29	12,325	7/28	9,076
East Fork	8/7-8	24,578	8/5	25,182
(Aerial survey)	8/10	110,000	8/7	44,000
Lateral Streams:				
Linda	8/4	383	7/31	868
Midway	7/28	382	8/3	408
Courts	7/27	147	8/3	195
Stumble	8/4	586	7/31	466
Jaeger	8/13	170	8/3	191
Summit	7/27	1	7/24	0
Cadia	8/4	76	7/31	65
Frazle	7/28	17	7/26	10
Hollow Fox	7/28	33	7/26	6
Valerian	7/31	476	8/3	468
Total lateral		2,271		2,677
Frazer River	8/18	267	8/13	213
Lake Shore	8/1	6,017	8/2	2,873
(Aerial survey)	8/17	9,450	8/7	6,480

Lake Studies

Zooplankton is examined at Frazer Lake to monitor changes in composition and abundance relative to increasing density of young sockeye rearing in the lake. In 1978, plankton was sampled from 6 June through 13 August (Table 12). Copepods and rotifers composed 98.7% of the samples. As in past years, cladocerans were least numerous. Average zooplankton density (5,133 per m^3) was approximately the same as in 1976 (5,400 per m^3): the last previous year that sampling was conducted for a comparable period.

Lake surface temperature and water chemistry (Table 13) were taken in conjunction with plankton samples. Water temperature varied from 7°C on 6 June to 15°C on 5 August. Alkalinity, dissolved oxygen, total hardness, and pH were within typical limits for an oligotrophic lake such as Frazer. Temperature profiles were not recorded in 1978. Air and water temperatures, water depth, and weather observations (Appendix Table 3) were also recorded in 1978 and 1979 at the Frazer fishpass. Both summers were relatively mild and wet.

GENERAL DISCUSSION

Sockeye and chinook salmon runs that were introduced into Frazer Lake by plants of eggs, fry, and adult sockeye spawners between 1951 and 1971 are maintained by operation of the fishpass at the falls. The successful development of Frazer Lake from a non-producing system to one that is a major producer of salmon on Kodiak Island has been a remarkable achievement. Of the many attempts to establish salmon in barren lakes on the Pacific Coast, the Frazer project is one of the few that has been successful (Blackett 1979).

FRED Division has a major responsibility, indeed an obligation, to assure perpetuation of the Frazer salmon runs by efficient operation of the fishpass. One of the primary goals of the Division has been to upgrade the fishpass facility and annually evaluate the effectiveness of salmon

Table 12. Zooplankton composition and density per cubic meter, Frazer Lake, 1978.

Date	Cladocerans		Copepods		Rotifers		Total No. Zooplankton
	No.	%	No.	%	No.	%	
6/6	290	4.3	4,756	70.7	1,682	25.0	6,728
6/11	0	0.0	4,137	59.4	2,823	40.6	6,960
7/5	4	0.0	2,958	33.1	5,974	66.9	8,936
7/9	0	0.0	2,552	44.4	3,190	55.6	5,742
7/20	4	0.1	2,262	35.8	4,050	64.1	6,316
7/28	116	3.9	1,276	43.1	1,566	52.9	2,958
8/5	58	2.6	1,276	57.9	870	39.5	2,204
8/13	58	4.8	870	71.4	290	23.8	1,218
TOTAL	530	1.3	20,087	48.9	20,445	49.8	41,062
$\bar{x}$	66		2,511		2,556		5,133

Table 13. Water temperature and chemistry, Frazer Lake, 1978.

Date	Surface Temperature (°C)	Total Alkalinity (ppm)	Dissolved Oxygen (ppm)	Total Hardness (ppm)	pH
6/6	7	34.2	13	34.2	7.0
6/11	8	27.4	12	51.3	7.0
6/24	9	41.0	18	68.4	7.0
7/5	8	34.2	14	68.4	7.0
7/9	8	34.2	14	85.5	7.0
7/20	9	34.2	12	51.3	7.0
7/28	13	41.0	11	51.3	7.0
8/5	15	34.2	12	51.3	7.0
8/13	12	27.4	10	51.3	7.0

passage to lake spawning areas. A week's delay in sockeye passage during the peak of migration can substantially reduce spawning success. The fishpass must be maintained and operated at maximal efficiency. A passage rate of 10% of the escapement goal per day or approximately 38,000 salmon per day should be achievable.

An important objective of the Frazer project has been the measurement and quantification of the salmon produced and those that return as mature fish to the fishpass. This is accomplished by sampling returning sockeye to determine age composition and, in turn, to determine the number of adults - to provide an estimate of the fish produced per parent year as well as sex and size composition to provide an estimate of the number of eggs potentially deposited. Evaluation needs to be expanded to other phases of the life cycle, i.e., number of smolts produced per parent year, ocean survival from smolt to returning adult, and a precise estimate of contribution to the commercial fishery. Unfortunately, the long-term success or failure of the sockeye and chinook introductions can never be fully documented, except in a quasi-scientific manner, until a comprehensive evaluation effort is established.

A theoretical escapement goal of 383,000 sockeye has been set for Frazer Lake on the basis of spawning and rearing area capacity (Blackett 1979). The assumptions for estimating capacity (density of one female per 2.0 m^2 of spawning area and density of 0.15 fry per m^3 of rearing area) needs to be tested. In theory, there is an optimal number of sockeye that the lake can support to produce a maximal return of adult fish. (At this point we don't know whether maximal return of adults will be produced by fewer large smolts or more small smolts). If optimal spawning densities are exceeded, egg and alevin survival will decrease. If optimal rearing densities are exceeded, the number of smolts produced per female spawner will decrease, and smolt to adult survival will be decreased if the smolts are in poor condition or undersized because of stress or lack of food during rearing in the lake. Underutilization of the lake system for production of salmon results in a wasted resource, lower lake productivity, and reduced future benefit to the public. Salmon production from Frazer Lake can never be optimized or tested without comprehensive evaluation and monitoring in future years.

Although sockeye and chinook salmon have been successfully established in the lake system, there are spawning areas that are not being utilized and other areas (i.e. East Fork of Pinnell Creek) that may have an overpopulation of fish during some years. Controlling spawner distribution and establishing spawners in unutilized areas may be a desirable means of optimizing production in the future.

This report summarizes project activities by FRED Division for 1978 and 1979. Annual operation of the fishpass at Frazer falls and long-term evaluation of sockeye and chinook salmon introductions need to be a continuing function of the division to assure perpetuation of the salmon runs and to achieve maximal benefit to the public from this fishery resource.

REFERENCES

Blackett, R.F. 1979. Establishment of sockeye (Oncorhynchus nerka) and chinook (O. tshawytscha) salmon runs at Frazer Lake, Kodiak Island, Alaska. J. Fish. Res. Board Can. 36:1265-1277.

APPENDIX A

APPENDIX A

Appendix Table 1. Projected sex ratio of sockeye in the 1978 escapement at Frazer Lake.

Sample Period	Sample Size	Sample Number and (%) Females	Sample Number and (%) Males	Adults Counted	Projected number in escapement Females	Projected number in escapement Males
6/1 - 6/7	65	18 (27.7)	47 (72.3)	1,205	334	871
6/8 - 6/14	100	50 (50.0)	50 (50.0)	9,461	4,730	4,730[1]
6/15 - 6/21	40	16 (40.0)	24 (60.0)	2,542	1,017	1,525
6/22 - 6/28	60	24 (40.0)	36 (60.0)	23,332	9,333	13,999
6/29 - 7/4	120	77 (64.2)	43 (35.8)	43,080	27,657	15,423
7/5 - 7/11	100	54 (54.0)	46 (46.0)	31,876	17,213	14,663
7/12 - 7/18	100	42 (42.0)	58 (58.0)	19,091	8,018	11,073
7/19 - 7/25	100	65 (65.0)	35 (35.0)	9,648	6,271	3,377
7/26 - 8/1	80	39 (48.7)	41 (51.3)	1,613	786	827
8/2 - 8/8	43	15 (34.9)	28 (65.1)	133	46	87
	808	400 (49.5)	408 (50.5)	141,981	75,405	66,575
					(53.1)	(46.9)

[1] Minus one fish because of rounding.

Appendix Table 2. Projected sex ratio of sockeye in the 1979 escapement at Frazer Lake.

Sample Period	Sample Size	Sample Number and (%) Females	Sample Number and (%) Males	Adults Counted	Projected number in escapement Females	Projected number in escapement Males
6/3 - 6/14	88	31 (35.2)	57 (64.8)	17,972	6,326	11,646
6/15 - 6/21	189	92 (48.7)	97 (51.3)	24,848	12,101	12,747
6/22 - 6/28	138	59 (42.8)	79 (57.2)	30,336	12,984	17,352
6/29 - 7/4	263	129 (49.0)	135 (51.0)	31,330	15,352	15,978
7/5 - 7/11	88	49 (55.7)	39 (44.3)	15,240	8,489	6,751
7/12 - 7/18	45	22 (48.9)	23 (51.1)	5,425	2,643	2,772
7/19 - 8/8	7	4 (57.1)	3 (42.9)	1,591	908	683
Total	818	386 (47.2%)	432 (52.8%)	126,742	58,813 (46.4%)	67,929 (53.6%)

Appendix Table 3. Mean temperature, water level, and weather observations, Frazer fishpass, 1978 and 1979.

Month	Air Temperature (°F) Max.	Min.	Obs.	Water Temperature (°F)	Water Gauge	Weather Observations Days of: Rain	Clouds	Sun
			1978					
May[1]								
$\bar{x}$	57	51	51	44	23.4			
Range	52 - 60	36 -44	49 - 55	43 - 45	23.1 - 23.6	1	3	0
June								
$\bar{x}$	60	42	51	46	24.1			
Range	50 - 76	36 - 46	44 - 64	43 - 50	22.2 - 27.0	14	14	2
July								
$\bar{x}$	64	48	56	50	21.6			
Range	54 - 74	40 - 55	48 - 67	46 - 59	20.4 - 23.5	12	15	3
August[2]								
$\bar{x}$	68	48	59	57	23.7			
Range	58 - 79	38 - 53	52 - 72	48 - 63	21.4 - 26.0	5	7	4

[1] May 28 - 31, 1978; May 23 - 31, 1979.

[2] August 1 - 16, 1978.

-Continued-

Appendix Table 3. Continued.

Month	Air Temperature (°F) Max.	Min.	Obs.	Water Temperature (°F)	Water Gauge	Days of: Rain	Clouds	Sun
			1979					
May[1]								
$\bar{x}$	64	41	57	43	15.8			
Range	56 - 75	32 - 54	45 - 73	43 - 45	15.7 - 16.0	3	3	3
			1979					
June								
$\bar{x}$	60	43	53	47	15.8			
Range	53 - 70	31 - 49	45 - 60	43 - 50	15.3 - 16.1	9	17	4
July								
$\bar{x}$	67	48	58	54	16.4			
Range	60 - 77	36 - 56	50 - 70	45 - 59	15.8 - 17.3	11	15	5
August[2]								
$\bar{x}$	67	51	58	58	14.7			
Range	59 - 70	41 - 54	52 - 68	52 - 63	12.0 - 16.7	6	6	1

[2] August 1 - 13, 1979.