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Annual Performance Report for

COHO SALMON STUDIES IN THE
RESURRECTION BAY AREA

by

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in the Resurrection
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ABSTRACT

Bear Lake was restocked with 227,800 Age 0.0 coho salmon, Oncorhynchus kisutch (Walbaum), fingerlings on June 7, 1982 to maintain smolt production.

The Bear Creek weir downstream migrant trap was operated continuously from May 18 through September 30. A total of 143,718 Age 1.0, 2.0 and 3.0 smolts were enumerated. Yearling (Age 1.0) smolt survival from the 1981 Bear Lake fingerling plant was 54.1 percent, with a 6.7:1.0 smolt-to-fingerling biomass (kilogram) yield. Age 2.0 smolt survival from the 1980 fingerling release was only 6.4 percent, with an 0.8:1.0 smolt-to-fingerling biomass ratio.

Bear Lake's smolt out-migration timing and abundance, age and size compositions and condition factors are presented. Bear Creek water temperatures and stream flow corresponding to migration peaks and durations are also given. The sudden increase in Bear Lake's 1982 yearling smolt production compared to the previous 2 years and tentative results of the recently-initiated lake fertilization project are discussed.

The Resurrection Bay salmon creel census (July 8 - September 8) indicated an estimated 17,813 coho were harvested in 25,403 man-days of sport effort. The mean seasonal catch per angler hour was 0.106. Enhanced coho production contributed an estimated 14.2 percent to the sport harvest. Most (52 percent) survived from 17,977 marked and 54,646 unmarked Bear Lake smolts that emigrated in 1981. The remaining 48 percent returned from several sources. There were 40,405 adipose-clipped, coded wire tagged and 122,935 unmarked Age 0.0 (1980 brood, Bear Lake origin) hatchery smolts released in both Seward Lagoon and lower Bear Creek in mid-June 1981. A number of fish were from "holdover" smolts which emigrated as yearlings in 1981 from the 1980 0-Age smolt plants in Seward Lagoon and Grouse Lake. Vagaries in hatchery coho production and low contribution to the sport fishery from the Age 0 smolt releases are reviewed.

The Bear Creek upstream migrant trap was operated continuously from May 18 through October 31. The coho upstream migration to the trap extended from September 7 to October 22, and consisted of 2,122 adults. The run was comprised of 77 adipose-clipped, coded-wire tagged fish, 32 left ventral and 2,013 unmarked coho. Hatchery fish (Ad-CWT) averaged 1.45 kilogram less than Bear Lake coho.

Total smolt-to-adult survival per release lot was 4.34 percent (Bear Lake), 0.91 percent (Bear Creek), 1.13 percent (Grouse Lake) and 0.81 percent (Seward Lagoon). Total survival of Bear Lake smolt out-migrations (1976-1980), Bear Creek (1969-1981, Grouse Lake (1976-1980) and Seward Lagoon (1968-1981) hatchery smolt releases are summarized.

The catch-to-escapement ratio of marked Bear Lake coho was 0.72:1.0. The male-to-female sex ratio was 1.5:1.0 in the Bear Lake escapement. An estimated 1,205,000 coho eggs were artificially spawned from 298 females and fertilized by 112 males from the Bear Lake return. Approximately 25 percent of the eggs died as a result of delayed fertilization at Elmendorf Hatchery in an ongoing experiment to eradicate bacterial kidney disease (BKD) from Bear lake coho.

Data on the timing and abundance of other fish species ascending and descending Bear Creek to the weir are presented. Minimum wild coho escapements in seven local index streams are reviewed.

KEY WORDS

Bear Lake, rehabilitation, fertilization, coho salmon, fingerling, smolt, stocking, Resurrection Bay, sport fishery, creel census, escapement, artificial spawning.

BACKGROUND

For historical background concerning the fishery and the area, see McHenry (1982). Table 1 lists the anadromous fish species indigneous to Resurrection Bay's tributaries and Figure 1 shows the Resurrection Bay drainage.

RECOMMENDATIONS

1. The present objectives of the study should be retained.
2. The 1984 stocking density of coho fingerlings in Bear Lake should be adjusted according to emigrating smolt abundance, age composition and condition factor in 1983.
3. Size of fingerlings stocked annually in Bear Lake should not average less than 772/kg (350/lb) to preclude residualism beyond Age 1.0 smolts.
4. The Bear Lake fertilization experiment should be continued if smolt biomass production increases significantly.

Table 1. Checklist of Fish Species Present in the Resurrection Bay
Drainage Tributaries.

Common Name	Scientific Name and Author
Dolly Varden	<u>Salvelinus malma</u> (Walbaum)
Rainbow-steelhead trout	<u>Salmo gairdneri</u> Richardson
Sockeye salmon	<u>Oncorhynchus nerka</u> (Walbaum)
Coho salmon	<u>Oncorhynchus kisutch</u> (Walbaum)
Chum salmon	<u>Oncorhynchus keta</u> (Walbaum)
Chinook salmon	<u>Oncorhynchus tshawytscha</u> (Walbaum)
Pink salmon	<u>Oncorhynchus gorbuscha</u> (Walbaum)
Threespine stickleback	<u>Gasterosteus aculeatus</u> Linnaeus
Sculpin	<u>Cottus</u> spp.

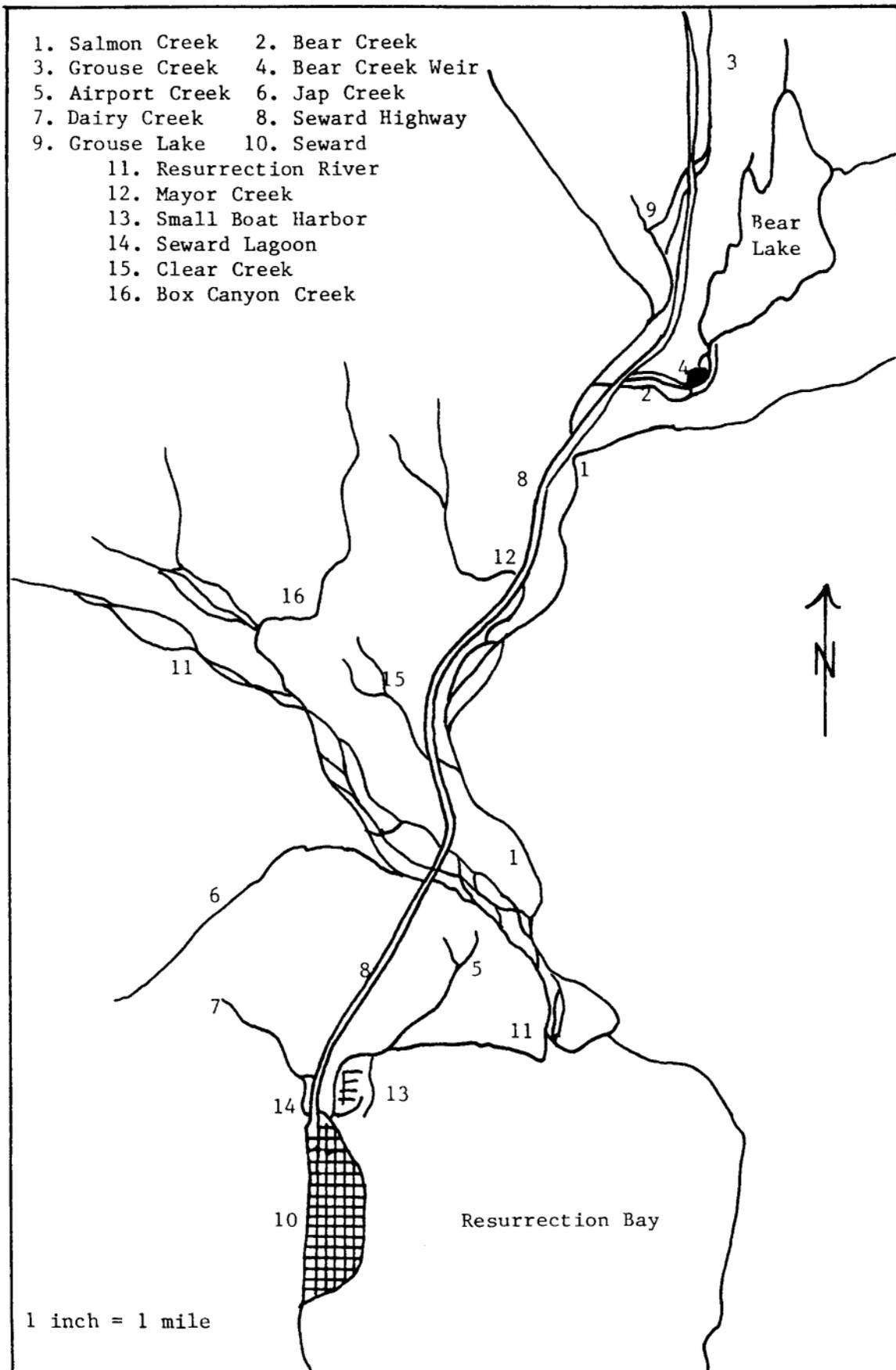


Figure 1. Resurrection Bay Watershed.

OBJECTIVES

1. To determine the distribution, abundance and timing of out-migrant and adult coho salmon in the Resurrection Bay area.
2. To determine the age and size composition of out-migrant and adult coho salmon populations in selected tributaries.
3. To determine the sport harvest and relative survival of wild and enhanced coho salmon stocks in Resurrection Bay.
4. To determine the methods and means of increasing or extending the freshwater spawning and rearing areas of the watershed, and mitigating freshwater mortality.
5. To provide recommendations for the management of coho salmon in these waters and direct the course of future studies.

TECHNIQUES USED

Techniques used are the same as outlined in McHenry (1982).

FINDINGS

Results

The findings presented are the 1981-82 research segment of the project. For a description of the Resurrection Bay drainage and past information collected on the project, see Logan (1962-1969) and McHenry (1970-1982).

Bear Lake Coho Smolt Migration:

The Bear Creek weir downstream migrant trap was operated continuously from May 18 through September 30, when the trap was removed due to cessation of the Bear Lake smolt emigration and excessive stream flows in late September. Abundance and timing of the coho salmon smolt out-migration are shown in Table 2. Stocked fingerlings emigrating Bear Lake were retained above the weir.

The out-migration to the downstream trap totaled 143,718 smolts. Trap mortality claimed only 104 smolts (0.07% of the run) due to careful manipulation of the fishpass elevation during fluctuating weir pool levels at migration peak. A total of 143,614 live smolts were released downstream. A predetermined 25.0% of the out-migration received a right ventral (RV) fin clip for recognition in the 1983 Resurrection Bay sport fishery and Bear Lake spawning escapement. Table 3 shows the number and percentage of smolts marked and sampled in each weekly period.

Table 2. Bear Lake Coho Salmon Smolts Enumerated at Bear Creek Weir by Weekly Periods, 1982.

Weekly Periods	Number of Smolts		Total
	Live	Dead	
May 20 - May 26	27	1	28
May 27 - June 2	37	1	38
June 3 - June 9	6,041	36*	6,077
June 10 - June 16	60,018	10	60,028
June 17 - June 23	34,110	5	34,115
June 24 - June 30	21,861	7	21,868
July 1 - July 7	9,109	8	9,117
July 8 - July 14	9,284	16	9,300
July 15- July 21	2,270	12	2,282
July 22 - July 28	351	0	351
July 29 - August 4	166	3	169
August 5 - August 11	177	0	177
August 12 - August 18	88	1	89
August 19 - August 25	5	0	5
August 26 - September 1	12	0	12
September 2 - September 8	31	3	34
September 9 - September 15	22	0	22
September 16 - September 22	2	0	2
September 23 - September 29	<u>4</u>	<u>0</u>	<u>4</u>
Total	143,615	103	143,718

* Includes 20 smolts killed for foregut analysis by F.R.E.D. Division's limnology section.

Table 3. Bear Lake Coho Salmon Smolts Marked and Sampled at Bear Creek Weir by Weekly Period, 1982.

Weekly Periods	Number of Live Smolts	Number Smolts Fin Clipped	Percent of Weekly Migration*	Number Smolts Sampled	Percent of Weekly Migration*
May 20 - 26	27	3	11.1	2	7.4
May 27 - June 2	37	12	32.4	1	2.7
June 3 - 9	6,041	1,466	24.3	50	0.8
June 10 - 16	60,018	16,778	28.0	600	1.0
June 17 - 23	34,110	6,691	19.6	400	1.2
June 24 - 30	21,861	5,113	23.4	175	0.8
July 1 - 7	9,109	2,574	28.3	135	1.5
July 8 - 14	9,284	2,271	24.5	35	0.4
July 15 - 21	2,270	788	34.7	31	1.4
July 22 - 28	351	119	33.9	5	1.4
July 29 - August 4	166	28	16.9	1	0.6
August 5 - 11	177	51	28.8	1	0.6
August 12 - 18	88	10	11.4		
August 19 - Sept. 29	76				
Total	143,615	35,904	25.0	1,436	1.0

* Minus the 103 smolts expiring from trap mortality.

Smolt emigration began on May 20, peaked (50% of out-migration) by June 17 and terminated September 26. The highest daily count occurred on June 16 when 12,464 (8.7% of the total run) were enumerated from the trap.

Mean stream temperatures when smolt emigration began, peaked and terminated were 3.6°C (38.5°F), 8.6° (47.5°F) and 10.3°C (50.5°F), respectively. Bear Creek stream flows ranged from 8 to 123 cfs during this period.

The smolt out-migration was comprised of 93.2% (134,003) Age 1.0, 6.7% (9,605) Age 2.0 and 0.1% (110) Age 3.0 smolts. Tables 4 and 5 present the mean fork length, weight, condition factor and relative percentage of Age 1.0 and 2.0 smolts in the weekly samples. Too few Age 3.0 smolts were observed for tabulation. Table 6 shows the weekly and seasonal abundance per smolt age group. An overall 1.0% (1,436 smolts) was representatively sampled during emigration (Table 3). An estimated 133,907 Age 1.0, 9,598 Age 2.0 and 110 Age 3.0 live smolts were released downstream.

The Age 1.0 smolt migration peaked during June 17-23 when Bear Creek water temperatures averaged 9.8°C (49.7°F), whereas Age 2.0 smolts peaked in the previous week, June 10-16, at a mean stream temperature of 7.4°C (45.4°F). The few Age 3.0 smolts emigrating were not detected in population sampling until the June 24-30 weekly period when Bear Creek averaged 11.3°C (52.4°F). The few Age 3.0 smolts emigrating were not detected in population sampling until the June 24-30 weekly period when Bear Creek averaged 11.3°C (52.4°F).

Bear Creek weekly stream temperatures averaged 4.2°C (7.4°F) colder than those measured during the same peak migration period in 1981, resulting in about a week's lag in the overall 1982 emigration as compared to 1981. Approximately 55% of the 1981 Bear Lake smolt migration had descended to the weir by June 16 when the weekly mean stream temperature was 11.6°C (52.8°F). Only 46% of the 1982 outmigration had reached Bear Creek weir by that date, however, at an average weekly stream temperature of 7.4°C (45.4°F). In previous years (1974-1979), about 65% of Bear Lake smolt migrations had reached the weir by the end of the first week that Bear Creek mean water temperature exceeded 10°C (50°F). Nearly 70% of the 1982 out-migration descended to the weir by June 23, although the June 17-23 mean water temperature was 0.2°C short of 10°C.

The 110 Age 3.0 smolts resulted from the eighth fingerling plant (225,000 Age 0.0 fingerlings in 1979) in Bear Lake following the 1971 lake rehabilitation project. Total fingerling-to-smolt survival from the 1979 plant was 51.6%. Age composition of this smolt production cycle was 46.9% Age 1.0, 53.0% Age 2.0 and 0.1% Age 3.0. Bear Lake coho fingerling plants since 1978 are summarized in Table 7, and smolt production since 1979 is presented in Table 8.

The 9,605 Age 2.0 smolts were produced from 150,000 Age 0.0 fingerlings stocked in 1980. With the 10,899 Age 1.0 smolts which emigrated in 1981, only 13.7% of that plant has survived to smolts thus far. This is the lowest measured percentage of Bear Lake fingerling releases resulting in smolts since that (9.6%) of the 1974 plant, the reasons for which are unknown. Theoretically, the relatively sparse stocking density

Table 4. Mean Fork Length, Weight and Condition Factor of Age 1.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1982.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor (K)*
May 20 -26	2	100.0	102.0 \pm 0.0	10.30 \pm 0.42	0.97
May 27 - June 2	1	100.0	123	17.9	0.96
June 3 - 9	46	93.9	115.3 \pm 5.6	15.17 \pm 2.27	0.99
June 10 - 16	539	90.0	114.8 \pm 7.5	14.99 \pm 2.20	0.99
June 17 - 23	377	94.5	115.8 \pm 6.8	14.98 \pm 2.55	0.97
June 24 - 30	164	94.3	123.8 \pm 6.6	18.86 \pm 2.91	0.99
July 1 - 7	134	99.3	126.7 \pm 7.3	20.58 \pm 3.43	1.01
July 8 - 14	35	100.0	134.2 \pm 6.5	24.57 \pm 3.25	1.02
July 15 - 21	30	96.8	136.5 \pm 5.5	26.63 \pm 3.12	1.05
July 22 - 28	4	80.0	143.8 \pm 7.0	32.00 \pm 3.90	1.08
July 29 - Aug. 4	1	100.0	143	29.7	1.02
August 5 - 11	1	100.0	157	40.2	1.04

* $K = \frac{W \times 10^5}{L^3}$, Where W = mean weight in grams, and L = mean fork length in millimeters.

Table 5. Mean Fork Length, Weight and Condition Factor of Age 2.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1982.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor (K)*
June 3 - 9	3	6.1	137.7 \pm 4.0	25.30 \pm 1.40	0.97
June 10 - 16	60	10.0	127.1 \pm 10.6	20.37 \pm 6.10	0.99
June 17 - 23	22	5.5	127.8 \pm 9.5	20.37 \pm 4.91	0.98
June 24 - 30	9	5.2	137.8 \pm 13.5	26.21 \pm 7.32	1.00
July 1 - 7	1	0.7	136	24.3	0.97
July 8 - 14	0	0.0			
July 15 - 21	1	3.2	145	32.5	1.07
July 22 - 28	1	20.0	183	57.8	0.94

* $K = \frac{W \times 10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in millimeters.

Table 6. Relative Abundance and Timing of Age 1.0, 2.0 and 3.0 Bear Lake Coho Salmon Smolts Migrating to Bear Creek Weir, 1982.

Weekly Periods	Number of Smolts			Total
	Age 1.0	Age 2.0	Age 3.0	
May 20 - 26	28			28
May 27 - June 2	38			38
June 3 - 9	5,706	371		6,077
June 10 - 16	54,025	6,003		60,028
June 17 - 23	32,239	1,876		34,115
June 24 - 30	20,622	1,137	109	21,868
July 1 - 7	9,053	64		9,117
July 8 - 14	9,300			9,300
July 15 - 21	2,209	73		2,282
July 22 - 28	281	70		351
July 29 - August 4	169			169
August 5 - 11	177			177
August 12 - Sept. 29*	<u>156</u>	<u>11</u>	<u>1</u>	<u>168</u>
Total	134,003	9,605	110	143,718
Percent	93.2	6.7	0.1	100.0

* Number of smolts per age group for August 12 - September 29 is estimated by overall age composition (93.2% Age 1.0, 6.7% Age 2.0 and Age 3.0) determined up to that point.

Table 7. Summary of Bear Lake Coho Salmon Fingerling Plants, 1978 - 1982.

Brood Year	Source of Eggs	No. Fish Stocked	Weight		Size*		Density		Dates of Plants	Planting Method
			lbs	kg	No./lb	No./kg	No./acre	No./ha		
1977	Bear Lake	157,000	457	207.3	345	757	353	871	June 20	Truck-boat
	Bear Lake	<u>68,800</u>	<u>216</u>	<u>98.0</u>	<u>320</u>	<u>705</u>	<u>154</u>	<u>382</u>	June 20	Scattered
	Total	<u>225,800</u>	<u>673</u>	<u>305.3</u>	<u>337</u>	<u>743</u>	<u>507</u>	<u>1,253</u>	1978	
1978	Bear Lake	<u>225,500</u>	<u>340</u>	<u>154.2</u>	<u>663</u>	<u>1,462</u>	<u>507</u>	<u>1,253</u>	May 24	Aircraft
									1979	Scattered
1979	Bear Lake	134,375	542	245.8	248	546	302	746	June 12	Aircraft
	Bear Lake	<u>15,625</u>	<u>68</u>	<u>30.8</u>	<u>231</u>	<u>508</u>	<u>35</u>	<u>86</u>	June 18	Truck-boat
	Total	<u>150,600</u>	<u>610</u>	<u>276.6</u>	<u>246</u>	<u>542</u>	<u>337</u>	<u>832</u>	1980	Scattered
1980	Bear Lake	143,427	439	198.9	327	716	322	796	June 2	
	Bear Lake	<u>104,418</u>	<u>291</u>	<u>131.9</u>	<u>359</u>	<u>792</u>	<u>235</u>	<u>580</u>	June 2	Truck-boat
	Total	<u>247,845</u>	<u>730</u>	<u>330.8</u>	<u>340</u>	<u>749</u>	<u>557</u>	<u>1,376</u>	1981	Scattered
1981	Bear Lake	<u>227,800</u>	<u>759</u>	<u>344.0</u>	<u>300</u>	<u>662</u>	<u>512</u>	<u>1,265</u>	June 7	Truck-boat
									1982	Scattered

* Weighted averages.

Table 8. Summary of Bear Lake Coho Salmon Smolt Abundance and Biomass Produced Since 1979 from Annual Fingerling Plants, 1979 - 1981.

Year of Plant	No. of Fingerlings and Weight (kg)	Smolt Production by Year				Total Production	Survival to Smolt (%)
		1979	1980	1981	1982		
1978							
Number	225,800	97,144	20,294	239	117,677	52.1	
Weight (kg)	305.3	1,808.0	504.8	10.2	2,323.0		
Weight Ratio		5.9:1	1.7:1	0.0:1	7.6:1		
1979							
Number	225,500		54,580	61,750	110	116,440	51.6
Weight (kg)	154.2		1,053.0	1,348.7	7.9	2,409.9	
Weight Ratio			6.8:1	8.7:1	0.1:1	15.6:1	
1980							
Number	150,000			10,899	9,605	20,504	13.7*
Weight (kg)	276.6			192.8	207.7	400.5	
Weight Ratio				0.7:1	0.8:1	1.4:1	
1981							
Number	247,845				134,003		54.1*
Weight (kg)	330.8				2,227.1		
Weight Ratio					6.7		

* Does not include Age 3.0 smolt production.

** Includes only Age 1.0 smolt production.

(337 fingerlings/acre) of fairly large smolts (246/lb) at release should have allowed a major portion to emigrate as Age 1.0 smolts. When this did not happen, it was further hypothesized (McHenry, 1982) that intense intraspecific competition and/or predation by Age 2.0 smolts and residuals from the 1979 plant may have seriously limited survival of the 1980 fingerling release. Since condition of the latter was noted as good and no mortalities were observed at stocking to indicate disease problems at the hatchery, it is likely that these fish could not compete against coho already present in the rearing environment and survive to smoltification. Excepting Age 3.0 smolt production from the 1980 release in 1983, age composition of Bear Lake's ninth smolt production cycle since the 1971 lake rehabilitation was 53.2% Age 1.0 and 46.8% Age 2.0.

The 134,003 Age 1.0 smolts survived from 247,845 Age 0.0 fingerlings released in Bear Lake in 1981. In contrast to the poor yearling smolt production of the 1980 fingerling plant, that of the 1981 release realized the highest proportion (54.1%) of any annual fingerling plant in the project's 20-year history resulting in Age 1.0 smolts. Whether this phenomenon is due to the recently initiated Bear Lake fertilization project or to natural cyclic processes inherent in the system is not known at this time. Age 2.0 smolt abundance in 1983 will depend upon the extent of Age 1.0 residualism and overwinter survival of the 1981 plant.

Age 1.0 smolts averaged 115.8 mm and 14.98 g for a condition factor (K) of 0.97 at migration peak, June 17-23. Growth of the 1981 Age 0.0 fingerlings surviving to yearling smolts was good considering that they averaged 50 mm and 1.33 g at release one year earlier. Age 2.0 smolts were virtually the same fork length, as in 1981 (127.1 mm vs 127.0 mm), but somewhat more robust (20.37 g vs 19.76 g) for a higher K (0.99 vs 0.96). The one Age 3.0 smolt sampled was 189 mm and 71.8 g for a K = 1.06.

Bear Lake's estimated smolt biomass production in 1982 was 2,442.7 kg, or 891.0 kg (1,964.3 lb) more than that produced in 1981. This yield was 411.6 kg and 47,935 smolts higher than the 9-year (1973-1981) average Bear Lake biomass production since the 1971 lake rehabilitation project. Table 9 summarizes total numbers of smolts, estimated annual biomass and seasonal condition factor of Bear lake smolt migrations since 1973.

Bear Lake was restocked on June 7, 1982 with 227,800 Age 0.0 coho salmon fingerlings (1981 brood, Bear Lake origin) averaging 662/kg (300/lb) to maintain smolt production.

Other Species:

The total sockeye salmon smolt out-migration enumerated from the trap was 46,265 fish. The first smolt was captured on May 20 and the last on August 3. The highest daily count occurred on May 31 when 8,716 smolts (18.8% of the migration) were enumerated. The majority (92.7%) emigrated between May 20 and June 16, when Bear Creek water temperatures ranged from 3.3°C to 8.9°C (38°F - 48°F) and stream flows from 12 to 44 cfs. The smolt out-migration was comprised of 46,142 (99.7%) Age 1.0 and 123 (0.3%) Age 2.0 smolts. Age 2.0 smolts were produced from the six females and six males that spawned in 1979. With the 2,805 Age 1.0 smolts estimated in 1981, a total of 2,928 smolts resulted from 673 males and 785 females in

Table 9. Summary of Abundance, Total Annual Biomass and Seasonal Condition Factor of Bear Lake Smolt Migrations, 1973 - 1982.

Year	Total No. of Smolts	Condition Factor (K)	Total Biomass (kg)
1973	77,343	1.06	2,149.3
1974	72,389	0.93	1,743.2
1975	168,036	0.89	3,381.3
1976	93,311	1.07	2,016.8
1977	99,970	1.03	1,940.2
1978	97,814	0.99	1,869.3
1979	105,316	1.05	2,063.0
1980	74,980	1.01	1,565.3
1981	72,888	1.04	1,551.7
1982	143,718	1.00	2,442.7
Average (1973-81)	95,783	1.02	2,031.1

the 1980 escapement. Evidently, spawning success was mediocre, with only 58.8 smolts produced per female. Both age groups peaked (50% of migration) during May 27-June 2. Age 1.0 smolts averaged 110.2 mm and 13.96 g for $K = 1.04$, and Age 2.0 smolts averaged 143.5 mm and 29.65 g for $K = 1.12$ at migration peak.

A total of 216 Dolly Varden was captured in the downstream trap and released below the weir. No threespine stickleback were caught in the trap or observed in Bear Lake during the field season.

Resurrection Bay Coho Salmon Harvest and Effort:

A stratified, random creel census to determine the Resurrection Bay coho sport harvest and effort was initiated at the Seward Small Boat Harbor on July 8 and terminated September 8. Few coho were taken before creel census began since most sport fishing effort was directed toward the more abundant rockfish from mid-May through early July.

The season's total harvest was an estimated 17,813 coho. This estimate was extrapolated from interviews with 4,347 anglers harvesting 2,576 coho during the creel census period. Peak of the harvest occurred on August 21, the eighth day of the Seward Silver Salmon Derby, when an estimated 820 coho (4.6% of the season's harvest) were taken. The season's total and derby harvests are summarized for 1978 through 1982 in Table 10. Marked adult coho contributed 1.8% or an estimated 320 fish to the 1982 Resurrection Bay sport harvest. An additional 2,201 unmarked coho resulting from the unmarked segments of hatchery smolt releases and the Bear Lake smolt out-migration in 1981 comprised an estimated 12.4% to the sport catch. The total contribution of enhanced adult coho production, therefore, was 2,521 fish or 14.2% to the sport fishery.

The Ad-CWT marked adult coho survived from 40,405 Ad-CWT marked Age 0.0 (1980 brood, Bear Lake origin) hatchery-reared coho smolts released in Seward Lagoon (25,940) and lower Bear Creek (14,465) in June 1981, and from "holdover" smolts which emigrated as yearlings (Age 1.0) in 1981 from the 1980 0-Age smolt plants in Seward Lagoon and Grouse Lake. The LV marked coho were produced by 17,977 Bear Lake smolts marked at Bear Creek weir. Unmarked hatchery coho resulted from 122,395 unmarked smolts (same brood and origin) stocked in Seward Lagoon (82,760) and lower Bear Creek (39,635) with the marked smolts in 1981. Unmarked hatchery adults returning from the above 1980 Age 0 smolt releases also entered the 1982 sport catch. Additional unmarked coho survived from 54,646 Bear Lake smolts released unmarked past Bear Creek weir in 1981.

A total of 67,200 unmarked Age 1.0 (1980 brood, Bear Lake origin) hatchery coho smolts were stocked in Seward Lagoon (53,970) Grouse Lake (13,230) on May 27, 1982. These plants were comprised of yearling smolts averaging (18.9 g or 24/lb) and should realize better smolt-to-adult survival compared to the previous Age 0 smolt releases. Age 1.1 unmarked adults surviving from these smolt releases will return in 1983.

The total sport fishing effort exerted for Resurrection Bay coho was an estimated 25,403 man-days. A total of 17.1% of the season's effort was sampled during the creel census period. The mean number and percentage of

Table 10. Derby and Total Sport Harvest of Coho Salmon in Resurrection Bay, 1978 - 1982.

Year	Total Sport Harvest	Derby Harvest	% Derby Harvest
1978	15,550	7,258	46.7
1979	17,785	6,073	34.1
1980	20,981	6,732	32.1
1981	15,743	4,753	30.2
1982	17,813	4,504	25.3

sport fishing boats returning daily to the Seward Small Boat Harbor are shown in Table 11. The average numbers of anglers per boat were as follows: weekdays, 3.08; weekends, 3.05; and salmon derby, 3.05. Fishing effort and mean seasonal catch per hour are summarized for 1978-1982 in Table 12. The fishing effort was 7,912 man-days on weekdays and 7,810 man-days on weekends, excluding the derby (9,681 man-days). Military personnel and dependents, fishing on boats provided by the Army and Air Force recreation camps at Seward, contributed 2,675 man-days (10.5%) to the total effort. Civilian anglers fishing on weekdays realized the highest coho catch per hour (0.195), whereas the lowest catch rate (0.077) occurred during the Derby when effort was more intense. The average number of hours anglers fished per day were as follows: weekdays, 4.77; weekends, 4.80; and salmon derby, 6.08.

An estimated 322 chinook salmon were harvested during the census period at an average rate of only 0.03 fish per boat. This harvest was only slightly below the 20-year average (1961-1980) catch of this species (371 fish) in Resurrection Bay. Chinook salmon were most abundant during July 22-28 when anglers averaged 0.05 chinook per boat. Most chinook taken were immature and in their first and second ocean years. Origins of these stocks are unknown as wild chinook rarely ascend Resurrection Bay streams. A total of 132 adult chinook salmon returned to the Box Canyon Creek from two annual (1978-1979) smolt releases in that tributary, according to two foot surveys conducted on July 27 and August 10. Of the 46 carcasses examined, 12 were Ad-CWT marked and 34 were unmarked. Code analysis of the Ad-CWT snout recoveries indicated that two-thirds were Age 0.3 adults and one-third was Age 0.4 adults. Therefore, the escapement was estimated to be comprised of 44 Age 0.4 adults from 150,500 smolts stocked in 1978 and 33 Age 0.3 adults from 218,500 smolts planted in 1979. No Ad-CWT marked chinook were observed in the sport harvest during creel census. Total smolt-to-adult survivals of the 1976 (25,100 smolts), 1977 (50,000), 1978 and 1979 smolt releases in Box Canyon Creek were estimated at 0.06%, 0.04%, 0.05% and 0.05% (minus Age 0.4 adults returning in 1983), respectively. This program was discontinued after 1979 due to the negligible returns obvious at that time.

The Resurrection Bay pink salmon sport catch in 1982 (8,788 fish) was third highest to the record harvest of 13,292 pink salmon in 1980. A commercial fishery conducted on July 26-27 and August 2-3 (48 hours) and August 9-10 (27 hours), by 11 seine boats harvested 139,600 pink and 6,400 chum salmon (Hammarstrom, pers. comm.). This was the second highest pink salmon catch on record since 1960 and nearly four times the even-year average. Pink and chum salmon escapements were considered good to excellent for all major production streams in Resurrection Bay. Pink salmon were most abundant in the sport fishery from mid-July through early August when anglers averaged 2.22 fish per boat. Pink salmon catch per man-day averaged 0.23 in 1982, compared to 0.46 in 1980, the parent brood year which produced the 1982 return.

Adult Coho Timing and Abundance in Index Streams:

Peak of the 1982 index escapements ranged from mid-October through early November, and peak of spawning occurred within the following 2 weeks in these tributaries. Estimated minimum escapements of wild coho salmon in

Table 11. Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor During Each Sampling Period, 1982.

Periods (hours)	Weekends		Weekdays	
	Mean No. of Boats	Percent	Mean No. of Boats	Percent
8:00 a.m. - 11:30 a.m.*	17.0	11.6	6.9	14.3
11:30 a.m. - 3:00 p.m.	33.7	22.9	11.6	24.0
3:00 p.m. - 6:30 p.m.	64.9	44.2	18.4	38.1
6:30 p.m. - 10:00 p.m.	<u>31.3</u>	<u>21.3</u>	<u>11.4</u>	<u>23.6</u>
Total	146.9	100.0	48.3	100.0

* Percentage for this period determined by three-year mean, 1964-1966.

Table 12. Derby and Total Sport Effort (Man-Days) Exerted for Coho Salmon and Mean Catch Per Hour in Resurrection Bay, 1978 - 1982.

Year	Period of Census	Total Effort	Derby Effort	% Derby Effort	Seasonal Catch Per Hour
1978	July 8 - Sept. 10	22,291	10,064	45.1	0.126
1979	July 8 - Sept. 9	24,651	8,280	33.6	0.131
1980	July 8 - Sept. 7	25,527	8,886	34.8	0.145
1981	July 8 - Sept. 8	22,937	7,933	34.6	0.122
1982	July 8 - Sept. 8	25,403	9,681	38.1	0.106

each stream index area since 1978 are presented in Table 13. The total minimum index escapement of 1,377 spawning coho indicated a fairly strong wild coho return occurred in 1982.

Bear Lake Upstream Migration:

The Bear Creek weir upstream migrant trap was operated continuously from May 18 through October 31. The first adult coho entered the trap on September 7 and the last one was captured October 22. A total of 105 coho spawned in lower Bear Creek after the adult run had entered the trap according to a foot survey conducted on November 4.

A total of 2,122 adults were enumerated from the trap. Abundance and timing of the adult coho migration are shown in Table 14. Weekly breakdown by marked release lot is presented in Table 15. The adult migration (50%) peaked on September 25, and the highest daily count of 338 (15.9% of the adult run) occurred on September 26. Mean stream temperatures at the beginning, peak and end of migration were 14.4°C (55.5°F), 10.8°C (50.0°F) and 1.9°C (35.5°F), respectively. Most of the migration (82.7%) occurred from September 16 through October 6 when Bear Creek temperatures ranged from 5.6°C to 12.2°C (42°F - 54°F) and flows from 18 to 123 cfs.

Most of the marked coho escapement to the weir (70.6%) returned from 14,465 Age 0.0 (1980 brood, Bear Lake origin) Ad-CWT marked hatchery smolts released below the weir in 1981. With the additional 55 estimated taken in the Resurrection Bay boat fishery, the total return of 132 Ad-CWT coho resulted in a 0.91% smolt-to-adult survival of this lot. Also, an estimated 362 unmarked adults survived from the 39,635 unmarked hatchery smolts (same brood and origin) stocked in lower Bear Creek with the marked segment in 1981.

Only 32 coho returned to the weir from 17,977 Age 1.0, 2.0 and 3.0 Bear Lake smolts marked with an LV fin clip at Bear Creek weir in 1981. Including the 23 estimated caught in the Resurrection Bay sport fishery, the total return of the marked Bear Lake lot was just 55 fish (0.31% smolt-to-adult survival). In contrast, an estimated 3,099 unmarked adult coho survived from the 54,646 Bear Lake smolts released unmarked passed the weir in 1981. Total smolt-to-adult survival of this lot was 5.67%. Table 16 shows the various run components comprising total adult returns of the Bear Lake, Bear Creek, Grouse Lake and Seward Lagoon production from 1981 smolt releases.

Mean fork length and weight of adult coho sampled at the weir are presented in Table 17. The nearly 90 mm and 1.45 kg mean size difference between the small Ad-CWT hatchery return versus Bear Lake coho is substantial. This growth discrepancy of hatchery coho compared to Bear Lake returns was noted previously (McHenry, 1981). The male to female sex ratio in the Bear Creek escapement was 1.5:1.

No Ad-CWT or unmarked hatchery coho smolts were released in lower Bear Creek in 1982 to augment the 1983 Bear Lake adult return, as was done in previous years. However, as was observed in both the Seward Lagoon and Grouse Lake hatchery coho runs in 1982, it is possible that a portion of

Table 13. Minimum Wild Coho Salmon Escapement in Seven Index Streams in the Resurrection Bay Area, 1978-1982.

Name of Stream	Minimum Escapement					Mean 1978-80
	1978	1979	1980	1981*	1982	
Airport	14	1	9	...	0	8
Box Canyon	28	121	32	...	248	60
Clear	59	42	88	...	241	63
Dairy	146	68	122	...	108	112
Grouse	360	14	108	...	307	161
Jap	51	61	49	...	328	54
Mayor	<u>50</u>	<u>30</u>	<u>94</u>	<u>...</u>	<u>145</u>	<u>58</u>
Total	708	337	502	...	1,377	516

* Due to press of other duties, insufficient foot surveys were performed in 1981 to delineate minimum escapements.

Table 14. Bear Lake Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1982.

Weekly Periods	Marked	Unmarked*	Male	Female	Total
Sept. 2 - 8		12	10	2	12
Sept. 9 - 15	1	157	105	53	158
Sept. 16 - 22	24	514	421	117	538
Sept. 23 - 29	58	1,020	598	480	1,078
Sept. 30 - Oct. 6	12	127	65	74	139
Oct. 7 - 13	9	113	56	66	122
Oct. 14 - 20	5	68	27	46	73
Oct. 21 - 27	—	<u>2</u>	<u>2</u>	—	<u>2</u>
Total	109	2,013	1,284	838	2,122

* Approximately 75% of the 1981 Bear Lake smolt out-migration was released unmarked to enhance smolt-to-adult survival.

Table 15. Marked Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1982.

Weekly Periods	Marked (Fin-clip)*		Total
	Ad-CWT	LV	
Sept. 2 - 8			
Sept. 9 - 15		1	1
Sept. 16 - 22	15	9	24
Sept. 23 - 29	39	19	58
Sept. 30 - Oct. 6	10	2	12
Oct. 7 - 13	9		9
Oct. 14 - 20	4	1	5
Oct. 21 - 27	—	—	—
Total	77	32	109

* Ad-CWT (adipose-coded wire tag) - 1981 Bear Creek smolts marked (26.7%) at Elmendorf Hatchery.

LV (left ventral) - 1981 Bear Lake smolt marked (24.8%) at Bear Creek weir.

Table 16. Estimated Adult Return Components of Bear Lake, Bear Creek, Grouse Lake and Seward Lagoon Enhanced Coho Salmon Production from 1981 Smolt Releases.

Water Body and Fin Mark	Boat Harvest*	Beach Harvest**	Escapement	Total Return	Smolt-to-Adult Survival (%)
Bear Lake***					
LV	23		23	55	0.31
UNM	1,297		1,802	3,099	5.67
Bear Creek					
Ad-CWT	55		77	132	0.91
UNM	151		211	362	0.91
Grouse Creek****					
Ad-CWT	47	19	46	112	0.72
UNM	129	42	102	273	0.79
Seward Lagoon					
Ad-CWT	95	28	77	200	0.77
UNM	<u>304</u>	<u>87</u>	<u>244</u>	<u>635</u>	<u>0.77</u>
Total					
Marked	200	47	232	499	0.67
UNM	1,881	139	2,383	4,369	2.06

* Boat harvests of Ad-CWT coho were apportioned after estimating the Bear Creek and Grouse Lake harvests by applying the 0.72:1 catch:escapement ratio of marked Bear Lake coho to the Ad-CWT Bear Creek escapement (including beach harvest). Boat harvests of unmarked (UNM) hatchery coho were apportioned according to UNM escapements estimated by Ad-CWT smolt-to-adult survivals per system.

** Beach harvests of Grouse Lake and Seward Lagoon hatchery coho were estimated after apportioning 74% (1973-1978 average) of the total beach harvest to the Seward Lagoon return. No Bear Lake or Bear Creek marked coho were detected in the beach fishery.

*** Boat harvest of UNM Bear Lake coho was estimated by applying the 0.72:1 catch:escapement ratio of the LV marked fish to the UNM Bear Lake escapement.

**** These fish returned from "holdover" smolts, stocked as 0-Age in 1980, which did not emigrate until 1981 at Age 1.0.

Table 17. Mean Fork Length (mm) and Weight (kg) of Adult Coho Salmon Sampled at Bear Creek Weir in 1982.

Lot	Males			Females			Sexes Combined		
	No.	FL	Wt.	No.	FL	Wt.	No.	FL	Wt.
LV	5	672.0	3.63	4	641.5	3.51	9	658.4	3.57
Ad-CWT	8	575.1	2.20	4	581.0	2.31	12	577.1	2.24
UNM	<u>199</u>	<u>661.5</u>	<u>3.54</u>	<u>205</u>	<u>668.8</u>	<u>3.83</u>	<u>404</u>	<u>665.2</u>	<u>3.69</u>
Total	212	658.5	3.49	213	666.6	3.80	425	662.2	3.65

the 54,100 Age-0 smolts stocked in 1981 did not emigrate until 1982 as yearlings (Age 1.0), and may return as Age 1.1 adults in 1983.

Coho Salmon Egg-Takes:

A total of 213 males and 661 females were held in the Bear Creek holding facility from September 8 to October 29. Stream temperatures ranged from 0.6°C to 13.3°C (33°F - 56°F), and flows from 10 to 123 cfs during this period. Male and female holding mortalities were 12.2% and 28.0%, respectively. A total of 298 females and 112 males were artificially spawned, yielding an estimated 1,205,000 fertilized eggs. Mean fecundity was 4,045 eggs per female, or 200 fewer than that obtained (4,245) from females in 1981. Eggs were fertilized at an average rate of 1 male:2.7 females.

For the third consecutive year, assistance was provided to Dr. Joseph Sullivan, F.R.E.D. Division pathologist, in continuing an experiment to eradicate bacterial kidney disease (BKD), from Bear Lake stock coho. All potential spawners held were injected with erythromycin-phosphate (Ery-P04) antibiotic at least 24 hours prior to artificial spawning. All fish and spawning utensils were sterilized with Betadine solution, and gametes (ova and sperm) taken were retained separately per individual spawner for delayed fertilization at Elmendorf Hatchery. Hindgut and kidney tissue samples were collected from each spawner for BKD and furunculosis analysis prior to uniting their gametes at the hatchery. Of the 430 coho spawned, 23 (5.3%) showed positive for one or both of the diseases, and their gametes were disinfected, then destroyed. Unfortunately, the delayed fertilization technique at the hatchery resulted in only 75% of the eggs being fertilized (Keifer, pers. comm.) versus the usual 95% characteristic of immediate fertilization at the weir. Therefore, the possible advantage of decreasing incidence of BKD at the source was at least partially offset by the 25% loss of fertilized eggs at the outset. Moreover, BKD and furunculosis are already prevalent in the hatchery system (Krolick, pers. comm.), so the efficacy of the above treatment to prevent further outbreaks of these diseases seems questionable at best.

Other Species:

A total of 463 adult sockeye salmon were captured in the upstream migrant trap from June 6 to September 9. Most adults (87.1%) were Age 1.2, surviving from 3,365 Age 1.0 smolts that emigrated Bear Lake in 1980. Excepting Age 1.3 adults returning in 1983, smolt-to-adult survival is 12.0% thus far. An estimated 25 Age 2.3 adults (5.4% of the run) survived from 701 Age 2.0 smolts which emigrated in 1979. With the two Age 2.1 jacks and 71 Age 2.2 adults enumerated in the 1980 and 1981 escapements, total smolt-to-adult survival of this cycle is 14.0%. An additional 22 Age 1.3, 5 Age 2.2 and 8 Age 3.2 adults comprised the remaining 7.5% of the 1982 spawning escapement. Mean sizes of the two-ocean and three-ocean fish were 545 mm in fork length (2.09 kg) and 595.7 mm (2.71 kg), respectively.

Pink salmon first entered the trap on July 22, and eventually moved downstream to spawn from mid-August to early September. An estimated 7,930 pink salmon spawned in lower Bear Creek in 1982 (Hammarstrom, pers. comm.).

Upstream migrating Dolly Varden ascended Bear Creek to the weir on July 15, and continued moving in and out of the trap throughout the remaining field season.

All fish species other than sockeye or coho salmon were retained below the weir due to the lack of suitable spawning area upstream and/or the undesirability of having those species depredating or competing with juvenile salmon in Bear Lake for survival.

Enhanced Coho Salmon Production:

Overall, smolt-to-adult survival of 1981 marked and unmarked Bear Lake smolts was 4.34%, or 3.61% lower than that realized for the 1980 out-migration. The 1981 out-migration was comprised of 84.7% Age 2.0 smolts with a relatively low condition factor ($K = 0.96$) at migration peak, and may have been responsible for this considerably reduced survival to returning adults. Table 18 summarizes Bear Lake smolt out-migrations since 1976 and subsequent adult returns through 1982.

Code analysis of wire tags dissected from 69 snouts recovered from coho taken in the fishery and on escapement surveys indicated that 45% of the 1982 enhanced coho production returned from hatchery smolts released in Seward Lagoon and Grouse Lake in 1980. The small size of these Age 0 smolts (34-39/lb) when stocked in Grouse Lake and Seward Lagoon resulted in smolt-to-adult survivals of only 0.25% and 0.37%, respectively (McHenry, 1982). However, the additional adult returns estimated in 1982 from the 1980 "holdover" smolts, which emigrated as yearlings (Age 1.0) in 1981, increased total smolt survivals to over 1.1% in these systems. The 0.81% and 0.91% smolt-to-adult survivals of Age 0 hatchery smolts stocked in Seward Lagoon and lower Bear Creek in 1981 may increase slightly in 1983 if significant smolt residualism also occurred in these releases. However, since these plants were comprised of normal sized smolts (25/lb), most probably emigrated when stocked and few, if any, adults are expected to return in 1983 from a similar smolt holdover phenomenon. Summaries of total survivals for Seward Lagoon, Bear Creek and Grouse Lake smolts releases are presented in Tables 19, 20 and 21.

Bear Lake Fertilization Project:

It may be possible to increase Bear Lake's carrying capacity of juvenile coho via artificial fertilization of its rearing environment. F.R.E.D. Division's Limnology section collected baseline data on Bear Lake's water chemistry, primary productivity levels, benthic communities and zooplankton populations from 1979-1981 to determine the feasibility of conducting such an experiment in Bear Lake. Their prefertilization report concluded that Bear Lake was producing mostly "dead-end" species of blue-green algal phytoplankton which are not utilized by the zooplankters (mainly cladocerans) that juvenile salmon prey upon. Water chemistry data indicated that Bear Lake had an unbalanced nitrogen: phosphorus ratio (in favor of the latter) which is conducive to Blue-green algal production. Therefore, the report recommended that Bear Lake be judiciously treated with ammonium-nitrate ($\text{NH}_4 \text{NO}_3$) liquid fertilizer to reverse its contribution of unusable phytoplankton to the salmonid food chain.

Table 18. Survival of Bear Lake Coho Salmon Adults from Seaward Migrations of Smolts Fin Marked at Bear Creek Weir, 1976-1981.

Seaward Migration Year	Number of Smolts Released	Age Composition of Out-Migration	Mean Fork Length (mm)	Fin-clip Used	Number of Adults Returning*	Percentage Return
1976	63,674	68.7% - age 1.0	106.3	Ad-RV	2,674	2.88
	28,031	30.2% - age 2.0	134.9	Ad-RV		
	1,010	1.1% - age 3.0	161.0	Ad-RV		
	<u>92,715</u>					
1977	49,689	49.8% - age 1.0	113.1	Ad-LV	3,835	3.84
	48,332	48.4% - age 2.0	129.5	Ad-LV		
	1,684	1.7% - age 3.0	182.8	Ad-LV		
	<u>99,844</u>	0.1% - age 4.0	192.0	Ad-LV		
1978	80,886	82.8% - age 1.0	120.0	LV,RV	3,910	4.00
	16,431	16.8% - age 2.0	134.8	LV,RV		
	<u>97,659</u>	0.4% - age 3.0	191.7	LV,RV		
1979	96,327	92.2% - age 1.0	120.6	LV	5,368	5.14
	<u>104,476</u>	7.8% - age 2.0	146.2	LV		
1980	54,538	72.8% - age 1.0	121.8	RV	5,956	7.95
	20,278	27.1% - age 2.0	134.8	RV		
	<u>74,922</u>	0.1% - age 3.0	191.0	RV		
1981	10,859	15.0% - age 1.0	121.5	LV	3,154	4.34
	61,526	84.7% - age 2.0	127.0	LV		
	<u>72,623</u>	0.3% - age 3.0	161.5	LV		

* Includes boat and shore sport harvest estimates plus escapements.

Table 19. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Seward Lagoon.

Brood Year	Origin	Mark	Smolt Liberation Data			Adult Return Data*				Total Number	Return Percent
			Release Date	Number	Fish/kg(1b)	0+Ocean No.	(jacks) %	1-Ocean No.	%		
1966	Oregon	Ad	4/18-22/68	42,200	40.1 (18.2)	0	0.00	15	0.04	15	0.04
1967	Oregon	Ad	5/6-7/69	27,100	32.2 (14.6)	1	0.00	6	0.02	7	0.03
1968	Bear Lake	Ad	5/19-27/70	39,750	23.8 (10.8)	952	2.39	5,114	12.87	6,066	15.26
1969	Bear Lake	Ad	5/17/71	10,900	31.3 (14.2)	3	0.03	1,519	13.94	1,522	13.96
1970	Kodiak	Ad	5/31/72	66,500	37.0 (16.8)	915	1.38	2,963	4.46	3,878	5.83
1971	Seward Lagoon	Ad-LV	5/7-9/73	30,200	19.6 (8.9)	140	0.46	125	0.41	265	0.88
1972	Kodiak	Ad-RV	5/6-11/74	100,000	20.7 (9.4)	4,764	4.76	3,885	3.89	8,649	8.65
1973	Seward Lagoon	Ad-LV	5/15-19/75	100,700	20.1 (9.1)	2,610	2.59	1,971	1.96	4,581	4.55
1974	Bear Lake	LV	5/4-10/76	100,600	28.2 (12.8)	600	0.60	4,513	4.49	5,113	5.08
1975	Bear Lake	RV	5/6-13/77	100,450	27.7 (10.3)	1,622	1.61	7,710	7.68	9,332	9.29
1976	Seward Lagoon	Ad-CWT	6/1-5/78	125,979	21.7 (9.9)	147	0.12	1,080	0.86	1,227	0.98
1977	Bear Lake	Ad-CWT	5/14-15/79	97,840	63.9 (29.0)	0	0.00	3,956	4.04	3,956	4.04
1979	Bear Lake	Ad-CWT	6/25/80	100,800	86.1 (39.1)	0	0.00	1,129***	1.12	1,129	1.12
1980	Bear Lake	Ad-CWT**	6/15/81	108,700	55.6 (25.2)	48	0.04	835	0.77	883	0.81

* Includes boat and shore sport harvest estimates plus escapements.

** Release consisted of 82,760 unmarked (76.1%) and 25,940 marked (23.9%) smolts.

*** An estimated 875 Age 1.1 adults returned in 1982 from "holdover" Age-0 smolts which did not emigrate until 1981.

Table 20. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Lower Bear Creek.

Brood Year	Origin	Mark	Smolt Liberation Data			Adult Return Data*				Total Number	Return Percent	
			Release Date	Number	Fish/kg(lb)	0+Ocean No.	(jacks) %	1-Ocean No.	%			
1967	Oregon	Ad	5/8-13/69	47,470	30.4 (13.8)	8	0.02	17	0.04	25	0.05	
1968	Bear Lake	Ad	5/27/70	6,400	22.7 (10.3)	76	1.19	285	4.45	361	5.64	
1969	Bear Lake	Ad	5/18-21/71	51,000	31.3 (14.2)	14	0.03	178	0.35	192	0.38	
1970	Kodiak	Ad	5/15-24/72	155,500	32.6 (14.8)	155	0.10	470	0.30	625	0.40	
1974	Bear Lake	Ad-LV	5/12-14/76	35,600	25.1 (11.4)	16	0.05	756	2.12	772	2.17	
1975	Bear Lake	Ad-RV	5/13-15/77	35,100	23.1 (10.5)	436	1.24	1,709	4.87	2,145	6.11	
1976	Seward Lagoon	Ad-CWT	5/31/78	28,574	22.2 (10.0)	153	0.54	1,343	4.70	1,496	5.24	
1977	Bear Lake	Ad-CWT	5/18/79	40,400	55.1 (25.0)	0	0.00	881	2.18	881	2.18	
1979**												
1980	Bear Lake	Ad-CWT***	6/17/81	54,100	56.2 (25.5)	0	0.00	494	0.91	494	0.91	

* Includes boat and shore sport harvest estimates plus escapement.

** No hatchery-reared smolts were released in Bear Creek in 1980.

*** A total of 39,635 smolts (73.3%) were unmarked, 14,465 (26.7%) were marked.

Table 21. A summary of Hatchery Reared Coho Salmon Smolt Releases in Grouse Lake.

Brood Year	Origin	Mark	Smolt Liberation Data			Adult Return Data*				Total Number	Return Percent
			Release Date	Number	Fish/kg(1b)	0+Ocean No.	(jacks) %	1-Ocean No.	%		
1974	Bear Lake	RV	5/10-12/76	35,200	26.8 (12.2)	50	0.14	1,498	4.26	1,548	4.40
1975	Bear Lake	LV	5/15-17/77	35,100	22.3 (10.1)	446	1.27	2,304	6.56	2,750	7.83
1976	Seward Lagoon	Ad-CWT	5/30/78	53,555	24.9 (11.3)	118	0.22	801	1.50	919	1.72
1977	Bear Lake	Ad-CWT	5/16/79	44,000	62.6 (28.4)	0	0.00	1,337	3.04	1,337	3.04
1979	Bear Lake	Ad-CWT	6/26/80	50,290	75.0 (34.0)	0	0.00	569***	1.13	569	1.13
1980**											

* Includes boat and shore sport harvest estimates plus escapements.

** No hatchery-reared smolts were released in Grouse Lake in 1981.

*** An estimated 385 Age 1.1 adults returned in 1982 from "holdover" 0-Age smolts which did not emigrate until 1981 as yearling (Age 1.0) smolts.

Two shipments each of 92 30-gallon barrels of fertilizer, an applicator pump and heated warehouse storage area were purchased with \$17,000 from the Seward Salmon Derby Fish Restoration Fund. Considerable logistic support, coordination and assistance were provided to F.R.E.D. Division personnel in transporting the fertilizer from Seward and dispersing it in Bear Lake. Additional support was given in collecting Bear Lake juvenile coho and sockeye for food habits and nutrient composition studies, as well as water chemistry, chlorophyll-a plankton samples during the ice-free season (June-October).

A total of 1,440 gallons (48 bbl) of the first fertilizer shipment was uniformly distributed on the surface of Bear Lake's northern portion from early September to late October, through fall overturn, in 1981. The ensuing high abundance of Bear Lake's 1982 sockeye and coho smolt migrations (46,265 and 143,718 fish, respectively) was unexpectedly large, but whether this reflected any effect of lake fertilization, initiated only 9-10 months earlier or was merely coincidental due to other natural factors, is not yet known. An additional 3,240 gallons (108 bbl) of fertilizer were applied to Bear Lake's northern epilimnion in 10-day increments from mid-July through late October 1982. The fertilizer consists of 32% nitrogen as 1/3 nitrate (NO_3^-), 1.3 ammonium (NH_4^+) and 1/3 urea (organic N).

According to Dr. Jeff Koenings, F.R.E.D. Division's chief limnologist, Bear Lake's inorganic nitrogen levels during winter (January/February) sampling in the prefertilization years of 1980 and 1981 were 40 ppb and 44 ppb, respectively. After fertilizer addition in 1982 (1/2 year) and 1983 (1 year), Bear Lake's nitrogen levels increased to 65 ppb and then to 135 ppb, respectively. Abundance of the undesirable, filamentous blue-green algae, was observed to diminish in bi-weekly sampling (Gary Kyle, pers. comm.). Also, Bear Lake's zooplankton community remained intact (i.e., showed no shift in species composition) with population densities of Diaptomus sp. and Bosmina longirostris increasing, and those of Epischura nevadensis and Daphnia longiremus staying about the same. The latter two species comprise the largest body-sized zooplankters favored as forage by coho fingerlings and sockeye fry, respectively. Thus, if Bear Lake produces another record abundance of smolts in 1983 and the aforementioned favorable lake conditions prevail, stocking density of coho fingerlings should be increased in 1984 to take advantage of the lake's newly expanded carrying capacity. Fertilization is expected to continue at least through the 1984 growing season.

DISCUSSION

Bear Lake's coho salmon smolt production in 1982 was unexpectedly high considering its recent trend of declining yearling (Age 1.0) smolt yields since 1979 and the near failure of the 1980 fingerling release to produce any smolts. The 54.1% yield of the 1981 fingerling plant resulting in yearling smolts is the highest proportion of any annual fingerling release in the Bear Lake project's 20-year history producing Age 1.0 smolts. Whether this sudden increase in Bear Lake's smolt biomass production was due to the recently initiated lake fertilization project or to natural cyclic processes inherent in the system is not known at this time.

Results obtained during the 1982 field season suggest that the lake fertilization experiment may in fact be expanding Bear Lake's carrying capacity for juvenile coho. Inorganic nitrogen levels in the lake's water column have increased from 40-44 ppb in prefertilization years (1980-81) to 135 ppb in early 1983 as a result of nitrates introduction. The consequent reduction in the abundance of Oscillatoria sp., undesirable blue-green algae contributing nothing to the lake's salmonid food chain, and an increase in population densities of important zooplankton species utilized as forage by juvenile salmon, are signs that the experiment may be working. Therefore, juvenile coho stocking levels probably will be elevated beginning in 1984 to take advantage of Bear Lake's improved quality and increased quantity of zooplankton forage. It is hoped that the lake fertilization project will double Bear Lake's current smolt production and thus contribute a similar increase in Bear Lake coho to the Resurrection Bay sport fishery.

Though the 1982 return of adult coho from residualism of the Age 0 hatchery smolts released in Seward Lagoon and Grouse Lake in 1980 improved smolt-to-adult survivals of those lots to 1.1%, their combined contributions to the 1981 and 1982 sport harvests were only 1.3% and 3.1%, respectively. Similarly, adult contributions of the 1981 Age 0 smolt releases in Seward Lagoon and lower Bear Creek to the 1982 sport catch were small (2.5% and 1.2%, respectively). These lots were comprised of normal-sized smolts (25/lb), and thus were anticipated to produce much higher returns than the 1980 plants consisting of 34-39/lb smolts. However, only 0.8-0.9% smolt-to-adult survivals were realized from the 1981 releases, with few if any additional adult coho expected in 1983 from holdover smolts. This strongly suggests that accelerated growth manipulation at the hatchery does not allow these fish adequate physiological development to adapt or imprint to their release environment and return successfully as adults. Therefore, the relative advantage of producing hatchery smolts in a year's less time seems to be heavily outweighed by their reduced survivals and the unpredictability of when they will return as adult coho to the fishery.

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