

STATE OF ALASKA

Bill Sheffield, Governor

Annual Performance Report for
RESURRECTION BAY COHO ENHANCEMENT

by

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ALASKA DEPARTMENT OF FISH AND GAME
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RESEARCH PROJECT SEGMENT

State: Alaska Name: Sport Fish
Investigations
of Alaska

Project: F-10-1

Study: S-31 Study Title: LOWER COOK INLET COHO
SALMON STUDIES

Job: S-31-2 Job Title: Resurrection Bay Coho
Enhancement

Cooperator: Edward T. McHenry

Period Covered: July 1, 1985 to June 30, 1986

ABSTRACT

Bear Lake was restocked with 300,000 Age 0.0 coho salmon, *Oncorhynchus kisutch* (Walbaum), fingerlings on June 5, 1985 to maintain smolt production. About 30 percent were undersized (1,465 per kilogram) because of a late feeding start on an experimental diet.

The Bear Creek weir downstream migrant trap was operated continuously from June 1 through September 10. A total of 105,880 smolts enumerated were comprised of 104,300 Age 1.0 and 1,580 Age 2.0 smolts. Yearling (Age 1.0) smolt survival from the 1984 Bear Lake fingerling plant was 47.4 percent, with a 5.9:1 smolt-to-fingerling biomass yield. Age 2.0 smolt survival was 0.8 percent, with a 0.3:1 biomass ratio. Excepting Age 3.0 smolts, total smolt survival and biomass production from the 1983 plant were 40.1 percent and 5.3:1, respectively. Total smolt survival of the 1982 plant was 50.7 percent, with a 5.9:1 biomass yield.

Bear Lake's predicted average coho smolt production of 2,000 kilograms, or 100,000 smolts, was nearly achieved (1,905 kilograms, or 99,114 smolts) from 1977 to 1982, despite the setback resulting from stocking undersized fingerlings (1,462 per kilogram) in 1979. Following 3 full years of fertilization, Bear Lake has averaged 1,902 kilograms, or 102,696 smolts, which is only a 3.6 percent increase in smolt abundance over prefertilization years. This minor change in Bear Lake's coho production may be due to natural variation rather than lake fertilization effects.

According to the Resurrection Bay salmon creel census (July 8-September 10), an estimated 11,738 coho salmon were harvested for 19,865 angler-days of sport trolling effort. The mean seasonal catch per angler-hour was 0.100 coho. Enhanced coho (1,376 fish) contributed an estimated 11.7 percent to the sport harvest; most of these fish

(76.5 percent) were from 40,700 and 34,100 Age 1.0 (1983 brood, Bear Lake origin) hatchery smolts released in Seward Lagoon and Grouse Lake on June 5 and 6, 1984, respectively. The remaining fish (23.5 percent) returned from 93,424 Bear Lake smolts that had emigrated in 1984. Estimated fishing mortalities of Seward Lagoon, Grouse Lake and Bear Lake smolt releases were 1.42, 1.39 and 0.35 percent, respectively. Exploitation rates of these returns in the sport fishery were estimated at 54, 73 and 6 percent, respectively.

The Bear Creek upstream migrant trap was operated continuously from June 1 through October 31. The coho upstream migration extended from September 3 to October 28, and consisted of 4,825 adults and 5 jacks. The adult run was comprised of 493 marked and 4,332 unmarked Bear Lake coho. Smolt-to-adult survivals of the 1984 marked and unmarked smolts were 2.26 and 6.68 percent, respectively, with an overall marine survival of 5.57 percent. Smolt-to-adult survivals of the 1984 Seward Lagoon and Grouse Lake hatchery smolt plants were 2.61 and 1.90 percent, respectively. Grouse Lake's coho survival may be low because of an underestimation of the escapement; the return's exploitation rate in the fishery was thereby estimated too high.

The 1985 catch-to-escapement ratio of marked Bear Lake coho (0.066:1) is the lowest ever estimated for this enhanced run. The male-to-female sex ratio was 1.1:1.0 in the Bear Lake escapement. After pathological screening for bacterial kidney and furunculosis diseases, an estimated 1,003,000 artificially spawned eggs from 264 females were fertilized by sperm from 115 males at Trail Lakes Hatchery. Incidence of bacterial kidney disease in the spawned salmon was only 2.8 percent overall. Eyed-egg mortality, after physical shocking at the hatchery, was 6.4 percent.

An estimated 10-15 coho utilized the lower Jap Creek spawning channel, constructed in 1985 as offsite mitigation for pink, *Oncorhynchus gorbuscha* (Walbaum), and chum salmon, *Oncorhynchus keta* (Walbaum), spawning habitat lost in Spring Creek. Additional coho may be accommodated in time, as spawner modification of the channel's substrate and streambank revegetation offer more protection from potential predators. Evaluation and development of new smolt-release sites near Fourth of July and Lowell Points may be timely to bolster coho returns to expanding shore fisheries in these areas.

Assuming a 4.0 percent wild coho smolt-to-adult survival and assuming that wild adult returns are estimated by marked Bear Lake coho catch-to-escapement ratios applied to wild coho harvests, Resurrection Bay's wild coho migrations have averaged 756,000 (373,000-1,240,000) smolts and 30,224 (14,903-49,769) adults from 1971 to 1985. Exploitation rates of adults have been moderate, averaging 40.6 (21.9-56.6) percent during this 15-year period.

KEY WORDS

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

BACKGROUND

Since 1961 the marine recreational fishery for Resurrection Bay coho salmon has become the second largest (effort and harvest) for this species in Alaska. Wild coho salmon production in Resurrection Bay is believed to be directly affected by the extreme fluctuations in stream flows and water temperatures characteristic of its coastal drainage tributaries. Therefore, it became imperative to stabilize or enhance Resurrection Bay's coho production to satisfy the rapidly growing angler demand evident in the early 1960s.

To eradicate competing threespine stickleback and subsequent annual restocking with coho fingerlings for increased smolt production, Bear Lake was chosen in 1962 as the main thrust for experimental coho salmon enhancement via lake rehabilitation. After reinfestation by stickleback and resultant decline of favorable smolt yields, Bear Lake was rehabilitated again in 1971. Threespine stickleback were completely eliminated and Bear Lake's yearling coho smolt yields from annual fingerling plants exceeded 50%; adult survival was up to 10% returns, contributing 14% to the Resurrection Bay sport harvest. Bear Lake is currently undergoing an artificial fertilization experiment to further increase its carrying capacity for juvenile salmon production.

Another facet of Resurrection Bay coho salmon enhancement began in 1968 with annual plants of hatchery reared smolts at three local release sites having diverse habitat characteristics. Though variable from one site and one year to another, smolt-to-adult survivals have ranged up to 15%; contributions to the sport harvest have been as high as 34%.

Lastly, impediments to smolt and spawning migrations, such as beaver dams, have been removed on a timely basis, and two natural rearing ponds were made accessible to juvenile coho in an attempt to improve wild stock survivals in the Resurrection River drainage.

For more detailed description and background information on the 23-year history of this project, see Logan (1969) and McHenry (1982). Figure 1 shows the Resurrection Bay drainage, and Table 1 lists the anadromous fish species indigenous to its tributaries.

RECOMMENDATIONS

1. The present objectives of the study should be retained.
2. The 1987 stocking density of coho fingerlings in Bear Lake should be adjusted according to emigrating smolt abundance, age composition and condition factor in 1986.

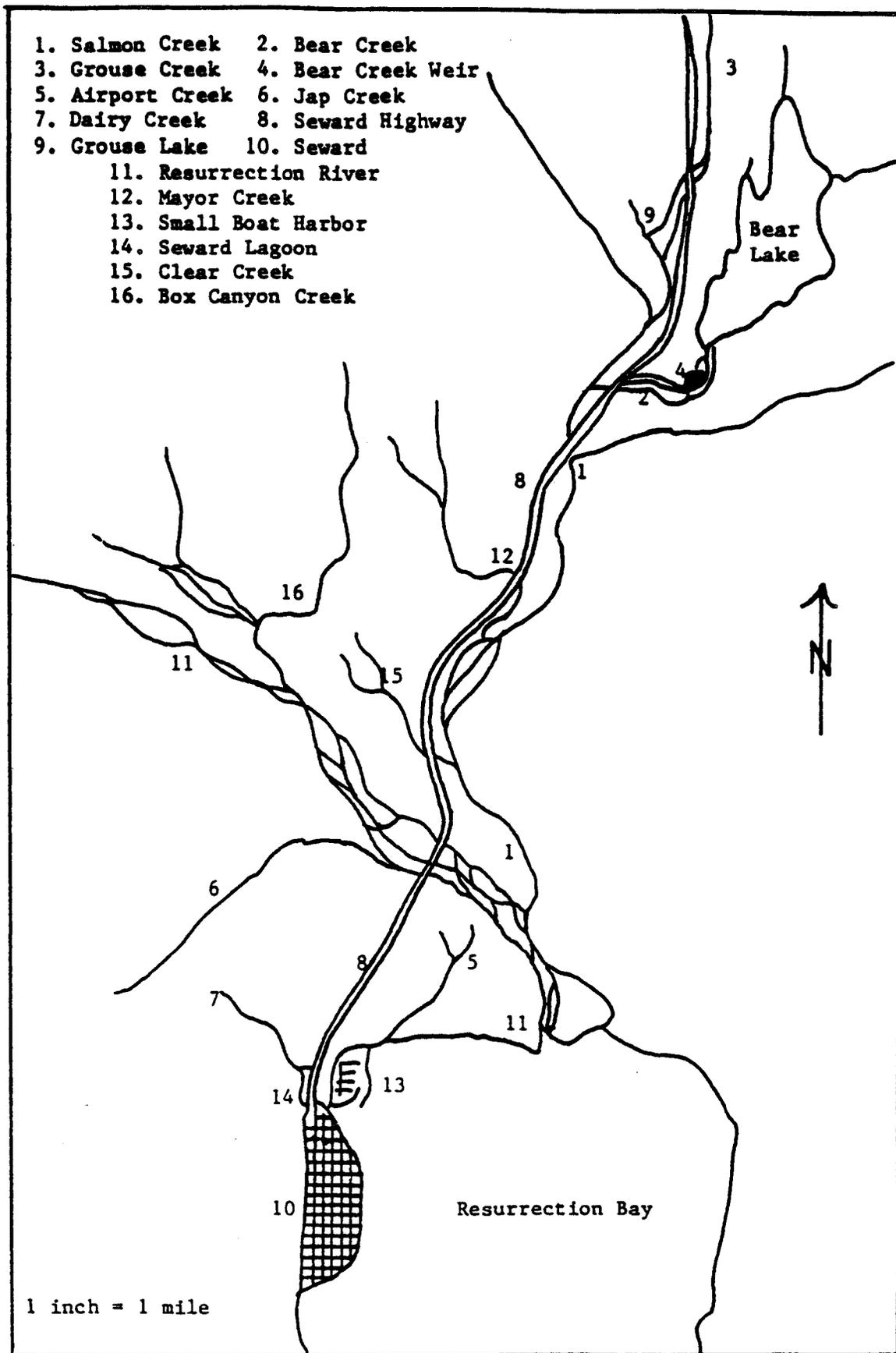


Figure 1. Resurrection Bay watershed.

Table 1. List of Common Names, Scientific Names and Abbreviations.

Common Name	Scientific Name and Author	Abbreviation
Chinook salmon	<i>Oncorhynchus tshawytscha</i> (Walbaum)	KS
Chum salmon	<i>Oncorhynchus keta</i> (Walbaum)	CS
Coho salmon	<i>Oncorhynchus kisutch</i> (Walbaum)	SS
Dolly Varden	<i>Salvelinus malma</i> (Walbaum)	DV
Pink salmon	<i>Oncorhynchus gorbuscha</i> (Walbaum)	PS
Rainbow/ steelhead trout	<i>Salmo gairdneri</i> Richardson	RT
Rockfish	<i>Sebastes</i> spps.	
Sculpin	<i>Cottus</i> spps.	
Sockeye salmon	<i>Oncorhynchus nerka</i> (Walbaum)	RS
Threespine stickleback	<i>Gasterosteus aculeatus</i> (Linnaeus)	TS

3. The Bear Lake fertilization experiment should be discontinued if Age 1.0 coho smolt production does not increase substantially.
4. Additional coho smolt release sites near Fourth of July and Lowell Point areas should be evaluated and developed to bolster adult returns for these expanding shore fisheries.

OBJECTIVES

1. To determine the abundance and timing of Bear Lake coho salmon outmigrants from May through September, and enhanced adult coho salmon in Bear Creek, Grouse Creek and Seward Lagoon tributaries from August through mid-November.
2. To determine the age and size composition of outmigrant and adult Bear Lake coho salmon populations from May through mid-November, and size composition of enhanced adult coho salmon returns from August through mid-September.
3. To determine the sport trolling effort and harvest of wild and enhanced coho salmon stocks in Resurrection Bay from July through September, and marine survivals of enhanced stocks from August through mid-November.
4. To determine minimum spawning escapements of wild adult coho salmon in seven Resurrection Bay index tributaries in October and November.
5. To determine the methods and means to increase or extend the freshwater coho salmon spawning and rearing areas of the Resurrection Bay watershed and mitigate freshwater mortality.

TECHNIQUES USED

All research methods employed in the past several years to accomplish the foregoing objectives remain essentially the same as previously described (McHenry 1982). Biological sampling frequencies of Bear Lake salmon migrations were altered slightly, according to differences in pre-season estimates of their abundance relative to previous years.

FINDINGS

Results

The findings presented are the result of the 1985-86 research segment of the project. For past information collected on the project, see Logan (1962-1969) and McHenry (1970-1985).

Bear Lake Coho Smolt Migration:

The Bear Creek weir downstream migrant trap was operated continuously from June 1 through September 10, when the trap was removed because of cessation of the Bear Lake smolt emigration. Abundance and timing of the coho salmon 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 105,880 smolts. Trap mortality claimed only 37 smolts (0.03% of the run) because of careful manipulation of the fishpass elevation during fluctuating weir pool levels at migration peak. A total of 105,843 live smolts were released downstream. A predetermined 25.0% of the out-migration received a left ventral (LV) finclip for recognition in the 1986 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.

Smolt emigration began on June 10, peaked (50% of out-migration) by June 27, and terminated September 7. The highest daily count occurred on June 18 when 9,050 smolts (8.5% of the total run) were enumerated from the trap. Mean stream temperatures, when smolt emigration began, peaked, and terminated, were 5.8°C (42.5°F), 11.7°C (53.0°F), and 12.2°C (54.0°F), respectively. Bear Creek stream flows ranged from 7 to 52 cfs during this period.

The smolt out-migration was comprised of 98.5% (104,300) Age 1.0 and 1.5% (1,580) Age 2.0 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 weekly samples. Table 6 shows the weekly and seasonal abundance per smolt age group. An overall 1.0% (1,059 smolts) were representatively sampled during emigration (Table 3). An estimated 104,264 Age 1.0 and 1,579 Age 2.0 live smolts were released downstream.

Bear Lake's ice cover did not thaw until the first 2 days of June because of extended cold weather in early spring. Consequently, smolt-emigration timing was delayed nearly 3 weeks later than in 1984 because of cooler water temperatures. Age 1.0 smolts peaked during June 24-30 when Bear Creek stream temperatures averaged 11.0°C (51.8°F), and Age 2.0 smolts peaked July 8-14 at a mean water temperature of 14.4°C (57.9°F). Similar to previous years, when approximately 65% of Bear Lake coho smolt outmigrations had passed the weir by the first week that Bear Creek's average stream temperature exceeded 10°C (50°F), 64.4% of the 1985 smolt emigration was processed through the trap by June 30.

The 1,580 Age 2.0 smolts were produced from 199,000 Age 0.0 fingerlings released in Bear Lake in 1983. With the 78,298 Age 1.0 smolts that emigrated in 1984, 40.1% of that plant has survived to smolts thus far. This 10.6% reduction in smolt yield, compared to the previous cycle's 50.7%, is not understood in view of the ongoing lake fertilization experiment. Excepting Age 3.0 smolt production in 1986, age composition of Bear Lake's twelfth smolt production cycle since the 1971 lake rehabilitation was 98.0% Age 1.0 and 2.0% Age 2.0. Bear Lake coho fingerling plants since 1979 are summarized in Table 7, and smolt production since 1982 is presented in Table 8.

Table 2. Bear Lake Coho Salmon Smolts Enumerated at Bear Creek Weir by Weekly Periods, 1985.

Weekly Periods	Number of Smolts		Total
	Live	Dead	
June 3 - June 9	39	0	39
June 10 - June 16	13,681	3	13,684
June 17 - June 23	27,839	6	27,845
June 24 - June 30	26,655	13	26,668
July 1 - July 7	12,471	7	12,478
July 8 - July 14	13,989	4	13,993
July 15 - July 21	5,606	0	5,606
July 22 - July 28	4,398	1	4,399
July 29 - August 4	292	0	292
August 5 - August 11	133	0	133
August 12 - August 18	440	2	442
August 19 - August 25	164	1	165
August 26 - September 1	44	0	44
September 2 - September 8	91	0	91
September 9 - September 15	<u>1</u>	<u>0</u>	<u>1</u>
TOTAL	105,843	37	105,880

Table 3. Bear Lake Coho Salmon Smolts Marked and Sampled at Bear Creek Weir by Weekly Period, 1985.

Weekly Periods	Number of Live Smolts	Number Smolts Finclipped	Percent of Weekly Migration*	Number Smolts Sampled	Percent of Weekly Migration*
June 3 - 9	39				
June 10 - 16	13,681	3,833	28.0	137	1.0
June 17 - 23	27,839	6,335	22.8	279	1.0
June 24 - 30	26,655	6,890	25.8	267	1.0
July 1 - 7	12,471	3,171	25.4	125	1.0
July 8 - 14	13,989	3,524	25.2	139	1.0
July 15 - 21	5,606	1,391	24.8	56	1.0
July 22 - 28	4,398	1,094	24.9	43	1.0
July 29 - August 4	292	73	25.0	4	1.4
August 5 - 11	133				
August 12 - 18	440	87	19.7		
August 19 - 25	164	53	32.1		
August 26 - Sept. 1	44				
September 2 - 8	91	19	20.9	9	9.9
September 9 - 15	<u>1</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
TOTAL	105,843	26,470	25.0	1,059	1.0

* Includes the 37 smolts expiring from trap mortality.

Table 4. Mean Fork Length, Weight and Condition Factor of Age 1.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1985.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor (K)*
June 10 - 16	136	100.0	117.9 \pm 6.8	15.47 \pm 2.65	0.94
June 17 - 23	275	98.6	118.9 \pm 9.0	15.64 \pm 2.53	0.93
June 24 - 30	265	99.3	124.7 \pm 7.1	18.11 \pm 3.02	0.93
July 1 - 7	123	98.4	131.4 \pm 6.0	21.75 \pm 2.87	0.96
July 8 - 14	136	97.8	133.8 \pm 6.6	23.28 \pm 3.23	0.97
July 15 - 21	51	92.7	137.8 \pm 5.8	26.24 \pm 3.01	1.00
July 22 - 28	43	100.0	140.9 \pm 4.8	28.62 \pm 2.69	1.02
July 29 - August 4	3	75.0	157.0 \pm 6.1	38.47 \pm 4.72	0.99
September 2 - 8	9	100.0	176.2 \pm 6.4	54.74 \pm 6.09	1.00

* $K = \frac{W \times 10^5}{L^3}$, 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, 1985.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor (K)*
June 17 - 23	4	1.4	158.5 \pm 18.1	35.85 \pm 13.65	0.90
June 24 - 30	2	0.7	158.5 \pm 0.7	38.85 \pm 2.62	0.98
July 1 - 7	2	1.6	147.5 \pm 16.3	32.35 \pm 9.82	1.01
July 8 - 14	3	2.2	167.7 \pm 16.3	41.53 \pm 8.51	0.88
July 15 - 21	4	7.3	187.5 \pm 16.4	66.18 \pm 17.50	1.00
July 29 - August 4	1	25.0	181	53.2	0.90

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

Table 6. Relative Abundance and Timing of Age 1.0 and 2.0 Bear Lake Coho Salmon Smolts Migrating to Bear Creek Weir, 1985.

Weekly Periods	Number of Smolts		Total
	Age 1.0	Age 2.0	
June 3 - 9	39		39
June 10 - 16	13,684		13,684
June 17 - 23	27,455	390	27,845
June 24 - 30	26,481	187	26,669
July 1 - 7	12,278	200	12,478
July 8 - 14	13,685	308	13,993
July 15 - 21	5,197	409	5,606
July 22 - 28	4,399		4,399
July 29 - August 4	219	73	292
August 5 - 11	120	13*	133
August 12 - 18	442		442
August 19 - 25	165		165
August 26 - September 1	44		44
September 2 - 8	91		91
September 9 - 15	1		1
Total	104,300	1,580	105,880
Percent	98.5	1.5	100.0

* The 13 Age 2.0 smolts estimated for this weekly period comprise the remaining Age 2.0 smolts emigrating Bear Lake in 1985, based on overall age composition (98.5% Age 1.0 and 1.5% Age 2.0) determined through August 4.

Table 7. Summary of Bear Lake Coho Salmon Fingerling Plants, 1979-1985.

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		
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>96</u>	June 18	Truck-boat
	Total	<u>150,000</u>	<u>610</u>	<u>276.6</u>	<u>246</u>	<u>542</u>	<u>337</u>	<u>842</u>	1980	Scattered
1980	Bear Lake	143,427	439	198.9	327	716	322	796	June 2	Truck-boat
	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	
	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
1982	Bear Lake	<u>199,000</u>	<u>603</u>	<u>273.4</u>	<u>330</u>	<u>728</u>	<u>447</u>	<u>1,104</u>	May 24	Truck-boat
									1983	Scattered
1983	Bear Lake	<u>220,000</u>	<u>757</u>	<u>343.5</u>	<u>291</u>	<u>640</u>	<u>494</u>	<u>1,222</u>	May 24	Truck-boat
									1984	Scattered
1984	Bear Lake	187,000	479	218.0	390	858	420	1,039	June 5	Truck-boat
	Bear Lake	<u>113,000</u>	<u>170</u>	<u>77.0</u>	<u>666</u>	<u>1,465</u>	<u>254</u>	<u>628</u>	June 5	Scattered
	Total	<u>300,000</u>	<u>649</u>	<u>295.0</u>	<u>462</u>	<u>1,017</u>	<u>674</u>	<u>1,667</u>	1985	

Table 8. Summary of Bear Lake Coho Salmon Smolt Abundance and Biomass Produced Since 1982 From Annual Fingerling Plants, 1981-1984.

Year of Plant	No. of Fingerlings and Weight (g)	Smolt Production by Year				Total Production	Survival to Smolt (%)
		1982	1983	1984	1985		
1981							
Number	247,845	134,003	7,938	307	142,248	57.4	
Weight (kg)	330.8	2,227.1	166.0	21.9	2,415.0		
Weight Ratio		6.7:1	0.5:1	0.1:1	7.3:1		
1982							
Number	227,800		100,368	15,206	115,574	50.7	
Weight (kg)	344.0		1,639.2	404.9	2,044.1		
Weight Ratio			4.8:1	1.2:1	5.9:1		
1983							
Number	199,000			78,298	1,580	79,878	40.1*
Weight (kg)	273.4			1,368.6	79.1	1,440.5	
Weight Ratio				5.0:1	0.3:1	5.3:1	
1984							
Number	220,000				104,300		47.4**
Weight (kg)	343.5				2,026.5		
Weight Ratio					5.9:1		

* Does not include Age 3.0 smolt production.

** Includes only Age 1.0 smolt production.

The 104,300 Age 1.0 smolts survived from 220,000 Age 0.0 fingerlings released in Bear Lake in 1984. The 47.4% yearling smolt production marks an 8.1% increase over that (39.3%) estimated for the 1983 fingerling plant. Whether this improvement was due to natural variation or lake fertilization effects is not known. Age 2.0 smolt abundance in 1986 will depend upon the extent of Age 1.0 residualism and overwinter survival of the 1984 plant.

Age 1.0 smolts averaged 124.7 mm and 18.11 g, for a condition factor (K) of 0.98 at migration peak (June 24-30). Growth of the 1984 Age 0.0 fingerlings was good, considering that they averaged 51 mm and 1.57 g when stocked in Bear Lake 1 year earlier. Age 2.0 smolts had a mean fork length of 167.7 mm and weighed 41.53 g for a K = 0.88 during July 8-14. Relative to previous years' Age 2.0 smolts, their high growth probably reflects their reduced abundance (less competition) as Age 1.0 residuals.

Bear Lake's estimated smolt biomass production was 2,098.5 kg, up 303 kg from the 1,795.5 kg produced in 1984 and 71.1 kg above the 12-year average of 2,027.4 kg following the 1971 lake rehabilitation project. Table 9 summarizes total smolt numbers, estimated annual biomass, and seasonal condition factor of Bear Lake smolt migrations since 1973.

Bear Lake was restocked on June 5-6, 1985 with 300,000 Age 0.0 coho salmon fingerlings (1984 brood, Bear Lake origin) to maintain smolt production. These fish were stocked in two separate lots, according to their size differences resulting from normal and late feeding start up at Trail Lake Hatchery. The first lot, 187,000 at 858/kg (390/lb), fed readily on the standard Oregon Moist Pellet diet, while the second lot, 113,000 at 1,465/kg (666/lb), refused to feed on an experimental diet until much later. It is noted that fingerlings stocked at the latter size in 1973 and 1979 severely reduced Bear Lake's smolt production for 2 years following because of excessive residualism and competition/predation of subsequent fingerling plants (McHenry 1985).

Other Species:

The total sockeye salmon smolt outmigration enumerated from the trap was only 1,552 fish. The first smolt was captured on June 12 and the last on August 28. The highest daily count occurred on July 10 when 205 smolts (13.2% of the migration) were enumerated. The majority (90.0%) emigrated between June 24 and July 28 when Bear Creek water temperatures ranged from 6.7°C to 17.2°C (44°F-63°F) and stream flows from 17 to 23 cfs. The smolt outmigration was comprised of 1,252 (80.7%) Age 1.0, 267 (17.2%) Age 2.0, and 33 (2.1%) Age 3.0 smolts. Age 3.0 smolts were produced by 309 males and 385 females that spawned in Bear Lake in 1981. With the 10,974 Age 1.0 smolts estimated in 1983 and 2,463 Age 2.0 smolts in 1984, a total of 13,470 smolts (35.0 per female) resulted from this escapement. Age 2.0 smolts were produced from 184 males and 279 females (about 1.0 smolt per female) in the 1982 spawning escapement. Only 3.4 smolts survived per spawning female thus far. Age 1.0 smolts peaked (50% of migration) during July 8-14, while Age 2.0 and 3.0 smolts peaked 1 week later. Age 1.0 smolts averaged 125.5 mm and

Table 9. Summary of Abundance, Seasonal Condition Factor and Total Annual Biomass of Bear Lake Coho Smolt Migrations, 1973-1985.

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
1983	108,398	0.98	1,810.7
1984	93,811	1.00	1,795.5
1985	105,880	0.97	2,098.5
Average (1973-84)	100,665	1.01	2,027.4

20.20 g for a condition factor (K) = 1.02; and Age 2.0 smolts, 175.6 mm and 51.42 g for a K = 0.95 at migration peak. The two Age 3.0 smolts sampled during their migration averaged 207.0 mm and 84.80 g for a K = 0.96.

A total of 476 outmigrant Dolly Varden were 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 1985 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 10. Few coho were taken before creel census began, since most sportfishing effort is traditionally directed toward the more abundant rockfish, *Sebastes* sp., from mid-May through early July.

The season's total harvest was an estimated 11,738 coho. This estimate was extrapolated from interviews with 3,123 anglers harvesting 1,750 coho during the creel census period. Peak of the harvest occurred on August 23 during the Seward Silver Salmon Derby when an estimated 409 coho (3.5% of the season's harvest) were taken. The season's total and derby harvests are summarized for 1981 through 1985 in Table 10.

Marked adult coho contributed 4.7%, or an estimated 558 fish, to the 1985 Resurrection Bay sport harvest. An additional 818 unmarked coho, resulting from the unmarked segments of hatchery smolt releases and the Bear Lake smolt out-migration in 1984, comprised an estimated 7.0% of the sport catch. The total contribution of enhanced adult coho production, therefore, was 1,376 fish, or 11.7% to the sport fishery.

Adipose-clipped and coded-wire tagged (Ad-CWT) adult coho survived from 40,700 (54.5% marked) and 34,100 (44.3% marked) Age 1.0 hatchery smolts released in Seward Lagoon and Grouse Lake, respectively, on June 5 and 6, 1984. These plants were comprised of Bear Lake origin (1982 brood) yearling smolts averaging 27.5 g (16.5/lb) and noted in good condition at release. Right ventral (RV) marked coho resulted from Bear Lake smolts finclipped at Bear Creek weir in 1984. These smolts averaged 19.2 g (23.7/lb) with a seasonal condition factor (K) = 1.00. Relative fishing mortalities of the Seward Lagoon, Grouse, and Bear Lake smolt releases were 1.42%, 1.39%, and 0.35%, respectively.

Seward Lagoon and Grouse Lake were planted with 50,200 (24.9% Ad-CWT) and 56,100 (38.3% Ad-CWT) Age 1.0 hatchery coho smolts of 1983 brood, Bear Lake origin, on May 22 and May 30, respectively. These smolts were noted in good condition, averaging 24.3 g (18.7/lb) and 27.7 g (16.4/lb) for the Seward Lagoon and Grouse Lake releases, respectively, and should provide good contributions to the 1986 sport fishery. A total of 102,000 Age 0.0 (1984 brood, Bear Lake origin) coho fingerlings (excess to other enhancement program requirements) were stocked at 1.9 g (240/lb) in Seward Lagoon on August 27, 1985 to rear naturally to smolts by 1986 and contribute adult coho for the 1987 sport fishery.

Table 10. Derby and Total Sport Harvest of Coho Salmon in Resurrection Bay, 1981-1985.

Year	Total Sport Harvest	Derby Harvest	% Derby Harvest
1981	15,743	4,758	30.2
1982	17,813	4,504	25.3
1983	12,646	3,477	27.5
1984	10,361	3,718	35.9
1985*	11,738	4,456	38.0

* Derby was extended 1 week longer than in previous years.

An estimated 496 coho were taken during the early August-September 15 shore fishery adjacent to the Seward Lagoon outlet and small boat harbor areas. Coded-wire tag analysis of 32 snouts recovered from Ad-CWT coho taken in this fishery disclosed that 93% were from Seward Lagoon and 7% from Grouse Lake. Therefore, estimated shore harvests of these returns were 271 (148 Ad-CWT + 123 UNM) for Seward Lagoon and 25 (11 Ad-CWT + 14 UNM) for Grouse Lake. An additional 57 (6 RV and 51 UNM) Bear Lake coho were estimated caught, with the remaining 143 unmarked fish harvested from Resurrection Bay wild stocks.

The total sport trolling effort exerted for Resurrection Bay coho was an estimated 19,865 angler-days. Sampling during creel census periods accounted for 15.7% of the season's effort. The mean number and percentage of sport fishing boats returning daily to the Seward small boat harbor are shown in Table 11. The number of anglers per boat averaged 2.94 on weekdays, 2.95 on weekends, and 2.88 during the salmon derby. Fishing effort and mean seasonal catch per hour are summarized for 1981-1985 in Table 12. The fishing effort was 5,241 angler-days on weekdays, and 5,458 on weekends, excluding the derby (9,166 man-days). Military personnel and dependents fishing on boats provided by the Army and Air Force recreation camps at Seward contributed 9.8% (1,941 angler-days) to the total effort. Civilian anglers fishing on weekdays realized the highest coho catch per hour (0.175); whereas, the lowest catch rate (0.079) occurred during the derby when effort was most intense. The number of hours anglers fished per day averaged 5.10 on weekdays, 4.58 on weekends and 6.10 during the salmon derby.

In 1985, with the intention of generating more ticket sales and greater revenues to local merchants, the Chamber of Commerce scheduled the salmon derby for one week longer than usual (August 10-15). During that extended period, however, ticket sales did not compensate for the monetary prizes. Salmon derby scheduling has therefore reverted to the usual 9-day period.

Examination of 251 scale samples randomly collected throughout the sport fishery disclosed that the Resurrection Bay wild coho population was comprised of 87.6% Age 1.1 and 12.4% Age 2.1 fish; no Age 3.1 fish were detected in the sample. Though 100% of hatchery coho and 86% of Bear Lake fish were Age 1.1, only 11.7% of these returns were harvested in the sport fishery. Therefore, it is unlikely that enhanced coho contributions to the fishery significantly biased the estimated wild age composition toward Age 1.1 coho. The abrupt departure of 1985 age composition to those of previous years is not understood. Table 13 shows the wild age composition trend from 1972 to 1978 and 1983 to 1985. Mean fork lengths and weights of wild coho in 1985 are presented in Table 14, and those for Ad-CWT hatchery coho sampled are shown in Table 15. The male-to-female sex ratio was 1.0:1.0 in the sport fishery.

The Resurrection Bay pink salmon sport catch was an estimated 6,614 fish in 1985. A limited commercial seine fishery conducted on July 23 and 30 for 12-hour periods and August 6 and 7 for one 24-hour period harvested 74,600 pink and 3,000 chum salmon, with 10-13 boats participating (Schroeder, pers. comm.). Pink salmon were most abundant in the sport

Table 11. Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor During Each Sampling Period, 1985.

Period (hours)	Weekends		Weekdays	
	Mean No. of Boats	Percent	Mean No. of Boats	Percent
8:00 am - 11:30 am*	14.3	11.6	5.5	14.3
11:30 am - 3:00 pm	33.5	27.1	9.0	23.6
3:00 pm - 6:30 pm	55.7	45.1	17.1	44.8
6:30 pm - 10:00 pm	<u>20.0</u>	<u>16.2</u>	<u>6.6</u>	<u>17.3</u>
Total	123.5	100.0	38.2	100.0

* Percentage for this period determined by 3-year mean, 1964-1966.

Table 12. Derby and Total Sport Effort (Angler-Days) Exerted for Coho Salmon and Mean Catch Per Hour in Resurrection Bay, 1981-1985.

Year	Period of Census	Total Effort	Derby Effort	% Derby Effort	Seasonal Catch Per Hour
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
1983	July 8 - Sept. 11	24,371	10,955	45.0	0.071
1984	July 8 - Sept. 9	21,064	8,675	41.2	0.079
1985*	July 8 - Sept. 10	19,865	9,166	46.1	0.100

* Derby was extended 1 week longer than in previous years.

Table 13. Age Composition of Wild Resurrection Bay Coho Salmon Populations, 1972-1978 and 1983-1985.

Year	Sampling Period	No. of Fish	Age Composition			Total
			1.1	2.1	3.1	
1972	July 4 - Sept. 4	179	34.7	59.2	6.1	100.0
1973	July 7 - Sept. 2	201	42.8	49.7	7.5	100.0
1974	July 2 - Sept. 1	236	49.1	49.2	1.7	100.0
1975	July 9 - Sept. 11	250	58.0	35.2	6.8	100.0
1976	July 8 - Sept. 3	213	77.0	21.6	1.4	100.0
1977	July 9 - Sept. 7	303	70.6	27.4	2.0	100.0
1978	July 8 - Sept. 10	377	68.0	27.3	4.7	100.0
1979-82*	Not Sampled					
1983	July 8 - Sept. 11	316	58.2	38.9	2.9	100.0
1984	July 8 - Sept. 9	296	57.8	39.2	3.0	100.0
1985	July 8 - Sept. 10	251	87.6	12.4	0.0	100.0

* Scale samples were not taken during these years because unmarked adults returning from hatchery reared smolt releases could not be differentiated from wild fish.

Table 14. Mean Fork Length (mm) and Weight (kg) of Wild Adult Coho Salmon Sampled From the 1985 Resurrection Bay Sport Fishery.

	Number of Fish	Mean Length (mm) and SD*	Mean Weight (kg) and SD
Males	128	693.3 ± 51.4	5.12 ± 1.22
Females	123	646.8 ± 59.7	4.03 ± 1.20
Total	251	670.5 ± 60.2	4.58 ± 1.32

* SD = Standard Deviation

Table 15. Mean Fork Length (mm) and Weight (kg) of Ad-CWT Marked Hatchery Coho Salmon Sampled From the 1985 Resurrection Bay Sport Fishery.

	Number of Fish	Mean Length (mm) and SD	Mean Weight (kg) and SD
Males	55	694.7 ± 52.8	4.72 ± 1.14
Females	53	665.0 ± 47.6	4.14 ± 0.91
Total	<u>108</u>	<u>680.1 ± 52.2</u>	<u>4.44 ± 1.07</u>

fishery from July 29 to August 4, when anglers averaged 3.01 fish per boat. Pink salmon catch per angler-day averaged 0.29 in 1985, compared to 0.17 in 1983, which was the parent brood year producing the 1985 return.

Only 191 chinook salmon were harvested during the census period, at an average of 0.03 per boat. This harvest was substantially below the 20-year average of 371 chinook (1961-80) in Resurrection Bay. Chinook salmon were most abundant during August 5-11 when anglers averaged 0.07 fish per boat; most of these were immature chinook in their first and second ocean years. Origins of these stocks are unknown as relatively few wild chinook ascend Resurrection River. During foot surveys on July 26 and August 5, 1985, an estimated 26 Age 0.2 chinook jacks and four adults were observed in Box Canyon Creek. The four adult chinook resulted from natural spawning; whereas, the 26 Age 0.2 jacks were the result of 54,500 Age 0.0 hatchery smolts (1982 brood, Crooked Creek origin) that had been released in Box Canyon rearing pond on May 27, 1983. Age 0.3 adults are expected to return in 1986 from this smolt plant. Age 0.2 jack chinook, resulting from 110,600 Age 0.0 (1983 brood, Crooked Creek origin) hatchery smolts released in Thumb Cove and Lowell Creek outflow on June 14 and 19, 1984 may contribute extra fish early in the 1986 Resurrection Bay sport fishery. Likewise, Age 0.1 jack chinook may return in 1986 from 132,700 Age 0.0 (1984 brood, Crooked Creek origin) hatchery smolts released off Lowell Creek and 53,250 Age 0.0 (1984 brood, late run Kenai River origin) hatchery smolts stocked in Seward Lagoon in June 1985. Age 0.3 and 0.4 adult chinook from the 1984 and 1985 smolt releases will return to Resurrection Bay in 1987-1989.

Adult Coho Timing and Distribution in Index Streams:

Peak of the 1985 index escapements ranged from mid-October to early November, and peak of spawning occurred within the following 2-3 weeks in index streams. Estimated minimal escapements of wild coho salmon in each stream index area since 1981 are presented in Table 16. The total minimal index escapement of 1,024 spawning coho indicates that the 1985 return was only slightly below the 1982-1984 average.

Bear Lake Upstream Migration:

The Bear Creek weir upstream migrant trap was operated continuously from June 1 through October 31. The first adult coho entered the trap on September 3 and the last one was captured October 28. A foot survey conducted on November 7 on lower Bear Creek did not locate any additional coho due to severe stream icing.

A total of 4,825 adults and 5 jacks were enumerated from the trap. Abundance and timing of the adult coho migration are shown in Table 17. The adult migration peaked (50%) on October 1, and the highest daily count of 447 (9.3% of the adult run) occurred on September 29. Mean stream temperatures at the beginning, peak, and end of migration were 13.3°C (56°F), 9.4°C (49°F), and 0.8°C (33.5°F), respectively. Most of

Table 16. Minimal Wild Coho Salmon Escapement in Seven Index Streams in the Resurrection Bay Area, 1981-1985.

Name of Stream	Minimum Escapement					Mean 1982-84
	1981*	1982	1983	1984	1985	
Airport	...	0	0	0	0	0
Box Canyon	...	248	154	144	112	182
Clear	...	241	62	140	190	148
Dairy	...	108	64	251	168	141
Grouse	...	307	408	396	336	370
Jap	...	328	85	121	120	178
Mayor	...	<u>145</u>	<u>69</u>	<u>138</u>	<u>98</u>	<u>117</u>
Total	...	1,377	842	1,190	1,024	1,136

* Insufficient foot surveys were performed in 1981 to delineate minimum escapements.

Table 17. Bear Lake Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1985.

Weekly Periods	AD or RV Marked	Unmarked*	Male**	Female	Total
Sept. 2 - 8	1	7	5	3	8
Sept. 9 - 15	1	2	3		3
Sept. 16 - 22	84	770	533	321	854
Sept. 23 - 29	125	1,043	639	529	1,168
Sept. 30 - Oct. 6	212	1,977	1,089	1,100	2,189
Oct. 7 - 13	58	454	241	271	512
Oct. 14 - 20	6	49	20	35	55
Oct. 21 - 27	6	27	33		33
Oct. 28 - Nov. 3	—	<u>3</u>	—	<u>3</u>	<u>3</u>
Total	493	4,332	2,563	2,262	4,825

* Approximately 75% of the 1984 Bear Lake smolt out-migration was released unmarked to enhance smolt-to-adult survival.

** Does not include 5 unmarked jacks returning prematurely from the 1985 out-migration.

the migration (97.9%) occurred from September 16 through October 13, when Bear Creek temperatures ranged from 5.6°C to 12.8°C (42°F-55°F) and flows from 5 to 83 cfs.

Most (491 RV) of the marked coho escapement to the weir returned from 23,418 Age 1.0, 2.0 and 3.0 Bear Lake smolts that had been marked with an RV finclip at Bear Creek weir in 1984. With the 33 RV coho estimated taken in the Resurrection Bay boat fishery and 6 RV coho caught in the shore fishery, the total return of 530 RV realized a 2.26% smolt-to-adult survival for marked Bear Lake coho. Two Ad-CWT marked coho recorded from the trap were probably strays from the Grouse Lake hatchery coho return.

The 4,332 unmarked coho enumerated from the upstream trap were produced from 70,006 Bear Lake smolts released without fin clips at Bear Creek weir in 1984. Including 291 unmarked coho estimated by the 0.066:1.0 catch-to-escapement ratio of RV marked coho caught in the Resurrection Bay boat fishery and 51 taken in the shore fishery, the total return of 4,674 coho resulted in a 6.68% smolt-to-adult survival for the unmarked Bear Lake smolts, or nearly three times that of marked smolts.

Analysis of 503 scale samples representatively sampled from 10% of the Bear Lake escapement indicated that the total run (catch plus escapement) was comprised of 4,491 Age 1.1 (86.3%) and 713 Age 2.1 (13.7%) adults. The adult age composition, therefore, translates to 1984 Bear Lake smolt-to-adult survivals of 5.76% for Age 1.0 (78,009 smolts) and 4.71% for Age 2.0 (15,135 smolts) fish. No Age 3.1 adults were detected in the sample, from an estimated 280 Age 3.0 smolts emigrating in 1984. The two Age 1.0 jack coho sampled were from the 1985 Bear Lake smolt outmigration.

Mean fork length and weight of adult coho salmon sampled at the weir are presented in Table 18. The male-to-female sex ratio in the Bear Lake escapement was 1.1:1.0.

Coho Salmon Egg Takes:

A total of 122 males and 287 females were held in the Bear Creek holding facility from September 20 to October 29. Stream temperatures ranged from 0°C to 11.7°C (32°F-53°F) and flows from 5 to 83 cfs during this period. Male and female holding mortalities were 1.6% and 3.1%, respectively. All fish were screened for bacterial kidney disease (BKD) and furunculosis by F.R.E.D. Division pathologists prior to uniting sperm and eggs at Trail Lakes Hatchery. Incidence of BKD was only 2.5% and 2.9% for males and females spawned, respectively, or 2.8% overall. Gametes from these fish were destroyed at the hatchery. A total of 115 males and 264 females were artificially spawned, yielding an estimated 1,003,000 fertilized eggs. Eggs were fertilized at an average ratio of 1.0 male:2.3 females. Dead egg loss after physical shocking at Trail Lakes Hatchery averaged 6.4%, which is about normal egg mortality previously experienced from immediate fertilization at Bear Creek weir.

Table 18. Mean Fork Length (mm) and Weight (kg) of Adult Coho Salmon Sampled at Bear Creek Weir in 1985.

Lot	Males			Females			Sexes Combined		
	No.	FL	Wt.	No.	FL	Wt.	No.	FL	Wt.
RV	35	666.0	3.80	29	670.8	4.13	64	668.2	3.95
UNM	<u>235</u>	<u>675.6</u>	<u>4.01</u>	<u>207</u>	<u>677.4</u>	<u>4.20</u>	<u>442</u>	<u>676.4</u>	<u>4.10</u>
Total	270	674.3	3.98	236	676.6	4.19	506	676.0	4.08

Other Species:

A total of 1,179 adult sockeye salmon were captured in the upstream migrant trap from June 3 to September 27. Most adults (78.5%) were age 1.3, surviving from 46,118 Age 1.0 Bear Lake smolts released past the weir in 1982. Including the 2,741 sockeye taken in the Bear Creek personal-use dipnet fishery, 301 harvested in the Resurrection Bay commercial seine and subsistence gillnet fisheries, and 56 trap mortalities, the total Bear Lake sockeye return was an estimated 4,277 fish. Therefore, 3,355 (78.5%) were estimated to be Age 1.3 adults. With the 29 Age 1.1 jacks and the 6,650 Age 1.2 adults estimated in the 1983 and 1984 escapements, respectively, total smolt-to-adult survival of the 1982 Age 1.0 smolts was 21.8%. The second most abundant (18.1%) in the run were 775 Age 1.2 adults, resulting from an estimated 10,784 Age 1.0 smolts in the 1983 Bear Lake sockeye outmigration. Smolt-to-adult survival thus far is 7.2%.

Age 1.3 adults from this cycle will return in 1986. The remainder of the 1985 Bear Lake sockeye return was comprised of an estimated 133 Age 2.2 (3.1%) and 14 Age 2.3 (0.3%) fish. Mean length and weight of the 2- and 3-ocean fish in 1985 were 538.2 mm and 1.92 kg and 603.8 mm and 2.75 kg, respectively. Because of the ongoing fertilization experiment to enhance Bear Lake's coho smolt production and sockeye fry are competitively advantaged over coho in an environment with expanding zooplankton populations, the potential 3,966 sockeye spawning escapement was limited to 1,179 fish (576 males and 603 females): a 1985 Board of Fisheries Bear Lake management directive.

Pink salmon first entered the trap on July 21 and eventually moved downstream to spawn in lower Bear Creek from mid-August to early September. A minimal estimated escapement of 4,100 pink salmon spawned in lower Bear Creek in 1985 (Schroeder, pers. comm.), according to foot surveys conducted in August and September.

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 because of the lack of suitable spawning area upstream and/or the undesirability of having these species predated upon or competing with juvenile salmon in Bear Lake.

Enhanced Coho Salmon Production:

Overall, total smolt-to-adult survival of the 1984 marked and unmarked Bear Lake smolts was 5.57%, or 1.57% higher than that realized for the 1983 outmigration. The reasons for this improved marine survival are not understood, although it is noted that returning adults averaged 0.32 kg (0.70 lb) heavier in 1985 than those measured at the weir in 1984. The increased growth of Resurrection Bay wild coho in 1985 (0.13 kg or 0.29 lb) over that of 1984 was less obvious, however. Table 19 summarizes Bear Lake smolt outmigrations since 1978 and subsequent adult returns through 1985.

Table 19. Survival of Bear Lake Coho Salmon Adults From Seaward Migrations of Smolts Fin-Marked at Bear Creek Weir, 1978-1984.

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
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		
	342	0.4% - Age 3.0	191.7	LV,RV		
	<u>97,659</u>					
1979	96,327	92.2% - Age 1.0	120.6	LV	5,368	5.14
	8,149	7.8% - Age 2.0	146.2	LV		
	<u>104,476</u>					
1980	54,538	72.8% - Age 1.0	121.8	RV	5,596	7.95
	20,278	27.1% - Age 2.0	134.8	RV		
	106	0.1% - Age 3.0	191.0	RV		
	<u>74,922</u>					
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		
	238	0.3% - Age 3.0	161.5	LV		
	<u>72,623</u>					
1982	133,907	93.2% - Age 1.0	115.8	RV	8,046	5.60
	9,598	6.7% - Age 2.0	127.1	RV		
	110	0.1% - Age 3.0	189.0	RV		
	<u>143,615</u>					
1983	99,862	92.6% - Age 1.0	114.8	LV	4,318	4.00
	7,898	7.3% - Age 2.0	128.6	LV		
	91	0.1% - Age 3.0	188.0	LV		
	<u>107,851</u>					
1984	78,009	83.5% - Age 1.0	115.9	RV	5,204	5.57
	15,135	16.2% - Age 2.0	134.2	RV		
	280	0.3% - Age 3.0	192.7	RV		
	<u>93,424</u>					

* Includes boat and shore sport harvest estimates plus escapements.

Adult production from the 1984 hatchery smolt releases in Grouse Lake and Seward Lagoon marked a slight but continued improvement in their contributions to the Resurrection Bay sport fishery. Return composition of Ad-CWT marked coho sampled during the marine sport fishery was proportional (60.0% Seward Lagoon and 40% Grouse Lake) of Ad-CWT smolts released at those sites. However, the relative percentage of Ad-CWT adults estimated in their respective escapements (77.4% and 22.6%) was disproportionate. This was probably due to the early freezing over of Grouse Lake that precluded sufficient foot surveys and carcass examination to fully assess its enhanced spawning escapement. Summaries of total survivals for Seward Lagoon and Grouse lake hatchery smolt releases are presented in Tables 20 and 21, respectively.

Bear Lake Fertilization Project:

Fertilization of Bear Lake's northern epilimnion continued in 1985; a total of 2,800 gallons of liquid ammonium nitrate was dispersed from early June to early September in 3-day increments. One hundred 28-gallon barrels of 32-0-0 formula comprised the season's fertilizer application. Considerable logistical support, coordination, and manpower assistance was also provided to F.R.E.D. Division's limnology personnel in receiving and unloading the fertilizer shipment, obtaining test fish, and cleaning fish holding pens in Bear Lake.

Age 0.0 coho fingerlings stocked in 1985 appeared to rear primarily in near shore waters (littoral zone), instead of migrating offshore to forage on zooplankton as they reputedly did in early fall 1984. This may have been caused by the delayed 1985 spring depression of seasonal Bear Lake water temperatures and, consequently, the early summer zooplankton pulse, or the inshore chironomid insect population, remaining abundant throughout the growing season (Kyle, pers. comm.). Field results for 1984-1985 are currently being analyzed and will be included in an interim research report on the Bear Lake fertilization experiment.

Rearing Ponds and Spawning Channels:

A 10-ft. wide by 350-ft. long spawning channel was excavated by J.G. Fisher and Associates in the lower Jap Creek area in late May 1985. This offsite spawning habitat was constructed to mitigate loss of natural spawning area in Spring Creek for an estimated 700 adult pink and chum salmon. Spring Creek was rechanneled for improved drainage during development of the Fourth of July marine industrial shiplift facility, with attendant siltation of streambed spawning gravels. After 4 chum and 62 pink salmon utilized the lower Jap Creek spawning channel in August and September (Kyle, pers. comm.), 31 adult coho were enumerated in the channel in mid-October. Most, however, moved through the channel to eventually spawn in more protected water above the water supply headgate. Ten to 15 coho were consistently counted on weekly foot surveys of the spawning channel through late November. It is believed that additional coho will be accommodated by this spawning channel in time, as natural bank vegetation and spawner modification of the stream bed begins to offer more protection from predators.

Table 20. 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(lb)	0+Ocean (jacks)		1-Ocean			
						No.	%	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
1980	Bear Lake	UNM	5/27/82	53,970	52.8 (24.0)	0	0.00	0	0.00	0	0.00
1981	Bear Lake	Ad-CWT	5/20/83	47,950	49.8 (22.6)	0	0.00	1,128	2.35	1,128	2.35
1982	Bear Lake	Ad-CWT**	6/06/84	40,700	36.4 (16.5)	13	0.03	1,062	2.61	1,075	2.64

* Includes boat and shore harvest estimates plus escapements.

** Release consisted of 22,200 marked (54.5%) and 18,500 unmarked (45.5%) smolts.

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(lb)	0+Ocean (jacks) No.	%	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	5/20/78	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	Bear Lake	UNM	5/27/82	13,230	52.8 (24.0)	0	0.00	0	0.00	0	0.00
1981	Bear Lake	Ad-CWT	5/20/83	49,900	49.8 (22.6)	1	0.00	868	1.74	869	1.74
1982	Bear Lake	Ad-CWT**	6/05/84	34,100	36.4 (16.5)	0	0.00	648	1.90	648	1.90

* Include boat and shore sport harvest estimates plus escapements.

** Release consisted of 15,100 marked (44.3%) and 19,000 unmarked (55.7%) smolts.

Field inspection measurements (McKay, pers. comm.) taken on December 17 with a headgate surface flow of 4.2 cfs indicated average depths and flows at stations 3 + 50 and 0 + 35 (downstream end) were 15.5 cm (5.6 cfs) and 11.6 cm (7.8 cfs), respectively. Water chemistry at 2.7°C showed a pH of 6.9, dissolved oxygen (DO) of 9.6 mg/l, and conductivity of 133 umhos/cm at the 2000 scale. On December 18, 20 hours after stopping the off-surface flows at the headgate, water measurements taken at stations 3 + 50 and 0 + 35 were 11.3 cm (2.1 cfs) and 10.1 cm (4.0 cfs), respectively, indicating that adequate groundwater flows existed for egg incubation and fry emergence. Water chemistry at 1.3°C for station 3 + 50 showed 7.2 pH, 8.2 mg/l DO, and 141 umhos/cm conductivity, while that for station 0 + 35 was 7.1 pH, 10.5 mg/l DO, and 141 umhos/cm conductivity. Hydraulic pump excavation of a staked spawning redd revealed successful egg fertilization and hatching of pink salmon alevins at that location. After erosional damage to the headgate-tailrace pool is repaired and consequent siltation of the settling pond dredged, the headgate will be reopened in late April to early May 1986 to increase flows and facilitate fry outmigration.

As mitigation for losing natural coho spawning and rearing habitat because of construction of the Suneel coal exporting facility in Seward, expansion of Box Canyon rearing pond into an improved rearing/spawning area complex is planned for construction in June 1986. A regulated inlet will be excavated into the existing pond, which will be partially deepened, and a chain of nine 15-ft. by 80-ft. ponds will be incorporated into a new outlet to Box Canyon Creek. This mitigation project will be reported on in greater detail in the 1986-1987 annual performance report.

Discussion

As previously stated (McHenry 1979), Bear Lake's optimal coho smolt production under natural conditions at a fingerling stocking rate of 1,250/ha (225,000 total) is estimated to be approximately 2,000 kg biomass, or 100,000 smolts annually. Bear Lake's coho smolt production from 1977-1982 averaged 1,905 kg biomass (99,114 smolts), despite the setback resulting from undersized fingerlings stocked in 1979 that adversely affected its smolt yields from 1980-1981 (McHenry 1985). After 3 full years (1982-1984) of fertilization, Bear Lake has averaged 1,902 kg (102,696 smolts), which is only a 3.6% increased smolt abundance over the previous 6 years without lake fertilization. This minor change in Bear Lake's coho production is believed to have been caused by natural variation rather than lake fertilization effects. The lake fertilization project is recommended to be terminated in 1987, with final evaluation of experimental results in 1989 if coho smolt production does not substantially increase (25-50%) in the interim.

The 0.066:1.0 catch-to-escapement ratio of RV-marked Bear Lake coho in 1985 is the lowest ever measured for this enhanced stock, resulting in only a 2.8% (324 coho) contribution to the Resurrection Bay sport harvest. Exploitation of Bear Lake's estimated total return of 5,204 coho was only 6% in the fishery. In contrast, 54% and 73% of the Seward

Lagoon and Grouse Lake hatchery coho returns contributed an estimated 4.9% (578 coho) and 4.0% (474 coho) to the season's sport harvest, respectively. The 73% exploitation rate of Grouse Lake's enhanced return is probably 20%± too high because of the early November freeze-up that precluded complete assessment of the spawning escapement; e.g., if an additional 250 enhanced coho were not enumerated in Grouse Creek, the total return of 898 hatchery fish would have realized a similar estimated smolt-to-adult survival (2.6%) and exploitation rate (53%) as those for the Seward Lagoon hatchery return. Since Grouse and Bear Lake coho migrate up the same access tributary (Salmon Creek) and have similar spawning run timing, the large discrepancy in their respective exploitation rates in the 1985 sport fishery is not understood.

It may be timely to evaluate and develop additional hatchery coho smolt release sites in Resurrection Bay, particularly near the Fourth of July and Lowell Point areas where shore fisheries are rapidly expanding. Experimental smolt releases should be conducted on a small, rather than massive, scale so as to not adversely impact wild coho stocks. Potentially negative impacts would include overloading the natural rearing capacity of Resurrection Bay for outmigrating smolts, overexploiting wild adult stocks by dramatically increased fishing effort targeting on enhanced coho, losing wild stock genetic integrity by their spawning with enhanced escapements, and eventual replacement or removal of wild stock segments via the cumulative effects of any or all of these factors. Assuming a 4.0% smolt-to-adult survival, estimated Resurrection Bay wild coho smolt and adult migrations have averaged 756,000 smolts (373,000-1,240,000) and 30,224 adults (14,903-49,769) from 1971-1985. According to catch-to-escapement ratios of marked Bear Lake coho applied to the estimated wild portions of annual sport harvests, exploitation rates of wild coho returns in the Resurrection Bay sport fishery during this 15-year time span have been moderate, averaging 40.6% (21.9%-56.5%).

Construction of artificial spawning channels and rearing ponds, as mitigation for natural habitat lost because of industrial development in the Resurrection Bay drainage, may hold some promise to offset resultant coho production losses. However, any benefits expected from these measures must be regarded as long term possibilities (rather than soon-to-be panacea) because of the long periods of time required to duplicate the natural flora, fauna, and protective cover to support wild coho populations in human made environments. In the short term, however, these facilities may prove useful as smolt imprinting sites to provide additional coho for the recreational fishery. Again, wild stock status in release tributaries should be given priority consideration for possible negative impacts to that resource.

LITERATURE CITED

- Logan, S.M. 1962. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1961-1962, Project F-5-R-3, 3(7-B-1): 57-74.

- _____. 1963. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1962-1963, Project F-5-R-4, 4(7-B-1): 175-194.
- _____. 1964. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1963-1964, Project F-5-R-5, 5(7-B-1): 133-151.
- _____. 1965. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1964-1965, Project F-5-R-6, 6(7-B-1): 129-145.
- _____. 1966. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1965-1966, Project F-5-R-7, 7(7-B-1): 79-99.
- _____. 1967. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1966-1967, Project F-5-R-8, 8(7-B-1): 83-102.
- _____. 1968. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1967-1968, Project F-5-R-9, 9(7-B-1): 117-134.
- _____. 1969. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1968-1969, Project F-9-1, 10(7-B-1): 131-149.
- McHenry, E.T. 1970. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1969-1970, Project F-9-2, 11(7-B-1): 75-89.
- _____. 1971. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1970-1971, Project F-9-3, 12(G-II-A): 1-20.
- _____. 1972. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1971-1972, Project F-9-4, 13(G-II-A): 1-20.
- _____. 1973. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1972-1973, Project F-9-5, 14(G-II-A): 1-22.

- _____. 1974. Silver salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1973-1974, Project F-9-6, 15(G-II-A): 1-19.
- _____. 1975. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1974-1975, Project F-9-7, 16(G-II-A): 1-21.
- _____. 1976. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1975-1976, Project F-9-8, 17(G-II-A): 1-23.
- _____. 1977. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1976-1977, Project F-9-9, 18(G-II-A): 1-24.
- _____. 1978. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1977-1978, Project F-9-10, 19(G-II-A): 1-32.
- _____. 1979. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1978-1979, Project F-9-11, 20(G-II-A): 1-38.
- _____. 1980. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1979-1980, Project F-9-12, 21(G-II-A): 1-39.
- _____. 1981. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22(G-II-A): 1-38.
- _____. 1982. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1981-1982, Project F-9-14, 23(G-II-A): 1-37.
- _____. 1983. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project F-9-15, 24(G-II-A): 1-35.
- _____. 1984. Coho salmon studies in the Resurrection Bay area. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1983-1984, Project F-9-16, 25(G-II-A): 1-37.

_____. 1985. Coho salmon studies in the Resurrection Bay area.
Alaska Department of Fish and Game. Federal Aid in Fish Restor-
ation, Annual Performance Report, 1984-1985, Project F-9-17,
26(G-II-A): 1-36.

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