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EVALUATION OF COHO SALMON *(Oncorhynchus kisutch)* ENHANCEMENT IN RESURRECTION BAY, ALASKA DURING 1986

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ABSTRACT

In 1986, 72,685 coho salmon (*Oncorhynchus kisutch* Walbaum) smolts and 952 sockeye salmon (*Oncorhynchus nerka* Walbaum) smolts emigrated from Bear Lake. The majority (84 percent) of the coho salmon smolts were age 1.0. A total of 5,485 adult coho salmon returned to Bear Lake, of which 98 percent were age 1.1. Bear Lake and Seward Lagoon enhanced stocks were estimated to have contributed 12 percent and 13 percent, respectively, to the combined coho salmon harvest by the boat and beach fisheries.

KEY WORDS: coho salmon, *Oncorhynchus kisutch*, Resurrection Bay, Bear Lake, enhancement contribution, chinook salmon, *Oncorhynchus tshawytscha*, sockeye salmon, *Oncorhynchus nerka*.

INTRODUCTION

The recreational fishery for coho salmon (*Oncorhynchus kisutch* Walbaum) in the marine waters of Resurrection Bay is one of the largest fisheries in effort and harvest for this species in Alaska (Mills 1986). A coho salmon enhancement program has been conducted in Resurrection Bay since 1962 when Bear Lake (Figure 1) was selected for experimental coho salmon enhancement. Bear Lake was rehabilitated to eradicate competing threespine stickleback (*Gasterosteus aculeatus* Linnaeus) at that time and an annual stocking with coho salmon fingerlings was begun. After reinfestation by stickleback and a decline in coho salmon smolt yields, Bear Lake was rehabilitated again in 1971 and threespine stickleback were completely eliminated at that time. Coho salmon smolt survivals from annual fingerling plants in Bear Lake have averaged 36% since 1971 (Vincent-Lang in press). Bear Lake also supports a small run of sockeye salmon (*Oncorhynchus nerka* Walbaum) which contributes to both commercial and personal-use fisheries.

Further enhancement of the Resurrection Bay coho salmon resource began in 1968 with annual plants of hatchery-reared smolts at additional sites in the Resurrection Bay area. Hatchery-reared chinook salmon (*Oncorhynchus tshawytscha* Walbaum) smolts have been released annually since 1983 in an effort to diversify the Resurrection Bay sport fishery. The Fisheries Rehabilitation, Enhancement, and Development (FRED) Division currently stocks coho salmon fingerlings in Bear Lake, coho salmon smolts in Seward Lagoon and Box Canyon Creek, and chinook salmon smolts at the Lowell Creek outlet into Resurrection Bay (Figure 1). In 1986, Bear Lake was stocked with 445,730 coho salmon fingerlings and Seward Lagoon and Box Canyon Creek received 51,500 and 53,600 hatchery-reared coho salmon smolts, respectively (Table 1). A total of 101,000 hatchery-reared chinook salmon smolts were released at Lowell Creek out-

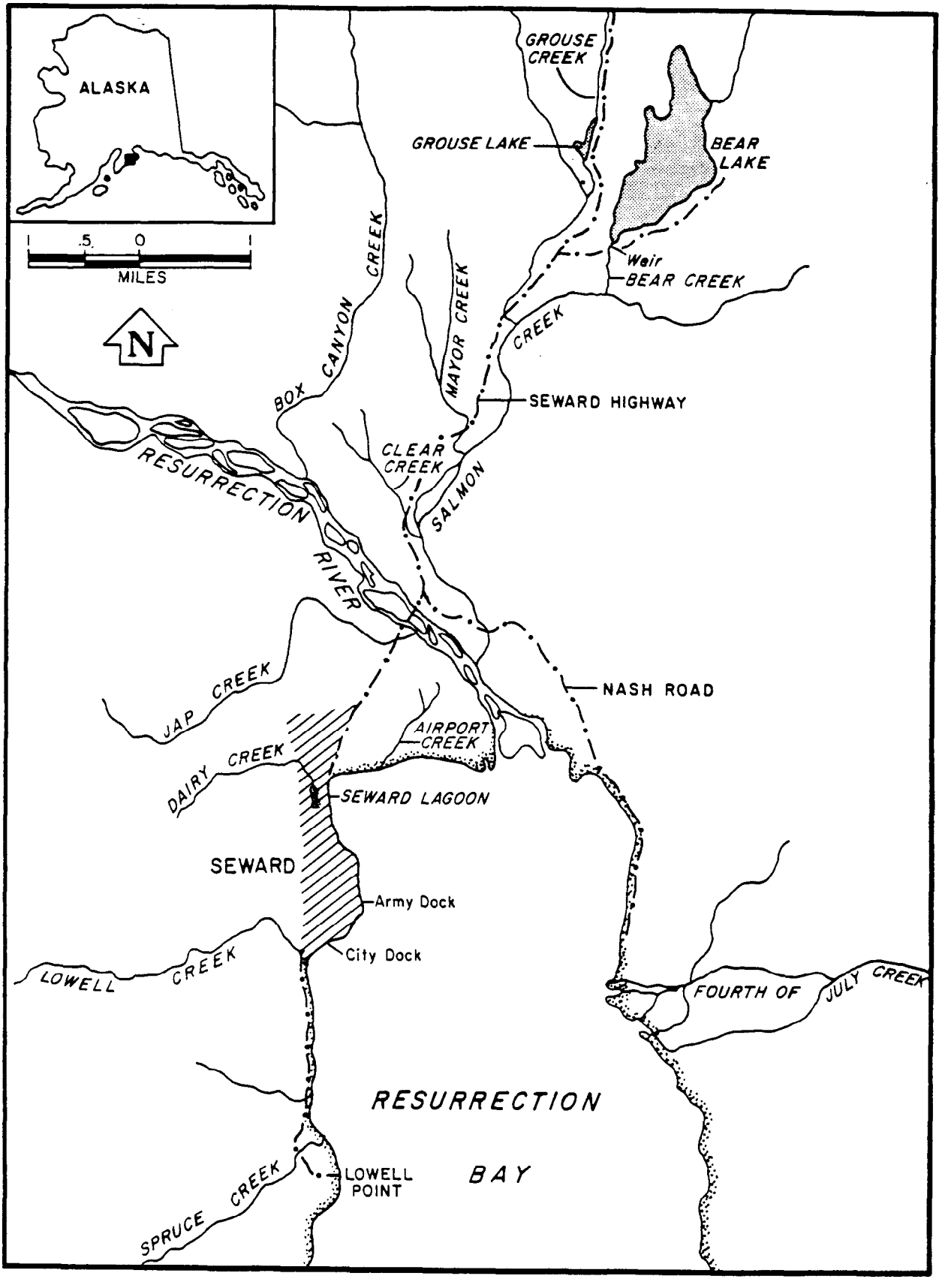

Figure 1. Map of Resurrection Bay, Alaska.

Table 1. Coho salmon fingerlings and hatchery-reared smolts of Bear Lake stock released in Resurrection Bay tributaries, 1986.

Brood Year	Release Date	Release Location	Stocking Data				Mark Type	No. Fish Marked
			No. Fish Released	Density (No./Ha)	Weight (Kgs)	Size (No./Kg)		
1985	7/09	Bear Lake	445,730	2,475	883	505.0	AD-CWT	47,148[1]
1984	5/29	Seward Lagoon	51,500	12,471	1,126	45.7	AD-CWT	15,221[2]
1984	5/30	Box Canyon Creek	53,600		1,212	44.2	AD-CWT	15,445[3]

[1] Adipose finclipped and coded wire tagged; 0.5 mm tag code 3 B 13/14.

[2] Adipose finclipped and coded wire tagged; 1.0 mm tag code A 31 17/21.

[3] Adipose finclipped and coded wire tagged; 1.0 mm tag code A 31 17/20.

let into Resurrection Bay in 1986 (Table 2). Other waters stocked in recent years were Grouse Lake (coho salmon smolts) and Box Canyon rearing pond, Thumb Cove, and Seward Lagoon (chinook salmon smolts).

Bear Lake is currently undergoing an artificial fertilization experiment to further increase its carrying capacity for juvenile salmon production. In 1986, fertilization was conducted weekly from early July to early September. One hundred, 106 liter barrels of fertilizer were dispersed in Bear Lake's northern epilimnion. Sixty of these barrels had N-P-K percentages of 32-0-0, and forty were 27-7-0. This is the final year of this experiment; results will be reported by FRED Division in 1987.

Evaluation of the coho salmon enhancement efforts requires that three major life history events of Resurrection Bay salmon be monitored: (1) freshwater residency; (2) harvest in the sport fishery; and (3) escapement. Numbers (1) and (3) are largely accomplished by operating a weir on Bear Creek (Figure 1) to collect data needed to estimate the abundance and biological characteristics (age, sex, and size composition) of the smolt out-migrations and the adult salmon escapements. Number (2) is accomplished by a creel survey designed to estimate: angler effort and coho salmon harvest by the Resurrection Bay sport fishery, the biological characteristics of harvested salmon, and the contribution of salmon from the enhancement program to the harvest. The objective of this report is to summarize data collected in conjunction with evaluating the various salmon enhancement activities in Resurrection Bay in 1986, particularly at Bear Lake, and to estimate the contribution of coho salmon from the enhancement program to the 1986 sport harvest. The creel survey is the subject of a separate report (Sonnichsen et al. in preparation). Vincent-Lang (in press) presents a summary of all coho salmon enhancement activities in Resurrection Bay, including estimates of survival rates and contributions to the sport fishery through 1986.

METHODS

Salmon Out-Migration

Bear Creek weir is a complete barrier to upstream and downstream fish migration. The weir is located 0.5 km downstream from the outlet of Bear Lake. All out-migrating salmon smolts and returning salmon adults must pass through a live fish box at the weir where they are counted and sampled for biological data.

Abundance and timing of coho and sockeye salmon smolt out-migrations from Bear Lake were estimated by daily enumeration of all smolts captured in the weir's downstream-migrant trap from mid-May to mid-September. Smolts were dipnetted from the trap, anesthetized in MS-222, and counted by species before being released into calm water to recover and resume migration. A portion of the coho salmon smolt out-migration in 1986 was adipose finclipped and tagged with 1.0 mm coded wire tags

(AD-CWT) using a Northwest Marine Technologies tagging unit. Additionally, some coho salmon smolts were marked with a right ventral (RV) finclip only. Smolts were marked for later recognition as adults in the 1987 Resurrection Bay sport fishery and Bear Lake spawning escapement.

The biological characteristics of the Bear Lake coho and sockeye salmon smolt out-migrations were estimated by randomly sampling about 250 smolts per time stratum throughout their migrations. The objective sample size was not always met due to low abundance during some strata. Smolts selected for sampling were anesthetized, scale sampled, the fork length measured to the nearest millimeter, and weighed to the nearest gram. Scale smears were taken and mounted on adhesive-coated cards. The cards were thermohydraulically pressed against plastic cards and the resulting scale impressions were displayed on a microfiche projector for age determination.

The age compositions of the coho and sockeye salmon smolt out-migrations were estimated for each temporal stratum. For each species, the total number of out-migrants during a stratum was multiplied by the estimated age composition for that stratum to estimate the total number of out-migrants by age group across the entire smolt run.

Letting $\hat{p}_{ij}$ be the estimated proportion of age group i in stratum j, the variance of the estimated number by age group was calculated as follows (Scheaffer et al. 1979):

$$(1) \quad V(\hat{N}_{ij}) = N_{Tj}^2[\hat{p}_{ij}(1-\hat{p}_{ij})/(n_{Tj}-1)]\ [1-\ (n_{Tj}/N_{Tj})];$$

where: N_{ij} = the estimated number of smolts of age group i out-migrating during stratum j,

N_{Tj} = the total number of smolts out-migrating during stratum j, and,

n_{Tj} = the total number of smolts sampled during stratum j.

Seasonal totals for estimated numbers and variances are the sums of these quantities over all strata. Estimates of means and standard errors for length and weight at age were calculated using standard normal procedures.

Salmon Escapement

Abundance and timing of coho and sockeye salmon escapements into Bear Lake were determined by daily enumeration of these fish in the upstream-

Table 4. Mean fork length (mm) and weight (g) of coho salmon smolts sampled at Bear Creek weir, 1986.

Period		Age Group: 1.0: Length	1.0: Weight	2.0: Length	2.0: Weight	3.0: Length	3.0: Weight
5/27-6/02	Mean	121.3	16.8	150.1	31.3	193.0	65.0
	Standard Error	2.3	0.8	3.6	2.4	2.0	3.0
	Sample Size	14	14	14	14	2	2
6/03-6/09	Mean	122.7	18.0	140.1	26.3	191	64
	Standard Error	0.4	0.2	1.9	1.2		
	Sample Size	212	212	56	56	1	1
6/10-6/16	Mean	125.8	19.5	137.0	24.9		
	Standard Error	0.5	0.2	1.7	0.9		
	Sample Size	161	161	49	49		
6/17-6/30	Mean	131.1	23.8	135.3	24.3	319.0	317.0
	Standard Error	0.3	0.2	1.7	0.9		
	Sample Size	270	270	9	9	1	1
7/01-7/14	Mean	140.3	27.6	143.5	29.5		
	Standard Error	0.3	0.2	8.5	3.5		
	Sample Size	247	247	2	2		
7/15-9/15	Mean	155.1	37.9				
	Standard Error	1.1	0.8				
	Sample Size	60	60				

migrant trap. Fish were dipnetted from the trap, examined for sex and fin clips (coho salmon only), counted, and released upstream. All adult coho salmon surplus to FRED Division's egg-take requirements were allowed to migrate into Bear Lake for natural spawning.

The biological characteristics of the coho and sockeye salmon escapements were estimated by randomly sampling returning adults during designated time strata. Adults were scale sampled, the sex identified, any finclips noted, and the mid-eye to fork-of-tail length measured in mm. Scales were removed from the preferred area (Clutter and Whitesel 1956); three scales were sampled per fish from coho salmon and one scale per fish from sockeye salmon. Scales were mounted on adhesive-coated cards and processed following the procedures described for the smolt scale samples. The age composition and mean length at age by sex of the salmon escapements were estimated using the procedures described for the salmon smolts.

Minimum spawning escapement of wild (naturally produced) coho salmon to seven Resurrection Bay tributaries were estimated by periodic foot surveys conducted from mid-October to early November. The streams surveyed in 1986 were: Lower Bear Creek, Box Canyon, Clear, Dairy Creek, Grouse, Jap, and Mayor Creeks (Figure 1). Both live and dead coho salmon observed during the surveys were counted. Carcasses were examined for finclips and sex determination and then mutilated to preclude recounting. Minimum (wild and enhanced) coho salmon escapements were estimated by adding previously observed mortalities to the last, or highest, live spawner count in each tributary.

Estimation of Enhanced Contributions to the Fishery

Different procedures were used to estimate the contributions of the various enhancement sites (Bear Lake, Seward Lagoon, and Grouse Lake) to the estimated harvests of coho salmon by the Resurrection Bay boat and beach sport fisheries.

Estimates of the contribution of coho salmon from Bear Lake enhancement (C_{BL}) to the boat and beach harvests were estimated as follows (Vincent-Lang in press):

$$\hat{C}_{BL} = (\hat{C}_T/n_2)\ (\hat{m}_c/p); \quad (2)$$

where: $\hat{C}_T$ = estimated boat or beach sport harvest of coho salmon;

n_2 = number of coho salmon examined in the boat or beach sport harvest;

$\hat{m}_c$ = number of coho salmon with Bear Lake marks observed in the boat or beach sport harvest; and,

p = proportion of coho salmon adults with Bear Lake marks observed in the escapement at Bear Lake weir.

The variance of $\hat{C}_{BL}$ has two components, variance due to $\hat{C}_T$ and variance due to $\hat{m}_c$. The variance of $\hat{C}_{BL}$ is equal to that for the product of two independent random variables (Goodman 1960) divided by a constant. It is assumed that the variance of p is negligible because the entire escapement to Bear Creek weir was examined for marks. The variance of $\hat{C}_{BL}$ was calculated as follows:

$$(3) \qquad V(\hat{C}_{BL}) = [C_T^2 V(\hat{m}_c) + \hat{m}_c^2 V(\hat{C}_T) - V(\hat{C}_T)V(\hat{m}_c)]/(n_2 p)^2.$$

The variance of $\hat{m}_c$ was calculated as follows (Clark and Bernard 1987):

$$(4) \qquad V(\hat{m}_c) = [n_2(n_2-1)\hat{C}_{BL}(\hat{C}_{BL}-1)p^2]/[\hat{C}_T(\hat{C}_T-1)] +$$

$$[n_2\hat{C}_{BL}p/\hat{C}_T] - [n_2 \hat{C}_{BL}p/\hat{C}_T]^2.$$

The contributions of the coho salmon from Seward Lagoon and Grouse Lake enhancements sites to the boat and beach harvests were calculated using the procedure of Clark and Bernard (1987). This procedure differs from the one described above because it incorporates the AD-CWT (adipose fin-clipped and coded wire tagged) fish used at these sites. The estimated contribution of the site under evaluation

($\hat{C}_s$) was calculated in the following manner:

$$(5) \qquad \hat{C}_s = (m_1/m_2)\ (a_1/a_2)\ (\hat{C}_T/n_2)\ (\hat{m}_c/p_r)$$

where: m_1 = number of snouts from fish with adipose finclips collected from the fishery and sent to the lab for processing that have a CWT present;

m_2 = number of snouts from fish with adipose finclips collected from the fishery and sent to the lab for processing that have decodeable CWTs;

a_1 = number of snouts from fish with adipose finclips collected from the fishery and sent to lab for processing;

a_2 = number of snouts from fish with adipose finclips collected from the fishery and sent to lab for processing that arrive at the lab;

m_c = number of snouts from fish with adipose finclips collected from the fishery, sent to the lab for processing, and decoded as a unique tag code;

p_r = for each tag code, the proportion of the total released that were marked with a CWT at the time of stocking;

and $\hat{C}_T$ and n_2 are defined under equation 2 listed above.

The variance of $\hat{C}_s$ was calculated by:

$$(6)\ V(\hat{C}_s] = [\hat{C}_T^2\ V(\hat{m}_c) + \hat{m}_c^2\ V(\hat{C}_T) - V(\hat{m}_c)\ V(\hat{C}_T)]\ [(m_1\ a_1)/(m_2\ a_2\ n_2\ p_r)]^2$$

and the variance of $\hat{m}_c$ (Clark and Bernard 1987) was calculated as follows:

$$(7)\quad V[m_c] = \left[\frac{m_2\,[m_2-1]\,a_2\,[a_2-1]\,n_2\,[n_2-1]\,\hat{C}_s\,[\hat{C}_s-1]p_r^2}{m_1\,[m_1-1]\,a_1\,[a_1-1]\,\hat{C}_T\,[\hat{C}_T-1]}\right] + \left[\frac{m_2\,a_2\,n_2\,\hat{C}_s\,p_r}{m_1\,a_1\,\hat{C}_T}\right] - \left[\frac{(m_2\,a_2\,n_2\,\hat{C}_T\,p_r)^2}{(m_1\,a_1\,\hat{C}_T)^2}\right].$$

Smolt to adult survival for coho salmon smolts from the 1985 Bear Lake out-migration ($\hat{S}_{BL}$) was also estimated. The variance of survival was calculated in the following manner:

$$(8)\quad V(\hat{S}_{BL}) = V(\hat{C}_{BL})/M_{BL}^2$$

where: M_{BL} = the number of out-migrating coho salmon smolts at Bear Lake weir in 1985, and

the variances of the coho salmon escapement and smolt out-migration are assumed to be negligible as they were completely enumerated.

The minimum smolt to adult survival rates for enhanced 1985 coho salmon smolts stocked in Seward Lagoon and Grouse Lake were estimated as above with the exception that escapements were not considered. In this case, M was equal to the number of smolts released at the time of stocking.

RESULTS AND DISCUSSION

Salmon Out-Migration

The Bear Lake coho salmon out-migration totaled 72,920 smolts from 24 May to 14 September (Appendix Table 1). After trap and marking mortalities, 72,685 live smolts were released downstream. Of these, 16,732 smolts (23.0%) were AD-CWT marked and 7,000 (9.6%) received an RV finclip.

The coho salmon smolt out-migration was composed of an estimated 60,860 (83.7%) age 1.0[1], 11,515 (15.9%) age 2.0, and 310 (0.4%) age 3.0 smolts (Table 3). While the mean length and mean weight of the age 1.0 smolts increased throughout the out-migration, the largest age 2.0 smolts left early in the migration, and the size of later age 2.0 migrants gradually decreased (Table 4).

The Bear Lake sockeye salmon smolt out-migration totaled only 955 smolts from 16 May to 12 July (Appendix Table 1) of which 952 live smolts were released downstream. The sockeye salmon smolt out-migration was composed of an estimated 841 (88.3%) age 1.0 and 111 (11.7%) age 2.0 smolts (Table 5). Similarly to the coho salmon smolts, the mean length and mean weight of the age 1.0 sockeye salmon smolts increased throughout the out-migration (Table 6).

Salmon Escapement

The coho salmon escapement to Bear Creek weir totaled 5,485 adults from 6 August to 4 November. Of the adults, 3,087 were males (including six jacks) and 2,398 were females (Appendix Table 2). There were 588 left ventral finclipped, 11 AD-CWT marked, and 4,880 unmarked fish (excluding jacks) in the coho salmon escapement. After trap and egg-take mortalities, 2,969 male and 2,146 female coho salmon were passed upstream.

Excluding the jacks, the coho salmon escapement was composed of an estimated 5,384 (98.3%) age 1.1 and 95 (1.7%) age 2.1 adults (Table 7). Age 1.1 coho salmon in the Bear Lake escapement averaged 594 mm in length and age 2.1 averaged 584 mm (Table 8).

The sockeye salmon escapement to the weir totaled 831 adults from 30 May to 8 October (Appendix Table 3). After trap mortalities, 343 male and 461 female sockeye salmon were passed upstream. The estimated age composition of the sockeye salmon escapement was 357 (43.0%) age 1.2, 43 (5.2%) age 2.2, 426 (51.3%) age 1.3 and 4 (0.5%) age 2.3 adults (Table 9). Sockeye salmon mean lengths ranged from 488 mm for age 1.2 females to 590 mm for age 2.3 males (Table 10).

Minimum coho salmon escapement estimates to Resurrection Bay tributary systems ranged from 71 in Lower Bear Creek to 977 in Grouse Creek (Table 11). Escapement in Grouse Creek (977) was much larger than the 1982-1985 average of 361 (McHenry 1985). The minimum escapement estimated in Mayor Creek (537) was also much larger than the 1982-1985 average of 112 coho salmon (McHenry 1985).

[1] European formula: Numeral preceding the decimal refers to the number of freshwater annuli, numeral following the decimal is the number of marine annuli. Total age from brood year is the sum of these two numbers plus one.

Table 3. Estimated abundance by age group of coho salmon smolts out-migrating through Bear Creek weir, 1986.

Period[1]		Age Group: 1.0	2.0	3.0	Total
5/20-6/02	Percent	46.7	46.7	6.6	100.0
(n = 30)	Estimated Number	1,443	1,443	207	3,093
	Standard Error	285	285	143	
6/03-6/09	Percent	78.8	20.8	0.4	100.0
(n = 269)	Estimated Number	15,457	4,083	73	19,613
	Standard Error	486	483	72	
6/10-6/16	Percent	76.7	23.3		100.0
(n = 210)	Estimated Number	18,535	5,641	0	24,176
	Standard Error	704	704		
6/17-6/30	Percent	96.4	3.2	0.4	100.0
(n = 280)	Estimated Number	8,415	280	31	8,726
	Standard Error	95	91	31	
7/01-7/14	Percent	99.2	0.8		100.0
(n = 249)	Estimated Number	8,301	67	0	8,368
	Standard Error	47	47		
7/15-9/15	Percent	100.0			100.0
(n = 60)	Estimated Number	8,709	0	0	8,709
	Standard Error	0			
Total	Percent	83.7	15.9	0.4	100.0
	Estimated Number	60,860	11,515	310	72,685
	Standard Error	908	906	163	

[1] n = number sampled.

Table 4. Mean fork length (mm) and weight (g) of coho salmon smolts sampled at Bear Creek weir, 1986.

Period		Age Group: 1.0: Length	1.0: Weight	2.0: Length	2.0: Weight	3.0: Length	3.0: Weight
5/27-6/02	Mean	121.3	16.8	150.1	31.3	193.0	65.0
	Standard Error	2.3	0.8	3.6	2.4	2.0	3.0
	Sample Size	14	14	14	14	2	2
6/03-6/09	Mean	122.7	18.0	140.1	26.3	191	64
	Standard Error	0.4	0.2	1.9	1.2		
	Sample Size	212	212	56	56	1	1
6/10-6/16	Mean	125.8	19.5	137.0	24.9		
	Standard Error	0.5	0.2	1.7	0.9		
	Sample Size	161	161	49	49		
6/17-6/30	Mean	131.1	23.8	135.3	24.3	319.0	317.0
	Standard Error	0.3	0.2	1.7	0.9		
	Sample Size	270	270	9	9	1	1
7/01-7/14	Mean	140.3	27.6	143.5	29.5		
	Standard Error	0.3	0.2	8.5	3.5		
	Sample Size	247	247	2	2		
7/15-9/15	Mean	155.1	37.9				
	Standard Error	1.1	0.8				
	Sample Size	60	60				

Table 5. Estimated abundance by age group of sockeye salmon smolts out-migrating through Bear Creek weir, 1986.

Period[1]		Age Group: 1.0	2.0	Total
5/13-6/02	Percent	90.0	10.0	100.0
(n = 60)	Estimated Number	441	49	490
	Standard Error	18	18	
6/03-6/16	Percent	85.7	14.3	100.0
(n = 21)	Estimated Number	370	62	432
	Standard Error	33	33	
6/17-7/14	Percent	100.0	0.0	100.0
(n = 6)	Estimated Number	30	0	30
	Standard Error			
Total	Percent	88.3	11.7	100.0
	Estimated Number	841	111	952
	Standard Error	38	38	

[1] n = number sampled.

Table 6. Mean fork length (mm) and weight (g) of sockeye salmon smolts at Bear Creek weir, 1986.

		Age Group:			
		1.0:		2.0:	
Period		Length	Weight	Length	Weight
5/27-6/02	Mean	122.8	18.3	167.0	47.5
	Standard Error	1.0	0.4	1.6	1.8
	Sample Size	54	54	6	6
6/03-6/16	Mean	130.7	22.8	165.0	46.7
	Standard Error	2.2	1.2	10.0	9.2
	Sample Size	18	18	3	3
6/17-7/14	Mean	136.0	26.5		
	Standard Error	4.8	2.8		
	Sample Size	6	6		

Table 7. Estimated abundance by age group of the coho salmon escapement to Bear Creek weir, 1986.

Sex[1]		Age Group: 1.1	2.1	Total
Male	Percent	58.2	1.0	59.2
(n=341)	Estimated Abundance	3,027	54	3,081
	Standard Error	21	21	
Female	Percent	40.1	0.7	40.8
(n=235)	Estimated Abundance	2,357	41	2,398
	Standard Error	19	19	
Total	Number Sampled	566	10	576
	Percent	98.3	1.7	100.0
	Estimated Abundance	5,384	95	5,479[2]
	Standard Error	28	28	

[1] n = number sampled.

[2] Does not include six jacks counted at weir.

Table 8. Mean length[1] (mm) by sex and age group of adult coho salmon sampled at Bear Creek weir, 1986.

Sex		Age Group: 1.1	2.1	Total
Male	Length	589	558	587
	Standard Error	3	24	4
	Sample Size	335	6	341
Female	Length	602	624	602
	Standard Error	4	10	3
	Sample Size	231	4	235
Total	Length	594	584	592
	Standard Error	3	18	3
	Sample Size	566	10	576

[1] Length measured from mid-eye to fork-of-tail.

Table 9. Estimated abundance by age group of the sockeye salmon escapement to Bear Creek weir, 1986.

Period[1]	Sex		Age Group: 1.2	2.2	1.3	2.3	Total
5/27 - 6/16 (n = 37)	Male	Percent	8.1	0	29.7	2.7	40.5
		Number	5	0	18	1	24
	Female	Percent	8.1	2.7	45.9	2.7	59.5
		Number	5	2	28	1	36
	Combined	Percent	16.2	2.7	75.7	5.4	100.0
		Number	10	2	46	2	60
		St. Error	2	1	3	1	
6/17 - 6/23 (n = 101)	Male	Percent	16.8	1.0	26.7	0.0	44.5
		Number	38	2	61	0	101
	Female	Percent	24.8	0.0	29.7	1.0	55.5
		Number	66	0	79	2	147
	Combined	Percent	41.6	1.0	56.4	1.0	100.0
		Number	104	2	140	2	248
		St. Error	9	2	9	2	
6/24 - 6/30 (n = 130)	Male	Percent	19.2	0.8	24.6	0.0	44.6
		Number	53	2	68	0	123
	Female	Percent	30.0	2.3	23.1	0.0	55.4
		Number	82	6	63	0	151
	Combined	Percent	49.2	3.1	47.7	0.0	100.0
		Number	135	8	131	0	274
		St. Error	9	3	9	0	
7/01 - 10/13 (n = 66)	Male	Percent	22.7	4.6	21.2	0.0	48.5
		Number	46	9	43	0	98
	Female	Percent	21.2	7.6	22.7	0.0	51.5
		Number	62	22	66	0	150
	Combined	Percent	43.9	12.2	43.9	0.0	100.0
		Number	108	31	109	0	248
		St. Error	13	9	13	0	
SEASON TOTAL	Male	Percent	17.1	1.6	22.9	0.1	41.7
		Number	142	13	190	1	346
	Female	Percent	25.9	3.6	28.4	0.4	58.3
		Number	215	30	236	3	484
	Combined	Percent	43.0	5.2	51.3	0.5	100.0
		Number	357	43	426	4	830
		St. Error	18	10	18	2	

[1] n = sample size.

Table 10. Mean length[1] (mm) by sex and age group of adult sockeye salmon sampled at Bear Creek weir, 1986.

Sex		Age Group: 1.2	2.2	1.3	2.3
Male	Length	515	529	574	590
	Standard Error	3	2	2	
	Sample Size	60	5	85	1
Female	Length	488	492	546	565
	Standard Error	2	4	2	5
	Sample Size	81	9	91	2
All Fish	Length	499	505	560	573
	Standard Error	2	5	2	9
	Sample Size	141	14	176	3

[1] Length measured from mid-eye to fork-of-tail.

Table 11. Summary of coho salmon escapement counts for Resurrection Bay tributaries that were foot surveyed in 1986.

Stream	Minimum Escapement	Carcasses: Male[1]	Female[1]	Marked: AD-CWT	Marked: LV	Un-Marked
Lower Bear Creek	71	15	15	1	1	28
Box Canyon Creek	119	2	2	0	0	19
Clear Creek	115	25	19	2	0	42
Seward Lagoon System[2]	255	83	83	37	0	129
Grouse Creek[3]	977	270	197	134	2	331
Jap Creek	131	4	2	0	0	6
Mayor Creek	537	134	131	53	0	212

1 Not all dead coho salmon could be sex identified due to mutilation or non-accessibility.

2 Seward Lagoon system includes Dairy Creek, Pasture Creek, Railroad Creek, and First Lake Creek.

3 Escapement counts include fish observed in Grouse Lake as well as the creek.

Estimation of Enhanced Contributions to the Fishery

The recovery of marked coho salmon in each of the Resurrection Bay sport fisheries in 1986 included 199 coho with coded wire tags and 35 coho with left ventral finclips (Appendix Table 4). The 1985 Bear Lake coho salmon out-migration of 105,843 smolts (Table 12) contributed adult coho salmon to the Resurrection Bay sport fishery and Bear Lake escapement in 1986. The majority of these smolts were from the 1983 and 1984 Bear Lake fingerling plants. Hatchery-reared smolts released in Seward Lagoon and Grouse Lake in 1985 (Table 12) also contributed to the sport fishery in 1986.

Enhanced chinook salmon returns in 1986 were from hatchery-reared smolts stocked in Box Canyon rearing pond in 1983, Thumb Cove in 1984, and Lowell Creek outlet in 1984 and 1985 (Table 2). The estimated harvest of chinook salmon by the boat sport fishery was 488 [standard error = 180] (Sonnichsen et al. in preparation). No chinook salmon were observed during the creel survey of the beach fisheries.

Bear Lake contributed an estimated 1,832 coho salmon to the Resurrection Bay sport fishery (Table 13), or approximately 12% of the coho salmon harvest. The estimated contributions to the sport fishery for Seward Lagoon and Grouse Lake were 2,015 (13%) and 392 coho salmon (2%), respectively. More than 60% of the coho salmon harvest by the beach fisheries was from enhanced stocks; Seward Lagoon contributed about 45% of the total harvest. About 22% of the harvest by the boat fisheries was from enhanced coho salmon (Figure 2).

The estimated smolt to adult survival for the Bear Lake coho salmon smolt out-migration in 1985 was 6.9% (standard error = 0.31%). The estimated minimum smolt to adult survival rates for coho salmon smolts planted in 1985 in Seward Lagoon and Grouse Lake were 4.0% (standard error = 0.51%) and 0.7% (standard error = 0.13%), respectively.

RECOMMENDATIONS

To better estimate the smolt-to-adult survival of coho salmon smolts planted in Seward Lagoon, we recommend that a fish trap be installed in the entrance to Seward Lagoon in 1987 so that the Seward Lagoon escapement can be enumerated. This will allow the number of marked fish returning to Seward Lagoon to be estimated and improve the estimates of the Seward Lagoon contribution to the sport fisheries and smolt-to-adult survival for Seward Lagoon smolts.

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Table 12. Summary of 1982-1984 Bear Lake coho salmon fingerling plants, 1985 Bear Lake coho salmon smolt out-migration, and 1985 hatchery-reared smolt releases contributing to the 1986 adult coho salmon return.

FINGERLING PLANTS:

Brood[1] Year	Release Date	Release Location	No. Fish Released	Stocking Data: Density (No./Ha)	Weight (Kgs)	Size (No./Kgs)	Mark Type	No. Fish Marked
1982	5/24/83	Bear Lake	199,000	1,104	274	727.6	None	0
1983	5/24/84	Bear Lake	220,000	1,220	343	640.7	None	0
1984	6/05/85	Bear Lake	187,000	1,037	217	860.7	None	0
1984	6/05/85	Bear Lake	113,000	627	77	1,465.7	None	0

SMOLT OUT-MIGRATION:

Brood Year	Date	Location	No. Out-Migrants	Stocking Data: Density (No./Ha)	Weight (Kgs)	Size (No./Kgs)	Mark Type	No. Fish Marked
1983	6/3-9/15/85	Bear Creek	1,579[2]	NA	NA	220.0	LVC[3]	
1984	6/3-9/15/85	weir	104,264[2]	NA	NA	50.9	LVC[3]	
		Total	105,843					26,470[4]

- continued -

Table 12. Summary of 1982-1984 Bear Lake coho salmon fingerling plants, 1985 Bear Lake coho salmon smolt out-migration, and 1985 hatchery-reared smolt releases contributing to the 1986 adult coho salmon return (continued).

SMOLT RELEASES:

Brood[1] Year	Release Date	Release Location	No. Fish Released	Stocking Data: Density (No./Ha)	Stocking Data: Weight (Kgs)	Stocking Data: Size (No./Kgs)	Mark Type	No. Fish Marked
1983	5/22/85	Seward Lagoon	50,200	12,157	1,202	41.7	AD-CWT[5]	12,500
1983	5/30/85	Grouse Lake	56,100	15,396	1,553	36.2	AD-CWT[6]	21,500

[1] All coho salmon plants were of Bear Lake brood stock.

[2] Estimated from age composition.

[3] Left ventral finclipped.

[4] Total marked of all out-migrants.

[5] Adipose finclipped and coded wire tagged, tag code 31-16-51.

[6] Adipose finclipped and coded wire tagged, tag codes 31-16-48 and 31-16-49.

Table 13. Estimated contribution of Bear Lake, Seward Lagoon, and Grouse Lake coho salmon to the Resurrection Bay boat and beach fisheries, 1986.

Source	Boat Fishery: Number	Boat Fishery: SE[1]	Beach Fishery: Number	Beach Fishery: SE	Total:[2] Number	Total:[2] SE
Total Sport Harvest[3]	13,190	760	2,084	274	15,274	808
Bear Lake	1,459	275	373	170	1,832	323
Seward Lagoon	1,085	158	930	201	2,015	256
Grouse Lake	371	72	21	21	392	74

[1] Standard error.

[2] Total harvest by boat fisheries and beach fisheries combined.

[3] Harvest estimates and standard errors reported in Sonnichsen et al. (in press).

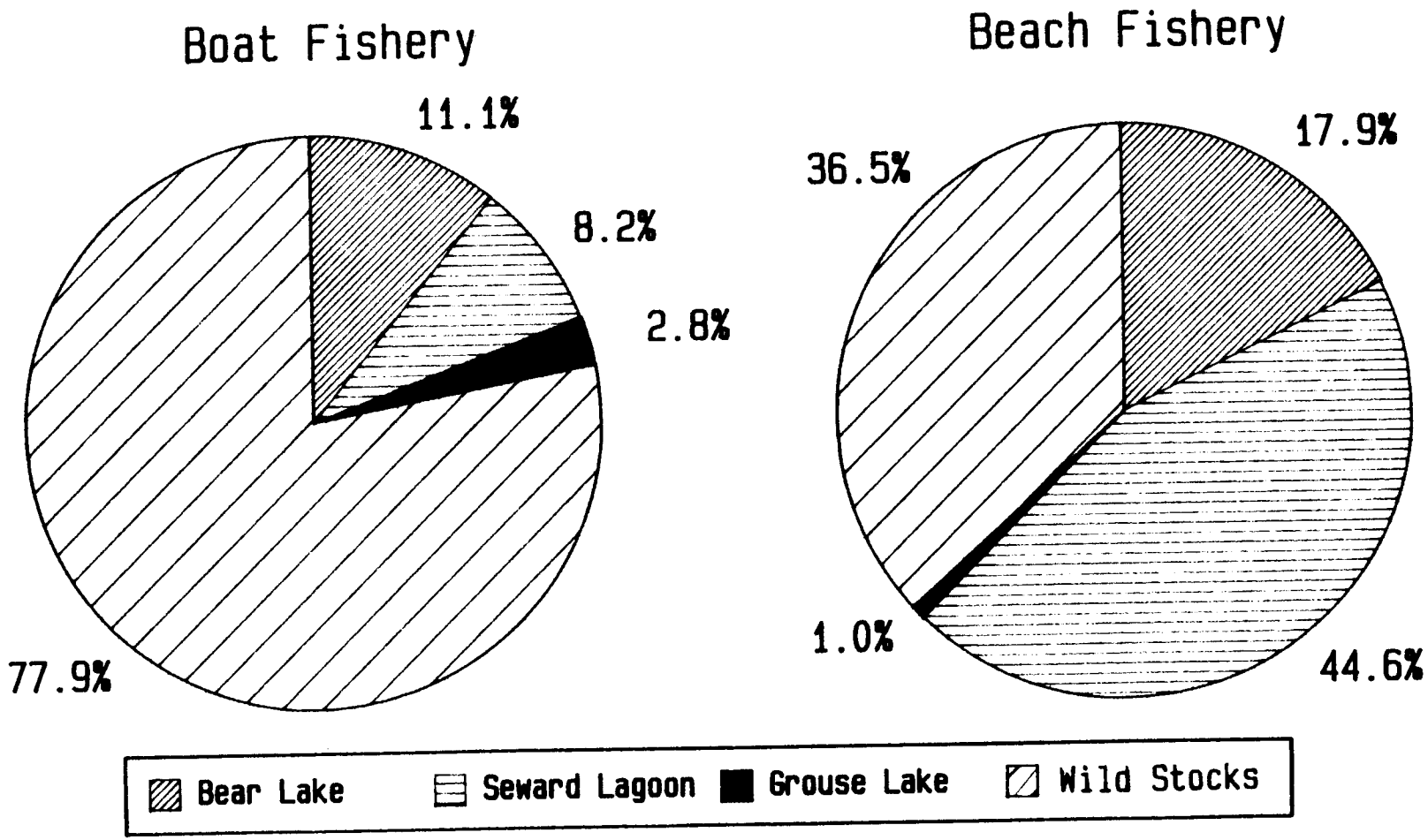

Figure 2. Estimated contribution of enhanced stocks to the coho salmon harvest by Resurrection Bay boat and beach fisheries, 1986.

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Appendix Table 1. Daily out-migration of coho and sockeye salmon smolts from Bear Lake, 1986.

Date	Coho Salmon Smolts: Total	Live	No. AD-CWT[1]	No. RVC[2]	Sockeye Smolts
5/16					1
5/17					0
5/18					0
5/19					15
5/20	0				0
5/21	0				0
5/22	0				0
5/23	0				0
5/24	56	56			41
5/25	32	32			49
5/26	0				0
5/27	0				0
5/28	189	189			92
5/29	180	180			159
5/30	195	194			32
5/31	830	830			69
6/01	970	970			25
6/02	652	642	352		8
6/03	640	640			29
6/04	1,417	1,415	1,030		21
6/05	4,258	4,249			14
6/06	2,924	2,922	1,257		98
6/07	1,663	1,657		788	54
6/08	4,663	4,660		1,352	21
6/09	4,071	4,070		1,203	5
6/10	2,626	2,625	2,214		4
6/11	4,539	4,537	2,036		62
6/12	3,451	3,451		704	49
6/13	3,071	3,068	2,607		13
6/14	3,268	3,267			34
6/15	2,726	2,724	1,455		12
6/16	4,506	4,504		1,100	18
6/17	2,555	2,555	1,025		5
6/18	606	606	603		0
6/19	333	333			2
6/20	502	502	502		1
6/21	567	567			1
6/22	521	521			1
6/23	723	722	693		1
6/24	502	501	468		0
6/25	796	795		325	2
6/26	785	785			2

-Continued-

Appendix Table 1. Daily out-migration of coho and sockeye salmon smolts from Bear Lake, 1986 (continued).

Date	Coho Salmon Smolts: Total	Live	No. AD-CWT[1]	No. RVC[2]	Sockeye Smolts
6/27	186	186			0
6/28	111	111			0
6/29	193	193		126	0
6/30	349	349			0
7/01	570	570			7
7/02	788	786	711		4
7/03	307	307		275	0
7/04	950	948			2
7/05	50	50			0
7/06	205	205			0
7/07	2,137	2,137		336	0
7/08	590	590			0
7/09	978	978			0
7/10	313	313			0
7/11	289	289			1
7/12	453	453			1
7/13	261	261			0
7/14	482	481	473		0
7/15	192	192	191		0
7/16	180	180	180		0
7/17	0				0
7/18	0				0
7/19	0				0
7/20	54	54		54	0
7/21	0				0
7/22	0				0
.[3]					
.					
8/01	0				0
8/02	286	284	282		0
8/03	409	409	407		0
8/04	665	665		337	0
8/05	246	246	246		0
8/06	144	144		100	0
8/07	0				0
8/08	712	712			0
8/09	547	547			0
8/10	1,019	1,019			0
8/11	336	335		200	0
8/12	239	239			0
8/13	453	453			0

-Continued-

Appendix Table 1. Daily out-migration of coho and sockeye salmon smolts from Bear Lake, 1986 (continued).

Date	Coho Salmon Smolts: Total	Live	No. AD-CWT[1]	No. RVC[2]	Sockeye Smolts
8/14	0				0
8/15	73	73			0
8/16	21	21			0
8/17	0				0
8/18	25	25			0
8/19	0				0
8/20	80	80			0
8/21	0				0
8/22	67	67			0
8/23	0				0
8/24	2	2			0
8/25	118	118		100	0
8/26	830	830			0
8/27	8	8			0
8/28	2,122	1,943			0
8/29	6	6			0
8/30	10	10			0
8/31	12	12			0
9/01	0				0
9/02	0				0
9/03	1	1			0
9/04	3	3			0
9/05	1	1			0
9/06	4	4			0
9/07	0				0
9/08	21	21			0
9/09	2	2			0
9/10	1	1			0
9/11	1	1			0
9/12	0				0
9/13	0				0
9/14	1	1			0
9/15	0				0
Total	72,920	72,685	16,762	7,000	955
Mortalities			30	0	3
Total Released			16,732	7,000	952

[1] Adipose finclipped and coded wire tagged; tag code 31-17-31.

[2] Right ventral finclipped.

[3] Trap was closed from 22 July to 31 July for fishpass repairs.

Appendix Table 2. Coho salmon escapement to Bear Creek weir, 1986.

Date	Males	Females	Total	Marked Fish: LVC[1]	Marked Fish: AD-CWT[2]
8/05					
8/06	1		1		
8/07	1		1		
8/08					
8/09					
8/10	1	1	2		
8/11					
8/12	1		1		
8/13		1	1		
8/14	2		2		
8/15	2		2		
8/16	1		1		
8/17		1	1		
8/18	2		2		
8/19	1		1		
8/20	2	1	3		
8/21	1		1		
8/22	3		3		
8/23	1	2	3		
8/24	3	3	6		
8/25	1		1		
8/26	6	1	7	1	
8/27	2		2		
8/28	18	9	27		
8/29	68	7	75	11	
8/30	132	36	168	22	
8/31	84	22	106	19	
9/01	72	8	80	7	
9/02	31	14	45	4	
9/03	17	6	23	7	
9/04	6	1	7	2	
9/05	4	1	5	1	
9/06	4	1	5	1	
9/07	12	3	15	2	
9/08	29	7	36	3	
9/09	43	13	56	9	
9/10	68	44	112	12	
9/11	25	16	41	9	
9/12	42	23	65	6	

-Continued-

Appendix Table 2. Coho salmon escapement to Bear Creek weir, 1986 (continued).

Date	Males	Females	Total	Marked Fish: LVC[1]	Marked Fish: AD-CWT[2]
9/13	35	14	49	4	
9/14	23	20	43	5	
9/15	53	34	87	12	
9/16	50	39	89	8	
9/17	91	78	169	19	
9/18	85	60	145	15	
9/19	66	41	107	20	
9/20	108	58	166	19	
9/21	228	158	386	40	
9/22	97	104	201	17	
9/23	33	28	61	14	
9/24	121	105	226	16	
9/25	102	62	164	28	
9/26	97	76	173	18	
9/27	87	67	154	19	
9/28	79	71	150	23	
9/29	41	45	86	3	1
9/30	57	36	93	7	
10/01	39	38	77	7	1
10/02	48	56	104	8	
10/03	37	42	79	6	
10/04	77	80	157	11	
10/05	124	126	250	21	1
10/06	59	68	127	13	1
10/07	43	37	80	10	1
10/08	23	30	53	3	
10/09	20	19	39	2	1
10/10	73	77	150	18	
10/11[3]					
10/12[3]					
10/13[3]					
10/14[3]					
10/15	15	25	40[4]	2	
10/16	131	114	245[4]	21	1
10/17	106	133	239[4]	21	2
10/18	69	99	168	15	
10/19	21	56	77	9	1
10/20	24	30	54	6	

-Continued-

Appendix Table 2. Coho salmon escapement to Bear Creek weir, 1986 (continued).

Date	Males	Females	Total	Marked Fish: LVC[1]	Marked Fish: AD-CWT[2]
10/21	10	24	34	3	
10/22	10	15	25	6	
10/23	7	4	11	2	
10/24	3	6	9	1	
10/25					
10/26					
10/27	1		1		
10/28	1		1		
10/29					
10/30					
10/31					
11/01					
11/02					
11/03	1	1	2		1
11/04[5]		1	1		
Total Adult	3,081	2,398	5,479	588	11
Total[6]	3,087	2,398	5,485	588	11

1 Left ventral finclipped.

2 Adipose finclipped and coded wire tagged.

3 Flood flows precluded trap operation and upstream migration.

4 Daily total includes trap mortalities resulting from excessive flows.

5 Weir operated through 15 November, no coho salmon counted after 4 November.

6 Totals including jack coho salmon.

Appendix Table 3. Sockeye salmon escapement to Bear Creek weir, 1986.

Date	Males	Females	Total	Trap Mortalities: Males	Trap Mortalities: Females	Live Fish: Males	Live Fish: Females	Live Fish: Total
5/27								
5/28								
5/29								
5/30	1		1			1		1
5/31	1		1			1		1
6/01		2	2				2	2
6/02								
6/03								
6/04								
6/05								
6/06		1	1				1	1
6/07								
6/08	1	3	4	1			3	3
6/09		1	1				1	1
6/10	1		1			1		1
6/11		5	5				5	5
6/12	3		3			3		3
6/13		3	3				3	3
6/14	2	1	3			2	1	3
6/15	3	3	6		1	3	2	5
6/16	12	17	29			12	17	29
6/17	10	22	32		4	10	18	28
6/18	25	36	61	1	6	24	30	54
6/19	5	10	15			5	10	15
6/20	12	26	38		1	12	25	37
6/21	10	15	25			10	15	25
6/22	24	15	39			24	15	39
6/23	15	23	38			15	23	38
6/24	26	18	44			26	18	44
6/25	7	16	23		1	7	15	22
6/26	30	42	72			30	42	72
6/27	15	24	39			15	24	39
6/28	16	14	30	1	1	15	13	28
6/29	17	14	31			17	14	31
6/30	12	23	35		2	12	21	33
7/01	18	25	43			18	25	43
7/02	15	22	37		3	15	19	34
7/03	4	9	13		1	4	8	12

-Continued-

Appendix Table 3. Sockeye salmon escapement to Bear Creek weir, 1986 (continued).

Date	Males	Females	Total	Trap Mortalities: Males	Trap Mortalities: Females	Live Fish: Males	Live Fish: Females	Live Fish: Total
7/04	12	13	25	1		11	13	24
7/05	6	12	18			6	12	18
7/06	3	4	7			3	4	7
7/07	5	1	6			5	1	6
7/08	4	6	10		1	4	5	9
7/09		1	1				1	1
7/10	9	11	20		1	9	10	19
7/11	2	7	9			2	7	9
7/12	2	5	7			2	5	7
7/13	3	8	11			3	8	11
7/14		5	5				5	5
7/15	2	5	7			2	5	7
7/16		1	1				1	1
7/17	2	1	3			2	1	3
7/18		1	1				1	1
7/19								
7/20		3	3		1		2	2
7/21	2	5	7			2	5	7
7/22	1		1			1		1
7/23		1	1				1	1
7/24		1	1				1	1
7/25	2		2			2		2
7/26	1	1	2			1	1	2
7/27		2	2				2	2
7/28								
7/29								
7/30								
7/31								
8/01								
8/02								
8/03	1		1			1		1
8/04								
8/05	1		1			1		1
8/06								
8/07								
8/08	1		1			1		1
After 8/08	3		3			3		3
Total	347	484	831	4	23	343	461	804

Appendix Table 4. Summary of marked coho salmon recovered during the Resurrection Bay creel surveys, 1986.

Fishery and Time Period	Number Examined	Number Marked: AD-CWT[1]	Number Marked: LVC[2]	Number Unmarked	CWT Source[3]
Early Boat (6/23 - 7/6)	29	1	0	28	1-G
Pre-Derby Boat (7/7 - 8/8)	689	8	3	678	5-S,3-N
Derby Boat (8/9 - 8/17)	1,454	88	24	1,342	34-S,23-G,24-N
Post Derby Boat (8/18 - 9/14)	356	37	3	316	12-S,3-G,9-N
Derby Beach (8/9 - 8/17)					
Seward Lagoon	16	7	1	8	3-S,1-G,3-N
Fourth of July	7	0	1	6	
Lowell Point	1	0	0	1	
Post Derby Beach (8/18 - 9/14)					
Seward Lagoon	227	58	1	168	26-S,28-N
Fourth of July	9	0	2	7	
Lowell Point	0	0	0	0	
Total Boat	2,528	134	30	2,364	51-S,27-G,36-N
Total Beach	260	65	5	190	29-S,1-G,31-N

[1] Adipose finclipped and coded wire tagged; not all AD-CWT coho salmon observed could be sampled for tags because some had already been processed by the angler.

[2] Left ventral finclipped.

[3] Number of tags from a source and source code: G = Grouse Lake, S = Seward Lagoon, and N = no tag present.