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STOCKINGS, MIGRATIONS, AND AGE, SEX, AND LENGTH COMPOSITIONS OF COHO, SOCKEYE, AND CHINOOK SALMON IN RESURRECTION BAY, ALASKA, DURING 1989[1]

By

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ABSTRACT

During 1989, Bear Lake was stocked with 491,340 hatchery-reared coho salmon *Oncorhynchus kisutch* fingerlings of Bear Lake origin, and Seward Lagoon and Lowell Creek were stocked with 152,161 and 66,606 hatchery-reared coho salmon smolts of Bear Lake origin, respectively. In addition, Seward Lagoon, Lowell Creek, and Spring Creek were stocked with 109,464, 122,800, and 75,063 hatchery-reared chinook salmon *Oncorhynchus tshawytscha* smolts of early-run Crooked Creek origin, respectively.

The emigrations of coho and sockeye *Oncorhynchus nerka* salmon smolts from Bear Lake during 1989 totalled 99,787 and 5,142 smolts, respectively. After trap mortalities, 99,433 live coho salmon smolts and 5,125 live sockeye salmon smolts were released downstream. The majority of the coho and sockeye salmon smolts were age 1.0 (96.8 and 71.8 percent, respectively). A total of 5,106 adult coho salmon and 185 adult sockeye salmon returned to Bear Lake. The majority of the returning coho salmon were age 1.1 (81.7 percent) and the majority of the returning sockeye salmon were age 1.2 (94.1 percent). An estimated 685 coho salmon returned to Seward Lagoon during 1989 all of which were of hatchery origin.

The estimated marine (smolt-to-adult) survival rates of coho salmon emigrating from Bear Lake during 1988 and stocked into Seward Lagoon and Lowell Creek during 1988 were 10.0, 3.6, and 2.0 percent, respectively.

KEY WORDS: Coho salmon, *Oncorhynchus kisutch*, Resurrection Bay, Bear Lake, chinook salmon, *Oncorhynchus tshawytscha*, sockeye salmon, *Oncorhynchus nerka*, migrations, age, length, sex, survival, weir.

INTRODUCTION

The recreational fishery in Resurrection Bay is one of the largest marine sport fisheries in effort and harvest in Alaska (Mills 1988). Historically, most of the effort in this fishery has been by private boat anglers targeting coho salmon *Oncorhynchus kisutch*. A growing charter boat industry has also developed in recent years. Effort in this fishery has averaged nearly 7,300 boat-trips annually from 1968 to 1989 (Carlon and Vincent-Lang in press) with harvests of coho salmon during this period having averaged about 15,200 coho salmon annually. In addition to the boat fishery, anglers also fish from shore for coho salmon. Effort and harvest in this fishery are minimal compared to the boat fishery.

To increase and stabilize the numbers of coho salmon available to the sport fisheries in Resurrection Bay, a stocking program for coho salmon was initiated in 1962. Bear Lake was chosen as the initial focus of the stocking effort (Figure 1). To increase the rearing capacity of the lake for young coho salmon, the lake was rehabilitated to eradicate competing threespine stickleback *Gasterosteus aculeatus* and an annual stocking of coho salmon fingerlings was begun. Survivals of fingerlings to smolt from these efforts have averaged 35% since 1971 (Vincent-Lang 1987). Bear Lake also supports a small run of sockeye salmon *O. nerka* which, in past years, has contributed to both commercial and personal-use fisheries. Vincent-Lang (1987) presents a complete summary of past stocking activities in Bear Lake with recommendations for future stockings. In accordance with the recommendations stipulated in Vincent-Lang et al. (1987), Bear Lake was stocked with 491,340 age 0 coho salmon fingerlings of Bear Lake origin in 1989 (Table 1).

Additional stockings of coho salmon in Resurrection Bay began in 1968 with annual releases of hatchery-reared smolts of Bear Lake origin at other sites. Release sites have included Seward Lagoon, the Lowell Creek outfall, Grouse Lake, and Bear and Box Canyon Creeks (Figure 1). In 1989, Seward Lagoon and Lowell Creek received 58,808 and 66,606 age 1 hatchery-reared coho salmon smolts of Bear Lake origin, respectively (Table 1). An additional 93,353 age 0 coho salmon smolts of Bear Lake origin were released at Seward Lagoon. Hatchery-reared chinook salmon *O. tshawytscha* smolts have also been released annually since 1983 in an effort to lengthen and diversify the Resurrection Bay sport fishery. In 1989, 109,464, 122,800, and 75,063 age 0 hatchery-reared chinook salmon smolts of early-run Crooked Creek origin were released at Seward Lagoon, Lowell Creek and Spring Creek, respectively (Table 2).

In conjunction with the stocking program, the Alaska Department of Fish and Game, Sport Fish Division, has conducted an ongoing research program to: (1) monitor the effort and harvest in the sport fisheries in Resurrection Bay and (2) determine the most effective stocking strategies by estimating the return of stocked fish. These objectives have principally been accomplished by monitoring the three major life history events of stocked salmon in the Resurrection Bay drainage: (1) freshwater residency and emigration, (2) harvest in the sport fishery, and, (3) immigration. Objectives (1) and (3) are currently accomplished by operating a weir on the outlet of Bear Lake (Figure 1) to collect data needed to estimate the abundance and biological characteristics (age, sex, and size composition) of the smolt emigrations and

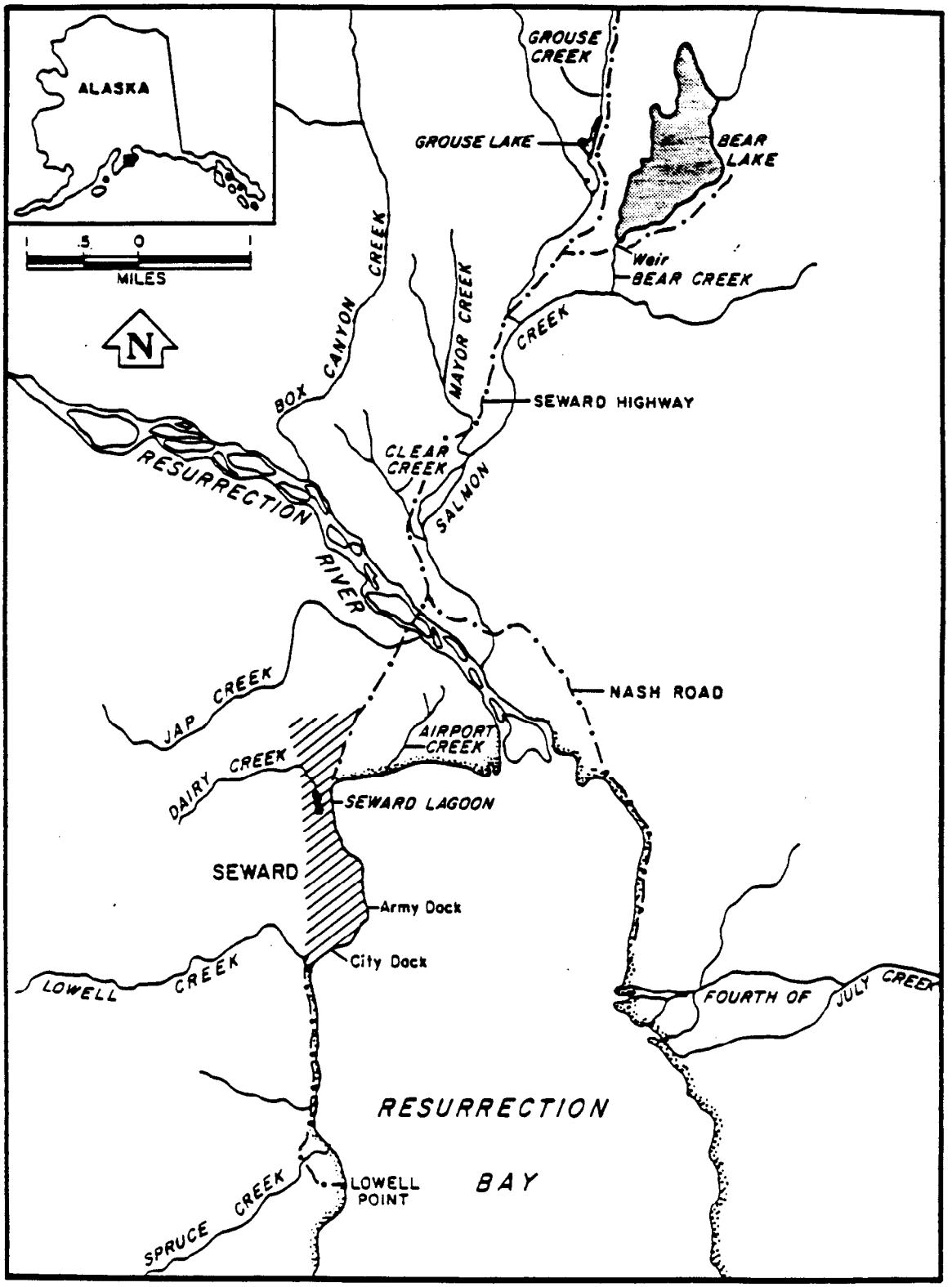

Figure 1. Map of Resurrection Bay, Alaska.

Table 1. Coho salmon fingerlings and hatchery-reared smolts of Bear Lake stock released in Resurrection Bay tributaries, 1989.

Brood Year	Type of Release[a]	Release Date	Release Location	Stocking Data: No. Fish Released	Density (No./Ha)	Weight (Kgs)	Size (No./Kg)	Mark Type	No. Fish Marked
1988	F	5/25	Bear Lake	491,340	2,727	368	1,335	AD-CWT	102,451[b]
1987	S	5/24	Seward	58,808	14,235	1,258	47	AD-CWT	16,063[d]
1988	SO[c]	5/30	Lagoon	93,353	22,597	1,732	54	AD-CWT	15,911[e]
			Total	152,161	36,832	2,990			
1987	S	5/25	Lowell Creek Outfall	66,606		1,435	46	AD-CWT	15,710[f]

[a] F = Fingerling release, S = Smolt release.

[b] Adipose finclipped and coded-wire tagged; 0.5 mm tag code 13/1/1/2/15.

[c] Age 0 smolt.

[d] Adipose finclipped and coded-wire tagged; 1.0 mm tag code A31 18/29.

[e] Adipose finclipped and coded-wire tagged; 1.0 mm tag code A31 18/27.

[f] Adipose finclipped and coded-wire tagged; 1.0 mm tag code A31 18/28.

Table 2. Chinook salmon smolts of early-run Crooked Creek origin released in Resurrection Bay tributaries, 1983-1989.

Brood Year	Release Date	Release Location	No. Smolts Released	Stocking Data: Weight (Kgs)	Stocking Data: Size (No./Kg)	Mark Type	Number Smolts Marked
1982	5/27/83	Box Canyon Rearing Pond	54,500	477	114	None	
1983	6/14/84	Thumb Cove	70,000	1,586	44	None	
1983	6/19/84	Lowell Creek[a]	40,600	1,026	40	None	
1984	6/6-6/7/85	Lowell Creek	132,700	2,281	58	None	
1984	6/13/85	Seward Lagoon	53,250[b]			Ad-CWT	53,001[c]
1985	6/13/86	Lowell Creek	101,000	1,422	71	None	
1986	6/02/87	Lowell Creek	95,963	1,484	65	None	
1987	6/01/88	Seward Lagoon	109,020	1,788	61	None	
1987	6/02/88	Lowell Creek	95,673	1,599	60	None	
1988	6/05/89	Seward Lagoon	109,464	2,343	47	None	
1988	5/31/89	Lowell Creek	122,800	1,663	74	None	
1988	6/09/89	Spring Creek	75,063	1,215	62	None	

[a] Lowell Creek release site is at the outfall of Lowell Creek.

[b] Late-run Kenai River brood source.

[c] Adipose finclipped and coded-wire tagged; tag code B4-14-13.

the adult salmon immigrations. Objective (2) is currently accomplished through a creel survey. The survey is designed to estimate angler-effort and harvest of coho and chinook salmon and groundfish by the sport fishery in Resurrection Bay, the biological characteristics of harvest, and the site-specific contribution of stocked salmon to the harvest.

Data collected for research objectives (1) and (3) are summarized in this report. Creel survey data are summarized by Carlon and Vincent-Lang (in press). Vincent-Lang (1987) presents a complete summary of past stocking activities in Resurrection Bay, including estimates of survival rates and contributions to the sport fishery.

METHODS

The weir on the outlet of Bear Lake is a complete barrier to upstream and downstream fish migration. It is located on Bear Creek, 0.5 km downstream from the outlet of Bear Lake. All emigrating salmon smolts and returning salmon adults captured at the weir were held in a live trap until they could be sorted by species, counted, and sampled for biological data.

Since the inception of the Bear Lake project in 1962, the weir has been operated by the Sport Fish Division. In 1989, operation of the weir was passed to the Cook Inlet Aquaculture Association (CIAA).

Salmon Emigration

Abundance and timing of the emigrations of coho and sockeye salmon smolts from Bear Lake were determined by daily sampling of a downstream-migrant trap at the weir. Trapped smolts were dip-netted from the holding trap, anesthetized in a solution of water and MS-222, sorted by species, and counted before being released into calm water to recover and resume their downstream migration.

The age composition, mean length, and mean weight of the coho and sockeye salmon smolt from Bear Lake were estimated by randomly sampling emigrating smolts during designated temporal strata. Smolts selected for sampling were anesthetized, scale sampled, and the fork length was measured to the nearest 1 millimeter (mm). A subsample of smolts was weighed to the nearest 1 gram. Scale smears were mounted on adhesive-coated cards. The cards were pressed against acetate cards in a heated, hydraulic press and the resulting scale impressions were read with a microfiche projector.

Age compositions of the coho and sockeye salmon smolt were estimated by temporal stratum. For each species, the total number of emigrants during a stratum was multiplied by a proportion of each age group in the sample stratum to obtain the total number of emigrants by age group.

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):

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

where:

$\hat{N}_{ij}$ = the estimated number of smolts of age group i emigrating during stratum j,

N_{Tj} = the total number of smolts emigrating 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-at-age and weight-at-age were calculated using standard normal procedures.

Salmon Immigration

Abundance and timing of the immigrating coho and sockeye salmon returning to Bear Lake were determined by daily sampling of these fish in the upstream-migrant trap at the weir. Fish were dip-netted from the trap, sorted by species, counted, and examined for sex and finclips. All sockeye salmon were released upstream to spawn naturally in Bear Lake. Adult coho salmon surplus to egg-take requirements were either released upstream to spawn or were sold to a commercial processor as part of CIAA's cost recovery program.

The age, sex, and length characteristics of the coho and sockeye salmon immigrations returning to Bear Lake were estimated by randomly sampling returning adults during designated temporal strata. Adults were scale sampled, the sex identified, any finclips noted, and the mid-eye to fork-of-tail length was measured to the nearest 5 millimeters. Scales were removed from the preferred area (Clutter and Whitesel 1956), 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 each species were estimated using the procedures described for the salmon smolts.

Minimum spawning escapements of coho salmon to Bear, Box Canyon, Mayor, Jap, Clear, and Grouse Creeks (Figure 1) were counted visually during periodic stream surveys conducted in October. Both live and dead coho salmon observed during the surveys were counted. Carcasses were examined for finclips and then mutilated to prevent recounting. Fish with a missing adipose fin were assumed to have a coded micro-wire tag implanted in their snouts to indicate their date and location of stocking. Heads were removed from all coho salmon carcasses having a missing adipose fin (indicating the presence of a coded wire tag). Tags were decoded and read to determine if the fish were strays from other original stocking sites. Minimum escapements of coho salmon to each stream were determined by adding mortalities observed to the count of live fish in each tributary.

Estimation of Marine Survival Rates

The marine (smolt-to-adult) survival rate of coho salmon smolts emigrating from Bear Lake (S_{BL}) during 1988 was estimated as:

$$\hat{S}_{BL} = (E_{BL}+\hat{C}_{BL})/M_{BL} \quad (2)$$

where:

E_{BL} = the escapement of coho salmon to the Bear Lake weir in 1989,

$\hat{C}_{BL}$ = the estimated harvest of Bear Lake fish in the Resurrection Bay sport fisheries during 1989, and

M_{BL} = the number of emigrating coho salmon smolts at Bear Lake weir in 1988.

The variance of this estimate was calculated as:

$$V(\hat{S}_{BL}) = V(\hat{C}_{BL})/M_{BL}^2 \quad (3)$$

where the variances of the coho salmon immigration and smolt emigration are assumed to be zero as they are completely counted.

The marine survival rate for coho salmon smolts stocked in Seward Lagoon during 1987 was estimated as for Bear Lake. Typically, the escapement of stocked fish into Seward Lagoon is calculated by subtracting the estimated proportion of naturally spawned fish from the estimated total escapement. However, in 1989 the observed marked to unmarked ratio was actually higher than that of the 1988 Seward Lagoon coho salmon smolt release. Therefore, the entire return was assumed to be of hatchery origin. In this case:

$\hat{C}_{SL}$ = the estimated harvest of Seward Lagoon fish in the Resurrection Bay sport fisheries during 1988, and

E_{SL} = the escapement of coho salmon to Seward Lagoon in 1989 estimated during stream surveys,

M_{SL} = the number of smolts stocked into Seward Lagoon during 1987.

A minimum estimate of the marine survival rate for coho salmon smolts stocked into Lowell Creek was calculated as described above for Seward Lagoon with the exception that E_{SL} could not be defined and was considered to be zero. A waterfall at the Lowell Creek outfall physically precludes spawning in Lowell Creek. Those fish surplus to the harvest stray to other systems or perish in saltwater. The associated survival rate for these smolts is therefore a minimum estimate.

RESULTS

Salmon Emigration

In 1989, 99,787 coho salmon smolt emigrated from Bear Lake (Appendix A1). Subtracting trap and marking mortalities, 99,433 live smolts were released downstream. The run timing of the 1989 migration was comparable to the historical migratory timing of coho salmon smolt from Bear Lake (Figure 2). Of the emigrants released, an estimated 96,228 smolts (96.8%) were age 1.0[1] and 3,205 smolts (3.2%) were age 2.0 (Table 3). The mean length of age 1.0 and age 2.0 smolts increased over the duration of the emigration (Table 4).

Five thousand one hundred forty-two sockeye salmon smolt emigrated from Bear Lake in 1989 (Appendix A1), of which 5,125 live smolts were released downstream. The run timing of the 1989 migration fell within the range of the historical migratory timing of sockeye salmon smolt from Bear Lake (Figure 2). The live emigration was composed of an estimated 3,681 (71.8%) age 1.0 smolts, 1,267 (24.7%) age 2.0 smolts, and 177 (3.5%) age 3.0 smolts (Table 5). The mean length of sockeye salmon smolts increased throughout the emigration (Table 6).

Salmon Immigration

The 1989 escapement of coho salmon to the Bear Creek weir was 5,106 fish. Males (50.4%) and females (49.6%) were about equally represented in the escapement (Appendix A2). Of the fish counted at the weir, 954 were Ad-CWT[2] marked (18.7%) and 4,152 (81.3%) were unmarked. After trap and egg-take mortalities and sale of fish for cost recovery, 282 male and 193 female coho salmon were released upstream to Bear Lake.

The proportion of Ad-CWT marked adult coho salmon at the Bear Lake weir was 0.19 (Appendix A2) a value that was significantly lower ($P > 0.05$) than the proportion of Ad-CWT marked smolts in the 1988 migration ($p = 0.38$, Table 7). This may be the result of straying of adults returning from a release of 257,461 unmarked hatchery-reared coho salmon fingerlings of Bear Lake origin into Box Canyon Creek during 1987 (Vincent-Lang et al. 1988). Given the low return rate of adult coho salmon to Box Canyon Creek during 1989 (171, Table 8), it is probable that a portion of these fish could have returned to Bear Lake during 1989. This would explain the discrepancy in tag ratios.

The run timing of adults in 1989 fell within the range of the historical migratory timing of coho salmon at Bear Lake, but peaked earlier than the historical average (Figure 3). The migration was composed of an estimated 4,174 (81.7%) age 1.1 adults and 932 (18.3%) age 2.1 adults (Table 9). While

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

[2] Adipose finclipped and coded wire tagged.

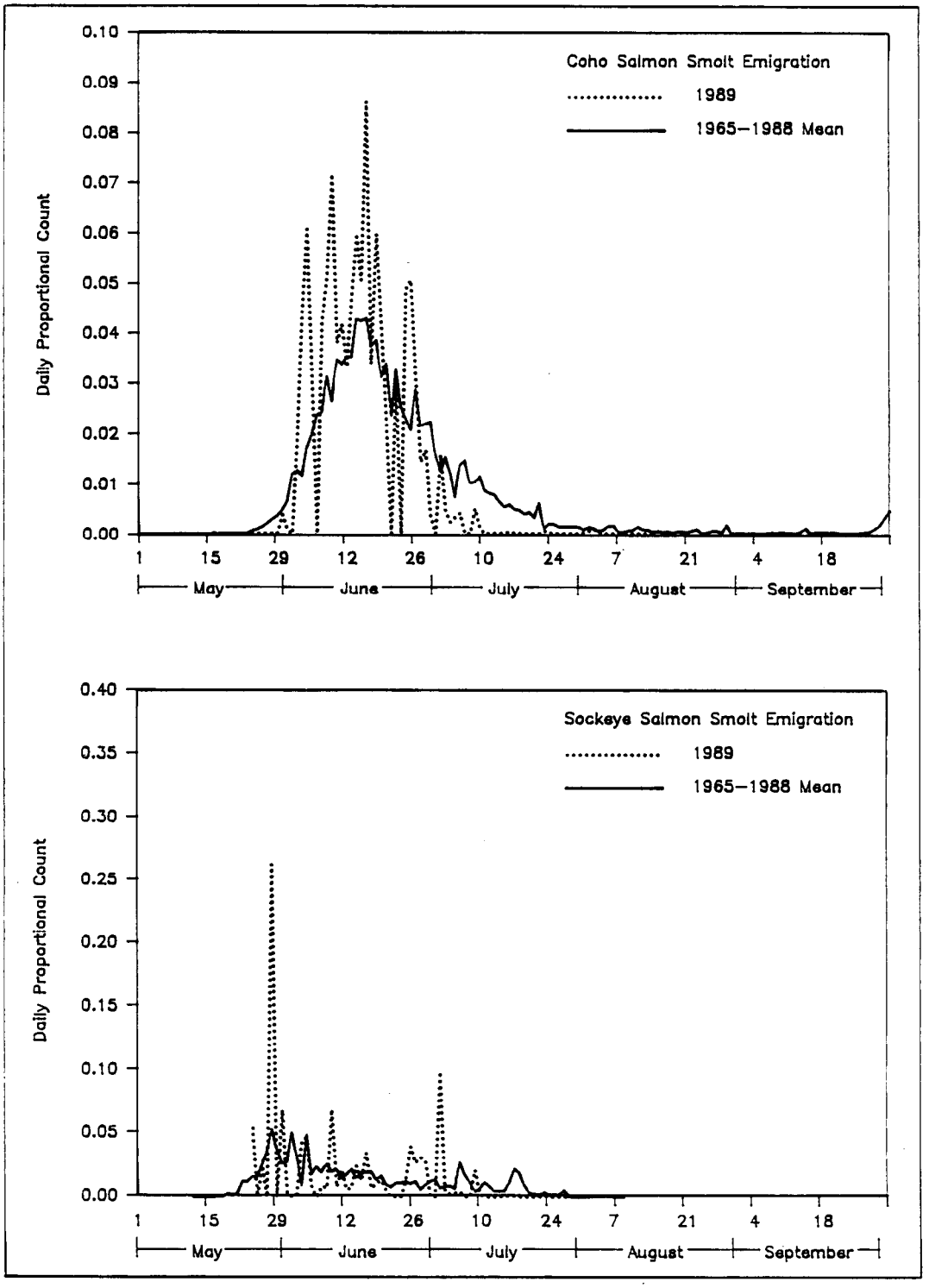

Figure 2. Migrational timing of the 1989 coho and sockeye salmon emigrations through Bear Creek weir compared to the historical emigrational timing of these species.

Table 3. Estimated abundance, by age group, of coho salmon smolts emigrating through the Bear Creek weir, 1989.

Period[a]		Age Group 1.0	Age Group 2.0	Total
5/16-6/07	Percent	99.0	1.0	100.0
(n = 199)	Estimated Number	18,581	188	18,769
	Standard Error	132	132	
6/08-6/15	Percent	96.5	3.5	100.0
(n = 144)	Estimated Number	35,054	1,271	36,325
	Standard Error	557	557	
6/16-6/30	Percent	98.0	2.0	100.0
(n = 149)	Estimated Number	39,807	812	40,619
	Standard Error	467	467	
7/01-8/14	Percent	74.9	25.1	100.0
(n = 171)	Estimated Number	2,786	934	3,720
	Standard Error	121	121	
Total	Percent	96.8	3.2	100.0
(n=663)	Estimated Number	96,228	3,205	99,433[b]
	Standard Error	749	749	

[a] n = number sampled.

[b] A total of 99,787 coho salmon smolts emigrated from Bear Lake in 1989. Trap mortalities accounted for 354 coho salmon smolts; 99,433 live smolts were released downstream.

Table 4. Mean fork length (millimeters) and weight (grams) of coho salmon smolts sampled at the Bear Creek weir, 1989.

Period		Age Group 1.0 Length	1.0 Weight	2.0 Length	2.0 Weight
5/16-6/07	Mean	113.8	13.7	137.8	
	Standard Error	0.3	0.2	4.8	
	Sample Size	197	59	12	
6/08-6/15	Mean	116.1	14.4	134.2	23.0
	Standard Error	0.5	0.5	5.0	
	Sample Size	139	29	5	1
6/16-6/30	Mean	119.6	16.7	133.0	19.5
	Standard Error	0.4	0.3	6.8	0.5
	Sample Size	146	58	3	2
7/01-8/14	Mean	140.7	28.1	145.6	32.2
	Standard Error	1.1	1.1	1.8	1.7
	Sample Size	166	58	43	27

Table 5. Estimated abundance, by age group, of sockeye salmon smolts emigrating through the Bear Creek weir, 1989.

Period[a]		Age Group 1.0	2.0	3.0	Total
5/24-6/07	Percent	65.8	29.3	4.9	100.0
(n = 82)	Estimated Number	1,721	766	128	2,615
	Standard Error	136	130	62	
6/08-6/15	Percent	81.1	17.5	1.4	100.0
(n = 143)	Estimated Number	628	135	11	774
	Standard Error	23	22	7	
6/16-7/31	Percent	76.7	21.1	2.2	100.0
(n = 180)	Estimated Number	1,332	366	38	1,736
	Standard Error	52	50	18	
Total	Percent	71.8	24.7	3.5	100.0
(n = 405)	Estimated Number	3,681	1,267	177	5,125[b]
	Standard Error	147	141	65	

[a] n = number sampled.

[b] A total of 5,142 sockeye salmon smolts emigrated from Bear Lake in 1989. Trap mortalities accounted for 17 sockeye salmon smolts; 5,125 live smolts were released downstream.

Table 6. Mean fork length (millimeters) and weight (grams) of sockeye salmon smolts sampled at the Bear Creek weir, 1989.

Period		Age Group 1.0 Length	1.0 Weight	2.0 Length	2.0 Weight	3.0 Length	3.0 Weight
5/24-6/07	Mean	121.5	18.8	151.5	35.6	191.8	69.0
	Standard Error	1.5	1.1	3.0	2.7	4.8	5.3
	Sample Size	54	35	24	21	4	4
6/08-6/15	Mean	125.4	20.6	155.0	30.4	198.0	
	Standard Error	0.8	1.2	3.7	6.8	6.0	
	Sample Size	116	18	25	5	2	
6/16-7/31	Mean	130.6	23.0	159.8	38.9	206.0	
	Standard Error	0.8	0.7	2.9	2.9	5.2	
	Sample Size	138	41	38	19	4	

Table 7. Summary of the 1986-1988 Bear Lake coho salmon fingerling plants, the 1988 Bear Lake coho salmon smolt emigration, and the 1988 hatchery-reared smolt releases contributing to the 1989 adult coho salmon return.

FINGERLING PLANTS

Brood[a] Year	Release Date	Release Location	No. Fish Released	Stocking Data: Density (No./Acre)	Stocking Data: Weight (Lbs)	Stocking Data: Size (No./Lb)	Mark Type	No. Fish Marked
1985	7/09/86	Bear Lake	445,730	1,002	1,946	229	Ad-CWT[b]	47,148
1986	7/07/87	Bear Lake	226,300	509	838	270	Ad-CWT[c]	50,226
1987	6/02/88	Bear Lake	347,200	781	766	454	Ad-CWT[d]	67,063

SMOLT EMIGRATION ENUMERATED AT BEAR CREEK WEIR IN 1988

Brood Year	Date		No. of Emigrants	Stocking Data: Density (No./Acre)	Stocking Data: Weight (Lbs)	Stocking Data: Size (No./Lb)	Mark Type	Proportion Marked
1985	5/16-8/12/88		13,283[e]	NA	NA	20.3	Ad-CWT[f]	
1986	5/16-8/12/88		50,492[e]	NA	NA	27.7	Ad-CWT[f]	
		Total	63,775					0.38[g]

-Continued-

Table 7. (Page 2 of 2).

SMOLT RELEASES

Brood[a] Year	Release Date	Release Location	No. Fish Released	Stocking Data: Density (No./Acre)	Stocking Data: Weight (Lbs)	Stocking Data: Size (No./Lb)	Mark Type	No. Fish Marked
1986	5/23,5/25/88	Seward Lagoon	118,741	11,641	1,202	98.8	Ad-CWT[h]	17,666
1986	5/24,6/02/88	Lowell Creek Outfall	63,806		618	103.2	Ad-CWT[i]	14,177

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

[b] Adipose finclipped and coded-wire tagged; tag code B3-13-14.

[c] Adipose finclipped and coded-wire tagged; tag codes B3-03-08, B3-03-09, B3-03-10, B3-03-11, and B3-15-08.

[d] Adipose finclipped and coded-wire tagged; tag code B3-02-05.

[e] Estimated from age composition.

[f] Adipose finclipped and coded-wire tagged; tag codes B3-13-14 (1986 release), B3-03-08, B3-03-09, B3-03-10, B3-03-11, and B3-15-08 (1987 release).

[g] Estimated from an examined sample of the coho smolt outmigration.

[h] Adipose finclipped and coded-wire tagged; tag codes A31-18-06, A31-17-44.

[i] Adipose finclipped and coded-wire tagged; tag code A31-18-07.

Table 8. Summary of coho salmon escapement counts for Resurrection Bay tributaries visually surveyed in 1989.

Stream	Minimum Escapement	Carcasses		
		Number Examined	Number Marked[a]	Number Unmarked
Lower Bear Creek	0			
Box Canyon Creek	171	11	0	11
Seward Lagoon System[b]	685	147	33[c]	114
Clear Creek	88	3	0	3
Mayor Creek	109	28	1[d]	27
Grouse Creek	113	2	0	2
Jap Creek	310	27	6[e]	21

[a] Marked with an adipose finclip.

[b] Seward Lagoon system includes Dairy Creek, Pasture Creek, Railroad Creek, and First Lake Creek.

[c] Seven of the 33 marked fish were sampled. Of these, 5 originated from the 1988 Seward Lagoon release and 2 originated from the 1988 Lowell Creek release.

[d] This fish originated from the 1988 Lowell Creek release.

[e] Five of the 6 marked fish were sampled. Of these, 3 originated from the 1988 Seward Lagoon release and 2 originated from the 1988 Lowell Creek release.

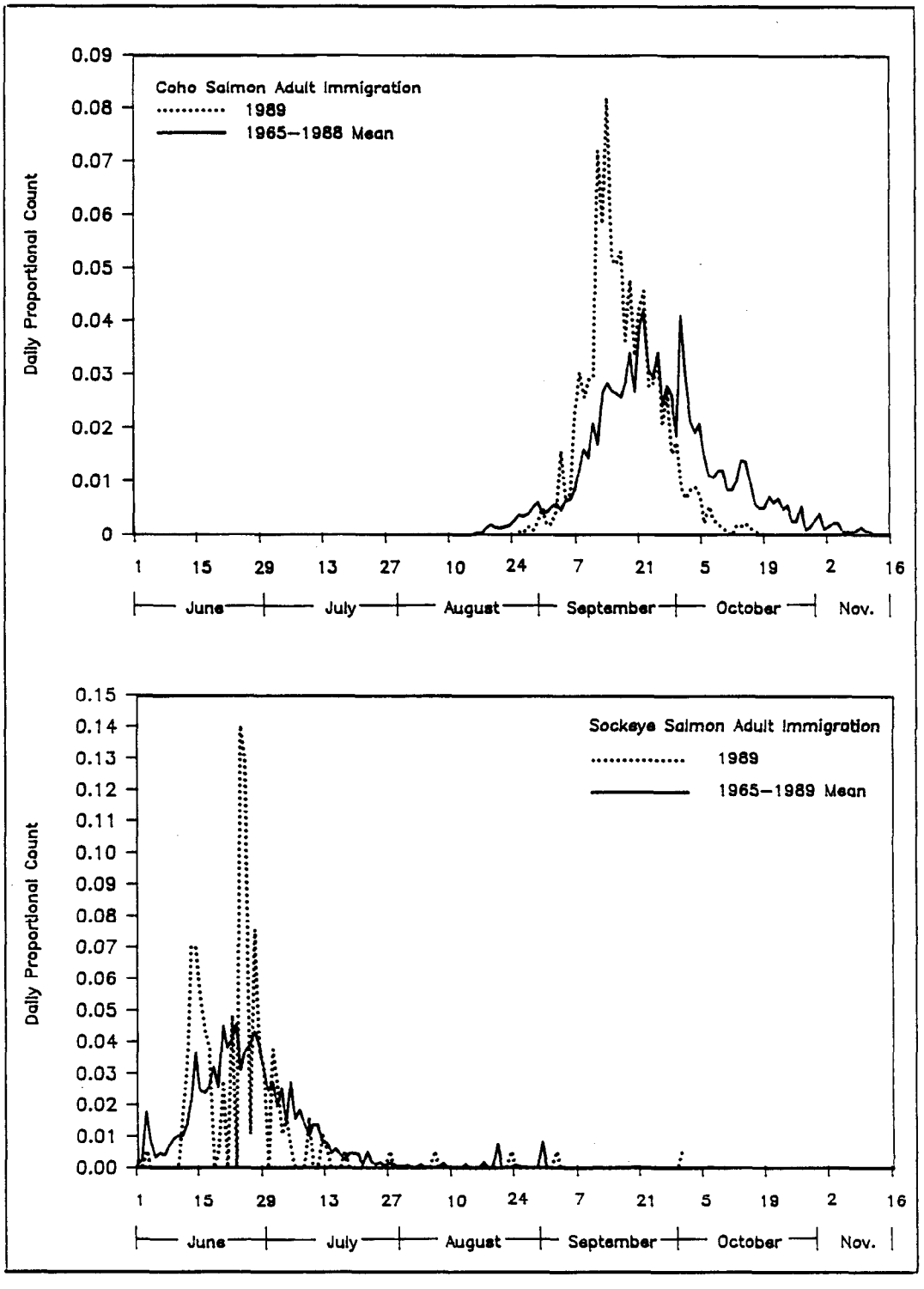

Figure 3. Migrational timing of the 1989 coho and sockeye salmon immigrations through Bear Creek weir compared to the historical immigrational timing of these species.

Table 9. Estimated abundance, by age group, of the coho salmon adult immigration through the Bear Creek weir, 1989.

Period[a]			Age Group 1.1	Age Group 2.1	Total
9/01-9/15					
(n=93)	Male	Percent	89.2	10.8	100.0
		Estimated Number	945	114	1,059
		Standard Error	33	33	
(n=48)	Female	Percent	75.0	25.0	100.0
		Estimated Number	429	143	572
		Standard Error	35	35	
9/16-9/30					
(n=83)	Male	Percent	84.3	15.7	100.0
		Estimated Number	1,126	210	1,336
		Standard Error	52	52	
(n=107)	Female	Percent	78.5	21.5	100.0
		Estimated Number	1,349	369	1,718
		Standard Error	62	66	
10/01-10/31					
(n=78)	Male	Percent	80.8	19.2	100.0
		Estimated Number	145	35	180
		Standard Error	6	6	
(n=83)	Female	Percent	74.7	25.3	100.0
		Estimated Number	180	61	241
		Standard Error	9	9	
Total					
	Male	Percent	86.1	13.9	100.0
		Estimated Number	2,216	359	2,575
		Standard Error	62	62	
	Female	Percent	77.4	22.6	100.0
		Estimated Number	1,958	573	2,531
		Standard Error	72	72	
	Combined	Percent	81.7	18.3	100.0
		Estimated Number	4,174	932	5,106
		Standard Error	95	95	

[a] n = number sampled.

no jacks were sampled for age, 6 were caught in the trap and passed upstream to Bear Lake. Age 1.1 males averaged 563 mm and age 1.1 females averaged 577 mm; age 2.1 males averaged 582 mm and age 2.1 females average 591 mm (Table 10). Minimum estimates of escapements of coho salmon and tag recoveries in other index tributaries in the Resurrection Bay drainage are presented in Table 8. These data indicate that straying of stocked fish did occur in many of the surveyed streams.

The immigration of sockeye salmon to the Bear Creek weir during 1989 totaled 185 adults (Appendix A3). All 185 adults (76 males and 109 females) were released upstream. The run timing of the immigration during 1989 was similar to the historical run timing, although the peak occurred earlier than average and solitary sockeye salmon continued to reach the weir from early July through late September (Figure 3). The estimated age composition of the immigration during 1989 was 174 (94.1%) age 1.2 and 11 (5.9%) age 1.3 adults (Table 11). Mean length-at-age of sockeye salmon ranged from 486 mm for age 1.2 females to 562 mm for age 1.3 males (Table 12).

Marine Survival Rate Estimates

The 63,775 coho salmon smolts that emigrated from Bear Lake in 1988 (Carlon and Vincent-Lang 1989) returned as adult coho salmon to the Resurrection Bay sport fishery and to Bear Lake weir in 1989 (Table 7). The majority of these smolts were from the 1986 and 1987 fingerling plants in Bear Lake. Estimated sport harvest of coho salmon from Bear Lake in the boat and beach fisheries during 1989 was 1,300 fish (SE = 162) (Carlon and Vincent-Lang in press). The total return (production) was the sum of the harvest and the escapement, or 1,300 + 5,106 = 6,406 adult coho salmon. The marine survival of the 1988 smolt cohort was 6,406/63,775 = 10.0% (SE = 0.3%) (Table 13). However, if fish stocked at Box Canyon Creek strayed to Bear Lake in 1989, the estimated marine survival rate of 1988 Bear Lake smolts may be lower.

Hatchery-reared smolts released in Seward Lagoon and Lowell Creek in 1988 also contributed to the 1989 return of coho salmon to Resurrection Bay (Table 7). The estimated sport harvests of Seward Lagoon and Lowell Creek coho salmon in the 1989 boat and beach fisheries were 3,618 (SE = 467) and 1,293 fish (SE = 195), respectively (Carlon and Vincent-Lang in press). These estimates and escapement (Seward Lagoon only) counts (Table 8) yield estimated minimum marine survival rates of 3.6% (SE = 0.4%) and 2.0% (SE = 0.3%), respectively, for smolts stocked in Seward Lagoon and Lowell Creek during 1989 (Table 13).

RECOMMENDATIONS

Straying of unmarked fish that were stocked at Box Canyon Creek biased, to some extent, our estimates of escapement and survival of fish stocked in Bear Lake. We do not think that the level of straying compromised the conclusions that we reached from these data.

Recent Board of Fisheries actions have rescinded escapement limits for sockeye salmon into Bear Lake and allowed for the stocking of sockeye salmon

Table 10. Mean length[a] (millimeters), by sex and age group, of adult coho salmon sampled at the Bear Creek weir, 1989.

		Age Group	
		1.1	2.1
Male	Mean	563	582
	Standard Error	3	8
	Sample Size	216	38
Female	Mean	577	591
	Standard Error	3	6
	Sample Size	182	56

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

Table 11. Estimated abundance, by age group, of the sockeye salmon immigration through the Bear Creek weir, 1989.

Sex		Age Group 1.2	1.3	Total
Male	Percent	95.5	4.5	100.0
	Est. Number	73	3	76
	Standard Error	2	2	
Female	Percent	93.0	7.0	100.0
	Est. Number	101	8	109
	Standard Error	3	3	
Total (n=101)[a]	Percent	94.1	5.9	100.0
	Est. Number	174	11	185
	Standard Error	4	4	

[a] n = sample size.

Table 12. Mean length[a] (millimeters), by sex and age group, of adult sockeye salmon sampled at the Bear Creek weir, 1989.

Sex		Age Group 1.2	Age Group 1.3
Male	Length	514	562
	Standard Error	4	12
	Sample Size	42	2
Female	Length	486	521
	Standard Error	3	9
	Sample Size	53	4

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

Table 13. Estimated smolt-to-adult survivals of hatchery-reared coho salmon smolts emigrating from Bear Lake and released into Seward Lagoon and Lowell Creek in 1988.

Location	Number of Smolts	Sport Harvest[a]		Escapement	Survival	
		Number	SE[b]		Percent	SE[b]
Bear Lake	63,775[c]	1,300	162	5,106[e]	10.0	0.3
Seward Lagoon	118,741[d]	3,618	467	685[f]	3.6	0.4
Lowell Creek Outfall	63,806[d]	1,293	195	---[g]	2.0	0.3

[a] Reported in Carlon and Vincent-Lang (in press).

[b] Standard error (expressed in percent).

[c] The number of live smolts that emigrated past the Bear Creek weir in 1988.

[d] The number of hatchery-reared smolts stocked into this location in 1988.

[e] Return of coho salmon to the Bear Creek weir in 1989.

[f] The estimated minimum escapement of smolts stocked in 1988 (see Table 9).

[g] A waterfall at the Lowell Creek outfall presents a physical barrier to fish migration and precludes spawning in this system. There is no escapement to this creek; fish surplus to the harvest stray to other systems or perish in salt water. The survival rate is therefore a minimum.

into the lake (Appendix B1). As part of their actions, the Board also mandated that there be no net loss of coho salmon production in Bear Lake as a result of these actions. This has resulted in a scheduled release of both sockeye and coho salmon fingerlings into the lake during 1990.

The weir on Bear Creek allows for a complete count of smolt that result from specific stocking efforts. Furthermore, smolt production data can be compared to similar data collected at Bear Lake for the past 26 years. Continued counts of smolt will be used to determine if increased rates of sockeye salmon stocking will cause a decrease in the production of coho salmon from Bear Lake. We recommend that:

1. The assessment of coho and sockeye salmon production from the annual stockings of coho and sockeye salmon fingerlings into Bear Lake be continued. This will allow for an evaluation of the effect of stocking strategies stipulated in Vincent-Lang et al. (1987) and the effect of interspecies interactions on smolt production.

2. The proportional contribution of stocked coho and sockeye salmon to the marine sport and commercial fisheries be examined. This will allow for an evaluation of smolt-to-adult survival rates for the stocked fingerlings as well as cost-benefit analyses of specific stocking strategies.

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APPENDIX A

Appendix A1. Daily emigration of coho and sockeye salmon smolts from Bear Lake, 1989.

	Coho Salmon Smolts			Sockeye Salmon Smolts		
Date	Dead	Live	Total	Dead	Live	Total
5/16	0	15	15			
5/17	0	0	0			
5/18	0	1	1			
5/19	0	0	0			
5/20	0	0	0			
5/21	0	0	0			
5/22	0	0	0			
5/23	0	0	0			
5/24	0	0	0	2	270	272
5/25	0	0	0	0	0	0
5/26	0	16	16	0	121	121
5/27	0	0	0	0	0	0
5/28	0	17	17	0	1,323	1,323
5/29	0	0	0	0	0	0
5/30	0	360	360	1	343	344
5/31	0	70	70	0	14	14
6/01	0	0	0	0	0	0
6/02	0	1,760	1,760	0	10	10
6/03	26	4,042	4,068	0	224	224
6/04	1	5,648	5,649	0	236	236
6/05	0	2,918	2,918	0	32	32
6/06	0	0	0	0	0	0
6/07	3	3,922	3,925	0	42	42
6/08	26	4,767	4,793	0	35	35
6/09	3	6,655	6,658	0	347	347
6/10	2	3,518	3,520	0	39	39
6/11	2	3,864	3,866	0	107	107
6/12	3	3,073	3,076	1	26	27
6/13	4	4,363	4,367	0	36	36
6/14	93	5,416	5,509	2	121	123
6/15	19	4,669	4,688	0	63	63
6/16	2	8,011	8,013	0	175	175
6/17	34	3,102	3,136	1	33	34
6/18	21	5,536	5,557	0	54	54
6/19	7	3,810	3,817	0	64	64
6/20	6	2,083	2,089	0	26	26
6/21	0	0	0	0	0	0
6/22	19	2,821	2,840	0	0	0
6/23	0	0	0	0	0	0
6/24	11	4,525	4,536	8	54	62

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	Coho Salmon Smolts			Sockeye Salmon Smolts		
Date	Dead	Live	Total	Dead	Live	Total
6/25	21	4,679	4,700	2	198	200
6/26	5	2,868	2,873	0	133	133
6/27	11	1,315	1,326	0	155	155
6/28	4	1,551	1,555	0	138	138
6/29	2	318	320	0	2	2
6/30	0	0	0	0	0	0
7/01	2	1,475	1,477	0	499	499
7/02	0	413	413	0	19	19
7/03	1	211	212	0	10	10
7/04	0	307	307	0	16	16
7/05	5	383	388	0	20	20
7/06	0	0	0	0	0	0
7/07	0	0	0	0	0	0
7/08	2	461	463	0	106	106
7/09	0	99	99	0	12	12
7/10	0	0	0	0	0	0
7/11	0	0	0	0	0	0
7/12	0	13	13	0	0	0
7/13	0	7	7	0	0	0
7/14	10	12	22	0	3	3
7/15	0	42	42	0	6	6
7/16	0	11	11	0	5	5
7/17	0	0	0	0	0	0
7/18	0	0	0	0	0	0
7/19	0	0	0	0	0	0
7/20	0	0	0	0	0	0
7/21	0	1	1	0	1	1
7/22	0	55	55	0	4	4
7/23	1	22	23	0	1	1
7/24	0	0	0	0	0	0
7/25	0	0	0	0	0	0
7/26	0	0	0	0	0	0
7/27	0	0	0	0	0	0
7/28	0	0	0	0	0	0
7/29	0	0	0	0	0	0
7/30	1	31	32	0	1	1
7/31	1	52	53	0	1	1
8/01	0	103	103			
8/02	0	20	20			
8/03	0	0	0			

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	Coho Salmon Smolts			Sockeye Salmon Smolts		
Date	Dead	Live	Total	Dead	Live	Total
8/04	0	0	0			
8/05	0	0	0			
8/06	0	0	0			
8/07	0	0	0			
8/08	0	0	0			
8/09	0	0	0			
8/10	0	0	0			
8/11	0	0	0			
8/12	0	0	0			
8/13	0	0	0			
8/14[a]	6	2	8			
Total	354	99,433	99,787	17	5,125	5,142

[a] Downstream migrant trap was closed on 8/14/88 to prevent straying juvenile salmonids from washing downstream.

Appendix A2. Daily immigration of coho salmon through the Bear Creek weir, 1989.

Date	Males			Females			Daily Total	Marked Fish[a]
	Dead	Live	Total	Dead	Live	Total		
8/28	0	3	3	0	1	1	4	1
8/29	0	2	2	0	1	1	3	1
8/30	0	5	5	0	4	4	9	4
8/31	0	2	2	0	3	3	5	1
9/01	0	8	8	0	5	5	13	5
9/02	0	21	21	0	5	5	26	5
9/03	0	10	10	0	0	0	10	3
9/04	0	9	9	0	2	2	11	2
9/05	0	16	16	0	8	8	24	7
9/06	0	55	55	0	26	26	81	16
9/07	0	26	26	0	6	6	32	6
9/08	0	26	26	0	14	14	40	9
9/09	0	87	87	0	29	29	116	25
9/10	0	116	116	0	40	40	156	29
9/11	0	88	88	0	44	44	132	31
9/12	0	98	98	0	51	51	149	29
9/13	0	103	103	0	49	49	152	24
9/14	0	221	221	0	148	148	369	78
9/15	0	163	163	0	136	136	299	55
9/16	0	194	194	0	226	226	420	82
9/17	0	106	106	0	158	158	264	37
9/18	0	106	106	0	154	154	260	53
9/19	0	105	105	0	168	168	273	50
9/20	0	85	85	0	101	101	186	29
9/21	0	127	127	0	118	118	245	50
9/22	0	67	67	0	105	105	172	40
9/23	0	82	82	0	134	134	216	38
9/24	0	114	114	0	121	121	235	40
9/25	0	69	69	0	73	73	142	26
9/26	0	65	65	0	80	80	145	29
9/27	0	89	89	0	86	86	175	27
9/28	0	47	47	0	58	58	105	13
9/29	0	53	53	0	85	85	138	27
9/30	0	27	27	0	51	51	78	18
10/01	0	28	28	0	61	61	89	12

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Appendix A2. (Page 2 of 2).

Date	Males			Females			Daily Total	Marked Fish[a]
	Dead	Live	Total	Dead	Live	Total		
10/02	0	18	18	0	27	27	45	5
10/03	0	14	14	0	21	21	35	4
10/04	0	18	18	0	26	26	44	5
10/05	0	19	19	0	27	27	46	10
10/06	0	20	20	0	18	18	38	9
10/07	0	4	4	0	8	8	12	3
10/08	0	13	13	0	15	15	28	7
10/09	0	4	4	0	11	11	15	4
10/10	0	8	8	0	3	3	11	0
10/11	0	4	4	0	3	3	7	1
10/12	0	1	1	0	3	3	4	1
10/13	0	0	0	0	0	0	0	0
10/14	0	4	4	0	6	6	10	2
10/15	0	6	6	0	3	3	9	1
10/16	0	7	7	0	5	5	12	0
10/17	0	5	5	0	2	2	7	0
10/18	0	3	3	0	2	2	5	0
10/19	0	2	2	0	0	0	2	0
10/20	0	1	1	0	0	0	1	0
10/21[b]	0	1	1	0	0	0	1	0
Total	0	2,575[c]	2,575	0	2,531[d]	2,531	5,106	954

[a] Adipose finclipped and coded-wire tagged.

[b] Passage of fish at the weir ceased on 10/21/89.

[c] Of 2,575 males returning to the weir, a total of 178 males were killed to fertilize the 1989 egg take.

[d] Of 2,531 females returning to the weir, a total of 349 females were killed for the 1989 egg take.

Appendix A3. Daily immigration of sockeye salmon through the Bear Creek weir, 1989.

Date	Males			Females			Daily Total
	Dead	Live	Total	Dead	Live	Total	
6/03	0	1	1	0	0	0	1
6/04	0	0	0	0	0	0	0
6/05	0	0	0	0	0	0	0
6/06	0	0	0	0	0	0	0
6/07	0	0	0	0	0	0	0
6/08	0	0	0	0	0	0	0
6/09	0	0	0	0	0	0	0
6/10	0	0	0	0	0	0	0
6/11	0	3	3	0	0	0	3
6/12	0	4	4	0	2	2	6
6/13	0	6	6	0	7	7	13
6/14	0	7	7	0	6	6	13
6/15	0	3	3	0	7	7	10
6/16	0	6	6	0	2	2	8
6/17	0	4	4	0	3	3	7
6/18	0	0	0	0	0	0	0
6/19	0	1	1	0	0	0	1
6/20	0	1	1	0	4	4	5
6/21	0	0	0	0	0	0	0
6/22	0	2	2	0	7	7	9
6/23	0	0	0	0	0	0	0
6/24	0	10	10	0	16	16	26
6/25	0	11	11	0	13	13	24
6/26	0	2	2	0	0	0	2
6/27	0	5	5	0	9	9	14
6/28	0	2	2	0	5	5	7
6/29	0	1	1	0	5	5	6
6/30	0	0	0	0	0	0	0
7/01	0	4	4	0	3	3	7
7/02	0	0	0	0	5	5	5
7/03	0	1	1	0	1	1	2
7/04	0	1	1	0	2	2	3
7/05	0	0	0	0	1	1	1
7/06	0	0	0	0	0	0	0
7/07	0	0	0	0	0	0	0
7/08	0	0	0	0	0	0	0
7/09	0	0	0	0	3	3	3
7/10	0	0	0	0	0	0	0
7/11	0	0	0	0	0	0	0

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Appendix A3. (Page 2 of 4).

Date	Males			Females			Daily Total
	Dead	Live	Total	Dead	Live	Total	
7/12	0	0	0	0	2	2	2
7/13	0	0	0	0	1	1	1
7/14	0	0	0	0	0	0	0
7/15	0	0	0	0	0	0	0
7/16	0	0	0	0	0	0	0
7/17	0	0	0	0	1	1	1
7/18	0	0	0	0	0	0	0
7/19	0	0	0	0	0	0	0
7/20	0	0	0	0	0	0	0
7/21	0	0	0	0	0	0	0
7/22	0	0	0	0	0	0	0
7/23	0	0	0	0	0	0	0
7/24	0	0	0	0	0	0	0
7/25	0	0	0	0	0	0	0
7/26	0	0	0	0	0	0	0
7/27	0	0	0	0	1	1	1
7/28	0	0	0	0	0	0	0
7/29	0	0	0	0	0	0	0
7/30	0	0	0	0	0	0	0
7/31	0	0	0	0	0	0	0
8/01	0	0	0	0	0	0	0
8/02	0	0	0	0	0	0	0
8/03	0	0	0	0	0	0	0
8/04	0	0	0	0	0	0	0
8/05	0	0	0	0	0	0	0
8/06	0	0	0	0	1	1	1
8/07	0	0	0	0	0	0	0
8/08	0	0	0	0	0	0	0
8/09	0	0	0	0	0	0	0
8/10	0	0	0	0	0	0	0
8/11	0	0	0	0	0	0	0
8/12	0	0	0	0	0	0	0
8/13	0	0	0	0	0	0	0
8/14	0	0	0	0	0	0	0
8/15	0	0	0	0	0	0	0
8/16	0	0	0	0	0	0	0
8/17	0	0	0	0	0	0	0
8/18	0	0	0	0	0	0	0
8/19	0	0	0	0	0	0	0

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Appendix A3. (Page 3 of 4).

Date	Males			Females			Daily Total
	Dead	Live	Total	Dead	Live	Total	
8/20	0	0	0	0	0	0	0
8/21	0	0	0	0	0	0	0
8/22	0	0	0	0	0	0	0
8/23	0	0	0	0	1	1	1
8/24	0	0	0	0	0	0	0
8/25	0	0	0	0	0	0	0
8/26	0	0	0	0	0	0	0
8/27	0	0	0	0	0	0	0
8/28	0	0	0	0	0	0	0
8/29	0	0	0	0	0	0	0
8/30	0	0	0	0	0	0	0
8/31	0	0	0	0	0	0	0
9/01	0	0	0	0	0	0	0
9/02	0	0	0	0	1	1	1
9/03	0	0	0	0	0	0	0
9/04	0	0	0	0	0	0	0
9/05	0	0	0	0	0	0	0
9/06	0	0	0	0	0	0	0
9/07	0	0	0	0	0	0	0
9/08	0	0	0	0	0	0	0
9/09	0	0	0	0	0	0	0
9/10	0	0	0	0	0	0	0
9/11	0	0	0	0	0	0	0
9/12	0	0	0	0	0	0	0
9/13	0	0	0	0	0	0	0
9/14	0	0	0	0	0	0	0
9/15	0	0	0	0	0	0	0
9/16	0	0	0	0	0	0	0
9/17	0	0	0	0	0	0	0
9/18	0	0	0	0	0	0	0
9/19	0	0	0	0	0	0	0
9/20	0	0	0	0	0	0	0
9/21	0	0	0	0	0	0	0
9/22	0	0	0	0	0	0	0
9/23	0	0	0	0	0	0	0
9/24	0	0	0	0	0	0	0
9/25	0	0	0	0	0	0	0
9/26	0	0	0	0	0	0	0
9/27	0	0	0	0	0	0	0

-Continued-

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Date	Males			Females			Daily Total
	Dead	Live	Total	Dead	Live	Total	
9/28	0	0	0	0	0	0	0
9/29	0	0	0	0	0	0	0
9/30	0	1	1	0	0	0	1
Total	0	76	76	0	109	109	185

APPENDIX B

5 AAC 21.375. BEAR LAKE MANAGEMENT PLAN.(a) Any restrictions in earlier board policies on the maximum number of indigenous Bear Lake sockeye salmon spawners are rescinded. The department shall establish an escapement goal for Bear Lake sockeye salmon stocks and shall manage all contributing fisheries to meet this goal.

(b) Enhancement activities related to either indigenous Bear Lake sockeye salmon stocks or transplanted sockeye salmon stocks must consider the impact on continuing enhancement of Bear Lake coho salmon. It is the intent of the Board of Fisheries that

(1) any enhancement of sockeye salmon must not cause a net loss of coho salmon production from Bear Lake;

(2) any enhancement of sockeye salmon in Bear Lake must maintain the early run timing of the indigenous stocks;

(3) the prime objective of any Bear Lake sockeye salmon enhancement must be to provide the opportunity for a commercially viable sockeye salmon fishery prosecuted with minimal conflict with the recreational fishery.