

## RESEARCH PROJECT SEGMENT

*State:* Alaska

*Project No.:* F-9-3

*Name:* Sport Fish Investigations of Alaska.

*Study No.:* G-11

*Study Title:* Sport Fish Studies.

*Job No.:* G-11-A

*Job Title:* Silver Salmon Studies in the Resurrection Bay Area.

*Period Covered:* July 1, 1970 to June 30, 1971.

## ABSTRACT

This report is a continuation of studies initiated in 1960 on silver salmon, Oncorhynchus kisutch, in the Resurrection Bay area.

The Bear Creek weir downstream migrant trap was operated continuously from May 18 to October 31. The silver salmon smolt outmigration began on June 3, peaked on June 23, and terminated October 8. The outmigration consisted of 6,147 unmarked (natural) smolts and three Ad-RV clipped age III smolts. No age III smolts were produced by the 1967 plant of Ad-LV marked fingerling in Bear Lake. The age composition of unmarked smolts was 8.2% age I, 59.2% age II, 32.2% age III, and 0.4% age IV. Mean fork length per age groups I through III were 107.8, 134.9, and 158.1 mm, respectively.

The Seward small boat harbor creel census was conducted from July 3 to September 8. An estimated 14,865 silver salmon were harvested in Resurrection Bay by 27,125 man-days of sport fishing effort. The mean seasonal catch per hour was 0.08 silver salmon. Fishing mortality of marked Bear Lake fish was an estimated 1.35%.

The Bear Creek weir upstream migrant trap was operated continuously from May 18 to November 14. The adult silver salmon upstream migration

extended from August 20 to November 11, and peaked on October 3. The adult migration was enumerated at 251 silver salmon, and consisted of 1 age 2.1 (Ad-LV clip), 14 age 2.1 (Ad-RV clip), 3 age 1.1 (Ad clip) and 233 unmarked fish. Unmarked fish were comprised of 7.9% age 1.1, 82.0% age 2.1, 9.0% age 3.1, and 1.1% age 4.1. Marine survival of the Ad-LV, Ad-RV, and Ad marked adults was 0.02, 0.28, and 0.01%, respectively. The adult male-to-female sex ratio was 1.5:1. An estimated 260,900 eggs were artificially spawned from 66 female silver salmon at Bear Creek weir. Average fecundity was 3,953 eggs per female.

Data on the timing and abundance of other fish species passing the Bear Creek weir are presented. The success of recent smolt plants in Bear Creek and Seward Lagoon, changes in age structures and size composition of natural Bear Lake smolts, and the increased abundance of threespine stickleback, Gasterosteus aculeatus, in Bear Lake are discussed.

Additional and detailed data collected during this report segment are on file at the Seward field office.

## RECOMMENDATIONS

1. Retain the present objectives of the study.
2. Adhere to the Alaska Board of Fish and Game's Bear Lake Management and Research Policy of February 22, 1971, to limit the Lake's production of red salmon.
3. Discontinue planting silver salmon fingerling of exotic (non-Alaskan) origin in Resurrection Bay waters.

## OBJECTIVES

1. To collect and analyze biological data concerning the distribution, abundance, and timing of out-migrant and adult silver salmon in the Resurrection Bay area.
2. To determine the age and size composition of juvenile and adult silver salmon.
3. To determine the sport harvest of silver salmon in Resurrection Bay and natural mortality in salt water.
4. To evaluate the freshwater environmental limitations on juvenile silver salmon production in this area.
5. To determine the methods and means of increasing or extending the freshwater spawning and rearing areas of the watershed, and mitigating freshwater mortality.
6. To provide recommendations for the management of silver salmon in these waters, and direct the course of future studies.

## TECHNIQUES USED

The timing and abundance of silver salmon smolts and fry emigrating from Bear Lake were determined by enumerating the downstream migrants through Bear Creek weir. Weir location and the downstream trapping facilities were described by Logan (1969). The timing and abundance of adult silver salmon migrating to Bear Lake were measured by upstream trapping facilities slightly modified in 1970. The prototype, wooden brail used in 1969 to raise adult salmon from the trap, was replaced by a heavy-gauge aluminum brail in 1970. Unlike the wooden brail, the new brail held water and thus minimized physical injury to the captured fish during handling. A tilted, salmon/trout dividing screen made of aluminum pipe with 1.5-inch clearance between pipes retained all adult salmon in the upper part of the

brail for processing while allowing the smaller salmonids (trout, char and juvenile salmon) to remain under the screen in the lower portion. A manually operated, sliding plate on the brail bottom permitted flushing of excess water into the adult trap below. A sliding plate on the side of the brail allowed "sluicing" of adult salmon down the tilted screen into a dip net for processing. When sampling of small salmonids was desired, a small-meshed dip net was held below the bottom hatch to capture these fish as they flushed out with the water. A salmon blocking gate which automatically lowered as the brail was raised prevented adult salmon from entering the trap when the brail was not in position. The brail was elevated 0.5 feet above the trap floor via steel channel legs to prevent injury to any fish underneath when lowered into position. The bar screen immediately above the upstream trap was modified from 1.5- to 0.75-inch spacing to retain most juvenile fish in or below the upstream trap. The pool level above the upstream trap was reduced from 24 - 12 inches to minimize turbulence inside the brail and thus fully utilize its fish holding capacity. Attraction flows through the trap were manipulated by adding or removing stoplogs above this pool. Bear Creek water temperatures and flow were recorded daily at the weir.

The age structures of marked silver salmon smolt and adult populations were determined by examining each fish throughout migration for a finclip combination assigned as a young-of-the-year fingerling. Age compositions of unmarked silver and red salmon smolt and adult populations were determined by examining representative scale impressions on 0.02-inch thick cellulose acetate with a microprojector. Random length and weight samples of salmon smolts were collected weekly at the weir after the fish had been anesthetized in a 1:20,000 solution of MS-222.

The Resurrection Bay silver salmon sport harvest and effort were measured by a stratified, random creel census conducted at the Seward small boat harbor. The sampling design and interview method were nearly identical to that described by Logan (1966). Fishing mortality was determined by examining as many silver salmon as feasible during creel census interviews to ascertain the finclipped fish harvest. Natural mortality was determined by examining adult silver salmon for fin clips as they were enumerated through Bear Creek weir. An index to silver salmon escapement abundance was measured by conducting weekly foot surveys on seven index streams. All carcasses were checked for clipped fins, sexed, and mutilated to preclude recounting on subsequent surveys.

## FINDINGS

The findings presented are the result of the 1970-71 segment of this project. For a description of the Resurrection Bay area and past information collected on the project, see Dunn (1961), Logan (1962 through 1969), and McHenry (1970).

## Bear Lake Project

Bear Lake was selected for the study and enhancement of salmon populations because it is the largest body of fresh water in the Resurrection Bay drainage, is an important salmon producer, and is accessible by road. The 445-acre lake offers the most stable rearing potential for silver salmon, Oncorhynchus kisutch, smolt production in the watershed since it is not subject to the fluctuations in stream flow and water temperature characteristic of the drainage's tributaries. The 1963 Bear Lake rehabilitation to eradicate competitor and predator species, subsequent annual plants, and survival of marked young-of-the-year fingerling and their egg sources were reviewed by Logan (1969).

### Bear Lake Downstream Migration

#### Silver Salmon:

The Bear Creek weir downstream migrant trap was operated continuously from May 18 through October 30. No silver salmon smolts were captured in the downstream trap until June 3, indicating that smolt outmigration had not occurred prior to installing the downstream migrant screens and trap. Due to an extended period of heavy rainfall raising the level of Bear Creek 0.4 feet on October 30, all downstream migrant screens were removed on October 31. Emigration of juvenile silver salmon had ceased 11 days prior to removing the migrant screens.

The total outmigration during the weir operation period was enumerated at 6,150 silver salmon smolts. This migration consisted of 6,147 unmarked (natural) smolts and three Ad-RV marked smolts. The three Ad-RV smolts captured were the only marked fish emigrating from Bear Lake. The timing and abundance of the Bear Lake silver salmon smolt and fry outmigrations are presented in Table 1. The smolt outmigration began on June 3, peaked on June 23, and terminated by October 8. The highest daily count occurred on June 20 when 740 smolts (12.0% of the total run) were enumerated through the trap. The stream temperature at initiation of the outmigration was 40°F (4.4°C), with 96.7% of migration occurring when water temperatures ranged from 38° - 50°F (3.3° - 10.0°C) between June 3 and July 21. Bear Creek flows varied from 30 - 56 cfs during this period. As in 1969, silver salmon fry showed no appreciable downstream "drift", with only 82 fry captured in the trap from August 19 to October 19. The majority (87.8%) of these juveniles emigrated from September 29 to October 15 when Bear Creek stream temperatures ranged from 46° - 34°F (7.8° - 1.1°C) and flows, from 18 - 15 cfs. Smolt and fry trap mortalities were 1.3 and 9.8%, respectively.

A total of 292 scale samples were randomly collected from unmarked smolts between June 7 and July 31. Table 2 shows the age composition as well as the mean fork length and range for three age classes of smolts sampled weekly during the outmigration. The percentage and extrapolated number of smolts released in each age class of unmarked smolt migration (6,070 smolts) were as follows: age I, 8.2% (498 fish); age II, 59.2% (3,593); age III, 32.2% (1,955); and age IV, 0.4% (24). The age I, II, and III smolts had mean fork lengths of 107.8, 134.9, and 158.1 mm, respectively.

TABLE 1 Silver Salmon Smolts and Fry Enumerated through Bear Creek Weir by Weekly Period, 1970.

Weekly Period	Hatchery Origin	Natural Origin	
	1966 Brood (Ad-RV Clip)	1965-1968 Broods (Unclipped)	1969 Brood (Fry)
6/ 3 - 6/ 9		55	
6/10 - 6/16	1	525	
6/17 - 6/23	1	2,421	
6/24 - 6/30	1	1,602	
7/ 1 - 7/ 7		851	
7/ 8 - 7/14		301	
7/15 - 7/21		189	
7/22 - 7/28		9	
7/29 - 8/ 4		61	
8/ 5 - 8/11		8	
8/12 - 8/18			
8/19 - 8/25		72	5
8/26 - 9/ 1		35	
9/ 2 - 9/ 8		2	3
9/ 9 - 9/15		11	
9/16 - 9/22		2	
9/23 - 9/29			4
9/30 - 10/ 6		2	46
10/ 7 - 10/13		1	18
10/14 - 10/20			6
Total	3	6,147	82
No. dead	1	77	8
No. released	2	6,070	74

TABLE 2 Mean Fork Lengths and Ranges (mm) of Three Age Classes of Silver Salmon Smolts Sampled at Bear Creek Weir by Weekly Periods, 1970.

Weekly Period	Age III (1966 Brood)			Age II (1967 Brood)			Age I (1968 Brood)		
	No.	Range	Mean	No.	Range	Mean	No.	Range	Mean
6/ 3 - 6/ 9	8	132 - 260	184.8	17	103 - 184	140.8	2	94 - 113	103.5
6/10 - 6/16	1	194	---	23	100 - 154	122.6	1	86	---
6/17 - 6/23	13	142 - 195	158.1	29	115 - 150	127.3	5	96 - 113	103.2
6/24 - 6/30	20	135 - 190	154.1	22	112 - 158	133.7	7	90 - 116	105.3
7/ 1 - 7/ 7	24	135 - 175	152.5	25	125 - 153	138.3	-	---	---
7/ 8 - 7/14	14	140 - 188	160.4	22	128 - 160	141.7	5	103 - 123	114.8
7/15 - 7/21	9	133 - 162	152.3	26	115 - 160	141.1	4	108 - 127	117.0
7/22 - 7/28	1	176	---	3	131 - 138	133.7	-	---	---
7/29 - 8/ 4	4	142 - 162	151.5	6	125 - 151	140.0	-	---	---
Total	94	132 - 260	158.1	173	100 - 184	134.9	24	86 - 127	107.8
Percent*	32.2			59.2			8.2		

\*Total percent does not equal 100.0% due to one smolt (0.04% of population sample) being age IV.

The 498 age I unmarked smolts resulted from the 1968 Bear Lake escapement of 2,280 males and 1,175 females of mixed Swanson River and Bear Lake stocks. No fingerling were stocked in Bear Lake after 1967 because of the lake's declining smolt production. The 3,593 age II smolts originated from the 1967 escapement of 2,661 males and 1,500 females, also of Bear Lake and Swanson River origin. The 1,955 age III smolts were produced by the 1966 escapement of 1,494 males and 1,261 females, primarily of Swanson River and Dairy Creek origin. All fingerling planted in 1967 were marked fish. The 24 age IV smolts resulted from the 1965 Bear Lake escapement of 127 males and 93 females of Swanson River stock, and from the 1966 Bear Lake plant of 360,800 fingerling, also of Swanson River origin.

The three Ad-RV smolts resulted from the 63,900 young-of-the-year fingerling marked at Fire Lake Hatchery and stocked in Bear Lake during August, 1967. These fish originated from fertilized eggs taken at Pasag-shak River, Kodiak Island, Alaska, in 1966. Fingerling-to-smolt survival for the Ad-RV plant were 2.10% age I (1968), 7.69% age II (1969), and 0.01% age III (1970). The total smolt production for the Ad-RV plant was therefore 9.80%. The fork length of the three Ad-RV smolts ranged from 164 - 169 mm. Since no age III Ad-LV smolts were produced by the 182,500 young-of-the-year fingerling also planted in Bear Lake in 1967, the total smolt production for this plant remained at 4.08% for age I and age II smolts. These fish originated from eggs taken at Big Creek, Oregon.

All three age groups of unmarked smolts in 1970 exhibited an average size increase over those of the two previous years, although with a corresponding decrease in the total number of natural smolts migrating. Table 3 shows the mean fork length and percent of population sample for each age class of unmarked smolts captured at Bear Creek weir since 1968.

TABLE 3 Age Composition and Mean Fork Length (mm) for Each Age Group of Unmarked Silver Salmon Smolt Migrations Sampled at Bear Creek Weir, 1968-1970.

Age Class	1968		1969		1970	
	Mean Length	%	Mean Length	%	Mean Length	%
I	74.3	0.7	102.4	6.9	107.8	8.2
II	114.6	90.0	120.9	77.2	134.9	59.2
III	150.3	9.3	152.7	15.6	158.1	32.2
IV	---	--	---	0.3	---	0.4
Total Unmarked Smolts	13,290		8,576		6,147	

The smolt age composition trend indicates a slight increase in percentage of age I smolts, but with a consistent shift from age II to age III smolts in these outmigrations. Age IV smolts were first detected in the population sample in 1969 (0.3%) and again in 1970 (0.4%). Both the 1969 and 1970 natural smolt migrations were comparable to that of 1963 when Logan (1964) estimated 7,208 smolts had migrated past the weir. Age composition of that migration was 27.3% age I, 70.9% age II, and 1.8% age III. Size compositions of the three age groups showed increases since 1968 in varying degrees, but most notably in age II smolts.

#### Other Species:

A total of 1,393 Dolly Varden, Salvelinus malma, were captured between May 23 and October 2. The highest daily count occurred on June 13 when 233 fish (16.7% of the migration) were enumerated. The majority (94.8%) of these char migrated past the weir by June 29 on their seaward migration. These downstream migrants are residuals and progeny of Dolly Varden which had gained access into Bear Lake during the autumns of 1965, 1966, and 1967 when flood flows negated Bear Creek weir as a total barrier.

The total red salmon, O. nerka, smolt migration was enumerated at 5,288 fish. The first smolt was captured on May 29 and the last fish on September 3. The highest daily count occurred on July 2 when 600 smolts (11.3% of the migration) were enumerated. The majority (99.0%) of these smolts migrated from June 3 to July 8, when water temperatures ranged from 39° - 50°F (3.9° - 10.0°C), and stream flows from 31 - 58 cfs. The migration was comprised of 66.0% age I, 29.0% age II, 4.6% age III, and 0.4% age IV smolts as determined by analyzing 241 scales collected weekly throughout the migration. Mean fork length of age I, II, and III smolts were 66.3, 92.6, and 126.5 mm, respectively. Fork lengths of 50 smolts measured during the peak of migration, June 17 to 23, ranged from 50 - 121 mm with a mean of 74.8 mm.

Twenty-one steelhead, Salmo gairdneri, smolts were enumerated downstream from June 19 to July 14. Stream temperatures ranged from 45° - 52°F (7.2° - 11.1°C), and stream flows from 30 - 55 cfs during their migration. Fork lengths for the 21 smolts ranged from 164 - 235 mm with a mean of 186.3 mm.

A total of 29,035 threespine stickleback, Gasterosteus aculeatus, were captured throughout the period of downstream trap operation. An additional estimate of 15,500 stickleback were removed from the downstream migrant screens during periodic screen cleanings. The majority (84.9%) of these fish emigrated from June through August. The number of stickleback enumerated from the trap each month were as follows: May, 83; June, 7,714; July, 8,173; August, 8,756; September, 3,852; and October, 457. This downstream stickleback migration is the largest recorded at the weir and indicates that a dense stickleback population currently exists in Bear Lake.

## Resurrection Bay Harvest and Effort

### Silver Salmon:

The creel census to determine the Resurrection Bay silver salmon sport harvest and effort was initiated on July 3 and terminated on September 8. Creel census commenced earlier in 1970 than in previous years because silver salmon were observed taken in 1969 on the July 4 weekend when considerable effort was estimated to occur. The total harvest was estimated at 14,865 fish, or nearly the same as that of 1969 (15,040 fish). This estimate was extrapolated from interviews with 9,074 anglers harvesting 4,682 silver salmon. The peak of the harvest occurred on August 8, the first day of the Seward Silver Salmon Derby, when an estimated 1,163 fish (7.8% of the season's harvest) were taken. The total season derby harvests are summarized for 1966 through 1970 in Table 4. A substantial portion of the total harvest (36.6%) occurred during the derby, which extended from August 8 to August 16, 1970.

TABLE 4 Derby and Total Silver Salmon Sport Harvests, Resurrection Bay, 1966-1970.

<u>Year</u>	<u>Tot. Sport Harvest</u>	<u>Derby Harvest</u>	<u>% Derby Harvest</u>
1966	9,590	4,326	45.1
1967	17,380	6,289	36.2
1968	22,560	8,187	36.3
1969	15,040	5,150	34.2
1970	14,865	5,440	36.6

The total sport fishing effort exerted for silver salmon was estimated at 27,125 man-days, with 33.4% of the anglers interviewed. Fishing effort and mean catch per hour since 1966 are summarized in Table 5. The 1970 seasonal effort was the largest ever recorded for the Resurrection Bay sport fishery. This was primarily due to the increased effort exerted during the silver salmon derby. Effort during the derby increased 32.8% over that estimated in 1969, illustrating the growing popularity of the fishery. A total of 3,253 derby tickets were sold in 1970, compared to 2,515 tickets in 1969, representing a 29.3% increase in ticket sales. The weekend and weekday fishing effort, excluding the derby, were 6,656 and 5,514 man-days, respectively. Military personnel and dependents, angling from boats provided by the Army and Air Force recreation camps at Seward, contributed 16.3% (4,421 man-days) of the total effort. The seasonal average catch per hour was 0.08 silver salmon. Civilian anglers fishing during weekdays realized the highest catch per hour (0.18 fish), whereas the lowest catch per hour (0.05) occurred during the derby.

TABLE 5 Derby and Total Sport Effort (Man-Days) for Silver Salmon and Mean Catch Per Hour in Resurrection Bay, 1966-1970.

<u>Year</u>	<u>Census Period</u>	<u>Tot. Effort</u>	<u>Derby Effort</u>	<u>% Derby Effort</u>	<u>Catch/Hr.</u>
1966	7/13 - 9/13	14,195	7,055	49.7	0.14
1967	7/12 - 9/12	20,100	8,505	42.3	0.15
1968	7/ 6 - 9/10	25,350	11,590	45.7	0.15
1969	7/ 9 - 9/ 9	24,655	11,262	45.7	0.12
1970	7/ 3 - 9/ 8	27,125	14,955	55.1	0.08

The average number and percentage of sport fishing boats returning to the Seward small boat harbor were determined for each of the three 3.5-hour sampling periods, extending from 11:30 AM to 10:00 PM, and are presented in Table 6. The period from 8:00 AM to 11:30 AM was not sampled because information collected from 1964 through 1966 showed that only 11.6 and 14.3% of weekend and weekday sport fishing craft, respectively, returned during this period. The mean number of craft returning during this period, based on these percentages, was added to those of the three periods sampled to determine the total daily effort. The greatest number of boats returned between 3:00 and 6:30 PM. The mean number of hours each angler fished per day was as follows: weekdays, 5.53; weekends, 6.05; and salmon derby, 7.15. The average number of anglers per boat was as follows: weekdays, 2.88; weekends, 3.09; and salmon derby, 3.15.

TABLE 6 The Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor during Each Sampling Period, 1970.

<u>Sampling Period (Hours)</u>	<u>Weekends</u>		<u>Weekdays</u>	
	<u>Mean No. of Boats</u>	<u>%</u>	<u>Mean No. of Boats</u>	<u>%</u>
8:00 AM - 11:30 AM*	10.5	11.6	5.8	14.3
11:30 AM - 3:00 PM	25.3	27.8	9.7	24.0
3:00 PM - 6:30 PM	34.3	37.8	17.9	44.4
6:30 PM - 10:00 PM	<u>20.6</u>	<u>22.8</u>	<u>7.0</u>	<u>17.3</u>
Total	90.7	100.0	40.4	100.0

\*Percentage of this period determined by three-year mean, 1964-66.

#### Other Species:

King salmon, O. tshawytscha, and pink salmon, O. gorbuscha, were taken incidentally with silver salmon during the season, although the creel census did not entirely encompass their period of availability, as indicated by catch rates for both species during the first week of census. An estimated 658 king salmon were taken during the census period at an average rate of 0.07 fish per boat. The fish were most abundant from July 15 to August 4 when anglers averaged 0.10 - 0.36 king salmon per boat. Pink salmon were in their usual even-year cycle of abundance in Resurrection Bay, as shown by anglers averaging 0.38 pink salmon per boat for the season. The total pink salmon harvest was estimated at 3,748 fish. Pink salmon were most abundant from the first day of the census on July 3 until August 4. During this period, anglers averaged 0.51 - 2.04 fish per boat and 0.04 - 0.09 fish per hour. Shore anglers fishing off Lowel Point access road had fair success for pink salmon and anadromous Dolly Varden. Thirty-six anglers contacted periodically from July 15 to August 15 averaged 0.17 pink salmon and 0.38 Dolly Varden per hour. Only one silver salmon was observed taken during this shore fishery, although others were reported caught.

#### Bear Lake Upstream Migration

##### Silver Salmon:

The upstream migrant trap was operated continuously from May 18 until November 14. The first adult silver salmon entered the trap on August 20 and the last one was captured on November 11. Two stream surveys after this date disclosed that an estimated 65 silver salmon were spawning in Bear Creek below the weir. No additional silver salmon entered the trap by November 24 when the weir was closed.

A total of 295 silver salmon (including precocious males or "jacks") migrating to Bear Lake were enumerated through the trap. The 44 "jacks" observed comprised 14.9% of the upstream migration. The abundance and timing of the adult silver salmon migration to Bear Creek weir are shown in Table 7. Timing of the upstream migration spanned a greater interval than in previous years, probably because the normally early fall rains did not occur until late October, 1970. The stream temperature at the beginning of migration was 51°F (10.6°C) on August 20, gradually dropping to 37°F (2.8°C) on November 11 when the run terminated. Most of the migration (74.9%) occurred between September 1 and October 17, when stream temperatures ranged from 52° - 35°F (11.1° - 1.7°C) and flows, from 14 - 28 cfs. Approximately 24% of the migration occurred after October 30 when Bear Creek flows rapidly increased from 15 - 106 cfs at peak (November 1), then gradually decreased to 35 cfs by November 11. The highest daily count of 27 fish (9.2% of the migration) occurred on November 1. By October 3, 50% of the unmarked adults but only three (16.7%) of the marked fish, had passed the weir, indicating some difference in their migration timing. However, due to the scarcity of

marked fish returning to the weir, any conclusion made on timing difference would be tenuous. The percentages of finclipped and unmarked silver salmon, excluding "jacks", were 7.2 and 92.8%, respectively. Silver salmon holding just below the weir could be induced to migrate into the upstream trap by increasing attraction flows with the removal of one or two stop logs.

TABLE 7 Adult Silver Salmon Enumerated through Bear Creek Weir by Weekly Period, 1970.

Weekly Period	Brood Year and Fin Mark				♂	♀	Tot.
	1967 (Ad)	1966 (Ad-LV)	1966 (Ad-RV)	1964-1967 (Unclipped)			
8/19- 8/25				7	7		7
8/26- 9/ 1				7	6	1	7
9/ 2- 9/ 8				13	7	6	13
9/ 9- 9/15				41	32	9	41
9/16- 9/22				25	12	13	25
9/23- 9/29			3	23	14	12	26
9/30-10/ 6				23	18	5	23
10/ 7-10/13			1	37	20	18	38
10/14-10/20				10	7	3	10
10/21-10/27							
10/28-11/ 3	3		7	26	23	13	36
11/ 4-11/10		1	3	17	4	17	21
11/11-11/17				4	1	3	4
Total	3	1	14	233	151	100	251

The various age classes and finclip combinations of the marked adult migration (Table 7) were as follows: 14 age 2.1 Ad-RV fish (1966 brood year), 1 age 2.1 Ad-LV fish (1966 brood year), and 3 age 1.1 Ad fish (1967 brood year). The Ad-RV and Ad-LV silver salmon resulted from the 1967 fingerling plants in Bear Lake of Pasagshak River, Kodiak, and Big Creek, Oregon, stocks, respectively, which migrated to sea as age 11 smolts in 1969. The Ad adults returned from the 47,470 age 1 smolts of Eagle Creek, Oregon stock (1967 brood year) planted in Bear Creek from May 8 to May 13, 1969. Eight "jacks" from this plant returned to Bear Creek weir in late January and February, 1970. Thirty-seven "jacks" returned from the 6,400 Ad smolts of Bear Lake origin (1968 brood year) planted on May 27, 1970, in Bear Creek.

The unmarked adult silver salmon are the result of natural production in Bear Lake tributaries from the 1964 through 1967 brood years. A total of 89 scale samples (35.4% of the unmarked adult escapement) collected from holding mortality and artificially spawned fish disclosed that 7.9% were age 1.1 (1967 brood year), 82.0% age 2.1 (1966 brood year), 9.0% age 3.1 (1965 brood year), and 1.1% age 4.1 (1964 brood year).

The mean fork lengths and ranges of adult silver salmon measured at Bear Creek weir are shown in Table 8. The male-to-female sex ratio, excluding "jacks", was 1.5:1. Males predominated the upstream migration until November when females comprised the majority until the run terminated.

Bear Lake stocks were used as a silver salmon egg source for the Fire Lake Hatchery in 1970 since the lake is scheduled for rehabilitation in 1971. All of the progeny resulting from natural spawning in the lake's tributaries would be eliminated during rehabilitation. Consequently, 89 of the 100 females which migrated and 70 males were held in the weir's holding tank to "ripen" for artificial spawning. Fish were held for varying lengths of time from September 11 to November 24, with stream temperatures ranging from 32° - 50°F (0.0° - 10.9°C). The overall female holding mortality was 25.8%, compared to 41.0% in 1969. A total of 66 females was spawned, yielding an estimated 260,900 eggs. The average fecundity was 3,953 eggs per female. Approximately one male was used to fertilize eggs from every three females. The dead egg loss after shocking at eyed stage was 7.2% compared to 11.1% in 1969.

#### Other Species:

The first adult red salmon was captured in the upstream trap on June 8 and the last one on August 21. A total of 5,831 fish were enumerated, with the highest daily count of 650 red salmon (11.1% of the run) occurring on June 24. The migration consisted of 2,903 adult males, 2,904 females, and 24 "jacks". The male-to-female sex ratio was 1.0:1. A sample of 278 scale samples collected periodically at Bear Creek weir disclosed the adult age composition was 7.2% age 1.2, 31.7% age 2.2, 34.9% age 1.3, 25.9% age 2.3, and 0.3% age 1.4. Age 2.3 fish, resulting from the 1964 Bear Lake escapement (4,500 red salmon) which produced a phenomenal return of 133,512 fish in 1968 and 121,424 fish in 1969, comprised a significant portion of the upstream migration. These fish averaged 592 mm in fork length. Mean fork lengths for ages 1.2, 2.2, and 1.3 fish were 536, 528, and 601 mm, respectively. Bear Creek water temperatures during the spawning migration ranged from 37° - 58°F (2.8° - 14.4°C), and stream flows from 22 - 58 cfs. Most of the migration (98.7%) occurred from June 12 to July 13 when stream temperatures ranged from 41° - 52°F (5.0° - 11.1°C), and flows from 31 - 56 cfs.

The Resurrection Bay commercial and subsistence fisheries harvested an estimated 1,767 and 165 red salmon, respectively, according to commercial fish tickets and 35 subsistence permits returned. The commercial fishing season was open continuously from June 24 to June 30. Most fish were caught by drift gill nets. Adjusting the total commercial and subsistence harvest by the ratio of Grouse Lake and Bear Lake escapements (172:5,831 fish), an estimated 1,876 (97.1%) red salmon taken were of Bear Lake stock. Therefore, the estimated total Bear Lake run was 7,707 red salmon.

TABLE 8 Mean Fork Length and Range (mm) of Adult Silver Salmon Measured at Bear Creek Weir, 1970.

	<u>Unmarked Fish</u>			<u>Ad-RV Fish</u>			<u>Ad Fish</u>		
	<u>No.</u>	<u>Range</u>	<u>Mean</u>	<u>No.</u>	<u>Range</u>	<u>Mean</u>	<u>No.</u>	<u>Range</u>	<u>Mean</u>
Males	52	490-740	619	2	670-680	675	2	625-780	703
Females	68	540-750	650	9	585-690	654	1	670	---
Total	120	490-750	637	11	585-690	658	3	625-780	692

Red salmon from Bear Lake were artificially spawned in 1970 to satisfy a continued request for fertilized eggs by the Japan Salmon Resources Preservation Association. A total of 45 females were spawned from August 27 to September 24, yielding an estimated 144,400 eggs. Average fecundity was 3,209 eggs per female. Dead egg loss after shocking averaged 13.3%, compared to 24.6% in 1969.

Upstream migrant Dolly Varden entered the trap in early July and varying numbers of these char moved in and out intermittently throughout the remaining field season. Mature pink salmon arrived in the upstream trap on July 22 and remained for a short period before migrating downstream to spawn in Bear Creek. Two chum salmon, *O. keta*, were recorded in the upstream trap in late September. No fish other than red or silver salmon were removed from the upstream trap and transferred above the weir, due either to the undesirability of having the species inhabit Bear Lake (Dolly Varden) or to the lack of suitable spawning area above the weir (pink and chum salmon).

#### Adult Silver Salmon Timing and Abundance in Index Streams

The relative timing and abundance of Resurrection Bay area adult silver salmon escapements have been measured each year since 1961 by foot surveys of selected index areas on seven clear streams near the road system. Timing of the 1970 escapement was about one week later than in 1969 when most runs peaked from October 25 to November 5. The various runs in 1970 peaked from November 1 to November 8, which corresponded to a period of increased stream flows following heavy rains. The peak of spawning occurred during mid-November. Minimum silver salmon escapements in each stream index area since 1966 are shown in Table 9.

TABLE 9 Minimum Silver Salmon Escapement in Seven Index Streams in the Resurrection Bay Area, 1966-1970.

Stream Name	Minimum Escapement					Mean 1966-69
	1966	1967	1968	1969	1970	
Airport Creek	127	55	67	36	26	71
Clear Creek	171	227	364	59	91	205
Dairy Creek	30	99	98	115	44	86
Grouse Creek	236	174	378	182	132	242
Jap Creek	228	172	229	78	79	177
Mayor Creek	135	66	41	64	38	77
Salmon Creek	234	329	1,037	19	105	405
Total	1,161	1,122	2,214	553	515	1,263

The period from 1966 to 1970 encompasses one complete life cycle, which is typically four years for Resurrection Bay silver salmon. The 1970 combined total escapement of 515 fish (40.8% of the 1966-1969 mean) is the lowest minimum escapement index recorded in spite of an adequate parent brood spawning in these stream index areas in 1966. No straying of marked Bear Lake fish was noted in any of the index streams. Insufficient carcasses were examined on the stream surveys to present any valid sex ratios for these escapements.

### Marked Silver Salmon Analysis

Finclipped adult silver salmon harvested in the Resurrection Bay fishery originated both from the 1969 Bear Lake marked smolt outmigration, and marked smolt plants made in Bear Creek and Seward Lagoon during May, 1969. A considerable number of marked "jacks" and large smolts (immature males and females) also entered the sport catch and were from Bear Creek and Seward Lagoon marked smolt plants made during May, 1970. The 1969 Bear Lake smolt outmigration was comprised of 4,035 age II Ad-LV smolts, 4,914 age II Ad-RV smolts, and 8,576 unmarked smolts of which 6.9% (592) were age I, 77.2% (6,621) age II, and 15.6% (1,338) age III fish. Also, a total of 47,470 age I Ad smolts of Eagle Creek, Oregon, stock were planted in Bear Creek in May, 1969. The number of adults returning to Bear Creek after 14 - 17 months of ocean life was as follows: 1 age 2.I Ad-LV fish, 14 age 2.I Ad-RV fish, 3 age 1.I Ad fish, and 233 unmarked fish (Table 7). The estimated number of unmarked adults returning per smolt age class, based on the adult scale analysis (mentioned earlier in report) was as follows: 18 age 1.I fish (7.9% x 233), 191 age 2.I fish (82.0% x 233), and 21 age 3.I fish (9.0% x 233). The one age 4.I adult (1.1% of the age composition) recorded in the population sample was disregarded in this analysis. The marine survival, defined as the survival of smolts released at the weir to adults returning to the weir, was 0.02% of the Ad-LV smolts (1/4,035 x 100), 0.28% for the Ad-RV smolts (14/4,914 x 100), 0.01% for the Ad smolts (3/47,470 x 100), and 2.72% for the unmarked smolts (233/8,576 x 100). Marine survivals for unmarked smolts were further estimated by age class and were: age I, 3.04% (18/592 x 100), age II, 2.85% (191/6,621 x 100), and age III, 1.57% (21/1,338 x 100). The factors related to these low and apparently reversed smolt-to-adult survivals for older smolts are unknown at this time.

The Bear Lake silver salmon contribution to the Resurrection Bay sport fishery was determined by recording marked fish observed during creel census interviews. Finclipped fish observed or reported by anglers at times other than during scheduled creel census periods were not considered in the marked catch analysis. The observed and calculated marked Bear Lake silver salmon harvests taken from 1966 to 1970 are summarized in Table 10. A total of 3,118 silver salmon were examined with the following marked fish observed: 3 Ad-LV, 22 Ad-RV, 14 Ad, and 110 Ad (juvenile). The percentage of marked Bear Lake silver salmon projected for the total sport

harvest of 14,865 fish yielded an estimated catch of 15 Ad-LV and 106 Ad-RV silver salmon. An additional 67 Ad adults and 73 Ad "jacks" and smolts were estimated caught from the 1969 and 1970 marked smolt plants in Bear Creek.

TABLE 10 Observed and Calculated Recoveries of Marked Bear Lake Silver Salmon in the Resurrection Bay Sport Fishery, 1966-1970.

Year of Recovery	No. Fish Sampled	Est. Tot. Catch	% Catch Sampled	No. Marked Fish Recovered	Calculated No. Marked Fish
1966	2,357	9,590	24.6	159	647
1967	4,029	17,380	23.2	286	1,233
1968	4,995	22,560	22.1	65	294
1969	3,448	15,040	22.9	119	519
1970	3,118	14,865	21.0	25	121

The number of unmarked Bear Lake silver salmon taken in the Resurrection Bay sport fishery was estimated by multiplying the 14,170 unmarked silver salmon harvested by the fishing mortality (1.35%) of marked Bear Lake fish (Ad-LV and Ad-RV only) observed in the fishery. Therefore, an estimated 191 unmarked Bear Lake adults were taken in the sport harvest. The total production from Bear Lake, with an estimated harvest of 312 and an escapement of 258 (including seven unmarked "jacks"), was estimated at 570 silver salmon. This production does not include the aforementioned returns from the 1969 and 1970 Bear Creek smolt plants, nor the estimated 65 adults spawning in Bear Creek below the weir.

#### Seward Lagoon Silver Salmon Stocking Evaluation

The Seward Lagoon was planted with 27,100 age 1 silver salmon smolts on May 5 and 6, 1969. These smolts resulted from eyed eggs of Eagle Creek, Oregon, stocks, hatched at Fire Lake Hatchery, and reared in the Fort Richardson generator cooling pond. All smolts were marked at the cooling pond with an Ad clip to identify them as returning adults from indigenous silver salmon spawning in the Lagoon tributaries. The purpose of the

experimental stocking was to determine the feasibility of planting smolts to supplement natural adult returns for the Resurrection Bay sport fishery. As in 1968, Seward Lagoon was gill netted in July with two 100' x 6', 1/2- to 1 1/4-inch (bar measure), variable mesh nylon gill nets to determine the relative number of smolts that failed to emigrate during normal outmigration timing. Logan (1969) discovered that a substantial portion of the 1968 smolt plant had not emigrated, probably due to not achieving sufficient growth to "smolt" by July 15. In 1969, only nine marked smolts, ranging from 90 - 118 mm with a mean fork length of 100.4 mm, were caught in 65 gill net hours, indicating that most smolts had emigrated by July 8.

The 15 Ad adult silver salmon observed in Seward Lagoon in January, 1970, resulted from the 1968 plant of 42,200 age 1 smolts of Big Creek, Oregon, stock. This return represented a minimum of 0.04% ocean survival of planted smolts to returning adults. One Ad "jack", resulting from the 1969 smolt plant of Eagle Creek, Oregon, stock, was also observed with these adults in January, 1970. The eight Ad "jacks" which returned to Bear Creek weir in late January and February also resulted from the 1969 plant of Eagle Creek, Oregon, smolts in Bear Creek, and displayed similar migration timing. As in 1969, no Ad adults were observed in the Seward Lagoon tributaries during the 1970 fall escapement surveys of natural spawning migrations. However, in January, 1971, six Ad adults had returned from the 1969 smolt plant. This return represented a minimum survival of 0.02%. Although the three Ad adults which returned to Bear Creek weir in 1971 showed fall migration timing, survival of these smolts to adults was only 0.01%.

A total of 39,750 Ad age 1 smolts (1968 brood year) of Bear Lake origin were stocked in Seward Lagoon from May 19 to May 27, 1970. An estimated 66 Ad "jacks", or 0.17% of the smolt plant, returned during the fall spawning migration timing of natural Resurrection Bay silver salmon. The 37 Ad "jacks" (0.58% of the smolt plant) returning to Bear Creek weir in 1970 resulted from the aforementioned plant of 6,400 age 1 smolts of Bear Lake origin. These fish also migrated upstream during the fall spawning migration timing of Bear Lake silver salmon.

The foregoing results show that little or no success can be obtained in stocking hatchery-reared smolts of non-Alaskan origin to supplement indigenous populations of silver salmon for the Resurrection Bay sport fishery. Apparently, very poor ocean survival or straying occurs, as well as late spawning migration timing, which causes the adults that do survive to return after the sport fishery has terminated. Depending on the adult return evaluation of the 1970 smolt plants, it appears that stocking hatchery-reared smolts of local origin has the greatest potential for supplementing natural silver salmon production for the Resurrection Bay sport fishery.

## LITERATURE CITED

- Dunn, Jean R. 1961. Silver Salmon Studies in the Resurrection Bay Area. Alaska Department of Fish and Game. Federal Aid In Fish Restoration, Annual Report of Progress, 1960-1961, Project F-5-R-2, 2:289-303.
- Logan, Sidney 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, 3:57-74.
- \_\_\_\_\_. 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, 4:175-194.
- \_\_\_\_\_. 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, 5:133-151.
- \_\_\_\_\_. 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, 6:129-145.
- \_\_\_\_\_. 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, 7:79-99.
- \_\_\_\_\_. 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, 8:83-102.
- \_\_\_\_\_. 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, 9:117-134.
- \_\_\_\_\_. 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, 10:131-149.
- McHenry, Edward 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, 11:75-89.

*Prepared by:*

Edward T. McHenry  
Fishery Biologist

*Approved by:*

s/Howard E. Metsker  
D-J Coordinator

*Date:* April 30, 1971

s/Rupert E. Andrews, Director  
Division of Sport Fish