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STATE OF ALASKA
Walter J. Hickel, Governor

ANNUAL REPORT OF PROGRESS, 1967 - 1968

FEDERAL AID IN FISH RESTORATION PROJECT F-5-R-9

SPORT FISH INVESTIGATIONS OF ALASKA

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INTRODUCTION

This report of progress consists of findings and work accomplished under the State of Alaska Federal Aid in Fish Restoration Project F-5-R-9, "Sport Fish Investigations of Alaska."

The project during this reporting period was composed of 21 separate studies. Of these, seven jobs continued the inventorying and cataloging of the numerous waters, providing a comprehensive index of the State's recreational waters. Nine jobs accomplished special studies involving Dolly Varden, grayling, silver salmon, king salmon and sheefish, among others. The remaining five jobs are designed to accomplish creel census, migration, access and silver salmon egg-take studies. The egg-take study, Job 7-F, was inactive because egg-takes were accomplished under other projects.

Special reports on specific phases of the Dolly Varden Life History Study have been published in the Department's Research Report series.

The information gathered from all of these studies provides the background necessary for better management and assists in development of future investigational studies.

The subject matter contained within these reports is often fragmentary in nature. The findings may not be conclusive and the interpretations contained therein are subject to re-evaluation as the work progresses.

RESEARCH PROJECT SEGMENT

STATE: ALASKA Name: Sport Fish Investigations of Alaska.
Project No: F-5-R-9 Title: Silver Salmon Studies in the Resurrection Bay Area.
Job No.: 7-B-1

Period Covered: July 1, 1967 to June 30, 1968.

ABSTRACT

This report is a continuation of studies on silver salmon, Oncorhynchus kisutch, in the Resurrection Bay area initiated by Dunn (1960) and continued by Logan (1961 through 1966).

An estimated 60,943 silver salmon downstream migrants were captured at the Bear Creek weir from May 18 through September 17, with the peak of the run occurring on June 11. The migration was comprised of 5,770 age II (Ad-LV clip) smolts with a mean length of 128.2 mm; 16,725 age II (unmarked) natural smolts with a mean length of 117.8 mm; and 38,448 age I (LV-RV clip) fish with a mean length of 69.9 mm. The smolt growth rate declined appreciably from past years.

Between August 8 and August 30, an estimated 182,500 Ad-LV and 63,900 Ad-RV clipped fingerlings were planted in Bear Lake.

The adult upstream migration consisted of 4,386 silver salmon and extended from August 16 to October 23 with the peak occurring on September 16. The run consisted of 2,866 age 1.1 Ad-LV clipped fish; 681 age 2.1 Ad-RV clipped fish and 839 age 1.1 unmarked fish. The ratio of males to females was 1.6:1. An estimated 643,800 eggs were artificially spawned from 179 females. The total minimum escapement in seven index streams was 1,122 silver salmon.

A creel census conducted at the Seward Small Boat Harbor from July 12 to September 12 showed an estimated 17,380 silver salmon were taken in Resurrection Bay by 20,100 man-days of effort. The average catch per hour was 0.15. An estimated 1,030 Ad-LV and 203 Ad-RV clipped silver salmon were taken in the fishery. The catch-to-escapement ratio was 0.35:1. The marine survival of the Ad-LV and Ad-RV clipped adults was 12.55 percent and 14.87 percent, respectively.

Seine samples and weir counts indicate threespine sticklebacks, Gasterosteus aculeatus (Linnaeus), are approaching their pre-rehabilitation levels in Bear Lake. The timing and abundance of Dolly Varden, Salvelinus malma (Walbaum), and red salmon, O. nerka, are also presented.

Detailed and additional data collected during this report segment are on file at the Seward Field Office.

RECOMMENDATIONS

1. Retain the present objectives of the study.
2. Modify the Bear Creek weir to preclude fish passing over it during high stream flows.
3. Postpone plans for an artificial incubation channel until the silver salmon smolt rearing potential is determined for Bear Lake.

OBJECTIVES

1. To collect and analyze biological data concerning the distribution, abundance, and timing of adult and outmigrant silver salmon smolts in the Resurrection Bay area.
2. To determine the age composition of adult and juvenile silver salmon smolts.
3. To determine the sport harvest of silver salmon in Resurrection Bay and natural mortality in salt water.
4. To investigate the freshwater environmental limitations on juvenile silver salmon 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 determine the reinfestation rate of non-salmon species in rehabilitated Bear Lake.
7. 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 fingerlings migrating out of Bear Lake were measured at Bear Creek, the outlet, with a concrete weir situated 1,750 feet downstream from the lake. The downstream migrant trapping facilities consisted of a series of vertical screen panels and a model "B" fishpass.

The abundance and timing of adult salmon into Bear Lake were determined with an aluminum slat barrier and trap constructed on the downstream side of the weir. The weir and its trapping facilities are described in detail by Logan (1966).

Length and weight samples of downstream and upstream migrants were collected weekly at the weir.

Stream flows and temperatures were recorded daily at the weir.

A silver salmon escapement index was ascertained by conducting weekly foot surveys on seven index streams. All carcasses were examined for clipped fins, sexed and mutilated to preclude recounting on subsequent surveys.

The age composition of most adult and juvenile silver salmon was determined by examining each fish for the various fin clip combination assigned to

it when it was a young-of-the-year. The ages of unmarked smolts were determined with a microprojector from 0.02-inch-thick cellulose-acetate scale impressions and length frequency information.

The silver salmon sport harvest and effort in Resurrection Bay were measured by a creel census conducted at the Seward Small Boat Harbor. The interview method and sampling design utilized were similar to that described by Logan (1965). The fishing mortality was determined by examining as many silver salmon as possible concomitant with creel census interviews to determine the percentage of fin-clipped fish.

Methods of increasing the freshwater rearing areas and mitigating freshwater mortality were evaluated by measuring production to smolt size of fingerlings stocked in rehabilitated Bear Lake. This was done through the enumeration of smolts at the Bear Creek weir and by measuring the growth rate of juveniles in Bear Lake by sampling with 100 by 6-foot gill nets having 20-foot panels of 1/2, 3/4, 7/8, 1, and 1 1/4-inch stretch mesh. Methods of extending the spawning areas are being evaluated by determining the suitability of the water in Inlet No. 3 of Bear Lake as a source for an artificial incubation channel.

The reinfestation rate of non-salmon species in Bear Lake was measured by determining the relative magnitude of downstream movement of these fish past the Bear Creek weir and by seining at a beach index site using a 35 by 5-foot seine by 1/2-inch stretch mesh.

FINDINGS

Past information collected during this project and a description of the Resurrection Bay area are presented in Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Progress Reports by Dunn (1960) and Logan (1961 through 1966).

Bear Lake Project

The Bear Lake system was selected for intensive study and the enhancement of silver salmon populations because it is the largest body of water in the Resurrection Bay area. This 445-acre lake was rehabilitated with rotenone in August of 1963 in an effort to mitigate freshwater mortality and increase its rearing potential for juvenile silver salmon (Logan, 1963). Bear Lake has been stocked annually with young-of-the-year silver salmon since the rehabilitation. The stocking rate has varied from 43,000 to 360,000 fingerlings, depending on their availability from the Fire Lake Hatchery near Anchorage. Most of the fingerlings planted originated from egg takes conducted on the Swanson River, a tributary to Cook Inlet, which drains the northwestern Kenai Peninsula. Engel (1965) reports that Swanson River silver salmon are primarily age 2.1 and rear in both lakes and streams. The effect of the Bear Lake rehabilitation on the growth rate and survival of the various plants was determined by measuring the size and number of silver salmon smolts passing the Bear Creek weir.

Information on 246,400 fingerlings stocked in 1967 is shown in Table 1. Fish originating from Oregon and Kodiak eggs were marked with separate fin clips at the Fire Lake Hatchery to determine the relative survival and growth rate of each stock of fish.

TABLE 1 - The Number, Size, and Fin Clip Combination of Silver Salmon Fingerlings Stocked in Bear Lake During 1967.

<u>Stocking Date</u>	<u>Number of Fingerlings</u>	<u>Number Per Pound</u>	<u>Fin Clip Combination</u>	<u>Origin of Eggs</u>
August 8	50,000	183	Ad-LV	Big Creek, Oregon
August 12	73,700	171	Ad-LV	Big Creek, Oregon
August 28	63,900	168	Ad-RV	Pasagshak River, Alaska
August 28	18,100	171	Ad-LV	Big Creek, Oregon
August 30	40,700	130	Ad-LV	Big Creek, Oregon

Bear Lake Silver Salmon Downstream Migration

The downstream migrant trap on the Bear Creek weir was in operation from May 18 through September 17. Silver salmon smolts were first captured on May 24 and it is unlikely that any substantial migration occurred prior to May 18, based on information collected on the timing of Bear Lake smolt runs since 1962. The entire downstream migration was estimated at 60,943 silver salmon. The run was composed of 38,448 silver salmon with a fork length less than 90 mm, 16,725 smolts having an Ad-LV clip. The 90-millimeter separation point divides the age I from the age II unmarked fish. Examination of Figure 1, illustrating the relative length frequency of unmarked silver salmon by weekly periods, shows two distinct size groups throughout the migration.

A total of 193 scale samples was collected periodically from unmarked fish during the main migration period. Analysis of the scales showed 13.7 percent of the age I fish exceeded 90 mm in length while 12.2 percent of the age II fish were less than 90 mm in length. This small overlap should be compensating and should not result in substantial errors when assigning age by fork length. The samples of 95 age I fish had a mean fork length of 71.8 mm and ranged from 55 to 115 mm while the sample of 98 age II smolts had a mean length of 110.6 mm and ranged from 71 to 156 mm. The smolts with the Ad-LV clip are age II because they were planted in Bear Lake as marked young-of-the-year in 1965.

Silver salmon smaller than 90 mm were marked at the weir with an LV-RV clip while those larger than 90 mm were left unmarked. The fish marked with an LV-RV clip originated from 360,800 unmarked fingerlings planted in Bear Lake from July 11 to August 9, 1966. These fish could not be distinguished from natural fish produced by the 1965 Bear Lake escapement of 127 males and 93 females. Because the egg potential of the 1965 run was so small, it probably did not contribute substantially to the present migration. Also, most of these fish should migrate in 1968 at Age II. The age II unmarked fish over 90 mm are natural smolts produced from the 1964 escapement of 593 males and 316 females. An estimated 21,109 age I unmarked smolts were produced by this brood year in 1966. This represents a total production of 37,834 smolts for 1966-1967 with an average of 12.0 smolts produced per female. The total migration of the 1964 brood year was comprised of 55.8 percent age I and 44.2 percent age II smolts.

The 5,770 Ad-LV smolts counted are a segment of the 1965 smolts from this plant that migrated at age I. The combined 1966 and 1967 migration of 29,245 fish represents an Ad-LV smolt production of 41.9 percent from the 1965 plant. The age composition of the total migration was 80.3 percent age I and 19.7 percent age II smolts. The number of smolts produced in 1966 is slightly higher than reported in the progress report for that year because a number of these fish were accidentally planted in lakes where red salmon, *O. nerka*, smolt transplants were made. Also, some fish that were not enumerated were released

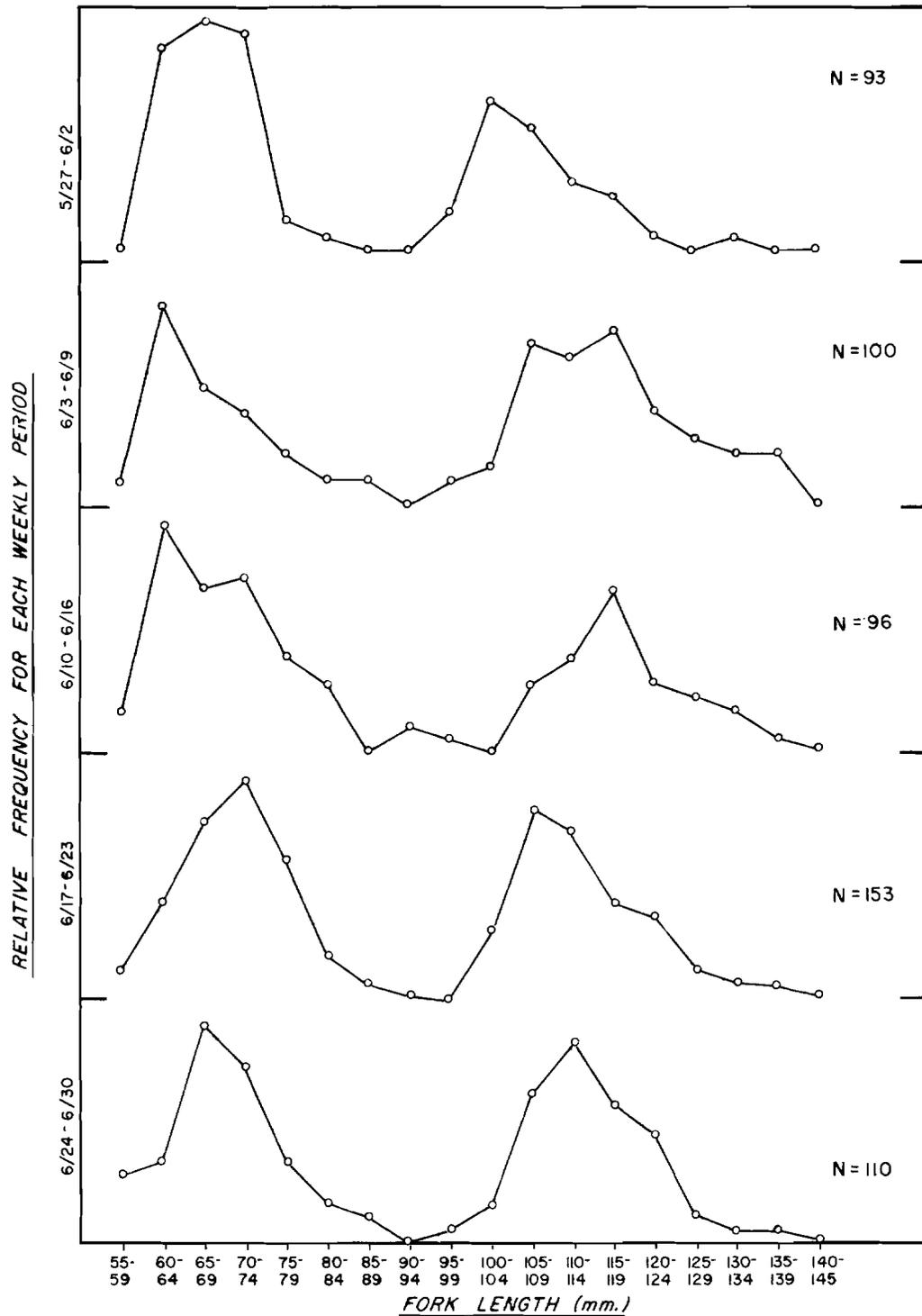


FIGURE 1. THE RELATIVE LENGTH FREQUENCY OF UNMARKED SILVER SALMON SMOLTS COLLECTED AT THE BEAR CREEK WEIR BY WEEKLY PERIODS DURING 1967.

downstream with red salmon smolts. The number of smolts not counted was estimated by sampling the five lakes where the fish were planted with gill nets for 809 net-hours. The ratio of silver to red salmon smolts was determined and this ratio was multiplied by the number of red salmon planted and released downstream.

The abundance and timing of the silver salmon downstream migration by weekly periods are presented in Table 2. The largest number of fish processed in one day was 7,843 on June 11. This comprised 12.9 percent of the total run and occurred when the mean water temperature was 48° F. Eighty-three percent of the total migration occurred when stream temperatures were between 44° F. and 54° F. Smolts that were produced naturally in Bear Lake tended to migrate earlier than fish that had been partially reared in the Fire Lake Hatchery (Figure 2). This same phenomenon occurred in 1966 with natural fish produced from the 1964 brood year.

A total of 2,170 fish (3.6 percent of the total run) died at the weir due to overcrowding in the trap or from handling while they were being sorted and enumerated. Most of the mortality (92.4 percent) occurred to fish less than 90 mm in length. These fish were more susceptible to injury in the trap due to their smaller size and because they were the only fish fin-clipped at the weir.

TABLE 2 - Hatchery-Reared and Natural Silver Salmon Smolts Enumerated Through the Bear Creek Weir by Weekly Periods During 1967.

Weekly Periods	<u>Hatchery-reared smolts</u>		<u>Natural smolts</u>	Total
	1964 brood (Ad-LV clip)	1965 brood (LV-RV clip)	1964 (unclipped)	
	Age II	Age I	Age II	
5/20-5/26	0	44	1	45
5/27-6/2	27	4,470	946	5,443
6/3 -6/9	647	7,017	9,410	17,074
6/10-6/16	3,591	19,573	3,753	26,917
6/17-6/23	1,291	6,150	1,412	8,853
6/24-6/30	188	1,127	945	2,260
7/1 -7/7	23	47	243	313
7/8 -7/14	2	2	11	15
7/15-7/21	0	12	2	14
7/22-7/28	1	4	1	6
7/29-8/4	0	2	1	3
8/5 -8/11	0	0	0	0
Total	5,770	38,448	16,725	60,943
No. Dead	115	2,005	50	2,170
No. Released	5,655	36,443	16,675	58,773

The average fork lengths and sample sizes of downstream migrants checked through the Bear Creek weir by weekly periods are shown in Table 3. The mean length of the Ad-LV smolts (age II) during the peak of their migration was 128.2 mm. Fish from this same plant which migrated in 1966 as age I smolts had a mean length of 107.0 mm. The age II unmarked smolts had an average length of 117.8 mm during the peak of migration while fish from this brood year migrating at age I had a mean length of 104.1 mm. The age I fish marked

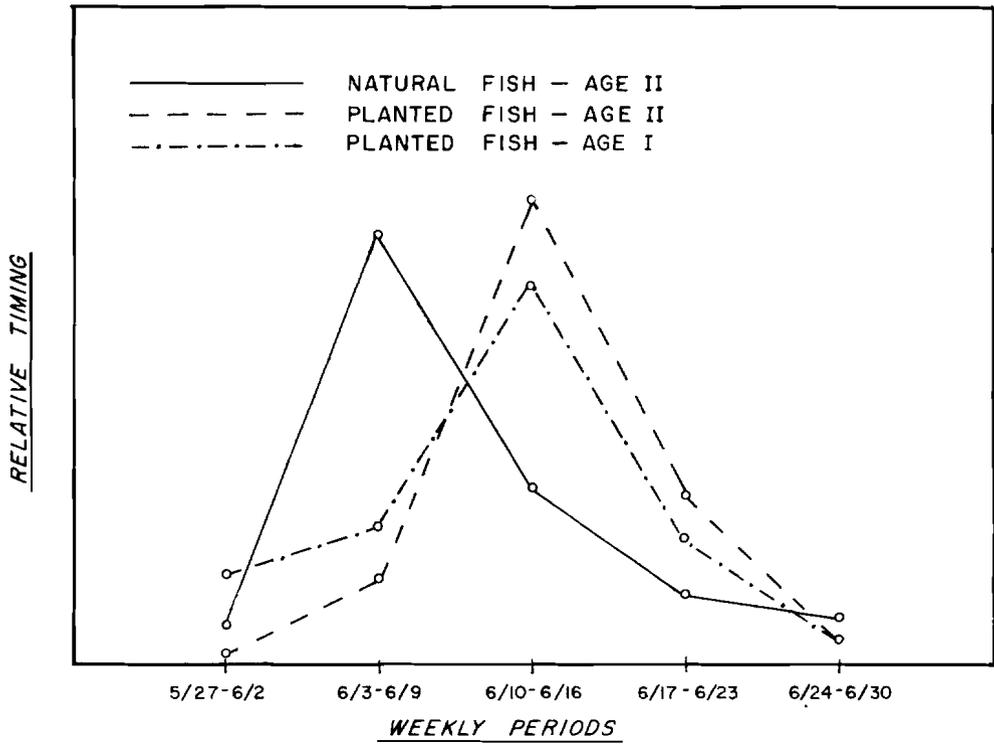


FIGURE 2. THE RELATIVE TIMING OF EACH AGE CLASS OF STOCKED AND NATURAL SILVER SALMON BY WEEKLY PERIODS AT THE BEAR CREEK WEIR, 1967.

with an LV-RV clip had a mean length of 69.9 mm during the peak of their migration. These fish experienced little growth since stocking; a sample of 50 collected on August 30, 1966, averaged 64.2 mm. These fish did not have the physical "smolt" characteristics when they passed through the weir, but instead had the appearance of rearing juveniles. Their average size of 69.9 mm was substantially smaller than the sizes of the following age I smolts from previous plants: 1964 - 95.2 mm, 1965 - 116.4 mm and 1966 - 107.0 mm. It is possible that these fish moved out of the lake to rear another year in a stream habitat. This is the first time this has occurred at Bear Lake except for the late summer downstream drift of planted fingerlings. The destination of these fish cannot be determined until the 1968 adult run is examined for LV-RV clipped fish.

TABLE 3 - The Mean Fork Lengths in Millimeters of Samples from Hatchery-Reared and Natural Smolts Enumerated Through the Bear Creek Weir by Weekly Periods During 1967.

Weekly Periods	<u>Hatchery-Reared Smolts</u>				<u>Natural Smolts</u>	
	1964 brood (Ad-LV clip)		1965 brood (LV-RV clip)		1964 brood (unclipped)	
	No.	Mean	No.	Mean	No.	Mean
5/20-5/26	-	-	43	69.5	-	-
5/27-6/2	22	125.4	61	68.5	28	113.1
6/3-6/9	35	127.9	38	69.3	57	117.8
6/10-6/16	35	128.2	59	69.9	37	119.0
6/17-6/23	69	132.5	78	70.4	74	112.5
6/24-6/30	53	137.4	55	70.0	55	114.6

Silver salmon fingerlings were first captured in the downstream trap on August 15, seven days after the first plant in Bear Lake. All fingerlings captured at the weir were returned to Bear Lake because they were undoubtedly drifting downstream as the planting site is about 300 yards from the outlet. An estimated 32,000 fingerlings were returned to the lake from August 15 to September 6, when high stream flows precluded further capture. Numerous dead fingerlings were observed on the weir screens throughout the period of their movement. An unidentified virus disease had occurred at the Fire Lake Hatchery prior to stocking and this probably contributed to the mortality. Dead fingerlings on the screens had not been observed in appreciable numbers in past years.

Bear Lake Downstream Migration - Other Species

The only pink salmon, *O. gorbuscha*, fry taken were three fish on May 18. There is little spawning area for pink salmon in Bear Creek above the weir and they have not been observed spawning in the inlets of Bear Lake.

Twenty-seven Dolly Varden were captured on the first day of weir operation, indicating that some fish moved out of the lake before May 18. A total of 6,442 Dolly Varden was enumerated between May 18 and August 24. The peak of the migration was May 29 when 1,014 fish were counted (15.7 percent of the total run). These fish were able to enter the lake during the fall of 1966 when high stream flows negated the weir as a fish barrier.

Stomach samples from Dolly Varden were collected during the early and late segment of their downstream migration and are summarized in Table 4. Stomachs collected from May 31 through June 6 showed salmon smolt predation

to be low, as 81.8 percent of the stomachs were empty. The June 17 through June 22 samples showed that smolt predation had increased markedly with 65.5 percent of the stomachs containing food and averaging 0.55 and 0.79 silver and red salmon smolts, respectively. The increased predation is probably due to the greater availability of smolts building up behind the weir and increased stream temperatures. The total predation of smolts is not believed to be high because 92.5 percent of the Dolly Varden had migrated past the weir by June 10.

TABLE 4 - Stomach Contents of 51 Downstream Migrant Dolly Varden Taken at the Bear Creek Weir in 1967 Expressed as Percent Frequency of Occurrence.

<u>Stomach Analysis</u>	<u>Sampling Periods</u>	
	<u>May 31 through June 6</u>	<u>June 17 through June 22</u>
	<u>Percent</u>	<u>Percent</u>
Stomachs with food	18.2	65.5
Stomach empty	81.8	34.5
Insects	4.5	10.3
Silver salmon	13.6	31.0
Mean no. per stomach	0.18	0.55
Red salmon	None	37.0
Mean no. per stomach	None	0.79
Number of fish	22	29
Mean fork length (mm)	220.1	228.2
Range (mm)	156-264	164-269

The red salmon smolt run extended from May 19 through July 30. A total of 38,147 smolts was released downstream while an estimated 116,300 fish were trapped at the weir and planted in several western Kenai Peninsula lakes in an effort to establish kokanee populations.

A sample of 108 scales collected throughout the main migration period was composed of 9.3 percent age I and 90.7 percent age II smolts. Age I smolts had a mean fork length of 82.8 mm and ranged from 77 to 89 mm while the age II smolts had a mean length of 101.3 mm and ranged from 90 to 111 mm. A sample of 84 smolts during the peak of the run had a mean length of 99.1 mm while smolts during the peak of the 1966 migration averaged 80.6 mm. The 1966 run was composed of virtually all age I fish, however.

Bear Lake Silver Salmon Upstream Migration

The upstream migrant trap on the Bear Creek weir was in operation from May 18 through October 28. The first adult silver salmon was captured on August 16 with the run extending to October 23. A total of 4,386 silver salmon was passed over the weir with the highest daily count of 282 fish (6.4 percent of the run) occurring on September 16. The migration was comprised of 80.9 percent planted fin-clipped fish and 19.1 percent naturally produced unmarked silver salmon. The various fin-clip combinations and age classes were as follows: 2,866 Ad-LV fish - age 1.1 (1964 brood year), 681 Ad-RV

fish - age 2.1 (1963 brood year), 839 unclipped fish - primarily age 1.1 (1964 brood year). The sex ratio of males to females was 1.6:1. Males predominated the first half of the run but the sex ratios were similar during the remainder of the migration.

The abundance and timing of the various age and fin-clip groups by weekly periods are presented in Table 5. With the exception of 1966, the run occurred about two weeks earlier than the naturally produced runs of previous years. The stream temperature at the beginning of the migration was 60° F. and dropped gradually to 38° F. at the termination of the run. An estimated 64.5 percent of the migration occurred between 58° F. and 48° F. Stream flows ranged from 18 to 110 cfs during the migration period. High stream flows, in excess of 80 cfs from September 18 through September 29 rendered the weir ineffective as a barrier. During this period, 468 silver salmon were enumerated as they swam over the weir and an additional 255 were estimated to have escaped uncounted. The estimated number of uncounted fish was determined daily by multiplying the number of daylight hours by the mean number of fish per hour for the number of hours counted. The fin-clip and sex for fish swimming over the weir were estimated by averaging the ratio of the various marks and sexes before and after the high water period. Further data on fin-clip and sex ratios were also obtained by dip-netting some fish from the inclined aluminum slat barrier during the high water.

TABLE 5 - Adult Silver Salmon Enumerated Through the Bear Creek Weir by Weekly Periods During 1967.

Weekly Period	1963 brood (Ad-RV clip)	1964 brood (Ad-LV clip)	1964 brood (unclipped)	♂	♀	Total
8/12-8/18	9	16	4	24	5	29
8/19-8/25	112	477	25	496	118	614
8/26-9/1	94	340	34	365	103	468
9/2-9/8	134	538	67	516	223	739
9/9-9/15	132	670	149	539	412	951
9/16-9/22	139	514	231	379	505	884
9/23-9/29	32	130	199	212	149	361
9/30-10/6	8	52	36	42	54	96
10/7-10/13	2	28	24	26	28	54
10/14-10/20	19	96	67	104	78	182
10/21-10/27	0	5	3	4	4	8
Total	681	2,866	839	2,707	1,679	4,386

Because the fingerlings stocked in Bear Lake originated from eggs taken in other areas of Alaska, it was necessary to determine if the returning adults were spawning in the lake's tributaries. Nine foot-surveys were conducted on each of the three Bear Lake inlets between September 21 and October 27. The percentages of the different groups of fish passed through the weir and found spawning in the inlets were similar (Table 6). The good spawning area in each of the inlets was measured using the following criteria: (1) At least one-third of the gravel must be between one-half and six inches in diameter, (2) the stream must not go underground during low flows, (3) the stream must not be blocked by barriers, (4) the stream must have a stable channel. The amount of good spawning area and percentage of fish spawning in each inlet were as follows: Inlet No. 1 - 51 square yards, 11.6 percent; Inlet No. 2 - 66 square yards, 13.7 percent; Inlet No. 3 - 63 square yards, 74.7 percent. Inlet No. 3 received most of the fish despite its limited spawning area. Several fish were observed spawning in Inlet No. 3 in areas

where the channel changes frequently and where portions of the stream go underground during low stream flows. Stocked silver salmon may prefer Inlet No. 3 because it is closest to the point where they enter the lake and is near the area where they were planted as fingerlings.

TABLE 6 - The Percentage and Origin of the Different Groups of Adult Silver Salmon Passing the Bear Creek Weir and Spawning in the Bear Lake Inlets During 1967.

Area of Sample	Ad-RV Clip	Ad-LV Clip	Unclipped
	Swanson River Ketchikan Area	Swanson River	Bear Lake Inlets
Bear Creek Weir	15.5	65.4	19.1
Bear Lake Inlets	14.8	68.8	16.4

Silver salmon were held at the weir as a source of eggs for the Fire Lake Hatchery. Natural spawning area is very limited in the Bear Lake system. There is no good spawning gravel between the weir and the lake and the three inlet streams contain only 180 square yards of suitable spawning area. The escapement of 1,679 females would provide very heavy seeding so a small portion was held for spawn collection. A total of 179 females and 46 males was held for varying periods of time from September 17 through October 20. Water temperatures during this period ranged from 53° F. to 40° F. and averaged 46.0° F. The holding loss was 24.9 percent. This high loss is due chiefly to nearly all the fish captured being "green" and requiring about two weeks to ripen, and because stream temperatures were still relatively high, being drawn off the surface of the lake. A total of 112 females was spawned at the weir and an additional 67 females were dip-netted at Inlet No. 3 and spawned. Spawn was taken between October 10 and October 17. The 179 females yielded an estimated 643,800 eggs. The average number of eggs per female was 3,595. The stocks of fish spawned originated from both Bear Lake and the Swanson River. Pure Bear Lake stocks spawned in 1962 averaged 4,200 eggs per female. An estimated 1,452 females actually spawned in the inlet streams when the holding loss, and the artificially spawned fish are subtracted from the total weir count.

The mean fork lengths and sample sizes of the females measured at the weir were as follows: 123 Ad-LV fish - 648 mm, 26 Ad-RV fish - 659 mm and 57 unmarked fish - 720 mm. There appeared to be no relationship between the size of smolts and size of returning adults. The average fork lengths of smolts producing this run were as follows: Ad-LV smolts - 107.0 mm, Ad-RV smolts - 153.9 mm, and unmarked smolts 104.1 mm. The adult fin-clipped fish were the same size despite the Ad-RV smolts being 30.5 percent larger than the Ad-LV smolts. The unmarked adults were substantially larger and this attributed to their naturally produced Bear Lake origin.

Bear Lake Upstream Migration - Other Species

The adult red salmon upstream migration commenced on June 1 and terminated on July 23. The run was comprised of 671 age 1.2 males, 785 age 1.2 females and 1,816 age 1.1 "jacks." The age was known because the 1963 brood year producing these adults spawned prior to the August 26 Bear Lake rehabilitation which eliminated all other classes.

An additional 298 Bear Lake red salmon were estimated to have been taken by a subsistence gill net fishery held in Resurrection River and Resurrection Bay from June 2 to July 1. The smolt run that produced the age 1.2 adults

consisted of 12,253 fish which migrated to sea in May and June of 1965. The total survival of these smolts to returning adults (harvest plus escapement) was 14.31 percent (1,754/12,253x100).

Water temperatures during the migration ranged from 44° F. to 60° F. with an average temperature of 53° F. during the peak of the red salmon run (June 27) when 209 fish were counted.

A total of 281 red salmon females was removed at the weir and given to local hospitals, leaving a spawning escapement of 504 females. The reduction of the red salmon egg potential was done to stabilize the red salmon population in Bear Lake. Having a low and relatively constant level of red salmon production permits an assessment of the effect of various levels of red salmon abundance on the production of silver salmon. Both 1966 and 1967 were years of high red salmon smolt production. Also, a stable red salmon population allows greater accuracy in measuring the production of the various silver salmon stocking densities.

An undetermined number of Dolly Varden were able to swim past the weir from September 18 through September 29 when high stream flows flooded the barrier. In anticipation of the weir being flooded, an estimated 2,500 Dolly Varden were removed from the upstream trap between September 7 and September 19 and were given to local hospitals. Dolly Varden gaining access to the lake will return to the sea in May and June of 1968 after spending the winter in the lake. Observations by the author in 1961 and 1962 indicated the Bear Lake inlets were not important spawning areas for Dolly Varden and that these fish did not prey substantially on salmon while wintering in the lake.

Adult Silver Salmon Abundance and Timing in Index Streams

The relative abundance of silver salmon in Resurrection Bay drainages has been measured annually since 1961 by foot surveys on selected index areas. The Resurrection River is the greatest producer of silver salmon in the area but its size and glacial water obviate direct survey techniques. Since the river cannot be easily surveyed, efforts have been directed toward collecting escapement data on seven small, clear index streams. The minimum escapement for each index stream since 1961 is shown in Table 7. The present combined escapement of 1,122 silver salmon is the largest recorded for an "odd" year. For the past six years runs have been generally weak on "odd" years and strong on "even" years. This apparent cyclic pattern cannot be explained at this time. The 1967 escapement is nearly double that of the 608 fish escapement of the 1963 parent run. The bulk of the silver salmon in the Resurrection Bay area is age 2.1.

TABLE 7 - Minimum Silver Salmon Escapements in Seven Index Streams in the Resurrection Bay Area, 1961 - 1967.

Name of Stream	Minimum Escapements						
	1961	1962	1963	1964	1965	1966	1967
Airport Creek	162	55	42	52	50	127	55
Clear Creek	96	78	40	217	56	171	227
Dairy Creek	249	603	188	245	48	30	99
Grouse Creek	24	210	76	294	106	236	174
Jap Creek	91	92	72	152	86	228	172
Mayor Creek	21	30	15	95	16	135	66
Salmon Creek	90	212	175	79	174	234	329
Total	733	1,280	608	1,134	536	1,161	1,122

Dairy Creek had an escapement of 99 fish. These are the first returns since the Corps of Engineers restored the Seward Lagoon after the dyke separating from the ocean had been destroyed by the 1964 March 27 earthquake. The progeny of silver salmon spawning in Dairy Creek rear in the 10.2-acre brackish-water lagoon. Prior to the earthquake, the lagoon produced primarily age I smolts. If this age structure persists, the current run of 99 fish was less than half of the 1964 parent run of 245 silver salmon. This could indicate the lagoon is not as favorable for rearing as it was before the earthquake.

The silver salmon sex ratios for each index stream were determined by carcass examination. The ratios of males to females and sample sizes for each stream are as follows: Airport Creek - 0.9:1, n = 39; Clear Creek - 1.1:1, n = 31; Dairy Creek - 1.0:1, n = 66; Grouse Creek - 1.1:1, n = 68; Jap Creek - 1.0:1, n = 22; Mayor Creek - 1.1:1, n = 15; Salmon Creek - 1.0:1, n = 41.

The timing of silver salmon migrations into the index streams was determined by weekly foot surveys. The timing of the first fish to the streams could not be recorded because of high turbid stream flows in late September. The dates of peak escapement for the index streams ranged from October 15 to October 27 which is similar to past years.

Resurrection Bay Silver Salmon Harvest and Effort

The creel census to determine silver salmon harvest and effort was initiated on July 12 and terminated on September 12. The total harvest was estimated at 17,380 silver salmon. This estimate was based on interviews with 5,191 completed fishermen who caught 4,354 silver salmon. The sport and commercial harvests since 1961 are presented in Table 8. Only a small area of Resurrection Bay, south of a line from Callisto Head to Hive Island to Cape Resurrection, was open to commercial fishing, but no fish were reported by commercial trollers fishing the area. This area was closed to commercial fishing for silver salmon by the Board of Fish and Game at their 1967 fall meeting. The peak of the silver salmon harvest occurred on August 12 when an estimated 1,472 fish (8.5 percent of the total catch) were taken. The Seward Silver Salmon Derby extended from August 12 through August 20 with 2,455 tickets sold. The estimated harvest of 6,289 fish taken during the Derby constituted 36.2 percent of the total catch.

TABLE 8 - Sport and Commercial Harvests of Silver Salmon in Resurrection Bay, 1961 - 1967.

<u>Year</u>	<u>Sport Harvest</u>	<u>Commercial Harvest</u>	<u>Total Harvest</u>
1961	5,500	1,330	6,830
1962	14,480	3,920	18,400
1963	7,290	2,250	9,540
1964	2,970	660	3,630
1965	4,020	None Recorded	4,020
1966	9,590	None Recorded	9,590
1967	17,380	None Recorded	17,380

The total catch for other salmon species was not calculated because of the small sample sizes. The observed catch for each species was as follows: 2 chum salmon, 14 pink salmon and 18 king salmon, O. tshawytscha.

The total fishing effort on silver salmon was estimated at 20,100 man-days with 25.8 percent of the fishermen being interviewed. An estimated 42.3 percent of the effort occurred during the nine-day Derby when 8,510 man-days were expended. The effort on weekends and weekdays, excluding the Derby, was 6,735 and 4,855 man-days, respectively. Military personnel fishing from charter boats of the Army and Air Force recreation camps at Seward accounted for 3,830 man-days (19.0 percent of the total effort). This is nearly double their 1966 effort. Fishing effort, catch per hour, and census periods since 1961 are shown in Table 9. The average silver salmon catch per hour of 0.15 was the second highest recorded. The weekday fishermen composed mainly of local people had the highest catch per hour of 0.21 while Derby anglers experienced the lowest catch per hour of 0.10.

TABLE 9 - Silver Salmon Sport Effort, Catch Per Hour and Length of Census in Resurrection Bay, 1961-1967.

<u>Year</u>	<u>Total Effort (man-days)</u>	<u>Derby Effort (man-days)</u>	<u>Catch Per Hour</u>	<u>Period of Census</u>
1961	6,000	2,870	0.10	7/11-9/9
1962	11,380	5,435	0.19	7/7-9/7
1963	15,430	7,480	0.07	7/17-9/10
1964	7,540	4,150	0.05	7/18-9/11
1965	13,380	8,900	0.05	7/14-8/27
1966	14,195	7,055	0.14	7/13-9/13
1967	20,100	8,505	0.15	7/12-9/12

The number and percentage of completed fishermen returning to the Seward Small Boat Harbor was determined for each of the three 3.5-hour sampling periods which extended from 1130 hours to 2200 hours. This information as summarized in Table 10 shows that the greatest number of fishermen terminated fishing during the period from 1500 to 1830 hours. The period from 0800 to 1130 hours was not sampled because data from the past three years showed only 11.6 percent and 14.3 percent of weekend and weekday anglers, respectively, completed fishing during this time. The percentage of anglers that finished fishing during this early period was added to the total for the remaining three periods which were sampled. The average number of anglers per boat was as follows: weekdays - 2.64, weekends - 2.88, Salmon Derby - 2.85. The mean number of hours fished per day was as follows: weekdays - 5.35, weekends - 5.79, Salmon Derby - 7.21.

TABLE 10 - The Average Number and Percentage of Silver Salmon Anglers Returning to the Seward Small Boat Harbor for Each Sampling Period on Weekends and Weekdays During 1967.

<u>Sampling Periods</u>	<u>Weekends</u>		<u>Weekdays</u>	
	<u>Mean Number of Anglers</u>	<u>Percentage</u>	<u>Mean Number of Anglers</u>	<u>Percentage</u>
0800 - 1130 hours*	15.8	11.6	4.1	14.3
1130 - 1500 hours	44.3	32.5	7.4	25.6
1500 - 1830 hours	48.3	35.4	13.3	46.2
1830 - 2200 hours	27.9	20.5	4.0	13.9

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

Fin-Clipped Silver Salmon Analysis

The fin-clipped adult silver salmon caught in the Resurrection Bay fishery and checked through the Bear Creek weir originated from the 1966 Bear Lake smolt migration. This migration consisted of an estimated 22,844 age I smolts with an Ad-LV clip from the 1964 brood year and 4,578 age II smolts with Ad-RV clip from the 1963 brood year. After from 14 to 17 months of ocean life, 2,866 Ad-LV and 681 Ad-RV clipped adults returned to the Bear Creek weir. The marine survival, defined as the survival of smolts released at the weir to adults returning to the weir, was 12.55 percent for Ad-LV smolts (2,866/22,844 x 100) and 14.87 percent for the Ad-RV smolts (681/4,578 x 100). The marine survival of the 14,083 age I unmarked smolts was 5.96 percent (839/14,083 x 100).

The contribution that Bear Lake smolts made to the Resurrection Bay fishery was measured by examining the sport catch for fin-clipped silver salmon concomitant with creel census. Fish were examined in a random manner and anglers bringing marked fish to the creel census observer were not used in the analysis. A total of 4,029 fish was examined of which 286 or 7.1 percent were fin-clipped. The observed fin-clipped fish catch consisted of 239 Ad-LV and 47 Ad-RV silver salmon. Fish with an adipose clip only comprised 2.5 percent of the marked fish and these were added to the two marked fish groups based on their ratio to each other. The percentage of marked fish groups expanded for the total harvest of 17,380 yielded an estimated catch of 1,030 Ad-LV and 203 Ad-RV clipped silver salmon. The observed and calculated recoveries of marked silver salmon from Bear Lake since 1963 are shown in Table 11. The ratio of the fin-clip groups found in the fishery and at the weir was similar. Ad-LV adults comprised 83.5 percent and 80.8 percent of marked fish checked in the fishery and at the weir, respectively.

TABLE 11 - Observed and Calculated Recoveries of Silver Salmon Smolts, Marked at Bear Creek, in the Sport and Commercial Fisheries in Resurrection Bay, 1963 - 1967.

<u>Year of Recovery</u>	<u>Number of Fish Sampled</u>	<u>Estimated Total Catch</u>	<u>Percentage of Catch Sampled</u>	<u>Number of Marked Fish Recovered</u>	<u>Calculated Number of Marked Fish</u>
1963	1,260	9,540	13.2	6	45
1964	630	3,630	17.4	27	155
1965	1,454	4,020	36.2	63	174
1966	2,357	9,590	24.6	159	647
1967	4,029	17,380	23.1	286	1,233

The efficiency of the sport fishery in harvesting silver salmon stocks in Resurrection Bay was determined by comparing the projected catch of marked fish to the escapement at the weir. The catch-to-escapement ratio of 0.35:1 (1,233/3,547) shows the 1967 run was not heavily exploited. A summary of these ratios since 1963 is presented in Table 12.

The number of unmarked fish harvested was estimated at 294. This was calculated by assuming the same catch-to-escapement ratio for unmarked fish as was determined for marked fish and multiplying this ratio by the unmarked escapement at the weir (0.35 x 839 = 294). The total Bear Lake adult production (harvest plus escapement of marked and unmarked fish) was estimated at 5,913 silver salmon.

TABLE 12 - The Catch-to-Escapement Ratio of Silver Salmon Marked at Bear Creek, 1963-1967.

Year of Recovery	Calculated Number Taken in Fishery	Number of Adults Returning to Weir	Total Adults	Catch-to-Escapement Ratio
1963	45	30	75	1.50:1
1964	155	436	591	0.36:1
1965	174	212	386	0.82:1
1966	647	2,469	3,116	0.26:1
1967	1,233	3,547	4,780	0.35:1

Bear Lake Population Sampling

Small-mesh gill net sampling was conducted periodically from July 25 to August 29 to determine the species composition and growth rate in Bear Lake. For every sampling period three nets were set on the bottom perpendicular to the southeast shore in depths ranging from 8 to 15 feet. A summary of the gill net sampling is presented in Table 13. The 131 silver salmon taken are believed to be chiefly age I juveniles from the 1966 plant. On May 25, a sample of 43 of these fish had a mean fork length of 69.5 mm, and by the end of August their length had increased to an average 107 mm (35.0 percent). No clipped fish from the 1967 plant were taken because they were too small for the net mesh. Stomach samples were collected from 125 silver salmon of which 10 (8.0 percent) were found to be empty. Analysis of the 115 stomachs containing food showed insects and snails in 86.1 percent of the stomachs while threespine sticklebacks were in the remaining 13.9 percent. Juveniles with stomachs containing insects and snails ranged in length from 82 to 117 mm with a mean of 103.7 mm, while those with sticklebacks ranged from 105 to 125 mm with a mean length of 114.4 mm. This suggests that rearing silvers reach a certain size, in this case more than 105 mm, before feeding on sticklebacks. Occurrence of sticklebacks was more prevalent in the August samples and this is probably because they had recently hatched.

The Dolly Varden catch per net-hour, which ranged from 0.17 to 0.30, indicated a substantially greater population remained in the lake during the summer than in past years. Should these fish continue to remain in the lake silver salmon rearing potential will be further reduced. Stomach samples were collected from 50 fish of which 9 (18.0 percent) were empty. The 41 stomachs with food contained either snails or insects. These fish ranged in length from 104 to 274 mm with a mean of 190.2 mm. Although these fish were of a sufficient size to prey on salmon, none were observed in the samples suggesting that, during this period at least, predation is limited.

On August 31, a seine sample was collected in Bear Lake off the terminus of Inlet No. 3 to determine the rate of threespine stickleback reinfestation. Two seine hauls captured 49 sticklebacks and 150 planted, clipped silver salmon. In 1966, only one stickleback was captured during two separate seine samples. The stickleback population, increasing substantially, is further evinced by examining the number captured in the downstream weir trap. In 1966, three sticklebacks were counted during the entire period of weir operation while this past season 286 were enumerated from May through August. The weir, prior to the Bear Lake rehabilitation, did not permit an assessment of stickleback abundance, but it is believed that the existing population is approaching pre-rehabilitation levels.

TABLE 13 - Summary of Test Fishing in Bear Lake During 1967 Using Three 100 by 6-Foot, 1/2 to 1 1/4-Inch Stretch Mesh, Gill Nets Per Sample.

Sampling Date	Fish Species	Number Caught	F.L. Range	Mean	Catch per Net-Hour
July 25	Silver Salmon	44	82-125	103.8	0.58
	Dolly Varden	23	143-270	202.3	0.30
August 8	Silver Salmon	40	90-117	104.6	0.55
	Dolly Varden	12	104-274	192.8	0.17
August 29	Silver Salmon	47	92-122	107.0	0.65
	Dolly Varden	15	125-265	189.3	0.21
	Red Salmon	5	110-120	114.0	0.07

Incubation Channel Water Supply Evaluation

Data on stream flows and temperatures were collected at Inlet No. 3 of Bear Lake to evaluate the stream as a source of water for a proposed artificial incubation channel. A stream gauging station was established in 1966 in cooperation with the U.S. Geological Survey. A 45-day Ryan thermograph was installed in the stream to record water temperatures while a second thermograph was buried approximately 20 inches below the stream bed to record subsurface water temperatures. At the time of this report, the data have not been evaluated by the U.S. Geological Survey.

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Prepared by:

Sidney M. Logan
Fishery Biologist

Date: April 15, 1968

Approved by:

s/ Louis S. Bandirola
D-J Coordinator

s/ Alex H. McRea, Director
Sport Fish Division