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STATE OF ALASKA
Keith H. Miller, Governor



ANNUAL REPORT OF PROGRESS, 1968 - 1969
FEDERAL AID IN FISH RESTORATION PROJECT F-9-1
SPORT FISH INVESTIGATIONS OF ALASKA

ALASKA DEPARTMENT OF FISH AND GAME
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THE STATE OF ALASKA
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INTRODUCTION

This report of progress involves the findings and work accomplished under the State of Alaska, Federal Aid in Fish Restoration, Project F-9-1, "Sport Fish Investigations of Alaska".

The work conducted during this reporting period constitutes effort on nine separate studies which are crucial in evaluating the sport fishing resources of the State. Recreational demands have necessitated broadening our knowledge of the fishery. All 20 jobs were of continuing nature enabling the Department to keep abreast of present and future impacts on certain fish species. Specifically, the work included work on inventory and cataloging of the sport fish and sport fish waters of the State, sport fishery creel census and access. Special emphasis was given to Dolly Varden, silver salmon, anadromous fish, grayling, salmon, sheefish, pike, and char. The information gathered has provided supporting documentation for better fish management and a basis for necessary future investigations.

The subject matter contained in these reports may be inconclusive. The findings and interpretation are subject to re-evaluation as the work progresses.

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RESEARCH PROJECT SEGMENT

STATE: ALASKA Name: Sport Fish Investigations of Alaska.
Project No: F-9-1 Title: Silver Salmon Studies in the Resurrection Bay Area.
Job No: 7-B-1
Period Covered: July 1, 1968 to June 30, 1969.

ABSTRACT

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

The downstream migrant trap on the Bear Creek weir was operated from May 22 through October 7, 1968. The silver salmon seaward migration consisted of 3,407 age I smolts with an AdLV clip, 1,342 age I smolts with an AdRV clip and 13,290 age II smolts marked at the weir with an Ad clip. The mean fork lengths of the AdLV, AdRV and Ad marked smolts were 80.4, 89.4 and 124.7 mm, respectively. The peak of the smolt migration occurred on June 18.

The adult silver salmon upstream migration was comprised of 153 age 1.1 LVRV clipped fish, 816 age 2.1 AdLV clipped fish and 3,325 age 2.1 unmarked fish. The male-to-female ratio was 1.3:1. The migration extended from August 22 through October 23, with the peak occurring on September 27. An estimated 1,904,600 eggs were artificially spawned at the Bear Creek weir from 529 females.

The total minimum escapement of 2,214 silver salmon for the seven index streams was the greatest observed.

A creel census conducted at the Seward Small Boat Harbor from July 6 through September 10 showed an estimated 22,560 silver salmon were taken in Resurrection Bay by 25,350 man-days of effort. The mean catch per hour was 0.15. The catch-to-escapement ratio of fin-clipped silver salmon was 0.30:1. The marine survival for the LVRV, AdLV and unmarked adults was 0.42, 14.40 and 19.94 percent, respectively.

Data on the timing and abundance of other fish species passing the Bear Creek weir are presented. The success of the silver salmon fry plants, changes in smolt growth rates and age structures and the increase in abundance of threespine stickleback, Gasterosteus aculeatus, is discussed.

Detailed and additional data collected during this report segment is on file at the Seward field office.

RECOMMENDATIONS

1. Retain the present objectives of the study.
2. Modify the Bear Creek weir to facilitate the processing of upstream migrants and holding of adult salmon for egg takes.
3. Rehabilitate Bear Lake to determine the lake's potential for rearing silver salmon fry to smolt size.

4. Adhere to the Alaska Department of Fish and Game's Bear Lake Management and Research Policy of June 26, 1968, which limits the production of red salmon.

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.
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 abundance and timing of silver salmon, *O. kisutch*, smolts and fry migrating out of Bear Lake were enumerated with a fish weir located in Bear Creek 1,750 feet downstream from Bear Lake. The downstream trapping facilities were comprised of a series of vertical screens which guided downstream migrants into a model "B" fishpass containing adjustable louvers to regulate water flows into the trap. The timing and abundance of adult silver salmon into Bear Lake were measured with a barrier constructed of aluminum slats which diverted upstream migrants into a standard "V" trap. The weir's trapping facilities are described in detail by Logan (1966).

The age structures of the fin-clipped silver salmon smolts and adults were determined by examining each fish for the fin-clip combination assigned to it when it was a young-of-the-year. The age composition of unmarked silver and red salmon, *O. nerka*, smolts and adults was found by examining scales pressed on 0.02-inch thick cellulose-acetate with a microprojector. 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 M.S.-222 (Tricaine Methanesulfonate). Stream temperatures and flows were recorded daily at the weir.

The salmon sport harvest and effort in Resurrection Bay were measured by a creel census conducted at the Seward Small Boat Harbor. The sampling design and interview method were nearly the same as that described by Logan (1965). Fishing mortality was determined by checking as many silver salmon as feasible concomitant with creel census interviews to ascertain the catch of fin-clipped fish. An index to silver salmon escapement 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.

Methods of increasing the freshwater rearing areas and mitigating the freshwater mortality of juvenile silver salmon were evaluated by determining the production, to smolt size, of fingerlings stocked in rehabilitated

Bear Lake. This was accomplished by enumerating smolts at the Bear Creek weir and measuring their relative age structures and growth rates. Means of increasing the silver salmon spawning areas are being determined by evaluating the suitability of the flows and temperatures of Inlet No. 3 of Bear Lake as a source of water for an artificial incubation channel.

The reinfestation rate of threespine stickleback, *G. aculeatus*, in Bear Lake was determined by measuring the relative magnitude of their downstream movement past the weir and by seining at a beach index site with a 1/2-inch stretch mesh 35 by 5-foot seine.

FINDINGS

The findings presented are the result of the 1968 segment of this project. For a description of the area and information collected on the project in past years, see Dunn (1960) and Logan (1961 through 1967).

Bear Lake Project

The Bear Lake system was selected for study and the enhancement of salmon populations because it is accessible by road and is the largest body of fresh water in the Resurrection Bay area. This 445-acre lake offers the greatest stable rearing area for silver salmon which are generally subjected to the vicissitudes in flows and temperatures characterizing the streams of the area. Bear Lake was rehabilitated with rotenone in August, 1963, in an effort to mitigate freshwater mortality and increase its rearing potential for juvenile salmon (Logan, 1963). Since the rehabilitation, the lake has been stocked annually with silver salmon young-of-the-year at a stocking rate ranging from 97 to 811 fish per acre with a five-year mean of 390. The disparity in stocking densities is due chiefly to the availability of fish from the Fire Lake Hatchery near Anchorage. The fingerling plants originated from eggs taken on the Kenai Peninsula, Kodiak Island and from the Ketchikan area in Alaska and at Big Creek in Oregon. The majority of the fish, however, originated from egg takes on the Swanson River which is a tributary to Cook Inlet draining the northwestern Kenai Peninsula. The silver salmon from this system are primarily age 2.1 and rear in both streams and lakes (Engel, 1965). The survival and growth rate of these various plants in Bear Lake were determined by measuring the abundance and size of silver salmon smolts migrating past the Bear Creek weir.

Bear Lake Silver Salmon Downstream Migration

The downstream migrant trap at the Bear Creek weir was installed on May 22, and operated continuously through October 7. Nine silver salmon smolts were captured the first day of operation. However, based on timing data collected on Bear Lake smolt runs since 1962, it is unlikely that any significant migration occurred before May 22. The entire migration during the period of weir operation was calculated at 18,115 silver salmon smolts. This run consisted of 3,407 AdLV clipped smolts, 1,342 AdRV clipped smolts, 13,290 unmarked smolts with a fork length greater than 90 mm, and 76 unmarked silver salmon with a fork length less than 90 mm. The 90 mm break-off point was selected to separate age I from age II smolts based on age-length information collected by Logan (1967). A total of 204 scale samples was collected from unmarked fish between May 28 and July 3. The age I, II and III smolts had mean fork lengths of 74.3, 114.6 and 150.3 mm, respectively (Table 1). Smolts over 90 mm were marked with an adipose clip, while those less than 90 mm were left unmarked. The percentage and number of smolts over 90 mm in each age class were as follows: Age I - 0.7 percent (93 fish), age II - 90.0 percent (11,961 fish), age III - 9.3 percent (1,236 fish). Smolts having an AdLV and AdRV clip were age I because they were stocked in Bear Lake as marked young-of-the-year in 1967.

TABLE 1 - Mean Fork Length and Range (mm) for Each Age Class of Unmarked Silver Salmon Smolts Captured at the Bear Creek Weir During 1968.

<u>Age Class</u>	<u>Number of Fish</u>	<u>Mean</u>	<u>Range</u>
I	41	74.3	50 - 98
II	149	114.6	80 - 157
III	14	150.3	120 - 163

The 11,961 age II smolts marked with an adipose clip originated primarily from 360,800 fingerlings planted in Bear Lake during the summer of 1966. An estimated 35,679 fish from this plant migrated at age I in 1967 and were marked with an LVRV clip. The combined 1967 and 1968 migrations represent a possible maximum production of 13.2 percent from the 1966 plant. This is because fish from this plant could not be distinguished from naturally produced smolts from the 1965 escapement of 127 males and 93 females. The 1,236 age III fish also marked with an Ad clip were natural smolts produced by the 1964 brood year of 593 males and 316 females. This brood year produced 21,109 age I smolts in 1966 and 19,494 age II smolts in 1967. The total production from this brood year was 41,839 smolts with an average of 132.4 smolts produced per female. The age composition of smolts produced by the 1964 brood year was 50.5 percent age I fish, 46.6 percent age II fish and 2.9 percent age III fish. The 3,407 AdLV and 1,342 AdRV clipped smolts resulted from 182,500 and 63,900 young-of-the-year, respectively, which were marked at the Fire Lake Hatchery and stocked in Bear Lake from August 8 to August 30, 1967. The age I smolt production for the AdLV plant was 1.87 percent and for the AdRV plant was 2.10 percent. The AdLV and AdRV fish originated from eggs taken at Big Creek, Oregon and the Pasagshak River on Kodiak Island, Alaska, respectively.

The abundance and timing of the silver salmon downstream migration are presented in Table 2. The highest daily count occurred on June 18 when 1,412 smolts (7.8 percent of the total run) were enumerated. The stream temperature at the initiation of the smolt migration was 40°F with 91.7 percent of the migration occurring between 42° and 56°F. Smolts originating from Oregon stocks migrated earlier than those of Alaskan origin. Fifty percent of the smolts from each group had migrated past the weir by the following dates: Oregon stock (AdLV fish) - June 7; Kodiak stock (AdRV fish) - June 15; and Bear Lake stock (Ad fish) - June 15. Silver salmon fry moved downstream through the weir substantially earlier than in past years. These fry were probably produced in Bear Creek above the weir. The 1967 adult escapement was the largest measured and silver salmon were observed spawning between the weir and the lake. This section of stream has heavy deposits of silt and decomposing sawdust and has not been used for spawning by past escapements. All fry were returned to Bear Lake. The average fork lengths of these fry measured periodically were as follows: July 8 - 36.2 mm (n=30); July 19 - 39.1 mm (n=31); August 1 - 41.1 mm (n=33); August 14 - 42.3 mm (n=30).

The mean fork lengths of silver salmon smolts that passed through the Bear Creek weir by weekly periods are shown in Table 3. The average lengths of the age I AdLV and AdRV smolts during the peak of their migration were 80.4 and 89.4 mm, respectively, while the Ad smolts (90.0 percent age II) had a mean length of 124.7 mm. The mean lengths of age I smolts during the peak of migration from previous Bear Lake plants were as follows: 1964 - 95.2 mm; 1965 - 116.4 mm; 1966 - 107.0 mm; 1967 - 69.9 mm; 1968 - 74.3 mm. The age II smolts from prior plants had the following average fork lengths: 1965 - 167.5 mm; 1966 - 153.9 mm; 1967 - 128.2 mm; 1968 -

114.6 mm. It is evident that the mean lengths of age I and II smolts have been gradually declining, since the Bear Lake rehabilitation, to a point where the average size is similar to that of pre-rehabilitation smolts. The age structure of the silver salmon smolts migration originating from stocked fingerlings has also changed appreciably since the rehabilitation. The age structure of smolts from these various young-of-the-year plants were as follows: 1963 plant - 64.1 percent age I and 35.9 percent age II; 1964 plant - 73.0 percent age I and 27.0 percent age II; 1965 plant - 80.3 percent age I and 19.7 percent age II. In the 1966 plant, there were few age I fish that could be classified as "typical" smolts (Logan, 1967) because the survival of these fish to returning adults was the lowest recorded (0.42 percent). The percentage of the various fingerling plants migrating as smolts has declined substantially. Nine percent of the 1963 plant migrated as smolts, even though these fingerlings were stocked through the ice in December when rearing conditions were probably unfavorable. A minimum estimate of 39.6 percent of the 1964 fry plant migrated as smolts. A maximum of 13.2 percent of the 1966 plant, including primarily age I fish not having "smolt characteristics" could have migrated as smolts, while an average of only 1.9 percent of the 1967 plant (age I) migrated downstream. A review of the aforementioned changes in population suggests that Bear Lake should be rehabilitated again if high silver salmon production is to be accomplished. This conclusion is based, in brief, on the following: (1) a gradual decline in the sizes of age I and II smolts, (2) the age structure of the smolt migrations reverting to age II fish again becoming dominant, (3) the declining production of fingerling plants to migrating smolts, (4) the substantial increase in the threespine stickleback population (reviewed later in the report), (5) a decline in the production of red salmon smolts.

TABLE 2 - Silver Salmon Smolts and Fry Enumerated Through the Bear Creek Weir by Weekly Periods During 1968.

Weekly Periods	Hatchery Origin			Natural Origin	
	1965 Brood (Ad Clip)	1966 Brood (AdLV Clip)	1966 Brood (AdRV Clip)	1966 Brood (Unclipped)	1967 Brood (Unclipped)
5/20-5/26	17	94	5	8	11
5/27-6/02	362	863	79	27	26
6/03-6/09	1,861	1,044	349	19	87
6/10-6/16	5,440	431	374	9	216
6/17-6/23	4,234	647	400	9	163
6/24-6/30	1,037	174	80	2	107
7/01-7/07	225	78	36	1	2
7/08-7/14	55	41	11	1	10
7/15-7/21	13	13	4	0	13
7/22-7/28	4	3	0	0	2
7/29-8/04	5	3	1	0	36
8/05-8/11	1	2	0	0	84
8/12-8/18	1	1	0	0	260
8/19-8/25	3	3	1	0	295
8/26-9/01	2	4	0	0	125
9/02-9/08	1	1	0	0	177
9/09-9/15	1	1	1	0	127
9/16-9/22	1	3	0	0	26
9/23-9/29	0	0	0	0	5
9/30-10/6	27	1	1	0	28
Total	13,290	3,407	1,342	76	1,800
No. Dead	84	76	12	9	0*
No. Released	13,206	3,331	1,330	67	0

*Fry mortality was not recorded.

TABLE 3 - The Mean Fork Lengths (mm) of Samples from Silver Salmon Smolts Enumerated Through Bear Creek Weir by Weekly Periods During 1968.

Weekly Periods	1965 Brood (Ad Clip)		1966 Brood (AdLV Clip)		1966 Brood (AdRV Clip)	
	Number	Mean	Number	Mean	Number	Mean
5/27-6/02	50	109.8	50	81.0	51	85.7
6/03-6/09	50	106.5	50	80.4	50	87.7
6/10/6/16	50	124.7	50	77.1	50	86.4
6/17-6/23	135	127.7	50	81.3	50	89.4
6/24-6/30	164	127.7	69	79.7	50	87.7
7/01-7/07	83	127.5	50	96.2	36	96.0

Bear Lake Downstream Migration - Other Species

A total of 349 Dolly Varden, *Salvelinus malma*, were captured between May 22, the first day of weir operation, and October 7. The highest daily count occurred on June 6 when 40 fish (11.5 percent of the total run) were enumerated. These fish were able to enter Bear Lake between September 18 and 29, 1967, when high stream flows negated the weir as a fish barrier.

A total of 385 red salmon smolts were captured on the first day of weir operation indicating some fish had moved out of the lake before May 22. The last smolt was taken on July 11. A total of 34,066 smolts were released downstream while 22,850 fish were trapped at the weir and stocked in three western Kenai Peninsula lakes in an effort to establish kokanee sport fisheries. The highest daily count occurred on June 4 when 11,442 smolts (20.1 percent of the run) were enumerated with the main stream temperature being 45°F. A sample of 108 scales, collected periodically throughout the migration, was comprised of 93.5 percent age I and 6.5 percent age II smolts. Fork lengths from 50 smolts collected during the peak of migration ranged from 80 to 98 mm with a mean of 89.5 mm.

A total of 5,893 threespine sticklebacks was taken from May 22 to October 7, with these fish still being abundant when the trap was closed. The highest daily count of 293 occurred on July 27 when water temperatures averaged 61.5°F. The number of stickleback counted each month were as follows: May - 64; June - 320; July - 1,814; August - 1,638; September - 1,745; October - 312.

Bear Lake Silver Salmon Upstream Migration

The upstream migrant trap was opened on May 22 and operated continuously until October 20 when it was closed down to facilitate weir modifications. The first adult silver salmon was captured on August 22, and a foot survey of Bear Creek on October 23, three days after the termination of trap operation, showed 34 fish remained in the stream. A total of 4,294 silver salmon were enumerated with the highest daily count of 778 fish (18.1 percent of the run) occurring on September 27. The percentages of fin-clipped and unmarked silver salmon were 22.6 and 77.4, respectively. The various age classes and fin-clip combinations were as follows: 153 age 1.1 fish (1965 brood year) with an LVRV clip; 816 age 2.1 fish (1964 brood year) with an AdLV clip and 3,325 age 2.1 fish (1964 brood year) which were unmarked. The LVRV clipped silver salmon resulted from the 1966 fingerling plant in Bear Lake. These fish were marked with an LVRV clip at the Bear

Creek weir during their 1967 downstream migration. The AdLV clipped silver salmon originated from the 1965 plant which migrated to sea as age II smolts in 1967. The unmarked silver salmon adults are the result of natural production from the 1964 escapement into Bear Lake. The sex ratio of males to females was 1.34:1. Males predominated the first segment of the migration with the sex ratio becoming similar during the latter portion of the run.

The timing and abundance of the various silver salmon age and fin-clip groups are presented in Table 4. The timing pattern of the 1968 run was similar to the majority of past migrations. Each group of returning adults was examined to determine if any appreciable differences existed between the timing of stocked fish and those naturally produced. Fifty percent of the LVRV and AdLV clipped fish, both of Swanson River origin, and unmarked fish produced naturally in Bear Lake had all passed the weir on September 29, suggesting no difference in their timing.

TABLE 4 - Adult Silver Salmon Enumerated Through the Bear Creek Weir by Weekly Periods During 1968.

Weekly Period	1965 Brood (LVRV Clip)	1966 Brood (AdLV Clip)	1966 Brood (Unclipped)	Male	Female	Total
8/19-8/25	1	4	10	13	2	15
8/26-9/1	3	3	15	14	7	21
9/2-9/8	1	6	14	13	8	21
9/9-9/15	19	110	226	269	86	355
9/16-9/22	4	6	20	23	7	30
9/23-9/29	50	344	1,619	1,274	739	2,013
9/30-10/6	46	244	994	610	674	1,284
10/7-10/13	14	75	328	191	226	417
10/14-10/20	13	18	73	40	64	104
10/21-10/27	2	6	26	16	18	34
TOTAL	153	816	3,325	2,463	1,831	4,294

The water temperature at the initiation of the upstream migration was 62°F, dropping gradually to 36°F at the termination of the run. Most of the migration (84.5 percent) occurred when stream temperatures were between 44°F and 56°F. Stream flows ranged from 7 to 37 cfs during the migration period.

Bear Lake stocks were used as a source of silver salmon eggs for the Fire Lake Hatchery. The Bear Lake run was selected because the escapement was greater than needed to seed the 180 square yards of good spawning area in the lake's three inlets and the lake may be rehabilitated in 1969. A total of 656 females were held at the weir for artificial spawning, leaving an escapement of 1,175 females to spawn naturally. Fish were held for varying periods of time from September 6 through October 16. Stream temperatures during this period ranged from 56° to 40 F with a mean of 49.4°F. The female holding mortality was 19.4 percent. This loss is believed to be due to overcrowding in the holding pens and above-average water temperatures. A total of 529 females were spawned, yielding an estimated 1,904,600 eggs with a mean of 3,600 eggs per female. Approximately one male was used to fertilize every three females. The fish spawned were a combination of Bear Lake and Swanson River stocks. Spawn was taken on six occasions, between September 30 and October 16, with stream temperatures ranging from 40° to 52°F.

The average fork lengths of the female silver salmon measured at the weir and used for spawning were as follows: LVRV fish - 645 mm, AdLV fish - 634 mm and unmarked fish - 642 mm. No attempt was made to select a certain

size of females for spawning because the magnitude of the escapement was not known when the egg take was initiated. Larger males, however, were retained for spawning. The mean fork length and range, as well as sample size of male and females measured at the weir, are shown in Table 5. No direct relationship appeared to exist between smolt size and the size of the returning adults. The LVRV clipped adults were the largest while the smolts that produced them showed the smallest mean size of the 1967 smolt run.

TABLE 5 - The Mean Fork Length and Range (mm) of Adult Silver Salmon Taken at the Bear Creek Weir During 1968.

	Unmarked Fish			AdLV Fish			LVRV Fish		
	Number	Mean	Range	Number	Mean	Range	Number	Mean	Range
Males passed over the weir	70	604	445-710	39	615	460-710	14	629	560-730
Males selected for spawning	33	726	600-810	18	665	580-735	7	690	560-800
Females passed over the weir and used for spawning*	228	642	510-770	92	634	530-710	16	645	575-760

*Females were not selected for spawning and therefore represent a random sample.

Bear Lake Upstream Migration - Other Species

The first adult red salmon was checked at the weir on May 23, and the last fish was taken on July 30. A total of 58,964 fish was enumerated with the highest daily count of 4,604 red salmon (7.8 percent of the run) occurring on June 23. The migration consisted of an estimated 30,063 females and 28,901 males. Sixty-four of the males were precocious (jacks). The sex ratio of males to females was 0.96:1. A sample of 220 scales was collected periodically throughout the migration. The adult age structure was comprised of 99.5 percent age 1.2 fish and 0.5 percent age 1.3 fish. The age 1.2 fish had a mean fork length of 523.8 mm and an average weight of 3.98 pounds. The 1966 smolt run that produced this adult return was comprised of virtually all age I fish, but the magnitude of the migration was unknown. Water temperatures during the migration ranged from 40° to 64°F with 83.5 percent of the run occurring when temperatures were between 43° and 57°F. This escapement was the greatest recorded for the system since 1924 when 41,000 fish were enumerated with a weir operated by the U.S. Fish and Wildlife Service. The red salmon run from 1961 through 1965, prior to the effects of the Bear Lake rehabilitation, ranged from 2,897 to 8,651 fish with a mean of 4,658. The number of fish measured at the Bear Creek weir represents the total run as Resurrection Bay has been closed to commercial red salmon fishing for a number of years. In view of the particularly large escapement, and because Bear Lake may be rehabilitated in 1969, 1,174 fish were donated to hospitals and 7,730 sold to canneries. An additional 201 red salmon were killed but not picked up by the cannery.

An estimated 71,672 and 2,876 red salmon were captured in the Resurrection Bay commercial and subsistence fisheries, respectively. The commercial harvest was determined by fish tickets and the subsistence catch through returns from the 107 subsistence permits issued. The commercial season was open continuously from May 27 through July 7 with nearly all the fish being taken by drift gill nets. The peak of the fishery occurred

from June 9 to June 15 when 37.1 percent of the catch was made. The commercially caught red salmon had an average weight of 4.60 pounds. The unusually large return is believed to be due to the very favorable rearing conditions in the lake for the progeny of the 1964 brood year which migrated to sea in 1966 as age I smolts. The 1965 rearing period was two years after the rehabilitation and threespine sticklebacks had not yet been observed. Also, there was a paucity of rearing silver salmon as the 1964 and 1965 plants were only 43,000 and 69,800 fingerlings, respectively.

Red salmon from Bear Lake were artificially spawned on August 7 and 8 to fulfill a request for eggs by the Japan Salmon Resource Preservation Association. The fish were captured by seining in the lake near Inlet No. 3. Eighty-eight females were spawned yielding an estimated 258,400 eggs with a mean of 2,936 eggs per female. The surface water temperatures of Bear Lake during the egg take ranged from 59° to 65°F.

One adult steelhead, *Salmo gairdneri*, was captured in the upstream trap on May 28. Adult pink salmon, *O. gorbuscha*, were first observed below the weir during late July and were abundant until the end of August. These fish were not passed upstream because of the very limited spawning area available to them (Logan, 1966). A foot survey of Bear Creek conducted on August 22 revealed 3,080 pink salmon of which 12.7 percent were dead.

Adult Silver Salmon Timing and Abundance in Index Streams

The relative timing and abundance of adult silver salmon in the Resurrection Bay area have been measured each year since 1961 by conducting foot surveys of selected index areas on seven streams. The Resurrection River, including its tributaries above the Seward Highway Bridge, is the greatest silver salmon producer in the area; but its inaccessibility, size and glacial water obviate direct survey methods. Because of this, effort has been directed toward obtaining timing and escapement information on seven clear streams near the road system. Each index stream was surveyed weekly from September 16 through October 30. Surveys during the past seven years showed fish did not usually ascend these streams until about September 20. The timing of the 1968 escapement was similar to past years with the peak of the various runs occurring from October 4 to October 30. The minimum silver salmon escapements in each index stream since 1961 are shown in Table 6. No marked fish from Bear Lake were found in any of the index streams. The 1968 combined escapement of 2,214 fish is the largest recorded since the surveys were initiated. Since the majority of silver salmon in the Resurrection Bay area are age 2.1, this escapement represents a 95.2 percent increase over the 1964 parent run of 1,134 fish. The Dairy Creek escapement of 98 fish is considerably below the four-year mean of 321 silver salmon which existed prior to the March 27, 1964 earthquake. Seismic sea waves resulting from this earthquake destroyed the dyke separating the Seward Lagoon from the ocean. This is the primary rearing area for Dairy Creek silver salmon. The 10.2-acre lagoon was restored by the Corps of Engineers during the summer of 1964, but the pre-earthquake salmon production has not been attained.

Silver salmon sex ratios for each index stream were determined by sexing carcasses concomitant with weekly foot surveys. The ratio of males to females in the 1968 migrations ranged from 0.9:1 in Dairy Creek to 1.3:1 in Clear Creek with a mean of 1.1:1 for all index streams. Sex ratios by stream since 1961 are presented in Table 7.

Resurrection Bay Salmon Harvest and Effort

The creel census to determine the salmon sport harvest and effort in Resurrection Bay was initiated on July 6 and terminated on September 10. The census was conducted at the Seward Small Boat Harbor which has the only docking and boat launching facilities for salmon anglers. All weekend

TABLE 6 - Minimum Silver Salmon Escapements in Seven Index Streams in the Resurrection Bay Area, 1961 to 1968.

Name of Stream	Minimum Escapements							Mean	
	1961	1962	1963	1964	1965	1966	1967		1968
Airport Creek	162	55	42	52	50	127	55	67	76
Clear Creek	96	78	40	217	56	171	227	364	156
Dairy Creek	249	603	188	245	48	30	99	98	195
Grouse Creek	24	210	76	294	106	236	174	378	187
Jap Creek	91	92	72	152	86	228	172	229	140
Mayor Creek	21	30	15	95	16	135	66	41	53
Salmon Creek	90	212	175	79	174	234	329	1,037	291
TOTAL	733	1,280	608	1,134	536	1,161	1,122	2,214	1,098

TABLE 7 - Ratio of Male-to-Female Silver Salmon in Seven Index Streams in the Resurrection Bay Area, 1961 to 1968 (Number of Fish Examined in Parentheses).

Name of Stream	Year								Average
	1961	1962	1963	1964	1965	1966	1967	1968	
Airport Creek	1.1:1 (58)	1.2:1 (38)	1.1:1 (32)	1.2:1 (11)	0.8:1 (10)	1.0:1 (40)	0.9:1 (39)	1.0:1 (22)	1.0:1
Clear Creek	0.8:1 (7)	1.1:1 (47)	1.0:1 (29)	1.4:1 (39)	0.5:1 (20)	1.2:1 (57)	1.1:1 (31)	1.3:1 (35)	1.1:1
Dairy Creek	1.7:1 (229)	1.0:1 (593)	1.2:1 (69)	0.8:1 (208)	1.4:1 (33)	1.0:1 (16)	1.0:1 (66)	0.9:1 (89)	1.1:1
Grouse Creek	--	1.1:1 (70)	1.3:1 (39)	1.5:1 (70)	1.1:1 (34)	1.0:1 (65)	1.1:1 (68)	1.1:1 (60)	1.2:1
Jap Creek	1.0:1 (38)	0.9:1 (52)	1.0:1 (41)	1.2:1 (107)	1.2:1 (28)	0.9:1 (90)	1.0:1 (22)	1.0:1 (31)	1.0:1
Mayor Creek	--	--	--	0.9:1 (27)	0.8:1 (7)	0.9:1 (49)	1.1:1 (15)	1.0:1 (18)	0.9:1
Salmon Creek	1.0:1 (10)	0.9:1 (94)	1.0:1 (45)	1.0:1 (10)	1.0:1 (22)	1.2:1 (41)	1.0:1 (41)	1.1:1 (122)	1.0:1

days and three of the weekdays, based on a Latin Square design, were sampled with only completed fishermen being interviewed. The total silver salmon harvest was estimated at 22,560 fish. This estimate was extrapolated from interviews with 7,238 fishermen who had caught 6,391 silver salmon. The sport and commercial silver salmon harvests since 1961 are shown in Table 8. Resurrection Bay has been closed to commercial silver salmon fishing since 1965. The peak of the catch occurred on August 11 when an estimated 1,458 fish (6.5 percent of the total catch) were taken. Most of the harvest occurs during the Seward Silver Salmon Derby which extended from August 10 through August 18. The estimated catch of 8,187 fish taken during the Derby comprised 36.3 percent of the total harvest.

TABLE 8 - Sport and Commercial Harvests of Silver Salmon in Resurrection Bay, 1961 to 1968.

<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	0	4,020
1966	9,590	0	9,590
1967	17,380	0	17,380
1968	22,560	0	22,560

The total silver salmon fishing effort was estimated at 25,350 man-days with 28.6 percent of the anglers being interviewed. This is the greatest effort observed in the history of the fishery and represents an increase of 323 percent over the 6,000 man-days recorded in 1961, the first year a creel census was conducted. Effort during the nine-day Derby was estimated at 11,590 man-days (45.7 percent of the total effort) with 2,675 Derby tickets sold. The fishing effort on weekends and weekdays, excluding the Derby, was 7,315 and 6,445 man-days, respectively. Military personnel angling from boats provided by the Air Force and Army Recreation camps at Seward comprised 21.0 percent of the effort (5,320 man-days). The average silver salmon catch per hour was 0.15. Local civilian anglers fishing chiefly during the weekdays had the highest catch per hour of 0.23 while the lowest occurred during the Derby (0.10). A summary of the fishing effort and mean catch per hour since 1961 is presented in Table 9.

TABLE 9 - Silver Salmon Sport Effort (Man-Days) and Mean Catch Per Hour in Resurrection Bay, 1961 to 1968.

<u>Year</u>	<u>Period of Census</u>	<u>Total Effort</u>	<u>Derby Effort</u>	<u>Catch Per Hour</u>
1961	7/11 - 9/9	6,000	2,870	0.10
1962	7/7 - 9/7	11,380	5,435	0.19
1963	7/17 - 9/10	15,430	7,480	0.07
1964	7/18 - 9/11	7,540	4,150	0.07
1965	7/14 - 8/27*	13,380	8,900	0.05
1966	7/13 - 9/13	14,195	7,055	0.14
1967	7/12 - 9/12	20,100	8,505	0.15
1968	7/6 - 9/10	25,350	11,590	0.15

*Sport fishery closed by emergency regulation on August 27.

The average number and percentage of completed anglers returning to the Seward Small Boat Harbor were determined for each of the 3.5-hour sampling periods which extended from 1130 to 2200 hours. The period for 0800 to 1130 hours was not sampled because information collected from 1964 thru 1966 showed only 11.6 and 14.3 percent of weekend and weekday fishermen, respectively, completed fishing during this period. The percentages of anglers that terminated fishing during these periods were added to the total for the three periods sampled to determine the total effort. The greatest number of weekend and weekday fishermen terminated fishing between 1500 and 1830 hours (39.4 percent) and 1130 to 1500 hours (34.7 percent) respectively. The number and percentage of anglers returning during each sampling period are summarized in Table 10. The mean number of hours each angler fished per day was as follows: weekdays - 5.73, weekends - 6.19, Salmon Derby - 7.23. The average number of fishermen per boat was as follows: weekdays - 2.98, weekends - 3.07, Salmon Derby - 3.05.

King salmon, *O. tshawytscha*, and pink salmon were caught concomitant with silver salmon although the creel census did not entirely encompass their period of availability. An estimated 380 king salmon were taken by boat fishermen during the census period with an average catch of 0.06 fish per boat. Pink salmon were available to boat anglers from the first day of the census on July 6 until early August with an estimated harvest of 1,865 fish occurring and a mean catch per boat of 0.61 fish. The catch dropped off during the Salmon Derby (August 10-18) when only 109 fish were taken, comprising 1.3 percent of the salmon catch. A shore fishery also existed for pink salmon from the City of Seward to Lowell Point, located two miles south of Seward. Eleven spot checks were made of shore anglers between July 20 and August 5. The 108 fishermen interviewed had taken 98 pink salmon for a mean catch rate of 0.83 fish per angler. The average minimum number of anglers enumerated on weekends and weekdays was 25.6 and 10.7, respectively. The mean catch rate and angler counts were extrapolated for the period of estimated pink salmon availability (July 1 through August 9) yielding a minimum shore effort of 580 man-days taking a minimum catch of 480 pink salmon. The highest observed catch rate was 1.9 fish per angler on July 21. Only one silver salmon was observed during the census of shore fishermen.

TABLE 10 - The Average Number and Percentage of Completed Silver Salmon Anglers Returning to the Seward Small Boat Harbor for Each Sampling Period on Weekends and Weekdays During 1968.

Sampling Periods	Weekends		Weekdays	
	Mean Number of Anglers	Percentage	Mean Number of Anglers	Percentage
0800-1130 hours*	13.5	11.6	4.1	14.3
1130-1500 hours	39.1	33.6	10.0	34.7
1500-1830 hours	45.7	39.4	9.8	34.0
1830-2200 hours	17.9	15.4	4.9	17.0
TOTAL	116.2	100.0	28.8	100.0

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

Marked Silver Salmon Analysis

The fin-clipped adult silver salmon taken in the Resurrection Bay fishery and passed through the Bear Creek weir originated from the 1967

Bear Lake smolt migration. This smolt migration was comprised of 5,665 age II fish with an AdLV clip, 36,443 age I fish with LVRV clip and 16,675 age II unmarked fish. The number of adult silver salmon returning to the Bear Creek weir after 14 to 17 months of ocean life was as follows: 816 age 2.1 fish with an AdLV clip, 153 age 1.1 fish with an LVRV clip and 3,325 age 2.1 unmarked fish. The marine survival, defined as the survival of smolts released at the weir to adults returning to the weir, was 14.40 percent for the AdLV smolts ($816/5,665 \times 100$), 0.42 percent for the LVRV smolts ($153/36,443 \times 100$) and 19.94 percent for the unmarked smolts ($3,325/16,675 \times 100$). The extremely poor survival of the LVRV smolts is undoubtedly due to a combination of the following: (1) this group of fish did not have "smolt" characteristics during their downstream migration and a certain percentage of them may not have migrated to sea (Logan, 1967), (2) both pelvic fins were excised, (3) their average fork length of 69.9 mm during the peak of migration was the smallest measured for age I smolts.

The contribution that Bear Lake smolts made to the Resurrection Bay fishery was determined by examining the sport catch for marked fish concomitant with the creel census interviews. Fish were checked randomly, and anglers bringing fin-clipped fish to the creel census observer were not used in the analysis. A total of 4,995 silver salmon was examined with 52 AdLV- and 13 LVRV-clipped fish observed. The percentage of marked silver salmon expanded for the total catch of 22,560 silver salmon yielded an estimated catch of 235 AdLV- and 59 LVRV-clipped fish. The observed and calculated harvests of fin-clipped silver salmon, since 1963, are summarized in Table 11. The percentages of the two fin-clip groups taken in the fishery and at the Bear Creek weir were similar with AdLV fish comprising 84.2 percent of the marked fish at the weir and 79.9 percent of those taken in the fishery.

TABLE 11 - Observed and Calculated Recoveries of Silver Salmon Smolts, Marked at Bear Creek, in the Sport and Commercial Fisheries in Resurrection Bay, 1963 to 1968.

Year of Recovery	Number of Fish Sampled	Estimated Total Catch	Percentage of Catch Sampled	Number of Marked Fish Recovered	Calculated Number of Marked Fish
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	23.2	286	1,233
1968	4,995	22,560	22.1	65	294

The efficiency of the sport fishery in harvesting Resurrection Bay silver salmon stocks was measured by relating the estimated harvest of marked silver salmon to those escaping to the Bear Creek weir. The catch-to-escapement ratio of 0.30:1 (294/969) evinced the 1968 run was lightly exploited. A summary of past catch-to-escapement ratios are shown in Table 12.

TABLE 12 - The Catch-to-Escapement Ratio of Bear Creek Marked Silver Salmon in the Resurrection Bay Area, 1963 to 1968.

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
1968	294	969	1,263	0.30:1

The number of unmarked silver salmon taken in the fishery was calculated by multiplying the catch-to-escapement ratio of marked fish by the unmarked escapement at the weir, assuming both groups of fish were captured at the same rate. The number of unmarked fish harvested was estimated at 998 (3,325 x 0.30). The total production from Bear Lake, with a calculated harvest of 1,292 fish and escapement of 4,294 fish, was estimated at 5,586 silver salmon.

Bear Lake Population Sampling

Small-mesh gill net sampling for rearing salmon was precluded in Bear Lake during the summer of 1968 because the very large adult red salmon escapement would have damaged the nets. Seine samples were collected in Bear Lake off the terminus of Inlet No. 3 to measure the rate of threespine stickleback reinfestation. Three seine hauls made from June 15 to August 23 captured an average of 124 sticklebacks and 31 silver salmon. The weir prior to the Bear Lake rehabilitation in 1963 did not permit a complete assessment of stickleback abundance; however, it is believed that the existing population is at pre-rehabilitation levels. The number of stickleback captured at the Bear Creek weir and from seine samples at the Bear Lake index site are presented in Table 13.

TABLE 13 - Threespine Sticklebacks Captured in the Downstream Trap of the Bear Creek Weir and from Seine Samples Collected at Bear Lake Index Site after the 1963 Rehabilitation of Bear Lake.

<u>Year</u>	<u>Number Taken in Downstream Weir Trap</u>	<u>Mean Number Per Seine Haul</u>
1964	0	0
1965	0	0
1966	4	1
1967	286	25
1968	5,893*	124

*Trap operated one month longer in 1968.

Seward Lagoon Silver Salmon Stocking Evaluation

The 10.2-acre Seward Lagoon was planted with 42,200 age I silver salmon smolts from April 18 to April 22, 1968. The purpose of the stocking was to determine the feasibility of planting smolts as a means of increasing the number of adults returning in 1969 which is expected to be a "weak" year. All fish were marked with an adipose clip and were the result of eyed eggs obtained from Big Creek, Oregon, incubated at the Fire Lake Hatchery and reared in the Fort Richardson Cooling Pond. The weighted mean fork length of the three plants was 129.5 mm. The lagoon was sampled for 12 hours on July 15 using two 100-foot nylon gill nets having five 20-foot panels of mesh ranging between 1/2- to 1 1/4-inch stretch width. A total of 103 marked silver salmon captured had a mean fork length of 116.5 mm. The gill net sampling suggests that, although the average size of the plant was greater than "typical" Resurrection Bay smolts, the smaller fish in the plant had not attained sufficient size by May and June to migrate to sea. The relative success of the larger planted fish cannot be measured until these fish return as adults to the Seward Lagoon and Dairy Creek in 1969. Forty-seven Dolly Varden and two starry flounder, Platichthys stellatus, were also captured during the gill net sampling.

Incubation Channel Water Supply Evaluation

Data on stream flows and temperatures was collected at Inlet No. 3 on Bear Lake to evaluate the stream as a source of water for a proposed artificial incubation channel for silver salmon. This stream has a drainage

TABLE 15 - Monthly Mean and Range of Surface and Subsurface Temperatures (F) for Inlet No. 3 of Bear Lake for the 1966 to 1967 and 1967 to 1968 Water Years.

Month	1966-67 Water Year				1967-68 Water Year			
	Surface		Subsurface		Surface		Subsurface	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
October	--	--	--	--	39.3	37 - 42	--	--
November	--	--	--	--	36.9	34 - 38	36.4	34 - 37
December	--	--	--	--	--	--	--	--
January	--	--	--	--	35.3	34 - 38	36.4	35 - 37
February	35.8	34 - 36	35.9	35 - 37	36.4	32 - 38	36.6	35 - 38
March	36.1	35 - 37	36.7	35 - 38	36.5	34 - 38	36.7	35 - 38
April	37.4	37 - 40	38.3	37 - 40	37.2	35 - 40	37.4	35 - 40
May	--	--	40.3	39 - 43	38.8	37 - 40	39.3	38 - 41
June	42.2	39 - 47	--	--	--	--	--	--
July	45.3	41 - 50	--	--	42.5	41 - 45	41.8	41 - 45
August	45.7	44 - 48	--	--	44.2	42 - 49	44.0	42 - 47
September	43.0	41 - 46	--	--	--	--	41.1	38 - 44

area of 1.63 square miles. A digital water-storage recorder was established by the U.S. Geological Survey in the stream 0.3 miles above Bear Lake. A 45-day Ryan thermograph was installed in Inlet No. 3 to measure temperatures with a second thermograph buried 20 inches below the streambed to record subsurface temperatures. Data was collected for the 1966-67 and 1967-68 water years (October through September). The minimum flow recorded was 82 cfs on September 17, 1967, and the minimum flow measured was 1.8 cfs occurring from April 16 through April 21, 1968. The stream flow data is summarized in Table 14. The information obtained from the two thermograph recordings is presented in Table 15. The records are not continuous because these instruments did not always operate properly. Also, the thermograph recordings may be higher than the temperatures taken, on days the thermograph tapes were changed, with a thermometer having one degree intervals were an average of 1.6°F. lower. The thermograph buried 20 inches below the streambed recorded an average temperature of 0.2°F. below that of the surface thermograph. A chemical analysis of a water sample collected from Inlet No. 3 on February 14, 1968, by the U.S. Geological Survey is shown in Table 16.

TABLE 14 - Monthly Discharge (cfs) Mean and Range for Inlet No. 3 of Bear Lake for the 1966 to 1967 and 1967 to 1968 Water Years.

<u>Month</u>	<u>Mean</u>	<u>Range</u>	<u>Mean</u>	<u>Range</u>
October	13.00	20 - 8.0	12.80	20 - 7.7
November	6.27	8.5 - 5.1	10.70	24 - 7.6
December	4.57	5.5 - 3.4	7.49	9.4 - 5.6
January	2.97	3.4 - 2.1	5.65	6.3 - 4.7
February	2.83	3.3 - 2.4	5.46	10 - 4.4
March	2.73	3.1 - 2.6	5.38	13 - 3.1
April	2.57	2.8 - 2.4	2.31	3.1 - 1.8
May	9.95	14 - 3.3	11.40	23 - 2.6
June	13.90	21 - 9.4	12.20	17 - 9.0
July	13.90	19 - 8.6	15.50	27 - 10
August	18.40	39 - 10	14.60	25 - 7.0
September	25.20	82 - 7.6	5.65	14 - 2.6
TOTAL	9.69	82 - 2.1	9.11	27 - 1.8

TABLE 16 - A Water Analysis of Inlet No. 3 of Bear Lake Collected on February 14, 1968.

<u>Chemical Characteristics</u>	<u>Milligrams Per Liter</u>
Bicarbonate (HCO ₃)	66.0
Calcium carbonate (CaCO ₃)	64.0
Noncarbonate	10.0
Calcium (Ca)	24.0
Chloride (Cl)	0.0
Fluoride (F)	0.1
Iron (Fe)	0.02
Magnesium (Mg)	0.8
Nitrate (NO ₃)	1.1
Potassium (K)	0.8
Silica (SiO ₂)	6.5
Sodium (Na)	1.4
Sulfate (SO ₄)	13.0
Dissolved solids	80.0

TABLE 16 (Cont.) - A Water Analysis of Inlet No. 3 of Bear Lake Collected on February 14, 1968.

<u>Chemical Characteristics</u>	<u>Milligrams Per Liter</u>
Specific conductance (micromhos at 25°C)	142.0
pH	7.7
Color	0.0

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Division of Sport Fish

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Alaska Department of Fish and Game, Federal Aid in Fish
1968, Silver Salmon Studies in the Kuskokwim Bay



Spaghetti tag being applied for population study of fish.