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STATE OF ALASKA

William A. Egan, Governor

ANNUAL REPORT OF PROGRESS, 1969 - 1970

FEDERAL AID IN FISH RESTORATION PROJECT F-9-2

SPORT FISH INVESTIGATIONS OF ALASKA

ALASKA DEPARTMENT OF FISH AND GAME

Wallace H. Noerenberg, Commissioner

DIVISION OF SPORT FISH

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INTRODUCTION

This report of progress consists of Job Segment Reports from the State of Alaska, Federal Aid In Fish Restoration, Project F-9-2, "Sport Fish Investigations of Alaska".

The studies reported herein are investigations evaluating the sport fish resources of the state. Recreational and other impacts on the fishery resources necessitates a continuous endeavor of ascertaining facts and knowledge of the fisheries. The 24 jobs reported on are of a continuing nature. The investigations are composed of 11 projects involved with the inventory and cataloging of the sport fish waters of the state, sport fishery creel censuses, and access. Fish species that received special investigational effort include: Dolly Varden, anadromous fish, grayling, sheefish, whitefish, pike, char, and salmon. The information gathered from the combined studies provides necessary background data for a better understanding of management problems and constitutes a basis for necessary future investigations.

The subject matter contained in these reports is incomplete, and the findings and interpretations subject to re-evaluation as work progresses.

RESEARCH PROJECT SEGMENT

State:	Alaska		
Project No.:	F-9-2	*Name:*	Sport Fish Investigations of Alaska.
Job No.:	7-C-1	*Title:*	**Evaluation of Sport Fish Stocking on the Kenai Peninsula-Cook Inlet Areas.**
Period Covered:	July 1, 1969 to June 30, 1970.		

ABSTRACT

Growth and survival rates are compared for rainbow trout, Salmo gairdneri, in four rehabilitated Kenai Peninsula lakes. Moderate, uniform trout growth was recorded from waters where threespine stickleback, Gasterosteus aculeatus, had been eradicated. The study shows that threespine stickleback adversely affect fingerling survival. Upon achieving a length of approximately 230 mm, stocked trout utilized stickleback as forage and entered a growth phase superior to that of fish in lakes containing only trout. Initial fingerling plants grew more rapidly than supplemental plants, but survival rates were similar after one year of lake residency.

Population sampling was conducted on six landlocked lakes containing transplanted red salmon, Oncorhynchus nerka, and one lake stocked with silver salmon, O. kisutch. Gill-net catch rates, mean lengths and weights are compared in various years. Information concerning sexual maturity and feeding habits are discussed.

Gill nets were set on Twin Lakes to evaluate the success of 1965 and 1966 Arctic grayling, Thymallus arcticus, plants. The presence of two naturally produced age classes suggests that the transplants were successful.

The results of a rainbow trout feeding habit study in Gruski Lake are presented. Threespine stickleback comprised more than 75% of the food (by volume) of trout larger than 254 mm. Nearly the entire winter diet of large trout consisted of stickleback. Food habits of trout 254 mm or less showed definite seasonal variation. Aquatic insects contributed most to the summer diet of small trout, but stickleback were the principal winter food.

A total of 204 lake trout, S. namaycush, from Skilak Lake were introduced into Upper Summit Lake in an attempt to establish a self-sustaining population. Transplanted male and female lake trout averaged 336.3 and 355.1 mm, respectively. Environmental characteristics of Upper Summit Lake are presented.

RECOMMENDATIONS

Retain present objectives of the study with emphasis directed toward the following:

1. Continue the Upper Summit Lake lake trout transplant.

2. Determine the seasonal distribution and spawning period of threespine stickleback in Johnson, Scout, and Bear lakes.

3. Initiate a study on North and South Twin lakes to determine survival and growth of stocked rainbow trout in a lake containing stickleback and in a lake where stickleback have been eliminated.

OBJECTIVES

1. To determine comparative survival and growth rates of stocked rainbow trout in lakes containing threespine stickleback and in waters where this species has been chemically controlled.

2. To investigate those aspects of the threespine stickleback life history which relates to their control with fish toxicants.

3. To determine duration of toxicity in lakes which have been chemically treated to control threespine stickleback populations.

4. To determine the success of introduced grayling, lake trout, and red salmon (kokanee) in waters of the job area.

5. To provide recommendations for the management of stocked lakes and to direct the course of future studies.

TECHNIQUES USED

Monofilament and multifilament gill nets (125- x 6-foot) having five mesh sizes ranging from 3/4- to 2-inch bar measure were used in most lakes to collect specimens and measure relative abundance. Also, multifilament gill nets (100- x 6-foot) having five mesh sizes ranging from 1/2- to 1 1/4-inch bar measure were used to collect rainbow trout from Gruski Lake and Arctic grayling from Twin Lakes.

Arctic grayling, silver salmon, and red salmon scales were mounted on glass slides and examined by microprojector for age determination. All fish were measured from the tip of the snout to the fork of the tail.

Rainbow trout feeding habits were determined by a technique described by Borgeson (1963). Six jars for each study month were individually labeled with the six length intervals into which the trout were grouped. Numbers of stomachs were recorded by month and length groups as their contents were emptied into the appropriate jar. Detailed analysis consisted of determining the volume of various food organisms by water displacement. All partially digested fish were considered to be stickleback.

Lake trout were captured from Skilak Lake by 125- x 6-foot gill nets having variable mesh sizes ranging from 3/4- to 2-inch bar measure. The fish were held in a holding pen prior to being transported to Upper Summit Lake by a hatchery tank truck. Oxygen was supplied throughout the 1 1/4 hours that the fish were in transit. The char were released into Upper Summit Lake within 24 hours of their capture.

Dolly Varden, Salvelinus malma, depth distribution was determined by suspending monofilament gill nets from the surface to the lake bottom. An aluminum pipe served as a roller float from which the nets were unwound until they reached the lake bottom. Mesh sizes were: 1/2-, 3/4-, 1-, 1 1/4-, and 1 3/4-inch bar measure. A detailed description of the nets and their method of operation have been presented by Engel (1967).

FINDINGS

Lake Stocking Evaluation

Hatchery-reared salmonids are being used in increasing numbers to supplement native game fish populations on the Kenai Peninsula. Cursory evaluation of the stocking program has not provided necessary answers for development of better planting practices. The present investigation was initiated to determine proper initial and supplementary stocking rates, including sizes and species of fish.

Rainbow Trout:

Rainbow trout, Salmo gairdneri, growth and relative survival rates were evaluated by examination of gill-net caught fish from four rehabilitated lakes. Sport, Arc, and Scout lakes received initial plants in 1966 and supplemental fingerling plants in 1968. Each lake had been treated with rotenone to remove threespine stickleback. Jerome Lake was rehabilitated and stocked with fingerling rainbow trout in 1968. Prior to chemical treatment, Jerome Lake contained Dolly Varden, coastrange sculpins, Cottus aleuticus, threespine stickleback, juvenile silver salmon, and Arctic grayling.

The physical characteristics and stocking rates for each of the study waters are presented in Tables 1 and 2, respectively. Trout stomach analysis and shoreline surveys indicate complete kills in Sport and Arc lakes, whereas stickleback densities have increased to a pre-rehabilitation level in Scout Lake. Dolly Varden were reported to have been stocked by the public in Jerome Lake after rehabilitation. A catch of one Dolly Varden during 51 gill-net hours confirmed the presence of char.

TABLE 1 Physical Characteristics of Kenai Peninsula Lakes Stocked with Rainbow Trout.

Lake	Surface Acres	Depth (feet) Maximum	Depth (feet) Mean	Acre Feet	Aquatic Vegetation
Sport	71.7	20	10.9	788	Extensive
Scout	95.0	24	12.7	1,205	Limited
Arc	16.0	16	8.6	138	Limited
Jerome	16.3	15	8.5	138	Limited

TABLE 2 Stocking Rates for Rainbow Trout in Kenai Peninsula Lakes.

Lake	Date Stocked	Fish/lb.	Fish/ Surface Acre	Fish/ Acre-Foot	Total Planted
Sport	7/66	1,160	400	37	29,000
	8/68	210	400	37	29,000
Scout	8/66	325	285	22	27,000
	8/68	210	230	18	22,000
Arc	7/66	1,160	400	46	6,380
	8/68	210	310	36	5,000
Jerome	8/68	210	525	62	8,550

The 1966 plants of 400 trout per surface acre in Sport and Arc lakes exhibited moderate uniform growth during succeeding years. At age I+, II+, and III+, the fish in both lakes averaged approximately 287, 373, and 420 mm, respectively. The annual increment of growth appeared slow after age II+, twenty-six months after introduction.

The size attained by trout in Scout Lake illustrates the effects of stickleback on growth. The Scout Lake plant of 285 fingerlings per surface acre initially grew slower than the fish in Sport and Arc lakes. Approximately one year after introduction, the trout embarked on an accelerated growth rate. Comparative gill netting in Arc and Scout lakes on July 31, 1967, produced catches that averaged 256 and 234 mm, respectively. Two months later, in September, 1967, the mean length of the Scout Lake trout (300.9 mm) had surpassed that of fish in Arc Lake (288.6 mm). By September, 1968, the trout in Scout Lake had obtained a mean length of 537.6 mm while those in Arc and Sport lakes averaged 373 mm.

Food competition with stickleback is believed responsible for the slow initial trout growth in Scout Lake. After attaining a larger size, the fish preyed on stickleback, entering a new growth phase. The conversion to piscivorous habits occurred at the 230 mm length.

Gill-net sampling indicated that the relative survival of the 1966 plants were highest in Sport Lake and lowest in Scout Lake during each year of investigation. The 1967 catch rates for Sport, Arc, and Scout lakes were 0.40, 0.27, and 0.15 fish per gill-net hour, respectively. By 1969 the catch per gill-net hour had dropped to 0.24 in Sport Lake, 0.05 in Arc Lake, and 0.04 in Scout Lake. Limited creel census observations indicate that the trout harvest was moderate in Sport and Arc lakes, whereas the recreational catch from Scout Lake was small. The relatively low gill-net catch rate recorded at Scout Lake may have resulted from competition between juvenile trout and stickleback and/or a lower stocking density. Gill-net catch data is summarized for each of the study waters in Table 3.

TABLE 3 Mean Lengths, Weights, and Catch Per Gill-Net Hour of Rainbow Trout Stocked in 1966.

Lake	Year	Length Range (mm)	Mean Length (mm)	Weight (lbs.)	Catch/ Hour
Sport	1967	240-318	286.4	0.64	0.40
	1968	340-397	373.2	1.55	0.47
	1969	388-469	419.3	1.86	0.24
Arc	1967	269-312	288.6	0.67	0.27
	1968	335-387	373.7	1.61	0.17
	1969	420-426	432.0	2.08	0.05
Scout	1967	260-331	300.9	0.83	0.15
	1968	490-575	537.6	4.82	0.04
	1969	487-560	525.5	4.15	0.04

A comparison of the 1966 and 1968 plants revealed a superior growth rate in the initial plant after one year of lake residency. Comparative gill-net sampling indicated that the relative survival of the two introductions was similar in each of the respective lakes (Table 4). The superior growth of the 1966 plant may be explained by a lack of food competition; however, the reason for similarity in survival rates is not clear. Apparently predation by the substantial population of larger trout had no measurable effect on survival of the 1968 fingerlings.

Silver Salmon:

Johnson Lake was treated with rotenone during July, 1967, to remove threespine stickleback. The landlocked lake has 85 surface acres and contains 861 acre feet of water. Maximum and average depths are 16 and 10.0 feet, respectively.

The lake was initially stocked during the fall of 1967 with 38,250 silver salmon, O. kisutch, averaging 105 fish per pound. An additional 26,000 silver salmon averaging 93 per pound were planted during the fall of 1968. The reoccurrence of stickleback in 1968 indicated that the rehabilitation had failed.

Gill-net sampling in late September, 1968, revealed that the initial plant averaged 153.6 mm in length and 0.08 pounds in weight. Comparative gill netting during the fall of 1969 indicated the initial plant averaged 211.7 mm and had a mean weight of 0.25 pounds. The mean length and weight of the 1968 plant after one year of lake residency were 171.3 mm and 0.14 pounds, respectively. Seven percent (all male) of the initial plant became sexually mature by 1969. No mature specimens were captured from the 1968 plant. The catch per gill-net hour during 1969 was 0.72 salmon for the initial plant and 1.1 salmon for the supplemental plant.

TABLE 4 Comparative Lengths, Weights, and Catch Per Gill-Net Hour for Rainbow Trout After One Year of Lake Residence.

Lake	Year Planted	Length Range (mm)	Mean Length (mm)	Weight (lbs.)	Catch/ Hour
Sport	1966	240-318	286.4	0.64	0.40
	1968	215-283	246.8	0.40	0.50
Arc	1966	269-312	288.6	0.67	0.27
	1968	225-264	248.6	0.45	0.29
Scout	1966	260-331	300.9	0.83	0.15
	1968	220-310	258.0	0.57	0.13
Jerome	1968	150-253	185.5	0.18	2.43

Red Salmon:

Experimental red salmon, O. nerka, transplants were evaluated by gill-net sampling in six lakes to determine relative survival and growth rates. Smolts captured at the Bear Creek weir near Seward were utilized for all introductions. The 1965 and 1966 transplants were predominantly age I, whereas the 1967 plant was primarily age II smolts. Table 5 illustrates the number of fish and lakes in which introductions were made.

With the exception of Bernice Lake, the physical and chemical features of the recipient waters have been described by Engel (1967, 1968). Upper Jean, Portage, and Sunken Island lakes have similar characteristics; each exceeds 40 feet in depth and is thermally stratified during the summer. Rock and Bottinentin lakes, both shallow, exhibit homoiothermous summer conditions. Bernice Lake, with approximately 146 surface acres and a maximum detph of 12 feet, becomes homoiothermous during the summer. Bernice Lake is stained with humic materials and aquatic vegetation is extensive.

The diverse lake environments offer opportunities to evaluate red salmon growth and survival potentials under conditions commonly encountered on the Kenai Peninsula. In past years the various annual transplants were identified solely on the basis of length frequency. The size and relative survival of red salmon planted in 1966 are shown in Table 6. During the fall of 1969, introduction dates could not be determined for most gill-netted salmon because of extensive length overlap. Identification by scale analysis was not possible because the 1966 and 1967 transplants were composed primarily of age I and II smolts, respectively.

TABLE 5 Number of Red Salmon Smolts Stocked in Kenai Peninsula Lakes, 1965-1967.

Lake	Date Stocked*	Fish/ Surface Acre	Total Fish Planted
Upper Jean	1965	25	1,150
	1966	754	34,670
	1967	196	9,020
Sunken Island	1966	224	31,350
	1967	94	13,140
Portage	1966	644	18,670
	1967	378	10,950
Rock	1966	1,038	8,300
	1967	1,279	10,230
Bernice	1966	127	18,500
	1967	152	22,160
Bottinentin	1967	137	38,220

*All lakes were stocked in June of each year indicated.

TABLE 6 Growth Comparisons for 1966 Red Salmon Transplants in Kenai Peninsula Lakes.

Lake	Year Sampled	No. of Fish	Size Range (mm)	Mean Length (mm)	Mean Weight (lbs.)	Catch/ Net Hour
Rock	1967	67	218-291	256.2	0.51	1.37
	1968	32	238-380	312.3	0.93	1.39
Upper Jean	1967	26	164-285	223.9	0.32	0.27
	1968	14	193-293	243.9	0.42	0.21
Sunken Island	1967	107	151-278	190.1	0.17	1.34
	1968	38	204-283	232.8	0.31	0.58
Portage	1967	13	153-211	108.7	0.14	0.20
	1968	41	181-321	207.3	0.22	0.81
Bernice	1967	10	162-204	185.0	0.18	0.08

A summary of the 1969 red salmon gill-net catches is shown in Table 7. The size attained by the 1967 plant increased the catch-per-hour rate over previous years' catches which were dominated by the 1966 transplants. The absence of red salmon in Rock Lake is attributed to an inadequate supply of dissolved oxygen during the spring of 1969. Winter oxygen levels ranging from 3.8 ppm to less than 1 ppm have been recorded at Rock Lake during recent years.

TABLE 7 Relative Catch and Growth Rates for Red Salmon in Six Kenai Peninsula Lakes, 1969.

Lake	No. of Fish	Length Range (mm)	Mean Length (mm)	Mean Weight (lbs.)	Catch/ Net Hour
Upper Jean	183	168-312	179.7	0.14	3.27
Portage	97	210-305	229.0	0.27	2.38
Sunken Island	75	228-328	248.4	0.39	0.81
Bernice	19	220-368	282.4	0.67	0.26
Bottinentin	26	205-280	233.2	0.36	0.24
Rock	No fish taken.				

Of the six lakes stocked with red salmon, Upper Jean, Portage, Sunken Island, and Rock lakes produced successful sport fisheries. With the exception of Rock Lake, all successful fisheries developed in deep lakes that maintain cool water temperatures during the summer. Rock Lake, prior to the 1969 winter-kill, produced the largest salmon recorded from the study years despite summer bottom temperatures in excess of 60°F. A dense population of amphipods, Gammarus sp., is believed responsible for superior growth of fish in Rock Lake. Salmon growth in Bernice and Bottinentin lakes was comparable to that of fish in the deeper lakes; however, survival appeared to be substantially less.

Principal food groups in the fall gill-net samples from Upper Jean, Sunken Island, and Portage lakes were cladocerans and copepods. Insects, stickleback, and leeches comprised the bulk of the diet of salmon from Bottinentin Lake, whereas stickleback and amphipods were the principal food consumed by the fish in Bernice Lake.

Mortalities due to sexual maturity varied considerably within the study waters (Table 8). Age IV+ males virtually comprised the entire spawning population in most lakes. However, a substantial number of age II+ males matured in Rock Lake during the fall of 1967. Anadromous red salmon normally return to the Bear Creek system as four- or five-year-olds.

Arctic Grayling:

Twin Lakes, with a surface area of 260 acres, is located in the Kenai Mountains at an elevation of 2,400 feet. Arctic grayling, Thymallus arcticus, from Crescent Lake were introduced in 1965 and 1966. The combined transplants totaled 273 predominantly age I+ grayling.

Seventy-one hours of gill-net effort on June 28, 1969, yielded eight age I and eight age II grayling. Mean fork lengths for age I and age II grayling were 113.5 and 240.1 mm, respectively. Anglers fishing Twin Lakes on August 12, 1969, provided the department with scales from five age I+ grayling having a mean length of 166.0 mm. The fishermen reported that small grayling were easily captured along the northern perimeter of the lower lake. The presence of two naturally produced year classes suggests that the transplant is progressing favorably toward a self-sustaining population.

TABLE 8 Sexual Maturity of Red Salmon in Six Kenai Peninsula Lakes.

Lake	Year Sampled	Sample Size	No. Mature Salmon Male	No. Mature Salmon Female	Mean Length Mature Fish (mm)	% Mature
Upper Jean	1967	39	10	0	253.3	26
	1968	21	0	0	---	--
	1969	183	2	1	259.3	2
Portage	1967	33	0	0	---	--
	1968	43	2	1	246.0	7
	1969	97	38	0	230.6	39
Sunken Island	1967	114	1	0	278.0	1
	1968	38	4	0	229.2	11
	1969	75	13	1	258.5	19
Bernice	1967	10	0	0	---	--
	1968	No sample				
	1969	19	1	0	294.0	5
Bottinentin	1968	11	1	0	174.0	9
	1969	26	2	0	251.0	8
Rock	1967	103	14	0	266.6	14
	1968	42	14	2	336.0	38

Rainbow Trout Feeding Habits

Threespine stickleback are important forage for rainbow trout in many Alaskan lakes (Baxter, 1956; Allin and Baxter, 1957). Utilization of stickleback by Kenai Peninsula rainbow trout has also been reported by Haley (1962). The size at which rainbow trout begin preying on stickleback and seasonal influence on piscivorous habits are important lake management considerations. This investigation summarizes the food items consumed by rainbow trout in Gruski Lake from February, 1967 through January, 1968.

Gruski Lake, located on the Kenai National Moose Range, has 95 surface acres with a maximum depth of 20 feet. This eutrophic lake is drained by a permanent outlet stream into the Swanson River. Established fish populations include rainbow trout; Dolly Varden; anadromous silver salmon; longnose suckers, Catostomus catostomus; threespine stickleback; and coastrange sculpins.

During the study, 712 rainbow trout ranging from 105 to 460 mm, were examined. Stomachs from 597 (83.8%) of these fish contained identifiable food. Using the technique described by Borgeson (1963), data was analyzed by month and size groups and then combined by season (ice covered, ice free, and before ice cover) for which food habits were similar. Seasonal food habits are summarized in Tables 9 through 14.

During all seasonal periods, stickleback comprised more than 75% of food (by volume) of trout larger than 254 mm (10 inches). The winter diet of large trout consisted primarily of stickleback. Insects, primarily trichopteran larvae, constituted a minor part of the diet during the summer, fall, and winter. Gastropod utilization was heaviest during the fall and winter.

TABLE 9 Stomach Contents of Rainbow Trout Less than 153 mm (6 inches) from Gruski Lake, February, 1967 through January, 1968.

	Volume and Percentage of Organisms					
	Winter (ice cover)		Summer (ice free)		Fall (before ice cover)	
	December - April*		June - August		October	
Food Organism	ml	%	ml	%	ml	%
Fish: Stickleback			0.8	5.1	0.5	22.7
Salmon eggs			---		1.1	50.0
Gastropoda			0.3	1.9	0.3	13.6
Insecta: Trichoptera			1.8	11.4	0.1	4.6
Diptera			3.7	23.4	---	
Coleoptera			1.2	7.6	---	
Hemiptera			0.8	5.1	---	
Unidentified insects and parts			7.1	44.9	0.2	9.1
Crustacea: Cladocera			Trace	---	---	
Vegetation			0.1	0.6	---	
Total volume of food (ml)			15.8		2.2	
No. of stomachs	0		20		16	
Avg. volume/ stomach (ml)	--		0.79		0.14	

*No samples taken during this period.

TABLE 10 Stomach Contents of Rainbow Trout 153 mm (6 inches) to 203 mm (8 inches) from Gruski Lake, February, 1967 through January, 1968.

	Volume and Percentage of Organisms					
	Fall (before ice cover)		Summer (ice free)		Winter (ice cover)	
	December - April		June - August		October	
Food Organism	ml	%	ml	%	ml	%
Fish: Stickleback	5.8	76.3	8.5	11.2	6.5	48.9
Salmon eggs	---		---		0.1	0.8
Gastropoda	0.7	9.2	2.9	3.8	0.8	6.0
Pelecypoda	---		0.1	0.2	Trace	
Insecta:						
Trichoptera	1.1	14.5	10.1	13.4	5.0	37.5
Diptera	---		7.1	9.4	---	
Coleoptera	---		7.9	10.4	Trace	
Hemiptera	---		0.1	0.1	---	
Neuroptera	---		0.1	0.1	---	
Unidentified Insects and parts	---		37.7	49.9	0.9	6.8
Vegetation	---		1.1	1.5	---	
Total volume of food (ml)	7.6		75.6		13.3	
No. of stomachs	13		65		35	
Avg. volume/ stomach (ml)	0.58		1.16		0.38	

TABLE 11 Stomach Contents of Rainbow Trout 204 mm (8 inches) to 254 mm (10 inches) from Gruski Lake, February, 1967 through January, 1968.

	Volume and Percentage of Organisms					
	Winter (ice cover)		Summer (ice free)		Fall (before ice cover)	
	December - April		June - August		October	
Food Organism	ml	%	ml	%	ml	%
Fish: Stickleback	24.5	98.0	30.9	41.7	16.9	39.3
Cottids	---		---		2.6	6.0
Salmon eggs	---		---		3.9	9.1
Gastropoda	---		4.2	5.7	2.2	5.1
Insecta:						
Trichoptera	0.5	2.0	17.0	22.9	14.4	33.5
Diptera	---		1.0	1.3	---	
Coleoptera	---		5.1	6.9	---	
Hemiptera	---		0.1	0.1	---	
Ephemeroptera	---		0.1	0.1	---	
Odonata	---		---		0.9	2.0
Unidentified Insects and parts	---		15.1	20.5	1.4	3.3
Crustacea:						
Amphipoda	---		---		0.2	0.5
Cladocera	---		Trace		---	
Vegetation	---		0.6	0.8	0.5	1.2
Total volume of food (ml)	25.0		74.1		43.0	
No. of stomachs	42		53		51	
Avg. volume/ stomach (ml)	0.60		1.40		0.84	

TABLE 12 Stomach Contents of Rainbow Trout 255 mm (10 inches) to 305 mm (12 inches) from Gruski Lake, February, 1967 through January, 1968.

		Volume and Percentage of Organisms					
		Winter (ice cover)		Summer (ice free)		Fall (before ice cover)	
		December - April		June - August		October	
Food Organism		ml	%	ml	%	ml	%
Fish:	Stickleback	86.6	95.4	95.2	78.9	57.9	74.3
	Cottids	2.3	2.5	---		1.2	1.6
	Salmonids	---		---		3.9	5.0
	Salmon eggs	---		---		0.2	0.3
Gastropoda		1.2	1.3	2.2	1.8	0.5	0.6
Insecta:							
	Trichoptera	0.7	0.8	6.9	5.7	12.1	15.5
	Diptera	---		3.9	3.2	---	
	Coleoptera	---		5.6	4.6	---	
	Odonata	---		0.1	0.1	Trace	
	Unidentified Insects and parts	---		6.8	5.6	0.7	0.9
Vegetation		---		---		1.4	1.8
Total volume of food (ml)		90.8		120.7		77.9	
No. of stomachs		56		58		41	
Avg. volume/ stomach (ml)		1.62		2.08		1.90	

TABLE 13 Stomach Contents of Rainbow Trout 306 mm (12 inches) to 356 mm (14 inches) from Gruski Lake, February, 1967 through January, 1968.

	Volume and Percentage of Organisms					
	Winter (ice cover)		Summer (ice free)		Fall (before ice cover)	
	December - April		June - August		October	
Food Organism	ml	%	ml	%	ml	%
Fish: Stickleback	55.3	95.3	166.2	85.3	45.3	87.4
Gastropoda	---		1.0	0.5	3.0	5.8
Pelecypoda	---		0.2	0.1	0.6	1.2
Insecta:						
Trichoptera	1.9	3.3	7.2	3.7	2.1	4.1
Diptera	---		3.3	1.7	---	
Coleoptera	---		5.2	2.7	---	
Odonata	---		0.2	0.1	---	
Ephemeroptera	---		Trace		---	
Unidentified Insects and parts	---		6.3	3.2	0.4	0.7
Crustacea: Amphipoda	---		---		0.1	0.2
Hirudinea: Leeches	0.4	0.7	5.0	2.6	---	
Vegetation	0.4	0.7	0.2	0.1	0.3	0.6
Total volume of food (ml)	58.0		194.8		51.8	
No. of stomachs	18		57		14	
Avg. volume/ stomach (ml)	3.22		3.42		3.70	

TABLE 14 Stomach Contents from Rainbow Trout Longer than 356 mm (14 inches) from Gruski Lake, February, 1967 through January, 1968.

	Volume and Percentage of Organisms					
	Winter (ice cover)		Summer (ice free)		Fall (before ice cover)	
	December - April		June - August		October	
Food Organism	ml	%	ml	%	ml	%
Fish: Stickleback	34.7	75.4	133.5	96.1	58.1	84.2
Gastropoda	11.3	24.6	---		5.5	8.0
Pelecypoda	---		---		0.4	0.6
Insecta:						
Trichoptera	---		2.6	1.9	3.0	4.3
Diptera	---		2.1	1.5	---	
Coleoptera	---		---		---	
Odonata	---		---		---	
Unidentified Insects and parts	---		0.7	0.5	0.4	0.6
Vegetation	---		---		1.6	2.3
Total volume of food (ml)	46.0		138.9		69.0	
No. of stomachs	8		34		16	
Avg. volume/ stomach (ml)	5.75		4.09		4.31	

Feeding habits of trout 254 mm or less showed definite seasonal variation. Aquatic insects contributed most in bulk to the summer diet of small trout. Diptera, Trichoptera, and Coleoptera were the principal insect groups consumed. The volume of stickleback ingested during the fall was slightly greater than insects. During the winter, stickleback comprised more than 75% of the diet of trout between 153 mm (6 inches) and 254 mm. Trichopteran larvae were the most common insect utilized during the fall and winter. No information was collected concerning the winter food of trout less than 153 mm.

The data indicates that stickleback dominate the fall and winter diets of trout larger than 152 mm. Summer food habits suggest that trout 254 mm or less prefer insects but will utilize substantial quantities of stickleback if their preferred food is not available. A comparison of the summer food consumed by all size groups indicates that trout change to predominantly fish diets after attaining a size of about 204 to 254 mm regardless of availability of other food (Table 15). Sculpins and salmonids comprised a minor part of the diet.

TABLE 15 Summer Food of Various Size Groups of Rainbow Trout from Gruski Lake, 1967.

	Percent of Total Volume of Organisms*	
Size Group (mm)	Insects	Stickleback
Less than 153	92.4	5.1
153-203	83.3	11.2
204-254	51.8	41.7
255-305	19.3	78.9
306-356	11.4	85.3
Greater than 356	3.4	96.1

*Percentages of miscellaneous food items not included.

Lake Trout Transplants

Lake trout, *Salvelinus namaycush*, were introduced into Upper Summit Lake in 1969 after studies suggested favorable conditions for establishment of a self-sustaining population. The lake's abundant, but lightly fished, Dolly Varden population offers potential forage for the transplanted char. Development of a lake trout fishery is not considered desirable because the endemic char attract few sport fishermen due to their small size.

Upper Summit Lake contains 10,729 acre-feet of water and has 258 surface acres (Figure 1). This oligotrophic lake has mean and maximum depths of 41.6 and 70 feet, respectively. Cool, well oxygenated water is available throughout the year at all depths. A thermocline is present during the summer and surface temperatures seldom exceed 55^{o}F (Table 16). Gravel and rubble make up a substantial part of the shoal substrate.

An abundance of forage is a prerequisite for successful lake trout introductions. Studies have shown that whitefish frequently produce sizable lake trout; however, there is a paucity of information on the value of Dolly Varden as forage.

The distribution, dwarf size, and abundance of Dolly Varden in Upper Summit Lake indicates that species may provide forage for the larger char. Gill-net sampling in 1968 and 1969 revealed that substantial numbers of Dolly Varden occupy deep water during the summer. Vertical gill-net sampling during August, 1969, yielded a catch of 355 Dolly Varden. Forty-four percent of the char were captured within ten feet of the bottom and 90% were gill netted in or below the thermocline (Figure 2). Surface and bottom temperatures at the

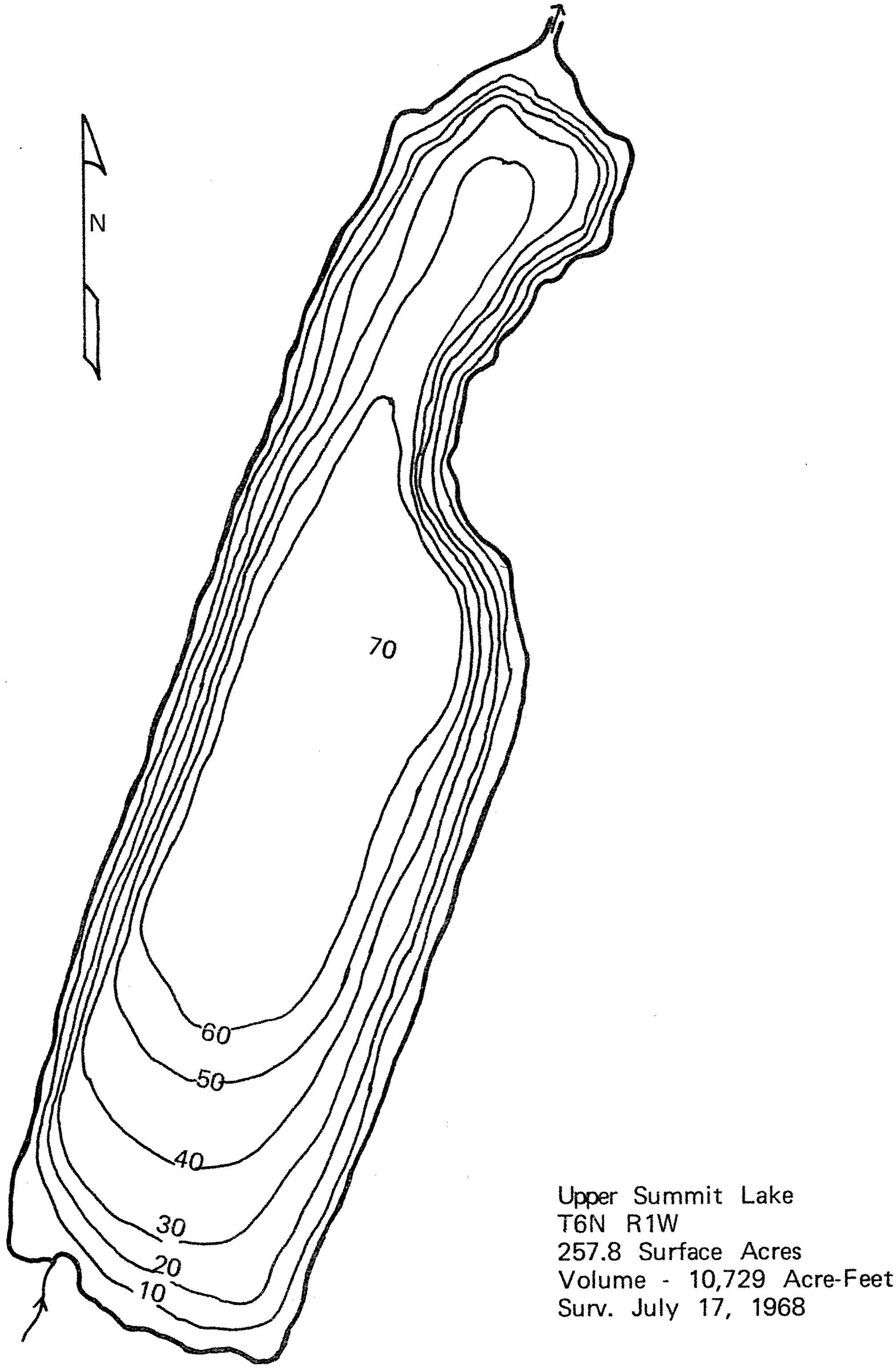

FIGURE 1 HYDROGRAPHIC MAP OF UPPER SUMMIT LAKE.

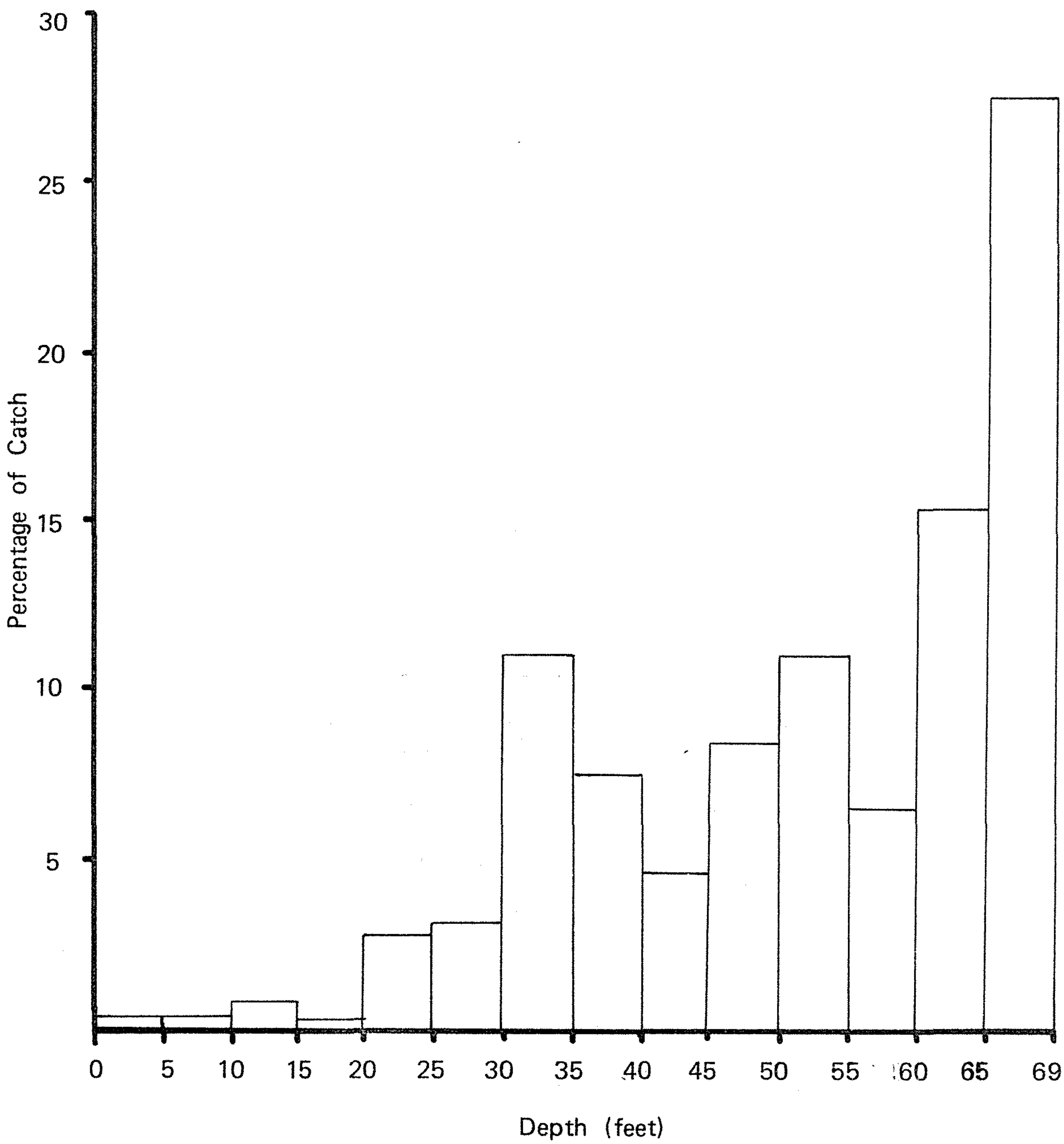

FIGURE 2 PERCENTAGE OF DOLLY VARDEN CAPTURED AT VARIOUS DEPTHS IN UPPER SUMMIT LAKE DURING AUGUST, 1969.

69-foot-deep gill-net station were 53 and 44°F, respectively.

TABLE 16 Upper Summit Lake Water Temperature Profiles, 1969.

	Temperature (°F)			
Depth (ft)	6/16	7/5	7/18	8/15
0	47.5	54.5	55.0	54.0
3	47.5	54.0	55.0	54.0
6	47.0	54.0	54.5	54.0
9	47.0	54.0	54.5	54.0
12	46.5	53.5	53.0	54.0
15	46.0	51.0	52.0	54.0
18	46.0	49.0	51.5	54.0
21	46.0	48.0	51.0	53.0
24	45.5	46.0	49.0	52.0
27	45.0	45.0	47.0	51.0
30	44.5	44.5	46.0	48.0
33	44.0	44.0	44.0	47.0
36	43.0	43.5	44.0	46.0
39	42.0	43.0	43.5	45.0
42	42.0	43.0	43.0	44.0
45	42.0	42.5	43.0	44.0
48	41.5	42.5	42.5	44.0
51	41.5	42.0	42.0	44.0
54	41.5	42.0	42.0	44.0
57	41.0	42.0	42.0	44.0
60	41.0	42.0	42.0	44.0
63	41.0	41.5	42.0	44.0
66	41.0	41.0	42.0	44.0

Male Dolly Varden averaged 165.3 mm fork length and weighed 0.12 pounds. Female Dolly Varden had a mean length of 159.7 mm and weighed 0.11 pounds.

Skilak Lake was selected as a donor site because of its accessibility and lightly fished trout population. Lake trout growth in Skilak Lake is extremely slow because of its unproductive silt-laden glacial water. From October 28 through November 4, 1969, three hundred sixty-seven lake trout were captured during 982 hours of gill-net sampling. All fish were captured within a three-mile radius of the lower Skilak Lake campground. Gill net and transfer mortalities resulted in the loss of 163 fish.

A total of 204 lake trout, in apparent good condition, were released in Upper Summit Lake. The adipose fin was removed from all transplanted fish for future identification. A sample of 156 dead char suggests that males ranged from 270 to 444 mm with a mean fork length of 336.3 mm, whereas females averaged 355.1 mm and ranged from 233 to 497 mm. The males and females averaged 0.93 and 1.10 pounds, respectively. The ratio of males to females was 0.8:1. Fifty-five percent of the char were sexually mature and had spawned prior to their capture.

Identifiable food was observed in 73% of the lake trout stomachs. Juvenile red salmon was the most common food item consumed.

Miscellaneous Studies

Substantial effort was devoted to locating two lakes with similar chemical, physical, and biological characteristics. Preliminary studies indicate that North and South Twin lakes have suitable environmental conditions for further research on rainbow trout - threespine stickleback relationships. After stickleback have been chemically removed from North Twin Lake, both waters will be stocked at equal fingerling rainbow trout densities. Survival and growth will be compared during succeeding years.

Rotenone was not available to measure the effect on stickleback and to determine the duration of toxicity in the area's lakes; consequently, this job segment was inactive.

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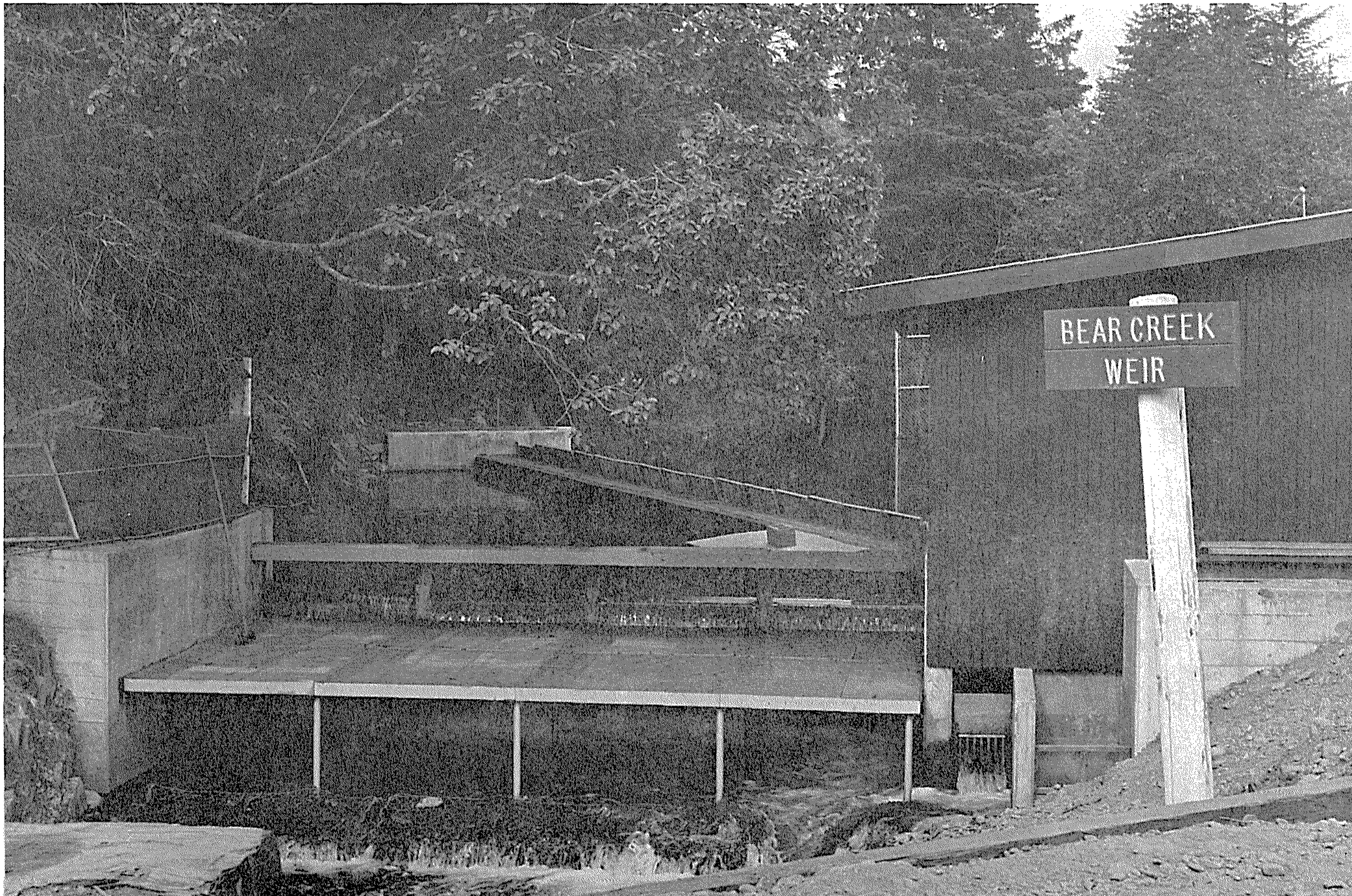

BEAR CREEK WEIR IS USED IN THE PLANNED PROGRAM OF INCREASING THE ADULT SILVER SALMON PRODUCTION OF BEAR LAKE, SEWARD, ALASKA.