Survey of the Fishery Resources on Adak Island, Alaska Maritime National Wildlife Refuge, 1993 and 1994

Final Report

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Key Words: Adak Island, Aleutian Islands, Lake Andrew, anadromous fish, migration timing, escapement, juvenile salmonids, water quality

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Abstract

Fishery surveys were conducted on 57 streams supporting anadromous fish on Adak Island. Spawning ground surveys were conducted on foot from July through November 1993 and from August through November 1994. A backpack electroshocker was used to examine distribution and abundance of juvenile salmonids and resident fish species. Information was collected on population abundance and associated age, sex, and length statistics. Habitats important for spawning and rearing were identified and water quality characteristics were described. Fish populations in Lake Andrew, the largest lake on the island, were sampled with experimental gill nets and minnow traps to examine species composition, relative abundance, and age and size structure. Water quality characteristics of Lake Andrew were also described.

Eight fish species were observed during surveys on Adak Island including pink (*Oncorhynchus gorbuscha*), coho (*O. kisutch*), sockeye (*O. nerka*), and chum salmon (*O. keta*), Dolly Varden (*Salvelinus malma*), rainbow trout (*O. mykiss*), coastrange sculpin (*Cottus aleuticus*), and threespine stickleback (*Gasterosteus aculeatus*). Pink salmon were the most abundant and widely distributed salmon species and were found in 50 streams. Pink salmon escapements observed during 1994 were much higher than those observed in 1993 with peak numbers observed during late August and early September. Finger Creek, a stream supporting the largest escapement of pink salmon on Adak Island, had an estimated escapement of nearly 100,000 fish in 1994 compared to only 20,000 in 1993. Three other streams supported pink salmon escapements of over 45,000 fish in 1994. Coho salmon were observed in 38 different streams. Adults began entering streams in early September and were present through October and November. Peak counts greater than 75 fish were observed in four streams with most streams supporting fewer than 50 fish. Sockeye salmon were observed in 15 different streams but numbers of fish observed were generally less than 50 adults except for two watersheds. The Hidden Creek watershed supported over 3,300 adults in both 1993 and 1994. The peak count of sockeye salmon in the Lake Constance watershed was 356 fish during 1994. Small numbers of chum salmon ($N \leq 15$) were observed in eleven different streams. Dolly Varden were observed in most streams, but enumeration was difficult in streams supporting large numbers of spawning salmon. Rainbow trout were found in two streams.

Six different fish species were identified in Lake Andrew and streams entering the lake. Dolly Varden, residual coho salmon, kokanee, threespine stickleback, and coastrange sculpin were captured in the lake. Dolly Varden, coastrange sculpin, sockeye (anadromous and lacustrine forms), pink, and coho salmon were observed in streams entering the lake. Anadromous sockeye and pink salmon were observed in four Lake Andrew tributaries during 1994. Anadromous fish access to this watershed is restricted during some years by debris which accumulates in the channel connecting the lake to the ocean.

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Introduction

Waters on and around Adak Island support five species of Pacific salmon *Oncorhynchus* spp. and Dolly Varden *Salvelinus malma*. Pink salmon *O. gorbuscha* and Dolly Varden are the most common and widely distributed species on the island. Less is known about the distribution and abundance of other fish species.

The most comprehensive evaluation of anadromous fish populations on Adak Island was conducted by the Alaska Department of Fish and Game in 1982 (Holmes 1982). During the study, aerial surveys conducted from a helicopter identified 36 streams on Adak Island which supported anadromous fish. All of the streams supported pink salmon and a few supported coho *O. kisutch* and sockeye *O. nerka* salmon. The helicopter surveys were conducted during late August and early September, the peak spawning period for pink salmon, and were too early to accurately assess coho salmon runs and too late to assess sockeye salmon runs. Dolly Varden were identified in some streams, however, this species was not the primary focus of the study. No streams were found which supported chum *O. keta* or chinook salmon *O. tshawytscha*.

Some effort has been expended to evaluate the fish populations occurring in Lake Andrew, the largest lake on Adak Island. A limited amount of experimental gill netting was conducted by the Alaska Department of Fish and Game and the Service between 1959 and 1972, but data collected are available only as raw data files. Fish species collected during these sampling efforts included Dolly Varden, kokanee, and rainbow trout (*O. mykiss*). The rainbow trout collected were probably remnants of fish stocked into Lake Andrew tributaries in the mid-1950's.

Uses of fishery resources on Adak Island include popular sport fisheries for salmon and Dolly Varden and a personal-use fishery directed at sockeye salmon in Hidden Bay on the southern coast. Fishery resources on the island also support local populations of piscivorous wildlife including bald eagles *Haliaeetus leucocephalus*, mergansers *Mergus* spp., and several species of marine mammals.

A survey of the fishery resources on Adak Island was conducted during 1993 and 1994 to assess the current status of anadromous fish populations and evaluate fish populations in Lake Andrew. Specific objectives were to:

1. Determine the migration timing, distribution, and relative magnitude of adult salmon and Dolly Varden escapements into streams supporting anadromous fish.

2. Identify barriers to anadromous fish migration.

3. Describe the age, sex, and length composition of adult salmon populations.

4. Determine the distribution and relative abundance of juvenile salmonids and resident fish species in streams supporting anadromous fish.

5. Describe the age and length composition of juvenile salmonid populations.

6. Determine the species composition, relative abundance, and age and size structure of fish populations in Lake Andrew.

7. Describe the water quality characteristics of anadromous fish streams and Lake Andrew.

8. Develop recommendations for the management of fish populations and their habitat on Adak Island.

This project was a joint effort between the U.S. Fish and Wildlife Service and the U.S. Navy and was funded through the Department of Defense's Legacy Resource Management Program.

Study Area

Adak Island, a member of the Andreanof Islands, lies in the Aleutian chain approximately 2,100 km southwest of Anchorage (Figure 1). Typical of other Aleutian islands, it is of volcanic origin having moderately rugged terrain with elevations ranging to 1,189 meters. Vegetation on the island is classified as maritime tundra and trees are lacking. Adak Island has a total land mass of 62,729 hectares and is part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge. The Adak Naval Station occupies 24,687 hectares on the northern part of the island.

There are many lakes and freshwater drainages found on the island. Lakes are generally small, most being less than 40 hectares. Lake Andrew is the largest lake having a surface area of 809 hectares and a maximum depth of 26 m. Most streams are narrow, swift, and short and are deeply entrenched in vegetation or peat mantle and have a bedrock, gravel, or colluvium channel bottom. Most streams not blocked by a waterfall at their terminus support anadromous fish populations. The majority of streams on Adak Island do not have official names and were named during the course of this study to simplify identification (Figure 2).

Methods

Field Techniques

Surveys of streams supporting anadromous fish on Adak Island were conducted from July through November during 1993 and from August through November during 1994. Spawning ground surveys were conducted on foot to estimate adult salmon and Dolly Varden escapements. Most streams supporting anadromous fish were surveyed a minimum of three times

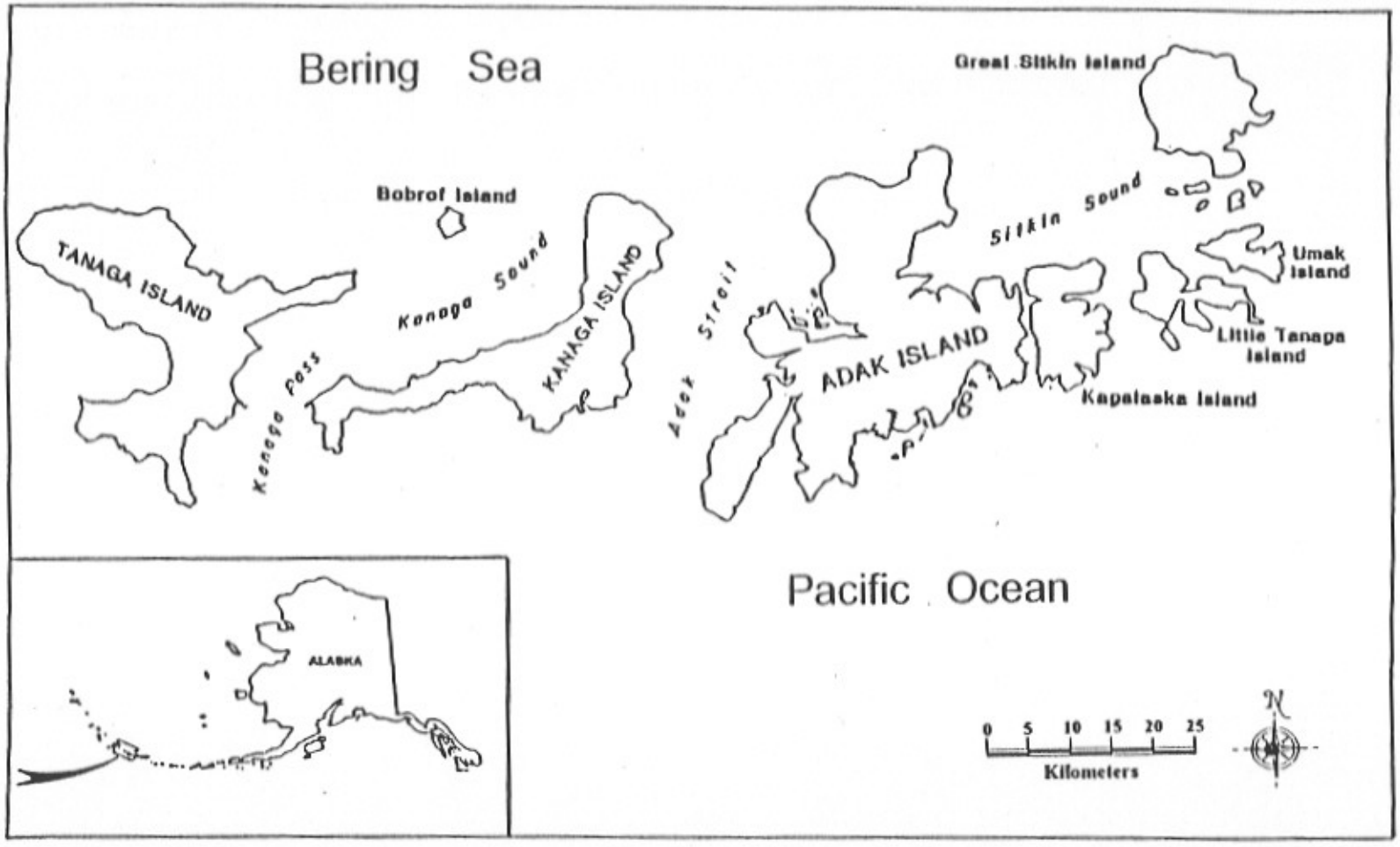
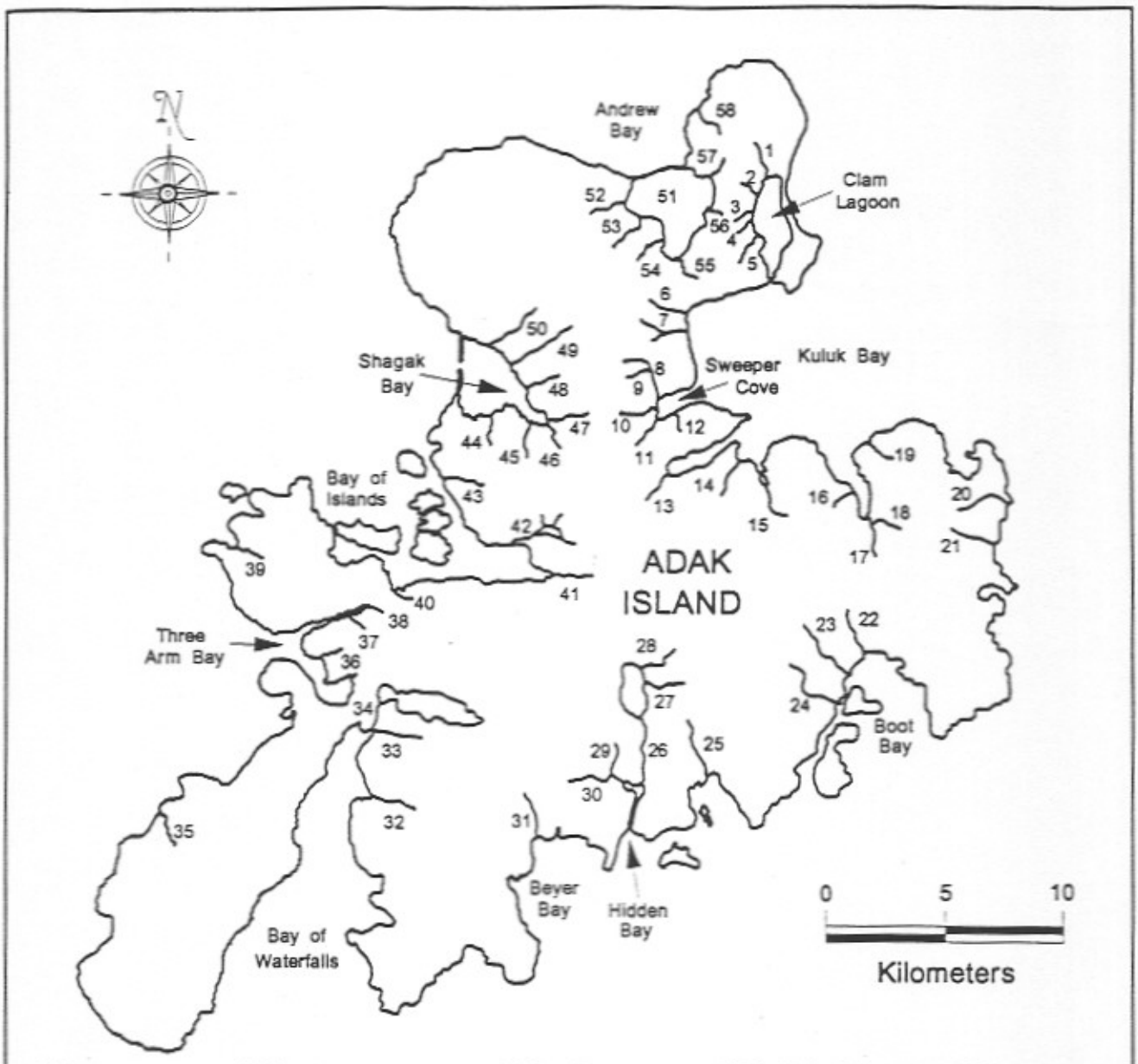


FIGURE 1.-Location of Adak Island, Alaska.



1 Range
2 Transpo
3 CDAA
4 Shotgun
5 NoName
6 NavFac
7 Airport
8 Sweeper
9 Amulet
10 Basin
11 Mitt
12 Leone
13 Finger
14 Little Thumb
15 Thumb
16 West Scabbard
17 Right Scabbard
18 Left Scabbard
19 NE Scabbard
20 North Kagalaska
21 South Kagalaska
22 Boot 1
23 Boot 2
24 Boot 3
25 Camel
26 Hidden
27 South Teardrop
28 North Teardrop
29 Right Cabin
30 Left Cabin
31 Beyer
32 Sabrina
33 Right Hatchet
34 Left Hatchet
35 Yakak
36 Middle Arm
37 South North Arm
38 East North Arm
39 Caribou
40 Unalga
41 Gannet
42 Constance
43 Amelia
44 Shagak 1
45 Shagak 2
46 Shagak 3
47 Shagak 4
48 Shagak 5
49 Shagak 6
50 Shagak 7
51 Lake Andrew
52 VW
53 Moffett
54 Nurse
55 Jean
56 East
57 Park
58 Adagdak

FIGURE 2.—Names and locations of streams and lakes sampled on Adak Island, Alaska, 1993 and 1994.

throughout the field season so that migration timing and relative magnitude of escapements could be evaluated for all anadromous species. Additional foot surveys were conducted on streams supporting large pink salmon runs and to evaluate coho salmon escapements during October and November. Surveys conducted during October and November were limited to eight streams on the northern part of the island.

During each survey, observers walked all sections of the stream accessible to anadromous fish and counted the escapement. Observers wore polarized sunglasses to reduce glare and used tally counters to record the number of fish by species. Migration barriers were documented for each stream and coordinates were recorded using a global positioning system receiver. Waterfalls and cascades were classified as migration barriers if no anadromous fish were observed upstream of the barrier.

Adult salmon carcasses were sampled opportunistically at various locations to describe age, sex, and length characteristics of spawning populations. Mid-eye to fork length was measured to the nearest 5 mm and otoliths were removed for age determination. Age, sex, and length information was not collected from Dolly Varden since few carcasses were encountered.

The distribution and relative abundance of juvenile salmonids and resident fish species in each stream were assessed using a Smith-Root® Model 15A backpack electroshocker. All fish captured were identified and enumerated. Fork lengths were measured to the nearest mm and scales were collected from a random sample of juvenile salmon.

Experimental gill nets and minnow traps were used to sample fish populations in Lake Andrew during July and August in 1993. Gill nets were 30.5 m long by 2.4 m deep with five 6.1-m panels of 2.5, 5.1, 6.4, 7.6, and 10.2-cm stretch monofilament mesh. Overnight sets were made each month using two floating and two sinking gill nets and six minnow traps baited with salmon eggs.

All fish captured in Lake Andrew were identified and enumerated. Fork lengths were measured to the nearest mm and weights were determined using spring scales graduated to different levels of precision. Generally, fish up to 500 g were measured to the nearest 5 g and fish over 500 g were measured to the nearest 10 g. Otoliths were collected from Dolly Varden, kokanee, and residual coho salmon for age determination.

Water quality characteristics of anadromous fish streams and Lake Andrew were measured using a variety of equipment. Stream water temperatures and conductivity were measured with a YSI® Model 33 meter. Dissolved oxygen and temperature profiles were measured at 1 m depth increments on Lake Andrew with a YSI® Model 57 meter. Alkalinity, pH, and total hardness were measured using Hach® test kits.

Data Analysis

Observations made during foot surveys were compiled to determine migration timing and distribution of adult anadromous fish on Adak Island. Total pink salmon escapements were estimated for streams when a minimum of three foot surveys were conducted during the spawning period. Total escapement estimates were derived using an area-under-the-curve (AUC) spawner abundance model (Johnson and Barrett 1988). A stream life of 15 days was assumed for pink salmon based on estimates from Kodiak Island (Barrett et al. 1990) and the Alaska Peninsula (Barrett 1990). Peak counts from foot surveys were used as indices of relative abundance for other species and for pink salmon when fewer than three foot surveys were conducted.

Catches from various gear types were compiled to determine species composition and distribution of juvenile salmonids and resident fish species in anadromous streams and Lake Andrew. Catch per unit effort with the backpack electroshocker was used as an index of relative abundance for juvenile salmon and resident fish species in streams. Catch per unit effort with experimental gill nets and minnow traps were used as indices of relative abundance for fish populations in Lake Andrew.

Otoliths were used to determine ages of adult salmon and Dolly Varden. Otoliths were aged with a 8-40x dissecting microscope using reflected light and techniques described by Jerald (1983) and Heiser (1966). Salmon age designation followed the European Method, where the initial numeral indicates the number of winters of freshwater life and the second indicates the number of winters of saltwater life (Koo 1962). Ages of Dolly Varden and kokanee were expressed as numerals corresponding to the actual number of hyaline rings or dark bands (winter checks) on the otolith.

Scales were used to determine ages of juvenile salmon. Scales were cleaned and mounted between two microscope slides and aged using a microfiche reader. Age designation for juvenile salmon followed methods used for adults.

Results

Eight fish species were observed on Adak Island during 1993 and 1994 (Table 1). Anadromous species included Dolly Varden, sockeye, pink, chum, and coho salmon. Resident species collected were rainbow trout, coastrange sculpin (*Cottus aleuticus*), and threespine stickleback (*Gasterosteus aculeatus*). Lacustrine forms of Dolly Varden, sockeye, and coho salmon occurred in Lake Andrew.

Fifty-five streams which supported anadromous fish were identified on Adak Island. The amount of spawning habitat available to anadromous fish in each stream was largely dependent on the location of migration barriers which were typically waterfalls. The coordinates of streams surveyed and barriers to fish migration appear in Appendix 1.

TABLE 1.—Occurrence of fish species (J=juvenile, A=adult, P=present) at locations sampled on Adak Island, 1993 and 1994.

	Species							
Stream/lake	Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden	Rainbow trout	Coastrange sculpin	Threespine stickleback
Range	A				P			
Transpo	A	J			P		P	
CDAA	A	J			P			
Shotgun	A	J			P		P	
NoName	A	JA		A	P		P	
NavFac	A	JA			P			P
Airport	A	J			P		P	
Sweeper	A	JA			P		P	
Amulet	A	J			P		P	
Basin[1]	A							
Mitt	A	JA	A		P		P	P
Leone	A	J			P		P	P
Finger	A	JA	A	A	P		P	
Little Thumb	A	JA	A	A	P		P	
Thumb	A	J			P		P	
West Scabbard	JA	JA			P		P	
Right Scabbard	A	J			P		P	
Left Scabbard	A	J		A	P		P	
NE Scabbard[1]	A							
North Kagalaska	A				P			
South Kagalaska	A				P			
Boot 1	A	J	A		P		P	
Boot 2	A				P		P	
Boot 3	A	A	A	A	P		P	
Camel	A				P		P	
Hidden	A	JA	JA	A	P		P	
South Teardrop			A		P			
North Teardrop			JA		P			
Right Cabin	A		A		P			
Left Cabin	A	J	A		P			
Beyer	A				P		P	
Sabrina	A	A			P		P	
Right Hatchet	A				P		P	
Left Hatchet	A	A		A	P		P	
Yakak[2]		J			P			
Middle Arm	A			A	P			

TABLE 1.—Continued

Stream/lake	Species							
	Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden	Rainbow trout	Coastrange sculpin	Threespine stickleback
South North Arm		J			P		P	
East North Arm	A	J			P		P	
Caribou	A	JA	A		P			
Unalga	A	J			P		P	
Gannet	A	JA	A	A	P		P	P
Constance	A	JA	A		P			
Amelia	A	J			P		P	
Shagak 1	A	J			P			P
Shagak 2	A	J					P	
Shagak 3	A	J			P	P	P	
Shagak 4	A	A			P	P	P	
Shagak 5	A	J			P		P	
Shagak 6	A	JA	A	A	P		P	
Shagak 7	A	J		A	P		P	
Lake Andrew		A[3]	A[4]		P		P	P
VW	A		A[4]		P		P	
Moffett	A		A[4]		P		P	
Nurse	A	J	A[5]		P		P	
Jean[1]			A[4]					
East			A[4]		P		P	
Park	A				P		P	
Adagdak					P			

[1] Spawning ground surveys only. No juvenile fish sampling.
[2] This stream was surveyed only once on July 30, 1993. Additional surveys were not possible due to remote location and high seas.
[3] Lacustrine population.
[4] Kokanee.
[5] Kokanee and anadromous adults.

Anadromous Streams

Sockeye salmon.—Sockeye salmon were found in 15 streams on Adak Island (Table 1). Adult sockeye salmon were first observed in Hidden Creek during early July in 1993 and occurred in Finger Creek through mid-October in 1993 (Figure 3). The Hidden Creek drainage, which includes North and South Teardrop creeks, supported the largest escapement of sockeye salmon on the island. Peak counts of 4,030 and 3,310 fish were observed in this drainage during August in 1993 and 1994, respectively (Table 2). Peak counts of adult sockeye salmon in other streams were less than 60 fish except for Constance Creek which had a peak count of 356 fish during August 1994. Anadromous and lacustrine populations of sockeye salmon were observed in streams entering Lake Andrew. Kokanee were observed spawning in VW, Moffett, Nurse, Jean, and East creeks (Table 1). Five anadromous adults were observed in Nurse Creek.

Three age groups of adult sockeye salmon were identified in Adak Island streams (Table 3). Fish from age group 2.2 were most abundant, comprising 87% of the fish that were aged. Males were slightly larger than females of the same age. Females accounted for 52% of the fish for which sex was determined (N=97).

Juvenile sockeye salmon were captured only in the Hidden Creek drainage. Catch per unit effort with the backpack electroshocker was low at 2.9 and 1.9 fish per five minute transect in Hidden and North Teardrop creeks, respectively (Table 4). Juveniles captured in Hidden Creek (N=3) ranged from 65-72 mm in length and were all age 1.0. Juvenile sockeye salmon captured in North Teardrop Creek (N=2) were 28 and 30 mm in length and were both age 0.0.

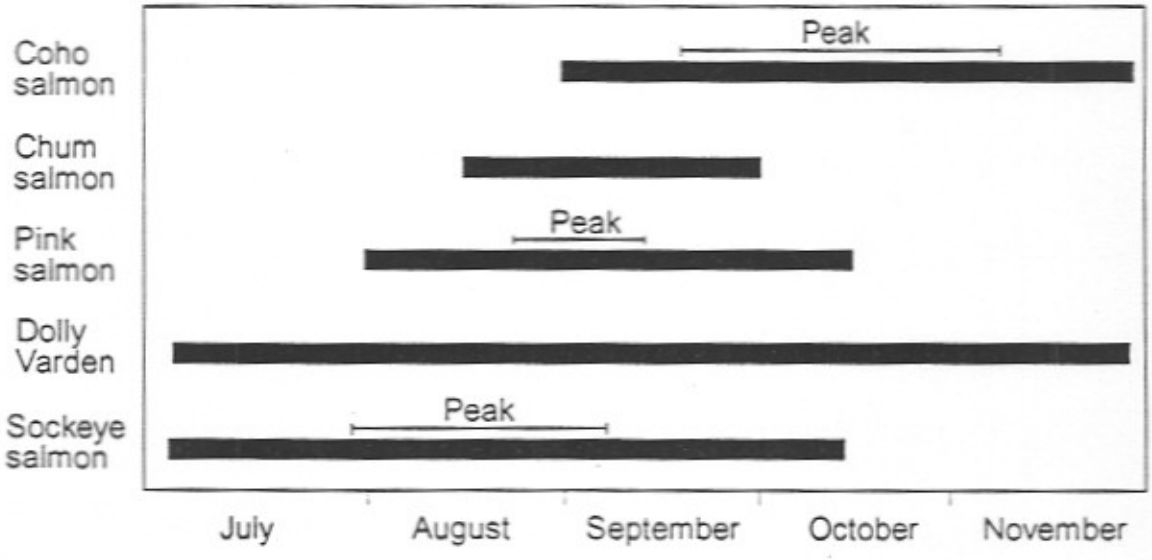


FIGURE 3.—Run timing of anadromous fish on Adak Island, Alaska.

TABLE 2.–Peak counts of adult coho, sockeye, and chum salmon in Adak Island streams during 1993 and 1994.

	Coho salmon		Sockeye salmon		Chum salmon	
Stream	1993	1994	1993	1994	1993	1994
NoName	1	7			1	0
NavFac[1]	10	119				
Sweeper[1]	17	81				
Amulet[1]	11	0				
Mitt[1]	3	4	2			
Finger[1]	30	49	8	2	6	1
Little Thumb[1]	77	15	4	3	6	0
Left Scabbard					1	0
Boot 3	20	3	55	1	2	15
Hidden[2]	12	0	4,030	3,310	1	0
Left Cabin			0	39		
Sabrina	5	2				
Left Hatchet					6	1
Middle Arm					1	0
Caribou	6	15	0	1		
Gannet[1]	35	77	20	4	2	6
Constance	15	12	98	356		
Shagak 6[3]	25	-	0	1	0	1
Shagak 7					0	1
Nurse[4]			-	5		

[1] Surveys were conducted on these streams during October and November in 1993 and 1994 to evaluate coho salmon escapements.
[2] Includes North and South Teardrop creeks.
[3] Surveys were conducted on this stream during October and November in 1993 to evaluate the coho salmon escapement.
[4] No surveys were conducted on this stream during 1993.

TABLE 3.–Mean length (mid-eye to fork) at various ages for adult sockeye, coho, pink, and chum salmon collected in streams on Adak Island, Alaska, 1993 and 1994.

		Females				Males			
Species	Age	N	Mean	Range	SE	N	Mean	Range	SE
Sockeye salmon	2.1	3	448	425-470	13.0	6	483	440-560	18.8
	2.2	46	521	425-575	5.0	38	535	440-600	7.3
	3.2	1	535			3	562	545-580	10.1
Coho salmon	2.1	13	598	545-685	9.8	10	517	230-630	40.2
	3.1	8	557	420-645	25.8	4	515	465-540	17.0
	4.1	1	620			0			
Pink salmon	0.1	58	444	410-480	2.5	42	462	400-530	4.7
Chum salmon	0.4	0				1	605		

TABLE 4.—Catch per unit effort (five minutes of current-on time) of fish species with backpack electroshocker at various streams on Adak Island, 1993 and 1994.

	Species						
Stream/lake	Pink salmon[1]	Coho salmon[1]	Sockeye salmon[1]	Dolly Varden	Rainbow trout	Coastrange sculpin	Threespine stickleback
Range				44.3			
Transpo		6.0		27.9		3.0	
CDAA		4.8		22.3			
Shotgun		12.9		20.3		1.8	
NoName		32.0		23.0		3.0	
NavFac		6.0		38.0			2.0
Airport		21.9		14.9		3.0	
Sweeper		31.6		50.0		4.1	
Amulet		52.1		41.1		3.2	
Mitt		25.7		16.8		1.0	1.0
Leone		10.9		30.6		16.8	4.9
Finger		42.4		3.0		5.9	
Little Thumb		7.7		11.2		21.0	
Thumb		11.5		27.5		18.6	
West Scabbard	6.7	1.1		1.1		5.6	
Right Scabbard		3.8		27.9		5.8	
Left Scabbard		4.8		35.8		2.9	
North Kagalaska				26.8			
South Kagalaska				50.0			
Boot 1		6.9		24.8		3.0	
Boot 2				9.1		1.0	
Boot 3				1.4		1.4	
Camel				49.5		1.0	
Hidden		7.8	2.9	14.6		7.8	
South Teardrop				9.1			
North Teardrop			1.9	10.6			
Right Cabin				11.7			
Left Cabin		3.7		8.7			
Beyer				5.1		3.4	
Sabrina				6.9		1.2	
Right Hatchet				31.0		5.8	
Left Hatchet				22.2		4.0	
Yakak		6.1		67.3			
Middle Arm				31.1			

TABLE 4.—Continued

Stream/lake	Species						
	Pink salmon[1]	Coho salmon[1]	Sockeye salmon[1]	Dolly Varden	Rainbow trout	Coastrange sculpin	Threespine stickleback
South North Arm		3.0		52.8		1.5	
East North Arm		14.0		31.1		6.0	
Caribou		14.0		24.9			
Unalga		2.6		9.3		14.5	
Gannet		8.3		2.8		3.7	0.9
Constance		17.3		15.0			
Amelia		3.1		54.8		22.8	
Shagak 1		17.6		3.5			3.5
Shagak 2		3.0				6.0	
Shagak 3		1.9		33.3	9.3	7.4	
Shagak 4				1.0	11.2	11.2	
Shagak 5		28.5		16.7		1.0	
Shagak 6		18.4		31.1		4.9	
Shagak 7		1.0		12.9		1.0	
VW				51.3		3.2	
Moffett				64.0		5.5	
Nurse		0.9		23.0		31.8	
East				34.2		40.8	
Park				84.9		70.8	
Adagdak				75.0			

[1] All salmon captured with the backpack electroshocker were juveniles.

Pink salmon.—Pink salmon were the most abundant and widely distributed salmon species and were found in 50 streams (Table 1). Adult pink salmon began entering streams in early August and were present until mid-October (Figure 3). Peak numbers of spawners were present during late August and early September. Pink salmon escapements observed during 1994 were much higher than those observed in 1993. Finger Creek supported the largest escapement of pink salmon on the island with an estimated total escapement of 19,926 fish in 1993 and 99,436 fish in 1994 (Table 5). Streams supporting pink salmon escapements over 45,000 fish in 1994 included Little Thumb, Gannet, and Shagak 6 creeks. These streams also supported some of the largest escapements observed during 1993. Four streams in the Lake Andrew watershed (VW, Moffett, Nurse, and Park creeks) supported pink salmon runs during 1994.

Age determinations made for pink salmon adults indicated that all fish were 0.1 (Table 3). Males were larger than females averaging 462 mm in length compared to 444 mm for females. Females were more abundant than males accounting for 58% of the fish for which sex was determined (N=100).

Juvenile pink salmon were observed in brackish water near the mouths of nearly every stream that supported pink salmon. The backpack electroshocker generally was not effective in brackish water habitats, however, juvenile pink salmon were collected with this gear at one location. Six pink salmon juveniles ranging from 39-49 mm in length were collected in the lower reach of West Scabbard Creek during early July in 1993 (Table 4).

Chum salmon.—Small numbers of adult chum salmon were observed in eleven different streams (Table 1). The largest number of chum salmon (N=15) were observed in Boot 3 Creek during September, 1994 (Table 2). Peak counts of six chum salmon were observed in Left Hatchet, Finger, and Little Thumb creeks during 1993 and Gannet Creek during 1994. Peak counts of chum salmon in other streams were two fish or less. Chum salmon were first observed in mid-August and were present until late September (Figure 3). No juvenile chum salmon were observed.

Coho salmon.—Adult coho salmon were observed in 16 streams on Adak Island (Table 1). Coho salmon began entering streams in early September and were present in low numbers during late November when the last surveys were conducted (Figure 3). Peak counts of adult coho salmon were observed from late September through early November. Peak counts greater than 75 fish occurred in Little Thumb Creek during 1993 and in NavFac, Sweeper, and Gannet creeks during 1994 (Table 2). Peak counts in other streams were less than 50 fish, however, several streams were not surveyed during October and November due to logistical constraints.

Three age groups of adult coho salmon were identified in Adak Island streams (Table 3). The most abundant age group was 2.1 comprising 64% of the fish that were aged. Females were larger than males averaging 598 mm (N= 13) for age 2.1 fish and 557 mm (N=8) for age 3.1 fish.

TABLE 5.—Peak counts and estimated total escapement of pink salmon in Adak Island streams during 1993 and 1994. Total escapement was estimated using an area-under-the-curve spawner abundance model (Johnson and Barrett 1988) when three or more ground surveys were conducted during the spawning period.

	1993			1994		
Stream	Number of counts	Peak count	Estimated escapement	Number of counts	Peak count	Estimated escapement
Range	2	0		4	43	46
Transpo	2	215		4	229	475
CDAA	2	0		4	40	48
Shotgun	2	185		4	710	1,224
NoName	2	225		4	1,260	1,745
NavFac	2	380		5	5,590	10,228
Airport	2	231		4	1,727	3,751
Sweeper	2	70		6	1,910	3,434
Amulet	2	1		6	228	437
Basin	0			2	1,032	
Mitt	2	0		4	30	53
Leone	2	17		3	910	1,604
Finger	6	14,500	19,926	10	45,400	99,436
Little Thumb	4	2,050	4,183	7	33,400	62,796
Thumb	2	335		5	3,682	7,377
West Scabbard	2	0		4	410	703
Right Scabbard	2	117		4	1,250	2,655
Left Scabbard	2	835		4	3,130	6,122
NE Scabbard	0			2	297	
North Kagalaska	2	1		1	2	
South Kagalaska	2	1		1	148	
Boot 1	2	15		3	1,525	3,543
Boot 2	2	14		3	65	173
Boot 3	2	550		3	4,200	7,729
Camel	2	2		1	8	
Hidden	2	1,200		2	6,270	
Right Cabin	2	0		2	18	
Left Cabin	2	15		2	70	
Beyer	2	85		1	267	
Sabrina	2	45		3	121	456
Right Hatchet	2	115		3	371	831
Left Hatchet	2	715		3	1,375	3,770
Middle Arm	2	500		2	7,760	
East North Arm	2	178		3	2,450	3,970
Caribou	2	215		2	3,235	
Unalga	2	59		3	1,530	2,789
Gannet	2	13,600		5	26,200	62,819
Constance	2	30		3	3,500	5,370
Amelia	2	273		3	5,860	19,232
Shagak 1	2	11		3	174	764
Shagak 2	2	1		3	490	1,242
Shagak 3	2	6		4	1,600	2,644

Table 5.—Continued.

Stream	1993 Number of counts	1993 Peak count	1993 Estimated escapement	1994 Number of counts	1994 Peak count	1994 Estimated escapement
Shagak 4	2	165		4	7,500	14,469
Shagak 5	2	145		2	1,450	
Shagak 6	4	3,775	7,824	5	20,590	45,940
Shagak 7	4	580	953	5	10,660	19,610
VW	0			3	24	36
Moffett	0			3	628	1,080
Nurse	0			3	433	637
Park	0			3	3	4

Females accounted for 61% of the fish for which sex was determined (*N*=36).

Juvenile coho salmon were captured in 34 streams which were accessible to anadromous fish (Table 1). Amulet Creek had the highest catch per unit effort with the backpack electroshocker at 52.1 fish per five minute transect (Table 4). Other streams with catch rates greater than 20 fish per five minute transect included NoName, Airport, Sweeper, Mitt, Shagak 5, and Finger creeks. Nurse Creek was the only stream in the Lake Andrew watershed where juvenile coho salmon were captured.

Four age classes of juvenile coho salmon were identified (ages 0.0, 1.0, 2.0, and 3.0). Length frequency analysis and age determinations of subsampled fish indicated a distinct break in lengths between age 0.0 and age 1.0 fish (Figure 4). Lengths for age 0.0 fish ranged up to 65 mm (N=4). Age 1.0 fish ranged from 62-110 mm in length (N=60) with a mean of 86 mm. Age 2.0 fish ranged from 88-165 mm in length (N=22) with a mean of 124 mm. Three age 3.0 coho salmon were captured in Boot 1 Creek. Fork lengths of these fish were 183, 184, and 200 mm.

Dolly Varden.—Dolly Varden were widely distributed on Adak Island and were found in 53 streams (Table 1). Both anadromous and stream-resident forms were observed with peak counts greater than 100 fish occurring in Constance, Gannet, NavFac, Airport, Shagak 6, Shagak 7, and Caribou creeks (Appendix 2). Peak run timing was not delineated because anadromous Dolly Varden were often difficult to distinguish from stream-resident fish and visual counts were considered highly variable.

Dolly Varden was generally the most abundant fish species captured with the backpack electroshocker. Catch rates of over 20 fish per five minute transect were observed in 32 streams (Table 4). The majority of Dolly Varden collected with the electroshocker (88%) were less than 200 mm in length with fish between 80 and 100 mm being dominant (Figure 4).

Other species.—Other fish species captured in anadromous fish streams with the backpack electroshocker included rainbow trout, coastrange sculpin, and threespine stickleback. Rainbow trout ranging from 135 to 348 mm in length were found in Shagak 3 and Shagak 4 creeks. Catch rates of rainbow trout in these streams were 9.3 and 11.2 fish per five minute transect, respectively (Table 4).

Coastrange sculpin was the most widely distributed non-game species and was captured in 39 different streams (Table 1). Catch rates for this species were generally less than 10 fish per five minute transect, however, catches of over 20 fish per five minute transect were observed in Little Thumb, Amelia, Nurse, East, and Park creeks (Table 4). Threespine stickleback were found in low numbers in five streams.

Lake Andrew

Fish species observed in Lake Andrew were Dolly Varden, kokanee, coho salmon (residuals), coastrange sculpin, and threespine stickleback (Table 1). The most common species captured in the lake with

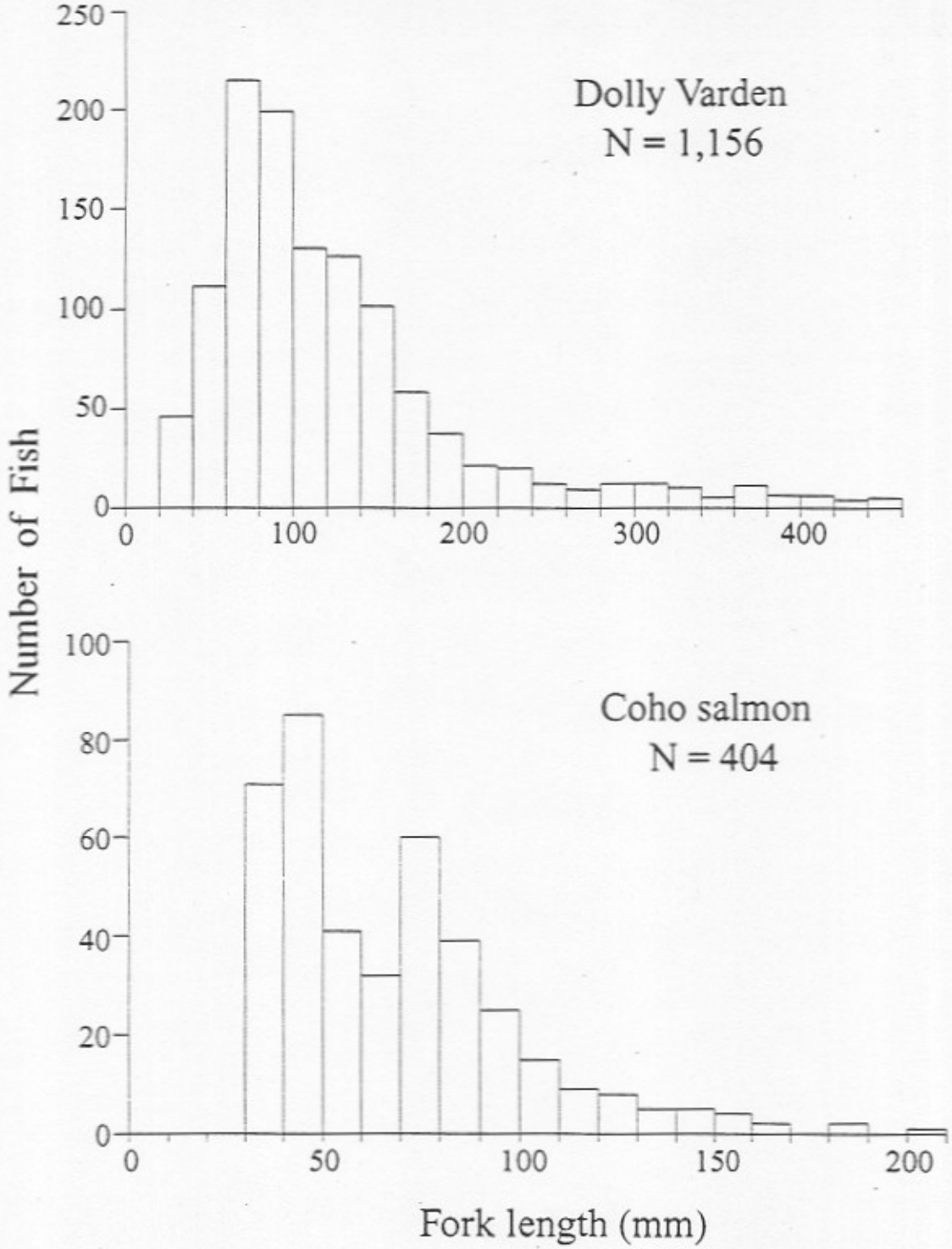


FIGURE 4.–Length frequency of coho salmon and Dolly Varden captured with backpack electroshocker on Adak Island, Alaska, 1993.

experimental gill nets was kokanee followed by Dolly Varden and residual coho salmon (Table 6). Kokanee appeared to be more abundant in the upper water column based on higher catch rates in floating gill nets during July (4.19 fish/hr) and August (4.43 fish/hr). Differences in depth distribution were not obvious for other species. Catches of coastrange sculpin and threespine stickleback in baited minnow traps were low and did not exceed 0.30 fish/hr.

Age determinations were made on otoliths from 65 Dolly Varden, 111 kokanee, and 2 coho salmon captured from Lake Andrew (Table 7). Dolly Varden ranged from 127-455 mm in length and were 3 to 9 years of age. The majority of fish (60%) were estimated to be ages 5 and 6. Kokanee ranged from 153-210 mm in length and were 2 to 4 years of age. Male kokanee were most abundant comprising 67% of fish examined. All kokanee examined were sexually mature. Both coho salmon captured in Lake Andrew were immature females and age 3.0.

Water Quality

Water quality measurements taken at various streams and Lake Andrew during 1993 appear in Appendix 3. Water temperatures ranged from 4°C in Moffett Creek during early July to 16°C in Mitt and Leone creeks during early August. Higher water temperatures (above 11°C) were typically associated with warmer air temperatures which occurred during late July and early August. Surface water temperatures in Lake Andrew were 9°C in July and 10.8°C in August during 1993. Temperature and dissolved oxygen profiles in Lake Andrew indicated nearly homothermous and well oxygenated (10-12 mg/L) water throughout the entire water column during both months.

Little variability was observed in pH values in Adak Island waters. Forty-six streams and Lake Andrew had pH values between 6.6 and 7.4. Slightly more acidic conditions were observed in North and South Kagalaska creeks which had pH values of 6.3 and 6.5, respectively.

The variability observed in conductivity, total hardness, and alkalinity during 1993 indicated that some waters on Adak Island are more productive than others. Conductivity measurements ranged from 33-310 μmho with some of the highest values occurring in streams entering Clam Lagoon, Sweeper Cove, and Shagak Bay. Streams with higher conductivities generally also had the highest alkalinity and total hardness measurements.

Discussion

Fish species observed on Adak Island during 1993 and 1994 were pink, coho, sockeye, and chum salmon, Dolly Varden, rainbow trout, coastrange sculpin, and threespine stickleback. These findings are generally consistent with surveys conducted by Holmes (1982) and the U.S. Fish and Wildlife Service (unpublished data) with one exception. Chum salmon were not documented on Adak Island prior to this survey. We observed small numbers of adult chum salmon ($N \leq 15$) in eleven different streams during our survey. Holmes (1982) documented chum salmon on five

TABLE 6.—Catch per unit effort (number of fish/hour) for various species in experimental gill nets (floating and sinking) and minnow traps in Lake Andrew during July and August, 1993.

Gear type	Kokanee	Coho salmon[1]	Dolly Varden	Coastrange sculpin	Threespine stickleback
		July			
Floating gill net	4.19	0.13	0.88		
Sinking gill net	1.03		1.22		
Minnow trap				0.30	
		August			
Floating gill net	4.43		1.22		
Sinking gill net	2.35		0.52		
Minnow trap				0.04	0.17

[1] Residuals.

TABLE 7.—Mean fork length and weight at various ages for Dolly Varden, kokanee, and coho salmon collected in Lake Andrew during 1993.

		Fork length (mm)			Weight (g)		
Age	*N*	Mean	Range	SE	Mean	Range	SE
			Dolly Varden				
3	7	168	127-198	9.1	56	36-80	5.6
4	8	210	180-270	9.8	101	59-210	16.8
5	19	252	208-305	6.5	166	85-305	15.2
6	20	297	257-393	7.6	300	165-730	31.5
7	7	335	278-371	13.2	385	225-590	44.0
8	3	364	310-405	28.3	437	240-610	107.4
9	1	455			930		
			Kokanee				
2	6	162	153-167	2.1	48	45-50	1.1
3	84	182	162-208	1.0	71	50-100	1.3
4	21	192	175-210	1.7	82	60-120	3.3
			Coho salmon				
3.0	2	197	190-204	7.0	61	49-73	12.0

Aleutian Islands including Atka and Kiska, but none were observed on Adak during aerial surveys conducted in 1982.

Sockeye salmon were documented in 15 streams on Adak Island, but only the Hidden and Constance creek watersheds had peak counts greater than 60 fish. The higher abundance of sockeye salmon in these watersheds can be attributed to the availability of lake rearing habitat. Sockeye salmon typically spawn in watersheds with accessible lakes because juveniles rear in limnetic habitats for one or two years before they migrate to sea (Burgner 1991).

The numbers of sockeye salmon observed in the Hidden and Constance creek watersheds during 1993 and 1994 were several times higher than previously observed. Holmes (1982) reported aerial survey counts of 821 fish in Hidden Creek and 3 fish in Constance Creek during late August and early September in 1982. We observed more than 2,500 sockeye salmon in the Hidden Creek watershed during the same time period in both 1993 and 1994. Foot survey counts in the Constance Creek watershed during this time period were 98 fish in 1993 and 253 fish in 1994. These findings suggest that sockeye salmon abundance has increased in these watersheds or that discrepancies exist between survey techniques.

Anadromous and lacustrine populations of sockeye salmon were observed in the Lake Andrew watershed. Kokanee are well established in the watershed as evidenced by high catch rates with experimental gill nets in Lake Andrew and observations of spawners in five tributary streams. Conversely, anadromous fish are poorly established in the watershed with only five anadromous spawners observed in Nurse Creek during 1994. This watershed is capable of supporting a larger run of sockeye salmon but is probably limited because of accessibility. Access to this watershed is blocked during some years by debris which accumulates in the channel connecting the lake to the ocean (U.S. Fish and Wildlife Service, unpublished data). The Adak Naval Station periodically removes debris from the outlet when water levels in Lake Andrew start flooding the road that skirts the lake.

Kokanee in Lake Andrew ranged from 153 to 210 mm in length and were 2 to 4 years of age. The absence of older fish in our collections and the observed sexual maturity of all fish examined suggest that many fish in these age groups comprised the spawning runs that were observed in Lake Andrew tributary streams. Scott and Crossman (1973) indicate that kokanee generally mature, spawn, and die at 4 years of age, but that fish age 2-4 may be in the spawning run. Spawners typically range from 180 to 300 mm although kokanee over 400 mm have been reported (Burgner 1991). Simpson and Wallace (1978) report similar ages and lengths at maturity, but indicate that maturity may occur at an older age in environments which have a poor food supply. The absence of older age groups in the Lake Andrew population may indicate that food is not a factor limiting their size.

Pink salmon were the most widely distributed salmon species on Adak Island. They were present in varying levels of abundance in nearly

every stream accessible to anadromous fish. One possible explanation for this widespread distribution is the homing behavior of this species. Pink salmon are less certain of their homing than other Pacific salmon. Heard (1991) indicated that homing precision in pink salmon is pronounced, but that a low level of straying occurs, especially when the natal stream is in close proximity to others. This type of homing behavior could result in a widespread distribution of pink salmon and is ideally suited to the Aleutian Islands where winter storms sometimes block passage to anadromous fish streams forcing fish to spawn in nearby streams.

Pink salmon escapements observed during 1994 were much higher than those observed in 1993. This even-year abundance of pink salmon is characteristic of many Alaska regions including most streams on Kodiak, Cook Inlet, Bristol Bay, and other Aleutian Islands (McLean et al 1977; Holmes 1982).

The largest pink salmon escapements on Adak Island during 1994 were observed in Finger Creek followed by Gannet, Little Thumb, and Shagak 6 creeks. Peak counts in these streams ranged from 20,590 to 45,400 fish. Although these peak counts were substantially higher than peak counts observed during 1993, they are much lower than peak counts observed in 1982 by Holmes (1982). Aerial counts of these streams conducted from a helicopter in 1982 ranged from 44,000 to 100,000 fish. These peak counts are about twice those observed in 1994 suggesting that the return in 1982 was exceptionally large or that discrepancies exist between aerial and ground survey techniques.

The AUC spawner abundance model used to estimate total escapement of pink salmon may have introduced bias into the estimates. The majority (75%) of escapement estimates in this study were derived using counts from three or four surveys. These survey frequencies are considered a minimum for obtaining an escapement estimate. Performance of the AUC model improves (increased accuracy of escapement estimates) as survey frequency increases. Additional surveys would have yielded more accurate estimates, but were not within the scope of this investigation. In addition, stream life of pink salmon can vary in different locations. It is possible that the 15 day value used in this study did not accurately represent stream life for pink salmon in Adak Island streams, thereby introducing some bias.

Coho salmon were widely distributed on Adak Island with adults or juveniles observed in 38 different streams. Juvenile coho salmon were captured in 34 streams compared to adults which were observed in only 16 streams. Adult coho salmon probably returned to most of the streams that supported juveniles but were not observed due to the late run timing of this species.

Escapements of coho salmon observed during 1994 were generally higher than those observed in 1993. Peak counts observed in NavFac and Sweeper creeks during 1994 were substantially higher than peak counts in 1993. Conversely, the peak count in Little Thumb Creek during 1994 was several times lower than the peak observed in 1993. It is difficult to fully

explain these annual differences in run strength based on available information. However, one possible explanation for NavFac Creek is the amount of angler effort that occurred each year. More angler effort was observed on NavFac Creek during 1993 (prior to military downsizing) than in 1994 (J. Meehan, Alaska Maritime National Wildlife Refuge, personal communication). Reduced angler effort during 1994 probably resulted in fewer fish harvested and a larger escapement.

Although no anadromous coho salmon were observed in tributaries to Lake Andrew, the occurrence of residuals in the lake and juveniles in Nurse Creek suggests that anadromous fish occasionally spawn in this watershed. Morrow (1980) reports that residual coho become sexually mature but never spawn. Hence, all residuals in Lake Andrew and juveniles in Nurse Creek are the offspring of anadromous parents. Like sockeye salmon, the coho salmon population in this watershed is probably limited because of accessibility. Poor or no recruitment to the population occurs during years when the outlet stream is blocked with debris. Debris accumulation in the outlet may also interfere with the smolt migration during some years, resulting in a higher level of residualism.

Dolly Varden were widely distributed on Adak Island, however, it was difficult to estimate their level of abundance. Visual counts of Dolly Varden were considered highly variable due to the small size and quick movements of this species. Enumeration was particularly difficult in streams supporting large numbers of salmon. When large numbers of salmon were present, observers concentrated on obtaining accurate counts of salmon and often overlooked or could not see these smaller fish.

Rainbow trout which were found in Shagak 3 and Shagak 4 creeks probably originated from fish stocked higher in the watershed 25-45 years ago. The military stocked rainbow trout in a number of lakes on the Naval Station from 1948-1968. Some of the rainbow trout stocked in one of the lakes in the upper Shagak 4 watershed apparently emigrated to the lower watershed and have established a small self-sustaining population. Rainbow trout found in Shagak 3 Creek probably originated from the Shagak 4 population. Both streams enter Shagak Bay in close proximity to each other.

Recommendations

This survey serves as a baseline inventory of anadromous fishery resources on Adak Island. The migration timing and relative magnitude of escapements were documented during odd and even-numbered years for the majority of streams on the island. To determine the relative strength of salmon returns in future years and monitor population trends, escapements of sockeye, pink, and coho salmon should be monitored annually in at least one stream. Two or three survey counts during the peak spawning period for a given species would provide an index of run strength and alert managers to potential threats to the resource.

We observed an abundance of kokanee in Lake Andrew that ranged from 153-210 mm in length. Despite their small size, these fish attract some angler effort throughout the year. Currently, the harvest limit for kokanee on Adak Island is the same as for salmon--five fish per day and five in possession. We would support an increase in harvest limits to 10 fish per day and 10 in possession. This is the harvest limit that is currently in place for most other lakes in Alaska that support kokanee populations. Even with more liberal harvest limits, we would expect a future decrease in total effort and harvest in this fishery because of reduced numbers of military personnel stationed on Adak Island.

Escapements of anadromous fish into the Lake Andrew watershed appear to be limited during some years by debris which accumulates in the channel connecting the lake to the ocean. Currently, the U.S. Navy removes debris from the outlet channel when water levels in Lake Andrew begin to flood the road that skirts the lake. This watershed has the potential to produce larger returns of sockeye, coho, and pink salmon if debris was removed from the channel on an annual basis. Debris removal scheduled in the spring of each year would provide better passage to both outmigrating smolts and to adults returning later in the summer and fall. Better access to the ocean could also cause some of the kokanee in the lake to revert back to anadromy, thereby reducing the size of the kokanee population. If an annual debris removal program is established, sport fish populations in the watershed need to be monitored to fully evaluate this habitat enhancement program.

Finger Creek supports the largest return of pink salmon on Adak Island. This large return of fish coupled with easy access to this stream results in the most popular sport fishery on the island. Many of the anglers which participate in this fishery have little or no experience fishing for pink salmon. These anglers and others could benefit from a bulletin board or kiosk at the parking area which provides sport fishing information and regulations.

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APPENDIX 1.—Location of streams surveyed and barriers to migration on Adak Island.

Stream	Coordinates of stream mouth		Coordinates of upstream barrier		Distance to barrier (km)[1]
	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)	
Range	51°57.23′	176°34.22′	51°57.41′	176°34.26′	0.4
Transpo	51°56.95′	176°34.78′	51°56.97′	176°34.87′	0.1
CDAA	51°56.71′	176°35.22′	51°56.74′	176°35.32′	0.1
Shotgun	51°56.20′	176°35.56′	51°56.22′	176°35.59′	0.1
NoName	51°55.89′	176°35.37′	51°55.34′	176°35.92′	2.3
NavFac	51°53.98′	176°37.34′	51°54.29′	176°39.13′	3.0
Airport	51°53.45′	176°37.56′	51°53.77′	176°38.60′	1.6
Sweeper	51°52.65′	176°39.02′	51°52.58′	176°39.86′	2.7
Amulet	51°52.31′	176°39.17′	51°51.97′	176°39.89′	1.1
Basin	51°51.18′	176°39.40′	51°51.50′	176°39.73′	0.8
Mitt	51°51.07′	176°39.02′	51°50.81′	176°39.39′	0.8
Leone	51°51.00′	176°38.33′	51°50.93′	176°38.33′	0.2
Finger	51°49.72′	176°37.99′	51°49.51′	176°38.17′	0.7
Little Thumb	51°50.13′	176°35.55′	51°49.29′	176°35.80′	2.2
Thumb	51°49.49′	176°34.77′	51°49.32′	176°34.77′	0.6
West Scabbard	51°48.97′	176°30.59′	51°48.96′	176°30.78′	0.1
Right Scabbard	51°48.80′	176°30.30′	51°48.60′	176°30.27′	0.8
Left Scabbard	51°48.80′	176°30.30′	51°48.51′	176°29.72′	1.0
NE Scabbard	51°50.68′	176°30.38′	51°50.51′	176°30.29′	0.8
North Kagalaska	51°49.12′	176°25.89′	51°49.29′	176°26.18′	0.8
South Kagalaska	51°48.12′	176°26.00′	51°48.32′	176°27.11′	1.4
Boot 1	51°45.84′	176°30.57′	51°46.24′	176°30.48′	0.8
Boot 2	51°45.31′	176°31.07′	51°45.38′	176°31.15′	0.1
Boot 3	51°44.77′	176°31.90′	51°44.59′	176°31.80′	0.2
Camel	51°42.90′	176°36.38′	51°43.39′	176°36.38′	1.0
Hidden	51°42.82′	176°39.02′	51°44.00′	176°38.64′[2]	2.4
South Teardrop	51°44.74′	176°37.72′	51°44.60′	176°37.35′	0.7
North Teardrop	51°45.08′	176°37.61′	51°45.24′	176°36.91′	1.1
Right Cabin	51°42.72′	176°40.00′	51°42.77′	176°40.17′	0.1
Left Cabin	51°42.68′	176°40.28′	51°42.85′	176°40.96′	0.8
Beyer	51°41.06′	176°43.26′	51°41.08′	176°43.19′	0.1
Sabrina	51°41.65′	176°49.13′	51°41.60′	176°49.07′	0.2
Right Hatchet	51°43.42′	176°49.04′	51°43.32′	176°48.97′	0.3
Left Hatchet	51°43.39′	176°49.02′	51°43.61′	176°48.91′	0.4
Yakak	51°40.62′	176°57.08′	51°40.53′	176°56.74′	0.7

APPENDIX 1.—Continued.

Stream	Coordinates of stream mouth		Coordinates of upstream barrier		Distance to barrier (km)[1]
	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)	
Middle Arm	51°45.14′	176°50.74′	51°45.35′	176°49.96′	0.7
South North Arm	51°46.20′	176°49.36′	51°46.08′	176°49.30′	0.3
East North Arm	51°46.32′	176°49.20′	51°46.37′	176°48.57′	0.6
Caribou	51°47.72′	176°54.32′	51°47.55′	176°52.46′	3.3
Unalga	51°46.84′	176°48.45′	51°46.81′	176°48.11′	0.3
Gannet	51°47.45′	176°42.23′	51°47.29′	176°41.41′	1.0
Constance	51°47.94′	176°43.55′	51°47.81′	176°42.26′[3]	1.8
Amelia	51°49.51′	176°46.44′	51°49.34′	176°46.09′	0.5
Shagak 1	51°51.12′	176°44.22′	51°51.10′	176°44.18′	0.2
Shagak 2	51°51.04′	176°43.61′	51°50.92′	176°43.50′	0.3
Shagak 3	51°50.96′	176°42.73′	51°50.86′	176°42.71′	0.2
Shagak 4	51°50.97′	176°42.69′	51°51.01′	176°42.49′	0.3
Shagak 5	51°51.66′	176°43.36′	51°51.78′	176°43.03′	0.4
Shagak 6	51°52.36′	176°43.77′	51°52.77′	176°41.87′	3.4
Shagak 7	51°52.60′	176°43.97′	51°53.10′	176°42.87′	2.3
VW	51°56.43′	176°39.67′	51°56.27′	176°39.69′	0.4
Moffett	51°56.24′	176°39.10′	Unknown[4]		
Nurse	51°55.51′	176°38.59′	51°55.43′	176°39.03′	0.8
Jean	51°54.86′	176°38.11′	51°54.75′	176°38.08′	0.6
East	51°56.93′	176°36.72′	51°56.94′	176°36.60′	0.1
Park	51°57.12′	176°36.82′	51°57.21′	176°36.77′	0.1
Adagdak	51°58.74′	176°37.30′	51°58.50′	176°36.76′	0.3

[1] Estimated distance from stream mouth to migration barrier.
[2] Migration barrier to all species except sockeye salmon. Barriers to sockeye salmon located on North and South Teardrop creeks.
[3] Migration barrier to all species except pink salmon. Barrier to pink salmon located approximately 100 m from stream mouth.
[4] Migration barrier on Moffett Creek located in a restricted entry zone.

APPENDIX 2.—Number of live salmon and Dolly Varden counted during foot surveys of streams on Adak Island, 1993 and 1994.

		Species				
Stream	Date	Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
		1993				
Range	16-Aug	0	0	0	0	0
Range	07-Sep	0	0	0	0	5
Transpo	16-Aug	4	0	0	0	15
Transpo	07-Sep	215	0	0	0	15
CDAA	16-Aug	0	0	0	0	5
CDAA	07-Sep	0	0	0	0	15
Shotgun	16-Aug	75	0	0	0	10
Shotgun	07-Sep	185	0	0	0	10
NoName	16-Aug	43	0	0	0	0
NoName	07-Sep	225	1	0	1	0
NavFac	15-Aug	42	0	0	0	0
NavFac	07-Sep	380	8	0	0	100
NavFac	15-Oct	0	8	0	0	0
NavFac	29-Oct	0	10	0	0	0
NavFac	19-Nov	0	2	0	0	0
Airport	19-Aug	8	0	0	0	0
Airport	13-Sep	231	0	0	0	25
Sweeper	17-Aug	7	0	0	0	40
Sweeper	11-Sep	70	1	0	0	35
Sweeper	13-Oct	0	17	0	0	0
Sweeper	28-Oct	0	17	0	0	0
Sweeper	19-Nov	0	3	0	0	0
Amulet	17-Aug	0	0	0	0	10
Amulet	11-Sep	1	0	0	0	40
Amulet	13-Oct	0	11	0	0	0
Amulet	28-Oct	0	10	0	0	0
Amulet	19-Nov	0	1	0	0	0
Mitt	02-Aug	0	1	0	0	0
Mitt	16-Aug	0	0	0	0	20
Mitt	08-Sep	0	0	2	0	30
Mitt	13-Oct	0	3	0	0	0
Mitt	27-Oct	0	0	0	0	0
Mitt	12-Nov	0	3	0	0	0
Leone	16-Aug	0	0	0	0	10
Leone	11-Sep	17	0	0	0	10
Finger	15-Aug	2,050	0	0	1	0
Finger	21-Aug	4,300	0	2	0	0
Finger	27-Aug	7,400	0	0	0	0
Finger	07-Sep	14,500	0	1	5	0
Finger	11-Sep	10,800	1	2	6	0
Finger	22-Sep	1,377	30	8	1	0
Finger	15-Oct	1	21	3	0	0
Finger	29-Oct	0	9	0	0	0
Finger	19-Nov	0	2	0	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
Little Thumb	18-Aug	530	0	0	0	0
Little Thumb	01-Sep	2,050	0	2	0	0
Little Thumb	15-Sep	2,025	65	4	6	0
Little Thumb	27-Sep	370	77	3	1	5
Little Thumb	18-Oct	0	44	0	0	0
Little Thumb	04-Nov	0	11	0	0	0
Little Thumb	18-Nov	0	0	0	0	0
Thumb	19-Aug	45	0	0	0	0
Thumb	15-Sep	355	0	0	0	0
West Scabbard	19-Aug	0	0	0	0	0
West Scabbard	15-Sep	0	0	0	0	0
Right Scabbard	19-Aug	5	0	0	0	0
Right Scabbard	15-Sep	117	0	0	0	0
Left Scabbard	19-Aug	125	0	0	0	0
Left Scabbard	15-Sep	835	0	0	1	0
North Kagalaska	18-Aug	0	0	0	0	0
North Kagalaska	08-Sep	1	0	0	0	10
South Kagalaska	18-Aug	0	0	0	0	0
South Kagalaska	08-Sep	1	0	0	0	5
Boot 1	23-Aug	15	0	0	0	25
Boot 1	16-Sep	8	0	0	0	20
Boot 2	23-Aug	0	0	0	0	12
Boot 2	16-Sep	14	0	0	0	10
Boot 3	23-Aug	550	0	55	0	0
Boot 3	16-Sep	158	20	35	2	0
Camel	23-Aug	2	0	0	0	30
Camel	16-Sep	0	0	0	0	20
Hidden	08-Jul	0	0	250	0	0
Hidden	24-Aug	1,200	0	3,200	0	0
Hidden	16-Sep	1,125	12	1,040	1	10
South Teardrop	24-Aug	0	0	330	0	0
South Teardrop	16-Sep	0	0	286	0	20
North Teardrop	24-Aug	0	0	500	0	0
North Teardrop	16-Sep	0	0	645	0	5
Right Cabin	31-Aug	0	0	4	0	0
Right Cabin	17-Sep	0	0	0	0	0
Left Cabin	31-Aug	15	0	50	0	0
Left Cabin	17-Sep	2	0	40	0	0
Beyer	31-Aug	85	0	0	0	10
Beyer	20-Sep	12	0	0	0	0
Sabrina	31-Aug	45	0	0	0	15
Sabrina	20-Sep	12	5	0	0	5
Right Hatchet	31-Aug	115	0	0	0	5
Right Hatchet	20-Sep	5	0	0	0	0
Left Hatchet	31-Aug	715	0	0	6	0
Left Hatchet	20-Sep	110	0	0	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
Middle Arm	02-Sep	500	0	0	1	0
Middle Arm	21-Sep	37	0	0	0	0
South North Arm	02-Sep	0	0	0	0	0
South North Arm	21-Sep	0	0	0	0	0
East North Arm	02-Sep	178	0	0	0	0
East North Arm	21-Sep	15	0	0	0	25
Caribou	02-Sep	215	1	2	0	100
Caribou	21-Sep	46	6	0	0	50
Unalga	02-Sep	59	0	0	0	10
Unalga	21-Sep	23	0	0	0	15
Gannet	02-Sep	13,600	0	20	1	50
Gannet	23-Sep	1,175	35	10	2	150
Gannet	31-Oct	0	20	0	0	0
Constance	19-Jul	0	0	15	0	0
Constance	02-Sep	30	0	98	0	300
Constance	24-Sep	0	15	1	0	100
Amelia	02-Sep	273	0	0	0	20
Amelia	21-Sep	52	0	0	0	0
Shagak 1	20-Aug	11	0	0	0	150
Shagak 1	26-Sep	0	0	0	0	60
Shagak 2	20-Aug	1	0	0	0	0
Shagak 2	26-Sep	0	0	0	0	0
Shagak 3	20-Aug	0	0	0	0	0
Shagak 3	26-Sep	6	0	0	0	0
Shagak 4	20-Aug	165	0	0	0	0
Shagak 4	26-Sep	36	0	0	0	0
Shagak 5	30-Aug	145	0	0	0	15
Shagak 5	14-Sep	125	0	0	0	25
Shagak 6	17-Aug	1,325	0	0	0	70
Shagak 6	29-Aug	3,775	0	0	0	75
Shagak 6	14-Sep	3,200	25	0	0	45
Shagak 6	26-Sep	272	4	0	0	30
Shagak 6	25-Oct	0	12	0	0	0
Shagak 6	19-Nov	0	8	0	0	0
Shagak 7	17-Aug	85	0	0	0	0
Shagak 7	29-Aug	580	0	0	0	5
Shagak 7	14-Sep	370	0	0	0	5
Shagak 7	26-Sep	56	0	0	0	45
Adagdak	16-Aug	0	0	0	0	10
Adagdak	13-Sep	0	0	0	0	20
		1994				
Range	11-Aug	0	0	0	0	0
Range	22-Aug	2	0	0	0	0
Range	10-Sep	43	0	0	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
Range	22-Sep	0	0	0	0	0
Transpo	11-Aug	0	0	0	0	15
Transpo	22-Aug	123	0	0	0	0
Transpo	10-Sep	229	0	0	0	0
Transpo	22-Sep	128	0	0	0	0
CDAA	11-Aug	0	0	0	0	0
CDAA	22-Aug	0	0	0	0	0
CDAA	10-Sep	40	0	0	0	0
CDAA	22-Sep	12	0	0	0	0
Shotgun	11-Aug	0	0	0	0	50
Shotgun	22-Aug	60	0	0	0	0
Shotgun	10-Sep	710	0	0	0	0
Shotgun	22-Sep	478	0	0	0	0
NoName	11-Aug	10	0	0	0	0
NoName	22-Aug	312	0	0	0	0
NoName	12-Sep	1,260	0	0	0	0
NoName	21-Sep	355	7	0	0	0
NavFac	11-Aug	315	0	0	0	20
NavFac	03-Sep	5,590	16	0	0	0
NavFac	14-Sep	3,550	79	0	0	0
NavFac	21-Sep	1,487	89	0	0	0
NavFac	14-Oct	25	119	0	0	0
NavFac	29-Oct	0	56	0	0	0
NavFac	12-Nov	0	13	0	0	0
Airport	12-Aug	733	0	0	0	40
Airport	27-Aug	1,727	0	0	0	0
Airport	12-Sep	1,389	0	0	0	80
Airport	21-Sep	406	0	0	0	100
Sweeper	12-Aug	61	0	0	0	50
Sweeper	03-Sep	1,910	0	0	0	0
Sweeper	14-Sep	1,302	2	0	0	0
Sweeper	21-Sep	644	3	0	0	0
Sweeper	06-Oct	40	8	0	0	0
Sweeper	14-Oct	6	19	0	0	0
Sweeper	29-Oct	0	48	0	0	0
Sweeper	11-Nov	0	81	0	0	0
Sweeper	27-Nov	0	29	0	0	0
Amulet	12-Aug	0	0	0	0	0
Amulet	03-Sep	204	0	0	0	0
Amulet	14-Sep	228	0	0	0	0
Amulet	21-Sep	96	0	0	0	0
Amulet	06-Oct	7	0	0	0	0
Amulet	14-Oct	0	0	0	0	0
Amulet	29-Oct	0	0	0	0	0
Basin	09-Sep	1,032	0	0	0	0
Basin	20-Sep	46	0	0	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
Mitt	12-Aug	0	0	0	0	0
Mitt	22-Aug	0	0	0	0	0
Mitt	03-Sep	6	2	0	0	0
Mitt	23-Sep	30	4	0	0	0
Leone	12-Aug	9	0	0	0	0
Leone	03-Sep	910	0	0	0	0
Leone	15-Sep	629	0	0	0	0
Finger	04-Aug	150	0	2	0	40
Finger	11-Aug	11,700	0	2	0	10
Finger	20-Aug	39,300	0	1	1	0
Finger	28-Aug	45,400	0	0	0	0
Finger	03-Sep	35,100	0	0	0	0
Finger	11-Sep	25,700	0	0	0	0
Finger	17-Sep	21,800	0	0	0	0
Finger	23-Sep	13,730	49	0	0	0
Finger	03-Oct	7,600	39	0	0	0
Finger	13-Oct	590	26	0	0	0
Finger	29-Oct	0	49	0	0	0
Finger	11-Nov	0	7	0	0	0
Little Thumb	06-Aug	1,050	0	3	0	0
Little Thumb	17-Aug	20,000	0	1	0	0
Little Thumb	28-Aug	33,400	0	0	0	0
Little Thumb	08-Sep	16,750	15	0	0	0
Little Thumb	16-Sep	12,320	0	2	0	0
Little Thumb	07-Oct	615	1	0	0	0
Little Thumb	20-Oct	3	0	0	0	0
Little Thumb	11-Nov	0	0	0	0	0
Thumb	06-Aug	275	0	1	0	0
Thumb	17-Aug	1,670	0	0	0	0
Thumb	28-Aug	2,843	0	0	0	0
Thumb	08-Sep	3,682	0	0	0	0
Thumb	16-Sep	2,290	0	0	0	0
West Scabbard	06-Aug	0	0	0	0	0
West Scabbard	28-Aug	280	0	0	0	0
West Scabbard	08-Sep	410	1	0	0	0
West Scabbard	22-Sep	90	0	0	0	0
Right Scabbard	06-Aug	0	0	0	0	0
Right Scabbard	28-Aug	945	0	0	0	0
Right Scabbard	08-Sep	1,250	0	0	0	0
Right Scabbard	22-Sep	620	0	0	0	0
Left Scabbard	06-Aug	335	0	0	0	0
Left Scabbard	28-Aug	2,390	0	0	0	0
Left Scabbard	08-Sep	3,130	0	0	0	0
Left Scabbard	22-Sep	910	0	0	0	0
NE Scabbard	28-Aug	150	0	0	0	0
NE Scabbard	08-Sep	297	0	0	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
North Kagalaska	17-Aug	2	0	0	0	10
South Kagalaska	17-Aug	148	0	0	0	0
Boot 1	02-Aug	361	0	0	0	0
Boot 1	21-Aug	1,525	0	0	0	0
Boot 1	19-Sep	548	0	1	0	0
Boot 2	02-Aug	0	0	0	0	0
Boot 2	21-Aug	65	0	0	0	10
Boot 2	19-Sep	47	0	0	0	0
Boot 3	02-Aug	450	0	0	0	0
Boot 3	21-Aug	4,200	0	0	0	0
Boot 3	19-Sep	610	3	1	15	0
Camel	21-Aug	8	0	0	0	0
Hidden	03-Aug	950	0	3,310	0	50
Hidden	26-Aug	6,270	0	2,190	0	0
South Teardrop	03-Aug	0	0	0	0	0
South Teardrop	26-Aug	0	0	121	0	0
North Teardrop	03-Aug	0	0	0	0	0
North Teardrop	26-Aug	0	0	256	0	0
Right Cabin	02-Aug	0	0	0	0	0
Right Cabin	26-Aug	18	0	0	0	0
Left Cabin	02-Aug	0	0	0	0	0
Left Cabin	26-Aug	70	0	39	0	0
Beyer	26-Aug	267	0	0	0	0
Sabrina	03-Aug	0	0	0	0	0
Sabrina	21-Aug	71	0	0	0	0
Sabrina	19-Sep	121	2	0	0	0
Right Hatchet	03-Aug	0	0	0	0	0
Right Hatchet	21-Aug	371	0	0	0	0
Right Hatchet	19-Sep	170	0	0	0	0
Left Hatchet	03-Aug	50	0	0	0	0
Left Hatchet	21-Aug	1,375	0	0	1	0
Left Hatchet	19-Sep	1,080	0	0	0	0
Middle Arm	01-Sep	7,760	0	0	0	0
Middle Arm	18-Sep	780	0	0	0	0
South North Arm	09-Aug	0	0	0	0	0
South North Arm	01-Sep	0	0	0	0	0
South North Arm	18-Sep	0	0	0	0	0
East North Arm	09-Aug	223	0	0	0	0
East North Arm	01-Sep	2,450	0	0	0	0
East North Arm	18-Sep	663	0	0	0	0
Caribou	01-Sep	3,235	2	1	0	0
Caribou	18-Sep	1,130	15	0	0	0
Unalga	09-Aug	148	0	0	0	0
Unalga	01-Sep	1,530	0	0	0	0
Unalga	18-Sep	640	0	0	0	0
Gannet	05-Aug	10,700	0	4	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
Gannet	18-Aug	25,100	0	2	6	0
Gannet	01-Sep	26,200	0	2	0	0
Gannet	18-Sep	9,180	77	0	0	0
Gannet	12-Oct	132	29	0	0	0
Constance	05-Aug	30	0	356	0	150
Constance	02-Sep	3,500	12	253	0	265
Constance	18-Sep	350	12	24	0	150
Amelia	09-Aug	340	0	0	0	0
Amelia	01-Sep	4,510	0	0	0	0
Amelia	18-Sep	5,860	0	0	0	0
Shagak 1	13-Aug	35	0	0	0	0
Shagak 1	24-Aug	165	0	0	0	0
Shagak 1	20-Sep	174	0	0	0	0
Shagak 2	13-Aug	0	0	0	0	0
Shagak 2	24-Aug	142	0	0	0	0
Shagak 2	20-Sep	490	0	0	0	0
Shagak 3	13-Aug	1	0	0	0	0
Shagak 3	24-Aug	278	0	0	0	0
Shagak 3	09-Sep	1,600	0	0	0	0
Shagak 3	20-Sep	1,100	0	0	0	0
Shagak 4	13-Aug	290	0	0	0	0
Shagak 4	24-Aug	5,190	0	0	0	0
Shagak 4	09-Sep	7,500	0	0	0	0
Shagak 4	20-Sep	3,870	1	0	0	0
Shagak 5	13-Aug	120	0	0	0	0
Shagak 5	24-Aug	1,450	0	0	0	0
Shagak 6	04-Aug	514	0	0	0	300
Shagak 6	20-Aug	17,100	0	1	1	0
Shagak 6	31-Aug	19,550	0	0	0	0
Shagak 6	09-Sep	20,590	0	0	0	0
Shagak 6	20-Sep	6,520	0	0	0	0
Shagak 7	04-Aug	16	0	0	0	150
Shagak 7	20-Aug	9,325	0	0	1	0
Shagak 7	31-Aug	10,660	0	0	0	0
Shagak 7	09-Sep	4,780	0	0	0	0
Shagak 7	20-Sep	1,640	0	0	0	0
VW	23-Aug	0	0	0	0	0
VW	12-Sep	24	0	72[2]	0	0
VW	21-Sep	16	0	85[2]	0	0
Moffett	23-Aug	70	0	0	0	0
Moffett	12-Sep	628	0	275[2]	0	0
Moffett	21-Sep	526	0	81[2]	0	0
Nurse	22-Aug	52	0	0	0	0
Nurse	12-Sep	433	0	608[3]	0	0
Nurse	21-Sep	241	0	659[4]	0	0
Nurse	29-Oct	0	0	12[2]	0	0

APPENDIX 2.—Continued.

Stream	Date	Species				
		Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Dolly Varden[1]
Jean	14-Sep	0	0	143[2]	0	0
Jean	21-Sep	0	0	256[2]	0	10
East	22-Aug	0	0	0	0	0
East	12-Sep	0	0	47[2]	0	0
East	21-Sep	0	0	67[2]	0	0
Park	22-Aug	0	0	0	0	0
Park	12-Sep	3	0	0	0	0
Park	21-Sep	1	0	0	0	0
Adagdak	10-Sep	0	0	0	0	0

[1] Counts of Dolly Varden are estimates of fish larger than 300 mm fork length.
[2] Kokanee.
[3] Five of these fish were large anadromous spawners.
[4] Four of these fish were large anadromous spawners.

APPENDIX 3.—Water quality characteristics from various streams and Lake Andrew on Adak Island, 1993.

Stream/lake	Date	Water temperature (°C)	pH	Conductivity (μmho)	Total hardness (mg $CaCo_3$/L)	Alkalinity (mg $CaCo_3$/L)
Range	01-Jul	7.5	7.4	125	50	40
Transpo	02-Jul	6.2	7.2	140	52	53
Transpo	16-Aug	9.0	7.0	110	60	55
Transpo	22-Sep	9.5	7.1	130	5	46
CDAA	02-Jul	9.2	7.1	152	60	68
Shotgun	02-Jul	10.0	7.2	109	42	63
NoName	02-Jul	8.0	7.4	132	44	54
NavFac	01-Jul	6.2	6.8	49	18	10
NavFac	15-Aug	13.0	6.9	50	19	13
NavFac	22-Sep	9.0	6.9	69	21	16
Airport	01-Jul	5.0	6.8	33	10	10
Sweeper	03-Aug	12.0	6.9	102	46	40
Amulet	03-Aug	13.0	7.2	107	41	44
Mitt	02-Aug	16.0	7.1	152	67	36
Leone	02-Aug	16.0	7.2	92	36	25
Finger	23-Jul	9.0	7.0	60	28	24
Finger	08-Aug	13.0	6.9	52	20	19
Finger	22-Sep	11.0	7.0	53	25	23
Little Thumb	12-Jul	9.0	7.0	52	27	17
Thumb	12-Jul	7.5	6.8	45	19	12
West Scabbard	05-Jul	8.8	7.1	70	34	21
Right Scabbard	05-Jul	9.6	7.1	69	33	31
Left Scabbard	05-Jul	9.0	7.3	73	46	35
North Kagalaska	12-Jul	10.0	6.3	48	13	20
South Kagalaska	26-Jul	12.0	6.5	40	12	5
Boot 1	23-Jul	14.0	6.9	59	17	15
Boot 2	23-Jul	15.0	7.0	70	24	21
Boot 3	23-Jul	14.0	6.9	59	15	8
Camel	07-Jul	6.0	7.0	88	19	9
Hidden	08-Jul	10.5	7.1	47	17	11
Cabin[1]	07-Jul	10.0	6.9	45	14	9
Beyer	07-Jul	8.8	6.6	37	8	4
Sabrina	24-Jul	14.0	6.8	52	14	11
Right Hatchet	24-Jul	17.0	7.0	69	18	20
Left Hatchet	24-Jul	14.0	6.9	52	15	10
Yakak	30-Jul	8.0	7.2	129	44	36
Middle Arm	21-Jul	11.0	6.7	51	14	4
South North Arm	21-Jul	10.0	7.0	80	30	27
East North Arm	21-Jul	9.0	6.7	82	32	27
Caribou	14-Jul	11.5	7.1	135	74	59
Unalga	19-Jul	10.0	7.0	100	20	7
Gannet	19-Jul	9.0	6.8	75	14	9
Constance	19-Jul	10.0	7.0	83	32	36
Amelia	28-Jul	12.0	7.2	62	38	30
Shagak 1	20-Jul	8.0	7.1	118	53	60
Shagak 2	20-Jul	8.0	7.1	78	38	28

APPENDIX 3.—Continued.

Stream/lake	Date	Water temperature (°C)	pH	Conductivity (µmho)	Total hardness (mg $CaCo_3$/L)	Alkalinity (mg $CaCo_3$/L)
Shagak 3	20-Jul	8.0	7.1	109	34	48
Shagak 4	20-Jul	10.0	7.0	138	36	24
Shagak 5	20-Jul	10.0	7.1	187	48	51
Shagak 6	20-Jul	8.0	6.9	271	28	25
Shagak 7	20-Jul	8.0	6.7	310	17	28
Lake Andrew	04-Jul	9.0	7.0	82	31	15
Lake Andrew	03-Aug	10.8	7.0	95	33	13
Moffett	05-Jul	4.0	6.7	59	29	9
Moffett	15-Aug	11.0	6.8	74	31	11
Moffett	22-Sep	8.0	6.8	90	41	9
Nurse	05-Jul	6.0	6.9	51	23	32
Adagdak	31-Jul	12.0	7.3	175	55	43

[1] Measurements taken below the confluence of Right and Left Cabin creeks.