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ALASKA SALMON RESEARCH

D. ROGERS, T. QUINN, AND B. ROGERS

ANNUAL REPORT—1998

TO

BRISTOL BAY PROCESSORS

ACKNOWLEDGMENTS

The contributions of graduate students to our program are important. Doug Peterson completed his Master's thesis in 1998 and Sayre Hodgson began her thesis research on sockeye salmon run timing. Other University of Washington students working on the program in 1998 were Jennifer Bahrke, Chris Boatright, Greg Buck, Richard Brocksmith, Jeremy Brower, Allison Cardwell, Brandon Chasco, and Michael Morris. Ryan Steen was hired as a new fisheries biologist and Luke Woodward, Jesse Rogers, and Mathias Cunningham assisted Tom Rogers (staff maintenance) in spring camp work. Dan Gray (ADF&G) provided preliminary length and weight statistics for 1998.

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KEY WORDS

Bristol Bay, escapements, forecasts, growth, Kvichak, Nushagak predation, spawning, sockeye salmon, Wood River Lakes

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INTRODUCTION

Fisheries Research Institute (FRI) was established in 1946 with the financial support of the major Alaska salmon (*Oncorhynchus* spp.) processors to investigate the causes of the declines in production that had occurred in most stocks since the 1930s, work with the government management agency to increase our knowledge of the biology of salmon and the effects of the fisheries on the stocks, and assist salmon processors by providing a second opinion on matters of salmon fisheries management. With the high levels of production since the 1980s, our primary objectives now are to determine how to maintain the high production (i.e., understand what has caused year-to-year variation) and provide information so that the salmon can be harvested and processed most efficiently (e.g., accurately forecast the run and facilitate even distribution of fishing throughout the run).

We presently have salmon research projects in Bristol Bay, Alaska Peninsula, and Chignik that are funded in part or entirely by the industry. In addition, we have a federally funded high-seas salmon project that was focused on the oceanic distribution of salmon and the vulnerability of North American stocks to foreign fisheries, but is now focusing on ocean carrying capacity for salmon. In recent years we have also worked in Kodiak, Southeast Alaska, and on the Yukon stocks. All of these projects have been carried out in cooperation with the Alaska Department of Fish and Game (ADFG) or the National Marine Fisheries Service (high seas), and we have also had cooperative research projects with salmon biologists from Japan and Russia.

This report is focused on our 1998 Bristol Bay research with emphasis on salmon forecasting and research relevant to escapement policies for maximizing production. Our Alaska Peninsula annual report will be completed in February and our Chignik report will be submitted in March.

FORECASTING

Preseason Forecasts

Forecasts of the 1999 Bristol Bay sockeye salmon (*O.*

nerka) runs and catches were provided to participating processors at our November 1998 meeting (Rogers 1998a). They are presented in Table 1 with the ADFG forecasts and the past forecasts and runs beginning in 1989. The two river system forecasts (FRI and ADFG) are based on the same data sources but different analytical methods have often been used. For the 1999 forecast, ADF&G changed the statistical data set (years) that was used in recent forecasts and this greatly reduced their forecast for 1999 (Hart and Geiger 1999). We made alternate forecasts for the 1999 run based on 1) recent trends in relative production and 2) the assumption that low marine survival for the 1997 and 1998 runs will occur in 1999. Both 1998 forecasts were for a large run and catch, and the actual run (18 million) and catch (10 million) were much smaller than the forecasts. The outlook for 1999 is for the run and catch to be below the recent years' average but larger than the 1997 and 1998 returns. Even assuming continued poor marine survival, a 1999 run of 26 million was forecasted. The Kvichak and Egegik combined are expected to produce nearly 60% of the Bristol Bay run in 1999.

The next large run (>20 million) to the Kvichak is likely to come in 1999. Fry from the 1994 escapement of 8 million had relatively poor growth and are likely to spend 2 years in the lake and return as adults mostly in 1999 (5 years after their parents). However, fry from the 1995 escapement of 10 million had relatively good growth and the majority are likely to spend only 1 year in the lake and thus return as adults also in 1999 (4 years after their parents).

Port Moller Forecast

The Port Moller inseason test fishery was conducted by ADFG during June and early July from 1968 through 1985, with a change in gear in 1985. There was no test fishery in 1986 and, beginning in 1987, FRI has conducted the test fishery each year. The test fishery now employs a 200-f gillnet that is 60 meshes deep and has 5 1/8-in stretched mesh. The web is multistrand monofilament (center core). Since 1994, we have used the fishing vessel *Cape Cross*. Four stations have been routinely fished along a transect 33 to 63 nmi out from Port Moller (16 to 42 nmi from the

nearest coastline). An almanac that provided statistics for forecasting the run was distributed to processors prior to the season (Rogers 1998b). Beginning June 11, catch, mean length, and water temperature data were sent daily by radio to Port Moller and then faxed into Bristol Bay. Scales and length data were sent periodically to ADFG (B. Cross, King Salmon), where they were aged and the age compositions and average lengths by age were reported.

From 1987 through 1996 the forecasts were very accurate. The runs differed from the forecasts made on June 25 and 30 by an average of 20%, and we were within an average of 12% on forecasts made about July 3 (Table 2). We have not done as well in forecasting the catch because river system forecasts and thus catches cannot be made until about July 3, when we have the first indication of where the salmon are going. In 1998, the number of fish in the Bristol Bay run was only about 40% of the forecasts during June 25 to 30. An average run was forecasted but a relatively small run occurred in the bay. The runs began much later than average in the bay but was only a little later than average as the fish passed Port Moller (Fig. 1). The distribution of the sockeye salmon as they passed Port Moller was ideal in 1998, as the fish were concentrated in the middle stations (i.e., 4 and 6; Fig. 2). Weather conditions in 1998 were typical of most years (i.e., mostly overcast sky and average water temperatures), which was in sharp contrast to the clear sky and warm temperatures in 1997.

The ADFG (B. Cross, Anchorage) provided preliminary length and weight statistics for 1999, and statistics from prior years were available (e.g., Yuen et al. 1981, Stratton and Crawford 1994) from which we could calculate mean lengths in the runs (Table 3). Both the 2-ocean and 3-ocean sockeye salmon in the 1998 run were below average in length. This was very unusual for a run of only 18 million and in season led to the expectation of a larger run. Average weights in the Bristol Bay fishing districts in 1998 ranged from 4.7 lb (Nushagak) to 6.5 lb (Togiak) and were close to or below the recent years' averages (Tables 4 and 5).

The Port Moller test fishery in 1998 provided an early indication to ADFG management that an average run was on the way; however, early catches were made only at Egegik. Fishery openings in the Naknek/Kvichak and Nushagak districts were much later than normal which made it difficult to interpret the statistics from Port Moller for a forecast of the total catch. The only over-escapement occurred in the Wood River and was again mainly a result of attempts to achieve a larger escapement from a relatively weak run to the Nushagak River (Table 6).

LAKE RESEARCH

During summer 1998, we continued our long-term studies of spawner distribution, growth and abundance of fry, and the physical and biological environment for the sockeye salmon of the Wood River (Nushagak) and Kvichak lake systems. Most of our annual observations in the Wood River Lakes extend over more than 40 years and constitute the longest continuous biological and environmental record on any salmon stock in Alaska. In 1998, we also conducted special studies of bear predation on spawning sockeye salmon and a thesis was completed on the effects of spawning salmon on stream biota (Peterson 1998). In addition, we provided a crew to ADFG for their Nuyakuk escapement enumeration.

Kvichak System

Our 1998 field season in the Kvichak system (Lakes Iliamna and Clark) consisted of estimating the sockeye salmon escapement into the Newhalen River in late June and July, and conducting spawning ground surveys in late August to early September to collect otoliths for sockeye age determination. We did not totnet in 1998 because the parent escapement in 1997 was small and our budget was limited.

Newhalen River Escapement

The annual escapements of sockeye salmon to the Kvichak lake system are estimated by ADFG from expanded 10-min counts on each bank of the river near Igiugig at the outlet of Lake Iliamna. Since 1979, we have estimated escapements up the Newhalen River by expanding 20-min counts, for each of 10 daylight hours, on the northwest bank of the river at the town of Newhalen. We assume that fish use both sides of the river equally and that migration rate does not vary over the course of the day. The daily counts at Newhalen are compared with those of ADFG at Igiugig to estimate a travel time. We calculate the daily proportions of the run at Igiugig that went up the Newhalen by lagging the Newhalen counts back the appropriate number of days (1 in 1998).

The cumulative daily escapements for the two rivers, timed to the Kvichak River, are given for 1993–98 (Table 7). In mid-July, milling fish often swim upriver along the banks of the Newhalen and are counted, only to drift back down in the middle of the river and return upstream to be counted again. This behavior inflates the counts for the escapement; therefore, we have used the average propor-

tion of the Newhalen count for day 5 to day 16 (day 1 equals the first day of about 100,000 in the Kvichak) and the season's total Kvichak escapement to estimate the Newhalen/Lake Clark escapement.

In 1998, we estimated that about 1.4 million of the Kvichak escapement of 2.3 million (about 60%) migrated to the Newhalen/Lake Clark system (Table 8). The aerial surveys conducted by ADFG (Regnart 1998) provided an estimate of Newhalen spawners (4,100) and this, by subtraction, yielded an estimate of 1.37 million for the Lake Clark escapement. Both our ground surveys and the ADFG aerial surveys of the Kvichak system spawning grounds suggests that we likely over-estimated the escapement to Lake Clark although high proportions of the lake system escapement also went to Lake Clark in 1979 and 1988.

Spawning Ground Surveys

Each year since 1956, we have collected scales or otoliths from spawned-out sockeye salmon from several major spawning grounds in the Kvichak River system. In 1998, we continued this work and sampled fish from most of our historically surveyed populations. Collections in the Newhalen River were limited by low number of spawners and river conditions. We were unable to collect otoliths from the Tazimina River because there were few fish in the lower end and no dead fish at the time of the survey.

Overall, the age pattern was similar to the composition of the entire lake system (Kvichak escapement). However, age 1.3 fish were scarce in beach and creek populations but quite abundant in the Gibraltar and Copper River samples. Age 1.2 fish were most abundant in the other spawning populations and it was this age group that was most abundant in the Kvichak run in 1998 (Table 9).

We had conducted annual aerial surveys of the Kvichak spawning grounds from 1956 until 1988, after which ADFG took over the surveys. The results of the 1998 survey were reported by Regnart (1998). These are summarized for 29 selected spawning grounds (Table 10). Aerial counts accounted for 11.6% of the relatively small (tower count) escapement into the Kvichak system. This percentage is comparable to the recent years average. Most of the 2.3 million escapement in 1998 returned to the rivers in Lake Iliamna with very low numbers of spawners on the beaches.

Sockeye Fry Abundance and Size

We have sampled the sockeye fry (age 0) in the Kvichak system in August of each year since 1962 (1961 brood

year) by townetting set stations in Lakes Iliamna and Clark at night (Table 11). In 1998, we did not sample in Lake Iliamna nor Lake Clark mainly because escapements were very small in 1997 and thus we could expect very low catches in 1998. We will resume sampling in 1999.

Wood River System

The Bristol Bay research program of FRI began with spawning ground surveys in the Wood River Lakes in 1946 to determine where, when, and how many sockeye salmon spawned there. During the early 1950s, methods were established to enumerate and sample the commercial catches, escapements (towers), and the smolts produced. By the late 1950s, we had established several important measurements, which we have maintained to the present in order to characterize each year's environment for spawning adults and rearing juveniles.

Environmental Observations

Spring 1998 was again early and ice breakup in Lake Aleknagik (recorded since 1949)—9 days earlier than average (Table 12 and Fig. 3). Early summer water temperatures were only a little above average, however, as skies were mostly overcast with above normal rainfall. Solar radiation (sunlight) was at a record low for the first half of July. Lake levels were well above normal with a record high in early June as a result of a large snow pack and above average rainfall in the spring, but lake levels were below average during most of the spawning season. The environmental conditions in 1998 when adult salmon were entering the lakes during late-June and early-July were very different from the extreme conditions in 1997 (low water, clear skies, and warm temperatures). Water levels were high, skies were overcast, and temperatures were about average in 1998 (Fig. 4).

The standing crop of phytoplankton (chlorophyll) and zooplankton volumes were below average during the summer of 1998 (Fig. 5). Zooplankters are the main source of food for juvenile sockeye salmon after they move offshore in late July. In 1998, there was a general scarcity of the larger forms of zooplankton (calanoid copepods and *Holopedium*) and a preponderance of relatively small cyclopoid copepods and *Bosmina* (Fig. 6). The abundance of *Bosmina* in late August, 1998 was the highest recorded for Lake Aleknagik.

Insects (mainly pupal and adult midges) are the main source of food in the spring when the fry are inshore. There

was an early peak in midge emergence in 1998 (June 11–15) and then the usual mid-summer peak in late July to early August corresponding with the early ice breakup (Table 13). In past years, midge emergence has usually peaked in either late July or early August. Water temperatures at the nearshore insect traps in 1998 were above average for June but below average for July and August.

Fry Abundance and Growth

In 1998, the sockeye salmon fry in Lake Aleknagik were of average length in June and experienced average growth during July and August, reaching about 56 mm by September 1 (Table 14). Fry abundance as measured by beach seine sampling in June and July and townet sampling around September 1 was well below the long-term average. The high water levels may have affected the beach seine catches in early summer; however, there should have been little effect on townetting. Threespine stickleback catches were also low in 1998 whereas their lengths and growth were average. The adult sockeye salmon returns to Lake Aleknagik have generally been large since 1978 even though fry abundances have often been low. This suggests that recent large runs have been caused mainly by improved ocean survival.

The mean lengths of sockeye salmon fry in Lake Nerka indicated that, in 1998, growth was below average whereas townet catches were about average (Table 15). Juvenile sockeye salmon in the Wood River Lakes system exhibit density-dependent growth, and we are analyzing our long-term data sets to determine the relative effects of physical and biological factors in the lakes on the growth of the sockeye salmon fry. In addition, we are examining year-to-year variation in zooplankton population composition along with annual variation in sockeye salmon fry and threespine stickleback abundance to determine the extent to which the fish alter their food resources. Lake productivity tends to be higher in lakes with sockeye salmon as a result of the nutrients brought in from the sea by adults (Reischauer 1996). We hope the information from these studies will help explain the observed variability in the freshwater phase of the sockeye salmon.

Arctic Char Predation

Each spring when sockeye salmon smolt are migrating seaward from the Wood River lake system, Arctic char (*Salvelinus alpinus*) concentrate in and around the interconnecting rivers to feed on the smolt. We conducted several studies of this predation during the 1950s to 1970s, and since then, we have sampled the char in Little Togiak

River on an opportunistic basis. In 1998, we caught, measured, and examined stomach contents of 22 char during June 15–25 (Table 16). The char were above average in length and contained an average percentage of sockeye salmon smolt in their stomachs (39%).

Spawning Ground Surveys

Sockeye salmon spawning ground surveys have been conducted annually in the Wood River Lakes system since 1946; however, it was not until the early 1950s that all major spawning grounds were included. We collect otoliths from the major spawning grounds for age determination and make ground counts of the number of spawners in the small streams. The ADFG estimates the numbers of spawners on the lake beaches and in the interconnecting rivers by aerial surveys; thus, the total escapement to the lake system can be apportioned to the individual lakes or type of spawning ground (creek, river, and beach). The distribution of spawners among the lakes is used in forecasting the Wood River runs. Even escapement distributions tend to produce larger returns than uneven distributions.

Aerial surveys were conducted by ADFG in 1998. The ground survey counts in 1998 for the major creek spawning grounds are given in Table 17. The creeks draining into Lake Aleknagik again contained relatively high counts of spawners. These higher than average counts have continued each year since 1987. Age compositions on the spawning grounds in 1998 differed from the age composition of the escapement to the lake system that was sampled by ADFG in that there were higher percentages of 3-ocean fish on the spawning grounds than observed for the entire system (Table 18). Unsampled spawning grounds in the upper lakes (Beverley and Kulik) likely contained higher percentages of 2-ocean fish based on the samples from Moose Creek and Grant River.

Bear Predation

We completed the ninth year of our bear/spawning sockeye salmon interaction study in Hansen Creek, a small tributary of Lake Aleknagik where predation by bears is high relative to larger creeks. During 21 July to 18 August, a large number of spawners were again observed in Hansen Creek (Table 19). Daily count and removal of sockeye salmon killed by bears indicated that 5,826 (49%) of 12,529 spawners were killed by bears in 1998 (Table 20). These estimates excluded dead fish from previous daily surveys that might have been attacked by bears (decisions to exclude fish were based on gill and body coloration, body firmness, and body deterioration). The number of

sockeye killed by bears in 1998 was the third highest for the 9-year period. In 1997 and 1998 we tagged dead salmon in Hansen Creek to estimate the magnitude of scavenging by bears. These studies revealed two patterns of bear scavenging that might affect estimates of run size and predation rate. First, many salmon that had died of senescence were subsequently bitten by bears, inflating the apparent predation rate. However, some carcasses were removed by bears from the area of the stream normally surveyed, leading to underestimates of run size and predation. In addition to the detailed studies at Hansen Creek, we record both senescent dead and bear-killed salmon during our annual surveys of all creeks. The daily records from Hansen Creek allow us to estimate the level of predation in the other streams from the once-a-year surveys. These predation data will be related to information on physical habitat, age and size of the fish in the different creeks and rivers.

We have devoted most of our attention to studies of bears but have been studying other ways in which salmon influence the stream fishes. First, salmon eggs and carcasses provide a direct source of food for large resident fishes (Eastman 1996). Second, the digging activity of females increases the availability of drifting insects, thus providing an indirect source of food for small as well as large resident fishes (Peterson 1998). Finally, the decomposition of salmon carcasses seems to enrich the trees growing along the streamside zone, based on data collected by visiting scientists at our sites in 1997 and 1998 (James Helfield, in preparation).

The daily counts on Hansen Creek are not only important as a basis for studies of predation but they also provide us with estimates of the percentages of the total number of spawners that are counted on a single "peak survey" date and, thus, a means of adjusting our annual survey

counts to equal the true number of spawners. Hansen Creek has been surveyed most often on August 6 in past years, but in 20% of the years, the survey was done on August 1 or earlier. The Hansen Creek sockeye salmon are about the earliest spawners in the lake system and the fish usually first enter the creek around July 22–25. On the basis of daily counts in 1990–98, if the surveys had been conducted on the single date of August 6, the peak survey counts would have been 67% to 89% of the totals; if the single surveys were done on August 1, the counts would have been 38% to 78% of the actual number of spawners (Table 20).

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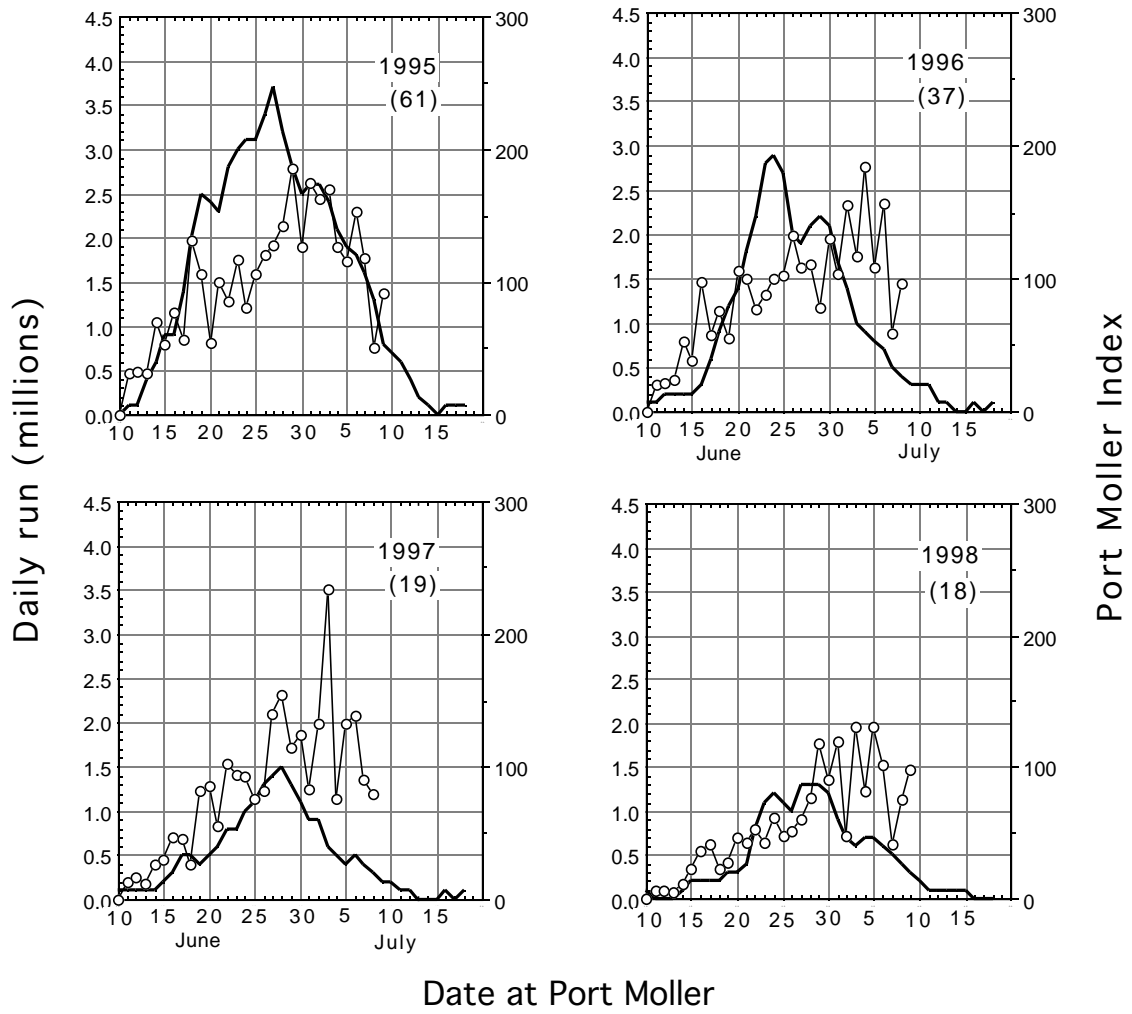


FIGURE 1. Daily Bristol Bay sockeye salmon runs reconstructed at Port Moller.

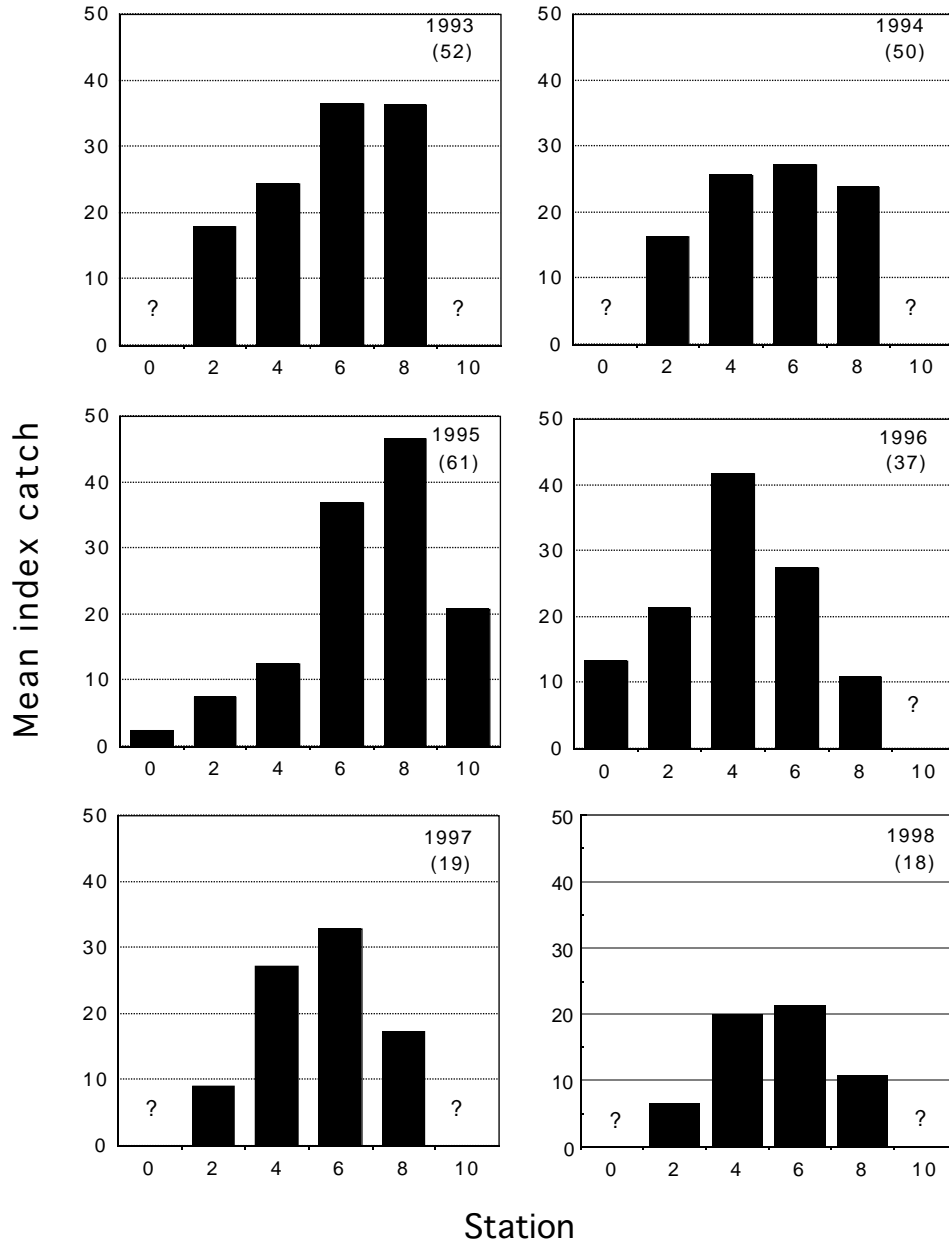


FIGURE 2. Average catches of sockeye salmon at Port Moller stations, June 11–July 5, 1993–98.

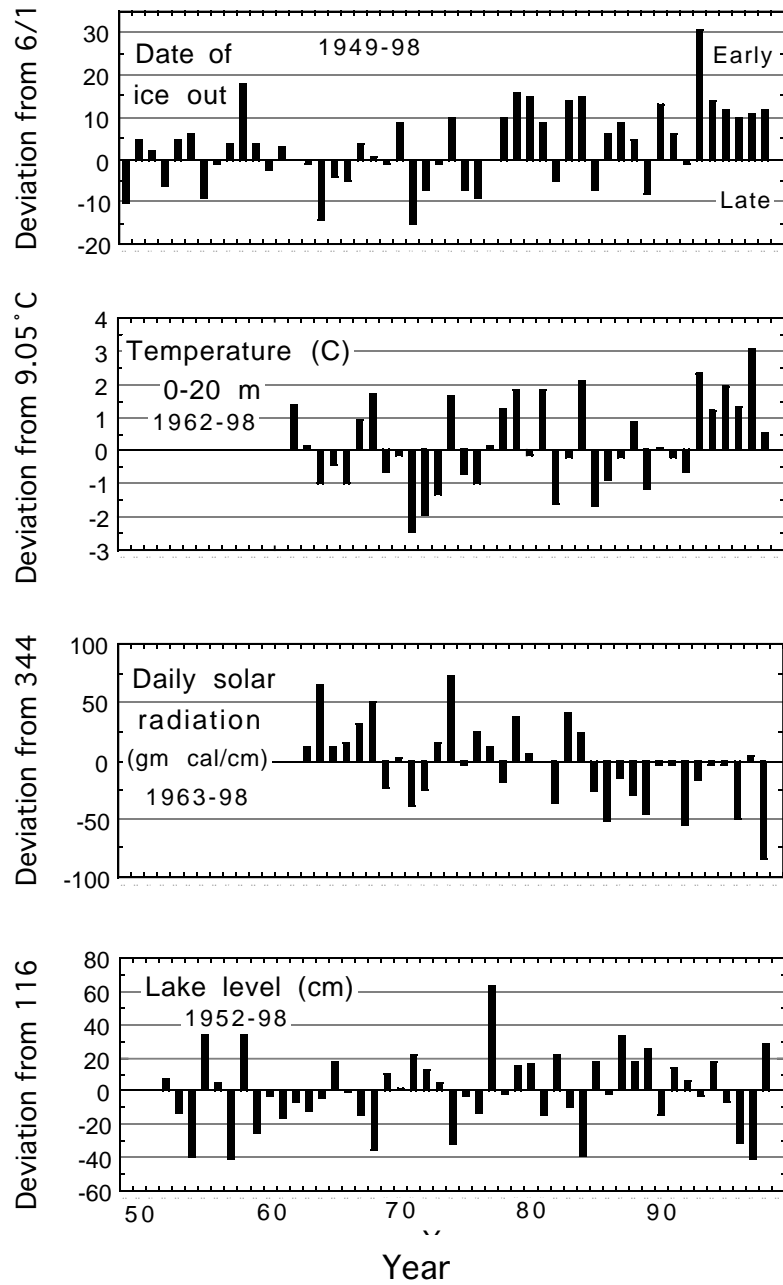


FIGURE 3. Annual deviations from averages of dates of ice out and summer averages of water temperature, solar radiation, and lake level in Lake Aleknagik.

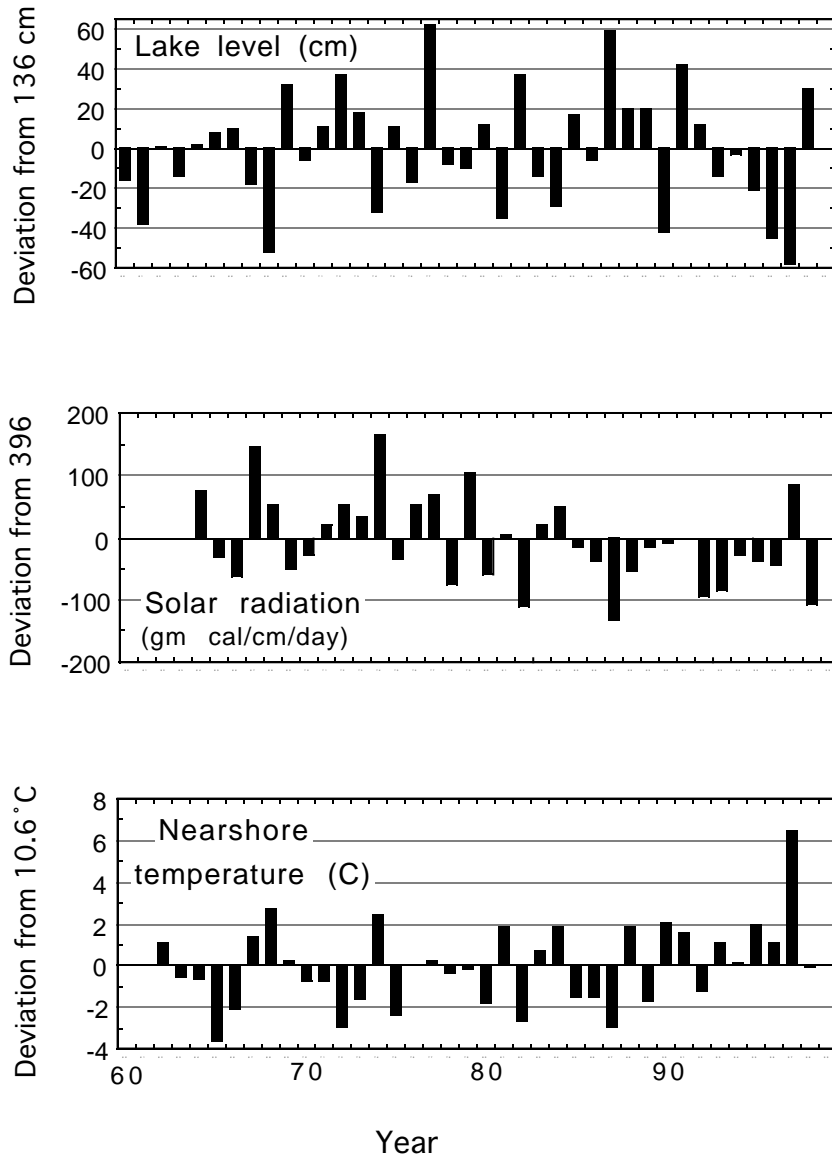


FIGURE 4. Annual deviations from averages of lake level, solar radiation, and surface temperatures during June 26–July 15.

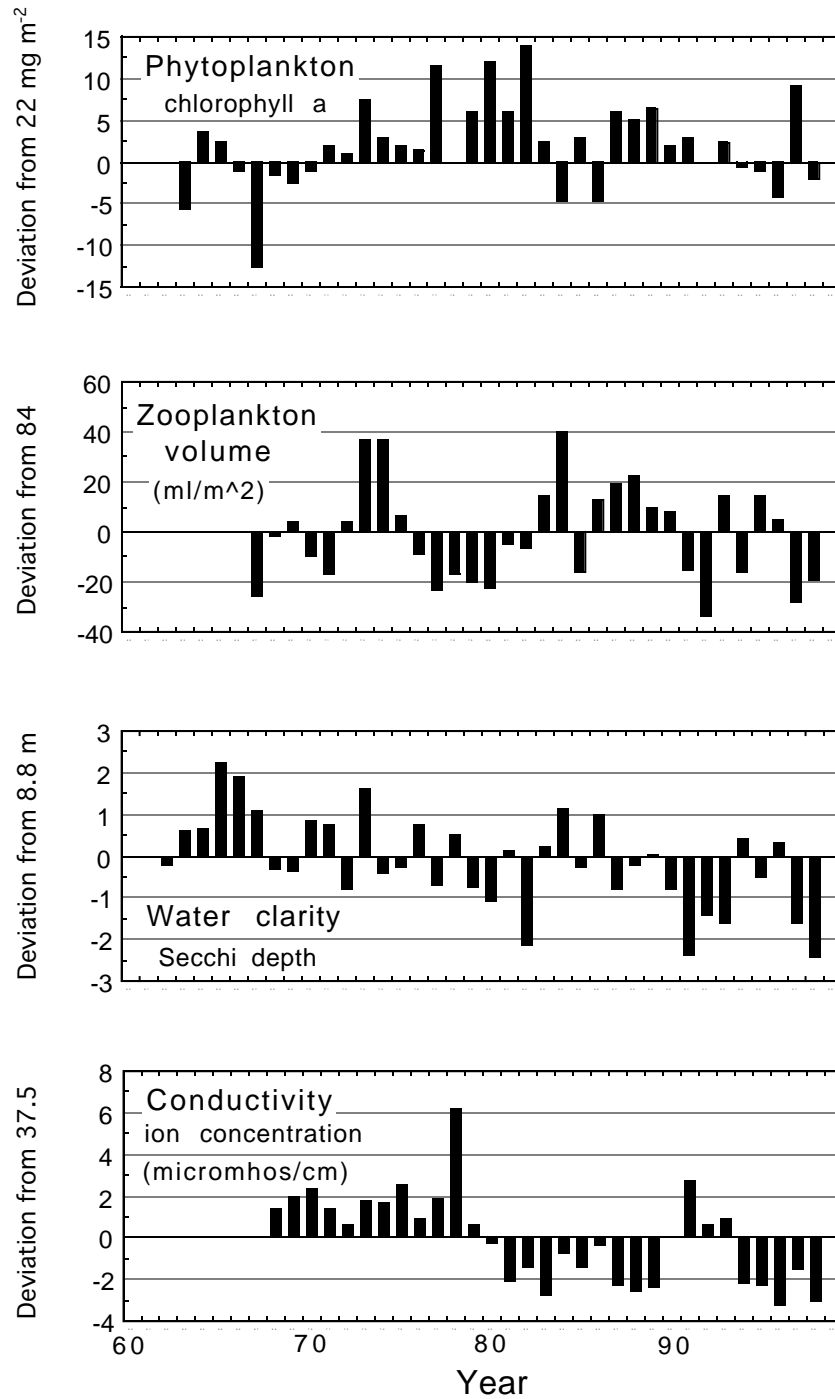


FIGURE 5. Annual deviations from averages of phytoplankton and zooplankton densities, water clarity, and conductivity in Lake Aleknagik.

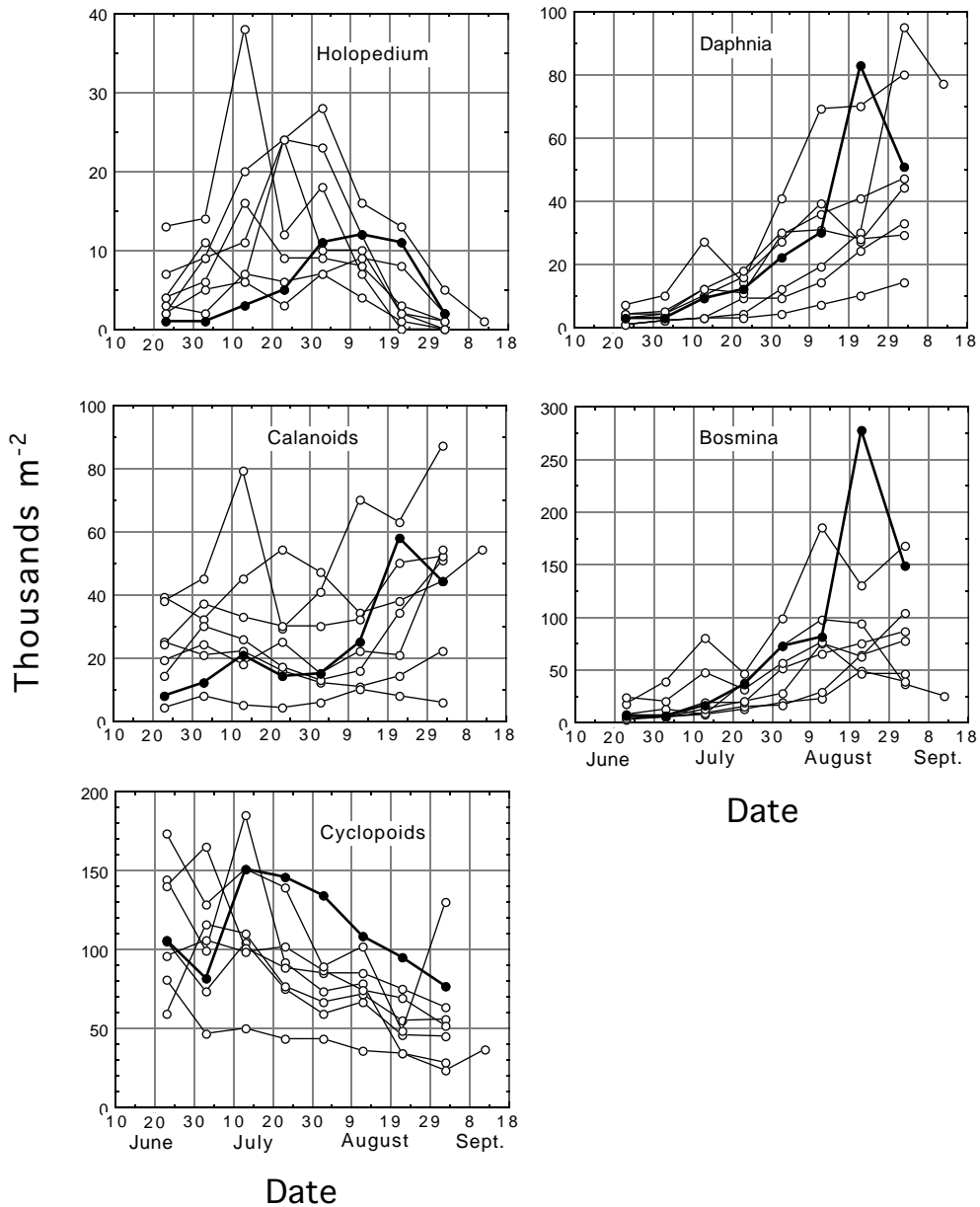


FIGURE 6. Summer densities of zooplankters in 1997 (solid line) compared with densities in 1991-97.

TABLE 1. Preseason forecasts of Bristol Bay sockeye salmon inshore runs (millions of fish).

Year	Forecast/run	Kvichak	Naknek	Egegik	Ugashik	Nushagak	Total run	Catch	%Error
1989	FRI	20.4	3.6	6.7	3.0	3.4	38.0	25.4	-13
	ADFG	12.5	3.1	5.6	3.6	3.1	28.9	16.2	-77
	Actual run	19.8	3.2	10.5	4.9	5.0	43.9	28.7	
1990	FRI	10.1	4.8	6.6	3.0	4.6	29.8	19.0	-74
	ADFG	8.9	3.6	5.6	3.1	3.5	25.4	14.7	-125
	Actual run	17.4	8.4	12.3	2.9	5.7	47.6	33.1	
1991	FRI	12.0	4.6	8.9	3.6	6.9	36.7	25.0	-5
	ADFG	7.6	6.0	8.2	3.5	3.8	30.0	21.2	-24
	Actual run	8.1	10.0	9.6	5.5	7.7	42.1	26.2	
1992	FRI	10.2	3.2	10.4	4.0	4.3	33.0	22.0	-45
	ADFG	12.2	4.2	10.7	4.3	4.6	37.1	26.3	-22
	Actual run	10.4	5.0	17.6	5.5	5.2	45.3	32.0	
1993	FRI	9.1	3.6	18.2	5.5	6.0	43.3	31.9	-28
	ADFG	11.7	3.4	15.8	4.9	5.1	41.8	32.0	-27
	Actual run	9.3	4.7	23.3	5.7	7.6	51.9	40.8	
1994	FRI	18.7	3.9	16.2	3.6	5.3	48.8	34.1	-3
	ADF&G	17.8	3.9	18.8	5.6	5.4	52.4	39.6	11
	Actual run	22.0	3.0	12.6	5.4	5.8	50.1	35.2	
1995	FRI	23.6	6.1	12.1	5.0	5.3	53.1	34.4	-29
	ADF&G	25.1	5.3	13.1	5.4	5.3	55.1	40.3	-10
	Actual run	27.5	3.6	15.7	5.8	6.7	60.8	44.4	
1996	FRI	8.0	4.5	15.7	7.8	7.7	45.2	33.4	11
	ADF&G	8.6	4.6	16.9	6.2	5.8	43.4	34.6	14
	Actual run	3.5	6.9	11.9	5.1	8.3	36.9	29.7	
1997	FRI	7.4	3.7	13.9	2.9	5.9	35.1	25.4	52
	ADF&G	6.9	3.3	12.8	3.8	5.7	33.6	24.8	50
	Actual run	1.7	1.4	8.7	2.0	4.6	18.8	12.3	
1998	FRI	10.4	3.5	8.4	4.3	6.2	33.8	23.5	57
	ADF&G	8.9	3.4	8.6	3.2	5.3	30.2	20.6	51
	Actual run	3.4	2.5	4.7	1.6	5.4	18.2	10.0	
1999	FRI	14.2	3.0	7.7	2.7	6.7	35.1	21.2	
	ADF&G	11.5	2.8	3.6	1.4	4.9	24.9	13.8	

Total run and catch include Branch River and Togiak District but exclude jacks (1-ocean age).

Percent error = error in forecasted catch (forecast-actual catch/forecast*100).

TABLE 2. Bristol Bay sockeye salmon runs and the predictions from the Port Moller test boat catches.

Bristol Bay			Run pred. on 6/25			Run pred. on 6/30			Final pred. (7/3-9)			Catch pred. (7/3-9)		
Year	Run	Catch	Pred.	R-P	%ofP	Pred.	R-P	%ofP	Pred.	R-P	%ofP	Pred.	C-P	%ofP
1987	27	16	27	0	0	27	0	0	26	1	4	15	1	7
88	23	14	15	8	53	15	8	53	22	1	5	12	2	17
89	44	29	50	-6	-12	37	7	19	42	2	5	28	1	4
90	48	33	42	6	14	56	-8	-14	39	9	23	25	8	32
91	42	26	48	-6	-13	37	5	14	37	5	14	21	5	24
92	45	32	49	-4	-8	45	0	0	41	4	10	29	3	10
93	52	41	61	-9	-15	57	-5	-9	56	-4	-7	44	-3	-7
94	50	35	37	13	35	41	9	22	43	7	16	29	6	21
95	61	44	47	14	30	49	12	24	50	11	22	33	11	33
96	37	30	45	-15	-33	44	-14	-32	41	-4	-10	34	-4	-12
97	19	12	39	-20	-51	41	-22	-50	26	-7	-27	17	-5	-29
98	18	10	29	-11	-38	31	-13	-42	20	-2	-10	11	-1	-9
Means	39	27	41	-3	-3	40	-2	-1	37	2	4	25	2	7
absol.				9	25		8	24		5	13		4	17

Numbers in millions of fish.

R= run, P= predicted and C= catch.

absol. = absolute error, ignoring the sign.

%ofP= the percentage that the actual run differed from the prediction.

1993-97 forecasts on 6/25 & 6/30 are from Bristol Bay almanacs (not adjusted for run timing).

TABLE 3. Mean lengths (mid-eye to tail-fork, mm) of sockeye salmon in the Bristol Bay runs.

Year	BB run (millions)	2-ocean			3-ocean			Both age groups	Percent 3-ocean
		Male	Female	Combined	Male	Female	Combined		
1958	6	527	508	517	586	562	572	544	48
1959	13	522	502	512	585	562	571	522	16
1960	36	496	480	489	580	553	562	498	12
1961	18	525	512	519	583	562	572	554	66
1962	10	527	508	518	582	566	574	535	30
1963	7	529	512	520	594	570	580	546	44
1964	11	517	499	508	584	564	571	522	22
1965	53	506	487	497	574	552	561	502	8
1966	18	514	503	508	581	561	569	554	75
1967	10	534	518	526	592	570	579	544	34
1968	8	516	503	510	594	572	581	535	36
1969	18	524	510	517	591	571	580	525	22
1970	39	511	497	504	572	549	558	509	9
1971	16	530	516	522	584	563	572	552	60
1972	5	521	505	514	583	562	572	543	51
1973	2	522	513	518	601	575	587	575	82
1974	11	525	508	518	581	566	574	528	19
1975	24	518	499	509	587	564	574	523	21
1976	12	531	514	523	592	568	578	543	36
1977	10	533	517	525	597	573	584	556	53
1978	19	520	502	512	595	570	582	539	38
1979	40	537	524	530	586	567	576	538	18
1980	62	519	503	511	583	553	567	525	26
1981	34	536	523	529	588	566	577	555	54
1982	22	522	508	515	587	566	576	561	75
1983	46	530	514	521	574	557	565	529	17
1984	41	515	501	508	580	561	570	526	30
1985	37	527	512	520	583	567	575	543	41
1986	24	535	521	528	583	561	571	553	58
1987	27	521	506	513	590	567	577	538	39
1988	23	525	513	519	592	571	581	554	56
1989	44	525	507	515	586	564	575	538	27
1990	48	507	491	499	578	557	566	528	43
1991	42	508	493	500	573	547	560	536	60
1992	45	511	496	504	568	544	557	531	52
1993	52	530	515	522	582	560	570	547	52
1994	50	512	498	504	575	550	561	524	34
1995	61	520	502	511	578	555	567	526	27
1996	37	522	506	513	585	562	574	558	76
1997	19	519	503	511	585	565	576	540	45
1998	18	505	492	499	570	550	560	531	53
Averages									
58-67	18	520	503	511	584	562	571	532	36
68-77	15	523	508	516	588	566	576	539	39
78-87	35	526	511	519	585	564	574	541	40
88-97	44	517	501	509	579	556	567	536	46

TABLE 4. Average weights of sockeye salmon (lb) in commercial catches on the east side of Bristol Bay, 1988–98.

District	Year	Catch millions	2-ocean			3-ocean			All males	All females	All fish	Percent 3-ocean	Percent females
			Male	Female	Comb.	Male	Female	Comb.					
Nak/Kvi	88	3.5	5.3	4.5	4.9	7.4	6.5	6.9	6.3	5.6	5.9	52	52
	89	13.8	5.3	4.6	4.9	7.3	6.2	6.8	5.8	4.9	5.3	21	55
	90	17.1	5.0	4.5	4.7	7.3	6.2	6.7	5.9	5.3	5.6	43	54
	91	10.6	4.9	4.3	4.6	7.2	6.0	6.5	6.6	5.5	6.0	71	54
	92	9.3	5.0	4.5	4.7	6.7	5.7	6.2	6.0	5.2	5.6	60	48
	93	8.9	5.3	4.8	5.1	7.1	6.2	6.6	6.3	5.6	5.9	54	53
	94	16.3	5.0	4.5	4.7	7.0	5.5	6.1	5.4	4.7	5.0	18	58
	95	20.4	5.0	4.4	4.8	6.9	5.9	6.5	5.5	4.7	5.2	22	44
	96	8.2	5.5	4.5	4.9	7.4	6.3	7.0	7.1	5.9	6.7	83	39
	97	0.6	5.4	4.8	5.1	7.6	6.3	7.0	6.7	5.6	6.2	55	50
98	2.6	5.3	4.7	5.1	6.8	6.0	6.5	6.2	5.6	5.9	60	44	
Means		10.2	5.2	4.6	4.9	7.2	6.1	6.6	6.2	5.3	5.7	49	50
Egegik	88	6.5	5.4	4.9	5.2	7.5	6.7	7.2	6.6	6.0	6.3	57	45
	89	8.9	5.2	4.6	4.9	7.4	5.9	6.7	6.0	5.0	5.5	33	51
	90	10.1	5.3	4.9	5.1	7.3	6.1	6.6	6.3	5.6	5.9	54	52
	91	6.8	5.3	4.4	4.9	7.3	6.0	6.6	6.4	5.3	5.8	55	52
	92	15.7	4.7	4.1	4.5	6.6	5.8	6.2	5.6	5.0	5.4	51	44
	93	21.8	5.5	4.8	5.1	7.1	6.2	6.6	6.3	5.6	5.9	52	54
	94	10.8	4.6	4.1	4.4	7.0	5.6	6.2	5.6	5.0	5.3	51	53
	95	14.5	5.3	4.5	4.9	6.9	5.9	6.4	5.8	5.0	5.4	32	48
	96	10.8	5.5	4.7	5.1	7.6	6.2	6.8	7.0	5.8	6.4	73	54
	97	7.6	5.3	4.4	4.9	7.8	6.6	7.2	6.4	5.4	5.9	44	47
98	3.6	4.7	4.5	4.7	6.5	5.8	6.2	6.0	5.6	5.8	75	47	
Means		10.8	5.2	4.6	4.9	7.2	6.1	6.6	6.2	5.4	5.8	52	50
Ugashik	88	1.5	5.4	4.8	5.2	7.5	6.6	7.1	6.4	5.9	6.2	54	43
	89	3.1	5.5	4.7	5.1	7.7	6.5	7.2	5.9	5.0	5.5	19	45
	90	2.1	5.0	4.5	4.7	7.4	6.4	6.9	6.1	5.6	5.9	53	49
	91	3.0	5.3	4.5	4.9	7.0	5.8	6.3	6.2	5.3	5.8	59	52
	92	3.4	5.0	4.5	4.8	6.8	5.6	6.4	6.2	5.2	5.8	64	37
	93	4.3	5.7	4.6	5.2	7.7	6.7	7.2	6.7	5.7	6.2	52	52
	94	4.3	4.9	4.2	4.7	7.1	6.0	6.6	6.0	5.3	5.8	55	40
	95	4.5	5.2	4.3	4.8	6.9	6.1	6.5	5.7	4.9	5.3	30	42
	96	4.4	5.2	4.8	5.0	7.6	6.3	7.0	7.3	6.1	6.7	85	47
	97	1.4	5.5	4.6	5.1	7.7	6.3	7.0	6.5	5.4	6.0	47	47
98	0.7	5.2	4.9	5.1	7.1	5.8	6.6	6.7	5.7	6.3	82	36	
Means		2.9	5.3	4.6	5.0	7.3	6.2	6.8	6.3	5.5	6.0	55	45

TABLE 5. Average weights of sockeye salmon (lb) in commercial catches on the west side of Bristol Bay, 1988–98.

District	Year	Catch millions	2-ocean			3-ocean			All males	All females	All fish	Percent 3-ocean	Percent females
			Male	Female	Comb.	Male	Female	Comb.					
Nushagak	88	1.7	4.9	4.3	4.7	7.8	6.2	7.0	7.1	5.9	6.5	79	49
	89	2.8	5.4	4.3	4.7	7.6	6.2	6.8	6.9	5.6	6.1	68	62
	90	3.6	4.5	4.1	4.4	7.6	5.9	6.7	6.6	5.5	6.0	71	50
	91	5.3	4.3	3.8	4.0	7.1	5.7	6.3	6.4	5.2	5.7	75	56
	92	2.8	4.7	4.0	4.4	6.5	5.4	6.0	5.7	5.0	5.4	61	45
	93	5.3	5.2	4.3	4.8	7.5	6.0	6.6	6.4	5.4	5.9	59	55
	94	3.4	4.3	4.0	4.2	6.9	5.9	6.2	6.3	5.8	6.0	87	60
	95	4.4	4.8	4.3	4.5	6.7	5.6	6.1	5.7	4.9	5.3	49	50
	96	5.8	5.0	4.1	4.5	7.3	5.9	6.5	6.5	5.4	5.8	68	57
	97	2.6	4.9	4.2	4.7	6.9	5.9	6.6	6.1	5.2	5.8	60	35
	98	3.0	4.3	3.7	4.0	6.9	5.3	6.2	5.4	4.2	4.7	34	54
	Means	3.7	4.7	4.1	4.4	7.2	5.8	6.4	6.3	5.3	5.7	65	52
Togiak	88	0.7	6.3	5.1	5.6	8.8	7.2	7.9	8.7	7.1	7.8	97	54
	89	0.1	5.9	4.7	5.4	8.4	6.3	7.1	7.8	6.1	6.8	82	57
	90	0.2	5.4	4.8	5.0	8.1	6.3	7.1	7.7	6.1	6.8	85	57
	91	0.5	5.9	4.8	5.4	8.1	6.2	7.1	7.4	5.8	6.6	69	50
	92	0.6	5.4	4.8	5.1	8.7	6.3	7.6	8.2	6.1	7.2	85	47
	93	0.5	6.2	5.0	5.6	9.2	6.5	7.9	8.5	6.2	7.3	76	49
	94	0.3	6.4	5.2	5.7	8.1	6.3	7.1	8.0	6.2	7.0	91	53
	95	0.5	6.0	5.1	5.5	7.9	6.6	7.2	7.2	6.1	6.6	66	53
	96	0.4	6.3	5.1	5.8	8.5	6.6	7.5	8.3	6.5	7.4	90	52
	97	0.1	6.2	5.3	5.7	8.2	6.6	7.4	7.8	6.3	7.1	80	49
	98	0.2	5.9	4.5	5.1	7.6	6.0	6.6	7.4	5.8	6.5	88	58
	Means	0.4	6.0	4.9	5.5	8.3	6.5	7.3	7.9	6.2	7.0	83	53

TABLE 6. Sockeye salmon escapement in excess of management goals for Bristol Bay rivers, 1989–98 (millions).

River system	Escapement goals		Escapement in excess of mid-point										
	Mid-point	Upper range	89	90	91*	92	93	94	95	96	97	98	
Kvichak Branch	variable	variable											
Naknek	1.00		.16	1.09	2.57	.61	.54	.00	.11	.08	.03	.20	
Egegik	1.00		.61	1.19	1.79	.95	.52	.90	.27	.08	.10	.11	
Ugashik	.70		1.01	.05	1.76	1.76	.71	.38	.60	.00	.00	.02	
Wood	1.00		.19	.07	.16	.29	.18	.47	.48	.65	.51	.76	
Igushik	.20		.26	.17	.56	.10	.21	.25	.27	.20	.00	.02	
Nuyakuk/Nush.	.50		.01	.17	.00	.20	.21	.01	.00	.00	.00	.00	
Togiak	.15		.00	.04	.13	.07	.04	.02	.06	.01	.00	.00	
Total			2.24	2.78	6.97	3.98	2.41	2.03	1.79	1.02	.64	1.11	
Bristol Bay run			44	48	42	45	52	50	61	37	19	18	
Catch			29	33	26	32	41	35	44	30	12	10	
			Escapement in excess of upper range										
Naknek		1.40	.00	.69	2.18	.21	.14	.00	.00	.00	.00	.00	
Egegik**		1.20	.41	.99	1.59	.75	.32	.70	.00	.00	.00	.00	
Ugashik**		.90	.81	.00	1.58	1.56	.51	.18	.10	.00	.00	.00	
Wood		1.20	.00	.00	.00	.09	.00	.27	.28	.45	.31	.56	
Igushik		.25	.21	.12	.51	.05	.16	.20	.22	.15	.00	.00	
Nuyakuk/Nush.		.76	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
Togiak		.25	.00	.00	.03	.00	.00	.00	.00	.00	.00	.00	
Total			1.43	1.80	5.89	2.66	1.13	1.35	.60	.60	.31	.56	

*Strike in 1991 delayed the start of fishing except at Ugashik.

**Upper range of escapement goals for Egegik and Ugashik were increased to 1.4 and 1.2 million for 1995.

TABLE 7. Cumulative daily escapements of sockeye salmon in the Kvichak and Newhalen rivers, 1993–98. (Numbers in 1,000s of fish, and Newhalen escapements estimated from expanded counts lagged back 2 days for 1992–95, and 3 days for 1996–97.) Kvi = Kvichak; New = Newhalen.

Date	1993		1994		1995		1996		1997		1998	
	Kvi	New	Kvi	New	Kvi	New	Kvi	New	Kvi	New	Kvi	New
6/22	13											
23	24		0									
24	34		0				0	0	0			
25	51	6	0		0		4	0	3		0	
26	121	67	1		41	7	25	1	6		0	
27	317	78	8		361	28	37	1	15	0	1	
28	559	157	24		724	48	40	1	42	1	3	
29	847	237	25		941	75	41	1	60	2	6	
30	932	394	25		1113	109	42	2	67	4	16	
7/1	1014	492	26	0	1610	158	47	2	73	5	26	0
2	1081	650	30	1	2338	255	90	2	76	8	32	0
3	1182	816	254	1	2798	309	224	3	83	13	32	0
4	1307	937	1550	321	3105	364	318	4	116	18	84	18
5	1678	1022	2727	558	3346	398	361	6	158	30	233	37
6	2372	1103	3518	775	3983	430	385	7	206	40	417	76
7	2733	1121	4273	921	4937	482	420	7	299	50	597	230
8	2932	1134	5132	1091	5930	581	468	8	439	63	753	256
9	3101	1163	5821	1286	7020	687	568	15	637	105	833	338
10	3264	1189	6473	1601	7683	805	669	22	797	132	980	592
11	3402	1220	7058	1884	8005	1050	769	23	950	182	1366	937
12	3574	1268	7268	2168	8169	1199	860	25	1053	224	1795	1137
13	3751	1322	7330	2372	8430	1226	1035		1140	230	2071	1361
14	3818	1353	7382	2450	8658	1378	1160		1200	239	2181	1450
15	3864		7495	2535	8878		1238		1291	253	2238	1573
16	3894		7540	2578	9017		1310		1349		2269	1680
17	3921		7631		9131		1332		1382		2280	1723
18	3958		7852		9248		1353		1412		2285	
19	3986		8099		9512		1397		1436		2291	
20	3996		8169		9703		1422		1456		2294	
21	4008		8193		9788		1436		1471		2295	
22	4016		8265		9876		1445		1486		2296	
23	4021		8338		9919		1451		1496			
24	4024				9954				1504			
25	4025				9994							

TABLE 8. The Kvichak lake system escapements and the percentages of fish going to the Newhalen River and Lake Clark.

Year	Kvichak system escapement (millions)	Newhalen/Lake Clark escapement (millions)	Percent of Kvichak (%)	Newhalen River spawners (millions)	Lake Clark escape. (millions)	Percent of Kvichak (%)	Tazimina River aerial count (thousands)
1979	11.22	9.00	80	0.56	8.44	75	504
1980	22.51	7.50	33	2.64	4.86	22	128
1981	1.75	0.26	15	0.03	0.23	13	28
1982	1.14	0.34	30	0.13	0.21	18	31
1983	3.57	1.08	30	0.41	0.67	19	212
1984	10.49	3.20	31	0.67	2.53	24	366
1985	7.21	1.62	22	0.15	1.47	20	186
1986	1.18	0.29	25	0.01	0.28	24	7
1987	6.07	---	--	1.46	--	--	246
1988	4.06	2.41	59	0.29	2.12	52	83
1989	8.32	2.59	31	0.10	2.49	30	30
1990	6.97	1.09	16	<i>0.07</i>	--	--	4
1991	4.22	1.93	46	<i>0.10</i>	--	--	16
1992	4.73	1.05	22	<0.01	1.04	22	13
1993	4.03	1.55	38	<0.01	1.54	38	38
1994	8.34	2.34	28	0.01	2.33	28	93
1995	10.04	1.12	11	0.12	1.00	10	54
1996	1.45	0.04	2	<0.01	0.03	2	10
1997	1.50	0.27	18	<0.01	0.27	18	11
1998	2.30	1.38	60	0.01	1.37	60	24

Newhalen River spawners estimated by two times the aerial survey estimate.

Italics = estimate of missing data.

TABLE 9. Age compositions of sockeye salmon on the Kvichak spawning grounds in 1998.

Spawning ground	Sex	Sample size (n)	Age composition (%)						
			1.1	2.1	1.2	2.2	1.3	2.3	0.4
Gibraltar River	M	99		3.0	44.4	8.1	38.4	6.1	
	F	75			42.7	16.0	40.0	1.3	
Copper River	M	89		1.1	13.5	39.3	42.7	3.4	
	F	97			8.2	37.1	52.6	2.1	
Chinkelyes Creek	M	97		7.2	66.0	21.6	5.2	0.0	
	F	97			69.1	14.4	11.3	5.2	
Newhalen River	M	27			81.5	7.4	7.4	3.7	
	F	16			87.5	6.2	6.3	0.0	
Tazimina River	M	0							
	F	0							
Woody Island beaches	M	96	1.0		92.7	1.0	4.2	1.0	
	F	93			87.1	2.1	9.7	1.1	
Knudson Bay beach	M	92		3.3	67.4	16.3	7.6	5.4	
	F	92		5.4	71.7	8.7	12.0	2.2	
Pedro Ponds	M	92		1.1	89.1	4.3	4.3	1.1	
	F	95			95.8	1.0	3.2	0.0	
Kvichak escapement (ADF&G, Igiugig)	M	584	1.2	2.4	60.4	15.0	16.3	4.3	0.4
	F	680	0.4	0.2	61.0	18.4	16.9	3.0	

TABLE 10. Spawning ground estimates of sockeye salmon on 29 selected spawning grounds in Lake Iliamna and the Newhalen River system, 1956–98.

Year	Aerial survey counts (1,000s)					Tower count escapement (1,000s)	Aerial count/ Escapement (%)	Aerial observer
	Rivers	Creeks	Beaches		Total			
			Mainland	Island				
56	775	--	--	--		9443		1
57	170	--	--	--		2843		1
58	44	--	--	--		535		1
59	84	--	--	--		680		1
60	841	--	--	--		14630		1
61	246	40	50	127	463	3706	12.5	2
62	140	52	21	12	225	2581	8.7	2
63	31	13	5	7	56	339	16.5	2
64	36	38	3	21	98	957	10.2	2
65	734	538	261	1352	2885	24326	11.9	2
66	248	153	134	46	581	3776	15.4	2
67	370	63	85	16	534	3216	16.6	3
68	131	64	14	64	273	2557	10.7	3
69	192	168	40	102	502	8394	6.0	3
70	790	574	216	506	2086	13935	15.0	3
71	177	194	27	50	448	2387	18.8	3
72	89	50	15	9	163	1010	16.1	3
73	35	18	6	6	65	227	28.6	3
74	294	269	72	122	757	4433	17.1	3
75	936	440	225	412	2013	13140	15.3	3
76	144	55	19	45	263	1965	13.4	3
77	124	20	88	28	260	1341	19.4	3
78	510	100	42	6	658	4149	15.9	3
79	1424	372	252	81	2129	11218	19.0	3
80	2189	317	77	201	2784	22505	12.4	3
81	187	85	16	20	308	1754	17.6	3
82	255	68	27	9	359	1135	31.6	3
83	743	123	75	9	950	3570	26.6	3
84	1902	359	597	84	2942	10491	28.0	4
85	672	296	260	247	1475	7211	20.5	4
86	57	16	12	5	90	1200	7.5	5
87	1313	111	397	123	1944	6100	31.9	5
88	481	123	116	15	735	4065	18.1	6
89	386	88	31	8	513	8318	6.2	6
90	138	50	19	26	233	6970	3.3	6
91	196	111	18	19	344	4223	8.1	7
92	198	151	35	19	403	4726	8.5	7
93	225	128	42	10	405	4025	10.1	7
94	506	231	41	30	808	8338	9.7	7
95	554	187	50	244	1035	10039	10.3	7
96	177	49	22	10	258	1451	17.8	7
97	255	69	87	11	422	1504	28.1	7
98	138	82	34	13	267	2296	11.6	7
Means								
61-66	239	139	79	261	718	5948	12.5	2
67-83	505	175	76	99	856	5702	17.6	3
84-90	707	149	205	73	1133	6336	16.5	4,5,6
91-98	281	126	41	45	493	4575	13.0	7

TABLE 11. Mean townet catches (geometric means of 20-min tows) and lengths of Sept. 1 live sockeye salmon fry (mm) in Lake Iliamna and Lake Clark.

Brood year	Kvichak escapement (millions)	Lake Iliamna		Lake Clark	
		Mean catch	Mean length	Mean catch	Mean length
61	3.7	90	53	13	50
62	2.6	12	45	54	50
63	0.3	5	54	3	50
64	1.0	7	62	2	50
65	24.3	170	53	23	52
66	3.8	67	57	15	47
67	3.2	78	62	47	59
68	2.6	43	62	9	50
69	8.4	386	61	11	55
70	13.9	127	44	20	38
71	2.4	4	50	15	41
72	1.0	3	58	17	48
73	0.2	2	71	12	57
74	4.4	491	54	80	55
75	13.1	252	49	105	49
76	2.0	16	53	--	--
77	1.3	11	61	--	--
78	4.1	339	62	65	56
79	11.2	282	53	60	48
80	22.5	134	61	26	59
81	1.8	37	52	58	46
82	1.1	9	68	18	57
83	3.6	242	64	40	56
84	10.5	147	46	84	51
85	7.2	63	54	16	49
86	1.2	10	60	--	--
87	6.1	79	63	11	56
88	4.1	22	58	21	48
89	8.3	181	55	19	47
90	7.0	336	54	--	--
91	4.2	-	56	20	47
92	4.7	135	57	27	61
93	4.0	64	57	26	55
94	8.3	83	55	21	54
95	10.0	126	62	-	-
96	1.5	23	67	-	-
97	1.5	-	-	-	-
98	2.3				

TABLE 12. Summary of 1998 measurements in Lake Aleknagik.

Measurement and first year measured	Dates	1997	All years	
			Average	Range
1. Date of ice breakup, 1949-		5/20	5/29	5/01-6/16
2. Water temperature, 0-20m (C) 1958-	6/22	6.7	5.8	3.7, 9.2
	7/13	8.6	8.4	5.7, 12.0
	8/3	12.0	10.8	7.7, 14.0
	9/2	10.8	11.2	9.3, 13.0
3. Water transparency Secchi depth (m) 1962-	6/22	4.8	7.9	5.3, 10.5
	7/13	6.2	8.2	5.0, 10.9
	8/3	6.8	9.2	6.3, 11.9
	9/2	7.6	9.1	5.8, 12.1
4. Water conductivity (micromhos/cm) 1968-	6/22	34.8	38.0	31.1, 52.1
	7/13	35.5	37.1	33.5, 42.6
	8/3	35.0	36.7	32.5, 40.5
	9/2	32.2	37.8	32.2, 47.9
5. Average daily solar radiation (gm/cal/cm) 1963-	June 1-15	345	406	305, 588
	June 16-30	288	404	265, 572
	July 1-15	277	383	277, 543
	July 16-31	309	349	192, 485
	Aug. 1-15	221	297	203, 402
	Aug. 16-31	184	255	164, 421
	Sept. 1-15	172	204	114, 282
6. Lake level (cm) of Lake Nerka 1952-	June 1-15	227	144	84, 227
	June 16-30	207	150	97, 218
	July 1-15	158	131	74, 199
	July 16-31	117	105	52, 172
	Aug. 1-15	90	85	34, 173
	Aug. 16-31	68	82	30, 184
	Sept. 1-15	62	82	29, 161
7. Chlorophyll "a", 0-20m (mg/m2) 1963-	6/22	15	28	10, 45
	7/2	27		
	7/13	30	26	10, 43
	7/22	25		
	8/3	21	21	6, 36
	8/11	14		
	8/24	15		
	9/2	15	23	12, 37
8. Zooplankton volume 0-60m (ml/m2) 1967-	6/22	46	52	20,168
	7/2	52		
	7/13	60	85	45-162
	7/22	64		
	8/3	101	117	43-226
	8/11	109		
	8/24	148		
	9/2	52	60	26-107

TABLE 13. Five-day averages of catches of emergent midges and water temperatures at three stations on Lake Aleknagik, 1998.

5-day period	Catch per day								Water temperature (°C)							
	1998				1969-68				1998				1969-98			
	W	H	B	Mean	Mean	Min	Max	W	H	B	Mean	Mean	Min	Max		
6/1-5					2	0	3					3.2	0.0	9.8		
6-10					9	0	70	6.0	7.5	8.0	7.2	5.6	0.0	10.4		
11-15	27	0	122	49	11	1	53	7.1	7.9	8.7	7.9	6.8	0.0	12.1		
16-20	43	1	4	16	15	1	168	7.5	10.5	11.3	9.8	8.4	3.9	12.7		
21-25	16	1	1	6	6	0	42	9.2	9.9	9.4	9.5	8.9	4.8	12.8		
26-30	3	1	1	2	4	0	12	12.9	13.2	15.2	13.8	9.8	6.0	13.9		
7/1-5	3	0	1	1	6	1	16	14.3	11.8	15.0	13.7	11.1	7.7	15.5		
6-10	1	0	0	0	12	2	61	11.2	12.6	12.8	12.2	11.9	9.3	16.0		
11-15	1	1	1	1	14	1	34	11.1	13.1	14.1	12.8	12.4	9.2	17.9		
16-20	1	1	5	2	15	2	36	10.9	14.0	12.9	12.6	12.4	8.5	17.0		
21-25	19	7	3	10	20	2	74	12.1	12.5	14.0	12.9	12.9	7.9	17.2		
26-30	27	4	6	12	27	5	59	12.4	12.4	13.0	12.6	13.3	8.9	16.1		
31-4	9	20	31	20	27	4	77	10.9	12.5	13.1	12.2	13.6	10.2	17.5		
8/5-9	5	5	4	5	20	3	80	12.4	12.0	12.2	12.2	13.6	10.4	17.1		
10-14	3	1	6	4	15	1	54	11.2	13.2	13.2	12.5	13.6	9.5	18.8		
15-19	1	1	4	2	13	1	70	11.4	12.7	12.7	12.3	13.5	11.0	16.2		
20-24	3	1		2	6	0	28	12.5	13.9		13.2	13.5	9.7	15.4		
25-29	1	2		2	5	1	11	13.0	13.0		13.0	13.3	11.3	14.7		
30-3	0	0		0	6	1	13	11.0	10.3	10.5	10.6	13.1	10.6	14.2		

W = Whitefish Bay; H = Hansen Bay; and B = Bear Bay.

TABLE 14. Average catches, lengths, and growth rates for sockeye salmon fry and age 1 threespine stickleback in Lake Aleknagik.

Year	Sockeye salmon fry					Sockeye Escape- ment in year-1 (1000s)	Threespine stickleback					Age 0 tow net catch
	Mean beach seine catch	Mean length on 6/23 (mm)	Mean length on 9/1 (mm)	Growth rate (mm/ day)	Mean tow net catch		Mean beach seine catch	Mean length on 6/23 (mm)	Mean length on 9/1 (mm)	Growth rate (mm/ day)	Mean tow net catch	
58	-	-	62.1	-	14	88	-	-	44.6	-	36	<1
59	-	-	62.7	-	13	63	-	-	46.7	-	136	10
60	-	-	55.5	-	111	205	-	-	43.4	-	53	2
61	-	-	58.4	-	103	85	-	-	42.0	-	38	<1
62	334	31.7	54.1	.31	54	153	317	31.0	43.5	.17	139	5
63	-	-	62.1	-	24	48	-	-	46.4	-	46	1
64	227	31.1	60.4	.42	24	31	352	31.2	43.1	.17	272	1
65	549	31.2	53.6	.32	103	155	202	29.1	39.5	.15	182	1
66	395	30.2	47.5	.25	219	220	258	27.1	39.4	.18	150	0
67	339	30.7	43.4	.18	49	287	426	28.2	41.3	.19	61	5
68	46	31.8	57.9	.37	10	92	212	30.8	43.4	.18	268	169
69	96	31.7	61.4	.43	78	177	215	33.4	44.2	.16	81	<1
70	164	31.4	59.0	.40	43	160	156	32.1	44.8	.18	87	<1
71	408	30.6	54.6	.35	17	302	261	29.6	43.4	.20	3	<1
72	126	30.6	54.8	.35	10	182	45	28.0	44.4	.24	12	1
73	30	29.0	66.7	.54	3	98	62	29.3	49.5	.29	8	1
74	47	35.3	62.8	.39	44	162	125	33.1	50.1	.24	119	<1
75	111	29.1	55.3	.39	8	242	69	32.5	42.4	.15	132	<1
76	178	30.1	49.8	.29	394	457	279	27.7	39.6	.17	30	<1
77	223	30.1	48.0	.27	25	314	184	29.3	40.8	.17	36	<1
78	34	32.8	62.7	.43	6	152	64	31.7	47.5	.23	21	1
79	312	31.6	51.5	.28	130	612	82	33.2	42.3	.13	50	18
80	46	31.0	56.4	.35	3	354	32	31.0	44.9	.19	24	<1
81	423	32.4	51.3	.27	6	1230	217	34.7	45.5	.15	12	<1
82	53	30.0	52.2	.33	131	454	63	30.2	43.2	.19	12	0
83	43	32.1	63.9	.45	22	337	12	30.9	48.4	.25	64	12
84	16	36.2	64.2	.41	3	245	54	35.9	48.8	.19	200	155
85	102	31.0	56.3	.36	1	329	109	34.3	40.9	.09	2	0
86	32	32.2	58.4	.37	10	188	24	31.4	45.0	.19	11	0
87	69	29.7	57.5	.40	3	341	27	31.7	44.9	.19	67	<1
88	31	31.2	58.8	.40	2	362	42	32.4	48.5	.23	8	1
89	45	31.4	55.4	.34	18	285	26	32.6	47.0	.21	17	1
90	100	32.7	57.7	.36	20	477	129	31.2	48.1	.24	27	1
91	63	30.1	52.9	.33	14	393	108	31.3	42.2	.16	41	1
92	242	30.0	46.1	.24	52	788	200	27.9	39.4	.17	222	<1
93	34	33.7	56.4	.33	10	357	55	31.7	46.5	.22	3	<1
94	55	32.0	51.7	.29	121	417	31	30.3	46.6	.24	38	2
95	39	32.0	53.9	.31	24	483	33	31.5	46.0	.21	181	31
96	26	32.6	54.8	.32	100	470	43	32.6	47.1	.21	103	7
97	38	33.1	52.1	.27	8	625	164	34.2	41.4	.10	155	141
98	16	31.6	55.8	.35	3	404	26	30.6	45.3	.21	6	0
Means	141	31.5	55.7	.35	48	335	131	31.2	44.5	.19	78	15

1. Beach seine catches at 10 stations for four dates during 6/22-7/14.
2. Tow net catches for 5-min hauls, two at each of six stations during Sept. 1-5.
3. Lengths measured to nearest mm on preserved fish, means adjusted to live measurement.
4. Threespine stickleback catches are for all ages (0-4), but mean lengths for age 1 only.

TABLE 15. Average townet catches and mean lengths of sockeye salmon fry (by lake area), number of parent spawners, and average catches and mean lengths (age 1) of threespine stickleback for Lake Nerka.

Year	Sockeye salmon fry						Sockeye salmon spawners			Threespine stickleback	
	Mean tow-net catch			Mean length (mm) on 9/1			in year-1 (1000s)			Mean tow-net catch	Mean length (mm) on 9/1
	South	Central	North	South	Central	North	South	Central	North		
58	4	4	10	62	60	61	73	57	52	26	44
59	17	9	4	66	61	61	163	58	188	35	43
60	62	42	42	58	55	51	564	332	395	11	42
61	108	57	64	59	56	54	231	137	214	8	41
62	2	7	26	64	59	59	49	50	143	6	47
63	58	18	55	62	60	62	97	73	126	9	48
64	3	7	44	57	55	64	56	65	110	8	45
65	15	8	93	57	54	54	110	159	161	9	40
66	4	7	70	57	54	54	60	77	184	6	44
67	8	18	58	64	58	59	149	141	246	12	46
68	4	11	8	68	64	65	44	64	114	25	48
69	15	4	27	65	61	60	46	103	150	14	46
70	2	5	21	64	65	63	51	56	266	5	43
71	3	9	197	54	52	58	141	132	229	4	42
72	2	11	8	57	55	55	68	73	178	8	45
73	1	3	11	61	61	61	37	82	109	4	45
74	5	4	34	69	64	64	19	29	83	107	50
75	7	15	9	59	55	53	236	141	242	60	44
76	1	9	40	52	49	45	128	69	297	17	40
77	19	50	143	55	54	51	77	69	176	17	42
78	<1	<1	4	56	61	63	67	65	173	18	46
79	3	17	50	64	54	58	151	181	460	61	47
80	1	14	37	52	49	47	246	142	287	33	41
81	3	16	13	59	55	55	219	224	566	6	46
82	1	6	38	54	56	54	89	169	348	24	45
83	2	4	4	66	63	63	29	43	396	1	48
84	1	11	2	72	61	63	66	84	243	14	50
85	1	2	123	61	56	55	57	89	371	2	45
86	2	16	12	50	54	64	50	106	492	2	42
87	1	7	21	57	56	55	34	64	253	4	43
88	<1	2	7	64	57	57	77	213	293	2	49
89	1	3	16	57	51	59	57	174	176	5	48
90	1	7	3	63	62	58	87	153	377	3	48
91	27	22	32	61	57	56	80	94	219	27	44
92	4	16	10	57	55	55	51	43	99	4	41
93	8	6	16	62	57	55	200	252	201	15	45
94	29	39	66	63	55	52	162	169	203	15	44
95	41	127	49	63	56	50	95	152	372	22	44
96	6	44		66	61		154	153	232	1	49
97	3	2	3	62	59	60	131	216	355	39	43
98	12	47	26	59	53	52	148	282	250	37	44
Means	12	18	37	60	57	57	113	123	245	18	45

TABLE 16. Occurrence and numbers of juvenile sockeye in stomachs of Arctic char (*Salvelinus alpinus*) collected by hook and line from Little Togiak River during 30 days after ice out.

Year	Date of ice out	Range in sampling dates	Number of char examined	Mean length (mm)	Percent of char with		Mean number per char		Sockeye escape. year-2
					Fry	Smolt	Fry	Smolt	
72	6/17	6/26-7/10	82	446	34	60	2.8	4.5	55
73	6/08	6/19-7/03	121	446	34	44	1.9	2.9	24
74	5/27	6/11-25	64	429	19	39	0.8	1.6	14
75	6/15	6/22-7/13	71	415	9	36	0.2	1.8	14
76	6/17	6/19-7/13	96	418	11	56	0.4	2.2	48
77	6/13	6/11-7/11	325	403	30	17	7.0	0.4	30
78	6/02	6/07-25	316	437	7	42	0.2	1.5	18
79	5/24	6/06-22	178	438	32	25	1.8	1.2	26
80	5/27	6/09-25	278	459	27	81	1.4	9.4	45
81	5/28	6/12-25	124	415	3	31	0.1	1.4	44
82	6/15	6/17-7/05	105	450	18	61	1.8	6.4	81
83	5/27	6/19-7/03	78	424	0	14	0.0	0.3	60
84	5/26	6/20-7/02	56	408	0	18	0.0	0.4	36
85	6/17	6/15-7/06	60	437	22	30	1.6	1.2	29
86	6/04	6/16-7/05	61	437	21	56	0.4	2.7	15
87	6/01	6/14-7/05	51	451	6	78	0.1	4.9	20
88	6/05	6/16-29	43	431	7	26	0.1	0.8	24
89	6/17	6/20-7/15	105	388	37	38	2.2	1.3	15
90	5/28	6/07-24	72	391	35	11	1.8	0.3	16
91	6/07	6/20-7/07	48	415	4	35	0.9	3.2	13
92	6/13	6/15-7/11	79	425	0	46	0.0	1.9	29
93	5/12	6/07-18	51	428	21	22	1.4	0.7	19
94	5/28	6/14-29	39	416	3	21	0.1	0.2	35
95	5/29	6/11-13	3	468	66	66	2.3	2.0	19
96	5/30	6/16-22	40	429	0	42	0.0	1.1	24
97	5/29	6/13-24	28	445	0	11	0.0	0.3	28
98	5/28	6/15-25	22	435	9	36	0.1	2.8	23
means	6/4		96	429	17	39	1.1	2.1	30

TABLE 17. Ground survey counts of sockeye salmon spawners in the Wood River lakes, 1998.

Location	Date	Estimated off mouth	In creek				Total
			Live	Dead	Natural	Bear kill	
Aleknagik							
Yako	8/01	300	1116	376	93	283	1792
Hansen	8/06	0	4153	4525	1572	2953	8678
Bear	8/05	1000	2338	317	85	232	3655
Happy	8/06	150	4265	4140	2173	1967	8555
Ice*	8/07	0	8717	1078	455	623	9795
Eagle	8/09	250	176	185	28	157	611
Mission	8/15	40	1030	240	157	83	1310
Whitefish	8/17	30	442	116	18	98	588
Nerka							
Fenno	8/07	0	2621	2106	2085	21	4727
Pick	8/21	0	2900	3910	1716	2194	6810
Lynx	8/22	200	664	688	250	438	1552
Hidden Lake	8/23	0	230	916	151	765	1146
Elva	8/25	0	54	45	27	18	99
Little Togiak River	8/25	0	2723	17	14	3	2740
Stovall*	8/22	200	800	400			1400

* Partial count; entire stream not surveyed.

TABLE 18. Age compositions (%) of sockeye spawners in the Wood River Lakes in 1998.

Location	Males						No. of fish	Females					No. of fish
	1.1	1.2	2.2	1.3	2.3	1.4		1.2	2.2	1.3	2.3	1.4	
Hansen	7.1	85.8	0.0	7.1	0.0	0.0	99	91.8	1.0	7.2	0.0	0.0	97
Happy	0.0	57.7	0.0	40.5	1.8	0.0	111	48.6	0.0	48.6	2.8	0.0	105
Bear	0.0	59.2	1.0	38.8	1.0	0.0	98	60.6	0.0	37.4	2.0	0.0	99
Ice	0.0	34.6	0.0	63.5	1.0	1.0	104	24.1	0.0	73.2	2.7	0.0	112
Agulowak River	0.0	24.3	0.0	75.7	0.0	0.0	107	7.5	0.0	92.5	0.0	0.0	80
Wood River	0.9	60.0	0.0	39.1	0.0	0.0	110	44.4	0.0	55.6	0.0	0.0	108
Fenno	1.0	68.8	0.0	30.2	0.0	0.0	96	63.3	0.0	35.7	1.0	0.0	98
Stovall	0.0	67.9	0.0	32.1	0.0	0.0	109	66.4	0.0	33.6	0.0	0.0	116
Lynx	0.0	60.7	0.0	39.3	0.0	0.0	112	43.6	0.0	56.4	0.0	0.0	110
Pick	0.0	56.1	0.9	43.0	0.0	0.0	107	57.1	1.0	41.9	0.0	0.0	105
LT River	0.0	54.3	0.0	45.7	0.0	0.0	105	24.3	0.9	74.8	0.0	0.0	115
N4-N6 beach	0.0	47.0	0.0	53.0	0.0	0.0	100	17.0	1.8	81.2	0.0	0.0	112
Hidden Lake	2.9	54.8	1.0	41.3	0.0	0.0	104	76.9	0.0	23.1	0.0	0.0	108
Anvil Bay beach	0.0	52.5	2.0	45.5	0.0	0.0	99	32.4	0.0	67.6	0.0	0.0	108
Agulukpak River	0.0	28.2	2.6	68.4	0.0	0.8	117	13.8	0.9	84.4	0.9	0.0	109
LT beaches	0.0	26.9	7.7	61.5	3.8	0.0	26	44.9	2.0	53.1	0.0	0.0	49
ABC creeks	0.0	72.0	4.0	24.0	0.0	0.0	25	70.0	0.0	30.0	0.0	0.0	30
Moose	0.0	88.0	0.0	12.0	0.0	0.0	108	88.0	0.0	12.0	0.0	0.0	108
Grant River	0.9	79.2	0.9	18.9	0.0	0.0	106	67.6	0.9	31.5	0.0	0.0	111
Unweighted mean	0.7	56.7	1.1	41.0	0.4	0.1	1843	49.6	0.4	49.5	0.5	0.0	1880
Wood River ADFG tower	0.1	67.3	3.5	28.0	0.1	0.0	539	69.1	4.1	26.1	0.6	0.0	533

ADF&G F age 1.1= 0.1%

TABLE 19. Daily counts of sockeye spawners in Hansen Creek, 1998.

Date	Estimate off mouth	In creek			In ponds			Total live	Total dead	Cumulative dead	Live+ cum. dead
		Live	Natural dead	Bear dead	Live	Natural dead	Bear dead				
Jul. 21		0	0	31	0	0	0	0	31	31	31
22		1294	1	8	0	0	0	1294	9	40	1334
23		889	55	70	69	0	0	958	125	165	1123
24		421	17	58	113	0	0	534	75	240	774
25		501	26	76	132	0	0	633	102	342	975
26		1102	85	100	129	0	0	1231	185	527	1758
27		631	31	100	117	0	0	748	131	658	1406
28		1079	70	241	169	0	5	1248	316	974	2222
29		2702	96	252	164	0	1	2866	349	1323	4189
30		3157	90	174	313	0	0	3470	264	1587	5057
31		3194	94	158	234	0	1	3428	253	1840	5268
Aug. 1		4155	87	223	181	0	2	4336	312	2152	6488
2		3631	67	226	216	0	2	3847	295	2447	6294
3		4020	147	355	265	1	9	4285	512	2959	7244
4		3784	208	349	382	4	1	4166	562	3521	7687
5		3381	217	195	392	2	1	3773	415	3936	7709
6		3940	267	315	213	6	1	4153	589	4525	8678
7		2320	402	295	233	5	1	2553	703	5228	7781
8		3147	212	188	273	7	0	3420	407	5635	9055
9		3522	336	303	242	1	0	3764	640	6275	10039
10		3028	460	563	234	11	11	3262	1045	7320	10582
11		2605	487	333	261	10	0	2866	830	8150	11016
12		2390	491	298	267	34	1	2657	824	8974	11631
13		1916	437	245	204	37	8	2120	727	9701	11821
14		1542	364	224	271	34	0	1813	622	10323	12136
15		1258	307	145	218	42	0	1476	494	10817	12293
16		895	279	99	203	38	0	1098	416	11233	12331
17		589	203	124	222	54	2	811	383	11616	12427
18		457	181	78	157	37	3	614	299	11915	12529
Totals			5717	5826		323	49				

Upper pond not counted

Dead fish removed on each survey.

TABLE 20. Summary of Hansen Creek spawning surveys, 1990–98.

Year	Date first fish entered	Survey date	Survey counts				Total from daily surveys	Percent peak count of total	Mortalities		
			Mouth	Live	Dead	Total			Natural dead	Bear- kill dead	Percent bear- kill
1990	7/28	8/1	??	3570	201	3771	6733	56	5139	1594	24
		8/6	25	4105	743	4873	6733	72			
1991	7/21	8/1	??	4460	1664	6124	16296	38	13671	2625	16
		8/6	500	8670	3735	12905	16296	79			
1992	7/18	8/1	??	4594	1085	5679	7292	78	5991	1301	18
		8/6	50	3518	2886	6454	7292	89			
1993	7/20	8/1	??	1359	685	2044	4212	49	2696	1516	36
		8/6	200	1482	1573	3055	4212	73			
1994	7/27	8/1	??	2314	718	3032	7413	41	3358	4055	55
		8/6	500	3205	1947	5652	7413	76			
1995	7/20	8/1	600	6509	2348	9457	17589	54	9854	7297	43
		8/6	100	7680	4425	12205	17589	69			
1996	7/18	8/1	1000	5076	1674	6750	9736	69	6476	2800	30
		8/6	200	3968	3345	7313	9736	75			
1997	7/18	8/1		1597	2183	3780	8845	43	3969	4831	55
		8/6	300	2163	3804	5967	8845	67			
1998	7/21	8/1		4336	2152	6488	12529	52	6040	5875	49
		8/6		4153	4525	8678	12529	69			