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ALASKA SALMON RESEARCH

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ANNUAL REPORT—1996

TO

BRISTOL BAY PROCESSORS

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Approved

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Acknowledgments

The contribution of graduate student research to our program is vital. In 1996, Alyssa Reischauer and Dan Eastman (Wood River system) and Paul Schlenger, and Frank Leonetti (Kvichak system) completed their MS theses while Troy Hamon, Doug Peterson, and Andrew Hendry conducted their thesis research. Other University of Washington students working on the program in 1996 were Megan McPhee, Kristina Ramstad, Megan Ferguson, Jason Griffith, Cimbal Irwin and Nicholas Kocan (high school student). We especially appreciated the assistance of several volunteers: John Field, Mike Kinnison, Claribel Coronado, and Richard Brocksmith.

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Key Words

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

ALASKA SALMON RESEARCH

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INTRODUCTION

Fisheries Research Institute was established in 1946 with the financial support of the major Alaskan 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 have been to determine how to maintain the high production (what has caused year-to-year variation) and how to harvest and process salmon most efficiently (e.g., accurate forecasts and fishing evenly distributed throughout the run).

We presently have salmon research projects in Bristol Bay, the 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. In 1996, Dr. Ole Berg (Norway) and Dr. Victor Bugaev (Russia) joined us in our field research.

This report is focused on our 1996 Bristol Bay research emphasizing salmon forecasting and research relevant to escapement policies for maximizing production. Our Chignik and Alaska Peninsula annual reports will be submitted in February.

FORECASTING

Preseason Forecasts

Forecasts of the 1997 Bristol Bay sockeye salmon (*O. nerka*) runs and catches were provided to participating processors at our October 1996 meeting (Rogers 1996). They are presented in Table 1 with the ADFG forecasts and the past forecasts and runs beginning in 1987. The two river system forecasts (FRI and ADFG) are based on the same data sources, but different analytical methods have often been used. Both 1996 forecasts were for a large run and catch, and the actual run (37 million) and catch (30 million) were smaller than forecast but within 20% of the forecasts. The outlook for 1997 is for the smallest run and catch since 1988. Egegik is expected to produce nearly 40% of the Bristol Bay run in 1997.

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). This will be confirmed if there is a very large smolt migration from the Kvichak in 1997 containing both age 1 and age 2 smolt.

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-in stretched mesh. The web is multistrand monofilament (center core). Since 1994, we have used the fishing vessel *Cape Cross* . Fur stations have been fished along a transect 33 to 63 nm out from Port Moller (13 to 43 nm from point to point coastline); however, in 1995 we also made some drifts at stations 0 and 10 (3 and 53 nm from the coastline) and in 1996 we made 3 drifts at station 0. 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 the scales were aged and the age compositions and average lengths by age were reported.

Since 1987, the forecasts have been very accurate. The runs have differed from the forecasts made on June 25 and 30 by an average of 20%, and we have been 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 1996, the Bristol Bay run was earlier than average although not as early as the 1993 run (Fig. 1). The distribution of the sockeye as they passed Port Moller was somewhat unusual in 1996 as the sockeye were located closer to shore than in past years and were especially scarce at the outermost station (station 8; Fig. 2). The test-fish catches projected that the 1996 run would be early in timing but still overforecast the run magnitude because the run was distributed closer inshore and the sockeye were larger than average and thus more vulnerable to the 5 in mesh.

ADFG (B. Cross, Anchorage) provided preliminary length and weight statistics for 1996, 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 1996 run were about average in length; however the average length of all sockeye in the run was well above average because 3-ocean fish constituted 76% of the 1996 run. Because there were higher percentages of 3-ocean fish in the eastside districts, the average sockeye caught there was about 20% heavier than the sockeye caught in the Nushagak district (Tables 4 and 5).

In 1996, the Port Moller test fishery provided an early indication to ADFG management that a large run was on the way, and the age composition suggested a large Egegik run. Although there was some overescapement in the Wood and Igushik rivers, the escapements in 1996 were closer to the goals than in any of the past 7 years (Table 6). Considering the situation in the Naknek/Kvichak district (a large Naknek run and small Kvichak run), management of the fishery was very good with a 84% harvest rate on the Naknek run and only 58% on the weaker Kvichak run. Good catches were made in all districts before large numbers of fish were counted past the towers.

LAKE RESEARCH

During the summer of 1996, 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. However, funding was reduced by about 30% in 1996 and this required that we reduced our field work in the Wood River Lakes by 1 week and in the Kvichak by 2 weeks. 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 1996, we also conducted special studies of bear predation on spawning sockeye salmon and the effects of spawning salmon on stream biota, especially insects. In addition, we provided a crew to ADFG for their Nuyakuk escapement enumeration and paid for the flying time necessary for ADFG to conduct aerial surveys of the Wood River spawning grounds.

Kvichak System

Our 1996 field season in the Kvichak system (Lakes Iliamna and Clark) consisted of the following: estimating the sockeye salmon escapement into the Newhalen River in late June and July, townetting for juvenile sockeye salmon and threespine stickleback (*Gasterosteus aculeatus*) in upper Lake Iliamna in August, and conducting spawning ground surveys in late August to collect otoliths for sockeye age determination. We did not tow in Lake Clark nor survey several spawning grounds that are usually sampled in September. In addition, we greatly curtailed our studies on the ecological relationship between sockeye salmon and sculpins, genetic differentiation of sockeye salmon spawning populations and spawning behavior of sockeye salmon.

Two MS theses were completed in 1996 on field work carried out in 1995. Studies of the potential competition between juvenile sockeye salmon and least cisco (*Coregonus sardinella*) in Lake Clark (Schlenger 1996) and the spawning behavior of island beach spawners in Lake Iliamna (Leonetti 1996) were completed. In addition, a paper on the effects of varying sex ratios on spawning behavior of Lake Iliamna beach spawners was published (Quinn et al. 1996)

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 day and night migration rates do not differ. The daily counts at Newhalen are compared with those from 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.

The cumulative daily escapements for the two rivers, timed to the Kvichak River, are given for 1991–96 (Table 7). In mid-July, milling fish often swim upriver along the banks of the Newhalen and are counted only to drift uncounted 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 proportion of the Newhalen count to Kvichak 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 1996, we estimated that only 36,000 of the Kvichak escapement of 1.45 million (about 2%) migrated to the Newhalen/Lake Clark system (Table 8). The aerial surveys conducted by ADFG in 1996 (Regnart 1996) provided an estimate of the Newhalen River spawners (4,000) and, thus, by subtraction, an estimate of the Lake Clark escapement of only 32,000, the smallest number on record.

Spawning Ground Surveys.—Each year since 1956, we have collected scales or otoliths from spawned-out sockeye salmon from nine major spawning grounds in the Kvichak River system. In 1996, we only sampled four of these in Lake Iliamna—three beaches and one river (Table 9). Overall, the age pattern was similar to the composition of the entire lake system (Kvichak escapement). However, age 1.3 fish were scarce in the island beach populations and age 1.2 fish were somewhat scarce in the Gibralter River samples.

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 1996 survey were reported by Regnart (1996). These are summarized for 29 spawning grounds (Table 10). Aerial counts accounted for 17.8% of the relatively small (tower count) escapement into the Kvichak system. This percentage is higher than average for recent years but comparable to percentages counted in the 1960s and 1970s. Most of the 1.45 million escapement in 1996 returned to the rivers in Lake Iliamna with very low numbers of spawners on the lake beaches and in Lake Clark.

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. In 1996, we sampled 11 sites in the eastern portion of Lake Iliamna. The geometric means of the catches per 20-min trawl provide a measure of the relative density. The mean lengths of fry adjusted to their predicted size on September 1 (based on daily growth estimates) provide a measure of the growing conditions for that year and can be used to estimate the proportion of fry that will migrate to the ocean at age 1 or 2.

The sockeye salmon fry of Lake Clark are usually smaller than those in Lake Iliamna because of the lower productivity of the lake, which results from both colder water temperatures and increased turbidity. In 1996, sockeye fry from Lake Iliamna averaged 62 mm and were slightly larger than the long-term average of 57 mm (Table 11). On the basis of an average size of 62 mm for Iliamna fry on September 1, we estimate that about 70% of fry resulting from the 1995 brood year will smoltify and migrate to sea in spring 1997, and about 60% of the adult production from the 1995 escapement of 10 million will return at age 1.2 in 1999.

Predation of Sockeye Eggs by Coastrange and Slimy Sculpins.—Since 1992, we have monitored the predatory intensity of sculpin species (*Cottus cognatus* and *C. aleuticus*) on sockeye salmon eggs during the sockeye spawning season. In 1996, we limited our work to surveys to the relative abundance and size of sculpins on some island beaches. If sculpin predation on sockeye eggs is a major factor in the cyclic nature of island beach spawners as we have hypothesized, then in years of low sockeye abundance, like 1996, sculpins should have a greater impact on the sockeye than in years of high spawner abundance. However, this was not the case in the three beaches surveyed in 1996. While sockeye abundance was the lowest observed in 5 years, the relative numbers of sculpins was even lower. Further, the large size classes of sculpins that can eat the most eggs and which have dominated in our previous surveys, were largely absent in 1996. Sculpins appear to have significant effects on sockeye spawning (duration and coordination) but, so far, not on the cycle of sockeye production.

Pedro Bay Spawning and Predation Studies.—In addition to river and beach spawning populations, Lake Iliamna also has a number of sockeye salmon populations that spawn in ponds fed by cold spring water. Pond spawning gravel has a very high proportion of fines in the spawning gravel, as would be expected from the low, controlled underground spring water flows. For the past 3 years, we have measured various aspects of the spawning ecology and behavior of sockeye salmon in the Pedro Bay ponds in an attempt to determine whether they have specifically adapted to this unique spawning (and possibly rearing) environment.

In 1996 we continued our observations of patterns of sockeye salmon habitat use and predation by brown bears.

Previous observations had revealed a low predation rate in 1994 (10% of males and 4% of females killed) and a high rate in 1995 (97% of males and 70% of females killed). However, salmon inevitably die after spawning, so predation by bears is not important for salmon unless it takes place before the females spawn. In 1994 and 1995, the great majority of females killed by bears had already spawned; however, in 1996 a relatively small population of spawning salmon and an exceptional abundance of bears resulted in 100% predation during our period of observation. Virtually no male salmon were seen and the ponds that had supported thousands of spawners in previous years had only a few redds. In all but the largest pond, most salmon were killed within a day of arrival. This heavy predation precluded sampling for age and size but will present a rare opportunity to examine the population-level response in subsequent years to the low number of spawners in 1996.

Sockeye Spawning Behavior Studies.—In 1996, we extended our studies on the role of color in spawning behavior. We are interested in the role of carotenoid-based red skin pigment in mate selection. Carotenoids are plant synthesized compounds that are bio-accumulated throughout the food chain. Sockeye salmon get their carotenoids largely from krill in the ocean. Carotenoids account for the orange-red color of sockeye salmon flesh. With the help of visiting scientists from the Universities of Victoria and British Columbia, and the US Fish and Wildlife Service, we measured the spectral characteristics of island beach waters and spawning sockeye salmon. We then tested what aspects of color (wavelength and brightness) male sockeye respond to in controlled experiments conducted on the spawning beaches. Males responded mainly to wavelength and only secondarily to brightness. Therefore, males can use color (wavelength) to select mates even during dusk and dawn when brightness is much reduced. Higher wavelengths (red) are relatively more abundant during these periods (accounting for red sunsets and sunrises); thus, the color red may provide an enhanced effect throughout most of a 24-h period.

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 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.

In 1996, our field season was shortened by 1 week, which resulted in the loss of townetting in the north arm of Lake Nerka, zooplankton and temperature sampling in the upper lakes, and the collection of otoliths for age determination from 4 of the 21 spawning grounds that we normally survey. During 1996, an MS thesis was completed on the impact of spawning sockeye salmon on resident fish—rainbow trout (*O. gairdneri*), Arctic char (*Salvelinus alpinus*), and Arctic grayling (*Thymallus arcticus*). Rainbow trout and char depended heavily on salmon eggs while grayling consumed very few (Eastman 1996). Another MS thesis was completed on a comparison of zooplankton populations in lakes with and without sockeye salmon. Zooplankton densities generally declined towards the end of the summer in those lakes with juvenile sockeye (presumably from predation), whereas there was a general late-summer increase in zooplankton in the lakes without salmon (Reischauer 1996).

Effects of Spawning on Invertebrates.—A new study was conducted in 1996 that focused on the impact of salmon spawning (redd excavation) on the substrate and aquatic community of two small streams. Observations in Bear and Whitefish creeks on Lake Aleknagik included assessment of changes in the physical habitat (gravel size), periphyton density, invertebrate density, and the foraging of resident fishes. Preliminary results indicate that a substantial increase in invertebrate drift accompanies the entry of spawning sockeye into the streams. This may result in an increase in available food for resident fishes.

Environmental Observations.—Spring 1996 was early and ice breakup in Lake Aleknagik (recorded since 1949) was 7 d earlier than average (Table 12 and Fig. 3). Early summer water temperatures were above average because solar radiation (sunlight) was above average during early June; however, for the entire summer, solar radiation was again lower than during the 1960s to early 80s. Water temperatures actually declined from early August to early September. Lake levels were well below normal in early June as a result of a small snow pack and lake level continued to be well below average for the remainder of the summer. Standing crop of phytoplankton (chlorophyll) was below average throughout the summer (fifth lowest since 1963), whereas zooplankton volumes were a little above average until September (Fig. 4). Zooplankters are the main source of food for juvenile sockeye salmon after they move offshore in late July. 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

1996 (mid-July) corresponding with the early ice breakup. In past years, midge emergence has usually peaked in either late July or early August (Table 13). Water temperature at the nearshore insect traps was warmer than average in 1996, but no records were set.

Fry Abundance and Growth.—In 1996, the sockeye salmon fry in Lake Aleknagik were 3% longer than average in June, but their growth during July and August was below average, and on September 1 they were 2% shorter than average (Table 14). Fry abundance, as measured by beach seine sampling in June and July and townet sampling around September 1, was only 34% below the long-term average. The number of parent spawners (482,000) in Lake Aleknagik in 1995 was above average for the lake. The relatively small size on September 1 indicates that the fry and sticklebacks had cropped down their main food supply, especially the larger forms of the zooplankton such as calanoid copepods, *Holopedium* and *Daphnia* (Table 12). The adult 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 1996, growth was above average; however, we were unable to tow in the north arm of the lake. Townet catches were above average in the central region of the lake (Table 15). Juvenile sockeye salmon in the Wood River Lakes system exhibit density-dependent growth, and we are analyzing our long-term data set for Lake Aleknagik to determine the relative effects of physical and biological factors in the lake 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. 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 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 1996, we caught, measured and examined stomach contents of 40 char during June 16-20 (Table 16). The char were about average in length and a typical percentage (42%) contained sockeye salmon smolt in their stomachs.

Spawning Ground Surveys.—Surveys of sockeye salmon spawning grounds have been conducted annually in the Wood River Lakes system since 1946; however, it was not until the early 1950s that all of the 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. 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 1996. The ground survey counts in 1996 for the major creek spawning grounds are given in Table 17. The creeks draining into Lake Aleknagik again contained relatively high counts of spawners. Hansen Creek contained a large number of spawners for the seventh consecutive year. Age compositions on the spawning grounds in 1996 varied in a typical manner with 3-ocean fish prominent in the rivers and some creeks while 2-ocean fish were preponderant on the beaches and creeks in Lake Nerka (Table 18).

Bear Predation.—We completed the seventh 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 18 July to 24 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 2,800 (30%) of 9,736 spawners were killed by bears in 1996 (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 1996 was about average for the 7-year period. Our experiences during stream surveys in 1995 suggested that the bear population had increased in the Wood River Lakes system; however, bear sightings were greatly reduced in 1996. We plan to continue the daily surveys in Hansen Creek until we obtain counts for a year when the number of spawners is near the median (2,500) and for a year when there is a small number of spawners (<1,000).

The daily counts on Hansen Creek are also providing 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 about July 22–25. On the basis of daily counts in 1990–96, if the surveys had been conducted on the single date of August 6, the peak survey counts would have been 69% 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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Figures

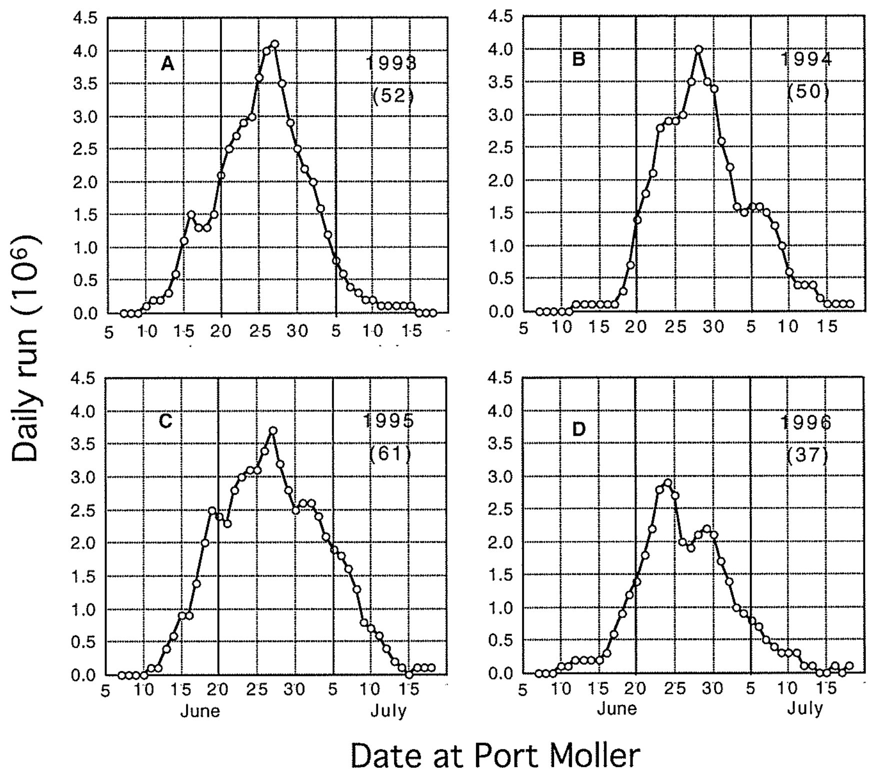

Figure 1. Daily Bristol Bay sockeye salmon runs reconstructed at Port Moller.

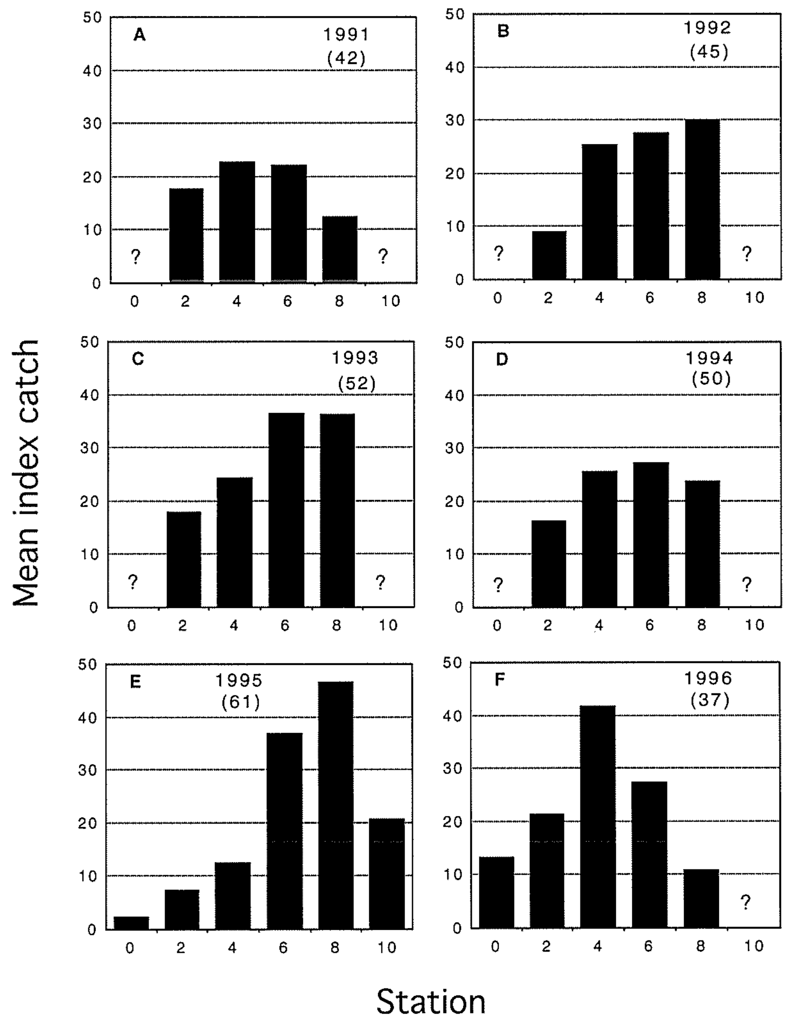

Figure 2. Average catches of sockeye salmon at Port Moller stations, June 11–July 5, 1991–96.

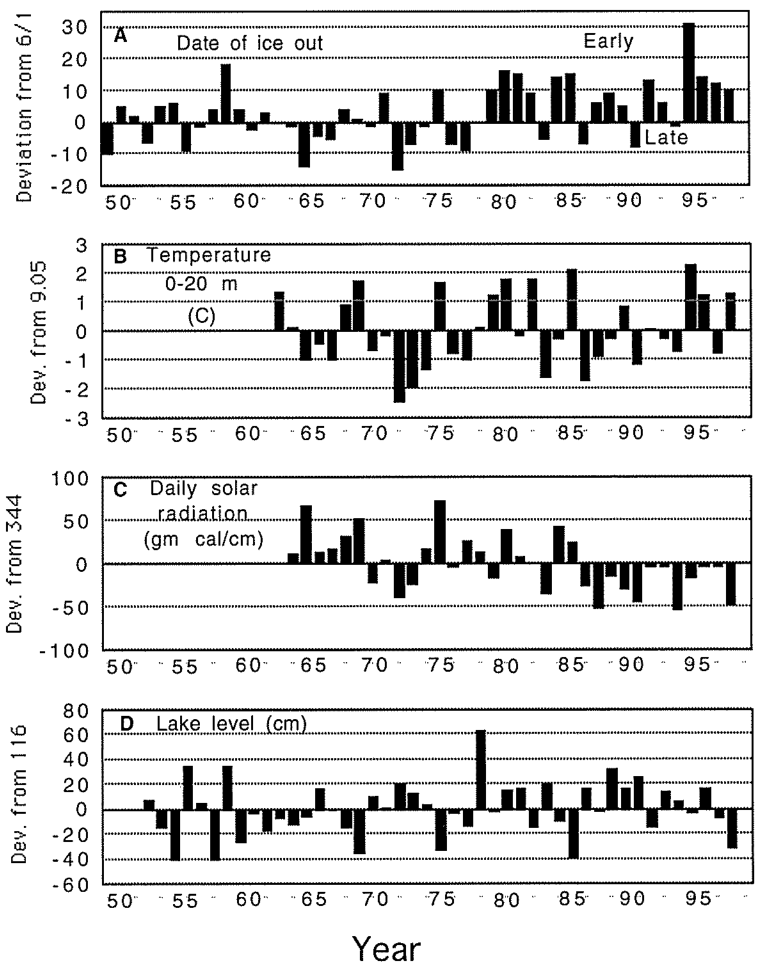

Figure 3. Annual deviations from averages of dates of ice out and summer averages of water temperature, solar radiation, and lake level in Lake Aleknagik.

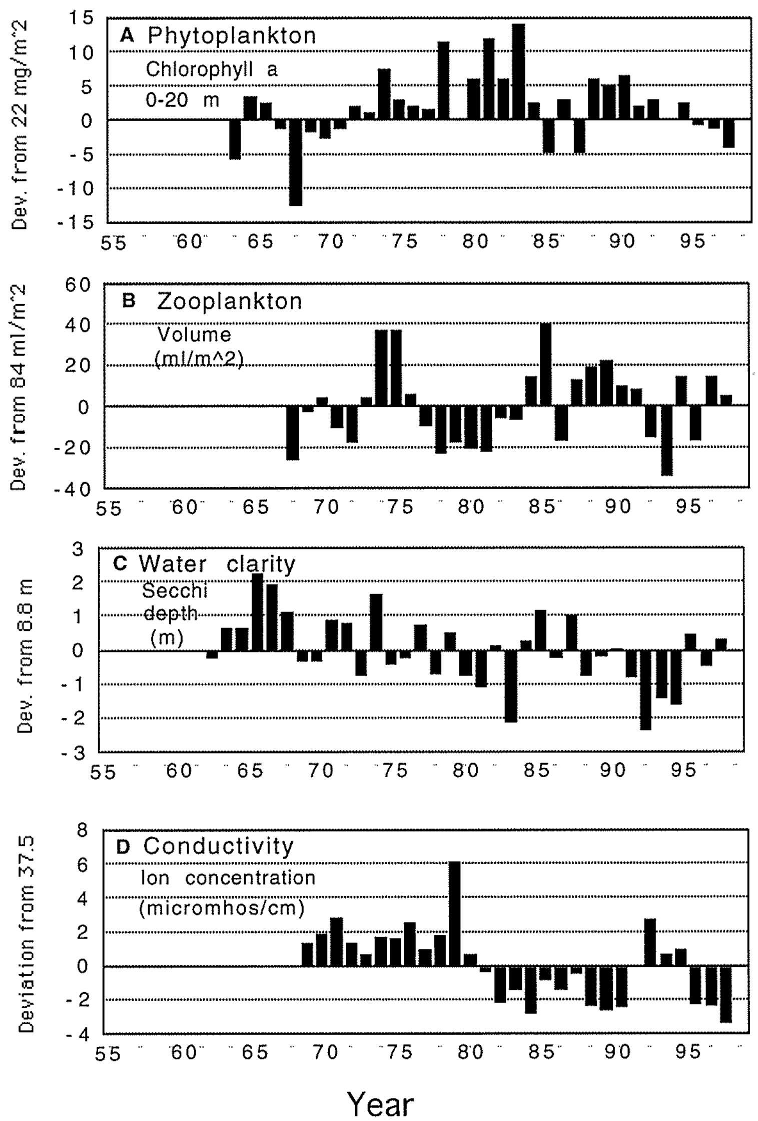

Figure 4. Annual deviations from averages of phytoplankton and zooplankton densities, water clarity, and conductivity in Lake Aleknagik.

Tables

Table 1. Preseason forecasts of Bristol Bay sockeye salmon inshore runs.

Year	Forecast/run	Kvichak	Naknek	Egegik	Ugashik	Nushagak	Total run	Catch	%Error
1987	FRI	2.8	2.0	5.8	3.1	5.1	19.5	12.4	29
	ADFG	2.7	2.1	4.9	3.1	3.3	16.8	9.3	78
	Actual run	9.6	2.4	6.6	2.8	5.2	27.4	16.0	
1988	FRI	12.3	3.1	6.2	3.1	5.0	30.6	20.8	34
	ADFG	9.3	2.5	5.6	3.2	5.6	26.5	16.8	18
	Actual run	6.7	1.7	8.1	2.2	3.2	23.0	13.8	
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	
	ADF&G	6.9	3.3	12.8	3.8	5.7	33.6	24.8	

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			Run pred. on 7/3			Catch pred. on 7/3		
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
Means	43	30	42	0	5	41	1	8	40	3	8	27	3	13
absol.				8	21		7	19		5	12		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.

1993-96 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 run.

Year	BB run (millions)	2-ocean Male	2-ocean Female	2-ocean Combined	3-ocean Male	3-ocean Female	3-ocean Combined	Both age groups	Percent 3-ocean
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
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
88-96	47	517	501	509	578	555	566	536	46

Table 4. Average weights of sockeye salmon (lbs) in commercial catches on the east side of Bristol Bay, 1985–96.

		Catch	2-ocean			3-ocean			All	All	All	Percent	Percent
District	Year	millions	Male	Female	Comb.	Male	Female	Comb.	males	females	fish	3-ocean	females
Nak/Kvi	1985	8.2	5.1	4.5	4.9	6.9	6.3	6.6	5.9	5.4	5.6	51	49
	86	2.9	5.4	4.7	5.0	7.2	6.2	6.6	6.7	5.8	6.2	73	59
	87	5.0	5.3	4.5	4.9	7.6	6.5	7.0	6.0	5.2	5.6	34	52
	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
	Means	10.3	5.2	4.5	4.8	7.2	6.1	6.6	6.1	5.3	5.7	49	51
Egegik	1985	7.5	5.6	4.8	5.2	7.6	6.5	7.1	6.4	5.6	6.0	44	48
	86	4.9	5.8	5.0	5.4	7.2	6.3	6.7	6.2	5.4	5.8	31	56
	87	5.4	5.2	5.1	5.2	7.8	6.5	7.0	6.4	5.8	6.1	48	55
	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
	Means	10.3	5.3	4.7	5.0	7.3	6.2	6.7	6.2	5.4	5.8	48	51
Ugashik	1985	6.5	5.6	4.7	5.2	7.3	6.3	6.9	6.2	5.4	5.8	38	43
	86	5.0	5.9	5.0	5.5	7.8	6.4	7.1	6.9	5.8	6.2	55	49
	87	2.1	5.5	4.9	5.2	7.9	6.7	7.3	6.9	6.0	6.5	61	47
	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
	Means	3.6	5.3	4.6	5.0	7.4	6.3	6.9	6.4	5.5	6.0	52	46

Table 5. Average weights of sockeye salmon (lbs) in commercial catches on the west sides of Bristol Bay, 1985–96.

		Catch	2-ocean			3-ocean			All	All	All	Percent	Percent
District	Year	millions	Male	Female	Comb.	Male	Female	Comb.	males	females	fish	3-ocean	females
Nushagak	1985	1.3	5.2	4.6	4.9	7.4	6.3	6.8	6.7	5.8	6.3	70	49
	86	2.7	4.7	4.5	4.6	7.3	6.1	6.6	6.9	5.9	6.3	86	55
	87	3.3	5.2	4.5	4.9	8.3	6.5	7.2	6.9	6.0	6.4	65	53
	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
	Means	3.3	4.8	4.3	4.6	7.3	6.0	6.6	6.5	5.5	6.0	70	53
Togiak	1985	0.1	5.0	4.4	4.6	7.7	6.0	6.7	7.3	5.8	6.4	85	59
	86	0.2	5.8	4.7	5.2	7.4	6.0	6.6	7.1	5.8	6.4	84	55
	87	0.3	5.9	4.9	5.5	8.6	6.9	7.6	7.5	6.4	6.9	68	55
	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
	Means	0.4	5.8	4.8	5.3	8.3	6.4	7.3	7.8	6.2	6.9	82	54

Table 6. Sockeye salmon escapement (in millions) in excess of management goals for Bristol Bay rivers, 1989–96.

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

*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, 1991–96. Numbers (1,000s) and Newhalen escapements estimated from expanded counts lagged back 2 d for 1991–96, 3 d for 1996.

	1991		1992		1993		1994		1995		1996	
Date	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen
6/22					13							
23			0		24		0					
24			1		34		0				0	0
25	0		2		51	6	0		0		4	0
26	1		10		121	67	1		41	7	25	1
27	3		17		317	78	8		361	28	37	1
28	50	7	81	5	559	157	24		724	48	40	1
29	125	46	255	18	847	237	25		941	75	41	1
30	277	95	446	67	932	394	25		1113	109	42	2
7/1	588	146	635	88	1014	492	26	0	1610	158	47	2
2	901	188	754	104	1081	650	30	1	2338	255	90	2
3	1256	330	798	132	1182	816	254	1	2798	309	224	3
4	1581	517	1093	196	1307	937	1550	321	3105	364	318	4
5	1925	620	1663	273	1678	1022	2727	558	3346	398	361	6
6	2141	805	2244	329	2372	1103	3518	775	3983	430	385	7
7	2208	1132	2688	406	2733	1121	4273	921	4937	482	420	7
8	2277	1531	2880	534	2932	1134	5132	1091	5930	581	468	8
9	2355	1721	2960	661	3101	1163	5821	1286	7020	687	568	15
10	2633	2048	2985	840	3264	1189	6473	1601	7683	805	669	22
11	3080	2202	3175	977	3402	1220	7058	1884	8005	1050	769	23
12	3460		3662	1057	3574	1268	7268	2168	8169	1199	860	25
13	3724		4066	1158	3751	1322	7330	2372	8430	1226	1035	
14	3822		4330	1258	3818	1353	7382	2450	8658	1378	1160	
15	3909		4438	1434	3864		7495	2535	8878		1238	
16	3999		4517	1491	3894		7540	2578	9017		1310	
17	4063		4578		3921		7631		9131		1332	
18	4098		4626		3958		7852		9248		1353	
19	4132		4685		3986		8099		9512		1397	
20	4166		4695		3996		8169		9703		1422	
21	4193		4710		4008		8193		9788		1436	
22	4213		4720		4016		8265		9876		1445	
23	4220		4726		4021		8338		9919		1451	
24					4024				9954			
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	*0.07*	--	--	4
1991	4.22	1.93	46	*0.10*	--	--	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

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 1996.

Spawning ground	Sex	Sample size (n)	Age composition (%) 2.1	1.2	2.2	1.3	2.3
Gibralter River	M	96		4.2	6.3	58.3	31.2
	F	93		4.3	22.6	51.6	21.5
Copper River	M	0					
	F	0					
Chinkelyes Creek	M	0					
	F	0					
Newhalen River	M	0					
	F	0					
Tazimina River	M	0					
	F	0					
Woody Island beaches	M	48		37.5	35.4	0.0	27.1
	F	50		24.0	32.0	4.0	40.0
Fuel Dump Island beach	M	49	2.0	40.8	20.4	4.1	32.7
	F	50		40.0	30.0	2.0	28.0
Knudson Bay beach	M	84		36.9	26.2	10.7	26.2
	F	58		41.4	24.1	12.1	22.4
Pedro Creek ponds	M	0					
	F	0					
Kvichak escapement	M	610	0.3	11.1	24.6	24.9	38.7
(ADF&G,Igiugig)	F	695		17.4	27.2	24.9	30.5

Table 10. Estimates of sockeye salmon spawners on 29 spawning grounds in Lake Iliamna and the Newhalen River system.

	Aerial survey counts (1,000s)					Tower count	Aerial count/	
			Beaches			escapement	Escapement	Aerial
Year	Rivers	Creeks	Mainland	Island	Total	(1,000s)	(%)	observer
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
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
91-96	309	143	35	55	542	5467	10.8	7

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

	Kvichak	Lake Iliamna		Lake Clark	
Brood year	escapement (millions)	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	-	-

Lake Iliamna tows in areas 7 & 8 only.

Table 12. Summary of 1996 measurements in Lake Aleknagik.

Measurement and first year measured	Dates	1996	All years Average	All years Range
1. Date of ice breakup 1949-		5/22	5/29	5/01-6/16
2. Water temperature, 0-20m (C) 1958-	6/22	7.0	5.8	3.7, 9.2
	7/16	9.4	8.4	5.7, 12.0
	8/3	12.7	10.8	7.7, 14.0
	9/1	12.3	11.2	9.3, 13.0
3. Water transparency Secchi depth (m) 1962-	6/22	8.8	8.0	5.3, 10.5
	7/16	8.7	8.2	5.0, 10.9
	8/3	9.4	9.3	6.3, 11.9
	9/1	9.5	9.2	5.8, 12.1
4. Water conductivity (micromhos/cm) 1968-	6/22	31.1	38.2	31.1, 52.1
	7/16	35.7	37.1	33.5, 42.6
	8/3	34.5	36.9	32.5, 40.5
	9/1	35.5	38.0	34.8, 47.9
5. Average daily solar radiation (gm/cal/cm) 1963-	June 1-15	502	408	305, 588
	June 16-30	320	409	265, 572
	July 1-15	339	385	284, 543
	July 16-31	234	355	194, 481
	Aug. 1-15	295	301	203, 402
	Aug. 16-31	226	257	170, 421
	Sept. 1-15	174	206	114, 282
6. Lake level (cm) of Lake Nerka 1952-	June 1-15	118	143	84, 222
	June 16-30	97	150	97, 218
	July 1-15	89	131	75, 199
	July 16-31	83	106	54, 172
	Aug. 1-15	70	86	34, 173
	Aug. 16-31	54	82	30, 184
	Sept. 1-15	45	82	29, 161
7. Chlorophyll "a", 0-20m (mg/m2) 1963-	6/22	24	29	10, 45
	7/2	11		
	7/16	13	27	10, 43
	7/22	10		
	8/3		22	6, 36
	8/13	22		
	8/24	4		
	9/1	19	24	12, 37
8. Zooplankton volume 0-60m (ml/m2) 1967-	6/22	56	52	20,168
	7/2	76		
	7/16	104	85	45-162
	7/22	166		
	8/3	143	119	43-226
	8/13	139		
	8/24	59		
	9/1	52	62	26-107

Table 13. Five-day averages of catches of emergent midges and water temperatures at three stations on Lake Aleknagik, 1996.

5-day	Catch per day							Water temperature (°C)						
	1996				1969-96			1996				1969-96		
period	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	10	7	2	6	9	0	70	8.8	5.4	8.7	7.6	5.6	0.0	10.4
11-15	10	4	1	5	11	1	53	10.1	8.4	10.4	9.6	6.8	1.0	12.1
16-20	4	1	1	2	15	1	168	8.1	9.3	10.8	9.4	8.5	3.9	12.7
21-25	5	1	0	2	6	0	42	6.7	8.8	11.0	8.8	9.0	4.8	12.8
26-30	7	1	2	3	4	0	12	9.4	10.0	11.6	10.3	9.9	6.0	13.9
7/1-5	4	0	28	11	6	1	16	13.2	11.7	15.7	13.5	11.0	7.7	15.5
6-10	2	10	32	14	12	2	69	11.3	11.5	15.2	12.7	11.9	9.6	16.0
11-15	3	21	25	16	14	1	34	9.6	11.2	13.2	11.3	12.4	9.2	17.9
16-20	16	86	7	36	15	2	36	13.1	14.0	13.5	13.5	12.3	8.5	17.0
21-25	16	54	2	24	20	2	74	13.5	16.5	15.7	15.2	12.8	7.9	17.2
26-30	5	11	11	9	27	5	59	8.7	12.7	13.6	11.7	13.5	8.9	16.1
31-4	10	2	1	5	27	4	77	11.4	11.9	12.3	11.9	13.6	10.2	17.5
8/5-9	10	1	1	4	20	3	80	12.3	12.6	13.4	12.8	13.6	10.4	17.1
10-14	16	2	5	8	15	1	54	13.2	13.5	14.0	13.6	13.6	9.5	18.8
15-19	6	6	4	5	13	1	70	14.1	14.6	15.2	14.6	13.6	11.0	16.2
20-24	2	0	0	1	6	0	28	13.5	14.0	14.5	14.0	13.6	9.7	15.4
25-29					5	1	11					13.3	11.3	14.7
30-3					6	1	13							

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.

	Sockeye salmon fry					Sockeye	Threepine stickleback					
Year	Mean beach seine catch	Mean length on 6/23 (mm)	Mean length on 9/1 (mm)	Growth rate (mm/ day)	Mean tow net catch	Escape- ment in year-1 (1000s)	Mean beach seine catch	Mean length on 6/23 (mm)	Mean length on 9/1 (mm)	Growth rate (mm/ day)	Mean tow net catch	Age 0 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	23	33.7	56.4	.33	10	357	55	31.7	46.5	.22	3	<1
94	21	32.0	51.7	.29	121	417	31	30.3	46.6	.24	38	2
95	34	32.0	53.9	.31	24	483	33	31.5	46.0	.21	181	31
96	21	32.6	54.8	.32	100	482	43	32.6	47.1	.21	103	7
Means	147	31.5	55.8	.35	51	325	133	31.1	44.5	.19	78	11

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.

	Sockeye salmon fry						Sockeye salmon spawners in year-1 (1000s)			Threespine stickleback	
	Mean tow-net catch			Mean length (mm) on 9/1						Mean tow-net catch	Mean length (mm) on 9/1
Year	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		160	158	210	1	49
Means	13	17	39	60	57	57	111	115	242	17	45

Table 16. Occurrence and numbers of juvenile sockeye in stomachs of Arctic char 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
72-96 means	6/4		102	428	18	40	1.2	2.2	30

Table 17. Ground survey counts of sockeye salmon spawners in the Wood River lakes, 1996.

Location	Date	Estimated off mouth	In creek Live	Dead	Natural	Bear kill	Total
Aleknagik							
Yako	8/01	1000	2847	407	227	180	4254
Hansen	8/06	200	4868	3021	1708	1313	8089
Bear	8/05	2000	3266	661	350	311	5927
	8/19	300	1656	3981	2550	1431	5937
Happy	8/08	200	3129	5729	3959	1770	9058
Ice*	8/09	3000	7490	2955	2727	228	13445
Eagle	8/14	2	889	304	122	182	1195
Mission	8/12	200	705	314	96	218	1219
Whitefish	8/11	300	410	216	81	135	926
Nerka							
Fenno	8/10	0	2003	1661	1608	53	3664
Pick	8/21	100	2684	3069	2991	78	5853
Lynx	8/20	1000	4053	1517	629	888	6570
Hidden Lake	8/22	150	1641	2514	964	1550	4305
Elva	8/21	400	53	42	40	2	495
Little Tigiak River	8/26	850	4196	20	20	0	5066
Kema*	8/27	0	69	300			369
Beverley							
Moose*	8/12	0	428	363	114	249	791

* Partial count; entire stream not surveyed.

Table 18. Age compositions (%) of sockeye spawners in the Wood River Lakes in 1996.

Location	Males 1.1	Males 1.2	Males 2.2	Males 1.3	Males 2.3	No. of fish	Females 1.1	Females 1.2	Females 2.2	Females 1.3	Females 2.3	No. of fish
Hansen	0.0	61.1	3.6	33.2	2.1	185	0.0	68.8	2.4	27.0	1.8	204
Happy	0.0	14.1	0.0	83.8	2.0	99	0.0	23.5	0.0	76.5	0.0	98
Bear	1.0	23.5	1.0	72.5	2.0	102	0.0	22.4	0.0	74.8	2.8	107
Ice	0.0	0.0	0.0	96.3	3.7	109	0.0	5.4	0.0	88.4	6.2	112
Agulowak River	0.0	2.8	0.0	93.6	3.6	109	0.0	2.8	0.0	89.7	7.5	107
Wood River	0.0	70.8	0.0	29.2	0.0	48	0.0	84.5	0.0	12.4	3.1	97
Fenno	0.0	77.9	0.0	22.1	0.0	104	0.0	89.2	0.0	10.8	0.0	102
Stovall	0.0	74.8	0.0	25.2	0.0	103	0.0	92.3	0.0	7.7	0.0	78
Lynx	0.0	94.9	0.0	5.1	0.0	99	0.0	99.0	0.0	1.0	0.0	98
Pick	0.0	75.0	0.0	25.0	0.0	84	0.0	74.1	0.0	25.9	0.0	143
LT River	0.0	84.0	0.0	16.0	0.0	100	0.0	74.7	0.0	24.2	1.0	99
N4-N6 beach	0.0	72.2	0.0	27.8	0.0	108	0.0	79.2	0.8	20.0	0.0	120
Kema	0.0	35.3	1.5	63.2	0.0	68	0.0	73.0	0.0	27.0	0.0	100
Hidden Lake	0.0	88.8	0.0	11.2	0.0	98	0.0	96.2	0.0	3.8	0.0	104
Anvil Bay beach	0.0	78.4	0.0	20.6	1.0	102	0.0	85.2	0.0	14.8	0.0	108
Agulukpak Rtver	0.0	10.9	0.0	85.9	3.3	92	0.0	10.9	0.0	80.9	0.0	110
LT beaches												
A, B, & C creeks												
Moose	0.0	62.1	0.0	36.8	1.1	95	0.0	73.8	0.0	26.2	0.0	103
Grant River												
Kulik beaches												
Unweighted mean	0.1	54.5	0.4	44.0	1.1	1705	0.0	62.1	0.2	35.9	1.3	1890
Wood River ADFG tower	0.0	33.4	0.2	59.2	5.3	445	0.0	56.7	1.0	37.0	2.9	703

Age 0.3: M 1.4%, F 0.3%; age 0.2: M 0.6%; age 1.4 F 0.1%

Table 19. Daily counts of sockeye spawners in Hansen Creek, 1996.

Date	Estimate off mouth	In creek Live	In creek Natural dead	In creek Bear dead	In ponds Live	In ponds Natural dead	In ponds Bear dead	Total live	Total dead	Cumulative dead	Live+ cum. dead
Jul. 17		0	0	0	0	0	0	0	0	0	0
18		339	38	27	65	0	0				
19		236	8	8	40	0	0				
20		240	0	1	42	0	0				
21		1121	58	4	93	0	0	1214	62	452	1666
22		1124	24	25	121	0	0	1245	49	501	1746
23		1303	21	76	168	0	0	1471	97	598	2069
24		1530	40	59	155	0	0	1685	99	697	2382
25		1468	27	49	197	0	0	1665	76	773	2438
26	1500	2315	51	9	761	0	0	3076	60	833	3909
27	2000	1942	30	35	1350	0	0	3292	65	898	4190
28		2001	45	100	1150	1	0	3151	146	1044	4195
29	2000	2485	52	88	1450	0	0	3935	140	1184	5119
30	2000	2402	90	104	1600	0	0	4002	194	1378	5380
31	1000	3217	95	93	1750	1	0	4967	189	1567	6534
Aug. 1	1000	3176	52	53	1900	0	2	5076	107	1674	6750
2		4605	130	70	1523	7	1	6128	208	1882	8010
3	300	4385	182	83	1180	7	0	5565	272	2154	7719
4		4145	208	212	1480	7	1	5625	428	2582	8207
5		3773	266	109	1250	9	0	5023	384	2966	7989
6	200	3557	254	114	411	11	0	3968	379	3345	7313
7	200	3825	242	119	1200	34	0	5025	395	3740	8765
8	200	3605	319	115	1200	28	0	4805	462	4202	9007
9		2683	244	117	1100	12	3	3783	376	4578	8361
10	300	3010	350	97	1100	21	3	4110	471	5049	9159
11	100	1508	371	108	1000	21	1	2508	501	5550	8058
12	50	2118	400	81	950	26	0	3068	507	6057	9125
13	30	2061	490	63	420	34	3	2481	590	6647	9128
14		1343	569	108	800	48	4	2143	729	7376	9519
15	0	777	427	145	680	41	7	1457	620	7996	9453
16	0	457	238	98	195	13	5	652	354	8350	9002
17	6	177	196	177	180	15	12	357	400	8750	9107
18	4	36	89	74	115	24	2	151	189	8939	9090
19								0	0	8939	8939
20								0	0	8939	8939
21								0	0	8939	8939
22								0	0	8939	8939
23								0	0	8939	8939
24	0	0	7	102	70	549	69	70	727	9666	9736
Totals			5567	2687		909	113				

Dead fish removed on each survey.
Dead counts from the side pond only through 8/18. Both ponds counted on 8/24.

Table 20. Summary of Hansen Creek spawning surveys, 1990–96

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