FRI-UW-9503
February 1995

FISHERIES RESEARCH INSTITUTE
SCHOOL OF FISHERIES WH–10
UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

ALASKA SALMON RESEARCH

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ANNUAL REPORT—1994

to

PACIFIC SEAFOOD PROCESSORS ASSOCIATION

Approved

Submitted 2/15/95 ______________________________

Director

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KEY WORDS

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

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 now are to determine how to maintain the high production (what has caused year-to-year variation) and how to harvest/process salmon most efficiently (e.g., accurate forecasts and fishing evenly distributed throughout the run).

We presently have salmon research projects in Bristol Bay, Alaska Peninsula, Southeast Alaska 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 at Kodiak and on the Yukon stocks. All of these projects have been carried out in cooperation with the Alaska Department of Fish and Game (ADF&G) 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 1994 Bristol Bay research with emphasis on salmon forecasting and research relevant to escapement policies for maximizing production. The Southeast pink salmon (*O. gorbuscha*) research will be reported separately through the University of Alaska; our Chignik salmon research is reported to the National Marine Fisheries Service, and a report on our Alaska Peninsula work was just completed (Rogers 1995).

FORECASTING

PRE-SEASON FORECASTS

Forecasts of the 1995 Bristol Bay sockeye salmon (*O. nerka*) runs and catches were provided to participating processors at our October 1994 meeting. They are presented in Table 1 with the ADF&G forecasts and the past forecasts and runs beginning in 1986. The two river system forecasts (FRI and ADF&G) are based on the same data sources, but different analytical methods have often been used. Both 1994 forecasts were for a large run and catch and they were remarkably close to the actual run (50 million) and catch (35 million) which were both the third largest on record. The outlook for 1995 is for another large run and catch

Port Moller Forecast

The Port Moller in-season test fishery was conducted by ADF&G 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, we have conducted the test fishery each year. The test fishery now employs a 200-fathom gillnet that is 60 meshes deep and has 5-in stretched mesh. The web is multistrand monofilament (center core). We used a new vessel (*Cape Cross*) in 1994 after the tragic loss of the Nettie H in fall 1993. Four stations were fished along a transect 33 to 63 nm out from Port Moller (13 to 43 nm from point to point coastline). 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 ADF&G (B. Cross, King Salmon) and the scales were aged and the age compositions and average lengths by age were reported.

The accuracy of the forecasts since 1987 has been very good. The runs have differed from the forecasts made on June 25 and 30 by an average of 19%, and we have been within an average of 10% 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 1994, the test-fish catches projected that the run would be late and larger than forecasted from past years with average run timing. Daily forecasts, from an almanac provided to Bristol Bay processors, tended to under-forecast the run until July 6. For the first time, the pre-season forecasts were closer than the inseason Port Moller forecasts; however the later correctly predicted the late run timing in 1994.

The very early or very late runs in Bristol Bay have usually been associated with very early (warm) or very late (cold) spring weather in the Gulf of Alaska (Fig. 1). However, there have been years with warm or cold springs when the runs only differed a little from average timing. The onset of the Bristol Bay escapements is generally correlated with spring weather in the Gulf and the closest correlation is for the Kvichak where only the 1985 observation was unusual—a cold spring but early arrival at the Kvichak tower (Fig. 2). Unfortunately, these air temperature data are not available soon enough for inseason forecasting, so the Port Moller program is especially important.

ADF&G (J. Miller, Anchorage) provided preliminary length and weight statistics for 1994, and statistics from prior years were available (e.g., Yuen et al. 1981, Stratton and Crawford 1992) so that we could calculate mean lengths in the runs (Table 3) . Both the 2-ocean and 3-ocean sockeye salmon in the 1994 run were much smaller than average. Large runs typically contain smaller fish because of density-dependent growth in their final spring at sea (Rogers 1980). Because there were high percentages of 2-ocean fish in the eastside catches, the average weights calculated from ADF&G sampling were well below average (Table 4). High percentages of 3-ocean fish in the Nushagak and Togiak districts resulted in average overall weights even though the sockeye were small at each age (Table 5).

The Port Moller test fishery in 1994 provided an early indication to ADF&G management that a large but late run was on the way, and the age composition suggested a large Kvichak run. Although there was some overescapement in the Naknek, Egegik, Ugashik and Igushik rivers, the escapements in 1994 were closer to the goals than in any of the past 5 yr (Table 6). Considering the size of the run and the late timing (second to 1971), management of the run was outstanding. Good catches were made in all districts before large numbers of fish were counted past the towers.

LAKE RESEARCH

During the summer of 1994, 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 30 yr and constitute the longest continuous biological and environmental record on any salmon stock in Alaska. In 1994 we also conducted special studies of bear predation on spawning sockeye salmon and stock-specific traits of sockeye spawning populations.

KVICHAK SYSTEM

Our 1994 field season in the Kvichak system (Lakes Iliamna and Clark) consisted of estimating the sockeye escapement into the Newhalen River in late-June and July, townetting for juvenile sockeye salmon and threespine stickleback (*Gasterosteus aculeatus*) in upper Lake Iliamna and for sockeye fry, stickleback, and least cisco (*Coregonus sardinella*) in Lake Clark in August. A special study was conducted in Lake Clark to examine the relationship between the populations of juvenile sockeye and least cisco that both occupy the epipelagic waters. The results of this work will be reported in 1996. We also conducted spawning ground surveys in late August–early September to collect otoliths for age determination. We continued our studies on the ecological relationship between sockeye salmon and two sculpin species—slimy sculpin (*Cottus cognatus*) and coastrange sculpin (*C. aleuticus*)—and on factors promoting the genetic differentiation of sockeye salmon populations.

Newhalen River Escapement

The annual escapements of sockeye salmon to the Kvichak lake system are estimated by ADF&G from expanded 10-min counts on each bank of the river at the outlet of Lake Iliamna (Igiugig). In addition, since 1979 we have estimated the escapements up the Newhalen River by expanding 20-min counts on one bank, for each of 10 daylight hours, to a daily count for both banks. We count when and where the visibility is best and assume that the fish utilize both banks equally and that their migratory rate does not change at night. The daily counts at Newhalen are compared with the counts at Igiugig to estimate a travel time; then, by lagging the Newhalen counts back to Igiugig the appropriate number of days, we can calculate the daily proportions of the Kvichak run that went up the Newhalen River.

The cumulative daily escapements for the two rivers, timed to the Kvichak, are given in Table 7 for 1990–94. In mid-July, milling fish often swim upriver along the banks of the Newhalen and are counted, and then drift down river in the middle where they cannot be seen, only to swim up river again. This inflates the counts for the escapement; therefore, we have used the average proportion of Newhalen count to Kvichak count for day 5 to day 16 (day 1 equals the first day of 100,000 in the Kvichak) and the season's total Kvichak escapement to estimate the Newhalen/Lake Clark escapement.

In 1994, we estimated that 2.3 million of the Kvichak escapement of 8.3 million (about 28%) returned to the Newhalen/Lake Clark system (Table 8). This was a little below the average for the past 6 yr (35%). The aerial surveys conducted by ADF&G in 1994 provided an estimate of the Newhalen River spawners and, thus by subtraction, an estimate of the Lake Clark escapement of 2.3 million.

Spawning Ground Surveys

We have collected scales or otoliths from spawned-out sockeye salmon from several major spawning grounds in the Kvichak system each year since 1956. In 1994 eight spawning grounds were sampled and the age compositions from the samples provided a similar pattern to the age composition in the lake system escapement (Table 9). Chinkelyes Creek had a high percentage of age 2.2, the Newhalen and Tazimina Rivers had high percentages of age 1.3, and Pedro Creek a high percentage of age 1.2 salmon; otherwise the age compositions were similar to the composition for the entire lake system (Kvichak escapement).

We had conducted annual aerial surveys of the Kvichak spawning grounds from 1956 until 1988 when ADF&G took over the surveys. The results of the 1994 surveys were provided by ADF&G (Regnart 1994) and are summarized for 29 selected spawning grounds in Table 10. In recent years the surveys have accounted for smaller percentages of the total (tower count) escapement than was typical for past years. This may have been caused by differences in observers, weather conditions (visibility) or distribution of sockeye salmon on the spawning grounds.

We continued our surveys of the run timing and size of beach spawning populations, focusing on a Woody Island beach that has been surveyed annually since 1992. Run timing was ~3 d later in 1994 than that observed previously, and this appeared to be consistent across all island beaches. The later run timing may be associated with the relatively late run of sockeye into the Kvichak system and/or it may be related to the relatively high surface water temperatures recorded in the lake during the spawning season.

Sockeye Salmon Fry Abundance and Size

We have sampled the sockeye fry (age 0) in the Kvichak system each year since 1962 (1961 brood year) by townetting at night. We towed in both Lake Iliamna and Lake Clark, but as usual we did not sample the fry in Six-Mile Lake (upper end of the Newhalen River), where fry from the Tazimina River are likely to concentrate. The geometric means of the catches provide a measure of the relative density (number per 20-min tow) and the mean lengths of the fry are adjusted each year, based on their daily growth rate, to September 1 (Table 11).

The sockeye fry of Lake Clark were smaller than those from Lake Iliamna in 1994 (1993 brood year), a difference that is common between the two systems because of the colder water in Lake Clark. In both lakes, the annual growth of fry is correlated with water temperature, which is mostly influenced by spring weather. Cold temperatures usually result in small fry (40–50 mm) which then spend 2 yr in the lake before seaward migration and tend to return as adults 5 yr after their parents. Warm temperatures usually result in large fry (>60 mm), which tend to migrate to sea after 1 yr and mostly return as 4-year-olds. The townet sampling has been useful in predicting, 3 yr in advance, the main age at return of the larger Kvichak escapements by utilizing the relationship between age at return and mean length of fry in Lake Iliamna. From the relatively large mean lengths in 1994 (57 and 55 mm, respectively, for Lakes Iliamna and Clark), we would expect most fish from the 1993 brood year to migrate at age 1 and to return mainly in 1997.

Sculpin Predation

In 1992 and 1993 we documented that sculpins migrate to sockeye spawning beaches in large numbers and likely have a large impact on sockeye egg survival. The survival of an individual female's nest appears to be related to when she spawns as more sculpins are found in nests early and late in the run than in the middle of the run.

In 1994 we expanded our studies across spawning beaches to determine the global nature of sculpin predation on sockeye eggs and to examine factors that may cause variation in predation rates across beaches (gravel size). We also investigated the sensory systems (sight and smell) that sculpins use to locate sockeye nests and the ecological parameters (temperature) that affect the distribution of sculpins and the vulnerability of sockeye nests to predation.

Preliminary results indicate that the extent of sculpin predation is directly related to the mean gravel size on beach spawning areas, with beaches with large gravel having both more and larger sculpins present than beaches with small gravel. Indeed, sculpins are absent from beach populations that spawn in fine silica, with the exception of juvenile sculpins, which can not consume eggs. In 1995, we will continue this work on unsurveyed beaches and on previously surveyed beaches to test the validity of these results over a larger number of spawning areas and over years.

We examined the sensory systems sculpins use to locate sockeye nests through field and laboratory studies. In the field, on four separate beaches, we tested if sculpins were attracted by visual and/or olfactory cues to nests. We did this by baiting minnow traps as follows:

- free eggs (detectable by both sight and smell);
- eggs held in clear, sealed ziplock (plastic) bags (sight only); and
- eggs held in black, sealed ziplock bags with holes (odor only), and eggs held in clear bags with holes (sight and odor).

Free eggs were the most attractive to sculpins, with an average of ~160 sculpins caught per overnight set of each trap. There was no difference among traps with eggs in bags that had holes in them (eggs visible or not) with ~100 sculpins caught per overnight set. In contrast, traps with eggs sealed in clear bags (visible, no odor), caught <10 sculpins per night. These results show that smell is the dominant sense in attracting sculpins to sockeye eggs. These results were supported by laboratory studies, which demonstrate that it may be possible to significantly reduce the sculpin predation of sockeye eggs by simply baiting traps on spawning grounds before the arrival of spawning sockeye.

We commenced studies to examine the effects of temperature on the distribution of slimy and coastrange sculpins and on their egg consumption rates. Trapping studies revealed that slimy sculpins occupied waters deeper than 15 m, with coastrange sculpins dominating the shallower, warmer waters. High-surface water temperatures during spawning (11–15°C) may have restricted the distribution of slimy sculpins to cooler, deeper waters, and hence lowered the overall predation of sockeye eggs. In previous years, with cooler surface water temperatures, slimy sculpins formed a greater proportion of the sculpins on the beaches, with higher numbers of sculpins observed overall. We will continue this work in 1995 with more extensive sampling of sculpins across depths over the course of the salmon spawning run. This work will be augmented by laboratory studies of the effects of temperature on egg consumption by the two sculpin species.

Spawning Behavior, Morphology, and Genetics

In Lake Iliamna, sockeye salmon spawn on exposed or wave-swept island beaches. This type of spawning habitat has been poorly studied in this and other lake systems where beach spawning occurs, primarily because it is a rare phenomenon. However, in Lake Iliamna, ≤30% of the spawning run has historically used this habitat during years of peak escapement. Therefore, this study was aimed at identifying and measuring beach spawning habitat characteristics and spawning behavior to elucidate spawning site selection criteria by beach spawning sockeye salmon. Habitat characteristics measured across site gradients were surface and intergravel water flow, dissolved oxygen (DO), and water temperature, along with gravel size. An innovative, yet simple, technique was employed in this study to measure water flow. Small Plaster of Paris cylinders were fabricated and then deployed throughout the spawning habitat (above and below the gravel surface) where they dissolved over time in relation to the amount of water flow. In this way, water flow between sites and depths was compared.

The results indicate significant habitat differences between immediately adjacent spawning and non-spawning sites, although among separate beaches and islands each spawning area is very distinct. In this study, spawning sites had larger and more homogeneous gravel size, higher intragravel DO levels, and greater surface and intergravel flow than adjacent non-spawning sites. Furthermore, at Woody Island, spawning occurred in greater densities in shallow (0.5 m) than deep water (2.5 m). Though habitat differences were similar across this depth gradient, surface and intergravel flow were significantly greater at 0.5-m depths because of increased water turbulence and wave action. Thus, female spawners may compete for favorable shallow sites where water flow within the egg pocket of a redd will be greater than at deeper depths.

To examine the possible effects of spawning habitat differences across spawning areas on sockeye genetic differentiation, we measured egg size in relation to the gravel characteristics of individual spawning grounds. We surveyed beach and river populations in Lake Iliamna and Lake Aleknagik. We determined that most of the variation in egg size among populations is explained by a positive correlation with spawning gravel size. Within populations, variation in egg size is positively related to female size. Within a given size, females with larger eggs tend also to have fewer eggs. These results indicate that local selection pressures have caused the genetic divergence in sockeye egg size. Given that fry size is related to egg size, sockeye populations with larger eggs give rise to larger fry than those spawning in small gravel with associated small eggs. In future years we will examine whether these initial size differences translate into growth differences among populations and hence possibly into different smolt ages.

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.

Environmental Observations

Spring 1994 was early and ice breakup in Lake Aleknagik (recorded since 1949) was 13 d earlier than average (Table 12). Although ice breakup was early, early-summer water temperatures were only average because solar radiation (sunlight) was below average during most of June and July. Lake levels were above normal until September, when heavy rainfall caused an increase to near spring levels in mid-September. Standing crop of phytoplankton (chlorophyll) was below average until September, whereas zooplankton volumes were about average until late-August. Zooplankton 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 1994 (early 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 1994, but no records were set.

Fry Abundance and Growth

In 1994 the sockeye fry in Lake Aleknagik were 2% longer than average in June, but their growth during July and August was below average, and on September 1 they were 7.5% shorter than average (Table 14). Fry abundance as measured by beach seine sampling in June and July was only 65% of the long-term average, but the mean catch in townet sampling in early September was about double the average for past years. The number of parent spawners (417,000) in Lake Aleknagik in 1993 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* (Fig. 3).

The mean lengths of sockeye salmon fry in Lake Nerka indicated that in 1994 growth was about average in the south arm of the lake but below average in the remainder. Townet catches were above average throughout 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.

Char Predation

We have sampled the Arctic char (*Salvelinus alpinus*) in Little Togiak River each spring since 1972 to follow the rate of predation on juvenile sockeye, especially smolts. There are ~5,000 char in and around the mouth of Little Togiak River. This short river flows from Little Togiak Lake into Lake Nerka, and the smolts are very vulnerable to the char for the few minutes it takes them to move from one lake to the next. Large char usually eat more juvenile sockeye than small char. The char caught in 1994 were smaller than average in length and they consumed only 0.2 smolt per day, a record low (Table 16). Our sampling in 1994 may have begun too late for much of the smolt migration because ice breakup was early and smolt migration begins soon afterward.

Spawning Ground Surveys

Sockeye salmon spawning ground surveys have been conducted annually in the Wood River lake 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. ADF&G 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 ADF&G in 1993–94 with industry funding. The ground survey counts in 1994 for the major spawning grounds are given in Table 17. The creeks draining into Lake Aleknagik again contained relatively high counts of spawners (especially Happy Creek), and Hansen Creek had a large number of spawners for the fifth consecutive year. Age compositions were nearly the same in 1993 and 1994 (Tables 18 and 19).

Bear Predation

We completed the fifth 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 25 July to 21 August, a large number of spawners were again observed in Hansen Creek (Table 20). Daily count and removal of sockeye salmon killed by bears indicated that 4,055 (55%) of 7,413 spawners were killed by bears in 1994 (Table 21). 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 1994 was the highest observed in the 5-yr period. We plan to continue the daily surveys in Hansen Creek until we obtain counts for a year when number of spawners is near the median (2500) and for a year when there is a small number of spawners (<1000).

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 are about the earliest spawners in the lake system and the fish usually first enter the creek about July 22–25. From the daily counts in 1990–94, if the surveys had been conducted on the single date of August 6, the "peak survey" counts would have been 72% 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 21). The percentage counted in 1992 on August 1 (78%) was relatively high because spawning was early, with the fish first entering the creek on July 18.

LITERATURE CITED

Regnart, J.R. 1994. Kvichak River sockeye salmon spawning ground surveys, 1955-1994. ADF&G Reg. Inform. Rep. 2A94-32. 22 p.

Rogers, D.E. 1980. Density-dependent growth of Bristol Bay sockeye salmon. Pages 267-283 *in* W.J. McNeil and D.C. Himsworth (eds.), Salmonid Ecosystems of the North Pacific. Oregon State Univ. Press, Corvallis.

Rogers, D.E. 1995. False Pass chum salmon, 1994. Report to Pacific Seafood Processors Assoc. Univ. Washington, School of Fisheries, Fish. Res. Inst. FRI-UW-9501. 41 p.

Stratton, B.L. and D.L. Crawford. 1992. Abundance, age, sex and size statistics for Pacific salmon in Bristol Bay, 1991. ADF&G Tech. Fish. Rep. 92-17. 168 p.

Yuen, H.J., B. Bue, and C.P. Meachum. 1981. Bristol Bay sockeye salmon (*Onchorhynchus*) age, weight, and length statistics, 1957 to 1977. ADF&G Tech. Data Rep. No. 67. 155 p.

FIGURES

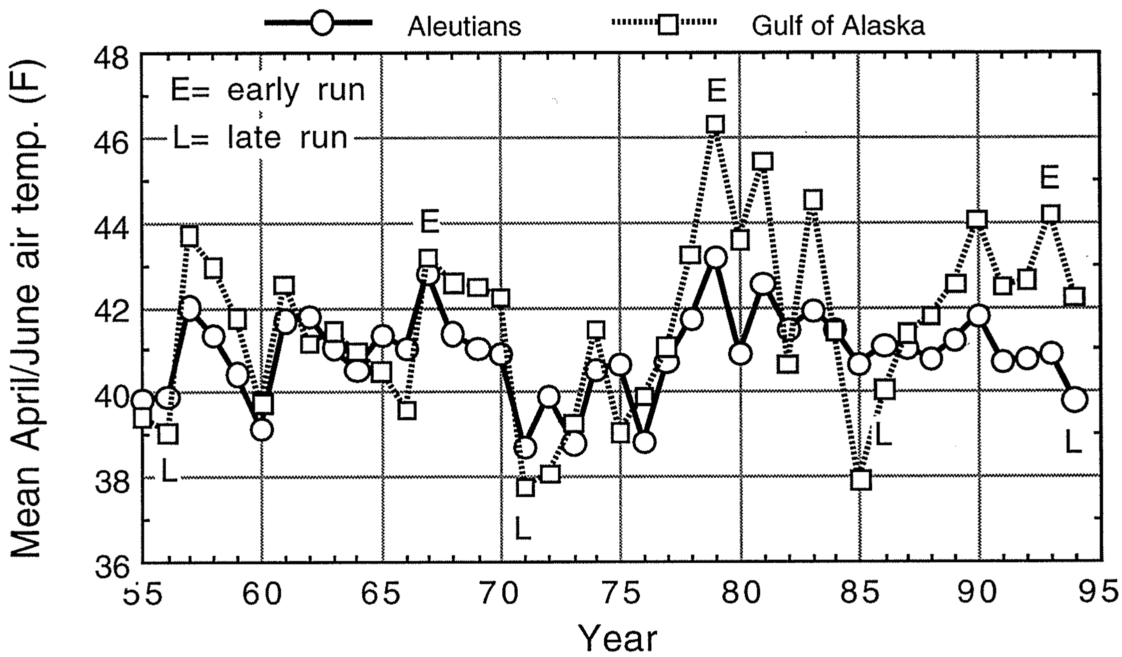

Figure 1. Spring air temperatures in the Aleutians (Adak and Dutch Harbor) and Gulf of Alaska (Cold Bay and Kodiak) and the years with unusual run timing in Bristol Bay.

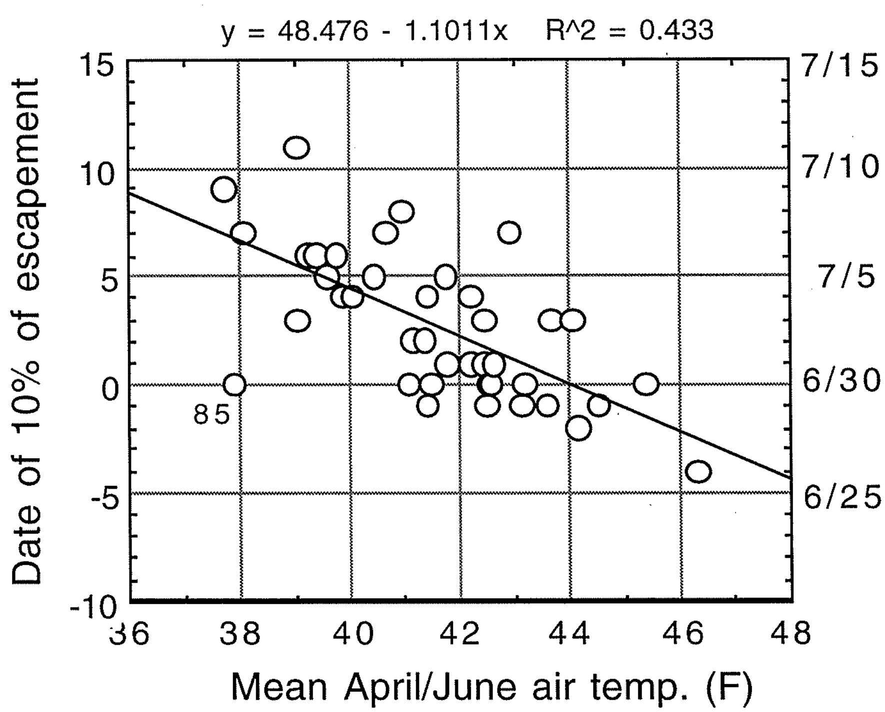

Figure 2. Regression of date of 10% of the Kvichak escapement on the mean spring air temperature at Cold Bay and Kodiak.

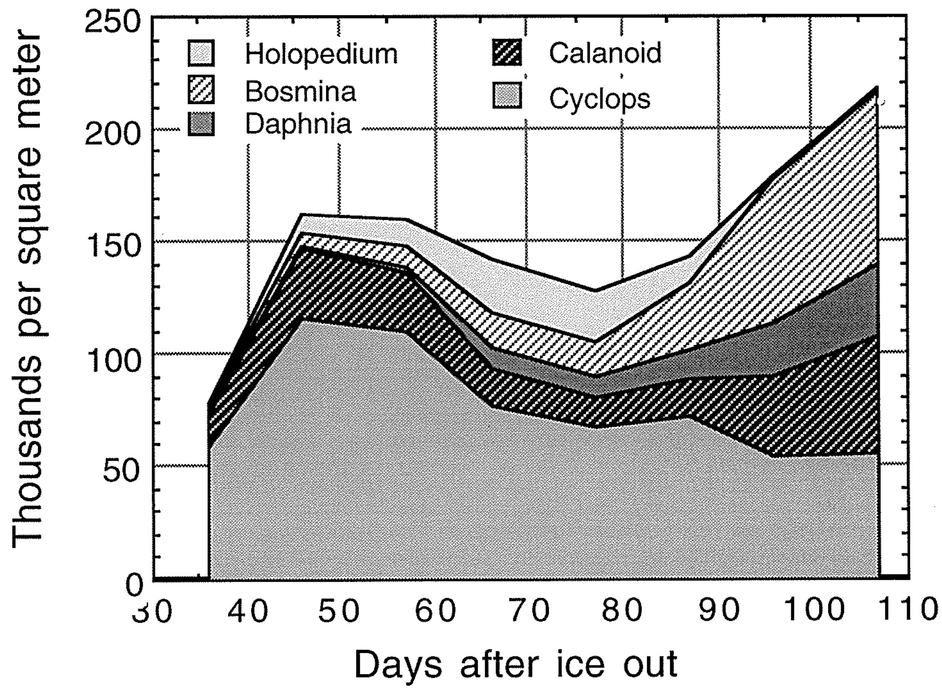

Figure 3. Abundance of zooplankters in Lake Aleknagik during summer 1994 (June 23–September 2).

TABLES

Table 1. Pre-season forecasts of Bristol Bay sockeye salmon inshore runs (millions).

Year	Forecast/run	Kvichak	Naknek	Egegik	Ugashik	Nushagak	Total run	Catch	%Error
1986	FRI	9.2	4.5	5.9	6.7	4.8	32.1	19.4	19
	ADFG	4.5	3.2	5.4	4.9	3.8	22.5	13.3	18
	Actual run	2.0	3.9	6.0	6.0	4.8	23.5	15.7	
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	
	ADF&G	25.1	5.3	13.1	5.4	5.3	55.1	40.3	
	Actual run								

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
Means	41	28	41	0	7	39	2	11	38	3	9	25	3	13
absol.				6	22		5	16		4	10		4	15

Numbers in millions of fish.

absol. = absolute error, ignoring the sign.
%ofP= the percentage that the actual run differed from the prediction.
1993-94 forecasts 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 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
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
88-94	47	516	500	507	577	554	565	534	45

Table 4. Average weights of sockeye (lb) in commercial catches on the east side of Bristol Bay.

District	Year	Catch millions	2-ocean Male	2-ocean Female	2-ocean Comb.	3-ocean Male	3-ocean Female	3-ocean Comb.	All males	All females	All fish	Percent 3-ocean	Percent 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
	Means	9.6	5.2	4.5	4.8	7.2	6.1	6.6	6.1	5.3	5.7	48	53
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
	Means	9.9	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
	Means	3.4	5.4	4.6	5.1	7.4	6.3	6.9	6.4	5.5	6.0	51	46

Table 5. Average weights of sockeye (lb) in commercial catches on the west side of Bristol Bay.

District	Year	Catch millions	2-ocean Male	2-ocean Female	2-ocean Comb.	3-ocean Male	3-ocean Female	3-ocean Comb.	All males	All females	All fish	Percent 3-ocean	Percent 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
	Means	3.2	4.8	4.3	4.6	7.4	6.0	6.6	6.6	5.6	6.1	72	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
	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 escapements in excess of management goals for Bristol Bay rivers, 1987-94 (in millions).

River system	Escapement goals Mid-point	Upper range	87	88	89	90	91*	92	93	94
			Escapement in excess of mid-point							
Kvichak	variable	variable								
Branch										
Naknek	1.00		.06	.04	.16	1.09	2.57	.61	.54	.00
Egegik	1.00		.27	.61	.61	1.19	1.79	.95	.52	.90
Ugashik	.70		.00	.00	1.01	.05	1.76	1.76	.71	.38
Wood	1.00		.34	.00	.19	.07	.16	.29	.18	.47
Igushik	.20		.00	.00	.26	.17	.56	.10	.21	.25
Nuyakuk/Nush.	.50		.00	.00	.01	.17	.00	.20	.21	.01
Togiak	.15		.13	.16	.00	.04	.13	.07	.04	.02
Total			.80	.81	2.24	2.78	6.97	3.98	2.41	2.03
Bristol Bay run			27	23	44	48	42	45	52	50
catch			16	14	29	33	26	32	41	35
			Escapement in excess of upper range							
Naknek		1.40	.00	.00	.00	.69	2.18	.21	.14	.00
Egegik**		1.20	.07	.41	.41	.99	1.59	.75	.32	.70
Ugashik**		.90	.00	.00	.81	.00	1.58	1.56	.51	.18
Wood		1.20	.14	.00	.00	.00	.00	.09	.00	.00
Igushik		.25	.00	.00	.21	.12	.51	.05	.16	.20
Nuyakuk/Nush.		.76	.00	.00	.00	.00	.00	.00	.00	.00
Togiak		.25	.03	.06	.00	.00	.03	.00	.00	.00
Total			.24	.47	1.43	1.80	5.89	2.66	1.13	1.08

*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, 1990-94 (number in 1000s) and Newhalen escapements estimated from expanded counts lagged back 2 d.

	1990		1991		1992		1993		1994	
Date	Kvichak	Newhalen	Kvichak	Newhalen	[illegible]	Newhalen	Kvichak	Newhalen	[illegible]	Newhalen
6/22							13			
23					0		24		0	
24	0				1		34		0	
25	1		0		2		51	6	0	
26	2		1		10		121	67	1	
27	3		3		17		317	78	8	
28	5	0	50	7	81	5	559	157	24	
29	8	1	125	46	255	18	847	237	25	
30	39	2	277	95	446	67	932	394	25	
7/1	46	37	588	146	635	88	1014	492	26	0
2	219	66	901	188	754	104	1081	650	30	1
3	825	90	1256	330	798	132	1182	816	254	1
4	1412	110	1581	517	1093	196	1307	937	1550	321
5	1874	139	1925	620	1663	273	1678	1022	2727	558
6	2399	204	2141	805	2244	329	2372	1103	3518	775
7	2901	304	2208	1132	2688	406	2733	1121	4273	921
8	3509	375	2277	1531	2880	534	2932	1134	5132	1091
9	4061	459	2355	1721	2960	661	3101	1163	5821	1286
10	4692	648	2633	2048	2985	840	3264	1189	6473	1601
11	5081	790	3080	2202	3175	977	3402	1220	7058	1884
12	5388	961	3460		3662	1057	3574	1268	7268	2168
13	5803	1079	3724		4066	1158	3751	1322	7330	2372
14	6208	1193	3822		4330	1258	3818	1353	7382	2450
15	6418	1297	3909		4438	1434	3864		7495	2535
16	6510		3999		4517	1491	3894		7540	2578
17	6603		4063		4578		3921		7631	
18	6674		4098		4626		3958		7852	
19	6733		4132		4685		3986		8099	
20	6781		4166		4695		3996		8169	
21	6827		4193		4710		4008		8193	
22	6876		4213		4720		4016		8265	
23	6915		4220		4726		4021		8337	
24	6941						4024			
25	6970						4025			

Table 8. The Kivchak lake system escapements and the percentages 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

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 1994.

Spawning ground	Sex	Sample size (n)	Age composition (%) 2.1	1.2	2.2	1.3	2.3
Gibralter River	M	97		3.1	71.1	13.4	12.4
	F	99		3.0	79.8	10.1	7.1
Copper River	M	100		0.0	90.0	3.0	7.0
	F	100		1.0	91.0	4.0	4.0
Chinkelyes Creek	M	100		1.0	99.0	0.0	0.0
	F	100		3.0	93.0	0.0	4.0
Newhalen River	M	100	1.0	7.0	79.0	10.0	3.0
	F	58		0.0	94.8	5.2	0.0
Tazimina River	M	99		3.0	84.9	10.1	2.0
	F	91		4.4	69.2	18.7	7.7
Woody Island beaches	M	48		54.2	43.7	2.1	0.0
	F	49		57.2	36.8	2.0	2.0
Fuel Dump Island beach	M	48	4.2	58.3	33.3	4.2	0.0
	F	48		66.7	29.2	4.1	0.0
Knudson Bay beach	M	97		3.1	83.5	10.3	3.1
	F	61		6.6	85.2	8.2	0.0
Pedro Creek ponds	M	101	1.0	41.6	54.4	2.0	1.0
	F	100		30.0	60.0	10.0	0.0
Kvichak escapement	M	1105	2.2	10.7	82.1	2.8	2.2
(ADF&G,Igiugig)	F	1726		9.0	86.2	3.2	1.5

Table 10. Estimates of sockeye salmon spawners on 29 selected 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
Means								
61-66	239	139	79	261	718	5948	12.5	2
67-83	505	175	76	99	856	5702	17.6	3
88-94	304	126	43	18	492	5809	9.1	6,7

Table 11. Mean townet catches (geometric means of 20-min tows) and lengths on 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				

Lake Iliamna tows in areas 7 & 8 only.

Table 12. Summary of 1994 measurements in Lake Aleknagik.

Measurement and first year measured	Dates	1994	Past years Average	Range
1. Date of ice breakup 1949-		5/18	5/31	5/01-6/16
2. Water temperature, 0-20m (C) 1958-	6/23	8.1	6.0	3.7, 9.2
	7/14	9.3	8.3	5.7, 12.0
	8/3	11.7	10.7	7.7, 14.0
	9/2	11.9	11.2	9.3, 13.0
3. Water transparency Secchi depth (m) 1962-	6/23	8.2	7.5	5.3, 10.5
	7/14	7.6	8.2	5.0, 10.9
	8/3	10.9	9.2	6.3, 11.9
	9/2	10.1	8.7	5.8, 12.1
4. Water conductivity (micromhos/cm) 1968-	6/23	36.5	38.6	34.7, 52.1
	7/14	34.5	37.5	33.5, 42.6
	8/3	33.5	37.2	32.5, 40.5
	9/2	36.5	38.3	34.8, 42.5
5. Average daily solar radiation (gm/cal/cm) 1963-	June 1-15	449	403	305, 588
	June 16-30	404	409	265, 572
	July 1-15	340	385	284, 543
	July 16-31	329	355	194, 481
	Aug. 1-15	323	301	203, 402
	Aug. 16-31	259	257	170, 421
	Sept. 1-15	208	206	114, 282
6. Lake level (cm) of Lake Nerka 1952-	June 1-15	170	143	84, 222
	June 16-30	163	152	97, 218
	July 1-15	127	133	75, 199
	July 16-31	130	107	54, 172
	Aug. 1-15	120	87	34, 173
	Aug. 16-31	89	83	30, 184
	Sept. 1-15	71	83	29, 161
7. Chlorophyll "a", 0-20m (mg/m2) 1963-	6/23	23	30	10, 45
	7/3	14		
	7/14	26	27	10, 43
	7/23	16		
	8/3	10	22	6, 36
	8/13	10		
	8/22	11		
	9/2	26	24	12, 37
8. Zooplankton volume 0-60m (ml/m2) 1967-	6/23	31	52	20,168
	7/3	57		
	7/14	88	83	45-161
	7/21	75		
	8/3	111	118	43-226
	8/13	91		
	8/22	47		
	9/2	43	62	26-107

Table 13. Five-day averages of catches of emergent midges and water temperatures at three stations on Lake Aleknagik, 1994.

5-day period	Catch per day 1994 W	H	B	Mean	Catch per day 1969-93 Mean	Min	Max	Water temperature (C) 1994 W	H	B	Mean	Water temperature (C) 1969-93 Mean	Min	Max
6/1-5				3								2.7	0.0	9.8
6-10	6	1	3	2	12	0	70	6.5	7.2	10.2	8.0	5.2	0.0	10.4
11-15	6	2	1	2	12	1	53	9.5	7.3	10.3	9.0	6.5	1.0	9.2
16-20	5	2	0	2	17	1	168	10.8	11.3	12.6	11.6	8.2	3.9	12.7
21-25	2	5	0	8	7	0	42	8.3	11.4	11.7	10.5	8.8	4.8	12.8
26-30	3	3	0	7	5	0	12	11.7	12.3	12.7	12.2	9.9	6.0	13.9
7/1-5	4	4	37	12	5	1	15	10.9	11.1	13.0	11.7	10.9	7.7	15.5
6-10	2	0	181	61	10	2	24	11.8	12.5	13.2	12.5	11.9	9.7	15.8
11-15	9	4	70	28	14	1	34	12.3	11.6	13.0	12.3	12.4	9.2	15.9
16-20	1	11	9	7	14	2	36	9.5	10.2	12.9	10.9	12.3	8.5	17.0
21-25	2	3	9	5	19	2	50	10.8	12.3	12.8	12.0	12.6	7.9	17.2
26-30	8	3	9	7	29	8	58	14.4	14.4	16.6	15.1	13.4	8.9	16.1
31-4	12	1	12	8	28	4	77	12.0	14.2	15.2	13.8	13.7	10.2	17.5
8/5-9	9	1	4	5	21	3	80	11.6	14.5	14.3	13.5	13.7	10.5	17.1
10-14	7	1	7	5	15	2	54	13.9	15.9	15.6	15.1	13.5	9.5	18.8
15-19	5	1	1	2	14	1	70	15.7	16.5	16.3	16.2	13.2	11.0	15.7
20-24	3	0	0	1	7	0	28	15.2	14.6	13.9	14.6	13.6	12.0	15.4
25-29														

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	189	24	31.4	45.0	.19	11	0
87	69	29.7	57.5	.40	3	343	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	286	26	32.6	47.0	.21	17	1
90	100	32.7	57.7	.36	20	474	129	31.2	48.1	.24	27	1
91	63	30.1	52.9	.33	14	460	108	31.3	42.2	.16	41	1
92	242	30.0	46.1	.24	52	794	200	27.9	39.4	.17	222	<1
93	34	33.7	56.4	.33	10	343	55	31.7	46.5	.22	3	<1
94	55	32.0	51.7	.29	106	417	31	30.3	46.6	.24	38	2
Means	155	31.4	55.9	.35	50	317	139	31.1	44.4	.19	74	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 fry (by lake area), and 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	10	44
95							95	152	372		
Means	12	14	38	60	57	57	111	114	238	17	45

Table 16. Occurrence and numbers of juvenile sockeye salmon in stomachs of Arctic char collected by hook and line from Little Togiak River 30 d after ice out.

Year	Date of ice out	Range in sampling dates	Number of char examined	Mean length (mm)	Percent of char with Fry	Percent of char with Smolt	Mean number per char Fry	Mean number per char Smolt	Sockeye escape. year-2
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									19
72-94 means	6/01		109	426	17	39	1.2	2.2	31

Table 17. Ground survey counts of sockeye spawners in the Wood River lakes, 1994.

Location	Date	Estimated off mouth	In creek Live	Dead	Natural	Bear kill	Total
Aleknagik							
Yako	8/05	300	1725	42	29	13	2067
Hansen	8/06	500	3205	1947	221	1726	5652
Bear	8/06	500	2708	314	220	94	3522
Happy	8/07	1000	4676	2799	2262	537	8475
Ice*	8/11	200	5765	1467	1305	162	7432
Eagle	8/12	20	781	196	16	180	997
Mission	8/14	30	1171	145	74	71	1346
Whitefish	8/14	0	384	48	17	31	432
Nerka							
Fenno	8/10	0	2673	397	366	31	3070
Pick	8/17	200	5364	576			6140
Lynx	8/19	400	1648	171	82	89	2219
Stovall*	8/23	0	200	280			480
Hidden Lake	8/25	0	285	482	117	365	767
Elva	8/27	0	72	29			101
Kema*	8/28	0	39	250			289
Beverley							
Moose*	8/12	0	357	287	131	156	644
Kulik							
Grant River*	8/21		No counts, but medium density; 95% dead				

* Partial count; entire stream not surveyed.

Table 18. Age compositions (%) of sockeye salmon spawners in the Wood River Lakes, 1993.

Location	Males 1.1	Males 1.2	Males 2.2	Males 1.3	Males 2.3	Males 1.4	No. of fish	Females 1.2	Females 2.2	Females 1.3	Females 2.3	Females 1.4	No. of fish
Hansen	0.0	71.3	0.0	28.7	0.0	0.0	247	71.6	0.0	28.4	0.0	0.0	285
Happy	0.0	48.3	0.0	50.0	0.9	0.8	118	63.2	0.0	35.0	0.9	0.9	114
Bear	0.0	37.9	0.0	62.1	0.0	0.0	103	36.5	0.0	62.5	0.0	1.0	104
Ice	0.0	38.9	0.0	61.1	0.0	0.0	108	38.4	0.0	60.7	0.0	0.9	112
Agulowak	0.0	14.3	0.0	85.7	0.0	0.0	105	13.3	0.0	86.7	0.0	0.0	113
Wood	0.0	86.5	0.0	12.5	0.0	1.0	104	81.3	0.0	18.7	0.0	0.0	107
Fenno	0.0	70.3	0.0	29.7	0.0	0.0	111	84.2	0.0	15.8	0.0	0.0	101
Stovall	0.0	82.4	0.0	17.6	0.0	0.0	91	86.6	0.0	13.4	0.0	0.0	119
Lynx	0.0	57.4	0.0	42.6	0.0	0.0	54	75.5	0.0	24.5	0.0	0.0	106
Pick	0.9	48.3	0.0	50.8	0.0	0.0	116	53.3	0.0	46.7	0.0	0.0	107
LT River	0.0	39.4	0.0	60.6	0.0	0.0	66	22.6	2.2	74.1	1.1	0.0	93
N4-N6 beach	0.0	38.1	0.0	61.9	0.0	0.0	84	36.4	1.0	61.6	1.0	0.0	99
Kema	0.0	60.7	0.0	39.3	0.0	0.0	61	63.6	0.0	36.4	0.0	0.0	107
Hidden Lake	0.0	44.4	0.0	53.7	1.9	0.0	54	53.8	1.0	45.2	0.0	0.0	104
Anvil Bay beach	0.0	29.3	0.0	69.5	1.2	0.0	82	32.3	0.0	65.5	2.2	0.0	93
Agulukpak	0.0	30.3	0.9	68.8	0.0	0.0	109	14.4	0.0	85.6	0.0	0.0	104
LT beaches	0.0	83.0	0.0	17.0	0.0	0.0	6	72.7	0.0	22.8	4.5	0.0	22
Moose	0.0	88.2	0.0	11.8	0.0	0.0	34	94.5	0.0	5.5	0.0	0.0	109
Grant River	0.0	82.3	0.0	15.2	2.5	0.0	79	94.1	0.0	5.9	0.0	0.0	101
Unweighted mean	0.0	55.3	0.0	44.1	0.3	0.1	1732	57.3	0.2	41.8	0.5	0.1	2100
Wood River ADF&G tower	0.2	49.7	1.4	45.7	2.2	0.0		64.2	0.6	33.2	1.8	0.0	

Other = males: age 0.2(0.1%), age 0.3(0.1%) and age 0.4(0.2%); females: age 0.3(0.2%),age 0.4(0.4%).

Table 19. Age compositions (%) of sockeye salmon spawners in the Wood River Lakes, 1994.

	Males						No. of	Females					No. of
Location	1.1	2.1	1.2	2.2	1.3	2.3	fish	1.1	1.2	2.2	1.3	2.3	fish
Yako	3.8	0.0	81.1	0.0	15.1	0.0	53	0.0	81.3	6.3	12.5	0.0	16
Hansen	4.0	0.9	85.3	0.4	9.3	0.0	225	1.0	82.7	1.0	15.3	0.0	98
Happy	1.0	0.0	20.0	2.0	77.0	0.0	100	0.0	25.3	0.0	74.7	0.0	91
Bear	0.0	0.0	53.7	0.0	46.3	0.0	95	0.0	36.6	2.0	61.4	0.0	101
Ice	0.0	0.0	25.7	0.0	74.3	0.0	105	0.0	18.2	1.8	80.0	0.0	110
Agulowak	0.0	0.0	9.4	0.0	90.6	0.0	106	0.0	8.2	0.0	91.8	0.0	110
Wood	1.0	0.0	60.4	2.0	36.6	0.0	101	0.0	53.8	2.9	43.3	0.0	104
Fenno	0.0	0.0	58.7	0.0	41.3	0.0	109	0.0	58.4	0.0	41.6	0.0	77
Stovall	0.0	0.0	48.4	0.0	51.6	0.0	95	0.0	69.8	0.0	30.2	0.0	86
Lynx	0.0	0.0	66.2	0.0	33.8	0.0	65	0.0	68.5	0.0	31.5	0.0	89
Pick	0.0	0.0	72.4	0.0	27.6	0.0	98	1.0	77.7	0.0	21.4	0.0	103
LT River	0.0	0.0	64.8	0.0	35.2	0.0	88	0.0	33.3	0.0	66.7	0.0	84
N4-N6 beach	2.5	0.0	53.8	0.0	43.7	0.0	119	0.0	52.7	0.0	46.6	0.7	146
Kema	4.8	0.0	61.9	0.0	33.3	0.0	42	1.1	80.0	0.0	18.9	0.0	95
Hidden Lake	1.9	0.0	77.6	0.0	20.6	0.0	107	0.0	84.5	0.0	15.5	0.0	103
Anvil Bay beach	0.0	0.0	56.4	1.0	42.6	0.0	101	0.0	62.2	1.0	36.7	0.0	98
Agulukpak	0.0	0.0	3.7	0.0	95.4	0.9	108	0.0	6.8	1.0	92.2	0.0	103
LT beaches	1.1	0.0	38.9	1.1	58.9	0.0	95	0.0	45.2	0.8	54.0	0.0	126
Moose	4.1	0.0	63.3	0.0	32.7	0.0	98	0.0	78.1	0.0	21.9	0.0	105
Grant River	2.2	0.0	68.5	2.2	27.2	0.0	92	0.0	64.7	1.0	34.3	0.0	102
Kulik beaches	4.1	0.0	92.8	1.0	2.1	0.0	97	0.0	96.2	1.0	2.9	0.0	104
Unweighted mean	1.3	0.0	54.1	0.5	44.0	0.0	2046	0.1	55.1	0.6	44.0	0.0	2051
Wood River ADF&G tower	0.5	0.2	43.5	0.5	53.6	0.8	1205	1.1	57.3	0.5	40.2	0.5	1618

Table 20. Daily counts of sockeye salmon spawners in Hansen Creek, 1994.

	Estimate	In Creek			In ponds			Cumu-	Live+
	off		Natural	Bear		Natural	Bear	lative	cum.
Date	mouth	Live	dead	dead	Live	dead	dead	dead	dead
Jul. 25		0	0	0	0	0	0	0	0
26		0	0	0	0	0	0	0	0
27		687	5	32	0	0	0	37	724
28		1183	4	90	99	0	0	131	1413
29		996	2	108	120	0	1	242	1358
30		1651	6	119	160	0	2	369	2180
31		2037	14	164	115	0	0	547	2699
Aug. 1		2122	6	159	192	0	6	718	3032
2		2503	5	193	212	0	4	920	3635
3		2218	18	234	340	0	2	1174	3732
4		1714	41	216	195	1	2	1434	3343
5		2432	53	178	231	0	1	1666	4329
6	500	2833	65	215	372	1	0	1947	5152
7		2437	135	211	508	0	1	2294	5239
8		2312	134	141	500	6	5	2580	5392
9		2568	199	209	101	3	2	2993	5662
10		2347	213	212	518	0	0	3418	6283
11		1935	331	297	500	25	5	4076	6511
12		1571	357	237	500	6	3	4679	6750
13		1161	228	243	300	30	9	5189	6650
14		1039	220	189	316	24	7	5629	6984
15		838	305	136	222	32	1	6103	7163
16		620	227	142	149	28	7	6507	7276
17		382	183	95	153	54	4	6843	7378
18		144	176	79	142	27	2	7127	7413
19		92	*36*	*16*	100	*39*	*3*	*7221*	7413
20		46	*32*	*14*	60	*37*	*3*	*7307*	7413
21		21	*6*	*2*	77	*0*	*0*	*7315*	7413
31		0			0				
Totals			3001	3931		313	70		

Dead fish removed on each survey.
Italics for estimates (no counts).

Table 21. Summary of Hansen Creek spawning surveys, 1990-94.

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