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ALASKA SALMON RESEARCH

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The contribution of graduate student research to our program is vital. In 1995, Dave Hand (Port Moller), Troy Hamon, Alyssa Reischauer and Dan Eastman (Wood River system), and Paul Schlenger and Frank Leonetti (Kvichak system) conducted their thesis research. Other University of Washington students working on the program in 1995 were Doug Peterson, Joe Miller, Larry Lehman, Megan McPhee, Lee Golding, and Cimbal Irwin. We also appreciated the assistance of Nicholas Kocan, a high school volunteer.

KEY WORDS

Bristol Bay, escapements, forecasts, genetics, growth, Kvichak, Nushagak, predation, spawning, sockeye salmon, 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 (ADFG) or the National Marine Fisheries Service (high seas), and we have also had cooperative research projects with salmon biologists from Japan and Russia.

This report is focused on our 1995 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 (Rogers 1995), and reports on our Alaska Peninsula work were recently completed (Rogers 1996a and b).

FORECASTING

PRE-SEASON FORECASTS

Forecasts of the 1996 Bristol Bay sockeye salmon (*O. nerka*) runs and catches were provided to participating processors at our October 1995 meeting. They are presented in Table 1 with the ADFG forecasts and the past forecasts and runs beginning in 1986. The two river system forecasts (FRI and ADFG) are based on the same data sources, but different analytical methods have often been used. Both 1995 forecasts were for a large run and catch, and the actual run (61 million) and catch (44 million) were even larger than forecast (the second largest and largest on record). The outlook for 1996 is for another large run and catch.

PORT MOLLER FORECAST

The Port Moller in-season 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). We have used a new vessel (*Cape Cross*) since 1994 after the tragic loss of the *Nettie H* in fall 1993. Four 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). Catch, mean length, and water temperature data were sent daily by radio to Port Moller and then faxed into Bristol Bay (after the season we processed salinity readings). 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 19%, 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 1995, the Bristol Bay run was unusual in that it was more spread out in time—starting early and ending late (Fig. 1). The distribution of the sockeye as they passed Port Moller was also unusual in 1995 as the sockeye were located much farther offshore than in past years (Fig. 2). The test-fish catches projected that the 1995 run would be average in timing, but under-forecast the run magnitude because the run was distributed so far offshore.

While the main goal of the Port Moller program is to provide an in-season forecast, it also provides an opportunity to examine some other questions of concern to the fishing industry (e.g., is there an interaction between Bristol Bay sockeye and Bering sea king crab). The mass migration of salmon in June, which contains tens of millions of fish, places an increased risk on planktonic organisms that the salmon eat. These food organisms include euphausiids, copepods, larval fish, and crab zoea. Of particular interest is the predation on crab zoea. The commercially important red king crab is known to spawn in the Black Hills/Port Moller area beginning in early April, and the zoea metamorphose to first instars in late July. Stomach and plankton samples as well as oceanographic measurements were collected in 1995 to determine the potential impact of sockeye salmon abundance on the recruitment of king crab. We plan to use population estimates and salmon energetics to estimate the impact of migrating salmon on the planktonic biomass in Bristol Bay.

ADFG (J. Miller, Anchorage) provided preliminary length and weight statistics for 1995, 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 1995 run were smaller than the long-term average but were typical of recent years with large runs. 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 and westside catches, the average weights calculated from ADFG sampling were well below average (Tables 4 and 5).

The Port Moller test fishery in 1995 provided an early indication to ADFG management that a large run was on the way, and the age composition suggested a large Kvichak run. Although there was some overescapement in the Ugashik, Wood, and Igushik rivers, the escapements in 1995 were closer to the goals than in any of the past 6 years (Table 6). Considering the size of the run (second to 1980), management of the run was outstanding. Good catches were made in all districts before large numbers of fish were counted past the towers. The rather even temporal distribution of the run contributed to management and allowed the industry to process the largest catch on record without limitations on fishing.

LAKE RESEARCH

During the summer of 1995, 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 years and constitute the longest continuous biological and environmental record on any salmon stock in Alaska. In 1995 we also conducted special studies of bear predation on spawning sockeye salmon, stock-specific traits of sockeye spawning populations, predation on sockeye eggs in streams, and the relative productivity of sockeye and non-sockeye lakes in the Nushagak region. In addition, we provided a crew to ADFG for their Nuyakuk escapement enumeration.

KVICHAK SYSTEM

Our 1995 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 and threespine stickleback (*Gasterosteous aculeatus*) in upper Lake Iliamna and for sockeye fry, stickleback and least cisco (*Coregonus sardinella*) in Lake Clark in August and; conducting spawning ground surveys in late August to early September to collect otoliths for sockeye age determination. We continued our studies on (1) the ecological relationship between sockeye salmon and two sculpin species, *Cottus cognatus* and *C. aleuticus*, (2) ecological factors promoting the genetic differentiation of sockeye salmon populations and (3) the spawning behavior of sockeye salmon.

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 1990–95 (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 100,000 in the Kvichak) and the season's total Kvichak escapement to estimate the Newhalen/Lake Clark escapement.

In 1995, we estimated 1.12 million of the Kvichak escapement of 10.04 million (about 11%) migrated to the Newhalen/Lake Clark system (Table 8). The aerial surveys conducted by ADFG in 1995 (Regnart 1995) provided an estimate of the Newhalen River spawners (120,000) and, thus, by subtraction, an estimate of the Lake Clark escapement of 1.0 million.

Spawning Ground Surveys

Each year since 1956, we have collected scales or otoliths from spawned out sockeye salmon from several major spawning grounds in the Kvichak River system. In 1995, we sampled nine separate spawning grounds: seven in Lake Iliamna and two in the Newhalen River system (Table 9).

Overall, the age pattern was similar to the composition of the entire lake system (Kvichak escapement). The vast majority of fish sampled at the island beach spawning sites (Woody and Fuel Dump islands) were age 2.2 (>98%) as were those sampled at mainland beaches (Knudson Bay, >88%) where they usually contain a significantly higher proportion of age 1.2 fish. This high proportion of freshwater age 2 island beach fish is consistent with the small proportion (8%) of age 1 smolts resulting from the 1990 escapement. However, the reduced proportion of age 1.2 fish of the island beaches was not seen across all other populations. In particular, the two populations sampled in the Newhalen River had a large proportion of age 1.2 fish. Jacks (1-ocean fish) were rare on the spawning grounds and nearly absent in the Kvichak escapement 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 1995 survey were reported by Regnart (1995). These are summarized for 29 selected spawning grounds (Table 10). Aerial counts accounted for 10.3% of the total (tower count) escapement into the Kvichak system. This percentage is lower than in the 1960s and 70s but it is consistent with that seen in the last 15 years. It is likely that a major part of the variation results from different observers, with weather conditions and distribution of spawners also producing variation across years.

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 1995, we sampled our 9 sites in Lake Clark and our 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 1995, sockeye fry from Lake Iliamna were only slightly larger than those in Lake Clark (55 vs. 54 mm) (Table 11). The size of fry in the two lakes within years is closely correlated to each other over years, indicating that large scale environmental effects (temperature) affect each in a similar fashion. The warmer the water temperatures during the first growing season of the fry, the greater their growth and the greater the percentage of fish that will smolt at age 1. On the basis of an average size of 55 mm for Iliamna fry on September 1, we estimate that nearly 40% of fry resulting from the 1994 brood year will smoltify and migrate to sea in spring 1996.

Predation of Sockeye Eggs by Coastrange and Slimy Sculpins

Since 1992, we have monitored the predatory intensity of sculpin species on sockeye salmon eggs during the spawning season. In 1992 and 1993, we documented that sculpins migrate to sockeye salmon spawning beaches in large numbers and potentially 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 salmon nests and examined the ecological parameters (temperature) that affect the distribution of sculpins and the susceptibility of sockeye nests to predation. In 1995, we continued to monitor the relationship between the run size of sockeye salmon on the beaches relative to the intensity of sculpin predation. If sculpin predation is related to the 5-yr cycle in sockeye abundance observed on the beaches and in the Kvichak as a whole, then the effects of predation must be depensatory. That is, the relative effects of predation at the peak of the cycle must be consistently much less than that at low points in the cycle.

We attempted to monitor sculpin density by two methods: (1) live traps with a set amount (40 g) of eggs, and (2) direct monitoring of sculpin density on the beaches in a series (24) of preset 1-m^2 quadrats which we have monitored since 1992. Unfortunately, the live-trap method was not useful this year because the sockeye salmon commenced spawning early (August 8th) on the beaches, and the traps are not useful once spawning has commenced. However, the results of the beach surveys were startling. Sockeye spawning density was very high across all beaches, including northwest Woody Island where sockeye spawning density was monitored in a series of 25-m^2 quadrats. The numbers were so high that, while the sockeye began spawning early, they also spawned later than we had seen during the three previous years. In addition, sockeye salmon were observed spawning on beaches of marginal quality where they had not been observed in 1992–94. While sockeye salmon numbers were high, sculpin numbers were both relatively and absolutely low; that is, not only were there fewer sculpins per spawning sockeye on the beaches in 1995, the actual number of sculpins was much lower than had ever been observed previously. Therefore, sculpin predation may act in a depensatory manner on sockeye egg survival.

The question remains as to whether the total number of sculpins across spawning beaches was actually lower or whether the sculpins were simply more dispersed in concordance with the greater number and spawning dispersal of sockeye salmon. Available evidence suggests that the total number of sculpins was actually lower. In 1994, we noted a severe drop in the numbers of one of the species, slimy sculpins, which we initially thought was related to warm surface-water temperatures (slimy sculpins move up from the cooler depths to feed on the beaches). However, the water temperatures were cooler in 1995, and the slimy sculpin numbers did not return to what we had seen in 1992 and 1993.

In 1996, we plan to monitor sockeye salmon and sculpin densities across the beaches so that we will have one 5-yr beach and Kvichak sockeye abundance cycle. We also plan to evaluate whether there has been a change in the absolute or relative numbers of sculpins.

Iliamna Beach Spawning Studies

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, ≤50% of the spawning run has historically used this habitat during years of peak escapement. In 1995, Frank Leonetti (graduate student) continued his investigation at two island beaches, one each on Northwest Woody, and Fuel Dump islands. Spawning gravel size at these two sites, and the depth of salmon egg deposition was measured in the nests of individually tagged females. Previously, research in 1994 focused on measuring surface and intragravel water flow and dissolved oxygen (DO) at beach spawning sites. Water flow and DO within individual redds of tagged females were also investigated across a depth gradient. At Woody Is., spawning density is negatively correlated with depth; more females spawn in shallow water (0.5 m) than in deep water (2.5 m). Intergravel water flow and DO were also negatively correlated with depth; shallow nests had greater water flow and provided higher oxygen concentrations to developing embryos than deep nests. Hence, the preference for shallow water by females may be due to selection for the best incubation environment for the developing embryos.

The change in water flow and oxygen with depth is related to the reduced effects of wave action with depth and the associated change in average gravel size. At Woody and Fuel Dump islands, DO is strongly negatively correlated with the percent of fines in the gravel. The greater effects of wave action at the surface result in a large average gravel size with few fines whereas with increasing depth, the effects of wave action decrease, resulting in decreased average gravel size and increased the percentage of fines. It is possible that egg survival is not affected by this reduced water flow at depth because eggs in nests with finer sediments do not settle to deeper depths within the gravel matrix as they do in shallow waters, where fines are virtually absent within spawning areas. Research planned for 1996 will focus on the disadvantages of spawning in shallow water; winter low-water levels and the scouring effects of ice may put shallow nests at risk of destruction.

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 rearing?) environment. The research is important in terms of documenting and correctly managing the diversity of sockeye salmon within the lake and is part of our ongoing project to study the biology/ecology of each of the major spawning types within the Kvichak system.

Pedro Pond sockeye salmon age composition is similar to that of the island beach spawners, with a varying proportion of age 1 and 2 smolts and with most fish spending 2 years in the ocean. Like the island beach spawners, the 1995 escapement consisted of a high proportion of 2-year-old smolts. However, their physical morphology is different from that of island beach spawning fish, with the pond males having smaller humps per a given length than those from the beaches. Predation studies conducted last year demonstrated that the pond fish suffer intense predation from bears, with large males being the most vulnerable. This predation may account for the divergence in spawning morphology, as beach spawning fish are relatively immune from this source of selective predation.

Also in contrast to the island beach spawning fish, which have large eggs in association with the large spawning gravel, females that spawn in the ponds have some of the smallest eggs ever observed in sockeye salmon. This appears to be an adaptation for the high proportion of fine sediments in the spawning gravel, which restricts water and oxygen flow to the eggs. Given that alevin and fry size is directly related to egg size, we predicted that pond fry would take longer (years) to smolt than beach spawning fish given their small initial size, but this was not the case. Therefore, we have commenced more detailed studies of pond environment temperature and the behavior of the fry that reside there; we plan to continue these studies in 1996.

Sockeye Spawning Behavior Studies

Since 1990, we have measured various aspects of sockeye salmon spawning behavior at the Iliamna island beach sites. In the past, we have examined the effects of male and female morphology on individual spawning success, described the change in male spawning dynamics over the course of the spawning run, and measured female spawning success in relation to nest site selection and spawning density and depth. In 1995, we extended these studies to examine the role of color in spawning behavior. In particular, we were interested in the role of the carotenoid-based red skin pigment in mate selection. Carotenoids are plant-synthesized compounds that are bioaccumulated throughout the food chain, with sockeye salmon getting their carotenoids largely from krill in the ocean. It is carotenoids that account for the valuable orange-red color of sockeye salmon flesh. These same carotenoids are largely transferred to the skin and eggs at spawning, leaving the flesh white in color. Using simple models, we were able to show that the color red is very important in mate selection by males, independent of whether they had or had not had any previous spawning experience. In contrast, green, black, and white—other colors apparent on the spawning fish—were not attractive to males. The attraction to red was so strong that we observed an average of over two spawnings per 5-min trials when red models were placed on the beaches. These results indicate that the ingestion and later mobilization of carotenoids from the flesh to the skin are very important in sockeye salmon mate choice, and may explain why sockeye have the reddest flesh of all Pacific salmon. In 1996, we hope to extend to this work by comparing other criteria that may be important in mate choice, and expanding our comparisons across populations.

Feeding Relationships Between Juvenile Sockeye Salmon and Least Cisco in Lake Clark

Juvenile sockeye salmon typically live in freshwater for one or more years before migrating to sea. During this time they reside in the limnetic zone and feed primarily on zooplankton. Experimental and field observations have indicated that sockeye salmon growth rates may be reduced in the presence of another limnetic planktivore, the threespine stickleback. In Lake Clark, juvenile sockeye salmon and least cisco reside in open waters and may compete for food resources.

In 1994, we completed the field component of a study to examine the feeding interactions of juvenile sockeye salmon and least cisco and determine whether the species compete for preferred resources. The Master's thesis (Paul Schlenger) resulting from this work will be completed in spring 1996. This research included an examination of the food habits (i.e., prey species and size), within-lake distributions, and feeding morphology of both species.

Underyearling sockeye salmon and least cisco numerically dominate the surface waters of the limnetic zone of Lake Clark. Sockeye fry were caught in high numbers throughout the surface waters of the lake, with yearling sockeye more concentrated at the southwestern (outlet) end of the lake. Least cisco were caught more frequently and in greater numbers in the surface waters of the northern half of the lake where the water is more turbid. Feeding at the surface by both species also occurred the during the day in the turbid parts of the lake, but not in the clearer, southwestern part of the lake.

The diets of the two species are very similar and they almost undoubtedly compete for the limited zooplankton available in the lake. We found that cisco had smaller spaces between their gillrakers and smaller mouth gapes than similar-sized sockeye salmon. Since mouth gape and gillraker spacing get larger with increasing fish size, we suspect that cisco are specifically adapted to feed on zooplankton throughout their lives. Supporting this hypothesis, the gillraker spacing and gape size of adult cisco are similar to that of yearling sockeye. Simply put, cisco are designed to not outgrow their food and hence likely compete for food with juvenile sockeye salmon throughout their lives.

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 1995 was early and ice breakup in Lake Aleknagik (recorded since 1949) was 12 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. Lake levels were above normal in early June but below average for the remainder of the summer. Standing crop of phytoplankton (chlorophyll) was below average throughout the summer, whereas zooplankton volumes were 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 1995 (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 1995, but no records were set.

Fry Abundance and Growth

In 1995, the sockeye salmon 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 3% shorter than average (Table 14). Fry abundance as measured by beach seine sampling in June and July and tow net sampling about September 1 was only 29% of the long-term average (Fig. 5). The number of parent spawners (483,000) in Lake Aleknagik in 1994 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 1995, growth was above 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.

Morphology and Gillnet Selection

We examined the effects of gillnet selectivity on locally differentiated spawning populations of sockeye salmon in Bristol Bay. The spawning populations differ in a consistent manner according to spawning habitats among and within lake systems. Different body shapes were evident for beach and stream spawners located <300 m apart. This differentiation—a different body depth relative to length—represents local adaptation of body form to spawning habitat. Gillnet selection acts directly on girth (body depth) of immature salmon. We correlated girth at the time of passage through the fishery to the morphological characters of sockeye salmon on the spawning grounds by tagging and measuring salmon as they entered the lake and then again on the spawning grounds a month later. Fishery catch and escapement data from 1994 were used to measure the effects of gillnet selectivity on mature spawners. There was opportunity for disruptive selection for populations of mixed ocean ages whereas directional selection was more likely to occur for populations of a single ocean age. We concluded that gillnet selection may result in significant additional selection on body form beyond that exerted by spawning habitat (Hamon 1995).

Spawning Ground Surveys

Sockeye salmon spawning ground surveys have been conducted annually in the Wood River Lakes system since 1946; however, it was not until the early 1950s that all 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 1995. The ground survey counts in 1995 for the major spawning grounds are given in Table 16. The creeks draining into Lake Aleknagik again contained relatively high counts of spawners. Hansen Creek contained a large number of spawners for the sixth consecutive year. Age compositions on the spawning grounds in 1995 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 (Table 17).

Bear Predation

We completed the sixth 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 24 July to 20 August, a large number of spawners were again observed in Hansen Creek (Table 18). Daily count and removal of sockeye salmon killed by bears indicated that 7,297 (43%) of 17,589 spawners were killed by bears in 1995 (Table 19). 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 1995 was the highest observed in the 6-year period. Our experiences during stream surveys in 1995 suggested that the bear population has increased in the Wood River Lakes system. 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 (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 1990–95, 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 19). 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.

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FIGURES

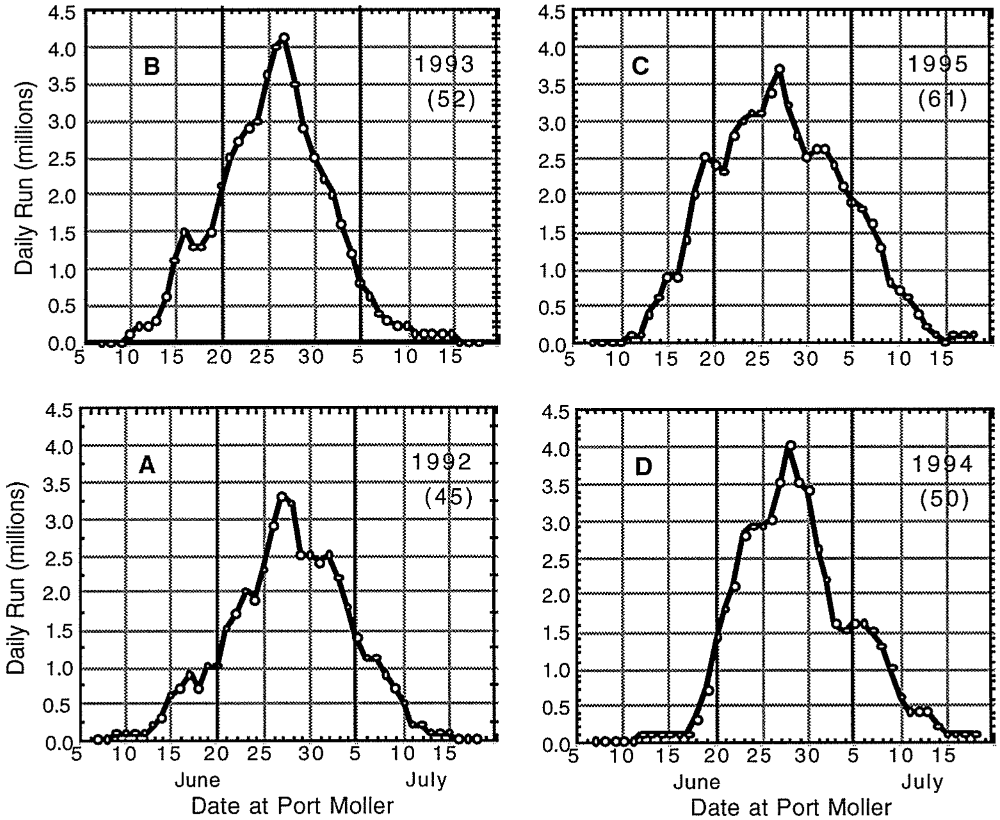

Figure 1. Daily Bristol Bay sockeye salmon runs reconstructed at Port Moller.

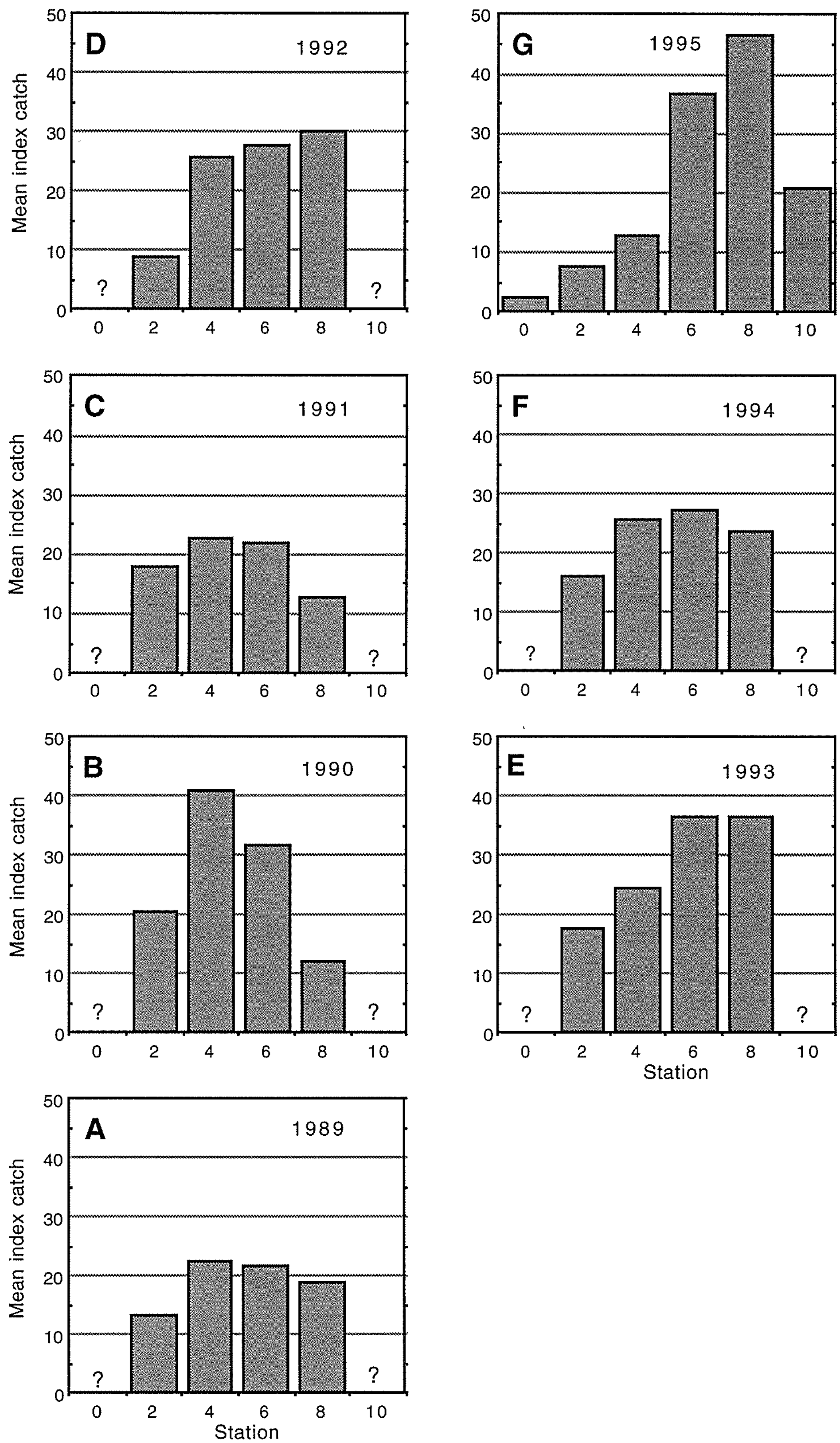

Figure 2. Average catches of sockeye salmon at Port Moller stations, June 11–July 5, 1989–95.

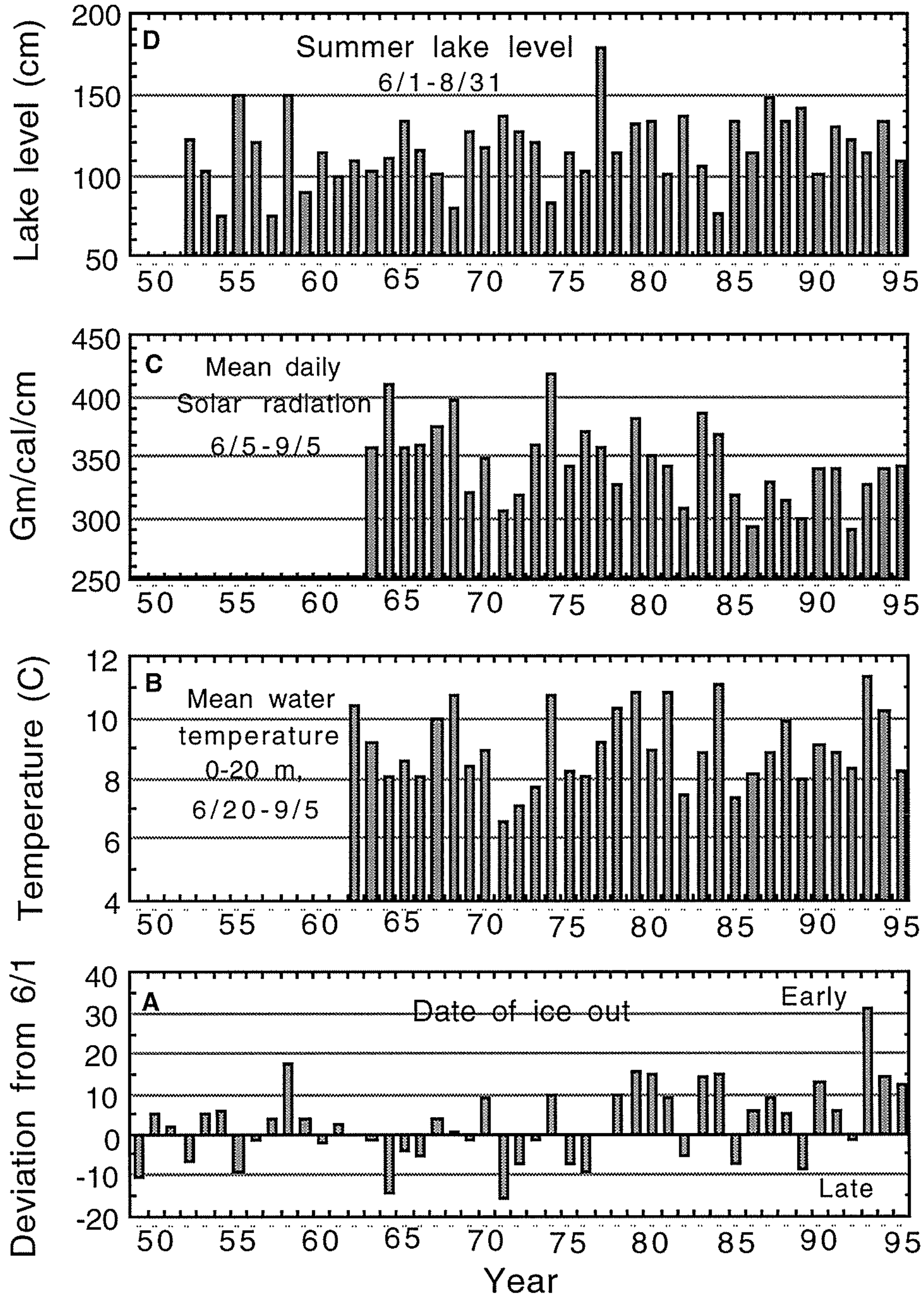

Figure 3. Dates of ice out and summer averages of water temperature, solar radiation, and lake level.

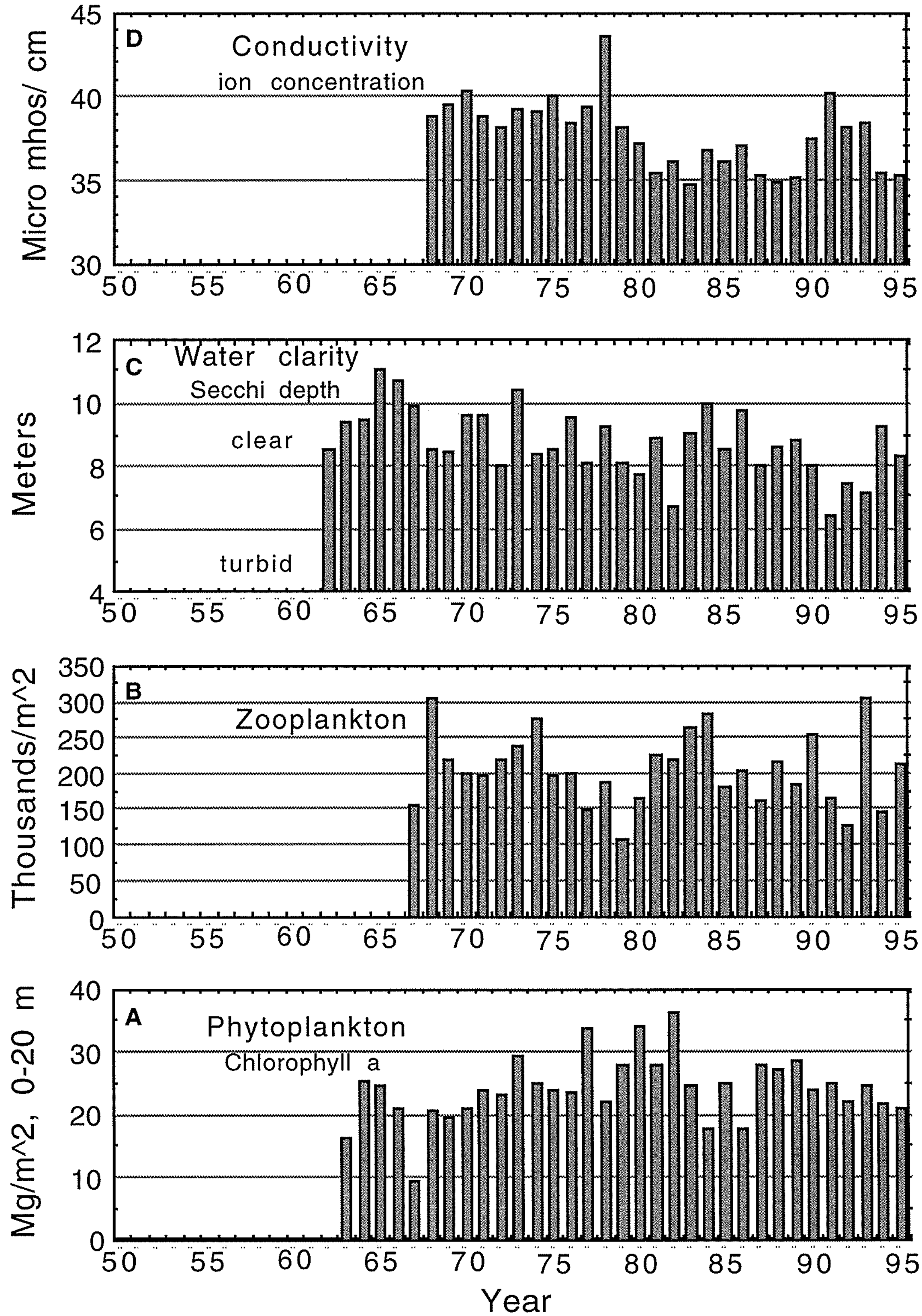

Figure 4. Phytoplankton and zooplankton densities, and water clarity and conductivity in Lake Aleknagik.

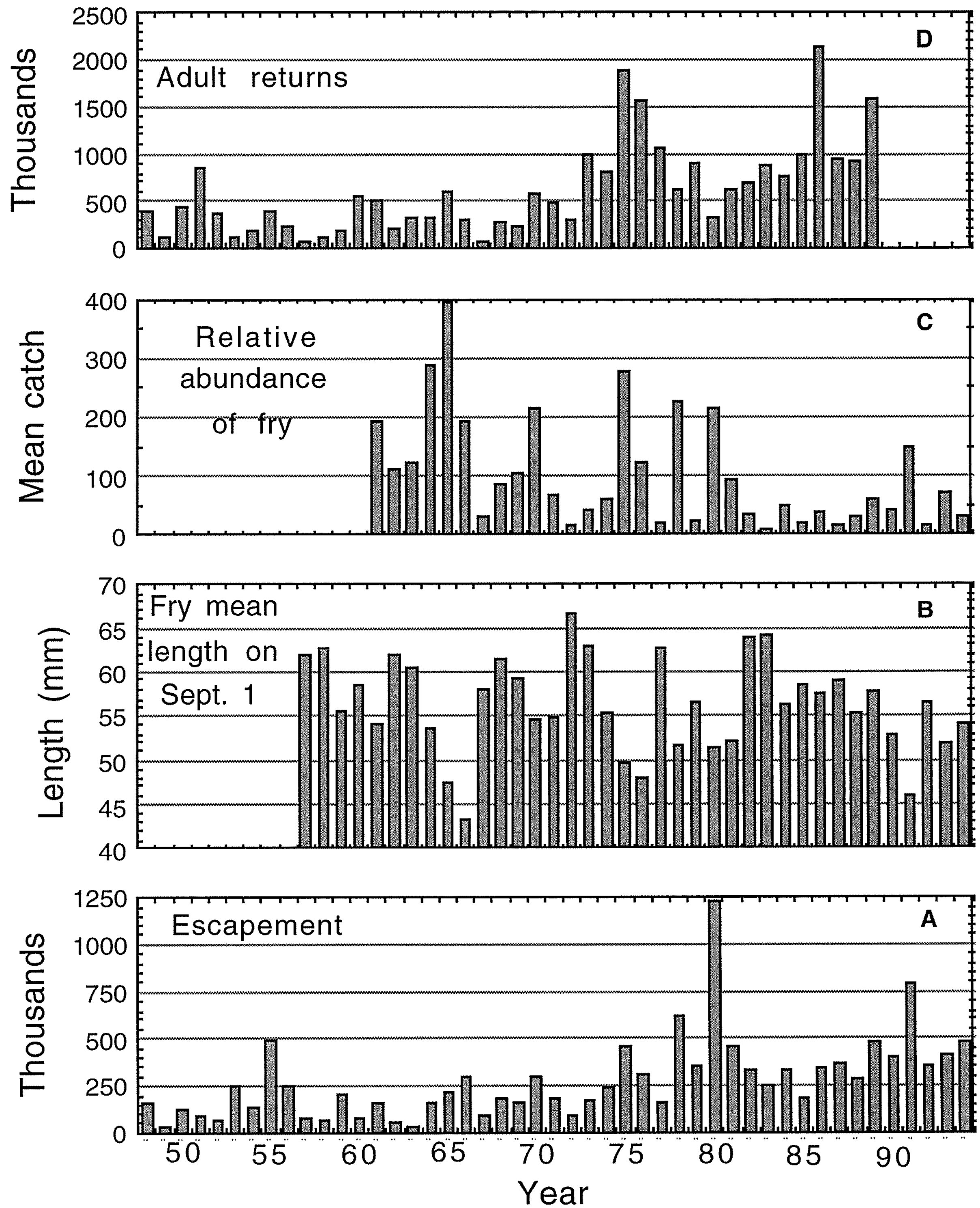

Figure 5. Parent escapements, mean lengths and abundances of fry, and adult returns to Lake Aleknagik.

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	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	60.7	44.3	

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
Means	44	30	42	2	9	40	3	12	40	4	10	26	4	16
absol.				7	20		6	17		5	12		4	17

Numbers in millions of fish.

absol. = absolute error, ignoring the sign.
%ofP= the percentage that the actual run differed from the prediction.
1993-95 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			3-ocean			Both age groups	Percent 3-ocean
		Male	Female	Combined	Male	Female	Combined		
1958	6	527	508	517	586	562	572	544	48
1959	13	522	502	512	585	562	571	522	16
1960	36	496	480	489	580	553	562	498	12
1961	18	525	512	519	583	562	572	554	66
1962	10	527	508	518	582	566	574	535	30
1963	7	529	512	520	594	570	580	546	44
1964	11	517	499	508	584	564	571	522	22
1965	53	506	487	497	574	552	561	502	8
1966	18	514	503	508	581	561	569	554	75
1967	10	534	518	526	592	570	579	544	34
1968	8	516	503	510	594	572	581	535	36
1969	18	524	510	517	591	571	580	525	22
1970	39	511	497	504	572	549	558	509	9
1971	16	530	516	522	584	563	572	552	60
1972	5	521	505	514	583	562	572	543	51
1973	2	522	513	518	601	575	587	575	82
1974	11	525	508	518	581	566	574	528	19
1975	24	518	499	509	587	564	574	523	21
1976	12	531	514	523	592	568	578	543	36
1977	10	533	517	525	597	573	584	556	53
1978	19	520	502	512	595	570	582	539	38
1979	40	537	524	530	586	567	576	538	18
1980	62	519	503	511	583	553	567	525	26
1981	34	536	523	529	588	566	577	555	54
1982	22	522	508	515	587	566	576	561	75
1983	46	530	514	521	574	557	565	529	17
1984	41	515	501	508	580	561	570	526	30
1985	37	527	512	520	583	567	575	543	41
1986	24	535	521	528	583	561	571	553	58
1987	27	521	506	513	590	567	577	538	39
1988	23	525	513	519	592	571	581	554	56
1989	44	525	507	515	586	564	575	538	27
1990	48	507	491	499	578	557	566	528	43
1991	42	508	493	500	573	547	560	536	60
1992	45	511	496	504	568	544	557	531	52
1993	52	530	515	522	582	560	570	547	52
1994	50	512	498	504	575	550	561	524	34
1995	61	520	502	511	578	555	567	526	27
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
88-95	49	516	500	508	577	554	565	533	42

Table 4. Average weights of sockeye salmon (lbs) 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
	95	20.4	5.0	4.4	4.8	6.9	5.9	6.5	5.5	4.7	5.2	22	44
	Means	10.5	5.2	4.5	4.8	7.1	6.1	6.6	6.0	5.3	5.6	45	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
	95	14.5	5.3	4.5	4.9	6.9	5.9	6.4	5.8	5.0	5.4	32	48
	Means	10.3	5.3	4.7	5.0	7.2	6.2	6.7	6.1	5.4	5.8	46	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
	Means	3.5	5.4	4.6	5.0	7.4	6.3	6.9	6.3	5.5	5.9	49	45

Table 5. Average weights of sockeye salmon (lbs) in commercial catches on the west sides of Bristol Bay, 1985–95.

		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 excess of management goals for Bristol Bay rivers, 1987–95 (in millions).

River	Escapement goals		Escapement in excess of mid-point								
system	Mid-point	Upper range	87	88	89	90	91*	92	93	94	95
Kvichak	variable	variable									
Branch											
Naknek	1.00		.06	.04	.16	1.09	2.57	.61	.54	.00	.11
Egegik	1.00		.27	.61	.61	1.19	1.79	.95	.52	.90	.27
Ugashik	.70		.00	.00	1.01	.05	1.76	1.76	.71	.38	.60
Wood	1.00		.34	.00	.19	.07	.16	.29	.18	.47	.48
Igushik	.20		.00	.00	.26	.17	.56	.10	.21	.25	.27
Nuyakuk/Nush.	.50		.00	.00	.01	.17	.00	.20	.21	.01	.00
Togiak	.15		.13	.16	.00	.04	.13	.07	.04	.02	.06
Total			.80	.81	2.24	2.78	6.97	3.98	2.41	2.03	1.79
Bristol Bay run			27	23	44	48	42	45	52	50	61
Catch			16	14	29	33	26	32	41	35	44
			Escapement in excess of upper range								
Naknek		1.40	.00	.00	.00	.69	2.18	.21	.14	.00	.00
Egegik**		1.20	.07	.41	.41	.99	1.59	.75	.32	.70	.00
Ugashik**		.90	.00	.00	.81	.00	1.58	1.56	.51	.18	.10
Wood		1.20	.14	.00	.00	.00	.00	.09	.00	.27	.28
Igushik		.25	.00	.00	.21	.12	.51	.05	.16	.20	.22
Nuyakuk/Nush.		.76	.00	.00	.00	.00	.00	.00	.00	.00	.00
Togiak		.25	.03	.06	.00	.00	.03	.00	.00	.00	.00
Total			.24	.47	1.43	1.80	5.89	2.66	1.13	1.35	.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, 1990–95 (number in 1,000s and Newhalen escapements estimated from expanded counts lagged back 2 days).

	1990		1991		1992		1993		1994		1995	
Date	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen
6/22							13					
23					0		24		0			
24	0				1		34		0			
25	1		0		2		51	6	0		0	
26	2		1		10		121	67	1		41	7
27	3		3		17		317	78	8		361	28
28	5	0	50	7	81	5	559	157	24		724	48
29	8	1	125	46	255	18	847	237	25		941	75
30	39	2	277	95	446	67	932	394	25		1113	109
7/1	46	37	588	146	635	88	1014	492	26	0	1610	158
2	219	66	901	188	754	104	1081	650	30	1	2338	255
3	825	90	1256	330	798	132	1182	816	254	1	2798	309
4	1412	110	1581	517	1093	196	1307	937	1550	321	3105	364
5	1874	139	1925	620	1663	273	1678	1022	2727	558	3346	398
6	2399	204	2141	805	2244	329	2372	1103	3518	775	3983	430
7	2901	304	2208	1132	2688	406	2733	1121	4273	921	4937	482
8	3509	375	2277	1531	2880	534	2932	1134	5132	1091	5930	581
9	4061	459	2355	1721	2960	661	3101	1163	5821	1286	7020	687
10	4692	648	2633	2048	2985	840	3264	1189	6473	1601	7683	805
11	5081	790	3080	2202	3175	977	3402	1220	7058	1884	8005	1050
12	5388	961	3460		3662	1057	3574	1268	7268	2168	8169	1199
13	5803	1079	3724		4066	1158	3751	1322	7330	2372	8430	1226
14	6208	1193	3822		4330	1258	3818	1353	7382	2450	8658	1378
15	6418	1297	3909		4438	1434	3864		7495	2535	8878	
16	6510		3999		4517	1491	3894		7540	2578	9017	
17	6603		4063		4578		3921		7631		9131	
18	6674		4098		4626		3958		7852		9248	
19	6733		4132		4685		3986		8099		9512	
20	6781		4166		4695		3996		8169		9703	
21	6827		4193		4710		4008		8193		9788	
22	6876		4213		4720		4016		8265		9876	
23	6915		4220		4726		4021		8338		9919	
24	6941						4024				9954	
25	6970						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

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 1995.

Spawning ground	Sex	Sample size (n)	Age composition (%)				
			2.1	1.2	2.2	1.3	2.3
Gibralter River	M	100		19.0	34.0	3.0	44.0
	F	100		15.0	31.0	6.0	48.0
Copper River	M	99		1.0	37.4	14.1	47.5
	F	99		0.0	58.6	0.0	41.4
Chinkelyes Creek	M	97		7.2	79.4	5.2	8.2
	F	99		5.1	73.7	5.1	16.2
Newhalen River	M	101	1.0	45.5	27.7	4.0	21.8
	F	65		52.3	18.5	0.0	29.2
Tazimina River	M	98		46.9	23.5	3.1	26.5
	F	98		45.9	23.5	7.1	23.5
Woody Island beaches	M	48		0.0	100.0	0.0	0.0
	F	49		0.0	98.0	0.0	2.0
Fuel Dump Island beach	M	49		2.0	98.0	0.0	0.0
	F	50		0.0	100.0	0.0	0.0
Knudson Bay beach	M	98		4.1	88.8	3.1	4.1
	F	99		1.0	92.9	2.0	4.0
Pedro Creek ponds	M	129	0.8	15.5	79.8	3.1	0.8
	F	114		9.6	78.1	7.9	4.4
Kvichak escapement	M	1555		7.5	78.6	2.6	11.3
(ADF&G,Igiugig)	F	2101		8.3	79.8	2.7	9.0

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
95	554	187	50	244	1035	10039	10.3	7
Means								
61-66	239	139	79	261	718	5948	12.5	2
67-83	505	175	76	99	856	5702	17.6	3
88-95	336	134	44	46	560	6338	9.3	6,7

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.

Brood year	Kvichak escapement (millions)	Lake Iliamna Mean catch	Lake Iliamna Mean length	Lake Clark Mean catch	Lake Clark 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				

Lake Iliamna tows in areas 7 & 8 only.

Table 12. Summary of 1995 measurements in Lake Aleknagik.

Measurement and first year measured	Dates	1995	Past years Average	Range
1. Date of ice breakup 1949-		5/20	5/29	5/01-6/16
2. Water temperature, 0-20m (C) 1958-	6/23	7.1	5.8	3.7, 9.2
	7/15	11.3	8.4	5.7, 12.0
	8/3	12.8	10.8	7.7, 14.0
	9/3	12.7	11.2	9.3, 13.0
3. Water transparency Secchi depth (m) 1962-	6/23	6.6	8.0	5.3, 10.5
	7/15	7.2	8.2	5.0, 10.9
	8/3	8.0	9.3	6.3, 11.9
	9/3	11.4	9.2	5.8, 12.1
4. Water conductivity (micromhos/cm) 1968-	6/23	36.9	38.5	34.7, 52.1
	7/15	32.0	37.2	33.5, 42.6
	8/3	35.9	37.0	32.5, 40.5
	9/3	36.0	38.2	34.8, 47.9
5. Average daily solar radiation (gm/cal/cm) 1963-	June 1-15	463	411	305, 588
	June 16-30	391	408	265, 572
	July 1-15	384	390	284, 543
	July 16-31	354	354	194, 481
	Aug. 1-15	254	299	203, 402
	Aug. 16-31	278	255	170, 421
	Sept. 1-15	184	208	114, 282
6. Lake level (cm) of Lake Nerka 1952-	June 1-15	167	143	84, 222
	June 16-30	138	152	97, 218
	July 1-15	111	132	75, 199
	July 16-31	90	106	54, 172
	Aug. 1-15	79	87	34, 173
	Aug. 16-31	73	83	30, 184
	Sept. 1-15	75	83	29, 161
7. Chlorophyll "a", 0-20m (mg/m2) 1963-	6/23	24	29	10, 45
	7/3	22		
	7/15	15	27	10, 43
	7/23	24		
	8/3	22	22	6, 36
	8/13	23		
	8/23	23		
	9/3	22	24	12, 37
8. Zooplankton volume 0-60m (ml/m2) 1967-	6/23	63	52	20,168
	7/3	130		
	7/15	142	85	45-162
	7/21	158		
	8/3	144	119	43-226
	8/13	82		
	8/24	56		
	9/3	43	62	26-107

Table 13. Five-day averages of catches of emergent midges and water temperatures at three stations on Lake Aleknagik, 1995.

5-day period	Catch per day 1995 W	H	B	Mean	Catch per day 1969-95 Mean	Min	Max	Water temperature (°C) 1995 W	H	B	Mean	Water temperature (°C) 1969-95 Mean	Min	Max
6/1-5	2	9	4	3	2	0	3	7.3	7.5	8.7	7.8	3.2	0.0	9.8
6-10	3	3	1	2	10	0	70	5.5	8.2	10.4	8.0	5.6	0.0	10.4
11-15	5	3	2	3	11	1	53	12.3	10.6	13.4	12.1	6.9	1.0	12.1
16-20	3	1	2	2	16	1	168	11.0	10.5	12.2	11.2	8.4	3.9	12.7
21-25	3	7	4	5	7	0	42	9.1	12.2	14.1	11.8	8.9	4.8	12.8
26-30	4	19	2	8	5	0	12	8.9	11.3	9.9	10.0	9.8	6.0	13.9
7/1-5	1	2	1	1	6	1	16	14.2	13.2	14.0	13.8	11.1	7.7	15.5
6-10	8	1	19	9	12	2	69	18.5	14.6	14.8	16.0	12.0	9.6	16.0
11-15	19	9	4	11	14	1	34	19.3	16.8	17.7	17.9	12.5	9.2	17.9
16-20	45	22	6	24	15	2	36	14.4	14.5	16.3	15.1	12.3	8.5	17.0
21-25	5	25	2	11	20	2	74	14.2	16.3	16.0	15.5	12.8	7.9	17.2
26-30	4	10	0	5	28	5	59	15.2	16.0	16.5	15.9	13.5	8.9	16.1
31-4	2	2	10	5	27	4	77	14.9	15.2	15.5	15.2	13.7	10.2	17.5
8/5-9	2	16	11	10	20	3	80	14.1	13.5	12.6	13.4	13.6	10.4	17.1
10-14	2	28	5	12	15	1	54	13.6	13.7	13.8	13.7	13.5	9.5	18.8
15-19	4	21	8	11	13	1	70	15.3	15.0	16.6	15.6	13.5	11.0	16.2
20-24	1	10	0	4	6	0	28	15.2	13.7	15.0	14.6	13.4	9.7	15.4
25-29	2	6	1	3	5	1	11	13.6	14.8	14.7	14.4	13.3	11.3	14.7
30-3	1	2	2	2	6	1	13	13.9	13.6	14.0	13.8			

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
Means	150	31.4	55.8	.35	49	320	135	31.1	44.5	.19	77	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
Means	13	17	39	60	57	57	111	115	242	17	45

Table 16. Ground survey counts of sockeye salmon spawners in the Wood River lakes, 1995.

Location	Date	Estimated off mouth	In creek: Live	In creek: Dead	In creek: Natural	In creek: Bear kill	Total
Aleknagik							
Yako	8/01	2000	1715	232	152	80	3947
Hansen	8/06	100	7680	4423	2175	2248	12203
Bear	8/03	1000	2983	91	76	15	4074
	8/25	250	771	3269	2285	984	4290
Happy	8/08	0	5274	3648	3101	547	8922
Ice*	8/11	0	2594	1552	1443	109	4146
Eagle	8/14	20	1647	172	77	95	1839
Mission	8/20	250	1182	1482	1177	305	2914
Whitefish	8/11	350	1852	209	178	31	2411
	8/26	0	535	1395	1153	242	1930
Nerka							
Fenno	8/10	0	841	2441	2392	49	3282
Pick	8/16	200	3381	853	294	559	4434
Lynx	8/23	100	239	164	75	89	503
Stovall*	8/25	0	111	362	97	265	473
Pike*	8/25	0	44	372	300	72	416
Hidden Lake	8/26	0	349	1363	702	661	1712
Elva	8/08	0	239	18	13	5	257
Kema*	8/28	0	157	300	260	40	457
Beverley							
Moose*	8/12	100	864	416	372	44	1380
Kulik							
Grant River*	8/25		No counts, but medium density; 90% dead				

* Partial count; entire stream not surveyed.

Table 17. Age compositions (%) of sockeye spawners in the Wood River Lakes in 1995.

Location	Males 1.1	1.2	2.2	1.3	2.3	No. of fish	Females 1.1	1.2	2.2	1.3	2.3	No. of fish
Hansen	0.0	67.6	9.5	22.9	0.0	275	0.0	77.8	10.1	12.0	0.0	316
Happy	0.0	69.3	7.9	21.8	1.0	101	0.9	69.0	6.0	24.1	0.0	116
Bear	0.0	36.1	14.4	48.5	1.0	97	0.0	48.5	16.2	35.4	0.0	99
Ice	0.0	29.1	10.7	60.2	0.0	103	0.0	21.0	15.0	63.0	1.0	100
Agulowak River	0.0	8.7	2.4	89.0	0.0	127	0.0	9.8	3.3	86.9	0.0	61
Wood River	0.0	48.4	13.4	38.1	0.0	97	1.1	36.8	21.0	40.0	1.1	95
Fenno	0.9	38.7	0.0	60.4	0.0	106	0.0	57.4	0.0	42.6	0.0	108
Stovall	0.0	35.7	0.0	64.3	0.0	70	0.0	59.1	0.0	40.9	0.0	88
Pike	0.0	85.1	0.0	14.9	0.0	87	0.0	76.3	0.0	23.7	0.0	97
Lynx	0.0	35.4	0.0	64.6	0.0	99	0.0	44.2	0.0	55.8	0.0	95
Pick	0.0	26.0	0.0	74.0	0.0	96	0.0	12.7	0.0	87.3	0.0	102
LT River	0.0	21.1	0.0	78.9	0.0	95	0.0	35.2	1.4	62.0	0.0	71
N4-N6 beach	0.0	56.6	1.2	42.2	0.0	83	0.0	57.5	0.0	42.5	0.0	106
Kema	0.0	68.5	1.1	30.4	0.0	92	1.0	85.3	2.9	10.8	0.0	102
Hidden Lake	0.0	94.0	1.0	5.0	0.0	101	0.0	96.2	0.9	2.8	0.0	106
Anvil Bay beach	0.0	78.3	0.0	21.7	0.0	92	0.0	55.1	3.1	41.8	0.0	98
Agulukpak Rtver	0.0	31.6	0.0	67.5	0.9	117	0.0	27.2	0.0	71.8	1.0	103
LT beaches	0.0	57.8	15.6	24.4	2.2	45	0.0	47.9	13.5	37.5	1.0	96
A, B, & C creeks						1	0.0	77.8	16.7	0.0	5.6	18
Moose	0.0	73.5	0.0	26.5	0.0	102	0.0	72.9	0.9	26.2	0.0	107
Hardluck Bay beach	0.0	100.0	0.0	0.0	0.0	10	0.0	92.3	0.0	7.7	0.0	13
Grant River	0.0	68.6	0.0	31.4	0.0	105	0.9	75.9	8.3	14.8	0.0	108
Kulik beaches												
Unweighted mean	0.0	53.8	3.7	42.2	0.2	2101	0.1	56.2	5.4	37.7	0.4	2205
Wood River ADFG tower	0.0	59.2	4.8	33.8	0.7	993	0.0	67.0	5.3	26.3	0.5	1784

L.T. River: females, age 1.4 (1.4%)

Wood River other = males: age 0.2(0.6%) and age 0.3 (0.4%); females: age 0.2(0.1%) and age 0.3 (0.1%).

Table 18. Daily counts of sockeye spawners in Hansen Creek, 1995.

	Estimate	In creek			In ponds					Cumu-	Live+
	off		Natural	Bear		Natural	Bear	Total	Total	lative	cum.
Date	mouth	Live	dead	dead	Live	dead	dead	live	dead	dead	dead
Jul. 20		0	0	0	0	0	0	0	0	0	0
21		11	89	357	*44*	0	6	55	452	452	507
22		2	14	58	*122*	0	1	124	73	525	649
23		1	1	0	*40*	0	0	41	1	526	567
24		1148	99	102	*228*	0	0	1376	201	727	2103
25	2650	4756	104	114	*240*	0	0	4996	218	945	5941
26	2000	3598	48	137	*414*	0	0	4012	185	1130	5142
27	2100	3757	36	138	*281*	0	2	4038	176	1306	5344
28	800	3849	83	68	*886*	0	0	4735	151	1457	6192
29	2100	5280	56	200	4434	0	1	9714	257	1714	11428
30	1300	4968	107	136	*540*	0	2	5508	245	1959	7467
31	1200	6253	75	85	*653*	2	2	6906	164	2123	9029
Aug. 1	600	4609	68	155	1900	2	0	6509	225	2348	8857
2	350	3093	156	135	2000	1	0	5093	292	2640	7733
3	400	4555	176	105	1385	7	0	5940	288	2928	8868
4	250	5953	284	138	1513	6	3	7466	431	3359	10825
5	300	5859	454	139	1700	9	1	7559	603	3962	11521
6	100	5980	298	163	*532*	2	0	6512	463	4425	10937
7	50	5313	295	221	*865*	11	2	6178	529	4954	11132
8	100	4651	411	222		35	4	4651	672	5626	10277
9	50	4263	421	367	*384*	32	1	4647	821	6447	11094
10	30	5013	643	338	*550*	34	1	5563	1016	7463	13026
11	25	4730	518	403	*449*	37	3	5179	961	8424	13603
12	45	3934	527	625	1338	62	225	5272	1439	9863	15135
13	0	3582	534	313	995	15	1	4577	863	10726	15303
14	3	3172	567	192	915	34	1	4087	794	11520	15607
15	6	2715	742	296	852	36	6	3567	1080	12600	16167
16	0	2163	521	321	898	44	4	3061	890	13490	16551
17		1670	569	249	*163*	50	17	1833	885	14375	16208
18	0	973	530	299	604	45	22	1577	896	15271	16848
19		577	379	225	636	52	21	1213	677	15948	17161
20	0	251	250	169	*126*	35	14	377	468	16416	16793
21	0	88	138	231	669	24	23	757	416	16832	17589
22	0	15	48	144	*323*	17	19	338	228	17060	17398
23	0	6	15	58	*278*	6	12	284	91	17151	17435
Totals			9256	6903		598	394				

Dead fish removed on each survey.
Italics indicate that only the side pond was counted.

Table 19. Summary of Hansen Creek spawning surveys, 1990–95.

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