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INTRODUCTION

The Fisheries Research Institute (FRI) was established in 1946 with the financial support of the major Alaska salmon (*Oncorhynchus* spp.) processors. There were three principle objectives: (1) investigate the causes of the declines in production that had occurred in most stocks since the 1930s, (2) 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 (3) assist salmon processors by providing a second opinion on matters of salmon fisheries management. With the high levels of production since the 1980s, our primary objectives now are to determine how to maintain the high production (i.e., understanding what has caused year-to-year and decade to decade variation) and provide information so that the salmon can be harvested and processed most efficiently by accurately forecasting the run and facilitating even distribution of fishing throughout the run.

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

This report is focused on our 2001 Bristol Bay research with emphasis on salmon forecasting and research relevant to escapement policies for maximizing production. We report on 2001 observations for our long-term studies in the Nushagak and Kvichak lake systems with brief descriptions of some short studies by graduate students.

FORECASTING

The 2001 total inshore run to Bristol Bay was 22.0 million sockeye salmon (*O. nerka*). Using the traditional method, our 2001 preseason forecast of 21.5 million was very close. However, our forecasted age composition of the run (42% age 1.3) was inaccurate with 81% of the run being age 1.3. Much of the preseason error was caused by the poor returns of ages 1.2 and 2.2 fish to the Kvichak. We had forecast 3.2 million 2-ocean sockeye and only about 100,000 showed up in the Kvichak. During the past 50 years, these two age classes have dominated all but two of the Kvichak runs until 2000 and 2001 when the runs were predominantly 3-ocean sockeye (Table 1). For the entire North Pacific, the sockeye returns in 2001 of 55 million were below the recent 10-year average as were the chum salmon runs (99 million) below the recent average of 115 million, whereas the pink salmon runs were a record 527 million (Rogers 2001a).

The Port Moller inseason forecast predicted a run of 41 million on June 25 and 38 million on June 30, and a final run of 15-25 million on July 9. Two factors caused this over-forecast: (1) an early run timing and (2) mostly large, 3-ocean fish. We recognized both of these factors were in play but since they were extreme values, the earliest and largest, we were not able to accurately predict their effect on the daily index catches that were used to forecast the final run. Therefore we only predicted a range rather than a point estimate (Table 2).

Preseason Forecasts for 2002

Forecasts of the 2002 Bristol Bay sockeye salmon runs and catches were provided to participating processors at our November 2001 meeting (Rogers 2001b). They are presented in Table 1 with the ADF&G forecasts and the past forecasts and runs beginning in 1992. The two river system forecasts (FRI and ADF&G) are based on the same data sources but different analytical methods are often used. The FRI forecast of the total 2002 Bristol Bay sockeye salmon run is 17.3 million with a predicted catch of 10.3 million. Both FRI and ADF&G primarily used sibling return relationships along with spawner return models to forecast the run. The low forecast for the 2002 run reflects the almost complete absence of jacks, and the small percentage of two ocean fish returning in 2001. Almost the same statistics preceded the 2001 run of just 22 million, low numbers of jacks and 2-ocean fish. We do not expect the Kvichak to have a large (>10 million) run until 2003 when the age 1.2 fish return from the 1999 escapement.

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, FRI has conducted the test fishery each year. The test fishery now employs a 200-fathom gillnet that is 60 meshes deep and has 5 1/8 inches stretched mesh. The web is multistrand monofilament (center core). From 1994-1998, we used the fishing vessel F/V *Cape Cross*. A new vessel, the F/V *Sojourn*, was employed in 1999. Four stations (2, 4, 6, 8) have been routinely fished along a transect 33 to 63 nautical miles out from Port Moller (16 to 42 nmi from the nearest coastline). Additionally, in 2000, we made numerous sets at stations 10, 12 and 14. An almanac that provided statistics for forecasting the run was distributed to processors prior to the season (Rogers 2001). Beginning June 11, catch, mean length, and water temperature data were sent daily by radio to Port Moller and then faxed into Bristol Bay. Scales and length data were sent periodically to ADF&G (D. Gray, King Salmon), where the scales were aged and the age compositions and average lengths by age were reported. From 1987 through 1996 the forecasts were very accurate. The runs differed from the forecasts made on June 25 and 30 by an average of 20%, and we were within an average of 12% on forecasts made about July 3 (Table 2). We have not done as well in forecasting the catch because river system forecasts and thus catches cannot be made until about July 3, when we have the first indication of where the salmon are going. In 1997 and 1998, we over-forecasted the inshore run. The weak runs in 1997, 1998, 2000, and 2001 still prove to be largely unexplained. However, we now plan to forecast the runs from Port Moller statistics including factors for run timing and fish body size or age. By establishing relationships between past Port Moller catches and Bristol Bay runs by major age group we should reduce much of the error experienced in the past 5 years.

The ADF&G (D. Gray, Anchorage) provided preliminary length and weight statistics for 2001, 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). In the 2001 run the 2-ocean sockeye salmon were smaller than average and 3-ocean sockeye were larger than average. Because the run was 93 % 3-ocean, the average length of sockeye salmon in the 2001 run was the largest recorded since 1958 when annual lengths were first available. Average weights in the Bristol Bay fishing districts in 2001 ranged from 6.5 lb (Nushagak) to 7.6 lb (Togiak) and were well above the recent years' averages (Tables 4 and 5). The percentage of 3-ocean fish was much higher than the recent years' averages for all districts due to the weak return of 2-ocean fish.

Escapement in excess of the upper limit occurred in the Naknek, Wood, Igushik, Nushagak and Togiak systems (Table 6). The Kvichak escapement was 1.1 million and in spite of all attempts to not fish directly on the run some were caught in the Naknek section. However, these fish would have made little difference to the Kvichak spawning grounds.

Spatial Distributions of Stock Composition

A model was developed for relating the spatial distributions and stock composition of migrating salmon in the Pt. Moller test fishery using differential age composition of the component stocks. The spatial distribution of each stock was modeled as a mean distance along the survey transect and the standard deviation of this distance. The model predicts the numbers and age-composition at different sampling stations and these were compared to the observed abundance and age-composition data. It appears that there is some stock separation at Pt. Moller and the ability to discriminate depends on both the uniqueness of the age composition and the relative magnitude of the stock component. If perfected, this may allow us to obtain stock-specific information from the test fishery data.

LAKE RESEARCH

During the summer of 2001, we continued our long-term studies of spawner distribution, growth and abundance of fry, and the physical and biological environment for the sockeye salmon of the Wood River (Nushagak) and Kvichak lake systems. Most of our annual observations in the Wood River lakes extend over more than 40 years and constitute the longest continuous biological and environmental record on any salmon stock in Alaska. In 2001, we continued studies involving bear predation, and we conducted the undergraduate class, "Aquatic Ecological Research in Alaska" for the third year. New paleolimnological research by our group is helping us develop methods to reconstruct historical sockeye escapement densities over the last several centuries. This research will enable us to better understand the responses of sockeye populations to long-term variation in climatic and ocean conditions.

Kvichak System

Our 2001 field season in the Kvichak system (Lakes Iliamna and Clark) consisted of estimating the sockeye salmon escapement into the Newhalen River in late June and July, conducting spawning ground surveys during August and September to collect otoliths for sockeye age determination, and conducting limnological and tow-net sampling in Lake Iliamna.

Newhalen River Escapement

In 2001 we initiated an intensive 2-year study conducted jointly with the U.S. Geological Survey's Biological Resources Division from the Alaska Science Center, Anchorage, Alaska.

The U.S. Fish & Wildlife Service's Office of Subsistence Management provides the funding for this research. The study is designed to monitor the escapement of sockeye salmon to the Newhalen River and the Tazimina River in the Lake Clark system. The investigations will help us to more accurately gauge the numbers of adult sockeye salmon leaving Iliamna Lake and spawning in the Tazimina River, the Newhalen River, and the Lake Clark system itself.

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 near Igiugig at the outlet of Iliamna Lake. 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 the migration rate does not vary over the course of the day. The daily counts at Newhalen are compared with those of ADF&G 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 (two days lag time in 1999).

The cumulative daily escapements for the two rivers, timed to the Kvichak River, are given for 1996–2001 (Table 7). In mid-July, milling fish often swim upriver along the banks of the Newhalen and are counted, only to drift back down in the middle of the river and return upstream to be counted again. This behavior inflates the counts for the escapement. Therefore, we have used the average proportion of the Newhalen count for day 5 to day 16 (day 1 equals the first day of about 100,000 in the Kvichak) and the season's total Kvichak escapement to estimate the Newhalen/Lake Clark escapement. In 2000, we estimated that about 0.6 million of the Kvichak escapement of 1.8 million (about 33%) migrated to the Newhalen/Lake Clark system (Table 8).

Counting crews and towers were established from 18 June to 10 August to count sockeye salmon at river mile 22, a location where FRI counted in past seasons but not recently. An estimated 222,414 sockeye salmon were counted past the River Mile (RM) 22 towers. This number represents approximately 20% of the estimated 1,084,556 Kvichak escapement. Aerial escapement estimates for 31 July 2001 indicated low returns of spawners to the Newhalen and Alexi Creek system compared to historical ADF&G estimates. Aerial estimates indicated 1,185 sockeye salmon spawning in the Newhalen and 600 to the Alexi Creek system. Additional counts were made from our typical station at river mile 1 near Newhalen village in order to get some idea of run timing. The ten-hour counts taken from 28 June to 17 July observed 178,716 sockeye salmon pass RM1.

The Tazimina pilot escapement program began 31 July and ended 24 August. The initial aerial escapement observations made on 31 July indicated 765 sockeye in the river above the tower sites. An estimated 7,014 sockeye salmon were counted past the tower placed on the Tazimina River for a total estimated return of 7,779. Difficulty was experienced obtaining accurate counts of sockeye into the Tazimina with the towers, as groups of fish moved up and down the river daily. A different site was selected for 2002 and different potential counting methods should be explored.

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. During 2001, we continued this work by sampling fish sites we have sampled recently at Copper River, Knutson Bay, Gibraltar Creek, Chinkelyes Creek, and the island beaches, Woody and Fuel Dump (Table 9). In addition, we sampled several populations that have been sampled only sporadically: Lower Talarik Creek, Dream Creek and Finger Beach. One of our regular sites, the spring-fed pond system of Pedro Bay, was devoid of salmon throughout August, with almost no redds seen at all. This situation was apparently a consequence of very poor runs and extreme predation by bears. This dearth of spawning also occurred in 1996, 1997, and 2000, and may have consequences for the run in this location. Given the very poor overall escapement, the runs were unevenly distributed on the spawning grounds. The island beach populations were extremely weak (we were entirely unable to obtain samples from Triangle Island, and the Woody Island populations were thin) and the mainland beach populations were also weak (e.g., Knutson Bay, Finger Beach). This seems to be part of a continuing trend of declining contribution by beach-spawning sockeye salmon to the Kvichak system (Stewart 2001). In addition, several populations we attempted to survey (e.g., Belinda, Chekok and Tommy creeks), had such poor escapement that we were unable to obtain samples, and the normally strong population at Lower Talarik Creek was very weak. On the other hand, several rivers flowing into the south side of the lake had strong runs, including Chinkelyes Creek (tributary to the Iliamna River), the Copper River, Gibraltar Creek and Dream Creek, a tributary of Gibraltar Lake. In general, the salmon were predominately 3-ocean fish, as expected from the catch and escapament data sets, and large for their age.

FRI conducted annual aerial surveys of the Kvichak spawning grounds from 1956 until 1988, after which the ADF&G took over the surveys. The 2000 survey results were reported by Morestad (unpublished data, 2000). These are summarized for 29 selected spawning grounds (Table 10). Aerial counts accounted for 10.5% of the escapement into the Kvichak system. This percentage is slightly lower than the recent years' average, due in part to survey conditions and pilot availability. Most of the 1.8 million escapement in 2000 returned to the rivers in Lake Iliamna with very low numbers of spawners on the beaches. Ian Stewart's Master's thesis (Stewart 2001) included an analysis of the patterns of coherence among spawning sites within years and the annual trends among years in strength of spawning at the major habitat types. The salient findings of this work include the following. First, the sum of all aerial counts is a small fraction of the count into the lake and the difference cannot be attributed to the Lake Clark system. This suggests significant under-counting in the Iliamna system, either by missing important sites, missing the peak or spread in the spawning, or missing fish during surveys. Second, there seems to be a trend towards proportionally fewer beach spawners than there were in the past. Third, the island beach populations show remarkable coherence in relative abundance within years, indicating that they are strongly affected by similar sources of mortality such as lake level and ice during the egg-to-fry stage. The mainland beaches are also very coherent but less so than the mainland beaches, and the creeks (the most heterogeneous habitat) are the least coherent. Given the common nursery lake used by these suites of populations, the coherence of abundance estimates argues for control during the incubation stages.

<u>Sockeye Fry Abundance and Size</u>

We have sampled the sockeye fry (age 0) in the Kvichak system in August of each year since 1962 (1961 brood year) by tow netting set stations at night in Lake Iliamna and, in many years, Lake Clark (Table 11). The size of the fish was very close to the ten-year average; although the catches were lower than average. However, the past few years have seen irregular sampling and some lack of consistency in stations. In 1999, we re-established tow net sampling coordinated with limnological sampling (conducted cooperatively with ADF&G in recent years) to better understand the links between lake conditions, fry density, growth and survival. The ADF&G's chief scientist for limnology, Jim Edmundson, and his staff visited the Porcupine Island camp to conduct the joint limnology studies. Samples were taken at 8 sites in the eastern end of Lake Iliamna from May through October. We continue to work with ADF&G in planning a multi-year limnology study of Lake Iliamna. In terms of environmental conditions that might affect fry, the winter of 2000-2001 was exceptional in that Iliamna Lake did not freeze over. In contrast, reports indicate an unusually early freeze-up in the winter of 2001-2002. In addition, lake levels were unusually high during the summer of 2001 but water temperatures were not unusual. The ADF&G monitoring of the smolt out migration from the Kvichak in the spring of 2001 indicates it was exceptionally large (fourth largest on record) but was comprised primarily of age-1 smolts. Another striking feature of the 2001 smolt migration was that the size of age-1 smolts was the smallest on record (1955-2000). In fact, age-1 smolts were 1.7 g lighter and 9mm shorter than the 1955-2000 average (Crawford 2001).

Wood River System

The FRI's Bristol Bay research program began with spawning ground surveys in the Wood River Lakes in 1946 to determine where, when, and how many sockeye salmon spawned there. During the early 1950s, methods were established to enumerate and sample the commercial catches, escapements (towers), and the number of 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

The winter of 2000-2001 was the mildest on record for Bristol Bay. Spring air temperatures (April-May) were just a little above average, smolt migrations were early, and river water temperatures were above average (Crawford 2001)

Ice breakup on Lake Aleknagik was three days earlier than normal in 2001(Figure 1, Table 12). Water temperatures were warmer than normal throughout the summer. Solar radiation levels were above normal for June and below average for the rest of the summer (Table 12). Lake water level was above normal until mid August. The environmental conditions in 2001 when adult salmon were entering the lakes during late-June and early-July were not very different from the long-term average conditions observed in the Wood River system except that water temperatures were above average (Figure 2, Table 12).

During the summer of 2001, the standing crop of phytoplankton (chlorophyll) was below normal in the early summer and a little above average in August. Zooplankton volumes were near the long-term average although their numbers were well above average (Figure 3, Table 12). Zooplankton is the main source of food for juvenile sockeye salmon after they move offshore in late July. Because zooplankton are effective grazers of phytoplankton, we expect to see this inverse relationship between zooplankton and phytoplankton abundance. Compared to recent years, the 2001 abundance of most zooplankton species were higher after mid-June (Figure 3).

Insects (mainly pupal and adult midges) are the main source of food for juvenile sockeye in the spring when the fry are inshore. We do not have the results of the 2001 insect catches; however, during 2000, insect densities were lower than average in June and July (Table 13). Despite the fact that insect densities were lower than normal for most of the season, their emergence timing peaked at the standard time (late July/early August). Except in early June when temperatures were slightly above normal, the near shore temperatures in 2000 were average.

Fry Abundance and Growth

In 2001, the growth rate for sockeye salmon fry in Lake Aleknagik was above average while their lengths were above average during June and September (Table 14). Threespine stickleback lengths and growth rates were near average for 2001 (Table 14). The catches of threespine sticklebacks and sockeye were much lower than average for both beach seining and tow netting. The adult sockeye salmon returns to Lake Aleknagik have generally been large since 1978 even though fry abundances have often been low. This suggests that recent large runs have been caused mainly by improved ocean survival rather than high survival during incubation and lake rearing.

The mean lengths of sockeye salmon fry in Lake Nerka indicated that, in 2001, growth was below average whereas tow net catches were below the long-term average except in Central Nerka (Table 15). Juvenile sockeye salmon in the Wood River lakes system exhibit density-dependent growth, and we are analyzing our long-term data sets to determine the relative effects of physical and biological factors in the lakes on the growth of the sockeye salmon fry. It is interesting to note that it appears that growth conditions for fry are not necessarily synchronized between lakes Aleknagik and Nerka, but are determined by fry densities in each of the lakes. In addition, we are examining year-to-year variation in zooplankton population composition along with annual variation in sockeye salmon fry and threespine stickleback abundance to determine the extent to which the fish alter their food resources. Lake productivity tends to be higher in lakes with sockeye salmon as a result of the nutrients brought in from the sea by adults (Reischauer 1996, Schindler unpublished data). We hope the information from these studies will help explain the observed variability in the fresh water phase of the sockeye salmon.

Sockeye Salmon Fry Spatial Distribution

As part of his PhD work, Mark Scheuerell has been investigating the spatial dynamics of salmonids. Juvenile sockeye salmon often display a diel vertical migration (DVM) behavior whereby they reside deep in lakes during the day and then move up in the water column at dusk. The timing of this migration is believed to be a trade-off between maximizing growth and minimizing predation risk. This decision process will be influenced by the fish's visual distance, and therefore will depend on both the intensity of incident light and how rapidly the light decreases with depth in the lake. However, no studies to date have investigated whether these salmon are attempting to maintain a constant light level and hence visual range during the course of their migration. Using hydroacoustics, we examined the timing and amplitude of DVM by juvenile sockeye salmon in Lakes Kulik, Nerka, and Little Togiak during early July when day length is approximately 21 hours and again in late August when day length is approximately 16 hours. Sockeye migrated from 70-80 m during the day to 5-15 m at night (Figure 4). Maximum likelihood analysis demonstrated that these fish experience a decrease in surface light levels spanning four orders of magnitude during their migration. However, through vertical migration the sockeye fry appear to track constant light levels within the water column, such that they can still forage on zooplankton while reducing their chance of visual detection by predators such as arctic char. These results provide us with better insight into the factors determining juvenile sockeye production in Alaskan lakes.

Ecological Impacts of Sockeye Salmon Redd Digging

Spawning sockeye salmon dig redds in the gravel of lakes and streams. As part of his Ph.D. research, Jon Moore is investigating the impacts of this redd-digging on gravel size, algae abundance, and invertebrate densities by comparing areas where salmon spawned to areas where salmon were prevented from spawning. Areas where salmon spawned had larger gravel compared to areas without salmon spawning, which accumulated silt (Figure 5). In some cases, so much silt accumulated in the absence of salmon spawning that it shaded out benthic algae. Thus, in some systems, redd-digging by spawning sockeye salmon could be critical for scouring out silt, maintaining benthic algae production, and displacing aquatic insect larvae from spawning areas.

Arctic Char Predation

Arctic char (*Salvelinus alpinus*) concentrate in the interconnecting rivers of the Wood River lake system to prey on sockeye salmon smolts during their seaward migration. We conducted several studies of this predation during the 1950s to 1970s, and since then, we have sampled the char in Little Togiak River on an opportunistic basis. In 2001, we sampled char only on June 13, 15, and 22 (Table 16). The average lengths of the fish were larger than average. Predation rates on sockeye smolts and fry were about normal during 2001. The high average for sockeye fry was caused by one stomach with 95 fry.

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 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. The ADF&G estimates the numbers of spawners 0on the lake beaches and in the interconnecting rivers by aerial surveys when these are conducted. Aerial surveys were not conducted in 1999-2001. Thus, the total escapement to the lake system could not be apportioned to the individual lakes or type of spawning ground (creek, river, and beach) for these recent years. 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.

The ground survey counts in 2001 for the major creek spawning grounds are given in Table 17. The creeks in Lake Nerka contained more spawners than those in Lake Aleknagik, which was a change in the distribution seen over the past several years. Age compositions from our otolith sampling showed a high proportion of 3-ocean fish in the Wood River system (Table 18). The age compositions were comparable to ADF&G's sampling at the Wood River tower; however, our sampling had a higher percentage of 2-ocean fish than did the ADF&G tower sampling. Unsampled spawning grounds in the upper lakes (Beverley and Kulik) likely contained higher percentages of 2-ocean fish based on the samples from Moose Creek. In addition to the higher than usual proportion of 3-ocean fish, samples of length-at-age at two index sites (Hansen Creek and Bear Creek) indicated that the sockeye were relatively large for their age.

Hansen Creek Daily Runs and Bear Predation

We completed the 12th year of our bear/spawning sockeye salmon interaction study in Hansen Creek, a small tributary of Lake Aleknagik (Table 19). In 2001, the run to Hansen Creek was a record low with a total of about 2400 spawners in the 2 km creek. This creek now shows a clear cycle with a 4-year period, having had progressively larger runs in 1987, 1991, 1995 and 1999. Predation rate is density-dependent on an inter-annual basis, and the rate in 2001 was 84%, the highest observed in our study (Table 20). The predation in Hansen Creek and elsewhere in the system (e.g., Pick and Bear creeks) is size-selective; larger fish are more vulnerable than smaller fish (Quinn and Buck 2001). In addition, males are generally more likely to be killed than females. The detailed studies at Hansen Creek are being applied to the more extensive but less intensive sampling that we conduct in association with the annual creek surveys throughout the system. These data demonstrate that the level of predation is a decreasing function of stream size (especially width) and the age structure and morphology of sockeye salmon are clearly related to habitat and predation (Quinn et al. 2001a). Larger rivers have more 3-ocean fish and fewer jacks. The fish are more deep-bodied for their size than the fish in smaller creeks and there are higher levels of size-selective predation. The level of predation among creeks is thus related to access by bears but the year-to-year pattern is largely related to fish density (Quinn, Gende, Ruggerone and Rogers, in preparation). Higher levels of escapement are associated with smaller percentages of the fish being killed as the absolute number killed reaches an asymptote. Not only does the level of predation vary among creeks as a function of size but also the proportion killed before they reproduce also varies. Hansen Creek sockeye are not only more vulnerable to bears than those in Pick Creek but they are killed earlier in their stream lives (Quinn, et al. 2001b), and this fact determines the influence of predation on actual population dynamics.

The daily counts on Hansen Creek are not only important as a basis for studies of predation but they also provide us with estimates of the percentages of the total number of spawners that are counted on a single "peak survey" date. This provides a means of adjusting our annual survey counts to equal the true number of spawners. Hansen Creek has been surveyed most often on August 6 in past years, but in 20% of the years, the survey was done on August 1 or earlier. The Hansen Creek sockeye salmon are about the earliest spawners in the lake system and the fish usually first enter the creek around July 22–25. On the basis of daily counts in 1990–2000, if the surveys had been conducted on the single date of August 6, the peak survey counts would have been 67% to 93% of the totals; if the single surveys were done on August 1, the counts would have been 38% to 78% of the actual number of spawners (Table 20). Spawning in 2001 was the earliest we have observed.

Historical Reconstructions of Sockeye Salmon Densities in Lake Nerka for the Last 250 Years

Historical sockeye salmon densities can be reconstructed from the chemical characteristics of the sediments from spawning lakes. Sockeye have a unique nitrogen isotope signature that accumulates in lake sediments in direct proportion to the local sockeye density. We have begun to use paleolimnological methods to reconstruct historical sockeye population dynamics. In Figure 6 we show our estimates of sockeye escapement to Lake Nerka in the Wood River system since 1750. We have also added the density of sockeye caught in the fishery since 1908 to our escapement estimates so as to obtain a total run estimate. Density of sockeye is given in thousands of sockeye per km^2 of lake area (left axis) and as the total run to Lake Nerka (right axis). Lake Nerka accounts for about 44% of the total run to the Wood River lakes system. These data show that there have been strong interdecadal oscillations in sockeye runs since the 1970s. The dominant oscillation has a period of 70 years and a sub-dominant 16-year oscillation is apparent since the early 1900s. These data also show that the total run to Nerka is currently producing about as many fish as it was through most of the 18^{th} and 19^{th} centuries.

Undergraduate Class

FRI has routinely employed undergraduate students as part of the field crew for years but until 1999 had no formal educational opportunity for them. In 1999 we initiated a class for academic credit at the University of Washington called “Aquatic Ecological Research in Alaska”. Six students, selected from many who applied, received hands-on training in 2001 at the Aleknagik, Nerka and Porcupine Island camps, had formal lectures, and collected data for their independent research. Jointly taught by Drs. Tom Quinn, Daniel Schindler and Ray Hilborn, the purpose of the class was to directly involve students in the research program and give them the kind of in-depth exposure to ecology and fisheries management that would be impossible in Seattle. The class was very popular with the students and will be continued in the future. Funding provided by the University of Washington for this class included funds to buy a new 24’ Workskiff for the Iliamna Lake camp in 1999. This boat is critical to the operation of our projects. In addition to class work, students helped the FRI program by assisting with sampling during the course. Several of them also worked for FRI either before or after the class (e.g., Newhalen counting, Lake Aleknagik field camp, and Port Moller test fishery), further cementing the connection between educational and research programs. The University of Washington contributed funds for the construction of a new 1000 sq. ft. building at the Lake Aleknagik field station that was constructed and became fully functional in 2001. The new facility features a classroom and wet lab for use by students and visiting faculty, and a laundry and washroom for general use. The funds for this building were used as matching in a successful application to the National Science Foundation for additional money to upgrade our facilities. The new NSF grant will replace the docks at Aleknagik and Porcupine Island, and will build a new building at Porcupine Island that will house students and visiting scientists, provide working space for all staff, and include a laundry and washroom. Our facilities at Porcupine Island have seen increased use and deteriorating condition in recent years and this building is much needed.

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Key words

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

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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
1992	FRI	10.2	3.2	10.4	4.0	4.3	33.0	22.0	-45
	ADFG	12.2	4.2	10.7	4.3	4.6	37.1	26.3	-22
	Actual run	10.4	5.0	17.6	5.5	5.2	45.3	32.0	
1993	FRI	9.1	3.6	18.2	5.5	6.0	43.3	31.9	-28
	ADFG	11.7	3.4	15.8	4.9	5.1	41.8	32.0	-27
	Actual run	9.3	4.7	23.3	5.7	7.6	51.9	40.8	
1994	FRI	18.7	3.9	16.2	3.6	5.3	48.8	34.1	-3
	ADF&G	17.8	3.9	18.8	5.6	5.4	52.4	39.6	11
	Actual run	22.0	3.0	12.6	5.4	5.8	50.1	35.2	
1995	FRI	23.6	6.1	12.1	5.0	5.3	53.1	34.4	-29
	ADF&G	25.1	5.3	13.1	5.4	5.3	55.1	40.3	-10
	Actual run	27.5	3.6	15.7	5.8	6.7	60.8	44.4	
1996	FRI	8.0	4.5	15.7	7.8	7.7	45.2	33.4	11
	ADF&G	8.6	4.6	16.9	6.2	5.8	43.4	34.6	14
	Actual run	3.5	6.9	11.9	5.1	8.3	36.9	29.7	
1997	FRI	7.4	3.7	13.9	2.9	5.9	35.1	25.4	52
	ADF&G	6.9	3.3	12.8	3.8	5.7	33.6	24.8	50
	Actual run	1.7	1.4	8.7	2.0	4.6	18.8	12.3	
1998	FRI	10.4	3.5	8.4	4.3	6.2	33.8	23.5	57
	ADF&G	8.9	3.4	8.6	3.2	5.3	30.2	20.6	51
	Actual run	3.4	2.5	4.7	1.6	5.4	18.3	10.0	
1999	FRI	14.2	2.0	7.7	2.7	6.7	35.1	21.2	22
	ADF&G	11.5	2.8	3.6	1.4	4.9	24.9	14.1	83
	Actual run	13.0	3.7	9.1	3.9	8.4	39.4	25.8	
2000	FRI	8.0	5.7	11.4	5.7	6.3	37.1	24.4	16
	ADF&G	9.5	5.2	7.9	4.3	5.4	32.7	22.3	8
	Actual run	2.9	4.8	8.1	2.2	8.6	28.2	20.5	
2001	FRI	4.2	1.8	5.3	1.4	7.9	21.5	13.8	1
	ADF&G	2.8	2.6	7.1	2.1	7.3	22.8	15.6	10
	Actual run	1.4	6.6	3.8	1.3	7.3	22.0	14.0	
2002	FRI	2.0	3.5	4.9	2.0	4.0	17.3	10.3	
	ADF&G	1.8	2.0	4.6	2.3	5.2	16.7	9.7	

Total run and catch include Branch River and Togiak District but exclude jacks (1-ocean age).
Percent error = error in forecasted catch (forecast-actual catch/forecast*100).

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

Bristol Bay			Run pred. on 6/25			Run pred. on 6/30			Final pred. (7/3-9)			Catch pred. (7/3-9)		
Year	Run	Catch	Pred.	R-P	%ofP	Pred.	R-P	%ofP	Pred.	R-P	%ofP	Pred.	C-P	%ofP
1987	27	16	27	0	0	27	0	0	26	1	4	15	1	7
88	23	14	15	8	53	15	8	53	22	1	5	12	2	17
89	44	29	50	-6	-12	37	7	19	42	2	5	28	1	4
90	48	33	42	6	14	56	-8	-14	39	9	23	25	8	32
91	42	26	48	-6	-13	37	5	14	37	5	14	21	5	24
92	45	32	49	-4	-8	45	0	0	41	4	10	29	3	10
93	52	41	61	-9	-15	57	-5	-9	56	-4	-7	44	-3	-7
94	50	35	37	13	35	41	9	22	43	7	16	29	6	21
95	61	44	47	14	30	49	12	24	50	11	22	33	11	33
96	37	30	45	-15	-33	44	-14	-32	41	-4	-10	34	-4	-12
97	19	12	39	-20	-51	41	-22	-50	26	-7	-27	17	-5	-29
98	18	10	29	-11	-38	31	-21	-68	20	-2	-10	11	1	9
99	39	26	33	6	18	35	4	11	41	-2	-5	26	0	0
00	28	20	42	-14	-33	37	-9	-24	29	-1	-3	20	0	0
01	22	14	52	-30	-58	49	-27	-55	15to25			10to15		
Means	37	25	41	-5	-7	40	-4	-4	37	1	3	25	2	8
absol.				9	24		8	22		5	13		4	18

Numbers in millions of fish.

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

absol. = absolute error, ignoring the sign.

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

1993-01 forecasts on 6/25 & 6/30 are from Bristol Bay almanacs (not adjusted for run timing).

The 2001 run was very early and contained the highest percent of 3=ocean fish observed, both factors led to the early overforecasts and this was told to the industry a final forecast was a range of 15 to 25 with a catch of 10 to 15.

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
1995	61	520	502	511	578	555	567	526	27
1996	37	522	506	513	585	562	574	558	76
1997	19	519	503	511	585	565	576	540	45
1998	18	505	493	499	570	550	560	530	83
1999	39	518	502	513	574	556	565	526	24
2000	28	516	497	506	564	556	560	545	72
2001	22	512	502	507	590	567	578	573	93
Averages 58-67	18	520	503	511	584	562	571	532	36
Averages 68-77	15	523	508	516	588	566	576	539	39
Averages 78-87	35	526	511	519	585	564	574	541	40
Averages 88-97	44	517	501	509	579	556	567	536	46
Averages 98-01	27	513	499	506	575	557	566	544	68

Table 4. Average weights of sockeye salmon (lbs) in commercial catches on the east side of Bristol Bay, 1988-2001.

		Catch	2-ocean			3-ocean			All	All	All	Percent	Percent
District	Year	millions	Male	Female	Comb.	Male	Female	Comb.	males	females	fish	3-ocean	females
Nak/Kvi	88	3.5	5.3	4.5	4.9	7.4	6.5	6.9	6.3	5.6	5.9	52	52
	89	13.8	5.3	4.6	4.9	7.3	6.2	6.8	5.8	4.9	5.3	21	55
	90	17.1	5.0	4.5	4.7	7.3	6.2	6.7	5.9	5.3	5.6	43	54
	91	10.6	4.9	4.3	4.6	7.2	6.0	6.5	6.6	5.5	6.0	71	54
	92	9.3	5.0	4.5	4.7	6.7	5.7	6.2	6.0	5.2	5.6	60	48
	93	8.9	5.3	4.8	5.1	7.1	6.2	6.6	6.3	5.6	5.9	54	53
	94	16.3	5.0	4.5	4.7	7.0	5.5	6.1	5.4	4.7	5.0	18	58
	95	20.4	5.0	4.4	4.8	6.9	5.9	6.5	5.5	4.7	5.2	22	44
	96	8.2	5.5	4.5	4.9	7.4	6.3	7.0	7.1	5.9	6.7	83	39
	97	0.6	5.4	4.8	5.1	7.6	6.3	7.0	6.7	5.6	6.2	55	50
	98	2.5	5.3	4.7	5.1	6.8	6.0	6.5	6.2	5.6	5.9	60	44
	99	8.9	4.9	4.5	4.7	7.1	6.0	6.5	5.3	4.9	5.1	23	49
	00		5.3	5.2	5.3	6.8	5.9	6.3	6.5	5.8	6.2	84	48
	01	5.2	4.7	4.6	4.6	7.8	7.3	7.5	7.7	7.1	7.4	97	51
	Means	9.3	5.1	4.6	4.9	7.2	6.1	6.7	6.2	5.5	5.8	53	50
Egegik	88	6.5	5.4	4.9	5.2	7.5	6.7	7.2	6.6	6.0	6.3	57	45
	89	8.9	5.2	4.6	4.9	7.4	5.9	6.7	6.0	5.0	5.5	33	51
	90	10.1	5.3	4.9	5.1	7.3	6.1	6.6	6.3	5.6	5.9	54	52
	91	6.8	5.3	4.4	4.9	7.3	6.0	6.6	6.4	5.3	5.8	55	52
	92	15.7	4.7	4.1	4.5	6.6	5.8	6.2	5.6	5.0	5.4	51	44
	93	21.8	5.5	4.8	5.1	7.1	6.2	6.6	6.3	5.6	5.9	52	54
	94	10.8	4.6	4.1	4.4	7.0	5.6	6.2	5.6	5.0	5.3	51	53
	95	14.5	5.3	4.5	4.9	6.9	5.9	6.4	5.8	5.0	5.4	32	48
	96	10.8	5.5	4.7	5.1	7.6	6.2	6.8	7.0	5.8	6.4	73	54
	97	7.6	5.3	4.4	4.9	7.8	6.6	7.2	6.4	5.4	5.9	44	47
	98	3.6	4.7	4.5	4.7	6.5	5.8	6.2	6.0	5.6	5.8	75	47
	99	7.4	5.1	4.3	4.7	7.8	5.9	6.9	5.7	4.6	5.2	23	50
	00	7.1	5.9	4.5	5.2	6.1	6.3	6.2	6.0	5.9	6.0	77	47
	01	2.8	5.5	5.0	5.2	7.3	6.4	6.8	7.0	6.3	6.6	86	58
	Means	9.7	5.3	4.6	4.9	7.1	6.1	6.6	6.2	5.4	5.8	55	50
Ugashik	88	1.5	5.4	4.8	5.2	7.5	6.6	7.1	6.4	5.9	6.2	54	43
	89	3.1	5.5	4.7	5.1	7.7	6.5	7.2	5.9	5.0	5.5	19	45
	90	2.1	5.0	4.5	4.7	7.4	6.4	6.9	6.1	5.6	5.9	53	49
	91	3.0	5.3	4.5	4.9	7.0	5.8	6.3	6.2	5.3	5.8	59	52
	92	3.4	5.0	4.5	4.8	6.8	5.6	6.4	6.2	5.2	5.8	64	37
	93	4.3	5.7	4.6	5.2	7.7	6.7	7.2	6.7	5.7	6.2	52	52
	94	4.3	4.9	4.2	4.7	7.1	6.0	6.6	6.0	5.3	5.8	55	40
	95	4.5	5.2	4.3	4.8	6.9	6.1	6.5	5.7	4.9	5.3	30	42
	96	4.4	5.2	4.8	5.0	7.6	6.3	7.0	7.3	6.1	6.7	85	47
	97	1.4	5.5	4.6	5.1	7.7	6.3	7.0	6.5	5.4	6.0	47	47
	98	0.7	5.2	4.9	5.1	7.1	5.8	6.6	6.7	5.7	6.3	82	36
	99	2.3	5.2	4.4	4.9	7.4	4.7	6.7	5.5	4.7	5.1	15	44
	00	1.5	5.5	5.3	5.4	7.5	6.3	6.9	7.1	6.2	6.7	85	44
	01	0.5	5.5	4.4	4.9	7.8	6.5	7.1	7.2	6.0	6.6	77	52
	Means	2.8	5.3	4.6	5.0	7.4	6.1	6.8	6.4	5.5	6.0	56	45

Table 5. Average weights of sockeye salmon (lbs) in commercial catches on the west side of Bristol Bay, 1988-2001.

		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	88	1.7	4.9	4.3	4.7	7.8	6.2	7.0	7.1	5.9	6.5	79	49
	89	2.9	5.4	4.3	4.7	7.6	6.2	6.8	6.9	5.6	6.1	68	62
	90	3.5	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	4.9	5.2	4.3	4.8	7.5	6.0	6.6	6.4	5.4	5.9	59	55
	94	3.4	4.3	4.0	4.2	6.9	5.9	6.2	6.3	5.8	6.0	87	60
	95	4.4	4.8	4.3	4.5	6.7	5.6	6.1	5.7	4.9	5.3	49	50
	96	5.8	5.0	4.1	4.5	7.3	5.9	6.5	6.5	5.4	5.8	68	57
	97	2.6	4.9	4.2	4.7	6.9	5.9	6.6	6.1	5.2	5.8	60	35
	98	3.0	4.3	3.7	4.0	6.9	5.3	6.2	5.4	4.2	4.7	34	54
	99	6.3	4.7	4.1	4.4	6.9	5.6	6.4	5.8	4.7	5.3	46	43
	00	6.4	5.0	4.3	4.6	7.3	5.9	6.6	6.5	5.3	5.9	63	50
	01	4.6	4.0	4.4	4.2	6.9	6.3	6.7	6.8	6.2	6.5	95	44
	Means	3.7	4.7	4.1	4.4	7.1	5.8	6.5	6.3	5.3	5.8	65	51
Togiak	88	0.8	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	0.7	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	0.4	6.4	5.2	5.7	8.1	6.3	7.1	8.0	6.2	7.0	91	53
	95	0.6	6.0	5.1	5.5	7.9	6.6	7.2	7.2	6.1	6.6	66	53
	96	0.5	6.3	5.1	5.8	8.5	6.6	7.5	8.3	6.5	7.4	90	52
	97	0.1	6.2	5.3	5.7	8.2	6.6	7.4	7.8	6.3	7.1	80	49
	98	0.2	5.9	4.5	5.1	7.6	6.0	6.6	7.4	5.8	6.5	88	58
	99	0.4	5.6	5.1	5.5	6.8	6.0	6.5	6.2	5.6	6.0	48	33
	00	0.7	6.4	5.2	5.8	8.1	6.6	7.4	8.0	6.5	7.2	90	50
	01	0.8	6.1	5.2	5.6	8.7	6.6	7.6	8.6	6.5	7.6	96	51
	Means	0.5	6.0	5.0	5.5	8.2	6.4	7.3	7.8	6.2	7.0	82	51

Table 6. Sockeye salmon escapements in excess of management goals for Bristol Bay rivers, 1990-2001 (in millions).

River	**Escapement goals**						**Escapement in excess of mid-point**							
System	**Mid-point**	**Upper range**	**90**	**91***	**92**	**93**	**94**	**95****	**96**	**97**	**98*****	**99**	**00**	**01**
Kvichak	variable	variable												
Branch														
Naknek	1.00		1.09	2.57	.61	.54	.00	.11	.08	.03	.10	.53	.28	.73
Egegik	1.00		1.19	1.79	.95	.52	.90	.27	.08	.10	.01	.63	.00	.00
Ugashik	.70		.05	1.76	1.76	.71	.38	.60	.00	.00	.04	.80	.00	.00
Wood	1.00		.07	.16	.29	.18	.47	.48	.65	.51	.66	.51	.30	.37
Igushik	.20		.17	.56	.10	.21	.25	.27	.20	.00	.02	.24	.21	.21
Nuyakuk/Nush.	.50		.17	.00	.20	.21	.01	.00	.00	.00	.00	.00	.00	.31
Togiak	.15		.04	.13	.07	.04	.02	.06	.01	.00	.00	.00	.20	.15
Total			2.78	6.97	3.98	2.41	2.03	1.79	1.02	.64	.83	2.71	.99	1.77
Bristol Bay run			48	42	45	52	50	61	37	19	18	39	28	22
Catch			33	26	32	41	35	44	30	12	10	26	20	14
							Escapement in excess of upper range							
Naknek		1.40	.69	2.18	.21	.14	.00	.00	.00	.00	.00	.23	.00	.43
Egegik		1.20	.99	1.59	.75	.32	.70	.00	.00	.00	.00	.53	.00	.00
Ugashik		.90	.00	1.58	1.56	.51	.18	.10	.00	.00	.00	.65	.00	.00
Wood		1.20	.00	.00	.09	.00	.27	.28	.45	.31	.46	.31	.10	.17
Igushik		.25	.12	.51	.05	.16	.20	.22	.15	.00	.00	.19	.16	.16
Nuyakuk/Nush.		.76	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.05
Togiak		.25	.00	.03	.00	.00	.00	.00	.00	.00	.00	.00	.10	.05
Total			1.80	5.89	2.66	1.13	1.35	.60	.60	.31	.46	1.91	.36	.86

* 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.
*** Goals raised to 1.1 million in 1998 for Naknek and Egegik, and .85 million for Ugashik.

Table 7. Cumulative daily escapements of sockeye salmon in the Kvichak and Newhalen Rivers, 1996-2001. (Numbers in 1,000s and Newhalen escapements estimated from expanded counts lagged back 3 days for 96-97, 1 day for 1998, and 2 days for 1999)

	1996		1997		1998		1999		2000		2001	
Date	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen
6/22											0	
23									0		0	
24	0	0	0						0		1	
25	4	0	3		0				0		2	
26	25	1	6		0				3		5	
27	37	1	15	0	1		0		21		14	
28	40	1	42	1	3		0		41		42	0
29	41	1	60	2	6		0	0	66		58	1
30	42	2	67	4	16		17	0	143		86	2
7/1	47	2	73	5	26	0	104	28	213		154	3
2	90	2	76	8	32	0	336	36	389		256	5
3	224	3	83	13	32	0	747	60	606		310	9
4	318	4	116	18	84	18	1085	105	701		396	14
5	361	6	158	30	233	37	1522	132	725		465	16
6	385	7	206	40	417	76	1826	155	731		595	17
7	420	7	299	50	597	230	2254	207	733		690	72
8	468	8	439	63	753	256	2786	255	736		747	131
9	568	15	637	105	833	338	3190	306	789		829	149
10	669	22	797	132	980	592	3586	398	868		878	161
11	769	23	950	182	1366	937	3802	473	891		950	165
12	860	25	1053	224	1795	1137	4030	520	1080		995	172
13	1035		1140	230	2071	1361	4330	600	1357		1013	177
14	1160		1200	239	2181	1450	4648	676	1508		1021	178
15	1238		1291	253	2238	1573	4947	735	1650		1024	179
16	1310		1349		2269	1680	5109		1712		1030	179
17	1332		1382		2280	1723	5420		1758		1061	179
18	1353		1412		2285		5849		1790		1072	
19	1397		1436		2291		6038		1813		1072	
20	1422		1456		2294		6108		1822		1075	
21	1436		1471		2295		6150		1825		1078	
22	1445		1486		2296		6175		1827		1082	
23	1451		1496				6196		1828		1085	
24			1504								1089	
25											1095	

Table 8. The Kvichak lake system escapements and the percentages going to the Newhalen River and Lake Clark, 1979-2001.

Year	Kvichak system escapement (millions)	Newhalen/ Lake Clark escapement (millions)	Percent of Kvichak (%)	Newhalen River spawners (millions)	Lake Clark escape. (millions)	Percent of Kvichak (%)	Tazimina River aerial count (thousands)
1979	11.22	9.00	80	0.56	8.44	75	504
1980	22.51	7.50	33	2.64	4.86	22	128
1981	1.75	0.26	15	0.03	0.23	13	28
1982	1.14	0.34	30	0.13	0.21	18	31
1983	3.57	1.08	30	0.41	0.67	19	212
1984	10.49	3.20	31	0.67	2.53	24	366
1985	7.21	1.62	22	0.15	1.47	20	186
1986	1.18	0.29	25	0.01	0.28	24	7
1987	6.07	---	--	1.46	--	--	246
1988	4.06	2.41	59	0.29	2.12	52	83
1989	8.32	2.59	31	0.10	2.49	30	30
1990	6.97	1.09	16	*0.07*	--	--	4
1991	4.22	1.93	46	*0.10*	--	--	16
1992	4.73	1.05	22	<0.01	1.04	22	13
1993	4.03	1.55	38	<0.01	1.54	38	38
1994	8.34	2.34	28	0.01	2.33	28	93
1995	10.04	1.12	11	0.12	1.00	10	54
1996	1.45	0.04	2	<0.01	0.03	2	10
1997	1.50	0.27	18	<0.01	0.27	18	11
1998	2.30	1.38	60	0.01	1.37	60	24
1999	6.20	0.60	10	*<0.01*	0.60	10	17
2000	1.83	0.60	33	<0.01	0.60	33	1
2001	1.10						

Table 9. Kvichak spawning ground age compositions in 2000 and 2001.

Year	Spawning ground	Sex	Sample size (n)	Age composition (%)						
				0.3	1.1	1.2	2.1	2.2	1.3	2.3
2000	Gibralter River	M	99			18.2		4.0	75.8	2.0
		F	99			24.2		2.0	68.7	5.1
	Copper River	M	99			38.4		12.1	47.5	2.0
		F	99			46.5		5.1	43.4	5.0
	Chinkelyes Creek	M	98			39.8		22.4	32.7	5.1
		F	100			42.0		12.0	38.0	8.0
	Lower Tularik Cr	M	21			4.7		14.3	81.0	0.0
		F	99			10.1		19.2	68.7	1.0
	Triangle Is.	M	132			2.3		33.3	63.6	0.8
		F	116			4.3		28.5	67.2	0.0
	Fuel Dump	M	127			20.5		19.7	57.5	2.3
		F	112			8.9		17.0	73.2	0.9
	Woody Is. beaches	M	91			7.7		36.3	56.0	0.0
		F	97			5.1		18.6	76.3	0.0
	Knutson Bay beach	M	96			22.9		27.1	46.9	3.1
		F	39			25.7		15.4	53.8	5.1
	Finger Beach	M	83			28.9		26.5	38.6	6.0
		F	2			50.0			50.0	
	Kvichak escapement (ADF&G,Igiugig)	M	434			13.5		20.4	58.6	7.5
		F	838			17.9		20.4	55.0	6.7
2001	Gibralter River	M	104			2.9			91.3	5.8
		F	103			1.9			95.1	3.0
	Copper River	M	102			0.9			97.1	2.0
		F	102			2.0		2.9	94.1	1.0
	Chinkelyes Creek	M	96		1.0	41.7		1.0	50.0	6.3
		F	97		0.0	15.5		0.0	79.4	5.2
	Finger Beaches	M	15			6.7			66.6	26.7
		F	0							
	Knutson Bay beaches	M	87			37.9	2.3		57.5	2.3
		F	14			21.4			78.6	0.0
	Island beaches	M	99			9.1		1.0	62.6	27.3
	Fuel/Woody	F	99			8.1			75.8	16.1
	Lower Talarik Cr	M	52			13.5			76.9	9.6
		F	26			3.8			92.4	3.8
	Dream Cr	M	99			7.1			92.9	0.0
		F	99			2.0			97.0	1.0
	Kvichak escapement (ADF&G, Igiugig)	M	520	0.2		9.2		1.3	80.6	8.3
		F	788	0.2		9.0		1.3	85.7	3.4

Table 10. Spawning ground estimates of sockeye salmon on 29 selected spawning grounds in Lake Iliamna and the Newhalen River system, 1956-2001.

Year	Aerial survey counts (1,000s)					Tower count Escapement (1,000s)	Aerial count Escapement (%)	Aerial observer
			Beaches					
	Rivers	Creeks	Mainland	Island	Total			
56	775	--	--	--		9443		1
57	170	--	--	--		2843		1
58	44	--	--	--		535		1
59	84	--	--	--		680		1
60	841	--	--	--		14630		1
61	246	40	50	127	463	3706	12.5	2
62	140	52	21	12	225	2581	8.7	2
63	31	13	5	7	56	339	16.5	2
64	36	38	3	21	98	957	10.2	2
65	734	538	261	1352	2885	24326	11.9	2
66	248	153	134	46	581	3776	15.4	2
67	370	63	85	16	534	3216	16.6	3
68	131	64	14	64	273	2557	10.7	3
69	192	168	40	102	502	8394	6.0	3
70	790	574	216	506	2086	13935	15.0	3
71	177	194	27	50	448	2387	18.8	3
72	89	50	15	9	163	1010	16.1	3
73	35	18	6	6	65	227	28.6	3
74	294	269	72	122	757	4433	17.1	3
75	936	440	225	412	2013	13140	15.3	3
76	144	55	19	45	263	1965	13.4	3
77	124	20	88	28	260	1341	19.4	3
78	510	100	42	6	658	4149	15.9	3
79	1424	372	252	81	2129	11218	19.0	3
80	2189	317	77	201	2784	22505	12.4	3
81	187	85	16	20	308	1754	17.6	3
82	255	68	27	9	359	1135	31.6	3
83	743	123	75	9	950	3570	26.6	3
84	1902	359	597	84	2942	10491	28.0	4
85	672	296	260	247	1475	7211	20.5	4
86	57	16	12	5	90	1200	7.5	5
87	1313	111	397	123	1944	6100	31.9	5
88	481	123	116	15	735	4065	18.1	6
89	386	88	31	8	513	8318	6.2	6
90	138	50	19	26	233	6970	3.3	6
91	196	111	18	19	344	4223	8.1	7
92	198	151	35	19	403	4726	8.5	7
93	225	128	42	10	405	4025	10.1	7
94	506	231	41	30	808	8338	9.7	7
95	554	187	50	244	1035	10039	10.3	7
96	177	42	22	12	253	1451	17.4	7
97	255	68	106	13	442	1504	29.4	7
98	138	69	34	16	257	2296	11.2	7
99	336	127	23	22	508	6196	8.2	8
00	102	54	22	14	192	1828	10.5	8
01	154	49	12	05	220	1096	20.1	8
Means								
61-66	239	139	79	261	718	5948	12.5	2
67-83	505	175	76	99	856	5702	17.6	3
84-90	707	149	205	73	1133	6336	16.5	4,5,6
91-98	281	123	44	45	493	4575	13.1	7
99-01	197	77	19	14	307	3040	12.9	8

Table 11. Mean tow net catches and lengths (on September 1 in mm) of sockeye salmon fry in Lakes Iliamna and Clark (geometric mean of 20 minutes tows), 1961-2001.

Brood Year	Kvichak Escapement (millions)	Iliamna Lake (tows in areas 7&8 only) Mean Catch	Mean Length	Lake Clark Mean Catch	Mean Length
61	3.7	90	53	13	50
62	2.6	12	45	54	50
63	0.3	5	54	3	50
64	1.0	7	62	2	50
65	24.3	170	53	23	52
66	3.8	67	57	15	47
67	3.2	78	62	47	59
68	2.6	43	62	9	50
69	8.4	386	61	11	55
70	13.9	127	44	20	38
71	2.4	4	50	15	41
72	1.0	3	58	17	48
73	0.2	2	71	12	57
74	4.4	491	54	80	55
75	13.1	252	49	105	49
76	2.0	16	53	--	--
77	1.3	11	61	--	--
78	4.1	339	62	65	56
79	11.2	282	53	60	48
80	22.5	134	61	26	59
81	1.8	37	52	58	46
82	1.1	9	68	18	57
83	3.6	242	64	40	56
84	10.5	147	46	84	51
85	7.2	63	54	16	49
86	1.2	10	60	--	--
87	6.1	79	63	11	56
88	4.1	22	58	21	48
89	8.3	181	55	19	47
90	7.0	336	54	-	-
91	4.2	_	56	20	47
92	4.7	135	57	27	61
93	4.0	64	57	26	55
94	8.3	83	55	21	54
95	10.0	126	62		
96	1.5	23	67		
97	1.5	-	-		
98	2.3	57	46		
99	6.2	38	44		
00	1.8	159	58		
01	1.1				

Table 12. Summary of 2001 environmental and limnological measurements in Lake Aleknagik.

Measurement and first year measured	Dates	2001	All years Average	All years Range
1. Date of ice breakup 1949-		5/25	5/29	5/1-6/16
2. Water surface temperature © 1958-	6/25	13.7	7.8	3.8, 13.7
	7/14	11.1	11.6	8.1, 18.0
	8/2	15.7	13.2	9.4, 18.8
	8/31	12.9	12.3	9.7, 16.0
3. Water transparency Secchi depth (m) 1962-	6/25	5.1	7.7	4.8, 10.5
	7/14	6.2	8.0	5.0, 10.9
	8/2	7.3	9.1	6.3, 11.9
	8/31	9.3	9.1	5.8, 12.1
4. Water conductivity (micromhos/cm) 1968-	6/25		37.9	31.1, 52.1
	7/14		37.0	32.0, 42.6
	8/2		36.7	32.5, 40.5
	8/31		37.8	32.2, 47.9
5. Average daily solar radiation (gm/cal/cm) 1963-	June 1-15	461	403	272, 588
	June 16-30	519	405	265, 572
	July 1-15	318	379	277, 543
	July 16-31	280	345	192, 485
	Aug. 1-15	195	290	195, 402
	Aug. 16-31	233	253	164, 421
	Sept. 1-15		205	114, 282
6. Lake level (cm) of Lake Nerka 1952-	June 1-15	136	144	84, 227
	June 16-30	157	151	97, 218
	July 1-15	137	131	74, 199
	July 16-31	126	105	52, 172
	Aug. 1-15	97	86	34, 173
	Aug. 16-31	75	81	30, 184
	Sept. 1-15	60	81	29, 161
7. Chlorophyll "a", 0-20m (mg/m2) 1963-	6/25	14	27	10, 45
	7/5	28		
	7/14	22	26	10, 43
	7/24	20		
	8/2		21	6, 37
	8/11	26		
	8/21	25		
	8/31	24	23	5, 41
8. Zooplankton volume 0-60m (ml/m2) 1967-	6/25	54	53	20,168
	7/5	64		
	7/14	84	85	45-162
	7/24	105		
	8/2	85	118	43-226
	8/11	122		
	8/21	87		
	8/31	65	61	26-107

Table 13. 5-day averages of catches of emergent midges and water temperatures at 3 stations on Lake Aleknagik, 2000.

	Catch per day							Water temperature (°C)						
5-day	2000				1969-2000			2000				1969-2000		
period	W	H	B	Mean	Mean	Min	Max	W	H	B	Mean	Mean	Min	Max
6/1-5	1	20	7	9	2	0	9	5.7	8.5	7.2	7.1	3.2	0.0	9.8
6-10	3	8	3	5	9	0	70	5.5	7.5	7.4	6.8	5.6	0.0	10.4
11-15	2	2	2	2	11	0	53	5.8	7.8	6.4	6.7	6.8	0.0	12.9
16-20	3	1	1	1	14	1	168	5.5	9.4	8.2	7.7	8.6	3.9	12.7
21-25	3	0	1	1	6	0	42	8.7	11.0	8.2	9.1	9.2	4.8	15.5
26-30	3	1	0	1	4	0	12	10.9	12.1	9.9	11.0	10.2	6.0	17.1
7/1-5	3	0	0	1	6	1	15	9.0	12.2	12.0	11.1	11.5	7.7	17.8
6-10	2	1	1	1	11	0	61	12.0	14.2	13.6	13.3	12.2	9.3	18.9
11-15	4	10	5	6	13	1	34	11.5	15.4	16.5	14.4	12.6	9.2	17.9
16-20	1	6	13	7	14	2	36	10.4	12.0	11.3	11.2	12.4	8.5	17.0
21-25	10	13	33	19	19	2	74	12.2	12.9	12.8	12.6	13.0	7.9	17.3
26-30	4	20	11	12	25	2	59	12.3	12.0	11.5	11.9	13.4	8.9	18.6
31-4	3	1	2	2	25	1	77	8.2	11.9	11.3	10.4	13.6	10.2	17.5
8/5-9	1	2	1	1	18	1	80	11.6	10.5	10.3	10.8	13.6	10.4	17.7
10-14	3	2	1	2	13	1	54	13.5	13.3	12.8	13.2	13.5	9.5	18.8
15-19	4	1	1	2	12	1	70	14.4	11.5	13.7	13.2	13.6	11.0	16.9
20-24	0	1	0	0	5	0	28	13.6	13.5	13.5	13.5	13.7	9.7	16.0
25-29	4	1	0	2	5	1	11	12.9	13.1	12.5	12.0	13.4	11.3	15.7
30-3	10	0	1	3	5	0	13	12.0	11.7	12.2	12.0	12.8	10.6	14.2
9/4-8	12	0	0	4				11.6	11.1	11.2	11.3			

Table 14. Average catches, lengths and growth rates for sockeye fry and age 1 threespine stickleback in Lake Aleknagik, 1958-2001.

	Sockeye salmon fry						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	Sockeye Escapement 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
1958	-	-	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	.37	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	30.1	46.1	.24	52	788	200	27.9	39.4	.16	222	<1
93	34	33.7	56.4	.33	10	357	55	31.7	46.5	.22	3	<1
94	55	32.0	51.7	.29	106	417	31	30.3	46.6	.24	38	2
95	39	32.3	54.3	.32	23	483	33	31.5	46.0	.21	181	31
96	26	32.6	54.8	.33	100	470	43	32.6	47.1	.21	103	7
97	38	33.1	52.1	.27	8	625	164	34.2	41.4	.10	155	141
98	16	31.6	55.8	.35	3	404	26	30.6	45.3	.21	6	0
99	30	30.9	61.5	.44	6	401	30	30.3	46.0	.22	4	0
2000	46	30.8	53.4	.33	22	490	34	32.3	45.4	.19	24	0
2001	15	34.0	60.0	.38	21	376	10	31.1	44.8	.20	22	4
means	133	31.5	55.9	.35	46	341	123	31.2	44.5	.19	74	20

Table 15. Average townet catches and mean lengths of sockeye fry (by lake area), number of parent spawners and average catches and mean lengths (age 1) of threespine stickleback for Lake Nerka, 1958-2001.

	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		
1958	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	67	79	247	14	50
85	1	2	123	61	56	55	62	84	377	2	45
86	2	16	12	50	54	64	51	106	492	2	42
87	1	7	21	57	56	55	35	65	253	4	43
88	<1	2	7	64	57	57	77	213	293	2	49
89	1	3	16	57	51	59	56	173	178	5	48
90	1	7	3	63	62	58	87	154	380	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	56	55	200	252	201	15	45
94	29	39	66	63	55	52	162	169	203	15	44
95	41	127	49	63	56	50	95	152	372	22	44
96	6	44		66	61		154	153	232	1	49
97	3	2	3	62	59	60	131	216	355	39	43
98	12	47	26	59	53	52	148	282	250	37	44
99	40	48	155	55	53	54	137	241	161	8	46
2000	3	6	20	57	54	54	140	118	358	<1	46
2001	11	34	9	57	56	54	167	198	261	13	45
means	13	18	39	60	57	57	116	127	246	17	45

Table 16. Occurrence and numbers of juvenile sockeye in stomachs of Arctic char collected by hook and line from Little Togiak River during 30 days after ice out or through June 30.

Year	Date of ice out	Range in sampling dates	Number of char examined	Mean length (mm)	Percent of Char with: Fry	Smolt	Mean number Per char Fry	Smolt	Sockeye escape. year-2
72	6/17	6/26-7/10	82	446	34	60	2.8	4.5	55
73	6/8	6/19-7/3	121	446	34	44	1.9	2.9	24
74	5/27	6/11/1925	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	6/2	6/7/1925	316	437	7	42	0.2	1.5	18
79	5/24	6/6/1922	178	438	32	25	1.8	1.2	26
80	5/27	6/9/1925	278	459	--	81	--	9.4	45
81	5/28	6/12/1925	124	415	3	31	0.1	1.4	44
82	6/15	6/17-7/5	105	450	18	61	1.8	6.4	81
83	5/27	6/19-7/3	78	424	0	14	0.0	0.3	60
84	5/26	6/20-7/2	56	408	0	18	0.0	0.4	36
85	6/17	6/15-7/6	60	437	22	30	1.6	1.2	31
86	6/4	6/16-7/5	61	437	21	56	0.4	2.7	17
87	6/1	6/14-7/5	51	451	6	78	0.1	4.9	21
88	6/5	6/16/1929	43	431	7	26	0.1	0.8	21
89	6/17	6/20-7/15	105	388	37	38	2.2	1.3	15
90	5/28	6/7/1924	72	391	35	11	1.8	0.3	19
91	6/7	6/20-7/7	48	415	4	35	0.9	2.5	15
92	6/13	6/15-7/11	79	425	0	46	0.0	1.9	29
93	5/12	6/7/2018	124	429	9	19	0.6	0.4	19
94	5/28	6/14/1929	52	420	0	15	0.0	0.2	35
95	5/29	6/11/2013	3	468	66	66	2.3	2.0	19
96	5/30	6/16/1922	40	429	0	42	0	1.1	24
97	5/29	6/13/1924	28	445	0	11	0	0.3	28
98	5/28	6/15/1925	22	435	9	36	0.1	2.8	23
99	6/20	6/28-7/1	12	469	17	50	0.4	0.9	45
00	5/30	6/20-6/29	67	430	0	48	0	1.4	53
01	5/29	6/13-6/22	41	451	15	34	3.7	1.7	21
means	6/5		93	431	15	39	1.1	2.0	31

Table 17. Ground survey counts of sockeye spawners in the Wood River lakes, 2001.

Location	Date	Estimated off mouth	In creek Live	Dead	Natural	Bear kill	Total	Remarks
Aleknagik								
Yako	8/3	0	873	574	317	257	1447	7 jacks; 2 chum
Hansen	8/2	0	254	1733	290	1443	1987	Total count= 2,369
Bear	8/10	0	1132	1537	911	626	2669	8 jacks; 1 chum; temp 12 C
Happy	8/7	50	667	1229	797	432	1946	12 jacks
Ice*	8/11	500	2960	2812	2202	610	6272	2 jacks,1 chum; temp 13C
Midnight	8/10	0	3	16	0	16	19	temp. 11 C
Eagle	8/12	70	39	36	7	29	145	2 jacks;temp 15 C
Mission	8/15	0	205	23	21	2	228	9 jacks; temp 6.5 C
Big Whitefish	8/14	100	244	87	13	74	431	9 jacks; temp 16.5 C
Little Whitefish	8/14			0			0	no fish
Nerka								
Fenno	8/8	0	4175	12121	10125	1996	16296	3 jacks,2 pink,4 chum
Pick	8/16	1000	5072	4126	3410	716	10198	1jack,2 chum
Lynx	8/22	0	1515	1961	1343	618	3476	1 jack
Hidden Lake Cr	8/16	200	2124	2851	2359	492	5175	1 pink
Hidden Lake	8/16		488	138	101	37	626	
Elva	8/25	700	31	103	29	74	834	
Little Togiak River	8/28	7000	14733	429	247	182	22162	
Stovall*	8/24	0	681	674	383	291	1355	1 chum
Pike	8/23	0	267	1485	514	971	1752	count to large beaver dam
Teal	8/23	0	98	914	379	535	1012	2 chum
Kema*	8/26	0	117	664	143	521	781	2 jacks
Sam	8/23	0	15	1699	260	1439	1714	very late survey
Little Togiak								
A Creek	8/15	0	19	0	0	0	19	
C Creek	8/15	0	49	3	3	0	52	1 chum
Beverly								
Moose*	8/21	0	387	1059	31	1028	1446	late, much bear sign
Kulik								
Grant River	8/20	40	2513	3776	3237	539	6329	4 jacks

* Entire creek not surveyed

Table 18. Age compositions (%) of sockeye salmon spawners in the Wood River Lakes in 2001.

	Males							**No. of fish**	**Females**					**No. of fish**	**Combined**							
Location	1.1	1.2	2.2	1.3	2.3	1.4	2.4		1.2	2.2	1.3	2.3	1.4		1.1	1.2	2.2	1.3	2.3	1.4	2.4	**sum**
Hansen	2.1	21.3	5.3	71.3	0.0			94	13.5	6.2	78.2	2.1		96	.78	16.39	5.87	75.65	1.32	.00	.00	100.00
Happy		17.4	1.8	79.9	0.0	0.0	0.9	109	20.2	2.0	75.8	2.0		99	.00	19.16	1.93	77.32	1.26	.00	.33	100.00
Bear		2.0	2.0	94.9	0.0	1.1		98	6.1	2.1	91.8	0.0		98	.00	4.58	2.06	92.95	.00	.41	.00	100.00
Ice		0.0	0.0	100.0	0.0			96	1.0	0.0	98.0	1.0		98	.00	.63	.00	98.74	.63	.00	.00	100.00
Agulowak River		0.9	0.0	99.1	0.0			105	0.9	0.0	99.1	0.0		108	.00	.90	.00	99.10	.00	.00	.00	100.00
Wood River		59.5	0.0	40.5	0.0			37	52.6	0.0	38.6	8.8		38	.00	55.15	.00	39.30	5.54	.00	.00	100.00
Fenno		3.8	0.0	96.2	0.0			106	6.6	0.0	93.4	0.0		106	.00	5.62	.00	94.44	.00	.00	.00	100.06
Stovall		52.0	0.0	47.0	0.0	1.0	0.0	102	68.0	0.0	32.0	0.0		103	.00	62.40	.00	37.55	.00	.37	.00	100.32
Pike		15.8	0.0	84.2	0.0			76	45.8	0.0	54.2	0.0		96	.00	35.30	.00	65.30	.00	.00	.00	100.60
Lynx		6.5	0.0	93.5	0.0			108	21.2	0.0	78.8	0.0		104	.00	16.06	.00	84.24	.00	.00	.00	100.29
Pick		1.0	0.0	98.0	0.0	1.0	0.0	101	2.9	0.0	97.1	0.0		103	.00	2.24	.00	97.43	.00	.37	.00	100.04
LT River		0.0	0.0	100.0	0.0			109	1.0	0.0	99.0	0.0		103	.00	.65	.00	99.37	.00	.00	.00	100.02
N4-N6 beach		5.3	0.0	94.7	0.0			95	4.0	0.0	95.0	1.0		101	.00	4.46	.00	94.89	.63	.00	.00	99.97
Kema		1.7	0.0	98.3	0.0			60	13.4	1.2	85.4	0.0		82	.00	9.31	.76	90.17	.00	.00	.00	100.23
Hidden Lake		4.1	0.0	95.9	0.0			97	18.6	0.0	81.4	0.0		97	.00	13.53	.00	86.77	.00	.00	.00	100.29
Anvil Bay beach		6.0	0.0	94.0	0.0			100	1.9	0.0	98.1	0.0		104	.00	3.34	.00	96.58	.00	.00	.00	99.92
Agulukpak River		0.0	0.0	99.0	0.0	1.0	0.0	101	1.0	0.0	99.0	0.0		104	.00	.65	.00	99.00	.00	.37	.00	100.02
LT beaches		1.0	0.0	99.0	0.0			98	1.8	0.9	96.4	0.9		111	.00	1.52	.57	97.36	.57	.00	.00	100.02
Moose		25.0	0.0	75.0	0.0			40	32.4	1.5	66.1	0.0		68	.00	28.60	.95	69.39	.00	.00	.00	98.93
Grant River		1.0	0.0	98.0	0.0	1.0	0.0	100	4.9	0.0	95.1	0.0		103	.00	2.90	.00	96.17	.00	.37	.00	99.44
Unweighted mean		11.2	0.5	87.9	0.0	0.9	0.2	92	15.9	0.7	82.6	0.8		96	.04	14.17	.61	84.59	.50	.09	.02	100.01
Wood River ADFG tower	0.1	2.6	0.0	96.3	0.1	0.1	0.0		4.9	0.1	93.7	0.9	0.2		0.1	4.0	0.1	94.7	0.7	0.4	0	100.00

Table 19. Daily counts of sockeye salmon spawners in Hansen Creek, 2001.

Date	Estimate off mouth	In creek Live	In creek Natural dead	In creek Bear dead	In ponds Live	In ponds Natural dead	In ponds Bear dead	Total live	Total dead	Cumu-lative dead	Live+ cum. dead
Jul. 15		0	10	0	Entrance blocked by beaver			0	10	10	10
16		274	43	161	dams. No fish in ponds.			274	204	214	488
17		172	53	47				172	100	314	486
18		83	1	76				83	77	391	474
19		66	10	96				66	106	497	563
20		31	7	41				31	48	545	576
21		15	0	53				15	53	598	613
22		10	0	13				10	13	611	621
23		603	33	135				603	168	779	1382
24		298	12	170				298	182	961	1259
25		196	2	151				196	153	1114	1310
26		417	49	60				417	109	1223	1640
27		220	24	130				220	154	1377	1597
28		156	13	80				156	93	1470	1626
29		104	7	49				104	56	1526	1630
30		64	8	71				64	79	1605	1669
31		50	1	18				50	19	1624	1674
Aug. 1		17	2	25				17	27	1651	1668
2		254	15	67				254	82	1733	1987
3		178	8	73				178	81	1814	1992
4		67	14	62				67	76	1890	1957
5		66	5	16				66	21	1911	1977
6		34	2	26				34	28	1939	1973
7		22	3	12				22	15	1954	1976
8 to 15		15	62	338				15	400	2354	2369
Totals			374	1970		0	0	3412	2354		

Dead fish removed on each survey.

Table 20. Summary of Hansen Creek spawning surveys, 1990-2001.

Year	Date First fish entered	Survey date	Survey counts Mouth	Live	Dead	Total	Total from daily surveys	Percent peak count of total	Mortalities Natural dead	Bear-kill dead	Percent bear-kill
1990	7/28	8/1	??	3570	201	3771	6733	56			
		8/6	25	4105	743	4873	6733	72	5139	1594	24
1991	7/21	8/1	??	4460	1664	6124	16296	38			
		8/6	500	8670	3735	12905	16296	79	13671	2625	16
1992	7/18	8/1	??	4594	1085	5679	7292	78			
		8/6	50	3518	2886	6454	7292	89	5991	1301	18
1993	7/20	8/1	??	1359	685	2044	4212	49			
		8/6	200	1482	1573	3055	4212	73	2696	1516	36
1994	7/27	8/1	??	2314	718	3032	7413	41			
		8/6	500	3205	1947	5652	7413	76	3358	4055	55
1995	7/20	8/1	600	6509	2348	9457	17589	54			
		8/6	100	7680	4425	12205	17589	69	9854	7297	43
1996	7/18	8/1	1000	5076	1674	6750	9736	69	6476	2800	30
		8/6	200	3968	3345	7313	9736	75			
1997	7/18	8/1		1597	2183	3780	8845	43	3969	4831	55
		8/6	300	2163	3804	5967	8845	67			
1998	7/21	8/1		4336	2152	6488	12529	52	6040	5875	49
		8/6		4153	4525	8678	12529	69			
1999	7/21	8/1		3347	2312	5659	19441	29	12961	3197	20
		8/6		7374	4837	12651	19441	65			
2000	7/19	8/1		192	1755	1947	3462	56	760	2682	78
		8/6		75	3153	3228	3462	93			
2001	7/15	8/1		17	1651	1668	2369	70	384	1970	84
		8/6		34	1939	1973	2369	83			

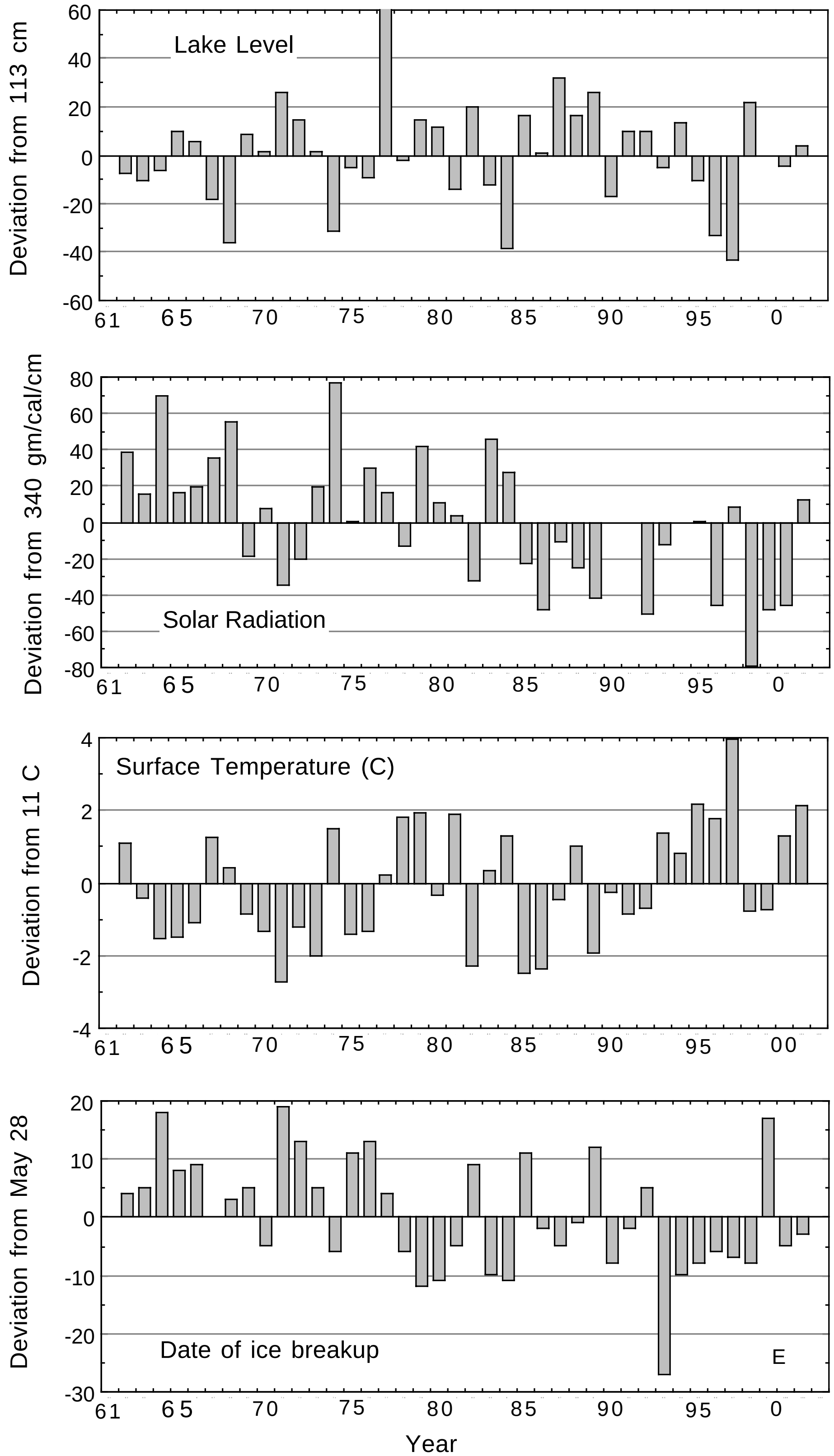

FIGURE 1. Deviations from mean of ice breakup dates, surface temperature, solar radiation, and lake level.

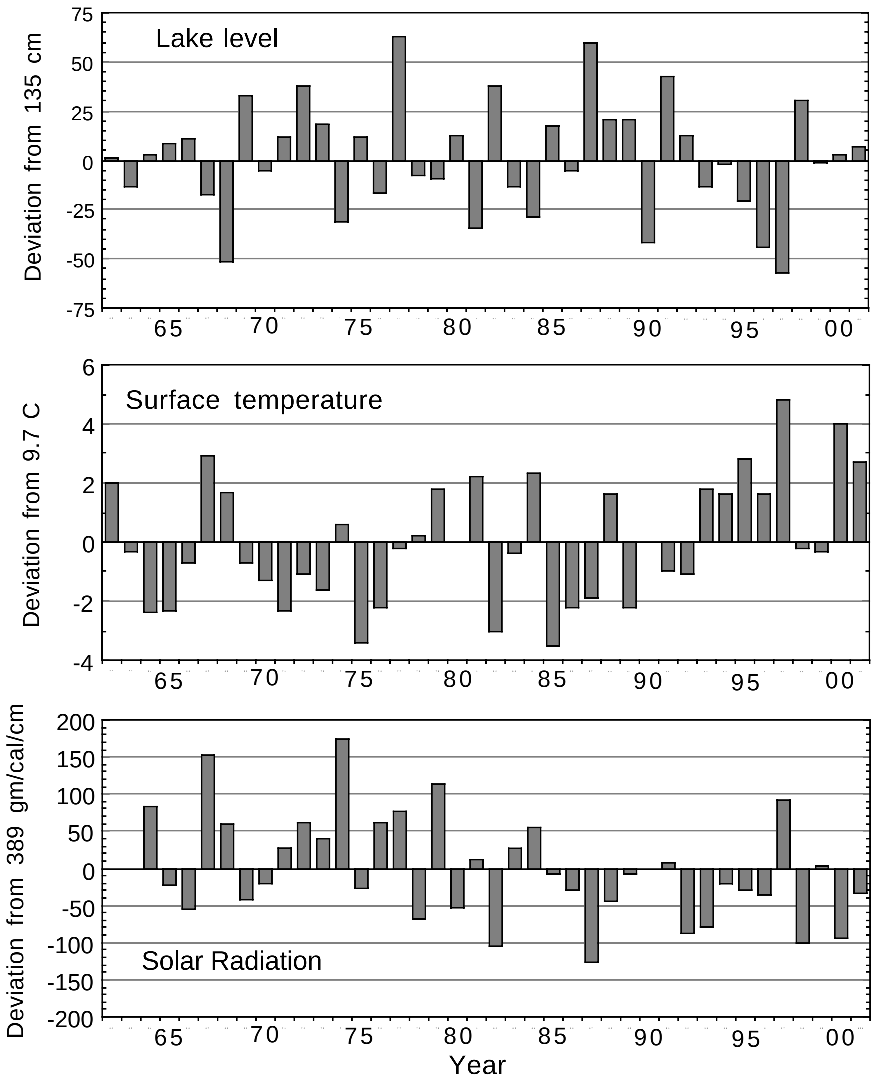

FIGURE 2. Deviations from mean values during June 26 to July 15.

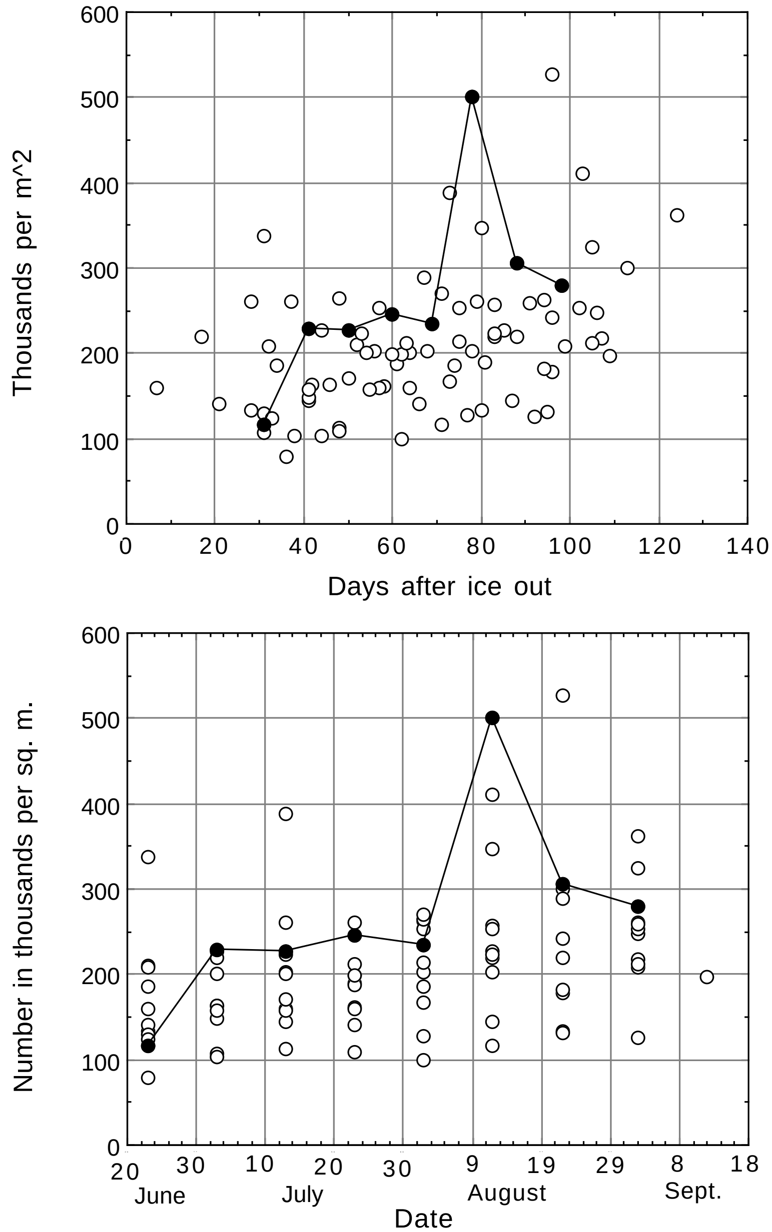

FIGURE 3. Total zooplankton density in Lake Aleknagik in 2001 (solid line) with densities from 1991 to 2000 by date (bottom) and days after ice out.

Figure 4. Depth distribution of large piscivorous fishes (box-and-whisker plot) combined with time series of the depth of juvenile sockeye (black dots) and the log of light intensity at the lake surface (solid line) for Lakes Kulik, Nerka, and Little Togiak, in July and September. Each data point for the depth of juvenile sockeye represents an average over a five-minute interval of hydroacoustics sampling.

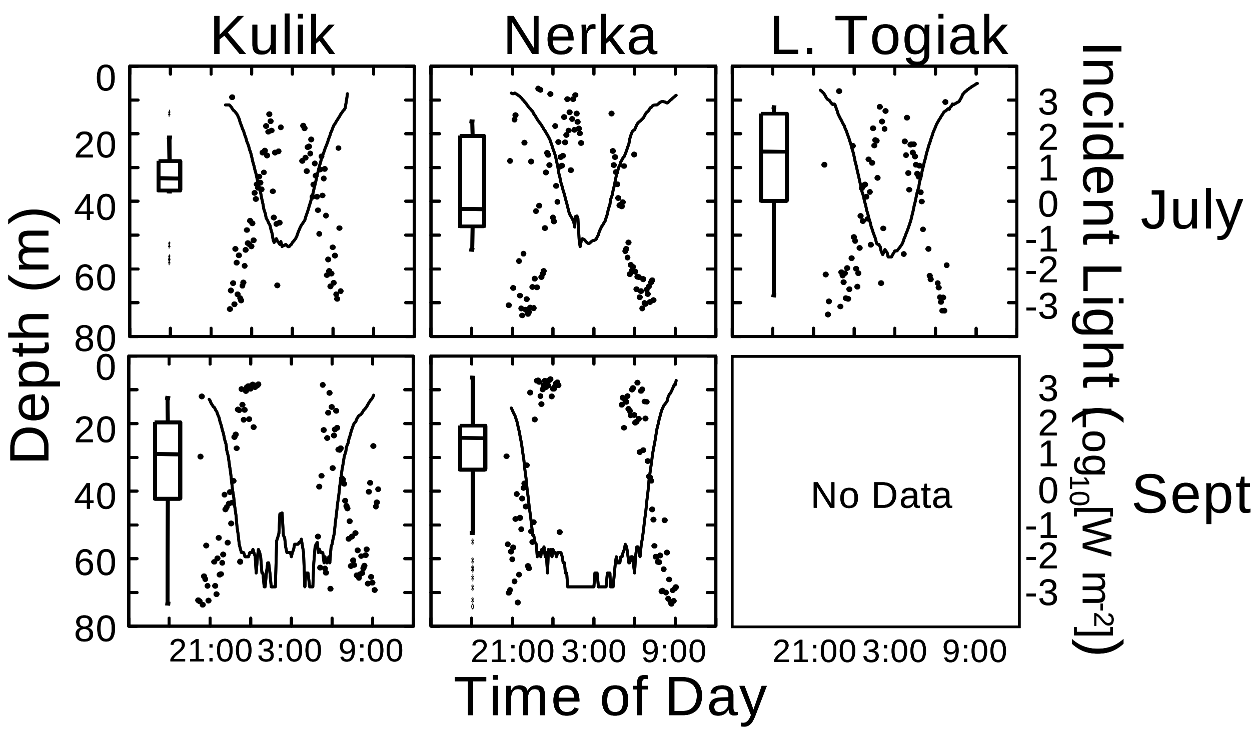

Figure 5. The cumulative distribution of gravel sizes in areas with or without spawning salmon. The proportion of gravel is based on the wet mass, note that the particle size is presented on a log scale.

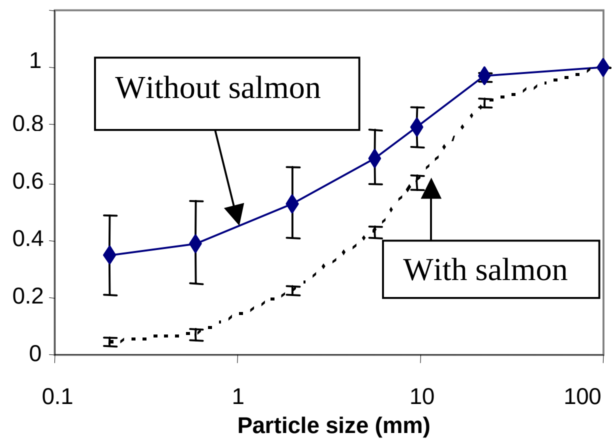

Figure 6. Reconstructed sockeye salmon runs from Lake Nerka in the time period from 1750 to 2000. Data prior to 1908 were reconstructed from lake sediment cores. Data after 1908 are direct counts, smoothed with a 5-year running mean.