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

ALASKA SALMON RESEARCH

D. ROGERS, PRINCIPAL INVESTIGATOR;
T. QUINN, ASSOCIATE PROFESSOR;
C. FOOTE, ASSISTANT PROFESSOR; AND
B. ROGERS , FISHERY BIOLOGIST

ANNUAL REPORT—1993

to

PACIFIC SEAFOOD PROCESSORS ASSOCIATION

Approved

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KEY WORDS

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

ALASKA SALMON RESEARCH

INTRODUCTION

Fisheries Research Institute was established in 1946 with the financial support of the major Alaskan salmon processors to (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 (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, the 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 is concerned with the oceanic distribution of salmon and the vulnerability of North American stocks to foreign fisheries. In recent years, we have also worked at Kodiak and on the Yukon stocks. All of these projects have been carried out in cooperation with the Alaska Department of Fish and Game (ADF&G) or the National Marine Fisheries Service (High Seas), and we have also had cooperative research projects with salmon biologists from Japan and Russia.

This report will focus on our 1993 Bristol Bay research with emphasis on salmon forecasting and research relevant to escapement policies to maximize production. The Southeast pink salmon (*Oncorhynchus gorbuscha*) research will be reported in a separate report from the University of Alaska; our Chignik salmon research is reported to the National Marine Fisheries Service; and a report on our Alaska Peninsula (False Pass) work we be completed soon.

FORECASTING

PRE-SEASON FORECASTS

Forecasts of the 1993 Bristol Bay sockeye salmon (*O. nerka*) runs and catches were provided to participating processors at our October 1992 meeting. They are presented in Table 1 with the ADF&G forecasts and the past forecasts and runs beginning in 1986. The two river system forecasts (FRI and ADF&G) are based on the same data sources, but different analytical methods have often been used. Both 1993 forecasts were for an average (recent years) run and catch, whereas the actual run was above average and the catch (41 million) was the largest on record. Since 1986, the actual catch has been between the two forecasted catches only once. In the other 7 years, the catch was either higher (6) or lower (1) than both forecasts. The 1993 catch was 28% greater than our forecast, which was near the average error since 1986 (31%). Our forecasts of the runs to the fishing districts have been closest for the Nushagak and farthest off for the Naknek/Kvichak, with the error in Egegik and Ugashik forecasts being intermediate.

PORT MOLLER FORECAST

The Port Moller in-season test fishery was conducted by ADF&G during June and early July from 1968 through 1985, with a change in gear in 1985. There was no test fishery in 1986 and, beginning in 1987, we have conducted the test fishery each year. The accuracy of the forecasts since 1987 has been very good. The runs have differed from the forecasts made on June 25 and 30 by an average of 16%, and we have been within an average of 10% on forecasts made about July 3 (Table 2). We have not done as well in forecasting the catch because river system forecasts and thus catches cannot be made until about July 3, when we have the first indication of where the salmon are going. In 1993, the test-fish catches projected that the run would be earlier and larger than the pre-season forecasts. Daily forecasts, from an almanac provided to Bristol Bay processors, tended to over-forecast the run until July 6 when the run was forecast exactly (52 million). Periodic adjusted forecasts (to account for the early run timing) were lower than the actual run by about 15%.

The test fishery at Port Moller employs a 200-fathom gillnet that is 60 meshes deep and has 5-in stretched mesh. The web is multistrand monofilament (center core). We have used a 70-ft vessel (*Nettie H*) and fished each day from June 11 through about July 5 (weather permitting). Four stations are fished along a transect ~30–60 mi out from Port Moller. Catch, mean length, and water temperature data are sent daily by radio to Port Moller and then faxed into Bristol Bay. The vessel comes into port every other day to deliver fish and salmon scales collected by the 2–3 biologists onboard. In 1993, scales and length data were sent periodically to ADF&G (B. Cross, King Salmon), and the scales were aged and the age compositions and average lengths by age were reported.

The statistics from Port Moller in 1993 were again a challenge to interpret, although they ultimately predicted the total run and age composition accurately. The sockeye salmon were larger than average for their age, and there was a higher than expected percentage of age 2.3 fish. Usually high percentages of 3-ocean fish and large body size are associated with small runs, but there were large index catches (especially early, June 14–17) indicating that a large run was coming with an early arrival in the bay. ADF&G provided preliminary daily catches and escapements for 1993, and from these data as well as published statistics (e.g., Stratton 1991) we reconstructed the run timing in the Bristol Bay fishing districts to compare with past years and with the Port Moller index catches (Fig. 1). The timing and magnitude of the 1993 run was fairly well predicted by the Port Moller catches assuming a 6-day travel time and that Ugashik fish passed Port Moller at the same time as the other stocks (Rogers 1990). In 1993, the fish arrived early off Port Moller and then took about 1 or 2 days less than average to reach the fishing districts.

ADF&G (B. Stratton, Anchorage) provided preliminary length and weight statistics for 1993, and statistics from prior years were available (e.g., Yuen et al. 1981 and Stratton 1991) so that we could calculate mean lengths in the runs (Table 3). The 2-ocean sockeye salmon in the 1993 run were much larger than average, whereas the 3-ocean fish were a little below average in length. 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 3-ocean fish in the catches, the average weights calculated from ADF&G sampling were above average except in the Nushagak District (Tables 4 and 5).

The Port Moller test fishery in 1993 provided an early indication to ADF&G management that an early and large run was on the way; however, the early distribution of the run, heavy to the Egegik District, created some doubt as to the size of the run (40–50 million). Although there was some overescapement in the Naknek, Egegik, Ugashik, and Igushik rivers, the escapements in 1993 were closer to the goals than in any of the past 4 years (Table 6). Considering the size of the run (a daily record of 5.3 million landed on July 2) and the early timing (second to 1979), management of the run was outstanding. Good catches were made in all districts before large numbers of fish were counted past the towers. The timings of most escapements were the earliest recorded. For Wood River, the 1993 run continued a trend towards earlier timing (Fig. 2). Escapements during the early 1900s were ~1 wk later than recent years (since 1953), and the escapements since 1977 have begun early (10% date) except for 1986. Two factors contribute to the recent early timing: (1) a majority of the years have had early or warm spring weather, and (2) there is a tendency to keep fishing closed until a significant number of fish have been counted past the upriver tower sites. The later timing of the escapements in the early 1900s was partly caused by the reverse situation (i.e., the fishery tended to fish more on the early part of the run than on the late part).

LAKE RESEARCH

During the summer of 1993, 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 1993, we also conducted special studies of bear predation on spawning sockeye salmon and stock specific traits of sockeye spawning populations.

KVICHAK SYSTEM

Our 1993 field season in the Kvichak system (Lakes Iliamna and Clark) consisted of estimating the sockeye escapement into the Newhalen River in late June and July, townetting for juvenile sockeye and threespine stickleback (*Gasterosteus aculeatus*) in upper Lake Iliamna and for sockeye fry, stickleback and least cisco (*Coregonus sardinella*) in Lake Clark in August. We also conducted spawning ground surveys in late August–early September to collect otoliths for age determination. We continued our studies on (1) the ecological relationship between sockeye salmon and two sculpin species, *Cottus cognatus* and *C. aleuticus*, and (2) factors promoting the genetic differentiation of sockeye salmon populations.

Newhalen River Escapement

The annual escapements of sockeye salmon to the Kvichak lake system are estimated by ADF&G from expanded 10-min counts on each bank of the river at the outlet of Lake Iliamna (Igiugig). In addition, since 1979 we have estimated the escapements up the Newhalen River by expanding 20-

min counts on one bank, for each of 10 daylight hours, to a daily count for both banks. We count when and where the visibility is best and assume that the fish utilize both banks equally and that their migratory rate does not change at night. The daily counts at Newhalen are compared with the counts at Igiugig to estimate a travel time; then, by lagging the Newhalen counts back to Igiugig the appropriate number of days, we can calculate the daily proportions of the Kvichak run that went up the Newhalen River.

The cumulative daily escapements for the two rivers, timed to the Kvichak, are given in Table 7 for 1989–1993. In mid-July, milling fish often swim upriver along the banks of the Newhalen and are counted, and then drift down river in the middle where they cannot be seen, only to swim up river again. This inflates the counts for the escapement; therefore, we have used the average proportion of Newhalen count to Kvichak count for day 5 to day 16 (day 1 equals the first day of 100,000 in the Kvichak) and the season's total Kvichak escapement to estimate the Newhalen/Lake Clark escapement.

In 1993, we estimated that 1.6 million of the Kvichak escapement of 4.0 million (about 38%) ended up in the Newhalen/Lake Clark system (Table 8). This was about average for the past 5 yr (35%). The aerial surveys conducted by ADF&G in 1993 provided an estimate of the Newhalen River spawners and, thus by subtraction, an estimate of the Lake Clark escapement of 1.5 million.

Spawning Ground Surveys

We have collected scales or otoliths from spawned out sockeye salmon from several major spawning grounds in the Kvichak system each year since 1956. In 1993, 8 spawning grounds were sampled and the age compositions from the samples provided a similar pattern to the age composition in the lake system escapement (Table 9). Chinkelyes Creek had a high percentage of age 2.2, the Newhalen and Tazimina Rivers had high percentages of age 1.3, and Pedro Creek had a high percentage of age 1.2; otherwise the age compositions were similar to the composition for the entire lake system (Kvichak escapement).

We had conducted annual aerial surveys of the Kvichak spawning grounds from 1956 until 1988, when ADF&G took over the surveys. The results of the 1993 surveys were provided by ADF&G (J. Regnart, King Salmon) and are summarized for 29 selected spawning grounds in Table 10. In recent years the surveys have accounted for smaller percentages of the total (tower count) escapement than was typical for past years. This may have been caused by differences in observers, weather conditions (visibility), or distribution of sockeye salmon on the spawning grounds.

We continued our survey of the spawning dynamics of sockeye salmon on the beaches of Fuel Dump Island. Preliminary results of 1993 indicated the possibility of local differentiation in spawning time between groups of sockeye salmon that were within 20 m of each another. We repeated our detailed transect counts of the area by snorkeling and collected various sets of physical data (gravel size, water temperature and measures of current). In addition, we tagged males within the two areas to measure the intermixing between groups and hence the possibility for stock differentiation. As in 1992, there was a difference in spawning time of a few days between two adjacent sites. Physical factors also differed between areas. In particular, water temperature commonly differed by nearly a degree (C) and the current flows differed considerably.

Sockeye Fry Abundance and Size

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

The sockeye fry are usually smaller in Lake Clark than in Lake Iliamna because temperatures are usually colder and Lake Clark has a shorter ice-free period; however this was not so in 1993 (1992 brood year). The fry in Lake Clark averaged a record 61 mm. In both lakes, the annual growth of the fry is correlated with water temperatures, which are mostly influenced by spring weather. Cold temperatures typically result in small fry (40–50 mm), which then spend 2 yr in the lake before seaward migration and tend to return as adults 5 yr after their parents. Warm temperatures usually result in large fry (>60 mm), which tend to migrate to sea after 1 yr and mostly return 4 yr after their parents. The townet sampling has been useful in predicting, 3 yr in advance, the main age at return from the larger Kvichak escapements by utilizing the relationship between age at return and mean length of fry in Lake Iliamna. From the mean lengths in 1993 (57 and 61 mm), we would expect most of the fish from the 1992 brood year to migrate as age 1 smolt and return mainly in 1996.

Sculpin Predation

In 1992 we examined the movement patterns and distribution of sculpins relative to sockeye spawning grounds, while concurrently measuring the single meal egg feeding potential of sculpins in laboratory conditions. The results indicated that sculpins could have a major impact on sockeye egg-to-fry survival on these beaches. In 1993 we extended the study four ways. First we estimated the maximum number of eggs sculpins could consume over the course of the spawning season. Second, we measured the digestion rate of both species when fed fresh and water-hardened eggs. Third, we estimated indirectly the hunger level of sculpins on the spawning grounds over the course of the spawning period, and hence the susceptibility of eggs to predation. Finally, we estimated the density of sculpins in relation to spawning site characteristics (gravel size) to determine if the intensity of egg predation varies among sites (habitats).

The number of eggs consumed by sculpins over the course of the spawning season increased in relation to sculpin size, with the largest sculpins (11 cm) consuming over 115 eggs in a 2-wk period. However, egg digestion was relatively slow, with residue of meals of five eggs sometimes still evident 6 d after feeding. The tendency of sculpins to fill up rapidly and digest slowly probably accounts for the marked decrease in the susceptibility of eggs to predation over the course of the spawning period. While 40 g of eggs in minnow traps attracted on average over 150 sculpins per trap when set overnight just before spawning started, the same traps often attracted no sculpins 5 d after spawning had begun. This suggests that sculpins were satiated once spawning was underway. However, the number of sculpins increased in the traps near the end of the spawning period, indicating that hunger levels were increasing.

This study indicates that sculpin predation can have a significant impact on egg to fry survival. Furthermore, the intensity of this egg predation is not random across the spawning period; fish spawning at the beginning and end of the spawning period undoubtedly suffer higher egg predation than those spawning in the middle. Hence, natural selection, in the form of sculpin predation, will favor sockeye salmon that spawn over a narrow period of time. This may account for the short spawning periods observed on island beaches where sculpins are abundant compared with the long periods of spawning observed in Knutson Bay and various rivers where sculpin densities are low. In the future, we will attempt to asses sculpin densities through depletion estimates. This will also test the feasibility of reducing local sculpin densities, thus reducing egg predation and increasing egg to fry survival.

Spawning Behavior, Morphology and Genetics

In 1993 we continued our work on sockeye salmon spawning behavior on island beaches, explored additional hypotheses to account for population differentiation in spawning morphology, initiated studies on physical factors affecting egg to fry survival and completed our preliminary examination of genetic variation (DNA) among sockeye salmon spawning populations in Bristol Bay.

We completed our work examining the behavior of males relative to females over the course of the spawning period. Unlike river spawning fish, those on the beaches do not adopt sneak positions relative to females when denied access by other males. Rather, as the number of males available per female increased over the spawning period, large aggregations of males (often over 10) began to appear. There were no obvious dominant males within these groups; rather all males attempted to participate in lone female spawnings. This caused repeated displacement of the female and a protracted individual spawning period.

Since 1988 we have explored hypotheses regarding population differentiation in spawning morphology. We have examined the significance of this variation within populations and described the variation among populations and related it to spawning habitat. In 1993 we examined the effect of parasite infestation on body shape for spawning populations in Lake Iliamna and Aleknagik (Wood River Lakes). Parasite infestation of *Philonema oncorhynchi* was directly related to freshwater age. Adults that had spent 2 yr in the lake prior to seaward migration had higher rates of infestation than those that spent only 1 yr in the lake. However, infestation rate was not related to body shape, indicating that the parasite caused a negligible cost to the host (sockeye salmon adult). This provided additional support that differences among populations in body morphology are likely genetic in origin and reflect adaptations to local spawning sites.

Preliminary DNA analyses of populations from several areas indicated that sockeye salmon populations from Lake Clark, Lake Iliamna, and Lake Aleknagik were genetically distinct from one another. Further, these Bristol Bay populations were more closely related to sockeye salmon from Russia than populations from southerly locations in North America. This technique (DNA analysis) holds great promise for identifying Bristol Bay stocks within the fisheries or at Port Moller.

In future work, we will examine physical and biotic factors that affect egg-to-fry survival (gravel size, flow and egg size). We will also examine the long-term effects of differentiation in egg size among populations by examining genetic differentiation in development rates in controlled experiments at the University of Washington, and by measuring individual growth rates of fry in the wild (daily growth rings on otoliths) in relation to their parental spawning location.

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

The spring of 1993 was the earliest for Bristol Bay since 1981. The April air temperature was the second warmest in history (since 1919) and ice breakup in Lake Aleknagik (recorded since 1949) was 1 mo earlier than average and 2 wk earlier than the previous record of May 14, 1958 (Table 12). Although ice breakup was early, mid-summer water temperatures were only a little warmer than average because solar radiation (sunlight) was below average during most of the summer. Lake levels were about normal until late August, when heavy rainfall caused a moderate increase. Standing crop of phytoplankton (chlorophyll) was about average during the summer, whereas zooplankton volumes were well above average in June and July but below average in August. Zooplankton are the main source of food for juvenile sockeye salmon after they move offshore in late July. Insects (mainly pupal and adult midges) are the main source of food in the spring, when the fry are inshore. There was an early peak in midge emergence in 1993 (early July) corresponding to the early ice breakup. In past years midge emergence has usually peaked in either late July or early August (Table 13). Water temperature at nearshore insect traps were warmer than average in 1993, but no records were set.

Fry Abundance and Growth

The sockeye fry in Lake Aleknagik in 1993 were longer than average in June, but their growth during July and August was only average, and on September 1 their lengths were typical of past years (Table 14). Fry abundance as measured by beach seine and townet sampling was below average, although the number of parent spawners (343,000) in Lake Aleknagik in 1992 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 and *Daphnia* .

The mean lengths of sockeye salmon fry in Lake Nerka indicated that in 1993 growth was about average, but the relative abundance of fry was below average as estimated from townet catches (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 comparing year-to-year variation in zooplankton population composition (1993 samples have not yet been counted) with annual variation in sockeye salmon fry and threespine stickleback abundance to determine the extent to which the fish alter their food resources. We hope the information from these studies will help explain the observed variability in the freshwater phase of the sockeye salmon.

Char Predation

We have sampled the Arctic char (*Salvelinus alpinus*) in Little Togiak River each spring since 1972 to follow the rate of predation on juvenile sockeye, especially smolts. This short river flows from Little Togiak Lake into Lake Nerka, and the smolts are very vulnerable to the char for the few minutes it takes them to move from one lake to the next. Large char usually eat more juvenile sockeye than small char. The char caught in 1993 were about average in length and they consumed about 1 smolt per d (Table 16). We were surprised to find sockeye salmon fry in the char stomachs in as late as mid-June in 1993 because ice breakup was so early. Perhaps timing of fry emergence in the river was normal in 1993. There are about 5,000 char in and around the river mouth, so that at just 1 smolt per char per night for a migration of 20 to 30 d, a significant number of smolts are lost from the production of this small lake in the system.

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. ADF&G estimates the numbers of spawners on the lake beaches and in the interconnecting rivers by aerial surveys; thus the total escapement to the lake system can be apportioned to the individual lakes or type of spawning ground (creek, river, and beach). The distribution of spawners among the lakes is used in forecasting the Wood River runs. Even escapement distributions tend to produce large returns and uneven distributions tend to produce small returns.

Aerial surveys were conducted by ADF&G in 1993 with industry funding; however, we have not yet compiled the aerial survey counts to estimate the escapements to the lakes. The ground survey counts for the major spawning grounds in 1993 are given in Table 17. The creeks draining into Lake Aleknagik again contained relatively high counts of spawners (especially Happy Creek) and Hansen Creek had a large number of spawners for the fourth consecutive year (Fig. 3).

Bear Predation

We completed the fourth year of our bear/spawning sockeye salmon interaction study in Hansen Creek, a small tributary of Lake Aleknagik where predation by bears is high relative to larger creeks. During 18 July to 22 August, a large number of spawners were again observed in Hansen Creek, but not as many in the prior 3 yr (Table 18). Daily count and removal of sockeye salmon killed by bears indicated that 1,504 (36%) of 4,212 spawners were killed by bears in 1993 (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). Numbers of sockeye killed by bears in 1993 was similar to the numbers in 1990 or 1992; however, the percentage of sockeye salmon killed by bears in 1993 was higher than in the past 3 yr (16% to 24%). 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 number (2,500) and 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 are about the earliest spawners in the lake system and the fish usually first enter the creek about July 22–25. From the daily counts in 1990–1993, had the surveys been conducted on the single date of August 6, the "peak survey" counts would have been 72% to 89% of the totals; if the single surveys were done on August 1, the counts would have been 38% to 78% of the actual number of spawners (Table 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

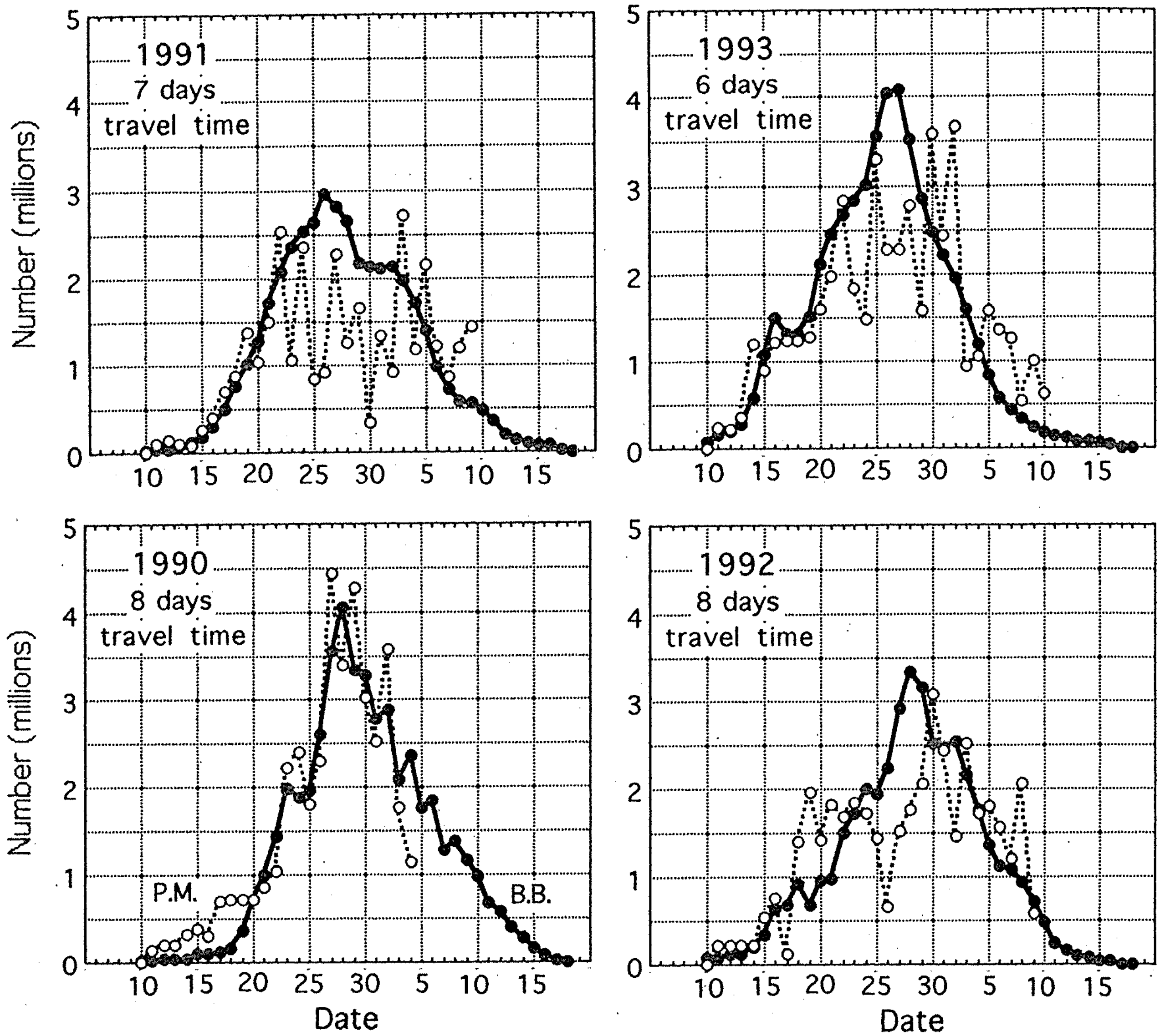

Figure 1. Reconstructed daily Bristol Bay sockeye runs at Port Moller and the daily sockeye salmon index catches (scaled: 1 index = 15,000), 1990–1993.

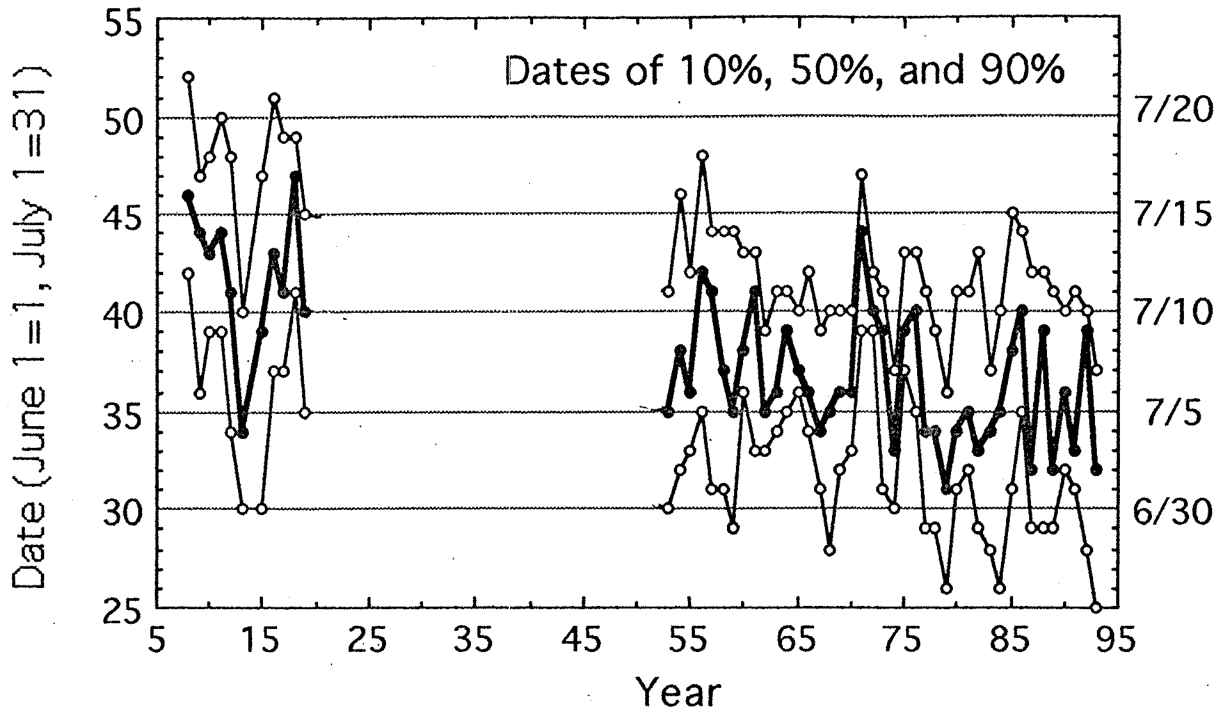

Figure 2. Timing of the sockeye salmon escapements to Wood River, 1908–1919 and 1953–1993.

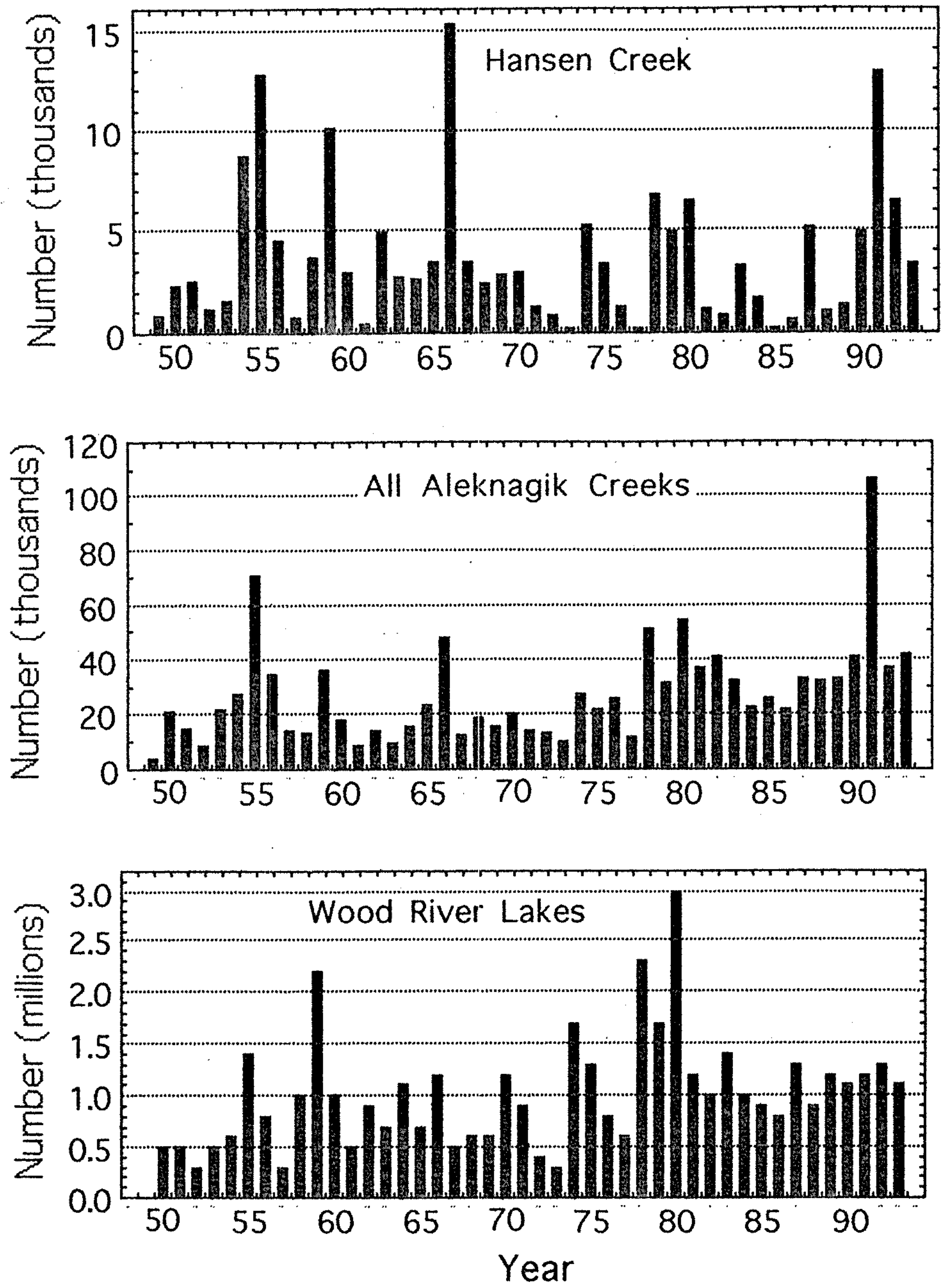

Figure 3. Annual escapements of sockeye salmon to the Wood River Lakes and annual stream survey counts for all Lake Aleknagik creeks and Hansen Creek, 1949–1993.

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
1985	FRI	12.2	5.3	5.8	4.4	4.3	33.0	18.2	29
	ADFG	12.2	4.9	6.6	5.6	4.3	35.0	20.3	
	Actual run	13.4	3.7	8.6	7.4	3.0	36.6	23.5	
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	
	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	
	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	
	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	
	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	
	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	
	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	
	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	
	Actual run	9.3	4.7	23.3	5.7	7.6	51.9	40.8	

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

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

	Bristol Bay		Run pred. on 6/25			Run pred. on 6/30			Run pred. on 7/3			Catch pred. on 7/3		
Year	Run	Catch	Pred.	R-P	%ofP	Pred.	R-P	%ofP	Pred.	R-P	%ofP	Pred.	C-P	%ofP
1987	27	16	27	0	0	27	0	0	26	1	4	15	1	7
1988	23	14	15	8	53	15	8	53	22	1	5	12	2	17
1989	44	29	50	-6	-12	37	7	19	42	2	5	28	1	4
1990	48	33	42	6	14	56	-8	-14	39	9	23	25	8	32
1991	42	26	48	-6	-13	37	5	14	37	5	14	21	5	24
1992	45	32	49	-4	-8	45	0	0	41	4	10	29	3	10
1993	52	41	61	-9	-15	57	-5	-9	56	-4	-7	44	-3	-7
Means	40	27	42	-2	3	39	1	9	38	3	7	25	2	12
absol.				6	16		5	16		4	10		3	14

Number in millions of fish.
R = run, P = predicted, and C = catch.
absol. = absolute error, ignoring the sign.
% of P = the percentage that the actual run differed from the prediction.
1993 forecasts are from Bristol Bay almanac (not adjusted for early run timing).

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

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
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
88-92	45	513	497	505	576	553	565	533	46

Table 4. Average weights of sockeye (lbs) in the east-side Bristol Bay commercial catches, 1984–1993.

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	84	14.5	5.2	4.5	4.9	7.1	6.1	6.6	5.6	4.9	5.2	22	48
	85	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
	Means	9.5	5.2	4.5	4.9	7.2	6.2	6.6	6.1	5.3	5.7	48	52
Egegik	84	5.2	5.1	4.5	4.9	7.5	6.8	7.1	6.0	5.7	5.8	43	44
	85	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
	Means	9.3	5.3	4.7	5.0	7.3	6.3	6.8	6.2	5.5	5.9	47	50
Ugashik	84	2.7	5.0	4.6	4.9	6.9	6.2	6.5	5.6	5.5	5.6	42	35
	85	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
	Means	3.3	5.4	4.7	5.1	7.4	6.3	6.9	6.3	5.6	5.9	50	45

Table 5. Average weights of sockeye (lbs) in the west-side Bristol Bay commercial catches, 1984–1993.

District	Year	Catch millions	2-ocean Male	2-ocean Female	2-ocean Comb.	3-ocean Male	3-ocean Female	3-ocean Comb.	All males	All females	All fish	Percent 3-ocean	Percent females
Nushagak	84	2.0	5.3	5.1	5.2	7.4	6.0	6.6	7.0	5.9	6.4	87	56
	85	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
	Means	3.1	4.9	4.4	4.7	7.4	6.0	6.7	6.6	5.6	6.1	72	53
Togiak	84	0.2	5.7	5.1	5.4	7.6	6.0	6.8	7.4	6.0	6.6	89	54
	85	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
	Means	0.3	5.7	4.8	5.3	8.3	6.4	7.2	7.7	6.1	6.9	82	54

Table 6. Sockeye salmon escapements in excess of management goals for Bristol Bay river (in millions), 1987–1993.

River system	Escapement goal Mid-point	Escapement goal Upper range	1987	1988	1989	1990	1991	1992	1993
			Escapement in excess of mid-point						
Kvichak	variable	variable							
Branch									
Naknek	1.00	1.40	.06	.04	.16	1.09	2.57	.61	.54
Egegik	1.00	1.20	.27	.61	.61	1.19	1.79	.95	.52
Ugashik	.70	.90	.00	.00	1.01	.05	1.76	1.76	.71
Wood	1.00	1.20	.34	.00	.19	.07	.16	.29	.18
Igushik	.20	.25	.00	.00	.26	.17	.56	.10	.21
Nuyakuk/Nush.	.50	.76	.00	.00	.01	.17	.00	.20	.21
Togiak	.15	.25	.13	.16	.00	.04	.13	.07	.04
Total			.80	.81	2.24	2.78	6.97	3.98	2.41
Bristol Bay run			27	23	44	48	42	45	52
catch			16	14	29	33	26	32	41
			Escapement in excess of upper range						
Naknek	1.00	1.40	.00	.00	.00	.69	2.18	.21	.14
Egegik	1.00	1.20	.07	.41	.41	.99	1.59	.75	.32
Ugashik	.70	.90	.00	.00	.81	.00	1.58	1.56	.51
Wood	1.00	1.20	.14	.00	.00	.00	.00	.09	.00
Igushik	.20	.25	.00	.00	.21	.12	.51	.05	.16
Nuyakuk/Nush.	.50	.76	.00	.00	.00	.00	.00	.00	.00
Togiak	.15	.25	.03	.06	.00	.00	.03	.00	.00
Total			.24	.47	1.43	1.80	5.89	2.66	1.13

Table 7. Cumulative daily escapements of sockeye salmon in the Kvichak and Newhalen Rivers, 1989–1993 (numbers in 1,000s and Newhalen escapements estimated from expanded counts lagged back 2 days).

Date	1989		1990		1991		1992		1993	
	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen
6/22									13	
23							0		24	
24	0		0				1		34	
25	58	17	1		0		2		51	6
26	298	97	2		1		10		121	67
27	525	162	3		3		17		317	78
28	653	200	5	0	50	7	81	5	559	157
29	892	454	8	1	125	46	255	18	847	237
30	1509	641	39	2	277	95	446	67	932	394
7/1	2052	712	46	37	588	146	635	88	1014	492
2	2566	785	219	66	901	188	754	104	1081	650
3	3287	892	825	90	1256	330	798	132	1182	816
4	4378	1185	1412	110	1581	517	1093	196	1307	937
5	5418	1287	1874	139	1925	620	1663	273	1678	1022
6	5947	1358	2399	204	2141	805	2244	329	2372	1103
7	6611	1567	2901	304	2208	1132	2688	406	2733	1121
8	7182	1962	3509	375	2277	1531	2880	534	2932	1134
9	7518	2317	4061	459	2355	1721	2960	661	3101	1163
10	7670	2478	4692	648	2633	2048	2985	840	3264	1189
11	7708	2614	5081	790	3080	2202	3175	977	3402	1220
12	7755	2728	5388	961	3460		3662	1057	3574	1268
13	7806	2829	5803	1079	3724		4066	1158	3751	1322
14	7860	2944	6208	1193	3822		4330	1258	3818	1353
15	7914		6418	1297	3909		4438	1434	3864	
16	8060		6510		3999		4517	1491	3894	
17	8130		6603		4063		4578		3921	
18	8164		6674		4098		4626		3958	
19	8205		6733		4132		4685		3986	
20	8245		6781		4166		4695		3996	
21	8273		6827		4193		4710		4008	
22	8287		6876		4213		4720		4016	
23	8295		6915		4220		4726		4021	
24	8302		6941						4024	
25	8312		6970						4025	

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

Year	Kvichak system escapement (millions)	Newhalen/Lake Clark escapement (millions)	Percent of Kvichak (%)	Newhalen River spawners (millions)	Lake Clark escapement (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

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 1993.

Spawning ground	Sex	Sample size (n)	Age composition (%)						
			2.1	1.2	2.2	0.3	1.3	2.3	1.4
Copper River	M	88	11.4	26.1	30.7		26.1	5.7	
	F	75		14.7	54.6		14.7	16.0	
Chinkelyes Creek	M	100	1.0	16.0	73.0		6.0	4.0	
	F	96		9.4	75.0		12.5	3.1	
Newhalen River	M	93	2.1	6.4	36.6	2.1	40.9	10.8	1.1
	F	78		12.8	24.4		48.7	14.1	
Tazimina River	M	99		3.0	47.5		34.3	15.2	
	F	94		14.9	37.2		42.6	5.3	
Woody Is. beaches	M	49	2.0	30.6	59.2		8.2	0.0	
	F	40		42.5	32.5		22.5	2.5	
Fuel Dump Is. beach	M	52		25.0	48.1		23.1	3.8	
	F	50		26.0	60.0		12.0	2.0	
Knudson Bay beach	M	94		28.7	36.2		30.9	4.2	
	F	108		26.9	40.7		28.7	3.7	
Pedro Creek	M	98	3.1	54.1	24.5		18.4	0.0	
	F	97		42.3	23.7		33.0	1.0	
Kvichak escapement	M	1630	5.7	21.1	41.6	1.4	24.5	5.2	0.1
(ADF&G,Igiugig)	F	1614	0.1	23.9	46.1	1.4	23.9	4.5	

Kvichak escapement: also for males; 0.3% age 0.2 and 0.1% age 1.1.

Table 10. Spawning ground estimates of sockeye salmon on 29 selected spawning grounds in Lake Iliamna and the Newhalen River system, 1956–1993.

	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
Means								
61-66	239	139	79	261	718	5948	12.5	2
67-83	505	175	76	99	856	5702	17.6	3
88-93	271	109	44	16	439	5388	9.1	6,7

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

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				

Lake Iliamna tows in areas 7 and 8 only.

Table 12. Summary of 1993 measurements in Lake Aleknagik (Wood River Lakes).

Measurement and first year measured	Dates	1993	Past years Average	Past years Range
1. Date of ice breakup 1949-		5/1	5/31	5/14-6/16
2. Water temperature, 0-20m (C) 1958-	6/22	8.8	5.8	3.7, 9.2
	7/13	11.1	8.3	5.7, 12.0
	8/3	13.1	10.7	7.7, 14.0
	9/2	12.3	11.2	9.3, 13.0
3. Water transparency Secchi depth (m) 1962-	6/22	5.4	8.2	5.3, 10.5
	7/13	8.5	8.2	5.0, 10.9
	8/3	7.8	9.3	6.3, 11.9
	9/2	7.0	8.7	5.8, 12.1
4. Water conductivity (micromhos/cm) 1968-	6/22	37.8	38.7	34.7, 52.1
	7/13	40.0	37.4	33.5, 42.6
	8/3	38.2	37.1	32.5, 40.5
	9/2	37.6	38.3	34.8, 42.5
5. Average daily solar radiation (gm/cal/cm) 1963-	June 1-15	376	409	305, 588
	June 16-30	397	410	265, 572
	July 1-15	356	393	284, 543
	July 16-31	406	354	194, 481
	Aug. 1-15	252	301	203, 402
	Aug. 16-31	250	255	170, 421
	Sept. 1-15	160	210	114, 282
6. Lake level (cm) of Lake Nerka 1952-	June 1-15	180	141	84, 222
	June 16-30	139	152	97, 218
	July 1-15	119	133	75, 199
	July 16-31	92	107	54, 172
	Aug. 1-15	69	86	34, 173
	Aug. 16-31	85	83	30, 184
	Sept. 1-15	129	83	29, 161
7. Chlorophyll "a", 0-20m (mg/m2) 1963-	6/22	34	30	10, 45
	7/4	24		
	7/13	22	28	10, 43
	7/21	20		
	8/3	18	23	6, 36
	8/12	24		
	8/21	27		
	9/2	22	24	12, 37
8. Zooplankton volume 0-60m (ml/m2) 1967-	6/22	83	51	20,168
	7/4	64		
	7/13	162	80	45-161
	7/21	94		
	8/3	92	119	43-226
	8/12	75		
	8/21	45		
	9/2	56	63	26-107

Table 13. Five-day averages of catches of emergent midges and water temperatures at three stations on Lake Aleknagik, 1993.

5-day period	Catch per day 1993 W	H	B	Mean	1969-92 Mean	Min	Max	Water temperature (°C) 1993 W	H	B	Mean	1969-92 Mean	Min	Max
6/1-5	4	1	3	3				8.0	7.0	11.5	8.8	2.3	0.0	9.8
6-10	3	1	1	2	13	0	70	7.5	7.6	10.4	8.5	5.0	0.0	10.4
11-15	1	5	1	2	13	1	53	7.3	8.1	10.2	8.5	6.4	1.0	9.2
16-20	0	3	4	2	18	1	168	10.1	9.7	11.3	10.4	8.0	3.9	12.7
21-25	4	3	17	8	7	0	42	12.1	12.8	13.3	12.7	8.5	4.8	12.8
26-30	5	5	12	7	5	0	12	7.1	10.6	11.6	9.8	9.9	6.0	13.9
7/1-5	9	6	21	12	5	1	15	6.8	9.0	9.8	8.5	11.1	7.7	15.5
6-10	13	10	58	27	9	2	24	11.7	12.5	13.3	12.5	11.9	9.7	15.8
11-15	4	40	9	18	14	1	34	13.9	14.2	15.8	14.6	12.2	9.2	15.9
16-20	8	30	18	19	14	2	36	16.9	16.3	16.6	16.6	12.0	8.5	17.0
21-25	12	10	27	16	19	2	50	14.7	16.4	17.0	16.0	12.6	7.9	17.2
26-30	16	3	10	10	30	8	58	15.3	16.1	16.8	16.1	13.2	8.9	15.7
31-4	4	3	5	4	30	4	77	14.5	16.3	17.0	15.9	13.5	10.2	17.5
8/5-9	3	9	6	6	22	3	80	15.9	16.0	16.7	16.2	13.5	10.5	17.1
10-14	1	3	1	2	16	2	54	16.0	16.4	16.3	16.2	13.3	9.5	18.8
15-19	1	1	1	1	15	2	70	13.5	13.6	13.9	13.7	13.2	11.0	15.7
20-24	0	1	0	0	7	1	28	12.3	12.0	12.0	12.1	13.7	12.0	15.4
25-29														

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

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

	Sockeye salmon fry					Sockeye	Threespine stickleback					
Year	Mean beach seine catch	Mean length on 6/23 (mm)	Mean length on 9/1 (mm)	Growth rate (mm/ day)	Mean tow net catch	Escape-ment in year-1 (1000s)	Mean beach seine catch	Mean length on 6/23 (mm)	Mean length on 9/1 (mm)	Growth rate (mm/ day)	Mean tow net catch	Age 0 tow net catch
58	-	-	62.1	-	14	88	-	-	44.6	-	36	<1
59	-	-	62.7	-	13	63	-	-	46.7	-	136	10
60	-	-	55.5	-	111	205	-	-	43.4	-	53	2
61	-	-	58.4	-	103	85	-	-	42.0	-	38	<1
62	334	31.7	54.1	.31	54	153	317	31.0	43.5	.17	139	5
63	-	-	62.1	-	24	48	-	-	46.4	-	46	1
64	227	31.1	60.4	.42	24	31	352	31.2	43.1	.17	272	1
65	549	31.2	53.6	.32	103	155	202	29.1	39.5	.15	182	1
66	395	30.2	47.5	.25	219	220	258	27.1	39.4	.18	150	0
67	339	30.7	43.4	.18	49	287	426	28.2	41.3	.19	61	5
68	46	31.8	57.9	.37	10	92	212	30.8	43.4	.18	268	169
69	96	31.7	61.4	.43	78	177	215	33.4	44.2	.16	81	<1
70	164	31.4	59.0	.40	43	160	156	32.1	44.8	.18	87	<1
71	408	30.6	54.6	.35	17	302	261	29.6	43.4	.20	3	<1
72	126	30.6	54.8	.35	10	182	45	28.0	44.4	.24	12	1
73	30	29.0	66.7	.54	3	98	62	29.3	49.5	.29	8	1
74	47	35.3	62.8	.39	44	162	125	33.1	50.1	.24	119	<1
75	111	29.1	55.3	.39	8	242	69	32.5	42.4	.15	132	<1
76	178	30.1	49.8	.29	394	457	279	27.7	39.6	.17	30	<1
77	223	30.1	48.0	.27	25	314	184	29.3	40.8	.17	36	<1
78	34	32.8	62.7	.43	6	152	64	31.7	47.5	.23	21	1
79	312	31.6	51.5	.28	130	612	82	33.2	42.3	.13	50	18
80	46	31.0	56.4	.35	3	354	32	31.0	44.9	.19	24	<1
81	423	32.4	51.3	.27	6	1230	217	34.7	45.5	.15	12	<1
82	53	30.0	52.2	.33	131	454	63	30.2	43.2	.19	12	0
83	43	32.1	63.9	.45	22	337	12	30.9	48.4	.25	64	12
84	16	36.2	64.2	.41	3	245	54	35.9	48.8	.19	200	155
85	102	31.0	56.3	.36	1	329	109	34.3	40.9	.09	2	0
86	32	32.2	58.4	.37	10	189	24	31.4	45.0	.19	11	0
87	69	29.7	57.5	.40	3	343	27	31.7	44.9	.19	67	<1
88	31	31.2	58.8	.40	2	362	42	32.4	48.5	.23	8	1
89	45	31.4	55.4	.34	18	286	26	32.6	47.0	.21	17	1
90	100	32.7	57.7	.36	20	474	129	31.2	48.1	.24	27	1
91	63	30.1	52.9	.33	14	460	108	31.3	42.2	.16	41	1
92	242	30.0	46.1	.24	52	794	200	27.9	39.4	.17	222	<1
93	23	33.7	56.4	.33	12	343	55	31.7	46.5	.22	3	<1
Means	158	31.4	56.0	.35	48	314	142	31.1	44.3	.19	75	11

1. Beach seine catches at 10 stations for four dates during June 22–July 14
2. Townet 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 length for age 1 only.

Table 15. Average townet catches and mean lengths of sockeye fry (by lake area), numbers 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	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	68	117	214	27	44
92	4	16	10	57	55	55	52	44	99	4	41
93	8	6	16	62	57	55	213	261	205	15	45
Means	12	13	38	60	57	58	107	109	241	17	45

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

Year	Date of ice out	Range in sampling dates	Number of char examined	Mean length (mm)	Percent of char with: 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	6/08	6/19-7/03	121	446	34	44	1.9	2.9	24
74	5/27	6/11-25	64	429	19	39	0.8	1.6	14
75	6/15	6/22-7/13	71	415	9	36	0.2	1.8	14
76	6/17	6/19-7/13	96	418	11	56	0.4	2.2	48
77	6/13	6/11-7/11	325	403	30	17	7.0	0.4	30
78	6/02	6/07-25	316	437	7	42	0.2	1.5	18
79	5/24	6/06-22	178	438	32	25	1.8	1.2	26
80	5/27	6/09-25	278	459	27	81	1.4	9.4	45
81	5/28	6/12-25	124	415	3	31	0.1	1.4	44
82	6/15	6/17-7/05	105	450	18	61	1.8	6.4	81
83	5/27	6/19-7/03	78	424	0	14	0.0	0.3	60
84	5/26	6/20-7/02	56	408	0	18	0.0	0.4	36
85	6/17	6/15-7/06	60	437	22	30	1.6	1.2	31
86	6/04	6/16-7/05	61	437	21	56	0.4	2.7	17
87	6/01	6/14-7/05	51	451	6	78	0.1	4.9	19
88	6/05	6/16-29	43	431	7	26	0.1	0.8	18
89	6/17	6/20-7/15	105	388	37	38	2.2	1.3	13
90	5/28	6/07-24	72	391	35	11	1.8	0.3	15
91	6/07	6/20-7/07	48	415	4	35	0.9	3.2	11
92	6/13	6/15-7/11	79	425	0	46	0.0	1.9	31
93	5/12	6/07-18	51	428	21	22	1.4	0.7	6
72-92 means	6/06		115	427	17	40	1.2	2.4	31

Table 17. Ground survey counts of sockeye spawners in the Wood River Lakes, 1993.

Location	Date	Estimated off mouth	In creek Live	Dead	Natural	Bear kill	Total
Aleknagik							
Yako	8/02	300	1506	523	102	421	2329
Hansen	8/06	200	1482	1573	683	890	3255
Bear	8/06	500	2402	1081	634	447	3983
Happy	8/07	200	2521	16269	13217	3052	18990
Ice*	8/09	150	3449	2481	1823	658	6080
Eagle	8/10	200	1200	50	5	45	1450
Mission	8/13	5	2086	636	520	116	2727
Whitefish	8/14	0	448	164	23	141	612
Nerka							
Fenno	8/11	10	408	4722	3027	1695	5140
Lynx	8/19	0	3019	359	293	66	3378
Stovall*	8/21	0	841	286	267	19	1127
Pick	8/13	0	2962	2201	1133	1068	5163
Kema*	8/26	0	no counts, but not heavy and 90% dead				
Hidden Lake	8/20	20	279	348	248	100	647
Elva	8/27	0	19	8	4	4	27
Beverley							
Moose*	8/12	0	546	406	268	138	952
Kulik							
Grant River*	8/24		no counts, but medium density; 95% dead				

*Partial count; entire stream not surveyed.

Table 18. Daily counts of sockeye salmon spawners in Hansen Creek, 1993.

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	Cumulative dead	Live+ cum. dead
7/18		0	0	1	0	0	0	1	1
19		0	1	1	0	0	0	3	3
20		303	6	3	0	0	0	12	315
21		216	3	28	0	0	0	43	259
22		148	2	19	2	0	0	64	214
23		143	3	11	0	0	0	78	221
24		69	2	53	0	0	0	133	202
25		13	7	36	0	0	0	176	189
26		512	15	16	0	0	0	207	719
27		427	7	38	10	0	0	252	689
28		947	11	57	47	0	0	320	1314
29		590	14	101	35	0	0	435	1060
30		1129	27	35	80	0	0	497	1706
31		1241	19	26	70	0	0	542	1853
8/1		1259	31	112	100	0	0	685	2044
2		1497	40	38	120	0	0	763	2380
3		1572	59	117	100	0	0	939	2611
4	100	1343	52	50	140	0	1	1042	2525
5	250	1707	91	52	150	1	0	1186	3043
6	200	1295	290	95	187	2	0	1573	3055
7	120	1133	121	94	200	0	0	1788	3121
8		1211	190	16	170	0	0	1994	3375
9		966	233	60	200	18	0	2305	3471
10		928	228	41	180	29	3	2606	3714
11	100	698	140	28	180	26	0	2800	3678
12	100	743	133	11	180	34	1	2979	3902
13	50	578	136	64	164	43	2	3224	3966
14	50	352	173	75	168	33	2	3507	4027
15	25	215			87			*3647*	3949
16		*133*			*88*			*3787*	4008
17		51	232	96	90	88	4	3927	4068
18	0	38	31	21	55	27	0	4006	4099
19		*30*			*48*			*4050*	4128
20		*23*			*40*			*4093*	4156
21		*15*			*32*			*4136*	4183
22	0	8	43	93	25	34	3	4179	4212
Totals			2340	1488		335	16		

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

Table 19. Summary of Hansen Creek spawning surveys, 1990–93.

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	2675	1504	36