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CHIGNIK SALMON STUDIES

INVESTIGATIONS OF SALMON POPULATIONS, HYDROLOGY, AND LIMNOLOGY OF THE CHIGNIK LAKES, ALASKA, DURING 1992

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for

CHIGNIK REGIONAL AQUACULTURE ASSOCIATION

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KEY WORDS

Chignik Lakes, Alaska Peninsula, sockeye salmon, limnology, lake depth, hydrology, fry and smolt migrations, sockeye salmon growth and abundance

EXECUTIVE SUMMARY

A variety of studies were conducted in Chignik and Black lakes during May to September 1992 for the purpose of monitoring sockeye salmon (*Oncorhynchus nerka*) habitat and populations. The ultimate goal of these studies was to provide information that could be used to maintain or enhance the production of sockeye salmon.

Water temperature of Black Lake fluctuated rapidly in response to ambient air temperature and sunlight intensity, as previously hypothesized. Water temperature increased 14°C during a 14-day period shortly after ice-out when water level was low. Temperature did not approach the lethal level for sockeye salmon (21-25°C, Coutant 1972). Depth of Black Lake averaged 1.9 m (6.2 ft) during moderately high water (-0.6 m). Up to 105.6 m^3/d (481 55-gallon drums) of sediment entered Black Lake from the side ("new") channel of Alec River during moderate flood events, indicating substantial transport of sediment into the lake. The sandspit extending across Black Lake, which was formed by sediment deposition and wind action, was altered slightly during the high water period in fall 1991.

We sampled outmigrating sockeye salmon smolts and fry in Black River from mid-May to mid-July and for several days in early September because we needed to determine whether many sockeye use Black Lake as a nursery area. Few sockeye smolts emigrated from Black Lake, indicating that few sockeye overwintered there. In contrast, many young-of-the-year sockeye fry (up to 700,000 per day) emigrated from Black Lake to Chignik Lake, even though they were growing rapidly in Black Lake. The large emigration of fry from Black Lake could increase intraspecific competition for food and reduce the growth of Chignik Lake and emigrating Black Lake sockeye fry. Movement of Black Lake fry to Chignik Lake might be influenced by (1) high densities of sockeye fry being discharged from the side channel of Alec River into the outlet of Black Lake rather than into the main lake area, (2) the sandspit extending across the lake that separates the outlet from the main lake and possibly hinders movement of fry from the outlet to the main lake area, and (3) shallow depth of the lake. Although a significant proportion of Black Lake sockeye fry emigrated to Chignik Lake, many large sockeye (ave. 64.8 mm) remained in Black Lake during September (geom. mean = 347 fry/10 min tow).

Upstream migrating sockeye fry and other fishes were captured in Black River during spring, as expected. However, the number of migrating sockeye fry was small (typically <10 fish/d), indicating that Black Lake was not a significant rearing habitat in 1992 for sockeye originating from Black River tributaries. The strong current entering Black River from Chiaktuak Cr. would likely block fry attempting to migrate along the left bank. Few sockeye migrated along the right bank in vicinity of Chiaktuak Cr. Smelt were the most numerous fish that migrated up Black River (1,048 smelt captured per day during peak migration).

Townet catches of juvenile sockeye salmon in Chignik Lake and length-at-age analysis indicated that a significant proportion of the age-0 sockeye (>50%) originated from Black Lake. The geometric mean catch of age-0 and age-1 sockeye salmon was 65 and 9 fish/10 min tow, respectively. Age-1 sockeye, which were presumably from the Chignik Lake stock, were less abundant than age-0 sockeye from both lakes. Few emerging sockeye salmon fry were captured

during spring by traps placed on shoreline spawning grounds of Chignik Lake relative to previous years.

Zooplankton abundance in Chignik Lake was high during mid-May to late August, averaging 640,000 zooplankton/m^2 (16,000 zooplankton/m^3). This abundance was greater than that of most sockeye lakes in Alaska. Chlorophyll *a* averaged 3.9 mg m^{-3} during late June to late August and was also higher than that of most other sockeye lakes.

A single incline plane trap was ineffective for the purpose of enumerating sockeye smolts in Chignik River (the trap sampled too small of an area). Recommendations are given for additional traps that would increase the sampling area. Length-at-age analysis indicated that only ~45% of the age-1 smolts leaving the Chignik lakes originated from Black Lake, suggesting that few Black Lake smolts migrated to sea during the later portion of the smolt migration. The two length-frequency modes of age-1 sockeye averaged 52 mm and 74 mm. Age-2 sockeye smolts averaged 72 mm. Smolt enumeration and length-at-age analysis could be essential for evaluating enhancement projects and for developing new forecast methods.

INTRODUCTION

This report is a compilation of studies involving sockeye salmon (*Oncorhynchus nerka*) at Black and Chignik lakes on the Alaska Peninsula (Figs. 1 and 2) during 1992. The studies at Black Lake are related to our ongoing investigation of factors that influence the unusually large fluctuations of adult sockeye salmon returning to the lake (Ruggerone et al. 1992). The working hypothesis is that the fluctuations are influenced by the shallow depth of the lake, which reduces the buffering capacity of the lake against environmental extremes. A second important factor is the rechanneling of Alec River from the main lake to the lake outlet. If rechanneling continues, then much of Black Lake could be lost as a rearing environment for juvenile sockeye salmon.

In 1992, studies were conducted to (1) determine whether juvenile sockeye salmon inhabited Black Lake throughout the summer, (2) identify the depth contours of Black Lake, (3) measure sediment transport in Alec River as a potential cause of reduced lake depth, (4) remeasure the sandspit that separates Black Lake from the outlet area and reduces access of sockeye fry to the lake, (5) enumerate the upstream migration of sockeye fry and other fishes in Black River in order to evaluate concepts to stabilize lake level by placing structures in Black River, and (6) evaluate the condition of sockeye stocks in Chignik Lake. The following text describes studies in Black Lake and is followed by a discussion of studies in Chignik Lake. To gain further insight to the following studies, the reader should examine the following: Ruggerone (1989), Ruggerone and Denman (1990), Ruggerone et al. (1991, 1992), and Ruggerone 1992.

BLACK LAKE STUDIES

LIMNOLOGY

Methods

Water temperature, water transparency, chlorophyll *a*, and zooplankton density were measured in Black Lake. Water temperature was measured every 2 h from 25 June 1991 to 20 June 1992 by a Ryan Temp Mentor thermograph placed 0.5 m above the bottom (2.5-m depth) near the old Fisheries Research Institute (FRI) shelter (i.e., entrance to Alec Bay). Water transparency (Secchi disk measurement) and chlorophyll were measured on 20 June, 6 July, and 6 September. Water was collected immediately below the surface of the well-mixed lake (15-25 km/h wind) and filtered through 1.2-μ filters. A spectrophotometer 20 was used to measure chlorophyll in the samples (samples taken in September were measured by a spectrophotometer 21). Details of the procedure for sampling chlorophyll are described by Rogers (1975). Zooplankton were sampled by pulling a 153-μ plankton net (0.5-m diameter) horizontally through the water for 20 m or 40 m. Samples were collected only on 20 June because the tremendous quantity of filamentous diatoms in the net indicated that the efficiency of the net would be reduced and subsequent counting of zooplankton mixed with the concentrated algae would be inaccurate.

Results and Discussion

The time series of water temperature near Alec Bay (Fig. 3) demonstrates a rapid temperature change in response to changes in air temperature, cloud cover, and wind at Black Lake. Lake bottom temperature increased 6.5°C over 9 days in early July 1991, then declined 6°C during the next 7 days. Temperature fluctuations at Black Lake reflected average air temperature changes at King Salmon, approximately 300 km northeast of Black Lake. On 18 November water temperature declined to 0°C, at which time the lake probably froze. Bottom temperature under the ice increased to 2.5°C during the next several days, apparently in response to heat stored in the sediments and the lack of wind-induced mixing of the water column. The numerous, brief temperature declines during 20 December to 1 February might reflect brief warming or rain periods when additional cold (0°C) water entered Alec Bay from the old channel of Alec River. In early March, water temperature under the ice increased slightly, corresponding to the increase in air temperature. On 2 May, ice remained on the main lake area, an unusually late time for the presence of ice. Alec Bay was 60% open and nearly all of the outlet was open. The sharp decline in water temperature during early May probably reflects the mixing of ice, water, and cold air by the strong northerly winds that occurred during the first half of May. Clear skies and warm air during mid-May caused a 14°C water temperature increase within a 14-day period. Within 2 weeks of ice-out (~10 May), Black River water temperature reached 21°C in moving water along the right bank. This exceptionally warm water was caused by the large, shallow mudflat areas in the outlet area, dark sediment, and long hours of sunlight. River temperatures did not fluctuate as rapidly after the lake level increased in early June.

Chlorophyll averaged 3.37 ± 0.43 mg/m^3 in Black Lake during the June, July and September sampling periods (Table 1). The lowest chlorophyll estimates tended to occur during July and the highest during September. The high chlorophyll concentration during September might reflect the influx of nutrients from decaying salmon carcasses.

Zooplankton density at the three stations in Black Lake averaged 15,600 zooplankton/m^3 (Table 2). *Cyclops* sp. was the dominant genus. Nauplii were also abundant. The zooplankton density estimates might underestimate the actual density of zooplankton in Black Lake if the tremendous quantity of filamentous diatoms reduced the filtration of water through the net. Use of a plankton pump could eliminate the problem with filamentous diatoms.

Zooplankton density in Black Lake has been examined infrequently because filamentous diatoms reduce net efficiency. Ruggerone (1992) reported a low density of zooplankton under ice in winter (157 zooplankton/m^3). Nearly all zooplankton in winter were *Daphnia* sp., which is unusual because no *Daphnia* were observed in Black Lake during summer and fall 1991 (Kyle 1991). Zooplankton density in July 1992 was less than that during July 1991 (30,000 zooplankton/m^3). *Bosmina* sp. rather than *Cyclops* was the dominant species group in 1991.

LAKE DEPTH SURVEY

Methods

A detailed depth survey of Black Lake was conducted during June. Lake depth measurements were standardized by the benchmark at the outlet of the lake. Seventeen transects were established across the lake, including Alec Bay and the outlet. A jet boat and depth sounder were used to make depth measurements to the nearest 3 cm every 15 seconds along the transect. Sounder measurements were calibrated by comparing sounder depths during transit with stationary measurements from a metric rod. All measurements were made during 3 calm days. Depth contours were drawn on a map of Black Lake at 0.5-m depth intervals. The average depth of Black Lake was estimated from these area-weighted depth contours.

Results and Discussion

The average depth of Black Lake during moderately high water (-0.60 m) was 1.9 m (6.2 ft; Fig. 4). Maximum depth in the main lake area was 4.2 m (13.9 ft), whereas maximum depth in the outlet and Alec Bay was 2.3 m (7.5 ft) and 2.5 m (8.2 ft), respectively. The shallowest area of the main lake was along the northwestern shore. The deepest area was along the north shore. Water volume in June was approximately 80 million m^3 or 2.8 times that during February 1992 (Ruggerone 1992).

Lake level was low during mid-May (-1.307 m) and increased gradually until the heavy rain on 4-8 June (-0.660 m to -0.390 m, Table 3). Lake level declined to -1.000 m on 9 July and remained low through August (-1.110 m).

ALEC RIVER SEDIMENT TRANSPORT AND DISCHARGE

Methods

Discharge in the old channel and the side ("new") channel were measured on 5 June, 2 days after the heaviest rain of spring. Discharge in the side channel was remeasured during a flood event on 28 June. Depth and water velocity were measured every meter across each channel, approximately 100-200 m downriver from the channel split. Velocity was estimated by a Gurely No. 622 current meter.

Sediment transport along the bottom of the side channel was measured by a Helly-Smith bedload sampler (Emmett 1980). A 56-cm^2 area was sampled for 1 minute every 2 meters across the channel. Samples were dried in an oven, then measured for weight and volume. Sediment transport was measured during two flood events during 5 and 28 June.

Results and Discussion

Water velocity during the subsiding flood event averaged 0.76 m/s (2.5 ft/s) in the old channel (max. 0.99 m/s) and 0.73 m/s (2.4 ft/s) in the side channel (max. 0.93). Depth of the old and side channels averaged 1.73 m and 1.25 m, respectively. Maximum depth was 2.65 m and 1.53 m, respectively. Discharge of the old and side channels was 37.7 m^3/s (1,331 cfs) and 30.4 m^3/s (1,074 cfs), respectively. Lake level during these measurements was -0.52 m and river level at the split was 0.72 m above the lake.

Comparison of percentage waterflow in the side channel with total discharge in Alec River (Fig. 5) indicated that the percentage of water in the side channel declined from 74% during low flow periods to 45% during moderately high flow periods. The shift in direction of waterflow was caused by the sandbar that deflects water to the side channel. As discharge in Alec River increased, more water passed over the sandbar and into the old channel.

Transport of bottom sediment in the side channel during the subsiding flood event on 5 June (30.4 m^3/s or 1,074 cfs) was 46.8 m^3/d or the equivalent of 225 55-gal drums. Most of the sediment was medium sand that had a density of 1.25 g/cc. Concentration of suspended sediment was 66 mg/L, which would produce 138 m^3/d (663 55-gal drums of silt). In contrast, sediment transport during rising water (18.5 m^3/s or 652 cfs) of the smaller flood event on 28 June produced twice the amount of sediment (105.6 m^3/d) or the equivalent of 481 55-gal drums. As expected, the majority of sediment transport occurred during increasing flow of the river. Nearly all transport of sand occurred within 7.5 cm of the bottom, i.e. the height of the bedload sampler. Lake level on 28 June was -0.71 m and river level at the split was 0.7 m above the lake.

These data indicate that considerable sediment can be transported from Alec River to Black Lake. More extensive field sampling of sediment transport in Alec and Black Rivers plus sediment transport modeling such as that reported by B. Denman (in Ruggerone et al. 1992) would be helpful in determining the annual loading of sediment in Black Lake.

Stakes were set a known distance from the side channel of Alec River in order to measure bank erosion during the next several years. Seven stakes were set parallel to the right bank of the side channel near the first bend. Starting with the upriver end, the stakes measured 8.3 m, 10.3 m, 10.3 m, 15.1 m, 12.35 m, 9.2 m, and 6.7 m from the closest point of the side channel. In 1991 we placed a stake 2.5 m from the left bank confluence with the main channel. Measureable erosion did not occur between June 1991 and June 1992.

SANDSPIT ELEVATION

Methods

The elevation of the sandspit extending from the Alec River delta was remeasured on 24 June 1992. The survey was conducted with a transit, leveling rod, and meter tape. Measurements were taken at 50-m intervals and calibrated to the outlet benchmark. Elevation measurements are important because the spit has grown considerably since 1960, and documentation of the growth rate is needed to determine the fate of Black Lake.

Results and Discussion

Elevation of the sandspit tended to be lower in 1992 relative to 1991, especially between 750 m and 1500 m from the Alec River delta (Fig. 6). A wide channel cut through the spit at 750 m, which is near the grass knoll that protects the inner benchmark. The two sandy knolls observed in 1991 near 1150 m and 1400 m were gone in 1992. The change in elevation probably occurred during the high water of fall 1991. The sandspit appeared to shift approximately 10 m towards the main lake area, apparently because winds from the southeast were consistent and strong. Observations of coarse sand atop compact sand and silt indicate that the spit will change shape as water level and wind direction change. The length of the spit was not measurably different in 1992.

JUVENILE SALMON EMIGRATION

Methods

Emigrating sockeye smolts and age-0 sockeye fry were enumerated by two winged-fyke nets in Black River and another fyke net placed in Chiaktuak Cr. during 15 May to 10 July 1992 (Fig. 7). The 3-m wings (1.25-cm bar mesh) of the fyke net were set ~1.8 m apart and funneled fish into the 1.22 m^2 frame of the fyke net. The diameter of the net decreased over a 3 m distance to fit a 2.4-cm semi-flexible tube that attached to the live box (1.2 m x 0.6 m x 0.6 m, 2 mm mesh; modified from Conlin and Tutty 1979). The fyke nets in Black River were placed 100 m above the mouth of Chiaktuak Cr. on the right bank of the river and 500 m below the mouth of Chiaktuak Cr. on the right bank of the main channel. The Chiaktuak Cr. fyke net was positioned approximately 200 m from the confluence with Black River. These sites were chosen based on water velocity, substrate stability, and accessibility. Water velocity was ~0.45 m/s (1.5 ft/s) at the upper Black River net, ~0.74 m/s (2.4 ft/s) at the lower net and ~0.87 m/s (2.8 ft/s) at the Chiaktuak Cr. fyke net. The fyke nets were deployed each evening at about sunset (~2230 h), and the water temperature was measured. During the following morning (~0830 h) all fishes were removed from the live box of each net. Sockeye smolt and fry were counted and, if in substantial numbers (usually >400), held for mark/recapture studies. Other fishes were enumerated by species and released. Periodic daytime sampling by the lower Black River net and the Chiaktuak Cr. net produced almost no juvenile sockeye salmon (<1% of night catches for each net). Approximately every 6 days, 50 sockeye fry were preserved in 10% formaldehyde for measurement, gut analysis, and scale samples. Piscivores, such as yearling coho (*O. kisutch*) salmon, were periodically kept for gut analysis to calculate predation on sockeye fry in the live boxes. The predation rate estimates were used adjust the daily count of sockeye fry.

Captured sockeye fry were marked with a dye and released during the following evening to determine the efficiency of each fyke net. Net efficiencies were then used to estimate the total number of sockeye migrating each day. Subsamples of sockeye fry were kept from the morning collections at each fyke net when the catch exceeded ~400 fry. Fry were placed in 5-gallon buckets of aerated Black River water and held in darkness for ~8 hours. No more than 500 fry were placed in a single bucket. After the 8-hour holding period, the fry were marked with

Bismark Brown Y immersion dye, which has been used successfully in salmonid mark/recapture studies in other systems (Mark Carr, Washington Department of Fisheries, pers. comm.). Approximately 0.238 g of Bismark Brown Y was added to each bucket to produce a 1:80,000 dilution of dye. The fry were kept in the dye solution for 2 hours, which produced a distinct bronze tinge, particularly in the fins. Following the marking period, the fry were transferred into fresh aerated Black River water and held for a 3-hour period. Mortality caused by the marking operation appeared to be low, e.g., 10 of 10 marked fry survived 10 days in an aerated container. Marked fry were released back into the watershed at dusk. Fry that were captured in the two Black River fyke nets were released approximately 2 km upriver from the upper Black River fyke net, while those that were captured in Chiaktuak Cr. were released 150 m above the Chiaktuak fyke net. In both cases, the fry were released in equal portions across the width of the stream. During the following morning, marked fry were counted in the live boxes of each fyke net. The number of fry recaptured divided by the number released gave the efficiency of each net. Daily efficiency values for each net were grouped based on water flow conditions and net placement. These average efficiency values were used to estimate total numbers of sockeye emigrating from Black Lake or Chiaktuak Cr.

We initially assumed that the upper Black River fyke net would estimate sockeye fry emigration from Black Lake, the Chiaktuak Cr. fyke net would estimate sockeye fry emigration from Chiaktuak Cr., and the lower Black River fyke net would estimate the sum of these emigrations minus the number of upstream-migrating fry leaving Chiaktuak Cr.

Results and Discussion

The upper fyke net in Black River caught significantly fewer sockeye fry per night (53 ± 9, mean ± SE) than the lower net (612 ± 98, Table 4) probably because the water velocity was considerably less at the upper site. The estimated efficiency of the upper net, based on mark/recapture tests, was not reliable. Thus, the upper net was not used to estimate fry and smolt emigration from Black Lake.

The Black River fyke net below Chiaktuak Cr., which was set in relatively swift water, produced the largest daily catches of fish and the most reliable estimates of net efficiency. Daily catches of sockeye fry were low between 16 May and 29 May (58 ± 8 fry), then increased rapidly to ~1,260 fry/night by 2 June (Fig. 8, Table 4). The increase in fry emigration occurred before the substantial rise in river level that began on 3 June. After the flood, daily catches of fry were relatively great (779 ± 119 fry), although highly variable from day to day. The large daily variability in fry catches is typical of emigrating sockeye salmon, which tend to emigrate in pulses. Sampling of emigrating sockeye fry terminated on 10 July, as initially planned. Resumption of fry sampling during 30 August to 4 September indicated that the emigration of fry had essentially stopped (9.8 fry captured/d).

Efficiency of the lower fyke net when capturing sockeye fry averaged 0.70 ± 0.14% (Table 5). When estimating the total daily migration of fry in Black River, daily efficiency estimates were grouped into days that had similar water flow characteristics, net placement, and efficiency estimates. Average net efficiencies were calculated for these time periods. Multiplication factors used to calculate daily fry migrations in Black River (i.e., the inverse of net efficiency values) ranged from 62x during 16 May to 2 June to 409x during 29 June to 5 July (Table 5). Net efficiency during the high water period (3-9 June) was assumed to be 409x. Thus, the net efficiency was relatively low, indicating that the precision of daily emigration estimates was low.

Total daily migration of sockeye fry in Black River was relatively low (5,400 ± 1,800 fry) until an estimated 160,000 fry emigrated on 31 May (Fig. 8, Table 4). By mid-June, daily migration of fry frequently exceeded 100,000 fry/day and reached 500,000 fry/day on several occasions. Neither fry captured each day in the net nor the total number migrating were related to river temperature, lake level, or wind conditions in the outlet area of Black Lake ($p>.05$). The total estimated number of fry migrating during 16 May to 10 July was 7 million ± 830,000 (SD) fry (including an assumed 84,000 fry/day during the unsampled flood period). Given the high rate of daily fry emigration during July when sampling ceased, the total emigration of fry was considerably greater than 7 million and could have conceivably reached 12 million fry. The large exodus of sockeye fry from Black Lake undoubtedly reduced food availability for the Chignik Lake stock of sockeye salmon (although zooplankton densities were exceptionally great in 1992 as discussed below). Sampling of emigrating fry in 1993 should extend to late August.

Nearly all fry captured by the lower Black River fyke net were believed to originate from Black Lake rather than Chiaktuak Cr. Length-frequency distributions of fry demonstrate that fry captured in the Black River net (Fig. 9) were considerably larger than those captured in the Chiaktuak Cr. net (Fig. 10), indicating that the Black River net sampled few fry from Chiaktuak Cr. Apparently emigrating Chiaktuak Cr. fry were held close to the left bank[1] of Black River by the current and passed to the left of the Black River fyke net. The distinct water color of Chiaktuak Cr. also moved along the left bank in the vicinity of the Black River net. Furthermore, upstream migrating fry, which are believed to be from Chiaktuak Cr., were captured in substantial numbers only along the left bank of Black River.

Only 266 sockeye smolts were captured in the lower Black River fyke net (Table 4), indicating that exceptionally few sockeye overwintered in Black Lake during 1991-92. The low abundance of smolts supports the findings of Ruggerone (1992), who captured no juvenile sockeye during winter in Black Lake but caught significant numbers of Black Lake sockeye in Chignik Lake (Black Lake fish identified from length-at-age measurements). Peak emigration of smolts occurred during mid-June. The total number of sockeye smolts emigrating from Black Lake is difficult to accurately quantify, but probably <350,000 smolts emigrated from Black Lake in 1992. If 15% of these smolts survived at sea, then <53,000 adults would return from this emigration (most would return in 1995). Clearly, the majority of adult production returning to Black Lake from the 1990 brood year will be from those sockeye that overwintered in Chignik Lake. An important question that should be addressed next summer is whether emigrating fry originate from the side (new) channel or both channels of Alec River discharging to Black Lake. If emigrating sockeye fry originate primarily from the side channel, then rediversion of Alec River into Alec Bay could benefit adult production.

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1 The left and right banks of a creek or river were defined as one looks downstream.

Nearly 10,000 sockeye fry were captured by the fyke net in Chiaktuak Cr. during 15 May to 9 July (Table 6). This estimate included an estimate of sockeye fry eaten by juvenile coho salmon in the live box (289 fry consumed during season)[2]. The percentage of fry captured by the fyke net averaged 1.06% based on the release of 5,259 marked fry during 17 nights. The estimated number of emigrating sockeye fry during the sampling period was 1.09 million fry.

Mean length (preserved) of emigrating sockeye fry in Black River increased from 32.4 mm in late May, to 34.6 mm in early June, to 38.3 mm in late June, and to 44.3 mm in early July (Fig. 9). The increasing length of fry from May to July indicated that fry spent some time in Black Lake and grew relatively fast prior to leaving the lake. Some sockeye fry reached 40 mm within 20 days after the ice left the lake, indicating that exceptionally rapid growth can occur shortly after ice-out. By early July, over 15% of the age-0 fry exceeded 50 mm. Emigration of fry <33 mm in early July indicated that fry were still emerging in Alec River and Fan Cr., and that some newly emerged fry emigrated from Black Lake. The few fry emigrating in early September averaged 50.1 mm and were significantly smaller than those captured by townet in the lake (64.8 mm). Thus, the emigrating fry appeared to be from a different population than those sampled in Black Lake.

In contrast to the large fry emigrating from Black Lake, fry emigrating from Chiaktuak Cr. remained small (range of means: 29.4-31.2 mm) throughout spring and early summer (Fig. 10). Thus, most fry left the creek shortly after emergence. The length frequency distribution in late May is biased high because the mesh of the live box in May allowed some small fry to escape. The mesh problem was corrected in June, and catch estimates were adjusted during this time period (see Table 6). A few fry emigrating in May were longer than those in late June and July.

The large size of age-1 sockeye smolts emigrating from Black Lake indicated that substantial growth occurred among those sockeye that remained in the lake over winter (Fig. 11). Age-1 sockeye smolts averaged 95 ± 1 mm and 9.60 ± 0.23 g. Back- calculation of sockeye length from scales indicated that the smolts were 78 mm at the end of the 1991 growing period (measured to outer edge of annulus). Thus, considerable growth occurred in Black Lake during spring, a characteristic that should be useful in distinguishing Black Lake and Chignik Lake adults in the fishery. Five of the aged smolts spent two winters in the lake. They were similar in size to age-1 smolts. All smolts appeared to be healthy.

Other fishes captured in the lower Black River fyke net during May through July included pond smelt (*Hypomesus olidus*), threespine stickleback (*Gasterosteus aculeatus*), ninespine stickleback (*Pungitius pungitius*), coho salmon, and pygmy whitefish (*Prosopium coulteri*). Smelt were most abundant (95 fish/night), followed by ninespine stickleback (13 fish/night), threespine stickleback (6.5 fish/night), yearling coho (4.7 fish/night), sculpin (*Cottus aleuticus*, 3.7 fish/night), coho fry (2.2 fish/night), and coho smolt (1.6 fish/night). During early September, stickleback were most abundant (665 fish/night), followed by whitefish (31 fish/night), and smelt (30 fish/night).

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2 Number of fry eaten per coho = 0.0022(# fry in box) + 0.47, r^2=0.74, n=16, p=0.001.

FALL TOWNET SURVEY

Methods

The density of juvenile sockeye remaining in Black Lake after the spring and summer emigration was estimated by townet during the night of 31 August. The townet was pulled on the surface between two skiffs and sampled a 1.8 m^2 area of water. Tow speed, estimated by a Gurley current meter, was 1.18± 0.03 m/s. Wind was less than 10 km/ hour. Six 10-min tows were made between 2200 h and 2410 h. An additional tow was stopped after 7.25 min because the net hit bottom as we passed Sand Pt. and entered the outlet of the lake. Five tows were made in area A (central part of lake) and two tows in area B (north shore of lake, Fig. 1). Sampling was not conducted in Alec Bay or the outlet because depth was ≤1.8 m. Additional tows were not conducted because catches of sockeye were consistently large.

Results and Discussion

The geometric mean catch of age-0 sockeye salmon was 347 fish/10-min tow (range: 127-894 fry/10 min). Sockeye averaged 64.8 ± 0.8 mm (Fig. 12). Smelt were next in abundance (110 fish/10 min), followed by ninespine stickleback (78 fish/10 min), threespine stickleback (70 fish/10 min), and coho salmon (1 fish/10 min). The large catches of sockeye salmon indicated that a significant number of sockeye remained in Black Lake after the emigration of fry during spring and summer had stopped. The geometric mean catch was similar to those reported by Narver (1966) during the early 1960s and translates to ~12 million sockeye based on Narver's expansion factors and tow speed (we assumed that sockeye density in the outlet and Alec Bay was similar to that of the sampled areas of the lake, as indicated by Narver's studies).

We could not townet in the outlet area and Alec Bay because water depth was too shallow. During our attempt to townet the outlet area near Sand Pt., the net hit bottom and filled with ~50 kg of aquatic vegetation. In contrast, maps of townet locations during 1962-67 show that tows with the same net size were frequently made in the outlet area and Alec Bay. In some years, tows were apparently made over the sandspit, although M. Dahlberg (NMFS, Auke Bay, Alaska, pers. comm.) indicated that the sandspit area was too shallow for townet operations. Narver (1966) mentioned that tows were made in the shallow area between areas A and D, which correspond to the sandspit area. This information suggests that depth of the outlet area and Alec Bay has become more shallow since the 1960s.

UPSTREAM MIGRATION OF FISHES

Introduction

Ruggerone et al. (1992) hypothesized that early-emerging sockeye fry in Chiaktuak Cr. move up Black River to rear in Black Lake rather than moving down to rear in Chignik Lake. This hypothesis was based on observations of early and late spawning sockeye in Chiaktuak Cr. (Narver 1963, 1966), the earlier potential for sockeye growth in Black Lake relative to Chignik Lake, and the relatively slow water velocity of Black River between Chiaktuak Cr. and Black

Lake. The early emerging sockeye fry produced by the early spawning population were hypothesized to migrate upstream to take advantage of the early productivity of Black Lake, whereas the late emerging fry produced by the late spawning population were believed to emigrate to Chignik Lake. Age determinations from otoliths collected from spawned sockeye in Chiaktuak Cr. and other Black River tributaries indicated that the freshwater age of these sockeye was more similar to that of the Black Lake stock than Chignik Lake stock, i.e., predominately age-1.x. Previously, Narver (1966) and Dahlberg (1968) assumed that all Black River tributary sockeye reared in Chignik Lake. They based this assumption on scale growth analyses.

Identifying the rearing habitat of Black River sockeye is important if the level of Black Lake is to be stabilized near the high water mark for the purpose of doubling sockeye habitat. Upstream migrating fishes must be allowed to migrate over structures that may be used to stabilize lake level. Furthermore, identification of the rearing habitat of Black River sockeyc is important to harvest management because Black River sockeye return at the same time as Black Lake sockeye (i.e., early run fish, Dahlberg 1968) and have similar age composition. Thus, harvest managers might mistakenly assume that Black River sockeye rear in Black Lake (i.e., the opposite of what Narver and Dahlberg suggested). In-season scale analysis based on age-2.3 sockeye cannot determine the lake of origin among age-1.3 sockeye.

Methods

To quantify numbers of upstream migrating sockeye in Black River, we placed blocking seines on the banks of the river during 15 May to 9 July 1992. Salmon fry can sustain swimming speeds up to 4.9 body lengths/s (Carpenter (1987); therefore any fry moving upriver should be close to the bank where water velocity is slow. Four 6.1-m x 1.2-m (3-mm ace mesh, which fry could not pass) nylon seines supported by aluminum stakes were deployed approximately 400 m and 500 m below the outlet of Black Lake (Fig. 7). Two seines were installed on each bank ~100 m apart. The upriver seine was used to check the capture efficiency of the lower seine. One end of each seine was anchored in the ground above the water line, and the seine was extended into the current and angled downstream to form a trap for migrating fishes. The stakes were driven into the sediment until they were secure and the lead line was on the river bottom. Two 3.7-m x 1.2-m (3-mm ace mesh) seines were similarly deployed in Black River below the mouth of Chiaktuak Cr., although they were removed between 3 June and 17 June due to heavy flooding in Black River. One seine was deployed on each bank of Black River approximately 300 m below the mouth of Chiaktuak Cr. These seines were intended to capture fry moving up Black River from other tributary creeks and Chiaktuak Cr. fry that were initially displaced downstream in Black River.

Water velocities at the outside edge of the seines near the outlet of the lake ranged from 14 to 24 cm/s (0.46-0.78 ft/s). Maximum velocity at seines on the left (#2) and right (#3) banks was 24 and 17 cm/s, respectively. Laboratory studies by Carpenter (1987) indicated that salmon fry can sustain short-term (15-min) swimming velocities up to 4.9 body-lengths/sec at 10°C. Thus, the average sockeye fry emigrating from Chiaktuak Cr. (31 mm) could negotiate water velocities up to 15.2 cm/s (0.50 ft/s). Velocity at the outer edge of the seines and the angle of the net along the river bank should have inhibited the upstream migration of most recently emerged sockeye fry. Water velocities at the blocking seines below Chiaktuak Cr. were 62-89 cm/s (2.0-2.9 ft/s), indicating that no sockeye fry swam around the nets.

The blocking seines were sampled in the morning, midday, and evening of each day. We approached the seines from downstream with dipnets and made several sweeps through the downstream-side of the seine, attempting to catch upstream-migrating fish caught between the seine and the shore. Fishes were enumerated by species and then released upstream of the blocking seine where they would not be recounted. This procedure was repeated on the upstream side of the seine and the release area was reversed. Water temperature, water level, and wind conditions were recorded at each sampling period. During the peak migration period, samples of sockeye fry were preserved in 10% formalin for length measurements.

Mark/recapture tests with Chiaktuak Cr. sockeye fry were also conducted to determine whether these fry migrate up Black River to Black Lake. Newly emerged sockeye fry from Chiaktuak Cr. were captured in the Chiaktuak Cr. fyke net and marked with Bismark Brown Y immersion dye as described above. We released 5,259 marked fry in Chiaktuak Cr. over 17 nights and attempted to recapture them in the Black River blocking seines. Additionally, we released 127 marked fry (including 3 coho fry) along the bank ~100 m below blocking seine No. 1 near the outlet of Black Lake. The fry used for this experiment were initially captured in Chiaktuak Cr. on 22 June.

Results and Discussion

Daily catches of upstream migrating sockeye fry in the lower blocking seines near the outlet of Black Lake peaked sharply during a 4-day period in late May, then remained at a low level from early June through mid-July (Fig. 13). Daily catches at lower seines Nos. 1 and 3 averaged 7.8 fry during 15-20 May, 100 fry during 21-24 May, 7.8 fry during 25-30 May, and 1.1 fry during 31 May to 9 July (Tables 7 and 8). The upper two seines (Nos. 2 and 4) averaged 6.6 fry/d during the peak capture period during 21-25 May (Tables 9 and 10), indicating that most fry migrating along the bank of the river were captured by the lower seines. Mean length of sockeye fry captured by the blocking seines in late May was 29.6 ± 0.2 mm, indicating that most upstream migrating fry had recently emerged and that the seines were capable of blocking the migration of most fry.

Of the 124 marked sockeye fry that were released along the bank below blocking seine No. 1, no sockeye fry were recaptured. In contrast, all three marked coho fry, which were longer than the sockeye fry, were recaptured in the blocking seines within 8 hours of release. This experiment also indicated that few sockeye emigrating from Chiaktuak Cr. attempted to migrate up Black River in late June. Additional experiments should be conducted in 1993 using fry captured in mid-May, the time period when most fry migrated upstream.

During the first week of sampling, numerous (~10/d) recently emerged sockeye were observed dead along the banks of Black River near the outlet and in upstream side of the blocking seines. Some fry were nearly dead. The cause of mortality was not known, although leeches were attached to some dead and live fry. Similar leeches have been observed on adult salmon in British Columbia and Washington (Becker and Katz 1965) . The fry did not appear emaciated. This was the first observation of its kind at Black Lake. The observed mortality rate would not measurably affect adult returns of sockeye salmon.

Daily catches of sockeye fry in the two blocking seines on the left and right banks of Black River below Chiaktuak Cr. differed significantly. Only five sockeye fry were captured along the right bank during 31 days of sampling (Fig. 14, Tables 11 and 12). In contrast, the seine on the left bank caught 269 fry or 10.8 fry/d. Nearly all fry were captured during 16-24 May. Thus, the peak upstream migration of fry in these nets occurred during the same general period as those ~2 km upriver near the lake outlet. Nearly all fry were captured along the same bank that Chiaktuak Cr. crossed ~200 m upriver, indicating that fry emigrating from Chiaktuak Cr. are kept near the left bank by the strong water velocity in this area. The lack of sockeye fry along the right bank suggested that few sockeye from other Black River tributaries (e.g., West Fork of Black River, Bearskin Cr.) migrated upriver to Black Lake. Sockeye fry that attempted to migrate upriver to Black Lake were probably produced by the early spawning adults because the fry emigration from Chiaktuak Cr. continued to be strong after the upriver migration of fry ceased. The possibility of fry migrating along the left bank and crossing the swift current of Chiaktuak Cr. as it enters Black River appears low. Thus, fry that are carried downstream from Chiaktuak Cr. apparently have little chance of reaching Black Lake.

In contrast to the predominance of sockeye fry in the left bank seine and lack of fry in the right bank seine, numerous pond smelt, ninespine stickleback, and threespine stickleback were captured in the right bank seine but not the left bank seine (Figs. 15, 16, and 17). Peak migration of these fishes occurred during late May. Daily catches during the peak migration period averaged 1,048 smelt, 169 ninespine stickleback, and 49 threespine stickleback. Fishes other than sockeye that were captured in the seines near the lake outlet were probably not actively migrating upriver because they were frequently caught on both sides of the seine. Smelt and sticklebacks, which are larger than sockeye fry, probably migrated to the deeper water beyond the reach of the blocking seines.

FALL SURVEY OF CHIAKTUAK CREEK

Methods

Spawning sockeye salmon were surveyed in Chiaktuak Cr. on 2 September. Sockeye were enumerated by the following categories: sockeye killed by bears, dead after spawning, and live. The survey started at the confluence with Black River and ended 200 m above the large tributary that enters the creek on the left bank (~6 km upstream). Only about 20% of the creek length was surveyed. The number of live sockeye was estimated by individual counts and estimation of fish numbers in relatively high densities.

Results and Discussion

Most sockeye were located >2 km upstream. Few fish were paired, indicating that many had not spawned. We estimated 7,000 live sockeye, 267 killed by bears, and 2 dead after spawning. Sixty percent of the sockeye killed by bears were male. Otoliths were taken from 28 fish. The average age composition estimated by two independent readers was age 1.3-48%, age 2.3-30%, age 2.2-20%, and age 1.2-2%.

The lack of dead sockeye was somewhat surprising because sockeye reportedly begin spawning in early August and continue spawning into September. Narver (1963) noted that Chiaktuak Cr. had both early and late spawning sockeye. Possibly the early spawning fish had been consumed by maggots and other scavengers, or they might have been washed downstream.

Aging of otoliths suggested that age-1.3 sockeye were the dominant age group, although the sample size was very small in 1992. The dominance of the age-1.x group is common for this stream and other Black River tributary stocks (see ADFG annual management reports and Appendix Table 1), even though most fry produced by these streams tend to rear in Chignik Lake. The relatively large component of age1.x sockeye in Black River tributaries may have important management implications in some years. Black River tributary sockeye tend to enter Chignik Lagoon with Black Lake sockeye and both groups can be dominated by age-1.3 fish. This may confound the use of age composition data to identify the strength of the Black Lake and Chignik Lake stocks in some years. Aerial surveys of Black River tributary sockeye in August, which were conducted by ADFG over many years, would help identify the percentage of early run sockeye that reared in Chignik Lake.

CHIGNIK LAKE STUDIES

SPRING SOCKEYE MORTALITY

Methods

Mortality of juvenile sockeye during spring has been observed on several occasions in Chignik Lake (Narver 1966; Ruggerone et al. 1991). Cold spring temperatures, such as those experienced during May 1992, delay the production of prey and might be associated with sockeye mortality events. Ice covered most of Chignik Lake until 16 May. Thus, we conducted foot surveys along ~250 m of lake and river shoreline near the outlet of Chignik Lake during 5 May to 13 May.

Results and Discussion

During 8 surveys, we counted a total of 28 juvenile sockeye, 5 threespine stickleback, 1 ninespine stickleback, 1 juvenile coho salmon, and 1 Dolly Varden char (*Salvelinus malma*). Fresh fox tracks indicated that some dead fish were taken by fox. Among the juvenile sockeye, 23% appeared emaciated and the rest appeared robust. The emaciated sockeye were slightly shorter (mean: 45 mm; range: 36-65 mm) than the robust sockeye (mean: 54 mm; range: 39-85 mm). All of the dead sockeye were age-1 or older. The small size of some sockeye (6 sockeye <40 mm; the condition factor of some of these fish could not be determined) indicated that sockeye in Chignik Lake continue to emerge from the spawning grounds during late summer and fall. The other fishes appeared robust, although the char had gillnet marks. Mortality of some fish might have been caused by wind-generated waves carrying fish onto the low gradient shore. Fish were sluggish in the cold water (1.0 to 3.3°C) and may not have responded quickly. The thin condition of a few sockeye may have contributed to their demise.

LIMNOLOGY

Methods

Water temperature, water transparency, chlorophyll *a*, and zooplankton density were measured in Chignik Lake on 19 May, 23 June, 11 July, and 31 August. Temperature and chlorophyll depth profiles were estimated in Clark Bay (station D) and near the Black River delta (station A, Fig. 2). Water was collected from 1 m, 3 m, 5 m, 7 m, 10 m, 15 m, and 20 m using a 2-L van Dorn water sampler. Temperature of the samples was immediately measured, then the samples were filtered through 1.2 µ filters for chlorophyll determinations (Rogers 1975). Zooplankton were sampled at five stations (Fig. 2) by vertically hauling a 153-µ plankton net (0.5-m diameter) from 40 m. Additional samples with a 223-µ net (0.5-m diameter) were taken on 6 June, 23 June, and 11 July for comparison with the 153-µ net. Samples taken on 6 June were taken to examine the distribution of zooplankton relative to a turbidity plume that resulted from recent rain storms. Water transparency was estimated from Secchi depth at each zooplankton station.

Results and Discussion

Ice left Chignik Lake on 17 May, an unusually late date for ice-out. Chignik Lake did not stratify during the sampling periods in late June and late August (Table 12). Frequent strong winds, which are typical of this region, prevented the lake from stratifying. Temperature was slightly lower in Clark Bay (8.7°C) than the Delta area (10.2°C) during late June, probably because of warm water entering the lake from Black River. During late August both ends of the lake were 10.8°C. Secchi depth ranged from 3.7 m during mid-May when ice covered part of the lake to 1.9 m during June, when suspended sediment entered the lake from rain runoff and glacial melt (Table 13). Secchi depth averaged 2.5 m during the summer.

Chlorophyll *a* averaged 4.47 mg/m^3 in Clark Bay and 3.37 mg/m^3 near the Delta during late June to late August (Table 13). Chlorophyll was highest during late August (5.82 mg/m^3), followed by late June (3.36 mg/m^3), and mid-July (2.59 mg/m^3). The high chlorophyll during late August might be related to nutrient input from decaying salmon carcasses in Black Lake and Black River tributaries (few sockeye in Chignik Lake had spawned by this time). These estimates of chlorophyll were greater than those of 22 major sockeye lakes sampled by Burgner et al. (1969).

Zooplankton abundance averaged 640,000 zooplankton/m^2 (16,000 zooplankton/m^3) during mid-May to late August (Tables 13 and 14). Abundance (zooplankton/m^2) declined from 504,000 in mid-May to 368,000 in late June, then increased to 512,000 in mid-July and 1,176,000 in late August. *Cyclops* was the dominant zooplankton during May through mid-July, although the rotifer *Asplanchna* sp. was also dominant in mid-July. *Bosmina* and *Daphnia* were dominant by late August. The observed seasonal pattern in species composition is typical of sockeye lakes in Alaska.

Zooplankton abundance in Chignik Lake (640,000 zooplankton/m^2) was high compared with that of other sockeye lakes. Lake Aleknagik near Bristol Bay averages ~250,000 zooplankton/m^2 (60 m net haul). Chignik zooplankton abundance in 1992 ranked third among 25 lakes surveyed by ADFG (Kyle 1991). Only Chenik and Chikat lakes, which are relatively small lakes, had greater abundances of zooplankton. In 1991, zooplankton abundance in Chignik Lake was much less (273,000 zooplankton/m^2), although still high relative to most other lakes.

The reason for the great abundance of zooplankton in Chignik Lake during 1992 is not known. Zooplankton abundance is generally inversely related to planktivorous fish abundance. However, townet catches (74 sockeye/10 min tow) during September indicated that the density of sockeye was relatively high. The net used to capture zooplankton in 1992 was different from that used in 1991 in that the 1992 net sampled a greater water volume and was designed to reduce clogging by filamentous algae (i.e., length: diameter was 6:1).

Zooplankton abundance at the edge of the turbidity plume (133,000/m^2) on 6 June was markedly less than that in relatively clear water (431,000/m^2) or turbid water (387,000/ m^2, Table 15). The 153-μ net caught 1.4 times the number of zooplankton caught by the 223-μ net.

SMOLT EMIGRATION

Methods

Sockeye smolts and fry emigrating from Chignik Lake were captured by incline plane trap (0.6-m x 0.9-m sampling area) during 16 June to 12 July. The trap was located approximately 10 m from the point at the outlet of the lake. The trap was sampled each day at approximately 0900 hours and 2200 hours. Water velocity at the trap site exceeded 0.8 m/s. The purpose of this sampling was to determine whether this trap would efficiently catch smolts, identify locations for future sampling of smolts, and estimate length-at-age of emigrating sockeye salmon. Sampling began after the typical mid-point of the smolt migration (1 June); therefore, we did not intend to estimate total abundance of smolts.

Results and Discussion

Sampling of smolts was conducted at the point near the outlet of the lake. The point was a good area in that water velocity was adequate, substrate was sufficient for anchoring the trap, and the trap was close to camp. We attempted to move the trap across the river where water velocity was greater, but the rock substrate was inadequate to anchor the trap. The area below the steep bank on the right side of the river is believed to be the best area for future sampling if we can develop a means to anchor the trap. The poor design of this borrowed trap inhibited adjustments of water flowing through the trap and prevented easy transport of the assembled trap to other areas downstream.

Only 271 sockeye smolts were captured by the trap during late June and early July (Table 16). Peak catches occurred during mid-June when the trap was first placed in the river. The small catches were not adequate to determine trap efficiency by mark and recapture tests. This incline trap sampled too little area to adequately enumerate smolts leaving Chignik Lake. Smolt sampling could be enhanced by a rotary screw trap, which samples over three times the area of the incline trap. The incline trap adequately sampled smolts for length-at-age measurements.

The length frequency distribution of age-1 sockeye migrants was bimodally distributed. Sockeye from the smaller mode averaged 52 mm and those from the larger mode averaged 74 mm (Fig. 18). Fish in the smaller mode probably represent the Chignik Lake sockeye, whereas those in the larger mode were probably from Black Lake. Some of the smaller sockeye may have inhabited lower Chignik River and Chignik Lagoon rather than moving out to sea (Iverson 1966). During February 1992, the lower and upper modes of sockeye length were 45 mm and 64 mm, respectively. The 7-mm and 10-mm increase in length between February and June is related to growth and to smaller individuals in each group remaining in the lake for an additional year.

During February 1992, 71% of the age-1 sockeye in Chignik Lake originated from Black Lake, whereas during June only 45% of the age-1 sockeye were from Black Lake. The relatively small percentage of Black Lake smolts among the age-1 group suggests that few Black Lake smolts entered the sea during the later portion of the smolt migration. However, an accurate forecast of adult Black Lake sockeye that return from this migration in 1995 is not possible since the entire migration period was not sampled in 1992 (late project funding and logistics prevented earlier sampling of smolts in Chignik River). More extensive sampling of the smolt emigration coupled with length-at-age analysis could be an important tool for forecasting adult returns from each lake and for evaluating enhancement projects.

Age-2 smolts averaged 72.3 ± 0.1 mm and 2.91 ± 0.13 g (Fig. 18). Most of these fish are probably from the Chignik Lake stock and are similar in length to those age-1 smolts originating from Black Lake. The age-2 smolts represented 39% of the total smolt emigration or approximately 54% of the smolts estimated to originate from Chignik Lake.

Over 600 age-0 sockeye fry were captured during late June and early July (Table 16). The fry averaged 36.1 ± 0.3 mm and 0.49 ± 0.02 g. The relatively long length of these fish suggests that many originated from Black Lake. Alternatively, some fry may have emerged during late summer from Chignik Lake spawning areas and may have been mistakenly aged as young-of-the-year fry. Sockeye typically do not lay down scales until they exceed 40 mm. Many of these fish may rear in lower Chignik River or Chignik Lagoon before migrating back to Chignik Lake (Iverson 1966).

FRY EMERGENCE

Methods

Ten fry traps were placed on each sockeye spawning ground at the South Hatchery and Delta beach areas. The traps were sampled approximately every 5-10 days from 18 May to 10 July. Details of the sampling methodology are given by Ruggerone (1989).

Results and Discussion

Daily emergence peaked during late May, which is earlier than that during previous years (i.e., early June). The exceptionally cold spring, which will cause emergence of fry in streams to occur at a later date, probably had little effect on emergence timing of sockeye fry along the lake shoreline. Groundwater that percolates over developing alevins is affected little by ambient air temperature and is nearly constant throughout the year. Early emergence in 1992 might be related to slightly earlier spawning of adult sockeye during 1991.

The rate of emergence during June 1992 was the lowest since initiation of the trapping operation in 1986 (Table 17). The geometric mean index of emerging fry in 1992 was 5.5 fry/m^2/30 days, which was low relative to the seven year average (16.2 fry/m^2/30 days).

LITTORAL ZONE FISHES

Methods

Fishes inhabiting the littoral area of Chignik Lake were sampled by beach seine during 6 June, 27 June, and 11 July. Sampling locations included Clark Bay, north and south Hatchery Beach, the Delta spawning area, north Cucumber Cove, and the lake outlet (Fig. 2). Fishes were enumerated by species.

Results and Discussion

Threespine stickleback (150 fish/set) and ninespine stickleback (21 fish/set) were the most abundant fishes in the littoral zone, although their distribution was patchy (Table 18). Most stickleback were caught in the outlet area, as is typical in most years. Sockeye fry (9.6 fry/set) were slightly more abundant in 1992 than in 1985-88 (<8 fry/set), whereas coho ≥70 mm (10 fish/set) were less abundant than in previous years. Age-1 and age-2 sockeye were less abundant in 1992 (11 fish/set) than in 1985-88 (130 fish/set). Few age-1 chinook salmon (*O. tshawytscha*) were captured (2.2 fish/set).

Sockeye lengths on 6 June could be separated into three modes: 30 mm, 48 mm, and 70 mm. The relatively small mode at 48 mm might have included small age-1 sockeye originating from Chignik Lake and age-0 sockeye that recently emigrated from Black Lake. On 27 June, the two smaller modes could not be distinguished from each other. The largest mode was at 76 mm. On 11 July length frequency modes could not be identified. Lengths ranged from 28 to 54 mm.

Juvenile coho are a major source of mortality for sockeye fry in the littoral area of Chignik Lake (Ruggerone 1989; Ruggerone and Rogers 1992). Sockeye fry typically spend little time in littoral areas of Chignik Lake before moving offshore to areas where coho are less abundant. This pattern is opposite of that in most lakes where sockeye inhabit littoral areas for 1-2 months before moving offshore. The large number of sticklebacks in the outlet area can provide some protection for sockeye fry because coho tend to consume fewer fry when fry aggregate with stickleback (Ruggerone 1992b).

FALL TOWNET SURVEY

Methods

The density of juvenile sockeye in Chignik Lake was estimated by townet during 3-6 September. The townet was pulled on the surface between two skiffs and sampled a 1.8-m^2 area of water. Tow speed was estimated by a Gurley current meter to be 1.18 ± 0.03 m/s. Wind was less than 20 km/h. Nine tows were made between 2015 h and 1130 h. Tow duration ranged from 3.3 min to 10 min in order to capture sockeye with scales. Capture rates were standardized to a 10 min tow duration. Tows were made near the Black River delta, Roos Bay, Hatchery Beach, Clark Bay, and the lake outlet (Fig. 2).

Results and Discussion

The geometric mean catch of age-0 and age-1 sockeye salmon was 65 and 9 fish/10 min tow, respectively, based on length-at-age data and townet catches. A gradient of increasing length of sockeye from the delta to lake outlet, which has been observed during other years (Narver 1966), was not apparent in 1992. Smelt were next in abundance (4.8 fish/10 min), followed by ninespine stickleback (2.6 fish/10 min), and threespine stickleback(2.3 fish/10 min).

Length-at-age analysis indicated that sockeye <72 mm were age-0, whereas 62% of sockeye 72-85 mm were age-1 (Fig. 19). Several length frequency modes were apparent. At the delta station, modes occurred at 29 mm, 44 mm, and 65 mm (Fig. 19). The mode at 65 mm probably represents sockeye originating from Black Lake, whereas the smaller two modes probably represent fish from Chignik Lake. Over 50% of sockeye captured in Chignik Lake probably emigrated from Black Lake during spring and summer. Length frequency analysis of sockeye captured during February 1993 should provide additional information on the relative abundance of Black Lake sockeye in Chignik Lake.

RECOMMENDATIONS FOR FUTURE MONITORING

The most important aspect for monitoring juvenile sockeye salmon populations in Black and Chignik lakes is enumeration of emigrating sockeye salmon in Black River and Chignik River and concomitant length-at-age analysis. This sampling would quantify the number and size of sockeye that overwinter in Black Lake, number of age-0 Black Lake sockeye that emigrate to

Chignik Lake, and number and size of smolts originating from Black Lake and Chignik Lake. This information is critical to the evaluation of enhancement projects in the Chignik Lakes and could be used to develop new forecasts of adult sockeye returning to Chignik Lake and Black Lake. Sampling of emigrating sockeye in Black River was reasonably successful in 1992. However, improvements could be made to by using a rotary screw trap that would capture more fish and keep the captured fish in better condition. Greater capture success would improve the precision of the enumeration process, which was marginal in Black River during 1992. Gear improvements are essential in Chignik River if smolts are to be enumerated. A large rotary screw trap could greatly improve the sampling success of sockeye smolts because the trap samples a large area while keeping the fish in good condition. A single rotary screw trap should be deployed in Chignik River in 1993. At the end of the year, the trap should be evaluated to determine whether an additional trap is needed.

Other monitoring projects should be continued, including daily water temperature, lake level, limnology, fry emergence rates, relative abundance and size of littoral zone fishes, size and abundance of sockeye in each lake during the fall, erosion of the Alec River side channel, and growth of the sandspit extending across Black Lake. Most of these projects would require relatively little additional field time and expenses if smolt and fry studies were continued.

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FIGURES

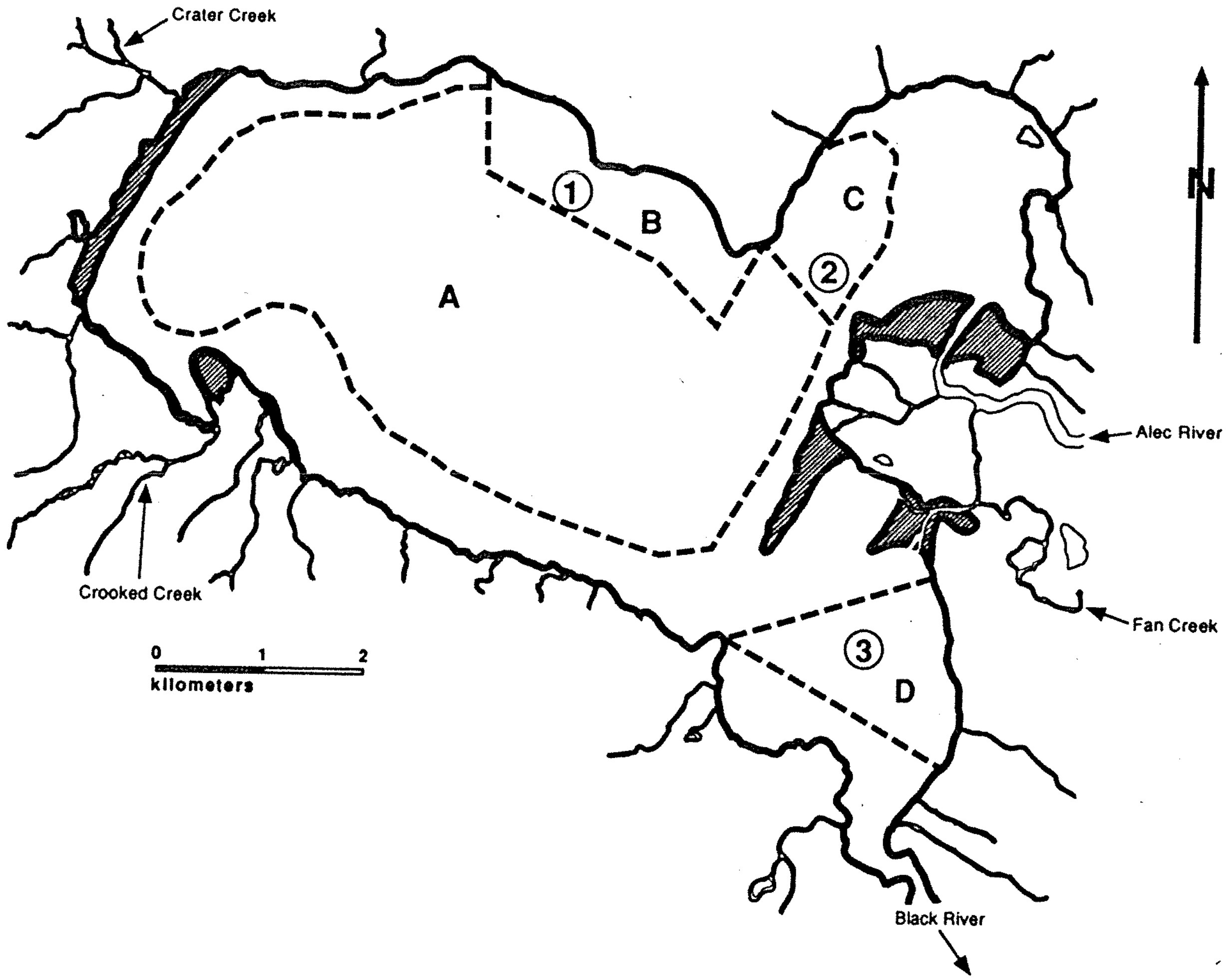

Figure 1. Townet areas (A, B, C, and D) and limnology stations (1, 2, and 3) in Black Lake. Shaded areas indicate exposed regions that were under water during the 1950s.

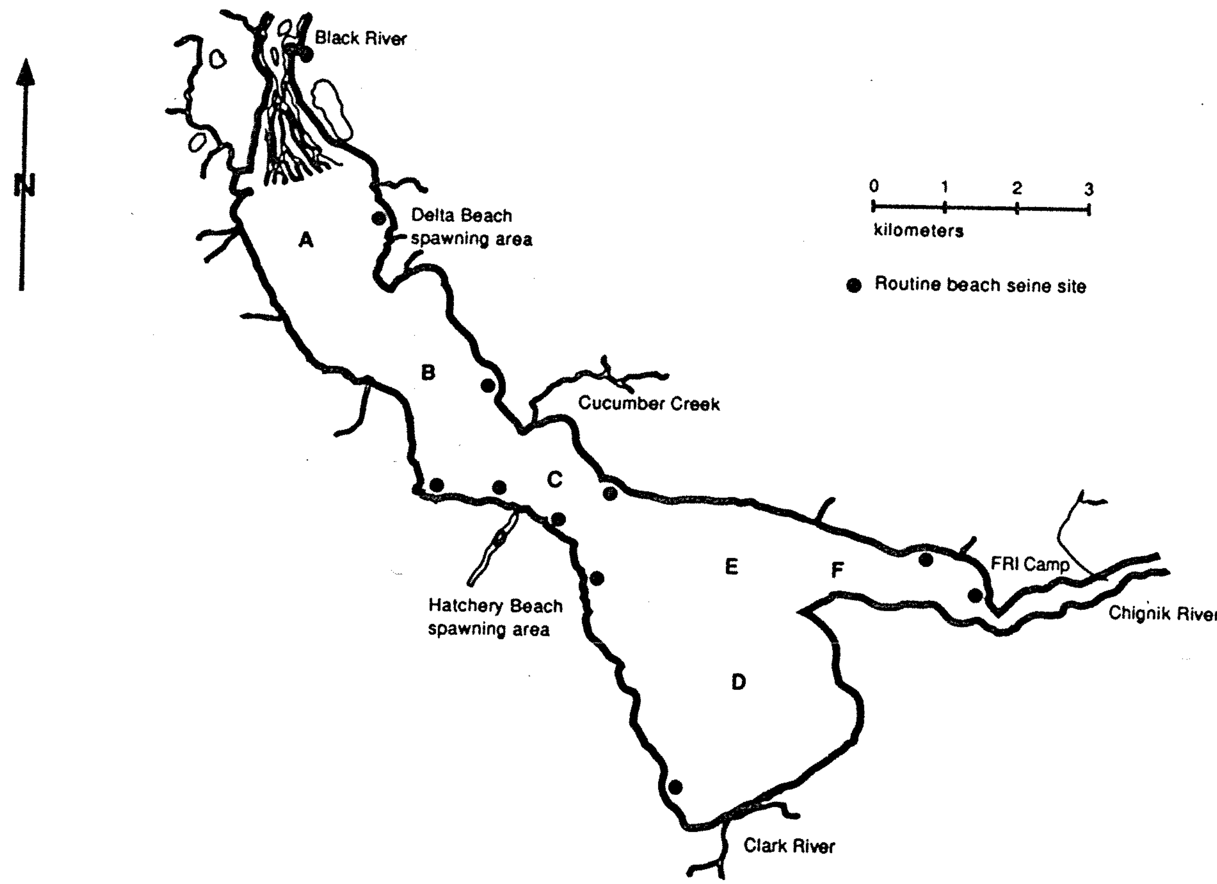

Figure 2. Locations of beach seine, limnology (A-E), and townet stations (A-F) at Chignik Lake.

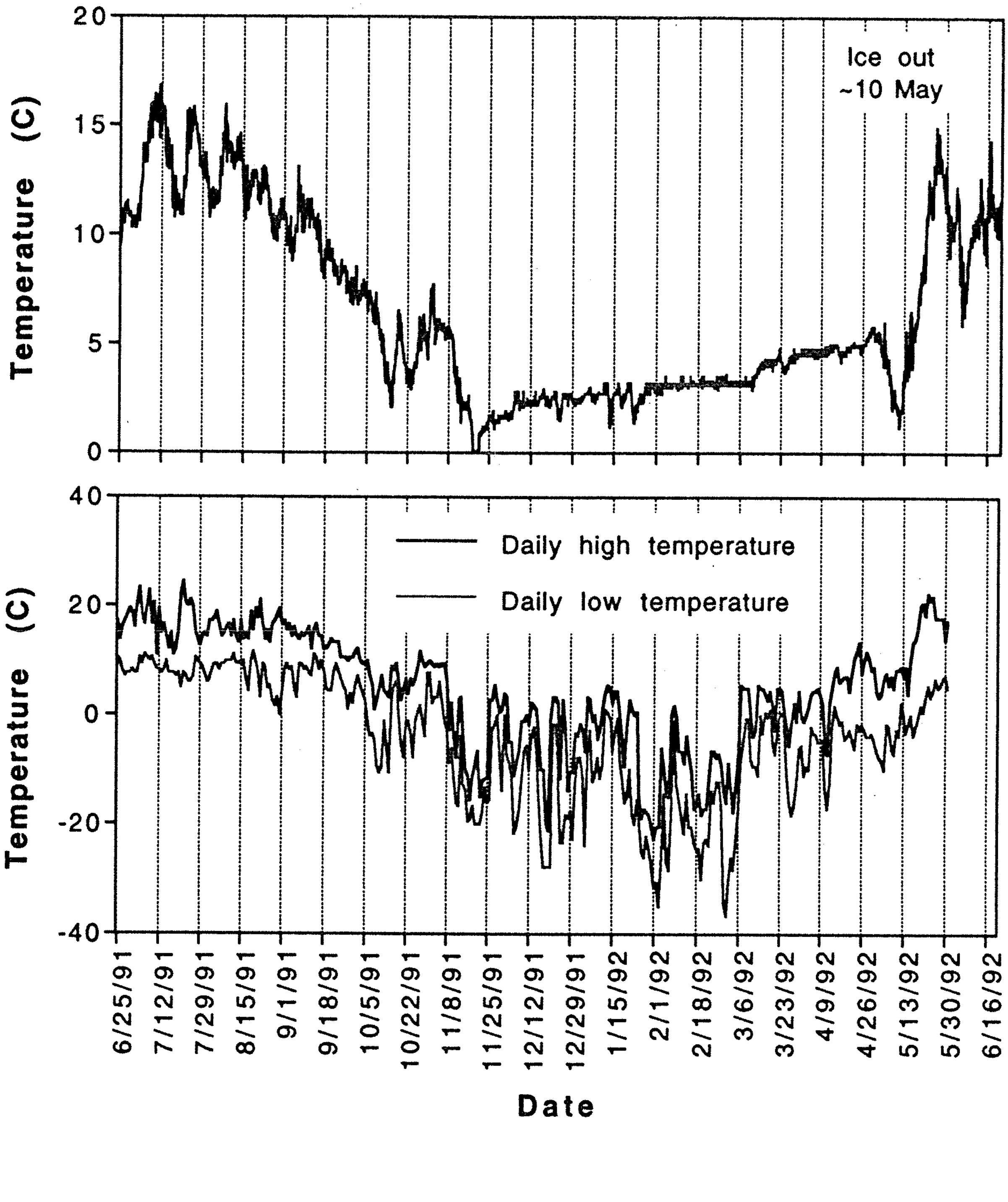

Figure 3. Black Lake water temperatures (upper graph) and King Salmon air temperatures (lower graph) for 1991-1992. Black Lake temperatures were recorded every 2 hours with a thermograph placed 0.5 m above the lake bottom near the old FRI shelter.

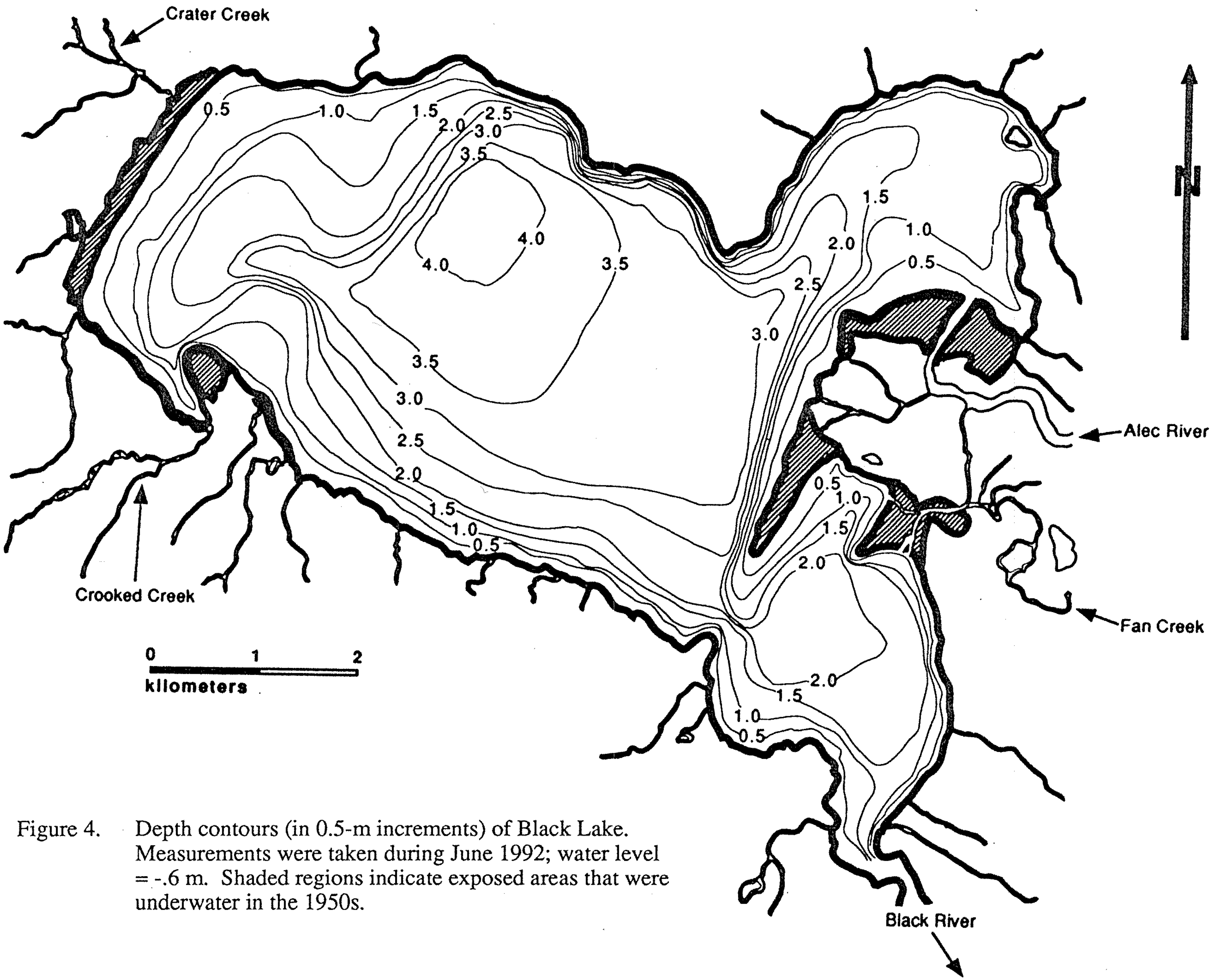

Figure 4. Depth contours (in 0.5-m increments) of Black Lake. Measurements were taken during June 1992; water level = -.6 m. Shaded regions indicate exposed areas that were underwater in the 1950s.

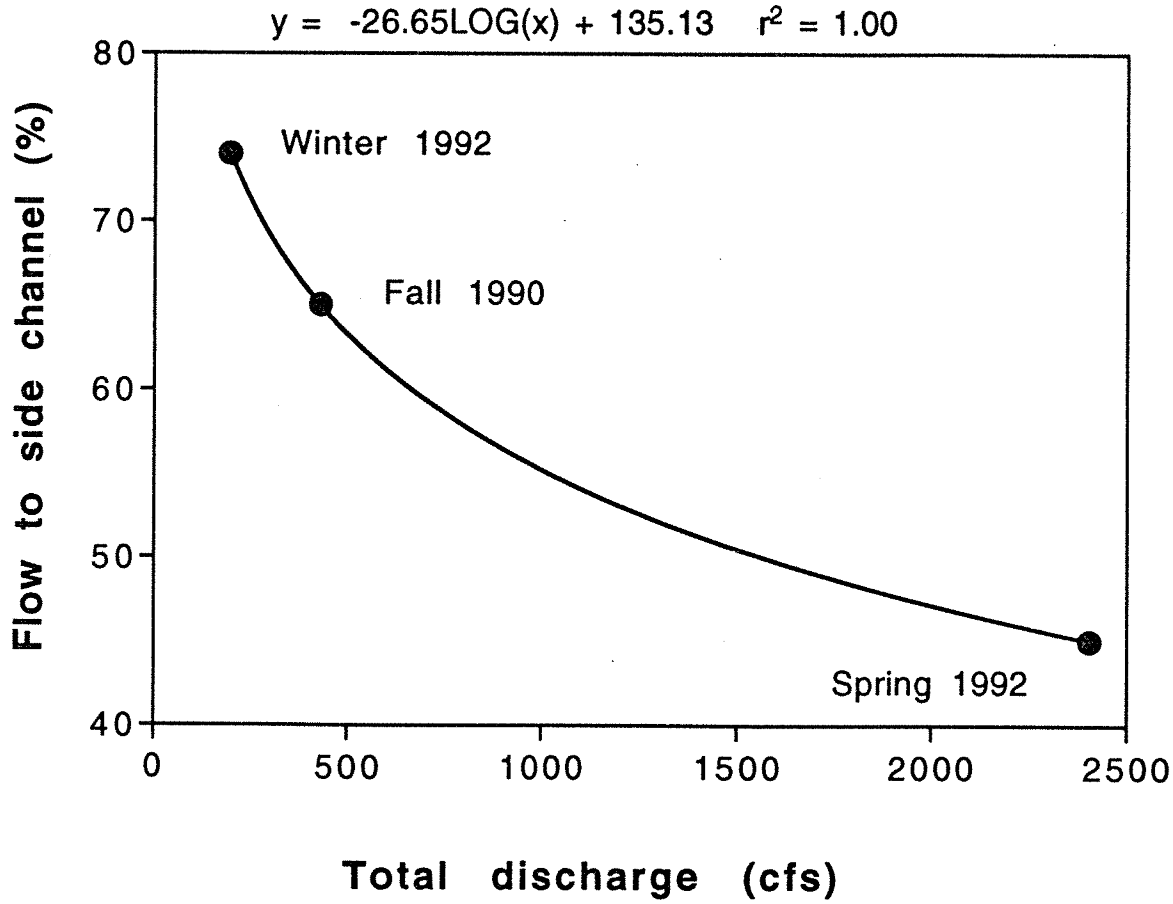

Figure 5. Relationship between total discharge of Alec River and discharge in side channel of Alec River.

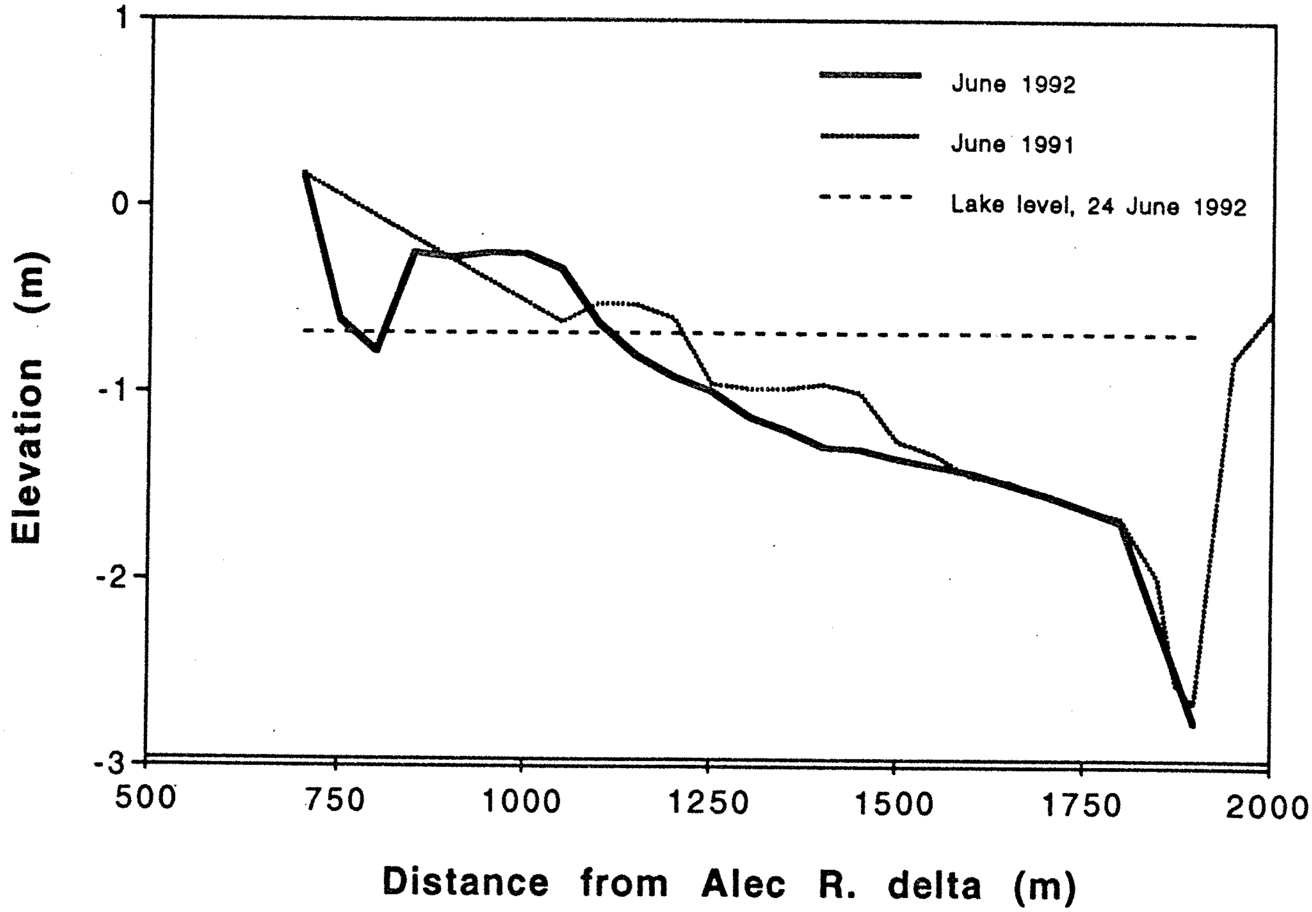

Figure 6. Comparison of sandspit elevation profiles in Black Lake during 1991 and 1992. Lake level elevation during the 1992 survey was -0.680 m.

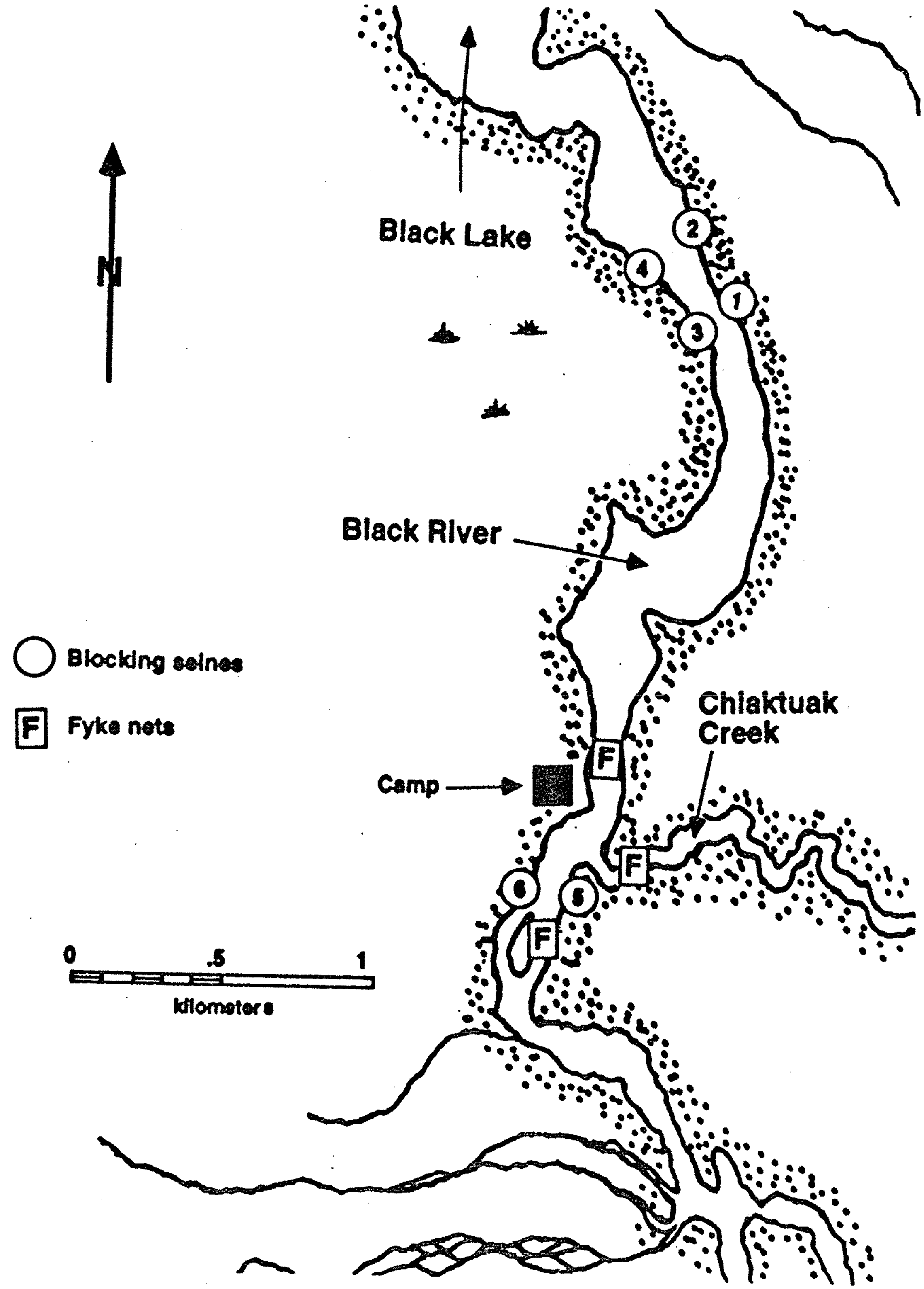

Figure 7. Locations of fyke nets and blocking seines in Black River and Chiaktuak Creek.

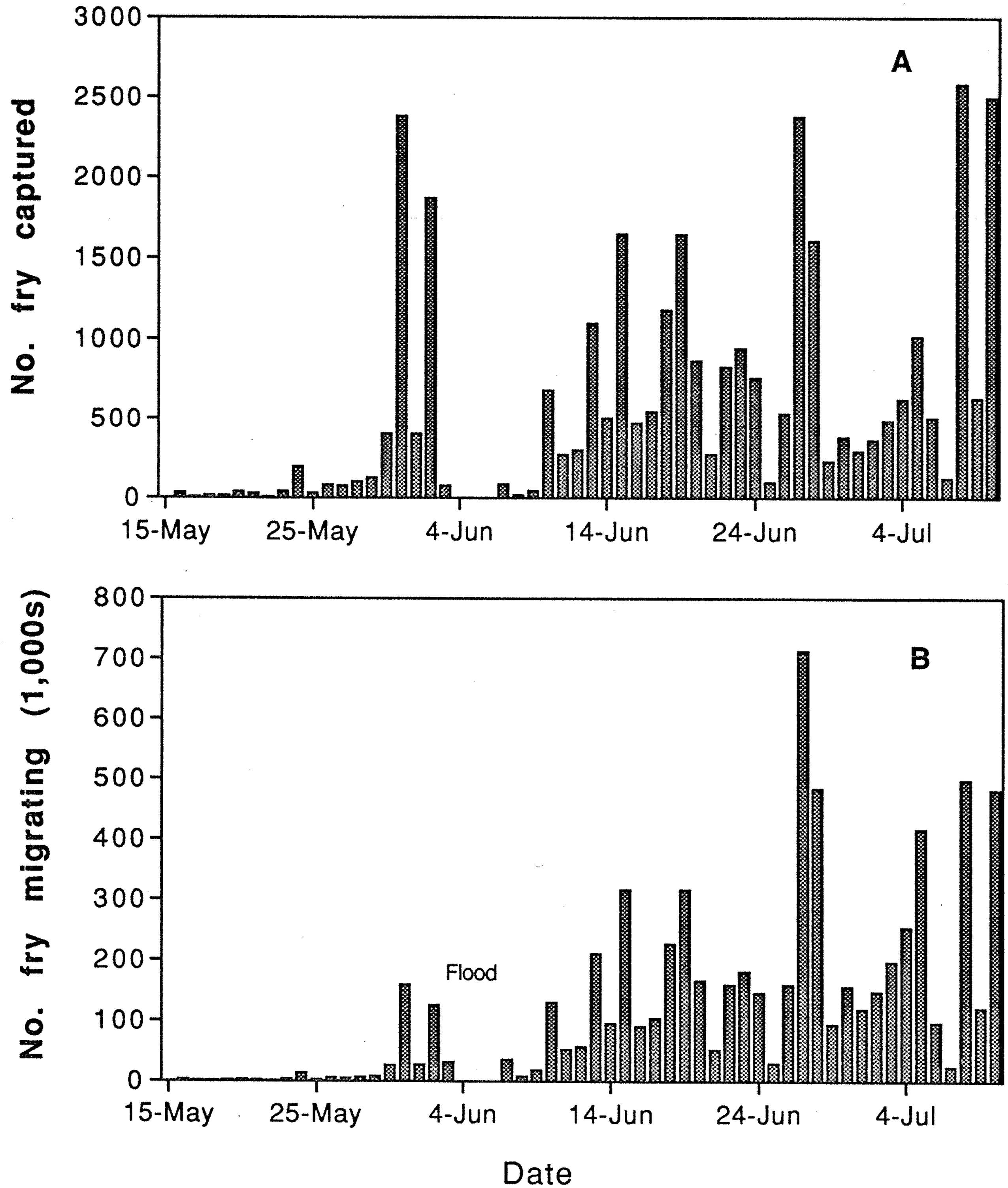

Figure 8. Time series of sockeye fry catches (A) and total daily fry migration (B) in Black River, 1992. Total fry migrations were estimated from mark-recapture tests.

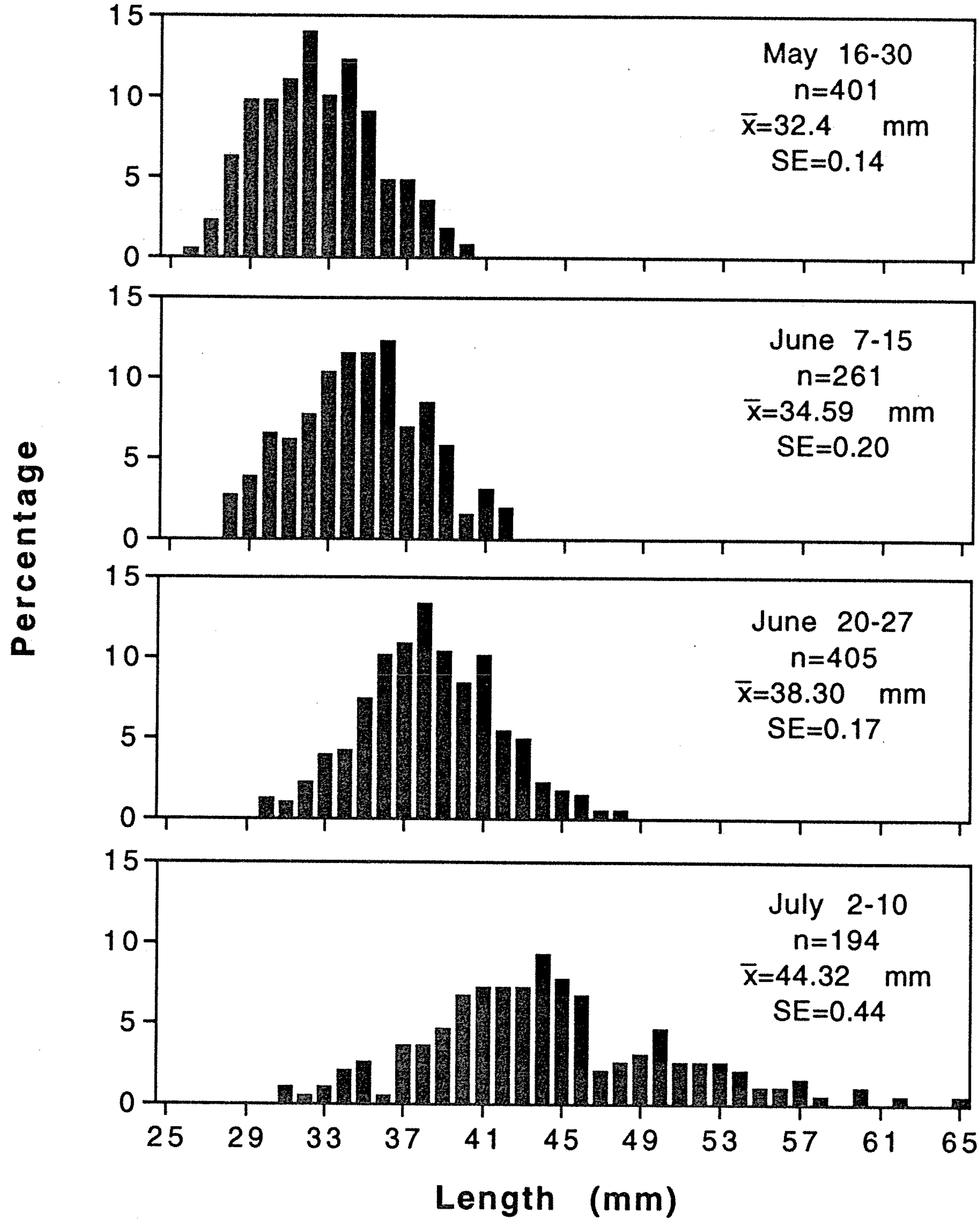

Figure 9. Length-frequency distributions of sockeye salmon fry captured in the fyke net and plane trap in Black River below the mouth of Chiaktuak Creek.

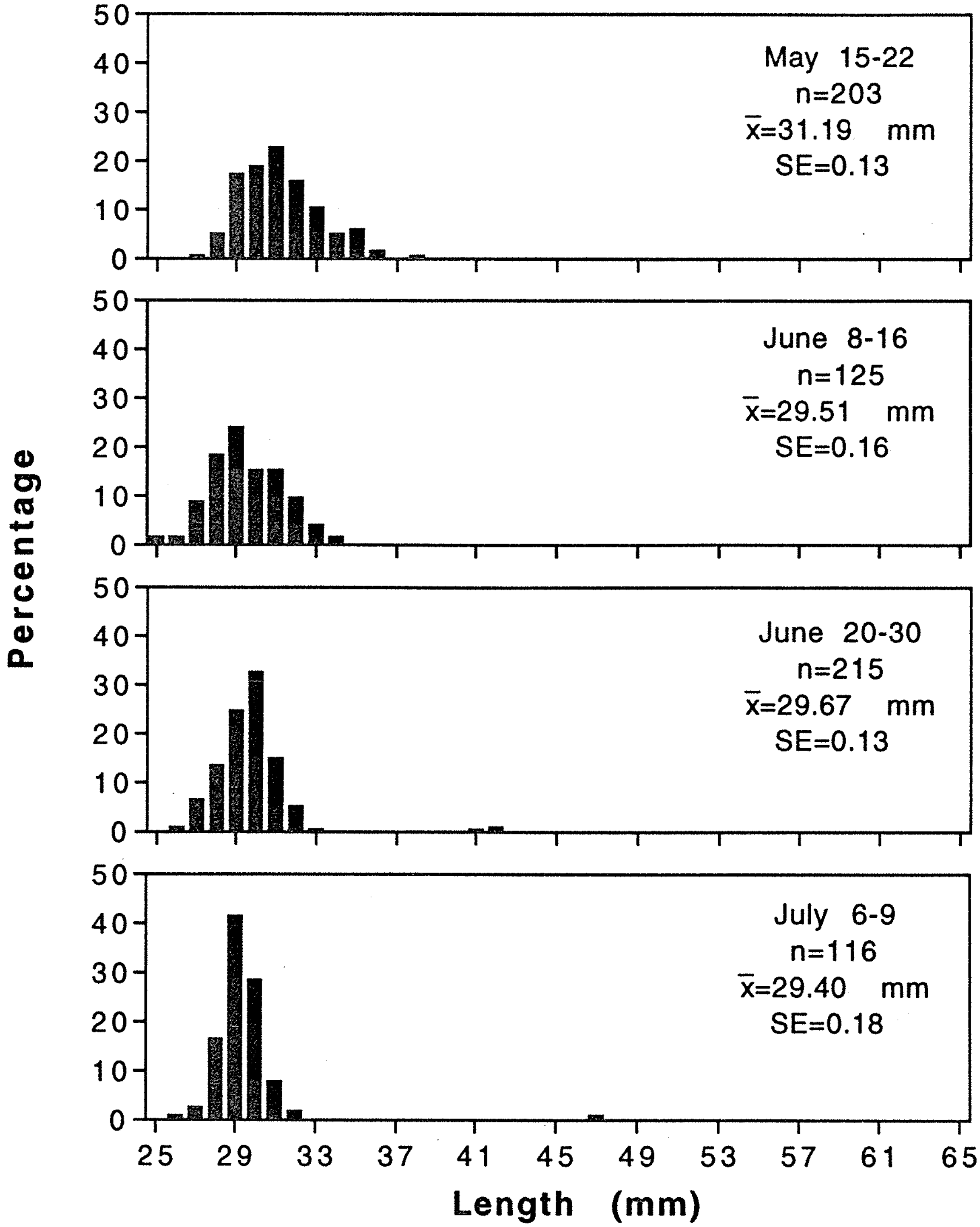

Figure 10. Length-frequency distributions of sockeye salmon fry captured in the fyke net in Chiaktuak Creek.

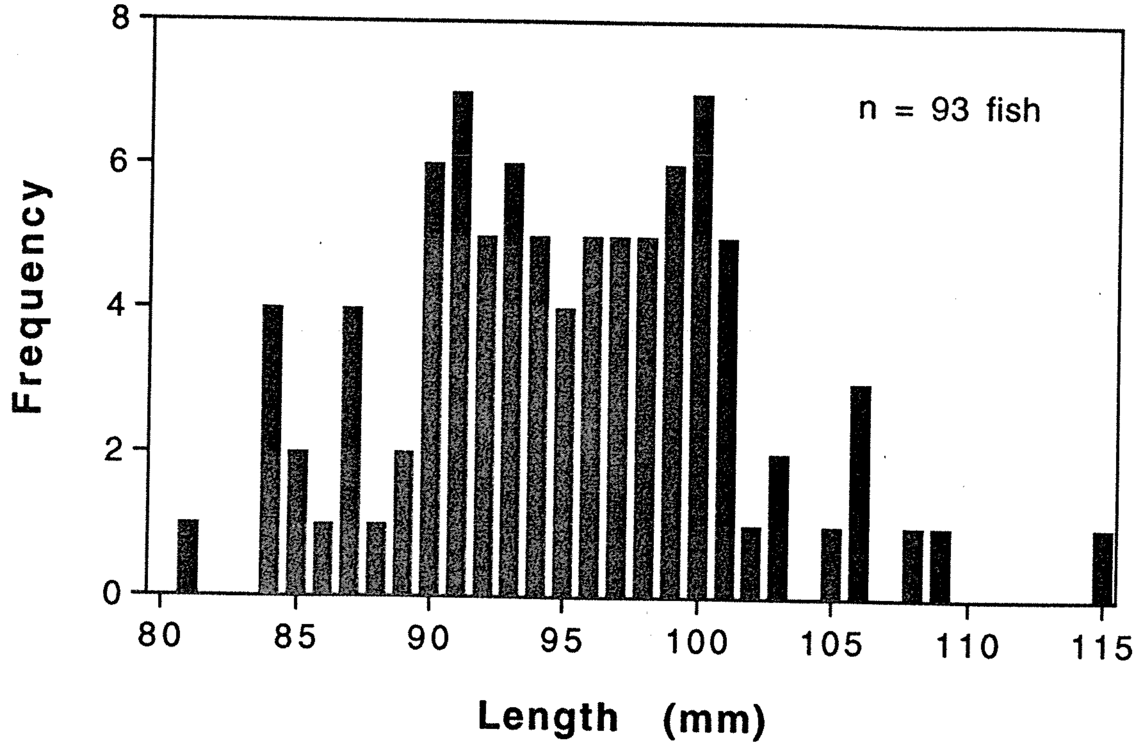

Figure 11. Length-frequency distribution of age-1 smolts captured in Black River in 1992.

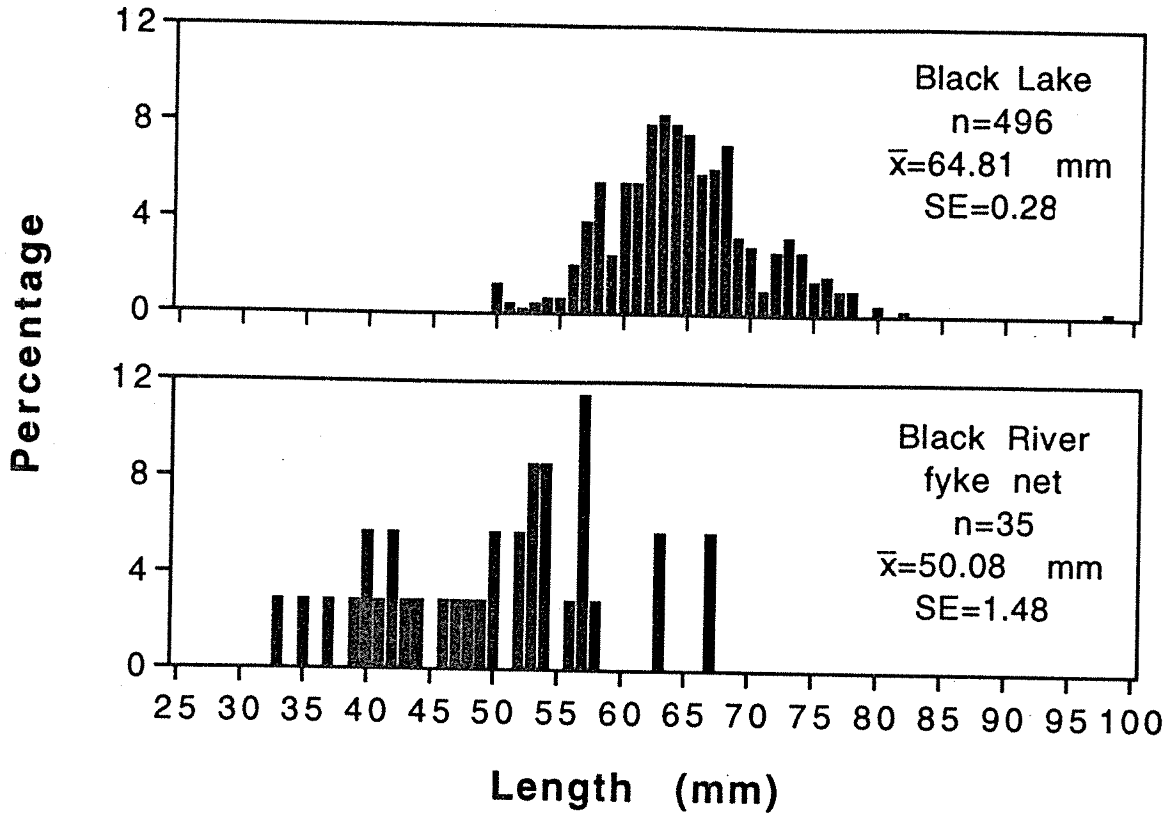

Figure 12. Length-frequency distributions of sockeye salmon fry captured in tow net hauls of Black Lake, August 31, 1992, and in the fyke net in Black River below the mouth of Chiaktuak Creek, August 30-September 4, 1992.

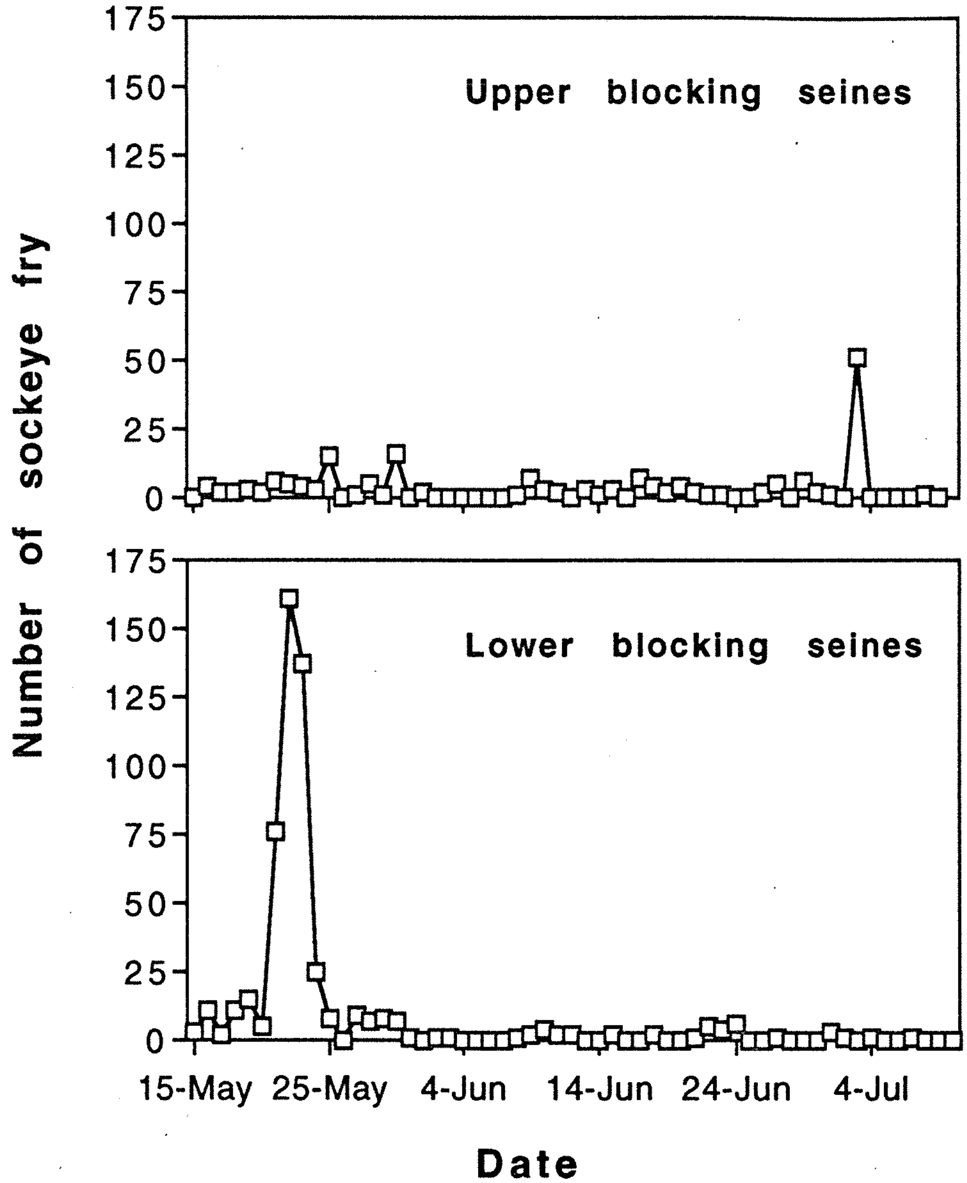

Figure 13. Daily catches of sockeye salmon fry in the two uppers (nos. 2 and 4) and two lower (nos. 1 and 3) blocking seines near the Black Lake outlet. Catches in the two pairs of nets were summed.

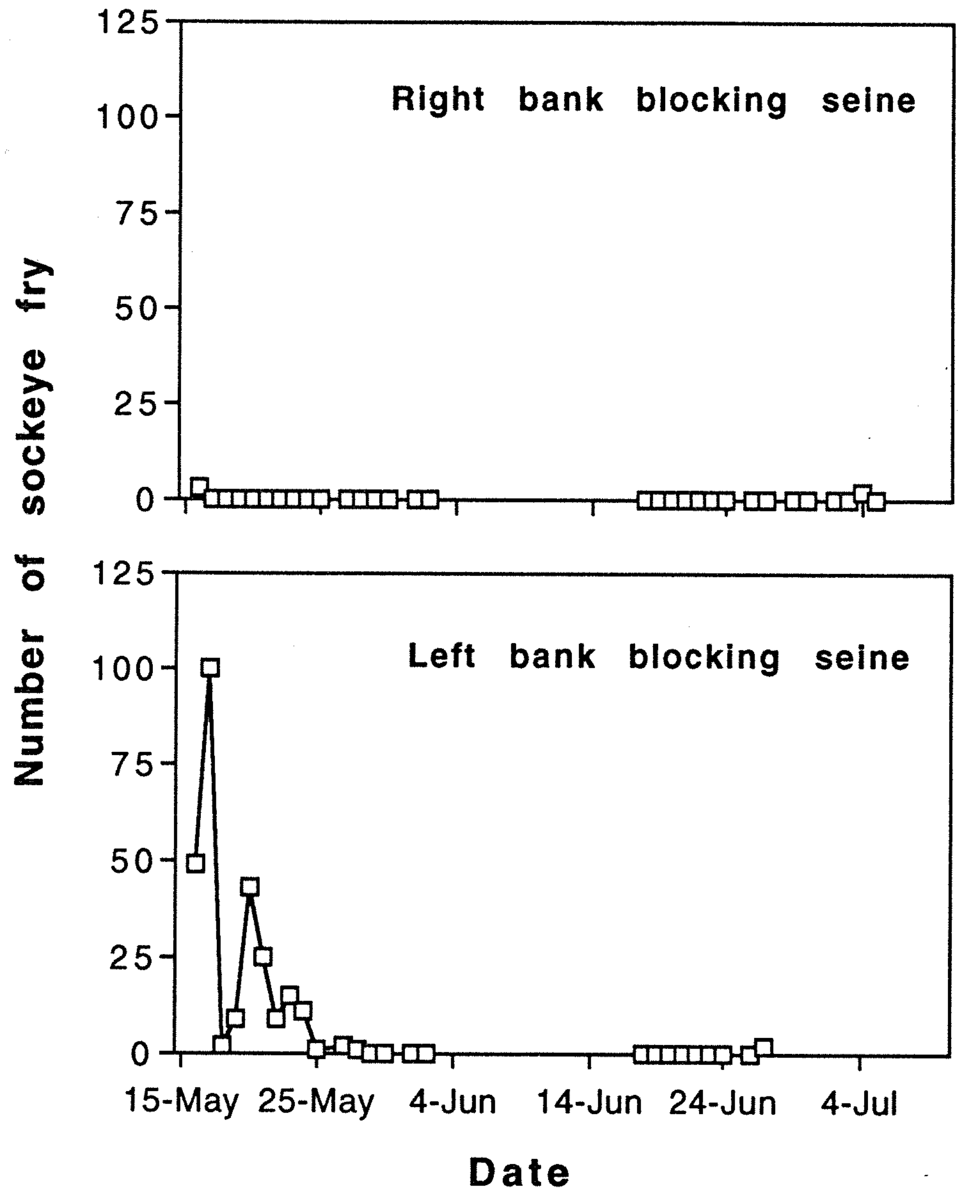

Figure 14. Daily catches of sockeye salmon fry in the blocking seines below the mouth of Chiaktuak Creek. "Left bank" refers to the bank that is crossed by Chiaktuak Creek.

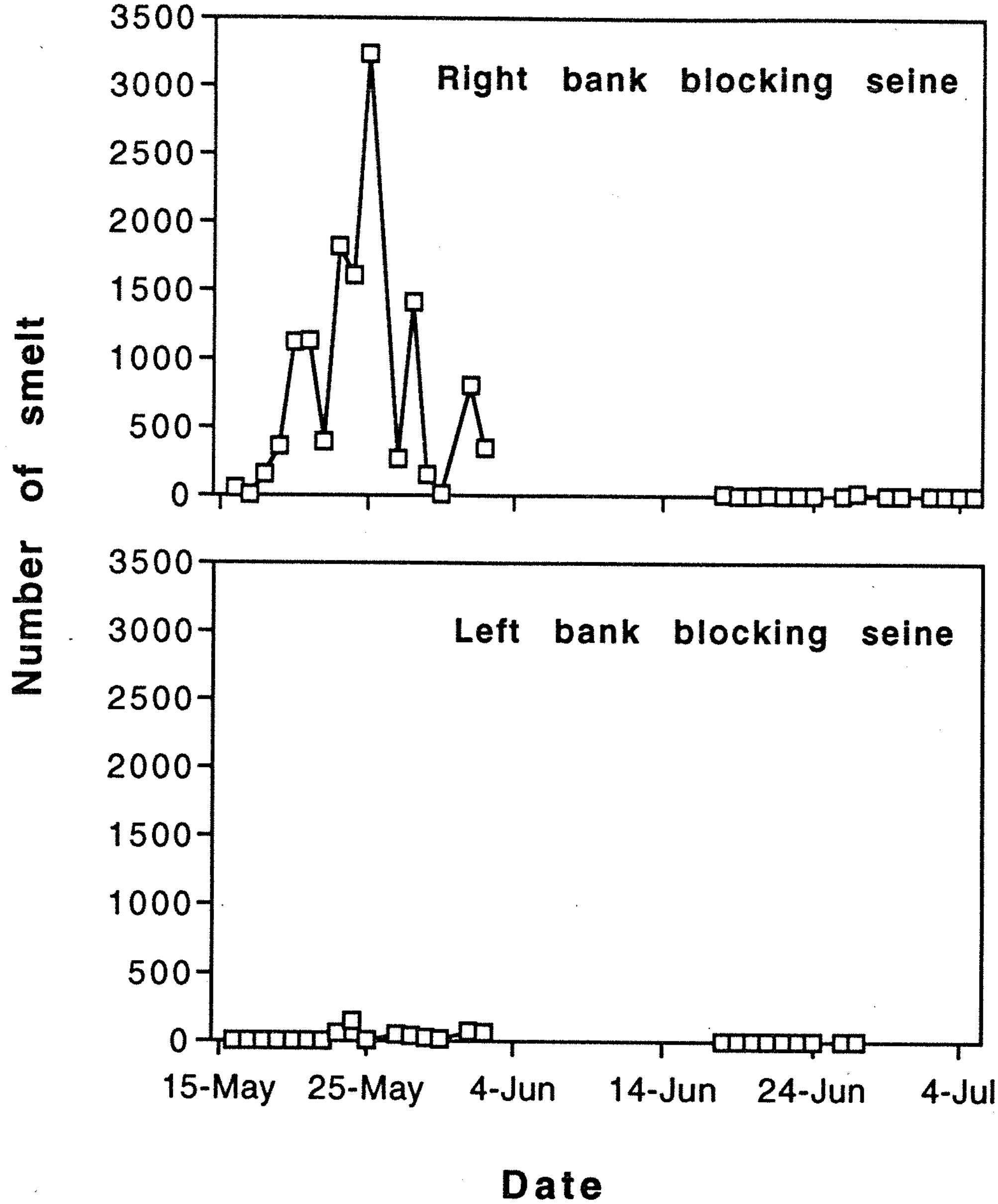

Figure 15. Daily catches of pond smelt in the blocking seines below the mouth of Chiaktuak Creek. "Left bank" refers to the bank that is crossed by Chiaktuak Creek.

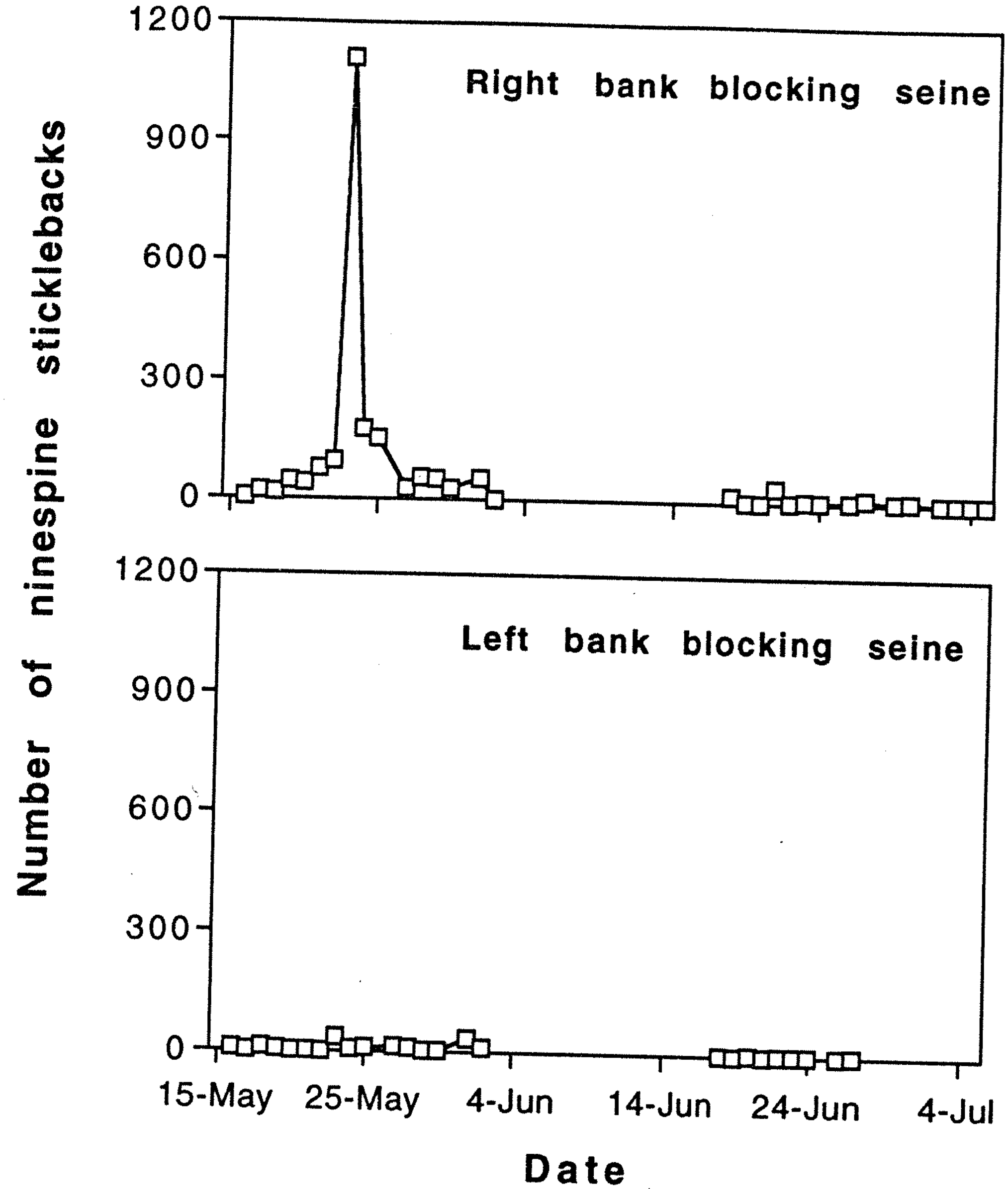

Figure 16. Daily catches of ninespine sticklebacks in the blocking seines below the mouth of Chiaktuak Creek. "Left bank" refers to the bank that is crossed by Chiaktuak Creek.

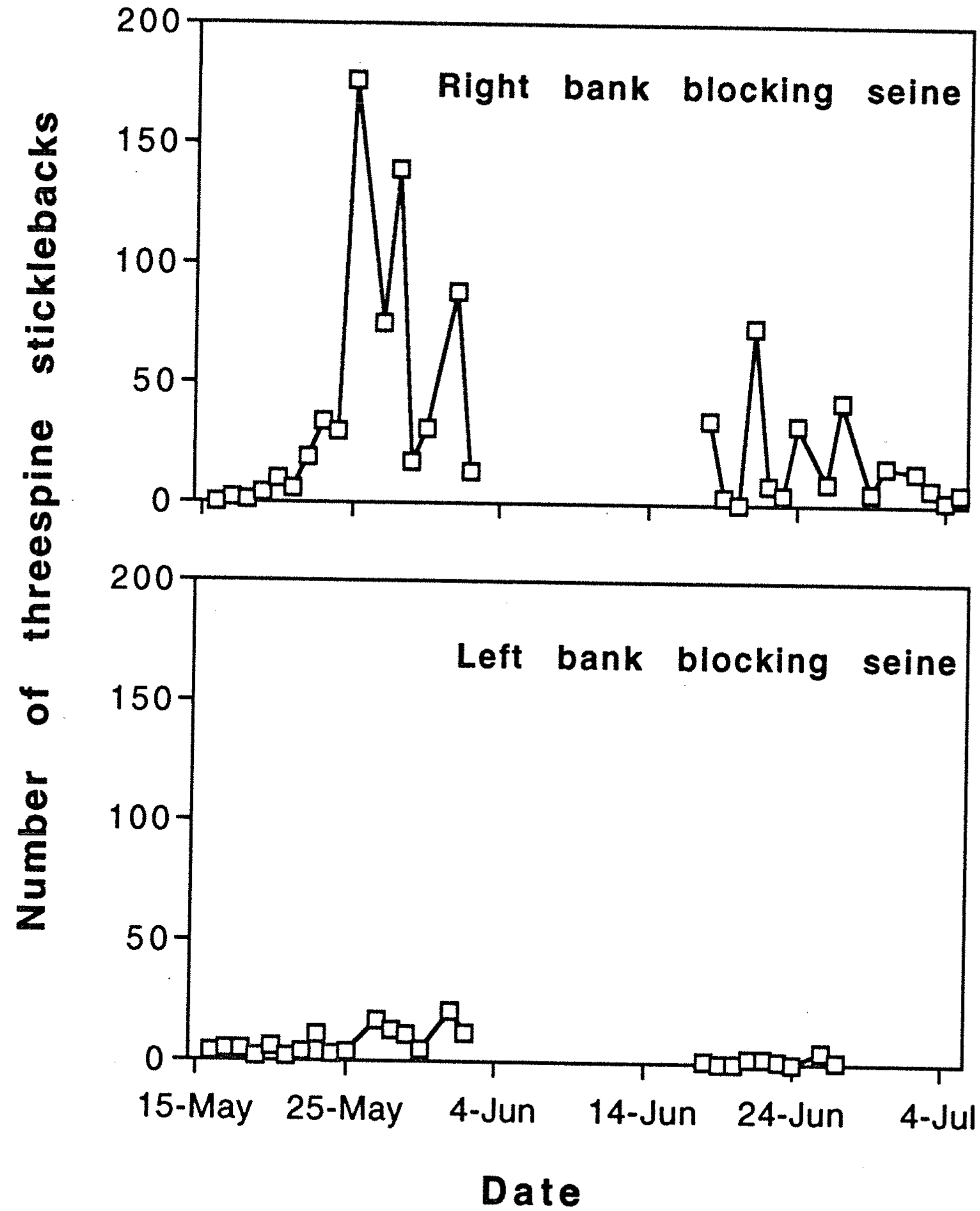

Figure 17. Daily catches of threespine sticklebacks in the blocking seines below the mouth of Chiaktuak Creek. "Left bank" refers to the bank that is crossed by Chiaktuak Creek.

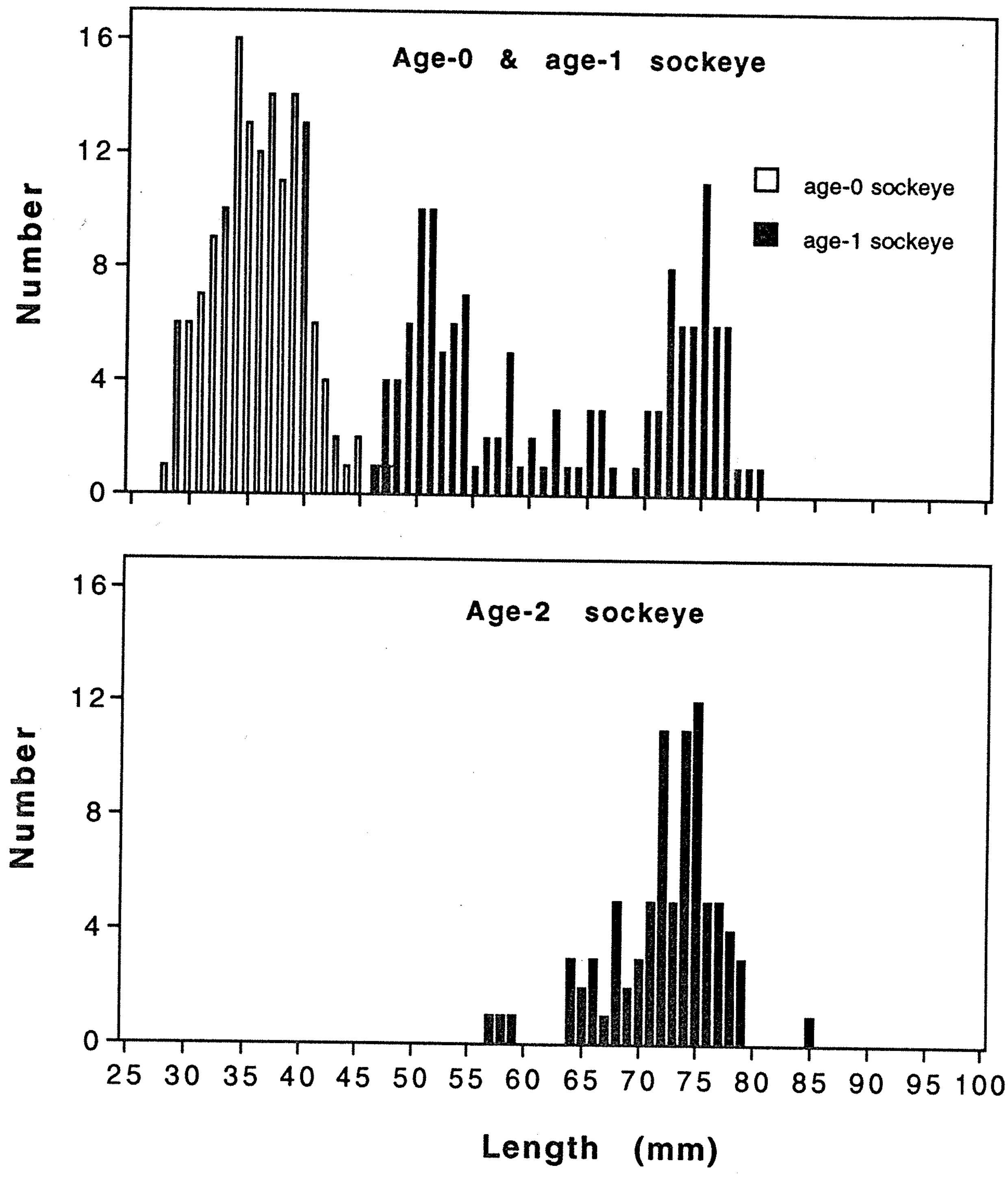

Figure 18. Length-frequency distributions by age of sockeye fry captured in Chignik River between 15 June and 4 July 1992.

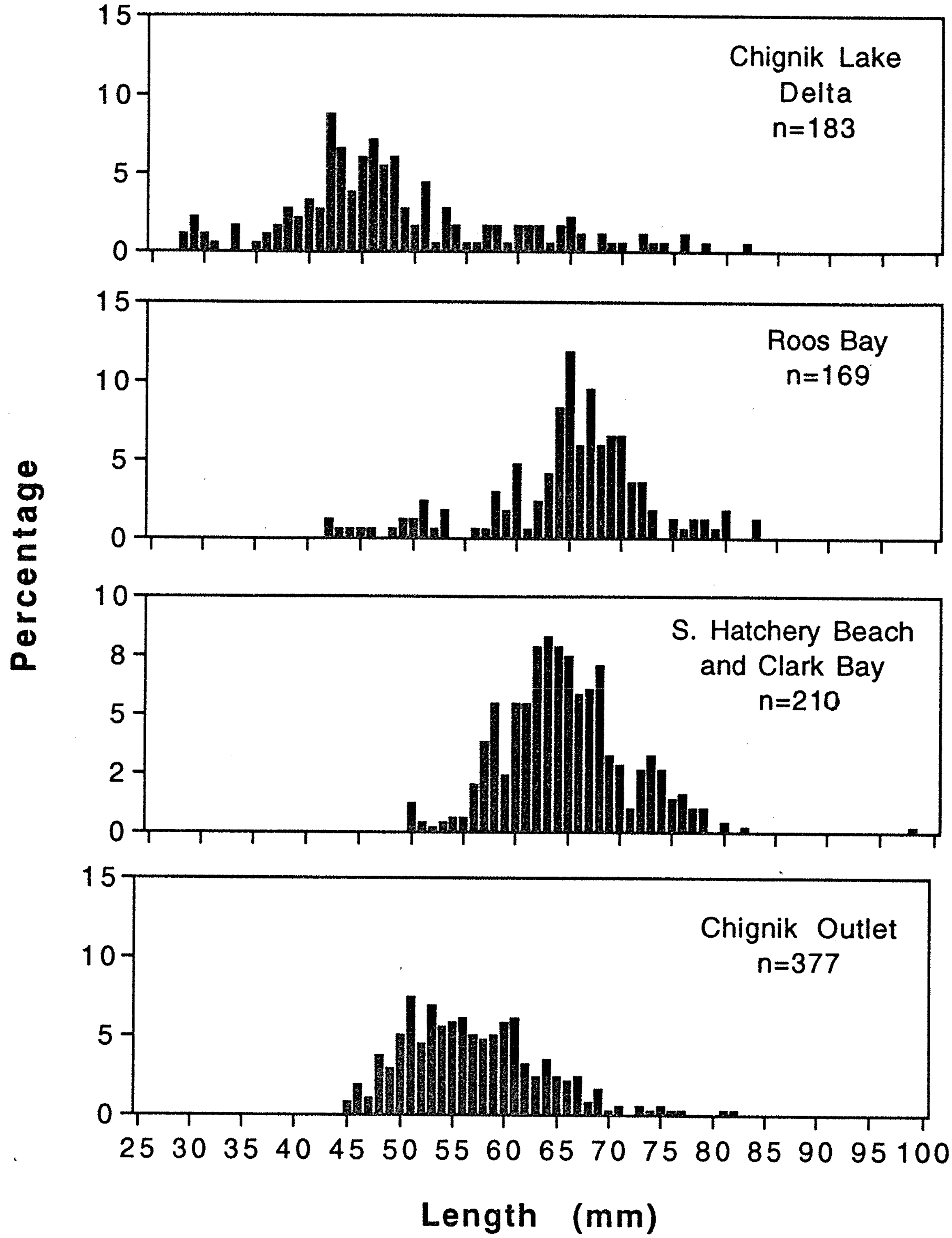

Figure 19. Length-frequency distributions of sockeye salmon fry captured in townet hauls of Chignik Lake, September 3-6, 1992.

TABLES

Table 1. Chlorophyll estimates in surface waters of Black Lake, 1992.

Date	Outlet chlorophyll a (mg/m^3)	Alec Bay chlorophyll a (mg/m^3)	North shore chlorophyll a (mg/m^3)
20-Jun	1.55	4.27	3.91
20-Jun	3.26	2.57	3.56
8-Jul	1.62	2.13	3.10

Table 2. Zooplankton abundance estimates (#/m^3) in Black Lake, 1992. Estimates based on 20-m or 40-m horizontal net hauls.

Date	Area	Total Zoop	Calanoid	Cyclopoid	Daphnia	Bosmina	Holopedium	Nauplii	Asplanchna	Other
20-Jun	1: Hydro Pt (20 m)	15,155	891	9,552	0	2,038	0	1,910	637	127
20-Jun	2: FRI (20 m)	20,632	4,075	7,005	0	764	0	7,769	1,019	0
20-Jun	3: Outlet (40 m)	11,016	255	6,877	0	1,210	0	1,847	764	64
	Average	15,601	1,741	7,811	0	1,337	0	3,842	807	64

Table 3. Level of Black Lake during 1992. Measurements conducted at the outlet benchmark.

Date	Lake level (m)	Wind direction	Wind speed (mph)
15-May	-1.307	NW	10-15.
4-Jun	-0.660	SE	10
5-Jun	-0.515	SE	20
8-Jun	-0.390	NW	15-20
16-Jun	-0.610	SE	15
18-Jun	-0.556	SE	15-20
22-Jun	-0.615	E	15
24-Jun	-0.680		0
27-Jun	-0.760	SE	15-20
28-Jun	-0.710	NW	15
29-Jun	-0.725		0
30-Jun	-0.830	SE	5
2-Jul	-0.780	NW	5
4-Jul	-0.890	SE	15
6-Jul	-0.850	NW	5
9-Jul	-1.000	SE	20
31-Aug	-1.110	SW	5
3-Sep	-1.055	SE	5

Table 4. Daily abundances of sockeye salmon fry and smolts emigrating from Black Lake, 1992. Estimates of total fry emigrating was based on mark-recapture tests.

	Lower fyke net		Smolts	Upper fyke net	
Date	Fry captured	Fry migrating	captured	Fry captured	Smolts captured
16-May	33	2,211	1	32	
17-May	7	469	7	4	3
18-May	16	1,072	1	6	3
19-May	17	1,139	0	4	0
20-May	40	2,680	0	5	0
21-May	29	1,943	0	3	0
22-May	8	536	1	2	0
23-May	42	2,814	0	22	0
24-May	196	13,132	0	10	0
25-May	33	2,211	1	28	0
26-May	83	5,561	17	47	0
27-May	76	5,092	0	11	0
28-May	101	6,754	0	5	0
29-May	126	8,442	2	52	0
30-May	401	26,867	0	160	0
31-May	2,381	159,527	5	123	0
1-Jun	403	27,001	0	30	0
2-Jun	1,868	125,156	0	35	0
3-Jun	77	31,493	3	63	0
4-Jun		**83,639**			
5-Jun		**83,639**			
6-Jun		**83,639**			
7-Jun	87	35,583		25	0
8-Jun	20	8,180	6	131	12
9-Jun	44	17,996	23	69	0
10-Jun	678	130,176	18	40	0
11-Jun	272	52,224	8	52	1
12-Jun	298	57,216	13	38	0
13-Jun	1,097	210,624	13	207	0
14-Jun	501	96,192	84	33	1
15-Jun	1,647	316,224	27	190	1
16-Jun	472	90,624	3	42	0
17-Jun	543	104,256	6	95	0
18-Jun	1,181	226,752	8	312	2
19-Jun	1,645	315,840	3	89	0
20-Jun	865	166,080	5	55	0
21-Jun	274	52,608	0	50	0
22-Jun	829	159,168	3	31	1
23-Jun	943	181,056	1	33	0
24-Jun	760	145,920	0	13	0
25-Jun	100	30,000			
26-Jun	532	159,600	0	62	0
27-Jun	2,376	712,800		26	0
28-Jun	1,607	482,100	0	38	0
29-Jun	230	94,070	0	20	0
30-Jun	381	155,829	0	10	0

Table 4—cont.

Date	Lower fyke net Fry captured	Fry migrating	Smolts captured	Upper fyke net Fry captured	Smolts captured
1-Jul	292	119,428	0	9	0
2-Jul	360	147,240	0	127	0
3-Jul	482	197,138	4	57	0
4-Jul	620	253,580	0	46	0
5-Jul	1,017	415,953	0	60	0
6-Jul	502	96,384	0	35	0
7-Jul	124	23,808	0	7	0
8-Jul	2,585	496,320	0	19	0
9-Jul	630	120,960	0		
10-Jul	2,499	479,808	3		
31-Aug	6	300	0		
1-Sep	10	500	0		
2-Sep	15	750	0		
3-Sep	9	450	0		
4-Sep	9	450	0		
Total	32,479	7,029,204	266	2,663	24

Table 5. Efficiency estimates for the lower fyke net in Black River and the fyke net in Chiaktuak Creek. Estimates are based on mark-recapture tests with sockeye salmon fry.

	Lower Black River			Chiaktuak Creek		
Date	number released	number recaptured	efficiency (% recaptured)	number released	number recaptured	efficiency (% recaptured)
16-May						
17-May						
18-May						
19-May						
20-May						
21-May						
22-May				137	3	2.190
23-May						
24-May						
25-May				85	1	1.176
26-May						
27-May						
28-May						
29-May	97	1	1.031			
30-May						
31-May				490	1	0.204
1-Jun						
2-Jun	192	5	2.604			
3-Jun						
4-Jun						
5-Jun						
6-Jun						
7-Jun						
8-Jun						
9-Jun						
10-Jun						
11-Jun	604	2	0.331			
12-Jun	910	5	0.549			
13-Jun	816	4	0.490			
14-Jun				895	0	0.000
15-Jun	1076	6	0.558			
16-Jun	915	3	0.328			
17-Jun	402	3	0.746			
18-Jun	490	0	0.000	159	0	0.000
19-Jun	1264	17	1.345			
20-Jun	1074	10	0.931	137	0	0.000
21-Jun	805	3	0.373			
22-Jun	203	4	1.970	127	0	0.000
23-Jun	768	12	1.563	280	0	0.000

Table 5—cont.

Date	Lower Black River			Chiaktuak Creek		
	number released	number recaptured	efficiency (% recaptured)	number released	number recaptured	efficiency (% recaptured)
24-Jun	527	2	0.380	273	0	0.000
25-Jun						
26-Jun						
27-Jun						
28-Jun						
29-Jun	851	2	0.235	177	0	0.000
30-Jun	201	0	0.000			
1-Jul	268	1	0.373			
2-Jul	223	0	0.000	225	0	0.000
3-Jul	360	1	0.278	378	6	1.587
4-Jul	470	1	0.213	705	16	2.270
5-Jul	95	1	1.053	235	12	5.106
6-Jul				398	5	1.256
7-Jul				371	5	1.348
8-Jul						
9-Jul				187	7	3.743
10-Jul						

Table 6. Daily abundances of sockeye salmon fry emigrating from Chiaktuak Creek, 1992. Estimates of total fry emigrating were based on mark-recapture tests.

Date	Fry captured	Fry migrating
15-May	33	1,848
16-May	316	17,696
17-May	100	5,600
18-May	66	3,696
19-May	25	1,400
20-May	114	6,384
21-May	304	17,024
22-May	293	16,408
23-May	176	9,856
24-May	205	11,480
25-May	194	10,864
26-May	88	43,120
27-May	36	17,640
28-May	74	36,260
29-May	Flood	46,223
30-May	303	148,470
31-May	38	18,620
1-Jun	27	13,230
2-Jun	37	18,130
3-Jun	Flood	13,130
4-Jun	Flood	13,130
5-Jun	Flood	13,130
6-Jun	Flood	13,130
7-Jun	Flood	13,130
8-Jun	83	7,470
9-Jun	135	12,150
10-Jun	102	9,180
11-Jun	115	10,350
12-Jun	180	16,200
13-Jun	75	6,750
14-Jun	100	9,000
15-Jun	208	18,720
16-Jun	189	17,010
17-Jun	277	24,930
18-Jun	110	9,900
19-Jun	247	22,230
20-Jun	161	14,490
21-Jun	232	20,880
22-Jun	309	22,248
23-Jun	290	20,880
24-Jun	308	22,176
25-Jun		15,912

Table 6—cont.

Date	Fry captured	Fry migrating
26-Jun	80	5,760
27-Jun	143	10,296
28-Jun	196	14,112
29-Jun	32	2,304
30-Jun	101	7,272
1-Jul	289	20,808
2-Jul	436	31,392
3-Jul	719	51,768
4-Jul	256	18,432
5-Jul	765	55,080
6-Jul	587	42,264
7-Jul	81	5,832
8-Jul	195	14,040
9-Jul	248	17,856
sum	9,678	1,087,291

note: some fry escaped from the live box during 5/15 to 6/8 due to improper mesh size on the live box; catches for this period were estimated from tests between 6/9 and 6/21.
Number of escaped fry = 0.601(#fry in box) + 6.75, $r^2=0.94$, $n=13$, $p=0.001$.

Table 7. Total daily catches of upstream-migrating fishes in blocking seine 1, Black River, 1992. Sampling days began at 2200 hrs on the previous day and ended at 2200 hrs on the date shown.

Date	Sockeye fry	Marked sockeye	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
15-May	1	0	0	22	29	17	1
16-May	5	0	4	6	11	4	0
17-May	0	0	13	17	16	11	0
18-May	5	0	4	3	7	3	0
19-May	6	0	2	6	12	4	0
20-May	4	0	2	1	4	2	0
21-May	57	0	11	0	25	2	1
22-May	91	0	5	1	19	1	0
23-May	4	0	1	2	31	1	1
24-May	4	0	3	0	13	2	8
25-May	1	0	0	2	11	9	0
26-May	0	0	0	0	0	0	0
27-May	2	0	8	1	8	1	0
28-May	0	0	2	6	8	1	0
29-May	2	0	2	2	8	0	0
30-May	0	0	4	3	3	0	0
31-May	0	0	3	1	2	0	0
1-Jun	0	0	33	1	10	6	0
2-Jun	0	0	8	1	2	0	0
3-Jun	0	0	3	0	1	0	0
4-Jun	No sampling due to flooding						
5-Jun	No sampling due to flooding						
6-Jun	No sampling due to flooding						
7-Jun	No sampling due to flooding						
8-Jun	1	0	2	1	4	0	0
9-Jun	2	0	2	0	2	2	0
10-Jun	4	0	12	0	2	0	0
11-Jun	0	0	5	0	1	5	0
12-Jun	2	0	12	1	3	0	0
13-Jun	0	0	7	0	1	0	0
14-Jun	0	0	3	0	1	0	0
15-Jun	1	0	3	3	1	0	0
16-Jun	0	0	7	0	0	0	0
17-Jun	0	0	7	0	0	0	0
18-Jun	2	0	3	0	0	0	0
19-Jun	0	0	2	0	0	0	0

Table 7—cont.

Date	Sockeye fry	Marked sockeye	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
20-Jun	0	0	1	0	1	3	0
21-Jun	0	0	0	0	0	0	0
22-Jun	0	0	2	1	0	0	0
23-Jun	2	0	3	0	0	0	0
24-Jun	1	0	3	1	0	0	0
25-Jun	No sampling						
26-Jun	0	0	59	2	2	0	0
27-Jun	1	0	16	1	1	2	0
28-Jun	0	0	0	0	0	0	0
29-Jun	0	2	11	1	1	0	0
30-Jun	0	0	3	0	5	2	0
1-Jul	0	0	0	0	0	0	0
2-Jul	0	0	3	0	2	0	0
3-Jul	0	0	13	0	1	2	0
4-Jul	0	0	24	2	1	3	0
5-Jul	0	0	10	0	0	0	0
6-Jul	0	0	0	2	0	0	0
7-Jul	0	0	1	0	0	0	0
8-Jul	0	0	0	0	0	0	0
9-Jul	0	0	0	0	0	1	0

Table 8. Total daily catches of upstream-migrating fishes in blocking seine 3, Black River, 1992. Sampling days began at 2200 hrs on the previous day and ended at 2200 hrs on the date shown.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
15-May	2	1	0	1	5	0
16-May	6	0	2	13	4	0
17-May	2	1	1	24	8	0
18-May	6	0	1	19	26	0
19-May	9	0	0	13	4	0
20-May	1	0	0	16	4	0
21-May	19	0	0	6	19	0
22-May	70	7	0	39	16	0
23-May	133	1	0	14	8	1
24-May	21	11	0	17	9	0
25-May	7	4	0	40	18	0
26-May	No sampling					
27-May	7	5	1	8	0	0
28-May	7	3	7	8	3	0
29-May	6	4	0	7	2	0
30-May	7	1	1	10	2	0
31-May	1	0	0	2	0	0
1-Jun	0	8	0	4	5	0
2-Jun	1	0	0	3	0	0
3-Jun	1	1	0	1	0	0
4-Jun	No sampling due to flooding					
5-Jun	No sampling due to flooding					
6-Jun	No sampling due to flooding					
7-Jun	0	1	0	1	1	0
8-Jun	0	0	0	1	0	0
9-Jun	0	1	0	4	2	0
10-Jun	0	3	0	5	0	0
11-Jun	2	6	0	2	1	0
12-Jun	0	1	0	0	0	0
13-Jun	0	3	0	1	0	0
14-Jun	No sampling					
15-Jun	1	0	0	1	0	0
16-Jun	0	0	0	0	0	0
17-Jun	0	0	0	0	0	0
18-Jun	0	0	1	0	0	0
19-Jun	0	0	0	0	0	0

Table 8—cont.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
20-Jun	0	2	0	2	0	0
21-Jun	1	0	0	0	0	0
22-Jun	5	2	0	1	6	0
23-Jun	2	1	0	4	4	0
24-Jun	5	1	0	1	1	0
25-Jun	No sampling					
26-Jun	0	0	0	2	1	0
27-Jun	0	6	0	2	0	0
28-Jun	No sampling					
29-Jun	0	0	0	2	0	0
30-Jun	0	2	0	1	3	0
1-Jul	3	0	0	0	1	0
2-Jul	1	1	0	1	1	0
3-Jul	0	0	0	0	0	0
4-Jul	1	1	0	1	0	0
5-Jul	0	1	0	2	2	0
6-Jul	0	2	0	0	0	0
7-Jul	1	3	0	2	3	0
8-Jul	0	0	0	0	0	0
9-Jul	0	1	0	1	0	0

Table 9. Total daily catches of upstream-migrating fishes in blocking seine 2, Black River, 1992. Sampling days began at 2200 hrs on the previous day and ended at 2200 hrs on the date shown.

Date	Sockeye fry	Marked sockeye	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
15-May	0	0	0	0	0	0	0
16-May	3	0	1	0	5	2	0
17-May	0	0	2	1	9	1	0
18-May	0	0	1	0	1	2	0
19-May	1	0	0	2	1	0	0
20-May	1	0	1	0	0	0	0
21-May	6	0	8	2	3	0	0
22-May	1	0	3	2	3	0	0
23-May	2	0	2	14	3	2	1
24-May	1	0	0	2	7	0	0
25-May	0	0	1	7	10	5	0
26-May	0	0	0	0	0	0	0
27-May	0	0	5	0	0	0	0
28-May	1	0	1	0	2	0	0
29-May	0	0	0	2	1	0	0
30-May	0	0	0	0	1	0	0
31-May	0	0	0	0	0	0	0
1-Jun	0	0	6	1	0	0	0
2-Jun	No sampling due to flooding						
3-Jun	No sampling due to flooding						
4-Jun	No sampling due to flooding						
5-Jun	No sampling due to flooding						
6-Jun	No sampling due to flooding						
7-Jun	0	0	1	2	2	0	0
8-Jun	0	0	5	1	0	0	0
9-Jun	1	0	0	0	1	0	0
10-Jun	0	0	0	0	0	0	0
11-Jun	0	0	1	0	1	0	0
12-Jun	0	0	0	0	0	0	0
13-Jun	0	0	0	1	1	0	1
14-Jun	0	0	1	2	0	3	0
15-Jun	0	0	0	0	0	0	1
16-Jun	0	0	0	0	0	0	0
17-Jun	0	0	1	0	0	0	0
18-Jun	0	0	1	1	0	0	0
19-Jun	0	0	1	0	0	0	0

Table 9—cont.

Date	Sockeye fry	Marked sockeye	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
20-Jun	0	0	0	0	0	0	0
21-Jun	No sampling						
22-Jun	0	0	3	0	1	0	0
23-Jun	0	0	1	0	0	0	0
24-Jun	0	0	0	0	0	0	0
25-Jun	No sampling						
26-Jun	0	0	2	0	0	0	0
27-Jun	2	0	3	0	0	0	0
28-Jun	No sampling						
29-Jun	5	2	1	0	0	0	0
30-Jun	0	0	2	0	0	0	0
1-Jul	0	0	0	0	0	0	0
2-Jul	0	0	6	0	0	0	0
3-Jul	50	0	18	0	1	0	0
4-Jul	0	0	1	0	0	0	0
5-Jul	0	0	13	0	0	0	0
6-Jul	0	0	1	0	0	0	0
7-Jul	0	0	5	0	0	0	0
8-Jul	0	0	2	0	0	0	0
9-Jul	0	0	7	0	0	0	0

Table 10. Total daily catches of upstream-migrating fishes in blocking seine 4, Black River, 1992. Sampling days began at 2200 hrs on the previous day and ended at 2200 hrs on the date shown.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
15-May	0	0	0	3	2	0
16-May	1	0	1	10	5	0
17-May	2	1	0	18	5	0
18-May	2	0	0	3	2	0
19-May	2	0	0	5	1	0
20-May	1	0	0	8	12	0
21-May	0	0	0	8	18	0
22-May	4	0	0	5	9	0
23-May	2	0	1	9	7	0
24-May	2	2	0	13	17	1
25-May	15	4	3	7	6	0
26-May	No sampling					
27-May	1	4	0	2	1	0
28-May	4	7	1	7	4	0
29-May	1	2	0	5	3	0
30-May	16	8	0	3	2	0
31-May	0	1	0	0	0	0
1-Jun	2	1	0	0	0	0
2-Jun	0	1	0	3	3	0
3-Jun	0	3	1	0	0	0
4-Jun	No sampling due to flooding					
5-Jun	No sampling due to flooding					
6-Jun	No sampling due to flooding					
7-Jun	0	0	1	2	3	0
8-Jun	1	2	1	10	1	0
9-Jun	6	1	0	22	3	0
10-Jun	3	6	0	3	0	0
11-Jun	2	4	0	12	5	0
12-Jun	0	2	0	1	0	0
13-Jun	3	1	0	4	0	0
14-Jun	1	1	0	3	7	0
15-Jun	3	1	0	2	1	0
16-Jun	0	3	0	4	0	0
17-Jun	7	1	2	2	0	0
18-Jun	4	2	1	15	26	0
19-Jun	2	1	0	1	3	0
20-Jun	4	1	2	14	2	0

Table 10—cont.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
21-Jun	2	2	0	12	2	0
22-Jun	1	2	0	7	1	0
23-Jun	1	2	1	5	0	0
24-Jun	0	1	0	1	0	0
25-Jun	No sampling					
26-Jun	2	2	0	2	0	0
27-Jun	3	2	0	3	0	0
28-Jun	No sampling					
29-Jun	1	2	0	11	0	0
30-Jun	2	1	0	1	1	0
1-Jul	1	1	0	0	1	0
2-Jul	0	2	0	1	0	0
3-Jul	1	2	0	2	0	0
4-Jul	No sampling					
5-Jul	0	0	0	0	0	0
6-Jul	0	0	0	2	0	0
7-Jul	0	10	0	5	5	0
8-Jul	1	0	0	2	0	0
9-Jul	0	1	0	2	5	0

Table 11. Total daily catches of upstream-migrating fishes in blocking seine 5, Black River, 1992.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond Smelt
15-May						
16-May	49	3	0	7	4	0
17-May	100	4	1	2	5	0
18-May	2	0	0	11	5	0
19-May	9	2	0	6	2	0
20-May	43	2	0	3	6	0
21-May	25	5	0	3	2	1
22-May	9	2	0	1	4	0
23-May	15	6	6	36	11	57
24-May	11	6	17	7	3	146
25-May	1	1	3	10	4	7
26-May	No sampling					
27-May	2	2	10	14	17	47
28-May	1	2	0	10	13	39
29-May	0	0	1	5	11	23
30-May	0	0	1	4	5	14
31-May	No sampling					
1-Jun	0	1	3	35	21	70
2-Jun	0	0	4	13	12	60
3-Jun	No sampling due to flooding					
4-Jun	No sampling due to flooding					
5-Jun	No sampling due to flooding					
6-Jun	No sampling due to flooding					
7-Jun	No sampling due to flooding					
8-Jun	No sampling due to flooding					
9-Jun	No sampling due to flooding					
10-Jun	No sampling due to flooding					
11-Jun	No sampling due to flooding					
12-Jun	No sampling due to flooding					
13-Jun	No sampling due to flooding					
14-Jun	No sampling due to flooding					
15-Jun	No sampling due to flooding					
16-Jun	No sampling due to flooding					
17-Jun	No sampling due to flooding					
18-Jun	0	0	0	1	1	0
19-Jun	0	0	0	0	0	0
20-Jun	0	0	0	2	0	0
21-Jun	0	1	0	0	2	0
22-Jun	0	2	0	1	2	0
23-Jun	0	2	0	1	1	0
24-Jun	0	0	0	1	0	0
25-Jun	No sampling					
26-Jun	0	8	0	0	5	0
27-Jun	2	8	9	1	1	0
28-Jun	Sampling stopped due to bears					

Table 12. Total daily catches of upstream-migrating fishes in blocking seine 6, Black River, 1992. Sampling days began at 2200 hrs on the previous day and ended at 2200 hrs on the date shown.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond smelt
15-May						
16-May	3	0	1	3	0	51
17-May	0	0	0	20	2	5
18-May	0	0	1	16	1	157
19-May	0	1	1	45	4	360
20-May	0	0	4	41	10	1124
21-May	0	0	1	77	6	1129
22-May	0	0	8	96	19	395
23-May	0	5	0	1111	34	1821
24-May	0	0	0	178	30	1610
25-May	0	0	0	154	176	3238
26-May	No sampling					
27-May	0	0	20	27	75	267
28-May	0	28	20	55	139	1417
29-May	0	6	4	52	17	149
30-May	0	0	10	28	31	13
31-May	No sampling					
1-Jun	0	33	22	54	88	803
2-Jun	0	3	11	0	13	346
3-Jun	No sampling due to flooding					
4-Jun	No sampling due to flooding					
5-Jun	No sampling due to flooding					
6-Jun	No sampling due to flooding					
7-Jun	No sampling due to flooding					
8-Jun	No sampling due to flooding					
9-Jun	No sampling due to flooding					
10-Jun	No sampling due to flooding					
11-Jun	No sampling due to flooding					
12-Jun	No sampling due to flooding					
13-Jun	No sampling due to flooding					
14-Jun	No sampling due to flooding					
15-Jun	No sampling due to flooding					
16-Jun	No sampling due to flooding					
17-Jun	No sampling due to flooding					
18-Jun	0	0	0	18	35	9
19-Jun	0	0	0	2	3	0

Table 12—cont.

Date	Sockeye fry	Coho fry	Coho yearling	Ninespine stickleback	Threespine stickleback	Pond smelt
20-Jun	0	0	0	1	0	0
21-Jun	0	4	8	39	74	5
22-Jun	0	1	0	2	8	1
23-Jun	0	7	1	5	4	3
24-Jun	0	1	3	4	33	1
25-Jun	No sampling					
26-Jun	0	2	7	4	9	0
27-Jun	0	26	5	11	43	19
28-Jun	No sampling					
29-Jun	0	38	0	3	5	0
30-Jun	0	2	0	6	16	2
1-Jul	No sampling					
2-Jul	0	0	0	0	14	0
3-Jul	0	8	0	1	7	0
4-Jul	2	12	0	1	2	1
5-Jul	0	10	0	0	5	0
6-Jul	Sampling stopped due to net damage					

Table 13. Depth profiles of chlorophyll and water temperature in Chignik Lake, 1992.

CLARK BAY

	23-Jun		11-Jul		6-Sep	
Depth (m)	Temperature (°C)	Chlorophyll a (mg/m^3)	Temperature (°C)	Chlorophyll a (mg/m^3)	Temperature (°C)	Chlorophyll a (mg/m^3)
1	9.0	3.71	9.7	3.38	10.8	5.08
3	9.0	3.68		3.77	10.8	
5	9.0	4.52		3.96	10.8	3.93
7	9.0	4.21		2.85	10.8	6.79
10	9.0	4.15		3.52	10.8	
15	8.5	4.34		3.09	10.8	
20	8.0	4.50		1.35	10.8	6.86
Wt. ave.		4.20		3.11		6.10

DELTA

	23-Jun		11-Jul		6-Sep	
Depth (m)	Temperature (°C)	Chlorophyll a (mg/m^3)	Temperature (°C)	Chlorophyll a (mg/m^3)	Temperature (°C)	Chlorophyll a (mg/m^3)
1	10.8	2.64	10.1	3.08	10.8	7.56
3	10.8	2.90		1.58	10.8	
5	10.8	2.80		2.16	10.8	5.81
7	10.8	2.32		1.93	10.8	3.72
10	10.4	2.13		1.65	10.8	3.67
15	10.2	2.98		2.24	10.8	6.88
20	9.5	1.70			10.8	5.20
Wt. ave.		2.51		2.07		5.53

Table 14. Zooplankton abundance estimates (#/m^3) in Chignik Lake, 1992. Estimates are based on 40-m vertical net hauls.

Date	Time	Area	Secchi depth (m)	Temp. (c)	Net size (μ)	Total zooplankton	Calanoid	Cyclopoid	Daphnia	Bosmina	Holopedium	Nauplii	Asplanchna	Other
19-May	1715	A			153	11,360	76	10,087	713	51	0	229	178	25
19-May	1700	B			153	21,633	30	20,504	505	30	0	446	119	0
19-May	2215	C	4.0	2.9	153	9,590	45	12,615	847	0	0	178	89	0
19-May	2145	E	3.9	3.0	153	10,844	0	8,514	1,516	0	0	548	267	0
19-May	2200	D	4.0	2.8	153	9,590	0	9,284	38	0	0	0	267	0
		Average				**12,604**	**30**	**12,201**	**724**	**16**	**0**	**280**	**184**	**5**
6-Jun	1300	C	1.3	7.0	153	9,628	85	9,467	382	0	0	297	1,359	0
6-Jun	1300	C	1.3	7.0	153	9,747	89	8,588	357	30	0	149	535	0
6-Jun	1300	C	1.3	7.0	223	9,628	0	8,692	490	0	0	0	446	0
6-Jun	1345	Transition	2.0	6.5	153	3,490	0	3,413	166	13	0	191	89	0
6-Jun	1345	Transition	2.0	6.5	153	3,031	13	2,050	166	25	0	178	599	0
6-Jun	1345	Transition	2.0	6.5	223	3,490	0	3,222	115	13	0	0	140	0
6-Jun	1215	D	2.5	6.0	153	9,838	64	8,406	191	0	32	0	64	0
6-Jun	1215	D	2.5	6.0	153	12,672	32	11,812	509	32	0	96	191	0
6-Jun	1215	D	2.5	6.0	223	9,838	32	9,138	605	0	0	0	64	0
23-Jun	1140	A	1.5	10.8	153	7,864	764	4,489	64	255	0	446	1,847	0
23-Jun		A			223	4,691	340	3,184	149	42	0	0	976	0
23-Jun	1045	B	1.5	10.5	153	9,494	178	6,954	446	0	0	401	1,516	0
23-Jun		B			223	10,341	204	7,539	408	51	0	153	1,987	0
23-Jun	1020	C	2.0	9.0	153	8,660	478	6,463	382	127	0	32	1,146	32
23-Jun		C			223	6,283	212	4,436	318	42	0	0	1,274	0
23-Jun	940	E (20 m)	2.5	8.5	153	5,383	255	1,936	509	68	0	357	2,259	0
23-Jun	1000	D	2.0	9.0	153	10,793	318	7,227	891	32	0	191	2,133	0
23-Jun		D			223	7,323	446	4,585	669	0	0	0	1,624	0
		Average	1.9	9.6	153	**9,203**	**435**	**6,283**	**446**	**103**	**0**	**267**	**1,660**	**8**
		Average			223	**7,160**	**300**	**4,936**	**386**	**34**	**0**	**38**	**1,465**	**0**

Table 14—cont.

Date	Time	Area	Secchi depth (m)	Temp. (c)	Net size (μ)	Total zooplankton	Calanoid	Cyclopoid	Daphnia	Bosmina	Holopedium	Nauplii	Asplanchna	Other
11-Jul	1300	A	1.8	10.1	153	12,685	306	7,234	713	306	0	102	3,923	102
11-Jul		A			223	8,707	149	4,606	535	565	0	0	2,823	30
11-Jul	1235	B	2.0	10.7	153	14,328	796	4,744	796	350	0	637	7,005	0
11-Jul		B			223	5,897	446	1,745	777	140	0	0	2,789	0
11-Jul	1215	C	1.8	10.4	153	11,441	722	4,542	679	340	0	212	4,946	0
11-Jul		C			223	7,590	382	1,656	586	306	0	0	4,661	0
11-Jul	1130	E	3.5	9.7	153	14,213	357	4,534	1,223	408	0	102	7,539	51
11-Jul		E			223	6,839	153	2,025	650	76	0	0	3,935	0
11-Jul	1150	D	3.5	9.7	153	11,284	509	3,770	841	586	0	76	5,476	25
11-Jul		D			223	8,172	233	2,483	531	255	0	0	4,670	0
		Average	2.5	10.1	153	**12,790**	**538**	**4,965**	**850**	**398**	**0**	**226**	**5,778**	**36**
		Average			223	**7,441**	**273**	**2,503**	**616**	**268**	**0**	**0**	**3,776**	**6**
31-Aug	1645	A	2.0	12.0	153	38,207	11,080	5,413	5,858	13,436	0	2,101	318	0
31-Aug	1630	B		11.5	153	35,193	8,873	5,137	5,773	12,481	0	1,953	976	0
31-Aug	1620	C			153	24,452	6,240	3,757	4,394	6,240	0	2,866	955	0
31-Aug	1615	E			153	21,803	4,687	3,770	3,923	4,636	0	3,260	1,528	0
31-Aug	1600	D	2.7	11.0	153	27,297	4,712	4,075	5,773	5,434	0	6,495	807	0
		Average			153	**29,390**	**7,118**	**4,430**	**5,144**	**8,445**	**0**	**3,335**	**917**	**0**
Seasonal average					**153**	**15,997**	**2,030**	**6,970**	**1,791**	**2,241**	**0**	**1,027**	**2,135**	**12**

Table 15. Zooplankton abundance estimates (#/m^2) in Chignik Lake, 1992. Estimates are based on 40-m vertical net hauls.

Date	Area	Net size (µ)	Total zooplankton	Calanoid	Cyclopoid	Daphnia	Bosmina	Holopedium	Nauplii	Asplanchna	Other
19-May	A	153	454,385	3,056	403,445	28,526	2,038	0	9,169	7,132	1,019
19-May	B	153	865,297	1,187	820,134	20,208	1,187	0	17,829	4,753	0
19-May	C	153	383,578	1,783	504,561	33,875	0	0	7,132	3,566	0
19-May	E	153	433,754	0	340,534	60,619	0	0	21,904	10,697	0
19-May	D	153	383,578	0	371,353	1,528	0	0	0	10,697	0
	Average		**504,119**	**1,205**	**488,005**	**28,951**	**645**	**0**	**11,207**	**7,369**	**204**
6-Jun	C	153	385,106	3,398	378,652	15,282	0	0	11,884	54,338	0
6-Jun	C	153	389,859	3,566	343,504	14,263	1,187	0	5,945	21,395	0
6-Jun	C	223	385,106	0	347,666	19,612	0	0	0	17,829	0
6-Jun	Transition	153	139,576	0	136,519	6,622	509	0	7,641	3,566	0
6-Jun	Transition	153	121,237	509	82,013	6,622	1,019	0	7,132	23,942	0
6-Jun	Transition	223	139,576	0	128,878	4,585	509	0	0	5,603	0
6-Jun	D	153	393,512	2,547	336,204	7,641	0	1,274	0	2,547	0
6-Jun	D	153	506,853	1,274	472,469	20,376	1,274	0	3,821	7,641	0
6-Jun	D	223	393,512	1,274	365,495	24,197	0	0	0	2,547	0
23-Jun	A	153	314,555	30,564	179,564	2,547	10,188	0	17,829	73,863	0
23-Jun	A	223	187,632	13,586	127,350	5,945	1,696	0	0	39,056	0
23-Jun	B	153	379,758	7,132	278,132	17,829	0	0	16,046	60,619	0
23-Jun	B	223	413,633	8,150	301,565	16,301	2,038	0	6,113	79,466	0
23-Jun	C	153	346,392	19,103	258,521	15,282	5,094	0	1,274	45,846	1,274
23-Jun	C	223	251,302	8,492	177,439	12,735	1,696	0	0	50,940	0
23-Jun	E (20 m)	153	107,657	5,094	38,714	10,188	1,360	0	7,132	45,168	0
23-Jun	D	153	431,717	12,735	289,085	35,658	1,274	0	7,641	85,325	0
23-Jun	D	223	292,905	17,829	183,384	26,744	0	0	0	64,949	0
	Average	153	**368,105**	**17,383**	**251,325**	**17,829**	**4,139**	**0**	**10,697**	**66,413**	**318**
	Average	223	**286,368**	**12,014**	**197,435**	**15,431**	**1,358**	**0**	**1,528**	**58,603**	**0**

Table 15—cont.

Date	Area	Net size (μ)	Total zooplankton	Calanoid	Cyclopoid	Daphnia	Bosmina	Holopedium	Nauplii	Asplanchna	Other
11-Jul	A	153	507,362	12,226	289,339	28,526	12,226	0	4,075	156,895	4,075
11-Jul	A	223	348,261	5,945	184,235	21,395	22,582	0	0	112,919	1,187
11-Jul	B	153	573,075	31,838	189,752	31,838	14,009	0	25,470	280,170	0
11-Jul	B	223	235,852	17,829	69,788	31,073	5,603	0	0	111,559	0
11-Jul	C	153	457,614	28,868	181,688	27,166	13,586	0	8,492	197,815	0
11-Jul	C	223	303,602	15,282	66,222	23,432	12,226	0	0	186,440	0
11-Jul	E	153	568,490	14,263	181,346	48,902	16,301	0	4,075	301,565	2,038
11-Jul	E	223	273,548	6,113	80,995	25,979	3,056	0	0	157,405	0
11-Jul	D	153	451,328	20,376	150,782	33,620	23,432	0	3,056	219,042	1,019
11-Jul	D	223	326,867	9,337	99,333	21,227	10,188	0	0	186,782	0
	Average	153	**511,574**	**21,514**	**198,581**	**34,011**	**15,911**	**0**	**9,034**	**231,097**	**1,426**
	Average	223	**297,626**	**10,901**	**100,114**	**24,621**	**10,731**	**0**	**0**	**151,021**	237
31-Aug	A	153	1,528,200	443,178	216,495	234,324	537,417	0	84,051	12,735	0
31-Aug	B	153	1,407,640	354,884	205,456	230,926	499,212	0	78,106	39,056	0
31-Aug	C	153	978,048	249,606	150,273	175,743	249,606	0	114,615	38,205	0
31-Aug	E	153	872,093	187,459	150,782	156,895	185,422	0	130,406	61,128	0
31-Aug	D	153	1,091,812	188,478	163,008	230,926	217,346	0	259,794	32,260	0
	Average	153	**1,175,559**	**284,721**	**177,203**	**205,763**	**337,800**	**0**	**133,395**	**36,677**	**0**
Seasonal average		**153**	**639,839**	**81,206**	**278,779**	**71,638**	**89,624**	**0**	**41,083**	**85,389**	**487**

Table 16. Daily catches of fishes by the incline plane trap set at the outlet of Chignik Lake, 1992.

	Temp.	Sockeye			Coho				3-spine	9-spine	Dolly	Pond	
Date	°C	Smolt	Fry	Yearling	Fry	Yearling	Smolt	Sculpin	stickleback	stickleback	Varden	smelt	Whitefish
16-Jun		12	2	0	0	0	0	0	2	0	0	0	0
17-Jun	6.5	95	34	0	0	1	0	41	3	0	0	0	0
18-Jun	7.0	42	23	0	0	2	0	28	7	0	0	0	0
19-Jun	7.0	19	29	0	0	0	0	54	1	0	0	0	0
20-Jun	7.3	26	22	0	0	0	1	49	11	2	0	1	0
21-Jun	7.6	15	49	0	1	2	0	32	9	0	0	0	0
22-Jun	16	28	108	0	0	0	0	47	2	0	0	1	0
23-Jun	17	3	141	0	0	0	0	22	1	1	0	1	0
24-Jun	19	4	77	0	0	0	0	37	3	3	0	0	2
25-Jun	9	5	31	1	0	0	0	22	3	1	0	0	0
26-Jun	16	0	33	2	0	0	0	22	3	0	1	0	0
27-Jun	16	1	9	1	0	0	0	18	0	0	0	0	0
28-Jun	18	3	6	0	0	0	0	32	2	1	0	1	0
29-Jun	19	2	9	0	0	0	0	15	1	1	0	0	0
30-Jun	20	4	16	0	0	0	0	17	3	4	0	0	0
1-Jul	19	0	8	1	0	0	0	11	2	0	0	0	0
2-Jul	19	0	5	1	0	0	0	16	0	2	0	0	0
3-Jul	18	0	2	0	0	0	0	6	3	1	0	0	0
4-Jul	19	1	0	0	0	0	0	19	2	2	0	0	0
5-Jul	19	0	0	1	0	0	0	12	2	0	0	0	0
6-Jul	18	0	0	0	0	1	0	12	1	0	0	1	0
7-Jul	18	1	0	0	0	0	0	9	0	1	0	0	0
8-Jul	19	0	0	0	0	0	0	7	3	2	0	0	0
9-Jul	19	0	0	0	0	0	0	12	10	0	0	0	0
10-Jul	20	0	0	0	0	0	0	15	1	2	8	0	0
11-Jul	20	0	0	0	0	0	0	0	0	5	1	2	0
12-Jul	20	10	0	0	0	0	0	0	0	5	0	0	0

Table 17. Summary of fry emergence rates in Chignik Lake during June 1986-92. Values are geometric and arithmetic mean fry per m^2 per 30 days.

Location	1986	1987	1988	1989	1990	1991	1992	Average
	Geometric mean emergence rates							
S. Hatchery South	6.3	9.5	18.4	6.6	2.8	8.1	5.6	8.2
S. Hatchery North	26.3	40.3	43.5	2.9	6.2	13.4	5.0	19.6
North Hatchery	17.5	28.3	32.7	8.4	8.0	8.1	5.6	15.5
Delta	12.8	25.1	40.4	15.8	12.3	2.7	6.3	16.5
Average	15.7	25.8	33.8	8.4	7.3	8.1	5.6	15.0
Area wt. index	18.0	29.2	36.4	7.8	7.5	8.8	5.5	16.2
	Arithmetic mean emergence rates							
S. Hatchery South	10.4	36.3	47.1	9.5	5.5	22.7	11.7	20.5
S. Hatchery North	106.7	63.2	114.6	9.4	14.3	40.9	13.6	51.8
North Hatchery	37.6	38.2	62.6	19.9	12.4	22.7	11.7	29.3
Delta	16.7	45.2	63.1	40.8	30.2	4.6	9.9	30.1
Average	42.9	45.7	71.8	19.9	15.6	22.7	11.7	32.9
Area wt. index	54.5	48.8	79.8	19.2	16.2	25.3	12.0	36.5

Note: In 1991 and 1992 the S. Hatchery South and North Hatchery areas were not sampled. Values shown are means of the S. Hatchery North and Delta areas.

Table 18. Mean catch of fishes in beach seine hauls in Chignik Lake. Standard errors are shown in parentheses.

		Sockeye		Coho				Threespine	Ninespine		
Date	n	age-0	age-1&2	LT 70 mm	GE 70 mm	Chinook	Char	stickleback	stickleback	Sculpin	Whitefish
6-Jun	8	17.4	13.2	6.4	6.1	0	3.9	29	6.9	5.8	0.6
		(8.2)	(4.7)	(2.4)	(1.8)	(0.0)	(0.9)	(25.6)	(2.4)	(2.6)	(0.3)
27-Jun	7	2.7	18.1	4.9	9.1	0	10.4	231	40	20.4	2.6
		(2.4)	(17.0)	(2.4)	(3.5)	(0.0)	(8.0)	(211.0)	(33.0)	(7.7)	(1.0)
11-Jul	6	8.8	2.2	5.7	14.3	2.2	23.3	192	15.7	7.2	6.7
		(5.2)	(1.6)	(1.7)	(5.7)	(1.5)	(7.4)	(123.0)	(5.0)	(2.0)	(3.7)
Average		9.6	11.2	5.7	9.8	0.7	12.5	150.7	20.9	11.1	3.3

APPENDIX

Appendix Table 1. Percentage of age 1.x sockeye on the spawning grounds of Black River tributaries, Alec River, and Chignik Lake creeks and shoreline spawning areas. Age composition determined from otolith readings. Data source: ADFG annual management reports 1964-80.

Year	Black River tributaries	Alec River	Chignik Lake
1964	76	91	21
1965	76	99	37
1966	27	62	33
1967	64	89	9
1968	53	93	12
1969			
1970	68	83	46
1971	91	91	30
1972	28	64	13
1973	72	98	18
1974	17	75	10
1975			
1976	84	82	19
1977			
1978	12	76	7
1979	17	23	35
1980	55	53	15