CHIGNIK WATERSHED ECOLOGICAL ASSESSMENT PROJECT SEASON REPORT, 2002

By

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ABSTRACT

The Chignik watershed serves as the freshwater rearing habitat for the majority of the salmon *Oncorhynchus nerka* that are harvested within the Chignik Management Area. The watershed consists of several separate habitats. Black Lake, via Black River, drains to Chignik Lake. Chignik Lake drains to Chignik Lagoon and the Gulf of Alaska via the Chignik River. The sockeye salmon carrying capacity of the watershed was last estimated in the 1960s; subsequently, adult sockeye salmon escapement goals were recommended and implemented. Morphological changes to the watershed since that time, specifically the natural erosion of Black Lake, has prompted a new investigation of the carrying capacity of the watershed. Data from this project will also serve as baseline information for assessment of future sockeye salmon production trends. Limnological data including water quality and zooplankton species composition, abundance, and size were collected. Juvenile sockeye salmon were sampled throughout the watershed and relative abundance, size, and age data were recorded. Sockeye salmon forage availability in Chignik Lake was identified as a likely limiting factor for sockeye salmon production in the Chignik watershed. Top-down pressures (through excessive historical escapements and subsequent grazing pressure) on the zooplankton community in Chignik Lake were thought to be disrupting the trophic flow of energy and nutrients to sockeye salmon. Based on this information, it was recommended that, in the near term, the lower range of the escapement goals to the Chignik watershed be targeted to alleviate the grazing pressure on the Chignik Lake zooplankton community. A complete review of the escapement goals to the Chignik watershed will be forthcoming.

INTRODUCTION

The Chignik watershed serves as the freshwater rearing habitat for the majority of the salmon *Oncorhynchus nerka* that are harvested within the Chignik Management Area (Owen et al. 2000). The sockeye salmon carrying capacity of the watershed was last estimated in the 1960s; subsequently, adult sockeye salmon escapement goals were recommended and implemented. Morphological changes to the watershed since that time, specifically the natural erosion of a portion of the watershed, has prompted a new investigation of the carrying capacity of the watershed. Data from this project will also serve as baseline information for assessment of future sockeye salmon production trends. This study seeks to provide additional insight into the dynamic relationships among the Chignik ecosystem and its juvenile sockeye salmon.

Two lakes, two major rivers, a lagoon, and various small creeks compose the Chignik watershed (Figures 1 through 4). Black Lake, at the head of the system, is an atypical sockeye salmon nursery lake; its surface area is large (41.1 km^2), yet it is shallow (mean depth 1.9 m, maximum depth 4.2 m; Ruggerone et al. 1993), and semi-turbid (Figure 2). Chignik Lake is a more typical sockeye salmon lake in that it has a relatively large surface area (24.1 km^2) but it is also deep (mean depth of 26 m). Black River connects the two lakes (Figure 3). Both lakes are considered oligotrophic (Kyle 1992) and each maintains its own genetically distinct sockeye salmon run (Templin et al. 1999). The early run, which returns during June and July (escapement goal range of 350,000 to 400,000 sockeye salmon; Nelson and Lloyd 2001), spawns in Black Lake and its tributaries. The smaller late run (escapement goal range of 200,000 to 250,000 sockeye salmon; Nelson and Lloyd 2001), that returns between July and September, utilizes the beaches of Chignik Lake and its tributaries for spawning. Chignik Lake drains into the Chignik Lagoon through the Chignik River (Figure 4). The lagoon is shallow, grassy and is composed of silty and cobbled beaches.

It has been noted that Black Lake has been progressively getting shallower and is approximately half the depth measured in the 1950s (Ruggerone et al. 1999). It has been suggested that a hydrostatic dam, created by a delta that once stood at the confluence of the West Fork and Black Rivers, was lost when the confluence of the two rivers moved two to three miles downstream approximately 40 years ago; the movement of the confluence allowed Black River to increase its velocity and entrench a deeper channel, which drains Black Lake at a faster rate (Buffington 2001). A spit has formed across a portion of Black Lake, which begins approximately 1.5 km north of the Fan Creek outlet and extends across roughly two-thirds of the lake's width, depending on lake level (Figure 2). The Alec River, Black Lake's main tributary, used to drain primarily into Alec Bay (on the northern side of the spit), but now partially drains through Fan Creek (on the southern side of the spit; Figure 2). Ruggerone et al. (1999) suggested that the reduced water volume of Black Lake has compromised effective sockeye salmon rearing habitat. Parr (1972) and Narver (1966) documented the downstream movement of juvenile sockeye salmon from Black Lake to Chignik Lake prior to winter and cited density dependent limitations as the reason for the migration. Narver (1966) also suggested that the carrying capacities of both Chignik and Black Lakes were density dependent. Similar studies in other sockeye salmon habitats have indicated that significant density dependent responses occurred within juvenile sockeye salmon populations (Kyle et al. 1988; Schindler 1992; Schmidt et al. 1995; Koenings and Kyle 1997; Milovskaya et al. 1998).

Phinney (1968) and Iverson (1966) indicated that migratory movement of juvenile sockeye salmon (pre-smolt) from Chignik Lake to Chignik River and Lagoon might also occur. Lagoon growth in juveniles is, at times, quite visible when examining scales from returning sockeye salmon adults (Patricia Nelson, Alaska Dept. of Fish and Game, Kodiak, personal communication). Recent data (Finkle and Bouwens 2001; Bouwens and Finkle 2003) indicate that juvenile sockeye salmon typically maintain a dynamic presence in the lagoon throughout the summer months. Rice et al. (1994) observed that underyearling (age 0.) sockeye salmon could migrate from limited lake-rearing habitats and survive in marine conditions. Conversely, Iverson (1966) claimed sockeye salmon fry moved upstream in the Chignik River, suggesting fry may have traveled from the lagoon and Chignik River to over-winter in Chignik Lake. However, this observation has not been documented since the 1960s. Ultimately the nursery role of Chignik Lagoon is still poorly understood, yet the lagoon cannot be dismissed as an alternate nursery for juvenile sockeye salmon.

Chinook salmon *O. tshawytscha*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, chum salmon *O. keta*, Dolly Varden *Salvelinus malma*, threespine stickleback *Gasterosteus aculeatus*, ninespine stickleback *Pungitius pungitius*, pond smelt *Hypomesus olidus*, starry flounder *Platyichthys stellatus*, Alaska Blackfish *Dallia pectoralis*, and coastrange sculpin *Cottus aleuticus* are also present throughout the Chignik system (Narver 1966; Parr 1972). Despite such a variety of other species, Parr (1972) downplayed interspecific competition as a limiting factor to sockeye salmon production, citing that divergent food habits prevented resource limitations. Juvenile sockeye salmon have also been documented as having a competitive edge over sticklebacks (Edmundson et al. 1994) which are abundant throughout the Chignik watershed (Narver 1966; Parr 1972). However, Ruggerone (1989) suggested that juvenile coho salmon maintain a significant predator-prey relationship with sockeye salmon fry in Chignik Lake.

Definitive ecological assessments of the Chignik watershed have not been performed since the sockeye salmon carrying capacity of the watershed was initially estimated in the 1960s (Narver 1966; Dahlberg 1968; Phinney 1968; Burgner et al. 1969). Because Black Lake is shallower than when the current escapement goals were established, it is necessary to reevaluate the escapement goals to the watershed. This reevaluation will be based on spawner-recruit relationships and estimates of watershed carrying capacity estimated with limnology and smolt production data. This project served as an initial step in this process.

OBJECTIVES

The objectives of this project were to:

1) describe the physical characteristics of both Black and Chignik Lakes including temperature, dissolved oxygen, and light penetration profiles;

2) describe the nutrient availability and primary production of both Black and Chignik Lakes;

3) describe the forage base available to juvenile sockeye salmon (zooplankton) in both Black and Chignik Lakes;

4) document the relative abundance of juvenile sockeye salmon throughout different portions of the watershed;

5) describe the age and size characteristics of juvenile sockeye salmon throughout the watershed, and;

6) describe the feeding habitat of juvenile sockeye salmon throughout the watershed.

METHODS

Limnology

In May 2002, four zooplankton and two water/zoolankton sampling stations were established on Chignik Lake; zooplankton stations 2 and 4 coincided with the water sampling stations (Figure 3). One station was established on Black Lake (Figure 2). Each station's location was logged on a global positioning system (GPS) and marked with a buoy (Appendix A). Sampling was conducted following protocols established by Finkle and Bouwens (2002) and Koenings et al. (1987). Zooplankton and water sampling occurred once every three to four weeks, beginning in May and ending in August (Table 1).

Temperature, Dissolved Oxygen, and Light

Water temperature (°C) and dissolved oxygen (mg/L) levels were measured with a WTW™ Oxi 197 meter. Readings were recorded at half-meter intervals to a depth of 5 m, then the intervals increased to every meter. Upon reaching a depth of 20 m, the intervals increased to every five meters. A mercury thermometer was used to ensure the meter's calibration. Measurements of photosynthetically active wavelengths (kLux) were taken with a Li-Cor™ Li-250 photometer. Readings began at the surface and proceeded at half-meter intervals until reaching a depth of 5 m. Readings were then recorded at one-meter intervals until the lake bottom or zero kLux light penetration was reached. The mean euphotic zone depth (EZD) was determined (Koenings et al. 1987) for each lake and incorporated into a model for estimating sockeye salmon fry production (Koenings and Kyle 1997). Secchi disc readings were collected from each station to measure water transparency. The depths at which the disc disappeared when lowered into the water column and reappeared when raised in the water column were recorded and averaged.

Water Sampling

Seven to eight liters of water were collected with a Van Dorn bottle from the epilimnion (1 m depth) and the hypolimnion (29 m depth) of Chignik Lake stations 2 and 4. Because of the shallow nature of Black Lake, water samples were collected from the epilimnion only. Water samples were stored in polyethylene (poly) carboys and refrigerated until processed.

One-liter samples were passed through 4.25-cm diameter 0.7 µm Whatman™ GF/F filters under 15 to 20-psi vacuum pressure for particulate Nitrogen (N) and Phosphorus (P) analyses. An additional one liter sample was filtered for chlorophyll *a*; approximately 5 ml of $MgCO_3$ solution was added to the last 50 ml of the remaining unfiltered chlorophyll *a* sample water. Upon completion of filtration, all filters were placed in individual petri dishes, labeled and frozen. For each sampled depth, 120 ml of sample water and 2 ml of Lugol's acetate were placed in a 125-ml poly bottle for phytoplankton analysis and stored at room temperature until processing.

The water chemistry parameters of pH and alkalinity were assessed on refrigerated water samples using a Corning™ Student pH meter in Chignik. Frozen water samples were then shipped to Kodiak for further analysis.

Analyses of water for total phosphorous (TP), total filterable phosphorous (TFP), filterable reactive phosphorous (FRP), total ammonia (TA), nitrate + nitrite, chlorophyll *a* and phaeophytin *a*. were performed at the Alaska Department of Fish & Game (ADF&G) Near Island laboratory. Additional samples were also sent to the Soldotna ADF&G limnology lab for total Kjeldahl nitrogen (TKN) analysis. All laboratory analyses followed the methods of Koenings et al. (1987) and Thomsen et al. (2002).

Zooplankton

Two vertical zooplankton tows per sampling event were made at each zooplankton station, with a 0.2-m diameter, 153 micron net (Table 1). All plankton tows started one meter above the lake bottom. One sample was placed in a 125-ml poly bottle containing 12.5 ml of concentrated formalin to yield a 10% buffered formalin solution. Subsamples of zooplankton were keyed to family or genus and counted on a Sedgewick-Rafter counting slide under 10X magnification. This process was replicated three times per sample then averaged and extrapolated over the entire sample. Length measurements were collected from a subsample of up to 15 individuals and a student's t-test used to determine the sample size necessary to achieve a confidence level of 95% (Koenings et al. 1987). Mean length measurements (0.01 mm) from each family or genus, per plankton tow, were taken from the three replicate counts. Biomass was calculated via species-specific linear regression equations between weight and length measurements (Koenings et al. 1987; Thomsen et al. 2002). The other 125 ml sample was decanted, reduced, and stored in a centrifuge tube and frozen for stable isotope analysis to be conducted at a later date.

Juvenile Sockeye Salmon Sampling

Three gear types were used to sample juvenile sockeye salmon: beach seine, fyke net and pelagic trawl (townet). The sampling protocol was as follows:

Beach Seine

Chignik Lagoon, Chignik River, Chignik Lake, and Black Lake were routinely sampled every two weeks with a beach seine (Table 2; Figures 2 through 4). A 3-mm mesh, 10-m long, 1-m deep seine was used.

One beach seine set was made per site, unless the net deployed poorly and required an additional attempt. Either two people (one on shore acting as an anchor and the other wading off shore to make the haul) or a boat (haul) and one person (anchor) were used to make the set, depending on bottom depth and weather conditions. The net was set in the same manner between sampling events to standardize effort.

Fyke Net

A fyke net with 3.05-m x 1.22-m wings, a 1.22-m x 1.22-m opening and a 3.66-m body with 6.4-mm mesh was used to sample the Black and Chignik Rivers. Specific sampling dates are listed in Table 3.

Townet

Paired tows were made on Chignik Lake approximately once per month (Table 4). Sampling occurred during daylight hours. Tows lasted 10 minutes. Transects ran between the established water sampling sites. Tows were intended to sample the water column at the surface, and at depth. Tow depths were adjusted by two sets of metered drop lines (10 and 20 m) that attached to each side of the net's opening (on the top corners) and to buoys on the other end of the drop lines. The actual depths of the tows are unknown because the net's drag would cause it to rise in the water column. The townet consisted of 10-mm mesh tapering down to a 1-mm mesh cod end, for a total length of 4.6 m. The opening was 1.82 m x 1.82 m. Boat speed was maintained at approximately 4.5 km/hr. The townet was retrieved by hand.

One tow was made in Black Lake in cooperation with the University of Washington, Fisheries Research institute (FRI) staff, using FRI gear, following Narver's (1966) protocol (Table 4).

Distribution, Abundance, and Size

Fish collected with beach seine, fyke net and townet gear were identified and enumerated by sampling event (i.e, per tow, beach seine haul, etc.). Species abundance of large catches (>500 fish) was estimated to prevent sample mortality. Up to 40 juvenile sockeye salmon and up to 20 juvenile chinook and coho salmon each were randomly sampled per sampling event. Age, weight and length (AWL) data, as described by Finkle and Bouwens (2002), were collected from the first 20 juvenile sockeye salmon. Length measurements only were taken from the second 20 juvenile sockeye salmon present in the catch. Juvenile coho and chinook salmon (up to 20 for each species) caught during a sampling event were sampled only for length. The fish that were to be sampled for AWL data were stored in a plastic bag with water until processed at the lab.

Scales were taken from the preferred area (INPFC 1963) of each fish sampled for AWL and placed on a labeled glass slide. Weight was measured to the nearest 0.1 g, and fork length (FL) was measured to the nearest 1 mm. Condition factor (Bagenal and Tesch 1978) was calculated for each fish sampled for both weight and length. All juvenile sockeye salmon scales were aged on a microfiche reader under 36X or 60X magnification and recorded in European notation (Koo 1962).

Digestive Tract Contents

A subsample of up to five juvenile sockeye salmon from each AWL sample group was stored frozen for digestive tract content analysis. Digestive tracts were removed, weighed and inspected according to the protocol described by Finkle and Bouwens (2002). Digestive tract contents were sorted and the identifiable organisms were tallied into the following categories: copepods, cladocerans, chironomids, other insects, and other crustaceans.

Dry weights were calculated for the zooplankton groups. It was assumed the dominant genus and size for a given group in the zooplankton samples represented all the prey items from that group. Dry weights for the copepods and cladocerans were calculated using regression equations as described in Thomsen et al. (2002). A 3 mm-long chironomidae larvae was assumed to represent the average insect prey. The majority of the prey items in the other crustacean category were either amphipods or pericaridans. A 3-mm *Gammarus* was assumed to represent the average amphipod prey and equations from Elliot (1972) were used to calculate the dry weights of these items. Cumaceans were used to represent the pericaridans and dry weight conversions from Schwinghammer et al. (1986) were used to estimate the biomass of these prey.

RESULTS

Limnology

Temperature and Dissolved Oxygen

Chignik Lake. A thermocline was not present in Chignik Lake in June through August 2002. Temperatures at 1-m depth ranged from 10.6 °C on June 19 to 12.5 °C on August 14 (Table 5; Figure 5). Both temperature and dissolved oxygen (DO) levels remained relatively homogenous over depth. The 1-m depth DO level at was at its maximum at 12.0 mg/L on July 27 (Table 6; Figure 5).

Black Lake. In Black Lake, the temperature at 1-m depth in June was 13.7 °C, increasing to 15.5 °C in late July (Table 7). DO levels at 1-m depth varied from 11.0 mg/L in June to 10.4 mg/L in July (Table 8; Figure 6).

Light Penetration and Water Transparency

Chignik Lake. Average monthly solar illuminance data for Chignik Lake are listed in Table 9. Chignik Lake had a calculated mean EZD of 15.0 m (Table 10; Figure 7). The euphotic volume (EV) averaged 361.4 x 10^6 m^3 in Chignik Lake for the 2002 season (Table 10).

Black Lake. Light penetrated the entire water column of Black Lake throughout the 2002 sampling season (Table 11; Figure 7). The calculated EZD was deeper than the average depth of the lake (Table 10). Therefore, the mean depth of the lake, not the actual EZD, was used to calculate the EV of 78.1 x 10^6 m^3.

Available Nutrients

Chignik Lake. The mean pH of Chignik Lake was about 7.45 and alkalinity averaged 24.6 mg/L $CaCO_3$ (Tables 12 and 13). TP averaged about 20 µg/L P, TFP was about 9 µg/L P and the mean FRP was about 4 to5 µg/L P. The Chignik Lake mean TKN concentration was 119.7 µg/L N. The mean ammonia concentration of Chignik Lake was about 6 to 7 µg/L N while the nitrate + nitrite level was 117.4 µg/L N. The mean chlorophyll *a* concentration was 2.34 µg/L and the mean phaeophytin *a* concentration was 1.34 µg/L.

Black Lake. The mean pH of Black Lake was 7.45 and alkalinity averaged 32.3 mg/L $CaCO_3$ (Tables 12 and 14). TP averaged 22 µg/L P, TFP averaged 10 µg/L P, and FRP was 5 µg/L P. The Black Lake mean TKN concentration was 323.5 µg/L N. The mean ammonia was about 4 to 7 µg/L N and the nitrate + nitrite level was about 7 to 8 µg/L N, depending on how the data were grouped. The Black Lake mean chlorophyll *a* level was 2.64 µg/L and the phaeophytin *a* concentration was 1.44 µg/L (Tables 12 and 14).

Zooplankton

Chignik Lake. In Chignik Lake, from May through mid-June, copepods were the most abundant zooplankton taxa, but by late-July, the cladoceran abundance approached the copepod abundance (Figure 8). Seasonally, the principal copepods were *Cyclops* (74,320/m^2) and *Epischura* (19,858/m^2), and the cladocerans were mainly comprised of *Bosmina* (28,046/m^2) and *Daphnia* (8,446/m^2; Table 15; Figure 8; Appendix B).

The biomass of Chignik Lake zooplankton generally increased over the summer, beginning with 43.32 mg/m^2 in May and ending with 615.16 mg/m^2 in August, averaging 299.98 mg/m^2 (Table 16). There were fewer cladocerans in the early part of the year than copepods, but they became a larger component of the total biomass in August (Table 16; Figure 9; Appendix C).

The mean sizes of the cladocerans *Bosmina* (0.31 mm), *Daphnia* (0.55 mm) and *Chydorinae* (0.28 mm) were relatively smaller than the copepods *Cyclops* (0.55 mm), *Diaptomus* (1.02 mm), and *Epischura* (0.68 mm) in Chignik Lake (Table 17).

Black Lake. Black Lake zooplankton exhibited trends similar to those of Chignik Lake. *Cyclops* (mean: 39,618/m^2) and *Epischura* (mean: 4,517/m^2) were the most abundant copepods, and *Bosmina* (mean: 99,846/m^2) and *Chydorinae* (mean: 18,408/m^2) were the most abundant cladocerans (Table 18). Black Lake copepods, like Chignik Lake copepods, were relatively more abundant than cladocerans until mid-June when the cladoceran abundance became greater than copepod abundance (Table 18; Figure 10; Appendix D).

The biomass of Black Lake zooplankton decreased in early June then increased again over the summer, beginning with 54.64 mg/m^2 in May, decreasing to 20.57 mg/m^2 in mid- June, then increasing to 344.7 mg/m^2 in early September, averaging 106.08 mg/m^2 (Table 19; Figure 11). Copepods biomass fluctuated from May through late July in response to *Diaptomus* and *Cyclops* blooms. Cladoceran biomass showed a similar trend, with the biomass generally increasing in late June and July. Copepods were generally the larger component of the total biomass in May and early June, and cladocerans were a larger portion of the total biomass in late June and July (Table 19; Figure 11; Appendix E).

The mean sizes of the major zooplankton species in Black Lake varied during the sampling season; *Bosmina* averaged 0.32 mm, *Chydorinae* measured 0.24 mm, *Cyclops* measured 0.47 mm and *Epischura* were 0.79 mm on average (Table 20).

Juvenile Sockeye Salmon

Of the 17,268 juvenile sockeye salmon caught by all gear types, in all locations, 49.3% were estimated to be age 0., 48.1% were estimated to be age 1., 2.5% were estimated to be age 2., and 0.1% were estimated to be age 3. sockeye salmon (Table 21).

Black Lake/River

Black Lake beach seine catches were highest in the June with an average catch rate of 405 sockeye salmon caught per haul, decreasing to 3 sockeye salmon per haul in August. The majority of juvenile sockeye salmon caught from Black Lake were less than 45 mm in length (Table 22; Appendix F).

One townet haul was performed in Black Lake in conjunction with FRI. The July trawl yielded a catch rate of 588 juvenile sockeye salmon per hour, 80 percent of which were over 45 mm in length (Table 23; Appendix G).

Black River sockeye salmon were sampled during June, July, and August with a fyke net. Catches averaged one sockeye salmon juvenile per hour in June, increasing to 11 per hour in July, and decreasing again to one per hour in August. The length of the sockeye salmon caught in Black River increased over the summer (Table 24; Appendix H).

All of the Black Lake and Black River sockeye salmon catches were age 0. (Tables 21 and 25).

The mean length of beach seine caught age 0. sockeye salmon in Black Lake increased from 37.0 mm in May to 57.7 mm in August (Table 26). Condition factors increased slightly over the summer. In general, larger fish were caught in the fyke net and townet than in the beach seine (Figure 12).

Chignik Lake

Chignik Lake beach seine catch rates decreased from May to June, increased in July, and decreased in August. The majority of juvenile sockeye salmon captured in Chignik Lake were over 45 mm (Table 22; Appendix F).

Townet catches decreased from 65 sockeye salmon per hour towed in May to very low catch rates the rest of the summer (Table 23; Appendix G). The majority of juvenile sockeye salmon captured by townet were over 45 mm in length.

Approximately 27.6% of the juvenile sockeye salmon captured during the season in Chignik Lake were age 0., 67.0% were age 1., and 5.4% were age 2. (Tables 21 and 27). The percentage of age 0. sockeye salmon caught by townet in Chignik Lake was low in May and then no age 0. sockeye salmon were caught until August (Table 27; Figure 13). The age 0. component of Chignik Lake beach seine catches steadily increased from May to July then declined in August. The percentage of age 1. sockeye salmon in the beach seine catches increased between May and June, decreased in July, and increased again in August. The majority of fish captured by townet were age 1. until August, when age 0. fish were more prevalent (Table 27; Figure 13). Few age 2. fish were captured in Chignik Lake with either gear type.

In Chignik Lake early in the season there was one distinct length group of juvenile sockeye salmon. As the summer progressed, smaller fish began appearing in the catches. The mean length of age 0. sockeye salmon increased over the summer, while the lengths of the older ages remained relatively constant or decreased with time. Generally, condition factors increased with both time and age (Table 28; Figures 14 and 15).

Chignik River

Beach seine catches in Chignik River increased from an average of 406 sockeye salmon per haul in May to 492 in June and then decreased to 262 in July (Table 22; Appendix F). The majority of juvenile sockeye salmon caught in Chignik River were over 45 mm in length.

Monthly fyke net catches in Chignik River increased from 1 sockeye salmon per hour in May and June to 21 sockeye salmon per hour in July and August (Table 24; Appendix H). The majority of juvenile sockeye salmon caught with the fyke net in Chignik River were over 45 mm in length.

The Chignik River yielded 41.8% age 0., 57.0% age 1. and 1.3% age 2. sockeye salmon for all gear types combined (Tables 21 and 29). The majority of juvenile sockeye salmon caught were captured with a beach seine. The proportion of age 0. sockeye salmon captured by beach seine was 0.0% in May, 21.0% in June, and 55.3% in July. Beach seine catches of age 1. fish showed an inverse pattern, with the majority of the catch being age 1. in the spring and fewer age 1. sockeye salmon captured in the fall (Table 29; Figure 16). The proportion of age 0. fish fell in June and increased again over the summer (Table 29; Figure 16).

The lengths of juvenile sockeye salmon caught in the Chignik River in May ranged from about 32 mm to 78 mm. In June, the size range was similar, but the majority of the fish ranged from 45 mm to 60 mm. In July and August, the range of fish lengths was narrower. With the exception of May, the mean lengths of the fish, by age, caught in the fyke net were larger than the lengths of the fish caught with the beach seine. (Table 30; Figures 17 and 18).

Chignik Lagoon

Chignik Lagoon beach seine catches peaked in June with 200 sockeye salmon per haul (Table 22). Juvenile sockeye salmon over 45 mm in length comprised the majority of the catches in the lagoon (Appendix F).

Larger proportions of age 0. (58.1%) juvenile sockeye salmon where caught in the lagoon than age 1. (40.1%); the remainder of the catch consisted of 1.5% age 2. fish and a very small amount were age 3. (0.3%; Tables 21 and 31). As with Black Lake, a beach seine was the only effective means of sampling in the lagoon because of its shallow and grassy nature. The percentage of age 0. sockeye salmon increased from 26.7% in May to 52.8% of the beach seine catch in June, and 86.2% in July. The proportion of age 1. sockeye salmon peaked at 63.3% in May. (Table 31; Figure 19).

The size distribution of juvenile sockeye salmon caught in Chignik Lagoon varied over the season (Figure 20). In May, a small number of sockeye salmon were about 30 mm to 35 mm in length. The majority of the sockeye salmon ranged from about 65 to 95 mm in length. In June, the fish ranged from about 30 mm to 80 mm in length. In July, only a few of the larger fish were caught, and averaged about 49 mm. In general, condition factors increased over the summer and the older fish were relatively heavier than the younger fish (Table 32; Figures 20 and 21).

Digestive Tract Contents

A total of 413 juvenile sockeye salmon were sampled for digestive tract content analysis (Table 33). Although the average number of identifiable prey items of each group varied widely within and between groups, copepods were the most frequently consumed (49.9 organisms/fish), followed by chironomids (13.1 organisms/fish), then cladocerans (3.0 organisms/fish, other crustaceans (2.9 organisms/fish) and other insects (0.2 organisms/fish; Table 33; Figure 22). When adjusted for prey size, however, insects accounted for the majority of the biomass in the digestive tracts of the fish captured in Black Lake, Chignik Lake, and Chignik River, while other crustaceans and insects were most prevalent in the fish caught in the lagoon (Table 34; Figure 23).

DISCUSSION

This project was designed to comprehensively assess the ecology of the Chignik watershed in terms of sockeye salmon production. Large amounts of data have been collected, and subsequent analyses are ongoing. This paper serves to report data from the 2002 field season, and conclusions are, at this point, limited.

Certain zooplankton species (e.g., *Daphnia*) are typically preferred by sockeye salmon. They are large and slow (thus easily captured) and efficiently transfer energy and nutrients from the primary producers to sockeye salmon in one trophic level (Kerfoot 1987). The zooplankton community is a complex dynamic web of different species that are susceptible to different pressures. The abundance, species composition, and even size of the zooplankton can change via either bottom-up pressures such as nutrient limitations and phytoplankton species composition or from top-down pressures such as extensive grazing by planktivorous fishes (Kerfoot 1987; Kyle 1996; Stockner and MacIsaac 1996).

The zooplankton can change in response to a change in the phytoplankton community (bottom-up limitation), which can be a result in nutrient levels. For instance, low N levels in comparison to P levels can facilitate a shift in the phytoplankton towards blue-green algae, which are largely unpalatable for zooplankton (Kerfoot 1987). However, N and P limitations are probably not the cause for the low zooplankton biomass in the Chignik watershed. Kyle (1992) reported that in 1991 the N and P levels in Chignik Lake (the nutrients that typically limit production; Spalinger and Bouwens 2003) had increased from Narver's (1966) readings to levels that would not limit phytoplankton growth. Current N and P levels are slightly higher than those measured in 1991.

Chlorophyll *a* levels were relatively high in both lakes during all three years as compared to other Alaska Peninsula and Kodiak Island Lakes (Honnold et al. 1993; Schrof and Honnold 2003). This is an indicator of a zooplankton community that is unable to transfer the energy and nutrients from the phytoplankton to sockeye salmon through a top-down limitation of zooplankton production (Kerfoot 1987). The primary production of the system was high, but it was not transferred up the food web to the juvenile sockeye salmon. A healthy system has low chlorophyll *a* standing stocks because the phytoplankton is consumed by zooplankton relatively quickly (Kerfoot 1987). These high chlorophyll *a* levels (along with nutrient data) also indicate that the juvenile sockeye salmon production in the Chignik watershed is not limited by nutrient abundance.

Grazing pressure by fish can also influence the zooplankton community through top-down limitation (Abrams 1987; Kerfoot 1987; Miller and Kerfoot 1987). High grazing pressure on zooplankton can cause multiple effects including an initial spike in zooplankton reproduction (Gliwicz et al. 1981; Kerfoot 1987), or, secondarily, a shift in zooplankton species composition to less available and less efficient species in terms of sockeye salmon forage (Kerfoot 1987; Koenings and Burkett 1987; Kyle 1996). The escapement and, presumably, the number of juvenile sockeye salmon (and subsequent grazing pressure) in the Chignik watershed has been above what was considered appropriate by Narver (1966) since 1975, which could overtax the forage base. Kyle (1992) reported that the species composition of the zooplankton in Chignik Lake in 1991 indicated high grazing pressure.

The zooplankton in both Black and Chignik Lakes in 2000 through 2002 were even more taxed when compared to data taken in 1991 (Kyle 1992). This is evident by examination of the zooplankton species composition. Recently, *Bosmina* and *Cyclops* dominated the macrozooplankton. Both of the dominant species are inefficient grazers on the phytoplankton, and are poor transmitters of energy and nutrients through the food web (Mazumder and Edmundson 2002). In 2000 through 2002 *Daphnia* were nearly absent in both lakes although in 1991 they were more abundant (Kyle 1992). Further, rotifers, another type of smaller zooplankton (microzooplankton), were very abundant in recent years (Tables 15 and 18).

Rotifers are too small for sockeye salmon to prey upon and the energy and nutrients tied up in these organisms are unavailable for sockeye salmon.

The size of individual zooplankton species (especially *Bosmina*) can change in response to high grazing pressure. The mean size of the *Bosmina* in both lakes from 2000 through 2002 was very small and below the elective feeding size threshold (0.35 to 0.40 mm; Kyle 1992) of juvenile sockeye salmon. The major zooplankton were generally larger, by species, in 1991, but were still considered small (Kyle 1992).

It is important to understand the patterns of habitat usage by rearing fry to identify the areas in the system that might be limiting freshwater production. It is believed that Black Lake is not a significant overwintering area for juvenile sockeye salmon. During the three years sampling this area, we caught only one sockeye salmon in Black Lake or Black River that appeared to have spent the winter in Black Lake. It appeared that juvenile sockeye salmon began to move from Black Lake into Chignik Lake beginning in July, continuing through the fall. Age 0. catches began to decline in Black Lake and increased in Chignik Lake during this time. This is consistent with findings of studies performed over 30 years ago by Parr (1972) and Narver (1966), and more recently by Ruggerone (1994). Using baited minnow traps, Ruggerone (1999) caught very few juvenile sockeye salmon through the ice in Black Lake in the winters of 1993, 1995, 1996, and 1997; however, sockeye salmon through the ice in Chignik Lake. In some years (1994-1996), emigrating smolt have shown distinct bimodal length distributions by age (Stopha and Barrett 1994; Vania and Swanton 1996; Kaplan and Swanton 1997), suggesting some Black Lake fish may have remained in Black Lake. In recent years (1998-2003) the distributions have been more unimodal (Perez-Fuentetaja et al. 1999; Bouwens et al. 2000; Bouwens and Edwards 2001; Bouwens and Newland 2003; Bouwens and Newland *in press*).

Based on parent run timing and typical water temperatures, it is likely that the early-run (Black Lake) stock of juvenile fish hatched and emerged from the gravel in early spring (March through May) while the late-run (Chignik Lake) hatched and emerged from May through early July (Ruggerone et al. 1993; Ruggerone 1994). Historically, juvenile sockeye salmon from the early run stock emigrated to sea as age 1. smolts and juveniles from the late run emigrated as age 2. smolts (Pappas et al. 2001). Our data indicates that the juvenile sockeye salmon from Black Lake have moved to Chignik Lake beginning in about July. Therefore, in recent years, Chignik Lake supported the majority of fry from the late-run stock for two entire summers and from the early run stock for the second half of their first summer. Because of this, the rearing capacity of Chignik Lake is most likely the limiting factor for sockeye salmon production within the watershed.

There have been recent measurable effects of high grazing pressure on the zooplankton in Chignik Lake. Edmundson and Mazumder (2001) reported that sockeye salmon are starving at a zooplankton biomass less than about 100 mg/m^2 and do not get increased benefit from a zooplankton biomass over about 1,000 mg/m^2. In 1991, the zooplankton biomass in Chignik Lake was 661 mg/m^2 (Kyle 1992). In 2000 through 2002, the zooplankton biomass in Chignik Lake averaged about 209 mg/m^2, and in 2001 it was about eight times lower than in 1991 with a biomass of about 85 mg/m^2.

The proportion of age 2. smolts in the smolt emigration has been decreasing in recent years (Newland and Bouwens *in press*), indicating poor freshwater survival of late-run sockeye salmon. The seasonal zooplankton biomass in Chignik Lake was very low in early spring and generally increased substantially in July and August (Bouwens and Finkle 2003; Finkle and Bouwens 2001; Kyle 1992; Narver 1966). The low zooplankton biomass in the spring in 2000 through 2002 probably did not impact the juvenile early-run sockeye salmon as much as the late run fish because they were still rearing in Black Lake during this time. However, both young of the year and age 1. juvenile sockeye salmon from the late run experienced very low zooplankton biomass until mid July. Therefore, the Chignik watershed was probably able to produce age 1. early-run smolts that were relatively healthy, but the late-run component of the juvenile biomass may have faced starvation conditions long enough to cause significant mortality. Total smolt emigration abundance data from the Chignik smolt project (Bouwens and Newland 2003; Newland and Bouwens *in press)* also appear to corroborate that juvenile sockeye salmon have experienced poor rearing conditions in recent years. Only about 6.75 million smolts emigrated in 2003 compared to an average of about 20 million smolts per year from 1997 through 2002; the majority of these were age 1.

There are other, less obvious, indicators of excessive juvenile sockeye salmon abundance in the Chignik watershed. Substantial numbers of juvenile sockeye salmon pre-smolts were caught in the Chignik River and Lagoon as part of this project and as part of the Chignik smolt enumeration project. This was especially apparent in 2001 when the zooplankton was suppressed in Chignik Lake (Bouwens and Finkle 2003; Bouwens and Newland 2003; Edwards and Bouwens 2002). Benthic macroinvertebrates have been cited as a significant food source for rearing juvenile sockeye salmon in littoral zones and shallow lakes such as Black Lake (Parr 1972; Honnold et al. 1996; Honnold et al. 1999). Benthic macroinvertebrates were the dominant food source, by weight, for juvenile sockeye salmon captured throughout the watershed. Juvenile sockeye salmon may have moved out of Chignik Lake and moved into the lagoon as pre-smolt, presumably because of low zooplankton availability in the lakes and (presumably) higher non-zooplankton forage availability in Chignik River and Lagoon. It is unclear, however, if these fish will survive into adulthood. There have never been a substantial number of adults returning to the Chignik watershed as age 0. freshwater adults. However, there is some evidence that these fish may return to Chignik Lake to overwinter, and may emigrate the following spring as age 1. smolt (Iverson 1966).

Data from this project have been valuable in assessing the ecological state of the Chignik watershed. Data from this project and the Chignik sockeye salmon smolt enumeration project have been used to recommend targeting the lower end of the escapement goals (350,000 early run and 200,000 late run) in 2002 and 2003. The overall concern was that the number of fry that were rearing in Chignik Lake exceeded its freshwater rearing capacity. Management decisions have been made based on these data with the goal to improve sustained sockeye salmon production, and the effects of these decisions will continue to be monitored through this and other projects.

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Table 1. Limnology and zooplankton sampling dates, 2002.

Lake	Date	Type of sampling
Black Lake	25-May	water and zooplankton
	22-Jun	water and zooplankton
	20-Jul	water
Chignik Lake	7-May	zooplankton
	22-May	water and zooplankton
	19-Jun	water and zooplankton
	24-Jul	water and zooplankton
	14-Aug	water and zooplankton

Table 2. Dates of beach seine samples, by area and site, 2002.

Black Lake		Chignik Lake		Chignik River		Chignik Lagoon	
Site[a]	Date	Site[a]	Date	Site[a]	Date	Site[a]	Date
1	15-May	1	20-May	1	17-May	1	16-May
1	30-May	1	4-Jun	1	1-Jun	1	1-Jun
1	14-Jun	1	18-Jun	1	14-Jun	1	15-Jun
1	11-Jul	1	3-Jul	1	28-Jun	1	29-Jun
		1	18-Jul	1	13-Jul	1	15-Jul
2	15-May	1	5-Aug	1	29-Jul	1	30-Jul
2	30-May						
2	15-Jun	2	20-May	2	17-May	2	7-May
		2	4-Jun	2	1-Jun	2	1-Jun
4	15-Jun	2	18-Jun	2	14-Jun	2	15-Jun
4	30-May	2	3-Jul	2	28-Jun	2	29-Jun
4	15-Jun	2	18-Jul	2	13-Jul	2	15-Jul
		2	5-Aug	2	29-Jul	2	30-Jul
5	15-May						
5	30-May	3	20-May	3	17-May	3	17-May
5	14-Jun	3	4-Jun	3	1-Jun	3	1-Jun
5	11-Jul	3	18-Jun	3	14-Jun	3	15-Jun
		3	3-Jul	3	28-Jun	3	29-Jun
		3	18-Jul	3	13-Jul	3	16-Jul
		3	5-Aug	3	29-Jul		
						4	7-May
		5	20-May			4	16-May
		5	4-Jun			4	1-Jun
		5	18-Jun			4	15-Jun
		5	3-Jul			4	29-Jun
		5	18-Jul			4	15-Jul
		5	5-Aug			4	30-Jul
		6	20-May			5	7-May
		6	4-Jun				
		6	18-Jun				
		6	3-Jul				
		6	18-Jul				
		6	5-Aug				
		7	20-May				
		7	4-Jun				
		7	18-Jun				
		7	3-Jul				
		7	18-Jul				
		7	5-Aug				
		8	20-May				
		8	4-Jun				
		8	18-Jun				
		8	3-Jul				
		8	18-Jul				
		8	5-Aug				

[a] Site locations can be found in Figures 2 through 4.

Table 3. Dates of fyke net samples, by location, 2002.

Location	Date
Black River	10-Jun
	22-Jun
	5-Jul
	20-Jul
	6-Aug
Chignik River	24-May
	13-Jun
	25-Jun
	16-Jul
	9-Aug

Table 4. Dates of townet samples by transect and location, 2002.

Location	Transect[a]	Date
Black Lake	Hydro Point	20-Jul
Chignik Lake	1 TO 2	30-May
	1 TO 2	26-Jun
	1 TO 2	13-Aug
Chignik Lake	2 TO 3	30-May
	2 TO 3	26-Jun
	2 TO 3	26-Jul
	2 TO 3	13-Aug
Chignik Lake	3 TO 4	30-May
	3 TO 4	26-Jun
	3 TO 4	26-Jul
	3 TO 4	13-Aug

Table 5. Water temperature, averaged over all stations, by depth and date, for Chignik Lake, 2002.

	Water temperature (^{o}C)		
Depth (m)	19-Jun	27-Jul	14-Aug
0.0	11.0	12.1	12.5
0.5	10.7	12.2	12.5
1.0	10.6	12.2	12.5
1.5	10.3	12.2	12.5
2.0	10.1	12.1	12.5
2.5	9.9	12.0	12.5
3.0	9.8	12.1	12.5
3.5	9.6	12.1	12.5
4.0	9.5	11.9	12.5
4.5	9.4	11.9	12.5
5.0	9.2	11.8	12.5
6.0	9.2	11.9	12.5
7.0	9.2	11.9	12.5
8.0	9.1	11.9	12.4
9.0	8.9	11.9	12.3
10.0	8.7	11.9	12.3
11.0	8.5	11.8	12.3
12.0	8.5	11.8	12.3
13.0	8.4	11.8	12.2
14.0	8.4	11.7	12.2
15.0	8.4	11.7	12.2
16.0	8.3	11.7	12.1
17.0	8.3	11.5	12.1
18.0	8.3	11.4	12.1
19.0	8.2	11.1	12.0
20.0	8.1	11.0	12.0
21.0	8.1	10.7	11.8
22.0	7.9	10.4	11.6
23.0	7.7	10.3	10.8
24.0	7.6	9.9	10.6
25.0	7.4	10.0	10.4
30.0	7.5	11.4	10.6
35.0		11.2	

Table 6. Dissolved oxygen readings, averaged over all stations, by depth and date, for Chignik Lake, 2002.

	Dissolved oxygen (mg/L)		
Depth (m)	19-Jun	27-Jul	14-Aug
0.0	11.9	12.7	10.7
0.5	11.9	12.2	10.4
1.0	11.8	12.0	10.4
1.5	11.8	12.0	10.4
2.0	11.9	11.7	10.3
2.5	11.9	9.3	10.3
3.0	11.8	9.3	10.3
3.5	11.7	11.8	10.3
4.0	11.9	11.7	10.3
4.5	12.0	11.6	10.2
5.0	12.1	11.6	10.2
6.0	12.0	11.6	10.2
7.0	12.1	11.4	10.2
8.0	12.1	11.4	10.2
9.0	12.2	11.3	10.2
10.0	12.2	11.3	10.1
11.0	12.3	11.3	10.1
12.0	12.3	11.3	10.1
13.0	12.3	11.3	10.1
14.0	12.4	11.2	10.0
15.0	12.3	11.1	10.0
16.0	12.3	11.1	9.9
17.0	12.2	11.1	9.9
18.0	12.3	11.1	9.9
19.0	12.3	11.1	9.8
20.0	12.1	11.1	9.8
21.0	12.1	11.0	9.7
22.0	12.0	10.8	9.6
23.0	12.1	10.6	9.6
24.0	12.0	10.6	9.5
25.0	12.0	10.4	9.5
30.0	11.9	10.0	9.1
35.0	11.7	9.9	8.6
40.0	11.5	9.1	7.8
45.0	11.3	8.7	8.0
50.0	3.6		7.4

Table 7. Water temperature of Black Lake, by date and depth, 2002.

	Water temperature (^oC)	
Depth	22-Jun	20-Jul
0.0	13.7	15.5
0.5	13.7	15.5
1.0	13.7	15.5
1.5	13.6	15.5
2.0	13.6	15.5
2.5	13.6	15.5
3.0	13.6	

Table 8. Dissolved oxygen levels of Black Lake, by date and depth, 2002.

	Dissolved oxygen (mg/L)	
Depth	22-Jun	20-Jul
0.0	11.1	10.4
0.5	11.0	10.4
1.0	11.0	10.5
1.5	10.8	10.5
2.0	10.9	10.5
2.5	10.8	10.5
3.0		

Table 9. Average monthly and seasonal average solar illuminance readings, by depth, for Chignik Lake, 2002, compared to 2000 and 2001 seasonal averages.

	Solar Illuminance (kLux)						
	2002					2000	2001
Depth	May	June	July	August	Average	Average	Average
0.0	1,552.0	2,347.0	1,054.5	619.8	1,393.3	2,473.4	1,799.34
0.5	1,141.5	1,668.0	796.3	557.9	1,040.9	1,768.3	1,053.27
1.0	877.5	1,100.2	546.0	462.3	746.5	1,214.3	733.70
1.5	690.3	677.5	392.6	335.0	523.8	710.5	613.97
2.0	538.5	592.4	289.4	248.1	417.1	523.8	474.65
2.5	431.5	289.3	233.2	179.8	283.4	365.9	367.37
3.0	295.3	259.5	169.7	134.8	214.8	252.8	308.90
3.5	239.5	183.7	121.3	91.3	158.9	183.6	270.77
4.0	187.5	137.3	95.3	69.4	122.4	127.3	216.63
4.5	132.4	94.4	74.7	50.0	87.9	91.5	171.60
5.0	107.0	69.7	57.1	35.0	67.2	73.4	140.67
6.0	65.7	40.5	33.9	19.5	39.9	36.8	98.29
7.0	40.2	24.5	21.7	9.9	24.1	21.5	66.93
8.0	26.4	15.6	13.3	7.2	15.6	11.5	45.98
9.0	15.8	10.7	9.0	3.0	9.6	6.2	33.64
10.0	10.0	8.0	6.2	1.6	6.4	3.8	24.70
11.0	6.2	6.3	5.2	0.5	4.6	2.3	11.73
12.0	2.6	5.3	3.7		3.8	1.5	8.63
13.0	2.4	4.7	2.9		3.3	1.0	6.55
14.0	1.7	4.4	2.7		2.9	0.7	5.21
15.0	1.5	3.6	2.1		2.4	0.6	4.34
16.0	0.9	3.1	3.2		2.4	0.8	3.75
17.0	0.7	2.9	2.0		1.9	0.7	3.31
18.0	0.3	5.9	2.6		2.9	0.4	2.90
19.0	0.2	5.7	2.3		2.7	0.4	2.70
20.0	0.1	5.5	1.9		2.5	0.4	2.49
21.0	0.2	5.0	1.8		2.3	0.3	2.29
22.0	0.1	5.6	1.9		2.5	0.3	2.52
23.0	0.0	5.5	1.9		2.5	0.2	2.47
24.0		5.0	1.8		3.4		3.40
25.0		6.2	2.1		4.2		4.16
30.0		2.1	2.1		2.1		2.10
35.0		1.6	1.6		1.6		1.60
40.0		1.5	1.5		1.5		1.50
45.0		1.6	1.6		1.6		1.60
50.0		1.5	1.5		1.5		1.50

Table 10. Monthly and seasonal Euphotic Zone Depth (EZD) and Euphotic Volume (EV) of Black and Chignik Lakes by month, 2002 compared to 2000 and 2001 seasonal averages.

		2002					2000	2001
Lake		May	June	July	August	Average[a]	Average[a]	Average[a]
Chignik	EZD	4.35	14.10	15.44	7.72	15.0	8.2	15.5
	Mean EV[c]	104.8	339.9	372.0	186.1	361.4	198.1	374.0
Black[b]	EZD	n/a	5.04	4.82	n/a	4.9	3.7	3.7
	Mean EV[c]	n/a	78.1	78.1	n/a	78.1	78.1	78.1

[a] Averages calculated from mean light reading (kLux) data.

[b] The mean depth of Black Lake is 1.9 m; this value was used for the EV calculations instead of the EZDs, which exceeded 1.9 m.

[c] EV units = x $10^6 m^3$.

Table 11. Average monthly and seasonal average solar illuminance readings, by depth, for Black Lake, 2002 compared to the 2000 and 2001 seasonal averages.

	Solar illuminance (kLux)				
	2002			2000	2001
Depth	June	July	Average	Average	Average
0.0	10,076.0	2,333.0	6,204.5	1,998.3	1,372.8
0.5	5,747.0	1,441.0	3,594.0	1,059.7	867.3
1.0	3,918.0	1,075.0	2,496.5	619.3	427.3
1.5	1,926.4	620.0	1,273.2	309.4	281.1
2.0	580.9	415.0	498.0	166.7	206.0
2.5	479.4	193.0	336.2	90.7	177.4
3.0	414.1		414.1	56.3	10.7
3.5				24.0	

Table 12. Seasonal mean general water quality parameters, nutrient concentrations, and photosynthetic pigments for Chignik Lake, by station, and Black Lake, 2002.

	Chignik Lake			Black Lake
Parameter	Station 2	Station 4	Mean[a]	Mean
pH	7.48	7.45	7.45	7.45
Alkalinity (mg/L)	24.3	24.7	24.6	32.3
Total P (ug/L P)	17.3	22.1	19.7	21.7
TFP (ug/L P)	8.0	9.1	8.5	10.1
FRP (ug/L P)	4.2	5.0	4.6	5.2
TKN (ug/L N)	119.7	n/a	119.7	323.5
Ammonia (ug/L N)	7.3	6.0	6.7	7.4
Nitrate + Nitrite (ug/L N)	119.4	115.4	117.4	7.3
Chlorophyll a (ug/L)	2.39	2.28	2.34	2.64
Phaeophytin a (ug/L)	1.48	1.19	1.34	1.44

[a] Mean values do not always exactly match values reported in Table 13 due to rounding.

Table 13. Mean (over station), by sample date, water quality parameters, nutrient concentrations, and photosynthetic pigments for Chignik Lake, 2002, compared to the 2000 and 2001 seasonal averages.

	2002					2001	2000
Parameter	22-May	19-Jun	24-Jul	14-Aug	Mean[a]	Mean	Mean
pH	7.27	7.56	7.51	7.47	7.45	7.51	7.88
Alkalinity (mg/L)	26.0	22.8	25.0	24.8	24.6	25.5	14.0
Total P (ug/L P)	20.9	25.2	16.6	16.6	19.8	27.3	15.0
TFP (ug/L P)	10.4	9.3	8.5	7.0	8.8	12.0	6.0
FRP (ug/L P)	5.3	5.0	1.4	5.1	4.2	8.3	6.0
TKN (ug/L N)	140.0	152.6	96.6	89.6	119.7	77.0	n/a
Ammonia (ug/L N)	2.0	6.1	10.2[b]	9.3	5.8	10.1	30.0
Nitrate + Nitrite (ug/L N)	161.7	104.3	89.1	114.6	117.4	191.8	182.0
Chlorophyll a (ug/L)	3.93	3.10	1.20	1.12	2.34	5.10	7.33
Phaeophytin a (ug/L)	2.24	1.50	1.04	0.56	1.34	1.33	1.06

[a] Mean values do not always exactly match values reported in Table 12 due to rounding.
[b] Station 4, 29 m omitted from station-wide average due to contamination.

Table 14. General water quality parameters, nutrient concentrations, and photosynthetic pigments for Black Lake, by sample date, 2002, compared to the 2000 and 2001 seasonal averages.

	2002					2001	2000
Parameter	25-May	22-Jun	19-Jul	15-Aug[a]	Mean	Mean	Mean
pH	7.54	7.34	7.47	7.46	7.45	7.525	7.43
Alkalinity (mg/L)	32.00	28.00	38.00	31.00	32.25	32.5	13.00
Total P (ug/L P)	n/a[b]	17	19	29	22	35	57
TFP (ug/L P)	n/a[b]	11	n/a[b]	9	10	10	11
FRP (ug/L P)	n/a[b]	4	n/a[b]	6	5	7	4
TKN (ug/L N)	332.5	315.0	338.8	307.7	323.5	n/a	n/a
Ammonia (ug/L N)	2.1	3.7	7.3	n/a[b]	4.4	3.3	37.0
Nitrate + Nitrite (ug/L N)	7.7	9.5	8.0	8.1	8.3	4.5	64.0
Chlorophyll a (ug/L)	2.88	1.92	1.92	3.84	2.64	4.26	18.06
Phaeophytin a (ug/L)	2.05	1.67	0.03	1.99	1.44	11.94	9.98

[a] Water samples processed at the ADFG Soldotna Lab.
[b] Sample contaminated.

Table 15. Average number of zooplankton per m^2 from Chignik Lake, by sample date, and seasonal average 2002, compared to the 2000 and 2001 seasonal averages.

	2002					2002	2001	2000
	Sample Date					Seasonal	Seasonal	Seasonal
Taxon	5/7[a]	5/22	6/19	7/24	8/14	Average	Average	Average
Copepods:								
Epischura	0	299	3,981	26,805	68,206	19,858	4,294	23,013
Ovigerous *Epischura*	0	0	0	0	0	0	24	119
Diaptomus	0	166	7,066	29,857	33,705	14,159	7,079	7,793
Ovigerous *Diaptomus*	0	0	0	1,858	7,697	1,911	48	468
Cyclops	42,795	78,888	90,549	93,020	66,348	74,320	18,533	90,630
Ovigerous *Cyclops*	0	166	1,095	11,611	16,189	5,812	2,020	1,185
Harpaticus	0	0	299	1,679	1,062	608	233	107
Nauplii	20,734	14,464	21,066	42,994	106,423	41,136	6,506	23,670
Total copepods:	63,528	93,982	124,055	207,823	299,629	157,803	38,738	146,985
Cladocerans:								
Bosmina	0	0	4,744	41,534	93,952	28,046	16,042	33,031
Ovigerous *Bosmina*	0	0	498	15,658	23,089	7,849	2,492	8,637
Daphnia	829	133	1,061	12,075	28,132	8,446	680	4,964
Ovigerous *Daphnia*	0	298	199	4,247	16,189	4,187	48	590
Chydorinae	0	0	2988	8691.5	8758	4,088	19,305	2,394
Total cladocerans:	829	431	9,490	82,205	170,119	52,615	38,567	49,616
Total Copepods + Cladocerans	64,358	94,413	133,544	290,028	469,748	210,418	77,306	196,601

-Continued-

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Taxon	2002 Sample Date 5/7[a]	5/22	6/19	7/24	8/14	2002 Seasonal Average	2001 Seasonal Average	2000 Seasonal Average
Rotifers:								
Kellicottia	142,649	64,955	66,680	135,550	118,631	105,693	25,996	44,285
Asplanchna	7,962	8,294	52,614	145,303	3,583	43,551	13,085	10,787
Keratella	19,241	54,770	117,237	13,933	1,592	41,355	22,904	11,524
Conochilus	0	663	22,890	360,271	89,172	94,599	7,277	75,731
other rotifers	0	663	7,796	513,535	943,472	293,093	2,369	6,997
Total Rotifers:	169,851	129,346	267,217	1,168,592	1,156,449	578,291	71,631	149,324
Other:								
Ostracoda	n/a	n/a	n/a	n/a	n/a	n/a	193	119

[a]Only station two sampled due to rough weather conditions.

Table 16. Biomass estimates and seasonal averages (mg dry weight/m^2) of the major zooplankton species in Chignik Lake by sample date, 2002, compared to the 2000 and 2001 season averages.

	2002							2001		2000	
	Sample Date					Seasonal	Weighted	Seasonal	Weighted	Seasonal	Weighted
Taxon	5/7[a]	5/22	6/19	7/24	8/14	Average	Average	Average	Average	Average	Average
Copepods											
Epischura	0.00	0.54	6.46	35.46	82.56	25.00	16.71	11.75	13.57	24.34	23.56
Ovigerous *Epischura*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.76	0.76
Diaptomus	0.00	0.93	26.51	127.44	143.02	59.58	58.24	24.92	13.85	39.41	37.64
Ovigerous *Diaptomus*	0.00	0.00	0.00	11.87	47.89	11.95	13.66	0.07	0.10	3.76	5.05
Cyclops	42.45	87.03	107.64	109.49	76.86	84.69	102.45	54.03	36.03	115.37	110.52
Ovigerous *Cyclops*	0.00	0.54	3.76	42.93	59.40	21.33	30.10	12.91	9.55	4.96	4.89
Harpaticus	0.00	0.00	0.20	0.18	0.18	0.11	0.46	0.22	0.29	0.07	0.07
Total Copepods:	42.45	89.03	144.58	327.38	409.91	202.67	221.62	103.94	73.44	188.67	182.50
Cladocerans											
Bosmina	0.00	0.00	4.25	35.95	80.73	24.19	28.30	13.01	5.21	37.81	37.63
Ovigerous *Bosmina*	0.00	0.00	0.70	22.29	32.95	11.19	12.54	3.28	1.43	13.75	13.70
Daphnia longiremis	0.87	0.17	1.17	14.18	35.13	10.30	17.05	2.75	3.60	6.35	6.33
Ovigerous *Daphnia longiremis*	0.00	1.06	0.61	13.78	55.27	14.14	16.99	0.08	0.10	1.33	1.32
Chydorinae	0.00	0.00	0.37	1.11	1.17	0.53	3.47	1.14	1.28	1.86	1.83
Total Cladocerans:	0.87	1.23	7.10	87.30	205.25	60.35	78.36	79.13	11.61	61.11	60.81
Total Biomass	43.32	90.26	151.68	414.68	615.16	263.02	299.98	183.07	85.05	249.79	243.31

[a]Only station two sampled due to rough weather conditions.

Table 17. Average length (mm) of zooplankton from Chignik Lake, by sample date, 2002, compared to the 2000 and 2001 seasonal averages.

	2002						2001	2000
	Sample Date					Seasonal	Seasonal	Seasonal
Taxon	5/7[a]	5/22	6/19	7/24	8/14	Average	Average	Average
Copepods:								
Epischura		0.86	0.83	0.54	0.50	0.68	0.76	0.67
Ovigerous *Epischura*						n/a	0.72	1.13
Diaptomus		1.11	1.12	0.90	0.95	1.02	0.84	1.15
Ovigerous *Diaptomus*				1.21	1.11	1.16	0.67	1.39
Cyclops	0.39	0.55	0.67	0.53	0.61	0.55	0.80	0.64
Ovigerous *Cyclops*		0.80	0.96	0.99	1.11	0.96	1.30	1.10
Harpaticus			0.44	0.46	0.48	0.46	0.60	0.48
Nauplii	0.27	0.26	0.26			0.26	0.25	n/a
Cladocerans:								
Bosmina			0.33	0.29	0.31	0.31	0.32	0.39
Ovigerous *Bosmina*			0.43	0.39	0.39	0.40	0.44	0.44
Daphnia longiremis	0.48	0.63	0.60	0.49	0.54	0.55	0.67	0.55
Ovigerous *Daphnia longiremis*		0.94	0.82	0.90	0.83	0.87	0.60	0.70
Chydorinae			0.29	0.26	0.28	0.28	0.12	0.29

[a]Only station two sampled due to rough weather conditions.

Table 18. Average number of zooplankton per m^2 from Black Lake, by sample date, 2002,compared to the 2000 and 2001 seasonal averages.

	2002						2001	2000
	Sample Date					Seasonal	Seasonal	Seasonal
Taxon	5/25	6/22	7/19	8/15	9/1	Average	Average	Average
Copepods:								
Epischura	0	663	2,123	12,633	7,166	4,517	1,327	3,925
Ovig *Epischura*	0	0	0	0	0	0	0	64
Diaptomus	13,535	663	0	1,115	1,592	3,381	619	1,788
Ovig. *Diaptomus*	0	0	0	0	0	0	0	0
Cyclops	27,070	13,270	26,539	57,962	73,248	39,618	3,654	17,699
Ovig. *Cyclops*	0	0	0	0	0	0	0	0
Harpaticus	0	0	0	0	0	0	265	0
Napulii	18,047	8,625	10,616	21,178	16,720	15,037	3,229	8,774
Total copepods	58,652	23,222	39,278	92,888	98,726	62,553	9,094	32,250
Cladocerans:								
Bosmina	0	12,606	64,756	135,244	286,624	99,846	12,889	19,228
Ovig. *Bosmina*	0	0	25,478	62,420	46,975	26,975	2,442	5,223
Daphnia l.	0	0	0	0	0	0	186	434
Ovig *Daphnia l.*	0	0	0	0	0	0	0	0
Chydorinae	0	0	11,677	62,049	18,312	18,408	263,048	5,816
Total cladocerans	0	12,606	101,911	259,713	351,911	145,228	278,565	30,701
Total copepods + cladocerans	117,304	59,050	180,467	445,489	549,363	270,335	296,753	95,201
Rotifers:								
Kellicottia	0	19,904	6,369	25,637	11,943	12,771	734	9,841
Asplanchna	0	663	9,554	6,688	11,943	5,770	29,910	60
Keratella	0	47,771	1,592	25,637	0	15,000	8,245	16,214
Conochilus	1,783	0	334,395	156,051	83,599	115,166	3,751	86,712
other rotifers	1,019	0	9,554	679,936	262,739	190,650	1,990	2,309
Total rotifers	2,803	68,339	361,464	893,949	370,223	339,355	44,630	115,136
Other:								
Ostracoda	17,102	1,990	0	0	0	3,818	4	30,732

Table 19. Biomass estimates (mg dry weight/m^2) of the major Black Lake zooplankton taxon by sample date, 2002, compared to the 2000 and 2001 season averages.

	2002							2001		2000	
	Sample Date					Seasonal	Weighted	Seasonal	Weighted	Seasonal	Weighted
Taxon	5/25	6/22	7/19	8/15	9/1	Average	Average	Average	Average	Average	Average
Copepods:											
Epischura	0.00	0.81	2.59	15.41	8.74	4.70	2.48	1.64	0.78	4.46	3.65
Diaptomus	38.45	1.89	0.00	3.17	4.52	10.88	7.36	2.18	1.93	4.39	4.43
Cyclops	16.19	7.93	15.87	34.66	43.80	18.66	26.94	4.63	4.56	16.78	16.05
Harpaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	n/a	n/a
Total copepods	54.64	10.63	18.46	53.24	57.07	34.24	36.78	8.90	7.71	25.63	24.12
Cladocerans:											
Bosmina	0.00	9.94	51.05	106.63	225.98	41.91	80.89	0.33	7.90	18.66	16.43
Ovigerous *Bosmina*	0.00	0.00	32.34	79.23	59.62	27.89	34.79	0.00	2.59	7.40	6.74
Daphnia longiremis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.24	0.23
Chydorinae	0.00	0.00	1.29	6.88	2.03	2.04	9.96	3.66	2.53	3.60	3.30
Total cladocerans	0.00	9.94	84.69	192.73	287.63	71.84	125.64	3.99	13.13	29.91	26.70
Total Biomass	54.64	20.57	103.15	245.97	344.70	106.08	162.42	12.89	20.85	55.54	50.82

Table 20. Average length (mm) of macrozooplankton in Black Lake by sample date, 2002, compared to the 2000 and 2001 seasonal averages.

	2002						2001	2000
	Sample Date					Seasonal	Seasonal	Seasonal
Taxon	5/25	6/22	7/19	8/15	9/1	Average	Average	Average
Copepods:								
Epischura		1.18	0.42	0.45	0.48	0.79	0.53	0.62
Diaptomus		1.24		0.68	0.67	0.63	0.86	0.82
Cyclops	0.59	0.42	0.42	0.45	0.44	0.47	0.56	0.54
Harpaticus						0.20	0.70	n/a
Nauplii	0.15	0.24				0.20	0.29	n/a
Cladocerans:								
Bosmina		0.30	0.29	0.29	0.31	0.32	0.24	0.33
Ovigerous *Bosmina*			0.36	0.38	0.38	0.37	0.31	0.39
Daphnia l.						n/a	0.27	0.38
Chydorinae			0.23	0.25	0.26	0.24	0.17	0.27
Other:								
Ostracoda						n/a	0.09	n/a

Table 21. Total catch of juvenile sockeye salmon, by age and location, from the Chignik watershed, 2002.

	Total Sockeye Catch		Sample age (> 45 mm)					Estimated age[a]				
Location	< 45 mm	> 45 mm	0.	1.	2.	3.	Total	0.	1.	2.	3.	Total
Black Lake/Black River	1,361	4,030	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
			116	0	0	0	116	5,391	0	0	0	5,391
Chignik Lake	86	1,081	21.8%	72.4%	5.8%	0.0%	100.0%	27.6%	67.0%	5.4%	0.0%	100.0%
			102	338	27	0	467	322	782	62	0	1,167
Chignik River	931	6,341	33.2%	65.3%	1.4%	0.0%	100.0%	41.8%	57.0%	1.3%	0.0%	100.0%
			115	226	5	0	346	3,039	4,142	92	0	7,272
Chignik Lagoon	856	2,582	44.3%	53.4%	2.0%	0.4%	100.0%	58.1%	40.1%	1.5%	0.3%	100.0%
			112	135	5	1	253	1,999	1,378	51	10	3,438
Entire watershed	3,234	14,034	37.6%	59.1%	3.1%	0.1%	100.0%	49.3%	48.1%	2.5%	0.1%	100.0%
			445	699	37	1	1182	8,518	8,299	439	12	17,268

[a] Sampled age compositions are used to apportion the sockeye catches > 45 mm; all sockeye < 45 mm were assumed to be age 0.

Table 22. Total beach seine hauls, total catch, and catch per haul, by month, of juvenile sockeye salmon from Black Lake, Black River, Chignik Lake, Chignik River, and Chignik Lagoon, 2000, 2001, and 2002.

		2002							2001			2000		
		Number	Sockeye Catch			Sockeye Catch/Haul			Sockeye Catch/Haul			Sockeye Catch/Haul		
Area	Month	of Hauls	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total
Black Lake	May	4	965	0	965	241	0	241	74	0	75	n/a	n/a	n/a
	June	7	2,250	587	2,837	321	84	405	15	2	16	1	327	328
	July	6	764	588	1,352	127	98	225	0	11	11	9	50	59
	August	4	0	12	12	0	3	3	n/a	n/a	n/a	14	0	14
Chignik Lake	May	7	1	217	218	0	31	31	14	195	209	n/a	n/a	n/a
	June	13	16	302	318	1	23	24	0	94	94	1	3	4
	July	14	69	378	447	5	27	32	5	10	15	7	19	26
	August	7	0	134	134	0	19	19	0	22	22	9	0	9
Chignik River	May	3	325	893	1,218	108	298	406	n/a	n/a	n/a	198	0	198
	June	9	492	3,935	4,427	55	437	492	9	265	274	n/a	n/a	n/a
	July	6	108	1,465	1,573	18	244	262	2	492	494	331	32	363
	August	0	n/a	n/a	n/a	n/a	n/a	n/a	1	218	219	218	1	219
Chignik Lagoon	May	6	11	6	17	2	1	3	134	84	218	22	0	22
	June	12	796	1,602	2,398	66	134	200	22	71	93	38	1	39
	July	7	49	936	985	7	134	141	1	78	79	14	12	26
	August	0	n/a	n/a	n/a	n/a	n/a	n/a	53	257	307	138	0	138

Table 23. Total hours towed, total catch, and catch per hour, by month, of juvenile sockeye salmon from Black Lake and Chignik Lake, 2000, 2001, and 2002.

		2002							2001			2000		
		Total	Sockeye Catch			Sockeye Catch / Hr towed			Sockeye Catch / Hr towed			Sockeye Catch / Hr towed		
Area	Month	hours	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total
Black Lake	June	0.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	194	1,571	1,765
	July	0.17	20	80	100	118	471	588	0	7,059	7,059	0	588	588
Chignik Lake	May	0.68	0	44	44	0	65	65	0	0	0	0	0	0
	June	1.02	0	1	1	0	1	1	6	43	49	6	44	50
	July	0.51	0	1	1	2	0	2	2	1,375	1,377	23	72	95
	August	1.02	0	4	4	0	4	4	2	1,304	1,306	63	66	129

Table 24. Fyke net hours fished, total catch, and catch per hour, by month, of juvenile sockeye salmon from Chignik and Black Rivers, 2000, 2001, and 2002.

		2002							2001			2000		
		Total hours	Sockeye Catch			Catch/Hr.			Catch/Hr.			Catch/Hr.		
Area	Month	fished	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total	< 45 mm	> 45 mm	Total
Black River	May	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	5	5	12	1	13
	June	9.08	7	0	7	1	0	1	0	1	1	0	0	0
	July	10.20	24	85	109	2	8	11	n/a	n/a	n/a	77	0	77
	August	6.47	0	9	9	0	1	1	n/a	n/a	n/a	n/a	n/a	n/a
Chignik River	May	4.75	4	3	7	1	1	1	n/a	n/a	n/a	n/a	n/a	n/a
	June	9.55	2	9	11	0	1	1	21	0	21	n/a	n/a	n/a
	July	2.00	0	7	7	0	0	21	9	0	9	0	15	15
	August	7.50	0	29	29	0	0	21	n/a	n/a	n/a	0	14	14
	September	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	56	56

Table 25. Total catch of juvenile sockeye salmon from Black Lake and Black River, by age and gear type, 2002.

			Total Sockeye Catch		Sample (> 45 mm)					Estimated age[a]				
Area	Gear Type	Month	> 45 mm	< 45 mm	0.	1.	2.	3.	Total	0.	1.	2.	3.	Total
Black Lake	Townet	July	80	20	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					17	0	0	0	17	100	0	0	0	100
Black Lake	Beach seine	May	0	965	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					0	0	0	0	0	965	0	0	0	965
	Beach seine	June	587	2,250	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					21	0	0	0	21	2,837	0	0	0	2,837
	Beach Seine	July	588	764	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					44	0	0	0	44	1,352	0	0	0	1,352
	Beach Seine	August	12	0	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					12	0	0	0	12	12	0	0	0	12
Black Lake Total	All	All	1,267	3,999	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					94	0	0	0	94	5,266	0	0	0	5,266
Black River	Fyke	June	0	7	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					0	0	0	0	0	7	0	0	0	7
	Fyke	July	85	24	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					16	0	0	0	16	109	0	0	0	109
	Fyke	August	9	0	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					6	0	0	0	6	9	0	0	0	9
	All	All	94	31	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					22	0	0	0	22	125	0	0	0	125
Black Lake/River Total	All	All	1,361	4,030	100.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%
					116	0	0	0	116	5,391	0	0	0	5,391

[a] Sampled age compositions are used to apportion the sockeye catches >45 mm; all sockeye <45 mm were assumed to be age 0.

Table 26. Mean length, weight, and condition factor, by age and gear type, of juvenile sockeye salmon captured in Black Lake and Black River, 2002.

				Length (mm)		Weight (g)		Condition factor	
Gear Type	Month	Age	Sample size	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
Beach seine	May	0	64	37.0	14.03	0.56	0.23	1.08	0.42
	June	0	115	40.6	19.00	0.66	0.42	1.11	0.52
	July	0	96	46.3	20.48	1.25	0.64	1.17	0.52
	August	0	12	57.7	10.29	2.49	0.48	1.22	0.22
Fyke net	May	0	7	41.1	5.60	0.69	0.09	0.98	0.13
	June	0	25	47.8	12.07	1.24	0.35	1.07	0.27
	July	0	9	47.2	7.27	1.34	0.22	1.29	0.21
Tow	July	0	19	51.68	11.46	1.82	0.45	1.23	0.27

Table 27. Total catch of juvenile sockeye salmon from Chignik Lake, by age and gear type, 2002.

		Total Sockeye Catch		Sample (> 45 mm)					Estimated age[a]				
Gear Type	Month	< 45 mm	> 45 mm	0.	1.	2.	3.	Total	0.	1.	2.	3.	Total
Townet	May	0	44	2.8%	83.3%	13.9%	0.0%	100.0%	2.8%	83.3%	13.9%	0.0%	100.0%
				1	30	5	0	36	1	37	6	0	44
Townet	June	0	1	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	100.0%
				0	1	0	0	1	0	1	0	0	1
Townet	July	0	1	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	100.0%
				0	1	0	0	1	0	1	0	0	1
Townet	August	0	4	75.0%	25.0%	0.0%	0.0%	100.0%	75.0%	25.0%	0.0%	0.0%	100.0%
				3	1	0	0	4	3	1	0	0	4
Townet Total	All	0	50	9.5%	78.6%	11.9%	0.0%	100.0%	9.5%	78.6%	11.9%	0.0%	100.0%
				4	33	5	0	42	5	39	6	0	50
Beach seine	May	1	150	0.0%	78.0%	22.0%	0.0%	100.0%	0.7%	77.4%	21.9%	0.0%	100.0%
				0	46	13	0	59	1	117	33	0	151
Beach seine	June	16	369	12.6%	86.2%	1.3%	0.0%	100.0%	16.2%	82.6%	1.2%	0.0%	100.0%
				20	137	2	0	159	62	318	5	0	385
Beach Seine	July	69	378	45.6%	53.0%	1.3%	0.0%	100.0%	54.0%	44.8%	1.1%	0.0%	100.0%
				68	79	2	0	149	242	200	5	0	447
Beach Siene	August	0	134	17.2%	74.1%	8.6%	0.0%	100.0%	17.2%	74.1%	8.6%	0.0%	100.0%
				10	43	5	0	58	23	99	12	0	134
Beach Seine Total	All	86	1,031	23.1%	71.8%	5.2%	0.0%	100.0%	29.0%	66.2%	4.8%	0.0%	100.0%
				98	305	22	0	425	324	740	53	0	1,117
Total	All	86	1,081	21.8%	72.4%	5.8%	0.0%	100.0%	27.6%	67.0%	5.4%	0.0%	100.0%
				102	338	27	0	467	322	782	62	0	1167

[a] Sampled age compositions are used to apportion the sockeye catches > 45 mm; all sockeye < 45 mm were assumed to be age 0.

Table 28. Mean length, weight, and condition factor by age and gear type, of juvenile sockeye salmon captured in Chignik Lake in 2002.

				Length (mm)		Weight (g)		Condition factor	
Gear type	Month	Age	Sample size	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
Beach seine	May	1	46	72.33	21.01	3.78	0.91	0.97	0.28
		2	13	74.92	11.96	4.49	1.21	1.04	0.17
	June	0	20	40.85	8.12	0.65	0.15	0.85	0.17
		1	138	68.11	30.86	3.31	1.73	0.99	0.45
		2	2	95.50	6.03	10.30	0.65	1.18	0.07
	July	0	100	54.71	22.96	2.16	1.11	1.03	0.43
		1	79	64.66	23.74	2.93	1.13	1.07	0.39
		2	2	75.50	4.77	4.35	0.28	1.00	0.06
	August	0	10	67.20	9.41	3.16	0.45	1.03	0.15
		1	43	68.93	19.40	3.55	1.03	1.07	0.30
		2	5	71.4	7.12	4.02	0.40	1.10	0.11
Townet	May	0	1	51.00	2.28	1.00	0.04	0.75	0.03
		1	30	69.07	16.5	2.75	0.67	0.82	0.20
		2	5	72.40	7.21	3.24	0.33	0.85	0.08
	June	1	1	64.0	2.86	2.20	0.10	0.84	0.04
	July	1	1	62.0	2.77	2.20	0.10	0.92	0.04
	August	0	3	52.7	4.08	1.43	0.11	0.98	0.08
		1	1	59.0	2.64	2.00	0.09	0.97	0.04

Table 29. Total catch of juvenile sockeye salmon from Chignik River, by age and gear type, 2002.

		Total Sockeye Catch		Sample (> 45 mm)					Estimated age[a]				
Gear Type	Month	< 45 mm	> 45 mm	0.	1.	2.	3.	Total	0.	1.	2.	3.	Total
Beach seine	May	325	893	0.0%	91.1%	8.9%	0.0%	100.0%	26.7%	66.8%	6.5%	0.0%	100.0%
				0	41	4	0	45	325	814	79	0	1,218
Beach seine	June	492	3,935	21.0%	78.4%	0.6%	0.0%	100.0%	29.8%	69.7%	0.5%	0.0%	100.0%
				34	127	1	0	162	1,318	3085	24	0	4,427
Beach seine	July	108	1,465	55.3%	44.7%	0.0%	0.0%	100.0%	58.4%	41.6%	0.0%	0.0%	100.0%
				57	46	0	0	103	919	654	0	0	1,573
Beach Seine Total	All	925	6,293	29.4%	69.0%	1.6%	0.0%	100.0%	35.5%	63.1%	1.4%	0.0%	100.0%
				91	214	5	0	310	2,562	4,553	104	0	7,218
Fyke net	May	4	3	0.0%	100.0%	0.0%	0.0%	100.0%	57.1%	42.9%	0.0%	0.0%	100.0%
				0	2	0	0	2	4	3	0	0	7
Fyke net	June	2	9	25.0%	75.0%	0.0%	0.0%	100.0%	38.6%	61.4%	0.0%	0.0%	100.0%
				2	6	0	0	8	4	7	0	0	11
Fyke net	July	0	7	71.4%	28.6%	0.0%	0.0%	100.0%	71.4%	28.6%	0.0%	0.0%	100.0%
				5	2	0	0	7	5	2	0	0	7
Fyke net	August	0	29	89.5%	10.5%	0.0%	0.0%	100.0%	89.5%	10.5%	0.0%	0.0%	100.0%
				17	2	0	0	19	26	3	0	0	29
Fyke Net Total	All	6	48	66.7%	33.3%	0.0%	0.0%	100.0%	70.4%	29.6%	0.0%	0.0%	100.0%
				24	12	0	0	36	38	16	0	0	54
Total	All	931	6,341	33.2%	65.3%	1.4%	0.0%	100.0%	41.8%	57.0%	1.3%	0.0%	100.0%
				115	226	5	0	346	3,039	4142	92	0	7,272

[a] Sampled age compositions are used to apportion the sockeye catches > 45 mm; all sockeye < 45 mm were assumed to be age 0.

Table 30. Mean length, weight, and condition factor by age and gear type, of juvenile sockeye salmon captured in Chignik River in 2002.

				Length (mm)		Weight (g)		Condition factor	
Gear type	Month	Age	Sample size	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
Beach seine	May	0	56	53.38	17.1	1.48	0.54	0.87	0.28
		1	4	62.50	3.81	2.30	0.21	0.95	0.08
	June	0	48	49.04	14.67	1.15	0.37	0.94	0.29
		1	131	58.31	26.02	2.36	1.23	1.13	0.55
		2	1	78.00	3.48	6.20	0.28	1.31	0.06
	July	0	68	51.90	17.94	1.56	0.58	1.07	0.37
		1	50	54.38	16.46	1.75	0.57	1.05	0.32
Fyke net	May	0	1	33.00	1.47	0.20	0.01	0.56	0.02
		1	4	41.75	3.81	0.63	0.07	0.74	0.07
	June	0	2	50.50	3.19	1.50	0.10	1.20	0.08
		1	6	58.67	6.42	2.63	0.29	1.33	0.15
	July	0	5	61.80	6.17	2.58	0.27	1.06	0.11
		1	2	69.00	4.36	2.65	0.17	0.81	0.05
	August	0	17	58.18	10.58	1.92	0.37	0.94	0.17
		1	2	61.00	3.87	2.50	0.16	1.07	0.07

Table 31. Total catch, by age, of juvenile sockeye salmon from Chignik Lagoon, 2002.

		Total Sockeye Catch		Sample (> 45 mm)					Estimated age[a]				
Gear Type	Month	< 45 mm	> 45 mm	0.	1.	2.	3.	Total	0.	1.	2.	3.	Total
Beach seine	May	11	44	8.3%	79.2%	12.5%	0.0%	100.0%	26.7%	63.3%	10.0%	0.0%	100.0%
				2	19	3	0	24	15	35	6	0	55
Beach seine	June	796	1,602	29.4%	68.6%	1.3%	0.7%	100.0%	52.8%	45.8%	0.9%	0.4%	100.0%
				45	105	2	1	153	1,267	1,099	21	10	2,398
Beach Seine	July	49	936	85.5%	14.5%	0.0%	0.0%	100.0%	86.2%	13.8%	0.0%	0.0%	100.0%
				65	11	0	0	76	850	135	0	0	985
Beach Seine Total	All	856	2,582	44.3%	53.4%	2.0%	0.4%	100.0%	58.1%	40.1%	1.5%	0.3%	100.0%
				112	135	5	1	253	1,999	1378	51	10	3,438

[a] Sampled age compositions are used to apportion the sockeye catches > 45 mm; all sockeye < 45 mm were assumed to be age 0.

Table 32. Mean length, weight, and condition factor by age and gear type, of juvenile sockeye salmon captured in Chignik Lagoon in 2002.

			Sample	Length (mm)		Weight (g)		Condition factor	
Gear type	Month	Age	Size	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
Beach seine	May	0	2	50.40	6.50	1.48	0.26	0.68	0.08
		1	19	77.63	18.02	4.09	1.03	0.82	0.19
		2	3	89.33	8.38	6.73	0.63	0.95	0.09
	June	0	45	44.25	20.97	0.10	0.66	1.01	0.54
		1	105	66.86	31.59	3.80	1.97	1.26	0.70
		2	2	86.50	6.77	8.75	0.77	1.20	0.09
		3	1	98.00	5.32	11.80	0.64	1.25	0.07
	July	0	65	51.03	21.58	1.45	0.70	1.04	0.44
		1	11	72.58	13.80	4.53	0.96	1.05	0.20

Table 33. Average fish weight, stomach weight, and total number of identifiable prey items, by group, of juvenile sockeye salmon from throughout the Chignik watershed, 2002.

			Fish	Stomach	Number				
Location	n		WT (g)	WT (g)	Cladocerans	Copepods	Chironomids	Other Insects	Other Crustacea[a]
Black Lake	97	Average	0.7	0.1	4.3	17.4	16.3	1.8	0.0
		Standard Dev.	0.4	0.1	11.7	22.4	13.3	2.6	0.0
Black River	12	Average	0.6	0.1	2.5	0.7	8.6	0.0	0.0
		Standard Dev.	0.1	0.0	1.5	0.4	2.2	0.0	0.0
Chignik Lake	126	Average	2.6	0.3	1.7	57.6	18.2	0.5	0.0
		Standard Dev.	1.6	0.2	6.0	123.1	24.2	0.8	0.1
Chignik River	90	Average	2.0	0.3	1.9	24.4	10.8	0.3	0.2
		Standard Dev.	1.2	0.2	6.6	40.0	8.8	0.3	0.5
Chignik Lagoon	88	Average	2.4	0.3	4.5	106.3	5.2	0.0	13.5
		Standard Dev.	1.4	0.2	14.3	144.3	6.2	0.1	14.5
Entire System	413	Average	1.9	0.2	3.0	49.9	13.1	0.2	2.9
		Standard Dev.	1.9	0.3	20.4	191.4	27.6	3.4	14.5

[a] Crustacea consisted primarily of pericaridans (609 counted individuals) and amphipods (302 counted individuals).

Table 34. Average estimated dry weight of identifiable prey items per fish, of juvenile sockeye salmon from throughout the Chignik watershed, 2002.

Location	Sample size	Mean fish weight (g)	Dry weight (mg)			
			Cladocerans	Copepods	Insects[a]	Crustacea
Black Lake	97	0.7	0.003	0.030	10.880	0.000
Black River	12	0.6	0.002	0.001	5.150	0.000
Chignik Lake	126	2.6	0.001	0.067	11.229	0.011
Chignik River	90	2.0	0.002	0.028	6.657	0.173
Chingik Lagoon	88	2.4	0.004	0.124	3.164	9.578

[a] Insect category includes both "chironomids" and "other insects" from Table 33.

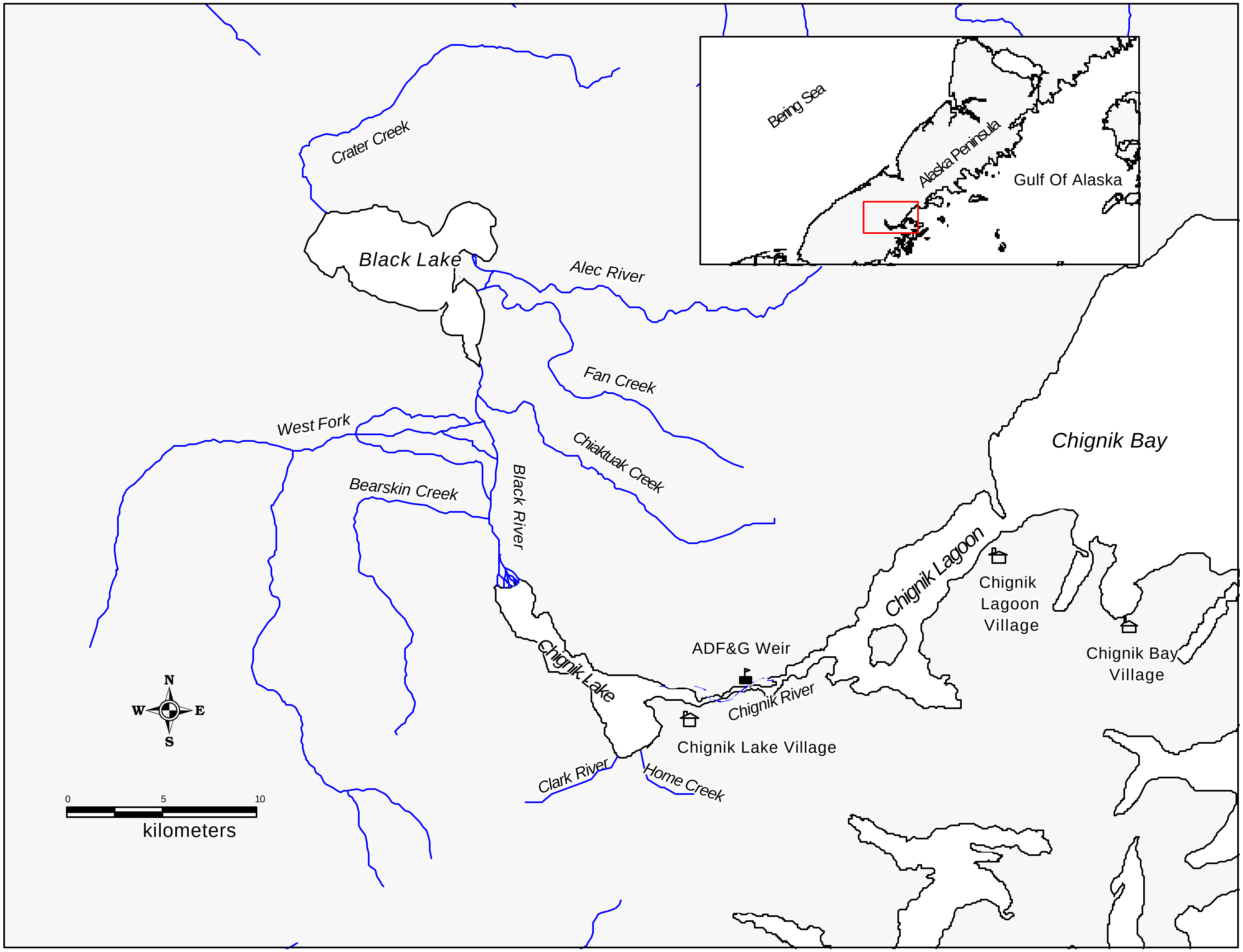


Figure 1. Map of the Chignik watershed with an inset of the Alaska Peninsula

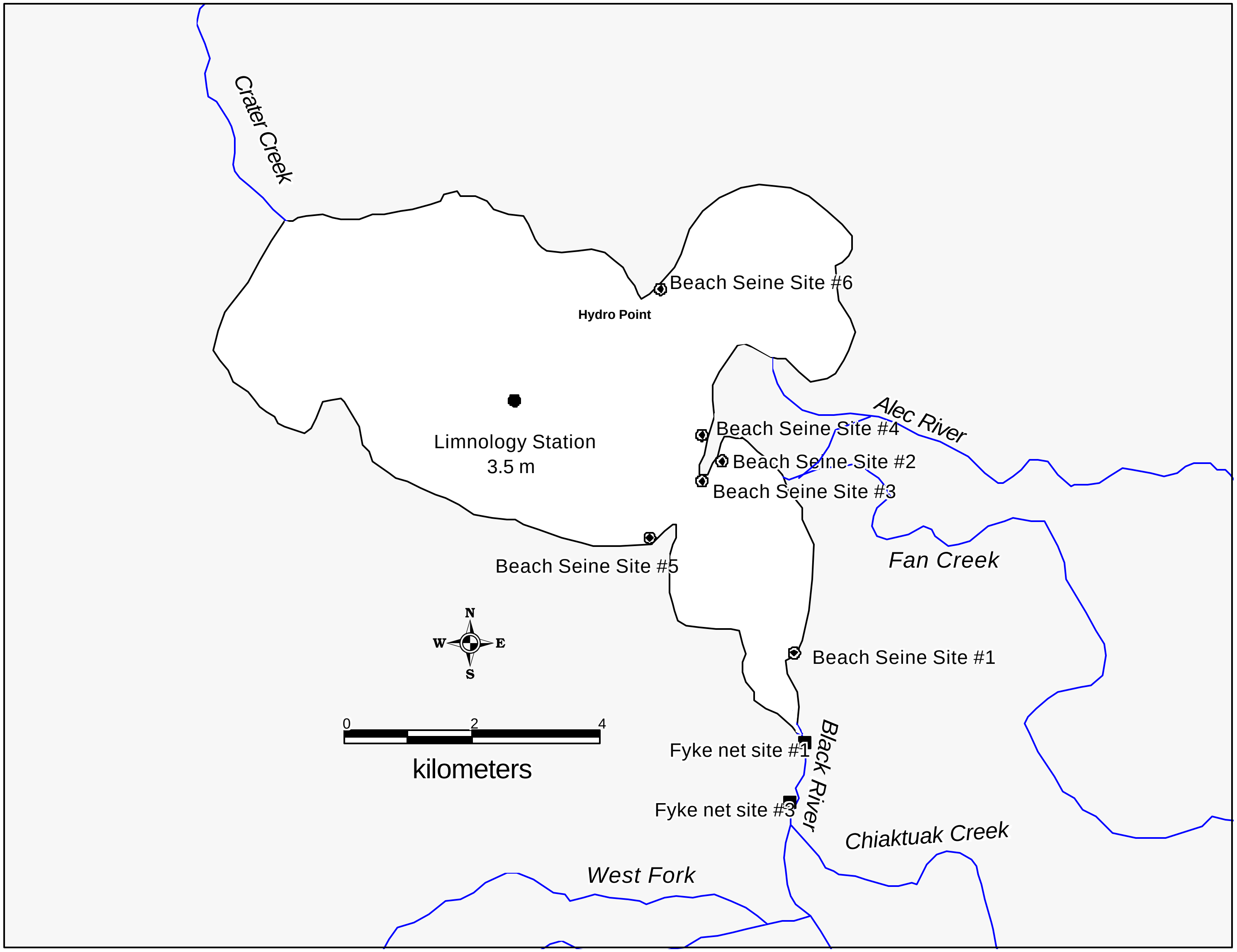


Figure 2. Map of Black Lake depicting the limnology station, beach seine sites, and fyke net sites.

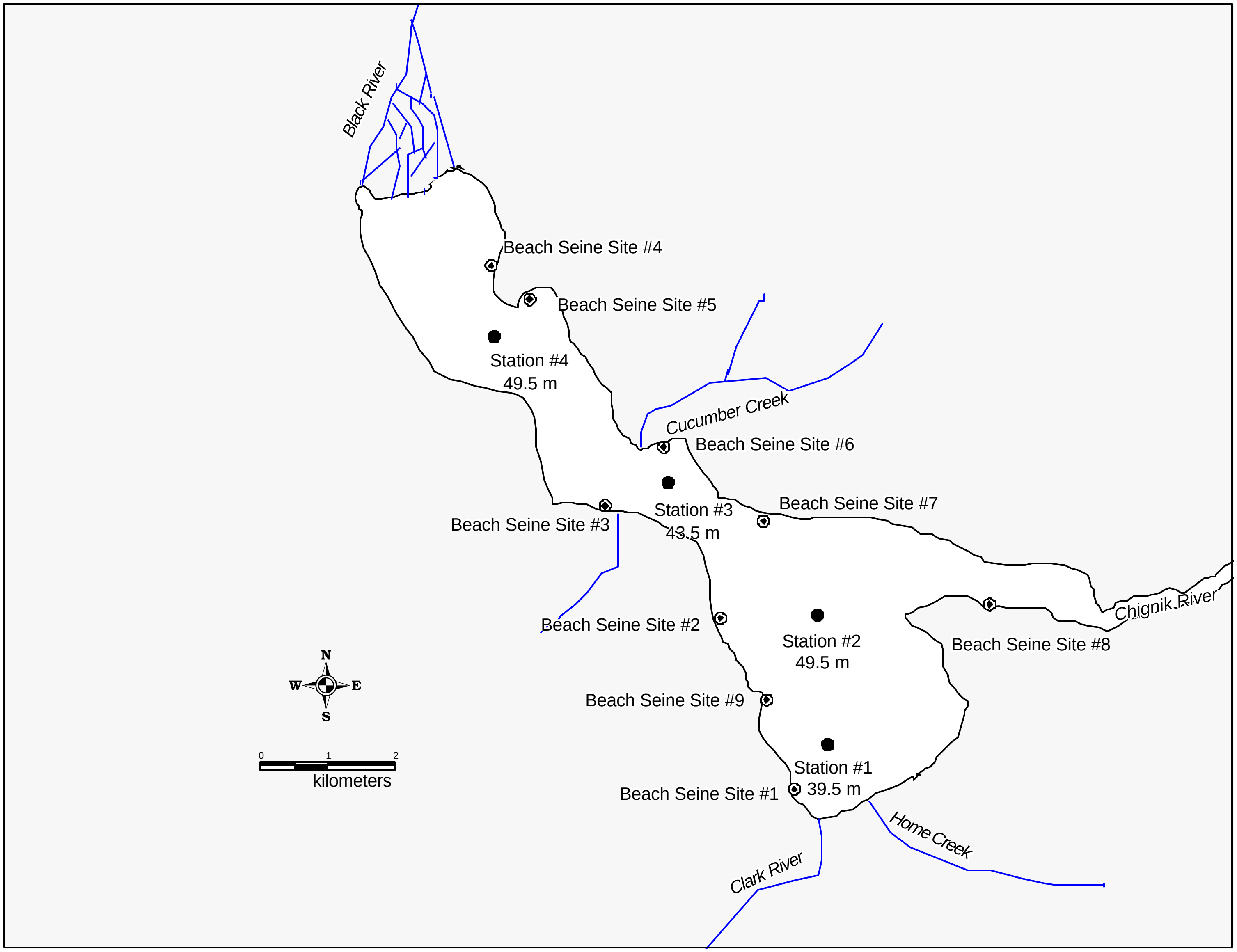


Figure 3. Map of Chignik Lake depicting the limnology stations and the beach seine sites.

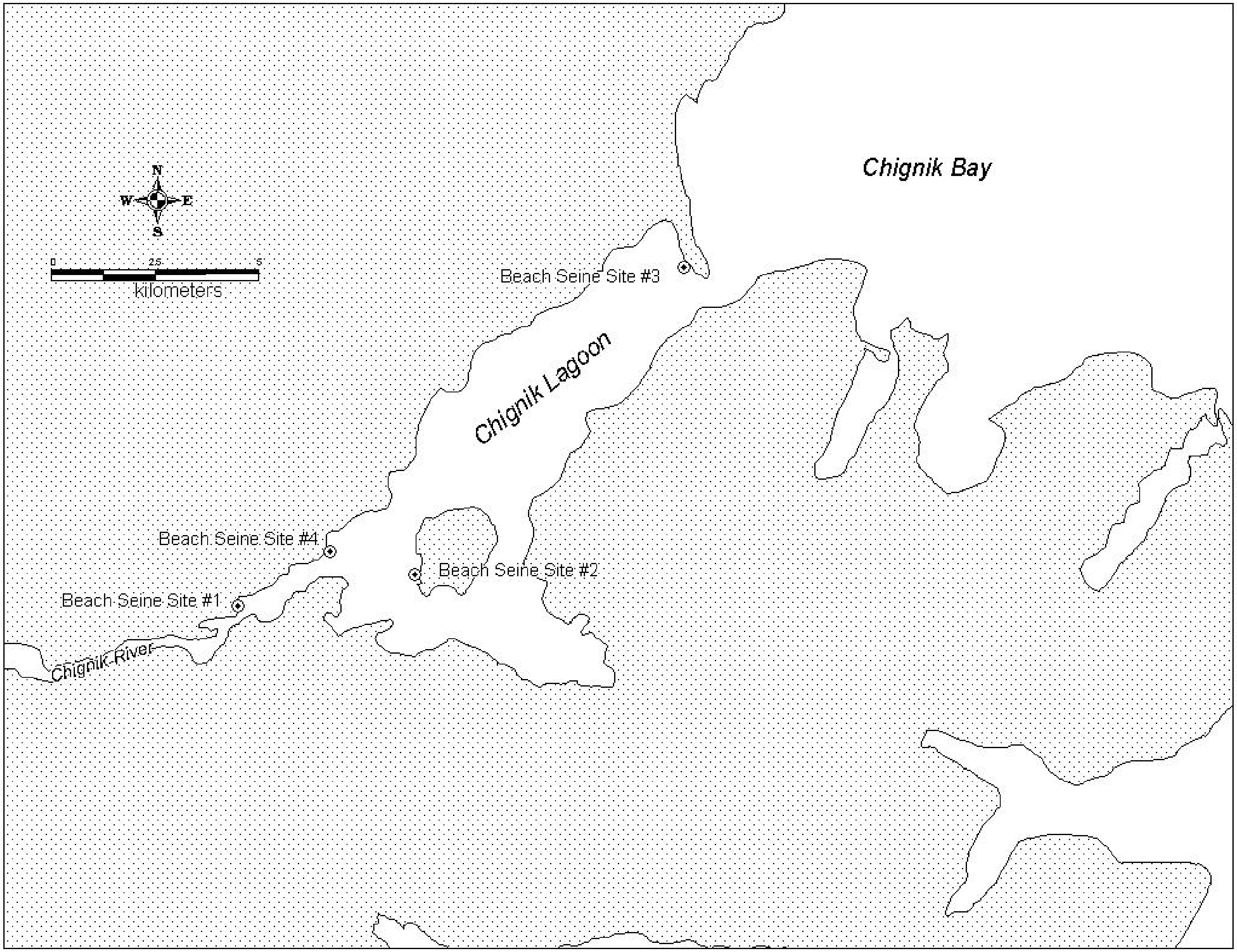


Figure 4. Map of the Chignik Lagoon depicting the beach seine sites.

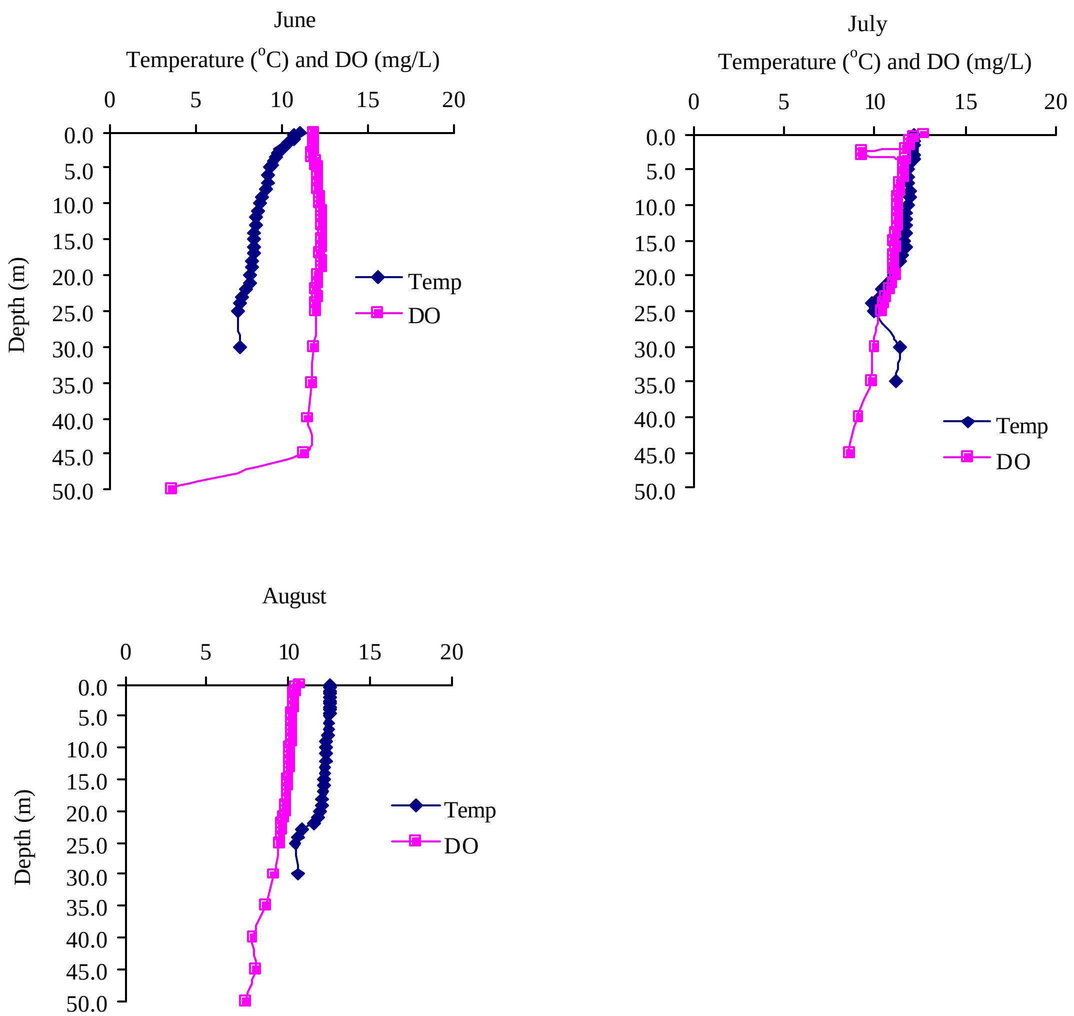
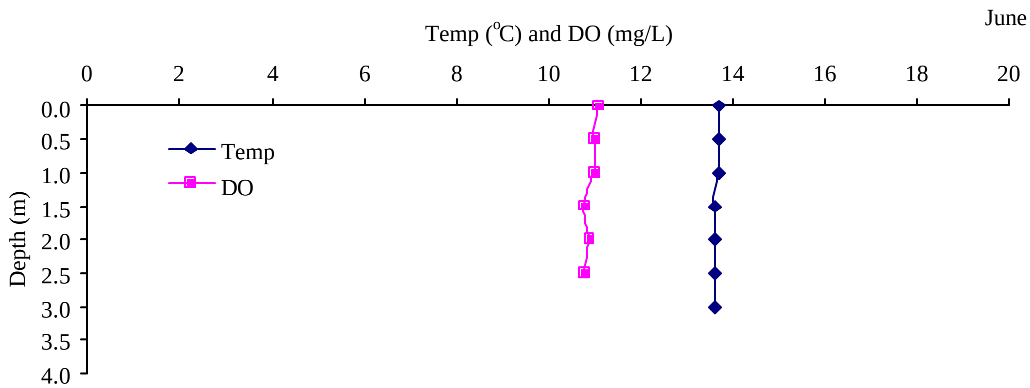


Figure 5. Mean monthly temperature and dissolved oxygen profiles for Chignik Lake, 2002.



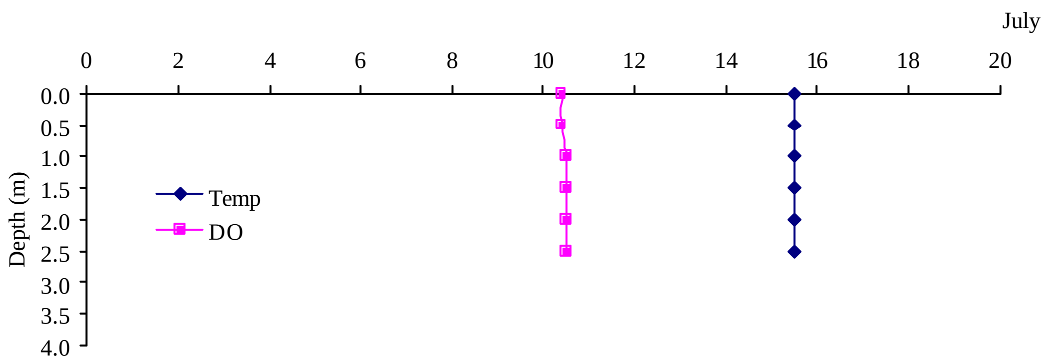


Figure 6. Mean monthly temperature and dissolved oxygen profiles for Black Lake, 2002.

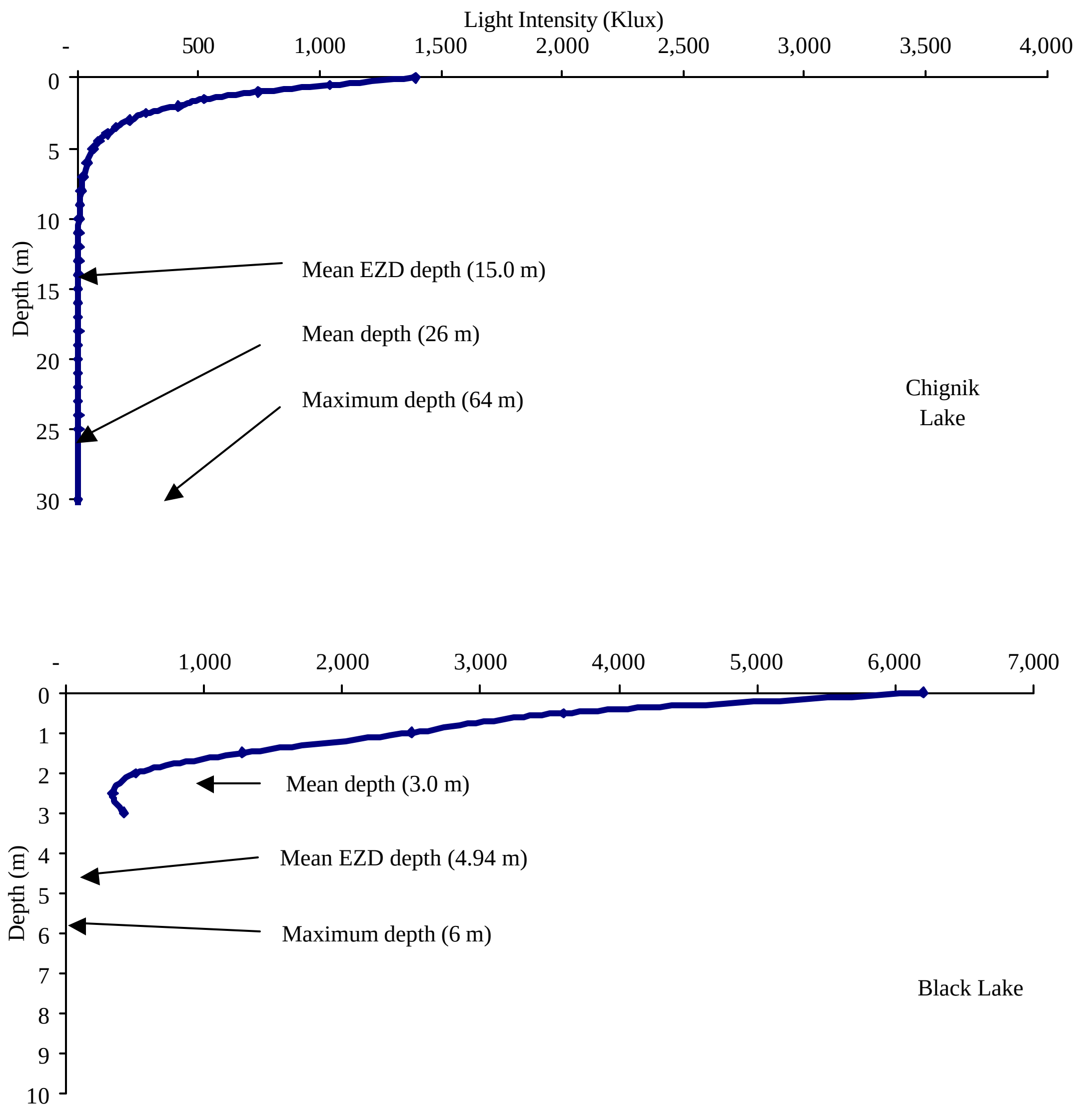


Figure 7. Light penetration curves in relationship to the mean depths, EZDs and maximum depths of Chignik and Black lakes, 2002.

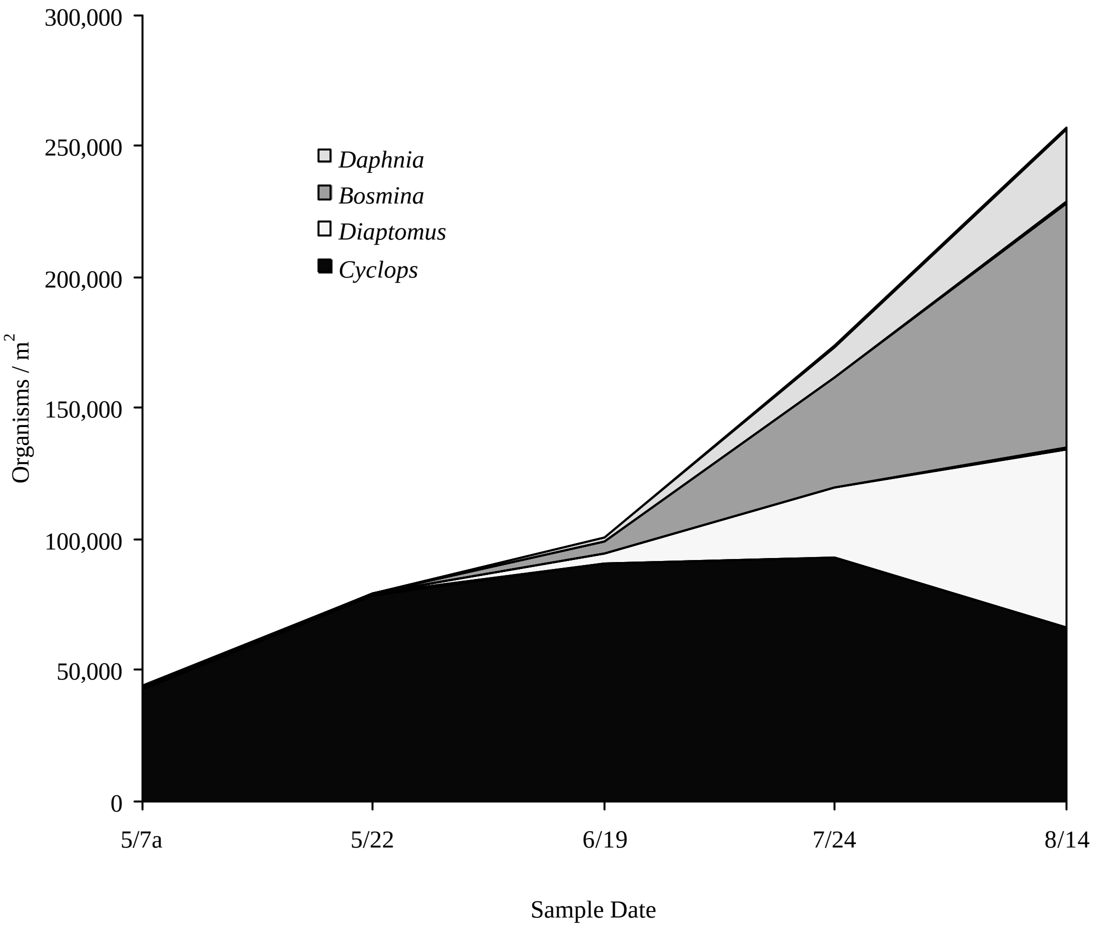


Figure 8. Number of organisms per m^2 of the major copepods (*Cyclops* and *Diaptomus*) and cladocerans (*Bosmina* and *Chydorinae*) in Chignik Lake, by sample date, 2002.

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[a] On 5/7/02 only station two was sampled due to rough weather.

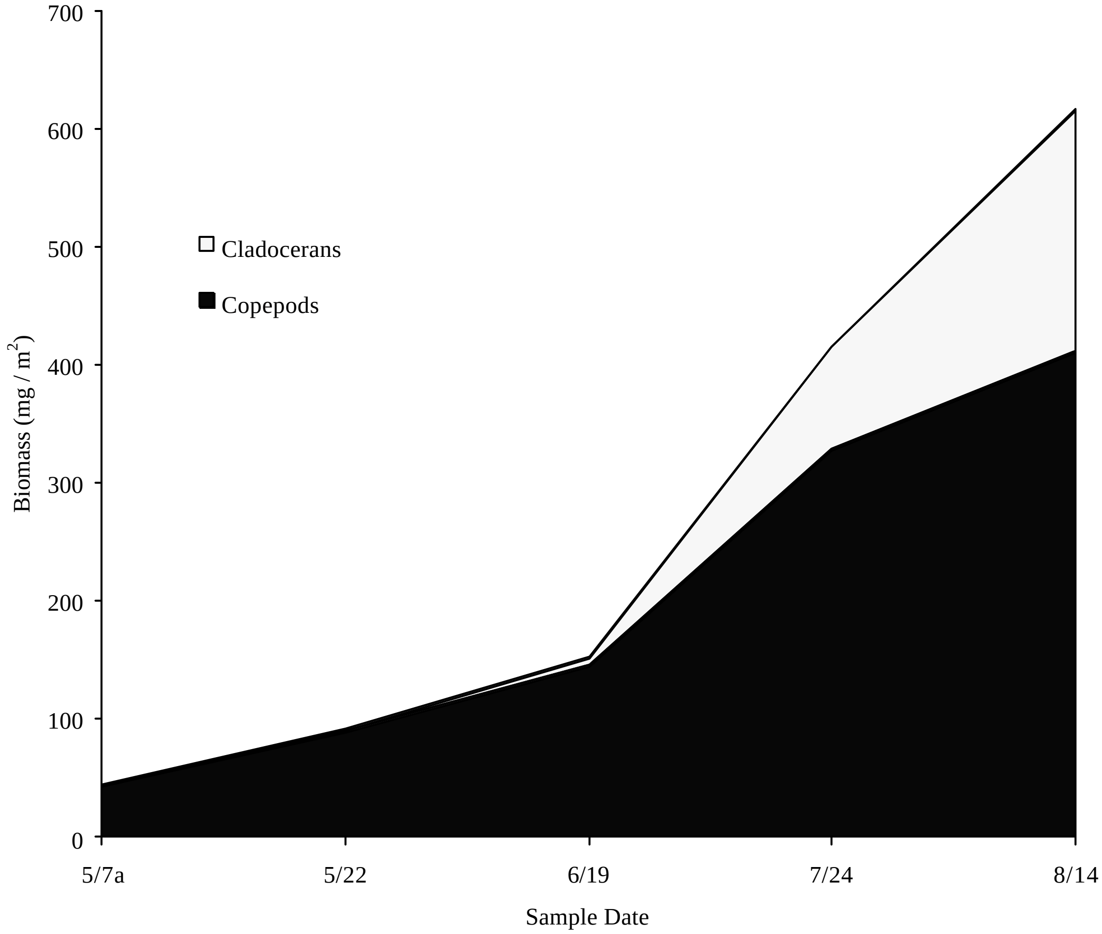


Figure 9. Mean biomass per m^2 of the major copepods and cladocerans in Chignik Lake, by sample date, 2002.

[a] On 5/7/02 only station two was sampled due to rough weather.

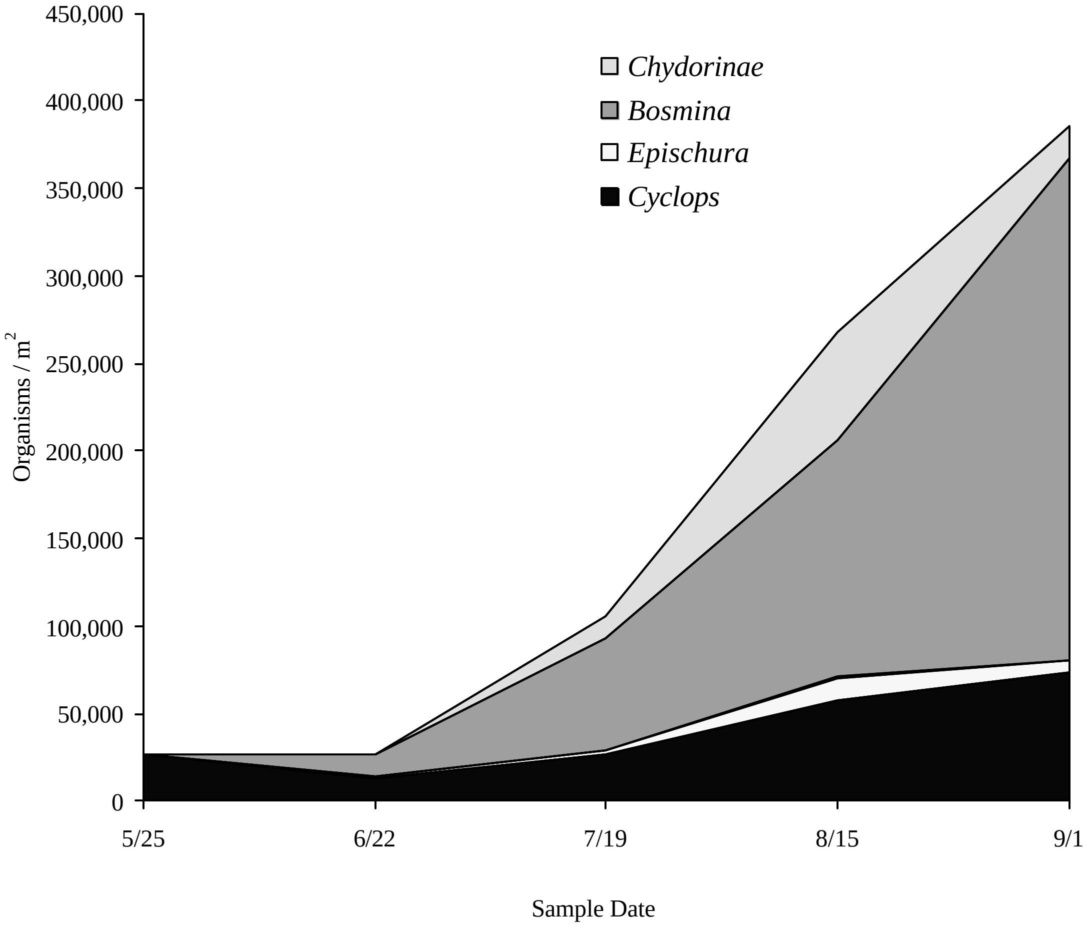


Figure 10. Number of organisms per m^2 of the major copepods (*Cyclops* and *Epischura*) and cladocerans (*Bosmina* and *Chydorinae*) in Black Lake, by sample date, 2002.

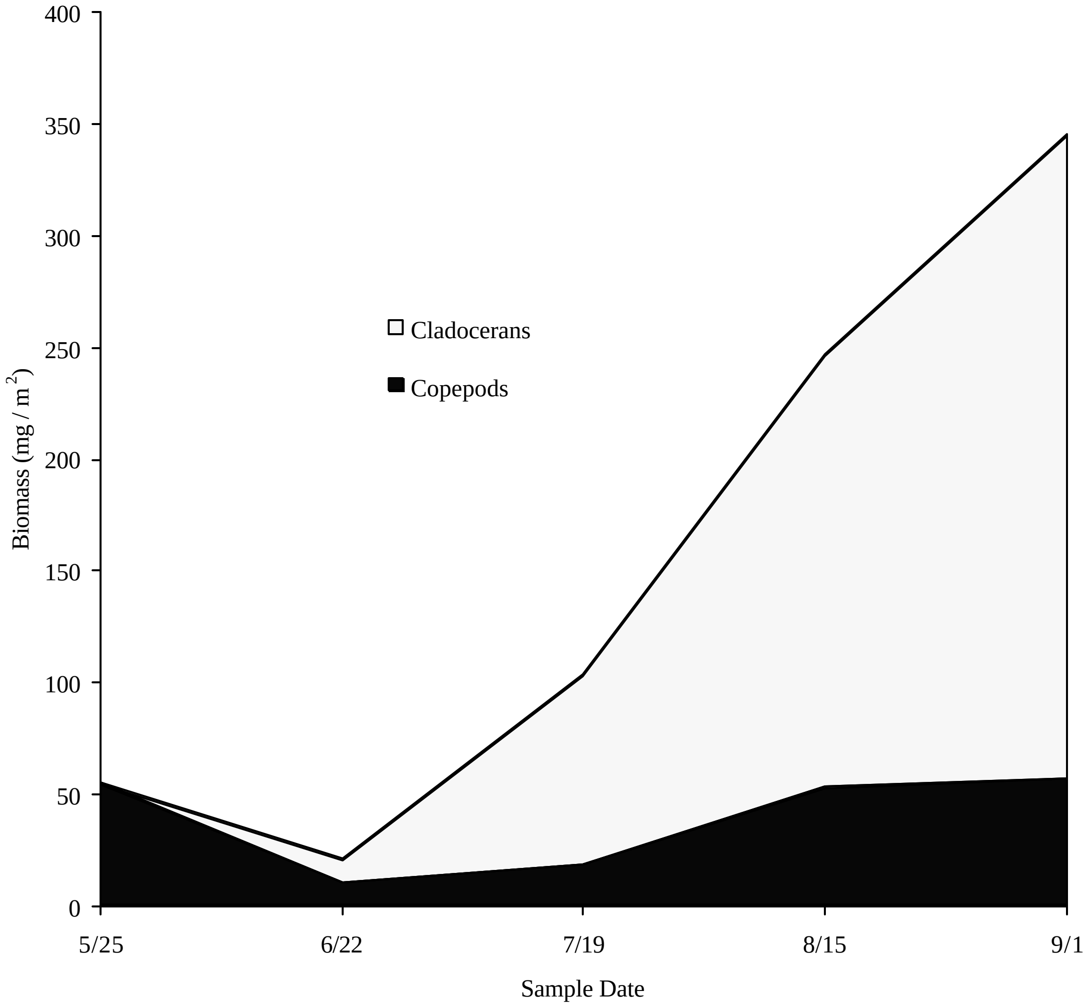


Figure 11. Mean biomass per m^2 of the major copepods and cladocerans in Black Lake, by sample date, 2002.

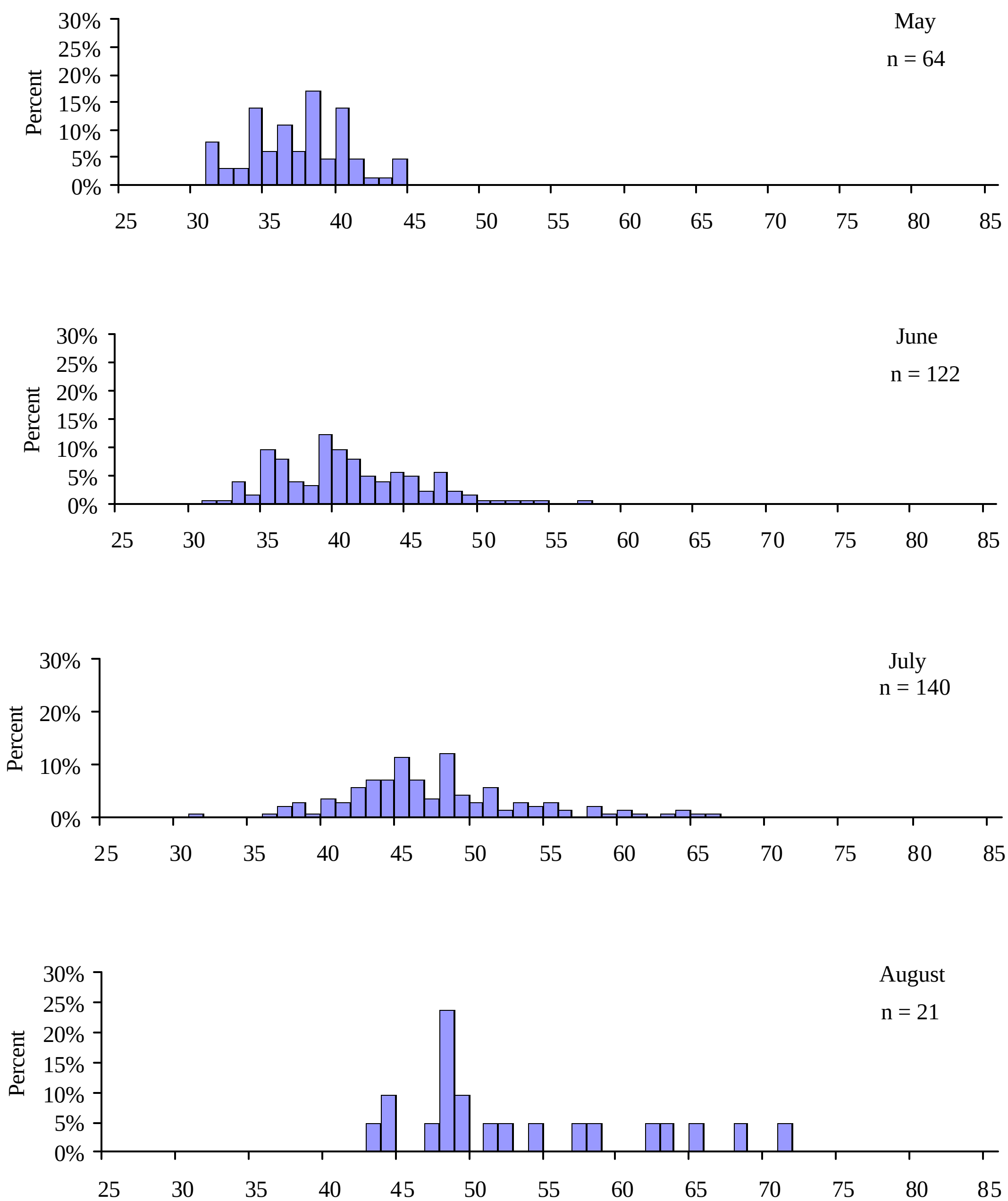
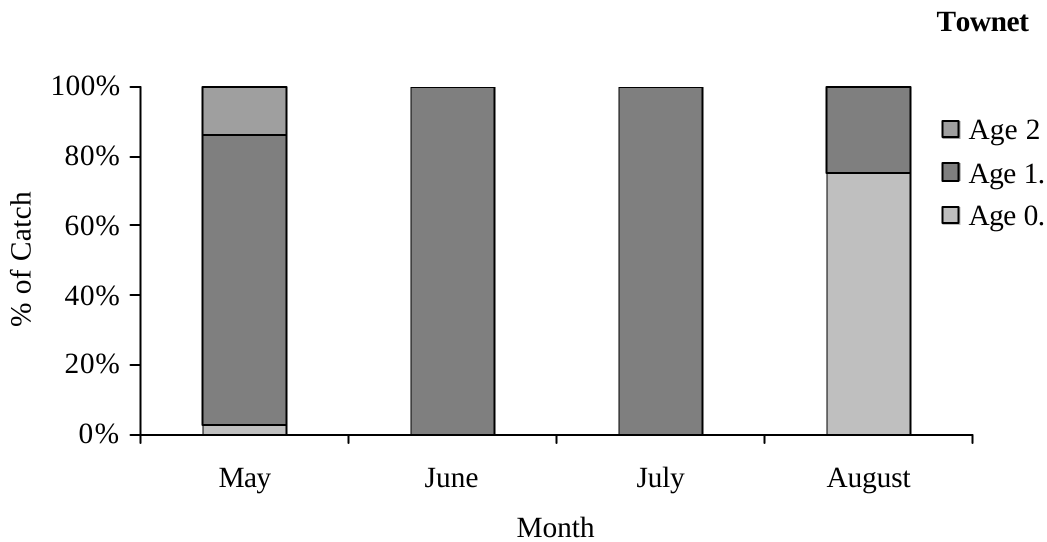


Figure 12. Length frequency histograms of juvenile sockeye salmon captured with a beach seine, fyke net and townet (July only) from Black Lake and Black River, by month, 2002.



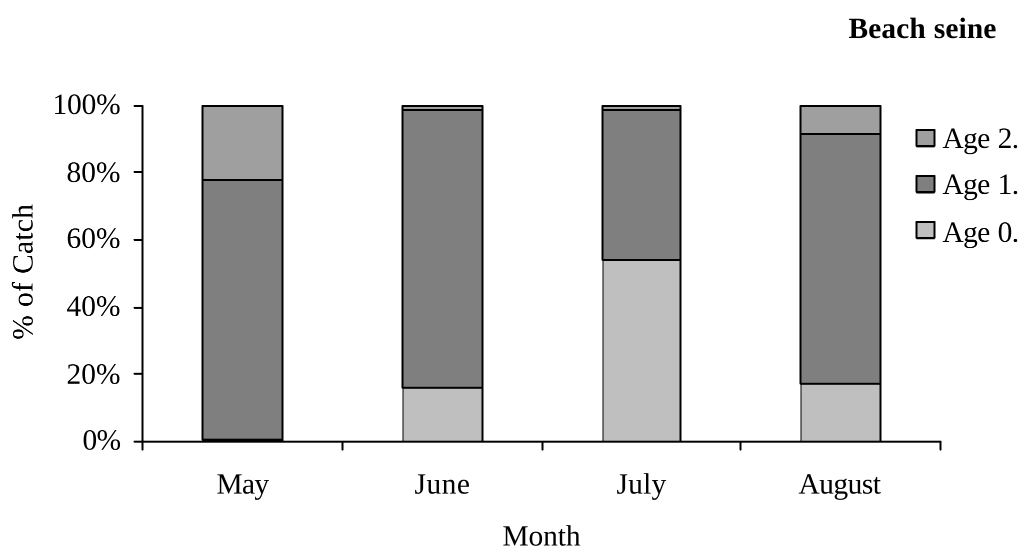


Figure 13. Estimated percent age in beach seine and townet catches from Chignik Lake, by month, 2002.

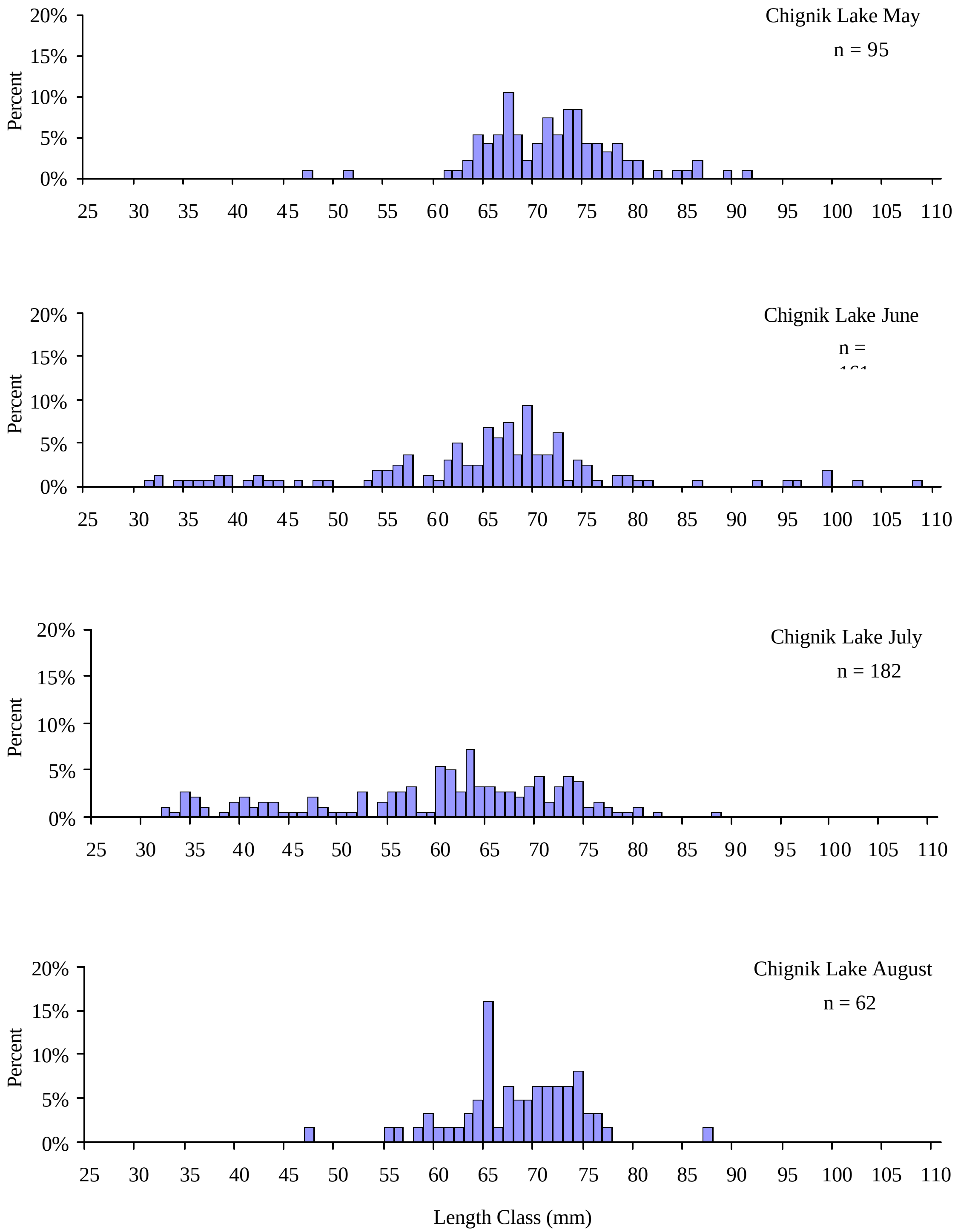


Figure 14. Length frequency histograms of juvenile sockeye salmon captured with a beach seine and a townet from Chignik Lake, by month, 2002.

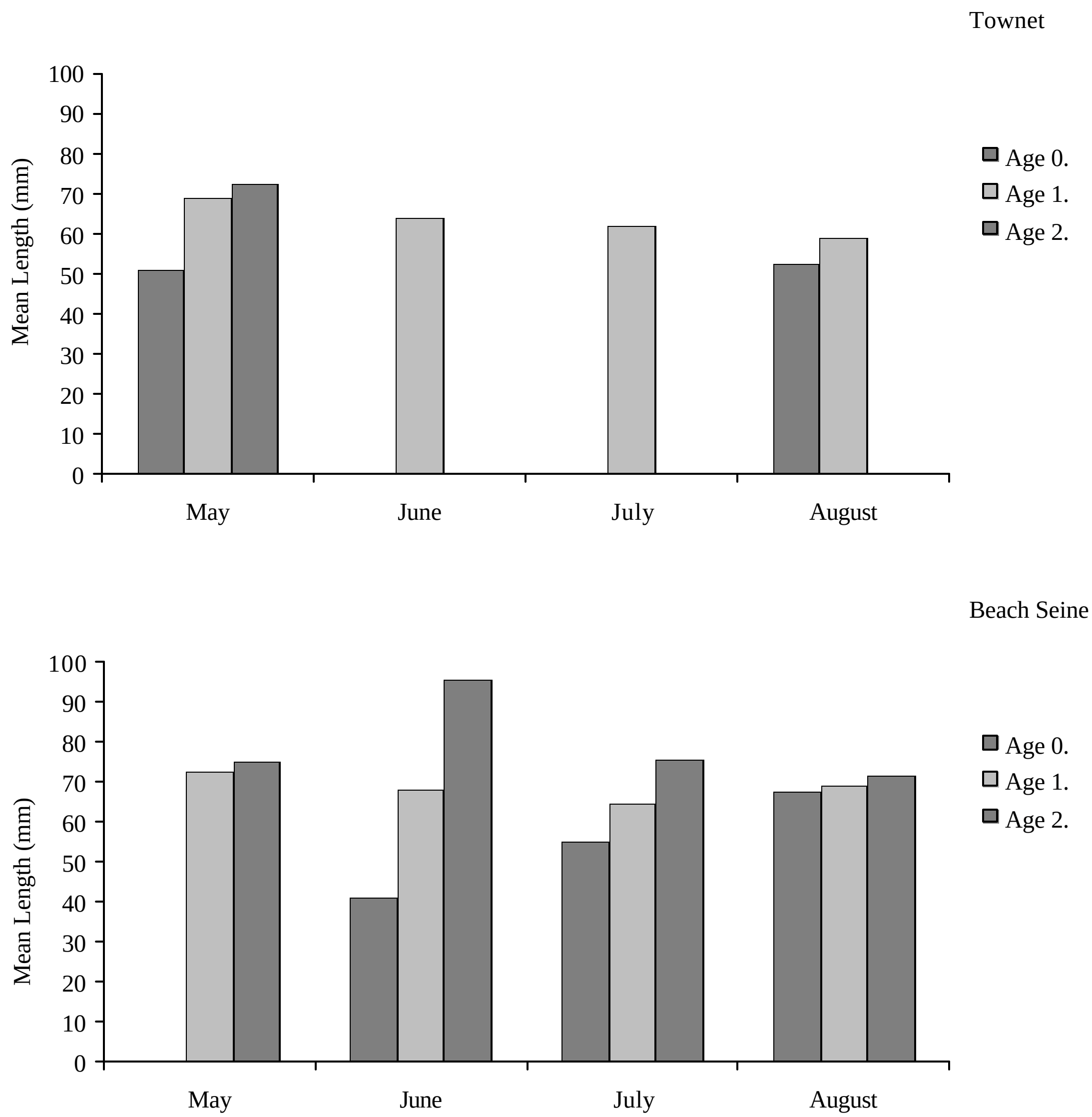


Figure 15. Mean lengths of townet and beach seine catches from Chignik Lake, by age and month, 2002.

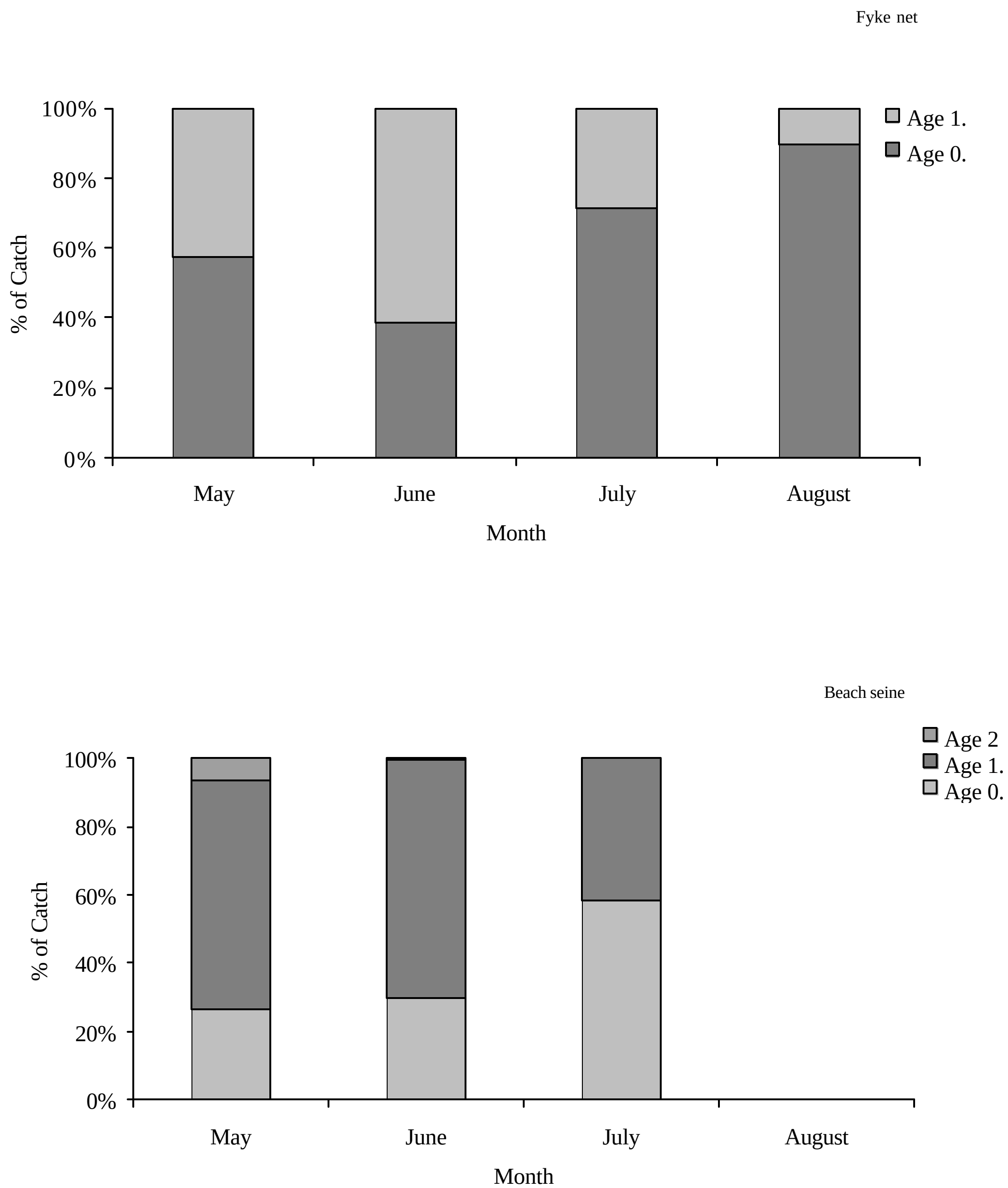


Figure 16. Age composition of fyke net and beach seine catches from Chignik River, by age and month, 2002.

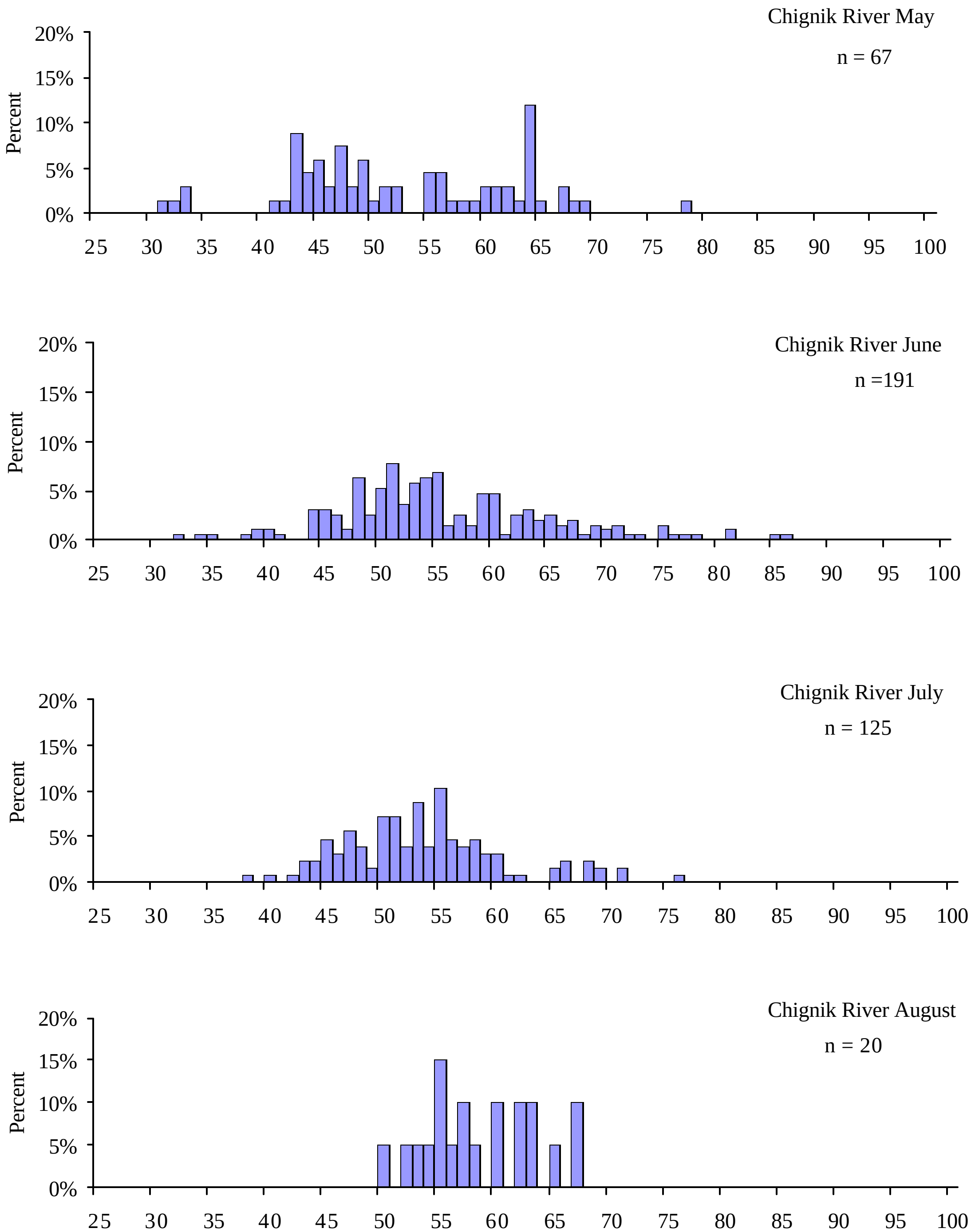
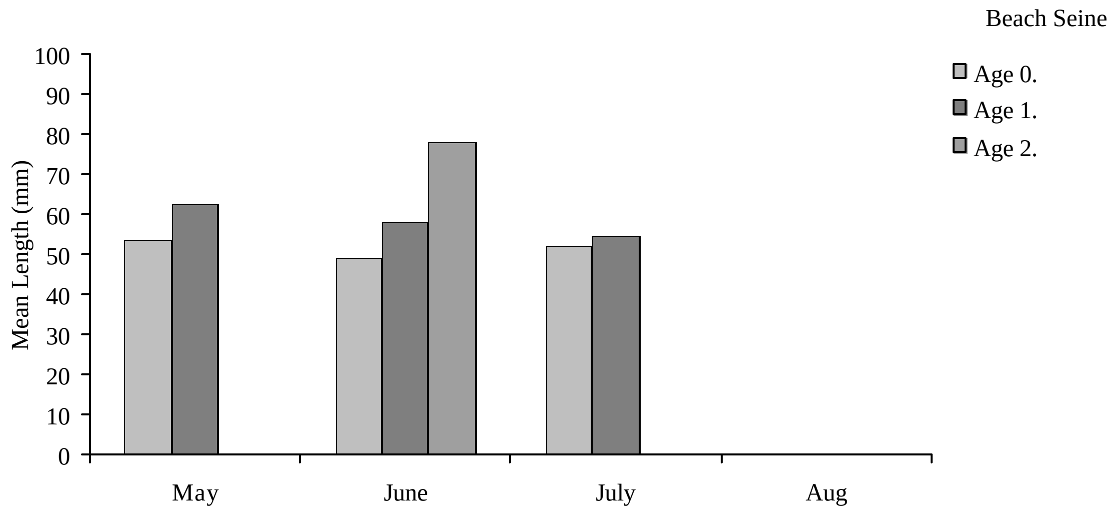


Figure 17. Length frequency histograms of juvenile sockeye salmon captured with a beach seine or a fyke net from Chignik River, by month, 2002.



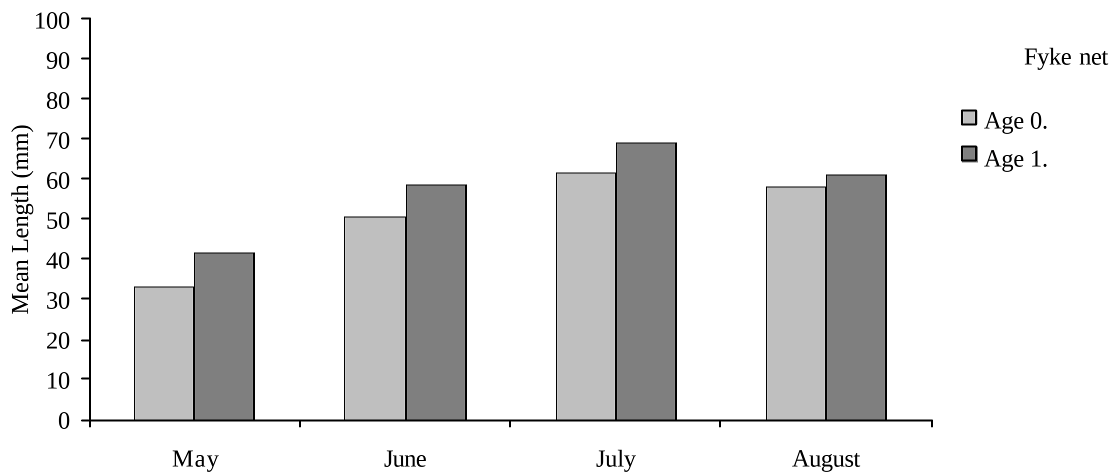


Figure 18. Mean lengths of beach seine and fyke net catches from Chignik River, by age and month, 2002.

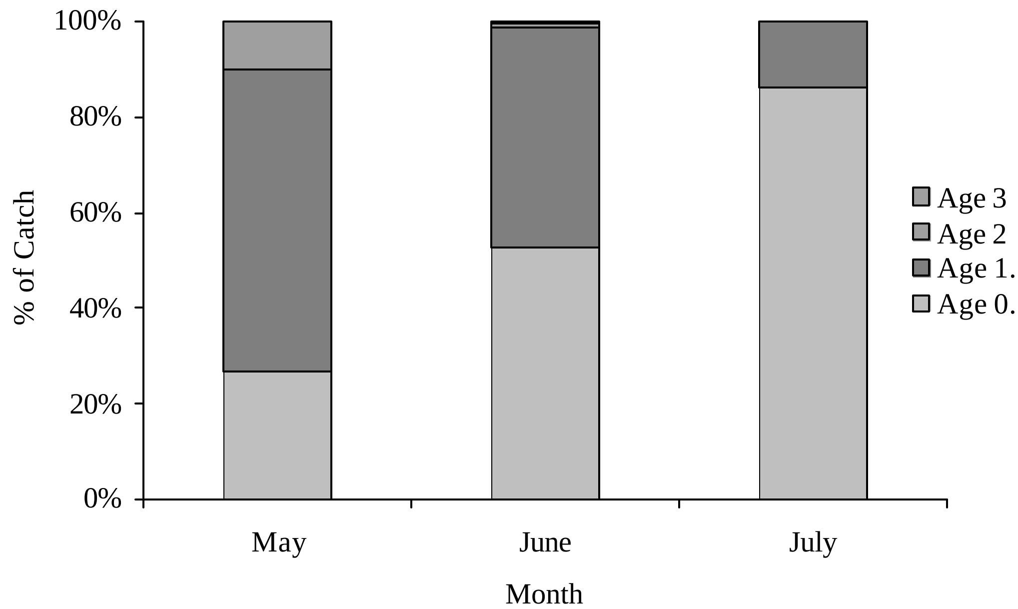
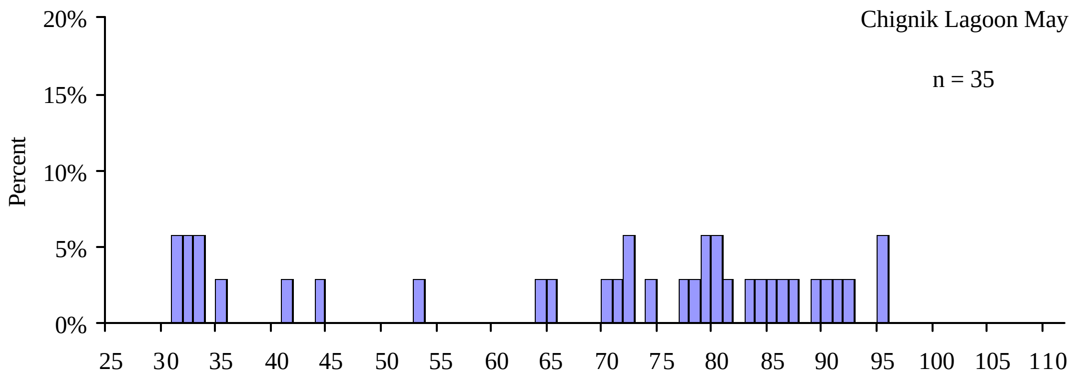
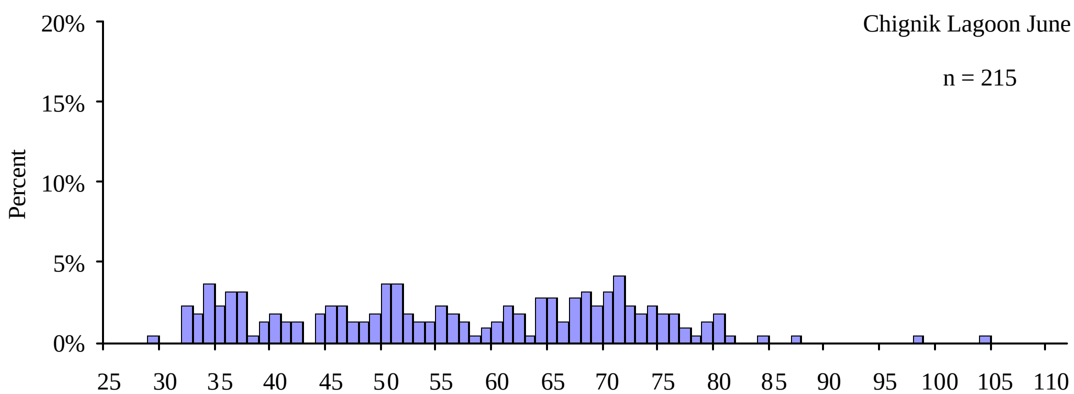


Figure 19. Estimated percent age in beach seine catches from Chignik Lagoon, by month, 2002.





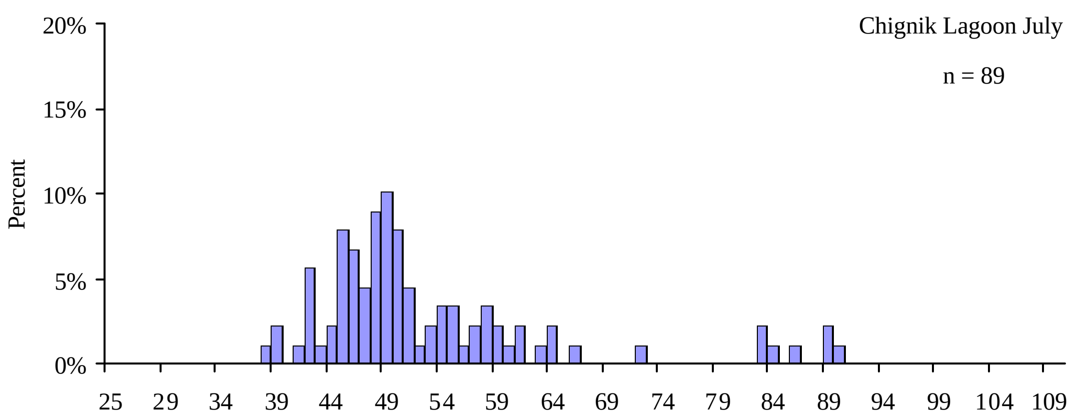


Figure 20. Length frequency histograms of juvenile sockeye salmon captured with a beach seine from Chignik Lagoon, by month, 2002.

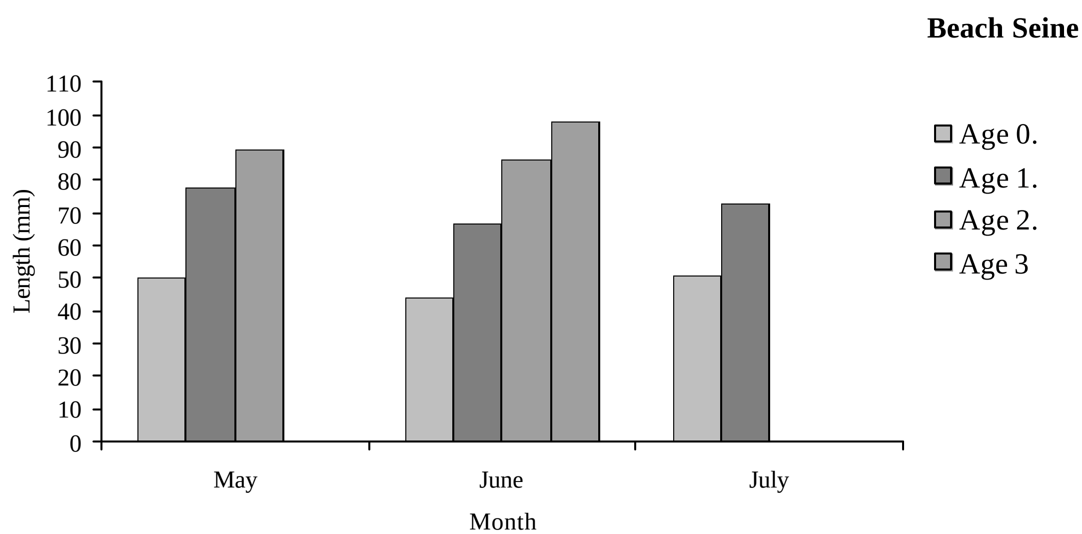


Figure 21. Mean lengths of beach seine catches from Chignik Lagoon, by age and month, 2002.

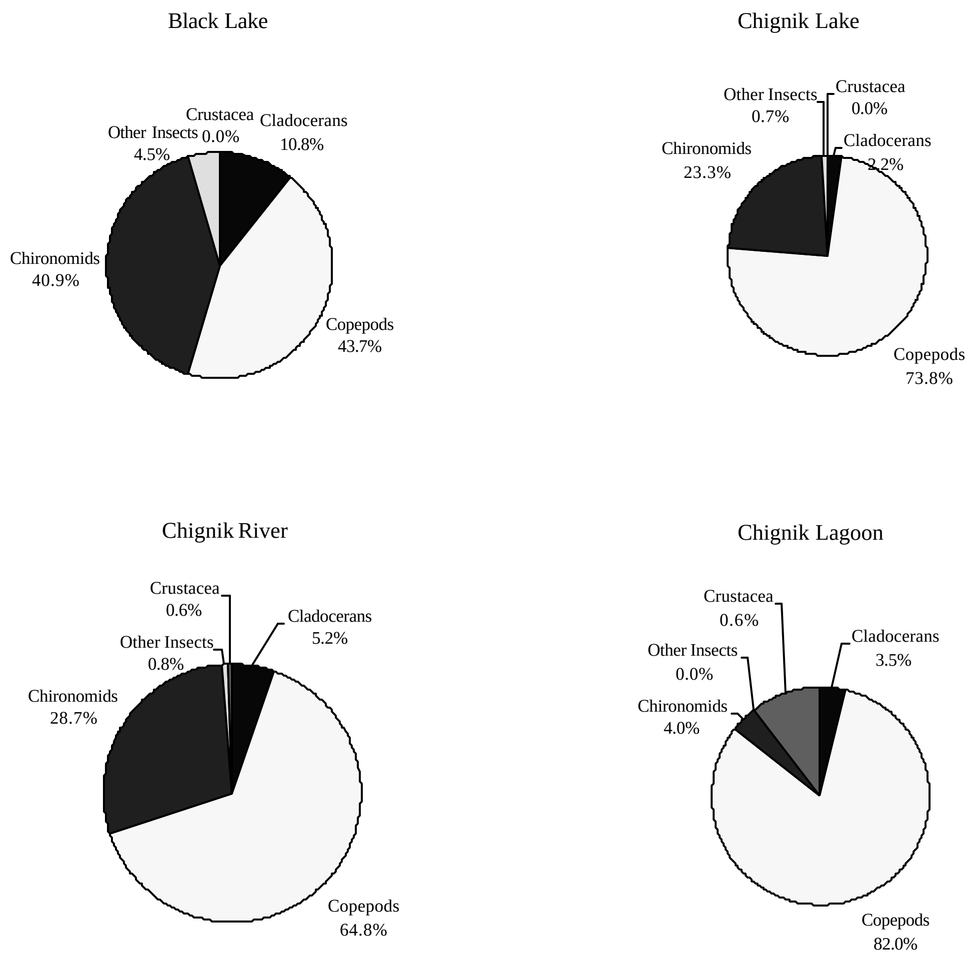


Figure 22. Percentage, by number, of identifiable groups of prey items in the digestive tracts of juvenile sockeye salmon from Black Lake, Chignik Lake, Chignik River, and Chignik Lagoon, 2002.

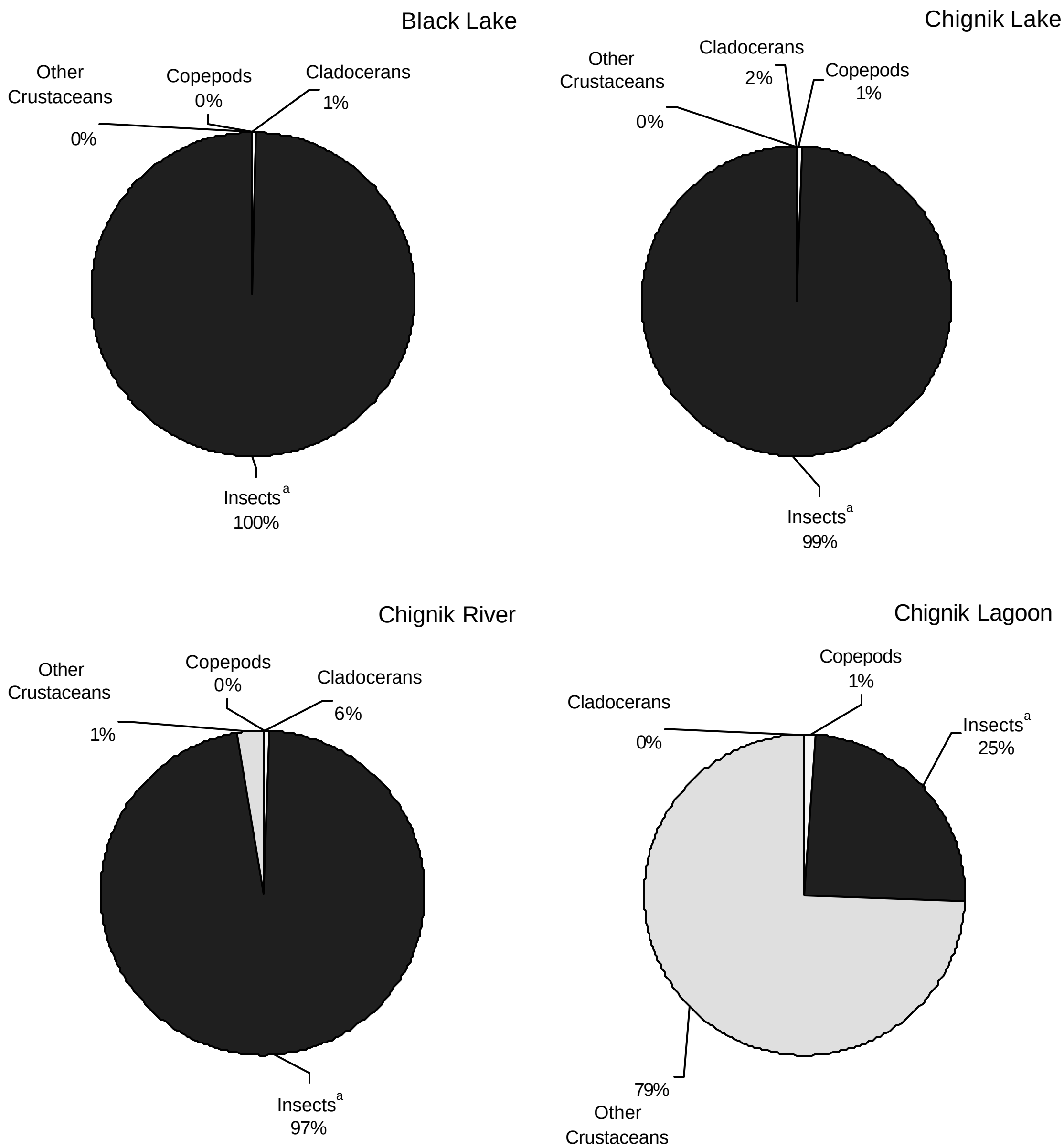


Figure 23. Percentage, by dry weight, of identifiable groups of prey items in the digestive tracts of juvenile sockeye salmon from Black Lake, Chignik Lake, Chignik River, and Chignik Lagoon, 2002.

APPENDIX

Appendix A. Location of the limnology sampling stations in Black and Chignik lakes, 2002.

Lake	Station	°Latitude (N)	°Longitude (W)
Black	1	56°27.207'	158°59.701'
Chignik	1	56°14.366'	158°48.834'
	2	56°15.344'	158°49.483'
	3	56°16.122'	158°50.612'
	4	56°17.316'	158°53.386'

Appendix B. Average number of zooplankton per m^3 from Chignik Lake, 2002.

	Number per m^3					
Taxon	5/7[a]	5/22	6/19	7/24	8/14	Average
Copepods:						
Epischura	0	13	87	582	1,421	421
Ovigerous *Epischura*	0	0	0	0	0	0
Diaptomus	0	3	145	645	691	297
Ovigerous *Diaptomus*	0	0	0	39	157	39
Cyclops	1,359	2,211	2,485	2,035	1,369	1,892
Ovigerous *Cyclops*	0	3	22	242	331	120
Harpaticus	0	0	6	23	29	12
Nauplii	658	395	704	945	2,207	982
Total copepods:	2,017	2,625	3,450	4,512	6,205	3,762
Cladocerans:						
Bosmina	0	0	122	900	1,940	592
Ovigerous *Bosmina*	0	0	10	333	482	165
Daphnia longiremis	26	10	22	277	569	181
Ovigerous *Daphnia longiremis*	0	14	4	89	332	88
Chydorinae	0	0	61	182	228	94
Total cladocerans:	26	24	219	1,780	3,551	1,120
Total Copepods + Cladocerans	2,043	2,649	3,669	6,292	9,756	4,882
Rotifers:						
Kellicottia	3,396	1,533	1,958	3,045	2,417	2,470
Asplanchna	190	203	1,604	3,185	73	1,051
Keratella	458	1,230	3,590	321	32	1,126
Conochilus	0	13	492	8,031	1,864	2,080
other rotifers	0	13	271	11,822	19,542	6,329
Total Rotifers:	4,044	2,991	7,916	26,402	23,926	13,056
Other:						
Ostracoda	n/a	n/a	n/a	n/a	n/a	n/a

[a]Only station two sampled.

Appendix C. Biomass estimates per m^3 of the major zooplankton species, by sample date, from Chignik Lake, 2002.

	mg dry weight/m^3						
Taxon	5/7[a]	5/22	6/19	7/24	8/14	Average	Weighted Average
Copepods:							
Epischura	0.00	0.02	0.14	0.77	1.68	0.52	0.28
Ovigerous *Epischura*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diaptomus	0.00	0.02	0.55	2.75	2.91	1.24	0.86
Ovigerous *Diaptomus*	0.00	0.00	0.00	0.25	0.98	0.25	1.13
Cyclops	1.01	2.46	2.93	2.39	1.59	2.08	1.95
Ovigerous *Cyclops*	0.00	0.01	0.08	0.90	1.22	0.44	3.06
Harpaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total copepods:	1.01	2.51	3.70	7.06	8.38	4.53	5.24
Cladocerans:							
Bosmina	0.00	0.00	0.11	0.78	1.66	0.51	0.50
Ovigerous *Bosmina*	0.00	0.00	0.01	0.47	0.69	0.24	0.44
Daphnia longiremis	0.02	0.01	0.02	0.33	0.71	0.22	0.32
Ovigerous *Daphnia longiremis*	0.00	0.06	0.01	0.29	1.13	0.30	0.51
Chydorinae	0.00	0.00	0.01	0.02	0.03	0.01	0.06
Total cladocerans:	0.02	0.07	0.17	1.89	4.22	1.27	1.82
Copepods to cladocerans	48.65	35.77	22.19	3.74	1.99	3.56	2.87
Total Copepods + Cladocerans	1.03	2.58	3.86	8.95	12.60	5.80	7.06

[a]Only station two sampled.

Appendix D. Average number of macrozooplankton per m^3 from Black Lake, by sample date, 2002.

	Number per m^3					
Taxon	5/25	6/22	7/19	8/15	9/1	Average
Copepods:						
Epischura	0	221	708	5,053	2,389	1,674
Ovig. *Epischura*	0	0	0	0	0	0
Diaptomus	13,535	221	0	446	531	2,947
Ovig. *Diaptomus*	0	0	0	0	0	0
Cyclops	27,070	4,423	8,846	23,185	24,416	17,588
Ovig. *Cyclops*	0	0	0	0	0	0
Harpaticus	0	0	0	0	0	0
Nauplii	18,047	2,875	3,539	8,471	5,573	7,701
Total copepods	58,652	7,741	13,093	37,155	32,909	29,910
Cladocerans:						
Bosmina	0	4,202	21,585	54,098	95,541	35,085
Ovig. *Bosmina*	0	0	8,493	24,968	15,658	9,824
Daphnia l.	0	0	0	0	0	0
Ovig. *Daphnia l.*	0	0	0	0	0	0
Chydorinae	0	0	3,892	24,820	6,104	6,963
Total cladocerans	0	4,202	33,970	103,886	117,304	51,872
Total copepods + cladocerans	58,652	11,943	47,063	141,041	150,212	81,782
Rotifers:						
Kellicottia	0	6,635	2,123	10,255	3,981	4,599
Asplanchna	0	221	3,185	2,675	3,981	2,012
Keratella	0	15,924	531	10,255		6,677
Conochilus	1,783	0	111,465	62,420	27,866	40,707
other rotifers	1019.1083	0	3185	271975	87579.62	72,752
Total rotifers	2,803	22,780	120,489	357,580	123,408	126,747
Other:						
Ostracoda	17,102	663	0	0	0	3,553

Appendix E. Biomass estimates per m^3 of the major zooplankton species, by sample date, from Black Lake, 2002.

	mg dry weight/m^3						
Taxon	5/25	6/22	7/19	8/15	9/1	Average	Weighted average
Copepods:							
Epischura	0.00	0.27	0.86	6.17	2.91	2.04	0.91
Diaptomus	38.45	0.63	0.00	1.27	1.51	8.37	6.26
Cyclops	16.19	2.64	5.29	13.86	14.60	10.52	13.49
Harpaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total copepods	54.64	3.54	6.15	21.30	19.02	20.93	20.66
Cladocerans:							
Bosmina	0.00	3.31	17.02	42.65	75.33	27.66	28.31
Ovig. *Bosmina*	0.00	0.00	10.78	31.69	19.87	12.47	12.70
Daphnia l.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chydorinae	0.00	0.00	0.43	2.75	0.68	0.77	3.77
Total cladocerans	0.00	3.31	28.23	77.09	95.88	40.90	44.78
Copepods to cladocerans	n/a	1.07	0.22	0.28	0.20	0.51	0.46
Total Biomass	54.64	6.86	34.38	98.39	114.90	61.83	65.44

Appendix F. Beach seine catch data by location, site and date, 2002.

Location	Site	Date	Water temp (°C)	Sockeye salmon > 45 mm	Sockeye salmon < 45 mm	Sockeye salmon Total	Coho	King	Stickleback	Pond smelt	Dolly Varden	Other
Chignik Lake	1	5/18	6.5	0	0	0	2	0	0	0	1	0
	1	6/4	7.0	0	0	0	0	0	0	0	0	0
	1	6/18	8.0	2	3	5	1	0	0	0	2	0
	1	7/3	11.5	9	0	9	4	1	0	0	21	0
	1	7/18	11.5	23	0	23	23	2	0	1	7	0
	1	8/5	11.0	2	0	2	8	0	5	0	16	0
Chignik Lake	2	6/4	7.5	67	0	67	3	3	0	0	3	0
	2	6/18	9.0	4	0	4	1	0	0	0	1	0
	2	7/3	11.0	3	16	19	0	0	1	0	0	1 sculpin
	2	7/18	11.0	9	0	9	14	1	0	9	27	1 steelhead, 1 chum
	2	8/5	12.0	31	0	31	2	0	5	46	57	0
Chignik Lake	3	5/18	5.0	0	1	1	0	0	1	0	0	0
	3	6/4	7.0	3	0	3	1	1	0	0	116	0
	3	6/18	9.0	1	6	7	1	0	0	0	5	0
	3	7/3	8.0	0	0	0	0	0	0	0	3	1 sculpin
	3	7/18	9.0	0	0	0	0	0	0	0	0	0
	3	8/5	11.5	0	0	0	22	0	7	7	26	0
Chignik Lake	5	5/18	7.0	65	0	65	8	19	23	0	25	3 sculpin
	5	6/4	8.0	123	1	124	12	6	162	0	10	0
	5	6/18	11.0	4	5	9	0	0	10	0	0	1 sculpin
	5	7/3	10.0	82	38	120	14	0	14	1	26	3 sculpin
	5	7/18	10.5	167	0	167	41	1	72	35	82	12 steelhead
	5	8/5	10.0	6	0	6	0	0	1	1	0	0
Chignik Lake	6	5/20	7.0	65	0	65	3	2	3	0	1	0
	6	6/4	9.0	19	0	19	1	0	0	0	0	0
	6	6/18	12.0	8	0	8	3	3	4	0	3	0
	6	7/3	10.5	3	13	16	0	0	1	0	1	2 sculpin
	6	7/18	10.0	6	0	6	2	0	0	0	0	0
	6	8/5	12.5	0	0	0	1	0	0	0	0	0

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Location	Site	Date	Water temp (°C)	Sockeye salmon > 45 mm	Sockeye salmon < 45 mm	Sockeye salmon Total	Coho	King	Stickleback	Pond smelt	Dolly Varden	Other
Chignik Lake	7	5/20	7.0	19	0	19	0	0	28	0	1	0
	7	6/4	13.5	33	0	33	11	9	4	0	3	0
	7	6/18	10.0	9	1	10	3	1	1	0	0	1 sculpin
	7	7/3	11.0	15	2	17	2	0	43	0	3	1 steelhead
	7	7/18	11.5	15	0	15	7	1	22	0	17	0
	7	8/5	12.5	11	0	11	2	0	13	0	1	1 sculpin
Chignik Lake	8	5/20	7.0	1	0	1	6	2	0	0	0	0
	8	6/4	8.5	23	0	23	20	11	68	0	13	2 sculpin
	8	6/18	9.5	73	0	73	54	28	291	1	23	0
	8	7/3	11.5	31	0	31	13	11	25	0	0	1 steelhead
	8	7/18	12.5	15	0	15	17	1	95	0	12	2 steelhead
	8	8/5	12.0	84	0	84	33	1	163	6	27	2 steelhead
Chignik River	1	5/17	5.7	700	300	1000	50	0	1000	1	2	3 sculpin
	1	6/1	8.0	114	0	114	13	5	49	2	0	2 sculpin
	1	6/14	9.0	807	1	808	2	0	29	0	0	0
	1	6/28	10.0	1600	400	2000	7	9	100	200	8	0
	1	7/13	10.5	229	19	248	11	1	4	2	4	4 sculpin
	1	7/29	11.0	321	1	322	18	0	29	22	3	3 sculpin
Chignik River	2	5/17	6.5	94	25	119	13	6	162	1	1	4 flounder, 1 sculpin
	2	6/1	7.5	124	24	148	14	17	409	2	2	4 flounder, 1 sculpin
	2	6/14	9.0	128	8	136	5	3	131	3	6	1 flounder, 4 sculpin
	2	6/28	10.0	860	40	900	24	10	195	70	3	1 sculpin, 1 flounder
	2	7/13	11.5	217	53	270	25	0	155	5	2	1 chum
	2	7/29	12.0	269	8	277	26	0	475	0	0	2 sculpin, 3 flounder
Chignik River	3	5/17	5.0	99	0	99	26	20	5	3	5	1 flounder
	3	6/1	9.0	113	13	126	44	11	305	0	7	2 flounder
	3	6/14	9.0	46	5	51	24	24	62	3	11	1 sculpin
	3	6/28	10.0	143	1	144	28	8	0	4	4	1 sculpin

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Location	Site	Date	Water temp (°C)	Sockeye salmon > 45 mm	Sockeye salmon < 45 mm	Sockeye salmon Total	Coho	King	Stickleback	Pond smelt	Dolly Varden	Other
	3	7/13	11.0	44	13	57	3	24	426	0	7	4 chum
	3	7/29	11.0	385	14	399	32	4	26	26	0	1 flounder
Lagoon	1	5/16	5.0	2	0	2	0	0	0	0	1	0
	1	6/1	7.0	120	13	133	2	0	1	1	0	0
	1	6/15	14.0	61	6	67	0	5	4	0	0	0
	1	6/29	16.0	565	55	620	18	41	194	3	9	0
	1	7/15	10.5	553	2	555	20	25	1	5	7	2 steelhead
	1	7/30	11.0	140	4	144	0	1	11	0	3	0
Lagoon	2	5/7	6.5	1	8	9	0	0	0	0	0	1 flounder
	2	6/1	9.5	4	40	44	0	0	4	0	0	3 flounder, 4 sculpin
	2	6/15	13.0	192	6	198	1	0	0	0	0	0
	2	6/29	14.5	88	0	88	3	4	17	0	9	0
	2	7/15	12.0	12	1	13	0	0	0	0	2	0
	2	7/30	13.0	6	1	7	0	0	2	0	0	0
Lagoon	3	5/17	6.0	0	0	0	0	0	0	0	13	0
	3	6/1	8.0	3	0	3	0	0	0	0	0	32 humpies
	3	6/15	13.0	478	0	478	2	1	0	0	145	4 humpies
	3	6/29	13.0	17	0	17	0	0	1	0	8	0
	3	7/16	12.5	8	0	8	0	0	0	0	6	5 sculpin
Lagoon	4	5/7	5.0	2	0	2	0	0	0	0	0	0
	4	5/16	8.0	1	3	4	0	0	0	0	1	0
	4	6/1	9.0	24	58	82	0	0	20	2	0	26 flounder
	4	6/15	13.0	7	616	623	0	0	1	3	0	7 flounder, 5 isopods
	4	6/29	15.0	43	2	45	0	1	1	0	0	7 flounder, 8 isopods
	4	7/15	12.0	200	34	234	0	3	2	3	5	1 sculpin, 1 flounder
	4	7/30	13.0	17	7	24	0	0	1	1	0	23 sculpin, 1 flounder

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Appendix F. (page 4 of 4)

Location	Site	Date	Water temp (°C)	Sockeye salmon > 45 mm	< 45 mm	Total	Coho	King	Stickleback	Pond smelt	Dolly Varden	Other
Lagoon	5	5/7	6.0	38	0	38	0	0	0	0	38	0
Black Lake	1	5/28	9.0	0	551	551	4	0	9	0	0	0
	1	6/7	11.5	0	978	978	0	0	31	0	0	0
	1	6/22	14.0	66	578	644	2	0	128	1	0	1 sculpin
	1	7/6	14.0	170	394	564	2	0	6	3	0	1 sculpin
	1	7/20	14.5	75	68	143	9	0	0	198	0	0
	1	8/7	16.0	5	0	5	16	0	16	0	0	0
Black Lake	2	5/28	10.5	0	4	4	0	0	0	0	0	0
	2	6/22	16.0	138	138	276	0	0	1	2	0	0
	2	7/6	14.0	0	2	2	0	0	0	5	0	0
	2	8/7	15.5	0	0	0	0	0	0	8	0	2 sculpin
Black Lake	4	5/28	10.5	0	311	311	0	0	1	0	0	0
	4	6/7	9.5	0	28	28	0	0	0	0	0	0
	4	6/22	15.0	0	79	79	0	0	7	0	0	0
	4	7/6	14	0	39	39	0	0	0	4	0	0
	4	8/7	15.5	1	0	1	1	0	10	8	0	0
Black Lake	5	5/28	8.5	0	99	99	1	0	6	0	0	0
	5	6/7	11.5	8	74	82	47	3	178	0	0	0
	5	6/22	15.5	375	375	750	100	0	200	0	0	0
	5	7/6	14.5	328	257	585	2	0	76	0	0	1 sculpin
	5	7/20	13.5	15	4	19	15	0	54	0	0	0
	5	8/7	16.0	6	0	6	16	0	700	0	0	0

Appendix G. Townet catch data by location, transect, and date, 2002.

Location	Transect	Date	Time start	Time stop	Tow duration (hrs)	Boat Speed (mph)	Depth (m)	Water temp (C)	Sockeye > 45 mm	Sockeye < 45 mm	Coho	King	Stickleback	Pond smelt	Dolly Varden
Chignik Lake	1 TO 2	5/30	9:57	10:57	0.17	3.3	0	6.0	16	0	0	0	2	0	0
		6/26	9:07	9:17	0.17	3.0	0	n/a	0	0	0	0	0	0	0
		6/26	14:54	15:04	0.17	3.3	10	10.5	0	0	0	0	0	0	0
		7/26	9:14	9:24	0.17	4.0	0	11.0	0	0	0	0	0	0	0
		8/13	9:44	9:54	0.17	3.5	0	12.5	0	0	0	0	0	0	0
		8/13	11:49	11:59	0.17	4.5	10	13.0	0	0	0	0	1	0	0
Chignik Lake	2 TO 3	5/30	10:21	10:31	0.17	3.4	0	6.5	0	0	0	0	2	0	0
		6/26	9:27	9:37	0.17	3.1	0	n/a	1	0	0	0	0	0	0
		6/26	14:30	14:40	0.17	3.2	10	10.5	0	0	0	0	0	0	0
		7/26	9:31	9:41	0.17	4.0	0	11.0	1	0	0	0	0	0	0
		8/13	10:06	10:16	0.17	3.9	0	12.5	1	0	0	0	0	0	0
		8/13	11:29	11:39	0.17	4.6	10	13.0	0	0	0	0	0	0	0
Chignik Lake	3 TO 4	5/30	10:42	10:52	0.17	3.5	0	7.0	28	0	0	0	1	0	0
		6/26	10:55	11:05	0.17	3.4	0	n/a	0	0	0	0	1	0	0
		6/26	14:00	14:10	0.17	3.4	10	10.5	0	0	0	0	2	0	0
		7/26	9:53	10:03	0.17	4.0	0	11.0	0	0	0	0	0	0	0
		7/26	10:18	10:28	0.17	4.0	10	11.0	0	0	0	0	0	0	0
		8/13	10:27	10:37	0.17	4.0	0	12.5	2	0	0	0	0	0	0
		8/13	10:55	11:05	0.17	4.3	10	12.5	1	0	0	0	0	0	0
Black Lake	FRI tows[a]	7/20	13:30	13:40	0.17	5.0	0	13.5	80	20	0	0	15	11	0

[a]Black Lake FRI tows begin approximately 0.5 km west of Hydro Point.

Appendix H. Fyke net catch data by location and date, 2002.

		Time		Total time	Temp °C		Sockeye Catch			Other Catch				
Location	Date	Set	Pulled	(hrs)	Water	Air	> 45 mm	< 45 mm	Total	Coho	Chinook	Stickleback	Dolly	Other
Black River	6/10	11:16	16:00	5.25	9.5	9.0	0	7	7	4	0	13	0	1 pond smelt
Black River	6/22	17:40	21:30	3.83	15.0	19.0	0	0	0	0	0	2	1	0
Black River	7/5	17:50	20:30	2.67	15.0	17.0	2	3	5	1	0	5	2	1 isopod
Black River	7/20	11:00	18:32	7.53	16.0	15.0	83	21	104	4	0	25	0	0
Black River	8/6	13:50	20:18	6.47	16.0	16.0	9	0	9	9	0	213	10	1 pond smelt
Chignik River	5/24	9:30	14:15	4.75	5.5	8.0	3	4	7	18	0	2	2	0
Chignik River	6/13	13:30	15:30	2.00	9.5	16.5	6	2	8	3	1	9	1	0
Chignik River	6/25	8:27	16:00	7.55	10.0	12.0	3	0	3	5	0	15	1	0
Chignik River	7/16	14:00	16:00	2.00	11.5	12.5	7	0	7	0	0	1	1	0
Chignik River	8/9	8:30	16:00	7.50	13.5	15.5	29	0	29	8	0	26	10	0