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SOCKEYE SMOLT POPULATION ESTIMATES, OUTMIGRATION TIMING, AND SIZE AT AGE CHARACTERISTICS FOR RED, AKALURA, AND FRAZER LAKES, 1995

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INTRODUCTION

In the Kodiak Management Area (KMA; Figure 1), sockeye salmon *Oncorhynchus nerka* spawn in approximately 40 systems (Brennan et al. 1993). A number of these systems are within the Kodiak National Wildlife Refuge, which was created in 1941 to preserve brown bear habitat. Sockeye salmon are an important food source for brown bear and an economic mainstay of the KMA commercial salmon fishery. The commercial fishery average harvest (1990-1993) of 4.9 million sockeye salmon has been worth about $ 29.3 million, annually (Brennan et al. 1993). The Kodiak salmon fleet consists of about 610 permit holders; 61% are Kodiak Island residents inclusive of six Native villages (K. Iverson, Alaska Department of Fish and Game, Commercial Fisheries Entry Commission, personal communication). The subsistence sockeye salmon fishery is also important, averaging 19,000 fish annually (1988-1993; Brennan et al. 1993).

In 1989, crude oil spilled from the *M/V Exxon Valdez* in Prince William Sound entered the Gulf of Alaska, and subsequently contaminated all of the traditional KMA salmon harvest areas (Barrett and Monkiewicz 1989). As a consequence of curtailed fisheries, sockeye salmon escapement goals were exceeded (overescapement) at several systems during 1989, including Afognak River, Akalura Creek, Dog Salmon River (Frazer Lake), and Ayakulik River (Red Lake).

The highest 1989 overescapements occurred at Red and Akalura Lakes. Schmidt et al (1993) reported that sockeye salmon productivity in these systems was likely damaged as a result. Previous studies (Kyle et al 1988) have documented that excessive escapements tax rearing-limited systems by overloading the lake with too many juvenile sockeye salmon fry. This in turn results in alteration of the overall zooplankton biomass, species composition and sizes, thereby lowering sockeye salmon survival (Koenings and Kyle 1991). These changes can reduce over-winter sockeye salmon fry survival, extend freshwater rearing for additional years, and affect multiple brood years.

In 1990, sockeye salmon smolt studies were initiated at Red, Akalura, and Upper Station (control) Lakes to measure responses from the 1989 escapement event (Figure 2; Barrett et al. 1993). This report documents the sixth (1995) year of the study and includes the 1994 and 1995 sockeye smolt work at Frazer Lake, conducted partially with oil spill funding. Frazer Lake was included in 1993 as an alternate control, replacing the Upper Station Lakes, for the Akalura and Red Lakes damage assessment. The 1989 Frazer Lake escapement, enumerated at 360,373 fish, was 80% above the upper escapement goal of 200,000. Lake fertilization has occurred for five years (1988-1992) to enhance zooplankton biomass and alleviate pre-1986 overescapement effects. Therefore, as a control it is not without problem.

OBJECTIVES

1. Estimate the number of sockeye salmon smolts by age class for Red, Akalura, and Frazer Lakes.

2. Estimate sockeye salmon smolt timing and growth characteristics (length, weight, and condition factor) by age class for each study lake.

3. Estimate the seasonal use of near-shore areas in Red Lake by young-of-year sockeye salmon fry (age 0.).

4. Examine the delayed mortality of sockeye salmon smolts associated with dye marking at the Red Lake field station.

5. Examine the detectability of dye marked sockeye salmon smolt over time at the Red Lake field station.

METHODS

Smolt Traps and Site Locations

At Red Lake two Canadian fan traps (Ginetz 1977) were operated from 07 May through 28 June 1995, at a site located 1.6 km downstream of the lake outlet where water depth averaged 0.4 m and velocity generally exceeded 0.9 m/sec. The traps were placed parallel to each other in the stream approximately 2 m and 6 m off the west bank. Both traps were equipped with perforated aluminum-plate leads (2.2 m each in length, 1 m width, 4.8 mm dia. holes) angled at 30° upstream. The two traps were connected together at the opening by an inverted V-shape structure fashioned from two pieces of perforated-plate lead. Both traps were fitted with live boxes (1.2 m long, 1.0 m wide, and 0.8 m high). The trap openings including the leads spanned about 30% of the stream width.

At Akalura Lake a single Canadian fan trap was operated from 04 May through 26 June 1995, approximately 5.6 km downstream of the lake outlet. The trap was equipped with a live box measuring 1.5 m long, 1 m wide, and 0.8 m high. Perforated-plate leads were attached to the trap opening extending 1.3 m to the west stream bank and 1.9 m to the east bank. The lead to the east was attached to the stream bank and effectively prohibited smolt passage on this side of the trap. The leads

spanned approximately 31% of the stream width. Stream depth was approximately 0.5 m and velocity about 1.0 m/sec.

At Frazer Lake, an inclined plane trap as described by Todd (1994) was operated from 11 May through 27 June 1995, approximately 1.2 km downstream of the lake outlet, upstream of the falls, and 76 m upstream of the diversion weir. The trap site was 14 m and 11 m from the east and west banks, respectively. Leads approximately 3.9 m in length were attached to the trap at an angle of about 30° towards both the east and west banks. The leads spanned approximately 20% of the stream width. This was the second year of operating a single trap above the falls. Before 1994, two traps were routinely fished below the falls (Barrett et al. 1993). The site selected above the falls was narrow and prohibited the use of two traps. Shields constructed of wood or aluminum were installed on the traps to reduce headlamp and lantern light in the trap entrances. All live boxes were covered with plastic fencing material to prevent predation.

Smolt Enumeration

At all locations traps were checked during the evening approximately every half hour for catch and proper operation using artificial light sources. During daylight hours the traps were monitored less routinely. For each check the total catch was enumerated by species and released; an exception was when a portion of the catch was held for sampling (described in later section). Species identification was made by visual examination of external characteristics (McConnell and Snyder 1972; Trautman 1973).

Smolt enumeration was completed using direct visual counts; the exception was that a catch-weight method was implemented when catch rates exceeded the crew's ability (> 10,000 smolts) to hand tally. For this method, the catch was transferred by dip net to a small mesh basket attached to a weight scale suspended over the stream by an A-frame support; each dip net load was individually weighed, with fish immediately released into the stream downstream of the traps. About every tenth dip net load was sampled to determine species count by weight. This entailed counting by species a dipnet load of fish into a water filled container, transferring the entire contents to the scale for weighing, and then releasing the fish downstream of the trap site. All catch weights were recorded to the nearest 0.1 kg.

All catch data were recorded by sampling day. A sampling day extended from noon to noon and was identified by the calendar day of the noon to midnight period.

Age, Weight, and Length Sampling

At each location, up to 70 sockeye salmon smolt were sampled daily for age, weight, and length (AWL), five days a week (dependent upon smolt availability). To prevent bias all fish in the live-box were stirred immediately before being removed for sampling. Each sampled fish was anesthetized with

MS-222 and a scale smear from the preferred area (INPFC 1963) was removed and mounted on a standard microscope slide for ageing. Smolt weight was recorded to the nearest 0.1 g using a digital balance and tip-of-snout to fork-of-tail length (TL) was recorded to the nearest 1.0 mm. After sampling, all smolt were revived and released downstream of each trap site. Ageing of scales was conducted using a 42X lens microfiche reader. All ages were recorded in European notation (Koo 1962).

Trap Efficiency Tests

Trap efficiency was determined at least weekly dependent upon smolt availability. At all sites except Frazer Lake, up to 500 smolt were dyed and released about 1 km upstream of the trap location in relatively low velocity water (<0.5 m/sec). At Frazer Lake, the number released was substantially greater (approximately 1,000 fish) due to the large smolt outmigrations that occur at Frazer Lake, while the distance to the release site, approximately 1 km upstream, was similar to the other sites. Smolts used for trap efficiency tests were collected from the trap(s) within three days and often within one day of each test. An instream covered live box with perforated sides was used to hold the smolts prior to upstream transport. Transport was performed using backpacks and 19 L plastic buckets equipped with battery-powered aerators. At the release sites, smolts were placed into instream live boxes and held for about 30 minutes before transfer into a continuously-oxygenated dye solution of 1.9 g Bismark Brown Y dye to 57 L of water for another 30 minutes. After dyeing, the smolt were held for about 60 minutes in an instream perforated live box with lid, and then placed in water filled 19 L buckets for release across the stream channel. At each step in the process, the smolt were counted, and those that behaved abnormally were destroyed. The dye test at each of the sites were scheduled so that the release time was approximately 2200 h. Following the release of dyed fish, the traps were checked for three or more days for recoveries. All recaptures were recorded separately from the unmarked fish catch and were not included in the daily trap catch totals.

Climate Observations

At the smolt trap locations of all three lakes, air and stream temperatures (C), stream height (cm), percent cloud cover, wind velocity, and wind direction were recorded at approximately 1800 hr. daily.

Littoral Zone Seining

At Red Lake, four shoal sites originally selected in 1992, were sampled weekly (May through at least June) using a beach seine measuring 15 m in length, 2 m deep, and about 6 mm stretch mesh. The

catch was counted and recorded by species with TL (mm) recorded for sockeye salmon only. Water temperature (C) was taken during each sampling event.

Townet Surveys

Townet surveys of oil spill study lakes have been conducted during 21 September-6 October annually since 1990 for indexing rearing fry abundance and size characteristics. Fish species composition is used in conjunction with fall hydroacoustic surveys to estimate fry populations. Surveys at Red, Upper Station, and Akalura Lakes were conducted using a 4.9 m rubber raft and 30 hp outboard motor operated at full rpm; at Frazer Lake a 5 m Boston whaler with 40 hp motor was used. The townet used for the 1990-1994 surveys measured 2 m x 2 m at the entrance and 7.5 m in length. The body of the net was constructed of variable mesh (3.8 cm, 1.3 cm, and 0.6 cm) knotless nylon and the cod end of the net was 0.5 m long with 0.3 cm mesh fitted with a zipper for catch removal. Plastic floats were attached to the top of the net entrance and a 3.8 cm diameter steel bar lashed to the bottom. Beginning is 1995, a new net constructed of monofilament and having identical dimensions to the knotless nylon net was used. Tow lines (1.27 cm polypropylene) used for the net were 91.5 m long, allowing for consistent fishing at 9.1 m depth. Previous hydroacoustic surveys have revealed that a majority of the sockeye fry were located at this depth.

Each survey consisted of three 10 to 35 minute tows along pre-selected transects for each lake. Catch from each tow was sorted, counted, and recorded by species, except when greater than 200 stickleback *Gasterosteus aculeatus* were captured for a single tow. When large numbers of stickleback were captured, a random grab sample of 100-150 stickleback were counted, weighed, and total catch numbers estimated using the catch-weight method previously described.

Townet surveys have been conducted at Frazer Lake since 1985, and at Red, Upper Station (Upper Olga Lake), and Akalura Lakes from 1990-1991. In 1992, only Red and Upper Station Lakes were surveyed. Akalura Lake was dropped from the survey program from 1992 - 1994 due to low catches of sockeye salmon relative to sticklebacks, and the lack of data utility related to accompanying hydroacoustic studies. In 1993 Frazer Lake was designated as the control lake, therefore Upper Station Lake townet data are not presented. During 1995 townet surveys were conducted at Frazer and Akalura Lakes. Townet surveys were not conducted at Red Lake during 1995 due to weather and personnel constraints. For ease of comparison we report the data collected since 1990.

Delayed Mortality Associated with Marked Fish

An additional objective during the 1995 season included examining the delayed mortality associated with the dye marking of smolt at Red Lake. An instream live box was constructed to conduct mortality experiments measuring the differential amount of mortality that occurs over time between dyed and undyed smolt. The live box was 0.9 m (3-ft) wide x 1.5 m (5-ft) long x 0.9 m (3-ft) deep

with perforated side and end panels, and divided into ten separate 30 cm (1-ft) x 46 cm (1.5-ft) compartments. Compartments on one side of the live box were labeled "Unmarked" and numbered 1 - 5. The opposite side was also labeled "Marked" and numbered 1 - 5. The live box was placed in the river adjacent and parallel to the bank in moving water > 0.3 m/s to facilitate ease of examination.

A minimum sample size of 500 sockeye smolts was obtained from the trap live box and placed in the instream live box used for dyeing smolt. The sample was then divided into two equal groups. One group was subjected to the same dye process that was used for mark-recapture trials (i.e. dye concentration, dye immersion period, aeration, recovery time, and transport procedures). Groups of 47 marked smolts were then placed into each of the five compartments labeled "Marked" for a total of 235 marked smolts. The second group of smolts were left unmarked but were also subjected to the same handling procedures that were used for the mark-recapture trials (i.e. aeration, recovery time, and transportation). Groups of 47 unmarked smolts were then placed into each of the five compartments labeled "Unmarked" for a total of 235 unmarked smolts. Only robust and healthy smolts were placed in the live box, the remaining smolts were released down stream of the trap.

After 24 hours had elapsed following the dye process, the first group (contained within compartment No's. 1-marked and unmarked) were inspected for mortality, counted, recorded, and released down stream of the trap. This same process was repeated each day at the same time until all smolts associated with the experiment had been released (five days later). This experiment was to be conducted about once weekly over four weeks.

Detection of Marked Smolt over Time

To evaluate delectability of marked fish at Red lake, an additional instream live box was constructed to hold marked and unmarked smolt. The live box was 0.9 m (3-ft) wide x 1.5 m (5-ft) long x 0.9 m (3-ft) deep with perforated side and end panels. The live box was divided into two equal compartments, labeled "Marked" and "Unmarked", and placed adjacent to the other live boxes. A sample size of 300 sockeye smolts was obtained from the trap live box and 150 unmarked smolts placed directly into the "Unmarked" live box compartment. The remaining 150 smolts were subjected to the same dye process that was used for the mark-recapture trials except that marked smolts were placed directly into the "marked" compartment after the dyeing process.

Envelopes were provided for each crew member containing random numbers of marked and unmarked fish that were to be placed into a dipnet and given to the other crew member for inspection each night of the experiment. One crew member opened the provided envelope and removed the first set of random numbers. Indicated numbers of marked and unmarked fish from the live box were placed into a dipnet and handed to the other person for counting. Numbers of marked and unmarked fish identified by the second person were recorded and the process was repeated with a second and third set of numbers. Then crew roles were reversed and the process repeated. Time of night, artificial light sources, dipnets employed, and time spent on inspection and handling of smolts simulated normal working conditions. The experiment was to be conducted about once weekly, for five consecutive nights, until four weekly replicates were completed. Since the experiment was conducted with two

participating crew-members, one experienced at detecting marked smolt and one inexperienced at detecting marked smolt, the data were stratified to test for differences in detection rate. This test was completed using a using a X^2 test of homogeneity at the $\alpha = 0.05$ significance level (Zar, 1994).

DATA ANALYSIS

To estimate smolt numbers from the catch-weight method (when employed) the following relationship was used:

$$\hat{C} = \frac{ac}{b}, \qquad 1$$

where *a* is the grand smolt weight total less basket weights; *b* is a sub-sample of total weight less basket weights; and *c* is the number of smolt from sub-sampled baskets.

In deriving trap efficiency from the mark-recapture and trap catch data the formulae used was:

$$\hat{e} = \frac{d_t}{D}, \qquad 2$$

$$d_t = \sum_{i=1}^{k} d_i \ , \qquad 3$$

where d_i is the number of marked fish recaptured on day *i* of *k* successive days after release of marked fish, and D is the number of marked fish released. Since mark-recapture trap efficiencies were estimated on a weekly basis, we tested for homogeneity between events for all systems by employing a X^2 test at α=0.05. For both Red and Akalura Lakes significant X^2 test statistics were generated (d.f. = 4 and 6 respectively, $p<0.001$). Therefore, we employed linear interpolation between weekly trap efficiency values to estimate daily trap efficiency for these systems. For estimates prior to the first and after the last mark-recapture events we used the first and last trap efficiency estimates for these days. A non-significant X^2 test statistic was found for Frazer Lake (d.f. = 6, $p<0.25$); a seasonal pooled trap efficiency estimate was employed for this system. Rawson (1984) reported statistical models for treating sockeye smolt mark-recapture data derived on a daily basis with population estimates generated by:

$$\hat{N}_i = n_i \left[\frac{D}{d_t} + \frac{(D - d_t)}{d_t^2} \right]; \qquad 4$$

with variance

$$\hat{\text{var}}\left[\hat{N}_i\right] = n_i\left(n_i + d_i\right) D\left(D - d_i\right)/d_i^2 \qquad 5$$

The overall annual smolt outmigration for a particular system was estimated by:

$$\hat{N} = \sum_{i=1}^{m} \hat{N}_i \qquad 6$$

with the overall variance estimated by:

$$\hat{\text{var}}\left[\hat{N}\right] = \sum_{i=1}^{m} \hat{\text{var}}\left[\hat{N}_i\right] \qquad 7$$

where:

i) $\hat{N}_i$ = Total population of smolt outmigrating on day *i*;

ii) n_i = Number of unmarked fish captured in traps during day *i*;

iii) $\hat{N}$ = Total smolt population outmigrating over *m* days.

The (1-α) confidence intervals for the smolt population estimates were derived assuming a normal distribution (Rawson 1984).

Condition factor for each smolt sampled was determined using:

$$K = \frac{W}{L^3} 10^5, \qquad 8$$

where W = weight in grams and L = length (tip-of-snout to fork-of-tail) in millimeters.

RESULTS

The 1995 daily sockeye smolt trap catch numbers and trap efficiency estimates for Red, Akalura, and Frazer Lakes are provided in Appendix A. Daily smolt population estimates and associated 95% confidence intervals are listed in Appendix B. Population estimates stratified by week and age class are provided in Appendix C. Smolt length, weight, and condition factor by age class and statistical week for each lake are summarized in Appendix D. Red Lake littoral zone seine catches for 1992-1995 are presented in Appendix E. Tow net survey catches and sockeye salmon fry length, weight, and age statistics from Red, Akalura, and Frazer Lakes for 1990-1995 are reported in Appendix F. The 1995 climatological data by system and day are reported in Appendix G. A map of the Red Lake beach seining sites is provided in Appendix H. Pre-season 1996 sockeye run forecasts for Red and Frazer Lakes are reported in Appendix I.

Red Lake

The smolt traps were operational on 07 May and ceased operation on 28 June, during which time a total of 31,477 smolt were caught (Appendix A.1). There were 2,822 smolt marked, 13,998 fish examined for marks, and 354 marked smolt recovered for a 12.5% seasonal trap efficiency. Trap efficiencies were significantly different among weeks and ranged from 6.2% to 17.7% over the course of the season. During 1995, 341,490 smolt (95% CI = 315,923 to 367,056) were estimated to have emigrated from Red Lake (Appendix B.1). The 1995 smolt outmigration was 221,200 less than in 1994 and about 48% less than the 1990-1994 average (Table 1; Figure 3). Age-2. smolt from the 1992 brood year (BR) were most abundant contributing 93% to the total, followed by age-3. smolt at 3.6% (1991 BR) and age-1. smolt at 3.3% (1993 BR) (Table 2). This is the second consecutive year that the smolt outmigration from Red Lake has been comprised of over 90% age-2. smolt.

The peak emigration timing of ages-1., -2., and -3. smolts during 1995 all occurred within the three week period beginning 31 May and ending 20 June (Figure 4; Appendix C.1.). The age-3. smolts peaked first followed by the age-2. smolts and finally the age-1. smolts.

The mean length and weight of age-1., -2., and -3. smolts increased in 1995 compared to 1994 (Figure 5, and Table 7). Mean length and weight of age-1. and -3. smolts in the 1995 outmigration are comparable to the average values measured since project inception.

A very large catch of age-0. sockeye fry during the week of 23 May was preceded by a good catch during the week of 16 May and followed by relatively low catches during the remainder of the season (Figure 6, Appendix E.1). Peak catches in 1994 and 1993 occurred later than in 1995 and good catches continued further into the season. Littoral zone rearing fry numbers observed during 1995 were about half of that observed in 1994 and about two-thirds of that observed in 1993. Stickleback catches observed during 1995 were substantially higher than those observed during 1994 (Appendix E.2.). For the years 1992-1995 a majority of sockeye fry and stickleback were found at site one near the northwest end of Red Lake (Appendix H.1). It is likely that the number of sockeye fry caught at this site were affected by close proximity to Connecticut Creek, the major sockeye spawning tributary. In all years, sockeye fry in the littoral zone averaged about 35 mm in length during May and June (Appendix E.3).

The results of the delayed mortality experiment conducted at Red Lake indicate that there was some differential delayed mortality between dyed and undyed fish. However, it was not possible to generate enough replicates due to low smolt catches to estimate this differential mortality in a rigorous manner. Of the three replicates that were performed, the differential mortality over the entire 5 day period ranged between 5% and 23% with an average of 15%. A similar experiment conducted at Chignik Lake during 1995 indicated an average differential mortality of 12% (ADF&G, unpublished data).

The dye detectability experiment performed at Red Lake during 1995 revealed that approximately 99.7% of dyed fish were detected by counting personnel. Additionally, when the data were stratified by observer (one experienced crew-member and one inexperienced crew-member), there was no difference in the ability to detect dyed smolt among observers (d.f. = 1, p=.98). A similar experiment conducted at Chignik Lake indicated a dye detectability rate of 99.8% (ADF&G, unpublished data).

Akalura Lake

The trap at Akalura Lake was installed on 04 May and operated through 26 June. A total of 13,167 sockeye smolts were captured of which 2,808 were marked. A total of 6,365 smolts were examined for marks and 285 marked fish recaptured over the season for a seasonal trap efficiency of 10.1%. Trap efficiencies were significantly different among weeks and ranged from 4.9% to 18.9% (Appendix A.2). The 1995 smolt outmigration was an estimated 134,117 smolts (95% CI 125,523 to 142,712) which is about 30% less than the 1994 smolt outmigration of 170,172 (Table 3). Age-2. smolts were the most abundant age class comprising 53% (1992 BR) of the total, followed by age-1. at 47% (1993 BR), and age-3. at less than 1% (1991 BR) (Table 4; Figure 7; and Appendix C.2). The 1995 smolt outmigration had the smallest age-3. contribution since 1990.

The peak of age-1. emigration in 1995 occurred during the second week of June and was very distinct (Figure 8, Appendix C.2). Age-2. emigration appeared less peaked or even bimodal between 10 May and 6 June.

Both age-1. and age-2. smolt were of smaller mean length and weight during 1995 than in 1994 (Table 7, Figure 9). The mean length and mean weight of all age classes of smolt from the 1995 outmigration were larger than the 1990-1994 average mean length and weight. Age-1. smolts averaged about 6.5 mm larger and weighed 1 g more than age-1. smolts from 1990-1994, and age-2. smolts were 7.9 mm larger and weighed 1.4 g more than age-2. smolts from 1990-1994.

Tow net sampling was reinitiated at Akalura Lake in 1995 after a 3 year hiatus. Sockeye fry CPUE during 1995 (2.2 fish/min.) was slightly higher than 1991 (2.1 fish/min.), but lower than observed in 1990 (3.4 fish/min.) (Appendix F.2). The stickleback CPUE observed during 1995 (14.8 fish/min.) was greatly reduced from both 1991 (153.8 fish/min.) and 1990 (60.7 fish/min.).

Frazer Lake

At Frazer Lake, a single inclined plane trap was operated from 11 May through 27 June (Appendix A.3). A total of 505,219 sockeye smolts were caught in the trap and 6,707 were marked. Over the season, a total of 103,131 smolts were examined for marks and 405 were recovered for a seasonal trap efficiency estimate of 6.0%. Trap efficiencies were not significantly different among weeks and ranged from 4.7% to 7.0% over the season. The total sockeye smolt outmigration was an estimated 8,386,087 smolts (95% CI = 7,595,899 to 9,176,275; Appendix B.3), which was the second largest observed smolt outmigration since 1991 (Tables 5 and 6). Age-2. (98%) smolt dominated the 1995 outmigration as compared to age-1. (0.7%) smolt. In comparison, during 1991 age-1. (40%) and -2. (59%) smolts represented most of the estimate, whereas in 1993 the smolt age composition was evenly divided between ages-2. and -3. (Figure 10).

The 1995 smolt outmigration peaked from 24-30 May, but large numbers of smolt were observed from 11 May through 6 June (Figure 11).

In 1995, age-2. smolts averaged about 91.2 mm which was nearly 5 mm less than the 1990-1994 average of 96.1 mm (Table 7; Figure 12). Age-2. smolt during 1995 weighed an average of 5.6 g as compared to the 1990-1994 average weight of 7.3 g.

The 1995 townet survey catches show markedly fewer rearing sockeye fry in 1995 than in surveys conducted during 1990-1993 (Appendix F.3). A total of two fry were caught during 1995 which may in-part have been due to poor survey conditions. Similar catches were observed during 1994 and 1993 when catches were 2 and 16 respectively. The 1995 stickleback CPUE of 3.9 fish / min. was approximately two thirds of the 1990-1994 average of 6.1 stickleback / min.

DISCUSSION

Red Lake

The 1995 Red Lake smolt outmigration completes the 1991 BR. An estimated 0.8 million sockeye smolts were produced from the 0.37 million 1991 escapement. This level of production is about half of what was estimated for the 1989 BR and nearly 4 times larger than for the 1990 BR. Smolt population estimates for the 1987 and 1988 brood years should be considered relative indices, as the population estimates for these years are marginal. The lack of confidence in these estimates is based upon age-2. smolt numbers which were adjusted using a 30% smolt to adult survival rate (Koenings et al. 1993) that was 4.5 times lower than the number of age 2. adult returns. We believe error in this estimate is centered around using a single smolt trap during 1990 that experienced substantial avoidance by age 2. smolts. Although two traps were used during 1991, trap avoidance still appeared to be a problem. Age-1. and -2. smolt estimates after adjusting for marine survival were 2.0 and 4.3 times lower, respectively than the numbers of freshwater age 1. and 2. returning adults. During 1992, trap configuration was modified, a smolt weir operated, and resulting smolt population estimates evaluated (Barrett et al. 1993).

It appears based upon sockeye smolt outmigrations during 1995, 1994, and 1993, that the adult return from the 1991 BR will be significantly better than anticipated from the 1990 BR. Assuming 30% ocean survival (mean length 108.6 mm) the 520,000 age-2. smolts from the 1991 BR will result in about 156,000 age 2.2 adults. The smolt sizes from the 1991 BR suggest that experiencing greater than 30% smolt-to-adult survival from these BR's is not anticipated.

The diminished index of littoral zone rearing fry numbers observed in 1995 indicates that the 1996 and 1997 smolt outmigrations may decline from the present level. However, the pattern of catches observed in 1995 suggests that fry may have moved offshore and become unavailable to the beach seine earlier than in previous years. We observed no apparent differences in the age-0. rearing fry length between years or within a year; however, rearing fry generally begin pelagic rearing at 35-40

mm in length (Barrett 1989). Therefore, fry lengths are probably a biased index of littoral zone rearing conditions. In addition, this premise is supported by there relatively static fry length observed.

An adult pre-season run forecast of 325,000 fish was derived for 1995. Most of the run (70%) was projected to be age to be 2 and 3 ocean fish. The actual run was an estimated 884,134 sockeye salmon comprised of a 317,832 fish escapement and 566,302 fish commercial catch. The difference represents over 100% forecast error. It has become clear that the present run reconstruction methods for the Ayakulik system are problematic in terms of catch assignment from the Inner and Outer Ayakulik sections (ADF&G 1993). Preliminary assignment of the catches to stock of origin using scale patterns has shown that other stocks are contributing to the June sockeye salmon catches within these sections (ADF&G, unpublished data). This could be responsible for confounding both our smolt production estimates and also be partially responsible for the high forecast error.

The 1996 pre-season run forecast is for 722,000 fish, which if accurate, will allow a harvest of approximately 422,000 (Appendix I.1). The 1996 run is projected to be about 36% 2.2 fish, 20% 1.2 fish, and 19% 1.3 fish.

Akalura Lake

Based on 1990-1995 smolt outmigrant estimates, the 1987, 1988 and 1989 BR's produced over twice the number of smolt as the 1990 and 1991 BR's. Overall, Akalura Lake has shown a steady decline in smolt production. However, the shift in age composition to fewer age-1. smolts and more age-3. smolts which has been evident in past years is less prevalent in the 1995 outmigration.

In 1995, Akalura Lake received an escapement of 2,010 fish for both the early and late runs combined. This exceedingly low level of escapement was far below the minimum escapement goal of 40,000. Preliminary run reconstruction numbers for 1994-95 indicate that the minimum escapement goal would not have been met given the complete absence of a commercial fishery in the Alitak Bay District for either year. This fishery is managed from late July throughout August for sockeye salmon returning to the Upper Station system and secondarily for coho salmon escapements into district streams. We believe that the escapements experienced at Akalura are in part a function of the commercial fishery. However, we do not believe that there is a major difference between the Akalura and Upper Station harvest rates. The poor escapements for the last two years are likely a function of the depressed sockeye smolt production from the associated broods. The 1996 sockeye run is not expected to meet minimum escapement requirements based upon smolt numbers produced from the 1990 and 1991 BR's and no commercial fishing time is expected within the Inner and Outer Akalura Sections (ADF&G 1993) in 1996.

Frazer Lake

Based on the 1992-1995 outmigrant smolt estimates, the 1990 BR produced an estimated 5,753,179 smolts from an escapement of 226 thousand adults. This is significantly below the 13 million smolts produced from the 1989 BR but similar to the 1991 BR (4.7 million, incomplete). The 1988 (incomplete), 1990, and 1991 (incomplete) BR's have produced roughly 50% fewer smolts than the 1989 BR, when the attendant escapement levels were about 20% less than in 1989. Overall, age-1. smolt production has dramatically decreased (1989-1993 BR's), whereas age-2. smolt numbers appear to be relatively stable or increasing (1988-1992). Age-3. abundance increased markedly (1987-1989) but the 1990 and 1991 BR's indicate a declining trend.

The 1996 pre-season Frazer Lake sockeye forecast is 1.48 million fish (Appendix I.2) which is approximately 50% larger than the actual 1994 run of 952 thousand. The 1996 run is projected to be comprised of 75% two ocean fish and about 25% three ocean fish.

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Table 1. Red Lake sockeye salmon smolt population estimates by year and age, 1990-1995.

Smolt Outmigration Year	Number and Relative Percentages of Smolt by Age Class			No. Smolt	95% CI	
	1.	2.	3.		Low	High
1990	240,500 32.5%	493,026 66.6%	6,427 0.9%	739,953	402,905	1,077,004
1991	105,467 40.0%	119,849 45.5%	38,184 14.5%	263,500	178,221	348,782
1992	29,482 2.1%	1,365,082 96.1%	25,792 1.8%	1,420,356	1,117,748	1,722,965
1993	303,462 52.0%	193,884 33.2%	86,644 14.8%	583,990	436,166	731,804
1994	40,404 7.2%	520,391 92.5%	1,895 0.3%	562,690	472,305	647,655
1995	11,337 3.3%	317,903 93.1%	12,250 3.6%	341,490	315,923	367,056

Table 2. Red Lake sockeye salmon escapement and smolt production by brood year, 1986-1995.

Brood Year	Escapement	Smolt Numbers by Age (and Percent) 1.	2.	3.	Total
1986	318,135	[a]	[a]	6,427	6,427[b]
1987	261,913	[a]	493,026	38,184	531,210[b]
1988	291,774	240,500	119,849	25,792	386,141
1989	768,101	105,467 19.7%	1,365,082 44.2%	86,642 36.1%	1,557,191
1990	371,282	29,482 13.1%	193,882 86.1%	1,895 0.8%	225,259
1991	374,859	303,462 36.3%	520,391 62.2%	12250 1.5%	836,103
1992	344,184	40,404	317,903	[c]	[b]
1993	286,170	11,337	[c]	[c]	[b]
1994	380,181	[c]	[c]	[c]	
1995	317,832				

[a] Population estimates not currently available

[b] Incomplete brood year data.

[c] Smolt of this age class have not outmigrated.

Table 3. Akalura Lake sockeye salmon smolt population estimates by year and age, 1990-1995.

Smolt Outmigration Year	Number and Relative Percentages of Smolt by Age Class				No. Smolt	95% CI	
	1.	2.	3.	4.		Low	High
1990	66,460	408,330	0	0	474,790	318,734	630,846
	14.0%	86.0%	0.0%	0.0%			
1991	9,086	299,591	1,251	0	309,928	237,981	381,875
	2.9%	96.7%	0.4%	0.0%			
1992	1,921	182,963	8,315	0	193,199	153,765	232,638
	1.0%	94.7%	4.3%	0.0%			
1993	3,259	73,062	12,315	238	88,874	35,943	141,802
	3.7%	82.2%	13.9%	0.3%			
1994	72,474	90,467	7,141	0	170,172[a]	130910	209433
	42.6%	53.2%	4.2%	0.0%			
1995	63,356	70,496	265	0	134,117	125,523	142,712
	47.2%	52.6%	0.2%	0.0%			

[a] An estimated 90 age 0. smolt outmigrated in 1994.

Table 4. Akalura Lake sockeye salmon escapement and smolt production by brood year, 1986-1995.

Brood Year	Escapement	Smolt Numbers by Age (and Percent) 1.	2.	3.	4.	Total
1986	9,800	[a]	[a]	0	0	[a]
1987	6,116	[a]	408,330	1,251	0	409,581[b]
1988	38,618	66,460 17.7%	299,591 80.0%	8,315 2.2%	238 0.1%	374,604
1989	116,029	9,086 4.4%	182,963 89.5%	12,315 6.0%	0 0.0%	204,364
1990	47,181	1,921 2.3%	73,062 89.0%	7,141 8.7%	0 0.0%	82,124
1991	44,189	3,259	90,467	265	[c]	[b]
1992	63,269	72,474	70,496	[c]	[c]	[b]
1993	30,692	63,356	[c]	[c]	[c]	[b]
1994	13,681	[c]	[c]	[c]	[c]	
1995	2,010					

[a] Smolt migration not monitored.

[b] Incomplete brood year data.

[c] Smolt of this age class have not outmigrated.

Table 5. Frazer Lake sockeye salmon smolt population estimates by year and age, 1991-1995.

Smolt Outmigration Year	Number and Relative Percentages of Smolt by Age Class				No. Smolt	95% CI	
	1.	2.	3.	4.		Low	High
1991	2,552,835	3,777,426	3,786	0	6,334,047	2,128,460	10,539,634
	40.3%	59.6%	0.1%	0.0%			
1992	108,489	5,739,150	557,584	0	6,405,223	2,649,678	10,160,766
	1.7%	89.6%	8.7%	0.0%			
1993	23,496	5,077,865	4,687,084	612	9,789,057	3,309,885	16,268,229
	0.2%	51.9%	47.9%	0.0%			
1994	727,781	4,608,258	566,824	0	5,902,863	5,285,225	6,520,501
	12.3%	78.1%	9.6%	0.0%			
1995	59,560	8,249,931	76,596	0	8,386,087	7,595,899	9,176,275
	0.7%	98.4%	0.9%	0.0%			

Table 6. Frazer Lake sockeye salmon escapement and smolt production by brood year, 1986-1995.

Brood Year	Escapement	Smolt Numbers by Age (and Percent) 1.	2.	3.	4.	Total
1986	126,529	[a]	[a]	[a]	0	[b]
1987	40,544	[a]	[a]	3,786	0	3,786[b]
1988	246,704	[a]	3,777,426	557,584	612	4,335,622[b]
1989	360,373	2,552,835 19.7%	5,739,150 44.2%	4,687,083 36.1%	0 0.0%	12,979,068
1990	226,960	108,489 1.9%	5,077,866 88.3%	566,824 9.9%	0 0.0%	5,753,179
1991	190,358	23,496	4,608,258	76,596	[c]	4,708,350[b]
1992	185,825	727,781	8,249,931	[c]	[c]	[b]
1993	178,391	59,560	[c]	[c]	[c]	[b]
1994	206,071	[c]	[c]	[c]	[c]	
1995	196,362					

[a] Population estimates not currently available

[b] Incomplete brood year data.

[c] Smolt of this age class have not outmigrated.

Table 7. Mean smolt length and weight by system, age, and year, 1990-1995.

System	Smolt Year	Age - 0. N	Age - 0. Length (mm)	Age - 0. Weight (g)	Age - 1. N	Age - 1. Length (mm)	Age - 1. Weight (g)	Age - 2. N	Age - 2. Length (mm)	Age - 2. Weight (g)	Age - 3. N	Age - 3. Length (mm)	Age - 3. Weight (g)	Age - 4. N	Age - 4. Length (mm)	Age - 4. Weight (g)
Red Lake																
	1990	0			342	106.5	10.0	1,052	111.8	11.0	20	117.9	13.0	0		
	1991	0			1,135	88.2	5.0	977	106.7	9.5	407	113.0	11.3	0		
	1992	0			85	99.5	8.8	1,667	110.2	11.8	63	119.7	15.2	0		
	1993	0			1,409	91.7	7.3	516	108.6	11.0	397	120.1	14.5	0		
	1994	0			225	86.2	5.1	1,718	98.7	7.6	7	104.9	9.0	0		
	1995	0			151	92.1	6.4	1,592	103.2	9.3	97	115.7	13.3	0		
Akalura Lake																
	1990	0			577	73.9	3.6	749	85.9	5.3	0			0		
	1991	0			41	77.2	4.3	1,382	77.5	4.0	22	97.3	8.9	0		
	1992	1	59.0	1.5	25	75.7	3.7	2,014	78.8	3.9	61	86.4	4.9	0		
	1993	0			74	61.8	1.2	992	85.8	5.7	94	90.8	6.8	2	101.5	2.5
	1994	2	73.0	3.4	721	87.5	6.1	763	93.1	7.3	146	95.8	7.7	0		
	1995	0			644	81.7	4.8	1,216	92.1	6.6	6	99.0	7.7	0		
Frazer Lake																
	1990	0			574	84.2	4.5	553	104.3	9.0	44	113.0	12.2	0		
	1991	0			746	89.7	5.4	1,344	89.5	5.6	4	120.8	15.7	0		
	1992	0			49	86.4	6.1	2,951	83.9	5.5	191	91.1	7.2	0		
	1993	0			8	89.9	6.1	682	100.3	8.3	913	104.2	9.2	3	121.3	9.4
	1994	0			713	86.3	5.2	1,456	102.6	8.1	302	112.8	10.7	0		
	1995	0			39	86.7	5.3	2,154	91.2	5.6	20	115.2	13.6	0		

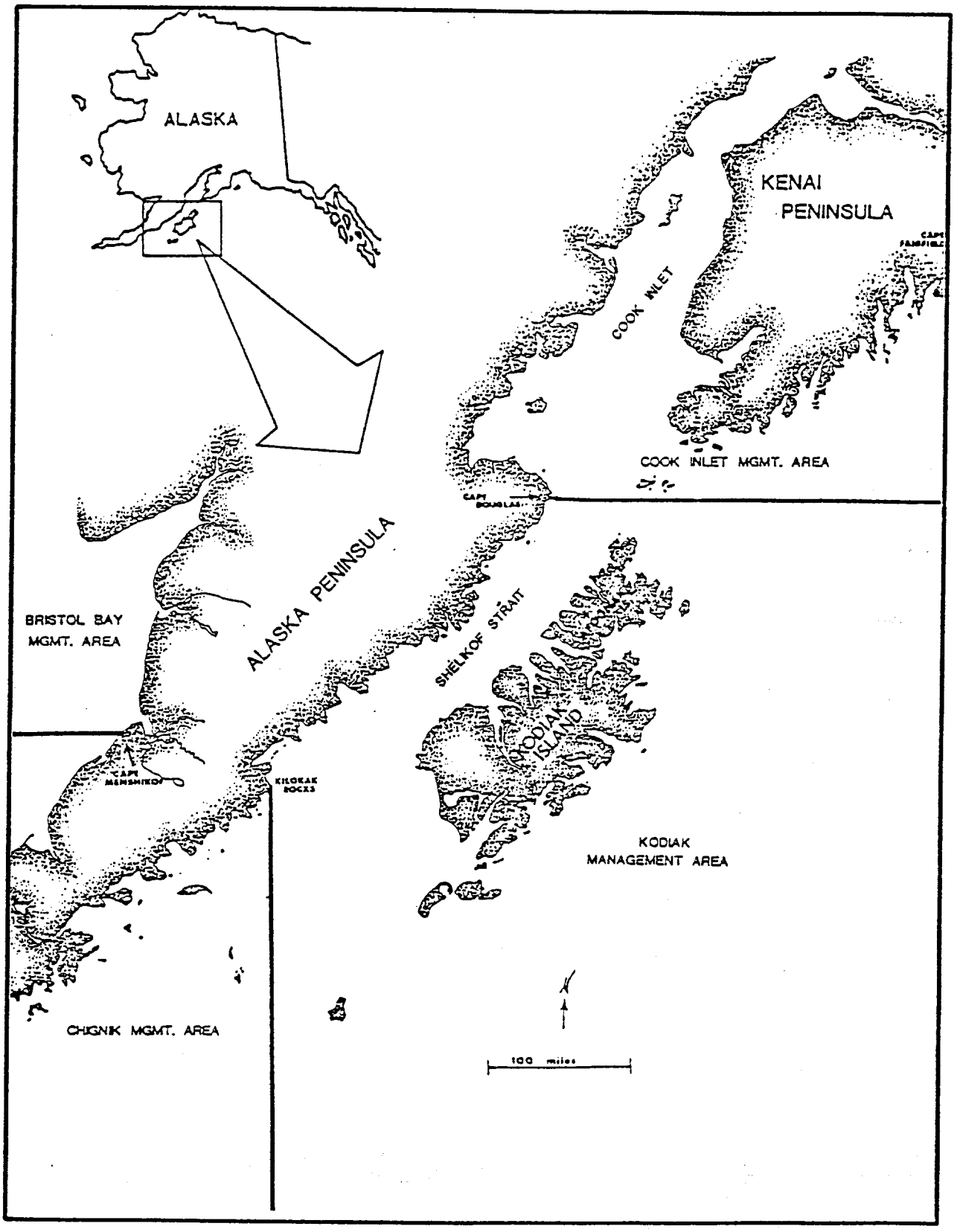

Figure 1. Map depicting Kodiak and adjacent salmon management areas.

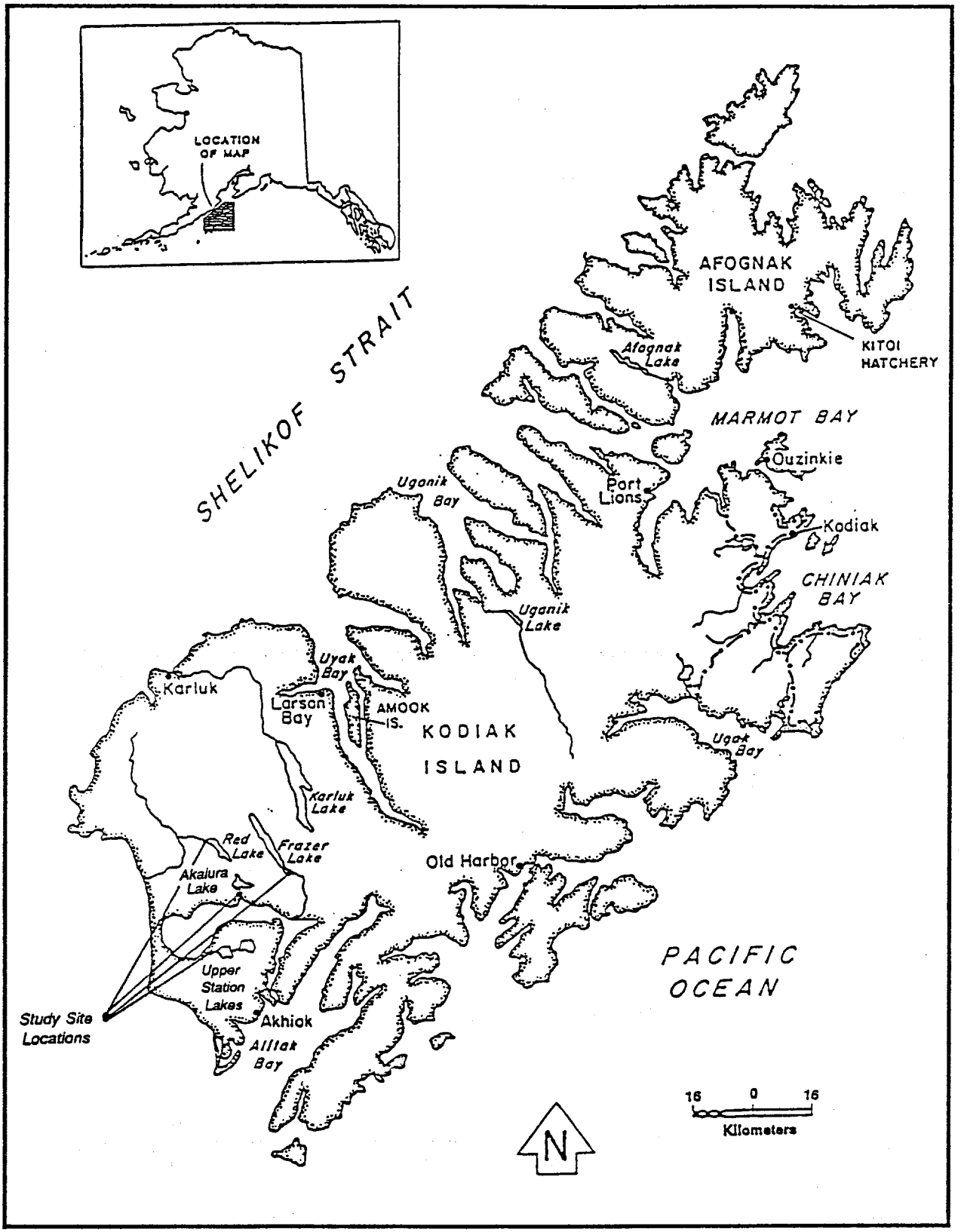

Figure 2. Map depicting locations of sockeye salmon smolt study sites at Red, Akalura, and Frazer Lakes, Kodiak Island, Alaska.

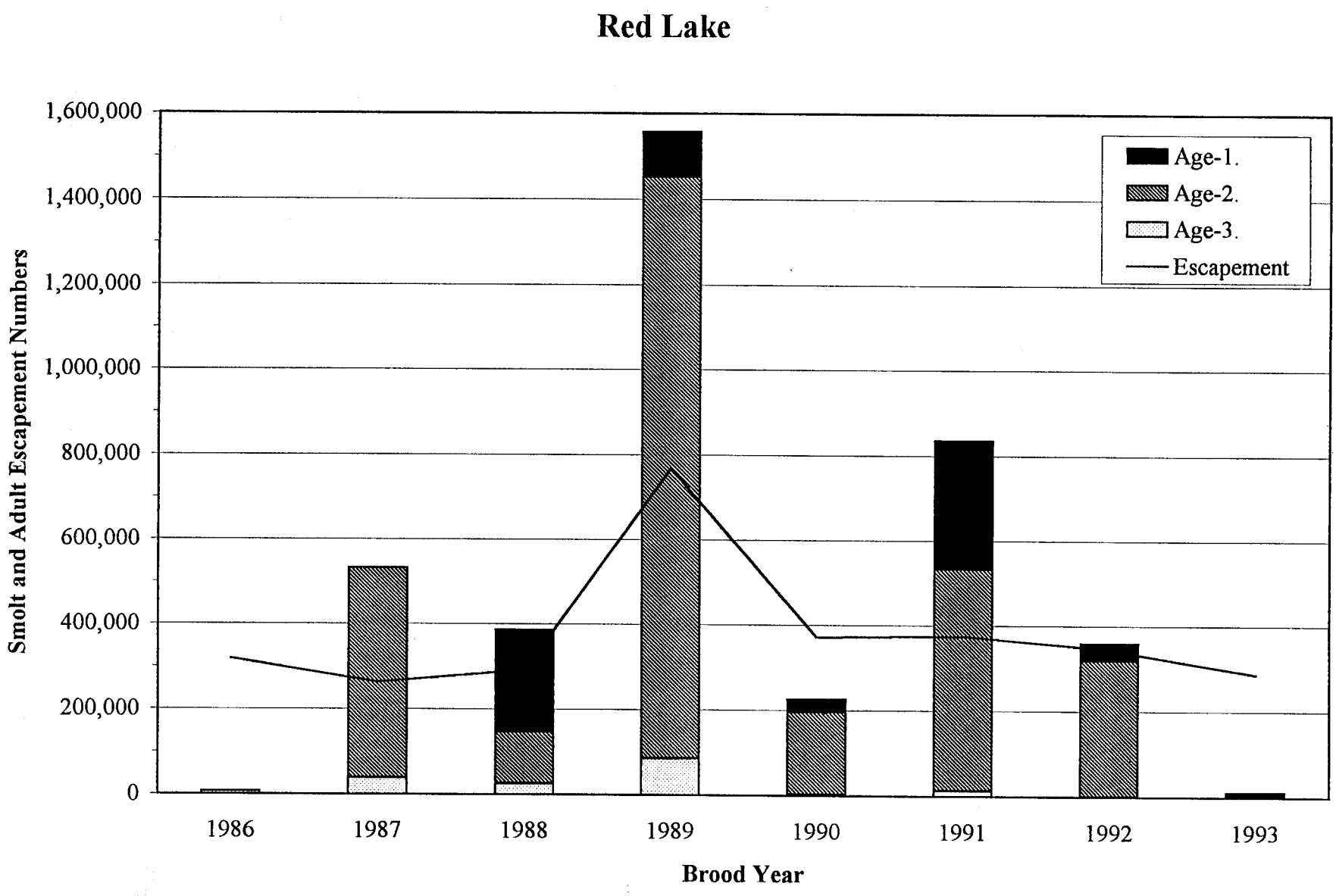

Figure 3. Sockeye salmon adult escapement and smolt production by age and brood year, Red Lake, 1986 - 1993.

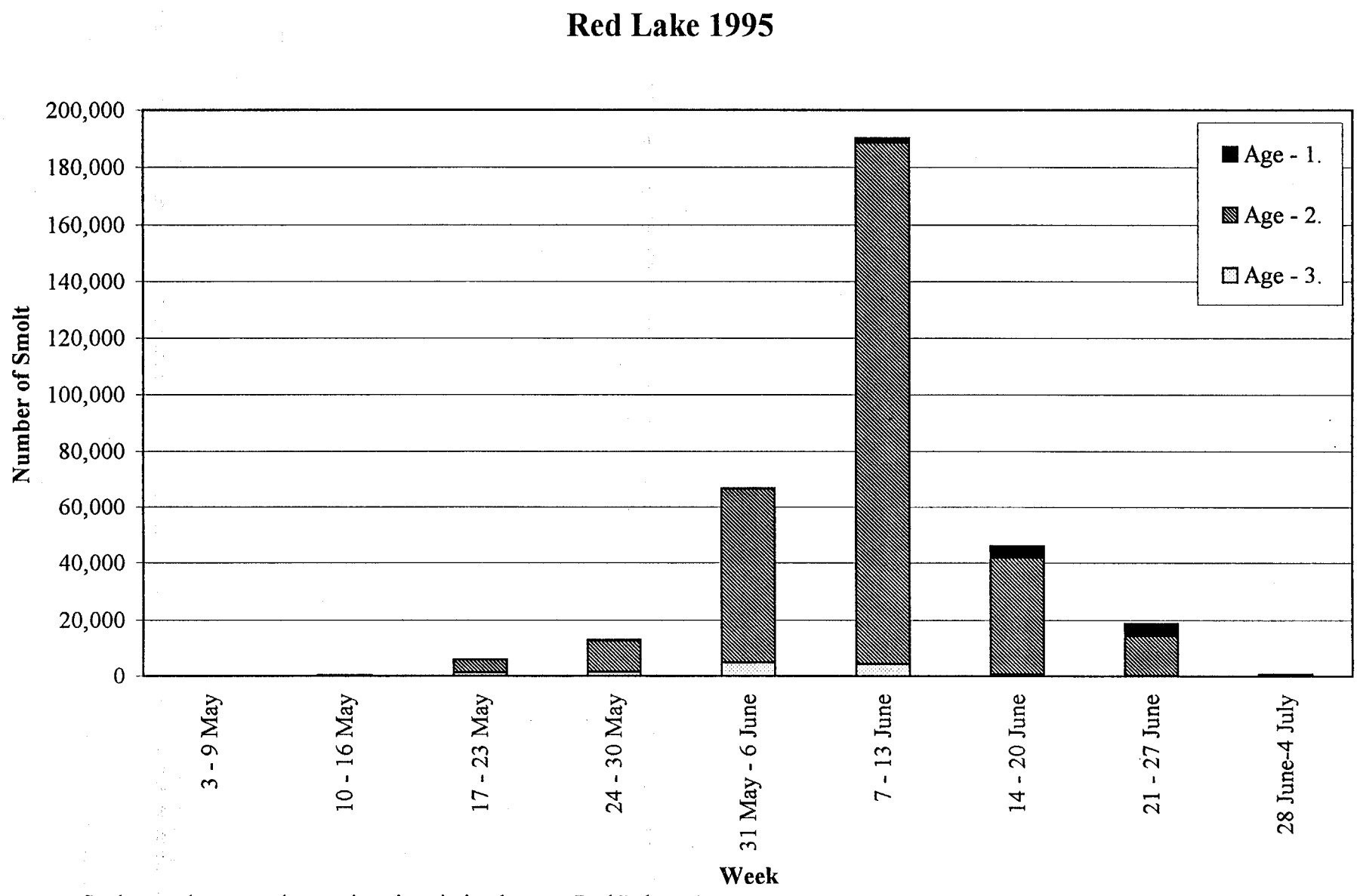

Figure 4. Sockeye salmon smolt outmigration timing by age, Red Lake, 1995

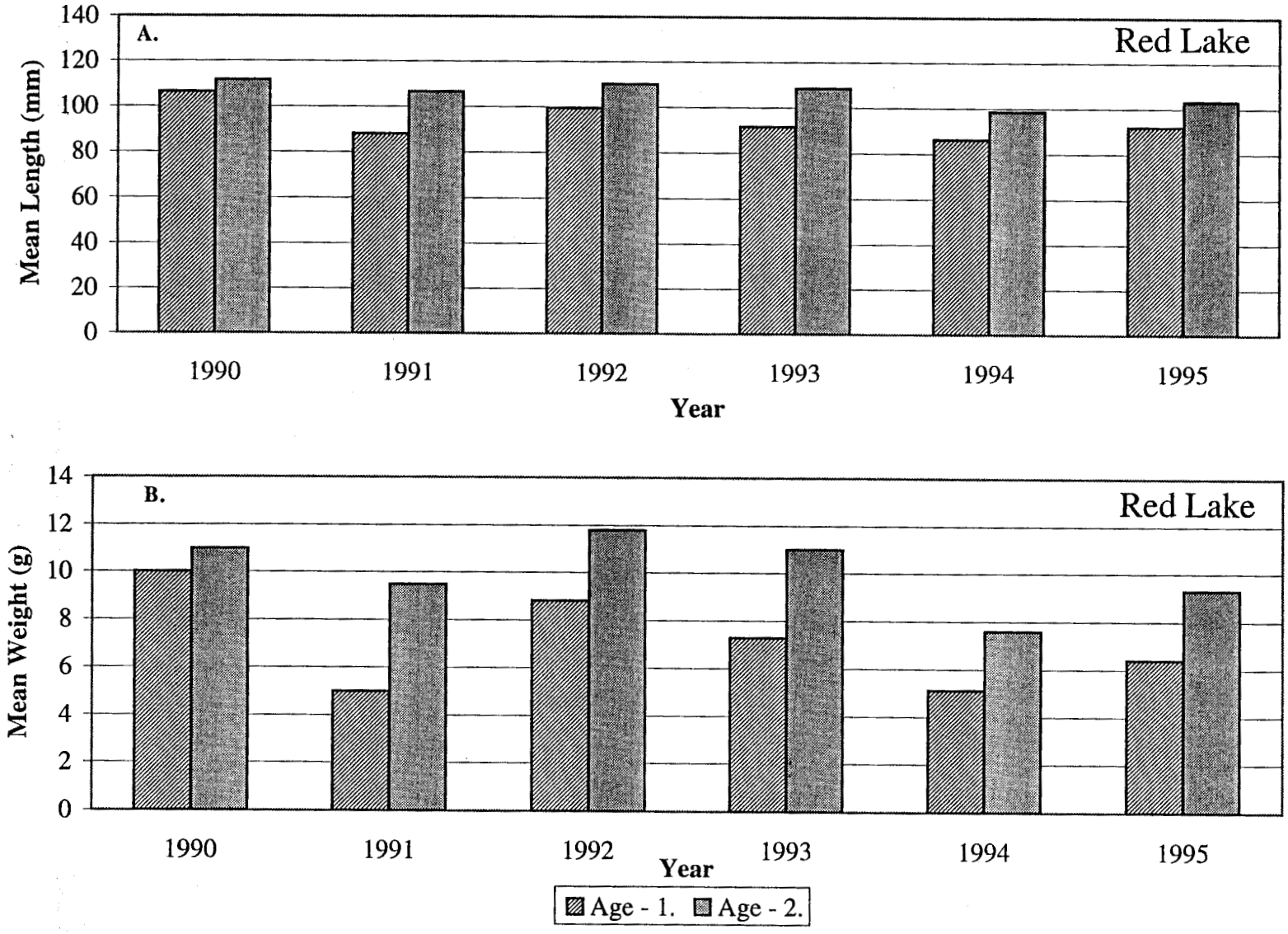

Figure 5. Red Lake mean smolt length (A) and weight (B) by year and age, 1990 - 1995.

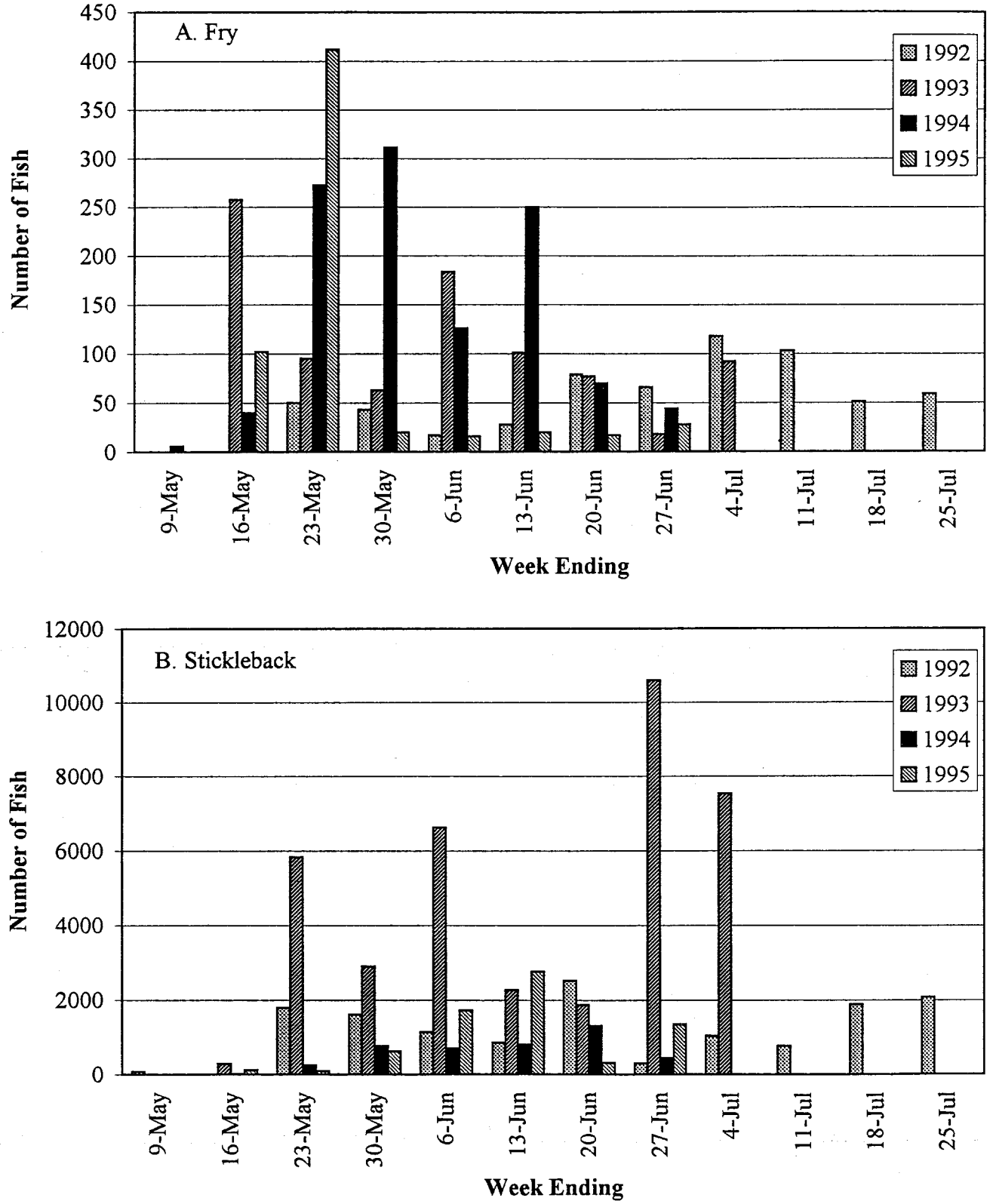

Figure 6. Sockeye salmon fry (A) and stickleback (B) littoral zone seine catch by week, Red Lake, 1992 1995.

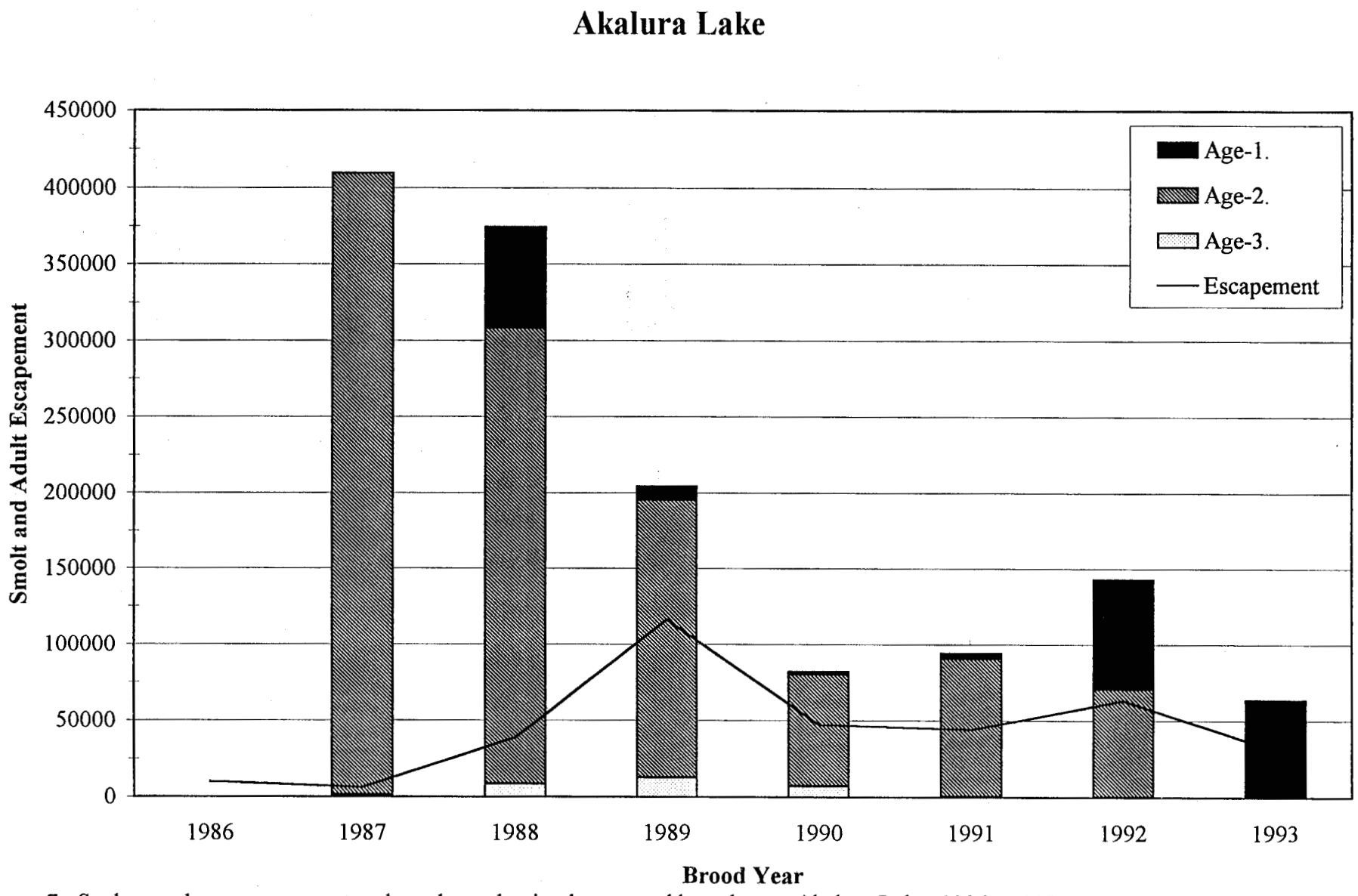

Figure 7. Sockeye salmon escapement and smolt production by age and brood year, Akalura Lake, 1986 - 1993.

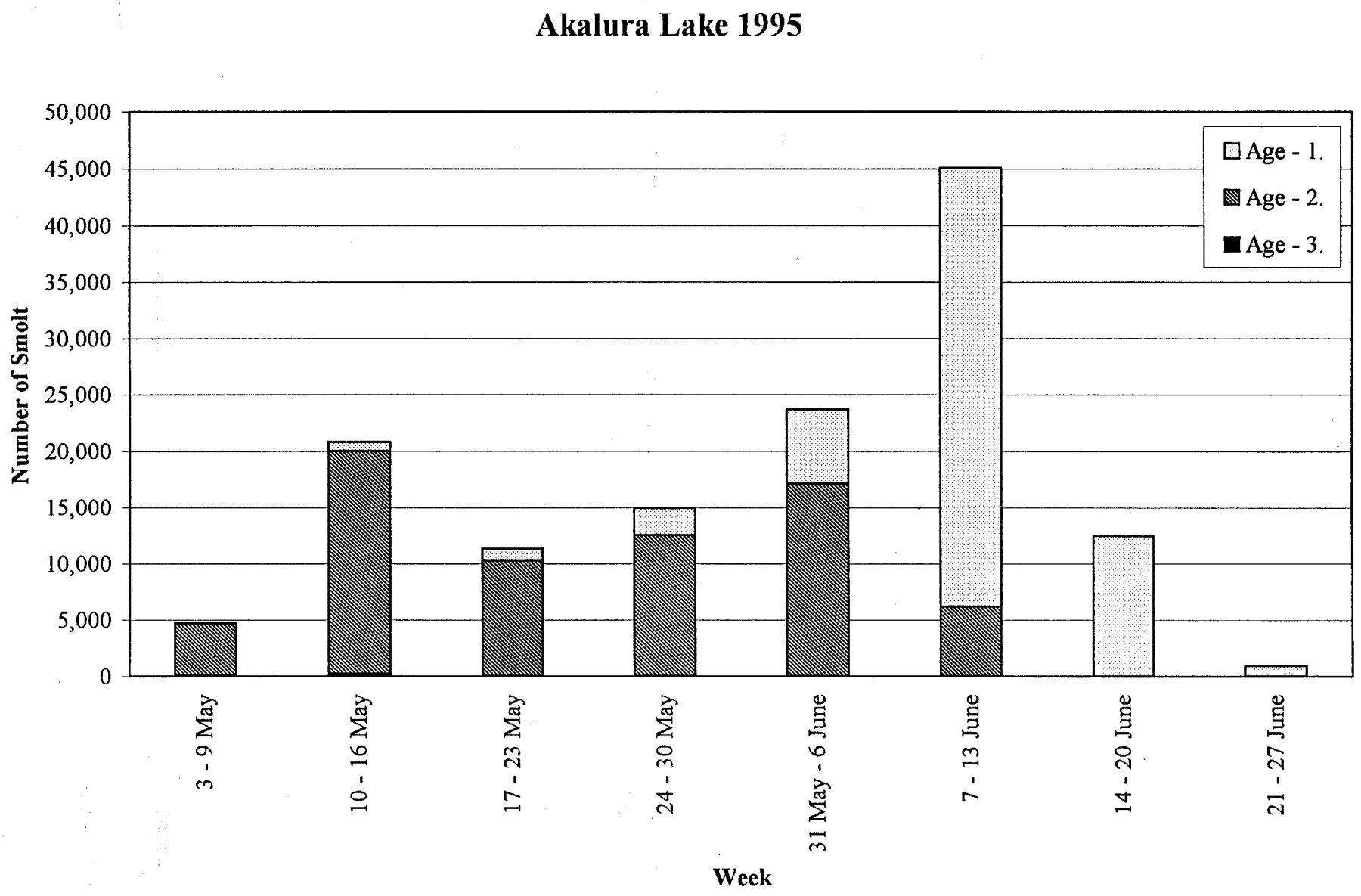

Figure 8. Sockeye salmon smolt outmigration timing by age, Akalura Lake, 1995.

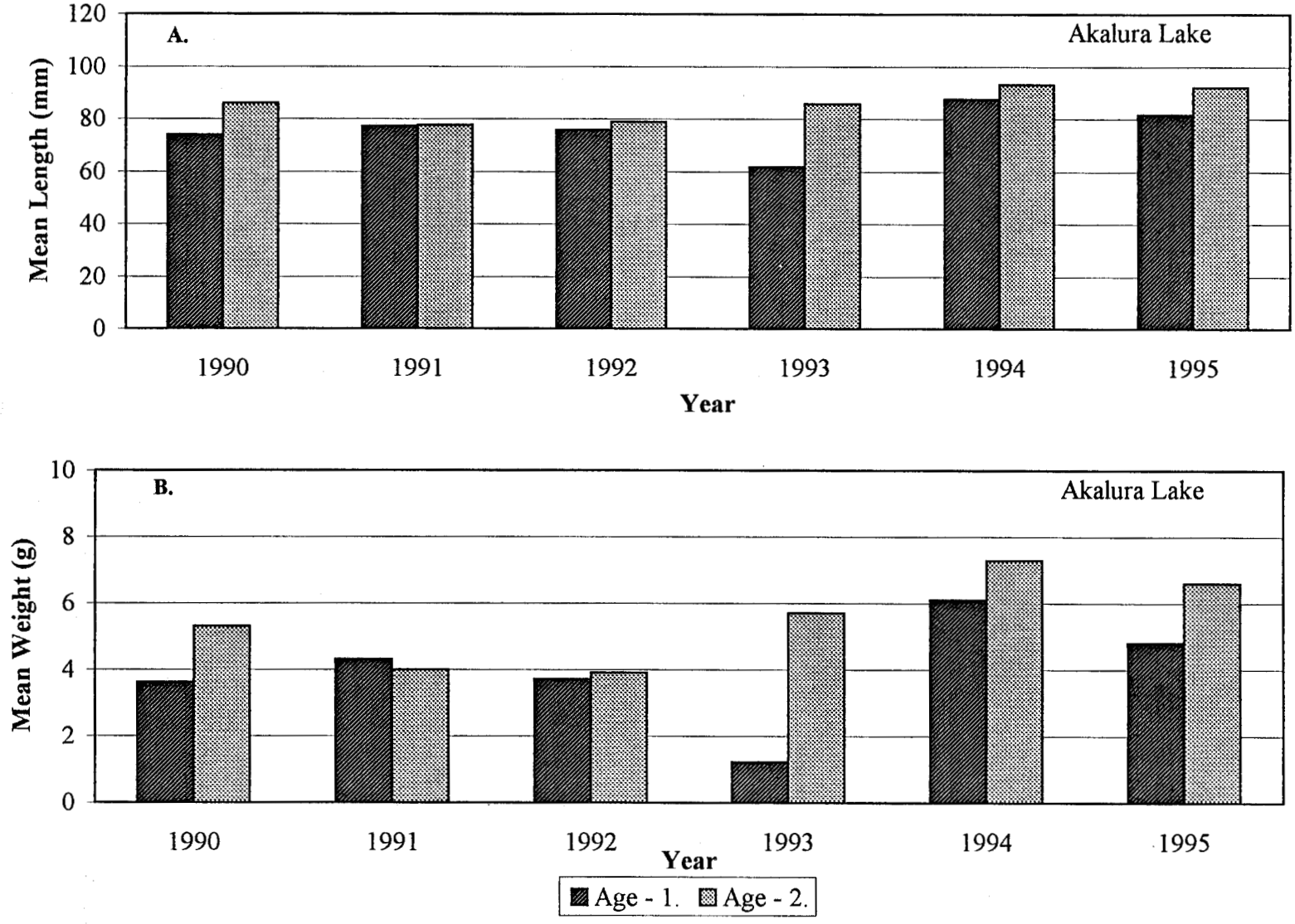

Figure 9. Akalura Lake mean smolt length (A) and weight (B) by year and age, 1990 - 1995.

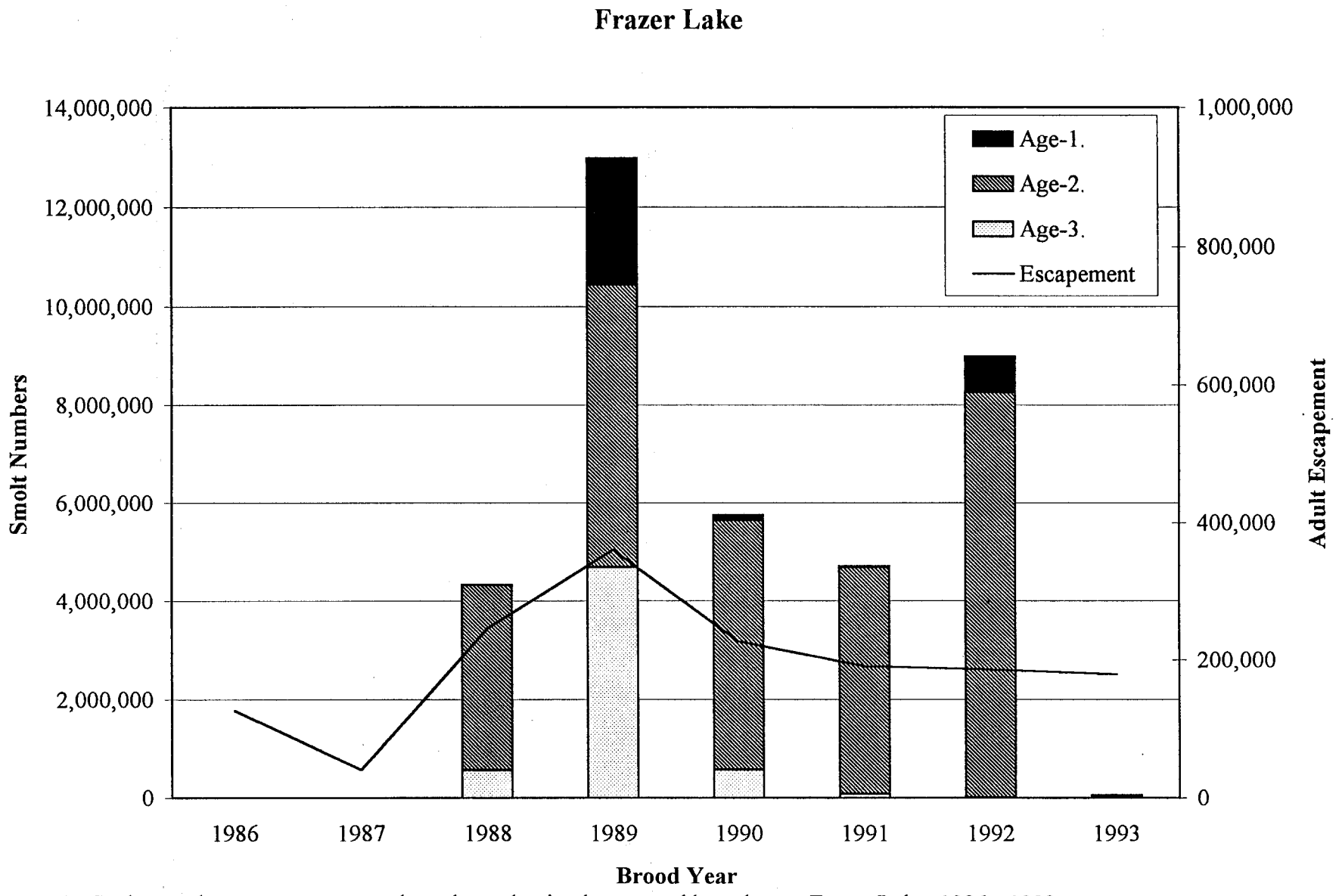

Figure 10. Sockeye salmon escapement and smolt production by age and brood year, Frazer Lake, 1986 - 1993.

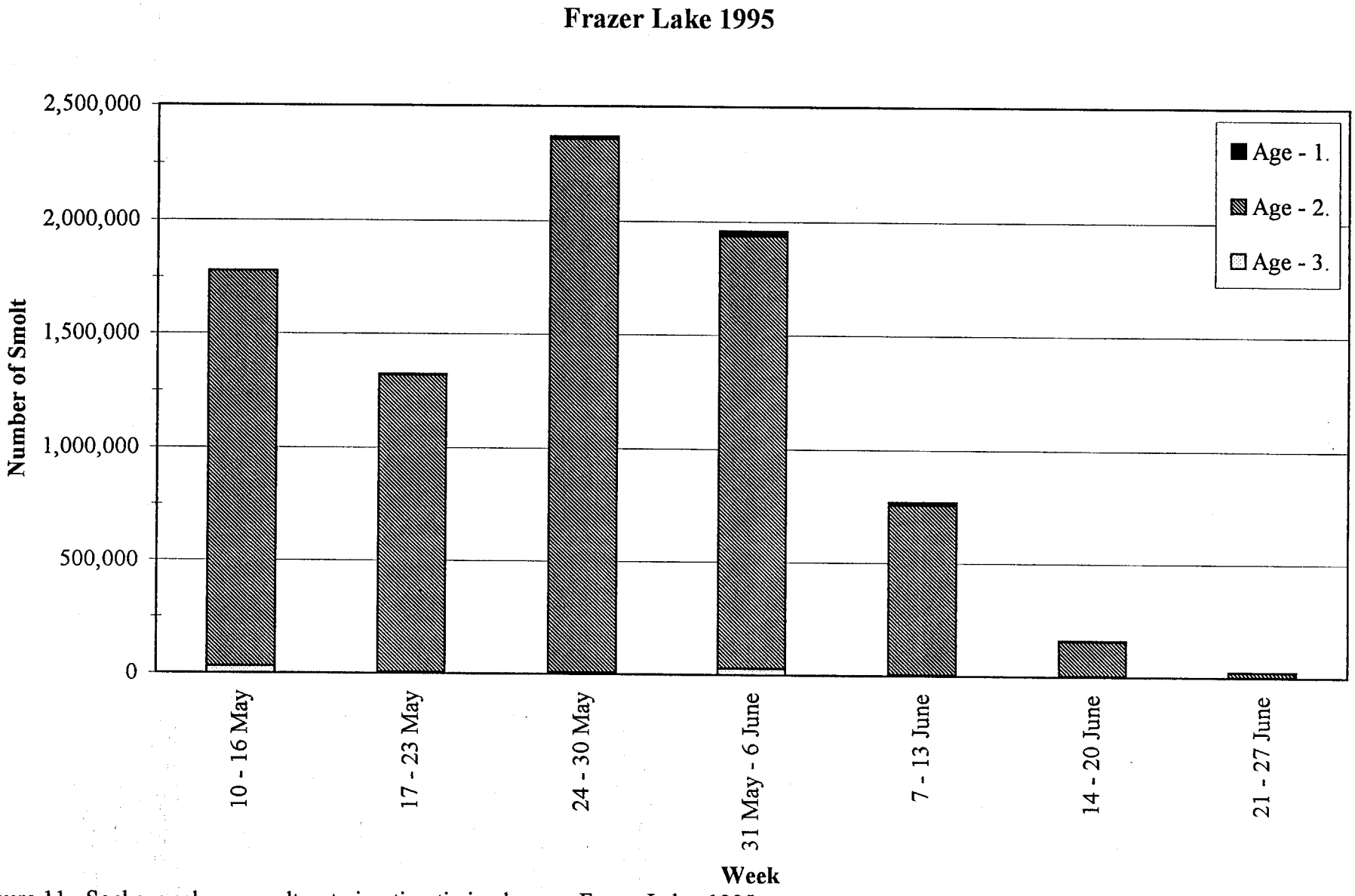

Figure 11. Sockeye salmon smolt outmigration timing by age, Frazer Lake, 1995.

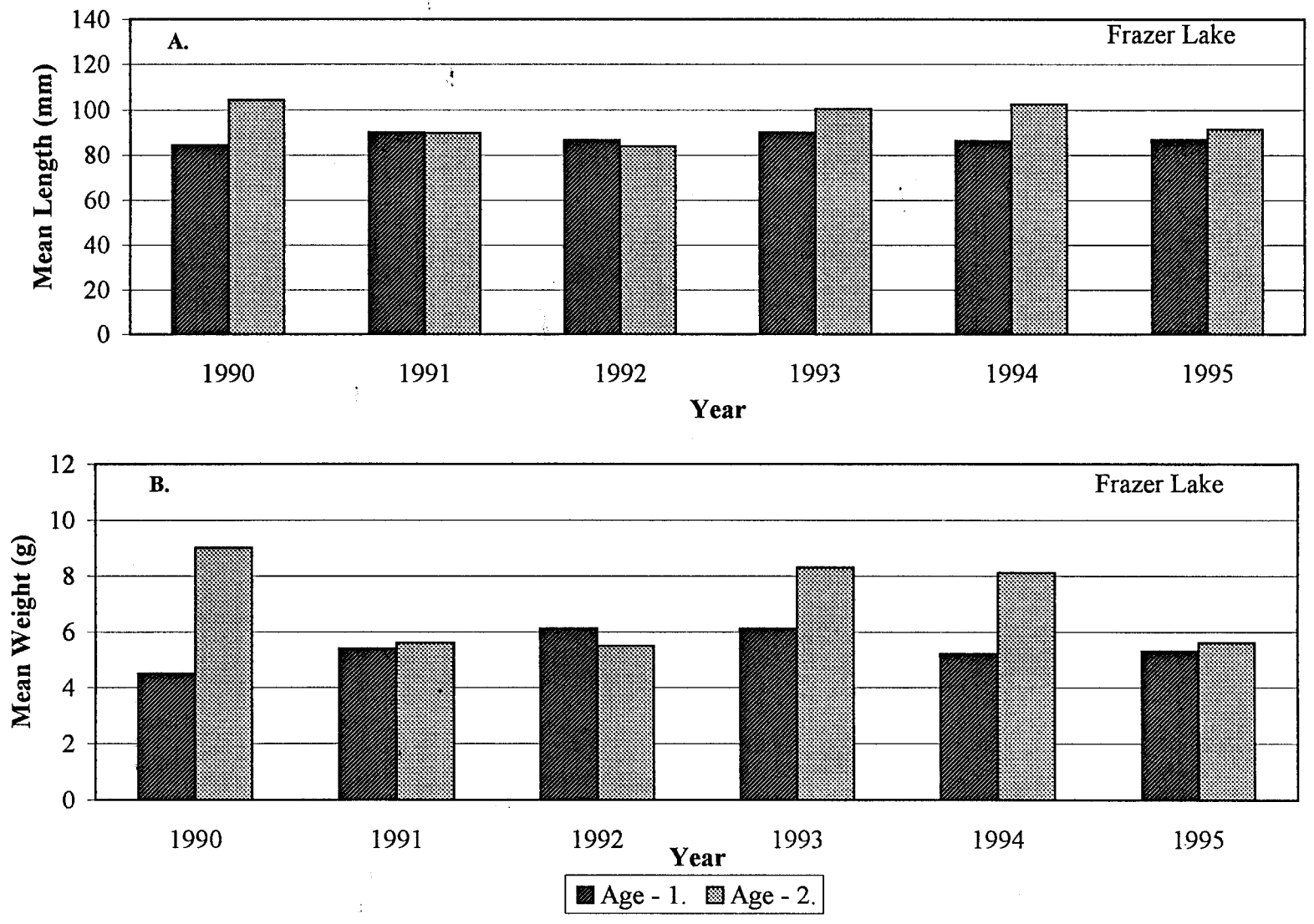

Figure 12. Frazer Lake mean smolt length (A) and weight (B) by year and age, 1990 - 1995.

APPENDIX

Appendix A.1. Red Lake sockeye salmon smolt trap catch and trap efficiency estimates, 1995.

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	cum.	Marked (dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate[d]
5/7	3	3					
5/8	3	6					
5/9	1	7					
5/10	10	17					
5/11	3	20					
5/12	18	38					
5/13	8	46					
5/14	9	55					
5/15	9	64					
5/16	10	74					
5/17	21	95					
5/18	47	142					
5/19	41	183					
5/20	92	275					
5/21	81	356					
5/22	708	1,064					
5/23	41	1,105	520	103	63		
5/24	40	1,145		67	27		
5/25	52	1,197		54	2	92	17.7%
5/26	13	1,210					
5/27	87	1,297					
5/28	82	1,379					
5/29	1,222	2,601					
5/30	478	3,079	581	548	70		
5/31	321	3,400		336	15		
6/1	613	4,013		614	1	86	14.8%
6/2	1,741	5,754					
6/3	206	5,960					
6/4	617	6,577					
6/5	1,477	8,054					
6/6	2,325	10,379	611	2,359	34		
6/7	1,239	11,618		1,263	24		
6/8	3,110	14,728		3,110	0	58	9.5%
6/9	981	15,709					
6/10	1,848	17,557					
6/11	1,859	19,416					
6/12	2,624	22,040					
6/13	3,043	25,083	517	2,988	21		
6/14	828	25,911		834	6		
6/15	188	26,099		193	5	32	6.2%
6/16	87	26,186					
6/17	863	27,049					
6/18	1,094	28,143					
6/19	431	28,574					
6/20	114	28,688					

-Continued-

Appendix A.1. (page 2 of 2)

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	cum.	Marked (dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate[d]
6/21	270	28,958					
6/22	567	29,525					
6/23	650	30,175	593	709	59		
6/24	633	30,808		659	26		
6/25	160	30,968		161	1	86	14.5%
6/26	108	31,076					
6/27	305	31,381					
6/28	96	31,477					
TOTAL	31,477		2,822	13,998	354		12.5%

[a] Each Date listed covers a 24-hour period extending from noon to noon and identifies the date of the first noon of the 24-hour period.

[b] Number of fish caught does not include mark recoveries from trap efficiency tests.

[c] Represents the sum of marked recoveries for the particular dye test period.

[d] Determined from the cumulative number of marked and recovered fish by test period.

Appendix A.2. Akalura Lake sockeye salmon smolt trap catch and trap efficiency estimates, 1995.

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	cum.	Marked (dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate[d]
5/1		0					
5/2		0					
5/3		0					
5/4	11	11					
5/5	69	80					
5/6	99	179					
5/7	160	339					
5/8	65	404	328	118	53		
5/9	481	885		489	8		
5/10	452	1,337		453	1	62	18.9%
5/11	439	1,776					
5/12	592	2,368					
5/13	129	2,497					
5/14	654	3,151					
5/15	342	3,493	522	401	59		
5/16	363	3,856		365	2		
5/17	161	4,017		161	0	61	11.7%
5/18	65	4,082					
5/19	417	4,499					
5/20	390	4,889					
5/21	232	5,121					
5/22	67	5,188					
5/23	129	5,317	293	156	27		
5/24	69	5,386		82	13		
5/25	158	5,544		161	3	43	14.7%
5/26	705	6,249					
5/27	1,069	7,318					
5/28	32	7,350					
5/29	20	7,370					
5/30	96	7,466					
5/31	86	7,552					
6/1	113	7,665					
6/2	714	8,379	292	742	28		
6/3	872	9,251		881	9		
6/4	393	9,644		398	5	42	14.4%
6/5	152	9,796					
6/6	417	10,213					

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Appendix A.2. (page 2 of 2)

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	cum.	Marked (dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate[d]
6/7	278	10,491					
6/8	319	10,810	564	326	7		
6/9	532	11,342		549	17		
6/10	270	11,612		274	4	28	5.0%
6/11	247	11,859					
6/12	156	12,015	514	160	4		
6/13	350	12,365		368	18		
6/14	148	12,513		151	3	25	4.9%
6/15	114	12,627					
6/16	135	12,762					
6/17	110	12,872					
6/18	143	13,015					
6/19	43	13,058					
6/20	34	13,092	295	41	7		
6/21	21	13,113		33	12		
6/22	28	13,141		30	2		
6/23	18	13,159		20	2		
6/24	5	13,164		6	1	24	8.1%
6/25	1	13,165					
6/26	2	13,167					
TOTAL	11,830		2,808	6,365	285		10.1%

[a] Each Date listed covers a 24-hour period extending from noon to noon and identifies the date of the first noon of the 24-hour period.

[b] Number of fish caught does not include mark recoveries from trap efficiency tests.

[c] Represents the sum of marked recoveries for the particular dye test period.

[d] Determined from the cumulative number of marked and recovered fish by test period.

Appendix A.3. Frazer Lake sockeye salmon smolt trap catch and trap efficiency estimates, 1995.

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	cum.	Marked (dyed)	Unmarked Fish Caught	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate[d]
5/11	8,953	8,953		8,953			
5/12	27,134	36,087		27,134			
5/13	675	36,762	1,108	675	43		
5/14	1,284	38,046		1,284	6		
5/15	13,781	51,827		13,781	3	52	4.7%
5/16	55,309	107,136		55,309			
5/17	13,506	120,642		13,506			
5/18	22,040	142,682		22,040			
5/19	988	143,670		988			
5/20	5,301	148,971		5,301			
5/21	5,462	154,433	1,125	5,462	41		
5/22	19,495	173,928		19,495	18		
5/23	12,867	186,795		12,867	0	59	5.2%
5/24	92,256	279,051		92,256			
5/25	7,208	286,259		7,208			
5/26	14,178	300,437		14,178			
5/27	10,272	310,709		10,272			
5/28	12,519	323,228	1,164	12,519	67		
5/29	3,428	326,656		3,428	10		
5/30	2,913	329,569		2,913	4	81	7.0%
5/31	4,796	334,365		4,796			
6/1	20,534	354,899		20,534			
6/2	20,460	375,359		20,460			
6/3	45,515	420,874		45,515			
6/4	15,125	435,999	995	15,125	56		
6/5	3,132	439,131		3,132	8		
6/6	8,519	447,650		8,519	3	67	6.7%
6/7	9,484	457,134		9,484			
6/8	5,272	462,406		5,272			
6/9	17,712	480,118		17,712			
6/10	3,552	483,670		3,552			
6/11	2,500	486,170	1,188	2,500	53		
6/12	5,077	491,247		5,077	21		
6/13	2,741	493,988		2,741	2		
6/14	281	494,269		281	1	77	6.5%
6/15	1,934	496,203		1,934			
6/16	3,839	500,042		3,839			
6/17	1,548	501,590		1,548			
6/18	318	501,908	1,127	318	41		
6/19	257	502,165		257	24		
6/20	1,510	503,675		1,510	2		
6/21	616	504,291		616	2	69	6.1%
6/22	268	504,559		268			
6/23	88	504,647		88			

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Appendix A.3. (page 2 of 2)

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	cum.	Marked (dyed)	Unmarked Fish Caught	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate[d]
6/24	211	504,858		211			
6/25	203	505,061		203			
6/26	67	505,128		67			
6/27	91	505,219		91			
TOTAL	505,219		6,707	505,219	405		6.0%

[a] Each Date listed covers a 24-hour period extending from noon to noon and identifies the date of the first noon of the 24-hour period.

[b] Number of fish caught does not include mark recoveries from trap efficiency tests.

[c] Represents the sum of marked recoveries for the particular dye test period.

[d] Determined from the cumulative number of marked and recovered fish by test period.

Appendix B.1. Red Lake daily sockeye salmon smolt population estimates, 1995.

Date	Population Estimate	95% Conf. Int. lower	95% Conf. Int. upper
5/7	17	0	35
5/8	17	0	35
5/9	6	0	16
5/10	57	24	90
5/11	17	0	35
5/12	103	56	149
5/13	46	16	75
5/14	51	20	83
5/15	51	20	83
5/16	57	24	90
5/17	120	69	171
5/18	268	183	353
5/19	234	156	311
5/20	525	388	661
5/21	462	338	586
5/22	4,038	3,249	4,826
5/23	234	156	311
5/24	228	152	304
5/25	297	206	387
5/26	77	36	117
5/27	531	388	674
5/28	519	375	663
5/29	8,027	6,374	9,680
5/30	3,261	2,577	3,946
5/31	2,190	1,714	2,666
6/1	4,182	3,320	5,045
6/2	12,944	10,261	15,628
6/3	1,707	1,281	2,133
6/4	5,679	4,319	7,039
6/5	15,571	11,684	19,458
6/6	24,446	18,533	30,360
6/7	13,027	9,842	16,213
6/8	32,700	24,815	40,585
6/9	10,315	7,778	12,852
6/10	21,263	15,861	26,665
6/11	24,118	17,609	30,626
6/12	38,091	27,258	48,924
6/13	50,605	34,020	67,190
6/14	13,770	9,194	18,345

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Appendix B.1. (page 2 of 2)

Date	Population Estimate	95% Conf. Int. lower	upper
6/15	3,126	2,024	4,229
6/16	1,246	796	1,697
6/17	10,597	7,555	13,640
6/18	12,006	8,762	15,250
6/19	4,275	3,139	5,412
6/20	1,014	718	1,309
6/21	2,211	1,655	2,767
6/22	4,239	3,273	5,206
6/23	4,527	3,594	5,459
6/24	4,408	3,499	5,317
6/25	1,114	847	1,382
6/26	752	557	947
6/27	1,455	1,121	1,790
6/28	669	490	847
Total	341,490	315,923	367,056

Appendix B.2. Akalura Lake sockeye salmon smolt population estimates, 1995.

Date	Population Estimate	95% Confidence Int. lower	upper
5/4	59	25	93
5/5	370	257	483
5/6	531	381	680
5/7	858	634	1,081
5/8	348	241	456
5/9	2,578	1,972	3,184
5/10	2,423	1,851	2,994
5/11	2,563	1,929	3,196
5/12	3,722	2,779	4,664
5/13	897	627	1,167
5/14	5,089	3,655	6,524
5/15	2,969	2,220	3,718
5/16	3,151	2,360	3,943
5/17	1,398	1,016	1,779
5/18	541	368	714
5/19	3,331	2,535	4,128
5/20	2,996	2,290	3,703
5/21	1,717	1,299	2,135
5/22	478	333	623
5/23	896	616	1,177
5/24	479	314	645
5/25	1,098	763	1,433
5/26	4,899	3,533	6,265
5/27	7,429	5,377	9,480
5/28	222	130	315
5/29	139	72	206
5/30	683	459	908
5/31	612	407	817
6/1	802	544	1,059
6/2	5,065	3,636	6,495
6/3	6,186	4,449	7,923
6/4	3,361	2,298	4,425
6/5	1,636	1,029	2,244
6/6	6,055	3,606	8,503
6/7	5,790	3,668	7,911
6/8	6,644	4,224	9,064
6/9	11,080	7,110	15,050
6/10	5,623	3,560	7,686

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Appendix B.2. (page 2 of 2)

Date	Population Estimate	95% Confidence Int. lower	upper
6/11	5,144	3,249	7,040
6/12	3,329	2,008	4,650
6/13	7,470	4,622	10,318
6/14	3,159	1,901	4,417
6/15	2,163	1,322	3,005
6/16	2,306	1,459	3,153
6/17	1,762	1,117	2,407
6/18	2,094	1,375	2,814
6/19	580	344	816
6/20	434	225	643
6/21	268	123	413
6/22	357	177	537
6/23	230	100	359
6/24	64	7	121
6/25	13	0	36
6/26	26	0	60
TOTAL	134,117	125,523	142,712

Appendix B.3. Frazer Lake sockeye salmon smolt population estimates, 1995.

Date	Population Estimate	95% Confidence Int. lower	95% Confidence Int. upper
5/11	148,610	134,300	162,921
5/12	450,395	407,658	493,132
5/13	11,204	9,869	12,539
5/14	21,313	19,011	23,615
5/15	228,750	206,890	250,609
5/16	918,069	831,282	1,004,857
5/17	224,185	202,755	245,615
5/18	365,840	331,067	400,613
5/19	16,400	14,566	18,234
5/20	87,991	79,392	96,589
5/21	90,663	81,813	99,514
5/22	323,596	292,802	354,390
5/23	213,578	193,148	234,009
5/24	1,531,349	1,386,798	1,675,901
5/25	119,645	108,064	131,226
5/26	235,339	212,859	257,820
5/27	170,504	154,131	186,877
5/28	207,802	187,915	227,688
5/29	56,901	51,234	62,568
5/30	48,353	43,492	53,213
5/31	79,608	71,800	87,417
6/1	340,842	308,424	373,261
6/2	339,614	307,311	371,917
6/3	755,500	684,024	826,975
6/4	251,059	227,097	275,020
6/5	51,988	46,784	57,191
6/6	141,406	127,774	155,038
6/7	157,424	142,283	172,565
6/8	87,509	78,956	96,063
6/9	294,000	265,994	322,006
6/10	58,959	53,098	64,821
6/11	41,497	37,284	45,711
6/12	84,273	76,025	92,521
6/13	45,498	40,907	50,089
6/14	4,664	3,978	5,351
6/15	32,102	28,777	35,428
6/16	63,723	57,413	70,034
6/17	25,695	22,977	28,414
6/18	5,278	4,529	6,028

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Appendix B.3. (page 2 of 2)

Date	Population Estimate	95% Confidence Int. lower	upper
6/19	4,266	3,621	4,911
6/20	25,064	22,406	27,723
6/21	10,225	8,985	11,465
6/22	4,449	3,785	5,112
6/23	1,461	1,135	1,786
6/24	3,502	2,939	4,066
6/25	3,370	2,820	3,919
6/26	1,112	834	1,390
6/27	1,511	1,178	1,843
TOTAL	8,386,087	7,595,899	9,176,275

Appendix C.1. Red Lake sockeye salmon smolt emigration by age class, 1995.

Dates	Population Estimate	Ages		
		1.	2.	3.
5/03-5/09/95	40	0	40	0
5/10-5/16/95	382	6	294	82
5/17-5/23/95	5,880	85	4,611	1,184
5/24-5/30/95	12,940	387	11,158	1,395
5/31-6/06/95	66,720	191	61,763	4,766
6/07-6/13/95	190,119	1,644	184,092	4,383
6/14-6/20/95	46,035	4,285	41,310	439
6/21-6/27/95	18,707	4,406	14,301	0
6/28-7/04/95	669	334	334	0
Total	341,490	11,337	317,903	12,250

Appendix C.2. Akalura Lake sockeye salmon smolt emigration by age class, 1995.

Dates	Population Estimate	1.	2.	3.
5/03-5/09/95	4,743	100	4,577	66
5/10-5/16/95	20,814	795	19,820	199
5/17-5/23/95	11,358	1,078	10,280	0
5/24-5/30/95	14,950	2,426	12,524	0
5/31-6/06/95	23,717	6,607	17,110	0
6/07-6/13/95	45,080	38,896	6,184	0
6/14-6/20/95	12,499	12,499	0	0
6/21-6/27/95	957	957	0	0
Total	134,117	63,356	70,496	265

Appendix C.3. Frazer Lake sockeye salmon smolt emigration by age class, 1995.

Dates	Population Estimate	Ages		
		1.	2.	3.
5/10-5/16/95	1,778,341	0	1,747,768	30,573
5/17-5/23/95	1,322,253	3,789	1,314,676	3,789
5/24-5/30/95	2,369,893	13,581	2,349,522	6,791
5/31-6/06/95	1,960,016	22,857	1,908,587	28,572
6/07-6/13/95	769,161	13,261	751,479	4,420
6/14-6/20/95	160,794	3,483	154,989	2,322
6/21-6/27/95	25,629	2,589	22,911	129
Total	8,386,087	59,560	8,249,931	76,596

Appendix D.1. Red Lake sockeye salmon smolt length, weight, and condition factor of samples collected, by age and week, 1995.

			Length (mm)			Weight (g)			Condition (K)		
Age	Week	Dates	n	Mean	Standard Error	n	Mean	Standard Error	n	Mean	Standard Error
1	20	5/10-5/16/95	1	61.0		1	1.6		1	0.7	
1	21	5/17-5/23/95	2	64.0	3.0	2	1.9	0.4	2	0.7	0.0
1	22	5/24-5/30/95	5	63.0	3.8	5	1.8	0.4	5	0.7	0.0
1	23	5/31-6/06/95	1	73.0		1	3.2		1	0.8	
1	24	6/07-6/13/95	3	93.7	4.3	3	6.9	1.0	3	0.8	0.0
1	25	6/14-6/20/95	39	91.5	1.3	39	6.2	0.3	39	0.8	0.0
1	26	6/21-6/27/95	65	94.1	0.7	65	6.8	0.2	65	0.8	0.0
1	27	6/28-7/04/95	35	96.0	1.0	35	7.2	0.2	35	0.8	0.0
Total			151	92.1	0.8	151	6.4	0.2	151	0.8	0.0
2	19	5/03-5/09/95	7	93.3	2.6	7	6.0	0.6	7	0.7	0.0
2	20	5/10-5/16/95	50	93.5	1.0	50	6.1	0.3	50	0.7	0.0
2	21	5/17-5/23/95	109	98.7	1.1	109	7.8	0.3	109	0.8	0.0
2	22	5/24-5/30/95	144	102.9	0.8	144	9.1	0.3	144	0.8	0.0
2	23	5/31-6/06/95	324	108.3	0.5	324	10.9	0.2	324	0.8	0.0
2	24	6/07-6/13/95	336	107.1	0.4	336	10.4	0.1	336	0.8	0.0
2	25	6/14-6/20/95	376	99.9	0.4	376	8.4	0.1	376	0.8	0.0
2	26	6/21-6/27/95	211	100.7	0.5	211	8.6	0.1	211	0.8	0.0
2	27	6/28-7/04/95	35	99.5	1.3	35	8.3	0.3	35	0.8	0.0
Total			1,592	103.2	0.2	1,592	9.3	0.1	1,592	0.8	0.0
3	20	5/10-5/16/95	14	114.8	1.7	14	12.7	0.6	14	0.8	0.0
3	21	5/17-5/23/95	28	113.8	2.0	28	12.7	0.7	28	0.8	0.0
3	22	5/24-5/30/95	18	116.6	2.3	18	13.6	0.8	18	0.8	0.0
3	23	5/31-6/06/95	25	119.9	1.4	25	14.8	0.5	25	0.9	0.0
3	24	6/07-6/13/95	8	112.1	3.7	8	12.2	1.2	8	0.9	0.0
3	25	6/14-6/20/95	4	109.0	2.5	4	11.1	0.7	4	0.9	0.0
Total			97	115.7	0.9	97	13.3	0.3	97	0.8	0.0

Appendix D.2. Akalura Lake sockeye salmon smolt length, weight, and condition factor of samples collected, by age and week, 1995.

			Length (mm)			Weight (g)			Condition (K)		
Age	Week	Dates	n	Mean	Standard Error	n	Mean	Standard Error	n	Mean	Standard Error
1	19	5/03-5/09/95	3	78.7	5.2	3.0	3.9	1.0	3	0.8	0.1
1	20	5/10-5/16/95	16	85.1	0.9	16	5.0	0.2	16	0.8	0.0
1	21	5/17-5/23/95	26	85.8	0.9	26	5.2	0.2	26	0.8	0.0
1	22	5/24-5/30/95	37	87.5	0.8	37	5.8	0.2	37	0.9	0.0
1	23	5/31-6/06/95	78	83.8	0.9	78	5.3	0.2	78	0.9	0.0
1	24	6/07-6/13/95	239	81.8	0.3	239	4.8	0.1	239	0.9	0.0
1	25	6/14-6/20/95	170	80.1	0.3	170	4.5	0.1	170	0.9	0.0
1	26	6/21-6/27/95	75	77.9	0.5	75	4.2	0.1	75	0.9	0.0
Total			644	81.7	0.2	644	4.8	0.0	644	0.9	0.0
2	19	5/03-5/09/95	138	91.8	0.4	138	6.4	0.1	138	0.8	0.0
2	20	5/10-5/16/95	399	90.8	0.2	399	6.1	0.0	399	0.8	0.0
2	21	5/17-5/23/95	248	91.6	0.3	248	6.4	0.1	248	0.8	0.0
2	22	5/24-5/30/95	191	92.6	0.3	191	6.9	0.1	191	0.9	0.0
2	23	5/31-6/06/95	202	94.8	0.3	202	7.5	0.1	202	0.9	0.0
2	24	6/07-6/13/95	38	93.6	0.9	38	7.1	0.2	38	0.9	0.0
Total			1216	92.1	0.1	1216	6.6	0.0	1216	0.8	0.0
3	19	5/03-5/09/95	2	101.5	2.5	2	8.1	0.7	2	0.8	0.0
3	20	5/10-5/16/95	4	97.8	3.3	4	7.4	0.8	4	0.8	0.0
Total			6	99.0	2.3	6	7.7	0.6	6	0.8	0.0

Appendix D.3. Frazer Lake sockeye salmon smolt length, weight, and condition factor of samples collected, by age and week, 1995.

			Length (mm)			Weight (g)			Condition (K)		
Age	Week	Dates	n	Mean	Standard Error	n	Mean	Standard Error	n	Mean	Standard Error
1	21	5/17-5/23/95	1	93		1	5.1		1	0.64	
1	22	5/24-5/30/95	2	91	1	2	4.9	0.1	2	0.66	0.04
1	23	5/31-6/06/95	4	87	3	4	4.6	0.5	4	0.69	0.02
1	24	6/07-6/13/95	6	73.8	3.1	6	3	0.4	6	0.71	0.03
1	25	6/14-6/20/95	6	88.8	7.9	6	6.1	2	6	0.76	0.03
1	26	6/21-6/27/95	20	89.1	2.6	20	6	0.7	20	0.79	0.02
Total			39	86.7	2	39	5.3	0.5	39	0.75	0.02
2	20	5/10-5/16/95	343	93.1	0.2	343	5.9	0	343	0.74	0.01
2	21	5/17-5/23/95	347	91.8	0.2	347	5.6	0	347	0.73	0.01
2	22	5/24-5/30/95	346	90.5	0.1	346	5.3	0	346	0.72	0.01
2	23	5/31-6/06/95	334	90.7	0.2	334	5.4	0	334	0.73	0.01
2	24	6/07-6/13/95	340	89.5	0.2	340	5.3	0.1	340	0.74	0.01
2	25	6/14-6/20/95	267	91.2	0.4	267	6	0.1	267	0.77	0.01
2	26	6/21-6/27/95	177	91.5	0.7	177	6.2	0.2	177	0.77	0.01
Total			2,154	91.2	0.1	2,154	5.6	0	2,154	0.74	0.01
3	20	5/10-5/16/95	6	101.8	4.2	6	8.1	0.9	6	0.76	0.03
3	21	5/17-5/23/95	1	86		1	4.9		1	0.78	
3	22	5/24-5/30/95	1	133		1	16.8		1	0.72	
3	23	5/31-6/06/95	5	129	5.2	5	17.6	1.8	5	0.82	0.02
3	24	6/07-6/13/95	2	138	5	2	23.4	3.7	2	0.89	0.05
3	25	6/14-6/20/95	4	97.8	7.3	4	7.9	1.9	4	0.8	0.03
3	26	6/21-6/27/95	1	162		1	35.2		1	0.83	
Total			20	115.2	5	20	13.6	1.9	20	0.8	0.02

Appendix E.1. Number of young-of-year (YOY) sockeye salmon captured by beach seining of standard littoral areas, Red Lake, 1992 - 1995.

	1992					1993					1994					1995				
	Site No.					Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
5/8	0	0	0	0	0															
5/9											2	0	0	4	6					
5/10																				
5/11																				
5/12																				
5/13						39	3	215	0	257										
5/14																15	4	0	83	102
5/15	0	0	0	0	0															
5/16											10	5	23	2	40					
5/17																				
5/18																				
5/19																				
5/20						10	26	1	58	95										
5/21	2	47	1	0	50															
5/22																83	0	313	16	412
5/23											250	16	6	0	272					
5/24																				
5/25																				
5/26																				
5/27						21	0	15	27	63										
5/28																				
5/29																11	0	8	1	20
5/30	16	1	0	26	43						252	2	1	56	311					
5/31						171	1	4	8	184										
6/1																				
6/2																				
6/3																				
6/4																				
6/5	2	0	0	15	17											0	0	14	2	16
6/6											116	2	5	3	126					
6/7																				
6/8						93	3	2	3	101										
6/9																				
6/10																				
6/11																16	1	2	1	20
6/12																				
6/13	23	2	0	3	28						241	1	1	7	250					
6/14						44	7	10	16	77										
6/15																				
6/16																				

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Appendix E.1. (page 2 of 2)

Date	1992 Site No. 1	2	3	4	Total	1993 Site No. 1	2	3	4	Total	1994 Site No. 1	2	3	4	Total	1995 Site No. 1	2	3	4	Total
6/17																				
6/18																12	0	4	1	17
6/19	53	20	0	6	79															
6/20											43	20	0	7	70					
6/21						4	8	5	1	18										
6/22																				
6/23																				
6/24																				
6/25																17	0	3	8	28
6/26																				
6/27	39	8	5	14	66						21	18	2	3	44					
6/28																				
6/29																				
6/30						52	21	18	1	92										
7/1																				
7/2																				
7/3																				
7/4	106	6	1	5	118															
7/5																				
7/6																				
7/7																				
7/8																				
7/9																				
7/10	73	2	20	8	103															
7/11																				
7/12																				
7/13																				
7/14																				
7/15																				
7/16																				
7/17	27	2	8	14	51															
7/18																				
7/19																				
7/20																				
7/21																				
7/22																				
7/23																				
7/24	24	4	31	a	59															

[a] Did not sample due to beach spawning sockeye.

Appendix E.2. Number of stickleback captured by beach seining of standard littoral areas, Red Lake, 1992 - 1995.

	1992					1993					1994					1995				
	Site No.					Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
5/8	0	0	0	78	78															
5/9											1	1		1	3					
5/10																				
5/11																				
5/12																				
5/13						174	20	86	10	290										
5/14																16	31	18	54	119
5/15	1	2	0	0	3															
5/16											5	12			17					
5/17																				
5/18																				
5/19																				
5/20						1916	139	1172	2600	5827										
5/21	1078	408	26	279	1791															
5/22																29	5	46	8	88
5/23											214	26	7		247					
5/24																				
5/25																				
5/26																				
5/27						1840	0	617	443	2900										
5/28																				
5/29																7	9	557	59	632
5/30	1091	9	0	502	1602						157	16	8	588	769					
5/31						5535	608	59	415	6617										
6/1																				
6/2																				
6/3																				
6/4																				
6/5	357	34	1	744	1136											1	27	949	750	1727
6/6											78	88	17	520	703					
6/7																				
6/8						736	882	147	513	2278										
6/9																				
6/10																				
6/11																614	39	1861	257	2771
6/12																				
6/13	685	124	0	58	867						679	71	36	24	810					
6/14						876	661	156	171	1864										
6/15																				
6/16																				
6/17																				
6/18																5	52	155	99	311

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Appendix E.2. (page 2 of 2)

	1992					1993					1994					1995				
	Site No.					Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
6/19	1685	805	0	24	2514															
6/20											154	1126	11	9	1300					
6/21						10000[a]	424	126	49	10599										
6/22																				
6/23																				
6/24																				
6/25																25	26	1222	72	1345
6/26																				
6/27	68	178	2	56	304						152	188	95	9	444					
6/28																				
6/29																				
6/30						7396	38	54	49	7537										
7/1																				
7/2																				
7/3																				
7/4	785	192	1	56	1034															
7/5																				
7/6																				
7/7																				
7/8																				
7/9																				
7/10	432	250	1	83	766															
7/11																				
7/12																				
7/13																				
7/14																				
7/15																				
7/16																				
7/17	894	121	768	95	1878															
7/18																				
7/19																				
7/20																				
7/21																				
7/22																				
7/23																				
7/24	553	501	1025[a]	b	2079															

[a] Estimated due to heavy algae.

[b] Did not sample due to beach spawning sockeye.

Appendix E.3. Average lengths of young-of-year (YOY) sockeye salmon captured by beach seining of standard littoral areas, Red Lake, 1992 - 1995.

	1992					1993					1994					1995				
	Site No.					Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
5/8																				
5/9											31			32	31					
5/10																				
5/11																				
5/12																				
5/13						32	33	31		32										
5/14																32	37		32	32
5/15																				
5/16											34	31	33	32	32					
5/17																				
5/18																				
5/19																				
5/20						30	32	31	34	33										
5/21	33	35	35		35															
5/22																33		33	32	33
5/23											33	32	33		33					
5/24																				
5/25																				
5/26																				
5/27						34		32	35	34										
5/28																				
5/29																34		33	33	34
5/30	35	30		35	35						33	34	33	33	33					
5/31						35		36	36	35										
6/1																				
6/2																				
6/3																				
6/4																				
6/5	32			33	33													36	37	36
6/6											34	34	34	34	34					
6/7																				
6/8						36	36	34	36	36										
6/9																				
6/10																				
6/11																39	29	41	37	39
6/12																				
6/13	34	37		36	34						34	34	32	34	33					
6/14						35	38	35	35	35										
6/15																				
6/16																				

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	1992					1993					1994					1995				
	Site No.					Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
6/17																				
6/18																36		31	36	35
6/19	34	40		34	36															
6/20											34	40		34	36					
6/21						36	39	35	32	37										
6/22																				
6/23																				
6/24																				
6/25																37		35	41	38
6/26																				
6/27	34	39	32	34	35						40	37	39	46	40					
6/28																				
6/29																				
6/30						38	41	33	36	37										
7/1																				
7/2																				
7/3																				
7/4	36	38	30	34	36															
7/5																				
7/6																				
7/7																				
7/8																				
7/9																				
7/10	34	36	32	37	34															
7/11																				
7/12																				
7/13																				
7/14																				
7/15																				
7/16																				
7/17	31	42	36	38	34															
7/18																				
7/19																				
7/20																				
7/21																				
7/22																				
7/23																				
7/24	40	48	39		40															

Appendix F.1. Tow net survey catches from Red Lake, 1990 - 1994.

	Tow		Catch by Species					
			Sockeye			Stickleback		
Year	No.	Min.	No.	%	CPUE	No.	%	CPUE
1990	1	30	7	1.9	0.2	370	98.1	12.3
	2	30	3	0.5	0.1	569	99.5	19.0
	3	30	10	1.9	0.3	513	98.1	17.1
Total		90	20	1.4	0.2	1452	98.6	16.1
1991	1	30	56	10.9	1.9	457	89.1	15.2
	2	30	22	3.6	0.7	593	96.4	19.8
	3	30	13	5.4	0.4	227	94.6	7.6
Total		90	91	6.7	1.0	1277	93.3	14.2
1992	1	30	10	3.2	0.3	304	96.8	10.1
	2	32	30	3.0	0.9	968	97.0	30.3
	3	30	22	1.1	0.7	1918	98.9	63.9
Total		92	62	1.9	0.7	3190	98.1	34.7
1993	1	20	21	17.5	1.1	99	82.5	5.0
	2	21	7	9.2	0.3	69	90.8	3.3
	3	21	13	4.8	0.6	257	95.2	12.2
Total		62	41	8.8	0.7	425	91.2	6.9
1994	1	20	32	6.5	1.6	462	93.5	23.1
	2	20	31	3.5	1.6	859	96.5	43.0
	3	20	23	3.8	1.2	588	96.2	29.4
Total		60	86	4.3	1.4	1909	95.7	31.8

Appendix F.2. Tow net survey catches from Akalura Lake, 1990, 1991, and 1995.

	Tow		Catch by Species					
			Sockeye			Stickleback		
Year	No.	Min.	No.	%	CPUE	No.	%	CPUE
1990	1	30	114	4.3	3.8	2545	95.7	84.8
	2	20	57	6.1	2.85	874	93.9	43.7
	3	20	66	7.3	3.3	833	92.7	41.7
Total		70	237	5.3	3.4	4252	94.7	60.7
1991	1	25	74	3.9	3.0	1807	96.1	72.3
	2	20	24	1.6	1.2	1466	98.4	73.3
	3	25	49	0.6	2.0	7492	99.4	299.7
Total		70	147	1.3	2.1	10765	98.7	153.8
1995	1	10	14	7.2	1.4	180	92.8	18.0
	2	10	29	29.9	2.9	68	70.1	6.8
	3	10	9	3.6	0.9	242	96.4	24.2
	4	10	34	25.4	3.4	100	74.6	10.0
Total		40	86	12.7	2.2	590	87.3	14.8

Appendix F.3. Tow net survey catches from Frazer Lake, 1990 - 1995.

	Tow		Catch by Species					
			Sockeye			Stickleback		
Year	No.	Min.	No.	%	CPUE	No.	%	CPUE
1990	1	20	0	0.0	0	15	100.0	0.8
	2	20[a]						
	3	20	46	93.9	2.3	3	6.1	0.2
	4	20	60	81.1	3	14	18.9	0.7
Total		60	106	76.8	1.8	32	23.2	0.5
1991	1	20	117	79.6	5.9	30	20.4	1.5
	2	20	9	64.3	0.5	5	35.7	0.3
	3	20	48	68.6	2.4	22	31.4	1.1
Total		60	174	75.3	2.9	57	24.7	1.0
1992	1	30	123	49.6	4.1	125	50.4	4.2
	2	30	163	16.6	5.4	820	83.4	27.3
	3	30	42	7.1	1.4	551	92.9	18.4
Total		90	328	18.0	3.6	1496	82.0	16.6
1993	1	20	3	2.8	0.2	106	97.2	5.3
	2	20	12	10.3	0.6	104	89.7	5.2
	3	20	1	3.4	0.1	28	96.6	1.4
Total		60	16	6.3	0.3	238	93.7	4.0
1994	1	20	1	0.2	0.1	506	99.8	25.3
	2[b]	20	0		0.0	0		0.0
	3	20	1	12.5	0.1	7	87.5	0.4
Total		60	2	0.4	0.0	513	99.6	8.6
1995	1	15	0	0.0	0.0	2	100.0	0.1
	2	15	0	0.0	0.0	10	100.0	0.7
	3	15	1	0.5	0.1	218	99.5	14.5
	4	15	1	25.0	0.1	3	75.0	0.2
Total		60	2	0.9	0.0	233	99.1	3.9

[a] Townet survey for this transect not conducted due to severe weather.

[b] Results from this tow are suspect, however owing to severe weather a replicate tow was not conducted.

Appendix G.1. Daily climatological observations, water temperature, and water depth monitored at Red Lake field station, 1995.

Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
5/5	1800	10	7	100	ENE	15-20	16	
5/6	1800	12	7	100	ENE	20-25	16	Intermittant rain
5/7	1800	13	6	85-90	NNE	~5	16	Occassional lite rain
5/8	1800	12	8	75	NNE	10-May	16	Occassional sunshine
5/9	1800	13	9	100	ENE	10-May	16	Occassional light rain
5/10	1800	20	9	25	E	10-May	16	Wind 15-25 this afternoon; lower this evening
5/11	1800	21	10	50	NE	5	16	Beautiful day!
5/12	1800	10	8	100	E	15-20	15	Occassional sunshine; 3-4,000' ceiling; vis. 5-10
5/13	1820	8	8	100	ENE	<5	15	1500 solid; visib. 3 miles
5/14	2000	8	8	100	W	5	15	2-3000 solid; vis. 3-5; occassional lt. rain; beach seine
5/15	1615	8	8	100	SW	~5	15	3000' solid; vis. 5-10; occassional hvy rain
5/16	1600	6	7	100	SW	5	15	3000' solid; patchy fog; vis 2-5 miles, occassional rain
5/17	1600	8	9	90	WSW	~5	15	Occassional rain showers; 2-3000 slightly broken; vis 3-5
5/18	1600	15	9	100	NE	5	15	5000+ thin overcast; vis. unlimited; nice day
5/19	1600	22	11	60	ENE	20-25+	15	3-4000 slightly broken; vis. 5-10; occassional lt rain
5/20	1600	12	9	95	ENE	20-25+	15	3-4000 solid; vis 5-10; winds aloft high
5/21	1600	16	9	90	E	10-May	14	3000 partially broken; vis 10+; occassional rain
5/22	1915	10	8	100	ENE	10-May	14	3000 solid; vis 5-10 miles; occ. hvy rain
5/23	1830	14	10	80	E	15-Oct	14	3-4000 broken; vis 10+; occ. drizzle
5/24	1800	13	10	50	SW	15-Oct	14	3000 broken; vis unlimited
5/25	1800	6	8	100	SW	15-Oct	14	1000' solid; vis 2-3 miles; rain-drizzle-fog
5/26	1800	8	8	100	NE	15-20	14	2000' solid; vis 5-10; occ. lt. rain
5/27	1800	12	8	100	NNE	15-20	15	2-3000 solid; vis 5-10; occ lt. rain
5/28	1800	8	7	100	NE	5	14	2000 solid; vis 5 miles; hvy rain
5/29	1830	10	8	100	NE	10-May	14	2-3000 solid; vis 5-10; occ. lt rain
5/30	1800	7	8	100	S	~5	14	2000 solid; vis 3-5; occ. rain
5/31	1800	10	8	100	SW	10-May	15	2000 solid; vis 3-5; occ rain
6/1	1800	5	8	100	SSW	5	15	1000 solid; vis 3-5; hvy rain
6/2	1800	12	9	60	SW	10-May	14	2-3000 broken; vis 5-10; occ hvy rain
6/3	1800	11	10	100	NE	20-25	14	3-4000; vis 5-10; cold!

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Appendix G.1. (page 2 of 2)

Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
6/4	1900	15	9	35	NE	20-25	15	3000 broken; vis 10+
6/5	1800	12	9	75	E	0-5	15	3000 broken; vis 10+; occ. rain
6/6	1800	11	9	100	variable	~5	14	2-3000 solid; occ. lt rain; vis 5-10
6/7	1800	9	8	100	W	10-May	14	2000 solid; lt. rain; vis 3-5
6/8	1830	9	9	100	W	10-May	14	1-2000 solid; vis 3-5; lt rain
6/9	1800	25	13	5	N	10-May	14	4-5 scattered; vis unlimited; lt night rain
6/10	1830	23	12	15	N	5	13	3-4000 scattered; vis unlimited; lt night rain
6/11	1930	29	in sun12	0	SSW	15-Oct	14	Lt haze; vis unlimited; lt early am rain; beach seine day
6/12	1800	30	in sun13	1	SSW	~5	13	Scattered clouds; lt haze; vis unlimited; no rain for ~36 hours
6/13	1830	18	12	40	SSE	15	13	3-4 scattered; fog patches; vis ~5
6/14	1800	15	12	100	NE	15-Oct	13	2000; fog patches; vis 5-10
6/15	1800	10	11	100	SW	10-May	13	1-2000; visib 2-3; fog; lt rain
6/16	1845	22	13	50	SW	15-Oct	13	4-5000 broken; visibility unlim.
6/17	1800	16	12	40	SW	15-Oct	13	3-4 broken; visib unlimited
6/18	1900	11	10	100	Variable	<5	13	2000 solid; fog patches; vis ~5 miles; occ. rain; beach seine
6/19	1800	11	11	100	SW	<5	13	2-3000 solid; vis. ~10
6/20	1800	11	11	100	SW	<5	13	1000 solid; fog patches; occ. hvy rain; vis. 2-5 miles
6/21	1800	19	14	60	SW	10-May	13	3-4 broken; visib 10+; occ. rain showers
6/22	1800	16	13	95	NNE	15-Oct	12	3-5000 slightly broken; visib 10+; occ rain showers
6/23	1740	16	12	100	W	<5	12	3000 solid; vis unlim.; occ. rain
6/24	1800	24	15	25	SW	10-May	12	3-4000 broken; visib. unlimited
6/25	1900	11	11	100	SSW	10-May	12	2-3000 solid; visib. 10-15
6/26	1800	21	15	50	SE	15-Oct	12	3-4000 broken; hazy sunshine; visib. 10-15
6/27	1800	29	16	60	SSE	15-Oct	12	3-4000 broken; visib. 10-15 miles
6/28	1730	19	16	90	SW	5	12	3-5000 broken; hazy; visibility 10-15
6/29	1900	15	14	100	calm	calm	12	500-2000 solid; patchy fog; visibility 2-5 miles
6/30	1800	15	14	100	Variable	<5	13	Occ lt rain/drizzle; 0-500 solid; visib 1-3 miles

Appendix G.2. Daily climatological observations, water temperature, and water depth monitored at Akalura field station, 1995.

Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
5/4	1800	7	7	90	S	15	45	Periods of rain/sleet; winds SE 25 by morning
5/5	1800	5	6	100	SE	25	48	Rain, winds >35 MPH most of afternoon; H20 velocity 1.5 m/sec.
5/6	1800	7	7	100	SE	25	53	Rain. By am rain stopped and winds SE<10; at 2400 H2O vel.=2m/sec.
5/7	1800	9	7	90	SE	10	55	Periods of rain. H20 velocity=1.5 m/sec. by 2200
5/8	1800	9	8	100	SE	25	55	Periods of drizzle; stream gauge=53 cm by 0200; calm winds by 0100
5/9	1800	10	8	100	E	5	53	Periods of rain; winds calm by evening; H2O vel.= 1 m/sec.
5/10	1800	9	8	60	E	10	53	Ceiling 3500' broken; clear by evening
5/11	1730	15	10	75	SE	10	53	Ceiling 3500' broken; partly sunny
5/12	1800	9	8	100	SE	20	53	Periods of drizzle
5/13	1830	11	8	95	SW	10	53	Ceiling 500'; winds calm by 0100
5/14	1800	7	7	100	SE	10	50	Periods of rain; winds SE 25 by nightfall
5/15	1800	6	8	100	NE	<5	50	Winds close to calm
5/16	1800	11	8	100	NE	5	50	Periods of rain; ceiling 500' solid
5/17	1800	10	9	50	SE	10	50	Partly sunny; periods of showers
5/18	1800	11	10	50	SW	15	50	Partly sunny
5/19	1745	11	10	75	SE	30	50	Rain by evening
5/20	1800	11	10	100	SE	15	50	Rain by evening
5/21	1800	10	10	90	SE	15	50	
5/22	1800	10	10	100	SE	20	50	Heavy rain by 0200 and winds SE 30
5/23	1800	10	9	100	SE	15	50	Clear by evening and sunny; wind SW 5 by evening
5/24	1800	11	10	20	SW	10	48	Sunny; CAVU
5/25	1800	9	10	100	SW	10	48	00 RDF
5/26	1800	9	10	100	SW	5	47	
5/27	1800	10	10	100	NW	10	47	
5/28	1800	9	10	100	N	5	52	
5/29	1800	9	9	100	SE	10	52	
5/30	1800	12	10	100	N	5	50	

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Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
5/31	1800	10	10	95	S	10	49	
6/1	1800	11	11	100	S	10	49	
6/2	1800	12	11	50	S	15	48	Nice; no precip.
6/3	1800	10	10	100	N	25	48	Rain
6/4	1800	15	12	100	N	20	46	Int. rain
6/5	1800	14	11	90	SW	10	45	
6/6	1800	14	12	100	S	30	45	Int. rain
6/7	1800	10	10	100	SE	15	45	
6/8	1800	12	11	100	S	15	45	
6/9	1800	18	14	30	SE	15	44	Sunny
6/10	1800	21	15	30	S	10	43	Nice day
6/11	1800	21	17	0	SW	10	43	Sunny and warm
6/12	1800	23	17	0	SW	15	42	Sunny and warm day
6/13	1800	17	14	100	SW	20	41	
6/14	1800	12	13	100	S	25	41	Light rain
6/15	1800	11	12	100	S	5	41	Rain
6/16	1800	17	15	40	N	15	41	Sunny
6/17	1800	17	16	30	SW	20	41	Warm, sunny
6/18	1800	9	12	100	N	30	40	Fog 0/0
6/19	1800	14	12	100	SW	20	40	Cool
6/20	1800	15	12	100	S	5	40	Cool, overcast
6/21	1800	17	14	70	SE	10	40	Mild
6/22	1800	19	14	80	N	15	40	Warm
6/23	1800	17	14	100	S	5	40	RDF
6/24	1800	19	16	30	SW	20	40	Warm, windy
6/25	1800	19	16	100	SW	15	39	Sunny, hot early in day
6/26	1800	15	15	90	SE	25	37	Windy

Appendix G.3. Daily climatological observations, water temperature, and water depth monitored at Frazer Lake field station, 1995.

Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
5/11	1800	12	5	50	E	5	42	Partly cloudy; water appeared approximately three cm higher at the start of this year than in 1994.
5/12	1800	10	5	100	SE	25	42	Cloudy
5/13	1800	7	5	100	NW	5	42	Cloudy
5/14	1800	6	5	100	E	20	42	Showers
5/15	1800	5	5	100	W	5	43	Cloudy
5/16	1800	7	5	100	E	5	43	Cloudy
5/17	1800	8	7	70	E	5	43	Partly cloudy
5/18	1800	8	6	100	E	20	42	Cloudy and windy
5/19	1800	8	6	100	E	35	41	Cloudy and very windy
5/20	1800	7	6	100	SE	20	41	Cloudy and very windy
5/21	1800	8	6	100	E	10	41	Cloudy
5/22	1800	8	6	100	E	10	43	Cloudy
5/23	1800	9	6	50	SE	25	42	Partly cloudy and windy
5/24	1800	11	7	10	NW	10	43	Mostly sunny
5/25	1800	6	6	100	N	10	43	Rain, drizzle, fog
5/26	1800	6	6	100	E	10	42	Cloudy
5/27	1800	10	6	95	NW	5	42	Cloudy
5/28	1800	9	6	100	NW	5	41	Rain showers, cloudy
5/29	1800	6	6	100	SE	5	41	Cloudy
5/30	1800	5	6	100	SE	5	41	Rain, drizzle, fog
5/31	1800	7	6	90	E	10	41	Mostly cloudy
6/1	1800	7	6	95	SE	15	40	Mostly cloudy
6/2	1800	8	6	20	SE	20	39	Partly cloudy
6/3	1800	8	6	100	NW	25	39	High solid clouds
6/4	1800	10	7	90	NW	15	39	Mostly cloudy--rain showers
6/5	1800	10	7	60	SE	15	37	Partly cloudy

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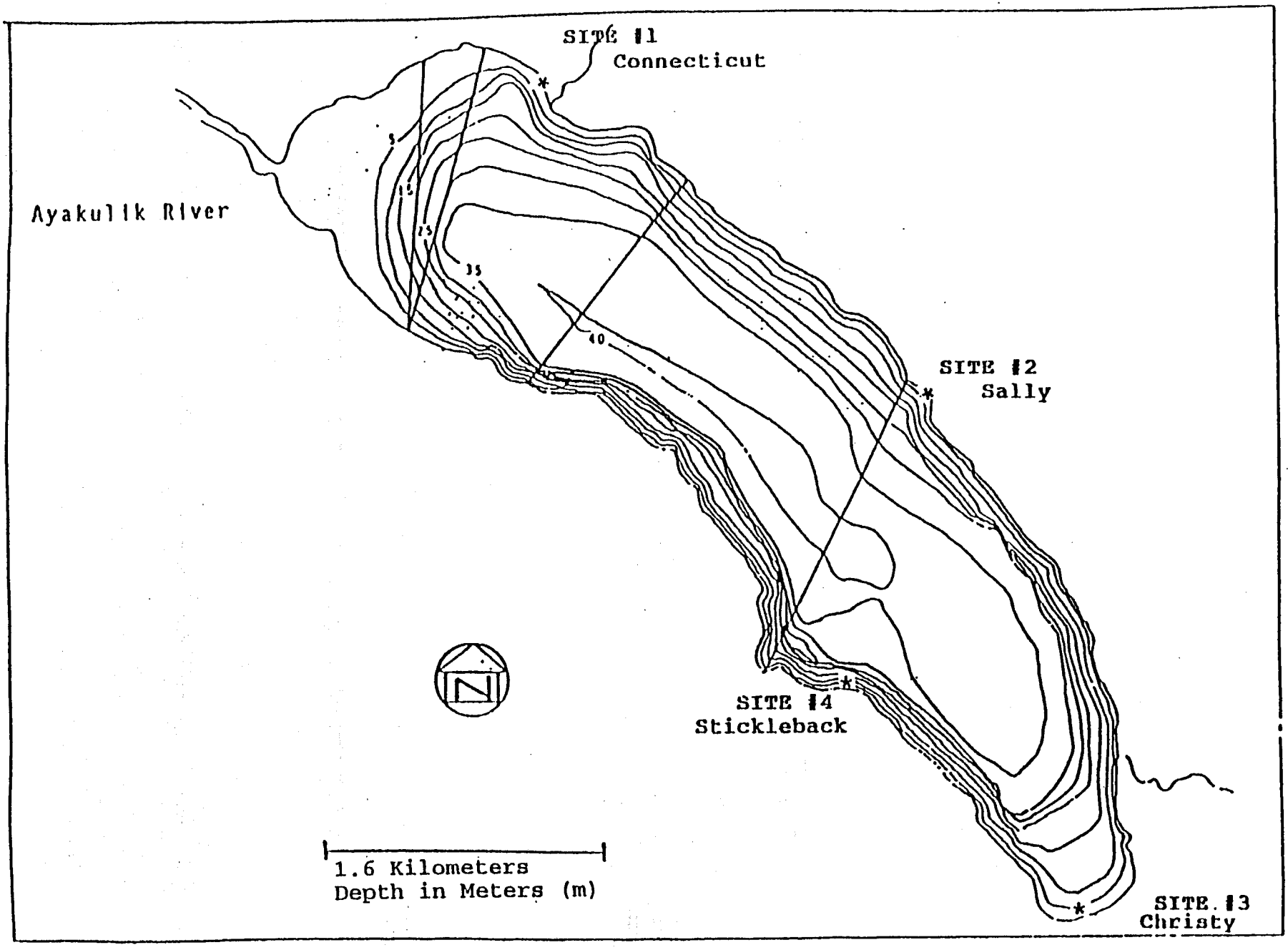
Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
6/6	1800	12	7	100	SE	15	36	Solid cloud cover
6/7	1800	10	7	100	SE	15	36	High solid clouds
6/8	1800	9	7	100	SE	15	36	High solid clouds
6/9	1800	15	8	15	NW	10	36	Mostly sunny
6/10	1800	16	9	65	SE	10	35	Sunny
6/11	1800	22	11	0	W	20	35	Clear and hot
6/12	1800	22	12	0	W	20	35	Clear, warm
6/13	1800	11	9	45	SE	15	34	Partly cloudy
6/14	1800	10	8	100	SE	25	34	Solid clouds at 3000'
6/15	1800	10	7	100	SE	5	34	Light rain
6/16	1800	14	9	40	W	20	33	Partly cloudy
6/17	1800	10	10	15	W	15	33	Mostly clear
6/18	1800	10	9	100	SE	10	33	Cloudy, light rain
6/19	1800	12	8	99	NE	20	33	Cloudy
6/20	1800	10	8	100	S	5	31	Cloudy
6/21	1800	14	9	95	NW	10	31	Cloudy
6/22	1800	12	9	100	NW	20	30	Cloudy
6/23	1800	11	10	100	SE	5	29	Light rain
6/24	1800	12	10	100	calm	0	28	Cloudy
6/25	1800	11	11	100	NW	15	27	Cloudy
6/26	1800	14	10	75	SE	15	26	High overcast--broken
6/27	1800	14	9	65	NE	20	25	Mostly cloudy
6/28	1800	15	9	100	SE	10	25	Cloudy



Appendix H.1. Map of Red Lake with littoral zone seine sites identified.

Appendix I.1. Preliminary forecast of the Ayakulik River (Red River), sockeye salmon run, 1996.

FORECAST AREA:Kodiak, Ayakulik River (Red River)

SPECIES: Sockeye Salmon

PRELIMINARY FORECAST OF THE 1996 RUN:

	Forecast Estimate (thousands)	Forecast Range (thousands)
Total Production:		
Total Run Estimate	722	210-1,358
Escapement Goal		200-300
Harvest Estimate	422	

FORECAST METHODS:

The Ayakulik (Red River) 1996 forecast was derived using simple linear regression models employing recent year (1980-1991) sibling relationships and smolt to adult survival indices from data collected since 1991. Selection of prediction models using sibling data encompassed analysis of outlier data points, residuals, and using dependent variable transformations (log and square root). Model selection for an age class estimate was based upon identifying that model having a reasonable biological interpretation coupled possessing low error and a high r^2 value. Subsequently, each sibling model estimate was compared to an estimate based upon smolt data. The forecast range was derived by combining the 80% prediction intervals for each individual age class estimate. The age 1.2 estimate was derived from the age 1.1 sibling relationship, age 1.3 and age 2.2 from age 2.1 returns, and age 2.3 from age 2.2 siblings. Other minor age classes (ages -1.1 and - 2.1 fish) were not estimated.

FORECAST DISCUSSION:

The 1996 run forecast is about 400,000 fish greater than that forecast for 1995 and about 100,000 fish less than the estimated 1995 actual run of approximately 820,000 sockeye salmon. The forecast range of 210,000 to 1,358,000 for 1996 indicates the level of confidence we place in this forecast which is poor. There is substantial disparity between numerical estimates provided from the sibling and smolt data relationships. The smolt data suggest that the lower end of the forecast range 200-350,000 is correct. The 1996 run regardless of size should be composed of 55% 5 year old fish , 20% 4 year old fish, with the balance being 6 year old fish.

The projected harvest of 422,000 fish is based upon achievement of the 300,000 fish escapement goal. Age 2.2 fish are projected to make up 36% of the run followed by age 2.3 fish at 25%, age-1.2 fish at 20%, and age 1.3 fish at 19%.

Use of only recent years data (1980-1991) is based upon the observed increased production trends (return per spawner indices) from this and other systems compared data from 1960-1979. Run reconstruction for this stock is suspected in recent years of having substantial catch assignment error thereby confounding forecasting future runs. Error in the 1995 forecast for this stock was approximately 38% and can be largely attributed to stronger than predicted age -2.2 and -2.3 returns.

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Regional Research	Fishery Biologist	Fishery Biologist	Regional Biometrician

Appendix I.2. Preliminary forecast of the Frazer Lake sockeye salmon run, 1996.

FORECAST AREA:Kodiak, Frazer Lake **DRAFT 12/21/95**

SPECIES: Sockeye Salmon

PRELIMINARY FORECAST OF THE 1996 RUN:

	Forecast Estimate (thousands)	Forecast Range (thousands)
Total Production:		
Total Run Estimate	1,480	764-2,100
Escapement Goal		140-200
Harvest Estimate	1,280	

FORECAST METHODS:

The Frazer Lake 1996 run forecast was derived using simple linear regression models employing recent year (1980-1991) sibling relationships and smolt to adult survival data (1990-1995). Selection of prediction models encompassed analysis of outlier data points, residuals, and using dependent variable transformations (log and square root). Model selection for an age class estimate was based upon identifying that model having a reasonable biological interpretation coupled with possessing low error and a high r^2 value.The forecast range was derived by combining the 80% prediction intervals for each individual age class estimate. The age 1.2 estimate was derived from the age 1.1 sibling relationship, age 1.3 and age 2.2 from age 2.1 returns, and the age 2.3 estimate from age 2.2 returns. Both age 3.2 and 3.3 estimates were derived from smolt to adult survival relationships that are tenuous. Estimates for the dominant age classes (ages-1.2,-1.3,-2.2,-2.3) were compared to estimates derived solely from existing smolt to adult survival indices and found to be similar in magnitude.

FORECAST DISCUSSION:

The 1996 run should be about 250,000-600,000 fish larger than the 1995 Frazer Lake run of 952,000 and should be composed of 75% two-ocean age fish with the balance being three-ocean age.

The 1996 run forecast is for the Alitak Bay District only ; we assume that fishing time and effort within Kodiak's westside commercial fisheries will be about the same as what occurred during 1995. If this assumption holds than a commercial harvest of greater than one million sockeye salmon will occur. Run timing of this stock is usually from mid-June to mid-July with the peak of the run typically occurring in late June.

Use of only recent years data (1980-1991) is based upon the observed increased production trends (return per spawner indices) from this and other systems data compared with 1960-1979. For the period selected, run reconstruction programs have been instituted and catch apportionment to system of origin has improved markedly. Confidence in this forecast is fair, owing to the overall forecast being comprised of 68% (1-million) age 2.2 fish and the lack of data for forecasting age 3.2 and 3.3 sockeye salmon for this system.

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Regional Research	Fishery Biologist	Fishery Biologist	Regional Biometrician

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