POPULATION ESTIMATES AND BIOLOGICAL ATTRIBUTES OF THE CHIGNIK LAKES SOCKEYE SALMON SMOLT OUTMIGRATION, 1997

By

David F. Kaplan

and

Charles O. Swanton

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AUTHORS

David F. Kaplan is a Region IV Salmon Research Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 211 Mission Road, Kodiak, AK 99615.

Charles O. Swanton is the Region IV Regional Finfish Research Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 211 Mission Road, Kodiak, AK 99615.

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EXECUTIVE SUMMARY

This was the fourth successive year that sockeye salmon smolt studies have been conducted by the Alaska Department of Fish and Game under contract with the Chignik Regional Aquaculture Association (CRAA; Stopha and Barrett 1994; Vania and Swanton 1996; Kaplan and Swanton 1997). The intention of this research is to annually estimate the numbers of sockeye salmon smolts emigrating from Chignik Lakes by age class. The long term objective is to improve the understanding of Chignik Lakes sockeye salmon lacustrine production parameters; increase understanding of density dependent rearing fry interactions; and to determine whether competition between stock specific fry productivity is occurring in Chignik Lake. This report summarizes data collected during the 1997 field season.

A total of 264,678 sockeye smolts were captured in two rotary-screw traps operated on the Chignik River from 3 May through 30 June. Overall trap catch efficiency was 1.1%, and the total sockeye smolt outmigration estimate was 25.6 million fish (95% CI 19.8 to 31.4 million). The peak of the outmigration occurred on 21 May. The age classes that made up the migration were age-0. (2.1%), age-1. (43.7%), and age-2. smolts (53.7%), with the balance being 0.5%, fish having spent three winters in freshwater. Delayed mortality of marked smolts was estimated to be ~1% but needs to be substantiated with additional data collection and analyses, and if correct will have negligible affects upon the total smolt population estimates. Previously, preliminary adult run estimates have been generated from sockeye smolt numbers documented during 1994-96. We feel that these estimates, owing to limited supporting information of smolt to adult survival rates specific to Chignik Lakes stocks, should be viewed as indices. The 1997-98 age-1.3 and age-2.3 adult returns will provide additional smolt to adult survival estimates with which to evaluate this program.

During 1996 an additional study component was implemented to ascertain if sockeye smolts continued to outmigrate post 30 June. This research continued in 1997 whereas a trap was operated from 1-26 July and captured 13,504 sockeye smolts in the Chignik River below the weir site. These numbers confirm that at least during 1996 and 1997, sockeye smolts continued to emigrate from the Chignik Lakes system post 30 June.

INTRODUCTION

Many of the variables related to the freshwater life history of sockeye salmon within the Chignik Lakes system are not well understood, particularly with regard to the interaction of the Black and Chignik Lakes stocks. Annual growth of sockeye fry varies between lakes, years, and within individual populations (Bumgarner 1993). Evaluation of the freshwater growth of Black and Chignik Lakes fry coupled with length and weight data from smolts should allow us to determine if competition between these two stocks is occurring within Chignik Lake. Smolt size-at-age data will refine our understanding of production and allow us to evaluate/improve preseason forecasts and assist with stock specific escapement goal evaluation. The Chignik Regional Aquaculture Association (CRAA) and Alaska Department of Fish and Game (ADF&G) are committed to evaluating potential habitat enhancement and rehabilitation projects, escapement goals, and management plans. This research includes estimating annual sockeye smolt population numbers, size-at-age, growth characteristics, and temporal structure of the smolt migrations.

The growth of juvenile sockeye salmon within both Chignik and Black Lakes is inversely related to the density of the parent population within each of the two lakes (Burgner et al. 1969). Therefore, knowledge of the number, age class structure, and physical condition of outmigrating sockeye smolt along with over-wintering juveniles could provide insight into improving current forecasting methods. These variables either directly or indirectly account for a portion of the variability of adult returns caused by changes in freshwater nursery conditions.

All juvenile sockeye salmon emigrating from the Chignik River do not go to sea, but may emigrate to the lower Chignik River in the summer and return to Chignik Lake in the fall (Roos 1957, 1959a; Iverson 1966). Previously, upstream and downstream movements of juvenile sockeye salmon have been observed post 30 June in Chignik River. Some of these movements were extensive, and raised questions as to the origins of these fish, and the importance of Chignik River, relative to other parts of the watershed, for sockeye fry rearing (Iverson 1966). The 1996 post 30 June outmigration study component provided an initial benchmark for smolts emigrating from the Chignik Lakes system during July and possibly into late summer.

Since May of 1994, the ADF&G has conducted sockeye salmon smolt emigration studies under contract with CRAA in the Chignik Lakes system (Figure 1). The agreed upon objectives for the 1997 field season were: 1) estimate the total number of outmigrant sockeye smolts by age class from the Chignik and Black Lake stocks; 2) estimate sockeye smolt emigration timing and size characteristics (length, weight, and condition) by age class; 3) conduct replicate experiments on delayed mortality of marked smolts to further refine trap catch efficiency and the accuracy of population estimates; 4) archive the smolt scales for future potential use with scale pattern analysis in determining stock composition of the 1997 outmigration from future returns; 5) Compare the freshwater scale patterns of Chignik Lakes sockeye smolt over time by age class; and 6) evaluate if additional substantive smolt outmigration is occurring post 30 June.

If smolt numbers by age class are accurate we can make three types of inferences: 1) what the health of the freshwater environment for smolt production is in the absence of additional data; 2) what the ocean survival of Black and Chignik Lake sockeye smolts is; and 3) production of smolts specific to brood year escapement and stock.

METHODS

Rotary-screw Traps and Site Description

Emigrating sockeye smolts are captured using two rotary-screw traps operated in tandem on a daily basis within the Chignik River, from about 3 May through 30 June. Each trap is constructed of a stainless-steel, 2 mm-mesh cone mounted on two aluminum pontoons (Figure 2). The cone entrance diameter is 1.5 m on the inshore trap (referred to as small trap), and 2.4 m on the offshore trap (referenced as the large trap), with one-half of each cone area submerged (small trap=0.9 m^2, large trap 1.1 m^2). The current propels an internal screw which rotates the cone at approximately 3-8 rpm during average flow conditions. Fish are funneled through the cone into a live box on the downstream end of the trap. The small trap live box measures 0.7 m^3 and the large trap 0.6 m^3. The large trap livebox was fitted with a rotating perforated stainless-steel drum for floating and partially submerged debris removal. To prevent mammalian and avian predation, vexar plastic cloth was secured over openings in each of the traps live boxes and was modified as needed.

Initially, traps were tied together and a plank was lashed across the top of the pontoons, perpendicular to the current extending to shore. This served as a fulcrum to maintain and adjust the trap position, but was replaced by a modified aluminum pipe apparatus during 1997; each trap was additionally secured to the riparian vegetation with polypropylene line above river flood stage height upstream.

The traps were operated in a constricted section of the Chignik River directly downstream of a location referred to locally as the "King Hole". This site is 8.6 km upstream from Chignik Lagoon and 1.9 km downstream from the outlet of Chignik Lake (Figure 3). River width at this location is 46 m with an average depth of 2.2 m, and flow rate of 1.2 m/sec. The traps fished approximately 8-9% (~4.2 m) of the river width. Both traps were fished continuously except during daily cleaning and adjustment periods which usually were <1.0 h in duration.

Traps were positioned close to shore in a depth that allowed the cones to rotate freely. Both trap cones could be adjusted vertically using a hand winch mounted to the inshore and offshore pontoons. Initially, the center of the small trap cone was positioned 5.9 m offshore, approximately 10-20 cm above the substrate. The center of the large trap cone was positioned 9.1 m offshore and approximately 30-40 cm above the substrate. A 4.5 m lead, constructed of vexar plastic cloth and supported by a 10 cm (4-in) x 15 cm (6-in) brace, was placed between the inshore pontoon of the small trap and stream bank to deflect fish towards the traps. As the water level fluctuated the traps and leads were adjusted accordingly. An offshore lead was not used owing to current, depth, and potential hazard to navigation.

Beginning 1 July the small trap was repositioned 4-5 m directly below the adult counting weir, (4.8 km upstream from Chignik Lagoon), approximately 35 m offshore from the North bank and operated continuously through 26 July (Figure 3); the large trap at this time was retired for the season.

Smolt Enumeration

Captured sockeye salmon smolts were removed and enumerated daily from each trap. Generally, the traps were checked approximately every 2 hours between 2100 and 0500 hours, and again at 1200 h. Traps were checked more frequently as catches increased to minimize trap induced mortality. All catch data were recorded by sampling day, which extended from noon to noon and was identified by the calendar day of the noon to midnight period (e.g. counts for 3 May represent smolt enumerated from noon 3 May until noon on 4 May).

Species identification of salmonids were made by visual examination of external characteristics (McConnell and Snyder 1972). Only sockeye salmon smolt were enumerated daily; catch of sockeye fry and other species were indexed counts which reflect some unknown fraction of the total number caught, however, in 1997 efforts were made to accurately count all incidental catch. Juvenile sockeye greater than approximately 40 mm in length with silver body coloration and eyes small relative to head size were considered smolts (Thedinga et al. 1994). Fish of similar size and smaller with prominent parr marks and large eyes relative to head size were assumed to be fry and were not enumerated into smolt counts. All juveniles greater than 55 mm were considered to be outmigrating smolts, regardless of coloration or proportional body morphology.

Age, Weight, and Length Sampling

Subject to availability, 70 sockeye smolts were sampled for age, weight, and length, five days a week. The sample was generally obtained from a single day's catch between 2100 and 0500 h using a dip net to remove fish from the live box. Samples were never mixed between days. Smolts were kept alive and sampled on the day of capture. Smolts were anesthetized prior to sampling in a tricaine methanesulfonate (MS-222) solution, and measured for length (tip-of-snout to fork-of-tail) to the nearest 1.0 mm, and weighed to the nearest 0.1 g with an electronic digital scale (OHAUS portable electronic balance). A scale smear was removed from the preferred area (INPFC 1963) and mounted on a standard microscope slide for aging with a microfiche reader (EYECOM 3000) under 36X or 60X magnification (Figure 4). Ages were recorded in European notation (Koo 1962). After sampling, fish were revived in aerated water and released downstream from the traps.

Estimation of Trap Efficiency

To estimate the total smolt outmigration, weekly trap catch efficiency tests were conducted using a Bismark Brown Y dye mark. Smolts used for trap efficiency trials were collected from the traps

and transferred in 19 L plastic buckets to instream covered flow-through liveboxes. Smolt were retained for a minimum of 10 hours to a maximum of three nights prior to dyeing, depending on smolt availability. If the target number of smolts collected for dyeing was not met after three nights, those available were dyed and released. Initially, an attempt was made to collect, mark, and release at least 1,000 sockeye smolt every four to seven days. Later the target sample size was increased to 4,000 smolts to increase the precision of trap efficiency estimates.

Smolts were dyed in the evening at approximately 2100 hours. Smolts were transferred from the live boxes into a continuously aerated solution of 1.9 g Bismark Brown dye to 57 L water for 30 minutes at a rate of up to 1,000 smolt/ 76 L dye solution (Ward and Verhoeven 1963; Lawler and Fitz-Earle 1968). All dyed smolt displayed a very distinct bright yellow/ orange color, especially in the fins. After marking, smolts were returned to the liveboxes and held for about 30 minutes to allow for recovery. At approximately 2230 hours, dyed smolts were collected from the liveboxes, transported to the dye release site 1.3 km upstream from the traps (Figure 3), and released evenly across the stream channel. At each step of the dyeing process, dead or stressed smolts were counted and removed. The mark- recapture experiments can be stressful for smolt and all efforts were made to minimize stress and mortality.

Delayed Mortality Associated With Marked Fish

Delayed mortality is a component related to estimating and accounting for error associated with mark-recapture trials used for smolt population estimation. This variable could bias the mark-recapture results and ultimately bias the smolt population estimates. If there is significant mortality occurring during mark-recapture trials, smolt population estimates generated during 1994-97 will be adjusted accordingly.

An instream flow-through live box was constructed for experiments estimating marked smolt mortality that occurs over time subsequent to the dye process. 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 positioned across the river from the traps, parallel to the flow, in slow moving water adjacent to the river bank to facilitate ease of examination.

The protocol for this experiment consisted of holding approximately ten percent of the smolts used for estimating weekly trap efficiency for three days. These fish were subjected to the same dye process that was used for mark-recapture trials (i.e. dye concentration, emersion period, aeration, recovery time, and transport procedures. Only robust and healthy smolts were placed in the live box which were defined as actively swimming fish maintaining routine respiration and responding to external stimuli. Any smolts not displaying this behavior were released down stream of the traps. The fish were inspected over a three day period and the number of dead smolt were counted, removed, and measured for weight and length.

Climate and Hydrology

Trap revolutions per minute (rpm) and daily climate observations, including air and stream temperature (C), stream height (cm), cloud cover (%), wind velocity (mph) and direction were recorded at approximately 1200 daily at the smolt trap site. During this time period, both traps were cleaned and any trap or lead adjustments were made accordingly due to the rise and fall of the water level. A water depth gauge was installed across the river from the smolt traps to provide daily water level metrics.

DATA ANALYSIS

Smolt Population Estimation

From 1994-96 all smolt population estimates for the Chignik Lakes system, both in total and by freshwater age class were derived using a statistical model forwarded by Rawson (1984); however, this estimator is being replaced because it generates incorrect abundance and variance estimates. A new smolt population estimator (Carlson et al. *In review*) was used for the 1997 Chignik Lakes smolt population estimates and will replace the original estimates generated for 1994-1997 (Stopha and Barrett 1994; Vania and Swanton 1996; and Kaplan and Swanton 1997).

Following the release of dyed fish, trap catches were examined for recaptures for three successive days. Recaptured smolts were recorded separately from unmarked fish and excluded from daily catch totals. The following variables are defined in the development of the smolt population estimator (Carlson et al. *In Review*):

h: stratum or period index (release event paired with a recovery period).
j: age index.
L: number of strata ($h = 1, 2, \ldots, L$).
M_h: number of marked releases in stratum h.
M: total number of marked releases ($= \Sigma M_h$).
m_h: number of marked recoveries in h.
u_h: number of unmarked smolt captured in h.
U_h: total population size of smolt in h, excluding marked releases and minus observed mortality.
U: total population size of smolt, excluding marked releases ($= \Sigma U_h$).
A_{jh}: number of age j smolt sampled in h.
A_h: number of smolt sampled in h.
θ_{jh}: proportion of age j smolt in h.
U_{jh}: total population size of age j smolt in h, excluding marked releases.
U_j: total population size of age j smolt, excluding marked releases ($=\Sigma U_{jh}$).

The approximately unbiased estimator of the total population within each stratum (U_h) is given as

$$\hat{U}_h = \frac{u_h(M_h+1)}{m_h+1}, \tag{1}$$

with variance

$$v\left(\hat{U}_h\right) = \frac{(M_h+1)(u_h+m_h+1)(M_h-m_h)u_h}{(m_h+1)^2(m_h+2)}. \tag{2}$$

The estimate of U is therefore

$$\hat{U} = \sum_{h=1}^{L} \hat{U}_h, \tag{3}$$

with variance estimate

$$v\left(\hat{U}\right) = \sum_{h=1}^{L} v\left(\hat{U}_h\right). \tag{4}$$

The 95% confidence intervals were estimated two separate ways each detailed in Carlson et al. (*In Review*). The first was to use the standard formula

$$\hat{U} \pm 1.96\sqrt{v(\hat{U})}, \tag{5}$$

which assumes that $\hat{U}$ is asymptotically normally distributed. The second was to use a parametric bootstrap procedure assuming the hypergeometric distribution.

To estimate the number of emigrating smolt by age class during each stratum h, the proportion of each age is first estimated as

$$\hat{\theta}_{jh} = \frac{A_{jh}}{A_h}, \tag{6}$$

with estimated variance

$$v\left(\hat{\theta}_{jh}\right) = \frac{\hat{\theta}_{jh}\left(1-\hat{\theta}_{jh}\right)}{A_h}. \tag{7}$$

Within each stratum, the total population size by age class is estimated as

$$\hat{U}_{jh} = \hat{U}_h\hat{\theta}_{jh}, \tag{8}$$

with estimated variance ignoring the covariance term

$$v\left(\hat{U}_{jh}\right) = \hat{U}_h{}^2 v\left(\hat{\theta}_{jh}\right) + v\left(\hat{U}_h\right)\hat{\theta}_{jh}{}^2 \quad (9)$$

Finally, the total population size of each age class among all strata is estimated as

$$\hat{U}_j = \sum_{h=1}^{L} \hat{U}_{jh}, \quad (10)$$

with estimated variance

$$v\left(\hat{U}_j\right) = \sum_{h=1}^{L} v\left(\hat{U}_{jh}\right) \quad (11)$$

Condition factor for each smolt sampled was estimated using:

$$\hat{K} = \frac{W}{L^3} 10^5, \quad (12)$$

where $\hat{K}$ is smolt condition factor, W is weight in grams, and L = length (tip-of-snout to fork-of-tail) in millimeters.

We did not anticipate any trap problems for the 1997 season whereas specific precautions were taken that would prevent damage and/or technical difficulties; however, in situations where daily trap operation is foregone, estimated daily smolt capture would be generated by linear interpolation of large trap catch on small trap catch for 5 days prior to and 5 days after the trap was inoperable.

RESULTS

In 1997, the traps were operated from 3 May through 30 June during which time 264,678 sockeye salmon smolts were caught. Mark-recapture trap efficiency trials were initiated beginning on 9 May and ended on 18 June with a total of 8 trials being conducted. A total of 14,285 marked fish were released and 154 marked smolts were recovered over the season (Appendix A). The largest numbers of marked fish were recaptured on the first night (73%) followed by 19% and 8% on subsequent nights. The total estimated sockeye smolt outmigration was 25.6 million fish (Table 1; Figure 5). Age-0. smolts comprised about 2.1% (500,000) of the total, age-1. smolts approximately 43.7% (11,000,000), and age-2. smolts 53.7% (14,000,000; Table 2). Age-3. smolts were only a minor component comprising of 0.5% (122,000). Overall, 94% of the sockeye smolts were caught in the large trap, and 6% in the small trap (Appendix B). Other species captured included coast-range sculpin *Cottus aleuticus*, coho salmon *Oncorhynchus kisutch*, chinook salmon *O. tshawytscha*, Dolly Varden *Salvelinus malma*, ninespine stickleback *Pungitius pungitius*, pond smelt *Hypomesus olidus*, pygmy whitefish *Prosopium coulteri*, starry flounder *Platichthys stellatus*, threespine stickleback *Gasterosteus aculeatus*, and Alaska blackfish *Dallia pectoralis* (Appendix A).

Smolt outmigration peaked on 21 May with an estimated 5 million smolts outmigrating (Figure 6). An estimated 2.2 million smolts emigrated on 20 May with an additional 2.2 million on 22 May, after which numbers then steadily declined. Modes for age-1. and age-2. occurred about 18-21 May, and for age-0. fish about 22-26 May (Figure 7). The percentage of age-0. smolts increased over the season from 1.2% (3-26 May) to 5.5% (27 May - 30 June; percentages of age-1. smolts increased over time from 40.6% (3-26 May) to 55.7% (27 May - 30 June; and percentage of age-2. fish declined from 57.7% (3-26 May) to 38.5% (27 May - 30 June); and age-3. smolts decreased in abundance from 0.5% (3-26 May) to 0.3% (27 May - 30 June; Appendix C). The daily temporal pattern of smolt outmigration occurred between the hours of 0100-0500 and was characteristic of the entire season.

A total of 2,327 smolts were sampled for age, weight, and length data from 3 May through 30 June (Appendix D and E). The average length of age-0. smolts was 46 mm (range: 40-53 mm, Figure 8). The mean length of age-1. smolts was 65 mm (range: 40-103 mm) and declined over time from 78 mm (3-31 May) to 56 mm (1-30 June); mean length of age-2. smolts was 83 mm (range: 58-116 mm) and also decreased over time (Figure 9). Comparisons of length-at-age show that age-1. smolts were slightly smaller in 1997 than in 1994 and 1996, but larger than those sampled during 1995, and age-2. fish from 1997 were larger than those from previous years (Table 3; Figure 10).

Post 30 June, a total of 13,504 smolts (representing 5.1% of the number of smolt captured from 3 May-30 June) were captured of which 330 were sampled for age, length, and weight (Figure 11; Appendices F and G). Mean length of age-0. smolts was 47 mm, for age-1. fish 57 mm, and for age-2. smolts 76 mm.

Comparison of the freshwater scale patterns of Chignik Lakes sockeye smolt over time by age class are shown in Figure 3. Generally, throughout the season, age-0. fish had scales with freshwater growth comprised of 1-3 circuli, which remained fairly constant. Smolts designated as age-1. were comprised of essentially two groups; one with a pattern consisting of 12-16 freshwater circuli and the second with 6-10 circuli. Age-2. smolts were generally categorized into three groups of scale patterns. The first with an annulus formed 4-5 circuli beyond the focus, the second at 6-8 circuli, and the third at about 10-12 circuli. The second annulus was somewhat consistent between these groups with about 6-12 circuli.

The freshwater scale pattern for age-0. smolts sampled post 30 June was composed of 1-3 circuli. Age-1. fish were characterized by two groups of scale patterns, one with 6-8 circuli and a second with 3-4 circuli with an additional 4-5 circuli of spring growth. The age-2. were represented by one group of fish with 4-6 circuli beyond the scale focus with the second years growth zone being 4-6 circuli in width.

Daily Climatological observations collected during the 1997 field season are reported in Appendix H.

Delayed mortality experiments were conducted over a span of three weeks where five replicates were completed. There was a total of 13 mortalities out of 1,208 smolts (~1.0%), which represents

a survival estimate of approximately 99% of marked fish. This represents a negligible error within the final annual smolt population estimates.

DISCUSSION

The smolt population estimate of 25.6 million for 1997 was the largest experienced from this system since 1994 and greater than a 10 fold increase over the sockeye smolt emigration of 1996. During the years 1991 and 1994, the Black Lake escapement goal of 400,000 adults was exceeded by about 250,000 and 360,000, respectively. This resulted in the 1994 brood year producing substantially depressed numbers of age-1. smolts. These excessive escapements could have resulted in depensation of production on the spawning grounds, egg-to-fry survival, or possibly at the rearing fry stage. Manzer and Miki (1986) showed that for sockeye salmon, increased spawner density caused an increase in egg retention by females after spawning, which was also shown with pink salmon following the overescapement event of 1989 (Swanton et al. 1993). Kyle et al. 1988 reported the effects of sequential years of sockeye overescapements for Frazer Lake on Kodiak Island, where sockeye smolts expressed substantial decreases in length (12 mm) and weight (1.7 g). This was not the case for either age-1. or age-2. smolts from either the 1991 or 1994 brood years for Chignik smolts. Unfortunately, supporting information regarding this hypothesis is largely anecdotal, specific to the freshwater life history. Additionally, previous research efforts point to large numbers of Black Lake juveniles emigrating to Chignik Lake thus possibly accentuating competition between rearing fry from both spawning stocks (Roos 1959; Ruggerone et al. 1993; Ruggerone 1994). Narver (1966) attributed these emigrations of Black Lake juveniles to density dependent responses to the limited rearing environment. There have also been sporadic large scale mortality of sockeye fry within both Black and Chignik Lakes that could have resulted in low numbers of smolts outmigrating (Dave Owen, Alaska Department of Fish and Game, personal communication).

Reliable sockeye smolt population estimates depend upon trap catches being of sufficient size to conduct unbiased mark-recapture trials. We have observed for the last three years (1995-1997) relatively static trap catch efficiencies averaging around 1.0%, as compared to an overall 1994 estimate of 0.5% (Stopha and Barrett 1994).

The increased trap efficiency estimates observed during 1995-97 can likely be attributed to the new trap location at the "King Hole". This site is an improved rotary-screw trap location with decreased stream width (46 m versus 73 m) and increased cone rotation speed (average of 8 rpm versus 6 rpm) both of which have been attributed to improved trap catches (Thedinga et al. 1994). Refinement of the population estimator has been under development for several years and has recently been validated with total smolt census data from a weir (Carlson et al. 1998, *In Review*). Differences between the two population estimators in terms of sockeye smolt numbers were less than 500,000 fish annually. The differences between the two estimators is explained in Carlson et al. (1998, *In Review*).

Delayed mortality experiments of marked fish conducted during 1997 showed, (if accurate), that this aspect of our studies is of little concern regarding differential mortality of marked fish. During 1998, we anticipate further validation of these results.

The annual timing of smolt emigrations from the Chignik Lakes system have shown a high degree of annual constancy, with peak catches recorded around 22 May for the years 1993 to 1997. There is also a large degree of agreement temporally with historic smolt catches from 1956-1959 with an approximate week of variation.

Year	Dates Fished	Total Catch	Maximum Daily Catch (Number Of Smolt)
1956[a]	21 May-23 June	151,916	26 May-45,795
1957[a]	27 April-29 June	17,431	17 May-4,252
1958[a]	25 April-7 July	50,412	31 May-7,548; 15 June-17,458
1959[a]	15 May-1 July	38,205	23 May-5,708; 3 June-7,642
1993[b]	9 May-2 July	46,000	19 May-8,000
1994[c]	5 May- 1 July	60,595	23 May-2,317; 3 June-2,237
1995[d]	6 May-30 June	74,383	25 May-12,976; 2 June-4,232
1996[e]	6 May-30 June	24,695	24 May-14,184; 3 June-2,304
1997	3 May-30 June	264,678	21-May-48,068

[a] Roos, 1959b.
[b] Ruggerone, 1994
[c] Stopha and Barrett, 1994.
[d] Vania and Swanton, 1996.
[e] Kaplan and Swanton, 1997.

This interannual consistency in sockeye smolt emigration timing supports Kaplan and Swanton's (1997) contention that it is unlikely that during 1996 smolts emigrated from the Chignik Lakes system earlier than in other years causing the low population estimate.

The cursory analyses of length-at-age coupled with freshwater scale patterns for sockeye smolts sampled during 1997 substantiates the contention that there are two distinct groups of age-1. smolts (Kaplan and Swanton 1997; Vania and Swanton 1996). The modes were ~ 85 mm for fish sampled during 3-31 May and ~53 mm for the second mode representing the period 1-30 June (Figure 9). Ruggerone (1994) suggested that there were three groups of age-1. smolts. Two of which have been substantiated during 1995-97. The third group, which he characterized as being ~100 mm in length, have not been observed during any years since 1993. For age-2. smolts there appear to be two size modes. One having an average length of ~88 mm, which emigrated during May, and another (based on a limited sample size) average length of ~80 mm. It is interesting that there appear to be three different scale patterns (two dominant) within this age class of smolts. Two distinct patterns for smolts that emigrated during May, and a third for fish that were sampled during June. The age-0. smolts that have been enumerated since 1995 show no distinct growth pattern

variability between years, nor do the numbers (~500,000 smolts) appear to be influential in terms of adult production.

The post-30 June outmigration study initiated in 1996 provided an initial benchmark for smolts emigrating from the Chignik Lakes system during July and possibly at a reduced level into late summer. The earliest recorded observations of this were described by Holmes (1929) who noted extensive upstream movements of fry in the lower Chignik River during late August. Roos (1959a) observed both upstream and downstream fry and age-1. fish in both the upper and lower Chignik River areas. During 1997 we captured about 11,000 more smolts in July than in 1996. This was not surprising as there was a 10 fold increase in numbers of smolts enumerated during May-June (Figures 5 and 11). We believe that further evaluation of this study component is justified for several more years. This may substanciate a relationship between numbers of smolts emigrating during May-June with post June indexed numbers.

Regardless of the size-at-age data, the scale patterns suggest that fry rearing within this system are experiencing differential growth. This observation has been persistent (1994-1997). Eluding to the possibility there is both spatial (Black Lake versus Chignik Lake rearing) and interannual competition between rearing fry for Black and Chignik Lake stocks that should be further investigated. Smolt to adult survival (SAS) estimates from the 1994 emigration specific to age class are 9% for age-1. (average length 67 mm) smolts and 17% (average 77 mm) for age-2. fish. These values are well within the range of literature based estimates reported by Koenings et al. (1993) and Koenings and Burkett (1987) for similar size smolts. These being the first such estimates specific to the Chignik Lakes system, we are reticent about making any projections until additional SAS values are available from this system.

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Table 1. Sockeye salmon smolt population estimates by age class for the Chignik Lakes syatem, 1994-1997.

Smolt Year		Number and Relative Percent of Smolt by Age Class						95% CI	
		Age-0.	Age1.	Age-2.	Age-3.	Total	SE	Lower	Upper
1994	No.	[a]	7,263,054	4,270,636	[a]	11,533,690	1,332,321	8,922,341	14,145,038
	%		63.0	37.0		100.0	***1,660,118***	***9,074,677***	***15,253,892*** [b]
1995	No.	735,916	2,843,222	5,178,450	[a]	8,757,588	1,753,022	5,321,664	12,193,512
	%	8.4	32.5	59.1		100.0	***1,958,950***	***6,056,028***	***14,425,828***
1996	No.	80,245	1,200,793	731,099	5,018	2,017,156	318,522	1,392,852	2,641,459
	%	4.0	59.5	36.2	0.2	100.0	***357,145***	***1,482,105***	***2,823,016***
1997	No.	528,846	11,172,150	13,738,356	122,289	25,561,641	2,962,497	19,755,145	31,368,136
	%	2.1	43.7	53.7	0.5	100.0	***3,309,665***	***20,854,749***	***33,927,095***

[a] No samples collected.

[b] Italicized standard error and confidence intervals (CI) from bootstraping methods.

Table 2. Sockeye salmon escapement and estimated number of smolt produced by brood year from both Chignik and Black lakes, 1991-1995.

Brood Year	Estimated Escapement by Lake System		Smolt Produced by Age Class (Both Lakes Combined) 1.	2.	Total No. Smolts
1991	Black :	657,511	[a]	4,270,636	4,270,636[b]
	Chignik :	382,587			
1992	Black :	360,681	7,263,054	5,178,450	12,441,504
	Chignik :	405,922	(58%)	(42%)	
1993	Black :	364,263	2,843,222	731,100	3,574,322
	Chignik :	333,114	(80%)	(20%)	
1994	Black :	766,909	1,200,793	13,738,356	14,939,149
	Chignik :	200,000	(8%)	(92%)	
1995	Black :	366,163	11,172,150	[c]	11,172,150
	Chignik :	373,757			

[a] Population estimates not available.

[b] Incomplete brood year.

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

Table 3. Summary of mean length, weight, and condition factor by age class of smolt sampled from the Chignik River, 1994-1997.

Outmigration Year	Freshwater Age Class	N	Smolt Mean Length (mm)	SE	Mean Weight (g)	SE[a]	Condition Factor (k)	SE
1994	0	[b]	[b]		[b]		[b]	
1995	0	286	45.7	0.2	0.7		0.74	0.01
1996	0	83	47.9	0.5	0.9		0.76	0.02
1997	0	154	46.3	0.3	0.8		0.82	0.01
1994	1	1,722	66.6[c]		2.3		0.75	
1995	1	1,275	60.2	0.3	2.0		0.83	0.01
1996	1	935	66.9	0.3	2.4		0.76	0.01
1997	1	1,393	64.7	0.4	2.5		0.80	0.002
1994	2	1,096	77.4		3.6		0.75	
1995	2	1,009	75.1	0.2	3.5		0.80	0.01
1996	2	429	79.5	0.4	4.1		0.79	0.01
1997	2	765	83.4	0.3	4.7		0.80	0.003
1996	3	3	100.3	5.5	8.4		0.81	0.07
1997	3	12	87.3	1.34	5.2		0.77	0.02

[a] Standard errors for weight estimates were less than the precision level of measurement (0.1g) therefore they were not reported.

[b] Age-0. smolts not sampled.

[c] Age-1. smolts <55 mm not sampled.

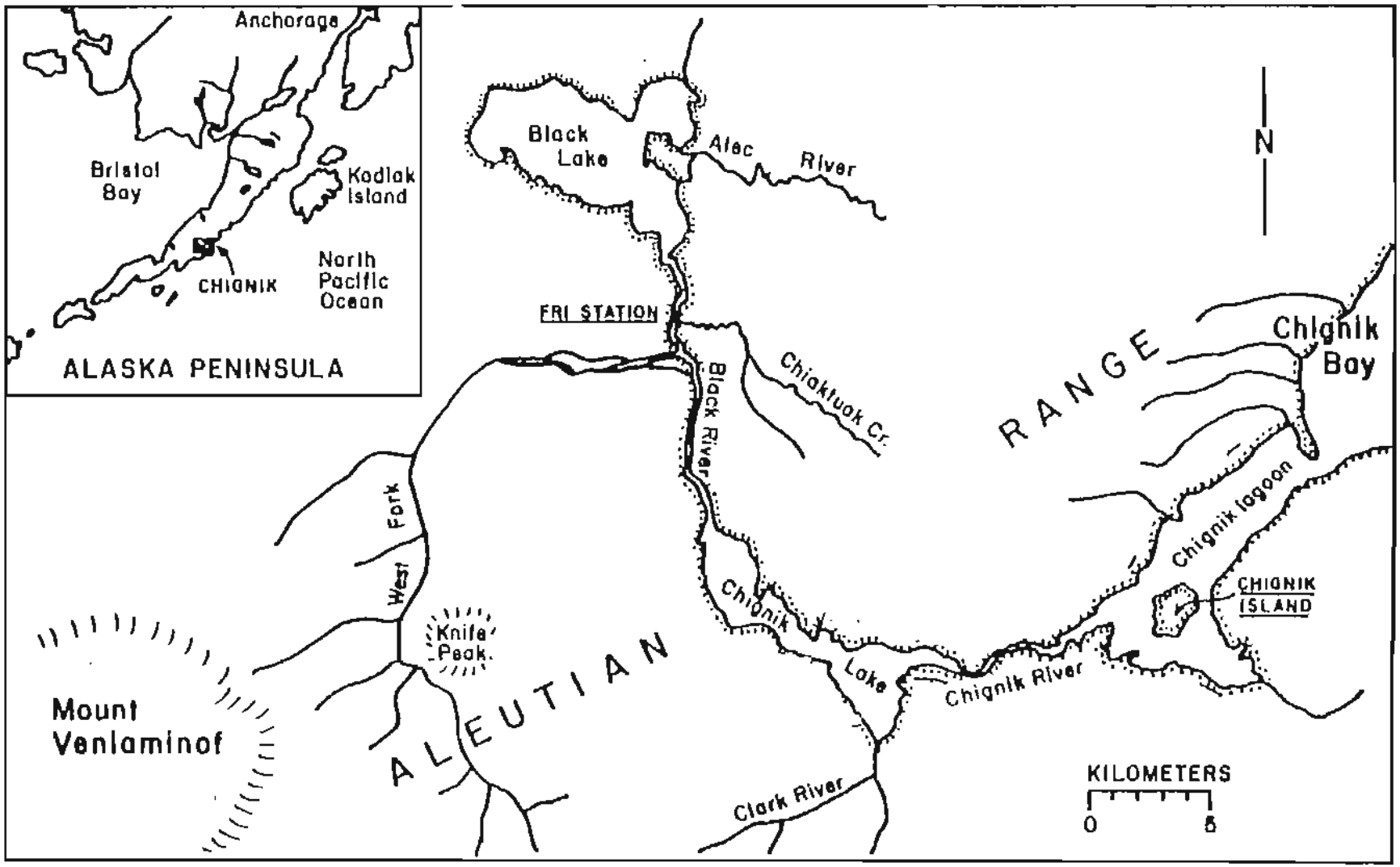
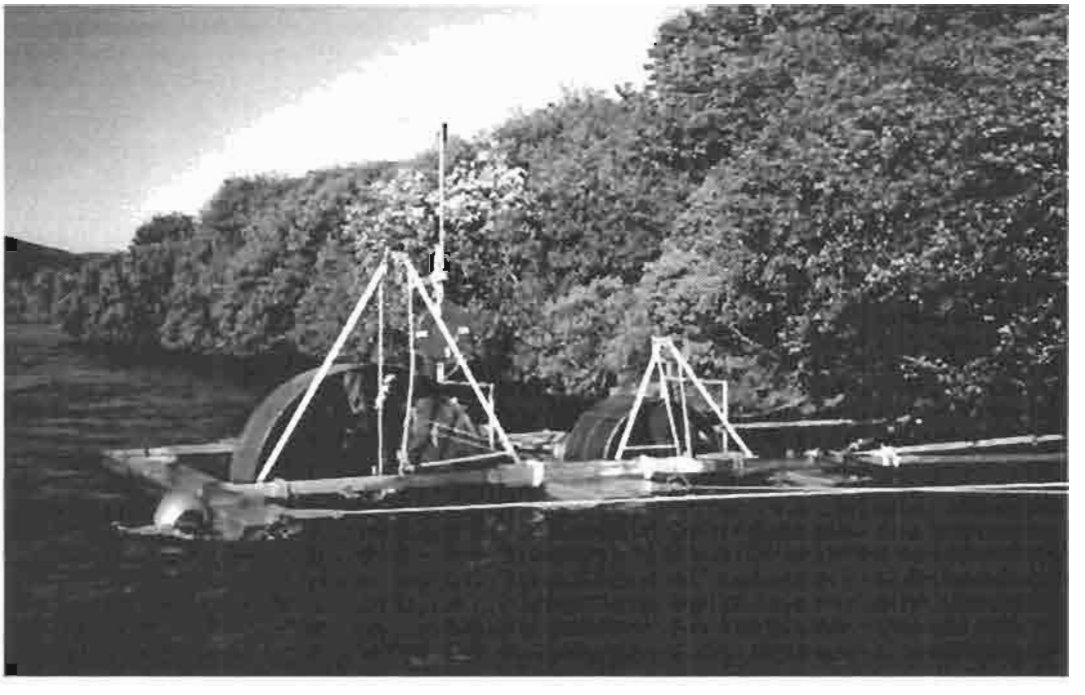


Figure 1. Map of the Chignik River watershed with inset of western Alaska.

(A)



(B)

Figure 2. Upstream (A) and downstream (B) views of rotary-screw traps with 2.4 m and 1.5 m diameter cones operating in the Chignik River.

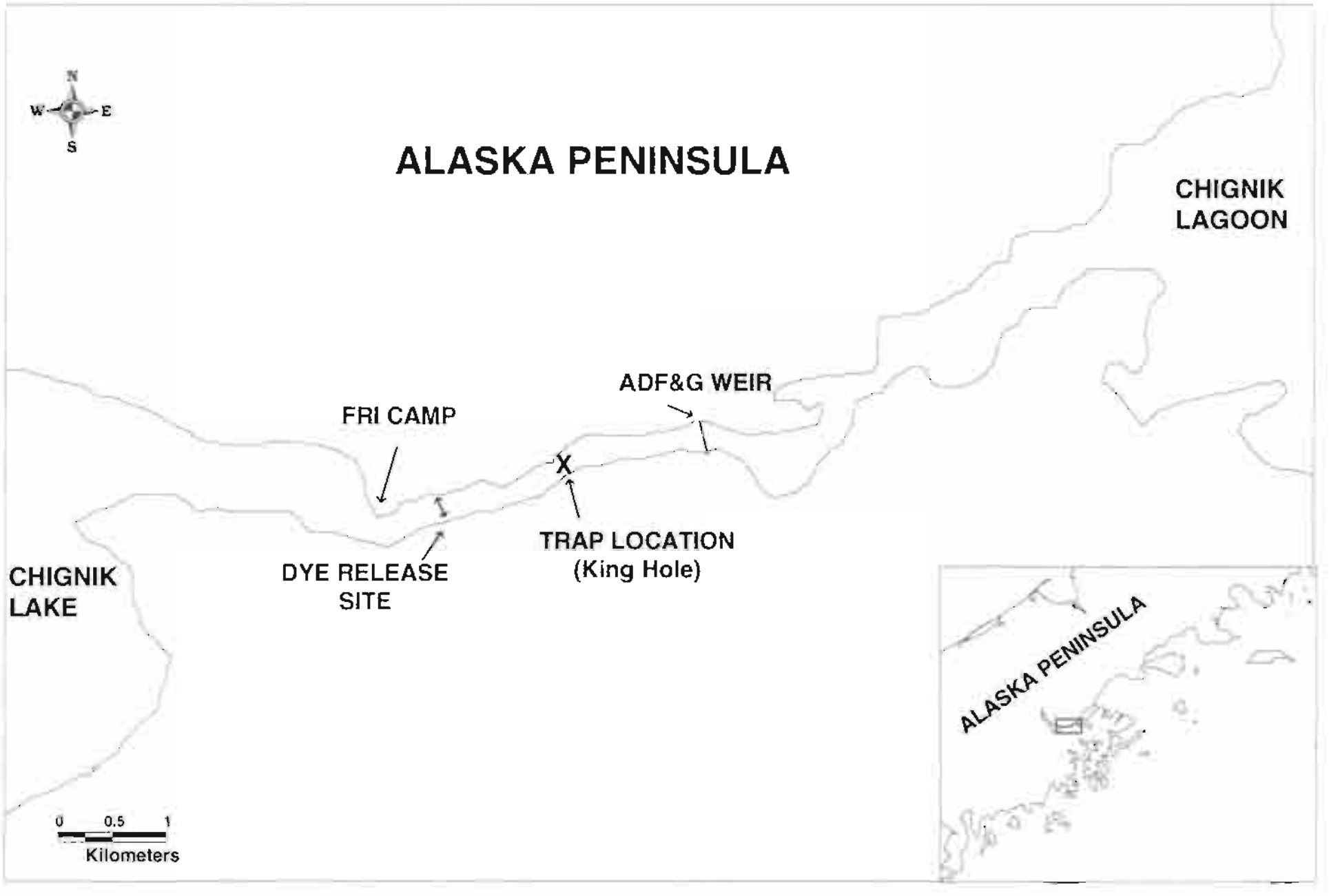


Figure 3. Location of rotary-screw trap (denoted by "X"), and release site of dyed fish on the Chignik River, Alaska.

Figure 4. Examples of age-0., age-1., and age-2, sockeye salmon smolt scales enlarged (60X), Chignik Lakes, 1997.

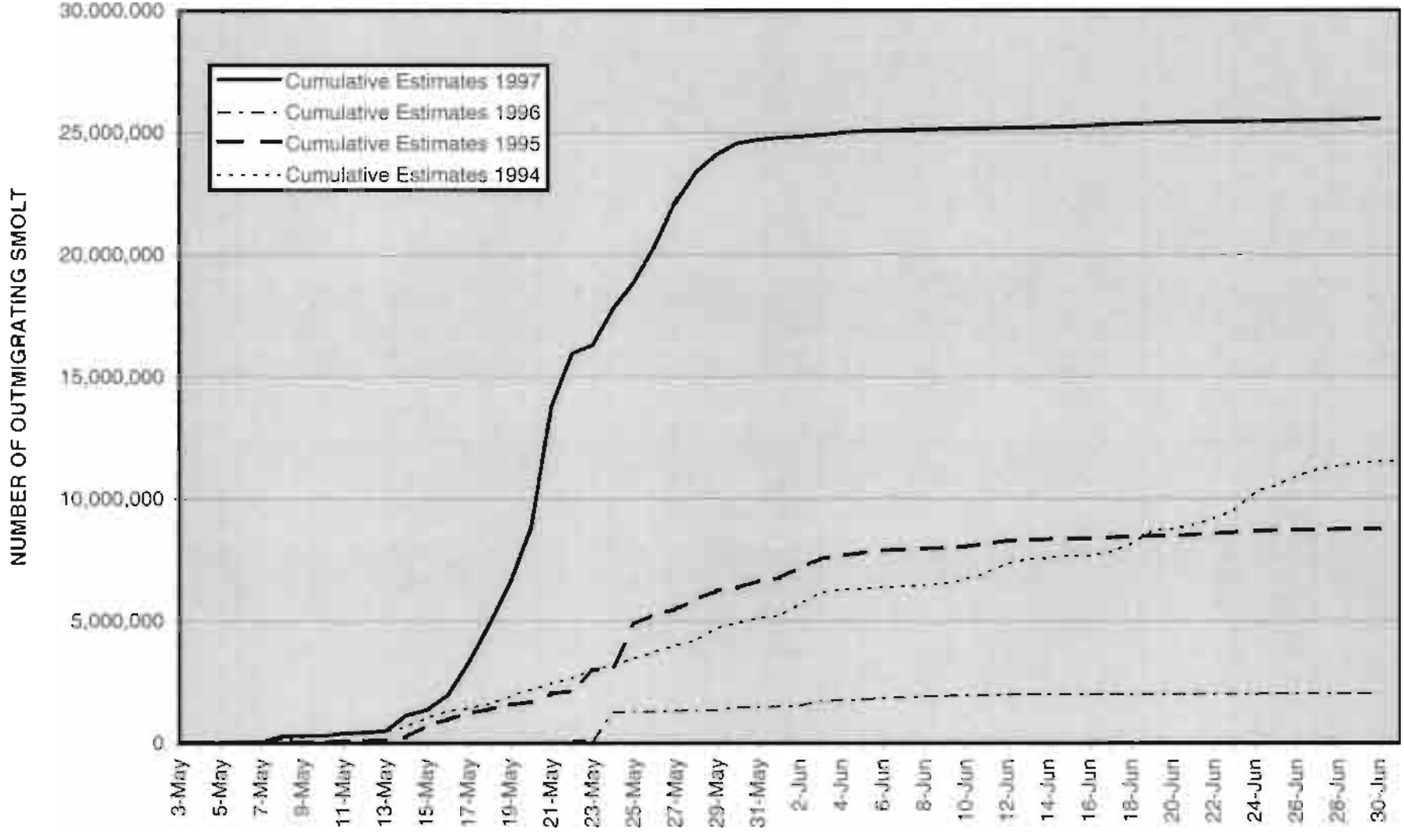


Figure 5. Cumulative number of sockeye salmon smolts estimated to have emigrated from the Chignik Lakes by year, 1994-1997.

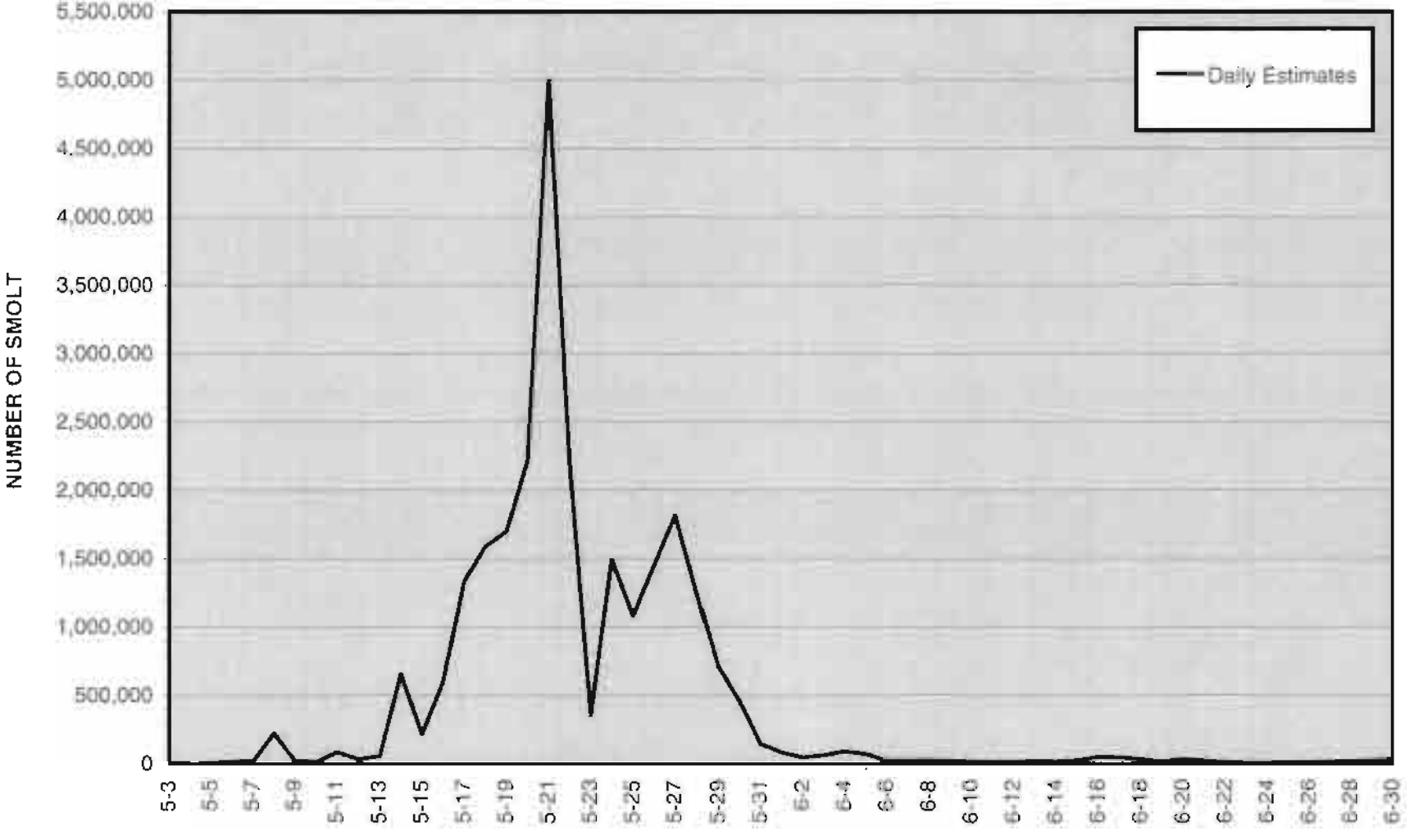


Figure 6. Daily estimates of emigrating sockeye salmon smolts from the Chignik Lakes, 3 May through 30 June, 1997.

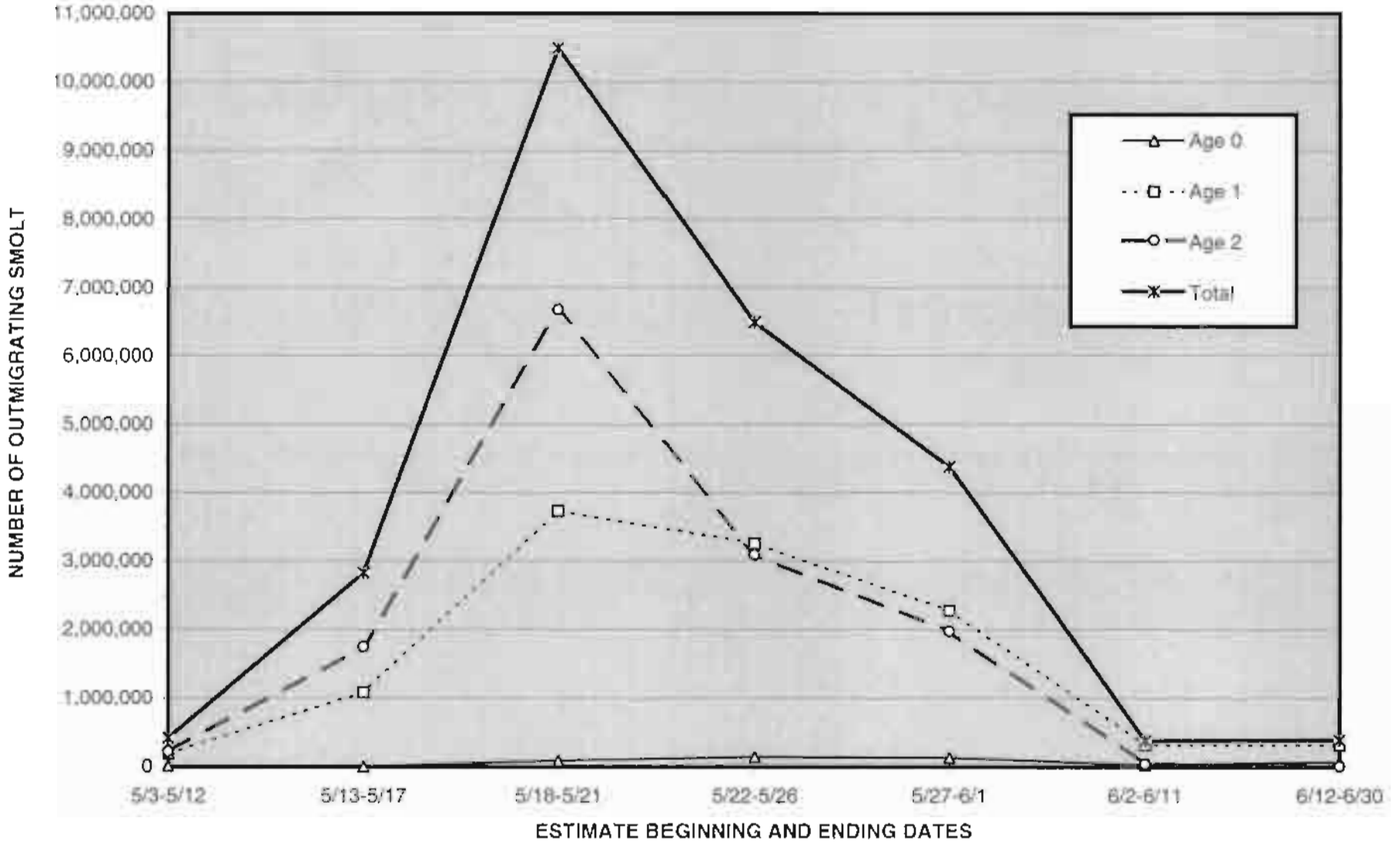


Figure 7. Estimates of outmigrating sockeye salmon smolts by age class from the Chignik Lakes, 1997.

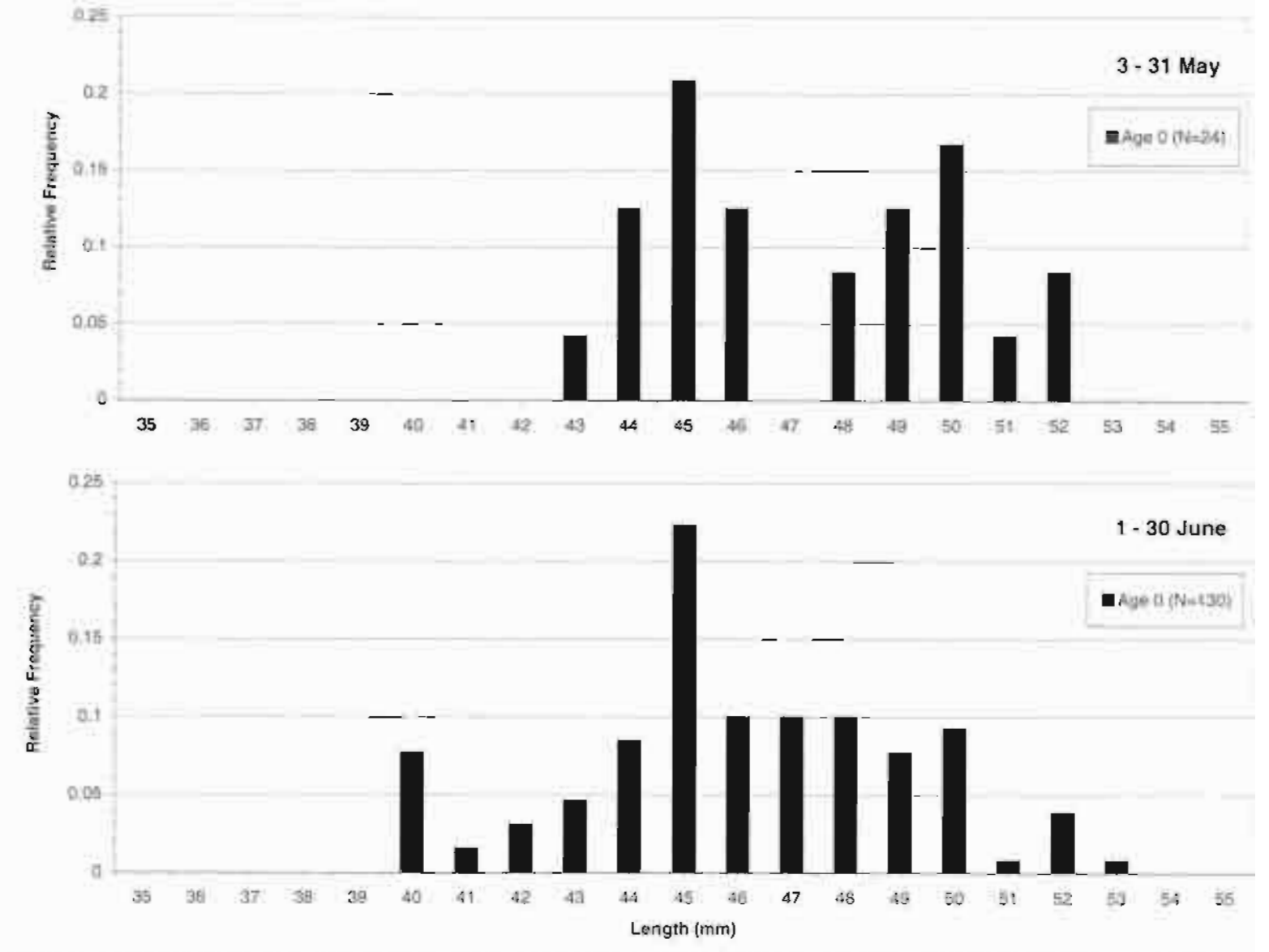


Figure 8. Relative length frequency of age-0. sockeye salmon smolts emigrating from Chignik Lakes, 3 May - 30 June, 1997.

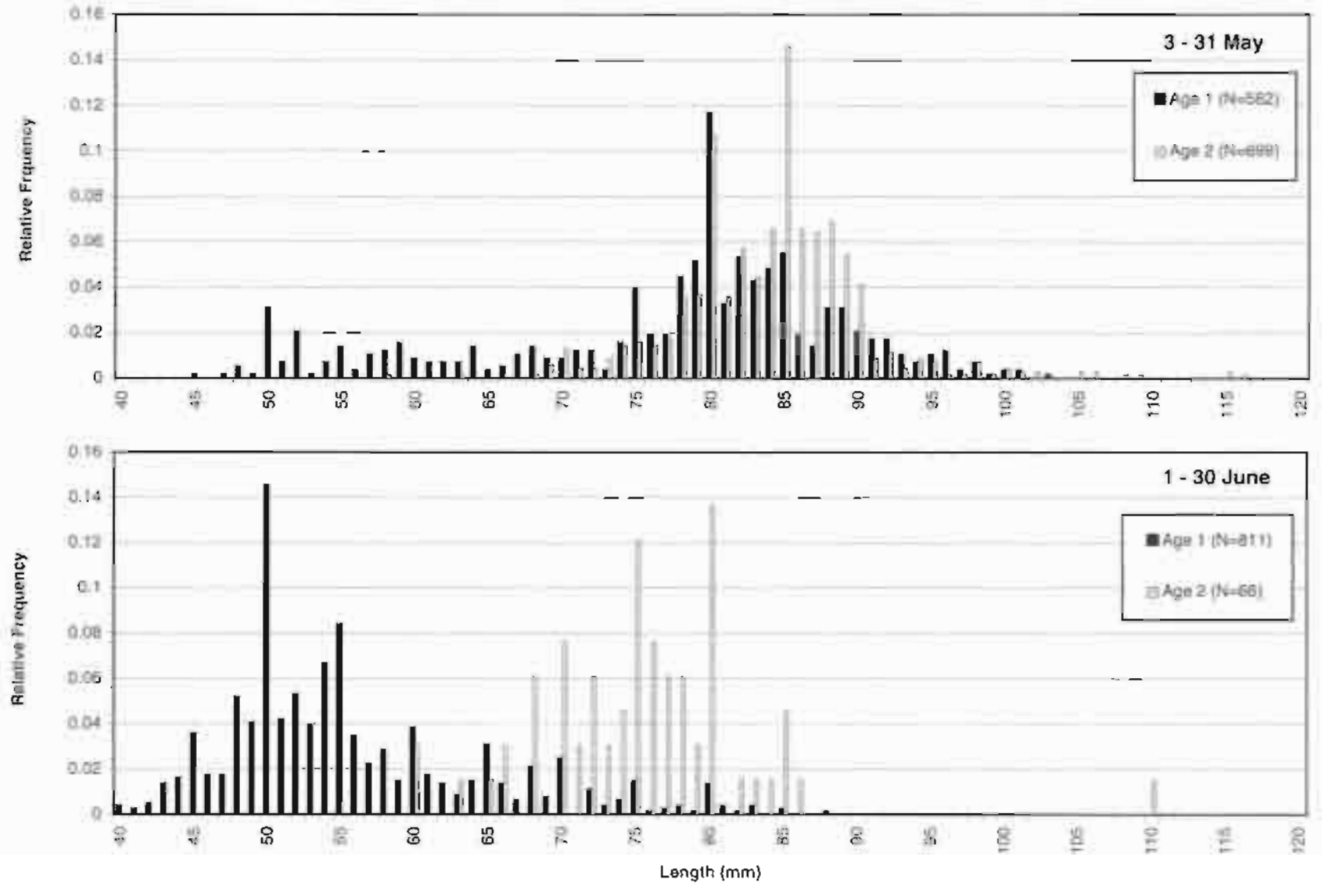
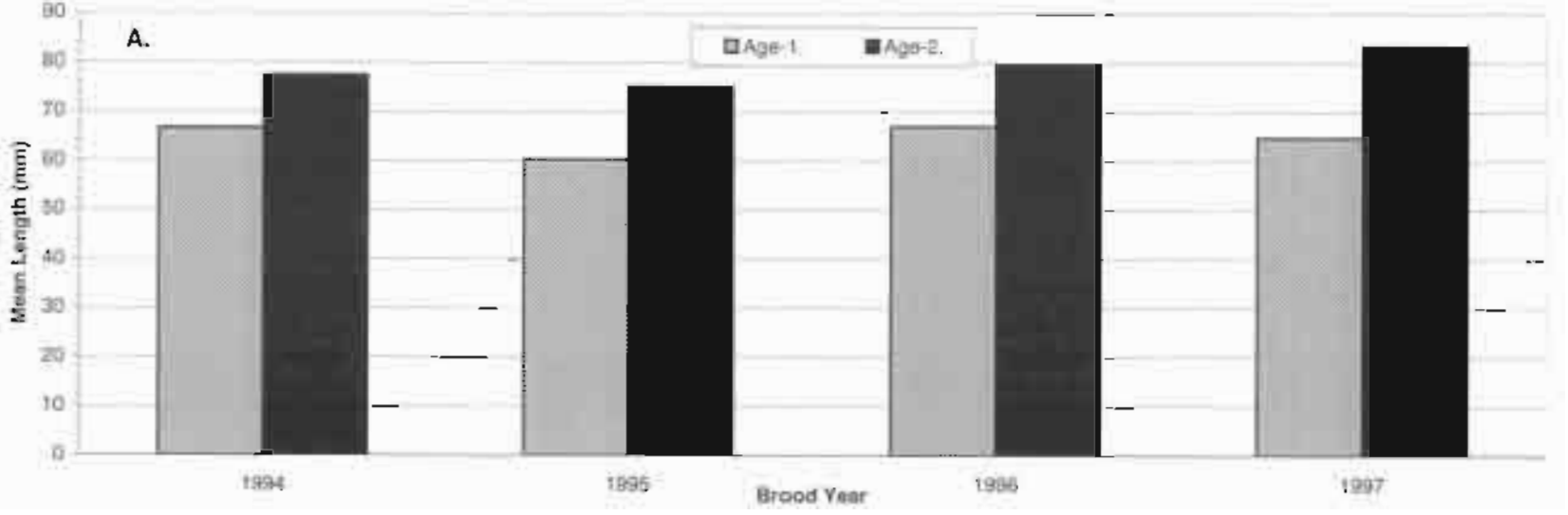


Figure 9. Relative length frequency of age-1. and age-2. sockeye salmon smolts emigrating from Chignik Lakes, 3 May - 30 June, 1997.



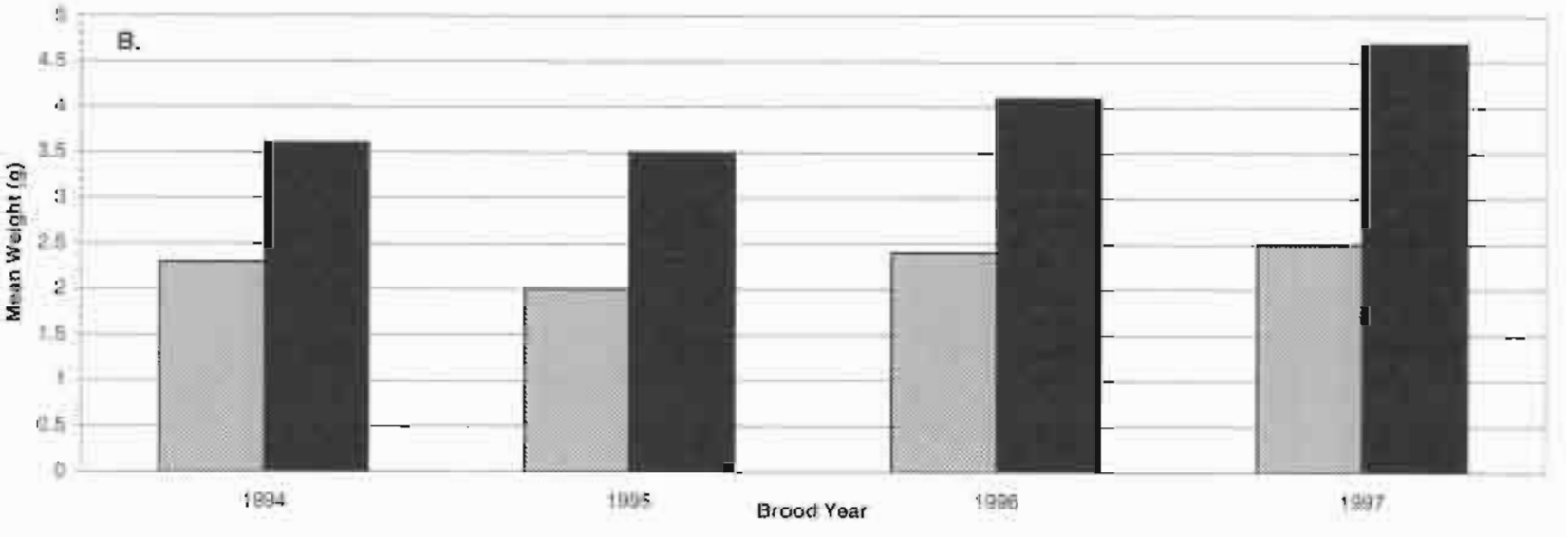


Figure 10. Chignik Lakes mean smolt length (A) and weight (B) by year and age, 1994-1996.

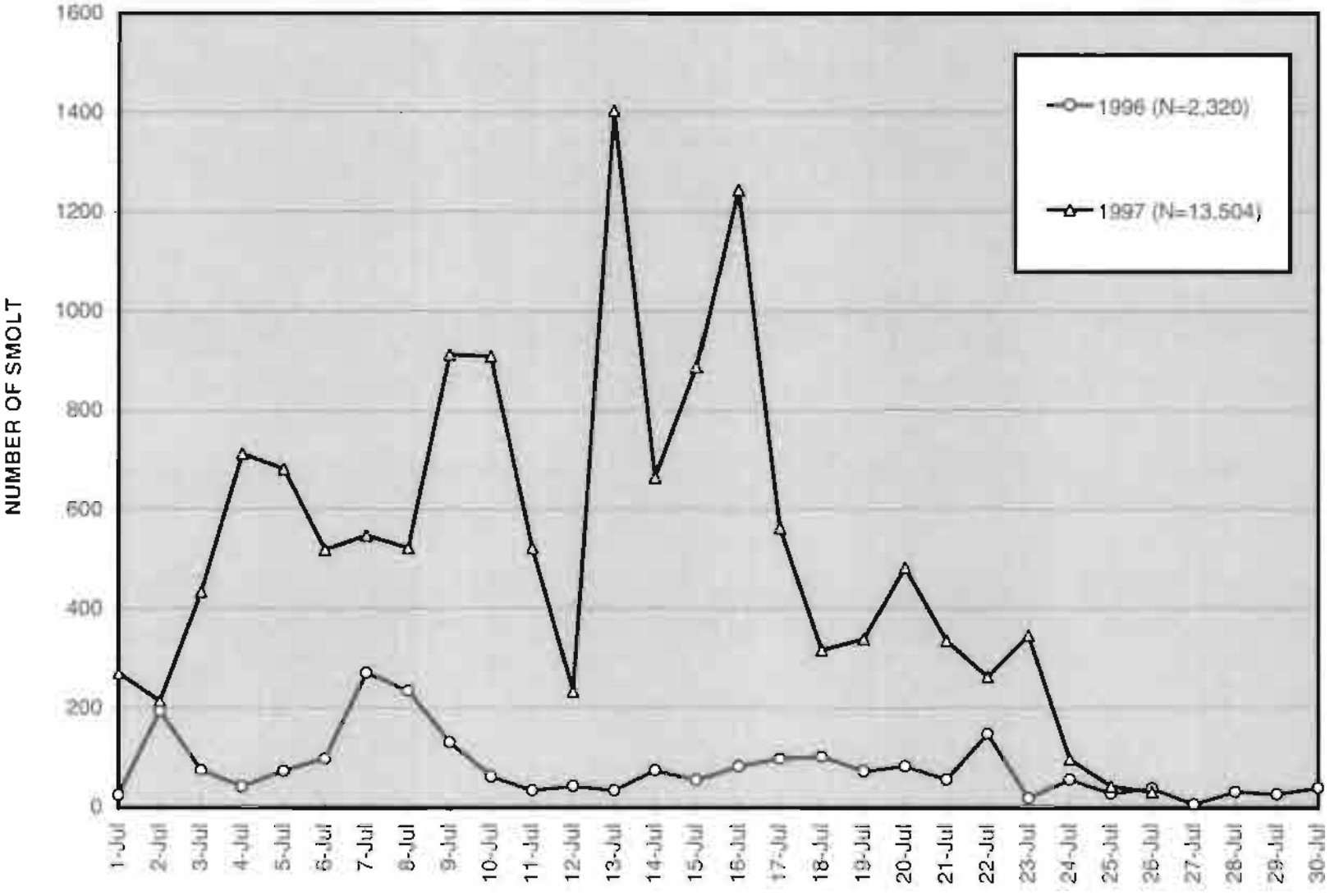


Figure 11. Daily number of sockeye salmon smolt caught post 30 June, 1996-1997.

APPENDIX

Appendix A. Number of sockeye salmon smolt caught with rotary-screw traps by day, Chignik River, 3 May-30 June, 1997.

	Combined Trap Catch[a]		Trap Efficiency Test					
Date[b]	Daily[c]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Marked Recoveries For Dye Test Period[d]	Recovery Rate %[e]	Incidental Catch[f]
3-May	71	71	0	0				Both traps fishing @ 1200 hrs; 18 S_f; 20 DV; 40 SB; 34 SC; 4 PS
4-May	25	96	0	0				Installed lead; 12 S_f; 22 DV; 51 SB; 30 SC; 4 PS; 3 SF
5-May	102	198	0	0				13 S_f; 4 CO_s; 29 DV; 70 SB; 26 SC; 7 PS; 3 SF
6-May	223	421	0	0				15 S_f; 7 CO_s; 35 DV; 97 SB; 63 SC; 14 PS; 3 SF; 1 blackfish
7-May	274	695	0	0				Adjusted lead; 19 S_f; 4 CO_s; 33 DV; 141 SB; 65 SC; 15 PS; 2 SF
8-May	3,331	4,026	0	0				5 S_f; 1 CO_s; 47 DV; 140 SB; 45 SC; 5 PS; 3 SF
9-May	343	4,369	1,057	351	8			22 S_f; 3 CO_s; 34 DV; 162 SB; 47 SC; 9 PS; 1 SF
10-May	214	4,583	0	217	3			23 S_f; 2 CO_s; 23 DV; 109 SB; 55 SC; 5 PS; 5 SF
11-May	1,289	5,872	0	1,293	4	15	1.42%	45 S_f; 1 CO_s; 36 DV; 291 SB; 85 SC; 5 PS; 6 SF
12-May	489	6,361	0	0				55 S_f; 9 CO_s; 28 DV; 289 SB; 52 SC; 1 PS; 1 SF
13-May	539	6,900	0	0				43 S_f; 2 CO_s; 12 DV; 346 SB; 44 SC; 1 PS; 1 SF
14-May	6,243	13,143	1,468	6,254	11			101 S_f; 2 CO_s; 24 DV; 321 SB 81 SC; 4 SF
15-May	2,043	15,186	0	2,045	2			117 S_f; 2 CO_s; 15 DV; 179 SB; 48 SC; 3 PS
16-May	5,714	20,900	0	5,714	0	13	0.89%	63 S_f; 1 CO_s; 12 DV; 131 SB; 4 PS; 2 SF
17-May	12,713	33,613	0	0				16 S_f; 5 DV; 113 SB; 15 SC;
18-May	15,254	48,867	0	0				130 SB; 14 SC; 1 PS; 1 SF
19-May	16,319	65,186	1,559	16,328	9			23 S_f; 1 DV; 52 SB; 10 SC; 1 PS
20-May	21,290	86,476	0	21,295	5			17 S_f; 1 CO_s; 2 DV; 48 SB; 17 SC; 1 PS
21-May	48,068	134,544	0	48,068	0	14	0.90%	Large numbers of sockeye smolt caught in traps, no bycatch indexed
22-May	26,056	160,600	0	0				123 S_f; 2 CO_s; 7 DV; 94 SB; 14 SC
23-May	4,214	164,814	4,026	4,251	37			15 DV; 90 SB
24-May	17,790	182,604	0	17,797	7			Adjusted lead; 26 S_f; 7 CO_s; 2 DV; 86 SB 8 SC; 1 PS
25-May	12,864	195,468	0	12,867	3	47	1.17%	56 S_f; 3 CO_s; 18 DV; 128 SB; 9 SC
26-May	17,285	212,753	0	0				27 S_f; 5 CO_s; 61 DV; 206 SB; 49 SC; 1 PS; 1 SF
27-May	16,565	229,318	0	0				42 S_f; 1 CO_s; 29 DV; 198 SB; 23 SC; 4 PS; 1 SF

-Continued-

	Combined Trap Catch[a]		Trap Efficiency Test					
Date[b]	Daily[c]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Marked Recoveries For Dye Test Period[d]	Recovery Rate %[e]	Incidental Catch[f]
28-May	11,408	240,726	4,056	11,431	23			8 S_f; 6 CO_s; 37 DV; 62 SB;35 SC; 6 PS; 2 Isopods
29-May	6,465	247,191	0	6,473	8			37 S_f; 6 CO_s; 36 DV; 97 SB; 42 SC; 1 PWF; 5 PS
30-May	4,155	251,346	0	4,160	5	36	0.89%	42 S_f; 6 CO_s; 34 DV; 104 SB; 30 SC; 6 PS 1 SF
31-May	1,304	252,650	0	0				34 S_f; 4 CO_s; 24 DV; 140 SB; 32 SC; 2 PWF; 1 PS; 1 SF
1-Jun	748	253,398	0	0				53 S_f; 1 CO_s; 24 DV; 239 SB; 26 SC; 2 PS; 2 SF
2-Jun	707	254,105	0	0				54 S_f; 2 CO_s; 49 DV; 251 SB; 56 SC; 2 PS
3-Jun	982	255,087	0	0				70 S_f; 3 C_s; 34 DV; 214 SB; 26 SC; 3 PS; 1 SF; 4 CH_s
4-Jun	1,405	256,492	947	1,416	11			51 S_f; 4 CO_s; 20 DV; 81 SB; 23 SC; 1 PS; 2 CH_s
5-Jun	1,101	257,593	0	1,104	3			70 SF; 7 CH; 32 DV; 126 SB; 29 SC; 2 PS; 4 CH_s; 3 Isopods
6-Jun	327	257,920	0	327	0	14	1.48%	35 S_f; 4 CO_s; 23 DV; 105 SB; 37 SC; 1 PS 10 CH_s; 1 Isopod
7-Jun	359	258,279	0	0				64 S_f; 11 DV; 90 SB; 18 SC; 7 CH_s
8-Jun	401	258,680	0	0				91 S_f; 1 CO_s; 17 DV; 144 SB; 38 SC; 5 CH_s
9-Jun	298	258,978	0	0				74 S_f; 1 CO_s; 7 DV; 338 SB; 13 SC; 7 CH_s
10-Jun	207	259,185	0	0				81 S_f; 1 CO_s; 4 DV; 168 SB; 17 SC; 1 PS; 3 CH_s
11-Jun	182	259,367	0	0				48 S_f; 2 CO_s; 7 DV; 96 SB; 17 SC; 1 PWF; 11 CH_s
12-Jun	166	259,533	0	0				47 S_f; 5 CO_s; 5 DV; 132 SB; 20 SC; 11 CH_s
13-Jun	242	259,775	0	0				77 S_f; 6 CO_s; 10 DV; 96 SB; 17 SC; 3 PS; 42 CH_s
14-Jun	197	259,972	0	0				28 S_f; 1 CO_s; 4 DV; 64 SB; 12 SC; 3 PS; 1 SF; 17 CH_s
15-Jun	315	260,287	0	0				31 S_f; 1 CO_s; 4 DV; 53 SB; 16 SC; 3 PS; 1 SF; 2 CH_s
16-Jun	672	260,959	0	0				33 S_f; 4 DV; 77 SB; 21 SC; 3 PS; 16 CH_s
17-Jun	595	261,554	0	0				97 S_f; 2 CO_s; 14 DV; 70 SB; 38 SC; 8 CH_s; 1 Adult Sockeye (450mm)
18-Jun	447	262,001	1,172	460	13			77 S_f; 3 CO_s; 11 DV; 112 SB; 24 SC; 8 PS; 3 CH_s
19-Jun	223	262,224	0	225	2			35 S_f; 4 CO_s; 14 DV; 111 SB; 21 SC; 7 CH_s; 1 Isopod
20-Jun	472	262,696	0	472	0	15	1.28%	43 S_f; 5 CO_s; 7 DV; 95 SB; 24 SC; 3 PS; 15 CH_s
21-Jun	297	262,993	0	0				56 S_f; 4 CO_s; 6 DV; 224 SB; 36 SC; 4 PS; 1 CH_s; 1 Isopod
22-Jun	133	263,126	0	0				19 S_f; 23 CO_s; 16 DV; 71 SB; 20 SC; 1 PS; 31 CH_s
23-Jun	71	263,197	0	0				22 S_f; 7 CO_s; 13 DV; 122 SB; 30 SC; 7 PS; 14 CH_s; 1 Isopod

-Continued-

	Combined Trap Catch[a]		Trap Efficiency Test					
Date[b]	Daily[c]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Marked Recoveries For Dye Test Period[d]	Recovery Rate %[e]	Incidental Catch[f]
24-Jun	78	263,275	0	0				12 S_f; 4 CO_s; 14 DV; 60 SB; 23 SC; 2 PS; 10 CH_s
25-Jun	101	263,376	0	0				14 S_f; 8 CO_s; 17 DV; 57 SB; 19 SC; 4 PS; 17 CH_s
26-Jun	137	263,513	0	0				4 S_f; 3 CO_s; 6 DV; 48 SB; 10 SC; 3 PS; 8 CH_s
27-Jun	180	263,693	0	0				6 S_f; 4 CO_s; 6 DV; 46 SB; 14 SC; 5 PS; 6 CH_s
28-Jun	209	263,902	0	0				14 S_f; 5 CO_s; 8 DV; 72 SB; 16 SC; 5 PS; 11 CH_s
29-Jun	318	264,220	0	0				27 S_f; 4 CO_s; 13 DV; 75 SB; 17 SC; 10 PS; 11 CH_s
30-Jun	458	264,678	0	0				19 S_f; 5 CO_s; 7 DV; 88 SB; 12 SC; 4 PS; 9 CH_s
								Pulled large trap for season; moved small trap to weir site
Total	264,678	264,678	14,285	162,548	154	154	1.08%	

[a] Traps fished had cone diameters of 1.5 m (small trap) and 2.4 m (large trap).

[b] Each date listed covers a 24-hr period extending from noon to noon and identifies the date of the 24-hr period.

[c] Number of fish caught does not include mark recoveries from trap efficiency test.

[d] Represents the estimated sum of marked recoveries for a particular dye test period.

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

[f] Incidental catch abbreviations are: S_f = sockeye fry; CO_s = coho smolt; CH_s = chinook smolt; DV = Dolly Varden; SB = stickleback; SC = sculpin; PWF = pygmy whitefish; PS = pond smelt; SF = starry flounder.

Appendix B. Number of sockeye salmon smolt caught by trap, by day, Chignik River, 3 May- 30 June, 1997.

	Small Trap		Large Trap		Combined		Percent of Total Daily Catch by Trap	
Date	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Small	Large
3-May	11	11	60	60	71	71	15%	85%
4-May	4	15	21	81	25	96	16%	84%
5-May	14	29	88	169	102	198	14%	86%
6-May	33	62	190	359	223	421	15%	85%
7-May	57	119	217	576	274	695	21%	79%
8-May	888	1,007	2,443	3,019	3,331	4,026	27%	73%
9-May	67	1,074	276	3,295	343	4,369	20%	80%
10-May	40	1,114	174	3,469	214	4,583	19%	81%
11-May	280	1,394	1,009	4,478	1,289	5,872	22%	78%
12-May	96	1,490	393	4,871	489	6,361	20%	80%
13-May	85	1,575	454	5,325	539	6,900	16%	84%
14-May	165	1,740	6,078	11,403	6,243	13,143	3%	97%
15-May	149	1,889	1,894	13,297	2,043	15,186	7%	93%
16-May	506	2,395	5,208	18,505	5,714	20,900	9%	91%
17-May	993	3,388	11,720	30,225	12,713	33,613	8%	92%
18-May	1,171	4,559	14,083	44,308	15,254	48,867	8%	92%
19-May	881	5,440	15,440	59,748	16,321	65,188	5%	95%
20-May	612	6,052	20,678	80,426	21,290	86,478	3%	97%
21-May	1,324	7,376	46,744	127,170	48,068	134,546	3%	97%
22-May	839	8,215	25,217	152,387	26,056	160,602	3%	97%
23-May	360	8,575	3,854	156,241	4,214	164,816	9%	91%
24-May	1,515	10,090	16,275	172,516	17,790	182,606	9%	91%
25-May	610	10,700	12,254	184,770	12,864	195,470	5%	95%
26-May	819	11,519	16,466	201,236	17,285	212,755	5%	95%
27-May	1,022	12,541	15,543	216,779	16,565	229,320	6%	94%
28-May	655	13,196	10,753	227,532	11,408	240,728	6%	94%
29-May	225	13,421	6,240	233,772	6,465	247,193	3%	97%
30-May	195	13,616	3,960	237,732	4,155	251,348	5%	95%
31-May	245	13,861	1,059	238,791	1,304	252,652	19%	81%
1-Jun	144	14,005	604	239,395	748	253,400	19%	81%
2-Jun	195	14,200	512	239,907	707	254,107	28%	72%
3-Jun	171	14,371	811	240,718	982	255,089	17%	83%
4-Jun	136	14,507	1,269	241,987	1,405	256,494	10%	90%
5-Jun	150	14,657	951	242,938	1,101	257,595	14%	86%
6-Jun	68	14,725	259	243,197	327	257,922	21%	79%
7-Jun	104	14,829	255	243,452	359	258,281	29%	71%
8-Jun	96	14,925	305	243,757	401	258,682	24%	76%
9-Jun	67	14,992	231	243,988	298	258,980	22%	78%
10-Jun	59	15,051	148	244,136	207	259,187	29%	71%
11-Jun	48	15,099	131	244,267	179	259,366	27%	73%
12-Jun	52	15,151	114	244,381	166	259,532	31%	69%
13-Jun	56	15,207	186	244,567	242	259,774	23%	77%

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Appendix B. (page 2 of 2)

	Small Trap		Large Trap		Combined		Percent of Total Daily Catch by Trap	
Date	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Small	Large
14-Jun	34	15,241	163	244,730	197	259,971	17%	83%
15-Jun	70	15,311	245	244,975	315	260,286	22%	78%
16-Jun	76	15,387	596	245,571	672	260,958	11%	89%
17-Jun	67	15,454	528	246,099	595	261,553	11%	89%
18-Jun	66	15,520	381	246,480	447	262,000	15%	85%
19-Jun	75	15,595	148	246,628	223	262,223	34%	66%
20-Jun	119	15,714	353	246,981	472	262,695	25%	75%
21-Jun	61	15,775	236	247,217	297	262,992	21%	79%
22-Jun	17	15,792	116	247,333	133	263,125	13%	87%
23-Jun	24	15,816	47	247,380	71	263,196	34%	66%
24-Jun	35	15,851	43	247,423	78	263,274	45%	55%
25-Jun	36	15,887	75	247,498	111	263,385	32%	68%
26-Jun	31	15,918	106	247,604	137	263,522	23%	77%
27-Jun	44	15,962	136	247,740	180	263,702	24%	76%
28-Jun	45	16,007	164	247,904	209	263,911	22%	78%
29-Jun	90	16,097	228	248,132	318	264,229	28%	72%
30-Jun	93	16,190	365	248,497	458	264,687	20%	80%
Total	16,190	16,190	248,488	248,488	264,678	264,678	6%	94%

Appendix C. Estimated number of sockeye salmon smolt outmigrating from Chignik Lakes by strata, age class and year, 1994-1997.

				Age-0				Age-1				Age-2				Age-3			
		Stratum	Dates	Population		95% CI		Population		95% CI		Population		95% CI		Population		95% CI	
Year	Stratum	Start	End	Estimate	SE	Lower	Upper	Estimate	SE	Lower	Upper	Estimate	SE	Lower	Upper	Estimate	SE	Lower	Upper
1994	1	5/5	5/13	[a]				217,902	97,808	26,200	409,605	231,678	103,903	28,029	435,327	[b]			
1994	2	5/14	5/19	[a]				429,881	155,768	124,575	735,186	1,030,879	365,401	314,694	1,747,064	[b]			
1994	3	5/20	5/26	[a]				952,641	229,010	503,781	1,401,500	844,503	204,226	444,220	1,244,787	[b]			
1994	4	5/27	6/3	[a]				1,402,107	470,129	480,653	2,323,561	1,041,398	351,408	352,639	1,730,159	[b]			
1994	5	6/4	6/10	[a]				374,906	109,024	161,218	588,594	181,869	54,282	75,478	288,263	[b]			
1994	6	6/11	6/16	[a]				671,943	181,128	316,932	1,026,954	267,976	81,179	128,865	447,086	[b]			
1994	7	6/17	6/23	[a]				1,599,731	462,689	692,862	2,506,601	267,514	84,726	101,451	433,576	[b]			
1994	8	6/24	7/1	[a]				1,613,943	405,076	819,990	2,407,895	384,819	104,937	179,142	590,496	[b]			
	Total							7,263,054	854,494	5,589,246	8,937,862	4,270,636	580,721	3,132,424	5,408,848				
1995	1	5/6	5/20	231,819	73,334	88,084	375,554	327,744	101,922	127,978	527,511	1,105,804	333,556	452,094	1,759,574	[b]			
1995	2	5/21	5/29	163,513	70,969	24,413	302,612	1,035,580	376,586	297,472	1,773,689	3,368,362	1,190,654	1,034,679	5,702,045	[b]			
1995	3	5/30	6/5	216,729	68,583	82,306	351,153	767,302	230,007	336,489	1,238,115	539,611	160,009	225,994	853,229	[b]			
1995	4	6/6	6/12	100,590	33,157	35,602	165,578	273,030	86,828	102,847	443,213	129,330	42,108	46,797	211,862	[b]			
1995	5	6/13	6/20	17,772	4,649	8,660	26,883	168,239	33,059	103,444	233,034	19,549	4,999	9,751	29,347	[b]			
1995	6	6/21	6/30	5,493	2,825	0	11,033	251,327	94,835	65,451	437,204	15,794	6,759	2,547	29,041	[b]			
	Total			735,916	127,464	486,086	985,746	2,843,223	471,847	1,919,206	3,768,238	5,178,450	1,247,543	2,733,266	7,623,634				
1996	1	5/6	5/29	16,679	6,935	3,088	30,271	688,026	155,202	383,831	992,221	619,223	140,143	344,543	893,903	4,170	3,086	0	10,219
1996	2	5/30	6/30	63,566	13,055	37,978	89,154	512,767	89,550	337,249	688,285	111,826	21,351	70,028	153,725	848	860	0	2,533
	Total			80,245	14,783	51,271	109,218	1,200,793	179,164	849,593	1,551,993	731,049	141,760	453,248	1,008,849	5,018	4,255	0	13,358
1997	1	5/3	5/12	11,603	4,328	3,121	20,086	188,554	46,535	97,346	279,762	216,596	53,163	112,396	320,795	3,868	2,139	0	8,060
1997	2	5/13	5/17	0	0	0	0	1,082,530	290,328	513,488	1,651,572	1,746,346	456,534	851,539	2,641,153	30,638	19,276	0	68,418
1997	3	5/18	5/21	68,956	91,302	0	267,908	3,736,158	1,038,378	1,700,938	5,771,378	6,871,710	1,723,924	3,292,819	10,050,601	0	0	0	0
1997	4	5/22	5/26	141,613	60,621	22,796	260,430	3,257,102	502,761	2,271,690	4,242,515	3,091,886	481,121	2,148,889	4,034,885	70,807	41,885	0	152,900
1997	5	5/27	6/1	192,374	62,584	69,710	315,039	2,276,428	391,285	1,509,509	3,043,347	1,971,836	345,113	1,295,413	2,648,258	16,031	16,211	0	47,804
1997	6	6/2	6/11	23,637	7,443	9,048	38,225	314,840	78,497	160,988	468,694	37,819	10,971	16,315	59,322	945	973	0	2,853
1997	7	6/12	6/30	70,663	18,229	34,934	106,390	316,536	76,640	166,323	466,752	2,163	1,350	0	4,810	0	0	0	0
	Total			528,846	127,805	278,348	779,344	11,172,150	1,258,011	8,706,448	13,637,852	13,736,356	1,979,858	10,053,834	17,422,878	122,289	48,931	26,384	218,194

[a] Age-0. smolts not sampled.

[b] Age-3. smolts not sampled.

Appendix D. Mean length, weight, and condition factor by age class and date of sockeye salmon smolt captured in the Chignik River, 3 May through 30 June, 1997.

		Length (mm)			Weight (g)			Condition		
Age	Week Beginning	Sample Size	Mean	Standard Error	Sample Size	Mean	Standard Error	Sample Size	Mean	Standard Error
0	05/03	7	48.4	0.90	7	0.7	0.05	7	0.65	0.023
0	05/10	5	48.8	1.39	5	0.8	0.06	5	0.67	0.043
0	05/17	4	45.2	1.60	4	0.6	0.04	4	0.65	0.035
0	05/24	6	46.2	0.79	6	0.7	0.04	6	0.71	0.016
0	05/31	14	46.0	0.82	14	0.7	0.05	14	0.75	0.036
0	06/07	22	47.0	0.94	22	0.9	0.07	22	0.87	0.024
0	06/14	47	45.4	0.49	47	0.8	0.03	47	0.87	0.011
0	06/21	32	46.0	0.42	32	0.8	0.03	32	0.83	0.021
0	06/28	17	47.3	0.67	17	0.9	0.04	17	0.84	0.017
	Totals	154	46.3	0.26	154	0.8	0.02	154	0.82	0.009
1	05/03	128	84.8	0.98	128	5.0	0.15	128	0.78	0.005
1	05/10	141	79.4	0.89	141	4.1	0.12	141	0.77	0.006
1	05/17	98	77.8	1.02	98	3.8	0.13	98	0.77	0.006
1	05/24	192	71.3	0.83	192	3.0	0.10	192	0.76	0.005
1	05/31	213	60.9	0.75	213	1.9	0.07	213	0.76	0.005
1	06/07	250	54.4	0.58	250	1.4	0.05	250	0.82	0.005
1	06/14	133	53.8	0.67	133	1.4	0.06	133	0.85	0.010
1	06/21	185	55.6	0.47	185	1.5	0.05	185	0.83	0.008
1	06/28	53	52.7	0.68	53	1.3	0.05	53	0.84	0.009
	Totals	1393	64.7	0.40	1393	2.5	0.05	1393	0.80	0.002

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Age	Week Beginning	Length (mm) Sample Size	Length (mm) Mean	Length (mm) Standard Error	Weight (g) Sample Size	Weight (g) Mean	Weight (g) Standard Error	Condition Sample Size	Condition Mean	Condition Standard Error
2	05/03	159	87.7	0.48	159	5.6	0.11	159	0.82	0.009
2	05/10	199	85.2	0.33	199	4.9	0.06	199	0.78	0.004
2	05/17	152	83.3	0.50	152	4.7	0.12	152	0.79	0.004
2	05/24	145	80.7	0.47	145	4.2	0.07	145	0.79	0.004
2	05/31	100	77.5	0.74	100	3.8	0.14	100	0.79	0.005
2	06/07	7	74.4	1.46	7	3.5	0.23	7	0.83	0.012
2	06/21	3	75.0	7.64	3	3.5	0.93	3	0.79	0.034
	Totals	765	83.4	0.25	765	4.7	0.05	765	0.80	0.003
3	05/03	3	91.7	2.73	3	6.5	0.89	3	0.83	0.039
3	05/10	3	89.0	0.58	3	5.5	0.12	3	0.78	0.005
3	05/17	2	82.5	2.50	2	4.2	0.90	2	0.74	0.093
3	05/24	3	86.7	1.45	3	4.7	0.09	3	0.73	0.025
3	05/31	1	80.0	0.00	1	3.9	0.00	1	0.76	0.000
	Totals	12	87.3	1.34	12	5.2	0.35	12	0.77	0.019

Appendix E. Summary of historic mean length-at-age and percent of sampled outmigration by age class for sockeye salmon smolts from the Chignik River.

Outmigration Year	Sample Size	Smolt: Percent Age Composition				Smolt: Mean Length (mm)				Parent Year Escapements[a]		Total Adult Return Produced by Parent Year Escapment[b,c]	
		Age-0.	Age-1.	Age-2.	Age-3.	Age-0.	Age-1.	Age-2.	Age-3.	Black Lake	Chignik Lake	Black Lake	Chignik Lake
1956	421	[d]	7.0	92.0	1.0	[d]	79	81	96	185,000	221,000	277,000	560,000
1957	4,613	[d]	24.0	74.0	1.3	[d]	80	83	102	257,000	278,000	526,000	776,000
1958	[e]	[d]	8.8	90.9	0.3	[d]	78	79	[e]	289,000	201,000	195,000	534,000
1959	[e]	[d]	34.3	60.1	5.6	[d]	76	85	104	192,000	483,000	239,000	617,000
1993	2,368	[d]	73.0	27.0	[d]	[d]	80	91	[d]	658,000	336,000	2,200,000	1,000,000
1994	2,818	[d]	63.0	37.0	[d]	[d]	67	77	[d]	361,000	383,000	663,000	923,000
1995	2,570	8.4	32.5	59.1	[d]	46	60	75	[d]	364,000	406,000		
1996	1,450	4.0	59.5	36.2	0.2	48	67	79	100	767,000	333,000		
1997	2,327	2.1	43.7	53.7	0.5	46	65	83	87	366,000	200,000		

[a] Historically Black Lake stocks have been generalized as age-1. smolts and Chignik Lake stocks as age-2. smolts.

[b] Total adult return includes estimated total catch and escapement of sockeye salmon. Catch figures do not include subsistence harvests.

[c] All adult returns are three years after outmigration year.

[d] No samples collected.

[e] Specific numbers not available.

Appendix F. Mean length, weight, and condition factor by age class and date of sockeye salmon smolt captured in the Chignik River, post 30 June, 1997.

		Length (mm)			Weight (g)			Condition		
Age	Week beginning	Sample Size	Mean	Standard Error	Sample Size	Mean	Standard Error	Sample Size	Mean	Standard Error
0	07/01	35	46.7	0.04	35	0.9	0.03	35	0.86	0.020
0	07/12	4	47.5	1.04	4	0.9	0.09	4	0.83	0.036
0	07/19	2	44.5	2.50	2	0.9	0.20	2	1.00	0.057
	Totals	41	46.7	0.38	41	0.9	0.03	41	0.86	0.018
1	07/01	102	56.8	0.71	102	1.7	0.07	102	0.88	0.008
1	07/12	122	57.1	0.66	122	1.7	0.06	122	0.89	0.006
1	07/19	56	56.4	0.89	56	1.7	0.09	56	0.90	0.007
	Totals	280	56.9	0.42	280	1.7	0.0	280	0.89	0.004
2	07/01	3	84.3	5.78	3	5.4	1.27	3	0.86	0.036
2	07/12	2	73.5	2.50	2	3.5	0.55	2	0.89	0.048
2	07/19	2	67.5	7.50	2	3.0	1.10	2	0.93	0.046
	Totals	7	76.4	4.05	7	4.2	0.70	7	0.88	0.023

Appendix G. Number of sockeye salmon smolts caught with rotary-screw trap by day, Chignik River, post 30 June, 1997.

Date	Small Trap Daily	Small Trap Cumulative	Incidental Catch[a]
7/1/97	271	271	Moved small trap behind ADF&G weir, 15 S_f; 1 CO_s; 5 DV
7/2/97	214	485	3 S_f; 1 CO_s; 11 SB; 7 SC; 1 PS; 3 CH_s; 2 Isopods
7/3/97	435	920	9 S_f; 3 CO_s; 2 DV; 16 SB; 6 SC; 2 PS; 4 CH_s
7/4/97	713	1,633	11 S_f; 11 SC; 7 CH_s; 3 isopods
7/5/97	682	2,315	13 S_f; 2 CO_s; 1 DV; 6 SB; 3 CH_s
7/6/97	519	2,834	6 S_f; 2 CO_s; 1 DV; 12 SB
7/7/97	548	3,382	12 S_f; 1 CO_s; 7 SB; 3 CH_s
7/8/97	523	3,905	4 S_f; 8 DV; 26 SB; 6 SC; 2 CH_s
7/9/97	913	4,818	16 S_f; 2 DV; 14 SB; 1 SC; 1 SF; 3 CH_s
7/10/97	909	5,727	10 S_f; 2 CO_s; 2 DV; 10 SB; 2 SC; 4 PS; 1 CH_s
7/11/97	523	6,250	8 S_f; 4 DV; 13 SB; 17 SC; 4 PS; 1 CH_s
7/12/97	234	6,484	2 S_f; 1 CO_s; 3 DV; 12 SB; 17 SC; 6 PS; 2 CH_s; 2 Isopods
7/13/97	1,404	7,888	6 S_f; 2 CO_s; 1 DV; 17 SB; 14 SC; 7 PS; 2 CH_s; 3 Isopods
7/14/97	665	8,553	3 S_f; 1 CO_s; 2 DV; 13 SB; 11 SC; 3 CH_s; 4 Isopods
7/15/97	888	9,441	9 S_f; 1 CO_s; 5 DV; 21 SB; 21 SC; 4 PS; 2 CH_s; 4 Isopods
7/16/97	1,245	10,686	7 S_f; 1 CO_s; 4 DV; 20 SB; 15 SC; 1 PS; 3 CH_s; 2 Isopods
7/17/97	563	11,249	2 S_f; 3 SC; 6 CH_s
7/18/97	317	11,566	11 S_f; 1 DV; 4 SB; 11 SC; 2 PS; 2 CH_s; 1 Isopod
7/19/97	339	11,905	14 S_f; 9 SC; 2 PS; 3 CH_s; 2 Isopods
7/20/97	483	12,388	6 S_f; 14 SC; 4 PS; 3 CH_s
7/21/97	336	12,724	11 S_f; 7 SB; 13 SC; 2 PS; 1 CH_s; 1 Isopod
7/22/97	263	12,987	13 S_f; 1 DV; 5 SB; 9 SC; 2 PS
7/23/97	346	13,333	3 S_f; 1 DV; 12 SB; 17 SC; 6 PS; 3 CH_s; 2 Isopods
7/24/97	97	13,430	7 S_f; 8 SB; 7 SC; 1 PS; 1 CH_s
7/25/97	43	13,473	5 S_f; 5 SB; 8 SC; 2 PS
7/26/97	31	13,504	8 S_f; 12 SB; 5 SC; pulled small trap for season
Total	13,504	13,504	

[a] Incidental catch abbreviations are: S_f = sockeye fry; CO_s = coho smolt; CH_s = chinook smolt; DV = Dolly Varden; SB = stickleback; SC = sculpin; PS = pond smelt; Sf = starry flounder.

Appendix H. Daily climatological observations, water temperature, water depth, and trap rpm at Chignik River, 1997.

Date	Time	Air (c)	Water (c)	Cloud Cover %	Wind Dir	Vel. (Mph)	Stream Guage (cm)	Trap RPM Small	Trap RPM Large	Comments
3-May	1200	8.5	4	50	NW	0-5	23	4.75	5.00	Traps commenced fishing at 1200 hrs.
4-May	1155	9.0	4.0	10	NW	0-5	25	5.25	5.00	Sunny/clear skies, vis. unlimited
5-May	1200	13.5	5.5	0	NW	5-10	27	5.25	5.50	Sunny/clear skies, vis. unlimited
6-May	1205	15.0	6.0	20	NW	0-5	28	5.50	5.50	Slightly broken, sunny
7-May	1150	9.0	4.5	25	SE	5-10	29	6.00	6.00	3000 broken, sunny, wind shift
8-May	1155	9.5	5.0	40	SE	0-5	30	6.00	6.00	3500 scattered, sunny
9-May	1200	8.0	4.5	80	SE	5-10	33	6.00	6.25	2500 broken, overcast
10-May	1205	9.0	5.0	75	NW	0-5	33	6.25	6.00	2500 broken, partly sunny
11-May	1200	9.0	5.0	90	SE	0-5	33	6.50	6.00	2500 slightly broken, light rain
12-May	1200	7.0	5.0	30	NW	15-25	38	7.00	6.50	3500 broken, sunny and windy
13-May	1205	7.0	5.0	80	SE	0-5	38	7.00	6.25	3000 partly broken
14-May	1155	7.0	5.0	90	NW	15	37	7.00	6.50	2000 partly broken
15-May	1205	8.0	5.0	80	NW	0-5	40.5	7.25	6.75	3500 broken
16-May	1205	9.0	5.0	50	NW	5-10	39	7.25	6.75	3000 broken, light drizzle
17-May	1200	7.0	5.0	25	NW	5	39	7.25	6.50	3500 scattered, sunny
18-May	1200	7.0	5.0	0	SE	25-35	41	7.00	6.25	2000 solid, raining and windy
19-May	1210	7.0	5.0	80	NW	5	40.5	6.50	7.50	2000 partly broken, drizzle
20-May	1215	10.0	6.0	80	NW	5-10	47	8.50	7.25	2500 broken, light drizzle
21-May	1210	9.0	6.0	90	NW	0-5	50	8.50	7.50	3000 broken, overcast
22-May	1205	8.0	6.0	90	SE	10	55	9.00	7.75	3000 partly broken
23-May	1200	11.0	6.0	0	SE	5	61	9.00	7.75	Sunny/clear skies, vis. unlimited
24-May	1205	9.5	6.0	50	SE	10-15	63	9.00	8.00	3500 scattered, sunny
25-May	1200	9.5	6.5	20	SE	10-15	59	9.00	7.75	3500 scattered, sunny
26-May	1205	12.0	7.0	0	SE	10-15	60	9.00	8.00	Sunny/clear skies, vis. unlimited
27-May	1215	10.0	7.0	0	SE	15	60	9.25	8.00	Sunny/clear skies, vis. unlimited
28-May	1205	9.0	7.0	100	SE	5	62	9.75	8.25	2000 solid, light rain
29-May	1205	10.0	7.5	100	NW	10	63	9.25	7.75	2000 solid, light drizzle
30-May	1200	10.0	7.0	30	SE	5	62	9.50	8.00	3000 solid, sunny

-Continued-

Date	Time	Air (c)	Water (c)	Cloud Cover %	Wind Dir	Vel. (Mph)	Stream Guage (cm)	Trap RPM Small	Trap RPM Large	Comments
31-May	1200	13.0	9.0	25	SE	5	63	9.5	8.25	3500 scattered, sunny
1-Jun	1205	14.0	8.5	0	NW	10	68	9.50	8.50	Sunny/clear skies, vis. unlimited
2-Jun	1210	13.0	9.0	0	SE	5	69	9.50	8.50	Sunny/clear skies, vis. unlimited
3-Jun	1200	9.0	9.0	90	SE	10	69.5	9.25	8.25	2000 slightly broken
4-Jun	1200	8.5	8.5	100	SE	5	67	9.25	8.25	1500 solid, light rain
5-Jun	1200	8.0	8.0	100	SE	5	65	9.00	8.00	1000 solid, rain
6-Jun	1210	10.0	8.5	80	SE	5	65	9.00	8.00	1500 partly broken, light drizzle
7-Jun	1200	8.0	9.0	90	SE	5	61	7.75	8.00	1000 partly broken, light drizzle
8-Jun	1205	9.0	8.5	75	SE	5	61	8.50	8.00	2500 broken, light rain
9-Jun	1200	9.5	8.5	50	NW	5	60	8.25	7.75	3000 broken
10-Jun	1205	8.5	9.0	75	SE	5-10	57.5	8.50	7.50	2000 partly broken
11-Jun	1200	9.0	9.0	100	SE	5-10	53.5	7.75	7.25	1000 solid, rain
12-Jun	1210	8.5	8.5	100	SE	10-20	53	7.50	7.00	800 solid, rain
13-Jun	1200	10.0	9.0	60	SE	5	51	7.50	7.25	1500 broken, drizzle
14-Jun	1205	7.5	8.5	60	SE	5	54	7.75	7.25	2000 broken, rain
15-Jun	1200	8.0	9.0	90	SE	5	59	8.00	7.50	1000 partly broken, rain
16-Jun	1200	10.0	9.5	80	NW	0-5	59	8.00	7.50	1500 partly broken, drizzle
17-Jun	1205	10.0	9.5	60	NW	0-5	57.5	8.00	7.50	2000 scattered
18-Jun	1200	10.0	9.0	30	NW	5	54.5	8.00	7.50	3000 scattered
19-Jun	1205	11.0	9.5	50	NW	5	52.5	8.00	7.50	2500 broken
20-Jun	1200	14.0	10.5	10	NW	10	50.5	7.50	7.25	Sunny/clear skies, vis. unlimited
21-Jun	1200	11.0	10.0	20	NW	15-20	49.5	7.50	7.25	3500 scattered, windy
22-Jun	1205	9.5	10.0	50	NW	20-25	52.5	7.75	7.25	2500 broken, very windy
23-Jun	1200	16.0	11.5	40	NW	5-10	52	7.25	7.00	3000 broken, warm
24-Jun	1200	11.5	10.5	65	NW	5	52	7.75	7.00	2500 broken
25-Jun	1205	11.0	11.0	80	NW	5	52	7.75	7.00	2000 slightly broken
26-Jun	1200	13.5	12.0	10	NW	15-20	49.5	7.75	7.00	3500, sunny and windy
27-Jun	1200	14.0	12.0	0	NW	5-10	49	7.00	7.00	Sunny/clear skies, vis. unlimited

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Appendix H. (page 3 of 3)

Date	Time	Air (c)	Water (c)	Cloud Cover %	Wind Dir	Vel.	(Mph)	Stream Guage (cm)	Trap RPM Small	Trap RPM Large	Comments
28-Jun	1210	16.0	12.0	0	NW	5		49	7.00	7.00	Sunny/clear skies, vis. unlimited
29-Jun	1215	12.0	11.0	100	SE	5		49	7.00	7.00	2000 solid, light rain
30-Jun	1205	11.5	11.0	100	SE	5		48	7.00	7.00	3000 solid, last day fishing with large trap
1-Jul	1200	11.0	11.0	100	NW	0-5		39.5	3.50		Small trap moved to weir site, 2000 solid
2-Jul	1445	13.0	11.0	100	SE	5		41.5	4.00		2000 solid
3-Jul	1230	14.0	11.5	0	SE	5		40	5.50		Sunny/clear skies, vis. unlimited
4-Jul	1230	16.0	12.5	0	0	0		37	5.25		Sunny/clear skies, vis. unlimited
5-Jul											No climatic observations recorded from 5 July to
6-Jul											11 July; no trap rpm recorded from 5 July to 7 July
7-Jul											
8-Jul									4.50		
9-Jul									5.25		
10-Jul									5.50		
11-Jul									6.25		
12-Jul	1310	12.0	12.0	40	NW	20-25		40	5.75		3500 scattered, windy
13-Jul	1200	12.5	11.5	50	NW	10-20		36	4.25		2500 broken, windy
14-Jul	1205	12.0	11.5	20	NW	10-15		37	4.50		3500 broken, windy
15-Jul	1200	12.0	12.0	10	NW	10-15		33	4.75		3000 scattered, light winds
16-Jul	1200	13.0	12.0	10	SE	5-10		34	4.50		1500 broken
17-Jul	1200	12.5	12.0	50	SE	0-5		36.5	4.00		3000 scattered
18-Jul	1200	11.5	12.0	20	SE	0-5		34	4.00		2000 scattered
19-Jul	1200	12.0	12.0	30	SE	0-5		35.5	4.00		2500 broken
20-Jul	1200	13.0	12.5	50	SE	5		36.5	4.25		2500 broken
21-Jul	1205	14.0	12.5	30	SE	5		35	4.25		2500 broken
22-Jul	1230	12.5	13.0	40	NW	0-5		34	4.00		3500 broken
23-Jul	1310	13.5	13.0	80	NW	5-10		37.5	4.00		3000 broken
24-Jul	1200	13.0	13.0	10	NW	20-25		36	3.75		1500 broken
25-Jul	1200	14	13.5	30	NW	20-25		33	3.50		2000 broken
26-Jul	1205	13.0	13.0	40	SE	10		36.5	3.75		2000 broken, pulled small trap for season