4K94-36

SOCKEYE SMOLT AND PRESMOLT ABUNDANCE, AGE COMPOSITION, AND CONDITION, AND THE USE OF THE PARASITE *PHILOMENA ONCORHYNCHI* AS AN INSEASON STOCK SEPARATION ESTIMATOR FOR RETURNING ADULT SOCKEYE SALMON, CHIGNIK LAKES, 1994

By:

Mark E. Stopha

and

Bruce M. Barrett

Regional Information Report[1] No. 4K94-36

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
211 Mission Road
Kodiak, AK 99615

October 1994

---

[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished division reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

ACKNOWLEDGEMENTS

The Chignik Regional Aquaculture Association provided funding for this project. ADF&G Chignik salmon field staff Mark Stopha, Tom Vania, and Bruce Barrett were responsible for data collection. Alan Quimby and David Owen provided field support. Richard Price, Keith Wible, John Cannon and Malcom Bennett assisted with the parasite stock separation study. Lucinda Neel contributed publication expertise. Jim Blackburn, Charlie Swanton, Dan Urban, and Ivan Vining provided editorial comments. References to equipment tradenames does not imply endorsement by the Alaska Department of Fish and Game.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

In the spring of 1994, the Chignik Regional Aquaculture Association commissioned the Alaska Department of Fish and Game (ADF&G) to conduct studies of juvenile sockeye salmon and stock separation techniques in the Chignik Lakes system. The specific study objectives were:

1. To estimate the total number, timing and growth characteristics of outmigrating sockeye smolt by age class.
2. To archive the smolt scales for later scale pattern analysis use in determining stock composition of the 1994 outmigration from future adult returns.
3. To estimate sockeye fry abundance and condition in each lake.
4. To determine the utility of the parasite *Philomena oncorhynchi* as a tool in assigning returning sockeye adults to their respective stock (lake) of origin.

A total of 60,595 sockeye smolt were captured in two rotary-screw traps operated on the Chignik River from 5 May through 1 July. Overall trap efficiency was 0.48%, and the total sockeye smolt outmigration estimate was 12.75 million fish. Peak in outmigration occurred during 17 - 30 May. Age-1 and age-2 smolt comprised 61% and 39% of the total outmigration, respectively. Based on the estimated number of outmigrating smolt, the total 1997 adult return forecast is 2.1 million fish (95% confidence interval 1.7 to 2.5 million fish). By system, the Black Lake forecast is 1.3 million fish, and the Chignik Lake forecast is 0.8 million fish.

Townet surveys were conducted in Black and Chignik Lakes on September 22 and 23, respectively. Catches indicated a pronounced decrease in juvenile sockeye abundance from 1992 and 1993 surveys, especially for Black Lake. The decline may have been caused by a die-off of Black Lake sockeye juveniles associated with an intense algal bloom on the lake reported to the ADF&G in mid-August prior to the surveys (David Owens, ADF&G, personal communication). Differences in sampling techniques in 1994 may also have influenced catch numbers.

The parasite *Philomena oncorhynchi* was present in 97% (range 96-100) of both Black Lake and Chignik Lake stocks, and therefore not useful for stock separation.

INTRODUCTION

Forecasts of salmon returns are an important aspect of Alaska's commercial salmon fishing industry. The accuracy of forecasts is crucial to fish processors for estimating fish prices, personnel and equipment needs, and to commercial fisherman for timing capital investments. Forecast methods in the Chignik River watershed (Figure 1), the primary producer of sockeye salmon *Oncorhyncus nerka* in the Chignik Management Area, are currently based on parent year escapement and historical age class relationships for Black Lake, and on average return per spawner for Chignik Lake. From 1984-1993, accuracy of forecasts has been quite variable. The absolute average percent difference between the forecast and actual run for both lakes combined is 17%, with a range of from 78% underforecast to 27% overforecast of the actual run (Probasco et al. 1983, 1984, 1985, 1986; Quimby and Owen 1994).

The primary limiting factor in sockeye production is the yearly variability in rearing conditions of the freshwater nursery areas of the Chignik Lakes, particularly Black Lake (Narver 1966; Ruggerone et al. 1992). Although variation in annual escapement levels is lower in Black and Chignik Lakes than in seven other Alaska systems (Wood R., Ugashik, Egegik, Red R., Kasilof, Kenai, and Coghill), return per spawner (R/S) variation among these same systems is greatest in Black Lake, whereas that of Chignik Lake is about average (Ruggerone et al. 1992). Black Lake R/S is uncorrelated with three nearby lakes (Chignik, Becharof, and Ugashik); consequently, R/S is not explained by variation in varying regional weather patterns (Ruggerone et al. 1992). Mortaility during the egg stage is not likely the cause of extreme variation in R/S, since the Black Lake watershed has spawning tributaries with low gradients, good to excellent spawning gravel, and no major problem with spawning ground scouring (Ruggerone et al. 1992; Dahlberg in Ruggerone et al. 1992).

Interaction between sockeye juveniles in Black and Chignik Lakes is likely a major source of the R/S variability in Black Lake. Studies of the lacustrine life of Black Lake juveniles indicate that a portion of yearlings rear in Black Lake, while others emigrate to Chignik Lake (Roos 1959, Ruggerone et al. 1993, Ruggerone 1994, Narver 1966). Narver (1966) attributed such emigrations to density-dependent factors that served as a population-regulation mechanism in Black Lake; however, when Black Lake emigrations combined with already abundant resident Chignik Lake sockeye, severe growth suppression and starvation occurred. Sporadic seasonal die-offs, which have been observed in both Black (Dave Owen, ADF&G, personal communication) and Chignik Lakes (Roos 1958), also undoubtedly contribute to R/S variability.

Knowledge of the numbers, age-class structure, and physical condition of outmigrating sockeye smolt and over-wintering juveniles can provide data to improve current forecasting methods by addressing the variability of adult returns caused by variable freshwater nursery conditions. In the spring of 1994, the Chignik Regional Aquaculture Association commissioned the Alaska Department of Fish and Game (ADF&G) to conduct studies of juvenile sockeye salmon in the Chignik Lakes system. The specific study objectives were:

1. To estimate the total number, timing and growth characteristics of outmigrant sockeye smolt by age class.
2. To estimate sockeye fry abundance and condition in each lake.

3. To archive the smolt scales for later scale pattern analysis use in determining stock composition of the 1994 outmigration from future adult returns.

In addition to the juvenile studies, the efficacy of the parasite *Philomena oncorhynchi* was investigated for use as a stock separation tool in assigning returning sockeye adults to their respective lake of origin.

METHODS

Rotary-screw Traps and Site Description

Two rotary-screw traps were operated side-by-side. Each trap was constructed of a stainless-steel, 2-mm-mesh revolving cone mounted between two aluminum pontoons (Figure 2). The cone entrance diameter was 1.5 m on the inshore trap (small trap), and 2.4 m on the offshore trap (large trap). Fish were funneled through the cone to a live box (small trap = 0.7 m^3; large trap = 0.6 m^3). The large trap livebox was fitted with a rotating perforated stainless-steel drum for debris removal. To discourage mammalian and avian predation, a wire mesh was secured over openings to the live box, and a fitted barrier (made of plastic fencing attached to a wooden rectangular frame) was inserted inside the live box of the large trap in front of the debris removal drum.

The traps were operated in the Chignik River at a location that was 8.3 km upstream from Chignik Lagoon (1.7 km upstream from the Chignik weir) and 2.2 km downstream from the outlet of Chignik Lake (Figure 3). This site, referred to locally as "Hawk's Bluff", is a constricted section of river with a width of 73 m, average depth of 2.7 m, and with a relatively fast current (≈ 1.3 m/sec). The large trap was installed on 5 May. On 8 May, the small trap was installed adjacent to and inshore of the large trap. Traps were fished continuously until 1 July, except for daily cleaning of each cone with a water pump and hose. Also, the small trap malfunctioned and was inoperative on 4 June, but was repaired and fishing the following day.

Traps were tied together for stability. A 10-cm (4-in) x 10-cm (4-in) x 3.7-m (12-ft) plank was lashed across the top of the front of the pontoons, perpendicular to the current, and butted the shore. This served as a fulcrum to maintain and adjust trap position offshore. Each trap was secured to shore with rope tied to alder bushes, and with a safety anchor line tied to the nearshore trap.

Traps were positioned as close to shore as possible to allow trap cones to rotate in the current close to the bottom, as well as to minimize hazards to navigation. A 2.4-m lead constructed of aluminum weir panels supported by wooden tripods was placed between the inshore pontoon of the small trap and shore to deflect fish towards the traps. As water level rose, the traps could be moved to within a meter of shore, thus eliminating the need for the lead. An offshore lead was not feasible due to fast current, excessive depth, and its potential hazard to navigation.

Smolt Enumeration

Captured sockeye salmon smolt were removed and enumerated from each trap daily. Traps were generally checked at least once between 0400 and 1200 hr, and again in the evening. Traps were checked more frequently as daily catches increased. 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.

Species identification of salmonids were made by visual examination of external characteristics (McConnel and Snyder 1972). Only sockeye salmon were enumerated daily, with presence of other species. 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, 1959; Iverson 1966). Narver (1966) estimated that the minimum threshold length for smoltification of age-1 juveniles was 65-mm and 70 mm for Chignik and Black Lakes, respectively. Based on this information, criteria for attempting to distinguish between emigrating smolts and juveniles that would possibly return to Chignik Lake were established. Juvenile sockeye less than about 55 mm in length with silvery body coloration and eyes not appearing large compared to body (Thedinga et al. 1994) were considered smolts. Similar size fish with prominent parr marks and a large head compared to the body were assumed to be age-0 and age-1 juveniles that would not emigrate to sea. All juveniles greater than about 55 mm were considered to be outmigrating smolts, regardless of coloration or proportional body morphology.

Age, Weight, and Length Sampling

Seventy sockeye smolt were sampled daily five days a week, subject to smolt availability. Fish were anesthetized with MS-222, and measured for length (tip-of-snout to fork-of-tail, in mm) and weight (nearest 0.1 g with a digital OHAUS portable electronic balance). A scale smear was removed from the preferred area (INPFC 1963) and mounted on a standard microscope slide for ageing with a microfiche reader under 42X or 48X magnification (Figure 3). Ages were recorded in European notation (Koo 1962). After sampling, fish were revived in aerated water and released downstream from the traps. Condition factor (K) for each smolt sampled was determined using:

$$K = \frac{W * 10^5}{L^3} \qquad (1)$$

where:
W = weight in grams and L = length (tip-of-snout to fork-of-tail) in millimeters (Barrett et al. 1993).

Estimation of Trap Efficiency

Trap efficiency was estimated at least weekly through mark-recapture experiments using dye to mark smolt. Smolt used for trap efficiency trials were collected from the traps and transferred

to instream covered live boxes. Smolt were retained for 10 hours to two days prior to release, depending on availability. If the target number of smolt collected for dyeing were not available after two days, those available were dyed and released. The following day, after checking for recaptures, the trap catch was held until evening, dyed and released. The number released over two release days was pooled to estimate the weekly trap efficiency. Initially, an attempt was made to mark and release at least 1,000 sockeye smolt weekly, subject to availability. Due to low initial estimated trap efficiency, the target weekly release population was increased to 2,000 fish on 29 May.

Smolt were dyed in the evening at approximately 2000 hours. Smolt were transferred from the live boxes into a continuously oxygenated or aerated solution of 1.9 g Bismark Brown dye to 57 L water (Ward and Verhoeven 1963; Lawler and Fitz-Earle 1968) for 30 minutes at a rate of up to 1,000 smolt/76 L dye solution. After the dyeing process, smolt were returned to the liveboxes and held for about 2.5 hours for recovery. At approximately 2230 hours, dyed smolt were collected from the liveboxes, transported 1.3 km upstream from the traps, and released across the stream channel (Figure 3). At each step of the dyeing process, dead or abnormally behaving smolt were counted and removed.

Following the release of dyed fish, trap catches were examined for recaptures for a minimum of three days. Recaptured smolt were recorded separately from unmarked fish and excluded from daily catch totals.

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

$$\hat{e}=\sum_{i=1}^{k}\frac{d_i}{D_i} \qquad (2)$$

where d_i = number of marked fish recaptured over (k) successive nights after release, and D_i = the number of marked fish released on day i (Barrett et al. 1993).

Rawson (1984) reported statistical models for treating sockeye smolt mark-recapture data derived on a daily basis with population estimates generated by:

$$\hat{N}_i = n_i\left[\frac{D_i}{d_i}+\frac{(D_i-d_i)}{d_i^2}\right]; \qquad (3)$$

with variance:

$$Var[\hat{N}_i]=n_i(n_i+d_i)\ D_i(D_i-d_i)/d_i^3. \qquad (4)$$

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

$$\hat{N}=\sum_{i=1}^{k}\hat{N}_i; \tag{5}$$

with the overall variance estimated by:

$$Var[\hat{N}]=\sum_{i=1}^{k}Var[\hat{N}_i] \tag{6}$$

where:

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

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

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

The (1-α) confidence intervals for the smolt population estimates were derived assuming a normal distribution (Rawson 1984). Trap efficiency in the large trap on 5 and 6 May, prior to installation of the small trap, was estimated as the product of: 1) the mean percent contribution of the large trap catch to the combined catch of both traps from 7 May through the end of the first mark-recapture event on 12 May; and 2) the overall mean trap efficiency for that week. For 4 June, when the small trap was inoperable, the trap efficiency was estimated as the product of: 1) the mean percent contribution of the large trap catch to the combined catch of both traps on 13 and 15 June; and 2) the overall mean trap efficiency for that week.

A chi-square test was used to test homogeneity ($\alpha = 0.05$) among weekly mark-recapture events. Student's t-test was used to test differences of mean length ($\alpha = 0.05$) between years.

Townet Survey

Townet surveys were conducted to determine the condition and relative abundance of fall rearing sockeye fry in Black and Chignik Lakes during 22-23 August. The townet (1.8-m x 1.8-m) used for both lakes sampled a 3.2-m^2 area of water. In Black Lake, the townet was pulled for about ten minutes at approximately 1 m/sec (35 hp Johnson at full speed) on the surface behind a skiff (16 foot Lund). In Chignik Lake, the net was similarly towed with a 20-foot aluminum skiff at about 1.4 m/sec (70 hp Yamaha). Each lake was sampled by area divisions defined in Ruggerone (1993) Figure 5). In Black Lake, five transects were sampled only from the deeper areas (A and B) of the lake due to low water. In Chignik Lake, five transects were sampled from areas A,B,C, and E. Length, weight, and age sampling procedures for townet-caught juveniles were similar to those used for smolt.

Climate and Hydrology

Trap revolutions per minute and daily climate observations, including air and stream temperature (C), stream height (cm), cloud cover (%), and wind velocity (mph) and direction were recorded at about 1930 daily (Appendix G). Water velocity (m/s) was measured at the trap location at the surface and at a 0.5-m depth with a Marsh-McBirney Model 201 portable water flow meter on 5 July.

Parasite Sampling

Adult sockeye salmon from the Black Lake spawning population and the Chignik Lagoon commercial catch were sampled for the occurrence of the parasite *Philomena oncorynchi.* In Black Lake, a total of 125 male, beach seine caught fish was sampled on 20, 22, and 23 June. From Chignik Lagoon, 100 fish from the commercial and test fish purse seine catches were sampled about every two weeks, without regard to sex, from 14 June through 3 August. Visual examination of the body cavity and organs was used to assess occurrence of the parasite. Fish negative for occurrence were double-checked by a second observer, when possible.

Ten smolt were taken from the AWL sample daily, from July 11 to 30, and examined for parasite presence. A microscope was helpful for further magnification, but not needed for detection of encysted and early adult stages of the parasite.

RESULTS

Smolt traps operated on the Chignik River from 5 May through 1 July, 1994, captured 60,595 outmigrating smolt. Of these, 16,232 were dyed and rereleased upstream of the traps, resulting in 78 recaptures. A chi-square test showed no significant difference ($P > 0.90$) among weekly mark-recapture events. Therefore, the pooled trap efficiency estimate of 0.48% (78 recaptured/16,232 released, Appendix A) was used to estimate a total sockeye smolt outmigration of 12.75 million fish (Table 1). Overall, 80% of the smolt were caught in the large trap, and 20% in the small trap (Appendix B).

Peaks in migration occurred during the 17 - 30 May and 21 - 27 June periods (Figure 6, Appendix C). Age-1 smolt outmigration peaked during the week of 24 May, steadily declined through 14 June, then increased slightly during the week of 21 June, and again declined the following week (Appendix D). Age-2 smolt showed similar trends, but with the initial peak of emigration about a week later than that of age-1 smolts. Length-frequency distributions showed a trend of decreasing size for both age classes from May through July, with the separation in length-frequency modes between age classes becoming less distinct (Figure 7).

Average length of age-1 and age-2 smolts was significantly less (t-test: $P < 0.001$ for both age classes) in 1994 than 1993 (Table 2, Appendix E). The magnitude of the difference may have been greater than indicated due to the sampling bias in 1994 of only sampling fish greater than or equal to 55 mm. Other species captured included coastrange sculpin *Cottus aleuticus*, coho

salmon *O. kisutch*, Dolly Varden *Salvelinus malma*, ninespine stickleback *Pungitius pungitius*, pond smelt *Hypomesus olidus*, pygmy whitefish *Prosopium coulteri*, starry flounder *Platichthys stellatus*, and threespine stickleback *Gasterosteus aculeatus*.

Townet surveys conducted on Black Lake resulted in a mean catch of sockeye juveniles of 2 fish/10 min (N = 5; geometric mean = 1.8 fish/10 min) (Table 4). For Chignik Lake, the mean catch was 6.6 fish/10 min (N = 5; geometric mean = 5.7 fish/10 min). Mean length in Black Lake was 65.5 mm (standard deviation of 6.1; range 51-74 mm), modal length about 66 mm (Figure 8) and mean weight was 3.2 g (standard deviation of 0.81 g; range 1.4-4.6 g). For Chignik Lake, mean length was 51.8 mm (standard deviation of 15.2; range 30 to 73 mm), modal lengths about 39 mm and 66 mm (Figure 8), and mean weight was 1.75 g (standard deviation = 1.38 g; range 0.2 to 4.2 g;). In Black Lake, all captured sockeye juveniles had readable scales for aging (Figure 9), and consisted of 30% age-0 and 70% age-1 fish. In Chignik Lake, only fish greater than 48 mm had readable scales (N=16); of these, 2 were age-0 (lengths of 49 and 62 mm) and the remainder (with length greater than 61 mm) age-1. If those fish less than 49 mm (N=17) are assumed as age-0, then the catch composition would be 58% age-0 and 42% age-1.

The parasite *Philomena oncorhynchi* showed a mean frequency of occurrence of 99% (range 96-100) and 97% (range 97-98), in the Black Lake escapement and Chignik Lagoon commercial catches, respectively (Table 5). However, smolt samples averaged 37% (range 11-90) frequency of parasite occurrence.

DISCUSSION

Although trap efficiency was less than 1%, the homogeneity of recapture rates over time and smolt size-shifts suggests uniform, unbiased sampling by the screw-traps over the course of the study. The low efficiency rate in this study was to be expected, as screw-trap efficiency estimates for Pacific salmon in other Pacific Northwest rivers (Terry Bendock, ADF&G, pers. comm.; Brandnt, Oregon Dept. of Fish and Wildlife, pers. comm.; Scott McPherson, ADF&G, pers. comm.; Thedinga et al., 1994) show both a decrease in trap efficiency with increased stream width, and species specific trap efficiency within the same river (Appendix G).

During 1993, estimation of rotary-screw trap efficiency in the Chignik River was not successful with one, 2.4-m trap fished alone at the Chignik Lake outlet (Ruggerone et al. 1993). Ruggerone et al. (1993) related low recapture rate (ca. 0.02%) to an inability to identify marked smolt, which lost their dye marking while remaining in the lake for more than 9 days before outmigrating past the trap again. The use of two traps in a restricted section of river such that nearly all recaptures of dyed fish released from the inriver site could be expected within 3 days of release contributed to increased success in estimating smolt outmigration in 1994.

Assuming that the estimated 7.75-million age-1 sockeye smolt were produced primarily from the 1992 Black Lake parent escapement of about 361,000 adult spawners results in a 21 age-1 smolts per spawner ratio (Table 3). Likewise, assuming the estimated 5.0-million age-2 smolt were produced primarily from the Chignik Lake 1991 escapement of 383,000 results in an estimated

13 age-2 smolts per spawner. Similar estimates for age-2 smolt of the 1990 brood year nor age-1 smolts of the 1992 brood year could not be made.

Previously collected smolt length-at-age data (1957, 1958, and 1992) had greater mean lengths for both age classes than those in 1994 (Appendix H). During 1927-1932, modal length ranged from 60-65 mm for mostly age-1 smolts (Kelez in Koos 1959), which is similar to the 67-mm mean length of 1994 age-1 smolts. The excessive escapement in 1991 may have created high fry density and depressed growth resulting in lower length-at-age of Black Lake smolt, assuming egg to fry survival was average. The mean length of age-1 smolts in 1993, however, did not indicate overcrowding or lowered condition factor values as would be expected with increased competition for food. The majority of these smolts were of Black Lake origin and reared in Chignik Lake in 1992, where favorable conditions created by an unusually high abundance of zooplankton may have overcome any overcrowding conditions (Ruggerone 1994). Therefore, relative zooplankton abundance may play more of a role in influencing smolt condition than smolt abundance.

The destiny of the seaward migrating juveniles smaller than 55 mm length remains uncertain. Roos (1957, 1959) reported upstream migrations of juvenile sockeye salmon into Chignik Lake, with an estimated 500,000 visually observed passing the outlet of Chignik Lake on both sides of the river on June 19, 1959. These fish ranged from 50 to 80 mm, with a mode of 65 mm. Iverson (1966) observed upstream movement of juvenile sockeye in Chignik River during June 1963, and June and July 1964. Juveniles sampled in 1964 (N=33), ranged from 52 to 77 mm, with a mean of 61 mm. Thus, the method of counting outmigrants 55 mm and greater should provide a more conservative estimate of those smolt actually outmigrating to sea, as opposed to counting all outmigrants caught and acknowledging that a larger unknown portion of these fish may not migrate to sea but later return to Chignik Lake as rearing juveniles. Quantitative study of the upstream migration of juveniles could provide information as to the proportion of outmigrating smolts that return upriver, and whether these fish remain another winter in freshwater or outmigrate again later the same year.

A forecast can be made based on the estimated outmigration of sockeye smolt, using the 16.7% (standard error of 9.8%) smolt-to-adult survival ratio estimator developed by Koenings et al. (1993) for small smolts (length 55 mm to 84 mm) for middle latitude (56°N to 60°N) sockeye nursery lakes. Assuming a normal distribution, this results in a 1997 forecasted total return of about 2.1 million fish (95% confidence interval 1.7 to 2.5 million fish). Assuming the age-1 component of the outmigrating smolt (61% of the total) will return to Black Lake, and the age-2 portion (39%) to Chignik Lake results in a first run (Black Lake) sockeye forecast of 1.3 million fish and late run (Chignik Lake) forecast of 0.8 million fish.

The geometric mean catch of sockeye juveniles (age-0 and age-1) in Black Lake indicates a substantial decrease of rearing juveniles. Geometric mean catch of age-0 sockeye salmon were 347 fish/10-min tow and 116 fish/10-min tow in fall townet surveys conducted in Black Lake in 1992 and 1993 (Ruggerone et al. 1993 and 1994). The decline may have been caused by a die-off of Black Lake sockeye juveniles associated with an intense algal bloom on the lake reported to the ADF&G in mid-August prior to the surveys (David Owens, ADF&G, personal communication). In addition, only one skiff was used to pull the townet in 1994. In 1992 and 1993, two boats were used, which may have caused increased catches due to a herding effect (Narver 1966). Chignik Lake catches were also lower in 1994 than in both 1992 (74 fish/10-min

tow) and 1993 (50 fish/10-min tow; Ruggerone et al. 1993 and 1994), indicating that mass emigration of smolt from Black Lake to Chignik Lake is unlikely. Monitoring of smolt outmigration in 1995 should indicate whether the low townet catches were a result of a herding effect, low sample size, or low egg-to-juvenile survival.

The parasite investigation showed that *P. oncorhynchi* was ubiquitous and therefore not useful as an inseason stock separation tool for returning adults. The discrepancy between occurrence rates in adults and juveniles may have been because the parasite was in the egg stage in most juveniles, and therefore not observed.

LITERATURE CITED

Barrett, B., C.O. Swanton, and P.A. Nelson. 1993. Sockeye salmon smolt abundance, timing and growth characteristics for Red, Akalura, Upper Station, and Frazer Lakes, 1993. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K93-32. Kodiak.

INPFC (International North Pacific Fisheries Commission). 1963. Annual Report 1961. Vancouver, British Columbia.

Iverson, R.W. 1966. Biology of juvenile sockeye salmon resident in Chignik River, Alaska. Master of Science Thesis, Oregon State University.

Koenings, J.P., H.J. Geiger, and J.J. Hasbrouck. 1993. Smolt-to-adult survival patterns ofsockeye salmon (Onchorynchus nerka): effects of smolt length and geographic latitude when entering the sea. Canadian Journal of Fisheries and Aquatic Sciences 50:600-611.

Lawler, G.H. and Fitz-Earle, M. 1968. Marking small fish with stains for estimating populations in Heming Lake, Manitoba. Journal of Fisheries Research Board of Canada, 25(2):255-266.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37-48 *in* Studies of Alaska red salmon. University of Washington Press, Seattle.

McConnell, R.J. and Snyder, G.R. 1972. Key to field identification of anadromous juvenile salmonids in the Pacific Northwest. National Oceanic and Atmospheric Administration Technical Report, National Marine Fisheries Service Circular 366, Seattle.

Narver, D.W. 1966. Pelagial ecology and carrying capacity of sockeye salmon in the Chignik Lakes, Alaska. Doctoral Dissertation, University of Washington.

Probasco, P., D. Hicks and L. Wright. 1983. Chignik management area finfish annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak.

Probasco, P., D. Hicks and J. Strickert. 1984. Chignik management area finfish annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak.

Probasco, P., J. Fox and S. Theis. 1985. Chignik management area finfish annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Westward region finfish management report 2-87. Kodiak.

Probasco, P., J. Fox and S. Theis. 1986. Chignik management area finfish annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Westward region finfish management report 2-87. Kodiak.

LITERATURE CITED (Cont.)

Quimby, A. and D.L. Owen. *In press.* Chignik management area finfish annual report. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Kodiak.

Rawson, K. 1984. An estimate of the size of a migrating population of juvenile salmon using an index of trap efficiency obtained by dye marking. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, Report 28, Juneau.

Roos, J.F. 1957. A report on the red salmon smolt studies carried out at Chignik in 1957. Unpublished manuscript. Fisheries Research Institute, University of Washington, Seattle.

Roos, J.F. 1959. Red salmon smolt studies at Chignik, Alaska in 1959. Unpublished manuscript. Fisheries Research Institute, University of Washington, Seattle.

Ruggerone, G.T., C. Harvey, J Bumgarner, and D.E. Rogers 1992. Investigations of salmon populations, hydrology, and limnology of the Chignik Lakes, Alaska. Annual data report, anadromous fish project. Fisheries Research Institute, University of Washington, Seattle.

Ruggerone, G.T., C. Harvey, J Bumgarner, and D.E. Rogers 1993. Investigations of salmon populations, hydrology, and limnology of the Chignik Lakes, Alaska, during 1992. Fisheries Research Institute, University of Washington, Seattle.

Ruggerone, G.T. 1994. Investigations of salmon populations, hydrology, and limnology of the Chignik Lakes, Alaska, during 1993. Draft. Natural Resource Consultants, Seattle.

SAS Institute, Inc. 1987. SAS/STAT guide for personal computers. SAS Institute Inc. Cary, North Carolina.

Thedinga, J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski 1994. Salmonid smolt yield determined with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. Draft. Auke Bay Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration Technical Report, Juneau.

Ward, F.J. and Verhoeven, L.A. 1963. Two biological stains as markers for sockeye salmon fry. Transactions of the American Fisheries Society 92(4):379-383.

Table 1. Population estimates and age composition of sockeye salmon smolt captured in rotary-screw traps fished in the Chignik River, 1994.

Year	Number and Relative Percent of Smolt by Age Class		Total No. Smolt	95% CI	
	1.	2.		Low	High
1993	25,397,684 (74)	8,754,782 (26)	34,152,467[a]	2,607,046	65,697,887
1994	7,736,438 (61)	5,016,654 (39)	12,753,093	12,317,017	13,245,169

[a] In 1993, only two marked smolts were recaptured out of a total of 10,617 marked releases. The two smolts were caught during a weekly mark-recapture experiment in which 1,000 dyed smolts were released (Ruggerone, 1994). This single recapture event (trap efficiency = 2/1000 or 0.02%) was used to compute the 1993 population estimate resulting in the correspondingly large confidence interval. The reliability of this estimate is therefore questionable, and likely an overestimate (Ruggerone 1994).

Table 2. Sockeye salmon escapement and estimated number of smolt produced by broodyear from Chignik and Black lakes, 1990-1992.

Brood Year	Estimated Escapement by Lake System		Smolt Produced by Age Class (Both Lakes Combined) 1	2	Total No. Smolts
1990	Black :	434,543	[a]	8,754,782[b]	8,754,782
	Chignik :	335,867			
1991	Black :	657,511	25,397,684[b]	5,016,654	30,414,338
	Chignik :	382,587			
1992	Black :	360,681	7,736,438	[c]	7,736,438
	Chignik :	405,922			

[a] Population estimates not available.

[b] In 1993, only two marked smolts were recaptured out of a total of 10,617 marked releases. The two smolts were caught during a weekly mark-recapture experiment in which 1,000 dyed smolts were released. (Ruggerone 1994). This single recapture event (trap efficiency = 2/1000 or 0.02%) was used to compute the 1993 population estimate resulting in the correspondingly large confidence interval. The reliability of this estimate is therefore questionable, and likely an overestimate (Ruggerone 1994).

[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.

Smolt year	Lake	Age-1 N	Age-1 Length (mm)	Age-1 Weight (g)	Age-1 Condition	Age-2 N	Age-2 Length (mm)	Age-2 Weight (g)	Age-2 Condition
1993	Black	a	a	a	a	a	107.0	a	a
	Chignik	a	82.0	a	a	a	90.0	a	a
1994		1,722	66.6	2.3	0.75	1,096	77.4	3.6	0.75

[a] Data not available.

Table 4. Townet catches from Black Lake (8/22/94) and Chignik Lake (8/23/94).

			Number Caught			
Lake	Tow #	Area	Sockeye	Stickleback	Pond Smelt	Coho
Black	1	A	1	8	29	0
	2	A	1	14	9	0
	3	A/B	3	8	11	0
	4	B/A	2	14	5	0
	5	A	3	8	16	0
Total:			10	52	70	0
Mean:			2.0	10.4	14.0	0
Geometric Mean:			1.8	10.0	11.8	0
Chignik	1	A	7	5	1	0
	2	B	4	6	1	0
	3	C	5	4	0	0
	4	C/E	14	35	2	2
	5	E	3	4	0	0
Total:			33	54	4	2
Mean:			6.6	10.8	0.8	0.4
Geometric Mean:			5.7	7.0	1.1	1.3

Table 5. Frequency of occurrence of the parasitic nematode *Philomena onchorynchi* in adult sockeye salmon from Black Lake escapement, Chignik Lagoon commercial catch, and sockeye salmon smolt catches from rotary-screw traps in the Chignik River, 1994.

Date	Location	Type	N	Frequency (%)
20-May	Black Lake	Adult escapement	33	100
22-May	Black Lake	Adult escapement	28	96
23-May	Black Lake	Adult escapement	59	100
		Total	120	99
14-June	Chignik Lagoon	Adult commercial	100	97
26-June	Chignik Lagoon	Adult commercial	95	98
05-July	Chignik Lagoon	Adult commercial	100	97
03-August	Chignik Lagoon	Adult commercial	100	98
		Total	395	97
10-June	Chignik River	Smolt	10	40
11-June	Chignik River	Smolt	9	11
13-June	Chignik River	Smolt	9	22
16-June	Chignik River	Smolt	10	50
17-June	Chignik River	Smolt	10	30
18-June	Chignik River	Smolt	10	70
20-June	Chignik River	Smolt	10	10
23-June	Chignik River	Smolt	10	50
24-June	Chignik River	Smolt	10	60
25-June	Chignik River	Smolt	10	40
27-June	Chignik River	Smolt	10	90
28-June	Chignik River	Smolt	10	30
30-June	Chignik River	Smolt	8	25
		Total	126	37

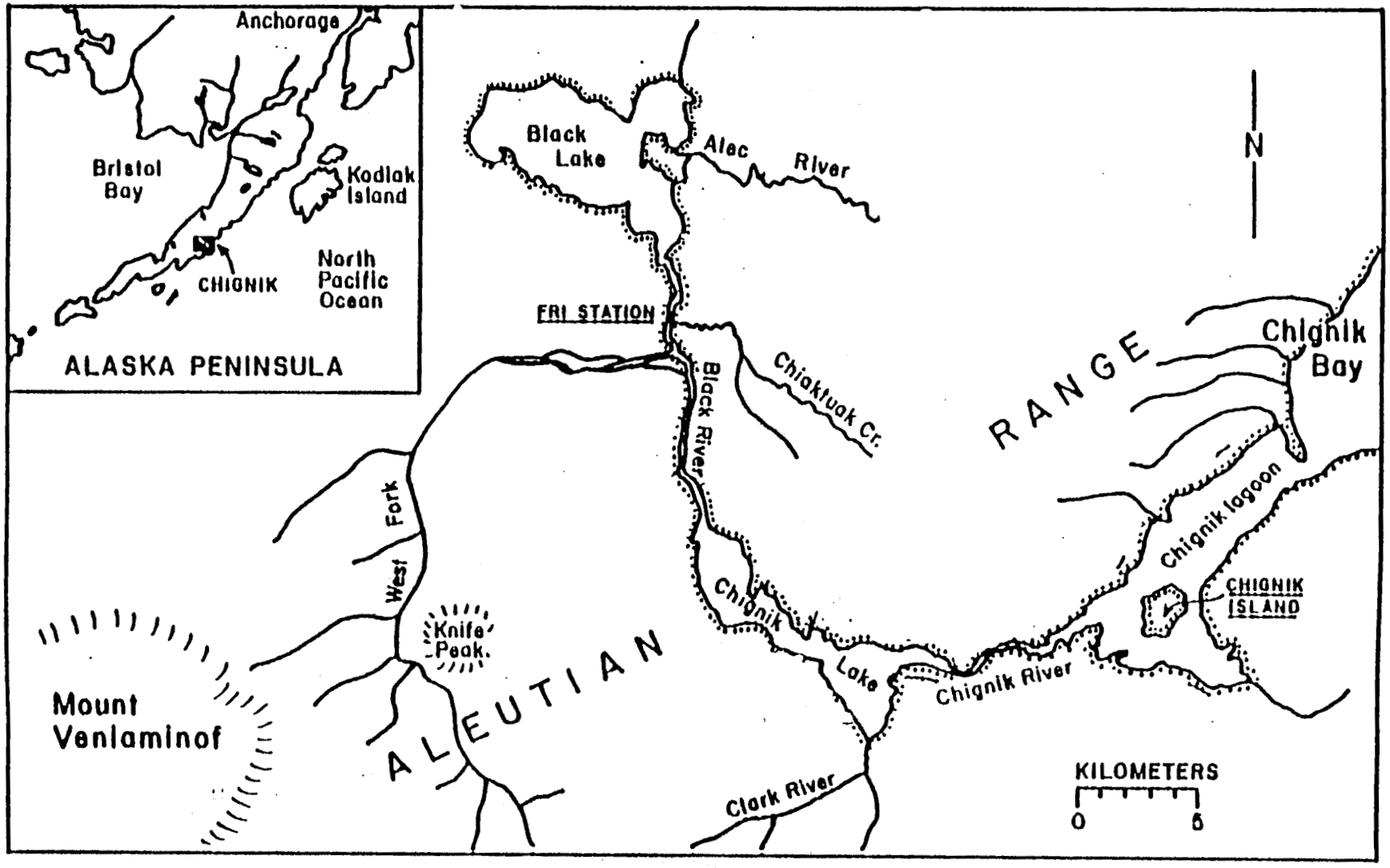

Figure 1. Map of the Chignik River watershed with inset of western Alaska.

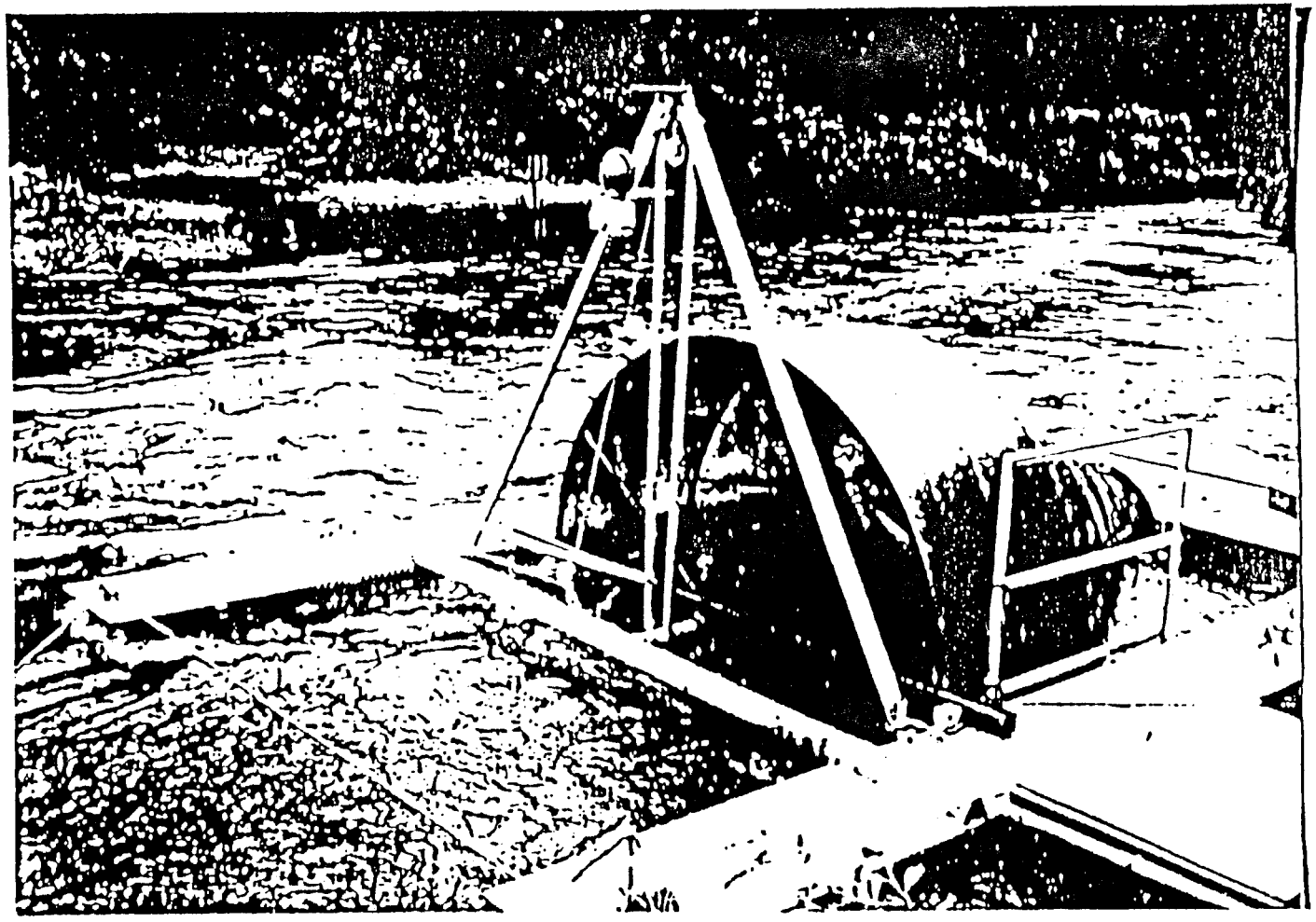

Figure 2. Rotary-screw trap with 2.4-m diameter cone. Photo from Thedinga et al. 1994.

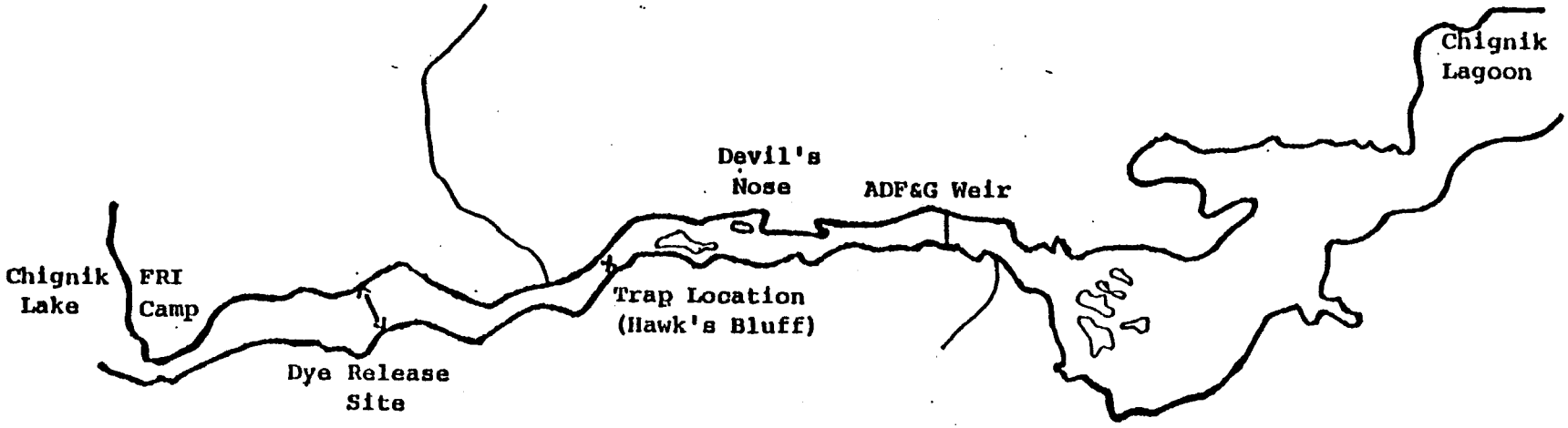

Figure 3. Location of rotary-screw trap location (denoted by "x"), and release site of dyed fish on the Chignik River Alaska.

Age 1
Length: 55 mm
Weight: 1.0 g
15-May, 1994

Age 1
Length: 73 mm
Weight: 2.7 g
11-June, 1994

Age 2
Length: 82 mm
Weight: 4.2 g
12-May, 1994

Age 2
Length: 71 mm
Weight: 2.5 g
11-June, 1994

Figure 4. Examples of age-1.0 and age-2.0 sockeye salmon smolt scales (54X), Chignik River, 1994.

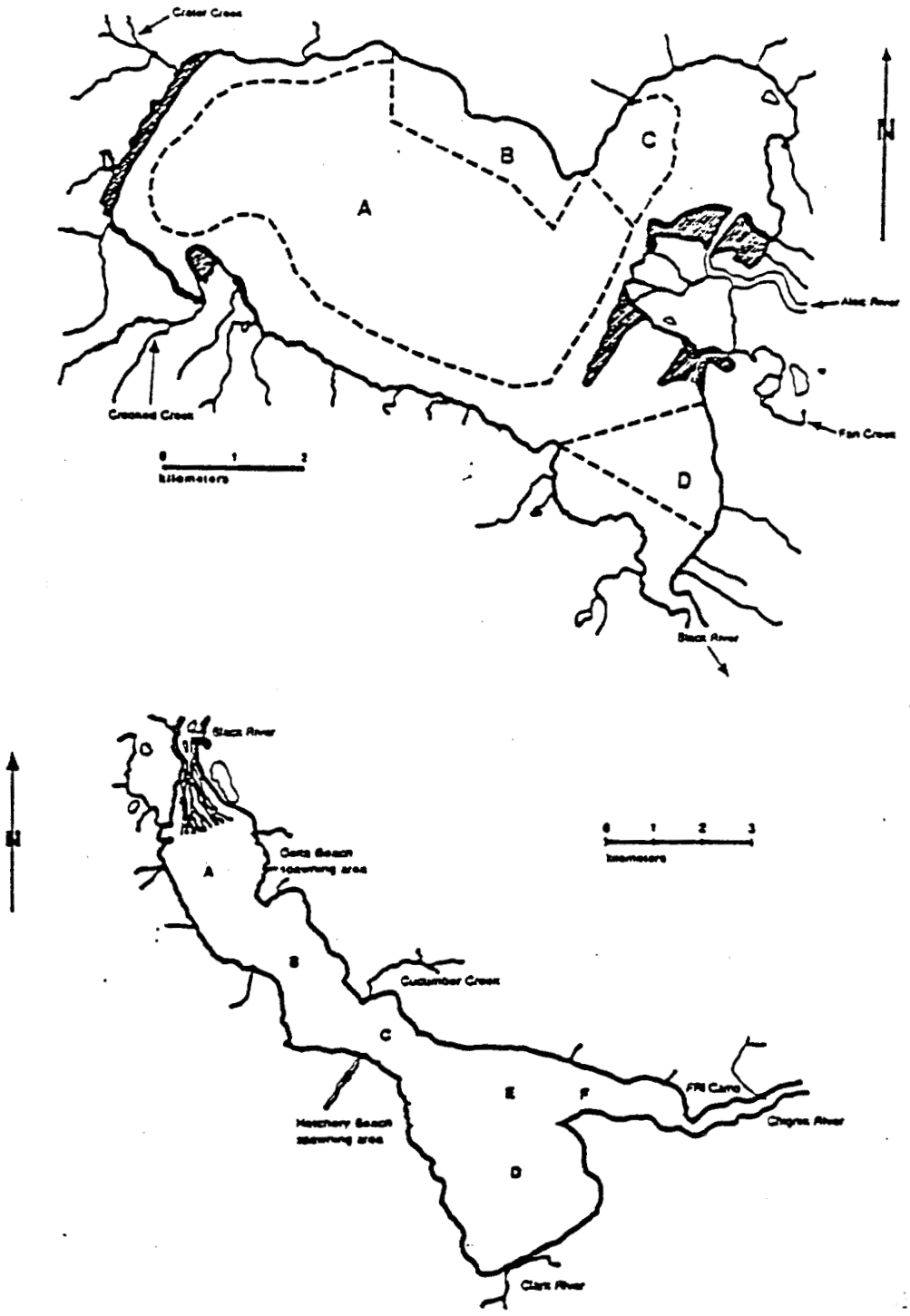

Figure 5. Townet sample areas (Ruggerone et al. 1993) of Black Lake (top; A-D) and Chignik Lake (A-F).

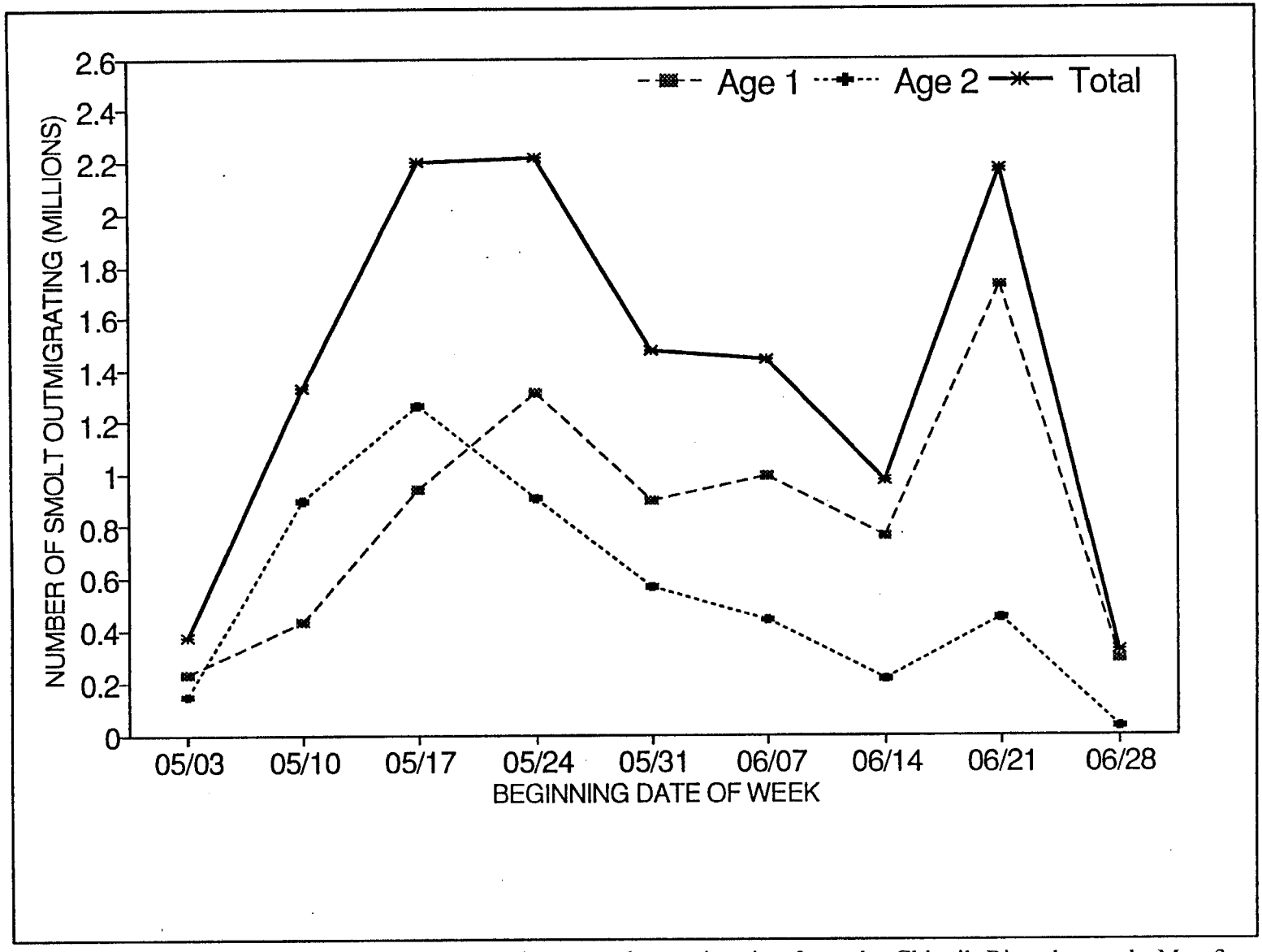

Figure 6. Estimated number of sockeye salmon smolt outmigrating from the Chignik River by week, May 3 to July 1, 1994.

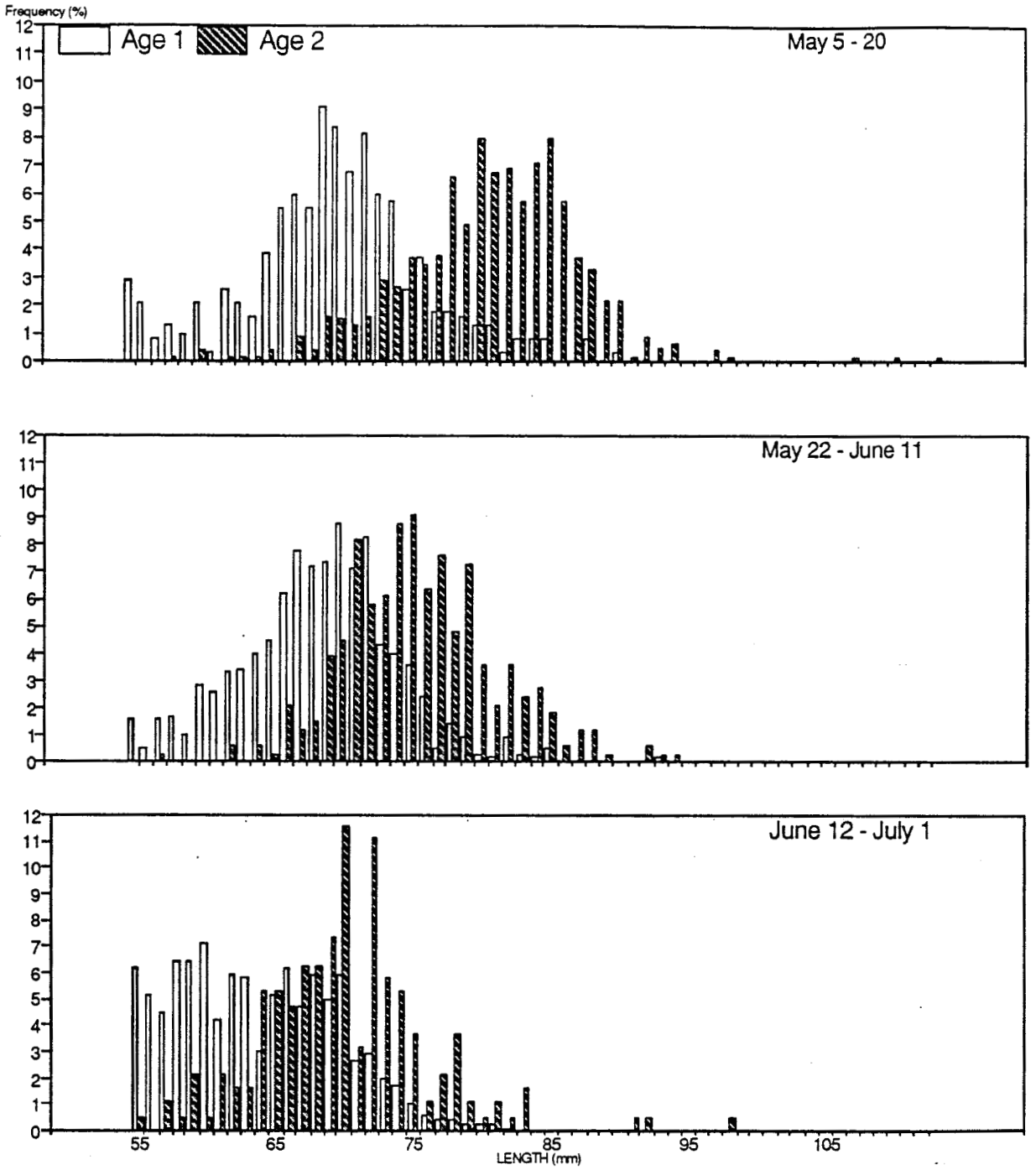

Figure 7. Length-frequency distribution (%) of age-1 and age-2 sockeye smolt (length of 55 mm and greater) captured with rotary-screw traps in the Chignik River, May 5 - July 1, 1994.

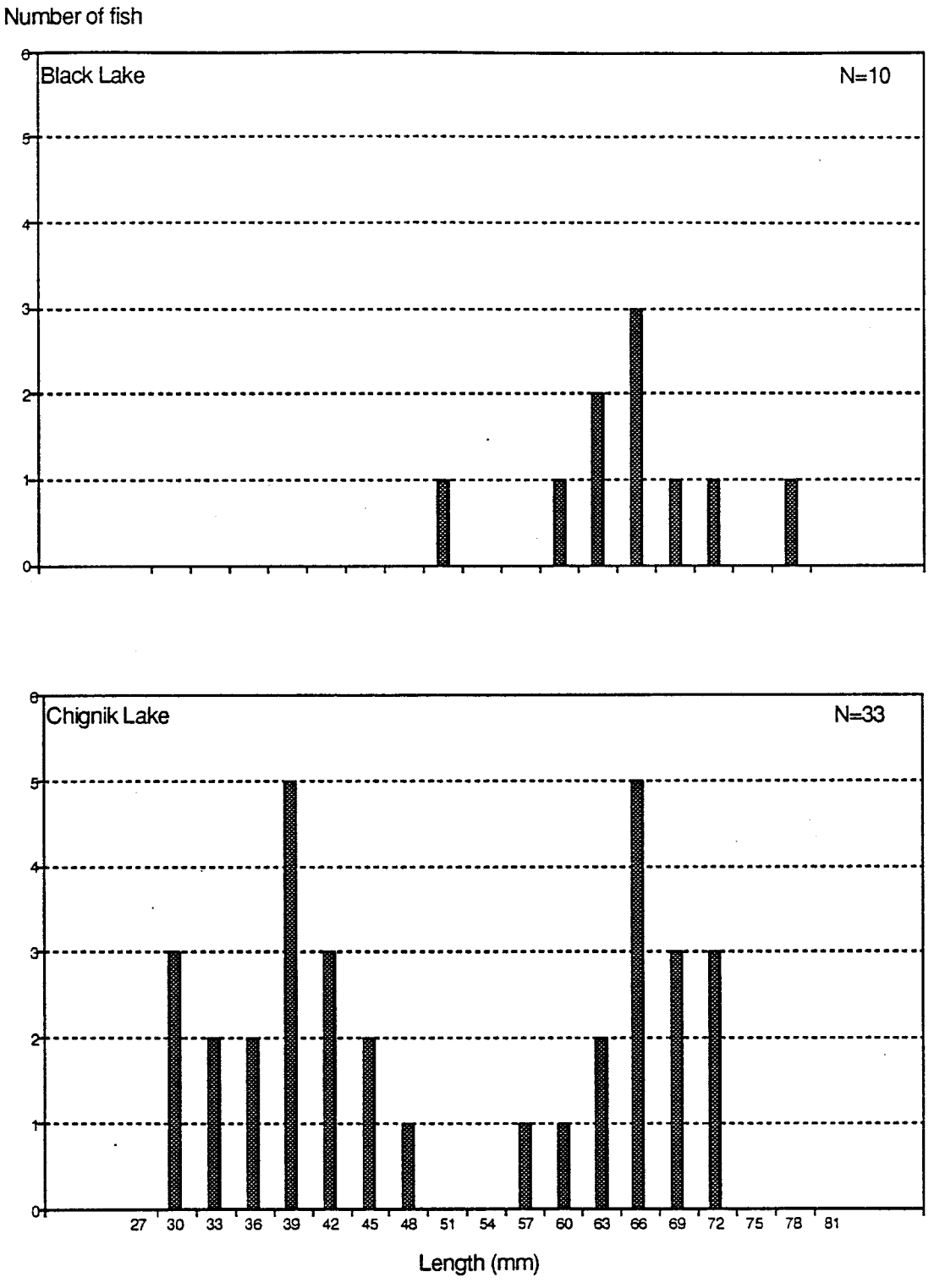

Figure 8. Length-frequency distributions of sockeye salmon fry captured in townet hauls in Black and Chignik Lakes, August 22-23, 1994.

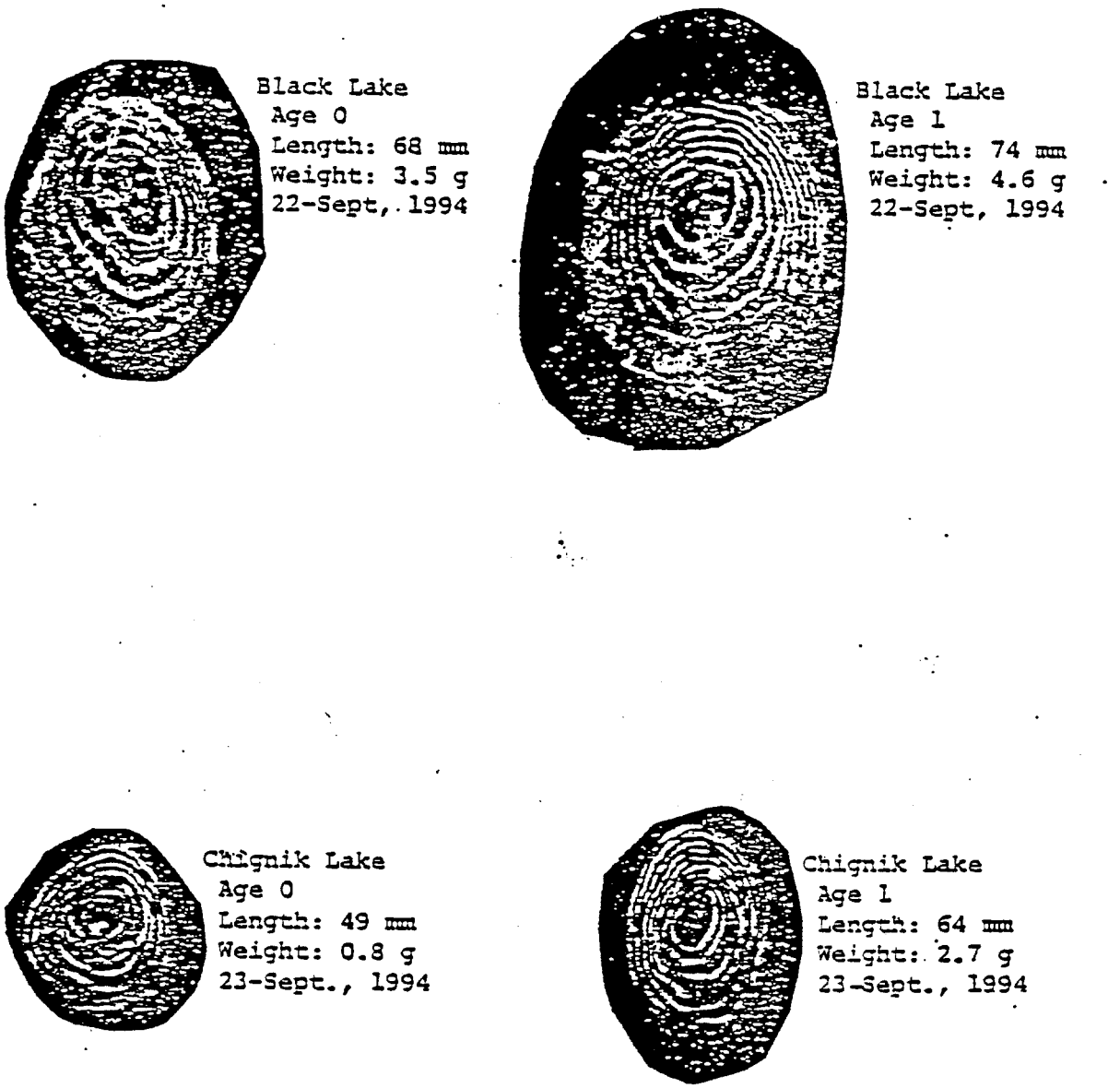

Figure 9. Examples of age-0.0 and age-1.0 sockeye salmon juvenile scales (54X), captured with townets in Black and Chignik Lakes, 1994.

APPENDIX

Appendix A. Number of sockeye salmon smolt caught daily with from two rotary-screw traps[a] operated on the Chignik River, 1994.

Date[b]	Combined Trap Catch		Trap Efficiency Test					Comments
	Daily[c]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Est. Marked Recoveries For Dye Test Period[d]	Recovery Rate%[e]	
05-May	52	52	0	0				Lrg. trap begins fishing @ 1630 hrs
06-May	218	270	0	0				
07-May	242	512	0	0				Sm. trap begins fishing @ 1730 hrs
08-May	792	1,304	0	0				
09-May	572	1,876	63	572	0	3	0.64%	
10-May	551	2,427	408	552	1			
11-May	284	2,711	0	285	1			
12-May	769	3,480	0	770	1			
13-May	330	3,810	0	0				0230 and 0915 hrs; put lead on traps
14-May	1,161	4,971	307	1,163	2	6	0.46%	
15-May	1,888	6,859	1,008	1,890	2			Both recaps morts
16-May	1,448	8,307	0	1,449	1			
17-May	603	8,910	0	604	1			Mink sign again at trap
18-May	933	9,843	0	933	0			
19-May	1,737	11,580	0	0				Moved trap inshore today
20-May	1,832	13,412	1,239	1,840	8	16	0.65%	
21-May	1,795	15,207	1,233	1,798	3			3 recaps dead or dying
22-May	1,420	16,627	0	1,424	4			All recaps in sm. trap; 3 dead/dying
23-May	2,317	18,944	0	2,318	1			Recap in sm. trap and dead
24-May	1,353	20,297	0	0				RPM only 3.5 due to 10+ ft tide
25-May	1,914	22,211	0	0				Larger % of coho in small trap than big
26-May	1,723	23,934	0	0				High tide/trap @ < 3 rpm @ 0530
27-May	1,270	25,204	0	0				
28-May	1,075	26,279	0	0				More mink sign at trap; high NW winds
29-May	2,435	28,714	1,682	2,440	5	7	0.42%	
30-May	945	29,659	0	947	2			
31-May	975	30,634	0	975	0			
01-Jun	388	31,022	0	0				
02-Jun	2,290	33,312	0	0				35 mph NW winds and overcast skies may have triggered "run"
03-Jun	2,237	35,549	0	0				
04-Jun	593	36,142	0	0				SE wind probably reduced counts
05-Jun	254	36,396	0	0				
06-Jun	356	36,752	2,011	364	8	10	0.50%	
07-Jun	186	36,938	0	188	2			
08-Jun	345	37,283	0	345	0			

-Continued-

Appendix A. (Page 2 of 2).

Date[b]	Combined Trap Catch: Daily[c]	Combined Trap Catch: Cum.	Trap Efficiency Test: Marked (Dyed)	Trap Efficiency Test: Examined For Marks	Trap Efficiency Test: Marked Recoveries	Trap Efficiency Test: Est. Marked Recoveries For Dye Test Period[d]	Trap Efficiency Test: Recovery Rate%[e]	Comments
09-Jun	215	37,498	0	215	0			Wind change to NW; slightly moved traps inshore 200 morts due to debris in trap
10-Jun	1,095	38,593	0	0				
11-Jun	1,502	40,095	1,186	1,505	3	10	0.58%	
12-Jun	2,486	42,581	877	2,492	6			
13-Jun	1,127	43,708	0	1,128	1			50% of smolts in each trap
14-Jun	225	43,933	0	226	1	2		Sm. trap not working
15-Jun	592	44,525	0	593	1			Sm. trap resumes at 1500 hrs; moved traps inshore; tripods and lead washed-out and not replaced due to high water
16-Jun	114	44,639	0	0				
17-Jun	532	45,171	307	533	1	1	0.33%	
18-Jun	1,109	46,280	0	1,109	0			
19-Jun	2,037	48,317	1,141	2,037	0			
20-Jun	179	48,496	1,642	184	5	9	0.32%	
21-Jun	539	49,035	0	542	3			Recaps faded-likely 6/20 release
22-Jun	1,013	50,048	0	1,013	0			Numerous > 5" coho smolt
23-Jun	1,236	51,284	0	1,237	1			Moved traps 5 ft offshore
24-Jun	3,518	54,802	898	3,520	2	14	0.43%	
25-Jun	1,210	56,012	2,321	1,216	6			Moved traps upstream 50'
26-Jun	1,601	57,613	0	1,607	6			
27-Jun	1,402	59,015	0	1,402	0			
28-Jun	556	59,571	0	556	0			
29-Jun	675	60,246	0	0				Water level dropping; some smolt w/white sheen
30-Jun	202	60,448	0	0				Wind changed to NW in am of 7/1
01-Jul	147	60,595	0	0				
Total	60,595		16,323	41,972	78	78	0.48%	

[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 first noon of the 24-hour period.

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

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

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

Appendix B. Daily number of sockeye salmon smolt caught by trap in the Chignik River, 1994. The small trap had a 1.5-m cone, and the large trap a 2.4-m cone.

Date	Small Trap		Large Trap		Combined		Small Trap % of Combined Daily Catch	Large Trap % of Combined Daily Catch
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative		
05/05/94	-	-	52	52	52	52	-	100%
05/06/94	-	-	218	270	218	270	-	100%
05/07/94	82	82	160	430	242	512	34%	66%
05/08/94	215	297	577	1,007	792	1,304	27%	73%
05/09/94	148	445	424	1,431	572	1,876	26%	74%
05/10/94	110	555	441	1,872	551	2,427	20%	80%
05/11/94	127	682	157	2,029	284	2,711	45%	55%
05/12/94	197	879	572	2,601	769	3,480	26%	74%
05/13/94	90	969	240	2,841	330	3,810	27%	73%
05/14/94	305	1,274	856	3,697	1,161	4,971	26%	74%
05/15/94	629	1,903	1,259	4,956	1,888	6,859	33%	67%
05/16/94	408	2,311	1,040	5,996	1,448	8,307	28%	72%
05/17/94	181	2,492	422	6,418	603	8,910	30%	70%
05/18/94	208	2,700	725	7,143	933	9,843	22%	78%
05/19/94	293	2,993	1,444	8,587	1,737	11,580	17%	83%
05/20/94	475	3,468	1,357	9,944	1,832	13,412	26%	74%
05/21/94	251	3,719	1,544	11,488	1,795	15,207	14%	86%
05/22/94	306	4,025	1,114	12,602	1,420	16,627	22%	78%
05/23/94	463	4,488	1,854	14,456	2,317	18,944	20%	80%
05/24/94	297	4,785	1,056	15,512	1,353	20,297	22%	78%
05/25/94	286	5,071	1,628	17,140	1,914	22,211	15%	85%
05/26/94	311	5,382	1,412	18,552	1,723	23,934	18%	82%
05/27/94	196	5,578	1,074	19,626	1,270	25,204	15%	85%
05/28/94	259	5,837	816	20,442	1,075	26,279	24%	76%
05/29/94	632	6,469	1,803	22,245	2,435	28,714	26%	74%
05/30/94	262	6,731	683	22,928	945	29,659	28%	72%
05/31/94	210	6,941	765	23,693	975	30,634	22%	78%
06/01/94	132	7,073	256	23,949	388	31,022	34%	66%
06/02/94	509	7,582	1,781	25,730	2,290	33,312	22%	78%
06/03/94	387	7,969	1,850	27,580	2,237	35,549	17%	83%
06/04/94	234	8,203	359	27,939	593	36,142	39%	61%
06/05/94	59	8,262	195	28,134	254	36,396	23%	77%
06/06/94	67	8,329	289	28,423	356	36,752	19%	81%
06/07/94	34	8,363	152	28,575	186	36,938	18%	82%
06/08/94	38	8,401	307	28,882	345	37,283	11%	89%

-Continued-

Appendix B. (Page 2 of 2).

Date	Small Trap Daily	Small Trap Cumulative	Large Trap Daily	Large Trap Cumulative	Combined Daily	Combined Cumulative	Small Trap % of Combined Daily Catch	Large Trap % of Combined Daily Catch
06/09/94	48	8,449	167	29,049	215	37,498	22%	78%
06/10/94	111	8,560	984	30,033	1,095	38,593	10%	90%
06/11/94	263	8,823	1,239	31,272	1,502	40,095	18%	82%
06/12/94	557	9,380	1,929	33,201	2,486	42,581	22%	78%
06/13/94	569	9,949	558	33,759	1,127	43,708	50%	50%
06/14/94	0	9,949	225	33,984	225	43,933	0%	100%
06/15/94	12	9,961	580	34,564	592	44,525	2%	98%
06/16/94	45	10,006	69	34,633	114	44,639	39%	61%
06/17/94	37	10,043	495	35,128	532	45,171	7%	93%
06/18/94	38	10,081	1,071	36,199	1,109	46,280	3%	97%
06/19/94	97	10,178	1,940	38,139	2,037	48,317	5%	95%
06/20/94	15	10,193	164	38,303	179	48,496	8%	92%
06/21/94	69	10,262	470	38,773	539	49,035	13%	87%
06/22/94	111	10,373	902	39,675	1,013	50,048	11%	89%
06/23/94	136	10,509	1,100	40,775	1,236	51,284	11%	89%
06/24/94	501	11,010	3,017	43,792	3,518	54,802	14%	86%
06/25/94	217	11,227	993	44,785	1,210	56,012	18%	82%
06/26/94	258	11,485	1,343	46,128	1,601	57,613	16%	84%
06/27/94	116	11,601	1,286	47,414	1,402	59,015	8%	92%
06/28/94	160	11,761	396	47,810	556	59,571	29%	71%
06/29/94	100	11,861	575	48,385	675	60,246	15%	85%
06/30/94	32	11,893	170	48,555	202	60,448	16%	84%
07/01/94	12	11,905	135	48,690	147	60,595	8%	92%
Total	11,905	11,905	48,690	48,690	60,595	60,595	20%	80%

Appendix C. Daily population estimates of sockeye salmon smolt outmigrating from the Chignik River, 1994.

Date	Population Estimate	95% CI Lower	95% CI Upper
05-May	8,226	4,435	12,017
06-May	34,486	22,774	46,199
07-May	51,044	38,213	63,876
08-May	167,054	128,779	205,328
09-May	120,650	92,535	148,765
10-May	116,221	89,076	143,366
11-May	59,903	45,119	74,687
12-May	162,203	124,990	199,415
13-May	69,606	52,687	86,525
14-May	244,886	189,584	300,188
15-May	398,229	309,395	487,064
16-May	305,422	236,881	373,963
17-May	127,189	97,641	156,736
18-May	196,794	152,012	241,577
19-May	366,379	284,509	448,250
20-May	386,417	300,166	472,669
21-May	378,613	294,068	463,158
22-May	299,516	232,266	366,765
23-May	488,717	380,098	597,335
24-May	285,384	221,225	349,543
25-May	403,713	313,680	493,747
26-May	363,426	282,202	444,651
27-May	267,877	207,546	328,207
28-May	226,746	175,412	278,080
29-May	513,606	399,546	627,666
30-May	199,326	153,990	244,661
31-May	205,653	158,933	252,374
01-Jun	81,839	62,233	101,446
02-Jun	483,022	375,648	590,395
03-Jun	471,843	366,913	576,772
04-Jun	125,079	95,994	154,165
05-Jun	53,575	40,186	66,965
06-Jun	75,090	56,966	93,214
07-Jun	39,232	29,015	49,450
08-Jun	72,770	55,155	90,384
09-Jun	45,349	33,776	56,922
10-Jun	230,965	178,708	283,222
11-Jun	316,812	245,780	387,843
12-Jun	524,363	407,951	640,776
13-Jun	237,714	183,981	291,448
14-Jun	33,696	21,656	45,735
15-Jun	124,869	95,829	153,908
16-Jun	24,046	17,224	30,867
17-Jun	112,213	85,946	138,480
18-Jun	233,918	181,015	286,820
19-Jun	429,657	333,951	525,363
20-Jun	37,756	27,866	47,646
21-Jun	113,689	87,099	140,280
22-Jun	213,669	165,195	262,142
23-Jun	260,705	201,943	319,467

-Continued-

Appendix C. (Page 2 of 2).

Date	Population Estimate	95% CI Lower	95% CI Upper
24-Jun	742,040	578,039	906,041
25-Jun	255,221	197,659	312,784
26-Jun	337,693	262,095	413,291
27-Jun	295,719	229,300	362,138
28-Jun	117,275	89,899	144,651
29-Jun	142,375	109,502	175,248
30-Jun	42,607	31,641	53,573
01-Jul	31,006	22,621	39,392
	12,753,093	12,317,017	13,245,169

[a] The large trap was installed on 5 May, and the small trap on 7 May. Trap efficiency and resulting population estimates for 5 and 6 May were based on the mean percent contribution of the large trap to the combined catch of both traps from 7 May to 12 May.

[b] The small trap was inoperative on 14 June. Trap efficiency and resulting population estimate for this day was derived from the mean percent contribution of the large trap to the combined catch of both traps on June 13 and June 15.

Appendix D. Estimated number of Chignik River sockeye salmon smolt outmigrating by age class, 1994.

Week Beginning	Population Estimate	Age Class 1	Age Class 2
05/03	381,461	230,760	150,700
05/10	1,356,469	440,286	916,183
05/17	2,243,625	957,880	1,285,745
05/24	2,260,078	1,336,675	923,403
05/31	1,496,102	914,759	581,342
06/07	1,467,205	1,014,467	452,738
06/14	996,153	779,846	216,308
06/21	2,218,736	1,762,310	456,426
06/28	333,264	299,455	33,809
Total	12,753,093	7,736,438	5,016,654

Appendix E. Mean length, weight, and condition factor, and population by age and date of sockeye salmon smolt captured in the Chignik River, 1994.

		Length			Weight			Condition			Population			
Age	Week beginning	Sample Size	Mean	Standard Error	Sample Size	Mean	Standard Error	Sample Size	Mean	Standard Error	Population Size	Mean Length	Mean Weight	Mean Condition
1	05/03	98	67.9	0.76	98	2.6	0.08	98	0.80	0.012	230,760	67.9	2.6	0.80
1	05/10	136	69.0	0.58	136	2.7	0.06	136	0.82	0.009	440,286	69.0	2.7	0.82
1	05/17	149	71.2	0.44	140	2.8	0.06	140	0.78	0.006	957,880	71.2	2.8	0.78
1	05/24	207	67.4	0.40	207	2.3	0.04	207	0.75	0.006	1,336,675	67.4	2.3	0.75
1	05/31	214	68.3	0.38	214	2.3	0.05	214	0.73	0.022	914,759	68.3	2.3	0.73
1	06/07	242	68.4	0.38	242	2.4	0.04	242	0.73	0.005	1,014,467	68.4	2.4	0.73
1	06/14	274	65.1	0.35	274	2.2	0.04	274	0.76	0.009	779,846	65.1	2.2	0.76
1	06/21	278	62.9	0.36	278	1.9	0.03	278	0.74	0.005	1,762,310	63.2	1.9	0.81
1	06/28	124	61.4	0.42	124	1.8	0.04	124	0.76	0.007	299,455	61.4	1.8	0.76
	Totals	1,722	66.7	0.17	1,713	2.3	0.02	1,713	0.75	0.003	7,736,438	66.7	2.3	0.75
2	05/03	64	79.3	0.94	61	3.8	0.12	64	0.77	0.012	150,700	79.3	3.8	0.77
2	05/10	283	81.9	0.38	283	4.4	0.07	283	0.78	0.004	916,183	81.9	4.4	0.78
2	05/17	200	80.1	0.41	180	4.0	0.08	200	0.77	0.006	1,285,745	80.1	4.0	0.77
2	05/24	143	75.4	0.51	143	3.2	0.07	143	0.72	0.006	923,403	75.4	3.2	0.72
2	05/31	136	75.8	0.42	136	3.0	0.06	136	0.69	0.005	581,342	75.8	3.0	0.69
2	06/07	108	75.0	0.62	108	3.0	0.09	108	0.71	0.011	452,738	75.0	3.0	0.71
2	06/14	76	72.1	0.86	76	3.0	0.18	76	0.78	0.024	216,308	72.1	3.0	0.78
2	06/21	72	68.6	0.70	72	2.5	0.08	72	0.75	0.012	456,426	68.6	2.5	0.75
2	06/28	14	69.4	2.00	14	2.3	0.14	14	0.69	0.025	33,809	69.4	2.3	0.69
	Totals	1,096	77.4	0.22	1,076	3.6	0.04	1,076	0.75	0.003	5,016,654	77.4	3.6	0.75

Appendix F. Daily climatilogical observations, water temperature, water depth, and trap cone revolutions per minute (RPM) at Chignik River, 1994.

Date	Time	Air (c)	Water (c)	Cloud Cover %	Wind Dir	Vel. (Mph)	Stream Guage (cm)	Trap RPM		Comments
								Small	Large	
05-May	0930								4.00	
06-May	0830								4.00	
07-May										
08-May	1715		6.0				0	3.20	4.10	
09-May	0900							3.10	4.00	
10-May	1900	5.0	4.0	80	NW	10-15	0	3.10	4.25	
11-May	1900	-	3.5	100	NW	10	0	4.00	3.75	Snow/rain
12-May	2000	10.5	4.0	100	-	0	1	3.80	3.80	Temps taken at weir
13-May	1900	6.0	5.0	100	NW	5-10	4	4.75	5.00	
14-May	1900	9.0	5.0	100	SE	5	5	-	-	
15-May	1900	7.0	4.5	90	SE	15	6	5.75	4.67	Temps taken at weir
16-May	1900	6.0	5.0	75	SE	5-10	8	5.25	5.60	
17-May	1925	4.0	4.0	100	SE	15	10	6.00	5.50	Steady rain
18-May	1900	8.5	6.5	100	NW	15	13	5.00	6.25	
19-May	2030	5.0	4.0	100	SE	10-15	15	5.75	6.25	Rain
20-May	1900	7.0	4.5	70	SE	15-20	17	5.75	6.25	Windy
21-May	2000	6.0	5.0	100	SE	15-20	18	6.25	5.50	
22-May	1930	7.0	4.5	100	-	0	20	6.25	6.00	
23-May	1930	-	5.0	100	SE	5	25	-	-	
24-May	1930	6.0	5.5	60	NW	5-10	30	6.85	7.00	
25-May	1930	6.0	5.5	55	NW	10	30	6.25	7.25	
26-May	1930	6.0	6.0	100	SE	15-20	30	7.00	6.00	Small fish rising
27-May	1930	6.0	6.0	100	SE	10	32	6.67	7.00	
28-May	1900	6.5	6.0	100	NW	15	32	-	-	
29-May	1815	4.5	6.0	100	NW	25-40	33	6.75	7.33	Windy
30-May	2100	6.0	6.0	10	NW	5	33	7.75	7.75	
31-May	2130	6.0	6.0	60	NW	15	32	5.00	5.00	
01-Jun	2130	5.5	6.5	30	NW	10	29	7.25	7.15	
02-Jun	2100	8.0	6.0	1	NW	15	25	-	-	
03-Jun	2100	10.0	7.0	25	NW	10	24	-	-	
04-Jun	2230	7.5	7.0	5	SE	15-20	24	6.00	6.00	

-Continued-

Appendix F. (Page 2 of 2)

Date	Time	Air (c)	Water (c)	Cloud Cover %	Wind Dir	Vel. (Mph)	Stream Guage (cm)	Trap RPM		Comments
								Small	Large	
05-Jun	2030	7.0	6.5	100	SE	15-20	23	-	-	
06-Jun	1930	7.5	6.5	100	SE	15-20	27	-	-	
07-Jun	2215	7.0	6.0	70	SE	10	30	8.10	7.25	
08-Jun	2000	7.5	7.0	100	SE	15	36	8.00	8.25	
09-Jun	1930	7.5	7.0	100	SE	20	36	7.50	8.00	
10-Jun	2200	8.0	6.0	50	SE	5-10	36	8.00	7.75	
11-Jun	2000	-	7.0	100	NW	10	37	-	-	
12-Jun	2000	8.5	6.0	100	NW	20	38	8.00	7.90	
13-Jun	1930	13.5	7.5	50	NW	20	41	8.50	8.00	
14-Jun	-	-	-	-	-	-	-	9.00	-	Small trap disabled
15-Jun	2000	9.0	8.0	30	NW	35	48	9.75	9.75	
16-Jun	2000	7.5	7.5	50	NW	25-40	44	-	-	
17-Jun	2000	8.5	10.5	0	NW	20	43	-	-	
18-Jun	2000	13.5	8.5	0	SE	10	46	-	-	
19-Jun	1800	-	9.0	100	SE	10	46	-	-	
20-Jun	2130	-	8.0	100	SE	25	46	-	-	
21-Jun	2000	9.5	9.0	95	NW	20	51	-	-	
22-Jun	2100	10.5	9.0	10	NW	20	51	9.75	11.00	
23-Jun	2100	8.5	9.0	99	SE	15	48	9.75	10.25	
24-Jun	1900	11.0	8.5	90	NW	10	46	9.00	10.00	
25-Jun	2130	8.0	8.0	100	NW	15	46	8.00	9.00	Moved traps
26-Jun	2015	8.5	8.5	100	SE	20	41	7.00	7.00	
27-Jun	2100	10.5	9.8	60	NW	25	38	8.00	8.25	
28-Jun							-	-	-	
29-Jun	2100	14.5	-	20	-	0	-	6.50	6.50	
30-Jun	1930	9.0	9.0	100	SE	30	28	-	-	
01-Jul	2000	9.0	8.5	80	SE	15	30	-	-	

Appendix G. Screw-trap efficiency estimates for various species and rivers.

Name	River Width (m)	Depth (m)	Diameter (m)	Screw-trap	Species	Mean Length (mm)	Efficiency (%)	Source
Chignik River, AK	73.0	2.7	2.4, 1.5		Sockeye	71	0.5	
Deep Creek, AK	14.6	3.0	2.4		Chinook	88	13.0	Terry Bendock, ADFG, pers. comm.
					Coho	> 88	12.0	
					Dolly Varden	> 88	14.0	
Grande Ronde, OR	40.0	5.3	2.4		Chinook	122[a]	2.0	Bradnt Gutermuth, ODFW, pers. comm.
Situk River, AK	25.0	0.8	2.4		Chinook	61-89	24.0	Thedinga et al., 1994.
					Coho	86-111	12.0	
					Sockeye	63-74	7.0	
					Steelhead	120-180	3.0	
Situk River, AK	22.9	0.8	2.4		Coho	100	4.5	Scott McPherson, ADFG, pers. comm.
Taku River, AK	91.4	4.6	3.7		Coho	105	0.6	Scott McPherson, ADFG, pers. comm.

[a] Represents average length of chinook smolt marked releases only.

Appendix H. Summary of mean length at age and percent age composition of outmigrating sockeye salmon smolt captured in the Chignik River, 1957, '58, '93 and '94. Numbers in parentheses represent parent year escapements into Black Lake (age-1) and Chignik Lake (age-2).

Year of Seaward Migration	Length (mm) Age-1	Age-2	1	2	3
1957	80	83	24.0 (257,000)	74.7 (278,000)	1.3
1958	78	79	8.8 (289,000)	90.0 (201,000)	0.3
1993	80	91	73.5 (658,000)	26.5 (336,000)	-
1994	67	77	61.1 (361,000)	38.9 (383,000)	-