AN ESTIMATE OF JUVENILE FISH DENSITIES IN SKILAK AND KENAI LAKES, ALASKA, THROUGH THE USE OF DUAL-BEAM HYDROACOUSTIC TECHNIQUES IN 1996–1998

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ABSTRACT

The number and distribution of juvenile sockeye salmon *Onchorhynchus nerka* rearing in two glacial lakes of the Kenai River drainage was estimated in 1996, 1997, and 1998 from hydroacoustic surveys and trawl sampling. Abundance estimates for juvenile sockeye salmon ranged from 6.0 to 25.6 million fish. Other fish species in the lakes composed less than 1% of the total fish population. The majority of juvenile sockeye salmon were located in Skilak Lake. *In situ* mean target strengths ranged from -55.6 to –57.8 dB. Juvenile sockeye salmon AWL data for each year and by lake are reported.

KEY WORDS: hydroacoustic survey, juvenile sockeye salmon, *Onchorhynchus nerka*, target strength, glacial lake, trawl sampling

INTRODUCTION

Annual fall hydroacoustic surveys and mid-water trawls have been conducted in Kenai and Skilak Lakes, Upper Cook Inlet, Alaska (Figure 1) since 1986 to develop a time series of juvenile sockeye salmon population estimates (Tarbox and King 1988a, 1988b, Tarbox, King, and Brannian 1993, Tarbox et. al. 1995, Tarbox et. al.1996). Program objectives for the 1996–1998 field investigations were: (1) estimate the number and spatial distribution of sockeye salmon juveniles; (2) determine the target strength distributions using dual-beam hydroacoustic techniques; (3) estimate the age composition of sockeye salmon in each lake; and (4) document the condition of juvenile sockeye salmon using length and weight measurements.

METHODS

The equipment used for data acquisition consisted of a Biosonics Inc. Model 105[1] echo sounder with dual-beam receivers, a 420 kHz 6°/15° dual beam transducer mounted in a V-fin for towing, a Model 171 tape recorder interface, a Sony[1] digital audio tape (DAT) player, a chart recorder, and an oscilloscope. The selected pulse width was 0.4 ms and the pulse repetition rate was 5 pulses/s. Biosonics, Inc. calibrated the system before and following the surveys. The entire system was powered by 12-V batteries and carried in a 7.2-m vessel powered by outboard motors. Vessel speed along each transect was estimated at 2.0 to 2.5 m/s. The transducer was towed approximately 1 m below the water surface during the surveys. Equipment procedures are outlined in King and Tarbox (1988).

Dual-beam data recorded on DAT were processed through a Biosonics, Inc. Model 281 Echo Signal Processor[1] (ESP). A returning pulse was accepted as a valid target if the amplitude was below the bottom threshold of 9000 mV and above the counting threshold of 300 mV. Single targets were separated from multiple targets if the pulse width was within 20% of the transmitted pulse width at -6 dB and -18 dB. The maximum half-angle selected for data processing was 4°. Data were stratified in 5-m increments for analysis starting 2 m below the transducer, or 3 m below the water surface. Only data collected at range less than 97 m were accepted for processing. Examination of oscilloscope traces and echograms indicated that few fish were present below this depth.

Data generated by the dual beam processor were transferred to computer data files for analysis using the Biosonics, Inc. software *Target Strength Post Processing Program ESPTS.*

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1 Use of a company name does not constitute endorsement by ADF&G.

Computations of mean target strength and back scattering cross section were made from individual echoes, and a hard copy of the results was printed for each 5-m depth interval.

Estimates of fish density were made for each transect by echo integration using a Biosonics, Inc. ESP Model 221[1] echo integrator. Correction from the 40 log(R) setting used during data collection to the 20 log(R) used for data processing was accomplished by adjusting the B constant value for each depth stratum.

The echo integrator compiled data in 1-min sequences along each transect and sent outputs to computer files for further reduction and analysis using the Biosonics, Inc. software *Echo Integration Post Processing Program ESPCRNCH.* Raw integrator outputs were edited to remove data that resulted from false bottom echoes. Where this occurred, fish densities were usually estimated using the average densities of adjacent sequences at the same depth. Overall fish density was obtained by calculating the average edited integrator output value across the transect for each depth stratum. These averages were multiplied by the integrator scaling factor derived from the mean back scattering cross-section value obtained from the ESPTS program. Mean back scattering cross section values were calculated for each depth stratum using data from those transects where false bottom did not occur or did not influence the target strength data.

The total number of fish (N_{ij}) for area stratum i based on transect j was estimated across depth stratum k. It consisted of an estimate of the number of fish detected by hydroacoustic gear in the mid-water section (M_{ij}) plus an estimate of fish unavailable to the hydroacoustic gear because of their location near the surface (S_{ij}) or bottom (B_{ij}), or

$$\hat{N}_{ij} = \hat{S}_{ij} + \hat{M}_{ij} + \hat{B}_{ij} .$$

The mid-water component was estimated as

$$\hat{M}_{ij} = \sum_{k=1}^{K} a_i w_{ijk} m_{ijk} ,$$

where a_i represented the surface area (m^2) of area stratum i which was estimated using a planimeter and USGS maps of Skilak and Kenai Lakes, and w_{ijk} was the average depth (5 m) of depth stratum k measured along transect j in area i. This depth would be less than the maximum 5 m if the bottom was detected within depth stratum k anytime along the transect. The estimated mean fish density in area i depth k across transect j was m_{ijk} in number/m^3.

The estimated number of fish near the surface (0–3 m) in area i was

$$\hat{S}_{ij} = a_{is} m_{ij1} ,$$

where a_{is} was the estimated volume (m^3) of the surface stratum (0–3 m), and m_{ij1} was the mean fish density for the first ensonified depth stratum (2–7 m below transducer) of transect j.

The estimated number of fish near the bottom was

$$\hat{B}_{ij} = \sum_{k=1}^{K} b_{ijk} m_{ijk} \ ,$$

where b_{ijk} was the estimated volume (m^3) in area i of depth k that could not be ensonified due to the proximity of the bottom along transect j, and m_{ijk} was the estimated fish density (number/m^3) along transect j in area i depth k that was ensonified. In cases where all of depth stratum k was along the bottom, the mean density m_{ijk-1} from the next shallower depth strata (k-1) was used.

Fish abundance in area i (N_i) became the mean abundance estimated by each transect j, or

$$\hat{N}_i = J^{-1} \sum_{j=1}^{J} N_{ij} \ ,$$

and its variance was estimated as

$$v(\hat{N}_i) = \sum_{j=1}^{J} \left(\hat{N}_{ij} - \hat{N}_i\right)^2 (J-1)^{-1} J^{-1} .$$

Total fish abundance (N) for each lake was estimated as the sum of the area estimates and the variance of N was estimated as the sum of the area variance estimates.

The abundance of juvenile sockeye salmon in each lake (N_s) was estimated as

$$\hat{N}_s = \hat{N}\hat{P} \ ,$$

where $\hat{P}$ is the estimated proportion of juvenile sockeye salmon in the lake. Age-specific numbers of juvenile sockeye salmon (N_{sa}) were estimated as

$$\hat{N}_{sa} = \hat{N} \ \hat{p}_a \ ,$$

where $\hat{P}_a$ is the estimated proportion of age-a sockeye salmon in the fish population. Variance estimates were calculated as

$$v(\hat{N}_s) = \hat{N}^2 v(\hat{P}) + \hat{P}^2 v(\hat{N}) - v(\hat{P}) v(\hat{N})$$

$$v(\hat{N}_{sa})=\hat{N}^2 v(\hat{P}_a)+\hat{P}_a^2 v(\hat{N})-v(\hat{P}_a)v(\hat{N}).$$

We used a stratified random sampling design for the night hydroacoustic surveys to distribute sampling effort and provide an appropriate way of estimating total abundance and variance. Each lake was divided into areas or sub-basins and survey transects were randomly selected within each area. The number of transects was chosen to reduce the relative error to approximately 25% for Skilak Lake and 30% for Kenai Lake. Our sample size was based on the average coefficient of variation observed from 1986 to 1995. Because of the configuration of Skilak Lake, transects perpendicular to shore were surveyed within 3 sub-basins (Figures 2,3,4). In Kenai Lake, transects were surveyed within 5 sub-basins (Figures 5,6,7).

Mid-water trawls (tow netting) were undertaken in both lakes to determine species composition of the targets and age composition, wet weight (g), and fork length (mm) of juvenile sockeye. In Skilak Lake in 1996 we used stratified cluster and stratified 2-stage sampling techniques (Scheaffer et al. 1986, Cochran 1977). Strata were defined by area and depth. Areas were the same as those used in the hydroacoustic sampling. Depth strata were developed to account for potential vertical variation in species and age composition. Three depth strata were defined: surface (0-10 m), mid-depth (15-25 m) and deep (30-40 m). Each tow was defined as a primary sampling unit and a minimum of 3 tows were conducted in each stratum. All fish captured in each tow were identified by species. A sample of sockeye fry was collected from each tow to estimate age composition and average length and weight. In Kenai Lake in 1996 we used a stratified random sampling technique using area and depth strata (Scheaffer et al. 1986, Cochran 1977). Three areas and two depth intervals were defined. Following the hydroacoustic sampling, area 1 was used, areas 2 and 3 were combined, and areas 4 and 5 were combined. Two depth strata were defined: surface (0-10 m) and mid-depth (15-25 m).

In 1997 and 1998 a cluster sampling technique (Scheaffer et al. 1986, Cochran 1977) was used to estimate species composition in both lakes. Age composition and average size (length and weight) of sockeye fry were estimated using 2-stage sampling (Scheaffer et al. 1986, Cochran 1977). Towing locations were selected randomly within each lake. The primary sampling unit was defined as an "oblique" tow, which consisted of combining fish collected at the surface, mid-depth, and deep intervals (defined above) after towing for a constant time period at each depth (usually 20 or 30 minutes). All fish captured in each oblique tow were identified by species and a sample of sockeye fry was collected to estimate age composition and average size.

All captured fish were enumerated, identified, and preserved in 10% formalin. In the laboratory juvenile sockeye salmon were measured to the nearest millimeter (fork length), weighed (wet) to the nearest 0.1 g, and the age determined from scale samples using criteria outlined by Mosher (1969).

RESULTS

September 1996

A total of 14,170 echoes were used to estimate target strength distributions in Skilak Lake. Mean target strength was –55.62 dB with a standard deviation (SD) of 5.0 dB. As in past fall surveys, calculated mean target strengths decreased with depth (Appendix Table A.2). The estimated fish population was 5,237,700 (Table 1) with a standard error (SE) of 644,000. An estimated 42% of the fish were located in area 1. Table 2 summarizes the contribution of juvenile sockeye salmon to the total fish population in Skilak and Kenai Lakes. In Skilak Lake 1530 fish were captured in the tow nets; 910 juvenile sockeye were sampled to determine age, fork length, and wet weight (AWL). Juvenile sockeye composed an estimated 99.1% of the fish population (SE = 1.6%). The estimated abundance of sockeye salmon in Skilak lake was therefore 5,190,588 (SE = 643,617). Age-0 sockeye were predominant, composing an estimated 92.2% (SE = 2.2%) of the fish, resulting in an abundance estimate of 4,829,624 (SE = 604,506). The estimated proportion of age-1 sockeye was 6.9% (SE = 0.11%), with an abundance of 360,964 (SE = 44,758). Average fork length and wet weight of age-0 sockeye (n = 835) was 51.4 mm (SE = 0.14) and 1.60 g (SE = 0.013), respectively. Average length and weight of age-1 sockeye (n = 75) was 69.9 mm (SE = 0.38) and 4.00 g (SE = 0.068), respectively.

A total of 5,913 echoes were used to estimate target strength distributions in Kenai Lake (Appendix Table A.3). Mean target strength was –55.71 dB (SD = 5.03). A total of 768,710 fish (SE = 79,010) were estimated in Kenai Lake (Table 1), of which 29% were located in Area 3. A total of 879 fish were captured in the tow nets and identified by species; 862 juvenile sockeye were sampled to determine AWL data. Sockeye salmon composed an estimated at 98.9% (SE = 2.6%) of the fish population. Thus, the estimated abundance of juvenile sockeye in Kenai lake was 760,508 (SE = 80,625). Age-0 sockeye predominated, composing an estimated 97.9% (SE = 3.9%), resulting in an abundance estimate of 752,828 (SE = 82,836). Average fork length and wet weight of age-0 sockeye (n = 854) was, respectively, 56.0 mm (SE = 0.19) and 2.30 g (SE = 0.023). Average length and weight of age-1 sockeye (n = 8) was, respectively, 78.1 mm (SE = 1.91) and 6.05 g (SE = 0.362).

The estimated total number of fish in both lakes was 6,006,410 (SE = 648,840) (Table 1). The estimated number of juvenile sockeye in both lakes was 5,951,096 (SE = 648,648), thus composing 99.1% of the total fish abundance. Skilak Lake accounted for 87.2% and Kenai Lake accounted for the remaining 12.8% of the sockeye abundance estimate. The estimated number of age-0 sockeye in both lakes was 5,582,452 (SE = 610,155), thus composing 93.8% of the total sockeye abundance.

September 1997

A total of 33,879 echoes in Skilak Lake and 10,011 echoes in Kenai Lake were used to estimate target strength distributions (Appendix Table A.4 and A.5). In Skilak Lake the mean target strength was –56.57 dB (SD = 4.17). Mean target strength in Kenai Lake was –56.64 dB (SD = 4.91).

The total estimated abundance of fish in both lakes was 25,733,000 (SE = 4,264,739) (Table 3). An estimated 23,399,000 (SE = 4,260,164), 90.9% of the total, were enumerated in Skilak Lake and the remaining 2,333,300 (SE = 196,033), 9.1% of the total, were counted in Kenai Lake. An estimated 57% of the fish in Skilak Lake were located in Area 1. In Kenai Lake an estimated 43% of the fish were located in Area 2.

Table 4 summarizes estimates of sockeye salmon contribution to the fish population in Skilak and Kenai Lakes. In Skilak Lake 2205 fish were captured in the tow nets and identified by species; of this catch 901 juvenile sockeye were sampled to obtain AWL data. Juvenile sockeye predominated, composing an estimated 99.3% (SE = 0.25%) of the fish population and corresponding to an abundance estimate of 23,239,823 (SE = 4,231,588). Age-0 sockeye salmon were also predominant in Skilak Lake, composing an estimated 98.3% (SE = 0.35%) of the fish population and corresponding to an abundance estimate of 23,000,241 (SE = 4,188,326). Age-1 sockeye composed only an estimated 1.0% (SE = 0.24%) of the fish population, with an abundance estimate of 239,582 (SE = 70,238). Average fork length and wet weight of age-0 sockeye (n = 892) was 41.7 mm (SE = 0.14) and 0.85 g (SE = 0.016), respectively. Average length and weight of age-1 sockeye (n = 9) was 66.4 mm (SE = 1.13) and 3.12 g (SE = 0.117), respectively.

In Kenai Lake 407 fish were captured in the tow nets and identified by species; 404 juvenile sockeye were captured and used to measure AWL data. All captured juvenile sockeye were age-0 composing an estimated 99.3% (SE = 1.61%) of the fish population. The estimated abundance of (age-0) juvenile sockeye was therefore 2,316,101 (SE = 198,138). Average fork length and wet weight of age-0 sockeye (n = 404) was 48.2 mm (SE = 0.42) and 1.27 g (SE = 0.018), respectively.

The estimated number of juvenile sockeye salmon in both lakes was 25,555,990 (SE = 4,236,236). Of this estimate, 25,316,385 (SE = 4,193,018) were age-0 juveniles produced by the 1996 spawning population; an estimated 239,582 (SE = 70,238) were age-1 juveniles produced by the 1995 spawning population.

September 1998

A total of 25,252 echoes in Skilak Lake and 9,798 echoes in Kenai Lake were used to estimate target strength distributions (Appendix Table A.6 and A.7). In Skilak Lake the mean target strength was –57.68dB (SD = 4.53). Mean target strength in Kenai Lake was –57.76dB (SD = 4.40).

The estimated total abundance of fish in both lakes was 23,721,000 (SE = 1,316,017) (Table 7). An estimated 17,854,000 (SE = 1,168,931), 75.3% of the total, were enumerated in Skilak Lake and the remaining 5,866,600 (SE = 604,599), 24.7% of the total, were counted in Kenai Lake. In Skilak Lake most fish (64%) were located in Area 1. In Kenai Lake fish distribution was fairly even with 29% of the targets located in Area 4.

Table 6 summarizes estimates of sockeye salmon contribution to the fish population in Skilak and Kenai Lakes. In Skilak Lake 862 fish were captured in the tow nets and identified by species; of these, 720 juvenile sockeye were sampled to obtain AWL data. Juvenile sockeye predominated, composing an estimated 99.7% (SE = 0.063%) of the fish population and corresponding to an abundance estimate of 17,791,863 (SE = 1,164,916). Age-0 sockeye salmon composed an estimated 85.9% (SE = 1.98%) of the Skilak Lake fish population, with an abundance estimate of 15,332,110 (SE = 1,064,106). Age-1 sockeye composed an estimated 13.8% (SE = 1.98%) of the fish population, with an abundance estimate of 2,459,753 (SE = 387,963). Average fork length and wet weight of age-0 sockeye (n = 619) was 38.8 mm (SE = 0.51) and 0.70 g (SE = 0.032), respectively. Average length and weight of age-1 sockeye (n = 101) was 52.4 mm (SE = 0.37) and 1.72 g (SE = 0.038), respectively.

In Kenai Lake 2283 fish were captured in the tow nets and identified by species; of these, 747 juvenile sockeye were sampled to obtain AWL data. All captured juvenile sockeye were age-0, composing an estimated 99.9% (SE = 0.17%) of the fish population. The estimated abundance of (age-0) juvenile sockeye was therefore 5,861,461 (SE = 604,152). Average fork length and wet weight of age-0 sockeye (n = 747) was 41.2 mm (SE = 0.24) and 0.86 g (SE = 0.011), respectively.

The estimated number of juvenile sockeye salmon in both lakes was 23,653,305 (SE = 1,312,261). Of this estimate, 21,193,560 (SE = 1,223,651) were age-0 juveniles produced by the 1997 spawning population. An estimated 2,459,746 (SE = 387,962) were age-1 sockeye salmon produced by the 1996 spawning population.

DISCUSSION

The abundance of juvenile sockeye salmon in Kenai and Skilak Lakes has varied significantly since 1986 when the project started (Figure 8). The lowest number of fish in the lakes was recorded during the 1996 rearing year. This coincided with a flood event in the Kenai in the fall of 1995, which was estimated to exceed the 1 in 100 year flood event. Significant scouring of the riverbed was observed and this may have contributed to the lower fry numbers. A return to high levels of fry abundance was recorded in the following years, although fry size decreased to the lowest measured (Figure 9). A relationship between fry size and numbers is evident in the system indicating density dependence mechanisms. The 1998 rearing fry were substantially smaller than expected and this may result in decreased over-winter survival and the subsequent adult return

(Figure 10). A full discussion of the rearing conditions and biological mechanisms observed in these lakes is in preparation as part of the Exxon Valdez Oil Spill funded projects dealing with the impacts of large sockeye salmon escapements in the Kenai River drainage.

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Table 1. Estimated number of fish in Skilak and Kenai Lakes, Alaska in September 1996.

Lake	Area	Transect	Estimated Number of Fish: Surface	Midwater	Bottom	Total	Area Mean	Variance
Skilak	1	1	3.4067E+04	2.0261E+06	4.7413E+04	2.1076E+06		
		2	4.2380E+03	1.6522E+06	8.1262E+04	1.7377E+06		
		3	4.9119E+04	1.3804E+06	7.0293E+04	1.4998E+06	2.2295E+06	7.0420E+10
		4	3.4002E+04	1.9855E+06	1.1335E+05	2.1328E+06		
		5	2.0073E+04	2.3936E+06	1.6319E+05	2.5769E+06		
		6	1.8976E+05	2.9330E+06	1.9918E+05	3.3219E+06		
	2	1	2.5517E+04	1.0631E+06	3.5896E+04	1.1245E+06		
		2	4.7359E+04	3.7301E+06	1.3367E+03	3.7788E+06	2.1062E+06	3.3496E+11
		3	5.4185E+04	1.7399E+06	6.5811E+04	1.8599E+06		
		4	3.0937E+04	1.5341E+06	9.6613E+04	1.6617E+06		
	3	1	1.0712E+05	6.6326E+05	2.8405E+04	7.9879E+05		
		2	5.7416E+04	8.3307E+05	1.6911E+04	9.0740E+05	9.0203E+05	9.3633E+09
		3	5.0416E+04	6.5357E+05	2.6895E+04	7.3088E+05		
		4	6.6258E+04	1.0732E+06	3.1607E+04	1.1711E+06		
	TOTAL						5.2377E+06	4.1475E+11
Kenai	1	1	0.0000E+00	5.8451E+04	4.2322E+03	6.2683E+04		
		2	1.4477E+03	3.8546E+04	3.0339E+03	4.3028E+04		
		3	1.5999E+02	6.0603E+04	9.0493E+03	6.9812E+04	1.3329E+05	1.2277E+09
		4	9.5743E+03	1.6040E+05	1.1678E+04	1.8165E+05		
		5	1.1416E+04	1.7378E+05	7.5978E+03	1.9095E+05		
		6	1.9651E+04	2.2691E+05	5.0764E+03	2.5164E+05		
	2	1	4.5020E+04	1.9503E+05	0.0000E+00	2.4005E+05		
		2	7.4569E+03	6.4531E+04	0.0000E+00	7.1988E+04		
		3	1.7333E+03	7.1140E+04	0.0000E+00	7.2873E+04	1.2416E+05	1.5781E+09
		4	1.2398E+04	9.9332E+04	0.0000E+00	1.1173E+05		
	3	1	5.6726E+04	2.5720E+05	0.0000E+00	3.1393E+05		
		2	1.6338E+04	3.0412E+05	0.0000E+00	3.2046E+05		
		3	1.9794E+04	1.3657E+05	0.0000E+00	1.5636E+05	2.2397E+05	1.7985E+09
		4	4.4900E+01	1.0562E+05	0.0000E+00	1.0566E+05		
		5	7.6837E+03	2.1576E+05	0.0000E+00	2.2344E+05		
	4	1	2.8414E+03	1.1400E+05	0.0000E+00	1.1684E+05		
		2	0.0000E+00	1.8775E+05	0.0000E+00	1.8775E+05		
		3	1.7697E+04	2.0714E+05	0.0000E+00	2.2484E+05	2.1179E+05	7.7566E+08
		4	5.9923E+03	2.6708E+05	0.0000E+00	2.7307E+05		
		5	2.2538E+04	2.3391E+05	0.0000E+00	2.5645E+05		
	5	1	0.0000E+00	8.2081E+03	0.0000E+00	8.2081E+03		
		2	3.5479E+03	1.5191E+04	0.0000E+00	1.8739E+04		
		3	9.2599E+03	2.8370E+04	0.0000E+00	3.7630E+04		
		4	5.3546E+03	1.2035E+05	0.0000E+00	1.2570E+05	7.5494E+04	8.6274E+08
		5	4.1840E+03	6.0641E+04	0.0000E+00	6.4825E+04		
		6	0.0000E+00	4.4664E+04	0.0000E+00	4.4664E+04		
		7	3.0714E+04	1.9797E+05	0.0000E+00	2.2868E+05		
	TOTAL						7.6871E+05	6.2427E+09
	TOTAL FOR BOTH LAKES						6.0064E+06	4.2099E+11

file name: S26396T.xls

Table 2. Estimated contribution of juvenile sockeye salmon to the total fish population in Skilak and Kenai Lakes, Alaska, September 1996. Total Fish estimates are from night hydroacoustic surveys. Fish composition data are from daytime tow net surveys.

		Estimated Abundance		
Lake	Total Fish	Sockeye Salmon[a]	Age-0[b]	Age-1[b]
Skilak[c]	5,237,700	5,190,600 (99.1%)	4,829,600 (92.2%)	361,000 (6.9%)
Kenai[c]	768,700	760,500 (98.9%)	752,800 (97.9%)	7,700 (1.0%)
Total[c]	6,006,400	5,951,100 (99.1%)	5,582,500 (92.9%)	368,700 (6.1%)

[a] Species composition sample size for Skilak Lake = 1530, for Kenai Lake = 879.

[b] Age composition sample size for Skilak Lake = 910, for Kenai Lake = 862.

[c] Rounded to nearest 100 fish.

Table 3. Estimated number of fish in Skilak and Kenai Lakes, Alaska in September 1997.

Lake	Area	Transect	Estimated Number of Fish: Surface	Midwater	Bottom	Total	Area Mean	Variance
Skilak	1	1	5.2165E+05	5.9423E+06	2.4394E+05	6.7079E+06		
		2	5.5870E+05	7.0696E+06	1.1604E+06	8.7887E+06		
		3	8.7794E+05	2.9478E+07	1.8502E+06	3.2206E+07	1.3231E+07	1.7042E+13
		4	6.5836E+05	1.5369E+07	1.0266E+06	1.7054E+07		
		5	7.1141E+05	7.5074E+06	5.5563E+05	8.7744E+06		
		6	8.7497E+05	4.6251E+06	3.5266E+05	5.8527E+06		
	2	1	4.4609E+05	6.0720E+06	1.0782E+05	6.6259E+06		
		2	3.8676E+05	7.8776E+06	2.4795E+05	8.5123E+06	8.1025E+06	9.4747E+11
		3	9.0462E+05	9.6249E+06	1.6219E+05	1.0692E+07		
		4	4.3013E+05	5.7789E+06	3.7119E+05	6.5802E+06		
	3	1	3.0551E+04	1.5292E+06	1.2620E+05	1.6860E+06		
		2	1.7881E+05	1.2192E+06	1.3588E+04	1.4116E+06	2.0661E+06	1.6016E+11
		3	4.9356E+05	2.5575E+06	1.7025E+05	3.2213E+06		
		4	1.6295E+05	1.7278E+06	5.4724E+04	1.9455E+06		
	TOTAL						2.3399E+07	1.8149E+13
Kenai	1	1	1.4118E+02	4.5752E+05	6.4137E+04	5.2180E+05		
		2	1.7859E+03	3.8003E+05	5.4299E+04	4.3611E+05		
		3	8.2635E+03	5.0984E+05	1.5948E+05	6.7758E+05	5.4407E+05	5.4349E+09
		4	3.2957E+04	7.0180E+05	1.0469E+05	8.3945E+05		
		5	5.1577E+04	3.5911E+05	2.7440E+04	4.1951E+05		
		6	0.0000E+00	3.3031E+05	3.9667E+04	3.6998E+05		
	2	1	1.0991E+03	7.9650E+05	0.0000E+00	7.9760E+05		
		2	2.1606E+04	7.8080E+05	0.0000E+00	8.0241E+05		
		3	2.6465E+03	1.2854E+06	0.0000E+00	1.2880E+06	1.0014E+06	1.4731E+10
		4	1.0862E+04	1.1066E+06	0.0000E+00	1.1175E+06		
	3	1	2.4445E+04	3.0532E+05	0.0000E+00	3.2977E+05		
		2	0.0000E+00	1.8852E+05	0.0000E+00	1.8852E+05		
		3	1.6591E+04	4.0340E+05	0.0000E+00	4.1999E+05	4.0945E+05	4.9288E+09
		4	1.5721E+03	5.2810E+05	0.0000E+00	5.2967E+05		
		5	3.2158E+03	5.7609E+05	0.0000E+00	5.7931E+05		
	4	1	3.9687E+03	1.4590E+05	0.0000E+00	1.4987E+05		
		2	4.9533E+04	2.4579E+05	0.0000E+00	2.9532E+05		
		3	2.5556E+04	2.5791E+05	0.0000E+00	2.8347E+05	2.2468E+05	2.7227E+09
		4	0.0000E+00	5.7866E+04	0.0000E+00	5.7866E+04		
		5	7.1821E+04	2.6504E+05	0.0000E+00	3.3686E+05		
	5	1	2.9022E+05	4.7825E+05	0.0000E+00	7.6847E+05		
		2	0.0000E+00	1.2147E+03	0.0000E+00	1.2147E+03		
		3	5.9284E+02	4.8769E+04	0.0000E+00	4.9362E+04		
		4	2.0054E+04	3.7483E+04	0.0000E+00	5.7537E+04	1.5371E+05	1.0612E+10
		5	0.0000E+00	3.4651E+04	0.0000E+00	3.4651E+04		
		6	0.0000E+00	8.5438E+04	0.0000E+00	8.5438E+04		
		7	1.3146E+03	7.7980E+04	0.0000E+00	7.9295E+04		
	TOTAL						2.3333E+06	3.8429E+10
	TOTAL FOR BOTH LAKES						2.5733E+07	1.8188E+13

file name: S25297T.xls

Table 4. Estimated contribution of juvenile sockeye salmon to the total fish population in Skilak and Kenai Lakes, Alaska, September 1997. Total Fish estimates are from night hydro-acoustic surveys. Fish composition data are from daytime tow net surveys.

		Estimated Abundance		
Lake	Total Fish	Sockeye Salmon[a]	Age-0[b]	Age-1[b]
Skilak[c]	23,399,000	23,239,900 (99.3%)	23,000,300 (98.3%)	239,600 (1.0%)
Kenai[c]	2,333,300	2,316,100 (99.3%)	2,316,100 (99.3%)	0 (0%)
Total[c]	25,732,300	25,556,000 (99.3%)	25,316,400 (98.4%)	239,600 (0.9%)

[a] Species composition sample size for Skilak Lake = 2205, for Kenai Lake = 407.

[b] Age composition sample size for Skilak Lake = 901, for Kenai Lake = 404.

[c] Rounded to nearest 100 fish.

Table 5. Estimated number of fish in Skilak and Kenai Lakes, Alaska in September 1998.

Lake	Area	Transect	Surface	Midwater	Bottom	Total	Area Mean	Variance
			Estimated Number of Fish					
Skilak	1	1	4.4459E+05	9.4085E+06	4.6108E+05	1.0314E+07		
		2	6.6959E+05	9.4319E+06	7.8052E+05	1.0882E+07		
		3	1.4213E+06	1.1673E+07	2.0274E+06	1.5122E+07	1.1433E+07	8.7227E+11
		4	1.7001E+06	7.0437E+06	4.5457E+05	9.1984E+06		
		5	6.8263E+05	8.4376E+06	6.8967E+05	9.8099E+06		
		6	1.7621E+06	1.0213E+07	1.2959E+06	1.3271E+07		
	2	1	3.2684E+04	2.6564E+06	5.1858E+04	2.7409E+06		
		2	1.0741E+05	4.3425E+06	7.6906E+04	4.5268E+06	4.5544E+06	4.3141E+11
		3	1.5569E+05	5.5882E+06	4.1662E+04	5.7856E+06		
		4	2.3067E+05	4.8998E+06	3.3683E+04	5.1642E+06		
	3	1	4.5549E+05	1.6747E+06	4.4888E+04	2.1751E+06		
		2	2.1148E+05	1.1315E+06	7.9279E+02	1.3438E+06	1.8668E+06	6.2722E+10
		3	8.5928E+04	1.4444E+06	1.8954E+04	1.5493E+06		
		4	1.7813E+04	2.3792E+06	2.0001E+03	2.3990E+06		
	TOTAL						1.7854E+07	1.3664E+12
Kenai	1	1	1.2606E+04	3.7461E+05	2.6082E+04	4.1330E+05		
		2	1.0540E+04	3.7437E+05	3.2843E+04	4.1775E+05		
		3	0.0000E+00	2.1688E+05	1.5838E+04	2.3272E+05	4.2855E+05	2.4678E+09
		4	5.2550E+04	4.6485E+05	4.9974E+04	5.6737E+05		
		5	4.0113E+03	4.6586E+05	3.1082E+04	5.4949E+05		
		6	5.9081E+04	3.1787E+05	1.3699E+04	3.9065E+05		
	2	1	1.6157E+04	1.6754E+06	0.0000E+00	1.6916E+06		
		2	4.9951E+04	8.2480E+05	0.0000E+00	8.7475E+05		
		3	4.3841E+04	8.7585E+05	0.0000E+00	9.1969E+05	1.0580E+06	4.5949E+10
		4	1.2252E+04	7.3385E+05	0.0000E+00	7.4610E+05		
	3	1	3.2885E+04	2.5080E+06	0.0000E+00	2.5409E+06		
		2	6.1691E+04	1.6052E+06	0.0000E+00	1.6669E+06		
		3	2.0474E+04	1.4468E+06	0.0000E+00	1.4673E+06	1.4021E+06	1.5704E+11
		4	3.0605E+04	1.2247E+06	0.0000E+00	1.2553E+06		
		5	7.9967E+04		0.0000E+00	7.9967E+04		
	4	1	1.1368E+05	1.0558E+06	0.0000E+00	1.1695E+06		
		2	8.1047E+04	1.0875E+06	0.0000E+00	1.1685E+06		
		3	8.1823E+04	9.8560E+05	0.0000E+00	1.0674E+06	1.7270E+06	1.3206E+11
		4	1.6985E+05	2.5057E+06	0.0000E+00	2.6756E+06		
		5	8.7858E+04	2.4660E+06	0.0000E+00	2.5539E+06		
	5	1	2.3635E+05	8.0976E+05	0.0000E+00	1.0461E+06		
		2	1.1267E+05	9.4306E+05	0.0000E+00	1.0557E+06		
		3	4.9119E+04	9.4893E+05	0.0000E+00	9.9805E+05		
		4	2.0582E+04	1.1420E+06	0.0000E+00	1.1626E+06	1.2509E+06	2.8028E+10
		5	3.1833E+04	9.3242E+05	0.0000E+00	9.6425E+05		
		6	2.5478E+04	1.2841E+06	0.0000E+00	1.3096E+06		
		7	1.4093E+05	2.0794E+06	0.0000E+00	2.2203E+06		
	TOTAL						5.8666E+06	3.6554E+11
	TOTAL FOR BOTH LAKES						2.3721E+07	1.7319E+12

file name: SK98T.xls

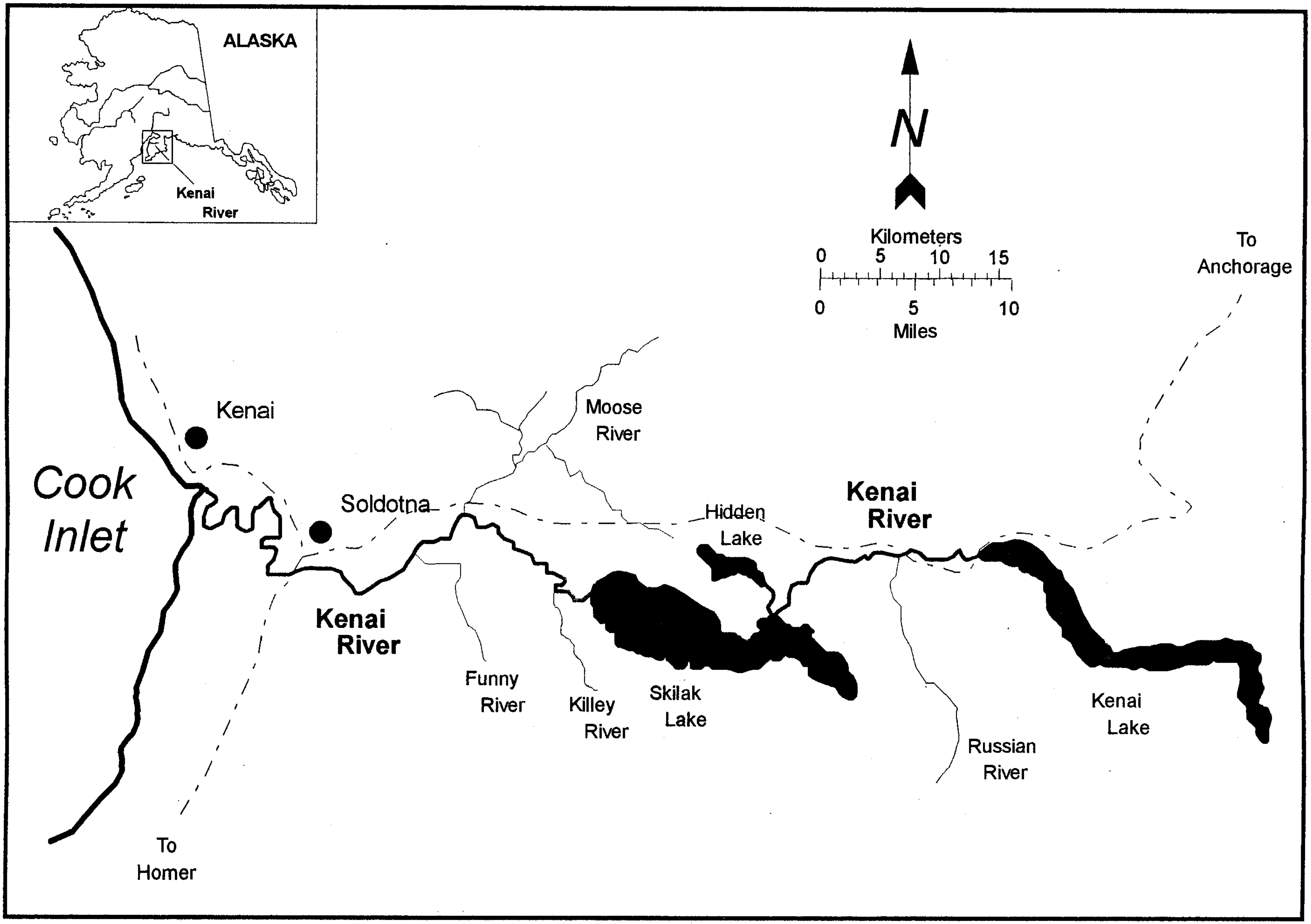
Table 6. Estimated contribution of juvenile sockeye salmon to the total fish population in Skilak and Kenai Lakes, Alaska, September 1998. Total Fish estimates are from night hydro-acoustic surveys. Fish composition data are from daytime tow net surveys.

		Estimated Abundance		
Lake	Total Fish	Sockeye Salmon[a]	Age-0[b]	Age-1[b]
Skilak[c]	17,854,000	17,792,000 (99.7%)	15,332,100 (85.9%)	2,459,700 (13.8%)
Kenai[c]	5,866,600	5,861,400 (99.9%)	5,861,400 (100%)	0 (0%)
Total[c]	23,720,600	23,653,300 (99.7%)	21,193,600 (89.3%)	2,459,700 (10.4%)

[a] Species composition sample size for Skilak Lake = 862, for Kenai Lake = 2283.

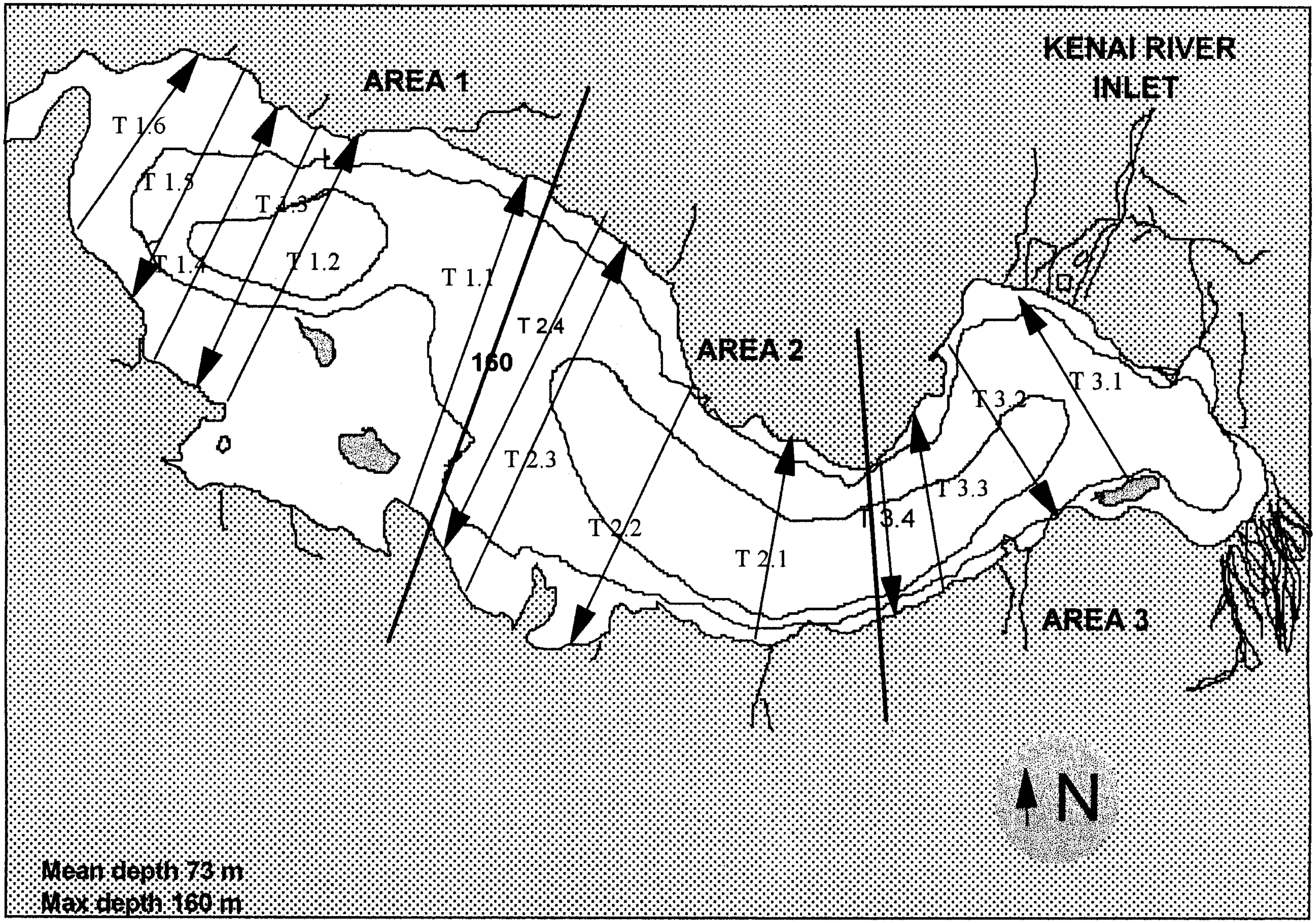
[b] Age composition sample size for Skilak Lake = 720, for Kenai Lake = 747.

[c] Rounded to nearest 100 fish.



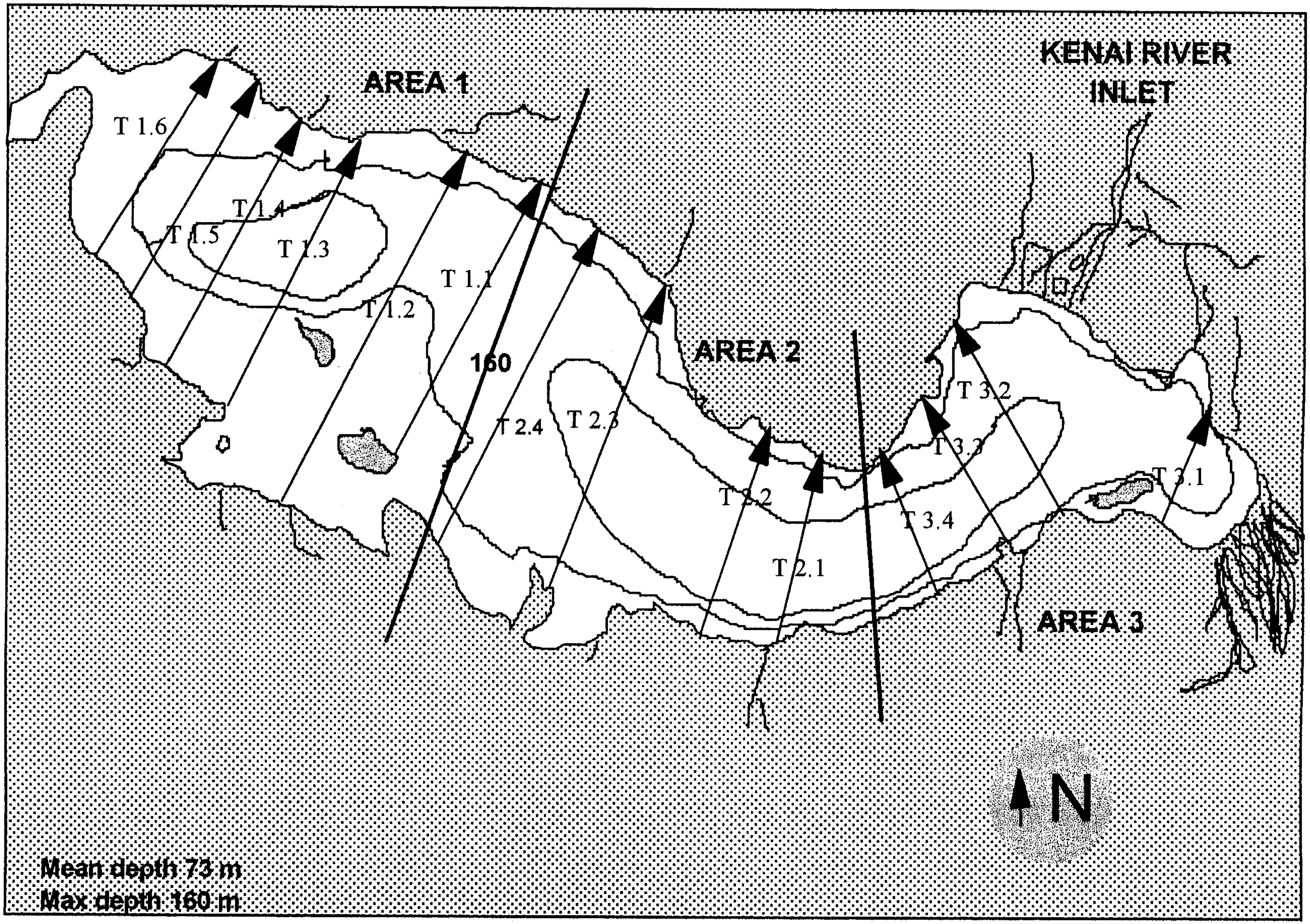
File: 1fig9698.pre

Figure 1. Map of the Kenai River drainage



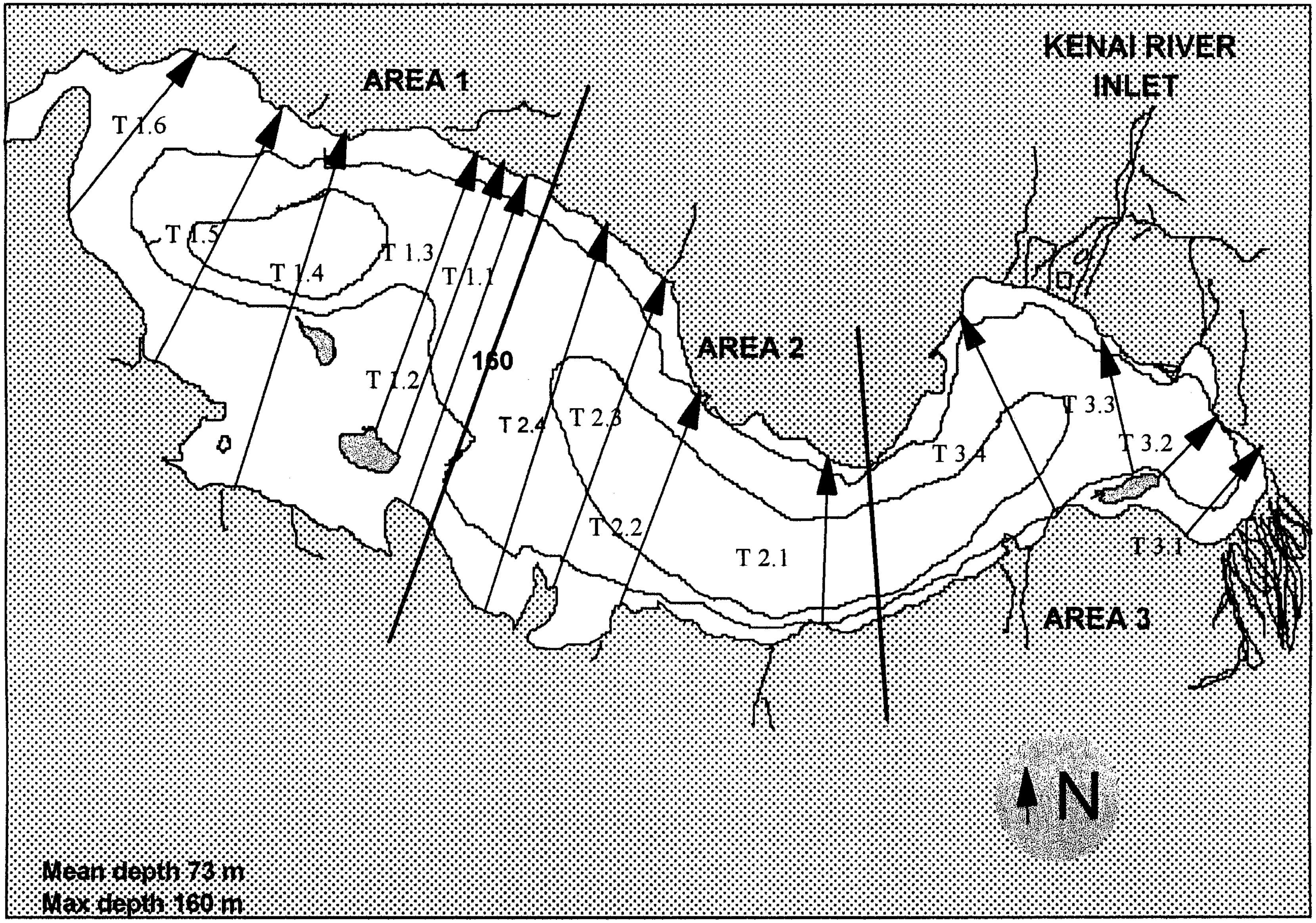
File: sep96map.pree

Figure 2. Hydroacoustic transects conducted in Skilak Lake, Alaska on 19 September 1996.



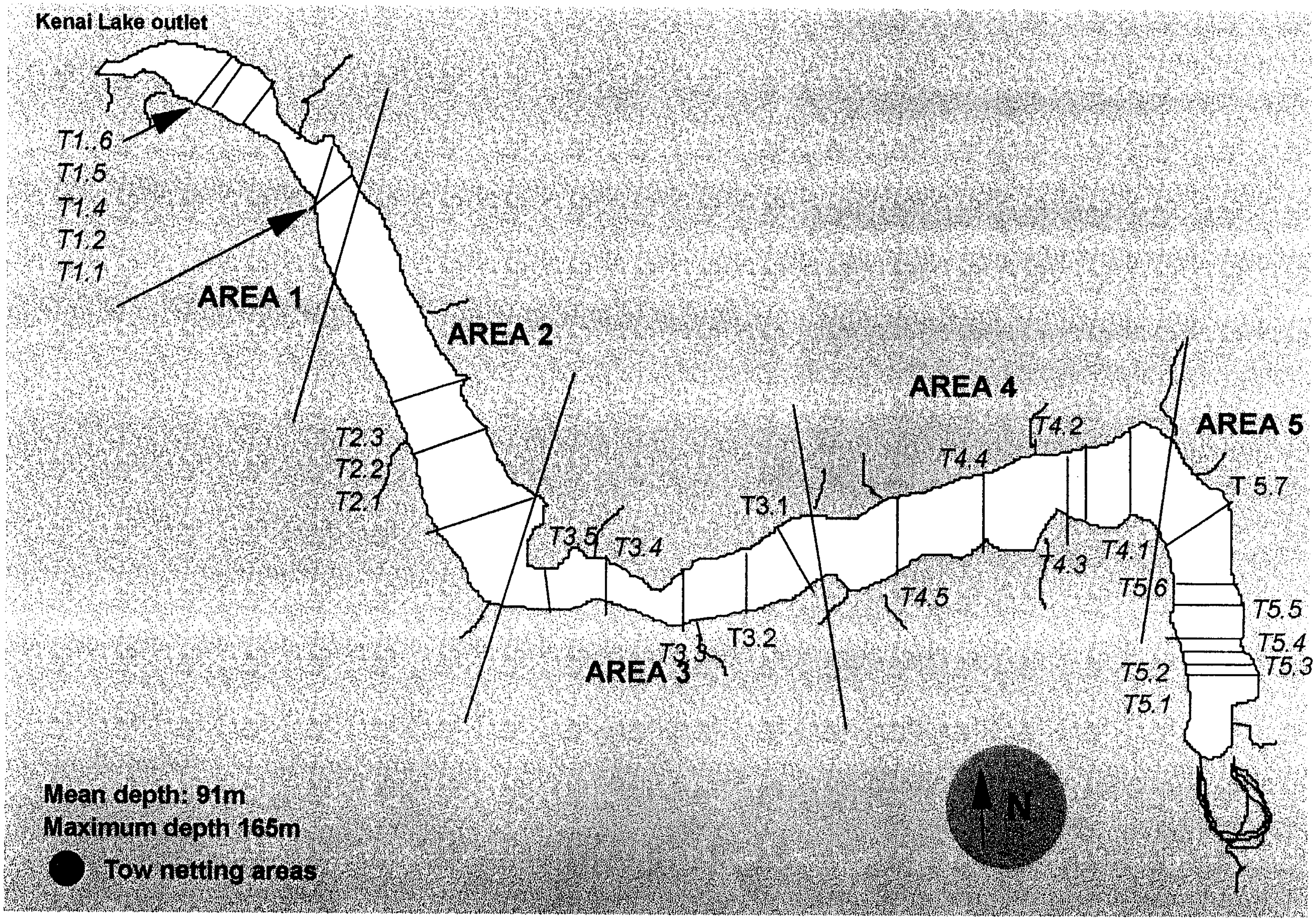
File: sep97map.pree

Figure 3. Hydroacoustic transects conducted in Skilak Lake, Alaska on 10 September 1997.



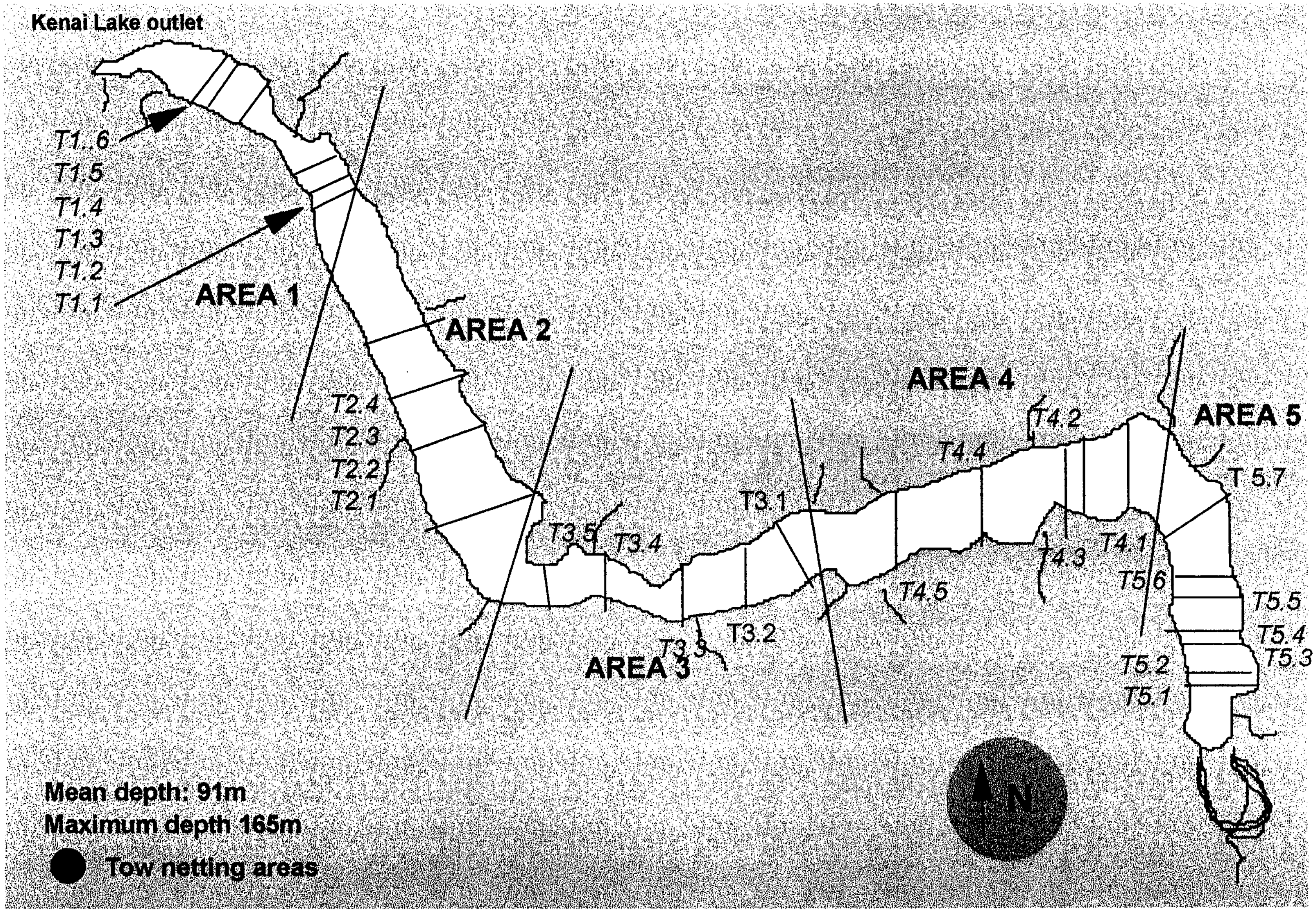
File: sep98map.pree

Figure 4. Hydroacoustic transects conducted in Skilak Lake, Alaska on 8 September 1998.



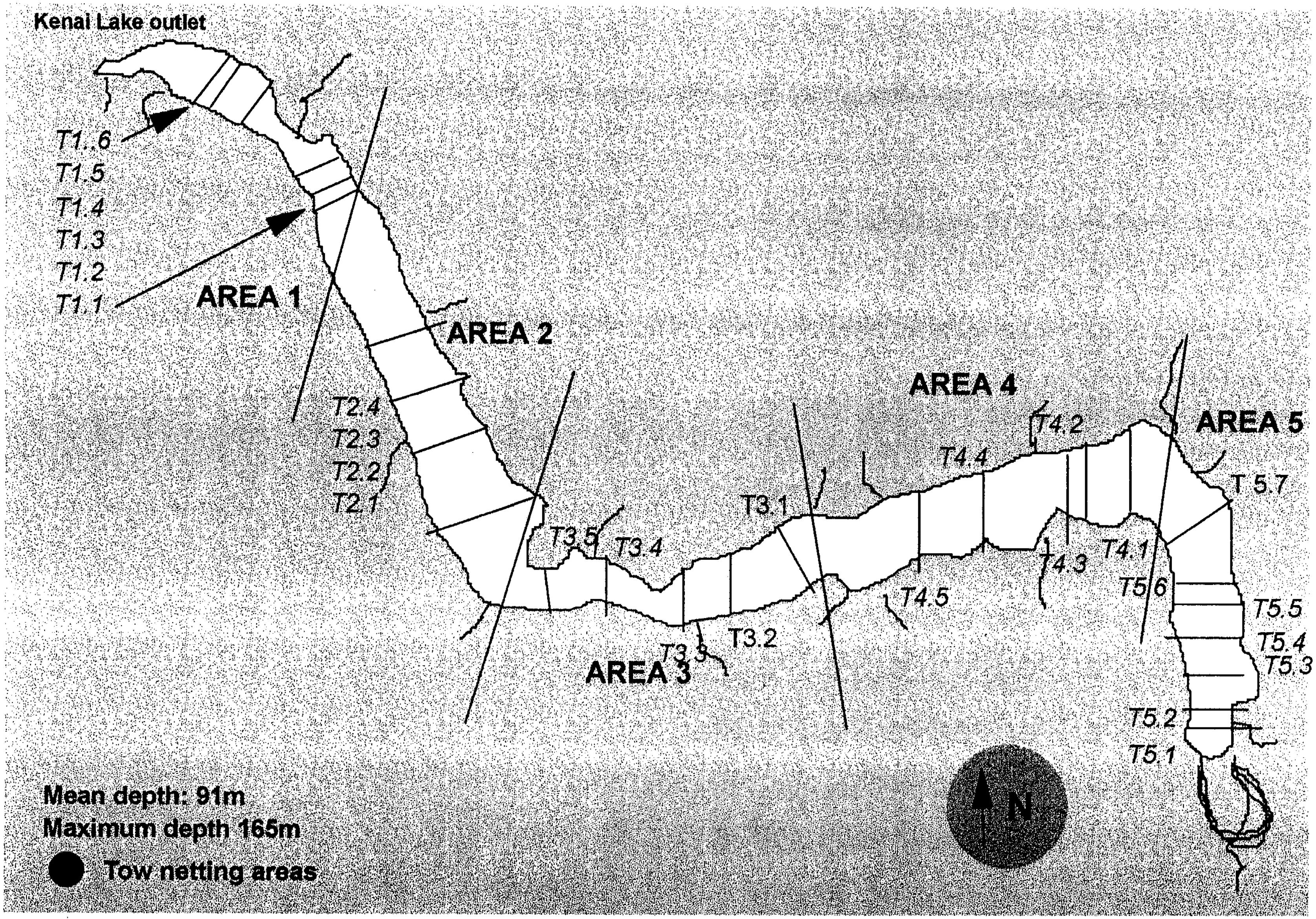
File: kemap96.pre

Figure 5. Hydroacoustic transects conducted in Kenai Lake, Alaska on 26 September 1996.



File: kemap97.pre

Figure 6. Hydroacoustic transects conducted in Kenai Lake, Alaska on 15 September 1997.



File: kemap98.pre

Figure 7. Hydroacoustic transects conducted in Kenai Lake, Alaska on 14 September 1998.

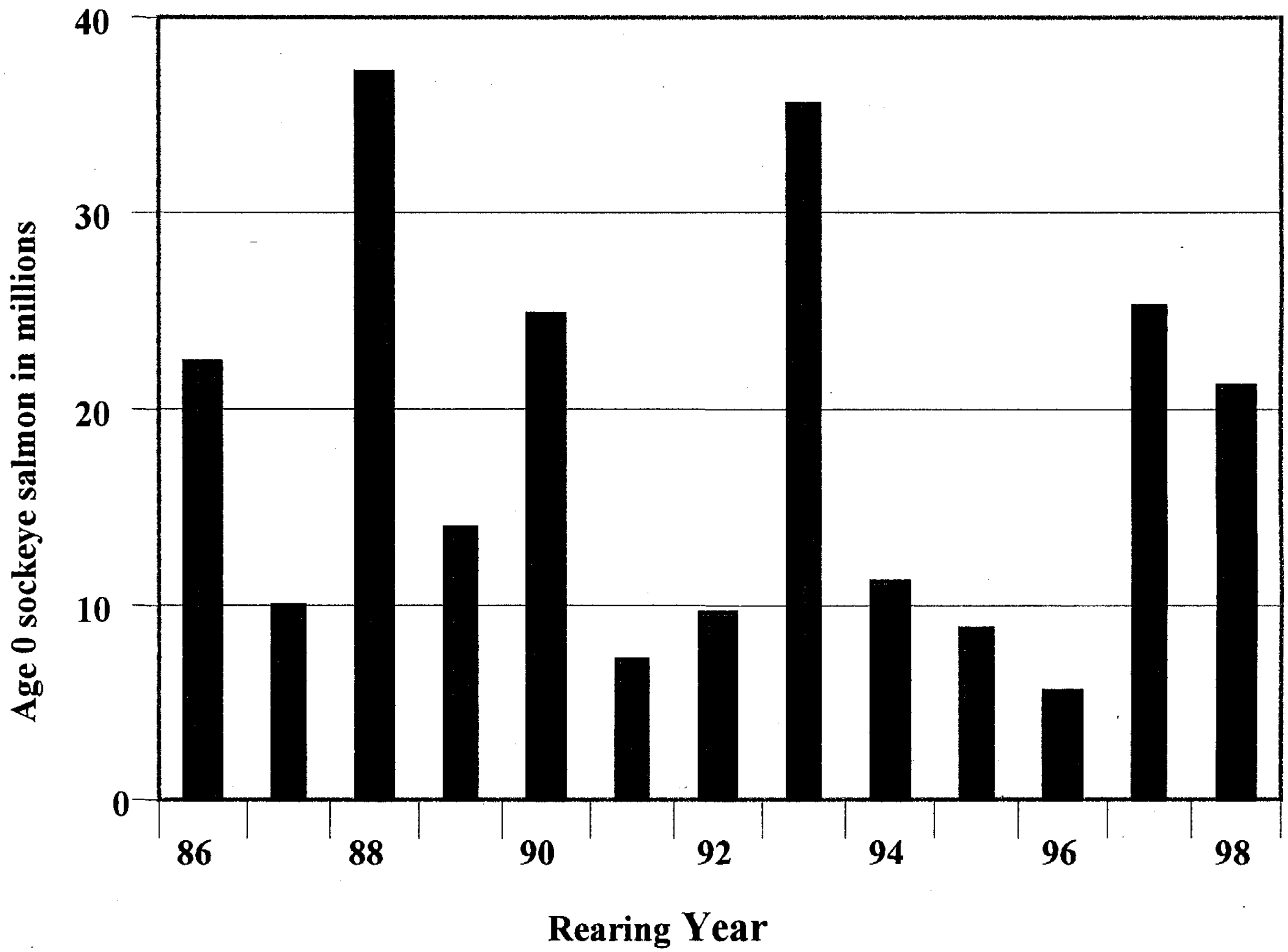


Figure 8. Number of sockeye salmon age 0 fall fry in Skilak and Kenai Lakes, Alaska

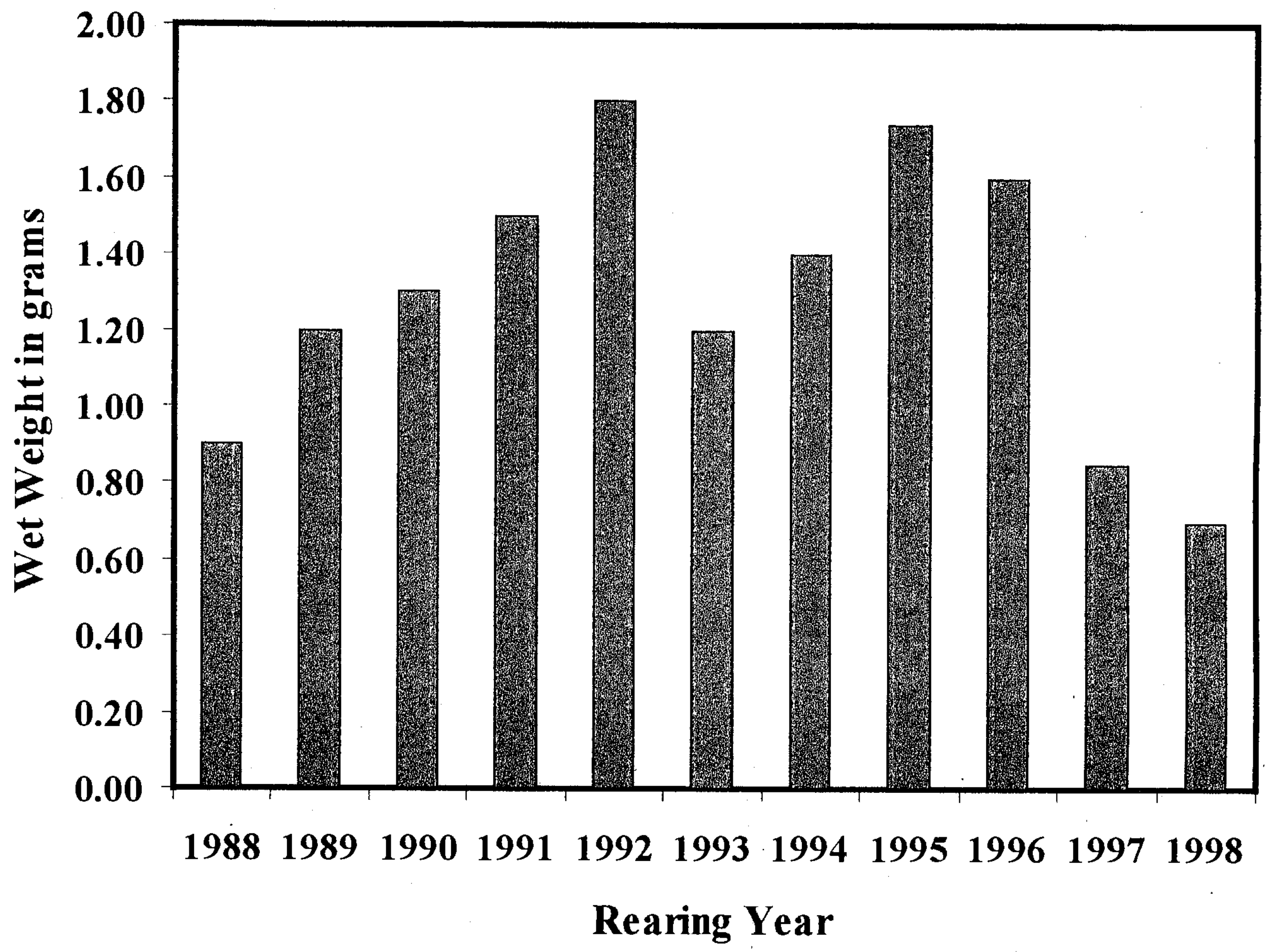


Figure 9. Wet weight of juvenile sockeye salmon measured in the fall in Skilak Lake, Alaska

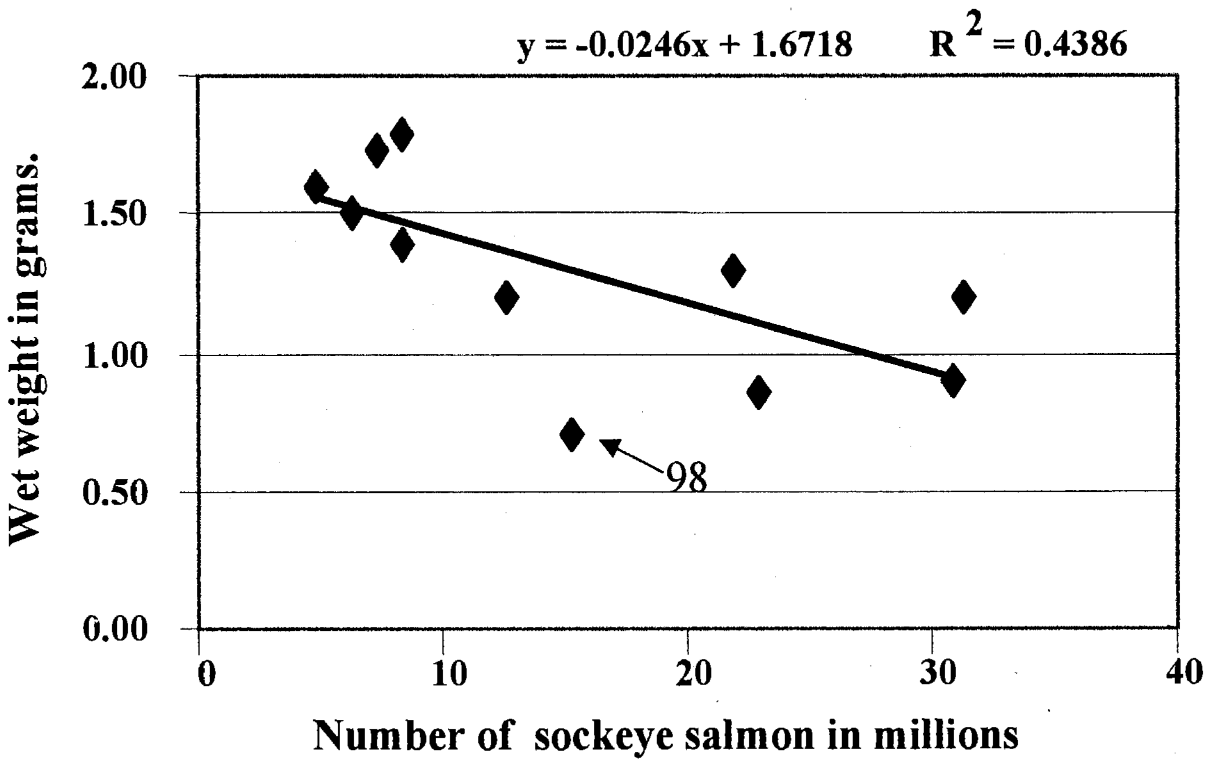


Figure 10. Relationship between the number of Skilak Lake age 0 sockeye salmon fall fry and wet weight.

APPENDIX

Appendix A.1. Calibration and processing parameters used in collection and analysis of Kenai and Skilak Lake, Alaska hydroacoustic data, 1993-1998.

Date	Source Level (dB)	Receiving Sensitivity 1 (db) 40 Log R	Receiving Sensitivity 2 (db)	Gain (dB)	Threshold (mv)	Wide Beam Dropoff (db)	Narrow Beam Pattern Factor	Power Function A Coefficient	Y=A*(X**B) B Coefficient	Bottom Threshold (mv)
May 1993	217.66	-165.77	-165.67	0	200	1.346	1.052E-03	1.289	0.61	9000
Sept 1993-Nov. 1993	216.74	-165.75	-165.39	6	200	1.31	1.093E-03	1.883	0.467	9000
April 1994	216.74	-165.75	-165.39	6	200	1.31	1.093E-03	1.883	0.467	7000
Sept. 1994	217.70	-166.86	-167.12	6	300	1.18	1.010E-03	1.919	0.424	9000
May 1996	217.73	-166.011	-165.916	6	300	1.1032	9.959E-04	1.8018	0.4666	9000
Sept. 1996	217.73	-166.011	-165.916	6	300	1.1032	9.959E-04	1.8018	0.4666	9000
Sept. 1997	217.73	-166.011	-165.916	6	300	1.1032	9.959E-04	1.8018	0.4666	9000
Sept. 1998	217.502	-164.587	-164.714	6	300	1.153	1.089E-03	1.969	0.429	9000

File: 1aptab98.xls

Appendix A.2. Average backscattering cross section (sigma) and target strenght data by depth strata for Skilak Lake, Alaska, 19 Sept. 1996.

Depth Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strenght Mean (dB)	Target Strenght Standard Deviation (dB)
2.0 - 7.0	64	7.2600E-06	1.1450E-05	-56.08	6.66
7.0 - 12.0	670	8.1370E-06	2.3330E-05	-54.70	5.88
12.0 - 17.0	2798	5.7220E-06	5.9350E-06	-55.11	5.37
17.0 - 22.0	4245	4.9600E-06	4.5990E-06	-55.38	5.06
22.0 - 27.0	3366	4.0770E-06	3.8240E-06	-55.97	4.68
27.0 - 32.0	1851	3.6110E-06	3.3930E-06	-56.45	4.56
32.0 - 37.0	465	3.0260E-06	2.7820E-06	-56.86	4.09
37.0 - 42.0	125	3.0860E-06	3.6040E-06	-57.62	4.77
42.0 - 47.0	89	4.3020E-06	4.3430E-06	-56.21	5.22
47.0 - 52.0	71	6.6840E-06	6.0870E-06	-53.81	4.87
52.0 - 57.0	127	6.7010E-06	5.8030E-06	-53.70	4.60
57.0 - 62.0	82	4.6930E-06	3.7060E-06	-54.78	3.94
62.0 - 67.0	77	5.1260E-06	3.5080E-06	-54.20	3.68
67.0 - 72.0	58	4.7800E-06	3.7320E-06	-54.81	4.16
72.0 - 77.0	54	3.5540E-06	2.2000E-06	-55.58	3.47
77.0 - 82.0	19	4.4890E-06	3.8400E-06	-55.20	4.14
82.0 - 87.0	9	4.0890E-06	2.6060E-06	-54.60	2.62
87.0 - 92.0	0	0.0000E+00	0.0000E+00	0.00	0.00
92.0 - 97.0	0	0.0000E+00	0.0000E+00	0.00	0.00
Total	14170	4.8170E-06	6.8540E-06	-55.62	5.00

[a] Target strenght determined from dual-beam data collected *in situ.*

File: 2-3aptab96.xls

Appendix A.3. Average backscattering cross section (sigma) and target strenght data by depth strata for Kenai Lake, Alaska, 23 Sept. 1996.

Depth Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strenght Mean (dB)	Target Strenght Standard Deviation (dB)
2.0 - 7.0	48	7.7880E-06	9.6410E-06	-54.32	5.59
7.0 - 12.0	210	1.2230E-05	2.7790E-05	-53.50	6.12
12.0 - 17.0	545	7.7510E-06	8.6550E-06	-54.02	5.72
17.0 - 22.0	1203	5.5440E-06	7.8780E-06	-55.01	5.14
22.0 - 27.0	1678	4.3560E-06	4.0140E-06	-55.73	4.78
27.0 - 32.0	1049	3.7410E-06	3.7370E-06	-56.29	4.59
32.0 - 37.0	604	3.5810E-06	6.1470E-06	-56.58	4.37
37.0 - 42.0	284	2.6940E-06	2.5930E-06	-57.60	4.29
42.0 - 47.0	149	2.3010E-06	1.7880E-06	-57.96	4.01
47.0 - 52.0	91	7.7430E-06	2.5530E-05	-57.28	5.76
52.0 - 57.0	18	1.8030E-06	1.6100E-06	-59.10	4.05
57.0 - 62.0	17	2.8450E-06	3.7600E-06	-57.82	4.42
62.0 - 67.0	4	9.8080E-07	1.2800E-06	-62.86	5.56
67.0 - 72.0	4	2.2110E-06	1.2840E-06	-57.09	2.49
72.0 - 77.0	1	1.5500E-06	0.0000E+00	-58.10	0.00
77.0 - 82.0	5	1.0290E-05	1.9150E-05	-56.23	8.30
82.0 - 87.0	2	5.6720E-05	1.9680E-05	-42.60	1.54
87.0 - 92.0	0	0.0000E+00	0.0000E+00	0.00	0.00
92.0 - 97.0	1	3.2900E-05	0.0000E+00	-44.83	0.00
Total	5913	4.9610E-06	8.6080E-06	-55.71	5.03

[a] Target strenght determined from dual-beam data collected *in situ*.

File: 2-3aptab96.xls

Appendix A.4. Average backscattering cross section (sigma) and target strenght data by depth strata for Skilak Lake, Alaska, 10 Sept. 1997.

Depth Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strenght Mean (dB)	Target Strenght Standard Deviation (dB)
2.0 - 7.0	445	3.9630E-06	5.3180E-06	-57.35	5.63
7.0 - 12.0	1912	4.2660E-06	4.8580E-06	-56.49	5.34
12.0 - 17.0	4804	3.6190E-06	3.3590E-06	-56.46	4.63
17.0 - 22.0	8742	3.3540E-06	5.4230E-06	-56.53	4.20
22.0 - 27.0	9493	3.2330E-06	3.0490E-06	-56.46	3.89
27.0 - 32.0	6113	2.8830E-06	2.5700E-06	-56.81	3.68
32.0 - 37.0	1904	2.6730E-06	2.1460E-06	-57.07	3.65
37.0 - 42.0	210	3.2300E-06	3.5080E-06	-56.69	3.91
42.0 - 47.0	54	6.0050E-06	9.1970E-06	-54.58	4.44
47.0 - 52.0	97	7.3620E-06	6.9850E-06	-52.92	3.86
52.0 - 57.0	15	5.9740E-06	5.4360E-06	-54.49	5.18
57.0 - 62.0	44	6.9300E-06	4.5390E-06	-52.60	3.37
62.0 - 67.0	21	6.8250E-06	5.4770E-06	-52.75	3.12
67.0 - 72.0	7	4.2360E-06	2.7510E-06	-54.33	2.29
72.0 - 77.0	12	6.9220E-06	4.2090E-06	-52.48	3.07
77.0 - 82.0	5	4.0480E-06	7.0620E-07	-53.98	0.78
82.0 - 87.0	1	1.8980E-06	0.0000E+00	-57.22	0.00
87.0 - 92.0	0	0.0000E+00	0.0000E+00	0.00	0.00
92.0 - 97.0	0	0.0000E+00	0.0000E+00	0.00	0.00
Total	33879	3.3180E-06	3.9470E-06	-56.57	4.17

[a] Target strenght determined from dual-beam data collected *in situ.*

File: 4-5aptab97.xls

Appendix A.5. Average backscattering cross section (sigma) and target strenght data by depth strata for Kenai Lake, Alaska, 15 Sept. 1997.

Depth Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strenght Mean (dB)	Target Strenght Standard Deviation (dB)
2.0 - 7.0	30	4.9600E-06	8.0900E-06	-57.69	6.37
7.0 - 12.0	258	5.6110E-06	6.4310E-06	-55.68	5.67
12.0 - 17.0	1331	4.7370E-06	6.2140E-06	-56.24	5.44
17.0 - 22.0	2458	4.0010E-06	4.8740E-06	-56.65	5.15
22.0 - 27.0	2896	3.4990E-06	3.3240E-06	-56.81	4.82
27.0 - 32.0	1959	3.4390E-06	3.0920E-06	-56.63	4.57
32.0 - 37.0	827	3.0540E-06	2.4760E-06	-56.84	4.23
37.0 - 42.0	207	2.8540E-06	1.8470E-06	-56.64	3.60
42.0 - 47.0	39	2.9690E-06	3.0200E-06	-57.17	4.33
47.0 - 52.0	3	7.0730E-06	9.7670E-06	-56.40	9.41
52.0 - 57.0	1	5.7070E-06	0.0000E+00	-62.44	0.00
57.0 - 62.0	0	0.0000E+00	0.0000E+00	0.00	0.00
62.0 - 67.0	1	5.3470E-07	0.0000E+00	-62.72	0.00
67.0 - 72.0	0	0.0000E+00	0.0000E+00	0.00	0.00
72.0 - 77.0	1	2.9120E-07	0.0000E+00	-65.36	0.00
77.0 - 82.0	0	0.0000E+00	0.0000E+00	0.00	0.00
82.0 - 87.0	0	0.0000E+00	0.0000E+00	0.00	0.00
87.0 - 92.0	0	0.0000E+00	0.0000E+00	0.00	0.00
92.0 - 97.0	0	0.0000E+00	0.0000E+00	0.00	0.00
Total	10011	3.7820E-06	4.2720E-06	-56.64	4.91

[a] Target strenght determined from dual-beam data collected *in situ*.
File: 4-5aptab97.xls

Appendix A.6. Average backscattering cross section (sigma) and target strenght data by depth strata for Skilak Lake, Alaska, 8 Sept. 1997.

Depth Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strenght Mean (dB)	Target Strenght Standard Deviation (dB)
2.0 - 7.0	470	4.3190E-06	8.5780E-06	-56.60	5.26
7.0 - 12.0	3132	3.5660E-06	3.7260E-06	-56.85	4.94
12.0 - 17.0	6406	2.9790E-06	2.9390E-06	-57.30	4.57
17.0 - 22.0	7371	2.4660E-06	2.3050E-06	-58.00	4.39
22.0 - 27.0	4897	2.1950E-06	2.1180E-06	-58.36	4.19
27.0 - 32.0	1840	2.1490E-06	2.0770E-06	-58.44	4.15
32.0 - 37.0	405	2.0130E-06	1.7730E-06	-58.57	3.93
37.0 - 42.0	158	1.6340E-06	1.2330E-06	-59.24	3.70
42.0 - 47.0	92	6.2000E-06	4.0640E-06	-53.32	3.84
47.0 - 52.0	102	6.6830E-06	5.3190E-06	-53.53	4.49
52.0 - 57.0	107	6.1400E-06	8.3640E-06	-54.26	4.38
57.0 - 62.0	137	5.1510E-06	3.7750E-06	-54.37	4.08
62.0 - 67.0	62	5.2490E-06	5.7170E-06	-54.61	4.19
67.0 - 72.0	37	6.4760E-06	4.5940E-06	-53.05	3.41
72.0 - 77.0	14	5.9520E-06	3.5940E-06	-53.02	2.70
77.0 - 82.0	12	3.2120E-06	2.1060E-06	-55.58	2.40
82.0 - 87.0	10	1.1900E-05	7.6200E-06	-50.32	3.54
87.0 - 92.0	0	0.0000E+00	0.0000E+00	0.00	0.00
92.0 - 97.0	0	0.0000E+00	0.0000E+00	0.00	0.00
Total	25252	2.7580E-06	3.0470E-06	-57.68	4.53

[a] Target strenght determined from dual-beam data collected *in situ.*
File: 6-7aptab98.xls

Appendix A.7. Average backscattering cross section (sigma) and target strenght data by depth strata for Kenai Lake, Alaska, 14 Sept. 1998.

Depth Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strenght Mean (dB)	Target Strenght Standard Deviation (dB)
2.0 - 7.0	86	4.4920E-06	5.1660E-06	-56.42	5.32
7.0 - 12.0	616	4.5410E-06	1.2520E-05	-56.17	4.95
12.0 - 17.0	2122	3.1380E-06	2.9310E-06	-57.11	4.65
17.0 - 22.0	2904	2.5270E-06	2.2510E-06	-57.80	4.33
22.0 - 27.0	2501	2.2760E-06	2.6370E-06	-58.26	4.23
27.0 - 32.0	1250	2.3390E-06	1.0190E-05	-58.27	3.80
32.0 - 37.0	283	1.7170E-06	1.3440E-06	-59.12	3.89
37.0 - 42.0	34	1.2390E-06	1.0190E-06	-60.49	3.64
42.0 - 47.0	0	0.0000E+00	0.0000E+00	0.00	0.00
47.0 - 52.0	0	0.0000E+00	0.0000E+00	0.00	0.00
52.0 - 57.0	1	3.9950E-06	0.0000E+00	-53.99	0.00
57.0 - 62.0	1	6.9420E-06	0.0000E+00	-51.58	0.00
62.0 - 67.0	0	0.0000E+00	0.0000E+00	0.00	0.00
67.0 - 72.0	0	0.0000E+00	0.0000E+00	0.00	0.00
72.0 - 77.0	0	0.0000E+00	0.0000E+00	0.00	0.00
77.0 - 82.0	0	0.0000E+00	0.0000E+00	0.00	0.00
82.0 - 87.0	0	0.0000E+00	0.0000E+00	0.00	0.00
87.0 - 92.0	0	0.0000E+00	0.0000E+00	0.00	0.00
92.0 - 97.0	0	0.0000E+00	0.0000E+00	0.00	0.00
Total	9798	2.6880E-06	5.3750E-06	-57.76	4.40

[a] Target strenght determined from dual-beam data collected *in situ.*

File: 6-7aptab98.xls