YUKON RIVER SONAR PROJECT REPORT

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by

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ABSTRACT

The Yukon River sonar project has provided daily passage estimates for chinook salmon *Oncorhynchus tshawytscha*, and summer and fall chum salmon *O. keta* for most years since 1986. During this time, the project has undergone important changes including a frequency switch from 420 kHz to 120 kHz and a change from an aspect transducer aim to one which maximizes fish detection. Fish passage for each species was estimated through a two component process: (1) estimation of total fish passage with 120 kHz single-beam sonar, and (2) estimation of species proportions by sampling with gillnets of six different mesh sizes. An estimated 1,768,255 ± 16,379 (s.e.) fish passed through the sonar sampling area between 6 June and 9 September, 34% along the right bank and 66% along the left bank, including 83,175 ± 4,441 large chinook salmon (>700 mm long), 38,871 ± 3,122 small chinook salmon (<700 mm), 830,633 ± 15,058 summer chum salmon, and 397,157 ± 7,696 fall chum salmon. Occasional sonar periods were missed due to heavy debris and strong wave action. Passage estimates include estimated data from the missed periods. Routine system analyses indicated that the equipment functioned properly during the field season, bottom profiles remained linear, and a reverberation band and signal loss problems were compensated for. Target species were not detected in the region behind the transducer during testfishing drifts designed to sample this area. Relationships between signal loss and hydrological parameters were explored.

KEY WORDS: salmon, hydroacoustic, escapement, species apportionment, net selectivity

INTRODUCTION

Commercial and subsistence fisheries harvest salmon *Oncorhynchus spp.* over more than 1,600 km of the Yukon River in Alaska and Canada. These salmon fisheries are critical to the way of life and economy of people in dozens of communities along the river, in many instances providing the largest single source of food and/or income to local residents.

Management of the commercial and subsistence salmon fisheries is difficult due to the number, diversity, and geographic range of fish stocks and multiple user groups. Information upon which to base management decisions comes from several sources, each of which has strengths and weaknesses. Assessments of abundance in tributaries obtained through aerial and foot surveys, mark-recapture, weirs, towers, or sonar techniques provide stock-specific estimates or escapement indices. Most of this information is obtained after the majority of the fisheries have been conducted. Gillnet test fisheries near the river mouth provide inseason indices of run-strength, but interpretation of these data is confounded by gillnet selectivity, changes in net site characteristics, and varying fish migration routes through the multi-channel river mouth. Also, the functional relationship between test-fishery catches and abundance is unknown.

Hydroacoustic estimates of fish passage from this project complement information obtained from other sources. The project uses fixed location, single-beam sonar to estimate daily upstream passage of fish. Gillnets of up to seven different mesh sizes are drifted through the acoustic sampling areas to apportion the passage estimates to species. The project is located at river km 197 near Pilot Station, far enough upriver to avoid the wide, multiple channels of the Yukon River delta. Because salmon migrate from the river mouth to the sonar site in two to three days, the project provides timely fish abundance information to fishery managers downstream of the sonar site. There is only one major spawning tributary (the Andreafsky River) downstream from the sonar site.

The Yukon River sonar project has provided fisheries management daily passage estimates for most years since 1986. The main challenges faced by the project have been to use sonar technology to detect fish migrating past the sonar site and develop viable methods for estimating the relative abundance of each species detected. The project has used hydroacoustic equipment since 1993 that operates at a lower frequency (120 kHz) than formerly (420 kHz), and is capable of detecting fish at longer ranges. In addition, species apportionment methodology has been streamlined, and net selectivity has been estimated more accurately (Fleischman et al. 1995). Project objectives in 1998 were to provide daily and seasonal passage estimates for chinook and chum salmon, estimate the precision of these estimates, and perform routine system analyses to ensure consistent data collection and processing and provide early detection of problems which might arise.

METHODS

Hydroacoustic Data Acquisition

Equipment

Sonar equipment used on the right bank (relative to a downstream perspective) of the Yukon River included: 1) a Biosonics[1] Model 101 (SN 83-036) 120/420 kHz echosounder configured to transmit and receive at 120 kHz; 2) an International Transducer Co. (I.T.C.) Model 5398 120 kHz user-configurable transducer (SN 003) configured for dual-beam use as case II (3.6°x9.2° narrow and 12.3°x22° wide beam); 3) two 304.8 m (1,000 ft) Carol Model 1302 microphone conductor cables (SN's 201 and 202) connecting the sounder and transducer; 4) an Hydroacoustic Technology, Inc. (H.T.I.) Model 403 chart recorder interface coupled with a Panasonic KXP 1624 dot matrix printer; and 5) a Hewlett Packard Model 54501A digital storage oscilloscope.

Left-bank sonar equipment included: 1) Biosonics Model 101 (SN 83-039) and 102 (SN 89-019) 120/420 kHz echosounders configured to operate at 120 kHz; 2) an I.T.C. Model 5398 120 kHz transducer (SN 005) configured for dual-beam use, case I (2.1°x4.9° narrow and 3.8°x9.7° wide beam) for the left-bank offshore stratum; an I.T.C. Model 5398 120 kHz transducer (SN 004) configured for dual-beam use, case I (2.0°x4.6° narrow and 3.9°x9.2° wide beam) for the left-bank nearshore stratum; 3) four 304.8 m (1,000 ft) Belden Model 8412 microphone conductor cables (SN's 501, 502 for left bank nearshore; and 503, and 504 for left bank offshore) connecting the sounders and transducers; 4) H.T.I. Model's 401 and 403 digital chart recorder interfaces coupled with Panasonic KXP1624 and KXP 2624 dot matrix printers; and 5) an Hewlett Packard Model 54501A digital storage oscilloscope.

The Biosonics Model 101 echosounder systems were professionally calibrated (Table 1), the echosounders functionally checked, physically examined, and comprehensive transmitter and receiver gain measurements were made prior to the field season. The Biosonics Model 102 echosounder was used on left bank from 31 July through 8 August and from 17 August through 9 September with the left bank equipment assemblage to take advantage of its ability to multiplex two transducers. This system was not calibrated preseason. Dual-beam data were digitized, processed, and electronically stored with a Biosonics Model 281 echo signal processor (ESP) installed in a Compaq 386 20e personal computer.

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[1] Mention of a company's name does not constitute endorsement.

Transducers were mounted on metal tripods and remotely aimed with Remote Ocean Systems (ROS) PT-25 dual-axis rotators. Rotator movements were controlled with a ROS PTC-1 controller with position feedback to the nearest 0.1°. Gasoline generators (3500 W) supplied 120 VAC power.

Sampling Procedures

We deployed two transducers on the left (south) bank and a single transducer on the right bank at a point where the river is approximately 1,000 m wide (Figure 1). The right bank has a stable, rocky bottom that drops off steeply to the thalweg (Figure 2) at a vertical angle of 9°, calculated from a depth of 23.5 m at a range of 150 m. We positioned the right-bank transducer 5-10 m from shore, adjusting the aim between three strata (0-50 m, 50-100 m, and 100-150 m) to position the beam as close to the river bottom as possible for each sample. The left-bank river bottom drops off gradually with a vertical angle of 2.3°, calculated from a depth of 11.9 m at 300 m, with a slightly steeper slope nearshore, 4.3° calculated from a depth of 3.8 m at 50 m (Figure 2). Two transducer's were originally deployed until debris and strong current created problems with the transducer located offshore. The nearshore transducer was deployed approximately 10 m from shore utilizing three aims to sample a nearshore stratum (0-70 m), a midshore stratum (70-250 m), and an offshore stratum (250-300 m). The transducer was repositioned frequently to compensate for the dynamic water level. During the latter portion of the field season, the original offshore transducer was positioned near shore slightly upstream of the left-bank system and aimed lower to maximize fish detection in the 0-12 m range. This stratum was sampled simultaneously with the original nearshore stratum by multiplexing the two transducers to avoid a loss in sampling time.

Each acoustic sampling stratum was subdivided into five equal range sectors. Sample data were tallied by sector in 15-minute intervals during daily sampling periods from 0530 to 0830, 1330 to 1630, and 2130 to 0030 alternating every ½ hour between strata.

We counted echo tracings as fish if at least one ping in the cluster passed the second threshold (see Equipment Settings, Thresholds, Data Storage) and the target did not resemble an inert downstream object. Multiple fish tracings were marked if there was a discontinuity in the tracing and the second cluster indicated movement in a direction different from the first. Fish tracings were tallied on field data forms, then entered into an R:Base database. The data were checked daily for data entry or tallying errors, then processed using commercial statistical data processing (SAS) software.

All personnel were trained to distinguish between fish tracings and non-target echoes. Chart printouts were reviewed daily by either the project leader, crew leader, or an experienced technician to check the accuracy of the marked fish tracings and reduce individual biases. Each chart image was checked for indications of signal loss and changes in bottom reverberation markings which might indicate a movement of the transducer or a change in bottom structure.

We sampled continuously for twenty-four hours on 18 June, 2 July, 16 July, 10 August, and 24 August and fourteen hours on 4 July, 5 July, and 6 July to estimate the uncertainty associated with the normal sonar sampling schedule. Sampling was divided among strata in proportions consistent with the regular sampling schedule.

Equipment Settings, Thresholds, Data Storage

We used a 40 log(R) time-varied gain (TVG), a 5 kHz bandwidth, and 0.4 ms transmit pulse duration during all sampling activities. Pulse repetition rates were set below the maximum allowed by range to avoid overloading printer buffers; right bank nearshore strata and left bank nearshore strata transmit intervals were set at 0.3 s, left bank midshore strata and right bank offshore strata at 0.4 s, and left-bank offshore strata at 0.5 s.

All sampling was conducted using a single elliptical beam. On right bank, the wide beam (12.3°x22°) was used exclusively to sample the nearshore strata (up to 100 m) and the narrow beam (3.6°x9.2°) was used to sample at ranges greater than 100 m. On left bank, the nearshore region was generally sampled using the wide beam (3.9°x9.2°), while the midshore and offshore regions were sampled with the narrow beam (2.0°x4.6°). Appendix A documents the beam type and threshold, transmit, receiver gain and attenuation settings by stratum.

Echoes were digitized by the chart recorders and printed on wide carriage, continuous-feed paper using dot matrix printers. Charts were archived, and a small portion of the data were taped using a Sony Betamax system in conjunction with a Model 171 chart recorder interface. Four printer thresholds, corresponding to degrees of gray-line, were set for all strata in approximately 3 dB increments. Initially, the lowest sampling threshold, set at –40 dB, was approximately 9 dB lower than the theoretical on-axis target strength of a chum salmon of minimal length (450 mm), calculated using Love's equation (1977). Lowering the threshold by 9 dB allows for detection across the nominal beam width (6 dB) and some variability (~3 dB) induced by fish aspect and noise corruption. To facilitate aiming on the left bank, the lowest threshold was reduced to approximately –44 dB, the level necessary to detect faint bottom reflections on this side of the river, but only targets greater than –40 dB were marked as fish. Left bank thresholds were adjusted frequently to compensate for environmentally induced signal loss by reducing the threshold to a level where bottom reflections were again detectable across the strata's range (Appendix A). On the right bank, the majority of sampling was conducted at a threshold of –37 to –40 dB. On occasion, this threshold was raised to eliminate unwanted noise (Appendix B). Threshold levels (in mV) were recorded and converted to target strength, TS_{dB}, as follows:

$$TS_{dB} = 20 \bullet \log\left(\frac{T_{mV}}{1000}\right) - \left(SL + G_S + G_R\right) \quad (1)$$

where

T_{mV} = chart recorder threshold in mV,

SL = transmitted source level in dB,

G_S = through-system gain.
G_R = receiver gain.

Aiming

The transducer was aimed to maximize fish detection. Horizontally, the beam was oriented along the best bottom profile approximately perpendicular to fish movement so the majority of fish would present the largest possible reflective surface. Since most fish travel close to the river bottom, the maximum response angle of the beam was oriented along the river bottom through as much of the range as possible.

Fluctuating water level required frequent repositioning and subsequent re-aiming of the transducer beam. The left-bank transducers were re-aimed more often to compensate for the dynamic bottom conditions on that side of the river. Rotator settings for each new aim were documented and chart printouts of the new aim were marked and dated. Because rotator position displays are only accurate to about 0.3 degrees, returning to the same rotator settings did not guarantee a return to the same aim. All personnel were trained to first reset pan and tilt settings, then match bottom striations on the current chart printout with those of displayed chart samples when changing between sampling strata and to notify a supervisor if a "good" aim could not be re-established.

System Analyses

The hydroacoustic system was routinely analyzed following procedures first established in 1995 (Maxwell et al., 1997). System analyses included a combination of equipment performance checks, bottom profiling using down-looking and side-scanning sonars, drifting through unsampled regions of the river using down-looking sonars, hydrologic measurements, and drift gillnetting behind the transducer to test for target species.

Hydroacoustic Equipment Checks

We measured the transmitter output through a 50 ohm load periodically during the field season and compared the results to values obtained from preseason calibrations. Weekly, we checked the time-varied gain circuitry of each echosounder by measuring the voltages of internally generated calibration signals amplified by the 40 log (R) TVG circuitry at four ranges (25 m, 50 m, 100 m, and 250 m) comparing the theoretical voltage at 1 m for each of the measured range values.

To verify that the sonar system was operating normally, we used a Biosonics Model 281 dual beam ESP to determine the target strength of two stainless steel targets (38.1 and 76.2 mm) *in situ*. Each target was suspended from the side of a skiff anchored offshore. We aimed the beam at the suspended target, maximizing the echo amplitude in both the horizontal and vertical planes. Signals were filtered for bandwidth (5 kHz) and half-amplitude pulse width (0.36-0.52 ms). The minimum threshold was set just above the noise floor. Target data were converted from the ESP software to an Access database. During post-processing, the target data were isolated from extraneous echoes by selecting echoes within a limited range bin.

We tested the accuracy of the print threshold levels by sending a TVG-amplified calibration tone through the digital chart recorder interface to the printer where signal amplitudes surpassing four incremental thresholds were displayed as different gray levels. Chart recorder range measurements were compared with corresponding oscilloscope time measurements at each threshold amplitude.

Transducer cables were tested for transmission loss preseason. The cables were tested by transmitting a 1 VAC signal through the cable and a 50 ohm load measuring the resulting voltage with a digital storage oscilloscope.

Bottom Profiles

Bottom profiles were recorded along both banks using a Lowrance X-15 fathometer (192 kHz) with a 20 degree circular beam to locate deployment sites with suitable linear bottom profiles. Inseason, the fathometer was used regularly to monitor changing bottom conditions and to watch for the formation of sandbars capable of re-routing fish to unensonified areas. We created a bathymetric map of the sampling area (Figure 3) during the season using depth at range measurements to document bottom conditions and sandbar formation.

Visual bottom images of the study area along both banks were recorded using an Imagenex Model 001 sidescanning sonar unit and digital audio tape (DAT) recorder. These data were recorded while motoring parallel to each shore in five minute segments and across the river between the two transducers.

Down-looking Sonar Drifts

We obtained echograms weekly using the Lowrance fathometer while drifting with the motor turned off to compare fish tracings nearshore along both banks to those in the thalweg to test whether fish migrate outside of the acoustic sampling range.

Hydrologic Measurements

Hydrologic measurements were recorded daily. Water level was measured using a staff gauge located offshore from the field camp and from United States Geological Survey, Water Resources Division benchmarks located approximately 500 m downstream of Pilot Station. Daily staff gauge measurements were adjusted to the benchmark for comparison to water levels from prior years. Conductivity, air and water temperature, and secchi disk measurements were collected daily offshore along both banks.

Species Composition Data Acquisition

Equipment and Procedures

Gillnets were drifted in three zones (right bank, left-bank nearshore, and left-bank offshore) within corresponding sonar sampling areas to estimate species composition. Six mesh sizes were fished to effectively capture all size classes of fish present and detectable by the hydroacoustic equipment. During the summer season (prior to 19 July), gillnets of mesh sizes 216 mm (8.5 in), 43 meshes deep (MD); 191 mm (7.5 in), 48 MD; 165 mm (6.5 in), 55 MD; 133 mm (5.25 in), 69 MD; 102 mm (4 in), 90 MD; and 70 mm (2.75 in), 131 MD, were used. Use of large mesh gear, 216 mm and 191 mm, was discontinued from 19 July through 23 July, and after 27 July. All nets were 45.7 m (25 fathoms, 52.5 stretch fathoms) long and 7.6 m (25 ft) deep. Nets were constructed of Momoi MTC-50 or MT-50, shade 11 or 3, double knot multifilament nylon twine and hung using a 2:1 hanging ratio.

Gillnetting took place between sonar sampling periods twice daily from 0915 to 1215 and 1715 to 2015. During each gillnet sampling period four nets were drifted within each zone for a total of 24 drifts per day. The shoreward end of the left-bank nearshore drift was approximately 5 to 10 m from shore. The left-bank offshore drift originated further offshore (approximately 70 m) so as not to overlap with the nearshore drift. All drifts with one net were completed before switching to the next net. The two left-bank drifts with a given net were not done consecutively (i.e., drifts were done on alternate banks: left-right-left), so that there was a minimum of 20 minutes between the drifts on the same bank.

Four times were recorded to the nearest second onto field data sheets for each drift: net start out (SO), net full out (FO), net start in (SI), and net full in (FI). Fishing time (t), in minutes, for each drift was defined as

$$t = SI - FO + \frac{FO - SO}{2} + \frac{FI - SI}{2}. \quad (2)$$

Drifts were generally eight minutes in duration but were shortened when necessary to avoid snags and limit catches during times of high fish passage.

Captured fish were identified to species and measured to the nearest 5 mm length. Salmon species were measured from mid-eye to fork of tail; non-salmon species were measured from snout to fork of tail. Fish species, length and sex were entered onto field data sheets. Each drift record included the date, fishing time, sampling period, mesh size, length of net and captain's initials. Scale samples were collected from chinook salmon, mounted on scale cards, and referenced to test-fishing data sheets. Data were transferred from field data sheets into an R:Base database and processed using SAS software. Captured fish were distributed to local residents or sold to processors whenever possible. Fish dispersal was documented daily.

Species Proportions

Species proportions were estimated from relative gillnet sampling catch-per-unit-effort (CPUE) data, after first adjusting for gillnet size-selectivity. Separate gillnet selectivity curves were used for chinook salmon (*Oncorhynchus tshawytscha*), summer chum salmon (*O. keta*), fall chum salmon, coho salmon (*O. kisutch*), pink salmon *(O. gorbuscha)*, whitefish *(Coregonus spp.)*, cisco *(C. sardinella, C. laurettae)*, and a combined group of all other species. Gillnet selectivity curves (Figures 4 to 7) were updated prior to the field season to include catch data through 1997.

Analytical Methods

Fish Passage

Daily fish passage was estimated by summing the counts over all sectors, converting this number to an hourly passage rate, averaging the passage rate from each sampling period, and expanding the final count temporally to obtain the daily estimate. Total daily passage was estimated separately for each zone. Zone 1 consisted of the entire counting range on the right bank, corresponding with strata 0-2. Zone 2 consisted of the left bank nearshore counting range from 0 m to 50-70 m (end range dependent upon the changing bottom profile) on the left bank, corresponding with stratum 3. Zone 3 consisted of the left bank offshore counting range extending from 50-70 m to 300-350 m (end range dependent upon signal strength at this range), corresponding with strata 4 and 5.

Total fish (y) passing through stratum s of zone z during sample q of sonar period p of day d was calculated by summing net upstream targets over all sectors c,

$$y_{dzpsq} = \sum_{c} y_{dzpsqc} . \qquad (3)$$

The passage rate (r) in fish per hour, for stratum s of zone z during sonar period p of day d, was computed as

$$r_{dzps} = \frac{\sum_q y_{dzpsq}}{\sum_q h_{dzpsq}}, \tag{4}$$

where h_{dzpsq} is the duration, in hours, of sample q of sonar period p of day d for stratum s of zone z. The passage rate for zone z during sonar period p of day d was computed as the sum of passage rates for strata associated with each zone,

$$r_{dzp} = \sum_s r_{dzps} \ . \tag{5}$$

The passage rate for zone z during day d was estimated by the average sonar period passage rate,

$$\hat{r}_{dz} = \frac{\sum_p r_{dzp}}{n_{sdz}}, \tag{6}$$

where n_{sdz} the number of sonar periods during day d on zone z. Finally, the total passage of fish in zone z during day d was estimated as

$$\hat{y}_{dz} = 24\hat{r}_{dz} \ . \tag{7}$$

Sonar sampling periods, each three hours long, were spaced at regular (systematic) intervals of eight hours. Treating the systematically sampled sonar counts as a simple random sample would over-estimate the variance of the total, since sonar counts were highly autocorrelated (Wolter 1985). To accommodate these characteristics of the data, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986) and modified from Wolter (1985), was employed;

$$\hat{V}ar(\hat{y}_{dz}) = 24^2 \frac{1 - f_{dz}}{n_{sdz}} \frac{\sum_{p=2}^{n_{sdz}} (\hat{r}_{dzp} - \hat{r}_{dz,p-1})^2}{2(n_{sdz} - 1)}, \tag{8}$$

where f_{dz} denotes the first-stage sampling fraction, 8 hrs/24 hrs = 0.33.

Missing Data

Equipment malfunctions and other uncontrollable events occasionally resulted in missing sonar data. When individual subsamples within a sonar period were missed, fish passage was estimated based on existing subsamples for that period. If a portion of a subsample was missed, fish passage was estimated from the remaining sample provided the sample contained at least five of the fifteen minutes. Data missing from a single stratum for an entire period or more was estimated from data obtained from period(s) sampled during the same day. Data missing from an entire day was estimated from the opposite shore's data surrounding the missing day.

Species Composition

The catch (c) of species i and length l during drift j of mesh m during gillnet sampling period f in zone z on day d was first adjusted for gillnet selectivity (s) of species i and length l in mesh m. Adjusted catch (a) was calculated as

$$a_{ildzfmj} = \frac{c_{ildzfmj}}{s_{ilm}}. \tag{9}$$

if selectivity was at least 0.10. If selectivity was less than 0.10, adjusted catch was set to zero.

Total effort (e), in fathom-hours, of drift j with mesh size m during gillnet sampling period f in zone z on day d was calculated as

$$e_{dzfmj} = \frac{25 \bullet t_{dzfmj}}{60}, \tag{10}$$

since all nets were 45.7 m (25 fathoms) long. CPUE (C) for length l of species i in drifts of mesh m during gillnet sampling period f in zone z on day d was computed as the total adjusted catch divided by total effort,

$$C_{ildzfm} = \frac{\sum_j a_{ildzfmj}}{\sum_j e_{dzfmj}}. \tag{11}$$

The mean CPUE across meshes having non-zero CPUE was computed, i.e.,

$$C_{ildzf} = \frac{1}{n_{mildzf}} \sum_m C_{ildzfm}, \tag{12}$$

where n_{mildzf} is the number of meshes having adjusted catches of length l of species i greater than 0 during test-fish period f of day d in zone z. The total CPUE for species i was computed by summing over all lengths,

$$C_{idzf} = \sum_{l} C_{ildzf} . \quad (13)$$

The proportion (p) of species i during test-fishing period f in zone z on day d was then estimated by the ratio of the sum of the mean CPUE of all lengths of species i having non-zero CPUE to the total of the same quantity summed over all species, i.e.,

$$\hat{p}_{idzf} = \frac{C_{idzf}}{\sum_{i} C_{idzf}} . \quad (14)$$

For zone z on day d, the proportion of species i was estimated as

$$\hat{p}_{idz} = \frac{\sum_{f} C_{idzf}}{\sum_{i} \sum_{f} C_{idzf}} , \quad (15)$$

which is equivalent to the mean of the two test-fishing period proportions, weighted by the total CPUE for all species in each test-fishing period.

The estimator of the variance of p_{idz} was adapted from Cochran (1977:64), weighting each replicate by total (all species) CPUE:

$$\hat{V}ar(\hat{p}_{idz}) = \frac{1}{n_{Tdz}} \sum_{f=1}^{n_{Tdz}} \left(\frac{\sum_{f} \sum_{l} \sum_{m} C_{ildzfm}}{\frac{1}{n_{Tdz}} \sum_{i} \sum_{f} \sum_{l} \sum_{m} C_{ildzfm}} \right)^2 \frac{(\hat{p}_{idzf} - \hat{p}_{idz})^2}{n_{Tdz} - 1} \quad (16)$$

where

n_{Tdz} is the number of gillnet sampling periods in zone z during day d.

Fish Passage by Species

The passage of species i in zone z during day d was estimated by

$$\hat{y}_{idz} = \hat{y}_{dz} \bullet \hat{p}_{idz} . \quad (17)$$

Passage estimates were summed over all zones and all days to obtain a seasonal estimate for species Y_i.

$$\hat{Y}_i = \sum_d \sum_z \hat{y}_{idz} \,. \tag{18}$$

Except for the timing of sonar and gillnet sampling periods, sonar-derived estimates of total fish passage were independent of gillnet-derived estimates of species proportions. Therefore the variance of their product (daily species passage estimates y_{idz}) was estimated as the variance of the product of two independent random variables (Goodman, 1960),

$$\hat{Var}(\hat{y}_{idz}) = \hat{y}_{dz}^2 \hat{Var}(\hat{p}_{idz}) + \hat{p}_{idz}^2 \hat{Var}(\hat{y}_{dz}) - \hat{Var}(\hat{y}_{dz}) \hat{Var}(\hat{p}_{idz}) \,. \tag{19}$$

Finally, passage estimates (equation 18) are assumed independent between zones and among days, so the variance of their sum (equation 19) was estimated by the sum of their variances,

$$\hat{Var}(\hat{Y}_i) = \sum_d \sum_z \hat{Var}(\hat{y}_{idz}) \,. \tag{20}$$

Assuming normally distributed errors, 90% confidence intervals were calculated as

$$\hat{Y}_i \pm 1.645\sqrt{\hat{Var}(\hat{Y}_i)} \,. \tag{21}$$

SAS program code (Maxwell and Huttunen, 1998) was used to calculate passage estimates and estimates of variance.

Missing Data

Equipment malfunctions, debris, and commercial fishery openings occasionally conflict with gillnet sampling. When insufficient gillnet sampling data is available for a given day, the data are pooled with data from an adjacent day with adequate data, and the pooled data are applied to the corresponding days of sonar passage estimates.

RESULTS

The Yukon River sonar project operated from 6 June through 9 September in 1998. Initial high water created a series of problems including range-dependent signal loss, a large reverberation band which partially masked targets in the left-bank nearshore range, and a heavy debris load. Debris prevented the collection of right bank sonar data on 8 June (Figure 8). Passage on this day was estimated using the relative passage on the left and right banks on days before and after the missing day. The reverberation band diminished rapidly after the first few days of sampling, thereafter obstructing only a short range of the left-bank nearshore stratum. We were able to compensate for the range-dependent signal loss throughout the field season. Infrequently, sonar data was unobtainable due to wave action against the transducer which caused the signal to fade in periodic intervals. Passage on such days was estimated from sonar data that was collected on those days. Passage estimates by species were transmitted to fishery managers in Emmonak daily.

Test-Fishing

A total of 10,256 fish were captured during 2,256 drifts totaling 15,556 minutes. The catch consisted of 3,545 summer chum salmon, 2,196 fall chum salmon, 408 chinook (700 mm length or greater), 190 "jacks" (chinook less than 700 mm in length), 1,306 coho salmon, 980 pink salmon, 665 whitefish, 760 cisco, and 206 fish of other species. Gillnet sampling was not conducted during two scheduled commercial fishery openings in District 2 (26 June and 2 July) to avoid disrupting commercial fishing activities. On both commercial fishing days, the entire suite of gillnets were drifted during one extended sampling period. One period of gillnet data (24 June, period 1) was lost during sampling. Data from missed or partial gillnet sampling periods were pooled with those from an adjacent day to estimate species proportions for both days. Data were also pooled when the daily total capture in a single zone was low.

Hydroacoustic Estimates

An estimated 1,768,255 ± 16,379 (s.e.) fish passed through the sonar beams during the 1998 field season; 606,273 ± 9,655 (34 %) along the right bank, 839,168 ± 12,137 (48 %) along the left bank nearshore, and 322,814 ± 5,272 (18 %) along the left bank midshore and offshore. Tables 2 and 3 provide daily passage estimates by zone, standard errors, and the total passage coefficients of variation for the summer and fall seasons, respectively.

Chum salmon was the most abundant species during both the summer and fall seasons (Figure 9). Chum salmon passage estimates totaled 1,227,790, with most (830,633 ± 15,058) passing the sonar site during the summer season and the remainder (397,157 ± 7,696) during fall season. The summer chum salmon run was dominated by three pulses, with peaks occurring on 25 and 30 June, and 9 July. The fall chum salmon run consisted of seven small pulses. Chinook salmon passage estimates were comprised of 83,175 ± 4,441 fish greater than 700 mm in length and 38,871 ± 3,122 "jacks" shorter than 700 mm. The coho salmon passage estimate was 176,792 ± 6,666, although this number may not include the entirety of the run. Although the first coho salmon was captured on 19

July, no more were captured until 30 July. Coho salmon numbers increased slowly peaking in the latter portion of August with the largest daily estimate occurring on 5 September. The sonar project is not designed to assess the entire coho salmon run which continues beyond the time frame of the project. The estimated passage of all other species combined totaled 241,627 $\pm$ 7,936, including pink salmon, cisco, whitefish, inconnu (*Stenodus leucichthys*), burbot (*Lota lota*), sucker (*Catostomus catostomus*), Dolly Varden (*Salvelinus malma*), sockeye salmon (*Oncorhynchus nerka*), and northern pike (*Esox lucius*) (Table 4). Daily passage estimates by species for the summer and fall seasons are listed in Tables 5 and 6, respectively.

Passage estimates for both chum and chinook salmon were very low compared to 1997 and 1995 estimates. Coho salmon estimates were only slightly lower when compared at similar ending dates (Figures 10 and 11). Summer chum salmon run timing was late with 25% of the 1998 run occurring five days later (25 June) compared to 1997 and 1995 runs (both 20 June) and 75% of the 1998 run passing through by 6 July compared to 5 July 1997 and 3 July 1995 (Figure 12). Twenty-five percent of fall chum salmon passed the sonar site by 9 August, eleven days later than in 1997 and 1995 with the majority of the run (75%) passing by 24 August in 1998.

Chinook salmon run timing was late with 25% of passage occurring on 25 June in 1998 compared to 12 June 1997 and 14 June 1995 (Figure 13). The majority of the chinook salmon (75%) passed the sonar site by 6 July, later than in previous years. The last chinook salmon captured on 16 August.

Relatively high correlations were observed between summer season passage estimates and gillnet CPUE for the right-bank, left-bank nearshore, and left-bank offshore zones ($R=0.717$, $R=0.858$, and $R=0.701$ respectively; $p<0.001$) (Figure 14). Fall season passage estimates and CPUE were significantly correlated for the right bank ($R=0.647$; $p<0.001$), but not for the left-bank nearshore and offshore data sets ($R=0.363$, $p<0.05$ and $R=0.332$, $p>0.05$) (Figure 15).

The percent of summer and fall passage was plotted in 20 m range increments by bank and season for 1995, 1997 and 1998 to illustrate the horizontal distribution of fish in the sampling area (Figures 16 and 17). Passage levels declined sharply as a function of the distance offshore. On the left bank, 90% of the detected passage occurred within 130 m of the transducer in 1998, 150 m in 1997, and 190 m in 1995. On the right-bank, 90% of the detected passage occurred within 70 m of the right-bank transducer during each of those years.

System Analyses

Estimates produced from twenty-four hour sampling periods were lower than 90% confidence intervals surrounding the routine nine hour estimates in three out of five trials, just above in one trial, and within the 90% confidence interval in one trial (Table 7). Three fourteen-hour sampling periods produced higher estimates than corresponding nine hour estimates, but all were within the nine hour estimates' confidence intervals.

Bottom profiles conducted along the left and right banks at the transducer locations revealed smoothly sloping linear profiles suitable for sonar deployment (Figure 2). No changes were noted in the steeply sloping, rocky bottom along the right bank. The left-bank bottom profile remained linear within the sampling range for the duration of the field season. The side-edge of the river bend sandbar, labeled in Figure 2, is located outside the left-bank sonar range (300-350 m) at approximately 500 m. The tip of the river bend sandbar extended from the river bend downstream past the left-bank sampling area encroaching within 200 m of the right-bank sampling area (Figure 3). A second sandbar, the Atchuelinguk sandbar, extended downstream along the right bank from the confluence of the Atchuelinguk and Yukon Rivers to slightly downstream of the First Slough entrance remaining well upstream of the sampling area. We monitored both sandbars closely throughout the field season.

A total of 90 drifts were conducted this field season while charting the bottom with the down-looking sonar, 34 drifts parallel to each shore and 22 drifts down the river's channel. Tracings that resembled single fish tracings were counted. Neither clumps of echoes nor unidentifiable traces were counted. The fish passage rate per square meter was calculated and compared among the three zones with the following results: left bank 30.6%, right bank 68.8%, and the thalweg 0.6%. If more of the questionable traces were added in, the right bank percentage would be higher with little gain in either the left bank or thalweg zones. The charts best illuminating fish traces for each region are depicted in Figures 18 to 20.

The Yukon River was rising when we arrived at the Pilot Station field camp. It crested on 13 June at 7.08 m, declined gradually reaching its lowest point (5.16 m) on 13 August, then rose sharply peaking at 6.59 m on 1 September (Figure 21). The crest was slightly lower compared to 1997, but more than 1 m higher than either 1996 or 1995's high points. Conductivity rose slowly during the field season then dropped sharply after 1 September (Figure 22) ranging from 97-272 µS off the left shore and 76-239 µS off the right shore when corrected to 25 °C. The daily fluctuations in conductivity are due to spatial rather than temporal differences in conductivity on the right side of the river. A comparison of water level and conductivity demonstrated an inverse relationship for both the right and left sides of the river ($R = -0.37$ and $R = -0.50$; $p < 0.001$). Offshore from the left bank, secchi disk visibility varied from 5-18 cm below the surface with an average visibility of 10 cm. Secchi disk visibility ranged from 8-26 cm off right bank with an average of 15 cm visibility. Water temperature ranged from 7-19 °C and averaged 14 °C.

Periodic inseason transmitter output measurements from the project's Model 101 echosounders showed little deviation (less than 1/2 dB) from preseason values (Figure 23). No preseason values are available for the Model 102 echosounder, but two inseason measures differ by less than 1/2 dB which was likely within measurement error. TVG function analyses (Figures 24 and 25) demonstrated relatively consistent performance with a maximum difference between field measures of less than 1½ dB for the narrow and wide beam channels of all project echosounders with the exception of the right bank narrow beam channel which differed by 2 dB between field measures.

Chart recorder print threshold analyses of echosounder 101-83-039 showed an average difference of -0.41 ± 0.26 dB (s.d.) (narrow beam channel) and -0.55 ± 1.05 dB (wide beam channel) between voltage levels translated into chart recorder ranges and time measurements of the same signal measured on a digital storage oscilloscope. The right bank echosounder (101-83-036) showed an average difference of 0.20 ± 0.21 dB (narrow beam channel) and 0.31 ± 0.41 dB (wide beam channel) while the printed thresholds of echosounder 102-89-019 differed by an average of –0.25 ± 0.22 dB (narrow beam channel) and –0.25 ± 0.18 dB (wide beam channel) from similar oscilloscope time measures.

Signal loss through the six 312.5 m (1,000 foot) transducer cables averaged 2.4 ± 0.8 dB prior to the field season. No comparative measures were made inseason or postseason.

Dual beam sonar target strength estimates of the stainless steel targets were highly variable (Table 8). Within this variability, one trend was noted. The 76.2 mm stainless steel sphere measured near the river surface produced an average target strength of 15 dB higher than the average target strength measured at a depth of 1.8 m, with no overlap between the central 90% of the two data sets (Figure 26). Both data sets were collected on 10 July at a range of 24.5 m. Target strength estimates of the same sphere on the same day measured at a longer range (99.5 m) near the surface of the river averaged –33 dB, overlapping the 90% confidence limits of both shorter range (24.5 m) data sets. The small stainless steel sphere (38.1 mm) measured at a range of 42.5 m offshore of the left bank averaged -42 dB with 90% of the target strength values between –48 and –38 dB. This same target when measured offshore of the right bank at a range of 36.5 m averaged -27 dB with 90% of the target strength values between –38 and –22 dB.

A reverberation band appeared in the left bank nearshore strata during the early and latter portions of the 1998 field season. The amplitude and range of this band were less than documented in 1997 (Maxwell and Huttunen, 1998). The reverberation band was typically broken into two dominant peaks, one always less in amplitude than the other ranging from 10 to 30 m wide, 10 m from the left-bank nearshore transducer (Figure 27). The unwanted signal was dispersed enough that fish tracings were detectable within the majority of this region during all but the first week of the field season.

On 26 June, we measured echo amplitudes from the reverberation band with a digital oscilloscope at an array of pan and tilt angles. These echo bands were 16 to 23 m wide in two distinct bands ranging from 6 to 38 m from the transducer. In the first series of measurements, we panned the transducer horizontally in approximately four degree increments adjusting the tilt to maximize the river bottom echoes at each pan angle (i.e. the 'best' sampling tilt for each horizontal position). The approximate peak and a 128-ping averaged peak of the reverberation band were measured. Peak and averaged peak amplitudes are displayed in Figure 28 (top) for each pan angle. No clear trend is discernable from this chart. The zero pan angle represents a perpendicular aspect to the river's current; negative values are downstream of perpendicular. Peak amplitudes ranged from –41 to –43 dB with the averaged peak value approximately 3.1 dB lower. During the second series of measurements, the transducer remained at the zero pan while the tilt was adjusted (Figure 28, bottom). The zero tilt angle is aimed far enough below the surface to avoid receiving backscattering energy from the air/water boundary. Decreasing angles tilt the transducer toward the river bottom. Peak measures ranged from –44 to –48 dB with the averaged value approximately 2.9 dB lower. The trend in this chart is clear. As the transducer is aimed closer to the river bottom, the amplitude of the reverberation band increases.

We experienced changing signal loss as a function of range during the field season. Signal loss always accompanied the reverberation band but frequently occurred when the reverberation band was not detected. Signal loss was detected by the decreased intensity of bottom reflections on the printed echograms at ranges beyond 150 m. We did not observe range-dependent signal loss on right bank echograms (however, the maximum range on this side of the river is less than 150 m). We compensated for range-dependent signal loss and penetrated the reverberation band through a combination of increasing transmit power, increasing receiver gain, adding TVG, lowering printer thresholds, and/or changing range strata to more closely match the pattern of signal loss. These techniques reduced left bank thresholds (Figure 29). We compared signal loss (using the changing threshold level in the outermost left bank strata to estimate the loss) with water level, secchi disk measures, conductivity, and water temperature to search for evidence of an environmental cause (Figures 30 and 31). Secchi disk values and water temperatures plotted against daily thresholds in the outermost left bank strata revealed weak but significant linear relationships ($R= 0.40$, $p< 0.001$; $R= -0.45$, $p< 0.001$). No relationship was observed between threshold and either water level ($R= 0.04$; $p> 0.1$) or conductivity ($R= -0.24$, $p> 0.01$).

DISCUSSION

The Yukon River sonar passage estimates agreed with other estimates of abundance and escapement. Most indicators showed low returns for chinook salmon and both runs of chum salmon.

The drift gillnet program captured sufficient numbers of fish in the left bank nearshore and right bank zones for daily species apportionment. However, gillnet catches in the left bank offshore zone were either low or in many cases zero, frequently requiring us to combine fishing data from multiple days to apportion the sonar estimates. On one occasion, it was necessary to combine five days of fishing data. We need to assess whether combining data across days or across range would better reflect species proportions during low catch periods. It may be necessary to include a menu system in the SAS programming code that will allow changing our strategy inseason if necessary.

Gillnet CPUE and passage estimates correlated reasonably well during the summer season, but very poorly during the fall season. This fall season showed the poorest correlation between these data sets when compared with data from 1997 and 1995. The lack of correlation on left bank during the fall season is most likely a result of the extremely low catch rates during that time.

Left bank horizontal range distribution charts show that fish were concentrated in a region closer to shore compared to prior years (Figures 16 and 17). This trend follows a decline in passage estimates in those same years suggesting a positive relationship between run size and the width of the migratory range. On the right bank, where the steep river bottom forces fish into a narrow region, no change was observed in the migratory range from 1995 to the present. The steep drop-off in fish numbers on both banks as range from shore increases suggests that few fish travel outside of the ensonified sampling range. However, this conclusion must be considered tentative. Another possibility is that detectability declines as horizontal range increases. With the large variability noted in target strengths and the difficulty of conducting target work at long ranges, this possibility has not been fully assessed.

Overall, twenty-four hour sampling periods produced lower estimates compared to routine nine hour sampling periods. We expect a slight reduction in these estimates due to the interference of the drift gillnet program which is actively sampling during six hours of the expanded acoustic sampling periods. This was the first year we collected data over fourteen-hour sonar sampling periods. The expanded portion of these periods took place overnight when there was no drift gillnetting in progress. These estimates were all larger than, but within the 90% confidence intervals of, nine hour estimates. With only three fourteen-hour sampling periods for comparison, any conclusions must be considered preliminary.

Bottom profiles on the right bank were very similar to prior years' profiles. We seldom note any substantial changes along this side of the river. On left bank, the profiles remained linear throughout the field season. Bottom profiles suitable for sonar assessment were found on both sides of the river.

Two sandbars observed in past years were present this field season. The Atchuelinguk sandbar remained far upstream of the sampling region. We don't expect to see a downward progression of this sandbar. The lower edge of the sandbar is washed away by the current of First Slough. The river bend sandbar had progressed downstream since the 1997 field season. In 1998, the side-edge of the sandbar was charted at 500 m offshore from the left bank transducer. The most downstream extension of this sandbar was observed 200 m upstream of the right bank transducer at a depth of over 50 ft. We fished the upper reaches of the sandbar on two occasions and tangled a coho salmon during one drift. No other fish were captured. It is difficult to determine the pathway fish might travel to approach this sandbar, or the degree to which they use it. The upper reaches of the sandbar are more than 1,000 m above the right bank transducer. It is likely that the captured coho salmon approached the sandbar from the right shore well after swimming past the transducer. As the fish on this side of the river migrate upstream, they pass the edge of the Atcheulinguk sandbar. Below this sandbar a cliff drops off very sharply to the thalweg (Figure 3). This would appear to be one likely location for fish to cross the narrow thalweg over to the sandbar. However, this is only speculation since we are unable to plot fish movement upstream from the site. Horizontal distribution plots (Figures 16 and 17) show no sign of offshore movement by fish. As mentioned previously, the fish migration corridor appeared to be closer to the left shore this season but showed no change on the right bank. If fish are traveling offshore to the sandbar either downstream of or at the sampling site, it would seem reasonable to observe a change in their horizontal distribution. During the next field season it will be extremely important to continue to plot the movement of the sandbar, monitor fish distribution, and fish with gillnets along the sandbar.

This season we altered the down-looking charting method used to search for fish in unensonified regions of the river from transecting across to drifting down the river. The cross-river transect method provided no useful data. Few fish tracings were observed at any range regardless of fish passage rates. In 1998 instead of transecting the river, we began drifting parallel to the left and right shores (within the sampling area) and down the thalweg (outside of the sampling area) in an attempt to reduce possible boat avoidance by migrating fish. Although more fish tracings were observed using this method, the results are still uncertain. The down-looking system overwhelmingly detected fish within the right bank zone. A higher pecentage might be expected due to the smaller migration corridor on this side of the river. Because the fish are more spread out on left bank, we expect fewer detections from the down-looking system. If we apply a correction factor to the data to take into account the smaller migratory width, the right bank count would drop from 69% to 52%, still a long way from the 25-35% passage typically observed from side-looking samples. Although the theoretical ensonified area was taken into account when calculating fish per zone percentages, the 20 degree beam information comes from the owner's manual. We have never calibrated nor obtained sensitivity plots of this system. The effective size of the beam can vary depending on many factors including but not limited to target size, attenuation, and multi-path interference. Another confounding factor is the current speed which is fastest in the channel and slowest along the left bank resulting in a larger sampling area over the thalweg compared to left bank. Since the right to left bank ratio is so different from what we observe with the side-looking system, the ratio of targets observed in the thalweg zone is also questionable. For the upcoming field season, more reliable data could be obtained by using a calibrated scientific down-looking sonar system, measuring current speeds in each zone sampled, and doing target work with the down-looking sonar to determine the effective beam size at various depths. Even with these improvements, the number of variables outside of our control may be too great to obtain meaningful data.

During the field season, we charted some very unusual echoes with the down-looking system. Some of these echoes can be attributed to water-logged debris. Other traces show active vertical movement suggesting the presence of an animate target. These targets were detected primarily during late August and early September (Figure 32). At this time we can only guess at what might reflect sound in this manner. The large pulse widths and long residence time in the beam suggest either a very large reflector or possibly an assemblage of targets. The tracings don't resemble targets traditionally identified as fish by this system (Figures 18 and 19). Coho salmon, chum salmon, and a few whitefish were captured in the drift gillnet test-fishing program prior to and after the recording of these unusual traces. No major changes were noted in species composition during this time of year with the exception of cisco. Although no cisco were captured on the day this chart was plotted, their numbers did increase during the latter portion of the season and many were captured in the days surrounding this time period. Because the targets were recorded with the down-looking, non-scientific system, the echo strength is unknown. A side-looking sonar sample collected at the same time in the same region did not produce any unusual tracings. It is possible that the tracings produced in Figure 32 are below the sampling threshold (approx. –40 dB) of the side-looking sonar system. A scientific down-looking system, set at a known threshold, would provide more information regarding these animate targets. These charts demonstrate the insufficiency of sonar data on non-target species in the Yukon River. Research needs to be done in this area.

Within recent years, we first noted large amounts of signal loss at the onset of the 1997 field season from the loss of bottom structure across printed charts at long ranges. High water and its accompanying silt load appeared to be the cause. As the water level rose, we began to lose signal in the outermost left bank range. As soon as the water level peaked, signal amplitudes increased. Following the 1997 field season, we compared water level with signal loss observing a significant but weak linear relationship ($R = -0.49$; $p < 0.001$) between the data sets. This same correlation was not observed in 1998. Taking a closer look at the relationship between range-dependent signal loss and changes in hydrology from 1997 and 1998 field seasons confused the situation further. The only common denominator between the two seasons was a correlation between threshold and secchi measures (1998 $R = 0.40$, $p < 0.001$; 1997 $R = 0.49$, $p < 0.001$). No other hydrology measures were significantly correlated across both field seasons. The correlation between secchi measures and threshold must be considered extremely tentative due to the crude tools used to measure both turbidity and signal loss. Numerous variables other than turbidity can affect the secchi disk measure including daylight levels, the visual acuity of the observer, and the strength of the current which affects the secchi disk angle in the water. The left bank outermost range threshold is not only a crude measuring tool but is biased at both ends. Minimum thresholds are determined by a combination of the equipment's capabilities, noise, and reverberation from the environment. The maximum threshold used on left bank is –44 dB. To further explore the relationship between turbidity and signal loss, it will be necessary to obtain a turbidity meter and an objective measure of signal loss at range.

As the highly variable data in Table 8 indicate, measuring echoes from a target provides an even less accurate measure of *in situ* signal loss. The dual-beam system restricts our ability to conduct target work beyond 100 m because the wide beam (3.8°) doesn't fit into the water column (3.3°) at or beyond this range. Since signal loss is most evident beyond 150 m, dual-beam target strength measures are an inappropriate measuring tool. A second problem stems from multi-path echoes. We frequently observe multi-path echoes from fish targets in the range of 25-70 m. At these ranges, some multiple pathways are different enough to produce over a meter separation between the direct and multiple path echoes. The longer the range, the more possibilities there are for non-direct routes back to the transducer, especially on the left bank of the Yukon River where the river bottom drops off very slowly. Interference from multiple returns arriving close in time will increase the variability in target strength estimation. A split beam system would allow us to extend the range of target work, but will not reduce error from multi-path echo interference.

Estimating fish passage in the Yukon River continues to present major technical and logistic challenges. The extremely dynamic nature of the water level, turbidity, bottom substrate, reverberation band, and range-dependent signal loss create a difficult sampling environment. The hydroacoustic system that we employ in the Yukon River appears to work well for the purpose of detecting passing salmon. We were able to compensate for identified signal loss throughout the field season by modifying equipment parameters in response to the frequent environmental changes. Successful estimation of fish passage depends upon constant attention to the frequent changes and diligent re-checking of every part of the acoustic and environmental system.

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Table 1. Preseason Yukon River sonar equipment calibration data. 1998.

Sounder	Cables	Transducer	Receiver Gain L	Std Volts In	G1 NB 40	G1 WB 40	-13 dB SL	-10 dB SL	-6 dB SL	-3 dB SL	0 dB SL
101-039	1000' Belden 502Y/501Y	ITC 004 Case I	0	1	-168.73	-168.33	211.73	214.70	218.65	221.60	224.70
101-039	1000' Belden 504Y/503Y	ITC 005 Case I	0	3	-169.38	-169.38	211.68	214.52	218.61	221.32	224.59
101-036	1000' Carol 202/201	ITC 003 Case II	0	3	-171.96	-176.57	207.30	210.44	214.23	217.39	220.32
102-019	1000' Belden 502Y/501Y	ITC 004 Case I	no calibration was performed with this combination of equipment.								
102-019*	1000' Belden 504Y/503Y	ITC 005 Case I	0	-3	-168.72	-168.06	209.83	212.73	216.49	219.38	222.37

* This calibration was completed postseason, May 1999.

Table 2. Daily estimates of fish passage by zone from 6 June to 18 July for the Yukon River sonar project, 1998.

Report Period	Date	Right Bank Passage	Std Error	Left Bank Nearshore[a] Passage	Std Error	Left Bank Offshore[b] Passage	Std Error	Total Passage	Std Error	Total Passage Coefficient of Variation	Percent Right Bank Passage	Percent Left Bank Passage
1	6/6/1998	360	41	938	246	446	84	1,744	264	0.151	20.64	79.36
1	6/7/1998	290	33	1,313	345	475	90	2,078	358	0.172	13.96	86.04
1	6/8/1998	1,112	126	1,123	295	402	76	2,637	329	0.125	42.17	57.83
2	6/9/1998	1,664	176	1,299	275	460	121	3,423	348	0.102	48.61	51.39
2	6/10/1998	1,649	174	1,022	217	346	91	3,017	293	0.097	54.66	45.34
3	6/11/1998	1,494	76	813	94	364	87	2,671	149	0.056	55.93	44.07
4	6/12/1998	1,045	149	1,428	228	309	94	2,782	288	0.103	37.56	62.44
5	6/13/1998	1,434	252	1,744	227	545	154	3,723	372	0.1	38.52	61.48
6	6/14/1998	2,164	206	2,732	485	674	205	5,570	565	0.102	38.85	61.15
7	6/15/1998	2,415	400	2,896	580	1,354	485	6,665	855	0.128	36.23	63.77
8	6/16/1998	2,371	82	2,391	169	884	85	5,646	206	0.036	41.99	58.01
9	6/17/1998	1,723	61	1,523	120	653	89	3,899	161	0.041	44.19	55.81
10	6/18/1998	1,345	245	1,917	147	780	132	4,042	314	0.078	33.28	66.72
10	6/19/1998	768	140	3,714	285	1,156	196	5,638	373	0.066	13.62	86.38
11	6/20/1998	1,177	44	3,411	715	939	80	5,527	720	0.13	21.3	78.7
12	6/21/1998	2,408	916	6,965	1901	1,899	713	11,272	2228	0.198	21.36	78.64
13	6/22/1998	7,071	1298	21,128	3330	7,855	2454	36,054	4336	0.12	19.61	80.39
14	6/23/1998	4,204	460	16,966	2724	5,864	561	27,034	2819	0.104	15.55	84.45
15	6/24/1998	16,519	2259	32,993	2624	8,255	774	57,767	3549	0.061	28.6	71.4
15	6/25/1998	19,288	2638	54,073	4301	9,947	933	83,308	5131	0.062	23.15	76.85
16	6/26/1998	12,818	1149	23,456	3626	9,619	1442	45,893	4068	0.089	27.93	72.07
17	6/27/1998	5,817	510	14,081	930	7,165	726	27,063	1285	0.047	21.49	78.51
18	6/28/1998	6,964	740	8,246	510	2,299	87	17,509	903	0.052	39.77	60.23
19	6/29/1998	15,637	4886	19,305	5786	3,284	1050	38,226	7645	0.2	40.91	59.09
20	6/30/1998	29,429	3862	52,028	1826	8,400	1001	89,857	4387	0.049	32.75	67.25
21	7/1/1998	32,808	1963	38,183	2428	10,511	1641	81,502	3527	0.043	40.25	59.75
22	7/2/1998	32,486	3262	34,810	3069	12,243	1445	79,539	4706	0.059	40.84	59.16
23	7/3/1998	17,935	954	28,675	3216	7,943	920	54,553	3478	0.064	32.88	67.12
24	7/4/1998	11,990	1422	12,765	676	4,983	448	29,738	1637	0.055	40.32	59.68
25	7/5/1998	11,277	357	11,382	487	2,333	229	24,992	645	0.026	45.12	54.88
26	7/6/1998	6,427	524	6,986	423	2,509	218	15,922	708	0.044	40.37	59.63
26	7/7/1998	5,576	455	3,809	230	1,564	136	10,949	528	0.048	50.93	49.07
27	7/8/1998	15,426	1600	9,153	898	4,257	1067	28,836	2123	0.074	53.5	46.5
28	7/9/1998	22,451	1972	20,741	507	8,498	430	51,690	2081	0.04	43.43	56.57
29	7/10/1998	19,690	1634	15,181	948	7,564	1045	42,435	2158	0.051	46.4	53.6
30	7/11/1998	22,567	1524	12,011	981	4,001	132	38,579	1817	0.047	58.5	41.5
31	7/12/1998	14,095	1652	10,512	501	3,241	349	27,848	1761	0.063	50.61	49.39
32	7/13/1998	5,088	270	7,365	562	1,747	161	14,200	644	0.045	35.83	64.17
33	7/14/1998	3,685	68	5,274	260	1,125	135	10,084	301	0.03	36.54	63.46
33	7/15/1998	3,749	69	5,561	275	2,230	268	11,540	390	0.034	32.49	67.51
33	7/16/1998	2,843	52	3,689	182	1,129	136	7,661	233	0.03	37.11	62.89
33	7/17/1998	2,002	37	2,996	148	695	83	5,693	174	0.031	35.17	64.83
33	7/18/1998	1,653	30	2,934	145	1,040	125	5,627	194	0.034	29.38	70.62
SUMMER TOTALS		372,914	9,406	509,532	11,429	151,987	4,704	1,034,433	15,531			

[a]Left Bank Nearshore Range: 0 to (50-70) m

[b]Left Bank Offshore Range: (50-70) m to 300 m

Table 3. Daily estimates of fish passage by zone from 19 July to 9 September for the Yukon River sonar project, 1998.

Report Period	Date	Right Bank Passage	Std Error	Left Bank Nearshore[a] Passage	Std Error	Left Bank Offshore[b] Passage	Std Error	Total Passage	Std Error	Total Passage Coefficient of Variation	Percent Right Bank Passage	Percent Left Bank Passage
34	7/19/1998	2,432	131	1,631	126	497	42	4,560	187	0.041	53.33	46.67
34	7/20/1998	1,537	83	1,655	128	625	53	3,817	161	0.042	40.27	59.73
34	7/21/1998	1,941	105	2,094	162	793	67	4,828	204	0.042	40.2	59.8
35	7/22/1998	3,174	115	3,185	121	833	57	7,192	177	0.025	44.13	55.87
35	7/23/1998	3,238	117	5,232	199	1,142	79	9,612	244	0.025	33.69	66.31
35	7/24/1998	4,074	147	4,644	177	924	64	9,642	239	0.025	42.25	57.75
36	7/25/1998	3,238	93	3,188	346	647	79	7,073	367	0.052	45.78	54.22
36	7/26/1998	2,139	62	3,962	430	1,217	149	7,318	459	0.063	29.23	70.77
36	7/27/1998	2,533	73	3,942	428	2,376	291	8,851	523	0.059	28.62	71.38
37	7/28/1998	2,057	92	4,488	231	2,698	243	9,243	348	0.038	22.25	77.75
37	7/29/1998	2,392	107	3,294	170	2,507	225	8,193	302	0.037	29.2	70.8
38	7/30/1998	2,508	124	2,028	148	1,496	144	6,032	241	0.04	41.58	58.42
38	7/31/1998	1,532	76	3,785	276	1,515	146	6,832	321	0.047	22.42	77.58
38	8/1/1998	2,182	108	5,093	371	1,603	154	8,878	416	0.047	24.58	75.42
39	8/2/1998	3,118	126	4,530	114	3,682	181	11,330	248	0.022	27.52	72.48
39	8/3/1998	3,097	125	4,834	122	4,039	198	11,970	264	0.022	25.87	74.13
39	8/4/1998	2,496	101	4,965	125	2,921	143	10,382	215	0.021	24.04	75.96
40	8/5/1998	3,433	178	4,956	457	3,660	413	12,049	641	0.053	28.49	71.51
40	8/6/1998	3,341	173	2,273	210	3,162	357	8,776	448	0.051	38.07	61.93
41	8/7/1998	5,105	260	4,319	344	3,822	151	13,246	457	0.034	38.54	61.46
41	8/8/1998	4,830	246	3,521	280	3,590	142	11,941	399	0.033	40.45	59.55
42	8/9/1998	7,727	321	7,046	326	4,499	160	19,272	484	0.025	40.09	59.91
42	8/10/1998	10,584	439	8,248	382	6,317	224	25,149	623	0.025	42.09	57.91
42	8/11/1998	7,738	321	7,418	343	4,751	168	19,907	499	0.025	38.87	61.13
43	8/12/1998	4,494	186	3,938	313	3,482	175	11,914	404	0.034	37.72	62.28
43	8/13/1998	3,606	149	3,127	248	2,618	131	9,351	318	0.034	38.56	61.44
43	8/14/1998	3,268	135	4,754	377	3,121	156	11,143	430	0.039	29.33	70.67
44	8/15/1998	4,872	519	8,306	472	5,216	583	18,394	912	0.05	26.49	73.51
44	8/16/1998	7,261	774	11,754	668	7,267	812	26,282	1305	0.05	27.63	72.37
45	8/17/1998	11,867	274	14,532	202	8,834	1323	35,233	1366	0.039	33.68	66.32
46	8/18/1998	6,691	902	13,408	835	6,448	630	26,547	1381	0.052	25.2	74.8
47	8/19/1998	4,462	175	7,681	566	6,526	528	18,669	793	0.042	23.9	76.1
47	8/20/1998	5,938	233	6,312	465	3,786	306	16,036	604	0.038	37.03	62.97
47	8/21/1998	5,975	234	7,481	551	4,203	340	17,659	689	0.039	33.84	66.16
48	8/22/1998	5,025	245	10,774	616	3,674	186	19,473	688	0.035	25.8	74.2
49	8/23/1998	6,342	792	17,212	1469	5,685	219	29,239	1683	0.058	21.69	78.31
50	8/24/1998	5,259	236	17,862	1693	5,894	440	29,015	1765	0.061	18.13	81.87
51	8/25/1998	5,096	145	11,263	510	4,059	228	20,418	577	0.028	24.96	75.04
51	8/26/1998	5,395	154	7,272	329	3,853	217	16,520	423	0.026	32.66	67.34
51	8/27/1998	5,536	158	7,422	336	3,306	186	16,264	415	0.026	34.04	65.96
51	8/28/1998	4,024	115	4,779	216	2,477	139	11,280	282	0.025	35.67	64.33
51	8/29/1998	3,356	96	2,562	116	1,447	81	7,365	171	0.023	45.57	54.43
52	8/30/1998	2,526	90	2,917	144	1,518	68	6,961	183	0.026	36.29	63.71
52	8/31/1998	2,346	84	3,196	158	1,664	74	7,206	194	0.027	32.56	67.44
52	9/1/1998	2,482	89	2,308	114	1,301	58	6,091	156	0.026	40.75	59.25
52	9/2/1998	2,467	88	1,843	91	1,250	56	5,560	139	0.025	44.37	55.63
52	9/3/1998	2,978	107	3,222	159	1,376	62	7,576	201	0.027	39.31	60.69
53	9/4/1998	5,956	456	9,390	1332	2,626	330	17,972	1446	0.08	33.14	66.86
54	9/5/1998	9,344	499	16,984	1211	5,877	520	32,205	1409	0.044	29.01	70.99
55	9/6/1998	7,644	613	13,094	1715	5,294	429	26,032	1871	0.072	29.36	70.64
56	9/7/1998	6,252	424	7,651	251	4,046	226	17,949	542	0.03	34.83	65.17
56	9/8/1998	3,382	229	4,826	158	2,539	142	10,747	312	0.029	31.47	68.53
56	9/9/1998	3,069	208	3,435	113	2,124	119	8,628	265	0.031	35.57	64.43
FALL TOTALS		233,359	2,178	329,636	4,084	170,827	2,379	733,822	5,204			
SEASON TOTALS		606,273	9,655	839,168	12,137	322,814	5,272	1,768,255	16,379			

[a]Left Bank Nearshore Range: 0 to (50-70) m
[b]Left Bank Offshore Range: (50-70) to 300 m

Table 4. Cumulative passage estimates by species for the Yukon River sonar project, 1998.

SPECIES	CUMULATIVE ESTIMATED PASSAGE	STANDARD ERROR	LOWER 90% CONFIDENCE INTERVAL	UPPER 90% CONFIDENCE INTERVAL
Large Chinook Salmon	83,175	4,441	75,869	90,481
Small Chinook Salmon	38,871	3,122	33,735	44,007
	=========			
Total Chinook Salmon	122,046			
Summer Chum	830,633	15,058	805,862	855,404
Fall Chum	397,157	7,696	384,497	409,817
	=========			
Total Chum	1,227,790			
Coho Salmon*	176,792	6,666	165,826	187,758
Other Species**	241,627	7,936	228,572	254,682
	=========			
TOTAL	1,768,255			

*This estimate may not include the entire run.

**Includes pink salmon, cisco, humpback whitefish, broad whitefish, sheefish, burbot, suckers, Dolly Varden, sockeye salmon, and northern pike.

Table 5. Daily estimates of fish passage by species from 6 June to 18 July for the Yukon River sonar project, 1998.

REPORT PERIOD	DATE	CHINOOK >700 mm	CHINOOK <700 mm	SUMMER CHUM	OTHER SPECIES	TOTAL ALL SPECIES
1	6/6/1998	290	26	812	616	1,744
1	6/7/1998	356	37	1,037	648	2,078
1	6/8/1998	303	31	884	1419	2,637
2	6/9/1998	731	72	2,248	372	3,423
2	6/10/1998	559	57	2,055	346	3,017
3	6/11/1998	113	183	1,721	654	2,671
4	6/12/1998	320	210	1,778	474	2,782
5	6/13/1998	562	138	2,902	121	3,723
6	6/14/1998	317	386	4,502	365	5,570
7	6/15/1998	2,183	501	3,024	957	6,665
8	6/16/1998	140	146	4,616	744	5,646
9	6/17/1998	55	208	3,433	203	3,899
10	6/18/1998	374	163	2,834	671	4,042
10	6/19/1998	607	286	4,011	734	5,638
11	6/20/1998	943	442	3,141	1001	5,527
12	6/21/1998	1,447	315	8,509	1001	11,272
13	6/22/1998	1,364	678	33,826	186	36,054
14	6/23/1998	1,032	978	24,399	625	27,034
15	6/24/1998	5,679	3,011	48,729	348	57,767
15	6/25/1998	8,150	4,328	70,382	448	83,308
16	6/26/1998	2,693	1,125	39,838	2237	45,893
17	6/27/1998	2,880	2,588	20,653	942	27,063
18	6/28/1998	1,110	377	15,195	827	17,509
19	6/29/1998	2,864	249	33,731	1382	38,226
20	6/30/1998	2,972	720	83,722	2443	89,857
21	7/1/1998	4,872	3,192	69,122	4316	81,502
22	7/2/1998	6,919	4,226	64,728	3666	79,539
23	7/3/1998	4,187	4,394	41,704	4268	54,553
24	7/4/1998	5,133	348	22,047	2210	29,738
25	7/5/1998	1,321	1,308	20,191	2172	24,992
26	7/6/1998	2,791	1,218	8,979	2934	15,922
26	7/7/1998	1,745	749	6,250	2205	10,949
27	7/8/1998	1,880	528	24,302	2126	28,836
28	7/9/1998	3,351	1,499	41,997	4843	51,690
29	7/10/1998	1,750	382	36,316	3987	42,435
30	7/11/1998	2,216	733	25,777	9853	38,579
31	7/12/1998	2,459	718	19,944	4727	27,848
32	7/13/1998	1,010	543	10,324	2323	14,200
33	7/14/1998	687	246	5,072	4079	10,084
33	7/15/1998	869	259	6,108	4304	11,540
33	7/16/1998	544	175	3,930	3012	7,661
33	7/17/1998	394	139	2,886	2274	5,693
33	7/18/1998	422	134	2,974	2097	5,627
SUMMER TOTALS		80,594	38,046	830,633	85,160	1,034,433

Table 6. Daily estimates of fish passage by species from 19 July to 9 September for the Yukon River sonar project, 1998.

REPORT PERIOD	DATE	CHINOOK >700 mm	CHINOOK <700 mm	FALL CHUM	COHO	OTHER SPECIES	TOTAL ALL SPECIES
34	7/19/1998	142	31	913	10	3,464	4,560
34	7/20/1998	132	31	719	6	2929	3,817
34	7/21/1998	166	39	908	8	3707	4,828
35	7/22/1998	213	71	3,947	0	2,961	7,192
35	7/23/1998	275	106	5,401	0	3,830	9,612
35	7/24/1998	245	101	5,338	0	3,958	9,642
36	7/25/1998	83	0	1,519	0	5,471	7,073
36	7/26/1998	55	0	1,372	0	5,891	7,318
36	7/27/1998	65	0	1,476	0	7,310	8,851
37	7/28/1998	14	27	4,427	0	4,775	9,243
37	7/29/1998	16	23	3,967	0	4,187	8,193
38	7/30/1998	61	36	913	17	5,006	6,032
38	7/31/1998	37	22	924	10	5,839	6,832
38	8/1/1998	53	31	1,107	15	7,672	8,878
39	8/2/1998	102	0	8,076	347	2,805	11,330
39	8/3/1998	108	0	8,630	350	2,882	11,970
39	8/4/1998	111	0	7,341	302	2,628	10,382
40	8/5/1998	135	0	4,309	510	7,095	12,049
40	8/6/1998	62	0	3,305	438	4,971	8,776
41	8/7/1998	89	0	9,538	401	3,218	13,246
41	8/8/1998	84	0	8,586	363	2,908	11,941
42	8/9/1998	103	0	15,633	2,130	1,406	19,272
42	8/10/1998	121	0	20,407	2,819	1,802	25,149
42	8/11/1998	109	0	16,151	2,207	1,440	19,907
43	8/12/1998	0	81	6,554	2,097	3,182	11,914
43	8/13/1998	0	64	5,102	1,647	2,538	9,351
43	8/14/1998	0	97	6,136	1,745	3,165	11,143
44	8/15/1998	0	26	15,593	2,264	511	18,394
44	8/16/1998	0	39	22,260	3,231	752	26,282
45	8/17/1998	0	0	23,689	8,915	2,629	35,233
46	8/18/1998	0	0	13,309	9,877	3,361	26,547
47	8/19/1998	0	0	10,562	6,212	1,895	18,669
47	8/20/1998	0	0	8,056	6,213	1,767	16,036
47	8/21/1998	0	0	8,997	6,665	1,997	17,659
48	8/22/1998	0	0	8,445	7,075	3,953	19,473
49	8/23/1998	0	0	17,194	9,195	2,850	29,239
50	8/24/1998	0	0	17,045	11,093	877	29,015
51	8/25/1998	0	0	9,246	8,722	2,450	20,418
51	8/26/1998	0	0	7,090	7,082	2,348	16,520
51	8/27/1998	0	0	6,944	6,912	2,408	16,264
51	8/28/1998	0	0	4,753	4,809	1,718	11,280
51	8/29/1998	0	0	2,908	3,099	1,358	7,365
52	8/30/1998	0	0	2,907	1,851	2,203	6,961
52	8/31/1998	0	0	3,116	1,930	2,160	7,206
52	9/1/1998	0	0	2,469	1,587	2,035	6,091
52	9/2/1998	0	0	2,242	1,401	1,917	5,560
52	9/3/1998	0	0	2,968	2,061	2,547	7,576
53	9/4/1998	0	0	12,280	4,116	1,576	17,972
54	9/5/1998	0	0	16,748	14,462	995	32,205
55	9/6/1998	0	0	11,712	14,236	84	26,032
56	9/7/1998	0	0	6,669	8,801	2,479	17,949
56	9/8/1998	0	0	4,095	5,311	1,341	10,747
56	9/9/1998	0	0	3,161	4,250	1,217	8,628
FALL TOTALS		2,581	825	397,157	176,792	156,467	733,822
SEASON TOTALS		83,175	38,871	397,157	176,792	241,627	1,768,255

Table 7. Twenty-four and fourteen hour sampling estimates compared with daily nine hour sampling estimates for the Yukon River sonar project, 1998.

Date	Sampling Method*	Right Bank Passage	Left Bank Nearshore Passage	Left Bank Offshore Passage	Total Passage	Upper 90% Confidence Interval	Lower 90% Confidence Interval
6/18/98	24-hr	1,174	1,977	702	3,853		
	9-hr	1,345	1,917	780	4,042	4,559	3,525
7/2/98	24-hr	26,569	30,700	12,869	70,139		
	9-hr	32,486	34,810	12,243	79,539	87,280	71,798
7/4/98	14-hr	11,355	13,521	5,075	29,950		
	9-hr	11,990	12,765	4,983	29,738	32,431	27,045
7/5/98	14-hr	11,138	12,097	2,523	25,758		
	9-hr	11,277	11,382	2,333	24,992	26,053	23,931
7/6/98	14-hr	7,287	7,290	2,143	16,720		
	9-hr	6,427	6,986	2,509	15,922	17,087	14,757
7/16/98	24-hr	3,144	3,595	1,350	8,089		
	9-hr	2,843	3,689	1,129	7,661	8,044	7,278
8/10/98	24-hr	9,964	7,334	6,314	23,611		
	9-hr	10,584	8,248	6,317	25,149	24,636	24,124
8/24/98	24-hr	5,750	13,920	5,972	25,643		
	9-hr	5,259	17,862	5,894	29,015	31,913	26,112
		=======	=======	=======	=======		
TOTAL	14 or 24-hr	76,381	90,434	36,948	203,763		
	9-hr	82,211	97,659	36,188	216,058		

*Note: All estimates are expanded to twenty-four hours.

Table 8. Target strength summaries of stainless steel targets recorded by Biosonics dual-beam echosounders using Biosonics Echo Signal Processor software, Yukon River sonar, 1998.

Date	Bank	Range (m)	Target Depth (m)	Average Target Strength[1] (dB)	5th Percentile (dB)	95th Percentile (dB)	90% Percentile Range (dB)	Minimum Threshold[2] (dB)	Number of Echoes
38.1 mm stainless steel sphere									
6/16	Left	42.5	0.6	-42	-48	-38	9	-46	1119
6/26	Right	36.5	shallow	-27	-38	-22	16	-43	1592
76.2 mm stainless steel sphere									
7/10	Left	24.5	shallow	-26	-34	-23	11	-52	833
7/10	Left	24.5	1.8	-41	-46	-38	8	-52	879
7/10	Left	99.5	shallow	-33	-44	-25	19	-52	1081
9/3	Left	58.5	shallow	-37	-43	-33	10	-49	2009

[1] Calculated from the backscattering acoustic cross section

[2] Thresholds set just above the noise level

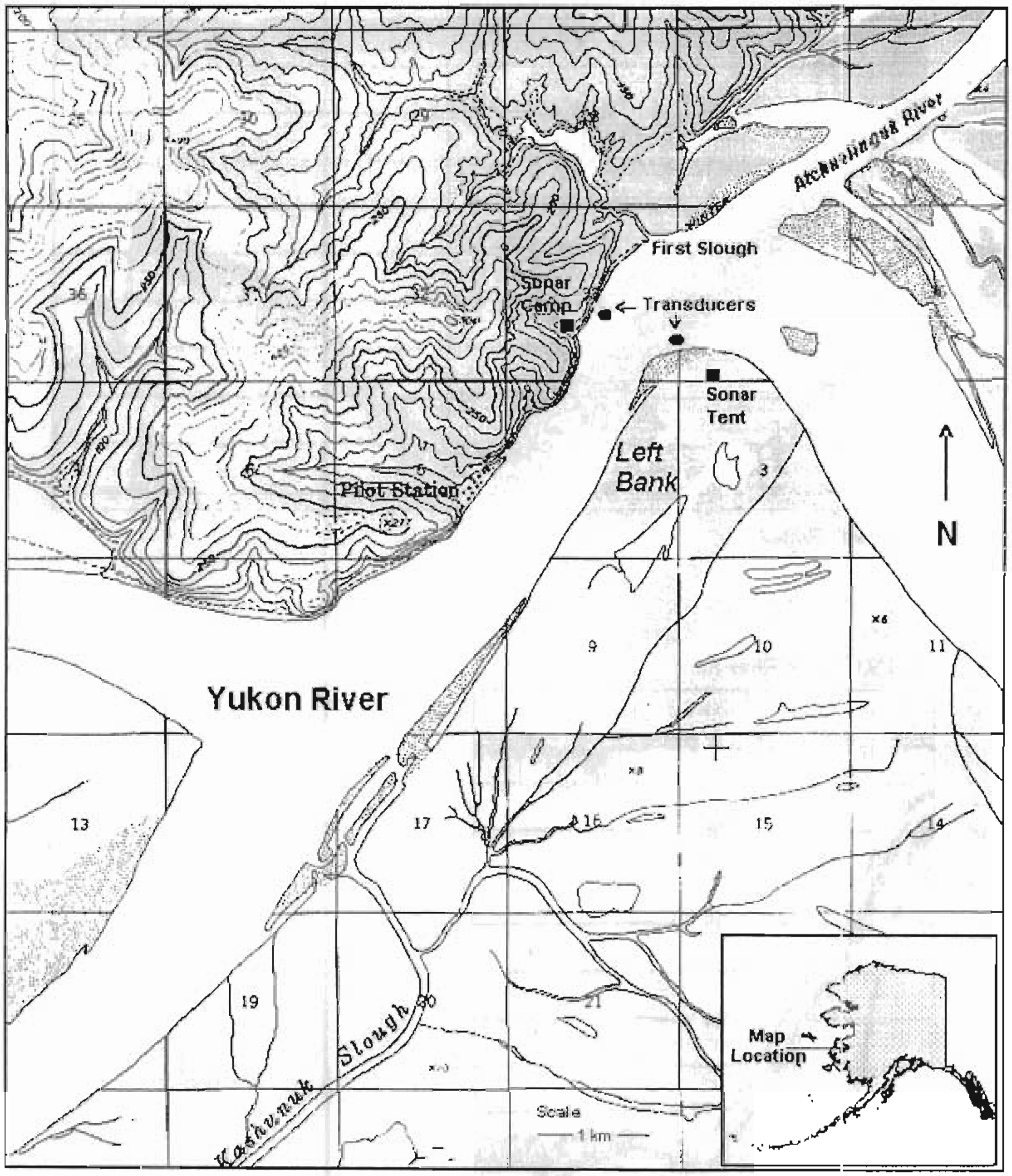
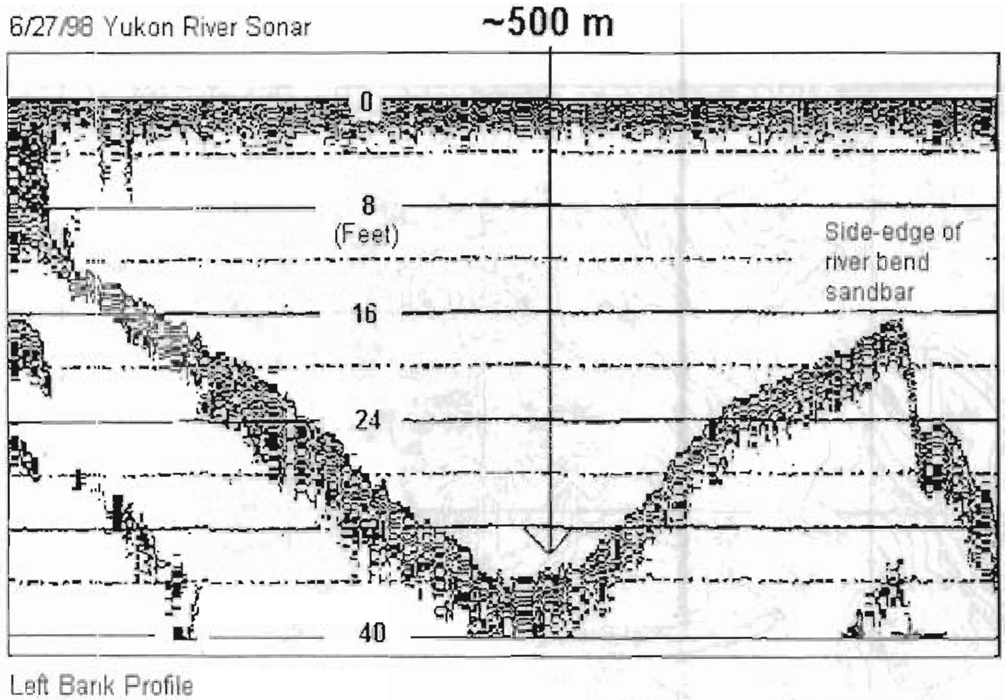


Figure 1. Topographical map of the Yukon River in the vicinity of the sonar site.



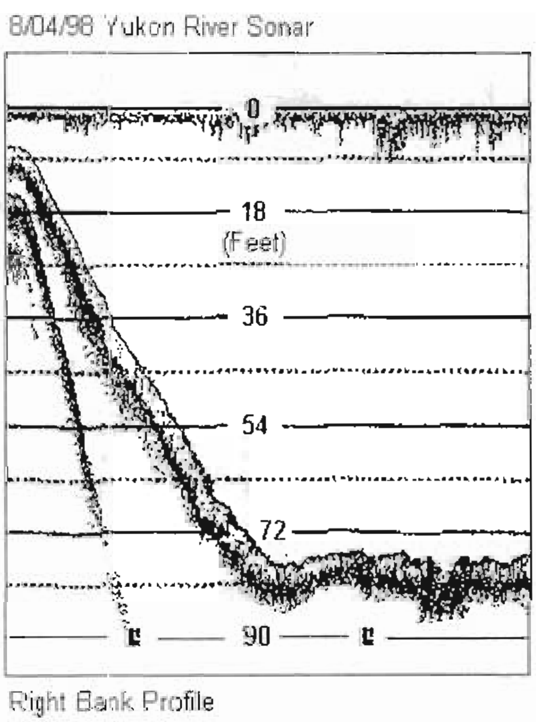


Figure 2. Left-bank profile (top) starting at the transducer moving cross-river. The river bend sandbar begins approximately 500 m from the left shore. The noise at the beginning of the transect is from the reverberation band. Right-bank profile (bottom) starting at the transducer moving cross-river.

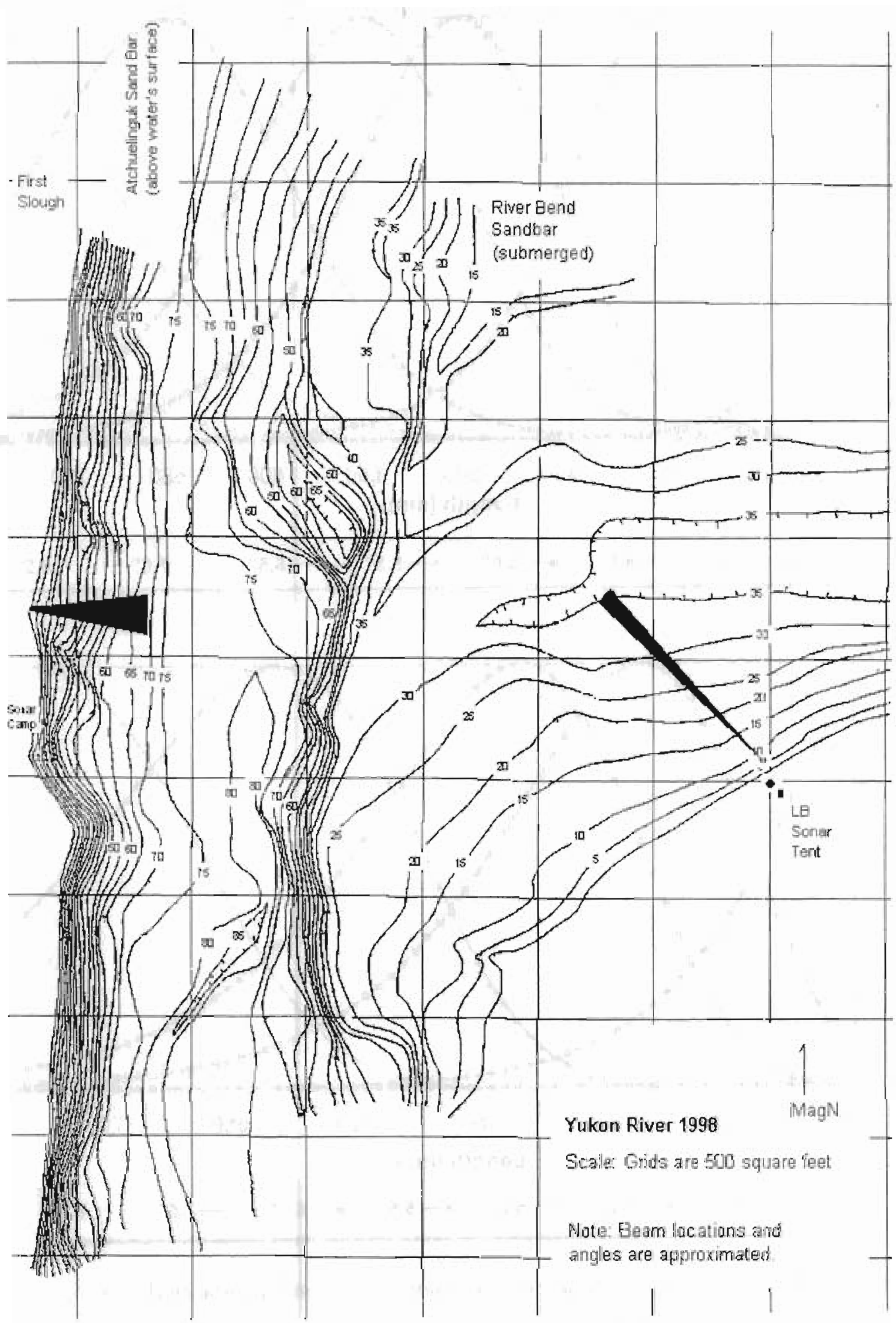
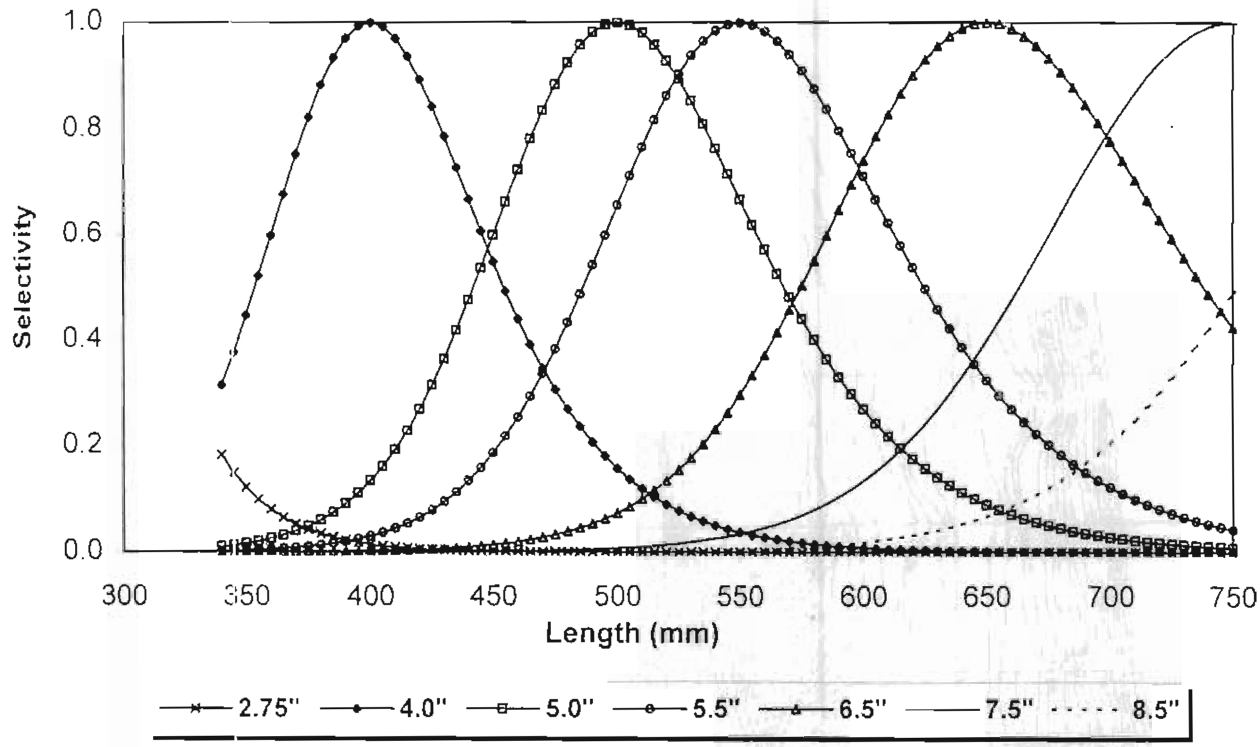


Figure 3. Bathymetric map of the Yukon River in the vicinity of the sonar site, 1998.



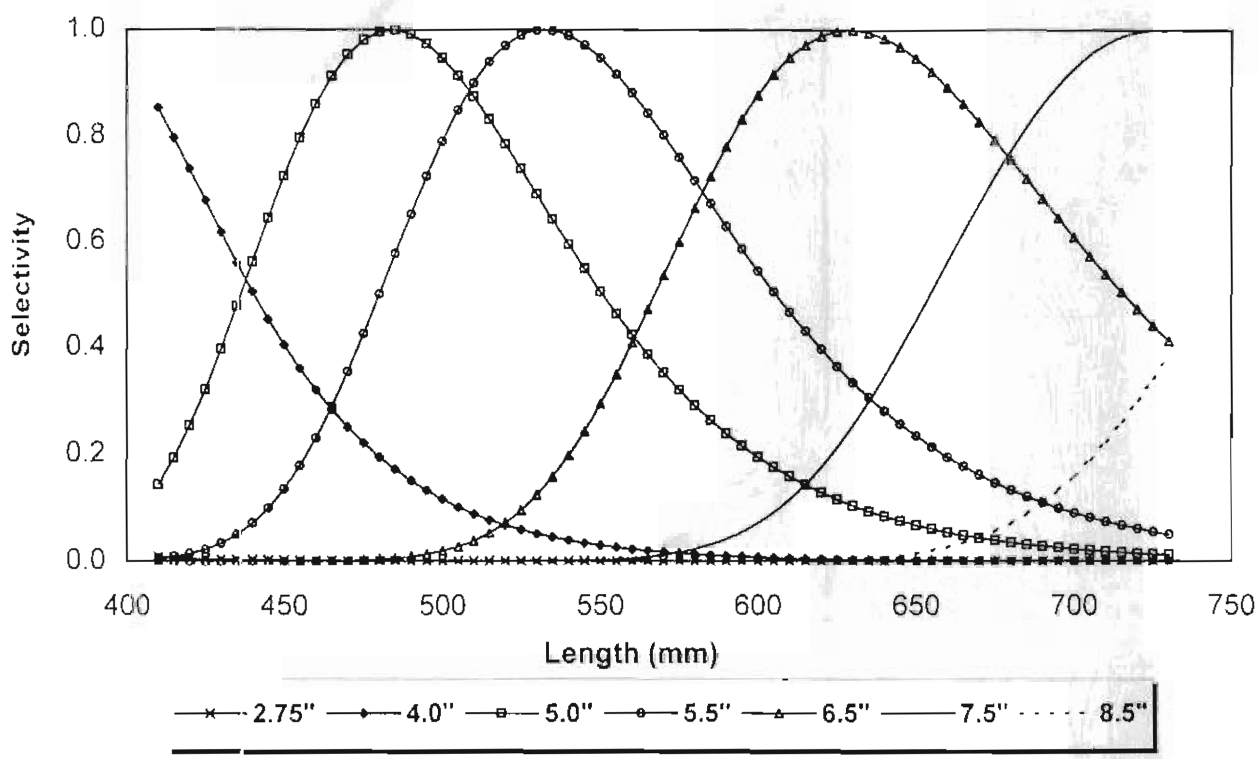


Figure 4. Net selectivity curves for chum salmon, summer (top) and fall season (bottom), Yukon River sonar, 1998.

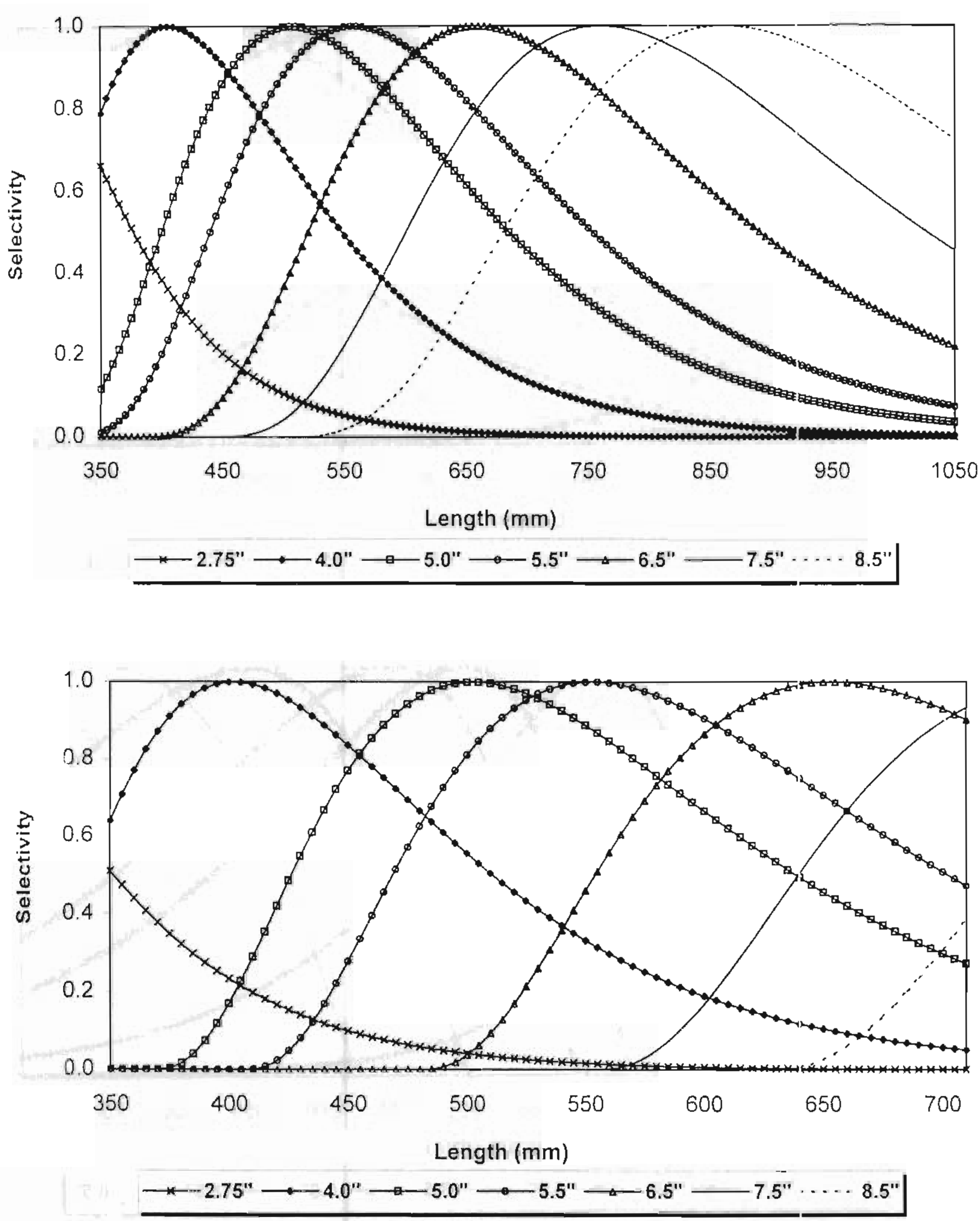


Figure 5. Net selectivity curves for chinook (top) and coho salmon (bottom), Yukon River sonar, 1998.

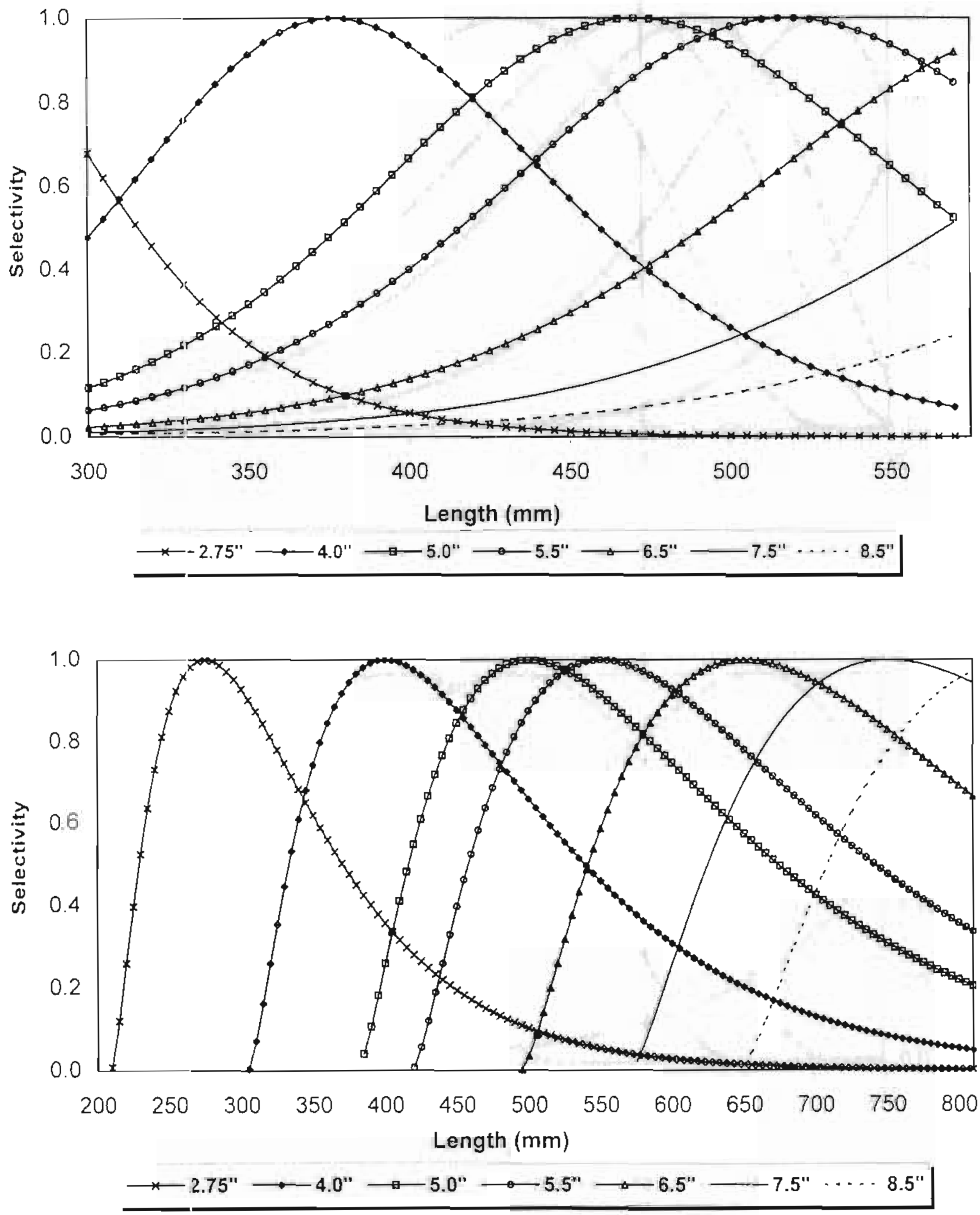


Figure 6. Net selectivity curves for pink salmon (top) and whitefish (bottom), Yukon River sonar, 1998.

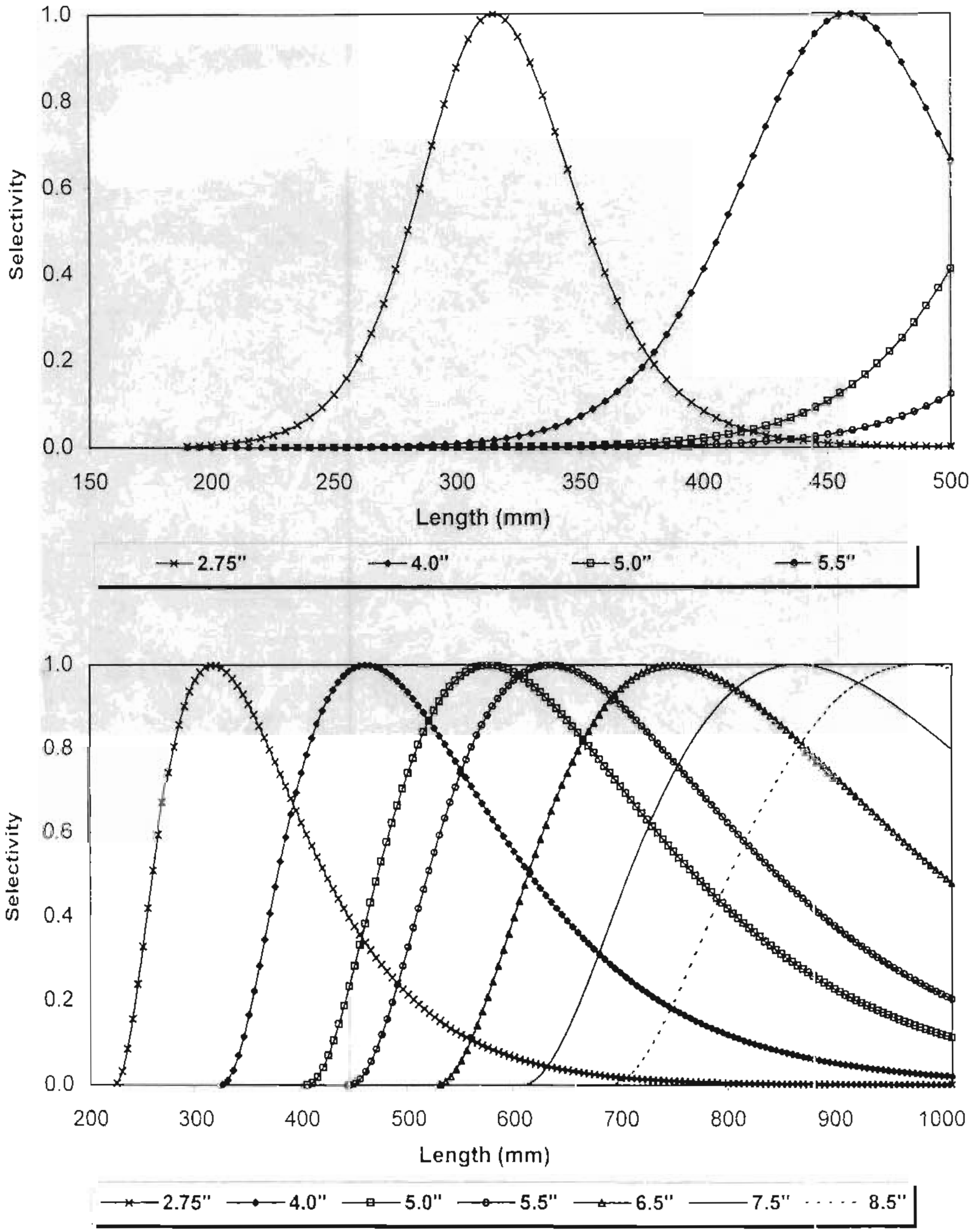


Figure 7. Net selectivity curves for cisco (top) and other fish (bottom). Yukon River sonar, 1998.

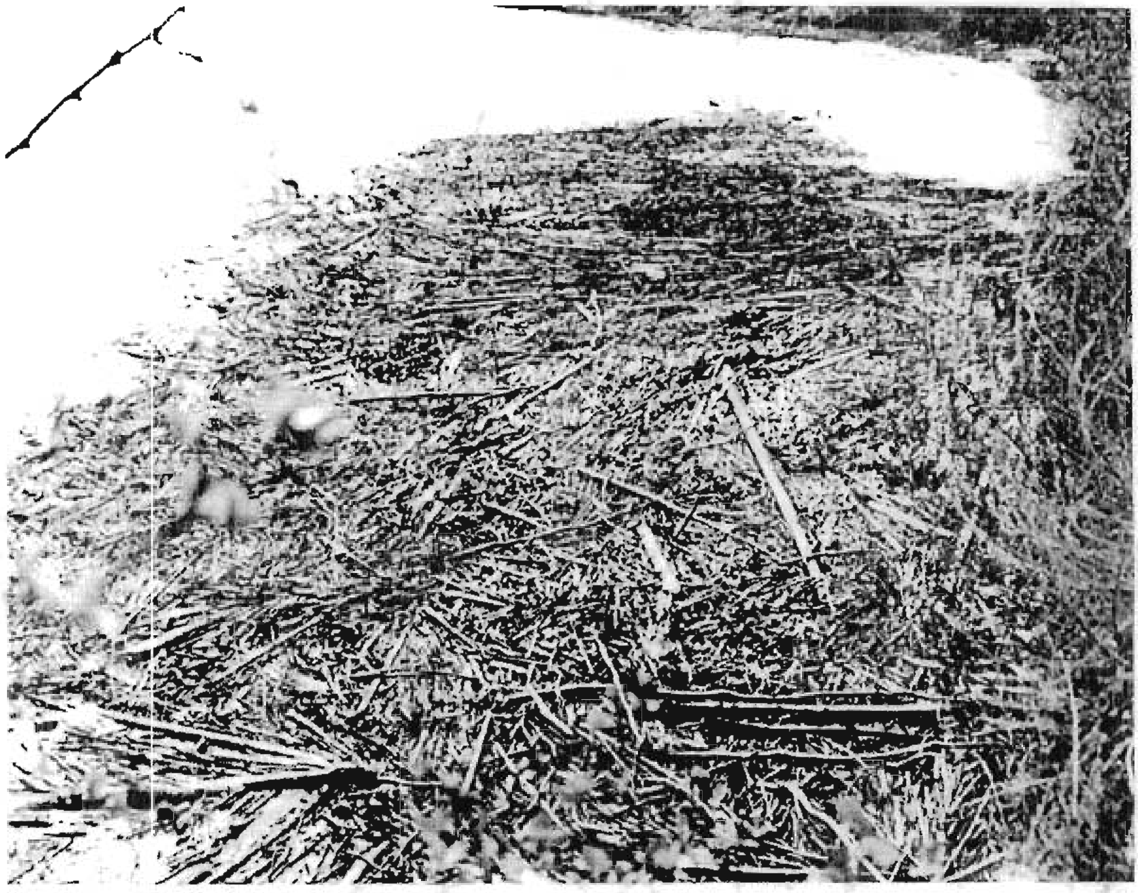
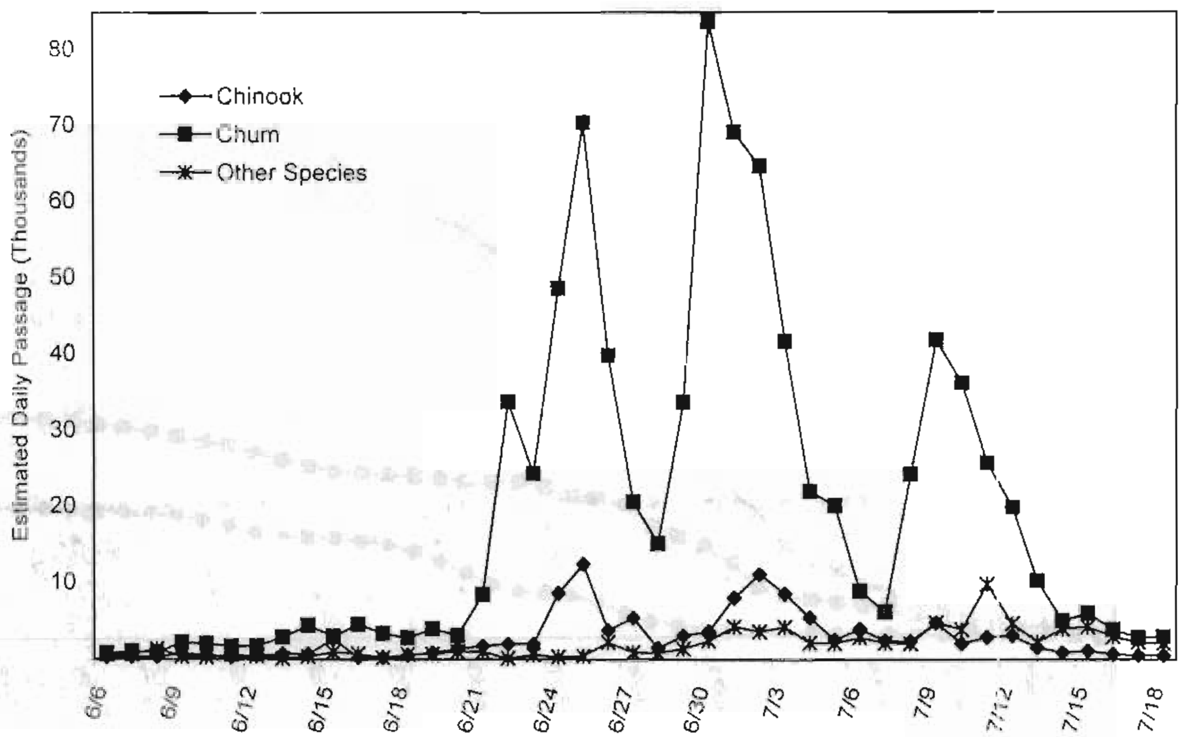


Figure 8. Debris in front of the Yukon River sonar camp, 8 June 1998.



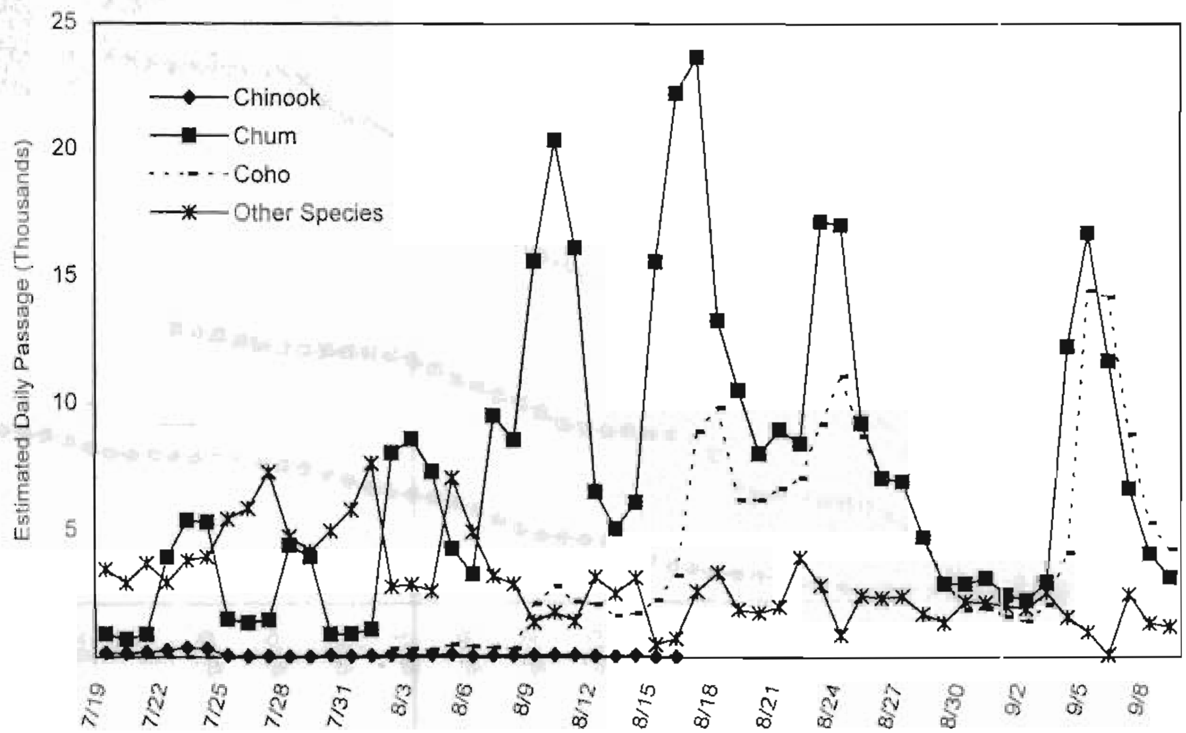
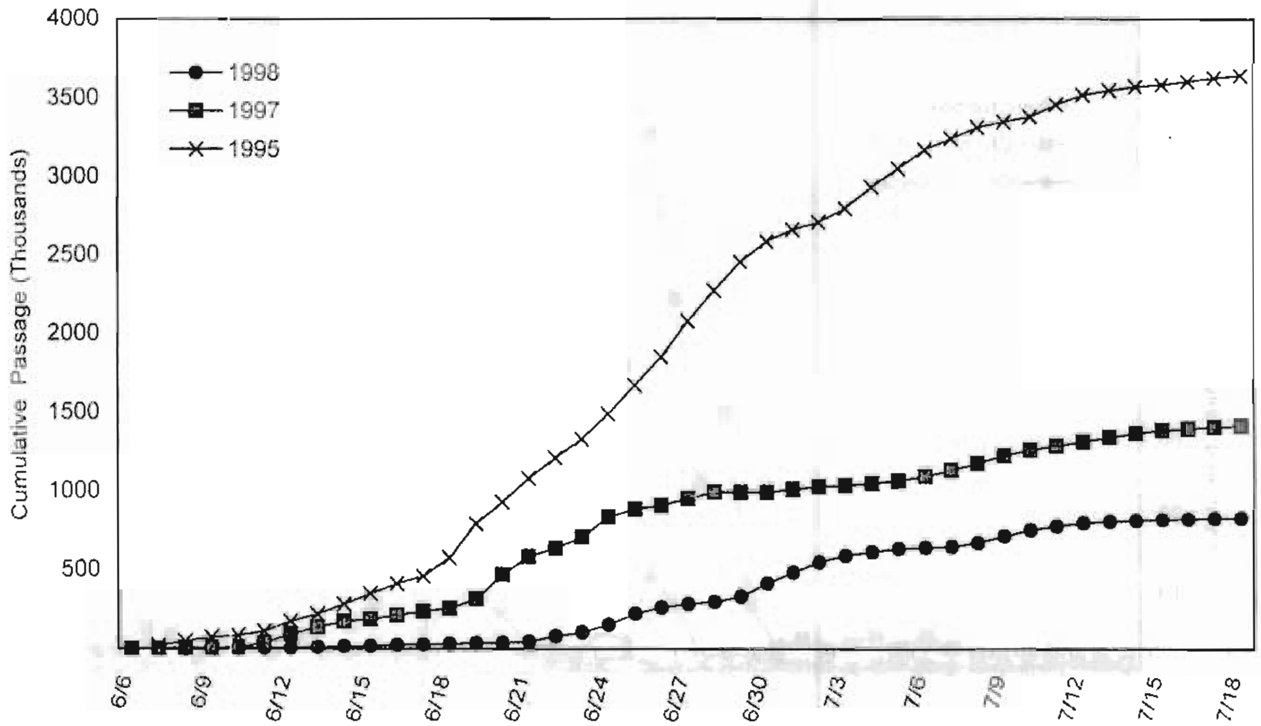


Figure 9. Estimated daily passage by species for summer season (top) and fall season (bottom), Yukon River sonar, 1998.



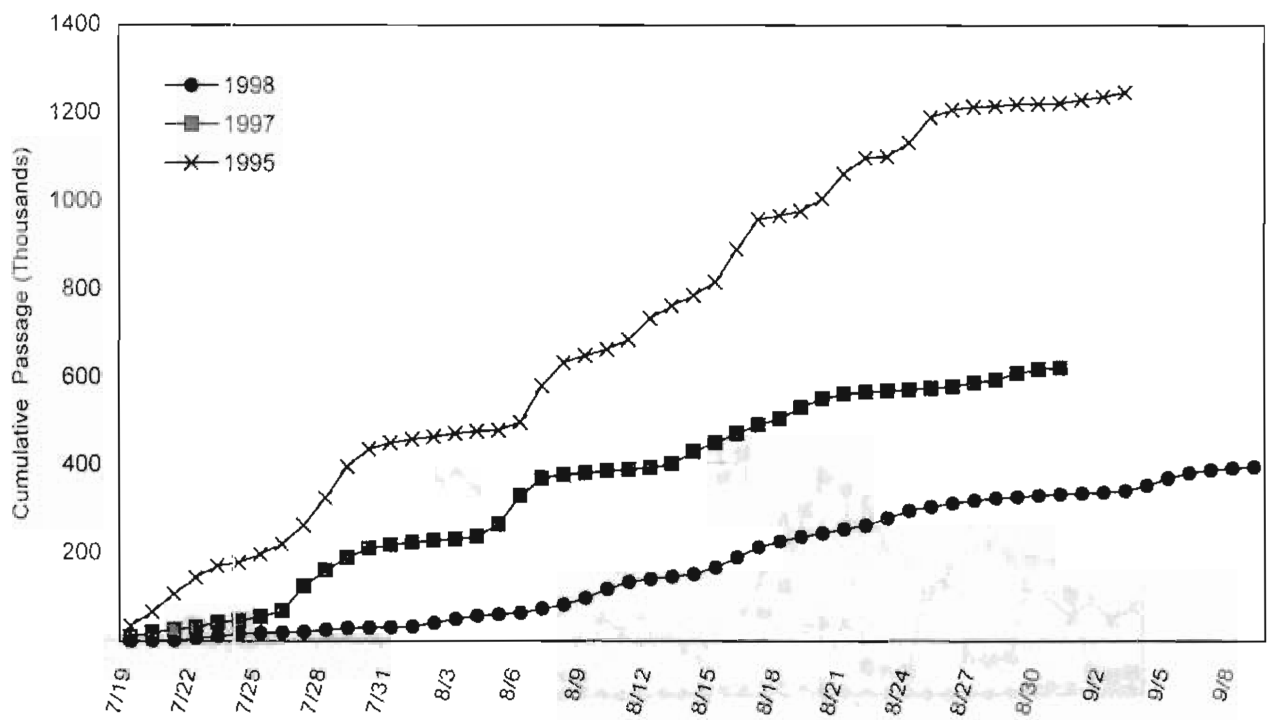
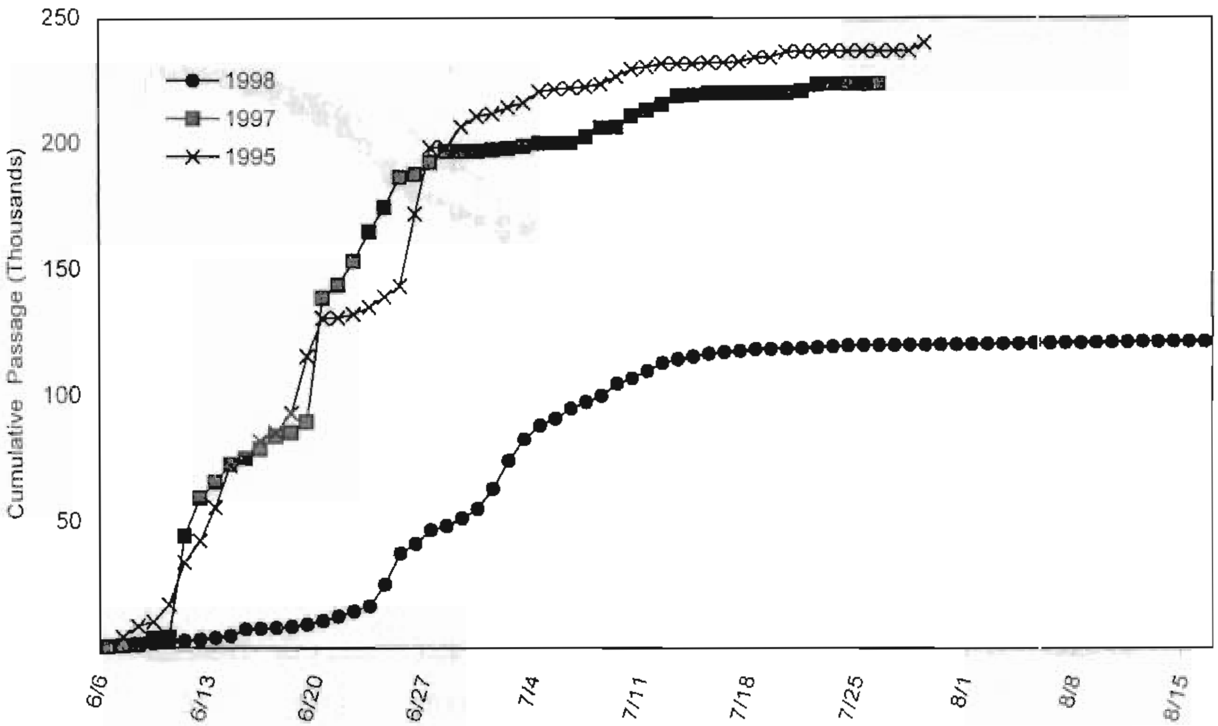


Figure 10. Cumulative passage for summer chum salmon (top) and fall chum salmon (bottom), Yukon River sonar 1995, 1997, and 1998.



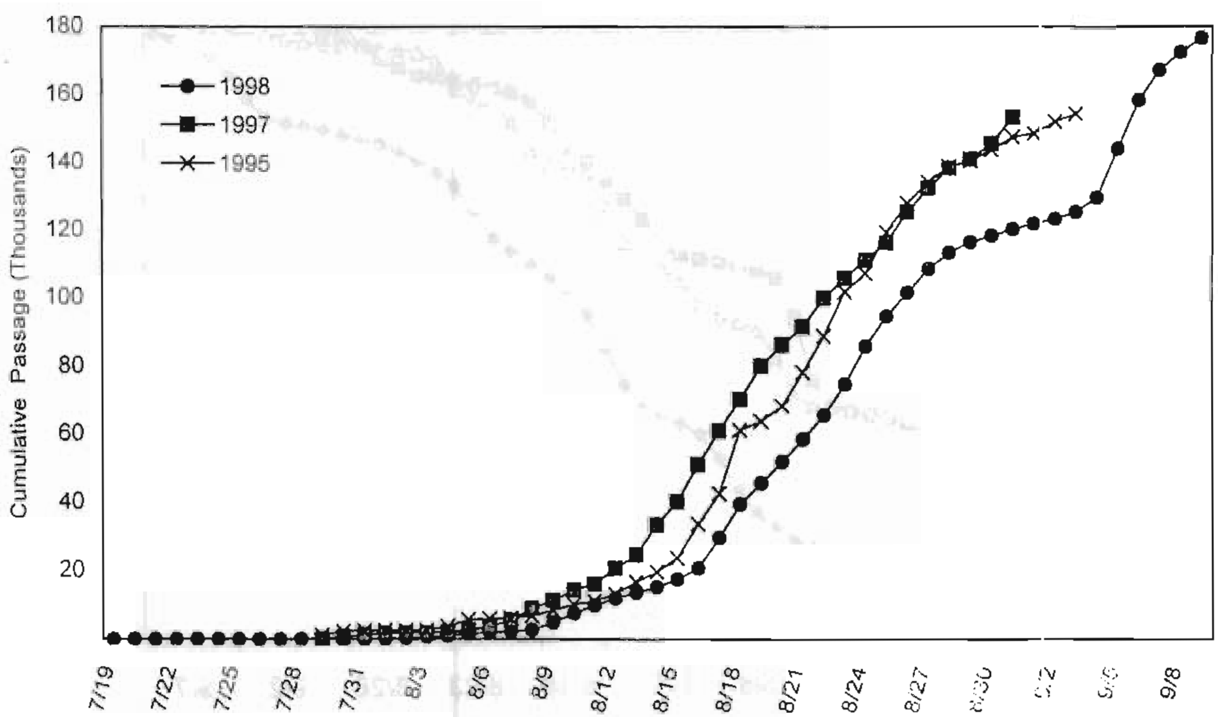
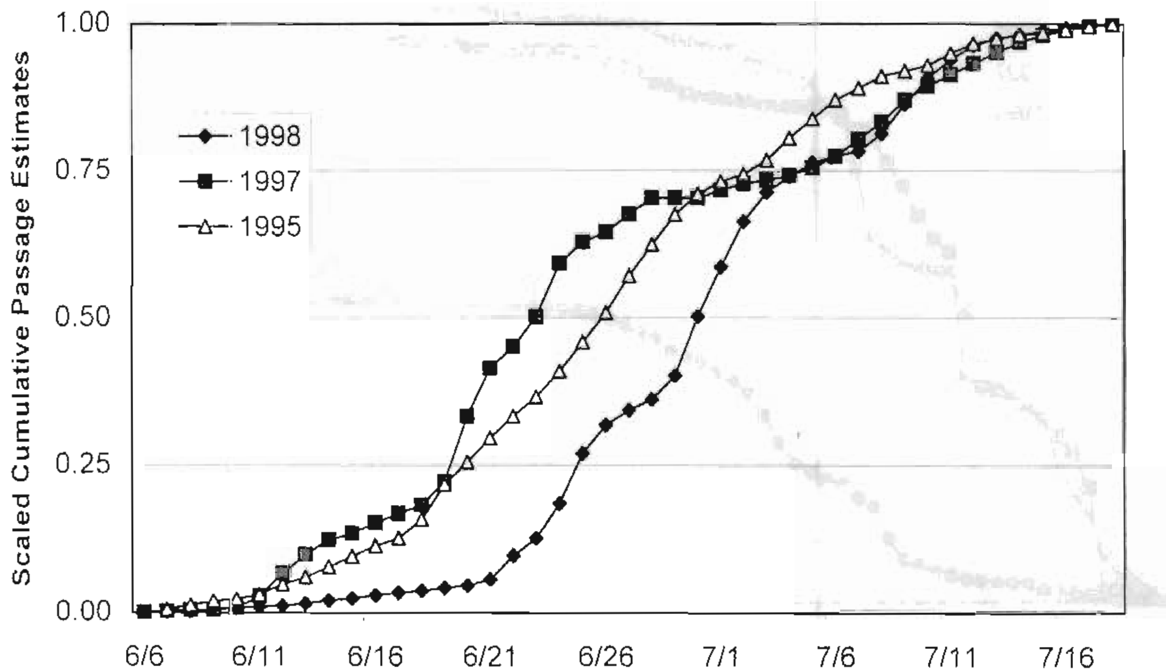


Figure 11. Cumulative passage for chinook (top) and coho salmon (bottom), Yukon River sonar 1995, 1997, and 1998.



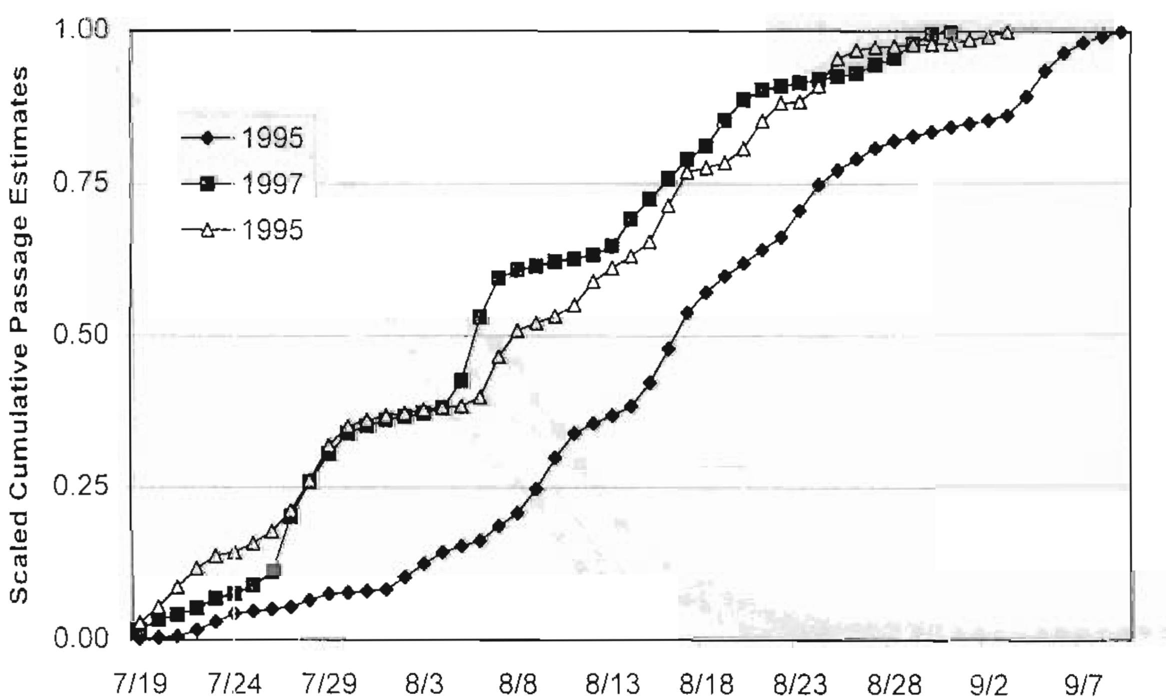


Figure 12. Scaled cumulative passage estimates by day for summer (top) and fall (bottom) chum salmon, Yukon River sonar.

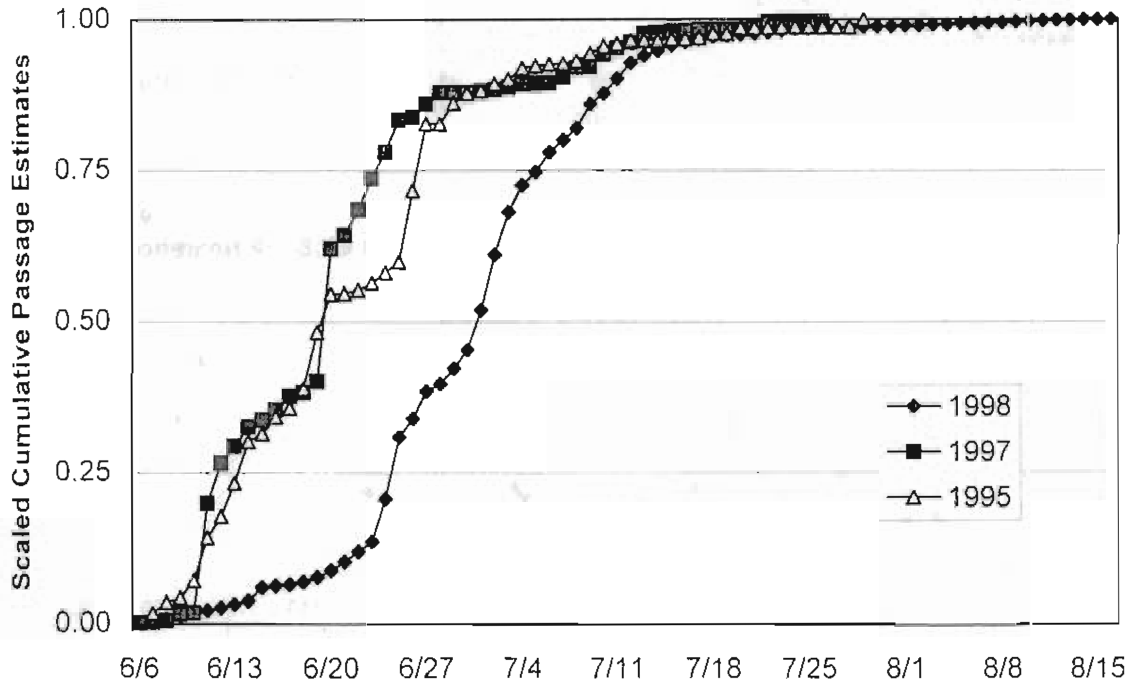


Figure 13. Scaled cumulative passage estimates by day for chinook salmon, Yukon River sonar.

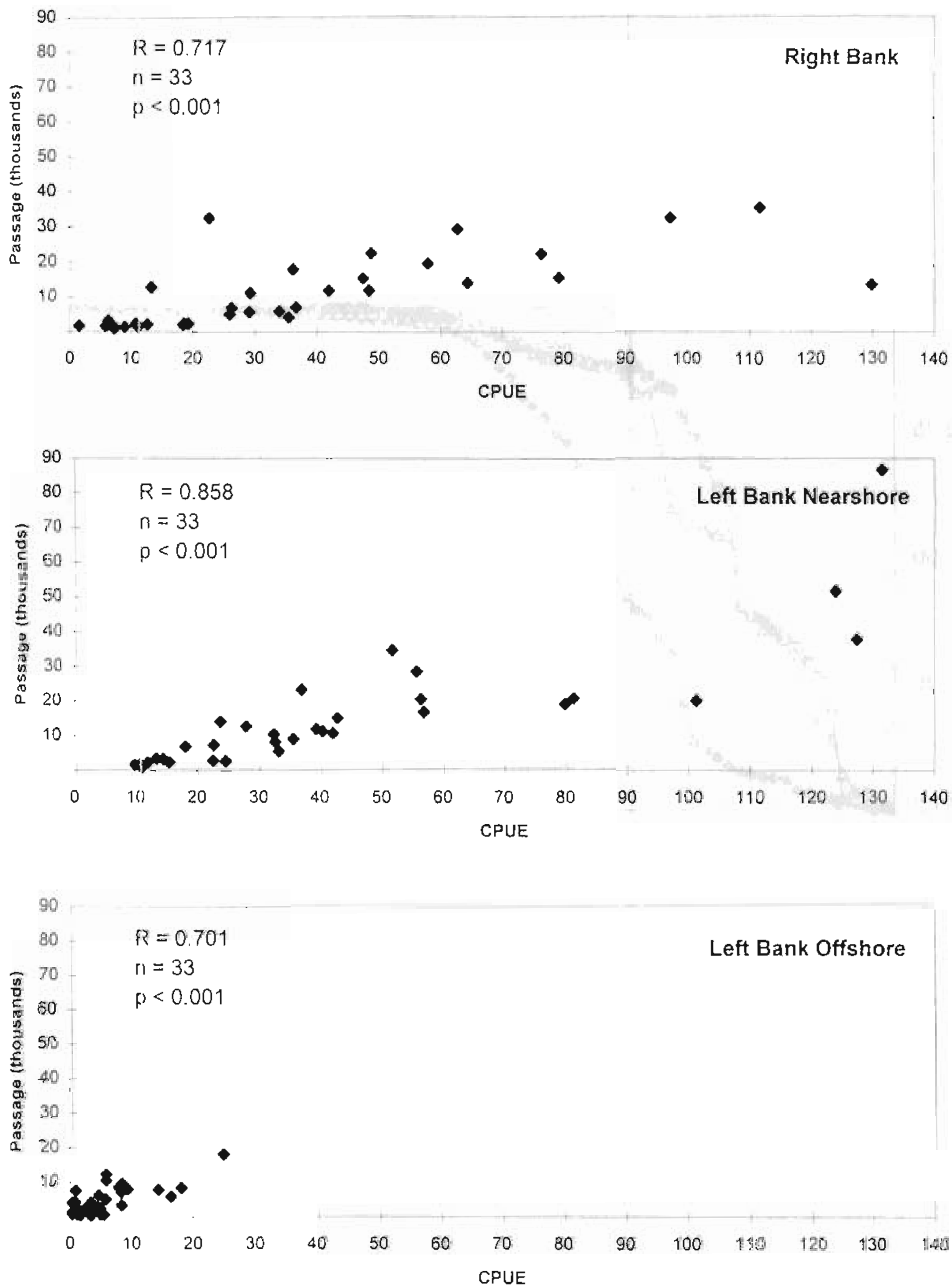


Figure 14. CPUE versus sonar passage estimates by report period and zone from 6 June to 18 July for the Yukon River sonar project, 1998.

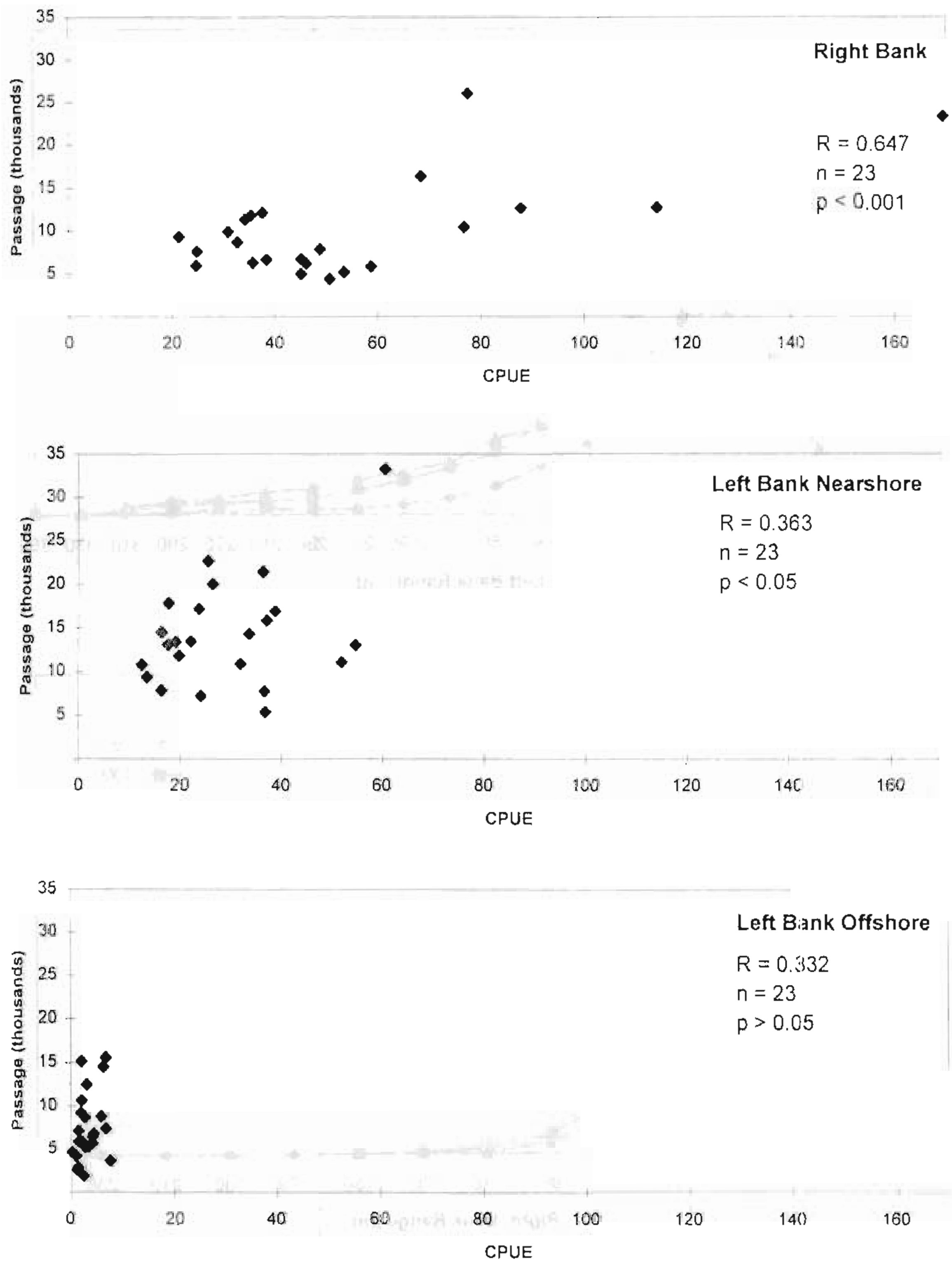
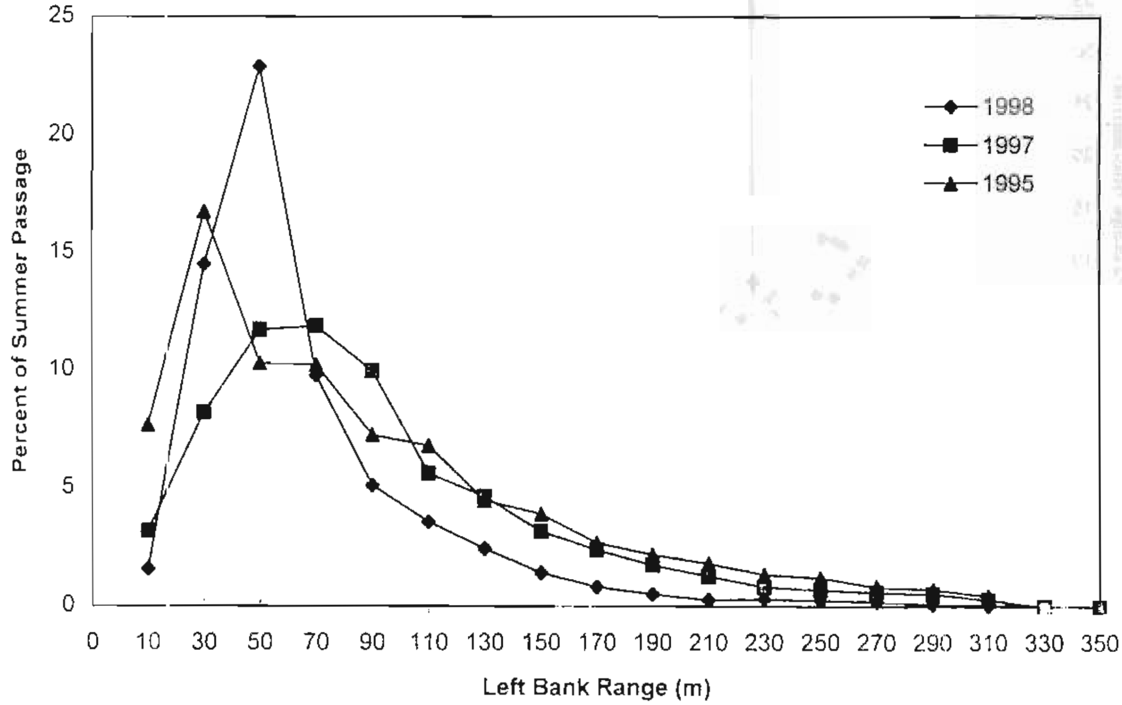


Figure 15. CPUE versus sonar passage estimates by report period and zone from 19 July to 31 August for the Yukon River sonar project, 1998.



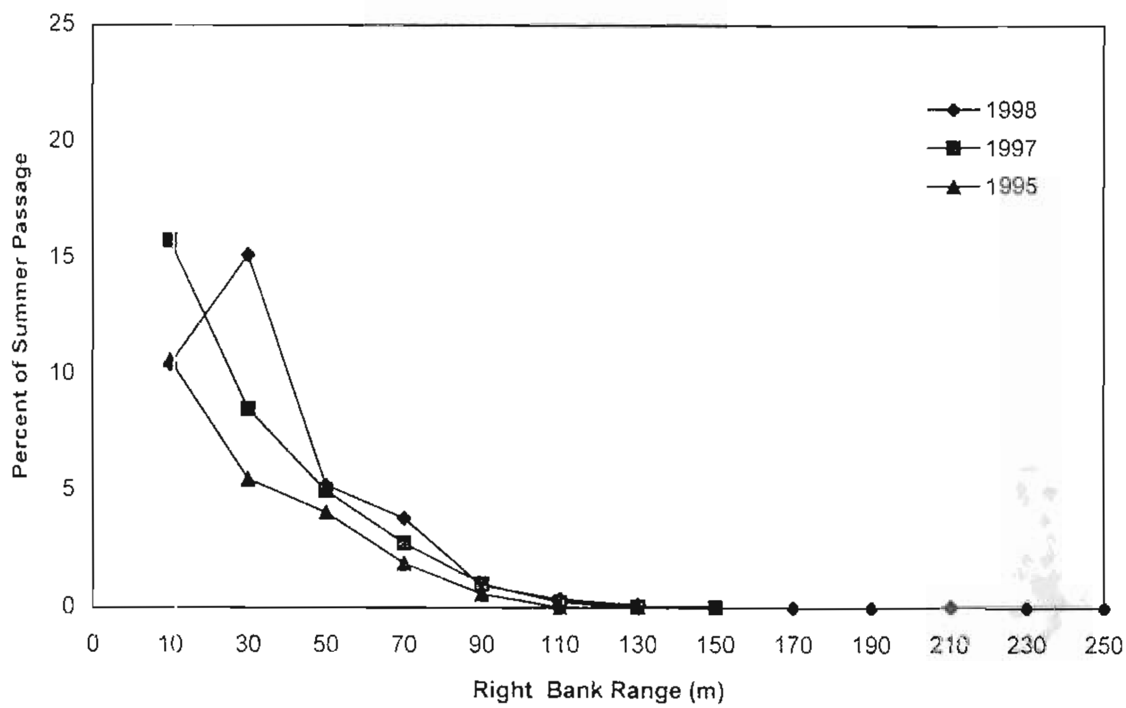
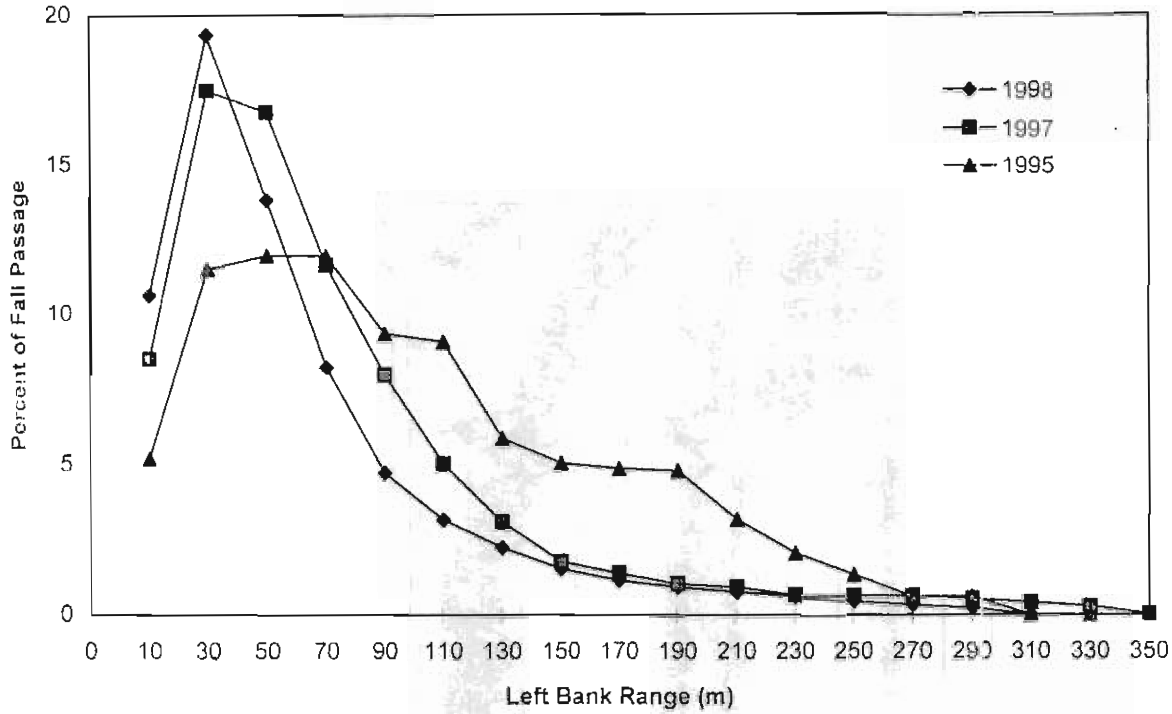


Figure 16. Summer season horizontal distribution of left- and right-bank passage on the Yukon River 1995, 1997 and 1998.



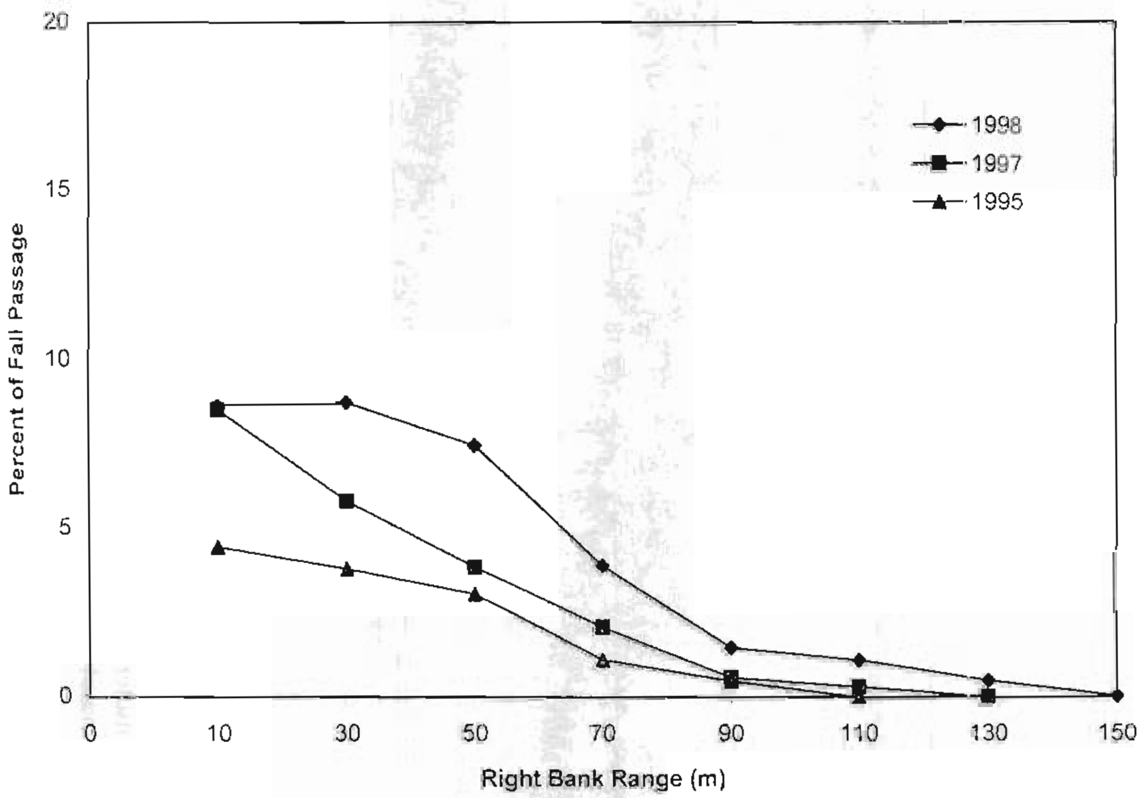


Figure 17. Fall season horizontal distribution of left- and right-bank passage on the Yukon River 1995, 1997 and 1998.

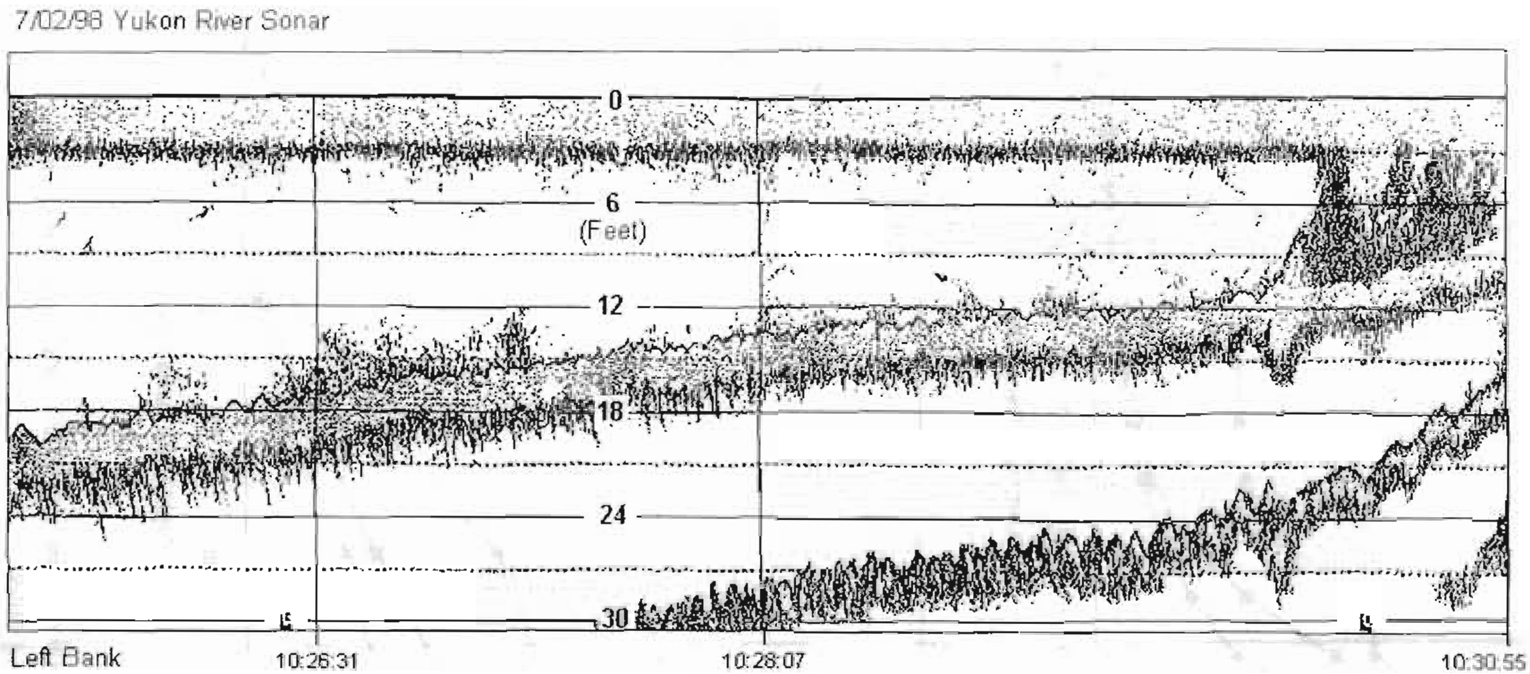


Figure 18. A fathometer chart depicting fish tracings along the left shore of the Yukon River recorded while drifting parallel approximately 20 to 30 m from shore, 1998.

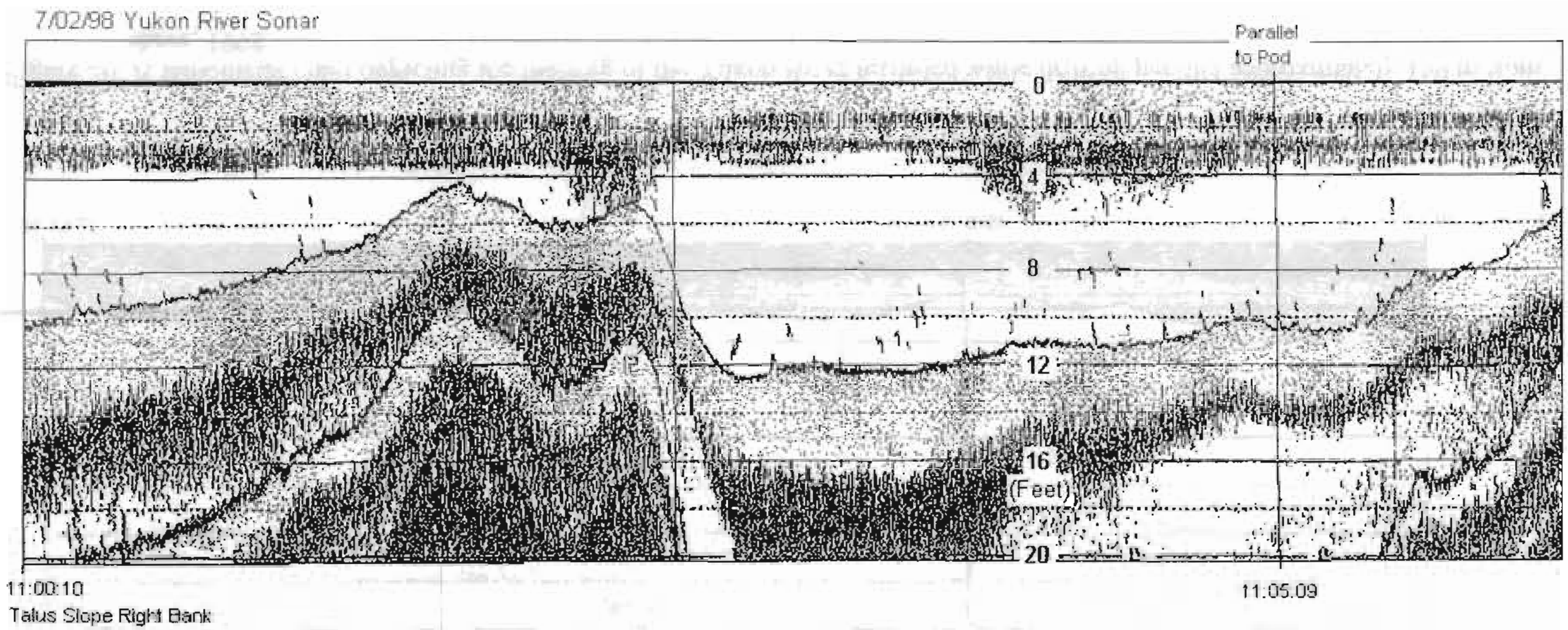


Figure 19. A fathometer chart depicting fish tracings along the right shore of the Yukon River recorded while drifting parallel approximately 5 to 15 m from shore, 1998.

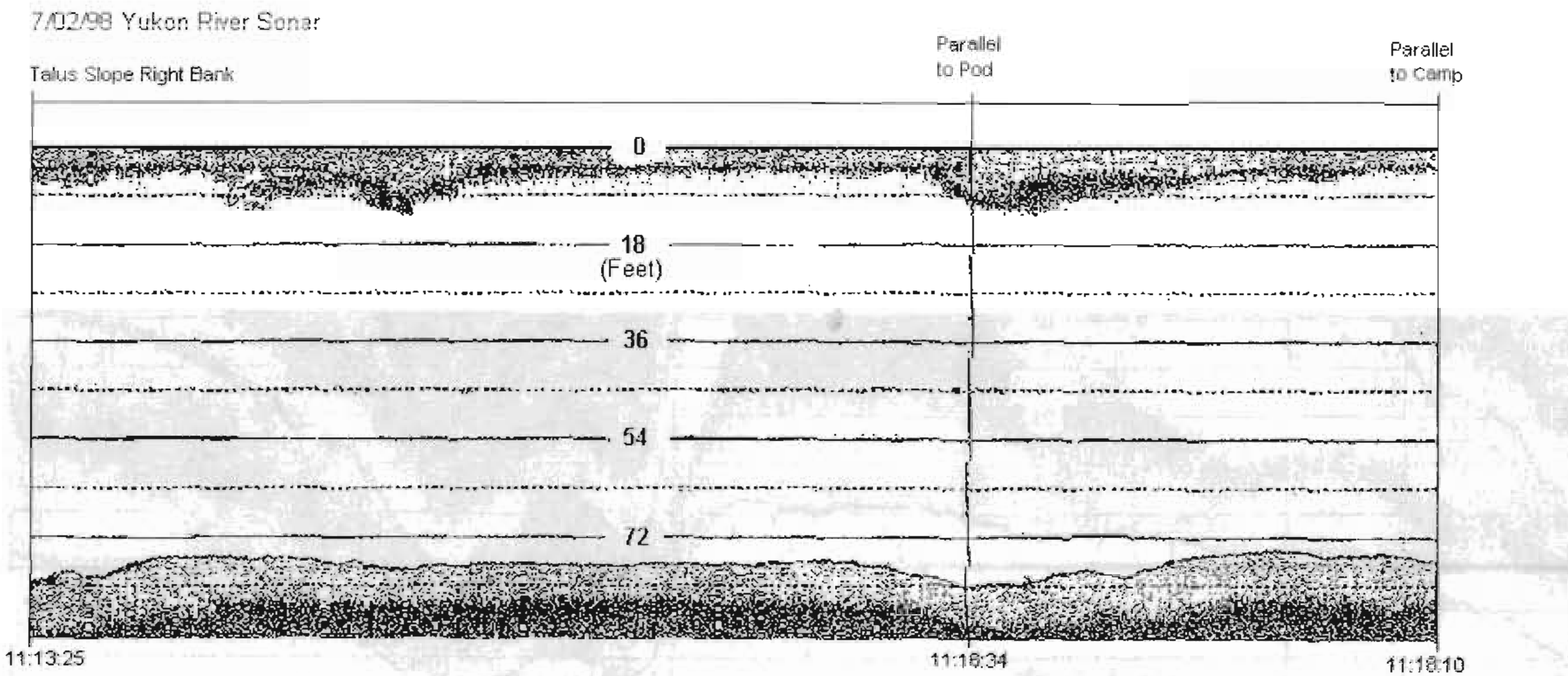


Figure 20. A fathometer chart depicting the thalweg of the Yukon River recorded while drifting parallel approximately 150 m from shore, 1998.

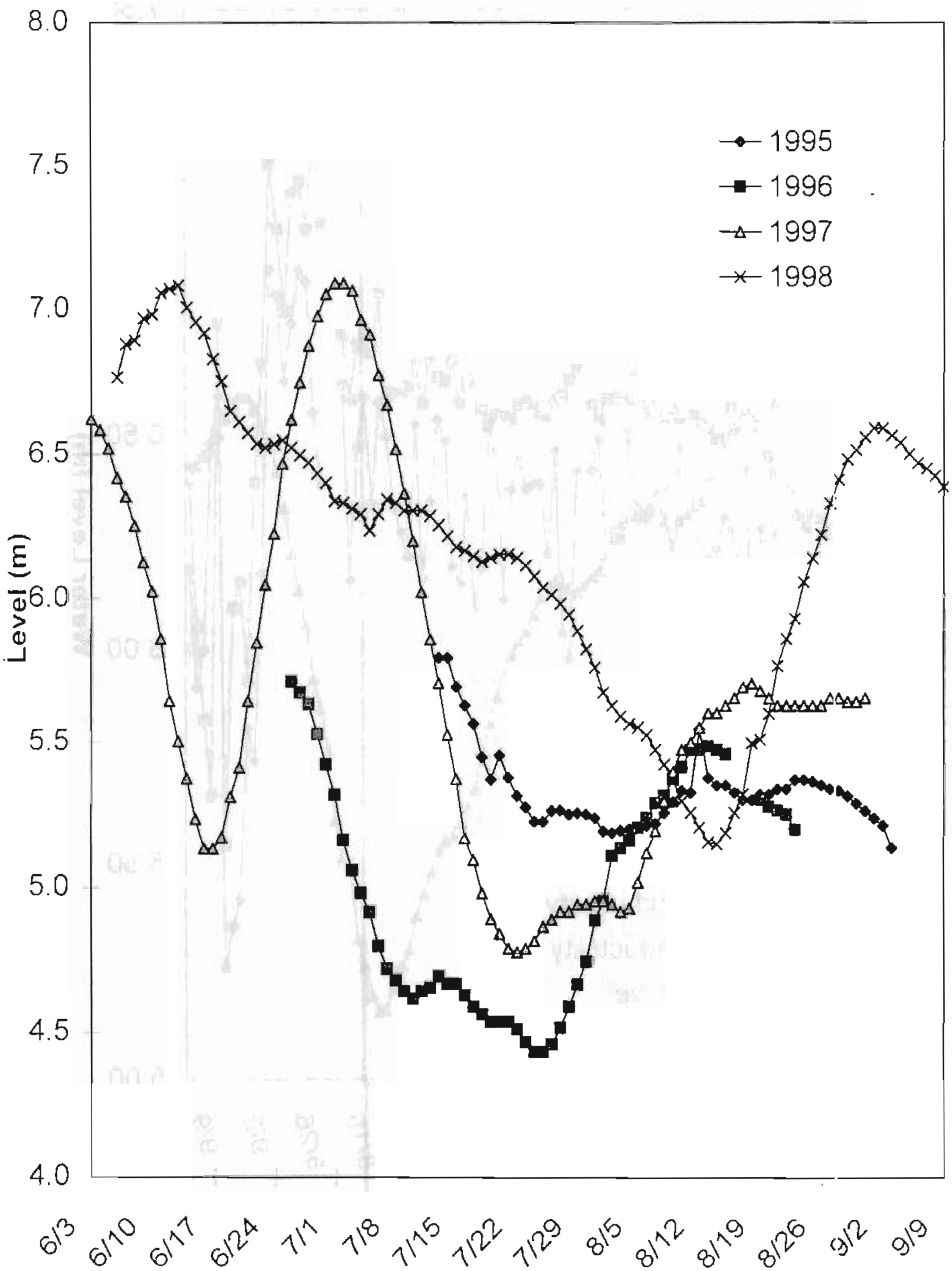


Figure 21. Water level 1995, 1996, 1997, and 1998 at the Yukon River sonar site.

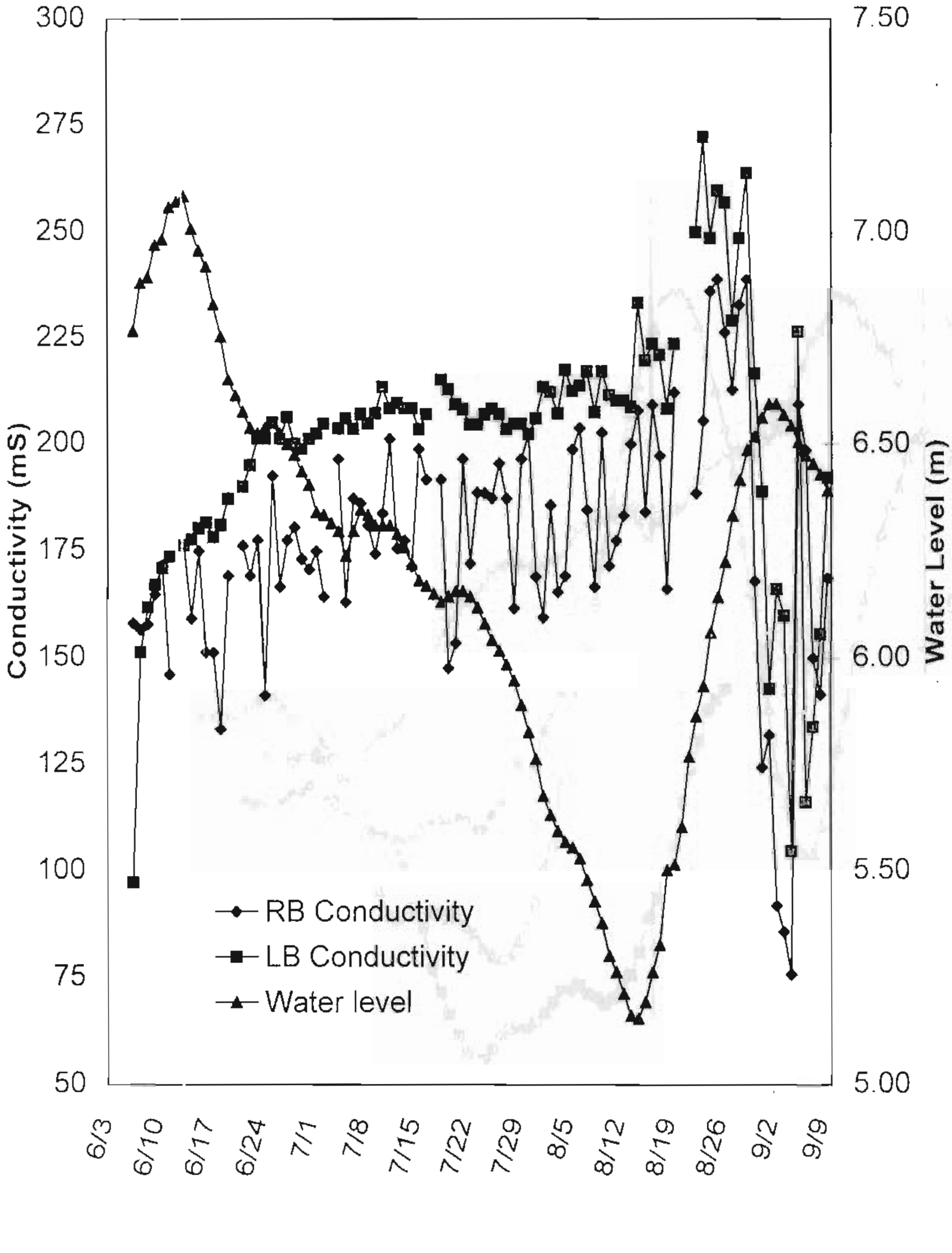


Figure 22. Conductivity and water level, Yukon River sonar 1998.

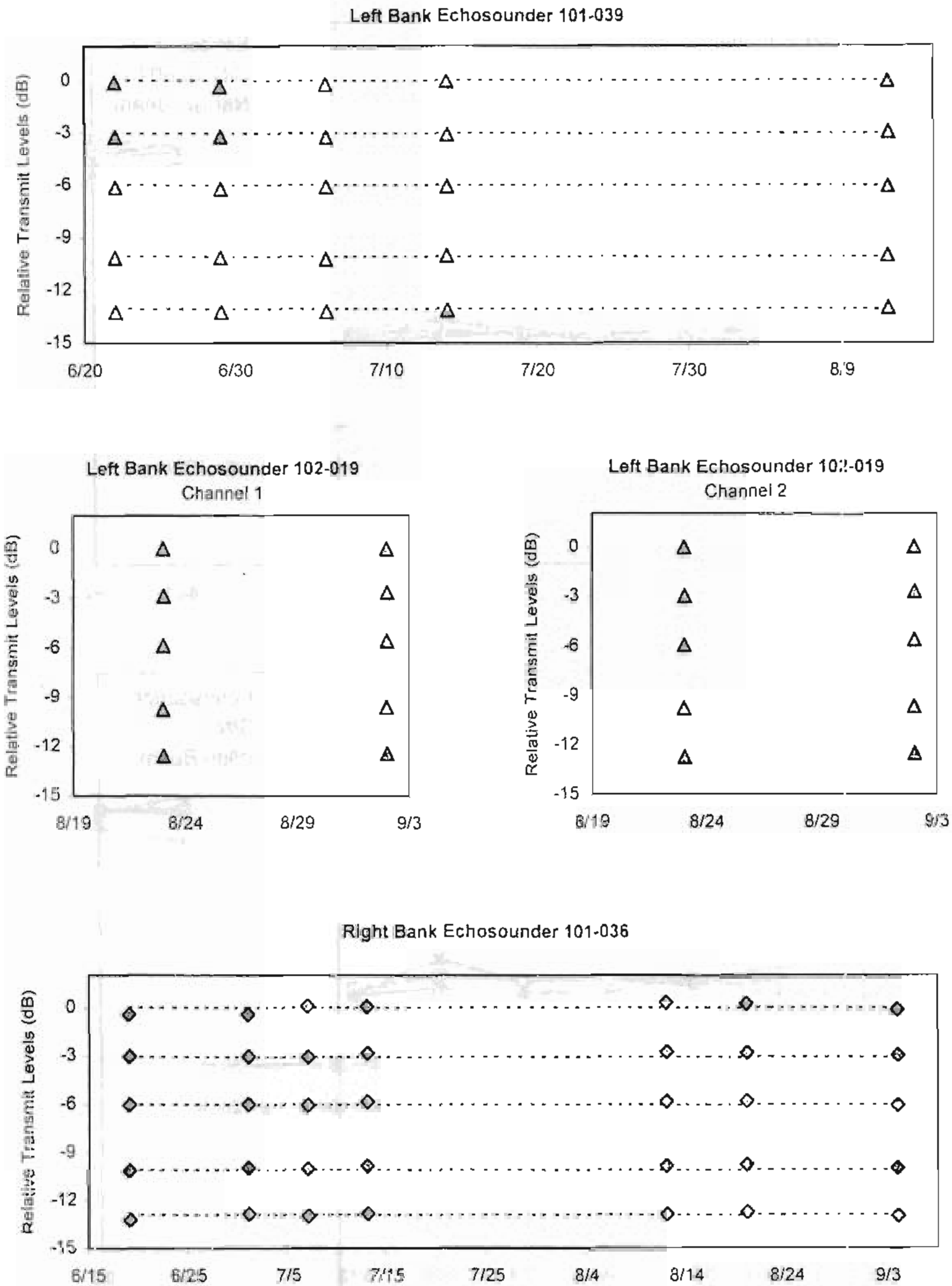
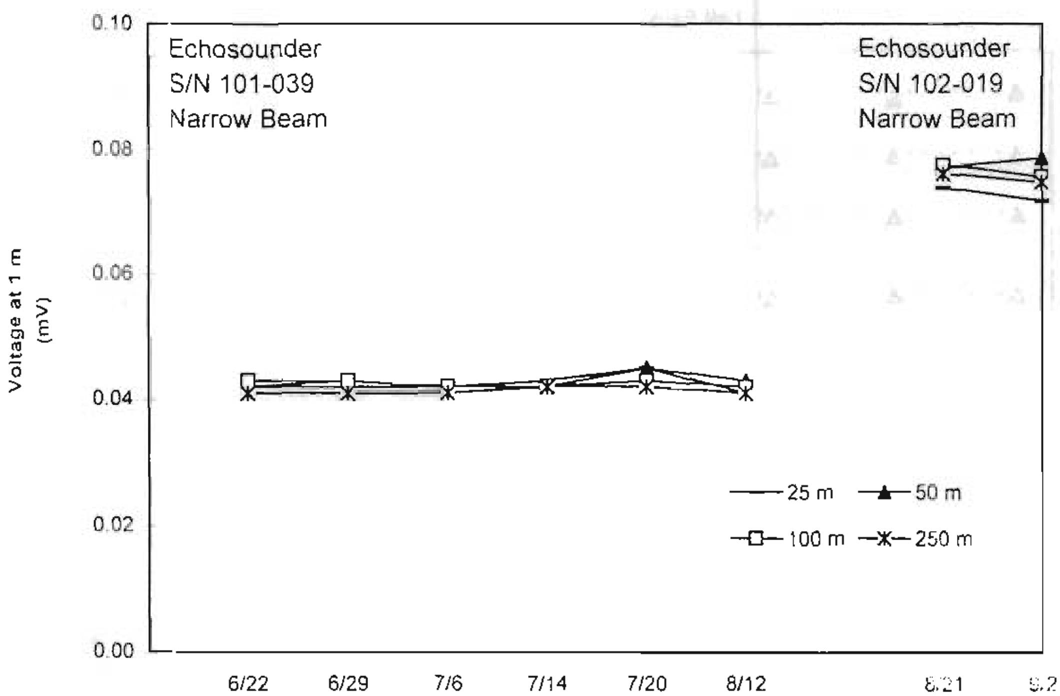


Figure 23. Comparison of transmitter output values preseason (dotted line) and inseason (diamonds) for the Yukon River sonar project's echosounders. 1998. Note: No pre-season values are available for echosounder 102-019.



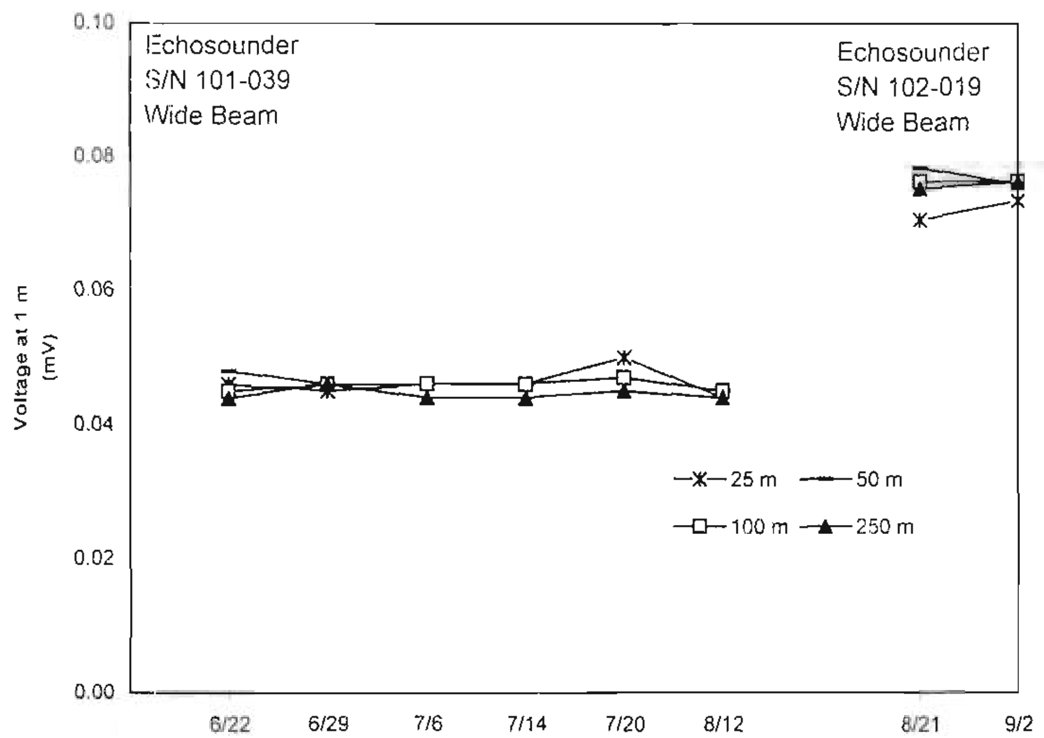
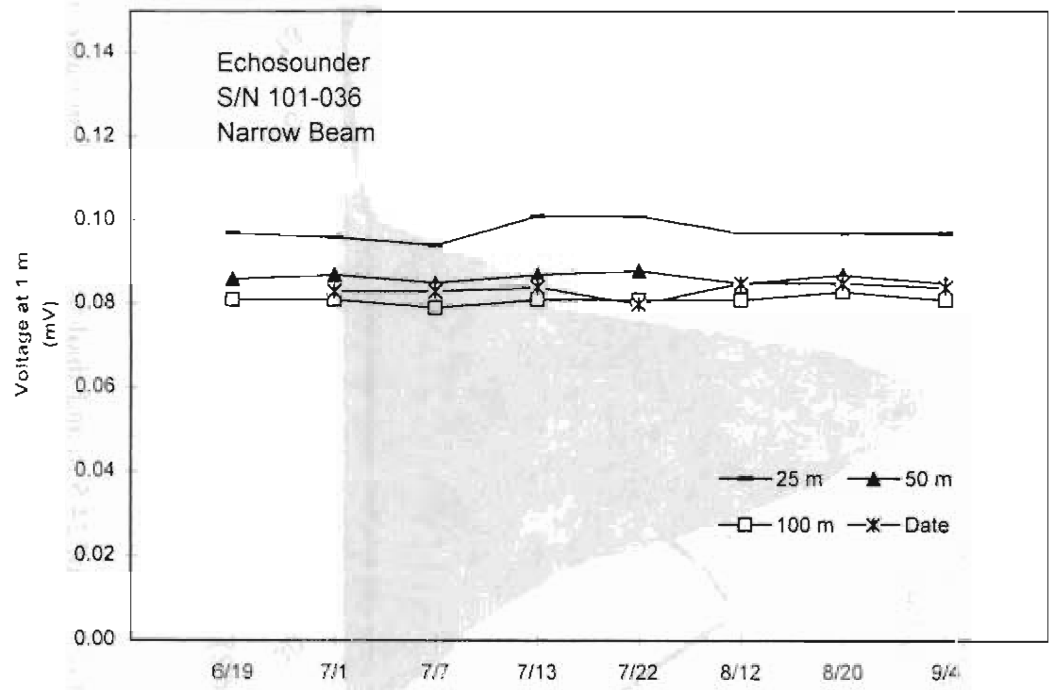


Figure 24. Time-varied gain performance verification for the Yukon River sonar echosounders 101-039 and 102-019, 1998.



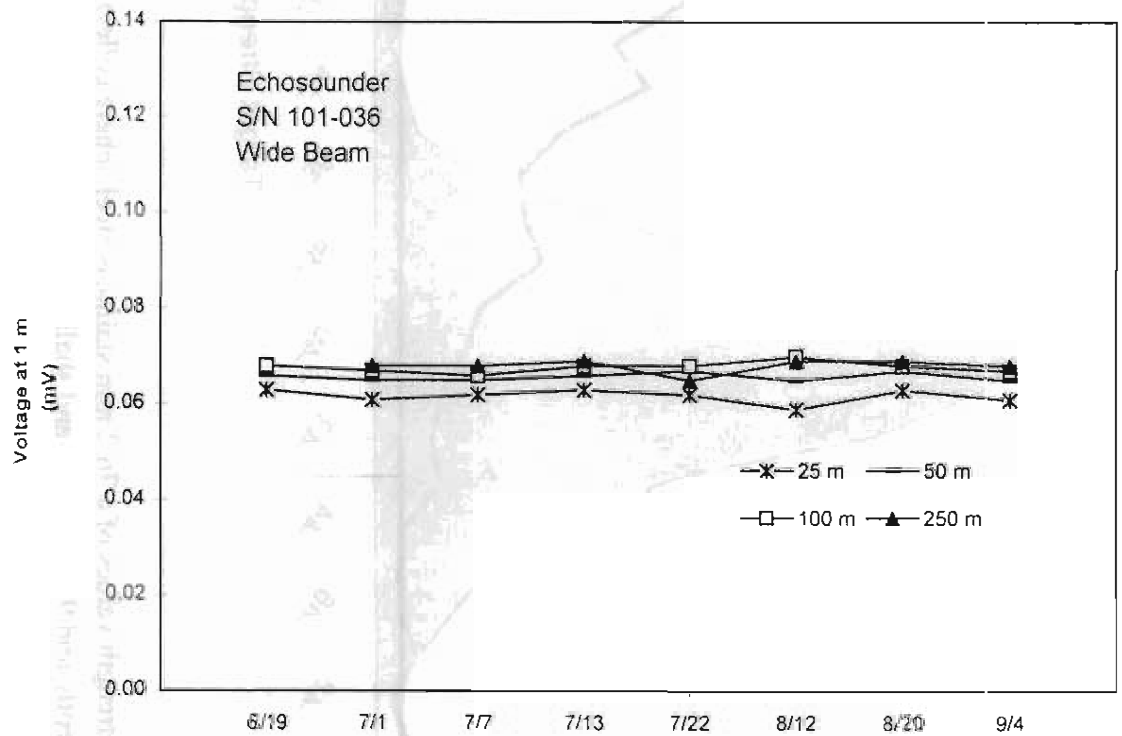


Figure 25. Time-varied gain performance verification for the Yukon River sonar echosounder 101-036, 1998.

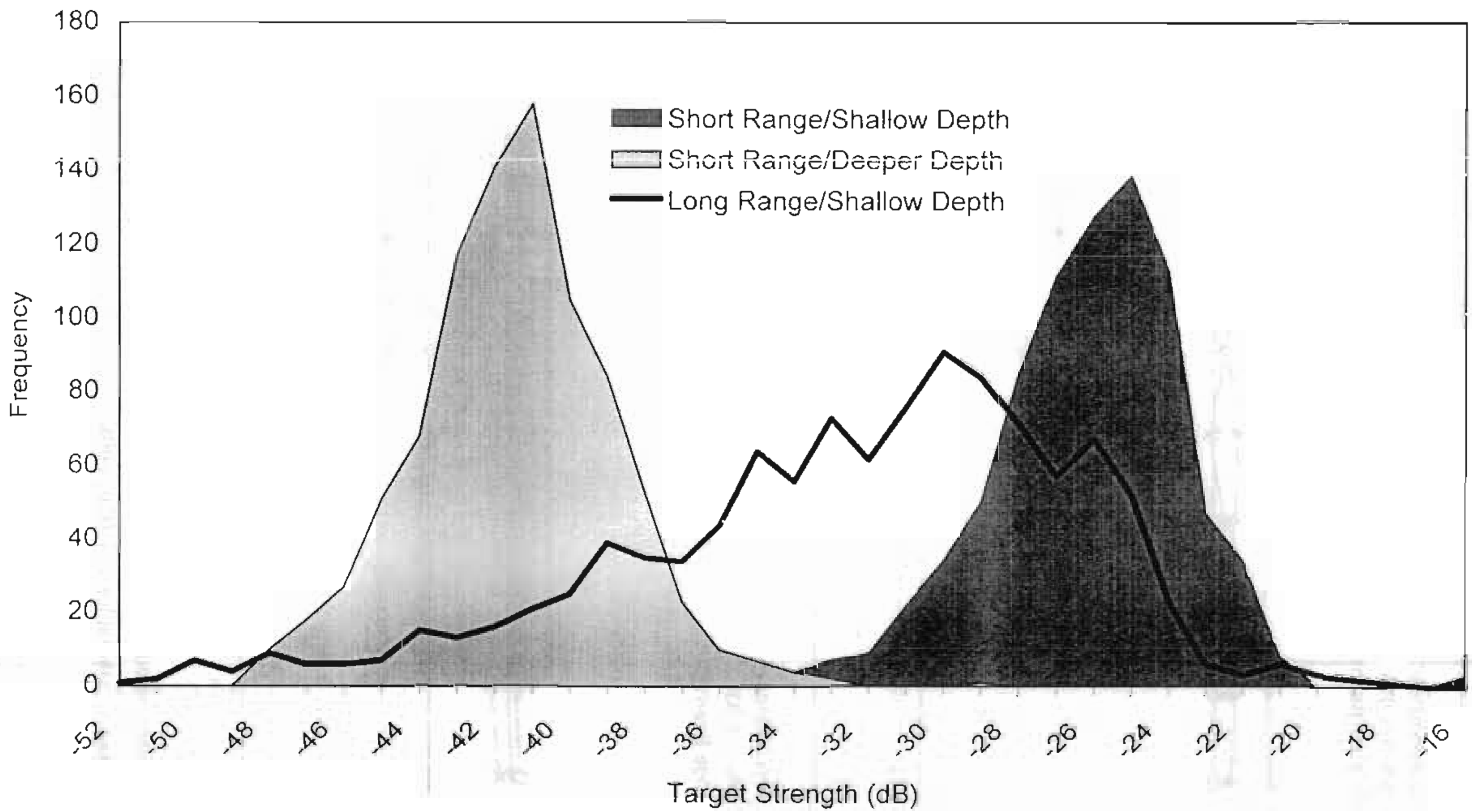


Figure 26. Target strength values of a 76.2 mm stainless steel sphere collected at a range of 24.5 m and shallow depth, 24.5 m range and 1.8 m depth, and 99.5 m range and shallow depth, Yukon River sonar 10 July 1998.

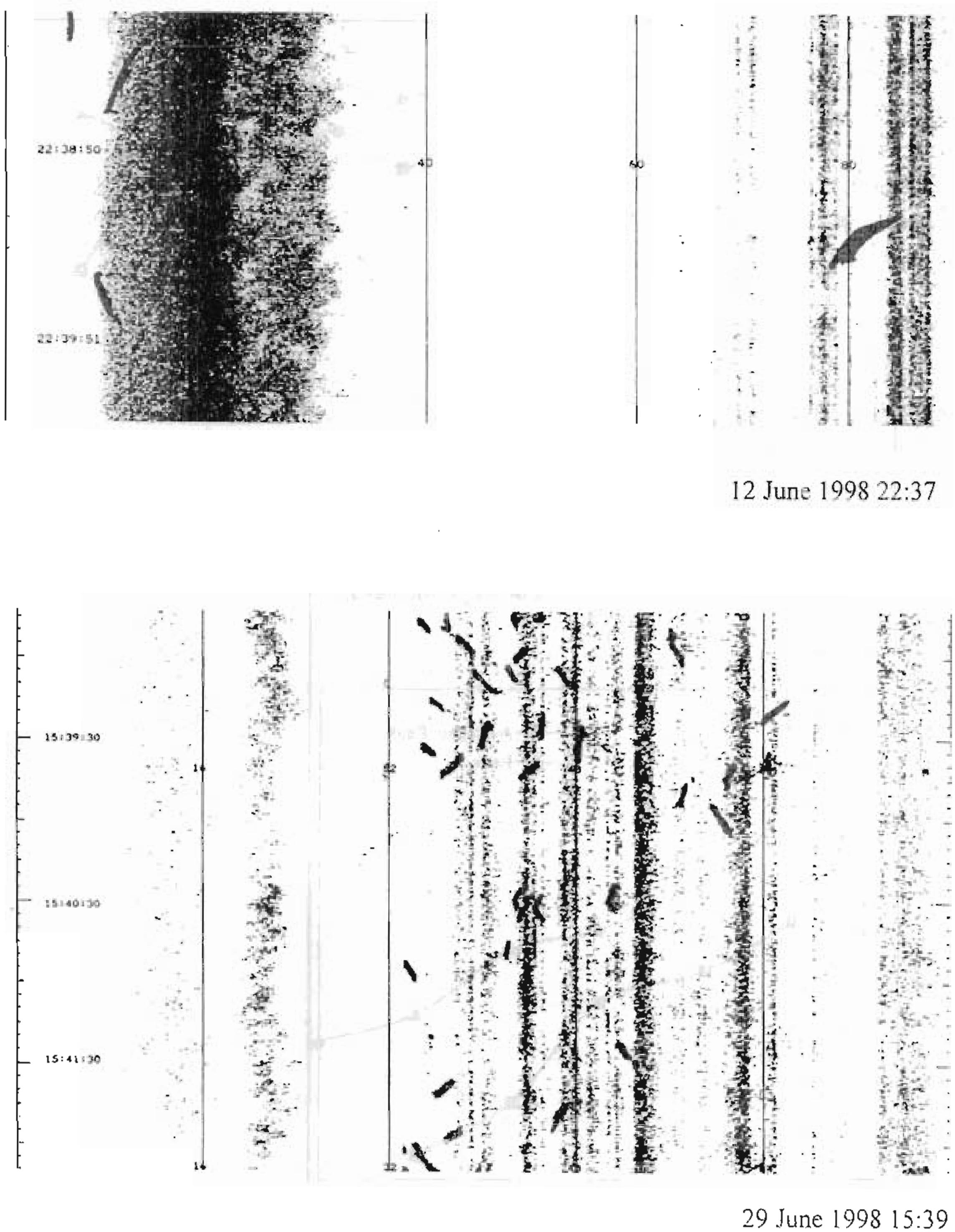
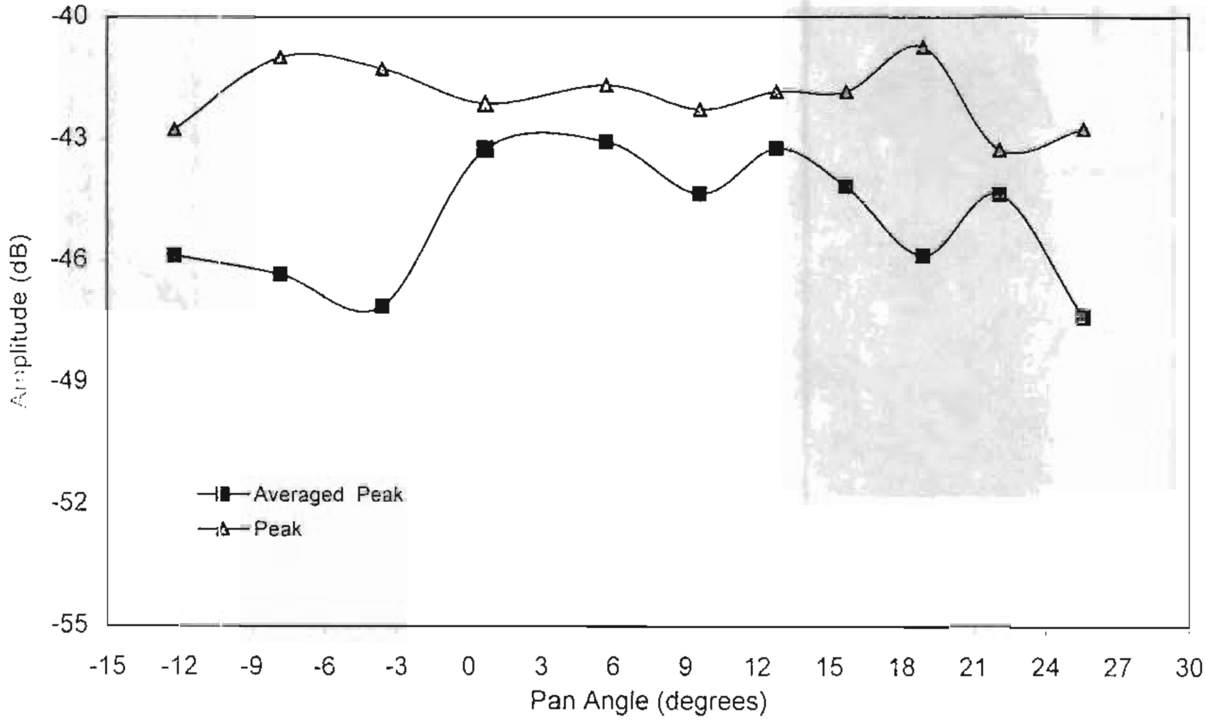


Figure 27. The dark band of echoes (top) of the reverberation band recorded early in the field season and the more diffuse band (bottom) recorded in late June on the Yukon River, 1998.



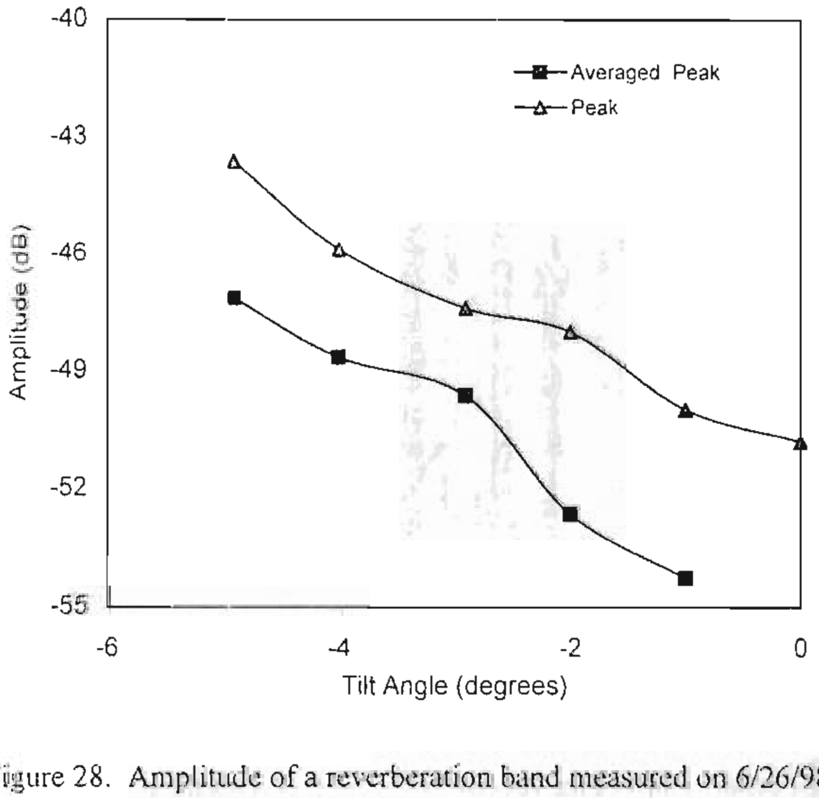
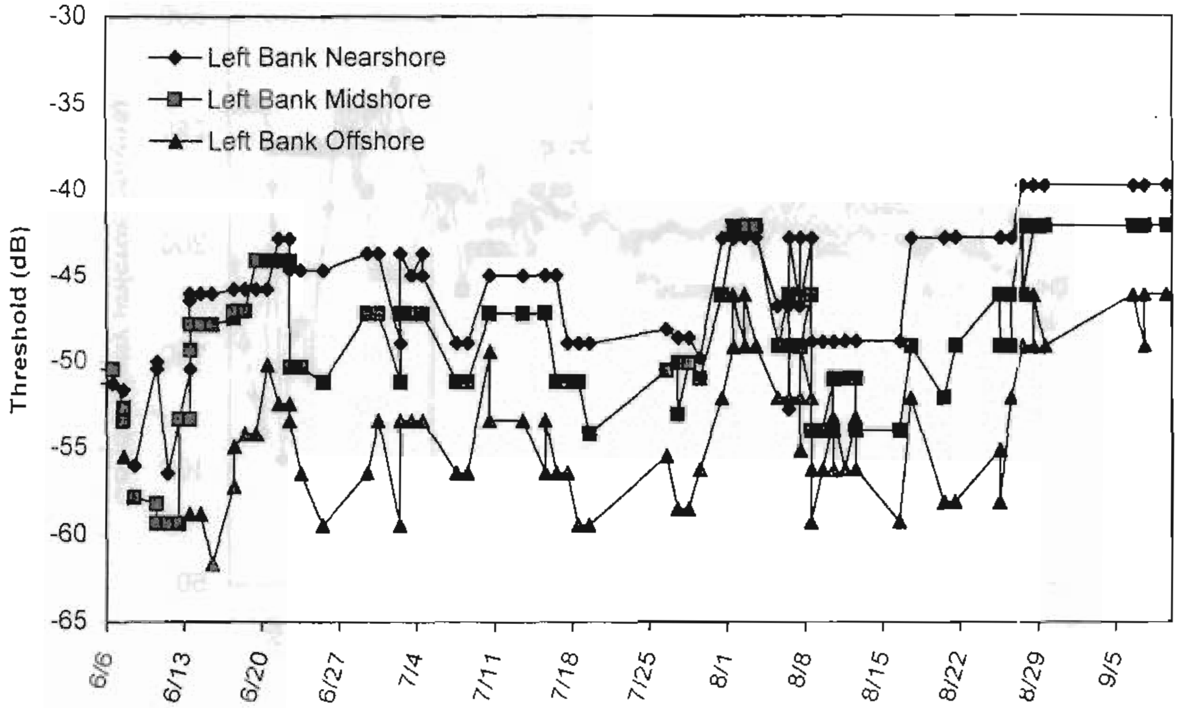


Figure 28. Amplitude of a reverberation band measured on 6/26/98. The zero pan (top) is perpendicular to current; positive degrees are upstream. The zero tilt (bottom) is near the surface; negative values are tilting toward the river bottom.



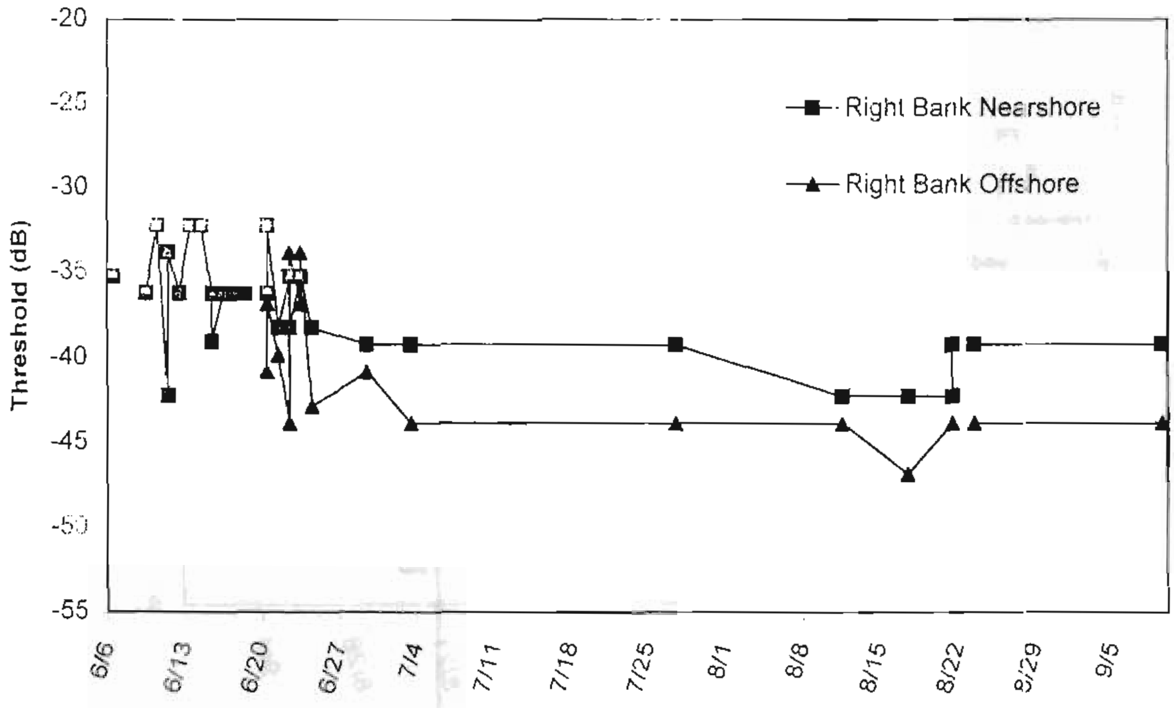
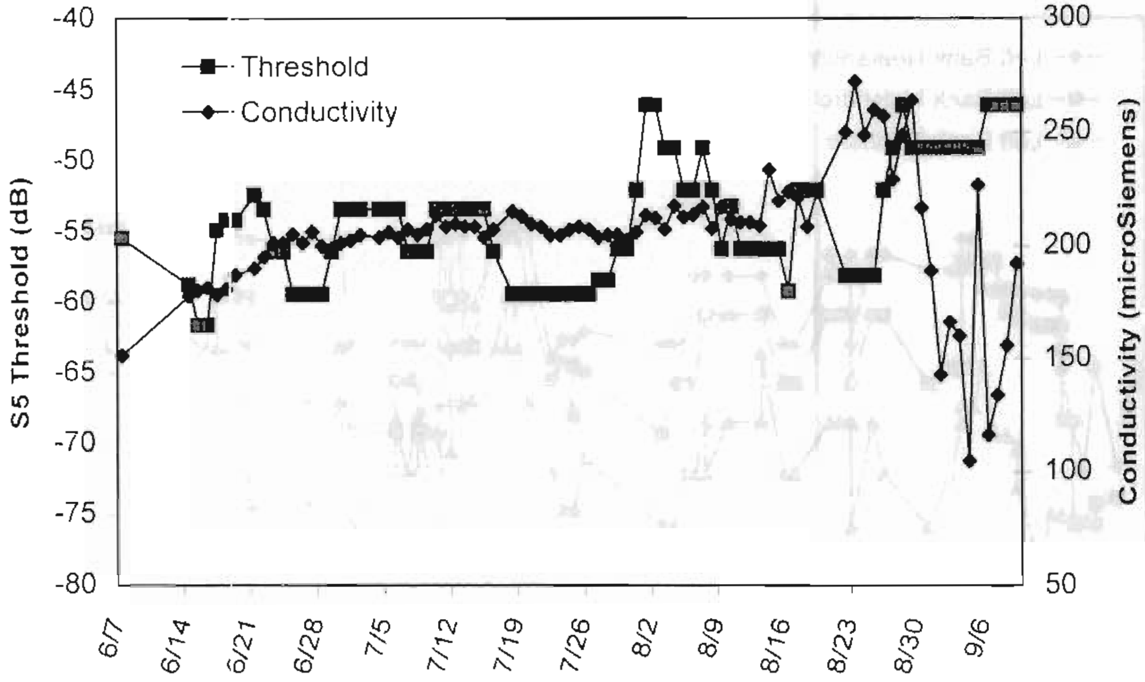


Figure 29. Threshold levels for left bank strata (top) and right bank strata (bottom), Yukon River sonar, 1998.



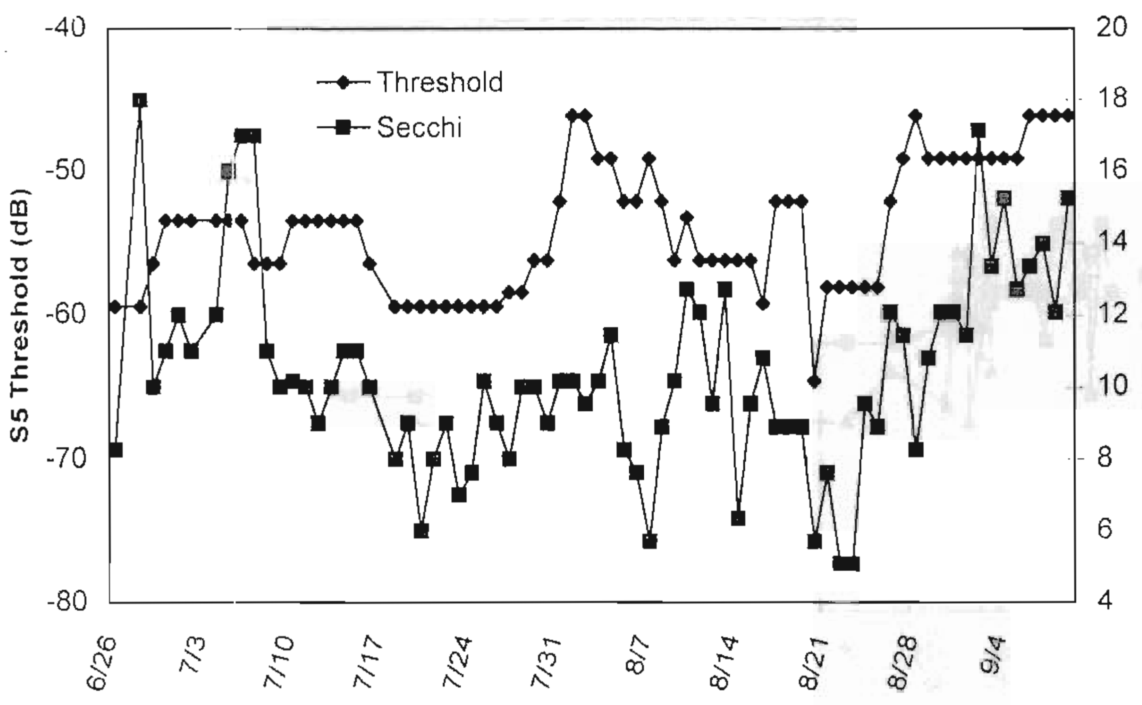


Figure 30. Left bank outermost zone threshold (S5) plotted against conductivity (top) and secchi disk values (bottom), Yukon River sonar 1998.

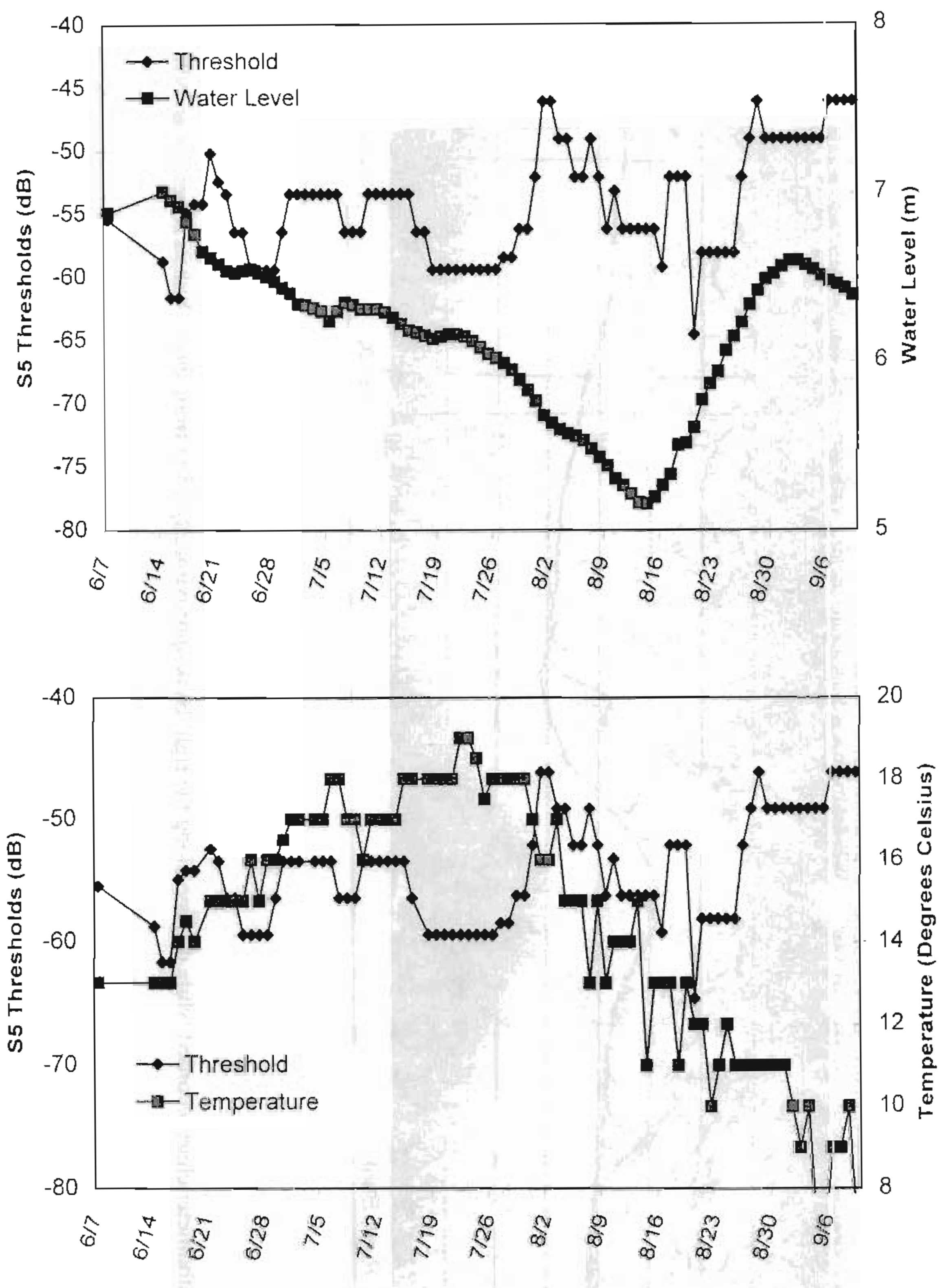


Figure 31. Left bank outermost zone threshold (S5) plotted against water level (top) and water temperature (bottom), Yukon River sonar 1998.

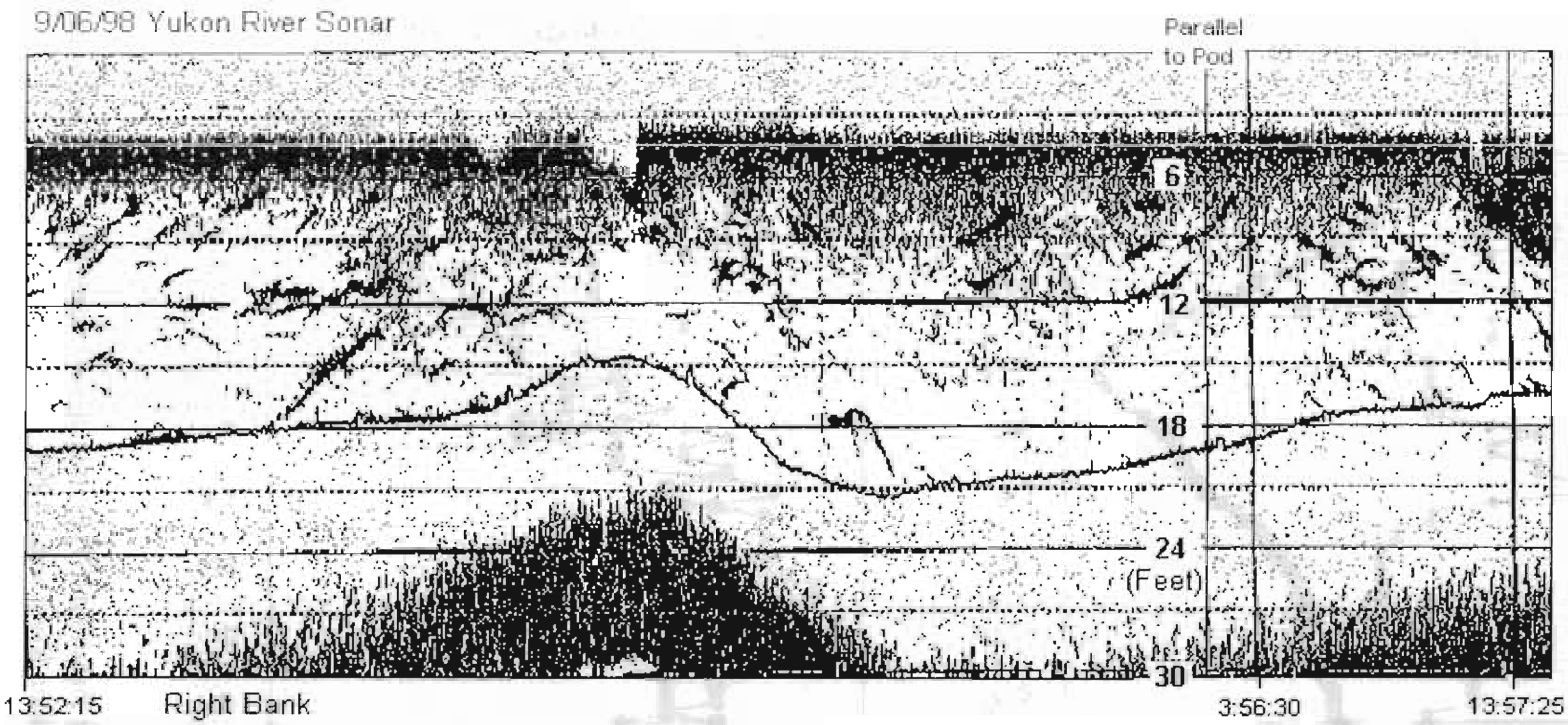


Figure 32. Fathometer chart recorded while drifting along the right bank approximately 15 m from shore, Yukon River Sonar 1998.

APPENDICES

Appendix A. Yukon River sonar threshold levels and sonar parameters for the left bank.

Calibration Data

		Source Level					Gain		System
		-13	-10	-6	-3	0	NB G1	WB G1	
transducer	4	211.7	214.7	218.7	221.6	224.7	-169	-168	LBNS pod
transducer	5	211.7	214.5	218.6	221.3	224.6	-169	-169	LBOS pod
ES 102	4					222.4	-169	-168	
ES 102	5					222.4	-169	-168	LBOS pod

Note: ES 102; xducer 004 is uncalibrated; calibration data estimated by using ES output data; ES 102 4.15 dB larger than ES 101

Date	Period	S3 Tx	Gr	Bm	alpha	S4 Tx	Gr	Bm	alpha	S5 Tx	Gr	Bm	alpha	thres Volts	Threshold S3 (dB)	S4 (dB)	S5 (dB)	Max rge (m)	S3B Tx	Gr	Bm	thres (dB)	Comments
6/6/1998	3	-10	-6	NB	6	-13	-6	NB	6					0.3	-51.3	-50.4		250					xducer 4
6/7/1998	2					-10	-6	NB	6					0.3		-52.7		300					xducer 5 LBOS: 50-250 m only
6/7/1998	3	-10	-6	NB	6	-10	-6	NB	6	-6	-6	NB	6	0.3	-51.6	-53.4	-55.5	300					xducer 4 & 5
6/8/1998	2													0.3									
6/8/1998	3	0	-12	WB	6	0	-12	WB	6					0.3	-56.0	-57.8		250					xducer 4 only; xducer 5 cables popped.
6/10/1998	2	-6	-12	WB	6	0	-12	WB	6					0.3	-50.0	-58.2		280					
6/10/1998	3	-6	-12	WB	8	0	-12	WB	8					0.3	-50.4	-59.3		280					
6/11/1998	2	0	-12	WB	8	0	-12	WB	8					0.3	-56.4	-59.3		280					
6/12/1998	2	-3	-12	WB	8	0	-12	WB	8					0.3	-53.4	-59.3		280					
6/12/1998	3	-3	-12	WB	8	-6	-12	WB	8					0.3	-53.4	-53.3		280					
6/13/1998	1	-6	-12	WB	8	-6	-12	WB	8					0.3	-50.4	-53.3		280					
6/13/1998	2	-10	-12	WB	8	-10	-12	WB	8					0.3	-46.4	-49.3		280					xducer 5 pod cables broken.
6/13/1998	3	-10	-12	WB	6	-10	-12	WB	6	0	-12	NB	6	0.3	-46.0	-47.8	-58.7	360					All strata on xducer 4 (LBNS)
6/14/1998	1	-10	-12	WB	6	-10	-12	WB	6					0.3	-46.0	-47.8		250					no S5 sample
6/14/1998	2	-10	-12	WB	6	-10	-12	WB	6	0	-12	NB	6	0.3	-46.0	-47.8	-58.7	360					
6/15/1998	3	-10	-12	WB	6	-10	-12	WB	6	0	-12	NB	10	0.3	-46.0	-47.8	-61.6	360					
6/17/1998	2	-10	-12	WB	6	-10	-12	WB	6	-3	-12	NB	8	0.3	-45.8	-47.5	-57.2	360					
6/17/1998	3	-10	-12	WB	6	-10	-12	NB	6	-6	-12	NB	9	0.3	-45.8	-47.1	-54.9	360					Changed S4 to NB
6/18/1998	1	-10	-12	WB	6	-10	-12	NB	6	-6	-12	NB	8	0.3	-45.8	-47.1	-54.2	360					
6/19/1998	3	-10	-12	WB	6	-13	-12	NB	6	-6	-12	NB	8	0.3	-45.8	-44.1	-54.2	360					
6/20/1998	1	-10	-12	WB	6	-13	-12	NB	6	-10	-12	NB	8	0.3	-45.8	-44.1	-50.2	360					
6/21/1998	3	-13	-12	WB	6	-13	-12	NB	6	-6	-12	NB	8	0.3	-42.8	-44.1	-52.4	250					Ran xducer 4 & 5 alternating nearshore
6/22/1998	1	-13	-12	WB	6	-13	-12	NB	6	-6	-12	NB	8	0.3	-42.8	-44.1	-52.4	250					Ran xducer 4 & 5 alternating
6/22/1998	2	-10	-12	WB	6	-6	-12	NB	6	-6	-12	NB	8	0.3	-44.6	-50.3	-53.4	360					xducer 5 (ES 101-039) redeployed nearshore
6/23/1994	1	-6	-12	WB	6	-3	-12	NB	6	0	-12	NB	8	0.3	-48.6	-53.3	-59.4	360					
6/23/1998	2	-10	-12	WB	6	-6	-12	NB	6	-3	-12	NB	8	0.3	-44.6	-50.3	-56.4	360					
6/23/1998	0	-10	-12	WB	6	-6	-12	NB	6	-3	-12	NB	8	0.3	-44.6	-50.3	-56.4	360					overnight sampling both transducers, 102 ES
6/25/1998	2	-10	-12	WB	6	-6	-12	NB	8	0	-12	NB	8	0.3	-44.6	-51.2	-59.4	360					
6/29/1998	2	-10	-12	WB	0	-10	-12	NB	8	-3	-12	NB	8	0.3	-43.7	-47.2	-56.4	360					
6/30/1998	3	-10	-12	WB	0	-10	-12	NB	8	-6	-12	NB	8	0.3	-43.7	-47.2	-53.4	360					
7/2/1998	0	-6	-12	WB	8	-6	-12	NB	8	0	-12	NB	8	0.3	-48.9	-51.2	-59.4	360					increased power due to faulty ribbon.
7/2/1998	2	-10	-12	WB	0	-10	-12	NB	8	-6	-12	NB	8	0.3	-43.7	-47.2	-53.4	360					
7/3/1998	2	-10	-12	WB	8	-10	-12	NB	8	-6	-12	NB	8	0.3	-44.9	-47.2	-53.4	360					
7/4/1998	2	-10	-12	WB	0	-10	-12	NB	8	-6	-12	NB	8	0.3	-43.7	-47.2	-53.4	360					
7/4/1998	3	-10	-12	WB	8	-10	-12	NB	8	-6	-12	NB	8	0.3	-44.9	-47.2	-53.4	360					
7/7/1998	2	-6	-12	WB	8	-6	-12	NB	8	-3	-12	NB	8	0.3	-48.9	-51.2	-56.4	360					
7/8/1998	2	-6	-12	NB	8	-6	-12	NB	8	-3	-12	NB	8	0.3	-48.9	-51.2	-56.4	360					
7/10/1998	2	-10	-12	NB	8	-10	-12	NB	8	-10	-12	NB	8	0.3	-44.9	-47.2	-49.4	360					
7/10/1998	3	-10	-12	NB	8	-10	-12	NB	8	-6	-12	NB	8	0.3	-44.9	-47.2	-53.4	360					
7/13/1998	2	-10	-12	WB	8	-10	-12	NB	8	-6	-12	NB	8	0.3	-44.9	-47.2	-53.4	360					
7/15/1998	1	-10	-12	WB	8	-10	-12	NB	8	-3	-12	NB	8	0.3	-44.9	-47.2	-56.4	360					
7/15/1998	2	-10	-12	WB	8	-10	-12	NB	8	-6	-12	NB	8	0.3	-44.9	-47.2	-53.4	360					
7/16/1998	1	-10	-12	WB	8	-6	-12	NB	8	-3	-12	NB	8	0.3	-44.9	-51.2	-56.4	360					
7/17/1998	3	-6	-12	WB	8	-6	-12	NB	8	-3	-12	NB	8	0.3	-48.9	-51.2	-56.4	360					
7/18/1998	3	-6	-12	WB	8	-6	-12	NB	8	0	-12	NB	8	0.3	-48.9	-51.2	-59.4	360					

-Continued-

Appenc ge 2 of 2.

Calibration Data

		Source Level					Gain		System
		-13	-10	-6	-3	0	NB G1	WB G1	
transducer	4	211.7	214.7	218.7	221.6	224.7	-169	-168	LBNS pod
transducer	5	211.7	214.5	218.6	221.32	224.59	-169	-169	LBOS pod
ES 102	4					222.37	-169	-168	
ES 102	5					222.37	-169	-168	LBOS pod

Note: ES 102; xducer 004 is uncalibrated; calibration data estimated by using ES output data; ES 102 4.15 dB larger than ES101

Date	Period	S3 Tx	Gr	Bm	alpha	S4 Tx	Gr	Bm	alpha	S5 Tx	Gr	Bm	alpha	thres Volts	Threshold S3 (dB)	S4 (dB)	S5 (dB)	Max rge (m)	S3B Tx	Gr	Bm	thres (dB)	Comments
7/19/1998	2	-6	-12	WB	8	-3	-12	NB	8	0	-12	NB	8	0.3	-48.9	-54.2	-59.4	360					
7/26/1998	2	-6	-12	WB	8	-6	-12	WB	8	-3	-12	NB	8	0.3	-48.1	-50.5	-55.5	300					*S3 0-30 (low aim); S4 30-180; S5 180-300 (LF)
7/27/1998	2	-6	-12	WB	8	-6	-12	NB	8	0	-12	NB	8	0.3	-48.6	-50.1	-58.5	300					Readjusted settings S3 back to slightly higher aim.
7/27/1998	3	-6	-12	WB	8	-3	-12	NB	8	0	-12	NB	8	0.3	-48.6	-53.1	-58.5	300					
7/28/1998	2	-6	-12	WB	8	-6	-12	NB	8	0	-12	NB	8	0.3	-48.6	-50.1	-58.5	300					
7/29/1998	2	-6	-12	WB	8	-6	-12	NB	8	-3	-12	NB	8	0.3	-49.6	-51.0	-56.2	300					sampling with xducer 4
7/31/1998	2	-10	-12	WB	0	-6	-12	NB	0	0	-12	NB	0	0.3	-42.8	-46.1	-52.1	300	-10	-12	WB	-42.8	ES 102, xducer 004; uncalibrated, calib estimated
8/1/1998	2	-10	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-42.8	-42.1	-49.1	301	-10	-12	WB	-42.8	
8/1/1998	3	-10	-12	WB	0	-10	-12	NB	0	-6	-12	NB	0	0.3	-42.8	-42.1	-46.1	302	-10	-12	WB	-42.8	
8/2/1998	1	-10	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-42.8	-42.1	-49.1	303	-10	-12	WB	-42.8	
8/2/1998	2	-10	-12	WB	0	-10	-12	NB	0	-6	-12	NB	0	0.3	-42.8	-42.1	-46.1	304	-10	-12	WB	-42.8	
8/3/1998	2	-10	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-42.8	-42.1	-49.1	305	-10	-12	WB	-42.8	
8/5/1998	3	-6	-12	WB	0	-3	-12	NB	0	0	-12	NB	0	0.3	-46.8	-49.1	-52.1	306	-10	-12	WB	-42.8	Wave Action signal loss
8/6/1998	1	-6	-12	WB	0	-6	-12	NB	0	0	-12	NB	0	0.3	-46.8	-46.1	-52.1	307	-10	-12	WB	-42.8	
8/6/1998	2	0	-12	WB	0									0.3	-52.8			308					Wave Action signal loss; entered S3 only; Stopped multiplexing
8/6/1998	3	-10	-12	WB	0	-3	-12	NB	0	0	-12	NB	0	0.3	-42.8	-49.1	-52.1	309					No multiplex because LBOS pod used with HTI system
8/7/1998	1	-6	-12	WB	0	-3	-12	NB	0	0	-12	NB	0	0.3	-46.8	-49.1	-52.1	310					
8/7/1998	2	-10	-12	WB	0	-3	-12	NB	0	-3	-6	NB	0	0.3	-42.8	-49.1	-55.1	311					
8/7/1998	3	-6	-12	WB	0	-3	-12	NB	0	-3	-12	NB	0	0.3	-46.8	-49.1	-49.1	312					
8/8/1998	1	-10	-12	WB	0	-6	-12	NB	0	0	-12	NB	0	0.3	-42.8	-46.1	-52.1	313					
8/8/1998	**2**	**-6**	**-12**	**WB**	**0**	**-3**	**-12**	**NB**	**8**	**-3**	**-12**	**NB**	**8**	**0.3**	**-48.8**	**-54.0**	**-56.2**	**300**					Back to ES 101 xducer 004; a calibrated system
8/8/1998	3	-6	-12	WB	0	-3	-12	NB	8	0	-12	NB	8	0.3	-48.8	-54.0	-59.2	300					
8/9/1998	1	-6	-12	WB	0	-3	-12	NB	8	-3	-12	NB	8	0.3	-48.8	-54.0	-56.2	300					
8/10/1998	1	-6	-12	WB	0	-6	-12	NB	8	-6	-12	NB	8	0.3	-48.8	-51.0	-53.2	300					
8/10/1998	0	-6	-12	WB	0	-3	-12	NB	8	-3	-12	NB	8	0.3	-48.8	-54.0	-56.2	300					
8/10/1998	2	-6	-12	WB	0	-3	-12	NB	8	-3	-12	NB	8	0.3	-48.8	-54.0	-56.2	300					
8/10/1998	3	-6	-12	WB	0	-6	-12	NB	8	-6	-12	NB	8	0.3	-48.8	-51.0	-53.2	300					
8/11/1998	2	-6	-12	WB	0	-6	-12	NB	8	-3	-12	NB	8	0.3	-48.8	-51.0	-56.2	300					
8/12/1998	1	-6	-12	WB	0	-6	-12	NB	8	-6	-12	NB	8	0.3	-48.8	-51.0	-53.2	300					
8/12/1998	2	-6	-12	WB	0	-3	-12	NB	8	-3	-12	NB	8	0.3	-48.8	-54.0	-56.2	300					
8/16/1998	2	-6	-12	WB	0	-3	-12	NB	8	0	-12	NB	8	0.3	-48.8	-54.0	-59.2	300					
8/17/1998	**2**	**-10**	**-12**	**WB**	**0**	**-3**	**-12**	**NB**	**0**	**0**	**-12**	**NB**	**0**	**0.3**	**-42.8**	**-49.1**	**-52.1**	**300**	**-10**	**-12**	**WB**	**-42.8**	ES 102, xducer 004; uncalibrated; calib estimated; Multiplexing
8/20/1998	2	-10	-12	WB	0	-6	-6	NB	0	0	-6	NB	0	0.3	-42.8	-52.1	-58.1	300	-10	-12	WB	-42.8	
8/21/1998	3	-10	-12	WB	0	-3	-12	NB	0	0	-6	NB	0	0.3	-42.8	-49.1	-58.1	300	-10	-12	WB	-42.8	
8/25/1998	2	-10	-12	WB	0	-6	-12	NB	0	-3	-6	NB	0	0.3	-42.8	-46.1	-55.1	300	-10	-12	WB	-42.8	
8/25/1998	3	-10	-12	WB	0	-3	-12	NB	0	0	-6	NB	0	0.3	-42.8	-49.1	-58.1	300	-10	-12	WB	-42.8	
8/26/1998	1	-10	-12	WB	0	-3	-12	NB	0	0	-12	NB	0	0.3	-42.8	-49.1	-52.1	300	-10	-12	WB	-42.8	
8/26/1998	2	-10	-12	WB	0	-6	-12	NB	0	0	-12	NB	0	0.3	-42.8	-46.1	-52.1	300	-10	-12	WB	-42.8	
8/27/1998	2	-13	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-39.8	-42.1	-49.1	300	-13	-12	WB	-39.8	
8/27/1998	3	-13	-12	WB	0	-6	-12	NB	0	-3	-12	NB	0	0.3	-39.8	-46.1	-49.1	300	-13	-12	WB	-39.8	
8/28/1998	1	-13	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-39.8	-42.1	-49.1	300	-13	-12	WB	-39.8	
8/28/1998	2	-13	-12	WB	0	-10	-12	NB	0	-6	-12	NB	0	0.3	-39.8	-42.1	-46.1	300	-13	-12	WB	-39.8	
8/29/1998	2	-13	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-39.8	-42.1	-49.1	300	-13	-12	WB	-39.8	
9/6/1998	3	-13	-12	WB	0	-10	-12	NB	0	-6	-12	NB	0	0.3	-39.8	-42.1	-46.1	300	-13	-12	WB	-39.8	
9/7/1998	1	-13	-12	WB	0	-10	-12	NB	0	-3	-12	NB	0	0.3	-39.8	-42.1	-49.1	300	-13	-12	WB	-39.8	
9/7/1998	2	-13	-12	WB	0	-10	-12	NB	0	-6	-12	NB	0	0.3	-39.8	-42.1	-46.1	300	-13	-12	WB	-39.8	
9/9/1998	3	-13	-12	WB	0	-10	-12	NB	0	-6	-12	NB	0	0.3	-39.8	-42.1	-46.1	300	-13	-12	WB	-39.8	Last sample period

Appendix B. Yukon River sonar threshold levels and sonar parameters for the right bank.

Calibration Data

Echosounder 101-83-036 Case II

		-13	-10	-6	-3	0
transducer	3	207.3	210.44	214.23	217.39	220.32
Sensitivity	WB	-176.57		NB		-171.96

Date	Per.	S0 Tx	S0 Gr	S0 Bm	S1 Tx	S1 Gr	S1 Bm	S2 Tx	S2 Gr	S2 Bm	thres Volts	Threshold S0 (dB)	Threshold S1 (dB)	Threshold S2 (dB)	Max rge (m)	Comments
6/6/1998	1				-13	-6	WB				0.3		-35.2		150	thres 0.3;0.5;0.7;1.3
6/7/1998	2															no signal
6/7/1998	3															marginal, but usable signal
6/8/1998	1															redeployed pod, no data
6/8/1998	2															pod not functional, heavy debris
6/8/1998	3															no data
6/9/1998	1															no data
6/9/1998	2															no data
6/9/1998	3				-6	-12	WB				0.3		-36.2		150	Signal returned
6/10/1998	3				-10	-12	WB				0.3		-32.2		150	
6/11/1998	2				0	-12	WB				0.3		-42.2		150	Wave action; periodic fading of signal
6/11/1998	3				-10	-12	WB				0.25		-33.8		150	Wave action; changed grey 1 to 0.25
6/12/1998	2				-6	-12	WB				0.3		-36.2		150	thres back to 0.3; 0.5; 0.7; 1.3
6/13/1998	2				-10	-12	WB				0.3		-32.2		150	
6/14/1998	1				-10	-12	WB				0.3		-32.2		150	
6/15/1998	2				-6	-12	WB				0.3		-36.2		150	
6/15/1998	3				-6	-12	WB				0.217		-39.0		150	thres 0.217;0.343;0.544;0.862
6/16/1998	1				-6	-12	WB				0.3		-36.2		150	thres 0.3; 0.5; 0.7; 0.9
6/17/1998	3				-6	-12	WB				0.3		-36.2		150	Changed 4th grey to 1.0 V
6/18/1998	2															Wave Action; no data
6/18/1998	3				-6	-12	WB				0.3		-36.2		150	Signal returns
6/19/1998	2															No data; poor aim
6/19/1998	3															No data; poor aim
6/20/1998	1															No data; poor aim
6/20/1998	2				-6	-12	WB	-6	-12	NB	0.3		-36.2	-40.8	250	Extended range, added a second strata
6/20/1998	3				-10	-12	WB	-10	-12	NB	0.3		-32.2	-36.8	250	
6/21/1998	2				-10	-6	WB	-13	-6	NB	0.3		-38.2	-39.8	250	
6/22/1998	2				-13	-6	WB	-3	-12	NB	0.3		-35.2	-43.8	250	
6/22/1998	3				-10	-6	WB	-13	-12	NB	0.3		-38.2	-33.8	250	
6/23/1998	2				-13	-6	WB	-10	-12	NB	0.3		-35.2	-36.8	250	
6/23/1998	3				-13	-6	WB	-13	-12	NB	0.3		-35.2	-33.8	250	
6/24/1998	2				-10	-6	WB	-10	-6	NB	0.3		-38.2	-42.8	150	Reduced range
6/29/1998	3				-3	-12	WB	-6	-12	NB	0.3		-39.2	-40.8	150	
7/3/1998	2				-3	-12	WB	-3	-12	NB	0.3		-39.2	-43.8	150	
7/27/1998	3	-3	-12	WB	-3	-12	WB	-3	-12	NB	0.3	-39.2	-39.2	-43.8	150	Divided range into 3, 50 m strata
8/11/1998	2	0	-12	WB	0	-12	WB	-3	-12	NB	0.3	-42.2	-42.2	-43.8	150	
8/17/1998	1	0	-12	WB	0	-12	WB	0	-12	NB	0.3	-42.2	-42.2	-46.8	150	
8/21/1998	1	0	-12	WB	0	-12	WB	-3	-12	NB	0.3	-42.2	-42.2	-43.8	150	
8/21/1998	2	-3	-12	WB	-3	-12	WB	-3	-12	NB	0.3	-39.2	-39.2	-43.8	150	
8/23/1998	1			WB			WB			NB						Wave action; no signal
8/23/1998	2	-3	-12	WB	-3	-12	WB	-3	-12	NB	0.3	-39.2	-39.2	-43.8	150	
9/9/1998	3	-3	-12	WB	-3	-12	WB	-3	-12	NB	0.3	-39.2	-39.2	-43.8	150	Last sampling period
Average												-40.5	-37.2	-41.3		
Maximum												-39.2	-32.2	-33.8		
Minimum												-42.2	-42.2	-46.8		

Appendix C. Yukon River sonar hourly passage rate by stratum, 1998.

Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
1	6/6/1998	1	13.9	.	.	.
1	6/6/1998	2	6.7	.	.	.
1	6/6/1998	3	24.4	39.1	18.6	.
1	6/7/1998	1	14.1	86.9	29.0	.
1	6/7/1998	2	.	.	24.0	.
1	6/7/1998	3	10.0	22.5	4.2	2.2
1	6/8/1998	1	*34.3	55.0	23.2	0.0
1	6/8/1998	2	*46.3	.	.	.
1	6/8/1998	3	*58.3	38.6	10.3	.
2	6/9/1998	1	.	44.7	9.7	.
2	6/9/1998	2	.	85.2	37.4	.
2	6/9/1998	3	69.4	32.5	10.5	.
2	6/10/1998	1	54.6	74.3	21.2	.
2	6/10/1998	2	86.3	21.2	11.6	.
2	6/10/1998	3	65.1	32.2	10.5	.
3	6/11/1998	1	69.3	34.7	19.3	.
3	6/11/1998	2	56.3	26.4	8.1	.
3	6/11/1998	3	61.1	40.5	18.1	.
4	6/12/1998	1	30.9	33.3	4.9	.
4	6/12/1998	2	36.7	73.0	20.0	.
4	6/12/1998	3	63.1	72.3	13.8	.
5	6/13/1998	1	53.6	99.8	35.9	.
5	6/13/1998	2	79.6	60.8	11.5	.
5	6/13/1998	3	46.0	57.5	11.4	9.2
6	6/14/1998	1	64.3	167.6	46.3	.
6	6/14/1998	2	90.0	84.9	12.9	0.0
6	6/14/1998	3	116.3	89.0	18.9	6.2
7	6/15/1998	1	89.0	166.9	60.0	37.6
7	6/15/1998	2	73.3	76.1	18.6	1.1
7	6/15/1998	3	139.6	118.9	47.8	4.1
8	6/16/1998	1	95.5	83.0	27.5	9.6
8	6/16/1998	2	105.8	111.4	29.5	13.9
8	6/16/1998	3	95.1	104.5	24.8	5.3
9	6/17/1998	1	74.5	70.5	18.2	0.0
9	6/17/1998	2	75.8	70.3	18.6	14.7
9	6/17/1998	3	65.0	49.5	27.9	2.2
10	6/18/1998	1	48.7	63.8	33.7	.
10	6/18/1998	2	45.7	90.5	32.7	2.1
10	6/18/1998	3	73.7	85.4	27.9	1.1
10	6/19/1998	1	32.0	110.0	53.1	7.5

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* Data was estimated from left bank data.

Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
10	6/19/1998	2	.	143.2	22.8	0.0
10	6/19/1998	3	.	211.2	56.8	4.3
11	6/20/1998	1	.	119.2	29.5	1.1
11	6/20/1998	2	47.0	92.5	33.1	4.2
11	6/20/1998	3	51.3	214.6	49.5	0.0
12	6/21/1998	1	27.3	191.1	48.8	4.0
12	6/21/1998	2	54.7	182.0	31.1	1.1
12	6/21/1998	3	219.0	497.5	152.5	0.0
13	6/22/1998	1	221.9	558.5	152.9	6.5
13	6/22/1998	2	212.5	789.5	192.0	10.7
13	6/22/1998	3	449.6	1292.9	605.3	14.5
14	6/23/1998	1	211.1	1016.9	292.8	16.1
14	6/23/1998	2	198.4	543.1	201.1	10.3
14	6/23/1998	3	116.0	560.7	204.0	8.8
15	6/24/1998	1	224.0	574.7	163.9	5.9
15	6/24/1998	2	616.6	1489.8	294.8	26.9
15	6/24/1998	3	1224.3	2059.6	522.4	18.0
15	6/25/1998	1	611.2	2589.6	417.1	27.1
15	6/25/1998	2	920.1	2009.4	455.1	22.8
15	6/25/1998	3	879.7	2160.0	311.6	9.8
16	6/26/1998	1	656.1	1144.6	204.8	10.2
16	6/26/1998	2	451.1	1205.6	397.5	29.0
16	6/26/1998	3	495.1	581.8	509.0	51.9
17	6/27/1998	1	259.4	672.0	360.0	19.3
17	6/27/1998	2	198.6	518.6	296.9	14.5
17	6/27/1998	3	269.1	569.5	190.5	14.5
18	6/28/1998	1	362.3	318.0	79.6	20.7
18	6/28/1998	2	234.5	385.3	87.7	1.0
18	6/28/1998	3	273.6	327.4	94.7	3.5
19	6/29/1998	1	175.0	236.7	46.6	11.4
19	6/29/1998	2	467.8	623.8	81.8	4.4
19	6/29/1998	3	1311.9	1552.5	247.8	18.6
20	6/30/1998	1	985.1	2000.3	203.8	29.5
20	6/30/1998	2	995.0	2301.7	315.8	24.2
20	6/30/1998	3	1698.5	2201.4	461.5	15.0
21	7/1/1998	1	1337.4	1418.4	266.3	88.6
21	7/1/1998	2	1213.6	1780.3	546.2	23.7
21	7/1/1998	3	1550.0	1574.1	380.0	9.1
22	7/2/1998	1	1064.2	1785.0	376.6	37.2
22	7/2/1998	2	1609.5	1504.4	415.2	18.3
22	7/2/1998	3	1387.0	1061.9	643.3	39.9

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Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
23	7/3/1998	1	813.7	1113.2	376.3	8.6
23	7/3/1998	2	799.4	1452.2	247.9	8.6
23	7/3/1998	3	628.8	1018.9	340.0	11.4
24	7/4/1998	1	479.3	553.3	244.1	15.8
24	7/4/1998	2	388.9	578.6	161.2	21.8
24	7/4/1998	3	630.7	463.7	176.9	3.1
25	7/5/1998	1	517.8	502.5	111.6	7.2
25	7/5/1998	2	455.7	502.4	80.7	0.0
25	7/5/1998	3	436.2	417.9	86.9	5.2
26	7/6/1998	1	362.9	367.2	76.6	8.8
26	7/6/1998	2	218.8	289.5	114.9	1.1
26	7/6/1998	3	221.7	216.6	100.3	12.0
26	7/7/1998	1	202.8	160.4	49.7	5.1
26	7/7/1998	2	179.7	141.1	68.3	4.1
26	7/7/1998	3	314.5	174.6	65.2	3.2
27	7/8/1998	1	427.8	274.6	91.4	6.8
27	7/8/1998	2	664.9	430.2	121.0	4.1
27	7/8/1998	3	835.5	439.3	285.5	23.2
28	7/9/1998	1	779.2	907.8	310.3	7.4
28	7/9/1998	2	1096.1	827.6	298.9	37.2
28	7/9/1998	3	931.0	857.3	377.5	31.0
29	7/10/1998	1	673.2	750.5	372.2	47.8
29	7/10/1998	2	749.9	589.8	234.6	8.2
29	7/10/1998	3	1038.1	557.3	263.8	18.9
30	7/11/1998	1	1119.7	432.0	144.8	11.3
30	7/11/1998	2	842.2	578.0	176.9	0.0
30	7/11/1998	3	859.0	491.3	160.0	7.1
31	7/12/1998	1	725.2	381.4	121.0	8.1
31	7/12/1998	2	666.0	430.2	157.9	5.2
31	7/12/1998	3	370.7	502.4	104.5	8.3
32	7/13/1998	1	201.7	343.4	61.1	3.2
32	7/13/1998	2	235.2	337.4	74.5	11.4
32	7/13/1998	3	198.9	240.0	64.1	4.1
33	7/14/1998	1	160.7	188.0	62.1	2 0
33	7/14/1998	2	144.2	211.5	33.2	0.0
33	7/14/1998	3	155.8	259.7	37.9	5.4
33	7/15/1998	1	168.8	271.0	53.1	1.1
33	7/15/1998	2	151.9	156.2	156.2	5.2
33	7/15/1998	3	148.0	267.9	60.0	3.1
33	7/16/1998	1	137.4	201.0	38.0	12.6
33	7/16/1998	2	112.6	143.2	48.6	3.2

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Appendix C. Page 4 of 8.

Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
33	7/16/1998	3	105.4	116.8	35.6	3.2
33	7/17/1998	1	85.7	98.9	24.6	0.0
33	7/17/1998	2	79.3	143.4	26.4	2.1
33	7/17/1998	3	85.3	132.2	30.5	3.1
33	7/18/1998	1	80.6	144.8	45.5	4.3
33	7/18/1998	2	55.0	96.6	26.9	7.2
33	7/18/1998	3	71.1	125.2	42.9	3.2
34	7/19/1998	1	80.4	63.1	25.3	3.1
34	7/19/1998	2	104.5	82.9	18.2	0.0
34	7/19/1998	3	119.0	58.0	15.5	0.0
34	7/20/1998	1	73.0	63.4	30.7	4.7
34	7/20/1998	2	48.4	87.5	26.9	0.0
34	7/20/1998	3	70.8	55.9	15.8	0.0
34	7/21/1998	1	88.0	108.0	29.0	5.0
34	7/21/1998	2	75.6	70.3	31.0	0.0
34	7/21/1998	3	79.1	83.4	34.1	0.0
35	7/22/1998	1	135.5	89.0	30.0	2.1
35	7/22/1998	2	113.3	142.4	31.6	0.0
35	7/22/1998	3	148.1	166.8	39.3	1.0
35	7/23/1998	1	104.6	193.0	46.0	4.0
35	7/23/1998	2	135.2	232.1	37.9	0.0
35	7/23/1998	3	165.0	228.8	52.8	2.1
35	7/24/1998	1	169.6	174.0	27.9	1.1
35	7/24/1998	2	156.1	208.5	29.5	5.2
35	7/24/1998	3	183.5	197.9	50.8	1.1
36	7/25/1998	1	161.9	119.0	24.8	3.1
36	7/25/1998	2	133.0	172.9	26.9	3.1
36	7/25/1998	3	109.9	106.8	23.0	0.0
36	7/26/1998	1	89.3	37.6	30.0	0.0
36	7/26/1998	2	83.6	202.4	53.8	5.3
36	7/26/1998	3	94.4	255.3	62.1	1.1
36	7/27/1998	1	95.6	154.1	124.1	14.4
36	7/27/1998	2	101.7	134.2	68.3	6.2
36	7/27/1998	3	119.5	204.4	76.6	7.4
37	7/28/1998	1	70.6	199.2	62.1	12.4
37	7/28/1998	2	80.7	165.5	118.9	18.6
37	7/28/1998	3	105.7	196.3	110.7	14.5
37	7/29/1998	1	104.0	135.0	66.1	13.4
37	7/29/1998	2	85.4	144.4	107.6	15.5
37	7/29/1998	3	109.6	132.2	92.1	18.6
38	7/30/1998	1	85.9	84.4	51.7	2.1

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Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
38	7/30/1998	2	121.8	83.4	48.4	5.4
38	7/30/1998	3	105.7	85.9	69.1	10.3
38	7/31/1998	1	73.4	111.0	29.4	9.5
38	7/31/1998	2	62.6	213.3	44.1	18.2
38	7/31/1998	3	55.6	148.8	66.3	21.9
38	8/1/1998	1	93.7	195.0	24.7	11.4
38	8/1/1998	2	91.5	180.0	48.6	21.4
38	8/1/1998	3	87.5	261.6	87.9	6.3
39	8/2/1998	1	103.1	168.0	164.4	10.7
39	8/2/1998	2	115.3	198.1	126.3	16.8
39	8/2/1998	3	171.3	200.0	122.3	19.6
39	8/3/1998	1	149.4	234.8	161.7	12.9
39	8/3/1998	2	136.5	194.7	124.8	23.2
39	8/3/1998	3	101.1	174.7	153.7	28.6
39	8/4/1998	1	113.0	189.6	91.5	12.9
39	8/4/1998	2	102.3	215.5	116.3	16.1
39	8/4/1998	3	96.6	215.6	106.9	21.4
40	8/5/1998	1	154.5	197.1	112.2	12.6
40	8/5/1998	2	149.4	254.4	141.1	38.5
40	8/5/1998	3	125.5	168.0	138.8	14.2
40	8/6/1998	1	113.8	102.9	82.1	9.1
40	8/6/1998	2	119.1	82.0		
40	8/6/1998	3	184.7	99.3	155.8	16.6
41	8/7/1998	1	211.1	197.5	113.6	19.1
41	8/7/1998	2	249.3	149.0	144.4	8.7
41	8/7/1998	3	177.9	193.2	169.7	22.1
41	8/8/1998	1	225.9	108.0	146.8	13.9
41	8/8/1998	2	185.6	163.4	107.8	34.9
41	8/8/1998	3	192.3	168.8	117.9	27.5
42	8/9/1998	1	268.9	240.0	162.0	29.0
42	8/9/1998	2	270.6	253.6	131.6	47.6
42	8/9/1998	3	426.4	387.1	153.2	39.0
42	8/10/1998	1	405.8	396.2	171.7	60.0
42	8/10/1998	2	486.0	321.1	205.9	76.6
42	8/10/1998	3	431.2	313.8	226.1	49.5
42	8/11/1998	1	386.2	394.9	180.0	49.0
42	8/11/1998	2	348.7	282.0	131.4	32.6
42	8/11/1998	3	232.3	250.4	147.4	53.5
43	8/12/1998	1	210.9	228.9	144.0	34.1
43	8/12/1998	2	194.0	160.0	86.8	40.0
43	8/12/1998	3	156.8	103.3	107.6	22.8

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Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
43	8/13/1998	1	175.3	124.2	104.2	33.1
43	8/13/1998	2	161.8	112.4	61.1	33.6
43	8/13/1998	3	113.7	154.4	73.9	21.4
43	8/14/1998	1	162.5	183.3	84.4	26.3
43	8/14/1998	2	113.1	132.2	79.3	29.5
43	8/14/1998	3	132.9	278.9	141.2	29.5
44	8/15/1998	1	217.7	390.6	183.1	26.8
44	8/15/1998	2	245.4	253.4	141.4	35.6
44	8/15/1998	3	145.8	394.1	225.5	39.7
44	8/16/1998	1	245.4	438.9	232.8	55.2
44	8/16/1998	2	227.1	473.7	124.1	70.7
44	8/16/1998	3	435.1	556.7	369.8	55.7
45	8/17/1998	1	469.7	630.0	411.9	82.2
45	8/17/1998	2	482.8	606.1	213.2	60.0
45	8/17/1998	3	530.9	580.4	271.0	66.0
46	8/18/1998	1	256.2	665.9	319.7	30.5
46	8/18/1998	2	355.7	543.1	204.8	46.6
46	8/18/1998	3	224.6	467.1	182.1	22.4
47	8/19/1998	1	164.5	285.9	347.0	69.8
47	8/19/1998	2	179.9	411.7	241.6	22.5
47	8/19/1998	3	213.4	262.5	109.2	25.7
47	8/20/1998	1	211.3	280.6	150.0	26.0
47	8/20/1998	2	212.4	300.0	114.9	40.3
47	8/20/1998	3	318.7	208.4	108.0	34.0
47	8/21/1998	1	253.7	399.6	169.3	40.7
47	8/21/1998	2	231.9	319.0	103.0	31.6
47	8/21/1998	3	261.2	216.4	161.4	19.3
48	8/22/1998	1	240.7	482.3	133.1	35.2
48	8/22/1998	2	196.5	401.8	136.8	24.4
48	8/22/1998	3	190.7	462.7	108.5	21.2
49	8/23/1998	1		585.3	213.7	21.7
49	8/23/1998	2	302.3	661.0	201.6	18.5
49	8/23/1998	3	226.2	905.1	220.7	34.3
50	8/24/1998	1	246.1	826.1	209.5	33.2
50	8/24/1998	2	203.5	849.3	200.7	11.3
50	8/24/1998	3	207.8	557.3	242.4	39.7
51	8/25/1998	1	168.3	603.0	177.9	37.5
51	8/25/1998	2	227.7	425.9	137.9	27.9
51	8/25/1998	3	240.9	379.0	120.0	6.2
51	8/26/1998	1	214.8	275.0	129.3	15.5
51	8/26/1998	2	242.6	307.2	144.8	72.0

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Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
51	8/26/1998	3	217.0	326.9	100.0	20.0
51	8/27/1998	1	262.5	242.1	58.0	31.3
51	8/27/1998	2	237.9	357.4	146.3	21.1
51	8/27/1998	3	191.5	328.3	128.3	28.3
51	8/28/1998	1	132.4	236.4	84.2	18.6
51	8/28/1998	2	197.7	228.6	100.7	13.9
51	8/28/1998	3	173.0	132.4	81.1	11.1
51	8/29/1998	1	140.0	174.4	65.1	8.3
51	8/29/1998	2	149.5	81.4	46.1	6.3
51	8/29/1998	3	129.9	64.4	43.9	11.2
52	8/30/1998	1	106.2	79.3	64.1	10.7
52	8/30/1998	2	94.0	163.3	61.1	
52	8/30/1998	3	115.7	122.1	48.8	5.1
52	8/31/1998	1	91.9	123.0	69.2	8.6
52	8/31/1998	2	107.6			
52	8/31/1998	3	93.8	143.3	47.1	13.7
52	9/1/1998	1	100.8	118.8	50.7	2.1
52	9/1/1998	2	119.7	91.1	50.0	11.6
52	9/1/1998	3	89.7	78.6	45.0	3.2
52	9/2/1998	1	120.5	82.5	52.9	9.3
52	9/2/1998	2	119.4	63.2	28.9	4.2
52	9/2/1998	3	68.5	84.7	48.2	12.6
52	9/3/1998	1	86.8	100.4	46.0	9.2
52	9/3/1998	2	122.9	123.4	42.4	9.3
52	9/3/1998	3	162.6	178.9	60.0	5.2
53	9/4/1998	1	193.9	241.1	73.0	6.4
53	9/4/1998	2	241.1	468.2	94.1	3.1
53	9/4/1998	3	309.6	464.4	136.8	14.7
54	9/5/1998	1	352.5	747.4	182.0	18.0
54	9/5/1998	2	430.9	789.8	266.9	15.5
54	9/5/1998	3	384.6	585.8	229.5	22.8
55	9/6/1998	1	351.3	636.8	204.4	46.2
55	9/6/1998	2	266.0	648.4	171.6	15.0
55	9/6/1998	3	338.1	351.4	201.8	22.8
56	9/7/1998	1	261.7	364.2	150.5	15.0
56	9/7/1998	2	319.4	332.9	181.0	23.2
56	9/7/1998	3	200.5	259.3	107.6	28.4
56	9/8/1998	1	190.1	210.6	88.5	8.6
56	9/8/1998	2	133.7	213.8	90.0	10.3
56	9/8/1998	3	98.9	178.8	96.2	23.8
56	9/9/1998	1	91.7	157.6	79.3	12.2

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Appendix C. Page 8 of 8.

Report Period	Date	Sonar Period	Right Bank	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
56	9/9/1998	2	176.7	135.3	63.9	35.2
56	9/9/1998	3	115.4	136.5	61.1	13.8

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Appendix D. Drift gillnetting catch results by day, Yukon River sonar 1998.

Date	Fishing Time (minutes)	Chinook >700 mm	Chinook <700 mm	Summer Chum	Fall Chum	Coho	Pink	Whitefish Species	Cisco Species	Other Species	Total Catch
6/6/98	172.72	3	0	8	0	0	0	1	2	3	17
6/7/98	164.66	3	0	4	0	0	0	0	0	3	10
6/8/98	107.08	2	1	10	0	0	0	1	0	1	15
6/9/98	164.48	3	1	7	0	0	0	0	0	1	12
6/10/98	161.61	4	1	16	0	0	0	1	1	2	25
6/11/98	162.48	5	4	23	0	0	0	1	1	1	35
6/12/98	163.30	7	4	31	0	0	0	0	0	6	48
6/13/98	159.86	10	3	43	0	0	0	0	0	2	58
6/14/98	164.92	5	4	77	0	0	0	0	2	3	91
6/15/98	145.56	12	5	36	0	0	0	1	1	5	60
6/16/98	170.30	3	3	65	0	0	0	0	0	6	77
6/17/98	171.23	1	3	33	0	0	0	0	1	1	39
6/18/98	170.09	9	3	32	0	0	0	2	0	5	51
6/19/98	153.85	1	5	38	0	0	0	0	2	6	52
6/20/98	178.08	9	3	37	0	0	0	0	1	8	58
6/21/98	177.94	8	3	59	0	0	0	2	2	2	76
6/22/98	153.48	7	5	202	0	0	0	1	1	1	217
6/23/98	163.35	11	9	150	0	0	0	0	1	5	176
6/24/98	65.74	10	2	75	0	0	0	0	1	1	89
6/25/98	145.07	20	12	227	0	0	0	0	1	2	262
6/26/98	104.58	8	3	88	0	0	0	1	1	1	102
6/27/98	141.39	14	12	71	0	0	0	0	3	0	100
6/28/98	154.03	9	4	82	0	0	0	1	3	1	100
6/29/98	140.35	17	3	182	0	0	0	1	6	1	210
6/30/98	141.34	4	3	245	0	0	0	2	3	1	258
7/1/98	113.22	16	11	208	0	0	9	1	4	2	251
7/2/98	99.94	12	6	74	0	0	0	1	0	2	95
7/3/98	137.84	10	11	134	0	0	9	1	5	3	173
7/4/98	154.67	16	3	103	0	0	7	1	0	2	132
7/5/98	156.67	7	10	103	0	0	10	0	1	2	133
7/6/98	154.53	16	6	65	0	0	8	2	5	5	107
7/7/98	175.71	19	2	33	0	0	6	1	1	4	66
7/8/98	152.19	16	3	140	0	0	12	1	1	2	175
7/9/98	153.90	15	7	188	0	0	24	4	1	0	239
7/10/98	155.85	11	3	148	0	0	21	2	5	0	190
7/11/98	138.43	11	4	111	0	0	13	2	4	3	148
7/12/98	149.87	12	3	121	0	0	25	2	0	1	164
7/13/98	156.91	9	4	61	0	0	18	0	4	1	97

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Date	Fishing Time (minutes)	Chinook >700 mm	Chinook <700 mm	Summer Chum	Fall Chum	Coho	Pink	Whitefish Species	Cisco Species	Other Species	Total Catch
7/14/98	169.38	13	5	59	0	0	23	0	1	0	101
7/15/98	164.11	6	1	55	0	0	26	7	1	2	98
7/16/98	162.37	4	1	43	0	0	50	8	4	1	111
7/17/98	164.54	3	0	35	0	0	25	10	1	0	74
7/18/98	163.52	6	1	23	0	0	29	9	2	3	73
7/19/98	172.83	4	0	0	18	1	40	14	4	1	82
7/20/98	171.90	1	1	0	25	0	47	17	3	5	99
7/21/98	169.43	1	1	0	36	0	21	6	8	3	76
7/22/98	175.86	1	2	0	65	0	13	9	1	3	94
7/23/98	175.97	2	1	0	70	0	17	10	6	0	106
7/24/98	179.35	1	2	0	46	0	37	18	8	4	116
7/25/98	185.16	2	0	0	21	0	14	15	11	0	63
7/26/98	182.04	0	0	0	10	0	15	9	4	0	38
7/27/98	186.02	0	0	0	28	0	26	23	9	4	90
7/28/98	167.88	1	2	0	73	0	33	29	11	0	149
7/29/98	180.91	1	0	0	33	0	65	23	12	1	135
7/30/98	185.43	1	1	0	16	1	40	25	16	1	101
7/31/98	188.26	1	1	0	7	0	64	28	18	4	123
8/1/98	185.91	0	0	0	9	1	35	22	0	2	69
8/2/98	187.34	0	0	0	32	0	28	11	4	0	75
8/3/98	176.13	0	0	0	40	1	47	10	17	0	115
8/4/98	180.37	1	0	0	24	7	14	8	9	6	69
8/5/98	172.50	1	0	0	39	4	23	15	23	3	108
8/6/98	177.27	1	0	0	21	9	15	16	8	1	71
8/7/98	170.40	0	0	0	68	2	8	8	9	4	99
8/8/98	175.29	1	0	0	26	6	19	4	1	1	58
8/9/98	181.12	1	0	0	100	6	17	2	0	2	128
8/10/98	161.92	0	0	0	81	15	7	4	4	0	111
8/11/98	169.14	0	0	0	56	14	1	1	4	3	79
8/12/98	174.06	0	0	0	17	15	4	6	7	2	51
8/13/98	175.69	0	0	0	17	14	0	2	8	2	43
8/14/98	176.63	0	1	0	28	11	6	3	4	2	55
8/15/98	176.44	0	1	0	75	18	2	4	3	1	104
8/16/98	173.71	0	0	0	64	13	1	6	2	1	87
8/17/98	174.63	0	0	0	95	53	1	4	12	3	168
8/18/98	173.92	0	0	0	55	77	1	3	16	3	155
8/19/98	170.54	0	0	0	22	39	0	2	4	1	68
8/20/98	166.54	0	0	0	38	61	0	4	7	1	111
8/21/98	125.61	0	0	0	54	46	0	12	5	1	118
8/22/98	150.40	0	0	0	50	60	0	5	32	3	150

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Appendix D. Page 3 of 3.

Date	Fishing Time (minutes)	Chinook >700 mm	Chinook <700 mm	Summer Chum	Fall Chum	Coho	Pink	Whitefish Species	Cisco Species	Other Species	Total Catch
8/23/98	153.56	0	0	0	112	74	0	7	2	1	196
8/24/98	169.07	0	0	0	78	79	0	5	27	2	191
8/25/98	164.18	0	0	0	41	83	0	13	18	1	156
8/26/98	167.19	0	0	0	38	51	0	10	25	0	124
8/27/98	160.91	0	0	0	44	32	1	6	32	2	117
8/28/98	170.03	0	0	0	32	42	0	13	60	4	151
8/29/98	182.61	0	0	0	18	30	0	18	28	5	99
8/30/98	158.20	0	0	0	8	19	2	19	105	5	158
8/31/98	155.92	0	0	0	8	15	1	11	5	1	41
9/1/98	164.56	0	0	0	15	21	0	15	1	4	56
9/2/98	169.70	0	0	0	6	13	0	24	20	3	66
9/3/98	164.34	0	0	0	26	15	0	13	20	1	75
9/4/98	163.82	0	0	0	65	25	0	9	5	4	108
9/5/98	149.97	0	0	0	96	57	0	7	6	0	166
9/6/98	154.25	0	0	0	55	76	0	8	0	0	139
9/7/98	163.71	0	0	0	48	120	0	20	15	3	206
9/8/98	163.69	0	0	0	23	56	0	10	13	0	102
9/9/98	162.84	0	0	0	24	24	0	12	15	1	76
Totals	15,556.29	408	190	3,545	2,196	1,306	980	665	760	206	10,256