YUKON RIVER SONAR PROJECT REPORT

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by

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And

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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 in aiming strategies from one in which the transducer was aimed at an angle to the current to one that is aimed closer to perpendicular in order to maximize fish detection. Fish passage for each species was estimated in 1999 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 a series of gillnets of different mesh sizes. An estimated 2,024,366 ± 24,744 (s.e.) fish passed through the sonar sampling area between 12 June and 31 August, 26% along the right bank and 74% along the left bank. Included were an estimated 183,104 ± 10,933 large chinook salmon (>655 mm long), 28,040 ± 2,483 small chinook salmon (<655 mm), 945,881 ± 21,893 summer chum salmon, and 510,891 ± 11,886 fall chum salmon. Occasional sonar periods were missed due to strong wave action. Passage estimates include estimated data from the missed periods. Routine system analyses did not reveal any problems that might interfere with sampling. Target species were not abundant in the region behind the transducer during testfishing drifts designed to sample this area. Relationships between signal loss and hydrological parameters continued to be 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 these fisheries is complex and difficult due to the number, diversity, and geographic range of fish stocks and user groups. Information upon which to base management decisions comes from several sources, each of which has unique 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 in-season 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. A series of gillnets with different mesh sizes were 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 managers of fisheries 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 daily passage estimates to fisheries managers 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 to 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 1999 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 to provide early detection of problems which might arise.

METHODS

Hydroacoustic Data Acquisition

Equipment

Sonar equipment for 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 transducer (SN 003) configured for dual-beam use as Case II (3.6°x9.2° narrow, 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 sounder to transducer; 4) a Hydroacoustic Technology, Inc. (H.T.I.) Model 401 digital chart recorder 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) a Biosonics 102 (SN 89-019) 120/420 kHz echosounder configured to operate at 120 kHz; 2) an I.T.C. Model 5398 120 kHz transducer (SN 008) configured for dual-beam use, Case I (2.0°x4.9° narrow, 4.2°x9.9° wide beam); an I.T.C. Model 5398 120 kHz transducer (SN 005) configured for dual-beam use, Case I (2.1°x4.9° narrow, 3.8°x9.7° wide beam); 3) four 304.8 m (1,000 ft) Belden Model 8412 microphone conductor cables (SN's 501 and 502 were used with transducer 008, and 503 and 504 were used with transducer 005) connecting sounder to transducers; 4) H.T.I. Models 401 and 403 digital chart recorders coupled with Panasonic KXP 1624 and KXP 2624 dot matrix printers; and 5) a Hewlett-Packard Model 54501A digital storage oscilloscope. The preseason plan was to use transducer 008 to monitor fish passage from 0-350 m and to deploy transducer 005 if significant numbers of fish were observed from 0-20 m. This proved to be unnecessary since the majority of the fish passed beyond 20 m.

In addition, a complete backup system was kept in camp in the event of a failure. This backup system consisted of: 1) a Biosonics Model 101 (SN 83-039) echosounder configured to operate at 120 kHz; 2) an I.T.C. Model 5398 120 kHz transducer (SN 004) configured for dual-beam use, Case I (2.0°x4.6° narrow, 3.9°x9.2° wide beam) and Case II (4°x9.4° narrow, 13°x22.5° wide beam); 3) two 304.8 m (1,000 ft) Belden Model 8412 microphone conductor cables (SN's 605K and 606K); 4) an H.T.I. Model 403 digital chart recorder; and 5) three Panasonic KXP 1624 dot matrix printers.

Each sounder/transducer/cable configuration was calibrated prior to the field season (Table 1). 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 by ADF&G.

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° (±0.3°). Gasoline generators (3500 W) supplied 120 VAC power.

Sampling Procedures

We deployed a single transducer on the left (south) bank and 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) with a vertical angle of 8.7° calculated from a depth of 22.9 m at a range of 150 m. We positioned the right-bank transducer 5-10 m from shore, adjusting the aim between two strata (0-60 m) and (60-135 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, 4.2° calculated from a depth of 3.7 m at 50 m (Figure 3). A single transducer was deployed nearshore approximately 10 m from shore utilizing three aims to sample a nearshore stratum (0-50 m), a midshore stratum (50-175 m), and an offshore stratum (175-350 m). Occasionally, during periods of high signal loss, the strata ranges were changed to (0-50 m), (50-150 m) and (150-350 m) in an effort to more accurately compensate for the loss at those ranges. The transducer was repositioned frequently to compensate for the dynamic water level.

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 echoes as fish if at least one ping in the cluster passed the second printer threshold level (see Equipment Settings, Thresholds, Data Storage) and the targets did not resemble inert downstream objects. Multiple fish tracings were marked if there was a discontinuity in the tracing and the second mark 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 or crew leader 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 either a movement of the transducer or a change in bottom structure.

We sampled continuously for 24 hours on 26 June, 11 and 24 July, and 8 and 21 August to estimate uncertainty associated with the normal sonar sampling schedule. Sampling was divided among sampling 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. Initially, the left bank echosounder's TVG range was configured for use from 2.5 to 250 m. This was changed on 30 June to a 5 to 500 m range to provide TVG amplification over the entire sampling range. Pulse repetition rates were set below the maximum allowed by range to avoid overloading printer buffers. On the left bank, the nearshore strata transmit intervals were set to 0.3 s, the midshore strata was set at 0.4 s and the offshore strata was set at 0.5 s. The transmit interval for the right bank offshore strata was set at 0.4 s and the nearshore strata was initially set at 0.3 s, but was later changed to 0.4 s to prevent overloading the printer buffer.

All sampling was conducted using elliptical dual beam transducers operating in single beam mode. On the right bank, the wide beam (12.3°x22°) was used exclusively. On the left bank, the nearshore region was sampled using the wide beam (4.2°x9.9°), while the midshore and offshore regions were sampled with the narrow beam (2.0°x4.9°).

Echoes were digitized by chart recorders, then 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 Biosonics 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 –42 dB, was approximately 11 dB lower than the theoretical on-axis target strength of a chum salmon of minimal length (450 mm), calculated using Love's equation (Love, 1977). Lowering the threshold by 11 dB allows for detection across the nominal beam width (6 dB) and some variability (~5 dB) induced by fish aspect and noise corruption. 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 –40 to –43 dB. On occasion, this threshold was raised to eliminate unwanted noise, or lowered to compensate for loss associated with wave action (Appendix B). Threshold levels (in mV) were recorded and converted to target strength, TS_{dB}, as follows:

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

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 always 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 substrate, 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 reaim to established pan and tilt settings, then refine that aim to 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 an acceptably close chart image match 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 equipment performance checks, bottom profiles using down-looking sonar, transects through unsampled regions of the river using down-looking sonar, hydrologic measurements, and drift gillnetting both behind the transducer and over the sandbar in the middle of the river to test for target species outside of the counting range.

Hydroacoustic Equipment Checks
We measured the transmitter output through a 50 ohm load periodically during the field season and compared our results to values obtained from pre-season calibrations. Twice a month we checked the TVG circuitry of both echosounders 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). We calculated and compared the theoretical voltage at 1 m using measured voltage and range values.

To verify that the sonar system was operating normally, we used a Biosonics Model 281 dual-beam echo signal processor (ESP) to measure the *in situ* target strength of a 76.2 mm stainless steel sphere. The 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. During data collection, 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 imported into an Excel spreadsheet for analysis. 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 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 by transmitting a 1 VAC signal through the cable and measuring the resulting voltage. This was later modified to transmitting from the echosounder (at each possible power setting) through the cable and measuring the signal through a 50 ohm load inserted into the end of the cable. This allowed us to test transmission loss using typical sampling signal levels.

Bottom Profiles

Bottom profiles were recorded along both banks using a Lowrance X-15 fathometer (192 kHz) with a 20 degree conical 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 4) during the season to document bottom conditions and sandbar formation.

Down-looking Sonar Drifts

Following procedures established in 1998 (Maxwell, 2000), a down-looking sonar system was drifted weekly, close to shore on both the right and left banks and mid-river in an attempt to assess the passage of fish outside of the counting area. In 1998, the mid-river drift was over the thalweg. In 1999, we drifted further upstream over the mid-river sandbar because we suspected that if fish altered their route this would be the most likely corridor of migration. The fish passage rate per square meter was calculated and compared among the three zones.

Hydrologic Measurements

Hydrological measurements were recorded daily. Water level was measured using a staff gauge located offshore from the field camp. The water level measurements were adjusted to the United States Geological Survey Water Resources Division reference located approximately 500 m downstream of Pilot Station to allow comparison of water levels from previous years. Conductivity, air and water temperature, and secchi disk measurements were collected daily offshore along both banks. Dr. Kazuhisa Chikita of Japan's Hokkaido University provided hourly turbidity data collected at Pilot Station from 5 June through 29 August, 1999.

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. Eight 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. The 216 mm (8.5 in) and 133 mm (5.25 in), were discontinued starting 19 July. At this time the following nets were added, 146 mm (5.75 in), 63 MD and 127 mm (5.0 in), 72 MD. 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 periods twice daily from 0915 to 1215 and 1715 to 2015. During each gillnet sampling period four nets were drifted within each of three zones, one on the right bank and two on the left bank, 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 approximated as

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

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. Scale data will be processed and reported separately.

Prior to 1999, any chinook salmon that was less than 700 mm in length was called a "jack". This length was originally calculated as the average length of a chinook salmon under 10 lbs (Tracy Lingnau, ADF&G, Anchorage, personal communication). In 1999, this length was changed when analysis of age and length data collected from 1993 through 1998 produced an average length of 655 mm separating four and five year old chinook salmon (Table 11).

Genetic sampling of chum salmon occurred from 5 July through 1 August. Captured chum salmon were marked using numbered floy tags to allow association of age, sex, length and genetic data. Thirty fish were selected at random following each fishing period. On days in which only one fishing period occurred, 60 fish were sampled from that period. Heart, liver and muscle tissues were extracted from the selected chum salmon, placed in numbered cryotubes, then frozen in liquid nitrogen. Analysis of these data will be done by the ADF&G genetics laboratory.

Captured fish were distributed to local villagers or sold to local 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 (Maxwell, 2000) were used for chinook salmon, summer run chum salmon, fall run 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.

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 to strata 1 and 2. Zone 2 consisted of the counting range from 0 to 50 m on the left bank, corresponding to stratum 3. Zone 3 consisted of the counting range from 50 to 350 m, corresponding to 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,

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

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

$$r_{dzps} = \frac{\sum_{q} y_{dzpsq}}{\sum_{q} h_{dzpsq}}, \quad \textbf{(4)}$$

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,

$$r_{dzp} = \sum_{s} r_{dzps}. \quad \textbf{(5)}$$

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

$$\hat{r}_{dz} = \frac{\sum_{p} r_{dzp}}{n_{sdz}}, \quad \textbf{(6)}$$

where n_{Sdz} is 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

$$\hat{y}_{dz} = 24\,\hat{r}_{dz}. \quad \textbf{(7)}$$

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

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

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

Missing Data
Equipment malfunctions and other uncontrollable events occasionally result 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.

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,

$$C_{idzf} = \sum_{l} C_{ildzf} \; . \tag{13}$$

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.,

$$\hat{p}_{idzf} = \frac{C_{idzf}}{\sum_{i} C_{idzf}} \; . \tag{14}$$

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

$$\hat{p}_{idz} = \frac{\sum_{f} C_{idzf}}{\sum_{i}\sum_{f} C_{idzf}} \; , \tag{15}$$

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:

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

where:

n_{Tdz} = 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

$$\hat{y}_{idz} = \hat{y}_{dz} \bullet \hat{p}_{idz} \; . \tag{17}$$

Finally, 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),

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

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,

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

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

$$\hat{Y}_i \pm 1.645\sqrt{\hat{V}ar(\hat{Y}_i)}. \tag{21}$$

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

Missing Data
Equipment malfunctions 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 then applied to the corresponding days of sonar passage estimates.

RESULTS

The Yukon River sonar project operated from 12 June through 31 August in 1999. Periods of high water appeared to cause range-dependent signal loss. We believe we were able to compensate for the range-dependent signal loss through changes in transmit levels, gain settings, absorption compensation and digital chart recorder thresholds (Figures 5 and 6). Infrequently, sonar data were unobtainable due to wave action which caused the signal to fade in periodic intervals. The missing data were estimated by averaging the hourly passage rates for sonar data collected during periods before and after the missing period(s). Passage estimates were transmitted to fishery managers in Emmonak daily.

Test-Fishing

A total of 6,818 fish were captured during 1,945 drifts totaling 13,309 minutes. The catch consisted of 2,897 summer chum salmon, 1,800 fall chum salmon, 459 large chinook salmon (655 mm length or greater), 80 "jack" chinook salmon, 584 coho salmon, 7 pink salmon, 398 whitefish, 442 cisco, and 151 fish of other species (Tables 2 and 3). Gillnet sampling was not conducted during scheduled Y2 commercial fishery openings (25 June and 28 June, 2 July and 5 July, and 3, 8 and 11 August) to avoid disrupting commercial fishing activities. On commercial fishing days, the entire suite of gillnets was drifted during one extended period. Data from missed or partial gillnet sampling periods were pooled with those from an adjacent day to estimate species proportions. When the day's total capture in a single zone was less than four, the reporting period was extended by including data from an adjacent day whose data (both passage rate and species composition) appeared most similar. In 1999, reporting periods longer than one day were used on 13 occasions.

Hydroacoustic Estimates

An estimated 2,024,366 ± 24,744 (s.e.) fish passed through the sonar beams during the 1999 field season; 534,941 ± 8,345 (26 %) along the right bank, 974,305 ± 20,722 (48 %) along the left bank nearshore, and 515,120 ± 10,637 (26 %) along the left bank midshore and offshore. Tables 4 and 5 provide daily records of passage estimates by zone, standard errors, and the total passage coefficients of variation.

Chum salmon were the most abundant species during both summer and fall seasons (Figure 7). Chum salmon passage estimates totaled 1,456,772 with 945,881 ± 21,893 passing the sonar site during the summer season from 12 June through 18 July and 510,891 ± 11,886 passing during the fall season from 19 July through 31 August (Table 6). The summer chum salmon run was dominated by a period of high passage from 24 June through 6 July, while the fall chum salmon run consisted of five significant pulses distributed throughout the season. Chinook salmon passage estimates were composed of 183,104± 10,933 fish greater than 655 mm in length, and 28,040 ± 2,483 "jacks" shorter than 655 mm. Coho salmon passage estimates reached 94,532 ± 4,812, although this estimate likely does not include the entire run. Other species, totaling 261,918 ± 12,738 fish, included 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*). Daily passage estimates by species for the summer and fall seasons are listed in Tables 7 and 8.

Passage estimates for both chum and coho salmon were lower than those from 1997 and 1995, but higher than 1998 estimates. Chinook salmon estimates were only slightly lower than those obtained 1997 and 1995, but much higher than 1998 (Figures 8 and 9). The summer chum salmon run started at about the same time as in 1998 with 25% of the 1999 run occurring by 25 June, about five days later than the 1997 and 1995 runs (both 20 June). About 75% of the 1999 run passed through by 4 July, compared to 9 July 1998, 5 July 1997 and 3 July 1995. Twenty-five percent of the fall season chum salmon run passed the sonar site by 24 July, earlier than in 1998, 1997 and 1995, with the majority of the run (75%) passing by 16 August, 1999 (Figure 10).

As in 1998, the 1999 chinook salmon run timing was late, with 25% of the passage occurring by 25 June compared to 12 June, 1997 and 14 June, 1995 (Figure 11). The majority of the chinook salmon (75%) passed the sonar site by 4 July, about the same time as in 1998 (6 July) but later than in 1997 (24 June) and 1995 (27 June). The last chinook salmon captured in 1999 was on 24 August.

Seasonal passage estimates and CPUE for both summer and fall seasons were significantly correlated (Figures 12 and 13). The correlation coefficients for the summer season were $R=0.856$ for right bank, $R=0.858$ for left bank nearshore and $R=0.754$ for left bank offshore, each with $p<0.0001$. For the fall season the correlation coefficients were $R=0.728$ for right bank, $R=0.784$ for left bank nearshore, and $R=0.675$ for left bank offshore, again each with $p<0.0001$.

The summer and fall passage was plotted as a percentage in 20 m range increments by bank and season for 1995 through 1999 to illustrate the horizontal distribution of fish in the sampling area (Figures 14 and 15). Passage levels declined sharply as a function of the distance offshore. On the left bank, 90% of the detected passage during the 1999 summer and fall seasons occurred within 110 m from the transducer compared to 130 m 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

Passage estimates based on five 24-hour sampling periods were 0.13% smaller than routine nine hour sampling during these same days (Table 9). Individual days varied from 14.52% fewer fish estimated during the 24-four hour sampling on 21 August to 4.21% more fish estimated on 26 June. The only day in which a 24-four hour estimate was outside of the 90% confidence interval of a 9 hour estimate was on 21 August.

Bottom profiles conducted along the left and right banks at the transducer locations revealed smoothly sloping areas suitable for sonar deployment (Figures 2 and 3). The side-edge of the mid-river sandbar, labeled in Figure 3, begins near the end of left bank's ensonified range (350 m). No changes were noted in the steeply sloping, rocky bottom along the right bank during the field season. The sandy, gently sloping left-bank bottom remained smooth and linear during the season within the sampling range.

Two sandbars, observed in prior field seasons (Maxwell et al., 1997; Maxwell and Huttunen, 1998), were also detected in 1999. The Atchuelinguk Bar (Figure 4) extended downstream along the right bank from the confluence of the Atchuelinguk and Yukon Rivers to slightly downstream of the First Slough entrance, well upstream of the sampling area. The mid-river sandbar extended from the river bend downstream past the left-bank sampling area approaching to within 250 m of the right bank's sampling area. Both sandbars were closely monitored throughout the field season. Fishing over the mid-river sandbar produced a total of 60 chum salmon, 9 chinook salmon and 2 non-salmon during 26 hours of drifting (52 drifts).

A total of 33 drifts using the down-looking sonar were conducted during the 1999 field season. Of these drifts, 11 were nearshore parallel to each bank, 10 were over the mid-river sandbar and was 1 down the river's main channel. The results of these drifts were inconclusive due to uncertainties associated with sampling and the non-scientific echosounder used for this purpose.

The Yukon River water level was falling when we arrived at the Pilot Station field camp. Water level varied considerably throughout the season (Figure 16) with local maxima occurring on 2 July (6.42 m), 13 August (5.50 m) and 26 August (5.73 m) and local minima occurring on 18 June (5.62 m), 26 July (4.57 m) and 19 August (5.37 m). Compared with previous years (1995 through 1998), the timing of the relative peaks and valleys were most similar to 1997, although the actual water levels were often different.

Conductivity rose slowly during the field season (Figure 17) ranging from 119-230 µS offshore of the left bank and 81 – 220 µS off the right bank. Daily fluctuations in right bank conductivity measures appear to be more a result of sampling location rather then temporal differences. Right and left bank conductivity measures had a higher correlation this year (R=0.83) compared to 1998 (R=0.78) but were less correlated than in 1997 (R=0.94). Unlike 1998, a comparison of water level and conductivity demonstrated no significant relationship for either bank. Offshore from the left bank, secchi disk measurements varied from 4 to 38 cm below the surface with an average visibility of 12 cm. Secchi disk visibility ranged from 4 to 53 cm off the right bank with an average visibility of 15 cm. Right bank secchi disk visibility remained higher throughout most of the field season compared to left bank (Figure 18). Daily water temperatures ranged from 11 to 21 °C and averaged 17 °C (Figure 19).

Inseason transmitter output measurements from the project's echosounders showed little deviation (less than 0.8 dB) from pre-season values (Figure 20). The maximum difference between TVG measurements throughout the season, at a given range, was 0.54 dB for the left bank and 2.5 dB for the right bank echosounders (Figure 21).

Chart recorder threshold analyses for the left bank echosounder 102-89-019 showed a minimum difference of –0.25 dB and a maximum of 0.48 dB between range measurements made on the oscilloscope and on the digital chart recorder. The right bank echosounder 101-83-036 displayed a minimum difference of –0.75 dB and a maximum of 0.28 dB.

Signal loss through the left bank cables averaged 0.61 dB on 28 July, the only time these measurements were made on this bank. On the right bank the cables were tested on 28 July and 5 and 9 August. Cable 202 on the right bank was broken and subsequently repaired on 5 August requiring additional testing to measure any transmission differences through the splice. On 28 July signal loss averaged 0.57 dB, on 5 August it averaged 1.49 dB (after the repair) and on 9 August it averaged 0.86 dB. Prior to 9 August signal loss was calculated by measuring the loss of a 1 volt signal applied to the cable, after this date it was calculated by comparing the echosounder output at the back of the echosounder to the output at the transducer end of the cable. Thus, the 9 August measurements may not be directly comparable to earlier measurements due to the large difference in applied voltage.

Dual beam target strength estimates using a 3" (76.2 mm) stainless steel sphere were collected on the left bank on four separate occasions; 7 and 13 July, and 12 and 22 August. The data collected on 7 July contains too much bottom reverberation in the vicinity of the target to be useful. On both 12 and 22 August, the dual beam setup was improperly configured making those data unusable. The data collected on 13 July was obtained with a correctly configured system and did not contain bottom reverberation, making analysis on those data possible. A total of four files were collected at ranges of 26.4, 16.9, 19.8 and 19.9 m with the target suspended at roughly the same distance above the bottom in each case. Mean target strength values were –29.5, -23.9, -33.6 and –37.6 dB for the four files (Table 10). The differences between the upper and lower 90% values were 11.5, 6.4, 13.4 and 11.8 dB for the data sets. In the second file 0.2% of the echoes were over axis while the other three files contained an excess of 42% over-axis echoes. No attempt was made at correcting over axis echoes nor were they eliminated from the analysis.

A reverberation band appeared briefly in the left bank nearshore strata this season but, unlike previous years, it did not appear to affect our ability to detect fish (Maxwell and Huttunen, 1998; Maxwell. 2000).

As in 1998, range-dependent signal loss was observed on left bank during the 1999 field season. Signal loss was detected by the decrease in signal amplitude reflected from the bottom structure. The majority of the signal loss was detected at ranges greater than 150 m. There was no apparent range-dependent signal loss observed on the right bank, however, the maximum range on right bank was less than 150 m. Comparisons were made between the threshold used in the outermost strata to the daily hydrological measurements collected at the site in an attempt to determine a possible explanation for the signal loss. Three measurements in particular displayed high correlations with the threshold used: Conductivity, adjusted for temperature, had a coefficient of determination (R^2) of 0.6076, natural log of the secchi depth had an R^2 of 0.7994, and turbidity (hourly measures averaged over a day) had an R^2 of 0.8484 (Figures 22 through 24). These results suggest that a relationship exists between water composition and signal loss, but any conclusions are confounded by the presence of autocorrelation in the regression residuals (Durbin Watson d= 0.92, 1.04 and 0.99 with n=71, 79 and 78 respectively).

We decided to pursue the relationship between signal loss and turbidity further due to the relatively high correlation between these variables. Utilization of the Cochrane-Orcutt method resulted in a new model with an R^2 of 0.8171 (Neter et. al. 1990). This is slightly lower than the previous linear model but the Durbin Watson statistic in this case shows no evidence of autocorrelation at α=0.05 (d=1.79, n=77). The new model is:

$$\hat{y}_n = -43.646 - 0.020308x_n + 0.512\varepsilon_{n-1}, \tag{22}$$

where $\hat{y}_n$ is the forecasted signal loss at time n, x_n is the turbidity at time n and ε_{n-1} is the residual at time n-1 calculated as

$$\varepsilon_{n-1} = y_{n-1} - \left(-43.646 - 0.020308x_{n-1}\right). \tag{23}$$

Bank to bank cross-talk was observed for the first time at the Yukon River sonar project this past season (Figure 25). The diagonal line observed on the right bank chart-recorder output was verified as cross-talk by disabling the echosounder on the left bank. The line disappeared, then resumed when the left bank echosounder was re-enabled. The cross-talk occurred early in the season when the turbidity was relatively low, and seemed to disappear as the suspended sediment load increased.

DISCUSSION

Yukon River sonar passage estimates for 1999 were not in strong agreement with many of the other salmon assessment projects in the drainage. This past season sonar estimates appeared high relative to most other indicators. One would suspect that, if anything, sonar estimates would tend to be conservative, and there is no satisfactory explanation for the disagreement among abundance indicators. There are problems associated with trying to determine the accuracy of the sonar counts using other abundance estimators, one of which is the fact that not all possible spawning tributaries (including mainstem) are monitored. Another difficulty is that the estimates used to ground truth the sonar abundance estimates have their own sources of error and typically do not have measures which allow calculation of variance. Still another problem associated with these comparisons is that operations at the Yukon River sonar project have been modified from year to year (utilization of different beam widths for example) in an attempt to more accurately assess passage (increase detectability). Over time, these modifications may introduce biases in the yearly comparisons of sonar estimates to other abundance estimates. The exact effects of these modifications and their relationship to historic data are not fully understood.

CPUE and passage estimates correlated well in all strata during both the summer and fall seasons (Figures 12 and 13). Overall the relationships in 1999 were as good as or better than those observed in 1995, 1997 or 1998.

The horizontal distribution of fish detected on the left bank was closer to shore than in previous years (Figures 14 and 15). Horizontal distribution is probably due to a combination of factors such as fish passage rate, species composition and water level. Although fish passage was a bit higher in

1999 compared to 1998, the water level was considerably lower throughout most of 1999. Both 1997 and 1995 had higher fish passage than 1999, but the water level information is more difficult to discern. In 1997 the water level followed a similar trend to 1999, although the changes were generally larger in magnitude and in 1995 the data are incomplete. In addition, starting in 1998 the project began utilizing a wider beam nearshore to count fish. This may have increased nearshore detectability and could explain some of the differences observed when comparing the 1998 and 1999 distributions to the distributions observed in 1995 and 1997. The horizontal distribution on the right bank was very similar to the distributions for 1997 and 1995 during both the summer and fall seasons. The sharp decline in fish passage with increasing range suggests that most fish pass within the ensonified range. Although detectability is also a function of range and may account for some of the decline, we believe the vast majority of all salmon pass through the ensonified regions of the river. A precise measure of signal loss is currently difficult to ascertain due to the high variability associated with target strength measurements.

The 24-hour sonar estimates compared favorably with the normal nine hour estimates. Of the five days in which 24-hour samples were collected, the 24-hour estimates were higher on three days and lower on two. Based on this small sample size, it appears that the normal sampling routine is adequate to assess fish passage at this site. Also, comparisons made in previous years have yielded similar observations (Maxwell, 2000; Maxwell and Huttunen, 1998; Maxwell et al., 1997).

Right bank bottom profiles were similar to prior years with little or no change throughout the season. On the left bank, the profile at the sampling site remained linear throughout the field season. Suitable profiles 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. Downward progression of this sandbar is unlikely due to its proximity to the cutbank on the Yukon River and the confluence of 1st Slough and the Yukon River downstream of the bar. The mid-river sandbar has continued to progress downstream since the 1997 field season. In 1999, the side-edge of the sandbar was charted 350 m offshore from the left bank transducer (compared to 500 m in 1998). The most downstream extension of this sandbar was observed slightly upstream of the right bank transducer (in 1998 the sandbar was roughly 200 m upstream) at a depth of about 13.7 m (45 ft). The upper portion of the bar was fished daily during the 1999 summer season and every other day during the fall season. The number of fish caught over the bar was small compared to the normal apportionment drifts.

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 upstream from the right bank transducer. It is possible that fish approach the sandbar from the right bank 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 4). This would appear to be one possible 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. If fish are traveling offshore to the sandbar either downstream of or at the sampling site, it would seem that a change in their horizontal distribution would be observed. This is not, however, the case. During the next field season it will remain important to continue monitoring the movement of the sandbar, the fish distribution, and the presence of fish along the sandbar.

As in 1998, there were disproportionally more fish observed in the right-bank drifts using the down looking sonar than would be expected from the side-looking counts. Much of this apparent discrepancy may be explained by the relatively narrow migration corridor on right bank. Although fewer fish travel up the right bank, they may be more concentrated, giving the illusion of greater numbers in the down-looking charts. Also, the down-looking sonar utilized is not a scientific echosounder and has no TVG correction or way of determining target size. Not only does this make it extremely difficult to determine whether the down and side looking systems are detecting the same size targets, the lack of TVG circuitry will also cause the detectability of fish to decrease with range in the down-looking system. This will invalidate, to some degree, comparisons made with drifts performed at different depths.

The acoustic results of the mid-river sandbar drifts were similarly confounded. First, as previously mentioned, this sonar system does not use a scientific echosounder so there is no way to verify that we are detecting the same size targets drift to drift or throughout the water column. Also, since the ratio of total observations on the right to left banks is so different from what we observe with the side-looking system, the relative number of targets observed over the mid-river sandbar is also questionable. Finally, since the drifts were performed slightly upstream of the transducers, there is no way to be certain that fish counted during the drifts had not previously crossed from one of the banks after being counted by the side-looking sonar. In the future, the possibility of configuring a calibrated scientific sonar system to function in a down-looking mode might be explored. This would eliminate much of the uncertainty associated with the target detectability. It would not, however, address the sampling problems associated with this method of assessment. Until the sampling issues are resolved, we cannot recommend the continuation of these drifts as a meaningful way of assessing passage outside of our normal acoustic sampling areas along both banks.

Signal loss, as determined from the threshold needed to detect bottom at the outermost range, varied considerably throughout the season. Early in the spring the river was relatively clear with little suspended sediment. As the summer progressed, the amount of sediment increased as did the amount of signal loss. Initial comparisons of signal loss to hydrological measurements showed high correlations with turbidity, the natural logarithm of secchi disk depth and with conductivity. Further analysis of the turbidity/signal loss relationship using the Cochrane-Orcutt method of eliminating autocorrelation resulted in a new model which explained more than 81% of the variability of signal loss. This result is encouraging, but additional follow-up work is needed. Purchasing a turbidity meter and including these measurements in the daily sampling program of the project should allow for further examination of this relationship. If a less subjective measure of signal loss could be obtained, it is worth pursuing. Unfortunately, target strength measurements collected with the project's dual-beam equipment are too variable to be useful for this purpose (Table 10).

Cross talk did not affect our ability to count fish. An observation worthy of note about the cross-talk was its first ever reported (at this project) detection across a range of almost 1000 m. Cross talk is not expected to cause problems with project operations in the future due to the normally turbid state of the Yukon River.

Estimating fish passage in the Yukon River continues to present major technical and logistic challenges. The sampling environment is often demanding due to the extremely dynamic nature of the water level, turbidity, bottom substrate, and range-dependent signal loss. 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. The system changes are largely subjective and thus, hard to objectively quantify as to absolute detectability. 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. Pre-season Yukon River sonar equipment calibration data, 1999.

Sounder	Cables	Transducer	Receiver Gain L	Standard Volts In	Vdet NB 40	G1 NB 40	Vdet WB 40	G1 WB 40	0 dB cal NB 40	0dB cal WB 40
101-83-036	1000' Carol 202/201	ITC 003 Case II	0	-8	2.395	-174.55	1.508	-178.57	6.400	4.210
101-83-039	1000' Belden 606K/605K	ITC 004 Case II	0	-8	3.480	-171.30	3.820	-170.49	5.820	3.075
101-83-039	1000' Belden 606K/605K	ITC 004 Case I	0	-3	2.900	-170.28	3.110	-169.67	2.860	3.090
102-89-019	1000' Belden 502Y/501Y	ITC 008 Case I	0	-3	3.795	-167.94	3.993	-167.50	4.905	4.910
102-89-019	1000' Belden 504Y/503Y	ITC 005 Case I	0	-3	3.470	-168.72	3.745	-168.06	4.675	4.930

Continued

Sounder	Cables	Transducer	-13 dB Vs	-13 dB SL	-10 dB Vs	-10 dB SL	-6 dB Vs	-6 dB SL	-3 dB Vs	-3 dB SL	0 dB Vs	0 dB SL
101-83-036	1000' Carol 202/201	ITC 003 Case II	-3.17	205.27	-0.22	208.22	3.72	212.16	6.67	215.11	9.71	218.15
101-83-039	1000' Belden 606K/605K	ITC 004 Case II	-2.76	205.68	0.29	208.73	4.25	212.69	7.18	215.62	10.20	218.64
101-83-039	1000' Belden 606K/605K	ITC 004 Case I	-6.44	207.65	-3.42	210.67	0.53	214.62	3.43	217.52	6.42	220.51
102-89-019	1000' Belden 502Y/501Y	ITC 008 Case I	-3.83	210.26	-0.95	213.14	2.85	216.94	5.71	219.80	8.72	222.81
102-89-019	1000' Belden 504Y/503Y	ITC 005 Case I	-4.26	209.83	-1.36	212.73	2.40	216.49	5.29	219.38	8.28	222.37

Table 2. Summary of daily testfishing catches by species from 9 June to 18 July for the Yukon River sonar project, 1999.

Date	Drift Time Minutes	Chinook >=655mm	Chinook <655mm	Summer Chum	Coho	Pink	Whitefish Species	Cisco	Other Species	Total Catch
06/09/1999	51.70	0	0	0	0	0	0	0	1	1
06/10/1999	174.96	0	0	0	0	0	8	0	11	19
06/11/1999	172.44	0	0	0	0	0	3	3	6	12
06/12/1999	182.24	1	0	0	0	0	5	2	8	16
06/13/1999	174.79	0	0	0	0	0	2	0	3	5
06/14/1999	184.75	0	0	0	0	0	2	2	6	10
06/15/1999	178.64	5	0	1	0	0	0	0	6	12
06/16/1999	181.00	2	1	2	0	0	2	2	3	12
06/17/1999	167.92	5	1	11	0	0	0	1	3	21
06/18/1999	181.53	3	0	7	0	0	1	0	3	14
06/19/1999	178.04	5	1	23	0	0	1	0	1	31
06/20/1999	175.50	9	1	39	0	0	0	1	6	56
06/21/1999	134.67	21	1	139	0	0	1	0	3	165
06/22/1999	142.24	23	6	96	0	0	0	1	2	128
06/23/1999	131.76	53	4	89	0	0	0	0	2	148
06/24/1999	111.41	18	3	190	0	0	0	1	4	216
06/25/1999	76.85	17	3	102	0	0	0	0	0	122
06/26/1999	111.12	19	5	185	0	0	0	0	0	209
06/27/1999	125.60	24	5	160	0	0	0	0	4	193
06/28/1999	76.52	29	2	108	0	0	0	1	0	140
06/29/1999	108.59	17	3	149	0	0	0	2	1	172
06/30/1999	126.36	24	6	137	0	0	1	1	1	170
07/01/1999	107.82	16	2	137	0	0	0	1	2	158
07/02/1999	99.78	14	3	49	0	0	0	0	0	66
07/03/1999	121.23	18	7	123	0	0	0	0	1	149
07/04/1999	115.56	15	0	157	0	0	0	3	1	176
07/05/1999	94.77	20	1	82	0	0	2	0	0	105
07/06/1999	129.00	13	3	90	0	0	2	1	0	109
07/07/1999	139.57	17	7	60	0	0	1	0	3	88
07/08/1999	154.27	10	2	88	0	0	0	2	1	103
07/09/1999	124.35	7	0	162	0	0	2	6	0	177
07/10/1999	123.28	15	1	134	0	0	0	1	1	152
07/11/1999	140.36	9	5	79	0	0	1	4	0	98
07/12/1999	165.99	6	4	49	0	0	0	1	2	62
07/13/1999	152.19	2	0	77	0	0	4	3	0	86
07/14/1999	168.75	6	1	55	0	0	4	7	3	76
07/15/1999	169.32	2	0	46	0	0	6	5	0	59
07/16/1999	174.66	0	0	38	0	0	9	10	3	60
07/17/1999	169.83	3	0	13	0	0	3	9	3	31
07/18/1999	172.68	0	2	20	0	0	6	4	1	33
Summer Totals	5,672.04	448	80	2,897	0	0	66	74	95	3,660

Table 3. Summary of daily testfishing catches by species from 19 July to 31 August for the Yukon River sonar project, 1999.

Date	Drift Time Minutes	Chinook >=655mm	Chinook <655mm	Fall Chum	Coho	Pink	Whitefish Species	Cisco	Other Species	Total Catch
07/19/1999	162.63	0	0	31	0	0	8	3	3	45
07/20/1999	166.29	4	0	69	0	0	1	0	2	76
07/21/1999	185.53	1	0	82	0	0	6	8	3	100
07/22/1999	186.67	0	0	27	0	1	13	2	1	44
07/23/1999	172.77	0	0	97	0	1	0	1	2	101
07/24/1999	158.00	1	0	126	0	0	4	3	1	135
07/25/1999	177.54	0	0	55	0	0	2	5	1	63
07/26/1999	179.31	1	0	19	0	1	6	4	1	32
07/27/1999	178.28	1	0	16	0	1	8	3	1	30
07/28/1999	198.07	0	0	13	0	0	14	2	1	30
07/29/1999	213.63	1	0	11	0	0	6	2	1	21
07/30/1999	207.29	0	0	19	0	1	3	3	1	27
07/31/1999	210.40	0	0	4	0	0	3	2	1	10
08/01/1999	189.25	0	0	84	0	0	8	3	1	96
08/02/1999	142.22	1	0	103	0	0	9	5	1	119
08/03/1999	132.41	0	0	25	1	0	11	2	1	40
08/04/1999	168.57	0	0	59	0	0	9	5	1	74
08/05/1999	195.32	0	0	49	0	0	9	2	3	63
08/06/1999	181.40	0	0	24	2	0	12	3	1	42
08/07/1999	176.41	0	0	16	1	0	6	1	0	24
08/08/1999	103.43	0	0	25	0	0	6	2	0	33
08/09/1999	177.92	0	0	23	6	0	14	1	2	46
08/10/1999	176.00	0	0	10	12	0	9	1	0	32
08/11/1999	85.91	0	0	3	3	0	8	7	0	21
08/12/1999	190.62	0	0	1	5	1	10	9	4	30
08/13/1999	192.43	0	0	2	7	0	10	2	2	23
08/14/1999	170.67	0	0	75	8	0	8	3	0	94
08/15/1999	178.51	0	0	73	11	0	11	18	1	114
08/16/1999	179.05	0	0	43	22	0	6	8	2	81
08/17/1999	174.95	0	0	42	14	0	3	7	0	66
08/18/1999	174.40	0	0	30	24	0	10	19	0	83
08/19/1999	185.65	0	0	10	17	0	10	16	0	53
08/20/1999	190.44	0	0	5	12	0	18	19	3	57
08/21/1999	183.31	0	0	30	12	0	19	11	2	74
08/22/1999	161.34	0	0	148	9	0	5	19	2	183
08/23/1999	148.16	0	0	125	33	0	6	10	0	174
08/24/1999	165.11	1	0	89	85	0	4	30	0	209
08/25/1999	165.02	0	0	40	66	0	6	16	0	128
08/26/1999	176.19	0	0	17	48	0	4	44	1	114
08/27/1999	173.16	0	0	25	43	0	5	9	1	83
08/28/1999	176.45	0	0	14	44	0	7	20	3	88
08/29/1999	176.89	0	0	16	42	0	6	7	0	71
08/30/1999	177.53	0	0	17	31	1	4	14	3	70
08/31/1999	172.06	0	0	8	26	0	5	17	3	59
Fall Totals	7,637.19	11	0	1,800	584	7	332	368	56	3,158
Season Totals	13,309.23	459	80	4,697	584	7	398	442	151	6,818

Table 4. Daily estimates of fish passage by zone from 12 June to 18 July for the Yukon River sonar project, 1999.

Report Period	Date	Right Bank Passage	Right Bank SE	Left Bank Nearshore[a] Passage	Left Bank Nearshore[a] SE	Left Bank Offshore[b] Passage	Left Bank Offshore[b] SE	Total Passage	Total Passage SE	Total Passage CV	Percent Right Bank	Percent Left Bank
1	6/12/99	1,912	132	922	51	435	51	3,269	150	0.046	58.49	41.51
1	6/13/99	1,404	97	1,318	73	465	55	3,187	133	0.042	44.05	55.95
1	6/14/99	1,292	89	1,110	61	315	37	2,717	114	0.042	47.55	52.45
2	6/15/99	1,066	35	1,374	67	602	39	3,042	85	0.028	35.04	64.96
2	6/16/99	1,162	38	1,855	90	910	59	3,927	114	0.029	29.59	70.41
2	6/17/99	1,036	34	1,555	75	655	42	3,246	93	0.029	31.92	68.08
3	6/18/99	1,175	50	2,270	363	1,506	150	4,951	396	0.080	23.73	76.27
3	6/19/99	1,577	67	4,482	717	2,681	267	8,740	768	0.088	18.04	81.96
4	6/20/99	5,059	1120	6,449	121	5,700	842	17,208	1407	0.082	29.40	70.60
5	6/21/99	5,157	547	17,770	1169	11,914	2902	34,841	3176	0.091	14.80	85.20
6	6/22/99	4,097	293	12,924	1143	9,719	301	26,740	1218	0.046	15.32	84.68
7	6/23/99	6,416	869	15,726	2352	12,053	1703	34,195	3031	0.089	18.76	81.24
8	6/24/99	20,277	827	32,582	1179	16,758	3985	69,617	4238	0.061	29.13	70.87
9	6/25/99	37,321	4961	44,155	9306	24,919	4592	106,395	11502	0.108	35.08	64.92
9	6/26/99	20,222	2688	35,544	7491	13,428	2474	69,194	8335	0.120	29.23	70.77
10	6/27/99	23,322	753	25,310	3826	14,818	3857	63,450	5486	0.086	36.76	63.24
10	6/28/99	23,144	747	72,202	10920	12,981	3379	108,327	11456	0.106	21.36	78.64
11	6/29/99	22,650	3711	32,979	2783	12,894	1230	68,523	4799	0.070	33.05	66.95
12	6/30/99	15,871	620	26,986	3223	8,492	892	51,349	3401	0.066	30.91	69.09
13	7/1/99	19,231	1261	33,737	2093	7,567	617	60,535	2521	0.042	31.77	68.23
14	7/2/99	17,894	944	23,687	3493	6,622	458	48,203	3647	0.076	37.12	62.88
14	7/3/99	16,635	878	19,204	2832	9,226	638	45,065	3033	0.067	36.91	63.09
15	7/4/99	21,058	638	29,069	4236	11,941	1644	62,068	4588	0.074	33.93	66.07
16	7/5/99	20,636	1620	16,145	3752	13,901	1309	50,682	4291	0.085	40.72	59.28
16	7/6/99	12,260	962	7,675	1783	9,690	912	29,625	2222	0.075	41.38	58.62
17	7/7/99	6,398	470	5,076	732	3,507	490	14,981	998	0.067	42.71	57.29
18	7/8/99	8,465	1260	6,404	1351	3,969	861	18,838	2038	0.108	44.94	55.06
19	7/9/99	19,882	1568	14,709	2205	8,198	1228	42,789	2972	0.069	46.47	53.53
20	7/10/99	10,682	1250	14,508	3077	8,755	969	33,945	3460	0.102	31.47	68.53
21	7/11/99	8,045	525	9,202	1168	6,303	950	23,550	1595	0.068	34.16	65.84
22	7/12/99	4,943	742	6,238	400	2,984	342	14,165	910	0.064	34.90	65.10
23	7/13/99	4,049	391	9,442	614	4,709	266	18,200	775	0.043	22.25	77.75
24	7/14/99	4,080	593	7,743	722	3,120	193	14,943	954	0.064	27.30	72.70
25	7/15/99	3,707	281	5,408	185	3,583	392	12,698	517	0.041	29.19	70.81
26	7/16/99	2,948	176	6,490	455	3,275	103	12,713	499	0.039	23.19	76.81
26	7/17/99	2,485	148	4,662	327	2,293	72	9,440	366	0.039	26.32	73.68
27	7/18/99	2,750	129	5,819	882	3,974	245	12,543	924	0.074	21.92	78.08
SUMMER TOTALS		380,308	8,047	562,731	19,623	264,862	9,744	1,207,901	23,341			

[a]Left Bank Nearshore Range: 0 - 50 m
[b]Left Bank Offshore Range: 50 - 350 m

Table 5. Daily estimates of fish passage by zone from 19 July to 31 August for the Yukon River sonar project, 1999.

Report Period	Date	Right Bank Passage	Right Bank SE	Left Bank Nearshore[a] Passage	Left Bank Nearshore[a] SE	Left Bank Offshore[b] Passage	Left Bank Offshore[b] SE	Total Passage	Total Passage SE	Total Passage CV	Percent Right Bank	Percent Left Bank
28	7/19/99	2,472	272	8,296	474	5,182	144	15,950	565	0.035	15.5	84.5
29	7/20/99	4,284	477	15,141	317	5,954	570	25,379	808	0.032	16.88	83.12
30	7/21/99	4,245	112	8,710	1513	7,940	1110	20,895	1880	0.09	20.32	79.68
31	7/22/99	3,078	102	6,919	445	4,926	452	14,923	643	0.043	20.63	79.37
32	7/23/99	4,661	265	16,417	1671	10,458	1265	31,536	2112	0.067	14.78	85.22
33	7/24/99	6,031	235	16,410	1231	16,697	278	39,138	1284	0.033	15.41	84.59
34	7/25/99	5,111	87	13,728	1461	13,527	1301	32,366	1958	0.061	15.79	84.21
35	7/26/99	3,960	286	6,498	549	6,065	1021	16,523	1194	0.072	23.97	76.03
36	7/27/99	2,909	148	5,743	201	3,390	275	12,042	371	0.031	24.16	75.84
36	7/28/99	1,831	93	7,220	252	3,069	249	12,120	366	0.03	15.11	84.89
37	7/29/99	2,299	162	6,788	849	4,600	639	13,687	1075	0.079	16.8	83.2
38	7/30/99	2,304	186	6,812	423	3,540	545	12,656	714	0.056	18.2	81.8
38	7/31/99	1,736	140	5,316	330	3,161	486	10,213	604	0.059	17	83
39	8/1/99	2,966	604	16,206	2122	6,091	884	25,263	2377	0.094	11.74	88.26
40	8/2/99	5,137	533	29,765	938	12,429	1522	47,331	1866	0.039	10.85	89.15
41	8/3/99	4,447	705	15,361	2311	10,669	298	30,477	2435	0.08	14.59	85.41
41	8/4/99	3,435	545	11,031	1660	8,879	248	23,345	1764	0.076	14.71	85.29
42	8/5/99	1,974	143	10,266	647	5,599	625	17,839	911	0.051	11.07	88.93
43	8/6/99	2,118	311	7,399	435	3,556	475	13,073	715	0.055	16.2	83.8
44	8/7/99	2,620	95	5,066	165	2,697	604	10,383	634	0.061	25.23	74.77
45	8/8/99	2,794	326	5,012	443	3,018	367	10,824	661	0.061	25.81	74.19
45	8/9/99	2,330	272	6,250	553	3,826	465	12,406	772	0.062	18.78	81.22
46	8/10/99	1,924	104	5,270	483	2,401	168	9,595	522	0.054	20.05	79.95
46	8/11/99	1,813	98	3,832	352	2,101	147	7,746	393	0.051	23.41	76.59
46	8/12/99	2,325	126	3,254	299	1,933	135	7,512	351	0.047	30.95	69.05
47	8/13/99	1,177	47	2,647	257	1,527	258	5,351	367	0.069	22	78
48	8/14/99	3,007	252	10,218	1488	5,101	940	18,326	1778	0.097	16.41	83.59
49	8/15/99	3,999	99	13,439	366	7,647	253	25,085	456	0.018	15.94	84.06
50	8/16/99	3,072	143	8,530	1093	5,431	410	17,033	1176	0.069	18.04	81.96
51	8/17/99	2,749	309	7,266	878	4,407	95	14,422	935	0.065	19.06	80.94
52	8/18/99	3,213	367	5,938	264	4,062	281	13,213	532	0.04	24.32	75.68
53	8/19/99	1,901	274	5,848	184	3,152	80	10,901	339	0.031	17.44	82.56
54	8/20/99	2,635	34	7,096	380	3,194	197	12,925	430	0.033	20.39	79.61
55	8/21/99	3,582	237	7,331	1078	4,108	212	15,021	1124	0.075	23.85	76.15
56	8/22/99	5,927	309	23,686	2705	9,815	676	39,428	2805	0.071	15.03	84.97
57	8/23/99	6,756	833	24,696	1570	11,948	492	43,400	1845	0.043	15.57	84.43
58	8/24/99	6,078	410	15,318	1323	9,440	1348	30,836	1933	0.063	19.71	80.29
59	8/25/99	6,004	725	7,969	662	6,912	1154	20,885	1515	0.073	28.75	71.25
60	8/26/99	4,897	320	5,540	435	3,612	323	14,049	630	0.045	34.86	65.14
61	8/27/99	3,809	204	5,225	238	3,489	197	12,523	370	0.03	30.42	69.58
62	8/28/99	4,338	277	4,520	69	3,402	103	12,260	304	0.025	35.38	64.62
63	8/29/99	4,068	154	4,708	446	3,644	823	12,420	949	0.076	32.75	67.25
64	8/30/99	4,178	422	4,550	430	4,161	351	12,889	697	0.054	32.42	67.58
65	8/31/99	4,439	279	4,339	468	3,498	342	12,276	643	0.052	36.16	63.84
FALL TOTALS		154,633	2,209	411,574	6,659	250,258	4,266	816,465	8,211			
SEASON TOTALS		534,941	8,345	974,306	20,722	515,120	10,637	2,024,366	24,744			

[a]Left Bank Nearshore Range: 0 - 50 m

eft Bank Offshore Range: 50 - 350 m

Table 6. Cumulative passage estimates by species for the Yukon River sonar project, 1999.

Species	Cumulative Estimated Passage	Standard Error	Coefficient of Variation	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Target Species					
Large Chinook Salmon	183,104	10,933	0.060	165,119	201,089
Small Chinook Salmon	28,040	2,483	0.089	23,955	32,125
	============				
Total Chinook Salmon	211,144				
Summer Chum	945,881	21,893	0.023	909,867	981,895
Fall Chum	510,891	11,886	0.023	491,339	530,443
	============				
Total Chum	1,456,772				
Non-target Species*					
Coho Salmon	94,532	4,812	0.051	86,616	102,448
Pink Salmon	2,165	922	0.426	649	3,681
Non-salmon	259,753	12,705	0.049	238,852	280,654
	============				
Total	2,024,366				

*Estimates used in the process of apportioning target species, not for estimating passage rates of non-target species.

Table 7. Daily estimates of fish passage by species from 12 June to 18 July for the Yukon River sonar project, 1999.

Report Period	Date	Chinook > 655 mm	Chinook < 655 mm	Summer Chum	Non-Salmon Species	Total all Species
1	6/12/99	39	0	0	3,230	3,269
1	6/13/99	55	0	0	3,132	3,187
1	6/14/99	46	0	0	2,671	2,717
2	6/15/99	928	161	946	1,007	3,042
2	6/16/99	1,176	176	1,298	1,277	3,927
2	6/17/99	968	157	1,032	1,089	3,246
3	6/18/99	1,257	88	2,834	772	4,951
3	6/19/99	2,252	175	5,010	1,303	8,740
4	6/20/99	3,464	570	11,344	1,830	17,208
5	6/21/99	5,571	120	27,913	1,237	34,841
6	6/22/99	5,960	667	19,811	302	26,740
7	6/23/99	13,596	852	19,546	201	34,195
8	6/24/99	5,759	703	60,876	2,279	69,617
9	6/25/99	11,740	3,043	91,612	0	106,395
9	6/26/99	8,135	1,988	59,071	0	69,194
10	6/27/99	9,809	1,873	50,846	922	63,450
10	6/28/99	17,848	4,014	85,287	1,178	108,327
11	6/29/99	8,983	1,040	54,755	3,745	68,523
12	6/30/99	6,553	1,124	42,873	799	51,349
13	7/1/99	10,223	1,648	47,883	781	60,535
14	7/2/99	7,203	2,355	38,434	211	48,203
14	7/3/99	7,500	2,075	35,319	171	45,065
15	7/4/99	5,965	0	54,552	1,551	62,068
16	7/5/99	13,422	713	35,559	988	50,682
16	7/6/99	8,090	393	20,555	587	29,625
17	7/7/99	3,894	1,903	8,127	1,057	14,981
18	7/8/99	3,012	332	14,767	727	18,838
19	7/9/99	1,085	0	39,799	1,905	42,789
20	7/10/99	2,002	83	31,434	426	33,945
21	7/11/99	2,675	837	19,251	787	23,550
22	7/12/99	2,331	677	10,298	859	14,165
23	7/13/99	233	0	15,868	2,099	18,200
24	7/14/99	1,256	42	10,264	3,381	14,943
25	7/15/99	297	0	9,508	2,893	12,698
26	7/16/99	469	0	5,443	6,801	12,713
26	7/17/99	357	0	4,123	4,960	9,440
27	7/18/99	0	231	9,643	2,669	12,543
Summer Totals		174,153	28,040	945,881	59,827	1,207,901

Table 8. Daily estimates of fish passage by species from 19 July to 31 August for the Yukon River sonar project, 1999.

Report Period	Date	Chinook > 655 mm	Chinook < 655 mm	Pink	Fall Chum	Coho	Non-Salmon Species	Total all Species
28	7/19/99	0	0	0	11,791	0	4,159	15,950
29	7/20/99	873	0	0	24,214	0	292	25,379
30	7/21/99	276	0	0	17,833	0	2,786	20,895
31	7/22/99	0	0	677	7,708	0	6,538	14,923
32	7/23/99	0	0	0	31,144	0	392	31,536
33	7/24/99	216	0	0	37,002	0	1,920	39,138
34	7/25/99	0	0	0	28,843	0	3,523	32,366
35	7/26/99	4,865	0	285	6,803	0	4,570	16,523
36	7/27/99	114	0	205	4,946	0	6,777	12,042
36	7/28/99	72	0	129	4,753	0	7,166	12,120
37	7/29/99	1,012	0	0	8,165	0	4,510	13,687
38	7/30/99	0	0	289	7,749	0	4,618	12,656
38	7/31/99	0	0	226	6,413	0	3,574	10,213
39	8/1/99	0	0	0	22,116	0	3,147	25,263
40	8/2/99	1,315	0	0	42,737	0	3,279	47,331
41	8/3/99	0	0	0	21,042	56	9,379	30,477
41	8/4/99	0	0	0	16,458	43	6,844	23,345
42	8/5/99	0	0	0	15,203	0	2,636	17,839
43	8/6/99	0	0	0	7,091	1,376	4,606	13,073
44	8/7/99	0	0	0	7,596	223	2,564	10,383
45	8/8/99	0	0	0	7,388	895	2,541	10,824
45	8/9/99	0	0	0	8,460	1,050	2,896	12,406
46	8/10/99	0	0	112	2,192	1,259	6,032	9,595
46	8/11/99	0	0	106	1,857	1,037	4,746	7,746
46	8/12/99	0	0	136	1,775	1,112	4,489	7,512
47	8/13/99	0	0	0	477	2,188	2,686	5,351
48	8/14/99	0	0	0	13,904	808	3,614	18,326
49	8/15/99	0	0	0	13,647	1,497	9,941	25,085
50	8/16/99	0	0	0	7,915	4,774	4,344	17,033
51	8/17/99	0	0	0	7,951	4,831	1,640	14,422
52	8/18/99	0	0	0	4,651	3,534	5,028	13,213
53	8/19/99	0	0	0	1,834	2,136	6,931	10,901
54	8/20/99	0	0	0	1,694	2,274	8,957	12,925
55	8/21/99	0	0	0	6,269	2,380	6,372	15,021
56	8/22/99	0	0	0	31,700	2,711	5,017	39,428
57	8/23/99	0	0	0	31,224	6,544	5,632	43,400
58	8/24/99	208	0	0	12,968	11,618	6,042	30,836
59	8/25/99	0	0	0	7,474	8,370	5,041	20,885
60	8/26/99	0	0	0	2,291	4,685	7,073	14,049
61	8/27/99	0	0	0	4,491	6,364	1,668	12,523
62	8/28/99	0	0	0	1,976	6,240	4,044	12,260
63	8/29/99	0	0	0	2,395	7,025	3,000	12,420
64	8/30/99	0	0	0	4,366	4,806	3,717	12,889
65	8/31/99	0	0	0	2,385	4,696	5,195	12,276
Fall Totals		8,951	0	2,165	510,891	94,532	199,926	816,465
Season Totals		183,104	28,040	2,165	510,891	94,532	259,753	2,024,366

Table 9. Comparison of 24-hour sampling estimates with daily nine-hour sampling estimates for the Yukon River sonar project, 1999.

Date	Sampling Method	Right Bank Passage	Left Bank Nearshore Passage	Left Bank Offshore Passage	Total Passage	Total % Differences
6/26/99	24-hr	24,340	31,496	16,272	72,108	4.21%
	9-hr	20,222	35,544	13,428	69,194	
7/11/99	24-hr	8,329	9,243	6,365	23,937	1.64%
	9-hr	8,045	9,202	6,303	23,550	
7/24/99	24-hr	6,879	16,018	15,049	37,946	-3.05%
	9-hr	6,031	16,410	16,697	39,138	
8/8/99	24-hr	2,875	4,606	3,216	10,697	-1.17%
	9-hr	2,794	5,012	3,018	10,824	
8/21/99	24-hr	3,380	5,640	3,820	12,840	-14.52%
	9-hr	3,582	7,331	4,108	15,021	
		========	========	========	========	
TOTAL	24-hr	45,803	67,003	44,722	157,528	-0.13%
	9-hr	40,674	73,499	43,554	157,727	
% Differences by zone:		12.61%	-8.84%	2.68%	-0.13%	

Table 10. Standard target data collected 13 July 1999 at the Yukon River sonar project.

File Name	Mean TS (dB)	Lower 90% (dB)	Upper 90% (dB)	Average Range (m)	N	Percent Over-Axis
19411RD2.xls	-29.5	-36.7	-25.2	26.4	2686	59.5%
19412RD2.xls	-23.9	-28.0	-21.6	16.9	2145	0.2%
19413RD2.xls	-33.6	-41.7	-28.3	19.8	2566	56.2%
19414RD2.xls	-37.6	-44.9	-33.1	19.9	938	42.8%

Note: All target work done using a 3" stainless steel sphere located in roughly the same position in relation to the river bottom.

Table 11. Yukon River chinook salmon mean length by year and the approximate length that separates the age groups, 1993-1998.

Year	Mean Length 1.2	1.3	1.4	1.5	Estimated Split Between: 1.2 & 1.3	1.3 & 1.4	1.4 & 1.5
1993	573	738	855	933	648	804	894
1994	577	749	854	909	667	802	881
1995	569	764	857	918	658	819	885
1996	553	744	846	904	651	796	875
1997	580	739	853	896	642	808	874
1998	557	754	837	891	665	797	863
Average	568	748	850	909	655	804	879

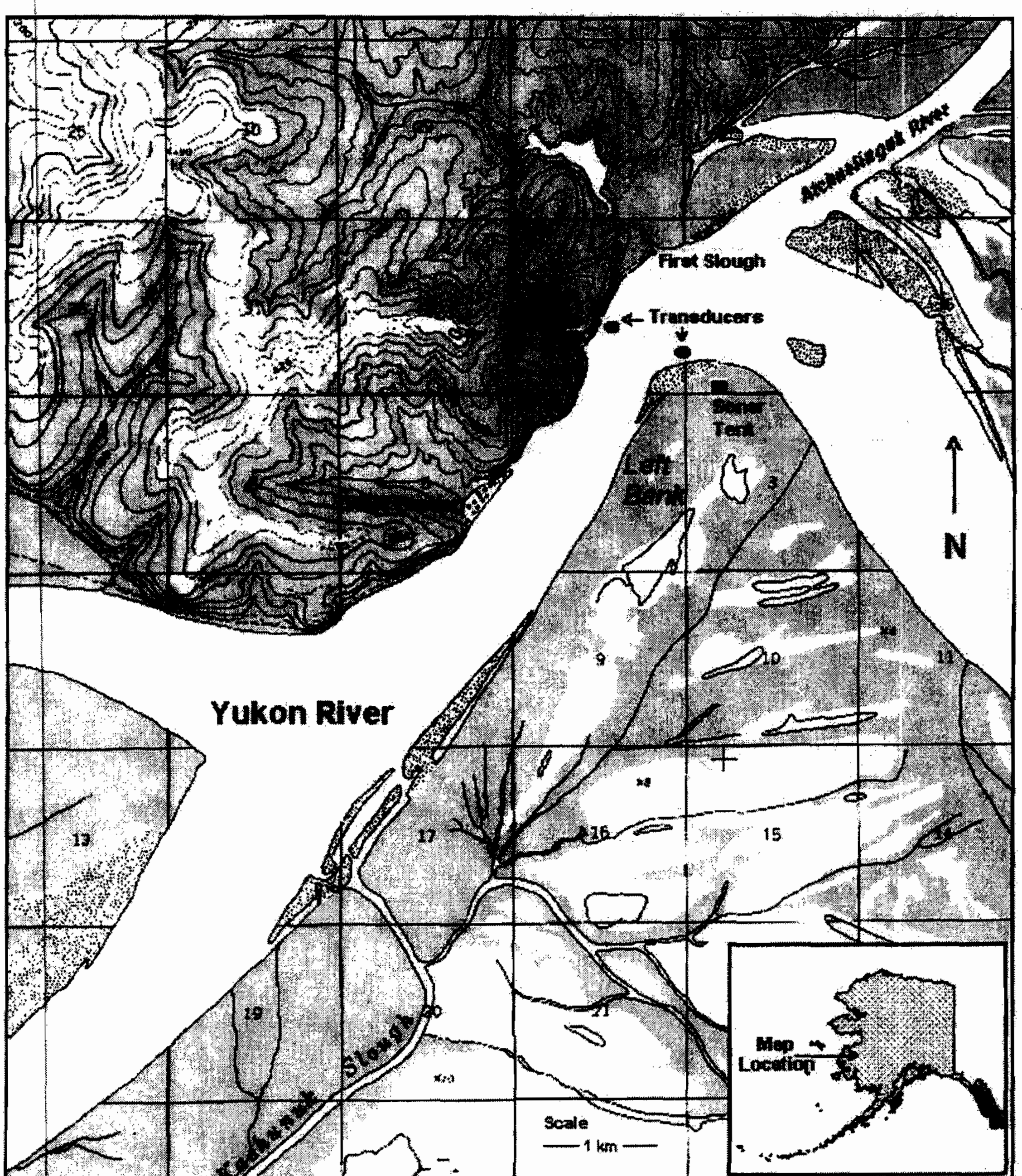


Figure 1. Topographical map of the Yukon River in the vicinity of the sonar site.

Right Bank Thalweg

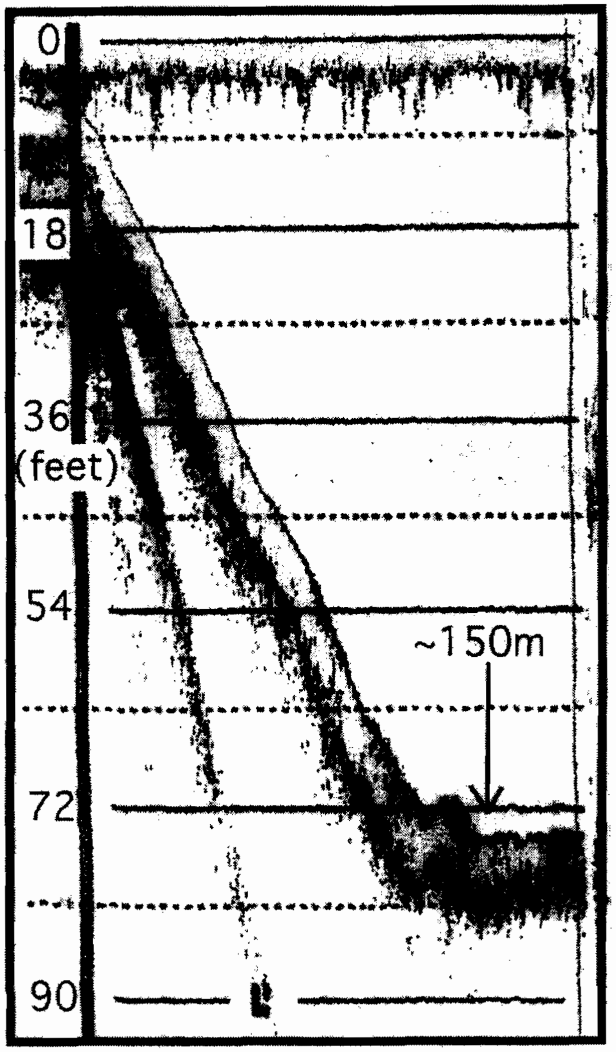


Figure 2. Yukon River right-bank profile recorded on 10 August 1999. The flat slope beginning at about 150 m is the thalweg beyond the project's ensonified range.

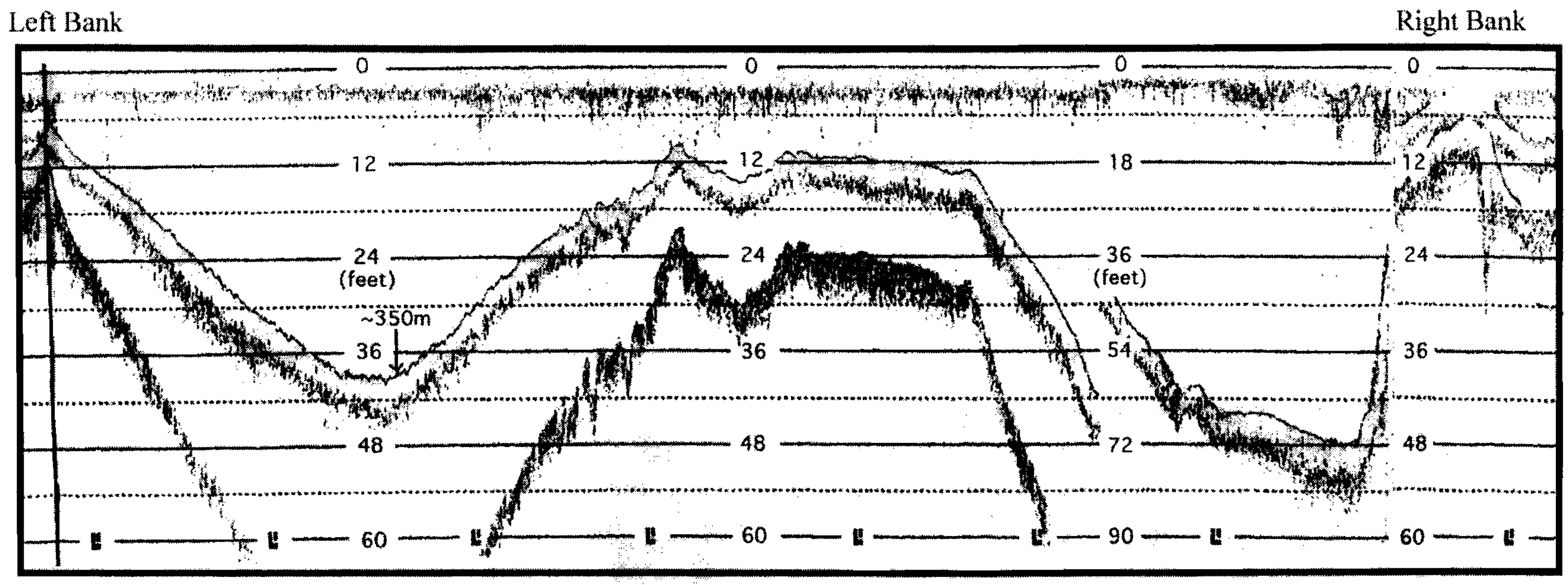


Figure 3. Yukon River left-bank profile recorded on 10 August 1999. The upward slope past the 350m point marks the edge of the mid-river sandbar beyond the project's ensonified range.

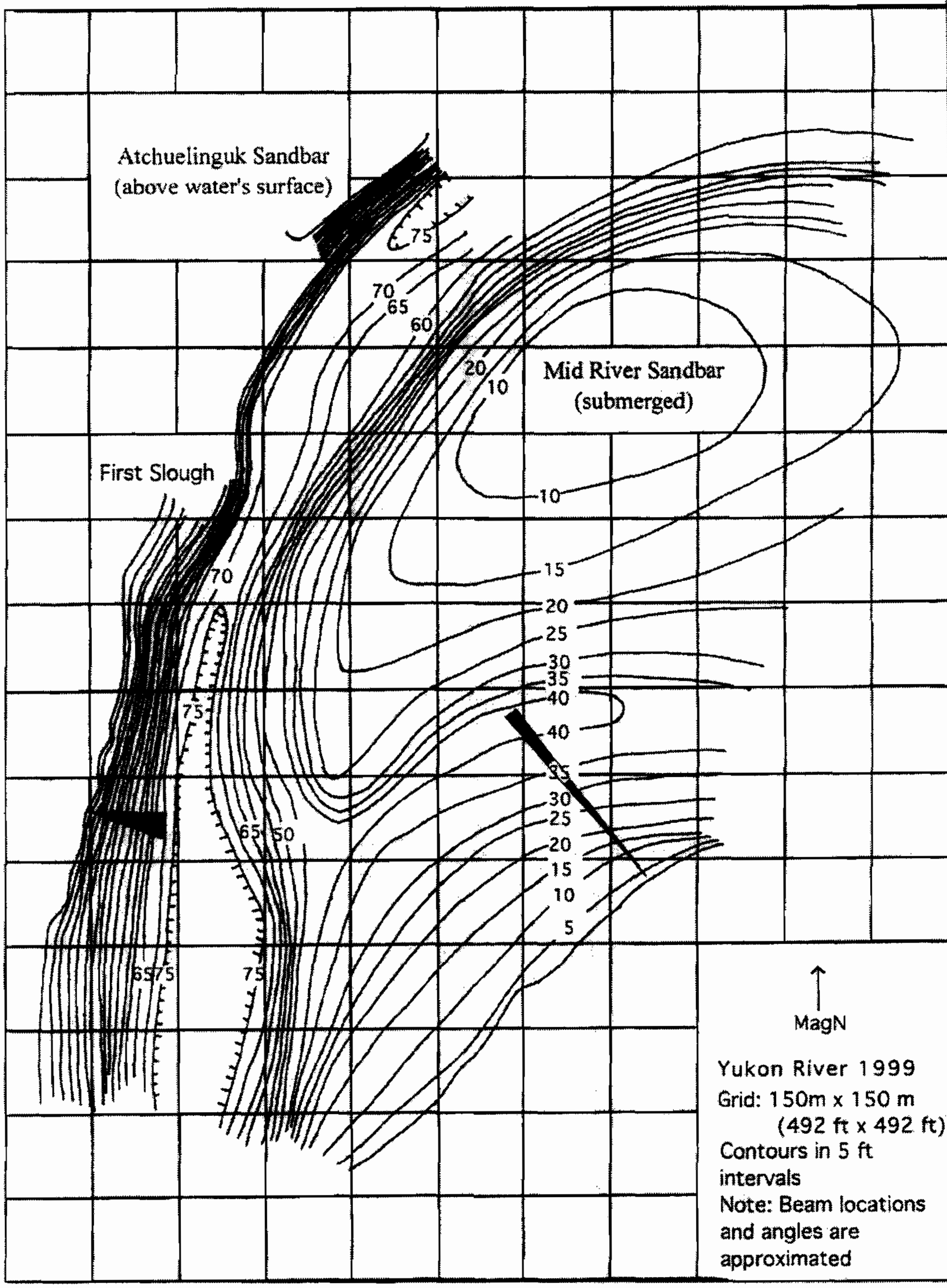


Figure 4. Bathymetric map of the Yukon River sonar sampling area, 1999.

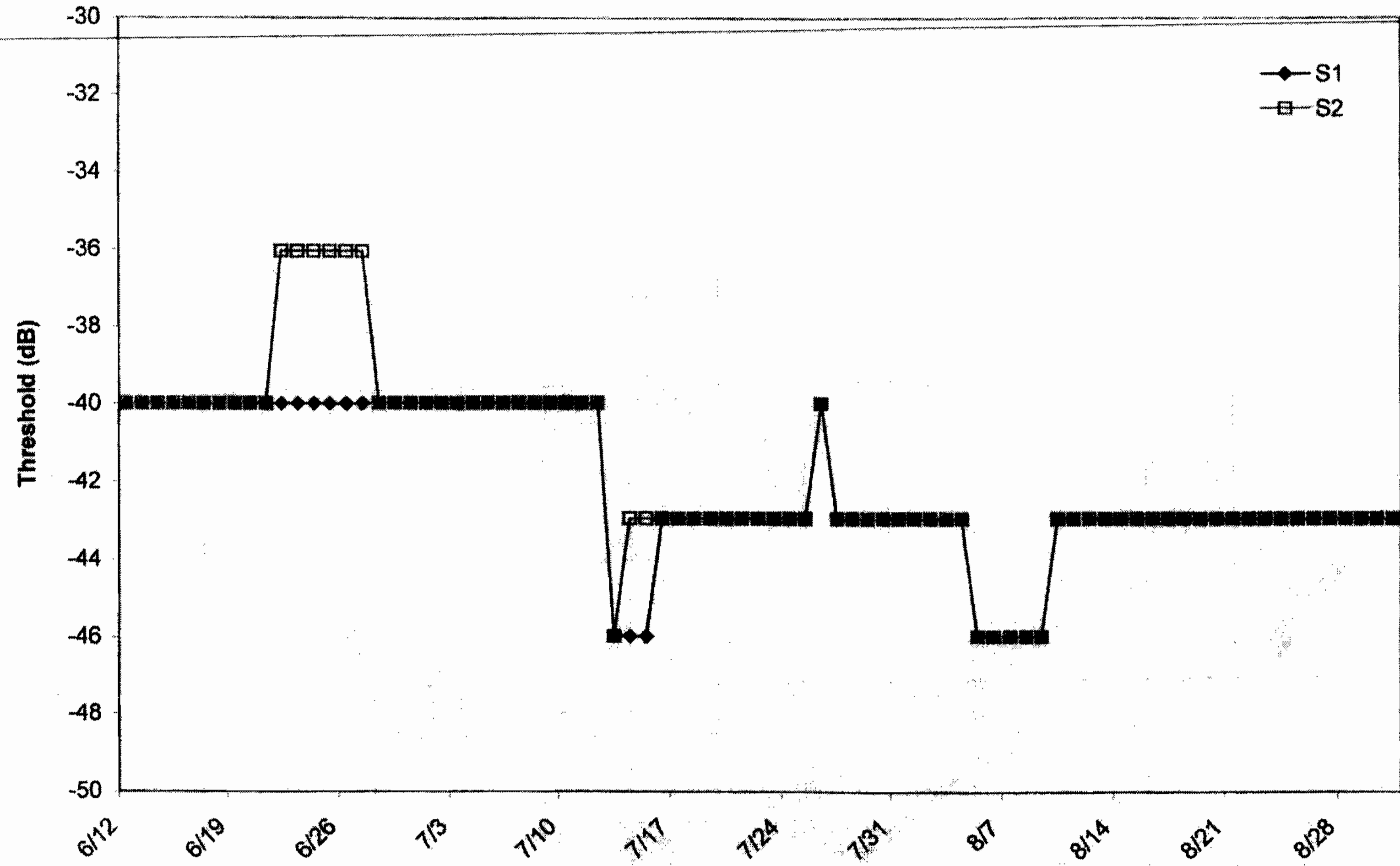


Figure 5. Thresholds used on right bank by strata and day, Yukon River sonar, 1999.

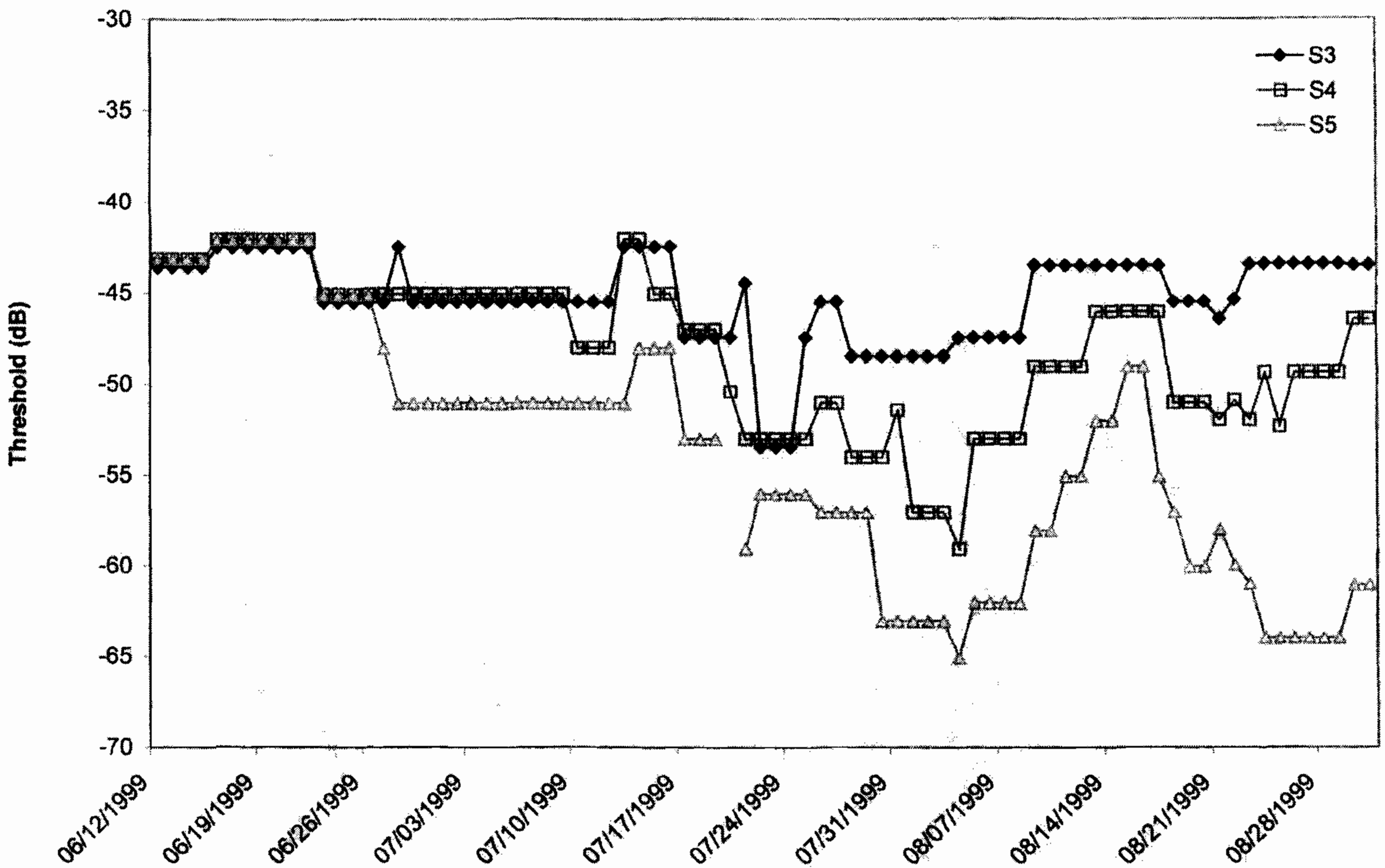
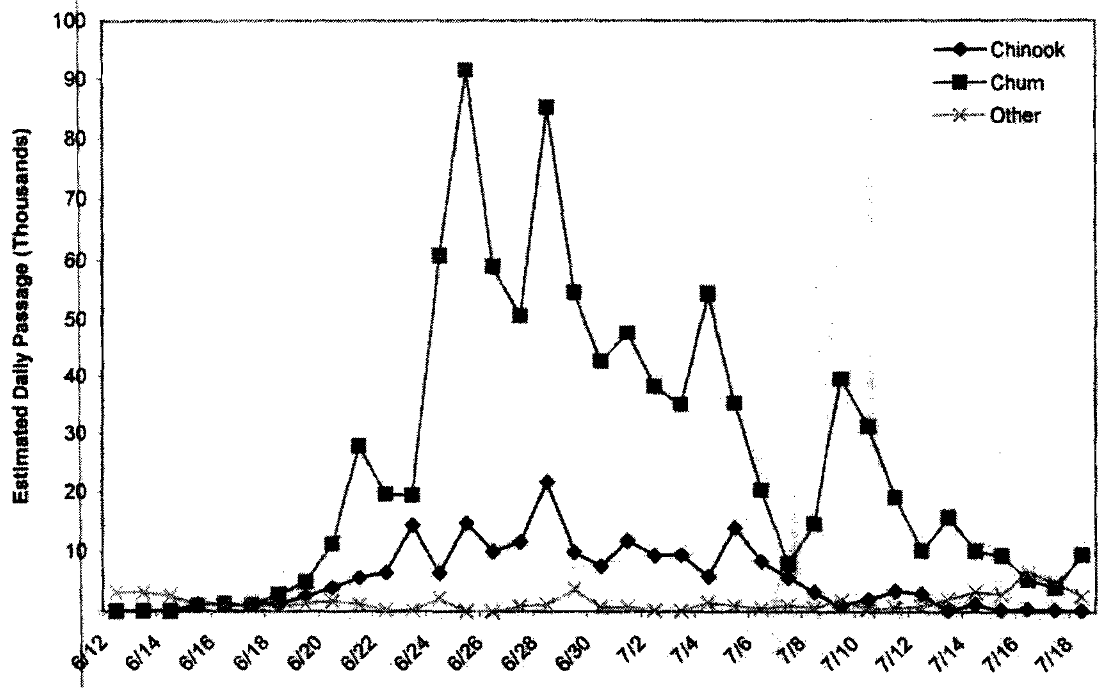


Figure 6. Thresholds used on left bank by strata and day, Yukon River sonar, 1999.



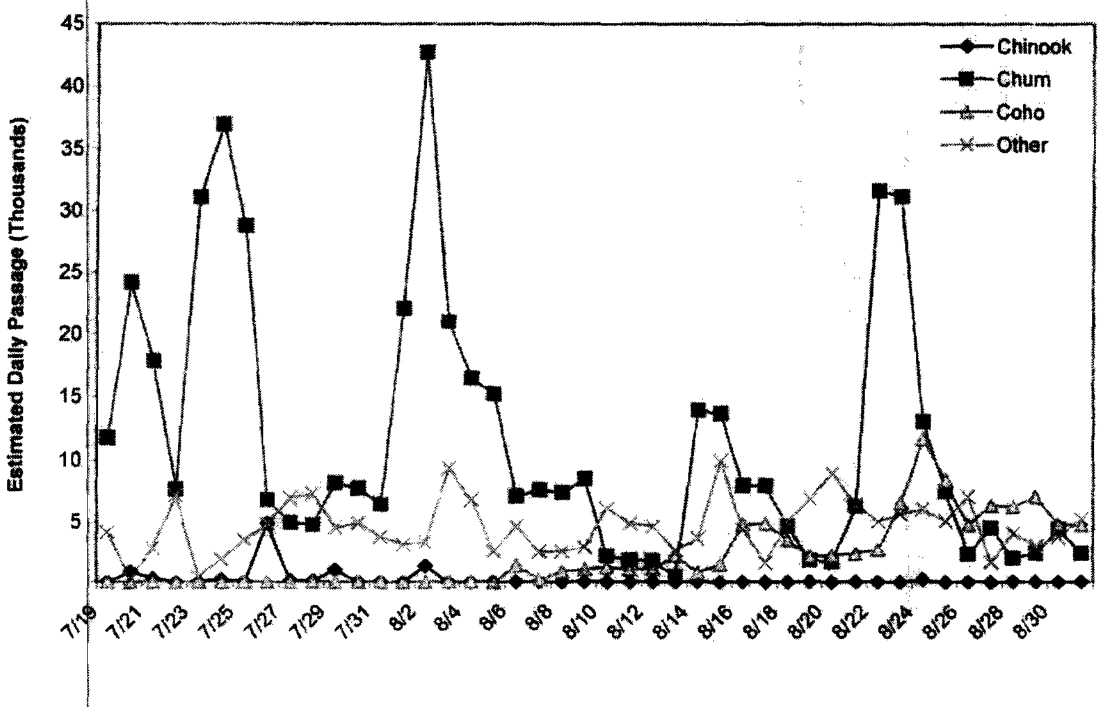
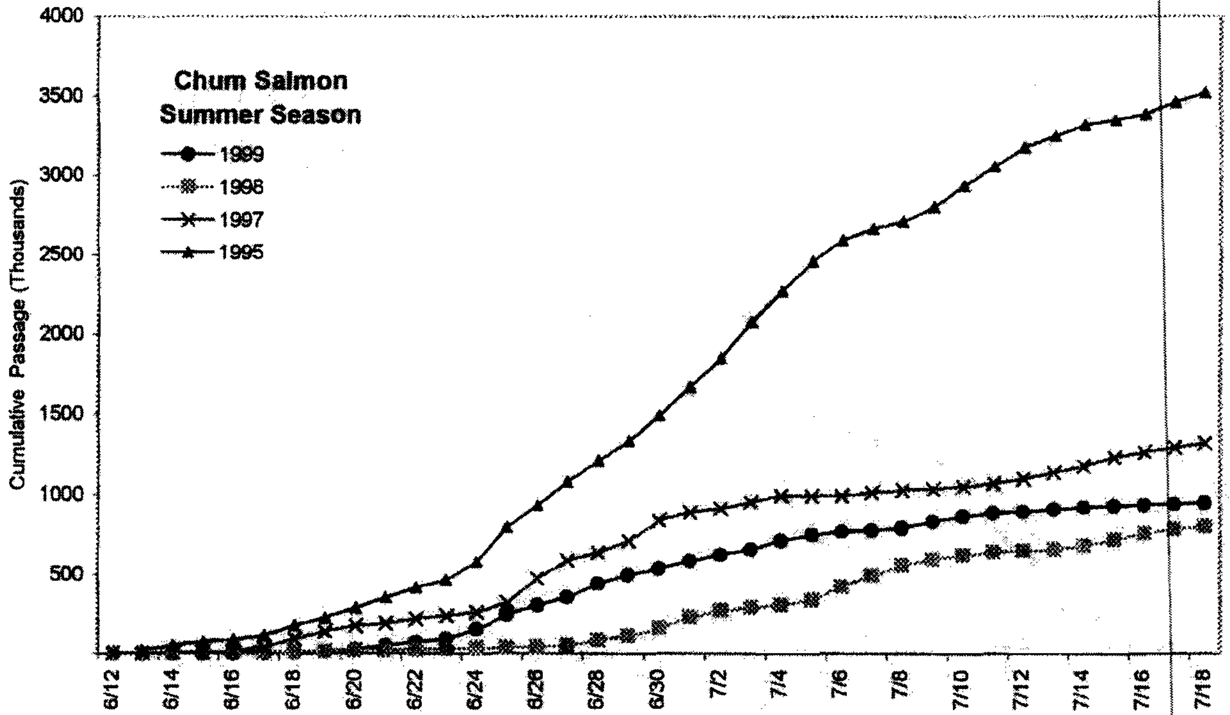


Figure 7. Estimated daily passage by species for summer (top) and fall (bottom) seasons, Yukon River sonar, 1999.



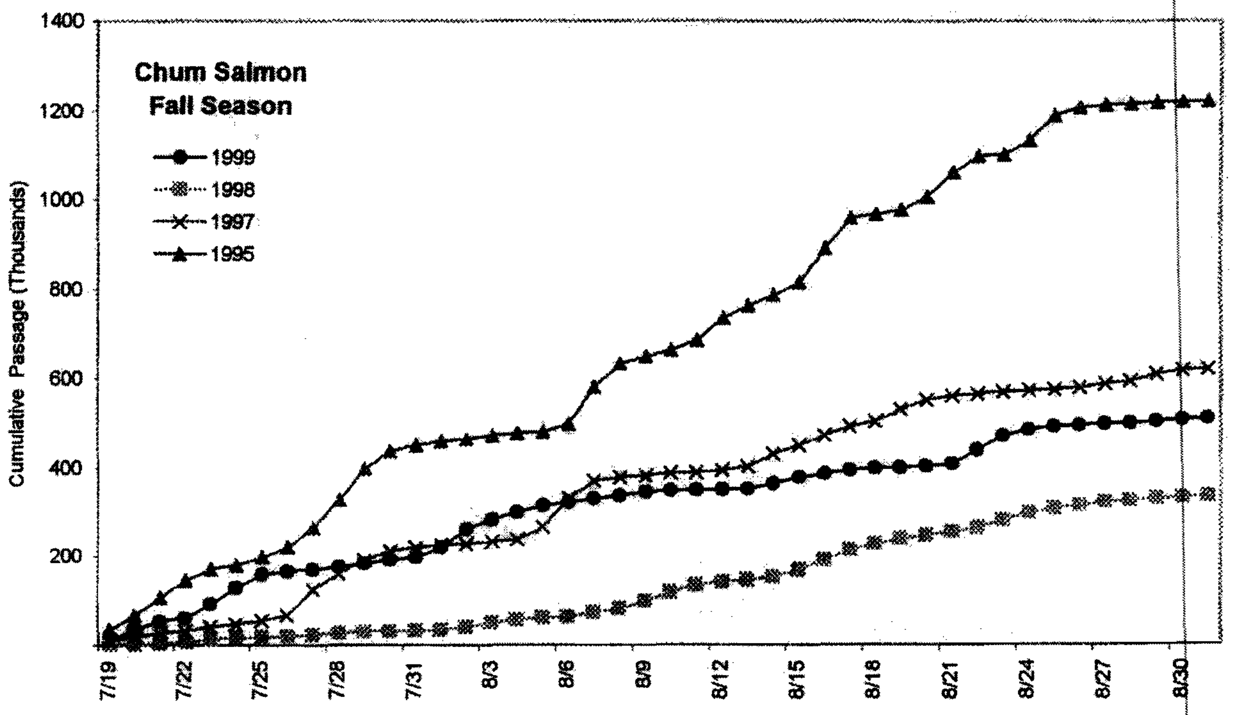


Figure 8. Cumulative passage for summer chum salmon (top) and fall chum salmon (bottom), Yukon River sonar 1995, 1997, 1998 and 1999.

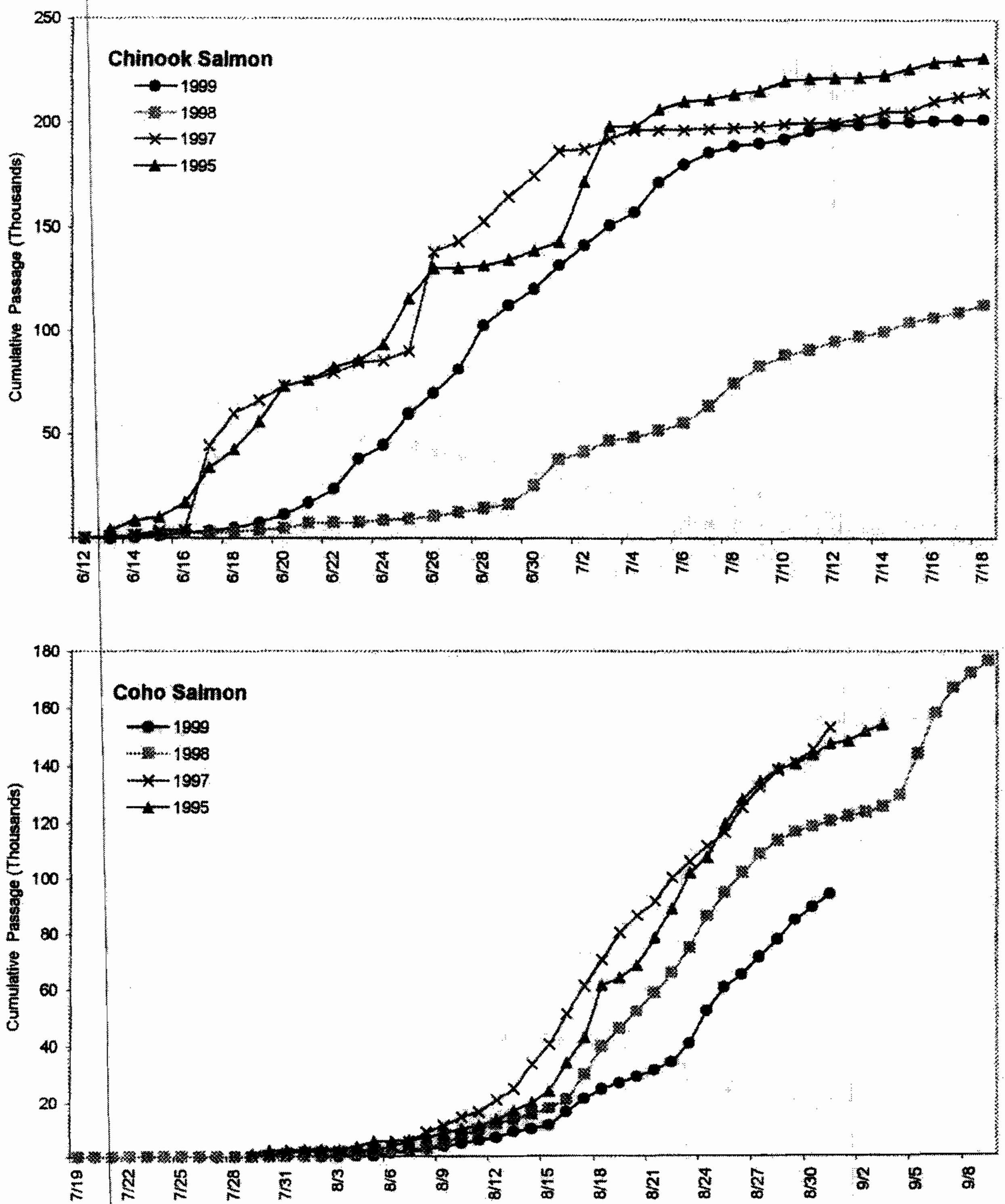
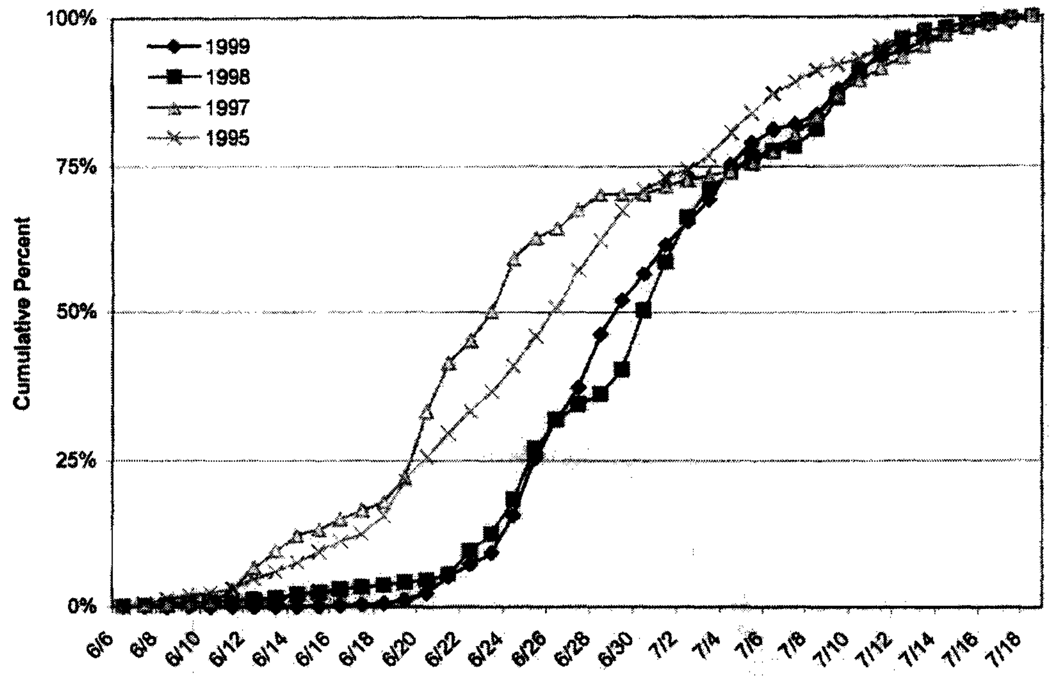


Figure 9. Cumulative passage for chinook salmon (top) and coho salmon (bottom), Yukon River sonar 1995, 1997, 1998 and 1999.



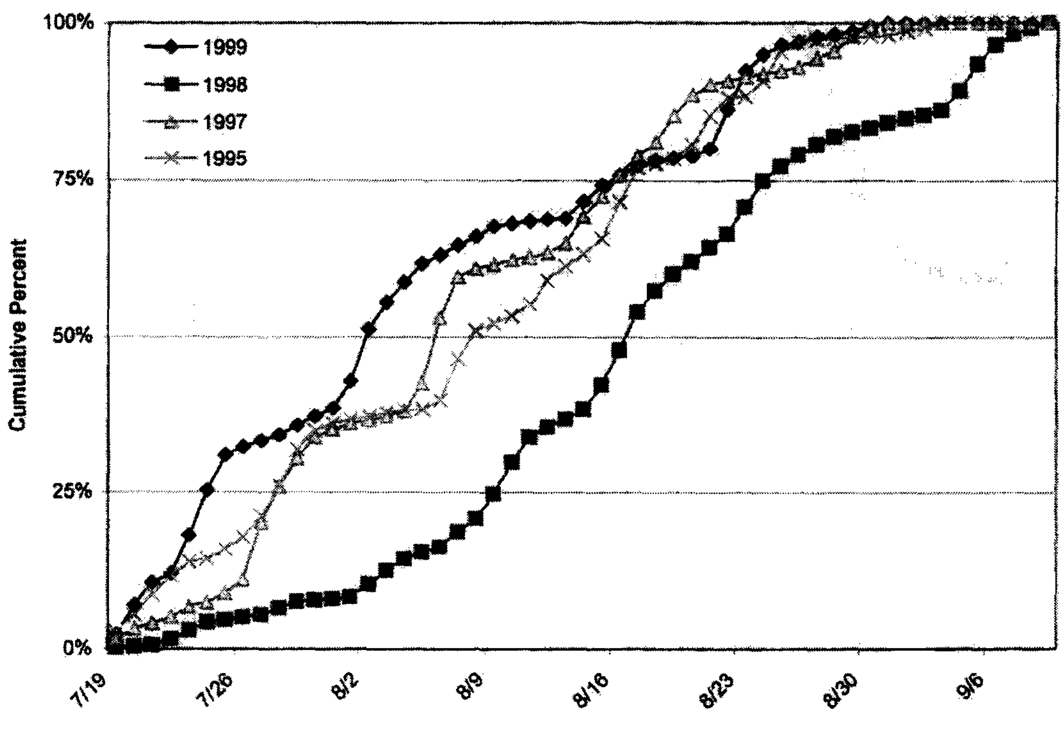


Figure 10. Cumulative percent of total passage by day for summer (top) and fall (bottom) chum salmon, Yukon River sonar, 1999.

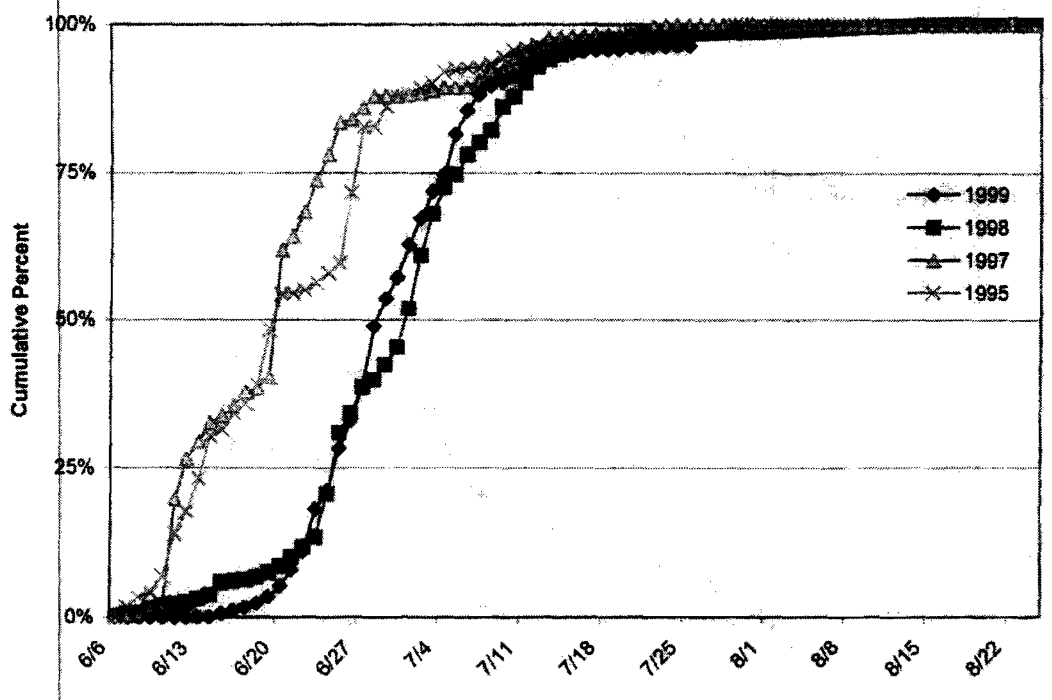


Figure 11. Cumulative percent of total passage by day for chinook salmon, Yukon River sonar, 1999.

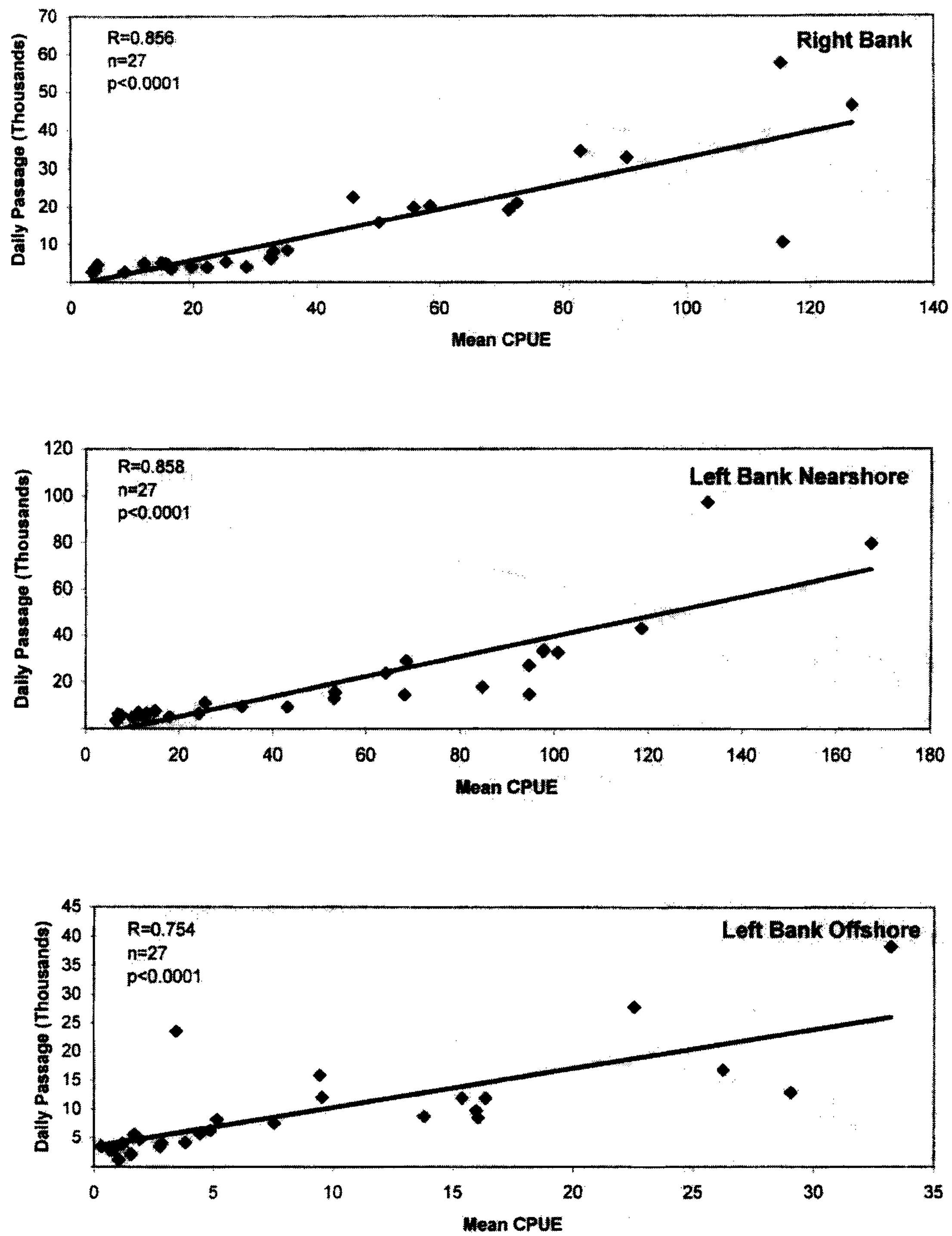


Figure 12. Mean CPUE versus daily sonar passage estimates by zone from 12 June to 18 July for the Yukon River sonar project, 1999.

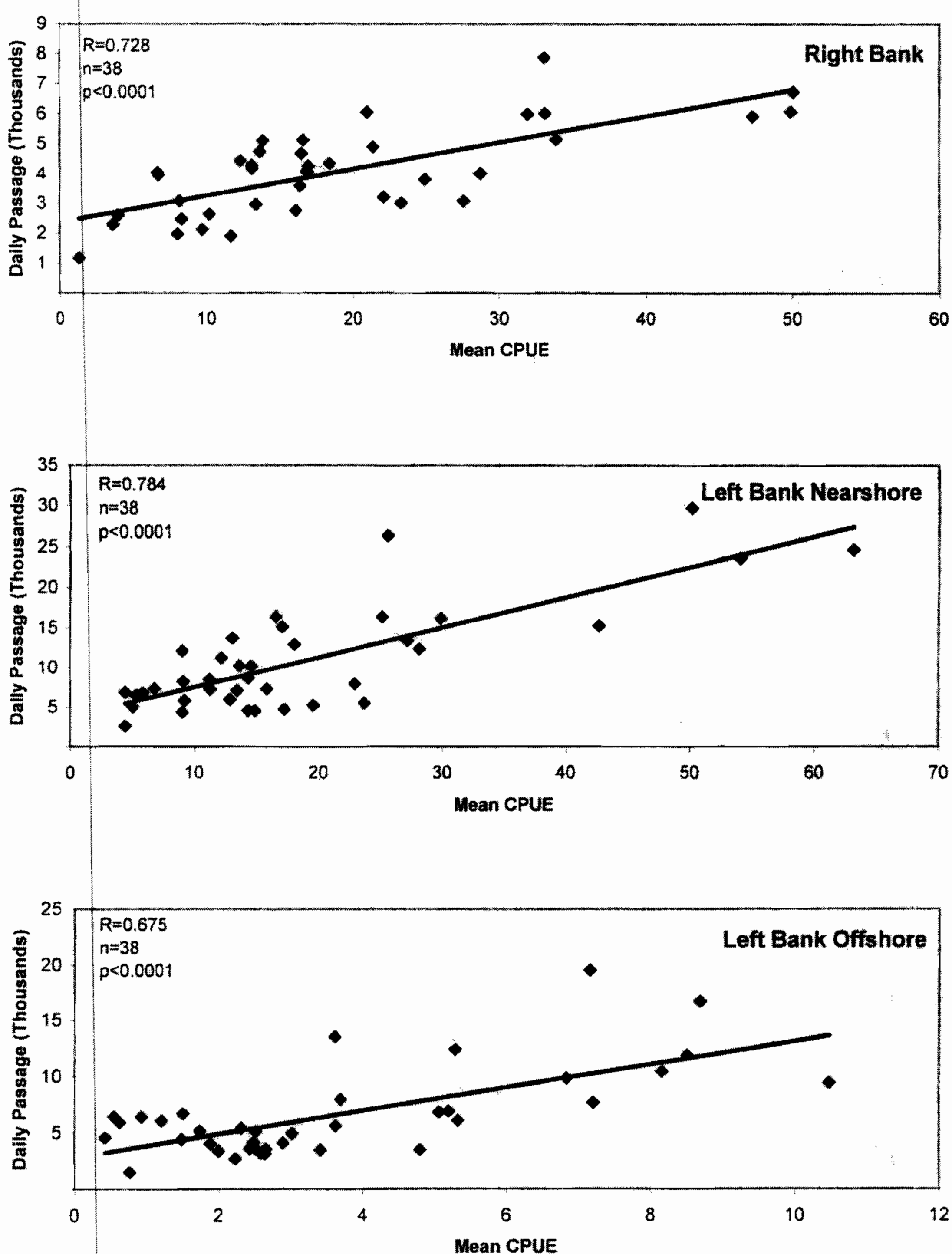


Figure 13. Mean CPUE versus daily sonar passage estimates by zone from 19 July to 31 August for the Yukon River sonar project, 1999.

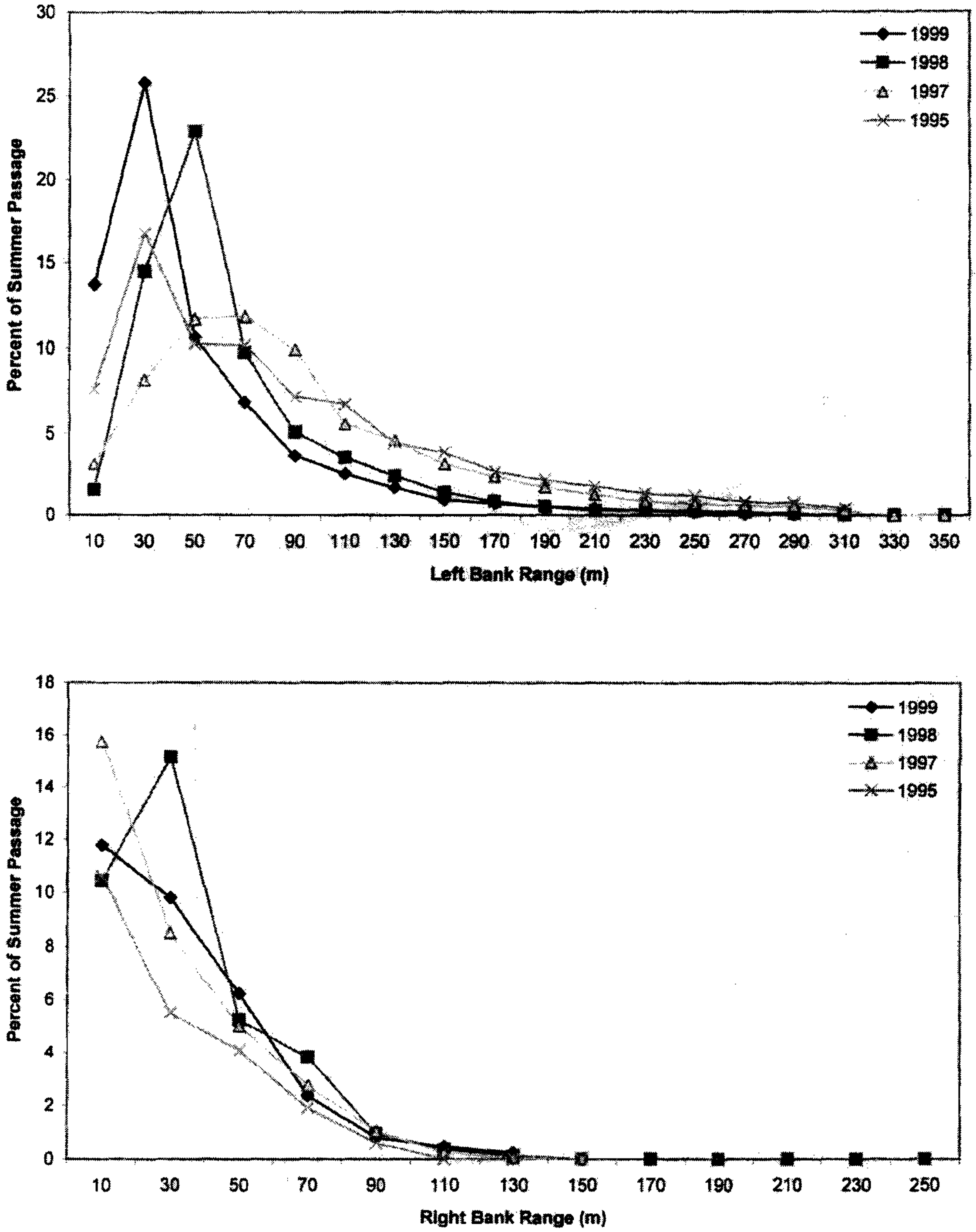


Figure 14. Horizontal distribution of left and right bank passage estimates for the Yukon River sonar project from 12 June through 18 July 1995 through 1999.

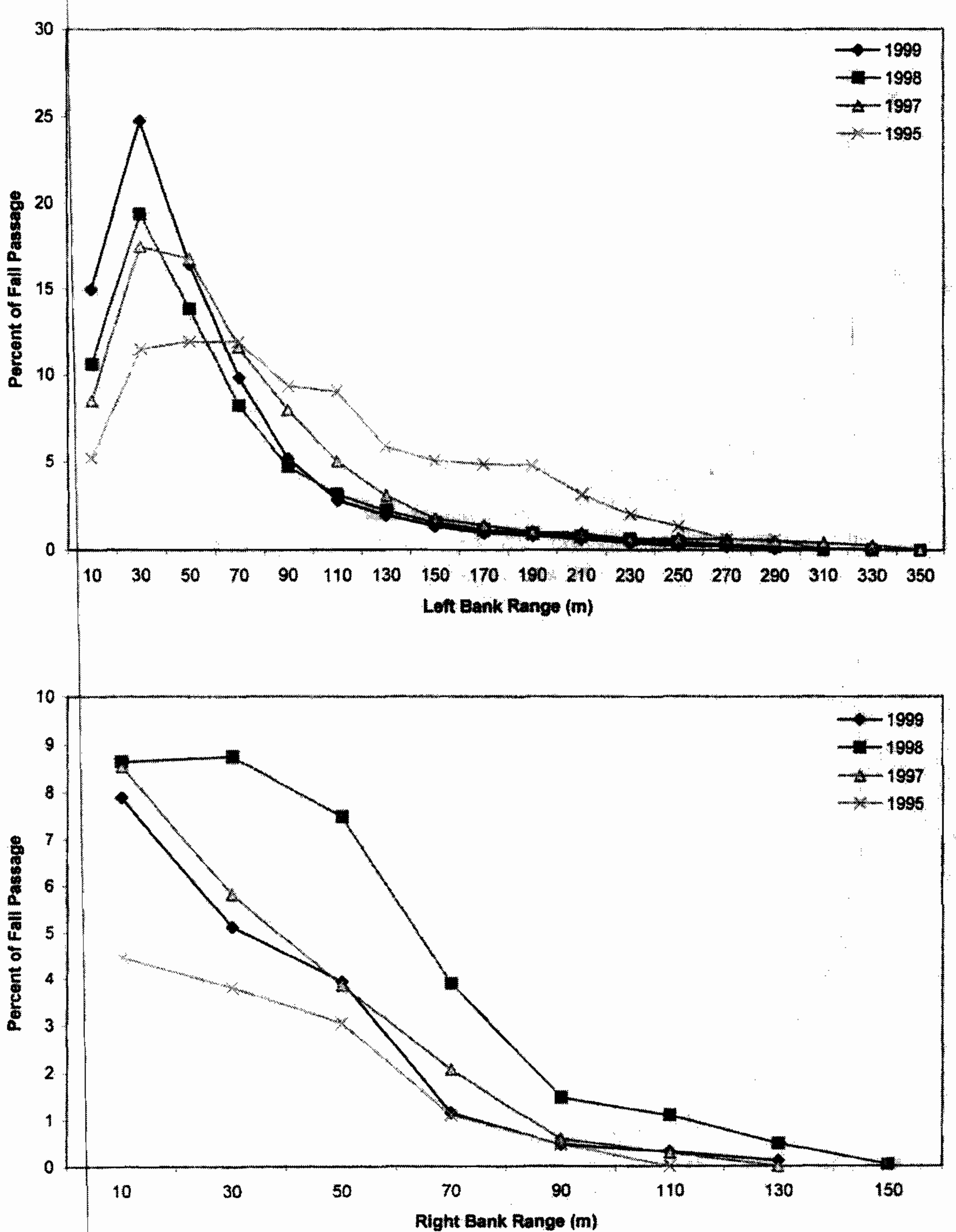


Figure 15. Horizontal distribution of left and right bank passage estimates for the Yukon River sonar project from 19 July through 31 August 1995 through 1999.

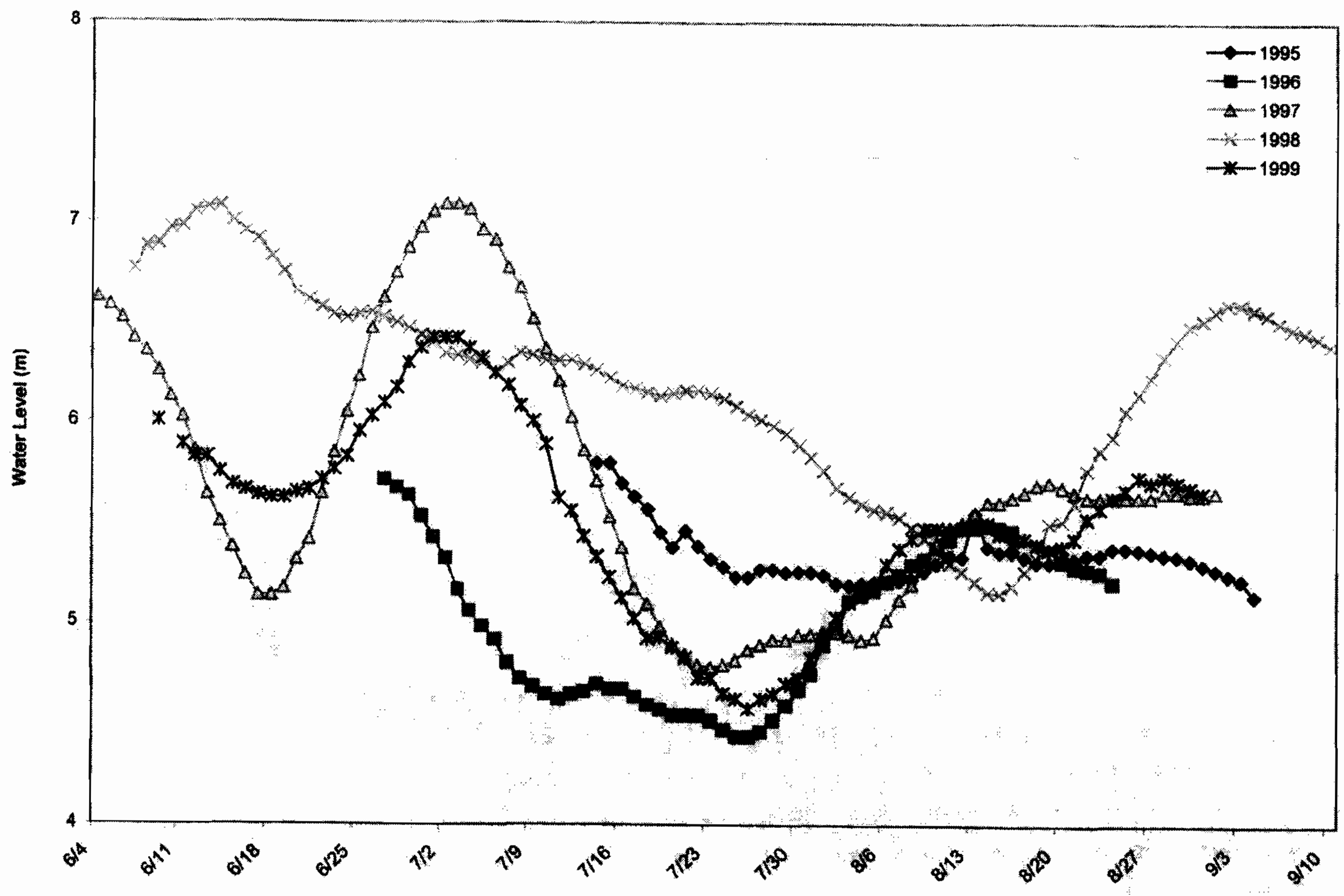


Figure 16. Yukon River daily water level, 1995 through 1999.

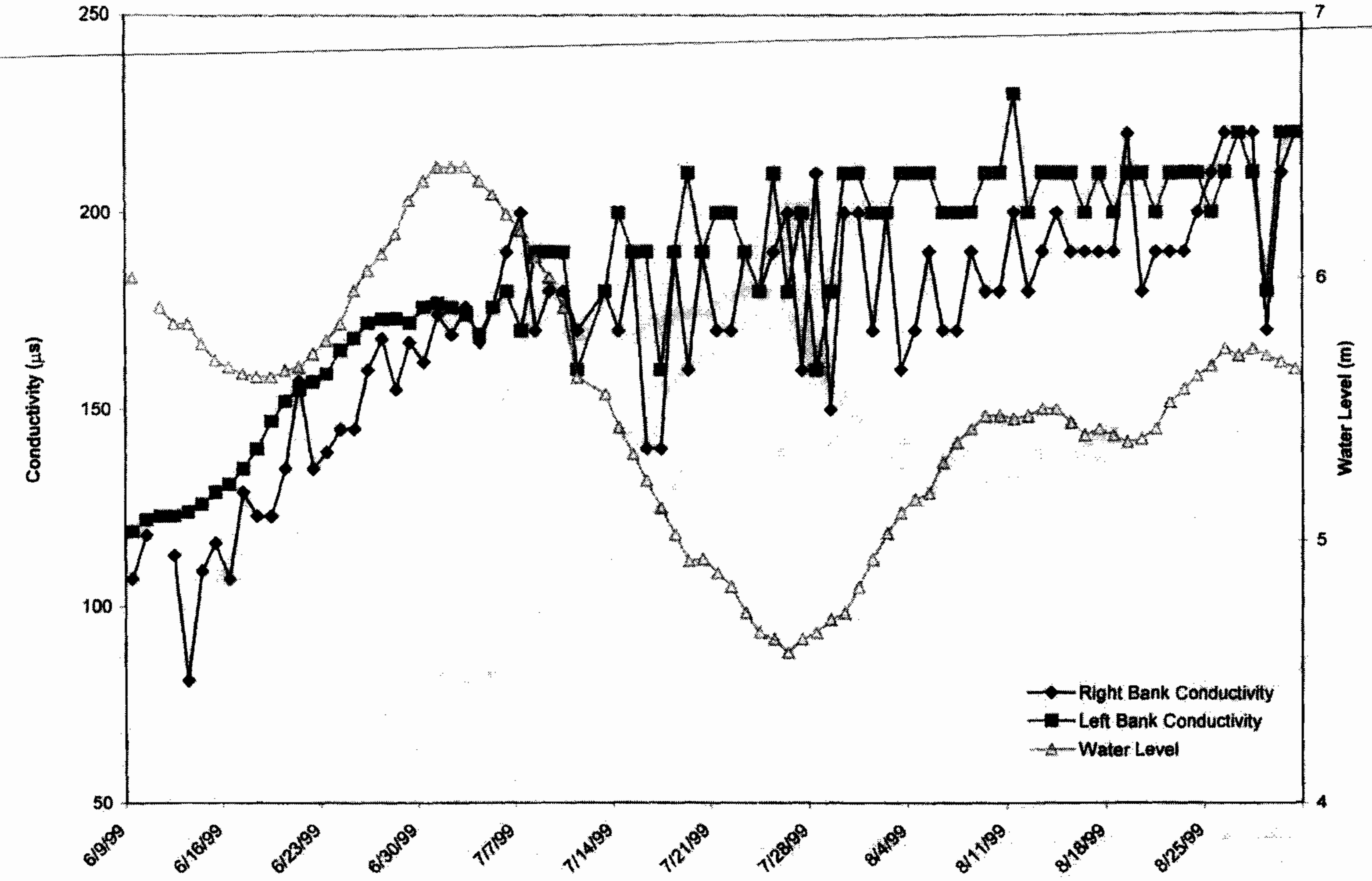


Figure 17. Daily Yukon River conductivity and water level recorded at the sonar project site, 1999.

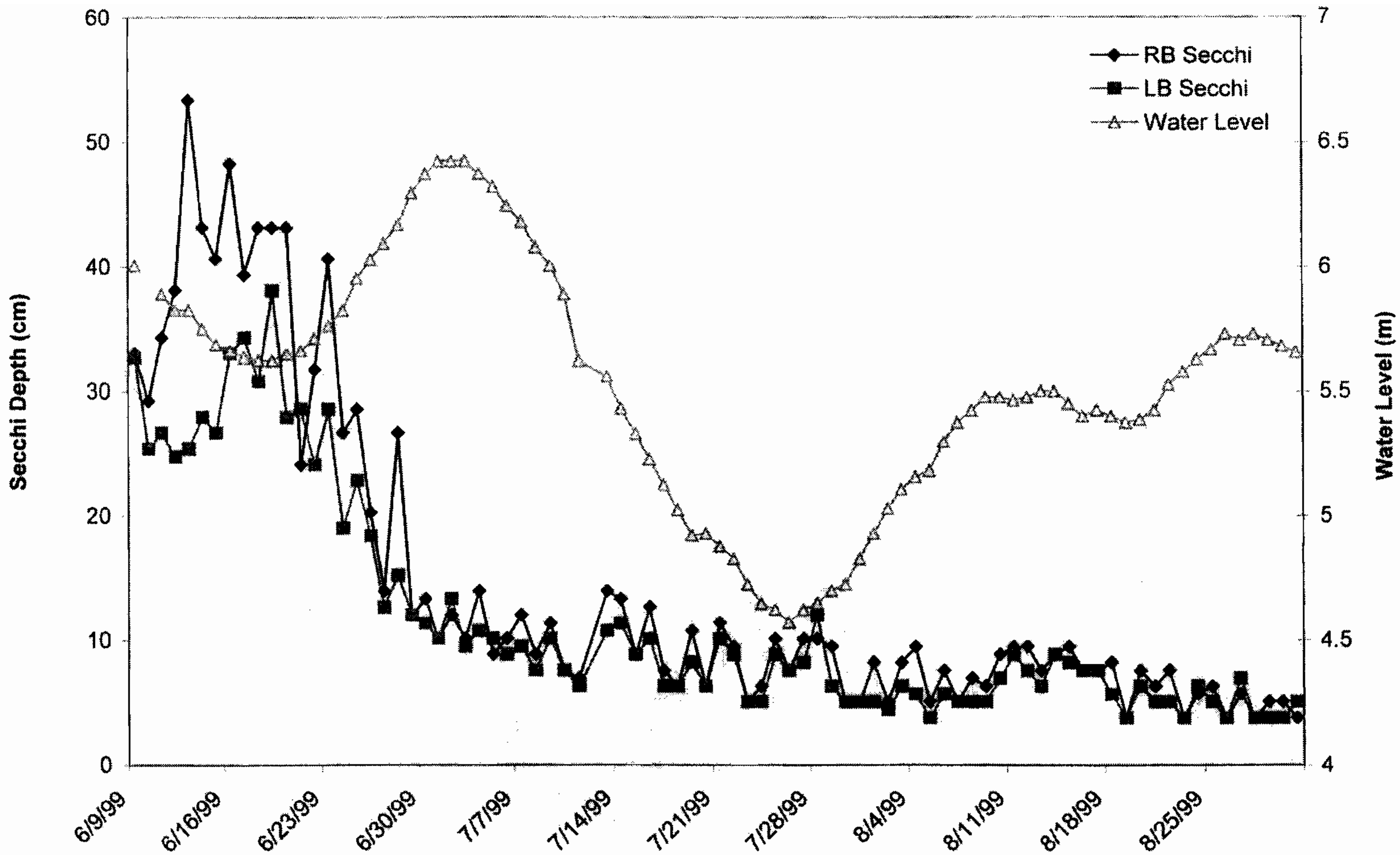


Figure 18. Comparison of daily right and left bank secchi measurements and water level at the Yukon River sonar project, 1999.

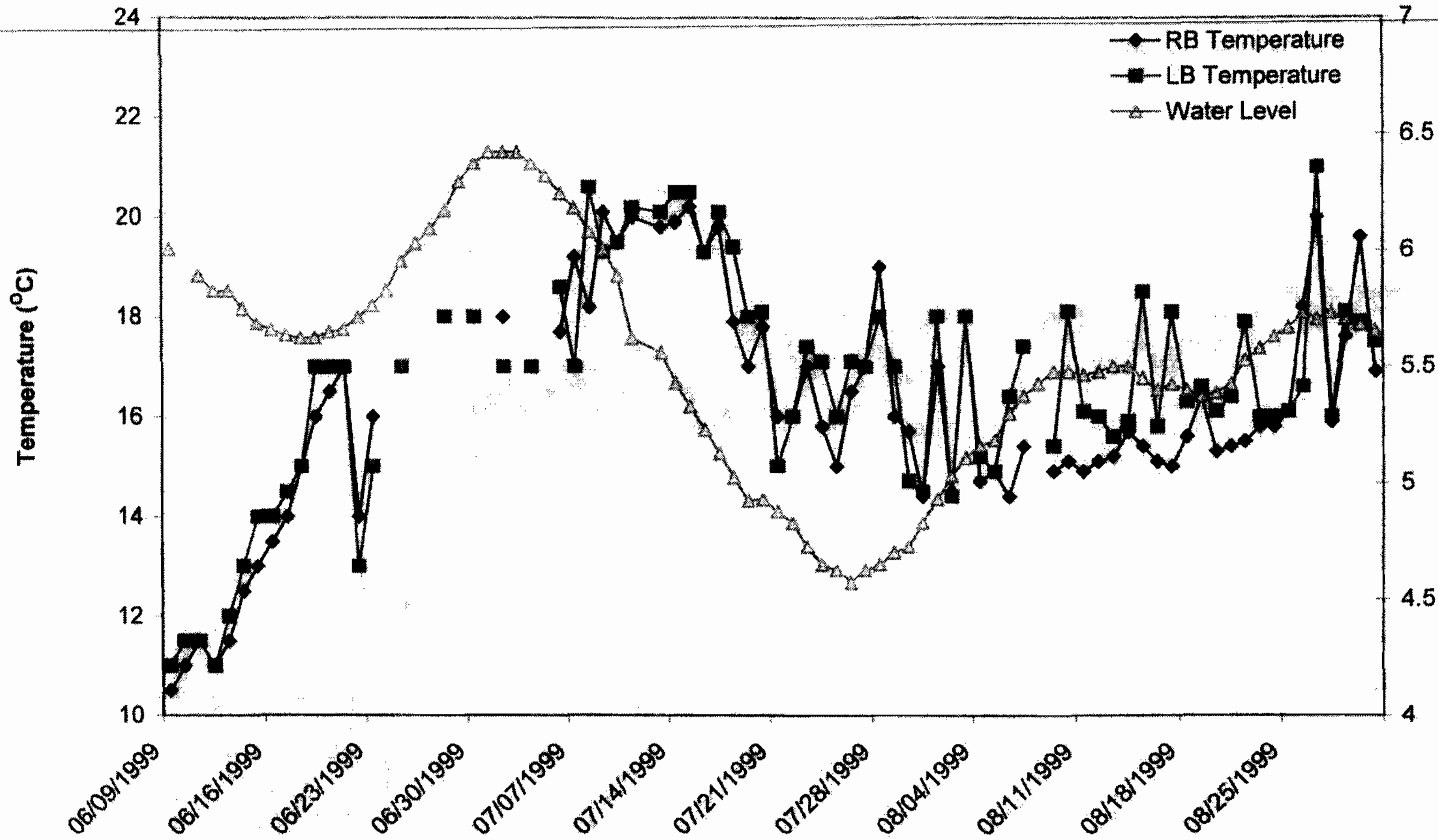
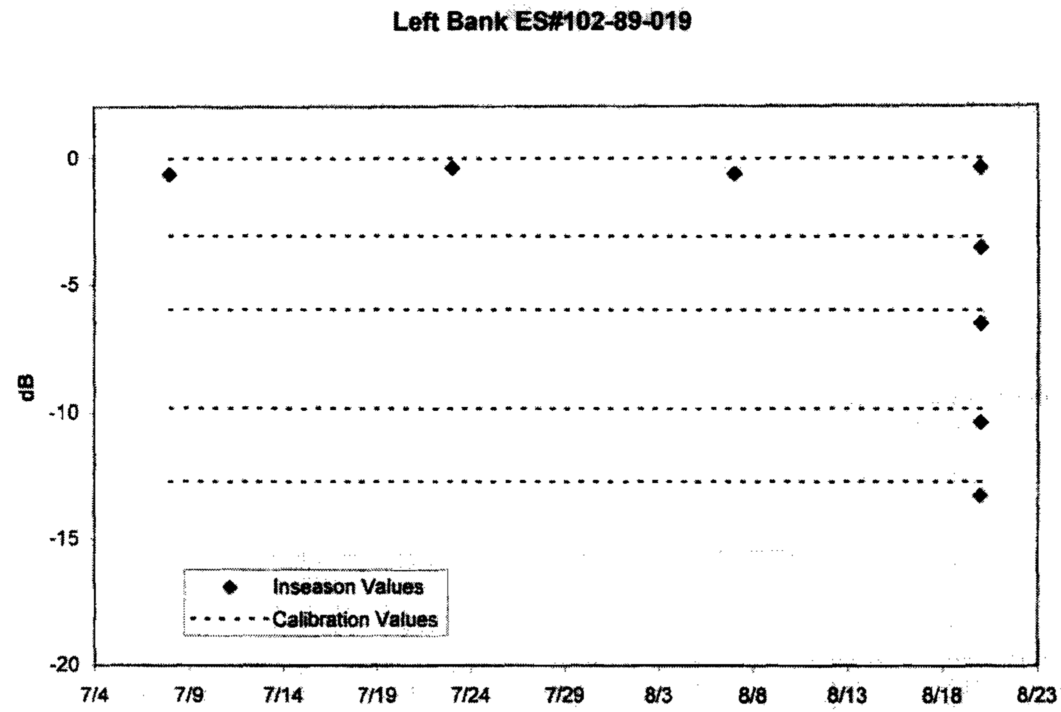
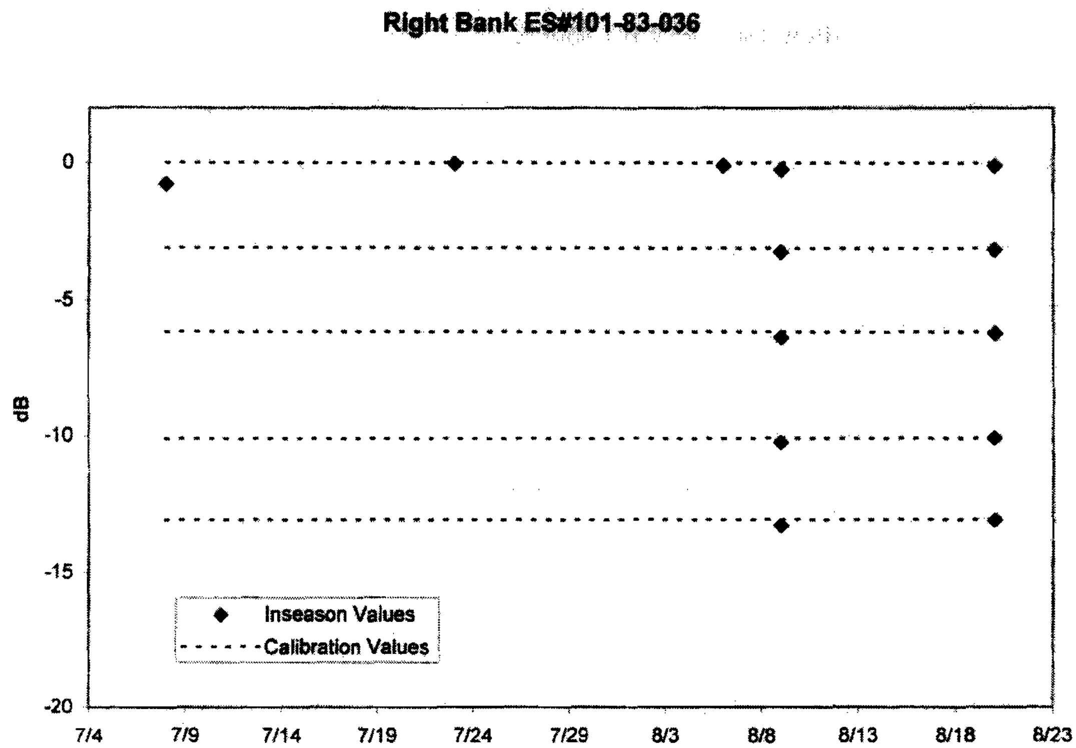
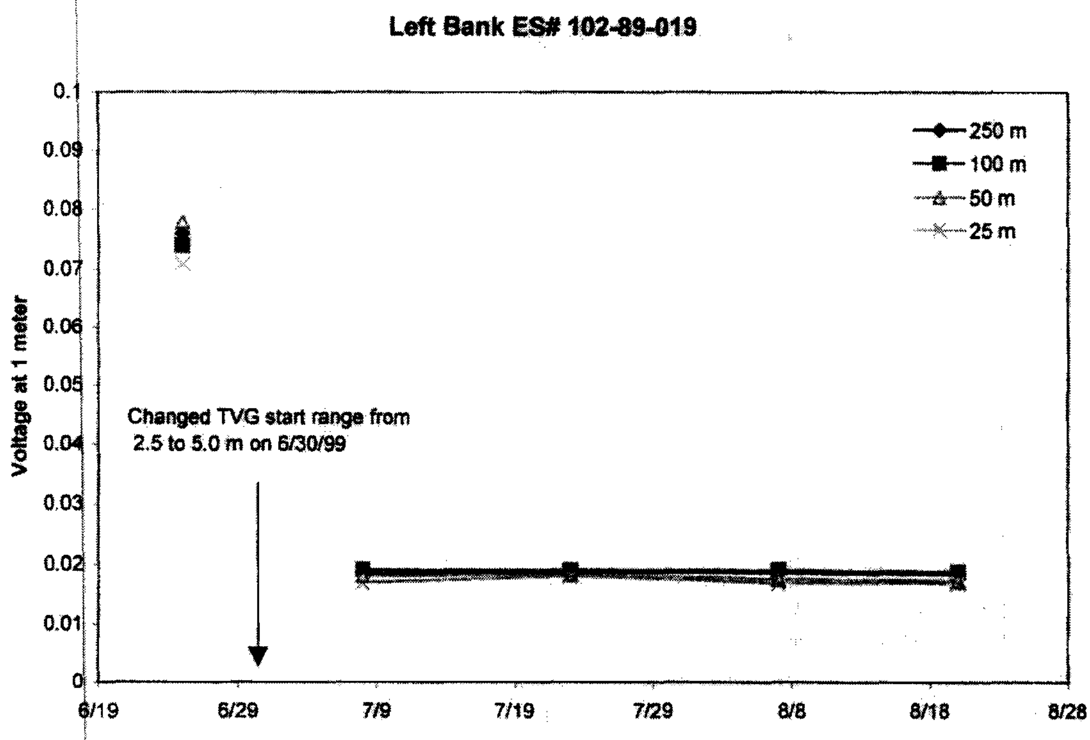


Figure 19. Comparison of daily right and left bank water temperatures and water level at the Yukon River sonar project, 1999.





igure 20. Transmitter output tests for Yukon River sonar project echosounders, 1999.



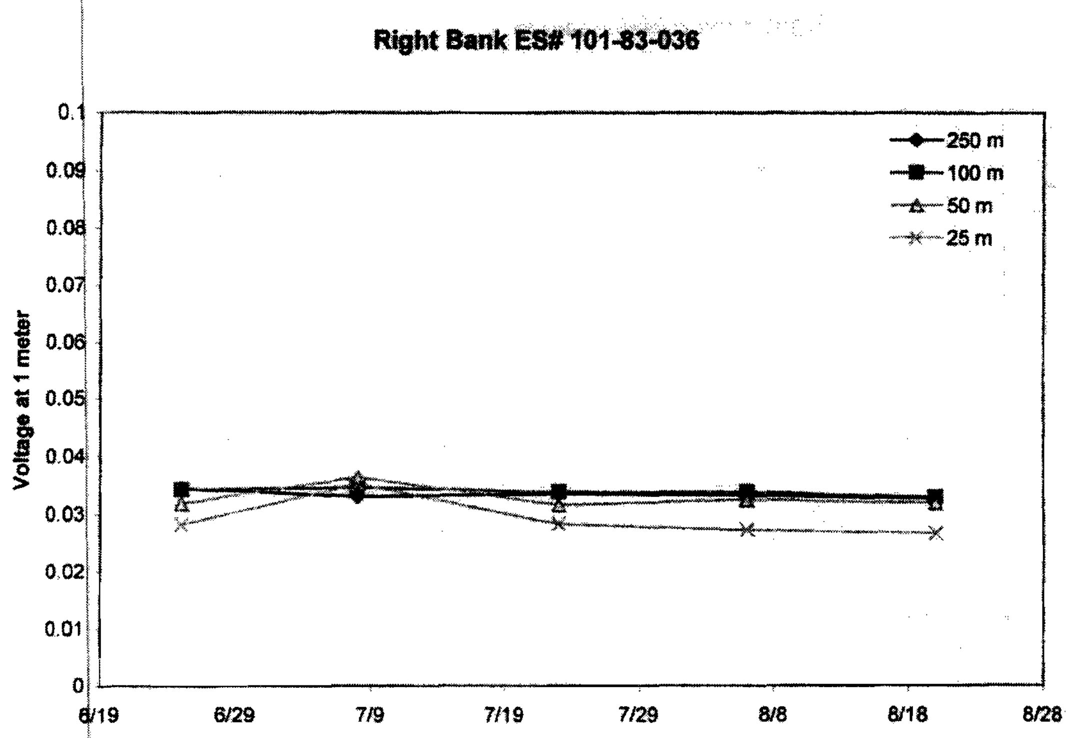


Figure 21. Time-varied gain performance of the Yukon River sonar project's echosounders, 1999.

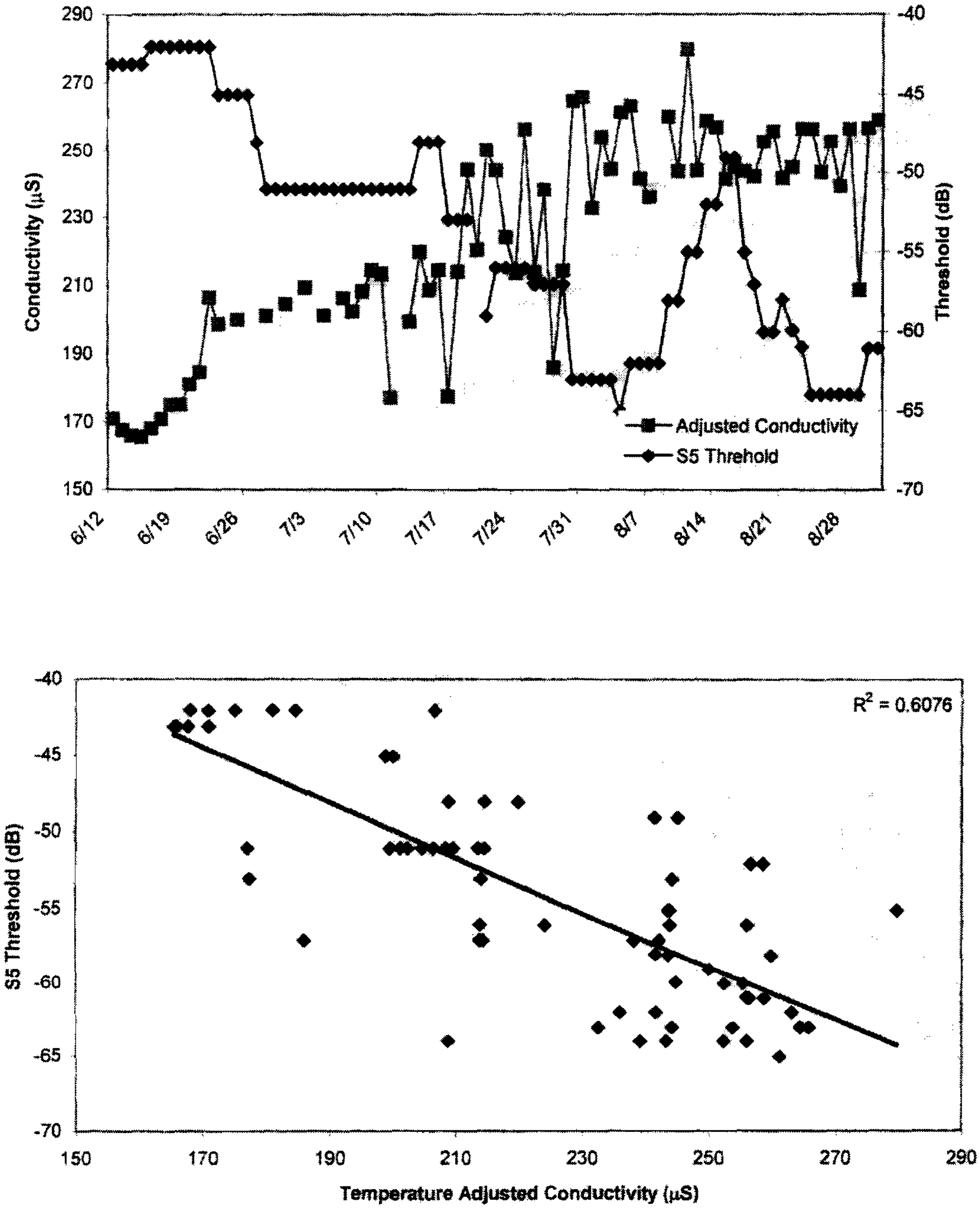
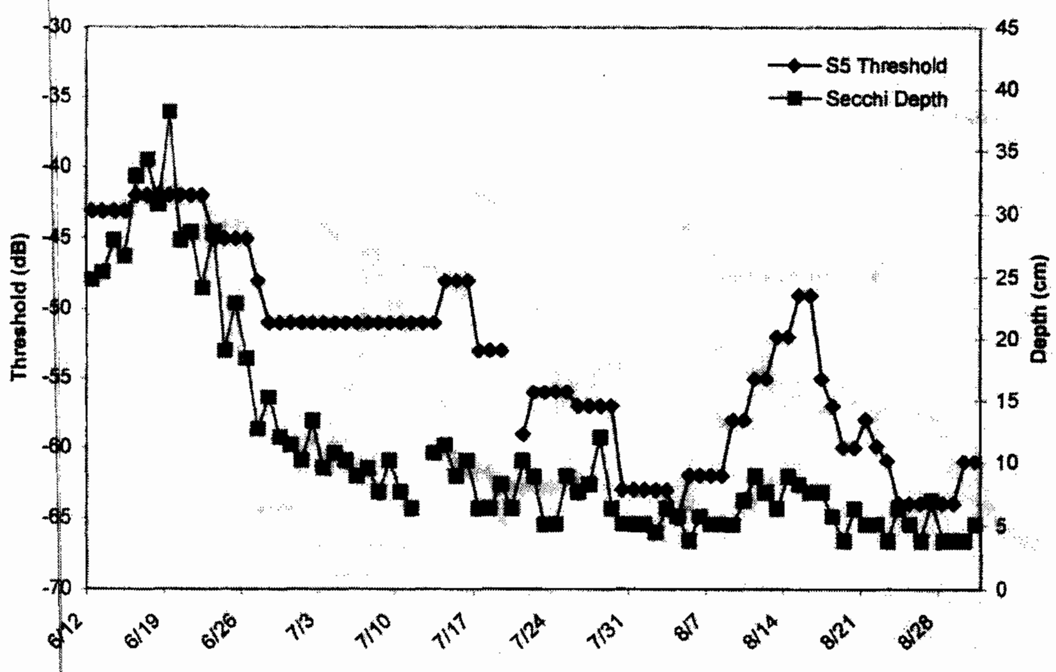


Figure 22. Temperature adjusted left bank conductivity versus stratum 5 threshold level for the Yukon River sonar project, 1999.



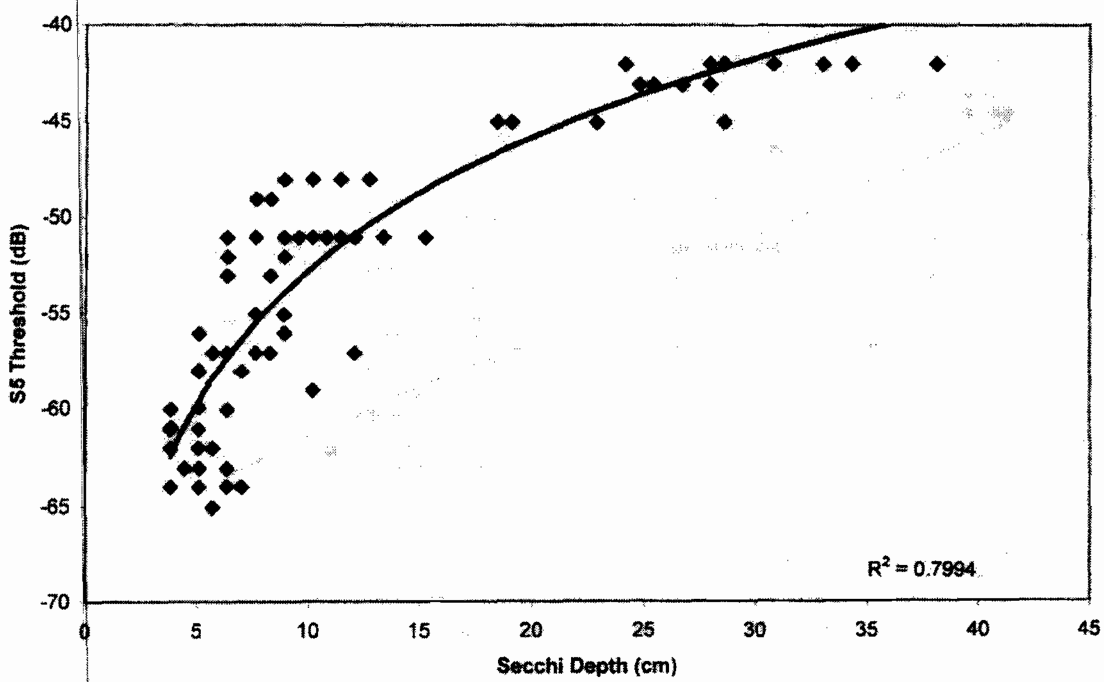


Figure 23. Comparison of daily left bank secchi readings and the stratum 5 thresholds used at the Yukon River sonar project, 1999.

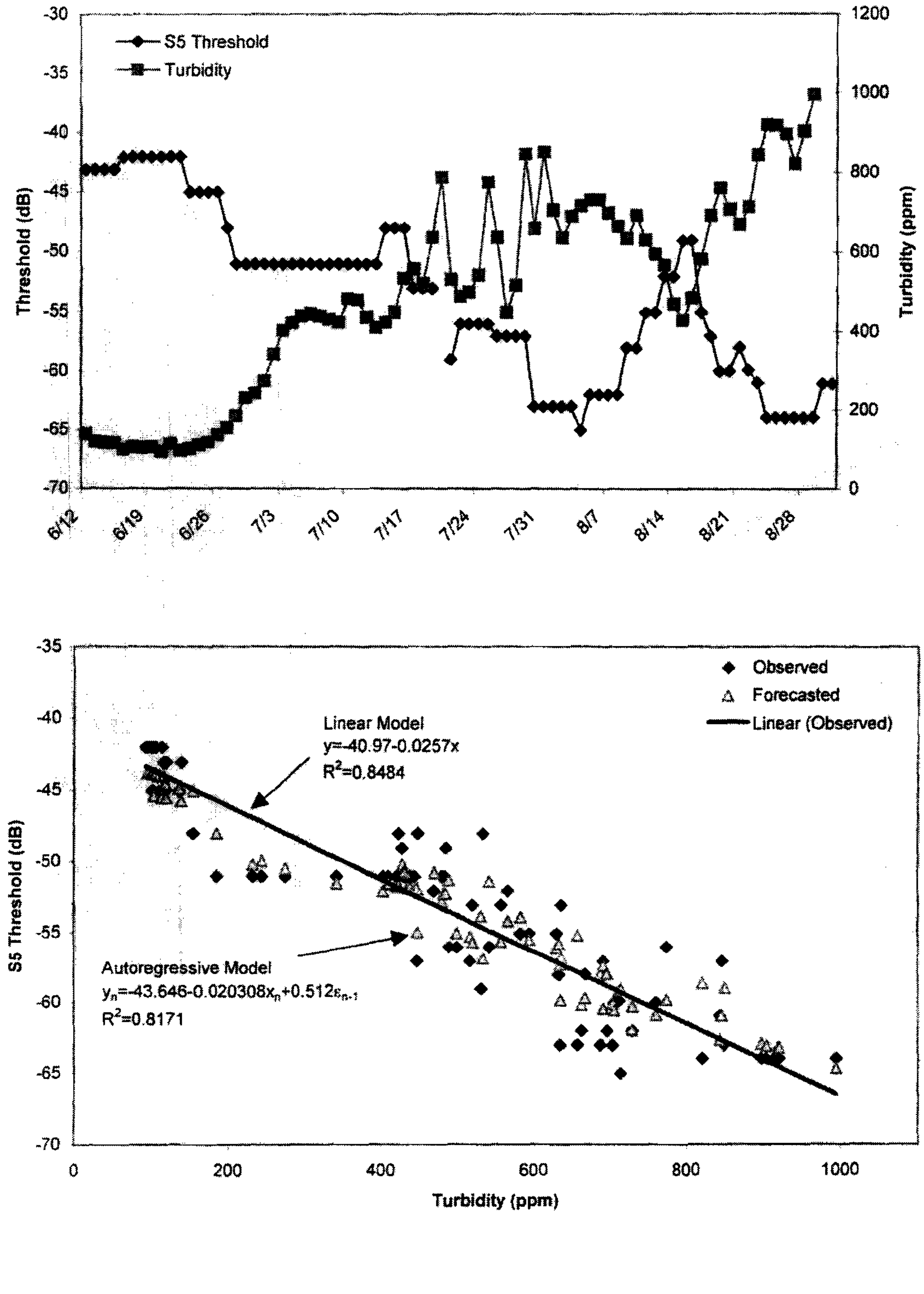


Figure 24. Comparison of daily average turbidity readings and stratum 5 thresholds used at the Yukon River sonar project, 1999.

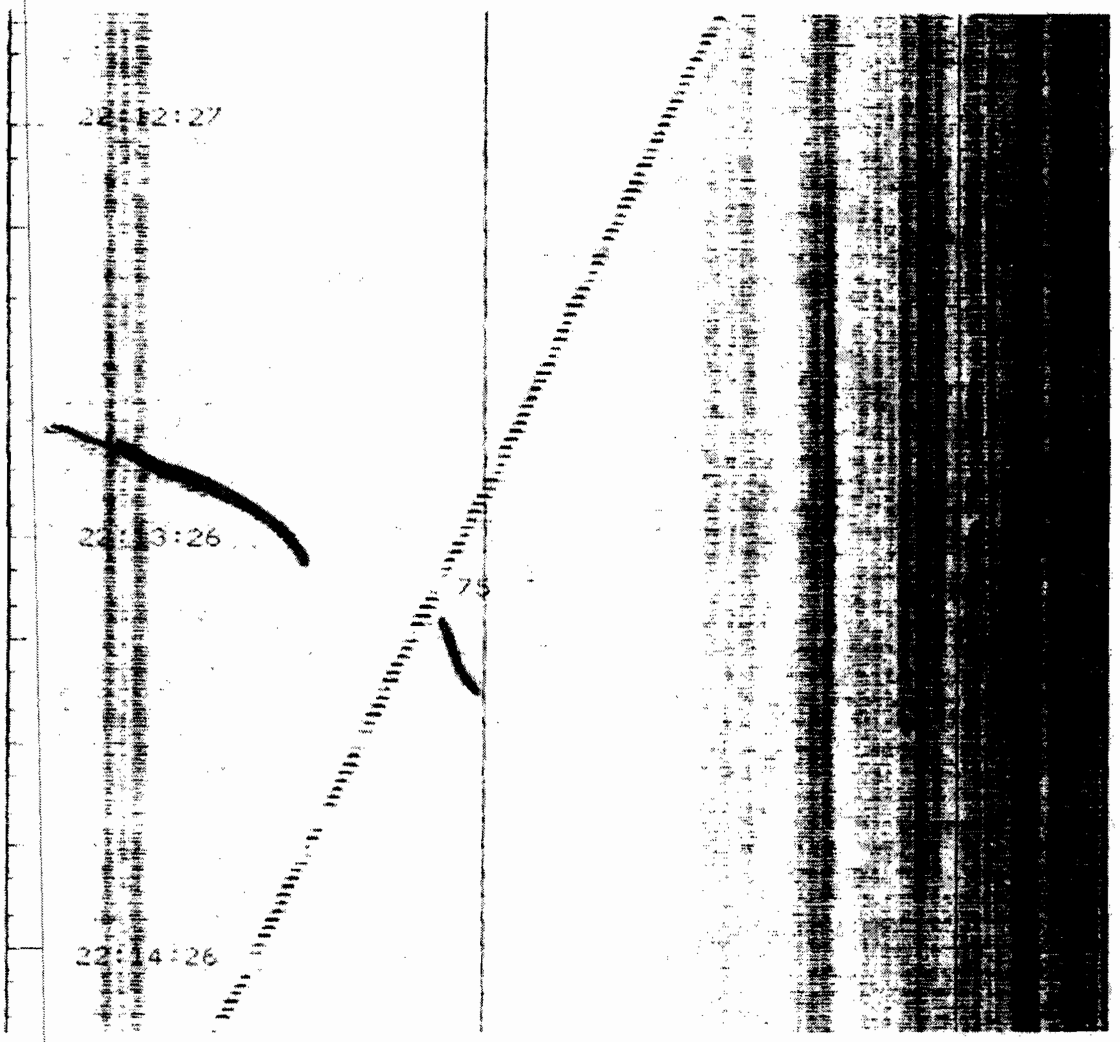


Figure 25. Cross talk observed at the Yukon River sonar project on 19 June 1999.

APPENDICES

Appendix A. Yukon River sonar threshold levels and parameters for the left bank, 1999.

Date	Stratum	Transmit (dB)	Receiver Gain (dB)	Threshold (Volts)	Attenuation	Source Level (dB)	System Gain (dB)	Threshold (dB)	Comments
6/12/99	3	-10	-12	0.35	0	213.94	-167.50	-43.56	
6/12/99	4	-10	-12	0.35	0	213.94	-167.94	-43.12	
6/12/99	5	-10	-12	0.35	0	213.94	-167.94	-43.12	
6/15/99	3	-10	-12	0.35	0	213.94	-167.50	-43.56	
6/15/99	4	-10	-12	0.35	0	213.94	-167.94	-43.12	
6/15/99	5	-10	-12	0.35	0	213.94	-167.94	-43.12	
6/16/99	3	-3	-18	0.39	0	219.80	-167.50	-42.48	
6/16/99	4	-3	-18	0.39	0	219.80	-167.94	-42.04	
6/16/99	5	-3	-18	0.39	0	219.80	-167.94	-42.04	
6/23/99	3	0	-18	0.39	0	222.81	-167.50	-45.49	
6/23/99	4	0	-18	0.39	0	222.81	-167.94	-45.05	
6/23/99	5	0	-18	0.39	0	222.81	-167.94	-45.05	
6/27/99	3	0	-18	0.39	0	222.81	-167.50	-45.49	
6/27/99	4	0	-18	0.39	0	222.81	-167.94	-45.05	
6/27/99	5	-3	-12	0.39	0	219.80	-167.94	-48.04	
6/28/99	3	-3	-18	0.39	0	219.80	-167.50	-42.48	
6/28/99	4	0	-18	0.39	0	222.81	-167.94	-45.05	
6/28/99	5	0	-12	0.39	0	222.81	-167.94	-51.05	
6/29/99	3	0	-18	0.39	0	222.81	-167.50	-45.49	
6/29/99	4	0	-18	0.39	0	222.81	-167.94	-45.05	
6/29/99	5	0	-12	0.39	0	222.81	-167.94	-51.05	
7/1/99	3	0	-6	0.39	0	222.81	-179.50	-45.49	
7/1/99	4	0	-6	0.39	0	222.81	-179.94	-45.05	
7/1/99	5	0	0	0.39	0	222.81	-179.94	-51.05	
7/10/99	3	0	-6	0.39	0	222.81	-179.50	-45.49	
7/10/99	4	-3	0	0.39	0	219.80	-179.94	-48.04	
7/10/99	5	0	0	0.39	0	222.81	-179.94	-51.05	
7/13/99	3	-3	-6	0.39	0	219.80	-179.50	-42.48	
7/13/99	4	-3	-6	0.39	0	219.80	-179.94	-42.04	
7/13/99	5	0	0	0.39	0	222.81	-179.94	-51.05	
7/14/99	3	-3	-6	0.39	0	219.80	-179.50	-42.48	
7/14/99	4	-3	-6	0.39	0	219.80	-179.94	-42.04	
7/14/99	5	-3	0	0.39	0	219.80	-179.94	-48.04	
7/15/99	3	-3	-6	0.39	0	219.80	-179.50	-42.48	
7/15/99	4	0	-6	0.39	0	222.81	-179.94	-45.05	
7/15/99	5	-3	0	0.39	0	219.80	-179.94	-48.04	
7/17/99	3	0	-6	0.31	0	222.81	-179.50	-47.48	
7/17/99	4	0	-6	0.31	0	222.81	-179.94	-47.04	
7/17/99	5	0	0	0.31	0	222.81	-179.94	-53.04	
7/19/99	3	0	-6	0.31	0	222.81	-179.50	-47.48	
7/19/99	4	0	-6	0.31	0	222.81	-179.94	-47.04	
7/19/99	5	0	0	0.31	0	222.81	-179.94	-53.04	
7/20/99	3	0	-6	0.31	0	222.81	-179.50	-47.48	
7/20/99	4	0	-6	0.31	sw[1]	222.81	-179.94	-47.04	
7/20/99	5								
7/21/99	3	-3	-6	0.31	0	219.80	-179.50	-44.47	
7/21/99	4	0	0	0.31	0	222.81	-179.94	-53.04	
7/21/99	5	0	6	0.31	0	222.81	-179.94	-59.04	
7/22/99	3	0	0	0.31	0	222.81	-179.50	-53.48	
7/22/99	4	0	0	0.31	0	222.81	-179.94	-53.04	

-Continued-

Appendix A. Page 2 of 3.

Date	Stratum	Transmit (dB)	Receiver Gain (dB)	Grey1	Attenuation	Source Level (dB)	System Gain (dB)	Threshold (dB)	Comments
7/22/99	5	-3	6	0.31	0	219.80	-179.94	-56.03	
7/25/99	3	0	-6	0.31	0	222.81	-179.50	-47.48	
7/25/99	4	0	0	0.31	0	222.81	-179.94	-53.04	
7/25/99	5	-3	6	0.31	0	219.80	-179.94	-56.03	
7/26/99	3	0	-6	0.39	0	222.81	-179.50	-45.49	
7/26/99	4	0	0	0.39	0	222.81	-179.94	-51.05	
7/26/99	5	0	6	0.39	0	222.81	-179.94	-57.05	lost s5 due to waves
7/28/99	3	-3	0	0.39	0	219.80	-179.50	-48.48	
7/28/99	4	-3	6	0.39	0	219.80	-179.94	-54.04	
7/28/99	5	0	6	0.39	0	222.81	-179.94	-57.05	
7/30/99	3	-3	0	0.39	0	219.80	-179.50	-48.48	
7/30/99	4	-3	6	0.39	0	219.80	-179.94	-54.04	
7/30/99	5	0	12	0.39	0	222.81	-179.94	-63.05	
7/31/99	3	-3	0	0.39	0	219.80	-179.50	-48.48	
7/31/99	4	-3	0	0.39	0	219.80	-179.94	-48.04	
7/31/99	5	0	12	0.39	0	222.81	-179.94	-63.05	
8/1/99	3	-3	0	0.39	0	219.80	-179.50	-48.48	
8/1/99	4	0	6	0.39	0	222.81	-179.94	-57.05	
8/1/99	5	0	12	0.39	0	222.81	-179.94	-63.05	
8/4/99	3	0	-6	0.31	0	222.81	-179.50	-47.48	
8/4/99	4	0	6	0.31	0	222.81	-179.94	-59.04	
8/4/99	5	0	12	0.31	0	222.81	-179.94	-65.04	
8/5/99	3	0	-6	0.31	0	222.81	-179.50	-47.48	
8/5/99	4	0	0	0.31	0	222.81	-179.94	-53.04	
8/5/99	5	-3	12	0.31	0	219.80	-179.94	-62.03	
8/9/99	3	0	-6	0.49	0	222.81	-179.50	-43.51	
8/9/99	4	0	0	0.49	0	222.81	-179.94	-49.07	
8/9/99	5	-3	12	0.49	0	219.80	-179.94	-58.06	
8/11/99	3	0	-6	0.49	0	222.81	-179.50	-43.51	
8/11/99	4	0	0	0.49	0	222.81	-179.94	-49.07	
8/11/99	5	0	6	0.49	0	222.81	-179.94	-55.07	
8/13/99	3	0	-6	0.49	0	222.81	-179.50	-43.51	
8/13/99	4	-3	0	0.49	0	219.80	-179.94	-46.06	
8/13/99	5	-3	6	0.49	0	219.80	-179.94	-52.06	
8/15/99	3	0	-6	0.49	0	222.81	-179.50	-43.51	
8/15/99	4	-3	0	0.49	0	219.80	-179.94	-46.06	
8/15/99	5	0	0	0.49	0	222.81	-179.94	-49.07	
8/17/99	3	0	-6	0.49	0	222.81	-179.50	-43.51	
8/17/99	4	-3	0	0.49	0	219.80	-179.94	-46.06	
8/17/99	5	0	6	0.49	0	222.81	-179.94	-55.07	
8/18/99	3	0	-6	0.39	0	222.81	-179.50	-45.49	
8/18/99	4	0	0	0.39	0	222.81	-179.94	-51.05	
8/18/99	5	0	6	0.39	0	222.81	-179.94	-57.05	
8/19/99	3	0	-6	0.39	0	222.81	-179.50	-45.49	
8/19/99	4	0	0	0.39	0	222.81	-179.94	-51.05	
8/19/99	5	-3	12	0.39	0	219.80	-179.94	-60.04	
8/21/99	3	0	-6	0.35	0	222.81	-179.50	-46.43	
8/21/99	4	0	0	0.35	0	222.81	-179.94	-51.99	
8/21/99	5	0	6	0.35	0	222.81	-179.94	-57.99	
8/22/99	3	-3	-6	0.28	0	219.80	-179.50	-45.36	

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Appendix A. Page 3 of 3.

Date	Stratum	Transmit (dB)	Receiver Gain (dB)	Grey1	Attenuation	Source Level (dB)	System Gain (dB)	Threshold (dB)	Comments
8/22/99	4	-3	0	0.28	0	219.80	-179.94	-50.92	
8/22/99	5	0	6	0.28	0	222.81	-179.94	-59.93	
8/23/99	3	-3	-6	0.35	0	219.80	-179.50	-43.42	
8/23/99	4	0	0	0.35	0	222.81	-179.94	-51.99	
8/23/99	5	-3	12	0.35	0	219.80	-179.94	-60.98	
8/24/99	3	-3	-6	0.35	0	219.80	-179.50	-43.42	
8/24/99	4	0	-6	0.35	sw	222.81	-176.54	-49.39	
8/24/99	5	0	12	0.35	0	222.81	-179.94	-63.99	
8/25/99	3	-3	-6	0.35	0	219.80	-179.50	-43.42	
8/25/99	4	-3	0	0.35	sw	219.80	-176.54	-52.38	
8/25/99	5	0	12	0.35	0	222.81	-179.94	-63.99	
8/26/99	3	-3	-6	0.35	0	219.80	-179.50	-43.42	
8/26/99	4	0	-6	0.35	sw	222.81	-176.54	-49.39	
8/26/99	5	0	12	0.35	0	222.81	-179.94	-63.99	
8/30/99	3	0	-6	0.49	0	222.81	-179.50	-43.51	
8/30/99	4	0	-6	0.49	sw	222.81	-176.54	-46.47	
8/30/99	5	0	12	0.49	0	222.81	-179.94	-61.07	

[1] In the case of saltwater attenuation correction, the threshold was calculated at a range of 100m. This setting was used infrequently and only in strata 4.

Appendix B. Yukon River sonar threshold levels and parameters for the right bank, 1999.

Date	Stratum	Transmit (dB)	Receiver Gain (dB)	Threshold (Volts)	Threshold (dB)	Comments
6/12/99	1	-6	-6	0.24	-39.99	
6/12/99	2	-6	-6	0.24	-39.99	
6/22/99	1	-6	-6	0.24	-39.99	
6/22/99	2	-10	-6	0.24	-36.05	
6/28/99	1	0	-12	0.24	-39.98	
6/28/99	2	0	-12	0.24	-39.98	
7/13/99	1	0	-6	0.24	-45.98	Changed due to waves
7/13/99	2	0	-6	0.24	-45.98	
7/14/99	1	0	-6	0.24	-45.98	
7/14/99	2	-3	-6	0.24	-42.94	
7/16/99	1	-3	-6	0.24	-42.94	
7/16/99	2	-3	-6	0.24	-42.94	
7/26/99	1	0	-12	0.24	-39.98	
7/26/99	2	0	-12	0.24	-39.98	
7/27/99	1	-3	-6	0.24	-42.94	
7/27/99	2	-3	-6	0.24	-42.94	
8/5/99	1	0	-6	0.24	-45.98	
8/5/99	2	0	-6	0.24	-45.98	
8/10/99	1	-3	-6	0.24	-42.94	
8/10/99	2	-3	-6	0.24	-42.94	

Appendix C. Yukon River sonar hourly passage rate by stratum, 1999.

Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
1	06/12/99	1	52.5	7.1			
1	06/12/99	2	83.9	17.9	38.9	8.4	5.4
1	06/12/99	3	54.5	23.0	37.9	19.3	3.2
1	06/13/99	1	44.1	11.2	40.7	14.2	4.4
1	06/13/99	2	62.7	8.3	64.1	10.3	2.1
1	06/13/99	3	40.9	8.3	60.0	15.5	11.5
1	06/14/99	1	42.8	10.1	43.7	8.9	4.2
1	06/14/99	2	35.2	5.5	41.4	8.7	1.0
1	06/14/99	3	42.2	25.8	53.7	11.4	5.2
2	06/15/99	1	24.9	16.9	46.6	18.6	3.1
2	06/15/99	2	27.5	8.0	65.2	27.4	3.0
2	06/15/99	3	39.3	16.4	60.0	12.5	10.7
2	06/16/99	1	37.7	11.5	90.5	26.9	7.2
2	06/16/99	2	40.9	6.6	79.3	38.0	10.0
2	06/16/99	3	40.2	8.3	62.1	23.4	8.3
2	06/17/99	1	40.9	5.3	56.6	22.1	5.3
2	06/17/99	2	30.4	12.0	71.2	30.0	1.0
2	06/17/99	3	38.9	2.1	66.5	19.3	4.2
3	06/18/99	1	35.2	13.0	87.5	59.0	10.3
3	06/18/99	2	36.8	4.9	78.3	46.6	5.2
3	06/18/99	3	37.9	19.1	118.0	62.2	5.2
3	06/19/99	1	45.7	15.9	119.0	52.8	6.7
3	06/19/99	2	52.5	20.9	122.2	123.1	13.3
3	06/19/99	3	51.8	10.3	319.1	122.1	17.3
4	06/20/99	1	51.2	12.3	279.7	125.2	10.3
4	06/20/99	2	153.2	64.3	260.3	230.3	4.3
4	06/20/99	3	271.0	80.5	266.2	303.1	39.3
5	06/21/99	1	105.0	35.5	705.0	218.6	4.1
5	06/21/99	2	169.5	62.0	831.9	370.7	25.9
5	06/21/99	3	219.1	53.5	684.4	845.2	24.8
6	06/22/99	1	124.1	36.8	671.8	351.3	20.7
6	06/22/99	2	101.2	48.3	541.0	398.6	25.4
6	06/22/99	3	145.9	55.9	402.7	399.3	19.7
7	06/23/99	1	124.1	37.9	520.3	280.3	15.5
7	06/23/99	2	191.9	64.2	526.8	479.0	17.6
7	06/23/99	3	318.2	65.6	918.6	690.0	24.2
8	06/24/99	1	717.3	83.7	1227.4	395.2	25.0
8	06/24/99	2	825.8	90.0	1423.7	955.7	58.8
8	06/24/99	3	736.9	80.9	1421.7	603.2	56.9
9	06/25/99	1	1138.7	98.7	1925.7	524.4	46.6
9	06/25/99	2	1131.7	62.3	3117.9	862.8	43.2
9	06/25/99	3	1972.7	261.2	475.8	1555.5	82.5

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
9	06/26/99	1	1141.3	95.7	1555.8	520.4	49.7
9	06/26/99	2	607.6	41.4	1634.4	654.7	34.7
9	06/26/99	3	588.3	53.6	1252.8	398.3	20.7
10	06/27/99	1	708.4	74.1	36.3	155.2	4.4
10	06/27/99	2	887.9	130.5	1983.1	317.9	17.9
10	06/27/99	3	961.4	153.1	1144.4	1315.9	41.1
10	06/28/99	1	855.3	110.0	2467.1	434.7	13.7
10	06/28/99	2	925.9	75.3	3259.3	602.1	32.1
10	06/28/99	3	842.0	84.5	3298.8	501.7	38.3
11	06/29/99	1	1261.4	179.3	1260.0	607.5	47.4
11	06/29/99	2	757.5	97.5	1592.1	546.2	32.1
11	06/29/99	3	484.2	51.2	1270.2	368.4	10.2
12	06/30/99	1	629.7	62.1	1236.0	236.8	12.4
12	06/30/99	2	623.2	79.3	875.0	328.4	20.7
12	06/30/99	3	476.6	113.2	1262.3	433.1	30.0
13	07/01/99	1	639.5	103.3	1158.2	227.0	9.0
13	07/01/99	2	768.4	139.5	1503.1	288.6	36.5
13	07/01/99	3	645.5	107.6	1555.9	361.0	23.8
14	07/02/99	1	696.7	64.0	1525.7	211.1	13.5
14	07/02/99	2	574.6	43.8	1195.2	234.9	47.2
14	07/02/99	3	782.9	74.7	240.0	251.8	69.3
14	07/03/99	1	553.0	75.3	452.5	232.0	41.0
14	07/03/99	2	651.4	67.1	727.2	411.7	49.7
14	07/03/99	3	668.3	64.2	1220.7	363.1	55.9
15	07/04/99	1	755.7	53.3	1721.7	334.0	26.9
15	07/04/99	2	773.8	85.1	1185.8	375.5	51.7
15	07/04/99	3	830.5	133.8	726.2	623.8	80.7
16	07/05/99	1	874.8	77.9	962.0	330.0	20.3
16	07/05/99	2	599.3	104.0	1010.5	573.0	127.4
16	07/05/99	3	725.5	198.0	45.8	600.0	86.9
16	07/06/99	1	579.3	55.3	331.0	406.7	51.4
16	07/06/99	2	488.3	103.4	349.7	370.7	38.9
16	07/06/99	3	261.8	44.1	278.6	317.6	25.9
17	07/07/99	1	250.6	33.8	288.4	166.6	15.5
17	07/07/99	2	201.1	25.1	225.0	149.5	20.7
17	07/07/99	3	242.7	46.2	121.0	80.0	6.2
18	07/08/99	1	245.5	26.5	111.9	49.7	11.2
18	07/08/99	2	255.0	23.1	324.2	147.7	15.8
18	07/08/99	3	456.6	51.4	364.3	245.5	26.3
19	07/09/99	1	626.7	38.0	555.3	185.2	15.5
19	07/09/99	2	833.6	109.7	785.1	393.1	21.1

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
19	07/09/99	3	777.3	100.0	498.3	391.0	18.9
20	07/10/99	1	432.1	46.7	822.3	256.6	12.4
20	07/10/99	2	500.7	37.9	376.3	401.4	29.5
20	07/10/99	3	286.2	31.8	615.0	360.0	34.6
21	07/11/99	1	372.7	25.3	497.9	181.1	27.4
21	07/11/99	2	273.1	29.3	307.1	311.4	28.4
21	07/11/99	3	272.5	32.7	345.3	224.2	15.5
22	07/12/99	1	253.8	51.1	212.5	95.2	10.2
22	07/12/99	2	152.8	21.4	278.4	124.2	27.9
22	07/12/99	3	123.6	15.3	288.8	103.9	11.5
23	07/13/99	1	115.9	10.0	462.7	157.2	11.4
23	07/13/99	2	131.2	29.3	398.2	185.2	29.0
23	07/13/99	3	190.1	29.7	319.3	193.2	12.6
24	07/14/99	1	157.1	29.0	410.5	114.8	23.4
24	07/14/99	2	104.8	14.5	316.5	120.0	22.5
24	07/14/99	3	176.2	28.4	240.9	97.6	11.6
25	07/15/99	1	159.5	22.1	238.8	90.5	9.3
25	07/15/99	2	146.6	18.6	211.5	149.0	17.0
25	07/15/99	3	101.4	15.2	225.8	149.0	33.1
26	07/16/99	1	100.2	8.7	325.7	124.4	20.8
26	07/16/99	2	118.7	11.3	233.2	110.7	21.1
26	07/16/99	3	119.3	10.5	252.4	123.2	9.3
26	07/17/99	1	97.5	5.5	254.7	95.6	7.1
26	07/17/99	2	117.2	11.7	151.5	79.7	14.5
26	07/17/99	3	69.0	9.6	176.5	75.4	14.4
27	07/18/99	1	86.5	14.5	213.4	131.0	14.0
27	07/18/99	2	105.3	18.6	185.6	142.8	12.4
27	07/18/99	3	107.7	11.0	328.3	177.9	18.6
28	07/19/99	1	80.7	9.2	346.6	186.1	26.8
28	07/19/99	2	106.0	10.0	310.2	212.1	15.5
28	07/19/99	3			380.3	190.2	17.1
29	07/20/99	1	150.0	16.6	597.6	131.3	36.2
29	07/20/99	2	184.8	33.8	652.6	184.3	36.2
29	07/20/99	3	124.0	26.5	642.5	320.0	36.2
30	07/21/99	1	136.9	38.4	513.1	402.3	52.6
30	07/21/99	2	159.1	27.2	266.4	207.9	41.1
30	07/21/99	3	135.3	33.7	309.2	224.5	64.1
31	07/22/99	1	112.0	19.3	253.7	141.7	15.3
31	07/22/99	2	96.7	22.9	269.5	186.2	48.6
31	07/22/99	3	111.8	22.1	341.7	211.0	12.9
32	07/23/99	1	130.6	28.4	520.0	288.0	23.6
32	07/23/99	2	180.0	25.5	792.9	482.1	40.3

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
32	07/23/99	3	174.1	44.1	739.3	442.8	30.5
33	07/24/99	1	232.3	50.2	629.5	626.8	36.2
33	07/24/99	2	195.0	45.5	783.2	667.1	44.2
33	07/24/99	3	198.4	32.4	638.6	601.0	111.7
34	07/25/99	1	170.0	31.4	726.2	636.6	74.5
34	07/25/99	2	173.9	42.9	596.9	420.0	65.1
34	07/25/99	3	187.5	33.2	392.9	428.3	66.4
35	07/26/99	1	128.8	45.3	271.9	255.0	37.0
35	07/26/99	2	153.4	32.4	311.5	258.5	62.1
35	07/26/99	3	114.5	20.5	228.8	123.5	22.1
36	07/27/99	1	92.0	24.3	213.7	128.1	35.3
36	07/27/99	2	103.6	12.8	260.0	118.9	29.4
36	07/27/99	3	111.4	19.5	244.1	96.7	15.3
36	07/28/99	1	74.3	13.1	254.2	72.2	9.3
36	07/28/99	2	58.7	11.4	319.3	143.8	21.7
36	07/28/99	3	63.2	8.1	329.0	108.6	27.9
37	07/29/99	1	96.0	7.6	289.3	124.4	13.4
37	07/29/99	2	90.7	15.9	218.6	162.4	2.2
37	07/29/99	3	73.0	4.2	340.7	249.3	23.2
38	07/30/99	1	51.1	8.3	283.2	137.3	12.6
38	07/30/99	2	87.3	13.8	340.8	167.4	15.0
38	07/30/99	3	111.3	16.2	227.6	102.7	7.5
38	07/31/99	1	79.8	10.3	250.5	69.5	3.3
38	07/31/99	2	62.7	7.6	232.9	204.2	11.4
38	07/31/99	3	52.5	4.0	181.0	95.4	11.4
39	08/01/99	1	46.7	7.8	415.9	127.2	22.8
39	08/01/99	2	85.0	25.5	755.4	280.7	20.3
39	08/01/99	3	170.0	35.7	854.5	301.1	9.3
40	08/02/99	1	161.1	26.6	1270.0	380.0	13.0
40	08/02/99	2	208.0	52.0	1301.8	594.4	40.0
40	08/02/99	3	156.3	38.2	1148.9	477.9	48.4
41	08/03/99	1	152.5	33.0	916.4	418.0	30.6
41	08/03/99	3	158.4	26.7	363.8	411.6	29.0
41	08/04/99	1	98.9	17.2	446.3	393.6	19.7
41	08/04/99	2	203.2	24.5	415.9	364.2	19.7
41	08/04/99	3	77.2	8.3	516.6	300.0	12.9
42	08/05/99	1	68.5	6.9	507.3	269.3	9.2
42	08/05/99	2			419.0	243.1	21.1
42	08/05/99	3	85.6	3.5	356.9	155.2	2.1
43	08/06/99	1	77.3	5.3	341.7	124.1	7.5
43	08/06/99	2	111.1	3.4	327.0	168.4	18.6
43	08/06/99	3	66.8	0.7	256.0	116.8	9.2

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
44	08/07/99	1	108.4	3.4	230.5	76.7	8.0
44	08/07/99	2	92.7	8.3	203.4	150.0	13.4
44	08/07/99	3	111.8	2.8	199.3	86.9	2.0
45	08/08/99	1	83.3	7.4	253.2	78.6	2.1
45	08/08/99	2	147.5	23.3	126.1	113.8	40.4
45	08/08/99	3	83.0	4.7	247.1	132.9	9.5
45	08/09/99	1	66.8	7.5	278.6	142.0	11.4
45	08/09/99	2	99.5	11.7	276.8	203.8	20.7
45	08/09/99	3	87.0	18.7	225.8	99.3	1.0
46	08/10/99	1	100.0	5.6	256.3	103.2	8.4
46	08/10/99	2	77.4	12.7	189.2	99.3	2.4
46	08/10/99	3	42.5	2.3	213.3	70.2	16.7
46	08/11/99	1	60.7	4.8	197.3	57.9	11.6
46	08/11/99	2	72.0	10.7	72.2	66.2	25.9
46	08/11/99	3	76.4	2.0	209.5	91.0	10.0
46	08/12/99	1	92.7	7.3	151.5	72.4	10.3
46	08/12/99	2	103.0	9.0	160.0	98.6	17.8
46	08/12/99	3	71.3	7.4	95.2	34.1	8.3
47	08/13/99	1	47.0	3.4	78.5	36.0	7.1
47	08/13/99	2	49.1	3.4	117.9	66.0	17.6
47	08/13/99	3	41.4	2.8	134.5	43.4	20.7
48	08/14/99	1	88.0	3.4	243.0	89.5	6.1
48	08/14/99	2	117.3	12.0	445.4	218.9	37.2
48	08/14/99	3	143.9	11.3	588.8	266.9	18.9
49	08/15/99	1	155.9	24.0	514.6	299.0	32.5
49	08/15/99	2	147.3	18.0	570.5	299.0	35.2
49	08/15/99	3	138.4	16.2	594.8	267.5	22.8
50	08/16/99	1	105.3	13.6	489.2	247.2	31.6
50	08/16/99	2	107.0	12.4	342.9	201.4	9.6
50	08/16/99	3	124.0	21.6	234.3	170.4	18.6
51	08/17/99	1	142.9	13.1	388.5	144.8	29.4
51	08/17/99	2	98.9	11.6	245.2	160.0	20.7
51	08/17/99	3	73.8	3.4	274.6	172.6	23.3
52	08/18/99	1	167.0	15.2	273.8	147.9	11.4
52	08/18/99	2	95.3	21.3	230.5	156.2	36.0
52	08/18/99	3	101.4	1.3	238.0	146.9	9.3
53	08/19/99	1	64.8	8.5	266.4	131.4	10.3
53	08/19/99	2	53.6	4.7	239.0	117.9	11.4
53	08/19/99	3	90.7	15.3	225.5	109.3	13.7
54	08/20/99	1	98.9	7.0	322.4	136.6	16.6
54	08/20/99	2	94.8	14.5	314.2	102.4	17.1
54	08/20/99	3	110.0	4.4	250.4	109.0	17.6

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
55	08/21/99	1	154.8	13.1	209.4	141.7	16.8
55	08/21/99	2	120.7	9.1	269.1	184.0	4.3
55	08/21/99	3	142.2	7.9	437.9	146.9	19.6
56	08/22/99	1	225.7	17.9	832.5	300.0	21.7
56	08/22/99	2	204.5	17.9	1196.9	360.0	62.0
56	08/22/99	3	266.6	8.2	931.5	449.0	34.1
57	08/23/99	1	252.4	15.2	1146.1	475.8	37.9
57	08/23/99	2	325.5	26.2	1098.9	481.0	50.7
57	08/23/99	3	216.3	8.9	842.1	400.3	47.8
58	08/24/99	1	264.1	15.2	779.0	343.4	23.8
58	08/24/99	2	256.4	21.1	661.0	479.0	23.2
58	08/24/99	3	192.1	10.7	474.7	306.3	4.3
59	08/25/99	1	310.2	12.7	379.0	295.9	13.7
59	08/25/99	2	263.2	12.4	363.0	348.2	24.2
59	08/25/99	3	150.7	1.4	254.1	175.9	6.2
60	08/26/99	1	191.0	10.3	285.8	137.1	13.7
60	08/26/99	2	210.7	20.0	227.8	162.1	13.4
60	08/26/99	3	162.9	17.2	179.0	110.7	14.4
61	08/27/99	1	147.7	12.1	244.1	160.3	10.3
61	08/27/99	2	163.1	12.0	204.4	130.5	11.4
61	08/27/99	3	138.4	2.7	204.6	112.1	11.4
62	08/28/99	1	201.1	17.3	196.8	138.9	6.3
62	08/28/99	2	164.0	10.0	187.2	137.6	11.2
62	08/28/99	3	140.4	9.3	181.0	130.2	1.0
63	08/29/99	1	173.0	10.9	168.6	113.8	9.0
63	08/29/99	2	150.7	6.8	230.5	194.5	24.6
63	08/29/99	3	160.0	7.1	189.3	104.5	9.2
64	08/30/99	1	166.7	11.6	180.0	137.6	6.2
64	08/30/99	2	179.3	28.2	223.0	170.5	28.9
64	08/30/99	3	128.8	7.5	165.8	156.2	20.7
65	08/31/99	1	138.3	17.5	222.7	116.3	17.6
65	08/31/99	2	182.7	22.7	196.6	155.4	18.5
65	08/31/99	3	178.0	15.9	123.1	105.8	23.8