U.S. Fish and Wildlife Service
Office of Subsistence Management
Fisheries Resource Monitoring Program

Assessing Methods to Estimate Inseason Salmon Abundance in the Lower Copper River

Annual Report No.FIS01-021-1

This report has been prepared to assess project progress. Review comments have not been addressed in this report, but will be incorporated into the final report for this project.

Native Village of Eyak

Alaska Department of Fish and Game

Aquacoustics, Inc.

LGL Alaska Research Associates, Inc.

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Annual Report Summary Page

Title: Assessing Methods to Estimate Inseason Salmon Abundance in the Lower Copper River

Study Number: FIS01-021-1

Investigators/Affiliations: Robert Henrichs/Native Village of Eyak; Steve Moffitt/Alaska Department of Fish and Game, Division of Commercial Fisheries; Don Degan/Aquacoustics, Inc.; Michael Link/LGL Alaska Research Associates, Inc.

Management Regions: Cook Inlet/Gulf of Alaska

Information types: Stock Status Trends, Fisheries Monitoring

Issues Addressed: Improve in-season escapement estimates of sockeye and chinook salmon in the lower Copper River, downstream of the Miles Lake sonar site.

Study Cost: $157,898 for 2001; Total for 2001 – 2003 = $449,871

Study Duration: 3 years, beginning March 2001.

Key Words: Copper River, in-season management, *Oncorhynchus nerka*, sockeye salmon, chinook salmon, *Oncorhynchus tshawytscha*, subsistence fishery, test fishery, Native Village of Eyak.

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EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (USFWS), through the Office of Subsistence Management, funded the Native Village of Eyak (NVE) to undertake a three-year study and work with the Alaska Department of Fish and Game (ADF&G) to assess and develop methods of monitoring salmon escapement in the lower Copper River near Cordova, Alaska. This project was designed to use fixed-aspect riverine acoustics and drift gillnetting techniques to monitor and study the behavior and distribution of salmon in the highly braided Copper River delta. The ultimate goal of this project is to develop an annual monitoring program that can provide fishery managers with more timely estimates of salmon escapement than those currently available from a sonar site (Miles Lake) 52 km upstream of the ocean commercial fishing boundary. A multi-faceted research design was developed in an attempt to significantly shorten the development time of a lower river test fishery by studying fish migratory behavior and by testing and comparing the utility of using acoustics and gillnets/driftnets as test fishing tools.

Fieldwork was conducted from 5 May until 7 June 2001 in the vicinity of the Mile-27 and Mile-37 Bridges on the Copper Valley Highway. Bathymetric maps were prepared for sections of river channels downstream of both these bridges using a digital echo sounder and a differential GPS system. Bathymetric maps were used in-season to aid in the selection of test fishing sites.

Drift gillnetting was conducted at the Mile-27 Channel for a total of 21 days from 13 May to 7 June. A total of 602 sockeye salmon and 18 chinook salmon were captured during 889 minutes of driftnet fishing. Daily test fishing indices for sockeye salmon peaked on 25 May at 1,176 fish per hundred fathom hours and the season cumulative index was 8,483. We compared the daily test indices to the upstream Miles Lake sonar counts lagged by one day to examine changes in catchability of the gillnet test fishery over time. These data suggest that there was a shift in the gillnet catchability between 26 and 28 May where the gillnet test fishery became less effective (a 50% reduction in catchability). This decline in catchability was coincident with rising river levels.

Acoustic sampling of the river and upstream migrating fish was conducted using both multibeam and single transducer acoustic systems. A multibeam sonar system was deployed to sample areas and conditions that are typically difficult to sample with single transducer systems. Conditions in the lower Copper River were more favorable for using single transducer systems than we originally envisioned, and therefore we discontinued use of the multibeam system. Splitbeam sonar systems were deployed at nine locations near Mile 27 and Mile 37 of the Copper River Highway. Transducers were either stationary (on river banks) or mobile (on a boat). We collected acoustic fish-count data from a site at Mile 27 (within the gillnet test fishing reach) from 13-27 May 2001. Fish counts were low (mean of 19/day) from 13-22 May, but increased more than 100-fold to a mean of 2104/day from 23-27 May. A peak daily count of 2,790 fish occurred on 26 May and 10,706 fish were counted during the entire 15-day period.

Results from 2001 indicated that it was easier to capture and count salmon in and near the Mile-27 Channel than originally believed. Test fishing indices from both the drift gillnet and acoustic gear indicate that sockeye salmon took one day to travel from the Mile-27 Channel to the Miles Lake sonar site in late May 2001. Travel time for the same section of river during early June may have been two days, but the data are less conclusive than they are for late May. Both acoustic and drift gillnet gear were capable of detecting the presence of fish in the Mile-27 Channel and the daily indices were correlated with subsequent upstream estimates from the Miles Lake sonar site.

Plans for the 2002 fieldwork include deployment of both acoustic and driftnet test fishing in the Mile-27 Channel from early May until early June. This will allow us to begin to characterize the among-year variability in catchability coefficients of the two gear types and in the time for sockeye salmon to travel from Mile 27 to the Miles Lake sonar site. In addition, fish passage should be regularly monitored near the Mile-37 Bridge in 2002 in order to minimize any confounding of data interpretation that could be caused by significant shifts in the distribution of fish between the two primary channels (Mile-27 and Mile-37) within and among seasons.

INTRODUCTION

The Copper River flows through the Chugach Mountains of Alaska and drains into the northern limits of the Gulf of Alaska, east of Prince William Sound (Figure 1). Including its tributaries, the Copper River stretches more than 466 km and has created a 70 km wide delta of primarily glacial silt (Brabets 1997). The average annual discharge of the Copper River is 1,625 m^3/s, second largest in Alaska. Despite carrying a very high sediment load, the Copper River is the largest salmon-producing river in Central Alaska (Merritt and Roberson 1986) and supports healthy stocks of sockeye salmon (*Oncorhynchus nerka*) and chinook salmon (*O. tshawytscha*).

The Copper River subsistence and commercial salmon fisheries are of great value to both native and non-native participants. In 2000, ADF&G permitted more than 9,000 people to fish the upper Copper River subsistence fisheries (ADF&G 2001). The ex-vessel value of the Copper River Commercial District salmon landings exceeded $12 million that same year (ADF&G in press). Recent (1990-99) average commercial harvests of sockeye and chinook salmon have been 1,500,000 and 48,000, respectively (Sharp et al. 2000). Upstream subsistence and sport harvests for sockeye and chinook salmon for the same period have averaged 160,000 and 12,000 (Taube and Sarafin 2001).

Most of the Copper River subsistence harvest is taken in the upper river and its tributaries, 150 km or more upstream of the ocean commercial fishery. Therefore, migrating fish are subjected to commercial fishing activity from two to four weeks (depending in part on river discharge) before they arrive in subsistence fishing areas (Merritt and Roberson 1986). The lack of early run assessment information can sometimes make it difficult for managers to meet escapement goals (number of fish allowed to spawn), while allowing sufficient fish for subsistence and commercial harvesters. Adding to this difficulty, the commercial salmon fishery covers a large area (approx. 1,200 km^2) and the rate at which salmon migrate through this area during the early part of the season varies among years. For instance, in some years, fish may mill in the commercial fishing district waiting for appropriate conditions to move into the river and out of the fishing area.

Fishery managers are often under tremendous pressure early in the season to ensure that enough salmon reach the spawning grounds, while providing subsistence and commercial harvests. Variable migratory behavior early in the season makes it difficult for managers to estimate the abundance of fish in the fishing district and how many have moved upstream. For example, if fish move quickly from the commercial fishing area into the river, the commercial fishery may forego large harvests at a time when the landed value of the fish is 100 to 200% more than it is later in the season. On the other hand, if fish are slow to move into the river, they may be subject to excess commercial fishing pressure.

Much effort has been expended over the last 40 years to develop a timely method of estimating salmon escapement for the Copper River. In 1978, a sonar system was placed 53 km (33 miles) upriver of the commercial fishery, just below the outlet of Miles Lake, where the river is confined to a single channel (Figure 2). The sonar system has provided daily salmon escapement estimates each season since 1978. However, because it can take anywhere from three to nine days for sockeye salmon to travel from the commercial fishing district to the Miles Lake sonar site, fishery managers sometimes face difficult decisions early in the season because timing of river entry is highly variable among years. In late June 1984, ADF&G assessed the utility of using a Bendix sonar counter about half way between Miles Lake and the commercial fishery (unpublished ADF&G data). The counts were generally 10-100 fish per day, but the work was hindered by high water levels and debris. A more extensive survey planned for 1985 was not funded.

Miles Lake sonar provides relatively reliable daily and annual estimates of salmon escapement and will likely do so well into the future. However, the early commercial fishery openings could be managed with greater confidence if escapement estimates were available earlier in the season. In 2000, under renewed pressure from commercial and subsistence users, ADF&G initiated a study to assess the feasibility of an early-season test-netting program in the Copper River delta (Moffitt et al. 2000). Both drift dip netting and gillnetting were investigated as possible means to index salmon returns in the lower part of the river. Moffitt et al. (2000) found that dipnets could be used to catch fish, but the catch would not be sufficient to provide a reliable index without a significant increase in effort.

Given the potential for changes in fish behavior among years and the expected changes in discharge among river channels of the Copper River, statistical relationships alone (between test indices and subsequent escapement at Miles Lake) can take many years to develop. These relationships may also suddenly change for no apparent reason and call into question the accuracy of subsequent escapement estimates.

With many of its members both subsistence and commercial fishermen, NVE understood the value and importance of improving early season estimates of the salmon escapement into the Copper River. Teaming up with ADF&G, NVE worked to design and propose a more extensive research effort than originally planned by ADF&G. This more intensive effort focused on shortening the development time of a lower river test fishery by studying fish migratory behavior and by examining and comparing the utility of using acoustics and driftnets as test fishing tools. NVE hoped to study and test assumptions about fish behavior that would facilitate and expedite the development of a test fishery.

In early 2001, USFWS, through the Office of Subsistence Management, funded NVE to undertake a three-year study and work with ADF&G to assess and develop methods of monitoring lower Copper River salmon escapement. The ultimate goal of this lower river test fishery (LRTF) project is to develop an annual monitoring program that can provide fishery managers with timely estimates of salmon escapement prior to those available from the Miles Lake sonar site.

OBJECTIVES

The principal objectives of the 2001 study were to:

1) Determine the early run behavior and the stream channel use of chinook and sockeye salmon in the lower Copper River;
2) Determine if the presence of eulachon interfere with acoustically counting adult salmon;
3) Assess the efficacy of sonar and test netting as indices of the abundance of early run salmon in the Copper River; and
4) Develop recommendations for the design of the 2002 study.

METHODS

Daily sampling of a consistent portion of the total fish run is required for successful and economical indexing of salmon abundance. Sampling times and locations are best when fish sampled represent a portion of the total number of fish swimming upstream in the system. The portion of a run sampled by a “test fishery” (e.g., 0.01 or 1%) for a given level of effort (e.g., 10 fathoms for 30 minutes, or 15 minutes of acoustic sampling at a particular site) is referred to as the catchability coefficient of the test fishery. The catchability coefficient is usually determined by comparing the daily (or season’s) test fishery index with an independent measure of the total daily (or seasonal) fish passage. Since the catchability coefficient of a test fishery must be consistent through the season and among years for the test fishery to be useful, it is best to sample at times and locations where we expect the catchability coefficient to be consistent among days and among years.

Selecting a location for sampling the salmon run in the lower Copper River began with researching existing knowledge (both printed and local) of the most appropriate sites. Local fishermen, scientists and fishery managers were consulted. Aerial surveys were flown along the river during low-water periods when river topography was exposed and appropriate sites were more evident. We also collected data at a number of specific locations. Acoustic systems were used to examine physical features (water depth and bottom contours), determine the presence or absence of fish, and assess fish behavior. A flow meter provided water velocity data. With these different sources of information, project staff identified the most promising test fishing sites in the area. Drift dipnets, drift gillnets, and acoustics were employed as test fishing tools for a portion of the 2001 season.

Bathymetry Survey

The efficacy of riverine acoustics to count upstream migrating salmon is heavily dependent on the cross-river profile of the bottom. Ideally, bottom slope offshore from a stationary transducer should have a smooth and continuous grade so that conical-shaped acoustic beams can effectively ensonify areas where fish migrate (i.e., close to the bottom). Bathymetry (bottom topography) of potential acoustic counting sites was determined by conducting an acoustic survey from a boat. A BioSonics DT6000 system with a 6-degree 200kHz splitbeam transducer and Visaq 4 acquisition software were used to collect time-stamped depth data. Power output and data collection thresholds were set to give a consistent bottom return. The ping rate was 5 – 10 per second (pps). Positional information during the survey was collected with a differential GPS with sub-meter accuracy and 10 Hz positioning rate. Sampling time was chosen to coincide with coverage of at least six satellites and a maximum PDOP (Position Dilution of Precision) of four satellites. Differential corrections were obtained from the US Coast Guard beacon on Hinchinbrook Island. XY data were recorded as a separate data stream and later matched by timestamp to corresponding depth records. To ensure accurate timestamps, the computer clock and the GPS time were synchronized to the nearest 10 milliseconds before, and periodically during data collection.

Survey transects were as uniformly spaced as the river conditions allowed. Real-time plotting of boat tracks gave feedback on boat position during the survey. Transects were run perpendicular to the channel, or in “S” shapes to define cross-channel patterns. Transects parallel to the river added definition of along-channel patterns. Wherever possible, shoreline points were collected by walking the shore with the GPS receiver.

Depth information was extracted from the acoustic data with BioSonics Visual Bottom Typer 1.9. A spreadsheet was used to check and edit errors that result from secondary bottom echoes. A standard database application was used to match depth and xy records. The resulting xyz dataset was plotted in ESRI ArcView 3.2 and again checked for outliers. After adding the shoreline points, the edited xyz data was interpolated with a kriging algorithm to create a continuous grid of the survey area. Further processing in ArcView 3.2 included contouring, hillshading, slope analysis, extraction of depth profiles, conversion to a triangulated irregular network for 3D display, and creation of maps. A spreadsheet was used to plot bottom profiles and overlay fish distributions.

Velocity

River velocity measurements were taken with an Edutech Technologies Corporation Flow Wand (Gibsons, BC, Canada, www.edutechcorp.com/wandl.html) that measured average water velocity in meters/second. Velocity measurements were made on 20 May at Mile 27 and on 21 May at Mile 37. Measurements were consistently taken at approximately 0.5 m under the surface of the river.

Single Transducer Systems

The acoustic systems used for monitoring fish passage in 2001 were two BioSonics DT6000 systems used in conjunction with one 6-degree single-beam and two 6-degree splitbeam transducers. Transducers were deployed either from shore, using a mount that was placed on the bottom, or from a hull mount on an anchored boat. All mount types allowed the transducers to be raised and lowered in depth and tilted. A continuous monitoring site was established and a pitch and roll sensor was used to periodically check the aim of the transducer.

Site Selection

The site for continuous deployment of the single transducer system was selected based on six criteria:

1) Ice-free channel with moving water;
2) An area where ADF&G netting in 2000 had indicated fish presence;
3) Bathymetric features favorable to effective acoustic monitoring such as continuity and steepness of slope, and features like sand bars that could potentially guide migrating salmon;
4) The characteristics of exposed shore such as even slope and absence of debris (given that we expected significant increases in water level);
5) Ease of access; and
6) Coverage of multiple migration routes (i.e., downstream of a confluence or upstream of a split).

Aim Verification

The along-the-bottom aim at the continuous sampling site was verified with a 4" plastic ball, which has an echo strength similar to adult salmon. This target ball was tied to a fishing rod, lowered to the bottom in front of the transducer, raised to about 10 cm above the bottom and moved in- and offshore as much as water depth and current allowed. The aim was confirmed when target ball echoes were clearly visible and strong enough to qualify as salmon at least every 0.5 m of the range.

Calibration

The acoustic system was calibrated to US Navy standards at the BioSonics, Inc. Laboratory in Seattle, Washington, prior to sampling. The system was also calibrated at Mile 27 with a tungsten carbide reference sphere with known acoustic size on 21 May. The calibration sphere was suspended 3.2 m from the transducer and approximately 1,000 pings were collected at both high and low power settings. The single echoes were filtered by range and off-axis angle. The average target strength (TS) was – 43.6 dB for low power and – 44.2 dB for high power.

Data Collection and Processing

Different power and threshold settings were tested in an effort to optimize data collection (specific parameters used are listed in the Results section). Data were processed by manually circling fish on an echogram in BioSonics Visual Analyzer 4.02 or with the Alpha-Beta Tracker. With both methods, echoes had to meet three criteria to be considered for tracks:

1) Pulse length ≥ 0.5 to 2 times the length of the transmitted signal;
2) Threshold ≥ -55 dB target strength (uncorrected for distance off axis); and
3) Pulse shape correlation factor ≥ 0.9.

Tracking parameters in the Alpha-Beta Tracker (Table 1) were developed through an iterative process and with input from the program developer (P. Withler, Nanaimo, BC, Canada, pers. comm.). Sample output from the Alpha-Beta Tracker was checked and edited in the Polaris Editor and periodically cross checked against the Visual Analyzer echogram. All tracked fish were merged into one database per site and filtered by average target strength and number of echoes. Finally, the database was used to retrieve information on hourly passage rates, average TS and direction of movement (i.e., slope of linear regression of "x" versus ping).

SM2000 Multibeam System

The SM2000 multibeam acoustic system has been developed by Simrad USA (Lynwood; WA, http://www.simradusa.com/fish_res/sm2000.php). This system comes with an array of 80 transducers that cover a total of 120 degrees, compared with 6 degrees of the single and splitbeam systems also used in this study. The advantage of this expanded view is that fish can be detected between boulders and similar obstacles that would completely shadow some fish in any 6 degree subsection but not the entire 120 degree swath. The SM2000 system had been used in the past for riverine salmon acoustic research (T. Mulligan, Nanaimo, BC, Canada, pers. comm.) and it provided this study an opportunity to examine otherwise difficult-to-sample areas of the lower Copper River.

The multibeam transducer was deployed on the same type of bottom mount used for the single transducers. No attempt was made to mount the multibeam transducer on a boat for mobile data acquisition due to time constraints and discouraging results obtained by other researchers (T. Mulligan, pers. comm.). The sounder, computer and monitor were set up either in an anchored boat (Mile 27) or in a tent on shore (Mile 37). Samples of raw, as well as beamformed data were collected. Sampling ranges were 5, 10, 20, 50, 100 and 200 m. Data was collected in two different ping-to-ping averaging modes: amplitude and "amplitude subtractive." Average-amplitude-subtractive mode, subtracts the average amplitude from each range bin in each beam. The purpose of this feature is to reduce the signal of stationary targets such as bottom reflections. Average-amplitude mode, on the other hand, averages the amplitude without subtraction. Target tests were performed in the same manner as for the single transducer systems. In addition, offshore target tests were done with a target suspended from an anchored boat.

Net Test Fishing

Two net sampling methods were used in 2001: dip nets and gillnets. Both types of gear were drift-fished from river skiffs. Most of the net sampling occurred in the Mile-27 Channel (Figure 2).

Sample Locations

The net sampling study area was located in the channel downstream of the Mile-27 Bridge (Figure 2). The channel starts above the Pete Dahl Slough fork approximately 21.6 km (13.4 mi) above the Copper River District markers at Castle Island channel, and ends at the Mile-27 Bridge. The Mile-27 Channel of the Copper River was our preferred site because:

1) it is road accessible most years by early to mid-May;
2) it has a good beach for launching boats;
3) it can be fished on a daily basis without a field camp; and
4) the water velocity is significantly less than in the Mile-37 Channel.

This area was selected because it is a constriction point where most of the west side of the Copper River is in a single channel, with no apparent tidal influence. The west side of the channel was selected for more intensive sampling because of the channel morphology and because most fish caught in pilot test netting in 2000 were near the west bank. The east side of the channel is a shallow mud bar that is difficult to fish effectively. In March and April of 2001, the west bank of the Mile-27 Channel was examined for possible test fish sites. Three sites downstream of the Mile-27 Bridge were selected and marked by applying surveyors flagging tape to shore vegetation. The three sites, at the mouths of small streams, were the only sites along the west shore without a significant number of snags embedded in the river bottom. Each site was 75 to 100 m long. Other sites upstream of the bridge and further downstream were also fished, but the majority of sampling occurred at the original three sites.

The Mile-37 Channel (Figure 2) was also sampled with gillnets one time in 2001. The Mile-37 Channel is more difficult to sample than Mile 27 because it is not road accessible most years by early to mid-May, it requires another 16.1 km (10 mi) of driving over a rough gravel road, it lacks a boat launch, and the channel has a much higher water velocity. The Mile-37 Bridge may provide a less timely index of abundance than a site further down river (e.g., Mile 27) because it is further upriver from tidewater and the commercial fishery.

Gear and Sampling Protocol

Dip nets: Dip nets consisted of aluminum frames 1.2 m wide by 0.92 m high (4 ft x 3 ft) with 10.2 cm (4 in) knotted nylon netting 1.5 m (5 ft) long. Each dipnet frame was attached to a tubular fiberglass pole 3.7 m (12 ft) long. Each dipnet pole was topped with a plastic shovel handle so the crew could maintain the orientation of the net in the river.

Dip nets were fished on the river bottom from a skiff, drifting with the river current. The time to complete each drift varied with the river current and wind speed. Generally, one person in the bow of the boat fished a dip net while the other crewmember used the engine to keep the boat floating parallel to the river current. Most drifts were within 15 m (50 ft) of the bank in water at least 1.2 m (4 ft) deep because it was believed that most sockeye salmon travel upriver near the bank (Burgner 1991). Captured fish were marked by clipping their adipose fin and released from the net as quickly as possible. For each drift, the following information was recorded: drift site, start and stop times, number of fish caught by species, distance from shore, and comments.

Gillnets: Drift gillnets were 18.3 m (10 fathoms) long and 20 meshes deep with a 13.7 cm (5 3/8 in.) stretched mesh web. Most gillnet drifts were set perpendicular to shore as close to the west bank as possible. The starting and stopping points for each drift were marked with surveyors flagging tape on bank vegetation. The sites were selected to avoid snags embedded in the river bottom. The boat was used to place tension on the net to keep it from bunching up in the current. Fish were released if possible, and most fish not released were sampled for species, length, weight, sex, and age. The following data was recorded for each set: drift site, distance offshore at start, distance offshore at stop, time the net started out, time the net was completely out, time the net started in, time the net was completely in, and number of fish captured by species.

River stage height and weather information was collected each day of sampling. The river stage height was read from a United States Geological Survey gauge mounted on the Mile-27 Bridge. The stage height provides a relative measure of the river elevation because the elevation above sea level of the bridge was not known. Weather information collected each day included cloud cover, precipitation, and wind speed (km/h) and direction.

Test Fishery Data Analyses

Mean fishing time (MT) in minutes, for each set was computed as in Gray (2000):

$$MT = SI - FO + \frac{(FO - SO) + (FI - SI)}{2}, \tag{1}$$

where:

SO = time the gillnet first entered water;
FO = time the gillnet was fully deployed;
SI = time the gillnet retrieval began and
FI = time the gillnet retrieval was completed.

The catch-per-unit-effort (CPUE) value, C_j, the number of sockeye salmon caught per 100 fathom hours, was computed for set *j* as in Gray (2000):

$$C_j = 6{,}000\frac{N}{G \text{ x } MT}, \tag{2}$$

where:

N = number of sockeye salmon caught; and
G = gillnet length in fathoms.

The daily test fish index, I_i, for day *i* was computed as the mean of CPUE values from sets made the same day (Gray 2000):

$$I_i = \frac{\sum_{j=1}^{s} C_j}{S_i}, \tag{3}$$

where

S = number of sets made on day *i*.

Four methods for estimating escapement from both daily and cumulative test netting data were explored. The travel time model used in Bristol Bay test fisheries since the late 1970's (Gray 2000) was evaluated along with a maximum likelihood approach and two variations of regression models. The models were fit by comparing test fish indices to lagged escapement data. Escapement data were lagged to account for the travel time of sockeye salmon from the test fish site to the Miles Lake sonar site. Lags were chosen by determining which lag resulted in the best model fit. Travel times that appeared unrealistic based on results of past studies or that produced unreasonable escapement estimates (e.g., less than observed escapement) were rejected even if they produced the best statistical fit to the data. All methods were examined for their ability to forecast future escapement estimates from the Miles Lake sonar.

Travel Time Approach

The travel time approach has been used successfully to forecast the escapement at upstream counting towers using test fishery data for several Bristol Bay systems for about 20 years (Gray 2000). For this method, escapement per index (EPI) was calculated by dividing the most recent cumulative sonar count by the cumulative test-fish indices lagged by the travel time:

$$EPI_d = \frac{\sum_{i=1}^{t} E_i}{\sum_{i=1}^{t-d} I_i} \quad . \tag{4}$$

where

EPI_d = number of sockeye salmon represented by each test fishing index point based on a travel-time of *d* days,
E_i = number of sockeye salmon traveling past the sonar on day *i*,
I_i = daily testfish index on day *i*, and
t = day of most recent escapement estimate.

The lag *d* that minimized the following sum of squares between the cumulative test-fish indices and the sonar counts was chosen:

$$SS = \sum_{j=1}^{t} (EPI \cdot \sum_{i=1}^{j} I_{i-d} - \sum_{i=1}^{j} E_i)^2 \quad . \tag{5}$$

Total spawning escapement (E) for day t+d was then estimated using:

$$\hat{E}_{t+d} = EPI_d \sum_{i=1}^{t} I_i \quad . \tag{6}$$

Maximum Likelihood Approach

The maximum likelihood approach provides better statistical properties than the travel time method. Escapement per index was estimated by minimizing the sums of squares of the difference between the observed and predicted escapements using

$$SS = \sum_{i=1}^{t} (EPI \cdot I_{i-d} - E_i)^2 \quad . \tag{7}$$

Assuming the model errors are normally distributed, minimizing the sums of squares will maximize the following equation, resulting in a maximum likelihood estimate (MLE) of EPI.

$$L(EPI, \sigma^2 \mid E_i, I_i) = \prod_{i=1}^{n} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(E_i - EPI \cdot I_{i-d})^2}{2\sigma^2}} \quad , \tag{8}$$

where σ^2 = variance of E_i. This method is the same as fitting a regression line with intercept equal to zero and EPI the slope:

$$E_i = EPI \cdot I_i \quad . \tag{9}$$

This model was fit with both daily and cumulative data.

Regression Approach

A linear regression model was fit both with and without covariates, such as tide and river stage height, to find the best linear relationship between the index and escapement. The regression equation fit was:

$$E_i = \alpha + \beta I_{i-d} \quad , \tag{10}$$

where α and β were estimates of the intercept and slope. Covariate terms were added as appropriate and data transformations were examined. The regression model was fit with both daily and cumulative data.

Forecasting Escapement at Miles Lake

Performance of the models used for forecasting the escapement was evaluated by hindcasting. The first forecast was made using the first four days of escapement and test fish data. The predicted escapement for the number of days lagged was compared to the actual escapement. The forecast was repeated for the remainder of the data set by adding a day of escapement and test-fish data to simulate each additional day of information.

RESULTS

Brabets' (1997) *The Geomorphology of the Lower Copper River* provided useful information about the lower river that assisted in site selection. Local residents and ADF&G scientists contributed local knowledge of the lower river that also helped with site selection. Channel openings were monitored by frequent road trips along the Copper River Highway and by an aerial survey on 14 May 2001. The river was ice free with a good flow of water near the Mile 27 site as early as 4 May; Mile-37 (and nearby Mile-36) channels were partially open by mid-May, but contained several ice floes and were not safe for bathymetry (boat) work until about 20 May. The two areas along the Copper River Highway that appeared most promising for fish sampling were the areas downstream of the Mile-27 and Mile-37 bridges (BR 331 and BR 342; Figs. 2 and 3).

Stage height (water level) of the Copper River was monitored during the study period at the Mile-27 and Million Dollar bridges (Table A-1; Figure A-1, A-2). The Miles Lake sonar site was operated by ADF&G from 16 May to 31 July 2001 (Table A-2). An estimated 323,000 salmon passed the Miles Lake sonar site from 16 May to 8 June 2001 (approximately the group of fish monitored by the lower river test fisheries).

Bathymetry

Mile 27

A bathymetry survey at Mile 27 was conducted on 5 May and 7 May below Bridge 331. Depth measurements were referenced to a water surface elevation of 9.3' on the Bridge 331 gauge. The survey covered an area 100 to 190 m wide, from Bridge 331 to 1,100 m downstream. In this reach, the river flows straight to the southwest. About 200 m downstream from Bridge 331, a second channel (from Bridge 1187) joins the main channel. Analysis of the bathymetry data revealed the following general patterns (Figure 4):

1) A maximum depth of 4 m was measured immediately downstream of the bridge;
2) More than half the area surveyed is between 1.5 and 2.5 m deep;
3) The right bank slopes at approximately 7 – 17 degrees;
4) The left bank slopes much more gently at approximately 2 – 6 degrees;
5) There is a varied pattern of areas of deposition and erosion, with a submerged bar 50 m off the right bank, extending from approximately 500 m to 1,000 m downstream of the bridge; and
6) In the first 500 m below the bridge, the deepest part of the channel is along the right shore. Further downstream the left side becomes the deeper side of the channel.

Mile 37

A bathymetry survey was conducted at Mile 37 on 22 and 28 May 2001 (Table 1). Depth measurements were referenced to a water surface elevation of 43.7 feet on the Bridge 342 gauge. The survey covered the main channel from Bridge 342 to about 500 m downstream. In this reach the river is approximately 180 – 250 m wide and runs south for about 200 m. The main flow then continues south southwestward, while a side channel splits off toward the southeast. The bathymetry in this area had the following features (Figure 5):

1) A deep scour hole on the right side, immediately below the bridge with a maximum depth of 12 m;
2) The maximum depth of the remaining area is 5 m;
3) The downstream edge of the scour hole continues to the southeast towards the side channel;
4) From the riprap on the right side, a bar extends to about 200 m downstream;
5) Above and below this bar the deepest part of the main channel is along the right side;
6) The right bank slopes approximately 30 – 40 degrees at the deepest part of the scour hole, 2 – 16 degrees along the middle of the bar, less than 2 degrees at the downstream end of the bar towards the trailing edge of the scour hole and 3 – 13 degrees further downstream;
7) Downstream of the bar the middle third of the main channel is flat with a gradient of less than 1 degree, followed by a gentle rise of 1 – 2 degrees towards the left bank; and
8) Upstream of the side channel the left bank slopes at 4 – 10 degrees.

Water Velocity

Velocities recorded in the Copper River in the Mile-27 Channel of the Copper River ranged from 0.24 m/s approximately 3 m inshore of the sonar transducer (Site 1) in very shallow water, to 0.82 m/s in the center channel (Figure 6). The average river velocity at the transducer at Site 1 on 20 May was 0.34 m/s. Water velocities in the Mile-37 Channel were slightly higher than the Mile-27 Channel and ranged from 0.25 m/s to 0.94 m/s (Figure 7).

Single Transducer Systems

Splitbeam sonar systems were deployed at nine locations near Mile 27 and Mile 37 of the Copper River Highway (Figs. 6 and 7). Transducers were positioned from the river bank or from an anchored boat. We collected acoustic fish-count data from Site 1 at Mile 27 from 13-27 May (Table 2).

Sample Site Selection

The initial sample location (Site 1) at Mile 27 was located approximately 1,000 m below the Copper River Highway Bridge 331 to allow water flowing under Bridge 1187 to rejoin the main channel upstream of our sample location. These two channels provided most of the flow during May 2001 because low water levels restricted flows to other channels. Continuous sampling was conducted at Site 1 from 13 May through 27 May 2001. The site was selected because there were fewer embedded tree limbs than there were in much of the right bank below Bridge 331. The underwater slope (-15°) was also similar to the above-water slope, insuring we would be able to sample this site if the water level increased during the study period. Sample range was less than 7 m during much of the sample period and project staff were able to sample fish near bottom throughout the sample range (Figure 8).

The heading, pitch, and roll (HPR) sensor output through the period 20-27 May was –12°. This would place the bottom edge of the 6° transducer beam on the bottom of the –15° slope. Since the bathymetry slope and aiming angle from the HPR sensor matched our observation of the 4-inch target sphere near bottom at all sample ranges, we concluded that fish were sampled on and near bottom at this site. The observation of bottom intrusion when sampling at the –65 and –75 dB threshold also supports this conclusion.

Small Fish – Eulachon

Echograms collected during the period sampled at Site 1 (Mile 27), indicate that a large number of small fish passed by the site near shore. The mean acoustic size of these fish was – 53.4 dB, approximately 20 dB less than the mean acoustic size of sockeye salmon (Figure 9). Eulachon were captured by dipnetting upstream at Bridges 331 and 1187 (a commercial fishery) and by the field crew onsite during the periods we observed small fish with the acoustic equipment. However, densities of eulachon did not reach a point where we could not count salmon migrating among eulachon. We sampled at a –70 dB threshold to determine whether eulachon would present a problem in our ability to track salmon between 18-22 May, and then increased our threshold to –55 dB to eliminate these small echoes from the sample to reduce the size of data files.

Second Transducer at Site 1

On 25 May, after it became evident that water velocities at Mile 27 would not be sufficient to force salmon to migrate near the bottom or near shorelines, we began sampling with a single beam transducer aimed down 3 degrees from the surface to sample the water column near surface and out 21 m from shore. Tracked fish were observed throughout the sample ranges for both transducers (Figure 10).

Fish Behavior

Fish were not present in high enough numbers prior to 23 May to examine relationships between fish passage and water levels, tides or daylight. No relationship between fish passage and tides or diel period during the period 23-26 May (when fish passage was high) were evident (Figure 11). However, this was a short period and did not provide a high-powered test of any relationship between tide stage or daylight and fish passage as measured by the acoustic gear. Nearly all of the larger fish tracked during the sample period were moving upstream, and little evidence of milling was indicated. Mean upstream swim speed (0.44 m/s) was calculated from the time the fish was in the beam for fish from 4 - 7 m from shore. Tracking of the splitbeam system characterized 3,110 of the 3,486 fish at Site 1 as moving upstream. It should be noted that these data likely underestimate the degree of upstream movement. Studies on the Wood River, Alaska, found that splitbeam transducers showed similar ratios of upstream/downstream movement to those we observed even though visual counts from adjacent towers indicated little or no downstream movement actually occurred. These errors were due to incorrect assignment of the location of the fish in the beam by the splitbeam tracking system (Cronkite et al. 2000).

SM2000 Multibeam System

The SM2000 multibeam system was deployed in the Copper River seven times during May 2001 (Table 1). Two sampling sites were at Mile 27 (Figs. 6) and one was at Mile 37 (Figure 7). Following 15 May, fish were seen at every Mile 27 deployment. None were seen at Mile 37.

Typically, fish and the test target could be traced through less than one third of the 120-degree arc of SM2000. When the sampling range on the unit was set to more than 6 m, it became increasingly difficult to see fish close in. This was due to the fact that the size of the echogram was fixed. When the total range increases, individual range bins are compressed to fit the echogram, resulting in narrow tracks. This made it especially difficult to see fish at close range where tracks were short. At the time, project staff were unaware that the start-up range can be set in a password protected file. Tests found that average-amplitude-subtractive mode gave a dark but still jittery background. Amplitude-average mode gave a much brighter but steady background and added fading "comet trails" to moving targets. It was much easier to visually pick out the trails of moving targets over a steady bright background than it was to see moving targets without trails over a darker but unsteady background.

As expected, the multibeam system required substantially higher data storage capacity than the single-transducer acoustic systems. We typically collected 50MB every 1 – 3 minutes of SM2000 operation, which is up to 500 times more than the 0.1 MB per minute usually collected with the single transducer systems.

Limited resources were available for reviewing the collected multibeam data. Replay of SM2000 raw files required the SM2000 unit itself. Review of raw data files was therefore limited to the lease period (May 2001). The replay did not quite look like the monitor display during the original recording. It is difficult to say what exactly the difference was, since the original recording was viewed only once. A number of times we thought a good sequence of fish had been recorded but these were not apparent in the playback. Ian Higginbottom of Sonar Data (http://www.sonardata.com/sonardata/) provided us with a trial version of EchoView 2.2, which allowed us to review beamformed data from the SM2000. The echogram produced in EchoView has a coarser resolution than the SM2000 display. Large targets moving over low noise areas were still clearly visible, but less obvious targets detected in the SM2000 display appear to be lost in the coarser EchoView display.

Acoustic Test Fishing

A splitbeam acoustic system was operated on the Mile-27 Channel continuously from 13 - 27 May 2001 (Table 2). A total of 7,884 fish were tracked from data collected during this period (Table 3). When expanded to account for periods of down time, these tracked fish represented an estimated 10,706 fish passing through the area sampled by the acoustic beam (Table 3). Although some fish smaller than salmon were tracked, all tracked fish with mean target strength of less than – 40 dB were excluded from the tracking results (Figure 9). Fish counts were low (mean of 19/day) from 13-22 May, but increased more than 100-fold to a mean of 2,104/day from 23-27 May (Table 3). A comparison of the daily acoustic estimates to the net test fishing indices is presented below.

Net Test Fishing

Net test fishing was conducted almost daily in the Mile-27 Channel from 13 May to 7 June (Table 4). Drift dipnets were used from 14 - 16 May and drift gillnets were fished a total of 889 minutes during 21 days from 13 May to 7 June. Eighteen chinook salmon and 602 sockeye salmon were captured by drift gillnets during this period. A peak daily sockeye salmon index of 1176 occurred on 25 May and the season cumulative index for sockeye was 8483 (Table 5).

To examine changes of catchability in the gillnet test fishery over time, we compared the daily test indices to the Miles Lake sonar counts lagged by one day (Figure 12). These data show an apparent shift in the catchability between 26 and 28 May where the gillnet test fishery became less effective (i.e., a higher fish per index point in Figure 12). This decline in catchability was coincident with rising river levels (Table A-1, Figs. A-1, A-2). Rising water levels will tend to decrease the sampling power of a given drift (migrating fish become more "dilute"), and therefore could explain the decline in driftnet catchability observed in 2001.

Study team members initiated an in-depth review of test netting data as outlined in the methods section. A full write up of these analyses and results was not possible prior to the 15 December deadline for this report. This was in part due to other demands on ADF&G staff and that their funding source (Commercial Fisheries Entry Commission and not OSM) had a different reporting timeline than that for the OSM-funded aspects of this effort (i.e., end of June 2002). The full analysis and results of the 2001 net test fishing data will be presented as an appendix to the OSM 2002 annual report.

Preliminary conclusions from the ADF&G analysis were consistent with the results presented here. A lag of one day between the gillnet test fishery and Miles Lake fit the data best early in the season. A significant shift in drift gillnet catchability on 27 May made the curve-fitting exercise less informative than it could have been. Clearly, the value of the curve-fitting and forecasting techniques for the test fishery data will be greater in years when fish require more time to travel from Mile 27 to Miles Lake sonar than we observed in 2001 (e.g., 5 or more days).

Comparison of Acoustic Counts and Net Test Fishing Indices

Daily acoustic counts and test gillnet indices from Mile 27 were somewhat correlated with one another (Figure 13). When few fish were present, both gears detected few fish. When a large pulse of fish moved through, indices from both gear types rose in tandem. However, the gillnet test fishery appeared to have detected a significant movement of fish through the Mile-27 Channel about one or two days earlier than the acoustic gear (i.e., on 21 and 22 May). Based on later counts at Miles Lake (Figs. 14,15), we suspect that there were significant numbers of fish moving through Mile 27 on at least 22 May, but the acoustic counts did not rise commensurate with this increased escapement (test indices on 21 May were based on only 7.7 min of fishing and a catch of three sockeye).

That the acoustics "missed" fish for this 1 or 2 day period may have simply been the result of fish being distributed offshore of the reach of the acoustic beam at Site 1. The acoustic beam at Site 1 sampled to a range of about 7 to 8 m and the first pulse of fish may have been offshore of this ensonified area. Rising water levels during this period (Figure A-1) may have shifted fish distribution from the middle of the river to near shore shortly after the pulse of fish began to move through the area.

Comparison of Mile 27 Indices and Miles Lake Counts to Estimate Travel Time

Comparison of the daily indices (acoustic and driftnetting) at Mile 27 and the Miles Lake sonar estimates suggests that fish may have taken as little as one day to travel the distance between the two sites in mid May and possibly 2 days in early June (Figs. 14, 15). Fish appeared to arrive in significant numbers at Mile 27 on 22 May (driftnetting) and 23 May (acoustics). Fish arrived at Miles Lake in significant numbers on 23 May (7,925) and 24 May (19,752). To estimate the time fish took to travel the distance between Mile 27 and Miles Lake, we plotted daily Mile 27 test netting indices against daily estimates from Miles Lake that were lagged from one to five days (Figs. 14, 15). These comparisons appeared relatively unambiguous – all lags greater than one day seemed very unlikely for the first pulse of fish. A lag of one day produced coincident peaks and valleys in the estimated abundance at Mile 27 and Miles Lake. The appropriate lag for early June is a little less clear than it was for mid-to-late May. During this later period, a lag of two days appears to fit the data as well or possibly better than a single day lag, but this conclusion is less certain than the conclusion that the mid-to-late May fish required just one day. Regardless of the ambiguity between one or two days, lags of three, four and five days for the Miles Lake data produced relationships between the two sites that seemed implausible (Figure 15).

DISCUSSION

Bathymetry

The BioSonics DT6000 operated in tandem with a differential GPS was an efficient and effective means of developing bathymetric maps of potential acoustic and net-based test fishing sites. Two people were able to collect all bathymetric data from a small, light boat in just two days at each of the two locations (Mile 27 and Mile 37). One person in the office for an additional two days (immediately following data collection) was able to prepare bathymetric maps that guided in-season decisions on deploying transducers.

SM2000 Multibeam System

We identified several limitations of the SM2000 Multibeam system for our study. The primary reason we chose to use the SM2000 was to provide a 120-degree view from the transducer assembly. However, the system we used appeared to view only about one third of that at any one time. The unit components were heavy and cumbersome, making deployment on the banks of the lower Copper River without mechanical or hydraulic assistance very difficult.

The SM2000 generated a huge volume of data and this made transfer and analysis of data time consuming. Unlike the single and splitbeam systems, it was difficult to differentiate between eulachon and salmon with the multibeam data. Unexpectedly, we did not find boulders and other large obstructions interfering with single-transducer operations, eliminating the potential advantage of a wider view. In summary, the multibeam system was more difficult to use than the single transducer systems and provided less information. As these limitations became more evident, the study team shifted emphasis to deploying and operating the single-transducer systems.

Fish Behavior

In May 2001, fish migration in the Mile-27 Channel was suitable for conducting a test fishing operation. Fish moved quickly through the area and there was no evidence of milling. Salmon were distributed some distance from shore (targets were observed up to 70 m from shore, the farthest range ensonified). Low flows encountered in 2001 may have contributed to this offshore distribution of salmon. Due to the low flows, surface water velocities in mid-channel were only 0.8 m/s. Salmon will likely become more shore oriented at higher flows. Regardless, there are two reasons why a fixed site capable of reaching well offshore is needed to monitor the site at Mile 27 in the future. First, it is necessary to index early run abundance when flows are low. Second, it would be helpful to document and characterize any shift in distribution of fish toward shore to aid in the design of an acoustic or net test fishery. It was possible to reach 70 m offshore from Site 2, and therefore this appears to be a good area to set up the fixed acoustic system in 2002.

Acoustic-based Test Fishery

The single and splitbeam acoustic systems we used proved dependable and relatively easy to operate in the Mile-27 Channel in 2001. Once the systems were set up, relatively inexperienced technicians were able to monitor the sites 24 hours per day, seven days per week (13 to 27 May) and conduct the basic operations of the system. Periodic ice floes, even at Mile 27, made it necessary for a staff member to be at the acoustic sites 24 hours per day if gear was left in the water. Given the time it took to set up the acoustic system and that our acoustic team members were needed for other activities, it was far more efficient to just leave the single transducer systems operating 24 hours per day.

Eulachon did not interfere with the counting of salmon in the vicinity of Mile 27. The single and splitbeam systems were able to track smaller fish (including eulachon) that had a target size of approximately 20 dB less than the mean acoustic size of adult salmon, and the acoustic threshold by 15 dB effectively eliminated these smaller targets. At no time during the deployment at Mile 27 were the densities of the eulachon so great to obscure salmon targets.

We found migrating fish were distributed through much of the river's cross-section at the Mile-27 Channel and this may potentially limit the sampling power (percentage of all fish ensonified) of any shore-based acoustic system. Limited observations from 2001 suggest that as river discharge increased from the low flows seen early in the season, the cross-river distribution of fish shifted from mid channel to near shore (hence the "missed" fish on 22 May). Moving the sampling site in the future to one with a range of acoustic coverage that extends farther offshore (e.g., Site 2, Figure 6) should minimize this problem. The acoustic system used at Site 2 in 2001 was capable of sampling to a range of 70 m offshore.

We found no patterns in the limited acoustic data we collected to suggest that passage rates at Mile 27 were related to the time of day or to the tide stage (Figure 11). However, even if there were influences by these factors, it would have been difficult to detect them with intensive weekly fishing downstream and the limited coverage from the acoustics in 2001. Acoustic coverage of 24 hours per day over a greater number of days in 2002 should allow us to better characterize any effects of time of day and tide stage on abundance at Mile 27.

Net Test Fishing

Drift gillnets were more productive than dipnets in 2001. Greater coverage of the channel and higher catches were possible with the drift gillnet than with the drift dipnetting. Drift gillnet test fishing was effective at sampling offshore areas in 2001.

In 2001, low water conditions during test fishing may have contributed to the efficacy of drift gillnet fishing and higher water levels may decrease the effectiveness of the drift gillnet gear. Changes in catchability of the test netting gear over the short 2001 season appear to support this hypothesis (Figure 12). Temporal trends or shifts in catchability may prove to be predictable in the future using water level information. In order to develop a reasonable predictive relationship, it will be critical to continue to monitor water levels during the season in future years. However, developing relationships between water level and catchability of the net gear may take many years, during which the river conditions may change and significantly alter the catchability of the gear. If dramatic shifts in catchability cannot be predicted by water level information or quickly accounted for by Miles Lake data, it may be difficult for any test fishing method to provide quantitative estimates of escapement inseason.

Among- and Within-Year Changes to Flow in River Channels

To develop a test fishery on the lower Copper River, it is important to consider among-year changes in the river channels of the Copper River delta. The river's high sediment load has produced numerous dynamic channels along its final 50 km making a lower river test fishery elusive to other researchers. The 1981 flood likely caused a major shift in the river flow from the Mile-27 Channel on the delta's west side, to the Mile-37 Channel on the east side (Brabets 1997). Based on observations in October 2001, it appears the Mile-27 Channel may have changed over the course of the 2001 summer more significantly than in previous years. These changes may eventually cause much more of the flow to move down the Mile-37 Channel. It is realistic to assume it may be necessary in the future to move a test fishery from Mile 27 to Mile 37. Until the conditions and/or data indicate that this is necessary, it will be useful to continue to monitor daily fish passage at Mile 27 so that we can characterize among-year variation in test fishery performance and travel times to Miles Lake.

Local traditional knowledge obtained from the fall workshop indicated that salmon might shift their entry point and channel use in the Copper River delta over the course of the summer. Typically, fish appear to predominately use Mile-27 Channel in May and early June and over the course of the summer shift toward the main flow coming from the Mile-37 Channel (Figure 2). This shift over time would certainly make test indices from Mile 27 of marginal value beyond mid June. However, the focus of this project is to develop a program to estimate the *early season* escapement into the Copper River (early May to early June), and therefore workshop participants thought that monitoring at Mile 27 would be an effective site for these early run fish.

A major shift in the distribution of fish from the Mile-27 Channel to the Mile-37 Channel (within a given year or among years) could confound the results and interpretation of test fishing data from Mile 27. For example, if fish begin to use Mile 37 during the sampling period and staff were not aware of this, they would see a decrease in the apparent catchability of the test fishery. It will be difficult to attribute this shift in catchability to a particular factor such as increasing water levels in the Mile-27 Channel unless it is clear there has not been a dramatic increase in the use of Mile 37 by salmon. To prevent this confounding, it would be helpful to routinely monitor the Mile-37 Channel for significant changes in fish use. This could be accomplished by acoustically monitoring fish passage at the Mile-37 Channel for several hours every two or three days during the test fishing season.

Presence/Absence versus a More Quantitative Index of Abundance

Fishery managers recognize two broad but useful levels of "precision" for escapement data from a lower river test fishery in the Copper River – presence/absence and more quantitative measures such as "more than a few hundred", less than 20,000, etc. Each year, in the earliest stages of the Copper District commercial fishery (mid May), uncertainty can reach a level where managers simply want to know "are there fish present in the river upstream of the fishery or not?" In this situation, a test fishery need only detect if fish are present (or absent) in channels that fish are known to use. This may sometimes be enough information to sway management decisions between opening or not opening the fishery. Results from 2000 and 2001 demonstrated that drift gillnets and acoustics can provide presence/absence information in the lower Copper River.

Clearly, a more quantitative measure of abundance would be better than simply knowing that fish have begun to move through the lower river. Given the size of the Copper Delta, complete coverage of every channel that fish may use is not possible, nor is it necessary, as only a few channels are open early in the season and the Miles Lake sonar can provide a complete count. A realistic goal of a quantitative test fishery might be to provide managers with crude range bins of passage based on historical test fishery performance. For example, a future test fishery might provide, say, four range bins of escapement ("essentially zero", a "few hundred", a "few thousand" and "more than 5,000").

The results from 2001 indicate that it is possible to develop a test fishery capable of providing more than presence/absence information in May and early June. A primary goal for the remaining two years of this project should focus on continued monitoring at Mile 27 to characterize the among-year variations in test fishery performance (drift gillnet and acoustic) and estimate sockeye salmon travel time from Mile 27 to the Miles Lake sonar site. Side-by-side comparisons of drift gillnet and acoustic techniques should allow identification of which method is superior.

Technical and Community Workshops 2001

Technical (29 November) and community (30 November) workshops were held in Cordova to review project progress and results prior to completion of the annual report (Table B-1). Posters were prepared that explained the concept and preliminary results from the first year of the study (Appendix C). Biologists, managers and administrators from several agencies were able to attend and information exchange among participants was very worthwhile. In addition, several fishermen and other local residents from around the Copper River Basin provided input and local traditional knowledge to the study team. These workshops were an excellent means of presenting the results to those who manage and depend on Copper River salmon. Moreover, input from these people clearly improved the synthesis of the results presented in this report.

Fieldwork for 2002 Season

In 2002, a well-functioning test fishing operation at Mile 27 will provide the greatest chance to evaluate several key variables needed to determine the utility or feasibility of a lower Copper River test fishery. The utility of a test fishery (beyond a presence/absence role) will be a function of how consistent the catchability is across a given season, and to a lesser extent, how much it varies among years. Therefore, the performance of both the acoustic and drift gillnet test fishery can best be evaluated by comparing changes in catchability within and across years.

During the fall workshop, there was discussion about the merits and feasibility of locating a test fishery farther downstream than Mile 27 and using a tagging study to measure the travel times of fish from this area to Miles Lake. Results from the 2000 and 2001 test fishing studies demonstrated that fish passage can be monitored over time at Mile 27 and that moving test fishing gear farther downstream will become more and more difficult. Moving fishing gear farther downstream from Mile 27 in the second year of a three-year study may limit the utility of the data from this project. First, based on observations of the field crews over the last two seasons, areas downstream of the Mile-27 Channel offer little chances of obtaining a month of continuous daily indices of fish movement. The river breaks up into several channels below the Mile-27 Channel making inferences as to why catchability may be changing over time much more difficult than with a single channel. Finally, and most importantly, a primary result from this study will be to characterize the among-year variability in test fishery catchability and sockeye salmon travel time to Miles Lake – moving to an entirely new site downstream, even if it were to provide daily indices, would limit this characterization to just two seasons (i.e., study years two and three).

Given that it is important to obtain multi-year observations of test fishery performance and measures of the sockeye salmon travel time to Miles Lake, it will be critical that acoustic and drift gillnetting occur daily in the Mile-27 Channel over the early run period in 2002. Depending on ice and river conditions, this early run period will range from about early May until early June (plus or minus 1-2 weeks). With this level of test fishing effort, it should be possible to obtain period-specific estimates of the catchability of each gear and estimate salmon travel time to Miles Lake in 2002. If fish behavior and river conditions are favorable, it may also be possible to use the peaks and valleys in the test fishery indices and the timing of the commercial fishery openings to estimate the time required for fish to travel from the commercial fishing boundary to Miles Lake. Finally, in order to prevent any confounding of results that could occur from a significant shift in migration of salmon from the Mile-27 Channel to the Mile-37 Channel, some regular monitoring of fish passage should occur in the Mile-37 Channel. Fixed acoustic gear appears more suitable for detecting fish in Mile 37 and should be able to provide an indication of dramatic shifts in distribution during the season.

CONCLUSIONS

1. Fish appeared to move through the Mile-27 Channel quickly and with little milling; this behavior was favorable for developing a test fishing program at Mile 27, and we expect to find similar behavior at Mile 37.

2. Eulachon were not a problem for acoustically counting salmon in 2001 at Mile 27, but the eulachon run in 2001 may have been less abundant and more protracted than in many other years.

3. The SM2000 multibeam sonar system wasn't very helpful for assessing presence or absence of fish in the lower Copper River – conditions in the area (bottom slope and lack

of debris and boulders) in the lower river allowed us to survey for fish as well or better with simpler single-transducer systems.

4. Drift gillnet fishing proved an effective test fishing tool; we were able to conduct nearly daily fishing over a 25-day period beginning in mid May. Catchability of the test fishery appears to have declined over the fishing period in 2001, possibly due to rising river levels.

5. A relatively simple acoustic system can monitor fish passage in the lower Copper River; a single transducer splitbeam system was operated 24 hours per day for 15 consecutive days beginning on 13 May.

6. Fish appeared to have traveled from the Mile-27 Channel to Miles Lake in about one day during May 2001 and two days in early June 2001.

7. Using the test netting and acoustic gear in tandem should greatly shorten the development time of a test fishery, in whatever form it may take.

RECOMMENDATIONS

Results from 2001 indicate that it is worthwhile to continue to examine the feasibility of developing a test fishery in the lower Copper River. Given the different advantages associated with acoustic and net gear, we recommend that both be deployed in 2002 in order to accelerate the development and refinement of a test fishery for the area. We recommend that the following activities be conducted from early May until mid June in 2002:

1) Operate drift gillnet and splitbeam acoustic gear at the Mile-27 Channel in a similar manner to what was done in 2001; attempt to locate the acoustic system on the river's left bank near Site 2 or at another location where the acoustic beam can reach well offshore.

2) Periodically (e.g., every two or three days) set up a shore-based acoustic system for four hours at a time at Mile 37 to monitor for presence/absence and to characterize any significant pulses of fish through these channels.

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Taube, T., and D. Sarafin. 2001. Area management report for recreational fisheries of the Upper Copper/Upper Susitna River management area, 1999. Alaska Department of Fish and Game, Division of Sport Fish. Fishery Management Report No. 01-7. Anchorage, AK. 121 pages.

FIGURES

Figure 1. Map of the Copper River basin showing the location of Miles Lake sonar and the test-fishing study area of the Copper River delta.

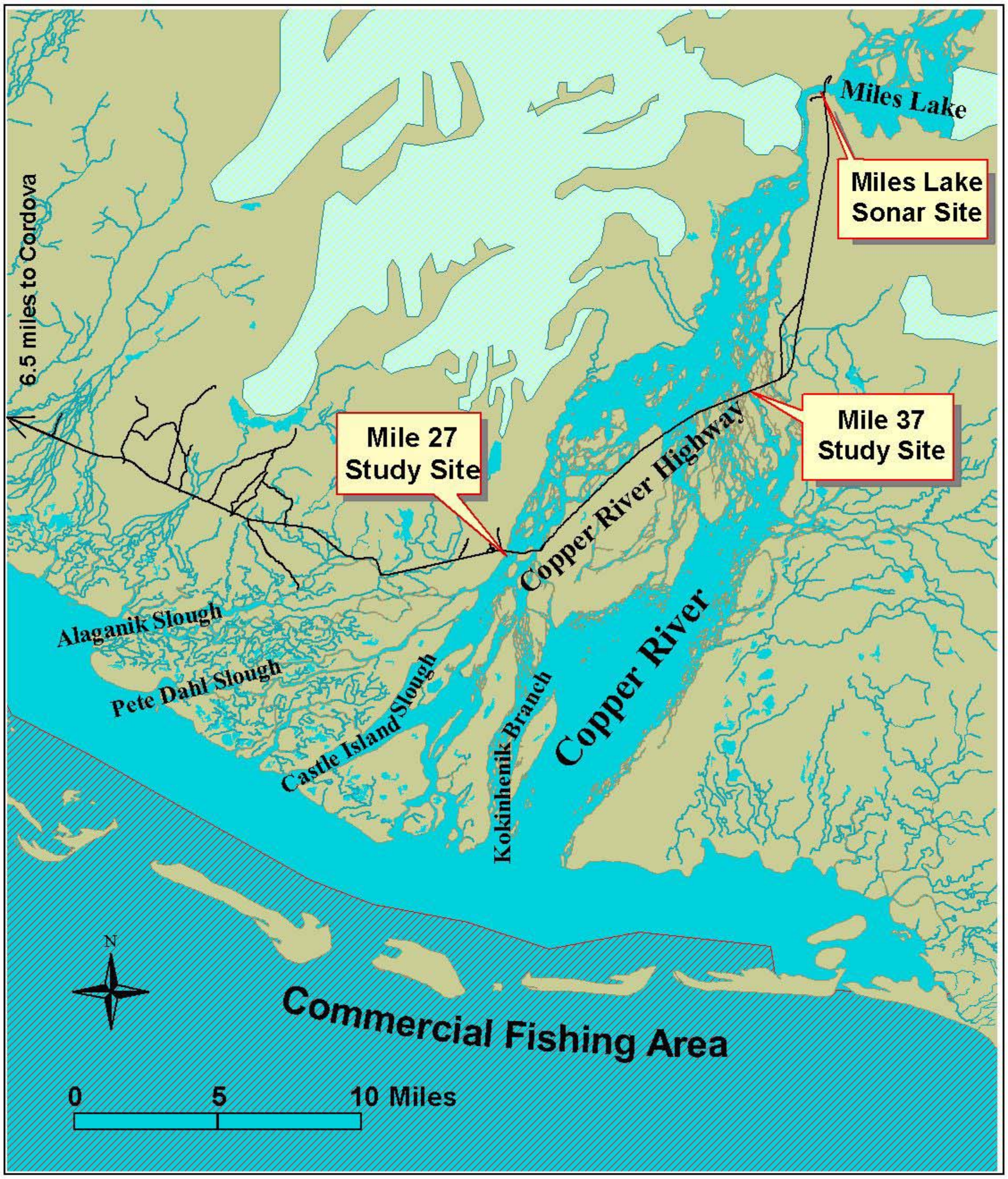


Figure 2. Map of the lower Copper River showing test fishing sites, the Miles Lake sonar site, and part of the commercial fishing boundary.

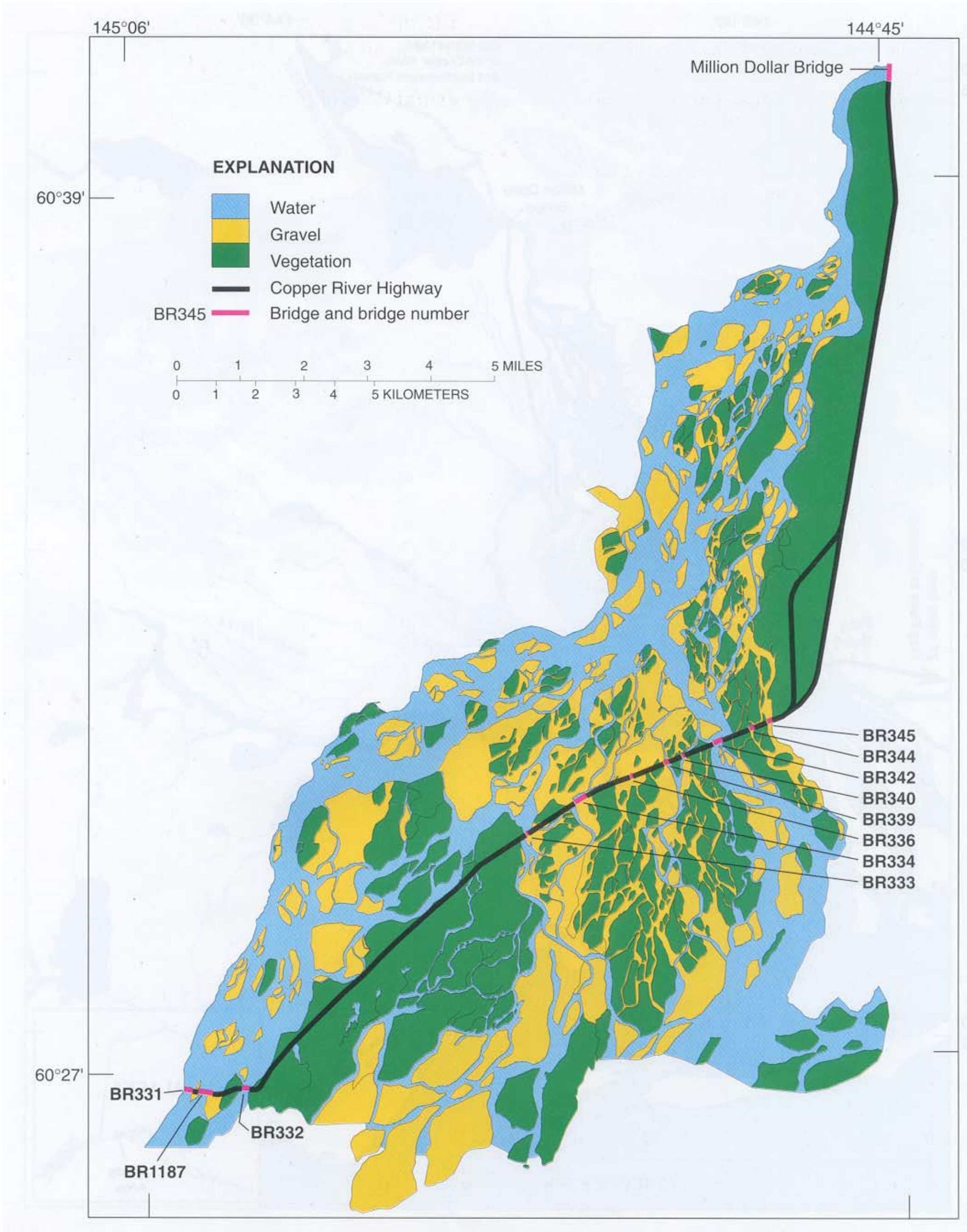


Figure 3. Locations of bridges (BR) along the Copper River Highway that cross the Copper River, 1991 (from Brabets 1997). Mile-27 Channel is fed from flow through BR331 and BR1187; Mile-37 Channel is fed from flow through BR342.

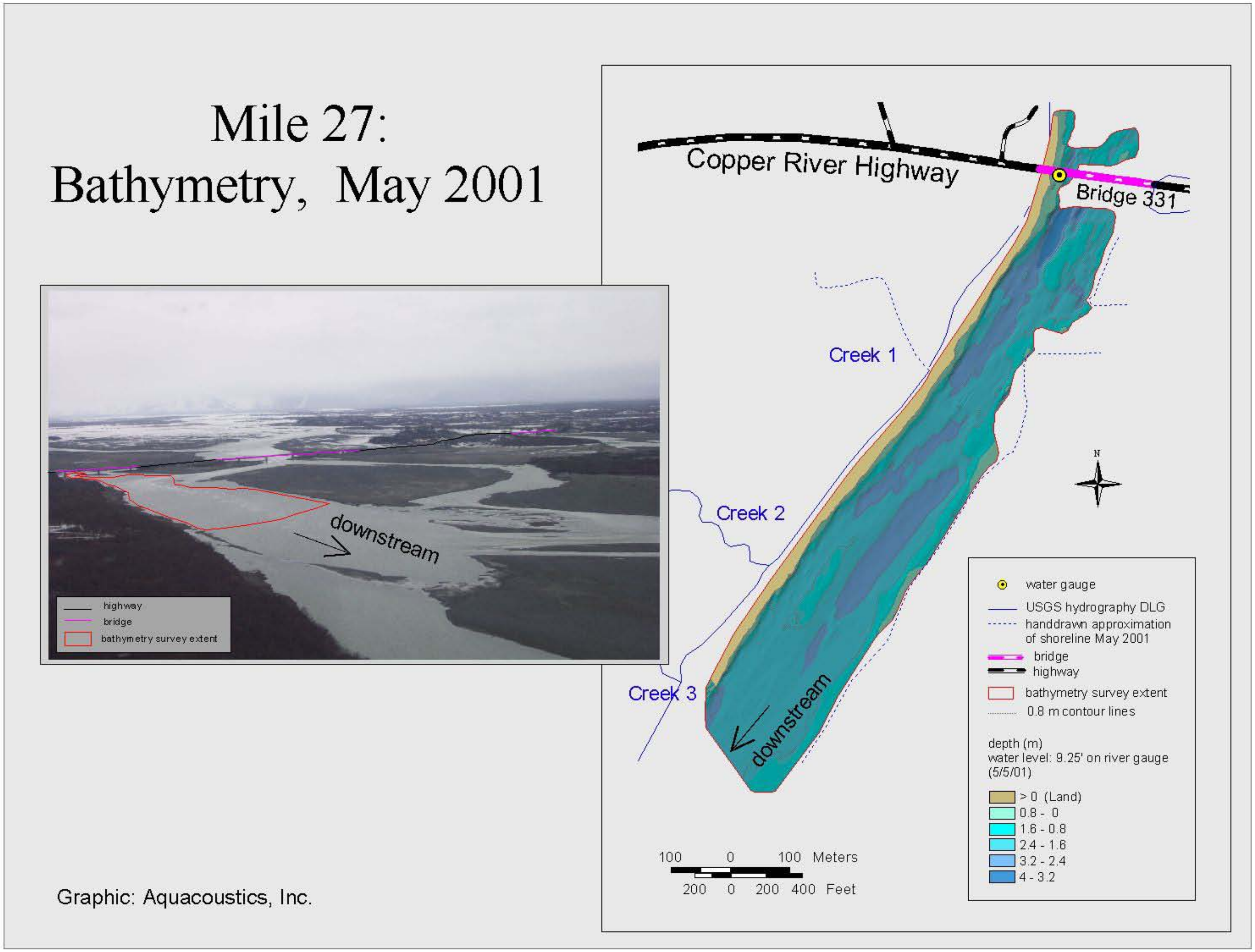


Figure 4. Bathymetry of the Mile-27 Channel of the Copper River, May 2001.

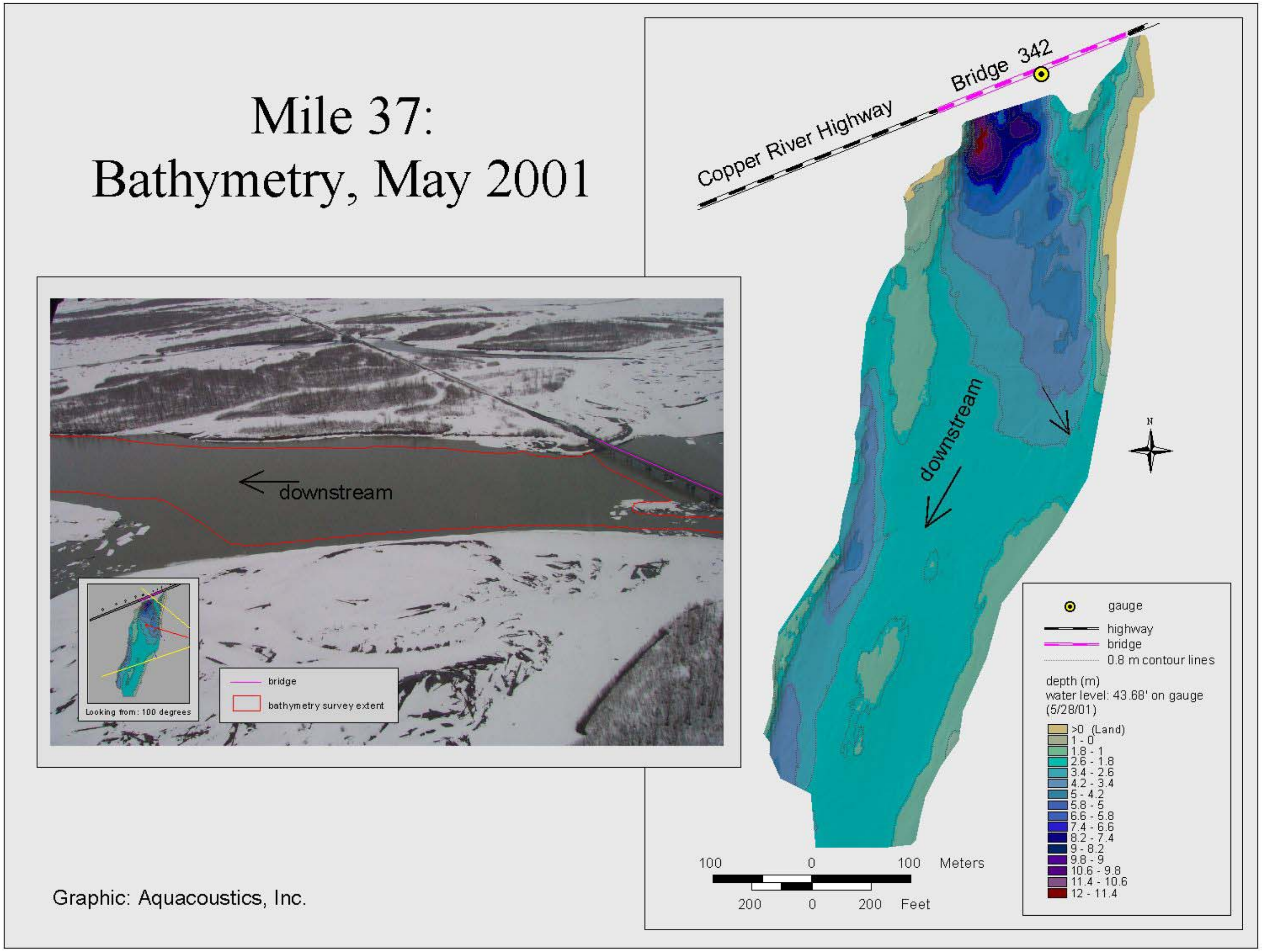


Figure 5. Bathymetry of the Mile-37 Channel of the Copper River, May 2001.

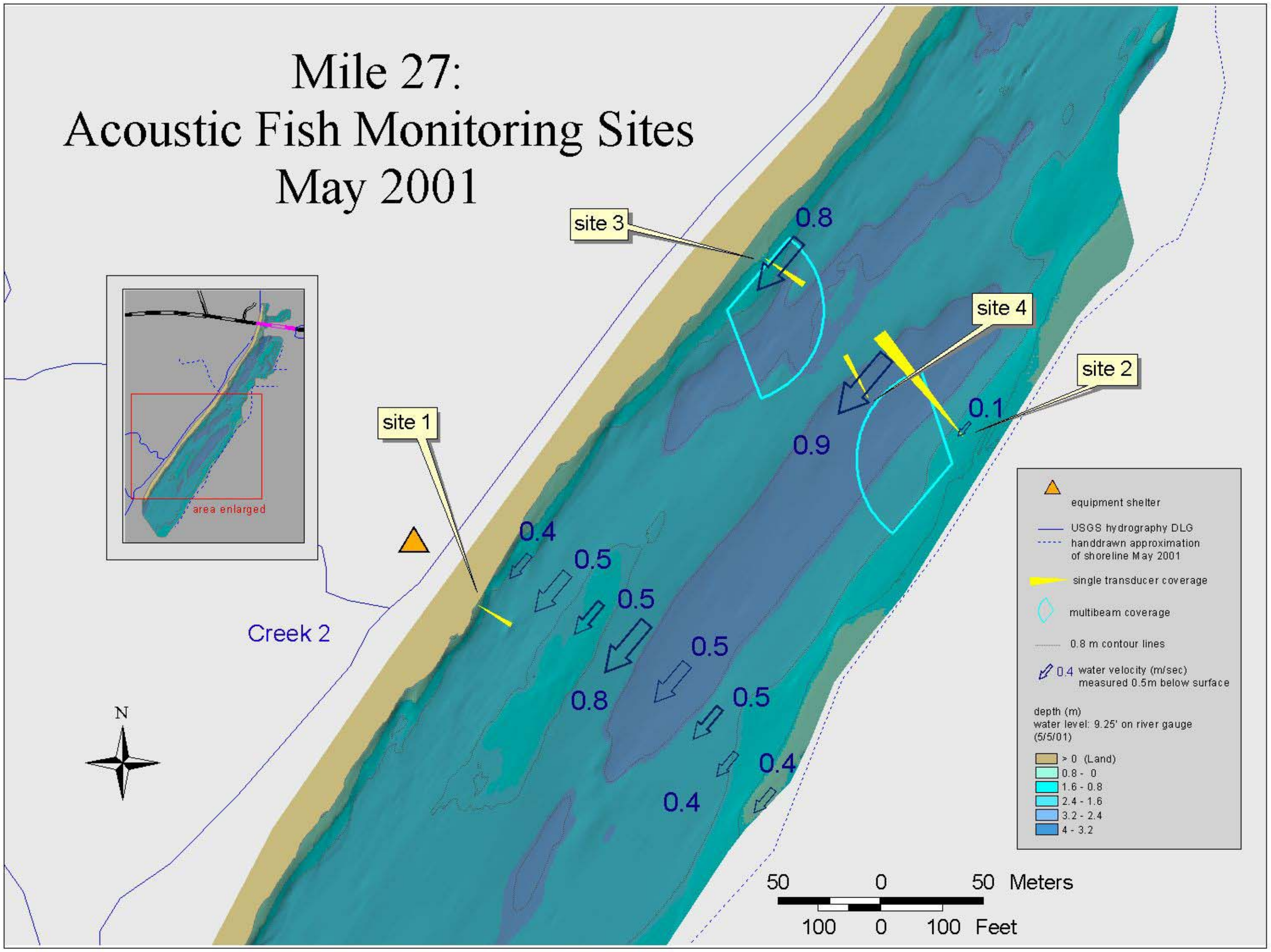


Figure 6. Acoustic sampling sites and water velocities in the Mile-27 Channel of the Copper River, May 2001.

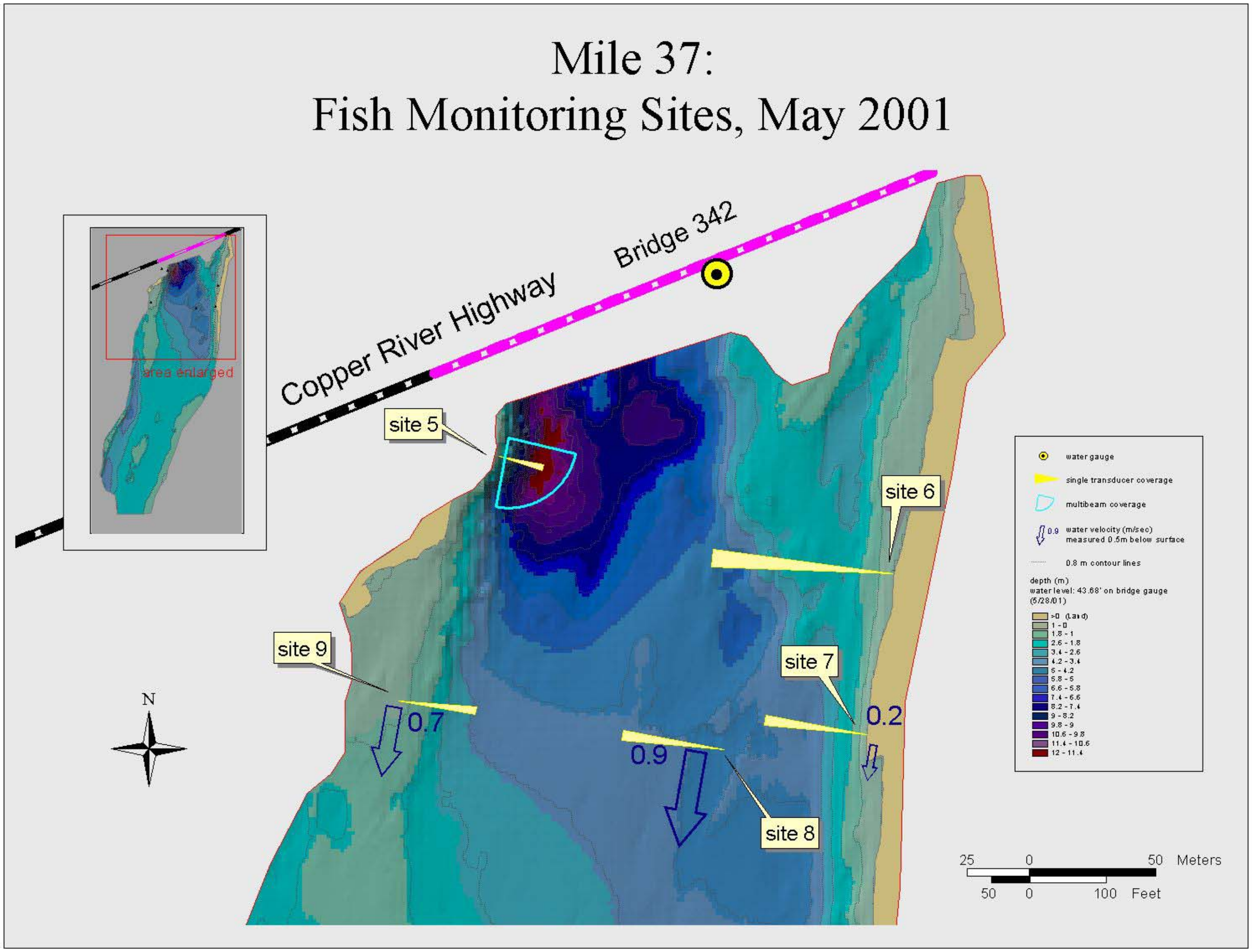


Figure 7. Acoustic sampling sites and water velocities in the Mile-37 Channel of the Copper River, May 2001.

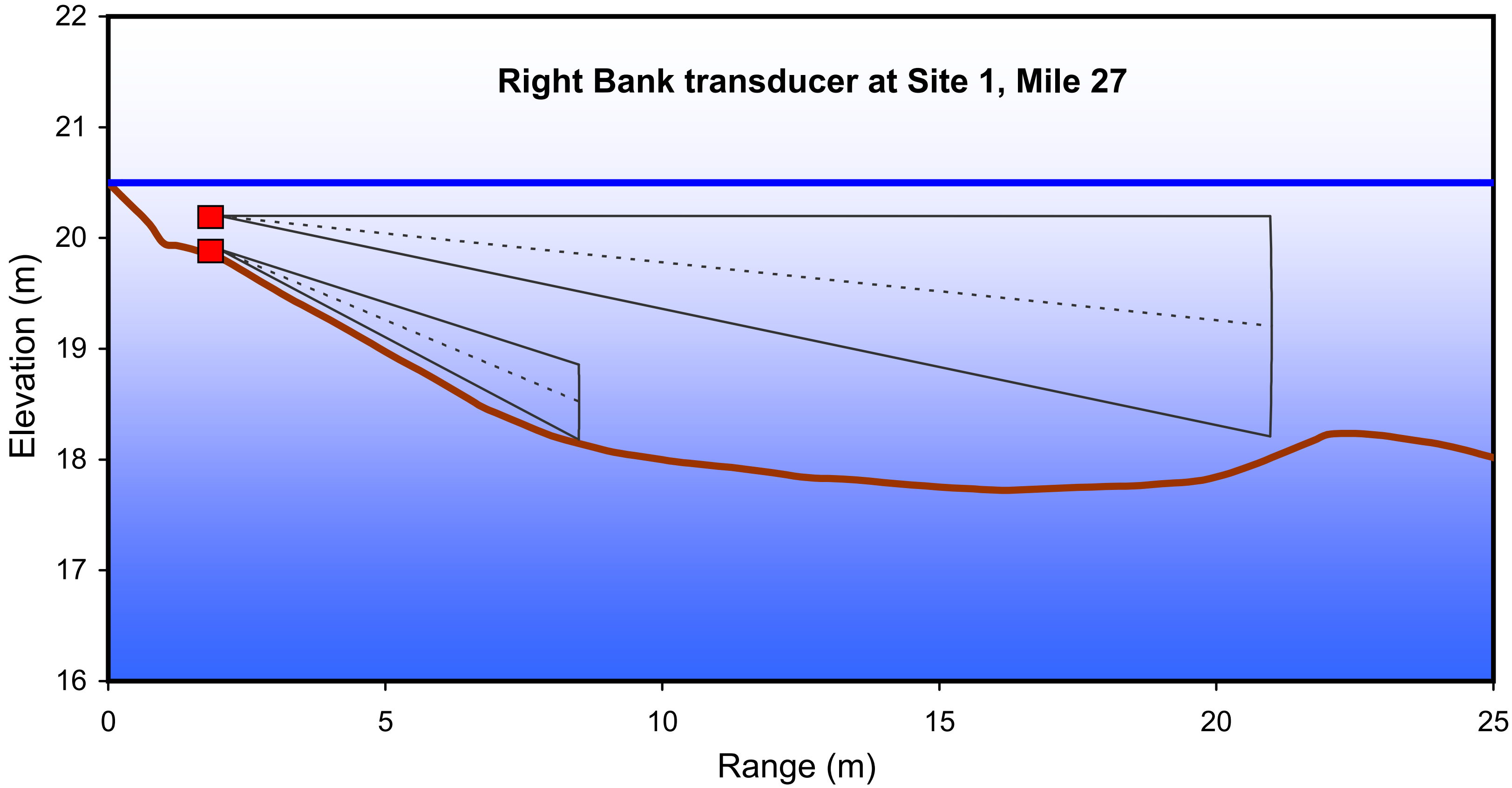
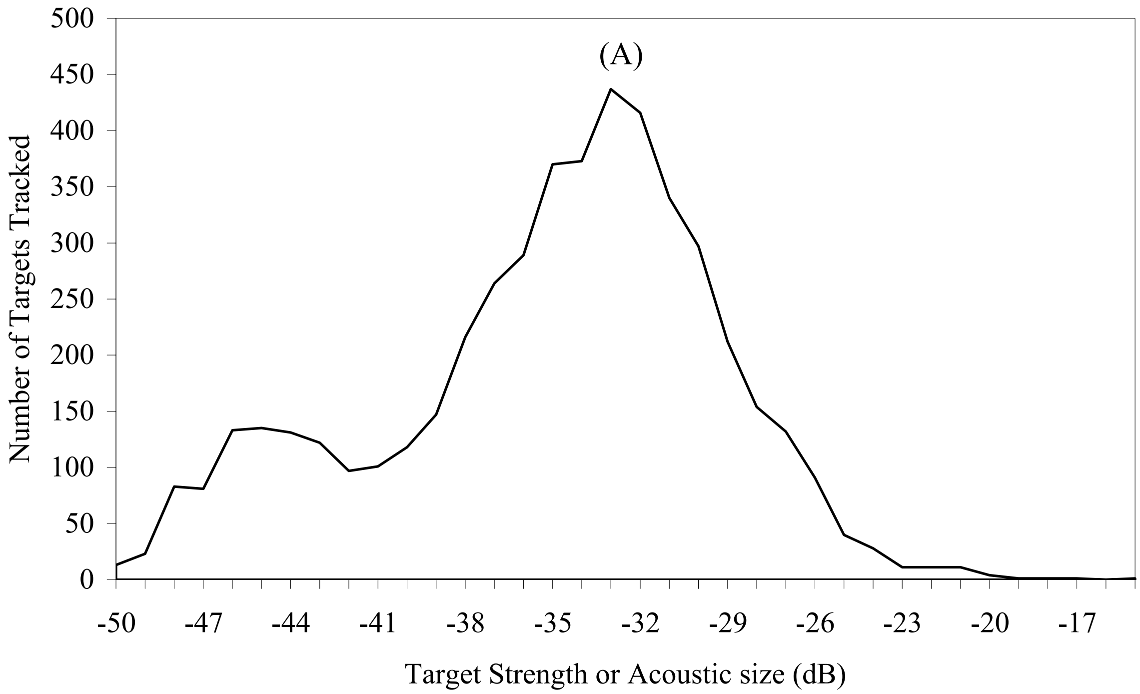


Figure 8. Bottom profile and acoustic beam range for the transducer at Site 1 in the Mile-27 Channel of the Copper River, 2001.



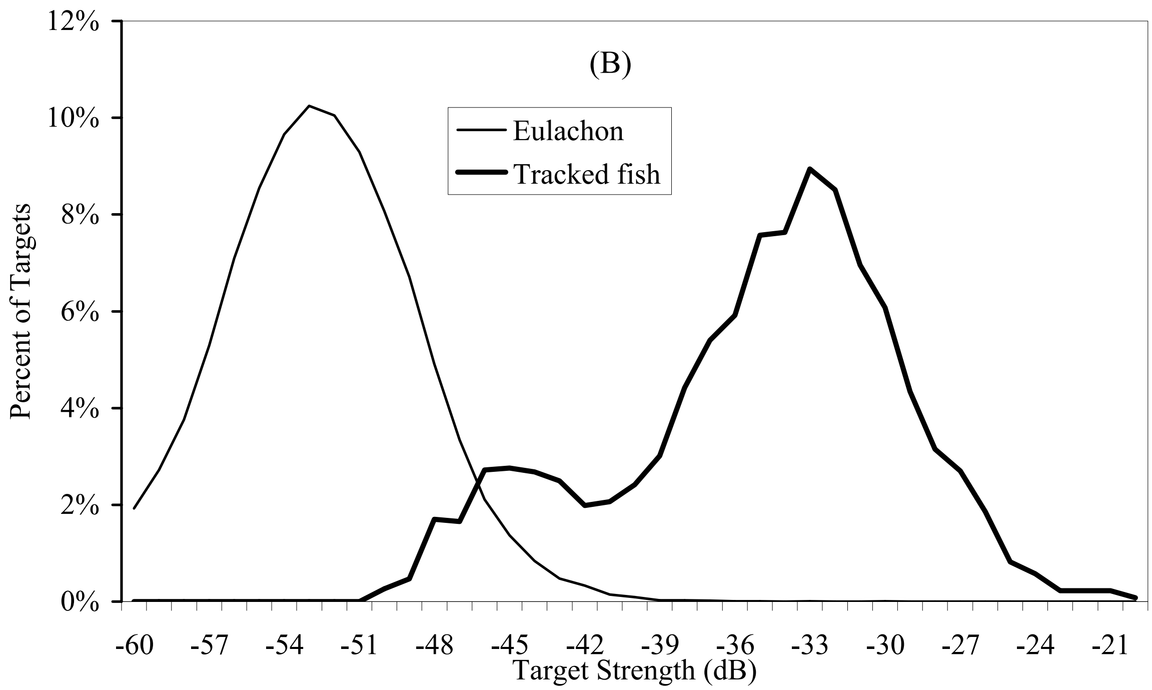


Figure 9. A) Size frequency distribution of all tracked fish from Mile-27 channel, Copper River, 2001.
B) Proportions of all eulachon and tracked fish by target strength, Mile-27 channel, Copper River, 2001. An upper threshold of -40 dB was used to classify eulachon.

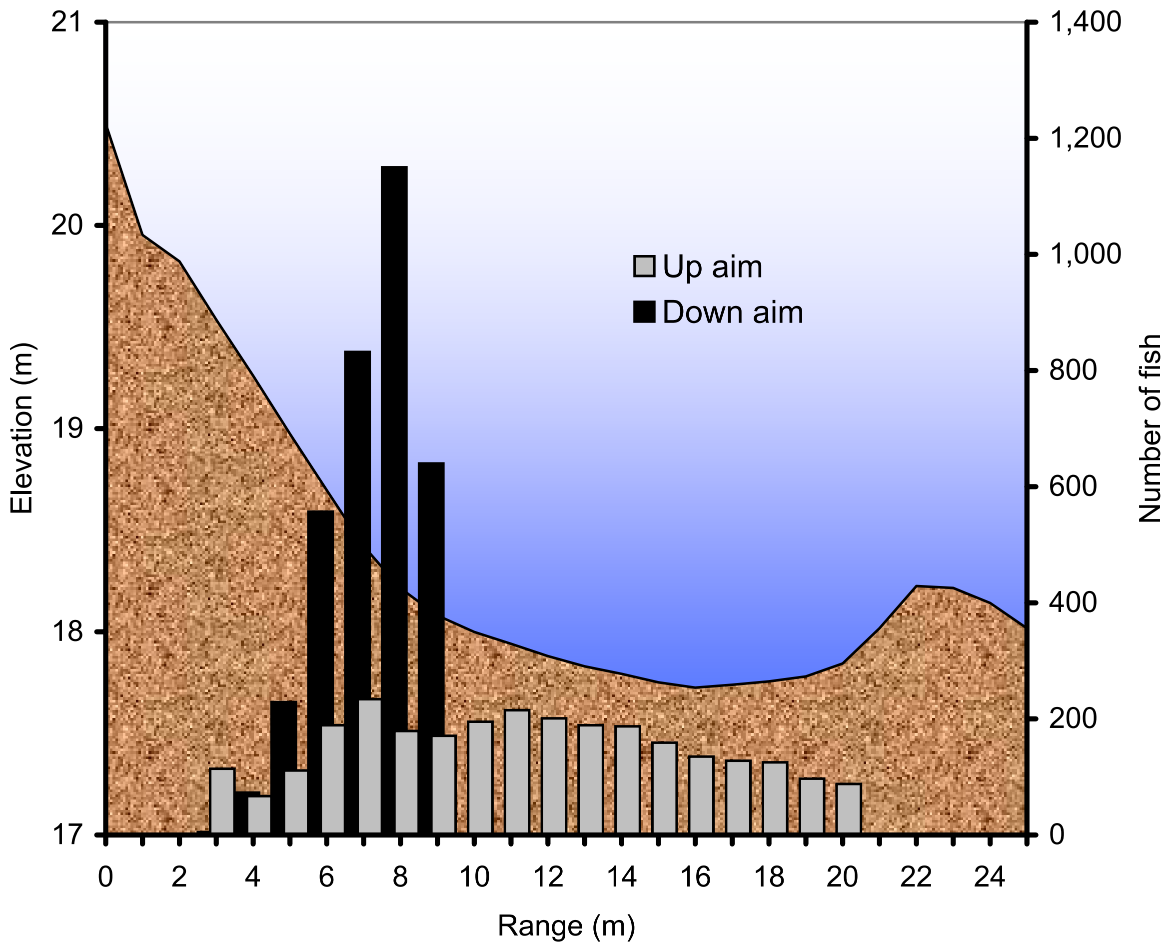


Figure 10. Distribution at range of fish tracked with single and splitbeam transducers in the Mile-27 Channel of the Copper River, 2001.

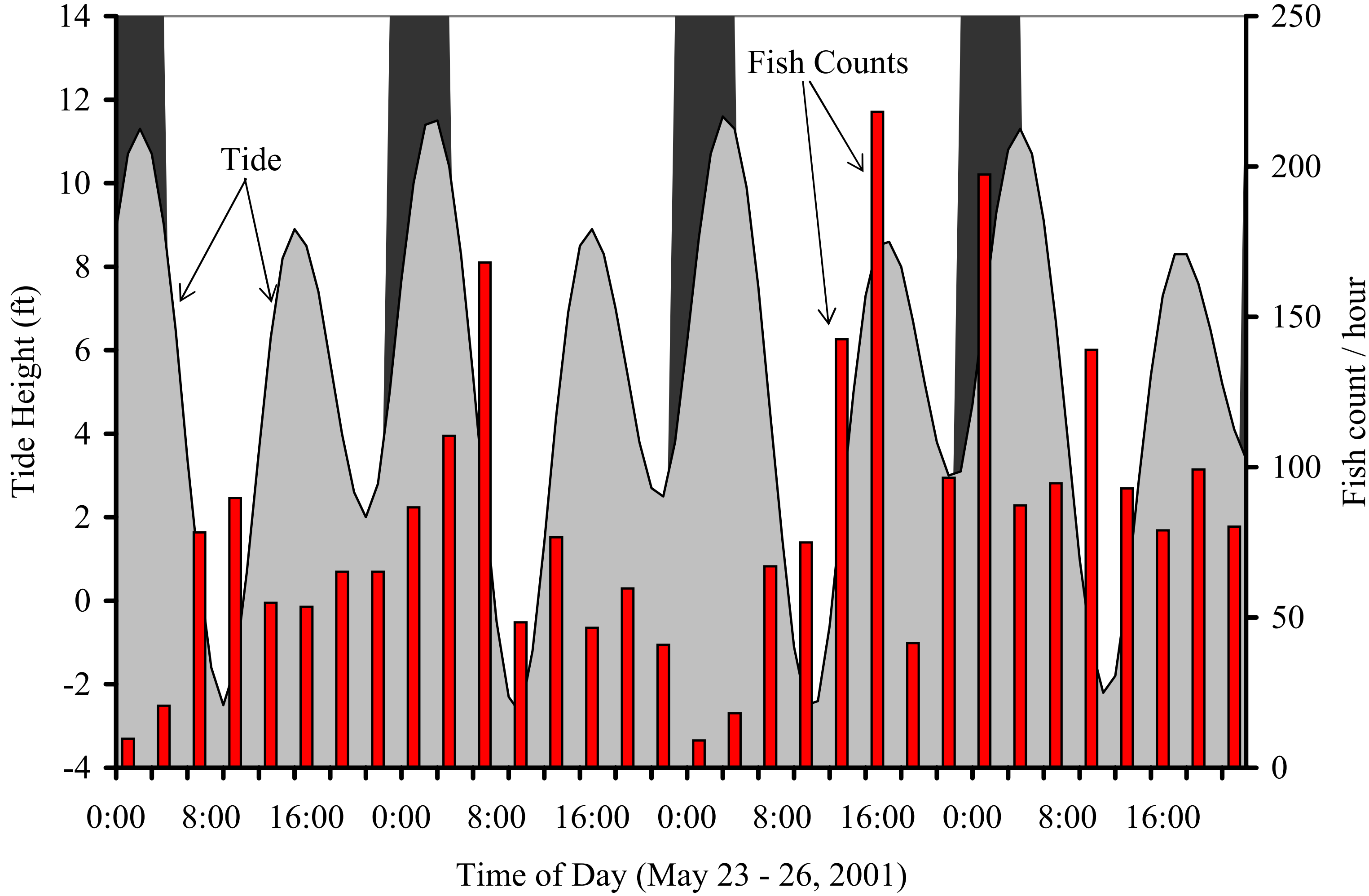


Figure 11. Acoustic fish counts at the Mile-27 Channel of the Copper River versus tide height, 23-26 May 2001.

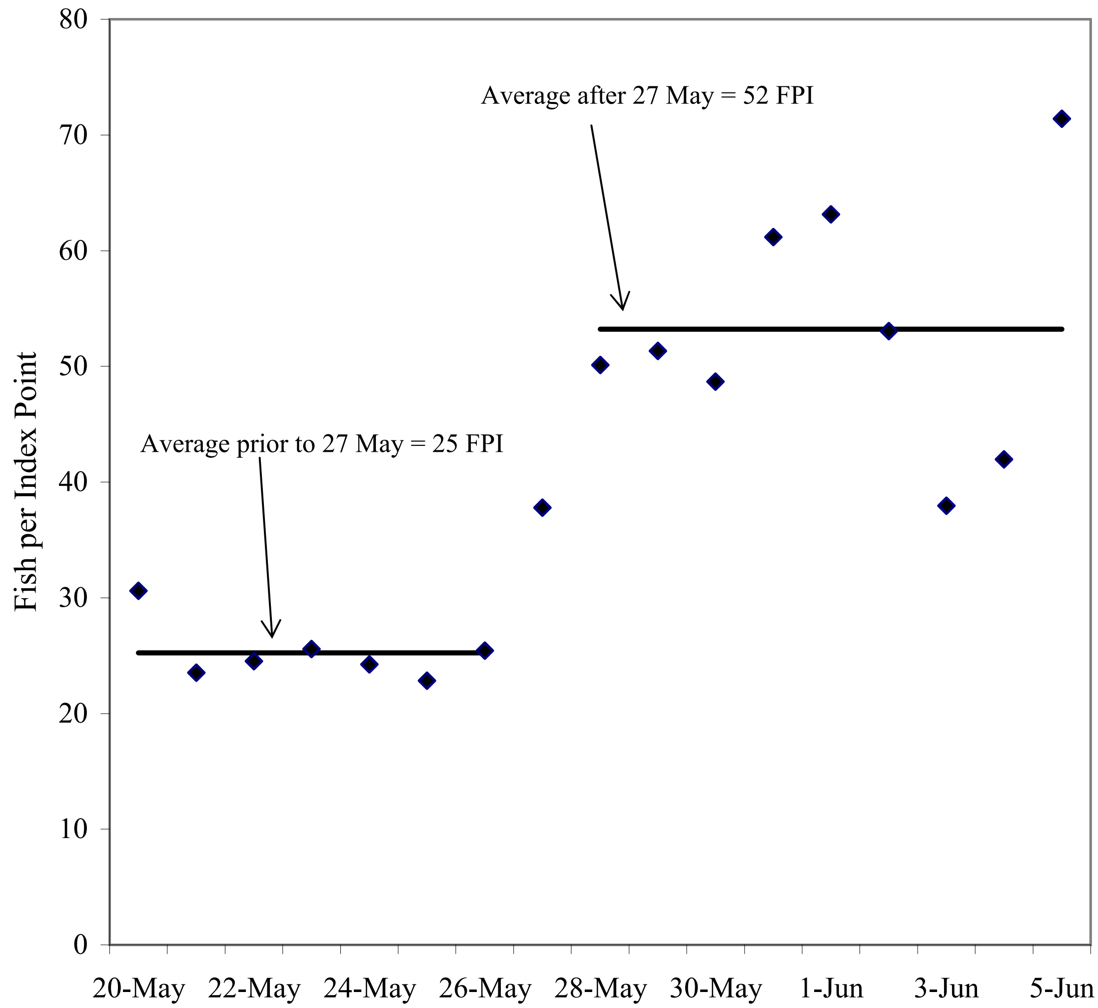


Figure 12. Three-day moving average of the catchability (fish per index point) of the drift gillnet test fishery on the Copper River, 2001 (based on Miles Lake sonar counts lagged one day).

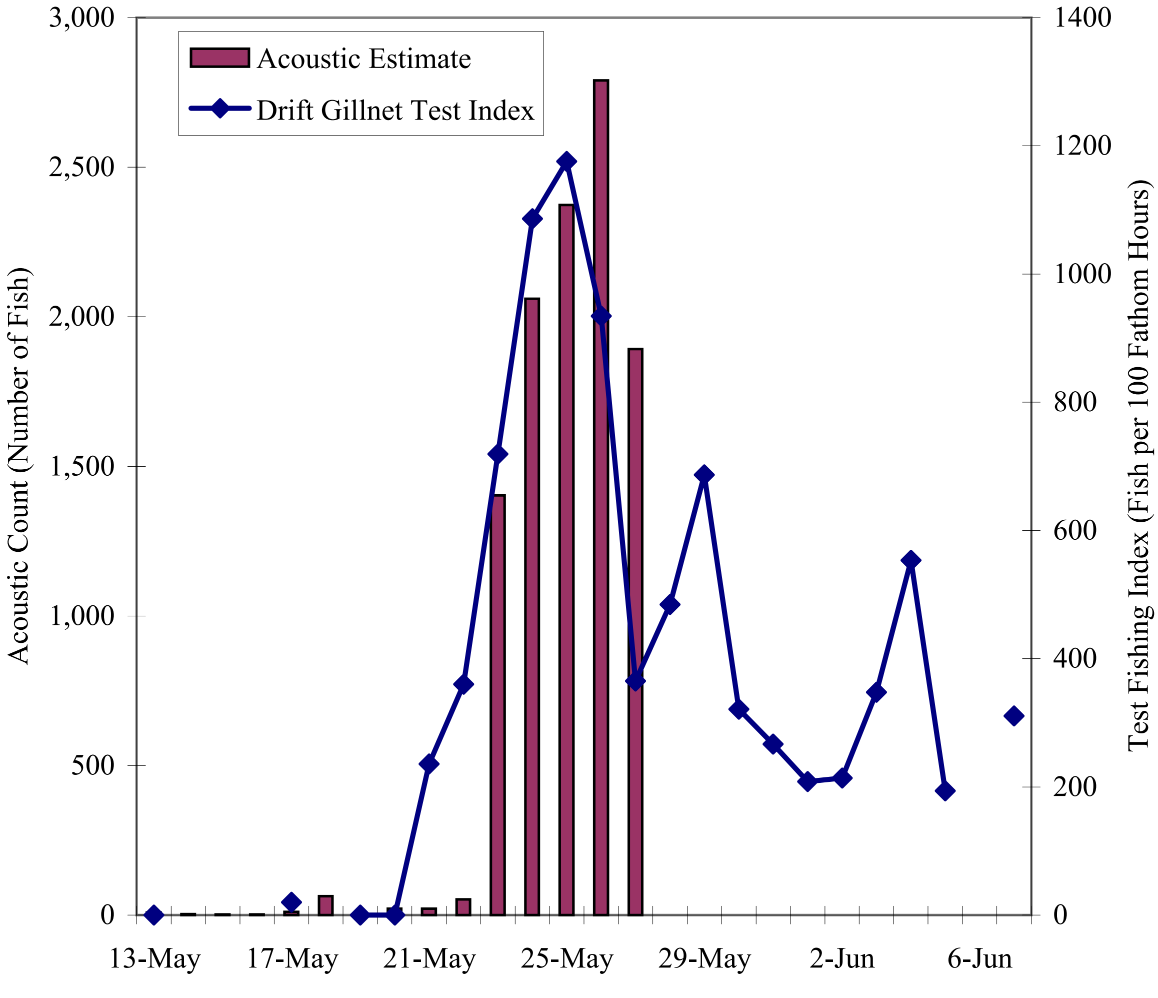


Figure 13. A comparison of daily gillnet and acoustic test fishing indices from the Mile-27 Channel, Copper River, 2001

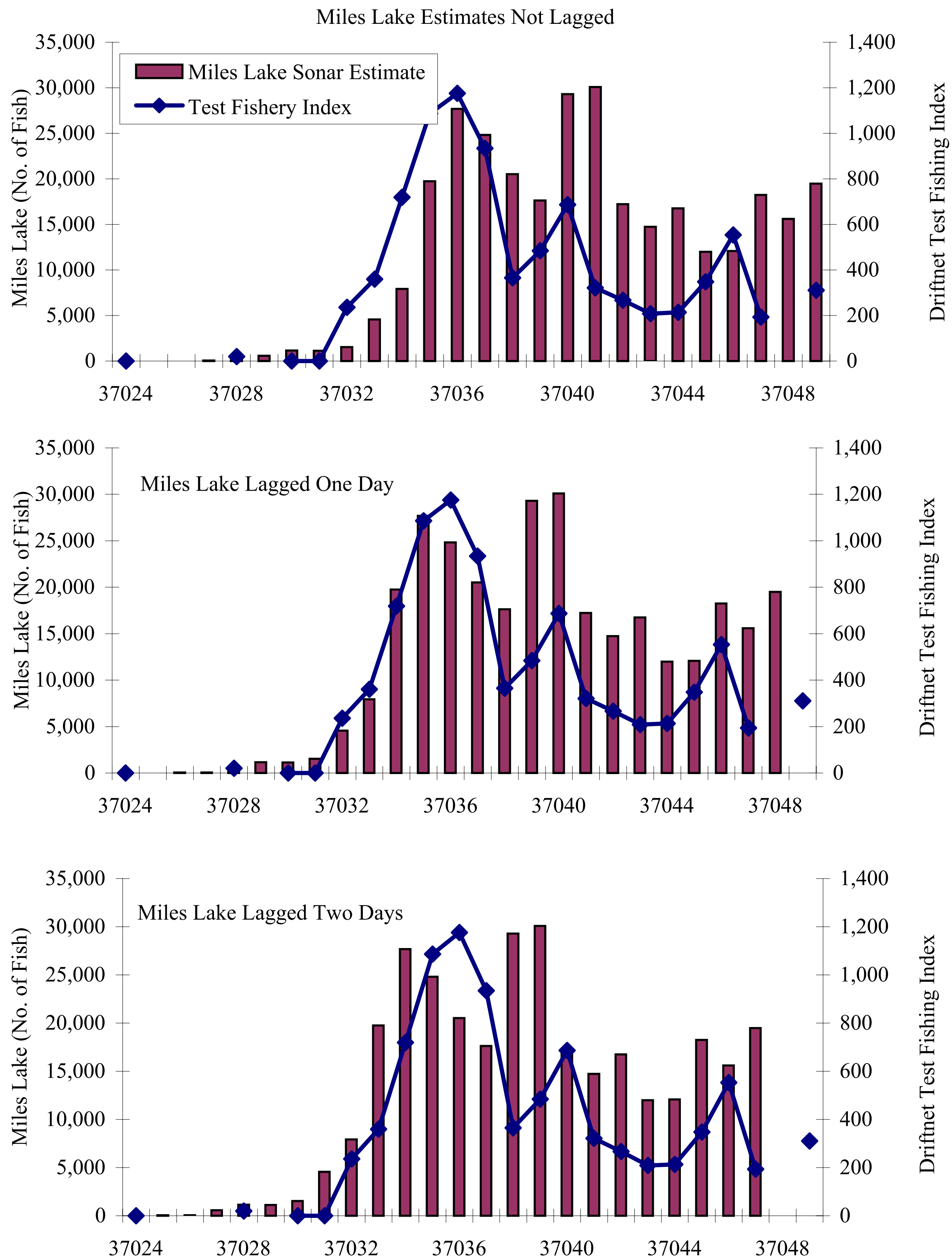


Figure 14. Comparison of daily Miles Lake sonar estimates and daily test fishing indices from the lower Copper River, 2001. Miles Lake estimates were lagged one and two days to estimate the time for sockeye salmon to travel between the two locations.

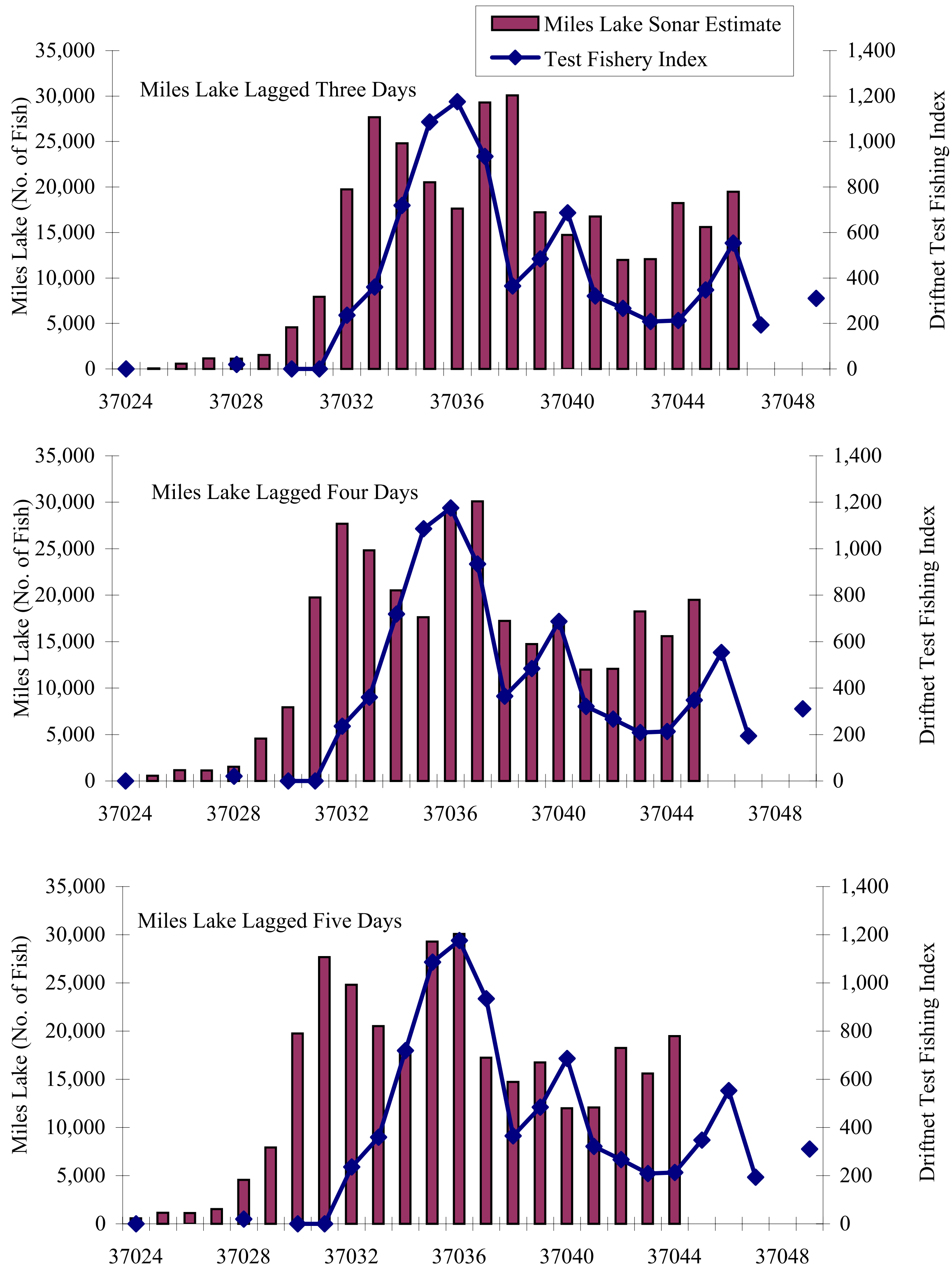


Figure 15. Comparison of lagged daily Miles Lake sonar estimates and daily test fishing indices from the lower Copper River, 2001. Miles Lake estimates were lagged three to five days to estimate the time for sockeye salmon to travel between the two locations.

TABLES

Table 1. Alpha-beta Tracker parameters used for tracking acoustic echoes collected at all locations on the Copper River, May 2001.

Parameter	X	Y	Z
Alpha	0.33	0.21	0.2
Beta	0.04	0.02	0.06
Weights	0.1	0.01	0.05
Initial Velocity	0	0	0
Minimum echoes	4		
Maximum missed echoes	10		
Search radius	6		

Table 2. Summary of sampling effort for acoustic gear operated on the Copper River, May 2001.

Date	Gear[a] Bathymetry	Multibeam	Single Beam	Splitbeam	Comments
05-May	x				Preliminary bathymetry survey, Mile 27
06-May					
07-May	x				Bathymetry survey at Mile 27
08-May					
09-May					
10-May					
11-May		x			MB briefly deployed, SPB set up on right bank at Mile 27
12-May		x		x	SPB set up on right bank of 27 Mile, MB tested right bank above bridge
13-May				x	24-hour SPB coverage begins at Site 1, Mile 27
14-May				x	
15-May		x		x	MB operated at Mile 27
16-May				x	
17-May		x		x	MB operated at Mile 27
18-May				x	
19-May		x		x	MB operated at Mile 27 and Mile 37 on right bank
20-May				x	
21-May				x	
22-May	x			x	Bathymetry survey at Mile 37
23-May				x	
24-May		x		x	MB operated on left bank of Mile 27 and offshore of right bank
25-May		x	x	x	MB operated on right and left banks at Mile 27; SB added to SPB at Site 1, Mile 27
26-May			x	x	
27-May			x	x	Last day of 24-hour coverage at Site 1, Mile 27
28-May	x			x	Bathymetry and fish monitoring conducted at Mile 37

[a] Bathymetry: BioSonics DT6000 with a 6-degree 200kHz splitbeam transuducer and Visaqu 4 acquisition software
Multibeam: Simrad SM2000 Multibeam
Single beam: Biosonics DT6000 with a 6-degree single beam transducer
Splitbeam: Biosonics DT6000 with a 6-degree splitbeam transducer

Table 3. Summary of raw and expanded counts of salmon from a splitbeam acoustic system operated in the Mile-27 Channel of the Copper River, 2001.

	Date in May 2001															
Hour	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Totals
0		0	0	0	0	0	0	2	0	1	5	64	7	182	8	270
1		0	0	0	1	0	0	1	1	0	14	94	9	159	85	364
2		0	1	0	0	0	0	3	0	0	9	102	10	251	79	455
3		0	0	0	0	0	0	1	1	0	23	97	17	218		356
4		0	0	0	0	0	0	1	1	0	11	93	3	0		110
5		0	0	0	2	0	0	2	0	0	28	141	35	44		252
6		0	0	0	0	0	1	2	0	0	9	152	37	160		361
7		0	0	0	1	0	1	0	0	0	82	192	69	0		345
8		0	0	0	0	0	0	2	0	2	144	161	95	124		528
9		0	0	0	0	0	0	0	0	1	134	145	72	135		487
10		0	0	0	1	0	0	2	0	0	115	0	76	126		320
11		0	0	1	0	0	0	2	1	0	21	0	76	156		257
12	0	0	0	0	0	2	0	0	1		7	143	153	15		321
13	0	0	0	0	0	1	0	0	1		18	35		264		319
14	0	2	0	0	0	4	0	0	1	2	140	52	132	0		333
15	1	0	0	1	0	0	0	2	1	2	28	24	224	1		284
16	0	0	1	0	1	7	0	0	2	1	37	52	275	205		581
17	1	0	0	0	0	4	0	0	2	4	95	64	155	31		356
18	1		0	0	1	11	0	0	1	4	103			168		289
19	0	0	0	0	1	5	0	0	1	6	0	55		13		82
20	0	0	0	0	1	6	0	0	0	8	93	64	42	117		330
21	0	1	0	0	0	7	0	0	3	4	68	54	290	118		544
22	0	0	0	0	1	5	0	0	0	8	70	38	0	10		132
23	1	0	0	0	0	2	0	0	2	1	58	31	0	113		209
Raw Count	4	3	2	2	10	55	2	20	20	45	1312	1852	1778	2609	171	7884
Proportion of time sampled	0.49	0.86	0.96	0.97	0.97	0.87	0.80	0.90	0.94	0.86	0.93	0.90	0.75	0.94	0.09	
Estimate for 24-hr period	8	3	2	2	10	63	3	22	21	52	1403	2061	2374	2790	1892	10,706

Table 4. Drift gillnet catches of sockeye and chinook salmon from the Mile-27 Channel of the Copper River, 2001.

Date		Drifts (no)	Chinook Salmon (no) [a]		Sockeye Salmon (no)	
			Daily	Cumulative	Daily	Cumulative
05-13		4	1	1	0	0
05-14	[b]			1		0
05-15	[b]			1		0
05-16	[b]			1		0
05-17		23	0	1	3	3
05-18	[c]			1		3
05-19		13	0	1	0	3
05-20		5	2	3	0	3
05-21		4	0	3	3	6
05-22		19	2	5	84	90
05-23		8	3	8	106	196
05-24		8	1	9	71	267
05-25		12	4	13	82	349
05-26		13	2	15	60	409
05-27		12	0	15	17	426
05-28		3	0	15	15	441
05-29		18	1	16	61	502
05-30		12	0	16	17	519
05-31		13	1	17	17	536
06-01		12	0	17	12	548
06-02		16	0	17	9	557
06-03		18	0	17	15	572
06-04		12	0	17	19	591
06-05		9	0	17	5	596
06-06	[c]			17		596
06-07		7	1	18	6	602

[a] Includes all catches from set used to calculate the index. Five additional sockeye salmon were caught in sets that were not usable for indexing due to the net snagging on debris.

[b] No drift gillnet fishing occurred.

[c] No test fishing occurred.

Table 5. Summary of sockeye salmon drift gillnet test fishing data for the Mile-27 Channel of the Copper River, 2001.

Date	Fishing Time (min)	Sockeye Catch (no) [a]		Index	
		Daily	Cumulative	Daily	Cumulative
05-13	11.8	0	0	0	0
05-14 [b]			0		0
05-15 [b]			0		0
05-16 [b]			0		0
05-17	86.7	3	3	20	20
05-18 [c]			3		20
05-19	92.7	0	3	0	20
05-20	13.3	0	3	0	20
05-21	7.7	3	6	236	256
05-22	126.7	84	90	360	616
05-23	83.3	106	196	719	1,335
05-24	45.3	71	267	1,086	2,421
05-25	43.9	82	349	1,176	3,597
05-26	41.3	60	409	934	4,532
05-27	35.2	17	426	365	4,897
05-28	19.6	15	441	485	5,381
05-29	54.0	61	502	687	6,068
05-30	32.7	17	519	321	6,389
05-31	33.1	17	536	267	6,656
06-01	38.5	12	548	208	6,864
06-02	27.2	9	557	214	7,078
06-03	34.3	15	572	348	7,425
06-04	28.0	19	591	553	7,979
06-05	19.1	5	596	194	8,172
06-06 [c]			596		8,172
06-07	14.8	6	602	310	8,483

[a] Includes all catches from set used to calculate the index. Five additional sockeye salmon were caught in sets that were not usable for indexing due to the net snagging on debris.

[b] No drift gillnet fishing occurred. All test fishing was with dip nets.

[c] No test fishing occurred.

APPENDICES

APPENDIX A

Copper River stage height data, May-June 2001

and

Daily sockeye salmon escapement estimates at Miles Lake sonar, 2001

.

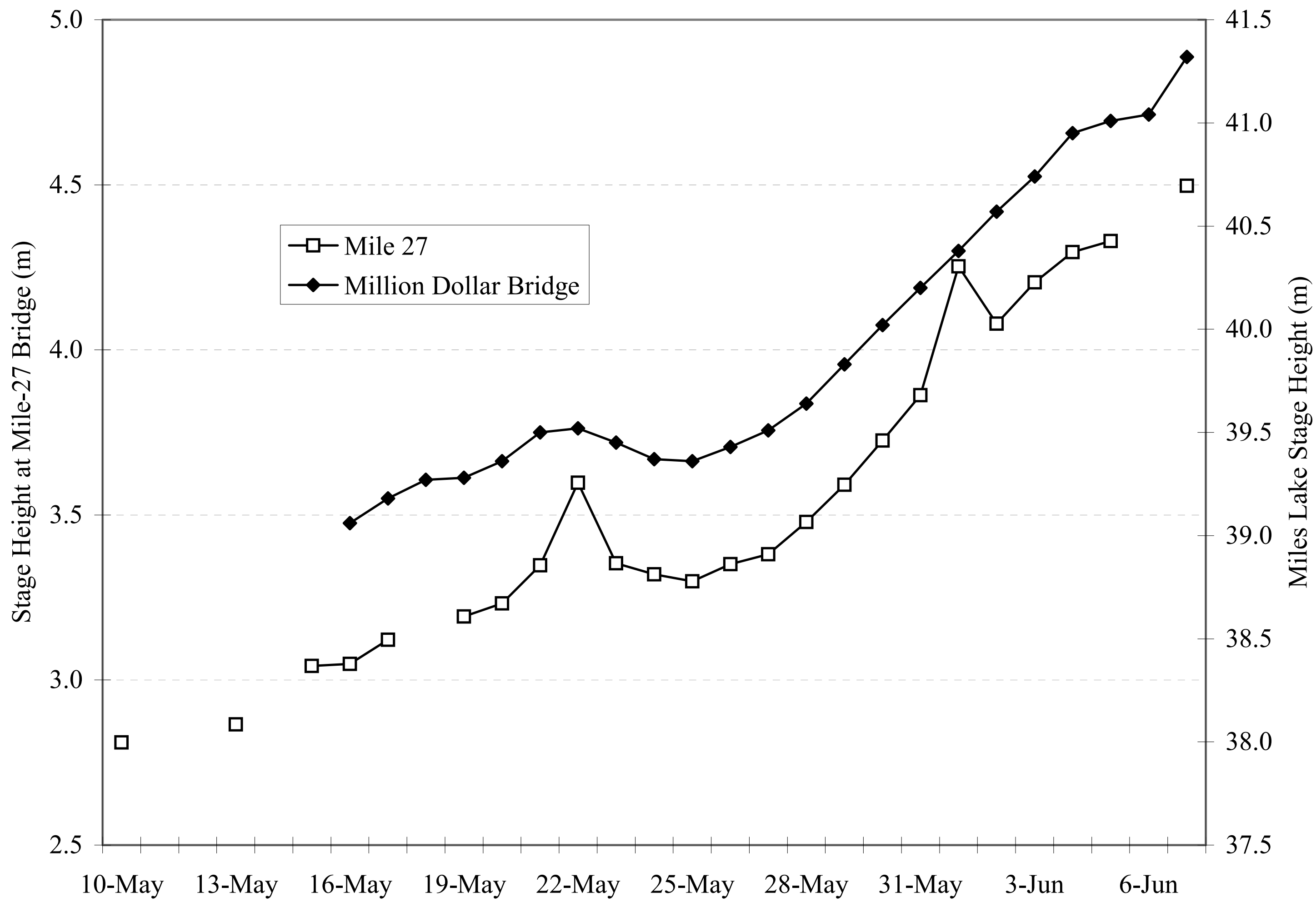


Figure A-1. Copper River stage height measured at the Mile-27 Bridge and the Million Dollar Bridge, 13 May to 7 June 2001.

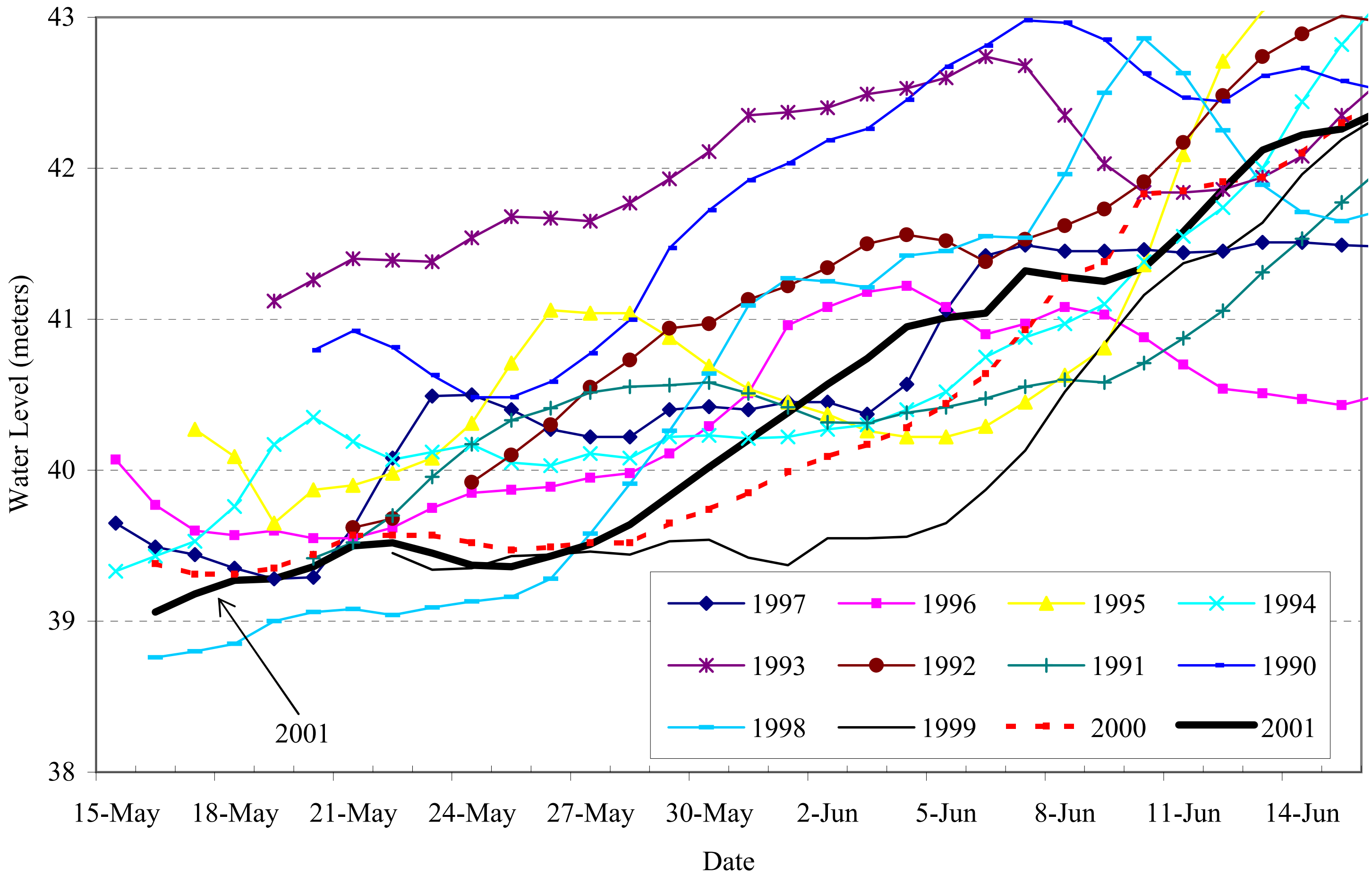


Figure A-2. Copper River water levels at the Million Dollar Bridge for the period 15 May to 15 June 1990-2001.

Table A-1. Stage height data for the Copper River from the Mile-27 Bridge of the Copper River Highway, May-June 2001.

		Stage Height [a]		Change from last reading	
Date	Time	feet	meters	feet	meters
10-May	11:30	9.22	2.81		
11-May [b]					
12-May [b]					
13-May	15:18	9.40	2.87	0.18	0.05
14-May [b]					
15-May	14:15	9.98	3.04	0.58	0.18
16-May	12:54	10.00	3.05	0.02	0.01
17-May	10:30	10.24	3.12	0.24	0.07
18-May [b]					
19-May	11:05	10.47	3.19	0.23	0.07
20-May	11:13	10.60	3.23	0.13	0.04
21-May	11:06	10.98	3.35	0.38	0.12
22-May	09:31	11.80	3.60	0.82	0.25
23-May	09:58	11.00	3.35	(0.80)	(0.24)
24-May	10:26	10.89	3.32	(0.11)	(0.03)
25-May	09:55	10.82	3.30	(0.07)	(0.02)
26-May	10:40	10.99	3.35	0.17	0.05
27-May	09:49	11.09	3.38	0.10	0.03
28-May	10:14	11.41	3.48	0.32	0.10
29-May	09:34	11.78	3.59	0.37	0.11
30-May	11:59	12.22	3.73	0.44	0.13
31-May	02:36	12.67	3.86	0.45	0.14
1-Jun	10:06	13.95	4.25	1.28	0.39
2-Jun	10:49	13.38	4.08	(0.57)	(0.17)
3-Jun	10:21	13.79	4.20	0.41	0.12
4-Jun	09:17	14.09	4.30	0.30	0.09
5-Jun	09:43	14.20	4.33	0.11	0.03
6-Jun [b]					
7-Jun	14:05	14.75	4.50	0.55	0.17

[a] Stage height measured using USGS gage. This is a relative measurement as the current bridge elevation above mean sea level is unknown.

[b] No data collected.

Table A-2. Daily sockeye salmon escapement estimates at the Miles Lake Sonar Site, 2001.

		Estimated Daily Escapement				Escapement Objective			
	Water	North	South					0600	Projected
Date	Level [a]	Bank	Bank	Daily	Cumulative	Daily	Cumulative	Count	Daily
16-May	39.06	18	37 [b]	55	426 [b]	392	392		
17-May	39.18	20	41 [b]	61	487 [b]	939	1,331		
18-May	39.27	90	482 [c]	572	1,059	1,320	2,650		
19-May	39.28	150	1,006	1,156	2,215	1,523	4,173		1,270
20-May	39.36	146	982	1,128	3,343	1,533	5,706		1,021
21-May	39.5	199	1,328	1,527	4,870	2,127	7,834		1,168
22-May	39.52	361	4,204	4,565	9,435	3,094	10,928		3,110
23-May	39.45	1,034	6,891	7,925	17,360	4,712	15,640		7,843
24-May	39.37	7,730	12,022	19,752	37,112	4,896	20,536		8,740
25-May	39.36	6,146	21,538	27,684	64,796	5,229	25,765		30,360
26-May	39.43	4,820	19,996	24,816	89,612	7,481	33,246		28,143
27-May	39.51	1,174	19,340	20,514	110,126	9,789	43,035		19,952
28-May	39.64	1,508	16,108	17,616	127,742	7,004	50,039		14,772
29-May	39.83	4,462	24,830	29,292	157,034	8,257	58,297		12,487
30-May	40.02	6,236	23,855	30,091	187,125	10,847	69,143		25,044
31-May	40.2	2,114	15,114	17,228	204,353	11,357	80,500		11,476
1-Jun	40.38	602	14,128	14,730	219,083	13,015	93,515		10,324
2-Jun	40.57	384	16,371	16,755	235,838	12,548	106,063		10,263
3-Jun	40.74	452	11,540	11,992	247,830	14,302	120,365		7,446
4-Jun	40.95	716	11,364	12,080	259,910	15,784	136,149		8,911
5-Jun	41.01	720	17,530	18,250	278,160	14,264	150,413		16,053
6-Jun	41.04	600	14,997	15,597	293,757	13,927	164,340		9,456
7-Jun	41.32	495	18,999	19,494	313,251	16,273	180,613	4,703	18,812
8-Jun	41.28	109	10,312	10,421	323,672	15,557	196,169	3,013	12,052
9-Jun	41.25	93	11,583	11,676	335,348	14,919	211,088	1,982	7,928
10-Jun	41.34	328	9,333	9,661	345,009	14,340	225,428	2,603	10,412
11-Jun	41.58	327	7,767	8,094	353,103	13,259	238,687	1,497	5,988
12-Jun	41.86	546	10,092	10,638	363,741	11,634	250,321	1,739	6,956
13-Jun	42.12	915	12,890	13,805	377,546	11,049	261,370	3,175	12,700
14-Jun	42.22	482	10,839	11,321	388,867	11,897	273,268	3,417	13,668
15-Jun	42.26	301	7,463	7,764	396,631	10,646	283,914	1,952	7,808
16-Jun	42.38	441	7,117	7,558	404,189	10,592	294,505	1,734	6,936
17-Jun	42.57	668	8,219	8,887	413,076	9,065	303,570	1,421	5,684
18-Jun	42.82	365	6,231	6,596	419,672	8,095	311,665	1,655	6,620
19-Jun	43.01	447	6,956	7,403	427,075	8,398	320,063	1,539	6,156
20-Jun	43.14	502	5,855	6,357	433,432	7,572	327,635	1,999	7,996
21-Jun	43.26	300	6,351	6,651	440,083	7,688	335,323	1,068	4,272
22-Jun	43.35	411	5,013	5,424	445,507	8,073	343,396	1,554	6,216
23-Jun	43.37	651	9,411	10,062	455,569	7,855	351,251	1,462	5,848
24-Jun	43.49	959	10,354	11,313	466,882	7,702	358,953	2,556	10,224
25-Jun	43.56	1,161	10,992	12,153	479,035	6,881	365,834	2,263	9,052
26-Jun	43.43	1,205	12,868	14,073	493,108	6,727	372,561	2,533	10,132
27-Jun	43.42	918	11,329	12,247	505,355	6,488	379,050	2,826	11,304
28-Jun	43.43	466	11,306	11,772	517,127	7,365	386,414	3,270	13,080
29-Jun	43.42	628	13,527	14,155	531,282	7,150	393,564	1,356	5,424
30-Jun	43.44	664	10,498	11,162	542,444	7,449	401,013	2,442	9,768
1-Jul	43.43	558	13,054	13,612	556,056	7,818	408,831	2,366	9,464
2-Jul	43.38	599	13,624	14,223	570,279	8,913	417,744	3,220	12,880
3-Jul	43.41	690	12,326	13,016	583,295	9,192	426,936	3,048	12,192
4-Jul	43.59	508	13,470	13,978	597,273	9,565	436,501	3,333	13,332
5-Jul	43.56	462	11,060	11,522	608,795	9,581	446,082	3,627	14,508

Table A-2. Daily sockeye salmon escapement estimates at the Miles Lake Sonar Site, 2001.

		Estimated Daily Escapement				Escapement Objective			
	Water	North	South					0600	Projected
Date	Level [a]	Bank	Bank	Daily	Cumulative	Daily	Cumulative	Count	Daily
6-Jul	43.38	646	7,215	7,861	616,656	9,521	455,603	1,915	7,660
7-Jul	43.17	718	4,851	5,569	622,225	10,489	466,092	1,382	5,528
8-Jul	42.98	1,815	7,805	9,620	631,845	11,097	477,189	2,241	8,964
9-Jul	42.81	2,429	9,183	11,612	643,457	12,734	489,923	3,411	13,644
10-Jul	42.76	1,562	9,822	11,384	654,841	11,960	501,883	2,690	10,760
11-Jul	42.67	2,725	11,819	14,544	669,385	13,057	514,940	2,788	11,152
12-Jul	42.58	2,390	13,793	16,183	685,568	12,074	527,014	2,729	10,916
13-Jul	42.5	1,489	12,689	14,178	699,746	12,927	539,941	4,779	19,116
14-Jul	42.38	1,147	9,957	11,104	710,850	11,300	551,240	2,745	10,980
15-Jul	42.36	1,702	9,044	10,746	721,596	12,456	563,697	2,249	8,996
16-Jul	42.43	2,172	10,135	12,307	733,903	11,436	575,132	2,720	10,880
17-Jul	42.51	1,860	7,958	9,818	743,721	11,680	586,812	2,194	8,776
18-Jul	42.64	1,738	9,185	10,923	754,644	12,274	599,086	2,666	10,664
19-Jul	42.82	1,272	8,492	9,764	764,408	13,241	612,326	2,492	9,968
20-Jul	43.06	549	6,359	6,908	771,316	10,979	623,306	1,874	7,496
21-Jul	43.45	358	3,872	4,230	775,546	9,630	632,936	1,396	5,584
22-Jul	43.89	240	2,676	2,916	778,462	9,177	642,113	492	1,968
23-Jul	44.24	219	1,607	1,826	780,288	8,637	650,750	625	2,500
24-Jul	44.17	496	3,456	3,952	784,240	7,691	658,441	514	2,056
25-Jul	43.82	1,130	3,347	4,477	788,717	6,775	665,216	1,023	4,092
26-Jul	43.62	1,077	4,048	5,125	793,842	6,389	671,605	1,387	5,548
27-Jul	43.41	2,147	7,505	9,652	803,494	6,166	677,770	1,838	7,352
28-Jul	43.29	2,589	5,528	8,117	811,611	5,316	683,086	1,964	7,856
29-Jul	43.23	2,179	5,423	7,602	819,213	5,227	688,314	1,229	4,916
30-Jul	43.15	2,527	5,524	8,051	827,264	4,755	693,069	1,410	5,640
31-Jul	43.06	1,751	4,554	6,305	833,569	4,452	697,521	1,359	5,436
1-Aug					833,569	4,140	701,661		
2-Aug					833,569	3,637	705,298		
3-Aug					833,569	2,984	708,283		
4-Aug					833,569	2,556	710,839		
5-Aug					833,569	2,340	713,179		

[a] Meters above sea level.

[b] South bank counts are estimates.

[c] Cumulative includes sonar counts from May 10 through May 15

APPENDIX B

Participants at project workshops conducted 29 and 30 November 2001.

Table B-1. List of participants at the project technical and community workshops held on 29 and 30 November 2001, in Cordova, Alaska.

The Native Village of Eyak (NVE) hosted a technical meeting and public symposium (29-30 November 2001) to review two three-year fisheries projects initiated in 2001. One project was designed to examine the feasibility of monitoring sockeye salmon escapement in the Copper River Delta (Lower River Test Fishery), and the other project was designed to estimate the annual escapement of chinook salmon to the Copper River (Chinook Escapement Monitoring).

Technical meeting participants:

Brady, James (ADFG)	Henrichs, Bob (NVE)	Merizon, Rick (ADFG)
Bue, Brian (ADFG)	Hoover, Mark (NVE)	Moffit, Steve (ADFG)
Cain, Bruce (NVE)	Joyce, Tim (USFS)	Regnart, Jeff (ADFG)
Degan, Don (Aquacoustics)	King, Mark (NVE)	Savereide, James (ADFG)
Evenson, Matt (ADFG)	Lambert, Michael (NVE)	Smith, Jason (LGL)
Gove, Nancy (ADFG)	Link, Michael (LGL)	Veach, Eric (NPS)
Gray, Dan (ADFG)	McBride, Doug (USFWS)	Webber, Mike (NVE)
Haley, Beth (LGL)	Maxwell, Suzanne (ADFG)	Williams, Kate (NVE)

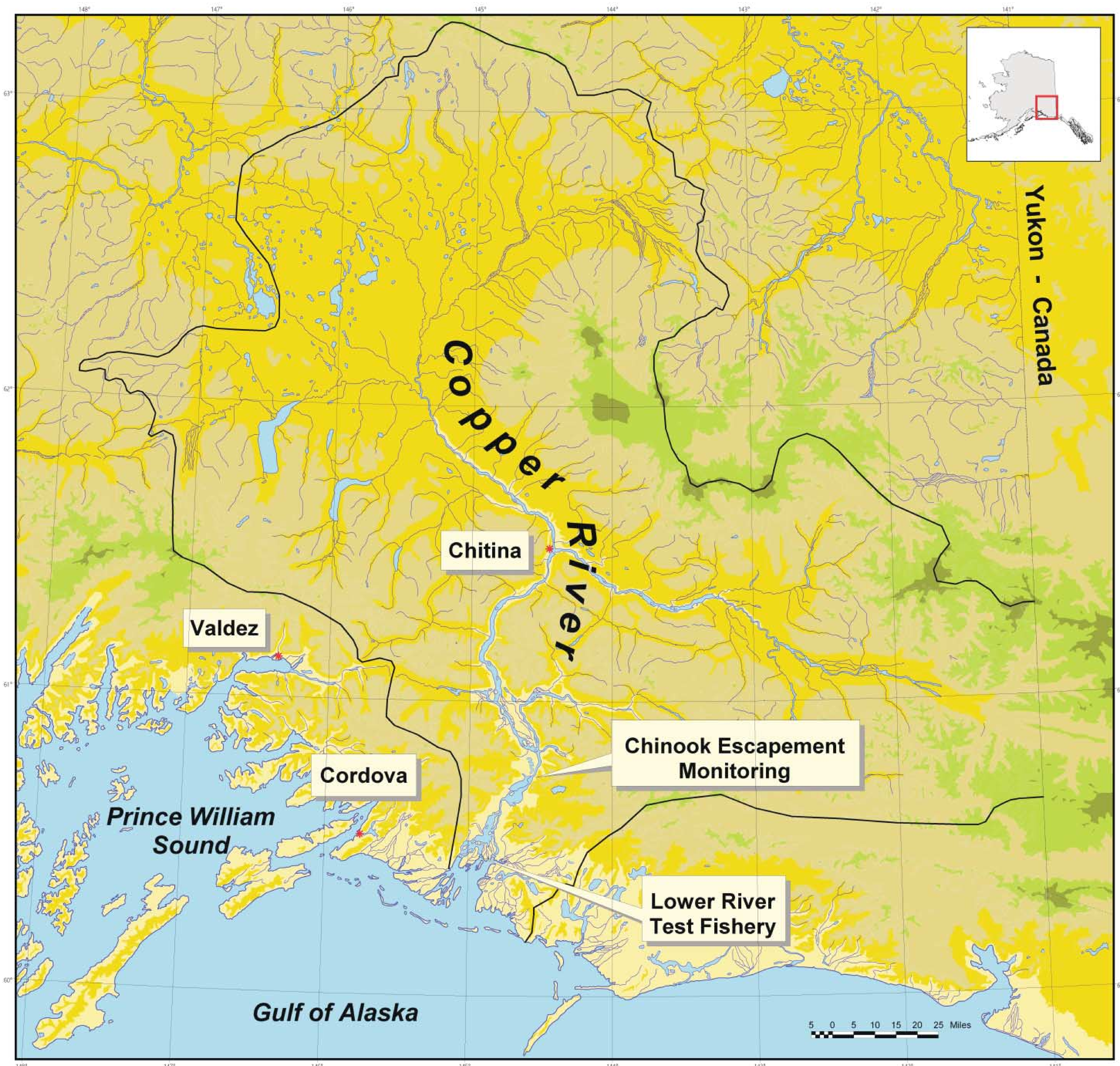
APPENDIX C

Project posters presented at the technical and community workshops held on 29 and 30 November 2001.

Community Fisheries Symposium
Native Village of Eyak, 2001

Native Village of Eyak

The Native Village of Eyak (NVE) welcomes you to our first Community Fisheries Symposium. NVE has been actively involved in environmental programs since 1997. In 2001, two projects were initiated to monitor salmon abundance in the lower Copper River.



Lower River Test Fishery (LRTF)

Designed to identify methods of assessing the escapement of sockeye salmon upstream of the commercial fishing district.

Chinook Escapement Monitoring (CEM)

Designed to estimate the escapement of chinook salmon for the entire Copper River each year.

These projects will provide information to fishery managers to regulate commercial and subsistence harvests to ensure the long-term sustainability of our valuable salmon resource.

Project partners:

Native Village of Eyak

Alaska Department of Fish and Game

LGL Alaska Research Associates, Inc.

Aquacoustics, Inc.

Projects funded by:

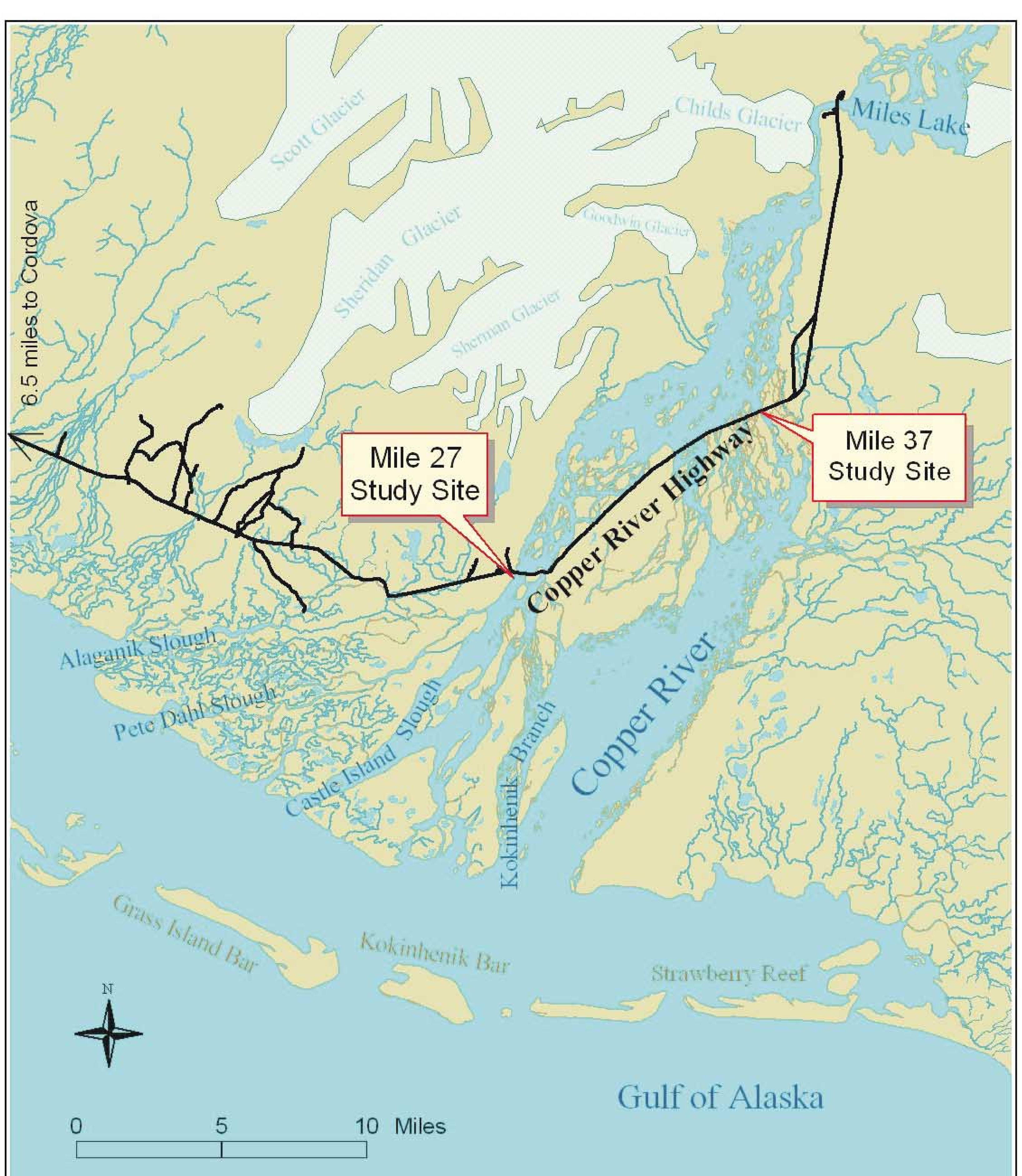
U.S. Fish and Wildlife Service
Office of Subsistence Management
Fisheries Resource Monitoring Program
Anchorage, AK
CEM: FIS01-020-1
LRTF: FIS01-021-1

Introduction (LRTF)

Copper River salmon populations support valuable subsistence, commercial and sport fisheries. As with many salmon stocks, Copper River salmon stocks must migrate through a series of fisheries, beginning with the ocean commercial driftnet fishery off the mouth of the Copper River.

Over the last 23 years, fishery managers have relied on a sonar system near Miles Lake to monitor the number of salmon moving upstream of the commercial fishery. This system provides a relatively complete count of all salmon on a daily basis.

Fishery managers must manage this commercial fishery to ensure that adequate numbers of fish escape to spawn while protecting harvests for upriver subsistence users.



It is commonly believed that salmon require 3 to 9 days to travel from the commercial fishing boundary to the Miles Lake sonar site. Differences in the annual timing of fish entry into the Copper River and their arrival at Miles Lake make fishery management difficult during May.

This project was initiated to investigate the feasibility of counting salmon as close to the commercial fishery as practical to provide more timely escapement information than Miles Lake provides.

Study Design (LRTF)

Native Village of Eyak

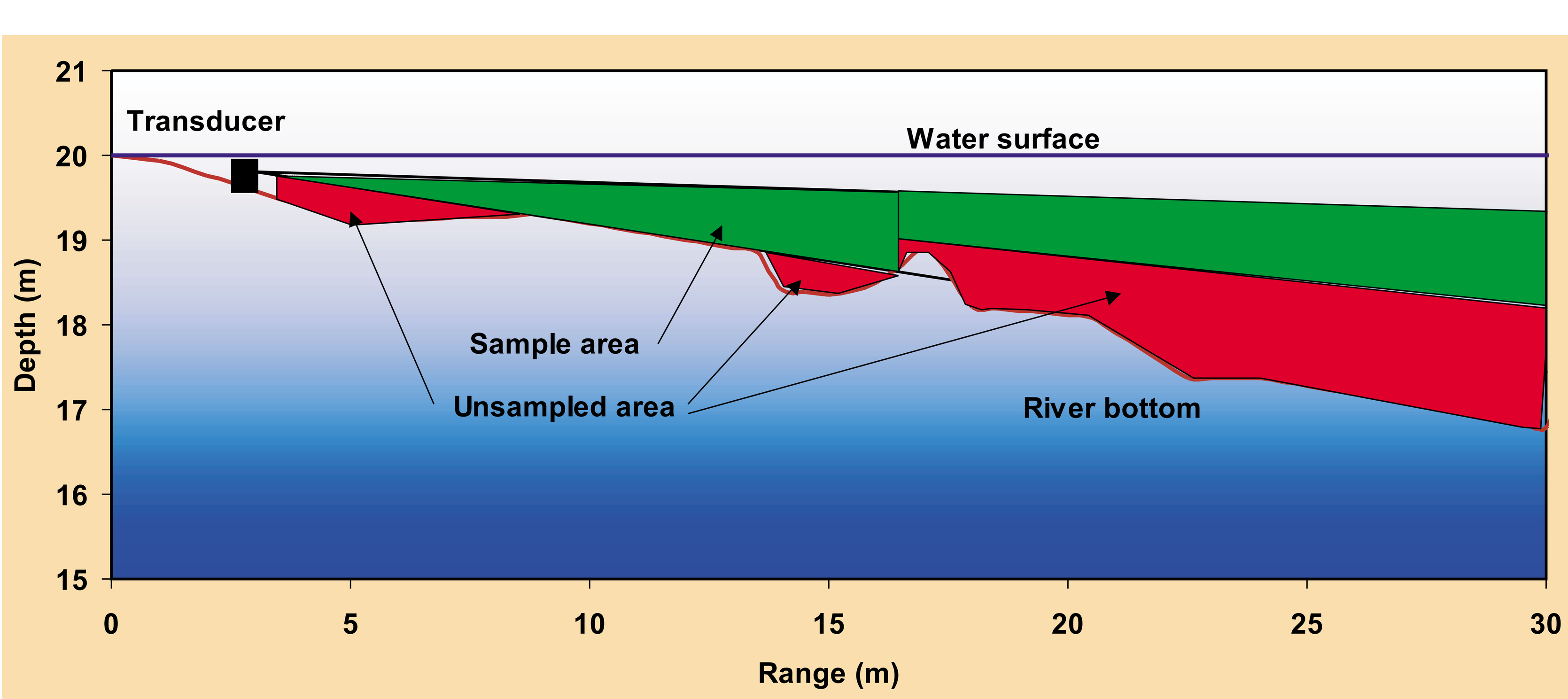
The study team proposed a multi-faceted approach to examining the feasibility of developing a test fishery in the lower Copper River.

A cost-effective test fishing method is to drift gillnets in a standardized manner in one or more channels of the river.

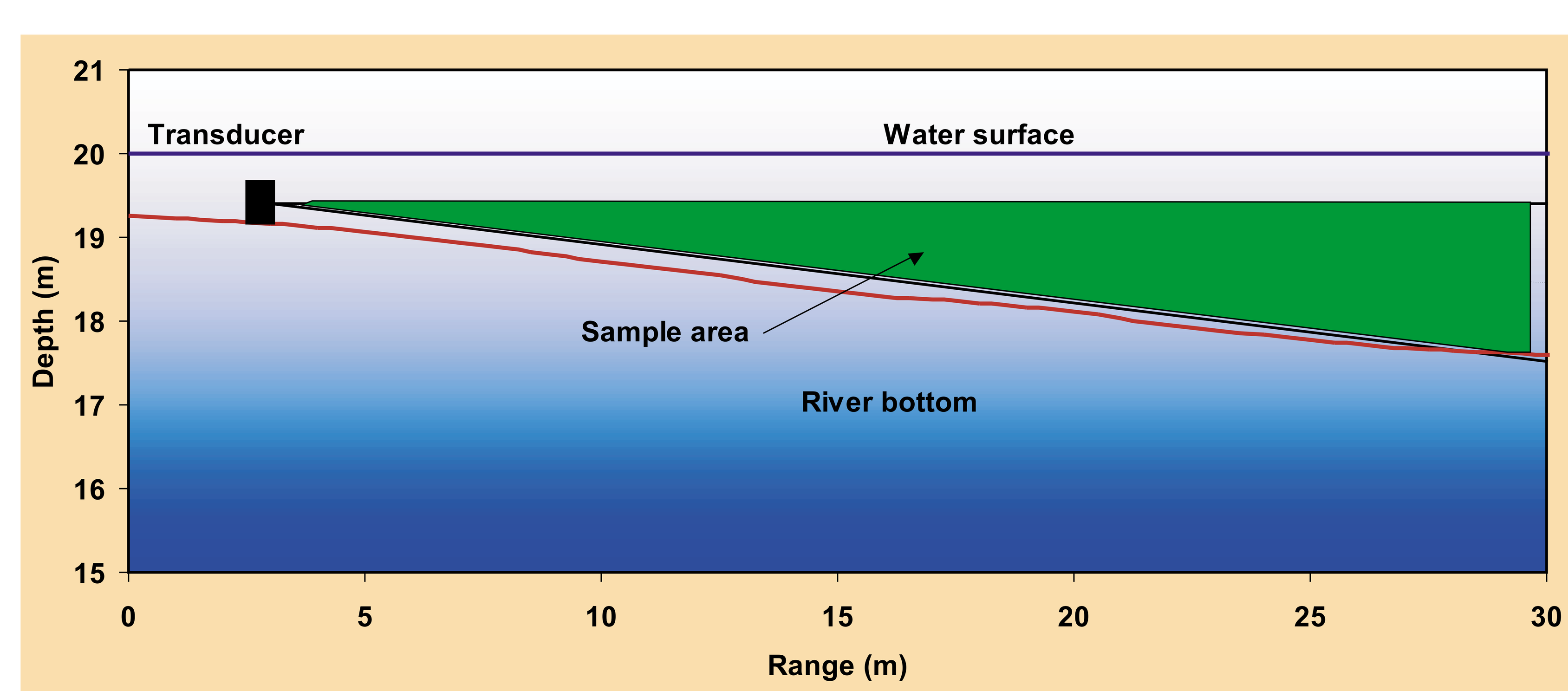
Sonar can also be used to monitor fish passage by setting a stationary transducer on the river bank looking out off shore.

Sonar provides a much larger sampling effort than drift fishing and it can provide more information about the behavior of fish (i.e., upstream/downstream movement, location of fish in water column).

A suitable bottom profile is required to successfully ensonify an area of the river where fish migrate upstream. A suitable profile is one where a conical sonar beam can travel offshore close to the bottom without hitting the bottom or any obstructions.



Good bottom profile



Poor bottom profile

To identify suitable sonar sites in the lower Copper River, surveys were made using a boat equipped with a sophisticated depth sounder and geographic positioning system (GPS). Bathymetric maps of the vicinity of 27-Mile and 37-Mile bridges were then prepared.

Results (LRTF)

Effort

Sockeye salmon drift gillnet test fishing data summary for the 27-Mile channel of the Copper River, 2001.

Date	Fishing Time (min)	Sockeye Catch (no) [a]		Index	
		Daily	Cumulative	Daily	Cumulative
13-May	11.8	0	0	0	0
14-May [b]			0		0
15-May [b]			0		0
16-May [b]			0		0
17-May	86.7	3	3	20	20
18-May [c]			3		20
19-May	92.7	0	3	0	20
20-May	13.3	0	3	0	20
21-May	7.7	3	6	236	256
22-May	126.7	84	90	360	616
23-May	83.3	106	196	719	1,335
24-May	45.3	71	267	1,086	2,421
25-May	43.9	82	349	1,176	3,597
26-May	41.3	60	409	934	4,532
27-May	35.2	17	426	365	4,897
28-May	19.6	15	441	485	5,381
29-May	54.0	61	502	687	6,068
30-May	32.7	17	519	321	6,389
31-May	33.1	17	536	267	6,656
1-Jun	38.5	12	548	208	6,864
2-Jun	27.2	9	557	214	7,078
3-Jun	34.3	15	572	348	7,425
4-Jun	28.0	19	591	553	7,979
5-Jun	19.1	5	596	194	8,172
6-Jun [c]			596		8,172
7-Jun	14.8	6	602	310	8,483

[a] Includes all catches from set used to calculate the index. Five additional sockeye salmon were caught in sets that were not usable for indexing due to the net snagging on debris.

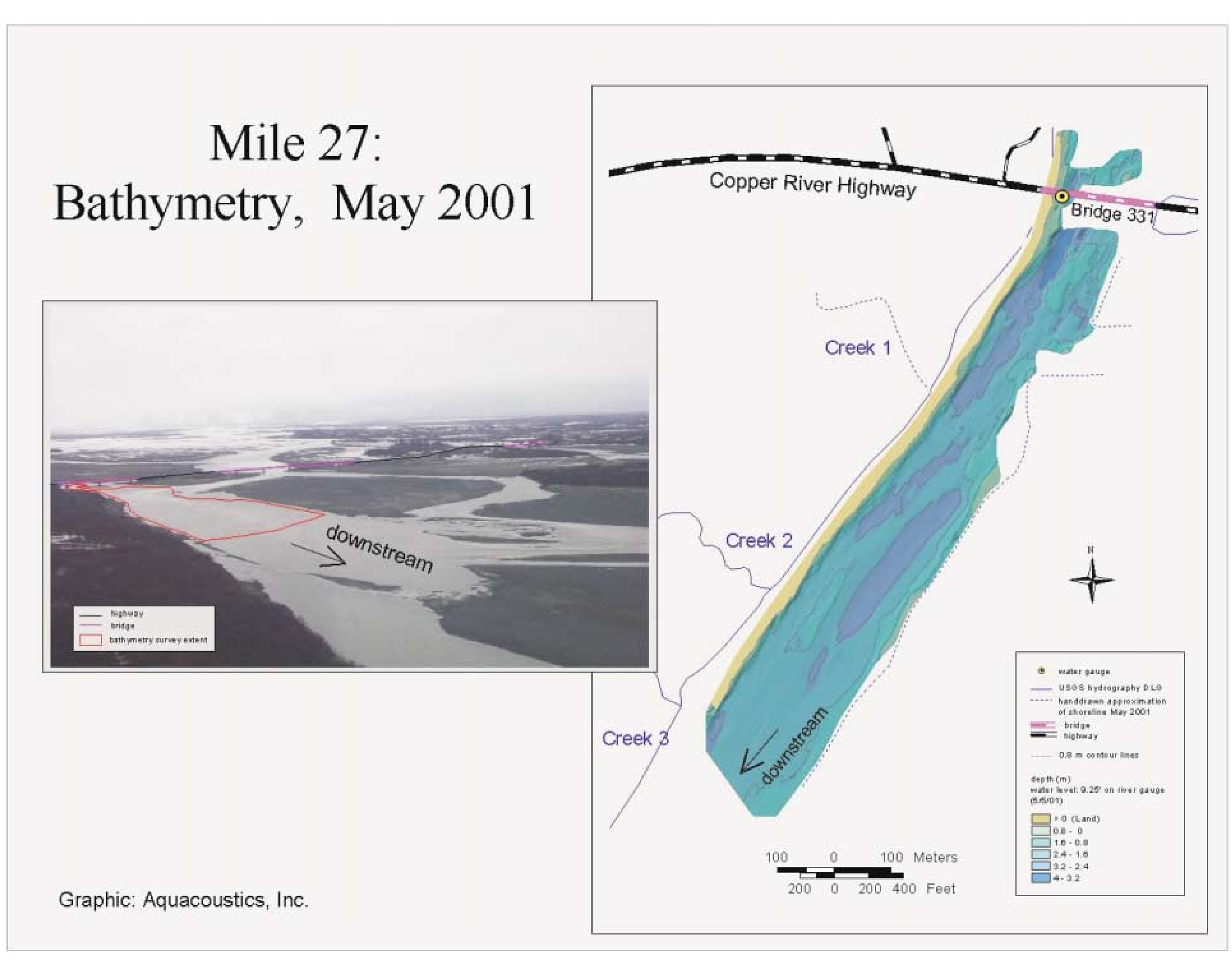
[b] No drift gillnet fishing occurred. All test fishing was with dip nets.

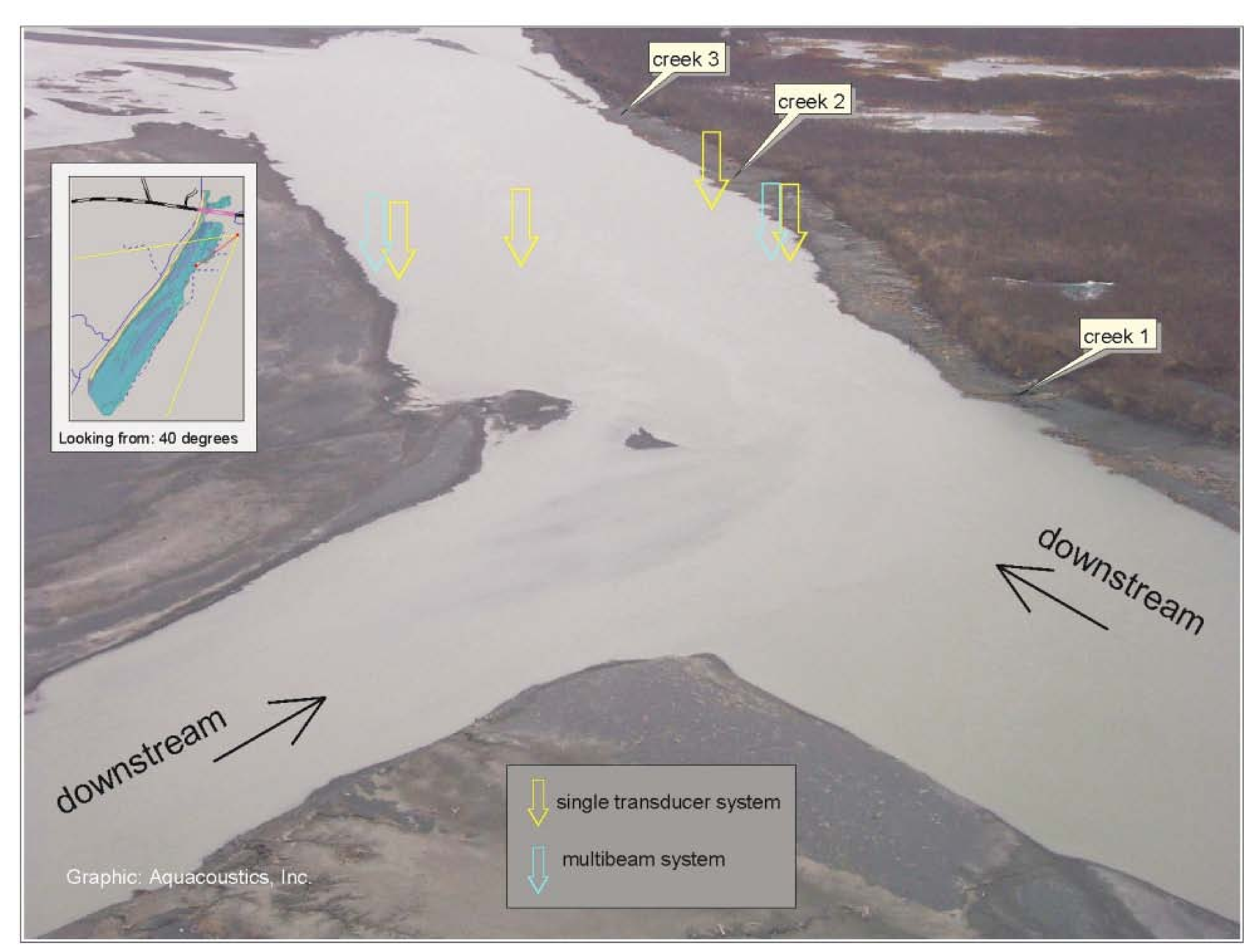
[c] No test fishing occurred.

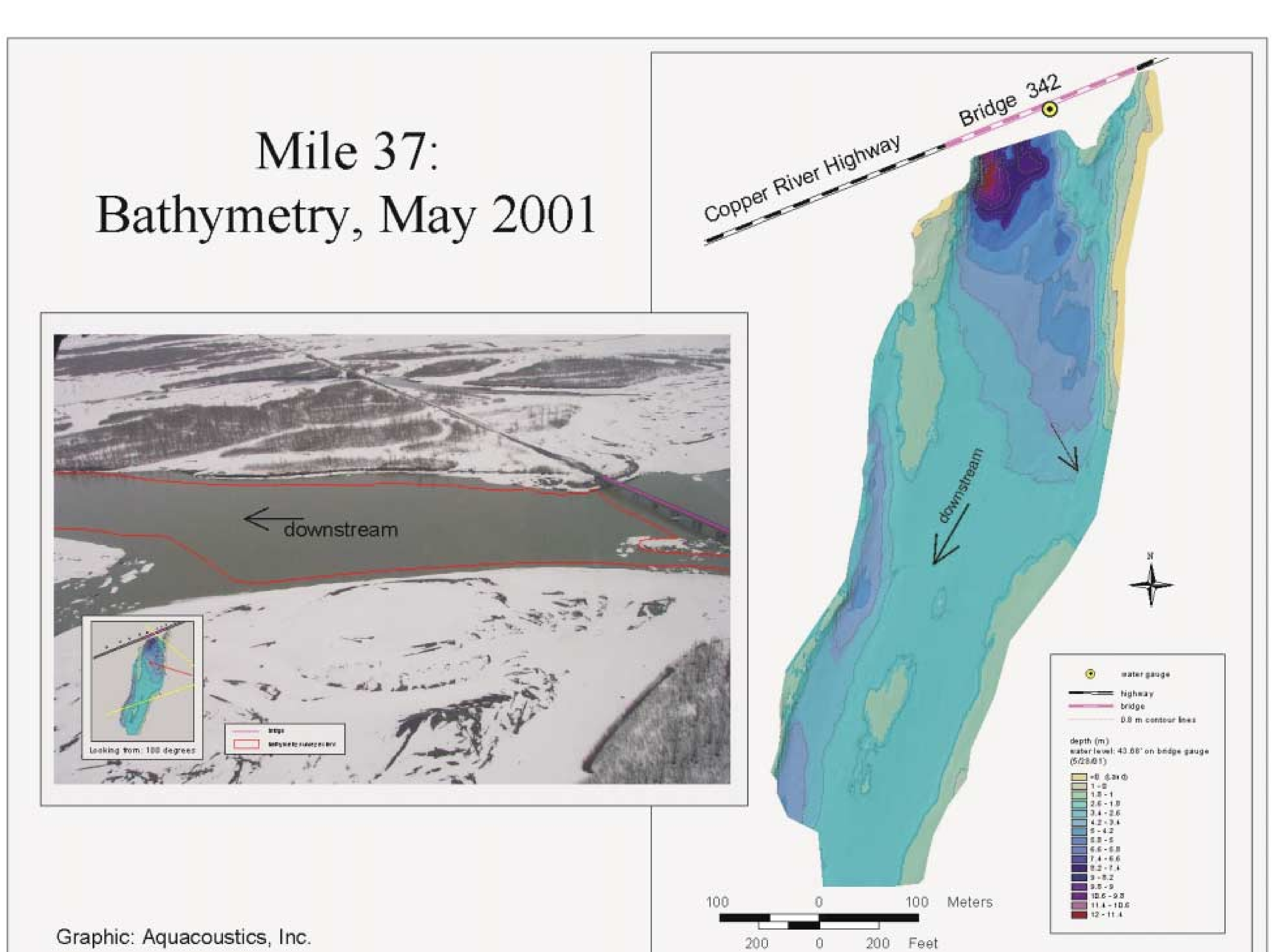
Summary of effort for acoustic gear operated on the Copper River, May 2001.

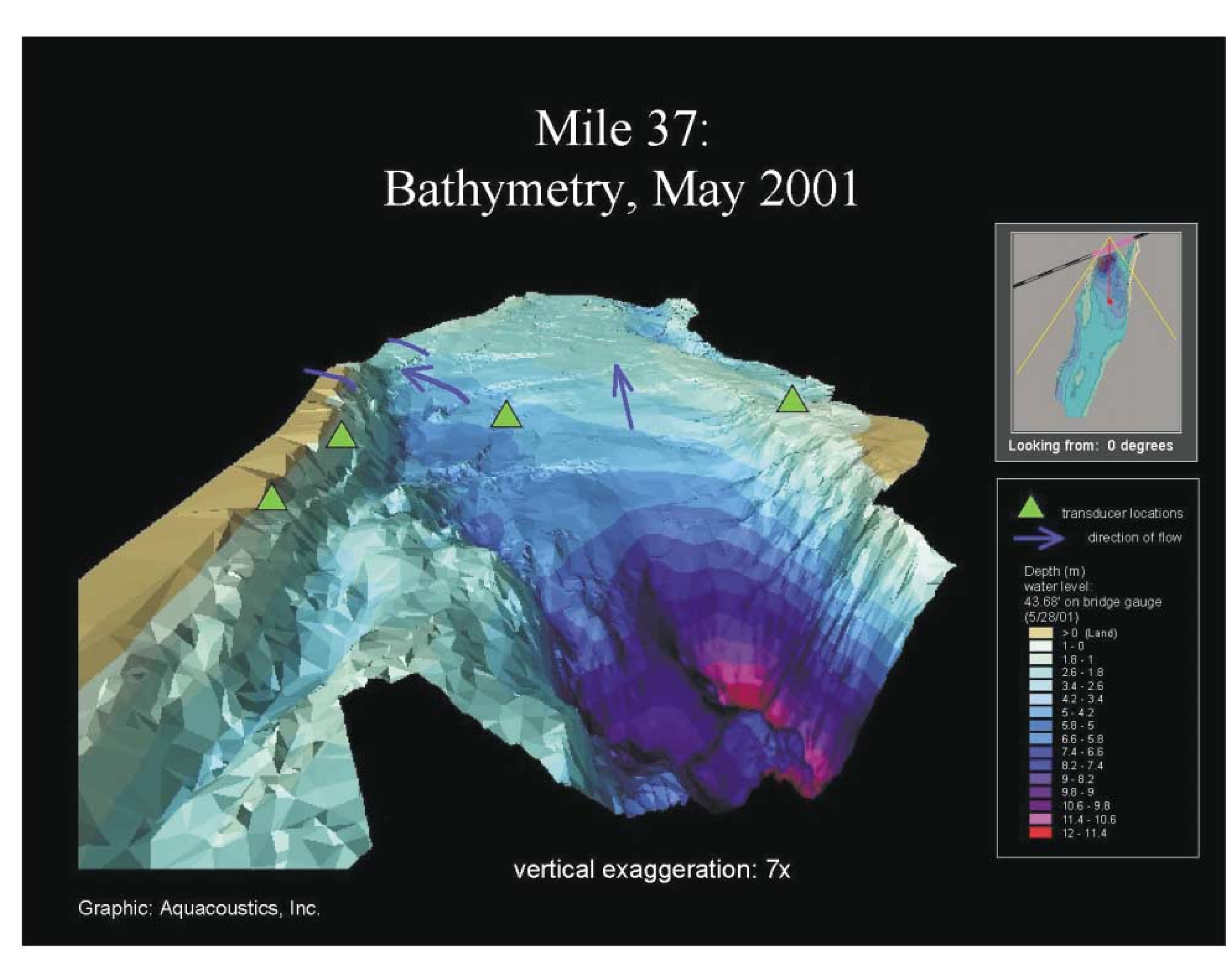
Date	Gear[a] Bath	MB	SB	SPB	Comments
05-May	x				Preliminary bathymetry survey, 27 Mile
06-May	x				Bathymetry survey at 27 Mile
07-May	x				Bathymetry survey at 27 Mile
08-May					
09-May					
10-May					
11-May		x			MB briefly deployed, SPB set up on right bank at 27 Mile
12-May		x		x	SPB set up on right bank of 27 Mile, MB tested right bank above bridge
13-May				x	24-hour SPB coverage begins at Site 1, 27 Mile
14-May				x	
15-May		x		x	MB operated at 27 Mile
16-May				x	
17-May		x		x	MB operated at 27 Mile
18-May	x			x	Bathymetry survey at 27 Mile
19-May	x	x		x	MB operated at 27 and 37 Mile on right bank; bathymetry survey at 27 Mile
20-May				x	
21-May	x			x	Bathymetry survey at 37 Mile
22-May	x			x	Bathymetry survey at 37 Mile
23-May				x	
24-May		x		x	MB operated on left bank of 27 Mile and offshore of right bank
25-May			x	x	SB added to SPB at Site 1, 27 Mile
26-May			x	x	
27-May			x	x	Last day of 24-hour coverage at Site 1, 27 Mile
28-May	x			x	Bathymetry and fish monitoring conducted at 37 Mile

[a]Gear: Bath: BioSonics DT6000 with a 6-degree 200kHz splitbeam transuducer and Visaqu 4 acquisition software
MB: Simrad SM2000 Multibeam
SB: Biosonics DT6000 with a 6-degree single beam transducer
SPB: Biosonics DT6000 with a 6-degree splitbeam transducer



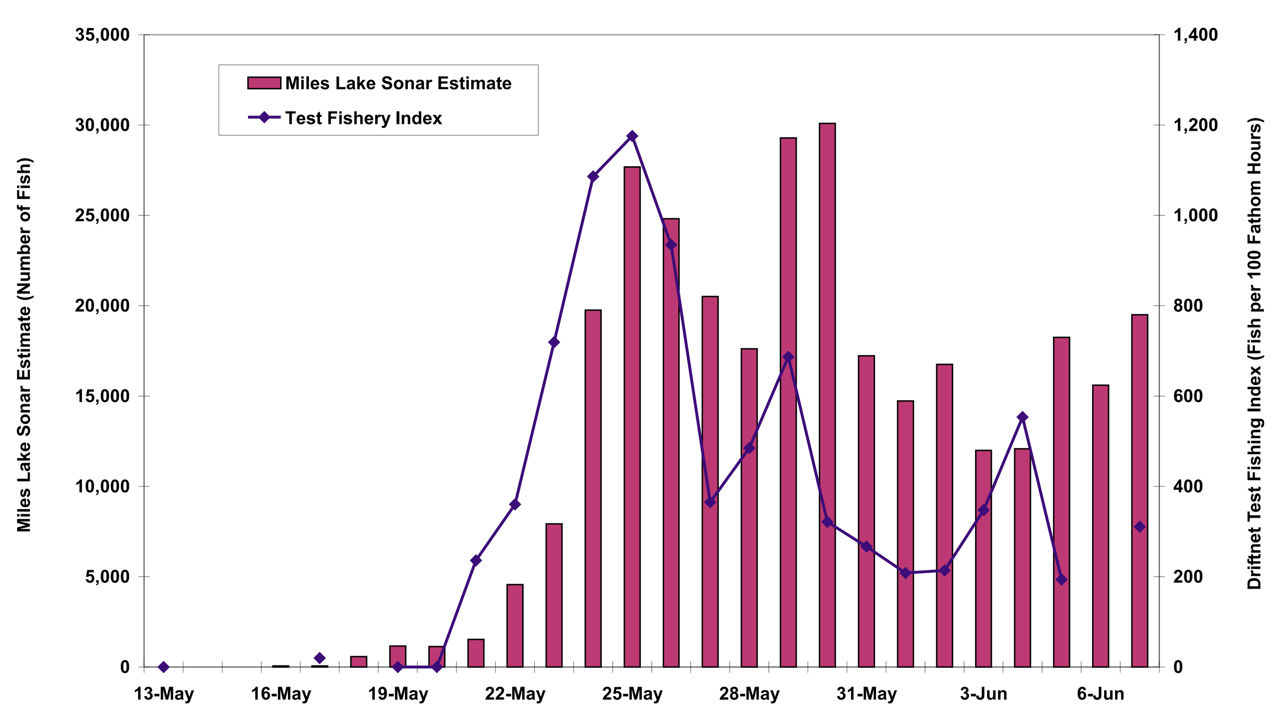


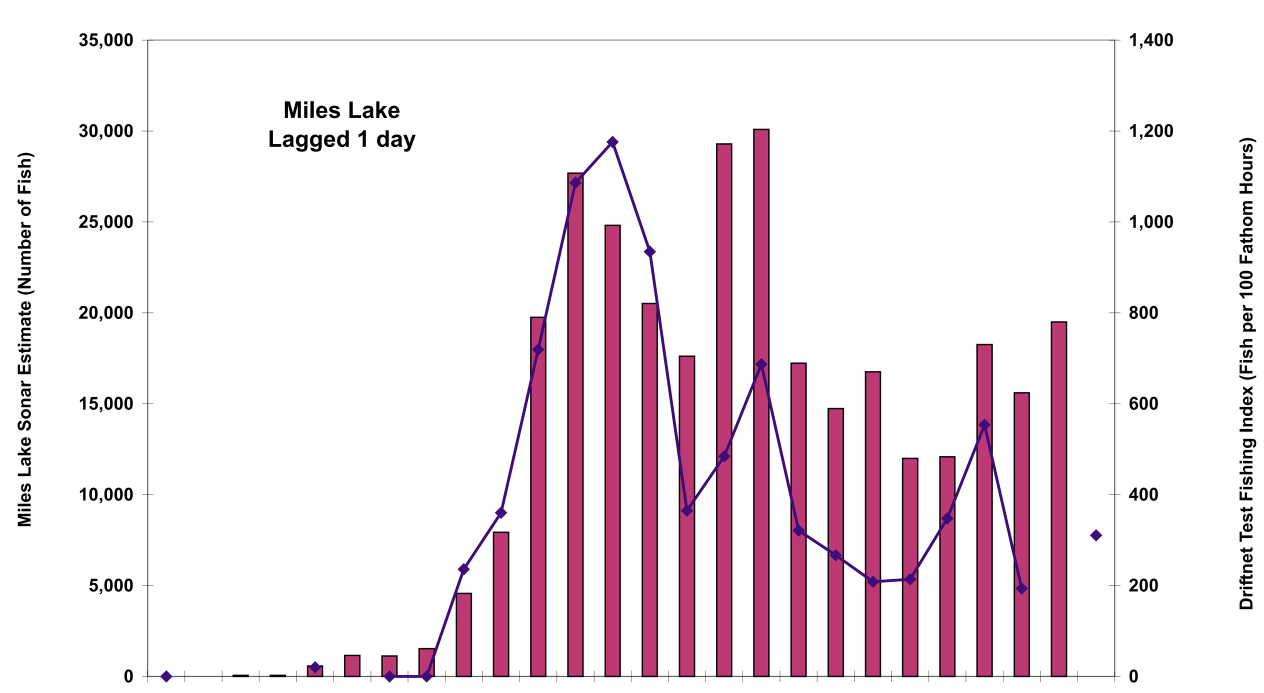


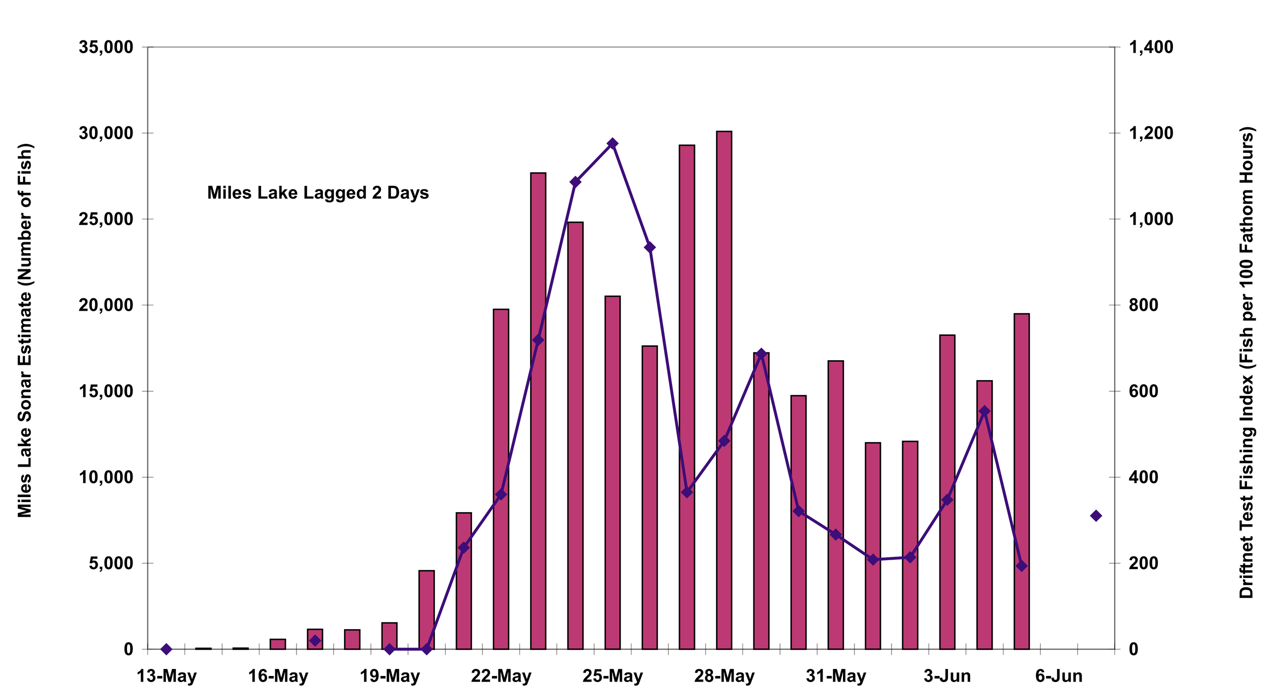


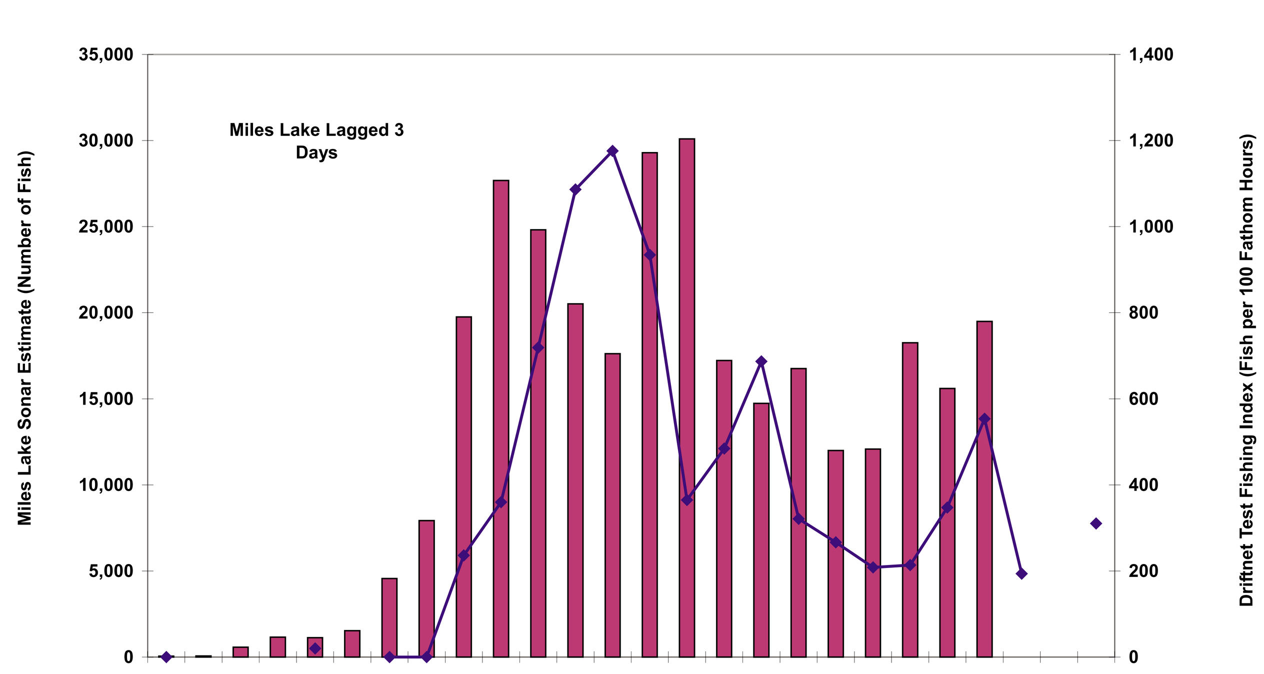
Results - Test Fishing

Comparision of Driftnet Test Fishing Index at 27-Mile and Miles Lake Sonar Estimates, 2001

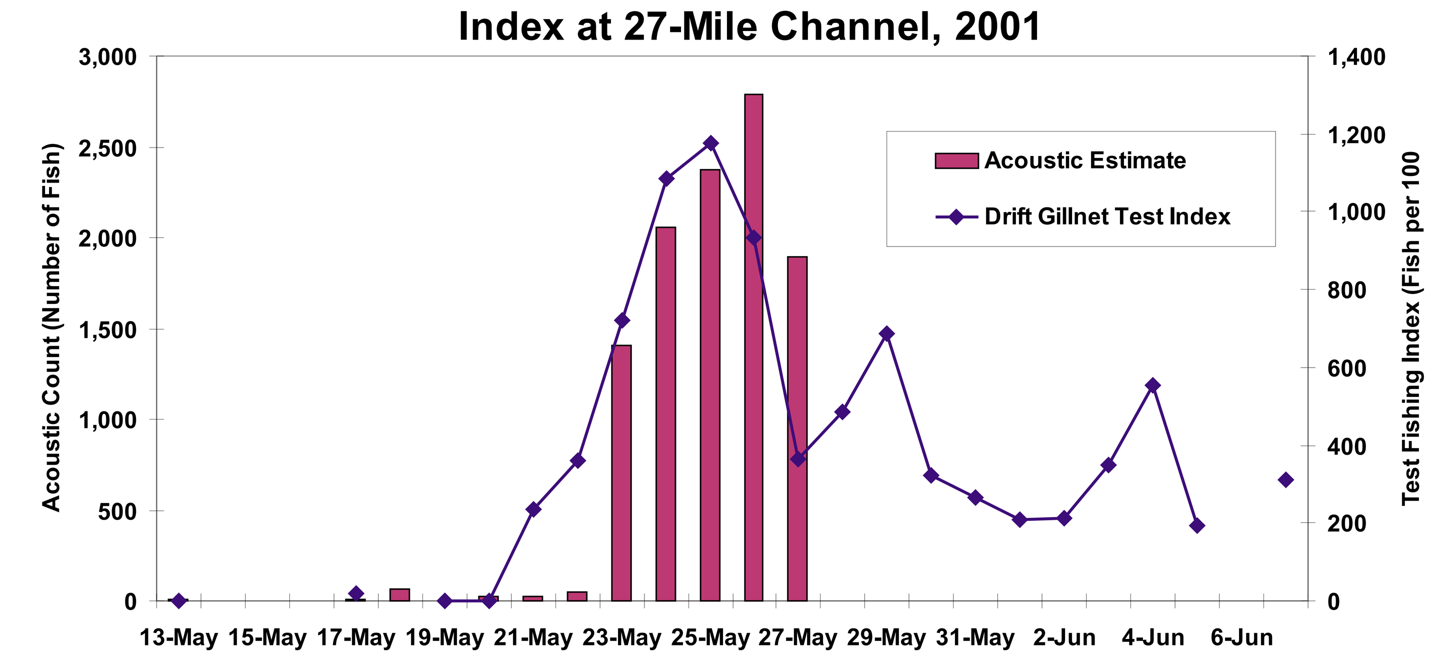






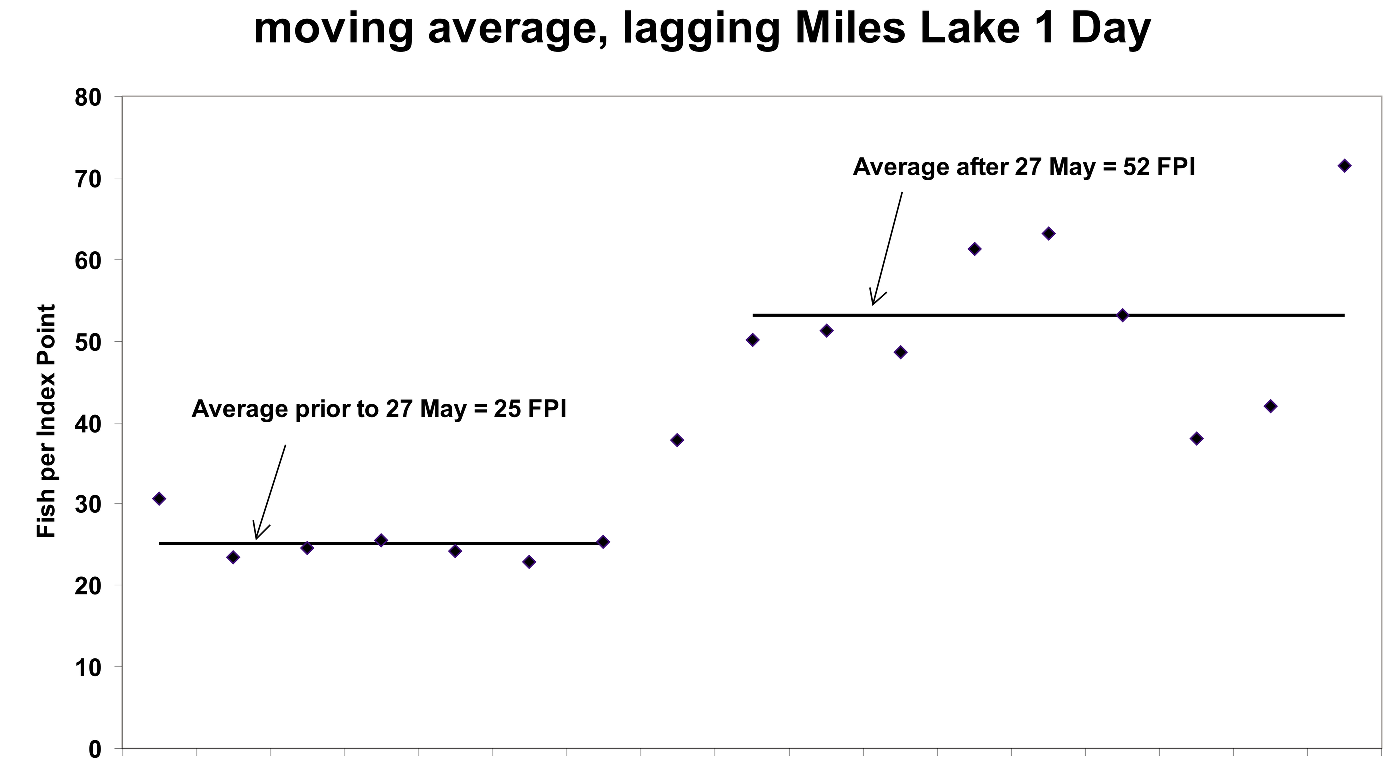


Comparison of Acoustic Estimates and Drift Test Fishing Index at 27-Mile Channel, 2001



Both driftnet and acoustic gear appeared to detect the large pulse of fish moving through the lower river on 21-23 May.

Driftnet test fishing, fish per index point, 3-day moving average, lagging Miles Lake 1 Day



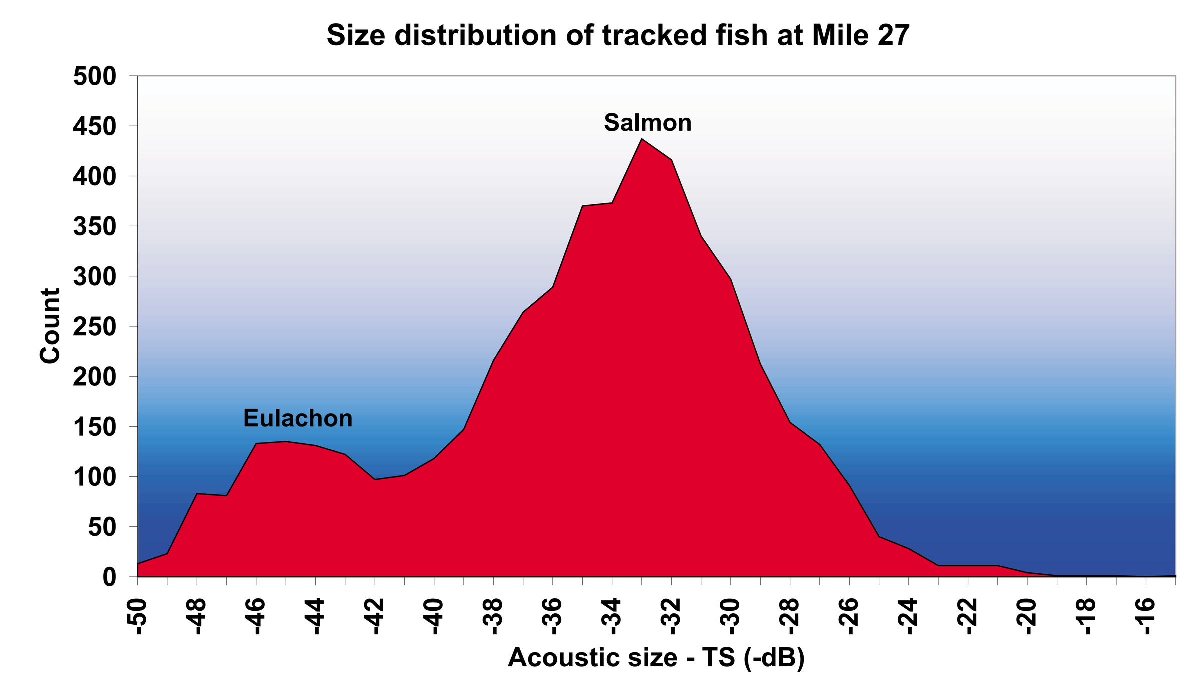
The efficiency of the gillnet gear appeared to decrease with time, possibly due to increased river discharge.

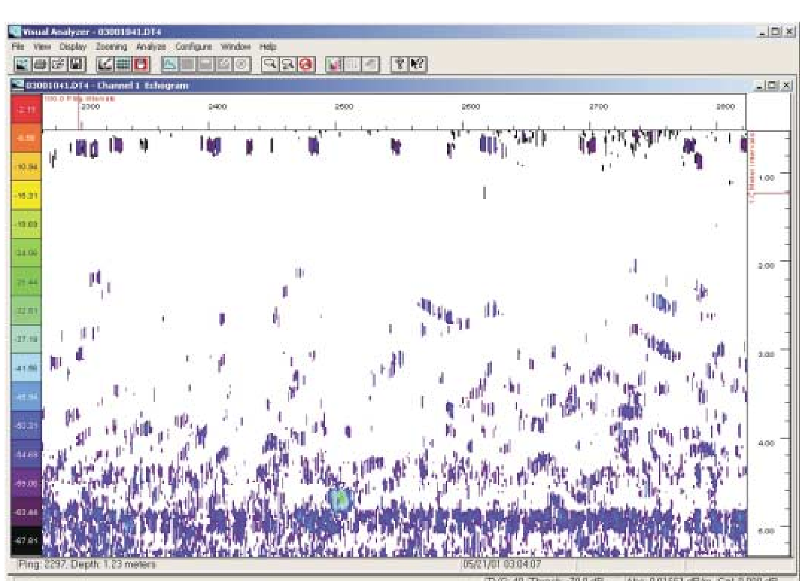
Conclusions (LRTF)

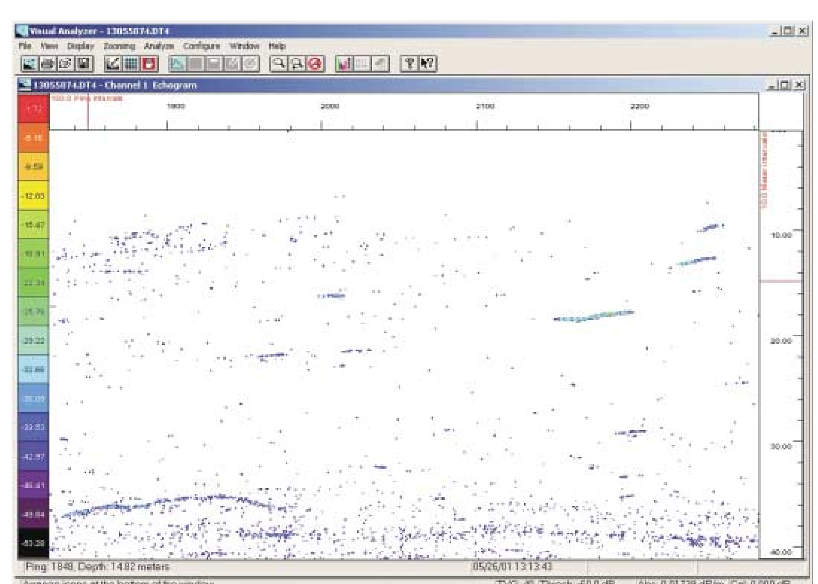
Native Village of Eyak

Fish moved through the lower Copper River quickly and we saw no signs of milling.

Eulachon did not interfere with acoustic counting of salmon.







Drift-gillnet fishing proved to be an effective test-fishing tool, although the catchability (efficiency) of the drift gillnet may be strongly affected by river discharge.

A relatively simple acoustic system can sample and count a large portion of the daily sockeye salmon escapement in the lower Copper River.

A combination of drift gillnets and acoustic gear used in tandem should greatly shorten the development time of a test fishery in the lower Copper River.

Finally, this project demonstrated that it is possible for Tribal, State and Federal governments to work together cooperatively in a multi-faceted and technical fisheries project.