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NOATAK RIVER SONAR ESCAPEMENT PROJECT

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by

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OEO/ADA Statement

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ABSTRACT

The Noatak River sonar project was designed to provide timely estimates of inseason escapement of chum salmon *Oncorhynchus keta* past commercial and subsistence fisheries in the Kotzebue area. In 1992, the fourth year of operation at river km 39, we estimated fish passage using single-beam 420 kHz hydroacoustic (sonar) gear deployed on the right bank of the river from 27 July through 29 August. We fished set and drift gillnets and used the data to apportion sonar counts to species. An estimated total of 146,230 fish passed within 120 m of the right bank transducer. The total included 70,379 chum salmon (s.e.= 4,587), 44,585 char *Salvelinus Alpinus* (s.e.= 4,389), 25,802 humpbacked whitefish *Coregonus pidschian* (s.e.= 2,520) and 4,010 pink salmon *O. gorbuscha* (s.e.= 890).

River conditions affected fish passage throughout the season. Fish distribution was clustered during periods of high water clarity (secchi > 100 cm) and random during periods of low water clarity (secchi < 100 cm). This was consistent with data collected in previous years and precludes the use of downward-looking sonar to sample cross-river transects during periods of low (clear) water when clumped fish distribution occurs. Consistent daily patterns of fish passage were not observed in 1992 when high (turbid) water occurred during periods of low ambient light late in the season. This was unlike previous years when diel movement of fish occurred late in the migration. Fish passage in 1992 was positively correlated with water level, and negatively correlated with water temperature and clarity.

Data were collected on the left bank of the river to test the feasibility of using radiotelemetry equipment. Radiotelemetry was used to remotely start and stop equipment, aim the transducer, and collect data on the left bank while operating the equipment from the right bank. This allowed simultaneous sampling of both river banks. Solutions to problems experienced with the system appear to be simple and easily implemented. Data were also collected from both banks of the river with 120 kHz sound. Comparisons of performance between the two frequencies are inconclusive due to lack of calibration data for either system, and resultant difficulty in assuring similar system sensitivities.

Recommendations for future development of this project include further testing of 120 kHz sonar, implementation of left bank sonar and gillnet sampling, and use of experimental gillnets to address questions regarding species composition of targets passing outside the range of the sample design and gillnets now being used.

KEY WORDS: salmon, char, Noatak River, sonar, hydroacoustic, species apportionment, escapement, radiotelemetry

INTRODUCTION

Noatak River chum salmon *O. keta* and Arctic char *S. alpinus* stocks support commercial and subsistence harvests in Kotzebue Sound and the lower Noatak River. Effective management of these fisheries requires knowledge of wild stock and hatchery escapement. Inseason escapement information is one of several factors which, taken together, provide a basis for fishery management decisions. Estimates of annual escapement may enable prediction of future year run strength and determination of escapement goals.

Silty water and the wide, multi-channel river mouth preclude the use of visual fish counting techniques, such as towers and weirs, which could otherwise provide daily estimates of fish passage. These conditions have historically necessitated the use of aerial surveys of clear water spawning areas as an index of wild stock escapement. Dissatisfaction with certain characteristics of aerial surveys, such as lack of timeliness, subjectivity of the method, and dependence of accuracy on variable weather and river conditions, prompted investigation into use of sonar for salmon escapement estimation on the Noatak River.

Initial sonar studies were conducted by Bird (1981a, 1981b) and Bigler (1983, 1984) using equipment manufactured by Bendix, Inc.[1] Fish passage beyond the range of the sonar, and difficulties with species composition estimation led to discontinuation of the Bendix project in 1983. In 1984, Biosonics, Inc.[1] sonar gear was purchased and deployed and the species composition estimation program was redesigned (Berning et al. 1987). Comparison of the chum salmon estimate generated through this project with aerial survey data indicated underestimation by the sonar. Potential sources of error included overestimation of beam size and river cross section coverage, and inadequate sample size for estimation of species composition. Lack of funding prohibited further study until 1988.

The current sonar site was selected in 1988 following examination of the lower Noatak River. The River flows approximately 680 km from its headwaters in the Schwatka Mountains to Kotzebue Sound. Multiple channels, slow current and/or unstable banks characterize the lower 30 km. The lower Noatak River canyon site, located at km 39 (Figure 1) was chosen for favorable features including a single, narrow (240 m) channel, stable banks, proximity to the river mouth, and smooth, v-shaped bottom profile of moderate (20 m maximum) depth.

A camp was constructed and sonar first deployed at this location during July and August 1989 (Fleischman and Huttunen 1990a). Site characteristics appeared favorable despite unusually high and turbid water conditions. Test netting at the site suggested that chum salmon might be

[1] Companies referenced in this report were listed for archival purposes only. Such references do not represent endorsement by the State of Alaska, Department of Fish and Game.

spatially segregated from other fish species. Such segregation would minimize the usually difficult problem of apportioning sonar estimates of total fish passage to species; neither dual-beam sonar nor extensive test netting would be needed to differentiate between chum salmon and other, smaller species. In both 1990 and 1991, test netting suggested that chum salmon were spatially segregated to a lesser degree than in 1989. Water levels were lower, water clarity was higher and fish displayed pronounced schooling behavior (Fleischman et al. 1990b; LaFlamme et al. 1992).

Estimates of fish passage by species were generated for the right bank of the river in 1990 and 1991. These data were consistent with other indicators of abundance, and were viewed by area fishery managers as valuable information for consideration in management decisions. Encouraged by the initial success of the project, we used the 1992 season to improve escapement estimates by addressing two areas. First, we tested deployment and operation of lower (120 kHz) frequency sonar gear. Recent research indicates that attenuation of previously used 420 kHz sound in fresh water may confound fish target strength and transducer beam cross-sectional area estimates. Lower frequencies may not be similarly affected. Secondly, we deployed sonar gear on the left bank of the river in order to increase ensonification of the river cross section, and tested radiotelemetry gear as a means of remote data collection control.

Objectives for 1992, in order of priority, were as follows:

(1) Provide estimates of right bank chum salmon passage to fishery managers twice per week.

(2) Continue to assess the physical and biological characteristics of the Noatak River and their impact on our ability to count migrating chum salmon with sonar.

(3) Test 120 kHz equipment on both banks of the river and collect associated sonar data.

METHODS

Sonar Data Acquisition

Sonar equipment included a Biosonics model 102 echo sounder, International Transducer Company (ITC) 4° x 7° elliptical dual-beam transducer, Biosonics model 111 thermal chart recorder, and a Hewlett Packard model 54501A digital-storage oscilloscope.[1] The transducer was mounted on a metal tripod placed 2 to 5 m offshore, and was aimed with a remote-controlled pan and tilt unit manufactured by Remote Ocean Systems (ROS).

Sound pulses were generated by the sounder at 420 kHz with a pulse width of 0.4 ms. Pulse repetition frequency was 3.3 Hz; maximum range was 120 m. The narrow beam signal was routed to the oscilloscope and to a chart recorder which ran continuously at a paper speed of 1/8 mm per pulse. Chart recorder threshold settings were between 0.10 and 0.14 V, depending on levels of electronic background noise or interference present in returning signals. When noise levels were high, the threshold was set high to enhance fish trace clarity. When noise levels subsided, the threshold was reduced to ensure receipt of signals from all passing fish.

Fish traces in 10 m range and 15 minute time intervals were tallied daily from chart recordings. Technicians counted fish traces and recorded data four times per day. The project leader supervised interpretation and recording of the data each day to ensure interpretive consistency.

Water level, read from a staff gauge in the river, was recorded at 0700, 1200, 1700, and 2200 hours daily. Secchi disk readings and water temperature data were collected twice daily while test netting. A log of sonar operations, water and weather conditions was maintained. Relationships between fish passage, water level, clarity, and temperature were examined using correlation analysis (Zar 1974).

Gillnet Data Acquisition

Set and drift gillnets were used to estimate species composition. Set gillnets fished waters from the shore out to 20 m range from the transducer to provide information on chum salmon distribution. Drift gillnets fished waters between the transducer and approximately 70 m range. The following nets, all 45.7 m (25 fathoms) long and hung at 2:1 ratio, were used:

1) 70 mm (2.75") mesh mono-twist (#1.5 x 10 strand) gillnet, 126 meshes (6.6 m) deep.
2) 102 mm (4") mesh mono-twist (#1.5 x 10 strand) gillnet, 70 meshes (5.3 m) deep.
3) 127 mm (5") mesh mono-twist (#1.5 x 10 strand) gillnet, 56 meshes (5.3 m) deep.
4) 152 mm (6") mesh mono-twist (#1.5 x 10 strand) gillnet, 47 meshes (5.4 m) deep.

Individual 4, 5, or 6 inch mesh nets were set on the right bank within 5 m downstream of the transducer. They reached from shore to approximately 20 m beyond the transducer. One of the nets was set at 1200 hours every third day, and fished until 1600 hours. The net was then removed from the water, and captured fish were identified to species and measured. Salmon were measured from mid-eye to tail fork; other species were measured from snout to tail fork.

We fished all mesh sizes of drift gillnets 7 days per week at 1000 and 1600 hours. The 2.75 and 6 inch mesh nets were drifted twice per day, and the 4 and 5 inch mesh nets were drifted once per day. Nets were fished with one end attached to a boat and the other end attached to a rope which was walked along shore. The distance from shore to the inshore end of the net varied between 5 and 25 m depending on inshore chum salmon distribution indicated by the set nets. Each drift originated no more than 5 m below the tripod and lasted 15 minutes. Drift duration was shortened when necessary to limit catches during periods of high fish passage. Captured fish were disentangled after the net was fully retrieved into the boat, and were subsequently identified to species and measured.

Data Processing

Estimating Total Fish Passage

Sonar counts were tallied by 15 minute interval except for brief and infrequent periods when the sonar was not operational. Total fish passage ($\hat{N}$) on day *j* was estimated as:

$$\hat{N}_j = 96 \cdot \bar{n}_j \qquad \textbf{(1)}$$

where $\bar{n}_j$ = average number of targets detected from 0 m to 120 m range during all 15 minute time strata on day *j*.

Species Apportionment

Drift gillnet catch per unit effort (CPUE) values, adjusted for net selectivity, were used to estimate species proportions. Because of the size selectivity of gillnets, catches from several nets were used to estimate the relative abundance of each species. Chum salmon relative abundance was estimated from catches in 4, 5, and 6 inch mesh nets (Appendix A). Arctic char relative abundance was estimated from catches in 2.75, 4, 5, and 6 inch mesh nets. Humpback whitefish *C. pidschian* relative abundance was estimated from catches in 2.75 and 4 inch mesh nets, and pink salmon *O. gorbuscha* relative abundance was estimated from catches in 2.75, 4, and 5 inch mesh nets.

Size selectivity of gillnets (relative probability of capture for each mesh size/length class combination) for chum salmon and char was estimated from 1990 Noatak test-netting data (Fleischman et al. 1990b), following Peterson (1966). Peterson's method assumes that selectivity of one mesh size for different size classes of fish is approximated by a normal probability distribution. Estimates of means and standard deviations which specify normal function selectivity curves for nets used on the Noatak River in 1992 are listed in Appendix B. Too few pink salmon and whitefish were caught in 1990 to estimate net selectivity for these species on the Noatak. Net selectivity parameters for pink salmon were estimated from 1986-1989 Yukon River sonar test-netting data and converted to Noatak net sizes. Whitefish catches on the Noatak were not adjusted for net selectivity in 1992. Data from 1991 and 1992 seasons will be used to update net selectivity curves prior to the 1993 season.

To apportion sonar passage estimates to species, catch c of species i and length class l on day j and test-fish period k was first adjusted for selectivity (differential probability of capture p) of species i and length class l in mesh m. Adjusted catch A was calculated as:

$$A_{iljkm} = \frac{c_{iljkm}}{p_{ilm}} \qquad (2)$$

For example, the estimated mean of the normal selectivity function for chum salmon in 6" gear was 657 mm; the estimated standard deviation was 60.5 mm (Appendix B). A 600 mm chum salmon caught in 6" gear is "z" = 57/60.5 = 0.94 standard deviations less than the net mean. The height of the normal curve is 64% of its maximum at z = -0.94, so the estimated (relative) probability of capture is 0.64. Therefore catches of 600 mm chum salmon in the 6" net were adjusted by dividing by p = 0.64.

In reality, due for example to tangling of large fish in small meshes, net selectivity functions probably depart from the assumed normal function (Hamley 1978). Furthermore, the effect of departures from normality grow larger with distance from the mean, where a normal function would predict low probability of capture and high adjustment factors. Therefore, to be conservative and minimize inclusion of tangled fish, fish whose lengths were very different from the selectivity mean for the net used were ignored. An arbitrary z value of 1.66, equivalent to an adjustment factor of 4.0, was chosen as the cutoff point.

CPUE was calculated after adjustment for capture probability. If fish of a given length class l were susceptible to capture by more than one mesh size (criterion: fish length within 1.66 standard deviations of the selectivity mean for that net), both adjusted catch and effort were summed over all meshes meeting the above criterion; i.e.,

$$CPUE_{iljk} = \frac{\sum_{m} A_{iljkm}}{\sum_{m} E_{jkm}} \qquad (3)$$

where E = effort in fathom-hours. CPUE was then summed across all length categories for species i:

$$CPUE_{i \cdot jk} = \sum_{l} CPUE_{iljk} \tag{4}$$

Proportion S_{ijk} of species i, out of all species present, for each test fishing period k on day j was estimated as:

$$\hat{S}_{ijk} = \frac{CPUE_{i \cdot jk}}{\sum_{i} CPUE_{i \cdot jk}} \tag{5}$$

To generate passage estimates by species, both sonar passage estimates and species proportions were pooled into two reporting periods per week, scheduled to provide the most timely information for fishery managers. The sonar estimate of total fish passage for report period t was calculated as:

$$\hat{N}_t = \sum_{j} \hat{N}_j \tag{6}$$

and pooled species proportions S_{it} for each reporting period t were estimated as:

$$\hat{S}_{it} = \frac{\sum_{j}\sum_{k} CPUE_{i \cdot jk}}{\sum_{i}\sum_{j}\sum_{k} CPUE_{i \cdot jk}} \tag{7}$$

and estimated passage $\hat{N}$ of species i during report period t was:

$$\hat{N}_{it} = \hat{N}_t \cdot \hat{S}_{it} \qquad \textbf{(8)}$$

When we required estimates of passage $\hat{N}$ for species i during individual day j, we used the pooled estimate of species proportion S for the report period t containing day j:

$$\hat{N}_{ij} = \hat{N}_j \cdot \hat{S}_{it} \qquad \textbf{(9)}$$

Estimating Variance

There are at least two components that contribute to the variance of species passage estimates: (1) the sonar estimate of total fish passage, and (2) the drift gillnet estimates of species proportions. For the purposes of variance calculations, the sonar component of variance is assumed to be zero due to the high sonar sampling intensity. Errors in species passage estimates are due almost solely to estimation of species proportions (Fleischman 1990b); therefore we report only the second component.

To estimate the variance of species proportion i during reporting period t, we treated the drift gillnet catch during day j and fishing period k as a replicate cluster sample and weighted each squared deviation by the relative adjusted CPUE (total for all species) for that fishing period (Cochran 1977:64):

$$\hat{Var}(\hat{S}_{it}) = \frac{1}{n_t} \sum_j \sum_k \left(\frac{m_{\cdot jk}}{\bar{m}_{\cdot t}} \right)^2 \frac{(\hat{S}_{ijk} - \hat{S}_{it})^2}{n_t - 1} \qquad \textbf{(10)}$$

where:
- n_t= number of test-fish periods in reporting period t
- $m_{\cdot jk}$= test-netting CPUE (all species) on day j, test-fish period k
- $\bar{m}_{\cdot t}$= mean test-netting CPUE (all species) during all test-fish periods in reporting period t

Estimated variance of species passage estimates N_{it} was:

$$\hat{Var}(\hat{N}_{it}) = \hat{N}_t^2 \cdot \hat{Var}(\hat{S}_{it}) \quad (11)$$

Finally, variance estimates for species *i* were summed over all report periods to estimate the variance of the season total passage $\hat{N}_i$:

$$\hat{Var}(\hat{N}_i) = \sum_t \hat{Var}(\hat{N}_{it}) \quad (12)$$

Sonar and test-netting data were entered into Quattro Pro worksheets and an Rbase for DOS database, respectively. Data processing was done with SAS programs (Release 6.04, Appendix C).

120 kHz Data Acquisition

We deployed and tested 120 kHz equipment on both banks of the river. Sonar equipment included a Biosonics model 102 echo sounder, Acoustic Transducers Incorporated (ATI) 4° circular single-beam transducer, Biosonics 10° x 25° circular dual-beam transducer, and a Biosonics model 111 thermal chart recorder.

Transducers were selected to best match the river bottom profile on each bank. The 4° ATI transducer was attached to a tripod with pan and tilt unit as previously described, and was deployed on the gently sloped right bank within 5 m downstream of the 420 kHz transducer. The 10° x 25° Biosonics transducer was similarly mounted and deployed directly across the river from the right bank transducer in order to maximize ensonification of water along the cutbank.

We set sounder parameters to best match conditions on each bank. Sounder parameter settings on the right bank were identical to those used for 420 kHz data collection; i.e., the pulse width was 0.4 ms, pulse repetition frequency was 3.3 Hz, and the maximum range was 120 m. The chart recorder threshold was set at 0.12 V. On the left bank the pulse width was 0.3 ms, pulse repetition frequencies were 5 and 6.7 Hz, and maximum ranges were 50 and 80 m. The chart recorder threshold settings were between 0.12 and 0.22 V.

Left bank data collection was tied to the radiotelemetry field test described below. We constructed a temporary wall tent and installed the echosounder and radiotelemetry gear. The telemetry gear allowed remote control of the sonar equipment from the right bank as well as reception of left bank data on a right bank chart recorder.

Radiotelemetry Field Test

The impracticality of controlling left bank data acquisition via hardwire connection to the right bank, and the cost of personnel required to monitor a separate left bank data station, pointed to the need for an alternative method of monitoring left bank fish passage. A radiotelemetry system, developed cooperatively by ADF&G and the University of Alaska's Geophysical Institute, was tested on the Noatak River in 1992. Telemetry equipment on each bank included a custom-manufactured control box, two uni-directional Yagi antennae, one whip antenna, and one antenna tower with base anchor.

We operated the radiotelemetry system and observed its performance of three primary functions: generator start and stop, pan and tilt control, and data acquisition. Technicians recorded performance observations in the sonar log book and tallied acquired fish traces in 10 m range intervals and 15 minute sample periods.

RESULTS

River Conditions

River conditions and fish behavior varied throughout the season. Between 27 July and 12 August, water level was relatively low while water clarity and temperature were at seasonal high levels (Figure 2). The water level increased dramatically between 13 and 15 August, while water clarity and temperature dropped to seasonal low levels between 11 and 18 August. By 18 August, water level had stabilized and water clarity was gradually increasing. Water temperature rose rapidly between 18 and 23 August, then remained stable until observations ended. Over the entire season there was an inverse relationship between water level and clarity ($r=0.75$, $p<0.001$) and between water level and temperature ($r=0.74$, $p<0.001$, $df=32$).

We observed fish schooling coincident with high water clarity. This behavior was apparent from drift gillnet catches and from fish trace distribution on chart recordings. Gillnet catches and fish traces were spread across temporal and spatial ranges during periods of low water clarity (<100 cm secchi), and were clustered in both dimensions during periods of high water clarity (>100 cm secchi) (Figure 3). Schools of 10-15 fish were frequently observed. There were statistically significant relationships between total fish passage and water level ($r=0.44$, $p<0.01$), temperature ($r=0.55$, $p<0.001$), and clarity ($r= 0.58$, $p<0.001$, $df=32$), as well as between estimated chum salmon passage and water level ($r=0.45$, $p<0.01$, $df=32$), temperature ($r=0.58$, $p<0.001$, $df=32$), and clarity ($r=0.47$, $p<0.005$, $df=32$). Fish passage was greatest at low water temperature, low water clarity, and high water level.

Fish Passage

The sonar equipment was installed and fully operational on 27 July. Collection of data continued through 29 August. The equipment ran continuously, 24 hours per day, 7 days per week, excluding two daily 15 minute periods, 12 hours apart, required for generator refueling and maintenance. Data acquisition was occasionally interrupted when changing river conditions necessitated moving the tripod or re-aiming the transducer.

We counted 139,424 traces on the chart recordings, and from those data estimated passage of 146,230 fish by the right bank sonar through 29 August (Table 1). The difference resulted in an average daily expansion factor of 1.001 and an overall seasonal expansion factor of 1.048 due to breaks in sampling for generator refueling and transducer relocation or aiming. Estimates of fish by species include 70,379 chum salmon (s.e.= 4,587), 44,585 char (s.e.= 4,389), 25,802 whitefish (s.e.= 2,520) and 4,010 pink salmon (s.e.= 890). The highest estimated chum salmon passage occurred between 16 and 21 August (Figure 4). Char passage was greatest between 19 and 25 August, and whitefish passage peaked on 03 August. Mean date of passage was 15 August for chum salmon, 18 August for char, and 07 August for whitefish (Table 2).

Range distribution of targets that passed the site for the overall season formed a broad peak from 50 to 80 m offshore from the transducer on the right bank (Figure 5). We examined the hourly fish count data for evidence of daily patterns of movement. No consistent trends were detected.

We deployed set gillnets seven times between 27 July and 14 August to determine nearshore distribution of chum salmon (Appendix D). High water and debris-loading prevented set net use after this date. The 4 and 5 inch mesh nets were deployed two times each, and the 6 inch mesh net was used three times. Fishing effort totaled 112, 76, and 176 fathom-hours for the 4, 5, and 6 inch meshes. The catch included 38 chum salmon, 10 char, 8 humpbacked whitefish, and 20 pink salmon. Four sheefish *Stenodus leucichthys*, 4 Northern pike *Esox lucius*, 7 starry flounder *Platichthys stellatus*, and 6 longnose sucker *Catastomus* were also captured in set nets.

We drifted gillnets 196 times from 27 July through 29 August. Fishing effort totaled 304, 153, 151, and 308 fathom-hours for the 2.75, 4, 5, and 6 inch meshes. The catch included 686 chum salmon, 300 char, 185 humpbacked whitefish, and 50 pink salmon (Appendix E).

Since set net results indicated passage of chum salmon within 20 m of the transducer, drift gillnet results from the entire sampling range (0-120 m) were processed for species allocation. These data indicate that 48% of the estimated fish passage for the time period observed were chum salmon, 30% were char, 18% were humpbacked whitefish, and 3% were pink salmon (Figure 6).

Length distributions of captured chum salmon and whitefish were unimodal and well separated in 1992 (Figure 7). Chum salmon mean length was 564 mm (s.d.=36.69, n=686). Whitefish mean length was 345 mm (s.d.=30.63, n=185) (Table 3). The separation of the means is 219 mm. Char length classes were bimodal and overlapped both whitefish (<430 mm) and chum salmon (>430 mm) distributions. Mean length was 356 mm (s.d.=40.43, n=161) for char overlapping whitefish, and 528 mm (s.d.=47.65, n=139) for char overlapping chum salmon. The separation of the means between chum salmon and char is 36 mm.

120 kHz Data Acquisition

We successfully deployed and collected data with 120 kHz sonar gear on the left and right banks of the river in 1992. We collected 93.2 hours of left bank data between 16 and 25 August. This period coincided with the seasonal peak of fish passage as indicated by right bank 420 kHz sonar. On the right bank, 120 kHz data was collected for a total of 36 hours on the 12th and 13th of August in addition to 420 kHz data used for fish passage estimation.

Between 16 and 25 August we counted 3,914 targets and estimated passage of 9,818 fish from the left bank data. During this same period, 225.9 hours of right bank sampling with 420 kHz gear resulted in 67,144 targets and an estimate of 71,427 fish passing the transducer. These data appear in Table 4. Over the entire 10 day period the estimates of left and right bank fish passage were 12 and 88 percent of the total. Daily left bank raw counts ranged from 4 to 23 percent of the daily right bank raw counts (Figure 8). Range distributions of sonar counts peaked at 80 m on the right bank (Figure 9). Left bank counts were nearly uniform across ranges, peaking slightly at 50 m.

On 12 and 13 August, the two days of 120 kHz data collection on the right bank, total fish passage estimates were 13 and 41 percent higher than those derived from 420 kHz data. On 12 August, displays from the 420 kHz system showed that strong bottom reverberation dominated the chart recordings at 20 and 40 m range. This interference was not observed on the 120 kHz displays. Specific range interval estimates of fish passage from the 420 kHz system were higher on August 12 at the two ranges. The systems otherwise showed similar distributions of fish at range (Figure 10).

Radiotelemetry Field Test

Radiotelemetry was used to remotely control 120 kHz data collection on the left bank for 10 days. The telemetry system allowed start up and shut down of the generator and sonar equipment, as well as pan and tilt control and data collection via radio signals originating on the right bank. Collected data was transmitted to and recorded on the right bank chart recorder.

The equipment worked consistently and effectively with three exceptions. We occasionally experienced difficulty initiating communication between the control site and the remote site. This problem was solved by manually resetting one or the other or both telemetry control boxes. An additional problem was strong winds which occasionally caused misalignment of the radio antennae, preventing stable communications. Again, manually repositioning the antennae easily solved the problem. Finally, and most troublesome, was the remote generator start feature. Traveling across the river to the left bank site to manually choke the generator was required at the start of each sample day due to the lack of a remotely operated carburetor choke. The remote start worked consistently once the generator was warm.

DISCUSSION

River Conditions

We recorded daily measures of water level, clarity, and temperature over three summers beginning in 1990. These data show an inverse relationship between water level and water clarity, and between water level and water temperature. There is no consistent seasonal pattern of variation in our observations of river conditions. They are affected primarily by ambient temperature and precipitation, which vary dramatically from year to year. There is, however, a consistent pattern of fish behavior which we believe is a function of river conditions.

Three years of data (1990, 1991, and 1992) indicate that fish pass the Noatak River sonar site in groups or schools during periods of low (clear) water. When the river level is high and water is turbid, fish pass singly. The 1992 data indicate that schooling behavior ends when secchi disk readings are less than 100 cm. Data from 1990 and 1991 support this conclusion. Water clarity met or exceeded this level 65 to 87 percent of the season in the three years observed.

Schooling of migrant fish has three implications for the sonar project, all of which involve sampling technique and intensity. First, it makes impractical any attempt to quantify fish passage in mid-river areas using downward-looking sonar to sample cross-river transects. As stated or implied in progress reports beginning in 1990 (Fleischman et al. 1990b; Laflamme et al. 1992), boat avoidance and clumped fish distribution make the resulting data highly variable and unreliable. Fortunately, other means of estimating fish passage in areas beyond the range of the right bank transducer are available and feasible. Addition of left bank sonar gear and use of 120 kHz frequency sound should allow full river cross-section sampling at levels which make most migratory behavior inconsequential.

Secondly, schooling behavior may decrease the precision of species composition estimates by increasing sample variance. Since variance increases when sampling a clumped distribution, we may need to increase gillnet sampling during clear water periods in order to maintain relative precision levels.

The third implication of observed fish schooling behavior is decreased capture gear effectiveness. Observance of fish schooling during periods of high water clarity implies that visual cues trigger this behavior. If fish school because they can see other fish, it may be that the visibility is great enough to permit avoidance of gillnets. Avoidance of the fishing gear would result in decreased accuracy and precision of estimates. If fish appear to avoid the fishing gear, we may choose to change gear type, gear size, mesh type, or mesh color.

Fish Passage

Fish did not exhibit pronounced daily patterns of movement as the season progressed into increased dark hours in 1992. During this time period (after 22 August) water clarity was low (<1.5 m). This behavior was inconsistent with that of 1990 and 1991, during which fish passage slowed between 0100 and 0500 hours (the period of lowest ambient light intensity) when water clarity was high (>1.5 m) over the same part of the season. Fleischman (1990b) suggested that clear water and high ambient light trigger social behavior among migrating fish, and that these social interactions (including schooling) are depressed by darkness. This is consistent with our observations in 1992, when absence of clear water during periods of low ambient light coincided with fish travel independent of light intensity.

The combination of set and drift gillnet data used in 1992 yielded satisfactory estimates of species composition with reasonably good precision. The set nets, although used minimally, provided consistent indications of chum salmon distribution nearshore. This information was important to the program, as we used it to determine the need for apportioning inshore (0-20 m) counts among species. The number of chum salmon captured nearshore in 1992 (n=38; CPUE=0.10) was substantially greater than in 1991 (n=19; CPUE=0.05). Data collected in 1989 and 1990 are not strictly comparable with 1991 and 1992 data because of differences in mesh sizes and net depths used.

The drift gillnet data was used for apportionment of sonar counts to species over the entire range ensonified. Estimates of species composition from drift gillnets are consistent with past year's estimates, considering changes in data collection methods that occurred in 1990, 1991, and 1992. Chum salmon estimates for the three years were 62, 75, and 48 percent of the total fish passage. Char percentages were 24, 9, and 30 for the three years, and whitefish percentages were 9, 12, and 18. The decrease in chum percentage and coincident increases in char and whitefish percentages in 1992 probably results from use of drift gillnet data for apportionment of species over the entire range ensonified as opposed to the previously used technique of fishing and apportioning from 20-120 m range. There were, however other differences in gear and techniques used between the years that could have impacted the results.

The precision of estimates was again poor for individual reporting periods, but much better for the season estimates. Standard error as a percent of the estimate within a reporting period ranged from 8 to 100 percent. These are comparable to 1990 and 1991 relative precision. For the season, standard error as a percentage of the estimate was 6 percent for chum salmon, 10 percent for char and whitefish, and 22 percent for pink salmon. Compared to past years, 1992 species composition estimates are more precise for all species except chum salmon, which was slightly more precise in 1991 (0.042 compared to 0.065).

Some of the differences observed between years may be due to differences in the types and sizes of gear used, as well as to the amount of effort expended, the method used to fish the nets, the time period sampled, and the number of fish available to the gear. In 1990, for example, we fished an entirely different suite of mesh sizes than we did in 1991 and 1992. We fished more mesh sizes and they were more closely spaced in 1990 (3, 4.5, 5, 5.5, and 5.85 inch) than in 1991 and 1992 (2.75, 4, 5, and 6 inch). The length of net was the same for all years, however net depth varied from 3.6 to 5.8 m in 1990 and from 5.3 to 6.6 m in 1991 and 1992. We fished the nets for an average of 15.28 minutes per drift in 1990 as opposed to 14.95 minutes per drift in 1991 and 11.09 minutes per drift in 1992.

Fishing technique has also varied. In 1990 nets were allowed to drift with the current, often ending up in the middle of the river or on the left bank. The present method, where one person maintains the inshore end of the net at a specified distance, has been used since 1991.

Precision of estimates and gear efficiency were aided in 1992 by starting sampling later than in 1990 or 1991. Fishing was thus concentrated during the period of greatest fish abundance and lowest species variability. Finally, estimated fish passage on the right bank has varied from

67,987 in 1990 to 146,230 in 1992. The availability of this number of fish to the gillnets improved precision through increased sample size (1,221 fish in 1992 compared to 697 and 915 in 1990 and 1991).

There are at least two areas of the species composition program in which we have made untested assumptions. The first of these is that fish species composition is the same inside and outside the sampling range of the gillnets. The nets sample the area from surface to 6.7 m (2.75 inch mesh) or to 5.5 m (4, 5, and 6 inch mesh). The slope of the right bank is about 11° and the entire water column is sampled out to approximately 47 m from the transducer. Beyond 47 m, to the 70 m maximum range fished, the gillnets did not extend to the river bottom. There was as much as 1.3 m of water below the maximum depth of the three larger mesh nets at the offshore end. More importantly, the maximum distance from shore that we sampled was 70 m, yet fish captured in that range were used to apportion sonar counts to species to 120 m from the transducer.

The second assumption made is that net selectivity data gathered for pink salmon and whitefish from the Yukon River and used to calculate selectivity adjustment factors for Noatak fish are not significantly different from Noatak whitefish and pink salmon data.

The species apportionment program could be improved by addressing these, as well as several other areas. More gillnet fishing should be done to test for homogeneity of species distributions. Water along the river's left bank should be sampled with gillnets to test for differences in species composition between banks. Similarly, the mid-river area should be sampled with drift nets for comparison with right bank drift net data in order to test the appropriateness of extending right bank species composition beyond the range actually sampled. Such sampling is also desirable, though more difficult, in the vertical plane. Capturing fish in deep and mid-river areas would require the use of very deep (18-20 m), or sunken gillnets. Selectivity coefficients, as discussed above, should be replaced with coefficients derived from Noatak River gillnet meshes and fish.

Other areas for improvement center around gear dimensions, sample design, and data analysis. Longer and/or deeper nets, for instance, would improve data quality by increasing the ensonified area sampled. Evaluation of existing data to determine whether gear avoidance occurs when water clarity is high will help to determine whether changes in net size, mesh size and color, fishing technique, or sample design are required for improved precision. Fishing set nets more frequently (once per day instead of once every three days) would provide data with which to more accurately assess nearshore fish passage, species composition, and migratory behavior. Recording the spatial distribution of captured fish may provide information of value in fine-tuning the species apportionment program.

Length distributions of fish caught in gillnets from the Noatak River appear favorable for separation of some species by target strength. The technique requires sufficiently large differences in target strength (a correlate of fish size) between species for statistical differentiation. Chum salmon must be distinguished from char and whitefish by this process. Data from 1990 through 1992 consistently show that chum salmon and whitefish length distributions are unimodal, with large (219 mm) differences between median or modal lengths. The bimodal distribution of arctic char lengths overlaps that of chum salmon, particularly between 470 and 570 mm, however relatively low frequencies of char in chum salmon size ranges is indicative of a small population. If this component of the char population is small enough, it is possible that failure to distinguish between the two species would not significantly impact the accuracy or precision of the chum salmon population estimate.

With the recent change of operating frequency from 420 kHz to 120 kHz, we are poised to collect data with which we can determine the feasibility of dual beam species allocation. Development of this technique could reduce or eliminate the need for a gillnet fishery, resulting in cost savings to the project.

120 kHz Data Acquisition

We successfully ensonified the river from both banks using 120 kHz sound. This was the first attempt at collecting sonar data from the left bank since operations were initiated in 1989. Unfortunately, the transducers we had planned to use did not arrive in time for deployment and we were forced to use others which were not calibrated with project echosounders and cables. The lack of calibration data makes information collected with 120 and 420 kHz systems not strictly comparable. The systems were, however, configured so that comparable background noise levels were received and recorded. Therefore, we believe these data provide qualitative but not quantitative indications of the differences between frequencies. We caution against using this comparative information to adjust estimates of fish passage from data collected with one of the frequencies to represent what it would have been had we used the other frequency. Although 120 and 420 kHz gear were operated simultaneously on the right bank, we feel that rigorous quantitative comparison of results is inappropriate and potentially misleading due to the lack of calibration data and resultant uncertainty surrounding threshold voltage and beam size for each system used.

Radiotelemetry Field Test

We used radiotelemetry to control equipment and collect data on the left bank. This device allowed us to remotely start and stop equipment, aim the transducer, and collect data from both banks simultaneously while operating all equipment from the right bank. The radiotelemetry gear worked consistently and effectively for the time it was used, with the three exceptions previously mentioned. Recent redesign of the control boxes will reduce problems encountered with establishing communications between left and right banks. Communications will also benefit from more careful alignment and securing of antennas. The problem of remotely starting the generator when it is cold requires development of a radio controlled generator choke valve.

CONCLUSIONS AND RECOMMENDATIONS

This was the fourth season of operation for the Noatak River sonar project, and the second year of providing inseason estimates of right bank chum salmon passage and variance for fishery management. Recent research indicates that these estimates should be viewed cautiously, as they may be biased by the effects of 420 kHz sound attenuation.

We estimated passage of 146,230 fish by the right bank sonar in 1992, of which 70,379 were chum salmon (s.e.=4,587), 44,585 were char (s.e.=4,389), and the rest were whitefish and pink salmon. A relationship existed between fish passage and river conditions in 1992. Fish passage was positively correlated with water level, and negatively correlated with water temperature and clarity.

Deployment and use of 120 kHz sonar on the Noatak River is feasible. Results of comparisons with 420 kHz systems conducted in 1992 are inconclusive due to lack of calibration data and consequent impossibility of assuring similar levels of sensitivity for 120 and 420 kHz systems. Radiotelemetry was successfully used to remotely control and acquire data from the left bank. Solutions to problems that were experienced with the system in 1992 appear to be simple and easily implemented.

We recommend the following:

1. further testing of 120 kHz sonar gear to determine whether it is affected by intolerable levels of sound attenuation, and eventual inclusion in the Noatak River sampling regime should it prove adequate.

2. implementation of left bank sonar and gillnet sampling at effort levels similar to those expended on the right bank.

3. use of experimental gillnets to address questions regarding species composition of targets outside the range of presently used gillnets.

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Table 1. Estimated right bank (0-120 m range) fish passage, total and by species, at the Noatak River sonar site from 27 July through 29 August, 1992. Fish passage and estimated species percentages are calculated by multiple day reporting periods. Periods are determined by nearshore distribution of chum salmon.

Report Period Ending	Period Total Passage	Estimated Percent (s.e.) of Total				Estimated Report Period Passage			
		Chum	Char	Pink	White	Chum	Char	Pink	White
28JUL92	6,663	42(13)	7(5)	9(6)	42(14)	2,799	466	600	2,799
31JUL92	5,018	21(8)	26(12)	11(7)	42(9)	1,054	1,305	552	2,108
02AUG92	6,643	33(20)	23(17)	1(1)	43(6)	2,192	1,528	67	2,856
04AUG92	5,900	13(4)	1(1)	4(2)	80(2)	767	59	236	4,720
07AUG92	8,989	50(7)	7(2)	9(5)	31(9)	4,495	629	809	2,787
11AUG92	12,350	84(7)	0	6(3)	6(5)	10,373	0	741	741
14AUG92	10,232	37(11)	17(9)	2(1)	40(14)	3,785	1,739	205	4,093
18AUG92	25,800	54(4)	31(4)	1(1)	14(5)	13,932	7,999	257	3,612
21AUG92	26,468	49(9)	46(10)	0	5(2)	12,969	12,175	0	1,324
25AUG92	21,890	28(10)	69(10)	1(1)	2(1)	6,130	15,103	218	437
29AUG92	16,277	73(14)	22(13)	2(1)	2(2)	11,883	3,581	325	325
	-----	---	---	---	---	------	------	-----	-----
Total	146,230					70,379	44,585	4,010	25,802
s.e.						4,587	4,389	890	2,520
s.e./total						0.065	0.099	0.223	0.098
Overall %		48	30	3	18				

Table 2. Historical migratory run timing statistics for chum salmon, char, and whitefish passage at the Noatak River sonar site in 1990, 1991, and 1992.

Year	Species	Mean date	Median date
1990	Chum salmon	09 Aug	11 Aug
	Arctic char	17 Aug	21 Aug
	Whitefish	06 Aug	05 Aug
1991	Chum salmon	12 Aug	14 Aug
	Arctic char	15 Aug	17 Aug
	Whitefish	01 Aug	28 Jul
1992	Chum salmon	15 Aug	17 Aug
	Arctic char	18 Aug	20 Aug
	Whitefish	07 Aug	05 Aug

Table 3. Historical mean length statistics of chum salmon, char, and whitefish caught at the Noatak River sonar site in 1990, 1991, and 1992.

Year	Species	Mean Length (mm)	Standard deviation	n
1990	Chum salmon	593	39.21	398
	Arctic char	421	77.92	172
	Whitefish	334	20.40	93
1991	Chum salmon	594	37.25	707
	Arctic char	465	99.62	52
	Whitefish	347	31.33	129
1992	Chum salmon	564	36.69	686
	Arctic char <430 mm	356	40.43	161
	Arctic char >430 mm	528	47.65	139
	Whitefish	345	30.63	185

Table 4. Comparative results of left and right bank Noatak River fish passage estimation between 16 and 25 August, 1992. Operating frequency on the left bank was 120 kHz; operating frequency on the right bank was 420 kHz.

Date	# raw targets LB	# raw targets RB	LB count as % of RB count	estimated passage LB	estimated passage RB	% of est. daily total LB	% of est. daily total RB
16 Aug	114	1659	0.07	688	8643	0.07	0.93
17 Aug	82	1937	0.04	406	9234	0.04	0.96
18 Aug	812	3906	0.21	1046	5192	0.17	0.83
19 Aug	537	2331	0.23	1531	7453	0.17	0.83
20 Aug	394	3430	0.11	1221	9945	0.11	0.89
21 Aug	531	5075	0.10	1159	9070	0.11	0.89
22 Aug	326	2591	0.13	1118	7145	0.14	0.86
23 Aug	536	2825	0.19	1017	5402	0.16	0.84
24 Aug	308	1569	0.20	958	5021	0.16	0.84
25 Aug	274	1887	0.15	674	4322	0.13	0.87
	====	=====	=====	=====	=====	====	====
Period Total	3,914	27,210	0.14	9,818	71,427	0.12	0.88

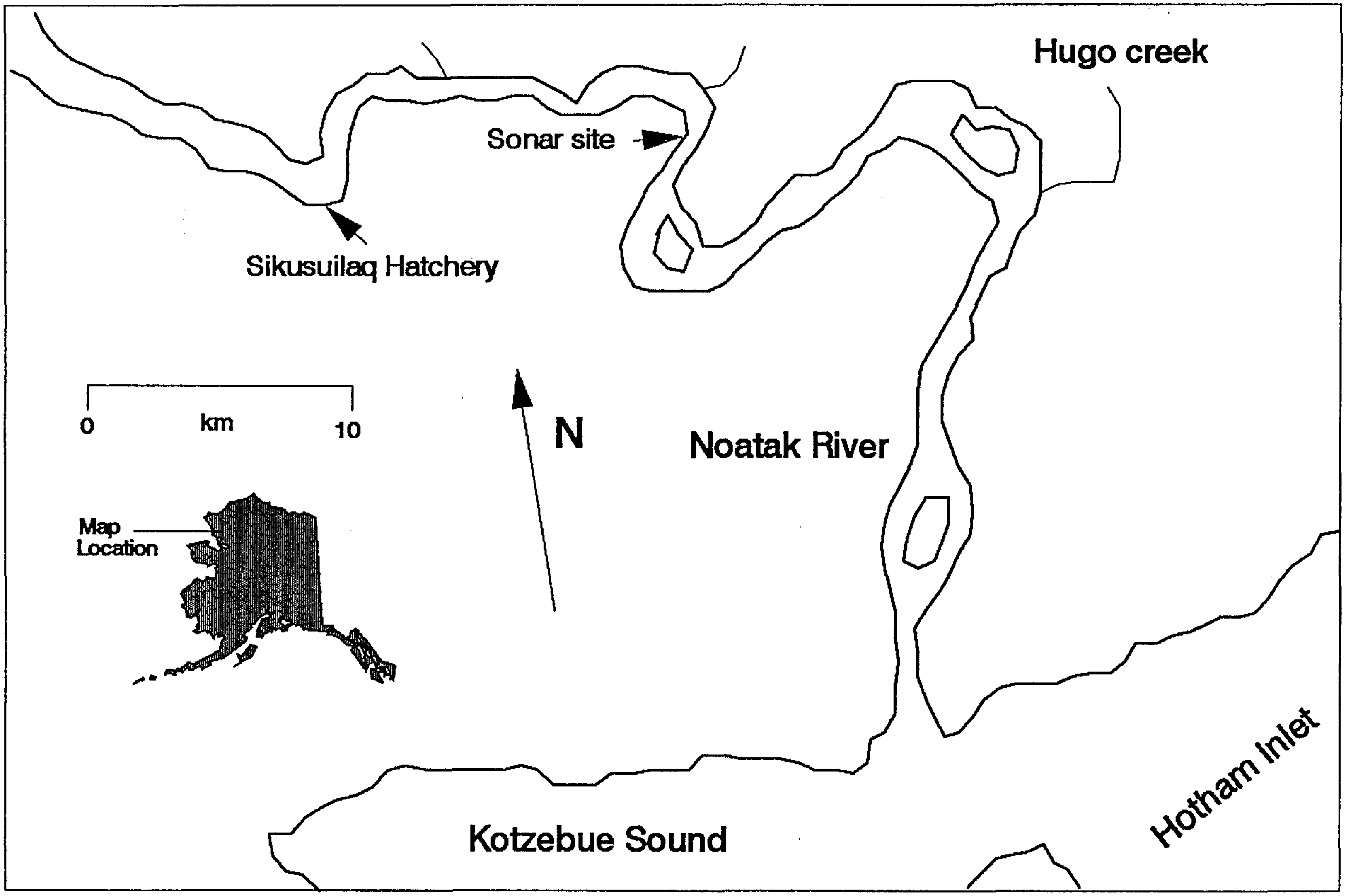

Figure 1. Location of Noatak River sonar at km 39, 1989-92.

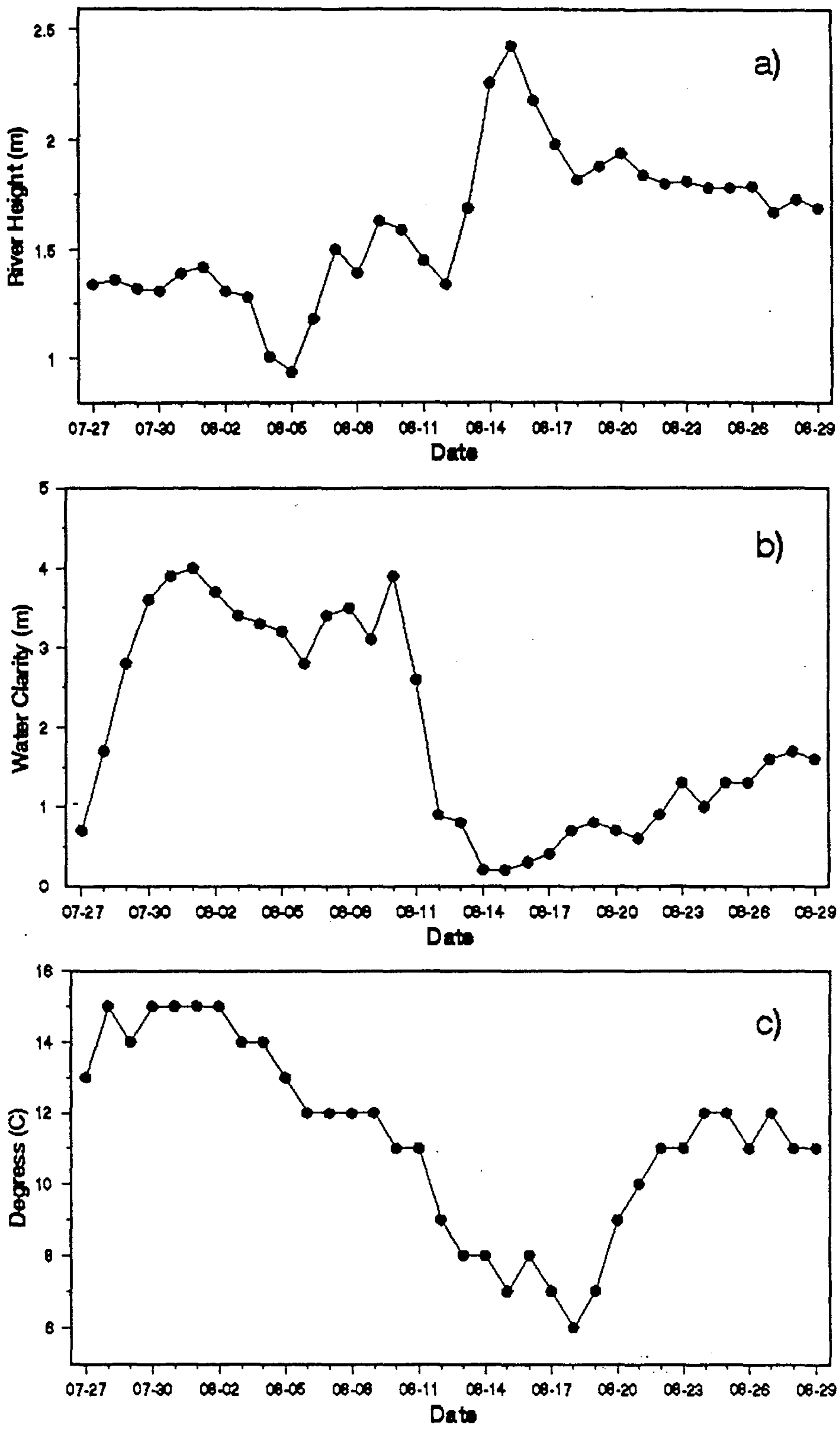

Figure 2. Mean daily a) water level, b) water clarity, and c) water temperature from 27 July through 29 August, Noatak River sonar, 1992.

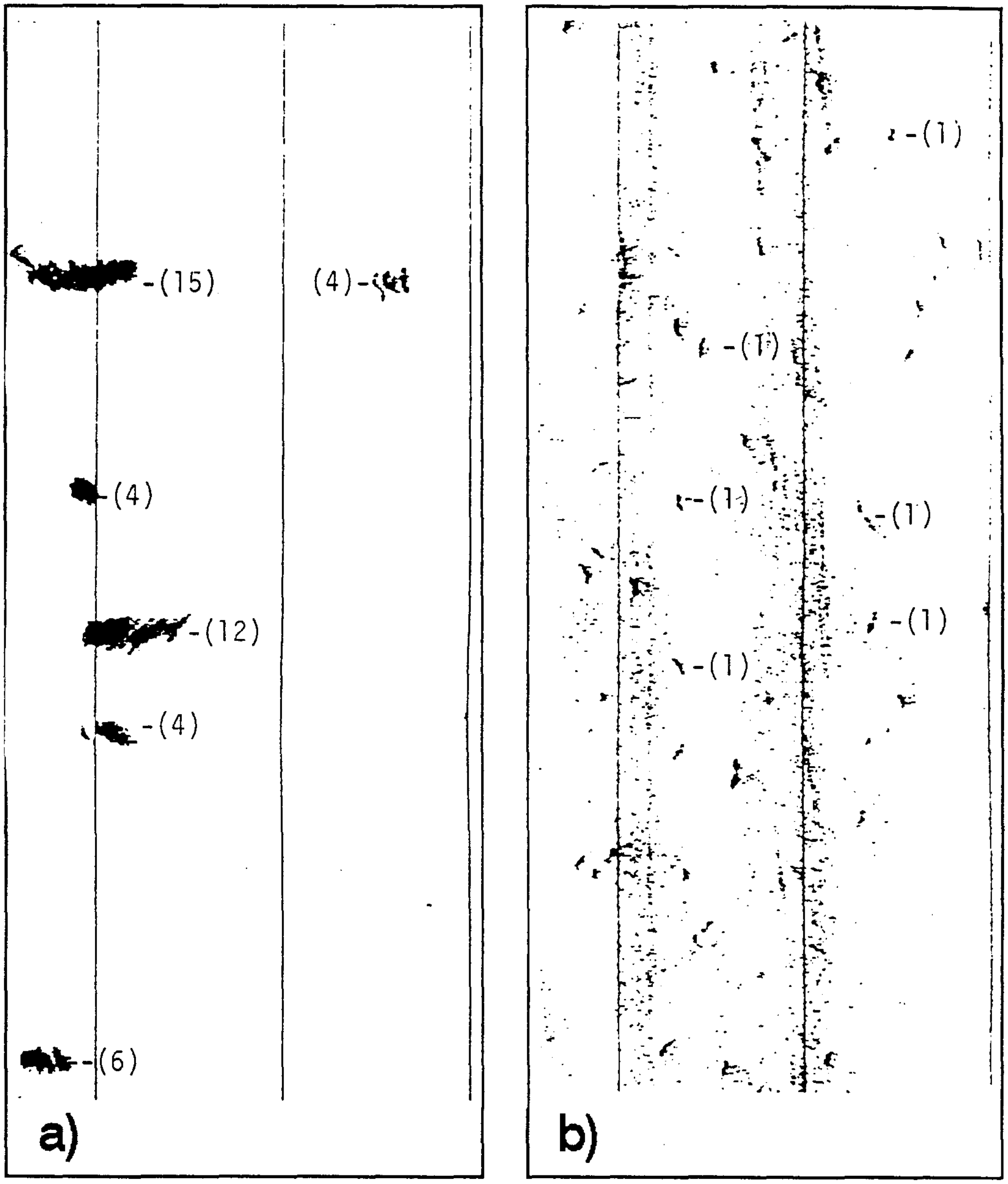

Figure 3. Chart recordings showing a) earlier season clustered traces and b) later season random traces, Noatak River sonar, 1992.

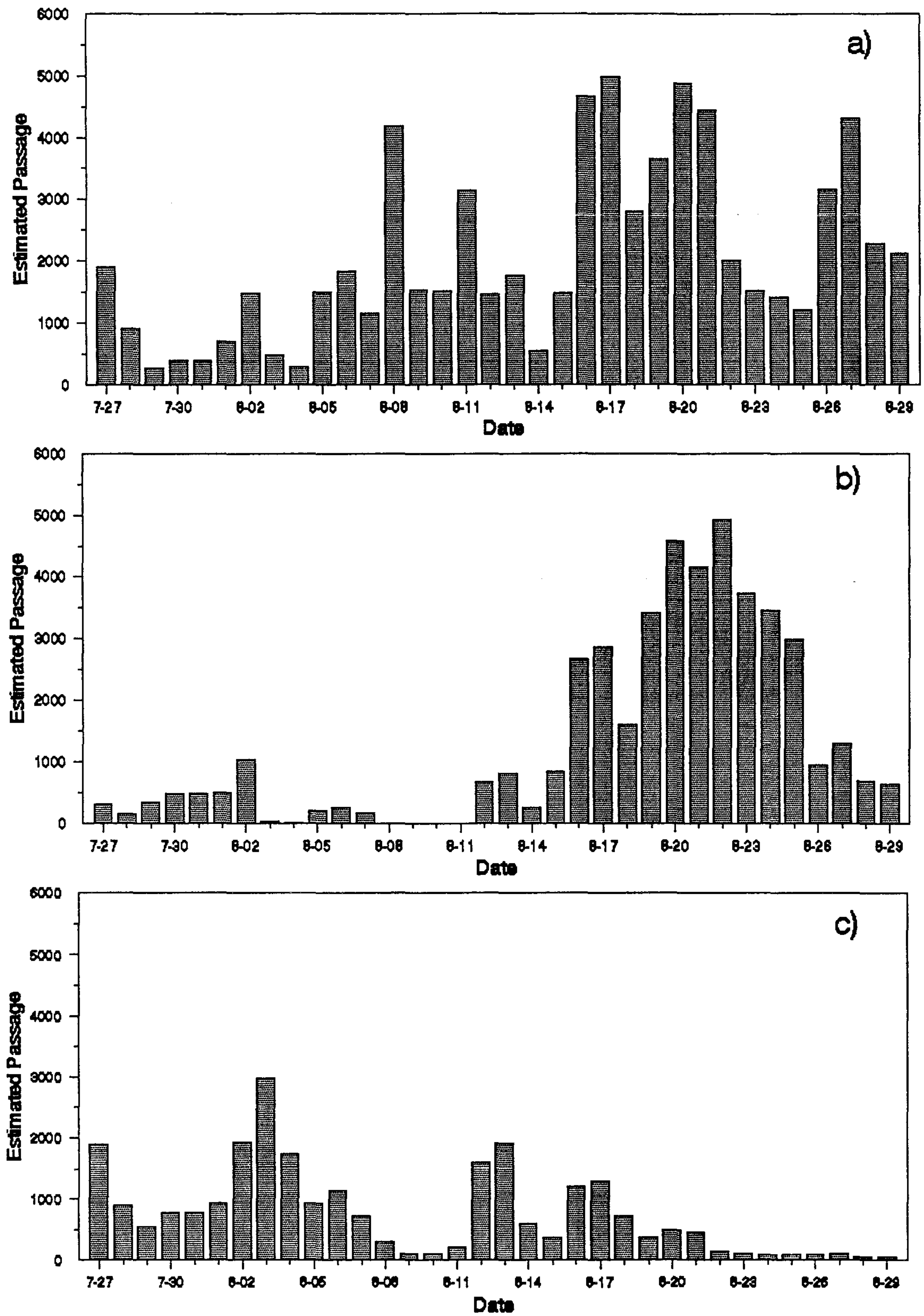

Figure 4. Daily passage estimates of a) chum salmon, b) char, and c) whitefish, from 27 July through 29 August, Noatak River sonar, 1992.

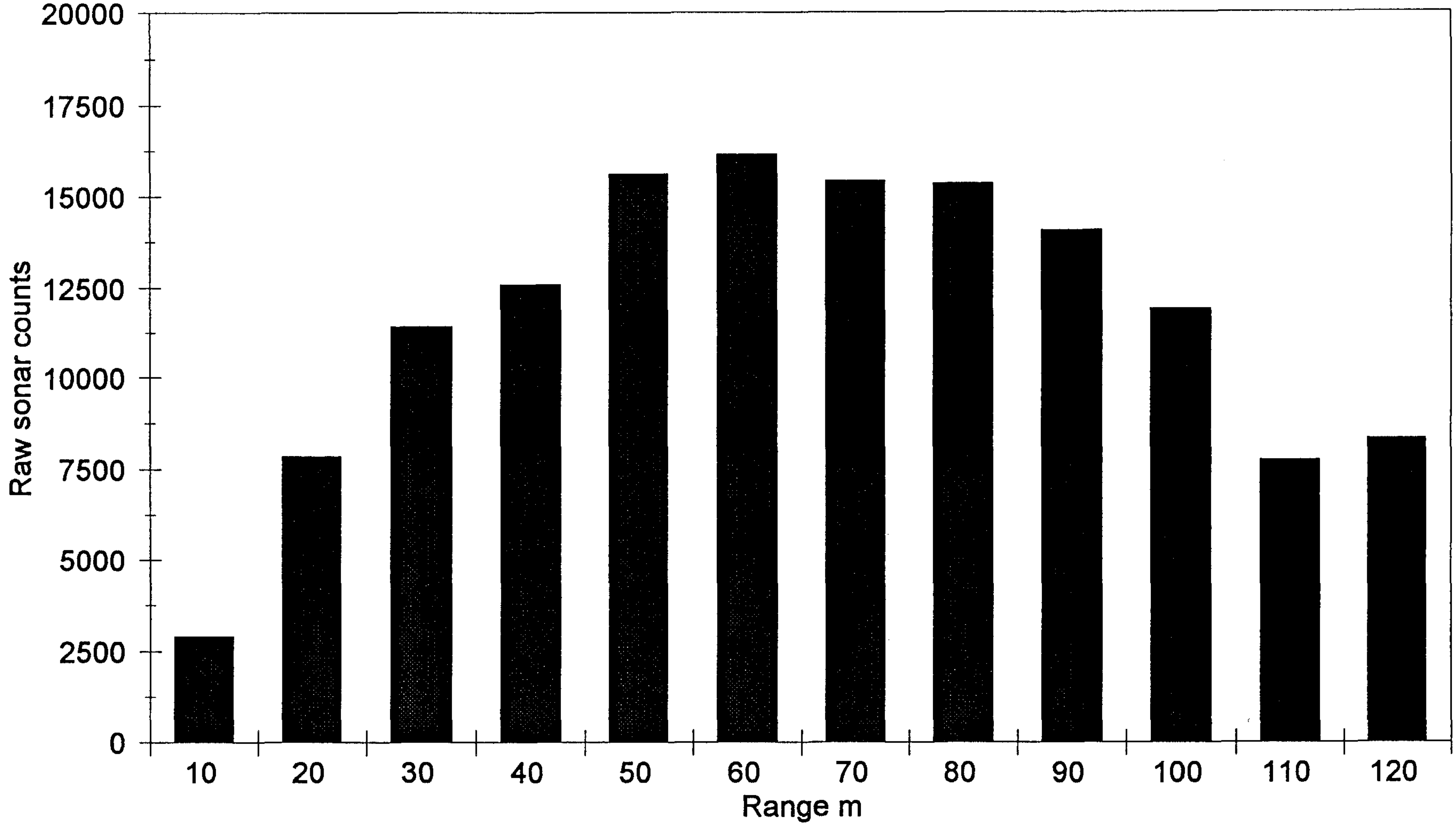

Figure 5. Range distribution of raw sonar count data collected with 420 kHz on the right bank at the Noatak River sonar site from 27 July through 29 August, 1992.

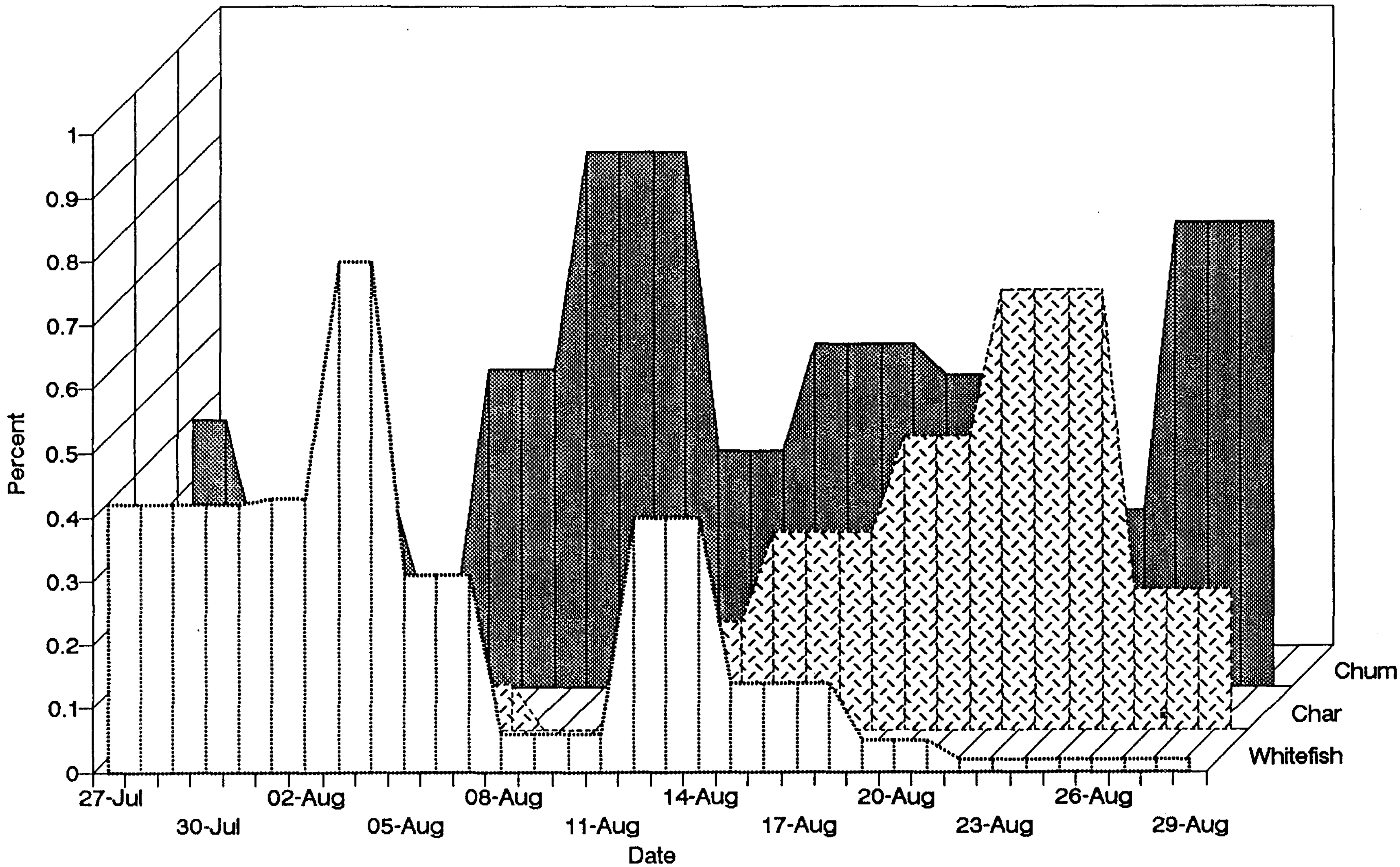

Figure 6. Estimated daily proportions of chum salmon, char, and whitefish from 27 July through 29 August, Noatak River sonar, 1992.

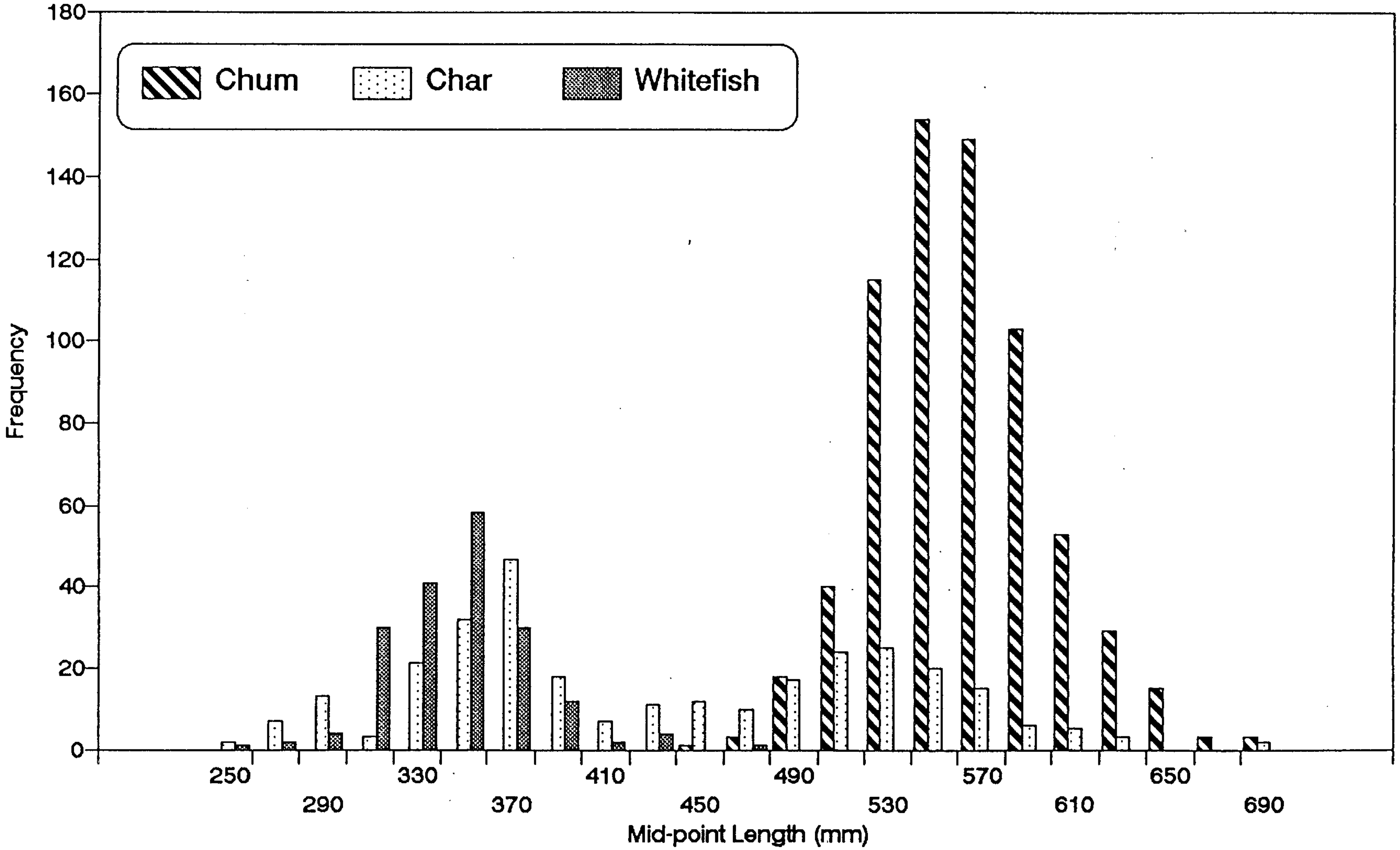

Figure 7. Length distributions of chum salmon, char, and whitefish caught in drift nets at the Noatak River sonar site, 1992.

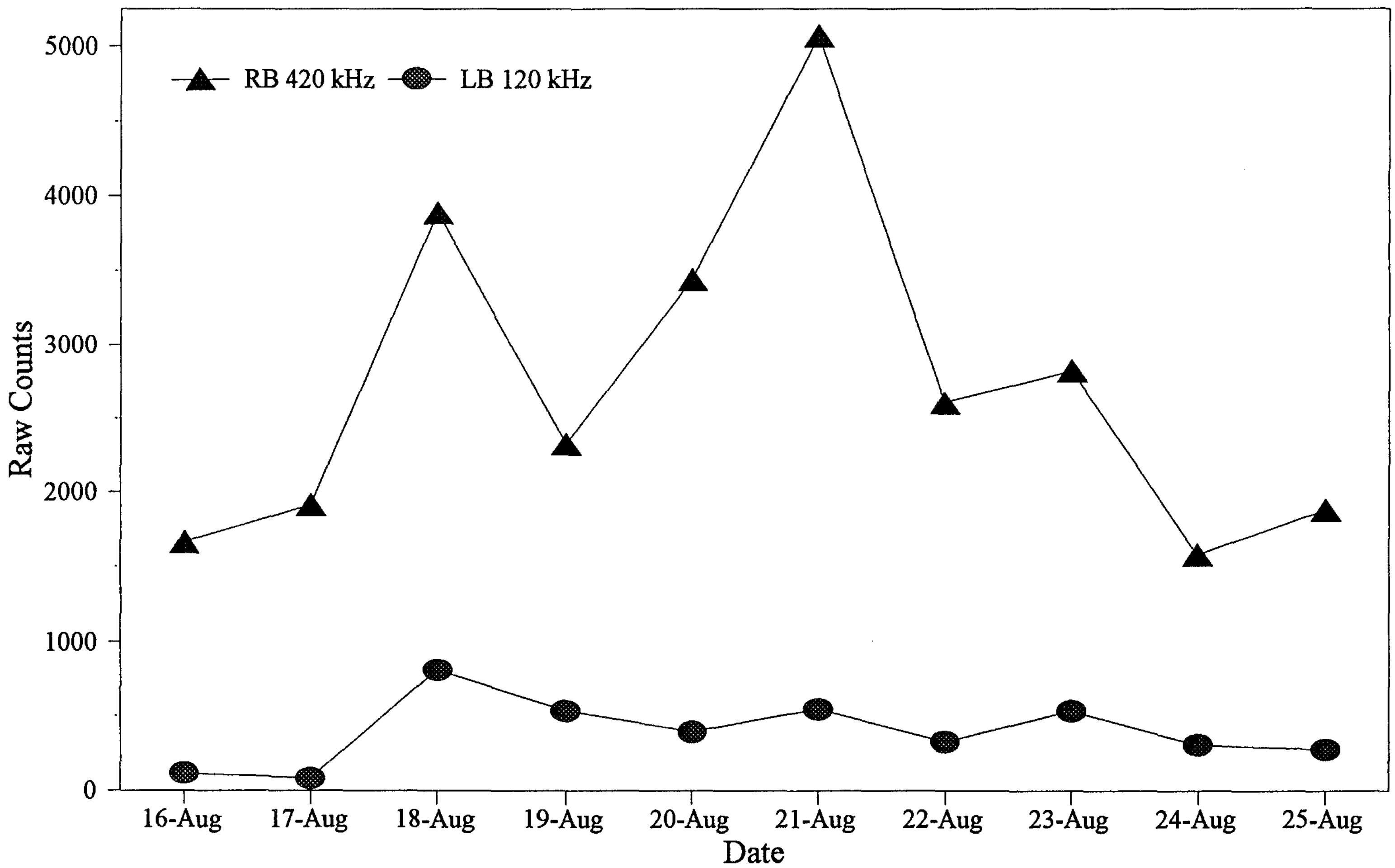

Figure 8. Daily unexpanded fish passage data from the left and right bank of the Noatak River between 16 and 25 August, 1992. Left and right bank operating frequencies were 120 and 420 kHz. Sample times were equal between banks.

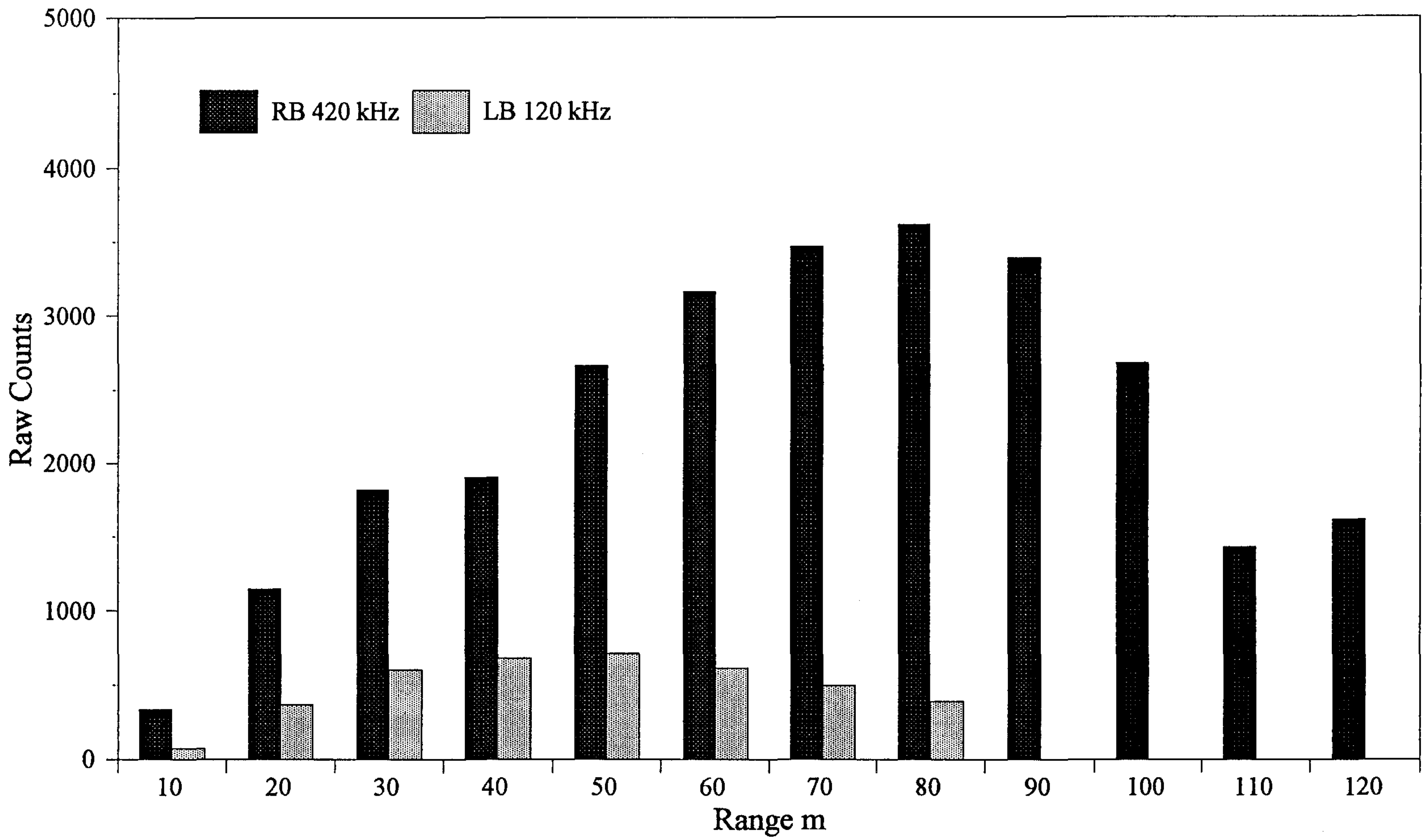

Figure 9. Range distributions of unexpanded fish passage data on the left and right bank of the Noatak River between 16 and 25 August, 1992. Left and right bank operating frequencies were 120 and 420 kHz. Left and right bank maximum ranges were 80 and 120 m. Sample times were equal between banks.

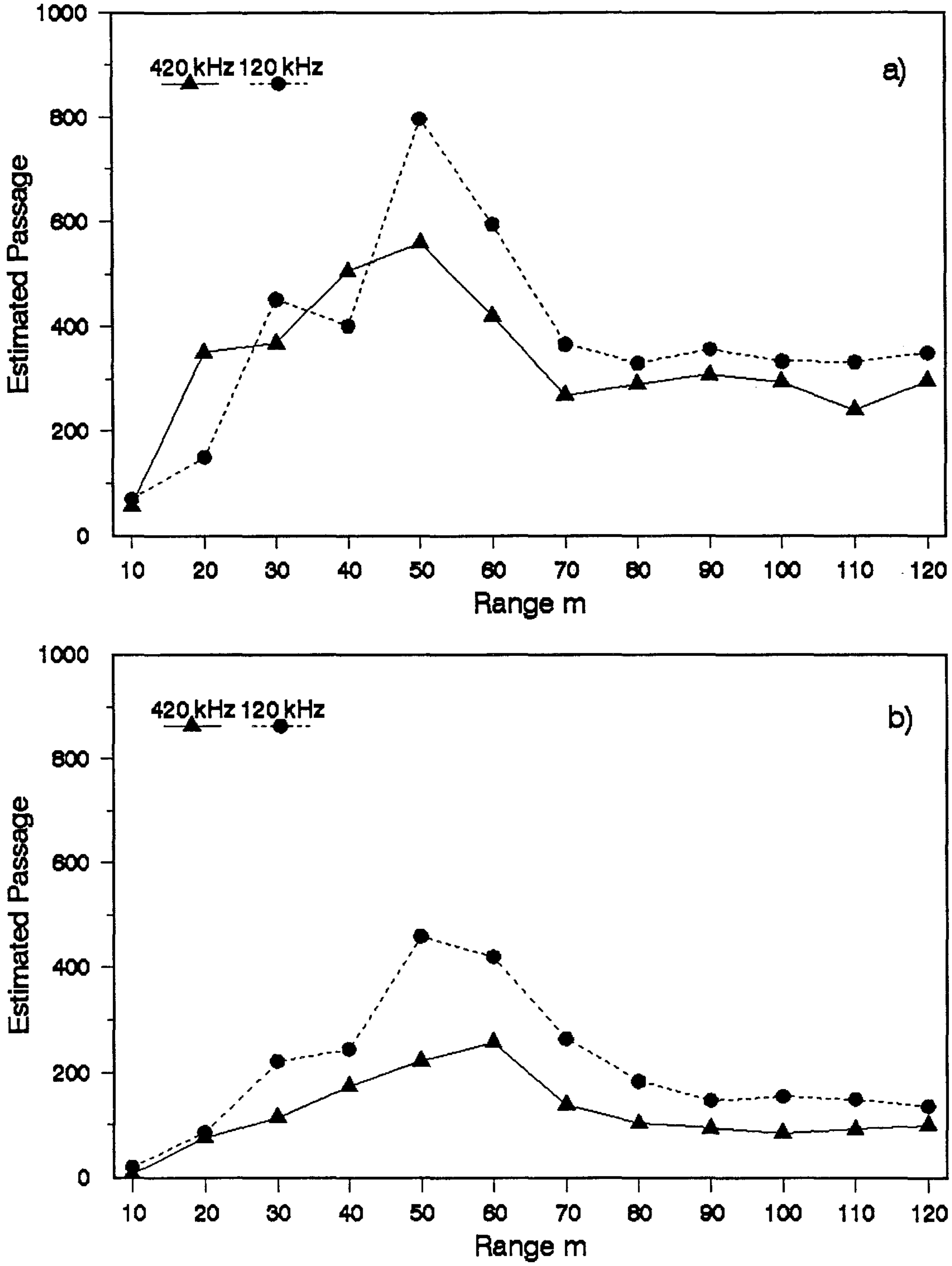

Figure 10. Range distribution of unexpanded fish passage data collected with 420 and 120 kHz sonar on the right bank at the Noatak River sonar site on a) August 12, and b) August 13, 1992.

APPENDIX

Appendix A. Mesh size parameter file used by SAS program to determine relative abundance of fish species present in the Noatak River.

SPECMESH.DAT: sets which meshes will be used (by YUKON1.SAS) to estimate CPUE for each species and also sets which species' catches will be adjusted for net selectivity.

A "1" in the column for a given mesh indicates that fish of that species caught in that mesh will be used to calculate relative CPUE and in turn allocate sonar counts to species.

A "Y" in the ADJUST column will cause the program to adjust catches of that species for net selectivity, a "N" will cause the program to not adjust. Don't change entries in the ADJUST? column.

	2.75	4.0	5.0	5.5	6.0	ADJUST?
CHINOOK	0	0	0	0	1	N
CHUM	0	1	1	0	1	Y
CHAR	1	1	1	0	1	Y
PIKE	0	0	1	0	1	N
PINK	1	1	1	0	0	Y
SHEEFISH	1	1	0	0	0	N
WHITE	1	1	0	0	0	N
FLOUNDER	0	0	1	0	1	N
OTHER	1	1	0	0	0	N
CISCO	1	0	0	0	0	N

Appendix B. Net selectivity parameter file used by SAS program.

N1NSNORM.DAT: these values were generated from 1990 Noatak data by running NOselect.sas on 31 Oct 1990, excluding all fish which were not caught in one of the the following mesh pairs for that species: chum 5.125, 5.875; char 4.625, 5.125; pink 4.0 5.0 (from yukon 86-89 data: gilled fish only). Then selectivity curve means (SCM's) for 1991 mesh sizes were calculated by assuming that SCM's were proportional to the mesh sizes themselves. Standard deviations were assumed to be the same for all mesh sizes within a species. Minimum fish per 2 bins was 5 for chum, 3 for char. Bin size was 20mm for chum, 40mm for char.

CHAR	2.75	275.3	55.4
CHAR	4.0	440.5	55.4
CHAR	5.0	550.7	55.4
CHAR	6.0	660.8	55.4
CHUM	5.0	547.6	60.5
CHUM	6.0	657.1	60.5
PINK	4.0	366.5	50.2
PINK	5.0	458.2	50.2

Appendix C. SAS data processing program.

```
title1 'Noatak Sonar In-Season Data Processing Program, 1991';

*IDENTIFY PATH OF DIRECTORY IN WHICH TO STORE PERMANENT SAS DATA SETS;
libname save '\sassave';

*SET PAGE LENGTH AND WIDTH FOR OUTPUT;
options linesize=79;
options pagesize=60;

*READ IN RAW DATA FROM FILE PRINTED FROM LOTUS 123;
*CALCULATE DURATION OF COUNTS IN HOURS;
*CALCULATE 15 MINUTE PASSAGE ESTIMATE;
data sonarcts;
        infile 'n1counts.prn';
        length counter $3;
        informat startime endtime time5.;
        input month 1 day 3-4 year 6-7 @9 startime @15 endtime@21counter$
        count1 27-29 count2 33-35 count3 39-41 count4 45-47 count5 51-53;
        count=sum(of count1-count5);
        date=mdy(month,day,year);
        hour=hour(startime);
        dstime=dhms(date,hour(startime),minute(startime),0);

detime=dhms(date+DATEPART(ENDTIME),hour(endtime),minute(endtime),0);
        hrsdur=(detime-dstime)/3600;
        hourpsg=count/hrsdur;
        min15psg=hourpsg/4;
        dst2hr=round(dstime,7200);
        dst6hr=round(dstime,21600);
        format startime endtime time5. date date7. dst2hr dst6hr
           datetime10.;
        label hour ='HOUR STARTING AT:' hourpsg='HOURLY PASSAGE';
        run;
*NOTE:  MIN15PSG= ESTIMATED COUNT FOR 15 MINUTES;

data rperiod;
        infile 'rperiod.dat' firstobs=7;
        informat date mmddyy8.;
        input reportno date;  *minrange maxrange;
        run;
```

-Continued-

```
*MERGE REPORT PERIOD INFO WITH THE SONAR DATA FILE;
proc sort data=sonarcts; by date; run;
data sonarcts; merge sonarcts(in=a) rperiod; by date; if a; run;

*OPTIONAL BAR CHARTS OF HOURLY SONAR COUNTS BY DAY;
proc chart data=sonarcts;
        vbar hour / type=mean sumvar=hourpsg discrete;
        by date;
        run;

*CALCULATE MEAN ESTIMATED 15 MIN PASSAGE RATES OVER 2, 6, AND 24 HOUR
PERIODS;
proc summary data=sonarcts;
        var min15psg;
        by dst2hr;
        output out=pass2hr mean=meanpass;
        run;

proc summary data=sonarcts;
        var min15psg;
        by dst6hr;
        output out=pass6hr mean=meanpass;
        run;

proc summary data=sonarcts;
        var min15psg;
        by reportno date;
        output out=pass24hr mean=meanpass;
        run;

*CREATE FILES OF ESTIMATED PASSAGE EVERY 2 AND 6 HOURS FOR CONSTRUCTION OF
GRAPHS IN LOTUS 123;
data print; set pass2hr;
file 'n2hrcts.out';
        sumpass=8*meanpass;
        month=month(datepart(dst2hr));
        year=year(datepart(dst2hr));
        day=day(datepart(dst2hr));
        hour=hour(dst2hr);
        put year month day hour sumpass;
        format sumpass 9.0;
        run;

data print; set pass6hr;
```

-Continued-

```
file 'n6hrcts.out';
        sumpass=24*meanpass;
        year=year(datepart(dst6hr));
        month=month(datepart(dst6hr));
        day=day(datepart(dst6hr));
        hour=hour(dst6hr);
        format sumpass 9.0;
        put year month day hour sumpass;
        run;

title2 'Sonar estimates of daily fish passage';
title3 'beyond 20m range';
data dailypsg; set pass24hr (drop= _type_ _freq_);
        dailypsg=96*meanpass;
        format meanpass 8.1 dailypsg 9.0;
        label  meanpass='MEAN  15  MIN  PASSAGE  RATE'  dailypsg='DAILY
PASSAGE';
        run;
proc print label noobs;
        var reportno date meanpass;
        sum dailypsg;
        run;

proc summary data=dailypsg;
        by reportno;
        var dailypsg;
        output out=reptpasg sum=passage;
        run;
*
*
*THIS CONCLUDES CALCULATIONS FOR THE SONAR DATA, NOW BEGIN TESTFISH DATA
 PROCESSING;
*
*
*


*READ DATA FROM RBASE EXPORT FILE, ONE LINE FOR EACH FISH, PLUS ONE LINE
FOR
 ANY DRIFTS DURING WHICH NO FISH WERE CAUGHT;
*CALCULATE EFFORT IN FATHOM HOURS;
*NOTE THERE IS NO CONTINGENCY FOR DRIFTS SPANNING MIDNIGHT;
data nltfish;
  length qmeth qsex $3;
  length meth sex $1;
```

-Continued-

```
  length species $8;
  infile 'e:\rbfiles\nltfish.dlm' delimiter=',';
*PATH;
  informat date mmddyy.  startout fullout startin fullin time8.;
  format date date7. startout fullout startin fullin time5.;
  input date tfperiod site mesh fathoms qmeth range1 range2
    startout fullout startin fullin spcode qsex length;
  meth=upcase(substr(qmeth,2,1));
  sex=upcase(substr(qsex,2,1));
  drifsecs    =    (startin-fullout)    +    (fullout-startout)/2    +
(fullin-startin)/2;
  fathhrs= fathoms*drifsecs/3600;
  if spcode=0 then catch=0; else catch=1;
  drop qmeth qsex fullout startin fullin drifsecs;
  if spcode = 1 then  species = 'CHINOOK ';
  if spcode = 2 then  species = 'CHUM';
  if spcode = 3 then  species = 'CHAR';
  if spcode = 4 then  species = 'PIKE';
  if spcode = 5 then  species = 'PINK';
  if spcode = 6 then  species = 'SHEEFISH';
  if spcode = 7 then  species = 'WHITE';
  if spcode = 8 then  species = 'FLOUNDER';
  if spcode = 9 then  species = 'OTHER';
  if spcode = 10 then species = 'CISCO';
  if spcode = 0 or spcode = . then species = 'NONE';
  if mesh=2.75 then meshcode=1;
  if mesh=4    then meshcode=2;
  if mesh=5    then meshcode=3;
  if mesh=5.5  then meshcode=4;
  if mesh=6    then meshcode=5;
  run;

*MERGE REPORT PERIOD INFO WITH TESTFISH DATA FILE;
proc sort data=nltfish; by date; run;
data nltfish; merge nltfish(in=a) rperiod; by date; if a; run;

*GENERATE CPUE DATA FOR COMPARISON WITH DOWNRIVER TESTFISH PROJECT;
data tfishrpt; set nltfish;
  if spcode eq 1 then delete;
  if spcode gt 2 then delete;
  if meshcode eq 5 or meshcode eq 3;
  run;

proc sort data=tfishrpt; by mesh date startout;
```

-Continued-

```
proc summary data=tfishrpt;
  var fathhrs catch;
  output out=drifcpue mean(fathhrs)=drifteff sum(catch)=drifctch;
  by mesh date startout; run;

proc summary data=drifcpue;
  var drifteff drifctch;
  output out=daycpue sum=dayeff daycatch;
  by mesh date; run;

data daycpue; set daycpue;
  if dayeff gt 0 then daycpue=daycatch/dayeff;
  else daycpue=0;
  format date date7. dayeff daycpue 7.2 daycatch 7.0;
  label dayeff='FATHOM HOURS' daycatch='NUMBER CAUGHT' daycpue='CPUE';
  run;

title2 'DAILY CHUM SALMON CATCH, EFFORT, AND CPUE, BY MESH';
title3 'no adjustments made for net selectivity';
proc print data=daycpue noobs label;
  var date daycatch dayeff daycpue;
  by mesh;
  run;

*CALCULATE EFFORT PER MESH;
proc sort data=nltfish; by date tfperiod mesh startout species; run;
proc summary data=nltfish;
  var fathhrs; id meth rangel range2;
  output out=drifsets mean(fathhrs)=effort;
  by date tfperiod mesh startout;
  run;

*AND CATCH PER MESH PER SPECIES;
proc summary data=nltfish;
  var catch; id meth rangel range2;
  output out=ds2 sum(catch)=sppcatch;
  by date tfperiod mesh startout species;
  run;

proc sort data=ds2; by date tfperiod mesh startout meth rangel range2;
run;
proc transpose data=ds2 out=tfsummar;
  by date tfperiod mesh startout meth rangel range2;
```

-Continued-

```
  var sppcatch;
  id species;
  run;

data tfsummar; merge tfsummar drifsets; by date tfperiod mesh startout;
        drftmins=effort*60/25;
        run;

data spplist;
        chum=0; char=0; pink=0; white=0; run;

data tfsummar; set tfsummar (in=a drop=_type_ _freq_) spplist;
  if a;
  format date date7. startout time5. effort 8.2;
  label effort='FATHOM HOURS' drftmins='MINUTES DEPLOYED';
  run;

proc sort data=tfsummar; by date meth mesh startout; run;
title2 'SUMMARY OF TESTFISH RESULTS';
title3 'only major species listed';
proc print data=tfsummar label noobs;
  var date tfperiod startout meth mesh;
  sum drftmins chum charr pink white;
  run;

*AND THEN BY SUMMING EFFORT FOR ALL DRIFTS IN A TFPERIOD WITH A GIVEN
MESH;
data drifsets; set drifsets; if meth='D'; run;
proc sort data=drifsets; by date tfperiod mesh; run;
proc summary data=drifsets;
  var effort;
  output out=effortl sum=meffort;  *(MESH EFFORT);
  by date tfperiod mesh;
  run;
*FINALLY, REARRANGE DATA TO PUT EFFORTS FOR ALL MESHES ON A SINGLE LINE;
proc transpose data=effortl out=effort2;
  var meffort; id mesh;
  by date tfperiod;
  run;
data effort; merge effortl effort2; by date tfperiod;
  drop _name_ _type_ _freq_;
  rename _2d75_  =effortl;
  rename _4      =effort2;
```

-Continued-

```
  rename _5      =effort3;
  rename _5d5    =effort4;
  rename _6      =effort5;
  format date date7.;
  run;

*READ IN AN EXTERNAL FILE WHICH SETS WHICH MESHES WILL BE USED TO ESTIMATE
 CPUE FOR EACH SPECIES, AND WHICH SPECIES CATCHES WILL BE ADJUSTED FOR NET
 SELECTIVITY;
data specmesh;
  infile 'nlspmesh.dat' firstobs=17;                              *PATH;
  length species $ 8;
  length adjust $ 3;
  input species usemesh1-usemesh5 adjust;
  run;

*READ NET SELECTIVITY CURVE PARAMETERS (MEAN, STD) FROM AN EXTERNAL FILE;
*REARRANGE NET SELECTIVITY DATA SO THAT ALL THE INFORMATION FOR EACH
SPECIES
 IS LOCATED ON EACH LINE;
data nsnormal;
  infile 'nlnsnorm.dat' firstobs=10;                              *PATH;
  input species $ mesh selmean stddev;
  run;
proc transpose data=nsnormal out=sm;
  var selmean; id mesh;
  by species; run;
data sm; set sm;
  drop _name_;
  rename _2d75   =sm1;
  rename _4      =sm2;
  rename _5      =sm3;
  rename _5d5    =sm4;
  rename _6      =sm5;
  run;
proc transpose data=nsnormal out=std;
  var stddev; id mesh;
  by species; run;
data std; set std;
  drop _name_;
```

-Continued-

```
  rename _2d75   =std1;
  rename _4      =std2;
  rename _5      =std3;
  rename _5d5    =std4;
  rename _6      =std5;
  run;
data nsnormal; merge nsnormal sm std; by species; run;

*MERGE SPECIES-MESH PAIRING DATA INTO TESTFISH DATA SET;
*DELETE FISH WHICH WERE NOT CAUGHT IN MESHES TARGETING THAT SPECIES;
proc sort data=nltfish; by species; run;
proc sort data=specmesh; by species; run;
data tfsm;
  merge nltfish(in=a) specmesh;
  by species;
  if a;
  array usemesh{5} usemesh1-usemesh5;
  if usemesh{meshcode}=0 then delete;
  run;

/*proc datasets library=work; delete testfish; run;*/

*MERGE NET SELECTIVITY CURVE DATA INTO TESTFISH (+SM) DATA SET;
proc sort data=tfsm; by species mesh; run;
data tfsmns; merge tfsm(in=b) nsnormal; by species mesh;
  if b;
  run;

/*proc datasets library=work; delete tfsm; run;*/

*MERGE EFFORT DATA INTO TESTFISH (+SM+NS) DATA SET;
*DECLARE ARRAYS;
data tfsmns; set tfsmns; drop fathhrs; run;
proc sort data=tfsmns; by date tfperiod mesh; run;
data tfsmnsef; merge tfsmns(in=c) effort; by date tfperiod mesh;
  if meth='D';
  if c;
  if length=0 then length=selmean;
  array usemesh{5} usemesh1-usemesh5;
  array sm{5} sm1-sm5;
  array zother{5} zother1-zother5;
  array std{5} std1-std5;
  array effort{5} effort1-effort5;
  *FOR MAJOR SPECIES, ADJUST CATCH (I.E., 1 FISH) FOR NET
```

-Continued-

```
SELECTIVITY;
  *IF FISH WAS VERY UNLIKELY TO HAVE BEEN CAUGHT IN THIS MESH,
   THEN DO NOT INCLUDE IT;
  zcutoff=1.66;
  meanpdf=(probnorm(zcutoff)-0.5)/zcutoff;
  adjcatch=0.399/meanpdf;
  if adjust='Y' then do;
    z=(length-selmean)/stddev;
    if  abs(z)<zcutoff then do;
      pdf=(1/sqrt(2*3.141592654))*exp(-z**2/2);
      adjcatch = 0.399 / pdf;
      end;
    else adjcatch=0;
    end;
  *THEN SUM EFFORT FOR ALL MESHES TARGETING THIS SPECIES DURING THIS TF
PERIOD;

  *IF SPECIES IS ADJUSTED FOR NET SELECTIVITY, THEN DO NOT CONSIDER THOSE
   MESHES IN WHICH THIS LENGTH FISH IS EXTREMELY UNLIKELY TO HAVE BEEN
   CAUGHT;
  *FINALLY, CALCULATE ADJUSTED CPUE FOR EACH FISH;
  sumeff=0;
  do imesh=1 to 5;
    if adjust='Y' then do;
      zother{imesh}=(length-sm{imesh})/std{imesh};
      if abs(zother{imesh})>zcutoff then usemesh{imesh}=0;
      end;
    if effort{imesh}=. then effort{imesh}=0;
    sumeff=sumeff+effort{imesh}*usemesh{imesh};
    end;
  adjcpue=adjcatch/sumeff;
  format date date7. startout time5.
    z zother1-zother5 5.2 meffort effort1-effort5 sumeff adjcatch 4.1;
  run;

/*proc datasets library=work; delete tfsmns; run;*/

*OPTIONAL PRINTOUT FOLLOWS: SHOWS INTERMEDIARY CALCULATIONS ON TESTFISH
DATA;
options linesize=120;
data print; set tfsmnsef;
title2 'PART OF DATA SET TFSMNSEF';
```

-Continued-

```
title3 'ONE LINE PER FISH, EACH LINE ALSO HAS INFORMATION ON NET
SELECTIVITY';
title4 'CURVE PARAMETERS AND EFFORT FOR EACH MESH DRIFTED DURING THAT
PERIOD';
  run;
  proc print data=print;
  var date startout mesh species length
      z pdf adjcatch meffort
      zother1 zother2 zother3 zother5 sumeff adjcpue;
  run;

*SUM ADJUSTED CPUE FOR EACH SPECIES DURING EACH TESTFISH PERIOD;
proc sort data=tfsmnsef; by reportno date tfperiod spcode;
proc summary data=tfsmnsef;
  var adjcpue adjcatch; id startout species;
  output out=spcpue sum=spcpue spcatch;
  by reportno date tfperiod spcode;
  run;

*TRANSPOSE BY ALL BUT SPECIES (CODE), CREATING A SEPARATE VARIABLE FOR
CPUE OF
 EACH SPECIES;
proc transpose data=spcpue out=spcpwide;
  by reportno date tfperiod;
  var spcpue;
  id spcode;
  run;

proc summary data=spcpue;
  by reportno date tfperiod;
  var spcatch startout;
  output out=catch sum(spcatch)=adjcatch mean(startout)=avestart;
  run;

*SUM CPUE'S FOR ALL SPECIES DURING A GIVEN TESTFISH PERIOD;
data spcpwide; merge spcpwide catch; by reportno date tfperiod;
  array cpue{10} _1-_10;
  sumcpue=0;
  do i=1 to 10;
    if cpue{i} = . then cpue{i} = 0;
    sumcpue= sumcpue + cpue{i};
    end;
  format date date7. avestart time5. _1-_10 adjcatch sumcpue 6.2;
  run;
```

-Continued-

```
/*
*OPTIONAL PRINTOUT FOLLOWS;
title2 'INTERMEDIARY DATA SET WORK.SPCPWIDE: CPUE BY SPECIES CODES'; run;
proc print data=spcpwide noobs label;
  var reportno date tfperiod adjcatch _1-_10 sumcpue;
  run;
*/
/*
*CREATE OPTIONAL BAR CHART OF SPECIES CPUE BY TESTFISH PERIOD;
data chartcp; merge spcpue catch; by reportno date tfperiod;
  datetime=dhms(date,hour(avestart),minute(avestart),0);
  format datetime datetime10.;
  label datetime='DATE AND HOUR';
  if spcode<2 or spcode=4 or spcode=6 or spcode>7 then delete;
  run;
title2 'TESTFISH CPUE, BY SPECIES, IN ALL TESTFISH PERIODS';
proc chart data=chartcp;
  vbar datetime / sumvar=spcpue subgroup=species discrete;
  run;
*/
*SUM CPUE, FOR EACH SPECIES AND FOR ALL SPECIES, ACROSS ALL TESTFISH
PERIODS
 WITHIN EACH REPORTING PERIOD;
*CALCULATE THE AVERAGE TOTAL (ALL SPECIES) CPUE IN EACH REPORT PERIOD;
*COUNT THE NUMBER OF TESTFISH PERIODS IN EACH REPORT PERIOD;
proc sort data=spcpwide; by reportno; run;
proc summary data=spcpwide;
  var _1-_10 sumcpue;
  output out=rncpue sum=rnspcp1-rnspcp10 rnsmcp
                    mean(sumcpue)=rnmncp
                    n=n;
  by reportno;
  run;

*MERGE THE ORIGINAL DATA SET WITH THE SUMMARIZED DATA SET, THEN CALCULATE:
 ESTIMATED PROPORTION OF EACH SPECIES DURING EACH TESTFISH PERIOD,
 ESTIMATED PROPORTION OF EACH SPECIES DURING EACH REPORT PERIOD,
 AND A WEIGHTED SQUARED DEVIATION OF THE TESTFISH PERIOD PROPORTION FROM
 THE REPORT PERIOD PROPORTION;
data varcalc;
```

-Continued-

```
  merge spcpwide rncpue;
  by reportno;
  array cpue{10} _1-_10;
  array rnspcp{10} rnspcp1-rnspcp10;
  array phatpr{10} phatpr1-phatpr10;
  array phatrp{10} phatrp1-phatrp10;
  array sqrdev{10} sqrdev1-sqrdev10;
  weight=sumcpue/rnmncp;
  do i=1 to 10;
    phatpr{i}=cpue{i}/sumcpue;
    phatrp{i}=rnspcp{i}/rnsmcp;
    sqrdev{i}=(weight**2)*(phatpr{i}-phatrp{i})**2;
    end;
  label phatpr1='CHINOOK' phatpr2='CHUM' phatpr3='CHAR' phatpr4='PIKE'
  phatpr5='PINK' phatpr6='SHEEFISH' phatpr7='WHITE' phatpr8='FLOUNDER'
  phatpr9='OTHER' phatpr10='CISCO';
  format phatpr1-phatpr10 3.2;
  format adjcatch 5.0;
  format date date7. avestart time5.;
  run;

*OPTIONAL PRINTOUT OF SPECIES PROPORTIONS BY TESTFISH PERIOD;
proc sort data=varcalc; by reportno date tfperiod;
title2 'ESTIMATED SPECIES PROPORTIONS AND TOTAL ADJUSTED CATCH BY TESTFISH
PERIOD';
run;
proc print label data=varcalc;
  var reportno date adjcatch
      phatpr1 phatpr2 phatpr3 phatpr4 phatpr5
      phatpr6 phatpr7 phatpr8 phatpr9 phatpr10;
  run;

*SUM THE SQUARED DEVIATIONS BY REPORT PERIOD;
proc sort data=varcalc; by reportno; run;
proc summary data=varcalc;
  var sqrdev1-sqrdev10 adjcatch;
  id phatrp1-phatrp10 n date;
  output out=varprop sum=smsqdv1-smsqdv10 adjcatch;
  by reportno;
  run;

*AND CALCULATE THE VARIANCE OF THE REPORT PERIOD PROPORTION (COCHRAN
1977);
```

-Continued-

```
data varprop; set varprop (drop = _type_ _freq_);
  phatoth=phatrp1+phatrp4+phatrp6+phatrp8+phatrp10+phatrp9;
  format phatrp1-phatrp10 phatoth stdprp1-stdprp10 3.2;
  format adjcatch 4.0 date date7.;
  label phatrp1='CHINOOK' phatrp2='CHUM' phatrp3='CHAR' phatrp4='PIKE'
      phatrp5='PINK' phatrp6='SHEEFISH' phatrp7='WHITE' phatrp8='FLOUNDER'
      phatrp9='OTHER' phatrp10='CISCO' phatoth='OTHER';
  label stdprp2='CHUM S.E.' stdprp3='CHAR S.E.' stdprp5='PINK S.E.'
      stdprp7='WHITE S.E.';
  array varprp{10} varprp1-varprp10;
  array smsqdv{10} smsqdv1-smsqdv10;
  array stdprp{10} stdprp1-stdprp10;
  array cvprop{10} cvprop1-cvprop10;
  array phatrp{10} phatrp1-phatrp10;
  do i = 1 to 10;
    varprp{i}=smsqdv{i}/(n*(n-1));
    stdprp{i}=sqrt(varprp{i});
    if phatrp{i} gt 0 then cvprop{i}=stdprp{i}/phatrp{i};
    else cvprop{i}=0;
    end;
  run;

title2 'ESTIMATED SPECIES PROPORTIONS AND STANDARD ERRORS';
title3 'BY REPORT PERIOD';
title4 'major species only';
proc print label data=varprop noobs;
  var reportno date adjcatch phatrp2 phatrp3 phatrp5 phatrp7 phatoth
                             stdprp2 stdprp3 stdprp5 stdprp7;
  run;

*
*
*NOW MERGE DATA SET CONTAINING COUNTS WITH DATA SET CONTAINING
PROPORTIONS,
 AND CALCULATE SPECIES PASSAGE ESTIMATES AND THEIR ESTIMATED VARIANCE;
*
*;

data reptstat;
  merge varprop reptpasg;
```

-Continued-

```
  by reportno;
  array phatrp{10} phatrp1-phatrp10;
  array varpsg{10} varpsg1-varpsg10;
  array varprp{10} varprp1-varprp10;
  array psg{10} psg1-psg10;
  do i=1 to 10;
    psg{i}=phatrp{i}*passage;
    varpsg{i}=(passage**2)*varprp{i};
    end;
  format passage psg1-psg10 8. varprp1-varprp10
         varpsg1-varpsg10 e9. phatrp1-phatrp10 5.3;
  run;


*OPTIONAL PRINTOUT FOLLOWS;
/*
title2 'Dataset reptstat';
proc print data=reptstat label;
  var reportno date passage phatrp1-phatrp10
      varprp1-varprp10 psg1-psg10 varpsg1-varpsg10;
  run;
*/

data reptstat; set reptstat (drop = _type_ _freq_);
*  file 'n1repsht.dat';                                      *PATH;
  label reportno='REPORTING PERIOD' date='ENDING ON';
  label psg1='CHINOOK' psg2='CHUM' psg3='CHAR' psg4='PIKE' psg5='PINK'
      psg6='SHEEFISH'    psg7='WHITE'    psg8='FLOUNDER'    psg9='OTHER'
psg10='CISCO';
  format psg1-psg10 7. varpsg1-varpsg10 e9.;
*  put reportno date psg1-psg10 / varpsg1-varpsg10;
  run;

title2 'ESTIMATED FISH SPECIES PASSAGE BY REPORTING PERIOD';
proc print label noobs data=reptstat;
  var reportno date;
  sum psg2 psg3 psg5 psg7 psg1 psg4 psg6 psg8 psg10 psg9;
  run;

proc summary data=reptstat;
  var psg1-psg10 varpsg1-varpsg10 date;
  output out=cumstat sum(psg1-psg10)=cumpsg1-cumpsg10
                     sum(varpsg1-varpsg10)=varcp1-varcp10
```

-Continued-

```
                     max(date)=enddate;
  run;

data cumstat; set cumstat (drop=_type_);
  rename _freq_=nreports;
  run;

proc transpose data=cumstat out=cs1;
  by nreports;
  var cumpsg1-cumpsg10; run;
data cs1; set cs1;
  label col1='PASSAGE TO DATE';
  rename col1=cumulpsg;
  length species $ 11;
  if _name_ = 'CUMPSG1 ' then  species = ' 9 CHINOOK ';
  if _name_ = 'CUMPSG2 ' then  species = ' 1 CHUM';
  if _name_ = 'CUMPSG3 ' then  species = ' 2 CHAR';
  if _name_ = 'CUMPSG4 ' then  species = ' 8 PIKE';
  if _name_ = 'CUMPSG5 ' then  species = ' 3 PINK';
  if _name_ = 'CUMPSG6 ' then  species = ' 6 SHEEFISH';
  if _name_ = 'CUMPSG7 ' then  species = ' 4 WHITE';
  if _name_ = 'CUMPSG8 ' then  species = ' 7 FLOUNDER';
  if _name_ = 'CUMPSG9 ' then  species = '10 OTHER';
  if _name_ = 'CUMPSG10' then  species = ' 5 CISCO';
  drop _name_;
  run;

proc transpose data=cumstat out=cs2;
  var varcp1-varcp10; run;
data cs2; set cs2;
  rename col1=variance;
  run;

data cumstat2; merge cs1 cs2;
  stderr=sqrt(variance);
  cv=stderr/cumulpsg;
  format cumulpsg 8. variance e10. stderr 7. cv 4.3;
  label nreports='REPORTS TO DATE'
    stderr='ESTIMATED STANDARD ERROR' cv='COEFFICIENT OF VARIATION';
  run;

proc sort data=cumstat2; by species; run;
title2 'CUMULATIVE STATISTICS BY SPECIES';
proc print noobs label;
  var nreports species cumulpsg stderr cv;
  run;
```

Appendix D. Summary of set gillnet test fishing results from 27 July through 14 August, Noatak River sonar, 1992.

Mon	Day	Mesh[a]	Mins[b] Out	Fath[c] Hrs	Number Caught Chum	Char	Pink	White	Other
Jul	27	4	258.53	51.71	*	*	5	5	11
Jul	30	6	298.63	59.72	1	*	2	*	*
Aug	2	5	272.19	54.44	9	9	5	*	1
Aug	5	6	300.00	60.00	6	*	*	*	1
Aug	8	4	300.00	60.00	1	*	5	3	7
Aug	11	6	280.00	56.00	21	*	2	*	*
Aug	14	5	107.00	21.40	*	1	1	*	1
			=======	======	===	===	===	===	===
			1816.35	363.27	38	10	20	8	21

(a) Gillnet stretched mesh (in inches).

(b) Total minutes net deployed.

(c) Area of net in square fathoms X hours deployed.

Appendix E. Summary of drift gillnet test fishing results from 27 July through 29 August, Noatak River sonar, 1992.

Mon	Day	Mesh[a]	Strt[b] Rng	Mins[c] Out	Fath[d] Hrs	Number Caught Chum	Char	White	Pink
Jul	27	6	25	11.08	4.62	1	.	.	1
Jul	27	5	25	11.00	4.58	2	.	.	2
Jul	27	2.75	25	11.17	4.65	.	.	1	.
Jul	27	2.75	25	11.28	4.70	.	.	2	.
Jul	27	4	25	11.04	4.60	.	1	.	.
Jul	27	6	25	11.08	4.61	4	.	.	1
Jul	28	6	25	13.08	5.45	.	.	.	1
Jul	28	4	25	13.00	5.42	.	.	1	.
Jul	28	2.75	25	13.08	5.45	.	.	2	.
Jul	28	2.75	25	13.08	5.45	.	.	2	.
Jul	28	5	25	13.00	5.42	2	.	.	1
Jul	28	6	25	12.83	5.35	.	.	.	.
Jul	29	6	25	16.25	6.77	.	.	.	.
Jul	29	4	25	16.08	6.70	.	.	.	3
Jul	29	2.75	25	15.92	6.63	.	.	6	.
Jul	29	2.75	25	16.08	6.70	.	.	2	.
Jul	29	5	25	15.83	6.60	.	.	.	1
Jul	29	6	25	16.17	6.74	6	.	.	.
Jul	30	6	25	15.75	6.56	2	.	.	.
Jul	30	4	25	15.67	6.53	.	1	.	2
Jul	30	2.75	25	16.08	6.70	.	.	.	.
Jul	30	2.75	25	16.08	6.70	.	.	2	.
Jul	30	5	25	15.92	6.63	.	.	.	.
Jul	30	6	25	15.50	6.46	.	1	.	.
Jul	31	6	25	14.08	5.87	4	.	.	.
Jul	31	4	25	13.25	5.52	.	5	1	.
Jul	31	2.75	25	13.17	5.49	.	.	4	.
Jul	31	2.75	25	12.92	5.38	.	.	1	.
Jul	31	5	25	13.00	5.42	.	.	.	1
Jul	31	6	25	12.92	5.38	2	.	.	.
Aug	1	6	25	12.92	5.38	1	.	.	.
Aug	1	4	25	13.08	5.45	.	5	.	1
Aug	1	2.75	25	12.92	5.38	.	.	13	.
Aug	1	2.75	25	13.17	5.49	.	.	1	.
Aug	1	5	25	12.92	5.38	.	.	.	.
Aug	1	6	25	12.83	5.35	.	.	.	.
Aug	2	6	25	16.08	6.70	12	.	.	.
Aug	2	5	25	16.03	6.68	1	.	.	.
Aug	2	2.75	25	16.24	6.77	.	.	6	.
Aug	2	2.75	25	13.20	5.50	.	.	.	.
Aug	2	4	25	12.88	5.37	.	.	.	.
Aug	2	6	25	13.13	5.47	9	.	.	.

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Appendix E. (page 2 of 5)

Mon	Day	Mesh	Strt Rng	Mins Out	Fath Hrs	Number Caught Chum	Char	White	Pink
Aug	3	6	3	15.83	6.60	2	.	.	.
Aug	3	4	3	15.83	6.60	.	.	.	1
Aug	3	2.75	3	15.92	6.63	.	.	12	.
Aug	3	2.75	3	13.75	5.73	.	.	12	.
Aug	3	5	3	13.00	5.42	.	.	.	.
Aug	3	6	3	12.92	5.38	5	.	.	.
Aug	4	6	3	15.83	6.60	2	.	.	.
Aug	4	5	3	15.75	6.56	.	1	.	1
Aug	4	2.75	3	16.08	6.70	.	.	8	.
Aug	4	2.75	3	16.00	6.67	.	.	15	.
Aug	4	4	3	15.92	6.63	2	.	2	2
Aug	4	6	3	16.17	6.74	3	.	.	.
Aug	5	6	3	13.00	5.42	10	.	.	.
Aug	5	4	3	12.92	5.38	1	2	.	3
Aug	5	2.75	3	13.08	5.45	.	.	11	.
Aug	5	5	3	13.17	5.49	4	.	.	1
Aug	5	6	3	13.08	5.45	9	.	.	.
Aug	6	6	3	13.33	5.56	7	.	.	1
Aug	6	5	3	13.00	5.42	7	2	.	1
Aug	6	2.75	3	13.33	5.56	.	.	11	.
Aug	6	2.75	3	13.50	5.63	.	2	6	.
Aug	6	4	3	12.75	5.31	3	2	.	7
Aug	6	6	3	12.83	5.35	14	.	.	2
Aug	7	6	3	13.17	5.49	1	.	.	.
Aug	7	4	3	10.75	4.48	.	.	.	.
Aug	7	2.75	3	12.83	5.35	.	.	1	1
Aug	7	2.75	15	13.17	5.49	.	.	.	.
Aug	7	5	15	12.75	5.31	.	.	.	.
Aug	7	6	15	12.75	5.31	10	.	.	.
Aug	8	6	15	12.75	5.31	5	.	.	.
Aug	8	5	15	13.33	5.56	12	.	.	.
Aug	8	2.75	15	13.17	5.49	.	.	.	.
Aug	8	2.75	15	13.00	5.42	.	.	.	.
Aug	8	4	15	12.67	5.28	.	.	.	2
Aug	8	6	15	12.92	5.38	11	.	.	.
Aug	9	6	15	16.58	6.91	5	.	.	.
Aug	9	4	15	6.18	2.57	1	.	.	1
Aug	9	2.75	15	11.10	4.63	.	.	.	.
Aug	9	2.75	15	11.05	4.60	.	.	1	.
Aug	9	5	15	11.06	4.61	1	.	.	.
Aug	9	6	15	11.09	4.62	8	.	.	.
Aug	10	6	15	10.67	4.44	3	.	.	.

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Mon	Day	Mesh	Strt Rng	Mins Out	Fath Hrs	Number Caught Chum	Char	White	Pink
Aug	10	5	15	11.17	4.65	.	.	.	.
Aug	10	2.75	15	11.25	4.69	.	.	.	.
Aug	10	2.75	15	11.00	4.58	.	.	.	.
Aug	10	4	15	10.75	4.48	.	.	.	.
Aug	10	6	15	11.00	4.58	.	.	.	.
Aug	11	6	20	11.25	4.69	13	.	.	.
Aug	11	4	20	11.17	4.65	.	.	.	1
Aug	11	2.75	20	11.08	4.62	.	.	.	.
Aug	11	2.75	3	11.30	4.71	.	.	1	.
Aug	11	5	3	11.00	4.58	.	.	.	.
Aug	11	6	3	10.83	4.51	.	.	.	.
Aug	12	6	3	10.83	4.51	4	.	.	1
Aug	12	5	3	10.83	4.51	.	.	.	1
Aug	12	2.75	3	11.33	4.72	.	.	10	.
Aug	12	2.75	3	9.00	3.75	.	.	2	.
Aug	12	4	3	11.00	4.58	.	3	4	.
Aug	12	6	3	11.17	4.65	7	.	.	.
Aug	13	6	15	11.25	4.69	17	1	.	.
Aug	13	4	15	11.08	4.62	.	2	3	1
Aug	13	2.75	15	11.33	4.72	1	.	.	.
Aug	13	2.75	15	11.08	4.62	1	1	2	.
Aug	13	5	15	10.75	4.48	2	1	.	1
Aug	13	6	15	10.67	4.44	1	2	.	.
Aug	14	6	3	10.83	4.51	6	1	.	.
Aug	14	5	3	11.00	4.58	2	1	.	.
Aug	14	2.75	3	11.58	4.83	1	1	2	.
Aug	14	2.75	3	11.33	4.72	.	1	1	.
Aug	14	4	3	10.67	4.44	.	.	2	.
Aug	14	6	3	11.17	4.65	2	.	.	.
Aug	15	6	15	7.92	3.30	8	.	.	.
Aug	15	5	15	8.08	3.37	.	1	.	1
Aug	15	4	15	7.83	3.26	.	.	.	.
Aug	15	2.75	15	8.08	3.37	.	.	.	.
Aug	16	6	15	11.05	4.60	15	1	.	.
Aug	16	5	15	11.08	4.62	7	10	1	1
Aug	16	2.75	15	11.20	4.67	.	.	1	.
Aug	16	2.75	15	11.33	4.72	.	2	.	.
Aug	16	4	15	11.01	4.59	1	5	.	.
Aug	16	6	15	10.95	4.56	12	1	.	.
Aug	17	6	20	11.00	4.58	18	.	.	.
Aug	17	4	20	11.00	4.58	.	1	.	.
Aug	17	2.75	20	11.08	4.62	.	.	5	.

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Mon	Day	Mesh	Strt Rng	Mins Out	Fath Hrs	Chum	Number Caught Char	White	Pink
Aug	17	2.75	15	11.25	4.69	.	6	8	.
Aug	17	5	15	10.67	4.44	9	7	.	.
Aug	17	6	15	10.75	4.48	7	2	.	.
Aug	18	6	15	11.08	4.62	14	.	.	.
Aug	18	5	15	10.92	4.55	10	9	.	.
Aug	18	2.75	15	11.25	4.69	.	1	4	.
Aug	18	2.75	15	10.83	4.51	.	2	1	.
Aug	18	4	15	10.67	4.44	.	5	1	.
Aug	18	6	15	11.25	4.69	21	.	.	.
Aug	19	6	15	10.58	4.41	29	4	.	.
Aug	19	4	15	10.75	4.48	2	8	.	1
Aug	19	2.75	15	11.42	4.76	.	1	2	.
Aug	19	2.75	15	11.33	4.72	.	2	.	.
Aug	19	5	15	11.17	4.65	6	1	.	.
Aug	19	6	15	11.08	4.62	20	.	.	.
Aug	20	6	20	10.83	4.51	19	10	.	.
Aug	20	5	20	8.08	3.37	6	2	.	.
Aug	20	2.75	20	8.25	3.44	.	4	2	.
Aug	20	2.75	20	8.08	3.37	.	15	.	.
Aug	20	4	20	8.08	3.37	2	11	.	.
Aug	20	6	20	7.92	3.30	13	.	.	.
Aug	21	6	10	8.17	3.40	20	2	.	1
Aug	21	4	10	8.08	3.37	2	12	.	.
Aug	21	2.75	10	8.00	3.33	1	3	3	.
Aug	21	2.75	10	8.08	3.37	.	7	2	.
Aug	21	5	10	7.75	3.23	17	4	.	.
Aug	21	6	10	5.75	2.40	5	1	.	.
Aug	22	6	10	8.17	3.40	8	4	.	.
Aug	22	5	10	7.92	3.30	8	3	.	.
Aug	22	2.75	10	7.75	3.23	.	12	1	.
Aug	22	2.75	10	7.83	3.26	.	30	.	.
Aug	22	4	10	7.67	3.19	1	13	.	2
Aug	22	6	10	8.17	3.40	1	.	.	.
Aug	23	6	10	8.13	3.39	17	6	.	.
Aug	23	4	10	7.95	3.31	1	5	.	.
Aug	23	2.75	10	8.05	3.35	.	4	.	.
Aug	24	6	10	8.08	3.37	8	.	.	.
Aug	24	5	10	8.08	3.37	1	.	.	.
Aug	24	2.75	10	7.83	3.26	.	.	.	.
Aug	24	2.75	10	8.00	3.33	.	1	2	.
Aug	24	4	10	7.83	3.26	.	1	.	.
Aug	24	6	10	7.67	3.19	10	1	.	.

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Mon	Day	Mesh	Strt Rng	Mins Out	Fath Hrs	Chum	Number Caught Char	White	Pink
Aug	25	6	10	8.08	3.37	8	5	.	.
Aug	25	4	10	7.92	3.30	1	1	.	.
Aug	25	2.75	10	8.17	3.40	.	.	.	.
Aug	25	2.75	10	8.08	3.36	.	4	.	.
Aug	25	5	10	7.92	3.30	6	3	.	.
Aug	25	6	10	7.67	3.19	15	.	.	.
Aug	26	6	10	7.92	3.30	4	.	.	.
Aug	26	5	10	7.75	3.23	.	1	.	.
Aug	26	2.75	10	7.83	3.26	.	.	1	.
Aug	26	2.75	10	11.08	4.62	.	6	.	.
Aug	26	4	10	10.92	4.55	1	1	.	.
Aug	26	6	10	10.75	4.48	15	.	.	.
Aug	27	6	15	6.67	2.78	28	.	.	.
Aug	27	4	15	7.83	3.26	4	1	.	.
Aug	27	2.75	15	8.58	3.58	1	1	.	.
Aug	27	2.75	15	8.00	3.33	.	1	.	.
Aug	27	5	15	5.92	2.47	21	1	.	.
Aug	27	6	15	7.92	3.30	2	.	.	.
Aug	28	6	20	5.92	2.47	25	1	.	.
Aug	28	5	20	3.75	1.56	2	.	.	.
Aug	28	2.75	20	6.25	2.60	.	.	.	.
Aug	28	2.75	20	6.42	2.67	.	3	.	.
Aug	28	4	20	5.92	2.47	3	1	1	1
Aug	28	6	20	6.00	2.50	.	.	.	.
Aug	29	6	20	5.83	2.43	.	.	.	.
Aug	29	4	20	6.25	2.60	.	.	.	.
Aug	29	2.75	20	6.25	2.60	.	.	.	.
Aug	29	2.75	20	8.17	3.40	.	13	.	.
Aug	29	5	20	8.08	3.37	2	1	.	1
Aug	29	6	20	8.17	3.40	.	.	.	.
				====	====	====	====	====	====
				2196	915	686	300	185	50

(a) Gillnet stretched mesh (in inches).

(b) Nearshore starting range of net deploynment.

(c) Total minutes net deployed.

(d) Area of net in square fathoms X hours deployed.