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# NOATAK RIVER SONAR 1990 PROGRESS REPORT

by

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## INTRODUCTION

Noatak River chum salmon (*Oncorhynchus keta*) and arctic char (*Salvelinus alpinus*) support commercial and subsistence harvests in Kotzebue Sound and the lower Noatak River. Effective management of the fisheries resource requires knowledge of wild stock escapement. Two indices of escapement are currently available: catch per unit effort (CPUE) data from a test-netting project near the river mouth, and results from aerial surveys of clear-water spawning areas. Silty water and the wide, multi-channel river mouth preclude visual counts of migrating fish.

This project was designed to assess the feasibility of using hydroacoustic (sonar) techniques to count migrating Noatak River chum salmon and char. Sonar estimates of daily fish passage would provide timely escapement information to fishery managers. In addition, sonar estimates of annual escapement would enable prediction of future year run strength and could eventually be used to establish escapement goals.

The Noatak River flows approximately 680 km from its headwaters in the Schwatka Mountains to Kotzebue Sound. The lower 50 km of the river was surveyed for possible sonar sites on 6-7 August 1988. Multiple channels, slow current and/or unstable banks characterize the lower 30 km. The lower Noatak River canyon (km 39, Figure 1) was chosen for sonar deployment because of the single, narrow channel; stable banks; proximity to the mouth; and favorable bottom profile. At km 39, the river is approximately 200 m wide and 20 m deep, and the river bottom has a relatively constant slope from both banks.

A camp was constructed and sonar first deployed at this location during July and August 1989 (Fleischman and Huttunen 1990). Unusually high and turbid water during summer 1989 had adverse effects on sonar performance, and we also had several equipment-related problems. Nevertheless the site itself appeared to be a favorable one. Test-netting at the site suggested that chum salmon might be spatially segregated from other fish species. If real, 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

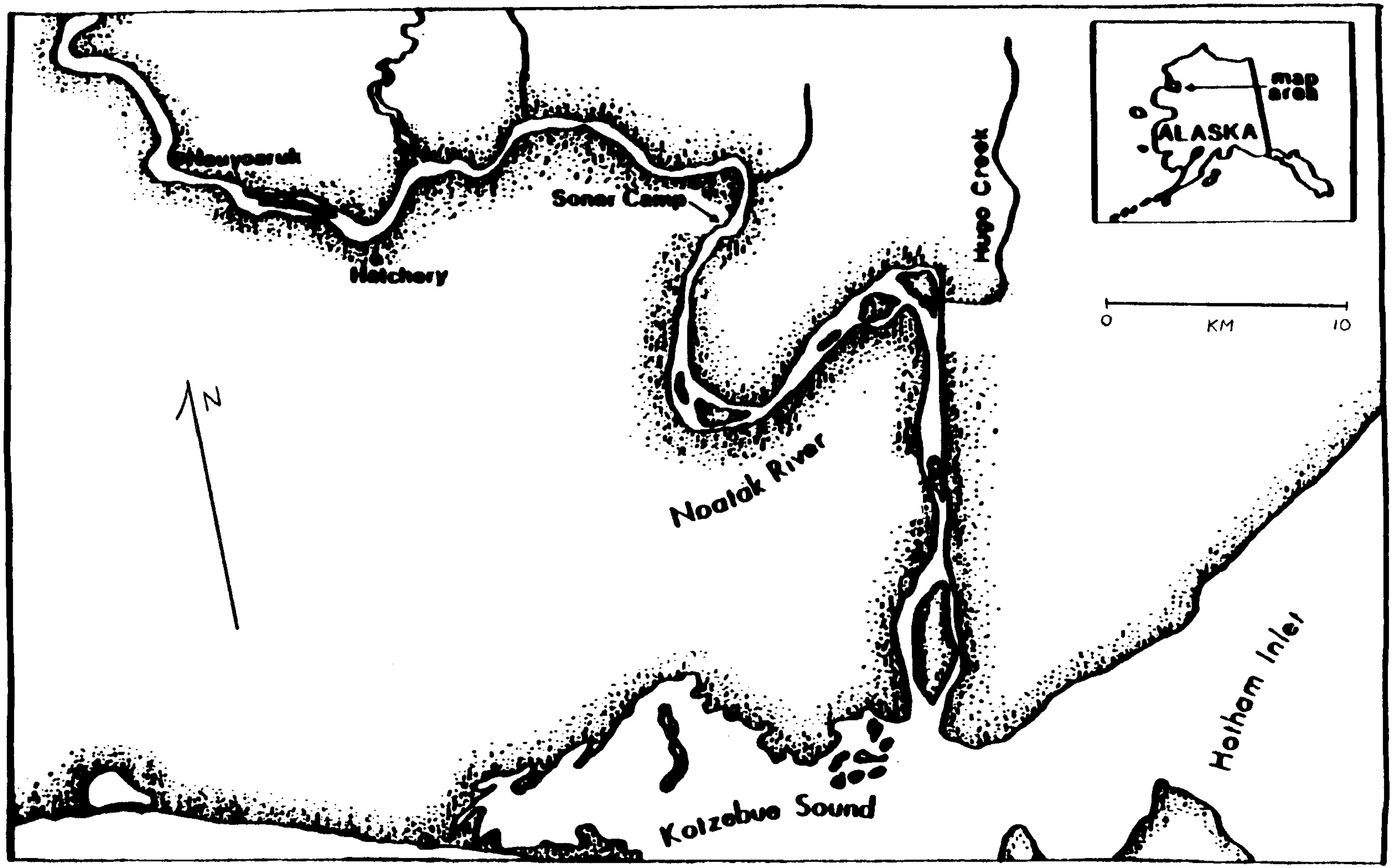


Figure 1. Location of Noatak River sonar, 1989 and 1990.

be needed to differentiate between chum salmon and other, smaller species.

This report summarizes preliminary results of the 1990 field season. Objectives for 1990, in order of priority, were as follows.

(1) To continue to assess the physical and biological characteristics of the Noatak River as they affect our ability to count migrating chum salmon with sonar.

(2) To begin to implement a one-bank single-beam sonar system, with gill-netting for species apportionment and fathometer transects for spatial expansion, to count migrating (right bank only) chum salmon.

(3) To continue to collect dual-beam sonar data.

## METHODS

### *Sonar Data Acquisition*

Sonar equipment included a Biosonics model 102 echo sounder; International Transducer Company (I.T.C.) 4°x10° elliptical dual-beam transducer; Biosonics model 111 thermal chart recorder; Biosonics Echo Signal Processor (ESP), with associated software, installed in a Compaq 386/20 personal computer; and a Hewlett Packard model 54501A digital-storage oscilloscope. The transducer was mounted on a metal tripod placed 3-10 m offshore, and was aimed with a remote-controlled dual-axis rotator manufactured by Remote Ocean Systems (R.O.S.). Clutch-like detents were removed from the rotator to enable more rigid attachment of the transducer to the tripod.

Sound pulses were generated by the sounder at 420 kHz with a pulse width of 0.4 ms. Pulse repetition rate was 4 $sec^{-1}$ or 5 $sec^{-1}$; effective range was 100 m. The narrow beam signal was routed to the chart recorder, which ran continuously at a paper speed of 1/8 mm per pulse. Chart recorder threshold was adjusted as conditions and aim dictated; threshold settings ranged from 0.20 V to 0.45 V. Prohibitive amounts of electrical interference on the wide-beam channel, from an unknown source, prevented collection of dual-beam data in 1990.

The sonar equipment was first installed on 18 July and was fully operational by 22 July; collection of sonar data continued through 28 August. The sonar equipment ran continuously, 24 hours per day, seven days per week, excluding half-hour periods at noon and midnight for generator refueling and maintenance. Data acquisition was occasionally interrupted when changing river conditions necessitated moving the tripod or re-aiming the transducer. Continuous monitoring of the sonar, as was done 16 hours per day in 1989, was suspended in 1990 to free project personnel for greater test-fishing efforts. Sonar operation was instead checked periodically throughout the day.

Fish traces were tallied daily on the chart recordings by 10 m range intervals every 15 minutes. Individual differences in interpretation of chart recordings are a potential problem when personnel are inexperienced. To minimize those differences, fish-counting "workshops" were held periodically and frequent consultation between counters was encouraged.

Water level, read from a staff gauge in the river, was recorded opportunistically 5-20 times daily. Water temperature and secchi disk readings were taken twice daily, while test-fishing; and water samples (500 cc) were collected every other day. A log was maintained of sonar operations, and of water and weather conditions. We used a Beckman Model RS5-3 Salinometer to measure water conductivity.

We used a Lowrance X-16 fathometer to run transects of downward-looking sonar across the river, with the objective of estimating cross-sectional distribution of fish in the Noatak.

### *Test-netting*

Gill nets were used to estimate species composition of passing fish. The following nets, all 45.7 m (25 fathoms) long, were deployed a total of 249 times from 10 July through 28 August.

1) 76 mm (3") mesh monofilament gill net, 80 meshes deep
2) 117 mm (4-5/8") mesh multi-mono (#1.5 x 6 strand) gill net, 40.5 meshes deep

3) 130 mm (5-1/8") mesh multi-mono (#1.5 x 8 strand) gill net, 45.5 meshes deep
4) 149 mm (5-7/8") mesh multi-mono (#1.5 x 10 strand) gill net, 45.5 meshes deep
5) 140 mm (5-1/2") mesh multifilament gill net, 55 meshes deep

We test-netted seven days per week from 22 July through 28 August, usually twice daily at 1000 and 1700. Nets were either set, with one end fixed to shore, or drifted. During drifts, one end of the net was controlled from a boat and the other attached to a rope which was walked along shore. We varied the length of the rope to control the range at which the net drifted, but always (after 25 July) kept the far end of the net within the 100 m effective range of the sonar. Set nets were located immediately (<20 m) downstream of the sonar tripod/transducer, and drifts originated within 100 m downstream from the tripod. From 22 July through 28 August, an average of 6.2 drifts/sets were made per day; on 28 of 38 days, nets 1-4 were drifted at least once each. When time or logistics restricted us to drifting with three nets, either the 4-5/8" or the 5-1/8" net was not fished.

### *Data Processing*

#### Estimating Total Fish Passage

Periodic set-netting from shore revealed moderate numbers of humpback whitefish (*Coregonus pidschian*) but very few upriver-bound chum salmon within 20 m of the tripod. Sonar counts and testnet results were therefore stratified into nearshore (0-20 m range, set nets), and offshore (20-100 m range, drift nets) strata. Since our objective was to estimate chum salmon escapement, and very few chum salmon were found in the nearshore stratum, only data from the offshore stratum were processed. Fifteen-minute sonar counts from 20 m to 100 m range were averaged by day, then multiplied by 96 (number of 15-minute periods in 24 hours) to generate daily estimates of total (offshore) fish passage.

Species Apportionment

Relative test-netting catch per unit effort (CPUE), adjusted for net selectivity, was used to generate daily estimates of species proportions. Set nets were used primarily to monitor near-shore species composition, which included almost no upriver-bound chum salmon at 0-20 m range. Therefore only drifted nets, deployed between 20 m and 100 m range, were used to apportion offshore fish passage. Because of the size selectivity of gill nets, catches from several nets were used to estimate the relative abundance of most species. Relative abundance of chum salmon was estimated from catches in 4-5/8, 5-1/8" and 5-7/8" mesh nets; of char from 3", 4-5/8", 5-1/8", and 5-7/8" nets; of humpback whitefish from 3" nets; and of pink salmon (*Oncorhynchus gorbuscha*) from 3", 4-5/8", and 5-1/8" nets.

Size selectivity of gill nets for chum salmon and char was estimated post-season from 1990 Noatak test-netting data, following the methods of Peterson (1966). Peterson's method assumes that net selectivity is approximated by a normal curve function; estimates of means and standard deviations for these normal curves, for nets used on the Noatak River in 1990, are listed in Appendix C. We caught too few pink salmon and whitefish to calculate net selectivity for these species on the Noatak. Net selectivity parameters for pink salmon were calculated from 1986-1989 Yukon River sonar data and converted to Noatak net sizes. Yukon sonar net selectivity means for broad whitefish (*Coregonus nasus*) did not appear to be correct for Noatak River humpback whitefish, so whitefish catches on the Noatak were not adjusted for net selectivity.

Selectivity curves were used to adjust catches for differential probability of capture. The normal curves were scaled so that the probability of capture (height of the curve) was 1.0 for fish of length equal to the net selectivity mean. Catches of fish of each length were divided by the height of the scaled curve at that length. For instance, the estimated selectivity mean for chum salmon in 5-7/8" gear was 642 mm, the estimated standard deviation 60.5 mm. A 600 mm chum salmon caught in 5-7/8" gear is "$z$" = 42/60.5 = 0.69 standard deviations away from the net mean. The height of the normal curve is 77% of its maximum at $z = -0.69$, so the estimated (relative) probability of capture is 0.77. Therefore catches of 600 mm chum salmon in the 5-7/8" net would be adjusted upward by a factor of 1/0.77 = 1.3. In reality, due for example to tangling of large fish in small meshes, net selectivity functions probably are not normal (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 therefore high adjustment factors. Therefore, to be conservative and minimize inclusion of tangled fish, fish whose lengths were very different from the selectivity mean for that net were ignored. An arbitrary $z$ value of 1.66, equivalent to an adjustment factor of 4.0, was chosen as the cutoff point; i.e., fish more than 1.66 standard deviations shorter or longer than the net selectivity mean were excluded from analysis.

After adjustment for capture probability, the new catch numbers were divided by effort (i.e., fathom-hours corrected for differences in net depth) to calculate CPUE. If fish of a given size were susceptible to capture by more than one mesh size (criterion: fish length less than 1.66 standard deviations from the selectivity mean for that net), adjusted catch was divided by the total effort expended for all mesh sizes meeting that criterion.

Adjusted CPUE was then summed over all length classes for each species, and species proportions were calculated as species CPUE divided by total (all species) CPUE. Species proportions were then multiplied by (sonar-estimated) total fish passage to estimate species passage.

Two or more estimates of species proportions per day are necessary to calculate daily variance estimates (see below), requiring that nets which effectively sample the entire range of species and size classes be fished twice daily. We were not always able to accomplish this, so data were pooled into two-day "reporting periods". I.e., two days of test-netting data were pooled to generate estimated species proportions, which were then multiplied by the two-day sonar count.

## 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 test-netting estimates of species proportions. On the Yukon River Sonar Project, where gill nets are also used to apportion sonar counts, the first (sonar) component is of relatively minor importance (Fleischman, unpublished ADF&G memo), even though the Yukon sonar is operational for only 7-8 hours per day (i.e., primary sampling fraction = 0.3). The Noatak sonar operates ca. 23 hours per day (sampling fraction > 0.9), so the sonar contribution to species passage variance on the Noatak is almost certainly negligible. In other words, errors in Noatak species passage estimates are due almost solely to estimation of species proportions, rather than to estimation of total fish passage. For purposes of variance calculations, the sonar component of variance (#1 above) was therefore assumed to be zero.

To estimate variance of species proportions during a given reporting period (Equation 1), we treated each day's test-netting catch as a replicate cluster sample and weighted each sample by relative total (adjusted) CPUE for that day (Cochran 1977:64). Variance of species passage estimates was then simply variance of the proportions multiplied by the square of the total fish passage estimate (Equation 2). Species passage variance estimates were calculated for each two-day reporting period, then summed to get variances of the season totals (Equation 3).

(1) *Spp proportions* ($\hat{p}_i$)

$$\hat{var}(\hat{p}_i) = \frac{1}{n_i} \sum \left( \frac{m_k}{\bar{m}_i} \right)^2 \frac{(p_k - \hat{p}_i)^2}{n_i - 1}$$

where: $\hat{p}_i$ = estimated proportion of one species (say chum salmon) out of total fish passage during reporting period i

$n_i$ = number of test-net samples (i.e., days) in reporting period i

$m_k$ = test-netting CPUE (all species) on day k

$\bar{m}_i$ = mean daily test-netting CPUE during reporting period i

$p_k$ = estimated proportion of one species during day k

k = 1 to $n_i$ days

$$\text{(2)} \quad \textit{Spp passage } (\hat{z}_i = \hat{y}_i * \hat{p}_i) \qquad \hat{var}(\hat{z}_i) = \hat{y}_i^2 \, \hat{var}(\hat{p}_i)$$

where: $\hat{z}_i$ = estimated passage of one species during reporting period i
$\hat{y}_i$ = estimated total fish passage during reporting period i

$$\text{(3)} \quad \textit{Seasonal spp. passage } (\hat{Z}) \qquad \hat{var}(\hat{Z}) = \sum \hat{var}(\hat{z})_i$$

Sonar and test-netting data were entered into Lotus 1-2-3 worksheets and an Rbase for DOS database, respectively. Data processing was done with SAS (Release 6.03, see Appendix B).

## RESULTS

### *River Conditions and Their Effects*

During the period from 22 July through 24 August, which encompassed the bulk of the 1990 chum salmon run, little or no rain fell and water level dropped abruptly and remained very low (Figure 2). Water clarity and water temperature were both high during this time. This was quite different from 1989, when the river remained very high and turbid for most of the summer (Fleischman and Huttunen 1990). The extended period of low and clear water in 1990 was associated with several new phenomena of note.

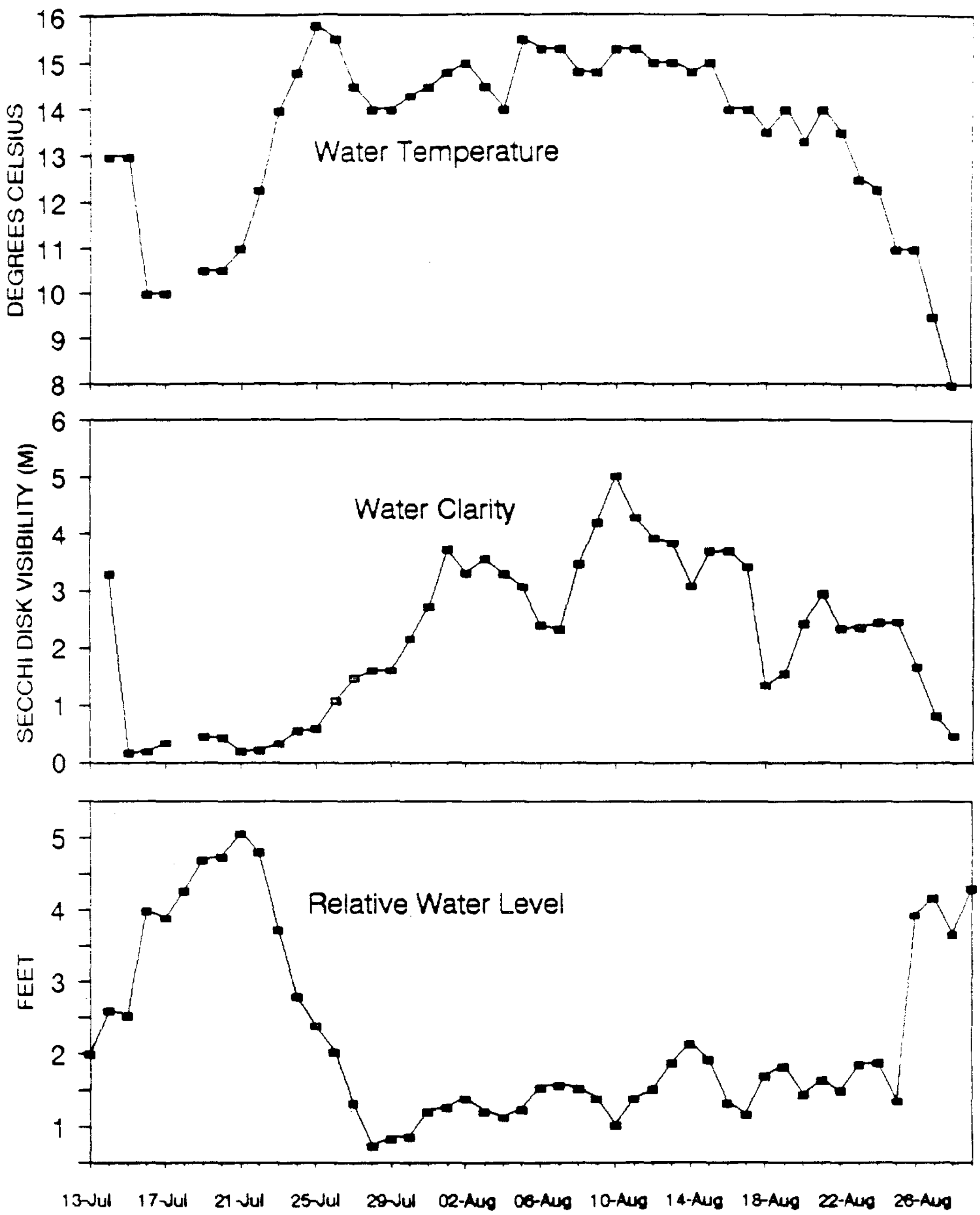


Figure 2. Mean water temperature ($^0$C.), water clarity, (meters secchi disk visibility), and water level (feet) from 13 July through 29 August 1990.

Tidal Influence

During the low-water period from 29 July through 25 August, tides caused 10-20 cm fluctuations in river level, lagged approximately 3.3 hours from those in Kotzebue Sound (Figure 3). Tidal fluctuations were not detectible at the sonar site before 29 July 1990, after 25 August 1990, nor at any time during July-August 1989.

Although tides affected river water level, we were unable to detect brackish water at the sonar site; conductivity measurements at depths from 0 to 50 feet (maximum cable length) failed to show any salinity. On 19 August, during a

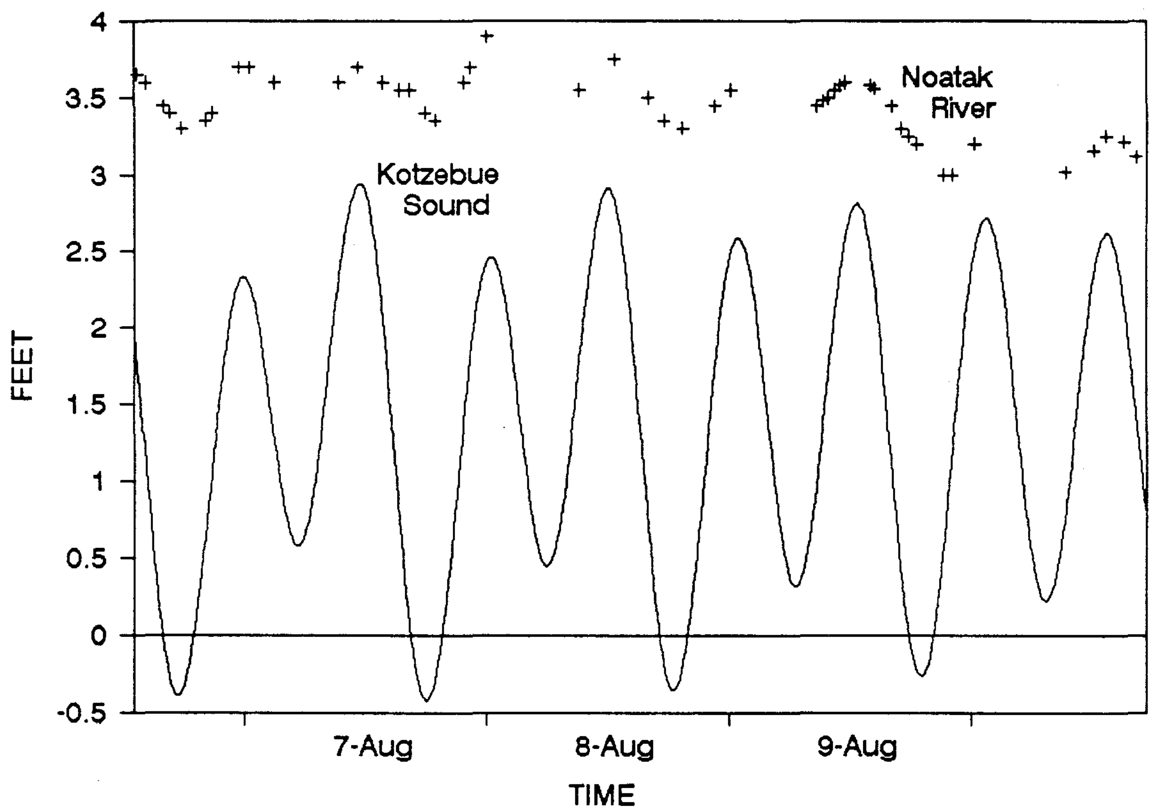


Figure 3. Predicted tides in Kotzebue Sound (NOAA 1989) and actual water level fluctuations at the Noatak River sonar site during early August 1990. Kotzebue Sound tides are shown lagged 3.3 hours.

rising tide, we measured conductivity at 2-3 km intervals downriver from the site and found no evidence of saltwater until >8 km away. Inspection of plotted tide and sonar data revealed no detectable influence of tide stage on fish migration rates.

Diel fish passage

Though apparently not affected by tides, fish passage at times exhibited a pronounced diel pattern: passage rate was often slowest during the darkest part of the day from 1:00 to 5:00 A.M. (Figure 4; no statistical test). This pattern was less pronounced when river water was turbid (i.e., secchi readings < 1.5 meters, Figure 4), and was not apparent in 1989, when secchi disk readings never exceeded 1 meter.

Schooling behavior

Water clarity also affected another aspect of fish behavior: fish began travelling in small schools as the secchi readings increased in late July. This was apparent from the manner in which chum salmon and char were captured in our test nets, and from clustering of fish traces on the chart recordings (Figure 5). Fish traces on the charts were occasionally clustered so tightly that individuals were difficult to distinguish; schools of 15-20 fish were not uncommon. This schooling behavior ceased abruptly when water clarity dropped in late August.

## *Fish Passage*

An estimated 67,987 fish passed 20-100 m from the right bank while the sonar was in operation (22 July - 28 August). From 10 July through 28 August we caught 400 chum salmon, 174 char, 98 humpbacked whitefish, and 25 pink salmon in drift and set nets (Appendix A). Six starry flounder (*Platichthys stellatus*), two northern pike (*Esox lucius*), two least cisco (*Coregonus sardinella*), one sheefish (*Stenodus leucichthys*), and one longnose sucker (*Catastomus catastomus*) were also

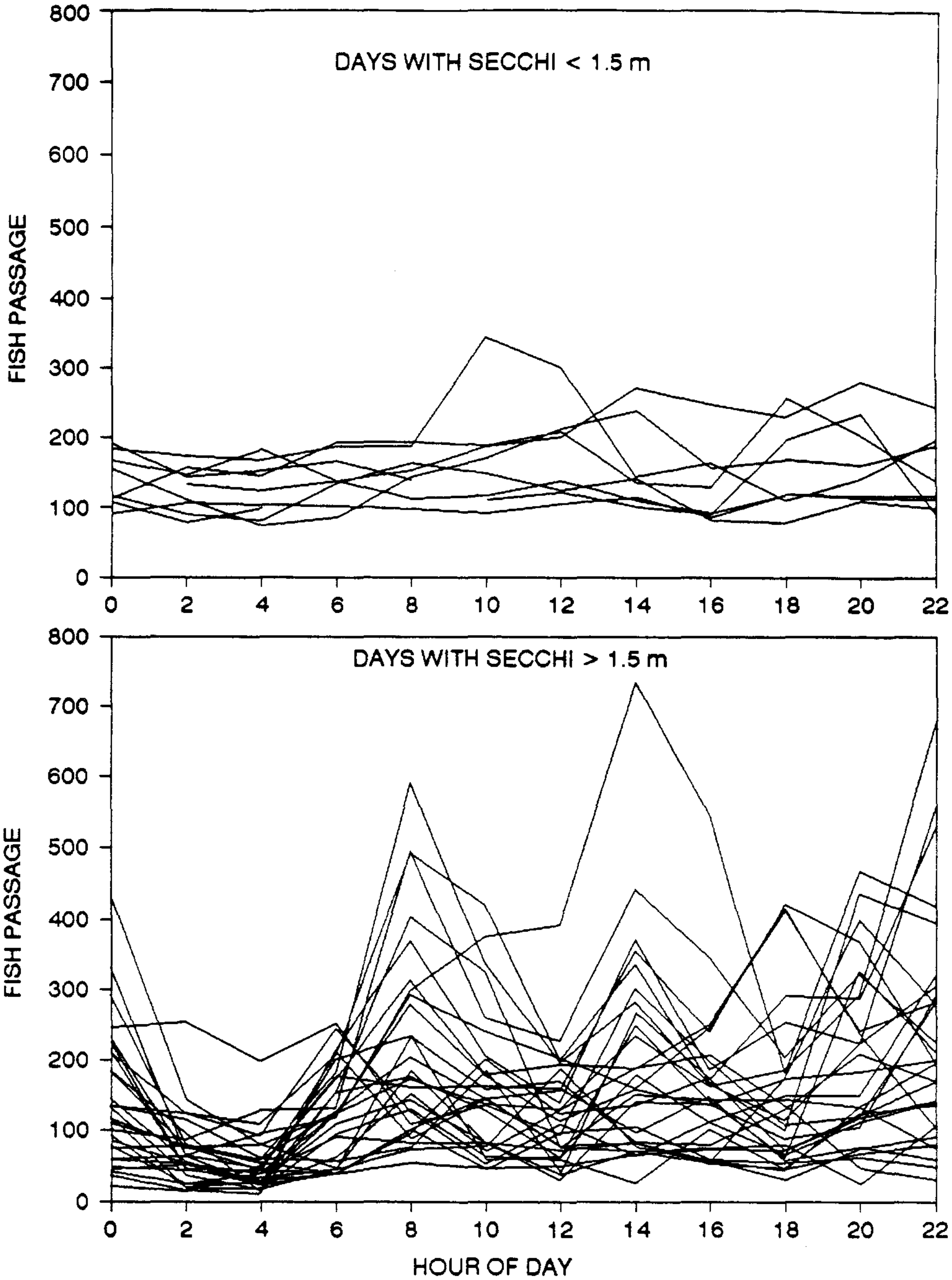


Figure 4. Fish passage 20-100 meters from the right bank, Noatak sonar, 1990. Each line represents one day and connects two-hour fish passage totals. Days are separated based on water clarity: top graph shows days with mean secchi disk visibility < 1.5 meters (22-27 July, 18 and 27-29 August); bottom graph shows days with visibility > 1.5 meters (28 July - 17 August, 19-26 August).

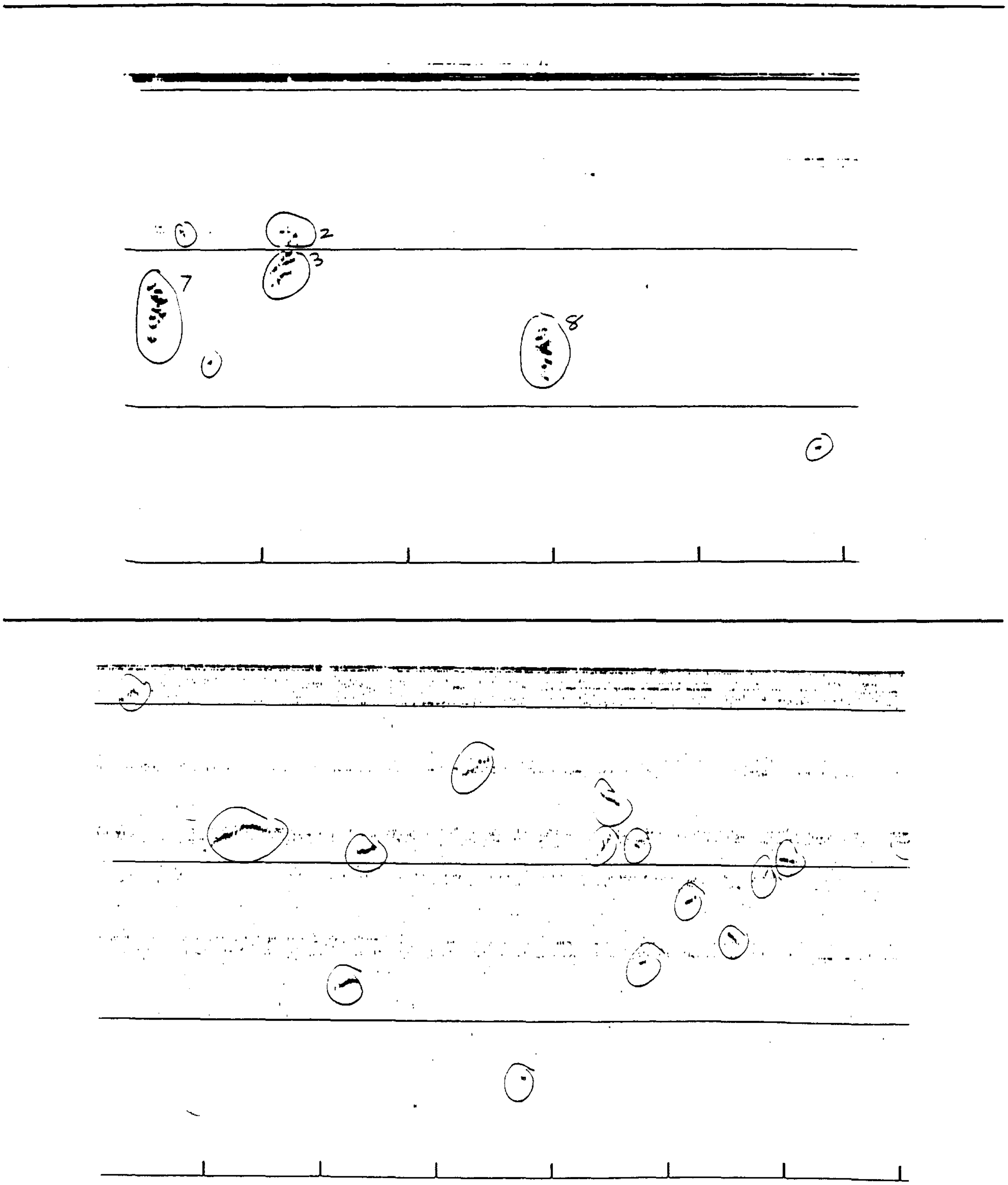


Figure 5. Sample chart recordings from when water was clear and fish were clustered (top), and when water was turbid and fish were scattered (bottom).

taken, primarily in set nets. Using driftnet data to apportion offshore sonar counts, chum salmon comprised an estimated 62% of offshore fish, along with 24% char, 9% humpback whitefish, and 5% pink salmon (Table 1). Char began to comprise substantial proportions of offshore fish in mid-August, and remained abundant until our last day of operation on 28 August (Figure 6). The char run overlapped with much of the chum salmon run.

### *Cross-sectional Distribution of Fish in the River*

When the water was clear and fish were schooled, we had difficulty detecting fish with the Lowrance fathometer. This may have been due to boat avoidance by fish in clear water and/or the reduced probability of encountering fish clustered in schools. We observed 165 targets which were undisputedly fish; two-thirds (109) of these were observed during the few days (7 of 38) when the water was murky (secchi < 1 m). Distribution of all 165 fish, uncorrected for differential probability of detection with depth, is shown in Figure 7. Forty-seven percent (77/165) of these fish would have been within the range of the main sonar (<100 m from the right bank).

It is tempting to use this information to estimate that 67,987 / .47 = 145,686 fish passed the sonar site (offshore, river-wide), and that 0.62 X 145,686 = 90,325 were chum salmon. It is important to note that these estimates may be highly inaccurate for 1990, as they are based on two very tenuous assumptions:

(1) that distribution of fish in the river does not vary with water clarity (most of the distribution data were obtained while the river was turbid but most fish passed the site while the river was clear), and

(2) that species proportions did not differ from bank to bank. (Almost all drift-netting for species apportionment was done within 100 meters of the right bank.) Species proportions do differ by bank at the Yukon River sonar site (D. Mesiar, ADF&G Anchorage, unpublished data).

If we elect to continue to use the above method to estimate river-wide chum salmon passage (see other alternatives, p. 21), we could test assumption 2 by drifting nets on both sides of the river. Assumption 1 may be less of a problem if we do not experience long periods of clear water during future years.

Table 1. Estimated right bank (20-100 m range) fish passage, total and by species, at the Noatak sonar site from 22 July through 28 August 1990. Fish passage and estimated species percentages are calculated by two-day reporting periods.

| 2-Day Period Ending | 2-Day Total Passage | Estimated Percent (s.e.) of Total | | | | Estimated 2-Day Passage | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Chum | Char | Pink | White | Chum | Char | Pink | White |
| 23JUL90 | 2111 | 61(37) | 0 | 0 | 39(37) | 1310 | 0 | 0 | 823 |
| 25JUL90 | 2704 | 40(32) | 0 | 60(32) | 0 | 1094 | 0 | 1645 | 0 |
| 27JUL90 | 3381 | 47(6) | 0 | 10(10) | 43(16) | 1585 | 0 | 343 | 1467 |
| 29JUL90 | 1666 | 70(0) | 30(0) | 0 | 0 | 1189 | 508 | 0 | 0 |
| 31JUL90 | 3846 | 100(0) | 0 | 0 | 0 | 3901 | 0 | 0 | 0 |
| 02AUG90 | 1903 | 100(0) | 0 | 0 | 0 | 1929 | 0 | 0 | 0 |
| 04AUG90 | 2246 | 45(25) | 0 | 23(10) | 32(14) | 1023 | 0 | 518 | 718 |
| 06AUG90 | 1806 | 60(21) | 7(8) | 10(9) | 23(20) | 1098 | 134 | 177 | 410 |
| 08AUG90 | 2534 | 78(17) | 22(17) | 0 | 0 | 2017 | 569 | 0 | 0 |
| 10AUG90 | 3846 | 84(19) | 6(7) | 10(12) | 0 | 3275 | 219 | 399 | 0 |
| 12AUG90 | 3944 | 93(4) | 4(2) | 0 | 0 | 3674 | 157 | 0 | 0 |
| 14AUG90 | 4964 | 81(18) | 0 | 0 | 19(18) | 4052 | 0 | 0 | 949 |
| 16AUG90 | 5099 | 84(14) | 0 | 0 | 16(14) | 4317 | 0 | 0 | 831 |
| 18AUG90 | 3399 | 46(5) | 41(17) | 0 | 13(12) | 1561 | 1412 | 0 | 432 |
| 20AUG90 | 6233 | 54(9) | 40(6) | 4(2) | 2(1) | 3387 | 2511 | 251 | 141 |
| 22AUG90 | 6492 | 33(31) | 64(30) | 0 | 2(1) | 2186 | 4208 | 0 | 138 |
| 24AUG90 | 4207 | 26(23) | 74(23) | 0 | 0 | 1091 | 3150 | 0 | 0 |
| 26AUG90 | 2331 | 50(10) | 50(10) | 0 | 0 | 1188 | 1170 | 0 | 0 |
| 28AUG90 | 4655 | 44(7) | 45(1) | 0 | 11(6) | 2073 | 2106 | 0 | 528 |
| | ----- | --- | --- | --- | --- | ------ | ------ | ----- | ----- |
| Total | 67,987 | | | | | 41,948 | 16,144 | 3,333 | 6,437 |
| s.e. | | | | | | 3,095 | 2,377 | 1,093 | 1,668 |
| s.e./total | | | | | | 0.074 | 0.147 | 0.328 | 0.259 |
| Overall % (s.e.) | | 62(5) | 24(4) | 5(2) | 9(2) | | | | |

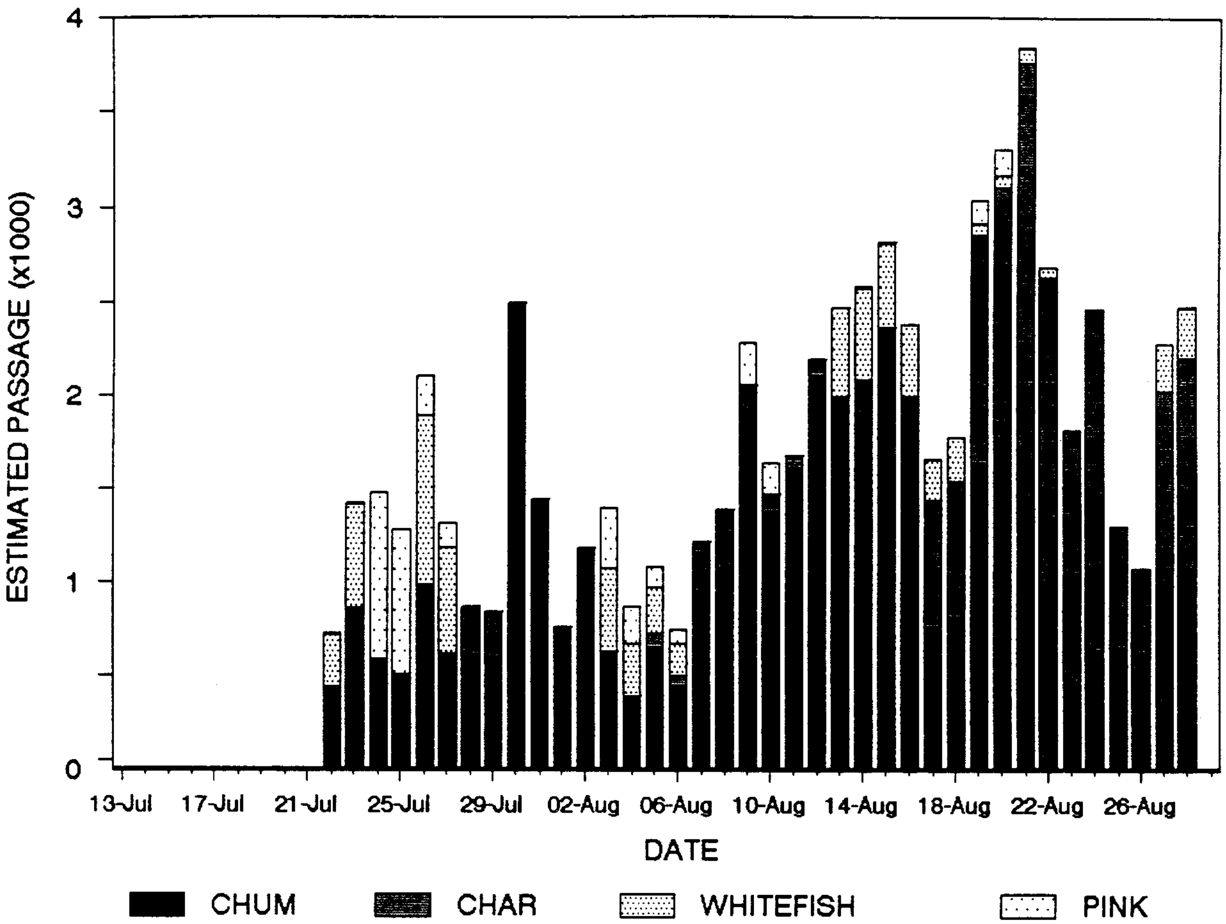


Figure 6. Daily fish passage estimates by species, Noatak sonar 1990.

## DISCUSSION

Water clarity appears to exert a strong, if difficult to understand, influence on Noatak River fish behavior. Fish passage rates declined during darkness, but only when the water was clear. Perhaps clear water and high ambient light trigger social behavior (including schooling) among migrating fish, and under these circumstances darkness depresses passage rates because it inhibits social interactions. Turbid water may preclude any social interactions at all, leading fish to travel independent of light intensity.

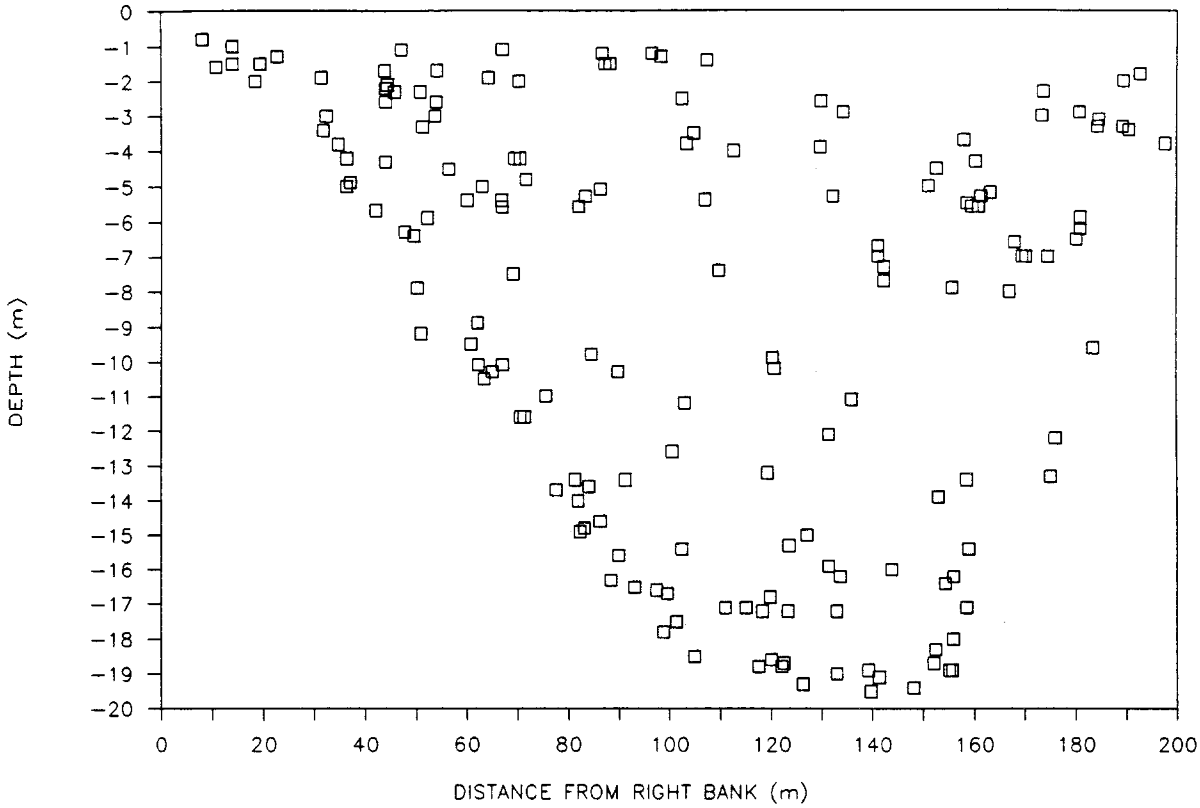


Figure 7. Distribution of fish detected with the Lowrance X16 fathometer, from horizontal transects of the Noatak River in 1990, uncorrected for differential probability of detection with depth.

In any event, we are fortunate that our first two seasons on the Noatak brought nearly opposite extremes in weather and water conditions. During the 1989 season, extremely high and turbid water was associated with inconsistencies in sonar performance. Low, clear, and warm water during the 1990 field season resulted in a tidal influence at the sonar site and the aforementioned changes in fish behavior. We've now experienced a wide range of physical and biological conditions and their implications for counting salmon with sonar; these will give us a broader perspective as new combinations of conditions occur in coming years.

Species apportionment on the Noatak will be somewhat more difficult than first perceived. After the 1989 field season, it appeared that it might be possible to apportion sonar targets to species based simply on distance from shore, since most whitefish and no salmon occurred near shore and >95% of offshore catches were chum salmon (Fleischman and Huttunen 1990). Distance from shore (range) information is available from the sonar, and therefore such an apportionment method would be extremely easy to carry out. However, we estimated that chum salmon comprised only 62% of offshore fish in 1990, much lower than 1989 (>95%). This was due primarily to a probable underestimate of 1989 char abundance. Seventy-two percent (107/149) of offshore char netted in 1990 were caught with a 3" mesh net. The smallest mesh drifted offshore in 1989 was 4"; therefore we probably missed many small char in 1989. Clearly, chum salmon on the Noatak River cannot be distinguished from other species (especially char) based solely on range, so species composition must be determined another way if we are to accurately quantify chum salmon escapement.

The test-netting method used in 1990 appears to have provided satisfactory estimates of species composition with reasonably good precision, and would be relatively easy to implement again in 1991. Relative precision of chum salmon passage estimates was poor for individual reporting periods (standard errors up to 94% of estimate), but was much better for the season total (standard error = 7% of estimate, Table 1). Precision could be improved by increasing test-fishing effort: doubling the number of drifts could be expected to improve the relative precision by approximately 29%. However such an increase in test-fishing effort would require additional labor expenditures.

Dual-beam sonar, which would apportion sonar counts to species based on target strength, has been considered as an alternative apportionment method which would not require intensive test-netting. Despite our failure to collect dual-beam data in 1990, prospects for deploying dual-beam sonar on the Noatak have improved. Recent work (P. Skvorc, ADF&G, Anchorage, unpublished data) has shown that high-frequency (420 kH) sonar signals may attenuate substantially with range; these findings may partially explain inconsistencies in 1989 dual-beam data (Fleischman and Huttunen 1990). If attenuation can be quantified further, we possibly could adjust for its effects; alternatively we could switch to low-frequency signals which attenuate less. Furthermore, size distribution of fish on the Noatak appears favorable for dual-beam separation of species. Length modes for whitefish, char, and pink salmon are all substantially less than that for chum salmon (Figure 8).

## *Outlook*

We have, on the Noatak River, a workable single-beam sonar / test-net species apportionment system which satisfactorily estimates right-bank chum salmon passage. Such a system provides, at the least, a good index to total chum salmon escapement. The next step is to somehow extend the operation or extrapolate our results to include both banks and thereby estimate total escapement. To that end, several alternatives are currently being considered:

(1) To continue attempting to expand our sonar counts to the entire river based on horizontal transects with a downward-looking fathometer. One major drawback is that it may be impossible to obtain adequate sample sizes during periods of clear water.

(2) To deploy an additional transducer on the left bank. Technology is currently being developed which would permit radio transmission of signals across the river; however implementation of such a radio-link on the Noatak is at least two years away.

(3) To attempt to ensonify most or all of the river from the right bank. Switching to a lower frequency (120 kHz or lower) sonar signal may reduce attenuation sufficiently to make this a possibility.

## *Summary / Conclusions*

(1) Opposite extremes of weather and water conditions in 1989 and 1990 have taught us much about deploying sonar in the Noatak River in a relatively short period of time.

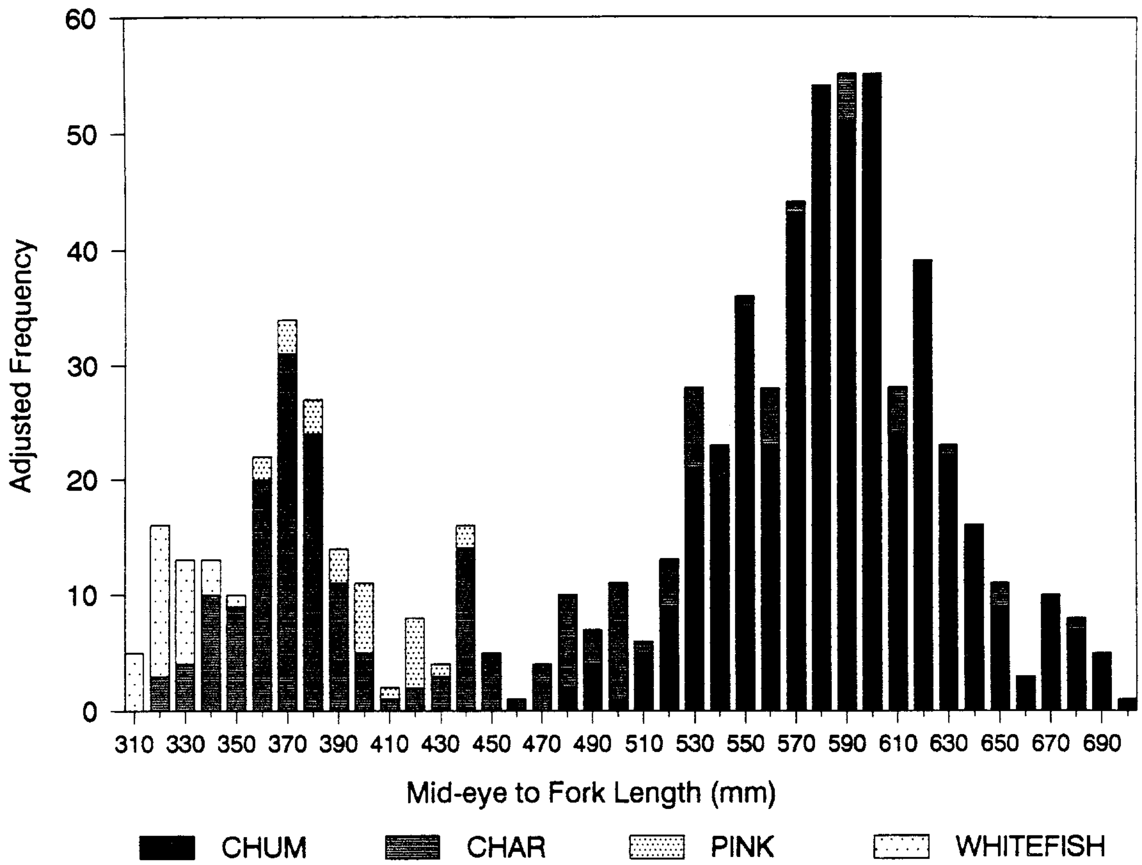


Figure 8. Length distribution of fish caught in drift nets at the Noatak sonar site, 1990. Numbers have been adjusted for unequal net effort, but not for net selectivity.

(2) We have a workable single-beam sonar system in place which satisfactorily estimates right-bank chum salmon passage.

(3) Prospects for deployment of dual-beam sonar on the Noatak have improved, despite failure to collect dual-beam data in 1990.

(4) The next step in sonar development on the Noatak is to somehow expand the operation to include both river banks.

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## ACKNOWLEDGEMENTS

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## APPENDIX A: SUMMARY OF TEST-NETTING RESULTS, 10 JULY - 28 AUGUST

| DATE | TIME[1] | METH[2] | MESH | MIN[3] RANGE | MAX[4] RANGE | FATHOM[5] HOURS | NUMBER CAUGHT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | CHUM | CHAR | PINK | WHITE |
| 10JUL90 | 15:06 | D | 5.500 | 0 | 200 | 38.37 | . | . | . | . |
| 13JUL90 | 10:37 | D | 5.500 | 0 | 200 | 19.81 | . | . | . | . |
| 14JUL90 | 18:54 | D | 5.500 | 0 | 200 | 22.28 | . | . | . | . |
| 15JUL90 | 13:26 | D | 5.125 | 0 | 200 | 11.89 | . | . | . | . |
| 16JUL90 | 21:05 | D | 5.125 | 0 | 200 | 13.45 | . | . | . | . |
| 18JUL90 | 11:38 | D | 3.000 | 0 | 200 | 9.82 | . | . | . | 3 |
| 18JUL90 | 1:07 | D | 5.125 | 0 | 200 | 12.27 | . | . | . | 5 |
| 19JUL90 | 15:40 | D | 3.000 | 0 | 200 | 6.87 | . | . | . | . |
| 19JUL90 | 12:30 | D | 5.125 | 0 | 200 | 9.77 | 1 | . | . | . |
| 20JUL90 | 23:27 | D | 5.875 | 0 | 200 | 11.49 | . | . | . | . |
| 21JUL90 | 19:16 | D | 3.000 | 0 | 200 | 8.18 | . | . | . | 1 |
| 21JUL90 | 19:32 | D | 3.000 | 30 | 300 | 15.47 | . | . | . | . |
| 21JUL90 | 17:46 | D | 5.875 | 30 | 300 | 19.65 | 5 | . | . | . |
| 21JUL90 | 18:58 | D | 5.875 | 0 | 200 | 11.22 | . | . | . | . |
| 22JUL90 | 13:55 | D | 3.000 | 0 | 200 | 9.33 | . | . | . | 1 |
| 22JUL90 | 14:14 | D | 3.000 | 30 | 300 | 15.22 | . | . | . | . |
| 22JUL90 | 12:39 | D | 4.625 | 30 | 300 | 10.41 | . | . | . | . |
| 22JUL90 | 13:05 | D | 4.625 | 0 | 200 | 5.11 | . | . | . | . |
| 22JUL90 | 11:36 | D | 5.125 | 0 | 200 | 8.02 | . | . | . | . |
| 22JUL90 | 12:04 | D | 5.125 | 30 | 300 | 13.21 | . | . | . | . |
| 22JUL90 | 17:26 | D | 5.875 | 0 | 200 | 9.70 | . | . | . | . |
| 22JUL90 | 17:41 | D | 5.875 | 30 | 300 | 17.22 | 1 | . | . | . |
| 23JUL90 | 13:27 | D | 3.000 | 30 | 300 | 19.89 | . | . | . | . |
| 23JUL90 | 17:44 | D | 3.000 | 30 | 300 | 14.90 | . | . | . | . |
| 23JUL90 | 18:27 | D | 4.625 | 30 | 300 | 13.18 | . | . | . | . |
| 23JUL90 | 11:17 | D | 5.125 | 30 | 300 | 11.91 | . | . | . | . |
| 23JUL90 | 10:35 | D | 5.875 | 30 | 300 | 20.15 | 1 | . | . | . |
| 23JUL90 | 18:54 | D | 5.875 | 30 | 300 | 16.41 | 2 | . | . | . |
| 24JUL90 | 11:06 | D | 3.000 | 30 | 200 | 7.69 | . | . | . | . |
| 24JUL90 | 10:28 | D | 4.625 | 30 | 200 | 4.92 | . | . | 1 | . |
| 24JUL90 | 11:26 | D | 4.625 | 30 | 200 | 7.19 | . | . | 2 | . |
| 24JUL90 | 18:31 | D | 5.125 | 40 | 200 | 12.03 | . | . | . | . |
| 24JUL90 | 13:36 | D | 5.875 | 30 | 200 | 9.87 | . | . | . | . |
| 24JUL90 | 19:03 | D | 5.875 | 40 | 200 | 8.65 | . | . | . | . |
| 24JUL90 | 17:58 | S | 3.000 | 0 | 40 | 102.63 | . | . | 1 | 12 |
| 24JUL90 | 18:22 | S | 4.625 | 0 | 40 | 56.78 | . | . | 2 | . |
| 24JUL90 | 10:17 | S | 5.875 | 0 | 30 | 88.71 | 1 | . | 1 | . |
| 25JUL90 | 18:21 | D | 3.000 | 25 | 70 | 12.28 | . | 1 | 4 | . |
| 25JUL90 | 11:48 | D | 4.625 | 0 | 130 | 9.46 | . | . | . | . |
| 25JUL90 | 17:43 | D | 4.625 | 25 | 70 | 11.36 | . | . | 2 | . |
| 25JUL90 | 11:00 | D | 5.500 | 0 | 130 | 27.85 | 2 | . | . | . |
| 25JUL90 | 10:25 | D | 5.875 | 50 | 130 | 20.55 | 4 | . | . | . |
| 25JUL90 | 18:51 | D | 5.875 | 25 | 70 | 15.15 | 3 | . | . | . |
| 26JUL90 | 10:41 | D | 3.000 | 25 | 70 | 12.28 | . | . | . | . |
| 26JUL90 | 18:22 | D | 3.000 | 25 | 70 | 15.22 | . | . | . | 2 |
| 26JUL90 | 11:14 | D | 5.125 | 25 | 70 | 15.70 | . | . | 1 | . |
| 26JUL90 | 19:03 | D | 5.875 | 25 | 70 | 15.78 | 5 | . | . | . |
| 26JUL90 | 10:21 | S | 5.500 | 0 | 30 | 102.95 | . | . | 1 | . |
| 26JUL90 | 18:04 | S | 5.500 | 0 | 30 | 121.41 | . | . | 1 | . |
| 27JUL90 | 10:53 | D | 3.000 | 0 | 70 | 12.77 | . | 2 | . | 3 |
| 27JUL90 | 18:15 | D | 3.000 | 25 | 70 | 17.31 | . | . | 1 | 2 |
| 27JUL90 | 11:30 | D | 4.625 | 0 | 70 | 10.47 | . | . | . | . |
| 27JUL90 | 18:53 | D | 5.125 | 25 | 70 | 12.27 | 3 | . | . | . |
| 27JUL90 | 10:25 | D | 5.875 | 25 | 70 | 14.69 | 1 | . | . | . |
| 27JUL90 | 17:45 | D | 5.875 | 0 | 70 | 13.52 | . | . | . | . |

(continued)

## APPENDIX A: CONT'D

| DATE | TIME[1] | METH[2] | MESH | MIN[3] RANGE | MAX[4] RANGE | FATHOM[5] HOURS | NUMBER CAUGHT CHUM | CHAR | PINK | WHITE |
|---|---|---|---|---|---|---|---|---|---|---|
| 28JUL90 | 11:23 | D | 5.125 | 25 | 70 | 13.29 | . | . | . | . |
| 28JUL90 | 10:48 | S | 5.500 | 0 | 40 | 83.81 | . | . | . | 1 |
| 29JUL90 | 18:31 | D | 3.000 | 25 | 70 | 12.28 | . | . | . | . |
| 29JUL90 | 19:04 | D | 4.625 | 25 | 70 | 9.84 | . | 1 | . | . |
| 29JUL90 | 12:40 | D | 5.125 | 25 | 70 | 15.78 | . | . | . | . |
| 29JUL90 | 11:48 | D | 5.875 | 25 | 70 | 25.87 | 3 | . | . | . |
| 29JUL90 | 17:46 | D | 5.875 | 25 | 70 | 13.71 | 1 | . | . | . |
| 30JUL90 | 11:39 | D | 3.000 | 25 | 70 | 13.38 | . | . | . | . |
| 30JUL90 | 18:06 | D | 4.625 | 25 | 70 | 10.91 | 1 | . | . | . |
| 30JUL90 | 18:45 | D | 5.125 | 25 | 70 | 13.68 | 8 | . | . | . |
| 30JUL90 | 10:27 | D | 5.875 | 25 | 70 | 15.28 | 17 | . | . | . |
| 30JUL90 | 17:56 | S | 5.500 | 0 | 35 | 104.29 | 1 | . | 1 | . |
| 31JUL90 | 19:10 | D | 3.000 | 25 | 70 | 12.52 | . | . | . | . |
| 31JUL90 | 12:09 | D | 4.625 | 25 | 70 | 9.53 | . | . | . | . |
| 31JUL90 | 17:46 | D | 5.125 | 25 | 70 | 11.80 | . | . | . | . |
| 31JUL90 | 10:30 | D | 5.875 | 25 | 70 | 14.60 | 12 | . | . | . |
| 31JUL90 | 18:10 | D | 5.875 | 25 | 70 | 13.79 | 5 | . | . | . |
| 31JUL90 | 10:23 | S | 3.000 | 0 | 35 | 55.00 | . | . | . | 14 |
| 01AUG90 | 10:42 | D | 3.000 | 25 | 70 | 12.60 | . | . | . | . |
| 01AUG90 | 18:51 | D | 3.000 | 25 | 70 | 20.62 | . | . | . | . |
| 01AUG90 | 17:41 | D | 4.625 | 25 | 70 | 14.76 | 3 | . | . | . |
| 01AUG90 | 11:04 | D | 5.125 | 25 | 70 | 11.80 | . | . | . | . |
| 01AUG90 | 18:19 | D | 5.875 | 25 | 70 | 16.77 | . | . | . | . |
| 01AUG90 | 19:22 | D | 5.875 | 25 | 70 | 27.05 | . | . | . | . |
| 01AUG90 | 10:37 | S | 5.500 | 0 | 35 | 60.83 | . | . | . | . |
| 02AUG90 | 10:54 | D | 3.000 | 25 | 70 | 27.66 | . | . | . | . |
| 02AUG90 | 11:35 | D | 5.125 | 25 | 70 | 19.70 | 4 | . | . | . |
| 02AUG90 | 18:00 | D | 5.500 | 35 | 80 | 36.52 | . | . | . | . |
| 02AUG90 | 10:22 | D | 5.875 | 25 | 70 | 27.05 | 1 | . | . | . |
| 02AUG90 | 18:42 | D | 5.875 | 25 | 70 | 30.02 | . | . | . | . |
| 02AUG90 | 17:43 | S | 3.000 | 0 | 45 | 9.33 | . | . | . | 1 |
| 03AUG90 | 11:22 | D | 3.000 | 25 | 70 | 12.60 | . | . | . | . |
| 03AUG90 | 17:42 | D | 3.000 | 25 | 70 | 22.02 | . | . | . | 2 |
| 03AUG90 | 10:56 | D | 4.625 | 25 | 70 | 10.88 | . | . | . | . |
| 03AUG90 | 18:21 | D | 5.125 | 25 | 70 | 23.83 | . | . | 1 | . |
| 03AUG90 | 10:22 | D | 5.875 | 25 | 70 | 14.51 | 1 | . | . | . |
| 03AUG90 | 18:59 | D | 5.875 | 25 | 70 | 27.59 | 2 | . | . | . |
| 04AUG90 | 10:53 | D | 3.000 | 25 | 70 | 11.29 | . | . | . | . |
| 04AUG90 | 10:20 | D | 5.125 | 25 | 70 | 19.07 | 1 | . | . | . |
| 04AUG90 | 10:16 | S | 5.500 | 0 | 45 | 76.33 | . | . | . | . |
| 05AUG90 | 17:50 | D | 3.000 | 25 | 70 | 14.49 | . | . | . | . |
| 05AUG90 | 11:15 | D | 4.625 | 25 | 70 | 13.25 | . | 1 | . | . |
| 05AUG90 | 18:14 | D | 5.125 | 25 | 70 | 12.98 | 2 | . | . | . |
| 05AUG90 | 10:35 | D | 5.875 | 25 | 70 | 23.44 | . | . | . | . |
| 05AUG90 | 18:48 | D | 5.875 | 25 | 70 | 12.13 | 6 | . | . | . |
| 05AUG90 | 10:33 | S | 3.000 | 0 | 40 | 68.99 | . | 1 | . | 9 |
| 06AUG90 | 18:52 | D | 3.000 | 25 | 70 | 24.92 | . | . | . | 2 |
| 06AUG90 | 10:27 | D | 4.625 | 25 | 70 | 13.94 | . | . | . | . |
| 06AUG90 | 18:18 | D | 5.125 | 25 | 70 | 20.92 | . | . | 1 | . |
| 06AUG90 | 10:56 | D | 5.875 | 25 | 70 | 20.01 | . | . | . | . |
| 06AUG90 | 17:36 | D | 5.875 | 25 | 70 | 24.79 | 6 | . | . | . |
| 06AUG90 | 10:13 | S | 5.500 | 0 | 30 | 92.79 | . | . | . | . |
| 07AUG90 | 19:03 | D | 3.000 | 25 | 70 | 21.11 | . | . | . | . |
| 07AUG90 | 11:30 | D | 4.625 | 25 | 70 | 15.99 | . | . | . | . |
| 07AUG90 | 11:00 | D | 5.125 | 25 | 70 | 17.34 | 1 | . | . | . |

(continued)

## APPENDIX A: CONT'D

| DATE | TIME[1] | METH[2] | MESH | MIN[3] RANGE | MAX[4] RANGE | FATHOM[5] HOURS | NUMBER CAUGHT CHUM | CHAR | PINK | WHITE |
|---|---|---|---|---|---|---|---|---|---|---|
| 07AUG90 | 17:35 | D | 5.125 | 25 | 70 | 21.23 | 1 | 1 | . | . |
| 07AUG90 | 18:22 | D | 5.875 | 25 | 70 | 23.80 | 1 | . | . | . |
| 07AUG90 | 10:55 | S | 5.500 | 0 | 35 | 90.78 | 1 | . | . | . |
| 08AUG90 | 11:36 | D | 3.000 | 25 | 70 | 21.07 | . | . | . | . |
| 08AUG90 | 17:42 | D | 3.000 | 25 | 70 | 22.10 | . | . | . | . |
| 08AUG90 | 18:14 | D | 4.625 | 25 | 70 | 17.03 | . | . | . | . |
| 08AUG90 | 10:53 | D | 5.125 | 25 | 70 | 21.23 | 2 | . | . | . |
| 08AUG90 | 9:27 | D | 5.875 | 25 | 70 | 24.66 | 5 | . | . | . |
| 08AUG90 | 18:44 | D | 5.875 | 25 | 70 | 24.88 | . | 1 | . | . |
| 09AUG90 | 18:09 | D | 3.000 | 25 | 70 | 15.26 | . | . | . | . |
| 09AUG90 | 10:26 | D | 4.625 | 25 | 70 | 15.87 | . | 1 | 2 | . |
| 09AUG90 | 19:12 | D | 4.625 | 25 | 70 | 12.49 | . | . | . | . |
| 09AUG90 | 11:05 | D | 5.125 | 25 | 70 | 21.39 | . | . | . | . |
| 09AUG90 | 18:35 | D | 5.125 | 25 | 70 | 17.22 | 3 | . | . | . |
| 09AUG90 | 17:39 | D | 5.875 | 25 | 70 | 18.93 | . | . | . | . |
| 09AUG90 | 10:22 | S | 5.500 | 0 | 40 | 94.18 | . | . | . | . |
| 10AUG90 | 11:25 | D | 3.000 | 25 | 70 | 16.86 | . | 1 | . | . |
| 10AUG90 | 17:49 | D | 3.000 | 25 | 70 | 15.80 | . | . | . | . |
| 10AUG90 | 10:19 | D | 4.625 | 25 | 70 | 14.26 | . | . | . | . |
| 10AUG90 | 18:16 | D | 5.125 | 25 | 70 | 15.81 | 3 | . | . | . |
| 10AUG90 | 10:50 | D | 5.875 | 25 | 70 | 17.40 | 1 | . | . | . |
| 10AUG90 | 18:53 | D | 5.875 | 25 | 70 | 18.39 | 3 | . | . | . |
| 11AUG90 | 12:12 | D | 4.625 | 25 | 70 | 12.30 | 1 | . | . | . |
| 11AUG90 | 20:10 | D | 4.625 | 25 | 70 | 8.14 | . | . | . | . |
| 11AUG90 | 11:28 | D | 5.125 | 25 | 70 | 16.99 | 1 | . | . | . |
| 11AUG90 | 19:36 | D | 5.125 | 25 | 70 | 15.45 | 4 | . | . | . |
| 11AUG90 | 10:55 | D | 5.875 | 25 | 70 | 19.38 | 1 | . | . | . |
| 11AUG90 | 19:05 | D | 5.875 | 25 | 70 | 12.31 | 3 | . | . | . |
| 11AUG90 | 10:39 | S | 3.000 | 0 | 40 | 141.91 | . | 1 | . | 11 |
| 11AUG90 | 10:26 | S | 5.500 | 0 | 40 | 166.49 | . | . | . | . |
| 12AUG90 | 11:58 | D | 3.000 | 25 | 70 | 18.17 | . | . | . | . |
| 12AUG90 | 17:43 | D | 3.000 | 25 | 70 | 21.36 | . | . | . | . |
| 12AUG90 | 10:16 | D | 4.625 | 25 | 70 | 11.36 | . | 1 | . | . |
| 12AUG90 | 10:48 | D | 5.125 | 25 | 70 | 15.81 | . | . | . | . |
| 12AUG90 | 19:03 | D | 5.125 | 25 | 70 | 20.53 | 16 | . | . | . |
| 12AUG90 | 11:18 | D | 5.875 | 25 | 70 | 19.02 | 1 | . | . | . |
| 12AUG90 | 18:17 | D | 5.875 | 25 | 70 | 22.49 | 5 | . | . | . |
| 13AUG90 | 11:49 | D | 3.000 | 25 | 70 | 17.23 | . | . | . | 1 |
| 13AUG90 | 11:11 | D | 4.625 | 25 | 70 | 13.85 | 1 | . | . | . |
| 13AUG90 | 17:58 | D | 4.625 | 50 | 95 | 16.75 | 1 | . | . | . |
| 13AUG90 | 17:04 | D | 5.125 | 40 | 85 | 24.07 | . | . | . | . |
| 13AUG90 | 10:31 | D | 5.875 | 25 | 70 | 19.74 | 3 | . | . | . |
| 13AUG90 | 16:45 | S | 3.000 | 0 | 40 | 53.20 | . | 2 | 1 | 5 |
| 13AUG90 | 10:25 | S | 5.500 | 0 | 30 | 135.34 | 3 | . | . | . |
| 14AUG90 | 12:47 | D | 3.000 | 25 | 70 | 17.43 | 1 | . | . | . |
| 14AUG90 | 10:35 | D | 4.625 | 50 | 95 | 14.10 | . | . | . | . |
| 14AUG90 | 16:28 | D | 4.625 | 25 | 70 | 12.49 | 1 | . | . | . |
| 14AUG90 | 11:56 | D | 5.125 | 25 | 70 | 16.87 | 5 | . | . | . |
| 14AUG90 | 17:05 | D | 5.125 | 25 | 70 | 15.10 | 1 | . | . | . |
| 14AUG90 | 11:02 | D | 5.875 | 50 | 95 | 19.20 | 3 | . | . | . |
| 14AUG90 | 16:07 | S | 3.000 | 0 | 40 | 89.62 | 3 | . | . | 4 |
| 14AUG90 | 16:21 | S | 5.500 | 0 | 40 | 86.03 | . | . | . | . |
| 15AUG90 | 12:24 | D | 3.000 | 25 | 70 | 16.70 | 1 | . | . | 1 |
| 15AUG90 | 11:16 | D | 4.625 | 50 | 95 | 11.99 | . | . | . | . |
| 15AUG90 | 17:35 | D | 4.625 | 25 | 70 | 13.56 | 1 | . | . | . |

(continued)

## APPENDIX A: CONT'D

| DATE | TIME[1] | METH[2] | MESH | MIN[3] RANGE | MAX[4] RANGE | FATHOM[5] HOURS | NUMBER CAUGHT CHUM | CHAR | PINK | WHITE |
|---|---|---|---|---|---|---|---|---|---|---|
| 15AUG90 | 10:23 | D | 5.125 | 25 | 70 | 16.55 | 9 | . | . | . |
| 15AUG90 | 16:31 | D | 5.125 | 50 | 95 | 16.99 | 1 | . | . | . |
| 15AUG90 | 11:46 | D | 5.875 | 50 | 95 | 18.57 | . | . | . | . |
| 15AUG90 | 16:23 | S | 3.000 | 0 | 40 | 54.92 | 1 | . | . | 6 |
| 15AUG90 | 17:29 | S | 5.500 | 0 | 40 | 46.88 | 1 | . | . | . |
| 16AUG90 | 11:31 | D | 3.000 | 40 | 85 | 15.22 | . | . | . | . |
| 16AUG90 | 10:30 | D | 4.625 | 40 | 85 | 11.95 | . | . | . | . |
| 16AUG90 | 10:53 | D | 5.875 | 40 | 85 | 17.53 | 4 | . | . | . |
| 16AUG90 | 10:08 | S | 5.500 | 20 | 40 | 53.60 | 1 | . | 1 | . |
| 16AUG90 | 19:19 | S | 5.500 | 20 | 40 | 35.90 | 7 | . | . | . |
| 17AUG90 | 11:10 | D | 3.000 | 50 | 95 | 17.19 | . | . | . | . |
| 17AUG90 | 11:43 | D | 5.125 | 50 | 95 | 14.63 | 1 | . | . | . |
| 17AUG90 | 16:18 | D | 5.125 | 40 | 85 | 16.52 | 2 | 9 | . | . |
| 17AUG90 | 17:29 | D | 5.875 | 40 | 85 | 20.01 | 7 | . | . | . |
| 17AUG90 | 11:04 | S | 5.500 | 0 | 40 | 84.17 | 1 | . | . | 1 |
| 18AUG90 | 17:39 | D | 3.000 | 25 | 70 | 16.94 | . | 2 | . | 2 |
| 18AUG90 | 17:09 | D | 4.625 | 25 | 70 | 14.57 | . | . | . | . |
| 18AUG90 | 10:47 | D | 5.125 | 40 | 85 | 17.03 | 5 | . | . | . |
| 18AUG90 | 11:37 | D | 5.875 | 40 | 85 | 19.38 | 5 | . | . | . |
| 18AUG90 | 16:23 | D | 5.875 | 25 | 70 | 18.44 | 8 | 1 | . | . |
| 18AUG90 | 10:35 | S | 5.500 | 20 | 35 | 54.42 | 14 | . | . | . |
| 19AUG90 | 10:38 | D | 3.000 | 25 | 70 | 16.25 | . | . | . | . |
| 19AUG90 | 17:10 | D | 3.000 | 25 | 70 | 15.08 | . | 11 | . | 1 |
| 19AUG90 | 11:17 | D | 4.625 | 25 | 70 | 12.87 | 5 | 1 | . | . |
| 19AUG90 | 16:17 | D | 4.625 | 25 | 70 | 13.25 | 5 | 5 | 1 | . |
| 19AUG90 | 17:51 | D | 5.125 | 25 | 70 | 12.50 | 1 | 4 | . | . |
| 19AUG90 | 12:25 | D | 5.875 | 25 | 70 | 19.47 | 16 | 2 | . | . |
| 19AUG90 | 10:32 | S | 5.500 | 0 | 40 | 111.30 | 12 | . | . | . |
| 20AUG90 | 11:05 | D | 3.000 | 20 | 65 | 11.54 | . | . | . | . |
| 20AUG90 | 17:05 | D | 3.000 | 20 | 65 | 12.28 | . | 1 | . | . |
| 20AUG90 | 10:35 | D | 4.625 | 20 | 65 | 8.52 | . | 1 | . | . |
| 20AUG90 | 17:27 | D | 4.625 | 20 | 65 | 9.40 | 4 | . | . | . |
| 20AUG90 | 12:03 | D | 5.125 | 20 | 65 | 11.32 | 1 | 3 | . | . |
| 20AUG90 | 16:26 | D | 5.125 | 20 | 65 | 11.56 | 6 | . | . | . |
| 20AUG90 | 11:25 | D | 5.875 | 20 | 65 | 14.60 | 2 | 2 | . | . |
| 20AUG90 | 18:02 | D | 5.875 | 20 | 65 | 12.85 | 3 | . | . | . |
| 21AUG90 | 10:26 | D | 3.000 | 20 | 65 | 13.01 | . | 1 | . | 1 |
| 21AUG90 | 18:11 | D | 3.000 | 20 | 65 | 13.26 | 1 | 34 | . | . |
| 21AUG90 | 11:47 | D | 4.625 | 20 | 65 | 8.67 | 1 | . | . | . |
| 21AUG90 | 16:26 | D | 4.625 | 20 | 65 | 9.46 | 1 | . | . | . |
| 21AUG90 | 16:54 | D | 5.125 | 20 | 65 | 11.17 | 2 | . | . | . |
| 21AUG90 | 11:05 | D | 5.875 | 20 | 65 | 12.94 | 2 | 3 | . | . |
| 21AUG90 | 17:28 | D | 5.875 | 20 | 65 | 14.06 | 5 | . | . | . |
| 21AUG90 | 10:58 | S | 3.000 | 20 | 40 | 31.17 | . | . | . | . |
| 21AUG90 | 10:58 | S | 3.000 | 20 | 40 | 31.17 | 2 | 21 | . | 5 |
| 22AUG90 | 11:02 | D | 3.000 | 20 | 65 | 11.29 | . | . | . | . |
| 22AUG90 | 18:16 | D | 3.000 | 50 | 95 | 13.63 | . | . | . | . |
| 22AUG90 | 16:53 | D | 4.625 | 50 | 95 | 9.12 | 5 | . | . | . |
| 22AUG90 | 10:27 | D | 5.125 | 20 | 65 | 12.03 | 4 | . | . | . |
| 22AUG90 | 11:29 | D | 5.875 | 50 | 95 | 16.14 | 5 | . | . | . |
| 22AUG90 | 17:34 | D | 5.875 | 20 | 65 | 12.62 | 7 | . | . | . |
| 23AUG90 | 10:34 | D | 3.000 | 50 | 95 | 11.58 | 1 | . | . | . |
| 23AUG90 | 17:46 | D | 3.000 | 20 | 65 | 11.54 | . | . | . | . |
| 23AUG90 | 11:29 | D | 4.625 | 20 | 65 | 9.65 | . | 6 | . | . |
| 23AUG90 | 17:20 | D | 4.625 | 35 | 80 | 7.82 | 1 | . | . | . |

(continued)

| DATE | TIME[1] | METH[2] | MESH | MIN[3] RANGE | MAX[4] RANGE | FATHOM[5] HOURS | NUMBER CAUGHT CHUM | CHAR | PINK | WHITE |
|---|---|---|---|---|---|---|---|---|---|---|
| 23AUG90 | 11:00 | D | 5.125 | 50 | 95 | 11.95 | 2 | . | . | . |
| 23AUG90 | 12:03 | D | 5.875 | 20 | 65 | 13.52 | 1 | . | . | . |
| 23AUG90 | 16:29 | D | 5.875 | 35 | 80 | 12.17 | 11 | . | . | . |
| 24AUG90 | 10:28 | D | 3.000 | 20 | 65 | 12.28 | . | 14 | . | . |
| 24AUG90 | 17:38 | D | 3.000 | 35 | 80 | 11.54 | . | 14 | . | . |
| 24AUG90 | 11:34 | D | 4.625 | 20 | 65 | 10.03 | . | 1 | . | . |
| 24AUG90 | 11:11 | D | 5.125 | 20 | 65 | 11.09 | . | . | . | . |
| 24AUG90 | 16:29 | D | 5.125 | 20 | 65 | 12.50 | 4 | . | . | . |
| 24AUG90 | 17:11 | D | 5.875 | 35 | 80 | 12.71 | . | . | . | . |
| 25AUG90 | 12:09 | D | 3.000 | 20 | 65 | 10.35 | . | 10 | . | . |
| 25AUG90 | 17:17 | D | 3.000 | 20 | 65 | 11.70 | . | . | . | . |
| 25AUG90 | 17:42 | D | 5.125 | 35 | 65 | 11.32 | 11 | . | . | . |
| 25AUG90 | 12:49 | D | 5.875 | 20 | 65 | 12.80 | 1 | . | . | . |
| 25AUG90 | 16:50 | D | 5.875 | 35 | 80 | 14.33 | . | . | . | . |
| 26AUG90 | 12:20 | D | 3.000 | 20 | 65 | 11.54 | . | 1 | . | . |
| 26AUG90 | 16:18 | D | 3.000 | 45 | 90 | 12.28 | 1 | 3 | . | . |
| 26AUG90 | 12:55 | D | 4.625 | 45 | 90 | 8.52 | 5 | . | . | . |
| 26AUG90 | 17:15 | D | 5.125 | 20 | 65 | 13.53 | . | . | . | . |
| 26AUG90 | 11:41 | D | 5.875 | 20 | 65 | 12.80 | 5 | . | . | . |
| 26AUG90 | 16:56 | D | 5.875 | 45 | 90 | 15.42 | . | . | . | . |
| 27AUG90 | 12:50 | D | 3.000 | 20 | 65 | 13.26 | . | 7 | . | 1 |
| 27AUG90 | 13:44 | D | 4.625 | 50 | 95 | 8.33 | 4 | . | . | . |
| 27AUG90 | 12:10 | D | 5.125 | 20 | 65 | 10.85 | 9 | . | . | . |
| 27AUG90 | 14:15 | D | 5.875 | 50 | 95 | 15.06 | 3 | . | . | . |
| 28AUG90 | 12:35 | D | 3.000 | 20 | 65 | 14.36 | 2 | 3 | . | 1 |
| 28AUG90 | 11:55 | D | 5.125 | 20 | 65 | 18.64 | 2 | . | . | . |
| | | | | | | ======== | ==== | ===== | ==== | ===== |
| | | | | | | 5810.98 | 400 | 174 | 25 | 98 |

(1) Start of net deployment.
(2) Method: S = set, D = drift.
(3,4) Minimum and maximum distance of net from right bank. On 21-23 July several drifts were made approx. 1 km upstream from the sonar site, where the river is 300+ meters wide.
(5) Area of net in square fathoms X hours deployed.

# APPENDIX B: SAS DATA PROCESSING PROGRAM

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

*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 save.sonarcts;
        infile 'f:\n90\counts\n0counts.prn';
        length counter $3;
        informat startime endtime time5.;
        input month 1 day 3-4 year 6-7 @9 startime @15 endtime @21 counter $
        count1 27-29 count2 33-35 count3 39-41 count4 45-47 count5 51-53;
        count=sum(of count2-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;

*OPTIONAL BAR CHARTS OF HOURLY SONAR COUNTS BY DAY;
/*proc chart data=save.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=save.sonarcts;
        var min15psg;
        by dst2hr;
        output out=pass2hr mean=meanpass;        run;

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

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

## APPENDIX B CONT'D

```
*CREATE FILES OF ESTIMATED PASSAGE EVERY 2 AND 6 HOURS FOR CONSTRUCTION OF
GRAPHS IN LOTUS 123;
data print; set pass2hr;
file 'f:\n90\counts\n02hrcts.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;
file 'f:\n90\counts\n06hrcts.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_);
        reportno=round(date-1,2)-11159;
        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 save.n0tfish;
  length qmeth qsex $3;
  length meth sex $1;
  length species $8;
  infile 'f:\rbfiles\n0tfish.dlm' delimiter=',';                  *PATH;
  informat date mmddyy.  startout fullout startin fullin time8.;
  format date date7. startout fullout startin fullin time5.;
```

```
  input date tfperiod site mesh netlngth qmeth range1 range2
    startout fullout startin fullin spcode qsex length;
  reportno=round(date-1,2)-11159;
  IF REPORTNO LT 0 THEN DELETE;
  meth=substr(qmeth,2,1);
  if meth='d' then meth='D';
  if meth='s' then meth='S';
  if mesh=3.0 then meshdeep=80;
  if mesh=4.625 then meshdeep=40;
  if mesh=5.125 then meshdeep=45;
  if mesh=5.5 then meshdeep=55;
  if mesh=5.875 then meshdeep=45;
  netdepfm=(mesh/sqrt(2))*meshdeep/72;
  squarfms=netlngth*netdepfm;
  sex=substr(qsex,2,1);
  if sex='f' then sex='F';
  if sex='m' then sex='M';
  drifsecs = (startin-fullout) + (fullout-startout)/2 + (fullin-startin)/2;
  fathhrs= squarfms*drifsecs/3600;
  catch=1;
  if spcode=0 then catch=0;
  drop qmeth qsex fullout startin fullin drifsecs;
  if spcode = 1 then  species = 'CHINOOK ';
  if spcode = 2 then  species = 'CHUM';
  if spcode = 3 then  species = 'CHARR';
  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 mesh=3.0 then meshcode=1;
  if mesh=4.625 or mesh=4.5 then meshcode=2;
  if mesh=5.125 then meshcode=3;
  if mesh=5.5 then meshcode=4;
  if mesh=5.875 then meshcode=5;  run;

*GENERATE CPUE DATA FOR COMPARISON WITH DOWNRIVER TESTFISH PROJECT;
data tfishrpt; set save.n0tfish;
  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;
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';
```

## APPENDIX B CONT'D

```
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=save.n0tfish; by date tfperiod mesh startout species;
proc summary data=save.n0tfish;
  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=save.n0tfish;
  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;
  var sppcatch;
  id species;  run;

data tfsummar; merge tfsummar drifsets; by date tfperiod mesh startout; run;

data tfsummar; set tfsummar (drop=_type_ _freq_);
  format date date7. startout time5. effort 8.2;
  label effort='FATHOM HOURS';  run;

proc sort data=tfsummar; by date meth mesh startout; run;
title2 'SUMMARY OF TESTFISH RESULTS';
title3 'major species listed only';
proc print data=tfsummar label;
  var date startout meth mesh rangel range2;
  sum effort 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;
```

## APPENDIX B CONT'D

```
data effort; merge effort1 effort2; by date tfperiod;
  drop _name_ _type_ _freq_;
  rename _3     =effort1;
  rename _4d625 =effort2;
  rename _5d125 =effort3;
  rename _5d5   =effort4;
  rename _5d875 =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 'f:\n90\sas\n0spmesh.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 'f:\n90\sas\n0snorm.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 _3     =sm1;
  rename _4d625 =sm2;
  rename _5d125 =sm3;
  rename _5d5   =sm4;
  rename _5d875 =sm5;  run;
proc transpose data=nsnormal out=std;
  var stddev; id mesh;
  by species; run;
data std; set std;
  drop _name_;
  rename _3     =std1;
  rename _4d625 =std2;
  rename _5d125 =std3;
  rename _5d5   =std4;
  rename _5d875 =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=save.n0tfish; by species; run;
proc sort data=specmesh; by species; run;
```

APPENDIX B CONT'D

```
data tfsm;
  merge save.n0tfish(in=a) specmesh;
  by species;
  if a;
  array usemesh{5} usemesh1-usemesh5;
  if usemesh{meshcode}=0 then delete;  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;

*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 save.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 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=4;
    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;
```

APPENDIX B CONT'D

```
*OPTIONAL PRINTOUT FOLLOWS: SHOWS INTERMEDIARY CALCULATIONS ON TESTFISH DATA;
options linesize=120;
data print; set save.tfsmnsef;
title2 'PART OF DATA SET SAVE.TFSMNSEF';
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';
  proc print data=print;
  var date startout mesh species length
      z pdf adjcatch
      zother1-zother5 sumeff adjcpue;  run;

*SUM ADJUSTED CPUE FOR EACH SPECIES DURING EACH TESTFISH PERIOD;
proc sort data=save.tfsmnsef; by reportno date tfperiod spcode;
proc summary data=save.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;

*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;
```

## APPENDIX B CONT'D

```
*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;
  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='CHARR' 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';
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);
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='CHARR' phatrp4='PIKE'
      phatrp5='PINK' phatrp6='SHEEFISH' phatrp7='WHITE' phatrp8='FLOUNDER'
      phatrp9='OTHER' phatrp10='CISCO' phatoth='OTHER';
  label stdprp2='CHUM S.E.' stdprp3='CHARR 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 save.reptstat;
  merge varprop reptpasg;
  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;

data save.reptstat; set save.reptstat (drop = _type_ _freq_);
  file 'f:\n90\sas\n0repsht.dat';                                    *PATH;
  label reportno='REPORTING PERIOD' date='ENDING ON';
  label psg1='CHINOOK' psg2='CHUM' psg3='CHARR' 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=save.reptstat;
  var reportno date;
  sum psg2 psg3 psg5 psg7 psg1 psg4 psg6 psg8 psg10 psg9;  run;

proc summary data=save.reptstat;
  var psg1-psg10 varpsg1-varpsg10 date;
  output out=cumstat sum(psg1-psg10)=cumpsg1-cumpsg10
                     sum(varpsg1-varpsg10)=varcp1-varcp10
                     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 CHARR';
  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;
*  df=nreports-1;
*  l90ci=cumulpsg-tinv(.95,df)*stderr;
*  if l90ci < 0 then l90ci = 0;
*  u90ci=cumulpsg+tinv(.95,df)*stderr;
  format cumulpsg /*l90ci u90ci*/ 8. variance e10. stderr 7. cv 4.3;
  label nreports='REPORTS TO DATE' /*df='DEGREES OF FREEDOM'*/
    stderr='ESTIMATED STANDARD ERROR' cv='COEFFICIENT OF VARIATION'
    /*l90ci='LOWER LIMIT 90% CONFIDENCE INTERVAL'
    u90ci='UPPER LIMIT 90% CONFIDENCE INTERVAL'*/;  run;

proc sort data=cumstat2; by species; run;
title2 'CUMULATIVE STATISTICS BY SPECIES';
proc print noobs label;
  var nreports /*df*/ species cumulpsg stderr cv /*l90ci u90ci*/;  run;
```

## APPENDIX C: NET SELECTIVITY PARAMETER FILE USED BY SAS PROGRAM

NSNORMAL.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 following mesh pairs for that species: chum 5.125, 5.875; charr 4.625, 5.125; pink 4.0 5.0 (from yukon 86-89 data: gilled fish only). Then selectivity curve means (SCM's) for other 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 charr. Bin size was 20mm for chum, 40mm for charr.

| | | | |
|---|---|---|---|
| CHARR | 3.0 | 330.4 | 55.4 |
| CHARR | 4.625 | 509.3 | 55.4 |
| CHARR | 5.125 | 564.3 | 55.4 |
| CHARR | 5.875 | 646.9 | 55.4 |
| CHUM | 4.625 | 506.5 | 60.5 |
| CHUM | 5.125 | 561.3 | 60.5 |
| CHUM | 5.875 | 643.4 | 60.5 |
| PINK | 3.0 | 274.9 | 50.2 |
| PINK | 4.625 | 423.8 | 50.2 |
| PINK | 5.125 | 469.6 | 50.2 |