Fecundity of Chum and Coho Salmon from the Unalakleet River, Alaska

2002 Annual Report

prepared for the

NORTON SOUND DISASTER RELIEF FUND

Fecundity of Chum and Coho Salmon from Norton Sound, Alaska

2002 Annual Report

Prepared by

Matt Nemeth, Beth Haley

LGL ALASKA RESEARCH ASSOCIATES, INC.
1101 E. 76th St, Suite B
Anchorage, AK 99518

and

Simon Kinneen

NORTON SOUND ECONOMIC DEVELOPMENT CORPORATION
420 "L" Street, #310
Anchorage, AK 99501

August 2003

Suggested format for citation:

Nemeth, M., B. Haley, and S. Kinneen. 2003. Fecundity of chum and coho salmon from Norton Sound, Alaska. Unpublished report for the Norton Sound Disaster Relief Fund by LGL Alaska Research Associates, Inc. and Norton Sound Economic Development Corporation. 25 p. + appendix.

TABLE OF CONTENTS

LIST OF TABLES ii
LIST OF FIGURES ii
LIST OF APPENDICES iii
EXECUTIVE SUMMARY 1
INTRODUCTION 2
STUDY AREA 3
METHODS 3
- Sample Collection and Storage 3
- Fecundity Estimate Study Design 4
- Data Analysis 5

RESULTS 6
- Run Timing, Age Classes and Fish Size 6
- Fecundity 6
  - Absolute fecundity mean and variance 6
  - ANOVA results 6
  - Fecundity vs. length 7
  - Relative fecundity 7
  - Standardized lengths 7
- Comparison of Fecundities among Fish Populations 7

DISCUSSION 7
CONCLUSIONS AND RECOMMENDATIONS 9
ACKNOWLEDGEMENTS 10
LITERATURE CITED 10

LIST OF TABLES

Table 1. Fecundity and length statistics for coho and chum salmon sampled from the Unalakleet River, 2002. 12

Table 2. ANOVA table for the effects of length and age on absolute fecundity of chum salmon sampled from the Unalakleet River in 2002. 13

Table 3. ANOVA table for the effects of length and run group (early vs. late) on fecundity of coho salmon sampled from the Unalakleet River in 2002. 14

LIST OF FIGURES

Figure 1. Map of study region and the Unalakleet River 15

Figure 2a. Entry times of salmon sampled for fecundity and of all chum salmon captured in the ADF&G test fishery in 2002. 16

Figure 2b. Entry times of salmon sampled for fecundity and of all coho salmon captured in the ADF&G test fishery in 2002 16

Figure 3a. Histogram of fecundities (absolute and cumulative %) of Unalakleet River chum salmon, 2002. 17

Figure 3b. Histogram of fecundities (absolute and cumulative %) of Unalakleet River coho salmon, 2002. 17

Figure 4. Boxplots showing absolute and relative fecundity by age class for chum salmon from the Unalakleet River, 2002. 18

Figure 5a. Regression of chum salmon absolute fecundity versus fish length (mm), Unalakleet River, 2002.. 19

Figure 5b. Regression of coho salmon absolute fecundity versus fish length (mm), Unalakleet River, 2002. 19

Figure 6a. Regression of chum salmon relative fecundity (eggs/ cm) vs. entry date to the Unalakleet River, 2002.. 20

Figure 6b. Regression of coho salmon relative fecundity (eggs / cm) vs. entry date to the Unalakleet River, 2002.. 20

Figure 7. POH length vs. absolute fecundity for chum and coho salmon from Unalakleet River, 2002. 21

Figure 8. Relative fecundity (eggs / cm length) of chum salmon from the Unalakleet River Compared to those from other North American rivers reported by Salo (1991).. 22

Figure 9. Fecundity (absolute) of coho salmon from the Unalakleet River compared to other North American populations reported by Sandercock (1991). 23

Figure 10. Fecundity of various chum salmon populations at POH lengths standardized to 58.8 cm (Beacham 1982)....24

Figure 11. Fecundity of various coho salmon populations at POH lengths standardized to 53.6 cm (Beacham 1982).. 25

LIST OF APPENDICES

Appendix A. Data used to report fecundity for chum and coho salmon returning to the Unalakleet River in 2002. 26

EXECUTIVE SUMMARY

Salmon fecundity is important because it places an upper limit on the egg deposition and eventual fry production of the population. Knowledge of egg deposition and fry production can benefit fisheries management by, among other things, improving estimates of habitat seeding, overwinter survival, and spawner-recruit correlations. In 2002, the fecundity of chum and coho salmon returning to the Unalakleet River, Alaska, was measured to generate initial fecundity estimates for the Norton Sound region. Approximately 100 fish of each species were collected by the Alaska Department of Fish and Game (ADF&G) during their annual test fishery on the Unalakleet River. Fish were measured for length (mid-eye to tail fork; or MEF), a scale was removed for age determination, and both egg skeins were removed and frozen. Egg skeins were then shipped to Anchorage, where they were later thawed and processed for fecundity counts. Fecundity was estimated by collecting subsamples of eggs from each skein, counting the eggs in each subsample, and multiplying the subsample count by the proportion of the total skein weight to the subsample weight. Subsamples were taken from three areas of each skein, and a replicate fecundity estimate was generated for each egg skein. Fish fecundity was take as the sum of the mean egg estimate for both skeins of each fish. The mean fecundity was 2,809 eggs (SE = 53) for chum salmon and 5,335 (SE = 1) for coho salmon. The effects of variables on fecundities (length and age for chum salmon and length and run timing for coho salmon) were tested with ANOVA. Length was the only factor found to have a significant influence on fecundities, and length influenced fecundity of both chum and coho salmon. Because fecundity varied with fish length, the relative fecundity was calculated and reported as eggs per cm of body length (MEF). The mean relative fecundity was 47 egg/cm (SE = 0.9) for chum salmon and 87.8 eggs/cm (SE = 2.2) for coho salmon. The relative fecundity of Unalakleet River chum salmon was higher than the fecundities of 11 populations reported by Salo (1991), and the total fecundity of Unalakleet River coho salmon was higher than the 12 populations reported by Sandercock (1991). MEF lengths of Unalakleet River chum and coho salmon were then converted to postorbital-hypural (POH) lengths to compare fecundities to published values that report POH lengths (Beacham 1982). Linear regression was used to establish relationships between fecundity and POH length for each species. Fecundities were then predicted at the standardized POH lengths (58.8 cm for chum salmon and 53.6 cm for coho salmon) used by Beacham (1982) to compare fecundities of salmon from the Unalakleet River to the fecundities reported by Beacham (1982) and Beacham and Murray (1993). Standardized mean fecundities were 2,904 eggs (SE = 57) for chum salmon and 4,672 eggs (SE = 175) for coho salmon. When standardized, the Unalakleet River chum fecundities were slightly lower than those reported by Beacham (1982) and the coho fecundities were slightly higher. Unalakleet River chum and coho salmon had high actual fecundities compared to populations reported in the literature, and coho salmon had high relative fecundities after accounting for fish body length. In 2003, the chum and coho salmon should again be sampled from the Unalakleet River to estimate interannual variability in fecundity. Chum and coho salmon should also be sampled from at least one other river to describe variation among spawning populations.

INTRODUCTION

Salmon fecundity – the number of eggs produced by a female fish – is important to fisheries management because it affects the potential reproductive capacity of a spawning population (Skaugstad and McCracken 1991). Fecundity data also assist with estimates of habitat seeding rates (Healey and Heard 1984), egg survival, and the back-calculation of the number of adults needed to achieve different rates of habitat seeding. The reproductive capacity of a population is important for management actions such as the development of biological escapement goals (BEGs) because populations that have lower production potential may require greater numbers of spawners to achieve the same level of production as a population with higher production potential. Salmon fecundity can vary among regions, among years, and within watersheds (Salo 1991), and the extent of this variability can further influence population dynamics and production potential (Beacham 1982).

Salmon fecundity can be an inherited trait and may be associated with any of several variables. Fecundity is known to be influenced by fish body length in chum and coho salmon (Salo 1991; Sandercock 1991) and by latitude in coho salmon (Sandercock 1991), and can also be associated with other variables such as egg size, inriver migration distance, and run time (Salo 1991; Beacham and Murray 1993). Large salmon, for example, often carry more eggs than small salmon (Skaugstad and McCracken 1991). In addition to population size, sex ratio, and fecundity, knowledge of the association between fecundity and fish characteristics is needed to accurately assess the reproductive capacity of the population.

Salmon fecundity is an important concern in Norton Sound, Alaska, because of recent substantial declines in the abundance of salmon returning to many Norton Sound tributaries. The average annual commercial salmon catch for the five years from 1998 to 2002 were the lowest for chum salmon since record-keeping began in 1961, and the lowest for coho salmon since 1979 (ADF&G 2002). The subsistence fishery has had similar declines in catch levels and harvest opportunity since 1998 (Menard 2001; ADF&G 2002). These declines have led to speculation that salmon production may be affected by reproductive capacity and the subsequent seeding of spawning grounds (e.g., Clark 2001). Fecundities of Norton Sound chum and coho salmon have not been assessed, however, and potential salmon production is thus unknown.

The Norton Sound Disaster Relief fund identified a need for estimates of chum and coho salmon fecundity (NSRRP 2002) and provided funding to estimate the fecundity of salmon returning to the Unalakleet River. In 2002, ovaries were thus taken from fish that were captured as part of the Unalakleet River test fishery, which is independent of the fecundity study and is operated each year by the Alaska Department of Fish and Game as part of their assessment effort in the region. The goal of the project in the first year was to provide initial estimates of Norton Sound coho and chum salmon fecundity, assess correlations between fecundity and fish characteristics, and to provide a basis for comparison within and outside of the region. The specific objectives of the project were to:

1) Estimate fecundity of chum and coho salmon returning to the Unalakleet River in 2002;

2) Determine the relationship between fecundity, age, and size;
3) Evaluate the feasibility of using Norton Sound fisheries to opportunistically collect biological data such as fecundity estimates, and;
4) Provide a basis for future estimates of spatial and temporal variability in fecundity.

STUDY AREA

The Unalakleet River arises in the Nulato Hills of western Alaska and runs approximately 210 km westward to empty into the Bering Sea in eastern Norton Sound (Figure 1; Kohler 2002). The river is one of the largest in the region, draining approximately 2,815 km^2, and is the largest producer of salmon in Norton Sound (Kohler 2002). Chinook, coho, chum, sockeye, and pink salmon all return to the Unalakleet River and spawn at various locations in the drainage. The river is fed by snow melt and rainfall; maximum flows are typically in June and minimum flows are typically in March. The United States Geological Survey (USGS) operates a water station on the Unalakleet River approximately 41 km upstream of its mouth, east of the confluence of the Chiroskey River. Since 1997, mean monthly flows have ranged from 103 ft^3/sec in March to 4,011 ft^3/sec in June.

The Unalakleet River salmon runs support a commercial fishery in Norton Sound and a subsistence fishery in the river and in Norton Sound. ADF&G conducts an annual test fishery to index the salmon run strength and help manage these fisheries. The test fishery has operated since 1981 at a site 5 km upstream from Norton Sound and the town of Unalakleet. In 2002, the test fishery operated from June 3 to September 8. The test net was fished from the northern edge of the river, six days per week, and all captured fish were retained for subsequent biosampling in Unalakleet (Kohler 2002).

METHODS

Chum and coho salmon ovaries were collected from fish sampled from the ADF&G's annual test net fishery on the Unalakleet River. Ovaries were removed from the fish by ADF&G staff in Unalakleet, frozen for several months, shipped to Anchorage, and subsampled for fecundity estimates by Norton Sound Economic Development Corporation (NSEDC) staff.

Sample Collection and Storage

Chum and coho salmon used for fecundity analysis were captured in a 37 m (20 fathom) gillnet with 14.9 cm (5 – 7/8 inch) stretched mesh. Nets were checked twice per day, and all captured fish were assumed to have entered the river from the ocean within a few hours of capture.

Within 24 hours of being caught, the fish were transported by skiff to the town of Unalakleet and sampled for age, sex and length data (a standard ADF&G sampling routine). As part of their standard sampling procedure, ADF&G staff measured each fish to the nearest millimeter from mid-eye to tail fork (MEF), removed scales from the preferred area of each fish, and preserved the scales

on a gum card (Skaugstad and McCracken 1991). Ages were then calculated by scale analysis conducted by ADF&G staff from Nome. For this fecundity study, egg skeins were removed from chum and coho salmon, placed in labelled plastic bags and stored in a freezer at the Norton Sound Seafood Plant in Unalakleet. Egg skeins were collected from most female coho salmon and approximately every 2nd female chum salmon to evenly distribute the target sample size (100 female fish of each species) among the anticipated total test fishery catch (average catch of 194 total coho salmon and 764 total chum salmon in the test fishery from 1997 to 2001; Kohler 2002). Eggs were then shipped to Nome and Anchorage for storage before processing for fecundity estimates.

Fecundity Estimate Study Design

Egg skeins from approximately 10 fish were removed from the freezer, thawed, and weighed to the nearest 0.01 g on a digital balance (Ohaus Navigator, model #N14120-2A1). Two subsamples of approximately 100 eggs each were collected from each skein; the subsample was composed of approximately 35 eggs each from the middle of the skein and 1/3 of the way from each end of the skein. Care was taken to collect whole eggs and avoid including egg fragments in the subsample. Each replicate was weighed to the nearest 0.01 g on the digital balance, and the number of eggs within it then counted.

Fecundity estimates were derived from the subsample egg count and the ratio of the egg skein weight to the subsample weight, similar to the methods of Skaugstad and McCracken (1991). The number of eggs in each skein was estimated by dividing the egg skein weight by the subsample weight, then multiplying by the number of eggs in the subsample. The process was replicated by repeating it with a second subsample, and the number of eggs in a skein was estimated as the average of the two replicates. The individual fish fecundity was estimated as the sum of the estimated egg count of both skeins (Equations 1 and 2).

$$f_{ij} = \frac{(G_j)(Egg_{ij})}{g_{ij}}; \qquad (1)$$

$$\text{Fecundity} = \frac{\sum f_{ij}}{n}; \qquad (2)$$

and

$$\text{Variance(Fecundity)} = \frac{\sum (f_{ij}) - F)^2}{n(n-1)}; \qquad (3)$$

where:

f_{ij} = estimated fecundity based on sub-sample i from ovary j;

G_j = weight of ovary j;

Egg_{ij} = number of eggs in sub-sample i from ovary j;

g_{ij} = weight of sub-sample i from ovary j;

F = Mean fecundity of individual fish k;

n = Number of egg group sub-samples taken from fish k, and;

V = Variance of mean fecundity of fish k.

Egg skeins from five fish of each species, selected randomly, were retained for total counts (including their subsamples) to check the accuracy of the fecundity estimates. These counts will be conducted in the spring of 2003 and reported in the next progress report.

Data Analysis

Chum and coho samples were separated into categories of run timing and age. The capture dates of the fish sampled for fecundity were compared to the capture dates of all the fish caught in the test fishery, and then assigned to different run time group according to their capture date in the test fishery. Fish ages were obtained from scale analyses conducted by ADF&G staff from Nome.

Mean and variance in fecundity and length were reported for each species, both for the entire sample and for individual categories of age and run time group. The effects of fish length, age, and run time group on fecundity were tested using analysis of variance (ANOVA; Systat 9, 1999). Variables with significant effects were then regressed against fecundity to obtain an estimate of the slope of the line.

Because fecundity is known to vary with fish length (Beacham and Murray 1993), the relative fecundity was also calculated as the fecundity divided by body length, and reported in units of eggs per cm of body length. This value was computed for each fish and was analysed for the sample population in the same way length and actual fecundity was. For the purposes of this report, absolute fecundity will refer to the total number of eggs estimated to be in each fish, and relative fecundity will refer to the number of eggs per cm of body length.

Fecundities of Unalakleet River salmon were compared to fecundities from other salmon populations reported in the literature. Absolute fecundity of Unalakleet River coho salmon, in total eggs per fish, was compared to populations reported by Sandercock (1991). Relative fecundity of chum salmon, in eggs/cm, was compared to North American populations reported by Salo (1991).

For further comparison of Unalakleet River fish fecundities to those of other fish populations, the MEF length of the Unalakleet River fish was converted to the postorbital-hypural (POH) length using the species-specific formulas from Beacham (1982). Simple linear regression was used to describe the relationship between POH length and absolute fecundity for coho and chum salmon. The regression equations were then used to predict fecundity at the standardized POH lengths (58.8 cm for chum salmon, 53.6 cm for coho salmon) used by Beacham (1982) to compare fecundity

among populations. Standard errors for predicted fecundity at the standard length were calculated using equation 16.26 of Zar (1996).

RESULTS

Run Timing, Age Classes and Fish Size

Chum salmon sampled for fecundity represented a relatively brief period of the overall run in the Unalakleet River (Figure 2a). Therefore, the sampled chum salmon were not assigned to different run periods for analysis. Coho salmon sampled for fecundity were distributed throughout the overall Unalakleet River coho run (Figure 2b.). Sampled coho salmon were allotted to an early run group from August 5 to August 22 (N = 49) and a late run group from August 29 to September 5 (N = 55).

The age distribution of Unalakleet River chum salmon sampled for fecundity was 39% age 0.3, 53% age 0.4 and 8% age 0.5 (Table 1). Age information for coho salmon caught in the 2002 test fishery is not yet available from ADF&G.

The mean (SE) fish length (MEF) of all sampled chum salmon was 597 mm (2) and 607 mm (3) for coho salmon (Table 1). Age 0.3 chum salmon averaged 590 mm (3), age 0.4 averaged 601 mm (3) and age 0.5 averaged 610 mm (11).

Fecundity

Absolute fecundity mean and variance

The mean (SE) absolute fecundity of fish sampled from the Unalakleet River was 2,809 (53) for chum salmon and 5,335 (89) for coho salmon (Table 1). Fecundity distributions were approximately normal for each species (Figures 3a and 3b). Chum salmon had mean fecundities of 2,577 (78) eggs at age 0.3, 2,963 (72) eggs at age 0.4 and 2,935 (147) eggs at age 0.5 (Figure 4a).

ANOVA results

Chum salmon fecundity was significantly influenced by fish length ($F = 4.191$, $P = 0.044$) but not by age ($F = 0.293$, $P = 0.746$; Table 2). The interaction between the age and length was not significant ($F = 0.335$, $P = 0.717$). Run timing effect on the fecundity of Unalakleet River chum salmon was not analysed because the sampled fish did not represent a wide enough range of the overall run to justify categorizing into different run time groups.

Coho salmon fecundity was significantly influenced by fish length (F = 9.378, P = 0.003,) but not by run timing group (F = 0.051, P = 0.821; Table 3). The influence of age on coho salmon fecundity will be evaluated when age data is available, and will be reported in the next annual report.

Fecundity vs. length

The linear regression of absolute fecundity versus length was y = 8.2541x – 2,120.6 for chum salmon and y = 11.195x – 1,492 for coho salmon (Figs 5a and 5b). Although the spread of data was wide, the correlation was significant for both chum (P = 0.0075, R^2 = 0.1132) and coho salmon (P = 0.001, R^2 = 0.1382).

Relative fecundity

The mean relative fecundity for all sampled chum salmon was 47 eggs/cm (SE = 0.9; Table 1). Relative fecundities by age class were 43.7 eggs/cm (SE = 1.3) for age 0.3, 49.3 eggs/cm (SE = 1.2) for age 0.4 and 48.1 eggs/cm (SE = 2.4) for age 0.5 (Table 1, Figure 4b). The mean relative fecundity for Unalakleet River coho salmon was 87.8 eggs/cm (SE = 1.3; Table 1).

The regression of relative fecundities against run timing was not significant for chum (P = 0.6207, R^2 = 0.0026) and coho salmon (P = 0.0052, R^2 = 0.0809; Figures 6a and 6b) from the Unalakleet River.

Standardized lengths

When converted from MEF to POH lengths, the mean (SE) POH length of chum salmon was 57.7 mm (SE = 0.2) and 58.6 mm (SE = 0.3) for coho salmon. The correlation of POH length and absolute fecundity yielded regression equations of y = 88.753x – 2,314.1 for chum and y = 132.03x – 2404.1 for coho salmon (Figure 7). Based on these equations, standardized fecundities (53.6 cm for chum salmon, 58.8 cm for coho salmon) were 2,904 eggs (SE = 57) for chum salmon and 4,672 eggs (SE = 175) for coho salmon.

Comparison of Fecundities among Fish Populations

The mean relative fecundity of 47 eggs/cm for 2002 Unalakleet River chum salmon was higher than the relative fecundities of 11 North American populations presented by Salo (1991; Figure 8). When standardized to 58.8 cm POH length, however, the absolute fecundity of chum salmon was slightly lower than the range reported by Beacham (1982) for other North American populations (Figure 9). The mean absolute fecundity of Unalakleet River coho salmon was higher than the absolute fecundities of the 13 North American and Russian populations reported by Sandercock (1991; Figure 9). When standardized to 53.6 cm, Unalakleet River coho salmon also had higher fecundities than those reported by Beacham (1982) for other North American populations (Figure 11).

DISCUSSION

Both chum salmon and coho salmon had average or high fecundities compared to the literature, whether it was for fecundities that were observed, relative (egg / cm), or standardized to a set length.

The only inconsistency in the 2002 data was that chum salmon had high relative fecundities compared to populations reported by Salo (1991; Figure 8) but only average standardized fecundities when compared to populations reported by Beacham (1982; Figure 9). This inconsistency may be due to inherent differences in the data reported by Beacham (1982) and Salo (1991), or to inadequacies in the formula for converting from MEF to POH body lengths (Beacham 1982) for salmon from Norton Sound.

The relationships between salmon fecundity and other variables in this study were consistent with those reported in the literature. Fecundity is known to be associated with body length for both species (Salo 1991; Sandercock 1991), chum salmon fecundity is not typically influenced by age (Salo 1991), and coho salmon fecundity is not thought to be affected by run timing (Sandercock 1991). The high coho salmon fecundities from the Unalakleet River are consistent with the trend of increasing coho fecundities with latitude (Sandercock 1991; Figure 10; Figure 11). The interpretation of chum salmon fecundity and latitude is less clear because of the conflict between standardized and relative fecundities from the 2002 data, and the poor information available from the literature (as per Salo 1991). On the one hand, the standardized fecundities of Unalakleet River chum were similar to those reported for other populations at lower latitudes (Figure 9), and there was therefore no evidence of a trend with latitude. On the other hand, the relative fecundities (eggs / cm body length) of Unalakleet River chum were higher than those reported for populations at lower latitudes (Figure 9). Although the 2002 data are insufficient to detect a latitudinal trend, the high relative fecundities are consistent with a weak correlation between latitude and fecundity for summer chum from Asia. The absence of such a trend in North America may be due as much to a general lack of data from high-latitude populations (e.g., Salo 1991) as to the true absence of a trend. Additional samples from populations within and around the Norton Sound region will be needed to determine whether such a trend exists.

Comparisons of fecundity among populations need to be interpreted carefully because populations from different regions may need different fecundities – relative or observed – to be evolutionarily successful. Fish fecundity realistically involves trade-offs in investment of energy in the individual vs. its offspring (Beacham and Murray 1993), and such trade-offs may be the cause of the frequent influence of latitude on fecundity (e.g., Fleming and Gross 1990). Realistically, the best inferences about the relative health of Norton Sound salmon fecundities may come from comparisons to other populations from similar latitudes. Such data are much fewer than they are for more southern populations, and are currently limited mostly to fish from the Yukon River and the Asian continent. Studies of variability over time and among Norton Sound drainages would also provide useful information for assessing the fecundity-related production issues in the region.

The 2002 data described in this report should be representative of the larger Unalakleet River chum and coho salmon populations. Sample size was high (> 90 fish) for each species, fecundity distributions were approximately normal (Figures 3a and 3b), and the estimates of the mean had relatively low 95% confidence intervals (chum salmon = 2809 +/- 105, coho salmon = 5335 +/- 174; Table 1). Most information analyzed thus far indicates that age, run timing, and size of sampled fish were similar to historical population data for the river (Kohler 2002). Chum salmon were sampled

from within a relatively narrow time window of the overall 2002 run, but age and size composition of sampled fish was similar to data from the 2001 run, the latest year for which populations data are available. Coho salmon sampled in 2002 were longer than fish sampled in 2001 (mean MEF of 607 mm in 2002 sample group vs. 568 mm in 2001 population), but the 2002 samples came from throughout the coho run and 2002 population data are not yet available for comparison.

Attempts to collect fish from the Eldorado River subsistence fishery were not successful because of low fish runs that limited opportunity by subsistence fishers, because of the displacement of some subsistence fishers from the river to the ocean, and because of the lack of advance planning by the study leaders. In 2002, samples were targeted by visiting the Eldorado River during fishing openers, but this strategy failed to find enough fishers during any of the openers. In the future, subsistence fishers on each target river will be identified and contacted before the season begins. Fishers willing to provide samples will then be contacted during the season to find out when and where to go to obtain egg samples. In addition, there may be opportunities to collect fish from other salmon assessment projects in the region.

CONCLUSIONS AND RECOMMENDATIONS

The collection of samples from the Unalakleet River test fishery proved to be efficient and to yield a plentiful amount of high-quality egg skeins with peripheral information that was clearly documented. Sample collection by ADF&G staff was highly effective, and preservation and transport of the eggs within Norton Sound was easy to accomplish. In the process, the study ground-truthed methods for making future studies more efficient and useful for the overall Norton Sound region. The 2003 study should repeat most of the 2002 study design, but with some modifications to the collection sites, community outreach, and lab processing. The overall emphasis should be to shift some sampling effort from the Unalakleet River to other rivers, to conduct community outreach in advance of the field season, and to streamline the lab processing times.

Specific recommendations for the 2003 field season are to:

1) Decrease the sample size from the Unalakleet River from 100 to 50 for both chum and coho salmon, and split the 50 fish per species evenly between the first and last parts of the run.
2) Use the 2002 data to conduct a power analysis to determine the approximate sample size needed to detect differences in fecundity among Norton Sound drainages. Use this power analysis to determine the number of samples needed from the two new sampling locations.
3) Identify two additional rivers from which to obtain chum and coho salmon egg skeins. At least one these new sample rivers should be from a river that has experienced a notable drop in salmon returns since 1998.
4) Communicate the purpose and value of the study to key community members to help identify potential sources of samples.
5) Label the right and left egg skeins to test for differences in fecundity; if there is no difference, consider sampling only one egg skein from each fish to speed the

processing time.

6) Measure both MEF and POH lengths from subsamples of fish to confirm the accuracy of the formulas used in 2002 and make the results as comparable as possible to literature reviews of fecundity.

ACKNOWLEDGEMENTS

Special thanks are extended to the Nome ADF&G staff for their overall support. Eva Oyoymick and Peter Nanouk collected and froze the salmon ovaries. Paul Thomson and Gary Knuepfer aged scales. We would also like to thank Vaughn Munn, Alicia Haskell, Shelly Schwenn and Gillian O'Doherty for their enthusiastic assistance in estimating fecundities.

The National Oceanic and Atmospheric Administration (NOAA) and the Norton Sound Economic Development Corporation (NSEDC) provided funding support for this project. NOAA funds were provided through the Fishery Disaster Relief Program for Norton Sound, Alaska.

LITERATURE CITED

ADF&G. 2002. Norton Sound Salmon Fisheries - summary of 2002 season . Preliminary season report to ADF&G, Division of Commercial Fisheries Alaska Department of Fish and Game, Nome, Alaska.

Beacham, T. D. 1982. Fecundity of coho salmon (*Oncorhynchus kisutch*) and chum salmon (*O. keta*) in the northeast Pacific Ocean. Canadian Journal of Zoology 60: 1463-1469.

Beacham, T. D. and Murray, C. B. 1993. Fecundity and egg size variation in North American Pacific salmon (*Oncorhynchus*). Journal of Fish Biology 42: 485-508.

Clark, J. H. 2001. Biological escapement goal for chum salmon in District One of Norton Sound (draft). Regional Information Report 3A01-09. ADF&G Div. Comm. Fish., AYK Reg., Anchorage, Alaska.

Fleming, I. A. and M. R. Gross. 1990. Latitudinal clines: a trade-off between egg number and size in Pacific salmon. Ecology 71:1-11.

Healey, M. C. and W. R. Heard. 1984. Inter- and intra-population variation in the fecundity of chinook salmon (*Oncorhynchus tshawystcha*) and its relevance to life history theory. Canadian Journal of Fisheries and Aquatic Sciences 41:476-483.

Kohler, T. 2002. Unalakleet River Test Net Project, 2001. Regional Information Report No. 3A02-34. Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage.

Menard, J. 2001. 2001 Norton Sound season summary. Memorandum to ADF&G, Division of Commercial Fisheries Alaska Department of Fish and Game, Nome, Alaska.

Norton Sound Research and Restoration Plan. 2002. Manuscript in preparation. Regional Information Report Series, Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage.

Salo, E. O. 1991. Life History of Chum Salmon. Pages 231-310 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. UBC Press, Vancouver, B.C.

Sandercock, F. K. 1991. Life history of Coho Salmon. Pages 395-446 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. UBC Press, Vancouver, B.C.

Skaugstad, C. and B. McCracken. 1991. Fecundity of chinook salmon, Tanana River, Alaska. Fishery Data Series Alaska Department of Fish and Game, Anchorage, Alaska.

SYSTAT 9. 1996. Linear Models III: General Linear Models. Chapter 16 *in* Statistics I. SPSS Inc., Chicago IL.

Zar, J. H. 1996. Biostatistical Analysis, 3rd ed. Prentice Hall. Upper Saddle River, New Jersey.

Table 1. Fecundity and length statistics for chum and coho salmon sampled from the Unalakleet River in 2002.

			Total fecundity				Relative fecundity (eggs/cm)				Length (mm)			
Species	Age	N	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD
Chum	0.3	38	2577	154	78.4	483	43.7	2.5	1.3	8.0	589.9	5.6	2.9	17.7
	0.4	51	2963	142	72.3	516	49.3	2.3	1.2	8.3	600.8	5.7	2.9	20.8
	0.5	8	2935	289	147.4	417	48.1	4.6	2.4	6.7	610	21.8	11.1	31.4
	Total	97	2809	105	53.4	526	47	1.7	0.9	8.4	597.3	4.3	2.2	21.4
Coho	Total	95	5335	174	89.0	867	87.8	2.6	1.3	13.1	606.8	5.8	2.9	28.7

Table 2. ANOVA table for the effects of length and age on absolute fecundity of chum salmon sampled from the Unalakleet River in 2002.

Categorical values encountered during processing are: AGE (3 levels) = 0.3, 0.4, 0.5
Dependent Variable: Absolute fecundity N: 97 Multiple R: 0.442 Squared multiple R: 0.196

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	*F* -ratio	P
Age	137708.37	2	68854.187	0.293	0.746
Length	983608.4	1	983608.4	4.191	0.044
Age*Length	157018.53	2	78509.26	0.335	0.717
Error	2.14E+07	91	234689.5		

Durbin-Watson D Statistic 1.676
First Order Autocorrelation 0.158

Table 3. ANOVA table for the effects of length and run group (early vs. late) on fecundity of coho salmon sampled from the Unalakleet River in 2002.

Run timing (2 levels) = Early run (before August 22), late run (after August 29)
Dependent Variable: Absolute fecundity N: 104 Multiple R: 0.416 Squared multiple R: 0.173

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	*F*-ratio	P
Run Timing	33870.05	1	33870.05	0.051	0.821
Length	6170517.6	1	6170517.6	9.378	0.003
Run Timing*Length	67926.54	1	67926.54	0.103	0.749
Error	65807600	100	658076.337		

Durbin-Watson D Statistic	1.587
First Order Autocorrelation	0.202

Figure 1. Map of Alaska (inset) and the Norton Sound region. Salmon sampled for fecundity in 2002 came from Unalakleet River, on the east side of Norton Sound.

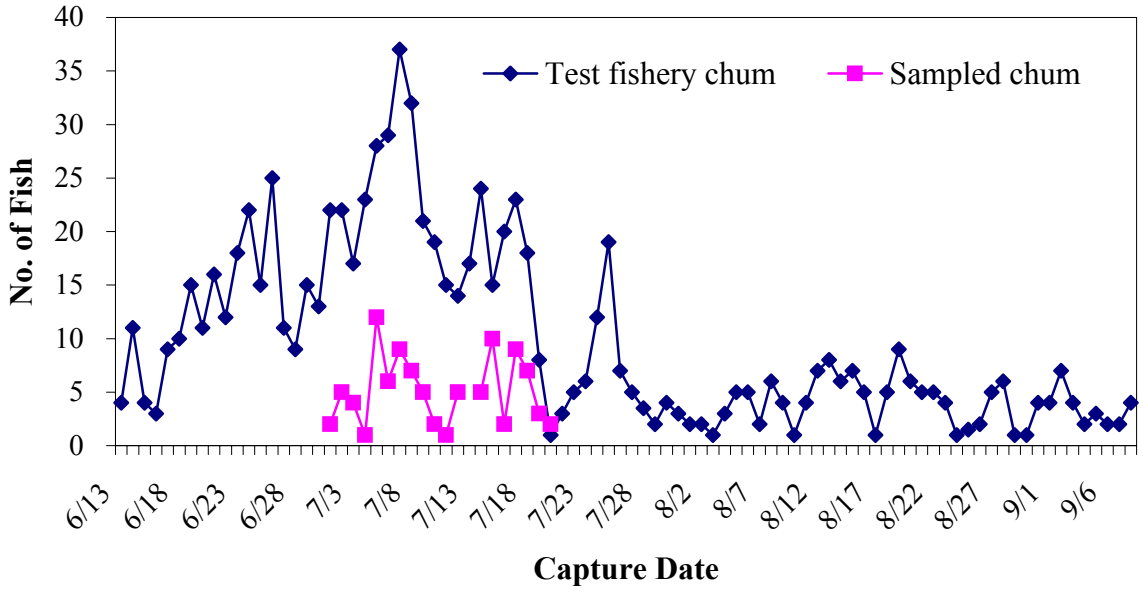


Figure 2a. Comparison of capture dates of chum salmon sampled for fecundity to daily catch from the ADF&G test fishery.

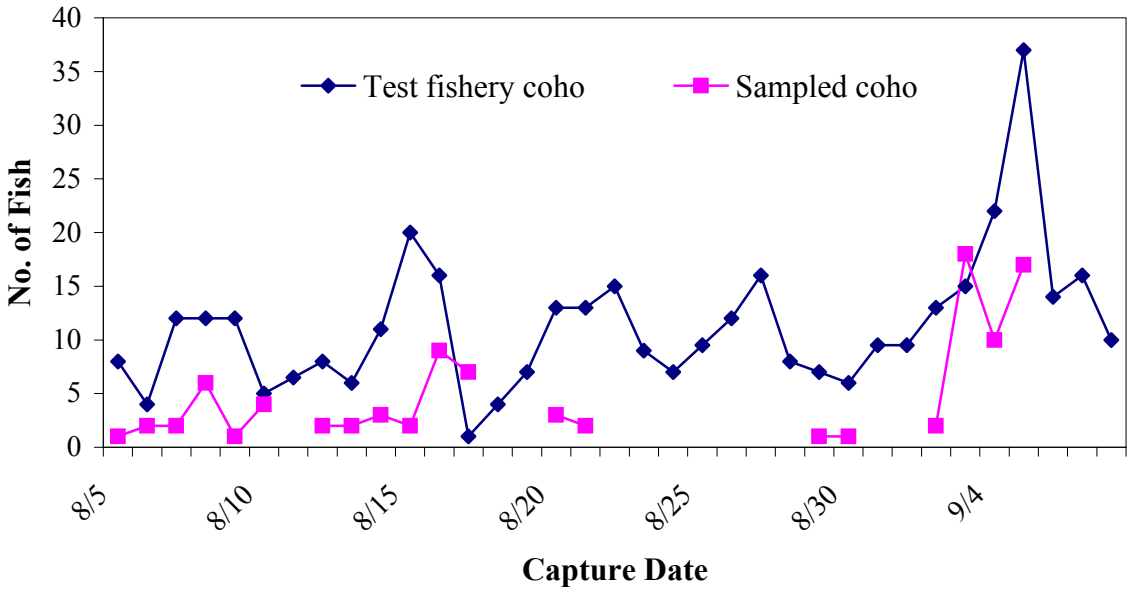


Figure 2b. Comparison of capture dates of coho salmon sampled for fecundity to daily catch from the ADF&G test fishery.

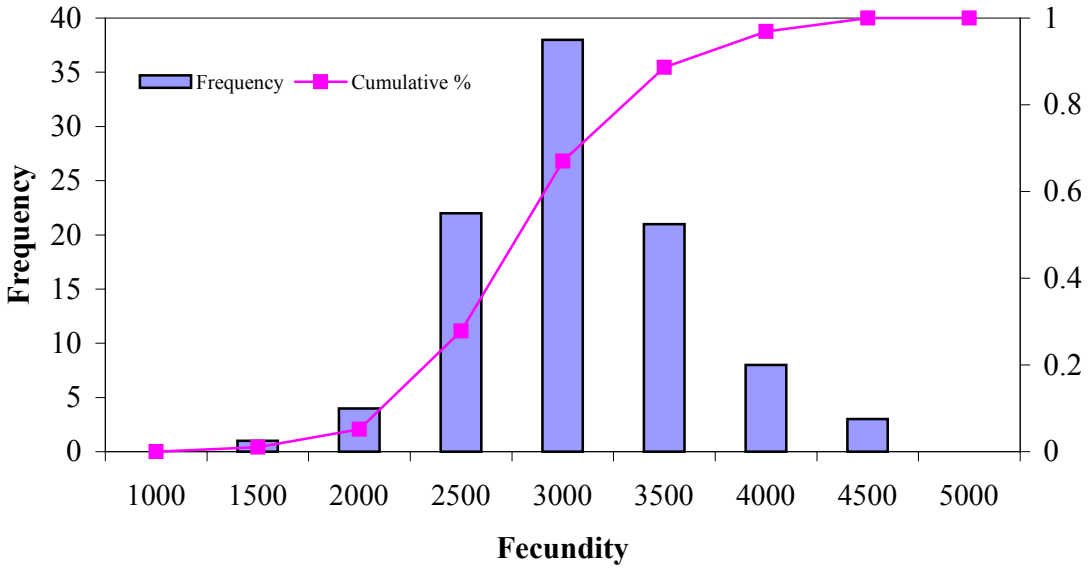


Figure 3a. Histogram of fecundities (absolute and cumulative %) of 97 chum salmon sampled from the Unalakleet River in 2002.

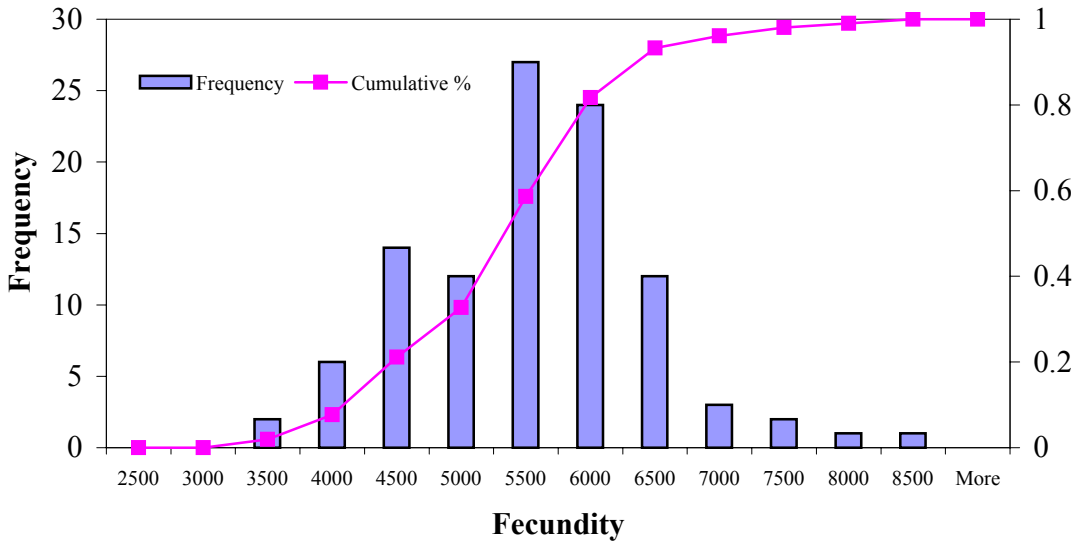
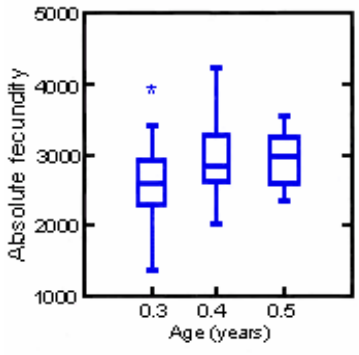
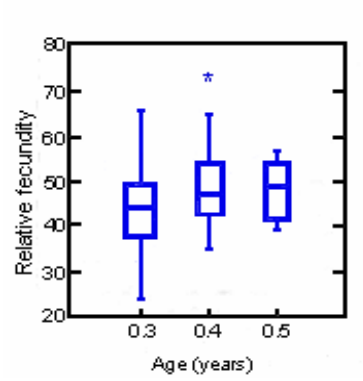


Figure 3b. Histogram of fecundities (absolute and cumulative %) of 95 coho salmon sampled from the Unalakleet River in 2002.





Figures 4a and 4b. Absolute and relative fecundity by age class for chum salmon from the Unalakleet River, 2002. Center vertical line is sample median, box edges are 1st and 3rd quartiles, and whiskers extend to 1.5 times the box length. Asterisks denote potential outliers.

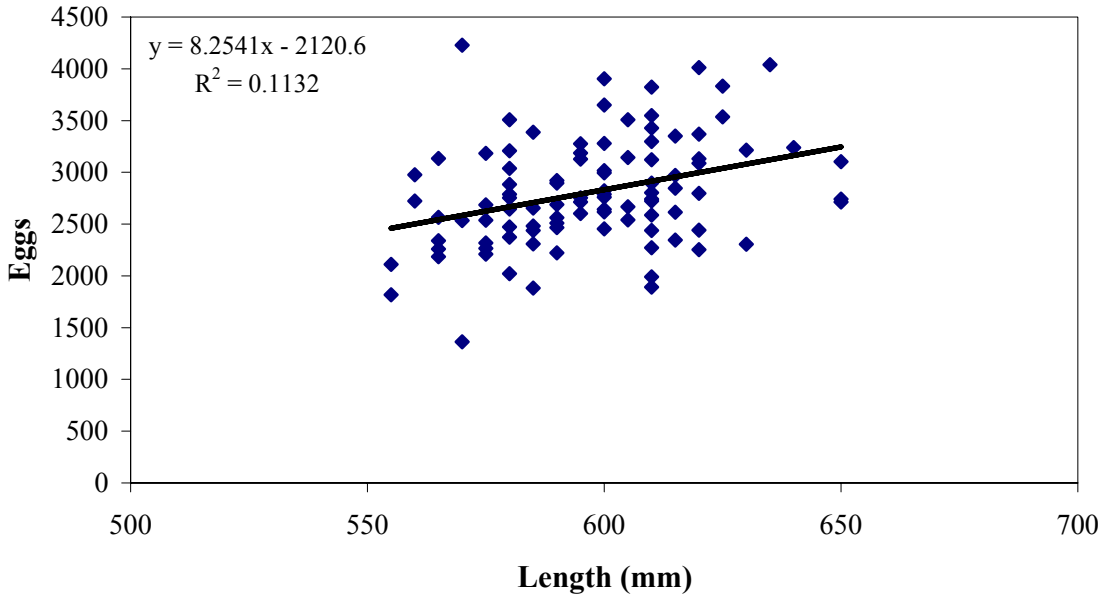


Figure 5a. Chum salmon absolute fecundity versus fish length (mm) for 97 fish sampled from the Unalakleet River in 2002.

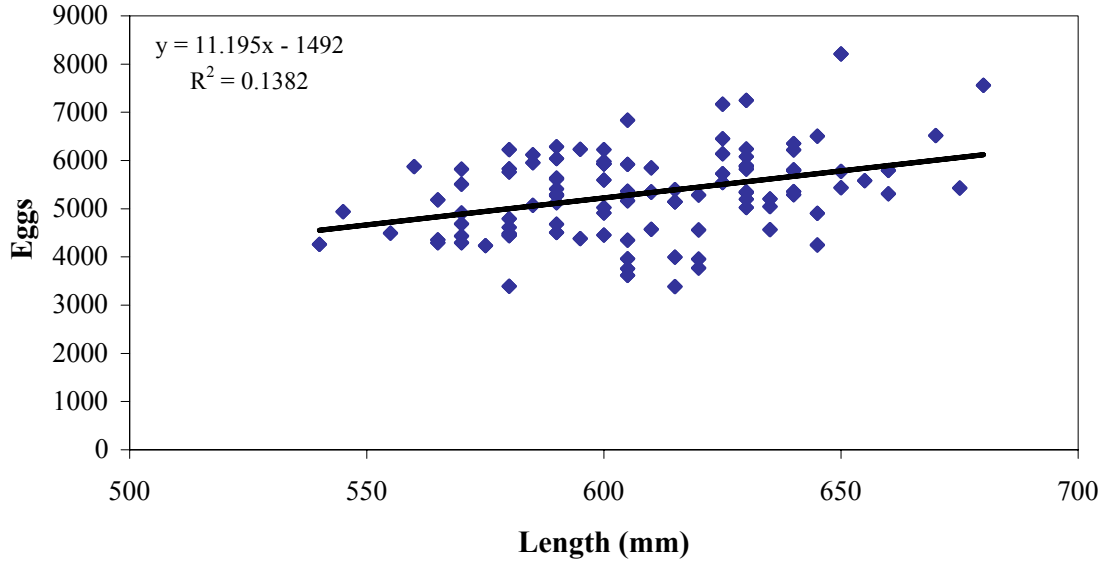


Figure 5b. Coho salmon absolute fecundity versus fish length (mm) for 95 fish sampled from the Unalakleet River in 2002.

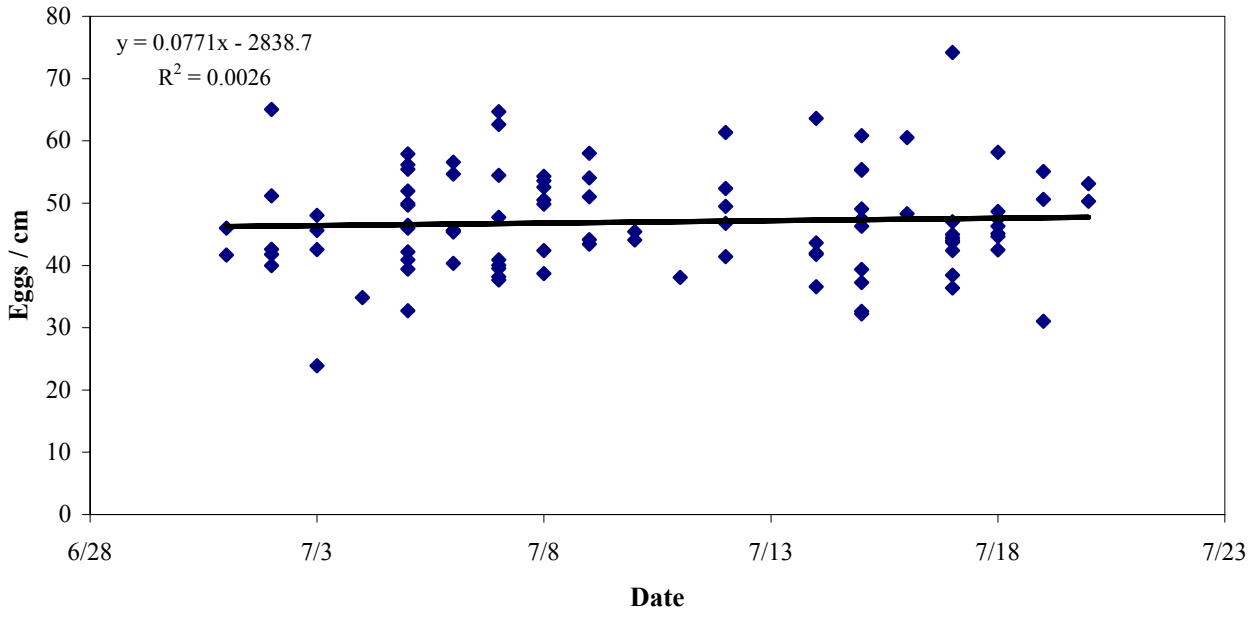


Figure 6a. Chum salmon relative fecundity vs. entry date to Unalakleet River, 2002.

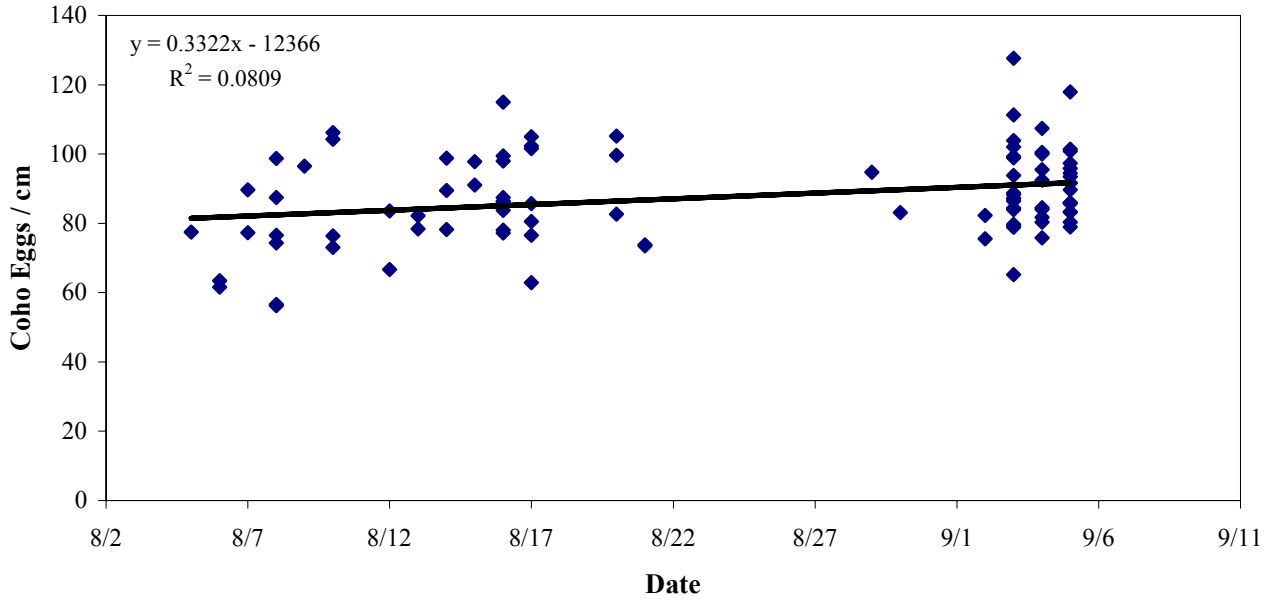


Figure 6b. Coho salmon relative fecundity vs. entry date to Unalakleet River, 2002.

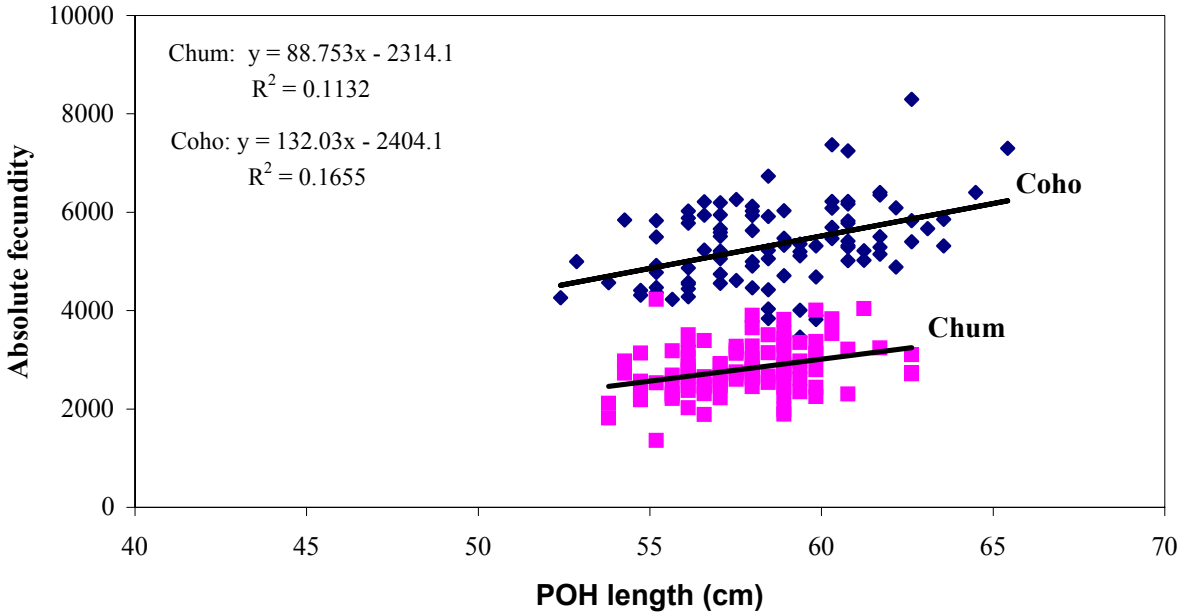


Figure 7. POH length vs. absolute fecundity for chum and coho salmon sampled from the Unalakleet River in 2002.

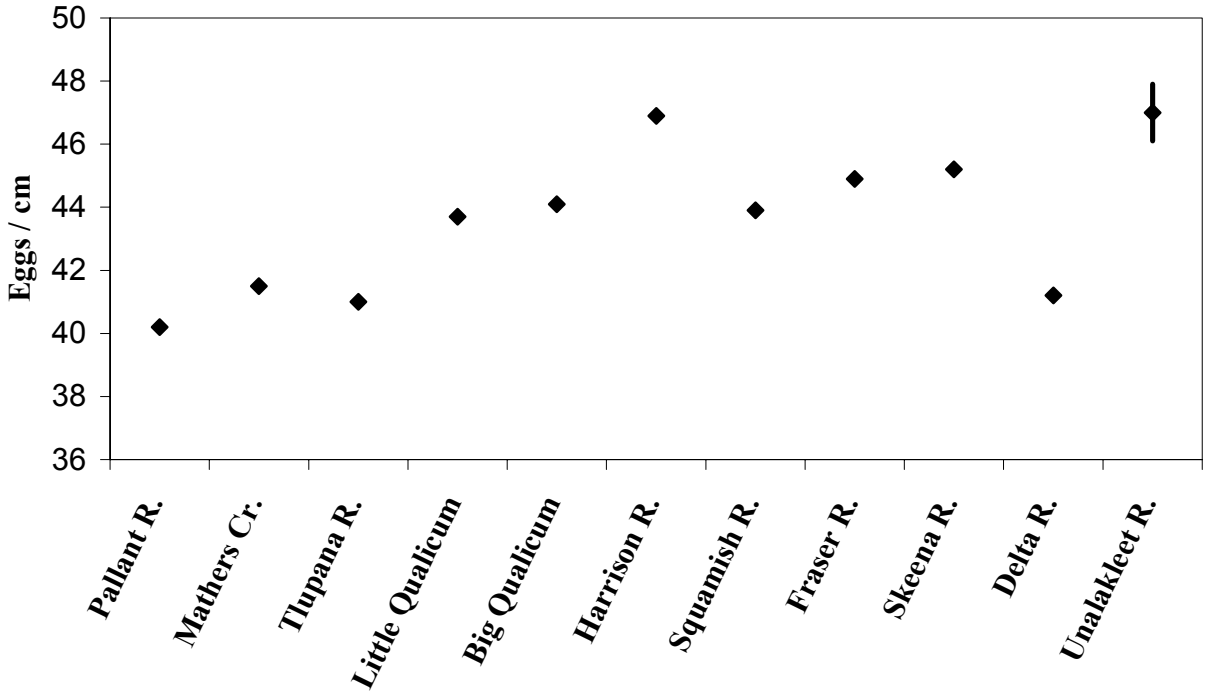


Figure 8. Mean relative fecundities (eggs / cm length) of chum salmon from the Unalakleet River compared to those from other North American rivers reported by Salo (1991). Point marker represents mean, whisker extends + / - 1 SE from mean. Standard error value available only for the Unalakleet River sample.

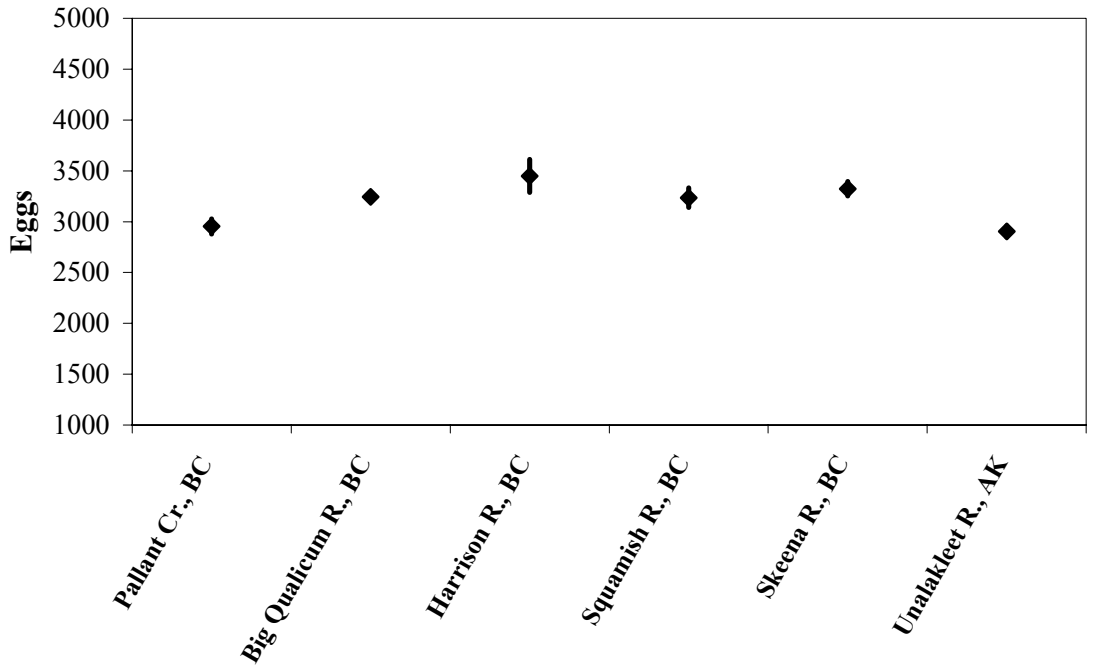


Figure 9. Fecundity of various chum salmon populations at 58.8 cm POH length (Beacham 1982). Point marker represents mean, whisker extends + / - 1 SE from mean.

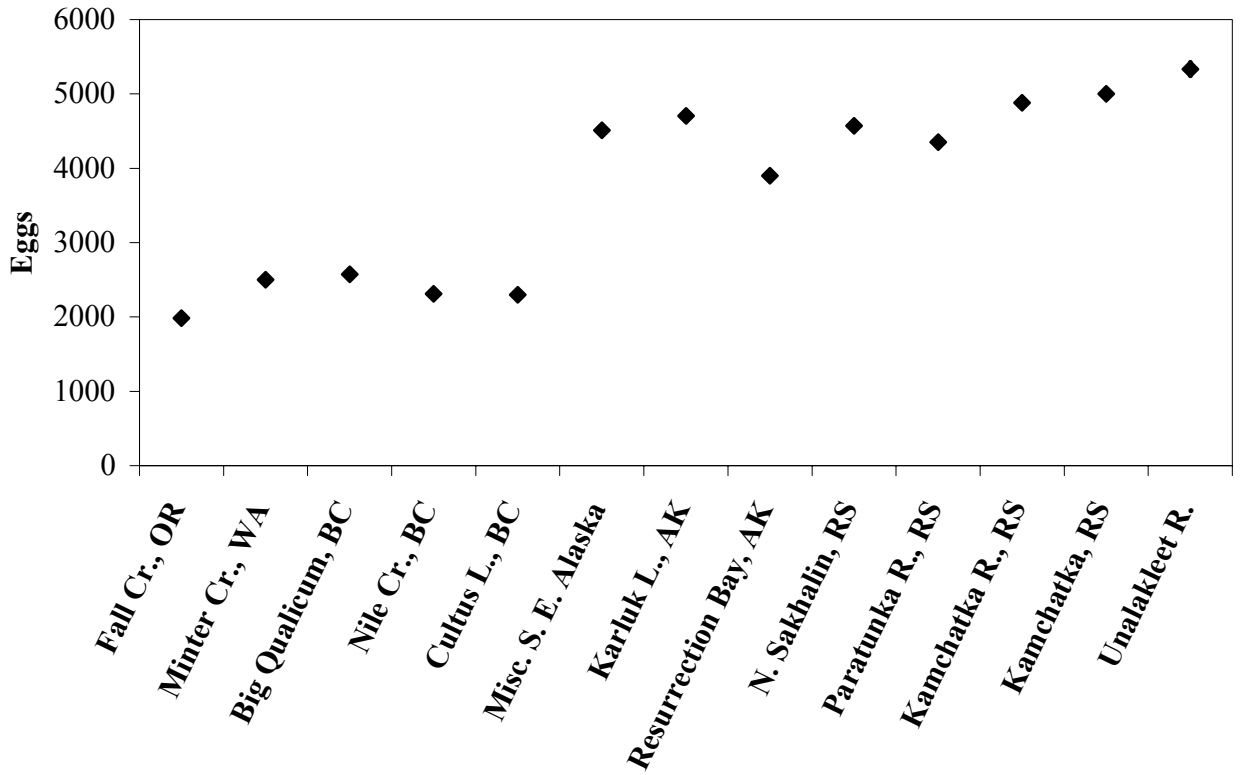


Figure 10. Mean fecundities (absolute) of coho salmon from the Unalakleet River coho compared to other North American populations reported by Sandercock (1991). Geographic latitude increases from left to right on x-axis. Point marker represents mean, whisker extends + / - 1 SE from mean. Standard error value available only for the Unalakleet River sample.

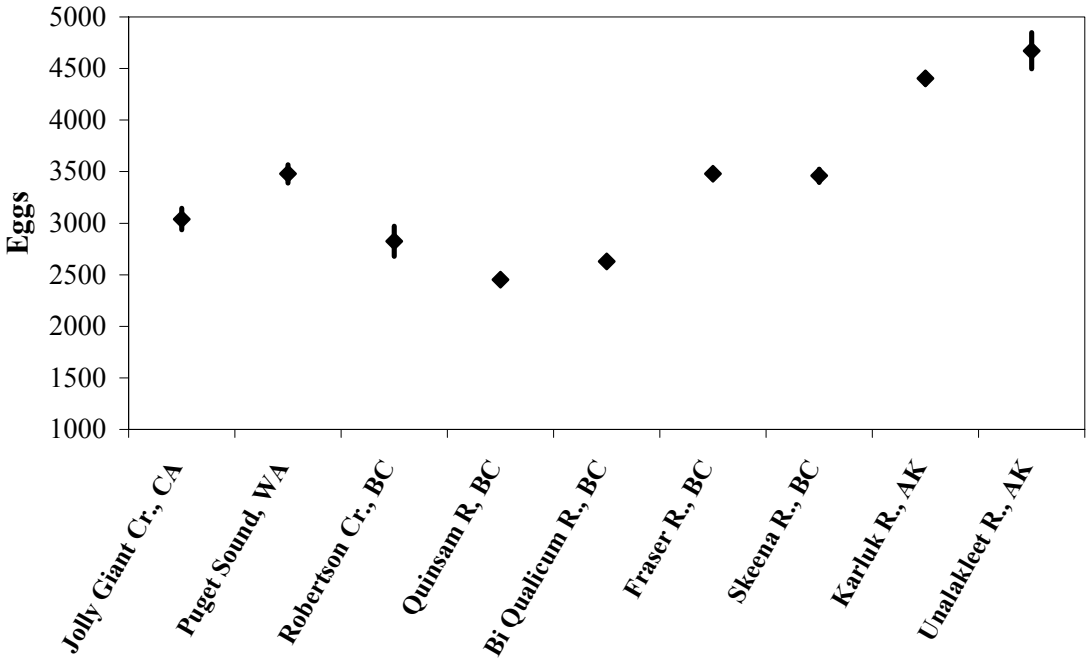


Figure 11. Fecundity of various coho salmon populations at 53.6 cm POH length (Beacham 1982). Point marker represents mean, whisker extends + / - 1 SE from mean.

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
NA	1	chum	7/1/2002	001-01	11/29/2002	205.09	187.59	22.81	23.01	141	140	21.97	21.89	144	131	2438	585	41.7	0.3
NA	2	chum	7/1/2002	001-02	12/6/2002	194.57	181.86	16.23	15.70	113	116	15.30	15.24	112	117	2759	600	46.0	0.3
NA	3	chum	7/2/2002	001-03	12/2/2002	204.76	210.91	18.67	16.13	174	155	18.43	16.15	179	144	3902	600	65.0	0.3
NA	4	chum	7/2/2002	001-04	12/2/2002	174.31	154.12	18.61	18.56	143	136	18.71	20.69	142	146	2440	610	40.0	0.4
NA	5	chum	7/2/2002	001-05	12/4/2002	148.67	141.32	15.07	14.03	129	122	15.42	14.01	133	115	2472	580	42.6	0.4
NA	6	chum	7/2/2002	001-06	12/4/2002	203.09	243.97	17.47	15.22	132	95	16.03	15.51	116	109	3121	610	51.2	0.4
NA	7	chum	7/2/2002	001-07	11/29/2002	269.04	291.16	21.62	22.30	99	112	24.36	22.60	118	111	2714	650	41.8	0.5
NA	8	chum	7/3/2002	001-08	12/2/2002	200.69	195.54	18.52	19.48	127	132	18.41	18.56	136	132	2787	580	48.1	0.4
NA	9	chum	7/3/2002	001-09	12/5/2002	119.95	113.41	18.60	17.83	100	105	16.32	19.08	111	100	1361	570	23.9	0.3
NA	10	chum	7/3/2002	001-10	12/4/2002	245.54	226.14	18.39	18.90	100	109	18.00	18.98	100	108	2645	580	45.6	0.3
NA	11	chum	7/3/2002	002-01	12/2/2002	163.50	152.62	19.46	17.41	155	142	20.35	17.53	155	141	2510	590	42.5	0.4
NA	12	chum	7/4/2002	002-02	12/3/2002	172.99	162.92	20.06	18.74	128	112	20.92	19.28	120	115	2021	580	34.8	0.4
NA	13	chum	7/5/2002	002-03	12/4/2002	166.23	179.02	16.60	15.23	149	143	16.03	15.02	149	130	3134	565	55.5	0.3
NA	14	chum	7/5/2002	002-04	12/3/2002	232.93	197.19	15.39	16.05	100	106	16.69	15.85	116	107	2883	580	49.7	0.5
NA	15	chum	7/5/2002	002-05	12/3/2002	219.50	240.00	18.14	16.80	128	104	18.43	16.65	120	106	2996	600	49.9	0.3
NA	16	chum	7/5/2002	002-06	12/3/2002	211.20	237.57	17.03	18.30	125	150	17.22	16.88	136	120	3427	610	56.2	0.4
NA	17	chum	7/5/2002	002-07	12/6/2002	205.18	222.26	18.52	18.11	102	107	17.89	18.11	107	101	2455	600	40.9	0.4
NA	18	chum	7/5/2002	002-08	12/5/2002	207.04	251.16	17.09	15.97	114	110	16.95	15.52	122	104	3142	605	51.9	0.4
NA	19	chum	7/5/2002	002-09	12/10/2002	243.63	254.80	19.31	19.27	100	105	18.94	19.27	107	110	2740	650	42.2	0.4
NA	20	chum	7/5/2002	002-10	12/6-9/02	263.85	251.86	22.58	18.47	118	102	21.94	18.18	117	101	2788	600	46.5	0.4
NA	21	chum	7/5/2002	003-01	12/9/2002	210.38	206.46	19.41	20.57	102	113	19.95	19.29	113	103	2267	575	39.4	0.3
NA	22	chum	7/5/2002	003-02	12/5/2002	180.51	189.54	15.53	14.37	143	136	14.81	14.19	132	128	3387	585	57.9	0.3

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
NA	23	chum	7/5/2002	003-03	12/11/2002	135.20	157.26	16.61		106	100	15.68	16.57	100	105	1817	555	32.7	0.3
NA	24	chum	7/5/2002	003-04	12/5/2002	204.90	194.27	16.80	15.05	120	105	16.82	15.79	121	107	2805	610	46.0	0.4
NA	25	chum	7/6/2002	003-05	12/6/2002	220.96	224.84	16.90	17.26	101	105	17.15	17.81	101	114	2714	595	45.6	0.4
NA	26	chum	7/6/2002	003-06	12/10/2002	181.06	192.00	17.53	17.15	114	105	16.43	17.03	100	105	2319	575	40.3	0.4
NA	27	chum	7/6/2002	003-07	12/4/2002	220.75	240.18	19.47	15.20	156	124	19.53	14.16	141	103	3534	625	56.6	0.5
NA	28	chum	7/6/2002	003-08	12/5/2002	222.18	234.30	16.54	16.96	127	120	15.39	15.60	106	111	3281	600	54.7	0.4
NA	29	chum	7/6/2002	003-09	12/5/2002	160.96	197.81	17.52	17.30	133	119	17.57	17.47	141	133	2690	590	45.6	0.4
NA	30	chum	7/6/2002	003-10	12/9/2002	234.61	230.63	20.22	20.36	116	111	19.72	20.33	115	118	2655	585	45.4	0.3
NA	32	chum	7/7/2002	004-02	12/9/2002	287.84	325.35	17.30	18.09	118	117	17.95	18.27	120	114	4011	620	64.7	0.4
NA	33	chum	7/7/2002	004-03	12/10/2002	237.27	234.34	17.16	15.00	125	104	17.74	15.16	130	104	3350	615	54.5	0.4
NA	34	chum	7/7/2002	004-04	12/10/2002	377.76	351.64	24.80	24.69	106	106	24.24	25.44	100	110	3102	650	47.7	0.5
NA	35	chum	7/7/2002	004-05	12/6/2002	218.65	260.51	23.79	22.94	116	111	22.62	22.37	112	104	2310	585	39.5	0.4
NA	36	chum	7/7/2002	004-06	12/4/2002	277.21	256.10	14.62	15.13	103	102	14.83	14.97	105	117	3822	610	62.7	0.4
NA	38	chum	7/7/2002	004-08	12/11/2002	168.79	169.70	17.19	15.45	124	103	16.75	15.45	117	111	2374	580	40.9	0.3
NA	40	chum	7/7/2002	004-10	12/12/2002	239.80	166.61	18.25	19.10	100	112	18.70	19.38	111	114	2347	615	38.2	0.4
NA	42	chum	7/7/2002	005-02	1/3/2003	192.44	184.00	17.15	17.71	102	104	17.45	17.83	106	102	2223	590	37.7	0.3
NA	43	chum	7/7/2002	005-03	12/12/2002	133.08	179.29	14.58	15.17	109	112	15.20	15.30	111	105	2260	565	40.0	0.4
NA	44	chum	7/8/2002	005-04	12/12/2002	188.94	168.71	18.25	18.54	112	105	18.23	16.14	116	101	2186	565	38.7	0.3
NA	45	chum	7/8/2002	005-05	12/12/2002	218.10	281.86	19.26	20.03	101	102	19.40	19.50	102	100	2586	610	42.4	0.4
NA	46	chum	7/8/2002	005-06	1/6/2003	298.47	281.93	24.43	19.78	134	109	24.46	20.45	132	106	3131	620	50.5	0.3
NA	47	chum	7/8/2002	005-07	1/8/2003	263.57	278.45	18.81	18.45	115	114	20.50	18.62	131	115	3368	620	54.3	0.4
NA	48	chum	7/8/2002	005-08	1/8/2003	239.77	265.97	16.63	17.06	101	105	17.81	17.04	112	101	3089	620	49.8	0.3

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
NA	49	chum	7/8/2002	005-09	1/9/2003	316.93	280.44	20.39	20.04	110	105	20.10	20.28	108	108	3188	595	53.6	0.5
NA	51	chum	7/8/2002	006-01	1/9/2003	259.36	291.26	20.39	19.06	115	108	20.22	19.14	118	107	3127	595	52.6	0.3
NA	53	chum	7/9/2002	006-03	1/8/2003	162.44	224.56	15.63	17.00	105	110	15.88	17.38	106	112	2538	575	44.1	0.3
NA	54	chum	7/9/2002	006-04	1/9/2003	236.68	209.60	15.61	15.40	123	106	15.56	15.72	110	121	3297	610	54.1	0.4
NA	58	chum	7/9/2002	006-08	1/9/2003	230.65	239.90	14.84	14.69	117	108	15.35	14.77	113	107	3509	605	58.0	0.4
NA	59	chum	7/9/2002	006-09	1/3/2003	241.64	293.17	17.65	18.17	110	106	18.13	17.87	112	105	3216	630	51.0	0.4
NA	61	chum	7/9/2002	007-01	1/9/2003	195.05	214.96	18.26	17.31	123	103	18.12	17.42	110	109	2561	590	43.4	0.4
NA	63	chum	7/10/2002	007-03	1/6/2003	208.87	203.39	16.18	16.73	107	109	16.42	16.69	103	108	2666	605	44.1	0.3
NA	65	chum	7/10/2002	007-05	1/6/2003	137.73	149.55	15.73	14.36	145	126	15.98	14.14	141	126	2565	565	45.4	0.3
NA	66	chum	7/11/2002	007-06	1/8/2003	163.83	156.06	17.19	16.87	113	109	17.42	16.69	114	114	2112	555	38.0	0.4
NA	68	chum	7/12/2002	007-08	1/9/2003	216.52	191.90	15.17	15.82	100	106	15.56	15.87	100	105	2687	575	46.7	0.3
NA	70	chum	7/12/2002	007-10	1/9/2003	201.00	232.59	16.97	16.62	118	114	16.69	15.70	118	112	3037	580	52.4	0.3
NA	71	chum	7/12/2002	008-01	1/8/2003	282.64	291.44	18.80	17.80	123	118	18.73	17.83	122	125	3833	625	61.3	0.4
NA	72	chum	7/12/2002	008-02	12/16/2002	194.54	134.97	16.09	16.24	118	112	16.82	16.11	114	120	2341	565	41.4	0.5
NA	73	chum	7/12/2002	008-03	12/16/2002	291.35	277.13	20.36	20.49	101	107	20.92	20.71	107	109	2921	590	49.5	0.3
NA	81	chum	7/14/2002	009-01	12/19/2002	326.04	293.46	17.64	16.46	118	106	17.69	16.46	112	109	4039	635	63.6	0.4
NA	82	chum	7/14/2002	009-02	12/31/2003	217.80	232.92	17.44	18.09	100	100	17.32	18.11	100	100	2540	605	42.0	0.4
NA	83	chum	7/14/2002	009-03	12/19/2002	177.72	210.98	17.55	16.77	114	105	17.58	16.62	111	105	2465	590	41.8	0.3
NA	84	chum	7/14/2002	009-04	12/19/2002	244.01	270.55	19.50	20.22	100	104	23.29	19.83	117	100	2617	600	43.6	0.3
NA	85	chum	7/14/2002	009-05	12/19/2002	186.00	210.05	18.35	18.43	106	105	17.47	17.76	101	107	2306	630	36.6	0.3
NA	86	chum	7/15/2002	009-06	12/31/2003	254.17	252.62	19.10	19.12	106	104	19.06	19.09	109	110	2847	615	46.3	0.4
NA	87	chum	7/15/2002	009-07	19&20-Dec	280.17	206.08	20.96	18.42	119	100	18.26	18.55	107	104	2753	580	47.5	0.3

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
NA	88	chum	7/15/2002	009-08	12/27/2002	151.77	161.57	14.66	16.46	107	120	14.67	14.06	105	102	2272	610	37.2	0.3
NA	89	chum	7/15/2002	009-09	12/23/2002	244.66	277.36	20.99	22.43	100	105	22.16	22.11	102	103	2441	620	39.4	0.5
NA	90	chum	7/15/2002	009-10	12/18/2002	222.32	210.92	16.00	13.43	130	113	13.16	13.72	110	121	3650	600	60.8	0.4
NA	91	chum	7/15/2002	010-01	1/2/2003	244.82	256.88	16.10	16.73	107	103	15.92	16.64	100	108	3207	580	55.3	0.4
NA	92	chum	7/15/2002	010-02	12/27/2002	209.50	107.06	16.60	18.10	102	100	16.75	17.12	101	100	1884	585	32.2	0.3
NA	93	chum	7/15/2002	010-03	1/2/2003	282.89	252.74	17.64	18.94	100	100	18.72	18.82	100	100	2896	590	49.1	0.4
NA	94	chum	7/15/2002	010-04	12/27/2002	258.82	323.45	17.93	19.71	104	109	19.44	19.64	100	106	3184	575	55.4	0.4
NA	95	chum	7/15/2002	010-05	12/31/2003	134.71	179.06	16.98	16.07	108	100	15.86	16.06	100	104	1990	610	32.6	0.3
NA	96	chum	7/16/2002	010-06	12/27/2002	324.01	285.40	18.17	18.35	109	104	18.81	18.21	107	103	3509	580	60.5	0.4
NA	97	chum	7/16/2002	010-07	12/26/2002	285.53	291.61	19.91	21.00	100	101	20.55	20.56	100	121	2971	615	48.3	0.4
NA	98	chum	7/17/2002	010-08	12/26/2002	236.21	222.48	18.04	18.14	112	108	19.05	19.17	115	123	2822	600	47.0	0.4
NA	99	chum	7/17/2002	010-09	12/26/2002	216.67	236.28	20.67	18.50	116	100	18.95	19.09	106	110	2533	570	44.4	0.3
NA	100	chum	7/17/2002	010-10	12/31/2003	195.47	205.42	18.31	17.14	112	105	17.00	17.06	107	106	2480	585	42.4	0.3
NA	102	chum	7/17/2002	011-02	12/26/2002	222.14	221.06	20.29	20.58	104	108	20.81	20.52	103	103	2254	620	36.4	0.3
NA	103	chum	7/17/2002	011-03	12/20/2002	186.27	200.72	15.63	15.56	104	105	17.36	15.70	117	106	2602	595	43.7	0.3
NA	104	chum	7/17/2002	011-04	12/23/2002	196.41	206.84	18.16	18.81	101	103	18.59	18.74	100	103	2209	575	38.4	0.3
NA	105	chum	7/17/2002	011-05	12/23/2002	215.26	291.89	12.57	13.05	100	118	13.35	13.76	123	100	4228	570	74.2	0.4
NA	106	chum	7/17/2002	011-06	12/17/2002	235.60	265.38	18.40	18.46	100	100	18.19	18.41	100	102	2742	610	44.9	0.4
NA	107	chum	7/17/2002	011-07	12/23/2002	202.80	207.89	16.68	16.80	109	107	17.29	17.45	112	111	2643	600	44.0	0.4
NA	108	chum	7/18/2002	011-08	12/23/2002	211.08	215.45	15.47	15.56	104	101	15.30	15.92	103	100	2796	620	45.1	0.4
NA	109	chum	7/18/2002	011-09	12/27/2002	231.10	221.45	16.52	16.88	100	100	16.50	16.59	100	100	2723	610	44.6	0.4
NA	110	chum	7/18/2002	011-10	12/27/2002	213.65	240.77	18.15	18.40	111	106	18.35	18.36	107	115	2724	560	48.6	0.4

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
NA	111	chum	7/18/2002	012-01	1/2/2003	233.28	251.40	16.72	16.64	119	119	16.77	16.24	127	121	3549	610	58.2	0.4
NA	112	chum	7/18/2002	012-02	1/6/2003	203.01	175.69	16.05	15.91	110	117	16.19	16.04	118	123	2755	595	46.3	0.3
NA	113	chum	7/18/2002	012-03	12/17/2002	245.19	266.99	22.65	21.28	115	110	25.55	21.62	131	109	2614	615	42.5	0.4
NA	114	chum	7/18/2002	012-04	1/3/2003	192.78	185.72	16.99	15.10	123	108	16.91	15.55	140	123	2895	610	47.5	0.4
NA	115	chum	7/19/2002	012-05	1/6/2003	245.65	202.61	23.01	24.45	100	100	23.85	24.05	100	102	1893	610	31.0	0.3
NA	116	chum	7/19/2002	012-06	12/17/2002	223.44	234.86	16.53	15.46	118	108	16.72	15.70	125	110	3276	595	55.1	0.5
NA	117	chum	7/19/2002	012-07	1/7/2003	192.91	188.26	15.20	14.05	126	120	14.02	14.19	119	123	3238	640	50.6	0.4
NA	118	chum	7/20/2002	012-08	1/2/2003	218.19	225.87	17.06	17.14	112	118	17.02	16.98	117	110	2975	560	53.1	0.4
NA	119	chum	7/20/2002	012-09	1/6/2003	320.47	322.38	23.19	23.62	109	111	23.20	23.30	110	108	3018	600	50.3	0.3
Early	1	Coho	8/5/2002	001-01	11/6/2002	265.92	271.92	18.27	16.99	148	139	20.78	17.00	170	167	4613	595	77.5	Analysis pending
Early	2	Coho	8/6/2002	001-02	11/6/2002	250.92	246.77	18.15	20.13	127	163	17.55	14.54	114	135	3838	605	63.4	Analysis pending
Early	3	Coho	8/6/2002	001-03	11/6/2002	264.73	256.42	16.53	18.88	97	163	15.53	14.99	116	111	3822	620	61.6	Analysis pending
Early	4	Coho	8/7/2002	001-04	11/6/2002	318.13	341.68	13.34	20.98	112	164	16.13	17.57	136	150	5471	610	89.7	Analysis pending
Early	5	Coho	8/7/2002	001-05	11/6/2002	310.94	287.01	17.80	19.34	142	141	16.95	19.89	141	157	4713	610	77.3	Analysis pending
Early	6	Coho	8/8/2002	001-06	11/20/2002	278.23	222.95	20.24	19.79	182	173	20.45	19.85	180	180	4461	600	74.3	Analysis pending
Early	7	Coho	8/8/2002	001-07	11/20/2002	220.56	201.00	16.11	16.66	131	132	19.11	16.76	163	138	3461	615	56.3	Analysis pending
Early	8	Coho	8/8/2002	001-08	11/6/2002	166.10	173.95	16.69	16.80	166	168	18.83	15.39	178	142	3283	580	56.6	Analysis pending
Early	9	Coho	8/8/2002	001-09	11/20/2002	257.77	253.59	24.38	19.68	211	160	19.22	15.66	175	129	4364	570	76.6	Analysis pending
Early	10	Coho	8/8/2002	001-10	11/20/2002	305.59	301.29	17.78	19.74	153	191	19.13	16.78	163	155	5466	625	87.5	Analysis pending
Early	11	Coho	8/8/2002	002-01	11/20/2002	284.49	318.67	15.23	17.05	159	175	17.05	17.52	172	183	6220	630	98.7	Analysis pending
Early	12	Coho	8/9/2002	002-02	11/20/2002	223.01	255.06	17.24	18.64	207	207	18.15	17.08	216	190	5501	570	96.5	Analysis pending
Early	13	Coho	8/10/2002	002-03	11/6/2002	243.14	248.27	18.47	20.33	164	179	16.21	20.84	153	185	4422	605	73.1	Analysis pending

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
Early	14	Coho	8/10/2002	002-04	11/21/2002	322.59	315.82	16.69	12.82	165	119	16.79	12.43	164	124	6211	585	106.2	Analysis pending
Early	15	Coho	8/10/2002	002-05	11/20/2002	258.12	246.85	20.60	17.08	244	195	19.71	20.09	235	222	5840	560	104.3	Analysis pending
Early	16	Coho	8/10/2002	002-06	11/20/2002	233.08	226.14	17.99	17.50	165	167	18.18	19.55	163	194	4315	565	76.4	Analysis pending
Early	18	Coho	8/12/2002	002-08	11/20/2002	305.03	291.67	17.28	17.51	153	148	19.72	18.64	170	148	5056	605	83.6	Analysis pending
Early	19	Coho	8/12/2002	002-09	11/6/2002	265.97	236.02	18.60	24.24	154	181	16.79	21.75	143	169	4032	605	66.6	Analysis pending
Early	20	Coho	8/13/2002	002-10	11/20/2002	340.52	345.08	18.95	18.61	140	145	16.94	16.14	124	128	5217	635	82.2	Analysis pending
Early	22	Coho	8/13/2002	003-02	11/21/2002	292.67	307.53	17.35	18.91	124	144	19.60	18.17	142	141	4470	570	78.4	Analysis pending
Early	23	Coho	8/14/2002	003-03	11/21/2002	273.98	260.00	14.34	15.68	142	142	13.57	14.67	133	153	5232	585	89.4	Analysis pending
Early	24	Coho	8/14/2002	003-04	11/21/2002	338.13	373.37	20.66	21.46	170	176	18.84	18.99	171	160	6030	610	98.8	Analysis pending
Early	25	Coho	8/14/2002	003-05	11/21/2002	260.78	236.63	20.37	21.50	191	197	22.18	22.09	202	195	4539	580	78.3	Analysis pending
Early	27	Coho	8/15/2002	003-07	11/21/2002	321.33	301.93	14.19	15.82	129	147	15.03	12.55	135	115	5690	625	91.0	Analysis pending
Early	28	Coho	8/15/2002	003-08	11/21/2002	367.64	338.96	16.38	16.31	136	138	17.27	15.96	144	134	5916	605	97.8	Analysis pending
Early	30	Coho	8/16/2002	003-10	11/21/2002	282.90	260.81	17.51	13.67	165	138	15.78	17.12	146	158	5162	590	87.5	Analysis pending
Early	31	Coho	8/16/2002	004-01	11/21/2002	261.39	295.92	22.06	20.35	201	198	21.98	22.40	200	213	5227	605	86.4	Analysis pending
Early	32	Coho	8/16/2002	004-02	11/21/2002	270.11	302.99	17.44	16.78	148	145	16.50	18.27	133	166	4920	570	86.3	Analysis pending
Early	33	Coho	8/16/2002	004-03	11/21/2002	316.27	310.73	18.69	19.32	176	193	18.72	20.43	185	206	6171	630	97.9	Analysis pending
Early	34	Coho	8/16/2002	004-04	11/21/2002	223.85	241.02	17.88	20.14	169	200	22.91	22.18	226	220	4554	590	77.2	Analysis pending
Early	35	Coho	8/16/2002	004-05	11/21/2002	202.22	236.58	20.92	18.30	222	171	18.86	20.49	185	215	4411	565	78.1	Analysis pending
Early	36	Coho	8/16/2002	004-06	11/21/2002	362.23	385.62	17.86	20.53	149	166	16.60	21.94	142	182	6219	625	99.5	Analysis pending
Early	37	Coho	8/16/2002	004-07	11/21/2002	293.30	274.75	24.91	17.22	199	147	20.54	21.46	176	183	4772	570	83.7	Analysis pending
Early	38	Coho	8/16/2002	004-08	11/21/2002	316.18	374.51	15.39	13.18	159	140	15.38	15.20	156	164	7246	630	115.0	Analysis pending
Early	39	Coho	8/17/2002	004-09	11/21/2002	276.42	295.27	22.94	19.92	162	135	20.56	19.33	144	125	3899	620	62.9	Analysis pending

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
Early	40	Coho	8/17/2002	004-10	11/21/2002	291.11	275.20	21.02	19.50	202	178	20.68	21.85	192	208	5316	660	80.5	Analysis pending
Early	41	Coho	8/17/2002	005-01	11/27/2002	278.68	252.31	18.59	19.32	202	214	17.51	18.42	193	202	5831	570	102.3	Analysis pending
Early	42	Coho	8/17/2002	005-02	11/27/2002	276.26	284.51	18.46	18.75	192	203	18.26	19.31	198	199	5941	585	101.5	Analysis pending
Early	43	Coho	8/17/2002	005-03	11/22/2002	328.05	313.91	12.70	10.99	106	89	11.46	13.90	100	110	5313	620	85.7	Analysis pending
Early	44	Coho	8/17/2002	005-04	11/27/2002	391.75	395.06	20.75	19.81	166	158	20.66	19.42	160	151	6195	590	105.0	Analysis pending
Early	45	Coho	8/17/2002	005-05	11/22/2002	379.23	252.07	22.92	21.04	161	148	21.13	28.75	149	202	4441	580	76.6	Analysis pending
Early	46	Coho	8/20/2002	005-06	11/25/2002	240.95	285.41	20.59	13.88	234	170	19.45	13.78	225	169	6261	595	105.2	Analysis pending
Early	47	Coho	8/20/2002	005-07	11/27/2002	311.99	307.17	19.11	19.60	185	175	19.14	18.15	183	166	5778	580	99.6	Analysis pending
Early	48	Coho	8/20/2002	005-08	11/25/2002	340.17	318.79	15.73	16.03	129	129	17.60	15.70	142	122	5288	640	82.6	Analysis pending
Early	49	Coho	8/21/2002	005-09	11/27/2002	347.46	345.51	17.01	19.81	104	121	15.32	19.15	93	117	4227	575	73.5	Analysis pending
Early	50	Coho	8/21/2002	005-10	11/22/2002	359.08	284.30	17.12	22.25	123	147	19.39	16.96	122	110	4281	580	73.8	Analysis pending
Late	91	Coho	8/29/2002	010-01	11/20/2002	325.97	340.56	16.32	17.61	116	160	19.08	17.18	153	159	5588	590	94.7	Analysis pending
Late	93	Coho	8/30/2002	010-03	11/20/2002	420.02	418.46	20.48	20.08	133	130	19.94	18.80	127	121	5403	650	83.1	Analysis pending
Late	107	Coho	9/2/2002	011-07	11/27/2002	322.28	289.27	17.19	19.94	127	150	19.91	20.28	155	161	4681	620	75.5	Analysis pending
Late	108	Coho	9/2/2002	011-08	11/26/2002	244.35	248.46	16.12	16.88	150	151	16.22	14.73	153	138	4564	555	82.2	Analysis pending
Late	111	Coho	9/3/2002	012-01	11/27/2002	338.32	331.15	19.00	18.30	144	137	22.45	21.28	172	155	5024	635	79.1	Analysis pending
Late	112	Coho	9/3/2002	012-02	11/26/2002	407.38	422.72	16.09	15.28	118	117	16.90	15.80	121	116	6122	600	102.0	Analysis pending
Late	113	Coho	9/3/2002	012-03	11/26/2002	426.04	421.26	15.55	20.32	107	138	12.57	16.40	89	113	5856	660	88.7	Analysis pending
Late	114	Coho	9/3/2002	012-04	11/22/2002	380.37	433.35	18.47	21.07	116	128	15.62	20.29	99	122	5019	630	79.7	Analysis pending
Late	115	Coho	9/3/2002	012-05	11/22/2002	319.72	326.01	21.41	20.22	158	151	19.63	19.34	149	149	4866	580	83.9	Analysis pending
Late	116	Coho	9/3/2002	012-06	11/25/2002	339.90	347.56	17.52	14.65	147	115	20.82	13.84	169	119	5664	655	86.5	Analysis pending
Late	117	Coho	9/3/2002	012-07	11/22/2002	301.05	339.43	15.78	14.92	132	124	15.08	15.72	127	128	5319	630	84.4	Analysis pending

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
Late	118	Coho	9/3/2002	012-08	11/25/2002	355.11	340.32	16.48	18.44	147	150	16.60	15.99	140	138	5934	600	98.9	Analysis pending
Late	119	Coho	9/3/2002	012-09	11/25/2002	451.74	450.86	14.90	14.71	102	102	18.09	16.21	126	120	6351	640	99.2	Analysis pending
Late	120	Coho	9/3/2002	012-10	11/26/2002	326.16	338.76	19.00	9.71	191	102	18.04	10.51	181	104	6731	605	111.3	Analysis pending
Late	121	Coho	9/3/2002	013-01	11/25/2002	273.27	309.47	14.88	14.20	130	136	15.48	18.18	145	161	5326	610	87.3	Analysis pending
Late	122	Coho	9/3/2002	013-02	11/26/2002	324.71	353.32	17.74	16.25	131	132	14.20	15.30	103	121	5209	590	88.3	Analysis pending
Late	123	Coho	9/3/2002	013-03	11/21/2002	337.14	377.30	18.99	16.63	159	150	17.85	16.63	151	131	6025	580	103.9	Analysis pending
Late	124	Coho	9/3/2002	013-04	11/27/2002	437.06	444.79	16.58	14.38	153	135	13.80	16.62	138	150	8297	650	127.6	Analysis pending
Late	125	Coho	9/3/2002	013-05	11/6/2002	322.96	347.97	19.28	26.66	134	172	20.32	29.04	144	198	4575	580	78.9	Analysis pending
Late	126	Coho	9/3/2002	013-06	11/20/2002	320.40	329.43	21.98	18.46	179	156	20.76	20.95	164	177	5354	615	87.1	Analysis pending
Late	128	Coho	9/3/2002	013-08	11/7/2002	353.25	410.81	17.70	14.46	138	100	15.72	20.22	112	155	5631	600	93.8	Analysis pending
Late	129	Coho	9/3/2002	013-09	11/22/2002	354.24	294.74	16.24	16.71	99	104	18.43	16.56	114	103	4009	615	65.2	Analysis pending
Late	131	Coho	9/4/2002	014-01	11/25/2002	422.41	420.41	23.26	21.18	138	121	25.36	20.90	151	117	4888	645	75.8	Analysis pending
Late	132	Coho	9/4/2002	014-02	11/22/2002	418.05	450.81	20.70	20.25	125	127	17.28	16.34	100	102	5293	630	84.0	Analysis pending
Late	133	Coho	9/4/2002	014-03	11/26/2002	459.94	442.03	18.21	18.93	118	124	16.89	18.63	110	117	5824	630	92.4	Analysis pending
Late	134	Coho	9/4/2002	014-04	11/21/2002	410.47	407.13	14.65	15.61	134	146	13.23	14.99	114	129	7301	680	107.4	Analysis pending
Late	135	Coho	9/4/2002	014-05	11/20/2002	443.28	305.24	17.03	21.76	146	182	18.95	15.68	165	133	6401	640	100.0	Analysis pending
Late	136	Coho	9/4/2002	014-06	11/25/2002	216.96	403.06	18.08	29.55	142	218	20.58	29.36	164	224	4741	590	80.4	Analysis pending
Late	137	Coho	9/4/2002	014-07	11/27/2002	357.40	361.02	19.02	19.31	159	160	20.34	20.70	174	173	6027	600	100.4	Analysis pending
Late	138	Coho	9/4/2002	014-08	11/22/2002	364.26	409.94	22.15	21.40	145	144	21.20	19.30	140	134	5197	615	84.5	Analysis pending
Late	139	Coho	9/4/2002	014-09	11/26/2002	544.81	532.42	16.88	21.95	105	129	15.57	23.32	94	131	6399	670	95.5	Analysis pending
Late	140	Coho	9/4/2002	014-10	11/22/2002	448.31	431.80	18.75	19.96	106	110	19.28	18.10	108	100	4906	600	81.8	Analysis pending
Late	141	Coho	9/5/2002	015-01	11/7/2002	429.76	418.67	22.74	24.26	142	151	25.52	22.79	166	120	5145	640	80.4	Analysis pending

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon retunring to the Unalakleet River in 2002.

						Total ovary weights (g)		1st subsample weight (g)		1st subsample egg count		2nd subsample weight (g)		2nd subsample count					
Run time group	Fish #	Species	Capture date	ADF&G code	Egg count date	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Ovary 1	Ovary 2	Estimated fish fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)
Late	142	Coho	9/5/2002	015-02	11/20/2002	408.65	358.66	19.20	19.07	125	132	18.67	19.07	125	125	5115	615	83.2	Analysis pending
Late	143	Coho	9/5/2002	015-03	11/22/2002	384.77	403.23	15.20	22.25	112	164	20.66	22.05	133	149	5505	640	86.0	Analysis pending
Late	144	Coho	9/5/2002	015-04	11/20/2002	303.63	309.89	18.47	17.11	128	119	17.69	21.68	123	151	4265	540	79.0	Analysis pending
Late	145	Coho	9/5/2002	015-05	11/21/2002	415.50	398.46	17.21	18.87	118	132	19.18	20.67	134	144	5657	590	95.9	Analysis pending
Late	146	Coho	9/5/2002	015-06	11/7/2002	350.99	335.51	23.22	19.10	185	172	19.80	18.86	143	139	5413	630	85.9	Analysis pending
Late	147	Coho	9/5/2002	015-07	11/20/2002	293.64	363.23	19.62	18.70	174	155	18.64	18.93	162	149	5513	590	93.4	Analysis pending
Late	148	Coho	9/5/2002	015-08	11/7/2002	421.68	365.13	19.58	19.59	174	145	24.00	19.51	154	161	6084	625	97.4	Analysis pending
Late	149	Coho	9/5/2002	015-09	11/7/2002	453.55	475.72	19.67	23.77	164	136	21.78	24.18	133	148	6092	645	94.5	Analysis pending
Late	150	Coho	9/5/2002	015-10	11/20/2002	413.94	443.51	21.01	18.08	136	131	18.51	18.31	123	120	5775	630	91.7	Analysis pending
Late	151	Coho	9/5/2002	016-01	11/25/2002	263.99	249.24	14.55	17.50	141	167	14.99	13.44	149	131	4995	545	91.7	Analysis pending
Late	152	Coho	9/5/2002	016-02	11/21/2002	465.41	503.74	22.37	21.49	162	162	16.93	20.43	133	159	7372	625	118.0	Analysis pending
Late	153	Coho	9/5/2002	016-03	11/27/2002	318.90	347.02	19.77	22.81	180	206	22.33	20.12	193	180	5949	590	100.8	Analysis pending
Late	154	Coho	9/5/2002	016-04	11/22/2002	381.17	377.88	19.20	15.54	144	122	16.61	14.70	131	114	5881	580	101.4	Analysis pending
Late	155	Coho	9/5/2002	016-05	11/22/2002	418.78	377.96	15.13	15.44	113	108	13.65	16.82	106	117	5826	650	89.6	Analysis pending
Late	156	Coho	9/5/2002	016-06	11/20/2002	421.93	366.31	20.21	21.53	133	138	23.54	20.37	146	132	5058	590	85.7	Analysis pending
Late	157	Coho	9/5/2002	016-07	11/20/2002	394.47	416.91	20.97	16.05	129	100	17.43	14.05	107	86	4999	600	83.3	Analysis pending