Fecundity of Chum and Coho Salmon from Two Rivers in Norton Sound, Alaska

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Fecundity of Chum and Coho Salmon from Two Rivers in Norton Sound, Alaska

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Cover Photo: ADF&G technician Glenn Ryan holds a salmon to be sampled for fecundity. Unalakleet River test net is in background.

EXECUTIVE SUMMARY

Salmon fecundity is an important aspect of population dynamics because it directly affects a population's reproductive capacity. Fecundity data can be used to model potential egg deposition and habitat seeding, juvenile survival, correlations between adult abundance and juvenile production, and to compare potential production from different escapements. Because fecundity is known to vary among populations and regions, models that use fecundity values from the literature instead of from local populations may include unknown levels of bias. We estimated fecundity of salmon from two rivers in Norton Sound, Alaska, to obtain empirical estimates from within the region. Fecundity was estimated for chum and coho salmon from the Unalakleet River in 2002 through 2004; chum salmon fecundity was also estimated from the Fish River in 2004. Total fecundity, relative fecundity (eggs per unit body length), and fecundity at a standard size were all reported to account for fish size and to allow comparisons to published literature. When compared to populations from other regions (using total, relative, or standardized fecundity), chum salmon fecundity from this study was approximately average and coho salmon fecundity was unusually high. Chum salmon fecundity was affected by body length in 2003 but not in 2004. Chum fecundity was not affected by year (2002 vs. 2004 only), by river (Fish River vs. Unalakleet River), or by run timing. Coho salmon fecundity was affected by body length and fish age, but not by year (2002 through 2004) or run timing. The overall results provide empirical data that can be used when modeling population dynamics of chum and coho salmon from Norton Sound. Variability among size classes, ages, and years should be considered when applying Norton Sound fecundity data to population models.

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INTRODUCTION

Fecundity – the number of eggs produced by a female fish – affects the reproductive potential of a spawning population (Rounsefell 1957) and is important to many models and estimates used in fisheries management. A salmon population's reproductive capacity, for example, has implications for the development of biological escapement goals (BEGs) because populations with different reproductive potential may require different numbers of spawners to achieve the same level of future production. Fecundity data have also been used to estimate habitat seeding rates (Healey and Heard 1984), egg to fry survival rates (Bradford 1995), and to back-calculate the number of adults needed to achieve different levels of juvenile production (Bocking and Peacock 2004). Salmon fecundity can vary substantially among regions, among years, and within watersheds (Salo 1991), introducing uncertainty into models that use fecundity data developed from other regions or years. Such uncertainty is particularly relevant to western Alaska salmon, where salmon fecundity has rarely been studied and data must be inferred from literature values derived from outside the region.

Salmon fecundity can be inherited, as well as associated with both fish morphology and environmental variables. These associations vary among populations and species, and can include fish body length, latitude, egg size, inriver migration distance, maternal effects, stock abundance, and run timing (Appendix A; Rounsefell 1957; Beacham 1982; Salo 1991; Beacham and Murray 1993). Knowledge of the association between fecundity and local biological or environmental variables can help indicate whether such variables must be considered when estimating a population's potential egg production. Such associations may be especially important in Norton Sound, Alaska, where salmon populations exist at the northern edge of their North American range and are likely subject to unusual environmental conditions.

Salmon production is of concern in Norton Sound, Alaska, because of the traditional importance of salmon to local, subsistence-based communities (Magdanz et al. 2003) and recent declines in salmon harvests throughout the region. Subsistence fishing opportunity has been reduced in northern Norton Sound in recent years and commercial salmon fisheries have largely ended in all but the Unalakleet and Shaktoolik subdistricts (Menard 2003). These harvest reductions are a direct result of low chum salmon returns in recent years, especially in 1999 (NSRRP 2002) and 2003 (Menard 2003). The declines have also led to the implementation of precautionary management and an emphasis on the development of improved escapement goals (Clark 2001). Current escapement goals have been developed assuming inherently low productivity of Norton Sound chum salmon because of the absence of quality salmon production data (Clark 2001). Knowledge of fecundity and potential egg deposition are thus elements that can help refine current harvest management at a critical time in the Norton Sound salmon fishery (NSRRP 2002).

Declines of salmon, particularly chum, in 1999 led to funding for the research and restoration of Norton Sound salmon stocks. The steering committee that directs these funds identified the need to improve knowledge of fecundity of Norton Sound populations of chum and coho salmon (NSRRP 2002). A convenient source of fish for fecundity analysis is the Unalakleet River test fishery, which is operated annually by the Alaska Department of Fish and Game (ADF&G) as part of their effort to assess returns of chum and coho salmon to the Unalakleet River (Kohler 2002). Salmon caught in the test fishery have historically been distributed to members of the

local community. In 2002 and 2003, eggs were counted from these fish, thereby generating fecundity estimates of Unalakleet River chum and coho without sacrificing additional fish (Nemeth et al. 2004). This work was continued in 2004, thereby improving estimates of variability among years and between Norton Sound and other regions. In addition, egg samples were also taken from chum salmon caught in subsistence nets in the Fish River, also in Norton Sound. The specific objectives in 2004 were to:

1) Estimate fecundity of chum and coho salmon returning to the Unalakleet River and at least one other Norton Sound river;
2) Determine the relationship between fecundity and fish age and length;
3) Compare differences in fecundity of Unalakleet River salmon among years (2002 to 2004);
4) Evaluate whether salmon used for fecundity assessments are representative (in length or age) of salmon returning to the Unalakleet River and Norton Sound, and;
5) 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). The river is the largest in the Norton Sound 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 snowmelt and rainfall; maximum flows are typically in June and minimum flows are typically in March. The United States Geological Survey (USGS) operates a water gauge on the Unalakleet River approximately 41 km upstream of its mouth, east of the confluence of the Chiroskey River. From 1997 to 2001, mean monthly flows have ranged from 103 ft^3/sec in March to 4,011 ft^3/sec in June (Meyer et al. 2002).

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 2004 the test fishery operated from June 3 to September 10. The test net was operated similarly to prior years, in that it 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).

The Fish River arises in the Bendeleben Mountains and runs approximately 80 km southward, emptying into Norton Sound at Golovin Bay (Figure 1). The drainage is believed to be the second largest producer for chum salmon (after the Unalakleet River) in Norton Sound, and supports commercial, subsistence and sport fishing in Subdistrict 2 (Todd and Kohler 2003). One of the largest tributaries is the Niukluk River, on which the ADF&G has operated a tower to count salmon since 1995. The tower operation includes beach seining to collect age, sex, and length information from returning salmon (Kohler 2001). Chum salmon eggs used for this study in 2004 were collected from subsistence users catching chum at the confluence with the Fox

River, approximately 20 km (12 miles) upstream of Golovin Bay and 10 km (6 miles) south of the Niukluk River confluence (Figure 1).

METHODS

Sample collection and storage

Chum and coho salmon from the Unalakleet River in 2004 were collected from fish captured during the ADF&G annual test fishery, which was conducted at the same site from 2002-2004. The net was made of 14.9 cm (5 – 7/8 inch) stretched mesh, extended 37 m (121.4 ft) from the riverbank, and was fished in the upper 1 m (3.3 ft) of the water column. The net was checked twice per day, and all captured fish were assumed to have entered the river from the ocean within a few hours of capture.

Sub-samples of chum and coho salmon from the test net were chosen without known bias. Within 24 hours of being caught, the fish were measured for length (mid-eye to fork of tail; MEF), scale samples were removed for age analysis, and both egg skeins were removed from the fish. The egg skeins were frozen for several months before being sampled for fecundity estimates. All salmon scales from the Unalakleet River were aged by ADF&G staff in Nome.

Chum salmon sampled from the Fish River were collected by a Norton Sound subsistence fisher using multiple sets of a beach seine on July 8, 2004. Fish were measured for length (MEF), scale samples were removed for age analysis, and both egg skeins were removed from the fish. Skeins were processed as described for the Unalakleet River fish. All salmon scales from the Fish River were aged by Birkenhead Scale Analysis (Lone Butte, B.C.).

Data analysis

Fecundity estimates

To estimate fecundity, egg skeins were thawed and weighed to the nearest 0.01 g on a digital balance and sub-sampled. Two sub-samples of ~110 eggs each were collected from one of the ovaries (egg skeins) of each fish; each sub-sample was composed of ~35 eggs from three sections of the skein, the middle and 1/3 of the way from each end. Care was taken to collect whole eggs and avoid including egg fragments in the sub-sample. Each sub-sample was weighed to the nearest 0.01 g and the number of eggs within it counted. Samples were taken from only one egg skein per fish because prior tests indicated no differences in fecundity between the two skeins of an individual fish (Nemeth et al. 2004).

Fecundity estimates were derived from the sub-sample egg counts and the ratio of the egg skein weights to the sub-sample weights, similar to the methods of Skaugstad and McCracken (1991). The number of eggs in each replicate was estimated by dividing the egg skein weight by the sub-sample weight, then multiplying by the number of eggs in the sub-sample (Equation 1). The number of eggs in the fish was estimated as the sum of the replicates.

$$F_{ij} = \frac{(G_j)(Egg_{ij})}{g_{ij}}; \quad (1)$$

where:

F_{ij} = estimated fecundity based on sub-sample *i* from skein *j*;

G_j = weight of skein *j*;

Egg_{ij} = number of eggs in sub-sample *i* from skein *j*; and,

g_{ij} = weight of sub-sample *i* from skein *j*.

Association between fecundity, length, age, and run timing

Length was regressed against fecundity to estimate the slope of the relationship. The effects of fish length, age, and run timing on fecundity were tested using analysis of variance (ANOVA; S-Plus 6). Because fecundity is known to vary with fish length (Beacham and Murray 1993), fish fecundity was also divided by body length (MEF) to report the fecundity per cm of fish body length. Throughout this report, total fecundity refers to the total number of eggs estimated per fish and relative fecundity refers to the number of eggs per cm of (MEF) body length.

The effect of run timing on fecundity was estimated in 2004, with length included as an interaction term. Chum samples were classified into three run time groups (early, middle, and late) based on their collection times and a postseason comparison to where they fell in relation to the run through the test fishery in 2004. Coho salmon were classified into two run time groups (early and late) using the same criteria. Only age 2.1 coho were used in the run timing assessment. Chum and coho run timing data through the test fishery were provided by W. Jones, ADF&G (unpublished data 2004).

Comparisons among populations and between years

The effect of river system and fish length was tested using ANOVA for Unalakleet and Fish River chum in 2004. The comparison between the two rivers was restricted to age 0.4 chum to remove any effect of age. The effect of year was tested for chum and coho from the Unalakleet River, with length included as a factor. To remove any effect of age, the comparison was limited to age 0.4 fish for chum and age 2.1 fish for coho. For chum salmon, this age restriction limited the yearly comparisons to 2002 vs. 2004 because of an inadequate sample size of age 0.4 fish in 2003.

Fecundity of salmon from the Unalakleet and Fish rivers was compared to fecundity from other salmon populations reported in the literature. Total fecundity of Unalakleet River coho salmon was compared to populations reported by Sandercock (1991). Relative fecundity of chum salmon was compared to North American populations reported by Salo (1991). The Salo (1991) study used total fork length to determine relative fecundity; therefore MEF lengths for

Unalakleet and Fish river chum were converted to total fork length using the equation (Helle 1979; Salo 1991):

$$7.9948 + 1.0706 * MEF \quad (2)$$

For further comparison to other fish populations, the MEF length of the Unalakleet and Fish river salmon was converted to the postorbital-hypural (POH) length using the species-specific formulas for coho salmon (Beacham 1982):

$$21.8 + 0.93 * MEF \quad (3)$$

and for chum salmon (Pahlke 1989):

$$-16.255 + 0.922 * MEF \quad (4)$$

Simple linear regression was used to describe the relationship between POH length and total fecundity for Unalakleet River coho and chum salmon. The regression equations were then used to predict fecundity at the POH lengths (58.8 cm for chum salmon, 53.6 cm for coho salmon) used by Beacham (1982) to standardized fecundity among populations. Standard errors for predicted fecundity at the standard length were calculated using equation 16.26 of Zar (1996).

RESULTS

Fecundity estimates

In 2004, 60 chum salmon were collected from the Unalakleet River and 33 chum salmon were collected from the Fish River. The sample (both rivers combined) consisted of 25% age 0.3, 74% age 0.4 and 1% age 0.2. The age structure in 2004 was most similar to the samples collected in 2002 (Table 1). Mean (SE) fecundity was 2,742 (71) for Unalakleet River chum, and 2,535 (78) for Fish River chum. The distributions of estimated fecundity were approximately normal for Unalakleet and Fish River chum (Figure 2).

Fifty-five coho salmon were collected from the Unalakleet River in 2004. The sample consisted of 13% age 1.1, 78% age 2.1, 2% age 3.1 and 7% unknown (Table 1). The age structure was similar to 2002 and 2003 (Table 1). Mean (SE) fecundity was 5,401 (129) for Unalakleet River coho (Table 1). The fecundity distribution was approximately normal for Unalakleet River coho (Figure 2).

Association between fecundity, length, age, run timing, and river

Chum salmon

The linear regression of total fecundity versus length was $y = 9.7069x - 3078$ for Unalakleet River chum and $y = 3.8859x + 375.68$ for Fish River chum in 2004 (Figure 3).

Chum fecundity from the Unalakleet and Fish Rivers was not affected by fish length or age (Table 2; Figure 4). Interactions between fish length and age were also not significant (Table 2). Fecundity did not differ between age 0.4 chum sampled from the Unalakleet and Fish Rivers, after accounting for length. There was no interaction between river and fish length (Table 3).

Chum salmon run timing in the Unalakleet River was divided into three groups based on the dates of apparent groups passing through the test fishery. These catch groups were from June 9 through June 24 for Group 1, from July 2 through July 13 for Group 2, and July 28 through July 30 for Group 3 (Figure 5). Fecundity did not differ among the run time groups (Table 4).

When chum from 2002 and 2004 were compared (age 0.4 chum from the Unalakleet River only), fecundity was not affected by year but was affected by fish length. The interaction between length and year was not significant (Table 5).

Coho salmon

The linear regression of total fecundity versus length was $y = 18.6x - 5511.7$ for Unalakleet River coho in 2004 (Figure 3). Coho fecundity was affected by both fish age and length (Table 2), with fecundity decreasing with age (Figure 6). The interaction between age and length was not significant.

Run timing of coho in the Unalakleet River was divided into two groups based on the dates of apparent groups passing through the test fishery. These catch groups were from July 20th through August 2nd for Group 1 and from August 16th through September 3rd for Group 2 (Figure 5). Only age 2.1 coho were included in the run timing analysis to avoid any interaction between fish age and run timing. Fecundity did not differ between the run time groups (Table 4).

For coho sampled from 2002 through 2004 (age 2.1 fish only), fecundity was not affected by year but was affected by fish length (Table 6). The interaction between length and year was not significant.

Comparisons among populations outside of Norton Sound

The fecundity of chum and coho salmon from the Unalakleet River in 2004 was average to higher than average compared to published reports for salmon from other regions. When standardized to 58.8 cm POH length, Unalakleet and Fish River chum fecundity was comparable to those reported by Beacham (1982) for other North American populations (Figure 7). When converted to relative fecundity, chum from the Unalakleet and Fish rivers each had 46 eggs / cm, which is approximately average when compared to relative fecundities of 11 North American populations presented by Salo (1991; Figure 8). When standardized to 53.6 cm POH length, Unalakleet River coho salmon fecundity was substantially higher than fecundities reported by Beacham (1982) for other North American coho populations (Figure 9). Without this standardization, the mean total fecundity of Unalakleet River coho salmon in 2004 was 5,401 eggs, substantially higher than the total fecundity of 13 North American and Russian populations presented by Sandercock (1991; Figure 10).

DISCUSSION

This study provides rigorous estimates of fecundity for chum and coho salmon that can be used in models of salmon population dynamics in the Norton Sound region. The study also indicates that two assumptions required to use egg abundance (or density) data to estimate salmon reproductive potential (reviewed by Rounsefell 1957) are not valid for chum and coho from the Unalakleet River. These invalid assumptions are that 1) the relation between fecundity and fish size is not linear for chum or coho; 2) fecundity does not appear to be independent of age in coho. Because of this, researchers should know a chum population's length structure and a coho population's age and length structures when attempting to model total egg deposition or production in Norton Sound. Such age and length data are routinely collected in the course of adult stock assessment projects, and rivers with these projects are thus probably the most feasible ones to apply the results of this study to. In Norton Sound, such salmon stock assessment projects are currently conducted on the Nome, Snake, Eldorado, Fish, Niukluk, Kwiniuk, Unalakleet, North, and Pikmiktalik rivers (Brennan et al. 2003). On rivers where such age and length data are not available, researchers should assume that chum fecundity falls in the middle of the range of the literature, and that coho fecundity is near the high end of the range.

The study also provides evidence of the transferability of fecundity data in Norton Sound. After accounting for the length and age factors described above, we did not detect a difference among two rivers (chum salmon only) or multiple years (chum and coho salmon). Similarly, run timing did not appear to affect fecundity in 2004. This evidence should be considered preliminary because it is based on relatively few spatiotemporal observations, thus reducing the chances of including an unusual year or river. The lack of difference between 2002 and 2004 for Unalakleet River chum gives some confidence that fecundity may not fluctuate substantially among years, but does not prove that such fluctuations cannot occur. Beacham (1982) detected annual differences among years in fecundity of both chum and coho salmon, but these years were generally further apart than the three years consecutive years compared for the Unalakleet River. Similarly, the lack of difference between chum from the Unalakleet and Fish rivers indicates that fecundity may be similar among the two rivers, but does not rule out differences in other years. For coho salmon from the Unalakleet River, the lack of fecundity difference among years came from three years (2002-2004), and is somewhat more rigorous than the two-year comparison for chum. As with chum, however, it does not prove that fecundity may not differ among some years.

The lack of differences among years and between rivers also ignores the distinction between statistical and biological importance. Our study did not detect differences that were statistically significant, meaning that the differences observed were probably within the range of random variation. There were slight differences in fecundity among all populations, however, and it is possible that these differences could be biologically significant. Fecundity per cm of body length varied by approximately 5% to 10% per year among same-age fish (both coho and chum) in the Unalakleet River (Table 1). If such differences translated to dozens or hundreds of returning spawners in the next generation, they could be biologically significant for the population even while being statistically insignificant.

The reporting of three different forms of fecundity (total eggs, eggs/cm of body length, and estimated eggs at a standard size) is intended to allow comparisons to the various values reported

in the literature. Of these three, standardized fecundity (Beacham 1982) should be considered the best measure of fecundity because it accounts for the allometric relationship often seen between length and fecundity (e.g., fecundity per unit length changes as fish length increases). Total or relative fecundity, while not being as rigorous, provided similar overall results and support the evidence that Norton Sound chum have average to above average fecundity and that Norton Sound coho have unusually high fecundity. It is important to note that the equations used to convert fork lengths to POH lengths in this study were derived from chum (Pahlke 1989) and coho (Beacham 1982) salmon outside of Norton Sound.

The associations between fecundity and other variables were consistent with the literature, with the exception of the decrease in fecundity with increased coho salmon age. Reviews of coho fecundity have not reported an association with fish age (Beacham 1982; Sandercock 1991), apparently because of insufficient age data (Beacham and Murray 1993). The increased fecundity with fish length is consistent with chum and coho salmon from other regions (Salo 1991; Sandercock 1991). The high fecundity of Unalakleet River coho is also consistent with Sandercock's (1991) report of an increase in fecundity with increased latitude. This trend is apparent when arranging the coho fecundity datasets from Beacham (1982) and Sandercock (1991) in order of increasing latitude. When Unalakleet River coho are added to these datasets, they become both the highest-latitude and the highest-fecundity population (Figures 9 and 10).

One purpose of this study was to establish a baseline for Norton Sound salmon fecundity while determining whether fecundity was unusually low. As a baseline, this study should provide ample opportunity for comparisons to other populations, or to a repeat study that attempts to detect future changes in fecundity of Norton Sound salmon. The baseline may be especially useful to have established now, in light of the potential for climate change, the recent changes in salmon age at maturity in the north Pacific Ocean, and the resulting changes in salmon reproductive potential (Bigler et al. 1996). As part of an investigation into the production potential of Norton Sound salmon, the study showed that chum and coho from the Unalakleet River clearly did not have low fecundity (relative to other populations) during the study period. Comparisons of fecundity among populations need to be interpreted carefully, however, because populations from different regions may need different egg production to be evolutionarily successful. Although Norton Sound chum and coho do not appear to have problematically low potential egg production, we cannot know what level they require for sustainability in the Norton Sound environment. The best indicator may come from other populations from similar latitudes (Alaska or Asia), but fecundity of such populations is not well known.

Based on fish length data available from other projects, our fecundity samples in 2004 excluded the smallest salmon returning to the Unalakleet River. In 2004, the ADF&G used seine nets to capture chum and coho salmon as part of projects unrelated to the test fishery (J. Estensen; P. Joy; ADF&G unpublished data 2005). These seine nets captured a small size class of salmon not captured by the gill net used to conduct the Unalakleet River test fishery and provide our fecundity samples. For chum salmon, the fecundity samples omitted fish from 460 mm to 530 mm, which comprised the smallest 1/3 of chum lengths recorded by all the ADF&G adult sampling projects (Figure 11). For coho salmon, the fecundity samples omitted fish from 470 to 530 mm, which comprised the smallest 1/5 of the coho lengths recorded by all the ADF&G adult sampling projects (Figure 12). Fecundity of these smaller chum and coho can be estimated from our regression equations (e.g., Figure 3), but researchers should be aware that these are

interpolations from larger fish. It is not known how many fish these size classes represent because the abundance of Unalakleet River chum and coho has never been estimated. The proportion of female fish in these smallest size classes of chum and coho is also not known.

The high fecundity of Unalakleet River coho salmon is interesting from an evolutionary biology perspective. Egg production involves some trade-off between egg size and quantity, which are usually inversely proportional (Roff 1992), and it appears that Unalakleet River coho have evolved to produce a large number of relatively small eggs. Fry from small eggs, however, generally have decreased survival and growth (Roff 1992); if these were the only important parameters, salmon would theoretically evolve to produce relatively few, large eggs. Both theoretical and empirical egg size studies, however, have shown that highly-fecund species (such as coho salmon) have evolved to produce an egg size that maximizes maternal fitness, which is essentially the product of the number of offspring and their average fitness (Smith and Fretwell 1974; Einum and Fleming 2000; Einum et al. 2002). When applied to Unalakleet River coho salmon, this would indicate that there is some advantage to producing the high number of small eggs observed in this study. This advantage, while unknown, would offset the decreased individual fry growth and survival that presumably results from producing smaller eggs.

One explanation for the evolution of small eggs has been that cold, low-oxygen waters – such as those in Norton Sound rivers in winter – are insufficient to meet the greater metabolic demands of large eggs. Recent tests with eggs of both brown trout (*Salmon trutta*) and Atlantic salmon (*Salmo salar*), however, found that incubation in low oxygen environments selected for large rather than small eggs (Einum et al. 2002). This selection is presumably because the increased surface area (which determines oxygen acquisition ability) of large eggs compensates for the increased egg volume or mass (which determines oxygen requirements). It thus seems likely that there is another explanation for the apparent evolution of relatively small eggs in Unalakleet River coho salmon. This explanation could be as simple as juvenile coho from Norton Sound having low survival rates, independent of fish size, thereby increasing the benefit of a greater number of total offspring.

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Special thanks are extended to Vaughn Munn (NSEDC), who performed all laboratory counts of fecundity. We also thank the Nome ADF&G staff for their support. Peter Nanouk, Allegra Banducci, and Glenn Ryan (ADF&G) collected and froze the salmon ovaries. Gary Knuepfer (ADF&G) and Carol Lidstone (Birkenhead Scale Analysis) aged scales. Wes Jones (ADF&G) provided age and run timing data and helped with transfer and storage of egg samples. Jeff Estensen, Phil Joy, and Wes Jones (ADF&G) provided salmon age, sex, and length data from other assessment projects.

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Table 1. Fecundity and length statistics for chum and coho salmon sampled from the Unalakleet River in 2002 - 2004, and the Fish River in 2004 (chum only).

						Total fecundity				Relative fecundity (eggs/cm body length)				Length (mm)			
Species	River	Year	Age	N	% of total	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD
Chum	Fish	2004	0.2	1	3	3266				59.9				545.0			
			0.3	12	36	2376	248	127	439	44.2	4.3	2.2	7.7	537.5	12.4	6.3	21.9
			0.4	20	61	2594	186	95	425	45.8	3.4	1.7	7.7	567.2	9.1	4.6	20.7
			Total	33		2535	153	78	449	45.6	2.7	1.4	7.9	555.7	8.6	4.4	25.1
	Unalakleet	2004	0.3	11	18	2810	289	147	488	47.5	5.0	2.5	8.4	591.8	9.8	5.0	16.6
			0.4	49	82	2726	160	82	571	45.3	2.6	1.3	9.1	601.3	5.0	2.6	18.0
			Total	60		2742	140	71	554	45.7	2.3	1.2	9.0	599.6	4.6	2.3	18.0
	Unalakleet	2003	0.3	45	88	2790	125	64	427	48.0	1.9	1.0	6.5	580.7	6.4	3.3	22.0
			0.4	5	10	3125	650	332	742	51.2	9.1	4.7	10.4	608.0	25.3	12.9	28.9
			Uknown	1	2	3809				58.2				655.0			
			Total	51		2843	133	68	483	48.5	1.9	1.0	7.0	584.8	7.1	3.6	25.7
	Unalakleet	2002	0.3	38	39	2577	154	78	483	43.7	2.5	1.3	8.0	589.9	5.6	2.9	17.7
			0.4	51	53	2963	142	72	516	49.3	2.3	1.2	8.3	600.8	5.7	2.9	20.8
			0.5	8	8	2935	289	147	417	48.1	4.6	2.4	6.7	610.0	21.8	11.1	31.4
			Total	97		2809	105	53	526	47.0	1.7	0.9	8.4	597.3	4.3	2.2	21.4

Table 1. Fecundity and length statistics for chum and coho salmon sampled from the Unalakleet River in 2002 - 2004, and the Fish River in 2004 (chum only).

						Total fecundity				Relative fecundity (eggs/cm body length)				Length (mm)			
Species	River	Year	Age	N	% of total	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD
Coho	Unalakleet	2004	1.1	7	13	6156	908	463	1226	105.2	13.4	6.8	18.1	582.9	18.0	9.2	24.2
			2.1	43	78	5311	258	132	864	90.4	4.0	2.0	13.3	586.5	6.9	3.5	23.0
			3.1	1	2	4787				76.6				625.0			
			Unknown	4	7	5198	1190	607	1215	88.5	19.7	10.0	20.1	586.3	13.7	7.0	14.0
			Total	55		5401	254	129	959	91.9	4.0	2.0	15.0	586.7	6.0		22.7
	Unalakleet	2003	1.1	3	8	6428	1001	511	885	101.3	13.2	6.8	11.7	633.3	18.2	9.3	16.1
			2.1	28	72	5750	345	176	931	94.2	5.2	2.7	14.1	610.0	11.1	5.7	30.1
			3.1	4	10	4572	250	128	255	75.8	2.7	1.4	2.8	602.5	15.2	7.8	15.5
			Unknown	4	10	8256	1837	938	1875	133.6	30.1	15.4	30.7	621.3	62.4	31.9	63.7
			Total	39		5938	415	212	1322	96.9	6.4	3.3	20.5	612.2	10.2	5.2	32.5
	Unalakleet	2002	1.1	7	7	6069	575	293	776	99.5	8.5	4.3	11.5	610.0	25.9	13.2	35.0
			2.1	65	68	5300	200	102	822	87.7	3.1	1.6	12.6	604.3	6.9	3.5	28.3
			3.1	11	12	5214	301	153	509	85.0	4.5	2.3	7.6	613.2	13.9	7.1	23.5
			Unknown	12	13	5207	705	359	1245	84.6	10.0	5.1	17.6	612.9	18.7	9.6	33.1
			Total	95		5335	174	89	867	87.8	2.6	1.3	13.1	606.8	5.8	2.9	28.7

Table 2. ANOVA results - effects of age and length on total fecundity of chum and coho salmon sampled from the Unalakleet and Fish Rivers, 2004.

	Type III Sum of Squares				
	Df	Sum of Sq	Mean Sq	F Value	P
Chum					
Fish River					
Age	2	766571	383285	2.020	0.1516
Length	1	157494	157494	0.830	0.3701
Age:Length	1	134935	134935	0.711	0.4062
Residuals	28	5313210	189758		
Unalakleet River					
Age	1	289839	289839	1.033	0.3139
Length	1	426820	426820	1.521	0.2227
Age:Length	1	274154	274154	0.977	0.3272
Residuals	56	15717675	280673		
Coho					
Unalakleet River					
Age	2	3803416	1901708	3.111	0.0541
Length	1	9175017	9175017	15.007	0.0003
Age:Length	1	967289	967289	1.582	0.2148
Residuals	46	28123161	611373		

Table 3. ANOVA results - effects of river and fish length on total fecundity of age 0.4 chum from the Unalakleet and Fish Rivers, 2004.

	Type III Sums of Sqaures				
	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
River	1	784747	784748	3.040	0.0859
Length	1	822199	822199	3.186	0.0790
River:Length	1	754516	754516	2.923	0.0921
Residuals	65	16776409	258099		

Table 4. ANOVA results - effects of run time grouping and fish length on total fecundity of chum and coho salmon sampled from the Unalakleet River, 2004.

		Type III Sums of Squares			
	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Chum					
Group	2	201745	100872.4	0.32	0.7264
Residuals	57	17883546	313746.4		
Coho					
Group	1	11408	11408	0.02	0.8902
Length	1	1539807	1539807	2.61	0.1145
Group:Length	1	7678	7678	0.01	0.9098
Residuals	39	23043082	590848		

Table 5. ANOVA results - effects of year and fish length on total fecundity of age 0.4 chum from the Unalakleet River, 2002 & 2004.

	Type III Sums of Sqaures				
	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Year	1	175033	175033	0.666	0.4165
Length	1	3729689	3729689	14.191	0.0003
Year:Length	1	144748	144748	0.551	0.4598
Residuals	96	25231102	262824		

Table 6. ANOVA results - effects of year and fish length on total fecundity of age 2.1 coho from the Unalakleet River, 2002 - 2004.

	Type III Sums of Sqaures				
	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Year	2	860823	430412	0.693	0.5021
Length	1	16101329	16101329	25.907	0.0000
Year:Length	2	916025	458013	0.737	0.4806
Residuals	130	80796568	621512		

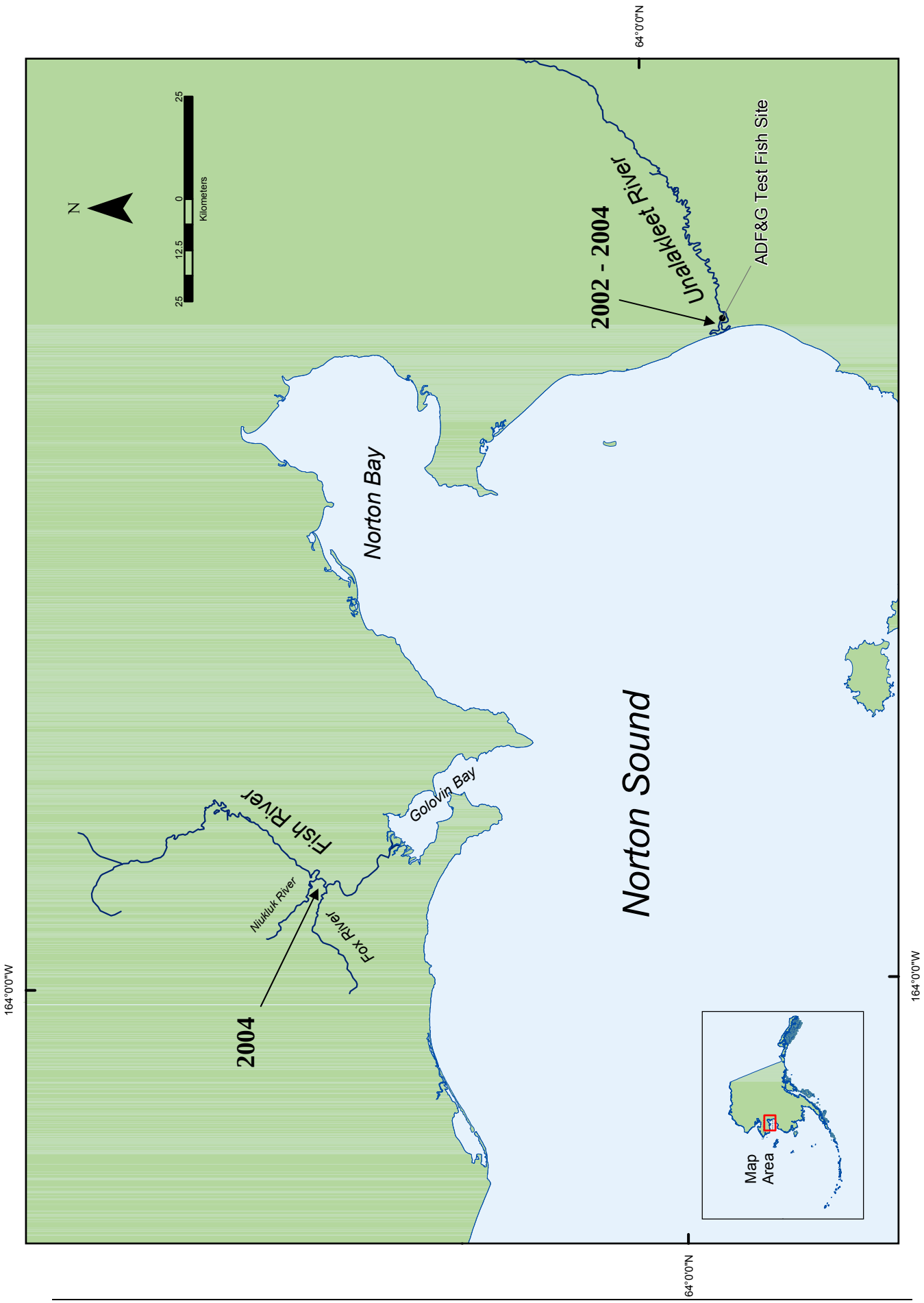
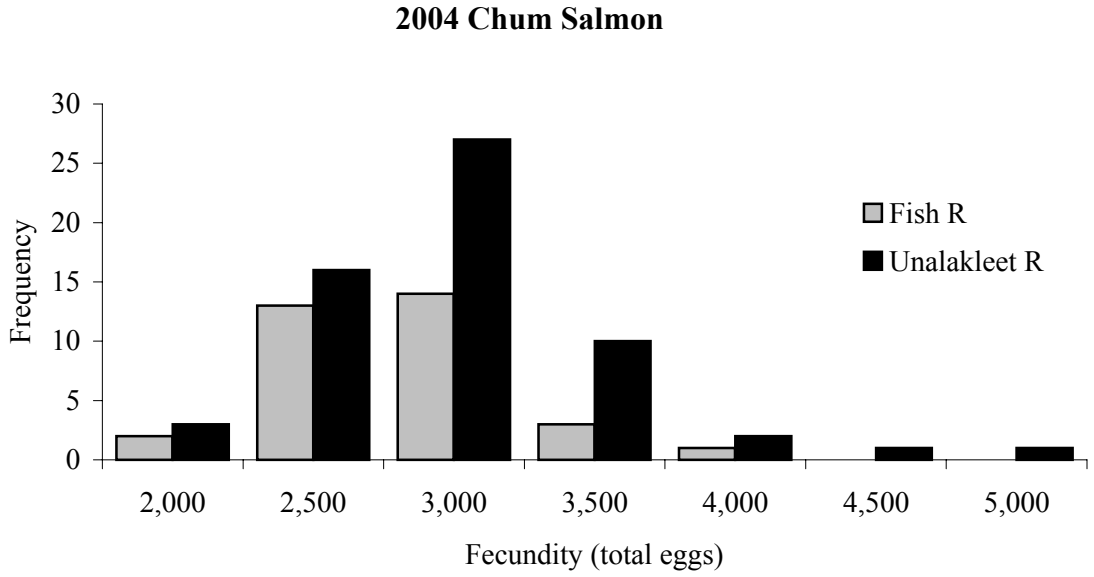


Figure 1. Map of Alaska (inset) and the Norton Sound region. Salmon sampled for fecundity came from the Fish River in 2004 and from the Unalakleet River from 2002 through 2004.



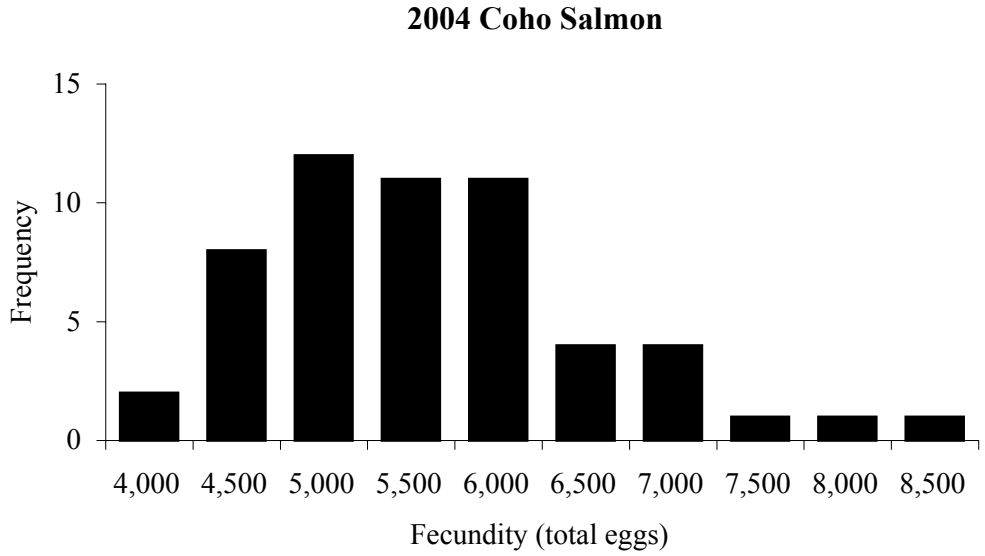


Figure 2. Histogram of fecundity for 33 Fish River chum, 60 Unalakleet River chum and 55 Unalakleet River coho in 2004.

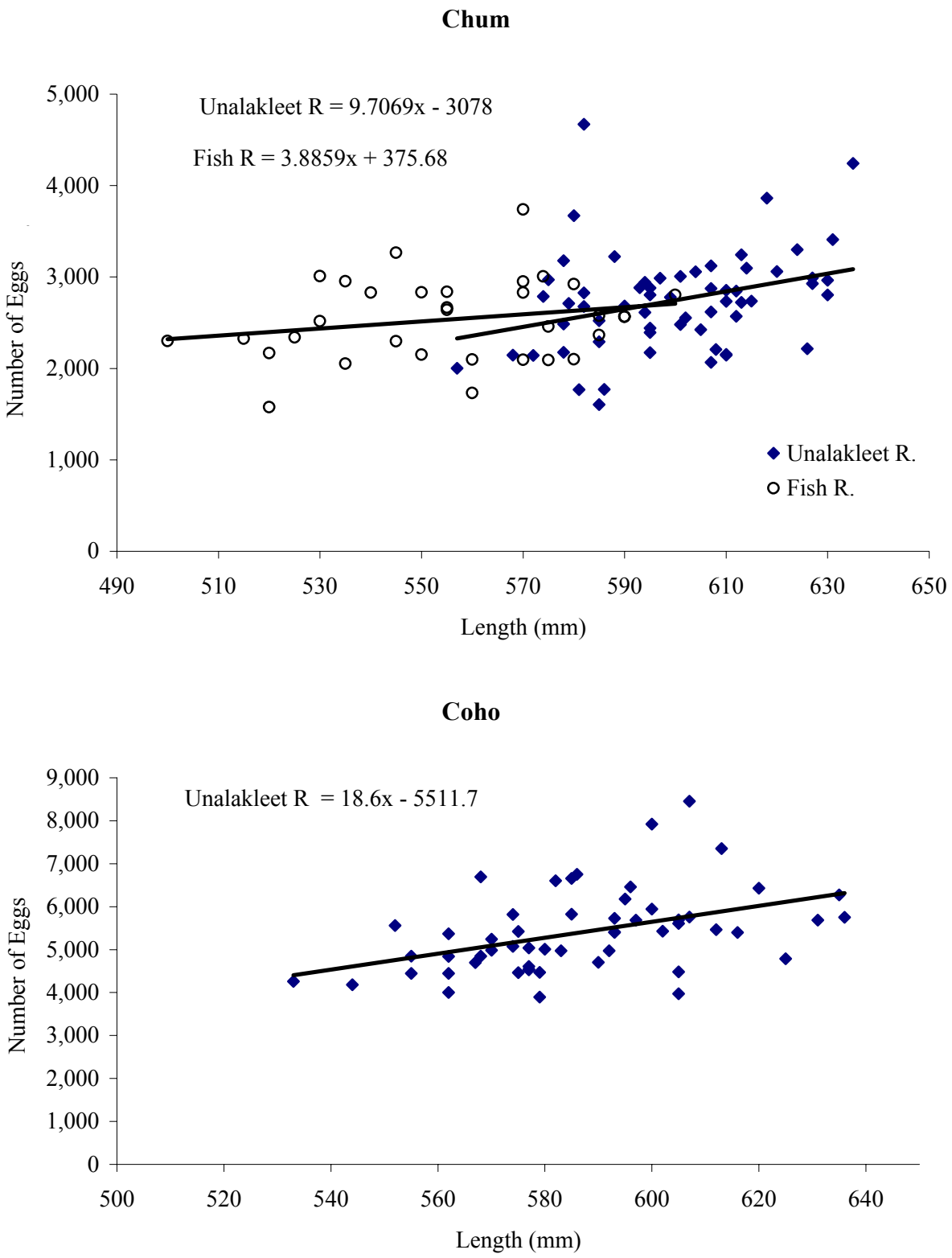


Figure 3. Total fecundity versus length for chum salmon and coho salmon sampled from the Unalakleet and Fish Rivers, 2004.

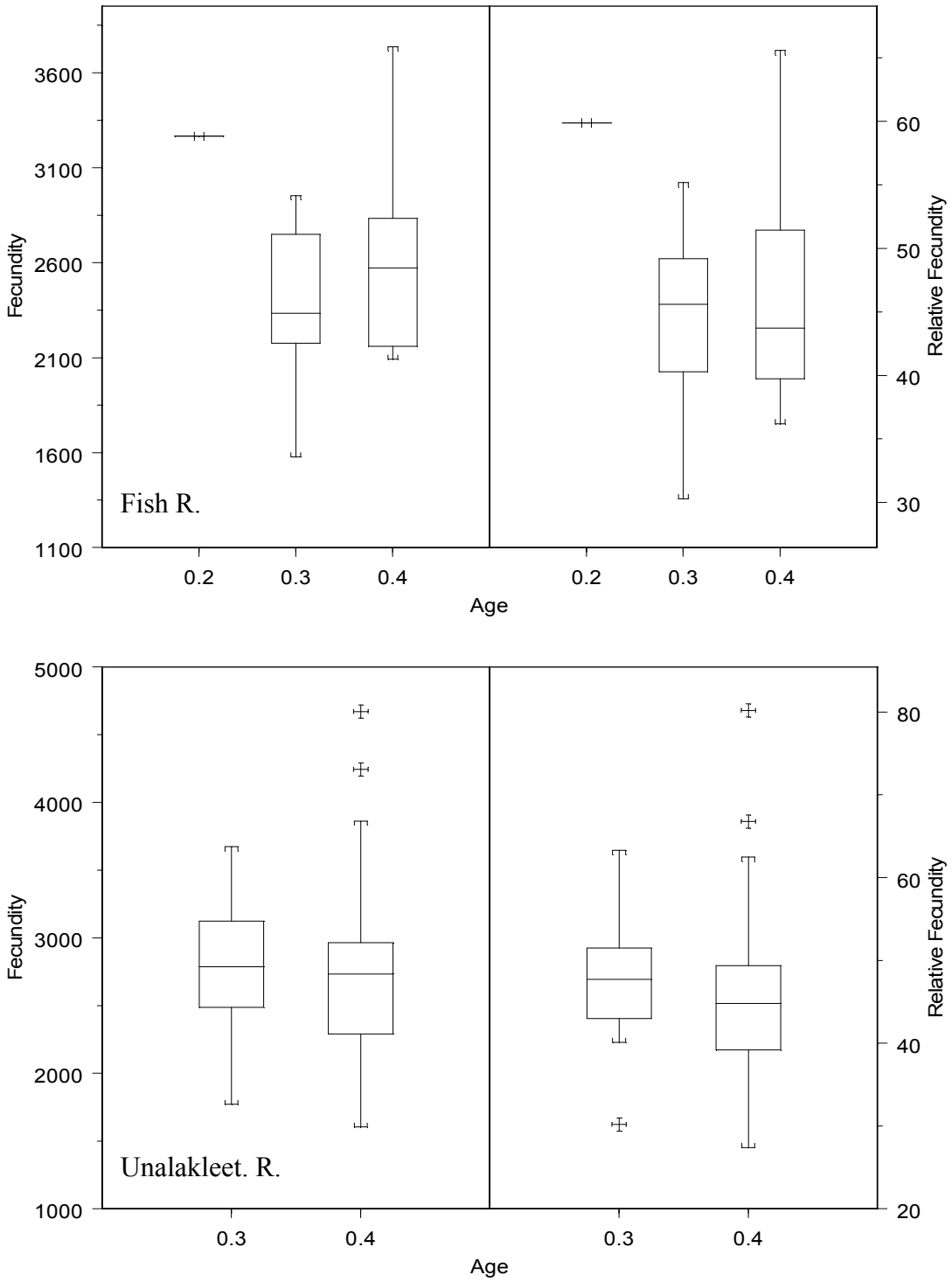
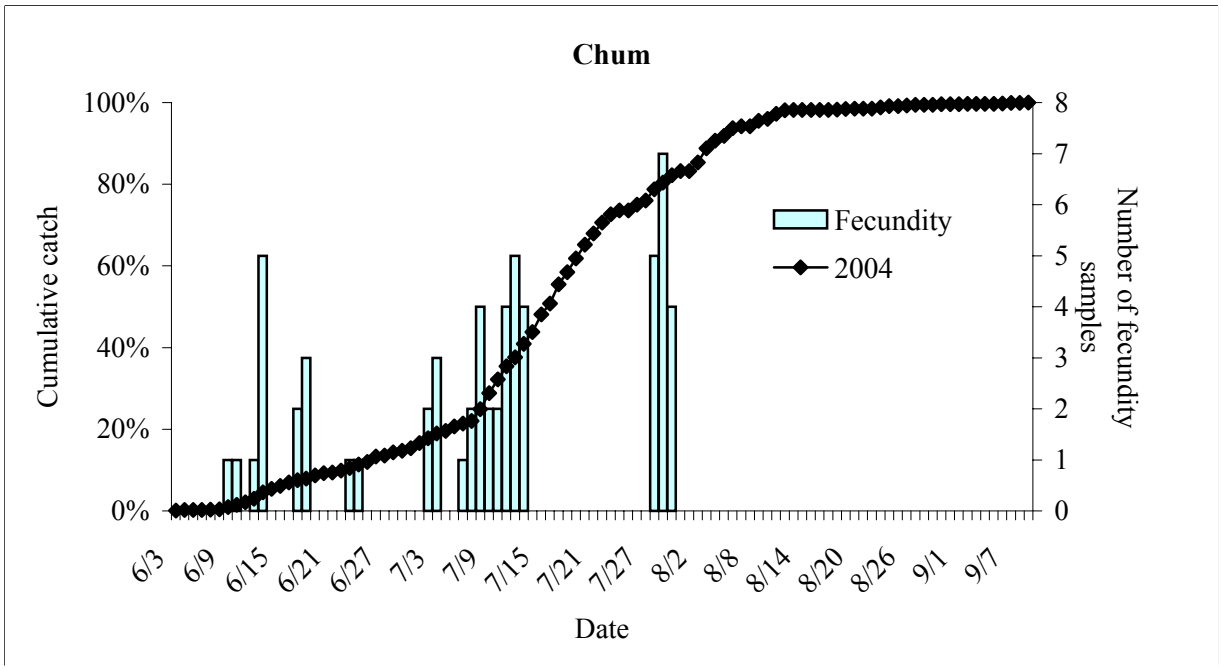


Figure 4. Box plots of total and relative fecundity (eggs/cm of body length) by age for chum salmon from the Fish and Unalakleet Rivers, 2004. Center horizontal line is sample median, box edges are 1st and 3rd quartiles, whiskers extend 1.5 times the inter-quartile range, and asterisks denote outliers.



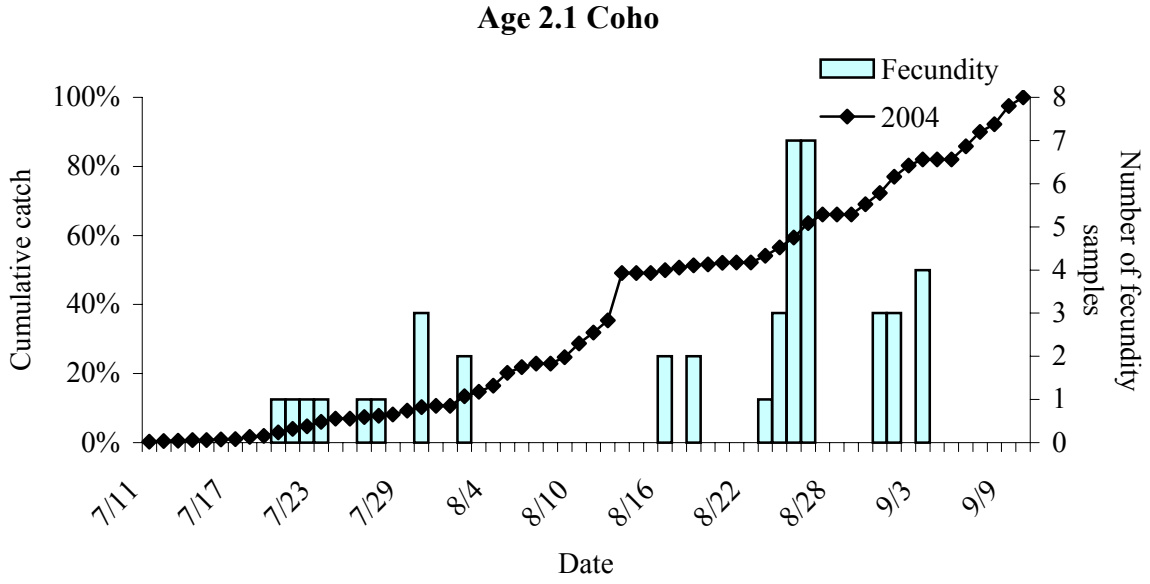


Figure 5. Comparison of capture dates of chum and age 2.1 coho salmon sampled for fecundity to cumulative daily catch from the ADF&G test fishery in 2004.

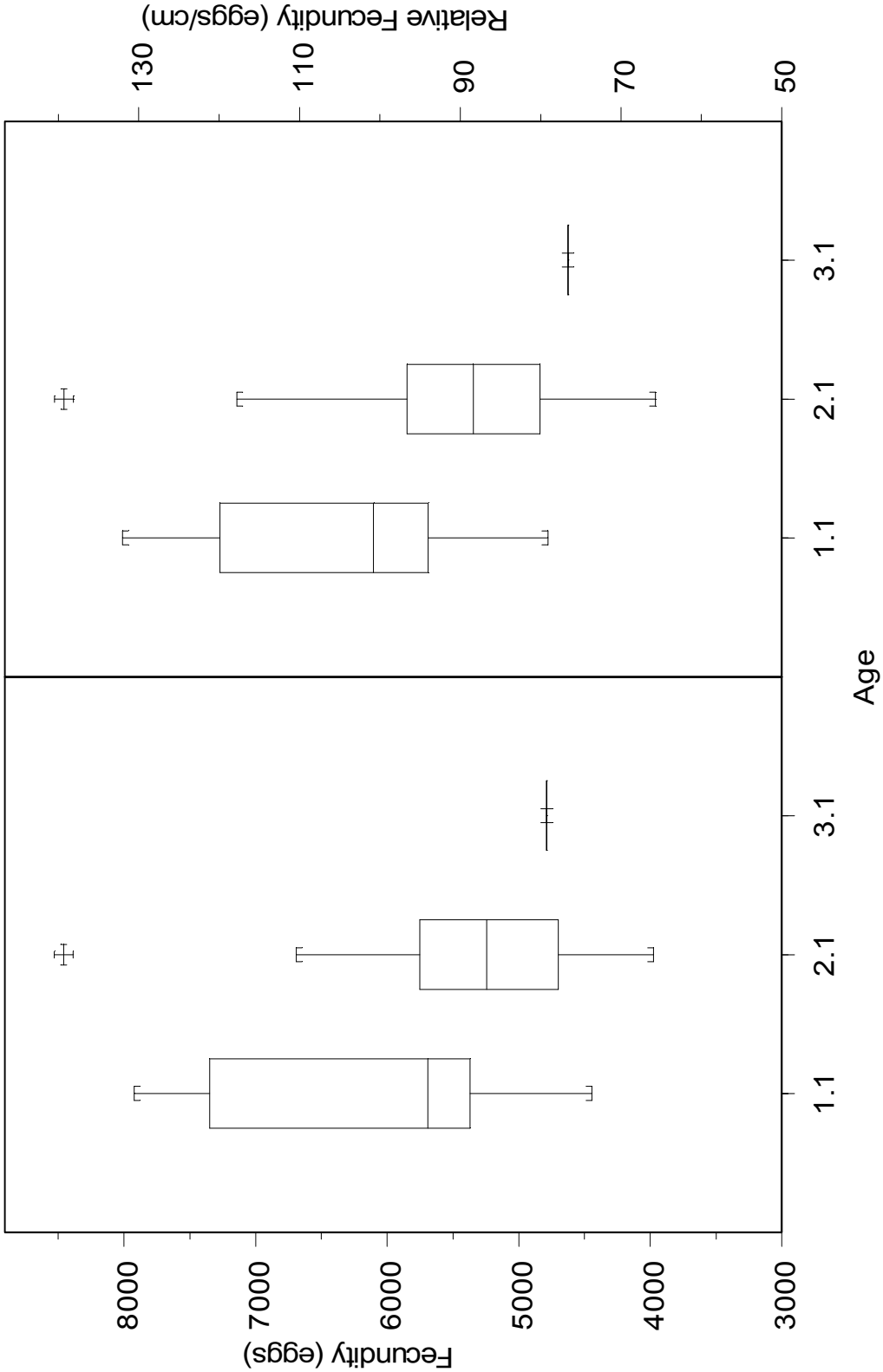


Figure 6. Box plots of total and relative fecundity (eggs/cm of body length) by age for coho salmon from the Unalakleet River, 2004. Center horizontal line is sample median, box edges are 1st and 3rd quartiles, whiskers extend 1.5 times the inter-quartile range, and asterisks denote outliers.

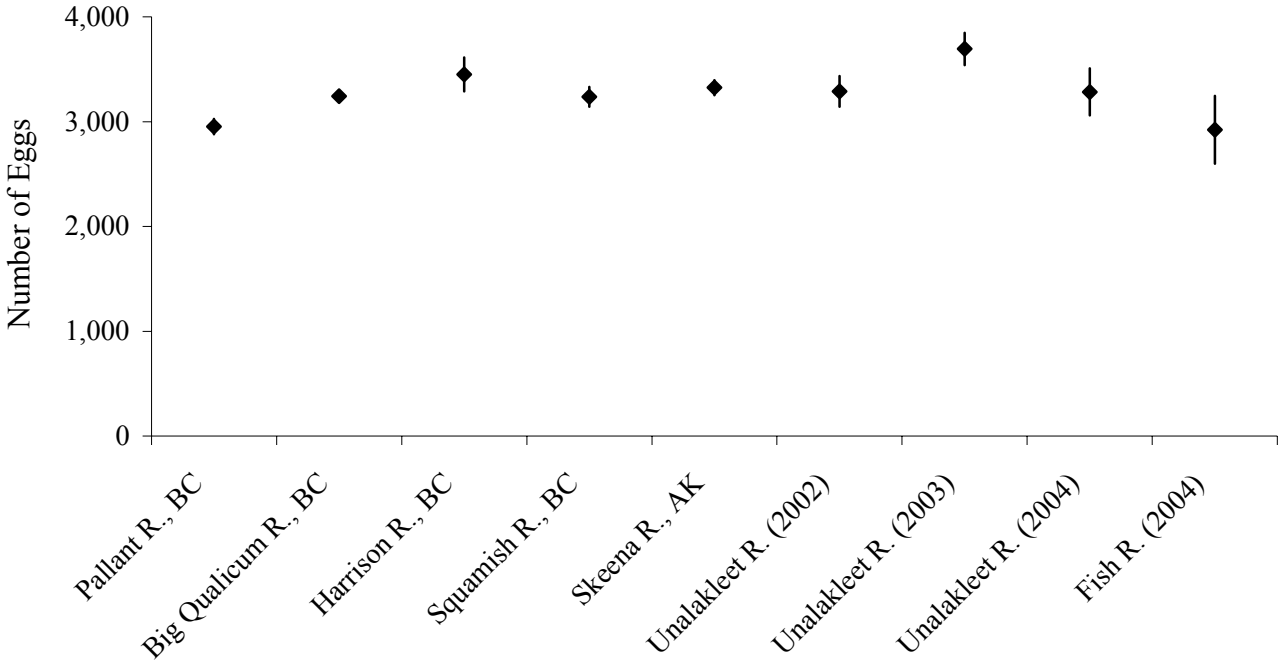


Figure 7. Fecundity of chum salmon populations from the Unalakleet and Fish Rivers compared to postorbital-hypural (POH) lengths, standardized to 58.8 cm, of select populations (Beacham 1982). Point markers represent mean, whickers extend + / - 1 SE from mean.

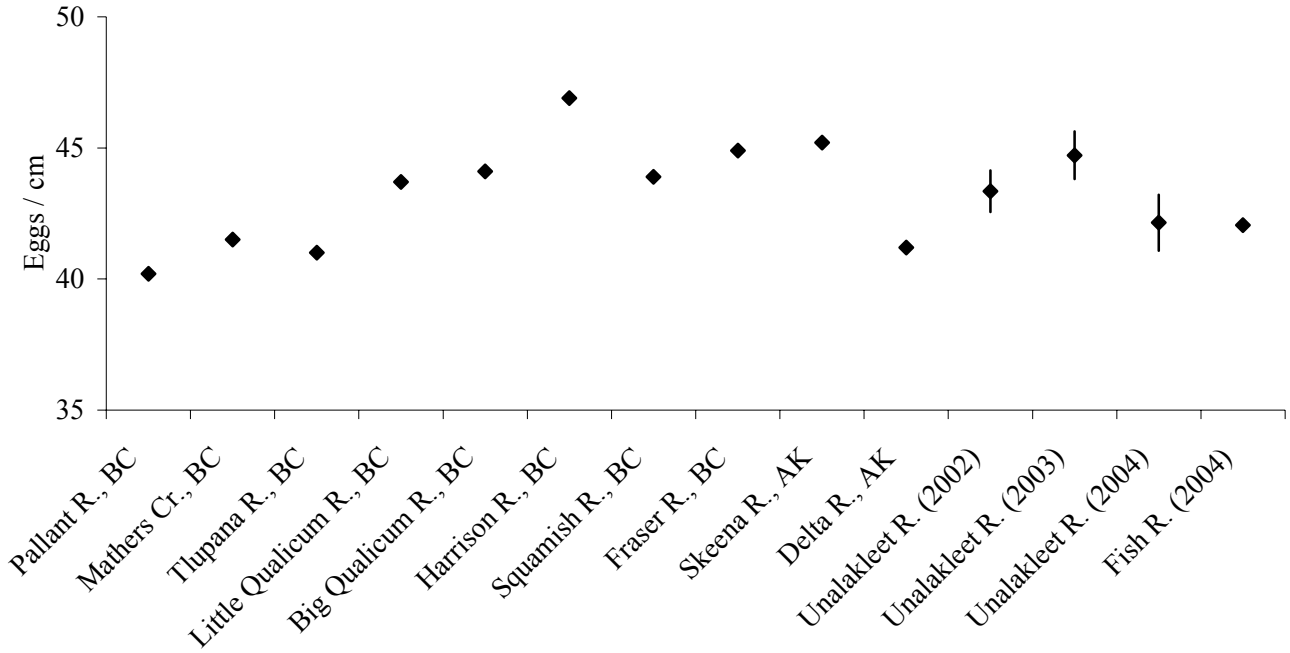


Figure 8. Mean relative fecundity (eggs / cm of fork length) of chum salmon from the Unalakleet and Fish Rivers compared to North American rivers reported by Salo (1991). Point markers represent means, whiskers extend + / - 1 SE from mean.

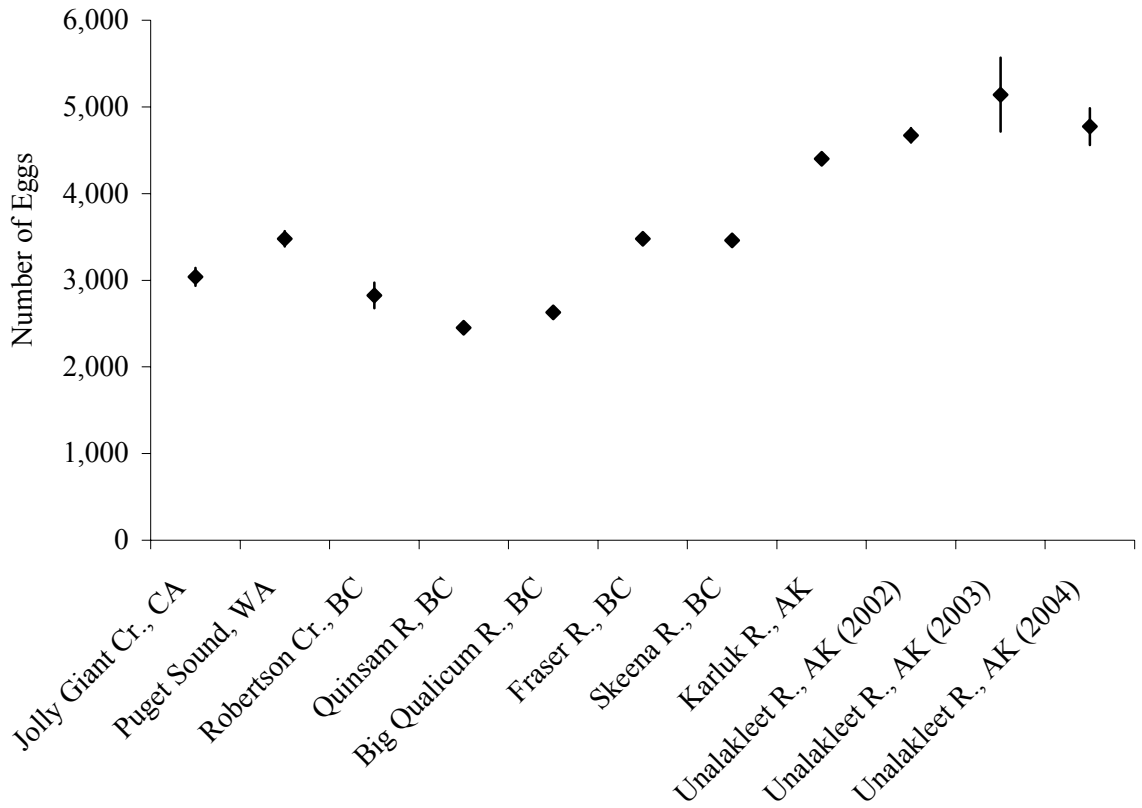


Figure 9. Fecundity of coho salmon from the Unalakleet River compared to postorbital-hypural (POH) lengths, standardized to 53.6 cm, of select populations (Beacham, 1982). Point markers represent mean, whiskers extend + / - 1 SE from mean. Populations are shown in order of increasing latitude.

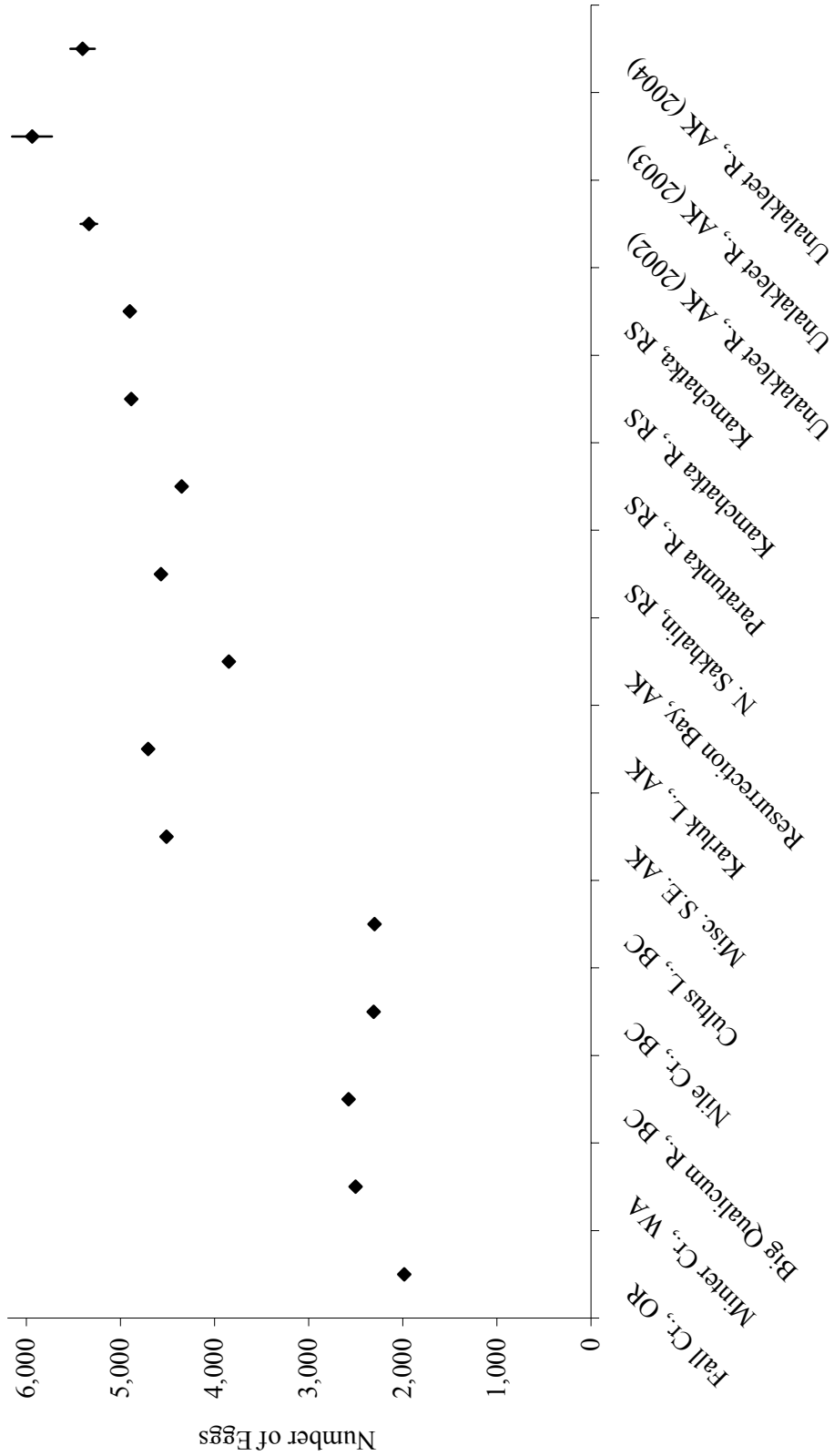
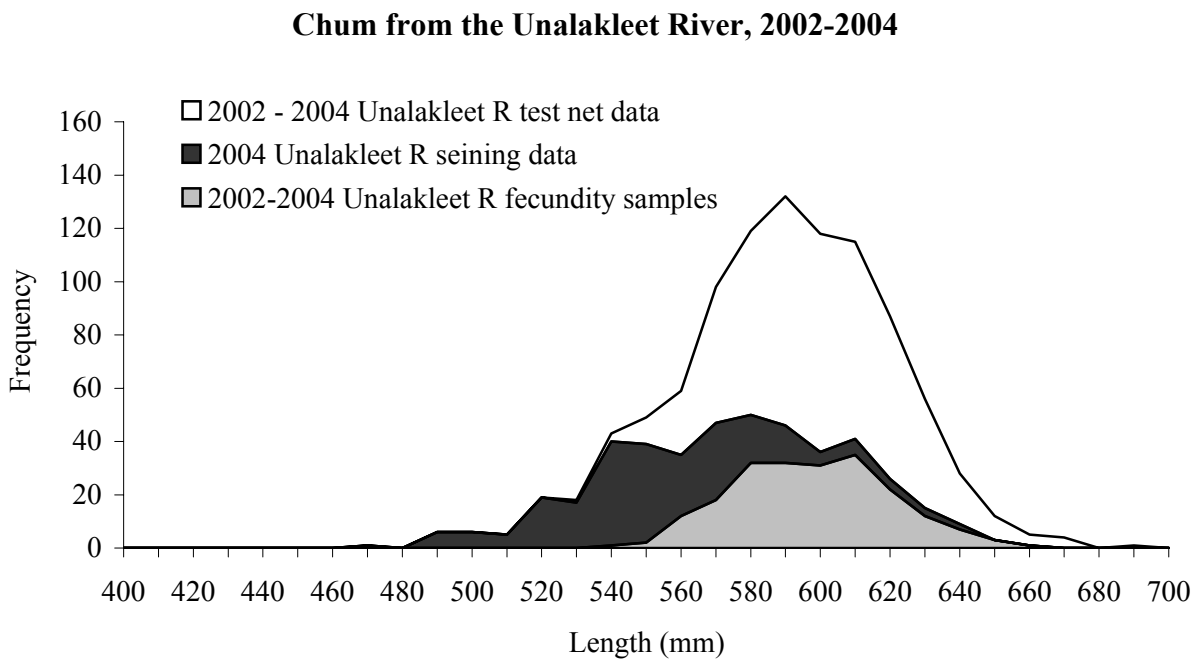


Figure 10. Mean total fecundities of coho salmon from the Unalakleet River compared to North American rivers reported by Sandercock (1991). Point markers represent mean, whiskers extend + / - 1 SE from mean. Populations are shown in order of increasing latitude.



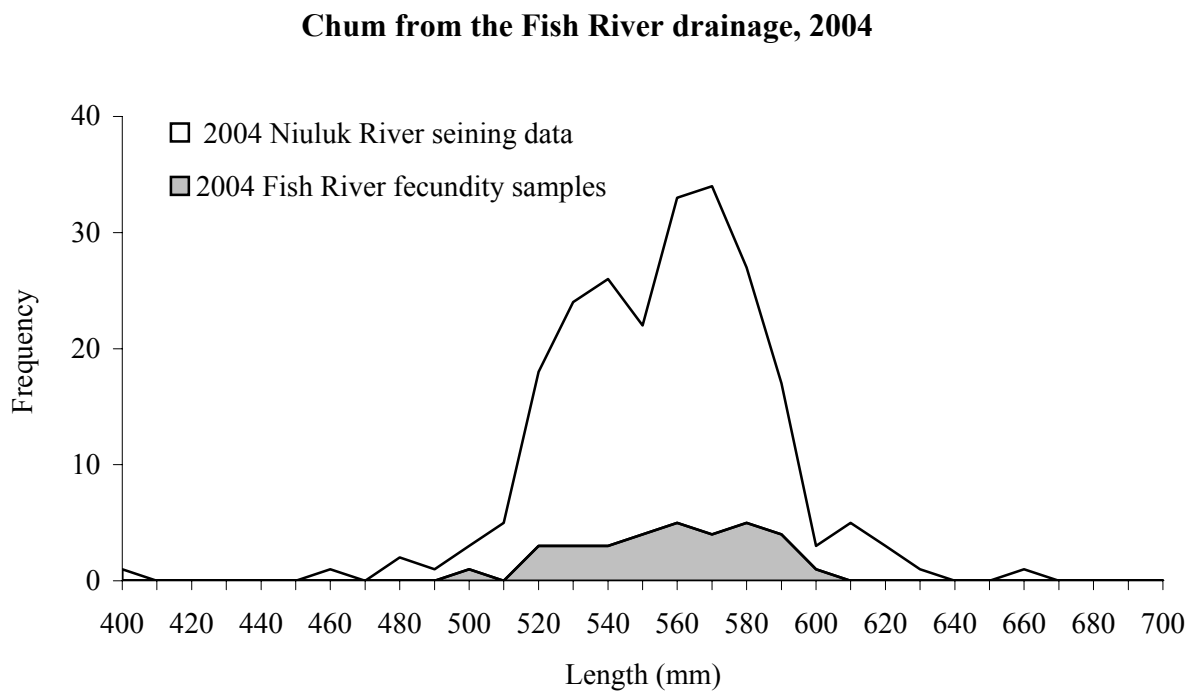


Figure 11. Length frequencies of chum salmon from the Unalakleet and Fish Rivers, compared to fecudity data reported in this study. (A) Unalakleet River catch data are from the test net (2002-2004) and seining (2004) (Joy 2005). (B) Fish River data are from seining in a tributary, the Niukluk River, in 2004 (Estensen 2005).

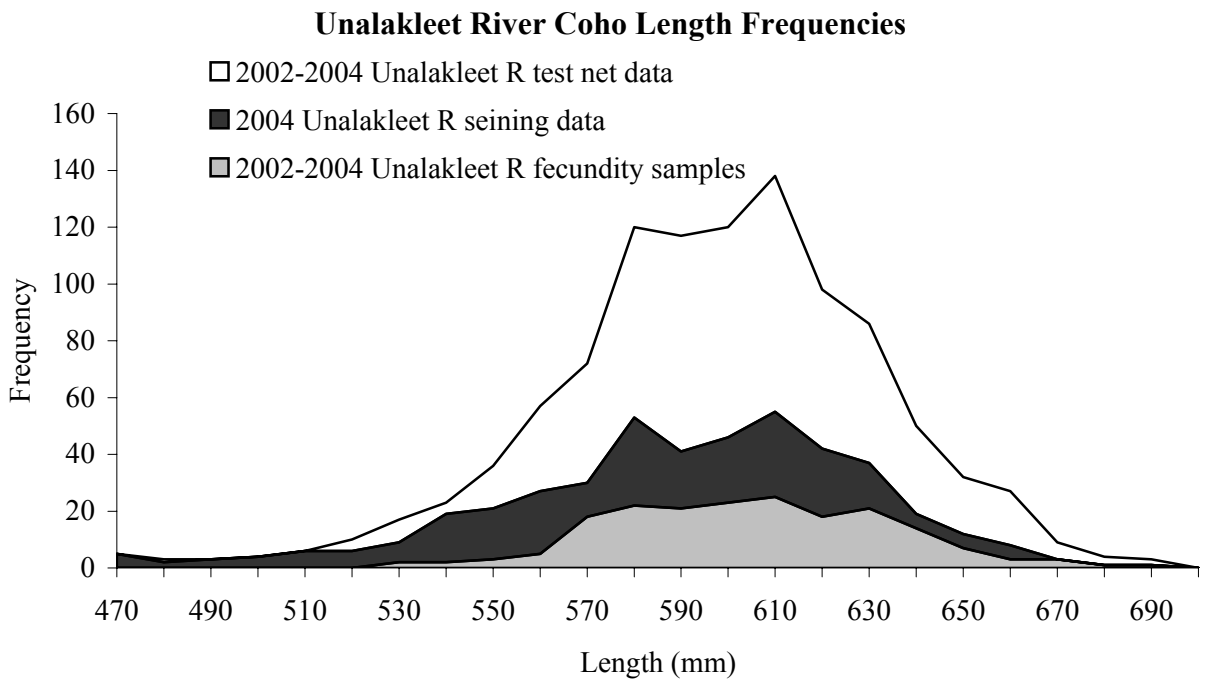


Figure 12. Length frequencies of coho salmon from the Unalakleet River compared to fecundity data reported in this study. Unalakleet catch data comes from gill nets and seine nets operated by ADF&G (Joy 2005).

Appendix A. Summary of known associations between fecundity and other variables, based on literature reports and this study.

		Effect on fecundity?	
Species	Variable	Literature	This study
Chum	Length	Yes (Salo 1991)	Yes
	Year	Yes (Beacham 1982)	No
	Latitude	Potential (Salo 1991)	Inconclusive
	Stream Size	Potential (Salo 1991)	NA
	Summer / Fall	Yes (Salo 1991)	NA
	Run timing	Potential (Beacham 1982)	No
	Freshwater migration distance	Yes (Beacham and Murray 1993)	NA
	Age	No (Beacham 1982)	No
Coho	Length	Yes (Sandercock 1991)	Yes
	Year	Yes (Beacham 1982)	No
	Latitude	Yes (Sandercock 1991)	Consistent with literature trends
	Run timing	Not Reported	No
	Freshwater migration distance	Yes (Beacham and Murray 1993)	NA
	Age	Not Reported	Yes
	Continent	Yes (Sandercock 1991)	NA

Appendix B. Data used to report fecundity for chum and coho salmon sampled from the Unalakleet and Fish rivers in 2004.

							1st sample		2nd sample						
Fish #	Sp.	River	Capture date	ADF&G code	Egg count date	Egg skein weight (g)	1st Egg count	1st Sample weight (g)	2nd Egg count	2nd Sample weight (g)	Total Eggs (fec.)	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)	POH length
1	chum	Fish	07/08/04		10/29/04	290.41	115	25.10	107	23.72	2641	555	47.6	0.4	49.5
2	chum	Fish	07/08/04		10/27/04	360.88	108	21.12	97	18.5	3738	570	65.6	0.4	50.9
3	chum	Fish	07/08/04		10/27/04	264.09	125	21.40	111	21.24	2923	580	50.4	0.3	51.9
4	chum	Fish	07/08/04		10/29/04	258.41	86	16.74	90	17.39	2665	555	48.0	0.3	49.5
5	chum	Fish	07/08/04		10/29/04	231.97	107	17.38	108	17.84	2832	550	51.5	0.3	49.1
6	chum	Fish	07/08/04		10/27/04	318.12	94	23.21	81	20	2577	585	44.0	0.4	52.3
7	chum	Fish	07/08/04		10/27/04	315.35	116	25.25	101	23.08	2829	570	49.6	0.4	50.9
8	chum	Fish	07/08/04		10/27/04	335.04	100	26.19	100	26.06	2565	590	43.5	0.4	52.8
9	chum	Fish	07/08/04		10/29/04	372.30	119	30.03	122	29.64	3008	574	52.4	0.4	51.3
10	chum	Fish	07/08/04		10/29/04	221.75	88	19.12	79	15.5	2151	550	39.1	0.4	49.1
11	chum	Fish	07/08/04		10/29/04	292.61	83	16.47	76	15.06	2951	570	51.8	0.4	50.9
12	chum	Fish	07/08/04		10/29/04	279.15	76	16.89	91	19.38	2567	590	43.5	0.4	52.8
13	chum	Fish	07/08/04		11/04/04	240.56	105	24.32	182	41.38	2097	560	37.4	0.4	50.0
14	chum	Fish	07/08/04		11/03/04	341.43	157	39.59	153	36.01	2805	600	46.7	0.4	53.7
15	chum	Fish	07/08/04		10/29/04	267.17	102	22.23	108	23.44	2457	575	42.7	0.4	51.4
16	chum	Fish	07/08/04		11/02/04	220.98	117	24.95	128	26.75	2094	570	36.7	0.4	50.9
17	chum	Fish	07/08/04		11/03/04	242.57	135	30.98	111	25.79	2101	580	36.2	0.4	51.9
18	chum	Fish	07/08/04		11/03/04	296.36	125	26.08	120	25.1	2837	555	51.1	0.4	49.5
19	chum	Fish	07/08/04		11/04/04	206.60	141	34.86	162	37.36	1732	560	30.9	0.3	50.0
20	chum	Fish	07/08/04		11/04/04	236.38	123	28.12	174	38.88	2092	575	36.4	0.4	51.4
21	chum	Fish	07/08/04		11/04/04	344.04	153	44.40	127	37.02	2366	585	40.4	0.4	52.3
22	chum	Fish	07/08/04		11/17/04	231.65	96	19.75	93	18.38	2298	545	42.2	0.3	48.6
23	chum	Fish	07/08/04		11/12/04	163.21	131	13.10	114	11.39	3266	545	59.9	0.2	48.6
24	chum	Fish	07/08/04		11/12/04	187.13	155	28.47	131	23.71	2053	535	38.4	0.3	47.7
25	chum	Fish	07/08/04		11/16/04	242.02	101	17.83	115	19.09	2829	540	52.4	0.4	48.2
26	chum	Fish	07/08/04		11/16/04	179.46	90	13.87	89	13.59	2340	525	44.6	0.3	46.8
27	chum	Fish	07/08/04		11/16/04	197.46	107	18.18	111	19.26	2300	500	46.0	0.3	44.5
28	chum	Fish	07/08/04		11/12/04	267.27	157	27.00	158	29	3010	530	56.8	0.4	47.2

Appendix B. Data used to report fecundity for chum and coho salmon sampled from the Unalakleet and Fish rivers in 2004.

							1st sample		2nd sample						
Fish #	Sp.	River	Capture date	ADF&G code	Egg count date	Egg skein weight (g)	1st Egg count	1st Sample weight (g)	2nd Egg count	2nd Sample weight (g)	Total Eggs (fec.)	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)	POH length
29	chum	Fish	07/08/04		11/16/04	191.58	98	17.44	92	16.14	2169	520	41.7	0.4	46.3
30	chum	Fish	07/08/04		11/10/04	225.89	143	25.13	134	24.6	2516	530	47.5	0.3	47.2
31	chum	Fish	07/08/04		11/16/04	255.61	120	21.14	75	12.76	2953	535	55.2	0.3	47.7
32	chum	Fish	07/08/04		11/17/04	129.27	137	21.96	96	16.1	1577	520	30.3	0.3	46.3
33	chum	Fish	07/08/04		11/18/04	199.94	137	24.05	124	20.89	2326	515	45.2	0.3	45.9
34	chum	UNK	06/09/04	001/001	10/27/04	137.86	170	16.36	100	16.06	2291	585	39.2	0.4	52.3
35	chum	UNK	06/10/04	001/002	10/22/04	222.07	140	21.09	139	21.01	2943	594	49.6	0.4	53.1
36	chum	UNK	06/13/04	001/004	10/26/04	147.93	101	16.68	100	16.98	1767	581	30.4	0.4	51.9
37	chum	UNK	06/13/04	001/006	10/21/04	164.79	121	18.43	136	20.52	2174	595	36.5	0.4	53.2
38	chum	UNK	06/17/04	001/010	10/21/04	199.90	102	15.31	100	15.61	2612	594	44.0	0.4	53.1
39	chum	UNK	07/02/04	002/008	10/21/04	116.28	164	7.91	164	8.44	4670	582	80.2	0.4	52.0
40	chum	UNK	07/03/04	002/009	10/21/04	161.11	124	19.59	98	16.1	2000	557	35.9	0.4	49.7
41	chum	UNK	07/03/04	003/001	10/21/04	203.33	139	20.36	113	17.83	2677	582	46.0	0.4	52.0
42	chum	UNK	07/06/04	003/003	10/20/04	199.82	92	22.81	79	19.78	1604	585	27.4	0.4	52.3
43	chum	UNK	07/07/04	003/005	10/21/04	202.17	130	18.11	126	17.78	2884	593	48.6	0.4	53.0
44	chum	UNK	07/10/04	004/001	10/21/04	195.26	136	22.15	118	19.3	2393	595	40.2	0.4	53.2
45	chum	UNK	07/11/04	004/004	10/26/04	206.11	136	20.05	133	19.48	2805	595	47.1	0.4	53.2
46	chum	UNK	07/12/04	004/008	10/27/04	171.39	89	14.38	134	20.57	2177	578	37.7	0.4	51.7
47	chum	UNK	07/12/04	004/009	10/20/04	224.51	134	28.35	163	33.73	2146	568	37.8	0.4	50.7
48	chum	UNK	07/12/04	005/001	10/20/04	200.65	120	16.07	139	20.2	2879	595	48.4	0.4	53.2
49	chum	UNK	07/13/04	005/003	10/28/04	213.20	128	20.38	103	19.94	2440	595	41.0	0.4	53.2
50	chum	UNK	07/28/04	005-006	10/21/04	260.29	142	26.33	118	21.58	2827	582	48.6	0.4	52.0
51	chum	UNK	07/28/04	005-008	10/29/04	242.65	150	22.25	115	17.59	3222	588	54.8	0.4	52.6
52	chum	UNK	07/29/04	006-003	10/20/04	169.85	116	18.25	160	25.55	2143	572	37.5	0.4	51.1
53	chum	UNK	07/29/04	006-004	10/27/04	201.92	93	12.95	123	16.33	2971	575	51.7	0.4	51.4
54	chum	UNK	07/30/04	007-001	10/27/04	252.05	103	20.61	120	23.94	2523	585	43.1	0.4	52.3
55	chum	UNK	06/13/04	001/008	11/16/04	147.00	113	14.45	131	19.34	2145	610	35.2	0.4	54.6
56	chum	UNK	07/02/04	002/006	01/07/05	285.82	137	27.75	148	30.91	2780	599	46.4	0.3	53.6

Appendix B. Data used to report fecundity for chum and coho salmon sampled from the Unalakleet and Fish rivers in 2004.

							1st sample		2nd sample						
Fish #	Sp.	River	Capture date	ADF&G code	Egg count date	Egg skein weight (g)	1st Egg count	1st Sample weight (g)	2nd Egg count	2nd Sample weight (g)	Total Eggs (fec.)	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)	POH length
57	chum	UNK	07/03/04	002/010	01/06/05	241.88	144	22.00	144	21.85	3177	578	55.0	0.3	51.7
58	chum	UNK	07/08/04	003/007	01/12/05	199.31	104	18.55	121	17.61	2487	578	43.0	0.3	51.7
59	chum	UNK	07/10/04	004/002	01/29/05	215.87	106	16.30	106	16.54	2787	574	48.6	0.3	51.3
60	chum	UNK	07/11/04	004/005	12/02/04	173.84	108	10.04	105	10.13	3672	580	63.3	0.3	51.9
61	chum	UNK	07/12/04	004/007	01/25/05	246.42	110	18.26	109	17.87	2988	597	50.0	0.3	53.4
62	chum	UNK	07/29/04	006-001	01/29/05	206.08	105	14.56	100	16.82	2711	579	46.8	0.3	51.8
63	chum	UNK	06/12/04	001/003	01/29/05	202.12	115	14.36	127	15.26	3301	624	52.9	0.4	55.9
64	chum	UNK	06/13/04	001/005	01/29/05	216.08	115	16.57	111	16.38	2964	630	47.0	0.4	56.5
65	chum	UNK	06/13/04	001/007	01/04/05	179.07	94	15.40	108	17.21	2217	626	35.4	0.4	56.1
66	chum	UNK	06/17/04	001/009	01/30/05	207.62	107	16.67	103	16.65	2617	607	43.1	0.4	54.3
67	chum	UNK	06/18/04	002/001	01/30/05	215.92	123	17.46	119	16.73	3057	604	50.6	0.4	54.1
68	chum	UNK	06/18/04	002/002	01/29/05	218.90	131	18.87	132	18.33	3096	614	50.4	0.4	55.0
69	chum	UNK	06/18/04	002/003	01/18/05	272.98	109	18.36	100	16.81	3245	613	52.9	0.4	54.9
70	chum	UNK	06/23/04	002/004	12/01/04	220.85	106	17.59	105	16.51	2735	615	44.5	0.4	55.1
71	chum	UNK	06/24/04	002/005	01/25/05	270.95	103	18.86	103	19.26	2929	627	46.7	0.4	56.2
72	chum	UNK	07/28/04	005-007	02/03/05	236.42	100	17.23	100	17.37	2733	610	44.8	0.4	54.6
73	chum	UNK	07/28/04	005-009	12/01/04	167.72	116	17.13	106	16.6	2207	608	36.3	0.4	54.4
74	chum	UNK	07/28/04	005-010	02/03/05	207.42	114	15.72	104	16.08	2846	612	46.5	0.4	54.8
75	chum	UNK	07/29/04	006-002	01/29/05	209.11	100	16.18	116	18.98	2570	612	42.0	0.4	54.8
76	chum	UNK	07/29/04	006-005	01/27/05	237.02	104	19.93	108	21.55	2425	605	40.1	0.3	54.2
77	chum	UNK	07/29/04	006-006	01/04/05	334.03	112	24.19	110	23.3	3124	607	51.5	0.3	54.3
78	chum	UNK	07/29/04	006-007	02/03/05	317.31	103	15.30	106	15.96	4244	635	66.8	0.4	56.9
79	chum	UNK	07/30/04	006-008	01/27/05	268.95	104	18.63	113	20.17	3008	601	50.1	0.4	53.8
80	chum	UNK	07/30/04	006-009	01/30/05	315.46	119	26.21	100	21.87	2875	607	47.4	0.4	54.3
81	chum	UNK	07/30/04	006-010	01/27/05	254.20	105	19.17	100	17.37	2856	610	46.8	0.4	54.6
82	chum	UNK	07/07/04	003/004	01/13/05	224.69	104	18.55	121	17.61	2804	630	44.5	0.4	56.5
83	chum	UNK	07/08/04	003/006	12/23/05	247.52	120	22.54	122	24.43	2554	602	42.4	0.4	53.9
84	chum	UNK	07/08/04	003/008	01/25/05	226.36	121	14.85	140	15.71	3862	618	62.5	0.4	55.4

Appendix B. Data used to report fecundity for chum and coho salmon sampled from the Unalakleet and Fish rivers in 2004.

							1st sample		2nd sample						
Fish #	Sp.	River	Capture date	ADF&G code	Egg count date	Egg skein weight (g)	1st Egg count	1st Sample weight (g)	2nd Egg count	2nd Sample weight (g)	Total Eggs (fec.)	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)	POH length
85	chum	UNK	07/09/04	003/009	01/29/05	207.66	100	14.16	100	13.62	2991	627	47.7	0.3	56.2
86	chum	UNK	07/09/04	003/010	01/13/05	148.45	134	22.65	21.29	128	903	586	15.4	0.3	52.4
87	chum	UNK	07/11/04	004/003	12/01/04	136.69	113	15.00	108	13.13	2154	610	35.3	0.4	54.6
88	chum	UNK	07/11/04	004/006	12/13/04	286.21	137	31.93	143	32.65	2482	601	41.3	0.4	53.8
89	chum	UNK	07/12/04	004/010	12/22/04	237.34	112	18.75	115	20.93	2722	613	44.4	0.4	54.9
90	chum	UNK	07/13/04	005/002	01/07/05	213.41	134	18.57	131	18.38	3061	620	49.4	0.4	55.5
91	chum	UNK	07/13/04	005/004	01/07/05	191.71	103	18.84	100	18.84	2066	607	34.0	0.4	54.3
92	chum	UNK	07/13/04	005/005	12/13/04	292.19	150	25.75	149	25.49	3410	631	54.0	0.4	56.6
93	chum	UNK	07/08/04	002/003	12/06/04	351.70	144	38.66	146	37.38	2684	590	45.5	0.4	52.8

Appendix B. Data used to report fecundity for chum and coho salmon sampled from the Unalakleet and Fish rivers in 2004.

							1st sample		2nd sample						
Fish #	Sp.	River	Capture date	ADF&G code	Egg count date	Egg skein weight (g)	1st Egg count	1st Sample weight (g)	2nd Egg count	2nd Sample weight (g)	Total Eggs (fec.)	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)	POH length
1	coho	UNK	08/02/04	102-004	10/14/04	241.02	261	25.78	294	29.46	4845	555	87.3	2.1	53.8
2	coho	UNK	08/16/04	102-008	10/14/04	237.38	131	14.82	140	15.38	4259	533	79.9	2.1	51.7
3	coho	UNK	08/25/04	103-007	10/14/04	384.76	133	15.95	153	18.29	6427	620	103.7	2.1	59.8
4	coho	UNK	08/25/04	103-009	10/21/04	398.86	183	23.07	154	19.77	6271	635	98.8	2.1	61.2
5	coho	UNK	08/26/04	104-004	10/14/04	277.56	163	16.59	161	15.76	5563	552	100.8	1.1	53.5
6	coho	UNK	08/31/04	105-001	10/14/04	264.58	157	18.96	175	20.55	4444	555	80.1	2.1	53.8
7	coho	UNK	09/01/04	105-005	10/12/04	371.74	201	30.88	138	21.67	4787	625	76.6	3.1	60.3
8	coho	UNK	09/01/04	105-006	10/12/04	401.96	113	16.59	130	17.35	5750	636	90.4	2.1	61.3
9	coho	UNK	09/01/04	105-008	10/14/04	446.40	112	17.85	138	21.33	5689	631	90.2	2.1	60.9
10	coho	UNK	09/03/04	106-003	10/22/04	257.51	155	18.87	154	19.16	4185	544	76.9	2.1	52.8
11	coho	UNK	07/21/04	101-002	11/03/04	200.19	109	9.33	109	9.24	4700	567	82.9	2.1	54.9
12	coho	UNK	07/22/04	101-003	11/03/04	175.08	100	7.31	112	8.01	4843	562	86.2	2.1	54.4
13	coho	UNK	07/27/04	101-006	11/04/04	195.11	176	17.33	193	18.63	4003	562	71.2	2.1	54.4
14	coho	UNK	08/18/04	102-009	11/10/04	245.93	135	14.68	137	15.18	4481	605	74.1	2.1	58.4
15	coho	UNK	08/24/04	103-002	11/03/04	372.66	124	14.07	99	10.83	6691	568	117.8	2.1	55.0
16	coho	UNK	08/24/04	103-003	11/03/04	349.57	152	12.72	102	8.33	8458	607	139.3	2.1	58.6
17	coho	UNK	08/24/04	103-004	11/03/04	316.30	124	14.18	112	13.44	5402	616	87.7	2.1	59.5
18	coho	UNK	08/25/04	104-001	11/23/04	287.82	115	12.00	118	12.54	5467	612	89.3	2.1	59.1
19	coho	UNK	08/31/04	105-002	11/17/04	400.46	96	19.75	93	18.36	3975	605	65.7	2.1	58.4
20	coho	UNK	09/03/04	106-002	11/16/04	376.55	124	18.66	106	16.08	4984	570	87.4	2.1	55.2
21	coho	UNK	09/03/04	106-004	11/12/04	458.83	143	25.48	147	25.28	5243	570	92.0	2.1	55.2
22	coho	UNK	07/20/04	101-001	11/10/04	185.80	150	12.91	163	13.12	4467	579	77.2	2.1	56.0
23	coho	UNK	07/23/04	101-004	11/10/04	248.36	134	13.19	142	14.18	5010	580	86.4	2.1	56.1
24	coho	UNK	07/26/04	101-005	11/10/04	217.72	142	12.05	133	12.04	4971	592	84.0	2.1	57.2
25	coho	UNK	07/27/04	101-007	11/10/04	210.18	107	11.04	97	10.97	3896	579	67.3	RE	56.0
26	coho	UNK	07/30/04	101-008	11/10/04	221.53	116	11.01	104	10.48	4532	577	78.6	RE	55.8
27	coho	UNK	07/30/04	101-009	11/19/04	213.33	137	10.76	150	12.06	5370	562	95.5	1.1	54.4
28	coho	UNK	07/30/04	101-010	11/19/04	257.17	146	14.57	137	14.32	5037	577	87.3	2.1	55.8

Appendix B. Data used to report fecundity for chum and coho salmon sampled from the Unalakleet and Fish rivers in 2004.

							1st sample		2nd sample						
Fish #	Sp.	River	Capture date	ADF&G code	Egg count date	Egg skein weight (g)	1st Egg count	1st Sample weight (g)	2nd Egg count	2nd Sample weight (g)	Total Eggs (fec.)	Fish length (mm)	Relative fecundity (eggs/cm)	Fish age (fresh.ocean years)	POH length
29	coho	UNK	07/30/04	102-001	11/18/04	242.62	131	12.17	127	13.06	4971	583	85.3	2.1	56.4
30	coho	UNK	07/30/04	102-002	11/23/04	252.40	132	13.52	148	15.68	4847	568	85.3	2.1	55.0
31	coho	UNK	08/02/04	102-003	11/23/04	285.79	140	14.01	118	11.61	5761	607	94.9	RE	58.6
32	coho	UNK	08/02/04	102-005	11/22/04	305.48	165	17.42	154	16.05	5825	585	99.6	2.1	56.6
33	coho	UNK	08/26/04	104-005	11/18/04	359.06	145	15.98	148	16.59	6461	596	108.4	2.1	57.6
34	coho	UNK	08/26/04	104-006	11/19/04	297.75	117	13.92	129	14.94	5074	574	88.4	2.1	55.6
35	coho	UNK	08/26/04	104-007	11/19/04	377.43	154	20.07	159	21.52	5685	597	95.2	2.1	57.7
36	coho	UNK	08/26/04	104-008	11/19/04	376.30	134	15.28	160	17.92	6660	585	113.8	2.1	56.6
37	coho	UNK	08/26/04	104-009	11/18/04	293.49	142	14.29	122	12.33	5820	574	101.4	2.1	55.6
38	coho	UNK	08/26/04	104-010	11/23/04	313.72	120	12.87	116	12.06	5943	600	99.0	2.1	58.0
39	coho	UNK	08/31/04	105-003	11/23/04	337.48	151	16.47	146	15.97	6179	595	103.9	2.1	57.5
40	coho	UNK	09/01/04	105-007	11/23/04	376.10	150	20.08	154	20.69	5609	605	92.7	2.1	58.4
41	coho	UNK	09/03/04	106-001	11/23/04	242.44	161	14.83	151	13.11	5424	575	94.3	2.1	55.7
42	coho	UNK	08/16/04	102-006	11/29/04	256.16	144	13.79	110	10.33	5403	593	91.1	2.1	57.3
43	coho	UNK	08/16/04	102-007	11/29/04	205.91	102	9.43	101	9.38	4444	562	79.1	1.1	54.4
44	coho	UNK	08/18/04	102-010	12/02/04	224.59	146	13.85	101	9.7	4706	590	79.8	2.1	57.1
45	coho	UNK	08/23/04	103-001	11/29/04	257.33	163	18.5	177	20.01	4544	577	78.7	2.1	55.8
46	coho	UNK	08/25/04	103-005	11/30/04	286.07	141	14.98	140	14.65	5426	602	90.1	2.1	58.2
47	coho	UNK	08/25/04	103-006	12/02/04	334.90	108	13.13	98	12.39	5404	593	91.1	2.1	57.3
48	coho	UNK	08/25/04	103-008	11/29/04	415.36	154	22.97	155	21.89	5726	593	96.6	2.1	57.3
49	coho	UNK	08/25/04	103-010	11/24/04	280.42	151	12.44	147	12.89	6602	582	113.4	RE	56.3
50	coho	UNK	08/25/04	104-002	11/30/04	325.20	132	19.41	114	16.48	4461	575	77.6	2.1	55.7
51	coho	UNK	08/26/04	104-003	11/29/04	336.23	140	20.52	130	18.9	4607	577	79.8	2.1	55.8
52	coho	UNK	08/31/04	105-004	11/30/04	357.39	159	19.90	136	17.15	5690	605	94.0	1.1	58.4
53	coho	UNK	09/02/04	105-009	12/22/05	459.83	135	15.83	130	14.94	7923	600	132.0	1.1	58.0
54	coho	UNK	09/02/04	105-010	11/29/04	389.87	136	15.80	173	19.86	6752	586	115.2	1.1	56.7
55	coho	UNK	09/06/04	106-005	11/30/04	379.72	160	16.96	168	16.93	7350	613	119.9	1.1	59.2