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

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

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EXECUTIVE SUMMARY

Salmon fecundity is important because it directly affects a population's reproductive capacity. Fecundity places an upper limit on potential egg deposition and eventual fry production from a given escapement level. Knowledge of egg deposition and fry production can benefit fisheries management by improving estimates of habitat seeding, overwinter survival of juvenile salmon, and correlations between the adult abundance and juvenile production. In 2003, 50 chum salmon and 50 coho salmon were collected from the Unalakleet River, Alaska as part of the second year of a multi-year study to estimate fecundity for each species in the Norton Sound region of northwestern Alaska. All salmon were collected by the Alaska Department of Fish and Game (ADF&G) during the annual test fishery on the Unalakleet River. Fish were measured for length (mid-eye to tail fork; or MEF), aged by scale analysis, and fecundity was estimated by subsampling at least one ovary from each fish. The total fecundity, the relative fecundity (eggs per cm of body length measured from middle of eye to fork of tail), and the fecundity at a standard size were all reported to allow comparisons to populations reported in the literature. The mean fecundity was 2,843 eggs (SD = 483) for chum salmon and 5,938 (SD = 1322) for coho salmon. Length had a significant influence on fecundities of both chum and coho salmon. When compared to various reports of fecundity in the literature (total, relative, or standardized fecundity), chum salmon from Norton Sound typically had above-average fecundities and coho salmon from Norton Sound typically had some of the highest fecundities reported. From 2002 to 2003, fecundity increased by 8.2% in age 0.3 chum salmon and 8.5% in age 2.1 coho salmon. As a result, managers may want to consider the potential for similar levels of annual escapements to have differing potential egg depositions in the Norton Sound region. Future research should continue sampling Unalakleet River populations to refine estimates of interannual variability, while sampling salmon from at least one other river to begin to characterize any spatial variability among Norton Sound salmon populations.

TABLE OF CONTENTS

EXECUTIVE SUMMARY III
LIST OF TABLES V
LIST OF FIGURES V
LIST OF APPENDICES V
INTRODUCTION 1
STUDY AREA 2
METHODS 2
Sample Collection and Storage 2
Data Analysis 3
Fecundity estimates 3
Association between fecundity, length, and age 4
Comparisons among populations and between years 4
RESULTS 5
Fecundity Estimates 5
Association Between Fecundity, Length, and Age 5
Comparisons Among Populations and Between Years 5
DISCUSSION AND CONCLUSION 6
RECOMMENDATIONS 7
ACKNOWLEDGEMENTS 7
LITERATURE CITED 8

LIST OF TABLES

Table 1. Fecundity and length statistics for chum and coho salmon sampled from the Unalakleet River in 2002 & 2003.. 10

Table 2. ANOVA tables of the effects of age and length on total fecundity of chum and coho salmon sampled from the Unalakleet River in 2003 11

Table 3. ANOVA tables of the effects of year on total fecundity, relative fecundity, and length of age 0.3 chum and age 2.1 coho salmon sampled from the Unalakleet River in 2002 and 2003 12

LIST OF FIGURES

Figure 1. Map of study region and the Unalakleet River 13

Figure 2. Histogram of fecundities (total and cumulative %) of 51 chum and 39 coho salmon sampled from the Unalakleet River in 2003 14

Figure 3. Total fecundity versus length for chum salmon and coho salmon sampled from the Unalakleet River in 2003.....15

Figure 4. Box plots of total and relative fecundity by age for chum and coho salmon from the Unalakleet River, 2003.....16

Figure 5. Comparison of capture dates of chum and coho salmon sampled for fecundity to daily catch from the ADF&G test fishery in 2003.. 17

Figure 6. Box plots of total fecundity, relative fecundity and length of age 0.3 chum and age 2.1 coho by year.....18

Figure 7. Fecundity of various chum salmon populations at POH lengths standardized to 58.8 cm (Beacham 1982).....19

Figure 8. Fecundity of various coho salmon populations at POH lengths standardized to 53.6 cm (Beacham 1982).....20

Figure 9. Mean relative fecundities (eggs / cm of fork length) of chum salmon from the Unalakleet River compared to those from other North American rivers reported by Salo (1991) 21

Figure 10. Mean total fecundities of coho salmon from the Unalakleet River compared to other North American populations reported by Sandercock (1991).....22

LIST OF APPENDICES

Appendix A. Data used to report fecundity for chum and coho salmon returning to the Unalakleet River in 2003. 23

INTRODUCTION

Fecundity – the number of eggs produced by a female fish – affects the potential reproductive capacity of a spawning population (Skaugstad and McCracken 1991) and is important to many of the 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 among regions, among years, and within watersheds (Salo 1991), introducing uncertainty into models that use fecundity data developed from other regions or years.

Salmon fecundity can be inherited, as well as associated with both fish morphology and environmental variables. Fecundity is known to be influenced by fish body length in chum and coho salmon (Salo 1991; Sandercock 1991), varies by latitude in coho salmon (Sandercock 1991), and may be associated with other traits such as genetics, egg size, inriver migration distance, maternal effects, stock abundance, and run timing (Beacham 1982; Salo 1991; Beacham and Murray 1993; Smoker et al. 2000). These relationships are not always present, however, and little is known about how different variables influence the fecundity of salmon at the northern edge of their North American distributions. Knowledge of the association between fecundity and biological or environmental variables can help provide inferences about a population's fecundity when direct calculations are not possible.

Salmon production is of concern in Norton Sound, Alaska, because of the traditional importance of salmon to local, subsistence-based communities (Magdanz et al. 2001) and recent declines in salmon harvests throughout the region. Subsistence fishing opportunity has been reduced in subdistricts 1 and 2 in recent years and commercial salmon fisheries have largely ended in all but subdistricts 5 and 6 (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 productivities 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).

The salmon decline 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 a fecundity study is the Unalakleet River test fishery, which is operated annually by the Alaska Department of Fish and Game 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; beginning in 2002 and continuing in 2003, eggs were made available from these fish, thereby providing an opportunity to estimate fecundity of Unalakleet River salmon without sacrificing additional fish

(Nemeth et al. 2003). The goal of the fecundity sampling project in 2003 was to provide a second year of estimates of Norton Sound coho and chum salmon fecundity, assess correlations between fecundity and fish characteristics, test for inter-annual variability, and provide a basis for comparison within and outside of the region. The specific objectives in 2003 were to:

1) Estimate fecundity of chum and coho salmon returning to the Unalakleet River;
2) Determine the relationship between fecundity and fish age or length;
3) Compare differences in fecundity between 2002 and 2003, 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). 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 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 station 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 2003, the test fishery operated from June 5 to September 8. 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).

METHODS

Sample Collection and Storage

Chum and coho salmon ovaries were collected from fish sampled during the ADF&G annual test fishery on the Unalakleet River in 2003. 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.

ADF&G staff subsampled chum and coho salmon from the test fishery for use in the fecundity analysis. Subsamples 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 subsampled for fecundity estimates.

Data Analysis

Fecundity estimates

To estimate fecundity, egg skeins were thawed and weighed to the nearest 0.01 g on a digital balance and subsampled. Two subsamples of approximately 105 eggs each were collected from each skein; each subsample was composed of approximately 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 subsample. Each subsample was weighed to the nearest 0.01 g on the digital balance, and the number of eggs within it counted.

Fecundity estimates were derived from the subsample egg counts and the ratio of the egg skein weights to the subsample 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 subsample weight, then multiplying by the number of eggs in the subsample (Equation 1). The number of eggs in a skein was estimated as the average between the replicates. Individual fish fecundity was estimated as the sum of the estimated egg count of both skeins (Equation 2).

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

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

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;

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

F = Mean fecundity of individual fish k;

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

Association between fecundity, length, and age

Length was regressed against fecundity to estimate the slope of the relationship. Fecundity and length data were also transformed and a second regression of ln(fecundity) vs. ln(length) was performed. Both regressions (i.e., transformed vs. untransformed data) were then compared. The effects of fish length and age 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. For the purposes of this report, total fecundity refers to the total number of eggs estimated to be in each fish and relative fecundity refers to the number of eggs per cm of (MEF) body length.

Comparisons among populations and between years

The effects of year and length on fecundity were tested with ANOVA to determine whether salmon from 2003 had different fecundities than salmon from 2002. Comparisons were limited to salmon of the same species and age (in years), and were only performed on age classes with sample sizes larger than 20 fish each year.

Fecundities of Unalakleet River salmon were compared to fecundities 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 the Unalakleet River MEF lengths were converted to total fork length using the equation (Helle 1979; Salo 1991):

$$7.9948 + 1.0706 * \text{MEF}$$

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

$$21.8 + 0.93 * \text{MEF}$$

and for chum salmon (Pahlke 1989)

$$-16.255 + 0.922 * \text{MEF}$$

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

Fecundity was estimated for 51 chum salmon and 39 coho salmon in 2003. Mean chum salmon fecundity was 2,843 eggs and ranged from 1,876 eggs to 4,386 eggs (Table 1). Mean coho salmon fecundity was 5,938 eggs and ranged from 4,065 eggs to 10,926 eggs (Table 1). Fecundity distributions were approximately normal for each species (Figure 2).

Association Between Fecundity, Length, and Age

The linear regression of total fecundity versus length was y = 12.05x – 4,204 for chum and y = 13.45x – 2298 for coho (Figure 3). The regression of (ln) length vs. (ln) fecundity yielded fecundity estimates that were similar to the untransformed regression; as a result, the untransformed data were used in all subsequent analyses.

Fecundity increased with length of both chum and coho salmon (Table 2; Figure 3). Total fecundity and relative fecundity were not associated with chum age (Table 2), but decreased with coho age (Table 2; Figure 4). Interactions between age and length were not significant for chum or coho (Table 2). Fifty of the chum salmon were aged; the sample consisted of 88% age 0.3, 10% age 0.4 and 2% unknown (regenerated scales). Thirty-five of the coho salmon were aged; the sample consisted of 8% age 1.1, 72% age 2.1, 10% age 3.1 and 10% unknown (Table 1).

The effects of run timing on fecundity were not assessed in 2003. Chum samples were all taken from the second half of the run (Figure 5), preventing separation into early and late portions of the run. Coho returning to the Unalakleet River in 2003 did not have a distinct separation of run time (Figure 5), making it difficult to assign sampled coho to different run timing groups.

Comparisons Among Populations and Between Years

Sample sizes were large enough to compare fecundities of 2002 to 2003 for age 0.3 chum salmon and for age 2.1 coho salmon. For age 0.3 chum salmon, fecundity increased from 2002 to 2003 even though fish length decreased (Figure 6). For age 2.1 coho salmon, fecundity increased from 2002 to 2003 (Figure 6), and fish length was not different.

The conversion from MEF to POH lengths yielded mean chum salmon POH lengths of 52.3 cm (SD = 2.37) and mean coho salmon POH lengths of 59.1 cm (SD = 3.02) for coho salmon. The regression of POH length and total fecundity yielded regression equations of y = 130.69x – 3,991.2 for chum and y = 144.65x – 2,613.0 for coho salmon. When converted to the standard lengths used by Beacham (1982; 58.8 cm for chum salmon, 53.6 cm for coho salmon), Unalakleet River chum salmon fecundity was 3,693 eggs (SE = 155; Figure 7) and coho salmon fecundity was 5,140 eggs (SE = 426; Figure 8).

Based on a number of fecundity assessments, both chum and coho salmon from the Unalakleet River in 2003 appeared to have higher fecundities than most populations reported in the literature. When standardized to 58.8 cm POH length, chum salmon fecundity was slightly higher than reported by Beacham (1982) for other North American populations (Figure 7).

Without this standardization, the mean relative fecundity of chum salmon was 44.7 eggs/cm, which is higher than most of the relative fecundities of 11 North American populations presented by Salo (1991; Figure 9). 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 8). Without this standardization, the mean total fecundity of Unalakleet River coho salmon was 5,938 eggs (SD=1322; Table 1), substantially higher than the total fecundities of 13 North American and Russian populations presented by Sandercock (1991; Figure 10).

DISCUSSION AND CONCLUSION

Chum and coho salmon from the Unalakleet River in 2003 had above-average or high fecundities compared to the literature, whether for total observed fecundity (Sandercock 1991), relative fecundity (Salo 1991), or fecundity at a standardized length (Beacham 1982). Fish fecundity is frequently associated with body size, and often has an allometric relationship with length (e.g., fecundity per unit length changes as fish length increases), so the best comparisons are those that account for these potential associations. Fecundity standardized to the POH lengths reported by Beacham (1982) account for these associations, and should thus be viewed as the best comparisons between Unalakleet River salmon and others reported in the literature. Comparisons based on total or relative fecundity, while not being as rigorous, provide comparative value and support the growing evidence that Unalakleet River coho and chum salmon have high fecundities.

Comparisons of fecundity among populations need to be interpreted carefully because populations from different regions may need different fecundities – relative or total – to be evolutionarily successful. Fish fecundity 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). 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 relatively scarce, and are currently limited mostly to fish from the Yukon River and the Asian continent (Salo 1991; Sandercock 1991). In addition, fecundity data should be collected from other Norton Sound salmon populations to evaluate spatial variability. The Unalakleet River is the largest river in Norton Sound and appears to have the highest salmon abundance. Beacham (1982) suggested that fecundity may increase with stock abundance and with river size; if so, the Unalakleet River may provide biased estimates of Norton Sound salmon fecundities. Data from other rivers will help detect such variability, while providing estimates for different categories of river systems if fecundity is affected by river size and stock abundance.

The differences in fecundity from 2002 to 2003 indicate the potential for interannual variability within populations of Norton Sound salmon. As a result, similarly sized salmon escapements may have different potential egg depositions in the Norton Sound region. The increase in chum salmon fecundity from 2002 to 2003 is especially notable because it came despite a decrease in chum length. Comparisons of 2002 to 2003 were limited to one age class per species (age 0.3

chum and age 2.1 coho). Future work should increase sample sizes of other age classes to provide the statistical power needed to detect interannual variation in all age groups.

The sampling dates of chum salmon captured in 2002 and 2003 are a potential source of uncertainty in comparisons of chum from 2002 to 2003. The 2002 sample was taken primarily from chum collected from the early portion of the run, whereas the 2003 sample came from the latter half of the overall run (Nemeth et al. 2003). Although the effect of run timing on chum salmon fecundity is unknown, it cannot be ruled out as a factor influencing fecundity. Run timing is known to affect egg size of pink salmon (Smoker et al. 2000), and egg size and egg quantity (i.e., fecundity) are often correlated. Future samples from the Unalakleet River should be collected from comparable proportions of the run to factor run time into interannual comparisons.

We have characterized the fecundity of chum and coho salmon by length and have not attempted to estimate the total number of eggs in the escapement in 2002 or 2003. Samples reported here were all taken from fish captured in a gill net, a capture method known to be size selective. Therefore, the group of samples analyzed here is not likely representative of the entire escapement. The samples do, however, cover enough of a range of lengths to be able to establish regressions between length and fecundity that can be used to estimate the fecundity of any size classes. In order to estimate the total eggs carried of a given escapement level, one would need take into account the size composition of the entire escapement. To do this would require sampling the run with a non-size-selective gear like a beach seine and above all areas where the fish are harvested at significant levels by size selective fishing (e.g., subsistence gillnets).

RECOMMENDATIONS

Specific recommendations for the 2004 field season are to:

1) Measure 50 chum and 50 coho for both total fork length and mid-eye fork length.
2) Split the 100 samples evenly between the first and fourth quartiles of average run timing through the test fishery.
3) Identify another location from which to obtain a minimum of 25 samples of chum and / or coho.
4) Compare the age and size composition of salmon from the Unalakleet Test fishery to fish captured by other gear types in Norton Sound.

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Table 1. Fecundity and length statistics for chum and coho salmon sampled from the Unalakleet River in 2002 & 2003.

					Total fecundity				Relative fecundity (eggs/cm)				Length (mm) *			
Species	Year	Age	N	% of total	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD	Mean	95% CI	SE	SD
Chum																
	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
		Re	1	2%	3809	NA	NA	NA	58.2	NA	NA	NA	655.0	NA	NA	NA
		Total	51	100%	2843	133	68	483	48.5	1.9	1.0	7.0	584.8	7.1	3.6	25.7
	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	100%	2809	105	53	526	47.0	1.7	0.9	8.4	597.3	4.3	2.2	21.4
Coho																
	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
		Re	4	10%	8256	1837	938	1875	133.6	30.1	15.4	30.7	621.3	62.4	31.9	63.7
		Total	39	100%	5938	415	212	1322	96.9	6.4	3.3	20.5	612.2	10.2	5.2	32.5
	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
		Re	12	13%	5207	705	359	1245	84.6	10.0	5.1	17.6	612.9	18.7	9.6	33.1
		Total	95	100%	5335	174	89	867	87.8	2.6	1.3	13.1	606.8	5.8	2.9	28.7

* Length = mid-eye to fork (MEF)

Table 2. ANOVA table showing effects of age and length on total fecundity of chum and coho salmon sampled from the Unalakleet River in 2003.

Species	Source	df	Sum of Sq	Mean Sq	F Value	P
Chum	age	1	505012	505012	3.44	0.070
	length	1	3347269	3347269	22.80	0.000
	age * length interaction	1	126890	126890	0.86	0.357
	Residuals	46	6753915	146824		
Coho	age	2	6730575	3365287	4.76	0.016
	length	1	3935258	3935258	5.57	0.025
	age * length interaction	2	715275	357637	0.51	0.608
	Residuals	29	20491685	706610		

Table 3. ANOVA table showing effects of the effects of year on fecundity and length of age 0.3 chum and age 2.1 coho salmon sampled from the Unalakleet River in 2002 and 2003.

Chum age 0.3

Total Fecundity	df	Sum of Sq	Mean Sq	F Value	P
year	1	924484	924484	4.51	0.037
residuals	81	16601720	204960		

Relative Fecundity					
year	1	376.6	376.6	7.150	0.009
residuals	81	4267	52.7		

Length					
year	1	1744.5	1744.5	4.30	0.041
residuals	81	32854.3	405.6		

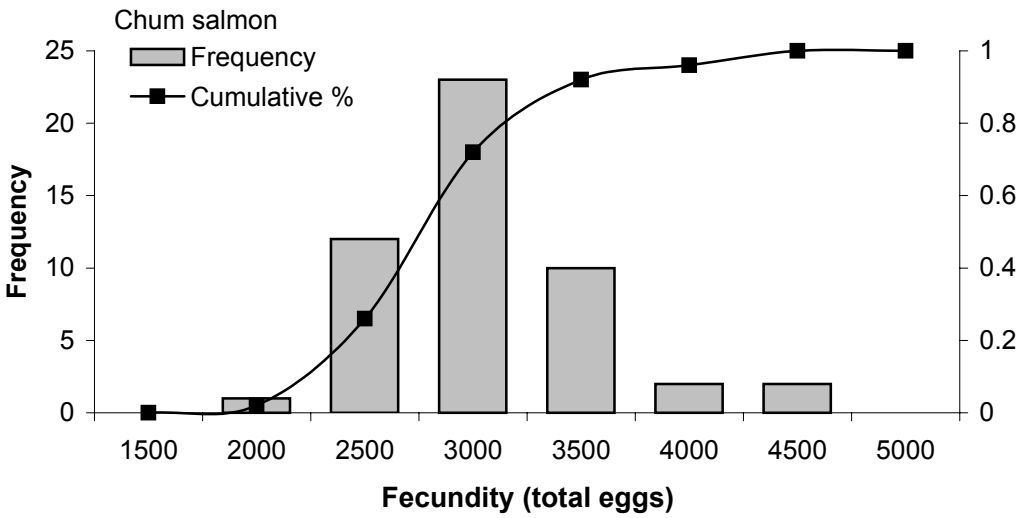
Coho age 2.1

Total Fecundity	df	Sum of Sq	Mean Sq	F Value	P
year	1	3961026	3961026	5.41	0.022
residuals	91	66627961	732175		

Relative Fecundity					
year	1	838.5	838.5	4.93	0.029
residuals	91	15483.7	170.2		

Length					
year	1	634.1	634.1	0.76	0.385
residuals	91	75793.9	832.9		

Figure 1. Map of Alaska (inset) and the Norton Sound region. Salmon sampled for fecundity in 2002 and 2003 came from Unalakleet River, on the east side of Norton Sound.



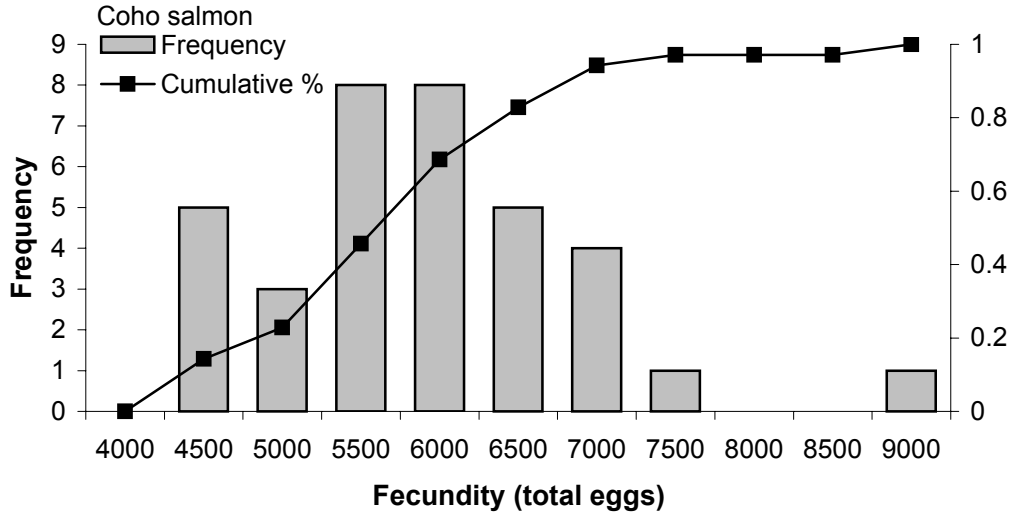


Figure 2. Histogram of fecundities (total and cumulative %) of 51 chum and 39 coho salmon sampled from the Unalakleet River in 2003.

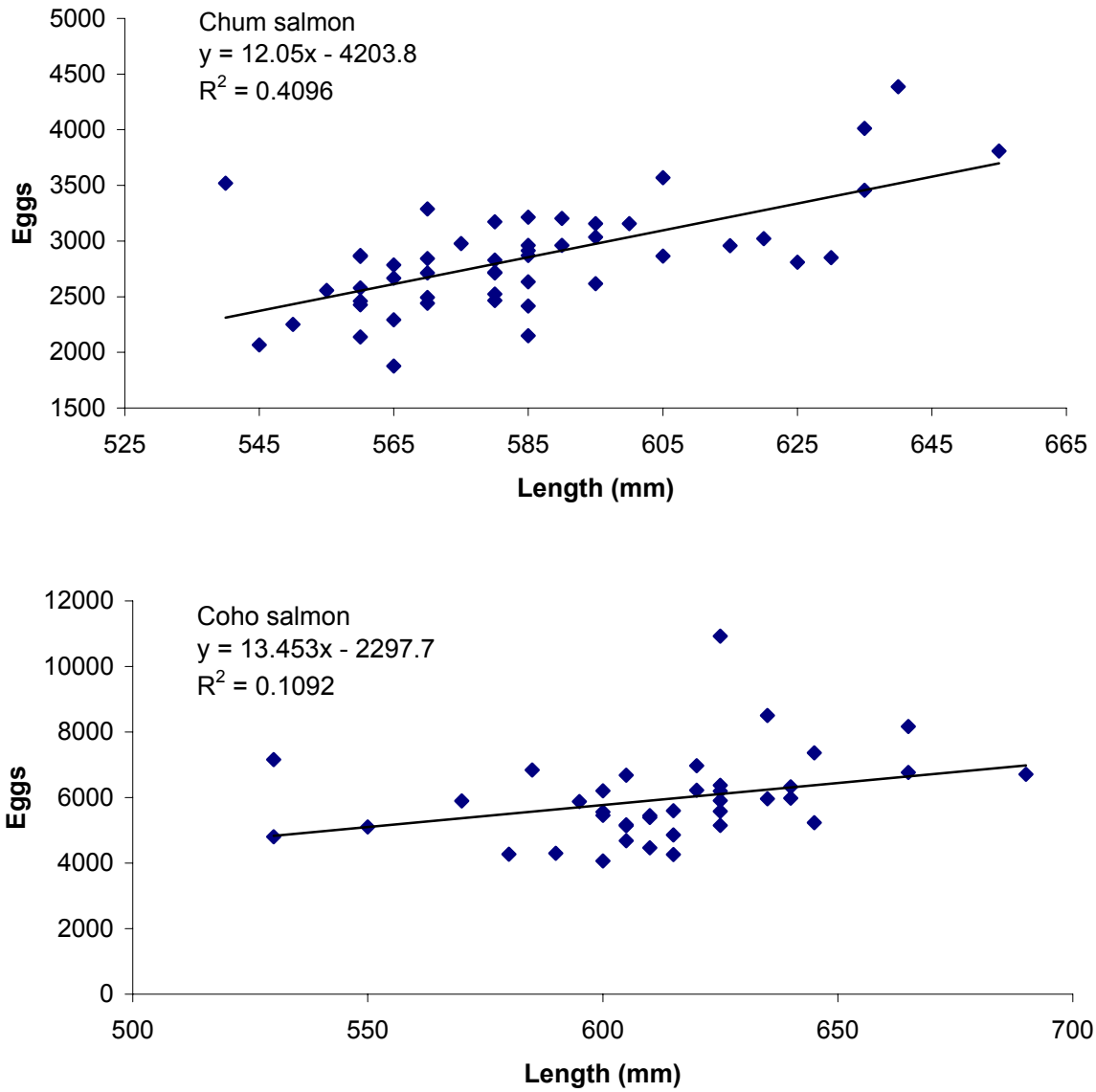


Figure 3. Total fecundity versus length for chum and coho salmon sampled from the Unalakleet River in 2003.

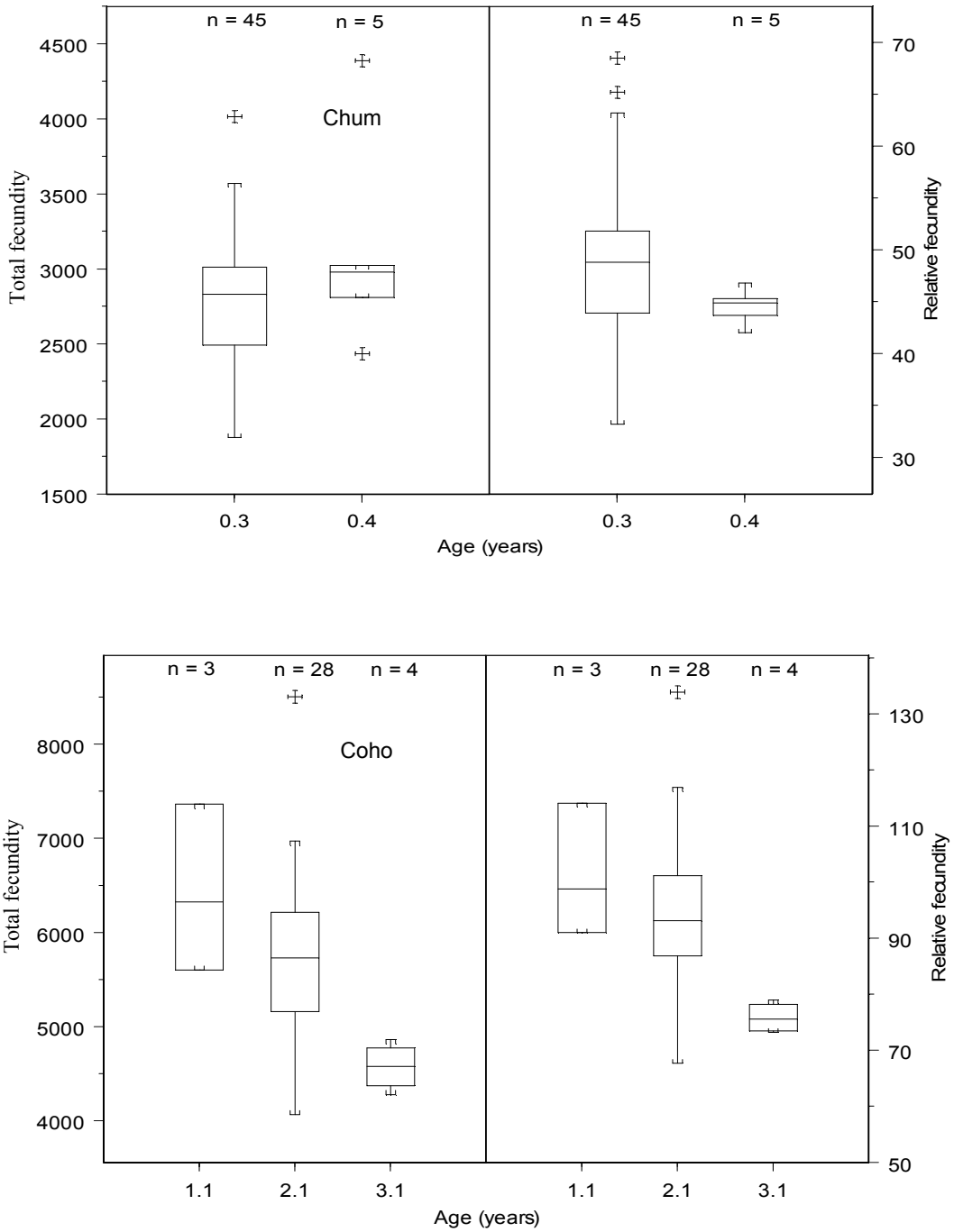
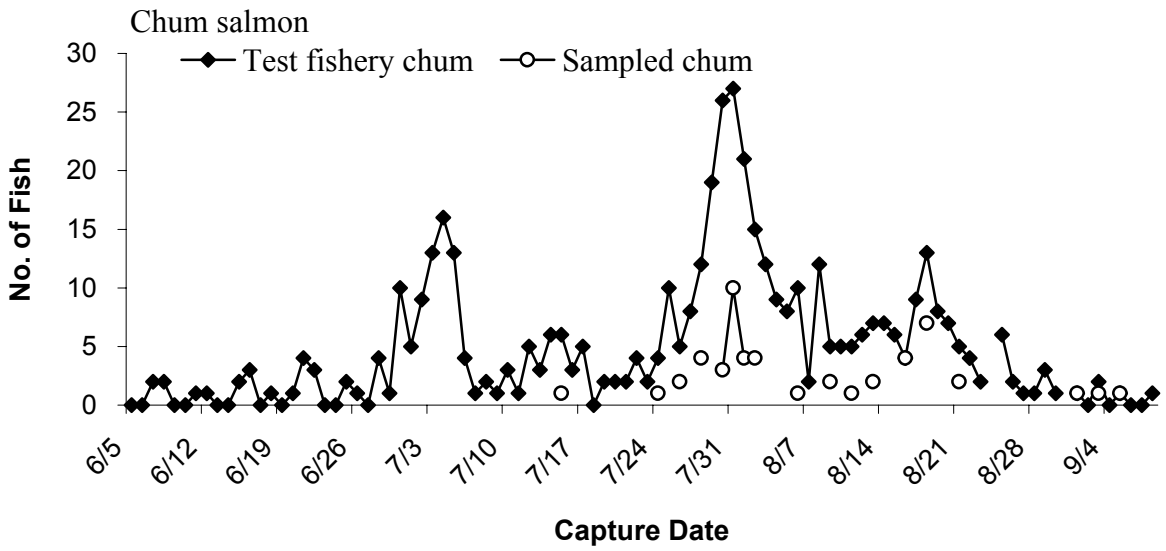


Figure 4. Box plots of total and relative fecundity (eggs/cm of body length) by age for chum and coho salmon from the Unalakleet River, 2003. Center horizontal line is sample median, box edges are 1st and 3rd quartiles, whiskers extend 1.5 times the inter-quartile range, and asterisks denote potential outliers.



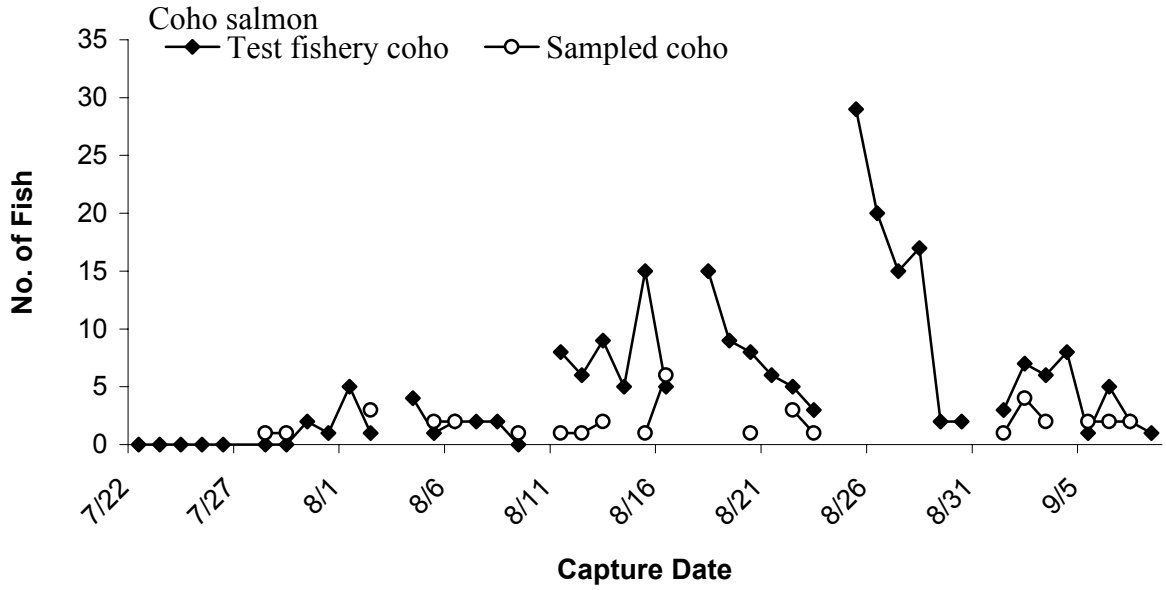


Figure 5. Dates of chum and coho salmon captured in the Unalakleet River test fishery in 2003 (solid diamonds) vs. dates of salmon sampled for fecundity (open circles).

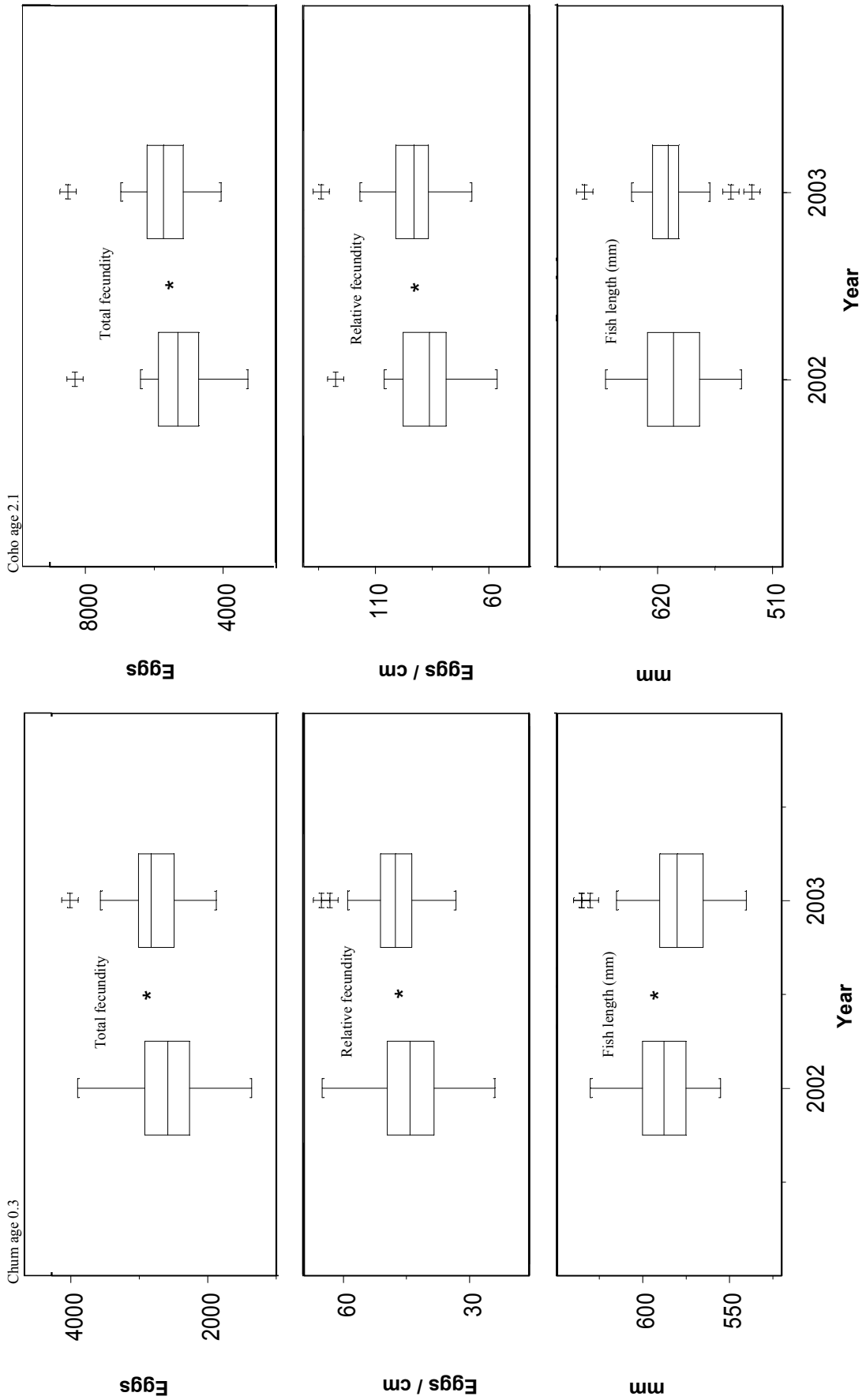


Figure 6. Total fecundity, relative fecundity (eggs/cm of body length) and length of age 0.3 chum and age 2.1 coho in 2002 and 2003. An asterisk (*) denotes a significant difference between years. Center horizontal line is sample median, box edges are 1st and 3rd quartiles, whiskers extend 1.5 times the inter-quartile range, and crosses denote potential outliers.

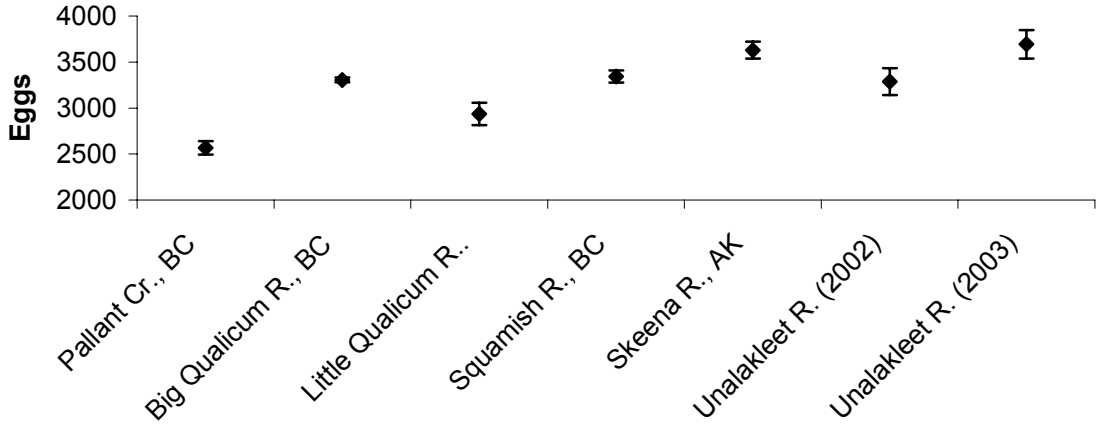


Figure 7. Fecundity of various chum salmon populations at POH lengths standardized to 58.8 cm (Beacham 1982). Point markers represent mean, whiskers extend + / - 1 SE from mean. Only populations with sample sizes > 30 are shown.

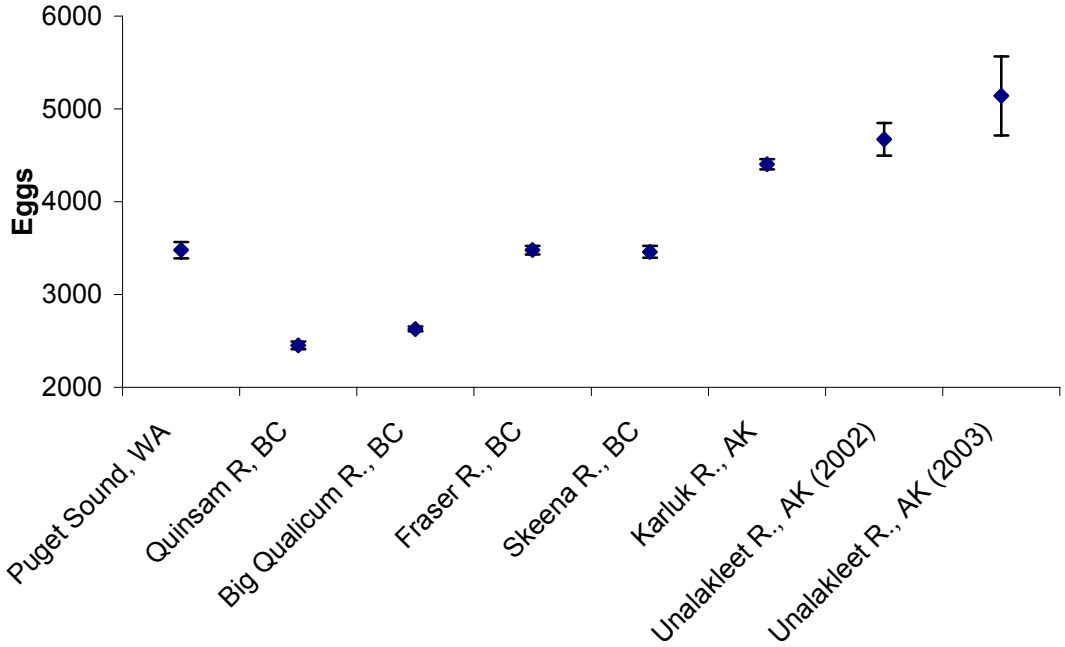


Figure 8. Fecundity of various coho salmon populations at 53.6 cm POH length (Beacham 1982). Point markers represent mean, whiskers extend + / - 1 SE from mean. Only populations with sample sizes > 30 are shown.

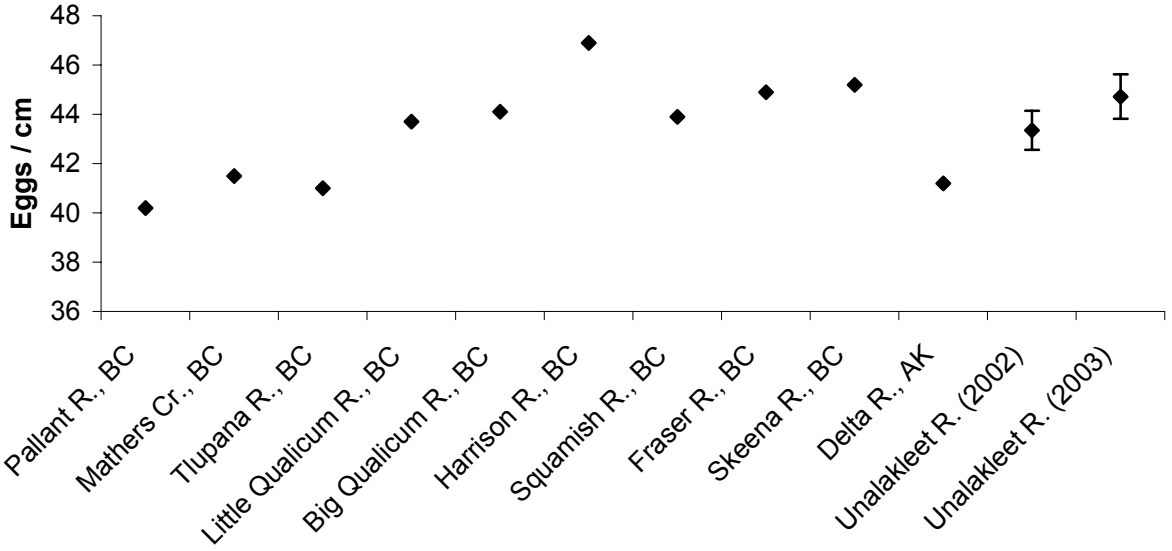


Figure 9. Mean relative fecundities (eggs / cm of fork length) of chum salmon from the Unalakleet River compared to those from other North American rivers reported by Salo (1991). Point markers represent means, whiskers extend + / - 1 SE from mean.

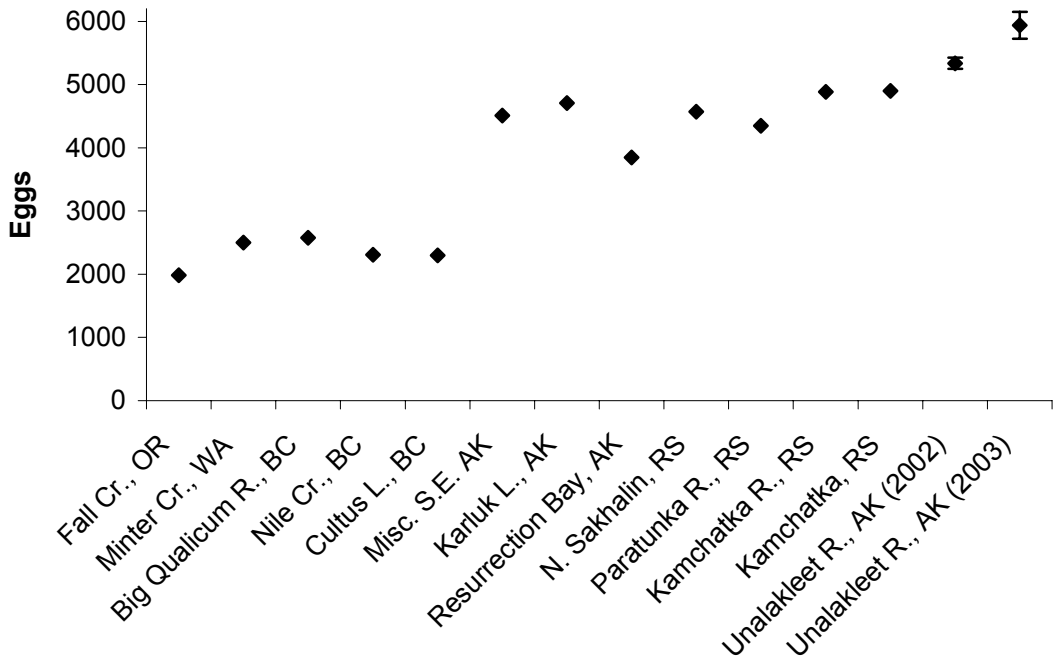


Figure 10. Mean total fecundities of coho salmon from the Unalakleet River compared to other North American populations reported by Sandercock (1991). Point markers represent mean, whiskers extend + / - 1 SE from mean. Standard error values are only available for the Unalakleet River samples.

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon returning to the Unalakleet River in 2003.

						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 fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Age (fresh.ocean years)	POH length
NA	11	chum	7/15/2003	002-01	3/25/2004	202.77	221.95	15.39	15.98	113	118	15.22	15.48	123	116	3215	585	55.0	0.3	52.3
NA	14	chum	7/24/2003	002-04	3/23/2004	210.65	233.85	16.99	17.37	101	102	17.67	17.77	100	102	2580	560	46.1	0.3	50.0
NA	15	chum	7/26/2003	002-05	3/16/2004	253.10	298.27	17.55	17.14	101	101	17.99	17.94	101	101	3157	595	53.1	0.3	53.2
NA	16	chum	7/26/2003	002-06	11/24/2003	169.61	172.11	17.47	18.01	108	112	17.65	18.18	116	110	2137	560	38.2	0.3	50.0
NA	17	chum	7/28/2003	002-07	3/24/2004	235.04	236.50	24.07	22.03	113	104	23.62	22.30	100	102	2148	585	36.7	0.3	52.3
NA	18	chum	7/28/2003	002-08	3/24/2004	409.36	412.31	24.65	25.53	112	114	24.95	25.40	119	121	3809	655	58.2	Re	58.8
NA	19	chum	7/28/2003	002-09	11/24/2003	303.62	319.61	21.98	22.02	111	114	23.18	24.60	121	121	3172	580	54.7	0.3	51.9
NA	22	chum	7/28/2003	003-02	3/19/2004	174.74	195.44	15.31	16.06	125	123	16.40	16.46	122	128	2872	585	49.1	0.3	52.3
NA	24	chum	7/30/2003	003-04	10/27/2003	245.88	241.02	19.42	20.73	105	107	18.96	21.33	129	117	2784	565	49.3	0.3	50.5
NA	25	chum	7/30/2003	003-05	10/30/2003	246.90	247.36	21.90	21.30	120	114	20.96	23.98	105	131	2632	585	45.0	0.3	52.3
NA	26	chum	7/30/2003	003-06	10/28/2003	172.08	181.08	18.41	17.98	109	108	20.43	19.87	117	114	2065	545	37.9	0.3	48.6
NA	27	chum	7/31/2003	003-07	3/10/2004	187.11	176.04	19.67	17.66	143	125	18.13	18.58	129	117	2523	580	43.5	0.3	51.9
NA	28	chum	7/31/2003	003-08	10/7/2003	220.80	197.70	18.44	18.17	158	156	18.46	19.15	162	156	3569	605	59.0	0.3	54.2
NA	29	chum	7/31/2003	003-09	11/20/2003	219.98	216.20	20.10	20.95	103	110	20.36	20.93	105	115	2292	565	40.6	0.3	50.5
NA	30	chum	7/31/2003	003-10	3/11/2004	224.28	208.29	18.79	26.66	105	151	19.06	22.09	102	127	2415	585	41.3	0.3	52.3
NA	32	chum	7/31/2003	004-01	10/7/2003	231.59	192.82	17.22	18.52	102	109	17.28	18.02	101	100	2465	580	42.5	0.3	51.9
NA	33	chum	7/31/2003	004-02	10/29/2003	163.21	167.25	17.81	17.85	101	100	18.40	17.99	103	105	1876	565	33.2	0.3	50.5
NA	34	chum	7/31/2003	004-03	3/23/2004	181.67	162.47	16.52	16.25	117	114	16.49	15.84	120	109	2433	580	42.0	0.4	51.9
NA	35	chum	7/31/2003	004-04	10/27/2003	246.22	239.36	18.89	17.90	110	107	18.45	18.40	107	105	2829	580	48.8	0.3	51.9
NA	36	chum	7/31/2003	004-05	3/16/2004	177.02	186.55	19.44	21.95	131	146	17.20	16.77	111	115	2428	560	43.4	0.3	50.0
NA	38	chum	7/31/2003	004-06	3/17/2004	319.82	292.27	19.53	18.38	111	105	18.42	19.22	101	110	3457	635	54.4	0.3	56.9
NA	40	chum	8/1/2003	004-07	3/16/2004	265.29	302.11	18.97	19.23	101	107	19.73	18.96	101	100	3022	620	48.7	0.4	55.5
NA	42	chum	8/1/2003	004-08	3/16/2004	236.96	226.82	18.40	18.72	121	122	18.27	18.75	114	119	2977	575	51.8	0.4	51.4
NA	43	chum	8/1/2003	004-09	11/11/2003	246.16	209.08	19.48	20.25	111	110	19.70	20.38	103	113	2492	570	43.7	0.3	50.9
NA	44	chum	8/1/2003	004-10	11/12/2003	217.03	202.01	17.46	17.14	115	112	17.16	17.55	105	109	2666	565	47.2	0.3	50.5
NA	46	chum	8/2/2003	005-02	11/19/2003	273.41	297.37	18.89	17.01	140	130	18.37	15.35	143	121	4386	640	68.5	0.4	57.4
NA	47	chum	8/2/2003	005-03	11/14/2003	291.48	261.83	20.67	19.01	107	100	19.46	20.36	101	103	2862	560	51.1	0.3	50.0
NA	48	chum	8/2/2003	005-04	10/3/2003	237.18	230.78	21.05	23.77	128	155	23.47	21.25	148	136	2960	590	50.2	0.3	52.8
NA	49	chum	8/2/2003	005-05	10/28/2003	205.30	192.62	19.36	19.50	112	113	18.31	19.12	101	106	2252	550	40.9	0.3	49.1
NA	51	chum	8/6/2003	005-06	10/2/2003	249.06	241.63	21.90	20.65	113	114	23.71	21.85	127	116	2618	595	44.0	0.3	53.2
NA	54	chum	8/9/2003	005-08	10/29/2003	298.89	282.95	18.24	18.69	108	114	18.06	20.63	108	128	3519	540	65.2	0.3	48.2
NA	58	chum	8/9/2003	005-09	10/22/2003	302.96	282.37	26.23	22.14	122	100	20.80	23.26	100	106	2714	580	46.8	0.3	51.9
NA	59	chum	8/11/2003	005-10	11/3/2003	302.41	289.77	18.88	18.72	130	123	18.65	19.02	128	129	4014	635	63.2	0.3	56.9
NA	61	chum	8/13/2003	006-01	10/7/2003	199.12	193.89	18.43	19.68	134	145	19.41	20.12	139	148	2864	605	47.3	0.3	54.2
NA	63	chum	8/13/2003	006-02	11/4/2003	326.45	274.22	20.03	20.86	102	102	20.08	20.19	102	100	3010	605	49.7	0.3	54.2
NA	66	chum	8/16/2003	006-04	11/20/2003	266.48	249.24	20.77	21.03	112	108	21.66	21.51	113	114	2714	570	47.6	0.3	50.9
NA	68	chum	8/16/2003	006-05	11/19/2003	235.20	285.81	18.03	18.30	100	100	18.97	18.92	100	100	2808	625	44.9	0.4	56.0
NA	70	chum	8/16/2003	006-06	10/3/2003	333.92	265.09	26.46	23.24	131	117	20.32	20.03	103	105	3035	595	51.0	0.3	53.2
NA	71	chum	8/16/2003	006-07	10/21/2003	190.84	250.42	18.53	17.29	111	100	17.73	17.49	100	101	2557	555	46.1	0.3	49.5
NA	72	chum	8/18/2003	006-08	10/30/2003	267.06	282.46	19.10	19.47	102	100	19.08	19.22	106	100	2915	585	49.8	0.3	52.3
NA	73	chum	8/18/2003	006-09	3/18/2004	207.67	242.50	18.94	18.52	103	102	18.75	18.68	100	101	2442	570	42.8	0.3	50.9
NA	81	chum	8/18/2003	006-10	11/11/2003	304.62	305.96	20.05	20.10	101	104	18.81	20.41	101	104	3156	600	52.6	0.3	53.7
NA	82	chum	8/18/2003	007-01	11/10/2003	245.21	228.35	16.23	17.18	105	104	17.02	17.08	100	113	2960	585	50.6	0.3	52.3
NA	83	chum	8/18/2003	007-02	11/4/2003	224.18	193.43	18.67	18.53	132	136	18.81	17.98	113	124	2843	570	49.9	0.3	50.9
NA	84	chum	8/18/2003	007-03	10/22/2003	245.61	192.23	18.94	18.59	102	103	18.83	17.98	109	104	2461	560	43.9	0.3	50.0
NA	85	chum	8/18/2003	007-04	10/21/2003	207.61	212.95	18.85	18.18	132	123	17.88	17.05	118	118	2869	560	51.2	0.3	50.0
NA	88	chum	8/21/2003	007-07	10/8/2003	290.45	282.74	17.82	18.25	101	100	18.18	18.09	103	100	3202	590	54.3	0.3	52.8
NA	89	chum	8/21/2003	007-08	10/1/2003	232.48	216.15	23.13	17.30	140	100	19.64	22.17	123	136	2719	580	46.9	0.3	51.9
NA	90	chum	9/1/2003	007-09	11/7/2003	268.79	241.08	17.90	19.18	101	111	17.75	18.20	104	108	2959	615	48.1	0.3	55.1
NA	91	chum	9/3/2003	007-10	11/11/2003	289.33	290.44	19.11	18.96	107	109	18.88	19.40	109	108	3289	570	57.7	0.3	50.9
NA	92	chum	9/5/2003	008-01	11/7/2003	347.39	289.03	23.26	24.03	106	106	23.42	24.36	107	106	2851	630	45.3	0.3	56.5
Early	1	Coho	7/28/2003	001-01	1/28/2004	200.33	216.23	10.59	10.41	104	106	10.47	10.67	100	101	4065	600	67.7	2.1	58.0
Early	3	Coho	7/29/2003	001-03	2/24/2004	294.53	284.76	15.90	14.29	166	146	15.88	14.12	160	147	5958	635	93.8	2.1	61.2

Appendix A. Data from fish and from egg counts used to report fecundity for chum and coho salmon returning to the Unalakleet River in 2003.

						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 fecundity	Fish length (mm)	Relative fecundity (eggs/cm)	Age (fresh.ocean years)	POH length
Early	5	Coho	8/2/2003	001-05	10/8/2003	317.35	300.07	16.56	16.41	139	140	16.53	15.19	136	125	5152	625	82.4	2.1	60.3
Early	6	Coho	8/2/2003	001-06	12/5/2003	199.42	220.90	10.33	7.90	145	109	10.80	8.25	154	116	5898	570	103.5	2.1	55.2
Early	7	Coho	8/2/2003	001-07	1/16/2004	215.00	230.14	10.43	10.42	123	122	9.30	9.92	107	108	5105	550	92.8	2.1	53.3
Early	8	Coho	8/5/2003	001-08	1/27/2004	334.78	297.08	14.62	14.97	128	130	14.43	14.83	124	126	5456	600	90.9	2.1	58.0
Early	9	Coho	8/5/2003	001-09	12/23/2003	211.04	248.52	12.71		160		12.05		156		5389	610	88.3	2.1	58.9
Early	10	Coho	8/6/2003	001-10	3/30/2004	230.41		12.15		115		11.99		109		4275	580	73.7	3.1	56.1
Early	11	Coho	8/6/2003	002-01	12/19/2004	238.54	205.35	9.27	9.11	117	109	8.95	9.45	110	115	5449	610	89.3	2.1	58.9
Early	12	Coho	8/9/2003	002-02	12/20/2004	296.89	349.94	17.03	17.26	113	114	17.39	17.01	115	111	4264	615	69.3	2.1	59.4
Early	15	Coho	8/11/2003	002-05	12/1/2003	249.17	254.42	15.77	15.76	135	134	15.06	15.33	129	131	4302	590	72.9	2.1	57.1
Early	19	Coho	8/12/2003	002-08	3/4/2002	348.74	351.71	16.51	16.73	133	133	16.96	16.43	136	127	5560	600	92.7	2.1	58.0
Early	22	Coho	8/13/2003	002-10	12/5/2003	411.60	382.39	14.46	14.62	120	122	14.32	14.91	114	112	6378	625	102.0	2.1	60.3
Early	23	Coho	8/13/2003	003-01	12/2/2003	377.02	350.03	16.84	16.70	117	117	16.55	16.64	119	119	5143	605	85.0	2.1	58.4
Early	27	Coho	8/15/2003	003-04	1/16/2004	426.57	447.93	16.56	15.53	132	116	15.90	15.44	133	125	6970	620	112.4	2.1	59.8
Early	28	Coho	8/16/2003	003-05	12/5/2003	338.89	330.41	15.68	15.00	118	113	15.52	15.79	108	111	4860	615	79.0	3.1	59.4
Early	34	Coho	8/16/2003	003-10	1/8/2004	276.34	301.59	11.33	12.04	143	133	12.44	11.04	123	151	6838	585	116.9	2.1	56.6
Early	36	Coho	8/16/2003	004-02	12/4/2003	436.18	435.79	13.42	13.45	124	125	13.79	13.26	126	130	8169	665	122.8	Re	64.0
Early	37	Coho	8/16/2003	004-03	1/13/2004	334.41	347.06	17.33	16.52	119	113	16.23	15.98	111	111	4684	605	77.4	3.1	58.4
Early	38	Coho	8/16/2003	004-04	1/9/2004	215.22	236.57	9.53	9.80	100	106	9.42	9.53	101	100	4804	530	90.6	2.1	51.5
Early	39	Coho	8/16/2003	004-05	12/5/2003	327.17	331.90	13.33	13.35	127	128	13.57	13.83	124	130	6204	600	103.4	2.1	58.0
Early	44	Coho	8/20/2003	004-10	12/4/2003	328.29	317.47	15.17	14.61	105	101	15.84	15.54	110	107	4466	610	73.2	3.1	58.9
Early	50	Coho	8/22/2003	005-06	12/3/2003	297.14	347.30	14.84	15.65	130	136	15.44	15.34	131	135	5599	615	91.0	1.1	59.4
Late	91	Coho	8/22/2003	005-07	12/2/2003	227.78	225.88	9.88	9.78	154	158	8.97	9.50	140	150	7161	530	135.1	Re	51.5
Late	108	Coho	8/22/2003	005-10	1/8/2004	383.93	356.68	11.84	11.37	109	105	12.32	12.52	112	113	6769	665	101.8	Re	64.0
Late	113	Coho	8/23/2003	006-03	1/15/2004	374.57	371.20	15.33	15.53	130	130	16.44	15.39	138	125	6221	620	100.3	2.1	59.8
Late	114	Coho	9/1/2003	006-04	12/16/2003	483.08	472.63	16.19	16.53	143	147	16.44	16.37	148	145	8503	635	133.9	2.1	61.2
Late	115	Coho	9/2/2003	006-05	12/9/2003	518.05	471.42	9.81	9.70	110	108	10.17	16.80	110	185	10926	625	174.8	Re	60.3
Late	116	Coho	9/2/2003	006-06	11/25/2003	403.88	386.66	17.70	16.37	141	132	15.15	16.05	122	127	6324	640	98.8	1.1	61.7
Late	117	Coho	9/2/2003	006-07	12/22/2003	471.10	409.19	18.52	18.83	118	116	18.60	18.83	121	118	5576	625	89.2	2.1	60.3
Late	118	Coho	9/2/2003	006-08	11/26/2003	382.59	372.35	15.70	16.05	109	107	17.14	15.98	120	108	5167	605	85.4	2.1	58.4
Late	119	Coho	9/3/2003	006-09	1/8/2004	623.26	618.48	21.14	21.01	113	112	20.34	19.68	116	103	6710	690	97.2	2.1	66.4
Late	122	Coho	9/3/2003	007-02	12/4/2003	353.56	337.77	14.34	14.99	107	109	13.63	15.69	106	122	5235	645	81.2	2.1	62.2
Late	125	Coho	9/5/2003	007-05	12/20/2004	258.72	247.20	9.80	9.64	117	117	8.96	9.54	105	104	5908	625	94.5	2.1	60.3
Late	126	Coho	9/5/2003	007-06	12/30/2003	460.75	546.71	16.51	16.20	121	118	16.45	17.29	124	123	7361	645	114.1	1.1	62.2
Late	128	Coho	9/6/2003	007-07	12/15/2003	492.34	481.98	17.31	20.54	112	133	17.20	17.34	109	107	6200	625	99.2	2.1	60.3
Late	132	Coho	9/6/2003	007-10	11/25/2003	437.80	467.16	17.05	17.61	112	113	18.45	17.61	120	122	5979	640	93.4	2.1	61.7
Late	134	Coho	9/7/2003	008-02	12/3/2003	445.19	401.85	20.89	16.73	148	118	16.85	16.13	113	112	5882	595	98.9	2.1	57.5
Late	135	Coho	9/7/2003	008-03	1/7/2004	424.76	385.77	15.13	16.12	120	135	15.60	15.49	132	127	6678	605	110.4	2.1	58.4