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Length Conversion Equations for Sockeye, Chinook, Chum, and Coho Salmon in Southeast Alaska

by

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State of Alaska Steve Cowper, Governor

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Many people contributed in the tedious task of collecting various length measurements over several years. The Petersburg port sampling crew, in particular Cathy Robinson collected much of the data. John E. Clark sampled chinook in Juneau and Scott Johnson, Scott McPherson, Andy McGregor and Ben Van Alen helped in the analysis of data.

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ABSTRACT

Predictive linear regression equations were determined for converting between different length measurements used in data collection for four species of Pacific salmon. Sockeye salmon (*Oncorhynchus nerka* Walbaum) were sampled for mid-eye to fork of tail (MEF), mid-eye to hypural plate (MEH), and postorbit of the eye to hypural plate (POH), and conversion equations were determined. Chinook (*O. tshawytscha* Walbaum), chum (*O. keta* Walbaum), and coho salmon (*O. kisutch* Walbaum) were sampled for MEF, MEH, POH, and in some cases snout to tip of tail (TOT) and snout to fork of tail (SNF). All possible length relationships were determined. Regression equations were significant in all cases ($P<0.0001$). Chinook and chum salmon were sampled in both ocean brite and mature dark conditions, and conversion equations were determined for each type.

KEY WORDS: Salmon, Southeast Alaska, length measurements, biological sampling, regression equations

INTRODUCTION

Management of the salmon fisheries of Southeast Alaska requires the exchange of data between a number of research agencies, management agencies, and governments. One of the most basic data sets collected by these agencies is the length of the fish in the catches and escapements of salmon. Accurate length measurements are essential in the estimation of age and weight and in run forecasting. Unfortunately, lengths have been taken with a variety of measurements and there is a need for a method to convert one measurement to another.

The Alaska Department of Fish and Game (ADF&G) generally measures salmon from mideye to the fork of the tail (MEF), while the Canadian Department of Fisheries and Oceans measures from the postorbit of the eye to the hypural plate (POH). ADF&G minimum size regulations for chinook salmon (*Oncorhynchus tshawytscha* Walbaum) refer to the total length (TOT), or snout to tip of the tail. The ADF&G coded-wire tag (CWT) samplers collect snout to fork (SNF) lengths. Another measurement used in fishery biology is mideye to hypural plate (MEH). Conversion formulas allow one measurement to be converted to another.

Duncan (1956) determined the MEF to MEH relationship for sockeye salmon in Bristol Bay. In Southeast Alaska Gray et al. (1981) reported the SNF to MEF equation for coho salmon, and Dangel et al. (1977) reported the MEH to MEF for chum salmon (*O. keta* Walbaum). Some length conversions for spawning chum salmon in Prince William Sound were determined by Helle (1979). ADF&G is continuing analysis of chum and pink salmon (*O. gorbuscha* Walbaum) measurements (J.D.Jones, Alaska Department of Fish and Game, Juneau, personal communication).

The objectives of this investigation were to determine the mathematical relationships and functions necessary to easily and accurately convert one length measurement to another for Southeast Alaska sockeye (*O. nerka* Walbaum), coho (*O. kisutch* Walbaum), chum and chinook salmon.

METHODS

Salmon measurements were collected in conjunction with existing ADF&G sampling programs. An attempt was made to sample fish from different geographic areas and fishing gear types to collect as wide a range of fish measurements as possible. It was beyond the scope of this investigation to examine geographic differences between salmon stocks within Southeast Alaska. Therefore, the different samples were combined by species into one or two samples representing Southeast Alaska. I did not examine potential differences between years or sexes and assumed all the stocks of a species in Southeast Alaska have similar relationships. Between year differences may be statistically significant (Duncan 1956), but for practical purposes, the differences are unimportant. There were no significant differences in MEF to POH equations between sexes of sockeye salmon sampled on the Taku River in 1987 (Andy McGregor, ADF&G, Juneau, personal communication), and I assume no differences between sexes for other species in MEF, POH, and MEH relationships.

Sockeye salmon were sampled from commercial gill net and seine fisheries throughout Southeast Alaska August 17-25, 1985. Measurements were taken on 348 fish from mixed District 111/115 gill net catches in Northern Southeast; 125 from District 112 seine catches in central Southeast; and 200 seine and 147 gill net caught sockeye salmon from District 101 in Southern Southeast Alaska.

Thirty-two chinook salmon were sampled from District 104 seine catches, 59 fish from District 115 gill net catches, 359 from Juneau area sport-catches, and 38 measurements from spawning fish were collected from Crystal Lake Hatchery near Petersburg. All chinook salmon measurements were collected in August 1987.

Coho salmon were sampled from gill net, seine and troll fisheries 7/24 -8/23, 1987. One hundred fish were measured from District 105 troll, 50 from District 115 gill net and 200 from District 104 seine fisheries.

In Southeast Alaska commercially caught chum salmon are usually graded as brite, semi-brite, or dark fish. Brite fish are silver with few of the morphological characteristics associated with spawning and little sexual dimorphism; dark fish are darkly colored and have pronounced sexual dimorphism with enlarged snouts and teeth; semi-brites are intermediate in this very subjective classification. Measurements were collected from brite and dark fish and analyzed separately. Measurements from 198 dark chum salmon were collected from District 115 gill net catches 7/28/88 and from 201 brite chum salmon from mixed District 101 and 106 gill net catches 7/27/88.

Each fish was laid flat on a measuring board and measured to the nearest millimeter with a flexible measuring tape stretched taut. Sockeye salmon were sampled for MEF, MEH, and POH lengths, while chinook, chum and coho salmon were measured for MEF, MEH, POH, and in some cases TOT and SNF. The sex of the fish was determined only for the chinook sport-caught sample.

The measurements were entered into Lotus 123 files and sorted and edited. Predictive linear regression equations, correlation coefficients, and standard errors were computed for all possible conversions of length measurements. The length conversion equations were determined by use of simple linear regression rather than the Geometric Mean (GM) regression preferred by Ricker (1973). Since these equations are intended to be used to predict one measurement from another the linear regression was used (H.J. Geiger, Alaska Department of Fish and Game, Juneau, personal communication).

Plotting the residuals in the regression analysis was not possible using the Lotus 123 regression procedure. The correlation coefficients (r) were calculated for each regression equation. The coefficient of determination (r^2) is equal to the proportion of the total variation in Y that is explained by the regression. The regression equations were tested for significance with the t-test. The t-test tests the probability that the estimate of b (the slope of the regression line) could have come from a population with an actual slope (B) of zero, which would indicate that Y is not dependent on X. The 95% CI around the predicted value of Y (Y) for a given X is given by the equation (Sokal and Rohlf 1981):

$$95\% \text{ CI} = \hat{Y} \pm t_{.05[n]} (S_y)$$

where: $$S_y = \sqrt{[\text{ SE of } Y_{est}]^2 \left[1 + \frac{1}{n} + \frac{(X_i - \bar{X})^2}{\sum x^2} \right]}$$

For this investigation $t_{.05[n]}$ is approximately equal to 2 (range 2.021 to 1.960) and S_Y (the standard error of the predicted value) ranges from 6.8 mm to 24.5 mm giving confidence intervals (CI) ranging between ± 13 and 50 mm for predicted length measurements. If, for a specific regression equation a series of CIs are calculated, a biconcave confidence belt is obtained. The limits change as the value of X used to predict Y changes. They are at a minimum when X equals the mean and increase as X moves in either direction from the mean. In other words, the farther a length X is away from the mean length for that measurement the less reliable is the predicted value of another length measurement Y. The confidence intervals for a specific predicted value in any conversion equation can be calculated using the above equations.

RESULTS

The correlation coefficients between the different length measurements were high with r values of greater than 0.94 in all cases. The regression equations were tested for significance with a t-test, and all were significant at P<0.0001 (Zar 1974).

Sockeye

Only MEH, POH and MEF measurements were collected from sockeye salmon. The r^2 values of the regression equations are all greater than 0.97 (Table 1). The SE of Y_{est} values range from 5 to 7.5 giving 95% CI for predicted lengths of approximately ± 13 to 15 mm for MEF versus POH or MEH and ± 10 mm for MEH versus POH.

Chinook

Chinook salmon were sampled both in ocean fisheries and in spawning condition. There were small differences between the resulting conversion equations for the two samples (Table 2 and 3). The lowest correlation coefficients and highest SE of Y_{est} involved converting TOT length measurements of spawning chinook salmon. The 95% CI around the predicted lengths ranged from approximately ± 14.5 mm for MEH to SNF conversions on ocean brite fish to approximately ± 50 mm for POH to TOT conversions for spawning chinook.

The slopes of the MEF to POH equations from the two samples were significantly different ($P<0.05$). The differences between samples result from the morphometric changes in maturing salmon. The lower correlation coefficients and higher SEs for the spawning sample may be due to the small sample size and the shorter range of lengths sampled coupled with the imprecision of measuring to the tip of the tail.

The sex of 190 sport-caught chinook was determined and predictive regression equations were computed for each sex. The differences between sexes in predicted lengths were less than 7 mm of each other which, for practical purposes is probably negligible. This is fortunate as the majority of chinook landings are dressed fish which can not be sexed accurately.

Coho

The regression equations and associated statistics for converting between various length measurements of ocean-caught coho salmon are presented in Table 4. The 95% CI around the predicted lengths ranged from approximately $\pm$ 6 mm for MEH to POH conversions to $\pm$ 27 mm for POH to SNF conversions.

Chum

Tables 5 and 6 present the regression equations and associated statistics for converting between length measurements of dark and brite chum salmon, respectively. The r_2 values and SE of Y_{est} values were similar to those of sockeye and coho salmon. The 95% CI around the predicted lengths ranged from $\pm$ 7 mm for MEH to POH conversions to $\pm$ 32 mm for POH to TOT conversions with the CIs around predicted values for dark chums being slightly larger than those around brites. The slopes of the MEF to POH equations from the two samples were significantly different ($P<0.05$).

DISCUSSION

Duncan (1956) looked at thousands of measurements over several years and found the between year differences in length conversion equations for Bristol Bay sockeye salmon to be statistically different, but felt that, in practical applications, the differences were unimportant. The length conversion table that he generated from the 1953 data is used by the Fisheries Research Institute of the University of Washington in a field manual (Koo 1964). Predicted measurements for Southeast Alaska sockeye salmon are within 10 mm of measurements predicted for Bristol Bay sockeye. Duncan concluded that the MEH versus MEF relationship was linear throughout the range of sizes of adult sockeye salmon in Bristol Bay and that there was no difference between sexes in this relationship.

The SNF to MEF equation for coho predicts lengths similar to one determined by Gray et al. (1981) for Southeast Alaska coho salmon. Gray et al. sampled 6,431 coho salmon during the commercial fishing seasons of 1969 and 1970 in Southeast

Alaska and the Yakutat District. They found the snout to fork length to be up to 2 cm longer on fish sampled late in the season and increasing faster in males than females as they matured. Coho salmon lengths (MEF) generally increase through fishing season for each age group (Wood and Van Alen 1987). The fish sampled in this report were sampled over a 1-month period and pooled into one sample.

Dangel et al. (1977) reported the MEF to MEH equation for spawning (dark) chum salmon. They used the geometric mean (GM) of the functional regression (Ricker 1973). Based on 1,582 samples collected in Southeast Alaska in 1975 the equation was: MEH = 0.94355(MEF) + 36.3687. This was quite different from the corresponding equation from this investigation: MEH = 0.931(MEF) - 11.665. The associated statistics were not provided by Dangel et al. (1977) so the usefulness of the two equations cannot be compared. When separated by sex, Dangels' predicted values varied by only one mm so the sexes were combined. Conversion formulas for predicting MEF, SNF and POH from MEH measurements of spawning chum salmon in Prince William Sound were determined by Helle (1979).

There were no significant differences in MEF to POH equations between sexes of sockeye salmon sampled on the Taku River in 1987 (Andy McGregor, ADF&G personal communication). I found negligible differences between the lengths predicted by separate equations for male and female chinook salmon. I assumed no differences between sexes for other species in MEF, POH, and MEH relationships. TOT and SNF lengths both include the length of the snout which undergoes sexual dimorphism in spawning salmon. For that reason I believe that any conversions containing either TOT or SNF should be used only for salmon in the same stage of the spawning run. More work is needed on differences by sex of the conversion equations for spawning salmon. The lowest r^2 values and highest SE of Y_{est} in this report are from equations using TOT or SNF measurements from dark chums and spawning chinook.

Each of the different length measurements has advantages and disadvantages. Hypural lengths, POH and MEH, were the most difficult and time consuming to collect, especially from live fish. Fork lengths, SNF and MEF, and total length TOT, all include the caudal fin which erodes on the spawning grounds. SNF and TOT change with spawning morphology and sexual dimorphism. The relationships between the five length measurements examined in this report are all strong enough to be used to convert from one type to any other type for fish of similar maturities.

The applicability of each regression equation depends on how the predicted length measurements are used. For example, length measurements are commonly used in salmon research to estimate the number of years a fish has spent in the ocean (ocean-age). An estimated length with a CI of $\pm$ 15 mm would be acceptable in most cases for age estimation while a CI of $\pm$ 30 mm might not. These type of applications were referred to by Duncan (1956) when stating that between year differences may be statistically significant, but for practical purposes, the differences are unimportant. With large sample sizes, temporal and geographic variation and sexual dimorphism will probably all show statistically significant differences. However for most applications, if the size of the 95% confidence interval around the predicted value is taken into account, these tables should provide a simple method of converting from one length measurement to another. If more accuracy is required for a specific purpose additional samples of the population in question should be collected and regression equations determined.

Caution should be used in predicting lengths outside of the range of lengths used to derive the equations. For values of the predictor above or below this range the function may not be the same, indeed the relationship may not even be linear in such ranges, even though it is linear within the observed range (Zar 1974).

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TABLES AND FIGURES

Table 1. Linear regression equations for converting between various length measurements (mm) of ocean-caught sockeye salmon in Southeast Alaska.

Length Conversion Data [a]				
Regression Equation[b]	n^c	r^2	SE Y_{est}	SE $_b$
MEH = 0.899(MEF) - 5.401	820	0.9743	6.825987	0.005105
MEF = 1.084(MEH) + 20.666	820	0.9743	7.494085	0.006153
POH = 0.891(MEF) - 9.064	820	0.9773	6.349520	0.004748
MEF = 1.097(POH) + 23.039	820	0.9773	7.046329	0.005848
POH = 0.982(MEH) + 0.606	820	0.9861	4.969875	0.004080
MEH = 1.004(POH) + 6.529	820	0.9861	5.023592	0.004169

	MEH	MEF	POH
Range	288-610	324-682	282-598
Average	512.9	576.5	504.5
Variance	1811.0	2182.9	1772.5
Sum(x^2)	1,787,755	1,483,218	1,451,657

[a] Where: SE Y_{est} = square root of the mean square error in regression;
SE $_b$ = Standard Error of slope;
n = sample size;
r = correlation coefficient;
r^2 = coefficient of determination;
MEF = Mideye to Fork of tail;
MEH = Mideye to Hypural plate;
POH = Postorbit of eye to Hypural plate;
$x^2 = (X_i - \overline{X})^2$

[b] Based on the formula Y = bX + a, where b = slope of regression line and a = Y intercept of regression.

[c] Sample sources: 348 District 111/115 gill net, 200 Dist. 101 seine, 125 Dist. 112 seine, 147 Dist. 101 gill net, August 17-25, 1985.

Table 2. Linear regression equations for converting between various length measurements (mm) of ocean-caught chinook salmon in Southeast Alaska.

Length Conversion Data[a]

Regression Equation[b]	n^c	r^2	SE Y_{est}	SE $_b$
MEH = 0.914(MEF) - 0.116	91	0.9961	6.498167	0.006054
MEF = 1.090(MEH) + 2.688	91	0.9961	7.097985	0.007223
POH = 0.848(MEF) + 26.386	449	0.9803	9.644018	0.005682
MEF = 1.155(POH) - 16.302	449	0.9803	11.25467	0.007739
SNF = 1.101(MEF) - 15.878	449	0.9916	8.111752	0.004779
MEF = 0.900(SNF) + 20.321	449	0.9916	7.334365	0.003907
TOT = 1.120(MEF) + 21.328	449	0.9766	13.90473	0.008192
MEF = 0.872(TOT) - 1.743	449	0.9766	12.26682	0.006376
POH = 0.976(MEH) + 4.485	91	0.9960	6.406890	0.006519
MEH = 1.021(POH) - 2.198	91	0.9960	6.551643	0.006818
SNF = 1.181(MEH) - 5.061	91	0.9883	13.36876	0.013604
MEH = 0.837(SNF) + 11.262	91	0.9883	11.25745	0.009647
TOT = 1.218(MEH) + 28.176	91	0.9912	11.93114	0.012141
MEH = 0.814(TOT) - 17.660	91	0.9912	9.75438	0.008115
SNF = 1.269(POH) - 31.812	449	0.9673	16.04688	0.011034
POH = 0.762(SNF) + 45.106	449	0.9673	12.43264	0.006623
TOT = 1.291(POH) + 5.172	449	0.9525	19.81493	0.013625
POH = 0.738(TOT) + 26.471	449	0.9525	14.97914	0.007786
TOT = 1.015(SNF) + 39.020	449	0.9810	12.52947	0.006675
SNF = 0.966(TOT) - 22.940	449	0.9810	12.22515	0.006354

	MEH	MEF	POH	SNF	TOT
Range	423-944	470-939	419-822	503-1,014	551-1.088
Average	601.4	721.7	638.7	779.0	829.8
Variance	10,729.1	6,429.5	4,720.9	7,864.7	8,261.2
Sum(x^2)	2,880,435	965,622	2,114,990	3,523,404	3,701,003

[a] Where: SE Y_{est} = Square root of the mean square error in regeression;
SE $_b$ = Standard Error of slope;
n = sample size;
$x^2 = (X_i - \overline{X})^2$
r^2 = coefficient of determination;
MEF = Mideye to Fork of tail ; MEH = Mideye to Hypural plate;
POH = Postorbit of eye to Hypural plate; SNF = Snout to Fork of tail; TOT = Total length; snout to tip of tail.

[b] Based on the formula Y = bX + a, where b = slope of regression line and a = Y intercept of regression line.

[c] Sample sources: for N = 91 - 32 fish from District 104 seine and 59 from District 115 gill net. For N = 449 those 91 were combined with 359 Juneau sport caught fish; all fish sampled August 1987.

Table 3. Linear regression equations for converting between various length measurements (mm) of spawning chinook salmon in Southeast Alaska.

Length Conversion Data[a]				
Regression Equation[b]	n^c	r^2	SE Y_{est}	SE $_b$
MEH = 0.907(MEF) - 21.874	38	0.9841	7.691757	0.019185
MEF = 1.085(MEH) + 36.340	38	0.9841	8.415663	0.022966
POH = 0.912(MEF) - 34.381	38	0.9848	7.576385	0.018897
MEF = 1.080(POH) + 49.228	38	0.9848	8.245917	0.022385
SNF = 1.124(MEF) - 5.625	38	0.9504	17.14589	0.042766
MEF = 0.846(SNF) + 44.126	38	0.9504	14.87662	0.032195
TOT = 1.091(MEF) + 48.677	38	0.9215	21.27932	0.053076
MEF = 0.845(TOT) + 21.242	38	0.9215	18.72268	0.041088
POH = 1.004(MEH) - 11.598	38	0.9984	2.453942	0.006697
MEH = 0.994(POH) + 12.643	38	0.9984	2.441060	0.006626
SNF = 1.217(MEH) + 36.912	38	0.9316	20.13917	0.054960
MEH = 0.765(SNF) + 19.497	38	0.9316	15.97067	0.034562
TOT = 1.179(MEH) + 92.028	38	0.8988	24.16289	0.065941
MEH = 0.762(TOT) + 0.524	38	0.8988	19.43105	0.042643
SNF = 1.211(POH) + 51.177	38	0.9326	19.98870	0.054263
POH = 0.770(SNF) + 7.068	38	0.9326	15.93499	0.034485
TOT = 1.173(POH) +106.137	38	0.8991	24.12320	0.065487
POH = 0.766(TOT) - 11.761	38	0.8991	19.50151	0.042797
TOT = 0.974(SNF) + 51.699	38	0.9751	11.99554	0.025960
SNF = 1.001(TOT) - 29.644	38	0.9751	12.16426	0.026695

	MEH	MEF	POH	SNF	TOT
Range	584-814	666-924	576-807	737-1,018	780-1,049
Average	698.3	794.2	689.8	886.8	915.2
Variance	4,344.2	3,629.0	3,667.4	5,770.7	5,611.7
Sum (x^2)	134,273	160,737	135,694	213,514	207,632

[a] Where: SE Y_{est} = Square root of the mean square error in regression;
SE $_b$ = Standard Error of slope;
r = correlation coefficient;
r^2 = coefficient of determination;
n = sample size;
$x^2 = (X_i - \bar{X})^2$
MEF = Mideye to Fork of tail; MEH = Mideye to Hypural plate; POH = Postorbit of eye to Hypural plate; SNF = Snout to Fork of tail; TOT = Total length; snout to tip of tail

[b] Based on the formula Y = bX + a, where b = slope of regression line and a = Y intercept of regression

[c] Sample sources: Crystal Lake Hatchery, August 1987

Table 4. Linear regression equations for converting between various length measurements (mm) of ocean-caught coho salmon in Southeast Alaska.

Length Conversion Data[a]

Regression Equation[b]	n[c]	r^2	SE Y_{est}	SE $_b$
MEH = 0.942(MEF) - 30.245	350	0.9648	9.267920	0.009641
MEF = 1.024(MEH) + 51.824	350	0.9648	9.663889	0.010482
POH = 0.936(MEF) - 35.751	350	0.9620	9.586673	0.009972
MEF = 1.027(POH) + 59.230	350	0.9620	10.04057	0.010939
SNF = 1.076(MEF) + 5.938	350	0.9833	7.215494	0.007506
MEF = 0.914(SNF) + 4.448	350	0.9833	6.651859	0.006379
TOT = 1.147(MEF) - 1.300	100	0.9745	8.305105	0.018738
MEF = 0.849(TOT) + 16.899	100	0.9745	7.143684	0.013863
POH = 0.993(MEH) - 5.392	350	0.9960	3.112690	0.003376
MEH = 1.002(POH) + 7.520	350	0.9960	3.126490	0.003406
SNF = 1.098(MEH) + 63.721	350	0.9421	13.44827	0.014587
MEH = 0.858(SNF) - 24.112	350	0.9421	11.88977	0.011402
TOT = 1.267(MEH) - 0.476	100	0.9636	9.934275	0.024883
MEH = 0.761(TOT) + 20.812	100	0.9636	7.697166	0.014937
SNF = 1.102(POH) + 71.364	350	0.9404	13.65097	0.014873
POH = 0.854(SNF) - 29.939	350	0.9404	12.01572	0.011523
TOT = 1.260(POH) + 15.023	100	0.9592	10.51686	0.026254
POH = 0.761(TOT) + 11.108	100	0.9592	8.175743	0.015866
TOT = 1.055(SNF) + 4.918	100	0.9940	4.034130	0.008281
SNF = 0.942(TOT) - 0.615	100	0.9940	3.813664	0.007401

	MEH	MEF	POH	SNF	TOT
Range	370-635	421-704	363-629	459-771	557-819
Average	528.1	592.7	519.3	643.5	710.8
Variance	2,435.2	2,647.8	2,413.8	3,115.5	2,681.9
Sum (x^2)	849,892	924,066	842,406	1,087,299	265,508

[a] Where: SE of Y = Square root of the mean square error in regression; SE $_b$ = Standard Error of the slope; n = sample size; $x^2 = (X_i - \bar{X})^2$; r^2 = coefficient of determination; MEF = Mideye to Fork of tail; MEH = Mideye to Hypural plate; POH = Postorbit of eye to Hypural plate; SNF = Snout to Fork of tail; TOT = Total length; snout to tip of tail;

[b] Based on the formula Y = bX + a, where b = slope of regression line and a = Y intercept of regression line.

[c] Sample sources: for N = 100 - fish from District 105 troll. For N = 350 - those 100 were combined with 50 fish from District 115 gill net, and 200 fish from Dist. 104 seine. Sampled 7/24 - 8/23/87.

Table 5. Linear regression equations for converting between various length measurements (mm) of ocean caught "dark" chum salmon in Southeast Alaska.

Regression Equation[b]	n^c	r^2	SE Y_{est}	SE $_b$
		Length Conversion Data[a]		
MEH = 0.931(MEF) - 11.665	198	0.9471	8.678930	0.015707
MEF = 1.018(MEH) + 46.204	198	0.9471	9.076633	0.017179
POH = 0.922(MEF) - 16.255	198	0.9557	7.836312	0.014182
MEF = 1.037(POH) + 45.633	198	0.9557	8.310506	0.015950
SNF = 1.171(MEF) - 49.806	198	0.9279	12.887600	0.023324
MEF = 0.792(SNF) + 86.278	198	0.9279	10.599650	0.015777
TOT = 1.254(MEF) - 47.429	198	0.9046	16.071990	0.029087
MEF = 0.721(TOT) + 96.150	198	0.9046	12.191050	0.016735
POH = 0.980(MEH) + 1.348	198	0.9883	4.018990	0.007606
MEH = 1.008(POH) + 5.549	198	0.9883	4.075436	0.007822
SNF = 1.219(MEH) - 12.126	198	0.9202	13.557650	0.025661
MEH = 0.754(SNF) + 56.432	198	0.9202	10.662140	0.015870
TOT = 1.313(MEH) - 11.360	198	0.9070	15.865760	0.030030
MEH = 0.691(TOT) + 62.925	198	0.9070	11.507300	0.015797
SNF = 1.236(POH) - 8.887	198	0.9184	13.704580	0.026303
POH = 0.743(SNF) + 54.082	198	0.9184	10.628420	0.015820
TOT = 1.329(POH) - 7.390	198	0.9042	16.106510	0.030913
POH = 0.680(TOT) + 60.804	198	0.9042	11.520120	0.015814
TOT = 1.073(SNF) + 3.921	198	0.9799	7.364182	0.010961
SNF = 0.913(TOT) + 10.651	198	0.9799	6.791679	0.009323

	MEH	MEF	POH	SNF	TOT
Range	505-697	561-761	490-694	603-839	652-913
Average	592.4	649.1	582.1	710.4	766.5
Variance	1,416.9	1,549.7	1,377.9	2,291.0	2,693.5
Sum (x^2)	279,131	305,299	271,453	451,324	530,619

[a] Where: SE Y_{est} = Square root of the mean square error in regression;
SE $_b$ = Standard error of slope;
n = sample size;
r = correlation coefficient;
r^2 = coefficient of determination;
$x^2 = (X_i - \bar{X})^2$
MEF = Mideye to Fork of tail
MEH = Mideye to Hypural plate
POH = Postorbit of eye to Hypural plate
SNF = Snout to Fork of tail
TOT = Total length; snout to tip of tail

[b] Based on the formula Y = bX + a, where b = slope of regression line and a = Y intercept of regression line.

[c] Sample source: District 115 gill net fishery, 7/28/88.

Table 6. Linear regression equations for converting between various length measurements (mm) of ocean-caught "brite" chum salmon in Southeast Alaska.

Length Conversion Data[a]				
Regression Equation[b]	n^c	r^2	SE Y_{est}	SE $_b$
MEH = 0.897(MEF) + 18.026	201	0.9648	7.499487	0.012143
MEF = 1.075(MEH) + 2.917	201	0.9648	8.210296	0.014554
POH = 0.892(MEF) + 11.792	201	0.9701	6.854927	0.011099
MEF = 1.088(POH) + 6.134	201	0.9701	7.570584	0.013538
SNF = 1.159(MEF) - 44.400	201	0.9577	10.658990	0.017259
MEF = 0.826(SNF) + 63.502	201	0.9577	9.001516	0.012308
TOT = 1.213(MEF) - 26.780	201	0.9321	14.334990	0.023211
MEF = 0.768(TOT) + 63.619	201	0.9321	11.406570	0.014696
POH = 0.987(MEH) - 2.081	201	0.9916	3.640007	0.006452
MEH = 1.005(POH) + 7.040	201	0.9916	3.671990	0.006566
SNF = 1.267(MEH) - 53.029	201	0.9546	11.041730	0.019573
MEH = 0.754(SNF) + 66.595	201	0.9546	8.517444	0.011646
TOT = 1.334(MEH) - 40.470	201	0.9403	13.448120	0.023839
MEH = 0.705(TOT) + 63.590	201	0.9403	9.774550	0.012593
SNF = 1.277(POH) - 46.621	201	0.9531	11.231590	0.020084
POH = 0.746(SNF) + 61.901	201	0.9531	8.588442	0.011743
TOT = 1.342(POH) - 32.322	201	0.9353	13.991880	0.025020
POH = 0.697(TOT) + 59.859	201	0.9353	10.081080	0.012988
TOT = 1.053(SNF) + 15.716	201	0.9840	6.950521	0.009504
SNF = 0.935(TOT) - 3.671	201	0.9840	6.549014	0.008437

	MEH	MEF	POH	SNF	TOT
Range	510-724	552-784	498-714	593-875	637-934
Average	586.9	634.1	577.3	690.4	742.6
Variance	1,591.2	1,907.1	1,563.6	2,674.1	3,012.0
Sum (x^2)	318,233	381,416	312,712	534,811	602,398

[a] Where: SE Y_{est} = Square root of the mean square error in regression;
SE $_b$ = Standard Error of the slope;
n = sample size;
r^2 = coefficient of determination;
$x^2 = (X_i - \bar{X})^2$
MEF = Mideye to Fork of tail;
MEH = Mideye to Hypural plate;
POH = Postorbit of eye to Hypural plate;
SNF = Snout to Fork of tail;
TOT = Total length; snout to tip of tail.

[b] Based on the formula Y = bX + a, where b = slope of regression line and a = Y intercept of regression line.

[c] Sample sources: District 101 and 106 gill net fisheries, 7/27/88.

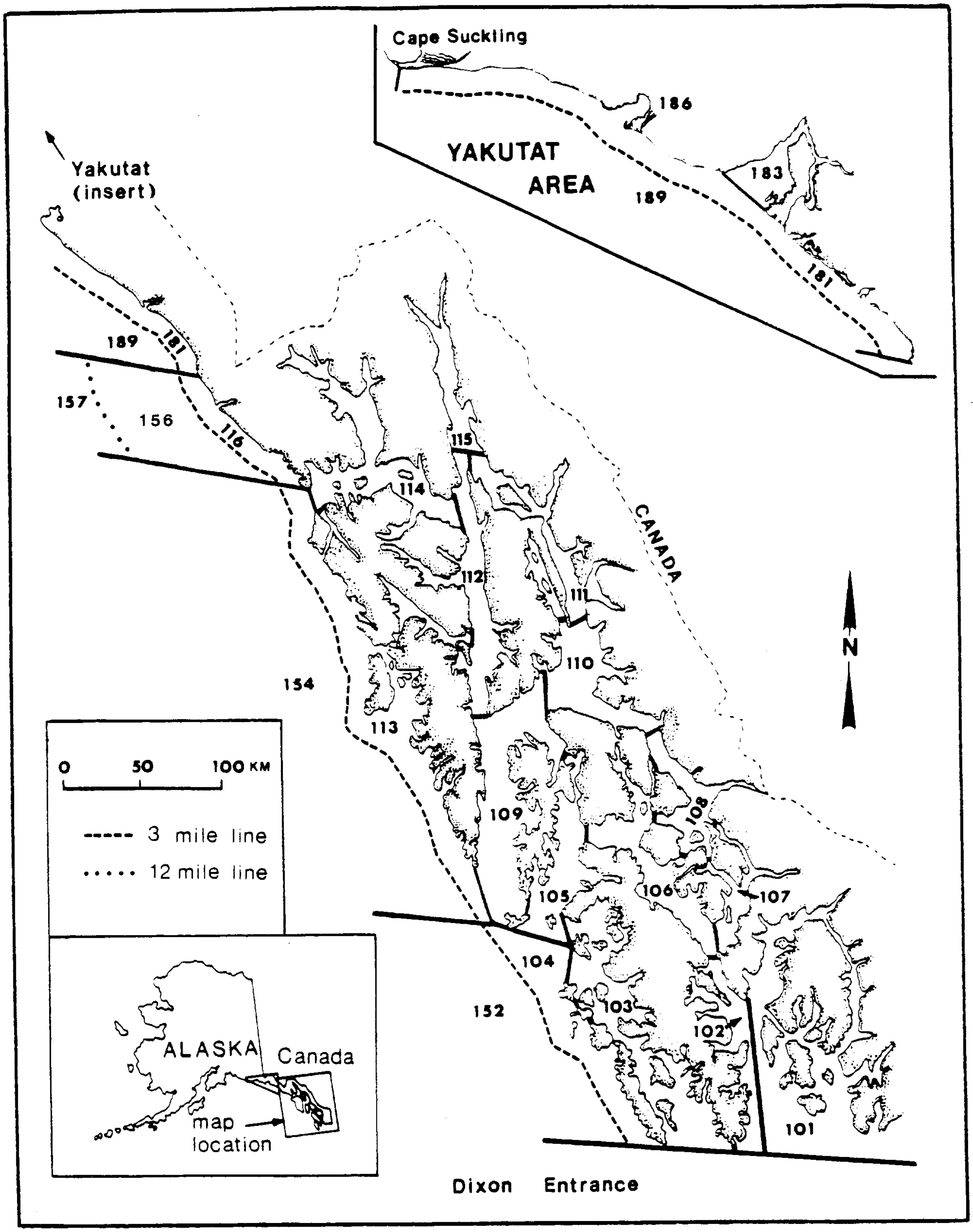

Figure 1. Map of Southeast Alaska showing the statistical fishing districts.