Weight and Girth of Yukon River Chinook Salmon *Oncorhynchus tshawytscha*

Final Report to the Yukon River Panel

For project titled: "Gillnet catch composition in lower and middle Yukon River fisheries." URE 07N-07

by

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Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

Table of Contents

Table of Contents……..……………………………………………………….…….1

Table of Figures…… ..…………………………………………………….......1

Abstract………………..…………………………………………………………….2

Introduction………..………………………….……………………………3

Methods……………………………………………………………………………3

Weight............…………………………………………………………...4

Girth………………………………………………………………………….4

Sampling Routine…………………………………………………………….4

Results and Discussion…………………………………………………………….5

Girth and Weight Relationships………………………………………………..6

Girth and Length Relationships……………………………………………...6

Length and Weight Relationships……..…………………………………………..6

Conclusions……………………………………………………………………..7

Literature Cited……………………………………………………………………7

Table of Figures

Figure 1. Regression of Chinook salmon girth and weight data…………………………8

Figure 2. Regression of Chinook salmon girth and length data………………………….9

Figure 3. Regression of Chinook salmon length and weight data………………………10

Abstract

Concern about possible changes in the age, sex, length, weight, and girth (ASLWG) composition of Yukon River Chinook salmon populations has grown in recent years. The goal of this project was to gain information about the weight and girth composition from set gillnets in the Big Eddy and Middle Mouth (BEMM) test fisheries located in the North, South, and Middle mouths near Emmonak and from fish wheels near Rampart Rapids (RRFW). Chinook salmon were sampled for paired age, sex, length, weight, and girth (ASLWG) data from June 3 to July 15, 2007 at BEMM sites and from June 20 to July 31, 2007 at the RRFW sites. A total of 718 fish collected using 8.5 inch mesh set nets at BEMM sites were sampled for ASLWG; 361 were female and 357 were male. At RRFW, a total of 809 fish were sampled for ASLWG; 199 were female and 610 were male. Regression analysis revealed a significant and similar power relationship for both the BEMM and RRFW sites girth-weight and length-weight relationships and a significant and similar linear relationship for girth-length relationships. These relationships were significant even though the BEMM and RRFW sites used different sampling gear and there were morphometric and demographic differences between the sites. The mean girth-weight-length of the RRFW samples were significantly less than those exhibited at BEMM. The differences may be due to variations in the morphological characteristics between stocks, differences in the demographic composition between stocks, weight or girth changes due to energetics of upstream migration, or size selective bias of or between the two gear types. Analysis of male girth-weight-length differences between sites was complicated by a higher proportion males, of which there were more ‘jacks’, sampled at the RRFW sites. Differences in girth-weight-length relationships between males and females and between upriver and downriver fish could have management implications since they could correlate to differences in gear selectivity. Gillnets are girth-selective, thus, if large-mesh gear is selecting for fish of large girth, then under conditions where the males have lower mean girth, this gear would tend to select disproportionately and the remaining population would have a higher proportion of small males.

Introduction

Concern about possible changes in the age, sex, length, weight, and girth (ASLWG) composition of Yukon River Chinook salmon populations has grown in recent years. One of the data needs that have been identified by several delegates to the US/Canada Yukon River Panel (Panel) is the weight and girth of Chinook salmon in the run. Data on the biological composition of the Chinook salmon run provide information about age, sex, and size trends and are important indicators of population health. Measurements of weight and girth are particularly important because these characteristics may be directly selected by harvest gear.

This project helps to fulfill the US/Canada treaty, the Yukon River Salmon Agreement, by supporting the collection of weight and girth data from Yukon River Chinook salmon sampled in the Lower Yukon Test Fishery (LYTF; river mile 20) and Rampart Rapids Fish Wheel fisheries (RRFW; river mile 731) (Figure 1). In the 2006 Budget Priorities Framework for the Restoration and Enhancement Fund, improving information on stock identification and biological composition of the run (age, sex, size) was identified as one of the highest priorities for the conservation of stocks and run assessment. The Joint Technical Committee (JTC) of the Panel also endorsed the collection of weight and girth data in their spring 2006 meetings. Weight and girth data represent significant information about the biological composition of Chinook salmon runs in the Yukon River.

The goal of this project is to gain information about catch composition from set gillnets in the Big Eddy and Middle Mouth test fisheries near Emmonak and from fish wheels near Rampart Rapids. In particular, we are interested in the weight and girth composition of Chinook salmon caught in these fisheries. This information will provide insight into the relative health of fish in the run and will contribute to the data resources for tracking weight and girth trends through time. Furthermore, these data are important for understanding the biological composition and quality of Chinook salmon runs in the Yukon River.

Methods

Chinook salmon collected during the daily catch at each site were sampled consistent with project protocols for paired age-sex-length-girth-weight (ASLWG) data. A maximum of 60 fish (maximum of 30 fish at each location in the Lower Yukon test fishery – Big Eddy and Middle Mouth) were sampled per day. There was no maximum for samples from Rampart Rapids; as many samples are collected as possible given the constraints of technician time and size of the daily catch. The data were collected by Yukon River Drainage Fisheries Association (YRDFA) locally hired technicians supervised by Alaska Department of Fish and Game (ADF&G) LYTF staff and Rapids Research Center local hire student technicians over the duration of the summer season.

Weight

Weight was collected as soon as feasible after harvesting and transporting fish to the sampling location. Fish were as fresh as possible, not bled, and not desiccated. Fish were relatively clean, without mud, sand, or debris adhering. Fish were weighed by suspending from the scale hook by the operculum (gill cover) and recording the weight to the nearest appropriate unit, e.g., ± 0.5 oz or ± 0.01 kg.

The scale was calibrated before the season and checked weekly throughout the season with known standard weights (commonly 15- and 25-lb) and adjusted accordingly if necessary (to ± 0.01 lbs). Weight checks and changes made to the adjusting mechanism were noted in the field logbook. The precision of the scale used was recorded. The scale was suspended above solid ground, using a tripod or other arrangement, so when the fish is suspended the tail is not touching the ground. The scale was handled carefully during transit and kept out of the weather, either covered or indoors, when not in use.

Girth

Girth was measured to the nearest millimeter using a Quick Medical™ girthometer, a specialized measuring tape with automatic retraction, or using a Dritz ¾-inch wide fiberglass tape measure. Girth was measured perpendicular to the longitudinal axis of the fish at a point just anterior and abutting the dorsal fin (Figure 2). The measuring device is wrapped taut around the fish and fully contacts the fish but is not tightened to the point of compressing the fish. In 2006, girth was measured when the fish was suspended from the scale hook and periodic rinsing of the girthometer was necessary for continued operation of the tape retraction mechanism. ADF&G had success using the Quick Medical™ girthometer and plans to continue using this product.

Sampling Routine

Each fishery sampling location developed similar routines. For example, fish are brought to the sampling location, moved from the boat and placed in sampling order. This order is kept throughout the sampling for each fish. Sampling supplies were prepared before sampling begins. For example, scale and girthometer was operating correctly, date and gear type recorded in log book, beginning fish number and scale card number in proper sequence, daily sample objective by gear type, and an adequate and clean area was available to lay out fish in sampling order. To increase efficiency, fish were placed in sampling order in groups of 10, and the sample routine followed in a stepwise manner: 1) weigh and 2) measure girth.

For projects that included additional data collection, the following sampling order was maintained: 3) remove scales, inspect for quality, and mount on gummed card, 4) measure length, and 5) cut fish and to visually identify sex organs. When fish were sampled for *Ichthyophonus*, an additional sample number is recorded and sexing is done by the *Ichthyophonus* sampling crew. Care was taken to collect all data with a consistent routine, keep fish in sampling order for all data (weight, girth, scales, length, sex, *Ichthyophonus*), and data was recorded neatly and legibly. Preprinted data sheets on Rite-in-Rain paper were used; an example is given in Figure 3.

Statistical analysis was performed to characterize weight and girth during the run and between sampling sites. Logistic regressions and Anovas were employed to examine trends between weight/girth and length and among the test fisheries. Appropriateness of the regression models were evaluated by conducting thorough residual analyses.

Results and Discussion

Chinook salmon were sampled for paired ASLWG data from June 3 to July 15, 2007 at BEMM sites in the lower Yukon River and from June 20 to July 31, 2007 at the RRFW sites near Rampart Rapids. A total of 718 fish collected using 8.5 inch mesh nets at BEMM sites were sampled for age, sex, length, weight, and girth; 361 were female and 357 were male. At RRFW, a total of 809 fish were sampled; 199 were female and 610 were male (Table 1.).

Table 1. Mean Chinook salmon girth, length, and weight sampled in the 2007 Lower Yukon Test Fisheries, Big Eddy and Middle Mouth (BEMM) and Rampart Rapids Fish Wheel (RRFW). Differences between groups are denoted by notation of same letter, ***very significant ($p < 0.001$), ** highly significant ($p < 0.01$), * significant ($p < 0.05$).

Site-metric	Mean	Std. Error	n
BEMM girth (mm) [a***]	507.65	2.17	717
RRFW girth (mm) [a***]	403.91	2.74	809
BEMM female girth (mm) [b***]	526.43	2.06	361
RRFW female girth (mm) [b***]	375.53	3.70	199
BEMM male girth (mm) [c***]	488.92	3.54	357
RRFW male girth (mm) [c***]	380.78	2.84	610
BEMM length (mm) [d***]	829.69	3.25	717
RRFW length (mm) [d***]	723.55	4.35	809
BEMM female length (mm) [e*]	858.27	2.62	361
RRFW female length (mm) [e*]	846.49	4.60	199
BEMM male length (mm) [f***]	801.19	5.55	357
RRFW male length (mm) [f***]	683.83	4.50	610
BEMM weight (lbs) [g***]	20.75	0.21	717
RRFW weight (lbs) [g***]	12.56	0.23	809
BEMM female weight (lbs) [h***]	22.57	0.22	361
RRFW female weight (lbs) [h***]	18.70	0.35	199
BEMM male weight (lbs) [i***]	18.94	0.34	357
RRFW male weight (lbs) [i***]	10.59	0.22	610

Girth-Weight Relationships

Regression analysis revealed a significant and similar power relationship for both the BEMM (R^2 = 0.9276) and RRFW sites (R^2 = 0.9746) girth and weight data (Figure 1). However, Anova revealed very significant differences of mean girths and mean weights between the sites (Table 1.). The mean girth of BEMM females was 151 mm larger (40 %) than RRFW female girth and BEMM males were 108 mm larger (28.3%) than RRFW males. This difference may be due to either variations in the morphological characteristics between stocks, weight or girth changes due to energetics of upstream migration, or selective bias between the two gear types. The fish sampled at the lower Yukon BEMM sites represent a "mixed bag" of fish stocks destined for tributaries throughout the Yukon drainage, whereas the fish sampled at RRFW are mostly representative of upper-river stocks. Gillnets are girth-selective, even though they are typically thought of as length-selective (Quang and Geiger, 2002), where fish collected by fish wheels do not have girth specific selective bias.

Girth-Length Relationships

There was a significant positive linear relationship between girth and length for both BEMM (R^2 = 0.8326) and RRFW (R^2 = 0.9259) (Figure 2). The linear equations for BEMM and RRFW had similar slope, however, the intercepts differed significantly. When comparing the girth-length relationships at each location, the data show that BEMM fish have greater girth than RRFW over all observable lengths. The mean length of BEMM females was only 12 mm longer (1.4 %) than RRFW females, however, BEMM males were 117.4 mm longer (17.2%) than RRFW males (Table 1.). The difference in male lengths may indicate that more 'jacks' were sampled at the RRFW sites. This is supported in part by the proportion of males sampled at RRFW (75.4%) being much higher than BEMM males (49.8%).

Length-Weight Relationships

Regression analysis also revealed a significant and similar power relationship for both the BEMM (R^2 = 0.9406) and RRFW sites (R^2 = 0.9645) length and weight data (Figure 3). At a given length, BEMM fish weigh more than RRFW fish over all observable lengths. The mean weight of BEMM females was 3.87 pounds more (20.7%) than RRFW females, however, BEMM males were 8.35 pounds more (78.8%) than RRFW males (Table 1). These results are not surprising since salmon tend to lose weight during upstream migration (Groot et al. 1995), but it may also be an indication that upper-river fish are more streamlined in an effort to facilitate somatic energy conservation (Crossin et al. 2004). When compared to the large weight difference exhibited by RRFW males and BEMM males the smaller RRFW female mean weight difference compared with BEMM females may due to energetic weight losses being compensated by increased reproductive weight due to egg maturation during the migration (Kinnison et al. 2001). Again, analysis is complicated by large difference in male mean weights that may be due to more 'jacks' sampled at the RRFW sites.

The length-weight relationships for BEMM and RRFW give some insight into the size correspondence between upriver and downriver fish. However, applying these relationships to historical data should be done with caution as they are based on data from only one year.

Differences in the length-girth relationships between males and females and between upriver and downriver fish have management implications since they could correlate to differences in gear selectivity. Gillnets are girth-selective, even though they are typically thought of as length-selective. If large-mesh gear is selecting for fish of large girth, then under conditions where the females have greater girth than males, this gear would tend to select disproportionately fewer males. However, this problem may be counteracted if the girth of females commonly exceeds the maximum girth retained by the gear.

CONCLUSIONS

The sample sizes achieved from the BEMM and RRFW test fisheries were adequate to produce significant girth-weight, girth-length and length-weight relationships. For future morphometric studies, it is recommended that a power analysis be conducted to estimate the sample sizes of girth and weight measurements needed to produce significant relationships. Reducing the sample size could greatly enhance the efficiency of the sampling process at some sites.

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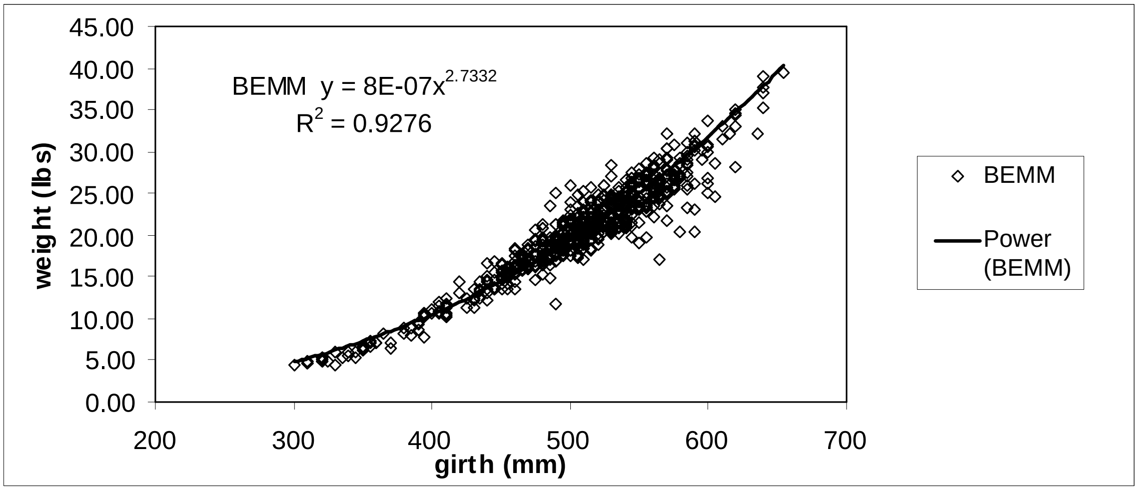

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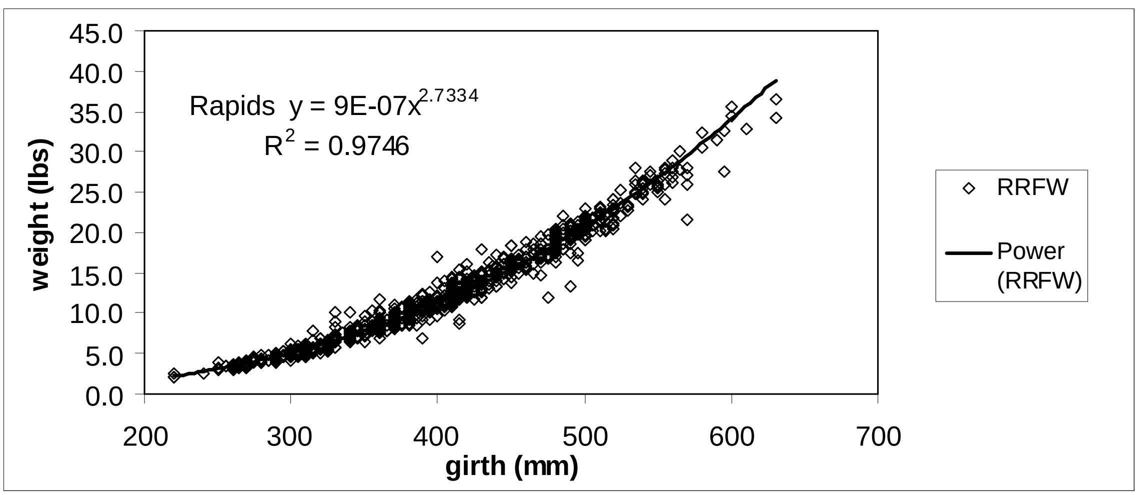
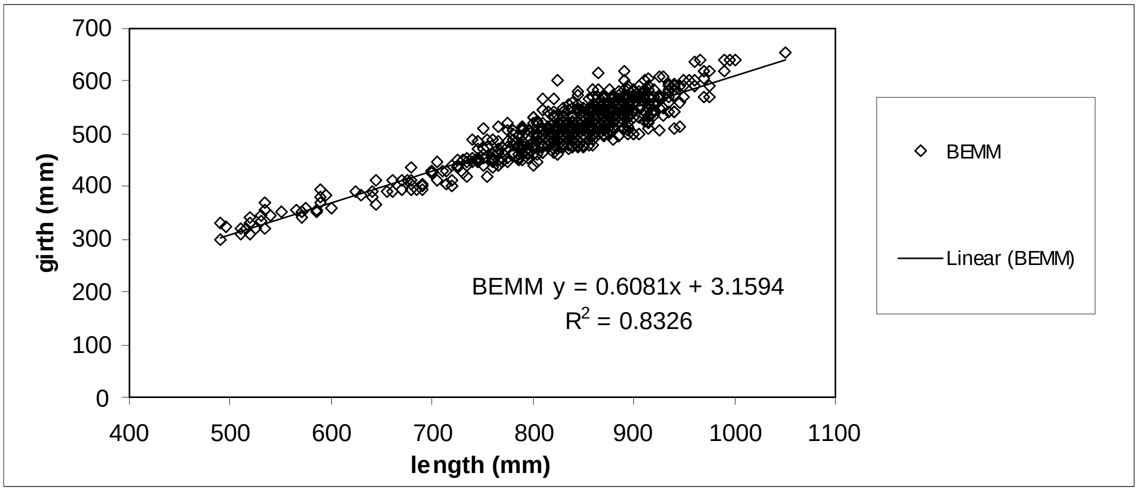


(b)

Figure 1. Regression of Chinook salmon girth and weight data collected during the 2007 test fisheries at Big Eddy and Middle Mouth (BEMM) sites (a) in the lower Yukon River and at Rampart Rapids fish wheels (RRFW) (b), middle Yukon River.



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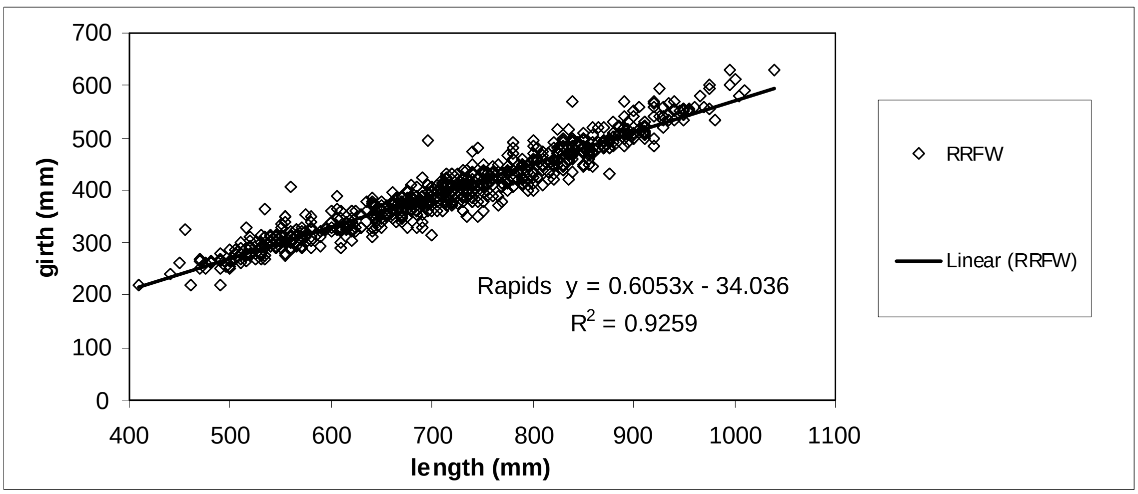
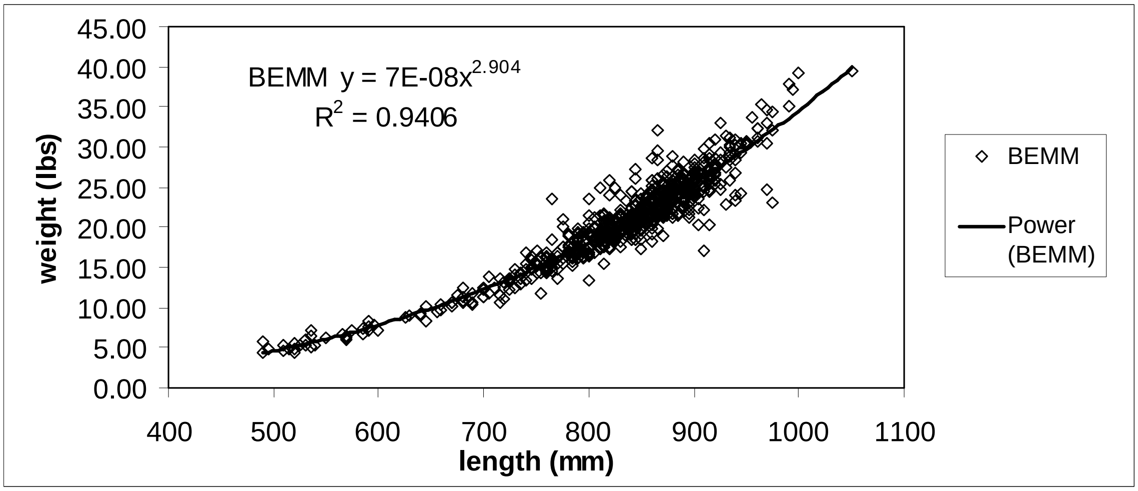
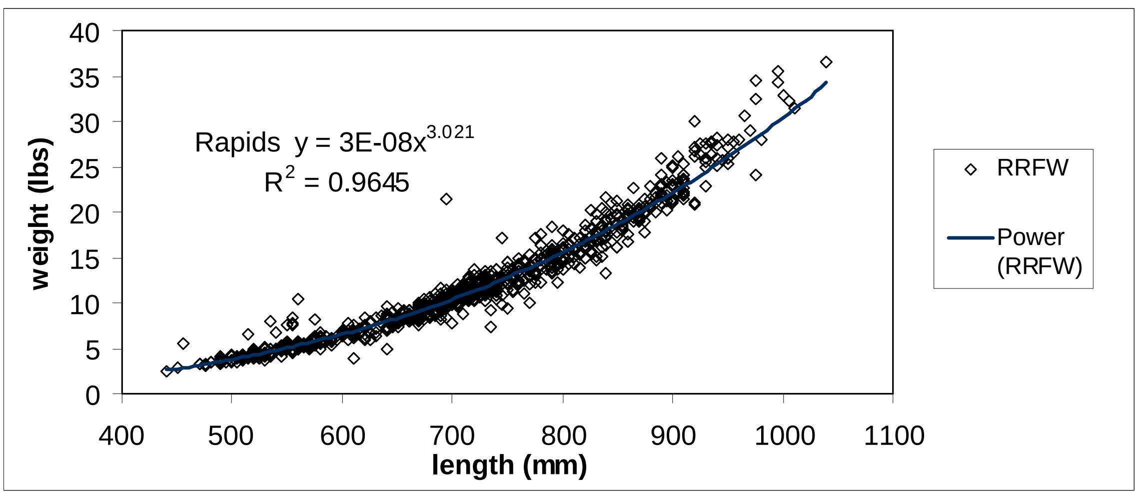


(b)

Figure 2. Regression of Chinook salmon girth and length data collected during the 2007 test fisheries at Big Eddy and Middle Mouth (BEMM) sites (a) in the lower Yukon River and at Rampart Rapids fish wheels (RRFW) (b), middle Yukon River.



(a)



(b)

Figure 3. Regression of Chinook salmon weight and length data collected during the 2007 test fisheries at Big Eddy and Middle Mouth (BEMM) sites (a) in the lower Yukon River and at Rampart Rapids fish wheels (RRFW) (b), middle Yukon River.