Fishery Data Series No. 10-92

Yukon River Chinook Salmon Comparative Mesh Size Study

by

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and

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December 2010

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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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)

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

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This document should be cited as:
Howard, K. G., and D. F. Evenson. 2010. Yukon River Chinook salmon comparative mesh size study. Alaska Department of Fish and Game, Fishery Data Series No. 10-92, Anchorage.

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ABSTRACT

Gillnet mesh size in the Yukon River Chinook salmon fishery has been unrestricted, leading many to believe that the fishery is size selective. The presented study used a test fishery in Yukon River District 1 near Emmonak to investigate catch composition of 7, 7.5, and 8-inch stretch-mesh drift gillnets. Age, sex, length, weight and girth (ASLWG) characteristics of Chinook salmon, and the species composition of the catch were examined. Comparisons among mesh sizes and with temporally congruent data from Lower Yukon River commercial and other test fisheries are included. Overall patterns indicate that larger mesh sizes catch a greater proportion of older fish, more Chinook relative to chum salmon, a greater proportion of females, and more larger fish with respect to length, weight and girth. This study provides important insight for management strategies and regulations concerning mesh size for Yukon River fisheries, as well as improves our understanding of potential effects of size-selective fishing.

Keywords: Yukon River, Chinook salmon, chum salmon, age, sex, length, girth, gillnet, mesh size, selective fishing.

INTRODUCTION

The Yukon River salmon fishery is extraordinarily complex. The mainstem river spans approximately 2,000 miles and, along with its tributaries, is the fourth largest drainage basin in North America. Subsistence, commercial and sport fisheries occur throughout the drainage. Due to the size of the river and dispersed fishing activity, the Yukon salmon fishery is considered a gauntlet fishery. Adding to this complexity, multiple species comigrate.

The summer season salmon gillnet fishery currently operates under unrestricted (no mesh size limits) and restricted statuses, depending on the target species, for both commercial and subsistence users. The subsistence salmon fishery is normally unrestricted. The commercial unrestricted gillnet fishery targets Chinook salmon in the Lower Yukon (an area ranging from the Yukon River delta to approximately 301 miles upstream, near the village of Holy Cross), though commercial fishing occurs upriver as well (Hayes et al. 2008). Additionally, in years of poor chum abundance, a >8-inch restricted mesh size may be implemented to target Chinook salmon while limiting chum salmon harvest. Typically, however, the restricted mesh size fishery refers to ≤6-inch stretch mesh, which targets summer chum salmon. Upriver gear types in the commercial and subsistence fisheries are variable and do include gillnets, but fish wheels are also commonly employed (Hayes et al. 2008).

In recent years, concerns have arisen about possible changes in the age, sex, length, weight, and girth (ASLWG) composition of Yukon River Chinook salmon *Oncorhynchus tshawytscha* populations. Many fishermen along the Yukon River have reported decreased size of Chinook salmon (JTC 2006). Limited empirical data support these assertions, although the cause is unknown (Hyer and Schluesner 2005; JTC 2006; Bigler et al. 1996; Hamazaki *In prep*). Such reductions in size may be attributable to changes in the ocean environment that limit oceanic salmon growth and productivity (Bigler et al. 1996) and/or selective fishing practices that preferentially target larger and older individuals (Hankin and Healey 1986; Hard et al. 2008), as well as other sources.

Net selectivity models based on Yukon River Chinook salmon data demonstrate that larger and older fish may be preferentially removed from the population by large mesh gillnets (Bromaghin 2005). Since various life history characteristics, such as age of maturation or length-at-age, are heritable traits in Chinook salmon (Hankin et al. 1993; Hard et al. 2008), this type of selectivity could potentially have evolutionary implications and increase the probability of population decline (Hankin and Healey 1986; Hard et al. 2008; Bromaghin et al. 2008).

The use of smaller mesh size, however, would likely increase the harvest of summer chum salmon, for which there is currently a more limited commercial market and little subsistence use in upriver communities, increasing the potential for wastage. Average chum to Chinook salmon commercial harvest ratios have been nearly 9 times higher in the restricted mesh size openings than in the unrestricted mesh size openings (44:1 in restricted openings and 5:1 in unrestricted openings (Hayes et al. 2006)). Increased "drop-outs" of Chinook salmon is also a concern expressed by fishermen in response to reduced mesh size. Drop-outs could occur where larger-sized fish are caught but not adequately entangled in the net, and drop out of the net upon net retrieval. Some of these drop-out individuals could be killed or mortally injured. Drop-outs may result in increased fish mortality, but this is extremely difficult to quantify and no studies that we are aware of have been able to directly link smaller mesh sizes to increased mortality of larger-bodied fish (JCTC 1997).

It is unlikely that a definitive causal relationship between selective fishing practices, oceanic conditions, or other factors and Chinook salmon size will be ascertained in the near future, especially given the complex life histories of these fish and the environments they inhabit. Recently, proposals have come before the State of Alaska Board of Fisheries and the Federal Subsistence Board to restrict gillnet mesh size in Chinook salmon-directed fisheries, with the primary contention being that the apparent diminution of these fish is attributable to selective fishing practices. For a more thorough review of the Chinook salmon size issue and management options to address this issue, see Howard et al. 2009.

Data are needed to address the effects of mesh size changes on gillnet catch composition. While data exist for various mesh sizes from the test fishery associated with the Pilot Station sonar project, fishermen typically hang nets differently and fish nets for longer durations (D. Bergstrom, Commercial Fisheries Biologist, ADF&G, personal communication). Thus, catch composition from Pilot Station sonar test fishery is not directly transferable to expected catch composition in commercial and subsistence fisheries. Information on species, age, gender, and phenotypic compositions of catches from various mesh sizes, comparable to fishing methods employed by commercial and subsistence users on the Yukon River, is necessary to inform regulatory decisions on mesh size.

This project, a cooperative effort between the Alaska Department of Fish and Game (ADF&G) and Yukon Delta Fisheries Development Association (YDFDA), is not intended to explore causal relationships between large mesh gillnets and Chinook salmon size, but rather to investigate the performance of gillnets with smaller mesh than those currently used in the unrestricted fishery. Hereafter referred to as the Mesh Size Study, this project attempts to fill data gaps for species, age, gender and phenotypic compositions of catches from three mesh sizes. Catch composition is investigated for 7, 7.5, and 8-inch stretch-mesh drift gillnets from a test fishery in the Lower Yukon River, near Emmonak. In particular, the effects of mesh size on the ASLWG of Chinook salmon caught and the number of incidentally caught non-target species, such as summer chum salmon, are explored. This information may provide insight into ways to implement management strategies and regulations to sustain Yukon River Chinook salmon while continuing to maintain subsistence and commercial fisheries.

OBJECTIVES

1. Compare species composition (Chinook salmon vs. chum salmon) of catch in 7, 7.5 and 8-inch mesh size gillnets.
2. Compare age composition of Chinook salmon in 7, 7.5 and 8-inch mesh size gillnets.
3. Compare sex ratios of Chinook salmon in 7, 7.5 and 8-inch mesh size gillnets.
4. Compare phenotypic composition of Chinook salmon (length, weight, and girth) caught by 7, 7.5 and 8-inch mesh size gillnets.

METHODS

MESH SIZE STUDY TEST FISHERY

For the 2007 through 2009 seasons, ADF&G worked with YDFDA to select 4 fishermen each year in District 1 (Y-1) to operate a test fishery using 3 different mesh sizes: 7, 7.5, and 8-inch stretched mesh. Fishermen chosen to collaborate on the study were given 3 gillnets, a stipend for their time, boat fuel, and a technician to assist them. The test fishery occurred in 2 sites in Big Eddy that are heavily used during the commercial fishery (Figure 1). Fishing was restricted to days when no Y-1 commercial fishery occurred.

The test fishery operated twice daily, with each of the selected fishermen participating during one shift per day. To reduce variability in location and fishing times, fishermen rotated between sites and shifts. During each fishing event, fishermen fished all 3 nets, 1 of each mesh size. Drift duration of each net was approximately 30 minutes, and a mandatory 20-minute break occurred between drifts. The following formula was used to determine drifting time:

$$T = ([(\text{set time} + \text{retrieval time})/2] + \text{soak time})$$

The order in which nets were fished changed daily to control for confounding factors associated with the removal of fish from certain mesh sizes. For example, fisherman ‘A’ may fish in the morning of day 1, at site 1, with first a 7, followed by a 7.5, and then by an 8-inch mesh size and the next day may be fishing in the evening at site 1, with first a 7.5, followed by an 8, and then by a 7-inch mesh size net. Nets used for drifting were 50 fathoms long, 45 meshes deep, and 7.0, 7.5, or 8.0-inch stretched mesh. All nets were marked at the 25-fathom cork.

After the final drift, the crew returned to the ADF&G dock in Emmonak to sample the catch for age, sex, length, weight and girth. The catch per unit of effort (CPUE) was calculated using fish per 100 fathom-hours:

$$\text{CPUE} = [((100 \text{ fathom} * 60 \text{ minutes}) * (n))/(L*T)]$$

where:

n= number of fish caught, L= length of net in fathoms, T= the time the net fished.

One locally hired technician travelled on each boat during the test fishery to assist the fishermen and record data. The total number of fish caught by species and any observed drop-outs were recorded along with time and auxiliary observations for each drift. Technicians tagged all

Chinook salmon with Floy[1] tags, with one color corresponding to each mesh size and site (6 colors, 2 sites and 3 mesh sizes). Upon return to the Emmonak dock, technicians conducted ASLWG sampling.

A cumulative sample size of 400 Chinook salmon per mesh size was targeted. The timing of the sampling period was relatively consistent among years in relation to the overall Chinook salmon run timing for that year.

ASLWG SAMPLING

Age, sex, length, weight and girth were collected and recorded using protocol established and standardized by ADF&G staff for Yukon River salmon sampling (see Horne-Brine et al. 2009 for details). All sampling occurred immediately upon the fisherman's return to the ADF&G dock. Fish were placed in sampling order by mesh size using the colored Floy tags for reference. This order was kept throughout sampling.

Scales were removed from the preferred area, on the left side of the fish and approximately two rows above the lateral line along a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Horne-Brine et al. 2009). If no scales were present in that area, they were removed from the same area on the right side of the fish, or if necessary, from any location where scales remained other than along the lateral line. Three scales were taken from each fish and mounted on gum cards. Information was recorded on data sheets and indexed to the scale cards by date and fish number. Age was determined by interpreting annuli patterns from fish scales pressed in clear acetate and viewed with a microfiche reader (Bales 2007).

Sex was determined by internal examination. Length was measured to the nearest 5 mm from mid-eye to fork of the tail using a Dritz ¾-inch wide fiberglass tape measure.

Clean fish (free of mud, sand or other debris) were weighed on a suspension scale and weight was recorded to the nearest ounce. The scale was calibrated before the season and checked throughout the study with known standard weights, and adjusted accordingly if necessary. The scale was suspended, using a tripod, so fish hung freely. Two weighing scales were available for use in this study, the 773-H Chatillon Hanging Warehouse Scale and the 4260-X-H Chatillon Hanging Scale. Accuracy specifications listed for the 4260-X-H model are: 0-3 lbs ± 0.5oz, 4-12 lbs ± 1.0oz, 13-25 lbs ± 1.5oz, and 26-60 lbs ± 2.5oz.

Girth was measured to the nearest millimeter using a Quick Medical™ girthometer, a specialized measuring tape with automatic retraction used to measure girth around an infant's head. Girth was measured perpendicular to the longitudinal axis of the fish at a point just anterior and abutting the dorsal fin (Horne-Brine et al. 2009). The measuring device was wrapped taut around the fish, but without compressing the fish. Girth was measured with the fish suspended from the scale hook.

All Chinook salmon were visually inspected for a missing adipose fin; an external marking for fish implanted with coded wire tags (CWT). Heads of CWT fish were collected from adipose clipped fish and were shipped to the Juneau tag lab, along with associated information, for coded wire tag analysis.

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[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

COMPLEMENTARY DATASETS

To place the Mesh Size Study into a broader context, results are displayed along with similarly sampled data from District Y-1 restricted and unrestricted commercial fisheries, as well as the Lower Yukon Test Fishery (8.5-inch set gillnet) in Emmonak. For commercial fisheries, CPUE and species composition ratios are not collected in a manner consistent with the Mesh Size Study protocols, which would make for incompatible comparisons, and, therefore, are not included. It should be noted that commercial fishery data do not include individual weight or girth information, and gender designation is established using external characteristics instead of gonadal examination. Additionally, only a subset of the test fishery data includes weight and girth data (See Table 1 for sample sizes). ASLWG sampling in complementary datasets was conducted using the same protocols adopted by the present study and is therefore comparable.

Unrestricted commercial catch and Lower Yukon Test Fishery catch are grouped in analyses and presented as 8.5-inch mesh. Both of these sources employ similar nets (typically 8.5-inch stretch mesh, 50 fathoms long), and are representative of typical fishing practices in the Lower Yukon. The unrestricted commercial fishery may use drift or set gillnets, but drifting occurs most often. The restricted commercial fishery is a chum salmon-directed fishery, and used here to provide context relative to small mesh size gear. Nets in this fishery are typically 5.5-inch stretch mesh, 50 fathoms long and 50 mesh deep. Data from this source are presented hereafter as 5.5-inch mesh. Due to poor Chinook salmon runs for the years of this study, commercial fisheries were severely restricted and, consequently, these data are limited, particularly for 2008 and 2009 (Table 1).

Analyses of mesh size-specific data from the Pilot Station test fishery are presented in the Appendix A. While data from this source are not ideal for mesh size selectivity comparisons relevant to the District Y-1 commercial fishery, this test fishery provides important information on net selectivity in general, as well as further context for the Mesh Size Study, and are presented with cursory comparisons to the Mesh Size Study. Further description of the Pilot Station test fishery is provided in the Appendix A.

To accommodate for variation in run composition and relative species abundances within and between seasons, only those data from complementary datasets collected at times corresponding to the Mesh Size Study are evaluated. For instance, 2007 Mesh Size Study sampling occurred from June 15 to June 30. There is approximately a 3-day travel time for Chinook salmon between Emmonak and the Pilot Station test fishery. Therefore, only those data from the Pilot Station between June 18 and July 3, 2007 are included in the analyses. Similar considerations are used for all datasets analyzed.

DATA ANALYSIS

Chi-square tests are used to examine differences in gender and age proportions among various mesh sizes. Analysis of Variance (ANOVA) tests are used to examine differences in Chinook/chum salmon ratios, lengths, weights, and girths among various mesh sizes. Tukey's method is employed to obtain pairwise differences between mesh size means, with a family error rate of 0.05. For data that do not meet the assumptions necessary for ANOVA, non-parametric Kruskal-Wallis tests are performed with multiple pairwise comparisons. Significant confidence intervals for all non-parametric tests are controlled at a family error rate of 0.2. F-statistics and p-values are presented for ANOVA calculations, and H-statistics and p-values are presented for Kruskal-Wallis tests. To account for variation in sample sizes among years, and possible bias due to interannual variation in run composition and relative abundance of Chinook and chum salmon, years are pooled for all datasets. Pooling also ensures robust sample sizes for statistical tests.

RESULTS

Sampling for this study occurred from June 15 through June 30 in 2007, June 15 through June 20 in 2008, and June 12 through July 4 in 2009. The sampling period for 2008 was truncated because of an unexpected poor run and need to support inseason management strategies. Sample sizes are shown in Table 2. Actual sample sizes are less than those targeted, primarily because of the shortened sampling period in 2008. However, overall sample sizes are still sufficient for statistical assessment.

CATCH COMPOSITION

After removing fishing events with null data points (i.e. no fish caught due to poor run strength at the time of the fishing event rather than due to mesh size selectivity), there is no evidence to support significant differences in CPUE among the mesh sizes used in this study (KW-test, H=1.23, p=0.541, n=54 for each mesh; Figure 2). However, significant differences are found in the catch composition. On average, approximately 40% of the catches using 7.0-inch mesh gear are Chinook salmon, whereas the larger mesh sizes average approximately 60% Chinook salmon. The Chinook-to-chum ratio is significantly different between the 7.0-inch and larger size mesh gear (KW-test, H=18.31, p<0.001; Figure 3).

ASLWG COMPOSITION

A higher percentage of older fish (age-6 and -7) were caught in larger mesh size nets (χ^2=23.861, p=0.001; Figure 4). Age-6 fish represent 61%, 65%, and 75% of the Chinook salmon catch for 7, 7.5, and 8-inch meshes, respectively. When including the complementary datasets, age composition remains significant (χ^2=696.795, p<0.001), and reinforces the pattern observed in the Mesh Size Study, with 41% and 79% age-6 Chinook salmon in 5.5 and 8.5-inch mesh nets respectively.

There is not a significant relationship between the percentage of females in the catch and mesh size used (χ^2=5.095, p=0.078). However, when including 5.5 and 8.5-inch mesh net data, thereby broadening the range of mesh sizes considered, gender is a significant factor (χ^2=91.456, p<0.001; Figure 5). The 5.5-inch mesh size is likely driving the significance of these results. Females make up approximately 33%, 44%, 47%, 52%, and 53% of the catch for smallest to largest mesh nets, respectively.

Chinook salmon length is significantly different between the 8-inch mesh and the smaller mesh nets in the Mesh Size Study (F=11.46, p<0.0001; Figure 6). Average Chinook salmon length for the 7, 7.5, and 8-inch meshes are 781, 793, and 811 mm, respectively. Addition of the complementary datasets reinforces this pattern (F=271.5, p<0.0001). Average Chinook salmon length for 5.5 and 8.5-inch meshes are 708 and 833 mm, respectively. For the time period sampled, the percentage of large size class fish (>900 mm) within the Chinook salmon catch was 4.17%, 6.03%, 5.80%, 7%, and 15.7% for smallest to largest mesh sizes, respectively (Figure 7).

Chinook salmon weight shows significant differences among each mesh size, with average weight increasing with increased mesh size among Mesh Size Study meshes (F=14.58, p<0.001; Figure 8). Average weights are approximately 17, 18, and 19.2 lbs for 7, 7.5 and 8-inch meshes, respectively. Again, addition of the complementary data strengthens this pattern (F=34.89, p<0.001). Average weight for 8.5-inch mesh size is 20.2 lbs.

Girth is also significantly related with mesh size: fish caught in 8-inch mesh exhibit larger girths than the smaller mesh sizes (F=15.31, p<0.001). Average girths of Chinook salmon from the 7, 7.5 and 8-inch meshes are 475, 482, and 497 mm, respectively. When compared to data from 8.5-inch mesh nets, 8-inch mesh nets show similar results, and both of these larger mesh nets are significantly different from the smaller meshed nets (F=33.65, p<0.001; Figure 9).

DISCUSSION

While the cause of apparent changes in Yukon River Chinook salmon are beyond the scope of this study, the Mesh Size Study does provide important information for guiding management decisions should mesh size restrictions be deemed necessary. Among those meshes employed in this study, there was no evidence indicating that Chinook salmon CPUE is affected by mesh size. However, this study was conducted during low run years when many of the drifts yielded no Chinook salmon, and differences in CPUE related to mesh size are apparent from the Pilot Station test fishery (Jeffrey Bromaghin, Research Statistician, USGS, Anchorage, AK, personal communication). Species (Chinook vs. chum salmon), age, and phenotypic (length, weight, girth) compositions, however, are demonstrably different among mesh sizes investigated. Overall patterns incorporating all datasets indicate that as mesh size increases, the catch contains more Chinook relative to chum salmon, a greater proportion of older fish, a greater proportion of females, and more larger fish in respect to length, weight and girth.

In a Chinook salmon-directed fishery, it is obviously important that any mesh size used would effectively catch Chinook salmon while minimizing incidental catch of other species. While the other two mesh sizes were equally competent, the 7-inch mesh size did not catch more Chinook salmon than chum salmon. As such, restrictions to 7-inch or smaller mesh size would not minimize non-target species (see Chinook-to-chum salmon ratios).

Chinook-to-chum salmon ratios from the complementary 8.5-inch mesh datasets are not directly comparable with the 7, 7.5 or 8-inch mesh nets. A Chinook-to-chum ratio of 1.54 from the unrestricted fishery is available for 2007; by estimating the number of Chinook and of chum salmon sold during unrestricted commercial openings throughout the period of the Mesh Size Study. Chinook-to-chum ratios from 2007 for the mesh size study nets are 0.48, 1.13, and 0.77 for 7, 7.5 or 8-inch mesh nets, respectively. Qualitatively, Mesh Size Study nets do not seem to target Chinook salmon as efficiently as the current unrestricted commercial fishery. However only one year of commercial harvest is represented, few fishing events occurred in the commercial fishery during the period investigated, and these data are combined with the Lower Yukon Test Fishery data for analyses. This comparison should be treated with caution as catch from commercial fishing may be kept for subsistence use, and commercial fishermen likely fish differently than those operating a test fishery that are constrained by scientific protocol. Additionally, since chum salmon are less profitable than Chinook salmon, it may be more likely that chum salmon would be retained for subsistence use, thereby inflating the Chinook-to-chum ratio.

In addition to species selectivity, mesh size restrictions should consider the component of the populations being targeted. Since the concern on the Yukon River is an apparent reduction in the number of larger and older individuals returning to spawn, protection of these fish may be needed to aid in population stability. In analyses involving additional datasets (8.5 and 5.5-inch mesh catches from commercial and test fisheries), age, gender and girth compositions of 8-inch mesh catch are similar to the 8.5-inch mesh catch. Hence, a reduction to 8-inch mesh size would not likely protect older or girthier individuals of either sex. Even though the 7.5-inch mesh performs comparably to the 8-inch mesh in terms of catchability of Chinook salmon (species composition and CPUE), the age and phenotypic characteristics of the catch are more similar to the 7-inch mesh. As such, the 7.5-inch mesh net performs similarly to the 8-inch mesh net for targeting Chinook salmon, but the average fish caught in the 7.5-inch mesh net is relatively younger and smaller.

Evidence that Yukon River Chinook salmon have undergone phenotypic alteration over time is limited but suggestive. Hyer and Schleusner (2005) documented a temporal decline in the proportion of large (>900 mm) Chinook salmon in escapements at several Yukon River tributaries, in 4 of 7 time series. Additional studies documented declines in the weight of commercial harvests over time (Bigler et al. 1996), a decline in the proportion of age-7 fish in the commercial harvest (Hamazaki *In prep*), and the near disappearance of age-8 fish (JTC 1998). Data from the Mesh Size Study indicate that mesh size restrictions of 8-inches or less could reduce the harvest of large (>900mm) Chinook salmon, which currently account for approximately 15% of the catch, by more than half (Figure 7). Regardless of the cause of this decline, protection of these individuals may help to prevent total loss of this size class, and the genetic component it represents, from Yukon River Chinook salmon populations.

In summary, even though comparisons with the current unrestricted mesh size fishery are limited, the Mesh Size Study does provide insight into the nature of the catch should a mesh size limit be enacted. This study suggests that a reduction to 7-inch mesh would likely change the species composition (fewer Chinook salmon compared to other species in the catch), and age and phenotypic compositions (smaller and younger individuals) of the fishery. A reduction to 8-inch mesh would not significantly change the age, gender or phenotypic composition of the catch relative to the current fishing practices, but would decrease the proportion of large size class Chinook salmon caught. A reduction to 7.5-inch mesh, however, would likely target younger and smaller individuals on average and even fewer large size class Chinook salmon, without impairing the Chinook salmon catchability beyond what it would be for an 8-inch maximum mesh size fishery.

ACKNOWLEDGEMENTS

We would like to extend our appreciation to the Yukon Delta Fisheries Development Association (YDFDA) for generously funding this project, and providing technical support and expertise. In particular, we would like to thank Jack Schultheis and Ragnar Alstrom of Kwik'pak Fisheries for their substantial contributions to ensuring this project was well supported and viable. We wish to express our gratitude to the large number of individuals whose assistance was instrumental in its success. Sampling in the vicinity of Emmonak, Alaska was conducted by Alaska Department of Fish and Game staff Maureen Horne-Brine and Dan Warnke, and YDFDA technicians Simeon Uisok, Brandon Kameroff, Evan Charles, Darin Hooch, Tracy Horn, Jerome Williams, and Isaiah Charles. Larry DuBois was the lead stock biologist on this project and oversaw all biological sampling, compiled raw data and assisted with preliminary analyses. Mick Leach was the crew leader and oversaw all test fishery operations. Dedicated fishermen, Robert Alstrom, Lorraine Murphy, Edward Andrews, David Tucker, Solomon Afcan, Jacob Damian, Billy Charles, Richard Agayer, Aaron Kameroff and Nicholas Uisok made this project possible. Finally, we would like to thank everyone who reviewed this work and provided critical insight and feedback, including Toshihide Hamazaki, Steve Hayes, Dan Bergstrom, Carl Pfisterer, and Jeff Bromaghin.

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TABLES AND FIGURES

Table 1.–Sample sizes by year for complementary datasets used in direct analyses with the Mesh Size Study.

	Unrestricted Commercial (~8.5-inch)					Lower Yukon Test Fishery (8.5-inch)					Restricted Commercial (~5.5-inch)				
	Age	Sex	Length	Weight	Girth	Age	Sex	Length	Weight	Girth	Age	Sex	Length	Weight	Girth
2007	1183	1200	1200		N/A	640	676	675	496	676	602	623	623		N/A
2008	No Unrestricted Commercial Openings					306	320	320	320	320	No Openings During Sampling Period				
2009[a]	No Unrestricted Commercial Openings					821	840	840	108	108	No Openings During Sampling Period				
Total	1183	1200	1200	N/A		1767	1836	1835	924	1104	602	623	623	N/A	

[a] Sale of incidentally caught Chinook salmon from the chum-directed fishery was prohibited throughout most of the 2009 run and sampling from this fishery was, therefore, extremely limited.

Table 2.–Mesh Size Study sample sizes for Chinook and chum salmon from 2007 to 2009.

Total Chinook salmon caught by mesh size				Total chum salmon caught by mesh size			
	7	7.5	8		7	7.5	8
2007	151	183	132	2007	312	162	171
2008	70	66	58	2008	150	59	45
2009	179	139	154	2009	252	104	82
Total	400	388	344	Total	714	325	298

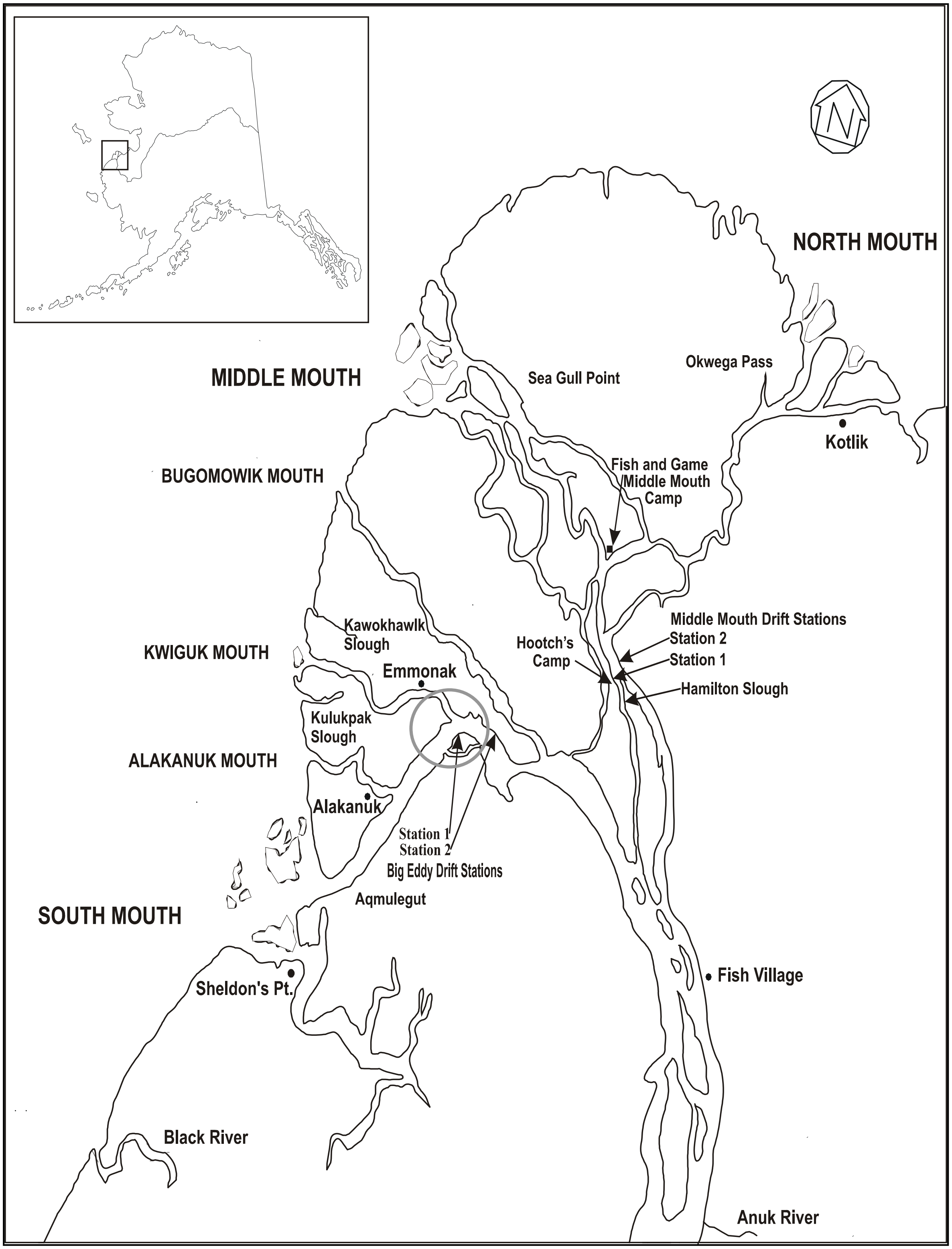

Figure 1.–Location of Mesh Size Study sampling sites in Big Eddy near Emmonak, Yukon River Delta, Alaska.

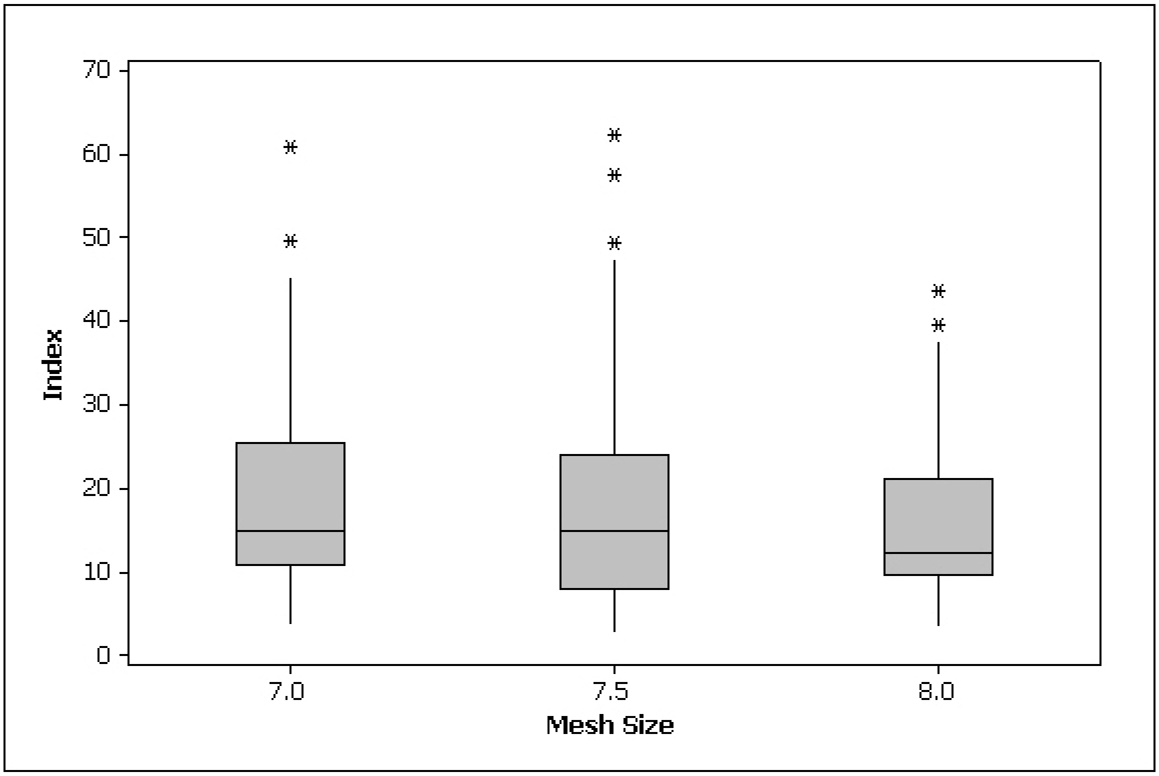

Figure 2.–Chinook salmon CPUE by mesh size.

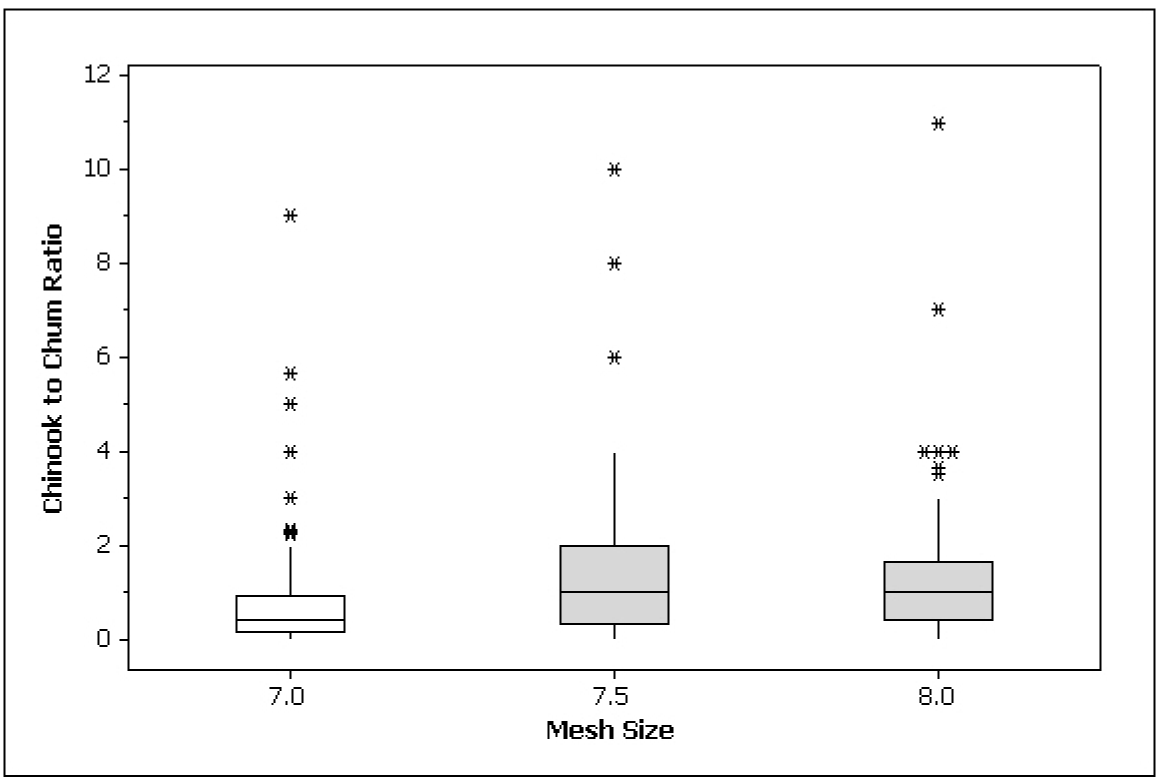

Figure 3.–Chinook-to-chum salmon ratio by mesh size.

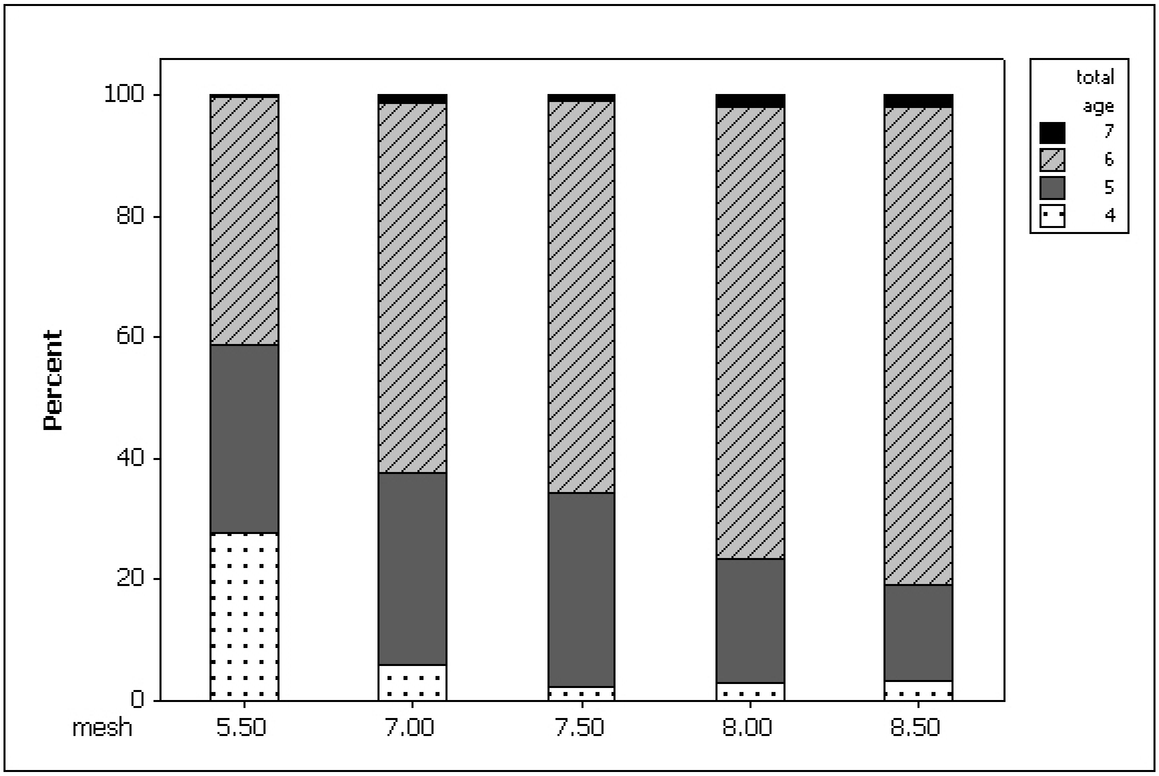

Figure 4.–Chinook salmon age composition by mesh size, including 5.5 and 8.5-inch mesh from commercial and test fisheries.

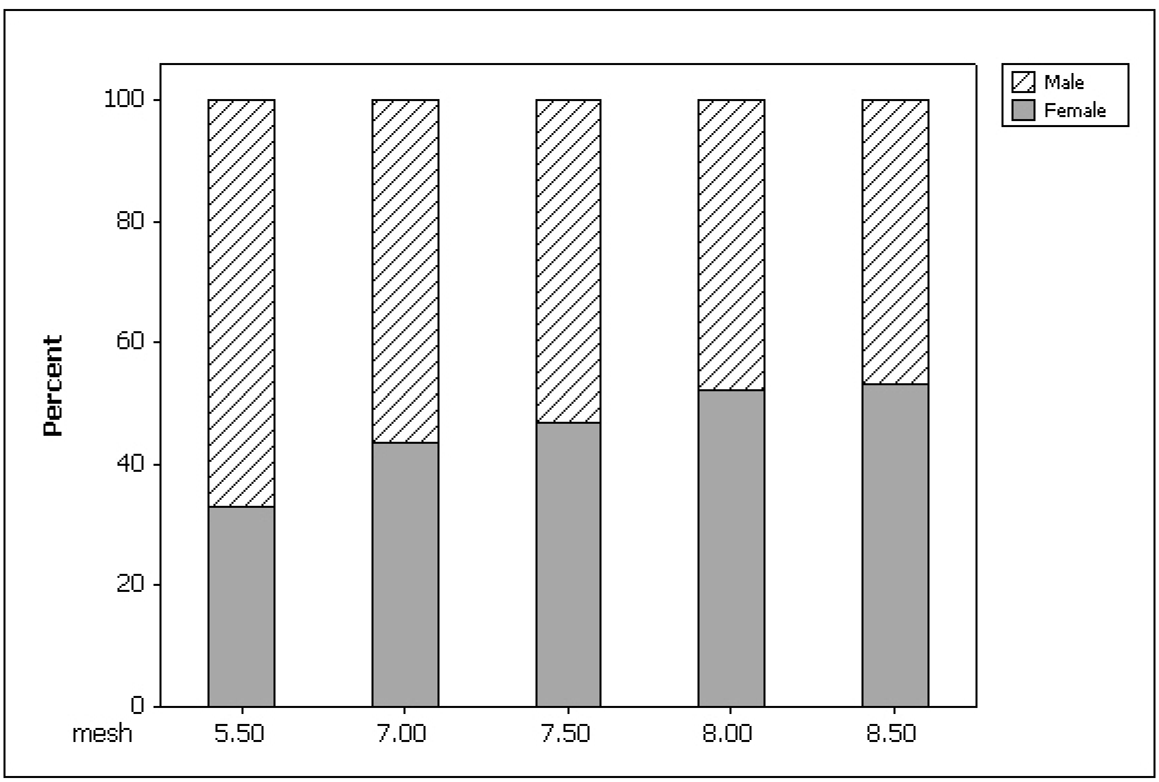

Figure 5.–Chinook salmon gender composition by mesh size, including 5.5 and 8.5-inch mesh from commercial and test fisheries.

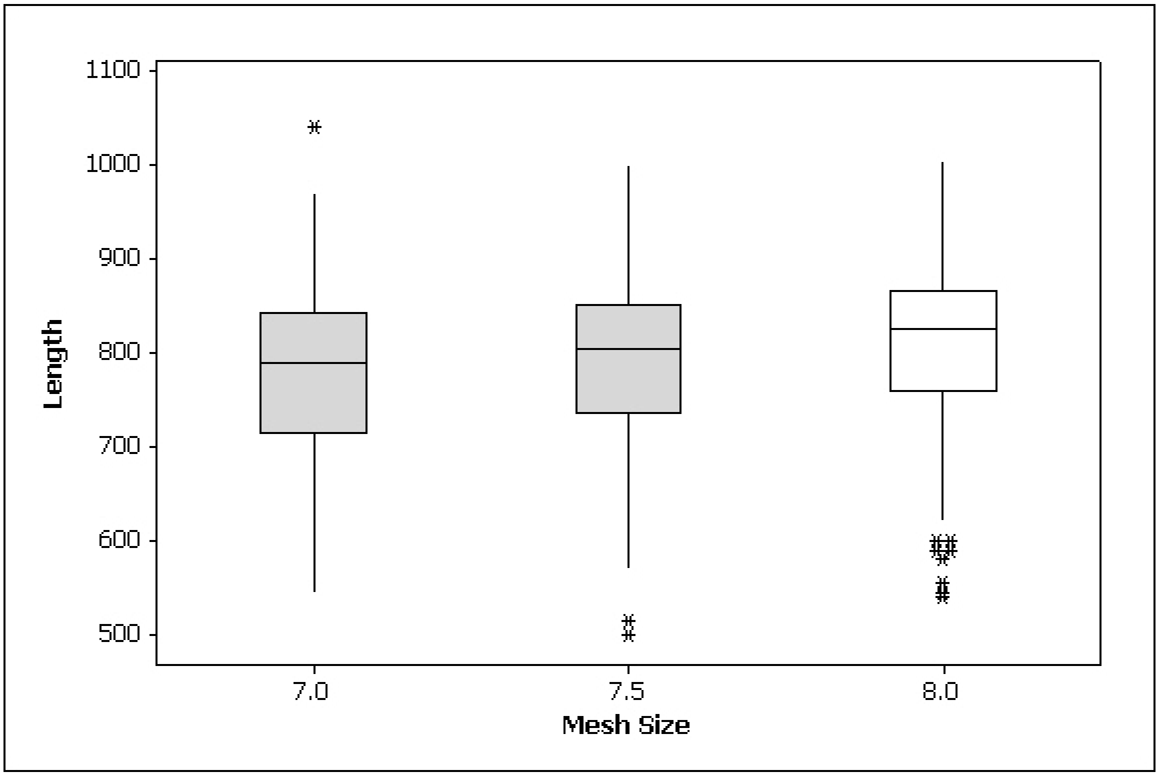

Figure 6.–Chinook salmon length by each mesh size in the Mesh Size Study.

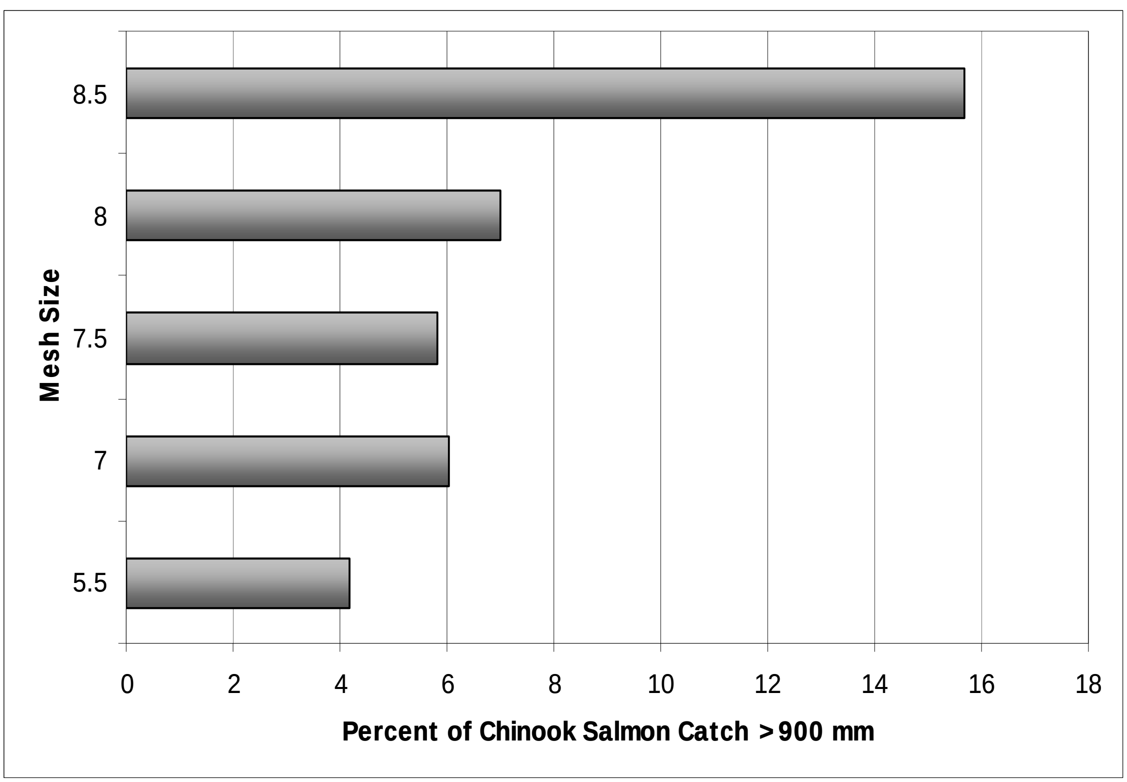

Figure 7.–Proportion of large (>900 mm) Chinook salmon in catch, including 5.5 and 8.5-inch mesh from commercial and test fisheries.

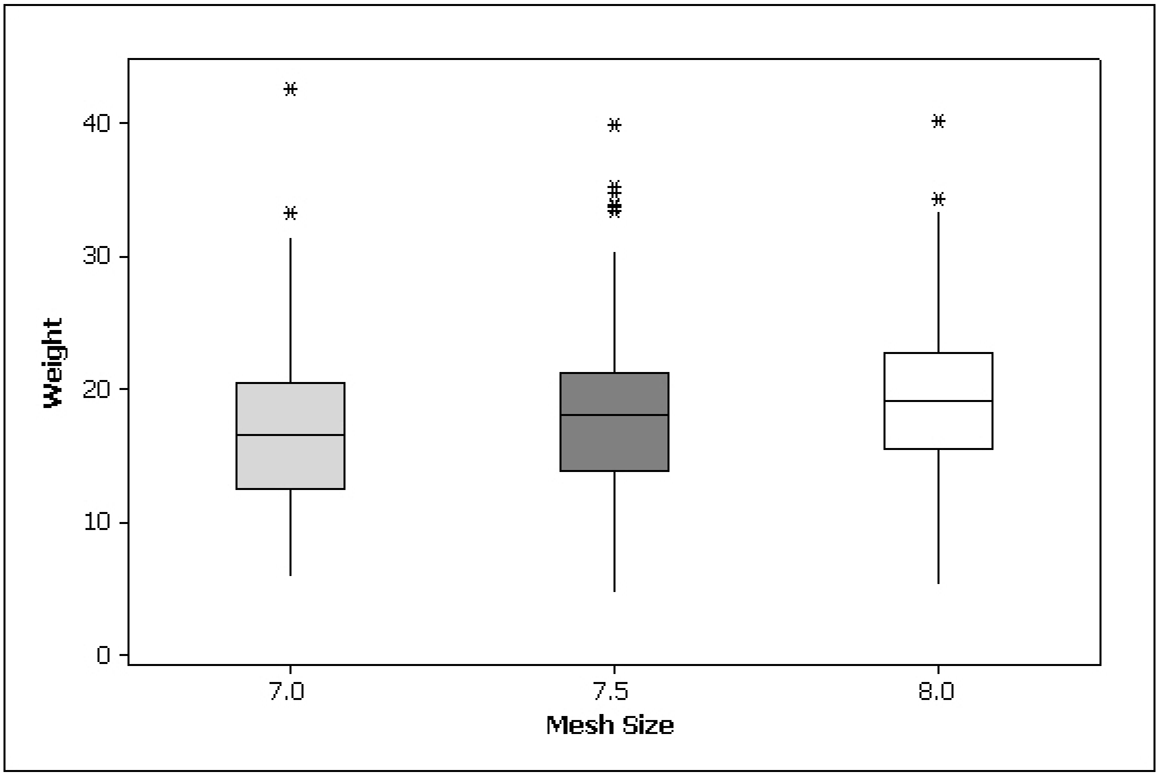

Figure 8.–Chinook salmon weight by each mesh size in the Mesh Size Study.

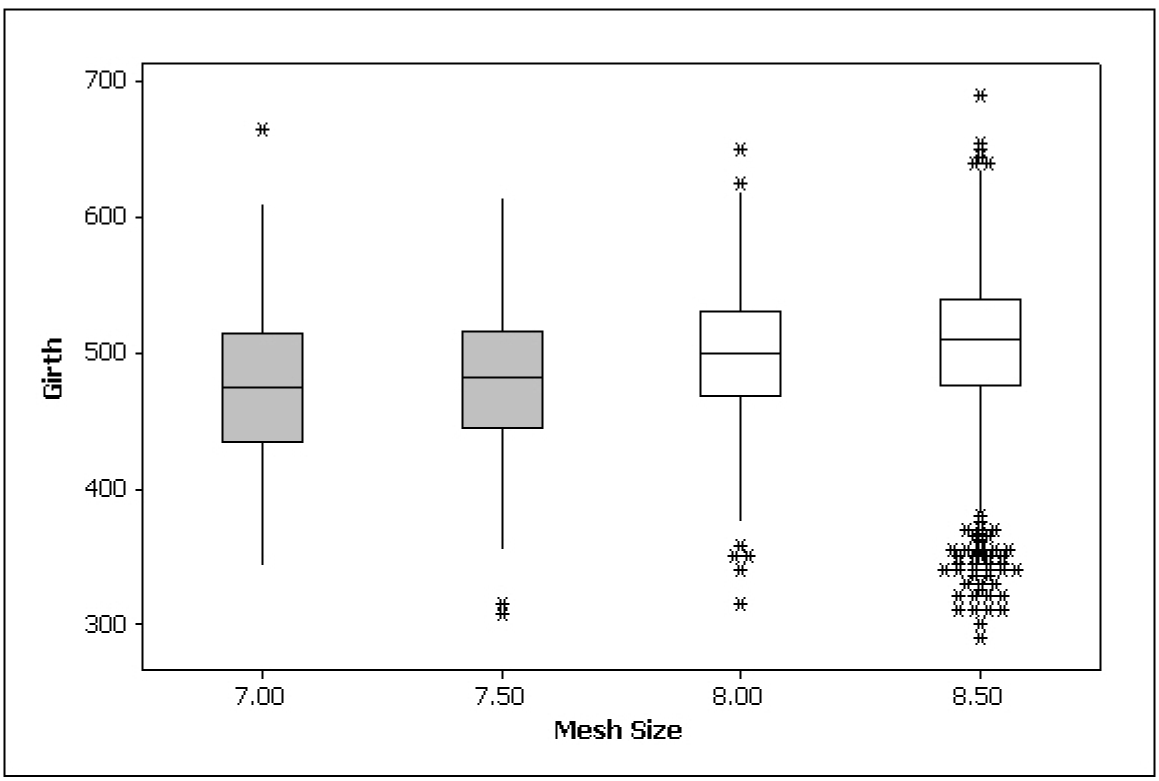

Figure 9.–Chinook salmon girth by mesh size, including 8.5-inch mesh from commercial and test fisheries.

APPENDIX A: PILOT STATION TEST FISHERY

Appendix A1.–Pilot station test fishery.

The Pilot Station test fishery is a drift gillnet fishery designed for species apportionment in conjunction with a sonar program intended to enumerate fish passage. The net sizes used are 2.75, 4, 5.25, 6.5, 7.5, and 8.5-inch stretch mesh. These nets are 25 fathoms long. Because the length of these nets is half of what is used in the Mesh Size Study or the previously mentioned complementary datasets, and gillnet length may have a profound impact on fish catchability, catches from these meshes are not directly comparable. Additionally, soak time of gillnets in this test fishery is far less (approximately 6 minutes) than in the Mesh Size Study, the Lower Yukon test fishery, or what would be expected in commercial fisheries, which could also alter catchability and make statistical evaluations with these datasets unsound. Mesh size comparisons within the Pilot Station dataset are, however, trustworthy, robust, and reveal important patterns.

Within the Pilot Station dataset, gender designation is based only on external characteristics and not gonadal examination. Length data is collected using the same protocol described in the Mesh Size Study. Girth and weight data are not taken in this test fishery and individual age information is currently unavailable. Therefore, only sex and length data are presented. As previously mentioned, data from the Pilot Station test fishery are limited to those dates compatible with the Mesh Size Study so that superficial comparisons could be made. Sample sizes from Pilot Station data used in the presented analyses are shown in Table A1.

Table A1.–Sample sizes from the Pilot Station test fishery for dates corresponding to the Mesh Size Study.

Total Chinook salmon caught by mesh size							Total chum salmon caught by mesh size						
	2.75	4	5.25	6.5	7.5	8.5		2.75	4	5.25	6.5	7.5	8.5
2007	3	18	35	97	174	99	2007	34	165	710	649	170	76
2008	1	14	12	78	112	40	2008	15	63	261	364	81	23
2009	9	36	44	175	338	194	2009	54	185	676	874	247	109
Total	13	68	91	350	624	333	Total	103	413	1647	1887	498	208

CATCH COMPOSITION

Average catch composition ranges from approximately 15% Chinook salmon in the smaller mesh sizes to 44% and 48% in the 7.5 and 8.5-inch mesh nets. These estimates are lower than what would be expected based on the Mesh Size Study where the 7.5-inch mesh averaged 59% Chinook salmon in the catch. Lower Chinook salmon representation at Pilot Station could be due, in part, to removal of fish downriver as a result of greater opportunity of harvest on these fish before reaching Pilot Station, which is approximately 100 miles upriver of the Mesh Size Study sites. Alternatively, the reduced soak time and shorter length gillnets used in the Pilot Station test fishery could potentially contribute to reduced catchability of Chinook salmon relative to the 50-fathom long nets employed in the Mesh Size Study.

As with the Mesh Size Study, the Chinook-to-chum ratio is significantly higher in the two larger size mesh gear than the smaller mesh nets (KW-test, H = 147.44, p < 0001; Figure A1), though the small sample size for the 2.75-inch mesh net should be considered.

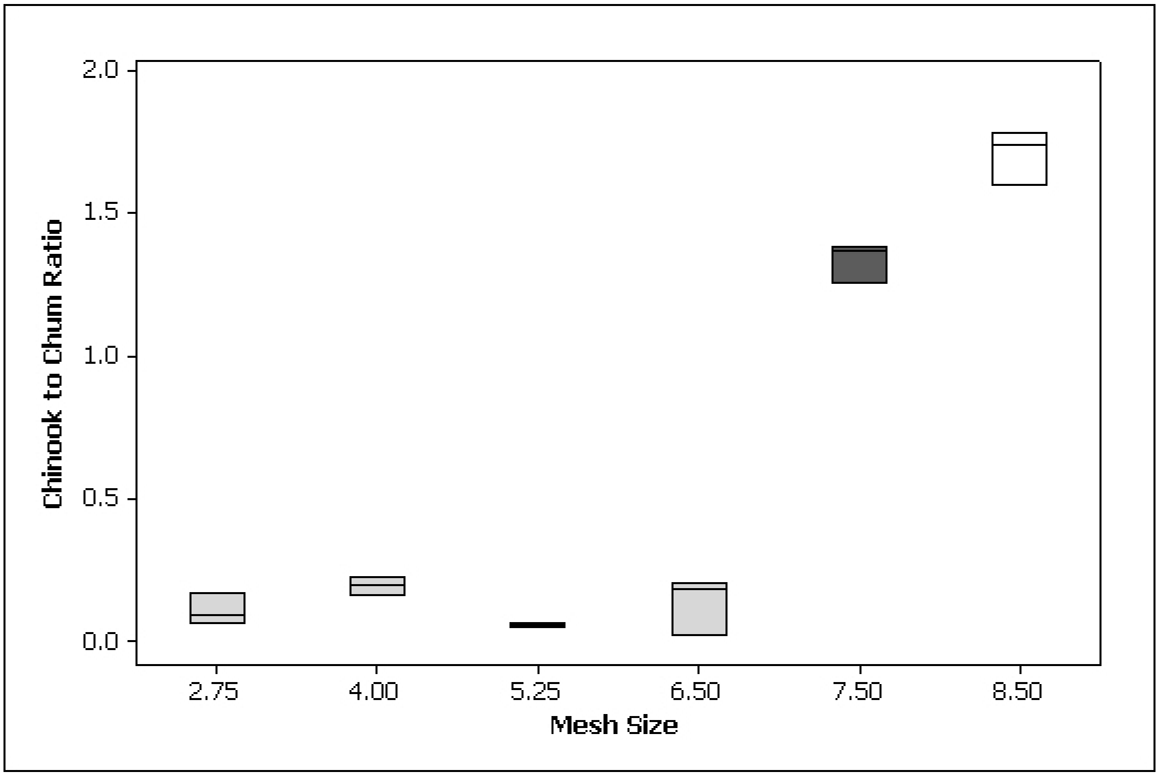

Figure A1.–Pilot Station Chinook-to-chum ratio for 6 mesh sizes.

SEX AND LENGTH COMPOSITION

The percentage of females is significantly higher in larger mesh size nets in the Pilot Station test fishery (χ^2 = 48.488, p <0.001; Figure A2). Females make up approximately 8%, 21%, 18%, 23%, 43%, and 42% of the catch for smallest to largest mesh nets, respectively. The proportion of females in the largest size meshes is lower than would be expected based on the Mesh Size Study and complementary datasets, where 7.5, 8 and 8.5-inch mesh sizes yield 47%, 52%, and 53% females, respectively. As previously mentioned, however, sex determination in this test fishery is based entirely on external characteristics, and is therefore less accurate than sex determination via gonadal examination, as employed by the Mesh Size Study.

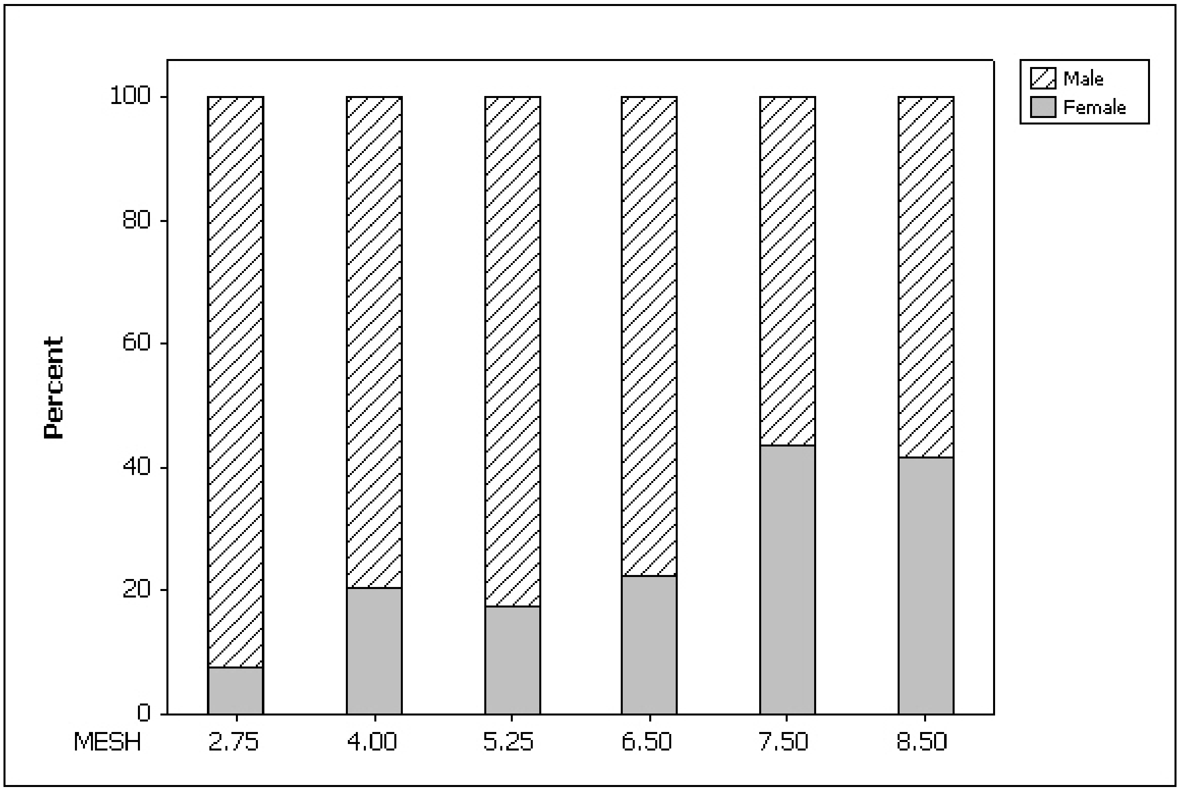

Figure A2.–Gender composition of the Pilot Station test fishery during times consistent with the Mesh Size Study.

Chinook salmon length is significantly different between the 7.5 and 8.5-inch mesh nets, and the smaller mesh nets ($F = 39.9$, $p < 0.0001$; Figure A3). Average lengths from the 7.5 and 8.5-inch nets (767 mm and 795 mm) are smaller than would be expected based on the Mesh Size Study, where average lengths for the 7.5 and 8-inch nets are 793 and 811 mm respectively. The average Chinook salmon length from the 8.5-inch mesh (from the complementary datasets previously mentioned) is 833 mm. As with the species composition data, this discrepancy may be due to a number of causes, including removal of larger fish downriver.

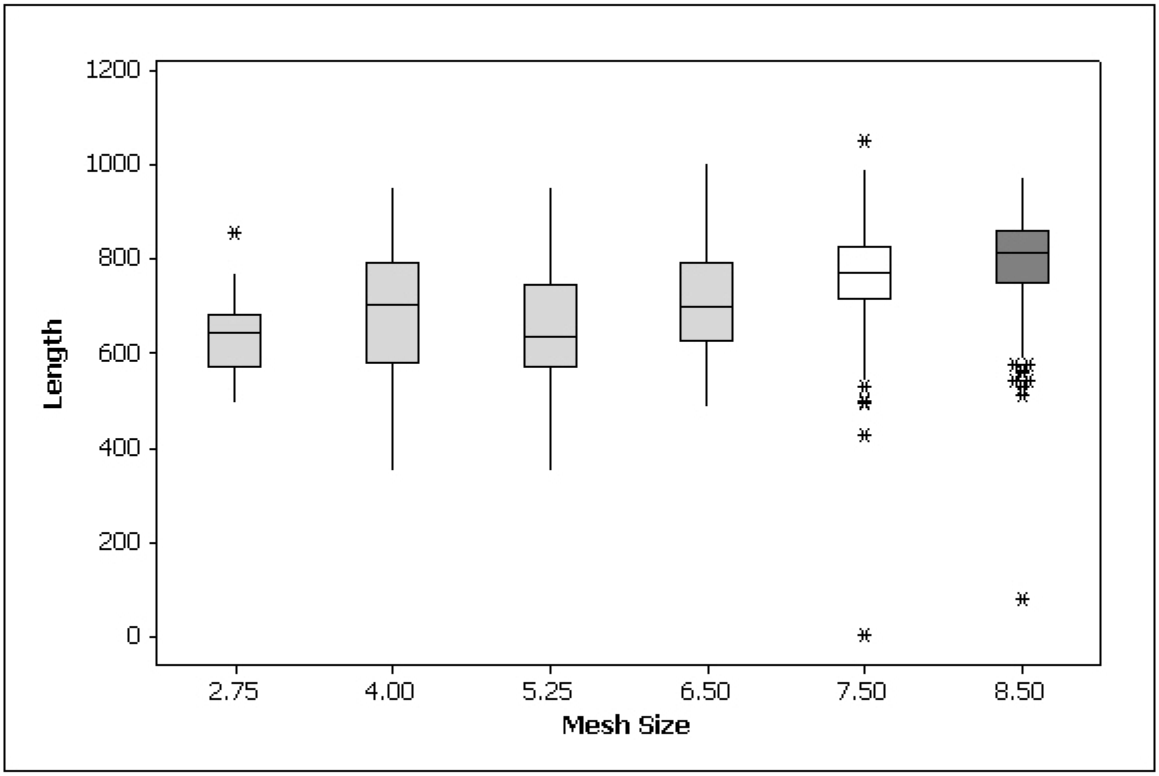

Figure A3.–Length composition of catch for the Pilot Station test fishery during times consistent with the Mesh Size Study.

Overall, data from the Pilot Station test fishery support the general patterns described in the Mesh Size Study. Larger mesh size tends to be associated with a greater proportion of Chinook salmon in the catch, a greater proportion of females, and larger fish. Also like the Mesh Size Study, comparisons between 7.5 and 8.5-inch mesh sizes signify important differences in the phenotypic characteristics of Chinook salmon caught. Unlike the Mesh Size Study and complementary datasets analyzed in the report, there are direct comparisons within Pilot Station data between Chinook-to-chum ratios for 7.5 and 8.5-inch mesh. For the Pilot Station dataset, the 8.5-inch mesh has a significantly higher Chinook-to-chum ratio than the smaller mesh size. Therefore, while a difference in Chinook-to-chum ratio between 7.5 and 8-inch mesh sizes is not apparent in the Mesh Size Study, the Pilot Station dataset suggests there may be a reduction in the proportion of Chinook in the catch when mesh size is reduced from 8.5-inch mesh size. Still, the Pilot Station 8.5-inch mesh net catch is not truly representative of District Y-1 commercial fishery catches, so this comparison should be cautiously considered.