EVALUATING THE SPECIES SELECTIVITY OF 8- AND 9-INCH MESH SET GILLNETS: A 1988 TEST FISHERY IN THE JOHN DAY RESERVOIR OF THE COLUMBIA RIVER

Technical Report 89-4

B. Paul Lumley
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COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
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ABSTRACT

An experimental gillnet fishery in the John Day Reservoir of the Columbia River was designed to test the effectiveness of 8- and 9-inch mesh gillnets in catching fall chinook and steelhead. The selectivity of the gear was evaluated by statistically comparing the catch per gillnet by mesh size and the fish sizes (fork lengths) by mesh size. The results infer that 8-inch mesh gillnets catch more steelhead than 9-inch mesh gillnets. However, there was no significant difference in the chinook catch between the mesh sizes. Furthermore, there was no significant difference in the sizes (fork lengths) by mesh size for both chinook and steelhead. The results of this experiment infer that a minimum mesh restriction of 9 inches would reduce the steelhead catch. At this time, a minimum mesh restriction of 9 inches would probably reduce the catch of both chinook and steelhead due to the low numbers of 9-inch mesh gillnets possessed by Indian fishers.

INTRODUCTION

The treaty Indian commercial fall fishing season typically takes place between early to mid-August and ends in mid-October. The commercial fall fisheries in the areas between Bonneville and McNary dams (Zone 6) are reserved exclusively for treaty Indian fisheries (Figure 1). The primary gear used to commercially harvest salmon and steelhead in the fall period is the set gillnet. During this period, the treaty Indian catches are typically dominated by fall chinook and steelhead, but significant numbers of coho and sturgeon are harvested.

Fall chinook and summer steelhead migrate through the Zone 6 commercial area during the same time period. In years when large numbers of adult fall chinook are returning to the Columbia River, such as in 1986-1988, a majority of management efforts have focused on providing maximum opportunities for harvesting chinook while not unduly impacting other species such as steelhead. In order to help accomplish this task, the Columbia River Fish Management Plan (CRFMP) directs the parties to explore additional harvest methods to improve catches (CRFMP 1988).

Toward the later portion of the fall management period, impacts on summer steelhead may approach harvest rate guidelines outlined in the CRFMP. The use of large mesh gillnets to differentially harvest chinook is one potential management option available to increase fishing time while remaining within the plan's guidelines during the late fall season. However, the effectiveness of mesh size in selectively harvesting chinook while reducing impacts on steelhead is unknown.

An experimental gillnet fishery in the upper portion of Zone 6, carried out after the fall season closed, was designed to test the effectiveness of different mesh sizes for catching chinook and steelhead. In addition, the effect of mesh size on the size (fork length) of chinook and steelhead caught was considered.

METHODS

The 84-hour experimental gillnet fishery took place from 6:00 a.m. September 28, 1988 to 6:00 p.m. October 1, 1988 and was limited to 30 gillnets each day. Individual fishers used one gillnet per site location. Of these 30 gillnet sites, 15 started with 20-centimeter (8-inch) mesh and 15 started with 22-centimeter (9-inch) mesh. Eight- and 9-inch mesh gillnets were rotated daily at each site in an effort to reduce site-specific biases. On-board monitors collected the following categories of data: total catch in each gillnet by species; mesh size to the nearest 0.65 centimeter (0.25 inch); and fork lengths of chinook and steelhead to the nearest 1.0 centimeter. Fork length measurements were used as an indication of size or girth (Ricker 1975). In addition, a ceiling of 300 steelhead was placed on the three-day catch.

An initial assumption was that each fisher would use gillnets that were exactly 8- or 9-inch mesh. Since the span of mesh sizes was greater than anticipated (7.75 to 9.25 inches) and recorded to the nearest 0.25 inch, the following convention was used: all gillnets with mesh size less than or equal to 8.25 inches are considered to be in the 8-inch mesh category and all gillnets with mesh size greater than or equal to 8.50 inches are considered to be in the 9-inch mesh category.

Catch of Chinook and Steelhead per Gillnet

A distribution-free method of inference, the Wilcoxon two-sample test, was used to explore differences in the cumulative frequency distributions associated with 8- and 9-inch mesh sizes for both chinook and steelhead, and to make inferences on the medians (Sokal and Rohlf 1981). The method took into consideration the ties that occur when ranking the data. A chi square (goodness of fit) test was also used to investigate the underlying distributions (Elliott 1977).

Due to the nature of the data for catch by mesh size, the usual statistics associated with the normal distribution must be used with caution. Obviously the data are integers, thus the continuous criterion of the normal distribution is violated. However, the two-sample t-test was used as a good approximation for comparing the mean catch per mesh size for chinook and steelhead largely because this test is insensitive to violations of the normal criterion (Daniel 1978). A logarithmic transformation was also used to normalize the data and reduce the skewness (Hogg and Craig 1978).

Lengths of Chinook and Steelhead by Mesh Size

The two-sample t-test was used to investigate differences in the mean fork lengths between mesh sizes for both chinook and steelhead (Hogg and Craig 1978).

RESULTS

Analysis of the chinook and steelhead catch was divided into two groups: catch per gillnet by mesh size, and lengths by mesh size.

Catch of Chinook and Steelhead per Gillnet

The total catch was 205 chinook and 272 steelhead. The daily catch for chinook, steelhead, coho, and sturgeon is summarized in Table 1 (7 walleye, 7 carp, and 3 catfish are not shown in this table). Of the 205 chinook, 90 were caught in 8-inch mesh and 115 in 9-inch mesh (Table 2). Of the 272 steelhead, 187 were caught in 8-inch mesh and 85 in 9-inch mesh (Table 2). The mean catch of steelhead in 8-inch mesh was discernibly higher than in any other category (Table 3). In this same category, the variance was also much higher (Table 3).

The cumulative distribution of steelhead caught in 8-inch mesh was consistently shifted to the right of the cumulative distribution of steelhead caught in 9-inch mesh (Figure 2). Chinook caught in 8- and 9-inch mesh did not exhibit the consistent shift as with steelhead (Figure 3). As expected, the Wilcoxon two-sample test inferred identity in the underlying distributions by mesh size for both chinook and steelhead. Furthermore, this test inferred that the median catch of steelhead was significantly higher in the 8-inch mesh than in the 9-inch mesh (p=0.05, Table 4). However, this test did not indicate a significant difference in the median catch of chinook (p=0.43, Table 4).

The skewed nature of the frequency distributions and the fact that the variances were greater than the means indicated that the underlying distributions of chinook and steelhead by mesh size may be negative binomial (Figure 4). The chi square (goodness of fit) test was used to confirm and establish this finding with a very high degree of probability (Table 5, Figure 5).

A two-sample t-test has inferred that the mean catch of chinook in 8- and 9-inch mesh gillnets was not significantly different at the 95% confidence level (p=0.18, Table 6). However, the mean catch of steelhead in the 8-inch mesh was higher than in the 9-inch mesh at the 95% confidence level (p=0.03, Table 6). The results are similar for the log transformed data (Table 6).

Lengths of Chinook and Steelhead by Mesh Size

Of the 125 chinook for which fork lengths were recorded, 57 were caught in 8-inch mesh and 68 in 9-inch mesh. Of the 241 steelhead for which fork lengths were recorded, 171 were caught in 8-inch mesh and 70 in 9-inch mesh. A few of the monitors recorded the numbers caught in each gillnet but did not record the fork length of each chinook and steelhead. Therefore, the sample sizes of chinook and steelhead fork lengths are not the same as the total catch.

The mean length of chinook caught in 8-inch mesh was 88.8 cm, and 92.1 cm in the 9-inch mesh (Table 7). The mean fork length of steelhead caught in 8-inch mesh was 79.9 cm, and 80.5 cm in the 9-inch mesh (Table 7). The high variances of chinook and steelhead fork lengths by mesh size (Table 7) may be explained by the different size groups associated with age classes.

The underlying distribution of fork lengths per gillnet by mesh size (Figure 6) satisfies the normal distribution criteria. The two-sample t-test indicated that there was no significant difference in the average fork length of the chinook and steelhead catch by mesh size at the 95% confidence level. The p-value for chinook was 0.11, and 0.68 for steelhead (Table 8).

DISCUSSION

This experimental test fishery was conducted on very short notice. The consistency of the data could be improved by standardizing the length and depth of each gillnet, the span of mesh sizes, and the amount of time each gillnet is in the water.

The chi square analyses show that the catch per gillnet, for both chinook and steelhead, are good fits to the negative binomial distribution. This confirmed the hypothesis that the data are not normally distributed. The Wilcoxon test shows that the underlying distributions by mesh size are the same. Furthermore, the Wilcoxon test infers that the median steelhead catch is higher in 8-inch mesh gillnets than in 9-inch mesh gillnets. However, no inferences can be made from the differences in the median catch of chinook in 8- and 9-inch mesh gillnets. Thus, a 9-inch minimum mesh restriction would probably reduce the catch of steelhead with an indeterminate effect on the catch of chinook. The t-test and the logarithmic transformation t-test confirm these results using the means.

The underlying distribution of fork lengths per gillnet by mesh size satisfies the normal distribution criteria and the t-test infers that mesh size does not affect the average fork length of chinook and steelhead caught. Therefore, a 9-inch mesh minimum appears not to be an effective management tool to select for size in this fishery.

The total number of chinook caught in 8- and 9-inch mesh gillnets suggests a slight difference between the two gear sizes. However, when considering the variability, no differences in selectivity for chinook can be detected. Additionally, the selective capability of 8- and 9-inch mesh gillnets on the average fork length of the chinook catch is undetectable. The selective capability of 8- and 9-inch mesh gillnets on the average fork length of the steelhead catch is also undetectable. The results of this experiment infer that 8-inch mesh catches more steelhead than 9-inch mesh. However, due to the low numbers of 9-inch mesh gillnets possessed by Indian fishers, overall effort would be considerably reduced. A reduction in effort would therefore reduce the catch of both chinook and steelhead.

Table 1. Daily catch by species in the John Day Reservoir experimental fishery.

Date	Number of nets	Chinook	Steelhead	Coho	Sturgeon
9/29/88	28	78	95	2	4
9/30/88	27	57	101	3	3
10/1/88	28	70	76	2	2
Total		205	272	7	9

Table 2. Total catch of chinook and steelhead separated by mesh size in the John Day Reservoir experimental fishery.

Mesh	Number of Nets	Chinook	Steelhead	Total
8-inch	44	90	187	277
9-inch	39	115	85	200
Total	83	205	272	477

Table 3. Descriptive statistics for chinook and steelhead catch per gillnet by mesh size in the John Day Reservoir experimental fishery.

	Chinook			Steelhead		
	8-inch	9-inch	Pooled	8-inch	9-inch	Pooled
Sample Size	44	39	83	44	39	83
Median	1	2	2	2	1	2
Mean	2.0	2.9	2.5	4.2	2.2	3.3
Variance	4.5	14.2	9.1	26.2	7.5	17.5
Standard Dev.	2.1	3.8	3.0	5.1	2.7	4.2
Standard Error	0.3	0.6	0.3	0.8	0.4	0.5
Minimum	0	0	0	0	0	0
Maximum	7	20	20	23	13	23

Table 4. Wilcoxon two-sample test statistics for chinook and steelhead catch per gillnet by mesh size in the John Day Reservoir experimental fishery.

	Chinook		Steelhead	
	8-inch	9-inch	8-inch	9-inch
Sum of Ranks	1,763	1,723	2,059.5	1,426.5
Sample Sizes	44	39	44	39

	Chinook	Steelhead
U-statistic	943	1,070
Sum of Ties	21,498	17,418
t-statistic	0.79	1.96
p-value	0.43	0.05

Table 5. **Chi square (goodness of fit) tests for chinook and steelhead catch per gillnet by mesh size in the John Day Reservoir experimental fishery.**

Chinook Catch in 8-inch Mesh

Numbers Per Net	Observed	Expected	Chi Square
0	13	11.61	0.17
1	9	10.63	0.25
2	8	7.80	0.01
3 - 4	8	8.62	0.05
>= 5	6	5.33	0.09

Sum of Chi Squares = 0.55

$\bar{x} = 2.04$, $\hat{k} = 1.66$, Df = 2

p-value > 0.5

Chinook Catch in 9-inch Mesh

Numbers Per Net	Observed	Expected	Chi Square
0	11	11.88	0.07
1	6	7.03	0.15
2 - 3	7	8.46	0.25
4	5	2.67	2.04
>= 5	10	8.88	0.14

Sum of Chi Squares = 2.65

$\bar{x} = 2.95$, $\hat{k} = 0.74$, Df = 2

p-value > 0.1

Steelhead Catch in 8-inch Mesh

Numbers Per Net	Observed	Expected	Chi Square
0	8	10.13	0.45
1	9	6.78	0.73
2	6	5.13	0.15
3	5	4.02	0.24
4 - 6	5	7.93	1.08
7 - 9	5	4.32	0.11
>= 10	6	5.24	0.11

Sum of Chi Squares = 2.86

$\bar{x} = 4.25$ $\hat{k} = 0.79$ Df = 4

p-value > 0.5

Steelhead Catch in 9-inch Mesh

Numbers Per Net	Observed	Expected	Chi Square
0	14	13.22	0.05
1	6	8.10	0.55
2	5	5.40	0.03
3 - 4	7	6.24	0.09
>= 5	7	6.03	0.16

Sum of Chi Squares = 0.87

$\bar{x} = 2.18$ $\hat{k} = 0.85$ Df = 2

p-value > 0.5

$\bar{x}$ = mean

$\hat{k} = \left[\bar{x}^2 - (s^2 \div n)\right] \div (s^2 - \bar{x})$, where s^2 = sample variance and n = sample size

Degrees of freedom = number of observation classes - number of parameters estimated - 1

Table 6. 95% confidence intervals and statistics for chinook and steelhead catch per gillnet by mesh size in the John Day Reservoir experimental fishery.

	Chinook	Steelhead
95% C.I. Same Variance	(-2.22 , 0.41)	(0.24 , 3.90)
95% C.I. Different Variance	(-2.27 , 0.46)	(0.30 , 3.84)
Computed t-statistic	-1.3645	2.2533
p-value	0.1761	0.0269

	Log. Transformed Chinook	Log. Transformed Steelhead
95% C.I. Same Variance	(-0.21 , 0.08)	(0.02 , 0.34)
95% C.I. Different Variance	(-0.21 , 0.08)	(0.02 , 0.33)
Computed t-statistic	-0.9287	2.1976
p-value	0.3558	0.0308

Table 7. **Descriptive statistics for chinook and steelhead fork lengths (cm) by mesh size in the John Day Reservoir experimental fishery.**

	Chinook			Steelhead		
	8-inch	9-inch	Pooled	8-inch	9-inch	Pooled
Sample Size	57	68	125	171	70	241
Median	90	93	92	84	83	83
Mean	88.8	92.1	90.6	79.9	80.5	80.0
Variance	148.6	124.1	135.2	128.7	137.1	131.1
Standard Dev.	12.2	11.1	11.6	11.3	11.7	11.4
Standard Error	1.6	1.4	1.0	0.9	1.4	0.7
Minimum	49	58	49	54	58	54
Maximum	112	112	112	105	99	105

Table 8. **95% confidence intervals and statistics for chinook and steelhead fork lengths (cm) by mesh size in the John Day Reservoir experimental fishery.**

	Chinook	Steelhead
95% C.I. Same Variance	(-7.48 , 0.79)	(-3.86 , 2.54)
95% C.I. Different Variance	(-7.52 , 0.82)	(-3.92 , 2.60)
Computed t-statistic	-1.6027	-0.4077
p-value	0.1116	0.6839

Figure 1. Map of the Mainstem Columbia River showing Zone 6, the test fishery areas, and Bonneville, McNary, and John Day dams.

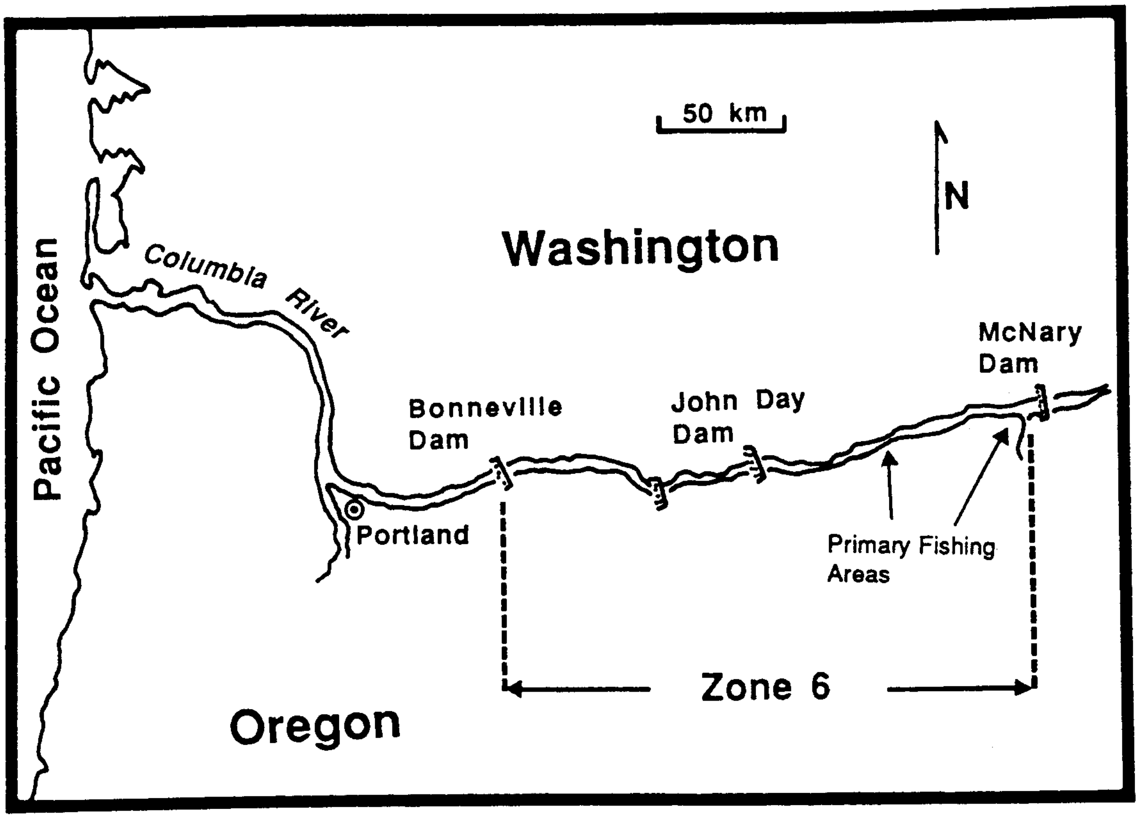


Figure 2. Cumulative frequency of steelhead catch by mesh size from the John Day Reservoir experimental fishery.

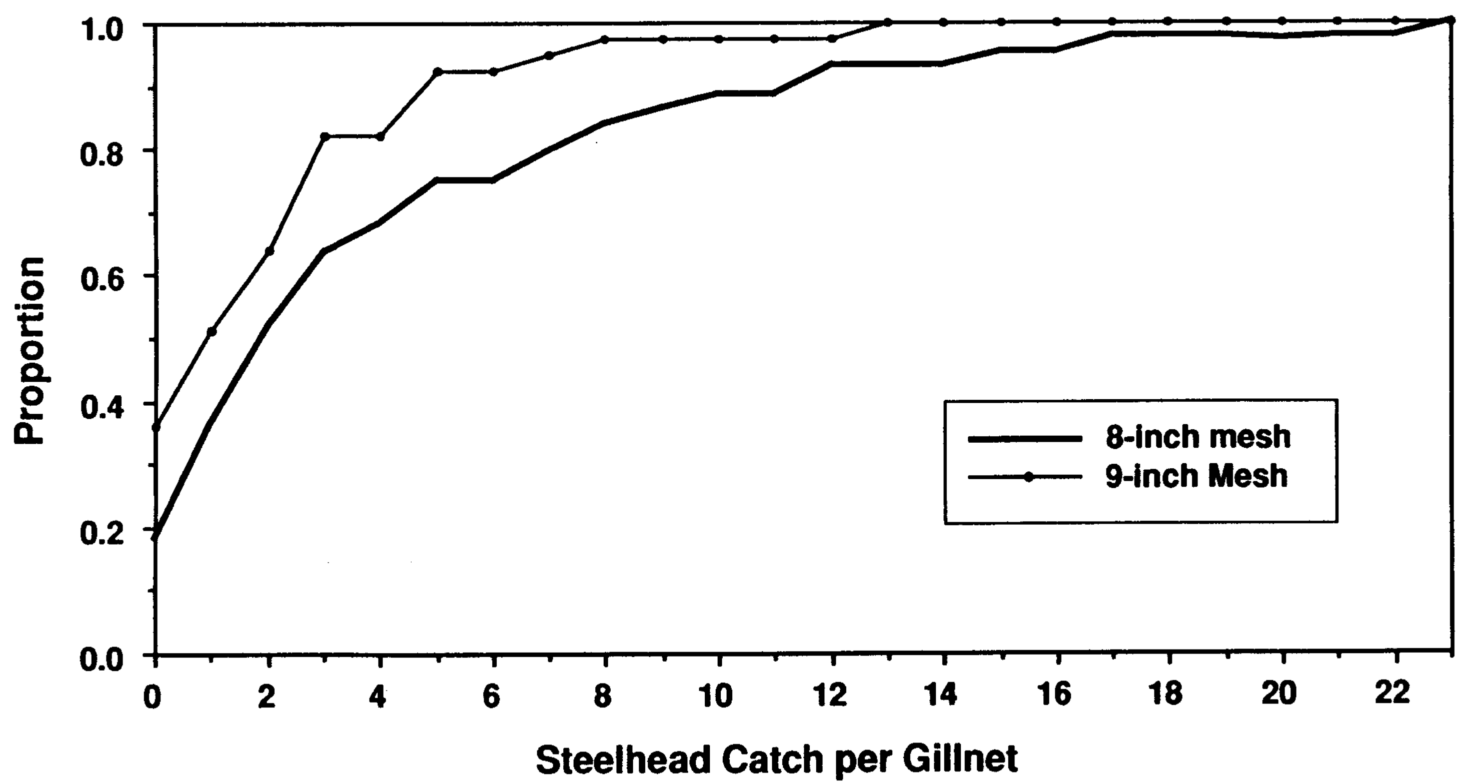


Figure 3. Cumulative frequency of chinook catch by mesh size from the John Day Reservoir experimental fishery.

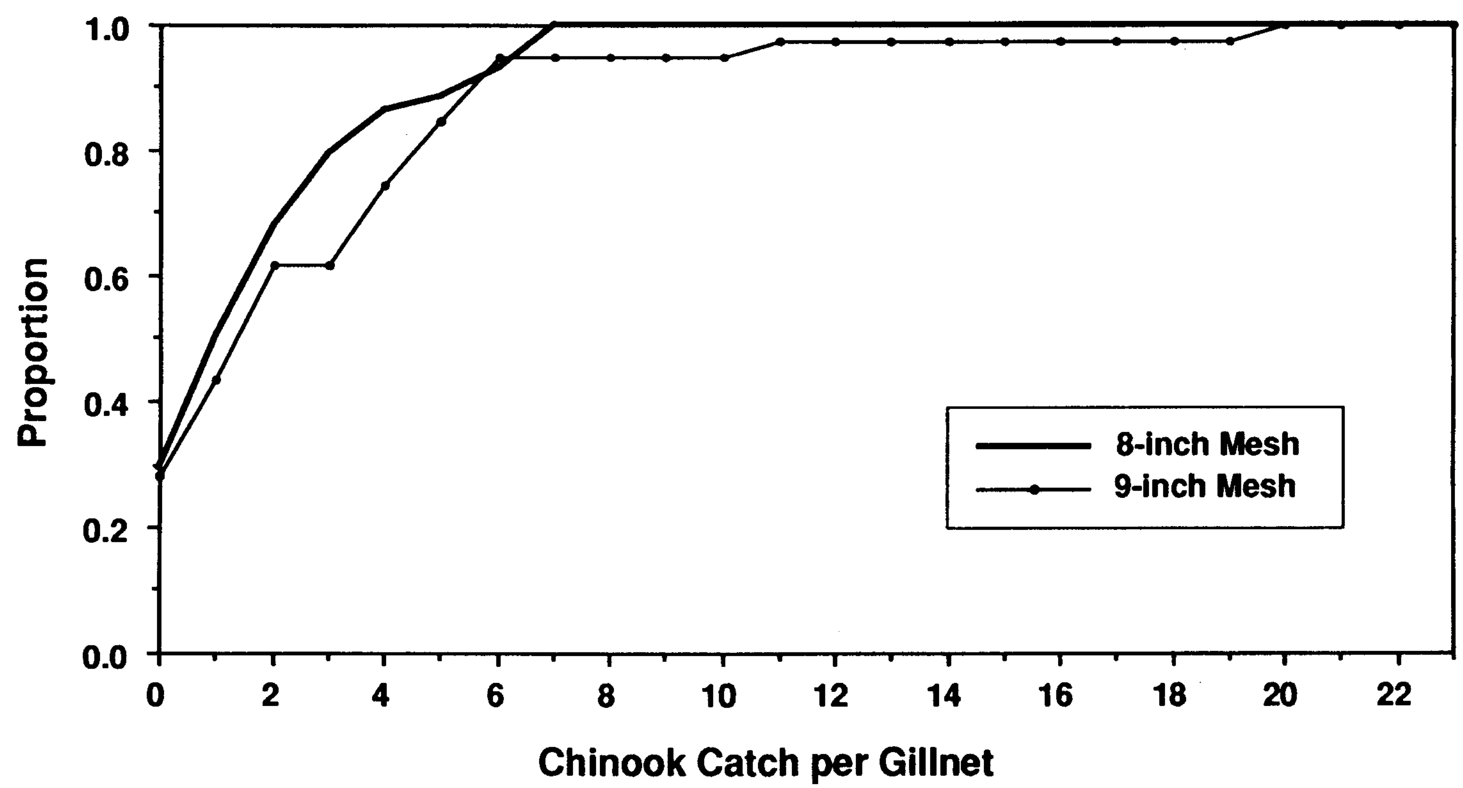


Figure 4. Frequency distributions of chinook and steelhead catch per gillnet by mesh size in the John Day Reservoir experimental fishery.

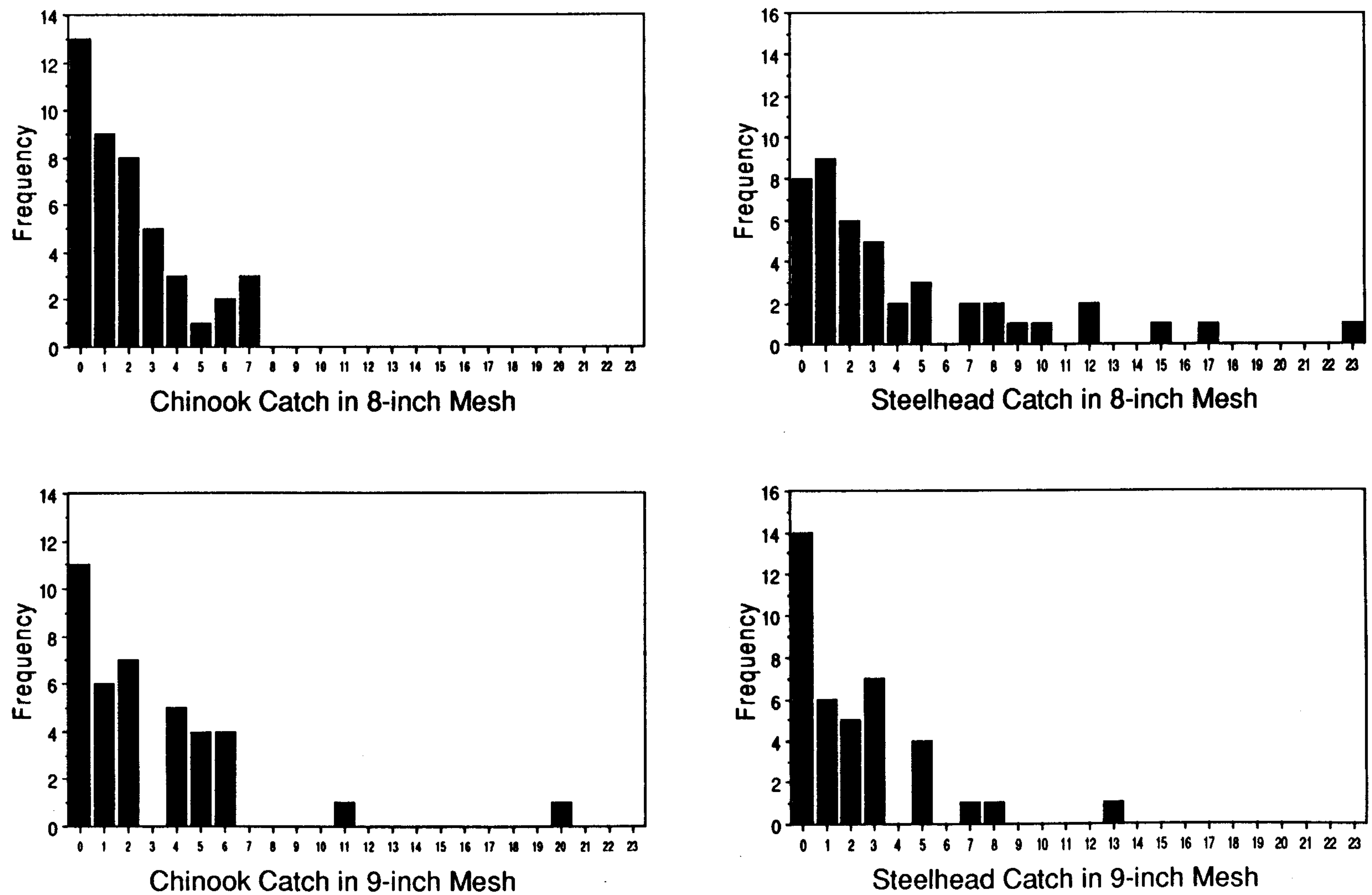


Figure 5. Observed and expected negative binomial distribution of chinook and steelhead catch per gillnet by mesh size in the John Day Reservoir experimental fishery.

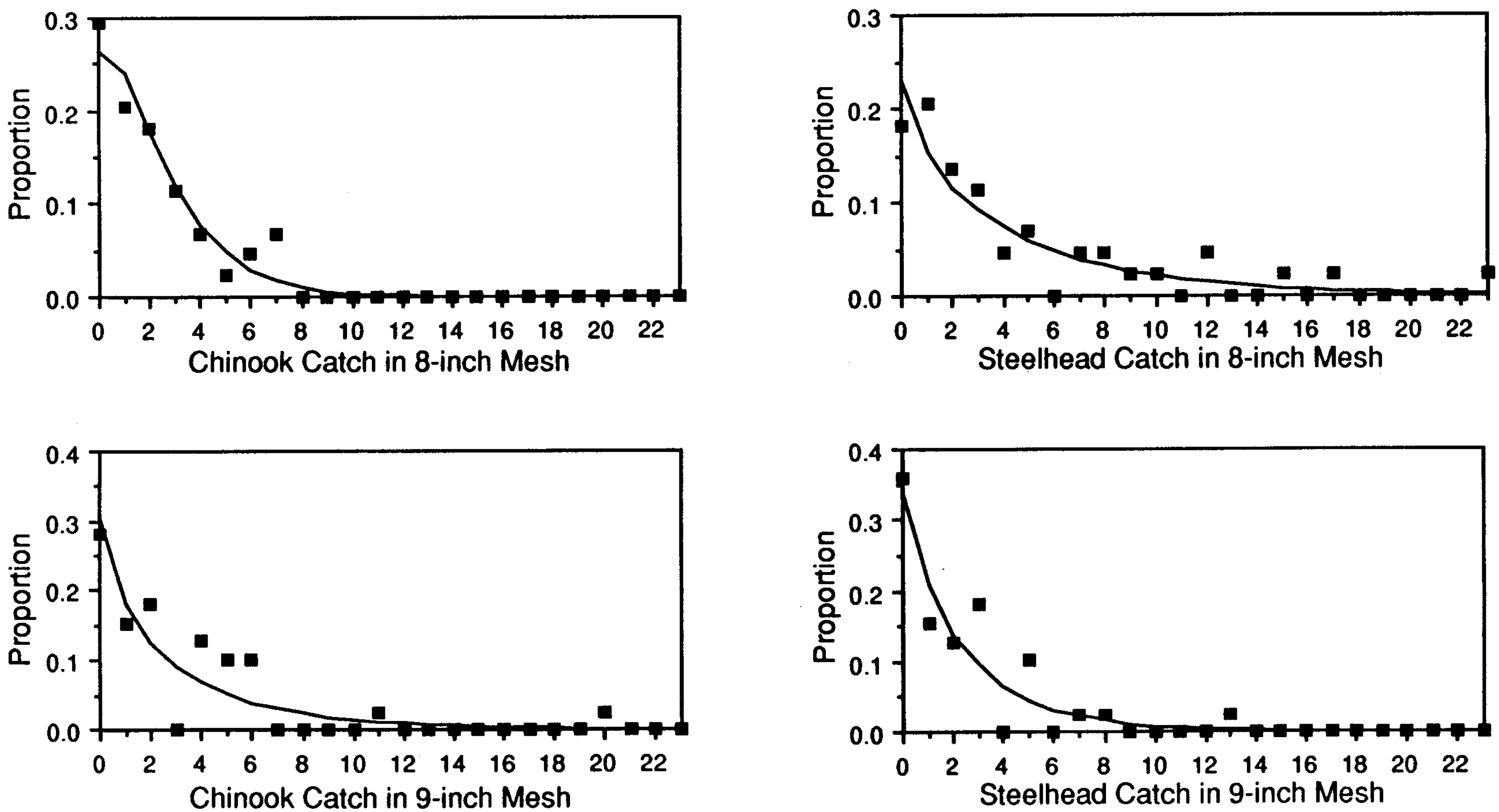
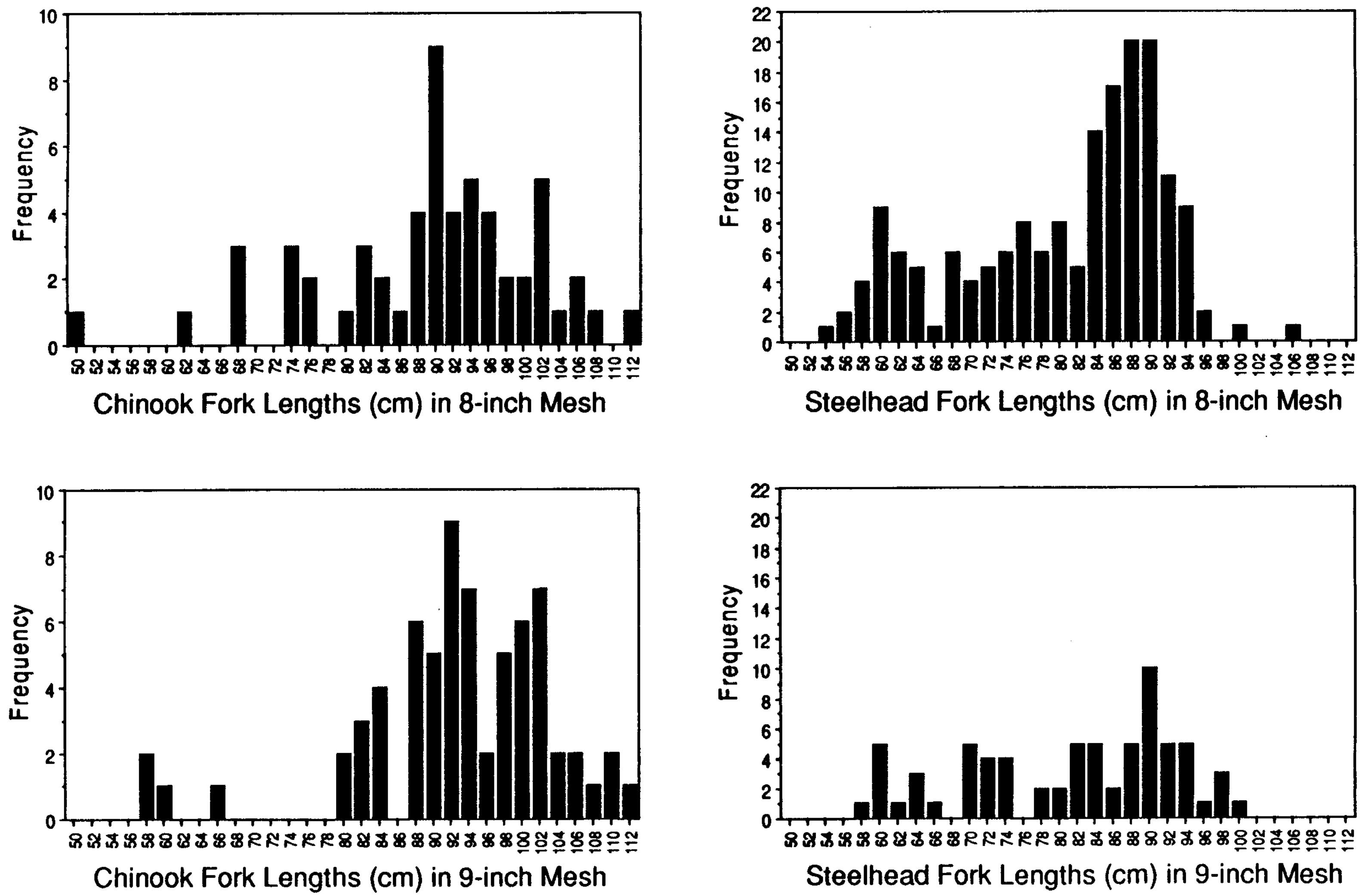


Figure 6. **Frequency distributions of chinook and steelhead fork lengths (cm) per gillnet by mesh size in the John Day Reservoir experimental fishery.**



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The **Columbia River Inter-Tribal Fish Commission (CRITFC)** is the coordinating fisheries agency for the Nez Perce, Umatilla, Warm Springs, and Yakima tribes—four Columbia River tribes that reserved fishing rights in 1855 treaties with the United States government.

Since time immemorial, Indian people have lived and fished in the Columbia River's vast basin, and salmon and steelhead have always been central to the culture and lifestyles of these Native Americans. Anadromous fish, in addition to being the mainstay of the diet, have great religious significance. Salmon and steelhead, which in prehistoric times were dried for trading to other tribes, have also been of great economic importance.

Court decisions in the 1960s and 1970s reaffirmed not only the tribes' right to fish, but also their right to co-manage this once plentiful renewable resource. To fulfill their responsibilities as co-managers, the Nez Perce, Umatilla, Warm Springs, and Yakima tribes formed CRITFC in 1977 to be their technical arm on fisheries issues. CRITFC, through its staff of biologists, policy analysts, law enforcement officers, and other specialists, works closely with state and federal agencies, citizen groups, and other tribes to help restore the Columbia Basin's salmon and steelhead runs.

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