ANNUAL PROGRESS REPORT

Abundance and Distribution of Walleye, Northern Squawfish and Smallmouth Bass in John Day Reservoir and Tailrace, 1983

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ABSTRACT

Walleye, northern squawfish and smallmouth bass abundances were estimated in portions of John Day Reservoir and tailrace using a multiple mark and recapture method. Sampling was conducted from March 28 to September 23, 1983, using gill nets, trap nets, boat electrofishing, angling and an angler survey. A total of 1,808 walleye, 6,423 northern squawfish and 974 smallmouth bass were collected.

Abundance was estimated using a modified Schnabel estimator. Discrete populations were defined according to observed movements of recaptured and radiotagged fish. Abundance estimates were corrected for angler harvest, size selectivity by gear and recruitment due to growth during sampling. In addition, the likelihood of biases resulting from differential mortality of marked fish and tag loss was examined.

Abundances of walleye with fork lengths greater than 250 mm were estimated as 6,877 below John Day Dam and 9,463 in the upper John Day pool. Extensive movements by walleye within pools were observed. Angler harvest of walleye between May 25 and September 6 was estimated as 527 in John Day tailrace and 465 in McNary tailrace.

Abundances of northern squawfish with fork lengths greater than 250 mm were estimated to be 32,126 below John Day Dam, 10,841 in John Day forebay and 27,771 in upper John Day pool. The estimated number of northern squawfish in the McNary tailrace boat restricted zone after cessation of spill (July 2) was twice the estimated abundance during spill (March 28-July 1). Smallmouth bass abundance was estimated as 1,087 below John Day Dam, 1,501 in John Day forebay and 3,450 in upper John Day pool.

INTRODUCTION

The goal of this study is to determine the distribution, abundance and rates of growth and mortality of walleye (Stizostedion vitreum vitreum), northern squawfish (Ptychocheilus oregonensis) and smallmouth bass (Micropterus dolomieui) in John Day Reservoir and tailrace. This study is part of a cooperative effort with the U.S. Fish and Wildlife Service (USFWS) to estimate the extent of predation on juvenile salmonids. This report summarizes work conducted in 1983, the second year of the study. Smallmouth bass were added to our study in 1983 because USFWS (Gray et al. 1984) found in 1982 that smallmouth bass prey on juvenile salmonids in John Day Reservoir. Further background information on this study and a description of the study area can be found in our report of 1982 results (Willis et al. 1985).

Objectives in 1983 were:

1. Describe and correct for biases associated with techniques for sampling walleye, northern squawfish and smallmouth bass.

2. Describe movements and distribution of walleye, northern squawfish and smallmouth bass.

3. Estimate abundances of walleye, northern squawfish and smallmouth bass.

    a. Adjust abundance estimates for recruitment because of growth during the time recoveries were being made.

    b. Adjust abundance estimates for harvest of marked and unmarked fish by anglers.

METHODS AND MATERIALS

Field Sampling

Capture and Handling

Sampling was conducted from March 28 to September 23 (Appendix A, Table A.1) to mark and recapture walleye, northern squawfish and smallmouth bass, describe changes in their relative abundance during sampling and evaluate size selectivities of gear with which they were captured. Sampling stations located in John Day tailrace (141). John Day forebay (159) and McNary tailrace (161) remained unchanged from 1982-(Willis et al. 1985) (Figure 1). -Sampling near Paterson Slough (Figure 2) was changed from 1982 to include stations near Irrigon but not stations in the Blalock Islands. Stations near Miller Island (Figure 3) and Arlington (Figure 4) were sampled as time allowed. Some stations *were* sampled with a given gear at least *once* in a two-week period to detect changes in relative fish abundance. Stations where at least three gears could be used were sampled with each gear on three days within a period to evaluate size selectivities of those gear.

Drift gill nets and box traps were used in 1983 (Appendix A, Table A.2) to sample areas of nigh flow and areas near the dam, respectively. Stationary gill nets, trap nets, electrofishing and angling were used as in 1982 (Willis et al. 1985). Drift gill nets were 61.0-m long and 6.1-m deep with 5.1-cm bar multifilament nylon mesh and were drifted for 5 to 15 minutes, perpendicular to flow in water 6.0 to 6.5-m deep. Box traps had fykes in each end, were 1.2-m long x 0.9-m wide x 0.9-m deep with 2.5-cm bar nylon mesh and were fished unbaited or baited with frozen juvenile salmon. Stationary gill nets were like those used in 1982, but each panel was 7.6-m long and total net length was 45.6 m. Trap nets were similar in design to those used in 1982 but were 3.0 or 4.6-m deep. Each trap net had a 61.0-m long lead and two 9.1-m long wings made of 3.8-cm and 3.2-cm bar nylon mesh, respectively. The heart of each trap net was made of 3.2-cm bar nylon mesh and funneled fish into a 2.5-cm bar nylon mesh capture box. The electrofishing boat was redesigned in 1983 so that two circular anodes were suspended 2-m in front of the bow; each with an array of six to eight probes.

Catches were identified and enumerated. Fork lengths (mm) and weights (g) of walleye, northern squawfish and smallmouth bass were determined and scale samples were taken. Fish in poor condition (those either bleeding excessively from the gills or unable to fully recover after handling) were sacrificed. Walleye and northern squawfish with fork lengths greater than 249 mm and smallmouth bass with fork lengths greater than 199 mm (see Willis et al. 1985) were marked by inserting spaghetti tags through their dorsal musculature and tying them over the back with an overhand knot. A hole was punched in the left opercle of each tagged fish to enable recognition if its tag was lost.

Samples were supplemented by walleye and smallmouth bass tagged and released by USFWS who also provided their catch records and recoveries of tagged fish.

Radio Telemetry

Movements of northern squawfish collected and released at the central entrance of the Oregon shore adult fishway at McNary Dam were monitored from June

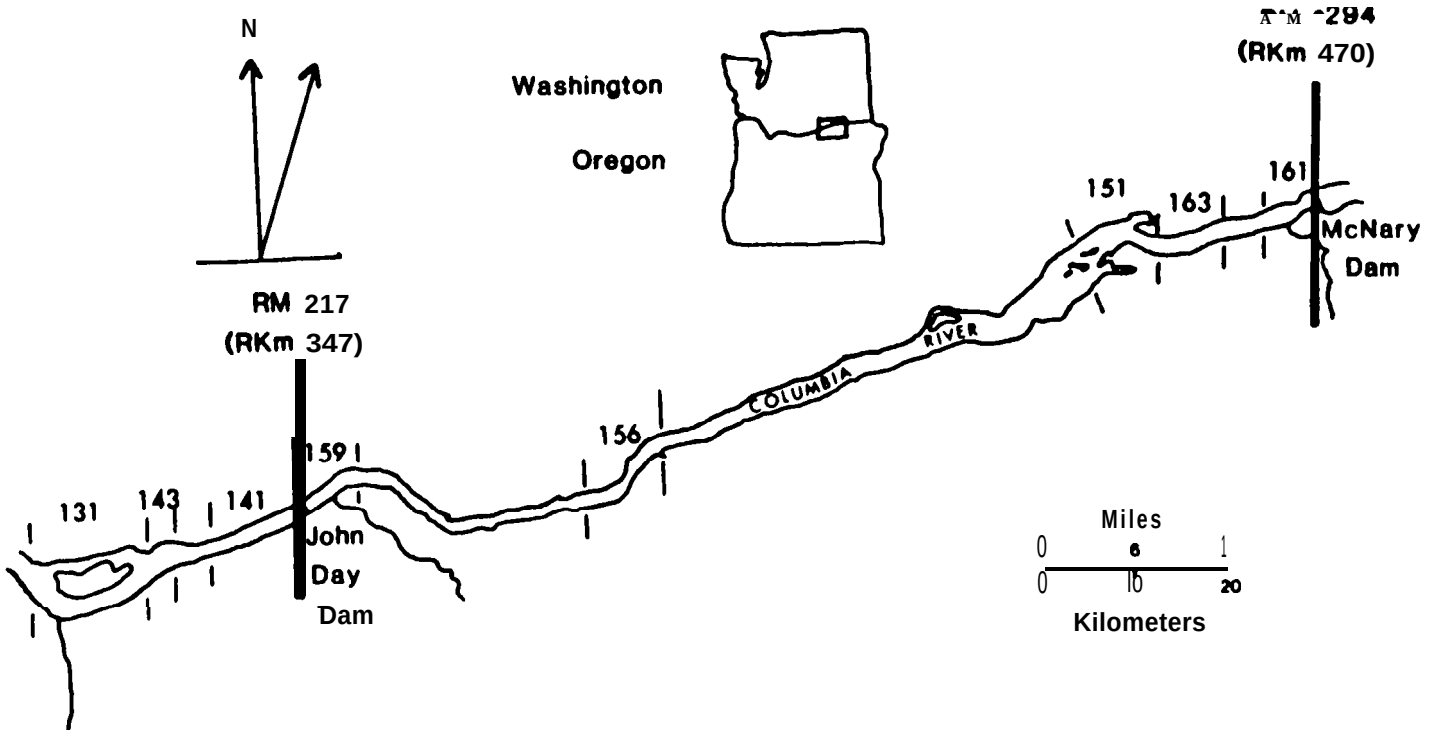

Figure 1. Locations of sampling stations in John Day Reservoir and tailrace, 1983.

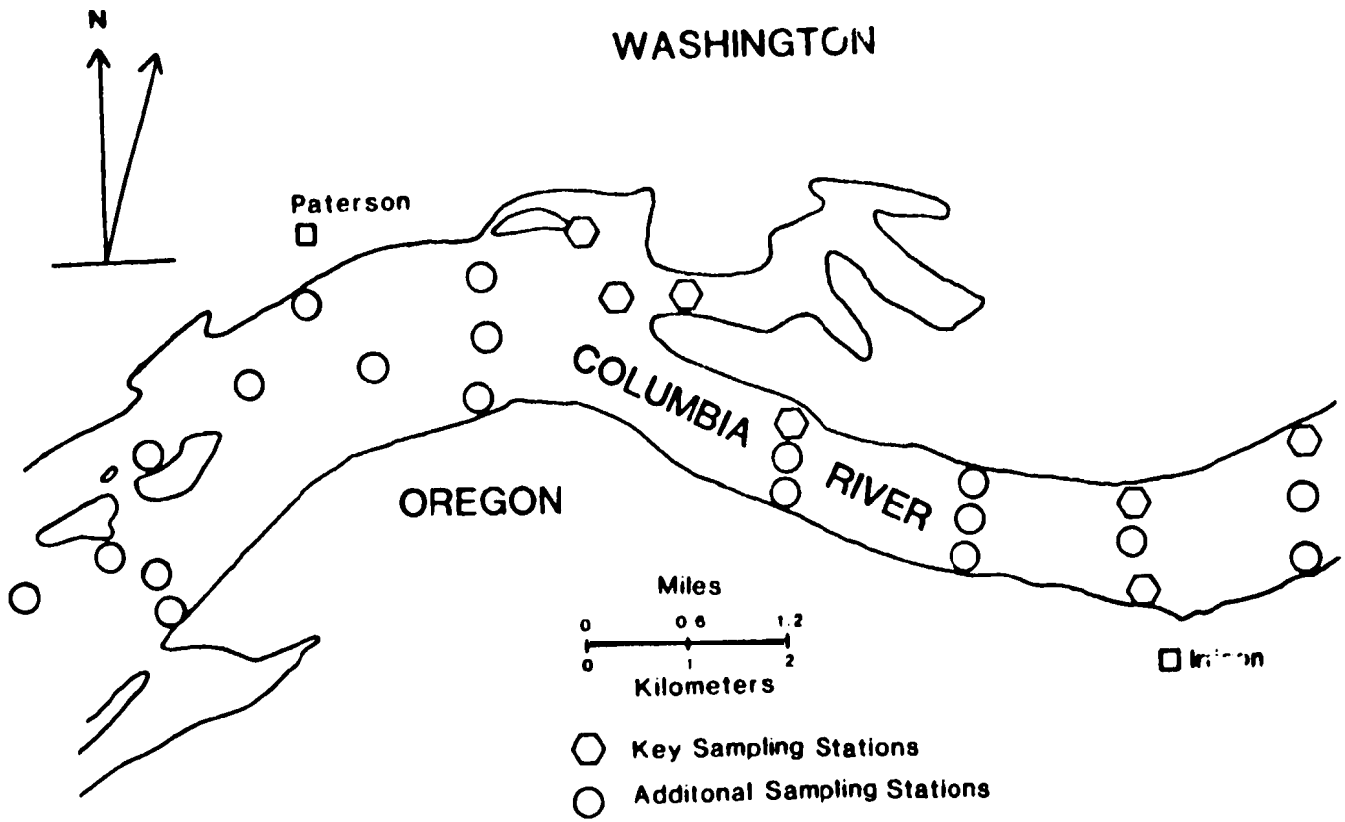

Figure 2. Locations of sampling stations near rrigon and Paterson (151,163), 1983.

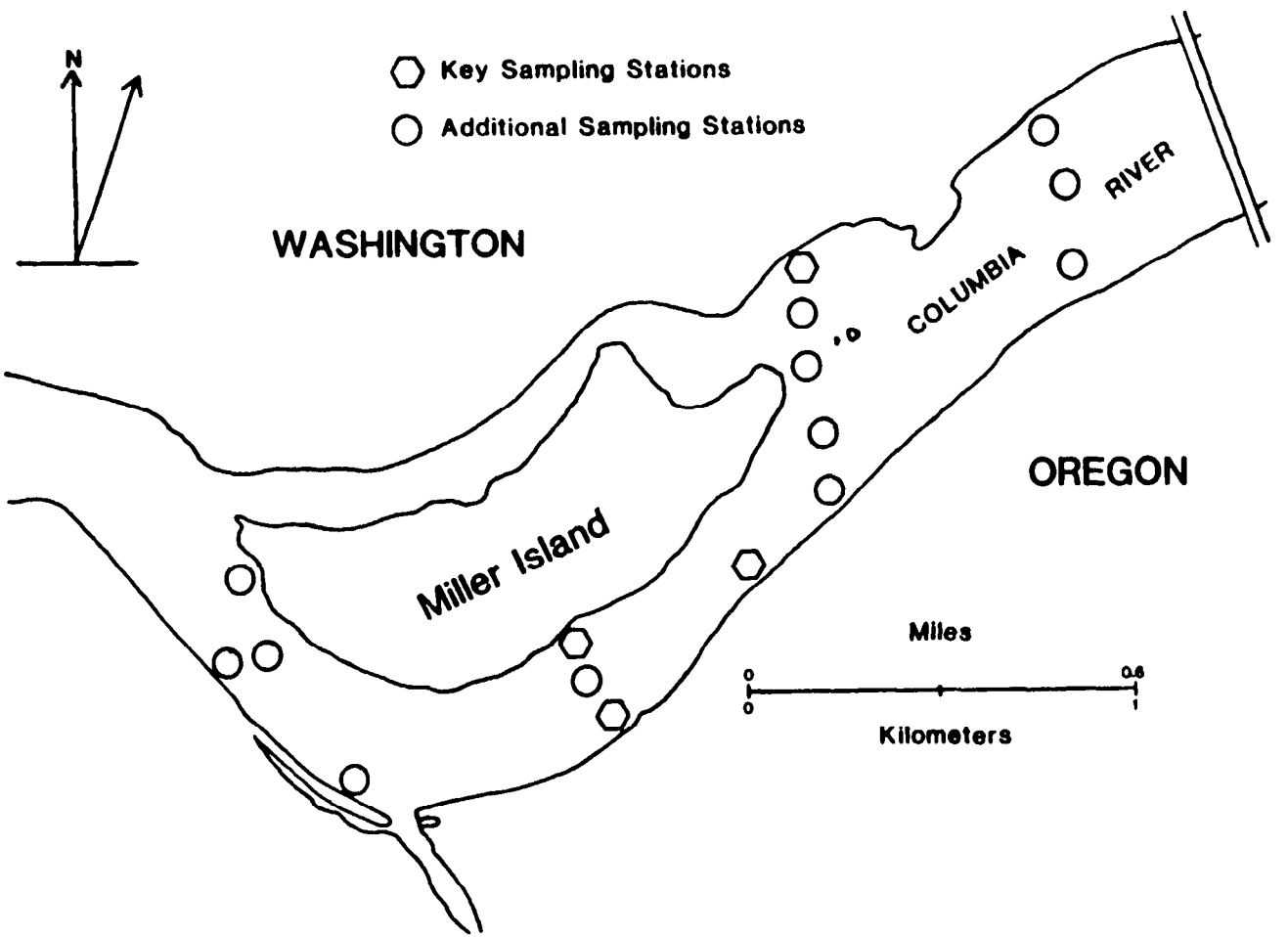

Figure 3. Locations of sampling stations near Miller Island (131,143), 1983.

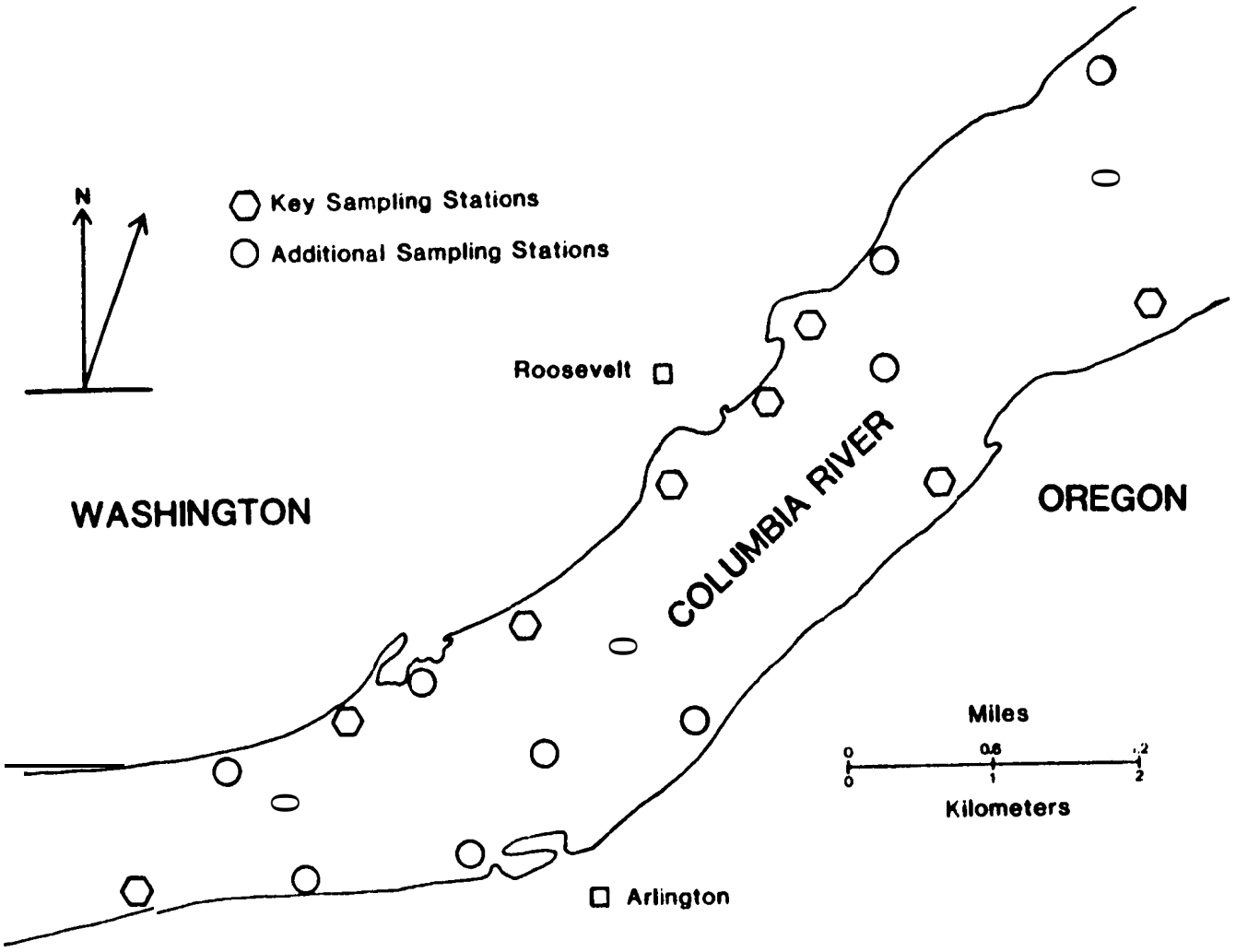

Figure 4. Locations of sampling stations near Arlington (156), 1983.

through September by radio telemetry to determine if they were discrete from northern squawfish collected elsewhere in McNary tailrace. Eight northern squawfish were collected from May 25 to June 24 (Table 1) and radio transmitters were surgically implanted in their body cavities using techniques described by Courtois (1981) and Winter (1983). Fish were held for three days in a covered stock tank to ensure recovery. Each transmitter had a 29-cm long and 0.1-cm diameter antenna which was threaded through the body wall and was allowed to trail alongside the body. Transmitters weighed 16 g in air and were cylindrical, measuring 4.2-cm long and 1.6-cm in diameter. Transmitters were powered by single stage 3.4 volt, 0.5 amp AA lithiun batteries and had *an* expected life of 180 days. Transmitter frequencies ranged from 40.50 to 40.57 MH,.

Radiotagged fish *were* located from boat or shore using peak and null signals. A directional loop antenna was used to get within 10 m of the signal source. Shorter lengths of omnidirectional antenna (ranging in length from 5 to 30 cm) were then used to pinpoint locations of fish within 5 m. Aircraft were used to search for radiotagged fish that could not be located in McNary tailrace. Omnidirectional antennae approximately 1.0-m long were mounted on the wing struts of the plane which then flew alternate sides of the reservoir at 100 mph, 400-800 ft above water level.

Anqler Surveys

Anglers were surveyed in John Day and McNary tailraces to estimate harvest of walleye, northern squawfish and smallmouth bass during sampling and recover marked fish. Surveys were conducted between May 25 and September 6 from John Day and McNary dams to points approximately 15-km and 8-km downriver, respectively. Both weekend days and two randomly selected weekdays were surveyed weekly in each tailrace; all holidays were surveyed (Appendix 8, Table 8.1). Fishing boats and bank anglers were counted from shore at three hour intervals (Appendix B, Table B.2). Starting time was randomly selected from among the first three hours of daylight. Each count was completed in approximately one hour but was considered instantaneous.

Anglers were interviewed to obtain information on effort, species and nunbers of fish kept and released, and species sought (Appendix B, Table 8.3). Walleye, northern squawfish and smallmouth bass were examined for tags, their fork lengths, weights and sex were recorded and scale samples were taken. Bank anglers were interviewed only when no boats were landing. Tag return boxes were placed at access points throughout the reservoir to encourage return of tags by anglers not interviewed.

Laboratory Analysis

Northern squawfish and walleye were collected from McNary tailrace and held at facilities at McNary Dam to assess the effects of capture and marking on their survival. Both species were collected with trap nets, gill nets and electrofishing, while only northern squawfish were collected by angling. Northern squawfish were collected in September and October 1982 and were held for 72 hours in 0.6-m square metal cages immersed in tanks measuring 1.2-m wide x 4.9-m long x 1.1-m deep with 6,307-ml/s inflow. Walleye were collected in May and June 1983 and were held for 72 hours in 630-l stock tanks with 946 ml/s inflow. Fish in poor condition at capture (as described earlier

Table 1. Descriptive data on eight northern squawfish collected, radio tagged and released near the Oregon shore adult fishway at McNary Dam.

Transmitter Frequency (MKZ)	Fork length (mm)	Weight (9)	Capture		Release	
			Date	Location	-Date	Location
40.500	--	--	05/25/83	Entrance	05/30/83	Entrance
40.510	458	1330	06/16/83	Entrance	06/20/83	Entrance
40.520	490	1670	06/16/83	Entrance	06/20/83	Entrance
40.530	483	1360	06/16/83	Entrance	06/20/83	Entrance
20.540	458	1190	06/23/83	Turbines	06/27/83	Entrance
40.550	460	1130	06/23/83	Attraction Water	06/27/83	Entrance
40.560	456	1070	06/23/83	Attraction Water	06/27/83	Entrance
40.570	457	880	06/23/83	Entrance	06/27/83	Entrance

under Capture and Handling) were held but not subjected to further treatment. Fish in good condition were sorted at random and were either held with no further treatment or were measured, weighed and marked as in normal field sampling. In addition, some northern squawfish caught by angling had their stomachs pumped (Gray et al. 1984). Fish were checked daily for mortality. Dissolved oxygen level, temperature and pH were monitored with a YSI model 54RC oxygen-temperature meter and Hach pH kit to insure no confounding changes in water quality.

Data Analysis

Catch Characteristics

Size selectivity of gear for walleye, northern squawfish and smallmouth bass was evaluated to determine whether length-frequency distributions of fish in catches were the same as those of their populations. Chi-square tests based on two-way contingency tables (FREQ procedure, SAS Institute, Inc. 1982a) were used to determine whether length-frequency distributions observed for each species were statistically independent of gear (Snedecor and Cochran 1967). Comparisons were made within John Day and McNary tailraces using catches from stations where at least three gears were used. Observations were grouped from March through June and July through September to minimize confounding effects of growth.

Size specific differences in vulnerability of walleye, northern squawfish and smallmouth bass to all gears combined were examined by treating marked fish at large as populations with known length-frequency distributions. Chi-square tests based on 2x2 contingency tables (FREQ procedure, SAS Institute, Inc. 1982a) were used to determine whether ratios of recaptures to marked fish at large were statistically independent of fish length (Snedecor and Cochran 1967). Marked fish were sorted into two length groups because low numbers of recaptures prevented comparisons if smaller length intervals were used. One group contained fish with fork lengths less than the modal length observed in catches and the other group contained fish with fork lengths equal to, or greater than, the modal length. Comparisons were made using catches from all stations within areas for which abundance estimates were made.

Movements and Distribution

Areas and time periods for which populations of walleye, northern squawfish and smallmouth bass were considered discrete were defined by plotting locations of marking and recapture by date. Plots of locations by date were also used to determine the extent and timing of movements of radiotagged northern squawfish in McNary tailrace

Pooulation Abundance

Population abundances of walleye, northern squawfish and smallmouth bass were estimated using a multiple mark and recapture method (Ricker 1975, Seber 1982). The sampling season was divided into consecutive two-week periods and catches within a period were pooled and treated as a single catch. Marked fish were treated as recaptures only when recovered in periods succeeding those in which they were marked. Estimates are of population abundance at the beginning of the census.

Abundance estimates for walleye, northern squawfish and smallmouth bass were made for three discrete areas, below John Day Dam (John Day tailrace and Miller Island), John Day forebay and upper John Day pool (McNary tailrace and Irrigon-Paterson). Abundance estimates were also made for northern squawfish in the boat restricted zones (BRZ) of John Day and McNary tailraces because USFWS describes food habits of northern squawfish in these areas. Separate abundance estimates were made for two length groups of walleye and northern squawfish below John Day Dam and in upper John Day pool because of differences in their vulnerability to capture.

Minimum lengths of walleye and smallmouth bass used in estimating population abundances were increased by 50 mm after June to compensate for growth and recruitment of smaller fish to taggable size during sampling. No adjustments were made for recruitment of northern squawfish, as growth increments could not be discerned and were thought to be quite small. Growth increments were calculated using length-frequency distributions of catches within areas for which abundance estimates were made (Appendix A, Figures A.l-A.3). Catches were pooled from March through June and July through September and modal lengths thought to correspond to mean lengths of age classes were identified. Growth increments were estimated as differences between modal lengths of corresponding age classes in each period.

Abundance estimates were corrected for known removals during sampling by using the Overton modification of the Schnabel estimator (Overton 1965, Appendix C). Known removals were fish that were killed incidental to sampling, sacrificed by USFWS for food habit studies or harvested by anglers. The number of walleye, northern squawfish and smallmouth bass harvested by anglers was estimated for each two week period used in estimating abundances as the product of estimated angler effort, species specific catch per hour by anglers and the proportion of catch that was killed (Appendix B). The number of marked fish of each species harvested by anglers was estimated as the product of estimated harvest of that species and the proportion of marked fish of that species observed during angler interviews. Estimated numbers of marked fish removed by anglers were compared with observed numbers based on angler interviews, mail returns and tag box returns to verify the accuracy of angler survey estimates.

Survival of marked and unmarked fish held at McNary Dam was compared to determine whether marking affected short term survival. Survival of marked and unmarked fish captured during sampling was compared to determine whether marking affected long term survival. Short term survival of fish in poor and good condition at capture was also compared to determine whether fish likely to die as a result of handling could be distinguished. Comparisons were made using chi-square tests based on 2x2 contingency tables (Snedecor and Cochran 1967). Comparisons using fish held at McNary Dam were made for each gear separately to eliminate gear effects. Comparisons using fish captured during sampling were made for all gear combined because of low sample sizes.

The extent of tag loss by species was determined by comparing the numbers of recaptures with and without tags. Locations of tag scars on recaptured fish without tags distinguished fish originally marked in 1982 from those marked in 1983.

RESULTS

Wall eye

Catch Characteristics

Notable differences existed among gear in numbers and length-frequency distributions of walleye sampled in John Day and McNary tailraces. About 60% of walleye sampled were caught by gillnetting, trapnetting and electrofishing (Table 2). Another 36% of walleye sampled were examined during angler interviews. Most walleye sampled with fork lengths less than or equal to 300 mm were caught by electrofishing (Figure 5). Over 95% of walleye caught in trap nets and all walleye caught in gill nets had fork lengths greater than 300 mm. Statistically significant ($p<0.05$) differences were observed among length-frequency distributions of walleye caught by gillnetting, trapnetting and electrofishing (Table 3).

Size specific differences in vulnerability of walleye to capture were apparent below John Day Dam and in upper John Day pool. Below John Day Dam, the ratio of recaptures to marks at large (Figure 6) for walleye with fork lengths less than or equal to 400 mm was statistically different ($X2= 5.8$, $df= 1$, $p<0.02$) from that of walleye with fork lengths greater than 400 mm. In upper John Day pool, there was a statistical difference ($X^2= 16.5$, $df= 1$, $p<0.01$) between the ratios of recaptures to marks at large for walleye with fork lengths less than or equal to 475 mm and those with fork lengths greater than 475 mm.

Movements and Distribution

Movements of marked walleye between McNary tailrace and Irrigon-Paterson and between John Day tailrace and Miller Island were common (Table 4 and Figure 7). Walleye moved between McNary tailrace and Irrigon-Paterson throughout the sampling season. Limited sampling at Miller Island prevented conclusions about the seasonality of movements between Miller Island and John Day tailrace. Of 154 marked walleye recaptured, only one was recovered outside the pool in which it was marked: a walleye marked and released near Miller Island in April was caught by an angler two months later in The Dalles Dan tailrace, 24-km downriver.

Population Abundance

Estimates of walleye abundance below John Day Dam and in upper John Day pool were 6,877 and 9,463 fish, respectively. Abundance estimates for walleye with fork lengths less than or equal to 400 mm were much less than those for walleye with fork lengths greater than 400 mm (Table 5).

Anglers harvested an estimated 527 walleye in John Day tailrace and an estimated 465 walleye from McNary tailrace from May 25 through September 6 (Table 6). The estimated harvest of marked walleye from John Day tailrace was 13 and from McNary tailrace was 8. Observed harvest of marked walleye was greater than estimated harvest in both tailraces. Anglers seldom harvested walleye with fork lengths less than 400 mm (Figure 8).

Survival of walleye held for 72 hours at McNary Dam was lower for walleye in poor condition at capture than for walleye in good condition at capture

Table 2. Total catch (and catch per hour) of walleye, (>250mm) by gear and location, March-September, 1983. Dashes indicate no effort.

Gear	All	LOCATION							
		Miller Island	John Day tailrace BRZ[a]	John Day tailrace outside BRZ[a]	John Day forebay	Arlington	Irrigon Paterson	McNary tailrace BRZ[a]	McNary tailrace outside BRZ[a]
Bottom gill net	379 (0.45)	2 (0.12)	14 (0.67)	77 (0.77)	0	0	67 (0.53)	0	219 (0.74)
Electrofishing	218 (2.62)	9 (4.50)	1 (0.50)	139 (4.63)	0	--	1 (0.14)	0	68 (2.00)
Trap net	187 (0.02)	--	--	50 (0.02)	0	--	19 (0.02)	--	118 (0.03)
Angling	0	--	--	0	0	--	--	0	0
Surface gill net	2 (0.04)	--	--	--	--	--	--	2 (0.07)	0
Drift gill net	2 (0.13)	--	--	0	--	--	2 (0.29)	--	0
Box traps	0	--	--	0	0	--	--	0	0
USFWS[b] gill net	209	--	2	11	0	--	116	1	79
USFWS[b] Electrofishing	187	--	1	106	0	--	17	0	63
USFWS[b] Trawl	54	--	--	--	--	--	--	--	54
Angler interviews	570	--	--	303	--	--	--	--	267
Totals	**1,808**	**11**	**18**	**686**	**0**	**0**	**222**	**3**	**868**

[a] Boat/restricted zone.
[b] U.S. Fish and Wildlife Service sampling, no effort data was available.

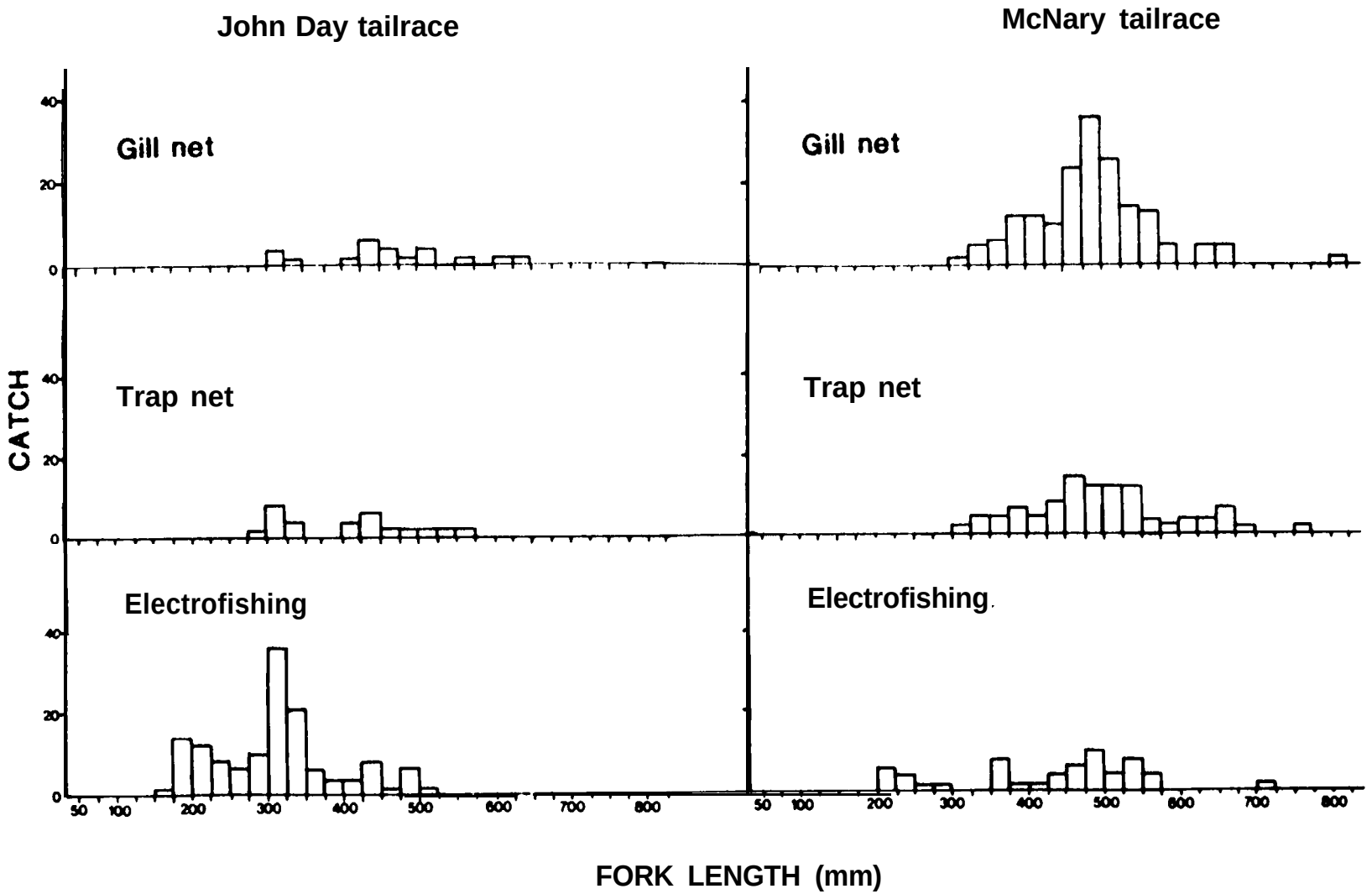

Figure 5 Length-frequency distributions of walleye collected at stations in John Day and McNary tailraces used to compare gear, March-June, 1983. Sample sizes at these stations were too small to compare lengh-frequency distributions from July-September, 1983.

Table 3. Statistical comparisons of length-frequency distributions of walleye caught by gillnetting, trapnetting and electrofishing at stations in John Day and McNary tailraces where all three gear were used, March-June[a], 1983.

Location	Chi-Square Statistic	Degrees of Freedom	Observed Probability Level
Below John Day Da	59.6[b]	6	< 0.01
Upper John Day Pool	69.7	8	< 0.01

[a] Sample sizes were too small for comparisons of length-frequency distributions from July-September 1983.

[b] Chi-square may not be a valid test because 25% of cells had expected counts less than 5.

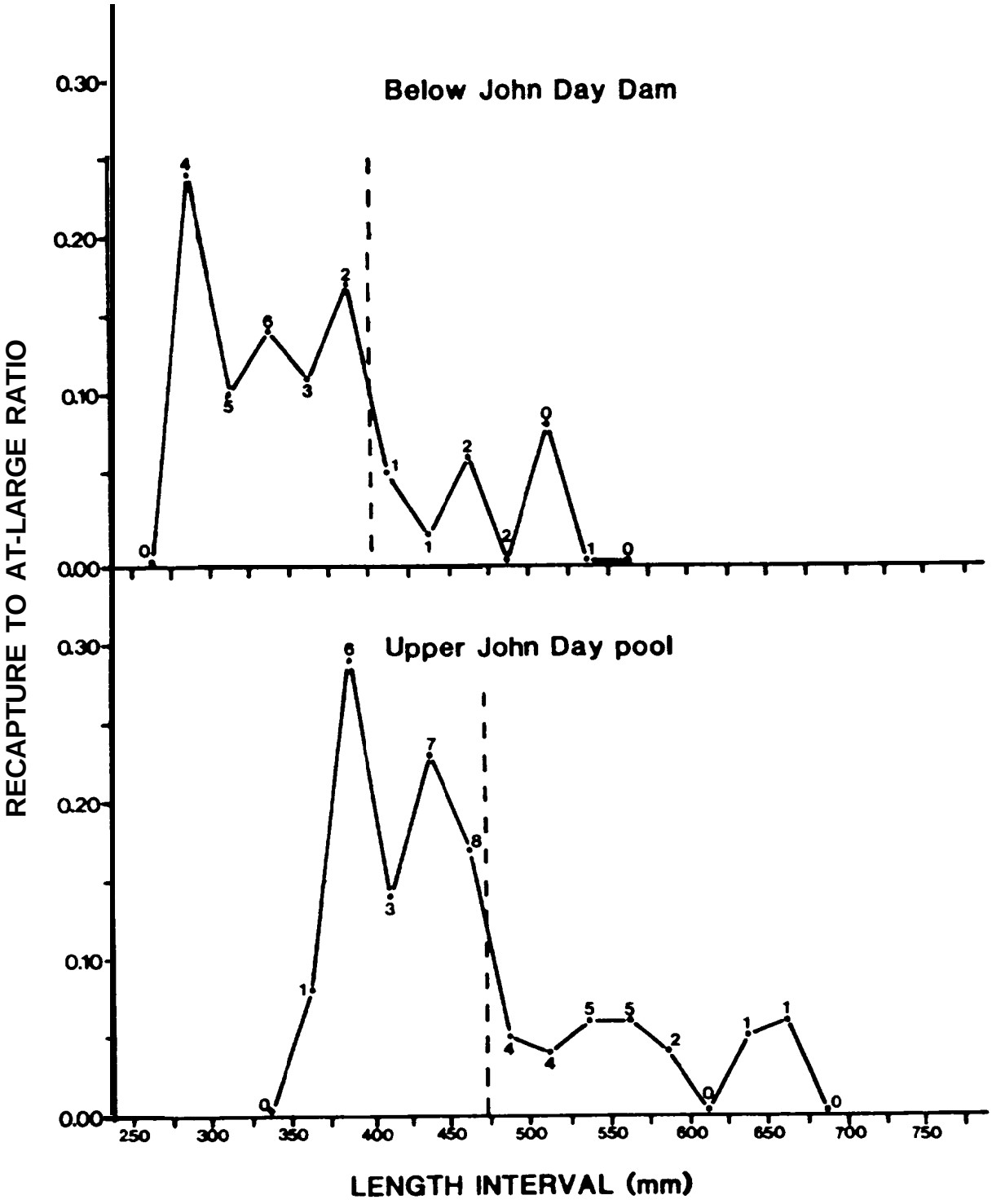

Figure 6. Ratios of recaptures to marks at large (vulnerability) for walleye by length interval and location, March-September, 1983. Total recaptures within a length interval is above each point. Dashed lines indicate modal lengths observed in the catch.

Table 4. Numbers of marked walleye released and recovered by location, March-September, 1983.

Location Released	Number Released	Location Recovered									
		A	B	C	D	E	F	G	H	I	J
A. Miller Island	11	5	--	--	--	--	--	--	--	--	1[a]
B. John Day tailrace	325	8	63	--	--	--	--	--	--	--	--
C. John Day tailrace BRZ[c]	18	--	1	0	--	--	--	--	--	--	--
D. John Day forebay	0	--	--	--	0	--	--	--	--	--	--
E. Arlington	0	--	--	--	--	0	--	--	--	--	--
F. Irrigon-Paterson	148	--	--	--	--	--	6	5	--	--	--
G. McNary tailrdce	471	--	--	--	--	--	12	51	1	--	2[b]
H. Mcnary tailrace BRZ	9	--	--	--	--	--	--	--	0	--	--
I. McNary forebay	0	--	--	--	--	--	--	--	--	0	--
J. Other	0	--	--	--	--	--	--	--	--	--	0

[a] The Dalles tailrace
[b] Blalock Islands, W. of Paterson
[c] Boat restricted zone.

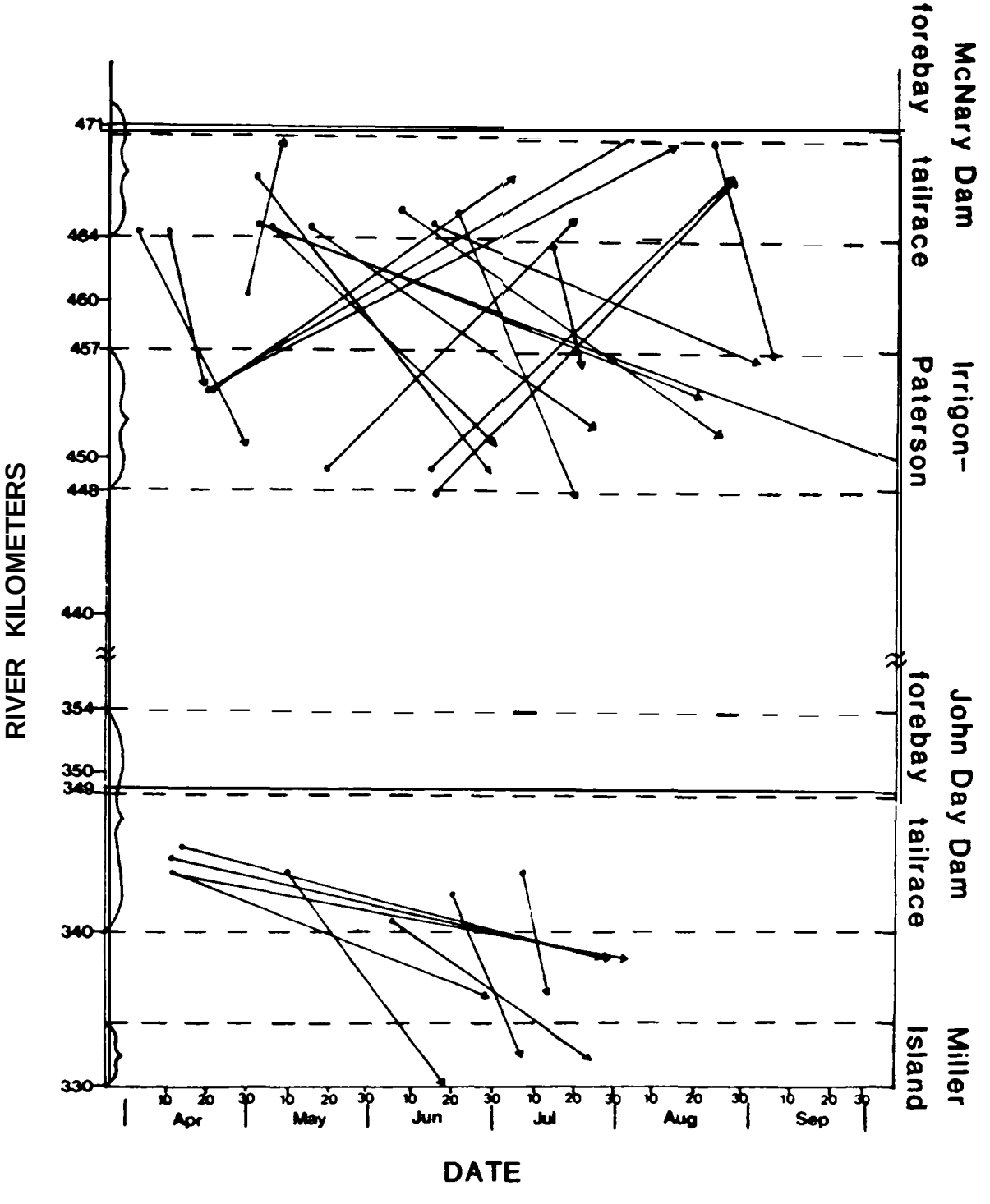

Figure 7. Locations and dates of releases and recoveries of marked walleye recovered in locations other than where marked, 1983. Areas sampled are indicated by brackets.

Table 5. Estimated abundance of walleye based on multiple mark and recapture survey and Overton's (1965) estimator, 1983.

Location	Time Interval	Length Interval (mn)	Estimate	95% Confidence Limits Lower	Upper
Below John Day Dam	Apr 10-Sep 24	250-400	963	615	1,544
		>400	5,914	2,484	16,064
		Total	6,877		
Upper John Day pool	Mar 27-Sep 24	250-475	1,143	765	1,737
		>475	8,320	5,310	13,343
		Total	9,463		

Table 6. Estimated and observed numbers of unmarked and marked walleye harvested by anglers, May 25 - September 6, 1983.

Location	Period I1	I2	I3	I4	I5	I6	I7	I8	Sum
John Day tailrace									
Unmarked									
Estimated	54	59	70	52	40	167	46	26	514
Observed	18	24	61	47	22	63	37	14	286
Marked									
Estimated	0	0	4	5	0	3	1	0	13
Observed	2	3	10	5	8	5	4	2	39
McNary tailrace									
Unmarked									
Estimated	141	8	0	38	30	81	115	44	457
Observed	14	4	0	24	20	56	94	50	262
Marked									
Estimated	0	0	0	0	3	1	1	3	8
Observed	0	0	1	2	1	2	4	0	10

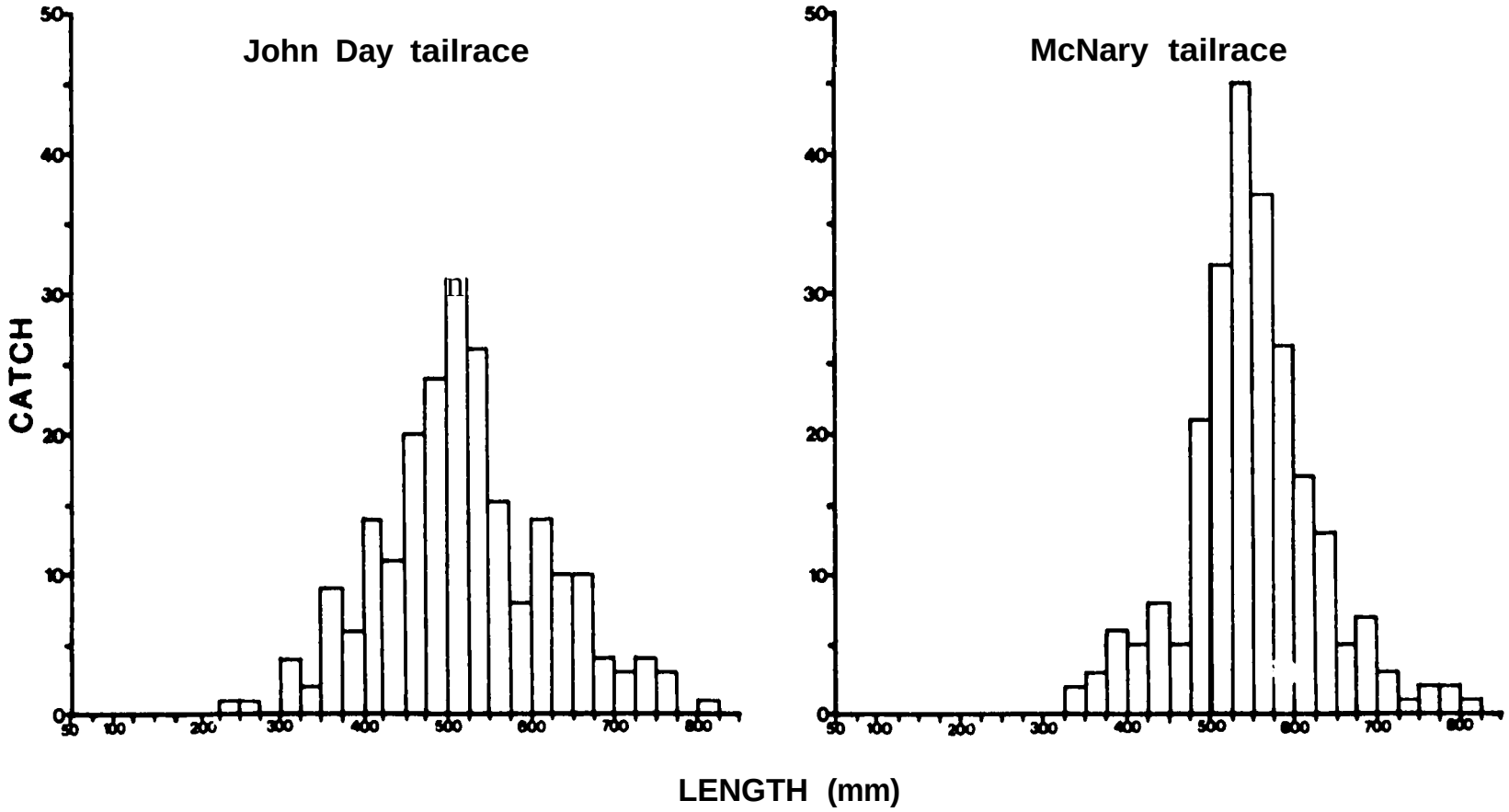

Figure 8. Length-frequency distributions of walleye harvested by anglers in John Day and McNary tailraces, Hay 25-September 6, 1983.

(Table 7). Marked walleye did not appear more likely to die than unmarked walleye over 72 hours Survival of unmarked and marked walleye captured during field sampling did not differ statistically (x^2 = 2.2, df= 1, p= 0.13).

None of 74 walleye recaptured during sampling had lost its tag.

Northern Squawfish

Catch Characteristics

Differences wrong gear in numbers and length-frequency distributions of northern squawfish sampled in John Day and McNary tailraces were similar to those observed for walleye. About 64% of northern squawfish sampled were caught by gillnetting, trapnetting and electrofishing (Table 8). Another 18% of northern squawfish sampled were caught by angling from John Day and NcNary dams. An additional 16% of northern squawfish sampled were examined during angler interviews. A disproportionate number of northern squawfish with fork lengths less than 200 mm were caught by electrofishing, when compared to trapnetting and gillnetting in John Day and McNary tailraces (Figures 9 and 10) OF to angling and gillnetting in McNary tailrace BRZ (Figure 11). Statistically significant ($p<0.05$) differences in length frequency distributions of northern squawfish among gear were observed in John Day tailrace and McNary tailrace BRZ (Table 9).

Size specific diffferences in vulnerability of northern squawfish to capture *were* apparent below John Day Dam, in upper John Day pool and in the McNary tailrace BRZ (Figure 12). Size specific differences in the ratio of recaptures to marks at large were Statistically Significant ($p<0.05$) Only in the McNary tailrace BRZ.

Movements and Distribution

Movements of marked northern squawfish between John Day tailrace and Miller Island and between McNary tailrace and Irrigon-Paterson were observed (Table 10 and Figure 13). Movements of marked northern squawfish between tailrace stations located in and out of the BRZ's were also observed. As with walleye, limited sampling at Miller Island prevented conclusions about the seasonality of movements of northern squawfish between Miller Island and John Day tailrace. However, marked northern squawfish moved between McNary tailrace and Irrigon-Paterson throughout the sampling season. Within John Day and McNary tailraces, many northern squawfish marked at stations outside the BRZ in April and May were subsequently recaptured at stations inside the BRZ in July and August. Of 179 marked northern squawfish recaptured, three were recovered outside the pool in which they were released. One northern squawfish released in McNary forebay was recovered in McNary tailrace. Two northern squawfish released in McNary tailrace were recovered in John Day tailrace, 115-km downriver.

Seven of eight northern squawfish radio tagged and released at the central entrance of the Oregon shore adult fishway inside the McNary tailrace BRZ were observed to leave the BRZ (Figure 14). The eighth (40.570) was lost. One NORTHERN squawfish (40.550) moved 53-km downriver. Another (40.530) TRAVELED to McNary forebay Only one northern squawfish (40.520) was observed to return to McNary tailrace BRZ after leaving, although 40.530 moved through the

Table 7. Survival of walleye held for 72 hours at McNary Dam by treatment, May and June, 1983.

Gear/Condition at Capture	Treatment			
	Control		Marked	
	Survivors	Mortalities	Survivors	Mortalitites
Gill net				
Good	6	0	6	0
Poor	**0**	3	0	0
Trap net				
Good	**16**	**0**	**5**	**0**
Poor	**0**	**0**	**0**	**0**
Electrofishing				
Good	5	0	6	**0**
Poor	**0**	1	0	**0**

fable 8. Total catch (and catch per hour) of northern squawfish (>250mm) by gear and locatton, March-September, 1983. Dashes Indicate no effort.

Gear	All	Miller Island	John Day tailrace BRZ[a]	John Day tailrace outside BRZ[a]	John Day forebay	Arlington	Irrigon Paterson	McNary tailrace BRZ[a]	McNary tailrace outside BRZ[a]
	LOCATION								
Bottom gill net	1,330 (1.58)	18 (1.06)	34 (1.62)	601 (2.09)	64 (1.02)	21 (0.91)	76 (0.60)	8 (0.89)	508 (1.72)
Electrofishing	565 (6.89)	14 (7.00)	12 (8.00)	90 (3.00)	71 (1.83)	--	24 (3.43)	200 (50.0)	154 (4.53)
Trap net	738 (0.09)	--	--	253 (0.08)	33 (0.14)	--	82 (0.07)	--	370 (0.10)
Angling	1,102 (2.27)	--	98 (1.10)	26 (1.08)	35 (0.37)	--	--	929 (3.40)	14 (2.80)
Surface gill net	78 (2.29)	--	--	--	--	--	--	68 (2.34)	10 (0.50)
Drlft gill net	5 (0.36)	--	--	1 (0.50)	--	--	0	--	4 (0.80)
Box traps	13 (0.005)	--	--	1 (0.001)	1 (0.001)	--	--	4 (0.01)	7 (0.01)
USFWS[b] net	37	--	1	18	0	--	1	1	16
USFWS[b] Electrofis/gill	1,623	--	176	601	389	--	39	226	192
USFWS[b] Trawl	24	--	--	--	--	--	--	--	24
Angler interviews	908	--	--	679	--	--	--		229
Totals	6,423	32	321	2,270	593	21	222	1.436	1,528

a Boat/restricted zone.
b U.S. Fish and Wildlife Service sampling, no effort data was available.

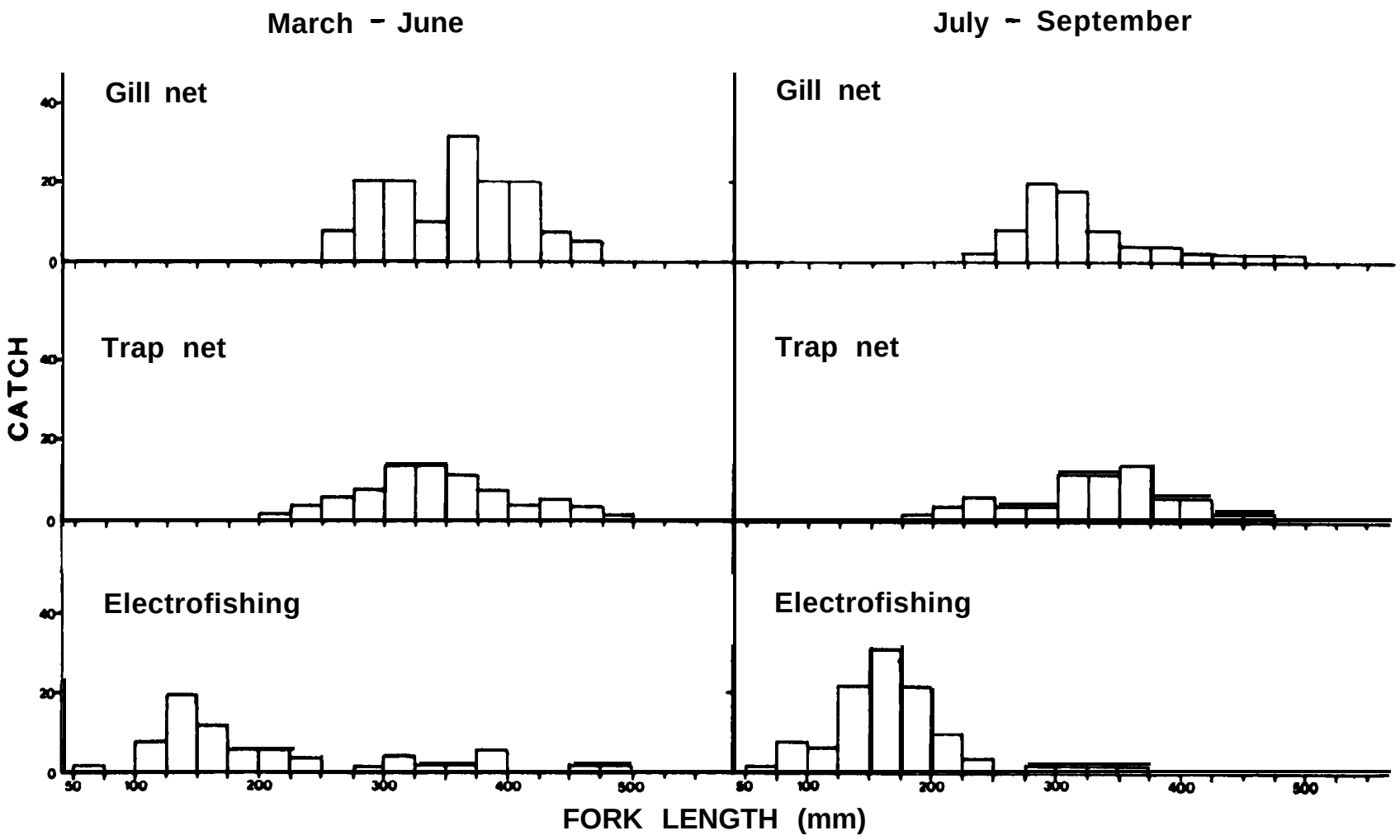

Figure 9. Length-frequency distributions of northern squawfish collected at stations in John Day tailrace used to compare gear, 1983.

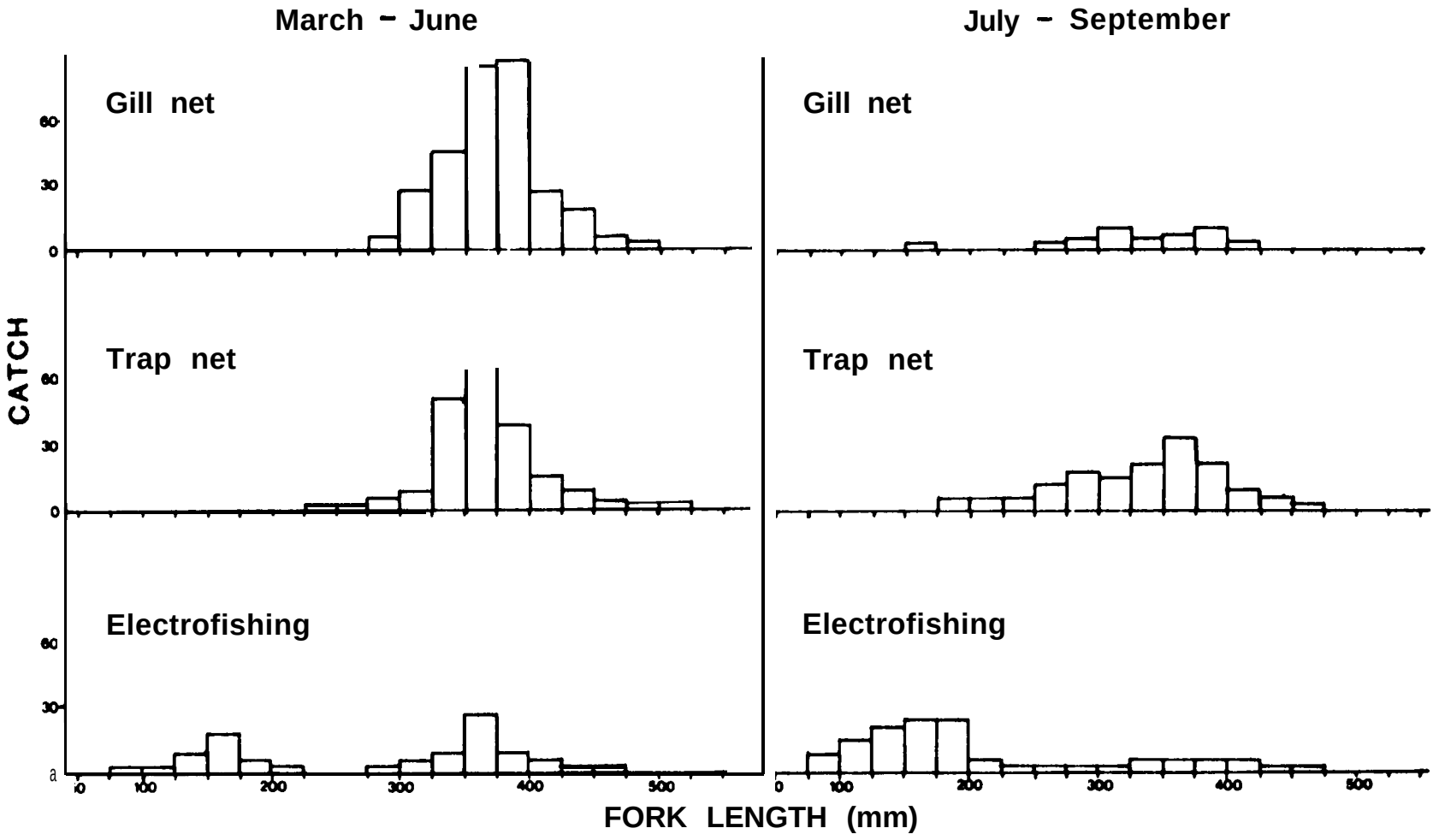

Figure 10. Length-frequency distributions of northern squawfish collected at stations in McNary tailrace used to compare gear, 1983.

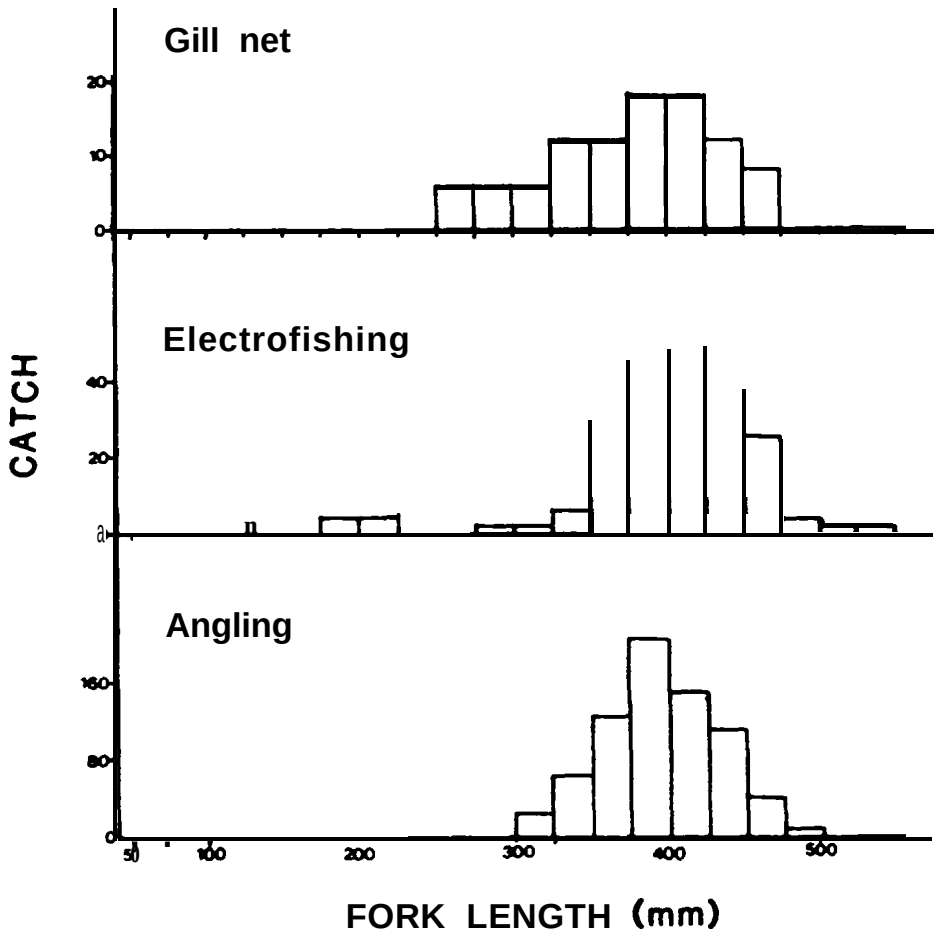

Figure 11. Length-frequency distributions of northern squawfish collected at stations in McNary tailrace boat restricts5 zone used to compare gear, July-September, 1983.

Table 9. Statistical comparisons of length-frequency distributions of northern squawfish caught by gillnetting (GN), trapnetting (TN), electrofishing (EF) and angling (AN) at stations in John Day tailrace, McNary tailrace and McNary tailrace boat-restricted-zone (BRZ) used to compare gear, 1983.

Location/Period	Gear	Chi-square Statistic	Degrees of Freedom	Observed Probability Level
John Day tailrace				
March- June	GN, TN, EF	189 .O	8	<0.01
July-September	GN, TN, EF	218.1	8	<0.01
McNary tailrace				
March-June	GN, TN, EF	22.0	14	0.08
July-September	GN, TN, EF	8.7	6	0.19
McNary tailrace BRZ				
July-September	GN, EF, AN	79.4	16	<0.01

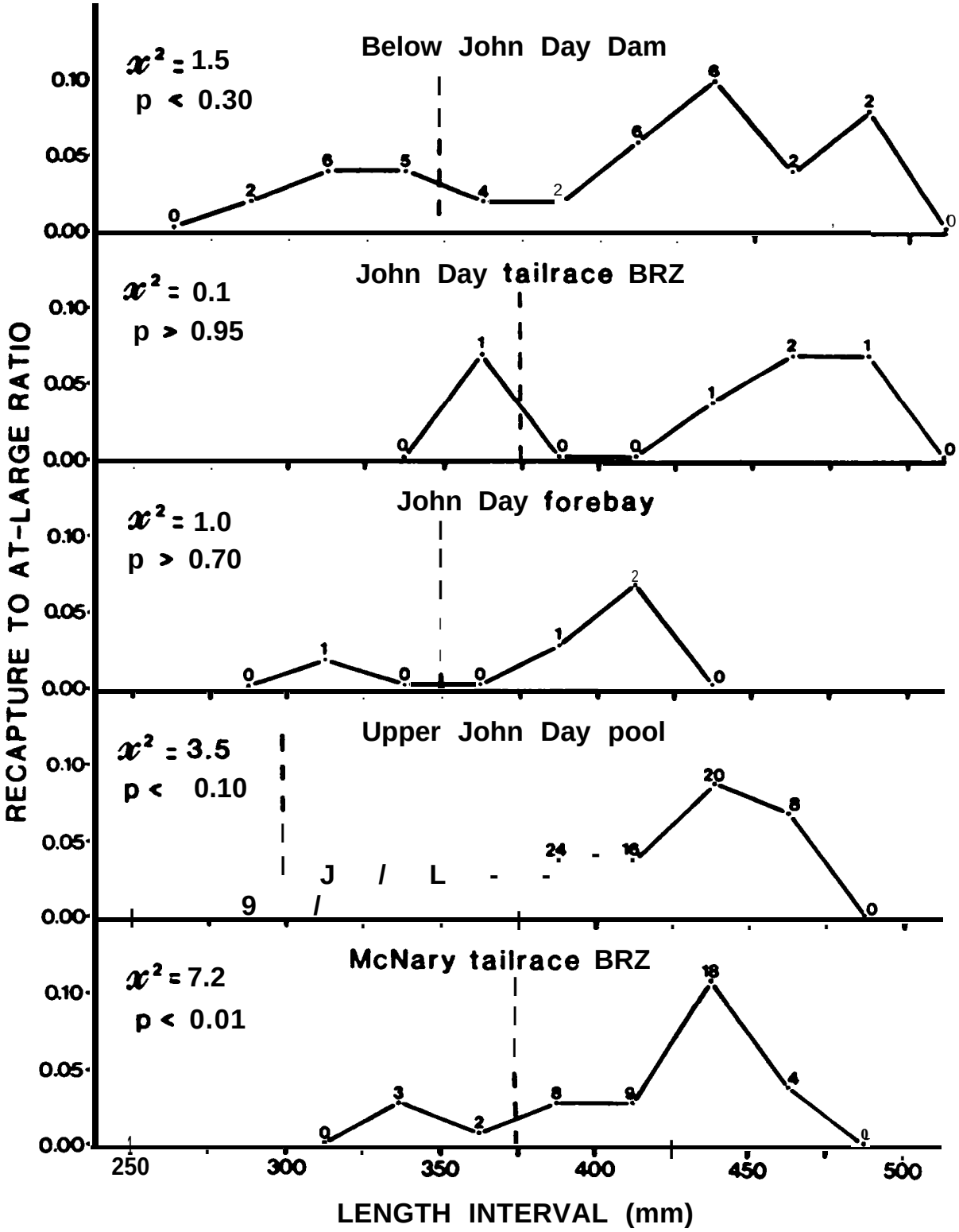

Figure 12. Ratios of recaptures to marks at large (vulnerability) for northern squawfish by length interval and location, March to September, 1983. Total recaptures within a length interval is above each point. Dashed lines indicate modal lengths observed in the catch. Chi-square values and observed probabilities for tests for independence between vulnerability and length above and below modal lengths are shown at left. BRZ is boat restricted tone.

Table 10. Numbers of marked northern squawfish released and recovered by location, March-September, 1983.

Location Released	Number Released	Location Recovered								
		A	8	C	D	t	F	G	H	I
A. Miller Island	28	0	--	--	--	--	--	--	--	--
B. John Day tailrace	824	1	33	4	--	--	--	--	--	--
c. John Day tailrace BRZ[a]	137	--	1	5	--	--	--	--	--	--
D. John Day forebay	187	--	--	--	8	--	--	--	--	--
E. Arlington	18	--	--	--	--	0	--	--	--	--
F. Irrigon-Paterson	164	--	--	--	--	--	1	1	--	--
G. McNary tailrace	949	--	2	--	--	--	2	41	12	--
H. McNary tailrace BRZ	1,143	--	--	--	--	--	--	13	49	--
I. McNary forebay	33	--	--	--	--	--	--	--	1	0

[a] Boat restricted zone.

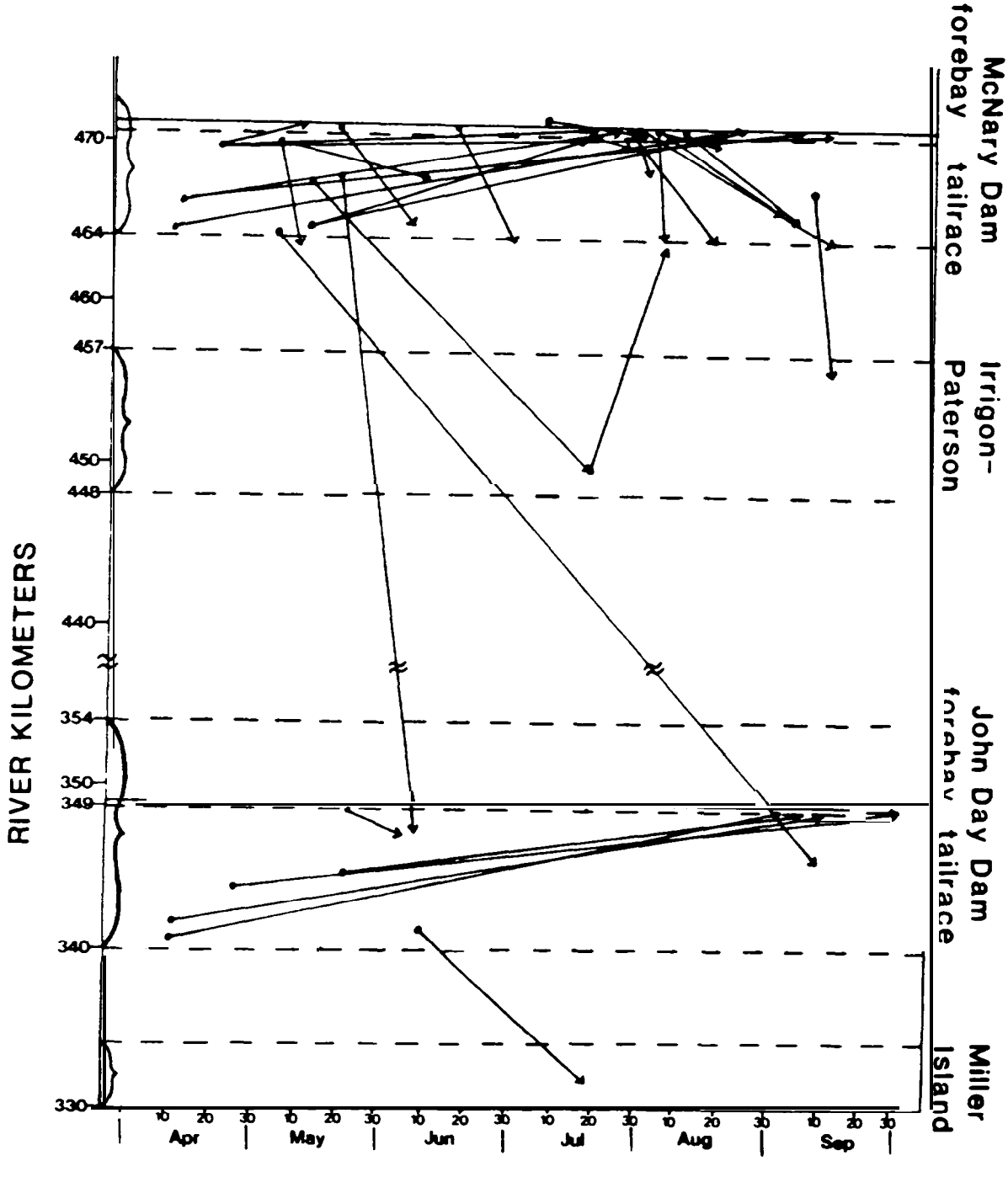

Figure 13. Locations and dates of releases and recoveries of marked northern squawfish recovered in locations other than where marked, 1983. Areas sampled are indicated by brackets.

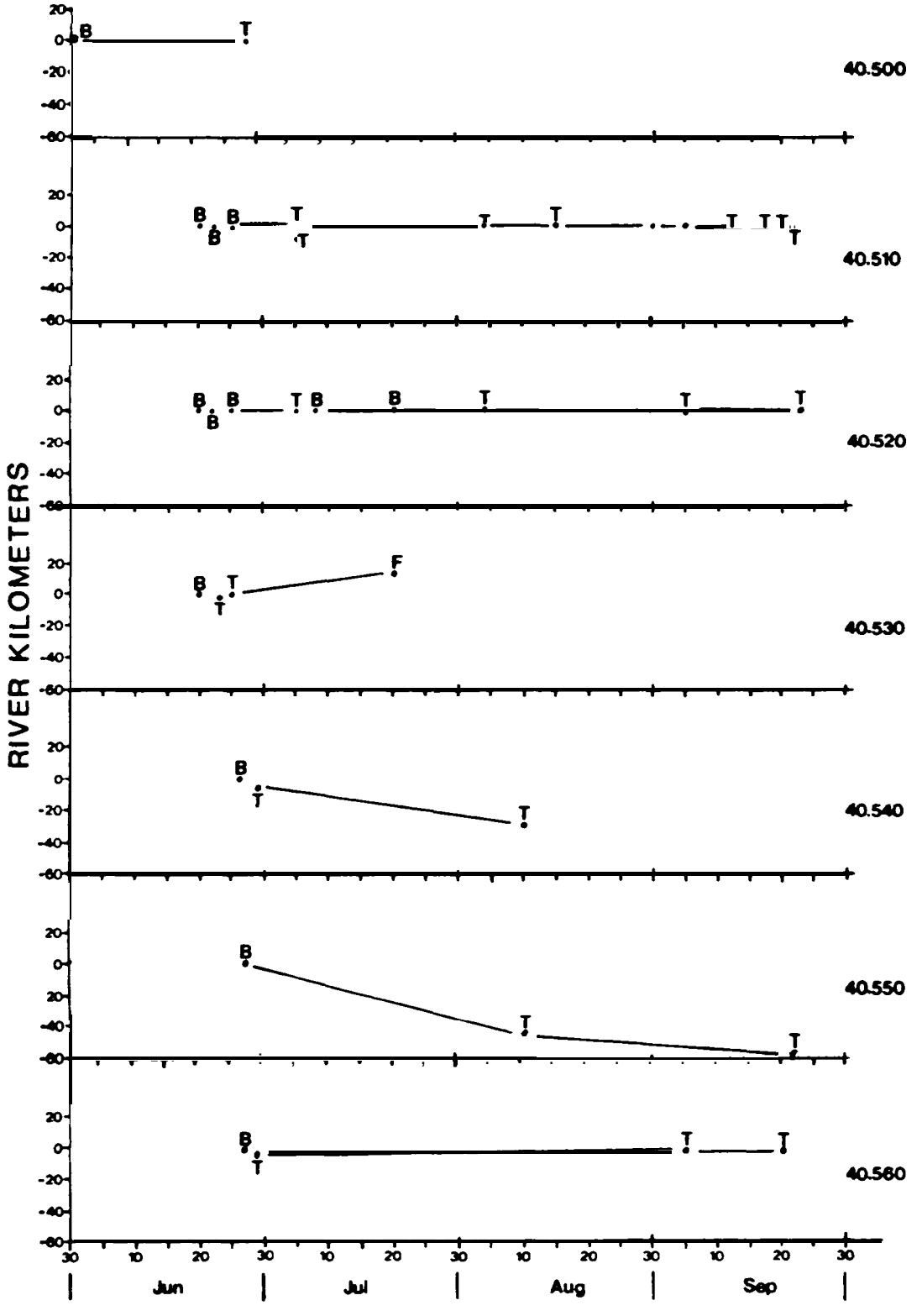

Figure 14. Distance traveled from release site by 7 radiotagged northern squawf i sh released in McNary tailrace boat restricted zone (B) and later observed in McNary tai l race (T) or McNa ry forebay (F), 1983. The transmi tter frequency (MHZ) is noted for each fish.

BRZ when it traveled from its location in the tailrace outside the BRZ to McNary forebay. In 5 of 7 cases, movements by northern squawfish out of the BRZ occurred within two weeks of release.

Population Abundance

Estimates of northern squawfish abundance below John Day Dam and in upper John Day pool were 32,126 and 27,771 fish, respectively (Table 11). An additional 10,841 northern squawfish were estimated to reside in John Day forebay.

Angler harvest of northern squawfish from May 25 through September 6 was much greater in John Day tailrace than in McNary tailrace (Table 12). The estimated harvest of marked northern squawfish was consistently less than observed harvest. Most northern squawfish harvested in John Day tailrace had fork lengths greater than 350 mn and in McNary tailrace had fork lengths greater than 300 mm (Figure 15).

Survival of northern squawfish held for 72 hours at McNary Dam was high for northern squawfish in good condition at capture (Table 13). Both northern squawfish in poor condition at capture died. Northern squawfish that were marked or were marked and stomach-pumped did not appear more likely to die than unmarked northern squawfish. Mortality of unmarked northern squawfish captured during field sampling was statistically ($p<0.05$) different ($\chi^2 = 3.9$, $df = 1$, $p = 0.047$) than that of marked northern squawfish; unmarked fish were more likely to die than were marked fish.

Three of 137 northern squawfish recaptured during sampling had lost their tags.

Smallmouth Bass

Catch Characteristics

Differences were observed among gear in the numbers of smallmouth bass sampled in John Day and McNary tailraces (Table 14). Approximately 59% of smallmouth bass sampled were caught by electrofishing. Another 31% of smallmouth bass sampled were examined during angler interviews. Only about 2% of smallmouth bass sampled were collected in gill nets. John Day tailrace was the only area in which smallmouth bass were collected with more than one gear at stations used to compare gear. However, catches were not large enough to enable statistical comparisons of length-frequency distributions. Trapnetting and electrofishing sampled smallmouth bass in the same length range, although electrofishing captured more smaller fish (Figure 16).

Vulnerability of smallmouth bass to capture did not appear related to size. Fish appeared fully recruited to gear at or below minimum taggable length (Figure 17).

Movements and Distribution

Marked smallmouth bass moved between John Day tailrace and Miller Island, and McNary tailrace and Irrigon-Paterson (Table 15 and Figure 18). No seasonal trends in movements were evident among the small number of smallmouth bass

Table 11. Estimated abundance of northern squawfish, based on multiple mark and recapture survey and Overton's (1965) estimator.

Location	Time Interval	Length Interval (mm)	Estimate	95% Confidence Limits Lower	Upper
Below John Day Dam					
	Mar 27-Sep 24	250-350	16,232	9,090	30,225
		>350	15,894	10,144	25,491
John Day tailrace BRZ[a]					
	Jul 17-Sep 24	>250	3,457	954	10,205
John Day forebay					
	Mar 27-Sep 24	,250	10,841	3,903	25,239
Upper John Day pool					
	Mar 27-Sep 24	250-300[b]	--	--	
		>300	27,771	23,050	345159
McNary tailrace BRZ					
	Mar 27-Jul 02	>250	7,080	1,954	20 ,900
	Jul 03-Sep 24	>250	15,241	10,366	21,376

[a] Boat restricted zone
b No squawfish in this length range were recaptured

Table 12. Estimated and observed numbers of unmarked and marked northern squawfish harvested by anglers, May 25 - September 6, 1983.

Location	Period 11	12	13	14	15	16	17	18	Sum
John Day tailrace									
Unmarked									
Estimated	80	162	237	174	97	191	53	17	963
Observed	12	50	55	87	38	81		5	331
Marked									
Estimated	0	0	6	0	0	0	0	0	6
Observed	0	0	2	1	3	0	1	1	8
McNary tail race									
Unmarked									
Estimated	14	5	27	27	11	2	2	0	88
Observed	2	4	4	8	4	2	3	0	27
Marked									
Estimated	0	0	0	0	0	0	1	0	1
Observed	2	1	0	1	0	0	1	0	5

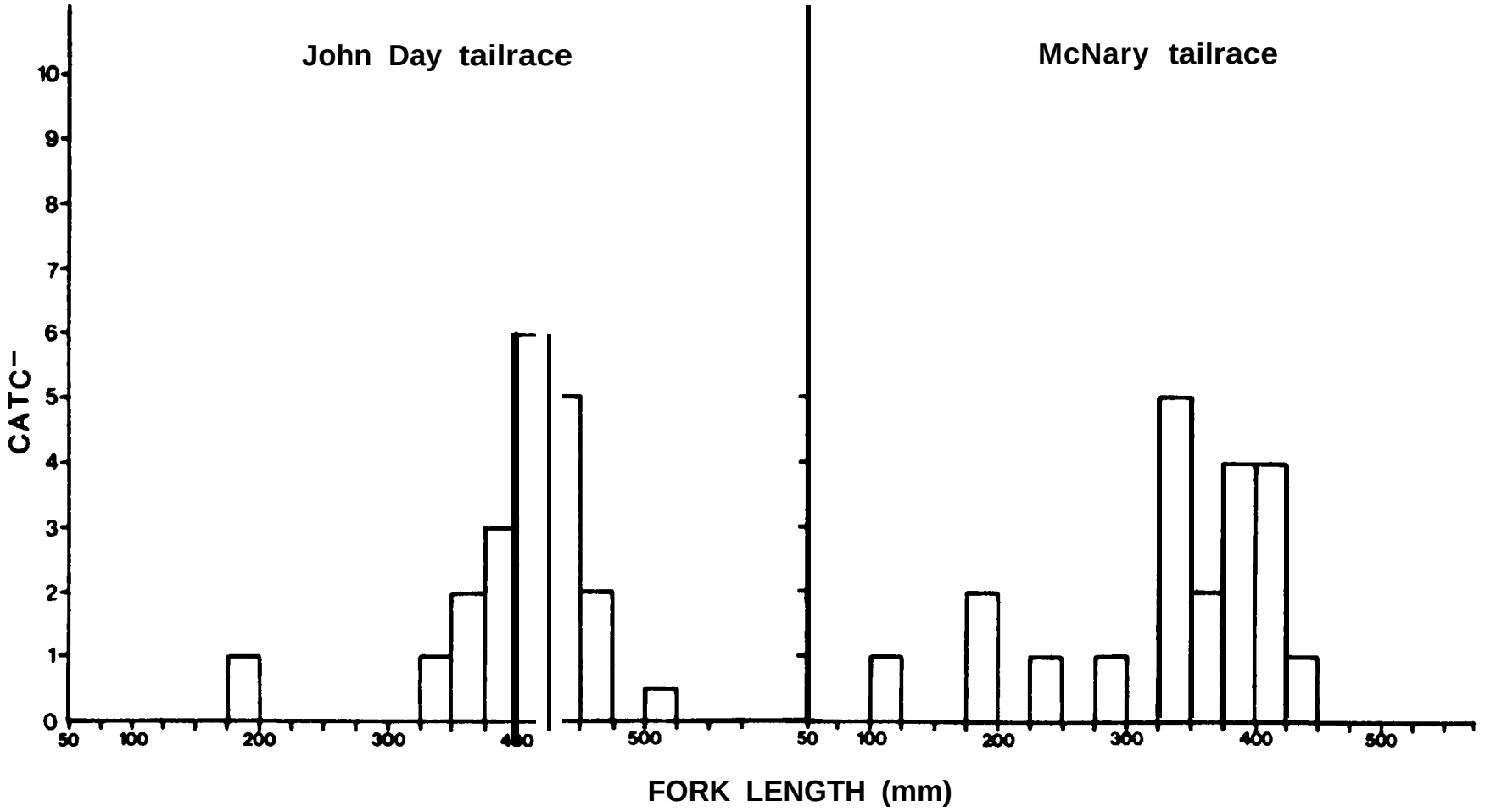

Figure 15. Length-frequency distributions of northern squawfish harvested by anglers in John Day and McNary tailraces, May 25-September 6, 1983.

Table 13. Survival of northern squawfish held for 72 hours at McNary Dam by treatment, September and October, 1982.

Gear/Condition at Capture	Treatment					
	Control		Marked		Marked and Stomach-pumped	
	Survivors	Mortalities	Survivors	Mortalities	Survivors	Mortalities
Gill net						
Good	3	0	7	0		
Poor	**0**	**0**	**0**	1		
Trap net						
Good			8	0		
Poor			**0**	0		
tlectrofishing						
Good	3	0	9	0		
Poor	**0**	**0**	**0**	**0**		
Angling						
Good	45	0	15	0	12	0
Poor	0	1	0	0	0	0

Table 14. Total catch (and catch per hour) of smallmouth bass (>200mm) by gear and location, March-September, 1983. Dashes Indicate no effort.

Gear	All	Miller Island	John Day tailrace BRZ[a]	John Day tailrace outside BRZ[a]	John Day forebay	Arlington	Irrigon Paterson	McNary tailrace BRZ[a]	McNary tailrace outside BRZ[a]
			LOCATION						
Bottom gill net	16 (0.02)	0	0	6 (0.02)	1 (0.02)	0	7 (0.06)	0	2 (0.01)
Electrofishing	189 (2.28)	1 (0.05)	0	88 (2.93)	35 (5.83)	--	17 (2.43)	0	48 (1.41)
Trap net	40 (0.004)	--	--	21 (0.010)	1 (0.004)	--	15 (0.010)	--	3 (0.001)
Angling	1 (0.002)	--	0	0	1 (0.01)	--	--	0	0
Surface gill net	0	--	--	--	--	--	--	0	0
Drift gill net	0	--	--	0	--	--	0	--	0
Box traps	0	--	--	0	0	--	--	0	0
USFWS[b] gill net	29	--	0	0	0	--	27	0	2
USFWS[b]	557	--	0	90	175	--	254	6	32
USFWS[b] Electrofishing Trawl	4	--	--	--	--	--	--	--	4
Angler Interviews	138	--	--	57	--	--	--	--	81
Totals	974	1	0	262	213	0	320	6	172

a Boat-restricted zone.
b U.S. Fish and Wildlife Service sampling, no effort data was available.

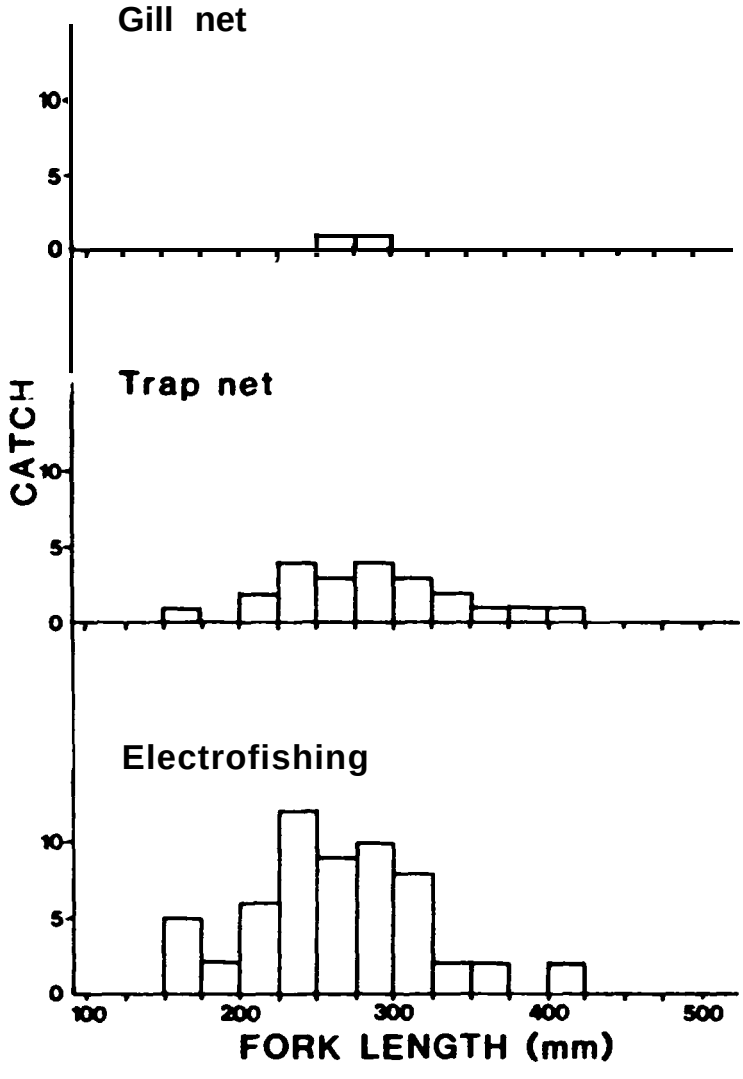

Figure 16. Length-frequency distributions of smallmouth bass collected at stations in John Day tailrace used to compare gear, March-June, 1983.

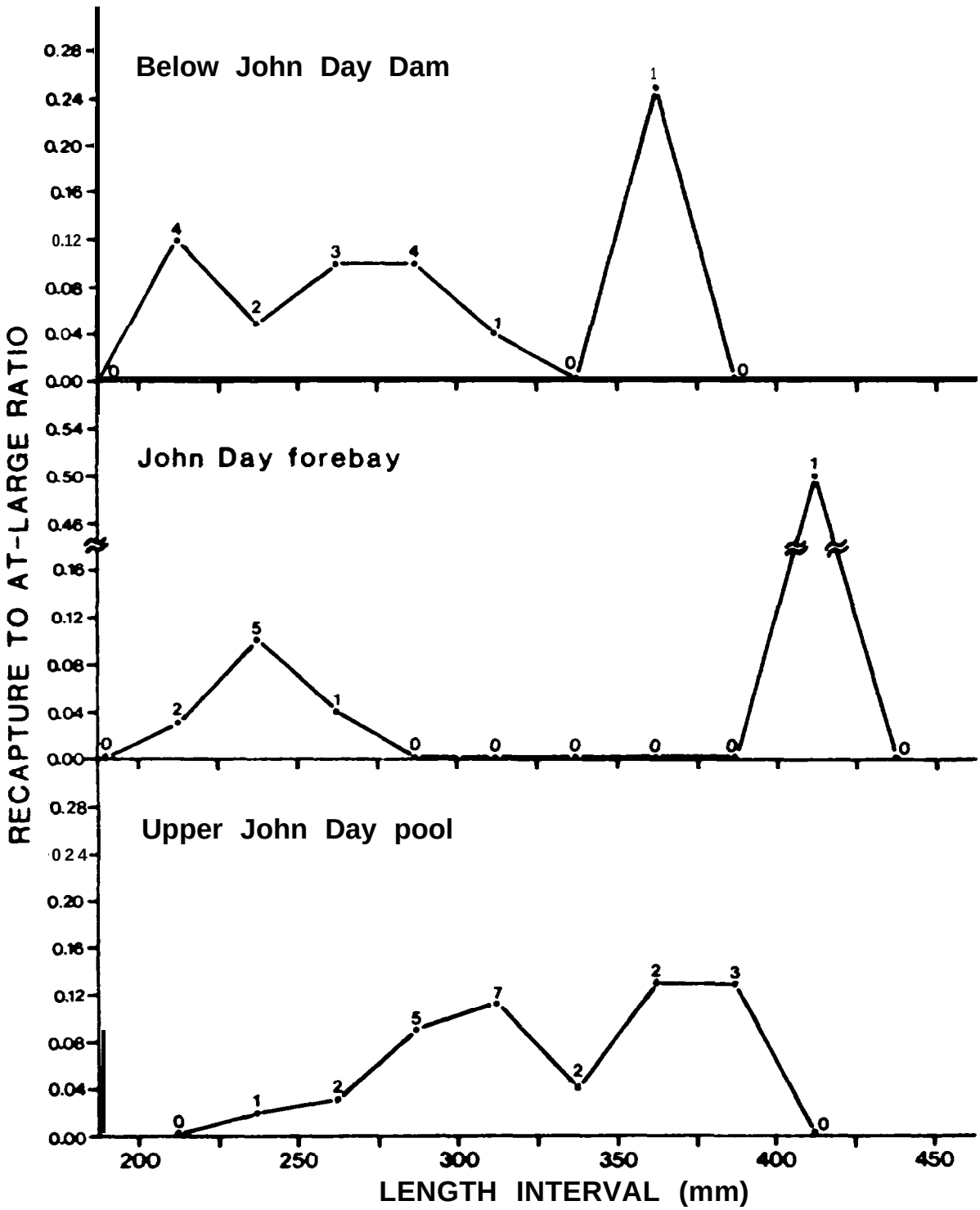

Figure 17. Ratios of recaptures to marks at large (vulnerability) for smallmouth bass by length interval and location, March-September, 1983. Total recaptures within a length interval is by each point.

Table 15. **Numbers of marked smallmouth bass released and recovered by location, March-September,** 1983.

Location Released	Number Released	Location Recovered								
		A	B	C	D	t	F	G	H	I
A. Miller Island	1	0	--	--	--	--	--	--	--	--
B. John Day tailrace	189	1	31	3	--	--	--	--	--	--
C. John Day tailrace BRZ[a]	1	--	--	0	--	--	--	--	--	--
D. John Day forebay	195	--	1	--	28	--	--	--	--	--
E. Arlington	0	--	--	--	--	0	--	--	--	--
F. Irrigon-Paterson	259	--	--	--	1	--	38	2	--	--
G. McNary tailrace	83	--	--	--	--	--	--	13	--	--
H. McNary tailrace BRZ	9	--	--	--	--	--	--	1	0	--
I. McNary forebay	0	--	--	--	--	--	--	--	--	0

a Boat restricted zone.

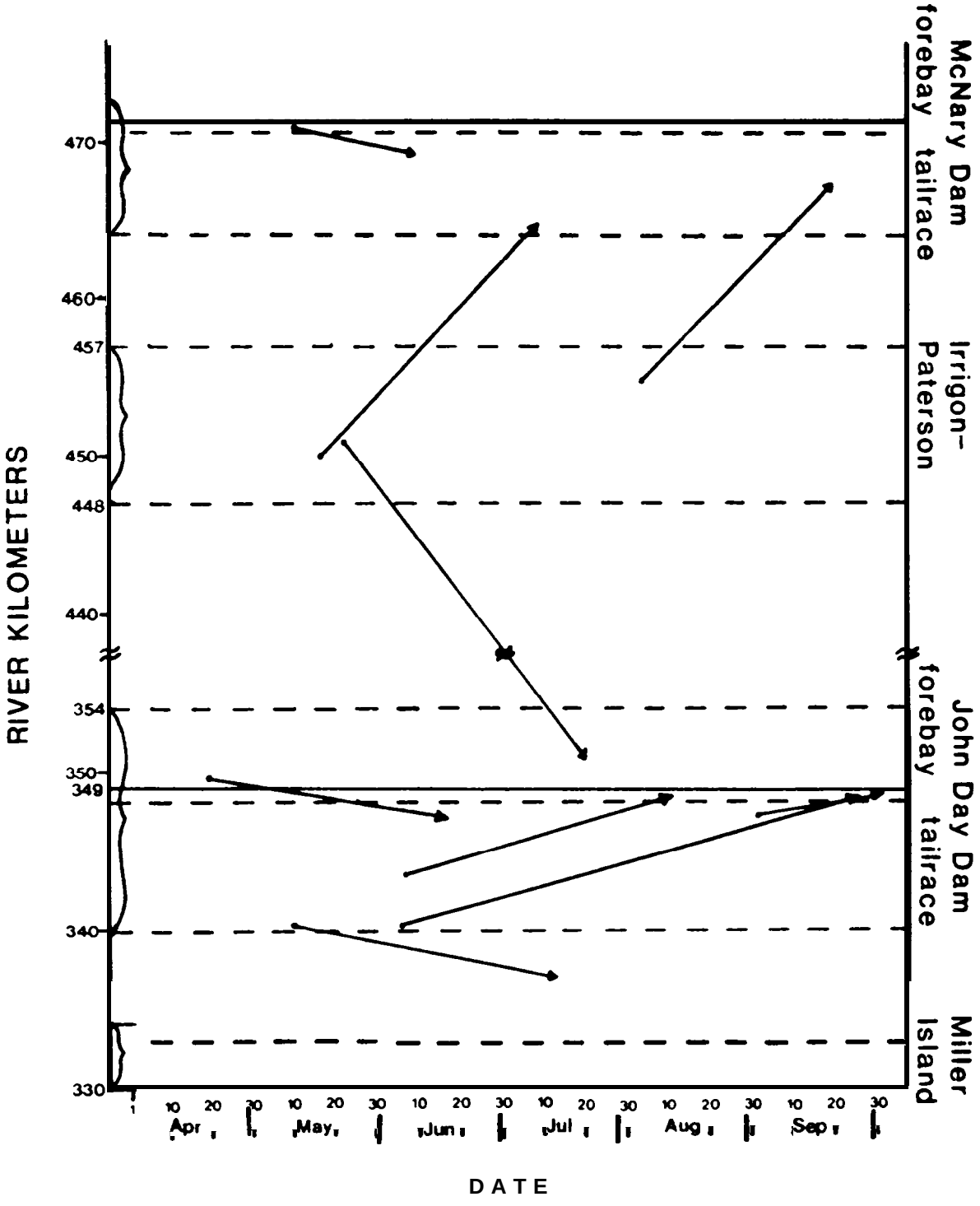

Figure 18. Locations and dates of releases and recoveries of marked snallmouth bass recovered in locations other than where marked, 1983. Areas sampled are indicated by brackets.

that moved between areas. One smallmouth bass moved from Irrigon-Paterson to John Day forebay and another from John Day forebay to John Day tailrace.

Pooulation Abundance

Estimates of smallmouth bass abundance in John Day Reservoir and tailrace totaled just over 6,000 fish (Table 16). Harvest of smallmouth bass by anglers was almost three times greater in McNary tailrace than in John Day tailrace (Table 17). Most smallmouth bass harvested had ;rk lengths greater than 200 mm (Figure 19).

Survival of unmarked smallmouth bass captured during field sampling was not statistically ($p<0.05$) different ($X^2=0.3$, df= 1, p= 0.61) from that of marked smallmouth bass. None of 47 smallmouth bass recaptured during sampling had lost its tag.

Table 16. Estimated abundance of smallmouth bass based on multiple mark and recapture survey and Overton's (1965) estimator, 1983.

Location	Time Interval		Length Interval (mm)	Estimate	95% Confidence Limits	
					Lower	Upper
Below John Day Da	Apr	10-Sep	24 ≥200	1,087	609	2,024
John Day forebay	Apr	10-Sep	24 ≥200	1,501	630	4,077
Upper John Day pool	Mar	27-Sep	24 ≥200	3,450	2,227	5,467

Table 17. Estimated and observed numbers of unmarked and marked smallmouth bass harvested by anglers, May 25 - September 6, 1983.

Location	Period 11	12	13	14	15	16	17	18	Sum
John Day tailrace									
Unmarked									
Estimated	11	37	33	6	11	0	13	4	115
Observed	1	6	7	5	1	2	6	9	37
Marked									
Estimated		7					0	0	13
Observed	0	5	0	0	0	0	0	0	13
McNary tai 1 race									
Unmarked									
Estimated	101	44	77	45	12	3	53	1	336
Observed	11	12	8	7	2	1	17	1	59
Marked									
Estimated	0	0	0	0	0	0	0	0	0
Observed	0	1	2	1	1	3	0	0	8

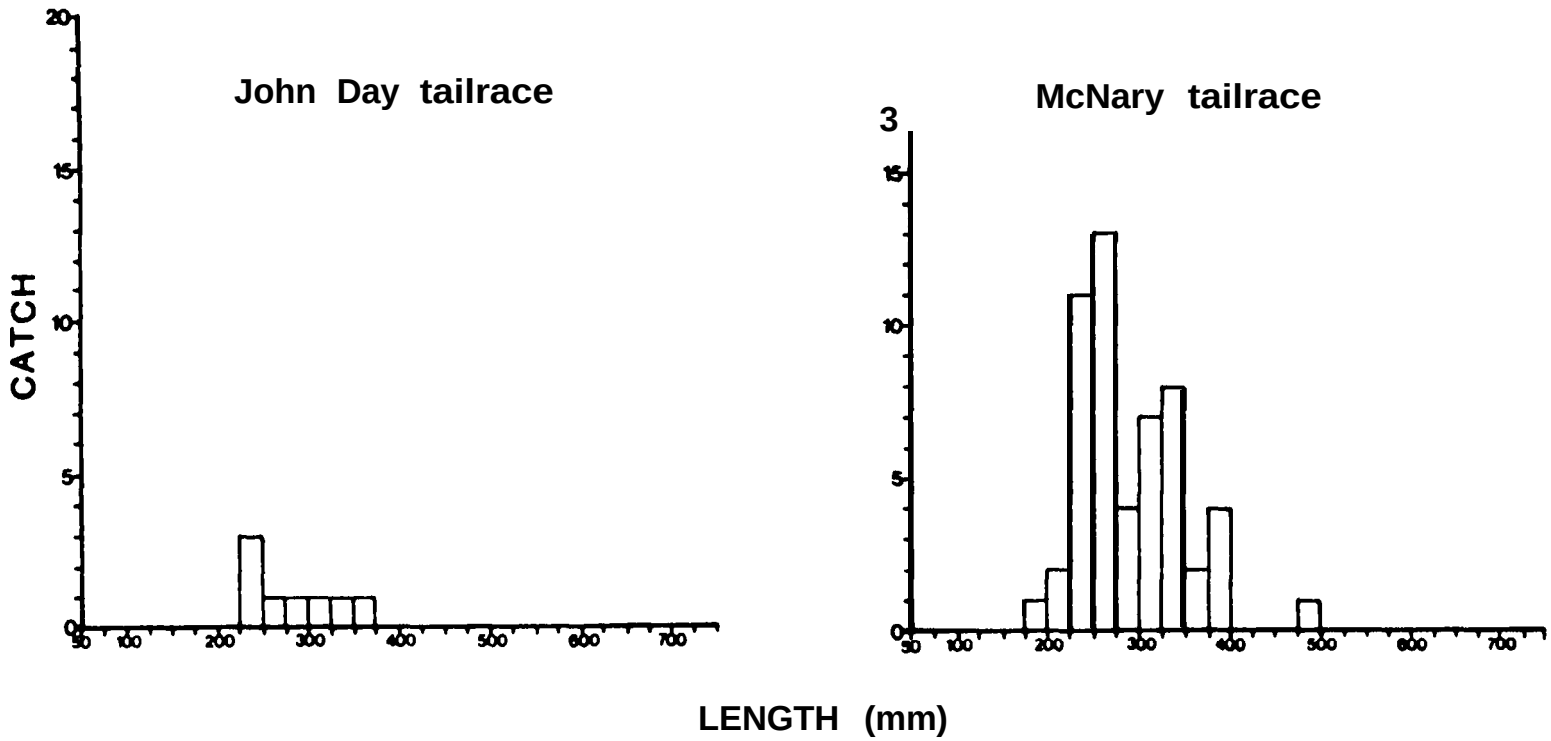

Figure 19. Length-frequency distributions of smallmouth bass harvested by anglers in John Day and McNary tailraces, May 25-September 6, 1983.

DISCUSSION

As in 1982 walleye and northern squawfish were caught under a variety of sampling conditions by gillnetting, trapnetting and electrofishing. Angling was again useful for sampling northern squawfish at the dams. Electrofishing was the only method that proved effective for sampling large numbers of smallmouth bass. Box traps and drift gill nets caught few fish of any species and will not be used in 1984. We will attempt to sample offshore habitats using vertical gill nets in 1984.

Areas for which estimates of abundance of walleye, northern squawfish and smallmouth bass were made did not encompass the whole study area. For walleye, abundance estimates for upper John Day pool may apply to the entire John Day pool and those for below John Day Dam may apply to The Dalles pool because of the high mobility of walleye. However, for northern squawfish and smallmouth bass, it is unknown what proportions of reservoir populations are represented by abundance estimates. Although we demonstrated in 1982 (Willis et al. 1985) that sample sizes adequate for estimating abundance cannot be obtained if effort is thinly distributed among all areas of the reservoir, we will attempt to more representatively sample John Day pool in 1984 by sampling at mid-reservoir stations near Arlington rather than below John Day Dam.

Confidence in abundance estimates varied with sample sizes. Low catches or numbers of recaptures cast some doubt on the accuracy of estimates of abundance of walleye with fork lengths greater than 400 mm in John Day tailrace or of northern squawfish in John Day tailrace BRZ, John Day forebay or McNary tailrace BRZ in spring. Sampling will not be conducted in John Day tailrace in 1984, but will be increased in John Day forebay to increase catches.

Estimates of northern squawfish abundance in John Day tailrace BRZ in 1983 were similar to recalculated estimates (accounting for removals during sampling) for the same period in 1982 (Table 18). However, estimates of northern squawfish abundance in McNary tailrace BRZ in 1983 were considerably higher than for a corresponding period in 1982. Willis et al. (1985) state that 1982 estimates of northern squawfish abundance in McNary tailrace BRZ may be of a local concentration of fish at the central entrance of the Oregon shore adult fishway during sampling and not of the whole population.

Populations were defined and sampling was designed to accommodate seven assumptions of the modified Schnabel estimator (Ricker 1975, Seber 1982): (1) populations are closed to immigration or emigration during sampling, (2) adjustments are made for removals of fish during sampling, (3) different sized fish are equally vulnerable to capture, (4) marked fish randomly mix with unmarked fish or subsequent sampling is random, (5) recruitment to the population because of growth is negligible during sampling, (6) marked and unmarked fish suffer the same mortality, and (7) marks are retained and recognized upon capture.

The assumption that populations are closed to immigration or emigration was addressed by defining populations according to observed patterns of movement by marked and radiotagged fish. Small numbers of fish were recaptured outside delineated areas, indicating that populations were not completely closed, but since movements between areas appeared to be limited, the resulting overestimation of abundance would likely be small.

Table 18. Estimated abundance of northern squawfish based on multiple mark and recapture survey and Overton's (1965) estimator, 1982.

Location	Time Interval	Estimate	95% Confidence Limits Lower	Upper
McNary tailrace BRZ[a]	May 22-Jul 02	2,008	894	3,921
	Jul 17-Nov 24	9,725	7,734	12,291
John Day tailrace BRZ[a]	Jul 17-Oct 08	4,948	2,709	8,239

a Boat restricted zone

The assumption that adjustments are made for removals of fish during sampling was accommodated by using Overton's modification of the Schnabel estimator. Angler surveys in John Day and McNary tailraces between May 25 and September 6 indicated that 8% of the estimated number of walleye in John Day tailrace and 6% of the estimated number of walleye in upper John Day pool were harvested by anglers. Estimated numbers of smallmouth bass were reduced by 12% in John day tai lrace and 10% in upper John Day pool over the same time. These harvest estimates are conservative because our survey did not include all times and areas where harvest occurred during sampling. Surveys di not begin until almost two months after the beginning of sampling and ang,ers were frequently observed in portions of the reservoir not included in the survey. Future surveys will be conducted over the entire sampling season and will include all areas where angling is appreciable.

Anglers also removed quite a few marked fish, and numbers of marked fish at large nad to be adjusted for angler removals to minimize overestimation of population abundance. Estimates of removal of marked walleye in John Day tailrace were less than half the number observed (interviews and mail returns) and raised questions about the validity of some angler survey estimates. Angler harvest of marked fish may have been underestimated because angler effort or harvest rate were underestimated or observed proportions of marked fish in angler catch were inaccurate. It is unclear which factors are suspect, but subsequent estimates of each should include confidence intervals so that adequacy of sample sizes can be evaluated.

The assumption that different sized fish are equally vulnerable to capture was addommodated by combining catches by different gear and by making separate abundance estimates for fish with different vulnerabilities to capture. Greater frequencies of fish of larger sizes in combined catches by all gear suggested that larger fish may be more vulnerable to capture than smaller fish. Differences among length groups in ratios of recaptures to marked fish at large supported the possibility of size-specific vulnerability to capture.

The assumption that marked fish randomly mix with unmarked fish or that subsequent sampling is randomized was accommodated by allowing marked fish sufficient time to disperse and by distributing sampling throughout an area for which abundance estimates were made. Random sampling proved to be impractical because of the great expenditure of time and effort required to travel to all portions of an area and our inability to effectively sample deeper, high flow habitats in the main river channel. Fish marked in the same two-week period as recovered were not treated as recaptures and we did not sample for three days between consecutive two-week periods so that marked fish were allowed 3 to 14 days to disperse from points of release. Observations of marked and radiotagged fish indicated that movements between sampling stations often occurred within a few days. Sampling stations were distributed throughout areas to maximize local mixing. Seber (1982) notes that dividing an area into subareas (our sampling stations), sampling each subarea with the same effort and releasing marked animals back into the subarea in which taken, is an acceptable alternative to random sampling if fish distribute themselves in unsampled areas.

The assumption that recruitment to the population because of growth is negligible during sampling was accommodated by increasing minimum lengths of fish included in calculations of abundance estimates as the season

progressed. Peaks in observed length-frequency distributions of walleye collected from March through June (Appendix A, Figure A.1) corresponded to average lengths at ages of walleye collected from John Day Reservoir and tailrace in 1982 (Gray et al. 1984). Peaks at 200 mm and 325 mm corresponded to ages I and II, respectively and the peak at 475 mm included fish aged III and older. For walleye collected from July through September, peaks in length-frequency distributions were shifted by 50 mm indicating that substantial growth occurred during sampling. Age II walleye were completely recruited to the population of taggable fish at the beginning of sampling, but most age I fish were recruited during the season and had to be excluded from abundance estimates.

Minimum lengths of northern squawfish included in abundance estimates were not increased during sampling because little growth was apparent during the season (Appendix A, Figure A.2). Growth of northern squawfish with fork lengths greater than 250 mm averaged less than 25 mm per year in other northwest USA waters (Beamesderfer 1983, Nigro et al. 1982 and Olney 1975).

An entire age class of smallmouth bass was apparently recruited to taggable length during sampling. Peaks at 175, 200, 325 and 400 mm in length-frequency distributions of smallmouth bass collected from March through June (Appendix A, Figure A.3) corresponded with average lengths at ages II, III, IV and V, respectively (Gray et al. 1984). Peaks in length-frequency distributions in July through September occurred at the same lengths as the early season peaks but were thought to represent ages I through IV since it is unlikely that no growth occurred over the entire summer. The minimum length of smallmouth bass included in abundance estimates was increased from 200 to 250 mm later in the season to minimize confounding effects of recruitment of age II fish.

The assumption that marked and unmarked fish suffered the same mortality was tested by holding fish for 72 hours at McNary Dam and by comparing mortality of marked and unmarked fish during sampling. Limited mortality of marked fish was observed when individuals were released in good condition. Only one northern squawfish and no walleye died over 72 hours when held at McNary Dam. Even less mortality would be expected of fish released in the field because of lack of stress associated with being held at the dam. Long term differential mortality cf marked fish was not observed since marked fish subsequently recaptured did not die more frequently than unmarked fish. By not marking fish believed to be in poor condition at capture, problems of differential mortality of marked and unmarked fish appeared to be minimized.

The final assumption that marks are retained and recognized upon capture was accommodated by using spaghetti tags instead of the T-anchor tags used in 1982. This solved problems caused by loss of tags in 1982 (Willis et al. 1985). Fish that had lost their tags were easily recognized by a hole in the left opercle and scars where tags were inserted through the tissue. Secondary marks other than a hole in the left opercle will be used in 1984 and subsequent years to distinguish the year when recaptures without tags were last marked.

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APPENDIX A

Sampling Periods, Sampling Effort, Population Length-Frequency Distributions and Catch Per Unit Effort.

Table A.l. **Dates corresponding to two-week sampling periods, March-September,** 1983.

Sampling Period	Beginning Date	Ending Date
7	Mar 27	Apr g
8	Apr 10	Apr 23
9	Apr 24	May 7
10	May 8	May 21
11	May 22	Jun 4
12	Jun 5	Jun 18
13	Jun 19	Jul 2
14	Jul 3	Jul 16
15	Jul 17	Jul 30
16	Jul 31	Aug 13
17	Aug 14	Aug 27
18	Aug 28	Sep 10
19	Sep 11	Sep 24

Table A.2. Distribution of sampling effort (in hours) by location, gear and period, March-September, 1983.

Location	Gear	Period 7	8	9	10	11	12	13	14	15	16	17	18	19	Sum
Miller Island	Bottom gill net	0	2	7	4	0	4	0	0	0	0	0	0	0	17
	Electrofishing	0	1	0	0	0	1	0	0	0	0	0	0	0	2
John Day tailrace BRZ[a]	Bottom gill net	0	0	0	0	0	0	0	0	4	4	5	3	5	21
	Angling	6	5	4	4	4	4	3	3	12	10	10	12	12	89
John Day tailrace	Bottom gill net	8	54	37	44	26	35	17	16	12	8	10	10	10	287
	Drift gill net	0	1	0	1	0	0	0	0	0	0	0	0	0	2
	Trap net	0	0	284	311	193	431	328	446	319	96	193	194	195	2,990
	Electrofishing	0	4	2	4	4	4	4	2	2	1	1	2	0	30
	Angling	0	0	0	0	0	0	0	0	8	4	4	4	4	24
	Box traps	0	0	193	357	133	0	0	0	0	0	0	0	0	683
John Day forebay	Bottom gill net	0	4	3	10	2	2	0	6	10	7	6	6	7	63
	Trap net	0	0	0	0	0	0	0	0	24	24	24	73	95	240
	Electrofishing	0	1	0	0	0	0	0	0	2	1	0	1	1	6
	Angling	16	7	2	4	4	4	4	4	14	12	7	8	8	94
	Box traps	0	0	0	0	0	0	0	0	145	144	144	144	173	750
Arlington	Bottom gill net	0	0	0	0	0	0	0	0	9	2	0	7	5	23
Irrigon -Paterson	Bottom gill net	0	32	19	10	6	7	6	5	12	8	8	9	4	126
	Drift gill net	1	1	1	1	1	1	1	0	0	0	0	0	0	7
	Trap net	0	0	0	0	0	0	0	0	265	268	261	262	141	1,197
	Electrofishing	0	1	0	1	0	0	0	0	1	1	1	1	1	7
McNary tailrace BRZ[a]	Bottom gill net	0	0	0	0	0	0	0	0	5	0	2	2	0	9
	Surface gill net	0	0	0	0	0	0	0	0	2	8	7	5	7	29
	Electrofishing	0	0	0	0	0	0	0	0	1	0	1	1	1	4
	Angling	9	8	11	8	10	25	10	8	41	39	35	35	34	273
	Box traps	0	0	0	0	0	0	0	0	0	96	198	141	144	579
McNary tailrace	Bottom gill net	8	49	65	42	15	28	20	18	18	5	9	10	9	296
	Surface gill net	0	0	0	0	0	0	0	0	0	1	1	2	1	5
	Drift gill net	0	2	1	1	1	1	0	0	0	0	0	0	0	6
	Trap net	0	0	262	327	190	414	697	525	308	202	261	246	263	3,695
	Electrofishing	0	5	3	3	1	3	3	3	3	2	3	2	3	34
	Angling	0	1	0	0	0	0	0	0	0	2	0	2	0	5
	Box traps	0	0	307	415	0	0	0	0	0	0	0	0	0	722
All Locations	Bottom gill net	16	141	131	110	49	76	43	45	70	34	40	47	40	842
	Surface gill net	0	0	0	0	0	0	0	0	2	9	8	7	8	34
	Drift gill net	1	4	2	3	2	2	1	0	0	0	0	0	0	15
	Trap net	0	0	546	638	383	845	1,025	971	916	590	739	775	694	8,122
	Electrofishing	0	12	5	8	5	8	7	5	9	5	6	7	6	83
	Angling	31	21	17	16	18	33	17	15	75	67	56	61	58	485
	Box traps	0	0	500	772	133	0	0	0	145	240	342	285	317	2,734

[a] Boat restricted zone.

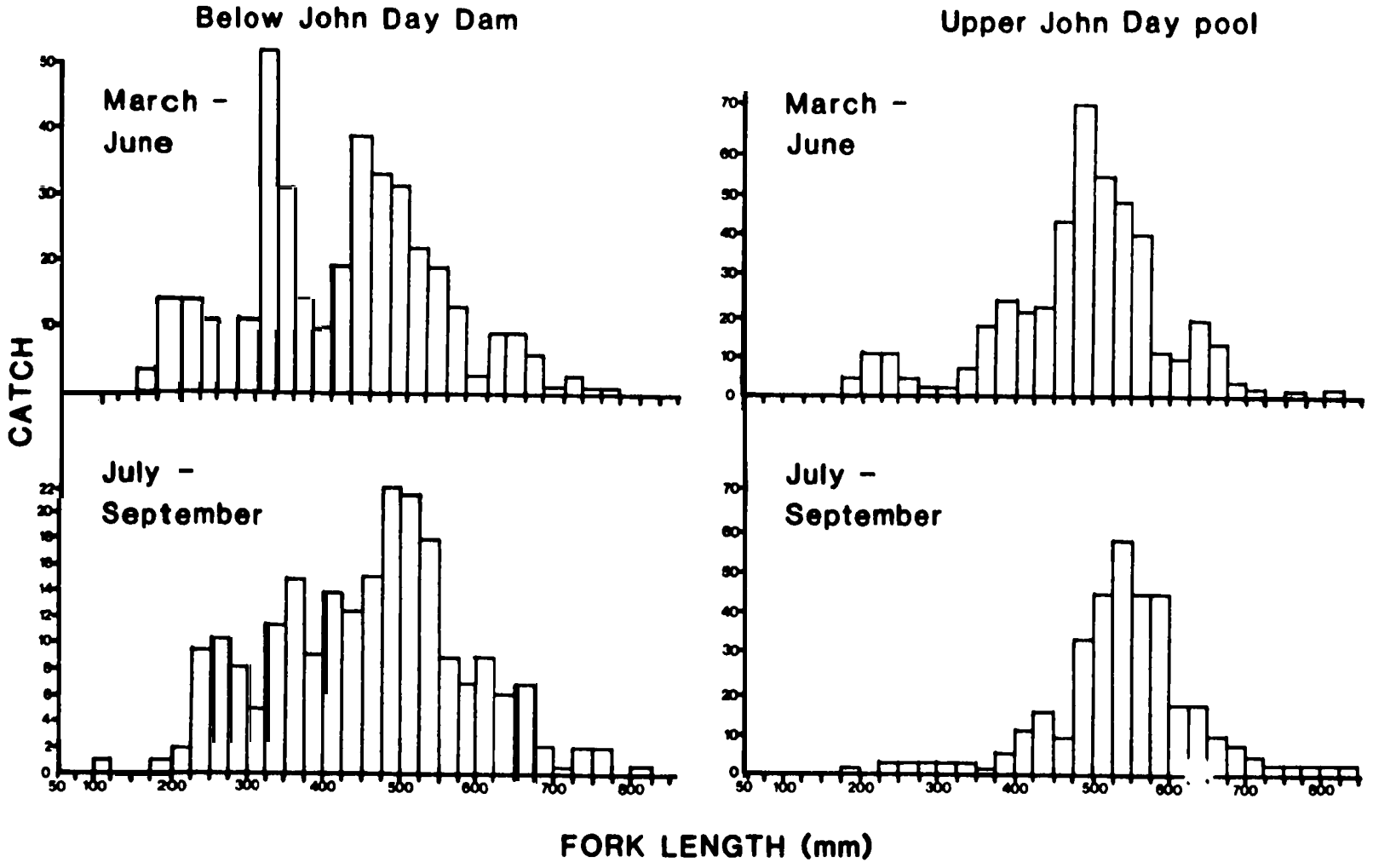

Figure A1. Length-frequency distributions of walleye captured or observed, 1983.

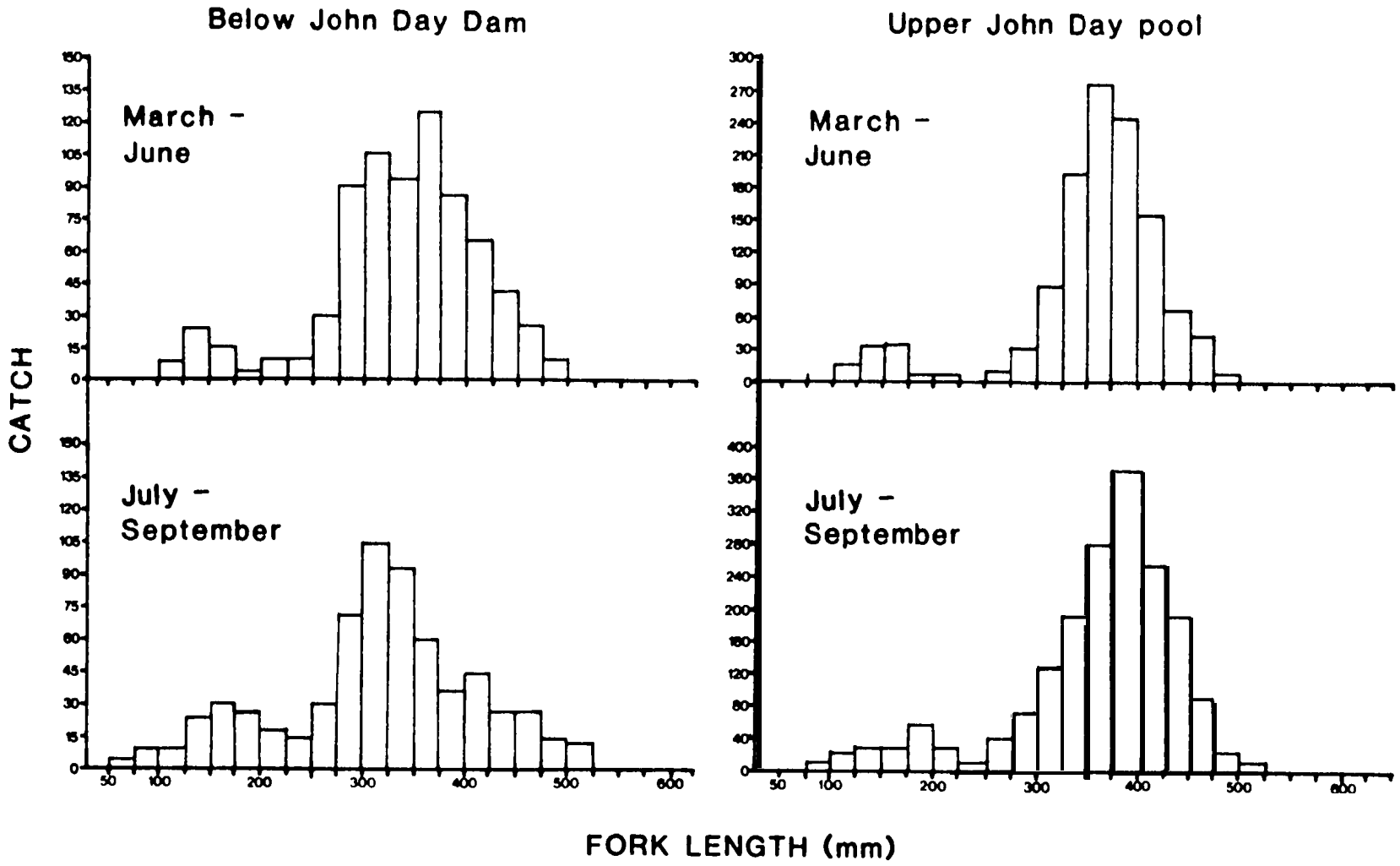

Figure A2. Length-frequency distributions of northern squawfish captured or observed, 1983.

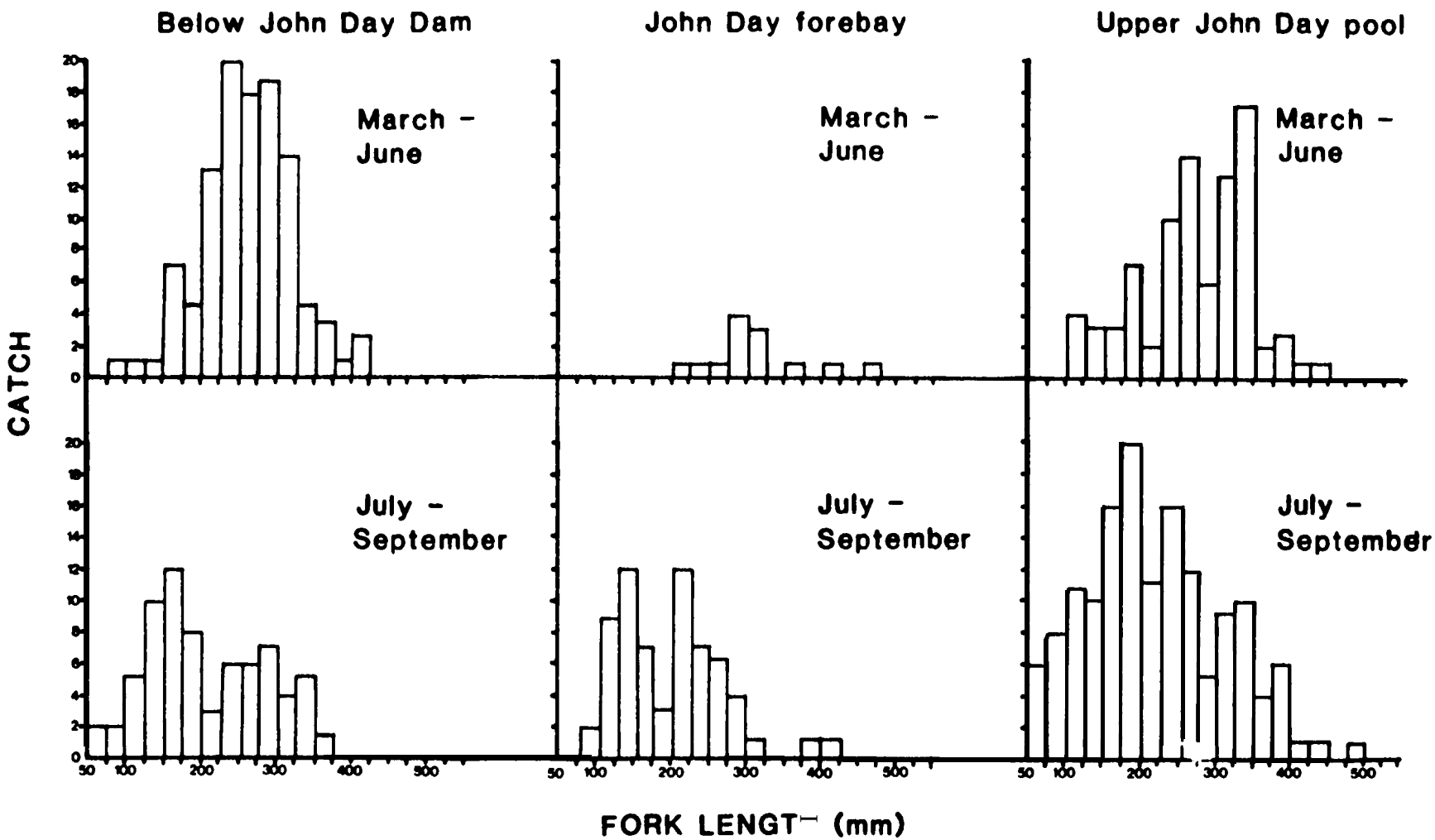

Figure A3. Length-frequency distributions of smallmouth bass captured or observed, 1983.

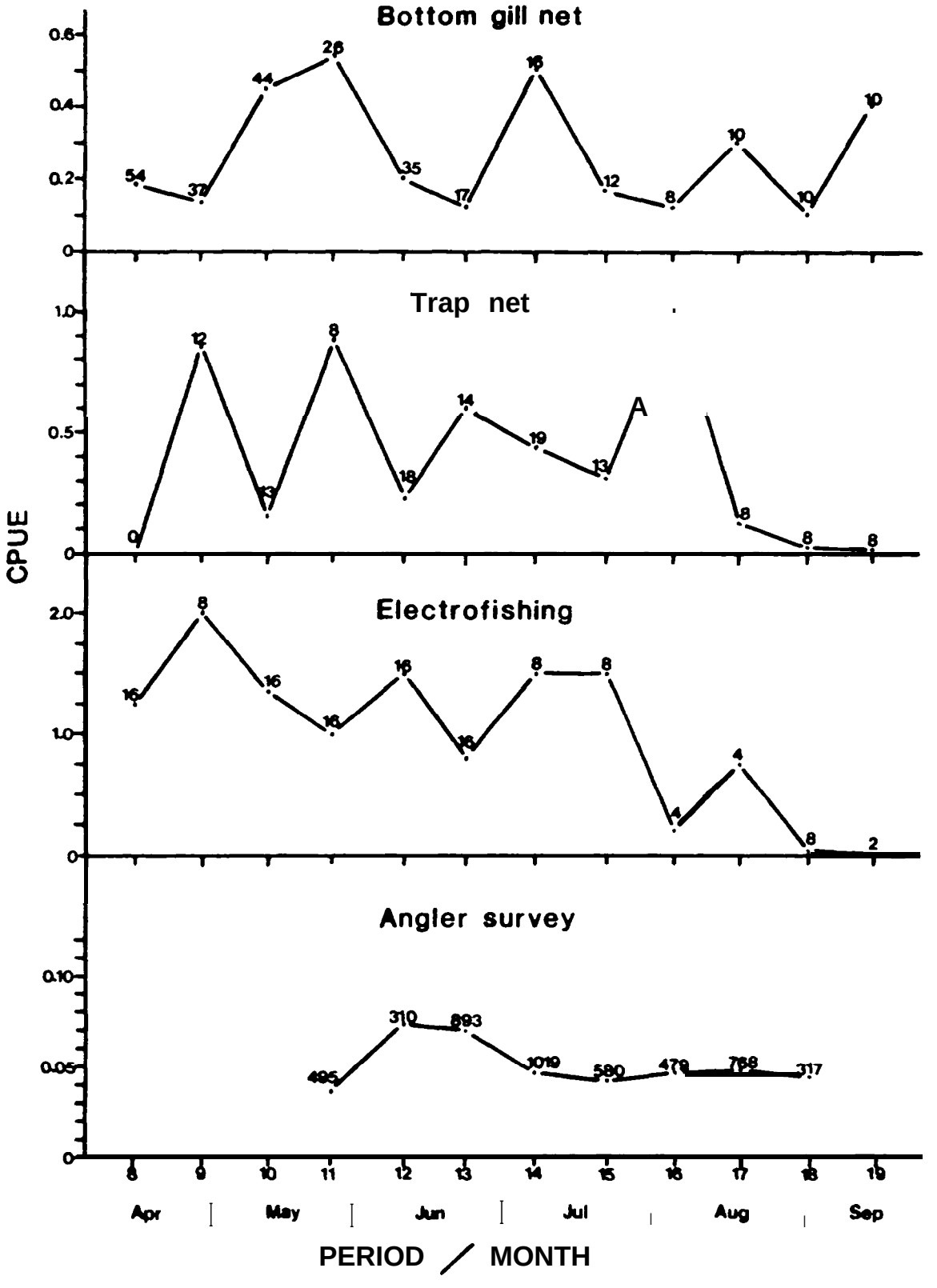

Figure A4. Catch per unit effort (CPUE) of walleye by gear in John Day tailrace, 1983. Units of effort are net hour (bottom gi 11 net), net day (trap net), 900 secondcurrent-on time (electrofishing) and angler hour (angler survey). Total effort within a period is above each point.

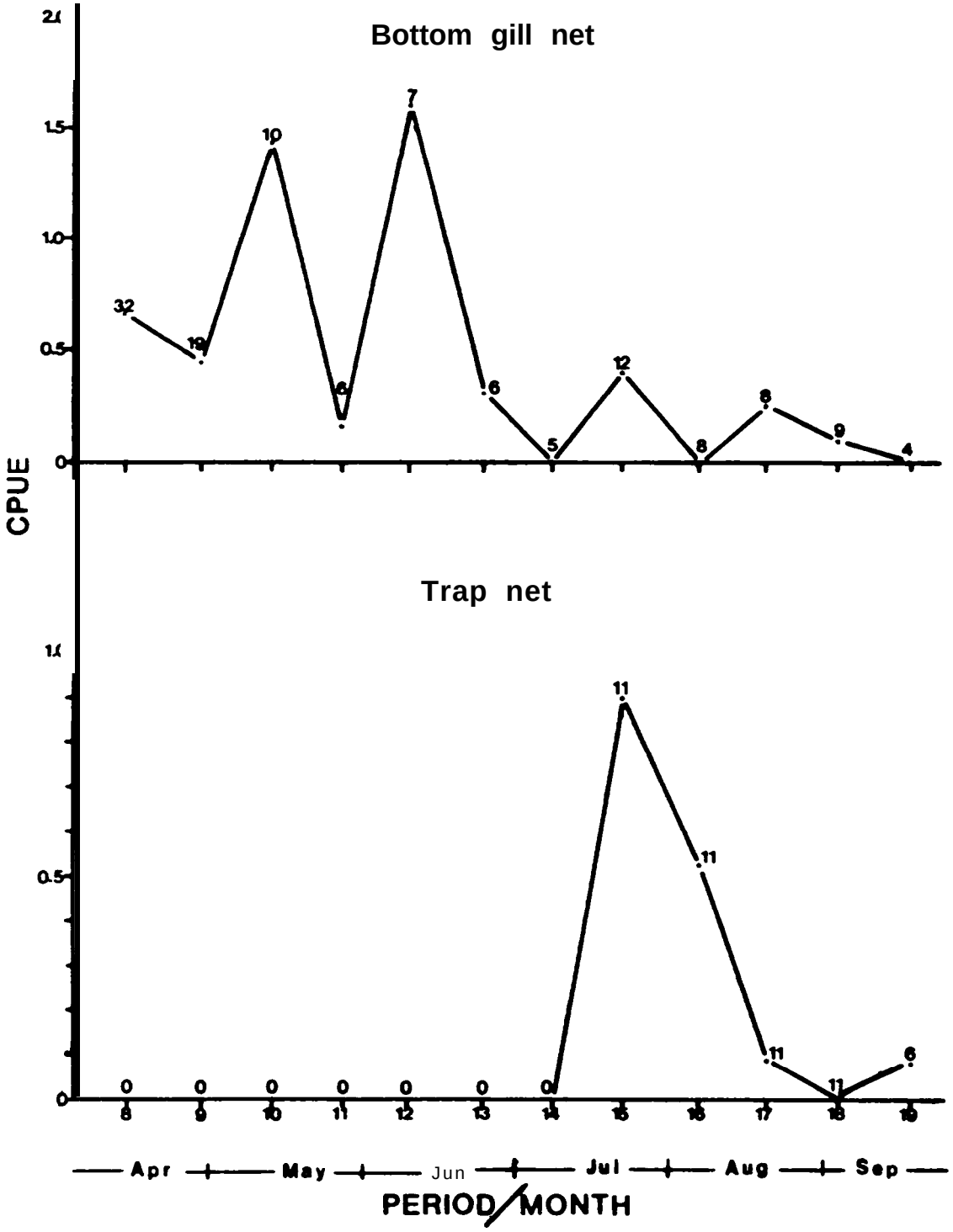

Figure A5. Catch per unit effort (CPUE) of walleye by gear in Irrigon-Paterson 1983. Units of effort are net hour (bottom gill net), and net day (trap net). Total effort within a period is above each point.

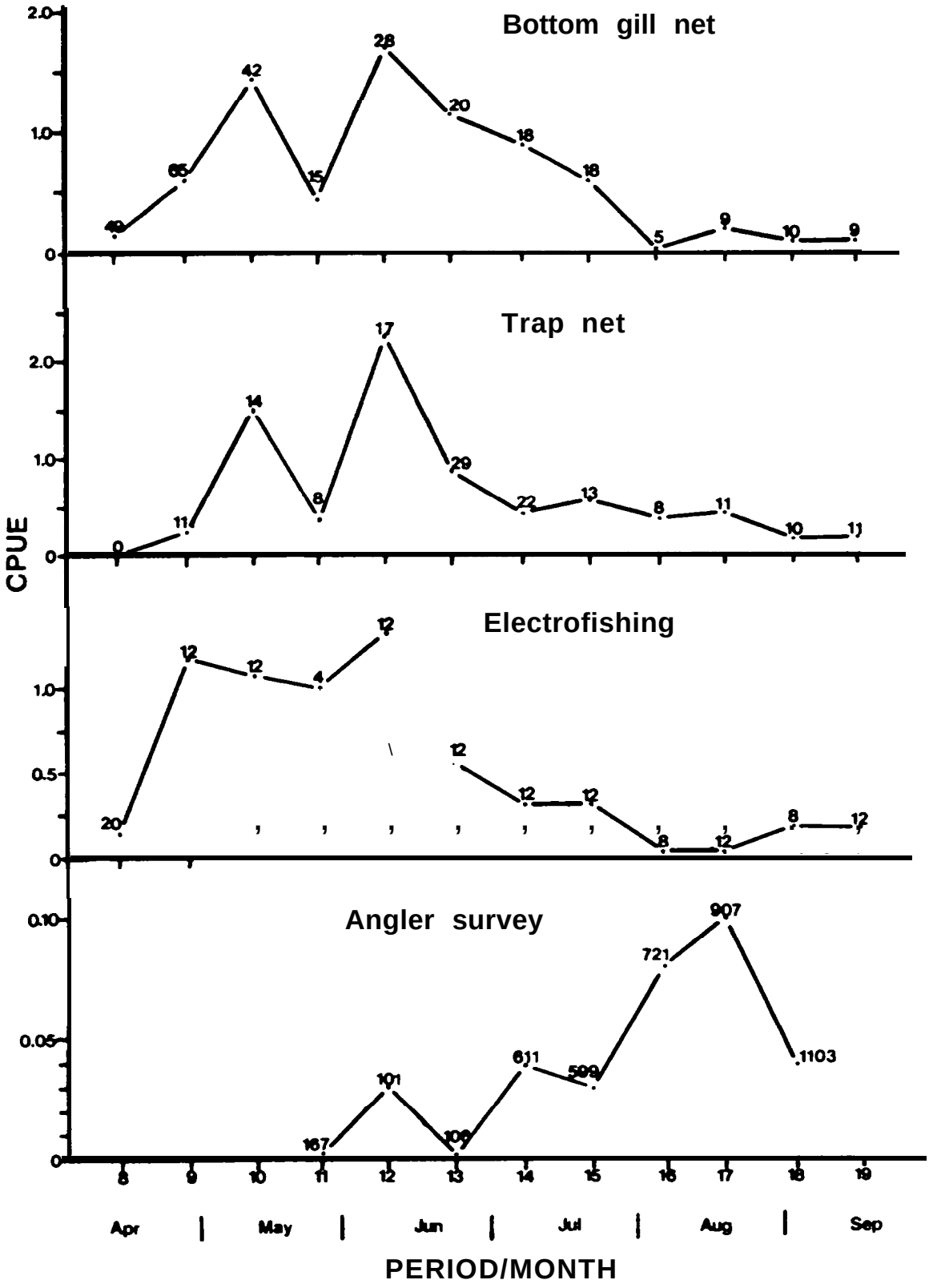

Figure A6. Catch per unit effort (CPUE) of walleye by gear in McNary tailrace, 1983. Units of effort are net hour (bottom gill net), net day (trap net), 900 second current-on time (electrofishing) and angler hour (angler survey). Total effort within a period is above each point.

Table A.3 Comparisons (Kruskal-Wallis) of walleye catch by gear among sampling periods, March-September, 1983.

Location/Period	Gear	Degrees of Freedom	Chi-square Statistic	Observed Probability Level
John Day tailrace				
	Bottom gill net[a]	--	--	--
	Trap net	10	14.4	0.156
	Electrofishing	11	13.0	0.296
Irrigon-Paterson				
	Bottom gill net	11	17.6	0.093
	Trap net	4	3.8	0.433
McNary tailrace				
	Bottom gill net	12	40.2	>0.001
	Trap net	10	27.6	0.002
	Electrofishing	11	30.0	0.002

a Lack of variation among samples precluded use of statistical test.

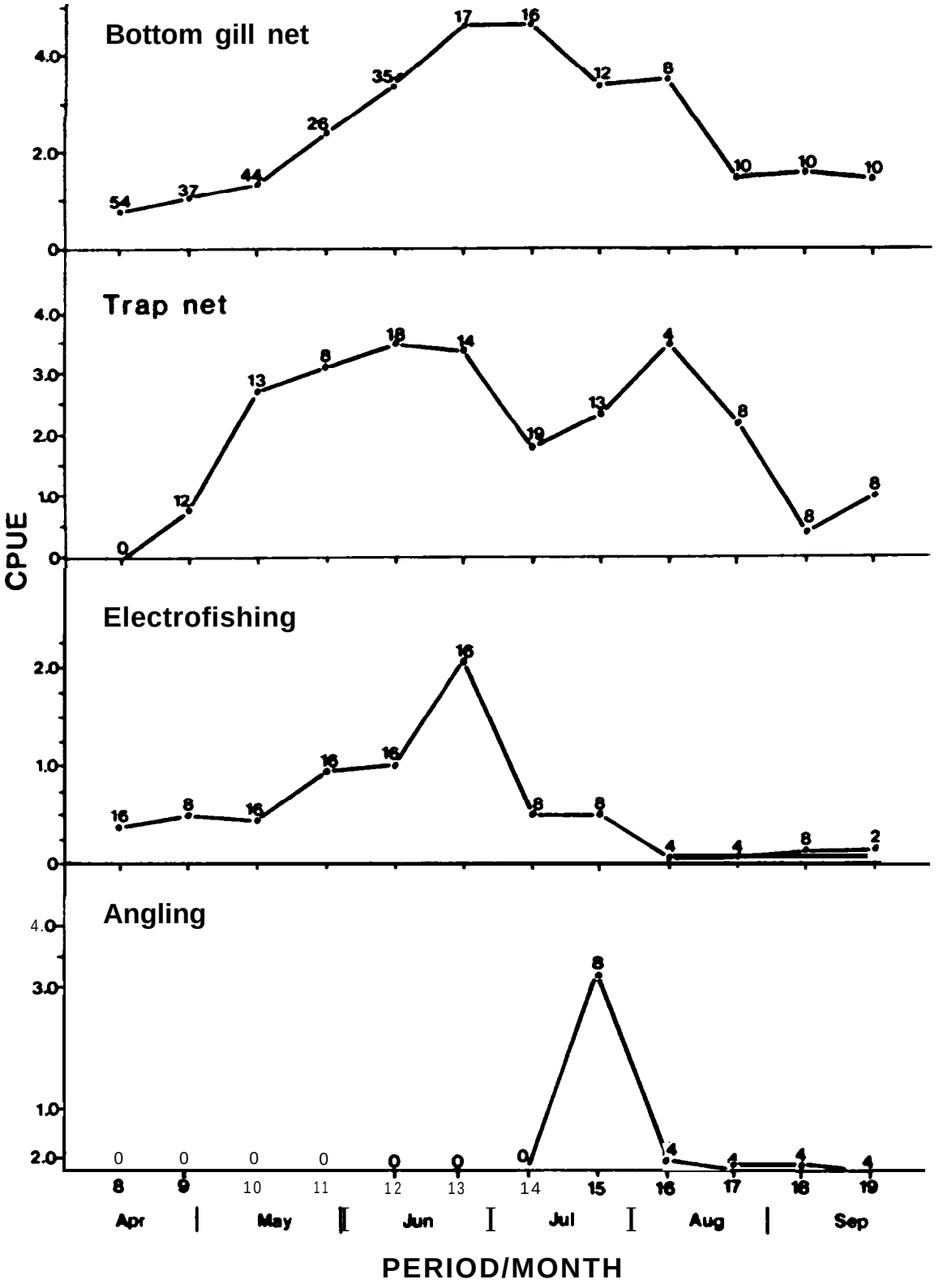

Figure A7. Catch per unit effort (CPUE) of northern squawfish by gear in John Day tailrace, 1983. Units of effort are net hour (bottom gill net), net day (trap net), 900 second current-on time (electrofishing), and angler hour (angling). Total effort within a period is above each point.

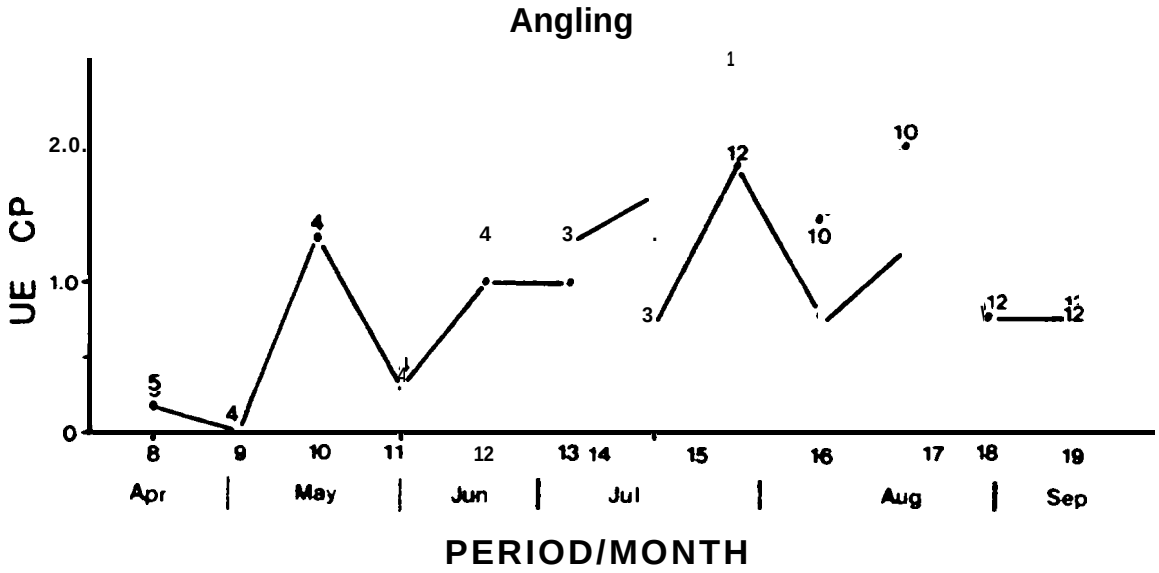

Figure A8. Catch per unit effort (CPUE) of northern squawfish by angling in John Day tailrace boat restricted zone, 1983. Unit of effort is angler hour. Total effort within period is above each point.

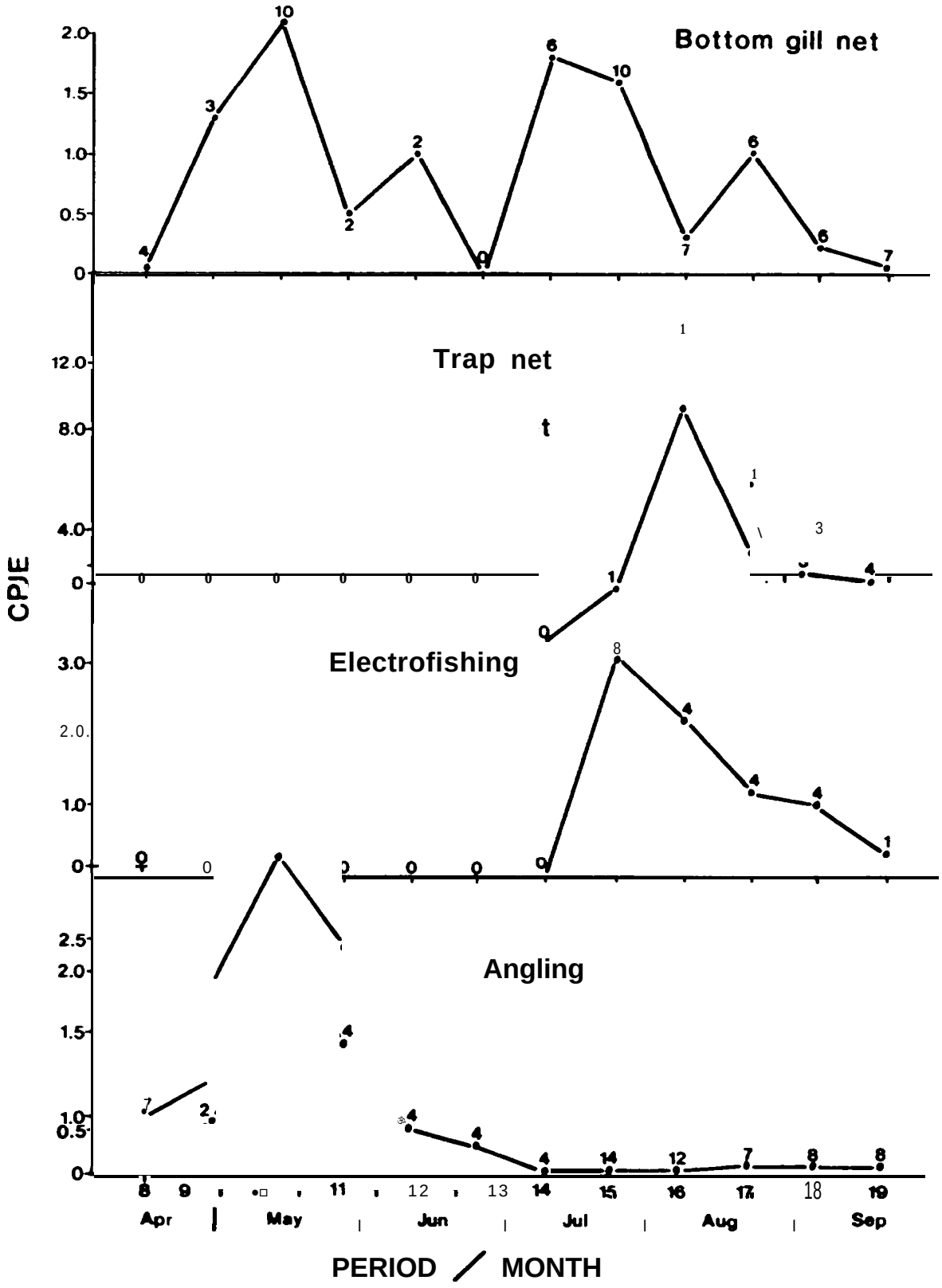

Figure A9. Catch per unit effort (CPUE) of northern squawfish by gear in John Day forebay, 1983. Units of effort are net hour (bottom gill net), net day (trap net), 900 second current-on time (electrofishing) and angler hour (angling). Total effort within a period is above each point.

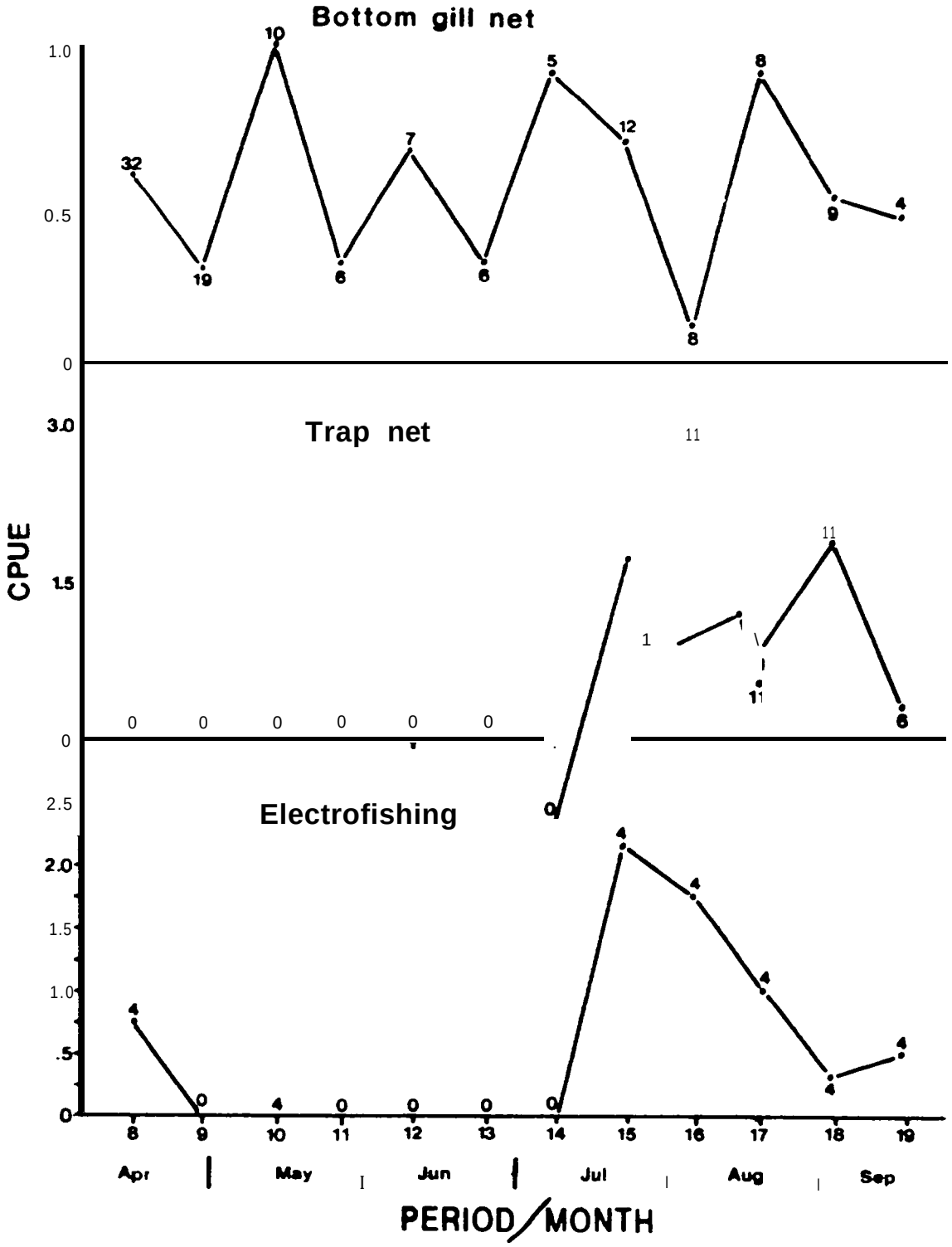

Figure A10. Catch per unit effort (CPUE) of northern squawfish by gear in Irrigon-Paterson, 1983. Units of effort are net hour (bottom gill net), net day (trap net) and 900 second current-on time (electrofishing). Total effort within a period is above each point.

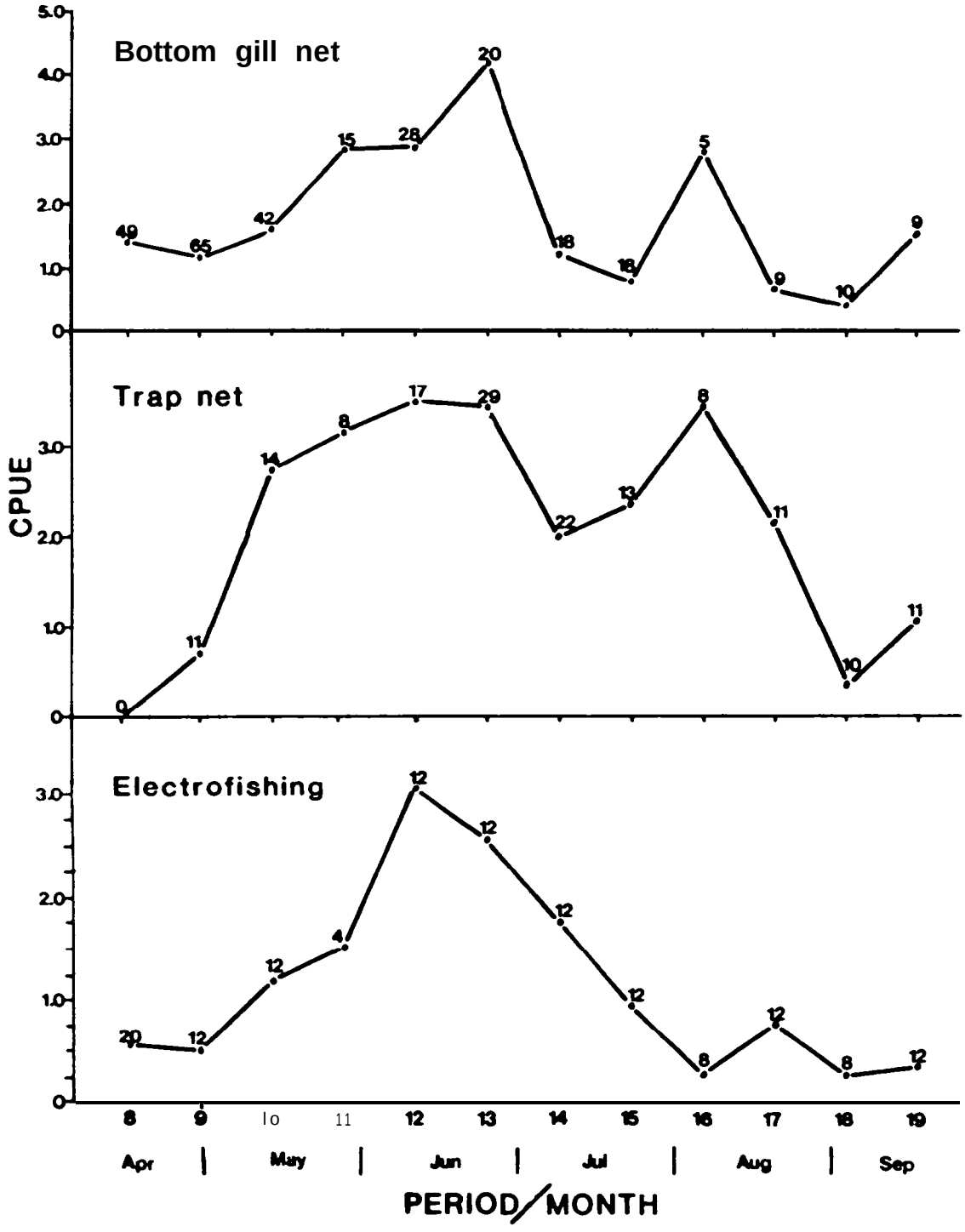

Figure All. Catch per unit effort (CPUE) of northern squawfish by gear in McNary tai 1 race, 1983. Units of effort are net hour (bottom gi 11 net), net day (trap net) and 900 second current-on time (electrofishicg). Total effort within a period is above each point.

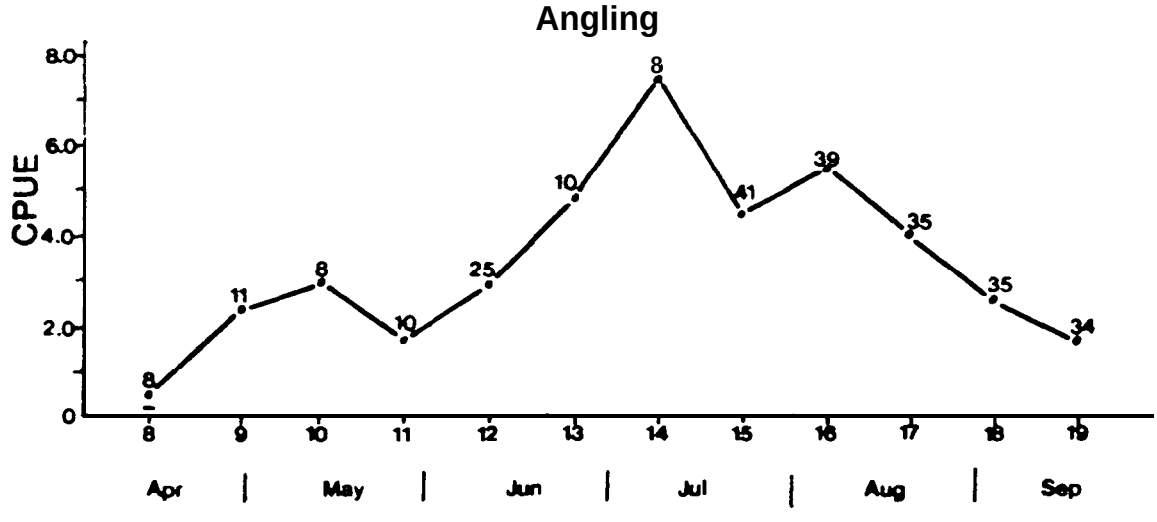

Figure A12. Catch per unit effort (CPUE) of northern squawfish by angling in the McNary tailrace boat restricted zone, 1983. Unit of effort is angler hour. Total effort within a period is above each point.

Table A.4 Comparisons (Kruskal-Wallis) of northern squawfish catch by gear among sampling periods, March-September, 1983.

Location	Gear	Degrees of Freedom	Chi-square Statistic	Observed Probability Level
John Day tailrace				
	Bottom gill net[a]	12	28.5	0.005
	Trap net	10	12.3	0.266
	Electrofishing	11	11.8	0.378
	Angling	--	--	--
John Day tailtace BRZ[b]				
	Angling	11	15.3	<0.171
John Day forebay				
	Bottom gill net	10	28.3	0.002
	Trap net		5.4	0.367
	Electrofishing	5	11.6	0.041
	Angling[a]	--	--	--
Irrigon-Paterson				
	Bottom gill net	11	9.1	0.610
	Trap net	4	5.2	0.271
	Electrofishing	6	4.2	0.651
McNary tai 1 race				
	Bottom gill net	12	35.7	<0.001
	Trap net	10	16.7	0.081
	Electrofishing	11	18.6	0.068
McNary tailrace BRZ				
	Angling	12	53.1	<0.001

a Lack of variation among samples precluded use of statistical test.
b Boat restricted zone.

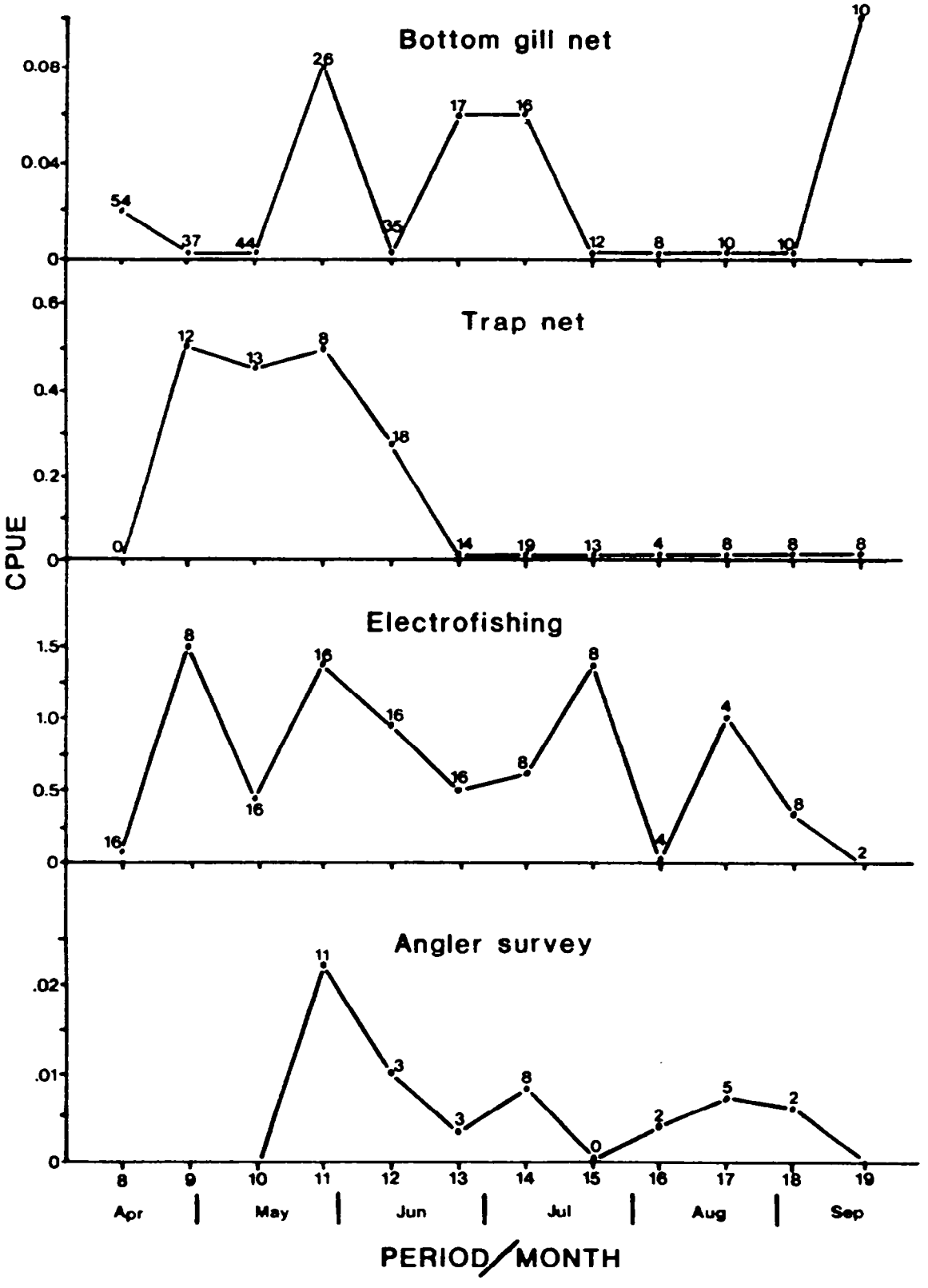

Figure A13. Catch per unit effort (CPUE) of smallmouth bass gear in John Day tailrace, 1983. Units of effort are net hour (bottom gill net), net day (trap net), 900 second current-on time (electrofishing) and angler hour (angler survey). Total effort within a period is above each point.

Table A.5 Comparisons (Kruskal-Wallis) of smallmouth bass by gear among sampling periods in the John Day tailrace, March-September, 1983.

Gear	Degrees of Freedom	Chi-square Statistic	Observed Probability Level
Bottom gill net[a]	--	--	--
Trap net	10	14.6	0.148
Elecrofishing	11	12.7	0.311

[a] Lack of variation among samples precludes use of statistical test.

APPENDIX B

Angler Survey Data and the Method Used to Estimate Angler Harvests.

Angler harvest of walleye, northern squawfish and smallmouth bass was estimated for two-week periods used for estimating abundance as the product of estimated angler effort, species specific catch per hour by anglers and the proportion of catch that was killed. Harvests were estimated by angler type and day type and were then summed within a period. Angler types were distinguished by species sought and whether fishing was conducted from a boat or from the Oregon or Washington bank. Day types were classified as weekday or weekend-holiday.

Angling effort within a period (1) was estimated as the sum of estimated efforts (f) by given angler types (j) on given day types (k) (Malvestuto 1983, Table 6.4). Effort of a given angler type on a given day type was estimated as the product of the mean number per count (A) of that angler type observed on that day type, the mean number (D) of that day type in the period and the mean number per day type (H) of hours available to anglers (sunrise to sunset):

$$f_{jkl} = (A_{jkl})(D_{kl})(H_l)$$

Species specific catch per hour (CPH) by a given angler type on a given day type in a period (Table 8.5) was estimated from observed catch (C) and effort (F) of interviewed anglers:

$$CPH_{jkl} = C_{jkl}/F_{jkl}$$

Proportion within a period of catches of walleye, northern squawfish and smallmouth bass kept by a given angler type (Table B.6) and mean trip lengths of given angler types (Table 8.7) were estimated from interviews.

Table B.1. Numbers of days available and surveyed during angler surveys, May 25 - September 6, 1983.

Location/Period	Weekdays		Weekdays & Holidays	
	Available	Surveyed	Available	Surveyed
John Day tailrace				
11	9	3	5	4
12	10	4	4	4
13	10	4	4	4
14	9	4	5	5
15	10	4	4	4
16	10	4	4	4
17	10	4	4	4
18	9	3	5	4
McNary tailrace				
11	9	2	5	4
12	10	4	4	4
13	10	4	4	4
14	9	4	5	5
15	10	4	4	4
16	10	4	4	4
17	10	4	4	4
18	9	3	5	4

Table 6.2. Numbers of angler counts made by time of day and period May 25 - September 6, 1983. Dashes indicate times when counts were precluded by darkness. Counts began within one-half hour of the times indicated.

Location/Time	Period 11	12	13	14	15	16	17	18	Sum
John Day tailrace									
0600	--	--	--	0	3	3	2	2	10
0700	2	2	1	4	1	3		2	18
0800	0	2	4	5		2	3	3	22
0900	1	1	0	0	3	2	2	2	11
1000	6	5	4	4	1	4		2	29
1100	0	2	4	5	4	2	3	2	22
1200	5	4	2	1	3	3	2	3	23
1300	2	2	2	3	1	3	3	2	18
1400	0	2	4	4	4	2	3	3	22
1500	4	4	3	0	3	3	2	2	21
1600	2	2	1	4	1	3	3	2	18
1700	2	2	4	5	4	2	3	3	25
1800	2	5	3	0	3	3	2	2	20
1900	5	1	1	4	1	3	3	2	20
2000	0	3	6	5	4	2	3	3	26
2100	1	3	1	--	--	--	--	--	5
McNary tailrace									
0600	--	--	--	0	1	2	2	2	7
0700	0	0	0	3	3	4	3	2	15
0800	0	0	1	3	3	2	3	3	15
0900	0	0	1	0	2	3	2	1	9
1000	6	6	5	4	3	3	3	3	33
1100	0	2	2	4	3	2	3	3	19
1200	6	4	4	1	1	3	2	2	23
1300	0	2	2	4	4	3		2	20
1400	0	2	2	5	3	2	3	3	20
1500	6	4	4	0	2	3	1	2	22
1600	0	2	2	4	3	4	3	2	20
1700	6	3	2	5	2	2	3	2	25
1800	0		4	0	2	2	2	2	15
1900	6	3	2	4	3	4	2	2	26
2000	0	2	2	5	3	2	3	1	18
2100	3	4	3	--	--	--	--	--	10

Table B.3. Numbers of anglers interviewed, May 25 - September 6, 1983.

Location/Anglertype	Period I1	I2	I3	I4	I5	I6	I7	I8	Sum
John Day tailrace									
Boat, Walleye	73	59	197	194	135	94	167	65	984
Boat, Sturgeon	9	19	32	80	29	26	38	19	252
Boat, Bass	0	0	0	0	2	4	0	0	6
Bank, Sturgeon	144	208	358	429	252	226	89	110	1,816
Bank, Shad[a]	2	17	77	27	3	6	0	0	136
Bank, Other	22	32	49	18	20	17	35	14	207
McNary tailrace									
Boat, Walleye	39	28	30	136	157	151	172	298	1,011
Boat, Sturgeon	5	28	38	77	84	41	50	24	347
Boat, Bass	4	10	0	11	11	12	52	0	100
Bank, Sturgeon	95	125	139	68	58	58	66	24	633
Bank, Other	73	108	97	82	139	16	105	14	634

[a] Washington bank only

Table B.4. Estimated efforts (hours) of anglers, May 25 - September 6, 1983.

Location/Anglertype	Period I1	I2	I3	I4	I5	I6	I7	I8	Sum
John Day tailrace									
Boat	1,321.8	694.3	1,065.3	1,774.1	1,532.5	1,685.0	1,153.1	742.2	9,968.3
Sturgeon, Bank, OR[a]	4,231.5	3,762.2	2,896.1	4,762.6	2,846.7	1,394.6	1,538.1	1,610.7	23,042.5
Sturgeon, Bank, WA[b]	1,149.5	1,367.1	4,195.9	4,742.7	3,000.0	2,460.0	1,579.6	1,007.1	19,501.9
Shad, Bank, OR	270.7	2,031.6	4,969.8	994.8	56.3	9.3	0	0	8,332.5
Shad, Bank, WA	0	912.5	1,480.8	899.4	60.4	3.1	0	0	3,356.2
Other, Bank, OR	609.1	390.1	673.4	559.6	444.9	271.8	254.1	199.1	3,402.1
Other, Bank, WA	139.5	157.0	72.0	145.1	177.2	82.3	50.5	99.4	923.0
McNary tailrace									
Boat	463.0	256.2	936.7	1,735.6	1,767.8	1,040.5	1,395.9	1,185.2	8,780.9
Sturgeon, Bank, OR	615.1	544.8	1,227.5	624.4	391.8	410.0	370.0	450.0	4,633.6
Sturgeon, Bank, WA	652.2	721.7	1,302.8	1,965.3	1,277.1	1,012.5	909.1	884.8	8,725.5
Shad, Bank, OR	0	309.5	2,144.4	1,881.7	348.9	24.8	0	0	4,709.3
Shad, Bank, WA	0	0	0	0	0	0	0	0	0
Other, Bank, OR	346.8	373.6	466.4	478.5	543.5	518.7	416.1	306.9	3,450.5
Other, Bank, WA	343.0	358.7	221.5	394.6	432.8	274.9	179.5	139.5	2,344.5

[a] Oregon
[b] Washington

Table B.5. Catch per hour of walleye, northern squawfish and smallmouth bass by anglers, May 25 - September 6, 1983.

Location/Species	Angler Type	Period I1	I2	I3	I4	I5	I6	I7	I8	Sum
John Day tailrace										
Walleye										
	Boat, Walleye	.04	.07	.07	.05	.04	.11	.05	.04	.06
	Boat, Sturgeon	0	0	0	0	t	0	0	0	t
	Boat, Bass	0	0	0	0	0	0	0	0	0
	Bank, Sturgeon	0	t	0	0	0	t	t	0	t
	Bank, Shad	0	.01	.01	0	0	0	0	0	.01
	Bank, Other	.02	0	.01	0	0	.05	0	0	.01
Northern squawfish										
	Boat, Walleye	.02	.10	.16	.09	.05	.14	.10	1.01	.09
	Boat, Sturgeon	0	.02	.01	.01	.03	0	.01	0	.01
	Boat, Bass	0	0	0	0	0	0	0	0	0
	Bank, Sturgeon	.01	.02	.01	.01	.01	.01	.01	0	.01
	Bank, Shad	0	.26	.05	.08	0	.05	0	0	.08
	Bank, Other	.06	.19	.29	.09	.05	.09	.05	1.04	.11
Smallmouth bass										
	Boat, Walleye	.02	.01	t	.09	0	t	.01	.01	.01
	Boat, Sturgeon	0	0	0	0	0	0	0	0	0
	Boat, Bass	0	0	0	0	.55	.12	0	0	.20
	Bank, Sturgeon		t	t	0	0	0	t	0	t
	Bank, Shad	0	0	.01	0	0	0	0	0	0
	Bank, Other	.01	.08	.04	0	.02	0	.02	0	.02
McNary tailrace										
Walleye										
	Boat, Walleye	0	.03	0	.04	.03	.08	.10	.04	.06
	Boat, Sturgeon	0	0	0	0	0	0	0	0	0
	Boat, Bass	0	0	0	0	0	0	0	0	0
	Bank, Sturgeon	0	0	0	0	0	0	0	0	0
	Bank, Shad	--	--	--	--	--	--	--	--	--
	Bank, Other	.20	.01	0	0	0	.03	.02	0	.03
Northern squawfish										
	Boat, Walleye	.01	.23	.03	.10	.02	.02	.01	.02	.03
	Boat, Sturgeon	0	0	0	.01	.01	t	.01	.02	.01
	Boat, Bass	0	0	0	.07	0	.07	0	0	.03
	Bank, Sturgeon	0	0	.01	.01	t	0	0	0	t
	Bank, Shad	--	--	--	--	--	--	--	--	--
	Bank, Other	.45	.02	.07	.04	.01	.02	.02	.08	.08
Smallmouth bass										
	Boat, Walleye	0	0	0	t	0	t	.01	0	t
	Boat, Sturgeon	0	0	0	0	0	0	0	0	0
	Boat, Bass	.17	.39	0	0	.04	0	.18	0	.12
	Bank, Sturgeon	0	0	0	0	0	0	0	0	0
	Bank, Shad	--	--	--	--	--	--	--	--	--
	Bank, Other	.15	.08	.14	.05	.01	0	.08	0	.07

Table B.6. Proportion of catch kept by anglers, by species and location, May 25 - September 6, 1983.

Location/Species	Angler Type	Sampling Period I1	I2	I3	I4	I5	I6	I7	I8	Sum
John Day tailrace										
Walleye										
	Boat, Walleye	.94	.96	.93	.98	.83	.98	.98	1.0	.95
	Boat, Sturgeon	--	--	--	--	1.0	--	--	--	1.0
	Boat, Bass	--	--	--	--	--	--	--	--	--
	Bank, Sturgeon	--	1.0	--	--	--	1.0	1.0	--	1.0
	Bank, Shad	--	1.0	1.0	--	--	--	--	--	1.0
	Bank, Other	1.0	--	1.0	--	--	1.0	--	--	1.0
Northern squawfish										
	Boat, Walleye	.18	.48	.16	.63	.77	.82	.03	1.0	.40
	Boat, Sturgeon	--	1.0	0	1.0	1.0	--	0	--	.80
	Boat, Bass	--	--	--	--	--	--	--	--	--
	Bank, Sturgeon	1.0	.92	.43	.67	.50	.75	0	--	.78
	Bank, Shad	--	0	.35	.84	--	0	--	--	.32
	Bank, Other	1.0	.17	.87	1.0	.66	.20	.16	1.0	.61
Smallmouth bass										
	Boat, Walleye	0	.30	t	.63	--	t	.71	1.0	.43
	Boat, Sturgeon	--	--	--	--	--	--	--	--	--
	Boat, Bass	--	--	--	--	1.0	.10	--	--	1.0
	Bank, Sturgeon	--	t	t	--	--	--	t	--	--
	Bank, Shad	--	--	1.0	--	--	--	--	--	--
	Bank, Other	1.0	1.0	1.0	--	1.0	--	.50	--	.91
McNary tailrace										
Walleye										
	Boat, Walleye	--	1.0	--	1.0	1.0	.96	1.0	1.0	.98
	Boat, Sturgeon	--	--	--	--	--	--	1.0	--	--
	Boat, Bass	--	--	--	--	--	--	--	--	--
	Bank, Sturgeon	--	--	--	--	--	--	--	--	--
	Bank, Shad	--	--	--	--	--	--	--	--	--
	Bank, Other	1.0	1.0	--	--	--	1.0	1.0	--	1.0
Northern squawfish										
	Boat, Walleye	0	0	0	.10	0	.16	.23	0	.08
	Boat, Sturgeon	--	--	--	0	0	t	0	0	t
	Boat, Bass	--	--	--	0	--	0	--	--	0
	Bank, Sturgeon	--	--	.19	0	t	--	--	--	t
	Bank, Shad	--	--	--	--	--	--	--	--	--
	Bank, Other	.03	.33	.40	.49	1.0	0	0	0	.14
Smallmouth bass										
	Boat, Walleye	--	--	--	t	--	t	1.0	--	1.0
	Boat, Sturgeon	--	--	--	--	--	--	--	--	--
	Boat, Bass	0	.28	--	--	1.0	--	1.0	--	.54
	Bank, Sturgeon	--	--	--	--	--	--	--	--	--
	Bank, Shad	--	--	--	--	--	--	--	--	--
	Bank, Other	1.0	.74	.79	1.0	1.0	--	.75	--	.86

Table B.7. Mean hours fished per angler trip May 25 - September 28, 1983. Boat anglers were interviewed upon completion of trip. Bank anglers were interviewed before trip's completion.

Location/Anglertype	Period I1	I2	I3	I4	I5	I6	I7	I8
John Day tailrace								
Boat, Walleye	7.1	5.6	4.8	5.6	4.5	5.4	4.9	5.2
Boat, Sturgeon	5.8	7.2	6.2	5.9	7.5	5.3	4.7	4.6
Boat, Bass	0	0	0	0	1.2	1.5	0	0
Bank, Sturgeon	6.8	6.7	5.9	7.2	6.4	5.2	6.6	5.7
Bank, Shad	.8	5.3	4.2	6.2	8.5	5.3	0	0
Bank, Other	3.0	1.8	2.0	3.5	2.2	3.4	3.1	1.9
McNary tailrace								
Boat, Walleye	4.6	3.4	3.4	4.8	4.1	5.0	5.6	4.0
Boat, Sturgeon	3.9	5.8	5.1	6.2	5.3	6.1	6.1	6.1
Boat, Bass	1.8	3.7	0	2.7	2.6	5.5	11.2	0
Bank, Sturgeon	3.5	3.7	4.8	2.9	4.9	4.3	5.1	3.0
Bank Shad	--	3.4	3.5	2.7	1.2	--	--	--
Bank, Other	1.2	2.0	1.5	1.6	1.5	2.1	2.4	3.2

APPENDIX C

Hark and Recapture Data and the Method Used to Estimate Population Abundances.

Overton's modification of Schnabel's method (Overton 1965) was used to calculate abundance estimates using mark and recapture data on walleye (Tables C.1 through C.4), northern squawfish (Tables C.5 through C.12) and smallmouth bass (Tables C.13 through C.15) in different areas of John Day Reservoir and tailrace.

Overton's modification of Schnabel's method accommodated for known removals of individuals from the population during the study period. The abundance estimate (N) is calculated as:

$$N = N_0 + A$$

Where N_0 is Chapman's modification of Schnabel's estimate (Ricker 1975) and A is an adjustment for changing population size that is calculated by an iterative scheme. A first approximation (A1) of A is:

$$A_1 = \frac{\text{E ZCM}}{\text{E CM}}$$

Where Z is the total number of fish removed from the population prior to a given sample, C is the number of fish caught in a given sample and M is the number of marked fish at large prior to a given sample.

Approximate confidence limits for N were calculated by considering E (where $E = E\,CM + E\,\frac{ZCM}{N-Z}$) as a Poisson variable and using Table A.1 in Seber (1982).

Table C.1. Walleye catch, recapture, marking and removal data below John Day Dam, April 11 - September 24, 1983. Includes fish between 250 and 400 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals Marked	Removals Unmarked	Marked Fish at Large
250-400	8	21	0	19	0	2	0
	9	27	1	24	0	2	19
	10	20	1	19	0	0	43
	11	20	1	14	0	11	62
	12	50	5	40	0	10	76
	13	19	2	7	0	10	116
300-450	14	33	5	16	6	13	123
	15	14	4	9	2	9	133
	16	14	1	6	4	34	140
	17	14	1	2	3	11	142
	18	0	0	0	1	5	141
	19	12	0	12	0	0	140
TOTALS		244	21	168	16	88	

Table C.2. Walleye catch, recapture, marking and removal data below John Day Dam, April 11 - September 24, 1983. Includes fish larger than 400 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					Marked	Unmarked	
>400	8	38	0	36	0	2	0
	9	12	0	12	2	0	36
	10	25	0	23	0	2	46
	11	33	0	15	2	50	69
	12	85	1	49	3	58	82
	13	68	4	7	5	65	128
>450	14	45	1	8	7	57	130
	15	22	0	5	5	35	131
	16	46	0	1	2	134	131
	17	23	0	2	3	45	130
	18	7	0	4	1	21	129
	19	14	0	14	1	3	132
TOTALS		418	6	**176**	31	497	

Table C.3. Walleye catch, recapture, marking and removal data in upper John Day pool, April 11 - September 24,1983. Includes fish between 250 and 475 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals Marked	Removals Unmarked	Marked Fish at Large
250-475	7	3	0	3	0	0	0
	8	2	0	2	0	0	3
	9	20	1	17	0	2	5
	10	56	1	42	1	9	22
	11	12	0	5	0	67	63
	12	62	11	42	0	7	68
	13	26	6	17	2	2	110
300-525	14	29	2	12	0	15	125
	15	25	2	7	3	18	137
	16	32	1	15	1	26	141
	17	35	1	1	4	41	155
	18	10	1	2	2	16	152
	19	2	0	2	0	0	152
TOTALS		314	26	167	13	203	

Table C.4. Walleye catch, recapture, marking and removal data in upper John Day pool, March 27 - September 24,1983. Includes **fish larger than 475 mm fork length at the start of the survey.**

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					Marked	Unmarked	
>475	7	28	0	27	0	1	0
	8	43	0	41	0	1	27
	9	46	0	37	1	9	68
	10	190	2	114	1	69	104
	11	16	1	8	0	76	217
	12	147	3	111	0	28	225
	13	64	3	53	2	6	336
>525	14	21	0	10	2	26	387
	15	34	4	18	1	24	395
	16	67	3	24	1	60	412
	17	84	4	4	7	79	435
	18	23	1	1	2	32	432
	19	2	0	2	1	0	431
TOTALS		765	21	450	18	409	

Table C.5. Northern squanfish catch, recapture, marking and removal data below John Day Dam, March 27 - September 24,1983. Includes fish between 250 and 350 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					Marked	Unmarked	
250-350	7	3	**0**	3	**0**	**0**	**0**
	8	25	**0**	16	**0**	8	**0**
	9	38	1	32	0	4	8
	10	26	0	24	0	2	12
	11	60	1	49	0	28	14
	12	182	2	87	0	125	42
	13	82	1	65	0	68	167
	14	184	3	54	1	161	235
	15	110	3	69	1	59	397
	16	38	0	29	0	51	457
	17	24	0	17	0	8	508
	18	70	1	17	1	57	516
	19	71	1	21	0	49	574
TOTALS		913	13	483	3	620	

Table C.6. Northern squawfish catch, recapture, marking and removal data below John Day Dam, March 27 - September 24,1983. Includes fish larger than 350 mn fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					Marked	Unmarked	
>350	7	21	0	21	0	0	0
	8	61	0	34	0	26	21
	9	30	0	29	0	0	55
	10	63	2	61	0	0	84
	11	48	2	45	0	63	145
	12	244	3	74	0	290	190
	13	85	1	72	1	190	264
	14	203	3	35	0	299	335
	15	81	1	61	1	95	370
	16	32	0	30	0	150	430
	17	27	1	23	1	6	460
	18	135	5	14	0	128	482
	19	120	3	33	0	81	496
TOTALS		1,150	21	532	3	1,328	

Table C.7. Northern squawfish catch, recapture, marking and removal data below John Day Dam, July 17 - September 24,1983. Includes fish larger than 249 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					harked	Unmarked	
>250	15	33	0	32	0	1	0
	16	22	0	22	0	0	32
	17	29	0	24	0	3	54
	18	91	4	13	0	72	78
	19	49	0	28	0	18	91
TOTALS		224	4	119	0	94	

Table C.8. Northern squawfish catch, recapture, marking and removal data in John Day forebay, March 17 - September 24, 1983. Includes fish larger than 249 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals marked	Removals Unmarked	Marked Fish at Large
,250	7	14	0	14	0	0	0
	8	130	1	34	0	94	14
	9	35	0	5	0	30	48
	10	30	0	30	0	0	53
	11	133	0	3	0	130	83
	12	4	0	2	0	1	86
	13	58	0	1	1	57	88
	14	11	0	11	0	0	88
	15	69	0	58	0	9	99
	16	29	1	26	0	2	157
	17	55	1	20	0	34	183
	18	73	3	16	0	55	203
	19	21	0	12	0	7	218
TOTALS		662	6	232	1	419	

Table C.9. Northern squawfish catch, recapture, marking and removal data in upper John Day pool, March 17 - September 24, 1983. Includes fish between 250 and 300mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals Marked	Removals Unmarked	Marked Fish at Large
250-300	7	0	0	0	0	0	0
	a	3	0	3	0	0	0
	9	4	0	3	0	0	3
	10	7	0	4	0	0	6
	11	5	0	3	0	4	10
	12	5	0	5	0	1	13
	13	11	0	8	0	7	18
	14	8	0	7	0	7	26
	15	8	0	5	0	3	33
	16	29	0	13	0	1	38
	17	16	0	12	0	1	51
	18	13	0	8	0	0	63
	19	12	0	7	0	0	71
TOTALS		121	0	78	0	24	

Table C.10. Northern squawfish catch, recapture, marking and removal data in upper John Day pool, March 27 - September 24, 1983. Includes fish larger than 300mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					Marked	Unmarked	
>300	7	39	0	23	0	14	0
	8	123	1	93	0	29	23
	9	126	2	120	0	3	116
	10	280	6	135	0	184	236
	11	a4	5	75	1	4	371
	12	308	9	224	0	62	445
	13	372	9	236	5	122	669
	14	153	0	143	5	5	900
	15	329	9	312	1	5	1,038
	16	494	11	332	3	203	1,349
	17	273	21	243	0	5	1,678
	18	190	16	165	2	2	1,921
	19	122	10	107	0	4	2,084
TOTALS		2,893	99	2,208	17	642	

Table C.ll. **Northern squawfish catch, recapture, marking and removal data in McNary tailrace** boat **restricted zone, March 27** - July 2, 1983. **Includes fish larger than 249mm fork length at the start of the survey.**

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals harked	Unmarked	Marked Fish at Large
,250	7	2	0	1	0	1	0
	a	7	0	5	0	2	1
	9	26	0	26	0	0	6
	10	139	0	27	0	110	32
	11	15	2	10	0	1	59
	12	73	2	58	0	2	69
	13	137	0	59	0	76	127
TOTALS		**399**	4	186	0	192	

Table C.12. **Northern squawfish catch, recapture, marking and removal data in McNary tailrace boat restricted zone, July 2 - September 24, 1983. Includes fish larger than 249 mn fork length at the start of the survey.**

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals		Marked Fish at Large
					Marked	Unmarked	
>250	14	61	0	58	0	3	0
	15	254	3	244	0	3	58
	16	**415**	5	270	0	139	302
	17	229	9	213	0	2	572
	18	166	10	149	0	1	785
	19	105	6	94	0	3	934
TOTALS		1,230	33	1,028	0	151	

Table C.13. Smallmouth bass catch, recapture, marking and removal data below John Day dam, April 10 - September 24, 1983. Includes fish larger than 199 mm fork length at the start of the survey.

Lengths(mm)	Period	Catch	Recaptures	Number Marked	Removals Marked	Removals Unmarked	Marked Fish at Large
>200	a	24	0	22	0	2	0
	9	19	0	18	0	0	22
	10	13	1	12	2	1	40
	11	30	2	27	1	2	50
	12	67	3	62	6	4	76
	13	14	1	10	2	1	132
>250	14	7	2	5	1	2	140
	15	9	2	7	2	2	144
	16	1	0	1	2	0	149
	17	4	0	3	0	0	148
	la	4	1	1	0	1	151
	19	9	1	a	0	1	152
TOTALS		**201**	**13**	**176**	**16**	**16**	

Table C.14. Smallmouth bass catch, recapture, marking and removal data in John Day forebay, April 10 - September 24, 1983. Includes fish larger than 199 mm fork length at the start of the survey.

Lengths (mm)	Period	Catch	Recaptures	Number Marked	Removals Marked	Removals Unmarked	Marked Fish at Large
>200	a	**41**	**0**	**29**	**0**	12	**0**
	9	**21**	**0**	**15**	**0**	6	**29**
	10	1	**0**	1	1	0	44
	11	33	1	28	0	2	44
	12	0	0	0	1	0	72
	13	46	2	43	0	0	71
>250	14	3	0	0	1	3	114
	15	3	0	2	4	0	113
	16	3	0	3	1	0	111
	17	7	1	5	0	0	113
	18	21	2	18	0	1	118
	19	5	0	5	0	0	136
TOTALS		**184**	6	149	8	24	

Table C.15. Smallmouth bass catch, recapture, marking and removal data in upper John Day pool between March 27 - September 24, 1983. **Includes fish larger than** 199 mm **fork length at the start of the survey.**

Lengths (mm)	Period	Catch	Recaptures	Number Marked	Removals Marked	Removals Unmarked	Marked Fish at Large
>200	7	27	0	26	0	1	0
	a	16	0	14	0	1	26
	9	8	0	8	1	0	40
	10	152	0	98	1	52	47
	11	29	1	17	4	97	144
	12	110	7	88	1	43	157
	13	15	2	7	3	74	244
>250	14	6	0	2	2	32	248
	15	6	0	5	0	8	248
	16	104	10	71	3	22	253
	17	29	2	14	1	37	321
	18	6	0	5	0	1	334
	19	1	0	1	0	0	339
TOTALS		**509**	22	356	16	368	

APPENDIX D

A Simulation of the Removal of Northern Squawfish from McNary Tailrace Boat Restricted Zone by Electrofishing and Angling.

An idea of how effectively sampling gear could reduce predator populations can be gained from estimates of population size and gear specific catch per unit effort (CPUE). Consider the example of McNary tailrace boat restricted zone (BRZ) where approximately 15,000 northern squawfish were present from July through September. Assuming that CPUE of electrofishing (the most effective gear) declines (from the observed average of 14.3 fish per electrofishing run) in direct proportion to decreasing population size (an assumption commonly made in removal methods of population estimates (Ricker 1975, Seber 1982)) an estimated 726 runs (Table 0.1) would be required to reduce northern squawfish abundance by half. This effort would require about 544 hours of sampling by a two-person crew or about 68 eight-hour days. If the two-person crew angled instead of electrofished, a total of 1,367 crew-hours or sampling of 171 crew days (Table 0.2) would achieve the same reduction.

A critical assumption of both estimates of efforts required to reduce northern squawfish abundance in McNary tailrace BRZ by half is that CPUE remain constant regardless of how frequently the area is sampled. Our experience indicates this assumption is not met. Since sampling success declines greatly with repeated sampling within short periods of time, the effort required to reduce northern squawfish abundance may be considerably greater than our estimates.

Table D.l. **Estimated changes in catch per unit effort (CPUE) by electrofishing in response to decreasing abundance of northern squawfish, and effort (number of hours) required to reduce that abundance by 500-fish increments, July - September, 1983, McNary tailrace boat restricted zone.**

Number Caught	CPUE[a]	Effort	Cumulative Removal	Cumulative Effort[b]
500	14.1	35.6	500	35.6
500	13.6	36.8	1,000	72.4
500	13.1	38.1	1,500	110.5
500	12.6	39.6	2,000	150.1
500	12.2	41.1	2,500	191.2
500	11.7	42.8	3,000	234 .O
500	11.2	44.6	3,500	278.6
500	10.7	46.6	4,000	325.2
500	10.3	48.7	4,500	373.9
500	9.8	51 .l	5,000	425.0
500	9.3	53.7	5,500	478.7
500	8.8	56.6	6,000	535.3
500	8.4	59.8	6,500	595.1
500	7.9	63.4	7,000	658.5
500	7.4	67.5	7,500	726 .O

[a] CPUE = 14.3 - (14.3/15,000) x cumulative removal
[b] An angling hour = 0.75 crew hours
A crew day = 8 crew hours

Table D.2. Estimated changes in catch per unit effort (CPUE) by angling in response to decreasing abundance of northern squawfish, and effort (number of hours) required to reduce that abundance by 500-fish increments, July through September, 1983, McNary tailrace boat restricted zone.

Number Caught	CPUE[a]	Effort	Cumulative Removal	Cumulative Effort[b]
500	3.7	133 .a	500	133.8
500	3.6	138.5	1,000	272.3
500	3.5	143.5	1,500	415.8
500	3.4	148.9	2,000	564.7
500	3.2	154.8	2,500	719.5
500	3.1	161.1	3,000	880.6
500	3.0	167.9	3,500	1,048.5
500	2.9	175.4	4,000	1,223.9
500	2.7	183.5	4,500	1,407.4
500	2.6	192.4	5,000	1,599.8
500	2.5	202.3	5,500	1,802.1
500	2.3	213.2	6,000	2,015.3
500	2.2	225.4	6,500	2,240.7
500	2.1	239 .o	7,000	2,479.7
500	2.0	254.4	7,500	2,734.1

[a] CPUE = 3.8 - (3.8/15,000) x cumulative removal
[b] An angling hour = 0.50 crew hours
A crew day = 8 crew hours