US Army Corps
of Engineers
Walla Walla District

Lower Granite Reservoir In-Water Disposal Test:

Results Of The Fishery, Benthic and Habitat Monitoring Program-Year 2 (1989)

Completion Report

David H. Bennett
James A. Chandler
Gwynne Chandler

November 1991

PLANNING
ENVIROMENTAL RESOURCES BRANCH
Fishery Library Publication # 721
Initials: ______ Duplicate: ______
ECOL INVST/Dredge

LOWER GRANITE RESERVOIR IN-WATER DISPOSAL TEST: MONITORING FISH AND BENTHIC COMMUNITY ACTIVITY AT DISPOSAL AND REFERENCE SITES IN LOWER GRANITE RESERVOIR, WASHINGTON Year-2 (1989)

Completion Report

To:

Department of the Army
Army Corps of Engineers
Walla Walla District,
Building 602, City-County Airport
Walla Walla, Washington 99362

David H. Bennett

James A. Chandler

and

Gwynne Chandler

Department of Fish and Wildlife Resources
University of Idaho
Moscow, Idaho 83843

October, 1991

TABLE OF CONTENTS

TABLE OF CONTENTS Cont.

EXECUTIVE SUMMARY

Introduction

The Lower Granite Lock and Dam Project on the Snake River was completed in 1975 to provide electrical power generation, flood control, navigation, and recreation. A levee system constructed on the Snake and Clearwater rivers protects the cities of Lewiston, Idaho, and Clarkston, Washington, from flooding. The integrity of the levee system, designed with 5 ft (1.5m) of freeboard, is being threatened by deposition of sediment in the upstream end of Lower Granite Reservoir. U.S. Army Corps of Engineer personnel estimate that in excess of 2 million cubic yards (1,529,200m^3) of sediment enters the confluence of the Snake and Clearwater rivers during an "average year" in Lower Granite Reservoir. Years with higher run-off result in greater inputs of sediment. Approximately 800,000 cubic yards (611,680m^3) of material collects annually in the upper end of Lower Granite Reservoir interfering with navigation and flood control aspects of the project.

One of several alternatives being examined to alleviate the flooding potential is dredging sediment and depositing dredged materials in-water approximately 19 miles (30.6km) downstream of the confluence in Lower Granite Reservoir. Experimental in-water disposal was conducted in 1988 and 1989 with construction of an under-water bench and island at mid-depth (20-60ft) and some additional disposal at deep (>60ft) sites.

Several monitoring projects have examined the biological significance of different habitat types and experimental disposal activities in Lower Granite Reservoir. These have shown that shallow water habitat serves as foraging and "holding" areas for juvenile anadromous salmonid fishes and also as spawning and rearing habitat for resident game fishes. Deep habitats supported fewer fishes, a majority of those were nongame catostomid and cyprinid fishes, although the white sturgeon *Acipenser transmontanus* inhabited the deeper waters. Mid-depth habitats supported a benthic community higher in diversity and abundance of game fishes than deep habitat but generally lower in abundance than shallow habitat. Catch rates of salmonids by surface trawling in the late spring and summer of 1988 were similar among shallow and mid-depth reference and mid-depth disposal stations. Catch rates of predators also were not significantly different between reference and disposal stations. The major difference between reference and disposal stations was the paucity of fishes in the 4-8 inch (100-200mm) and larger than 12 inch (300mm) size classes at the disposal stations suggesting that spawning and/or rearing habitat at the disposal stations may not be suitable for certain species. Results of the first year of monitoring suggested few differences between disposal and reference stations. This report summarizes results of monitoring during 1989 and compares with those of previous years and between reference and disposal stations.

Sampling for fall chinook salmon commenced in 1990. Findings will be presented in the Year-3 report (1990).

OBJECTIVES

1) To compare abundance of fishes at two in-water disposal sites with those of reference sites.
   - a. To assess the abundance of larval and juvenile predators with special emphasis on northern squawfish *Ptychocheilus oregonensis*.
   - b. To evaluate the suitability and desirability of the newly created shallow water habitat for spawning and rearing of salmonid fishes and potential predators.
2) To compare benthic community abundance at in-water disposal sites with those of reference sites; and,
3) To provide "ground truthing" for a hydroacoustical survey.

A total of ten stations were sampled in Lower Granite Reservoir during 1989 (Figure 1). Of these, three were associated with habitat created from in-water disposal events (1, 2, 4), one each with mid-depth reference (6) and deep reference (8) and five with shallow water reference (3, 5, 9, 10, 11). However, not all stations were sampled to accomplish each of the stated objectives.

Objective 1: To compare abundance of fishes at two in-water disposal sites with those of reference sites.

Gear types varied by habitat type. Surface trawling was used to assess pelagic salmonid fish abundance. Gill nets were used to assess potential predator abundance among stations, whereas beach seines and nighttime electrofishing were used at shallow stations.

Larval fish sampling was conducted at biweekly intervals from June through mid-September. Juvenile predator abundance was assessed using paired 1.6 ft (0.5m) cone plankton nets and a custom built hand-drawn beam trawl. Three paired hauls were made at each station each night we sampled. The beam trawl was pulled by two people over a standard distance of 50 ft (15m) along the shoreline during the daytime. Three such hauls were made along the shoreline in < 1 m and three in > 1 m for a total of six hauls/station/sampling date.

To evaluate the suitability and desirability of the disposal and selected references sites for spawning, we snorkeled the shorelines and recorded fish activity from June through September.

During 1989, we collected 17,567 fishes representing 20 species and 3 genera. We collected the highest number in spring 1989 (10,907). During the summer, 4,614 fish were collected, whereas during the fall 2,046 adult and subadult fish were collected.

Relative abundance of fishes varied by station and season. During [redacted] most abundant [redacted] followed in decreasing order of abundance by largescale sucker *Catostomus macrocheilus* (25.8%), and more distantly by steelhead *O. mykiss* (6.4%), chiselmouth *Acrocheilus alutaceus* (5.4%), and [redacted] During [redacted] and more distantly by white crappie *Pomoxis annularis* (5.4%) and [redacted] During [redacted] smallmouth bass [redacted] Largescale suckers were the most abundant species at the disposal stations 1, 2, and 4.

Size composition of the catch was generally similar except that [redacted]

[redacted]

Pelagic and deep water fish abundance varied by station and species. [redacted] Catches of channel catfish *Ictalurus punctatus* at disposal stations were significantly lower than at all reference stations but one.

Comparison of fish abundance among previous years of monitoring indicated several changes from 1988-1989. Catch/effort of white sturgeon was similar among years 1987-1989. [redacted] Catch/effort of channel catfish was lowest at the mid-depth disposal station and has not changed from 1987-1989.

Littoral fish abundance varied by station, time of day and among years sampled. During the night, based on electrofishing, no differences in catch/effort in steelhead, chinook salmon and northern squawfish were found between island and reference stations. Catch/effort of smallmouth bass was significantly lower at island stations than at reference stations.

Several changes in littoral fish abundance have been observed among years. Catch/effort of steelhead during the day has generally decreased from 1987-1989. Daytime catches of steelhead were significantly lower in up-reservoir stations than down-reservoir stations. Chinook salmon abundance during the day was similar among 1988 and 1989. Daytime catch per unit effort (CPUE) of northern squawfish, mostly juveniles, increased significantly in 1989 over 1988. At night, based on shoreline electrofishing, no station differences in CPUE of chinook salmon were significant although those in 1988 were higher than in 1989. Steelhead CPUE at night were significantly higher in 1989 than in 1987 and 1988. Few station differences in the abundance of smallmouth bass were found from 1987-1989 although no yearly differences were found. Northern squawfish abundance varied among years and among stations; highest CPUEs were at reference stations.

Larval fish abundance was highest at the shallow water reference stations (5 and 11) although confidence intervals were wide and overlapping. Beam trawling along the shoreline indicated the presence of larval smallmouth bass at all stations. Larval squawfish were collected by beam trawling once at island disposal stations (1 and 2) but in considerably less abundance than at a shallow-water reference station (11). Results from half meter nets indicated highest abundance of larval sized predator fish off the island (1) and at a shallow reference station (11). Larval smallmouth bass were highest in abundance at island stations, whereas northern squawfish were highest in abundance at an up-reservoir reference station (11).

Our assessment of activity at the newly created island revealed smallmouth bass nests and later fry at the channel-side of the island. No nesting was observed on the shore-side of the island, presumably a result of the sandy substrate and erosion from the island.

Objective 2: To compare benthic community abundance at in-water disposal sites with those of reference sites.

Benthic community abundance was assessed by taking 12 Shipek dredge samples at each station during July 1989. Number and wet weights were determined and expanded to numbers and biomass/m^2.

Benthic community biomass consisted of 25% oligochaetes and 75% chironomids. Total benthic community biomass was significantly lower at disposal stations and one reference station (3) than at other shallow, mid-depth, and deep water reference stations. Chironomid biomass was not significantly different among stations during 1989. Oligochaete biomass ranged from 1-2 to 11 g/m^2 and significantly lower at disposal and one shallow-water reference stations than at shallow, mid-depth and deep water reference stations.

Numerical density of benthos varied among stations and by taxon. Although not statistically different, density of oligochaetes in 1989 was highest at the mid-depth disposal station. Chironomid density was significantly lower at the mid-depth disposal station (4) than other shallow water reference stations.

Yearly comparisons indicated total benthic community biomass was significantly lower following disposal of dredged materials than prior to disposal of dredged materials. Our results indicated that benthic community biomass at the mid-depth disposal station did not change 15 months following disposal. Numerically, chironomid density decreased at most stations from 1987-1989 although this decrease was not statistically significant. However, chironomid density decreases were significantly lower in 1989 than from the predisposal at the mid-depth disposal station. Year-to-year differences in chironomid density were not significant at the mid-depth reference station although they were different at a shallow water reference station during 1987-1989. Oligochaete densities were significantly lower among 1987, 1988, and 1989 at the mid-depth disposal and reference stations.

Objective 3: To provide for "ground truthing" for the hydroacoustical survey.

Horizontal and vertical gill nets were fished at eleven preselected transects during April, June, and October, 1989. A total of six nets, two each experimental horizontal multifilament gill nets, 225 ft (69m) long by 6 ft (1.8m) deep and 1.5, 1.75, and 2.0 inch (3.2, 4.4 and 5.1cm) bar measurements, generally were set on the bottom adjacent and perpendicular to both shorelines. Also, two additional mid-depth horizontal nets were set at each station. Two each vertical nets, 125 ft long, also experimental with two panels each 6 ft (1.8m) wide of 1.5 and 2.0 inch (3.2 and 5.1cm) mesh were fished from the surface to the bottom in mid and deep water habitats along each transect. When shallow water was not available, only four nets were set. Nets were set for two 6 hour periods each day and night. Catches of various species were grouped into salmonids, predators and "others" and expressed as the percentage of the community in three sections (lower-RM 109-114; middle-RM 116-125; and, upper-RM 127-134). Bass, northern squawfish and channel catfish were considered predators. All species not salmonids (sockeye, chinook and juvenile steelhead) or predators were lumped in the "other" category.

A total of 836 "other" species, 263 predators and 53 salmonids were collected during the ground truthing effort for the hydroacoustics evaluation. Of these, 314, 518 and 320 were collected in the lower (RM 109-114), middle (RM 119-125), and upper (RM 127-134) reservoir sections, respectively. A multivariate statistical analysis indicated that these species categories were discrete and permitted an analysis of variance of the influence of season, reservoir location, habitat, and time on CPUE. Only habitat was a significant ($P<0.05$) main effect which indicated a pooling of all the other variables was appropriate. Once the significance of habitat was determined, we computed the mean predator abundance as 21.8% (95% Bound 17.8-25.8%) in shallow water, 24.3% (95% Bound 16.4-32.2%) for mid-depth waters, and 21.8% (95% Bound 7.1-36.5%) in deep waters. Other species were 76.8% (95% Bound 72.2-81.4%), 73.8% (95% Bound 64.8-82.8%), and 72.4% (95% Bound 0.21-100%) in shallow, mid-depth and deep water habitats, respectively. These comparisons show that "other" species are about 3+ times more abundant than predators in all habitats. Only three species, smallmouth bass, northern squawfish, and channel catfish, were considered predators, compared to numerous species that were classified as "others". Abundance of salmonids during the spring was 8.5% (95% Bounds 0.7-16.3%) which was considered a minimum estimate because of large mesh size on the gill nets and the consistent year-to-year trend not to capture salmonid smolts in high abundance regardless of mesh size.

In summary, results of Year-2 monitoring show neither strong positive nor negative impacts from the in-water disposal in Lower Granite Reservoir. Few temporal changes in the fish and benthic communities have been found and those that have been found are probably balanced in terms of positive and negative impacts. Year-3 sampling will provide another year's data and provide a clearer picture of the impacts of in-water disposal in Lower Granite Reservoir.

ACKNOWLEDGMENTS

We thank the U.S. Army Corps of Engineers, Walla Walla, Washington for continued support of this project. Ms. Teri Barila and Sarah Wik were extremely helpful in project management and support. Messrs. Ed Buettner and Lance Nelson from the Idaho Department of Fish and Game were helpful in assisting our purse seining efforts and use of the purse seine barge. Numerous students at the University of Idaho contributed greatly to this project especially Messrs. Tom Curet and Tom Dresser. Others such as Joe Lucas and Ken Lepla made numerous sacrifices to conduct the field sampling and laboratory analyses.

INTRODUCTION

The Lower Granite Lock and Dam Project on the Snake River was completed in 1975 to provide electrical power generation, flood control, navigation, and recreation. A levee system constructed on the Snake and Clearwater rivers protects the cities of Lewiston, Idaho, and Clarkston, Washington, from flooding. The integrity of the levee system, designed with 5 ft (1.5m) of freeboard, is being threatened by deposition of sediment in the upstream end of Lower Granite Reservoir. U.S. Army Corps of Engineer personnel estimate that in excess of 2 million cubic yards (1,529,200m^3) of sediment enters the confluence of the Snake and Clearwater rivers during an "average year" in Lower Granite Reservoir. Years with higher run-off result in greater inputs of sediment. Approximately 800,000 cubic yards (611,680m^3) of material collects annually in the upper end of Lower Granite Reservoir interfering with navigation and flood control aspects of the project.

One of several alternatives being examined to alleviate the flooding potential is dredging sediment and disposing of dredged materials in-water approximately 19 miles (30.6km) downstream of the confluence in Lower Granite Reservoir. Experimental in-water disposal was conducted in 1988 and 1989 with construction of an under-water bench and island at mid-depth (20-60ft) and some additional disposal at deep (>60ft) sites.

Several monitoring projects have examined the biological significance of different habitat types and experimental disposal activities in Lower Granite Reservoir. Bennett and Shrier (1986) showed that shallow habitat serves as foraging and "holding" areas for juvenile anadromous salmonid fishes and also as spawning and rearing habitat for resident game fishes. Their study also showed that deep habitats supported fewer fishes, a majority of those were nongame catostomid and cyprinid fishes, although the white sturgeon *Acipenser transmontanus* inhabited the deeper waters. Bennett et al. (1988) reported that mid-depth habitats supported a benthic community higher in diversity and abundance of game fishes than deep habitat but generally lower in abundance than shallow habitat. Bennett et al. (1990) showed that catch rates of salmonids by surface trawling in the late spring and summer of 1988 were similar among shallow and mid-depth reference and mid-depth disposal stations. Catch rates of predators also were not significantly different between reference and disposal stations. The major difference between stations was the paucity of fishes in the 4-8 inch (100-200mm) and larger than 12 inch (300mm) size classes at disposal stations suggesting that spawning and/or rearing habitat may not be suitable for certain species. Results of the first year of monitoring suggested few differences in the fish and benthic communities between disposal and reference stations (Bennett et al. 1990). This report summarizes results of monitoring during Year-2 (1989), and compares findings between reference and disposal stations and with previous years.

Sampling for fall chinook salmon commenced in 1990. Findings will be presented in the Year-3 report (1990).

Specific objectives of this project were to:

OBJECTIVES

1) Compare abundance of fishes at two in-water disposal sites with those of reference sites.
    a. Assess the abundance of larval and juvenile predators with special emphasis on northern squawfish *Ptychocheilus oregonensis*.
    b. Evaluate the suitability and desirability of the newly created shallow water habitat for spawning and rearing of salmonid fishes and potential predators.

2) Compare benthic community abundance at in-water disposal sites with those of reference sites; and,

3) Provide "ground truthing" for a hydroacoustical survey.

STUDY AREA

A total of ten sampling stations were sampled in Lower Granite Reservoir during 1989 (Figure 1). Of these, three were associated with habitat created from in-water disposal events (1, 2 and 4), one each with mid-depth reference (6) and deep reference (8) and five with shallow water reference (3, 5, 9, 10, 11) stations. However, not all stations were sampled to accomplish each of the stated objectives. Specific location of sampling was as follows (numbering follows that of Webb et al. [1987] to standardize station numbering):

Site No.	Location
1	RM-120.48-120.19 - shoreline adjacent to the island created with dredged materials;
2	RM-120.48-120.19 - open water shoreline adjacent to the island created with dredged materials;
3	RM-120.48-120.19 - reference station with shoreline area inside the mid-depth site (on-shore);
4	RM-120.48-120.19 - the mid-depth fill site that created the underwater bench.
5	RM-127 - the shallow reference site (SR2S in Bennett and Shrier 1986; LG2S in Bennett et al. 1988);
6	RM-114.0-114.92 - a mid-depth reference site (LG1M in Bennett et al. 1988);

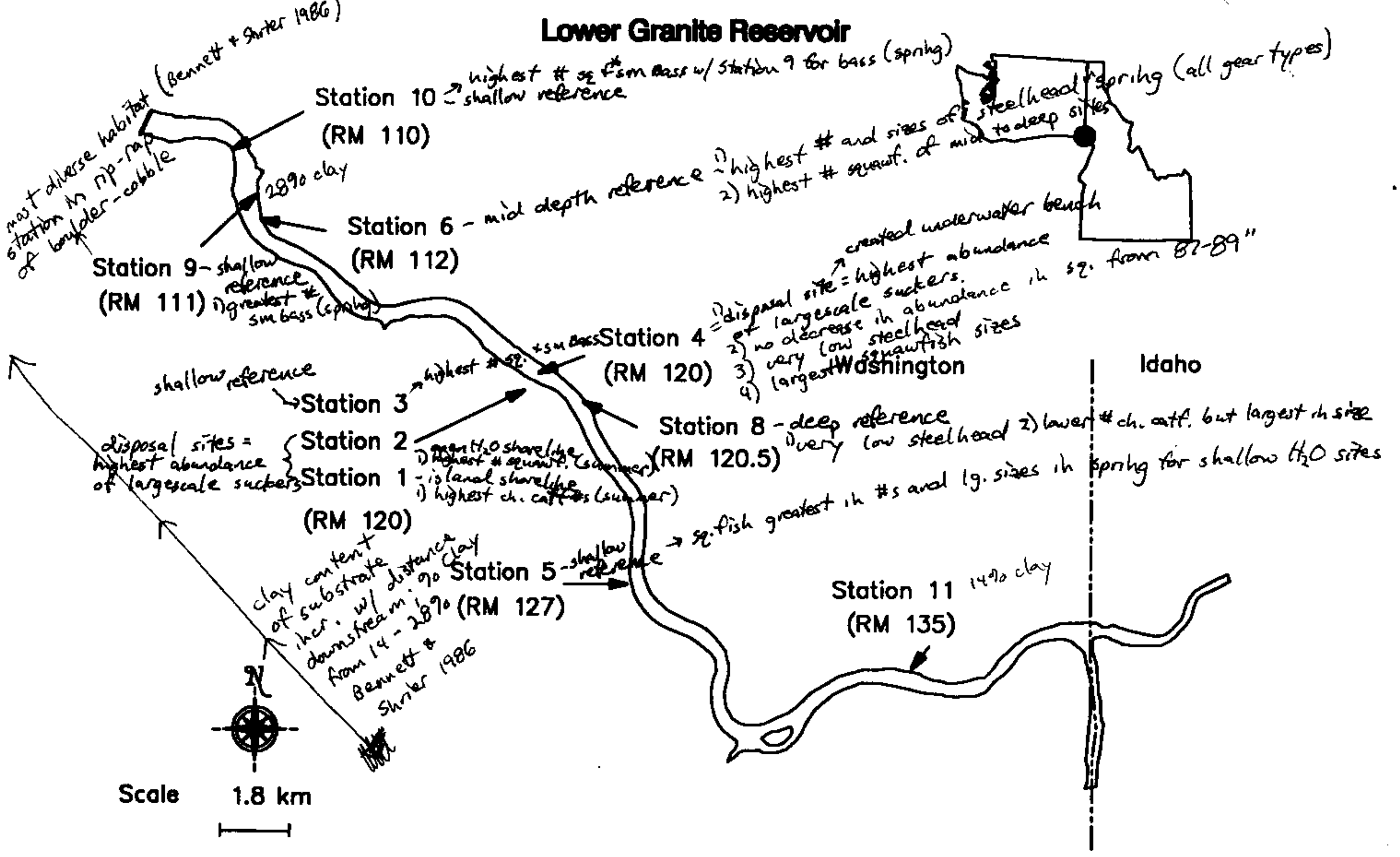


Figure 1. Map of Lower Granite Reservoir, Idaho-Washington on the Snake River, showing sampling locations.

NOTE: No Station 7 sampled 1989 for deep water disposal.

8 RM-120.5 - deep water reference site;

9 RM-111 - shallow site (LG1S in Bennett et al. 1988);

10 RM-110 - shallow site on south side of the reservoir;

11 RM 135 - shallow site on the north side of the reservoir (LG5S in Bennett et al. 1988);

Objective 1: To compare abundance of fishes at two in-water disposal sites with those of reference sites.

METHODS

Sampling gear used in 1989 was based on results of the 1988 monitoring that indicated surface trawling was one of the more effective gear types to assess pelagic salmonid abundance (Bennett et al. 1990). Surface trawling could be fished over the mid-depth disposal station, whereas the purse seine could not. Gill nets were used to assess potential predator abundance among stations, whereas beach seines and electrofishing were especially effective at shallow stations during the day and night, respectively.

Surface trawling was conducted in April, May and June. The surface trawl was constructed of 1.5 inch (3.8cm) mesh netting, with a cod end of 0.25 inch (0.64cm) mesh. The inside of the cod end had a metal container which served as a baffle to prevent mortality of captured fish from impingement against the net. The surface trawl was designed to be towed behind and between two boats to prevent "scattering" fish from the "prop wash". The two boats were approximately 148 ft (45m) apart, with 148 ft long tow ropes. Two tows, the length of each station, were made each time a station was sampled. Towing speed varied from 1.7ft/s (0.53m/s) to 5.25 ft/s (1.6m/s) (mean = 1.2 m/s; 3.9ft/s). For surface trawling, CPUE was expressed as number of fish/meter of trawling.

Limited purse seining was conducted during 1989, primarily as a check of the 1988 findings (Bennett et al. 1990) to assess the concentration of steelhead and chinook salmon juveniles in the lower reservoir. Because of the shallow water, purse seining was not possible at the mid-depth disposal station with the gear available in 1989. Methods used for purse seining were similar to those used in 1988 (Bennett et al. 1990).

Standardized beach seine hauls were used to sample shoreline areas during the day at stations 1, 2, 3, 5, 9, and 10. Beach seining was conducted twice monthly during April, May and June and at monthly intervals during July, August, September, and October using a 100 x 8 ft (30.5 x 2.4m) seine constructed of 1/4 inch (0.64cm) knotless nylon mesh with a 8x8x8 ft ($2.4x2.4x2.4m^3$) bag. A standard haul was made by setting the seine parallel to the shoreline using 50 ft (15m) extension ropes which sampled approximately 0.08 acres. Three hauls were made at each station. Catches were expressed as numbers/haul.

Horizontal, multifilament experimental gill nets, 225 ft (69m) long by 6 ft (1.8m) deep that were 1.5, 1.75, and 2.0 inch (3.2, 4.4 and 5.1cm) bar measurements, were fished at all stations except 9, 10 and 11, during April, May, June, August, and October. Nets were set for a total of a 6 hour period each day which included 3 hours of daylight and 3 hours of dark. This time schedule allowed sampling during the crepuscular period, a time which many species of fish are most active. Nets were checked on a 2 hour schedule at stations 1, 2, 3, 4, and 5 to avoid destructive sampling of adult salmonids. Nets at mid-depth and deep stations were checked on a 3 hour schedule because few adult salmonids were collected. Catches were expressed as number of fish/hour.

Standardized nighttime electrofishing was conducted twice monthly during April, May and June and monthly during July, August, September, and October at stations 1, 2, 3, 5, 9, and 10. Electrofishing was conducted by paralleling as possibly close to the shoreline for three-5 min passes. An output of approximately 300 volts and 4-5 amps was found to adequately stun fish while virtually causing no mortalities or visual evidence of injury. Catches were expressed as numbers of fish/5 min pass.

Fish collected with all gear types were identified to species and total lengths (mm) were taken (except adult anadromous fishes). All adult anadromous salmonids were released immediately without removing them from the water.

In addition, larval fish sampling was conducted at biweekly intervals from June through mid-September. To assess juvenile predator abundance, we used paired 1.6 ft (0.5m) cone plankton nets and a custom built hand-drawn beam trawl (LaBolle 1985) at stations 1, 2, 4, 5, and 11. Cone nets were towed at night approximately 5.25 ft/s (1.6m/s) at the surface and 3.3 ft (1m) depth for 3 min at each depth. Three paired hauls were made at each station each night we sampled. Samples from the cone nets were preserved separately which provided six samples/sampling location/sampling date. The beam trawl was pulled along the shoreline by two people over a standard distance of 50 ft (15m) during the daytime. Three such hauls were made along the shoreline in shallow (<1m) and deeper (>1m) water for a total of six hauls/station/sampling date. All samples were preserved in 10% formalin for later laboratory enumeration.

To evaluate the suitability and desirability of the disposal and references sites (1, 2, 5, 9, and 10) for spawning, we snorkeled the shorelines at weekly intervals and recorded fish activity. Spawning activity was recorded as the presence of fish, other signs of spawning activity (cleaned gravel, nest construction, etc.) and the presence of recently spawned juveniles. We conducted these surveys from June through September.

RESULTS

Species Composition and Relative Abundance

During 1989, we collected 17,567 fishes representing 20 species and 3 genera. The highest number was collected in spring 1989 when we collected 10,907 fish (Table 1). During the summer, 4,614 adult and subadult fish were collected (Table 2), whereas during the fall 2,046 adult and subadult fish were collected (Table 3).

During spring 1989, chinook salmon was the most abundant species accounting for 45.6% of all fishes collected followed, in decreasing order of abundance, by largescale sucker (25.8%), and more distantly by steelhead (6.4%), chiselmouth (5.4%), and smallmouth bass (4.4%).

During summer 1989, catches of largescale suckers were highest (38.2%) followed by smallmouth bass (30.0%) and more distantly by white crappie (5.4%) and northern squawfish (4.5%). Number of salmon and steelhead collected during the summer was low (Table 2).

During the fall, 2,046 fish representing 20 species were collected at all stations (Table 3). Numerous largescale suckers, smallmouth bass, northern squawfish, and chiselmouth

Table 1. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington in spring 1989.

complex habitat with island

sh. ref.

5 - shallow ref.
mid - reservoir
6 - mid-depth ref.

sh. ref.

sh. ref.

Species	Stations 1	2	3	4	5	6	8	9	10	TOTAL
White sturgeon							36			36
Chinook salmon	172	406	370	172	2,640	594		477	145	4,976
Sockeye salmon						1				1
Steelhead	3	75	13	22	113	353	6	67	43	695
Mountain whitefish	3	1		1	1					6
Chiselmouth	100	24	79	16	246	1		49	78	593
Common carp	7	5	12	5	32	13	7	2	11	94
Peamouth	13		6	4	4			1		28
Northern squawfish	46	25	24	28	126	48	14	9	32	352
Redside shiner	2		3						3	8
Bridgelip sucker	20	11	7	8	16			27	7	96
Largescale sucker	427	323	319	247	518	64	6	295	621	2,820
Brown bullhead	2	3	4	5	18	4		4	1	41
Channel catfish	6	3	8	2	14	21	29	4		87
Lepomis spp.									23	23
Pumpkinseed	4	1	8	3	36			5	91	148
Bluegill									2	2
White crappie	33	51	51	22	101	11		2	58	329
Black crappie	1								9	10
Yellow perch	3	1	10	10	59			1		84
Smallmouth bass	23	19	76	6	46	3		185	119	477
Cottid spp.			1							1
TOTALS	865	948	991	551	3,970	1,113	98	1,128	1,243	10,907

smallest sizes

largest sizes stations

smallest size

Table 2. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington in summer 1989.

	Stations									
	created with island habitat		- shallow ref					- sh. ref.	- sh. ref.	
Species	1	2	3	4	5	6	8	9	10	TOTAL
White sturgeon		1		1			54			56
Chinook salmon						1				1
Steelhead			3		2		3	2	8	18
Chiselmouth	5	5	11		1			28	126	176
Common carp	8	11	33	20	20		5		1	98
Peamouth	2							3	4	9
Northern squawfish	33	45	26	6	11	8	5	18	55	207
Redside shiner	5	1	1					2	2	11
Bridgelip sucker	1	3		2	2			16	2	26
Largescale sucker	469	493	204		175	6	28	191	199	1,765
Brown bullhead	11	8	10	5	8	3		6		51
Channel catfish	69	14	25	11	9		2			130
Lepomis spp.		14	12		206					232
Pumpkinseed	3	3	24		31			11	10	82
Bluegill			1		5					6
Pomoxis spp.					3					3
White crappie	35	44	45	20	92	8		1	2	247
Black crappie	10	1	4		33			1	3	52
Yellow perch	7	7	9	2	34					59
Smallmouth bass	25	198	446	8	152	4		250	299	1,382
Cottid spp.			1		2					3
TOTALS	683	848	855	75	786	30	97	529	711	4,614

Table 3. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington in fall 1989.

created habitat associated with island

shallow ref

shallow ref.

Species	1	2	3	4	5	6	8	9	10	TOTAL
	Stations									
White sturgeon							7			7
Chinook salmon			1		4					5
Steelhead	4	1	3	6	12	1	1	1	2	31
Mountain whitefish	2		1		2					5
Chiselmouth	6	10	18	4	4	1		44	58	145
Common carp				2	7	3	3			15
Peamouth		2				2		1	4	9
Northern squawfish	26	30	22	6	18	19	3	17	49	190
Redside shiner	10	8	2					3	7	30
Bridgelip sucker	2	1	3	1	3	1		21	1	33
Largescale sucker	111	71	134	15	152	32	12	129	138	794
Brown bullhead	2	1	3	1	5	3		3		18
Channel catfish	3				3	1	10			17
Lepomis spp.		10	2		78					90
Pumpkinseed	1		4		9			2		16
Blue Gill								2	1	3
White crappie	2	5	1		23	11		1		43
Black crappie	3	1			18					22
Yellow perch		4	3	2	29	1				39
Smallmouth bass	8	54	173		77	2		130	88	532
Cottid spp.			1		1					2
TOTALS	180	198	371	37	445	77	36	354	348	2,046

were collected. Highest numbers of the predators, smallmouth bass and northern squawfish, were collected from reference stations 3 and 10. Largescale sucker was the most abundant species at disposal stations 1, 2 and 4.

Size Structure

Size structure of the key fishes, northern squawfish, smallmouth bass, channel catfish, white sturgeon, chinook salmon and steelhead, in Lower Granite Reservoir has been compared among stations. This analysis represents those fish collected by all gear types. In general, larger fish were collected by gill nets while smaller ones were collected by beach seines. Nighttime electrofishing generally collected smaller and some larger fish. Surface trawling collected larger modal size of chinook salmon than the purse seine although this relationship was reversed in steelhead. Little effort was expended using the purse seine during 1989, which in addition to the timing, could influence the size composition of the catch.

Spring 1989

During the spring of 1989, modal size of chinook salmon juveniles collected by all gear types was 150 mm (Figures 2-3). Although different numbers were collected at various disposal and reference stations, size distributions were similar. Smallest chinook collected were in the 50 mm size class.

Similar size distributions of juvenile steelhead were found among stations (Figures 4-5). The range of size classes collected by all gear types during the spring was 100-375 mm; the smallest steelhead were collected at

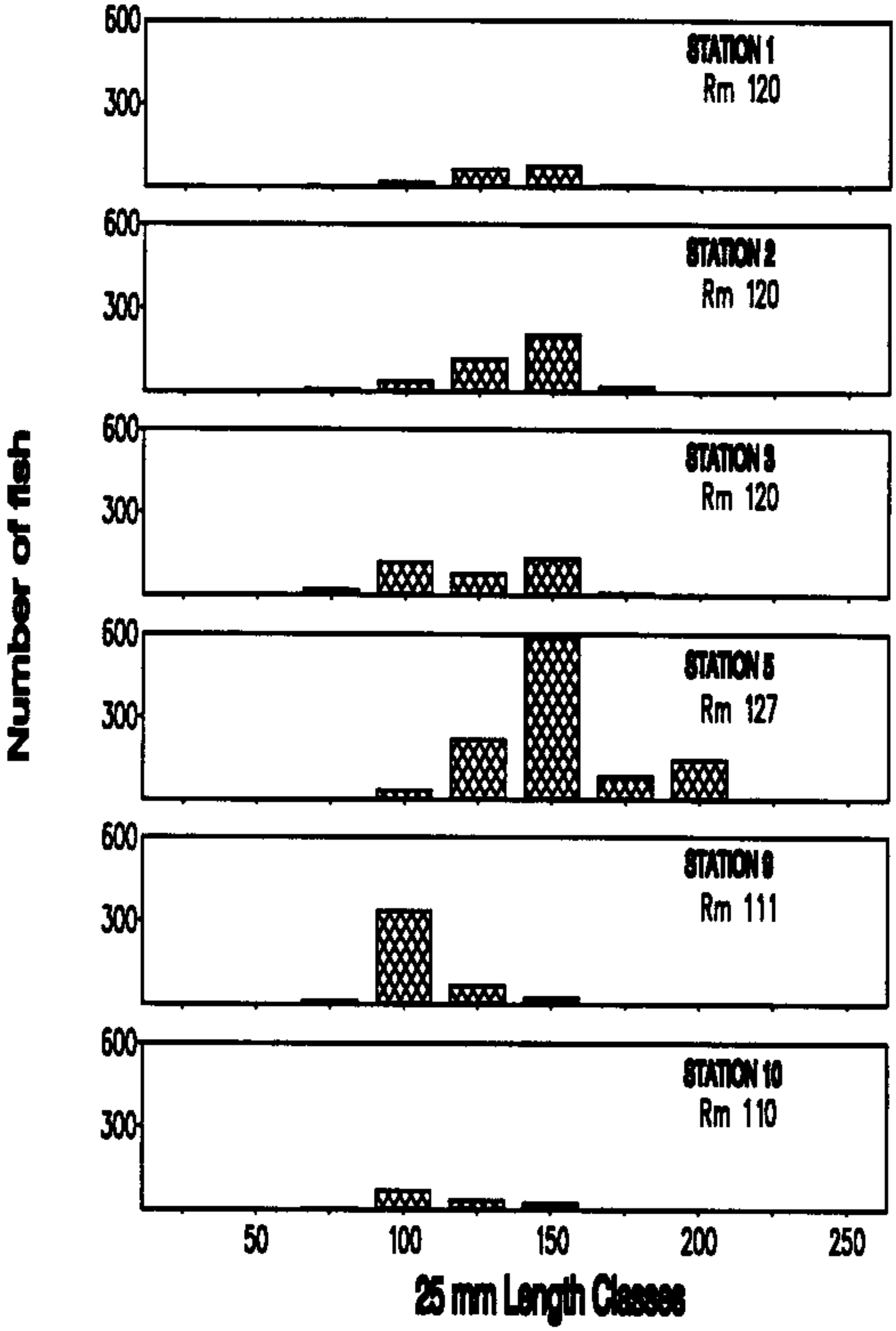


Figure 2. Length frequency distributions of chinook salmon sampled by all gear types at shallow water stations in Lower Granite Reservoir, during spring, 1989.

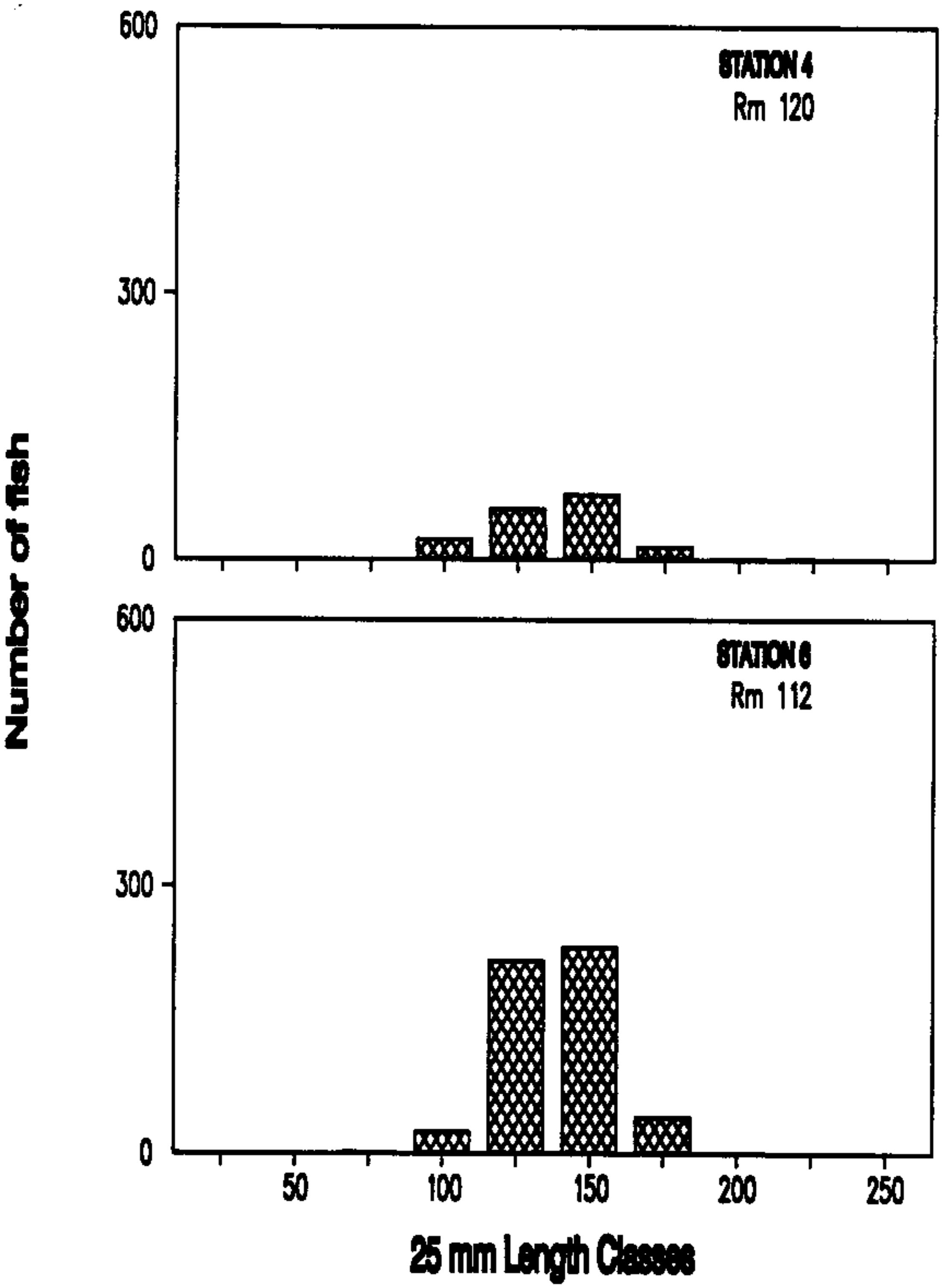


Figure 3. Length frequency distributions of chinook salmon sampled by all gear types at stations 4 and 6 in Lower Granite Reservoir, during spring, 1989.

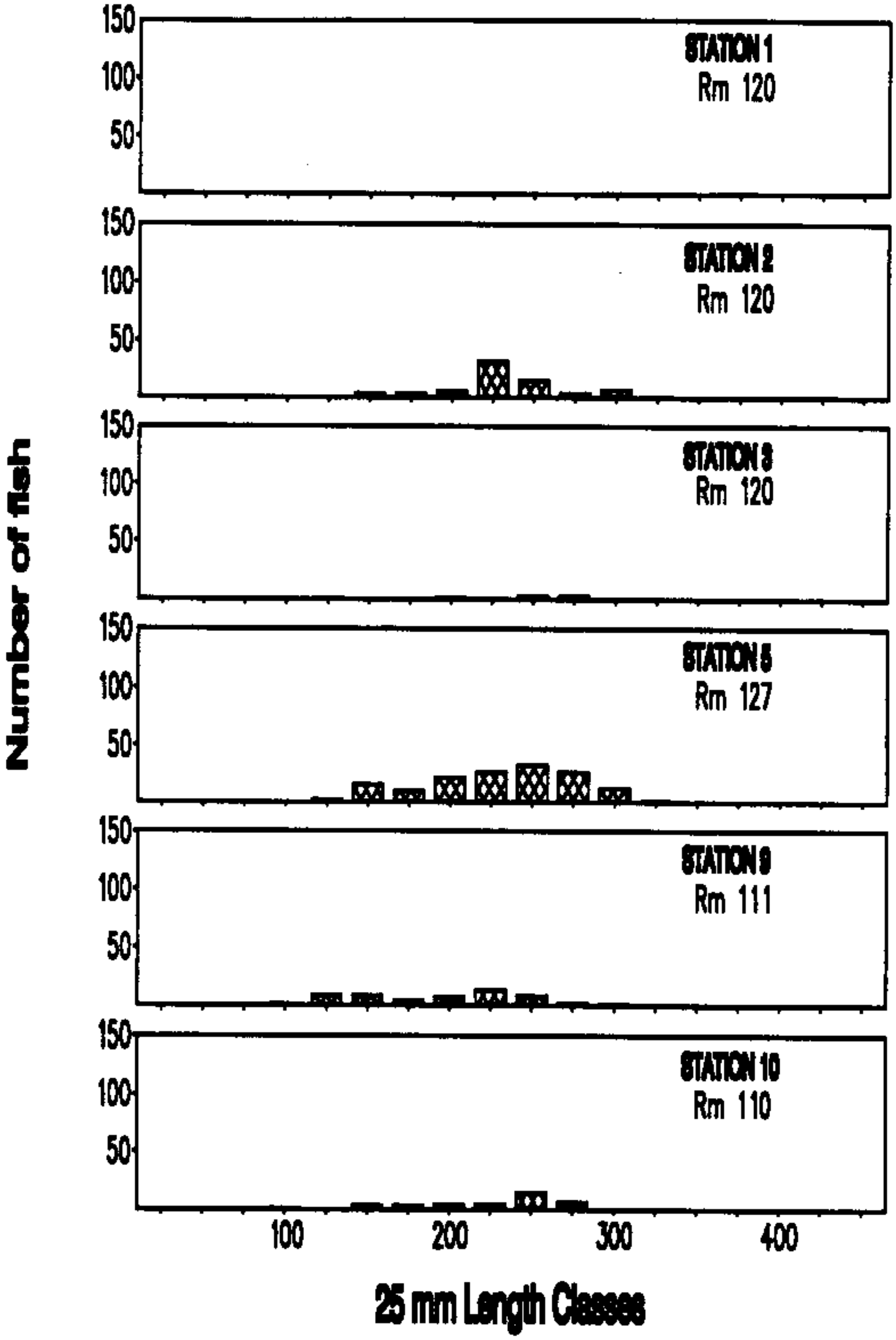


Figure 4. Length frequency distributions of steelhead sampled by all gear types at shallow water stations in Lower Granite Reservoir, during spring, 1989.

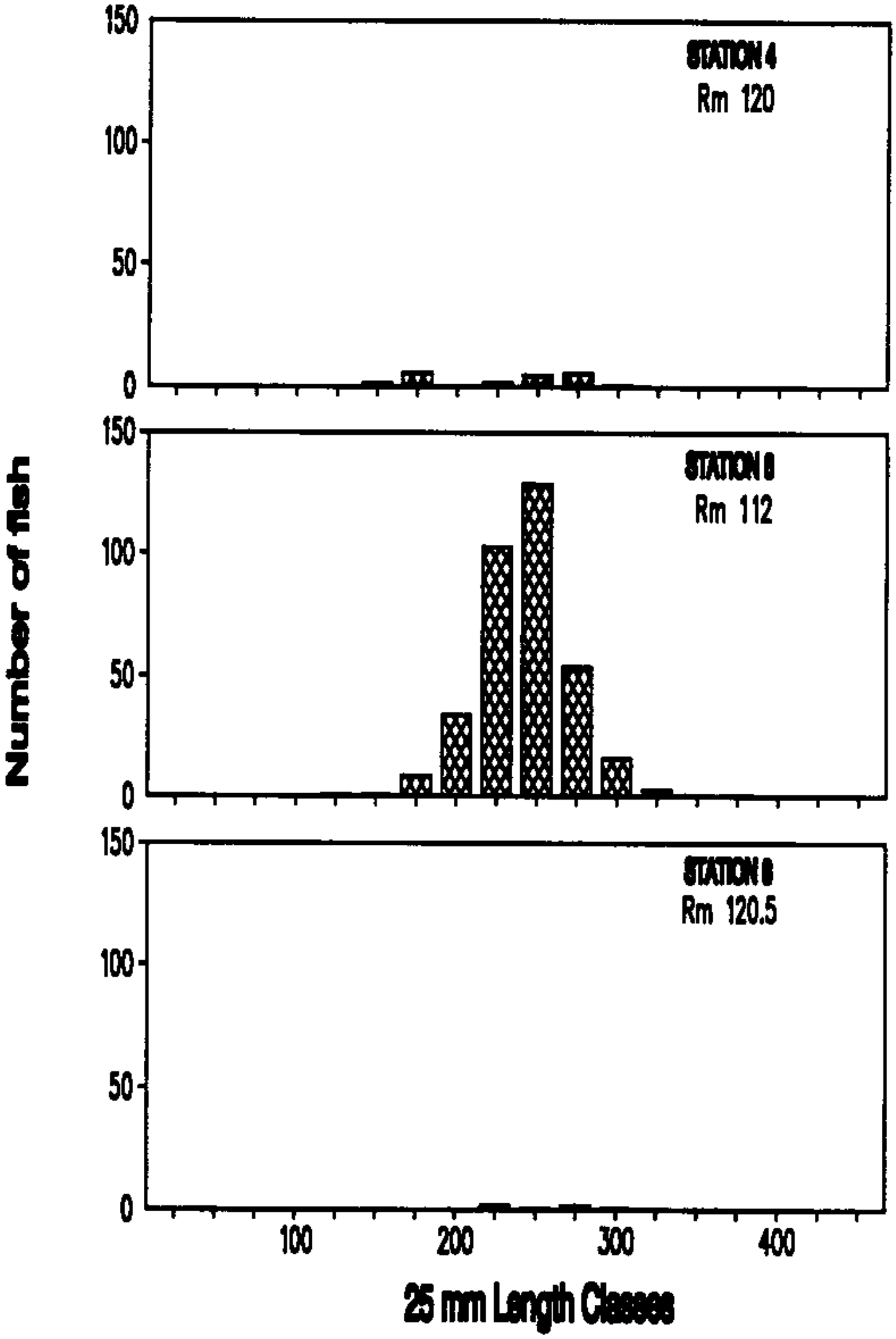


Figure 5. Length frequency distributions of steelhead sampled by all gear types at stations 4, 6 and 8 in Lower Granite Reservoir, during spring, 1989.

station 9 in the lowerreservoir. Modal size was in the 225 and 250 mm size class.

Size composition of northern squawfish collected by all gear types during the spring ranged from 50-600 mm; modal size varied from station to station (Figures 6-7). In general, modal size was smaller at the disposal and reference shallow stations than at the mid-depth and deep water reference stations. Modal size at the shallow reference station 5 was an exception at 375 mm, similar to that from mid-depth disposal station 4.

Size composition of smallmouth bass collected by all gear types during the spring also varied by station (Figure 8). Although fewer bass were collected at the island disposal stations (1 and 2), modal size was from 275-325 mm compared to 175 mm at shallow reference station 9. Too few bass were collected at mid-depth disposal station 4 and mid-depth reference station 6 for comparison. Bass at the mid-depth disposal station 4 ranged from 225-325 mm.

Large channel catfish were collected by gill nets during spring, 1989 in Lower Granite Reservoir (Figures 9-10). The smallest sized fish, in the 225 mm size class, and the largest fish, in the 675 mm class, were collected from the deep reference station 8. Generally, too few channel catfish were collected during the spring from the disposal stations to provide a good comparison of size composition between reference and disposal stations.

Summer 1989

Too few salmonid juveniles were collected in the summer of 1989 to provide a good comparison of size composition. The majority of steelhead collected were from shallow reference station 9 and these ranged from

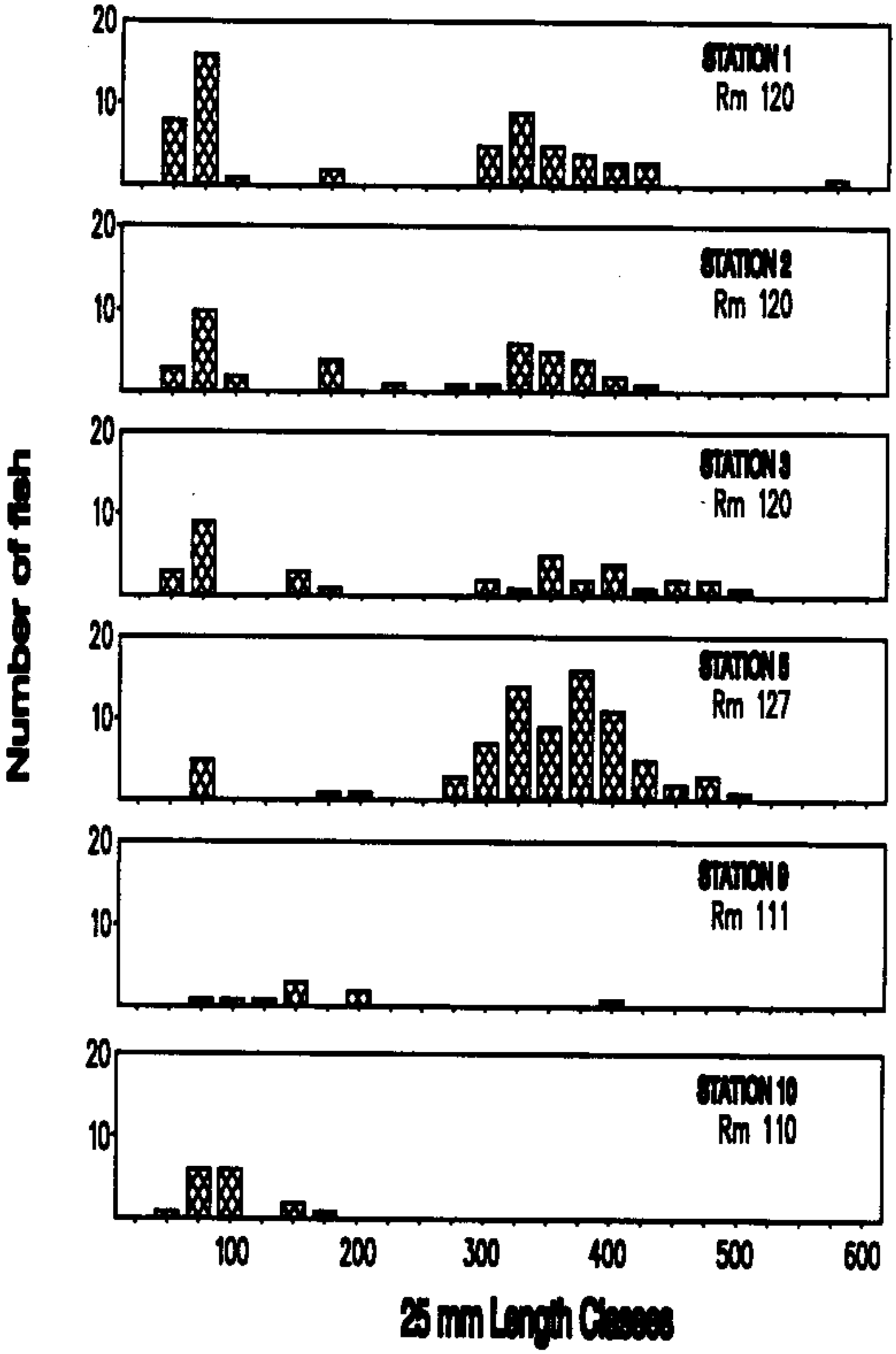


Figure 6. Length frequency distributions of northern squawfish sampled by all gear types at shallow water stations in Lower Granite Reservoir, during spring, 1989.

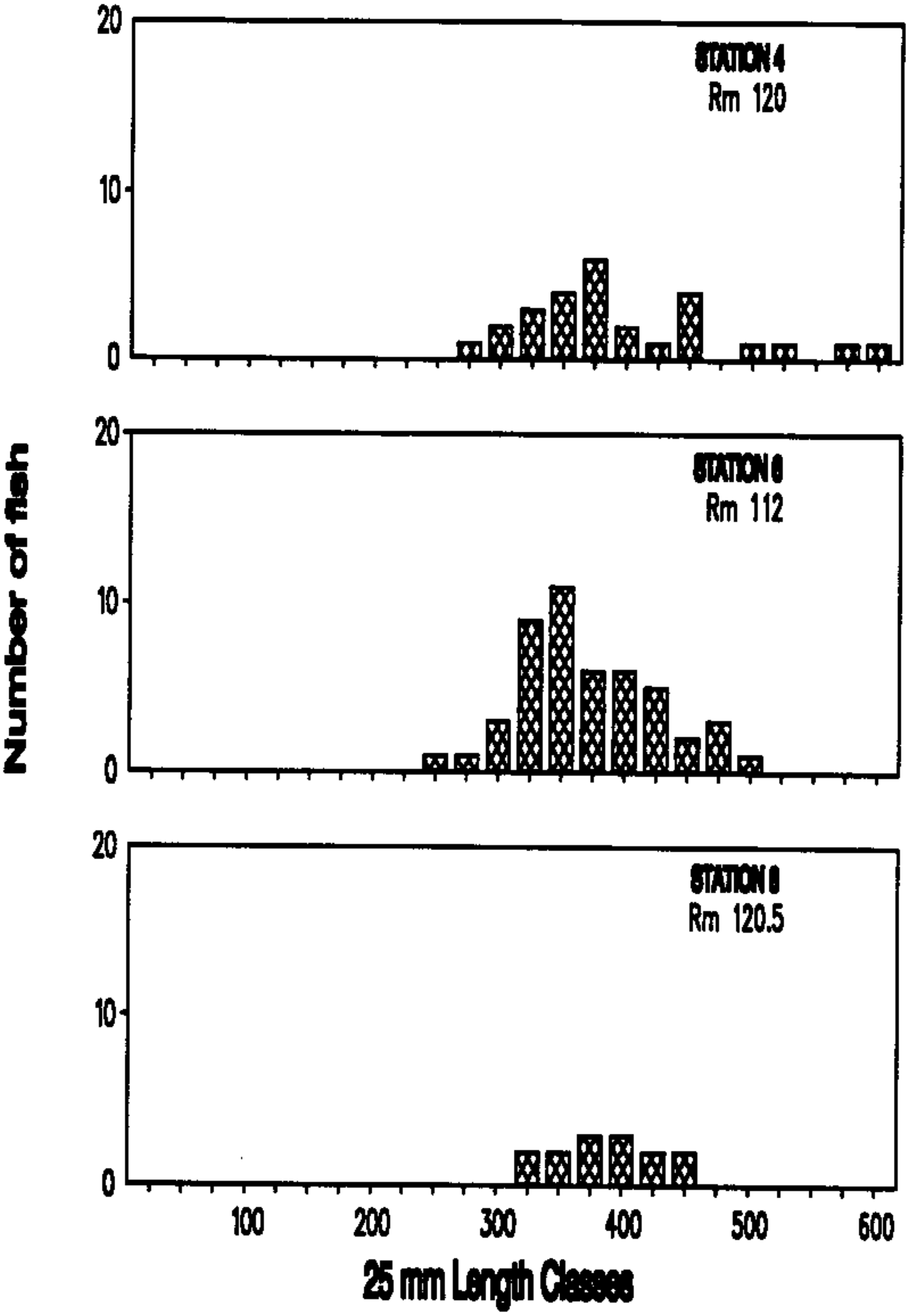


Figure 7. Length frequency distributions of northern squawfish sampled by all gear types at stations 4, 6 and 8 in Lower Granite Reservoir, during spring, 1989.

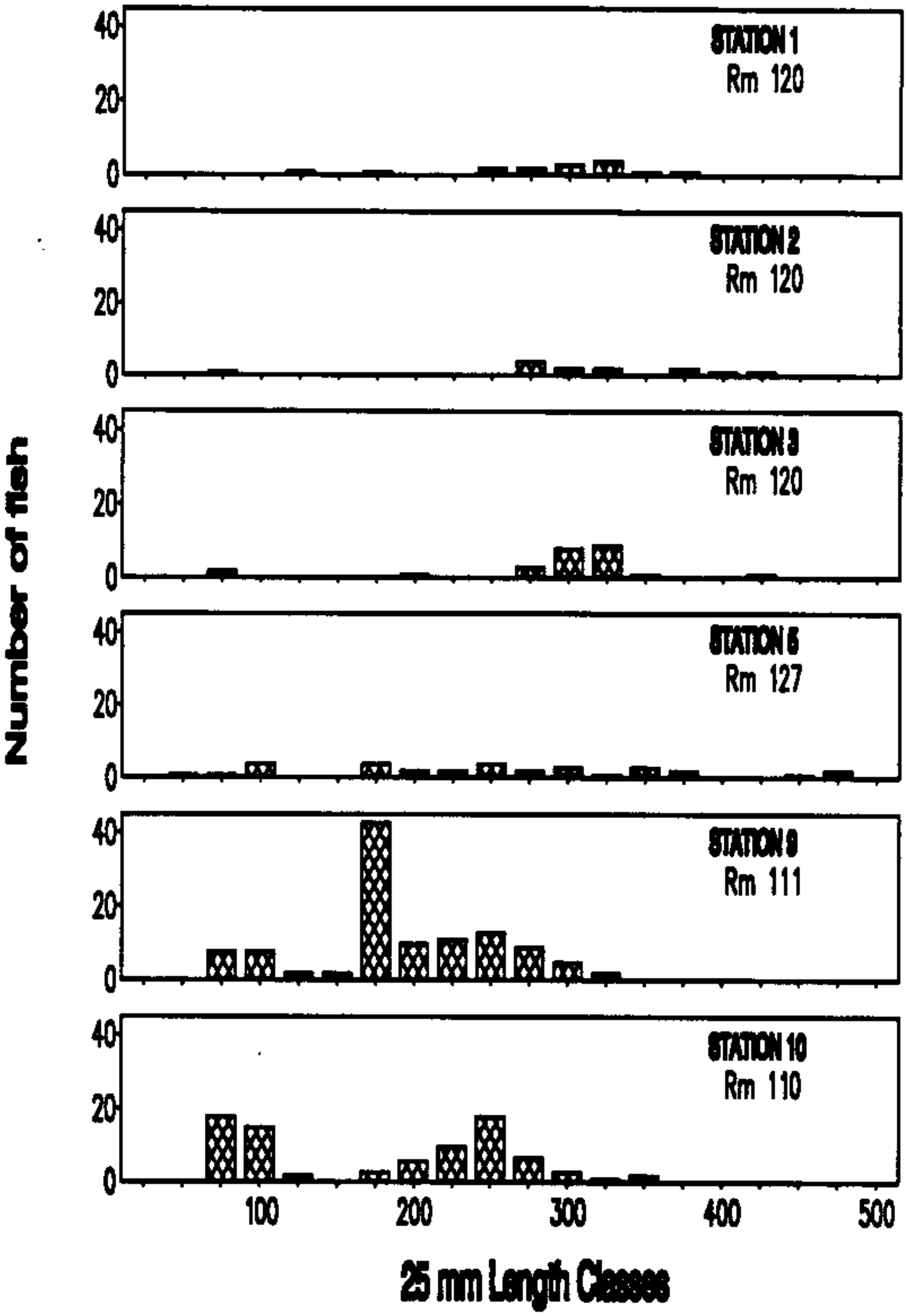


Figure 8. Length frequency distributions of smallmouth bass sampled by all gear types at shallow water stations in Lower Granite Reservoir, during spring, 1989.

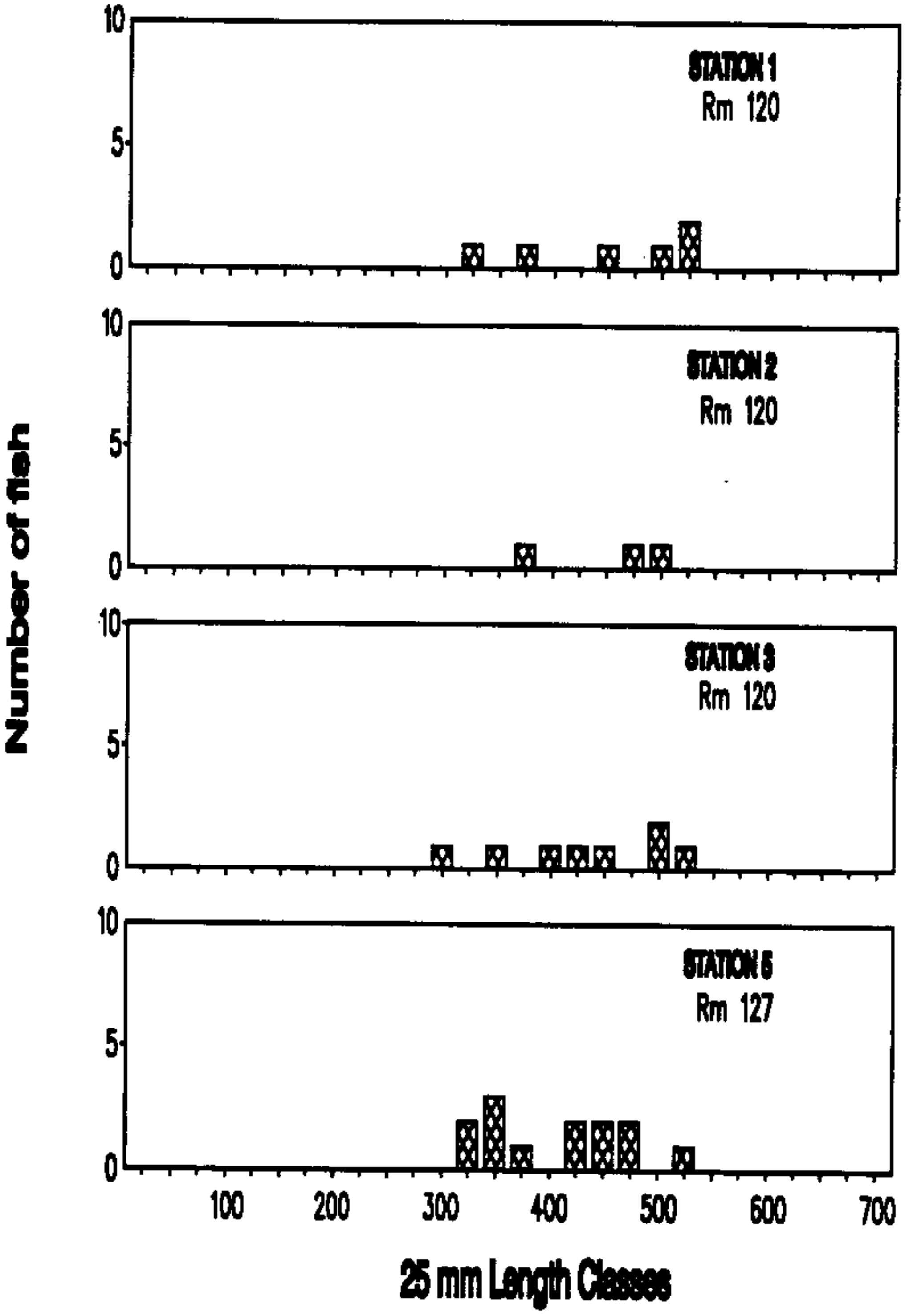


Figure 9. Length frequency distributions of channel catfish sampled by all gear types at shallow water stations in Lower Granite Reservoir, during spring, 1989.

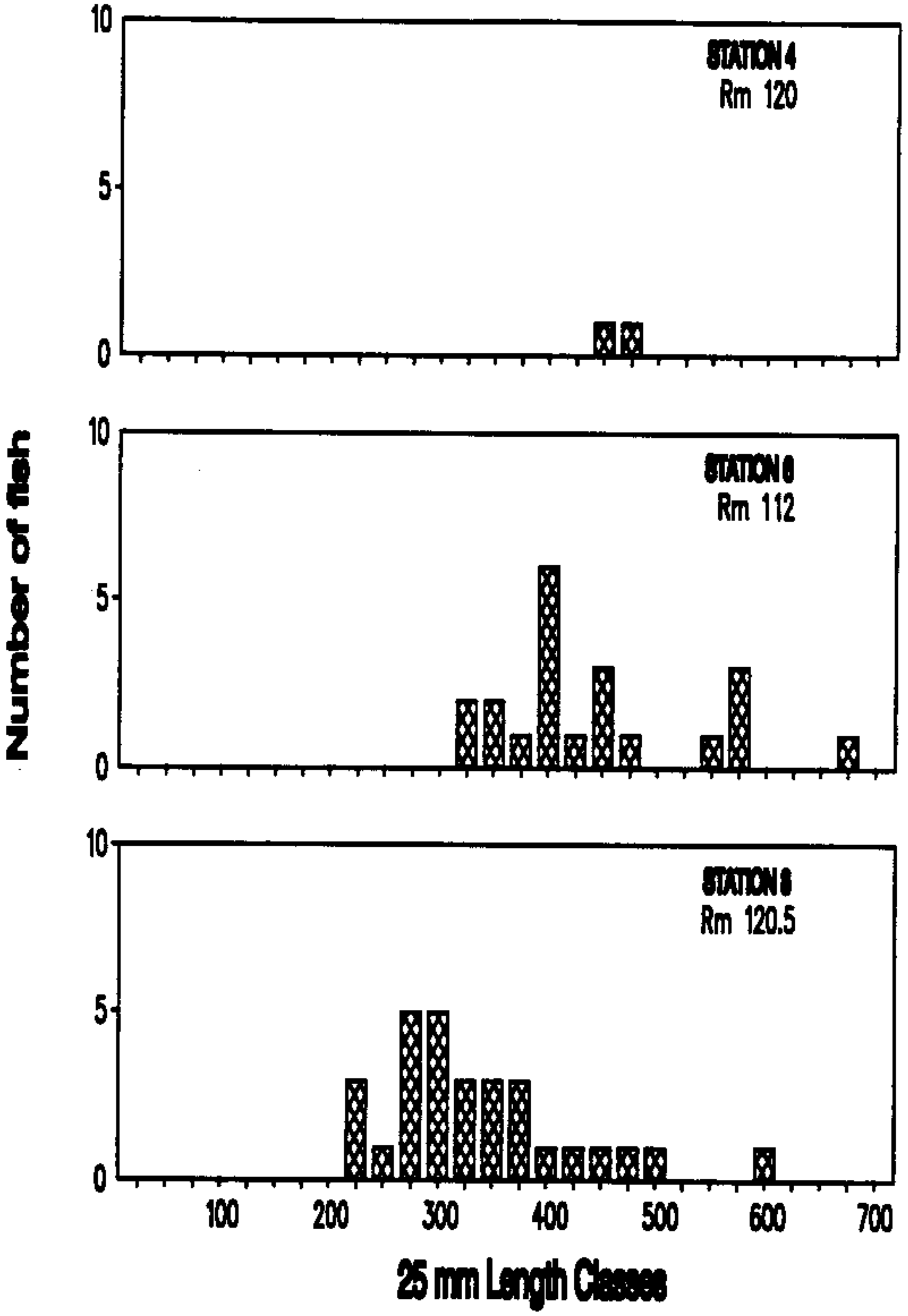


Figure 10. Length frequency distributions of channel catfish sampled by all gear types at stations 4, 6 and 8 in Lower Granite Reservoir, during spring, 1989.

125-275 mm. In addition, two smaller steelhead in the 100 mmsize class were collected from station 1 during the summer.

The size composition of white sturgeon collected during the summer ranged from 600-1025 mm. The size distribution was nearly normal and modal size was 775 mm. Too few sturgeon were collected at stations other than the deep water reference station (8) to provide a comparison of size and location differences. The few sturgeon collected at other stations were within the size range collected at station 8.

Channel catfish collected during the summer of 1989 by all gear types (Figures 11-12) were similar in size composition (175-625 mm) to those sampled in the spring (Figures 9-10). The majority of channel catfish collected during the summer were at station 1. Modal size from stations 1 and 3 was similar at 275 mm.

A majority of the smallmouth bass collected during the summer were small as modal sizes ranged from 50-75 mm (Figure 13). Bass collected at the mid-depth disposal station (4) were limited in number although those fish ranged from 225-300 mm. Size composition of bass collected from station 2 was similar to the adjacent reference station 3 and reference stations 5 and 9.

Size structure of northern squawfish sampled by all gear types during the summer varied widely between mid-depth and shallow stations (Figures 14-15). In general, we collected mainly smaller squawfish at shallow reference and island disposal stations although a few larger ones were sampled. Squawfish collected at the mid-depth and deep water stations were larger (275-450 mm) although larger size was probably related to size bias by gill netting.

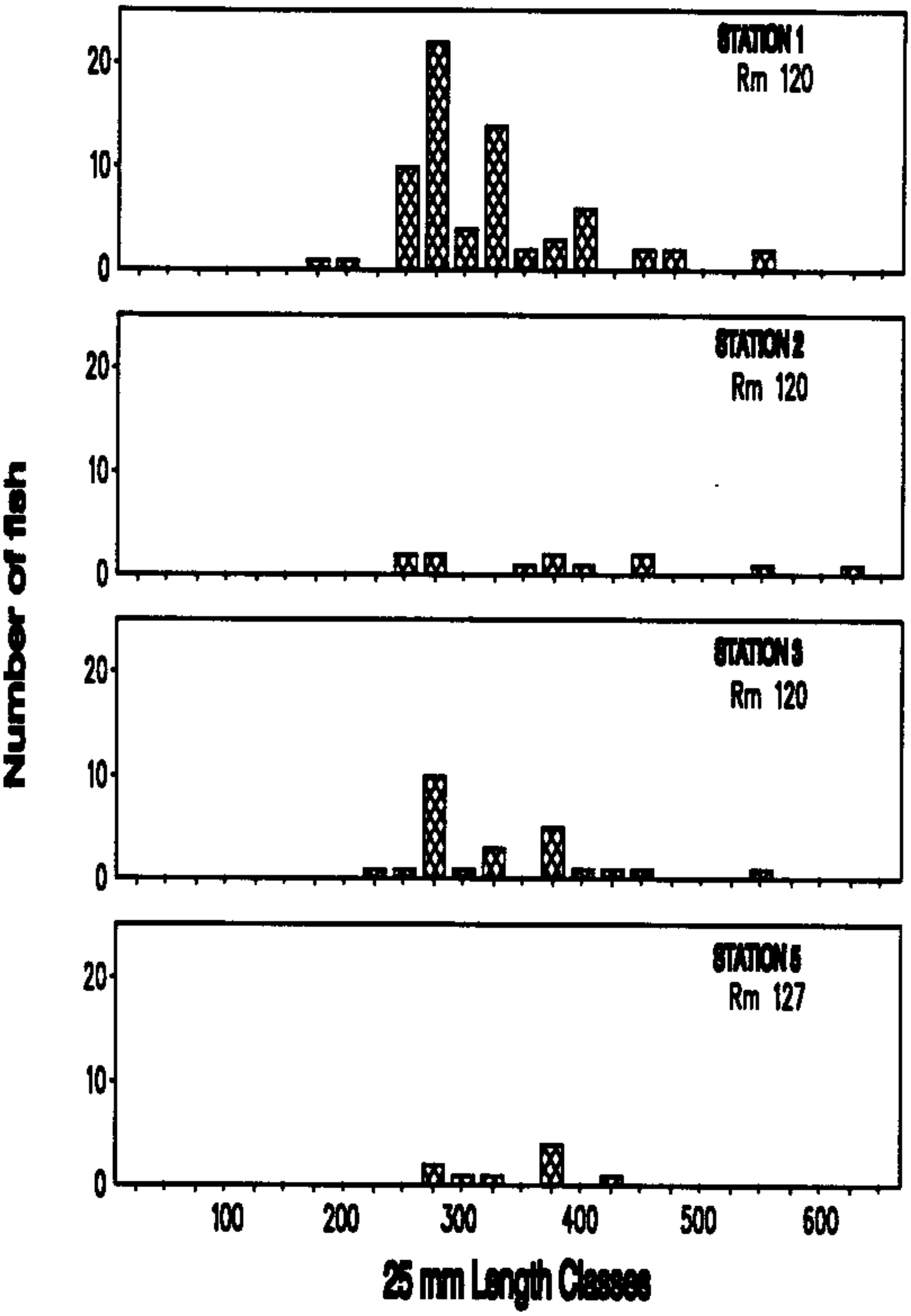


Figure 11. Length frequency distributions of channel catfish sampled by all gear types at shallow water stations in Lower Granite Reservoir, during summer, 1989.

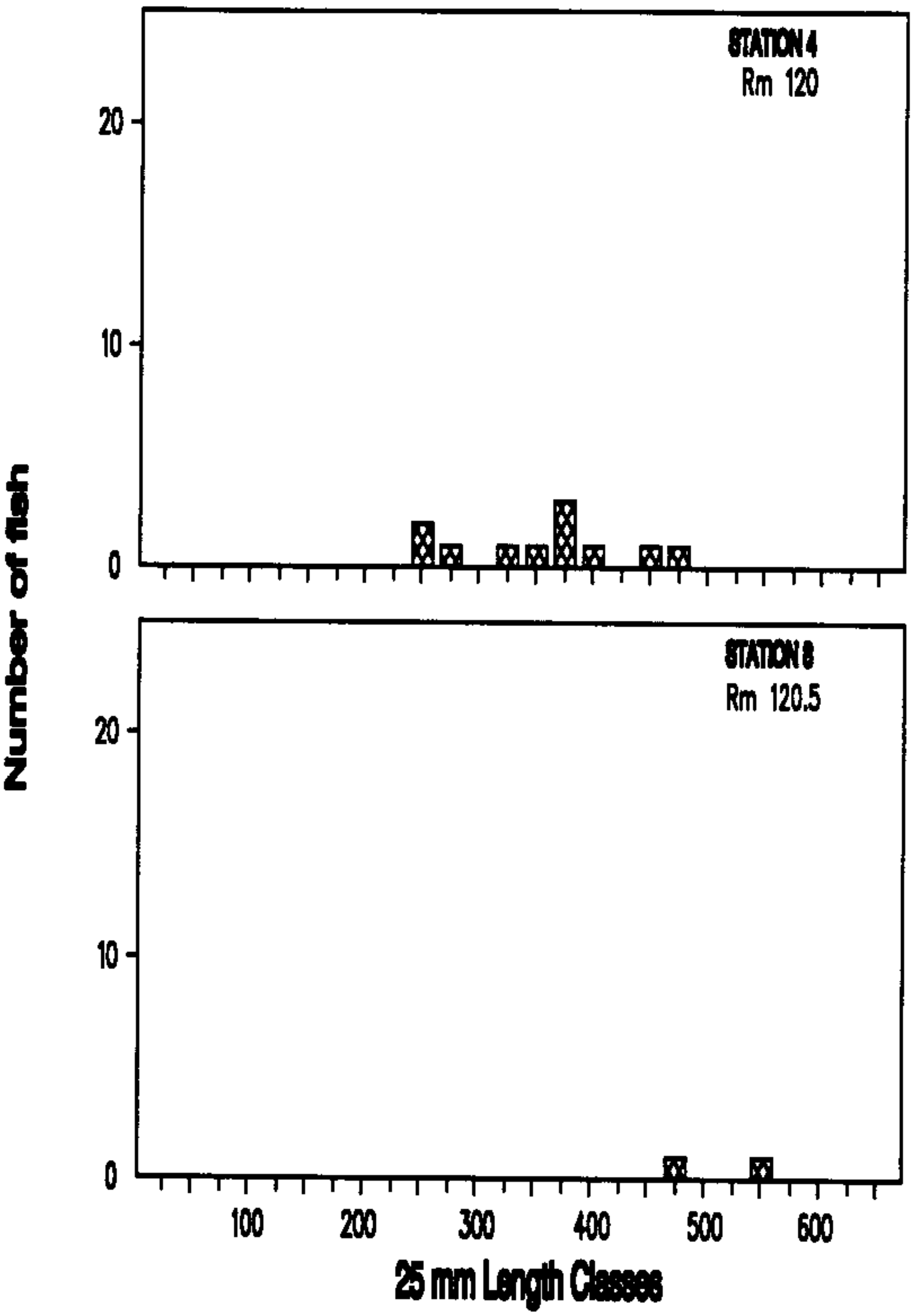


Figure 12. Length frequency distributions of channel catfish sampled by all gear types at stations 4 and 8 in Lower Granite Reservoir, during summer, 1989.

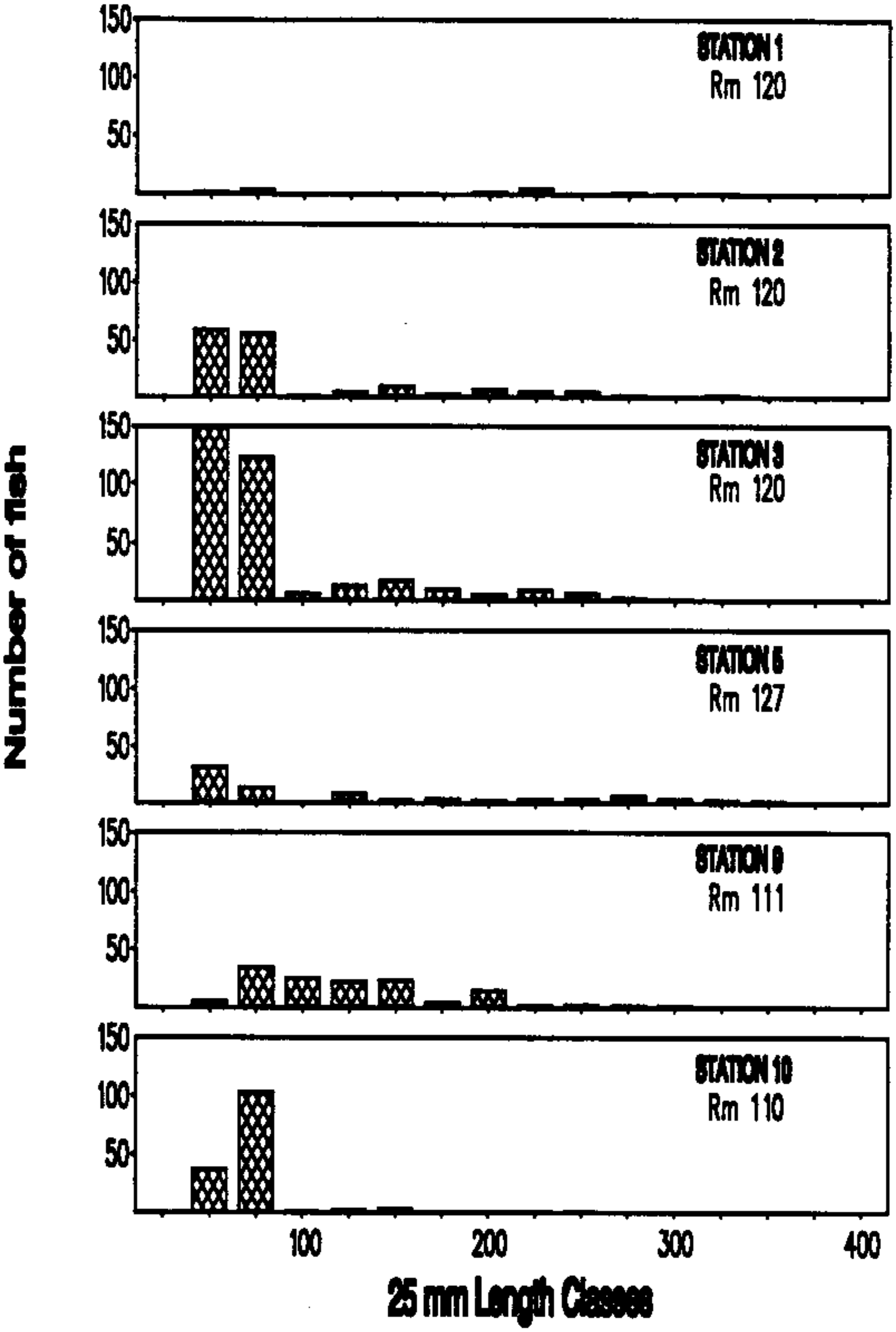


Figure 13. Length frequency distributions of smallmouth bass sampled by all gear types at shallow water stations in Lower Granite Reservoir, during summer, 1989.

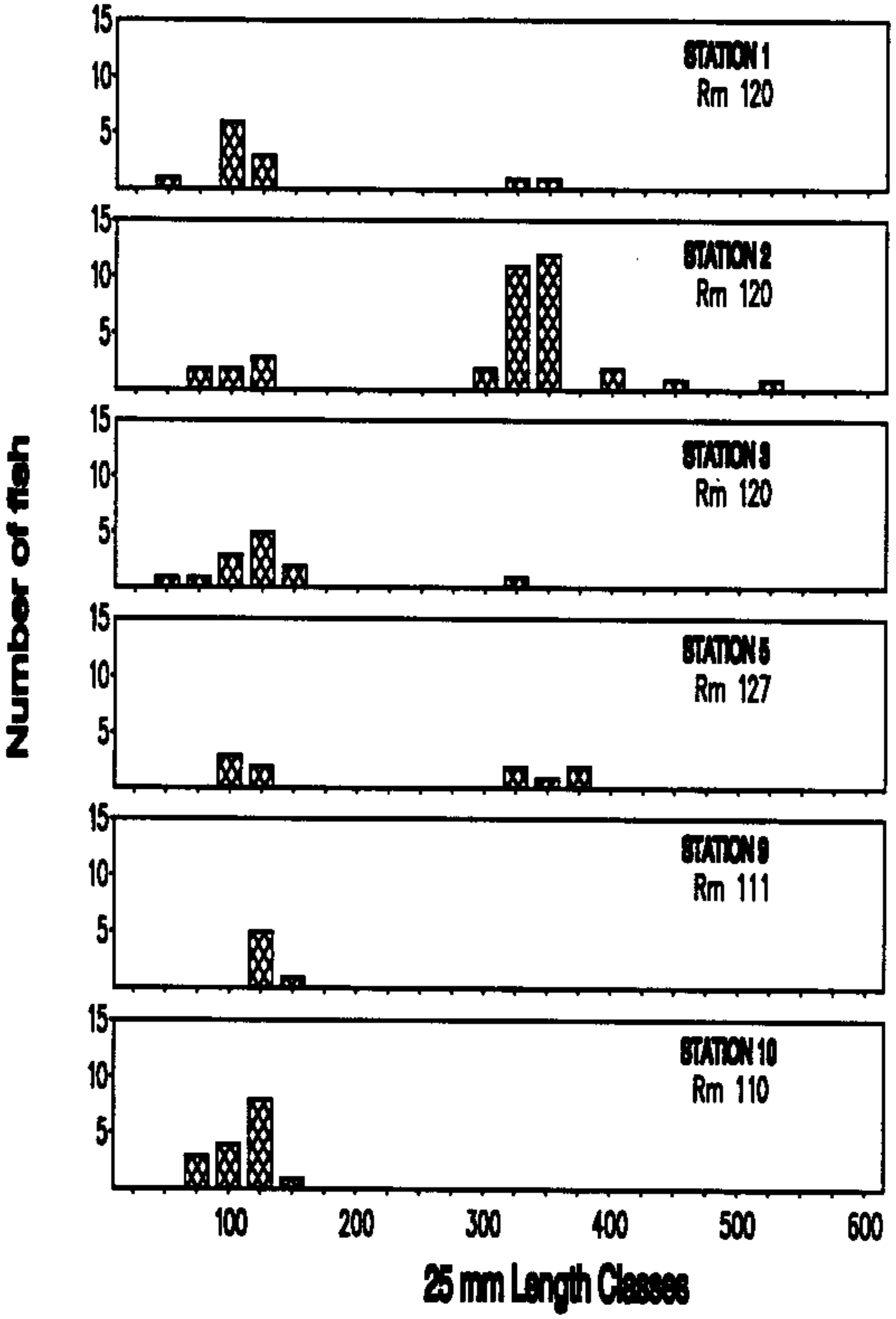


Figure 14. Length frequency distributions of northern squawfish sampled by all gear types at shallow water stations in Lower Granite Reservoir, during summer, 1989.

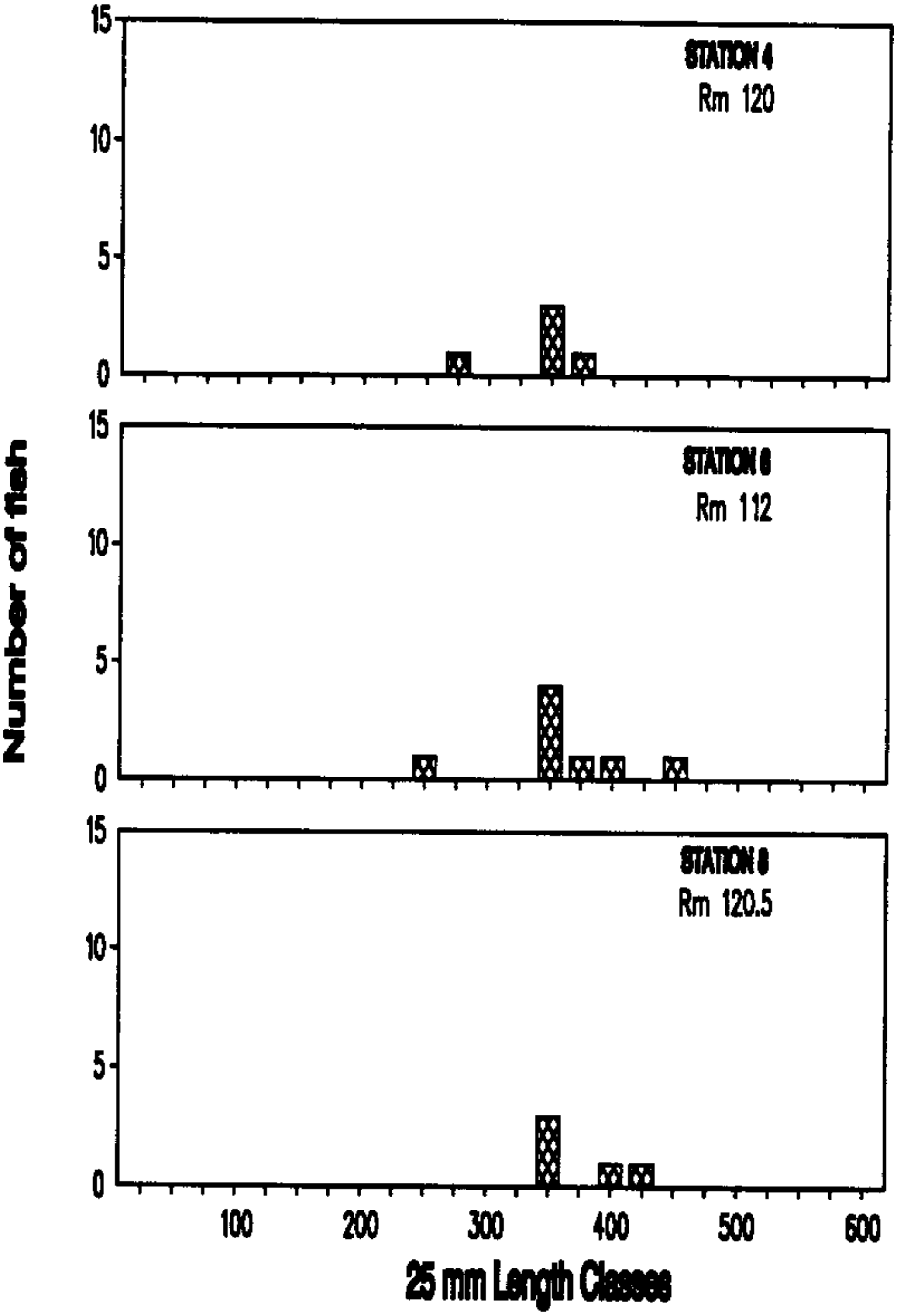


Figure 15. Length frequency distributions of northern squawfish sampled by all gear types at stations 4, 6 and 8 in Lower Granite Reservoir, during summer, 1989.

Fall 1989

During fall 1989, few salmonid juveniles were collected in Lower Granite Reservoir. The few steelhead collected ranged from 150-350 mm.

Station 8 was the only station where white sturgeon were collected in the fall. Size classes ranged from 600-1000 mm, similar to that observed during the summer. Modal size was 725 mm.

Size composition of northern squawfish in the fall ranged from 75-500 mm (Figures 16-17). As in the summer, larger squawfish were collected from mid-depth and deep water stations than from shallow reference and disposal stations. Two distinct size distributions of squawfish were present at stations 1, 2, 3, and 5. Modal classes were variable at 125-150 mm to 325-350 mm.

Channel catfish were collected in low numbers during the fall although length classes were similar to those in the summer (225-600mm). The widest range of sizes were collected from station 8.

The size composition of smallmouth bass collected during the fall was similar among stations (Figure 18). Bass in the 50-75 mm size classes were present at all reference and island disposal stations.

Catch/Effort Abundance

Catch rates of fishes varied among stations, years, and gear types. For purposes of this study, we have identified chinook salmon, steelhead/rainbow trout, white sturgeon, northern squawfish, smallmouth bass, and channel catfish as the key species in Lower Granite Reservoir. We have made abundance comparisons based on statistical analysis of catch/effort for surface trawling, beach seining, electrofishing, and gill netting.

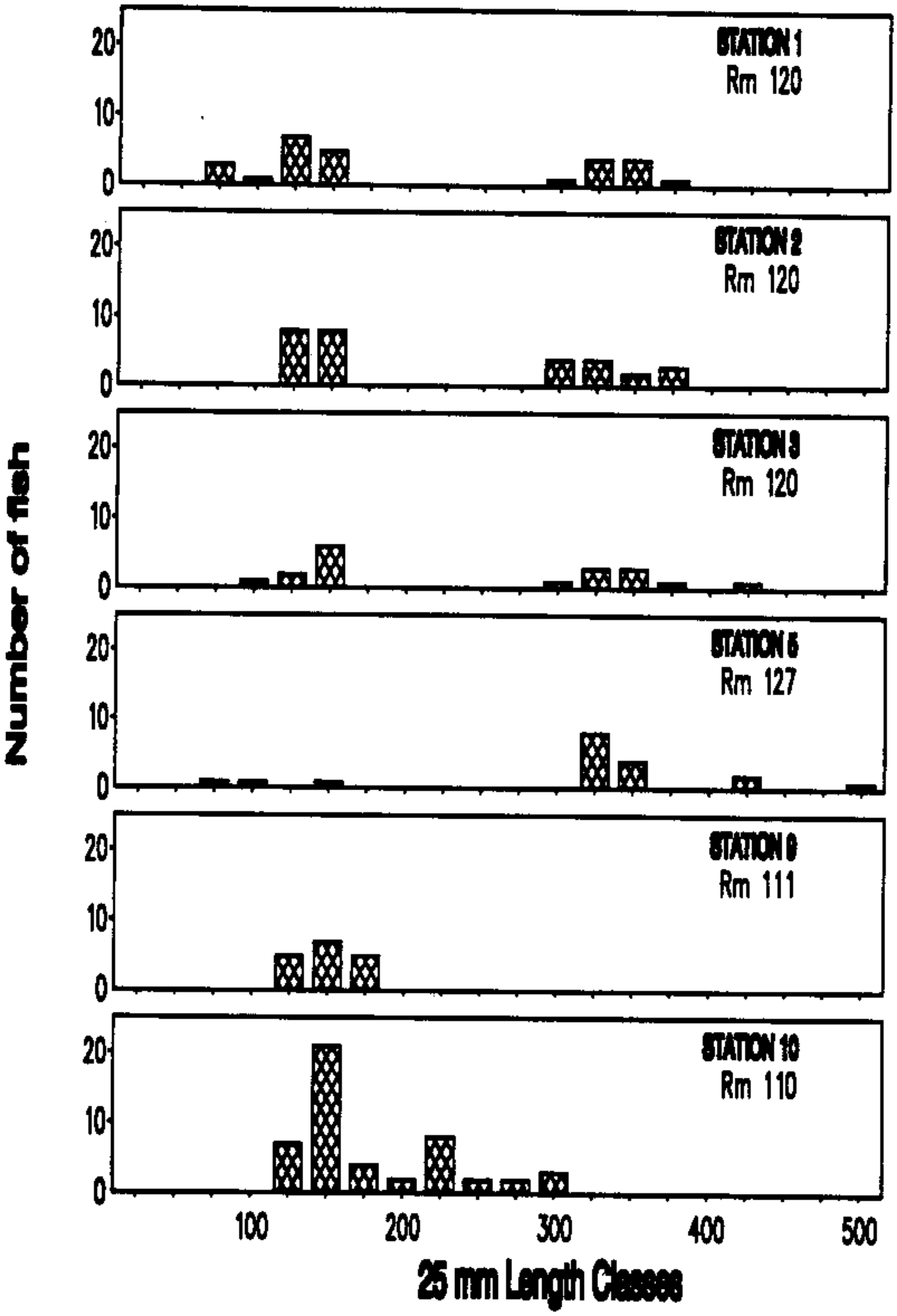


Figure 16. Length frequency distributions of northern squawfish sampled by all gear types at shallow water stations in Lower Granite Reservoir, during fall, 1989.

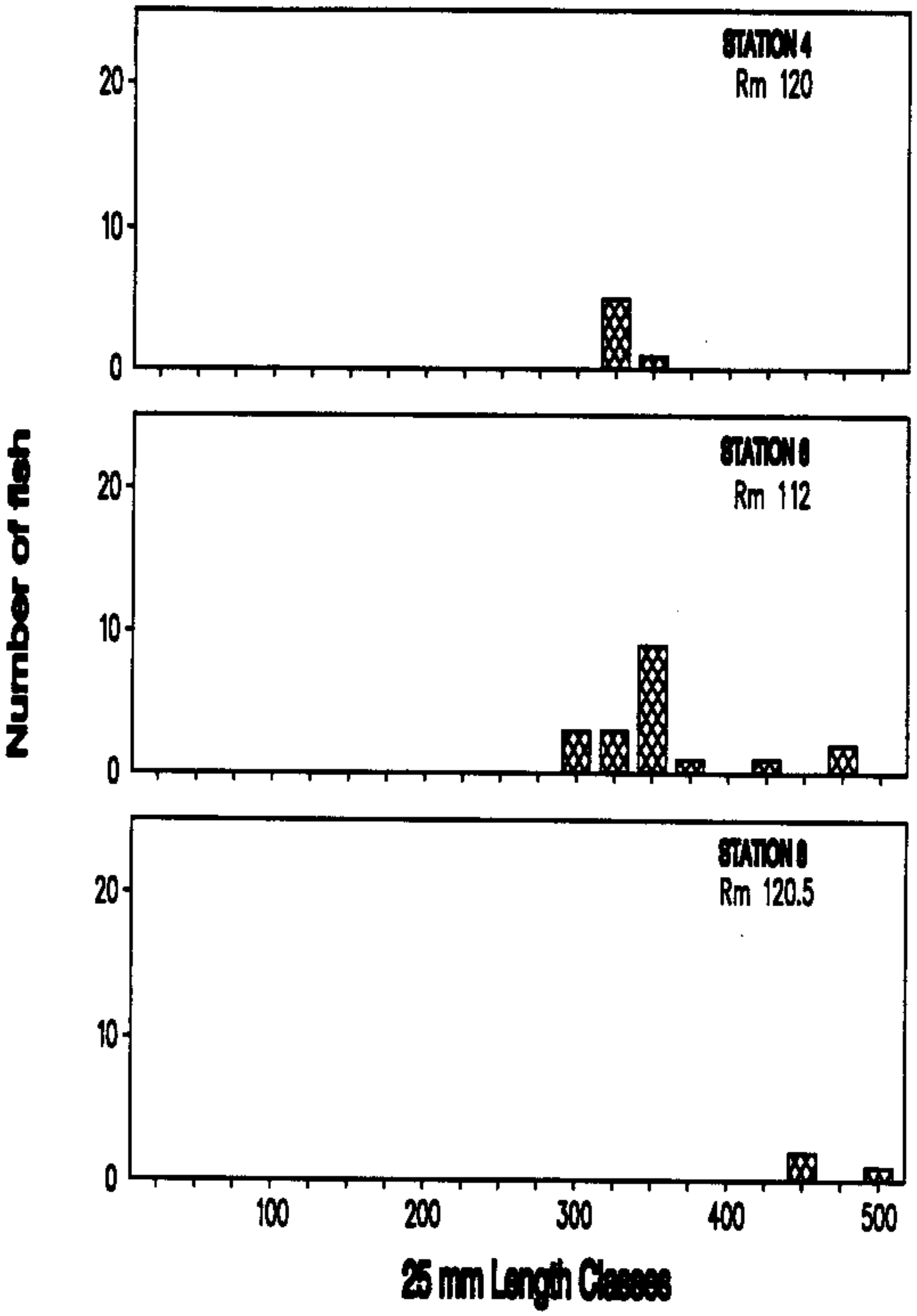


Figure 17. Length frequency distributions of northern squawfish sampled by all gear types at stations 4, 6 and 8 in Lower Granite Reservoir, during fall, 1989.

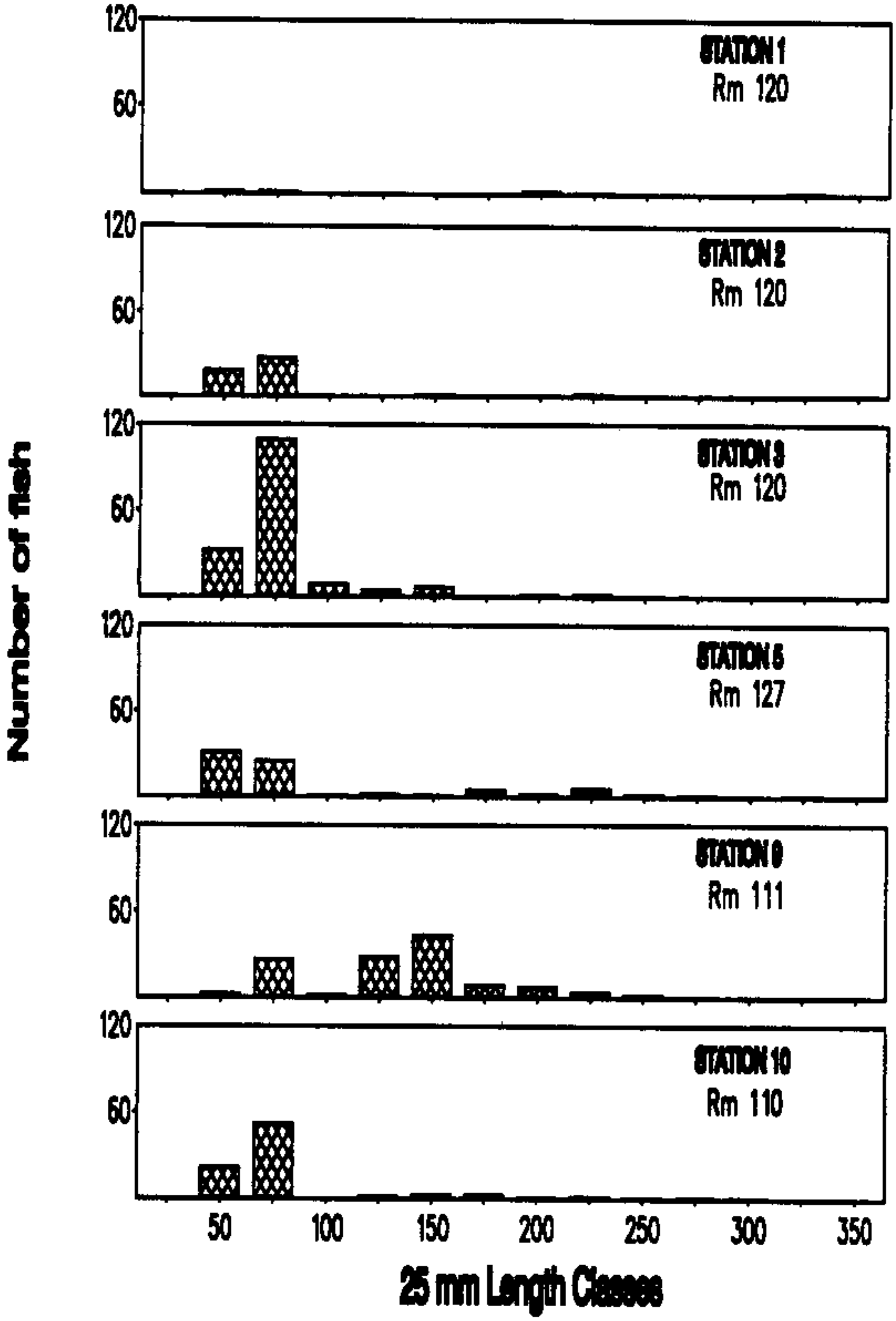


Figure 18. Length frequency distributions of smallmouth bass sampled by all gear types at shallow water stations in Lower Granite Reservoir, during fall, 1989.

All Seasons

Littoral Abundance. During 1989, highest catch/5 min of nighttime electrofishing for steelhead juveniles was at reference stations 9 and 10 (Figure 19). Catch/effort was lowest at stations 1 and 3 followed closely by station 5. Differences in catch/5 min pass were few and scattered among stations. Station 9 was significantly higher than all stations except station 10. The difference observed in the lower river stations from the up-river stations probably reflects locational differences rather than habitat quality differences (Figure 20).

Abundance of smallmouth bass based on nighttime electrofishing indicated highest abundance at reference stations 9, 10 and 3 (Figure 21). Lowest catches/effort were at disposal stations 1 and 2; these were significantly lower than at all reference stations (Figure 22).

Comparison of CPUE by electrofishing for chinook salmon and northern squawfish indicated that these were similar in abundance and not significantly different among stations (Figure 23). Overall, mean catch/5 min pass was highest for both species at station 5 with similar catches of chinook salmon at the other stations. Catches of northern squawfish by electrofishing were next highest in abundance at stations 1 and 2. Differences in mean CPUE were wide for each species but their statistical nonsignificance among stations demonstrates the wide variation in catch rates of these species.

Littoral abundance of juvenile steelhead trout during the daytime was assessed by beach seining. Catch/haul was highest at reference stations 9 and 10 followed by disposal station 2 (Figure 24). Lowest catch/haul was on the inside of the island (station 1) followed by reference stations 5 and 3. Mean catch/haul at stations 2, 9 and 10 were not significantly different and the

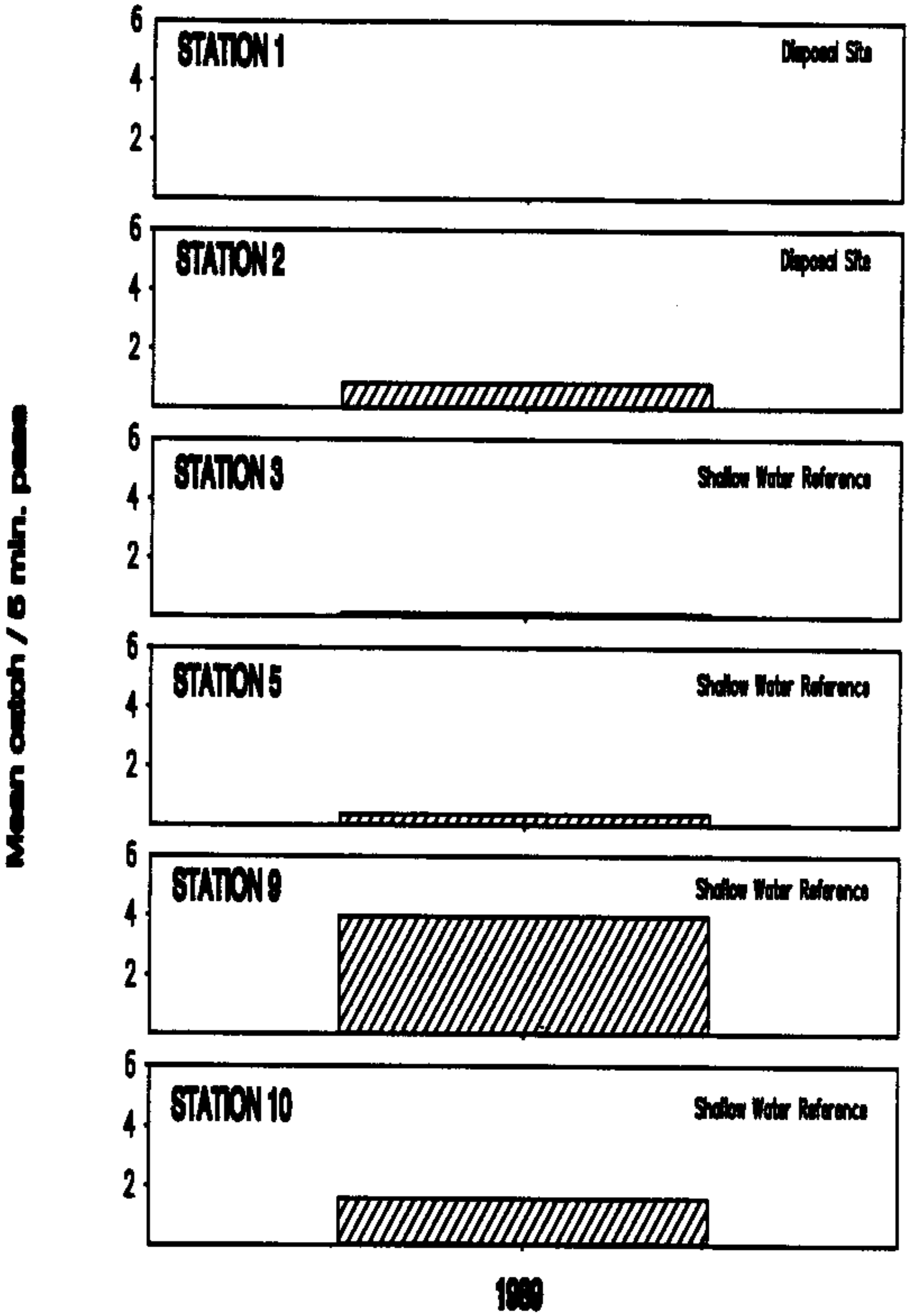


Figure 19. Mean catch per 5 minute pass of steelhead by shoreline electrofishing at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

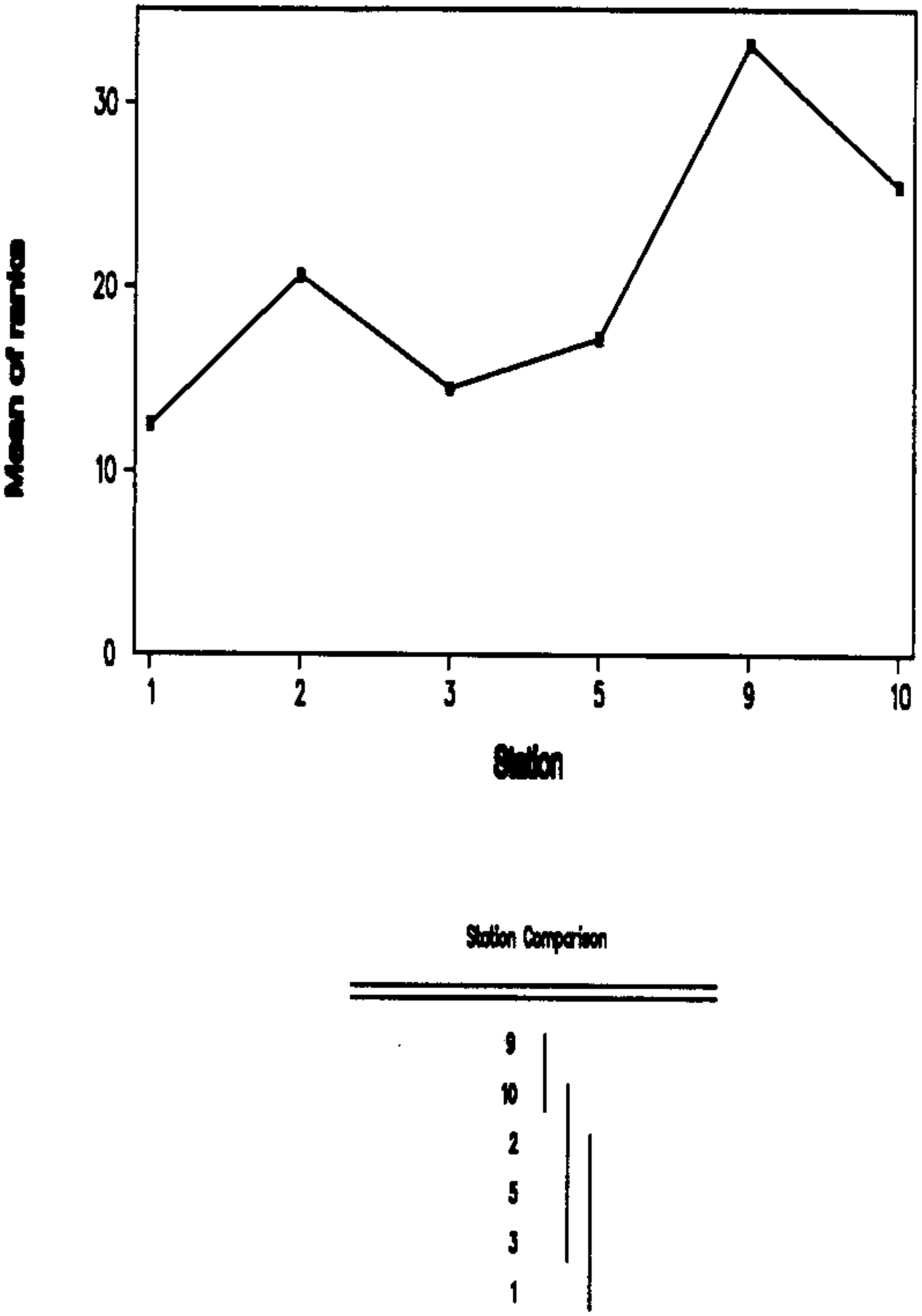


Figure 20. Statistical comparisons of the mean of ranks of abundance of steelhead by electrofishing at shallow water stations in Lower Granite Reservoir, Idaho-Washington during 1989. Stations connected by lines were not significantly (P>0.05) different.

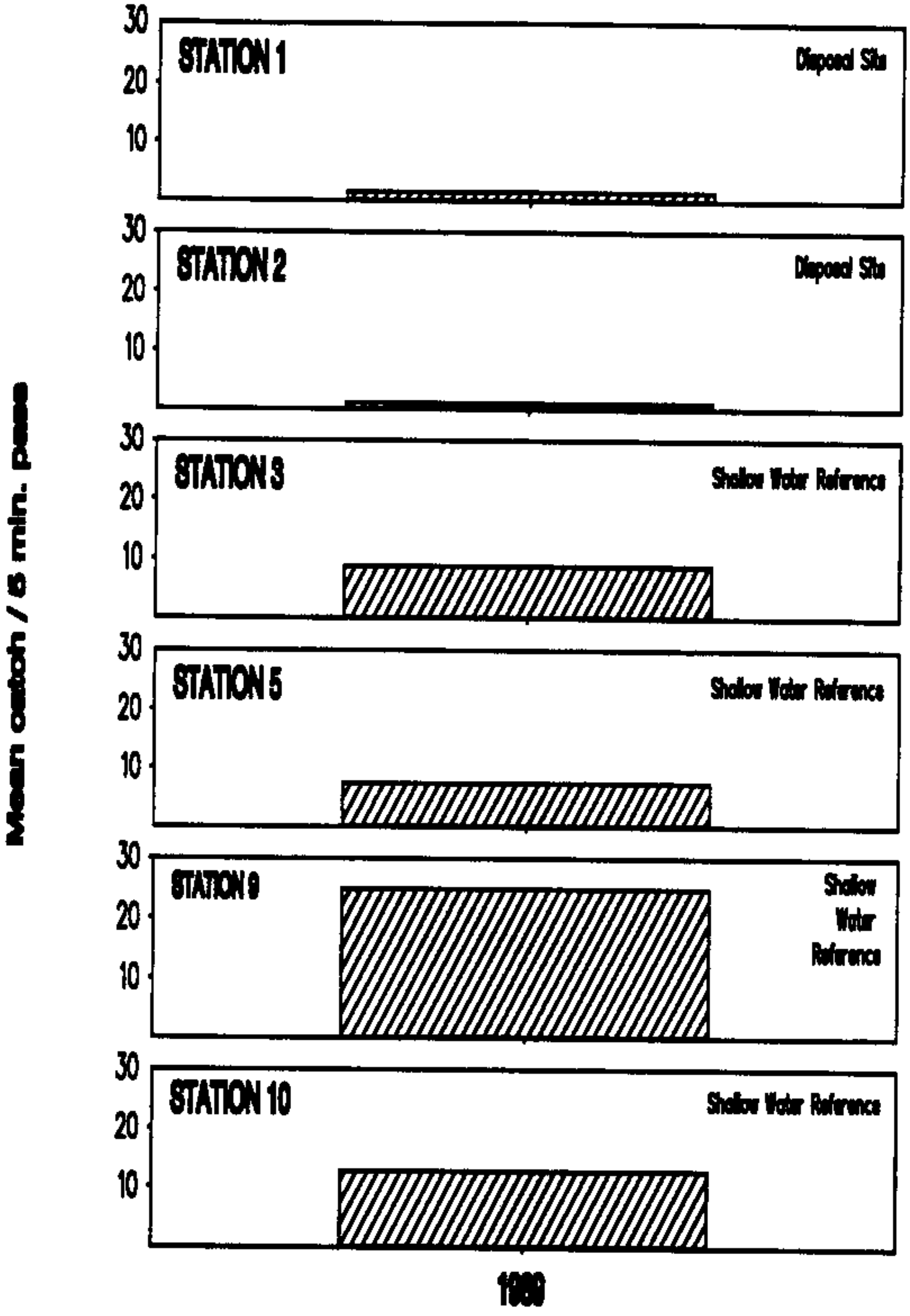


Figure 21. Mean catch per 5 minute pass of smallmouth bass by shoreline electrofishing at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

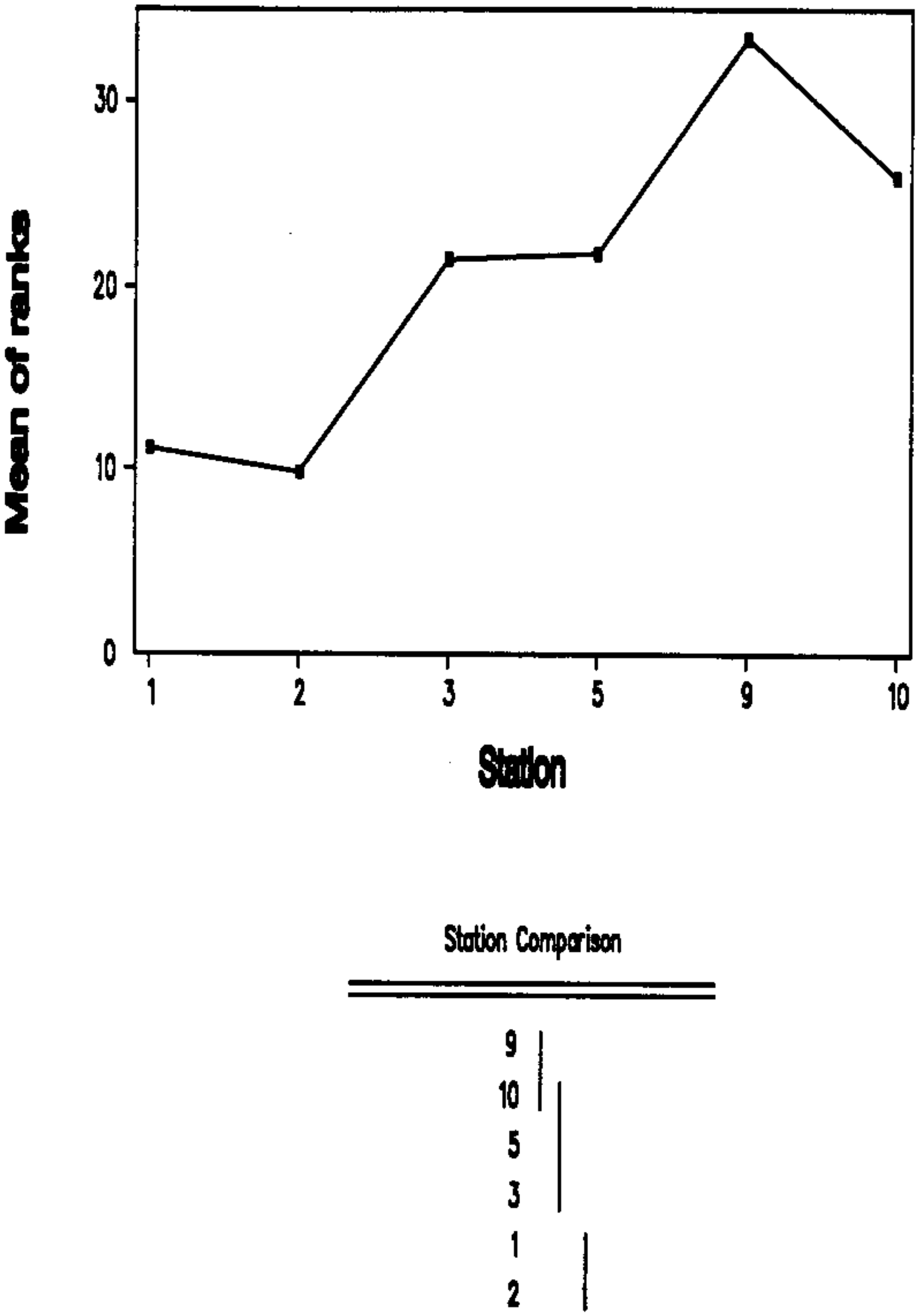


Figure 22. Statistical comparisons of the mean of ranks of abundance of smallmouth bass by electrofishing at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989. Stations connected by lines were not significantly (P>0.05) different.

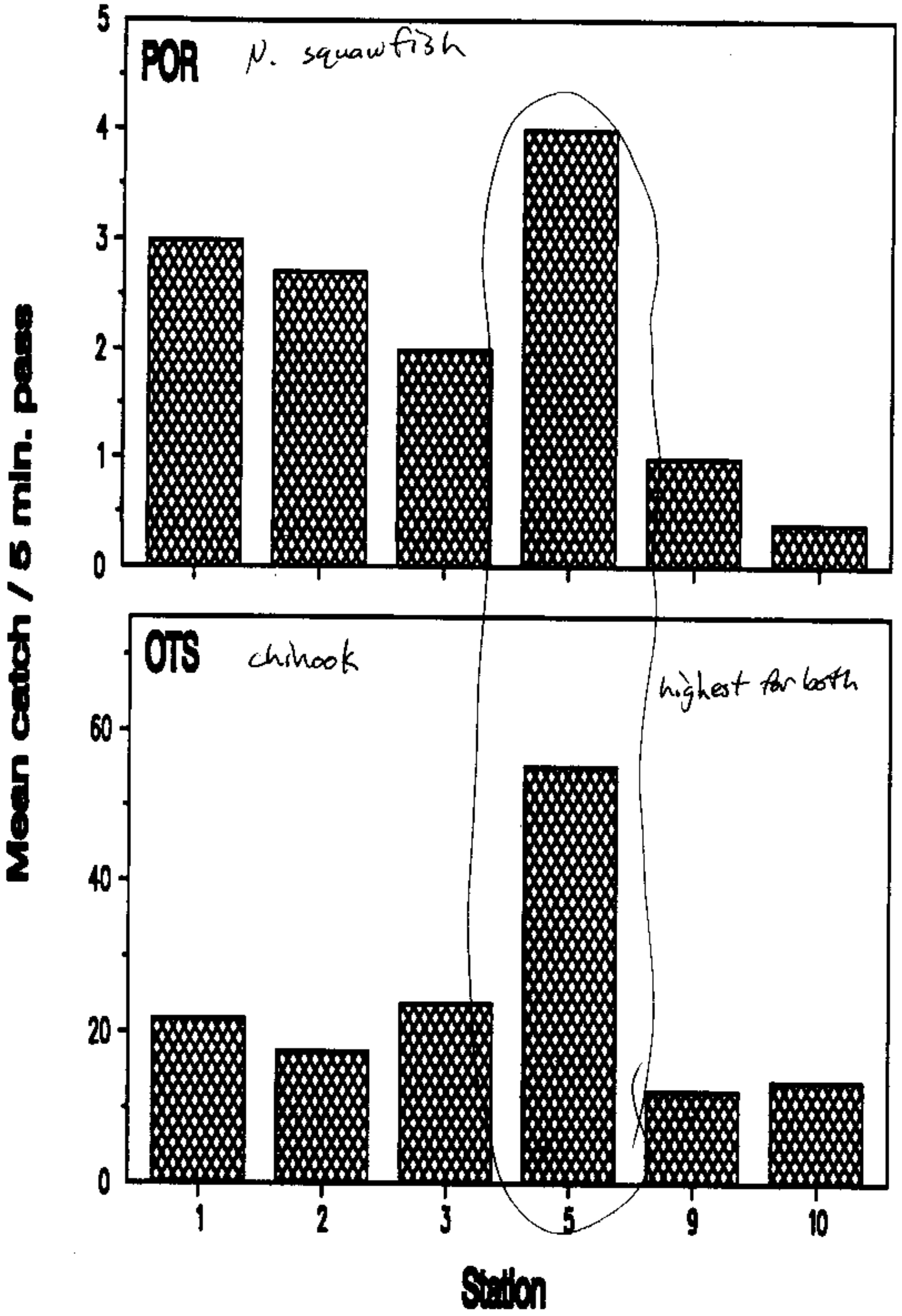


Figure 23. Mean catch per 5 minute pass of northern squawfish by shoreline electrofishing at shallow water stations in Lower Granite Reservoir, Idaho-Washington during 1989.

1) similar in abundance
2) not signif. diff. among stations

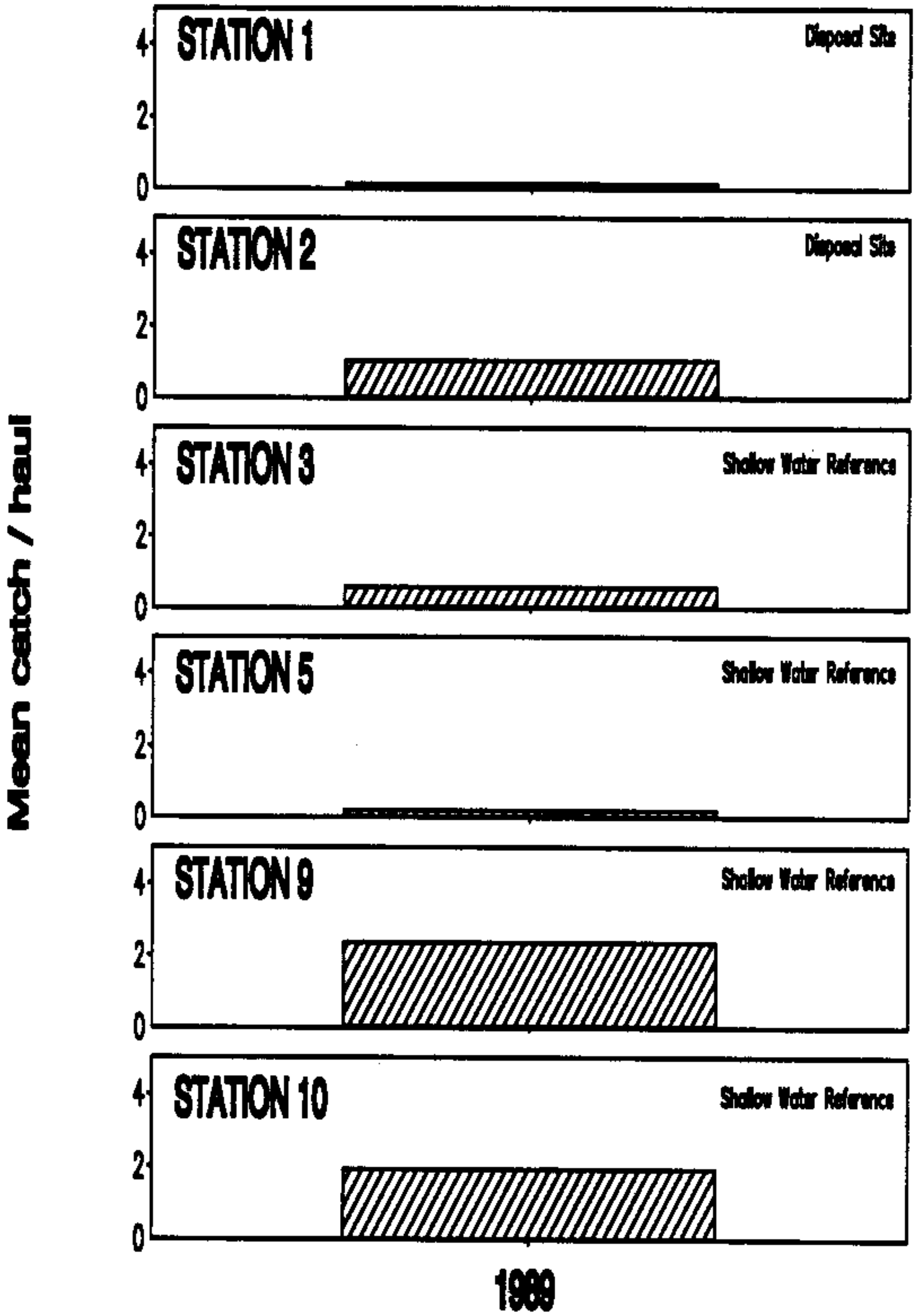


Figure 24. Mean catch per haul of steelhead by shoreline beach seining at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

catch rates at station 2 were not statistically different from those at stations 3 and 5 (Figure 25).

Comparison of mean catch/haul of smallmouth bass by beach seining indicated highest daytime littoral abundance at stations 10 and 9 (Figure 26). Catches at reference stations 3 and 5 were low. Significant differences in these catch rates were varied and generally indicated no differences in smallmouth abundance between the island disposal stations and near-by reference stations 3 and 5 (Figure 27).

Daytime abundance of northern squawfish based on beach seining was highest at stations 10 and 1 (Figure 28). Mean catch/haul was low at stations 2, 3, 5, and 9. Significant differences among stations were scattered and generally indicated that the abundance of squawfish at disposal stations 1 and 2 was similar to that at reference stations 9, 5, and 3 (Figure 29).

Daytime abundance of chinook salmon based on beach seining was similar among stations. None of the differences in mean catch/haul were statistically significant among stations.

Pelagic Abundance

Spring.- During 1989, highest catch rates for white sturgeon by gill netting were at station 8 followed distantly by disposal stations 4 and 2 (Figure 30). Catch rates for white sturgeon at all reference and disposal stations were statistically similar except at station 8 (Figure 31).

Catch/effort for northern squawfish by gill netting in the spring was highest at station 5 followed by stations 6, 1 and 2 (Figures 32-33). Catch rates at other stations were low during the spring. Statistical comparisons among stations indicated that the catch rates of northern squawfish at

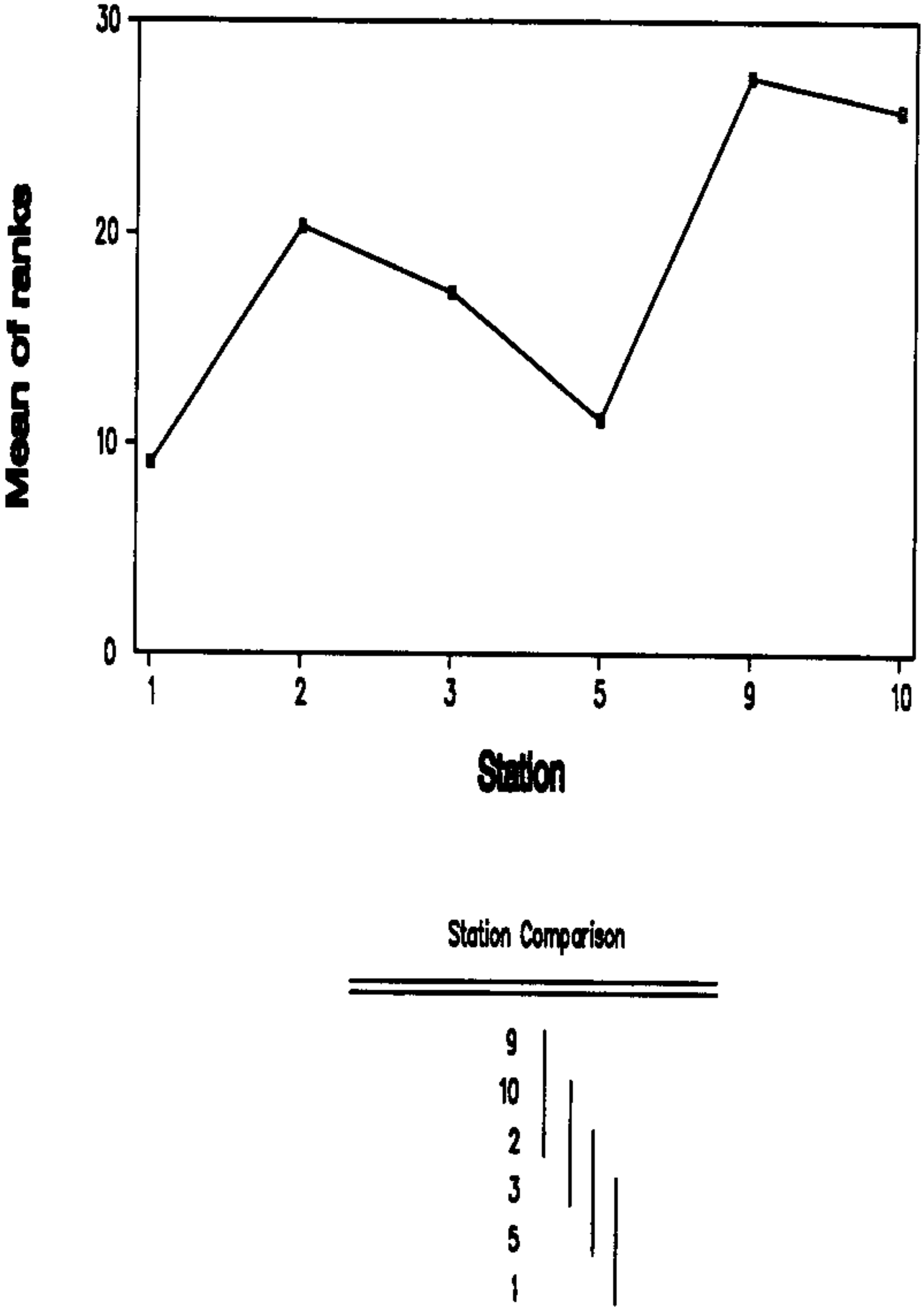


Figure 25. Statistical comparisons of the mean of ranks of abundance of steelhead by shoreline beach seining at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989. Stations connected by lines were not significantly (P>0.05) different.

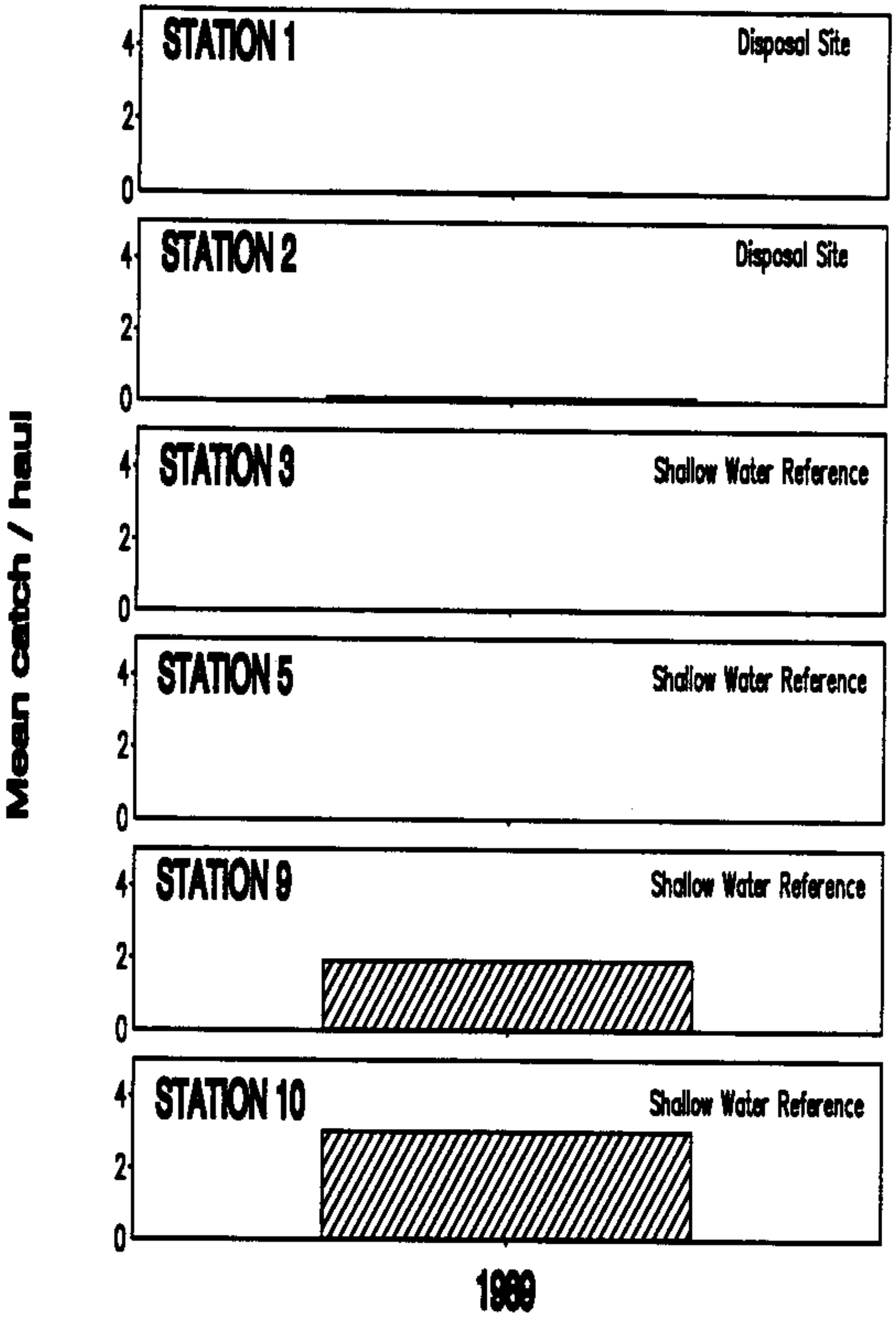


Figure 26. Mean catch per haul of smallmouth bass by shoreline beach seining at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

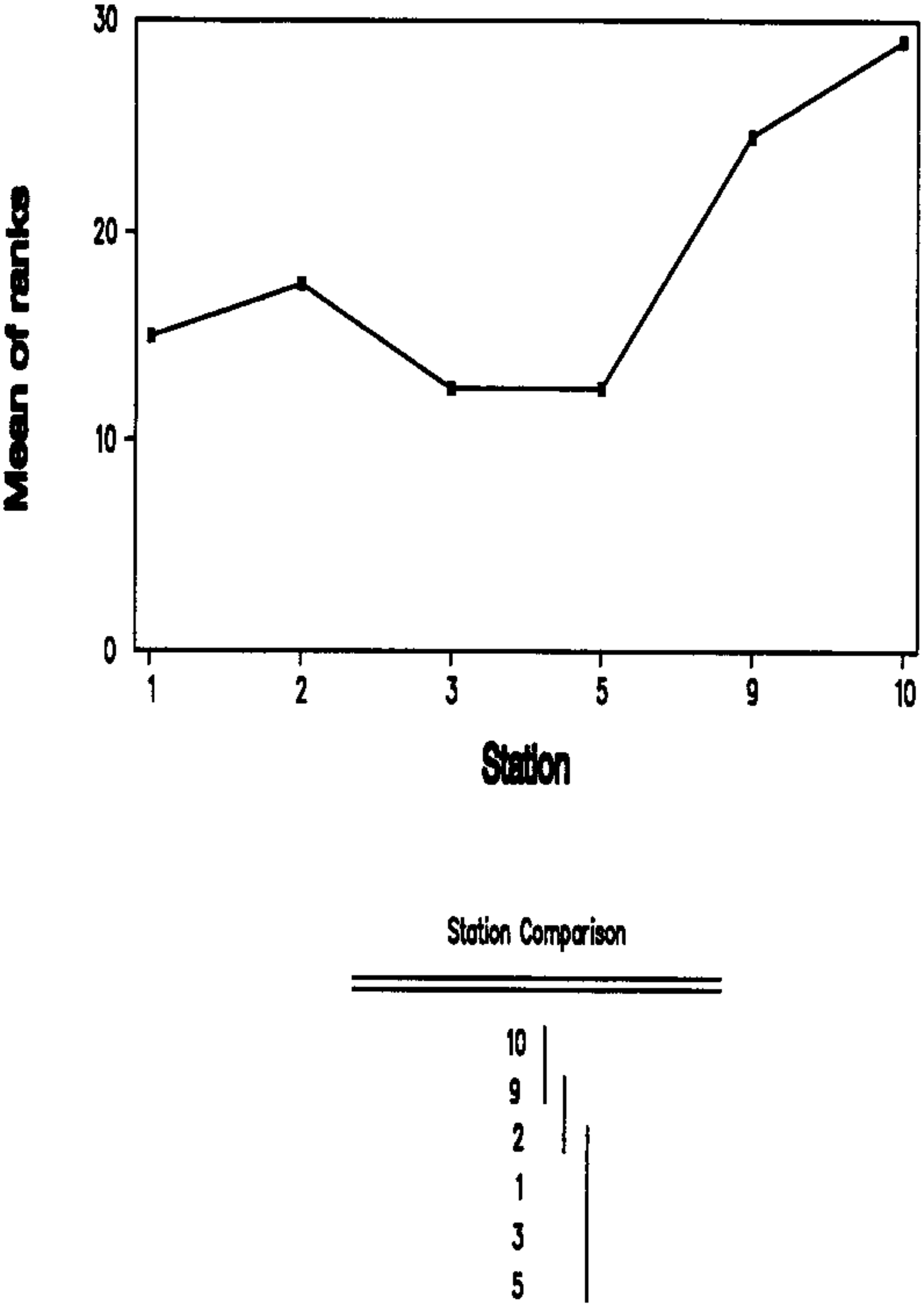


Figure 27. Statistical comparisons of the mean of ranks of abundance of smallmouth bass by shoreline beach seining at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989. Stations connected by lines were not significantly (P>0.05) different.

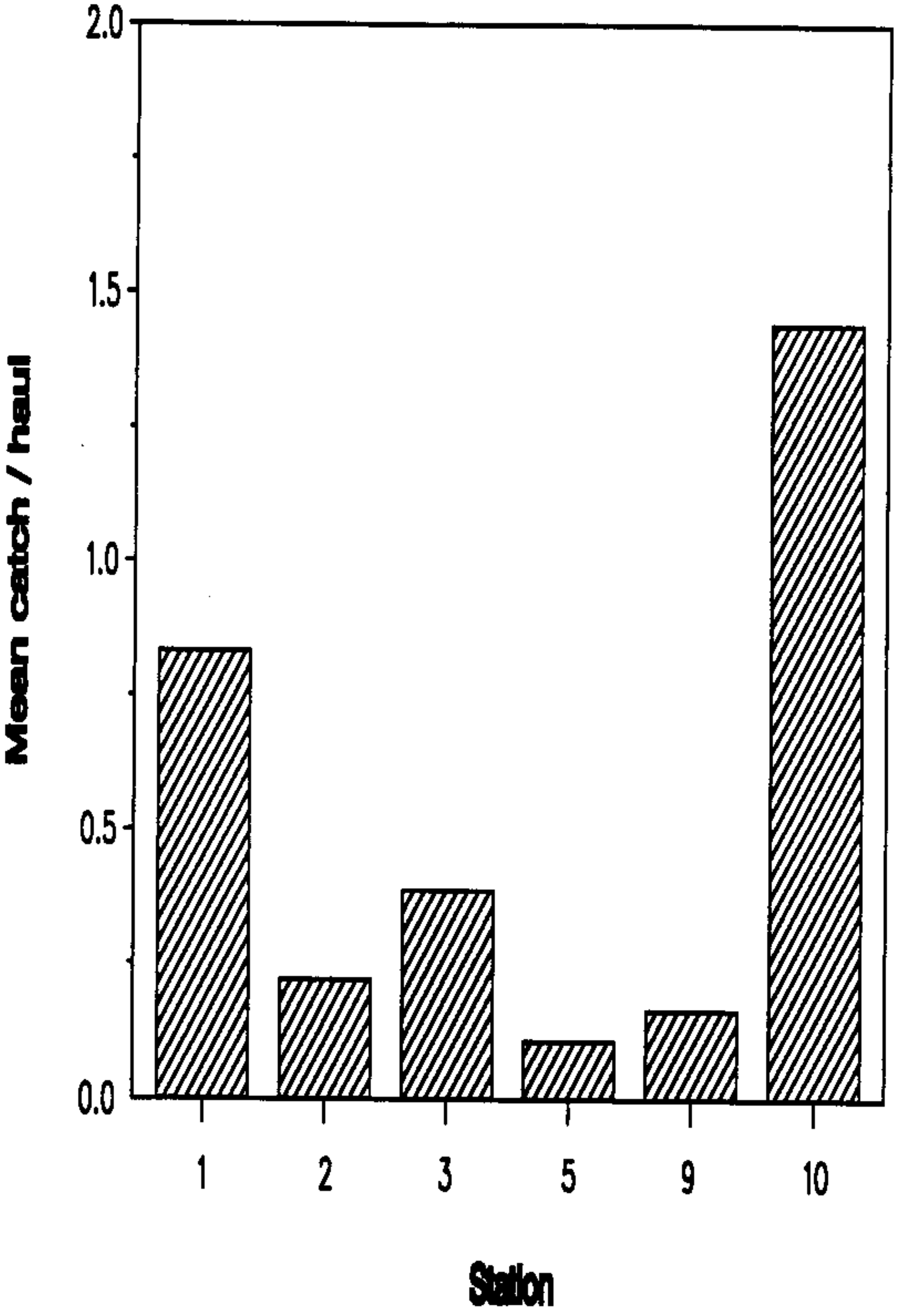


Figure 28. Mean catch per haul of northern squawfish by shoreline beach seining in Lower Granite Reservoir, Idaho-Washington, during 1989.

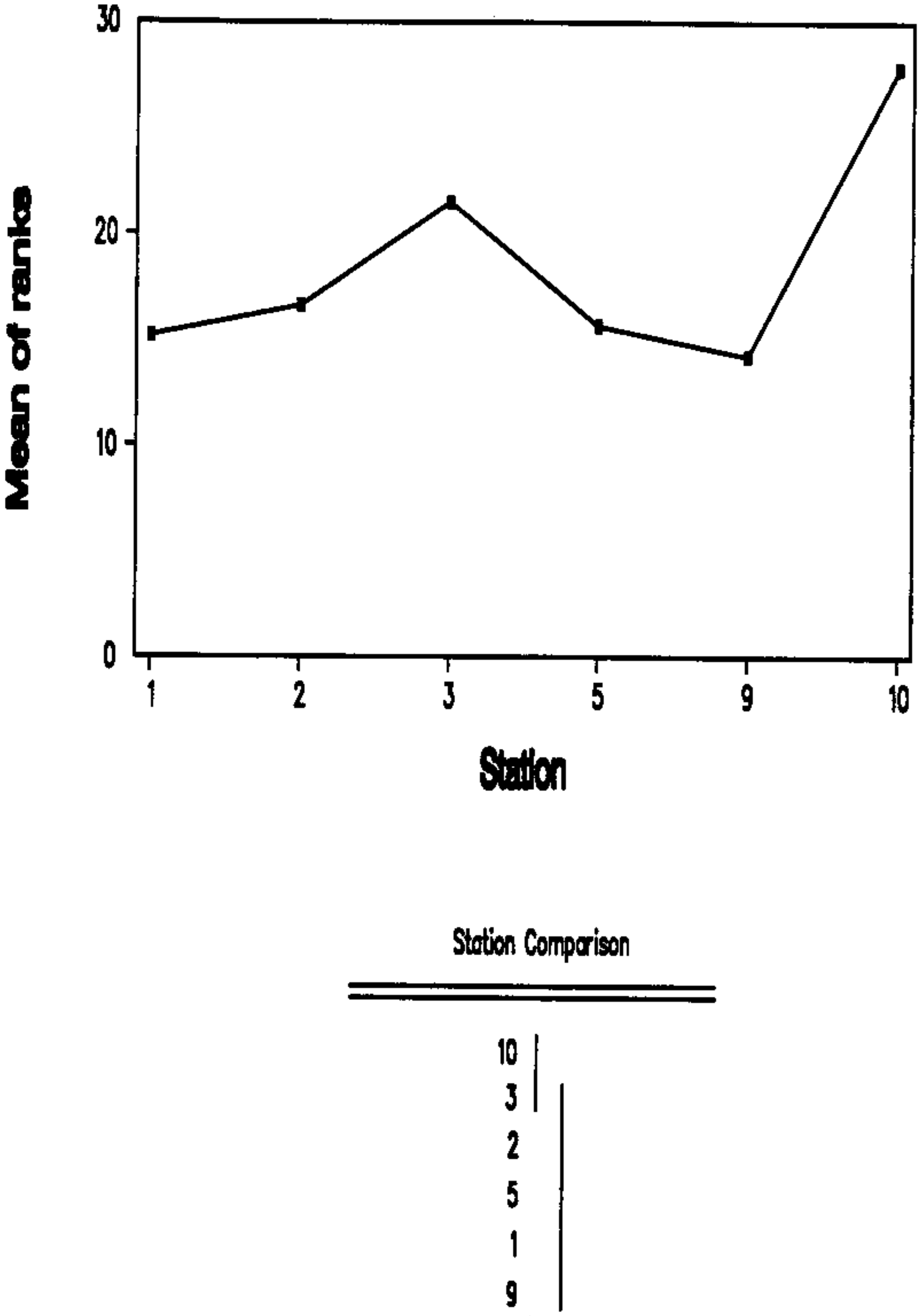


Figure 29. Statistical comparisons of the mean of ranks of abundance of northern squawfish by shoreline beach seining at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989. Stations connected by lines were not significantly (P>0.05) different.

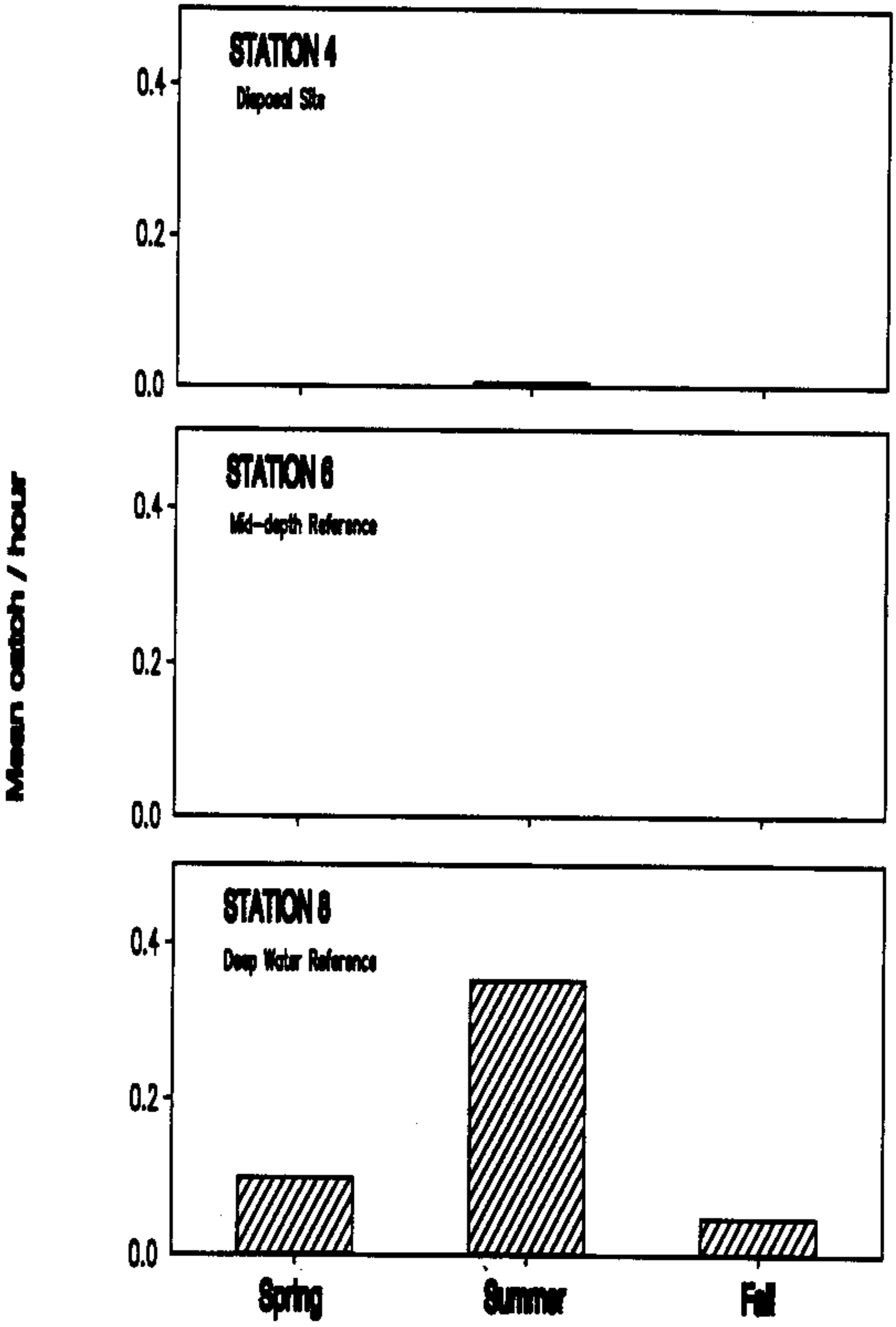
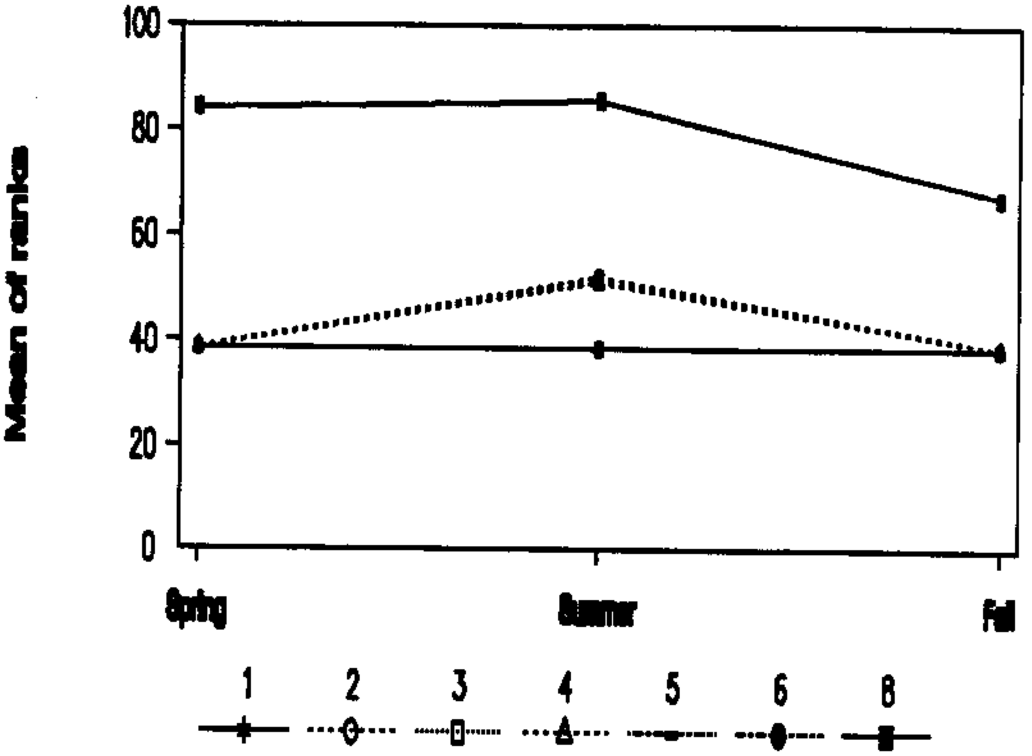


Figure 30. Mean catch per hour of white sturgeon by gillnetting at stations 4, 6 and 8 in Lower Granite Reservoir, Idaho-Washington, during 1989.



Station within season comparison

Spring	Summer	Fall
1	1	8
2	3	2
3	5	4
4	6	6
5	4	5
6	2	3
8	8	1

Season within station comparison

1	2	3	4	5	6	8
Sp	Sp	Sp	Sp	Sp	Sp	Su
Su	Fa	Su	Fa	Su	Su	Sp
Fa	Su	Fa	Su	Fa	Fa	Fa

Figure 31. Statistical comparisons of the mean of ranks of abundance of white sturgeon from gillnetting in Lower Granite Reservoir, Idaho-Washington, during 1989. Lines connecting seasons and stations indicate statistical nonsignificance ($P>0.05$).

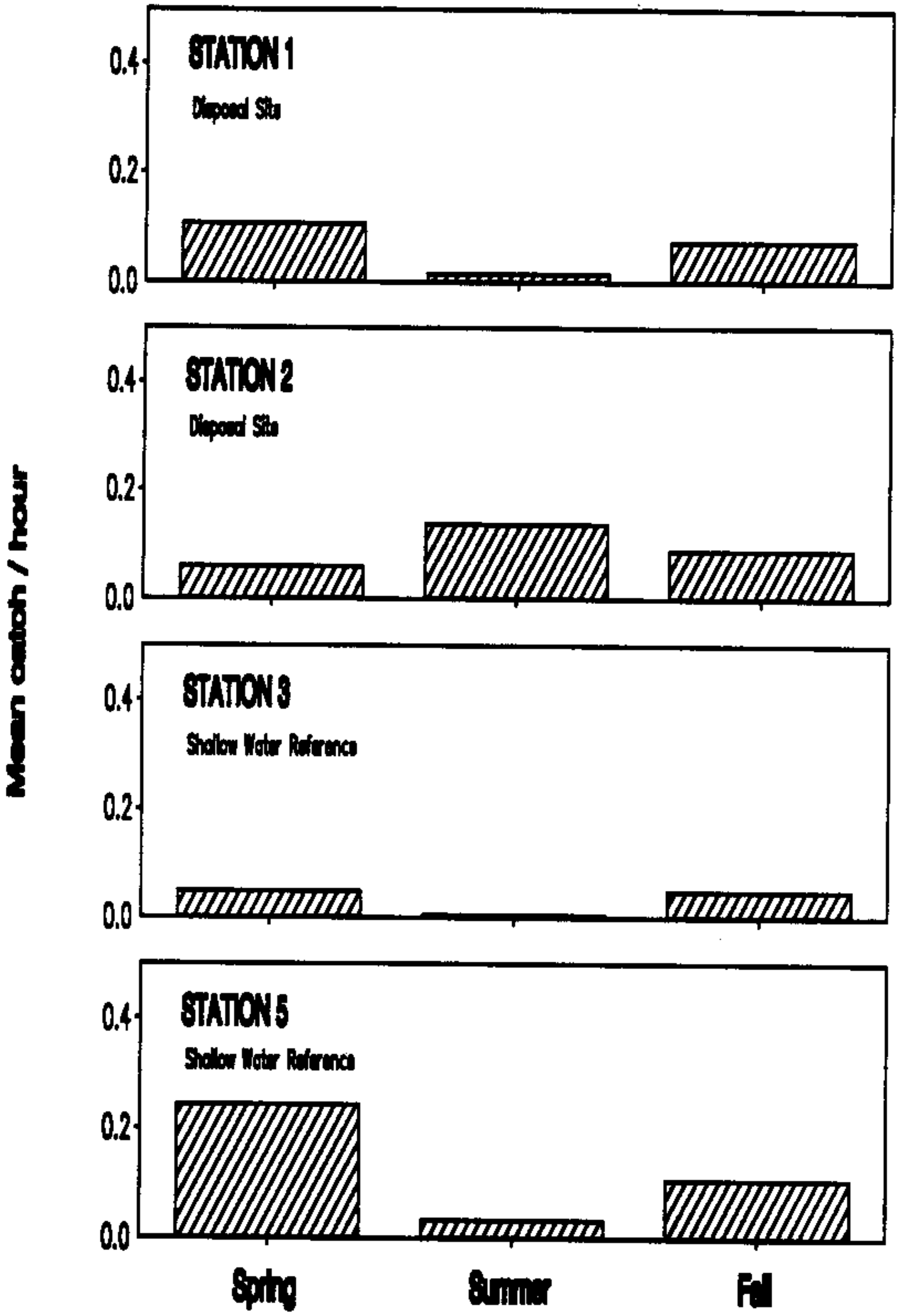


Figure 32. Mean catch per hour of northern squawfish by gillnetting at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

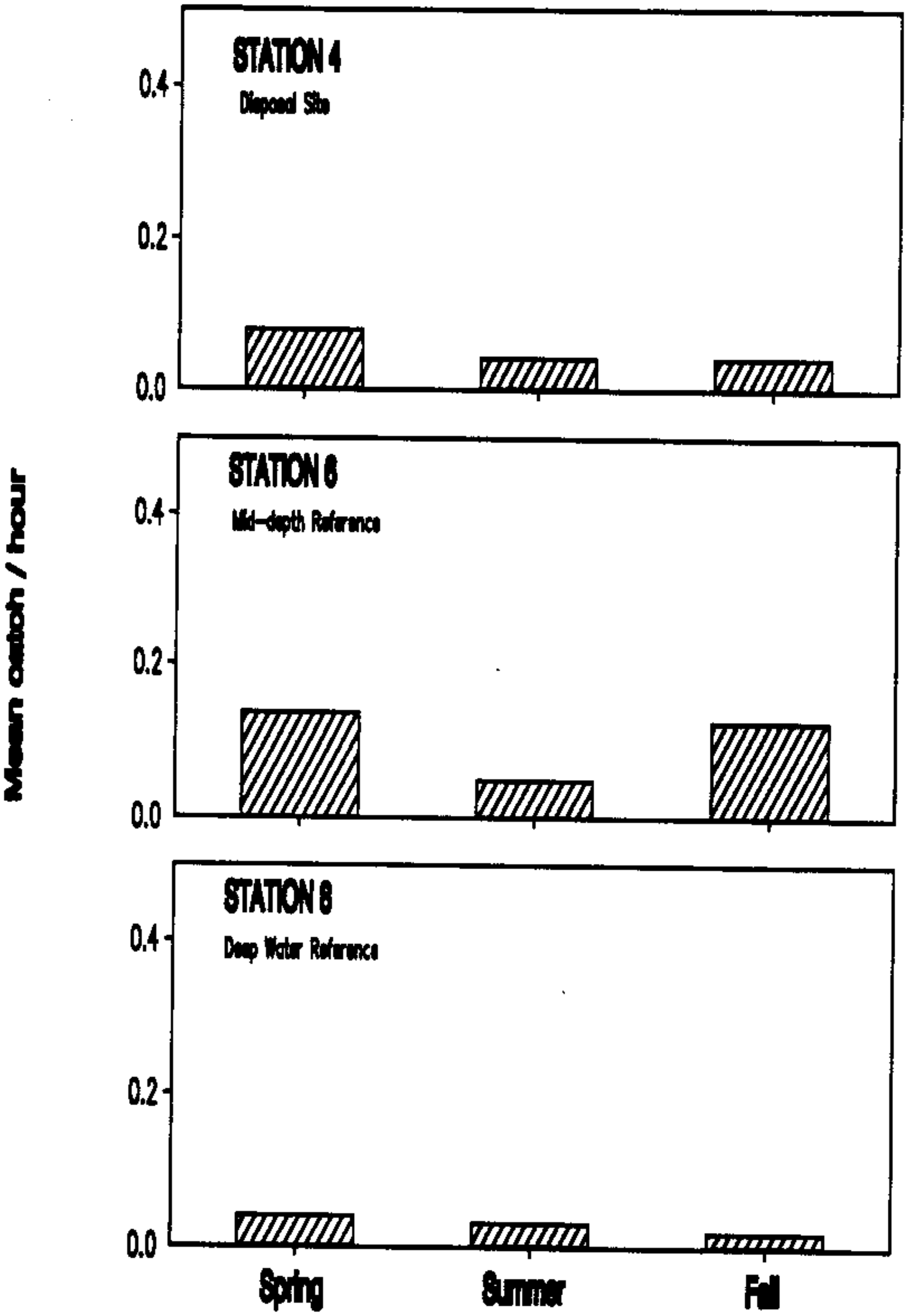


Figure 33. Mean catch per hour of northern squawfish by gillnetting at stations 4, 6, and 8 in Lower Granite Reservoir, Idaho-Washington, during 1989.

stations 5, 6, 1, and 2 were not significantly different and that catch rates of squawfish at all disposal stations (1, 2 and 4) were similar (Figure 34).

Catch rates of channel catfish during the spring of 1990 were generally low but highest at stations 8 and 6 (Figures 35-36). Catch/effort of channel catfish at disposal stations 2 and 4 during spring, 1989 was consistently low and significantly lower than at all reference stations except station 3 (Figure 37). Abundance based on mean CPUE was intermediate at disposal station 1 being similar to that at the highest stations 8, 6, 5, and 3.

Summer.- Catch rates of white sturgeon in the summer were highest at station 8 (Figure 30). Catches at other stations generally were low (Figure 38). Statistically, mean catch rates at station 8 were different from all other stations while those at stations 2 and 4 were similar but significantly higher than other mid-depth and shallow reference stations (Figure 31).

During the summer of 1989, mean catch/hour of northern squawfish by gill netting was generally lower than that in the spring except at disposal station 2 where they increased (Figures 32-33).

Mean catch/hour by gill netting of channel catfish generally increased from spring to summer (Figures 35-36). Highest catch rates in the summer were at station 1 followed by reference station 3 and disposal stations 4 and 2; however, these high catch rates were not significantly different (Figure 37).

Fall.- During fall 1989, catch rates of white sturgeon continued to be low at all stations except the deep water station 8 (Figure 30). These differences in catch rates among all other stations and station 8 were significant (Figure 31).

Catch rates of northern squawfish in the fall of 1989 increased over those in the summer (Figures 32-33). Abundance of squawfish based on gill net

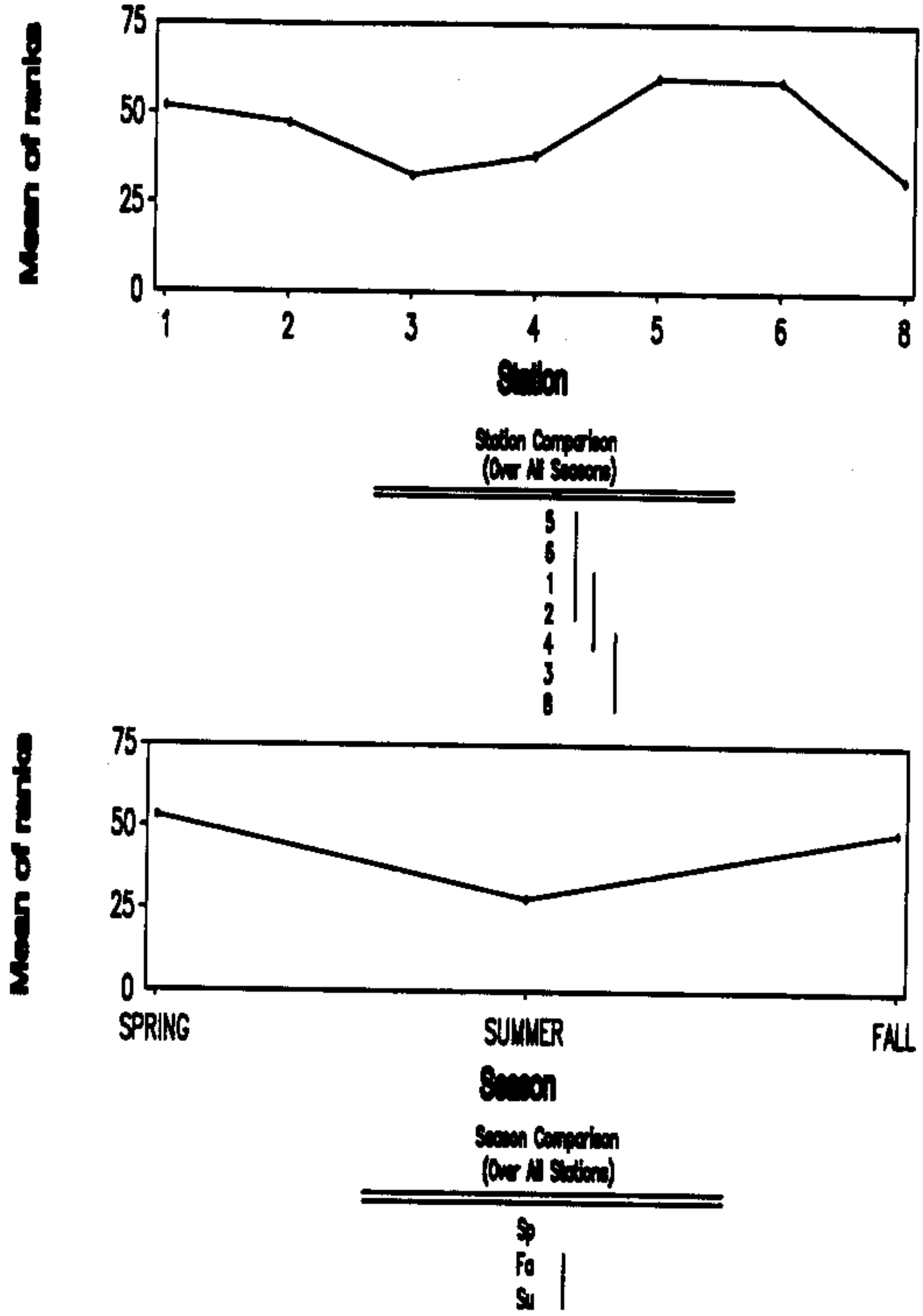


Figure 34. Statistical comparisons of the mean of ranks of abundance of northern squawfish by gillnetting in Lower Granite Reservoir, Idaho-Washington, during 1989. Lines connecting seasons and stations indicate statistical nonsignificance (P>0.05).

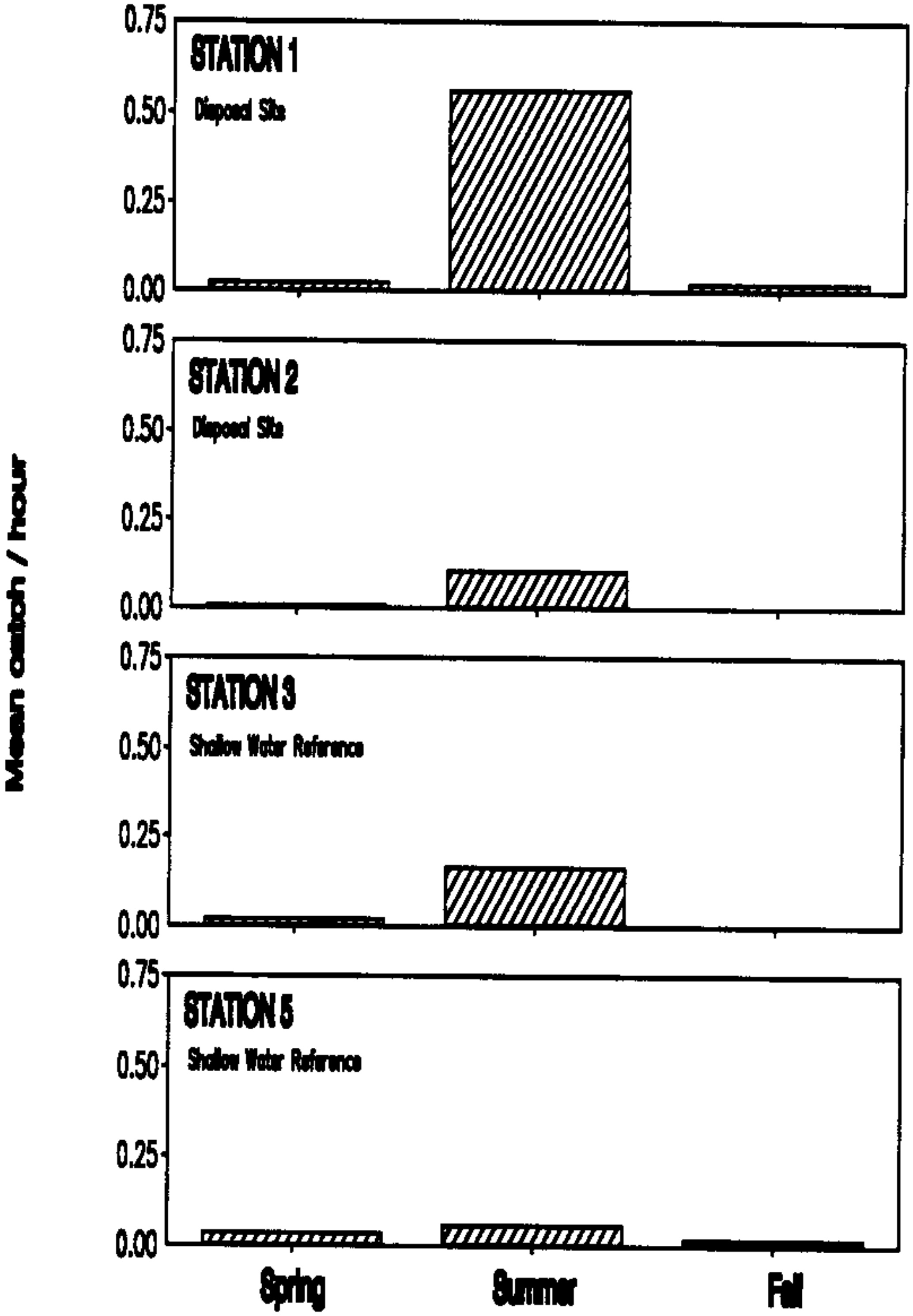


Figure 35. Mean catch per hour of channel catfish by gillnetting at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

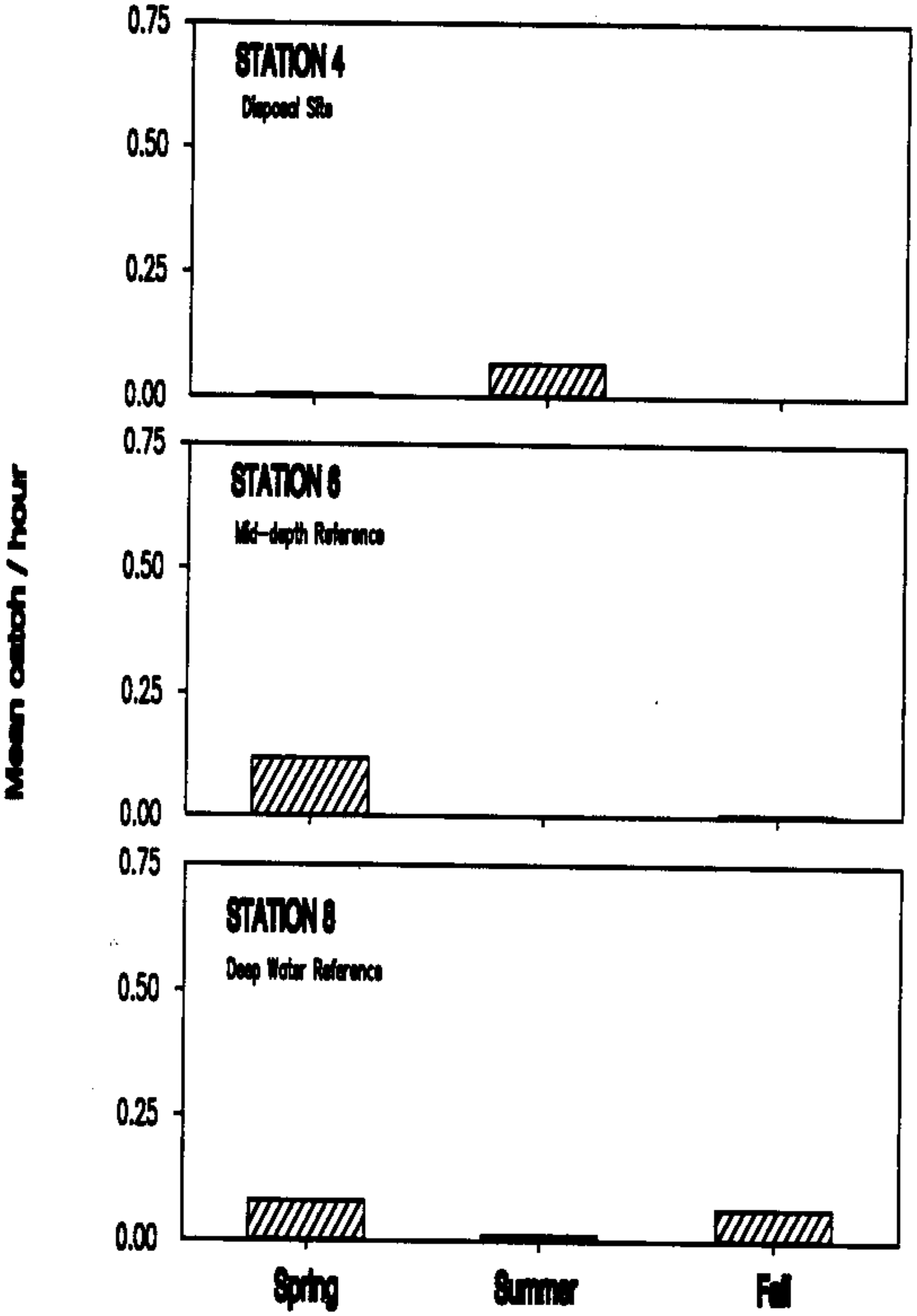


Figure 36. Mean catch per hour of channel catfish by gillnetting at stations 4, 6, and 8 in Lower Granite Reservoir, Idaho-Washington, during 1989.

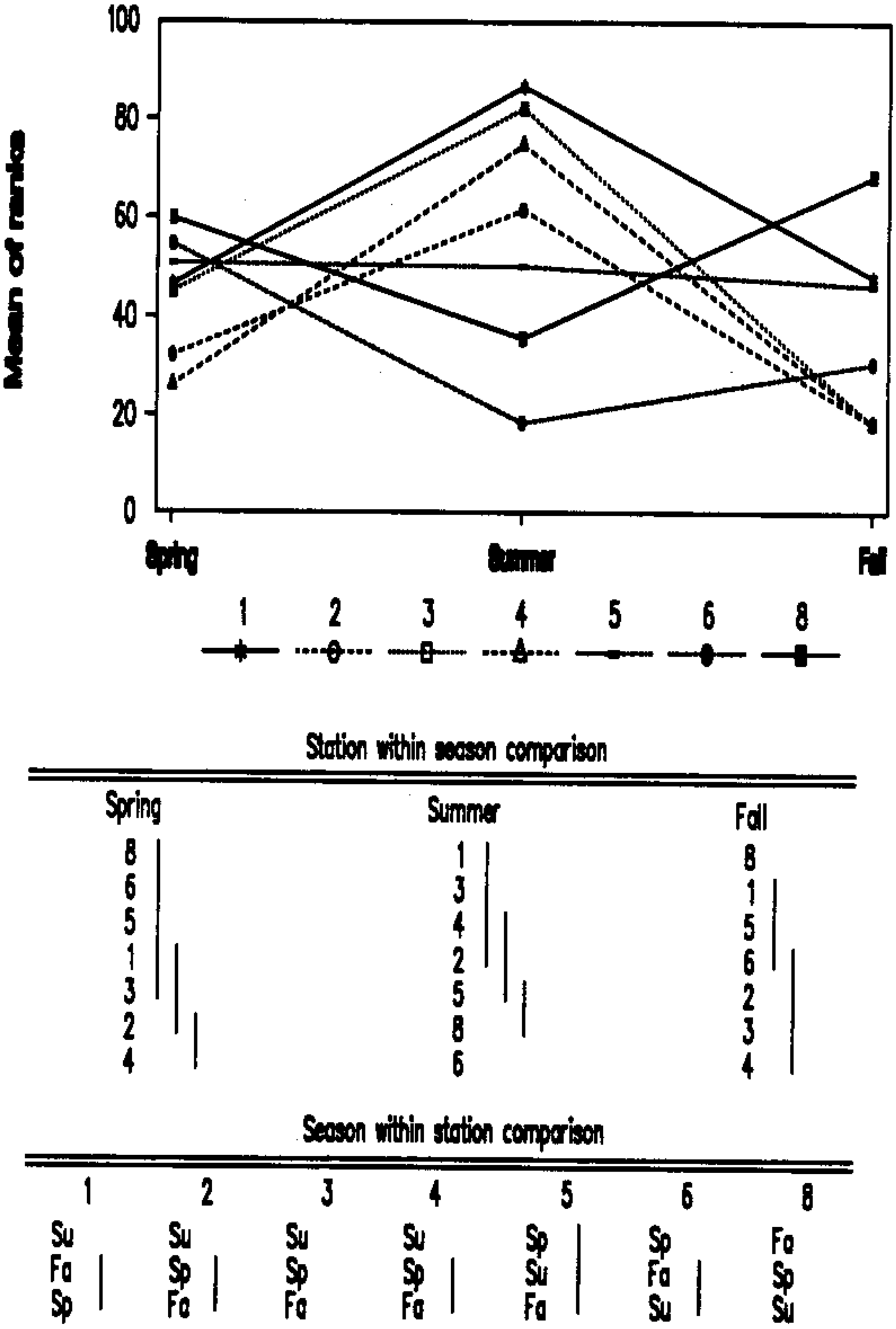


Figure 37. Statistical comparisons of the mean of ranks of abundance of channel catfish by gillnetting in Lower Granite Reservoir, Idaho-Washington, during 1989. Lines connecting seasons and stations indicate statistical nonsignificance (P>0.05).

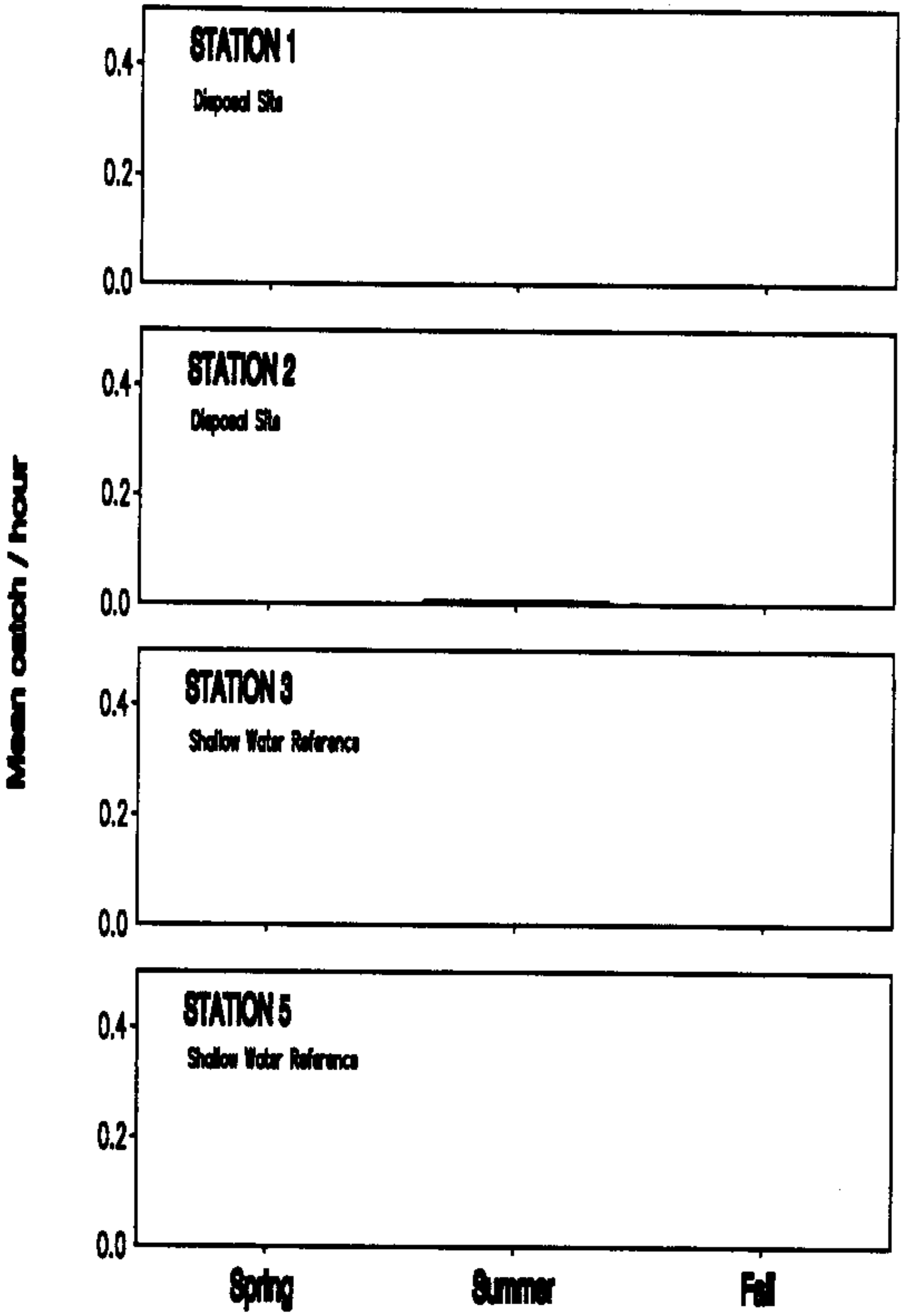


Figure 38. Mean catch per hour of white sturgeon by gillnetting at shallow water stations in Lower Granite Reservoir, Idaho-Washington, during 1989.

CPUE was highest at stations 5, 6, 1, and 2, but not significant. However, they were significantly higher than those at stations 3 and 8 (Figure 34).

Abundance of channel catfish during the fall based on gill netting was highest at station 8 followed by stations 5 and 1 (Figures 35-36). This difference in catch rates between station 8 and other stations was significant as was the difference between catch rates at disposal station 1 and the other disposal stations (Figure 37).

Comparison of Abundance Among Years

Pelagic Abundance

1988 - 1989

[redacted]igure 39). [redacted]. Generally, few station differences have been found. Seasonal differences were significant at some stations and not at others. Of all the stations, station 4 has been the most consistent in catch rates of white sturgeon between 1988 and 1989. [redacted] two [redacted](Figure 40). Catch rates of sturgeon at the mid-depth reference station 6 and the mid-depth disposal station 4 are not significantly different among the three years of sampling. [redacted]

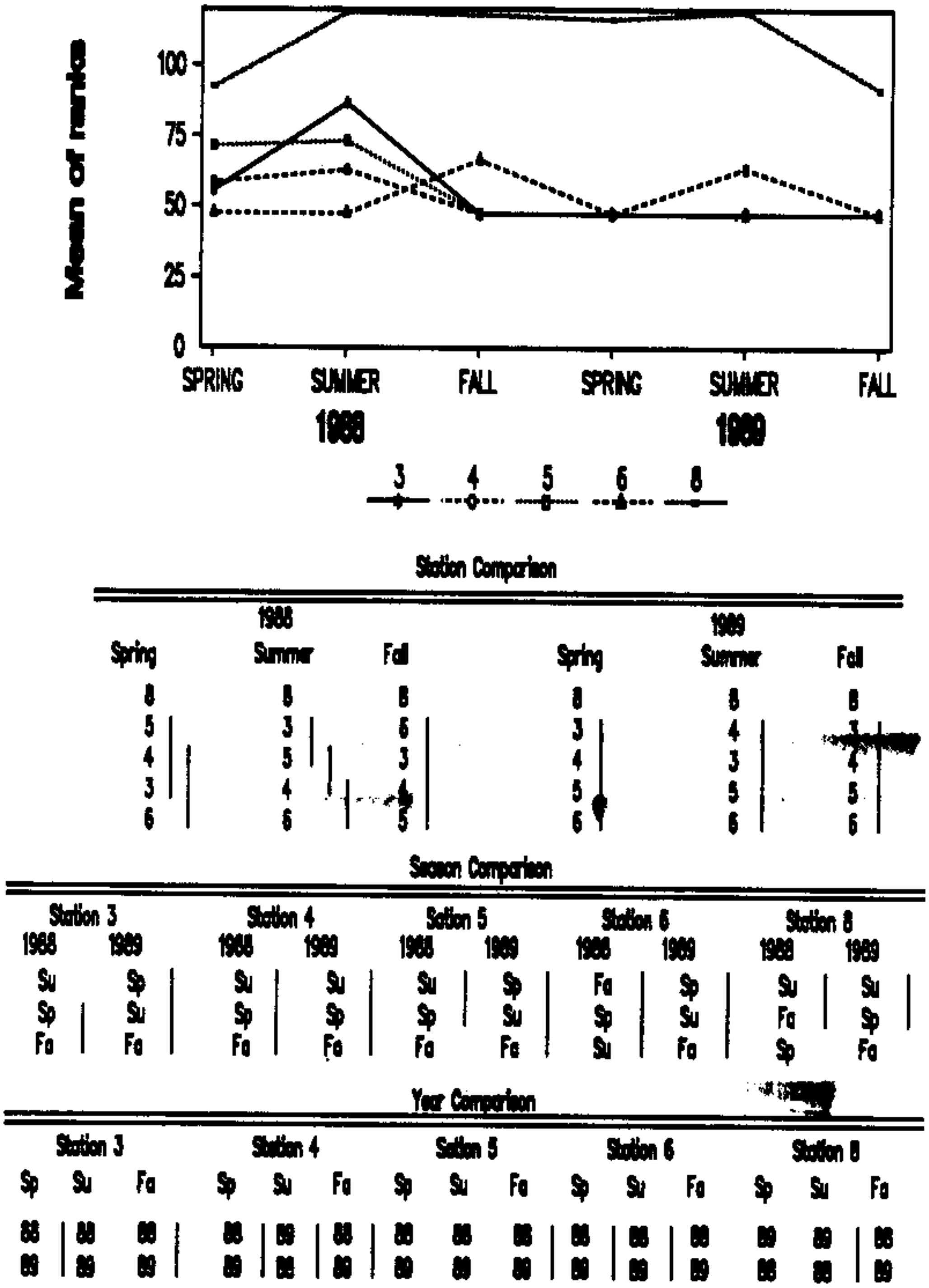
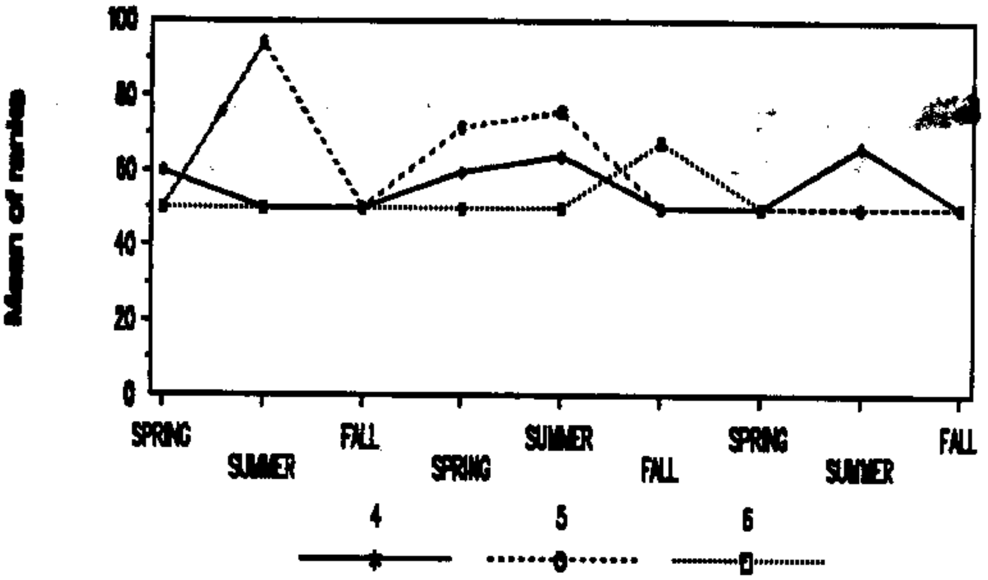


Figure 39. Statistical comparisons of the mean of ranks of abundance of white sturgeon by gillnetting in Lower Granite Reservoir, Idaho-Washington, for 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).



Station Comparison

1987			1988			1989		
Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
4	5	4	5	5	6	4	4	4
5	4	5	4	4	4	5	5	5
6	6	6	6	6	5	6	6	6

Season Comparison

Station 4			Station 5			Station 6		
1987	1988	1989	1987	1988	1989	1987	1988	1989
Sp	Su	Su	Su	Su	Sp	Sp	Fa	Sp
Su	Sp	Sp	Sp	Sp	Su	Su	Sp	Su
Fa	Fa	Fa	Fa	Fa	Fa	Fa	Su	Fa

Year Comparison

Station 4			Station 5			Station 6		
Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
1987	1989	1987	1988	1987	1987	1987	1987	1988
1988	1988	1988	1987	1988	1988	1988	1988	1987
1989	1987	1989	1989	1989	1989	1989	1989	1989

Figure 40. Statistical comparisons of the mean of ranks of abundance of white sturgeon by gillnetting in Lower Granite Reservoir, Idaho-Washington, for 1987, 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).

¿ is bounty working? No, no bounty till 1991!

[redacted](Figure 41). Abundance at stations 4 and 8 has not changed significantly between years while those at other stations have exhibited a significant decrease.

1987 - 1989

We found a significant year*season*station interaction with northern squawfish at stations 4, 5 and 6 (Figure 42). Comparison of catch/hour by gill nets indicated that over 1987-89 and all seasons that station 5 has had significantly higher squawfish abundance than both stations 4 and 6. Seasonal and yearly differences were also significant. Mean catch/hour has been generally highest during the fall which probably accounts for the seasonal differences (Figure 43).

Comparison of catch rates for channel catfish indicated a general decrease from 1988 and 1989 (Figure 44). With the exception of the summer, channel catfish abundance at station 4 was lowest of all stations sampled. Comparison of catch rates of channel catfish by gill netting indicated a similar level of abundance from 1987 and 1989 over all stations (Figure 45). During all three years, the abundance of channel catfish has not significantly changed as a result of creation of the mid-depth disposal relative to the reference stations 5 and 6.

Littoral Abundance

1988 - 1989

Comparison of mean catch/haul by beach seining for chinook salmon juveniles indicated a slight increase in reservoir abundance between 1988 and 1989 at each of the four reference stations (Figure 46). These differences,

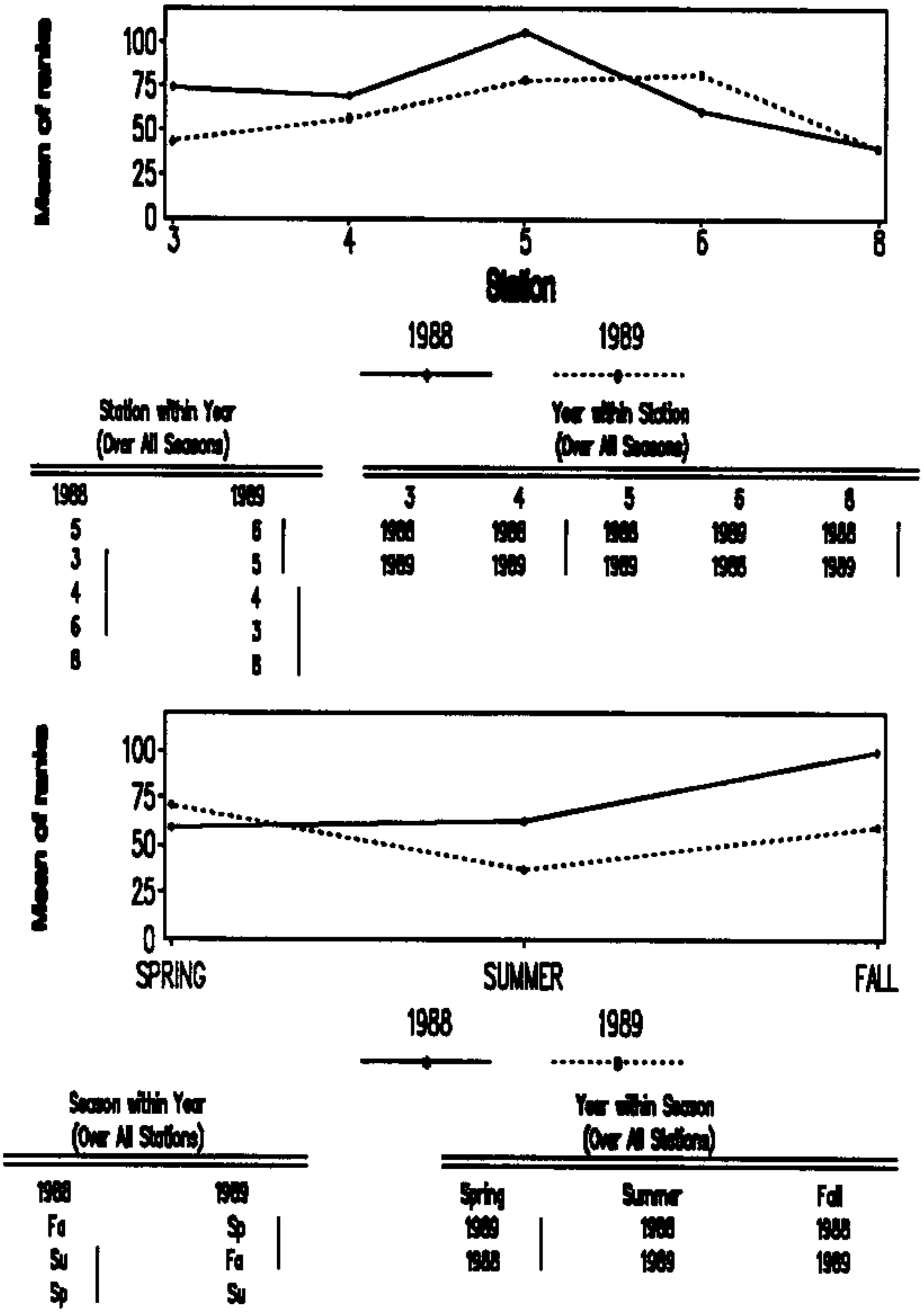
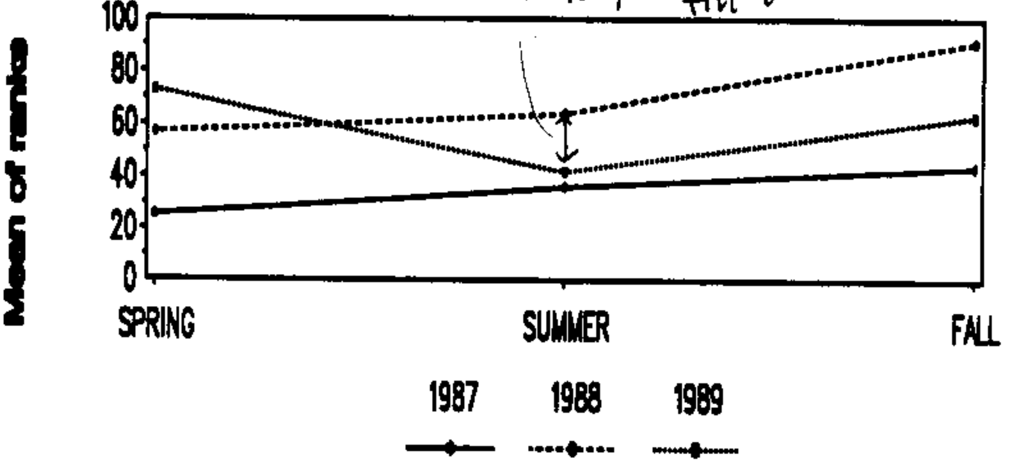


Figure 41. Statistical comparisons of the mean of ranks of abundance of northern squawfish by gillnetting in Lower Granite Reservoir, Idaho-Washington, for 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).

¿ ~~effect of bounty program~~ ?
NO, no bounty till 1991

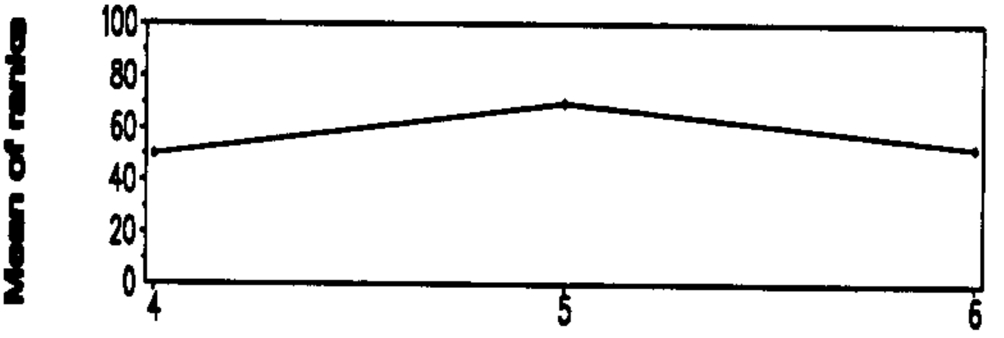


Season within Year
(Over All Stations)

1987	1988	1989
Fa	Fa	Sp
Su	Su	Fa
Sp	Sp	Su

Year within Season
(Over All Stations)

Spring	Summer	Fall
1989	1988	1988
1988	1989	1989
1987	1987	1987



Station Comparison
(Over All Years and Seasons)

5
6
4

Figure 42. Statistical comparisons of the mean of ranks of abundance of northern squawfish by gillnetting in Lower Granite Reservoir, Idaho-Washington, for 1987, 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).

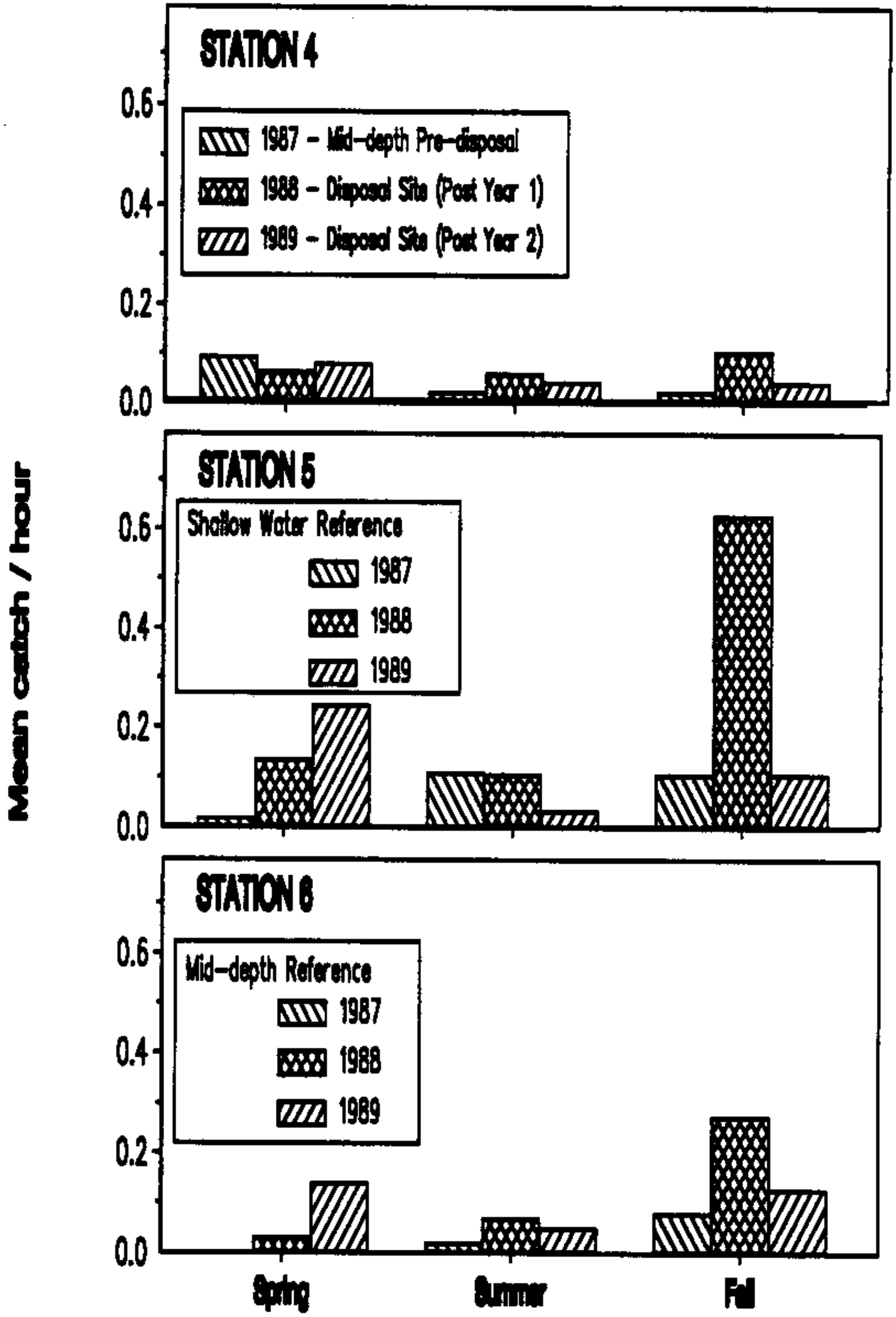


Figure 43. Mean catch per hour of northern squawfish by gillnetting at stations 4, 5, and 6 in Lower Granite Reservoir, Idaho-Washington during 1987, 1988 and 1989.

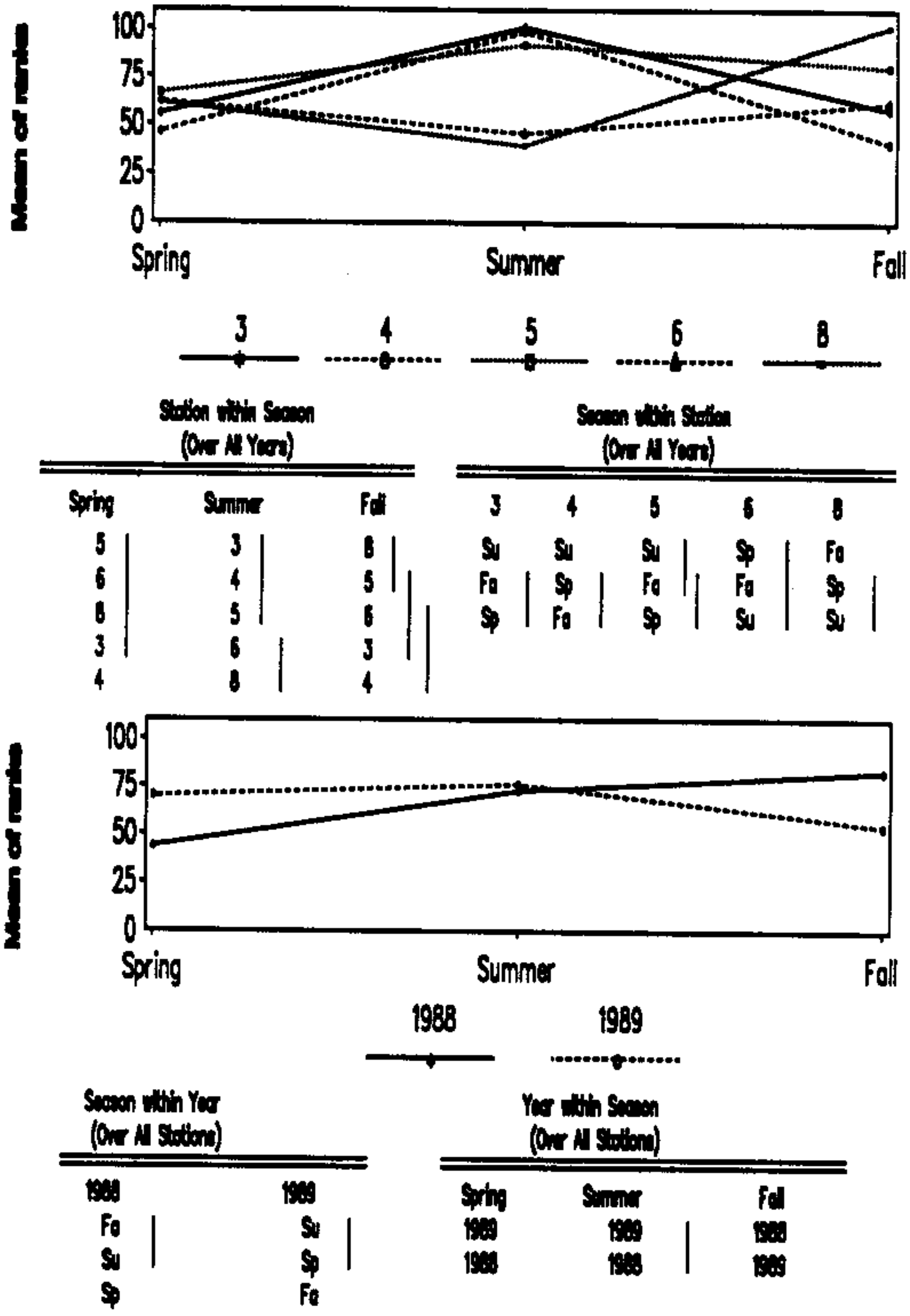
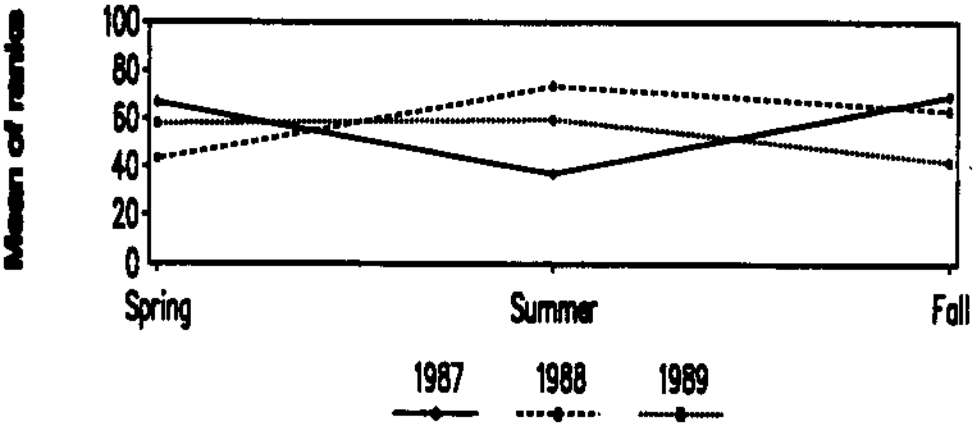


Figure 44. Statistical comparisons of the mean of ranks of abundance of channel catfish by gillnetting in Lower Granite Reservoir, Idaho-Washington, for 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).

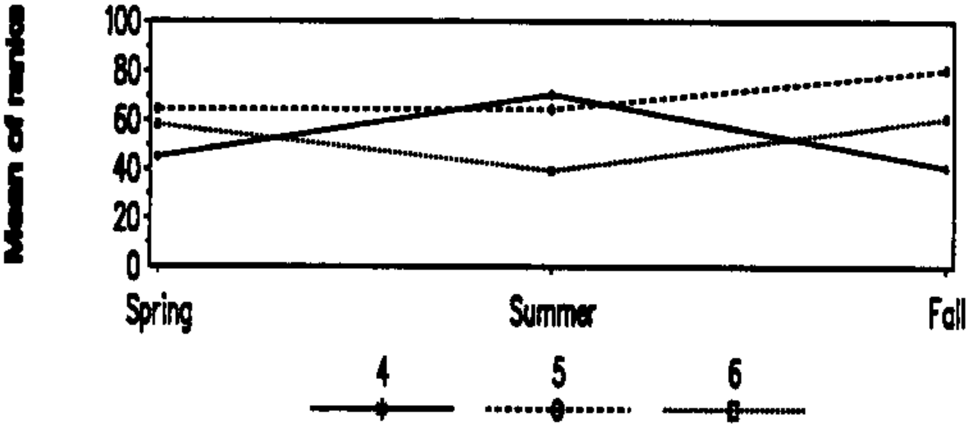


Season within Year
(Over All Stations)

1987		1988		1989	
Fa	│	Su	│	Su	│
Sp	│	Fa	│	Sp	│
Su		Sp		Fa	│

Year within Season
(Over All Stations)

Spring		Summer		Fall	
1987	│	1988	│	1987	│
1989	│	1989	│	1988	│
1988		1987		1989	



Station within Season
(Over All Years)

Spring			Summer		Fall
5	│		4	│	5
6	│	│	5	│	6
4		│	6		4

Season within Station
(Over All Years)

4		5		6	
Su		Fa	│	Fa	│
Sp	│	Sp	│	Sp	│
Fa	│	Su	│	Su	

Figure 45. Statistical comparisons of the mean of ranks of abundance of channel catfish by gillnetting in Lower Granite Reservoir, Idaho-Washington, for 1987, 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).

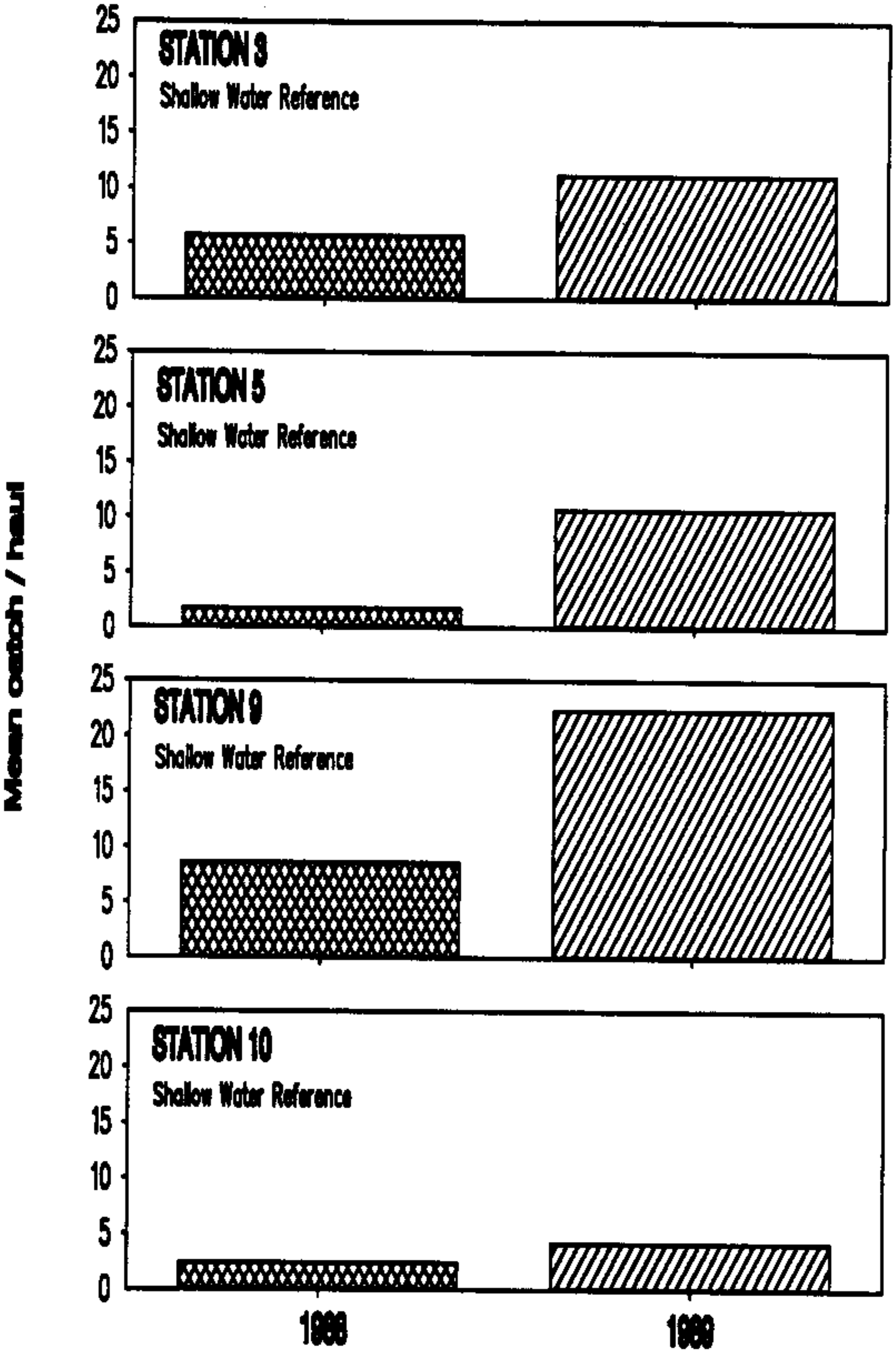


Figure 46. Comparison of mean catch per haul of chinook salmon by beach seining at shallow water stations between 1988 and 1989.

however, were not statistically significant. Comparison of catch/haul at reference stations 5 and 9 from 1987-89 indicated no significant change in abundance with time and location (Figure 47).

Comparison of mean catch/haul by beach seining for juvenile steelhead has indicated a general decrease in abundance at the reference stations (Figure 48). Station and year effects were both significant. Mean catch/haul of steelhead was significantly higher in 1988 than 1989 and catch/haul at up-reservoir reference stations 3 and 5 was significantly lower than at the down-reservoir reference stations 9 and 10 (Figure 49). Catch rates for steelhead from 1987-89 showed both station and year differences (Figure 50). During that period, catch/haul of steelhead at station 5 was significantly lower than at station 9. Differences in mean catch/haul were not significant between 1987 and 1988 although both years were significantly higher than 1989.

Mean catch/haul by beach seining for smallmouth bass was generally higher during 1988 than in 1989 (Figure 51). Statistically, catch rates were different during those years and catches were higher in down-reservoir reference stations than in up-reservoir reference stations (Figure 52). Comparison of abundance of smallmouth bass for 1987-1989 at stations 5 and 9 indicated significant station and year differences as catch rates during 1987 were higher than either 1988 or 1989 (Figure 53).

Abundance of northern squawfish based on catch/haul by beach seining has decreased from 1988-1989 at station 3 but increased at station 10 (Figure 54). These differences in catch/haul have shown a general and significant increase for squawfish between 1988 and 1989 (Figure 55). Squawfish abundance based on beach seining, was significantly higher at reference stations 3 and 10 than stations 5 and 9. Comparison of mean catch/haul of northern squawfish among

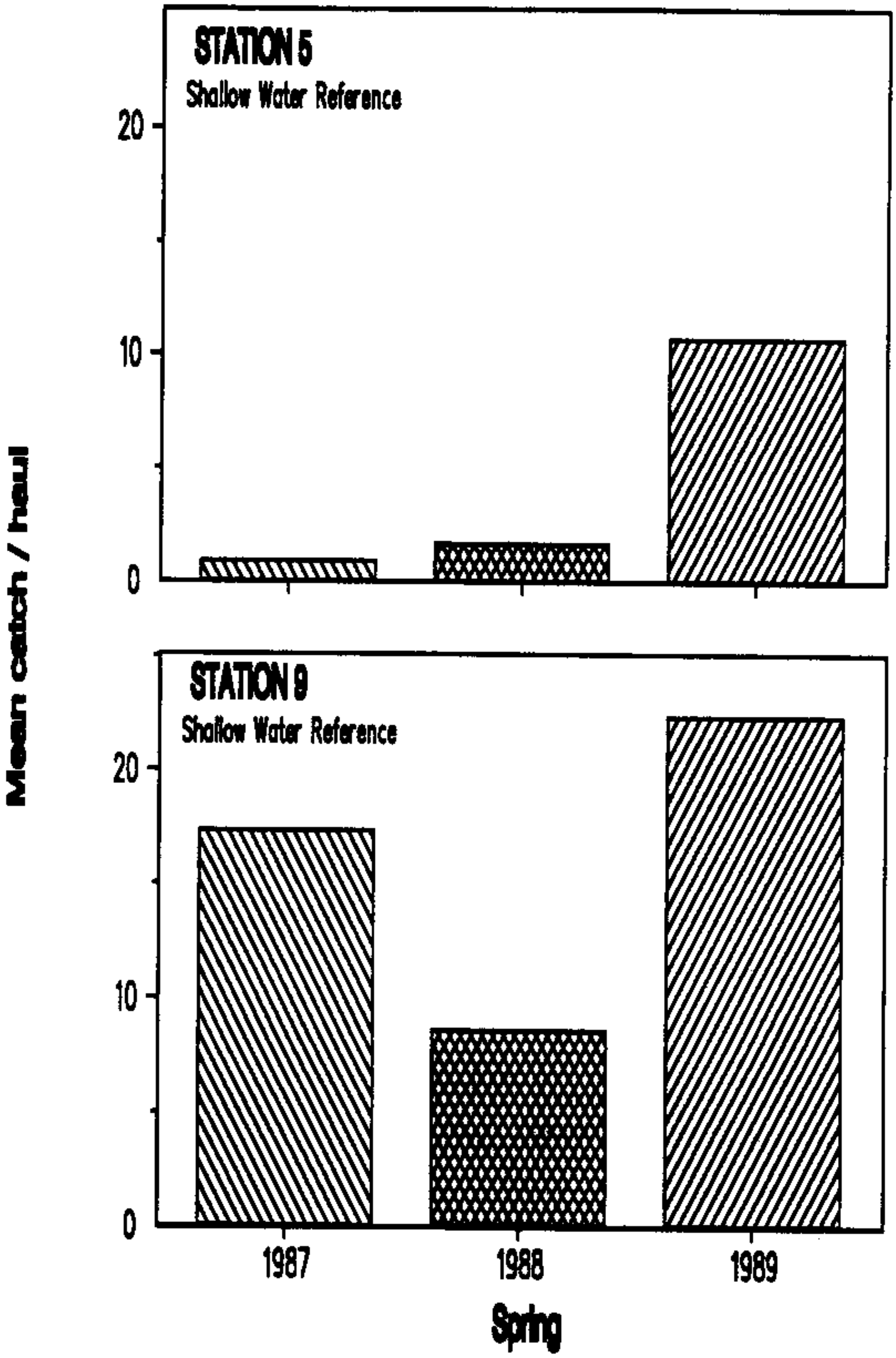


Figure 47. Comparison of mean catch per haul of chinook salmon by beach seining at stations 5 and 9 among 1987, 1988 and 1989.

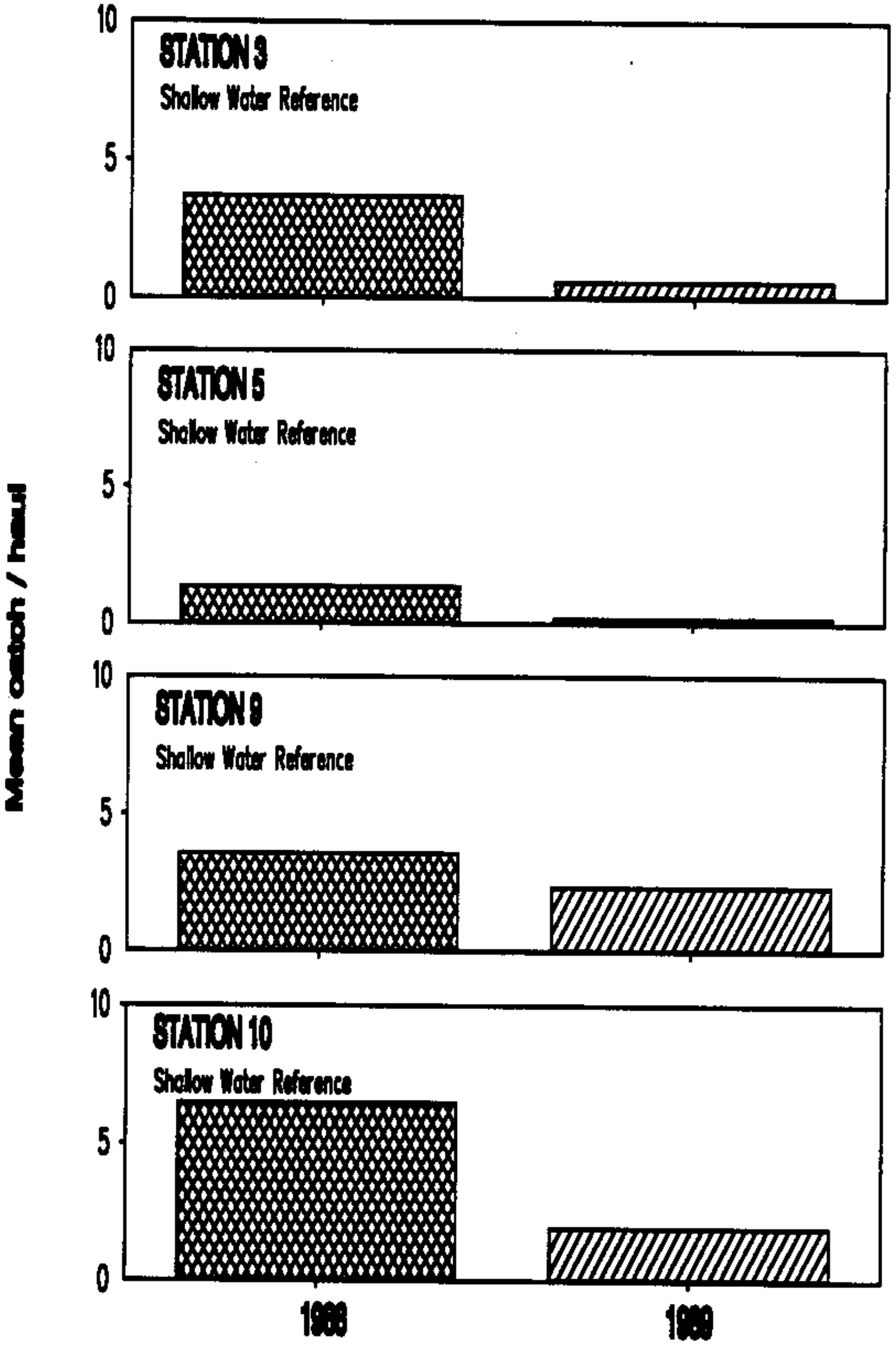


Figure 48. Comparison of mean catch per haul of steelhead by beach seining at shallow water stations between 1988 and 1989.

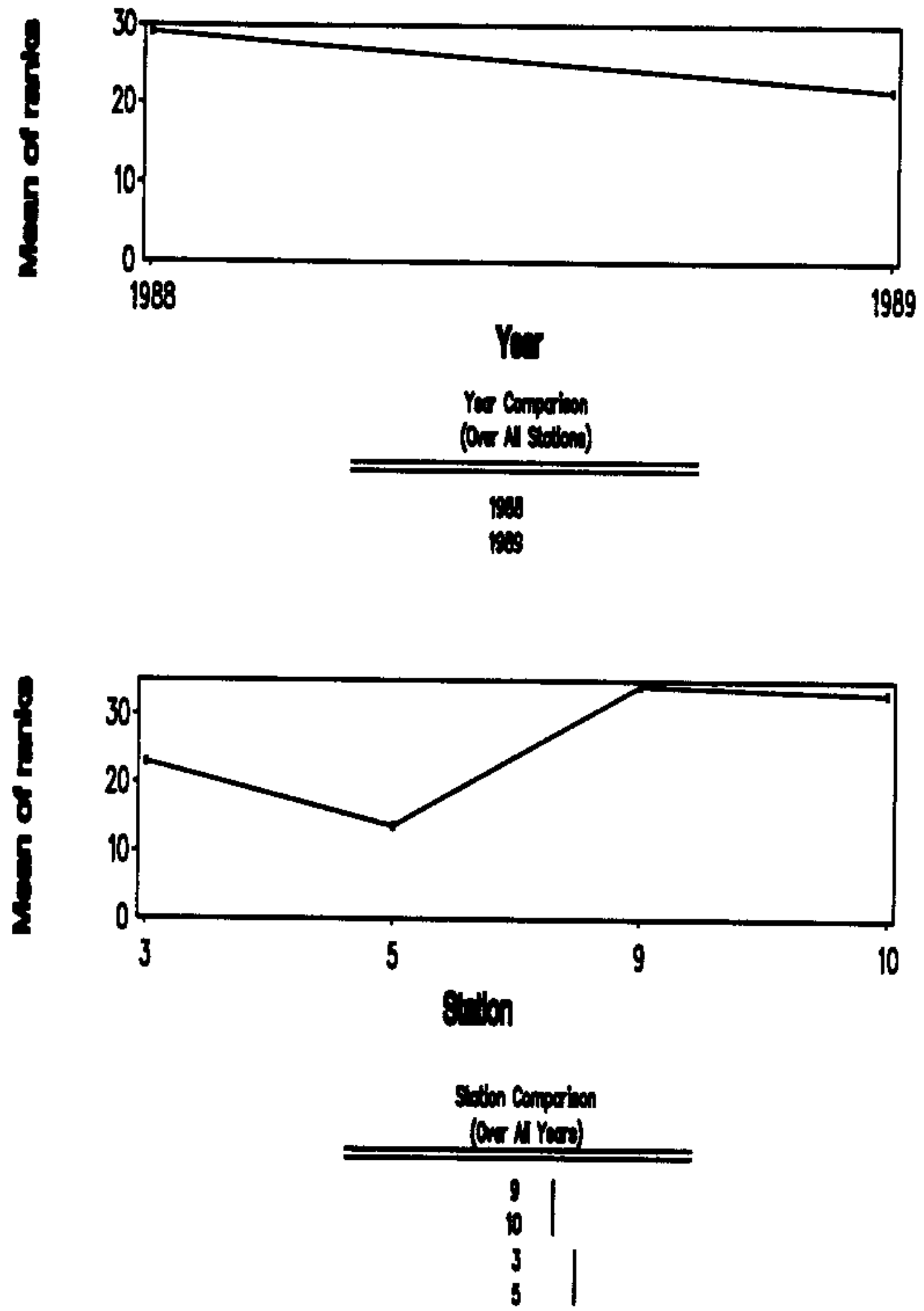


Figure 49. Statistical comparisons of the mean of ranks of abundance of steelhead by beach seining in Lower Granite Reservoir, Idaho-Washington, for 1988 and 1989. Lines connecting years, seasons and stations indicate statistical nonsignificance (P>0.05).

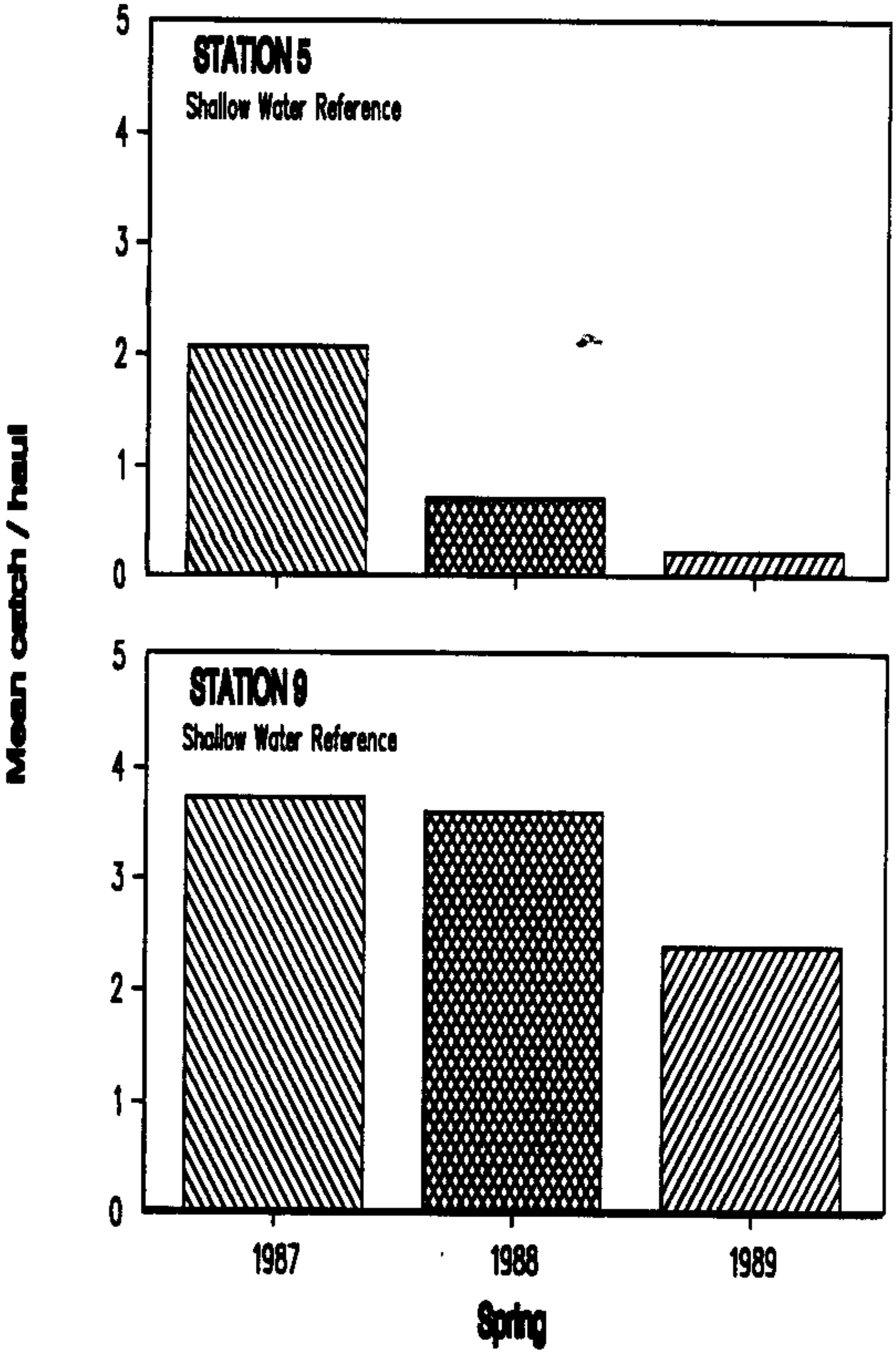


Figure 50. Mean catch per haul of steelhead by beach seining at stations 5 and 9 among 1987, 1988 and 1989.

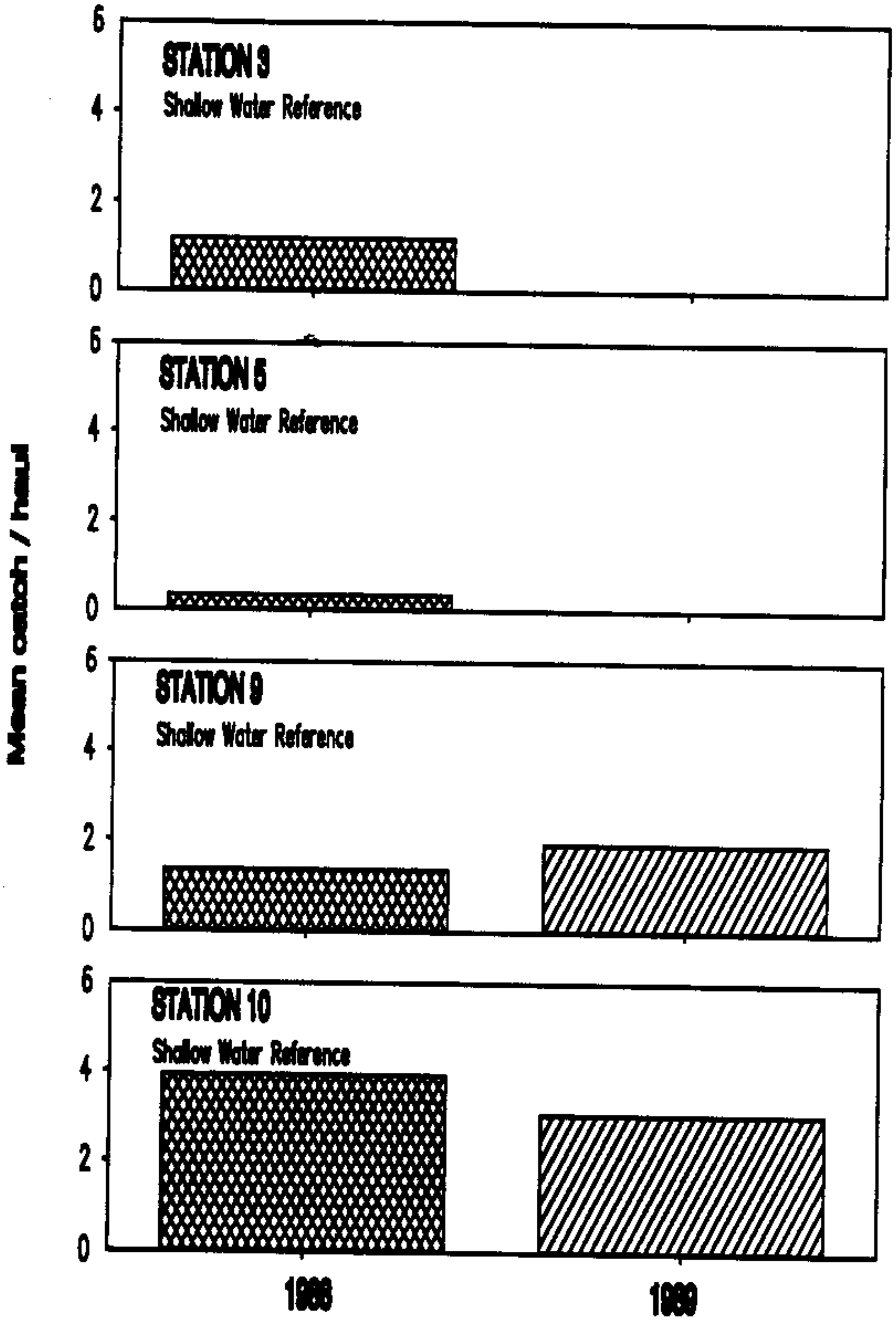


Figure 51. Mean catch per haul of smallmouth bass by beach seining at shallow water stations 3, 5, 9 and 10 between 1988 and 1989.

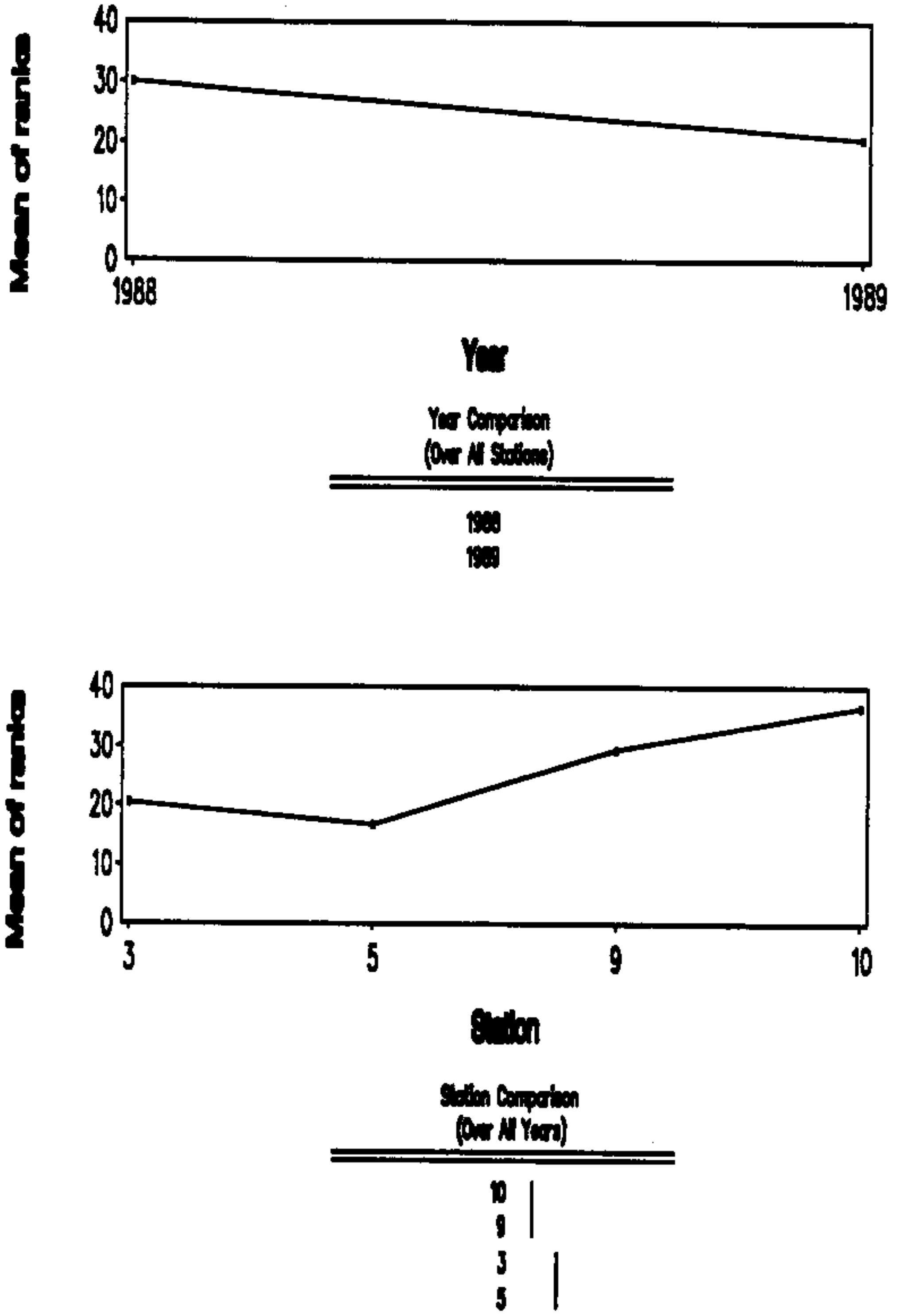


Figure 52. Statistical comparisons of the mean of ranks of abundance of smallmouth bass by beach seining in Lower Granite Reservoir, Idaho-Washington, for 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance (P>0.05).

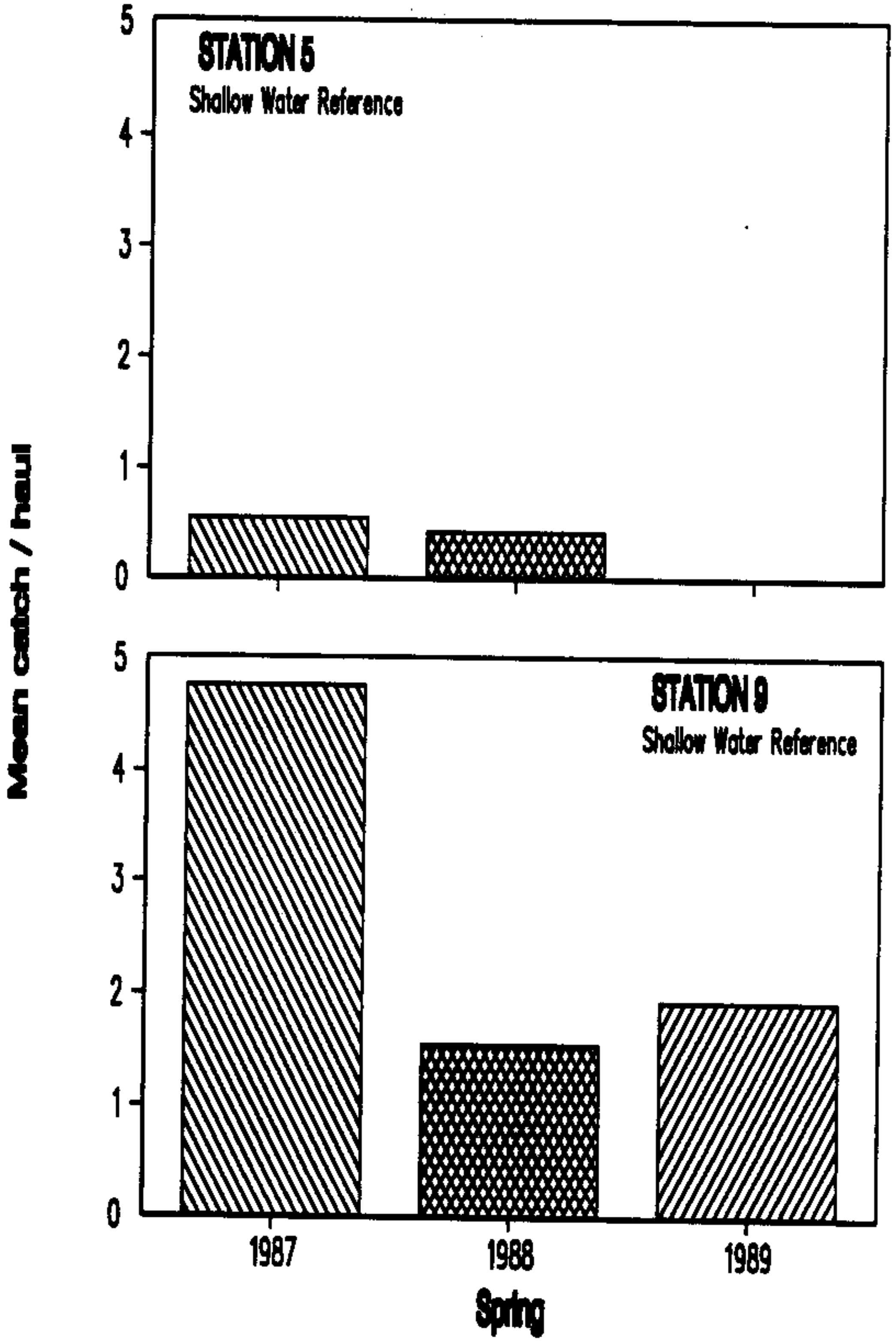


Figure 53. Mean catch per haul of smallmouth bass by beach seining at shallow water stations 5 and 9 among 1987, 1988 and 1989.

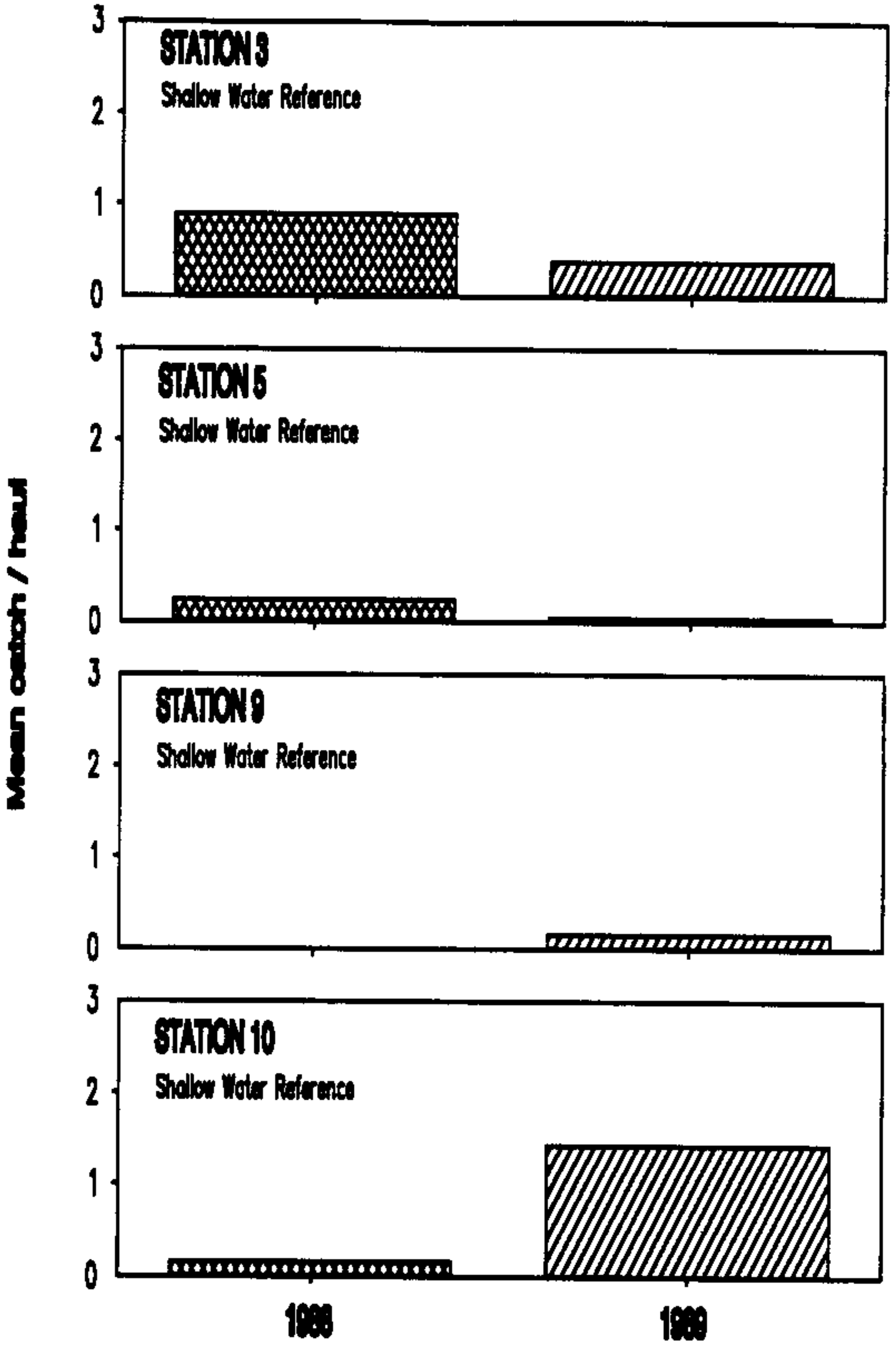
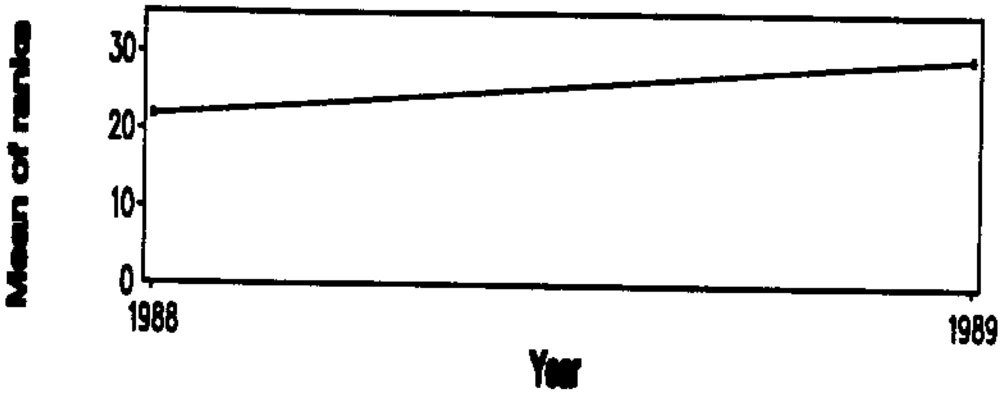
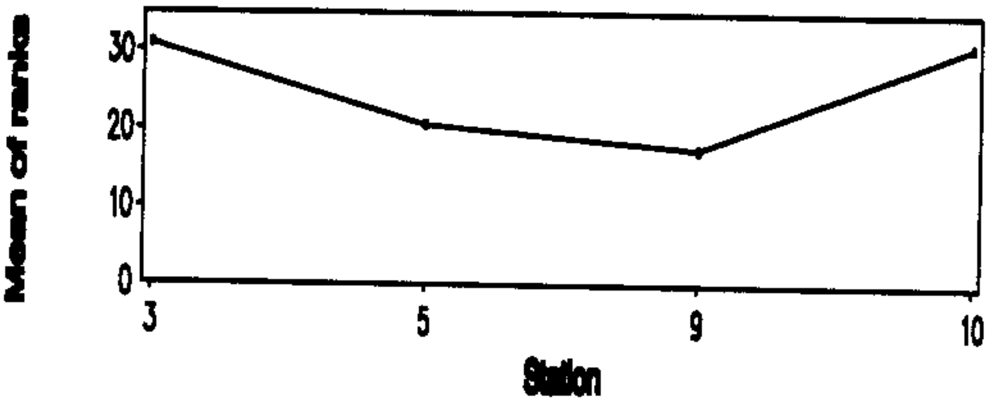


Figure 54. Mean catch per haul of northern squawfish by beach seining at shallow water stations 3, 5, 9 and 10 for 1988 and 1989.



Year Comparison
(Over All Stations)

1988
1989



Station Comparison
(Over All Years)

3 |
10 |
5 |
9 |

Figure 55. Statistical comparisons of the mean of ranks of abundance of northern squawfish by beach seining in Lower Granite Reservoir, Idaho-Washington, for 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance (P>0.05).

stations 5 and 9 revealed no station differences in abundance but that catch rates during 1987 were significantly higher than those in 1988 (Figure 56).

Mean catch/5 min pass by nighttime electrofishing for chinook salmon indicated higher catch rates in 1989 compared to 1988 (Figure 57). Highest catches of chinook salmon have been at reference stations 5, 10, and 3 for the two years. These station differences were not significant although the year differences were significant. When comparing catches of chinook salmon by electrofishing from 1987-89, catch rates at station 5 were significantly higher than at station 9 while the year effect was not significant (Figure 58).

Mean catch/electrofishing pass for juvenile steelhead during 1988 was generally higher than during 1989 (Figure 59). During 1989, catch rates were lower at stations 3 and 5 than during 1988. Statistically, catches at reference stations 10 and 9 were significantly higher than those at mid-reservoir reference stations 5 and 3. Also, steelhead catches/electrofishing pass in 1988 were significantly higher than those in 1989. Catches were low in 1987 at both stations 5 and 9 and significantly different over the 3 years (Figure 60). Catch rates during 1988 were significantly higher than both 1987 and 1989.

Mean catch/pass by electrofishing for smallmouth bass was generally higher in 1989 than 1988 at all shallow stations. These year-to-year differences were not significant although catches at reference station 9 were significantly higher than those at reference stations 5 and 3. Catches/pass of smallmouth bass in 1987 were low at station 5 but higher at station 9 (Figure 61). Yearly differences among 1987-89 were not significant although catches/pass during that interval were significantly higher at station 9 than 5.

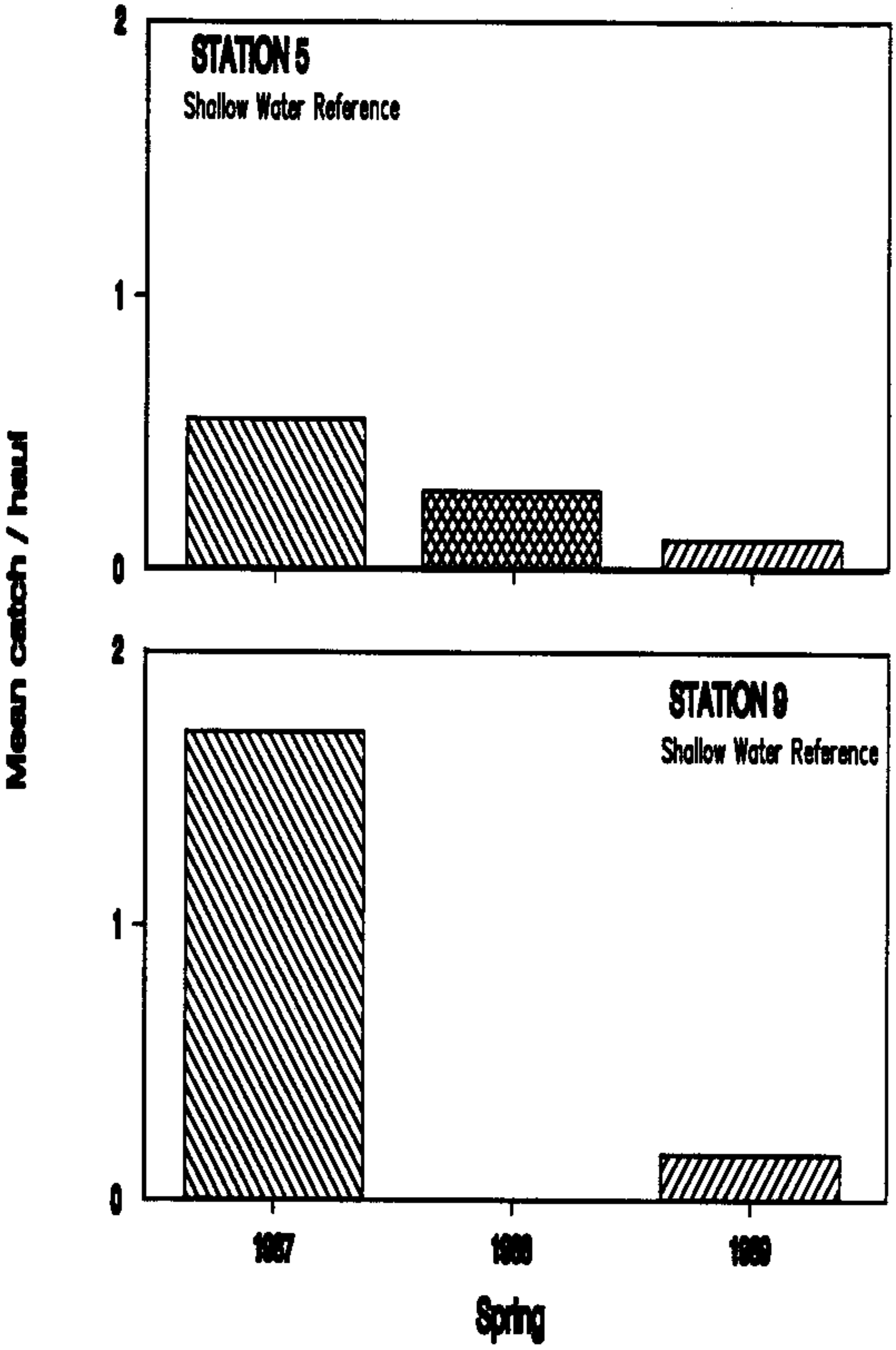


Figure 56. Mean catch per haul of northern squawfish by beach seining at shallow water stations 5 and 9 for 1987, 1988 and 1989.

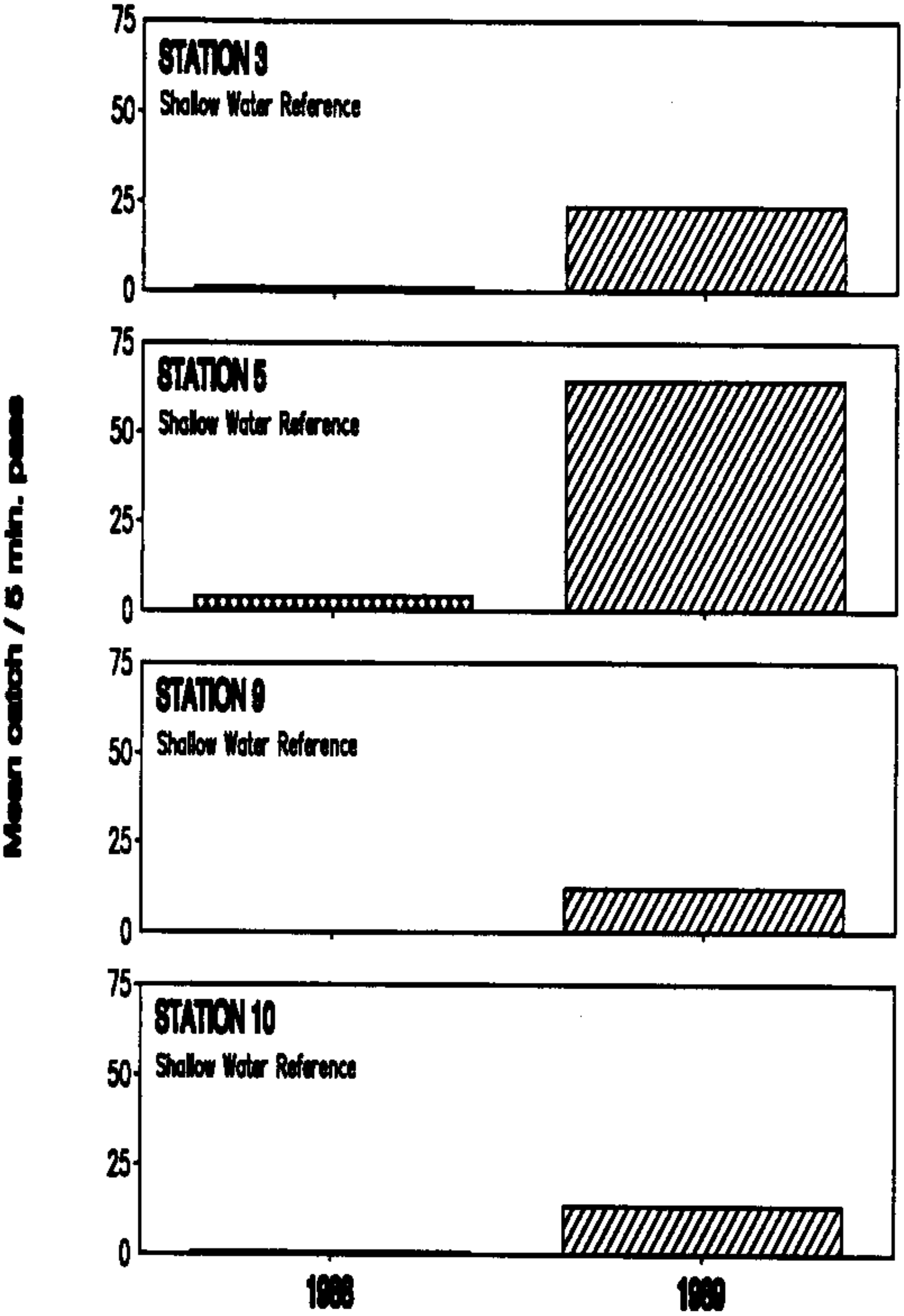


Figure 57. Mean catch per 5 minute pass of chinook salmon by electrofishing at shallow water stations 3, 5, 9 and 10 for 1988 and 1989.

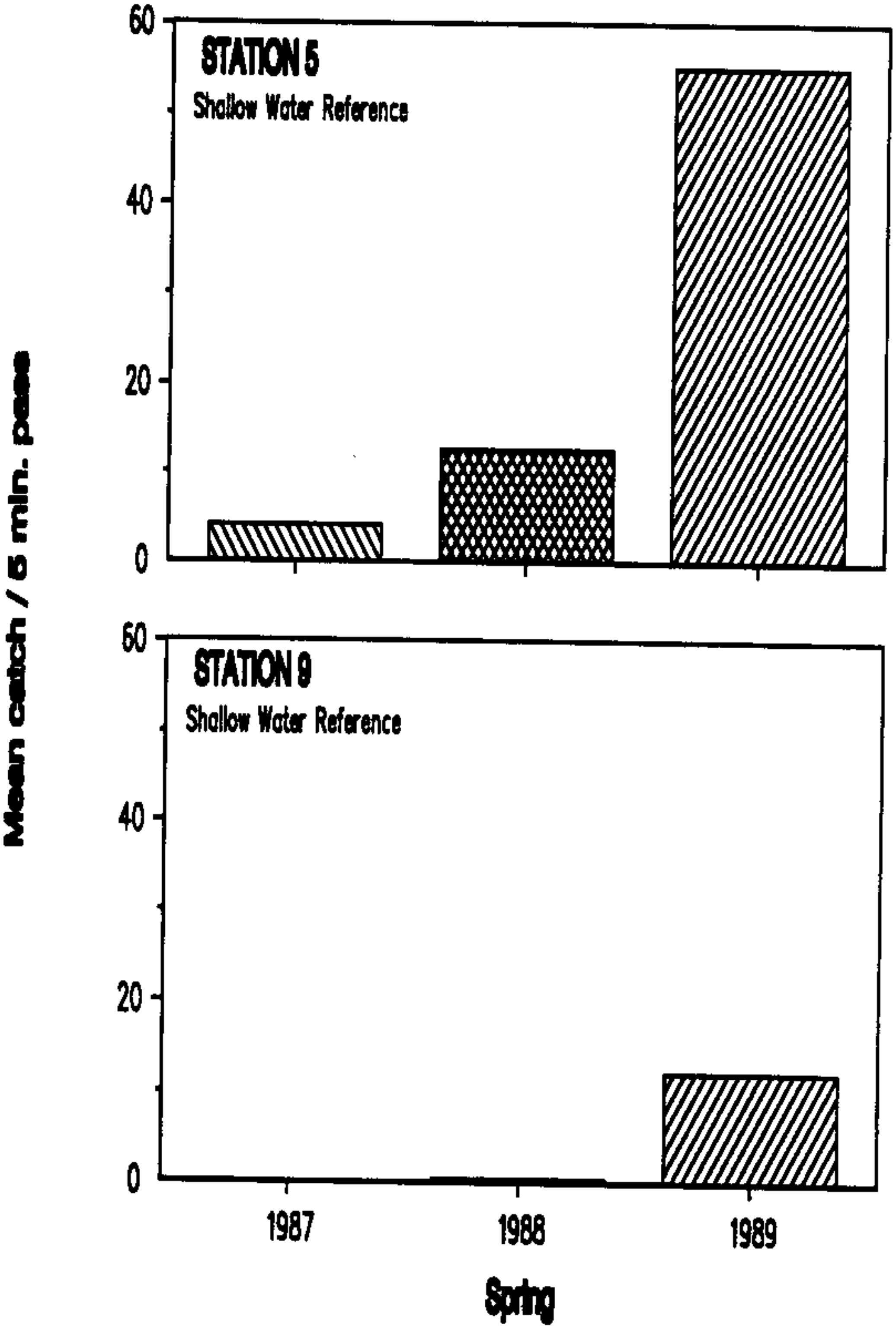


Figure 58. Mean catch per 5 minute pass by electrofishing for chinook salmon at shallow water stations 5 and 9 for 1987, 1988 and 1989.

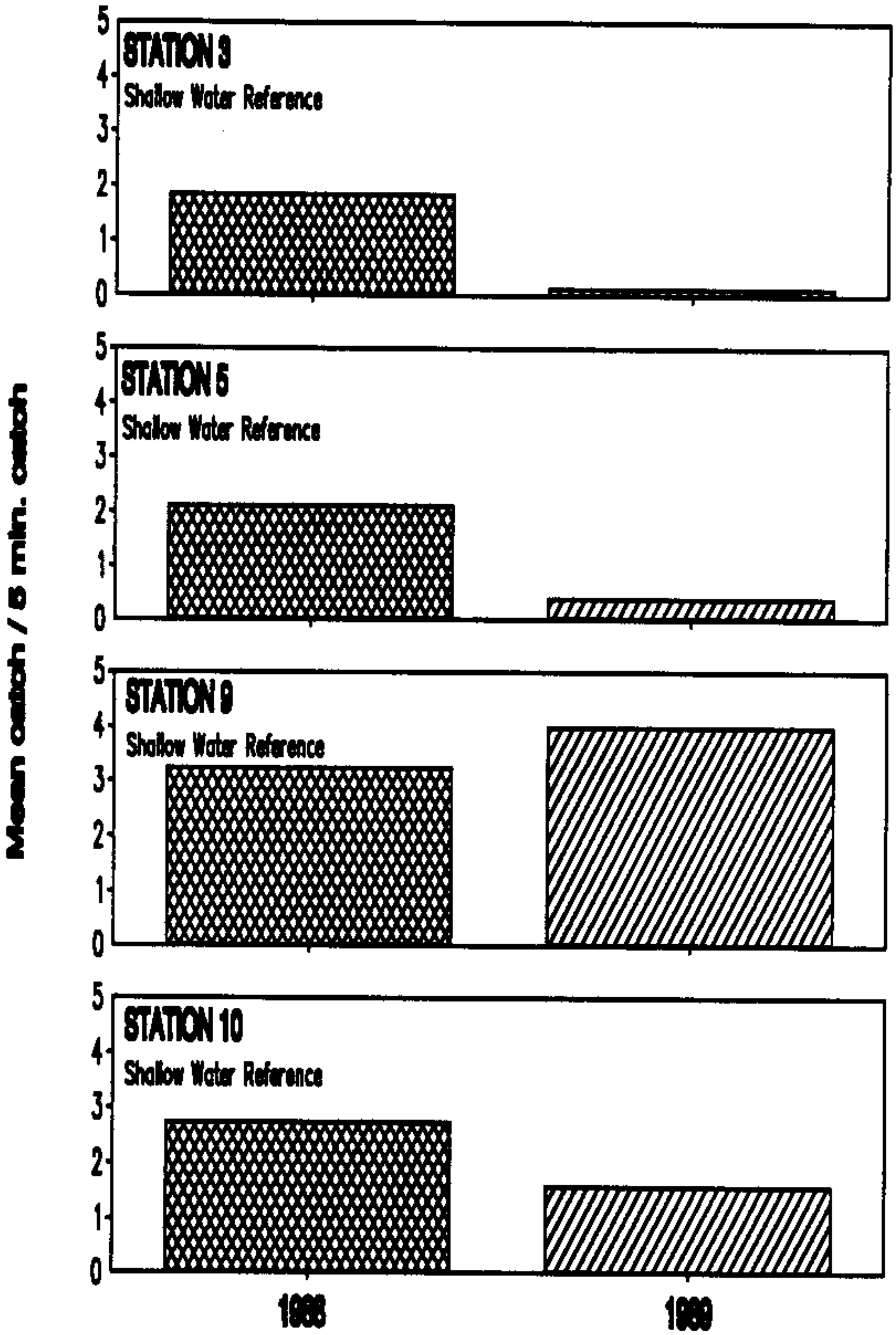


Figure 59. Mean catch per 5 minute pass by electrofishing of steelhead at shallow water stations 3, 5, 9 and 10 for 1988 and 1989.

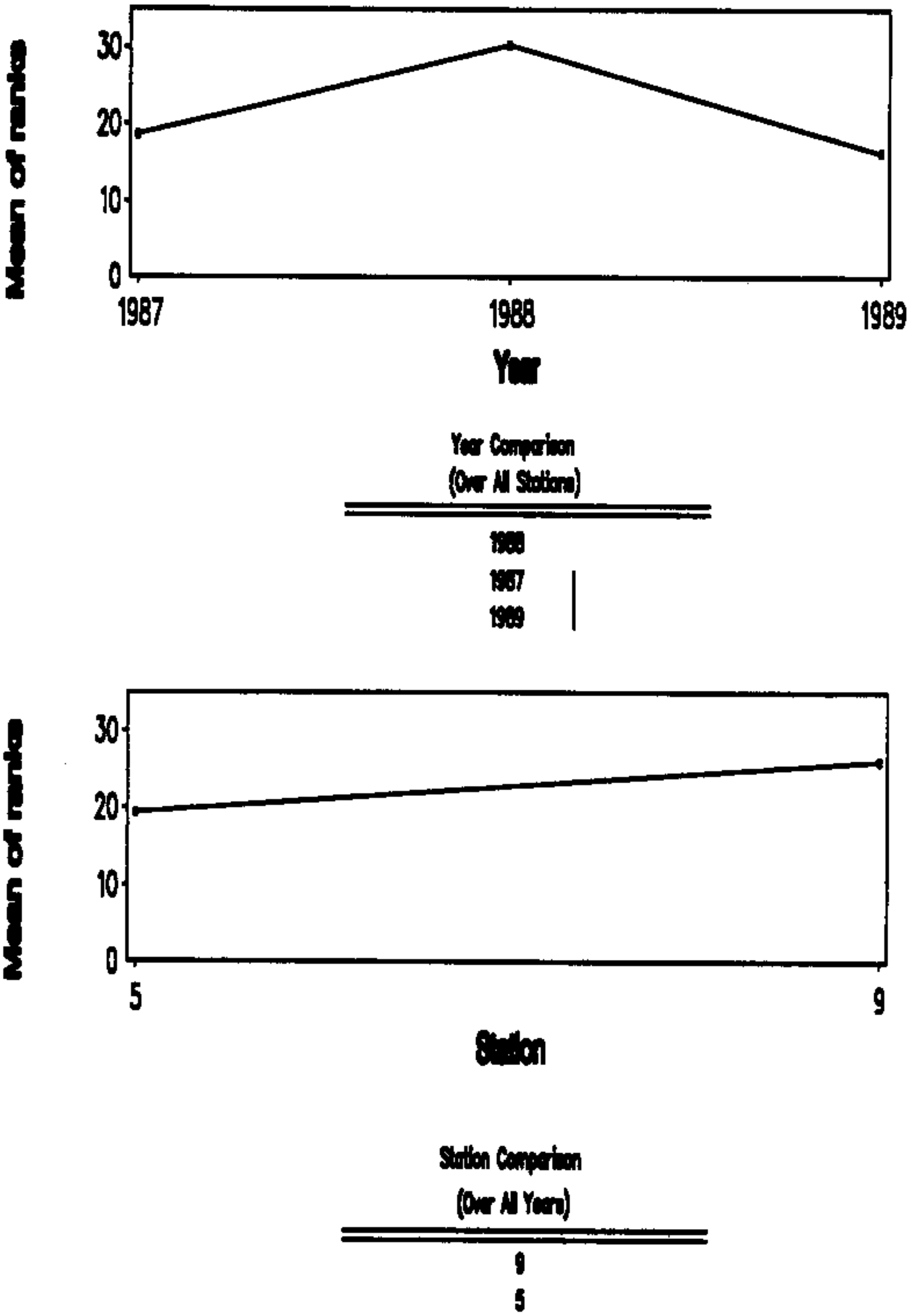


Figure 60. Statistical comparisons of the mean of ranks of abundance of steelhead collected by electrofishing in Lower Granite Reservoir, Idaho-Washington, for 1987, 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance (P>0.05).

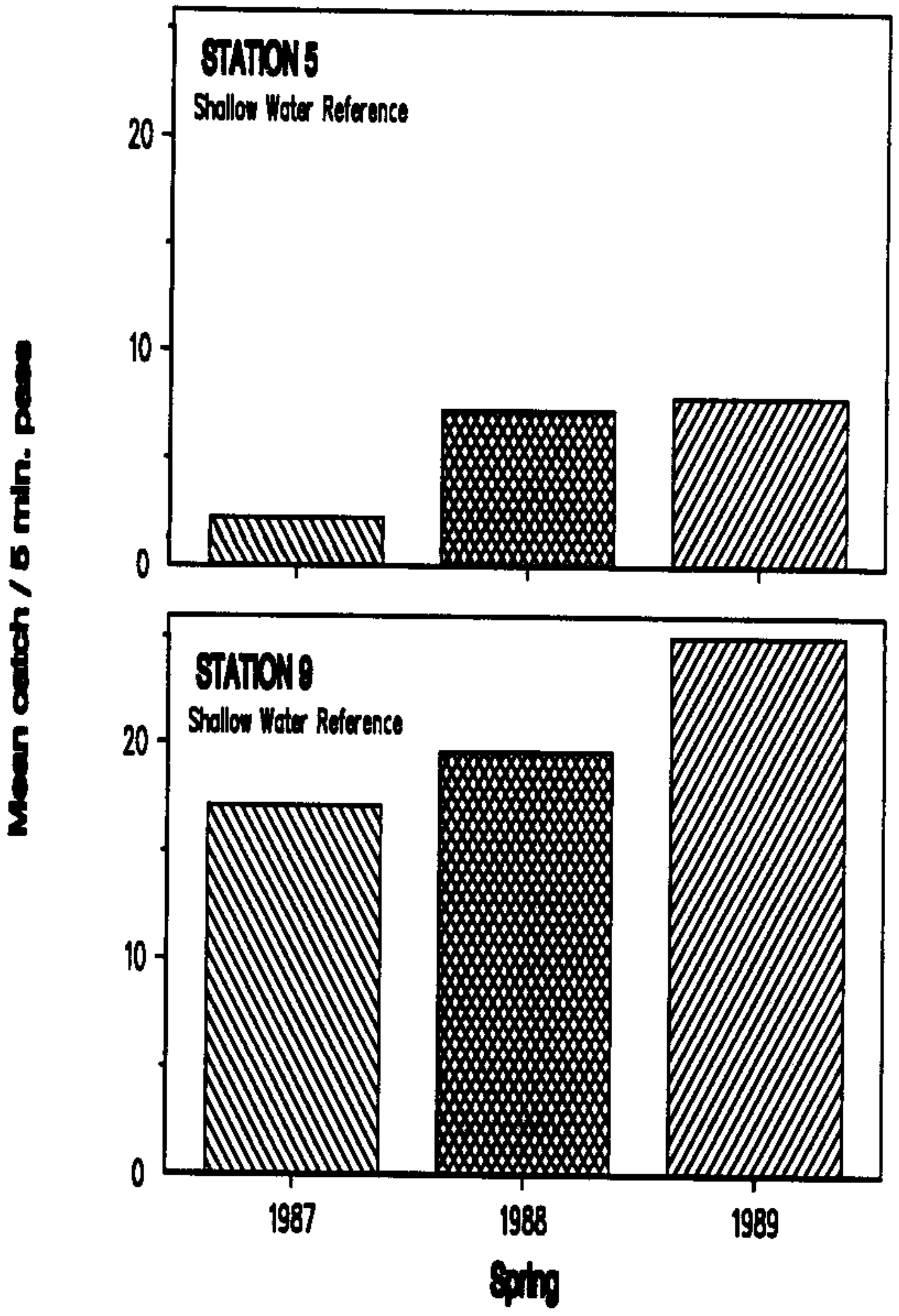


Figure 61. Mean catch per 5 minute pass by electrofishing for smallmouth bass at shallow water stations 5 and 9 for 1987, 1988 and 1989.

A significant difference in catch/pass by electrofishing was found with northern squawfish for 1988 and 1989 (Figure 62). Station 5 had the highest catch rates followed by 3, 10 and 9 over both years. Significant differences in mean catch/pass for northern squawfish were between stations 5 and 9 and 10. CPUE of northern squawfish at station 5 was significantly higher than station 9 when comparing catches from 1987-89.

Larval Fish Abundance

During 1989, the highest number of larval fishes collected by beam trawl was in the shallow water. Highest total number of larval fishes varied by date but was generally at reference stations 5 and 11 (Table 4). As expected, confidence intervals were wide and generally encompassed zero. Of the disposal stations, the channel side of the island (2) generally had the highest numbers of larval fishes collected by beam trawl compared to station 1, inside the island.

what is depth here? if very shallow avian predation could be an effect.

Abundance of larval sized predator species sampled by beam trawl varied by station. For example, larval smallmouth bass were collected at all stations; abundance at different stations generally varied between the 2 week period of sampling. Larval northern squawfish were collected once each at stations 1 and 2 but in far lesser abundance than at reference station 11 where they attained highest abundance. Mean number were considerably higher at the reference station although confidence intervals overlapped. Other species in abundance in larval samples collected by beam trawl were *Lepomis* spp. and *Micropterus* spp. Based on numbers in the reservoir these were most likely pumpkinseed and smallmouths although their larval development was not sufficient to make a positive identification. Some larval American shad

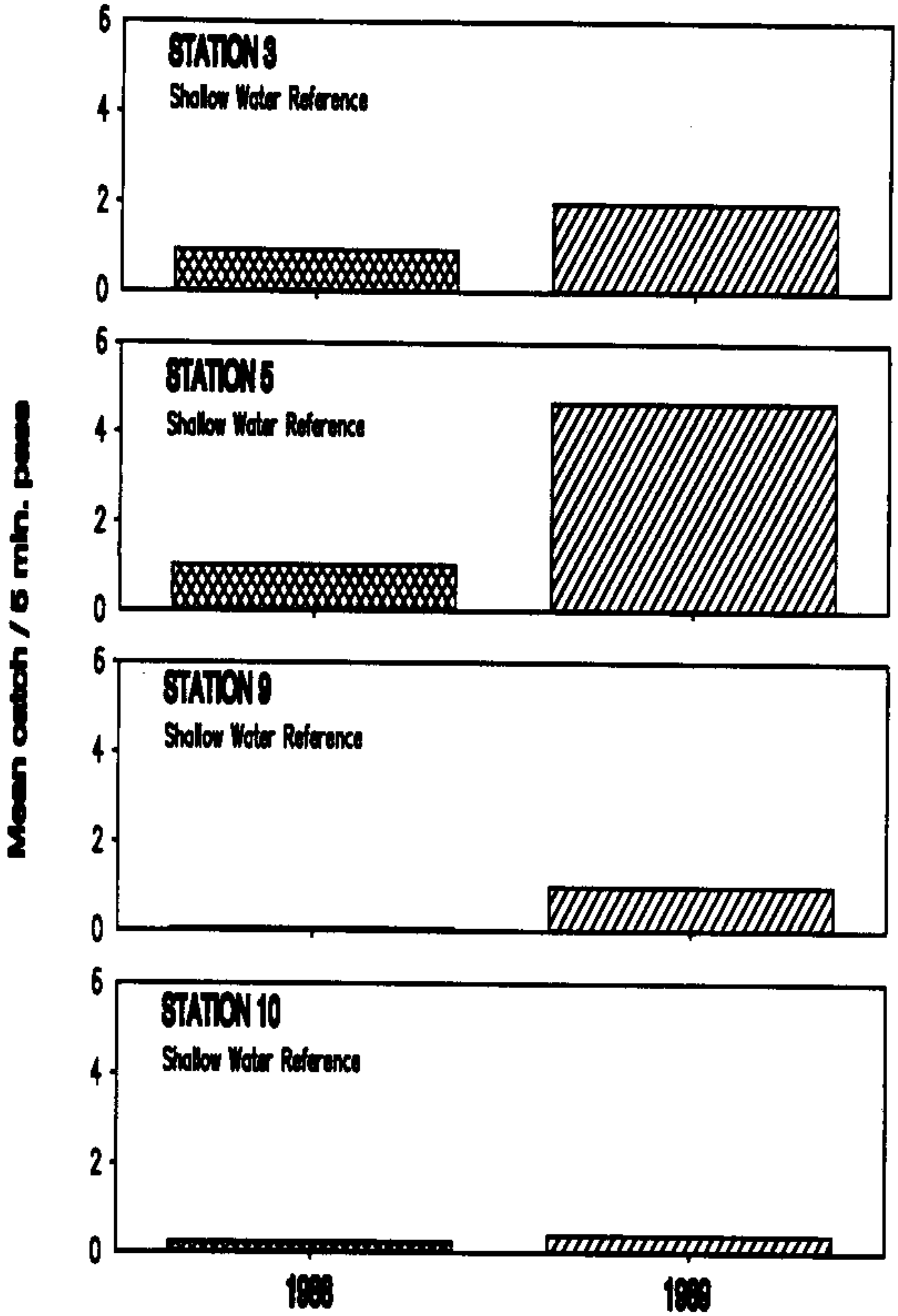


Figure 62. Mean catch per 5 minute pass by electrofishing for northern squawfish at shallow water stations 3, 5, 9 and 10 for 1988 and 1989.

TABLE 4. CATCH/VOLUME OF WATER FILTERED (NO./10,000M^3) FOR LARVAL BEAM TRAWL SAMPLES IN SHALLOW (S) AND DEEPER (D) WATERS ALONG THE SHORELINE DURING 1989. ABBREVIATIONS USED: MCA-CHISELMOUTH; CSP-MISCELLANEOUS CATOSTOMIDS; MDO-SMALLMOUTH BASS; PNI-BLACK CRAPPIE; LSP-MISCELLANEOUS *LEPOMIS*; MSP-MISCELLANEOUS *MICROPTERUS*; PAN-WHITE CRAPPIE; PSP-MISCELLANEOUS *POMOXIS*; CYP-CYPRINIDS; POR-SQUAWFISH; LGI-PUMPKINSEED; ASA-AMERICAN SHAD; CLU-CLUPEIDS; CI-95% CONFIDENCE INTERVALS.

DATE	STATION	DEPTH	MCA MEAN	CI UPPER	CI LOWER	TOT MEAN	CI UPPER	CI LOWER
08-JUL	1	D						
		S				301.10	2545.30	0.00
	2	D				1535.70	8564.70	0.00
		S				51049.60	208057.70	0.00
	5	D				271.00	2290.80	0.00
		S				12130.60	42670.70	0.00
	11	D				542.00	4581.60	0.00
		S				22764.20	139213.30	0.00
13-JUL	1	D						
		S				1283.70	9309.50	0.00
	2	D				677.50	5727.00	0.00
		S				4200.50	19077.20	0.00
	5	D				34391.50	219639.80	0.00
		S				3205.00	10532.80	0.00
	11	D				4403.80	10757.60	0.00
		S				13348.20	34513.60	0.00
27-JUL	1	D				34552.80	202100.90	0.00
		S				2303.50	7647.40	0.00
	2	D				7678.40	22351.80	0.00
		S				2669.30	11237.70	0.00
	5	D				5748.50	29133.20	0.00
		S				2546.00	17213.40	0.00
	11	D				2792.10	8654.80	0.00
		S	36606.80	259030.70	0.00	42611.60	290965.90	0.00
09-AUG	1	D	10840.10	54860.30	0.00	13550.10	74979.60	0.00
		S				1580.80	4151.90	0.00
	2	D				542.00	4581.60	0.00
		S				6160.10	28589.30	0.00
	5	D				2129.30	10904.90	0.00
		S				102058.30	615567.90	0.00
	11	D				1806.70	10713.10	0.00
		S				985.50	5843.50	0.00
24-AUG	1	D				86720.90	421512.40	0.00
		S				542.00	3213.90	0.00
	2	D				903.30	7636.00	0.00
		S				135.50	1145.40	0.00
	5	D				1806.70	15271.90	0.00
		S				1580.80	5716.60	0.00
	11	D				2371.30	9051.10	0.00
		S				271.00	1280.90	0.00
13-SEP	1	D				14566.40	93050.00	0.00
		S				2201.90	12061.30	0.00
	2	D						
		S				813.00	6872.40	0.00
	5	D				271.00	2290.80	0.00
		S				3237.00	16430.60	0.00
	11	D				271.00	2290.80	0.00
		S						

TABLE 4 CONTINUED.

DATE	STATION	D OR S	PSP MEAN	CI UPPER	CI LOWER	CYP MEAN	CI UPPER	CI LOWER
08-JUL	1	D						
		S						
	2	D	1279.70	6073.40	0.00			
		S	271.00	2290.80	0.00			
	5	D						
		S						
	11	D						
		S						
13-JUL	1	D						
		S	677.50	5727.00	0.00			
	2	D	338.80	2863.50	0.00	1332.40	7735.10	0.00
		S				903.30	7636.00	0.00
	5	D				444.70	2290.20	0.00
		S				2822.90	3664.50	0.00
	11	D				12986.90	33042.30	0.00
		S				4065.00	34361.80	0.00
27-JUL	1	D				135.50	1145.40	0.00
		S						
	2	D						
		S				1437.10	7805.20	0.00
	5	D						
		S						
	11	D				542.00	3213.90	0.00
		S						
09-AUG	1	D						
		S						
	2	D				135.50	1145.40	0.00
		S				387.10	3272.60	0.00
	5	D				180.70	1527.20	0.00
		S						
	11	D				492.70	4165.10	0.00
		S				677.50	5727.00	0.00
24-AUG	1	D						
		S						
	2	D						
		S						
	5	D						
		S	677.50	5727.00	0.00			
	11	D						
		S						
13-SEP	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

TABLE 4 CONTINUED.

DATE	STATION	D OR S	POR MEAN	CI UPPER	CI LOWER	LGI MEAN	CI UPPER	CI LOWER
08-JUL	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
13-JUL	1	D						
		S						
	2	D						
		S	451.70	3818.00	0.00			
	5	D						
		S						
	11	D	180.70	1527.20	0.00			
		S						
27-JUL	1	D				406.50	3436.20	0.00
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	135.50	1145.40	0.00			
		S						
09-AUG	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	84688.30	415919.60	0.00			
24-AUG	1	D						
		S	903.30	7636.00	0.00			
	2	D						
		S						
	5	D						
		S						
	11	D	135.50	1145.40	0.00			
		S	14566.40	93050.00	0.00			
13-SEP	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

TABLE 4 CONTINUED.

DATE	STATION	D OR S	ASA MEAN	CI UPPER	CI LOWER	CLU MEAN	CI UPPER	CI LOWER
08-JUL	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
13-JUL	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
27-JUL	1	D						
		S						
	2	D						
		S						
	5	D						
		S	225.80	1909.00	0.00			
	11	D				1084.00	7706.30	0.00
		S				2710.00	22907.90	0.00
09-AUG	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24-AUG	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
13-SEP	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

TABLE 4 CONTINUED.

DATE	STATION	D OR S	MSP MEAN	CI UPPER	CI LOWER	PAN MEAN	CI UPPER	CI LOWER
08-JUL	1	D						
		S						
	2	D	23207.30	164214.10	0.00	6022.30	50906.40	0.00
		S						
	5	D	7226.70	30790.90	0.00			
		S	542.00	4581.60	0.00			
	11	D						
		S						
13-JUL	1	D	1141.10	9645.40	0.00			
		S						
	2	D	835.60	2441.20	0.00	1016.30	8590.50	0.00
		S	29874.80	227134.20	0.00			
	5	D	142.60	1205.70	0.00	302.00	1432.80	0.00
		S				338.80	2863.50	0.00
	11	D						
		S						
27-JUL	1	D				813.00	4311.40	0.00
		S				903.30	7636.00	0.00
	2	D				310.00	1466.50	0.00
		S						
	5	D						
		S				1642.40	5260.20	0.00
	11	D						
		S						
09-AUG	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24-AUG	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
13-SEP	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

TABLE 4 CONTINUED.

DATE	STATION	D OR S	PNI MEAN	CI UPPER	CI LOWER	LSP MEAN	CI UPPER	CI LOWER
08-JUL	1	D	301.10	2545.30	0.00			
		S						
	2	D	13324.30	105160.50	0.00	6140.60	27763.50	0.00
		S						
	5	D	1161.40	9817.70	0.00	3742.40	11436.80	0.00
		S						
	11	D						
		S						
13-JUL	1	D	142.60	1205.70	0.00			
		S						
	2	D	677.50	5727.00	0.00			
		S						
	5	D	1871.00	10881.10	0.00	159.40	1347.50	0.00
		S	790.40	3824.80	0.00	451.70	3818.00	0.00
	11	D				180.70	1527.20	0.00
		S						
27-JUL	1	D	406.50	2155.70	0.00	271.00	1280.90	0.00
		S				1806.70	15271.90	0.00
	2	D	749.20	3845.20	0.00	1450.70	6973.80	0.00
		S	246.40	2082.50	0.00	3613.40	20444.90	0.00
	5	D				1982.60	13858.80	0.00
		S	225.80	1909.00	0.00	246.40	2082.50	0.00
	11	D	142.60	1205.70	0.00	848.70	5737.80	0.00
		S						
09-AUG	1	D				1580.80	4151.90	0.00
		S				542.00	4581.60	0.00
	2	D				6024.60	27654.30	0.00
		S				1355.00	11453.90	0.00
	5	D				101877.70	614043.50	0.00
		S				903.30	4269.70	0.00
	11	D				492.70	2328.90	0.00
		S						
24-AUG	1	D				542.00	3213.90	0.00
		S						
	2	D				135.50	1145.40	0.00
		S						
	5	D				1580.80	5716.60	0.00
		S				338.80	2863.50	0.00
	11	D						
		S						
13-SEP	1	D				2201.90	12061.30	0.00
		S						
	2	D				813.00	6872.40	0.00
		S				271.00	2290.80	0.00
	5	D				3237.00	16430.60	0.00
		S				271.00	2290.80	0.00
	11	D						
		S						

TABLE 4 CONTINUED.

DATE	STATION	D OR S	CSP	CI		MDO	CI	
			MEAN	UPPER	LOWER	MEAN	UPPER	LOWER
08-JUL	1	D						
		S	993.70	4742.20	0.00	542.00	4581.60	0.00
	2	D	1075.40	6114.00	0.00			
		S						
	5	D						
		S						
	11	D	22764.20	139213.30	0.00			
		S						
13-JUL	1	D						
		S						
	2	D						
		S	3161.70	26725.90	0.00			
	5	D	285.30	2411.40	0.00			
		S						
	11	D						
		S	30487.80	212478.90	0.00			
27-JUL	1	D	271.00	1280.90	0.00			
		S	4968.40	17105.80	0.00			
	2	D	159.40	1347.50	0.00			
		S				451.70	3818.00	0.00
	5	D	135.50	1145.40	0.00	427.90	3617.00	0.00
		S	451.70	3818.00	0.00			
	11	D	3252.00	25991.50	0.00			
		S						
09-AUG	1	D						
		S						
	2	D						
		S				387.10	3272.60	0.00
	5	D						
		S				903.30	7636.00	0.00
	11	D						
		S	677.50	5727.00	0.00	677.50	5727.00	0.00
24-AUG	1	D						
		S						
	2	D						
		S				1806.70	15271.90	0.00
	5	D						
		S				1355.00	11453.90	0.00
	11	D				135.50	1145.40	0.00
		S						
13-SEP	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Alosa sapidissima were collected by beam trawl during the latter part of July at reference stations 5 and 11 (Table 4).

Results of sampling by larval 1/2 m plankton nets generally were similar to those of the larval beam trawl. Highest total number of larval fishes varied by date but was generally at reference stations 5 and 11 (Table 5). Of the disposal stations, station 2 had the highest number, while larval fish abundance at station 4 generally was low.

Abundance of larval sized predator species based on 1/2 m nets was high at disposal station 1 and reference station 11, near the Port of Wilma. Smallmouth bass were highest at station 1 and 2, whereas northern squawfish attained highest abundance at station 11 followed by station 2.

Other species collected in abundance by 1/2 m plankton nets were catostomid and cyprinid species. None of these fish were sufficiently developed to facilitate species identifications.

The second part of Objective 1 was to evaluate the suitability and desirability of the newly created shallow water habitat for fishes. Underwater observations of fish activity were made on both sides of the island (stations 1 and 2) at about 2 week intervals. Our [redacted] No other observations from mid-June to early August suggested that the island was being heavily utilized for spawning and/or rearing by other potential salmonid predators.

TABLE 5. CATCH/VOLUME OF WATER FILTERED (NO./10,000M^3) FOR 1/2M LARVAL SAMPLES. UPPER AND LOWER REFER TO 95% CONFIDENCE INTERVALS. ABBREVIATIONS USED: CSP-MISCELLANEOUS CATOSTOMIDS; RBA-REDSIDE SHINERS; CYP-CYPRINIDS; LSP-MISCELLANEOUS <u>LEPOMIS</u>; PAN-WHITE CRAPPIE; PNI-BLACK CRAPPIE; MDO-SMALLMOUTH BASS; INE-BROWN BULLHEADS; ISP-MISCELLANEOUS <u>ICTALURUS</u>; CEN-MISCELLANEOUS CENTRARCHIDS; POR-SQUAWFISH; MCA-CHISELMOUTH.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	PAN Mean	PAN Upper	PAN Lower	PNI Mean	PNI Upper	PNI Lower
14 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
20 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
06 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
19 Jul	1	180	1.5	0.196	53.015	31.44	245.21	0			
	2	180	1.5	0.196	53.015	62.88	333.28	0	62.88	333.28	0
	4	180	1.5	0.196	53.015	377.26	1475.63	0	597.32	2994.99	0
	5	180	1.5	0.196	53.015				31.44	245.21	0
	11	180	1.5	0.196	53.015						
01 Aug	1	60	1.5	0.196	17.672				282.94	1597.24	0
	2	60	1.5	0.196	17.672	94.31	753.63	0			
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672				94.31	735.63	0
	11	60	1.5	0.196	17.672						
16 Aug	1	30	1.5	0.196	8.836						
	2	30	1.5	0.196	8.836						
	4	30	1.5	0.196	8.836						
	5	30	1.5	0.196	8.836						
	11	30	1.5	0.196	8.836						
04 Sept	1	60	1.5	0.196	17.672	94.31	735.63	0			
	2	60	1.5	0.196	17.672	94.31	735.63	0			
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672	188.63	1471.26	0			
22 Sept	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015	31.44	245.21	0			

TABLE 5 CONTINUED.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	MDO			INE		
						Mean	Upper	Lower	Mean	Upper	Lower
14 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
20 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
06 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
19 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015	31.44	245.21	0			
01 Aug	1	60	1.5	0.196	17.672	377.26	1659.88	0	565.88	3707.67	0
	2	60	1.5	0.196	17.672	94.31	735.63	0	94.31	735.63	0
	4	60	1.5	0.196	17.672				94.31	735.63	0
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
16 Aug	1	30	1.5	0.196	8.836						
	2	30	1.5	0.196	8.836						
	4	30	1.5	0.196	8.836						
	5	30	1.5	0.196	8.836						
	11	30	1.5	0.196	8.836						
04 Sept	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 Sept	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						

TABLE 5 CONTINUED.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	ISP Mean Density	ISP Upper	ISP Lower	CEN Mean Density	CEN Upper	CEN Lower
14 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
20 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
06 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
19 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
01 Aug	1	60	1.5	0.196	17.672	94.31	735.63	0	94.31	735.63	0
	2	60	1.5	0.196	17.672				94.31	735.63	0
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
16 Aug	1	30	1.5	0.196	8.836						
	2	30	1.5	0.196	8.836						
	4	30	1.5	0.196	8.836						
	5	30	1.5	0.196	8.836						
	11	30	1.5	0.196	8.836						
04 Sept	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 Sept	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						

TABLE 5 CONTINUED.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	POR Mean	POR Upper	POR Lower	MCA Mean	MCA Upper	MCA Lower
14 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
20 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
06 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
19 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
01 Aug	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672	94.31	735.63	0			
	5	60	1.5	0.196	17.672				94.31	735.63	0
	11	60	1.5	0.196	17.672	4810.01	10137.16	0	1037.45	2873.90	0
16 Aug	1	30	1.5	0.196	8.836						
	2	30	1.5	0.196	8.836						
	4	30	1.5	0.196	8.836						
	5	30	1.5	0.196	8.836						
	11	30	1.5	0.196	8.836	565.88	3194.49	0			
04 Sept	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 Sept	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						

TABLE 5 CONTINUED.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	CSP			RBA		
						Mean	Upper	Lower	Mean	Upper	Lower
14 Jun	1	180	1.5	0.196	53.014	251.50	1475.80	0			
	2	180	1.5	0.196	53.014	628.76	1262.91	0			
	4	180	1.5	0.196	53.014	188.63	762.24	0			
	5	180	1.5	0.196	53.014	1288.96	2502.01	76			
	11	180	1.5	0.196	53.014	660.20	2373.04	0			
20 Jun	1	180	1.5	0.196	53.014	408.69	802.87	15			
	2	180	1.5	0.196	53.014	1540.46	4358.68	0			
	4	180	1.5	0.196	53.014	377.26	1313.96	0			
	5	180	1.5	0.196	53.014	5375.90	10329.69	422			
	11	180	1.5	0.196	53.014	2043.47	5427.55	0	62.88	490.42	0
06 Jul	1	180	1.5	0.196	53.015	31.44	245.21	0			
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015	62.88	333.28	0			
	5	180	1.5	0.196	53.015	282.94	1004.72	0			
	11	180	1.5	0.196	53.015	314.38	1289.33	0	31.44	245.21	0
19 Jul	1	180	1.5	0.196	53.015	565.88	1931.34	0			
	2	180	1.5	0.196	53.015	1980.59	5238.06	0			
	4	180	1.5	0.196	53.015	1163.20	3841.75	0			
	5	180	1.5	0.196	53.015	157.19	551.36	0			
	11	180	1.5	0.196	53.015	1163.20	4277.23	0			
01 Aug	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672	188.63	999.83	0			
	4	60	1.5	0.196	17.672	471.57	2559.54	0			
	5	60	1.5	0.196	17.672	4055.49	9064.31	0			
	11	60	1.5	0.196	17.672	2546.47	6362.15	0			
16 Aug	1	30	1.5	0.196	8.836						
	2	30	1.5	0.196	8.836						
	4	30	1.5	0.196	8.836						
	5	30	1.5	0.196	8.836						
	11	30	1.5	0.196	8.836						
04 Sept	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 Sept	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						

TABLE 5 CONTINUED.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	CYP Mean	CYP Upper	CYP Lower	LSP Mean	LSP Upper	LSP Lower
14 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
20 Jun	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
06 Jul	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015						
19 Jul	1	180	1.5	0.196	53.015	1068.89	2990.45	0	62.88	333.28	0
	2	180	1.5	0.196	53.015	220.07	1058.96	0	62.88	333.28	0
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015	31.44	245.21	0	125.75	666.55	0
	11	180	1.5	0.196	53.015	1194.64	3709.52	0			
01 Aug	1	60	1.5	0.196	17.672	943.14	1754.34	132	2829.42	6803.49	0
	2	60	1.5	0.196	17.672	1226.08	3314.05	0	282.94	1143.35	0
	4	60	1.5	0.196	17.672	377.26	1659.88	0	471.57	2559.54	0
	5	60	1.5	0.196	17.672	94.31	735.63	0	2169.22	6070.18	0
	11	60	1.5	0.196	17.672	188.63	999.83	0			
16 Aug	1	30	1.5	0.196	8.836						
	2	30	1.5	0.196	8.836	188.63	1471.26	0	1320.39	4409.37	0
	4	30	1.5	0.196	8.836				943.14	3308.19	0
	5	30	1.5	0.196	8.836				19617.27	36321.00	2914
	11	30	1.5	0.196	8.836				377.26	2942.51	0
04 Sept	1	60	1.5	0.196	17.672				471.57	1654.09	0
	2	60	1.5	0.196	17.672				282.94	1143.35	0
	4	60	1.5	0.196	17.672				377.26	1659.88	0
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 Sept	1	180	1.5	0.196	53.015						
	2	180	1.5	0.196	53.015						
	4	180	1.5	0.196	53.015						
	5	180	1.5	0.196	53.015						
	11	180	1.5	0.196	53.015				31.44	245.21	0

TABLE 5 CONTINUED.

Date	Station	Duration Sec	Speed M/Sec	Area M2	Volume M3	TOTAL		
						Mean	Upper	Lower
14 Jun	1	180	1.5	0.196	53.014	251.50	1475.80	0
	2	180	1.5	0.196	53.014	628.76	1262.91	0
	4	180	1.5	0.196	53.014	188.63	762.24	0
	5	180	1.5	0.196	53.014	1288.96	2502.01	76
	11	180	1.5	0.196	53.014	660.20	2373.04	0
20 Jun	1	180	1.5	0.196	53.014	408.69	802.87	15
	2	180	1.5	0.196	53.014	1540.46	4358.68	0
	4	180	1.5	0.196	53.014	377.26	1313.97	0
	5	180	1.5	0.196	53.014	5375.90	10329.69	422
	11	180	1.5	0.196	53.014	2106.35	5679.60	0
06 Jul	1	180	1.5	0.196	53.015	31.44	245.21	0
	2	180	1.5	0.196	53.015	0.00	0.00	0
	4	180	1.5	0.196	53.015	62.88	333.28	0
	5	180	1.5	0.196	53.015	282.94	1004.72	0
	11	180	1.5	0.196	53.015	345.82	1464.80	0
19 Jul	1	180	1.5	0.196	53.015	1729.09	4717.30	0
	2	180	1.5	0.196	53.015	2389.28	5072.94	0
	4	180	1.5	0.196	53.015	2137.78	4941.36	0
	5	180	1.5	0.196	53.015	345.82	860.65	0
	11	180	1.5	0.196	53.015	2389.28	860.65	0
01 Aug	1	60	1.5	0.196	17.672	5187.26	8236.03	2138
	2	60	1.5	0.196	17.672	2074.90	3697.31	452
	4	60	1.5	0.196	17.672	1509.02	5441.48	0
	5	60	1.5	0.196	17.672	6507.65	12364.36	651
	11	60	1.5	0.196	17.672	8582.56	11464.90	5700
16 Aug	1	30	1.5	0.196	8.836			
	2	30	1.5	0.196	8.836	1509.02	4753.84	0
	4	30	1.5	0.196	8.836	943.14	3308.19	0
	5	30	1.5	0.196	8.836	19617.27	36321.00	2914
	11	30	1.5	0.196	8.836	943.14	5119.07	0
04 Sept	1	60	1.5	0.196	17.672	565.88	1559.40	0
	2	60	1.5	0.196	17.672	377.26	1659.88	0
	4	60	1.5	0.196	17.672	377.26	1659.88	0
	5	60	1.5	0.196	17.672			
	11	60	1.5	0.196	17.672	188.63	1471.26	0
22 Sept	1	180	1.5	0.196	53.015			
	2	180	1.5	0.196	53.015			
	4	180	1.5	0.196	53.015			
	5	180	1.5	0.196	53.015			
	11	180	1.5	0.196	53.015	62.88	333.28	0

TABLE 6. COMPARISON OF SPAWNING AND REARING USE OF VARIOUS STATIONS IN LOWER GRANITE RESERVOIR, WASHINGTON, SPRING 1989.

Station	Date	Water Temp C	Time	Nests Observed	Minimum Nest Depth ft	Maximum Nest Depth ft	Nests with Fish	Nests with Eggs	Visible ft	Transect Width ft	Comments
1	62289	16	1615	2	1.5	1.5	0	0	good	---	
1	62889	17	1330	0	0	0	0	0	moderate	3	Appear old/deserted
1	70989	---	1200	0	0	0	0	0	good	3	
1	80589	21.5	---	0	0	0	0	0	good	4	
2	62289	16	1615	2	2	2	0	1	good	---	Very clean
2	62889	17	1330	3	1	3	0	0	moderate	9	
2	70989	---	1200	4	0.5	3	0	2	good	5	5 swarms of fry
2	80589	[illegible]	---	0	0	0	0	0	good	4	
5	62389	16	1330	4	2	0	0	0	moderate	3	
5	62889	18	1130	4	1.5	2.5	0	0	good	6	
5	70989	---	1330	3	2	2	0	0	fair	1	12 swarms of fry
5	72689	---	1015	0	0	0	0	0	poor	1.5	
5	80589	22	---	0	0	0	0	0	poor	1.5	
9	62289	16	1430	1	2	4.5	0	0	poor	6	
9	62889	17	1500	14	1	4	25	2	good	6	25 total bass observed on the 14 nests
9	70989	---	945	9	1.5	4	3	3	good	4	A lot of larval fish scattered thru the weeds
9	80489	21	---	0	0	0	0	0	good	3	
10	62289	16	[illegible]	1	2.5	2.5	0	0	poor	3	
10	62889	17	[illegible]	12	1	4	9	3	mod-good	9	8 bass showing aggressive behavior
10	70989	---	[illegible]	6	2	4	1	0	fair	2.5	5 distinct swarms of yoy bass
10	80489	21.5	---	0	0	0	0	0	good	3	

DISCUSSION

Little change in the size composition of fishes has been observed since 1987. In general, during spring, summer, and fall, modal sizes of northern squawfish at the disposal and one shallow reference station were smaller than at mid-depth and deep water stations. A few larger smallmouth bass were collected at mid-depth and island disposal stations than at reference stations but numbers were small.

Changes in fish abundance were scattered and few were related to in-water disposal. Juvenile steelhead collected at night by shoreline electrofishing were more abundant in down-reservoir stations than up-reservoir stations. Lowest catch rates at night were at the shoreline side of the island followed by the adjacent reference station. This trend generally was similar to that found during the daytime although juvenile steelhead were collected in similar abundance in the lower reservoir reference stations and at the channel-side of the island. This suggests that [redacted]. No other differences were found in littoral fish abundance during 1989.

Temporal changes in littoral abundance also have been few. Highest catch rates of juvenile steelhead were in 1988 followed by 1989 and 1987, presumably related to flow conditions through Lower Granite Reservoir. [redacted]. These differences in abundance, however, were not directly associated with in-water disposal but possibly our removal activities for predator food habit analyses. Higher mortality of adults may have increased survival of juvenile squawfish in a compensatory response. This apparent increase in abundance of juvenile squawfish may provide insight into the on-going adult squawfish removals at the dams on the Snake and Columbia rivers.

Smallmouth bass abundance was generally higher during the daytime in 1988 than in 1989 but just the opposite during the night. These differences probably reflect differences in sizes of fish sampled as the assessments made at night generally reflect subadult and adult abundance, while those made during the daytime reflect young-of-the-year abundance. Increased abundance of larger bass probably reflect recent strong year-classes of smallmouth associated with lower flows and warmer water temperatures. Shuter et al. (1980) clearly demonstrated the importance of water temperature on smallmouth bass survival in the northern part of their range. These changes in juvenile and subadult/adult smallmouth bass abundance, however, are not associated with in-water disposal based on our sampling to date.

Pelagic fish abundance varied seasonally and among species. White sturgeon at the deep water reference station had significantly higher CPUEs during spring, summer, and fall than at any other station. Although disposal activities were conducted downstream, sturgeon abundance at the deep water reference station was high. [redacted] for reference stations. Catch rates of sturgeon at the mid-depth disposal station have been low but the most consistent of all those at disposal and reference stations.

Pelagic abundance of northern squawfish at disposal stations during the spring, summer and fall of 1989 was not different from that at shallow and mid-depth reference stations. Northern squawfish abundance declined from 1988-1989, which may have been related to removal associated with smolt consumption studies. However, this seems unlikely since less than 750 squawfish have been removed. [redacted]

CPUEs of channel catfish during sampling year 1989 were similar to those from reference stations. The trend in catch rates of channel catfish has been down although we have not seen a correlation with in-water disposal. Catch rates of channel catfish in Lower Granite Reservoir have been consistently lower than those in Little Goose Reservoir (Bennett et al. 1983).

Larval fish abundance was highest at shallow water reference stations and generally differed between shallow water sampling (hand trawl) and pelagic (1/2m net) sampling gear. Statistical differences in abundance of larval fishes were not evident because of wide confidence intervals. [redacted]. However, [redacted] based [redacted] near [redacted] (Bennett and Shrier 1986). The reason for their short presence at the island is not known. Two possibilities exist: they could have grown sufficiently to avoid the larval nets and/or migrated elsewhere to rear. Squawfish typically grow slowly and it is unlikely that they would have grown sufficiently within a 2 week period to avoid the nets. Habitat suitability for rearing appears to exist. Both of these areas are very similar in [redacted] Squawfish in the 50-150 mm range in the St. Joe River preferred similar areas, but with slightly more current and deeper water.

The presence of spawning smallmouth bass at the island was not unexpected. Based on our observations, bass are using the channel-side of the island for nesting. This side of the island has been armored by cobble and rubble, a common substrate sought after by spawning bass (Scott and Crossman 1973). The shore-side of the island was not utilized for spawning probably because of the rapid erosion and small particle size of the substrate.

Objective 2: To compare benthic community abundance at in-water disposal sites with those of reference sites.

METHODS

Twelve benthic samples, treated as statistical replicates, were collected during July 1989 using a Shipek dredge (1072.5cm^2) at stations 1, 2, 3, 4, 5, 6, and 8. The sampling locations at each of the seven stations were at three points along each of four transects evenly spaced throughout each station.

Sediment was washed through a 0.595 mm sieve bucket (#30) and organisms preserved in a 5% formalin solution. Organisms were later separated into major taxonomic groups (Pennak 1978), enumerated and weighed. Wet weights were determined by blotting organisms in each taxonomic group for 1 to 3 minutes (depending upon the group size) and weighing in a tared, water-filled, covered vessel. Weighing in this manner precluded variations associated with evaporative water loss. Sample numbers and weights were expanded (x 9.32) for density estimates (nos/m^2 and g/m^2).

RESULTS

Biomass

Benthic community standing crops sampled in July 1989 at the seven stations ranged from about 1.5 g/m^2 at station 2 to about 13 g/m^2 at station 6 (Figure 63). Approximately 25% of the benthic community biomass was oligochaetes while the remaining 75% was that of chironomids. Standing crops were highest at the mid-depth reference

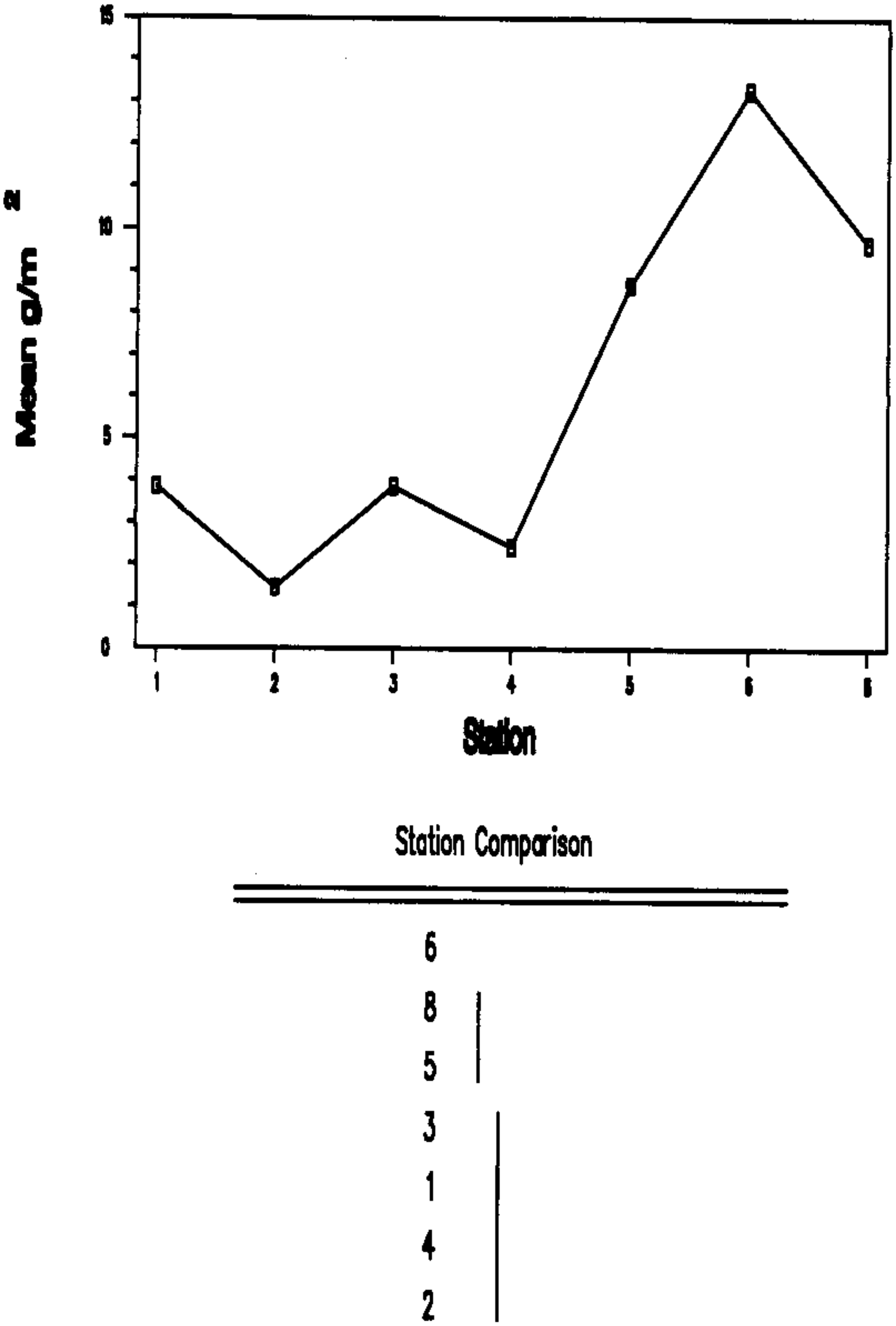


Figure 63. Statistical comparison of mean biomass collected from various stations in Lower Granite Reservoir, during 1989.

station (6) followed by those at the deep water and shallow reference stations. No trends existed between river mile and total standing crop. Benthic community standing crops at stations 1, 2, 3, and 4 were significantly ($P<0.05$) lower during 1989 than those at stations 5, 6 and 8 (Figure 64).

Chironomid biomass was less variable than total biomass among stations (Figure 65). Highest chironomid standing crops were at stations 1, 5 and 6. Widest variation was found at station 1 followed by stations 3, 5 and 6. Station differences in chironomid biomass were not significant.

Biomass of oligochaetes during 1989 generally was low (Figure 66). Differences among stations were substantial ranging from less than 1-2 g/m^2 at stations 1-4 to the highest at station 6 of about 11 g/m^2. Low oligochaete biomass was also observed at the shallow reference station 3 adjacent to the disposal stations. Oligochaete biomass at stations 1-4 was significantly lower than at stations 5, 6 and 8 with differences being up to four to five fold (Figure 66).

Numerical

Numerical density of the oligochaetes and chironomids differed among stations. The mid-depth disposal (4) station had the highest numerical density of oligochaetes in 1989 although similar to that at the shallow and deep water reference stations (3, 5 & 8) (Figure 67). Statistically, oligochaete densities at the island stations (1 & 2) were not different ($P>0.05$) from those at the mid-depth reference station (6) (Figure 68). In comparison, mean chironomid density was lowest at the

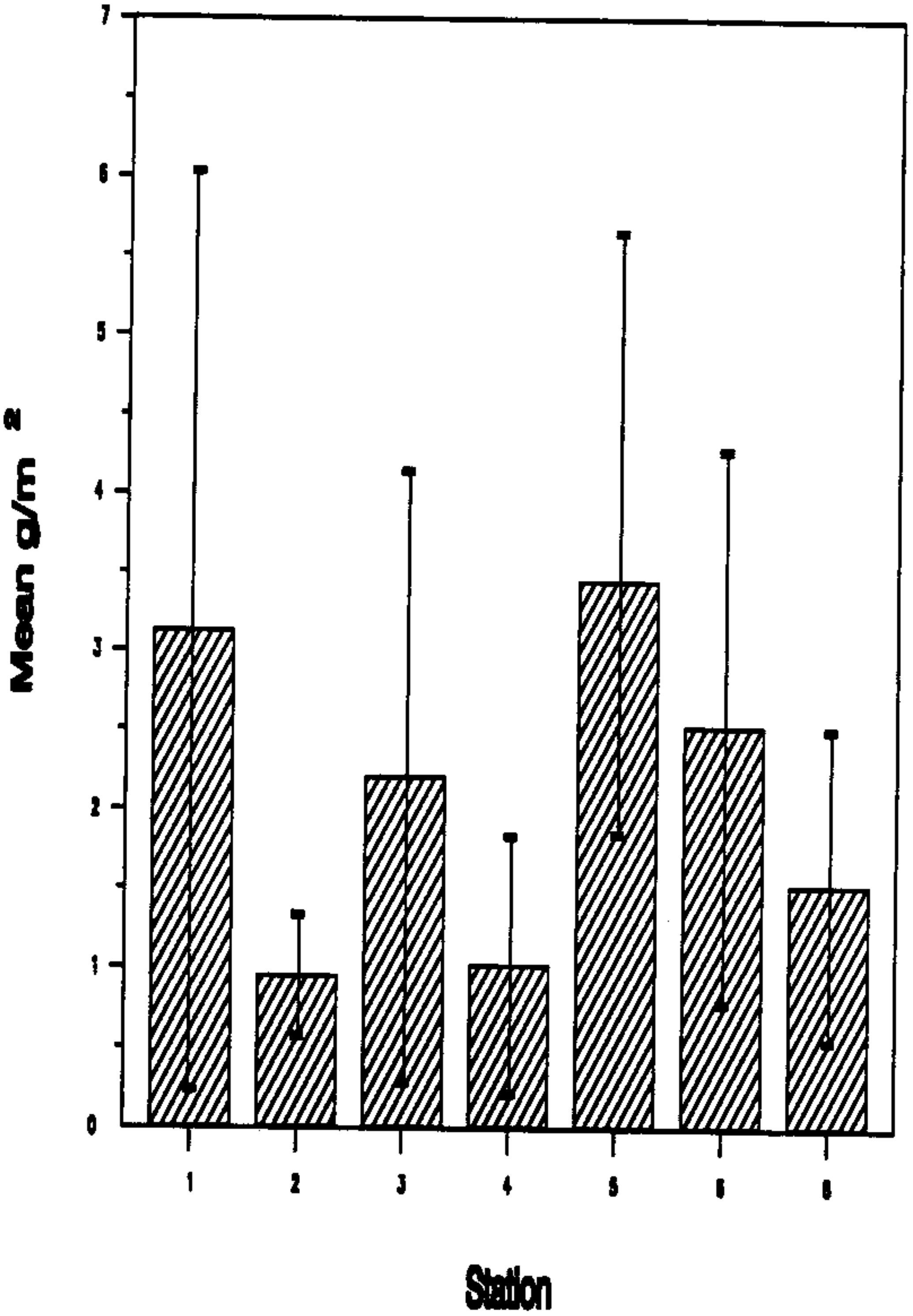


Figure 64. Mean biomass of chironomids collected at various sampling locations in Lower Granite Reservoir, during 1989. Lines represent +/- 2 standard errors from the mean.

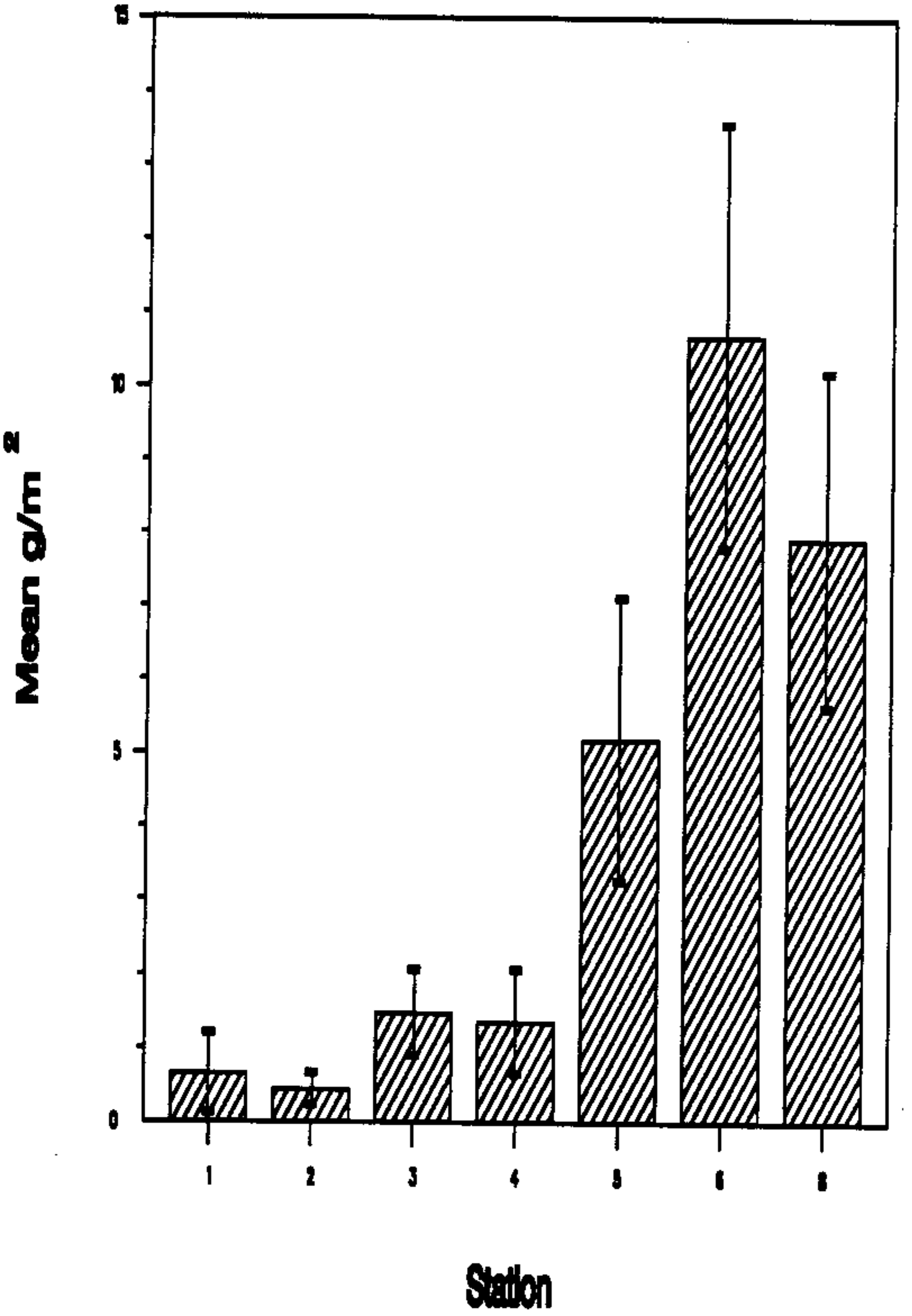


Figure 65. Mean biomass of oligochaetes collected at various sampling locations in Lower Granite Reservoir, during 1989. Lines above means represent +/- 2 standard errors from the mean.

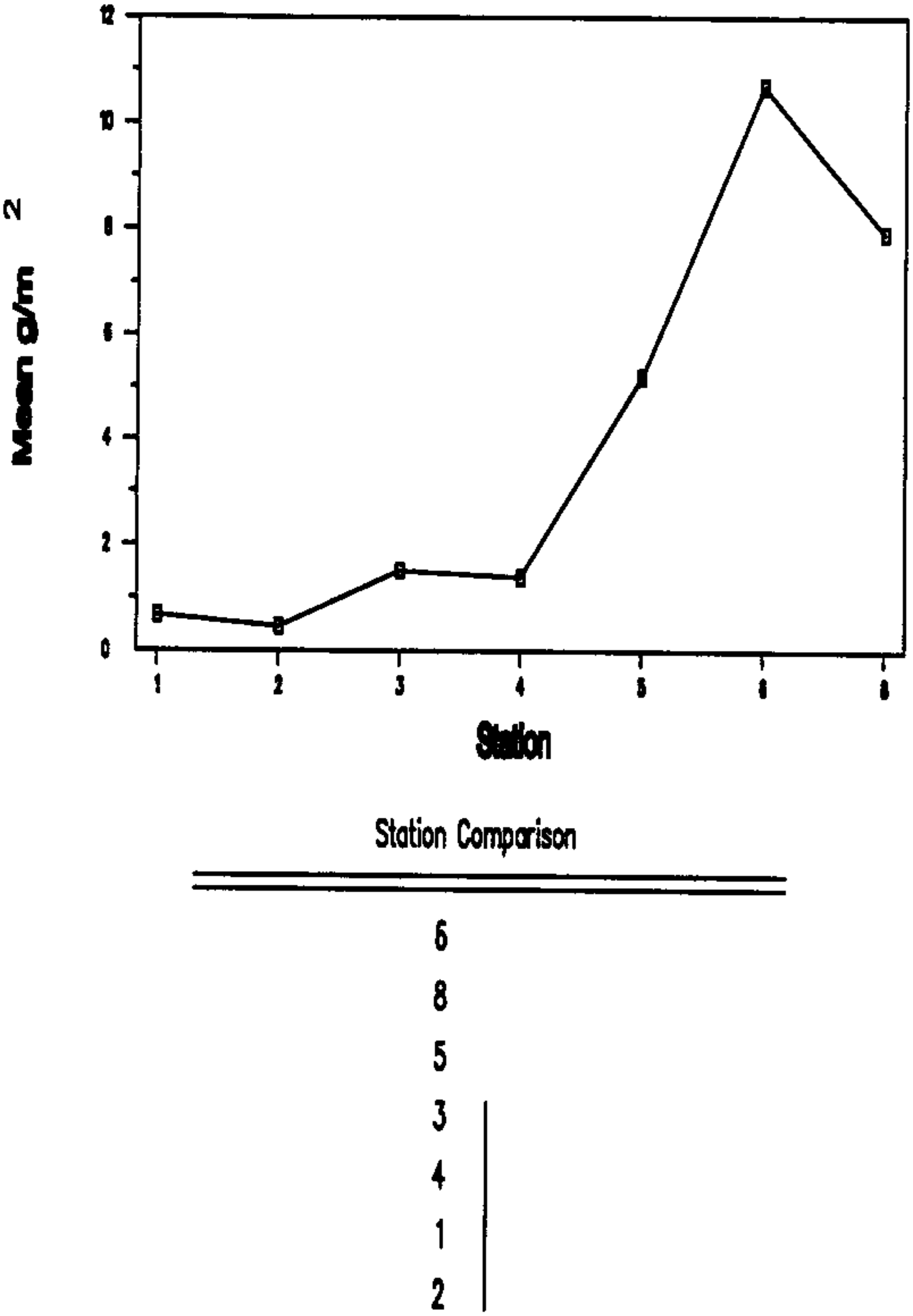


Figure 66. Statistical comparison of mean biomass of oligochaetes collected from various stations in Lower Granite Reservoir, during 1989. Lines connecting stations indicate statistical nonsignificance (P>0.05).

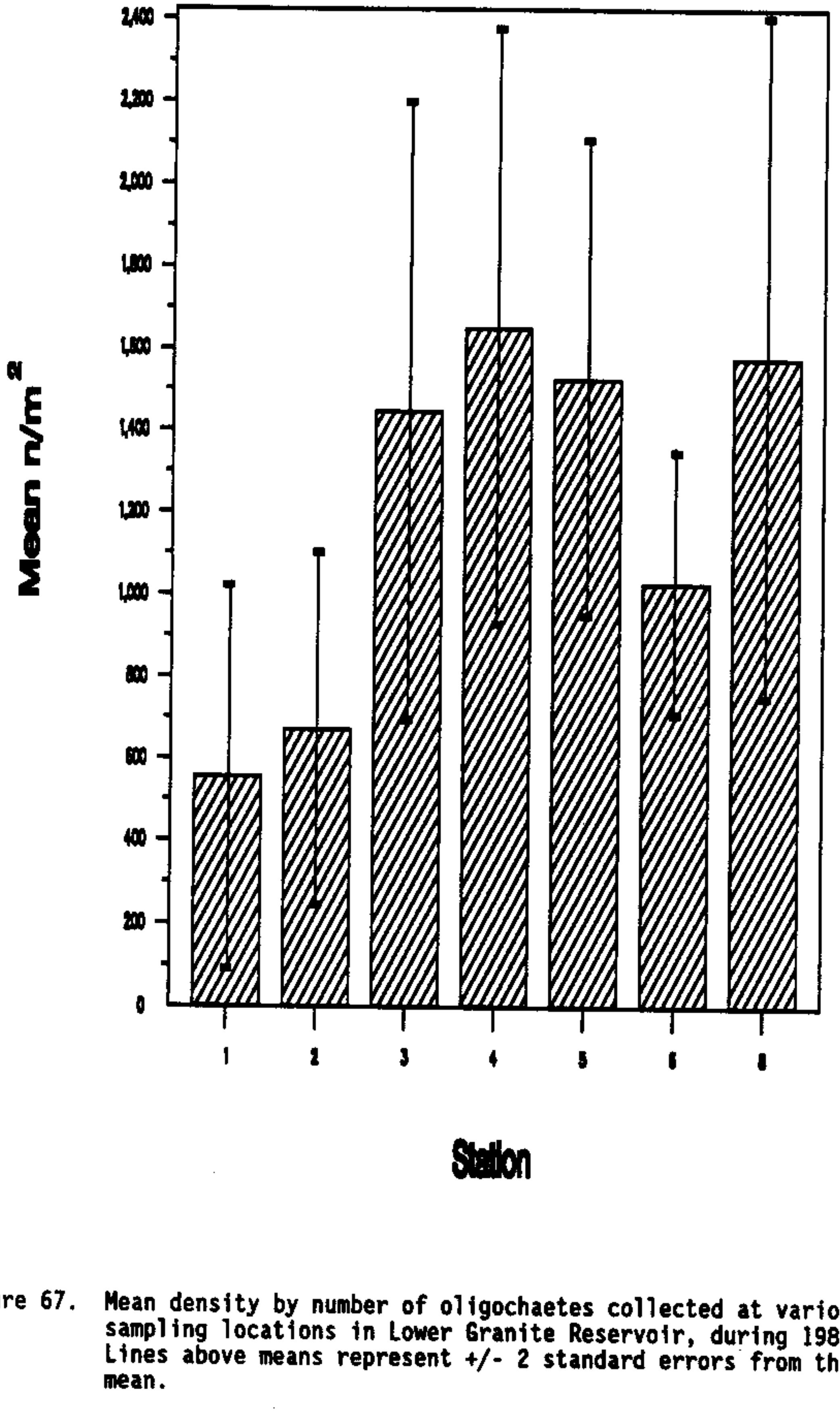


Figure 67. Mean density by number of oligochaetes collected at various sampling locations in Lower Granite Reservoir, during 1989. Lines above means represent +/- 2 standard errors from the mean.

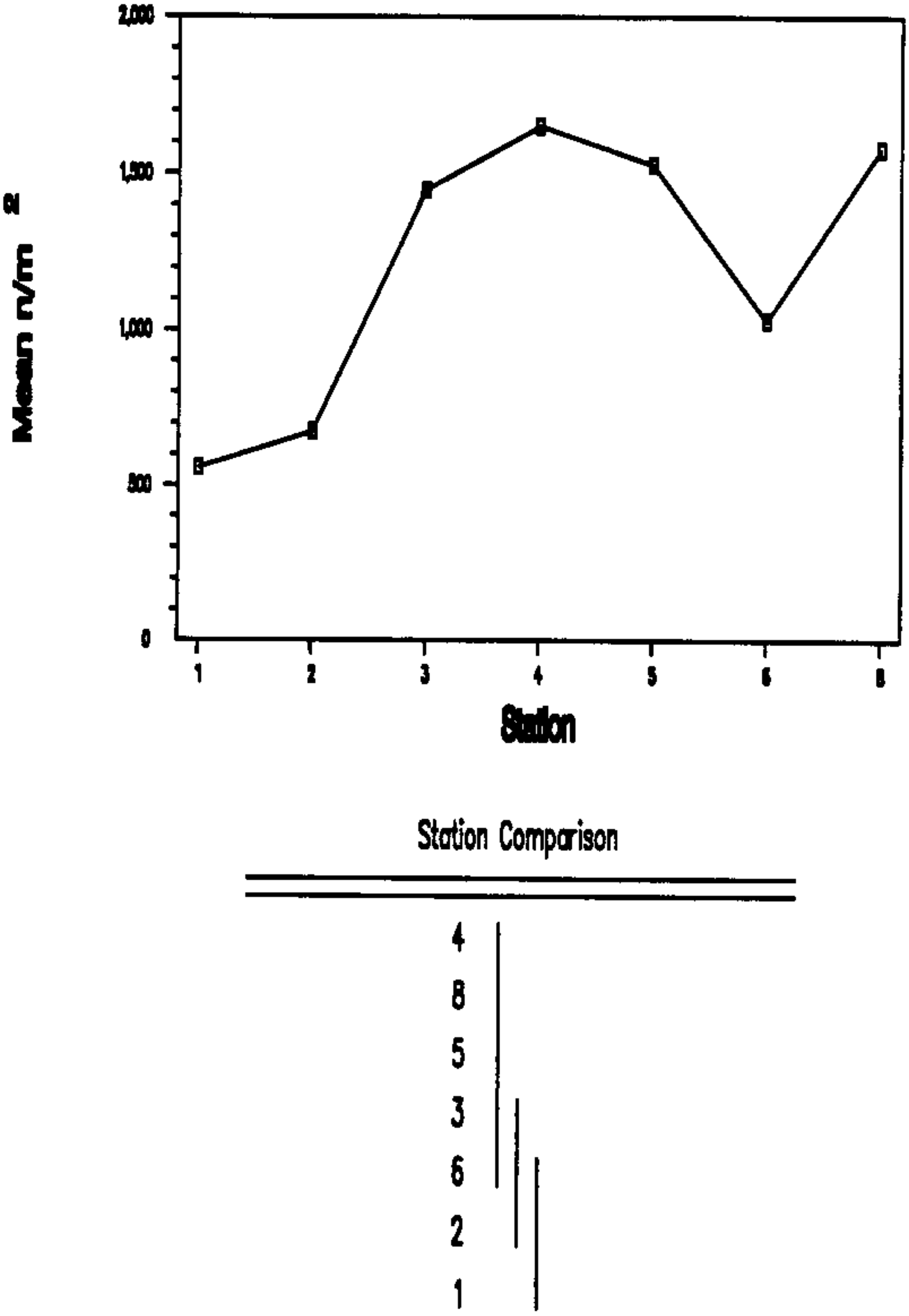


Figure 68. Statistical comparison of mean number of oligochaetes collected from various stations in Lower Granite Reservoir, during 1989. Lines connecting stations indicate statistical nonsignificance (P>0.05).

mid-depth disposal station (4) followed by the deep reference (Figure 69). The island disposal stations (1 & 2) had mean densities similar to the shallow water reference stations (3 & 5). Chironomid densities at the mid-depth disposal station were significantly lower than those at the mid-depth and shallow reference stations (Figure 70).

Year-Station Comparisons

Biomass

Significant ($P<0.05$) temporal differences in benthic community biomass were found at the mid-depth disposal station coinciding with the pre (1987) and post (1988 and 1989) disposal condition (Figure 71). Total community biomass at the mid-depth disposal station was lower than that from the predisposal condition. These comparions demonstrate that the biomass at the mid-depth disposal station has not changed significantly from 1988 or 3+ months after disposal to 1989 or 15 months following disposal. During this same time period, trends in benthic community biomass at the mid-depth and shallow reference stations have exhibited a general decrease (Figure 71). These decreases were not statistically different between 1987 and 1988 at the shallow water reference station although they were significant at the mid-depth reference station. Comparison of standing crops between 1988 and 1989 has indicated significant differences between years at stations 5 and 8, while those at stations 3, 4 and 6 were not different (Figure 72).

Analysis of community differences through time indicates that chironomid biomass has generally followed the same trends as the total benthic community. Statistically, the year*station interaction was significant (Figure 73). Biomass of chironomids was significantly lower

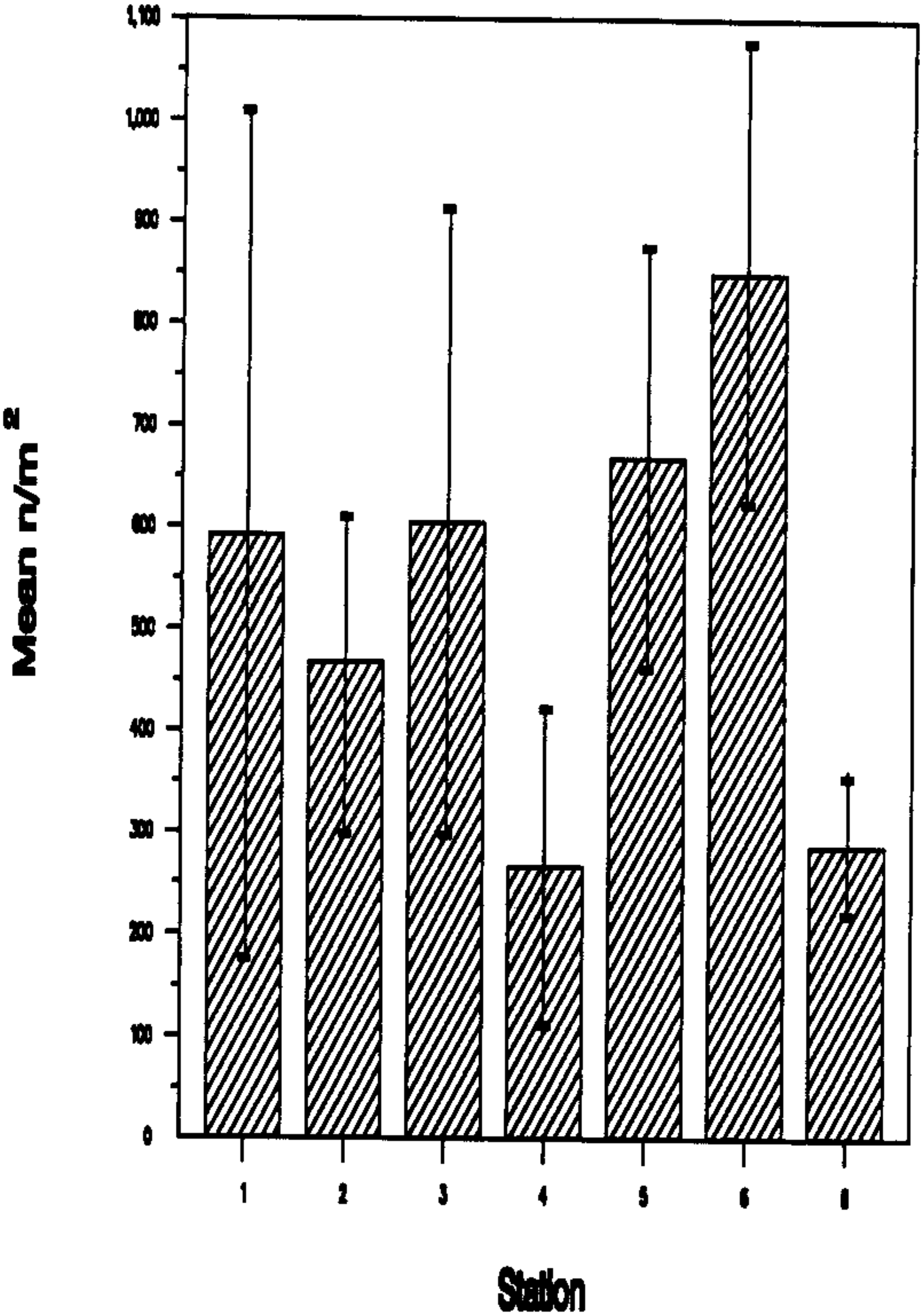
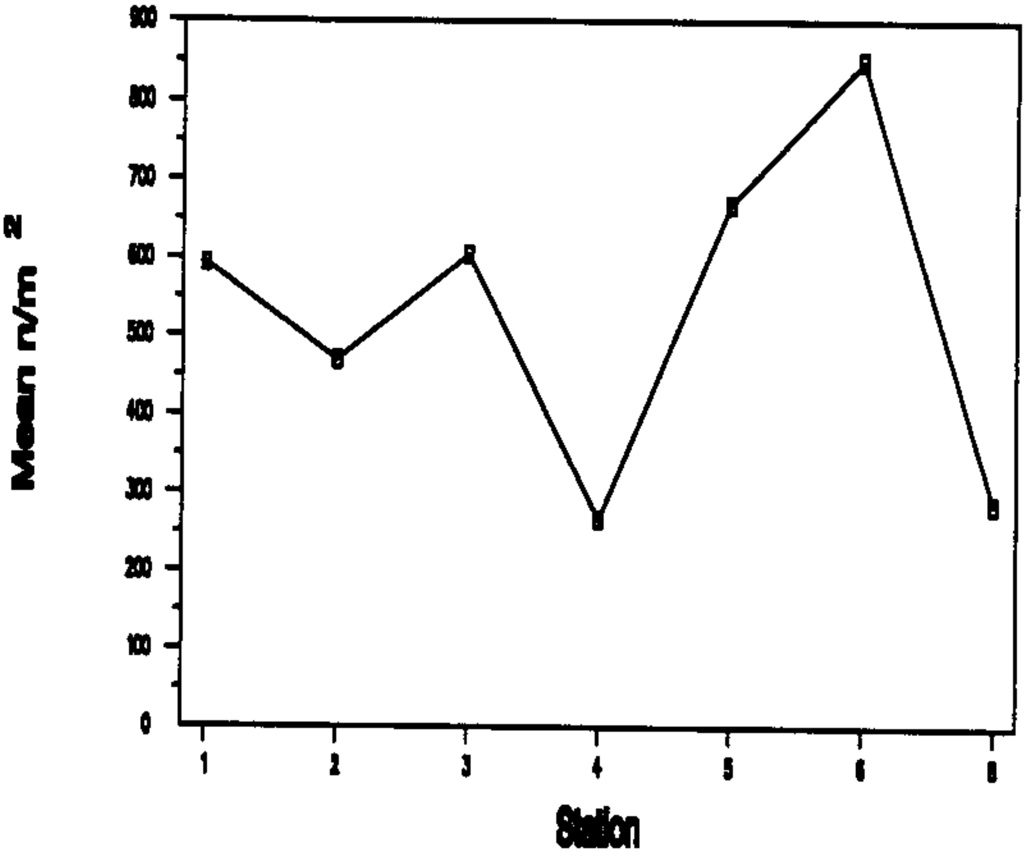


Figure 69. Mean density by number of chironomids collected at various sampling locations in Lower Granite Reservoir, during 1989. Lines above means represent +/- 2 standard errors from the mean.



Station Comparison

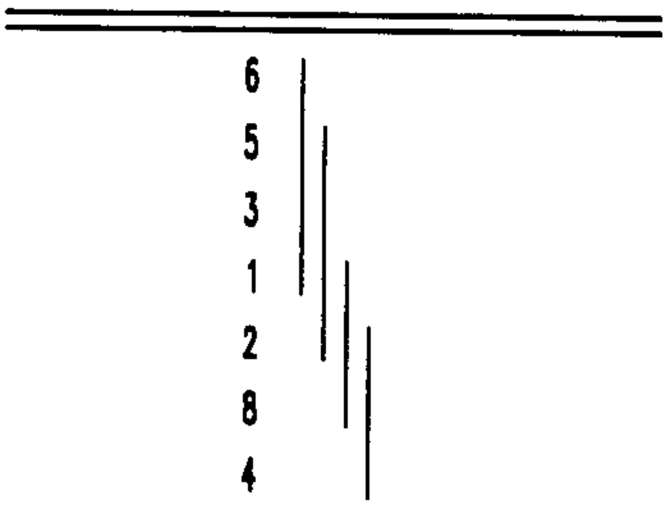


Figure 70. Statistical comparison of mean number of chironomids collected from various stations in Lower Granite Reservoir, during 1989. Lines connecting stations indicate statistical nonsignificance (P>0.05).

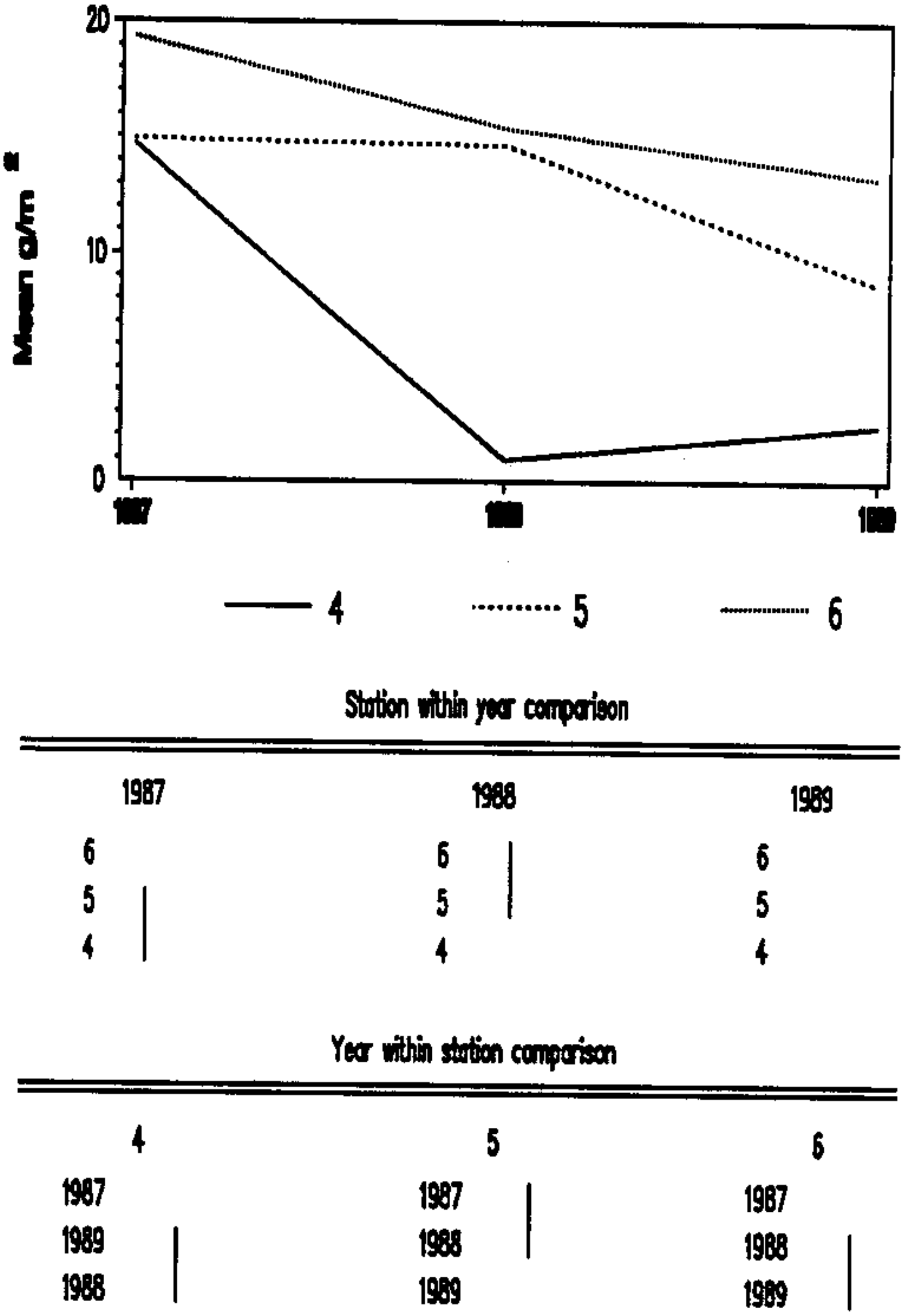


Figure 71. Statistical analysis of the significant ($P<0.05$) year*station interaction for the total biomass of benthic invertebrates for 1987, 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance ($P>0.05$).

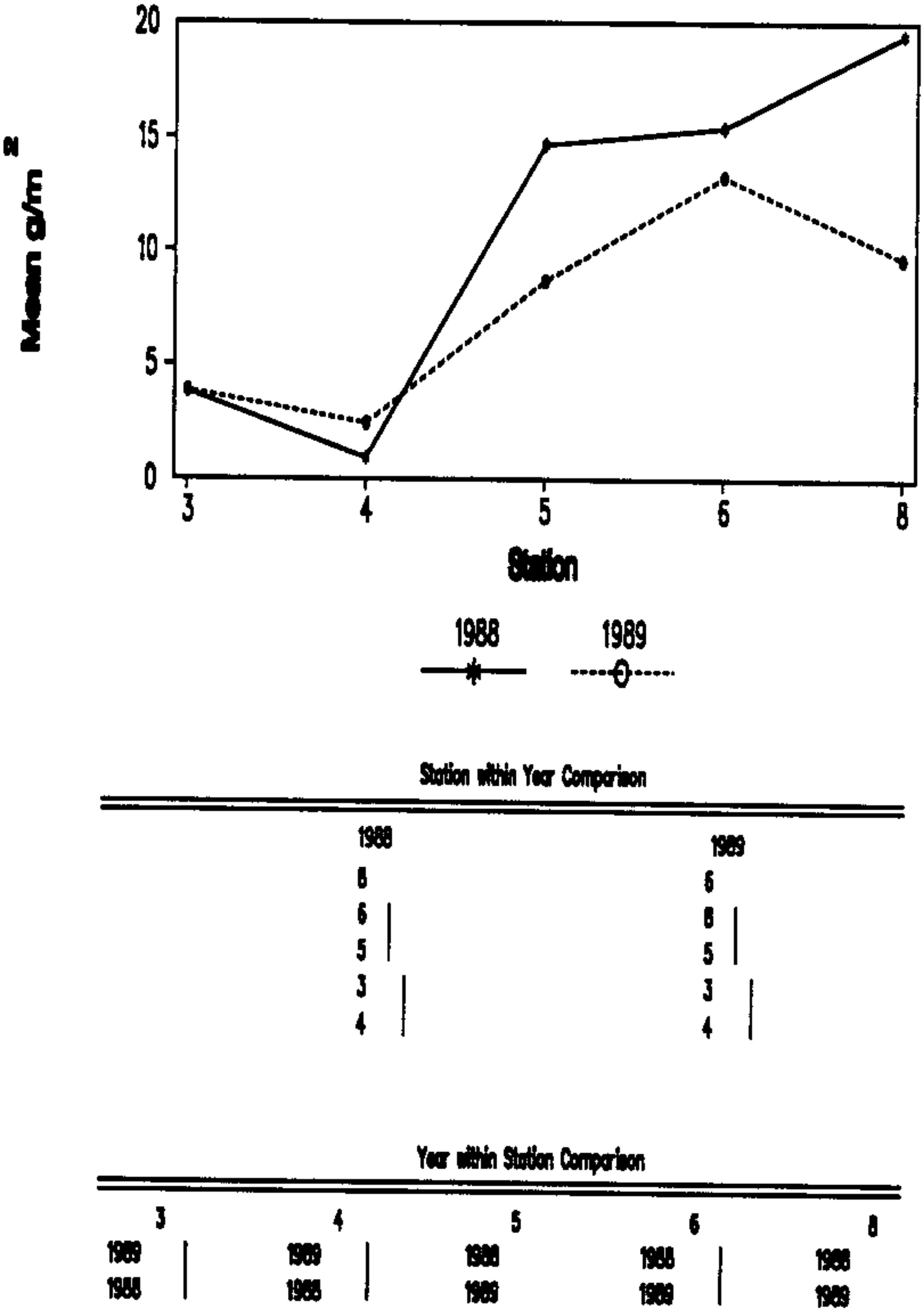


Figure 72. Statistical comparison of the total benthic community biomass collected from various stations in Lower Granite Reservoir, during 1988 and 1989. Lines connecting stations and years indicate statistical nonsignificance (P>0.05).

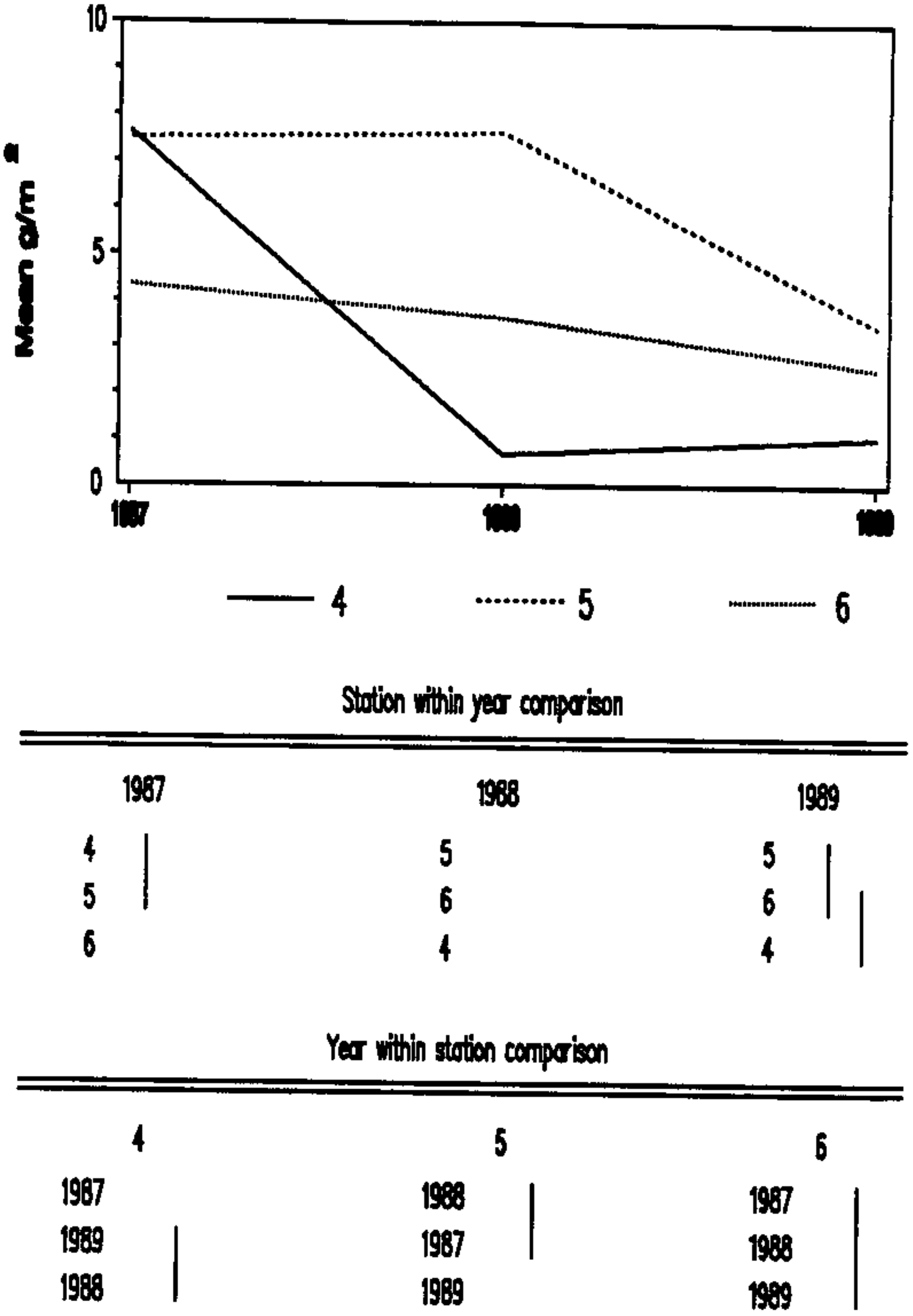


Figure 73. Statistical analysis of the significant ($P<0.05$) year*station interaction for chironomid biomass for 1987, 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance ($P>0.05$).

at the mid-depth disposal station following placement of the dredged materials in 1988 and also in 1989 over that in 1987. As with the total biomass, no significant increase has occurred from 1988 to 1989. Year-to-year differences at the mid-depth reference station were not significant although chironomid standing crops were significantly lower at the shallow reference station during 1989 than 1988. Comparison of chironomid biomass between 1988 and 1989 indicates no significant differences at stations 3, 4 and 6, while those at stations 5 and 8 were significantly lower in 1989 (Figure 74).

Analysis of oligochaete biomass has indicated a significant year*station interaction. Differences between 1988 and 1989 were significant over all stations (Figure 75). Station comparisons over 1988 and 1989 have indicated that oligochaete biomass at stations 3 and 4 were not significantly different although those at stations 5, 6 and 8 were different.

STATISTICAL COMPARISON

Numerical

Mean numerical density of chironomids from 1987 to 1989 has generally exhibited a decrease although these differences were not statistically different (Figure 76). The decrease in chironomid density at the mid-depth disposal station was significantly different between 1987, the pre-disposal condition, to the post disposal densities in 1988 and 1989. These year-to-year differences were not statistically different at the mid-depth reference station although they were

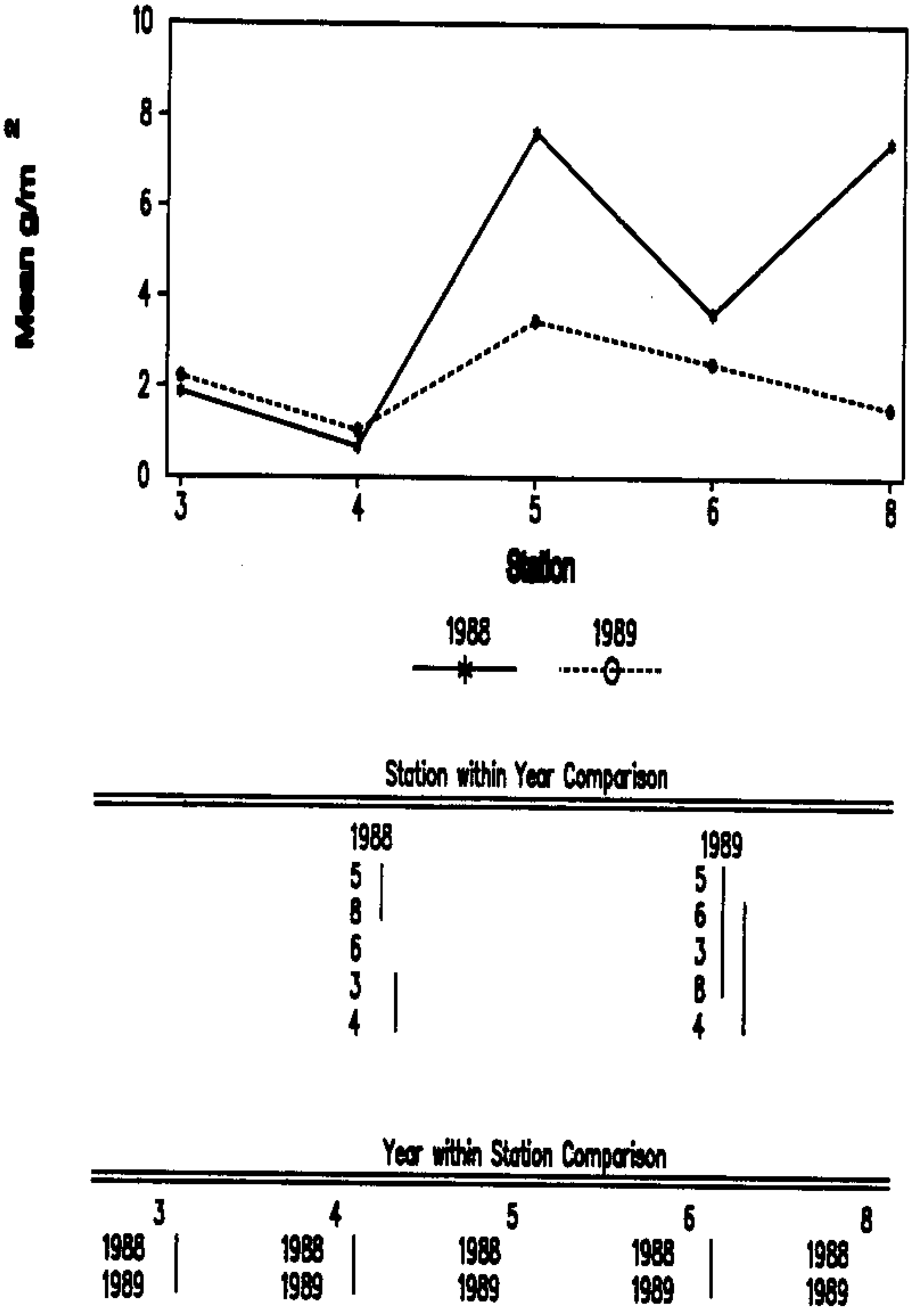


Figure 74. Statistical comparison of chironomid biomass between 1988 and 1989 collected from various stations in Lower Granite Reservoir. Lines connecting stations and years indicate statistical nonsignificance (P>0.05).

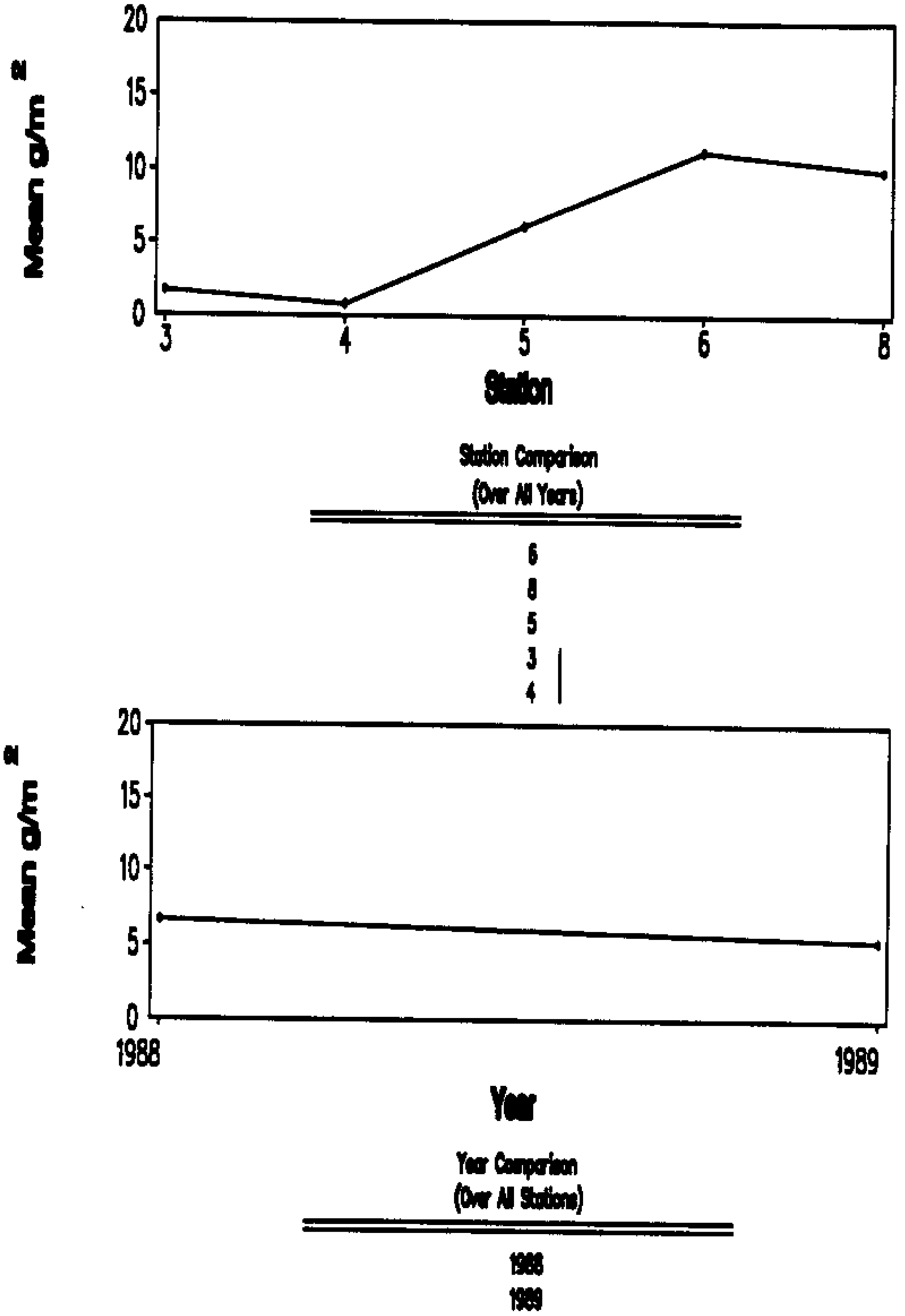


Figure 75. Statistical comparison of oligochaete biomass between 1988 and 1989 collected from various stations in Lower Granite Reservoir. Lines connecting stations and years indicate statistical nonsignificance (P>0.05).

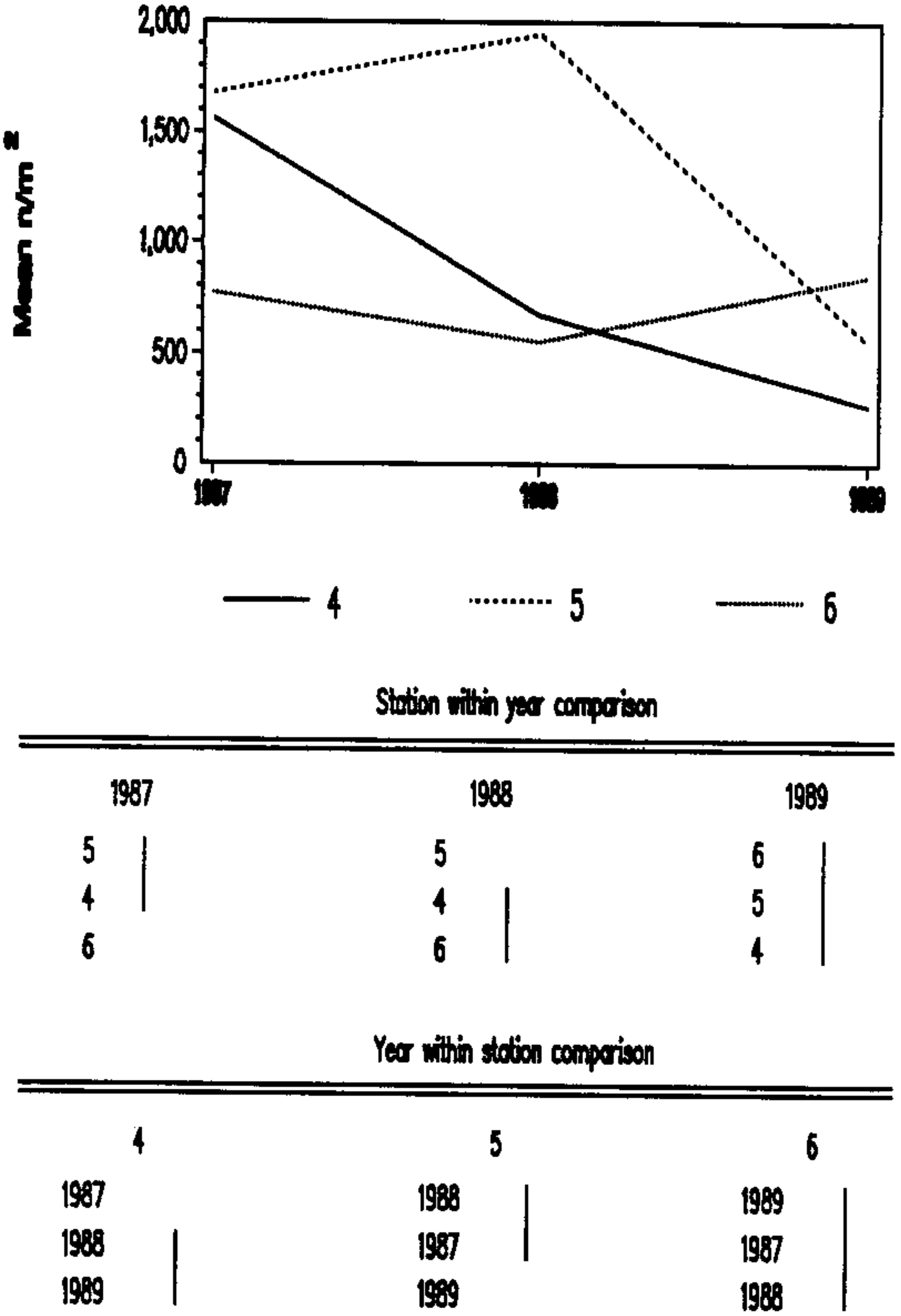


Figure 76. Statistical analysis of the significant ($P<0.05$) year*station interaction for chironomid numbers for 1987, 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance ($P>0.05$).

different at the shallow reference station between 1989 and 1987 and 1988. Comparisons between 1988 and 1989 have indicated statistical differences in the numerical density of chironomids at stations 3, 5 and 8, while those at stations 4 and 6 were not significantly different (Figure 77).

Oligochaete densities have exhibited similar decreases in the last 3 years (1987-1989) as the total benthic community (Figure 78). There has been a significant ($P<0.05$) decrease in oligochaete densities from 1987 to 1988 and 1989 at the mid-depth disposal station; differences in oligochaete densities at the shallow reference station are also significant among the three years. Between 1988 and 1989, oligochaete numbers have been similar at stations 3 and 6, while those at stations 4, 5 and 8 have been significantly lower in 1989 (Figure 79).

DISCUSSION

Comparison of total benthic community among stations for 1989 indicated that mean biomass at the disposal stations (1, 2 and 4) was one to two fold lower than mid-depth reference (6) and shallow reference stations (5) although similar to a near-by reference station (3) (Figure 62). Year-to-year comparisons revealed significant differences in benthic community biomass at the mid-depth disposal station that coincides with the pre (1987) and post (1988 and 1989) disposal condition (Figure 71). These comparions also demonstrate that the biomass has not changed significantly from 1988 or 3+ months after disposal to 1989 or 15 months following disposal. Trends in benthic community biomass at the mid-depth and shallow reference stations have

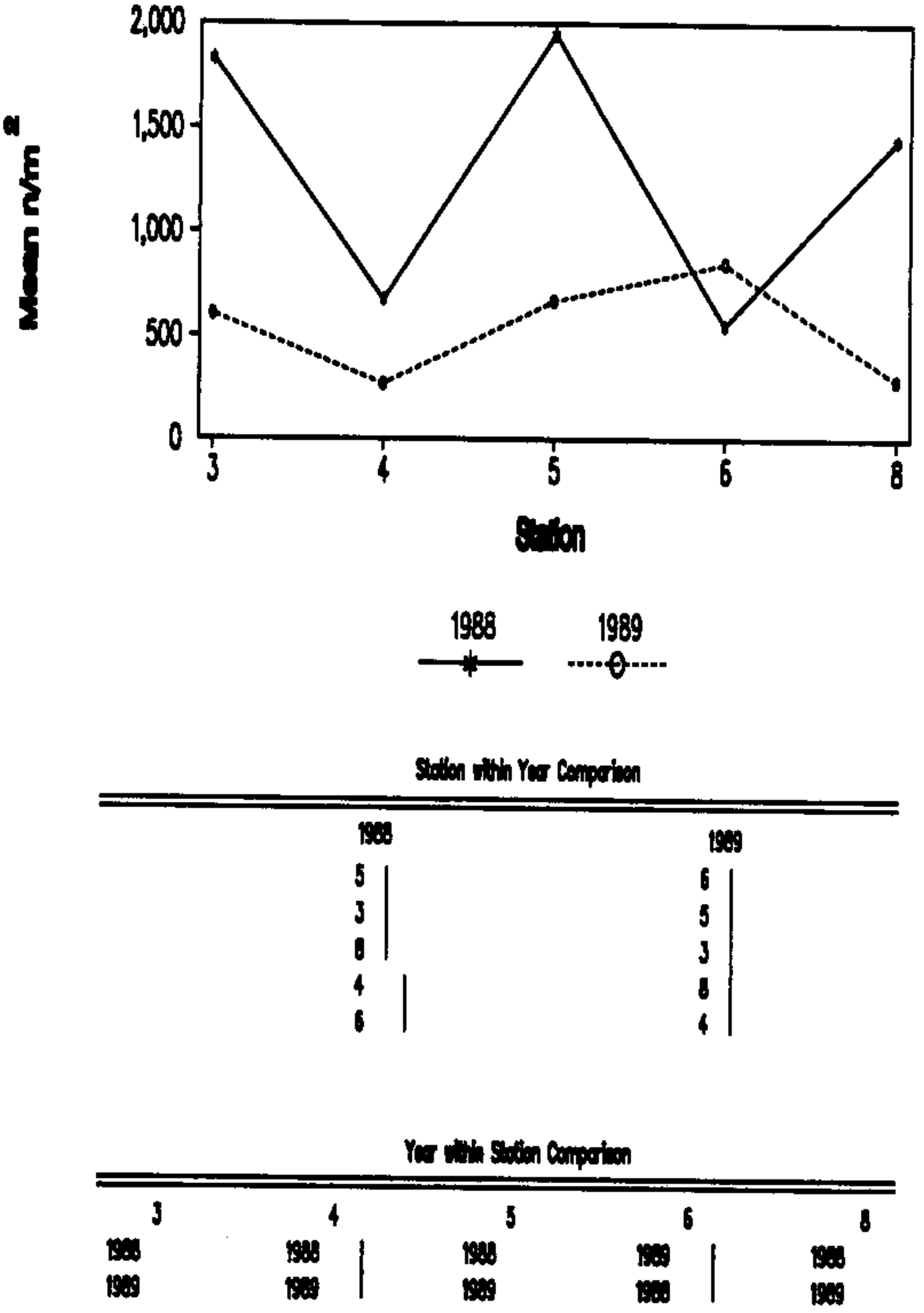


Figure 77. Statistical comparison of chironomid numbers between 1988 and 1989 collected from various stations in Lower Granite Reservoir. Lines connecting stations and years indicate statistical nonsignificance (P>0.05).

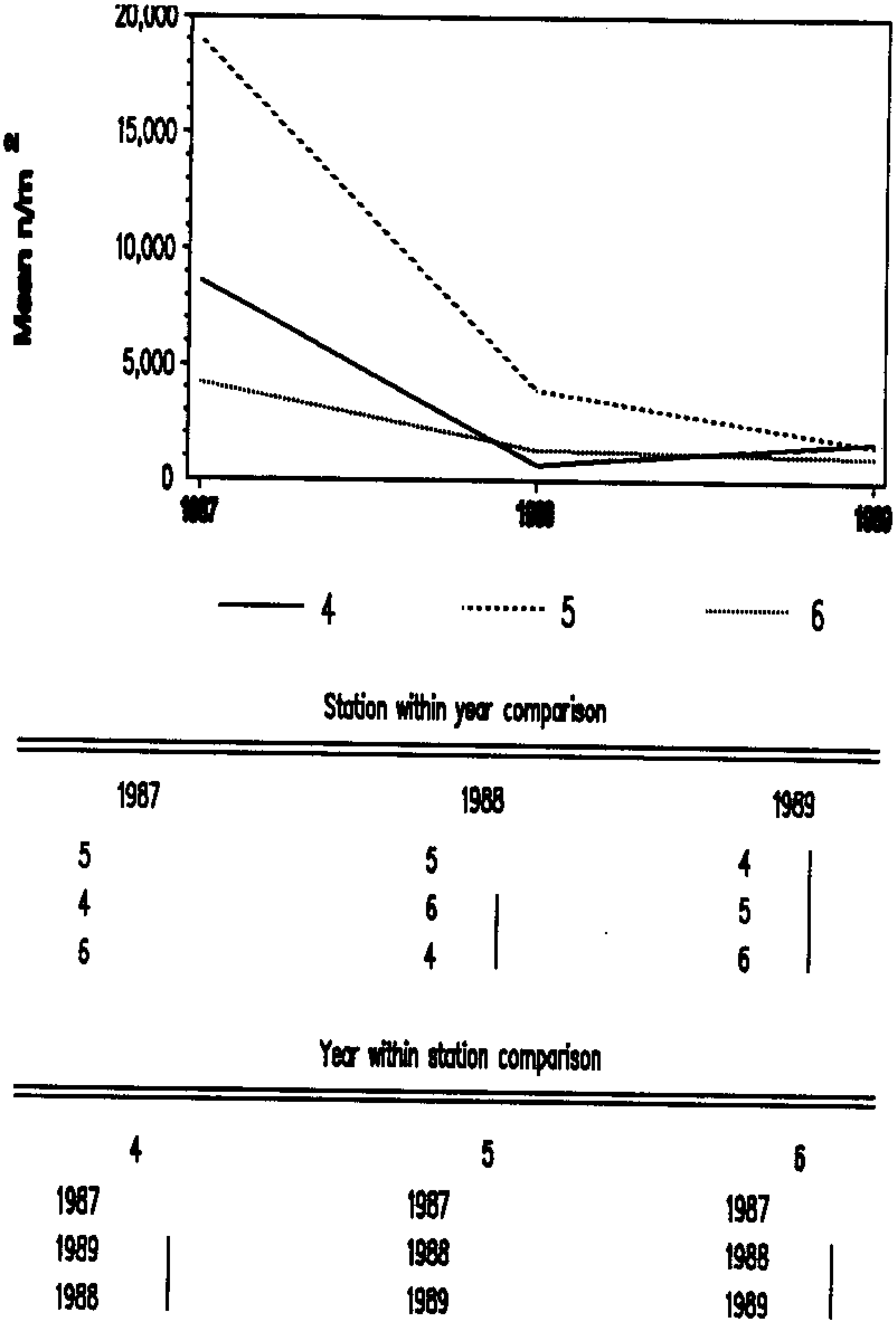


Figure 78. Statistical analysis of the significant (P<0.05) year*station interaction for oligochaete numbers for 1987, 1988 and 1989. Lines connecting years and stations indicate statistical nonsignificance (P>0.05).

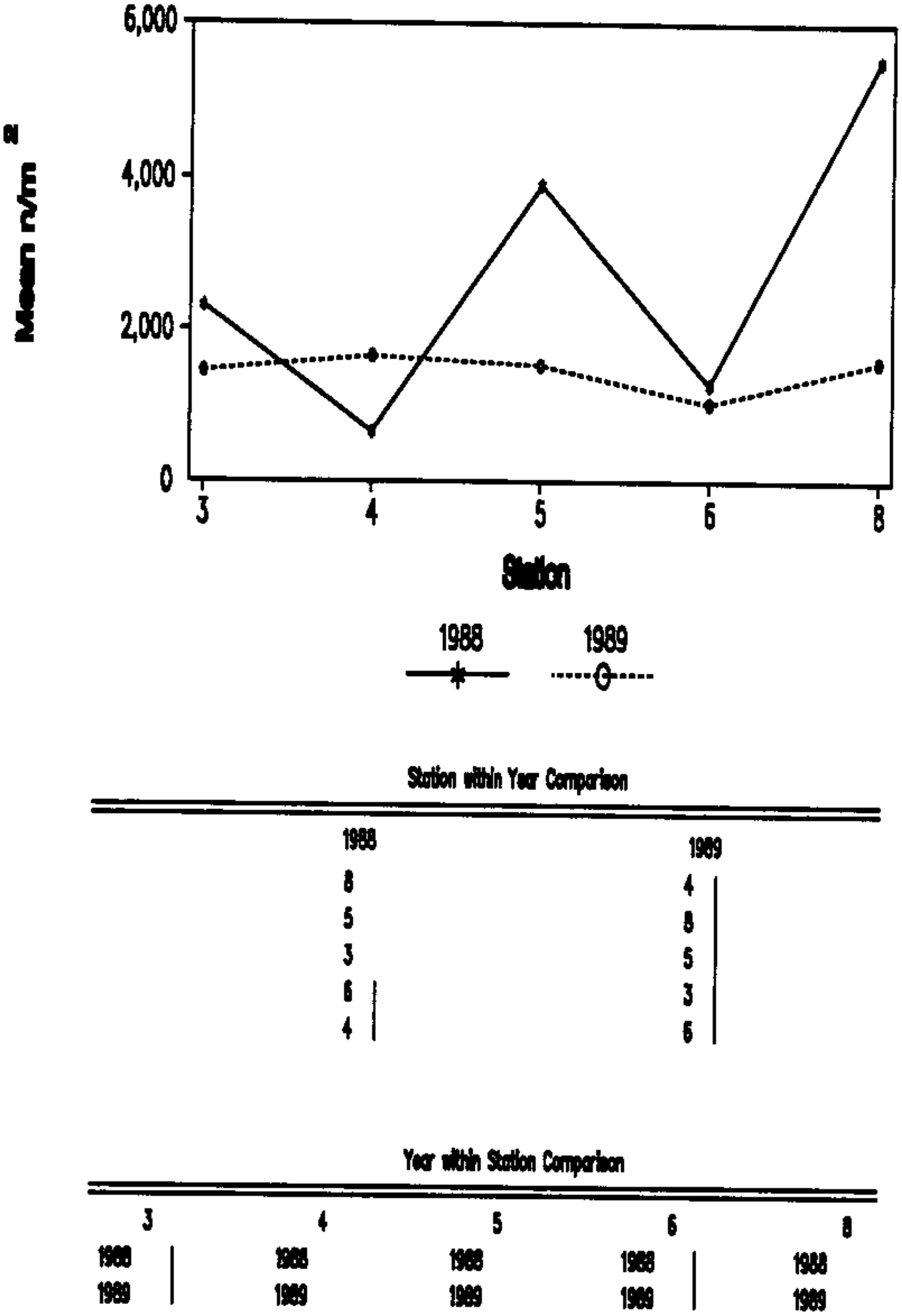


Figure 79. Statistical comparison of oligochaete numbers between 1988 and 1989 collected from various stations in Lower Granite Reservoir. Lines connecting stations and years indicate statistical nonsignificance (P>0.05).

also been a general decrease. From these analyses we have found that the mid-depth disposal station will probably continue to have low standing crops of benthos similar to the biomass at the shallow reference station 3. Low densitites are probably correlated to the sandy substrate that constituted the bulk of the material in the two disposal events.

The benthic community in Lower Granite Reservoir is composed of predominatly oligochaetes and chironomids. Of the total biomass, approximately 75% is composed of chironomids (Bennett et al. 1988, 1990). Because of this and availability, biomass or numerical density of chironomids is probably the best indicator of fish food production. Chironomids are consumed by salmonids in Lower Granite Reservoir (Bennett and Shrier 1986) although the importance of oligochaetes probably lies in their contribution to the food chain. Oligochaetes have not been found directly in the diet of fishes examined in Lower Granite Reservoir although crayfish consume them. Crayfish comprise an extremely important food item of smallmouth bass, channel catfish and northern squawfish in Lower Granite Reservoir (Bennett and Shrier 1986; Bennett et al. 1988).

Objective 3: To provide for "ground truthing" for the hydroacoustical survey.

Methods

Horizontal and vertical gill nets were fished at eleven preselected transects during April, June and October, 1989. A total of six nets, two each experimental horizontal multifilament gill nets, 225 ft (69m) long by 6 ft (1.8m) deep and 1.5, 1.75 and 2.0 inch (3.2, 4.4 and 5.1cm) bar measurements, were set immediately below the surface adjacent and perpendicular to both shorelines. Two each vertical nets, 125 ft long, also experimental with two panels each 6 ft (1.8m) wide of 1.5 and 2.0 inch (3.2 and 5.1cm) mesh were fished from the surface to the bottom in mid and deep water habitats along each transect. Nets were set for two 4 hour periods each day and night. Catches of various species were grouped into salmonids, predators and "others" and expressed as the percentage of the community in three sections (lower-RM 109-114; middle-RM 116-125; and, upper-RM 127-134). Bass, northern squawfish and channel catfish were considered predators. All species not salmonids (sockeye, chinook and juvenile steelhead) or predators were lumped in the "other" category. Although nets were set in the spring and summer during the night and day, catches were pooled because of low catches.

RESULTS

A total of 836 "other" species, 263 predators and 53 salmonids were collected during the ground truthing effort for the hydroacoustics evaluation (Table 7). Of these, 314, 518 and 320 were collected in the lower (RM 109-114), middle (RM 119-125), and upper (RM 127-134) reservoir sections, respectively.

Reservoir Location Differences

In Lower Granite, CPUEs of predators, "other" species and salmonids for spring, summer and fall pooled, were generally similar among reservoir sections. CPUEs of "other" species in shallow water was consistently the highest among lower, middle and upper reservoir sections (Figures 80-82). Predators were the second highest in abundance in shallow, mid and deep water areas of Lower Granite and also very similar among sections. Variation in catches was high. Salmonid abundance based on our ground truthing was about 10-50% the abundance of predators; CPUE of predators was about 20-40% the abundance of "other" species. Few salmonids were generally collected in all sections and at all depths. CPUEs were lower in the mid-depth habitats followed by the deep water habitats. CPUEs were about 10-30% in deep waters as that in shallow waters.

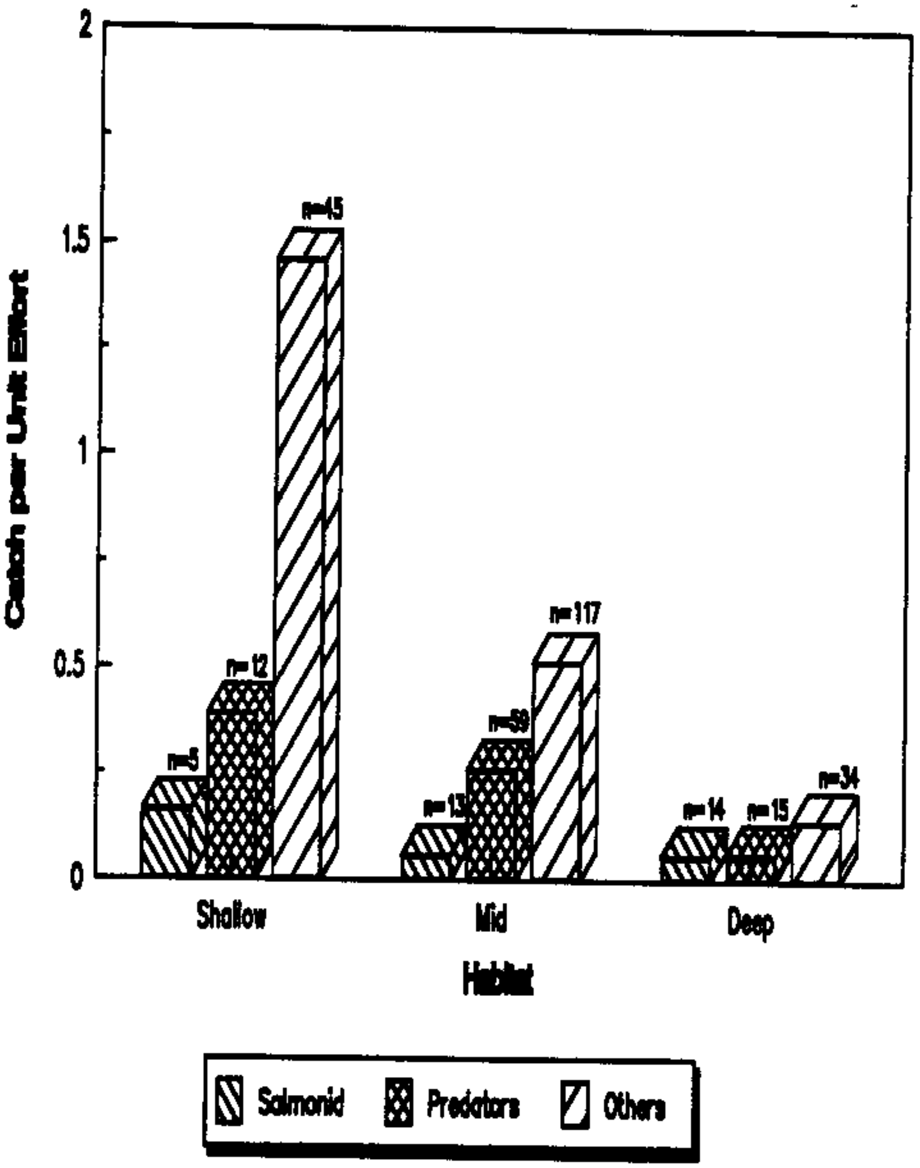


Figure 80. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20′), mid-depth (20-60′) and deep water (>60′) habitat in the lower (RM 109-114) section of Lower Granite Reservoir, Washington, for spring, summer and fall, 1989.

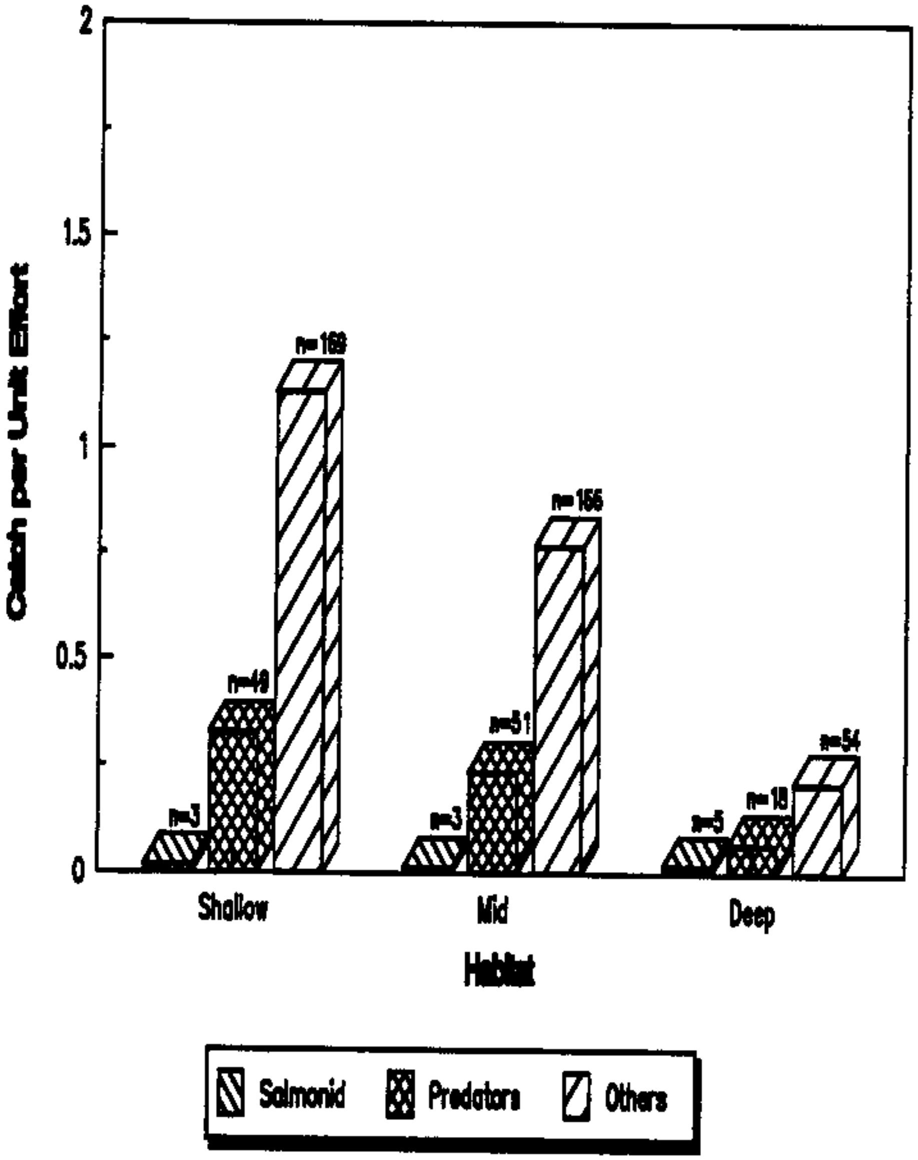


Figure 81. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20′), mid-depth (20-60′) and deep water (>60′) habitat in the middle (RM 116-125) section of Lower Granite Reservoir, Washington, for spring, summer and fall, 1989.

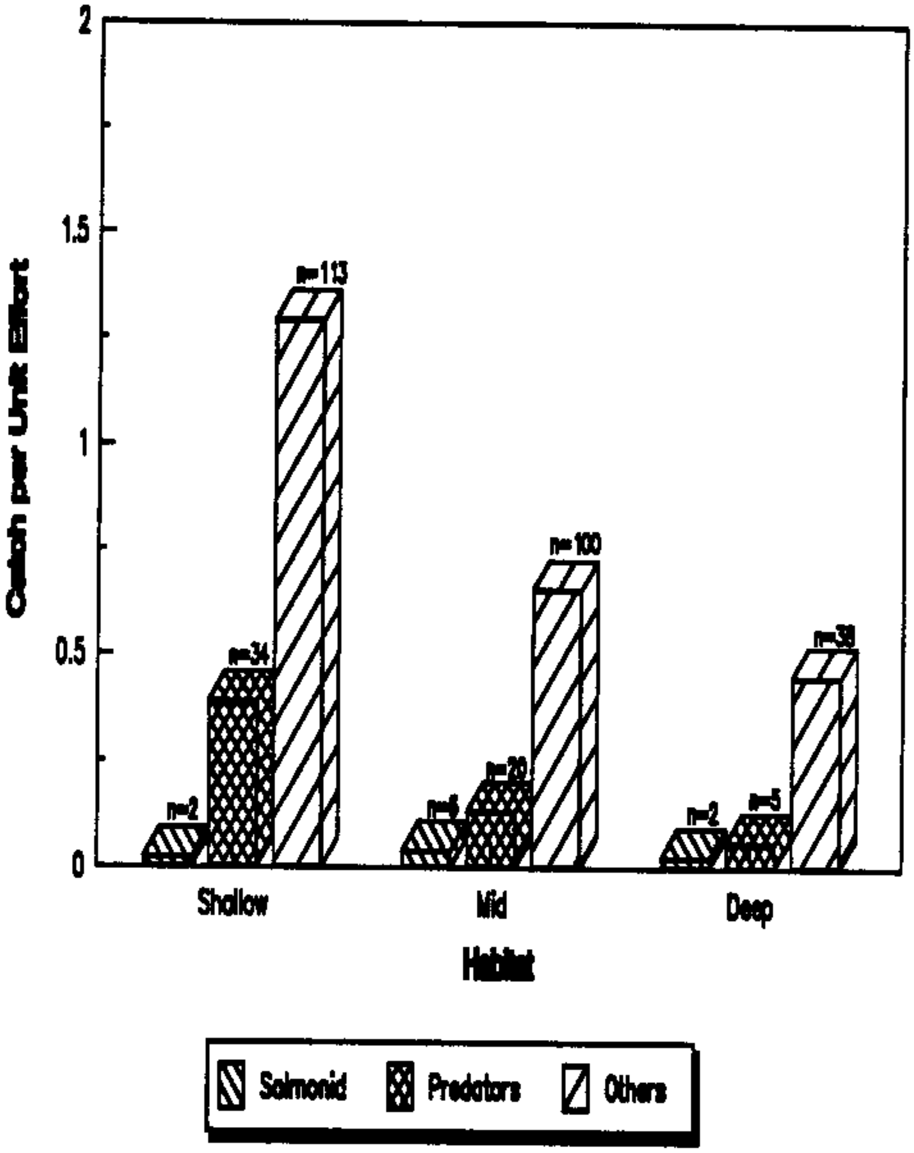


Figure 82. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20'), mid-depth (20-60') and deep water (>60') habitat in the upper (RM 127-134) section of Lower Granite Reservoir, Washington, for spring, summer and fall, 1989.

Seasonal Differences

Spring

Ground truthing efforts during spring 1989 were impaired by high flows which precluded effective vertical gill netting at narrow locations of Lower Granite Reservoir. Catches were reasonably high in horizontal gill nets which suggested that their efficiency was not overtly affected.

Results of ground truthing were generally similar for all species groups and all seasons in the three habitats (shallow, mid-depth, deep) sampled (Figures 83-85). CPUEs were highest for all seasons in shallow habitats followed by mid-depth and deep habitats. Smaller differences in CPUEs among species groups were found in the deep water habitats.

In the lower reservoir, largescale suckers and northern squawfish were abundant in all habitat types. Common carp were also abundant in deep waters.

In the middle reservoir, largescale suckers, common carp, white crappie, and northern squawfish were more abundant in shallow habitats. Largescale suckers and northern squawfish dominated the mid-depth and deep waters in the middle reservoir although white sturgeon and channel catfish also were caught in deep waters in this section. In the upper reservoir section (RM 127-134), largescale suckers and northern squawfish dominated the catches in shallow habitats. Largescale suckers, pumpkinseeds, and yellow perch appeared in the catches in mid-depth waters. Northern squawfish were generally low in relative abundance accounting for 8% of the fish caught in that section during the day. The only successful deep water set in this section caught 100% northern squawfish. In the nighttime samples, species composition

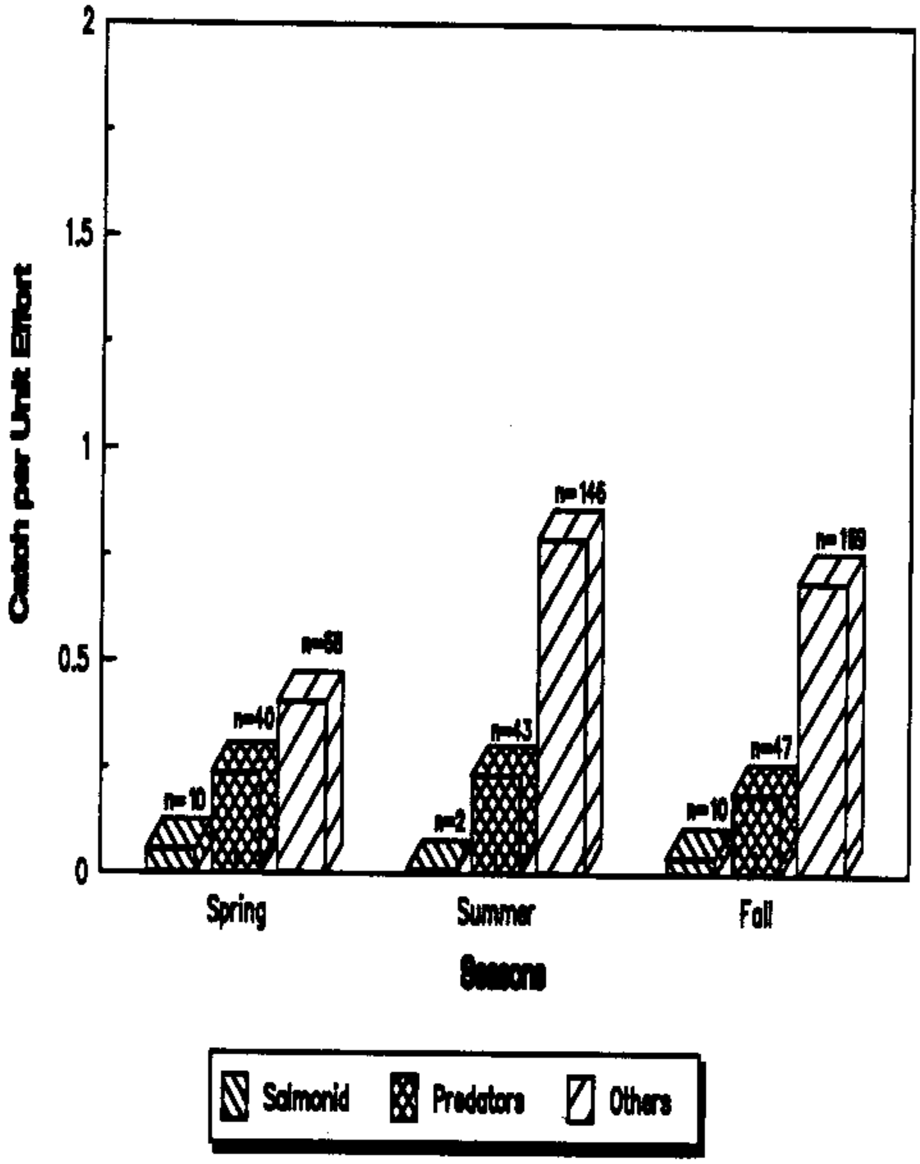


Figure 83. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for spring, summer and fall seasons at mid-depth habitats (20-60') in Lower Granite Reservoir, Washington, during 1989.

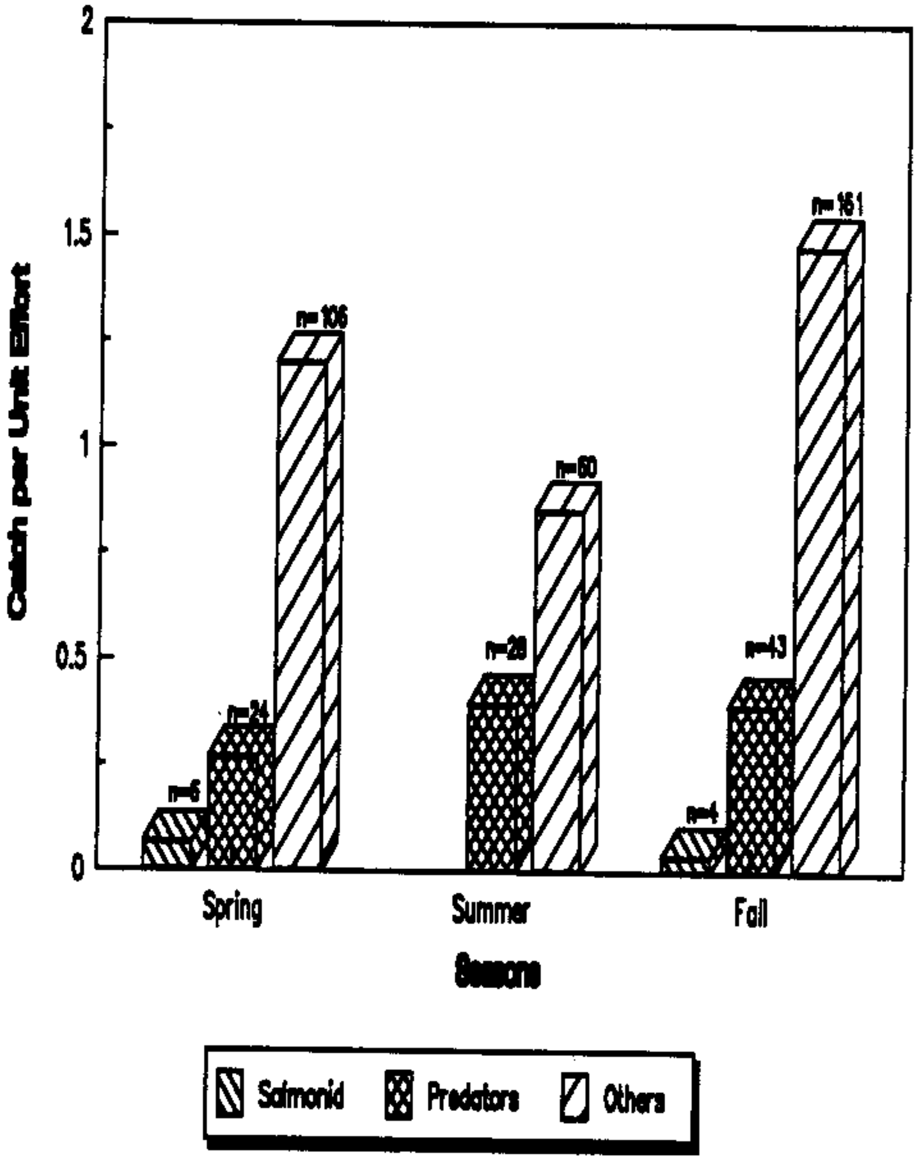


Figure 84. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for spring, summer and fall seasons at shallow water habitats (<20′) in Lower Granite Reservoir, Washington, during 1989.

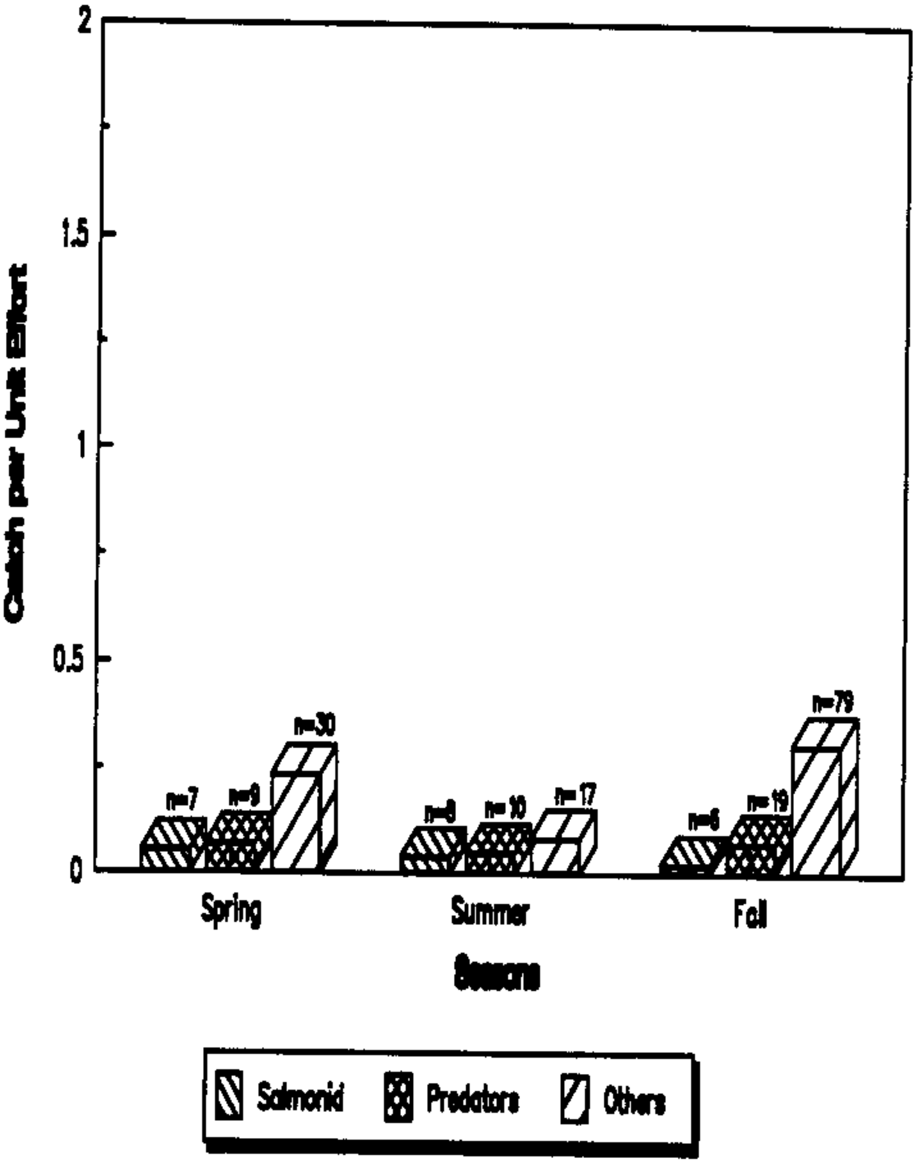


Figure 85. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for spring, summer and fall seasons at deep water habitats (<60') in Lower Granite Reservoir, Washington, during 1989.

generally was similar although juvenile steelhead were present in the collections along with white sturgeon in deep waters.

In the spring, mean CPUEs were consistently highest for "other" species followed generally by predators (Figures 86-88). Fewer number of individuals were available for comparison among species groups which greatly increased the variability. These seasonal comparisons showed, however, that within the spring, species in the "other", predator, and salmonid category, were generally similarly distributed in abundance throughout Lower Granite Reservoir in shallow, mid-depth, and deep waters.

Summer

During summer 1989, a higher number of fishes were collected than during the spring. Night and day catches generally were similar throughout the reservoir.

In the lower section from RM 109-116, largescale suckers, white crappies, and northern squawfish accounted for most of the fish in shallow water. Largescale suckers, common carp, northern squawfish, and channel catfish, accounted for most of the fish at mid-depth habitats. Gill netting in deep water showed a high number of species present. Largescale suckers, carp and channel catfish were high in abundance in deep waters.

In the middle section, largescale suckers, channel catfish, and white crappies were abundant in shallow waters. Mid-depth waters in the middle section were dominated by largescale suckers. Few northern squawfish were collected in mid-depths. Catches in deep waters for channel catfish, white sturgeon and white crappies were high in

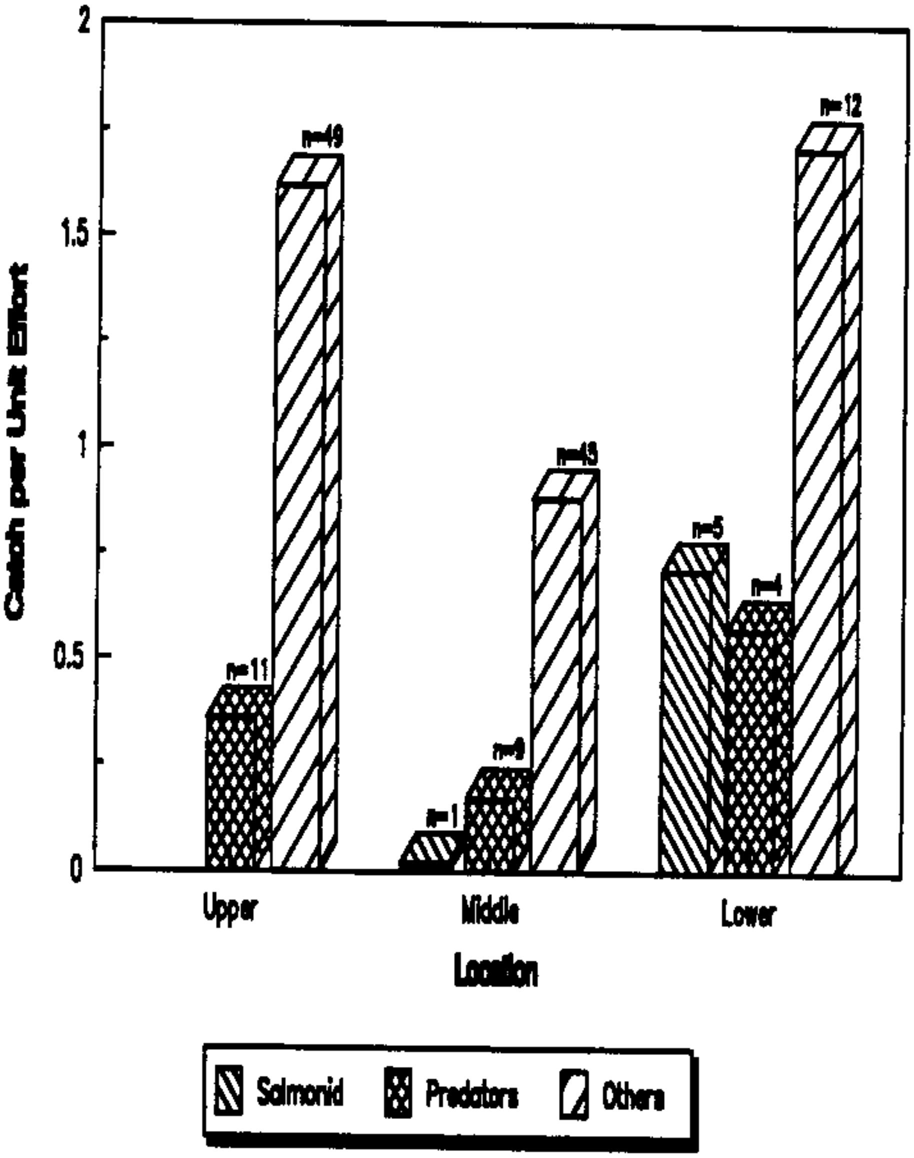


Figure 86. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow water habitat (<20') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the spring, 1989.

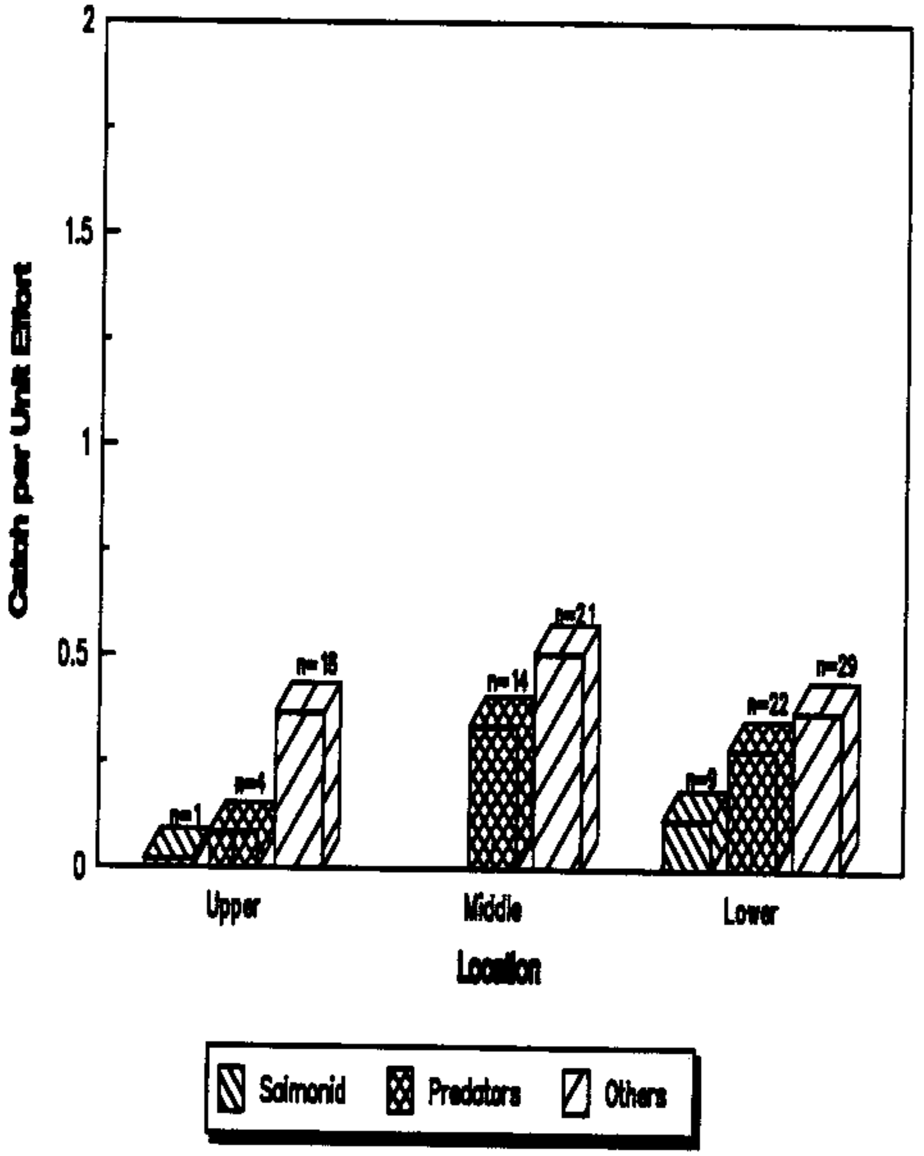


Figure 87. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for mid-depth habitat (20-60') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) section of Lower Granite Reservoir, Washington, during the spring, 1989.

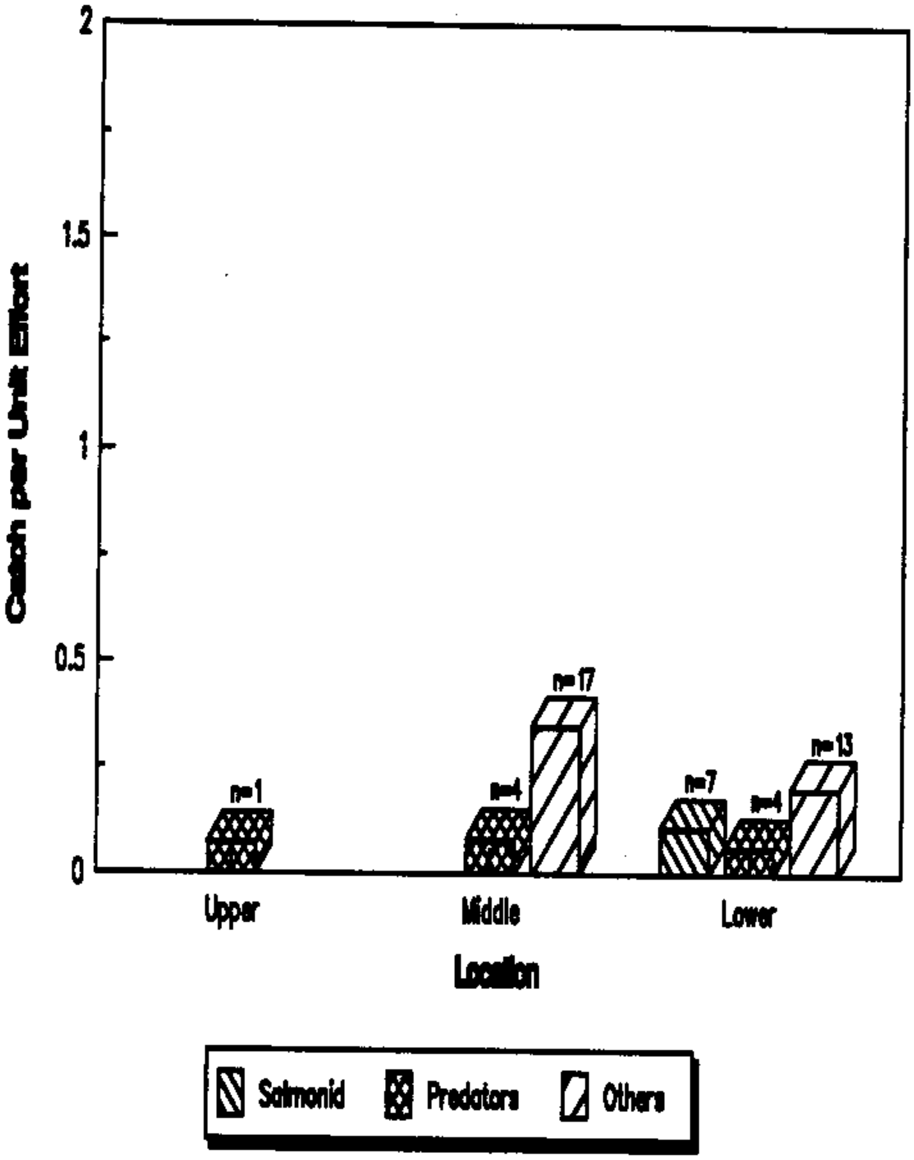


Figure 88. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for deep water habitat (>60') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the spring, 1989.

the middle section. No northern squawfish were collected in deep waters during the summer.

Catches in the upper section were diverse as crappies, yellow perch and largescale suckers accounted for the bulk of the fishes sampled in shallow water. In mid-depth habitat, catches were diverse with white sturgeon and largescale suckers accounting for 75% of the fish caught. Northern squawfish were about 25% abundant.

As in the spring, catches were similar between night and day although juvenile steelhead, white sturgeon and channel catfish were collected in higher frequency at night.

During the summer, less difference in CPUEs were found between shallow and mid-depth habitats whereas CPUEs in deep waters were similar among species categories (Figures 89-91). In the mid-depth habitats, CPUEs were similar for predators among reservoir locations but those for "other" species were significantly lower in the upper section. Few salmonids were collected during the summer.

Fall

Ground truthing during fall, 1989 provided the best information on fish relative abundance within the water column. Flows were suitable throughout Lower Granite Reservoir to fish with both vertical and horizontal gill nets in all habitats. Because of the shortened photoperiod, nets were fished from late afternoon into the night.

Diversity of fishes sampled during the fall was similar to that during the summer and much higher than in the spring. Diversity generally decreased with depth although mid-depth and shallow were similar in the number of species

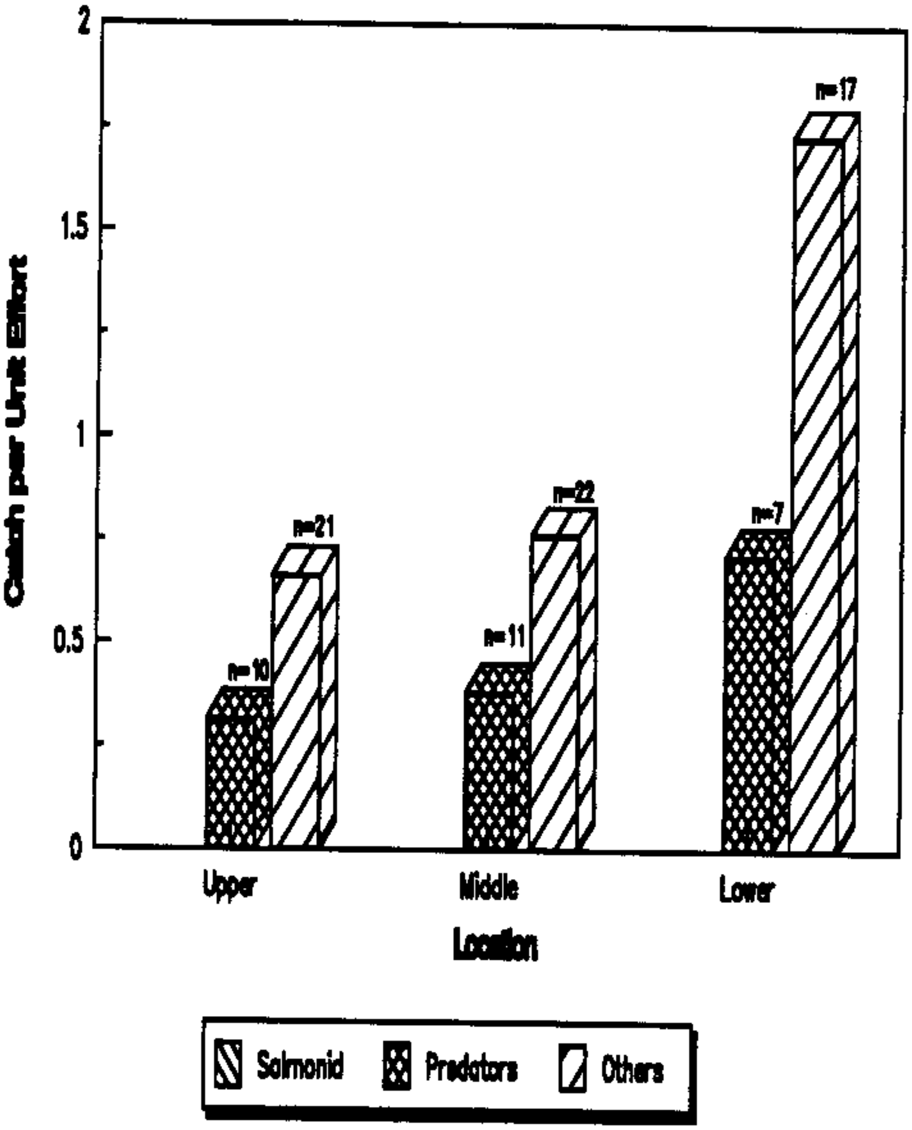


Figure 89. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow water habitat (<20') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the summer, 1989.

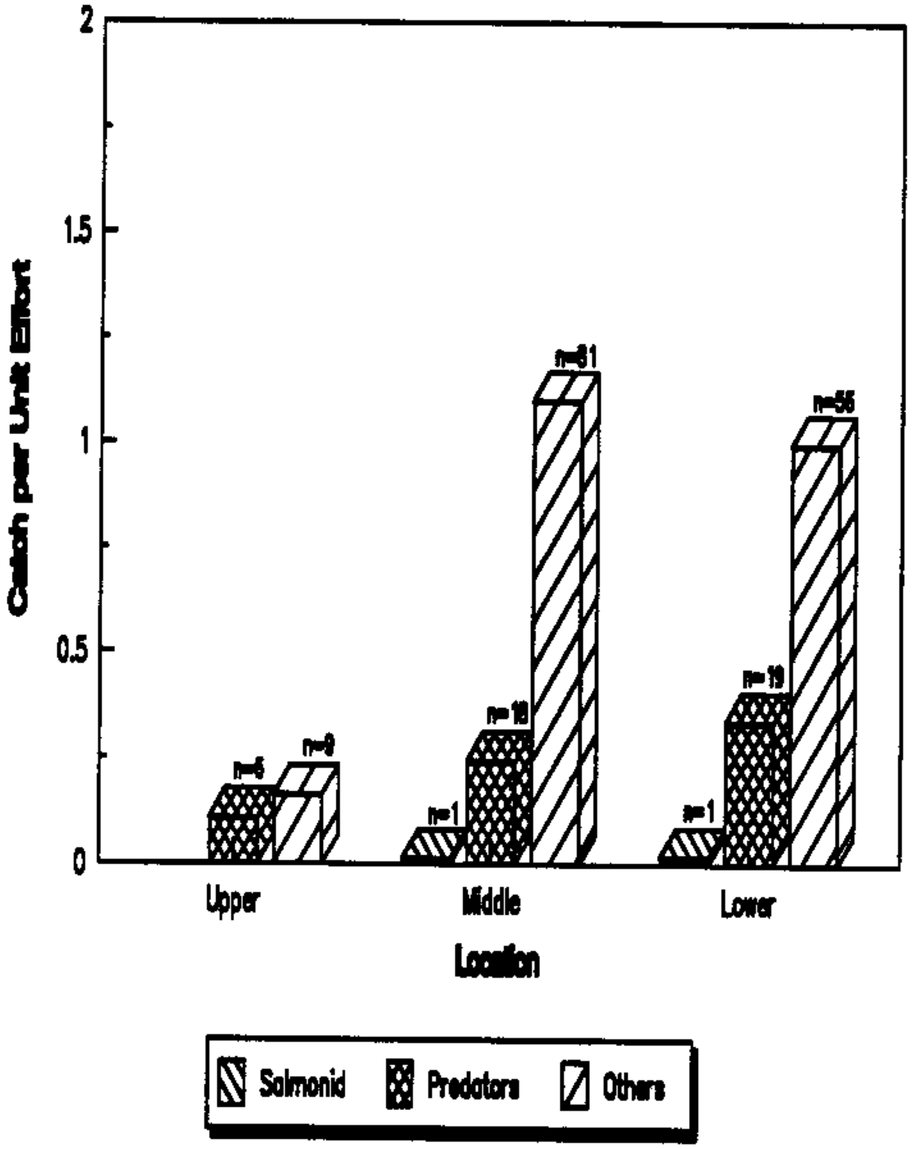


Figure 90. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for mid-depth habitat (20-60') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the summer, 1989.

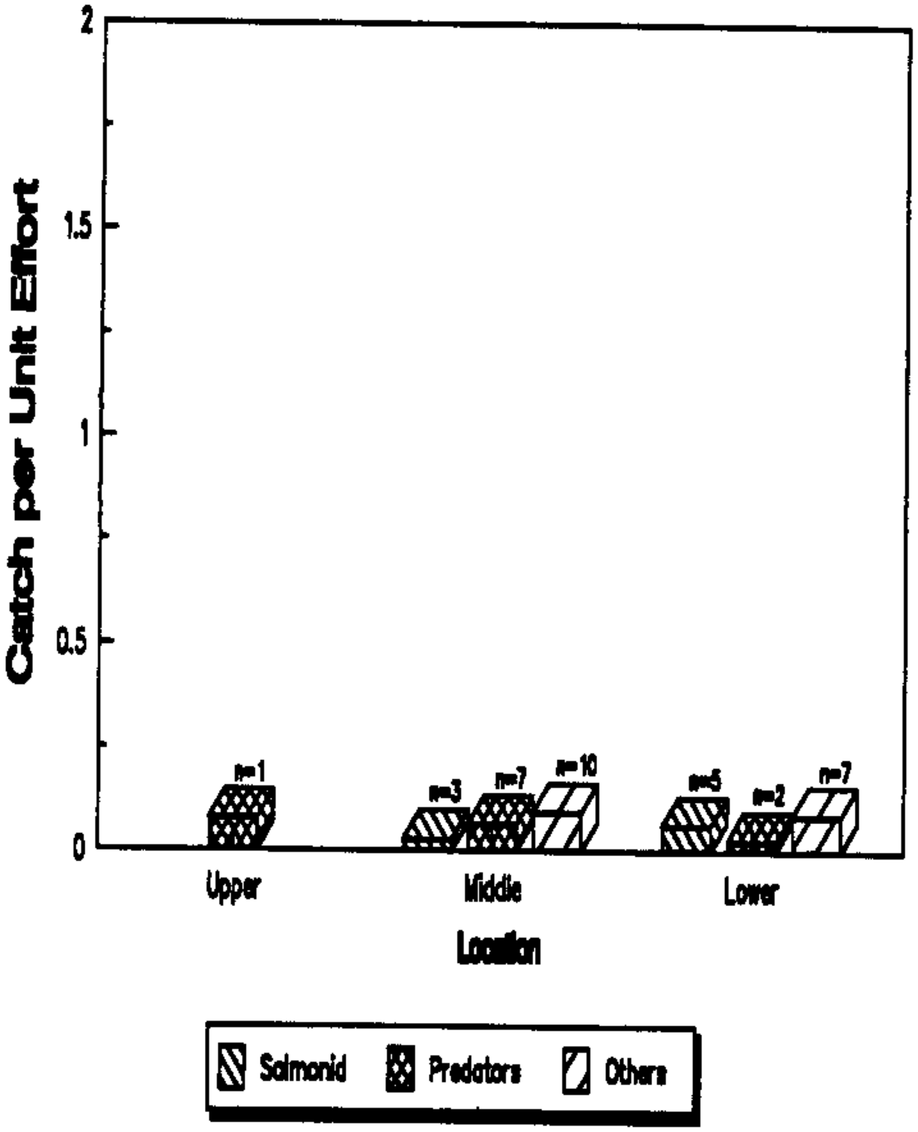


Figure 91. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for deep water habitat (>60′) at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the summer, 1989.

collected in various parts of Lower Granite Reservoir.

In the lower section during the fall, largescale suckers were abundant in shallow, mid-depth and deep water habitats followed closely by northern squawfish. Catch rates of northern squawfish were high in the lower section. Species sampled in mid-depth waters included white crappies, brown bullheads and channel catfish. In deep waters, catch rates of largescale suckers and northern squawfish were lower than those in mid-depth waters. Chinook salmon and juvenile steelhead were collected in low numbers near Lower Granite Dam.

In the middle section during the fall, largescale suckers were most numerous in shallow water followed by northern squawfish and chiselmouth. Largescale suckers and northern sqauwfish were the two dominant species in the mid-depth habitats during the fall. Catch rates of squawfish were high in comparison to the entire reservoir. In deep waters, largescale suckers were clearly the highest in relative abundance although a number of species were collected.

In the upper section, largescale suckers were highest in relative abundance followed by northern squawfish, channel catfish and bridgelip suckers. Largescale suckers and squawfish were more abundant in mid-depth waters. Juvenile steelhead also were collected during the fall in mid-depth waters although CPUE's were low. Largescale suckers, white sturgeon, and chiselmouth were collected in highest abundance in the deep waters of this section. Some additional juvenile steelhead were collected in the deep waters. In general, fewer species were collected in deep waters than in mid-depth waters.

During the fall, CPUEs for "other" species and predators were consistently highest in shallow waters (Figure 92). In mid-depth

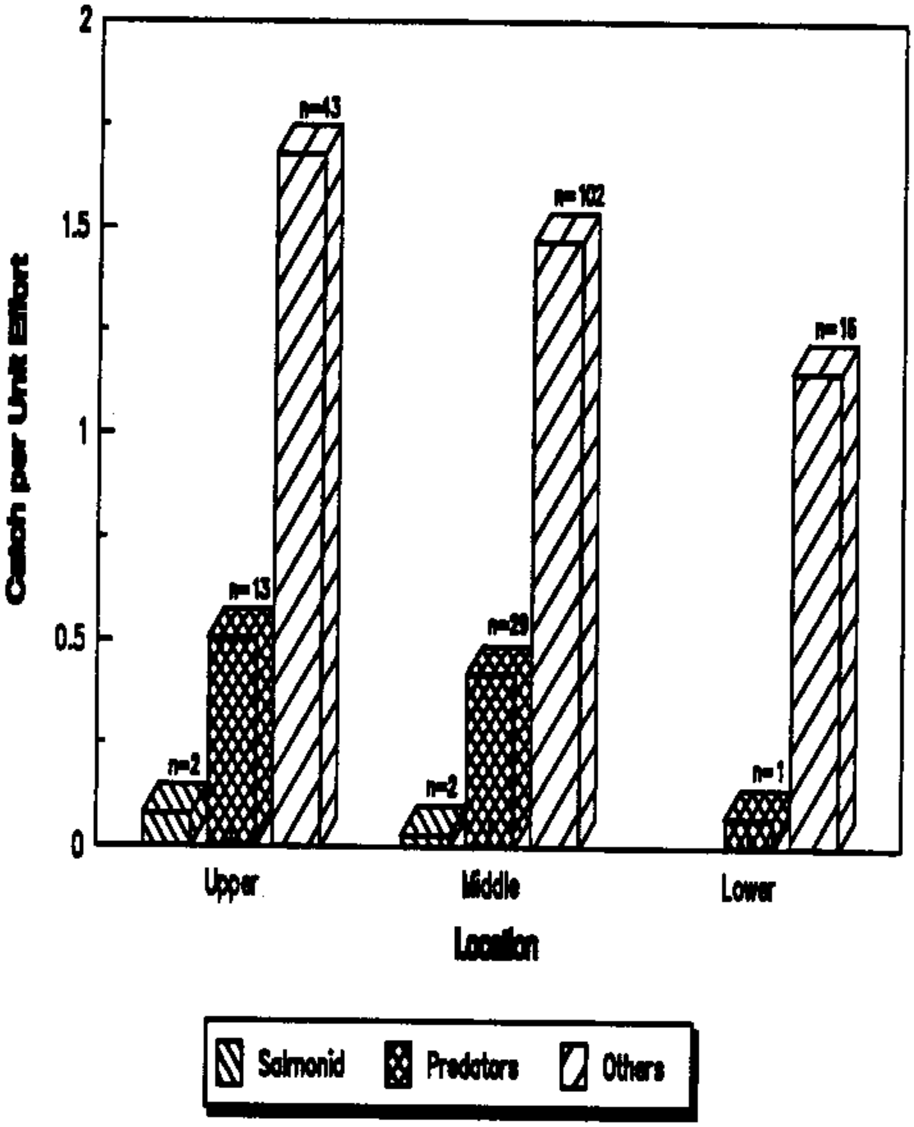


Figure 92. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow water habitat (<20') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the fall, 1989.

waters, "other" species were highest in the upper (RM 127-134) and middle reservoir (RM 119-125) sections while in the lower section (RM 109-114), salmonids and predators had higher CPUEs (Figure 93-94). In the fall, CPUEs for salmonids were low but indicated their presence in the reservoir in the mid-depth and deep water habitats.

Diel Comparisons

CPUEs for predators and "other" species were higher but generally similar within the lower section during the spring and summer between night and day (Figures 95-96). One of the major differences was the considerably higher CPUEs during the night time for salmonids in the spring and summer. CPUEs decreased from shallow to deep waters with those from the mid-depth waters being intermediate.

In the middle reservoir section during spring and summer daytime hours, CPUEs were about two times higher for "other" species than during the night at mid and deep water habitats (Figures 97-98). In shallow waters, however, CPUEs were higher during the night. As in the lower reservoir, salmonids were exclusively caught during the night. Predator abundance was similar between night and day based on CPUE.

A similar trend in CPUEs was found between day and night in the upper reservoir (Figure 99-100). CPUEs were highest for "other" species at mid-depth habitats for both night and day although in the shallow habitat, highest CPUE was during the night. CPUE of predators generally was similar among habitats and night and daytime. Too few species other than "other" species were collected to ascertain many differences in the upper reservoir between night and day.

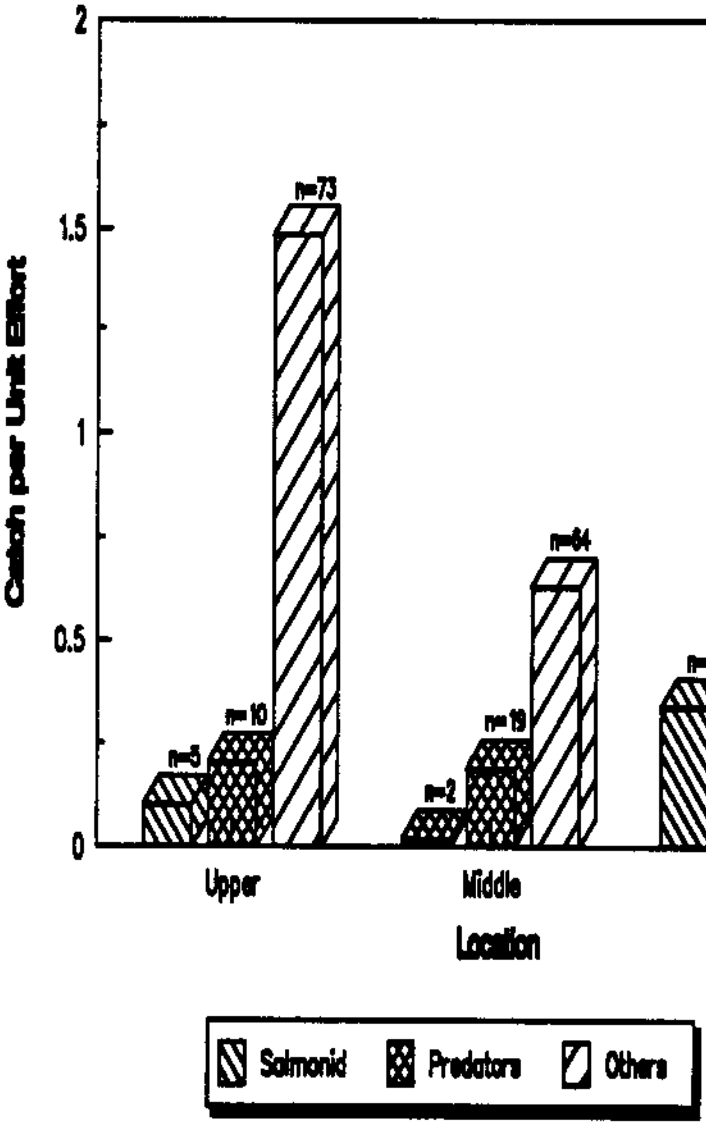


Figure 93. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for mid-depth habitat (20-60') at upper (RM 127-134), middle (RM 116-125) and lower (109-114) sections of Lower Granite Reservoir, Washington, during the fall, 1989.

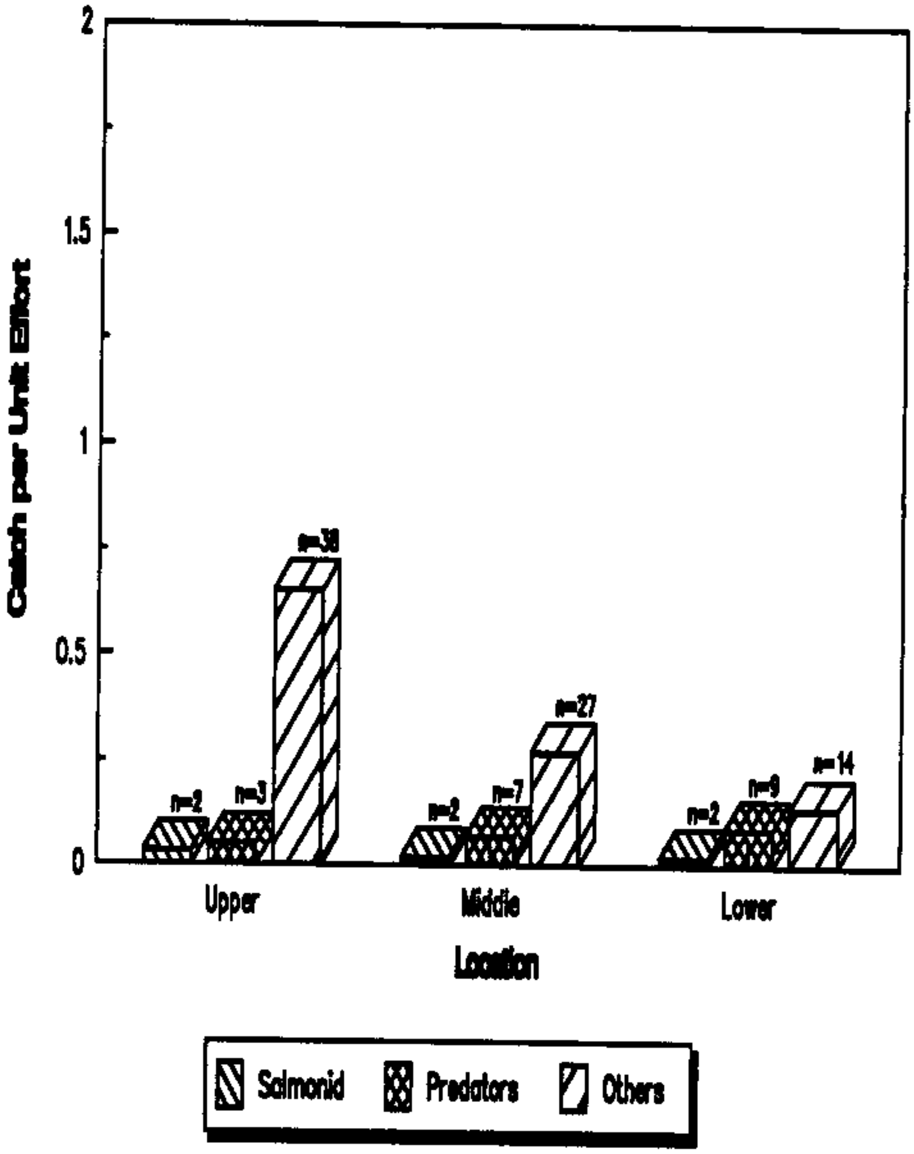


Figure 94. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for deep water habitat (>60') at upper (RM 127-134), middle (RM 116-125) and lower (RM 109-114) sections of Lower Granite Reservoir, Washington, during the fall, 1989.

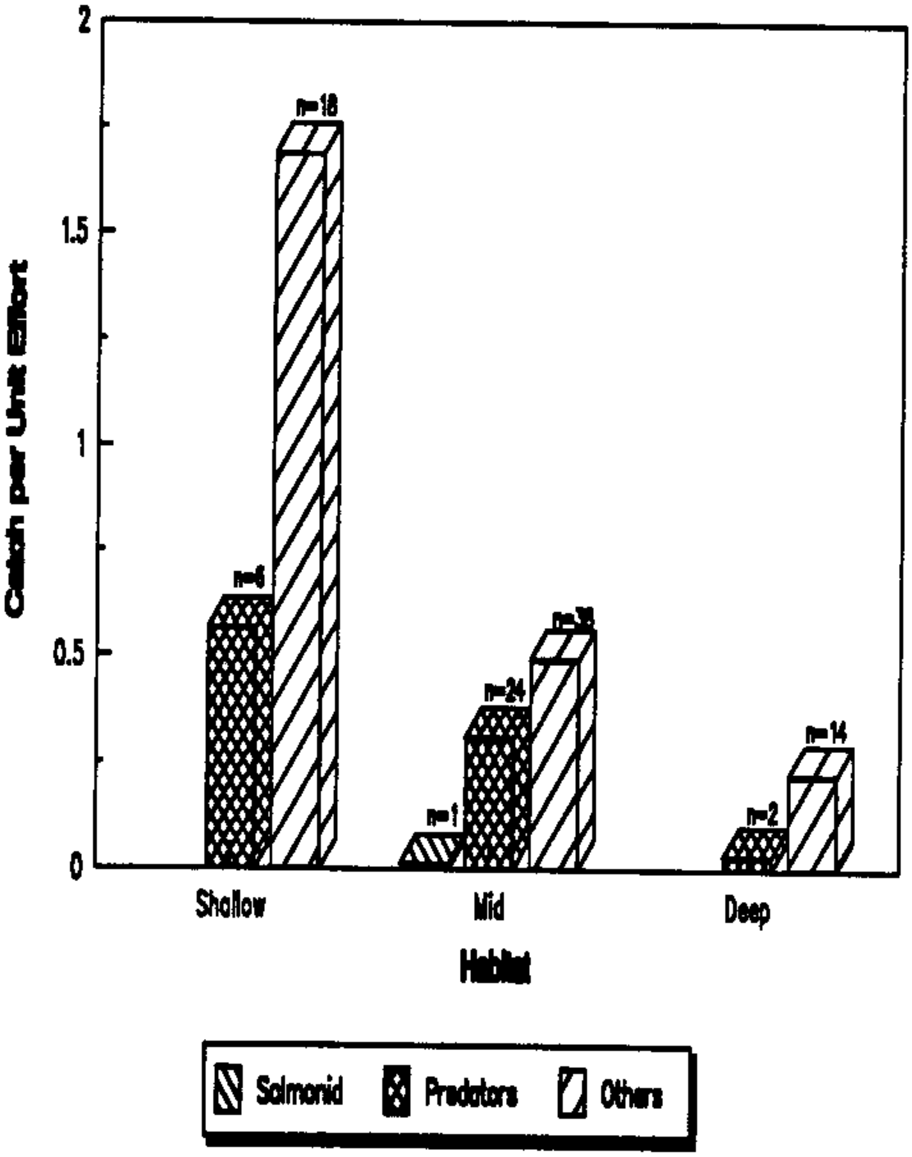


Figure 95. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20'), mid-depth (20-60') and deep water (>60') habitat in the lower (RM 109-114) section of Lower Granite Reservoir, Washington, during the day in the spring and summer seasons, 1989.

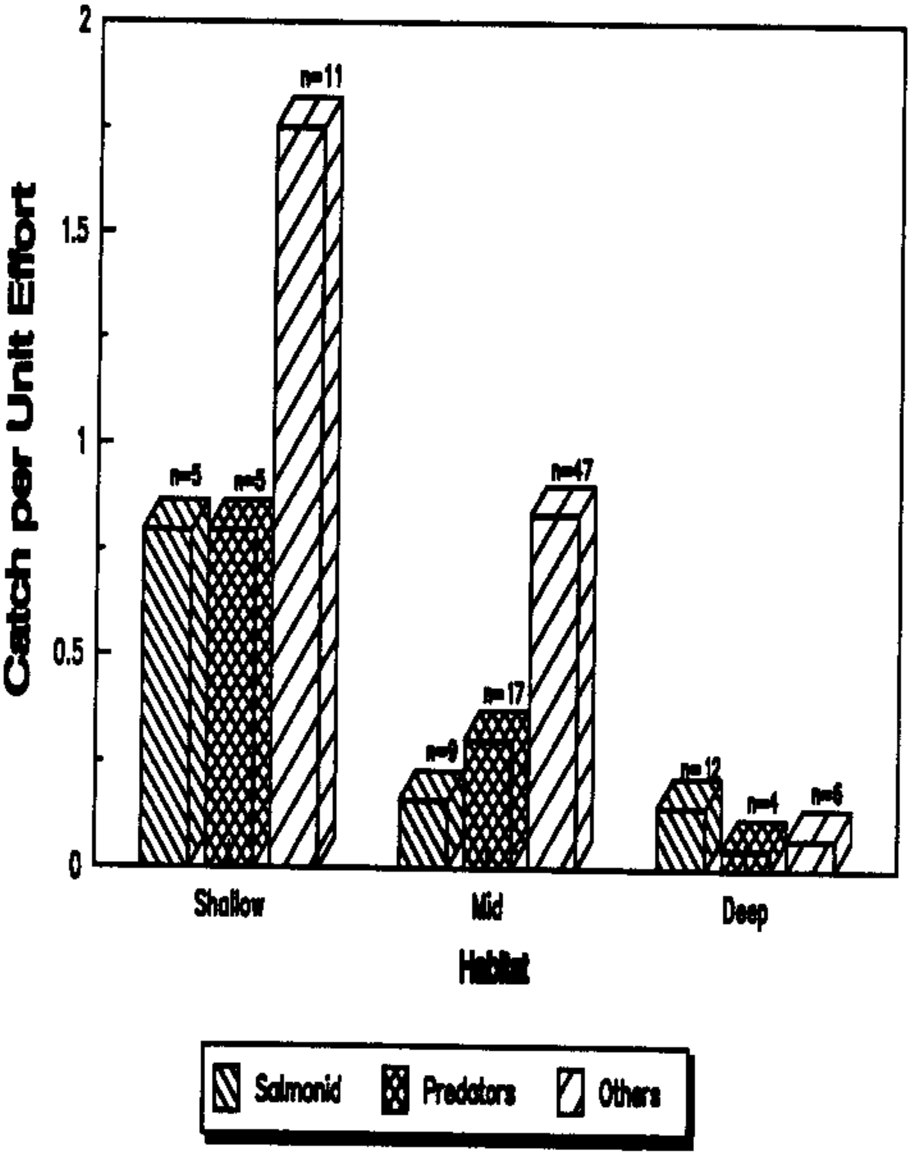


Figure 96. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20'), mid-depth (20-60') and deep water (>60') habitat in the lower (RM 109-114) section of Lower Granite Reservoir, Washington, during the night in the spring and summer seasons, 1989.

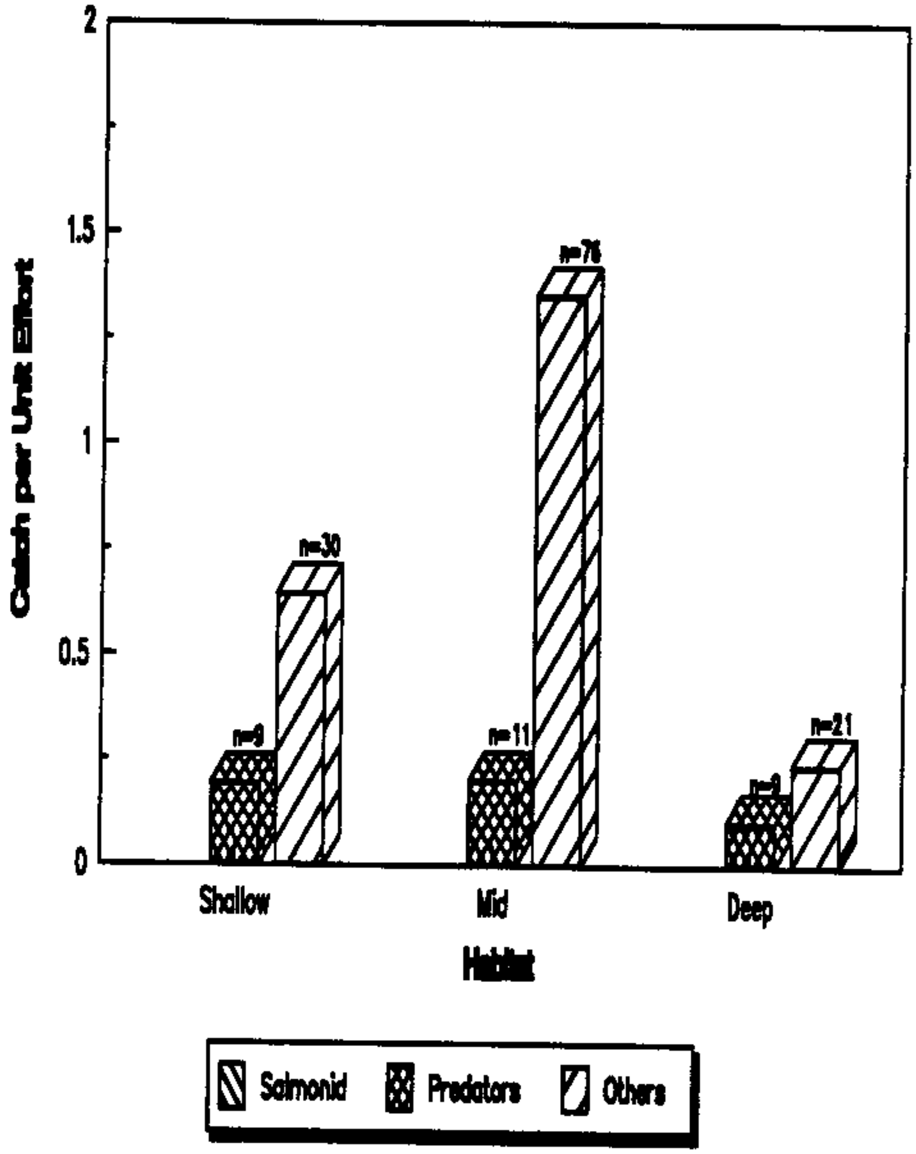


Figure 97. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20'), mid-depth (20-60') and deep water (>60') habitat in the middle (RM 116-125) section of Lower Granite Reservoir, Washington, during the day in the spring and summer seasons, 1989.

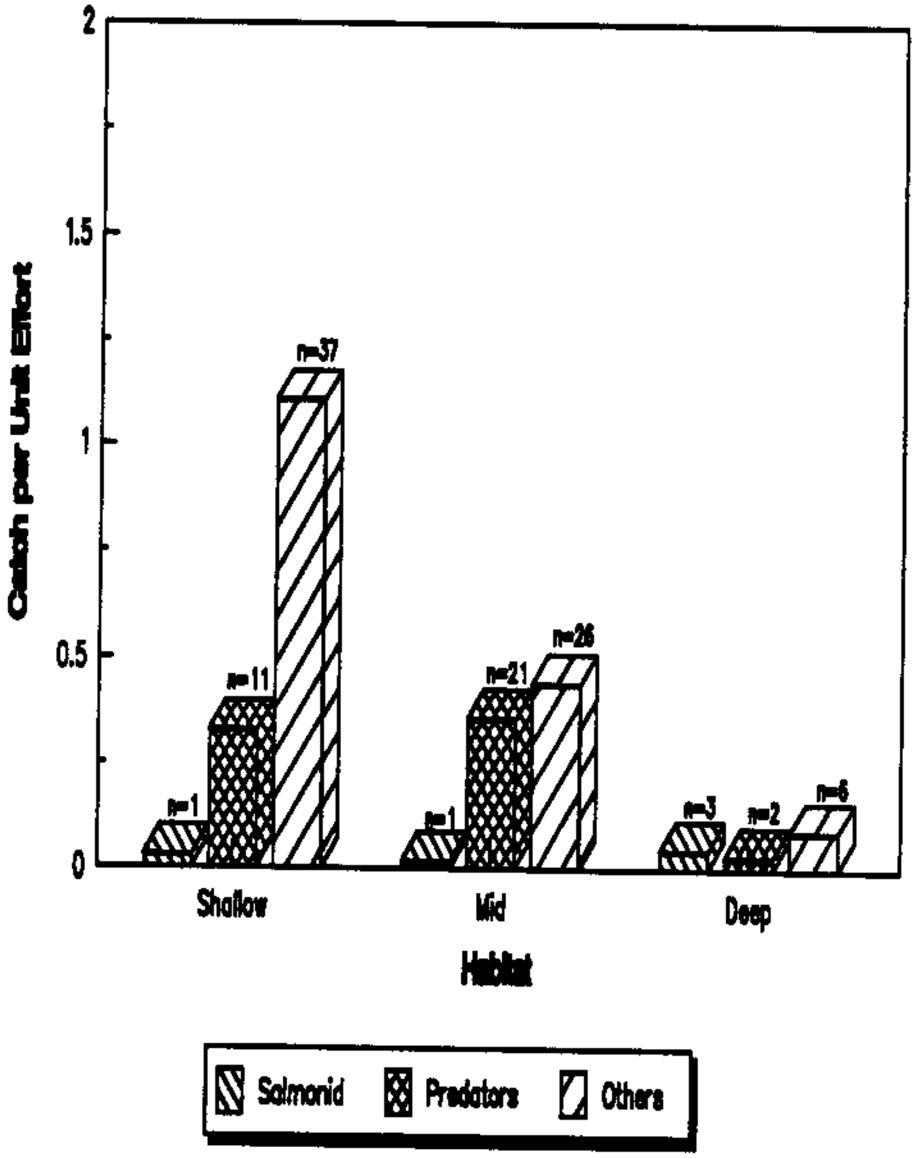


Figure 98. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20'), mid-depth (20-60') and deep water (>60') habitat in the middle (RM 116-125) section of Lower Granite Reservoir, Washington, during the night in the spring and summer seasons, 1989.

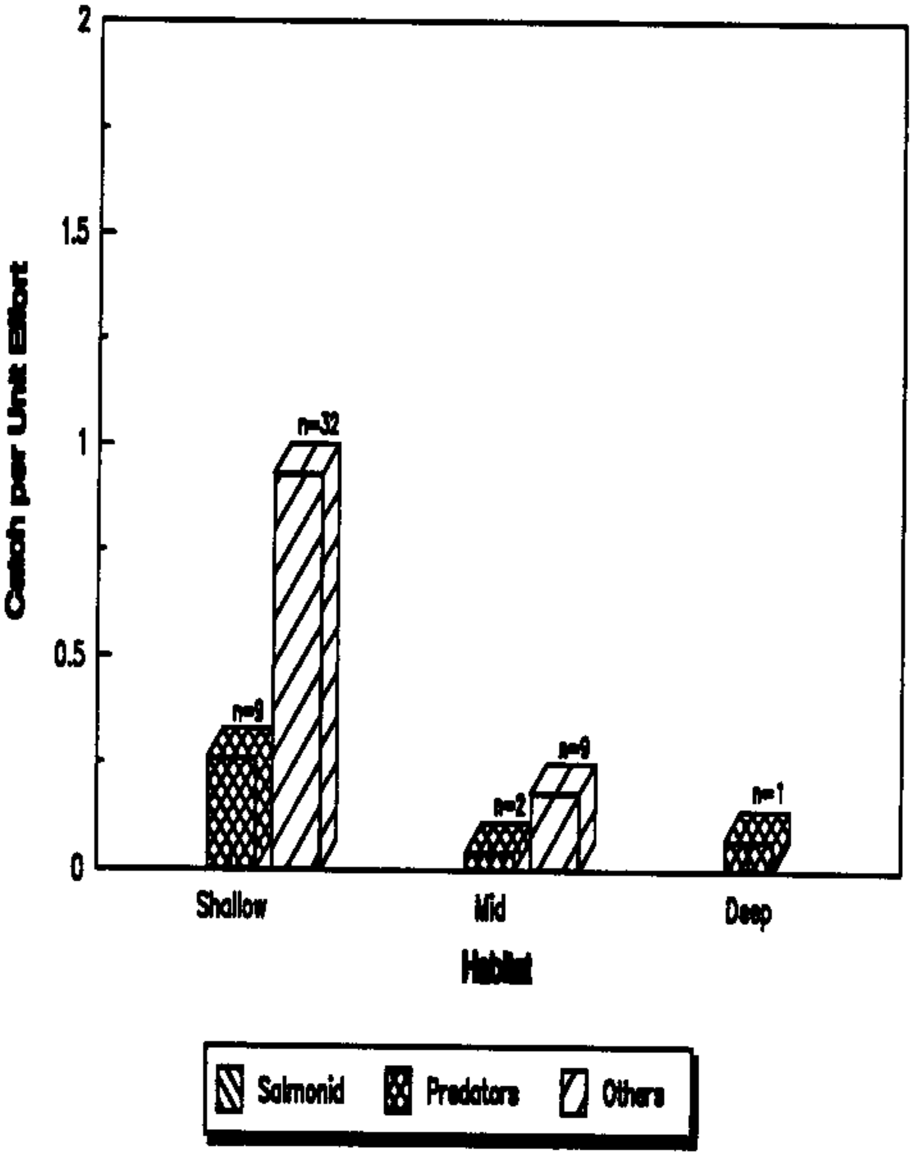


Figure 99. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20′), mid-depth (20-60′) and deep water (>60′) habitat in the upper (RM 127-134) section of Lower Granite Reservoir, Washington, during the day in the spring and summer seasons, 1989.

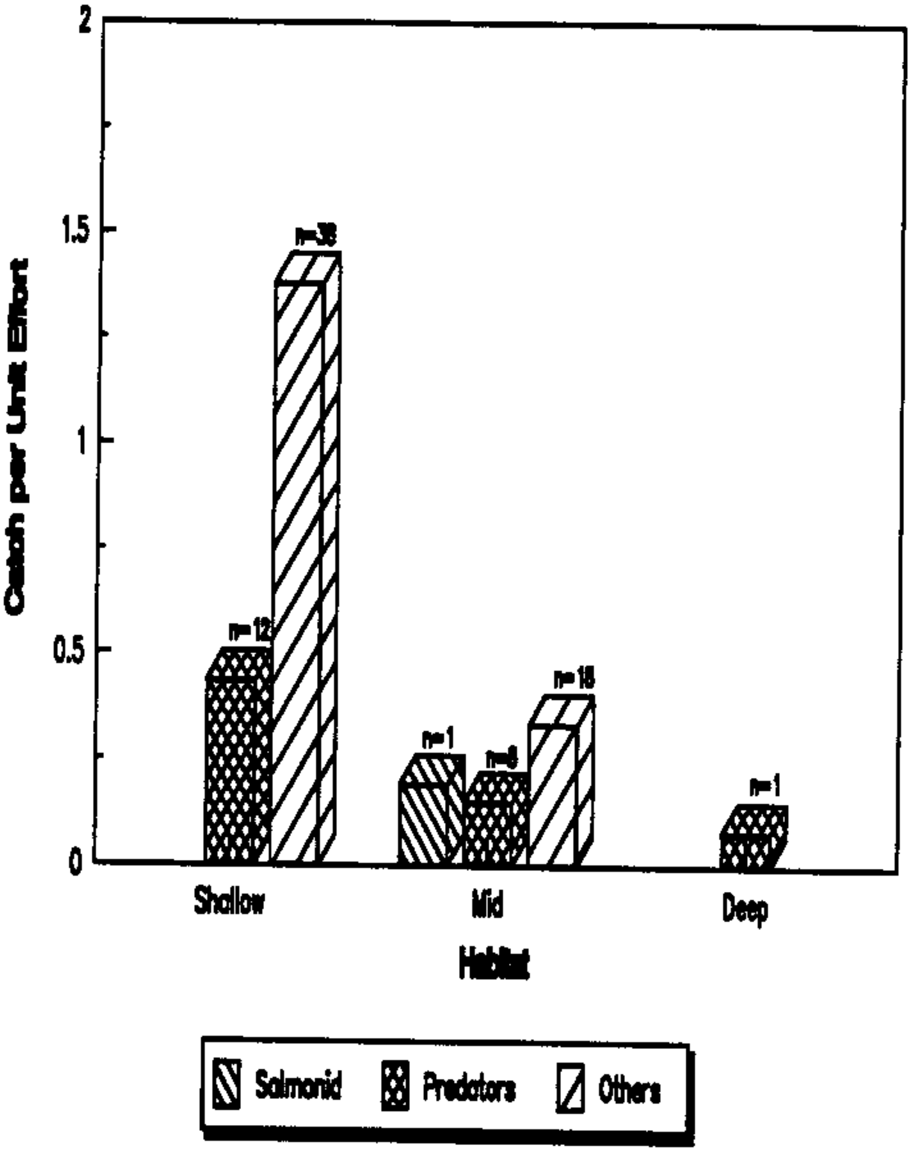


Figure 100. Catch per unit effort comparisons based on vertical and horizontal gillnetting for species groupings of salmonids, predators and "others" for shallow (<20'), mid-depth (20-60') and deep water (>60') habitat in the upper (RM 127-134) section of Lower Granite Reservoir, Washington, during the night in the spring and summer seasons, 1989.

STATISTICAL COMPARISONS AND BEST ESTIMATES OF ABUNDANCE

Results of our MANOVA indicated that species groupings were valid and that the predators, "others" and salmonids should be analyzed separately. Results of an ANOVA indicated that habitat was a significant variable for predators and other species although time, reservoir location, and season were not significant. As a result these variables were pooled to provide the best estimate of abundance. Predator abundance was 21.8% (95% Bound 17.8-25.8%) in shallow water, 24.3% (95% Bound 16.4-32.2%) for mid-depth waters, and 21.8% (95% Bound 7.1-36.5%) in deep waters. Other species were 76.8% (95% Bound 72.2-81.4%), 73.8% (95% Bound 64.8-82.8%), and 72.4% (95% Bound 0.21-100%) in shallow, mid-depth, and deep water habitats, respectively.

The four way interaction between time, habitat, reservoir location, and season were significant which precluded assessment of the main effects. As a result of these analyses and the fact that salmonids are generally present in highest abundance during the spring (although their catchability increases as they grow), we determined that 8.5% (95% Bound 0.7-16.3%) of the targets were salmonids during the spring throughout Lower Granite Reservoir.

DISCUSSION

The ground truthing data needs to be cautiously examined. For example, during spring and summer, velocities were often too high to fish vertical nets in narrow channels. Horizontal nets could be adequately anchored but vertical nets afforded excessive resistance. We believe that our fall estimates of predator and "other" fish abundance were the best, but statistical analyses of CPUE indicated no difference in abundance by seasons.

We found wide variation in CPUEs among the species groups, locations and habitats. Although mean CPUE was often high, wide variances precluded detecting significant differences in all variables but habitat. Regardless, we believe that the mean estimates of abundance of "others" and predators are probably representative although salmonid abundance is minimal. Our gill nets had the smallest mesh size of 1 1/4 inch (3.2cm) mesh which means most of the smolts were not sampled because of their smaller size. Even in previous years (Bennett and Shrier 1986; Bennett et al. 1988), when the smallest mesh size was 1/2 inch (1.25cm), few salmonids were collected. Ground truthing in 1989, collected the larger juvenile steelhead and no chinook salmon which grossly underestimated the salmonid abundance.

Our best estimates of predator abundance indicated that they were from 21.8-24.3% of the fish community. Bounds (95%) on these estimates were tight with the exception of deep waters where they were wide because fewer fish were collected overall and catches were variable.

OVERALL DISCUSSION

Effects of in-water disposal on the fish and benthic communities based on analysis of data collected during the second year of monitoring have been scattered without a clear suggestion of either a strong positive or negative benefit to Lower Granite Reservoir. Fish community relative abundance has changed little as a result of the in-water disposal. We collected over 17,500 fish in 1989 and have confidence in our estimates of relative abundance.

The size composition of the fish community has changed little in the last few years. In general, during spring, summer and fall, modal size of northern squawfish was smaller at the disposal and one shallow reference station than at mid-depth and deep water stations. A few larger smallmouth were collected at mid-depth and island disposal stations than at reference stations, although numbers were small, which suggests a small but possible benefit to the resident fishery in Lower Granite Reservoir.

Changes in fish abundance were scattered and few were related to in-water disposal. Lowest catch rates at night were at the shoreline side of the island followed by the adjacent reference station. During the daytime, juvenile steelhead were collected in similar abundance in the lower reservoir reference stations as at the channel-side of the island which suggests that the island may provide favorable "holding" habitat for steelhead during the daytime. No other differences were found in littoral fish abundance during 1989 which could be linked to in-water disposal activites.

A few temporal changes in littoral abundance of fishes has occurred but these are probably more related to hatchery releases and rates of migration through the reservoir, as in steelhead, than to the benefits or disadvantages of in-water disposal. Decreases in adult and subadult may be related to mortality from food habits sampling and possibly favorable years of spawning and rearing of smallmouth bass that may consume smaller squawfish.

Other temporal changes in littoral abundance have been insignificant. Highest catch rates of steelhead were in 1988 followed by 1989 and 1987 presumably related to flow conditions through Lower Granite. Catch rates of northern squawfish in littoral areas increased from 1988-1989; most of these fish are juvenile in the 40-100 mm range. These differences, however, were not associated with in-water disposal but probably our removal activites for predator food habits analysis that may have indirectly increased survival of juveniles by increasing mortality of adults. Smallmouth bass abundance was generally higher during the daytime in 1988 than in 1989 but vice-a-versa during the night which probably reflect differences in size distribution as the assessments made at night generally reflect subadult and adult abundance, while those made during the daytime reflect young-of-the-year abundance. These changes in smallmouth bass abundance, however, have not been linked to in-water disposal activities.

Pelagic fish abundance varied seasonally and among species. White sturgeon are far more abundant than earlier monitoring studies (Bennett and Shrier 1986; Bennett et al. 1988; Bennett et al. 1990) indicated. Although disposal activites were conducted downstream, sturgeon abundance at the deep-water reference station was high and apparently unaffected by downstream disposal.

Abundance of the large pelagic predators, channel catfish and northern squawfish, at disposal stations during the three seasons of 1989 was not different than at shallow and mid-depth reference stations. The trend in catch rates of channel catfish has been down although we have not found any relationship with in-water disposal in Lower Granite Reservoir.

Larval fish abundance was highest at shallow reference stations but differed between shallow and open water samples. Statistical comparisons of abundance were not possible because of wide confidence intervals but predator production was consistently higher in shallow water at shallow reference stations than disposal stations. However, pelagic larval sampling indicated that the backwater behind the island was an important rearing area for young squawfish although their abundance was of short duration based on our biweekly sampling. Highest abundance of larval squawfish of any station was station 11, a shallow reference station known to support high populations of squawfish (Bennett and Shrier 1986). Both of these areas are very similar in habitat; shoreline gradient is gentle sloping, sandy substrate, and is relatively shallow. These backwater areas can provide suitable rearing habitat for young-of-the-year squawfish (Beamesderfer 1983).

Probably the most significant finding to date is that benthic community standing crops are low compared to some other reference stations. However, the adjacent reference station to the disposal stations also has low community abundance. These reference and disposal stations generally have sandy substrate, substrate known to be low in benthic biomass (Bennett and Shrier 1986). Further analysis of the benthic community indicates that the chironomid biomass of the interior island station is highest followed by the two shallow and mid-depth reference stations.

From a fish food standpoint, total community biomass is probably not the most important measure. The biomass and numerical density of chironomids is important because they are important food items of downstream migrating smolts and resident fishes (Bennett and Shrier 1986; Bennett et al. 1988). Therefore, although total benthic community biomass is low at disposal stations, fish food abundance is comparable and even high relative to reference stations.

Recolonization of disposal areas occurred within three months and sampling results in 1989 suggest that no significant change in the dynamics of the benthic community has occurred over the 15 month period. Our results also have shown some significant decreases in the benthic community at reference stations. The reason for these changes is unclear but may indicate natural variation in benthic abundance in Lower Granite.

Results of the 1989 ground truthing for the hydroacoustical work provided information on fish community abundance. To reduce variation, CPUEs were calculated on groups such as salmonids, predators and "others". Results of the multivariate analysis of variance indicated that this breakdown was appropriate. This led to analysis of variance of CPUEs by habitat, season, time-night or day, location in Lower Granite Reservoir, which showed that habitat was the only significant effect for predator and other fishes. Another analysis of variance indicated that habitat was indeed highly significant ($P<0.0001$) in affecting the abundance of these two groups. Therefore, seasonal comparisons by reservoir section (upper, middle, and lower) were not meaningful because of the wide variation in CPUE that obscured finding significant differences in these main effects. Our best comparison consisted of pooling the seasons, and comparing CPUE by species groupings among depth habitats. These comparisons show that "other" species are about 3-4 times more abundant than predators in shallow water, regardless of reservoir location, 2-3 times more abundant in mid-depth waters and about equal in deep waters. CPUEs for these two groups generally were statistically different. Because of the wide variation in CPUE, a precise estimate of the number of predators within Lower Granite Reservoir by seasons, location in the reservoir, and depth habitat is not possible.

The abundance of salmonid fishes was underestimated because of the mesh size of gill nets and their avoidance. Only larger steelhead juveniles were consistently sampled by gill nets. Our estimate of 8.5% is a minimum estimate. The wide bounds on the estimate (0.7-16.3%) are indicative of the high variation.

The variation in the estimates of abundance from ground truthing were wide but not unexpectedly. Lower Granite Reservoir has in excess of 20 species that range in abundance from <1.0-30% which suggest that variation will probably be high in comparison to systems with less than five species but other factors such as high flows contributed also. Grouping the fishes into the three general categories helped reduce some of the variation.

In summary, results of Year-2 monitoring show neither strong positive nor negative impacts from the in-water disposal in Lower Granite Reservoir. Few temporal changes in the fish and benthic communities have been found and those that have been found are probably balanced in terms of positive and negative impacts. Year-3 sampling will provide another years' data and provide a clearer picture of the impacts of in-water disposal in Lower Granite Reservoir.

REFERENCES

Beamesderfer, R.C. 1983. Reproductive biology, early life history, and microhabitat of northern squawfish (*Ptychocheilus oregonensis*) in the St. Joe River, Idaho. M.S. Thesis. University of Idaho, Moscow.

Bennett, D.H., P.M. Bratovich, W. Knox, D. Palmer, and H. Hansel. 1983. Status of the warmwater fishery and the potential of improving warmwater fish habitat in the lower Snake Reservoirs. Completion Report No. DACW68-79-C-0057. U.S. Army Corps of Engineers, Walla Walla, Washington, USA.

Bennett, D.H. and F.C. Shrier. 1986. Effects of sediment dredging and in-water disposal on fishes in Lower Granite Reservoir. Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., L.K. Dunsmoor, and J.A. Chandler. 1988. Fish and benthic community abundance at proposed in-water disposal stations, Lower Granite Reservoir. Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., J.A. Chandler, and L.K. Dunsmoor. 1990. Lower Granite Reservoir in-water disposal test: Results of the fishery, benthic and habitat monitoring program-Year-1 (1988). Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Labolle, L.D., Jr., H.W. Li, and B.C. Mundy. 1985. Comparison of two samplers for quantitatively collecting larval fishes in upper littoral habitats. Journal of Fish Biology 26 (2):139-146.

Pennak, R. W. 1987. Freshwater invertebrates of the United States. Second Edition. John Wiley and Sons. New York, New York, USA.

Shuter, B.J., J.A. MacLeon, F.E.J. Fry and H.A. Regier. 1980. Stochastic simulation of temperature effects on first-year survival of smallmouth bass. Transactions of the American Fisheries Society 109: 1-34.

Webb, T.M., N.C. Sonntag, L.A. Greig, and M.L. Jones. 1987. Lower Granite Reservoir in-water disposal test: Proposed monitoring program. Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.