MONITORING FISH COMMUNITY ACTIVITY AT DISPOSAL AND REFERENCE SITES IN LOWER GRANITE RESERVOIR, IDAHO-WASHINGTON YEAR 6 (1993)

by

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EXECUTIVE SUMMARY

Completion of the Lower Granite Lock and Dam Project on the Snake River in 1975 provided electrical power production, flood control, navigation and recreation to the eastern Washington-west central Idaho areas. Annual sediment inflows from upstream sources contribute about 2.3 million cubic yards (2.1×10^6 m^3) of fine substrate annually to the Lower Granite system that has necessitated dredging and in-water disposal downstream of river mile 120 (RM 120) as a management alternative.

Dredging began in 1986 with land disposal and experimental in-water disposal was initiated in 1988. Three in-water disposal sites were examined; in 1988 a mid-depth site originally 6.1 to 12.1 m (20-40 ft) deep was modified to a depth of 1.8 to 3.6 m (6-12 ft), thereby creating an underwater plateau; in 1989 an island was created immediately downstream of the underwater plateau; and in 1992, the third type of in-water disposal alternative, a deep water disposal site was built. Monitoring of the fish and benthic communities began in 1988 and continued through 1993. This report provides information on the results of monitoring the fish and benthic macroinvertebrate communities and utilization of these habitats in year 6 (1993) and provides and overall summary of results from the 6 years of study.

OBJECTIVES

1. *To monitor abundance of juvenile and adult predators with special emphasis on northern squawfish Ptychocheilus oregonensis at in-water disposal sites and compare with those of reference sites;*

2. *To provide a second year of monitoring fish utilization and characterize habitat at the newly constructed deep water disposal site;*

3. *To monitor salmonid abundance and habitat utilization at reference and disposal sites in Lower Granite Reservoir;*

4. *To assess movements and habitat utilization of white sturgeon Acipenser transmontanus in Lower Granite Reservoir with emphasis on deep water habitat downstream from RM 120;*

5. *To assess subyearling chinook salmon Oncorhynchus tshawytscha abundance and habitat utilization at disposal and reference sites in Lower Granite Reservoir;*

6. *To assess biotic components associated with in-water disposal including macrophyte development including utilization and interactions with fish and zooplankton abundance; and*

7. *To assess patterns of fish community abundance and composition in Lower Granite Reservoir from 1985 through 1993.*

STUDY AREA

Eleven sampling stations were used to monitor fish abundance during 1993 in Lower Granite Reservoir. Stations sampled to evaluate the use of dredged material to enhance habitat included stations 1, 2, 4 and 7. Stations 3, 5, 9, 10 and 11 were shallow reference stations. To assess subyearling chinook salmon abundance, we stratified the reservoir into habitat types and randomly sampled within each habitat type. White sturgeon abundance was determined from sampling along nine transects.

Objective 1. To monitor abundance of juvenile and adult predators with special emphasis on northern squawfish at in-water disposal sites and compare with those of reference sites.

We used gill nets, beach seines, electrofishing and half-meter plankton nets and a hand-drawn beam trawl during 1993 to make representative fish collections in Lower Granite Reservoir. Gill nets were used to assess the relative abundance of potential predators and white sturgeon in pelagic waters. No surface trawling was conducted in 1993 to assess pelagic salmonid abundance. Beach seining and electrofishing were used to sample shallow stations during diurnal and nocturnal hours, respectively. Plankton nets and a beam trawl were used to estimate larval predator abundance and distribution.

Sampled larval fishes were preserved and later identified to species and measured. All fish larger than larval size were identified to species, measured to total length (mm) and released immediately after data collection. Adult salmonid fishes were released immediately without being removed from the water.

A total of 7,512 fishes representing 21 species and 3 genera was collected at disposal (1, 2, 4 and 7) and reference (3, 5, 6, 8, 9, 10 and 11) stations during 1993 in Lower Granite Reservoir. The highest number (5,256) of adult and subadult fishes was collected from 1 April through 30 June, the spring sampling interval. A total of 627 subadult and adult fishes was collected during summer and 1,629 during fall 1993.

Largescale sucker *Catostomus macrocheilus* were the most abundant species sampled during spring 1993 accounting for 42.1% (n=2,218) of the fishes collected. Next in abundance was smallmouth bass *Micropterus* *dolomieu* (12.4%; n=651) followed by juvenile chinook salmon (8.3%; n=435), chiselmouth *Acrocheilus alutaceus* (6.6%; n=350) and northern squawfish (5.4%; n=284).

The highest numbers of juvenile and adult predator fishes, smallmouth bass and northern squawfish, sampled during spring by all gear types were collected from shallow reference stations 3 and 9 (n=152). Abundances of smallmouth bass and northern squawfish at shallow disposal stations 1 and 2 were generally variable from 13.4 to 2.0%.

During the summer sampling interval, 1 July through 30 September, 1993, northern squawfish abundance was highest (35.6%, n=223) followed by smallmouth bass (28.5%, n=179) and largescale sucker (17.1%, n=107). Catches of juvenile salmon and steelhead *O. mykiss* were low during summer 1993. The highest number of predators was collected at reference station 11 during summer, although numbers collected were generally low as a result of reduced sampling because of the 1973 Endangered Species Act restrictions.

During the fall 1993 sampling interval (1 October through 31 October) largescale sucker (63.7%; n=1,038) dominated the catches followed by yellow perch *Perca flavescens* (7.2%, n=118). Abundance of predators was highest at reference stations 9, 3 and 5 during fall.

Length distributions of fishes varied by gear type. Generally, gill netting sampled large, beach seining sampled small and electrofishing sampled intermediate sized fishes. Smaller fishes generally were sampled at shallow stations and larger fishes were sampled at mid depth and deep water stations.

The abundance of channel catfish *Ictalurus punctatus* based on gill net collections during 1993 varied little among stations, although seasonal differences in catch/effort were found. Among year comparisons in catch/effort indicated higher abundance in 1992 and 1993 than other years, although differences from other years were not all statistically different.

Night and daytime catches of smallmouth bass by electrofishing and beach seining showed few seasonal differences in catch/effort with few statistical differences among stations. Since 1989, few statistical differences in catch/effort by beach seining and electrofishing have been found among stations and years, although catch/efforts at disposal stations sampled by electrofishing were statistically lower than reference stations. Abundance of large smallmouth bass based on catch/efforts by gill netting was generally similar among stations and years.

White sturgeon were collected at reference and disposal stations in 1993. Catch/efforts of white sturgeon at deep reference station 8 and deep disposal station 7 were significantly ($P < 0.05$) higher than other stations. Catch/efforts by gill netting since 1989 has been consistently high at reference station 8, but little consistency in catch/efforts from 1989 through 1993 was found.

Northern squawfish abundance in 1993 was low at disposal stations 7, 1 and 2 with a strong seasonal influence based on catch/effort by gill netting. Catch/efforts by beach seining and electrofishing showed intermediate abundance in 1993 at shallow disposal stations. Multiyear comparisons of catch/effort by gill netting suggested significantly lower abundance in 1992 and 1993 compared to previous years. Lower catch/efforts by beach seining and electrofishing showed no evidence of compensation associated with decreased adult abundance in Lower Granite Reservoir.

The highest abundance of larval predator fishes during 1993 was at reference station 11. About 9,800 larval fishes were collected in 1993. Larval catostomids dominated the catches in June and July, cyprinids dominated the August catches and centrarchids dominated samples in September.

Objective 2. To provide a second year of monitoring fish utilization and characterize habitat at the newly constructed deep water disposal site.

Gill netting in the evening and nighttime was used to sample the newly constructed in-water deep disposal station 7 (RM 119.0) during April, May, June and October (Objective 1). Sampling times were altered to comply with ESA requirements.

Macrohabitat characteristics of depth and bottom topography were assessed using an Eagle Mach I echosounder by Lowrance (single transducer recording echosounder). Numerous transects were conducted to assess the size and slopes of the area. Shoreline morphometry and reservoir width were obtained from the National Oceanic and Atmospheric Administration (NOAA) Nautical Chart 18548 (Washington - Idaho Snake

River, Lower Granite Reservoir). Shorelines were drawn on Freelance 4.1 to scale from the NOAA nautical chart and depths recorded at points along each transect where an appreciable change in depth occurred.

Depth changed in 1993 as the dredged material spread along the bottom from the original underwater island. Dredged material spread from east to west and the cross channel dimensions changed little.

Catch/efforts by gill netting for northern squawfish, smallmouth bass, channel catfish and white sturgeon were not statistically different between deep reference station 8 and deep disposal station 7 in 1993. No statistical annual differences between catch/efforts in 1992 and 1993 were found for white sturgeon, smallmouth bass and northern squawfish. Catch/effort for channel catfish was significantly higher at deep reference station 7 in 1993 than in 1992.

Objective 3. To monitor salmonid abundance and habitat utilization at reference and disposal sites in Lower Granite Reservoir.

Two-boat trawling was not conducted in 1993 as a result of equipment failure. However, no significant differences in catch/effort were found for juvenile chinook salmon abundance by surface trawling between 1989 through 1992 at any stations. During this 4-year period, we found higher catch/efforts at shallow reference station 5 and mid-depth reference station 6 compared to those at shallow disposal station 2 and mid-depth disposal station 4. Catch/effort for juvenile chinook was lowest at shallow disposal station 2, while that at mid-depth reference station 6 was highest.

Comparisons of catch/effort for juvenile steelhead by surface trawling from 1989 to 1993 indicated significant ($P<0.05$) differences among stations and years. Catch/efforts for juvenile steelhead were significantly ($P<0.05$) higher at shallow and mid-depth reference stations 5 and 6 than at shallow and mid-depth disposal stations 2 and 4. Catch/effort was highest at shallow reference station 5 and lowest at mid-depth disposal station 4.

Objective 4. To assess movements and habitat utilization of white sturgeon in Lower Granite Reservoir with emphasis on deep water habitat downstream from RM 120.

White sturgeon sampling was conducted along nine transects in Lower Granite Reservoir from April through June and October through mid-November 1993. Gill netting was the primary technique used to assess white sturgeon abundance, although setline sampling was also conducted in 1993. All captured sturgeon were measured, weighed, marked and released.

Approximately 2,329 gill net and 833 setline hours of effort were employed to capture 78 white sturgeon in Lower Granite Reservoir. Approximately 68% of all sturgeon (n=54) were collected in the upper portion of Lower Granite Reservoir between RM 127.0 and 137.1 Total lengths of white sturgeon sampled by gill netting ranged from 19.4 to 156.4 cm with a mean length of 63.1 cm. Approximately 96% of the sturgeon sampled were < 122 cm. No sturgeon > 168 cm were sampled during 1993.

Depths at which white sturgeon were collected ranged from 9 to 36.8 m (29.5-120 ft). Sturgeon were collected at a modal depth of 24 m (79 ft).

Catch/efforts were high for white sturgeon at RM 133.7 and 137.1. Higher flows in 1993 precluded sampling during early spring in areas upstream of RM 127. During spring, catch/efforts for sturgeon were low at all transects downstream of RM 127.

Objective 5. To assess subyearling chinook salmon abundance, habitat utilization and migration in Lower Granite Reservoir.

Subyearling chinook were collected by beach seining during 1993 using identical methods employed for juvenile predator sampling (Objective 1). Areas of concentration of subyearling chinook were identified based on stratified random sampling in various habitat types. Macrohabitat characteristics were taken. Population abundance and growth estimates were made.

A total of 331 subyearling chinook salmon was captured by beach seining between 10 April through 15 July, 1993 in Lower Granite Reservoir. No subyearling chinook salmon were collected in littoral areas after 15 July, 1993, about 2 months later than in 1992. Population abundance peaked on 2 June at 6,346 fish.

A total of 210 subyearling chinook salmon (83.5%) was captured over substrates that consisted of > 75% fines (< 2 mm in diameter). Four years of beach seining data indicated subyearling chinook in Lower Granite Reservoir exhibit a strong selection for habitats consisting primarily of sand and a moderate avoidance of both sand/talus and sand/cobble habitats. During 1993, 5% of subyearling chinook salmon were collected over rip-rap compared to 0% in previous years.

Growth rates of subyearling chinook salmon averaged < 1 mm/day. The overall rearing period in Lower Granite during 1993 was 100 days compared to 75 days in 1992. Littoral rearing in 1993 (96 days) was considerably longer than in 1991 and 1992, although the timing of migration from the shoreline coincided with about the same shoreline temperature (16°C). Flows in 1993 were considerably higher than in 1987 and 1992 when shoreline rearing peaked in mid-May. Shoreline rearing of subyearling chinook in Lower Granite Reservoir is closely linked to inflows; high spring inflows generally maintain low water temperatures. Water temperatures from 16 to 19°C coincide with the timing of subyearling chinook migration from the shoreline in Lower Granite Reservoir. Subyearling chinook are unable to bioenergetically maintain their body weight at about 18°C.

Objective 6. To assess biotic components associated with in-water disposal including macrophyte development including utilization and interactions with fish and zooplankton abundance.

Aquatic macrophyte growth and development were first observed during early July 1993. *Potamogeton crispus* and *P. filiformis* were the only two species of macrophytes collected throughout 1993. Macrophyte growth and development occurred between 0.76 and 1.0 m (2.5 and 3.28 ft) relative to 733 ft elevation, or minimum operating pool in Lower Granite Reservoir, whereas in 1992 macrophytes were found to 3.5 m.

Highest biomass of macrophytes was collected at reference station 10 followed by disposal station 2. Mean biomass (g/m^2 dry weight) of aquatic macrophytes was highest in mid-August. Mean biomass was generally about 1 g/m^2, a little lower than in 1992. Variability in macrophyte density was high among and within stations and, as a result, confidence intervals of biomass generally encompassed zero.

Zooplankton abundance was determined from the surface to 1 m deep from the six composite larval fish samples. Fourteen genera were collected; highest densities were collected on sampling dates of 27 August and 4 September, 1993. The highest zooplankton densities (846-915/L) were collected at shallow and mid-depth disposal stations. Zooplankton densities at reference stations 5 and 11 were low over the entire 1993 sampling period.

Densities of *Daphnia* spp. were the highest of all zooplankters collected. *Leptodora* spp. was second in abundance followed by *Sida crystallina* and *Latonopsis* spp. Abundances of these species generally followed those of the entire zooplankton community.

Objective 7. To assess patterns of fish community abundance and composition in Lower Granite Reservoir from 1985 through 1993.

We summarized patterns of fish community abundance at disposal and reference stations in Lower Granite Reservoir from 1989 through 1993 and examined persistence and stability from 1985 through 1993. We assessed effects of perturbations in the reservoir (inflow of low temperature water, minimum operating pool operations, variable flow years and the 1992 test drawdown) on patterns of fish community abundance. Resident fishes were assigned feeding guilds and then compared between reference and disposal stations and among years.

Trends in percent tolerant fishes were similar among shallow disposal and reference stations during 1989 through 1993. The proportion of tolerant species increased at disposal station 7 in 1993, primarily a result of high carp *Cyprinus carpio* catches.

Feeding guilds varied differently through time. Insectivores and omnivores showed no selection for disposal or reference stations whereas herbivores and insectivore-piscivores were collected more frequently at reference than disposal stations. Feeding guilds varied similarly across years at disposal and reference stations.

Principal components analysis using a species*station data matrix accounted for the majority of the variation in species abundance patterns. Station loadings appeared related to station depths and were significantly correlated. Fish assemblages at mid and deep stations were more stable than those at shallow stations.

Resident fish assemblages at reference stations 5 and 9 exhibited stability from 1985 through 1993 with significant variation from year to year in total relative abundance. Carp, peamouth *Mylocheilus caurinus*, redside shiners *Richardsonius balteatus* and bridgelip suckers *Catostomus columbianus* exhibited declines while centrarchids exhibited increases in overall abundance.

Guild analysis indicated general increases in omnivorous fishes following 1985 and decreases in abundance of insectivore and insectivore-piscivore fishes. Trends in herbivore species were not found and their abundance was variable from 1985 through 1993.

DISCUSSION

Monitoring of the experimental in-water disposal alternatives as suggested at two dredging workshops was completed in 1993 (Webb et al. 1987). Monitoring of in-water disposal events was confounded in 1990, 1991 and 1992 by inflows of low temperature waters and an experimental test drawdown.

Juvenile anadromous salmonids were not consistently collected at any station in high abundance from 1989 to 1993. One hypothesis emanating from the planning workshop was that the in-water disposal areas might become overly attractive to salmonids and possibly inhibit "normal" migration. Our data do not support this hypothesis as habitat created by dredged material was not more attractive to juvenile salmonids. Abundance of juvenile steelhead in the reservoir during the sample period accounted for 5% of all fishes sampled compared to other years when few were collected was related to inflows. Low inflows as in 1992 resulted in numerous juvenile steelhead being trapped in Lower Granite Reservoir for a year.

Another concern was that the habitat created could become too favorable and result in residualization of smolts. Comparison of catch/effort by beach seining, electrofishing and two-boat trawling has indicated that smolts do not concentrate in the newly constructed habitats and any residualization in the reservoir is probably attributed to other factors (i.e. low flows as with juvenile steelhead in 1992 and 1987).

Shallow water predator numbers were generally higher at reference stations than at disposal stations. Reference stations 9, 3 and 10 supported the highest abundances of northern squawfish and smallmouth bass. Smallmouth bass abundance was also low at the island, based on electrofishing, whereas gill net data showed high abundance during spring. We attribute this high number to the "armored" rock face that attracts prespawning smallmouth bass.

The decrease in the northern squawfish population has probably been a result of the Sport Reward Program. Our catch/efforts by gill netting for 1992 and 1993 were the lowest of all years sampled indicating a reduction in population abundance. At the initiation of the Sport Reward Program, some biologists predicted that compensation could occur resulting in increased survival of juvenile squawfish and an increase in abundance. We have not seen increased catch/efforts of squawfish by beach seining and electrofishing, both techniques have shown success in sampling smaller squawfish. Although the number of salmonid smolts consumed by squawfish in Lower Granite Reservoir was similar to that in John Day Reservoir (Chandler 1993), our results indicated predation was not a major source of mortality in the reservoir (Bennett et al. 1993b).

Channel catfish abundance has been increasing in the last few years but has been lower at the disposal stations than reference stations. Catch/efforts were significantly higher at reference stations 5 and 6 than at the island, underwater plateau, and deep disposal station 7.

Several concerns expressed at the inception of the dredging and in-water disposal have been allayed from our monitoring. A principal concern was over creating habitat highly favorable for predators such as smallmouth bass and northern squawfish. As indicated, the squawfish population has not increased as a result of the disposal events and actually has decreased. The abundance of smallmouth bass has increased in Lower Granite Reservoir, but not as a function of in-water disposal, but changes in flow characteristics. Our data does not indicate the habitat created by in-water disposal contributed to changes in predator abundance.

Deep disposal and reference stations 7 and 8 were attractive to white sturgeon in 1992 and 1993. Catch/effort of white sturgeon was highest at station 7 in 1992 than the other reference and disposal stations, whereas in previous years, highest catches of white sturgeon at sampling stations occurred at deep reference station 8. In 1993, catch/effort of carp increased substantially at station 7.

Abundance of the more abundant resident fishes since 1989 has shown few changes. Numbers of adult, subadult and juvenile northern squawfish have not decreased in Lower Granite Reservoir since sampling began in 1985. Abundance based on gill net captures was significantly

(P < 0.05) higher at reference than disposal stations. Numbers of squawfish collected by beach seining have been variable but have generally declined since 1989. We have found no evidence of compensatory mortality.

Smallmouth bass abundance at the disposal stations has been generally stable and beach seining data showed fluctuations in abundance of smaller bass. Abundance of adult sized bass has generally stayed constant. Year class strength of bass seems to be inversely related to inflows.

Abundance of larval fishes has increased in Lower Granite Reservoir, but not as a result of the in-water disposal. Larval fish abundance was extremely high in 1991, 1992 and 1993 compared to 1989 and 1990. Larval fish abundance at the disposal stations, however has consistently been low. We attribute the increase in abundance to more stable water levels that occurred as a result of operating at minimum operating pool. No substantial increases in catch/effort for age 0 and age 1 northern squawfish by beach seining and electrofishing suggest that factors other than number of larval squawfish regulate the northern squawfish population in Lower Granite Reservoir.

Predation of salmonids by northern squawfish and smallmouth bass has been examined. Daily ration of salmonids by northern squawfish was about six times higher than in 1990 and 1991. Also during 1992, smallmouth bass consumed nearly 32,000 subyearling chinook salmon. This high level of consumption may be related to the 1992 test drawdown that reduced the crayfish population. The higher incidence of predation on juvenile salmonids by northern squawfish and smallmouth bass following the drawdown may be a result of decreased crayfish availability; crayfish are the most important food item of these predators.

Subyearling chinook salmon abundance in Lower Granite Reservoir in 1993 was generally higher than previous years. Nearly 7,000 subyearlings reared in Lower Granite Reservoir in 1993 compared to about 4,000 in previous years. Subyearlings exhibited strong preference for finer substrata with > 92% being sampled over sand and other fines < 2 mm. Subyearling chinook were sampled in habitats with similar shoreline gradients and substrata that were created at Centennial Island. No subyearlings were collected downstream of the island which may indicate a paucity of suitable habitat for them in the lower reservoir.

Macrophyte densities were low in 1992 and 1993 in comparison to other systems with abundant aquatic vegetation. Our observations suggested that the drawdown in the spring of 1992 and high inflows and low water temperatures adversely affected macrophytes. Macrophytes provide cover and fish food with higher invertebrate diversity and standing crops than in similar areas without macrophytes.

Community composition at disposal stations was similar to reference stations and did not exhibit significant variability in species abundance and composition during 1989 through 1993. We no found evidence that species richness or the percent tolerant species were different between disposal and reference stations. Fish community abundance and composition were more variable among shallow disposal and reference stations than mid-depth and deep stations, possibly reflecting their susceptibility to environmental disturbances.

Disposal of in-water sediments to create shallow water habitat in Lower Granite Reservoir has potential for increasing localized fish diversity. Shallow water habitats can provide spawning and rearing areas for warmwater fishes and might increase the abundance and availability of forage for insectivorous fishes, including outmigrating juvenile salmonids.

Creating mid and deep disposal sites provides an alternative for disposal, if management of a diverse resident fish fauna were not desirable. These disposal alternatives provided habitat that was inhabited by few species in low relative abundance to shallow water habitat.

Interestingly, high impact environmental changes such as inflows of low temperature water, the 1992 test drawdown, and operating at minimum operating pool did not destabilize the resident fish community. The fish assemblages at shallow stations 5 and 9 have been persistent and well structured since 1987.

Although community structure was generally stable, abundance of some species changed. Reduced abundances in juvenile and adult redside shiners, peamouth, carp and northern squawfish were found along with increases in smallmouth bass, pumpkinseed *Lepomis gibbosus* and crappie *Poxomis annularis*. The only relationship between species abundance and environmental factors was station depth. The pattern of reservoir inflows the previous year and total relative abundance was interesting.

Abundances of certain species (redside shiner, bridgelip sucker and northern squawfish) were positively correlated with inflows, while that of pumpkinseed was negative. High average flows were correlated with water turbidity which could alter species distribution, reduce predation efficiency and increase habitat volume.

Use of dredged material has potential to create more shallow water habitat in Lower Granite Reservoir. Creating more shallow water habitat could increase fish species richness, increase availability of food items to outmigrating yearling salmonids, and increase available rearing habitat for subyearling chinook. If managers have concerns for increased species richness, dredged material can be disposed of in mid to deep habitats with no apparent ill effects. These disposal stations were represented by few species and low overall abundance.

In summary, monitoring from 1989 through 1993 in Lower Granite Reservoir revealed several positive effects from the in-water disposal of sediment in the reservoir but no measurable negative effects. Increased benthic invertebrate abundance in disposal areas and possibly their increased availability to fishes and increased fish diversity and rearing habitat for subyearling chinook salmon are apparent benefits to the system. Increasing availability of potential food items for subyearling and possibly yearling chinook salmon in the lower portion of Lower Granite Reservoir seems to be the most promising beneficial use of dredged materials.

INTRODUCTION

Sediment deposition in Lower Granite Reservoir, Idaho-Washington, has concerned managers over the ability of the levee system on the Snake and Clearwater rivers to protect the cities of Lewiston, Idaho and Clarkston, Washington. Lower Granite Reservoir as part of the Lower Granite Project provides electrical power generation, flood control, navigation and recreation. Sediment inflow during spring runoff is adversely affecting these uses and the safety of the project by threatening the integrity of the levee system. Estimates of sediment deposition by U.S. Army Corps of Engineer personnel have indicated that nearly 2.3 million cubic yards ($2.1x10^6$ m^3) annually enter the confluence of the Snake and Clearwater rivers at the upper end of Lower Granite Reservoir.

A number of alternatives are being evaluated to alleviate the accumulation of sediment, although dredging and in-water disposal are immediate solutions. Sediment dredging was initiated in 1986 with land disposal (Bennett and Shrier 1986). In 1988, 1989 and 1992 experimental in-water disposal of sediment was made approximately 20 miles (32.2 km) downstream of the confluence of the Snake and Clearwater rivers in Lower Granite Reservoir to construct an island at river mile 120 (RM 120) and an underwater plateau at mid-depth (20-60 ft; 6-18 m) located at RM 119.5.

Historically, dredged material has been considered a liability, however use of dredged material can be beneficial. Monitoring of fish and benthic community responses to sediment disposal has been conducted since 1988 (Bennett et al. 1990). Shallow water habitat only constitutes about 10% of the surface area in Lower Granite Reservoir. The importance of shallow water habitat in Lower Granite Reservoir has been attributed to short-term foraging by yearling anadromous fishes, such as chinook salmon *Oncorhynchus tshawytscha*, steelhead trout *O. mykiss* and early rearing by subyearling chinook salmon (Bennett and Shrier 1986; Bennett et al. 1988, 1990, 1993a, 1993b, 1994d). In 1990, Bennett et al. (1993a) found that about 10% of all subyearling chinook salmon collected in Lower Granite Reservoir were collected from shorelines adjacent to the island (Centennial Island).

Fishery managers are concerned with in-water disposal and the potential for increased abundance of predators as a result of providing suitable habitat for their production. Initial findings have indicated catch rates of larval and juvenile predators at experimental disposal sites have not been elevated above those at reference sites (Bennett et al. 1989, 1990, 1993a, 1993b, 1994d). A majority of the larval northern squawfish *Ptychocheilus oregonensis* rearing occurs in the upper portion of Lower Granite Reservoir near RM 135, and numbers collected from experimental in-water disposal sites have generally been statistically ($P < 0.05$) similar to those at reference stations (Bennett et al. 1993b). Changes in the fish community have been related to annual differences in physical factors and reservoir operations but not from the in-water disposal of dredged materials.

As a result of these concerns over potential habitat and aquatic community changes, the final year of this project was funded to continue evaluation of the in-water disposal of dredged material.

OBJECTIVES

1. To monitor abundance of larval, juvenile and adult predators with special emphasis on northern squawfish at in-water disposal sites and compare with those of reference sites;

2. To provide a second year of monitoring fish utilization and characterize habitat at the newly constructed deep water disposal site;

3. To monitor salmonid abundance and habitat utilization at reference and disposal sites in Lower Granite Reservoir;

4. To assess movements and habitat utilization of white sturgeon *Acipenser transmontanus* in Lower Granite Reservoir with emphasis on the deep water habitat downstream from RM 120;

5. To assess subyearling chinook salmon abundance and habitat utilization at disposal and reference sites in Lower Granite Reservoir;

6. To assess biotic components associated with in-water disposal including macrophyte development including utilization and interactions with fish and zooplankton abundance; and

7. To assess patterns of fish community abundance and composition in Lower Granite Reservoir from 1985 through 1993.

STUDY AREA

Eleven sampling stations in Lower Granite Reservoir were used to monitor fish abundance during 1993 (Objective 1; Figure 1). Stations 1, 2, 4 and 7 were in areas created by in-water disposal of dredged material. Stations 3, 5, 6, 8, 9, 10 and 11 were classified as reference stations. Not all stations were sampled to fulfill each stated objective.

Specific locations of sampling stations follow:

Station	Location
1	RM 120.48-120.19: shallow disposal site with shoreline adjacent to Centennial Island created with dredge materials in 1989;
2	RM 120.48-120.19: shallow disposal site off the shoreline adjacent to Centennial Island created with dredge materials;
3	RM 120.48-120.19: shallow reference site with shoreline area inside the mid-depth site (on-shore);
4	RM 120.48-120.19: mid-depth disposal site that created the underwater bench made in 1988;
5	RM 127.0: shallow water reference site (SR2S in Bennett and Shrier 1986; LG2S in Bennett et al. 1988);
6	RM 111.5-112.0: mid-depth reference site (LG1M in Bennett et al. 1988);
7	RM 119.0: deep water disposal site (1988, 1989, 1992);
8	RM 120.5: deep water reference site;
9	RM 111.0: shallow water reference site (LG1S in Bennett et al. 1988);
10	RM 110.0: shallow water reference site on the south side of the reservoir; and

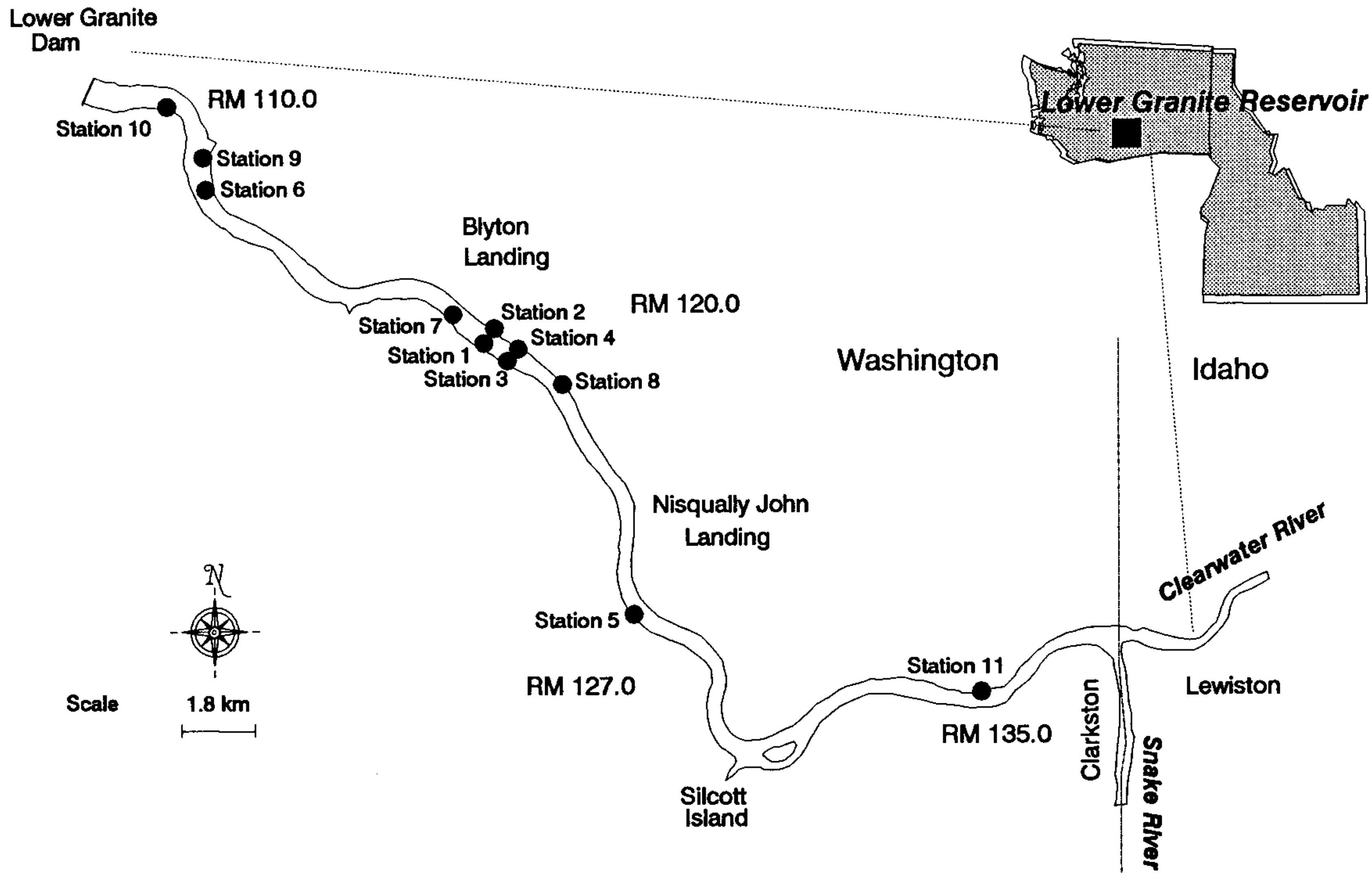


Figure 1. Map of sampling locations where adult, subadult, juvenile and larval fish abundance were assessed during spring, summer and fall 1993 in Lower Granite Reservoir, Idaho-Washington. ● indicates sampling station.

11	RM 135.0: shallow water reference site on the north side of the reservoir (LG5S in Bennett et al. 1988).

Random sampling locations were chosen to assess the relative abundance of subyearling chinook salmon in Lower Granite Reservoir (Objective 5). Lower Granite Reservoir was stratified into habitat types based on shoreline characteristics (rip rap, sand, talus, etc.) and location in the reservoir. Each stratum was beach seined using methods similar to those employed under Objective 1 for juvenile predator sampling.

A systematic gill net survey of 20 hydroacoustic transects used by Biosonics Inc. in 1989 to quantify fishes in Lower Granite Reservoir (Bennett et al. 1990; Thorne et al. 1992) was used to assess relative white sturgeon abundance (Objective 4). Preliminary information collected from the systematic gill net survey identified main channel and bench areas with low and high concentrations of sturgeon. Nine transects between RM 108.0 and RM 137.1 were randomly selected for additional gill net and setline sampling to compare locations with varying concentrations of sturgeon and associated habitat (Figure 2).

Transect	Location
R1S1	RM 108.0: transect is located 0.5 mile upstream from Lower Granite Dam;
R1S11	RM 110.5: transect 0.5 mile downstream of Wawawai Landing;
R1S17	RM 113.0: transect at Granite Point;
R1S29	RM 116.5: transect 1.4 miles upstream of Knoxway Canyon Bay;
R2S2	RM 117.7: transect 2.5 miles upstream of Knoxway Canyon Bay;

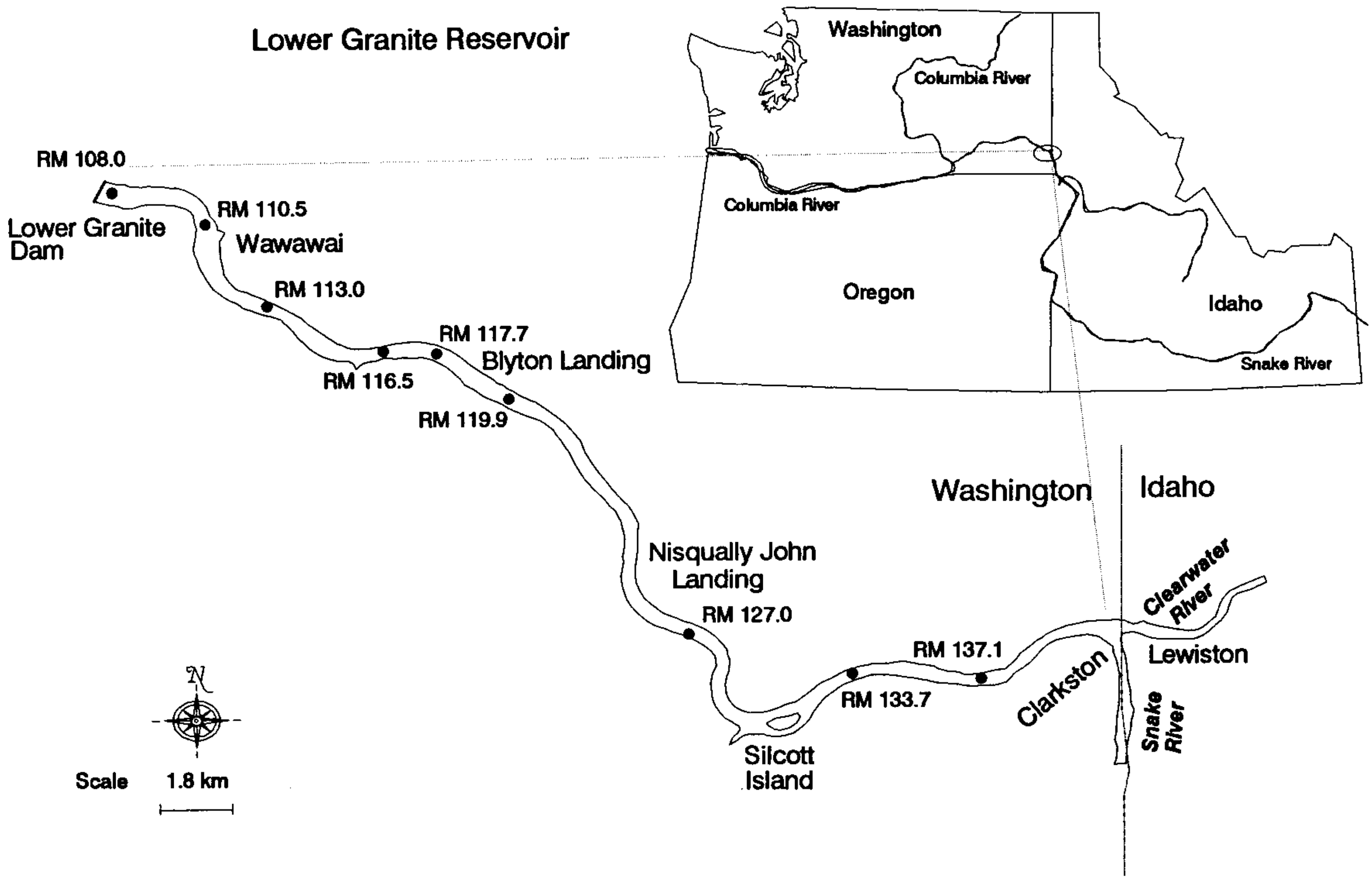


Figure 2. Map of river mile locations where white sturgeon were sampled during 1993 in Lower Granite Reservoir, Idaho-Washington. ● indicates sampling location.

R2S8	RM 119.9: transect 0.5 miles upstream of Blyton Landing;
R2S17	RM 127.0: transect 1.5 miles upstream of Nisqually John Landing;
R3S9	RM 133.7: transect 0.5 miles downstream from Port of Wilma; and
R3S12	RM 137.1: transect 0.2 miles downstream from Red Wolf Bridge.

Objective 1. To monitor abundance of larval, juvenile and adult predators with special emphasis on northern squawfish at in-water disposal sites and compare with those of reference sites.

METHODS

To assess abundance of juvenile and adult fishes, reduce sampling gear bias and make representative collections, we sampled by gill netting, beach seining and electrofishing during 1993 in Lower Granite Reservoir. Pelagic abundance of fishes was assessed by gill netting and littoral abundance was assessed by gill netting, beach seining and electrofishing. Half-meter plankton nets and a handbeam trawl were used to sample larval predator abundance.

Eight horizontal, multifilament gill nets 68.6 m x 1.8 m (225 ft x 6 ft) consisting of three graded panels with bar measurements of 3.8, 4.4 and 5.1 cm (1.5, 1.75 and 2.0 inches; Webb et al. 1987) were fished at stations 1, 2, 3, 4, 5, 6, 7 and 8. We sampled with gill nets from 1 April to 27 June when our efforts were curtailed to comply with the 1973 Endangered Species Act (ESA) concerns over potential mortality to upstream migrating endangered adult sockeye salmon *O. nerka*. Sampling with gill nets resumed during the fall effort on 1 October. Horizontal, multifilament gill nets 76.2 m x 1.8 m (250 ft x 6 ft) consisting of 5 graded panels with bar measurements of 5.1, 7.6, 10.1, 12.7 and 15.2 cm (2, 3, 4, 5 and 6 inches) were used to sample white sturgeon. Gill nets were set perpendicular to the shoreline and fished on the bottom for approximately 3 hours of daylight and 3 hours of dark for a total of 6 hours. We have found that catches are generally higher during the evening crepuscular period than other times during the day and night

(Bennett et al. 1988). Gill nets were checked every 2 hours at stations 1, 2, 3, 4 and 5 to avoid destructive sampling to salmonids and other fish species. A 3-hour schedule was used at mid-depth (6) and deep (8) reference stations and deep disposal station 7 because few salmonids have been collected at these stations. As in 1992, gill nets were numbered to further refine estimates of fish abundance. Individual numbering of the nets enabled us to use the net as a sampling unit compared to a net night used in previous surveys (Bennett et al. 1988).

A 30.5 m x 2.4 m (100 ft x 8 ft) beach seine with a 2.4 m^3 (8 ft^3) bag constructed of 0.64 cm (0.25 inch) mesh was used to sample fish along the shoreline at shallow stations 1, 2, 3, 5, 9, 10 and 11 (Figure 1). Beach seining was employed at biweekly intervals during the daytime in April, May and June and at monthly intervals during July, August, September and October. Three seine hauls were conducted at each station sampled. Standardized beach seine hauls were made by setting the seine parallel and approximately 15.2 m (50 ft) from shore with attachment lines and then drawing the seine perpendicular toward the shoreline. An area equivalent to 1,524 m^2 (5,000 ft^2) was sampled each haul.

Nighttime electrofishing was conducted by paralleling the shoreline, as close as possible, at shallow stations 1, 2, 3, 5, 9, 10 and 11 (Figure 1). Electrofishing was conducted bimonthly during April, May and June. All sampling by nighttime electrofishing was curtailed from 27 June to 15 September to satisfy ESA concerns over potential mortality to adult sockeye salmon migrating through the system. Electrofishing efforts resumed at monthly intervals during the fall sampling period. Electrofishing effort generally consisted of three periods of 5 minutes at each station. Two periods of 5 minutes at each station were used at shallow disposal stations 1 and 2 because of their small size. A constant output of 400 volts at 3-5 amps was found to adequately stun fish without causing mortality or visual evidence of injury.

All fish collected by the various gear types were identified to species and measured to total length (mm) and released, except adult salmonids were released immediately without being removed from the water.

Abundance of larval fishes was sampled biweekly from 23 May through 11 September, 1993 at stations 1, 2, 4, 5 and 11 (Figure 1). Two paired, half-meter plankton nets (19.7 in diameter) were towed for three minutes at the surface and at 1 m (3.3 ft) depth at a speed of approximately 1.5 m/s (4.9 ft/s). Larval towing was conducted at night to increase efficiency (Houde 1969; Isaacs 1964; Netsch et al. 1971). A total of three paired samples (n=6) was taken at each station during each sampling date. All samples were filtered through a 1.0 mm (0.004 inch) mesh screen and preserved immediately in a 10% formalin solution.

Larval fish abundance adjacent to the shoreline and during diurnal periods was assessed by using a custom built, handbeam trawl (Labolle et al. 1985). Shallow stations 1, 2, 5 and 11 were sampled by handbeam trawl at biweekly intervals from the end of May through mid-September during 1993. The handbeam trawl was drawn by hand over a standard distance of 15.2 m (50 ft). A total of three hauls was made at 0.5 m

(1.6 ft) and 1.0 m (3.3 ft) depth for a total of six samples/sampling location/sampling date. Each sample was preserved in a 10% formalin solution.

Larval fish were separated in the laboratory from debris and plankton utilizing a 3-diopter binocular magnifier and then examined using a variable power (10x-30x) stereomicroscope. All larval fish were identified to the lowest possible taxon using a dichotomous key developed for the Lower Snake River reservoirs (Bratovich 1985).

Estimates of larval fish density were determined using a quadrant sampling scheme (Scheafer et al. 1986) for both plankton nets and handbeam trawl samples. Mean density (M) was determined by the following:

$$\text{Mean density} \quad M = N/a;$$

where: N = mean number of fish among samples (n=3 or n=6), and
a = area of 1 half-meter plankton net or handbeam.

Total density (T) was determined by multiplying the mean density by total volume sampled (half-meter plankton net 318.1 m^3 or handbeam trawl 68.4 m^3 or 34.2 m^3 depending on depth)

$$T = M * A;$$

where: M = mean density and
A = total volume.

The variance (V(T)) was determined by

$$V(T) = A^2 * M/a*N;$$

where: M = mean density,
A^2 = square of total volume,
a = volume of one sample, and
N = number of samples.

The bound (β) was (β = 0.05) calculated by

$$\beta = 2 * A * M/a * N.$$

Upper and lower bounds were determined by adding and subtracting the bound (β) from the mean density (M).

RESULTS

Relative Abundance

A total of 7,512 fishes representing 21 species and 3 genera was collected at disposal (1, 2, 4, 7) and reference (3, 5, 6, 8, 9, 10 and 11) stations in Lower Granite Reservoir, Idaho-Washington during 1993 (Tables 1-4). The highest number (n=5,256) of adult and subadult fishes was collected from 1 April through 30 June during the spring sampling interval (Table 2). A total of 627 fishes was collected during summer (Table 3), 1 July through 30 September, and 1,629 fishes were collected during fall, 1 October through 31 October (Table 4). Catches during the summer sampling season were low due to suspended sampling activities to comply with the 1973 ESA. On 27 June, 1993 gill netting and electrofishing were curtailed to satisfy ESA concerns over potential mortality to upstream migrating adult sockeye salmon. Gill netting and electrofishing were resumed for fall sampling on 1 October, 1993.

Largescale sucker *Catostomus macrocheilus* was the most abundant species sampled during spring 1993 accounting for 42.1% (n=2,218) of the fish collected (Table 2). Next in abundance was smallmouth bass *Micropterus dolomieu* (12.4%, n=651) followed by juvenile chinook salmon (8.3%, n=435), chiselmouth *Acrocheilus alutaceus* (6.6%, n=350) and

Table 1. List of species codes, scientific names and common names for fishes sampled during 1993 in Lower Granite Reservoir.

Codes	Scientific Name	Common Name
LTR	Entosphenus tridentatus	Pacific lamprey
ATR	Acipenser transmontanus	white sturgeon
ASA	Alosa sapidissima	American shad
ONE	Oncorhynchus nerka	sockeye salmon
OTS	Oncorhynchus tshawytscha	chinook salmon
OMY	Oncorhynchus mykiss	steelhead trout
PWI	Prosopium williamsoni	mountain whitefish
AAL	Acrocheilus alutaceus	chiselmouth
CCA	Cyprinus carpio	carp
MCA	Mylocheilus caurinus	peamouth
POR	Ptychocheilus oregonensis	northern squawfish
ROS	Rhinichthys osculus	speckled dace
RBA	Richardsonius balteatus	redside shiner
CSP	Catostomus spp.	misc. juv. sucker
CCO	Catostomus columbianus	bridgelip sucker
CMA	Catostomus macrocheilus	largescale sucker
AME	Ameiurus melas	black bullhead
ANA	Ameiurus natalis	yellow bullhead
ANE	Ameiurus nebulosus	brown bullhead
NGY	Noturus gyrinus	tadpole madtom
IPU	Ictalurus punctatus	channel catfish
LSP	Lepomis spp.	misc. juv. sunfish
LGI	Lepomis gibbosus	pumpkinseed
LMA	Lepomis macrochirus	bluegill
MDO	Micropterus dolomieu	smallmouth bass
MSA	Micropterus salmoides	largemouth bass
PSP	Pomoxis spp.	misc. juv. crappie
PAN	Pomoxis annularis	white crappie
PNI	Pomoxis nigromaculatus	black crappie
PFL	Perca flavescens	yellow perch
COT	Cottus spp.	sculpin

Table 2. Number of fishes sampled by all gear types during spring 1993 (1 April - 30 June) in Lower Granite Reservoir. Gill netting was suspended on 27 June to 1 October to satisfy ESA concerns.

Species	Stations											Total
	1	2	3	4	5	6	7	8	9	10	11	
white sturgeon					2		6	5				13
sockeye salmon											1	1
chinook salmon	24	18	56		200	1			44	11	81	435
steelhead trout	16	25	16	1	11	7	1		70	9	29	185
mountain whitefish	88	15	19		16				1	3	123	265
chiselmouth	33	7	73	8	176	2	2		23	17	9	350
carp	5	2	9	4	13	10	14		1	2	1	61
peamouth	21	7	6	6	2	2					2	46
northern squawfish	30	8	61	8	37	21	6	4	1	12	96	284
redside shiner	1											1
bridgelip sucker	4	3		3	22				7	1	8	48
largescale sucker	246	206	404	149	503	62	22	3	400	129	94	2,218
yellow bullhead						3	1					4
brown bullhead	10	5	21	2	11	5	3					57
channel catfish	24	24	11	8	4	21	11	10				113
mad tom									1			1
Lepomis spp.	63	2	2		27				4	30	1	129
pumpkinseed	24	3	9		24				22	12	4	98
bluegill	14	2	7		9	5			5	1		43
smallmouth bass	63	54	91	1	108	3			151	134	46	651
Pomoxis spp.										2		2
white crappie	10	5	34	5	7				1	4	5	71
black crappie	34	9	6	2	18	7			8	12		96
yellow perch	6	8	12	12	32						12	82
sculpin									1	1		2
Total	716	403	837	209	1,222	149	66	22	740	380	512	5,256

Table 3. Number of fishes sampled by all gear types in Lower Granite Reservoir during summer (1 July - 30 September) 1993. Gill netting was suspended on 27 June to satisfy ESA concerns.

	Stations							
Species	1	2	3	5	9	10	11	Total
chinook salmon						1		1
steelhead trout					1			1
moutain whitefish				2				2
chiselmouth	2		1	1				4
carp			1					1
peamouth					1			1
northern squawfish	3		5				215	223
redside shiner				1			12	13
bridgelip sucker			1		4	7		12
largescale sucker	13	8	15	11	38	11	11	107
brown bullhead	1					1		2
pumpkinseed	2	2	1	2	13	3	1	24
bluegill			1	1	3	1		6
smallmouth bass	5	6	20	21	92	35		179
white crappie		1	11	5	4	4	19	44
black crappie				6		1		7
Total	26	17	56	50	156	64	258	627

Table 4. Number of fishes sampled by all gear types during fall 1993 (1 October - 31 October) in Lower Granite Reservoir. Gill netting was suspended on 27 June to 1 October to satisfy ESA concerns.

Species	Stations											Total
	1	2	3	4	5	6	7	8	9	10	11	
white sturgeon				1	9		1	6				17
chinook salmon						1				2		3
steelhead trout	3	2	2	4	5							16
chiselmouth	8	4	7	2	19			1	1		4	46
carp	2	1	3	1	5	12	15	7				46
peamouth	6	6	7	13	2	7				1		42
northern squawfish	4	8	8	4	8	6	8	1		3		50
redside shiner	1											1
bridgelip sucker			1		2			2	2	12		19
largescale sucker	178	168	97	60	145	126	111	105	28	14	6	1,038
yellow bullhead						1		1				2
brown bullhead	1	1	4		1	5		1	2			15
channel catfish	6	6	3	1	7	10	9	25				67
pumpkinseed		2		3	2	5			6	2		20
smallmouth bass	3	4	20	1	7	4			58	7		104
white crappie	1	1		1	5	6					1	15
black crappie			1	1		6	2					10
yellow perch	11	26	26	30	22	3						118
Total	224	229	179	122	239	192	146	149	97	41	11	1,629

northern squawfish (5.4%, n=284). Over 250 mountain whitefish *Prosopium williamsoni* were also collected at shallow water stations during spring.

The highest numbers of adult and subadult predators, smallmouth bass and northern squawfish, sampled during spring by all gear types were collected from shallow reference stations 3 and 9 (n=152) followed by shallow reference stations 10 (n=146), 5 (n=145) and 11 (n=142; Table 2). Abundances of smallmouth bass and northern squawfish at shallow disposal stations 1 and 2 were varied. Relative abundances of smallmouth bass at stations 1 and 2 were 8.8% and 13.4%, while abundances of northern squawfish were 4.2% and 2.0%, respectively.

During the summer 1993 sampling season, 1 July through 30 September, northern squawfish abundance was highest (35.6%, n=223) followed by smallmouth bass (28.5%, n=179), largescale sucker (17.1%, n=107) and white crappie *Pomoxis annularis* (7.6%, n=44). Catches of juvenile salmon and juvenile steelhead were low during summer.

The highest number of juvenile and adult predators, northern squawfish and smallmouth bass, sampled during summer was collected from shallow reference station 11 (n=215). Next in abundance of predators was shallow reference station 9 (n=92) followed by shallow reference station 10 (n=35). Shallow disposal station 2 had the lowest abundance of predators sampled (n=6), however, numbers sampled at all stations were low during summer because of limited sampling to comply with ESA concerns. Smallmouth bass abundances at stations 1 and 2 were 19.2% and 35.3%, while abundances of northern squawfish were 11.5% and 0%, respectively.

A total of 1,629 fishes was collected by all gear types during fall 1993 sampling season, 1 October through 31 October (Table 4). Largescale sucker (63.7%, n=1,038) dominated the catches followed by yellow perch *Perca flavescens* (7.2%, n=118), smallmouth bass (6.4%, n=104), channel catfish *Ictalurus punctatus* (4.1%, n=67) and northern squawfish (3.1 %, n=50).

Numbers of smallmouth bass and northern squawfish collected during fall were highest at shallow reference station 9 (n=58) followed by shallow reference stations 3 (n=28) and 5 (n=15). Relative abundances of smallmouth bass at shallow disposal stations 1 and 2 were 1.3% and 1.7%, while those of northern squawfish were 1.7% and 3.5%, respectively.

Length Comparisons

Length distributions of various fishes sampled in 1993 were strongly influenced by the sampling technique. For example, gill nets generally collected large (200->800 mm) individuals (Appendix Figures 1-6). Beach seining collected primarily small (25-200 mm) individuals which contributed to the large number of small fishes collected at station 11 (Appendix Figures 7-10). Electrofishing collected median-sized fish with modal lengths approximately 150 to 200 mm (Appendix Figures 11-13). Length distributions at shallow stations, sampled by beach seining and electrofishing, are generally small and contain a high number of individuals. Mid depth and deep stations are sampled by gill netting and generally reflect the abundance of large individuals.

Spring

Comparison of length frequency distributions of fishes collected in the spring from shallow, mid depth and deep stations indicated differences in modal size classes among all stations (Figures 3 and 4). The length distributions generally showed the prevalence of small fishes at shallow reference (3, 5, 9, 10 and 11) and disposal (1 and 2) stations and larger fishes at mid-depth (4 and 6) stations. Length distributions at stations 2 and 5 were the widest of all stations and at stations 1, 3 and 5 the distributions were skewed to small fishes. We sampled predominantly small fishes at station 11 and stations 9 and 10 had similar distributions (Figure 4).

Summer

Too few fish were collected during summer 1993 to describe the length distributions (Figure 5). Few trends were observed with the exception of the prevalence of small fish at station 11.

Fall

During fall 1993, fishes were collected in higher abundance than summer and length frequency distributions generally were bimodal (Figures 6 and 7). Peaks in length distributions were generally around 200-300 mm and 450 mm. The length distributions at station 9 provided some exception with a major peak at 125 mm with few fish > 400 mm (Figure 7).

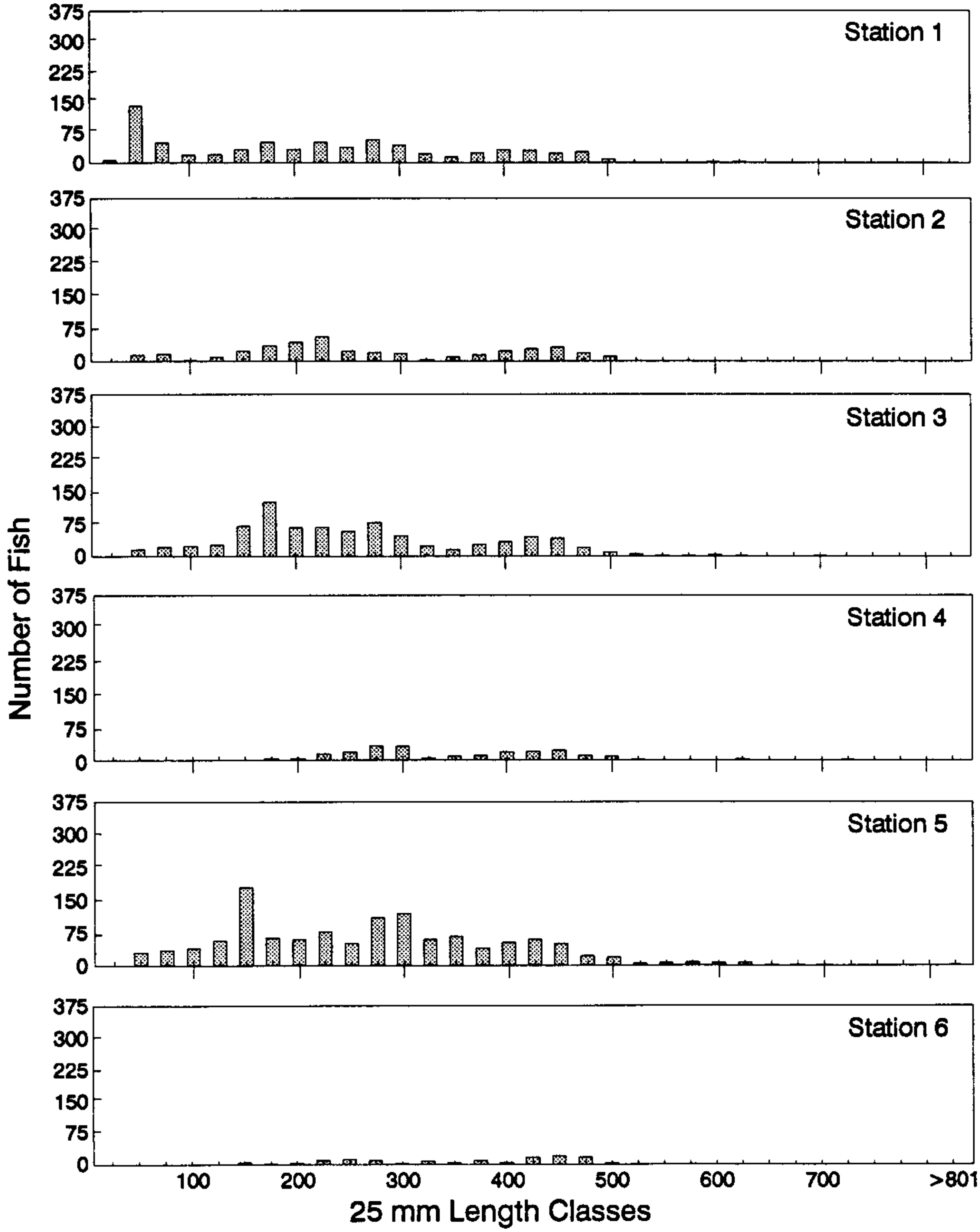


Figure 3. Length distributions of fishes sampled at shallow (1 and 2) and mid-depth (4) disposal stations and shallow (3 and 5) and mid-depth (6) reference stations during spring 1993 in Lower Granite Reservoir.

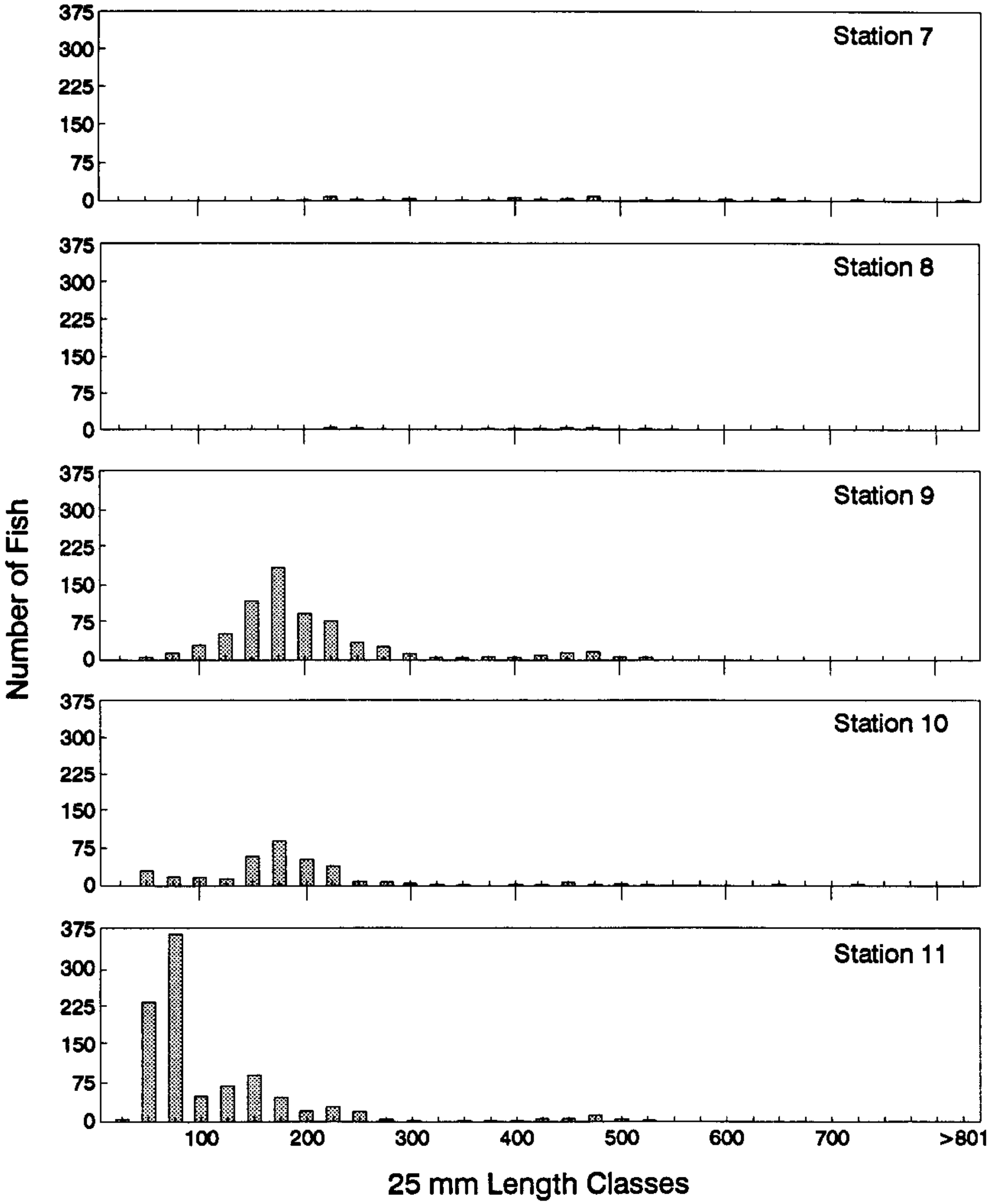


Figure 4. Length distributions of fishes sampled by all gear types at shallow (9, 10 and 11) and deep (8) reference stations and deep disposal station 7 during spring 1993 in Lower Granite Reservoir.

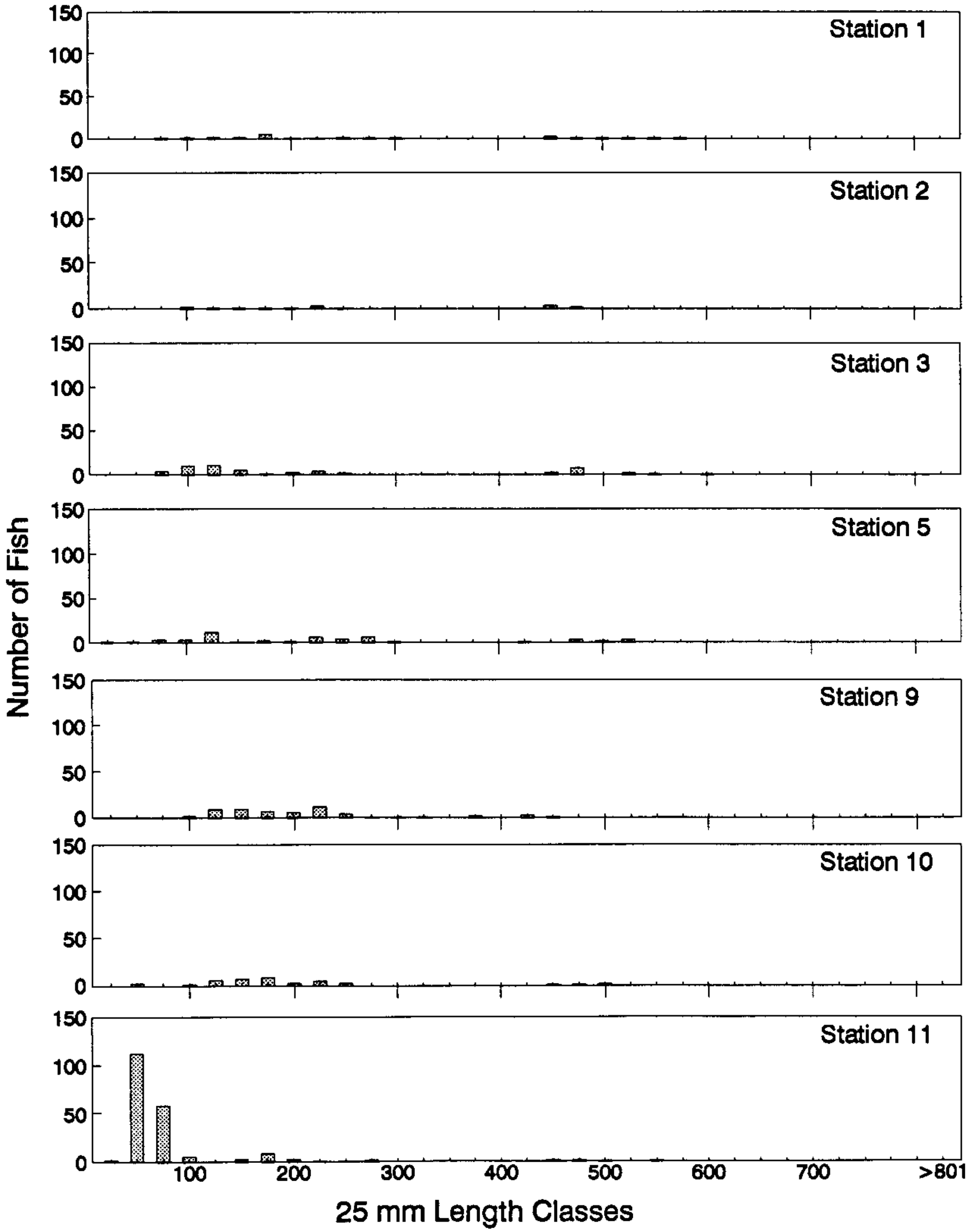


Figure 5. Length distributions of fishes sampled by all gear types at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during summer 1993 in Lower Granite Reservoir.

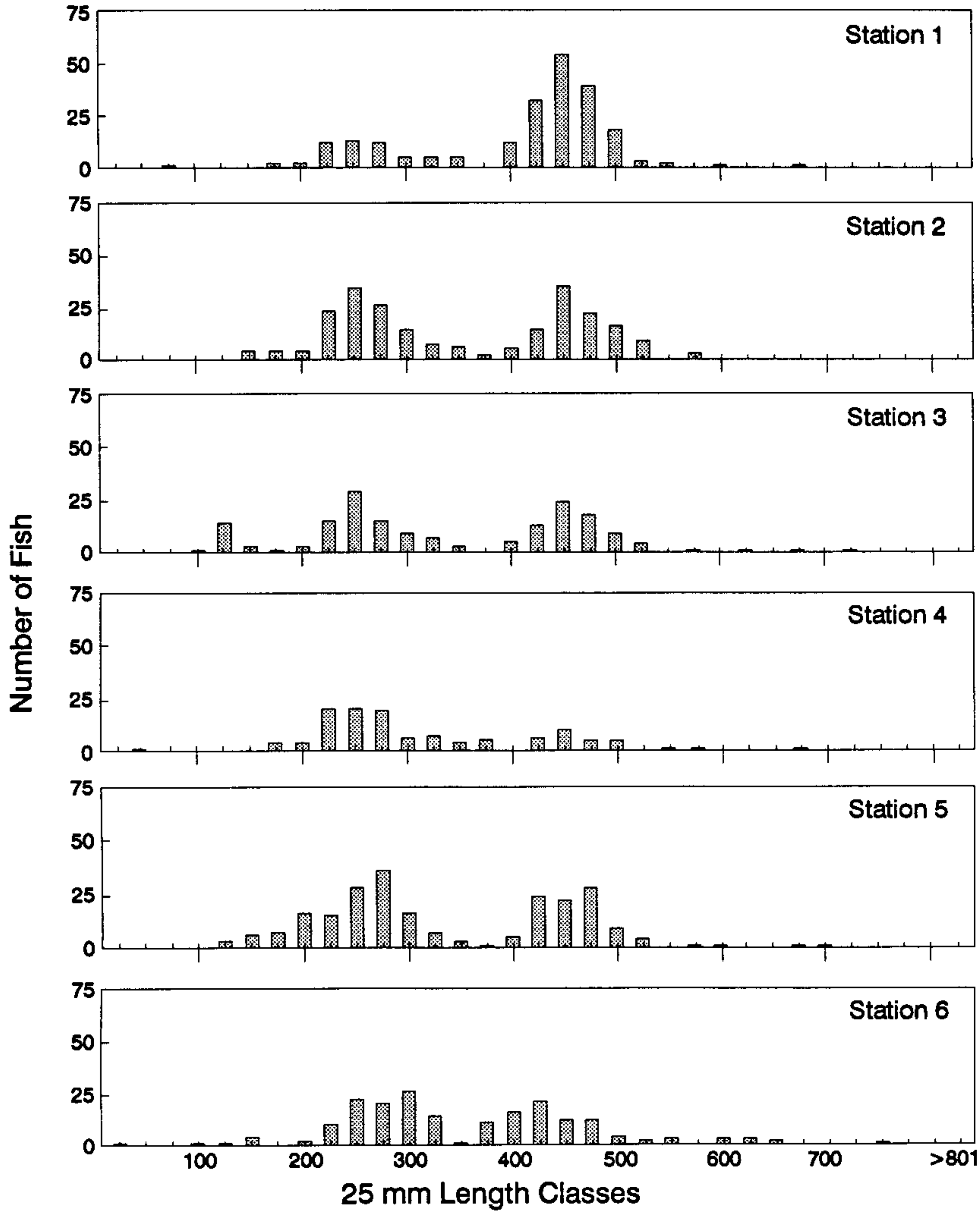


Figure 6. Length distributions of fishes sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow (3 and 5) and mid-depth (6) reference stations during fall 1993 in Lower Granite Reservoir.

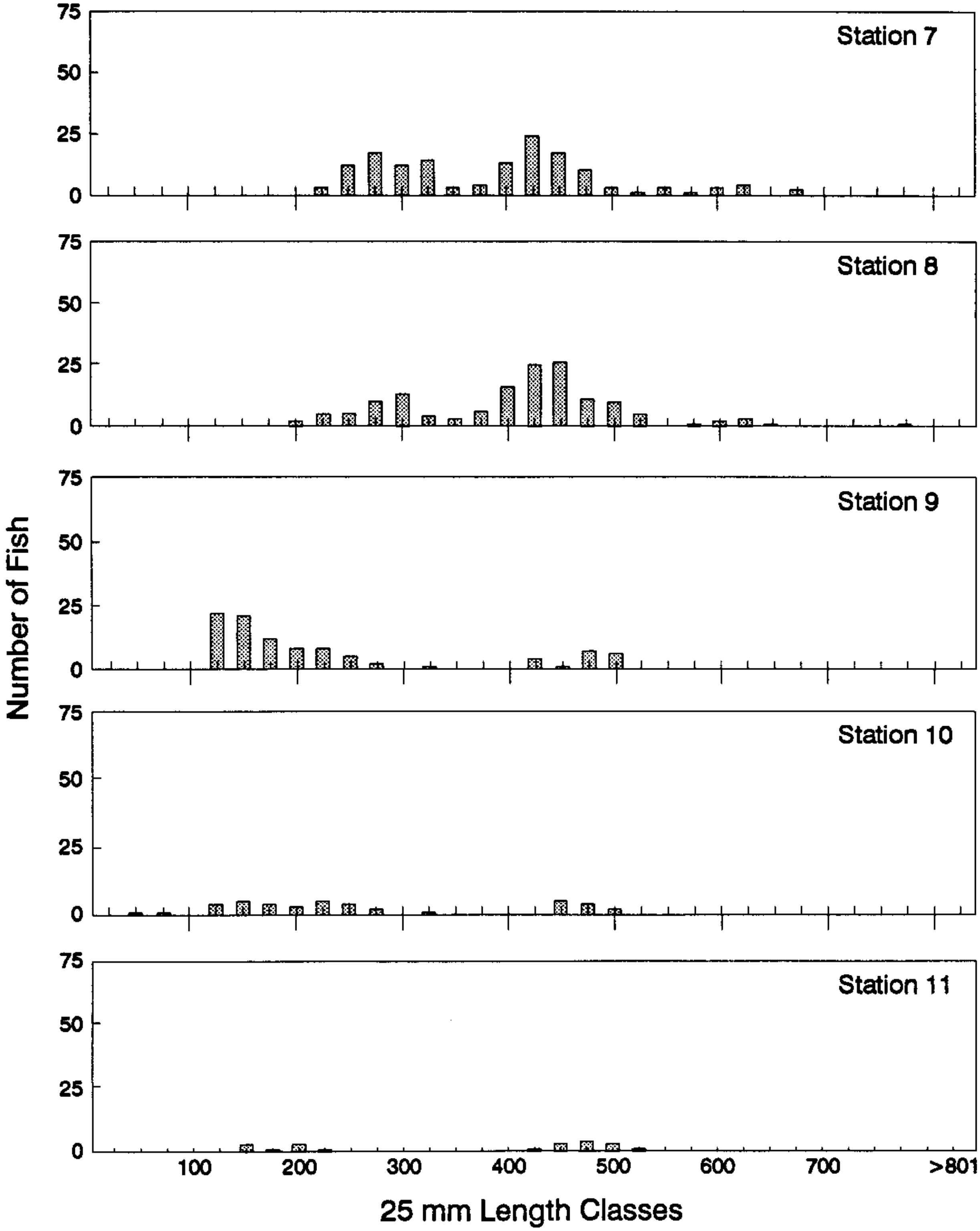


Figure 7. Length distributions of fishes sampled by all gear types at shallow (9, 10 and 11) and deep (8) reference stations and deep disposal station 7 during fall 1993 in Lower Granite Reservoir.

Length Structure

Spring

Chinook salmon.- Juvenile chinook salmon were collected in abundance during spring 1993 at stations 5 and 11 (Figures 8 and 9). The modal size class for juvenile chinook salmon was 150 mm at stations 2, 3 and 5 whereas at station 11 the modal size class was 75 mm for chinook salmon.

Steelhead.- Length composition of juvenile steelhead collected during spring was variable among stations (Figures 10 and 11). Juvenile steelhead were smaller at stations 9 and 11 compared to stations 1 and 2.

Northern squawfish.- Little can be stated about the length composition of northern squawfish during spring, with the exception of a myriad of small northern squawfish collected at station 11 (Figures 12 and 13). Northern squawfish collected at stations 3 and 5 were generally the widest in length composition.

Smallmouth bass.- Smallmouth bass sampled from most stations were < 300 mm (Figures 14 and 15). The modal size class was generally between 200 and 250 mm in the spring.

Channel catfish.- Length composition of channel catfish collected from Lower Granite Reservoir during spring 1993 generally ranged from 250 to 500 mm (Figures 16 and 17).

White sturgeon.- A small number of large (>800 mm) white sturgeon were collected at disposal station 7 (Figure 18). Too few fish were

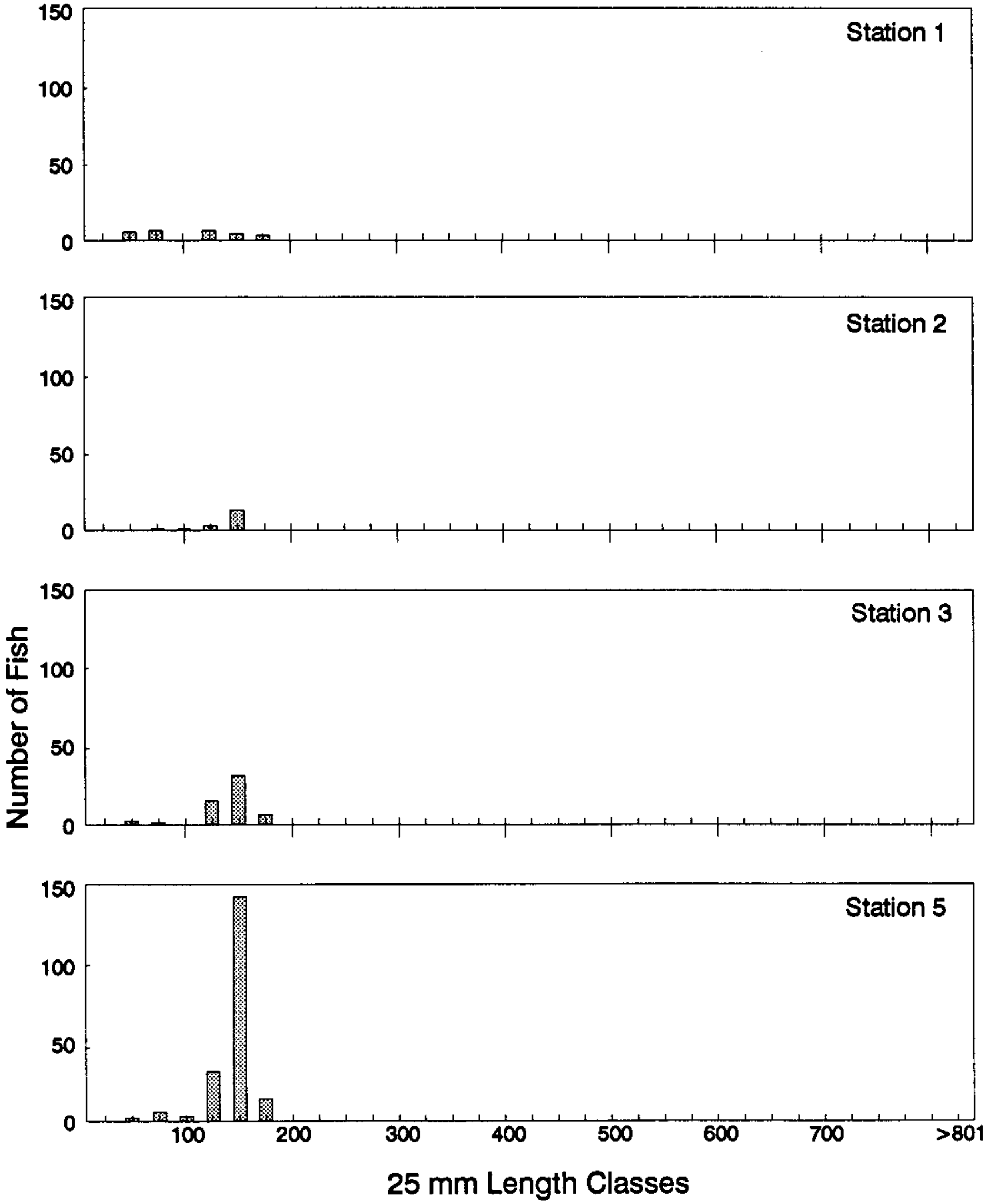


Figure 8. Length distributions of juvenile chinook salmon sampled by all gear types at shallow disposal (1 and 2) and reference (3 and 5) stations during spring 1993 in Lower Granite Reservoir.

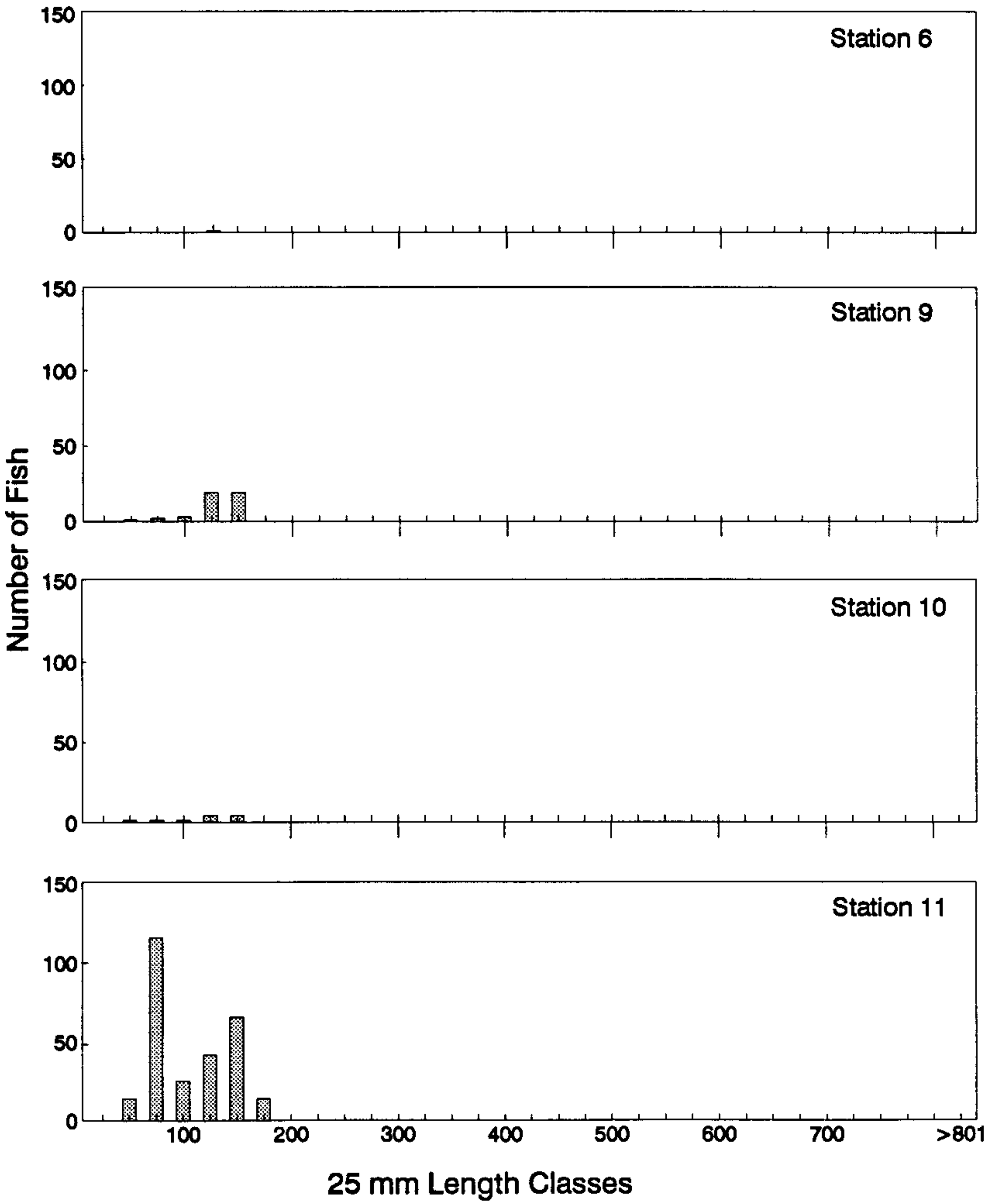


Figure 9. Length distributions of juvenile chinook salmon sampled by all gear types at shallow (9, 10 and 11) and mid-depth (6) reference stations during spring 1993 in Lower Granite Reservoir.

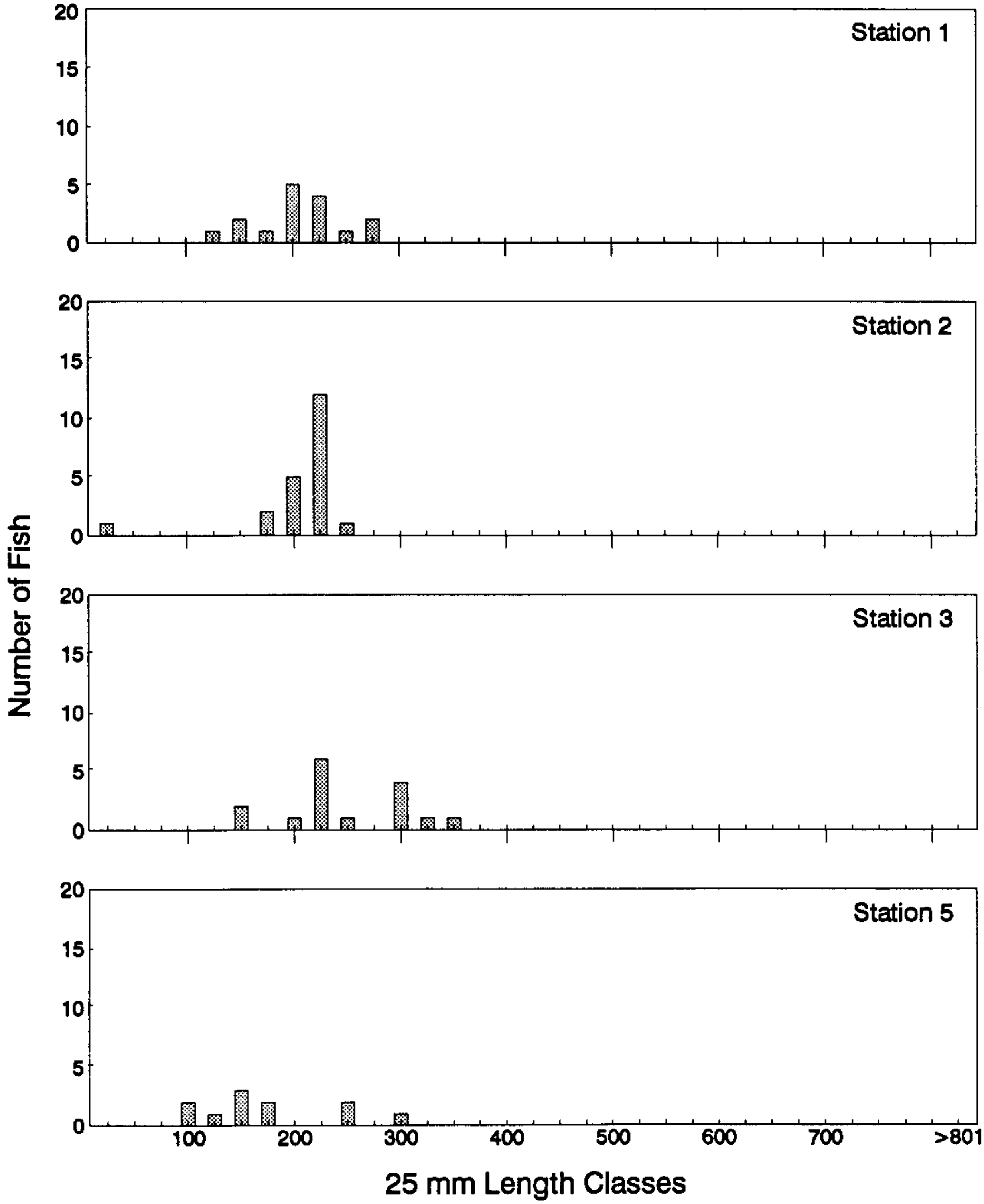


Figure 10. Length distributions of juvenile steelhead sampled by all gear types at shallow disposal (1 and 2) and reference (3 and 5) stations during spring 1993 in Lower Granite Reservoir.

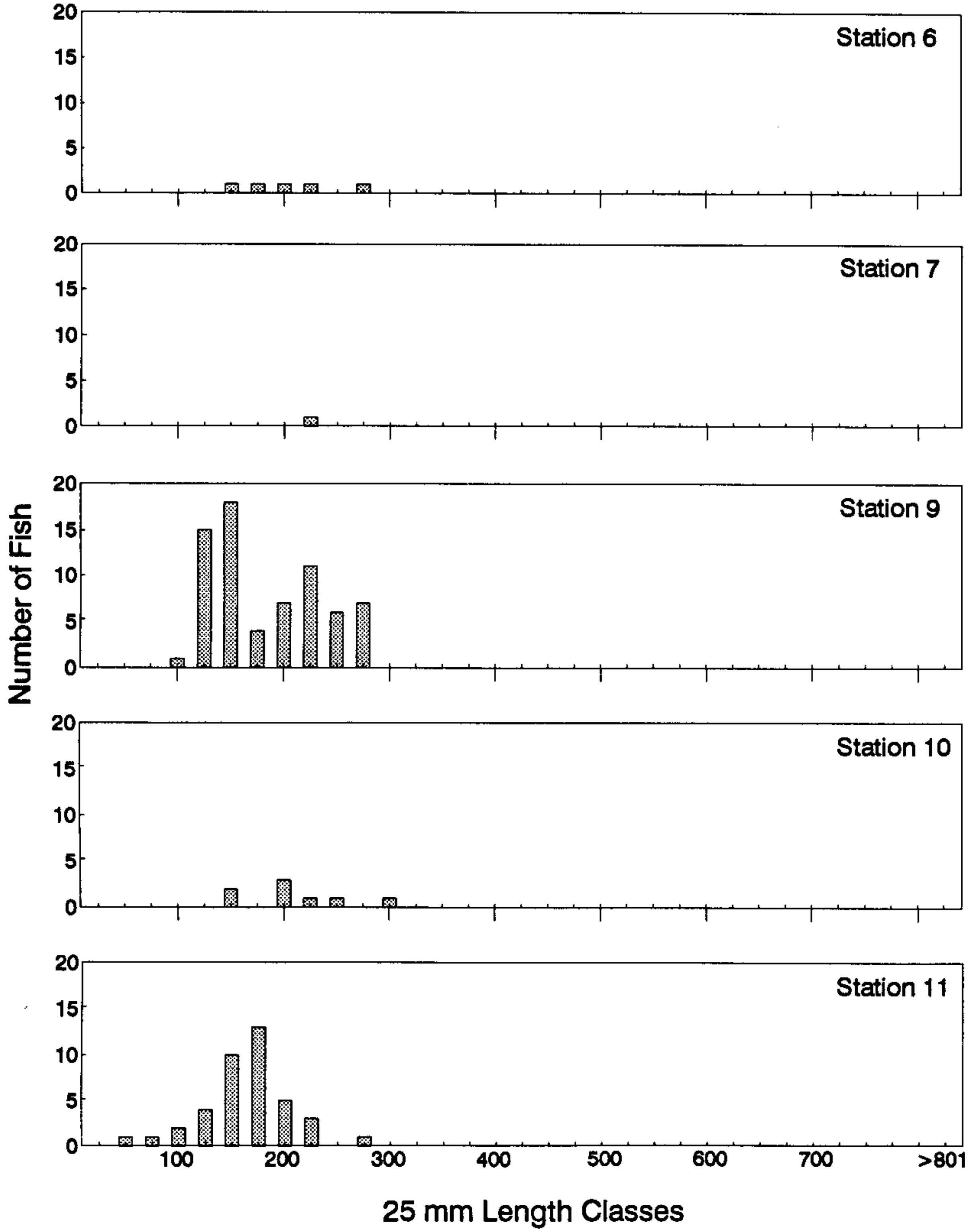


Figure 11. Length distributions of juvenile steelhead sampled by all gear types at shallow (9, 10 and 11) and mid-depth (6) reference stations and deep disposal station 7 during spring 1993 in Lower Granite Reservoir.

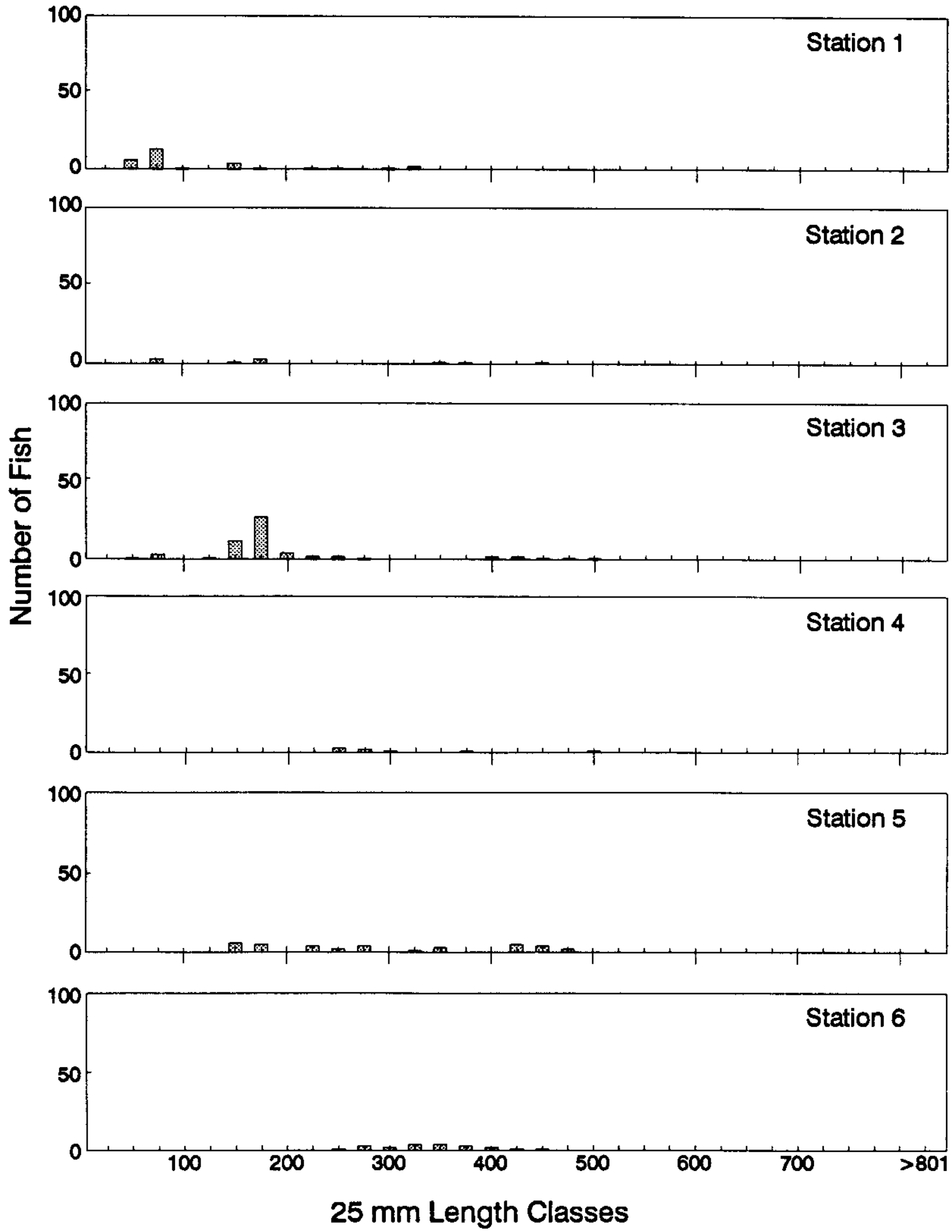


Figure 12. Length distributions of northern squawfish sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow (3 and 5) and mid-depth (6) reference stations during spring 1993 in Lower Granite Reservoir.

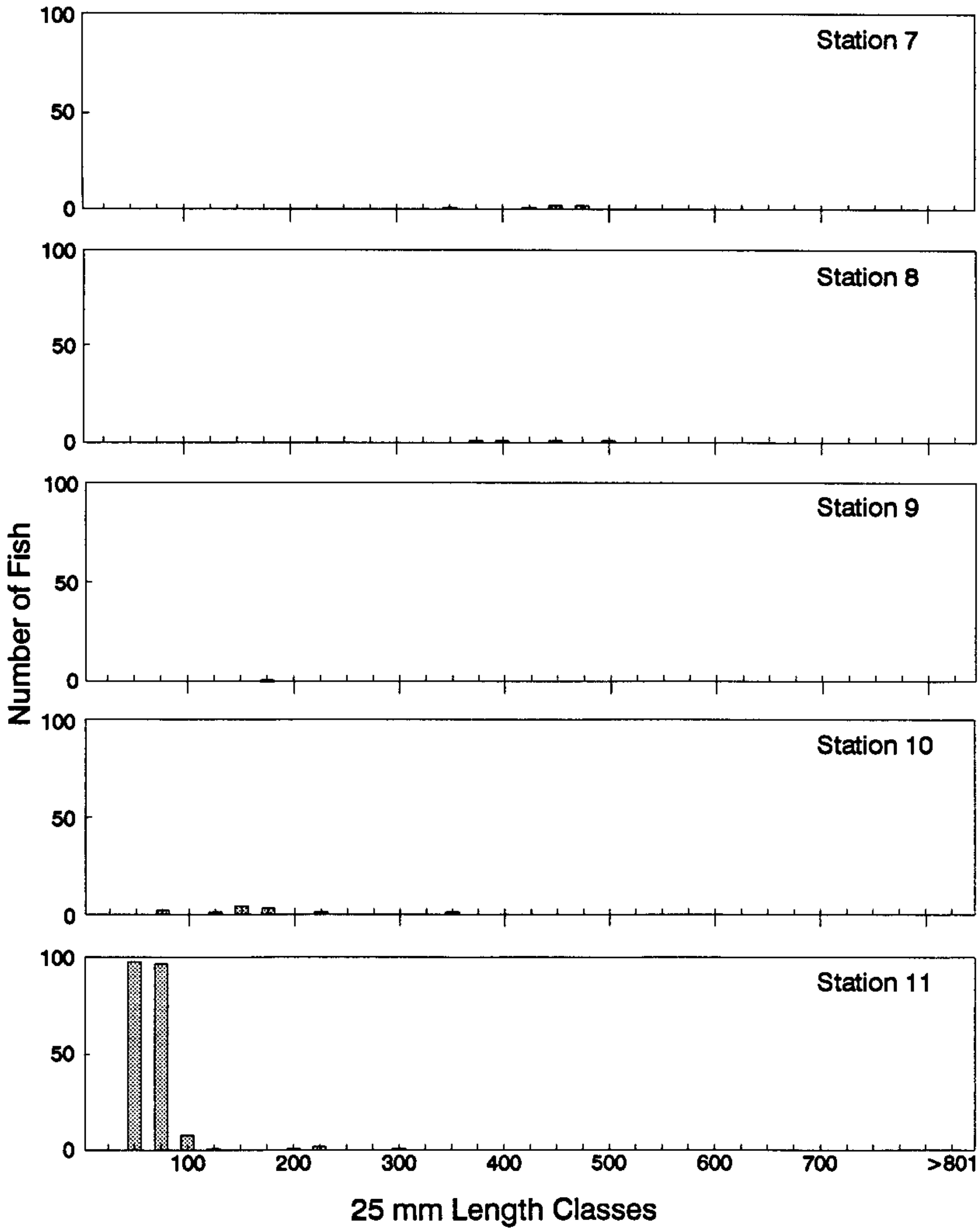


Figure 13. Length distributions of northern squawfish sampled by all gear types at shallow (9, 10 and 11) and deep (8) reference stations and deep disposal station 7 during spring 1993 in Lower Granite Reservoir.

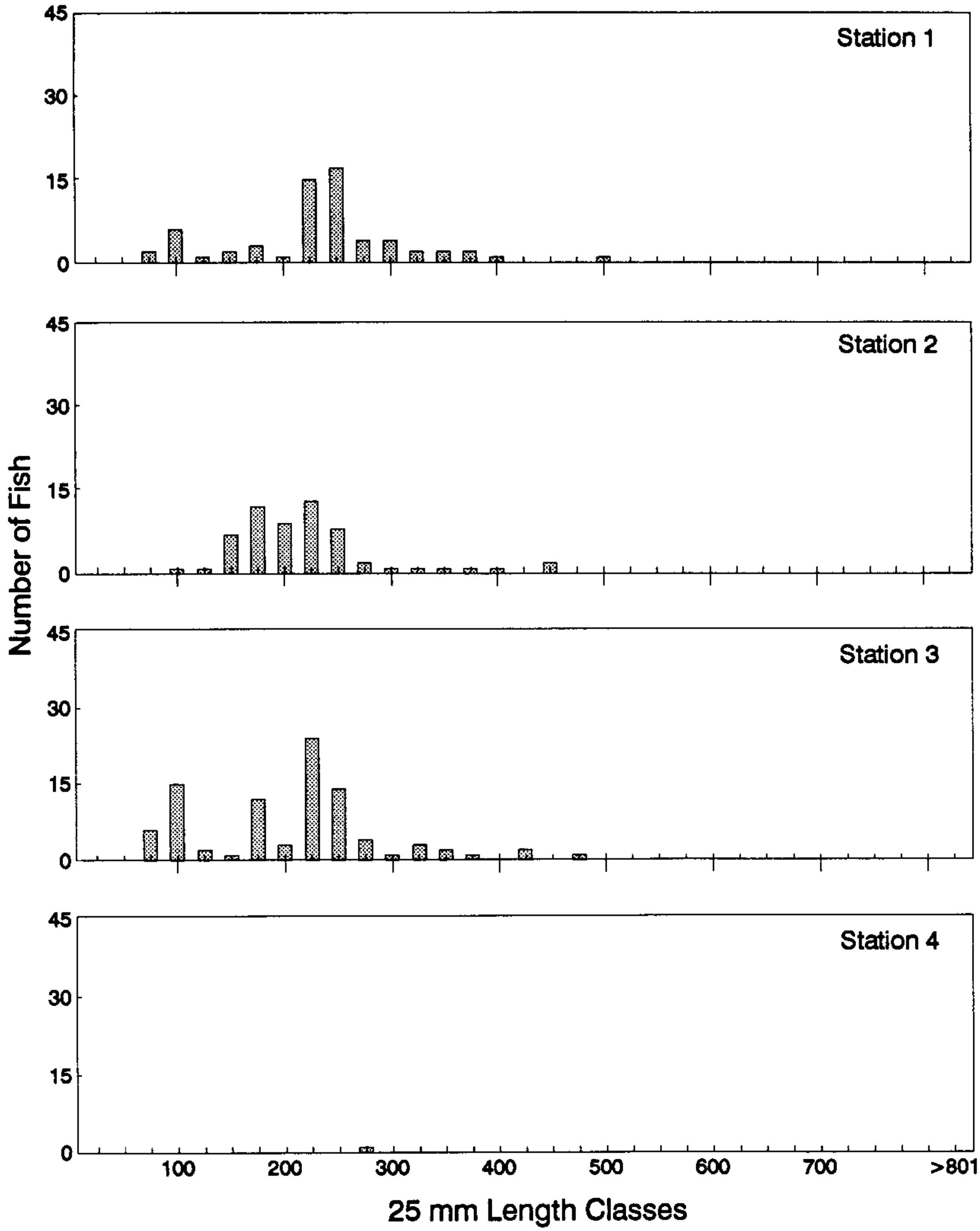


Figure 14. Length distributions of smallmouth bass sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during spring 1993 in Lower Granite Reservoir.

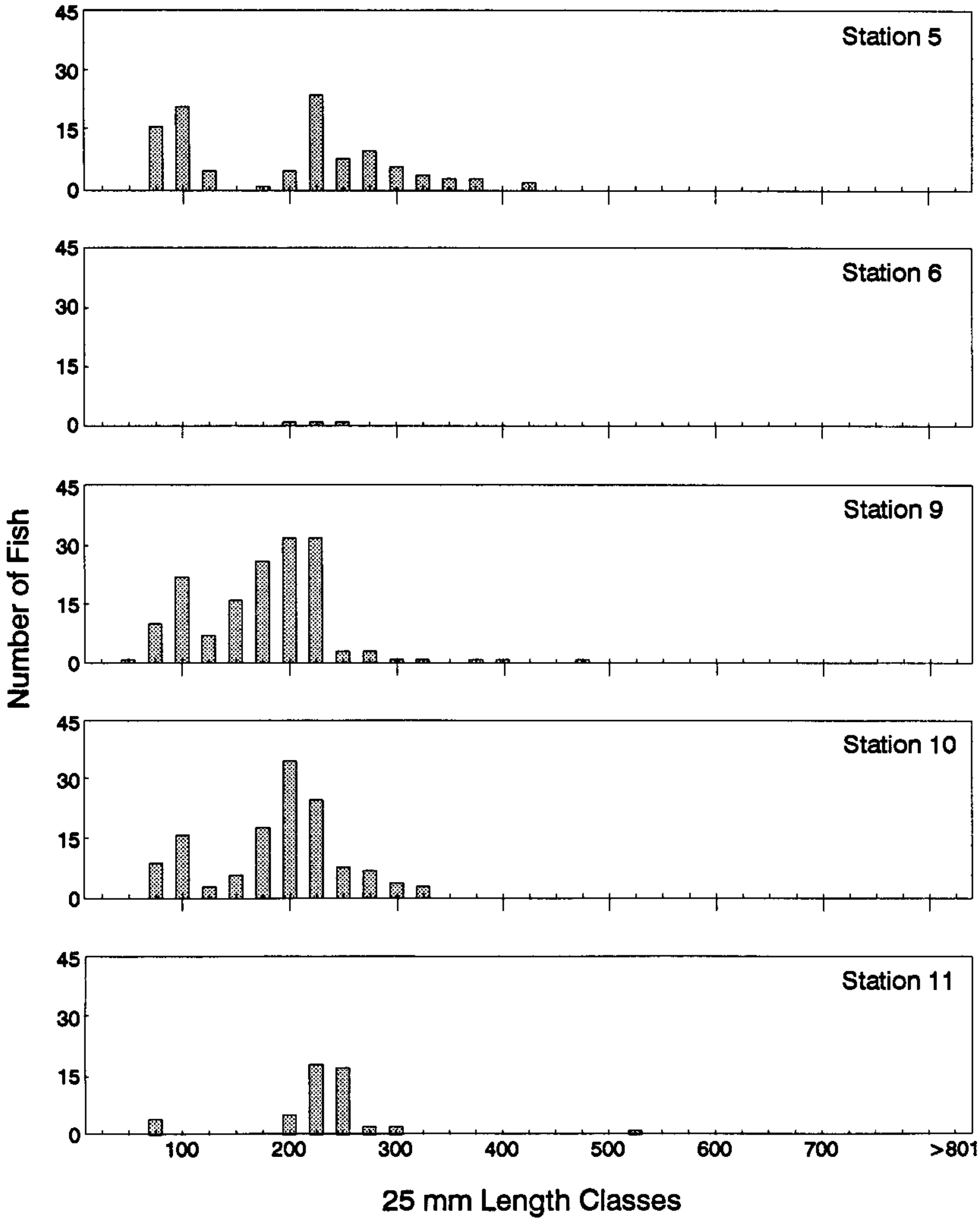


Figure 15. Length distributions of smallmouth bass sampled by all gear types at shallow (5, 9, 10 and 11) and mid-depth (6) reference stations during spring 1993 in Lower Granite Reservoir.

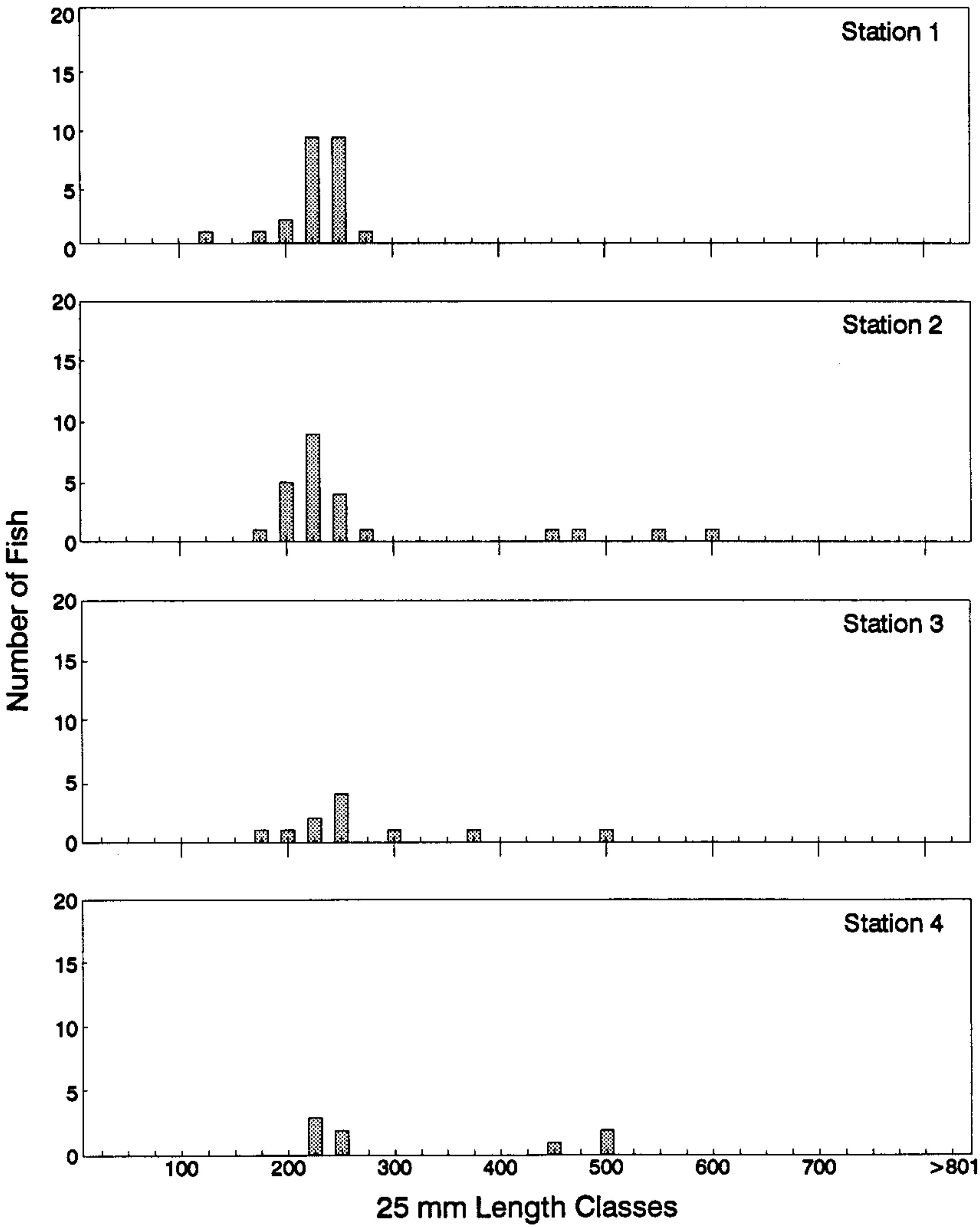


Figure 16. Length distributions of channel catfish sampled by all gear types at shallow disposal (1 and 2) and reference (3) stations and mid-depth disposal station 4 during spring 1993 in Lower Granite Reservoir.

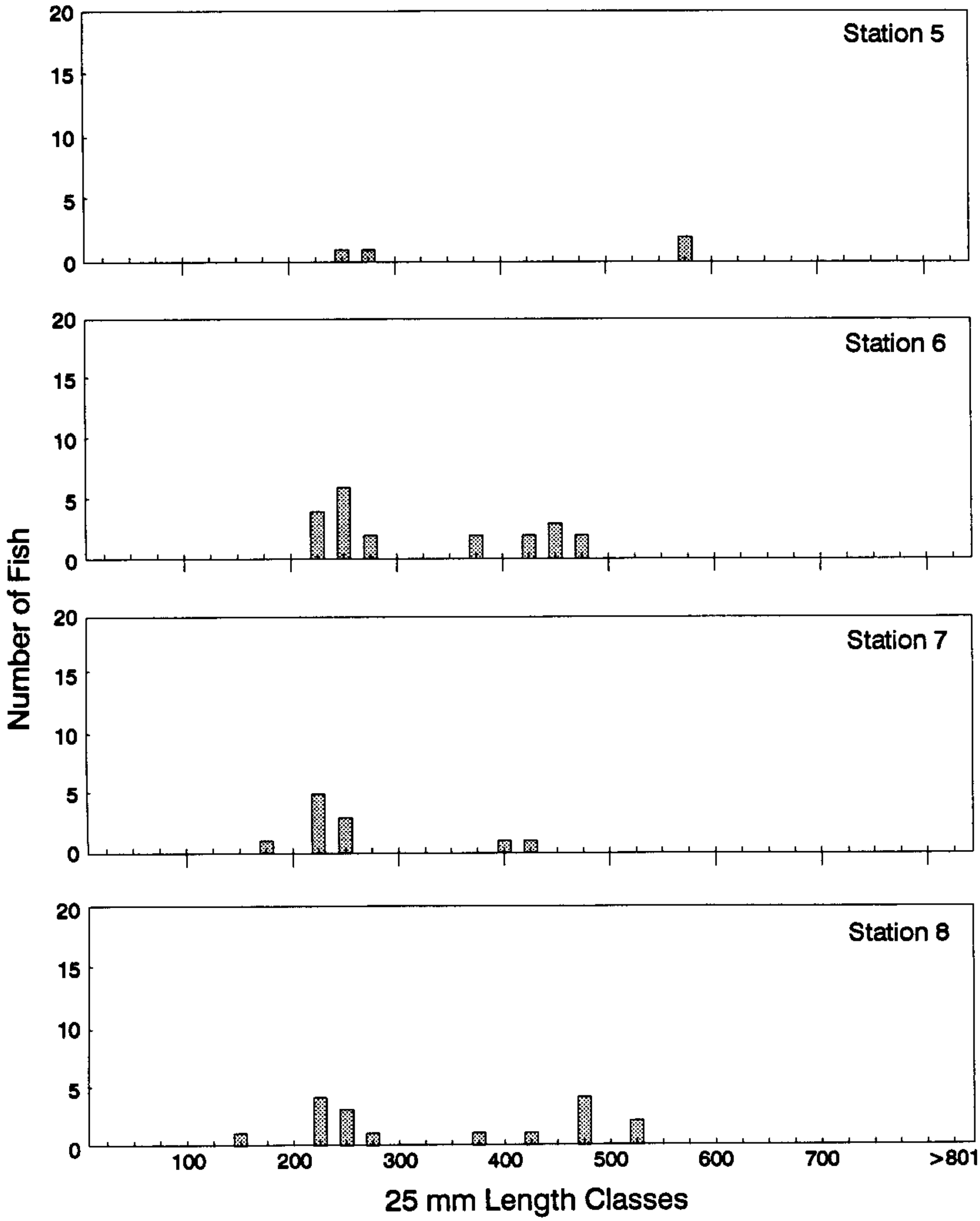


Figure 17. Length distributions of channel catfish sampled by all gear types at shallow (5), mid-depth (6) and deep (8) reference stations and deep disposal station 7 during spring 1993 in Lower Granite Reservoir.

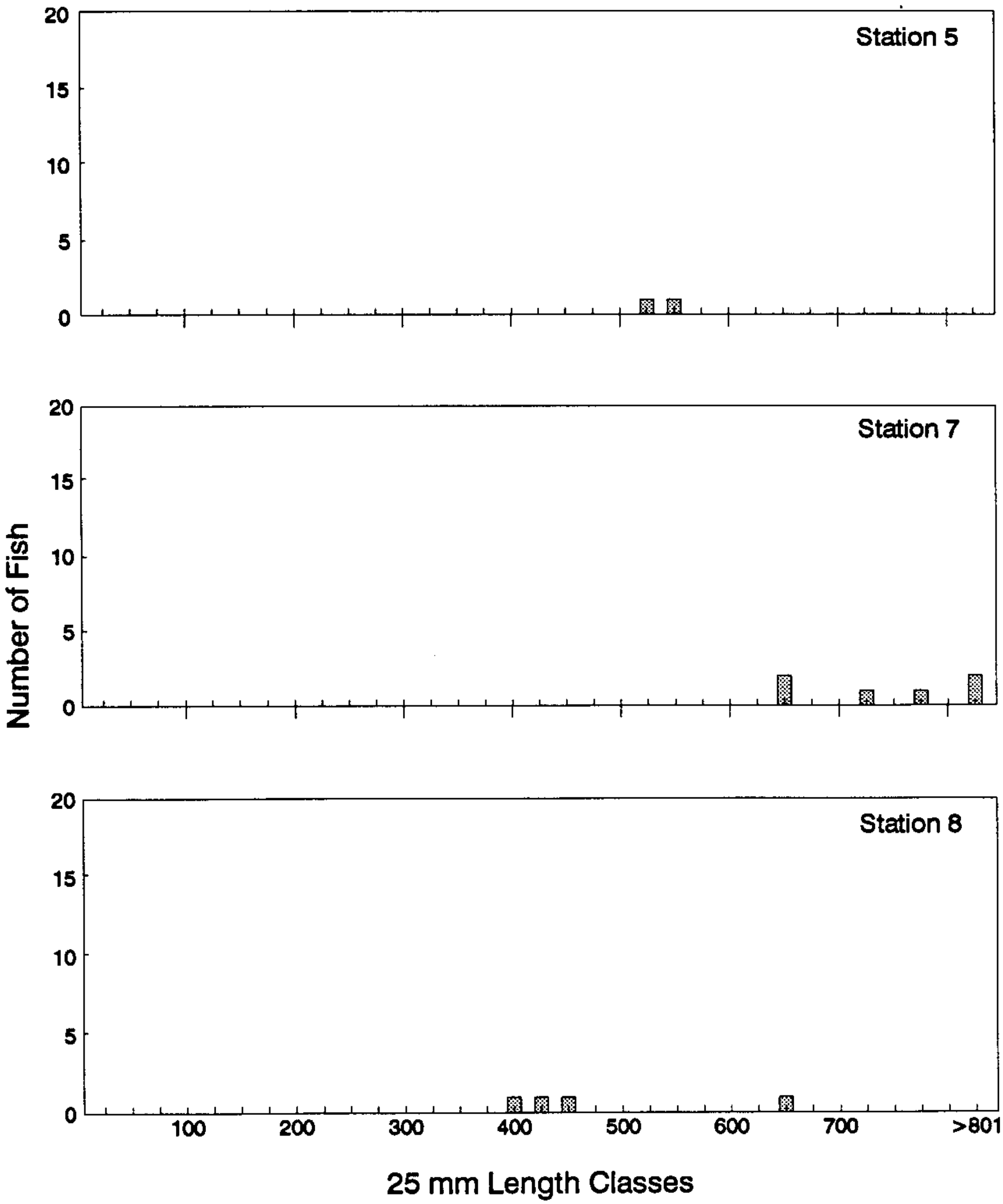


Figure 18. Length distributions of white sturgeon sampled by gill netting and set lines at shallow (5) and deep (8) reference stations and deep disposal station 7 during spring 1993 in Lower Granite Reservoir.

collected at other stations to provide a meaningful comparison of length structure.

Summer

During summer 1993, too few juvenile steelhead and northern squawfish were collected to compare among stations (Figures 19 and 20). Numbers of smallmouth bass collected during summer were also low and generally ranged from 100 to 200 mm (Figure 21).

Fall

Numbers of fishes were collected during fall 1993. Lengths of northern squawfish generally ranged from 200 to 400 mm (Figures 22 and 23). Length distributions of smallmouth bass were variable and most bass collected were generally < 200 mm (Figures 24 and 25). Channel catfish lengths generally ranged from 200 to 500 mm and were similar to lengths sampled during spring (Figures 26 and 27). Most white sturgeon collected in fall 1993 were smaller than those collected in the spring (400->800 m) and generally ranged from 200 to 300 mm (Figure 28).

Length Comparisons of Abundant Resident Species from 1987 through 1993

Northern Squawfish

Numbers of northern squawfish sampled from 1987 to 1993 were variable among years, but generally showed an overall decrease in number of larger squawfish in Lower Granite Reservoir (Figure 29). During all

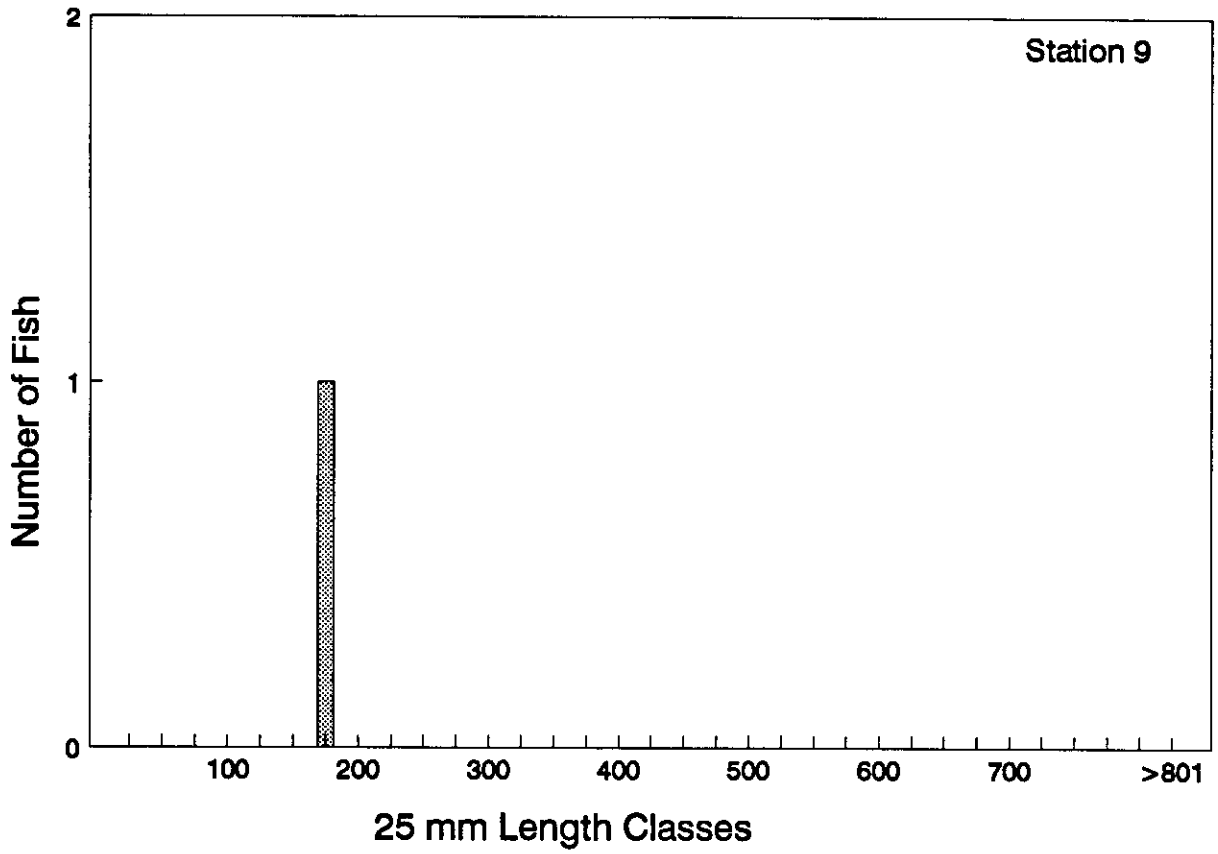


Figure 19. Length distribution of juvenile steelhead sampled by all gear types at shallow reference station 9 during summer 1993 in Lower Granite Reservoir.

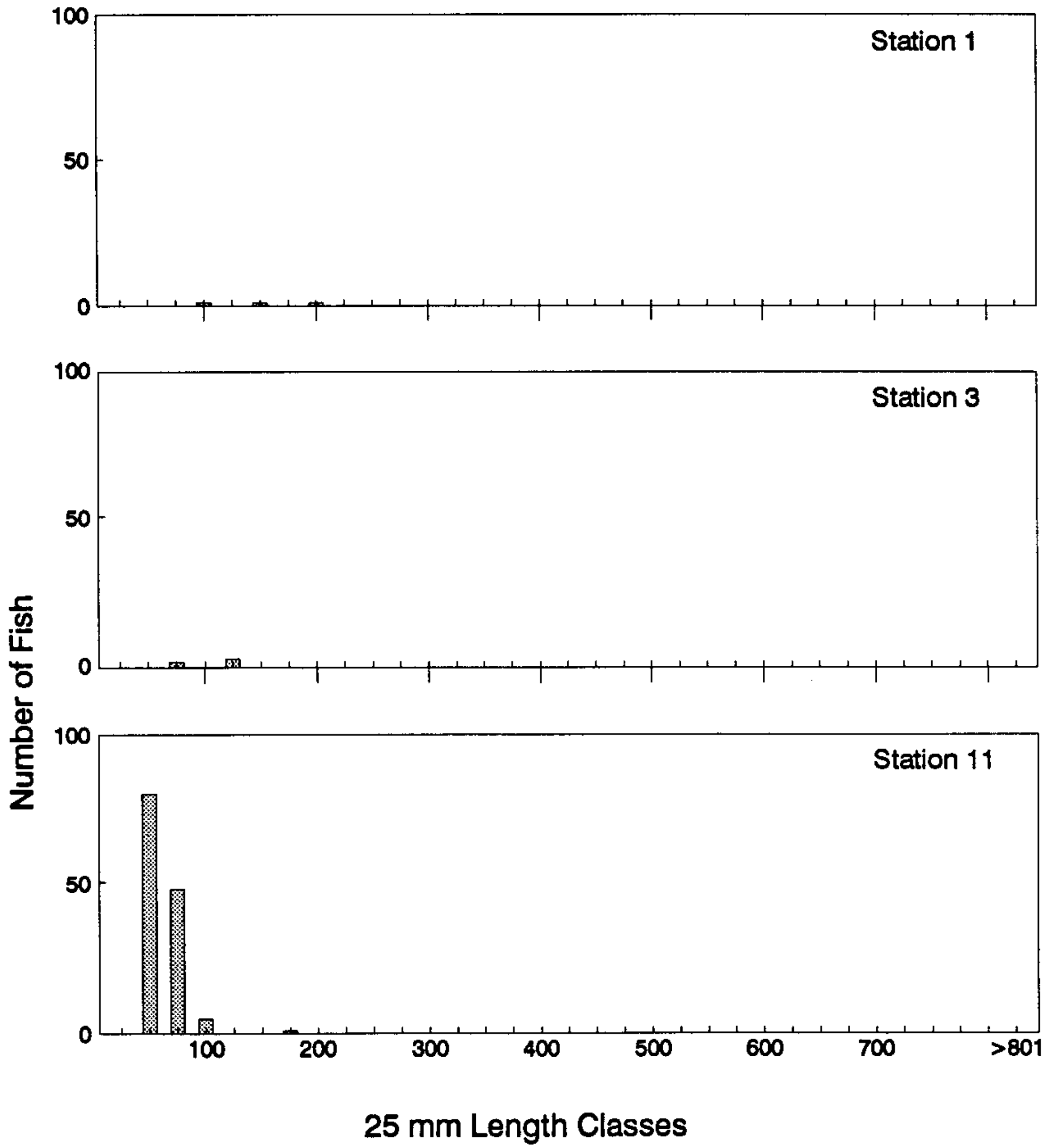


Figure 20. Length distributions of northern squawfish sampled by all gear types at shallow disposal (1) and reference (3 and 11) stations during summer 1993 in Lower Granite Reservoir.

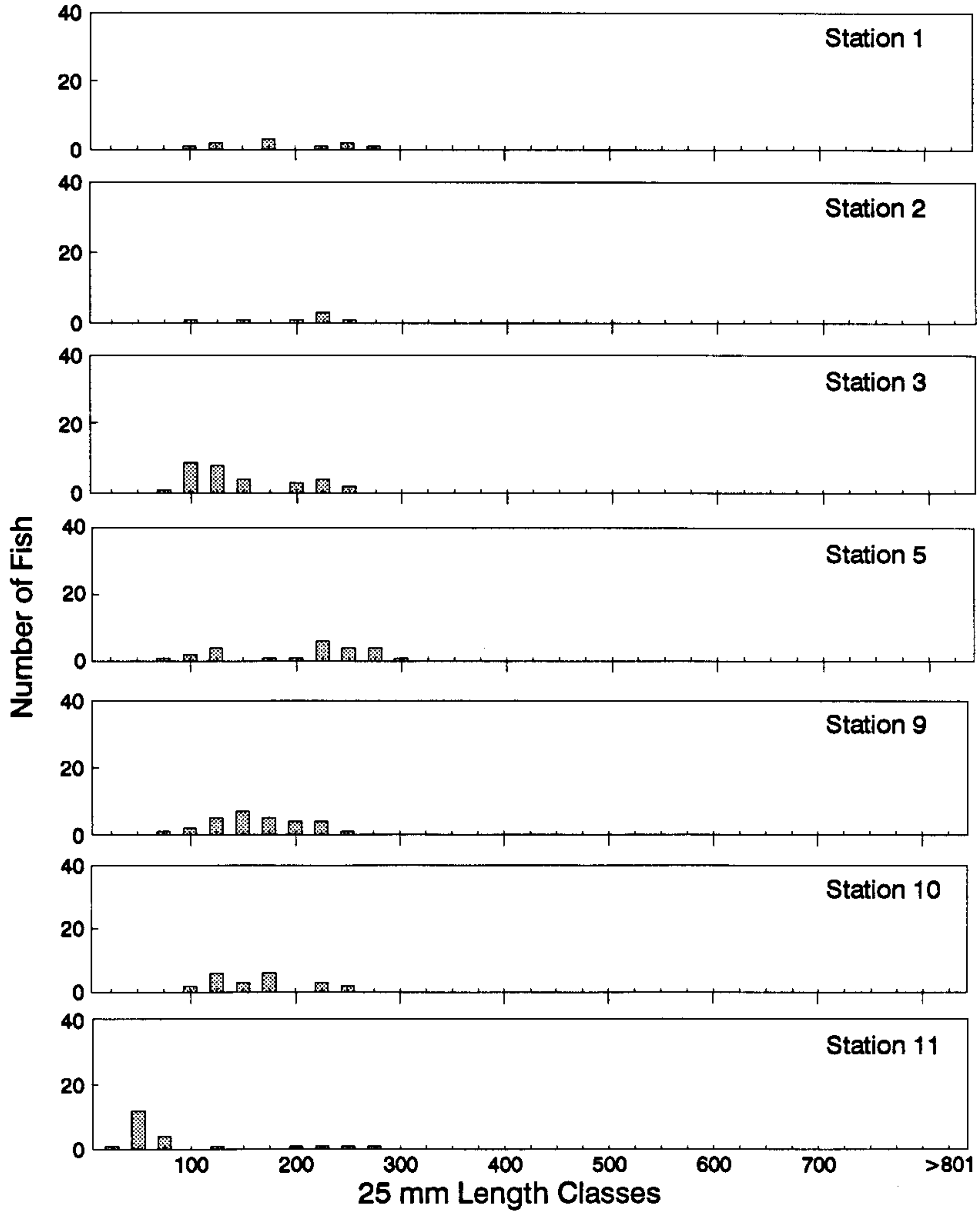


Figure 21. Length distributions of smallmouth bass sampled by all gear types at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during summer 1993 in Lower Granite Reservoir.

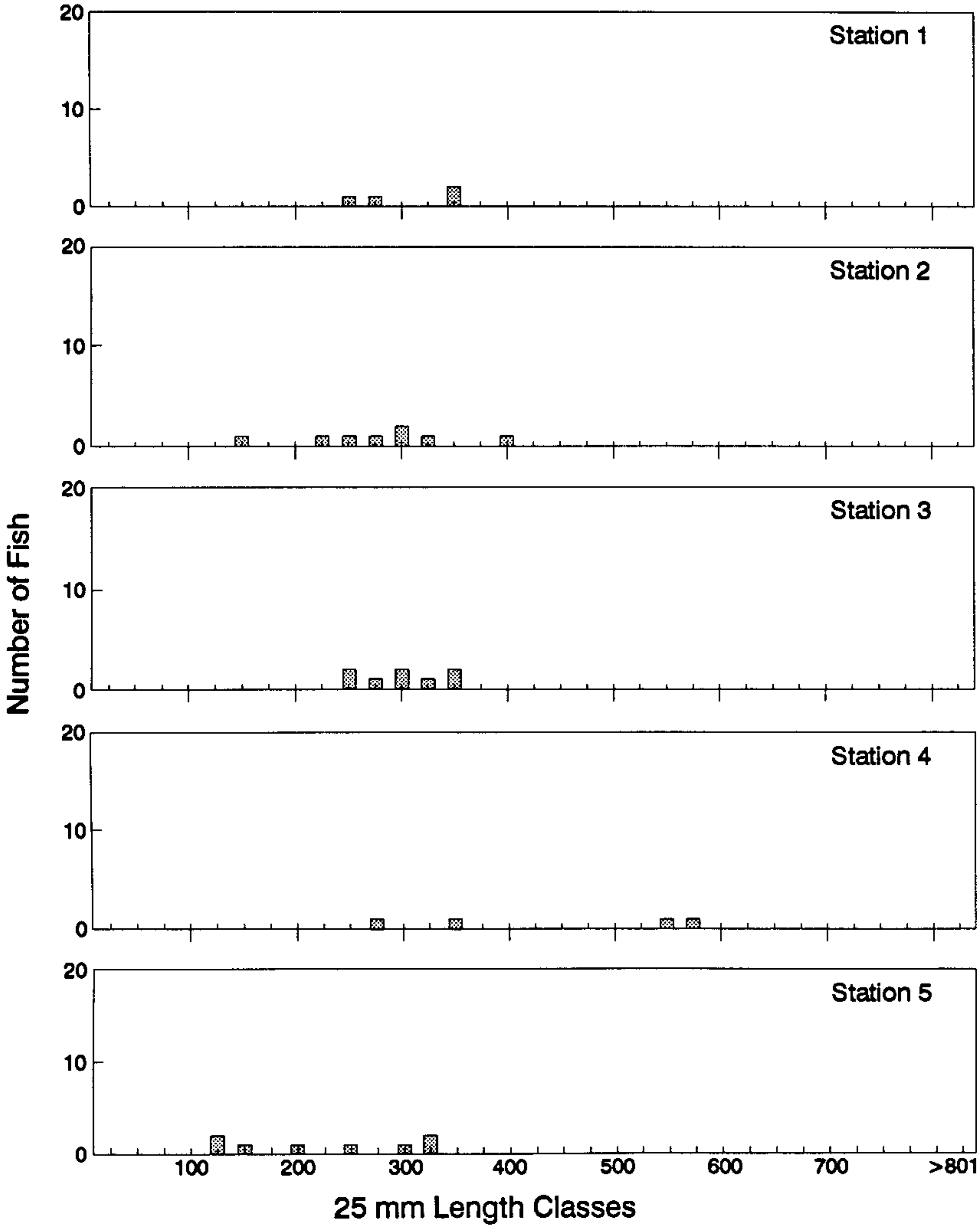


Figure 22. Length distributions of northern squawfish sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow (3 and 5) reference stations during fall 1993 in Lower Granite Reservoir.

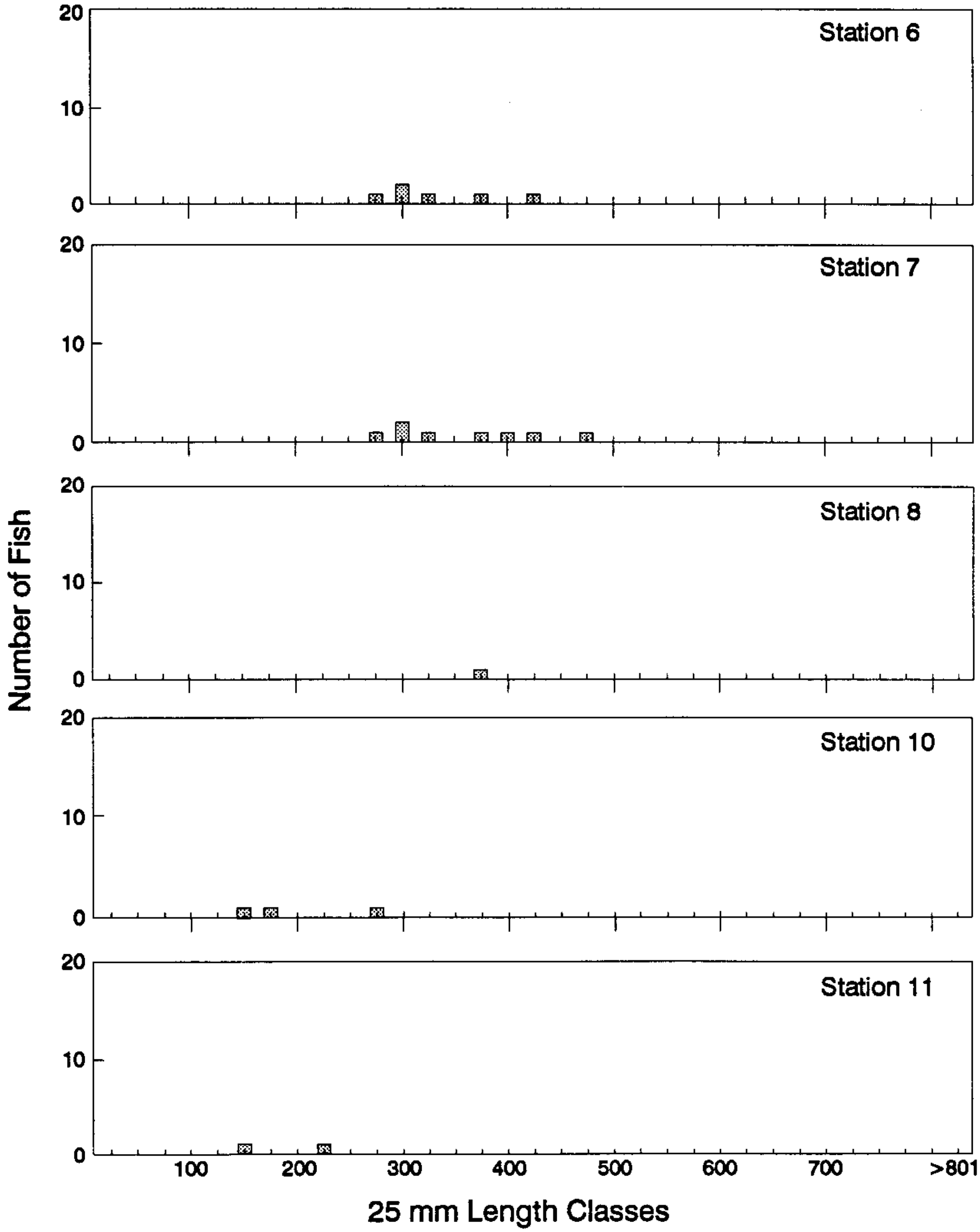


Figure 23. Length distributions of northern squawfish sampled by all gear types at shallow (10 and 11), mid-depth (6) and deep (8) reference stations and deep disposal station 7 during fall 1993 in Lower Granite Reservoir.

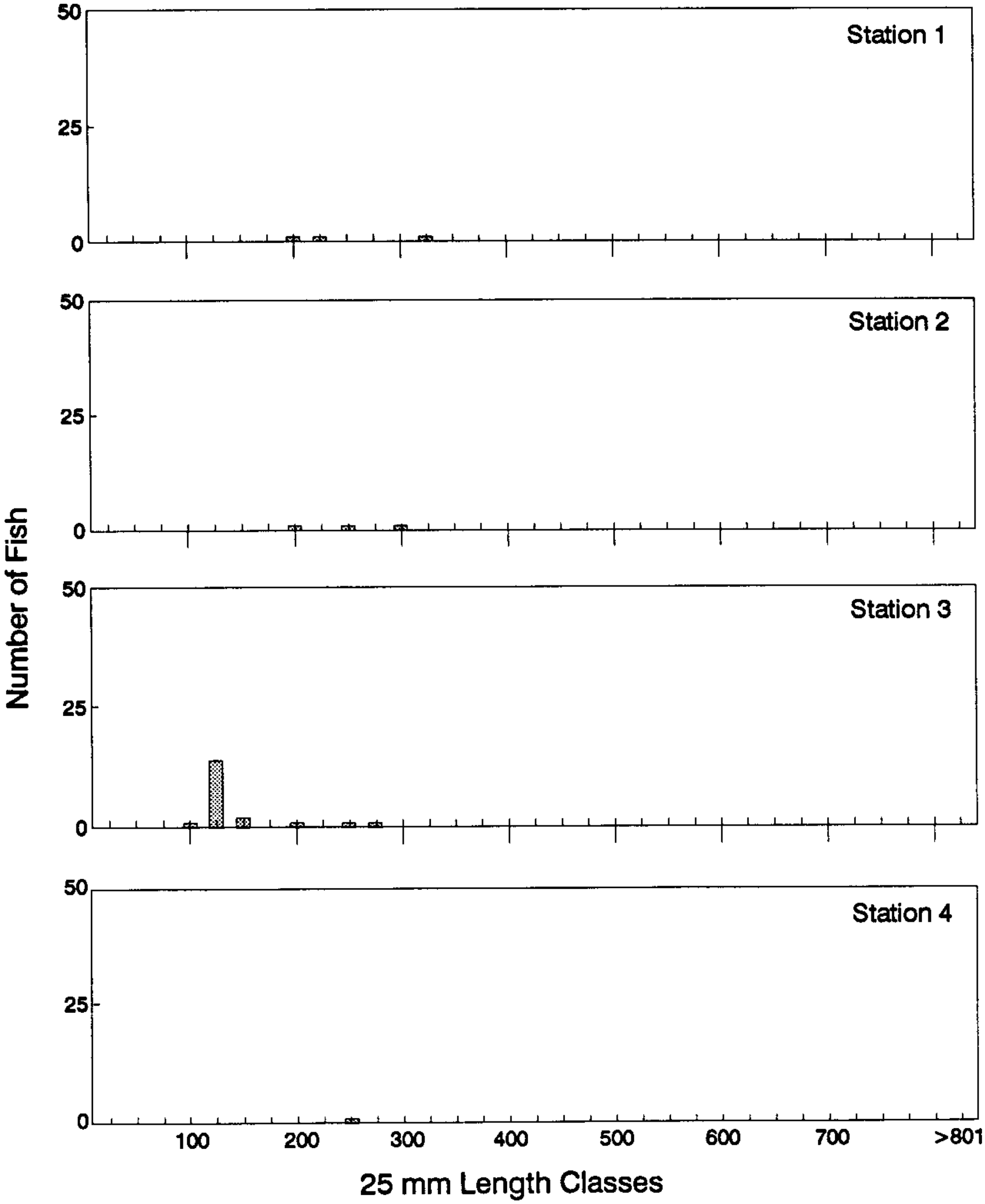


Figure 24. Length distributions of smallmouth bass sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during fall 1993 in Lower Granite Reservoir.

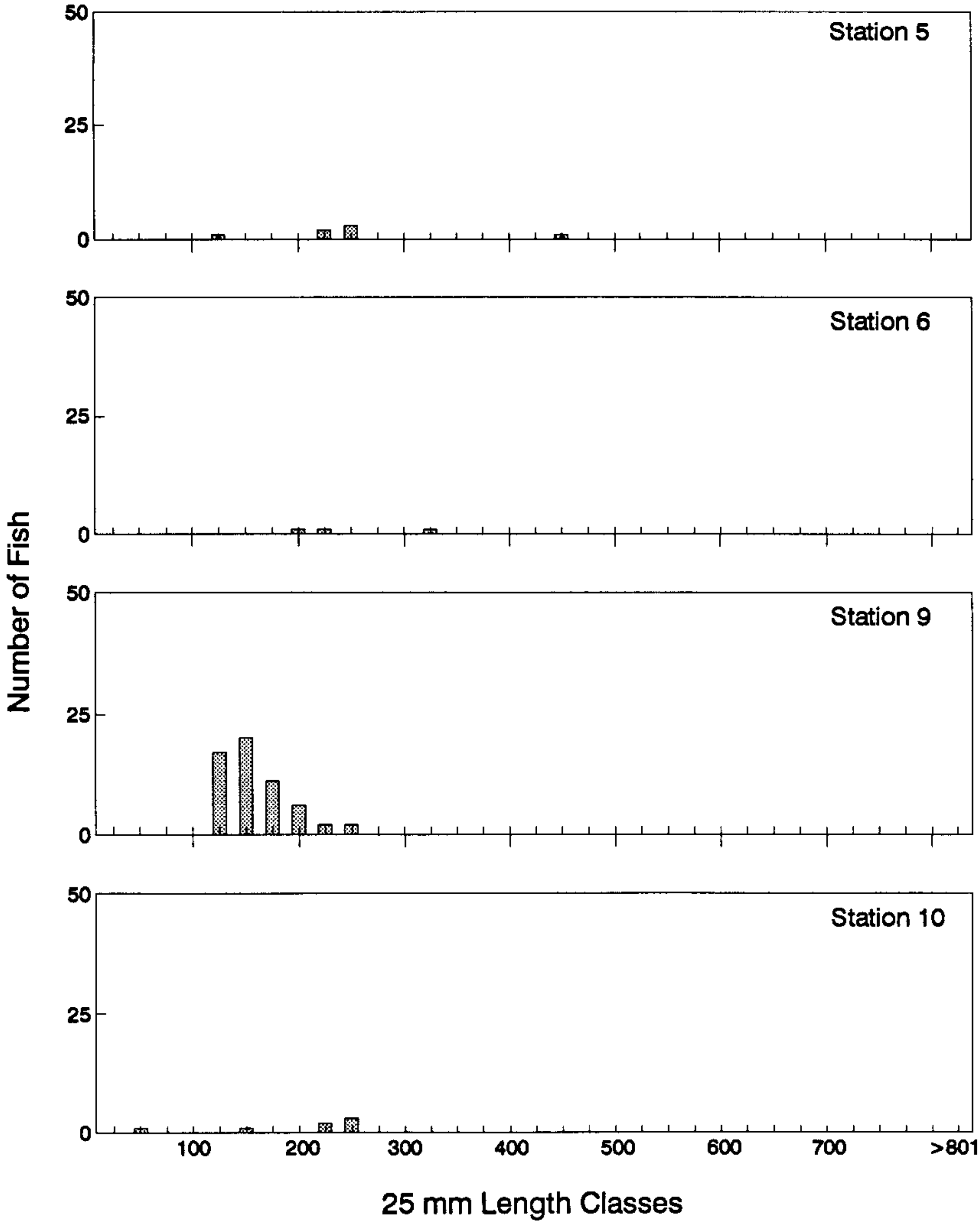


Figure 25. Length distributions of smallmouth bass sampled by all gear types at shallow (5, 9 and 10) and mid-depth (6) reference stations during fall 1993 in Lower Granite Reservoir.

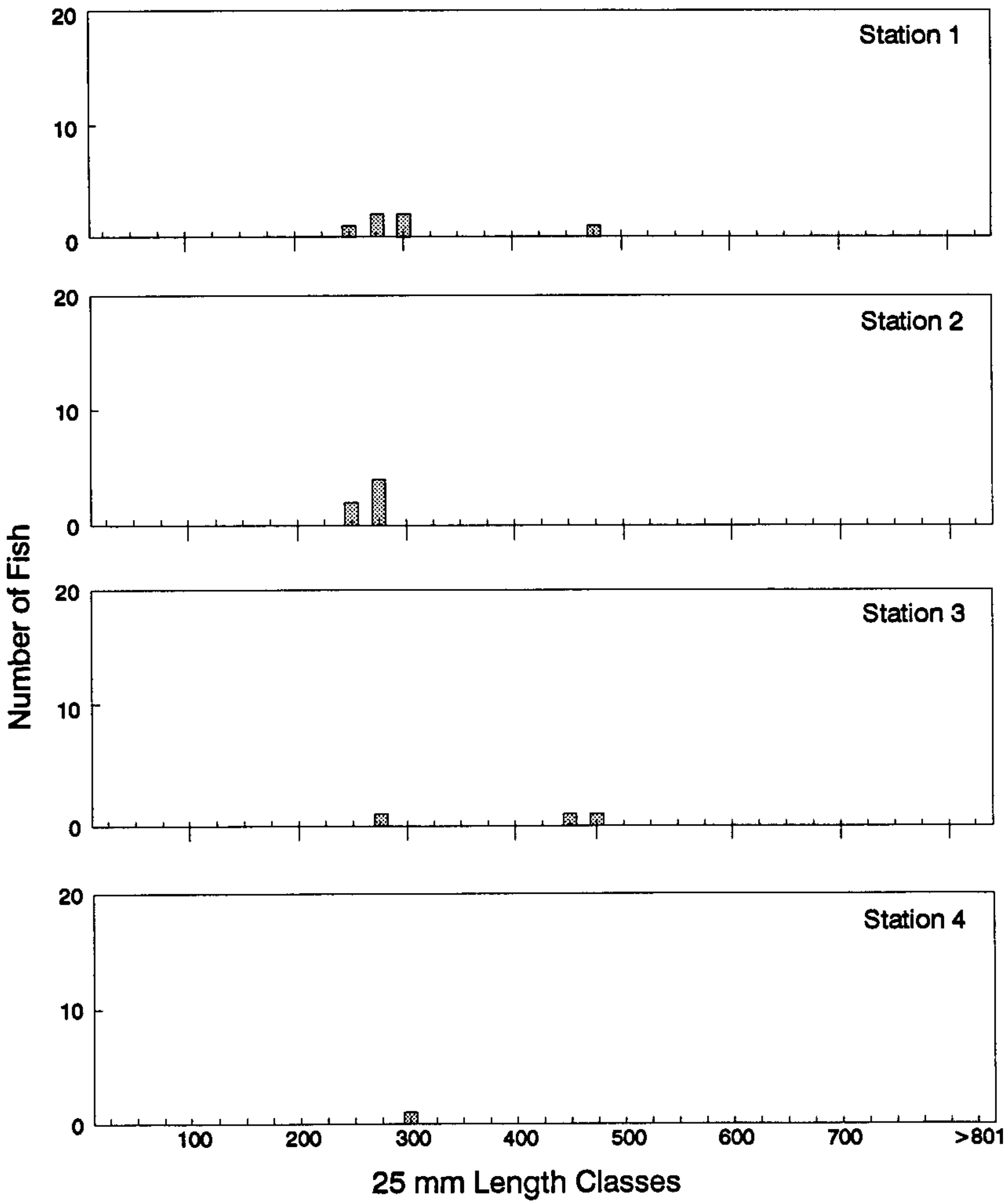


Figure 26. Length distributions of channel catfish sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during fall 1993 in Lower Granite Reservoir.

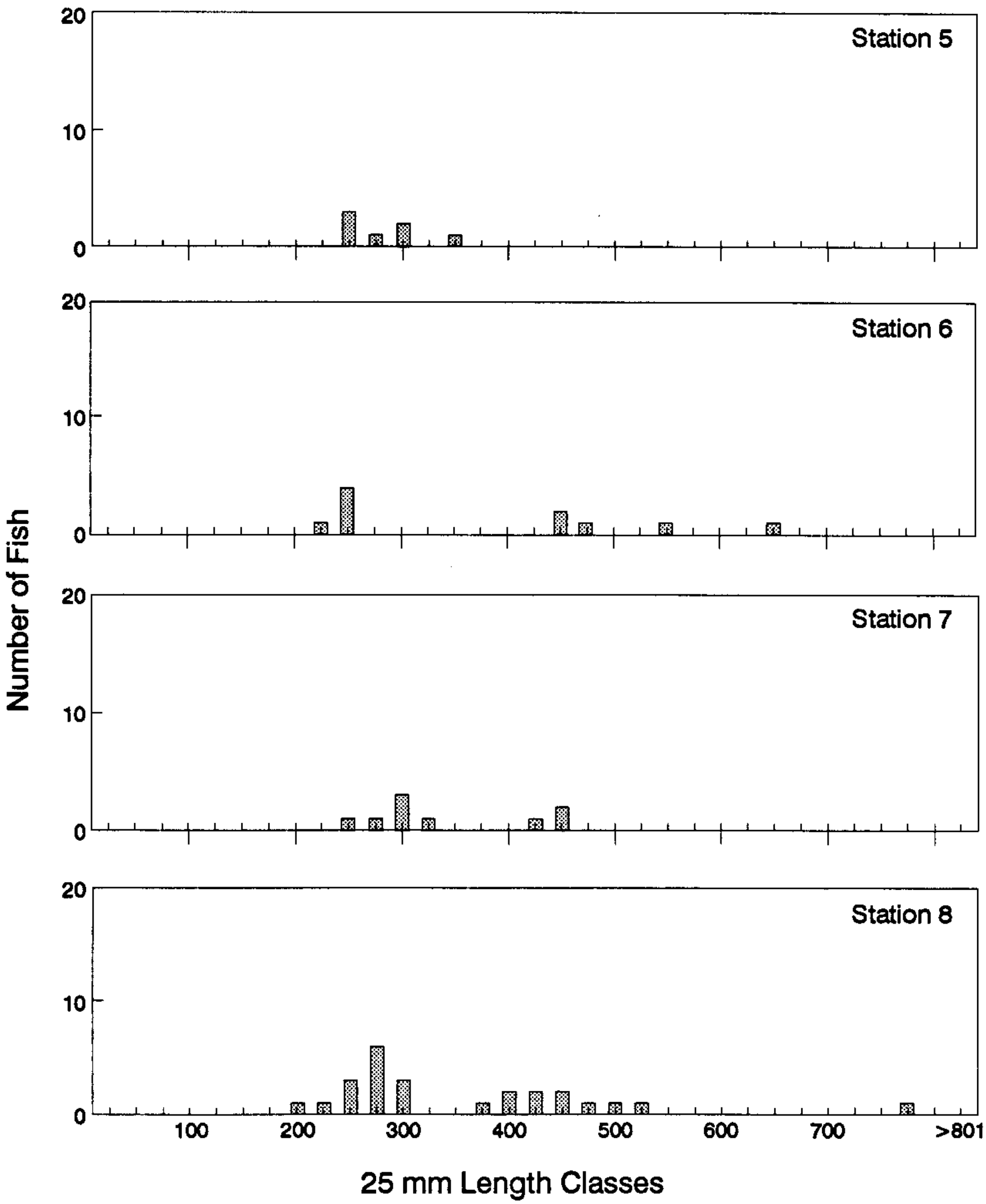


Figure 27. Length distributions of channel catfish sampled by all gear types at shallow (5), mid-depth (6) and deep (8) reference stations and deep disposal station 7 during fall 1993 in Lower Granite Reservoir.

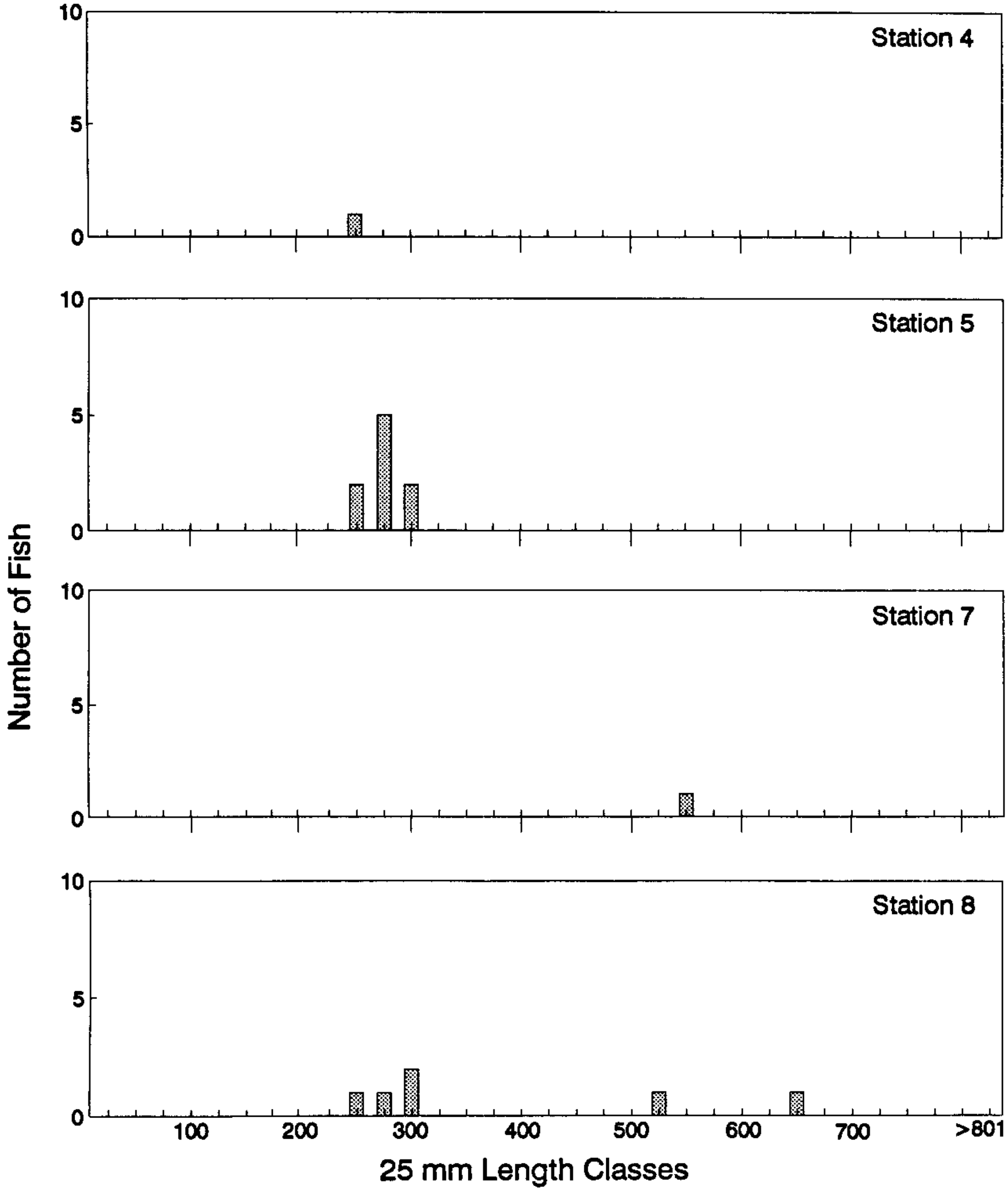


Figure 28. Length distributions of white sturgeon sampled by gill nets and set lines at mid-depth (4) and deep (7) disposal stations and shallow (5) and deep (8) reference stations during fall 1993 in Lower Granite Reservoir.

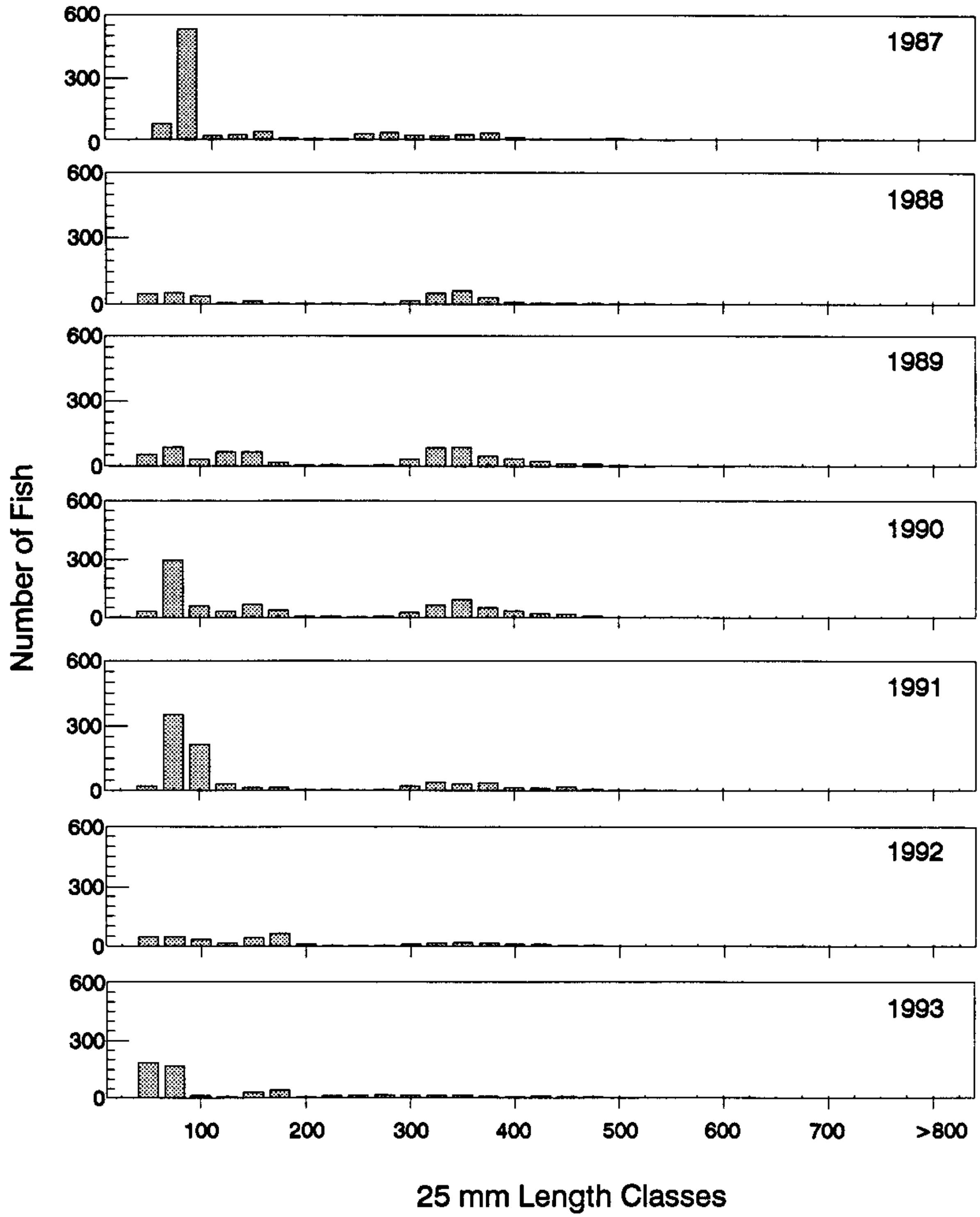


Figure 29. Length distributions of northern squawfish sampled by all gear types during 1987 through 1993 in Lower Granite Reservoir.

years, low numbers of northern squawfish from 100 to 300 mm were sampled. Peak sizes sampled were at or < 100 mm during all years sampled with smaller peaks around 350 mm. However, after 1990 a lower number of northern squawfish from 300 to 400 mm were sampled. Northern squawfish > 500 mm were rare in our samples from 1987 through 1993.

Smallmouth Bass

Length distributions of smallmouth bass differed little from 1987 through 1993 (Figure 30). Peak abundance occurred in the 75 to 100 mm lengths in 1989 through 1991, whereas in 1987, 1988, and 1992 and 1993 about equal numbers of bass from 100 to 200 mm were sampled. Abundance based on the number of small smallmouth bass sampled in 1993 was much lower than the previous 6 years. The largest sized smallmouth bass sampled in any appreciable abundance were around 400 mm.

Channel Catfish

Length distributions of channel catfish have largely been different for every year sampled since 1987 (Figure 31). Length distributions during 1987, 1988, and 1991 were generally uniform, whereas those in 1989, 1992 and 1993 exhibited peaks in abundance from 200 to 300 mm. Based on the size distributions, the abundance of larger catfish (>600 mm) generally has not changed in Lower Granite since 1987. Year classes that produced 200 to 400 mm catfish were strong and continue to show their abundance in the reservoir.

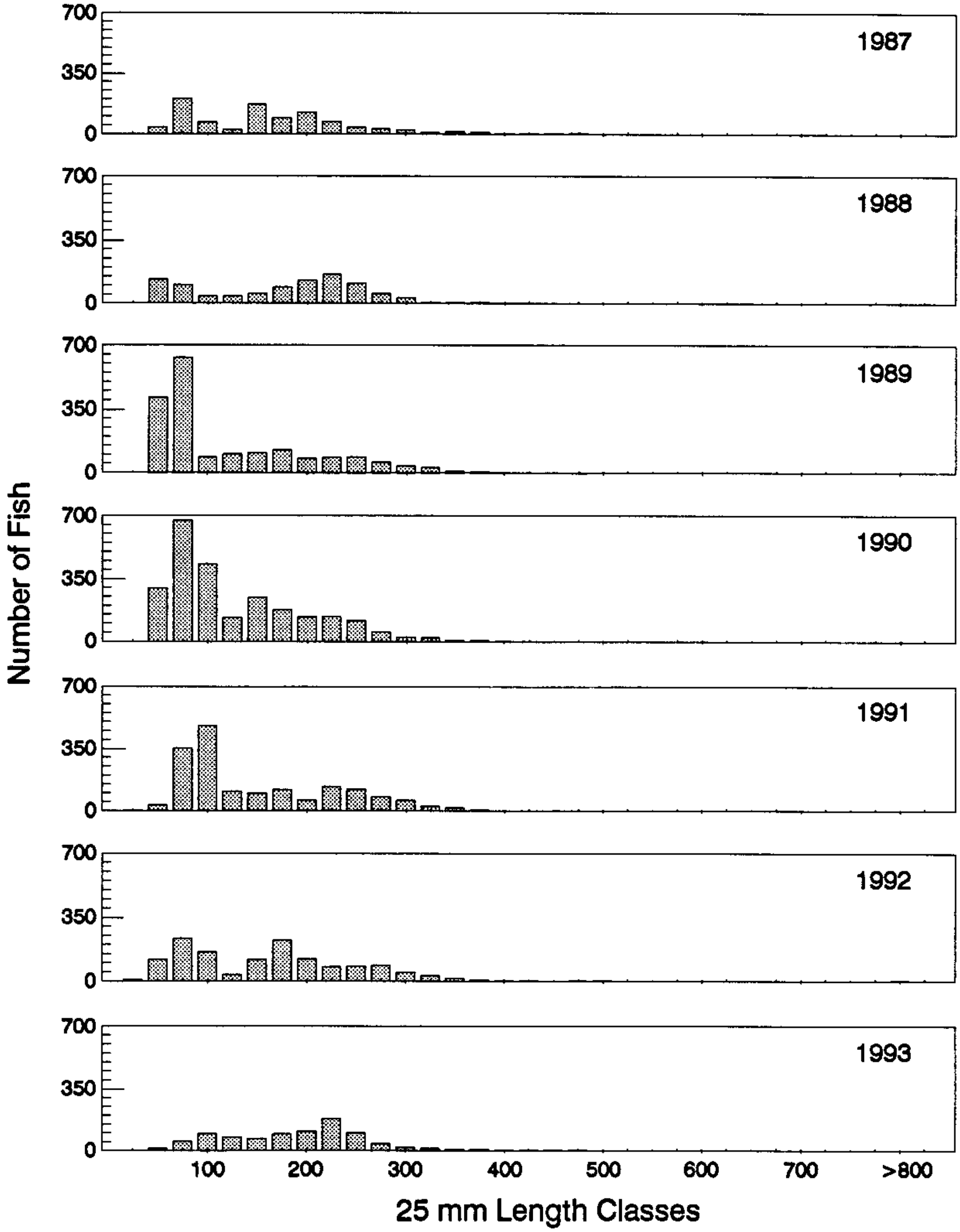


Figure 30. Length distributions of smallmouth bass sampled by all gear types during 1987 through 1993 in Lower Granite Reservoir.

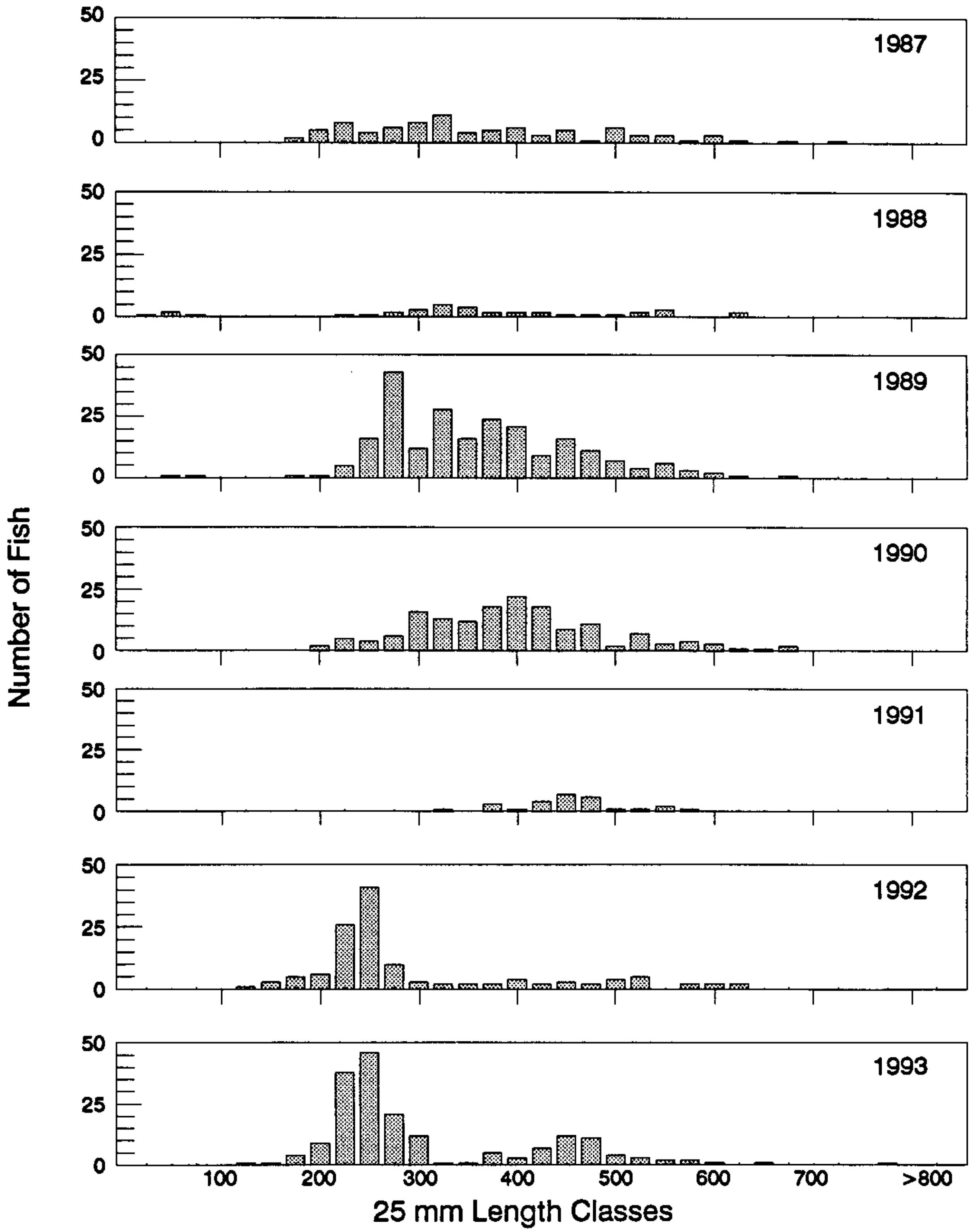


Figure 31. Length distributions of channel catfish sampled by all gear types during 1987 through 1993 in Lower Granite Reservoir.

White Sturgeon

Lengths of white sturgeon have generally been similar since 1987 (Figure 32). Fewer white sturgeon were captured in 1988, 1991 and 1993 than other years of sampling and size distributions were similar, although smaller fish increased in abundance in the samples since 1987. Sturgeon > 800 mm were the dominant size class from 1987 through 1990 whereas smaller sturgeon were abundant after 1992.

Largescale Sucker

Length distributions of largescale sucker were generally similar in Lower Granite Reservoir from 1987 to 1993 (Figure 33). Sucker > 500 mm were generally low in abundance during this period. Three peaks in abundance of sucker were generally found; < 100 mm, 300 mm and 450 mm were sizes that were abundant in our samples. Fewer suckers < 100 mm were collected in 1993 than in any of the other 6 years.

Chiselmouth

Size-frequncy distributions of chiselmouth from 1987 through 1993 generally showed three peaks in abundance at 75, 200 and 300 mm (Figure 34). Higher abundances of small chiselmouth were found in 1987 and 1992 than other years sampled and noticeable peaks at 200 and 300 mm were found in 1989, 1990 and 1991. Maximum lengths of chiselmouth sampled each year since 1987 were about 400 mm.

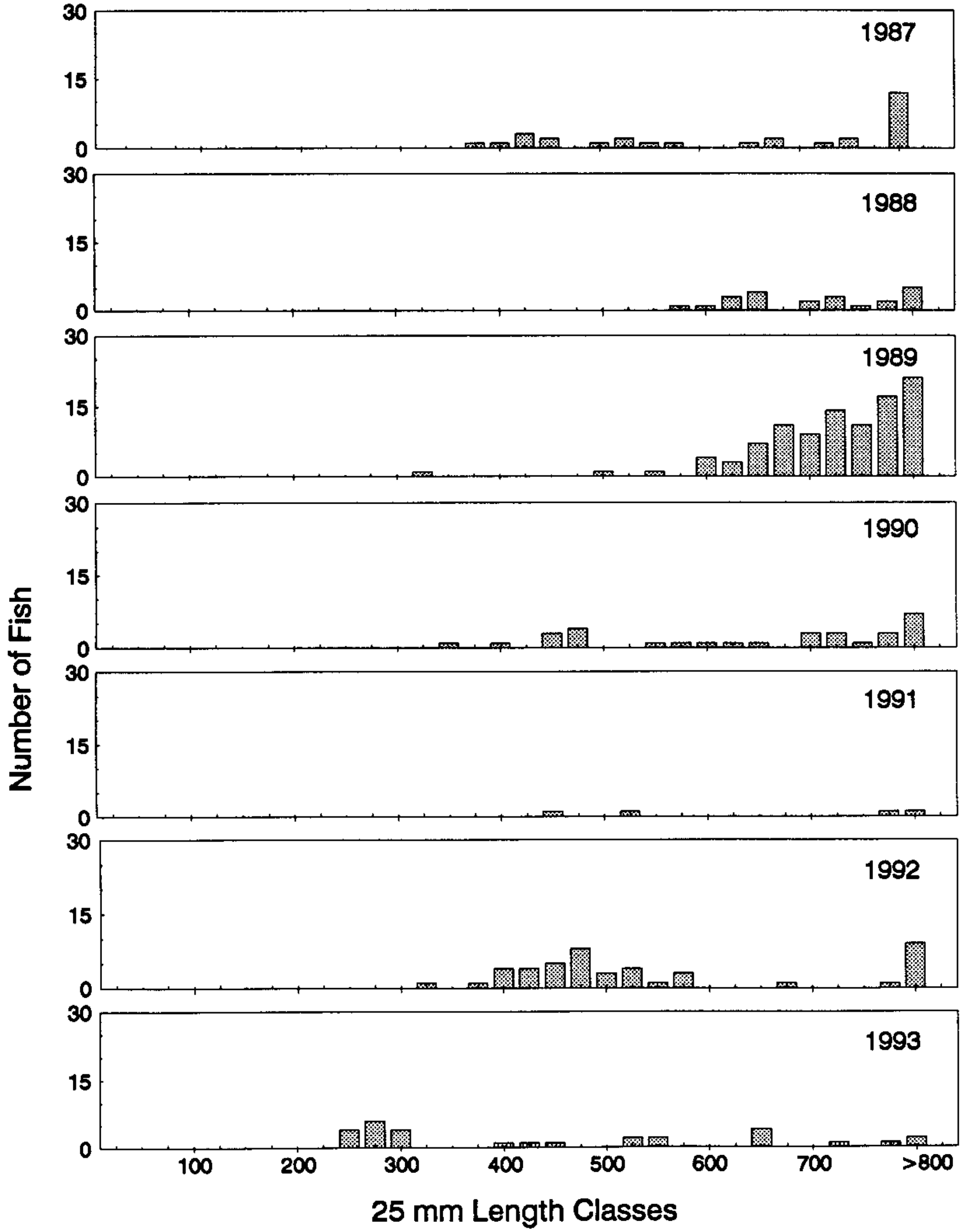


Figure 32. Length distributions of white sturgeon sampled by all gear types during 1987 through 1993 in Lower Granite Reservoir.

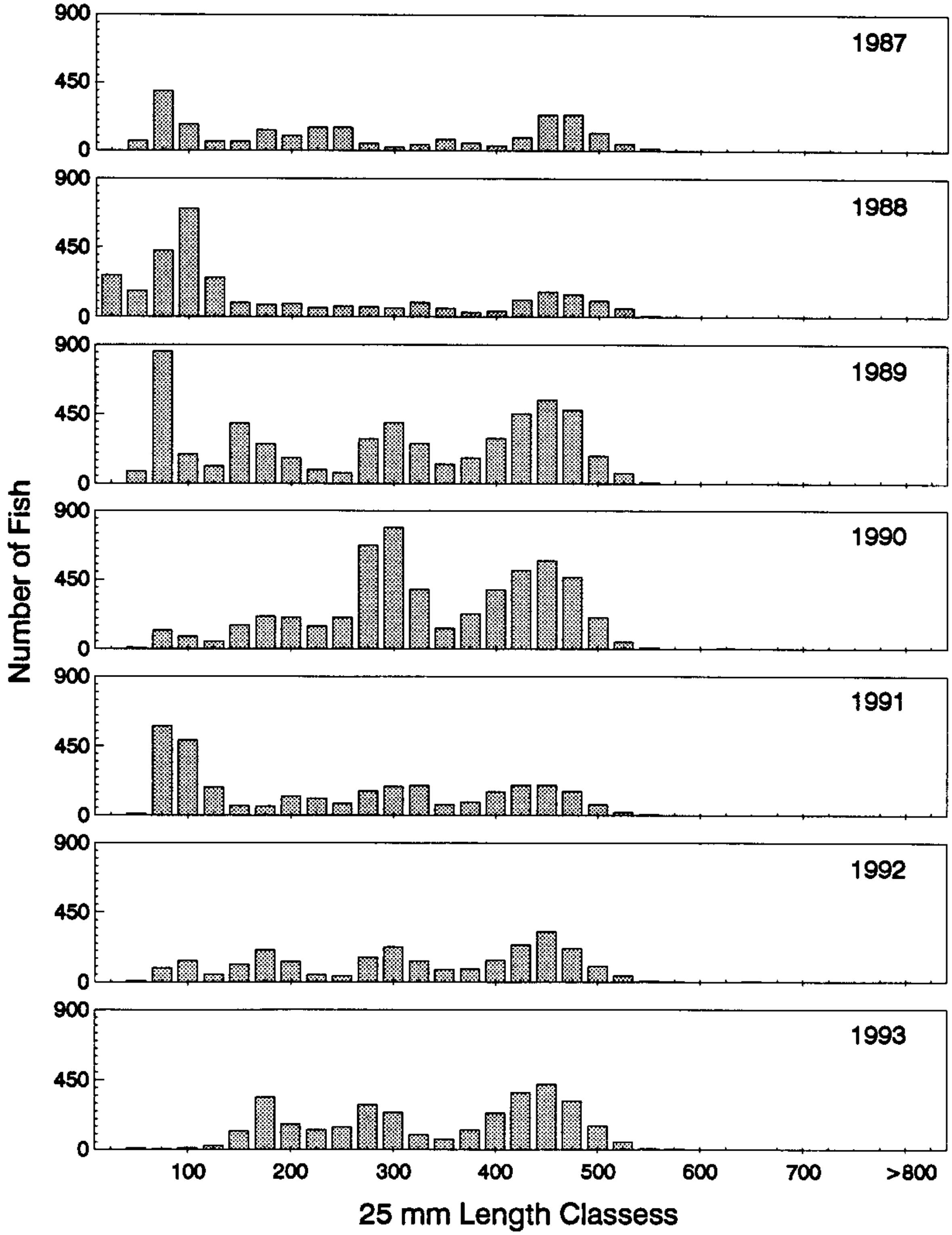


Figure 33. Length distributions of largescale sucker sampled by all gear types during 1987 through 1993 in Lower Granite Reservoir.

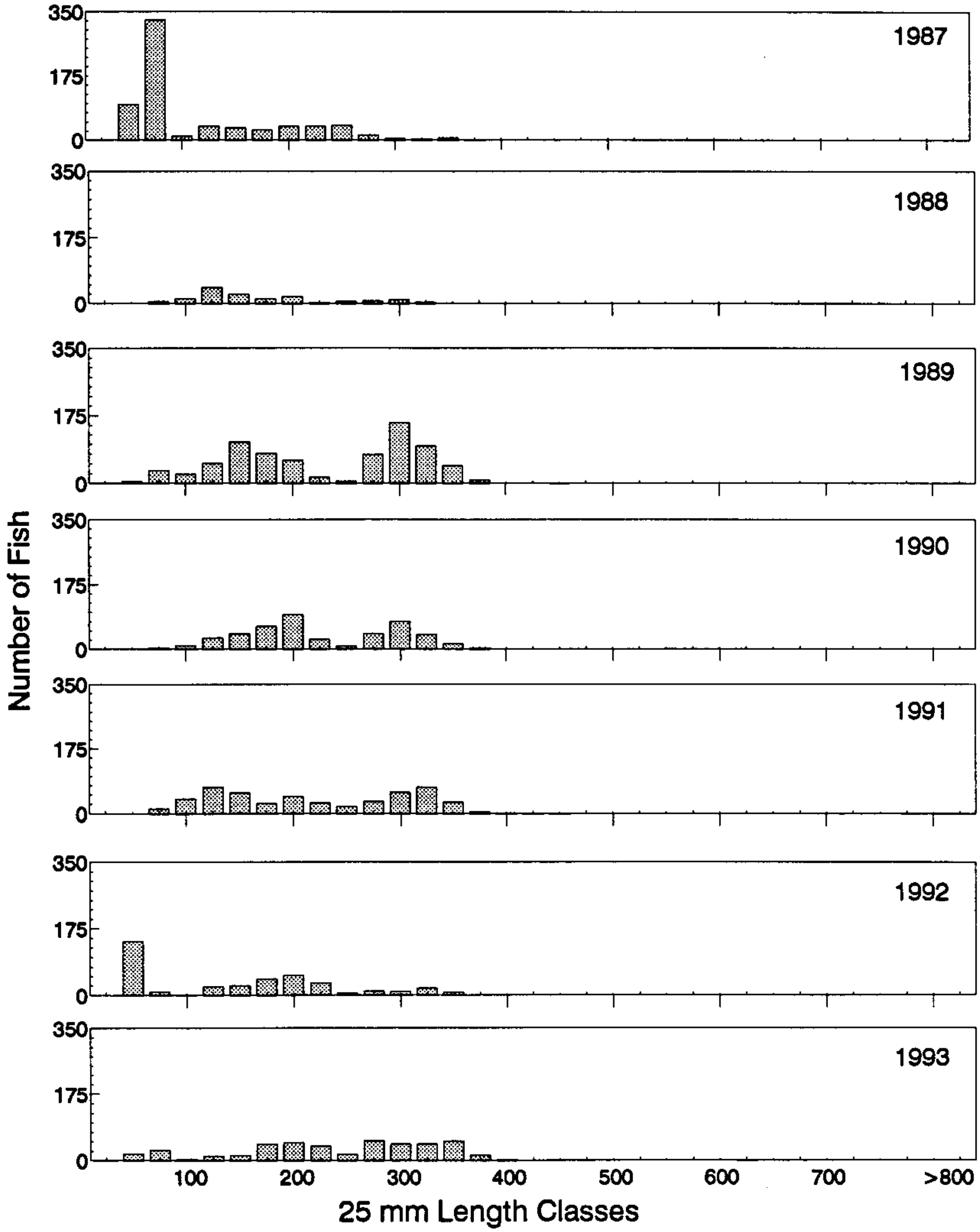


Figure 34. Length distributions of chiselmouth sampled by all gear types during 1987 through 1993 in Lower Granite Reservoir.

Abundance of Fishes by Gear Types

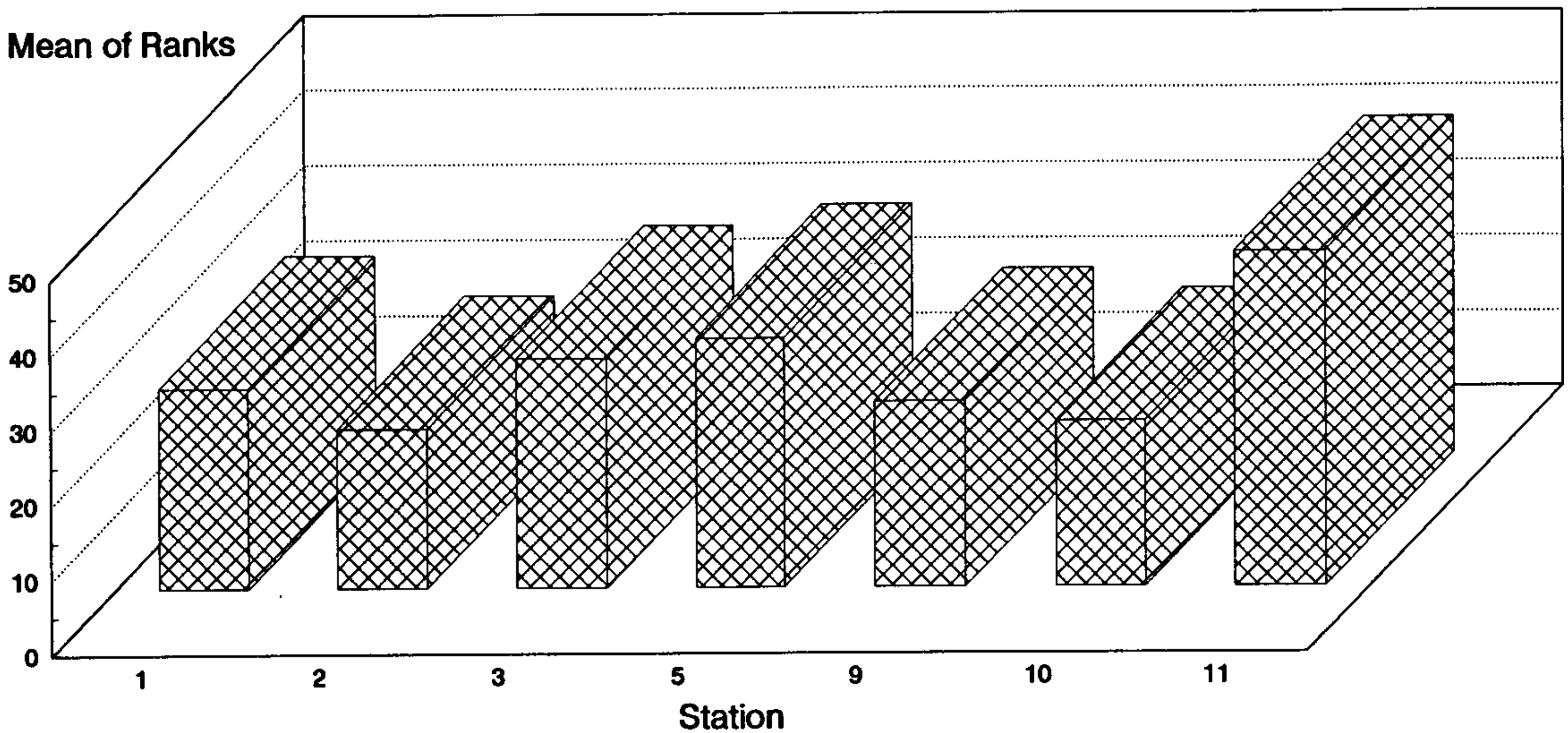
1993

Chinook salmon.- Comparisons of catch/effort for juvenile chinook salmon by beach seining during 1993 indicated few station differences were found (Figure 35). Catch/effort for juvenile chinook salmon was significantly higher at shallow reference station 11 than reference stations 9 and 10 and disposal stations 1 and 2. Catch/efforts for juvenile chinook salmon by beach seining at reference stations 11, 5 and 3 were statistically similar.

A similar trend in catch/effort for juvenile chinook salmon sampled by electrofishing was found (Figure 36). Few differences in catch/effort were found and generally a similar index of abundance was found by electrofishing to that by beach seining.

Steelhead.- Abundance of juvenile steelhead based on comparisons of catch/effort by beach seining during 1993 indicated no significant difference in abundance among shallow reference stations 5 and 10 and shallow disposal stations 1 and 2 (Figure 37). The catch/effort for juvenile steelhead was significantly ($P < 0.05$) higher at reference station 9 than all other shallow stations. We found no seasonal differences in abundance for juvenile steelhead sampled by beach seining in 1993. No statistical differences ($P > 0.05$) in catch/effort were found among spring, summer and fall.

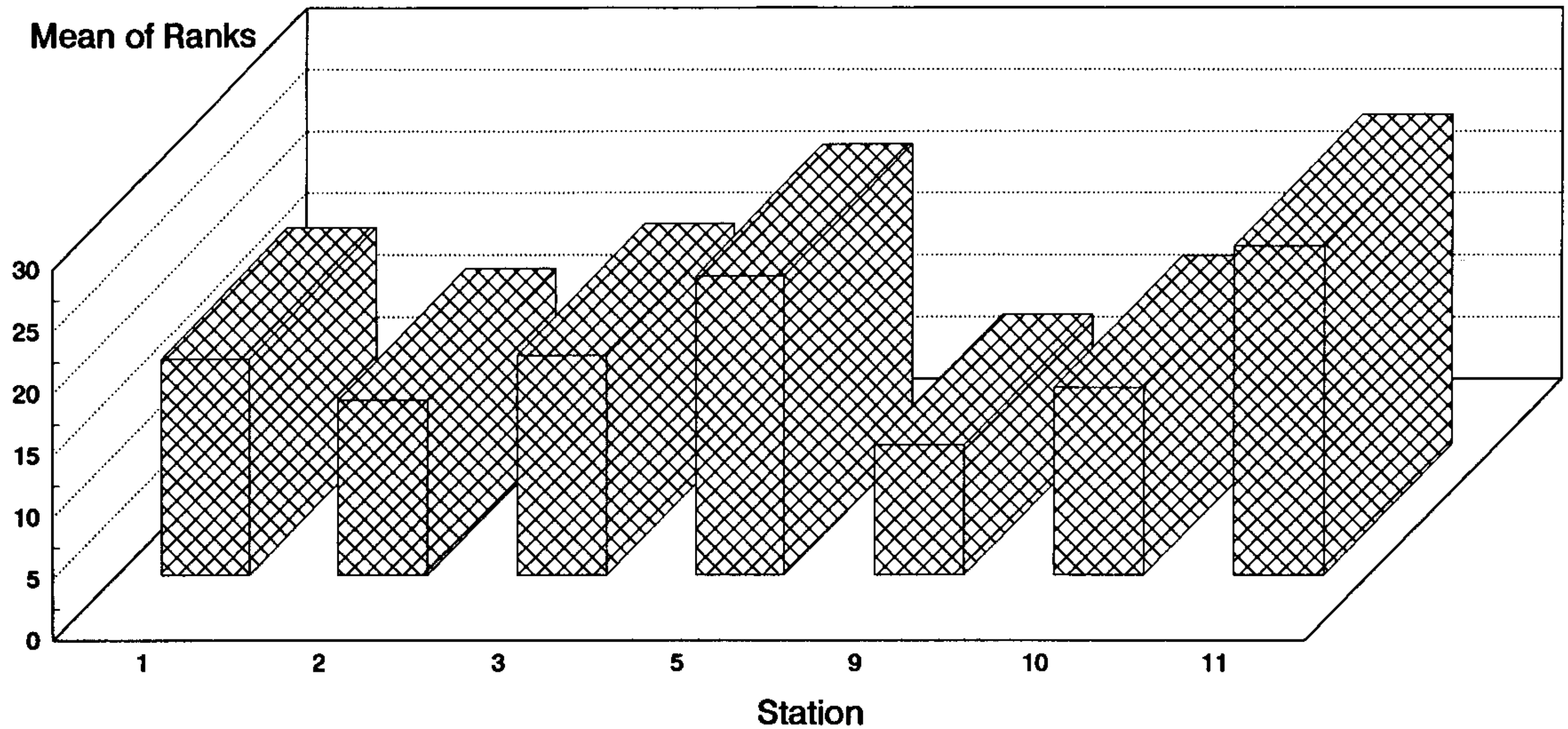
Abundance of juvenile steelhead based on comparisons of catch/effort by electrofishing showed similar results as beach seining, as no station differences and one seasonal difference in abundance were found (Figure 38). Catch/effort at station 9 was the highest and that



Station Comparison

11 5 3 1 9 10 2

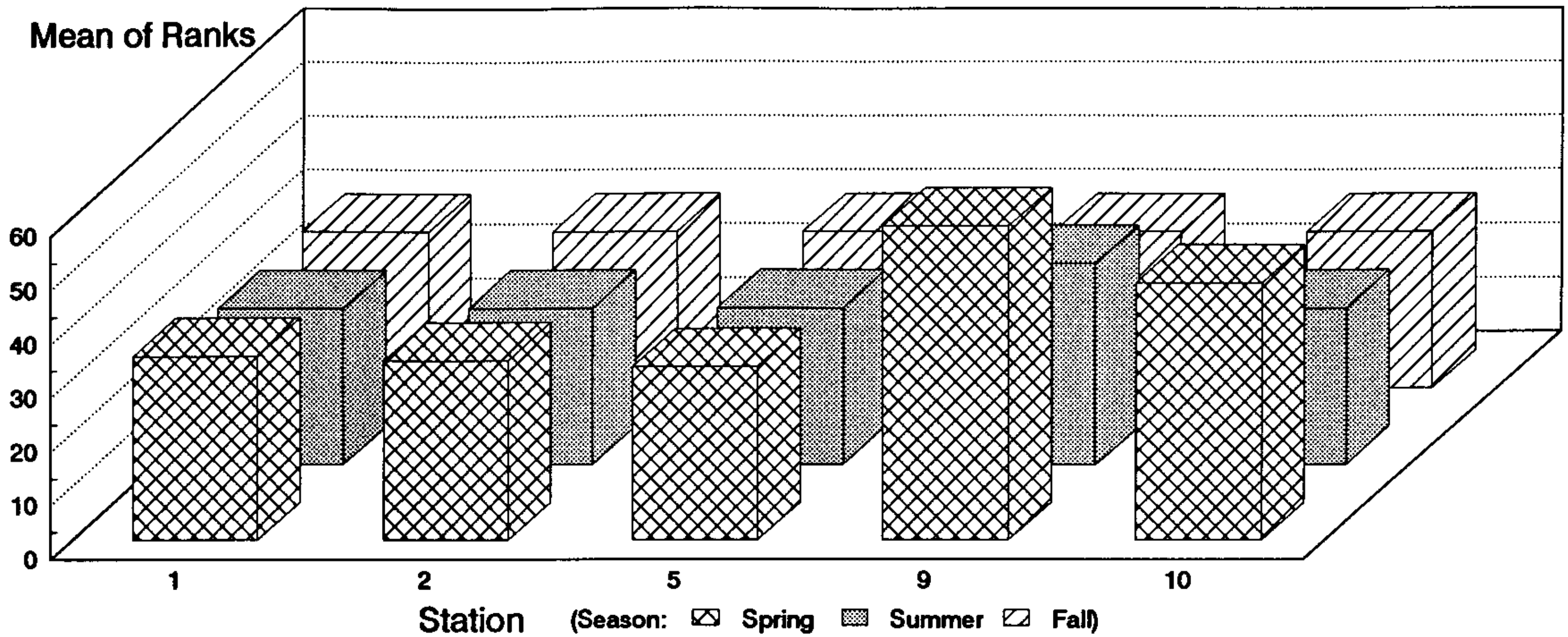
Figure 35. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance ~~sampled~~ sampled by beach seining during 1993 in Lower Granite Reservoir. Horizontal lines under the station comparison indicate statistical nonsignificance (P > 0.05).



Station Comparison

11 5 3 1 10 2 9

Figure 36. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by electrofishing during 1993 in Lower Granite Reservoir. Horizontal lines under the station comparison indicate statistical nonsignificance (P > 0.05).



Station Comparison

9 10 1 2 5

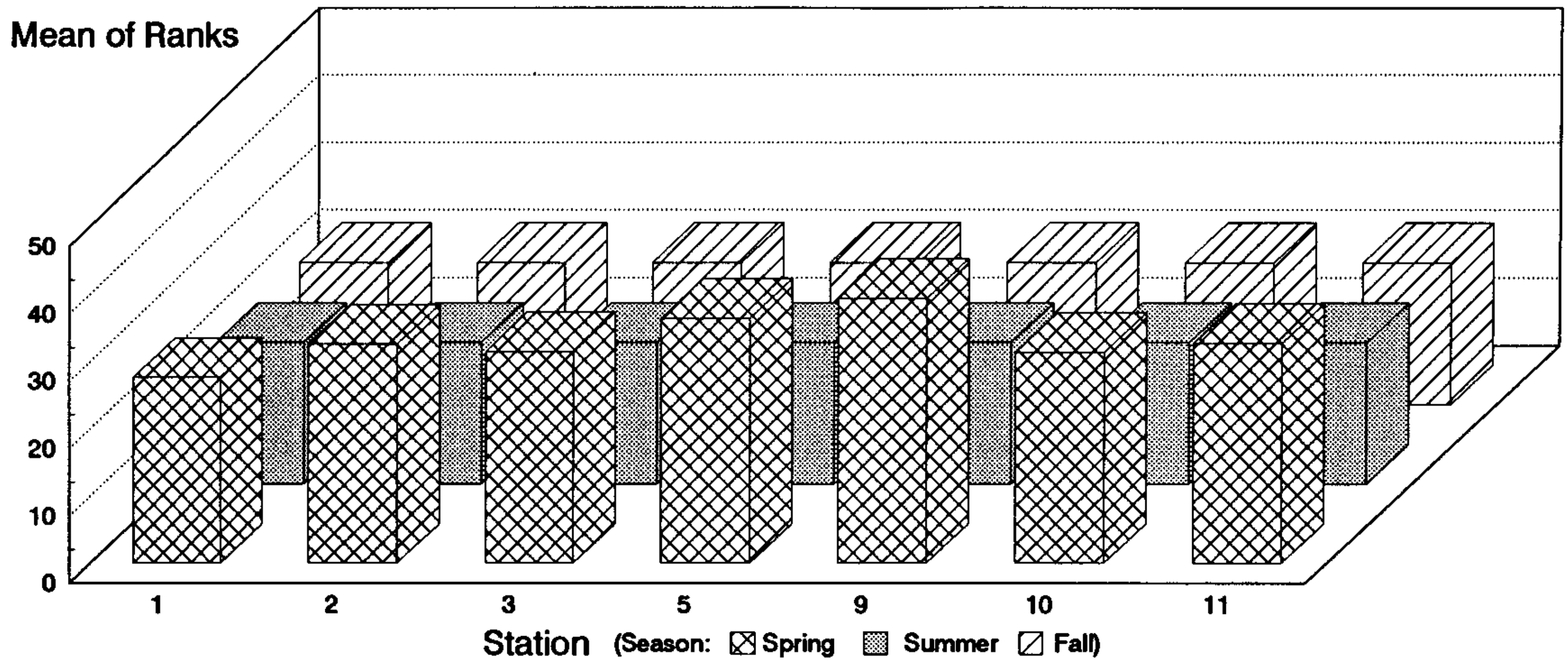
(underline spans 10, 1, 2, 5)

Season Comparison

Spring Summer Fall

(underline spans Spring, Summer, Fall)

Figure 37. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by beach seining during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

9 5 11 2 3 10 1

Season Comparison

Spring Fall Summer

Figure 38. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by electrofishing during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).

at station 1 was the lowest, although differences were not significant ($P > 0.05$). Seasonal differences in catch/effort for juvenile steelhead sampled by nighttime electrofishing in 1993 were found (Figure 38). Catch/effort by electrofishing was highest in spring followed by fall and summer, although differences in catch/effort for fall and summer were statistically ($P > 0.05$) similar.

Northern squawfish.- A significant interaction of catch/effort between seasons and stations was found for northern squawfish sampled by gill netting in 1993 (Figure 39). During spring, the three lowest catch/efforts were found at disposal stations 7, 1 and 2, while catch/effort was highest at reference station 6 followed by station 5. Both reference stations were significantly ($P < 0.05$) higher than three of the disposal stations (1, 2 and 7). Comparisons of catch/effort indicated intermediate abundance of northern squawfish at disposal station 4 during both spring and fall (Figure 39). The ordering of catch/effort during fall changed among stations from spring. The highest catch/effort occurred at reference station 3 and lowest at reference station 8. As in the spring, catch/efforts at disposal stations were intermediate. Seasonal abundance of northern squawfish sampled by gill netting during 1993 varied among stations between spring and fall (Figure 39). Statistical ($P < 0.05$) differences in seasonal catch/effort were at reference stations 5 and 6 where abundance was highest at both stations during spring.

Comparisons of catch/effort of northern squawfish sampled by beach seining in 1993 showed no significant station*season interactions

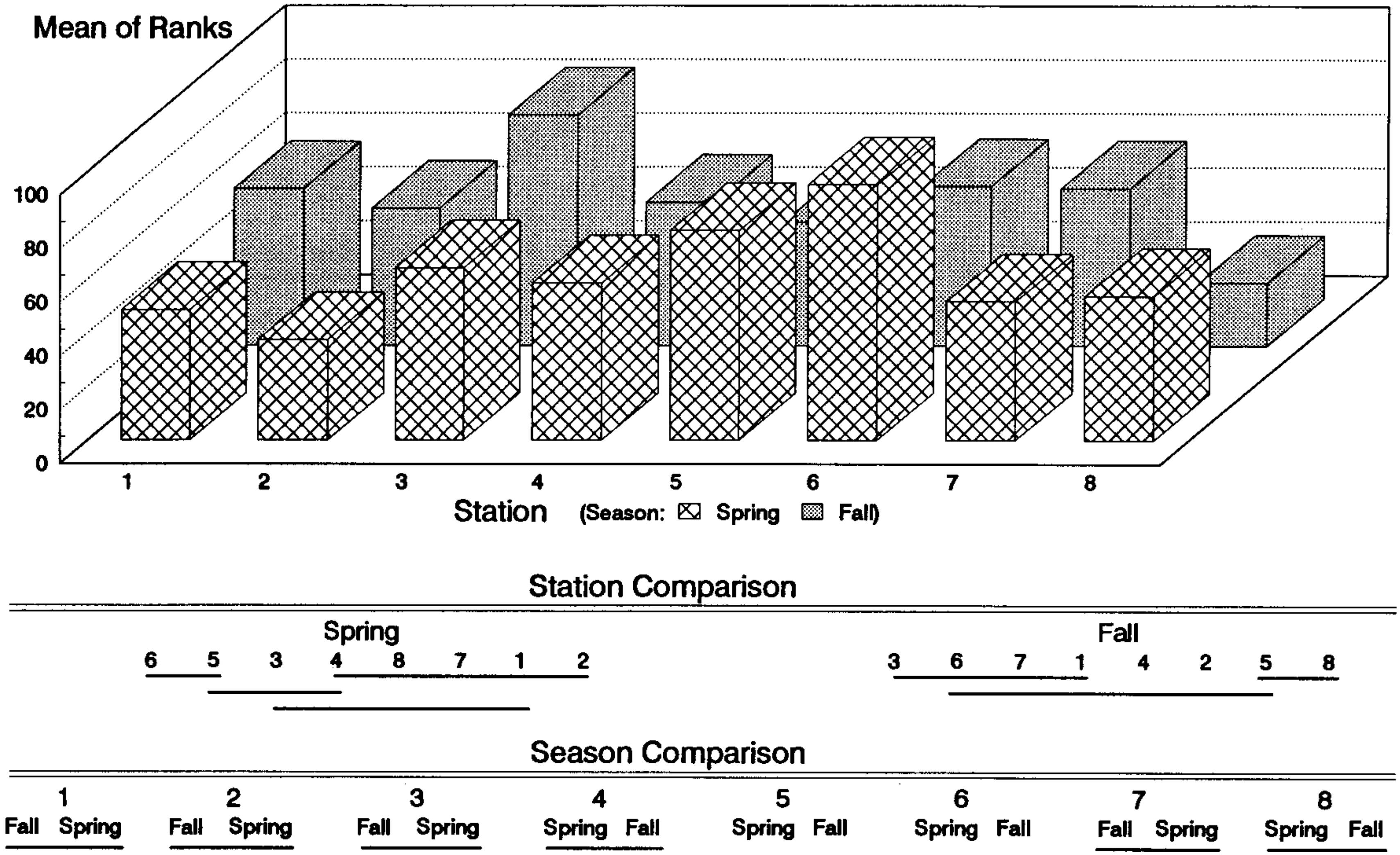
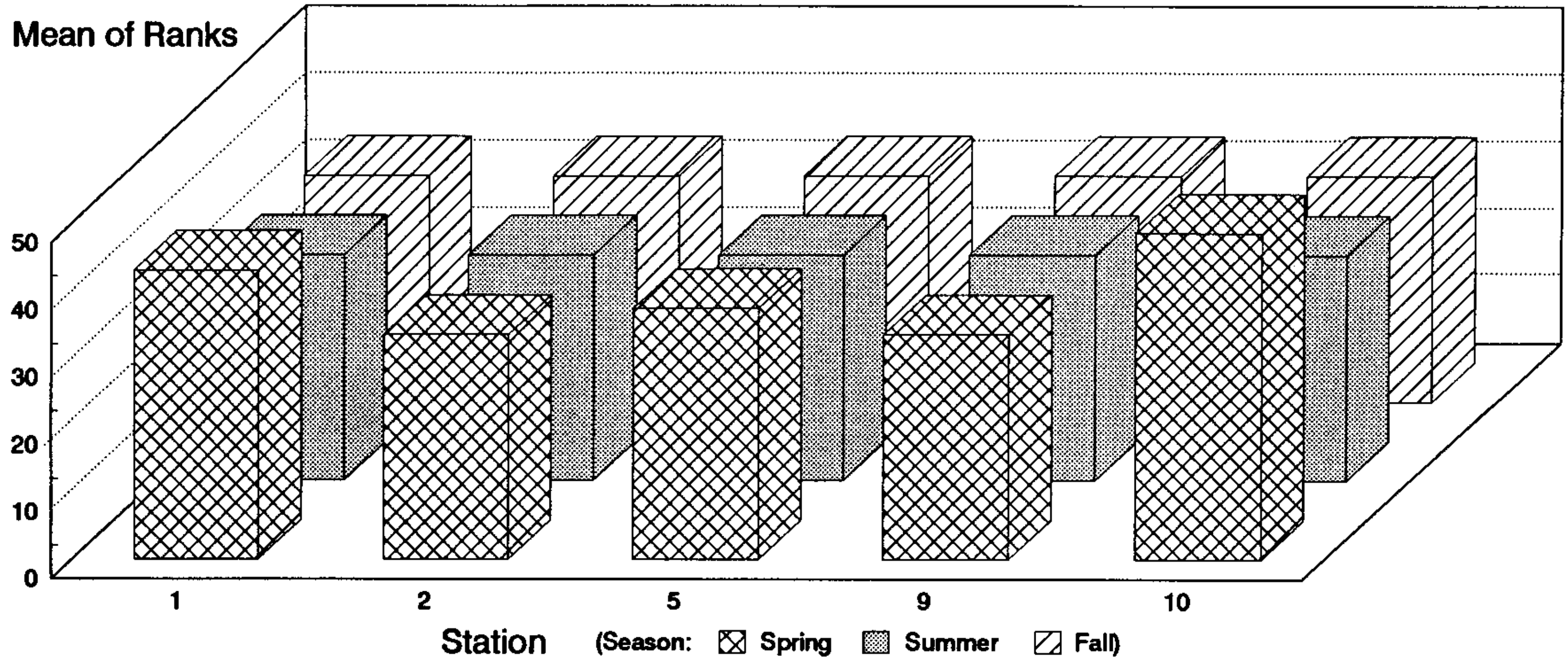


Figure 39. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).

(Figure 40). Although station differences were limited, catch/effort at reference station 10 was significantly the higher than other stations sampled (Figure 40). No seasonal differences in catch/effort by beach seining were found, although catch/effort was highest during spring and summer was lowest.

Comparisons of catch/effort by electrofishing for northern squawfish in 1993 suggested few station and season differences in abundance (Figure 41). Catch/effort for northern squawfish was intermediate at disposal stations 1 and 2 and not significantly different from that at most of the reference stations. Seasonal differences in catch/effort were found between spring and fall but not between spring and summer and summer and fall.

Smallmouth bass.- Abundance of smallmouth bass based on comparisons of catch/effort by gill netting showed a significant season*station interaction (Figure 42). During spring 1993, catch/efforts were significantly higher at reference stations 3 and 5 and disposal station 1 than other reference and disposal stations. During fall, significantly ($P < 0.05$) higher catch/efforts were found at reference station 6 and disposal station 2 than disposal station 7 and reference stations 3, 5 and 8. Based on catch/effort, abundance of smallmouth bass in fall of 1993 was similar among disposal stations 1, 2 and 4 and reference station 6. Seasonal comparisons of catch/effort for smallmouth bass within stations indicated significantly ($P < 0.05$) higher catch/effort between spring and fall were found at shallow



Station Comparison

10 1 5 2 9

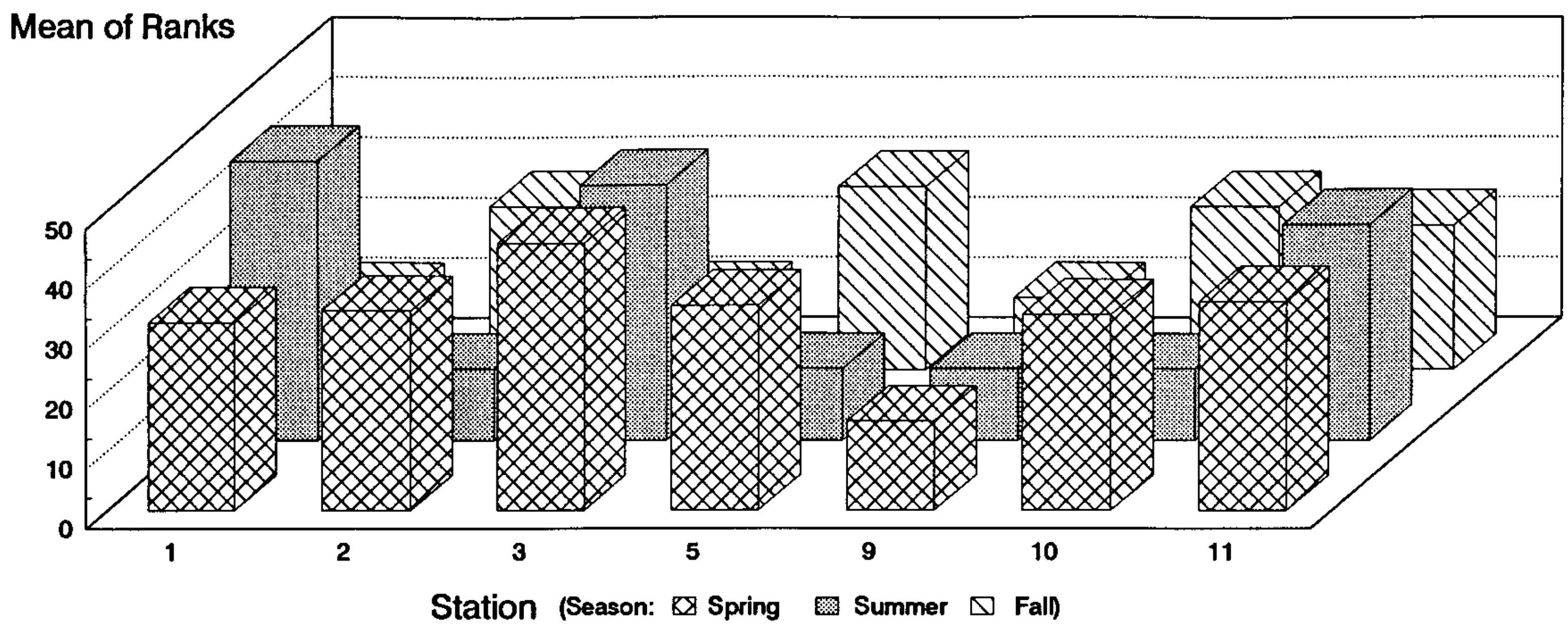
(Horizontal line under: 1 5 2 9)

Season Comparison

Spring Fall Summer

(Horizontal line under: Spring Fall Summer)

Figure 40. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by beach seining during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).



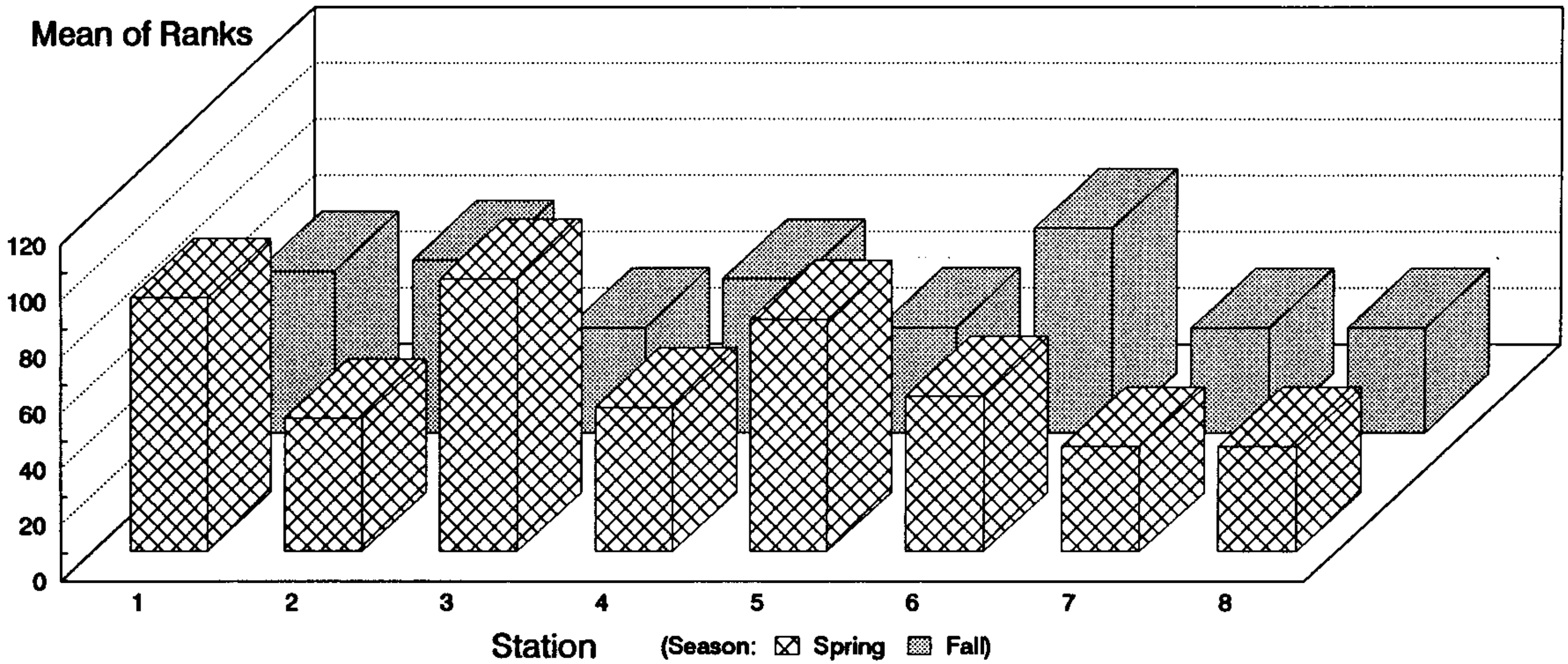
Station Comparison

3 11 5 2 10 1 9

Season Comparison

Spring Summer Fall

Figure 41. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by electrofishing during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statsitical nonsignificance (P > 0.05).



Station Comparison

Spring

3 1 5 6 4 2 7 8

Fall

6 2 1 4 3 5 7 8

Season Comparison

1	2	3	4	5	6	7	8
Spring Fall	Fall Spring	Spring Fall	Fall Spring	Spring Fall	Fall Spring	Spring Fall	Spring Fall

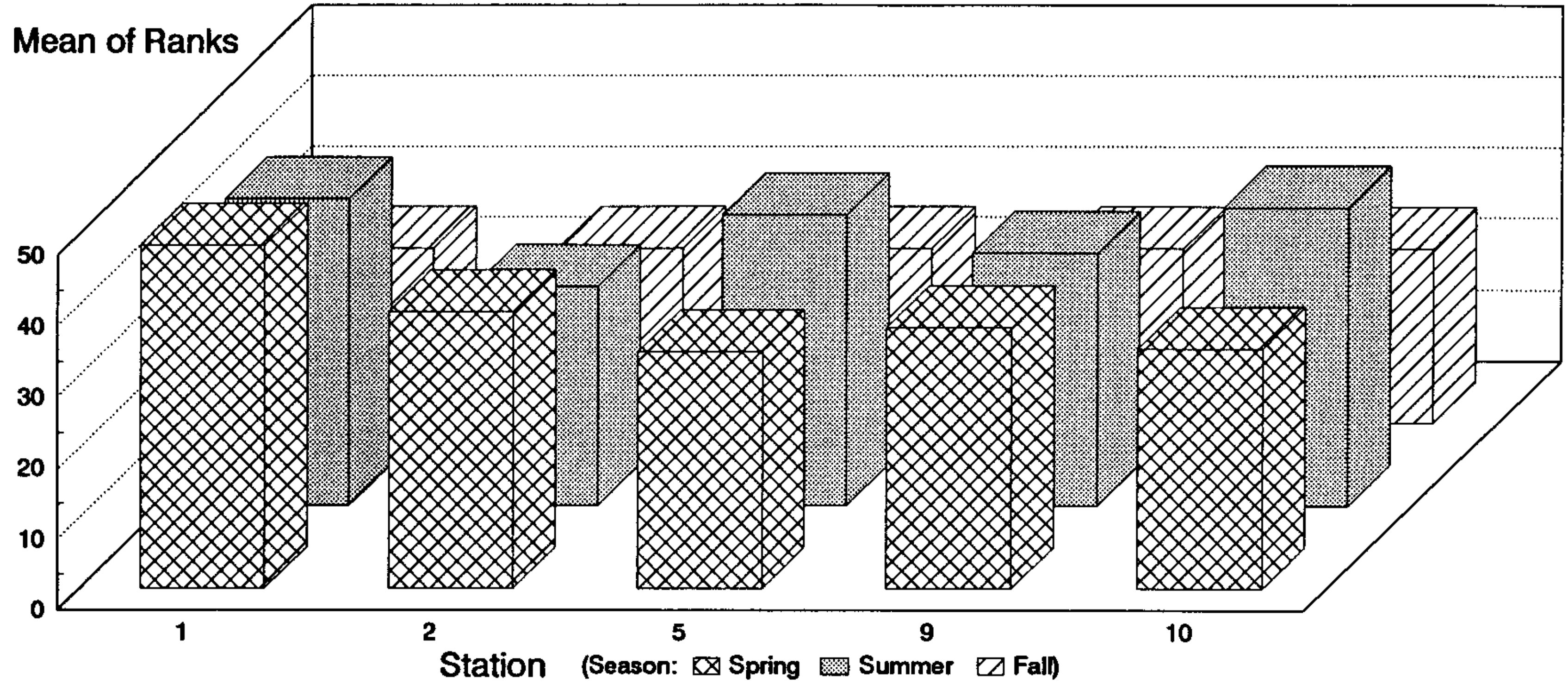
Figure 42. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).

stations 1, 3 and 5 (Figure 42). Abundance was consistently higher in the spring at these stations.

Comparisons of catch/efforts for smallmouth bass by beach seining indicated no station differences in abundance and one seasonal difference (Figure 43). Catch/efforts were high at disposal stations 1 and 2 and low at reference stations 9 and 5. Catch/efforts for smallmouth bass during the summer and spring were significantly ($P < 0.05$) higher than that of fall for all stations combined.

Comparisons of catch/effort for smallmouth bass sampled by electrofishing indicated few station differences and no seasonal differences in abundance (Figure 44). Catch/effort was significantly higher at reference station 9 than reference stations 5 and 11 and disposal stations 1 and 2. Catch/effort for smallmouth bass by electrofishing was highest in summer followed by spring and fall, although these differences weren't statistically significant ($P > 0.05$) (Figure 44).

Channel catfish.- Comparisons of catch/effort for channel catfish in 1993 sampled by gill netting were affected by station*season interaction (Figure 45). During spring, catch/efforts were variable and few significant differences in abundance were found. Spring abundance generally was high at disposal stations 1 and 2 and reference stations 6 and 8. During fall, catch/effort was highest at reference station 8 followed by disposal station 7. Catch/effort at station 8 was significantly ($P < 0.05$) different from other stations sampled, except deep disposal station 7. Seasonal differences of catch/effort for



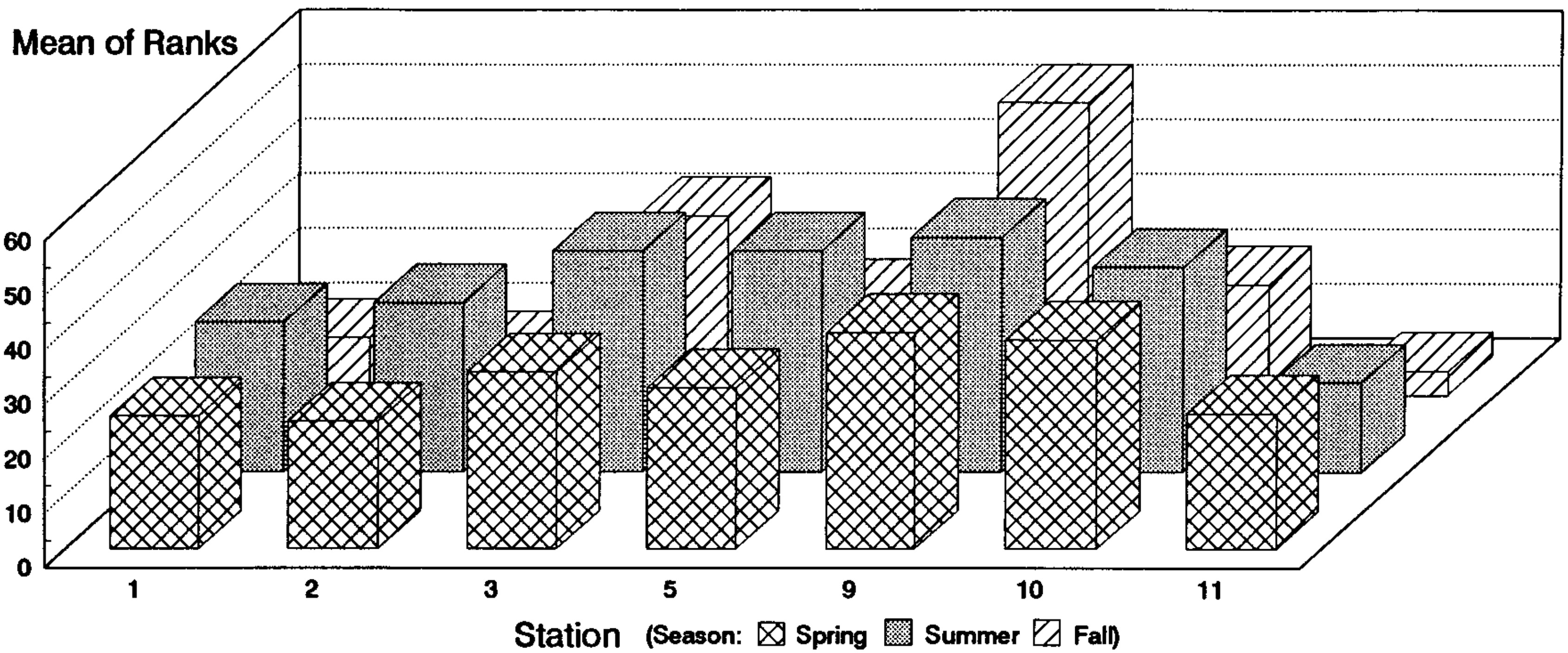
Station Comparison

1 2 10 9 5

Season Comparison

Summer Spring Fall

Figure 43. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by beach seining during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

9 10 3 5 1 2 11

Season Comparison

Summer Spring Fall

Figure 44. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).

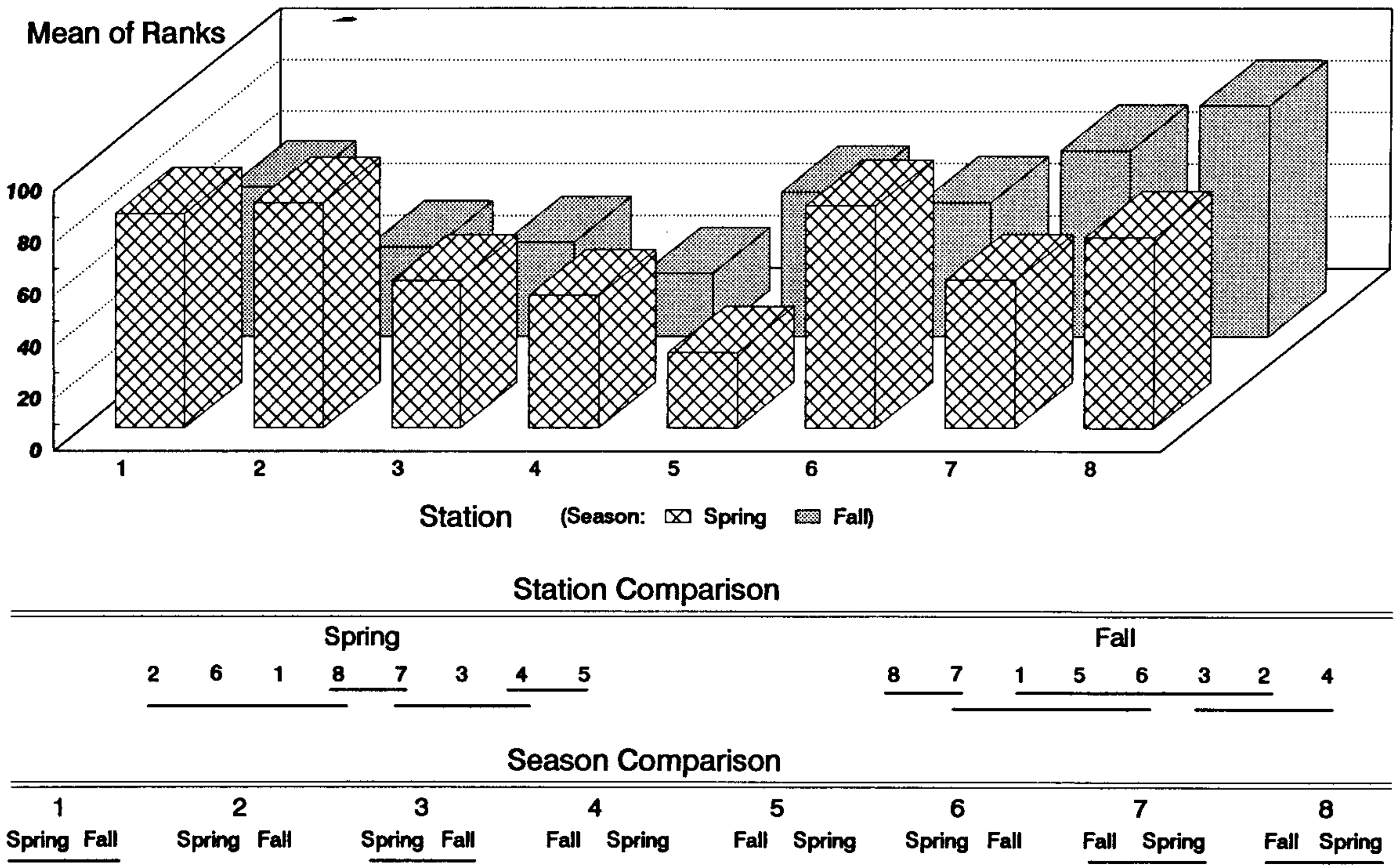


Figure 45. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).

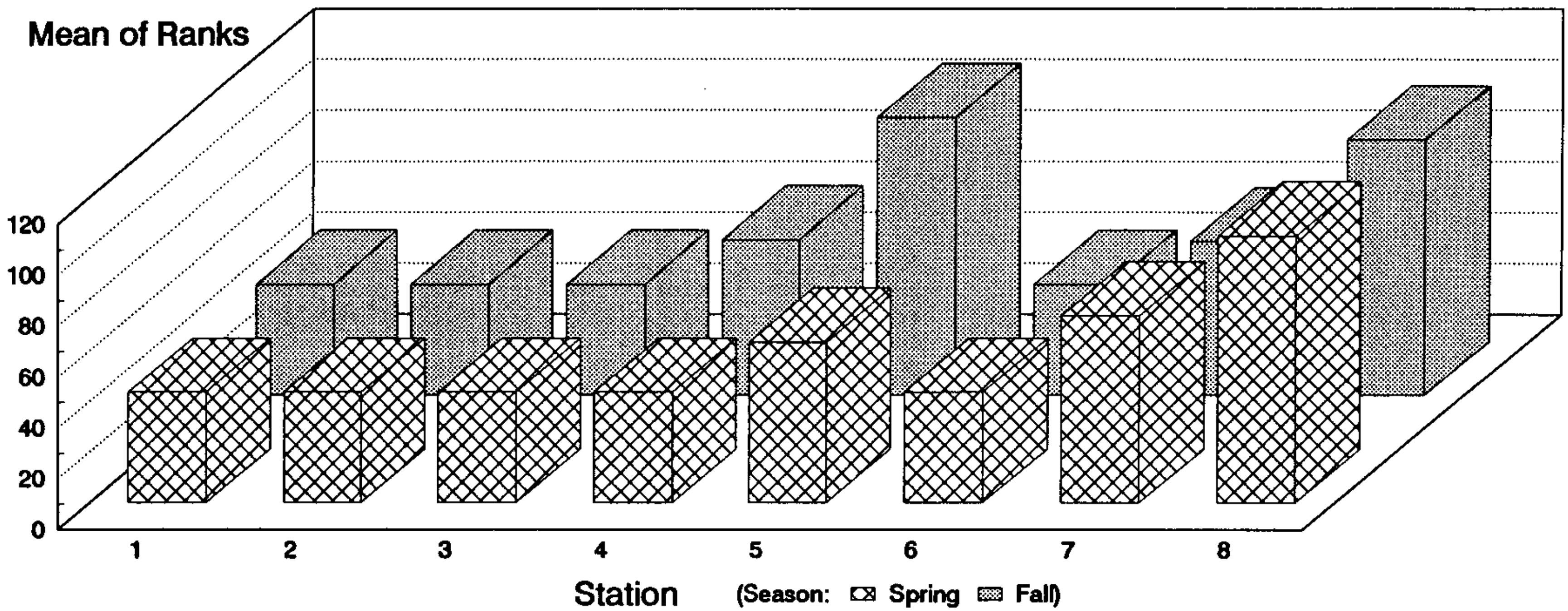
channel catfish by gill netting varied among stations. Catch/efforts were generally highest in the spring at shallow stations (Figure 45). Significant differences in seasonal catch/effort were found at stations 2, 4, 5 and 6; catch/efforts at two (2 and 6) stations were higher in the spring and two (4 and 5) were higher in the fall.

White sturgeon.- White sturgeon abundance based on comparisons of catch/effort varied seasonally as the station*season interaction was significant (Figure 46). During spring 1993, significantly ($P < 0.05$) higher catch/effort was found at reference station 8 followed by those at disposal station 7 and reference station 5. In the fall, catch/efforts grouped into three clusters; those at reference stations 5 and 8 were highest followed by the cluster of disposal stations 4 and 7 and the remaining reference and disposal stations in the third cluster. All significant differences in seasonal abundance based on catch/effort were found at stations 4, 5 and 7 and all catch/efforts were higher in the fall (Figure 46). Differences in abundance at the other stations were not statistically significant and abundances were higher in the spring.

Multiyear Comparisons and Trends in Abundance

1989-1993

Chinook salmon.- Comparisons of catch/effort for juvenile chinook salmon by beach seining from 1989 through 1993 indicated few annual and station differences in abundance (Figure 47). Overall, catch/efforts were lowest at disposal stations 1 and 2 and highest at reference



Station Comparison

Spring

8 7 5 1 2 3 4 6

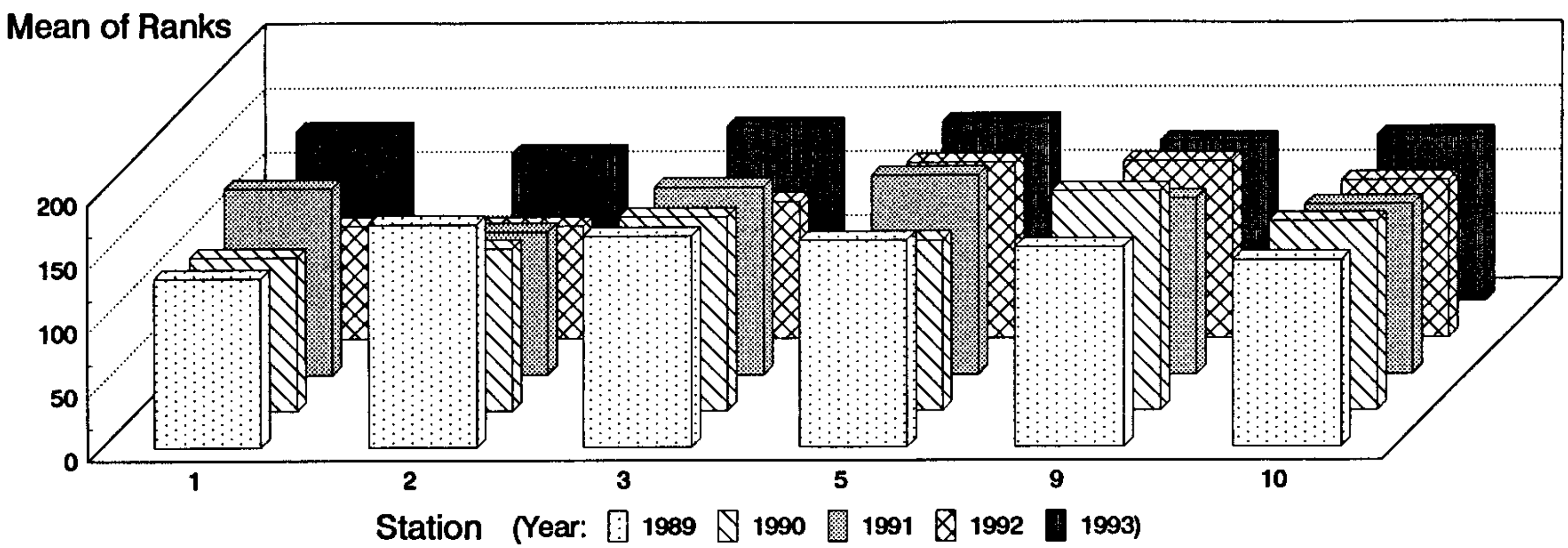
Fall

5 8 4 7 1 2 3 6

Season Comparison

1	2	3	4	5	6	7	8
Spring Fall	Spring Fall	Spring Fall	Fall Spring	Fall Spring	Spring Fall	Fall Spring	Spring Fall

Figure 46. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

5 3 9 10 1 2

Year Comparison

1989 1990 1991 1993 1992

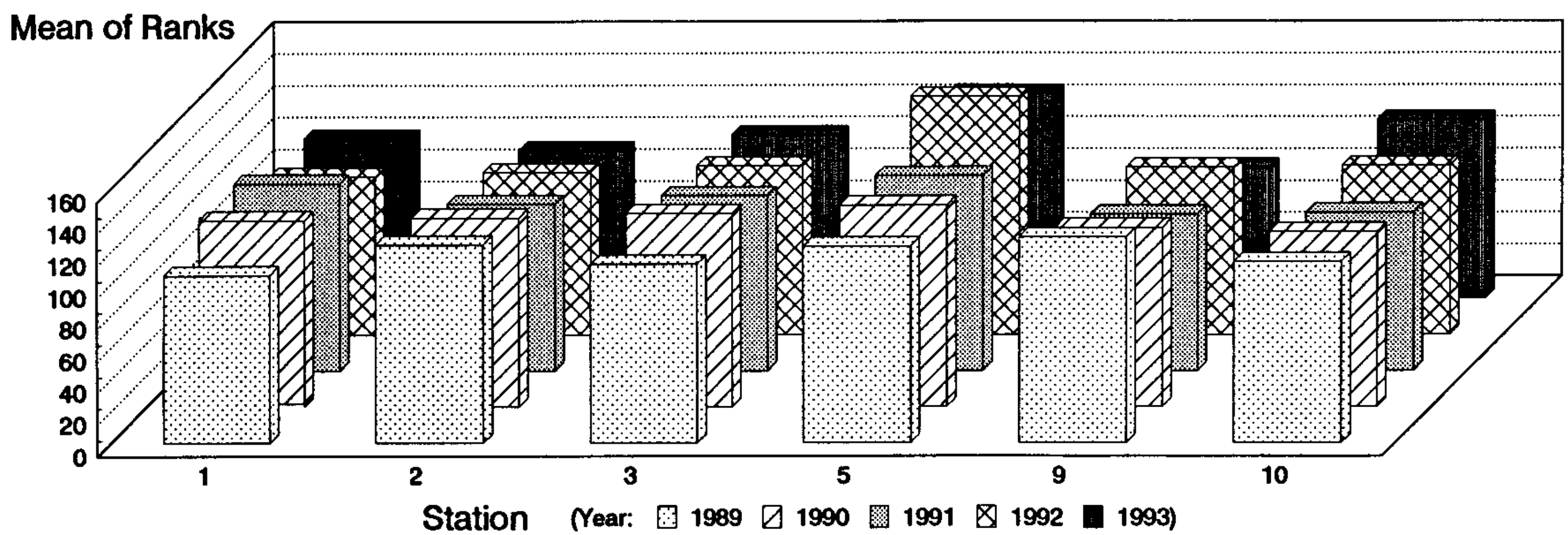
Figure 47. Grapical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by beach seining during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

station 5. Abundances at reference station 5 and disposal station 2 were significantly ($P<0.05$) different. Annual differences were few as only catch/effort in 1992 was significantly lower than the other 4 years.

Comparisons of station and year abundance of juvenile chinook salmon based on catch/effort by electrofishing indicated no annual differences and few station differences (Figure 48). Catch/effort at reference station 5 was significantly higher than that at reference station 9 whereas all other station differences were not significant. Catch/efforts of juvenile chinook salmon at disposal stations were intermediate and statistically similar to those of the reference stations.

Steelhead.- Differences in abundance of juvenile steelhead based on catch/effort by beach seining were found among year and station comparisons (Figure 49). Catch/efforts were significantly higher for juvenile steelhead at reference stations 9 and 10 than other shallow disposal and reference stations. Catch/efforts at stations 2, 3 and 5 were significantly higher than that at disposal station 1. Catch/efforts were significantly ($P<0.05$) higher for juvenile steelhead sampled by beach seining in 1989 and 1992 than for other years (1991 and 1993) sampled (Figure 49). Catch/effort in 1990 was intermediate.

Comparisons of catch/effort for juvenile steelhead by electrofishing generally showed similar levels of abundance among stations (Figure 50). Abundance based on catch/efforts was highest at reference station 9 followed by station 10 and lowest at disposal



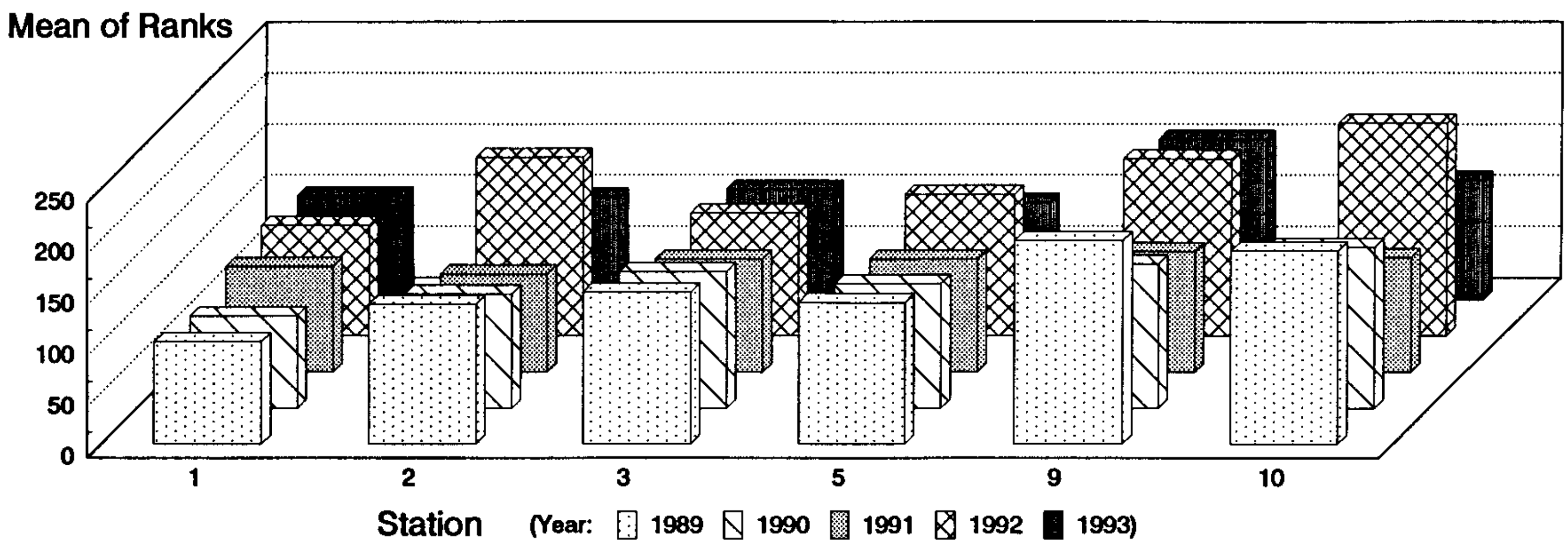
Station Comparison

5 3 1 2 10 9

Year Comparison

1992 1989 1990 1991 1993

Figure 48. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by electrofishing during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



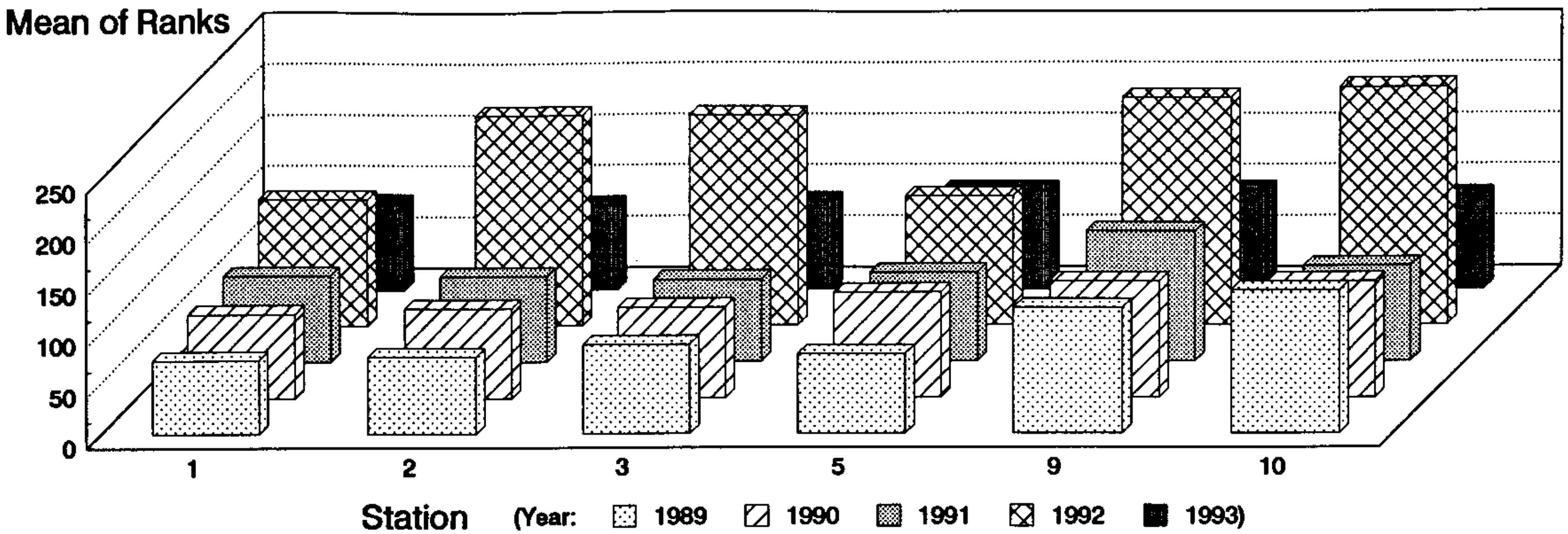
Station Comparison

9 10 | 3 2 5 | 1

Year Comparison

1989 1992 1990 1991 1993

Figure 49. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by beach seining during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

9 10 2 5 3 1

Year Comparison

1992 1990 1991 1993 1989

Figure 50. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by electrofishing during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

station 1. These differences were significant, although catch/effort at station 10 was not significantly different from those at reference stations 5 and 3 and disposal station 2. Annual differences in catch/effort for juvenile steelhead by electrofishing were significantly higher in 1992 than from 1989 through 1991 and 1993 (Figure 50). No other differences in catch/effort by electrofishing were found.

Northern squawfish.- Abundance of northern squawfish based on comparisons of catch/effort by gill netting varied among stations and years (Figure 51). Catch/efforts at reference stations 5 and 6 were significantly higher in the 5 year period, 1989 to 1993, than other disposal and other reference stations. Catch/efforts at disposal stations 1, 2 and 4 were not significantly different from reference stations 3 and 8. Annual differences in abundance of northern squawfish were found based on catch/effort by gill netting in the earlier years of study (Figure 51). The highest catch/effort was found in 1991 and significantly ($P < 0.05$) lower catch/efforts occurred in 1993 and 1992.

Abundance of northern squawfish based on comparisons of catch/effort by beach seining revealed several station and year differences (Figure 52). Catch/effort at reference station 10 was significantly higher than other reference and disposal stations, except station 3 which followed station 10 in abundance. Several other significant differences in catch/effort were found, although those at disposal stations 1 and 2 were similar to those at reference station 5. Annual abundance of northern squawfish as determined by beach seining has generally decreased as catch/efforts in 1989 and 1991 were

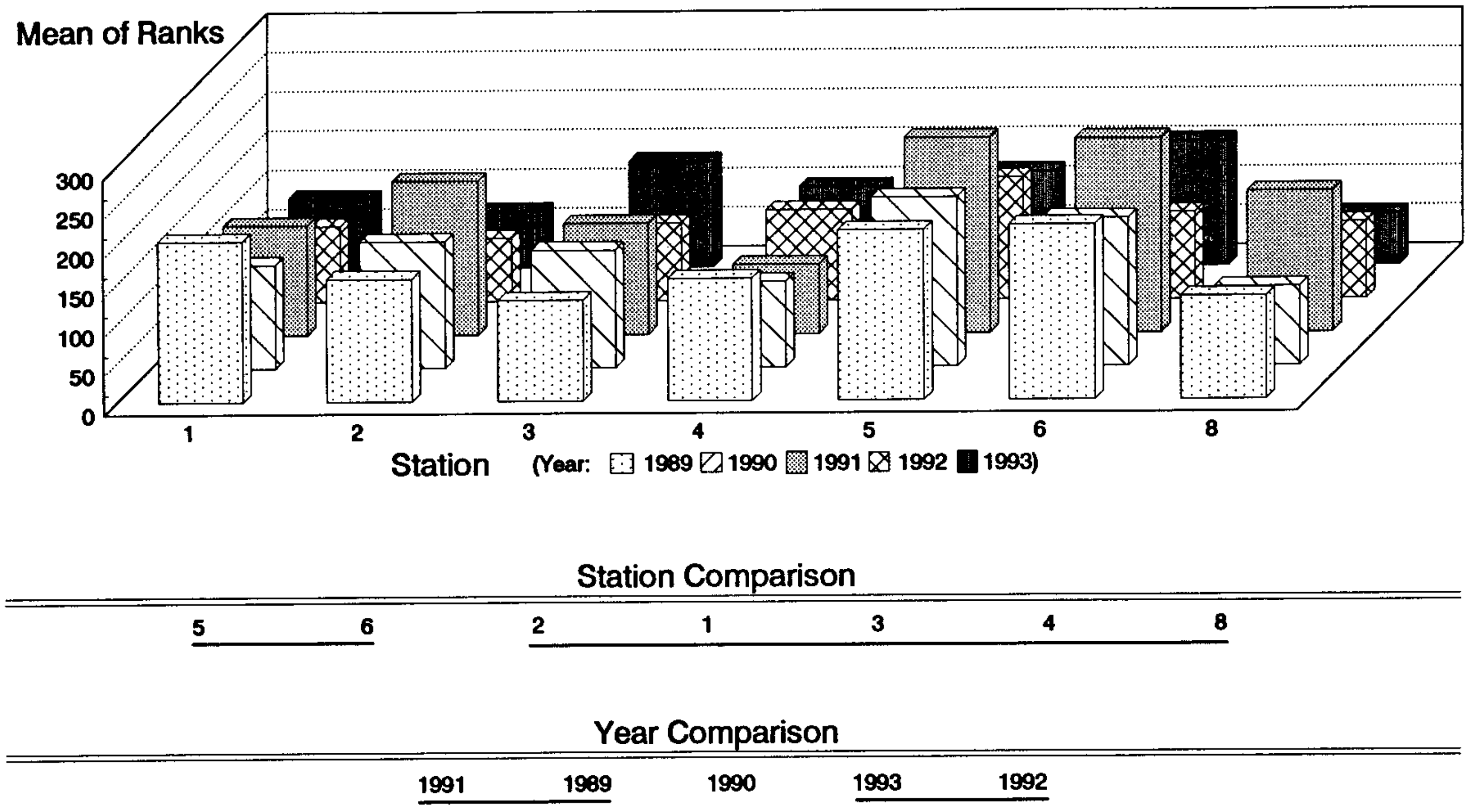


Figure 51. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).

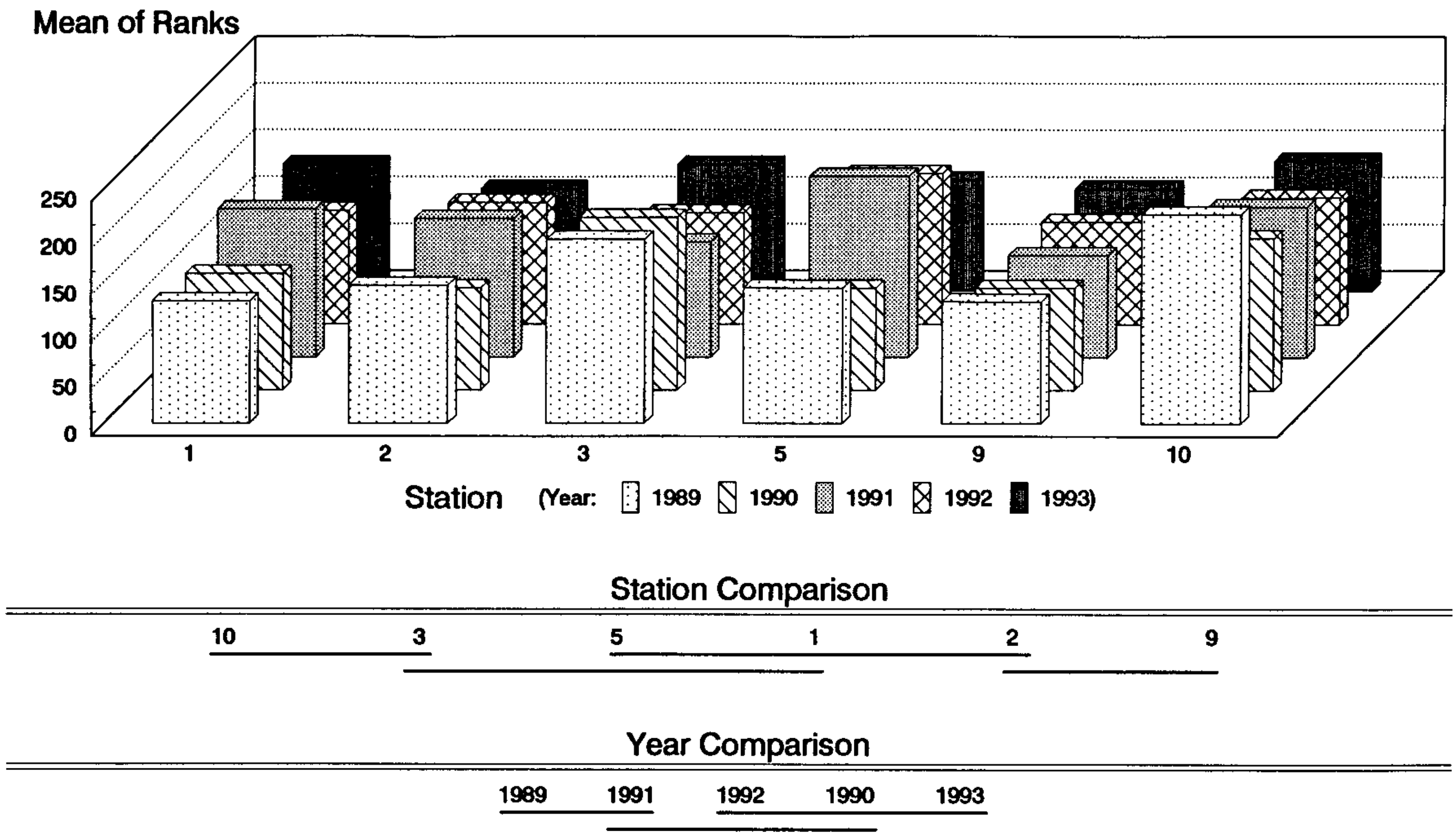


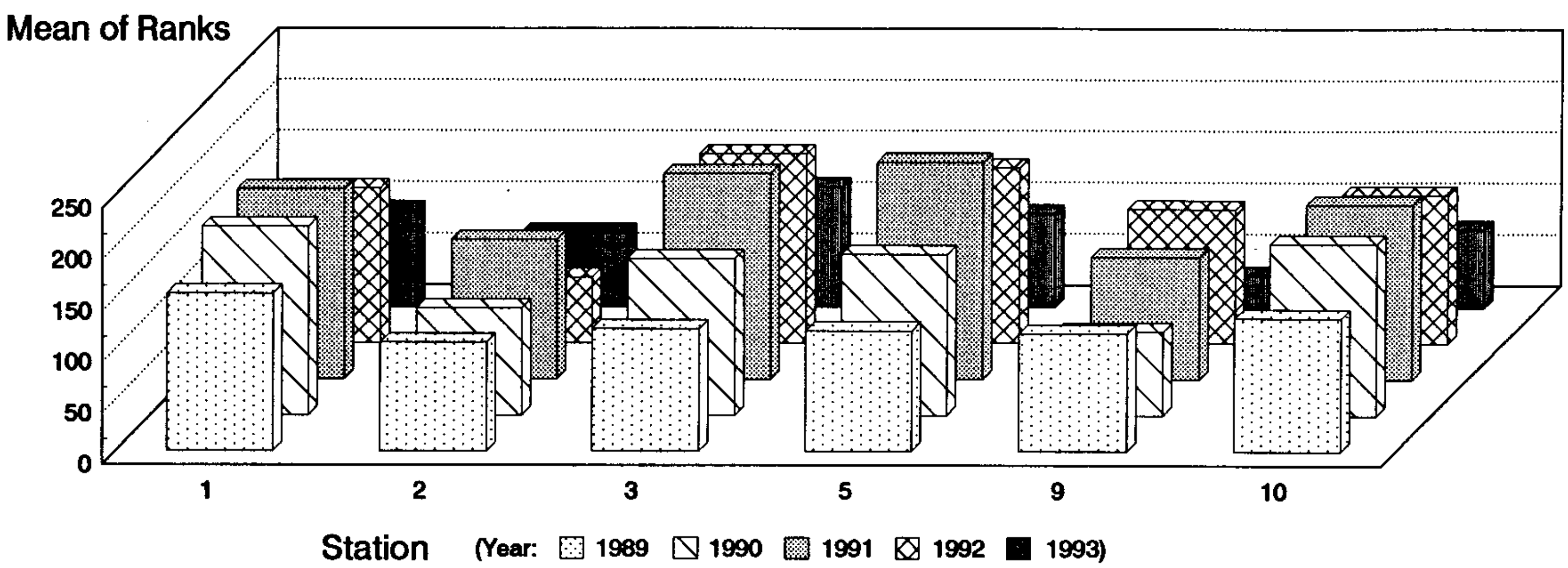
Figure 52. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by beach seining during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

significantly higher than 1993 (Figure 52). Catch/efforts were similar among 1991, 1992 and 1990.

Comparisons of catch/effort for northern squawfish by electrofishing indicated highest abundance at the reference stations and disposal station 1 (Figure 53). Catch/efforts at disposal station 2 and reference station 9 were low and statistically similar and both were significantly lower than the other four stations. As with beach seining, catch/effort in 1993 for northern squawfish by electrofishing was significantly lower than other years (Figure 53). Catch/effort was generally similar among other years.

Smallmouth bass.- Smallmouth bass abundance based on comparisons of catch/effort by gill netting indicated few differences among stations and years (Figure 54). Two clusters of catch/effort were found; reference stations 3 and 5 and disposal stations 1 and 2 were in the cluster with high catch/efforts followed by reference stations 6 and 8 and disposal station 4 in the cluster with low catch/efforts. Comparisons of catch/effort for smallmouth bass among years showed higher abundance in 1990, 1991 and 1992 compared to 1989 and 1993 (Figure 54). Catch/effort was significantly higher in both 1991 and 1992 than in 1989 and 1993.

A two-way station*season interaction of catch/effort for smallmouth bass by gill netting was found (Figure 55). During spring, catch/efforts were high at stations 3, 5, 1, 2 and 4, whereas during fall those at stations 6, 5, 3 and 2 were high. Statistical differences among season comparisons were few and no consistency in abundance was



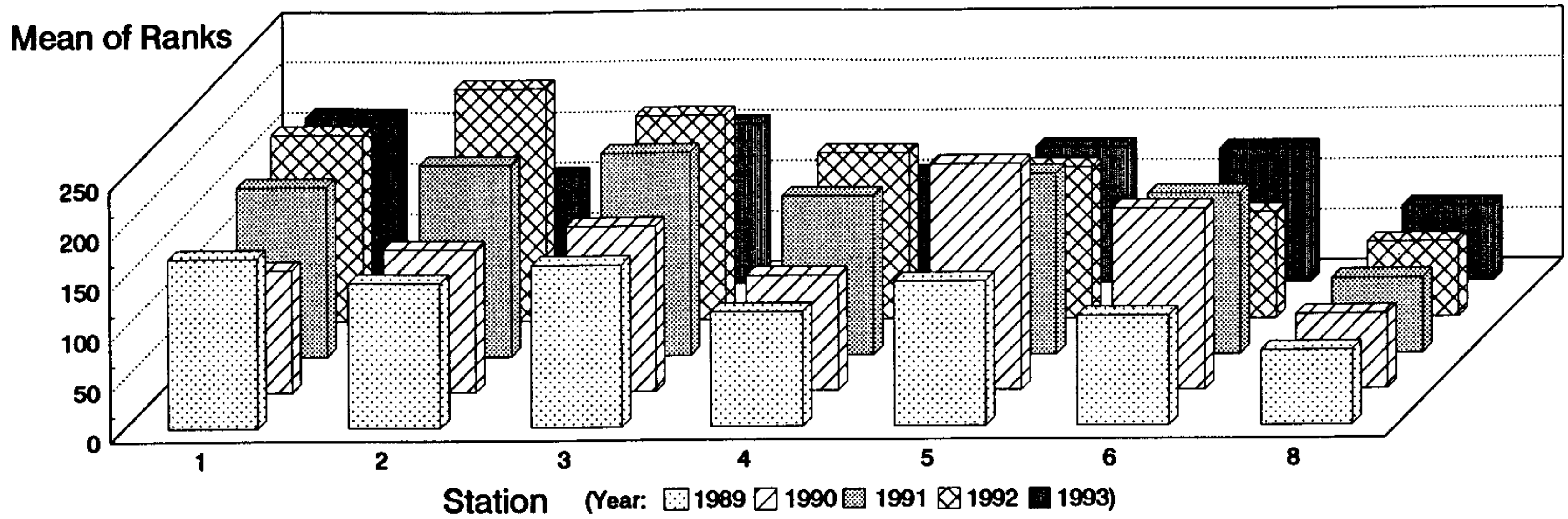
Station Comparison

3 5 1 10 2 9

Year Comparison

1991 1992 1990 1989 1993

Figure 53. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by electrofishing during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignifcance ($P > 0.05$).



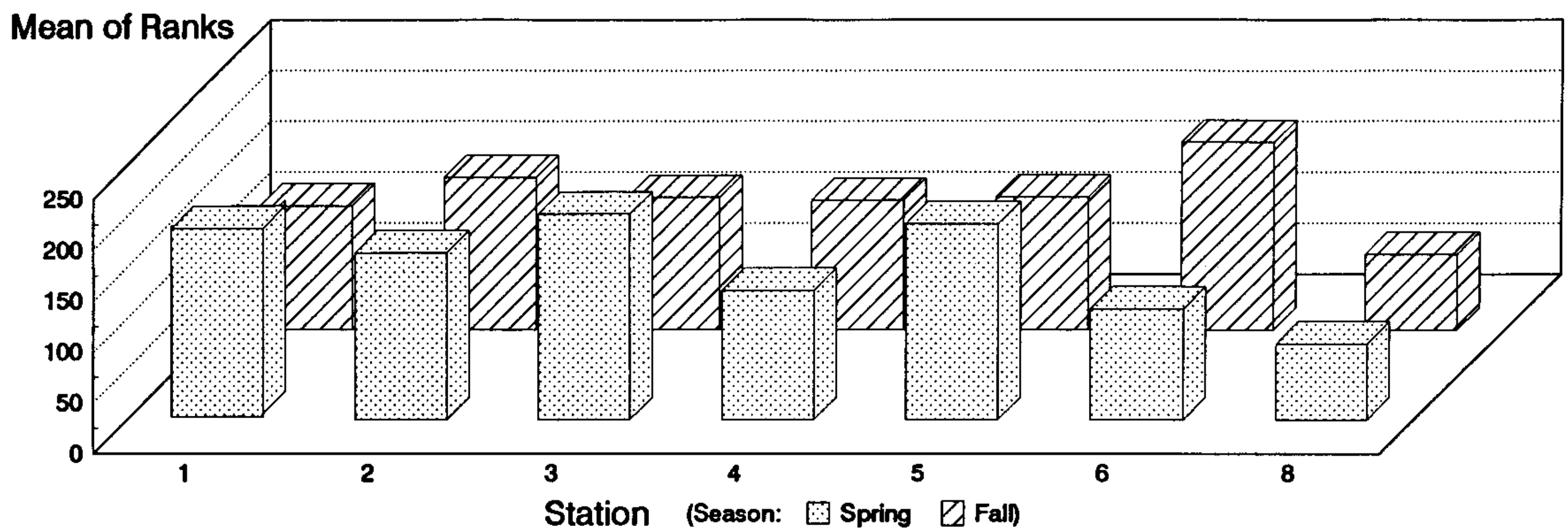
Station Comparison

3 5 1 2 6 4 8

Year Comparison

1991 1992 1990 1989 1993

Figure 54. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

Spring

3 5 1 2 4 6 8

Fall

6 2 5 3 4 1 8

Season Comparison

1 Spring Fall

2 Spring Fall

3 Spring Fall

4 Spring Fall

5 Spring Fall

6 Fall Spring

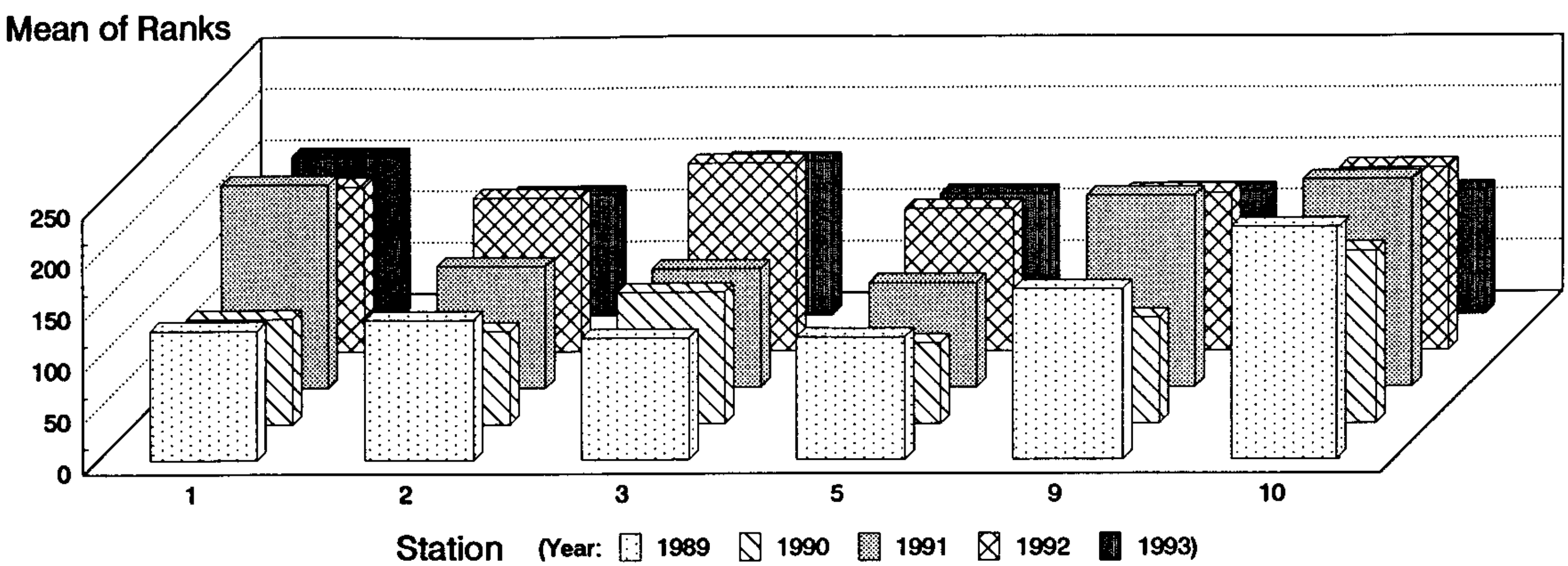
8 Fall Spring

Figure 55. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).

found between spring and fall. Abundance of smallmouth bass at reference station 6 was significantly ($P<0.05$) higher in the fall than spring. No other seasonal differences in catch/effort at the various reference and disposal stations were significant.

Comparisons of catch/effort for smallmouth bass by beach seining indicated abundance was significantly ($P < 0.05$) higher at reference station 10 than other reference and disposal stations (Figure 56). Catch/efforts for smallmouths at reference stations 3 and 9 were similar to those at disposal stations 1 and 2. Two clusters of abundance based on catch/effort for various years for smallmouth bass by beach seining were found from 1989 through 1993 (Figure 56). Abundance was similar among 1989, 1991 and 1992 and between 1993 and 1990. The only statistical difference was between 1990 and 1992.

Comparisons of catch/efforts for smallmouth bass by electrofishing indicated several differences in abundance among years and stations (Figure 57). Catch/effort was highest at reference station 9. Those at reference stations 10, 3 and 5 generally were similar, while those at disposal stations 1 and 2 were lower and significantly different from all reference stations. Abundance based on catch/effort comparisons among years was highest in 1991 and lowest in 1993 (Figure 57). Significant differences in abundance among 1989, 1992 and 1993 were not found while catch/efforts from 1991, 1990 and 1992 were also not significantly different. However, catch/efforts in 1991 and 1990 were significantly higher than those in 1989 and 1993.



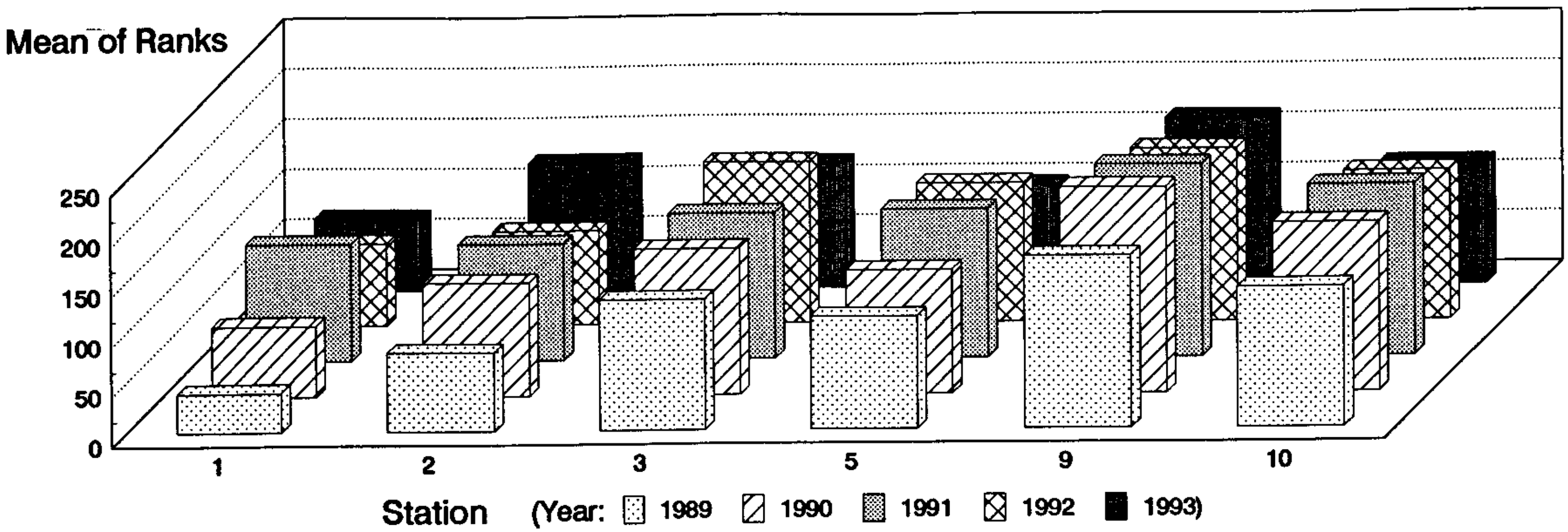
Station Comparison

10 1 9 3 2 5

Year Comparison

1992 1991 1989 1993 1990

Figure 56. Graphical and statistical comparisons of the mean of ranks forsmallmouth bass abundance sampled by beach seining during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

9   10   3   5   2   1

Year Comparison

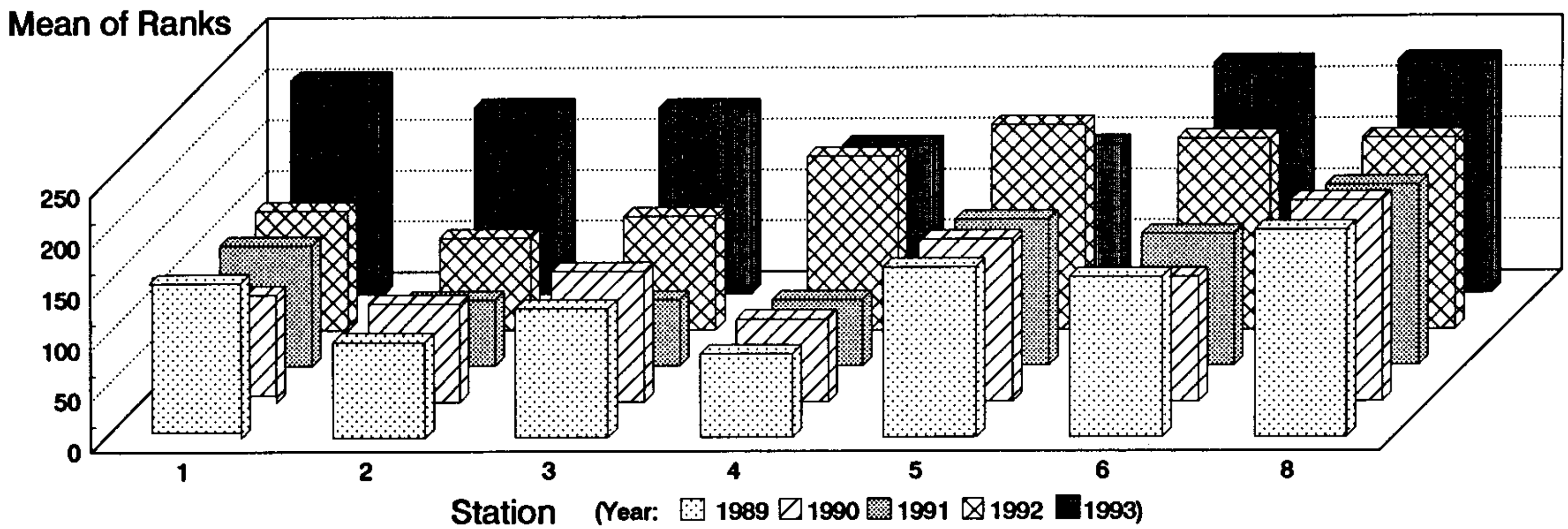
1991   1990   1992   1989   1993

Figure 57. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).

Channel catfish.- Abundance of channel catfish based on comparisons of catch/effort by gill netting was highest in 1993 and at deep reference station 8 (Figure 58). Catch/efforts were clustered among several stations but those at disposal station 4 were lower than the other stations. Catch/effort by gill netting for channel catfish indicated abundance was highest in 1993 followed by 1992, 1989 and 1990 (Figure 58). Comparisons between 1993 and other years were significant as well as those between 1992 and 1991.

The two-way interaction of catch/effort for channel catfish by gill netting between seasons and stations was significant (Figure 59). During spring, catch/efforts for channel catfish were significantly higher at reference stations 8 and 6 than those at disposal stations 2 and 4. During fall, catch/efforts at reference stations 5 and 8 were significantly higher than those at stations 4, 3 and 2. The only significant difference in catch/effort by gill netting for channel catfish within stations was at reference station 5 where abundance was highest in the fall (Figure 59). Abundances were high in the spring at all shallow stations, although these were consistently not statistically significant.

White sturgeon.- White sturgeon abundance from 1989 through 1993 varied among stations, as was evident from the significant year*station interaction. Catch/efforts by gill netting were highest at reference station 8 for all years but 1991 when that at reference station 5 was highest (Figure 60). Abundance among years was not statistically different at disposal stations 1 and 2 and reference stations 3 and 6,



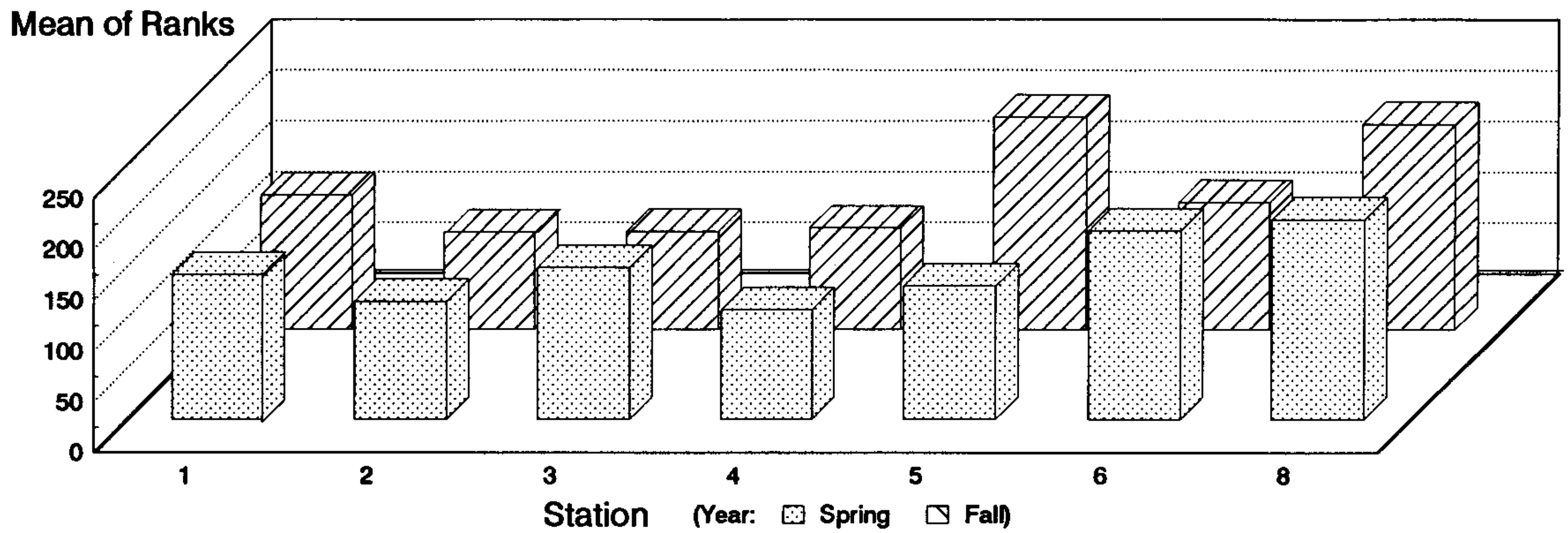
Station Comparison

8   5   6   1   3   2   4

Year Comparison

1993   1992   1989   1990   1991

Figure 58. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

Spring

8 6 3 1 5 2 4

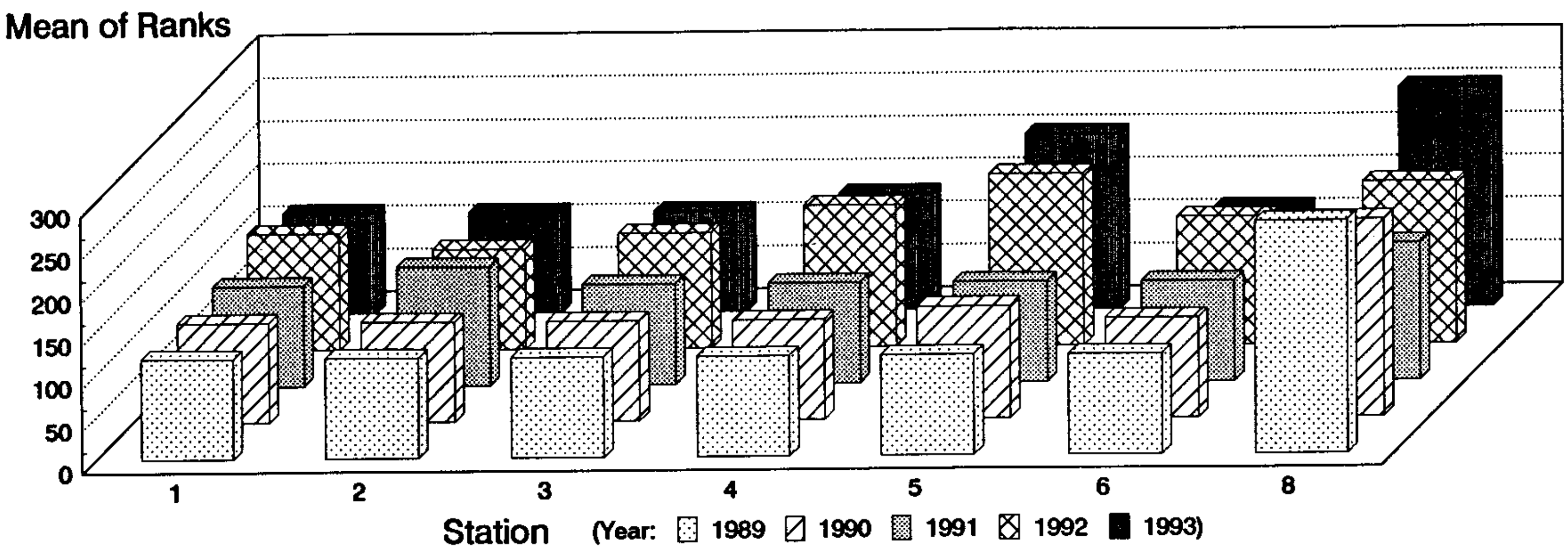
Fall

5 8 1 6 4 3 2

Season Comparison

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

Figure 59. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

1989	1990	1991	1992	1993
8 1 2 3 4 5 6	8 5 2 3 4 1 6	8 1 2 3 4 5 6	5 8 4 6 1 3 2	8 5 4 1 2 3 6

Year Comparison

1	2	3	4	5	6	8
92 89 90 91 93	91 89 90 92 93	92 89 90 91 93	92 93 89 90 91	93 92 90 89 91	92 89 90 91 93	89 93 90 92 91

Figure 60. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1989-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

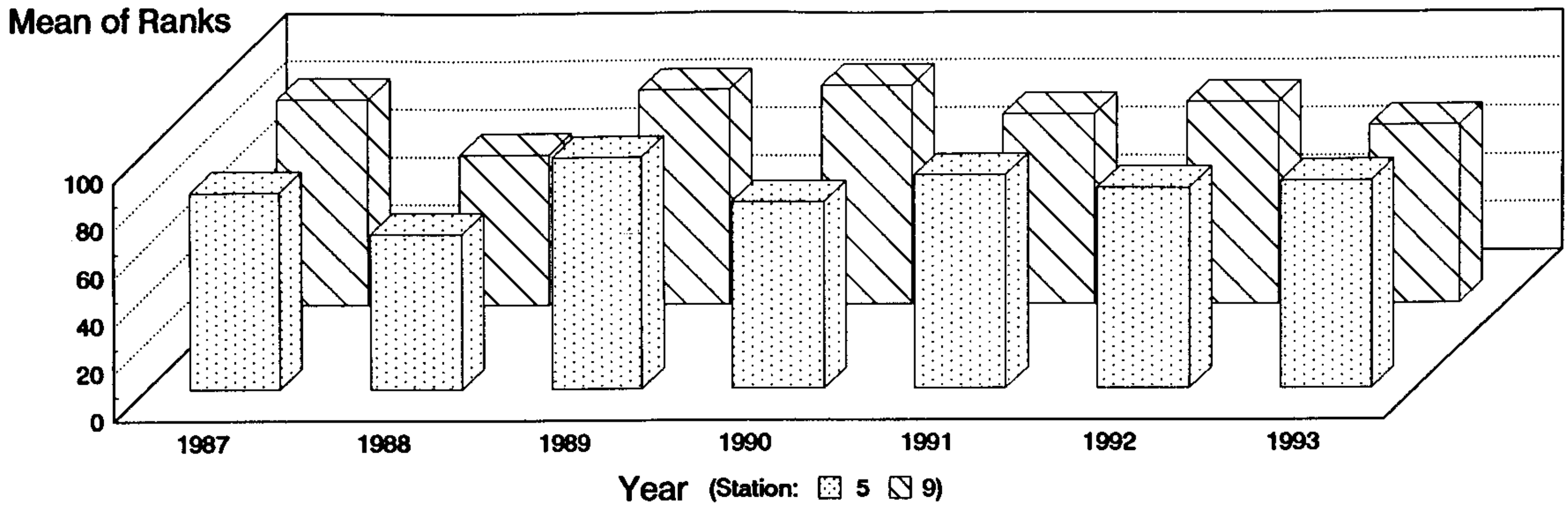
while those at stations 5 and 8 showed two clusters of abundance. Little consistency in catch/effort was found among stations. For example, higher catch/efforts by gill netting for white sturgeon was found in 1992 and 1993 at some stations (4 and 5) whereas those in 1989 were the highest at station 8.

1987 - 1993

Collections made at reference stations 5 and 9 from 1987 through 1993 allowed long-term assessments of abundance. Comparisons of abundance of white sturgeon, smallmouth bass, northern squawfish, and channel catfish were made from 1987 through 1993 at stations 4, 5 and 6. Spatial comparisons were made within years and among stations and within stations among years which were illustrative of temporal differences in abundance.

Chinook salmon.- During the period from 1987 through 1993, no differences in abundance of juvenile chinook salmon were found between stations 5 and 9 based on comparisons of catch/effort by beach seining (Figure 61). Catch/effort was significantly ($P<0.05$) lower in 1988 than 1989, 1991 and 1990 whereas other annual comparisons were not significant.

Abundance of juvenile chinook salmon based on comparisons of catch/effort by electrofishing indicated significant differences between stations 5 and 9 (Figure 62). No annual differences in catch/effort were statistically significant ($P>0.05$), although catch/effort in 1992 was highest and that in 1993 was the lowest.



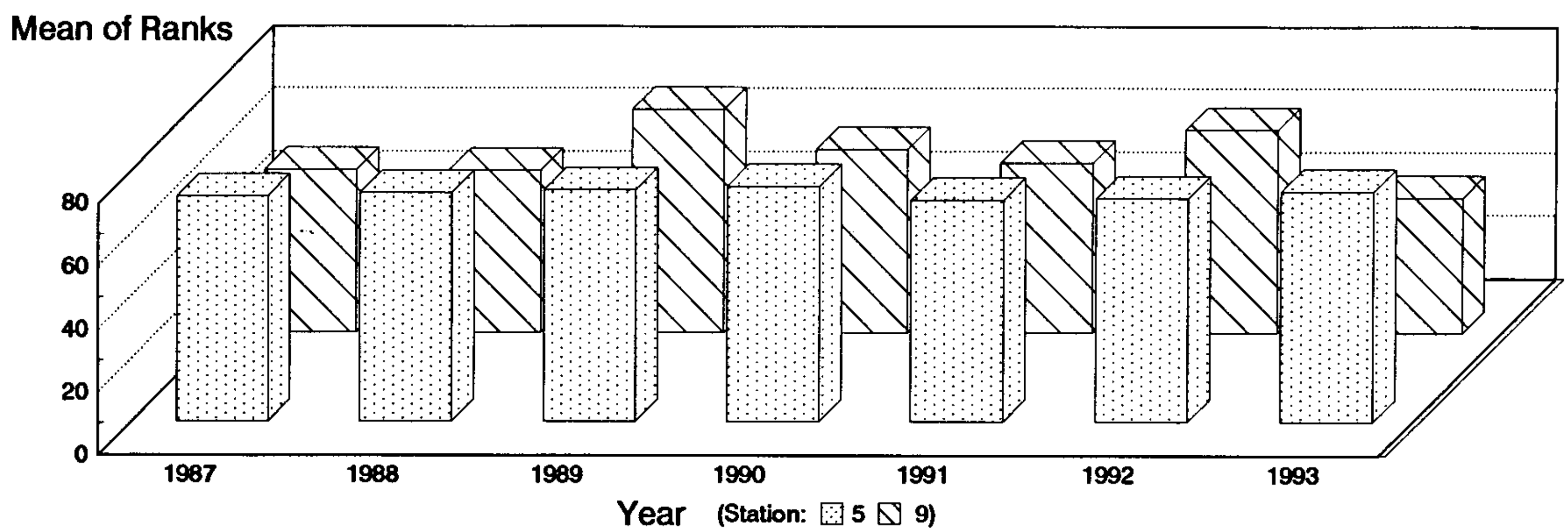
Station Comparison

5 9

Year Comparison

1989 1991 1990 1987 1993 1992 1988

Figure 61. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by beach seining during 1987-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

5 9

Year Comparison

1992 1989 1990 1991 1988 1987 1993

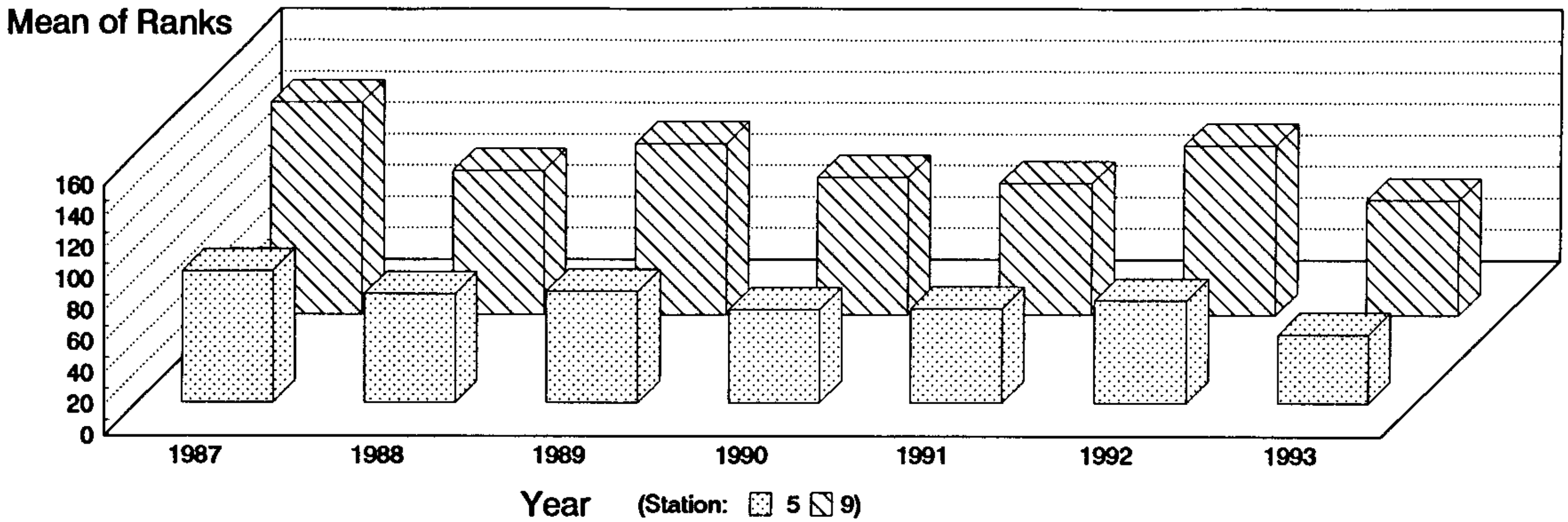
Figure 62. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by electrofishing during 1987-1993 in Lower Granite Reservoir. The horizontal line under the year comparison indicates statistical nonsignificance (P > 0.05).

Steelhead.- Juvenile steelhead abundance was significantly different between stations 5 and 9 from 1987 through 1993 based on differences in catch/effort by beach seining (Figure 63). Abundance varied among years and was highest in 1987 and lowest in 1993. The cluster of catch/efforts from 1990-1993 was not significantly different while that in 1987 was different from all years except 1989.

Abundance of juvenile steelhead based on comparisons of catch/effort by electrofishing indicated significantly higher abundance at station 9 than at station 5 (Figure 64). Abundance during several years were statistically different and clusters of nonsignificance over lapped. Catch/effort in 1992 was the highest and was significantly different from all years except 1988.

Northern squawfish.- Comparisons of catch/effort by gill netting for northern squawfish indicated significant year and station effects and the year*season interaction was significant ($P<0.05$; Figures 65 and 66). Station differences indicated catch/efforts for northern squawfish were high at reference stations 5 and 6 and lowest at disposal station 4. Based on annual comparisons, northern squawfish have recently exhibited a decline in abundance in Lower Granite Reservoir. Statistical differences in catch/effort for northern squawfish were found between 1988-1991 and 1992 and 1993.

Annual differences of catch/effort for northern squawfish within seasons were not statistically significant in the spring (Figure 66). During fall, catch/efforts were lowest in 1993 and 1992 and highest in 1988; other annual comparisons of abundance were not significant.



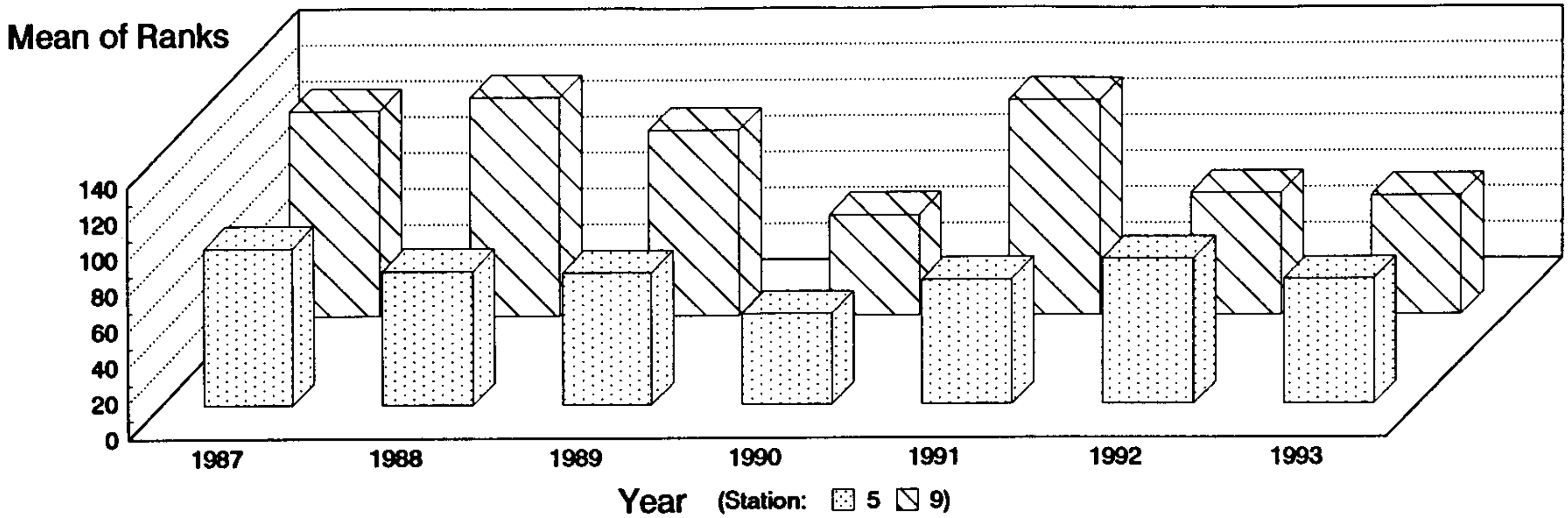
Station Comparison

9 5

Year Comparison

1987 1989 1988 1990 1992 1991 1993

Figure 63. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by beach seining during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignificance (P > 0.05).



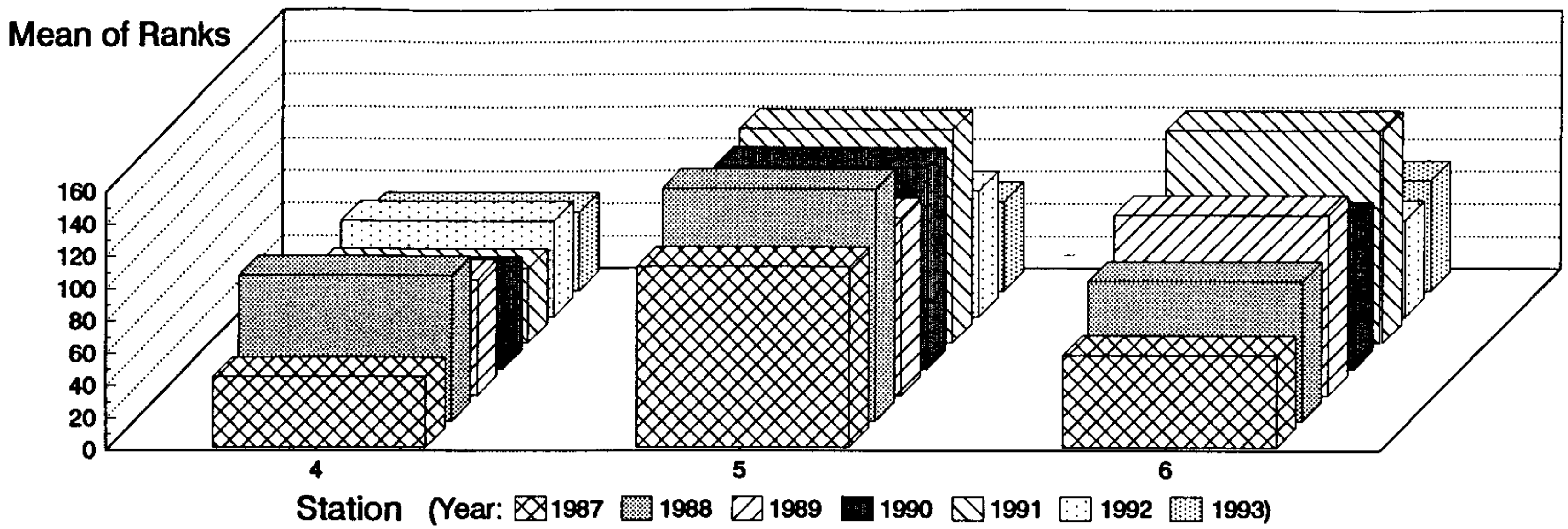
Station Comparison

9 5

Year Comparison

1992 1988 1987 1990 1991 1993 1989

Figure 64. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by electrofishing during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignficance (P > 0.05).



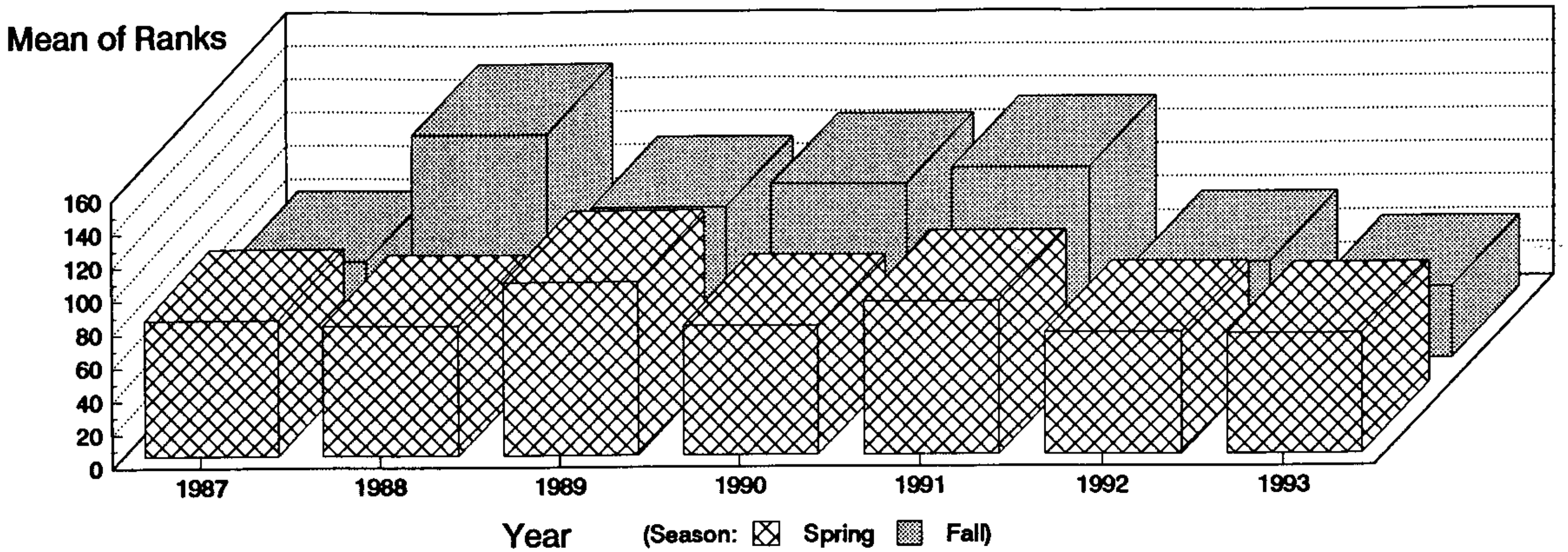
Station Comparison

5 6 4

Year Comparison

1991 1989 1988 1990 1987 1992 1993

Figure 65. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignificance (P > 0.05).



Year Comparison

Spring

1989 1991 1987 1990 1988 1993 1992

Fall

1988 1991 1990 1989 1987 1992 1993

Season Comparison

1987	1988	1989	1990	1991	1992	1993
Spring Fall	Fall Spring	Spring Fall	Fall Spring	Fall Spring	Fall Spring	Spring Fall

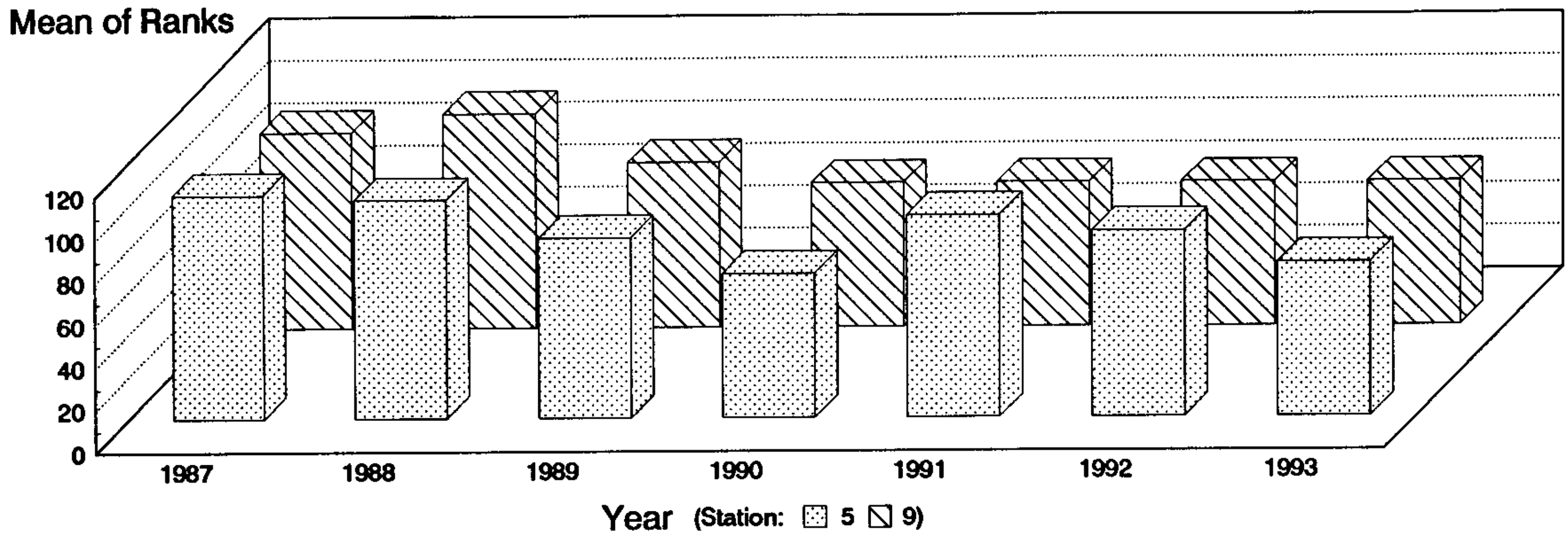
Figure 66. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under year and season comparisons indicate statistical nonsignificance (P > 0.05).

Within year comparisons indicated northern squawfish abundance based on catch/efforts was statistically similar between fall and spring in all years except 1988 (Figure 66). Catch/efforts varied between seasons and within years.

Abundance of northern squawfish by beach seining from 1987 through 1993 differed between stations 9 and 5 (Figure 67). Based on catch/effort, abundance at station 9 was significantly higher than that at station 5. Annual differences during this 7-year period were found, but no major differences occurred. Abundance during 1993 based on catch/efforts by beach seining was lower than all years in this period except 1990 which had the lowest catch/effort.

Comparisons of catch/effort for northern squawfish sampled by electrofishing from 1987 through 1993 showed significant differences between stations 5 and 9 (Figure 68). These results showed higher abundance at station 5 than station 9. During this 7-year period, two clusters of similar levels of abundance were found. The period from 1989-1992 was represented by the period of highest catch/effort compared to years 1987, 1988 and 1993.

Smallmouth bass.- Comparisons of catch/effort for smallmouth bass by gill netting indicated significant ($P<0.05$) year and station effects and season*station interactions (Figures 69 and 70). Station comparisons suggested smallmouth bass abundance based on gill netting was significantly higher at station 5 than stations 6 and 4. Highest catch/effort was found in 1990; which was significantly higher than those from 1993, 1989 and 1987.



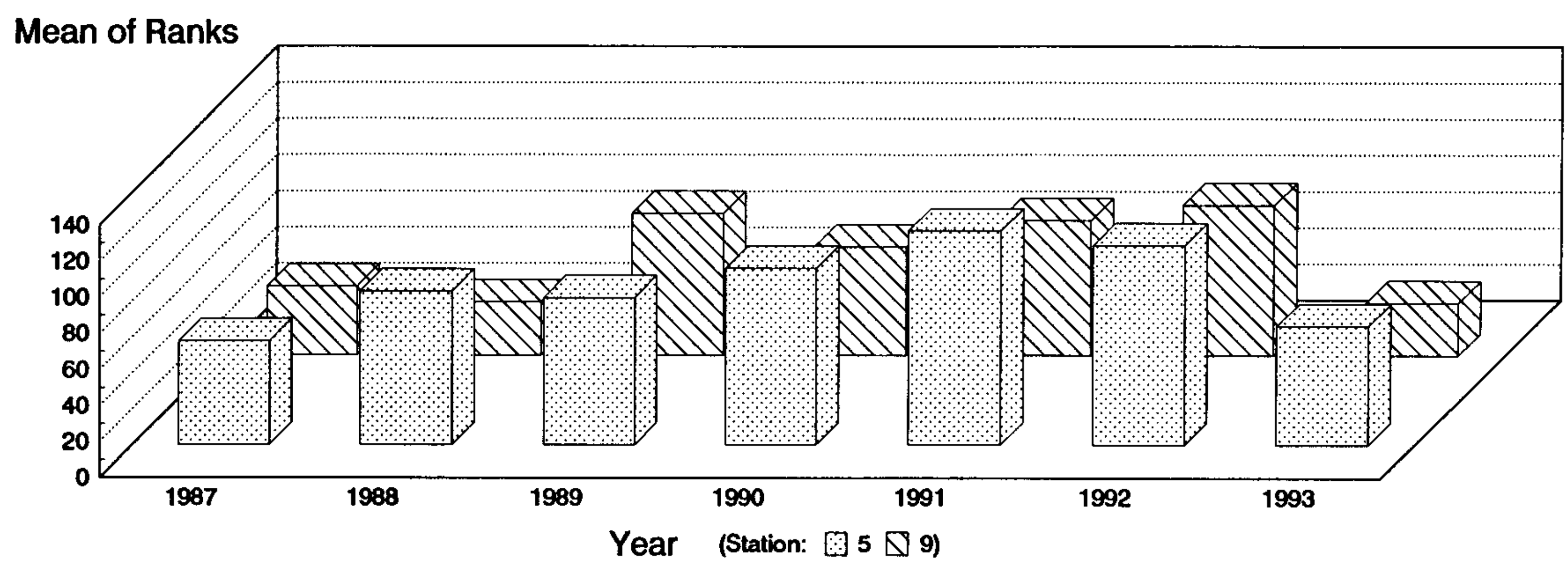
Station Comparison

9 5

Year Comparison

1987 1991 1992 1988 1989 1993 1990

Figure 67. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by beach seining during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignificance (P > 0.05).



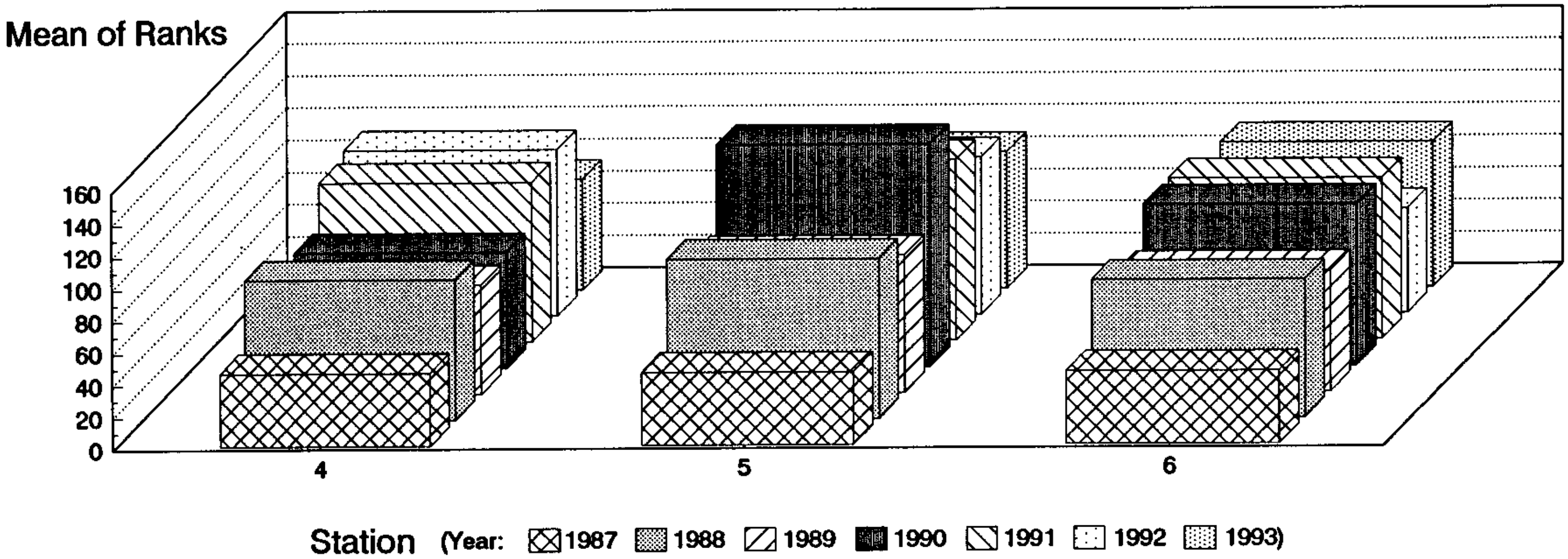
Station Comparison

5 9

Year Comparison

1992 1991 1990 1989 1988 1993 1987

Figure 68. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by electrofishing during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignificance (P > 0.05).



Station Comparison

5 6 4

Year Comparison

1990 1991 1988 1992 1993 1989 1987

Figure 69. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

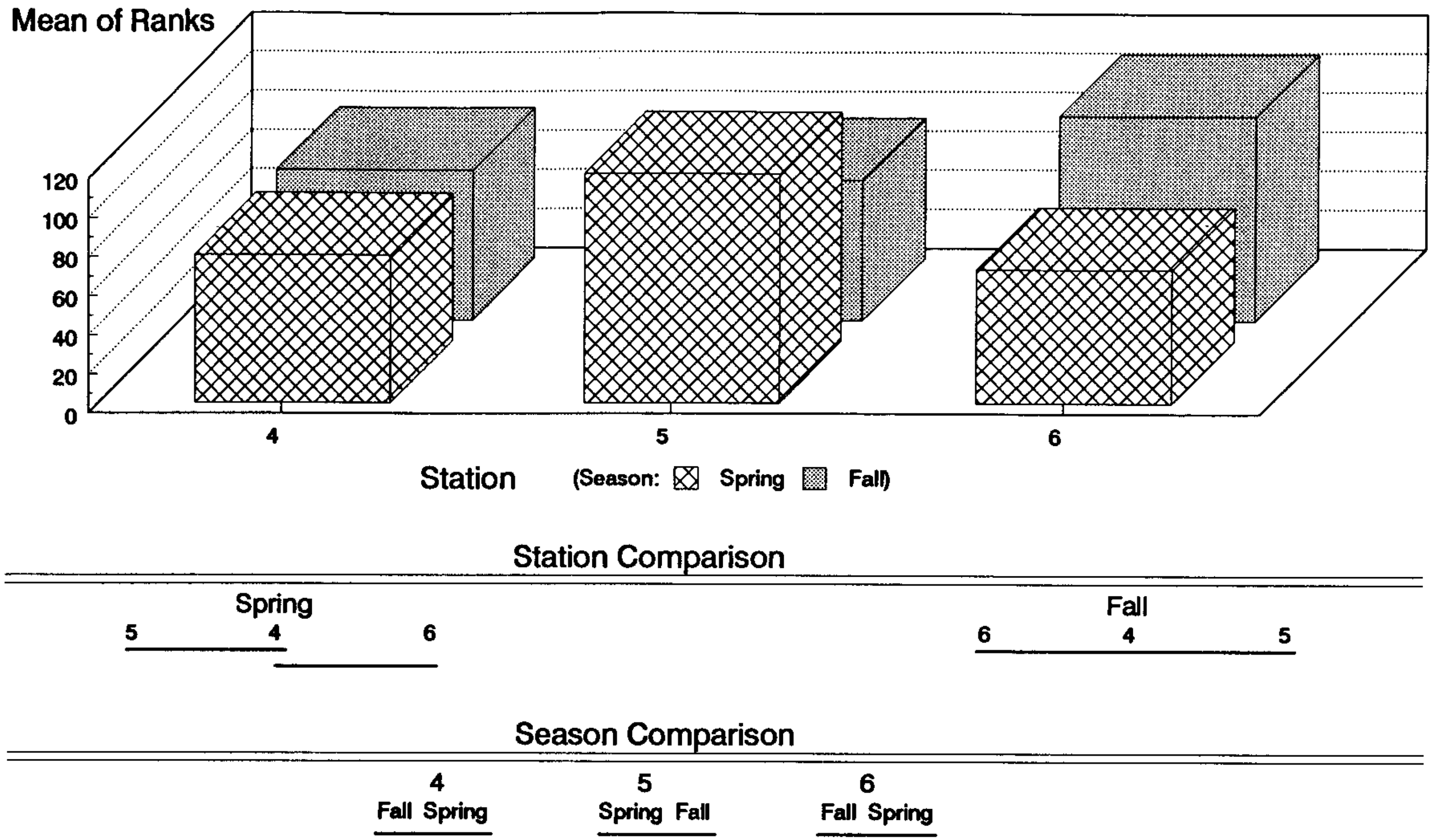


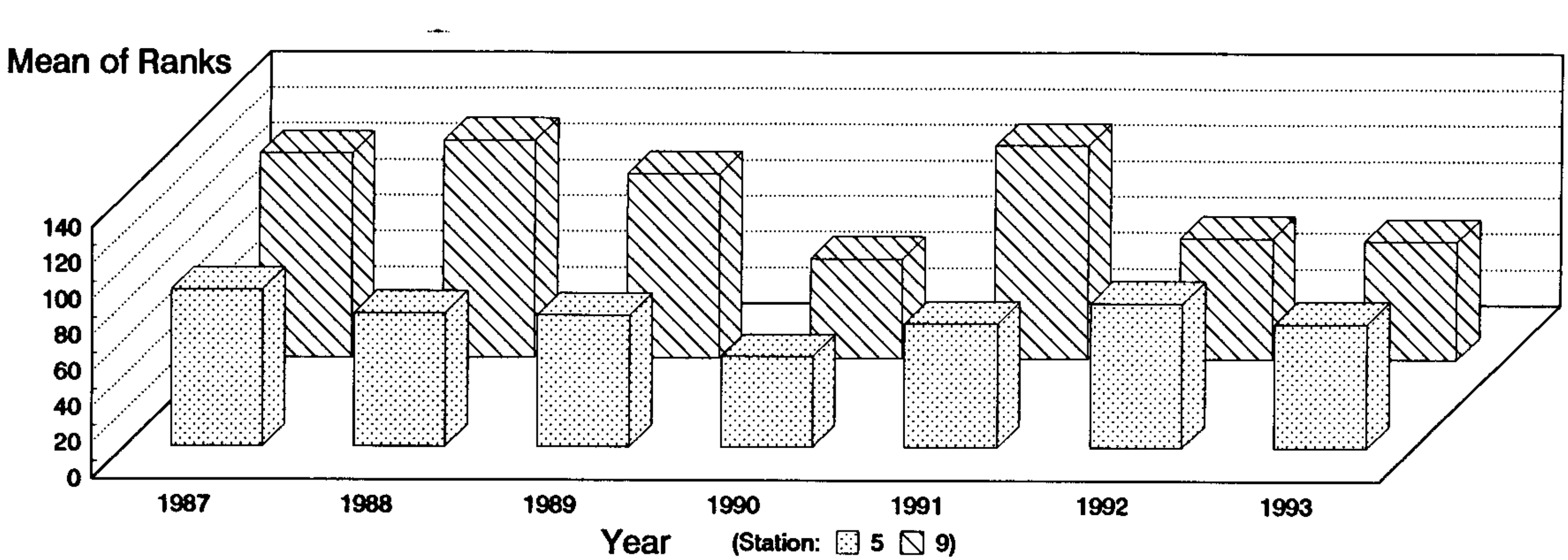
Figure 70. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).

Within station comparisons of catch/effort for smallmouth bass indicated no significant seasonal differences (Figure 70). During spring, catch/effort for smallmouth bass was significantly higher at reference station 5 than at reference station 6. During fall, no differences in catch/effort among stations were found for smallmouth bass.

Abundance of smallmouth bass based on comparisons of catch/effort by beach seining suggested a significant difference in abundance between stations 9 and 5 (Figure 71). Annual differences in catch/effort were found and high abundance occurred in 1987 and 1988 and low abundance occurred in 1993 and 1990. Catch/efforts in 1987, 1988 and 1991 were significantly ($P<0.05$) higher than those in 1993 and 1990.

A significant season*year interaction was found in the comparisons of catch/effort of smallmouth bass by beach seining (Figure 72). Estimates of catch/effort for smallmouth bass indicated few significant differences among years, however during spring, catch/effort in 1987 was significantly higher than other years sampled. Significant seasonal differences in abundance were found among years as abundance was consistently higher in the summer. This difference was significant in 1988, 1991 and 1993.

Abundance of smallmouth bass by electrofishing as determined from comparisons of catch/effort indicated a significant difference between stations 9 and 5 (Figure 73). Also, two clusters of abundance were found within years, the more recent period of 1989-1993 having high abundance and the 1987 to 1988 period with low abundance.



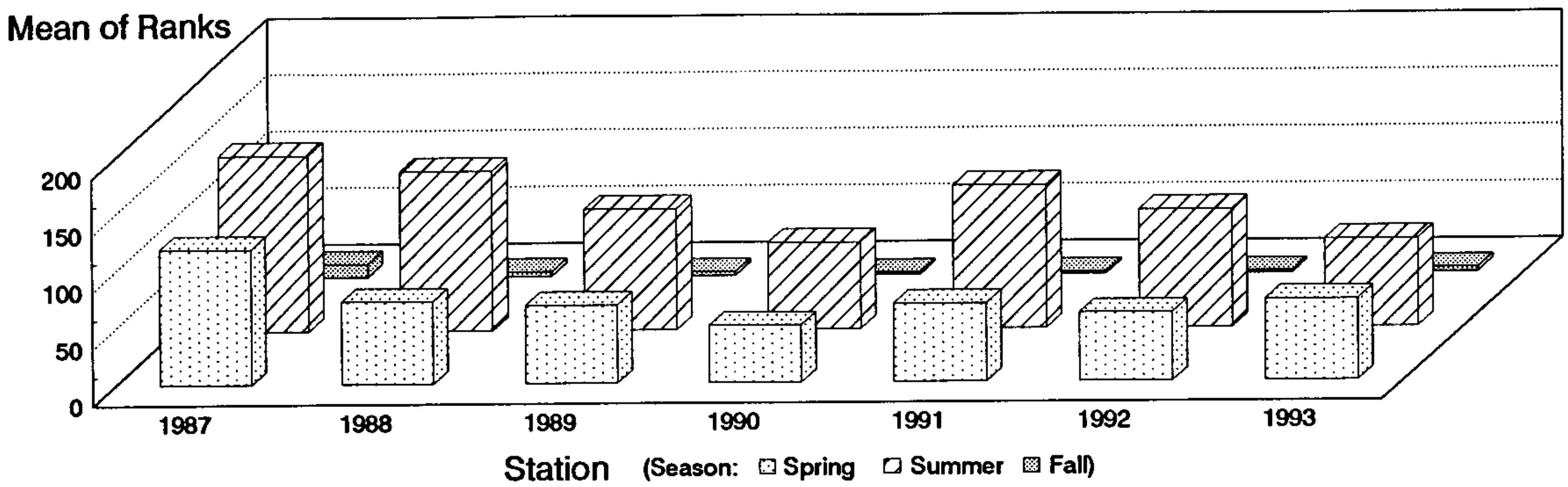
Station Comparison

9 5

Year Comparison

1987 1988 1991 1989 1992 1993 1990

Figure 71. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by beach seining during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignificance (P > 0.05).



Year Comparison

Spring

1987 1988 1993 1989 1991 1992 1990

Summer

1987 1988 1991 1989 1992 1993 1990

Fall

1987 1988 1993 1989 1991 1990 1992

Season Comparison

1987: Su Sp Fa

1988: Su Sp Fa

1989: Su Sp Fa

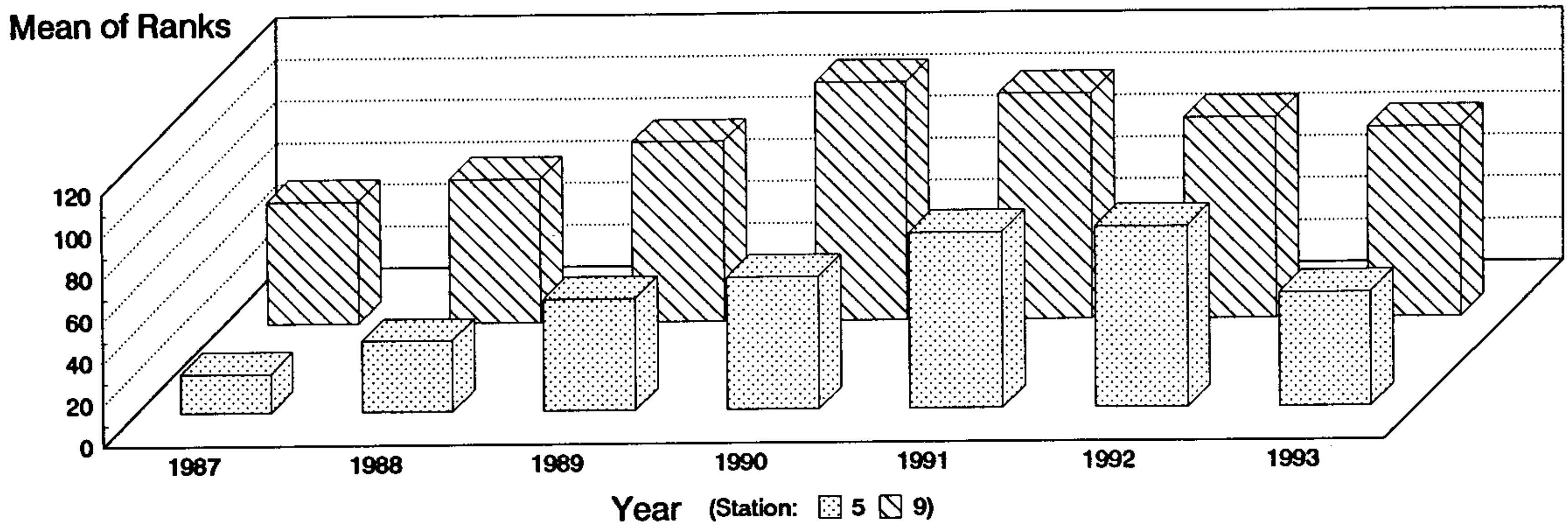
1990: Su Sp Fa

1991: Su Sp Fa

1992: Su Sp Fa

1993: Su Sp Fa

Figure 72. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by beach seining during 1987-1993 in Lower Granite Reservoir. Horizontal lines under year and season comparisons indicate statistical nonsignificance (P > 0.05). Abbreviations: Sp-spring, Su-summer, Fa-fall.



Station Comparison

9 5

Year Comparison

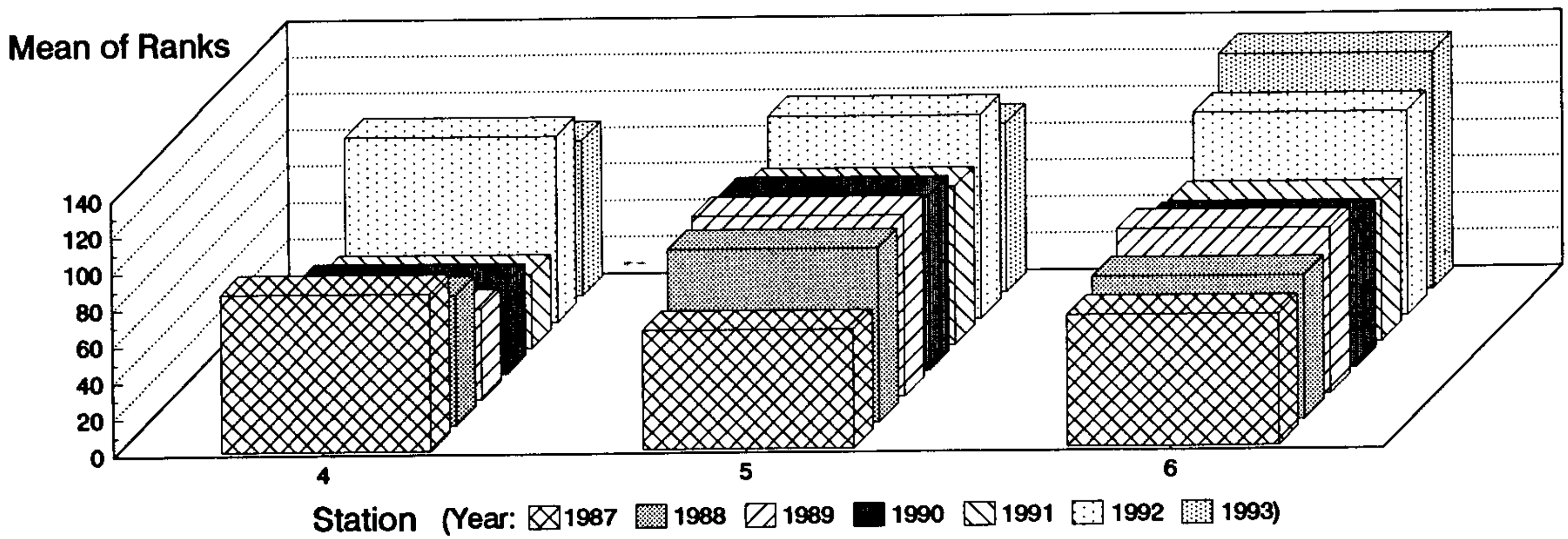
1991 1990 1992 1989 1993 1988 1987

Figure 73. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1987-1993 in Lower Granite Reservoir. Horizontal lines under the year comparison indicate statistical nonsignificance (P 0.05).

Channel catfish.- Comparisons of catch/effort by gill netting for channel catfish revealed significant year and station effects and station*season and year*season interactions (Figures 74-76). Statistical comparisons of catch/effort among stations 4, 5 and 6 showed 5 and 6 were similar and significantly higher than that at station 4 (Figure 74). Abundance of channel catfish has apparently declined at station 4 following the construction of the mid-depth disposal. Few annual differences in catch/effort for channel catfish were significant, except in 1992 and 1993 which were higher than 1987-1991.

During the period of 1987 through 1993, we found no significant seasonal differences in abundance between spring and fall for channel catfish within years (Figure 75). Within station*season comparisons also showed few differences among years (Figure 76). No season within station comparisons of catch/effort for channel catfish were significant ($P>0.05$).

White sturgeon.- Comparisons of catch/effort for white sturgeon sampled by gill netting indicated nonsignificance ($P>0.05$) in the season effects and all interactions. Few station differences were found in catch/efforts for white sturgeon abundance by gill netting (Figure 77). Catch/effort was significantly ($P<0.05$) higher at station 5 than those at disposal station 4 and reference station 6 during the 1987-1993 period. Highest catch/effort was in 1992 and the lowest was in 1991. Among year comparisons showed catch/effort was higher in 1992 and 1993 than other years except 1988 (Figure 77).



Station Comparison

5 6 4

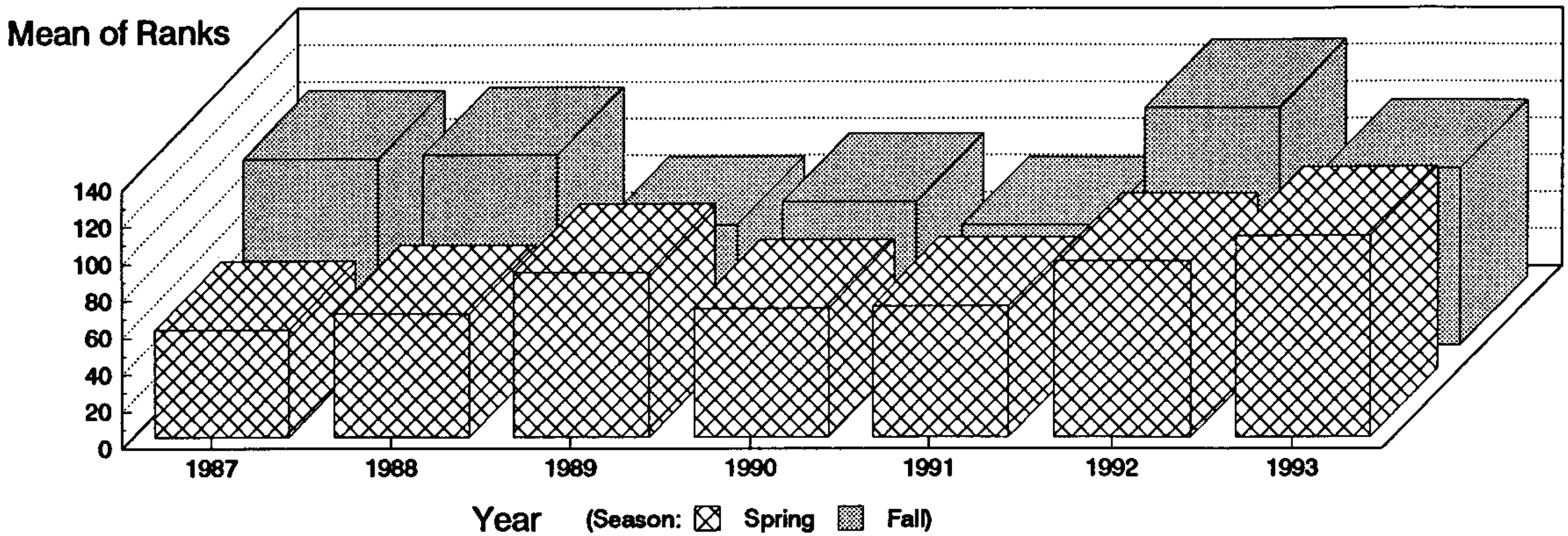
(5 and 6 underlined together)

Year Comparison

1992 1993 1988 1989 1990 1987 1991

(1992–1993 underlined together; 1988–1991 underlined together)

Figure 74. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



Year Comparison

Spring							Fall						
1993	1992	1989	1991	1990	1988	1987	1992	1988	1987	1993	1990	1989	1991

Season Comparison

1987	1988	1989	1990	1991	1992	1993
Fall Spring	Spring Fall	Spring Fall	Fall Spring	Spring Fall	Fall Spring	Spring Fall

Figure 75. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under year and season comparisons indicate statistical nonsignificance ($P > 0.05$).

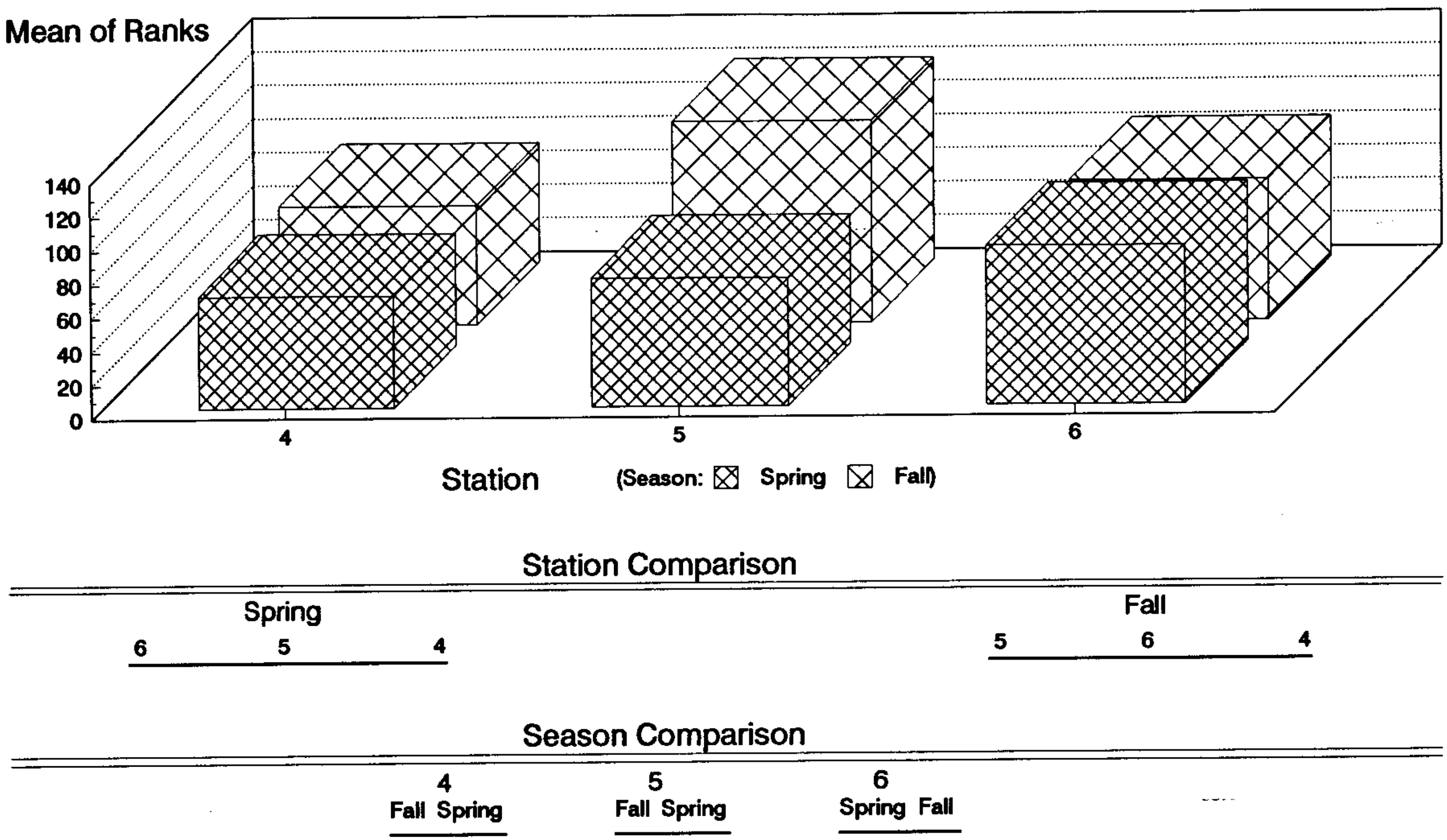
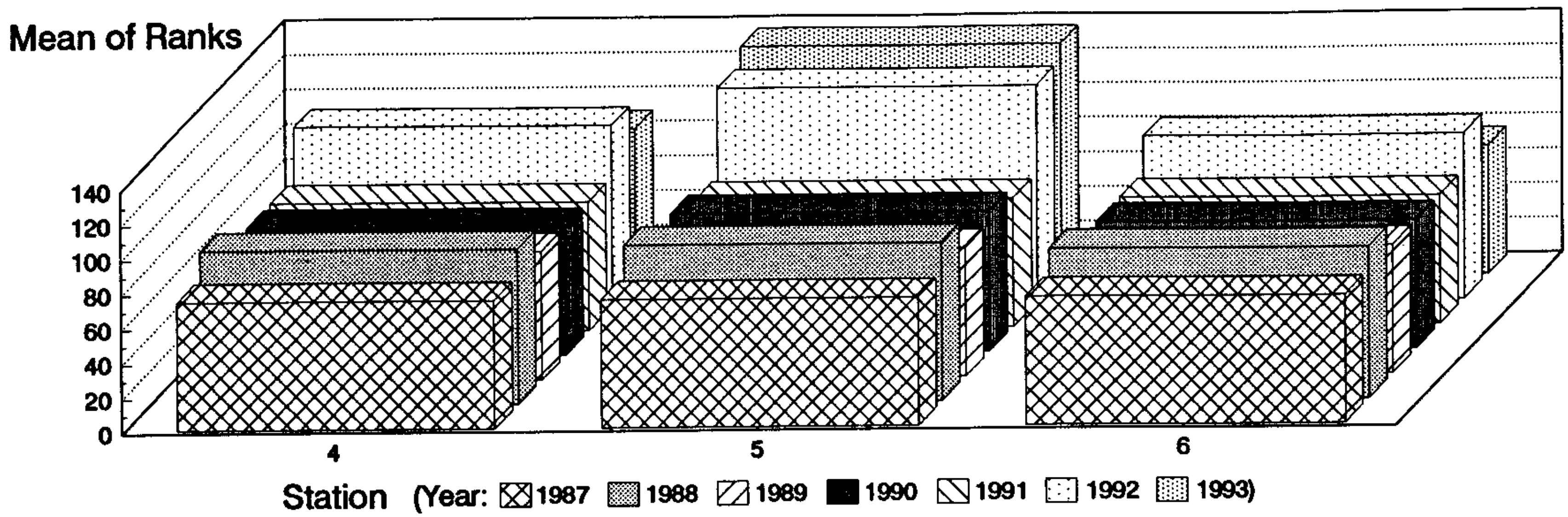


Figure 76. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

5 4 6

(4 and 6 underlined together)

Year Comparison

1992 1993 1988 1990 1987 1989 1991

(1992–1993 underlined together; 1993–1988 underlined together; 1990–1991 underlined together)

Figure 77. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1987-1993 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

Larval Abundance

A total of 9,774 larval fish was collected by paired half-meter plankton nets and a handbeam trawl during 10 June through 11 September, 1993 in Lower Granite Reservoir (Table 5, Appendix Tables 1 and 2). Fourteen fish species and four genera representing six families were collected by larval sampling. Samples collected by handbeam trawl accounted for 81.6% (n=7,974) of the total number of larval fishes collected. Catostomids dominated handbeam trawl and half-meter plankton net catches during June and July, whereas cyprinids dominated catches during August and centrachids dominated catches during September (Figure 78).

The abundance of larval predators collected in Lower Granite Reservoir during 1993 were low for both handbeam and plankton net samples. Larval smallmouth bass were collected at shallow disposal station 1 (n=3) and reference station 5 (n=4) during July. During August, larval smallmouth bass were collected at only reference station 5 (n=64). No larval smallmouth bass were collected at shallow disposal station 2 or reference station 11. Larval northern squawfish were collected only at shallow reference station 11 during 1993. Catches of northern squawfish by half-meter plankton nets were low at station 11 in June, July, August and September. Larval squawfish were collected by handbeam trawl at station 11 during August (n=40). No larval squawfish were collected in 1993 at stations 1, 2 or 5.

Table 5. Larval fishes collected by half-meter plankton nets and a handbeam trawl during 1993 in Lower Granite Reservoir.

Species	May	June	July	August	September	Total
American shad		11	35	86		132
mountain whitefish	1					1
chiselmouth			185	61		246
Cyprinus spp.		153	1,360	969		2,482
carp			1			1
peamouth		2	375	196		573
northern squawfish		1	1	42	1	45
redside shiner			4			4
Catostomid spp.		855	4,524	470		5,849
largescale sucker		22	8	2		32
yellow bullhead				3		3
channel catfish		1				1
Centrarchid spp.			65	231	9	305
smallmouth bass			6	67	1	74
Pomoxis spp.			5	2	10	17
white crappie		2				2
yellow perch				2		2
unknown spp.		1		3		4
Total	1	1,049	6,569	2,134	21	9,774

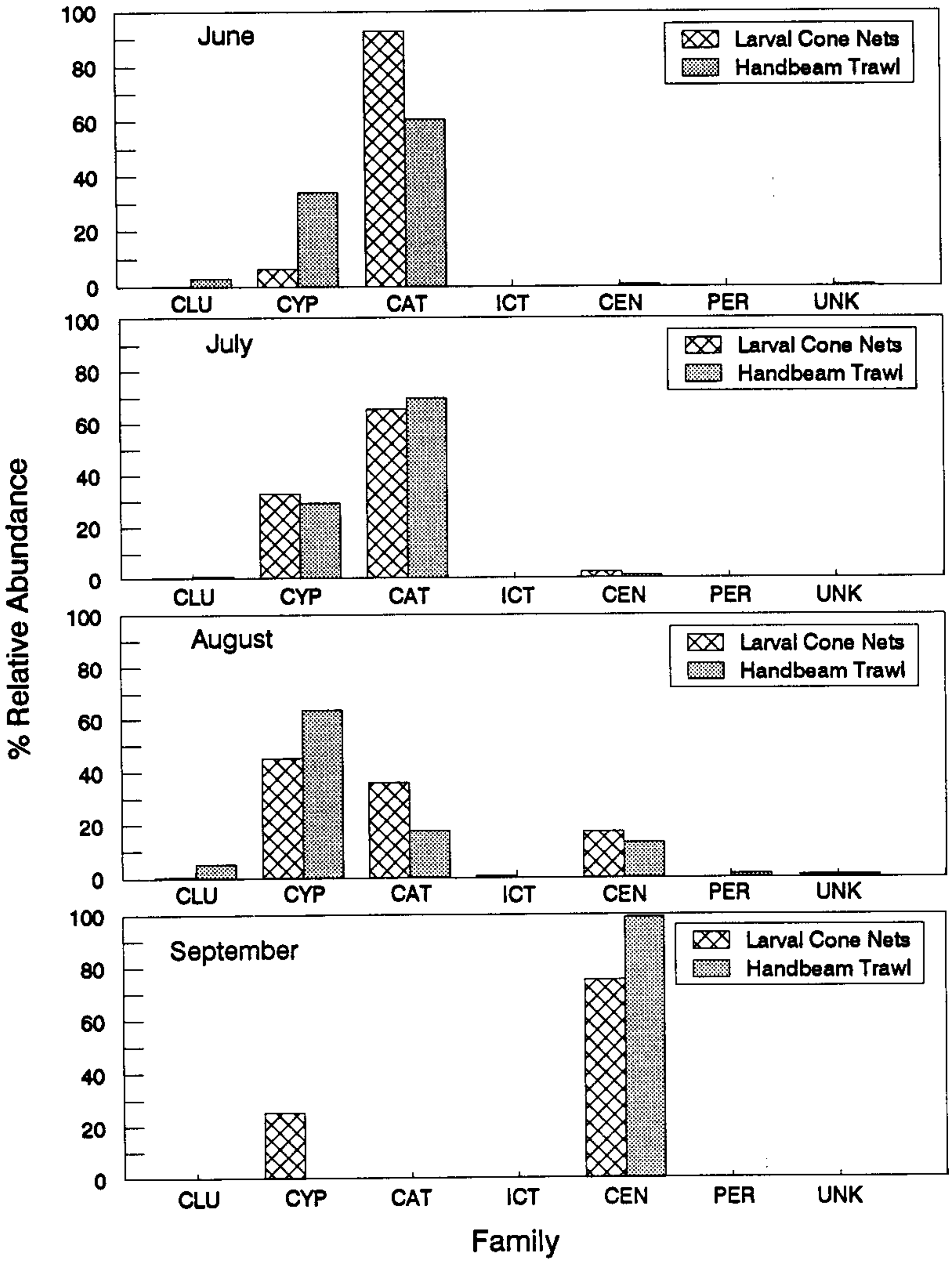


Figure 78. Larval abundance sampled by half-meter plankton nets and a handbeam trawl during 1993 in Lower Granite Reservoir. Family abbreviations include: CAT-Catostomid, CEN-Centrarchid, CLU-Clupeidae, CYP-Cyprinid, ICT-Ictalurid, PER-Pericid, UNK-unknown.

DISCUSSION

Total number of fishes collected in 1993 was 24 species, similar to that in other years. About 7,500 fishes were collected throughout 1993 compared to some other years from 1987 to 1993 when over 16,000 were collected (Bennett et al. 1988, 1990, 1991, 1993a, 1993b and 1994d). Largescale suckers comprised about 42% of the catch in the spring and about 64% in the fall. In the summer northern squawfish accounted for about 36% of the fish community. During spring, summer and fall, highest numbers of predators were consistently collected at station 9.

Sizes of fishes collected in Lower Granite Reservoir were largely related to the type of gear used. Gill netting collected the larger individuals generally from 100 to 800 mm. Beach seining collected the smaller individuals from 25 to 200 mm and electrofishing collected fish predominantly in the 150 to 200 mm length group. Model length for juvenile chinook salmon was 150 mm in 1993. No real differences in length classes were observed among stations when gear type selectivities were considered.

We observed several changes in modal sizes and trends in lengths of the more commonly captured fishes in Lower Granite Reservoir during the period from 1987 to 1993. We observed a decrease in the number of larger northern squawfish. Since 1990, we collected lower numbers of northern squawfish from 300 to 400 mm; fish > 500 mm have been rare. Peak sizes of squawfish were consistently < 100 mm. Little change has been observed in the sizes of smallmouth bass collected from 1987.

Channel catfish sizes were different among all years, although the number of catfish > 600 mm has not changed. Strong year-classes of catfish produced fish in the 200 to 400 mm size range. Largescale suckers have generally been of similar size since 1987; we have observed three peaks in length of suckers: < 100 mm, 300 and 400 mm. Chiselmouth experienced three peaks in abundance at 75, 200 and 300 mm. Higher numbers of small chiselmouth were collected in 1987 and again in 1992.

Abundance of juvenile chinook salmon in 1993 was highest at station 11 based on comparisons of catch/effort sampled by beach seining and electrofishing. Differences in catch/effort were significant between station 11 and stations 10, 2 and 9. In 1985, we also collected juvenile chinook salmon in abundance at station 11 (Bennett and Shrier 1986).

Juvenile steelhead were significantly more abundant at station 9 than stations 2 and 1 based on beach seining and electrofishing in 1993, respectively. Catch/effort for steelhead by beach seining was not different among seasons, although seasonal effects were significant and catch/effort was higher in the spring using electrofishing.

Northern squawfish abundance in 1993 was generally lower at disposal stations than most of the reference stations. Comparisons of catch/effort among stations by gill netting indicated a seasonal influence. The highest abundance during the spring was at reference station 6 and the catch/effort there was significantly higher than those at all disposal stations (1, 2, 4 and 7). Since gill nets collect large squawfish, these comparisons represent adult/subadult abundance. Beach seining, a technique that collects mainly age 0 and 1 northern squawfish, indicated highest catch/effort at reference station 10. Abundances of small sized squawfish, based on catch/effort, were similar among disposal stations 1 and 2 and reference stations 5 and 9. Intermediate sized northern squawfish, sampled with nighttime electrofishing, were widely dispersed across reference and disposal stations. Statistical differences were limited to the highest catch/effort at reference station 3 being significantly higher than that at reference station 9. A significant seasonal difference in abundance was found; catch/effort was significantly higher with electrofishing in spring 1993 than in the fall.

Catch/effort comparisons for smallmouth bass using various gear types indicated few station differences, although a significant season effect was found. Catch/efforts by gill nets were significantly higher in the spring at reference stations 3 and 5 and disposal station 1 than other reference and disposal stations. In the fall, smallmouth abundance was highest and similar among reference station 6 and disposal stations 1, 2 and 4. Smallmouth bass collected by beach seining were similarly distributed in abundance as no station differences were detected in 1993. Catch/effort was significantly higher in the spring and summer than in the fall. Catch/efforts by electrofishing for smallmouth bass indicated only one station difference as that at station 9 were significantly higher than those at reference stations 11 and 5 and disposal stations 1 and 2.

Channel catfish abundance in 1993 was generally similar among stations but varied seasonally. During spring, catch/efforts were high at shallow stations while in the fall catch/efforts were high at reference station 8 and deep disposal station 7. These comparisons indicate channel catfish probably move to shallow waters, possibly to feed on salmonid smolts in the spring, and then migrate to deeper waters in the fall. Bennett et al. (1983) reported channel catfishes were significant predators in Little Goose Reservoir, especially in the tailwater of Lower Granite Dam in 1979 and 1980.

White sturgeon abundance among disposal and reference stations in 1993 also was affected by seasonal differences. During both spring and fall, catch/efforts of sturgeon sampled by gill netting were high at stations 5 and 8; in the spring, high catch/effort was also found at deep disposal station 7. In the fall, catch/efforts were directly related to station depth; stations 5 and 8 experienced high catch/efforts followed by stations 4 and 7 and then the shallow water complex of stations 1, 2 and 3 and mid-depth reference station 6.

We observed few differences in catch/effort among years 1989 to 1993 to indicate overall changes in abundance. Some differences in catch/effort within stations during this 5-year period (1989-1993) occurred.

We observed low catch/efforts of juvenile chinook salmon sampled by beach seining at disposal stations 1 and 2 and highest catch/effort at reference station 5 from 1989 through 1993. Catch/efforts at other disposal and reference stations indicated similar levels of abundance as that at station 5. Catch/efforts were significantly higher in the period from 1989 to 1991 and 1993 than in 1992. Results from electrofishing showed similar trends in abundance, although catch/effort at reference station 5 was significantly higher than that at station 9, which was the lowest. No other statistical differences were found.

We detected few differences in abundance among years and stations based on catch/effort comparisons of juvenile steelhead. Catch/efforts by beach seining were higher at reference stations 9 and 10, in the lower reservoir, than mid-reservoir stations (3, 2, 5, and 1). Annual differences were scattered among years with little statistical difference in catch/effort. Similar results were found for catch/efforts by electrofishing with stations 9 and 10 also showing the high abundances, although in 1992 catch/effort was significantly higher than other years. Higher catch/effort during 1992 is probably a function of the high numbers of steelhead that remained in Lower Granite Reservoir as a result of extremely low flows and numerous juvenile steelhead trapped in the reservoir.

Since 1989, we collected high numbers of adult/subadult northern squawfish/effort at reference stations 5 and 6. Catch/efforts from gill nets indicated intermediate levels of abundance of northern squawfish at shallow disposal stations 1 and 2 and mid-depth disposal station 4.

Highest numbers of small squawfish were collected by beach seining at reference stations 10 and 3 with those at disposal stations 1 and 2 near the lowest. Few annual differences in abundance were found and numbers of small northern squawfish varied based on catch/effort comparisons.

Results from electrofishing showed high abundances of intermediate sized squawfish at reference stations 3 and 5 followed by disposal station 1 and reference station 10. Catch/effort of squawfish by electrofishing was lowest in 1993 compared to the other 4 years, 1989 through 1992.

The abundance of large smallmouth collected by gill nets showed a significant interaction between season and station. The order of abundance between stations were similar from spring to fall; catch/efforts at disposal stations during both seasons were intermediate. Annual differences in catch/effort for smallmouth bass by gill netting were found, however, there was little evidence of a decline or increase in abundance.

Results from beach seining indicated abundance of the smallest size group of smallmouth bass was significantly higher at reference station 10 than other stations sampled during the 5-year period. As with gill netting, a few statistical differences in catch/effort were found but no trends were obvious.

Catch/efforts for electrofishing indicated high abundance at reference stations 9 and 10 and significantly ($P<0.05$) lower abundance at disposal stations 1 and 2. As with gill netting and beach seining, no trends were found in abundance based on electrofishing.

Catch/efforts by gill nets indicated high abundance at deep (8), shallow (5) and mid-depth (6) reference stations and low abundance at disposal stations 2 and 4. The season*station interaction was significant, although the order of abundance changed little within either the spring or fall season. Catch/effort of channel catfish was highest in 1993 compared to other years; 1992 was second from the highest which may suggest an overall increase in abundance in Lower Granite Reservoir during the last 2 years.

Little consistency in catch/efforts of white sturgeon sampled by gill netting were found among stations from 1989 to 1993, and a significant year*station interaction corroborated this interpretation. During some years (1989, 1990 and 1993), catch/efforts were highest at reference station 8. During other years, the highest catch/effort was primarily at shallow reference station 5.

We sampled at several stations from 1987 through 1993. Some stations were reference stations whereas mid-depth disposal station 4 was created in 1988. If changes in catch/effort occurred at station 4 from 1987, prior to the disposal event, to the present, we would have some evidence of an altered fish community associated with disposal. Also, construction of Centennial Island in 1989 followed by completion of the deep water disposal in 1992 could also reveal changes in the fish community.

Since 1987, catch/effort of juvenile chinook salmon by beach seining has not showed any differences between stations 5 and 9, although electrofishing results showed significantly higher abundance at station 5. A few annual differences in catch/effort by both electrofishing and beach seining were significant but no trends were apparent.

We found opposing differences in catch/effort results of juvenile steelhead abundance by beach seining and electrofishing at stations 5 and 9 that could reflect time of use differences. Beach seining conducted during the day may reflect possible deeper orientation of juvenile steelhead whereas at night, they may concentrate around station 9 in the lower part of Lower Granite Reservoir. During low flow years, catch/efforts have generally been higher for juvenile steelhead than during average flow years of 1991 and 1993.

We found a season*year effect of northern squawfish by gill netting in Lower Granite Reservoir. Our results generally showed an overall decrease in northern squawfish in Lower Granite Reservoir since mid-1980s. Catch/effort was low in 1993 and 1992 suggesting a decrease in abundance, possibly the result of the Sport Reward Program for northern squawfish.

Catch/efforts of northern squawfish by electrofishing and gill netting generally showed similar decreasing trends in abundance. Catch/effort of squawfish by electrofishing was lowest in 1993, although catch/efforts were also low in 1987 and 1988. We attribute low catch/efforts in 1987 and 1988 to use of a less efficient electrofisher than in successive years.

Concerns over possible compensation for decreased abundance of northern squawfish in Lower Granite Reservoir are not supported by our beach seining data. As indicated, beach seining largely catches age 0 and age 1 northern squawfish. If compensation were occurring, catch/efforts should be increasing. Catch/efforts from beach seining were generally similar among years with a few differences, although no trend exists.

Smallmouth bass abundance fluctuated among years (1987-1993), but high catch/efforts with gill netting occurred in 1992 and 1993. Catch/efforts during this period of time were significantly higher at reference station 5 than mid-depth disposal station 4.

Beach seining results showed higher age 0 and 1 abundances in 1987 and 1988 than in 1993 and 1990. Also during this time, catch/effort was significantly higher at reference station 9 than reference station 5.

Results from electrofishing show similar significant differences in catch/efforts between stations 9 and 5. The period from 1989 to 1993 showed similar catch/efforts which were higher than those in 1987 and 1988. These differences are probably related to differences in electrofishers than fish abundance.

Channel catfish, known to prey on salmonid smolts, showed an increase in abundance based on significantly higher catch/efforts in gill nets since 1987 and 1988. The years from 1987 to 1991 experienced lower catch/efforts for channel catfish than 1992 and 1993. We do not know why but do not believe the differences can be attributed to the in-water disposal. Catch/efforts at reference stations 5 and 6 have consistently been significantly higher than at mid-depth disposal station 4. Catch/efforts at station 4 decreased following disposal.

We have seen significantly higher catch/efforts of white sturgeon by gill netting in 1992 and 1993 than the years of 1987 and 1989 to 1991 suggesting a possible increase during the 7-year period of study. During this time, catch/effort was significantly higher at reference station 5 than both mid-depth disposal station 4 and reference station 6. Higher catch/effort for white sturgeon following disposal shows adverse affects were not observed on white sturgeon abundance associated with construction of the mid-depth plateau in 1988.

Nearly 10,000 larval fishes were collected in 1993. We have seen that different fish families generally dominate the catches during 1 to 2 months. For example, catostomids dominate our larval samples in June and July, cyprinids dominate in August and centrarchid fishes dominate the September catches. During 1993, larval northern squawfish were only collected at reference station 11, while none were collected at reference station 5 and disposal stations 1 and 2.

Objective 2. To provide a second year of monitoring fish utilization and characterize habitat at the newly constructed deep water disposal site.

METHODS

Gill netting was used to sample the newly constructed in-water deep disposal station 7 (RM 119.0) during April, May, June and October (Objective 1). Sampling by gill nets was curtailed on 27 June to satisfy ESA concerns and was resumed on 1 October, 1993. Sampling was conducted in the evening and night with 68.6 m x 1.8 m (225 ft x 6 ft) multifilament experimental gill nets with bar mesh sizes of 3.8, 4.4 and 5.1 cm (1.5, 1.75, and 2 inches; Webb et al. 1987). Gill nets were set for 3 to 4 nights on the bottom for a total of approximately 6 hours and checked 3-hour intervals at stations 7 and 8 to preclude destructive sampling to all fishes, especially salmonids. All fish captured were identified to species, measured for total length (mm) and released alive immediately after processing.

Macrohabitat characteristics of depth and bottom topography at deep disposal station 7 were assessed during 1992 (Bennett et al. 1994d).

RESULTS

Island Topography

Habitat at station 7 changed in depth between 1992 and 1993 (Figures 79 and 80). Based on our soundings in 1992, the deep water disposal of dredged material was rather clumped and the overall area resembled an underwater island. The dimensions of the disposal were about 305 m (1,000 ft) north to south and about 152 m (500 ft) east to

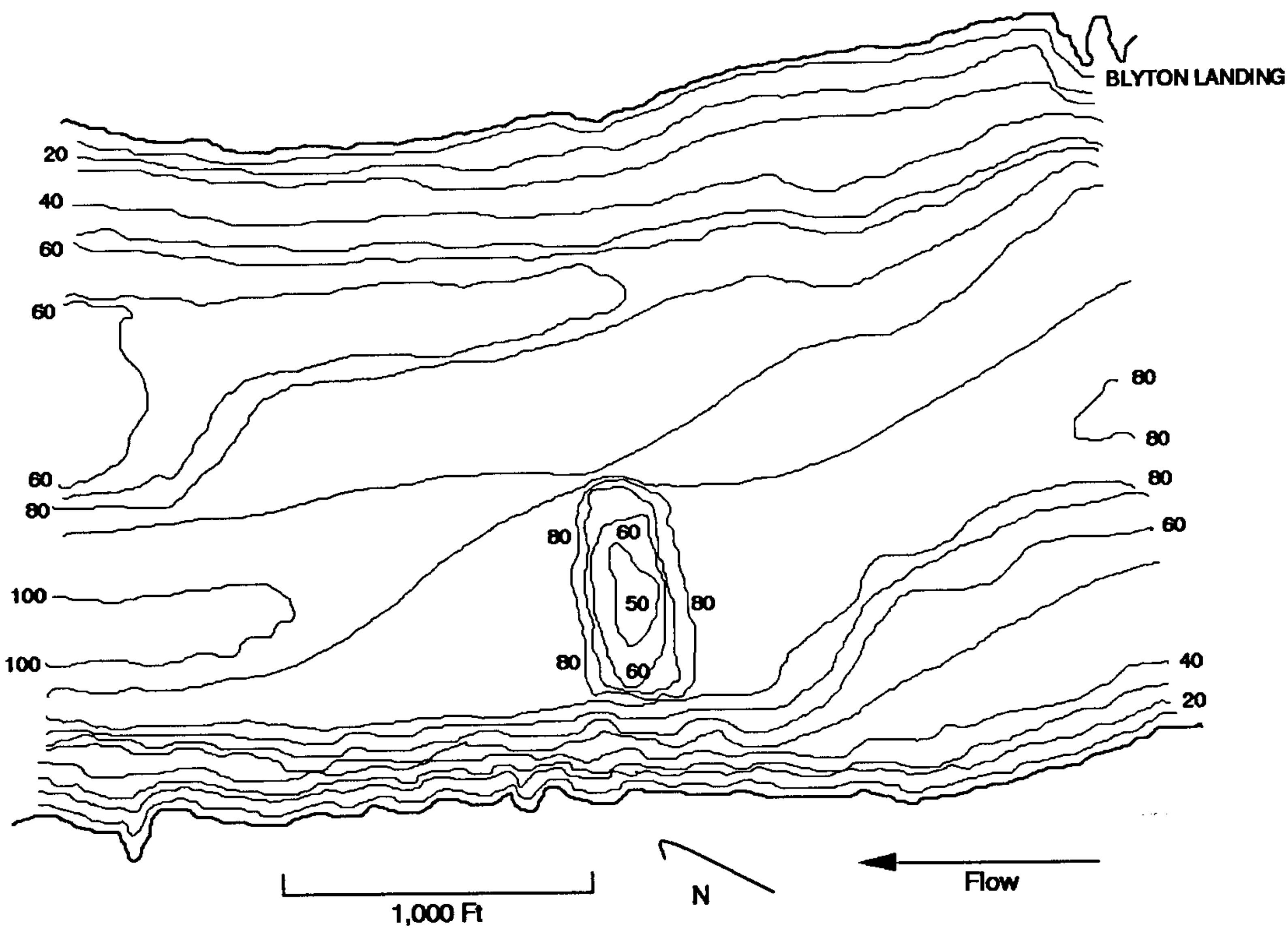


Figure 79. Map of the newly created deep water disposal station 7 at river mile 119.0 during 1992 in Lower Granite Reservoir. Contour lines represent 10 ft.

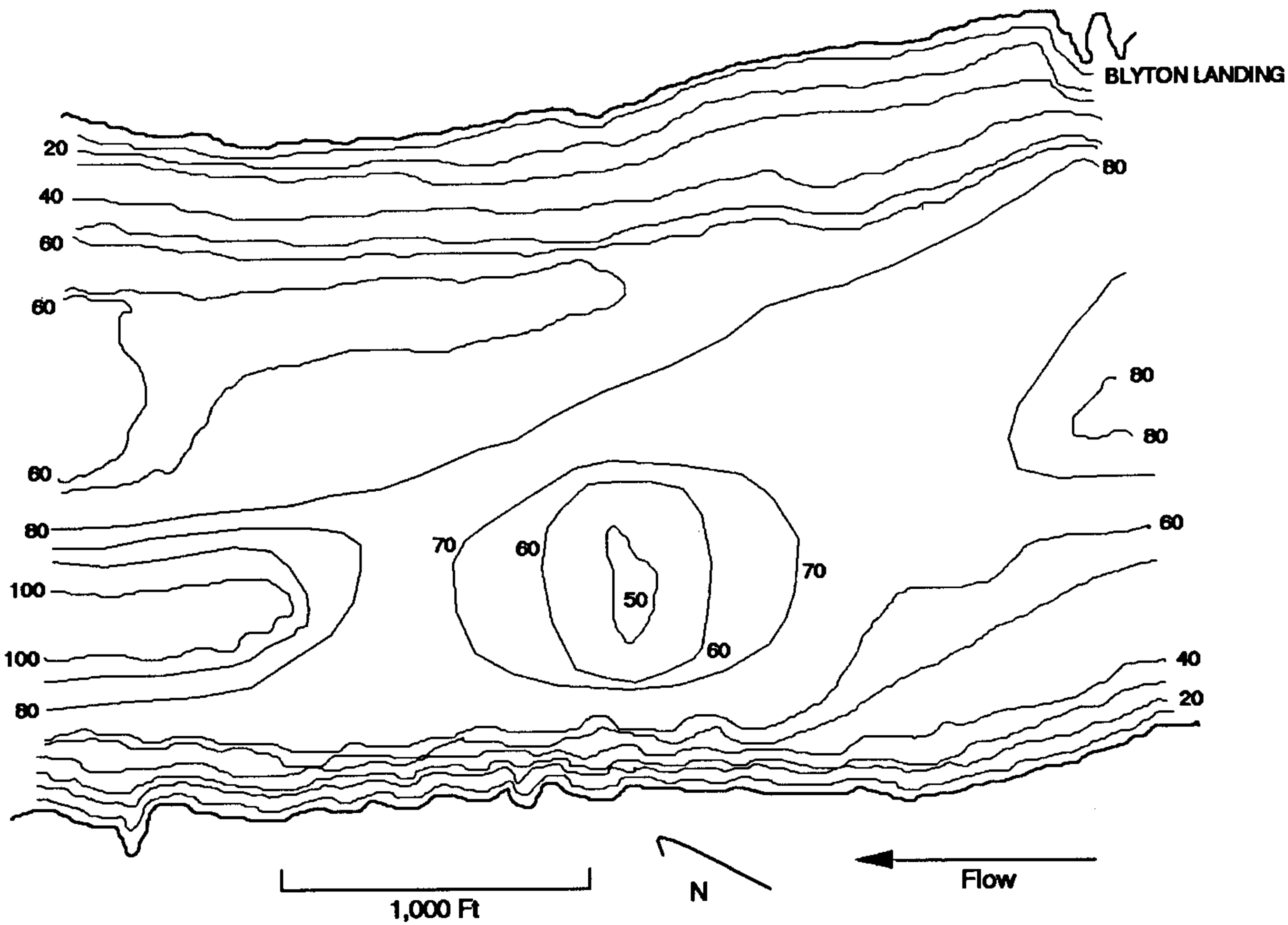


Figure 80. Map of deep water disposal station 7 at river mile 119.0 during 1993 in Lower Granite Reservoir. Contour lines represent 10 ft.

west. During 1993, the dredged material seemed to have spread along the bottom of the reservoir, although the nucleus of the disposal remained constant. The size of the disposal clump was enlarged immensely from East to West and the cross channel dimensions changed little.

Catch/Effort Comparisons Between Stations 7 and 8

Northern Squawfish

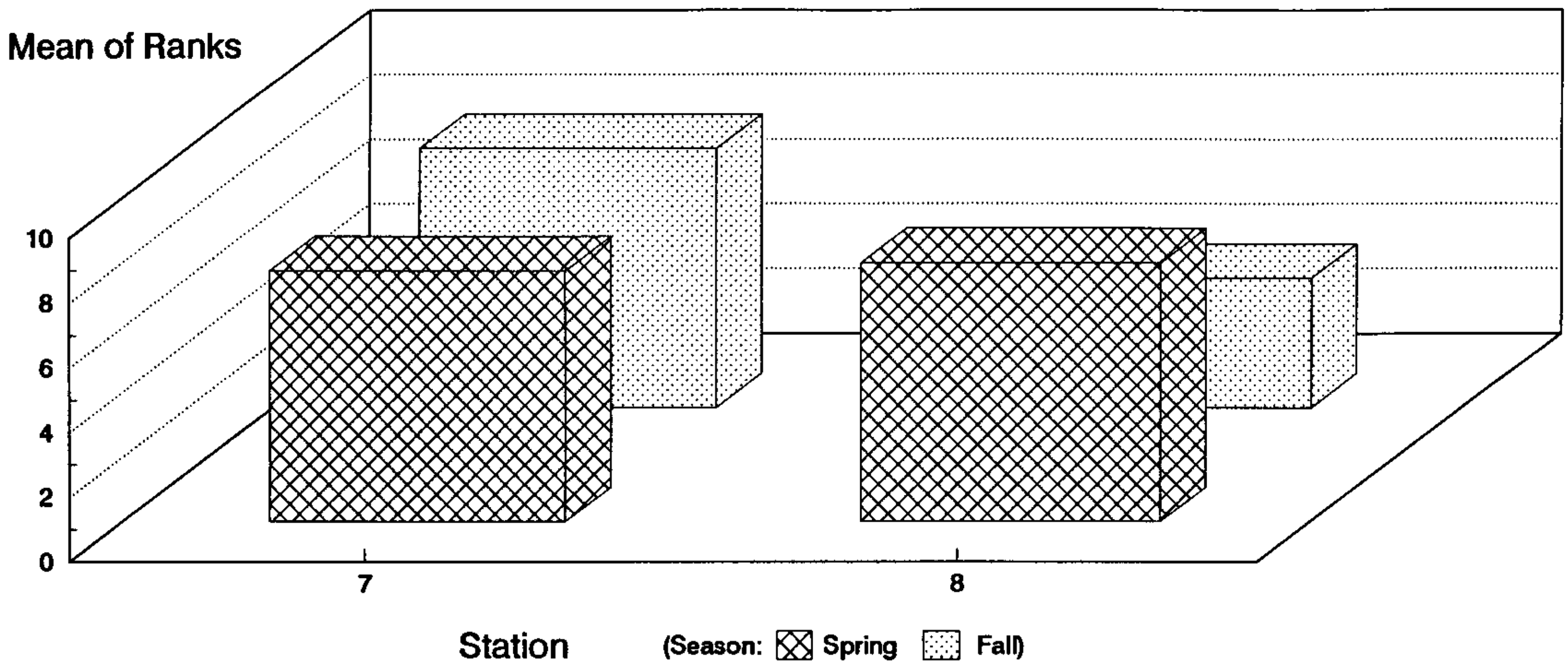
Comparisons of catch/effort for northern squawfish by gill netting during 1993 showed no statistical differences between deep disposal station 7 and deep reference station 8 within and between spring and fall (Figure 81). Catch/efforts for northern squawfish between stations 7 and 8 varied between seasons, but none of the comparisons were significant.

Smallmouth Bass

Comparisons of catch/effort for smallmouth bass by gill netting in 1993 showed no statistical differences between deep disposal station 7 and deep reference station 8 within and between spring and fall (Figure 82). High catch/efforts occurred during spring at both stations.

Channel Catfish

Comparisons of catch/effort for channel catfish by gill netting in 1993 showed no statistical differences between deep disposal station 7 and deep reference station 8 within and between spring and fall (Figure



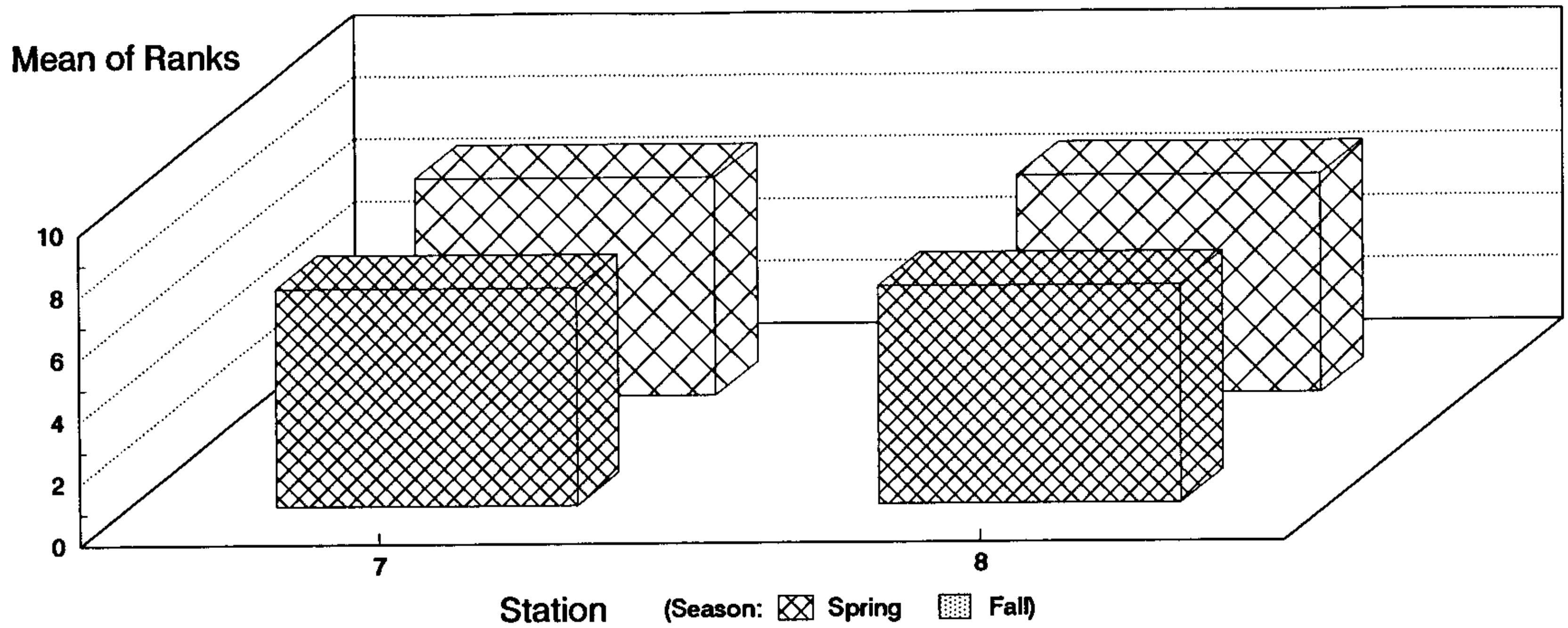
Station Comparison

Spring	Fall
8 7	7 8

Season Comparison

7	8
Fall Spring	Spring Fall

Figure 81. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

Spring	Fall
7 8	7 8

Season Comparison

7	8
Spring Fall	Spring Fall

Figure 82. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).

83). High catch/efforts occurred during fall at both stations, but these seasonal differences were not significant (P>0.05).

White Sturgeon

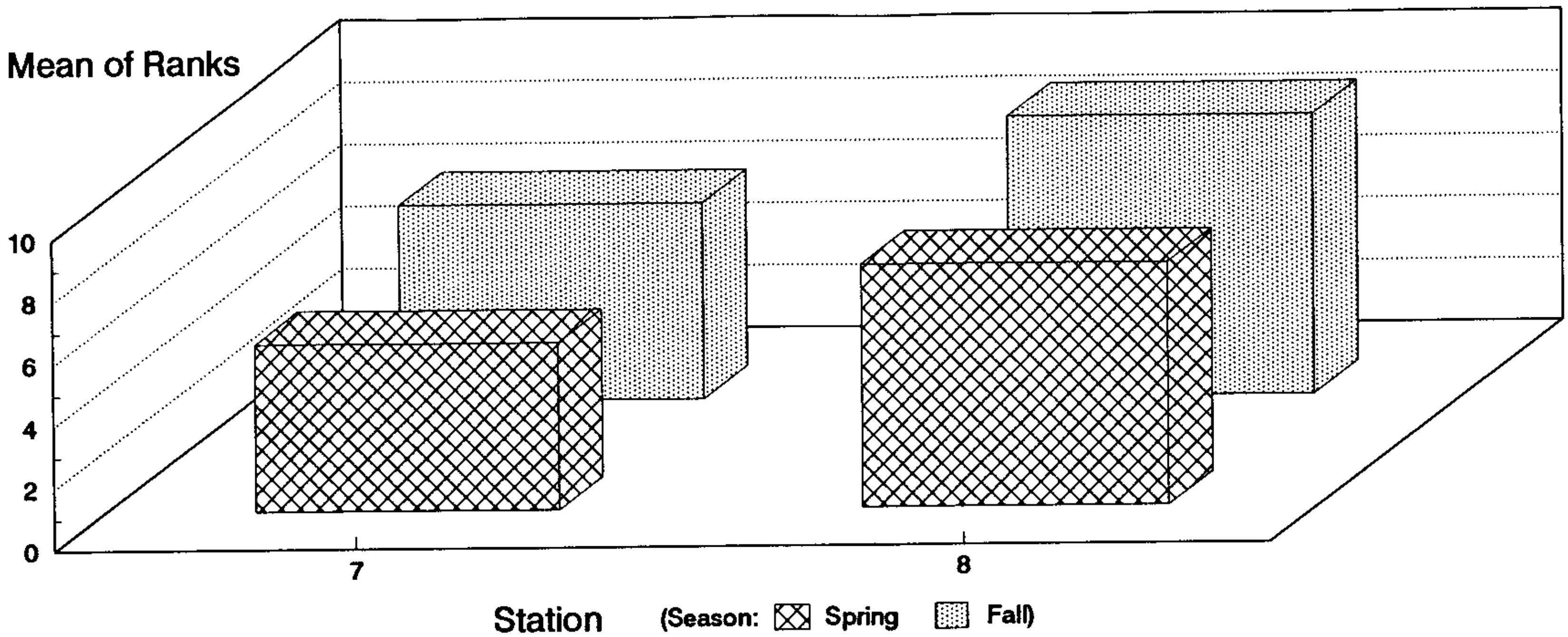
As with the other species, catch/efforts of white sturgeon by gill netting in 1993 showed no statistical differences between deep disposal station 7 and deep reference station 8 within and between spring and fall (Figure 84). Catch/efforts were high during spring at both stations, but these seasonal differences were not significant (P>0.05).

Catch/effort Comparisons Between 1992 and 1993

Construction of the deep disposal station in 1992 provided the third test of in-water disposal in Lower Granite Reservoir. Comparisons of catch/effort of resident fishes by gill netting between 1992 and 1993 at disposal station 7 and reference station 8 were made.

Northern Squawfish

We found no statistical differences in catch/effort for northern squawfish between stations 7 and 8 and years 1992 and 1993 (Figure 85). Although catch/efforts were higher for northern squawfish in 1993 than 1992 and that at station 8 was higher than station 7, these differences were not significant (P>0.05).



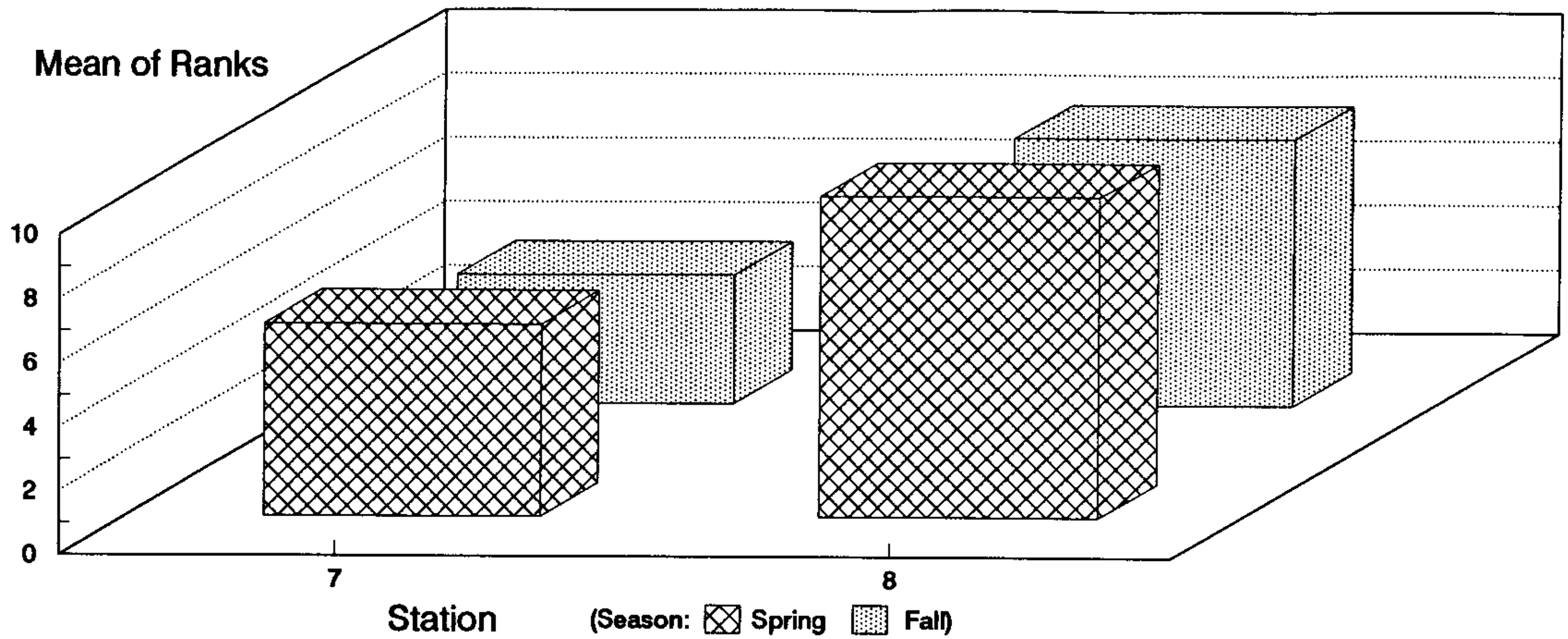
Station Comparison

Spring	Fall
8 7 (underlined)	8 7 (underlined)

Season Comparison

7	8
Fall Spring (underlined)	Fall Spring (underlined)

Figure 83. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance (P > 0.05)



Station Comparison

Spring

8 7

Fall

8 7

Season Comparison

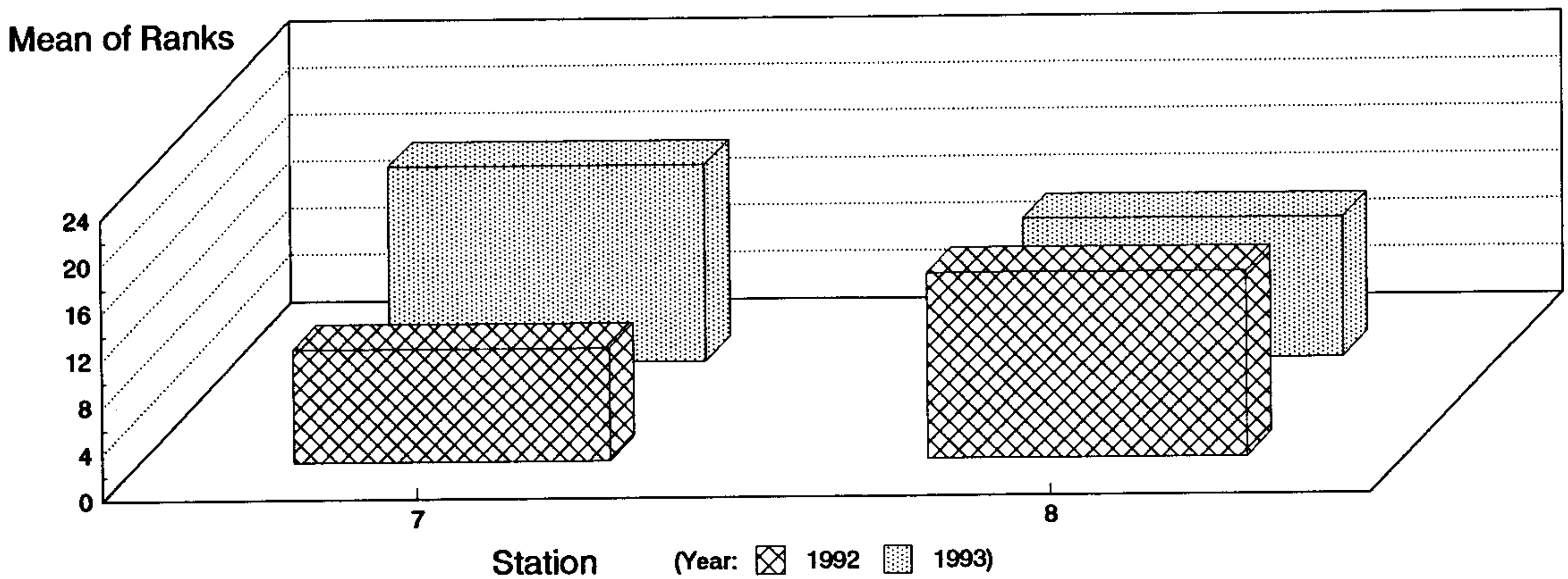
7

Spring Fall

8

Spring Fall

Figure 84. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and season comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

8 7

Year Comparison

1993 1992

Figure 85. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1992 and 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).

Smallmouth Bass

We found no statistical differences in catch/effort for smallmouth bass during 1992 and 1993 at stations 7 and 8 (Figure 86). Catch/effort was higher for smallmouth bass in 1992 than 1993 and that at station 7 was higher than station 8, although these differences were not significant ($P>0.05$).

Channel Catfish

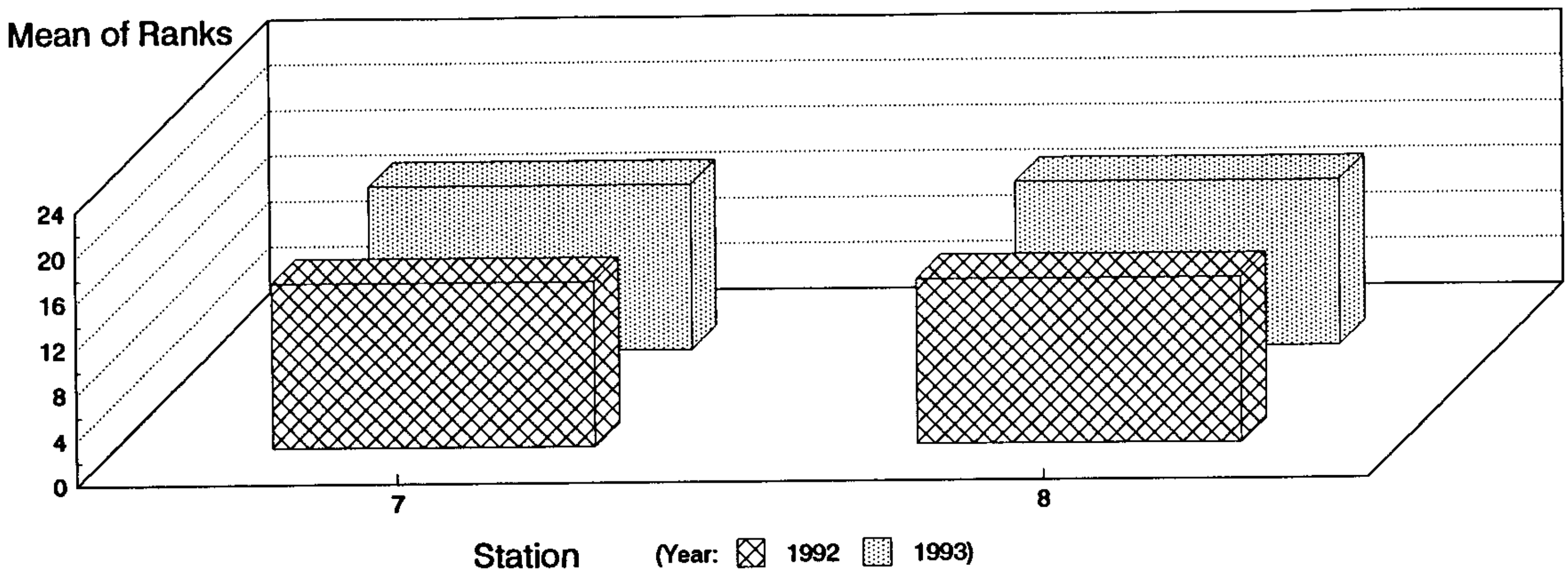
We found statistical differences in catch/effort for channel catfish between 1993 and 1992 but not between stations 7 and 8 (Figure 87). Seasonal differences in catch/effort were not significant within stations and years (Figure 88). Catch/efforts were high during fall at both stations 7 and 8 in 1992 and 1993.

White Sturgeon

We found no statistical differences in catch/effort for white sturgeon between 1993 and 1992, although catch/effort in 1993 was higher than that in 1992 (Figure 89). Catch/efforts between stations 7 and 8 were not statistically different ($P > 0.05$) and that at station 8 was higher than station 7.

DISCUSSION

Soundings made in late 1993 indicated the dredged material disposed at station 7 had repositioned. The movement of material from 1992 to 1993 indicated a general spreading from upstream to downstream.



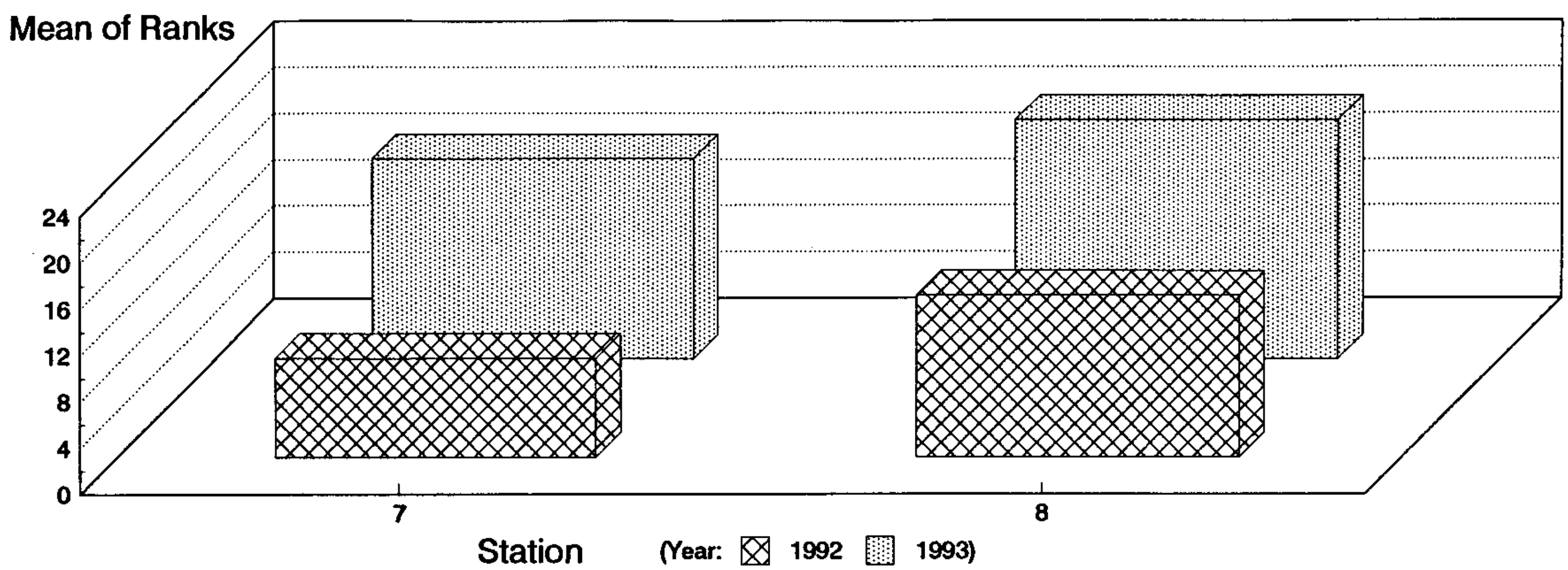
Station Comparison

7 8

Year Comparison

1992 1993

Figure 86. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1992 and 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



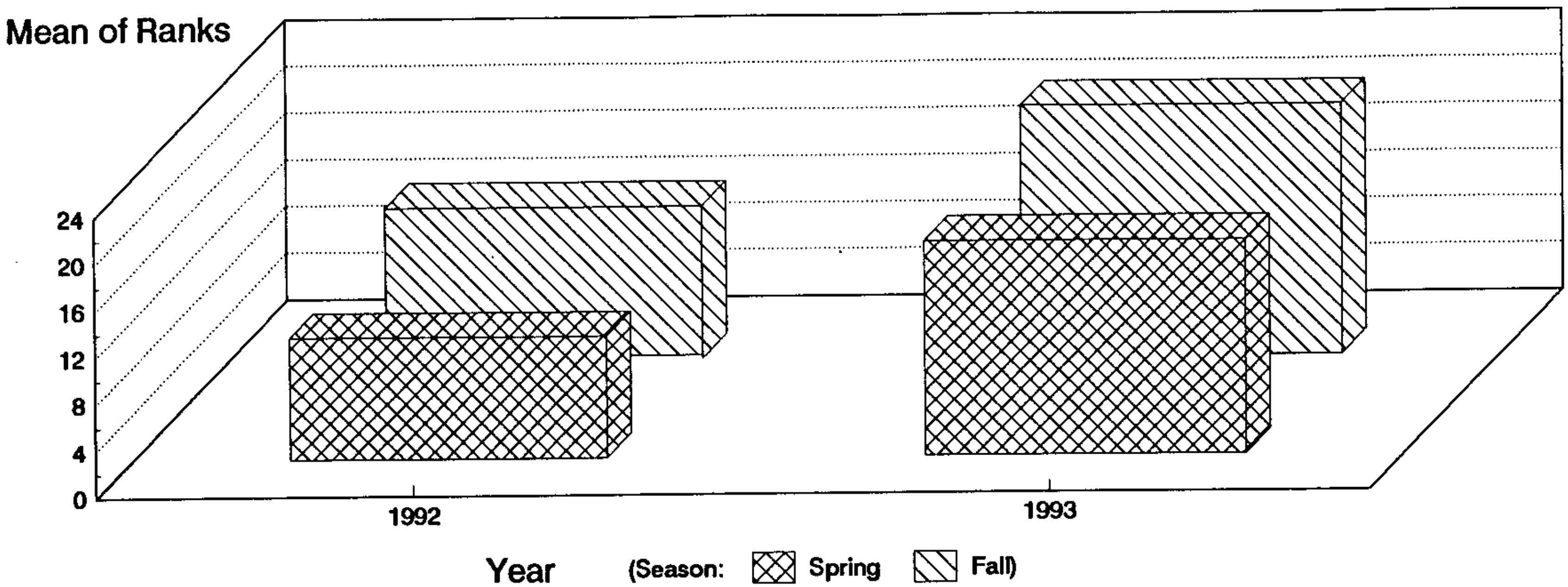
Station Comparison

8 7

Year Comparison

1993 1992

Figure 87. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1992 and 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. The horizontal line under the station comparison indicates statistical nonsignificance ($P > 0.05$).



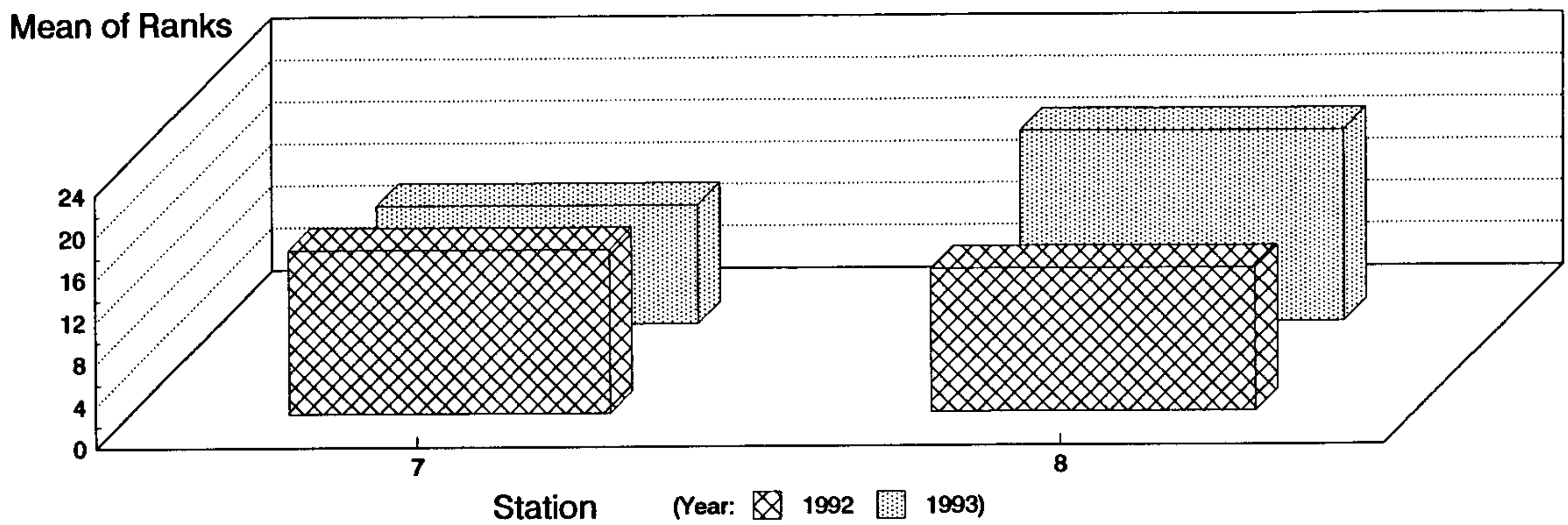
Year Comparison

Spring	Fall
1993 1992	1993 1992

Season Comparison

1992	1993
Fall Spring	Fall Spring

Figure 88. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1992 and 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under year and season comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

8 7

Year Comparison

1993 1992

Figure 89. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1992 and 1993 at deep disposal (7) and reference (8) stations in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

We do not know whether the spreading of dredged material was in response to the higher flows in 1993 than 1992 or general settling.

Few differences in catch/effort of resident fishes by gill nets were found between deep reference station 8 and deep disposal station 7. No significant differences in catch/effort were found for northern squawfish, smallmouth bass, channel catfish and white sturgeon during 1993. Comparisons of catch/effort for channel catfish between 1993 and 1992 was significantly higher in 1993 at both stations 7 and 8, but no statistical differences were found for northern squawfish, smallmouth bass and white sturgeon between years 1992 and 1993 at stations 7 and 8.

Although the morphometry of station 7 changed between 1992 and 1993, few differences were found in the abundance of various species. Based on the catch/effort data collected from 1992 and 1993, we conclude that the deep water disposal had no measureable effect on the fish community in time and space. Fish community changes may occur after the dredged material has become stabilized, but during the first 2 years following disposal, no detectable changes in fish abundance has occurred.

Objective 3. To monitor salmonid abundance and habitat utilization at reference and disposal sites in Lower Granite Reservoir.

METHODS

Two-boat trawling was proposed to compare abundance of salmonid fishes at the disposal island station 2 and the mid-depth disposal station 4, and the shallow reference station 5 and mid-depth reference station 6. Equipment failure in 1993 precluded two-boat trawling during the spring sampling effort. However, results from the 1992 trawling effort are included in this report to compare our findings since year 1 (1988). Previous years have indicated sampling with this gear type captures few fish, therefore summer, fall and winter sampling was not conducted with two-boat trawling because it is not cost effective during these seasons.

Daytime beach seining and nighttime electrofishing were conducted during 1993 at stations 1, 2, 3, 5, 9, 10 and 11 to provide estimates of abundance of juvenile salmonid fishes and potential predators, especially northern squawfish and smallmouth bass (Objective 1). We sampled by beach seining during April, May and June at each of the stations and at monthly intervals from July through October. Electrofishing was conducted during April, May and June. Our electrofishing efforts were curtailed on 27 June and resumed in September to satisfy ESA concerns over potential mortality of adult sockeye salmon migrating through the system.

All fish collected in the 1992 sampling effort were identified to species, measured to total length (mm) and released. Adult salmonids were released immediately without being removed from the water.

RESULTS

Chinook Salmon

1992

Differences in catch/effort for juvenile chinook salmon by surface trawling among stations were not significant ($P>0.05$) during spring 1992 (Figure 90). Catch/effort for juvenile chinook was lowest at shallow disposal station 2, while that at mid-depth reference station 6 was highest. Catch/effort in the forebay was similar to those at disposal stations 2 and 4.

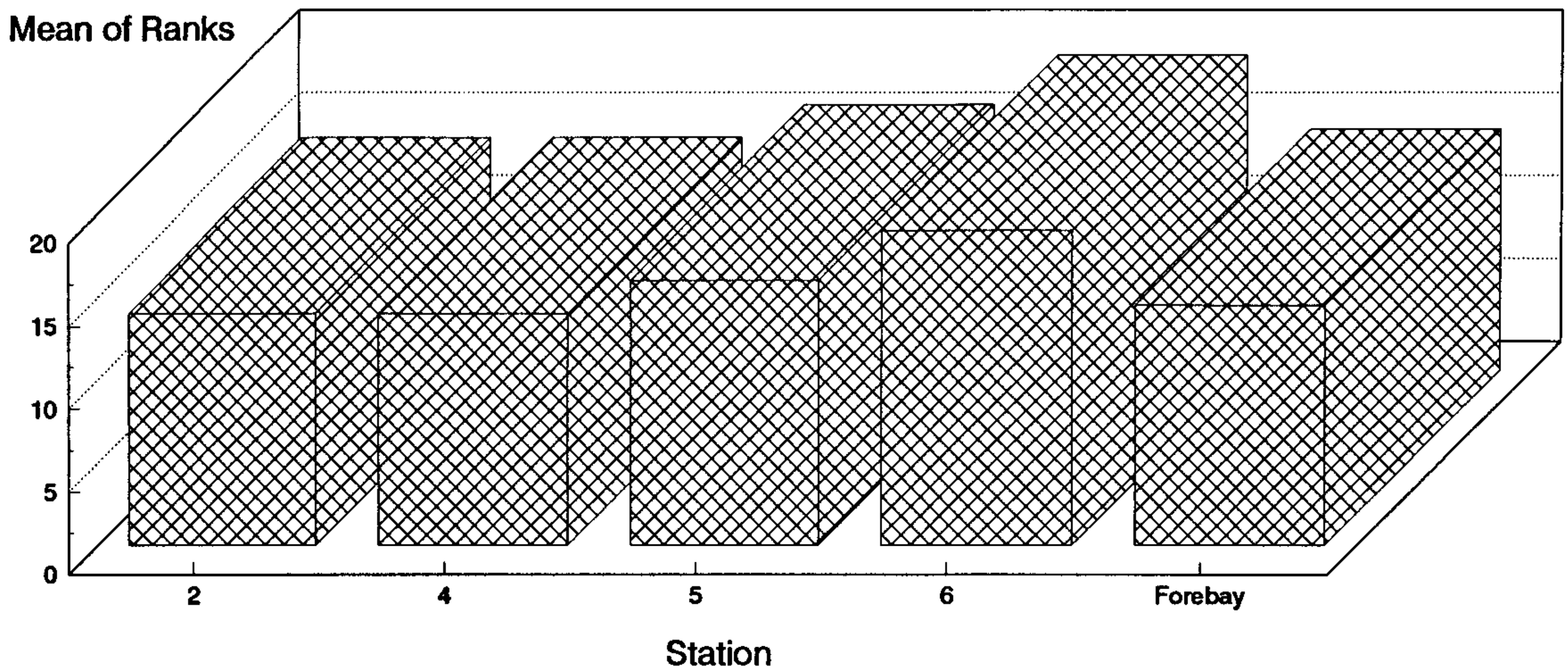
1989-1992

Differences in catch/effort by surface trawling for juvenile chinook salmon generally were similar among stations from 1989 through 1992 (Figure 91). Catch/efforts were significantly ($P<0.05$) higher at reference stations 5 and 6 compared to disposal stations 4 and 2. Annual differences in catch/effort by surface trawling for juvenile chinook salmon were found (Figure 91). Catch/efforts for juvenile chinook salmon were significantly ($P<0.05$) higher during 1991 and 1989 than in both 1990 and 1992. Catch/effort of juvenile chinook salmon was highest in 1991 and lowest in 1992.

Steelhead

1992

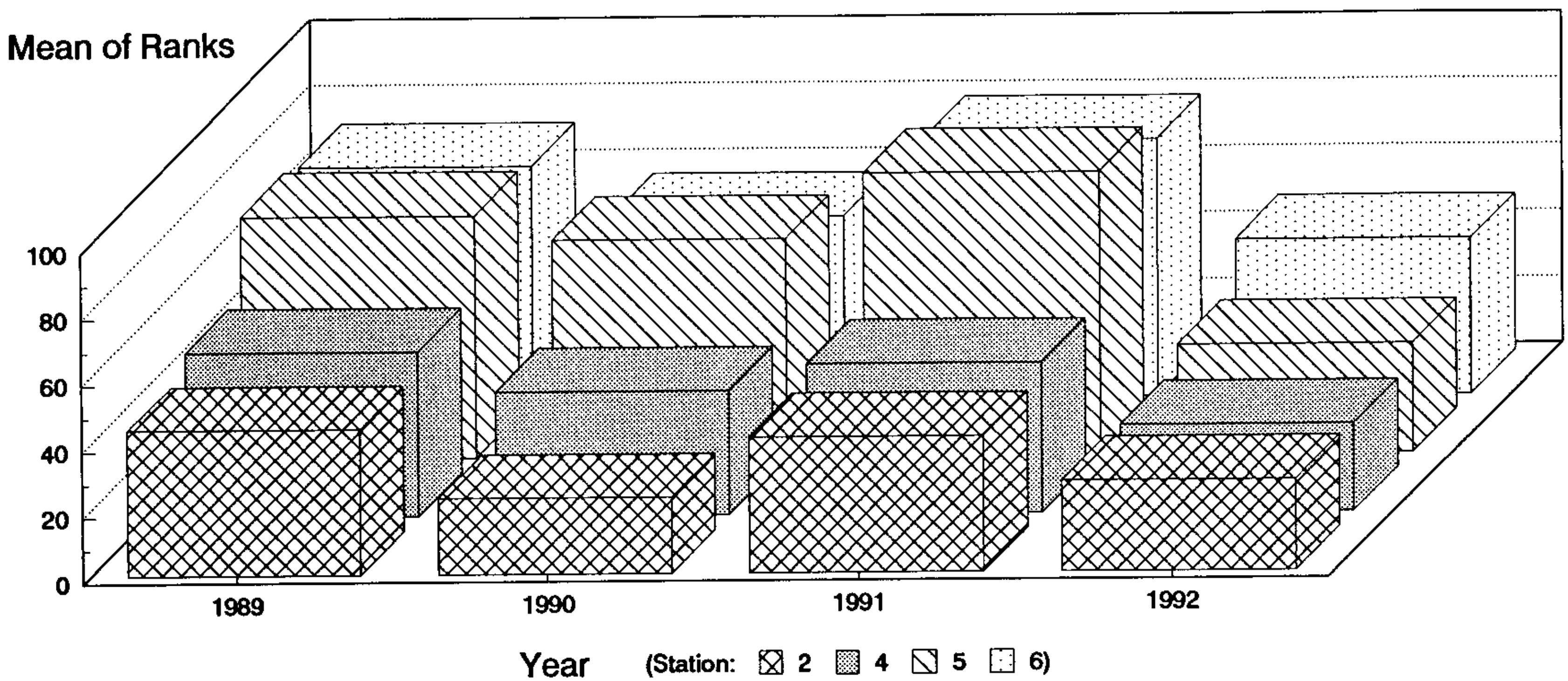
Comparisons of catch/effort by surface trawling for juvenile steelhead indicated no significant ($P>0.05$) differences among stations



Station Comparison

6 5 Forebay 4 2

Figure 90. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by surface trawling during 1992 in Lower Granite Reservoir. The horizontal line under the station comparison indicates statistical nonsignificance ($P > 0.05$).



Station Comparison

5 6 4 2

Year Comparison

1991 1989 1990 1992

Figure 91. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by surface trawling during 1989-1992 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

(Figure 92). Catch/effort was highest at mid-depth reference station 6 followed by shallow reference station 5. Catch/effort of juvenile steelhead was lowest at the forebay.

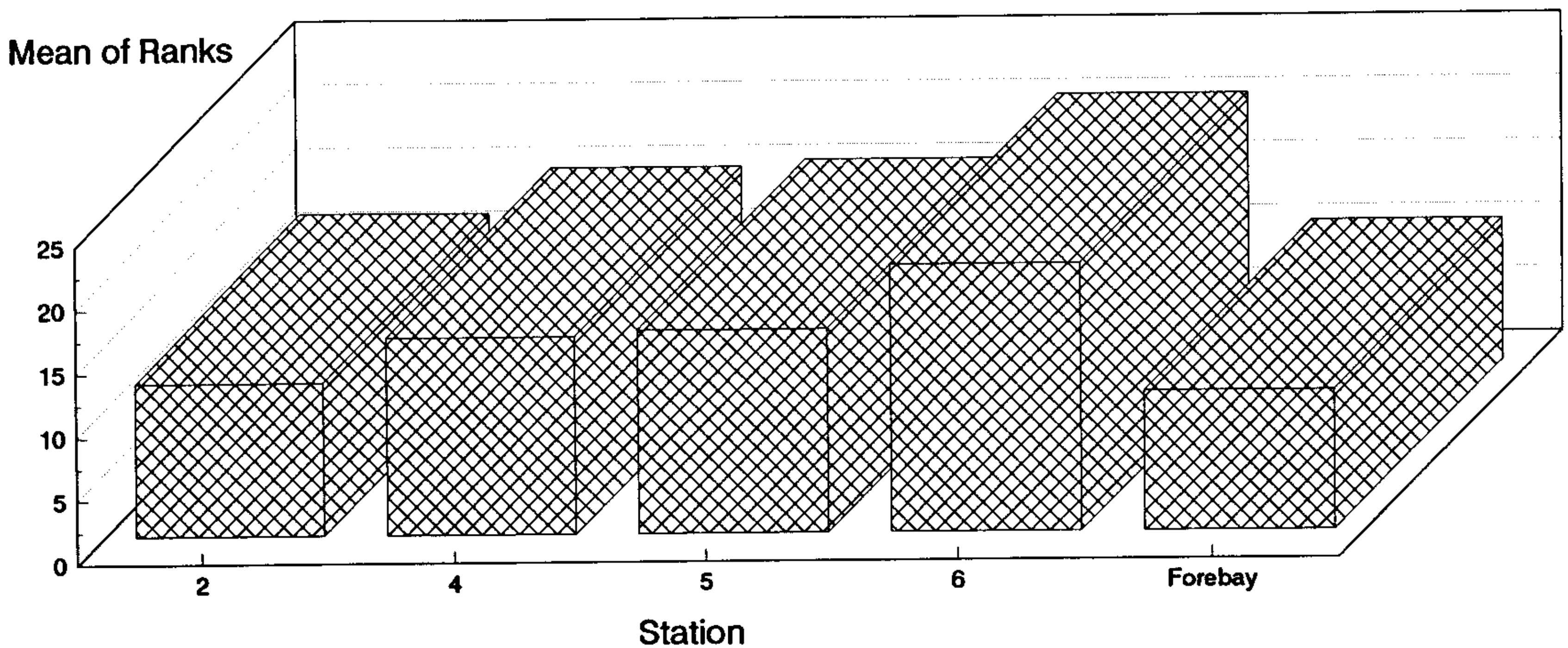
1989-1992

Comparisons of catch/effort for juvenile steelhead by surface trawling from 1989-1992 indicated significant ($P<0.05$) differences among stations and years (Figure 93). Catch/efforts for juvenile steelhead were significantly ($P<0.05$) higher at shallow and mid-depth reference stations 5 and 6 than at shallow and mid-depth disposal stations 2 and 4. Catch/efforts were highest at station 5 and lowest at station 4.

Annual differences in catch/effort for juvenile steelhead by surface trawling during 1989 to 1992 indicated the highest catch/effort occurred during 1992 (Figure 93). Catch/efforts for 1991 and 1992 were significantly ($P<0.05$) higher than those in 1989 and 1990.

DISCUSSION

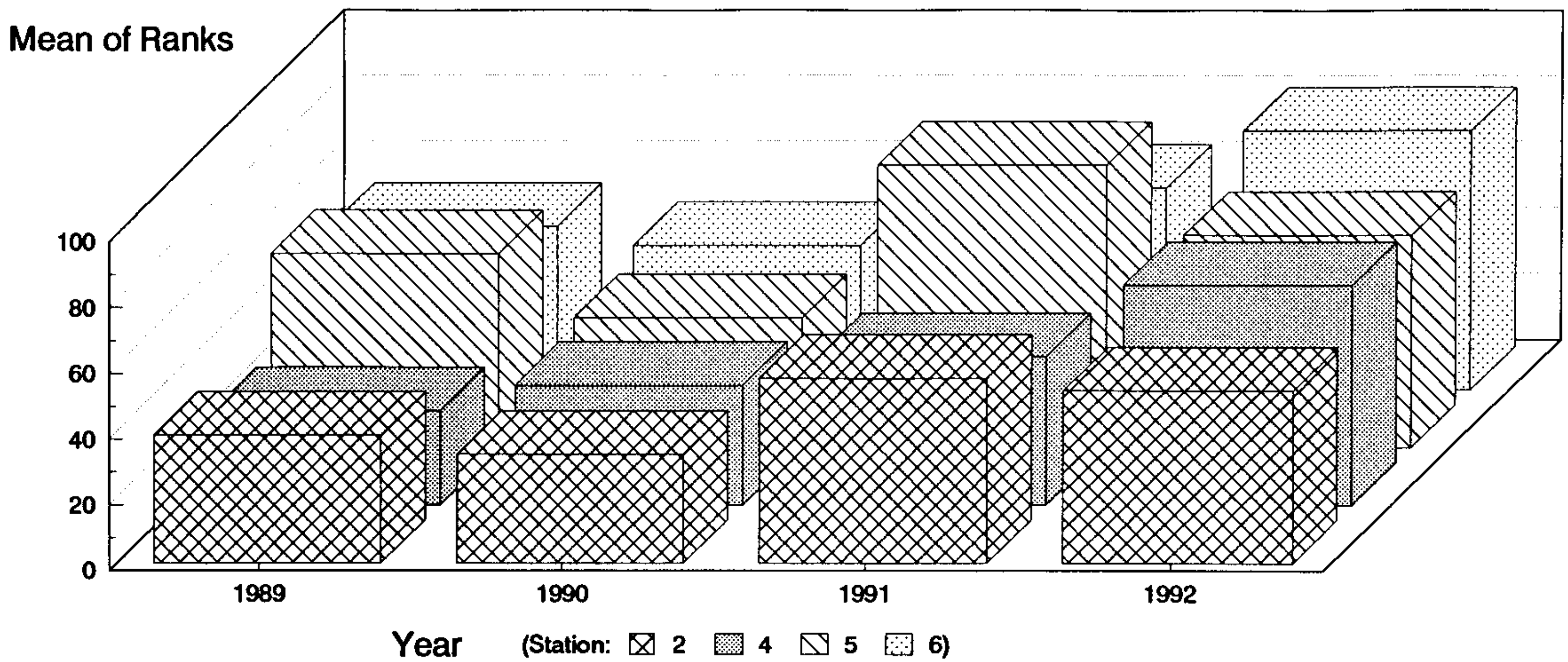
Catches by surface trawling, a technique that samples pelagic abundance, indicated juvenile chinook salmon abundance was generally similar among stations including the forebay area of Lower Granite Dam during 1992. However, overall catch/effort of juvenile chinook salmon by surface trawling since 1989 has been significantly higher at reference stations 5 and 6 than at disposal stations 4 and 2 (Figure 91). Overall catch/efforts of juvenile chinook salmon along the



Station Comparison

6 5 4 2 Forebay

Figure 92. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by surface trawling during 1992 in Lower Granite Reservoir. The horizontal line under the station comparison indicates statistical nonsignificance ($P > 0.05$).



Station Comparison

5 6 2 4

Year Comparison

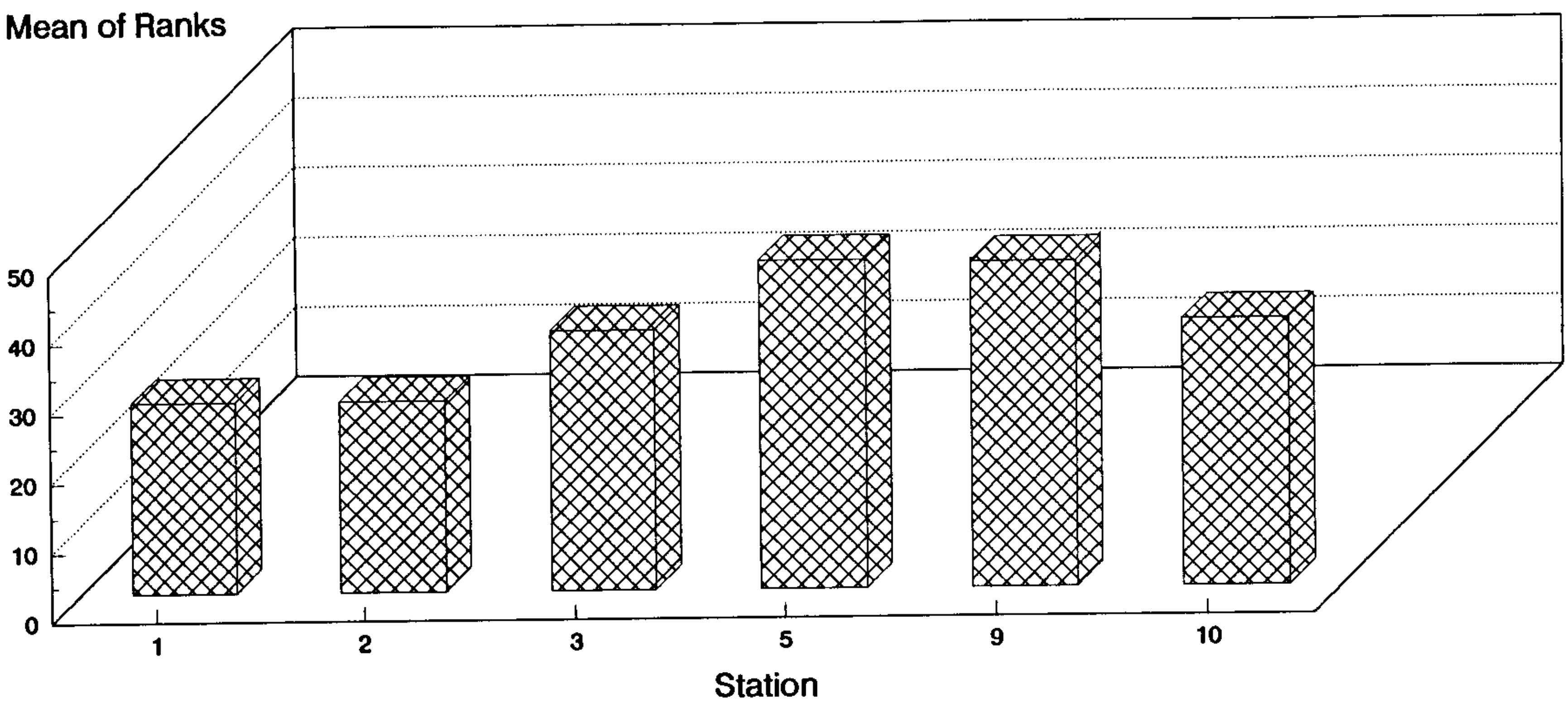
1992 1991 1989 1990

Figure 93. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by surface trawling during 1989-1992 in Lower Granite Reservoir. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

shoreline by beach seining and pelagically by surface trawling was lower in 1992 than in other years (Figures 91 and 94) which may relate to travel time and duration of habitation in Lower Granite Reservoir. Years when juvenile chinook reside longer in the reservoir result in higher catch/effort (Figure 95). Catch/effort for juvenile chinook salmon is higher during years of low flow.

No statistical differences were found in pelagic abundance in 1992 for juvenile steelhead. However, over all catch/effort of juvenile steelhead by surface trawling since 1989 has been significantly higher at shallow and mid-depth reference stations 5 and 6 than at shallow and mid-depth disposal stations 2 and 4. As with juvenile chinook, catch/effort for juvenile steelhead is higher during low flow years or years when flows during the later part of May are reduced and fish are more abundant.

Our data show that the abundance of juvenile steelhead and chinook salmon are statistically lower at disposal stations 2 and 4 than at both the shallow and mid-depth reference stations. These data, in part, should allay concerns that the disposal areas would be overly attractive to juvenile salmonids, especially spring and summer chinook salmon.



Station Comparison

9 5 10 3 1 2

Figure 94. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by beach seining during 1992 in Lower Granite Reservoir. The horizontal line under the station comparison indicates statistical nonsignificance (P > 0.05).

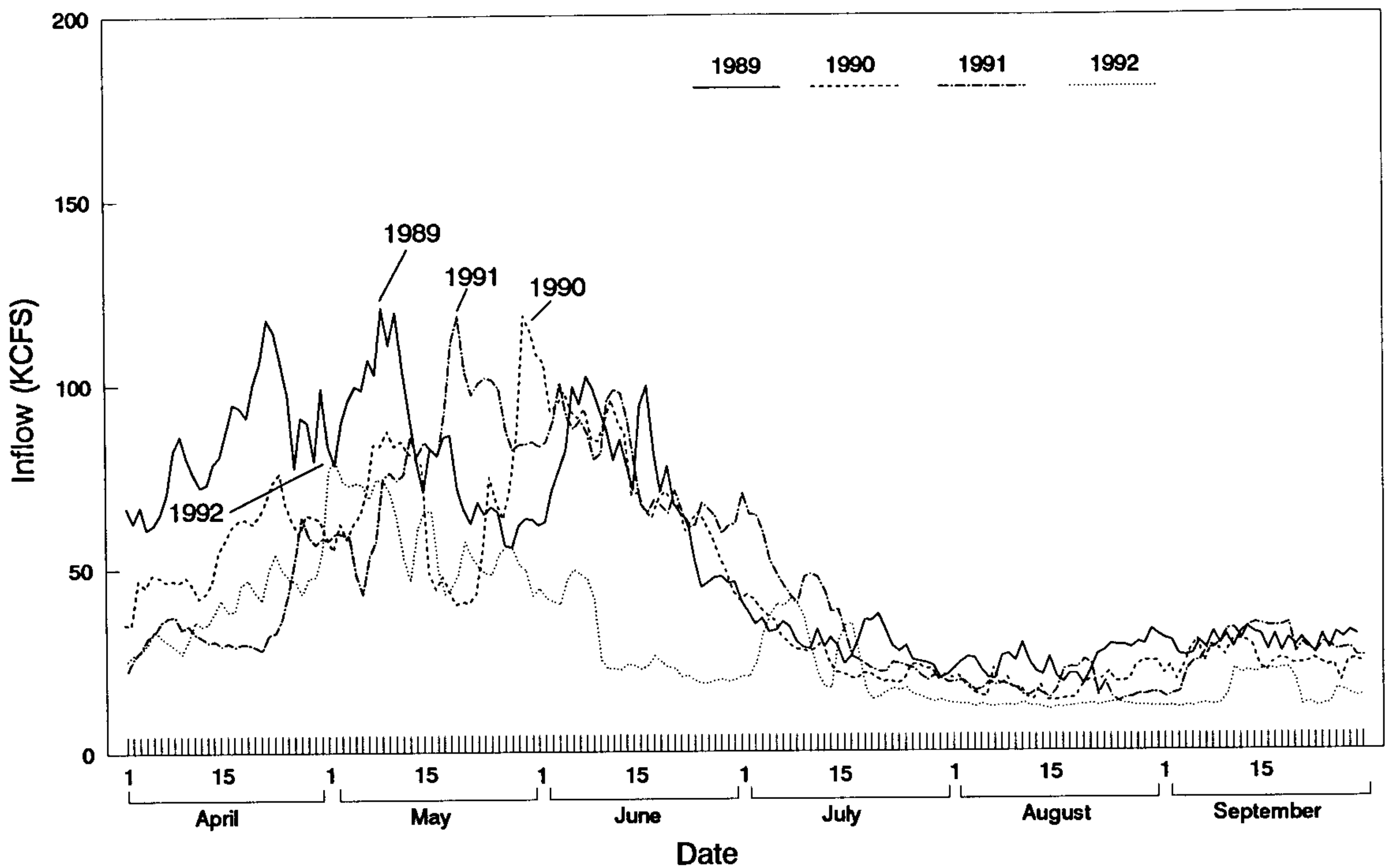


Figure 95. Daily average inflows during 1989, 1990, 1991 and 1992 into LowerGranite Dam.

Objective 4. To assess movements and habitat utilization of white sturgeon in Lower Granite Reservoir with emphasis on the deep water habitat downstream from RM 120.

METHODS

Sampling by gill nets and setlines was conducted for white sturgeon during spring (5 April to 25 June) and fall (1 October to 15 November) 1993 in Lower Granite Reservoir (Figure 2). Nine transects were sampled throughout Lower Granite Reservoir using eight experimental gill nets (1.8 x 61.2 m, 6 ft x 200 ft) with bar mesh ranging in size from 2.5 to 15.0 cm (1 to 5.9 inches). Gill nets were set on the bottom perpendicular to the shoreline. Four nets were fished at the deepest cross section of the main channel and four nets were set adjacent to the main channel typically on bench areas. Gill nets were fished for a total of 6 hours and checked at 3 hour intervals to preclude destructive sampling to all fishes.

Setlines were employed to supplement gill net efforts and reduce potential gear bias and were fished for 48 hours per transect. Setlines consisted of a 122 m (400 ft) mainline (6.3 mm, 0.25 inch, nylon cord) weighted on the bottom. One tuna circle hook was attached every 3 m (9.8 ft) for a total of 24 hooks. Gangen lines were constructed with a stainless steel halibut snap and 4/0 ball bearing swivel attached to 100 to 250 kg test gangen twine. A stainless steel hog ring crimped onto a cadmium-tin, coated circle tuna hook was tied to each gangen line with hooks ranging in size from 16/0, 14/0 and 12/0. Each gangen line measured approximately 60 cm (23.6 in) from mainline to a hook and was rigged onto the mainline in random order. Hooks were primarily baited with Pacific lamprey *Entosphenus tridentatus*, pickled herring and largescale sucker. A 61 m (200 ft) foam-filled rope coupled with an ultrasonic transmitter was attached and submerged with the mainline to facilitate locating the line and to prevent theft and navigation hazards. Setlines were retrieved by locating the sonic transmitter and intercepting the submerged float line with a grapple hook.

All captured sturgeon were measured, weighed, marked and released. Each sturgeon was marked with a passive integrated transponder (P.I.T.) injected into the dorsal musculature midway between the leading edge of the dorsal fin and right lateral row of scutes. An external numbered aluminum lap seal tag was also crimped around the leading right pectoral fin ray for ease of identification. Movement of white sturgeon was assessed by recapturing marked sturgeon and tracking previous capture records.

RESULTS

Approximately 2,329 gill net and 833 setline hours of effort were expended to capture 78 white sturgeon in Lower Granite Reservoir from 5 April to 15 November, 1993. Seventy-six white sturgeon were sampled by gill nets and 2 with setlines. Sampling with gill nets was curtailed on 25 June until 1 October to satisfy ESA concerns over possible mortality to upstream migrating, adult sockeye salmon in the system.

Total lengths of white sturgeon ranged from 19.4 to 156.4 cm with a mean total length of 63.1 cm (Figure 96). Approximately 96% of the sturgeon sampled were < 122 cm. No sturgeon > 168 cm were sampled in Lower Granite Reservoir during 1993.

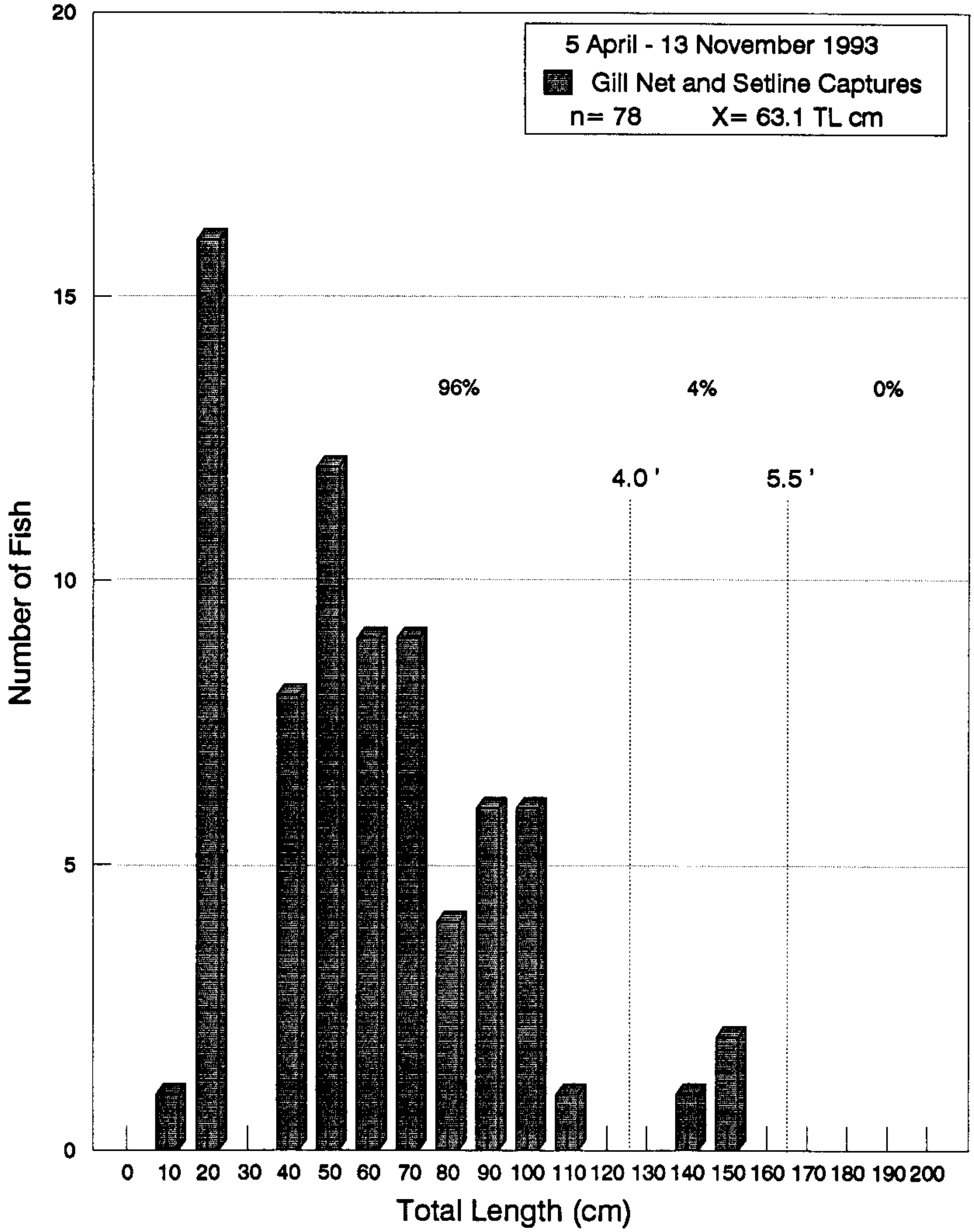


Figure 96. Length distributions of white sturgeon sampled during spring and fall sampling seasons during 1993 in Lower Granite Reservoir. TL indicates total length.

Approximately 68% of all sturgeon (n=54) collected were located in the upper portion of Lower Granite Reservoir between RM 127.0 and RM 137.1 (Figure 97). No sturgeon were sampled at RM 113.0, 119.9 and 137.1 during spring.

Transects at RM 127.0 and RM 133.7 had the highest catch/efforts (0.04 and 0.014, respectively) during the spring sampling interval (Figure 98). Catch/efforts for sturgeon at other transects were low and similar during spring. Due to high flows in the upriver portions of the reservoir, less effort was expended at transects at RM 127.0, RM 133.7 and RM 137.1. Catch/efforts during the fall ranged from 0.0 (RM 113.7) to 0.21 (RM 133.7). The highest catch/effort was at RM 133.7 (0.21) followed by RM 137.1 (0.06) and RM 127.0 (0.06; Figure 98).

Sturgeon were collected at depths ranging from 9 to 36.8 m (29.5-120 ft) with a mean depth of 21 m (69 ft; Figure 99). Modal captures of white sturgeon were at 24 m (79 ft). Depths of main channel areas sampled by experimental gill nets and setlines for white sturgeon between RM 108.0 and RM 137.1 ranged from 18 to 36.8 m (60-120 ft) with adjacent bench areas typically ranging from 9 to 17 m (29.5-55.7 ft) deep. White sturgeon captures were significantly higher ($P < 0.05$) in main channel areas at RM 108.0, 110.5, 117.7 and 127.0 than bench areas (Figure 100). Sixteen (20%) of the 79 sturgeon collected were sampled on bench areas adjacent to the main channel.

Statistical comparisons of white sturgeon captures by gill netting, based on mean of rank and river mile, indicate catch/effort was significantly ($P<0.05$) higher at RM 133.7 than other transects (Figure

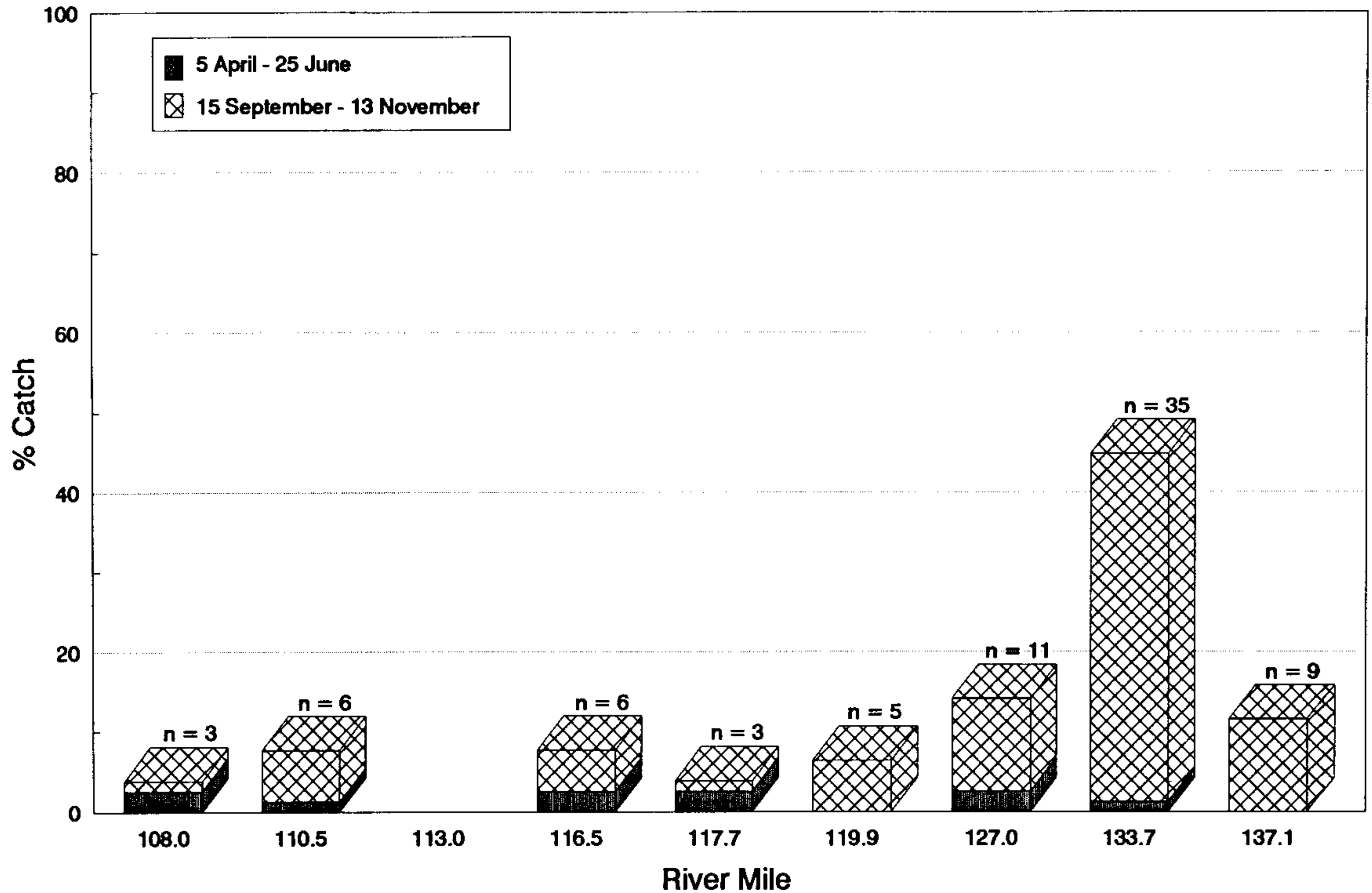


Figure 97. Percent catch of white sturgeon sampled by gill netting and set lines in spring and fall seasons during 1994 between river miles 108.0 and 137.1 in Lower Granite Reservoir.

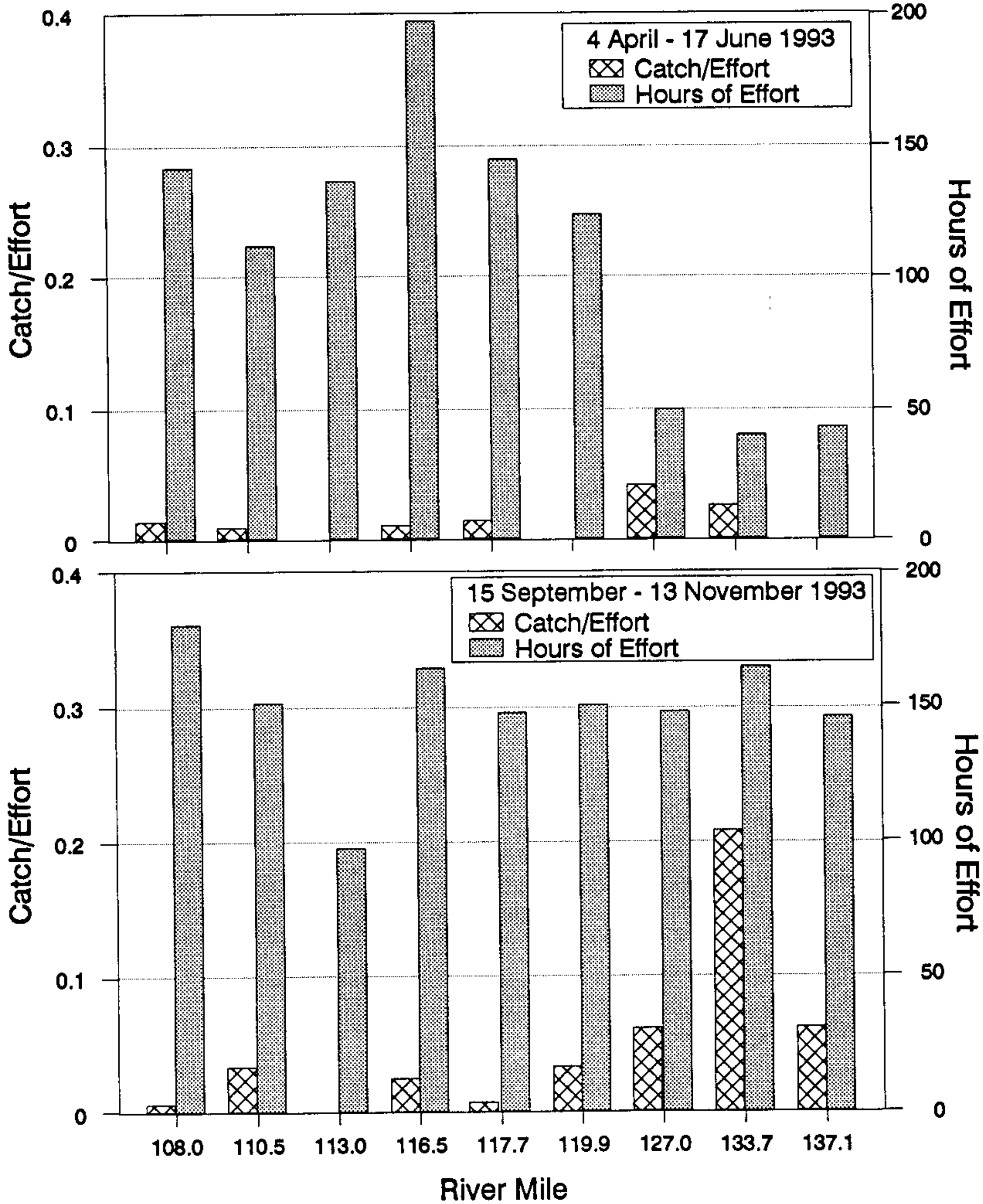


Figure 98. Comparisons of catch/effort for white sturgeon sampled during spring and fall seasons, 1993 in Lower Granite Reservoir.

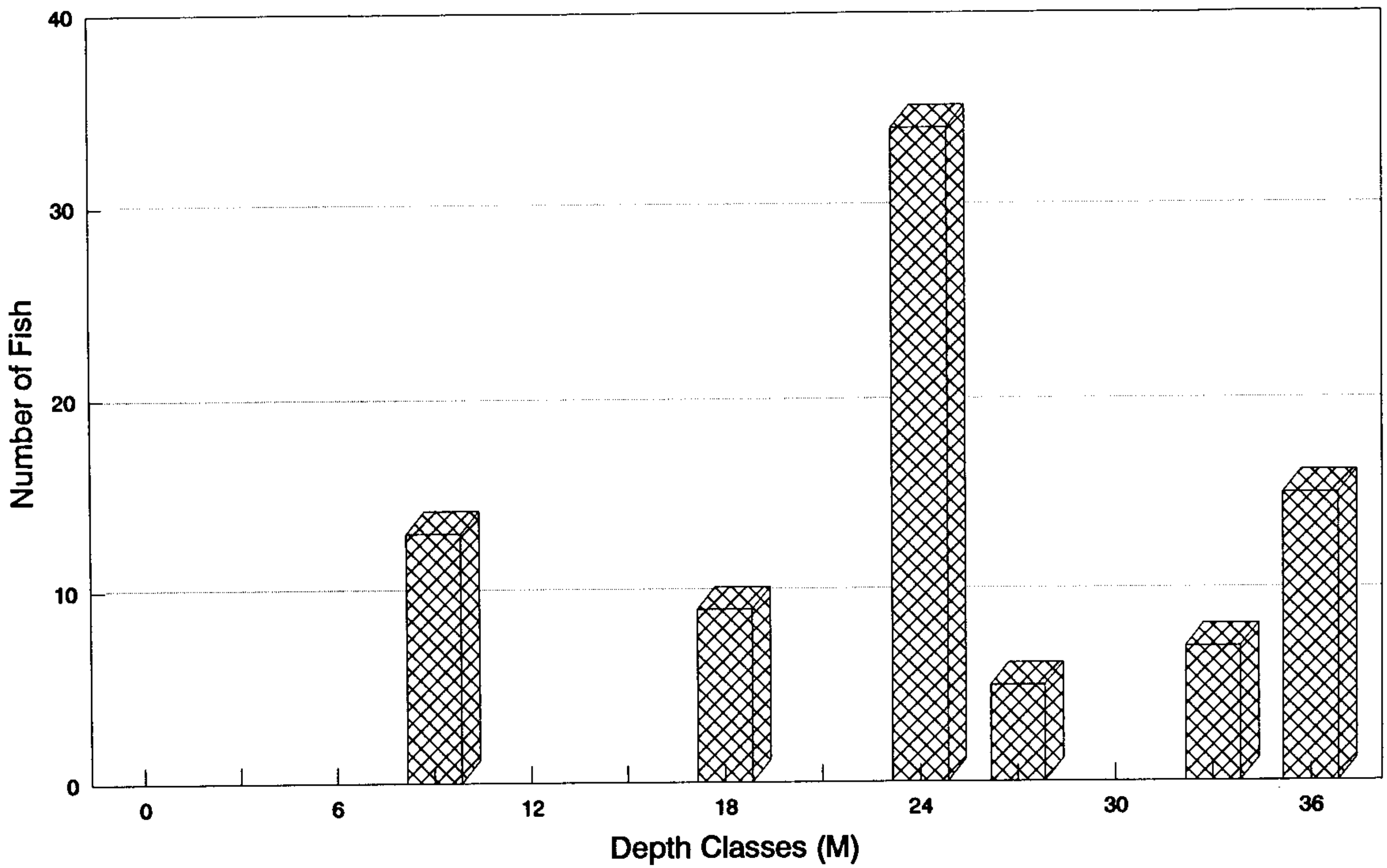


Figure 99. Relationship between depth and number of white sturgeon sampled during 1993 in Lower Granite Reservoir.

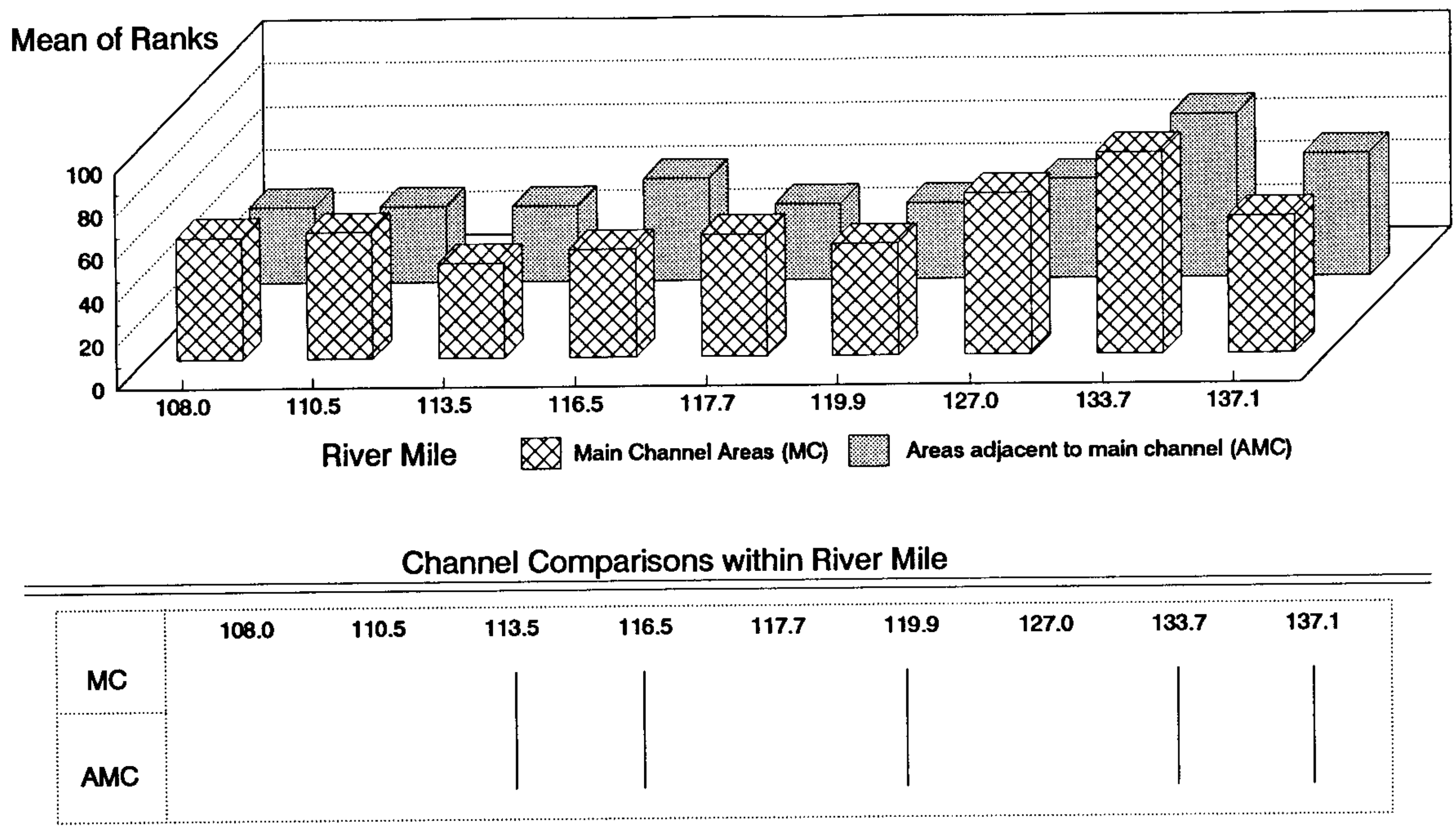


Figure 100. Graphical and statistical comparisons of mean of ranks for white sturgeon abundance sampled in main channel areas (MC) and areas adjacent to the main channel (AMC) during 1993 in Lower Granite Reservoir. Vertical lines under the channel comparison indicate statistical nonsignificance ($P > 0.05$).

101). Catch/efforts were nonsignificant (P>0.5) between other transects with the exception of RM 113.5, which was significantly (P<0.05) lower than RM 137.1 and RM 127.0.

We have found few changes in the abundance of white sturgeon in 1990 and 1993 based on comparisons of catch/effort at various transects. Catch/effort for white sturgeon has been relatively low at RM 108 and 113.7 and not statistically different between 1993 and 1990 (Figure 102). We also did not see spatial differences in catch/effort within both 1990 and 1993. Few statistical differences in catch/effort were found for white sturgeon among years 1990 through 1993 (Figure 103). The highest catch/efforts occurred at RM 133.7 and differences in abundance between years 1990 and 1993 were not significant. Ranked order of catch/effort have been generally similar within the years of 1990 to 1993.

Few seasonal differences in catch/effort for white sturgeon were observed within transects sampled (Figure 104). The only significant (P<0.05) difference in seasonal catch/effort was found at RM 116.5 from 1990 to 1993. No other significant seasonal differences in catch/effort were found at the transects sampled.

A significant year*season interaction occurred among catch/efforts of white sturgeon (Figure 105). Differences in catch/effort for white sturgeon within spring between the years 1990 to 1992 and 1993 were significant. This difference was not significant for the fall season and none of the seasonal differences in catch/effort within years was significant.

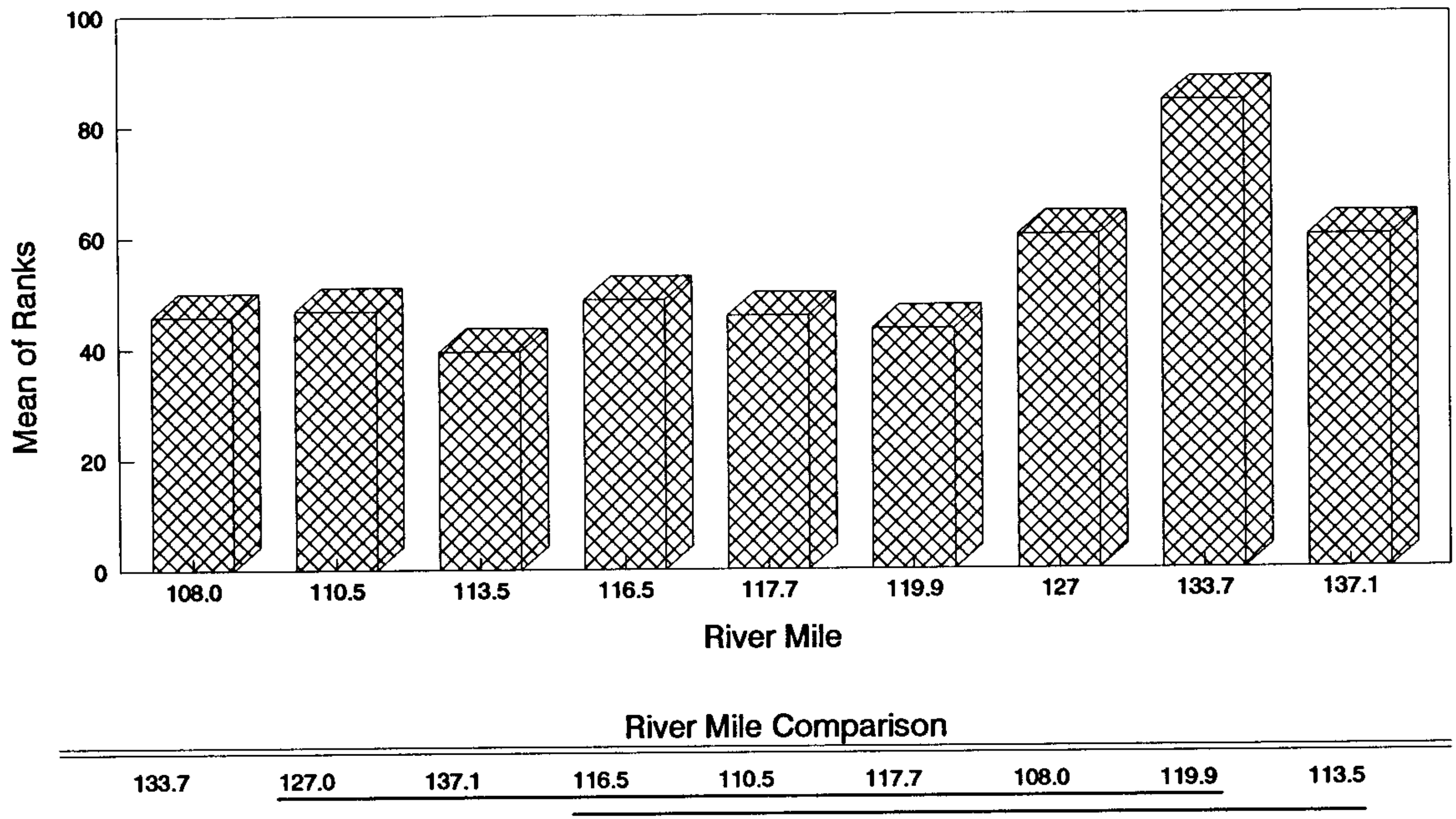
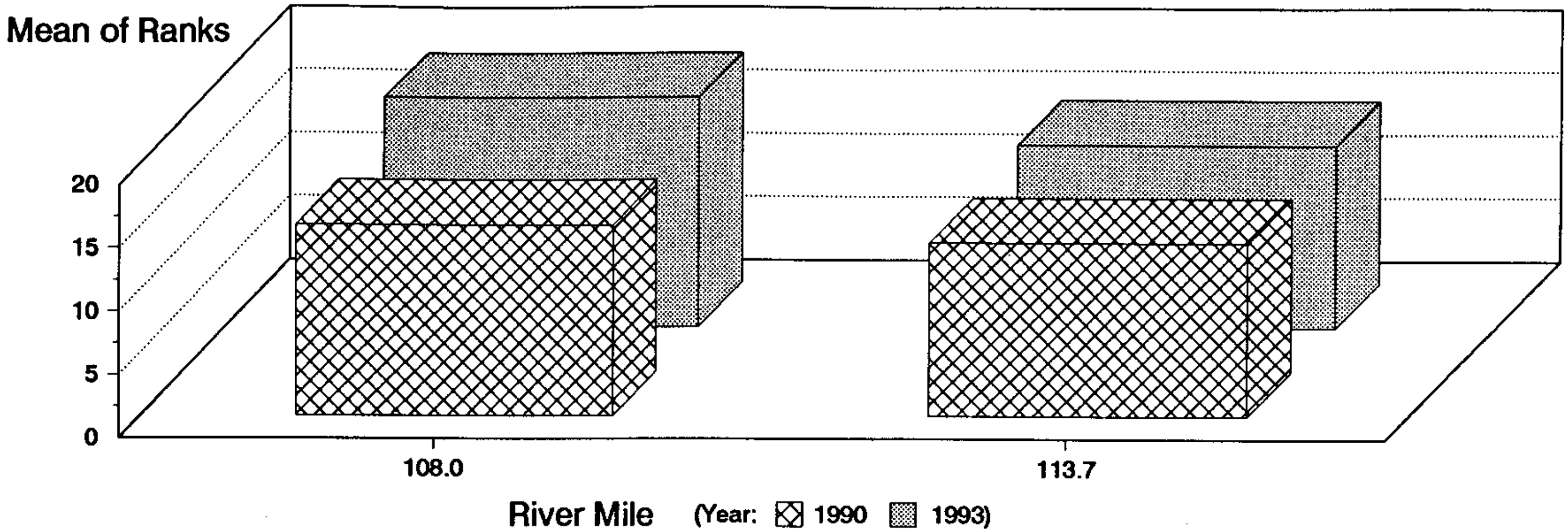


Figure 101. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance during 1993. Horizontal lines under the river mile comparison indicate statistical nonsignificance ($P > 0.05$).



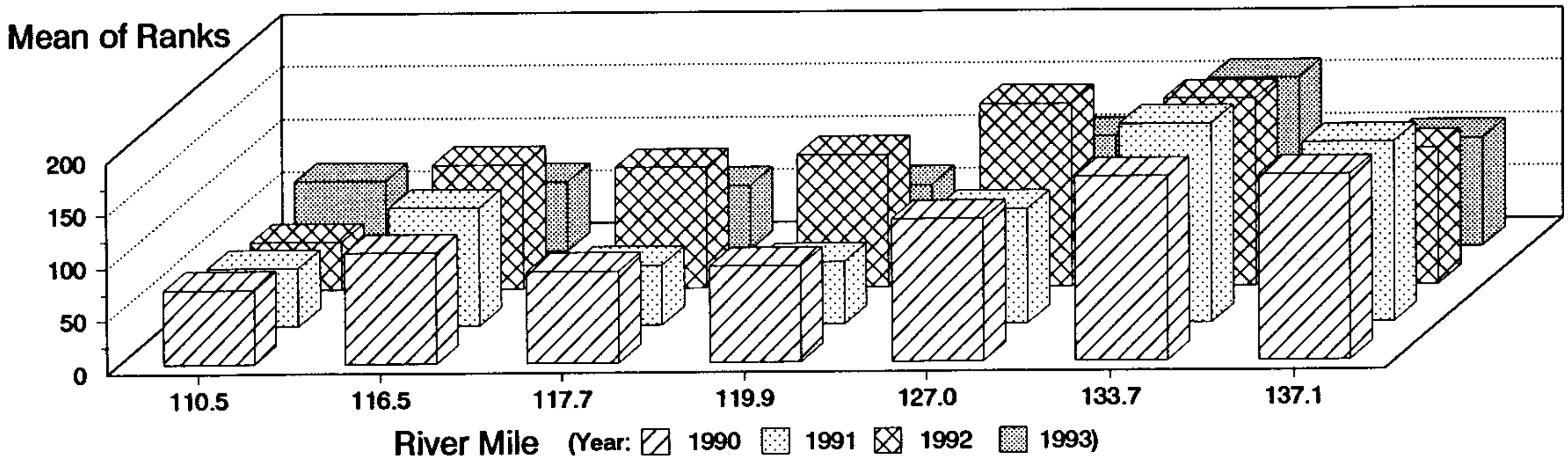
River Mile Comparison

108.0	113.7
1993 1990	1993 1990

Year Comparison

1990	1993
108.0 113.7	108.0 113.7

Figure 102. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled during 1990 and 1993 in Lower Granite Reservoir. Horizontal lines under river mile and year comparisons indicate statistical nonsignificance ($P > 0.05$).



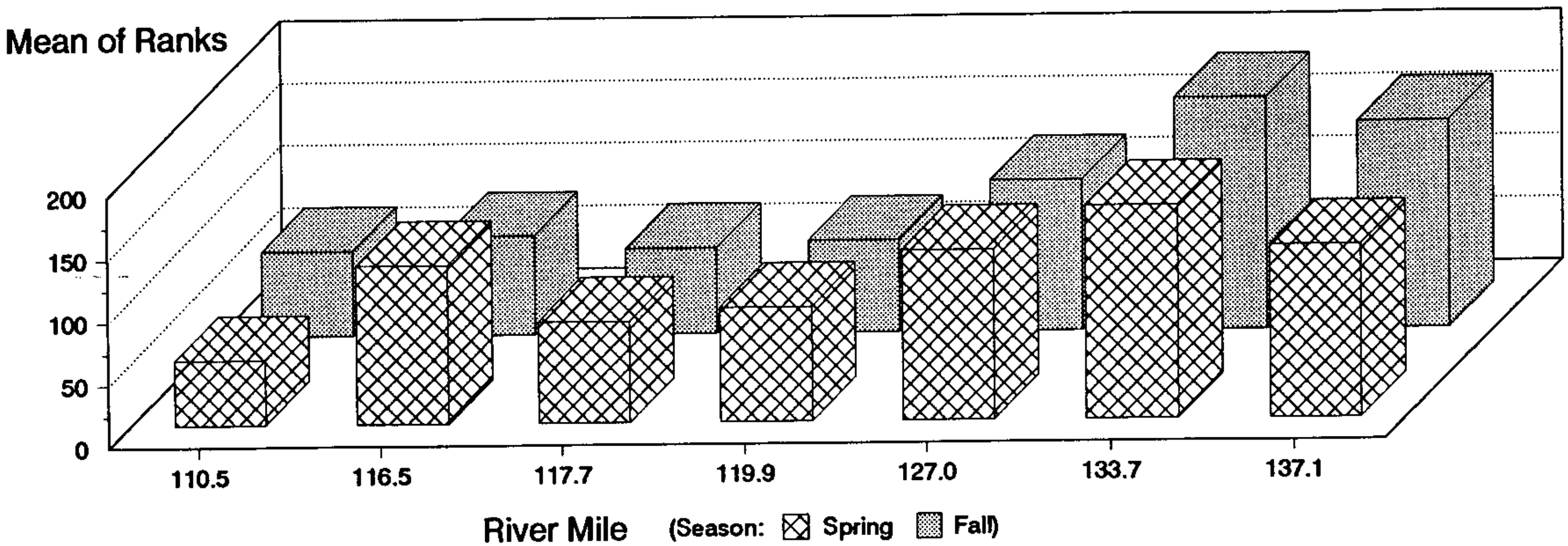
River Mile Comparison

110.5	116.5	117.7	119.9	127.0	133.7	137.1
1990	1992	1992	1992	1992	1991	1990
1993	1991	1990	1990	1990	1992	1991
1991	1990	1993	1993	1991	1990	1992
1992	1993	1991	1991	1993	1993	1993

Year Comparison

1990	1991	1992	1993
137.1	133.7	133.7	133.7
133.7	137.1	127.0	127.0
127.0	116.5	137.1	137.1
116.5	127.0	119.9	110.5
119.9	119.9	117.7	116.5
117.7	117.7	116.5	117.7
110.5	110.5	110.5	119.9

Figure 103. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled during 1990-1993 in Lower Granite Reservoir. Vertical lines beside river mile and year comparisons indicatate statistical nonsignificance (P > 0.05).



River Mile Comparison

Spring

133.7 137.1 127.0 116.5 119.9 117.7 110.5

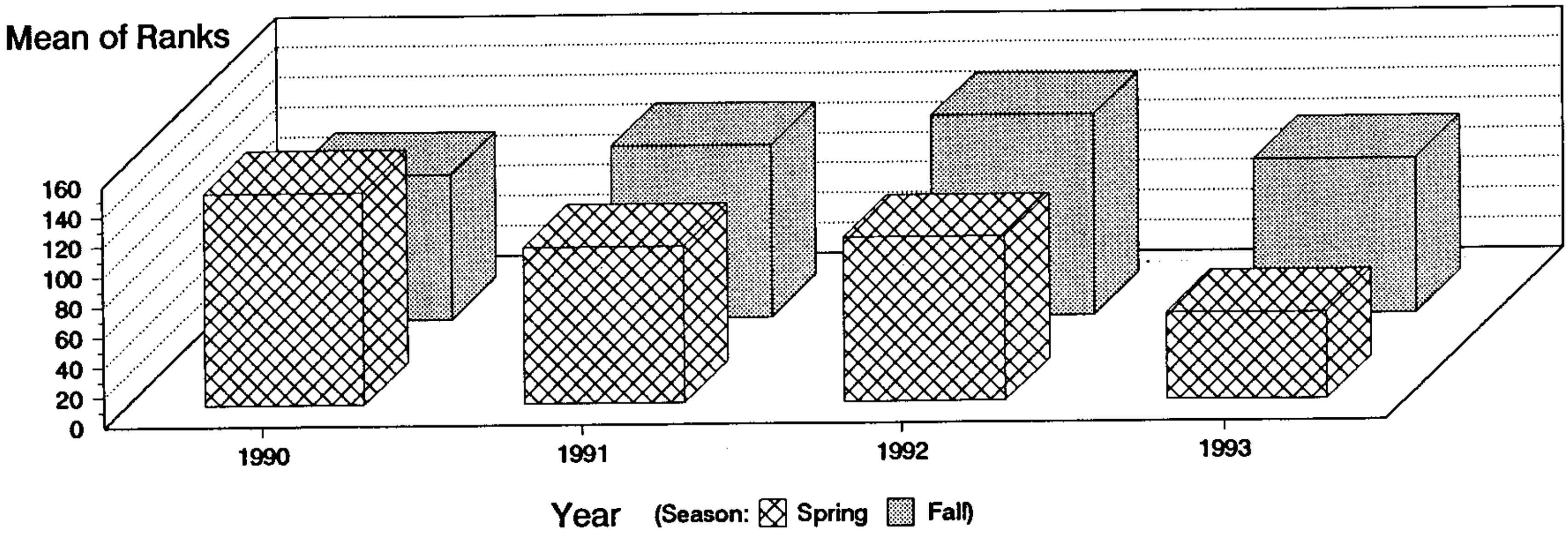
Fall

133.7 137.1 127.0 116.5 119.9 117.7 110.5

Season Comparison

110.5	116.5	117.7	119.9	127.0	133.7	137.1
Fall Spring	Spring Fall	Spring Fall	Spring Fall	Spring Fall	Fall Spring	Fall Spring

Figure 104. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled during 1990-1993 in Lower Granite Reservoir. Horizontal lines under river mile and season comparisons indicate statistical nonsignificance (P > 0.05).



Year Comparison

1990	1991	1992	1993
Spring Fall	Fall Spring	Fall Spring	Fall Spring

Season Comparison

Spring

1990 1992 1991 1993

Fall

1992 1991 1993 1990

Figure 105. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled during 1990-1993 in Lower Granite Reservoir. Horizontal lines under year and season comparisons indicate statistical nonsignificance ($P > 0.05$).

A total of nine white sturgeon was recaptured from 5 April to 13 November, 1993. Of these nine fish, only one had retained it's metal tag allowing us to identify the original capture site at RM 119.9 on 1 October 1991. The eight other white sturgeon showed signs of tag loss (metal tag and spaghetti tag scars) and were tagged in our earlier sampling efforts (Lepla 1994) prior to PIT tags use (Bennett et al. 1990, 1991).

No population estimate was calculated for 1993 due to low numbers of white sturgeon sampled.

DISCUSSION

Although we found few differences in catch/effort among years, substantially fewer sturgeon (78) were collected during 1993 compared to other years. Several reasons accounted for the low catch of sturgeon in 1993. One reason was the higher flows in 1993 compared to 1992 and in-part to 1990 and 1991. Higher flows precluded us from sampling in the upstream portions of Lower Granite Reservoir because of the high velocities that occur with higher flows. For example, no sturgeon were collected in the spring of 1993 at RM 137.1. Although high velocities reduced the window for sampling sturgeon in the upstream areas, 68% (n=54) of all sturgeon collected were sampled between RM 127 and RM 137.1. Also, sampling was curtailed from June 25 to October 1, 1993 to satisfy ESA concerns over causing possible mortality with gill nets to endangered sockeye salmon.

Depths at which white sturgeon were collected in 1993 was similar to previous years. Lepla (1994) reported that catch rates for white sturgeon in 1990 to 1992 were highest at depths of 18 to 22 m. The highest number of sturgeon collected in 1993 was in the 24 to 27 m class and lengths ranged from 9 to 36 m, similar to lengths sampled in 1991 through 1992 which ranged from 6.1 to 39.6 m. High catch/effort of white sturgeon occurred in the upper portion of Lower Granite Reservoir which is more shallow and has higher flows than the lower portion of the reservoir. However, during 1993 few sturgeon were sampled in the upper areas due to flows and those that were collected in these areas were caught in deeper waters than previous years.

Size composition of sturgeon sampled in 1993 was similar to those collected during other years. We have typically found the majority of white sturgeon collected in Lower Granite Reservoir are < 1.2 m (<4 ft) long. In 1993, 96% of the 78 sturgeon collected were < 1.2 m. Lepla (1994) reported an average length for 778 white sturgeon collected by gill net in Lower Granite Reservoir was 62.3 cm (24.5 inches) compared to 63.1 cm (24.8 inches) collected in 1993.

Movement information was not collected in 1993 because of tag loss and the limited number of recaptures (n=9). Most recaptured sturgeon lost their metal tags. Passive integrated transponder tags were not used until the last few years and the recaptures made in 1993 showed signs of either metal or spaghetti tag loss.

Objective 5. To assess subyearling chinook salmon abundance and habitat utilization at disposal and reference sites in Lower Granite Reservoir.

METHODS

To assess subyearling chinook salmon abundance in Lower Granite Reservoir, we conducted surveys throughout the reservoir during April, May, June and July, 1993. Limited information on subyearling chinook abundance was collected under Objective 1 as few subyearling chinook salmon were collected at the disposal and reference stations. Lower Granite Reservoir was stratified into habitat types based on shoreline characteristics (rip rap, sand, talus, etc.) and location in the reservoir. Each stratum was beach seined using methods similar to those employed under Objective 1 for juvenile predator sampling. Macrohabitat characteristics (depth, gradient, substrate and cover) associated with abundance of subyearling chinook salmon were determined at each sampling location. Frequent sampling in areas of concentration enabled us to estimate growth and abundance of subyearling chinook salmon during their residence in Lower Granite Reservoir.

RESULTS

A total of 331 subyearling chinook salmon was captured by daytime beach seining between 10 April and 15 July, 1993 in Lower Granite Reservoir. No subyearling chinook salmon were collected along the shoreline after 15 July (Figures 106 and 107).

The estimated population size of subyearling chinook salmon along the shoreline in Lower Granite Reservoir peaked on 2 June, 1993 at 6,346

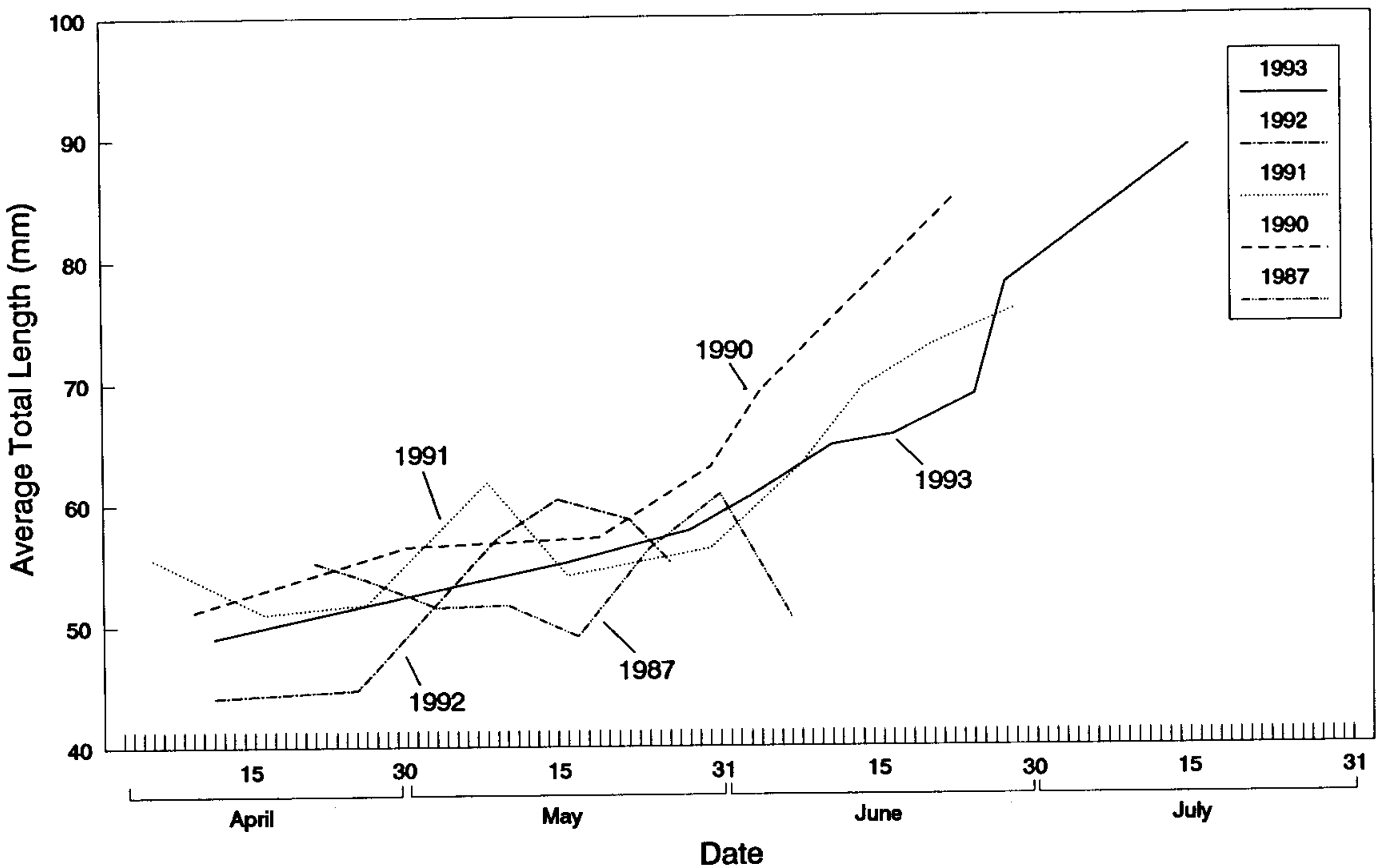


Figure 106. Average total length of subyearling chinook salmon sampled during 1987, 1990, 1991, 1992 and 1993 in Lower Granite Reservoir.

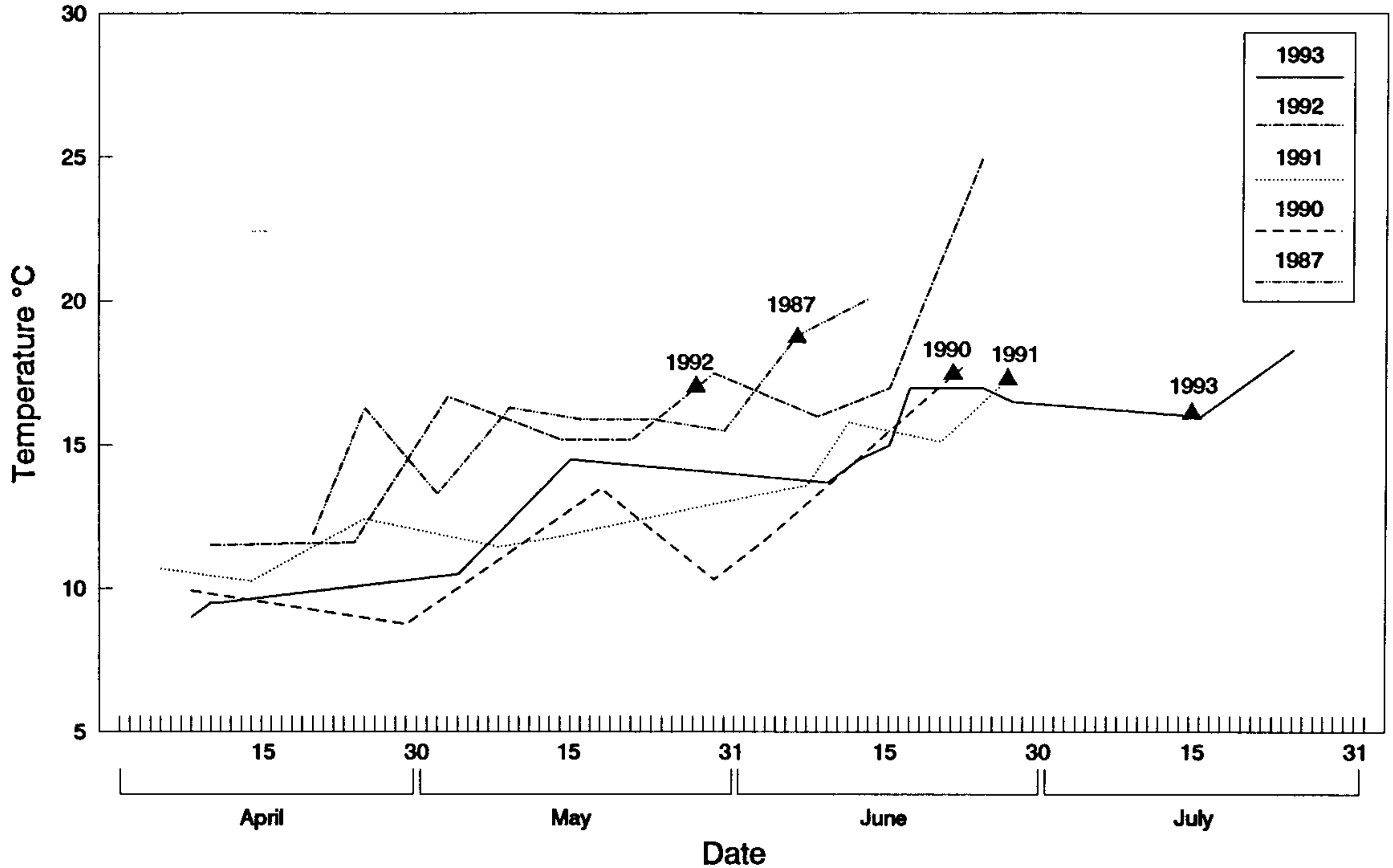


Figure 107. Mean shoreline temperatures during 1987, 1990, 1991, 1992 and 1993 in Lower Granite Reservoir. Dates and marks indicate the disappearence of subyearling chinook salmon from littoral areas.

fish (Figure 108). Numbers before and after 2 June were considerably lower. Peak catches along the shoreline of subyearling chinook salmon in 1993 did not correspond to the estimated peak population. The highest catch/effort by beach seining in 1993 occurred on 17 June (Figure 109). In comparison, peak catches in 1990 and 1991 occurred on 3 June and 29 May, respectively and 16 May, 1992.

Two hundred and ten subyearling chinook salmon (83.5%) were captured over substrates that consisted of > 75% fines (< 2 mm in diameter; Figure 110). Subyearling chinook salmon collected throughout Lower Granite Reservoir were associated with either sand (84%), sand/talus (6%), sand/cobble (5%), or rip-rap (5.5%). Subyearling chinook were collected over rip-rap only on 2 June, 1993, coinciding with the highest population estimate.

Densities of subyearling chinook salmon collected from Lower Granite Reservoir during 1990 through 1993 by beach seining were spatially compared using the Jacobs Utilization Index (Figure 111). Subyearling chinook salmon rearing along the shoreline of Lower Granite Reservoir exhibited a strong preference for sand substrate for years 1990 through 1993. During spring 1993, subyearling chinook showed an avoidance of cobble/sand and talus/sand, although less than in other years.

Mean total length of subyearling chinook salmon from mid-April to mid-July increased nearly linearly during spring 1993 (Figure 112). In mid-April, fish averaged approximately 50 mm and by mid-July mean size increased to approximately 90 mm. Growth rates averaged < 1 mm/day.

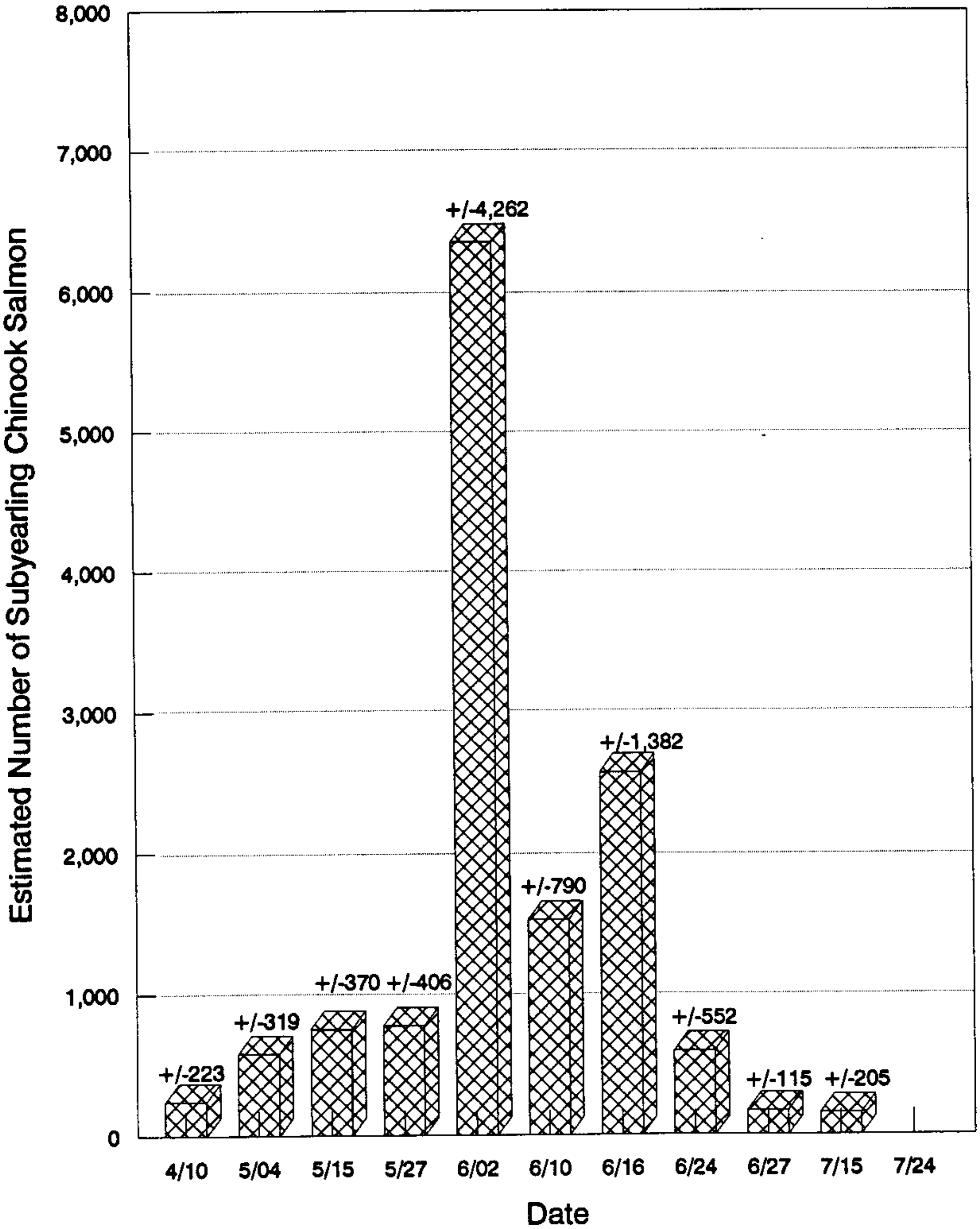


Figure 108. Population estimates of subyearling chinook salmon by date using stratified random samples during 1993 in Lower Granite Reservoir.

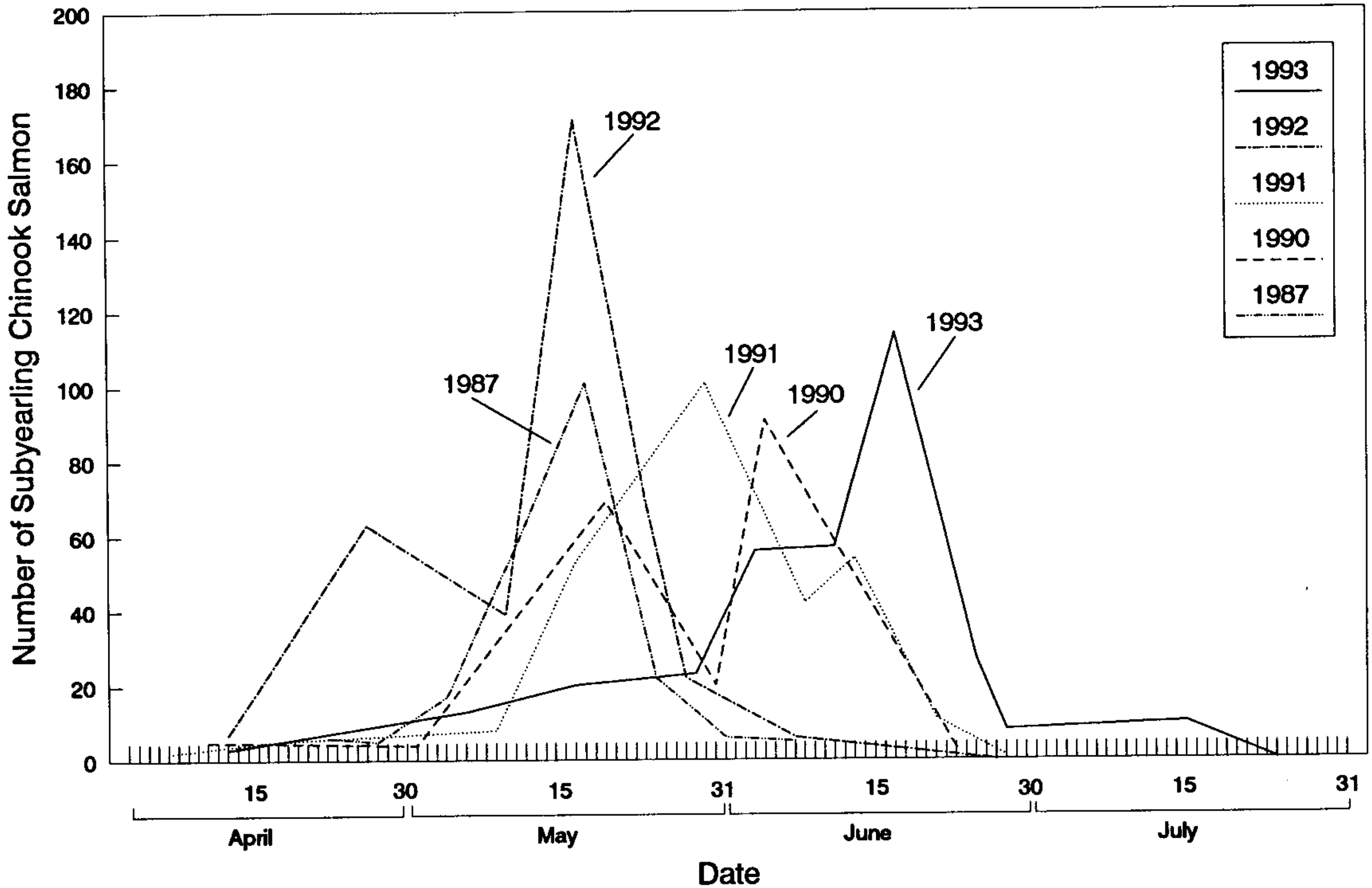


Figure 109. Annual comparisons of shoreline abundance of subyearling chinook salmon sampled during 1987, 1990, 1991, 1992 and 1993 in Lower Granite Reservoir.

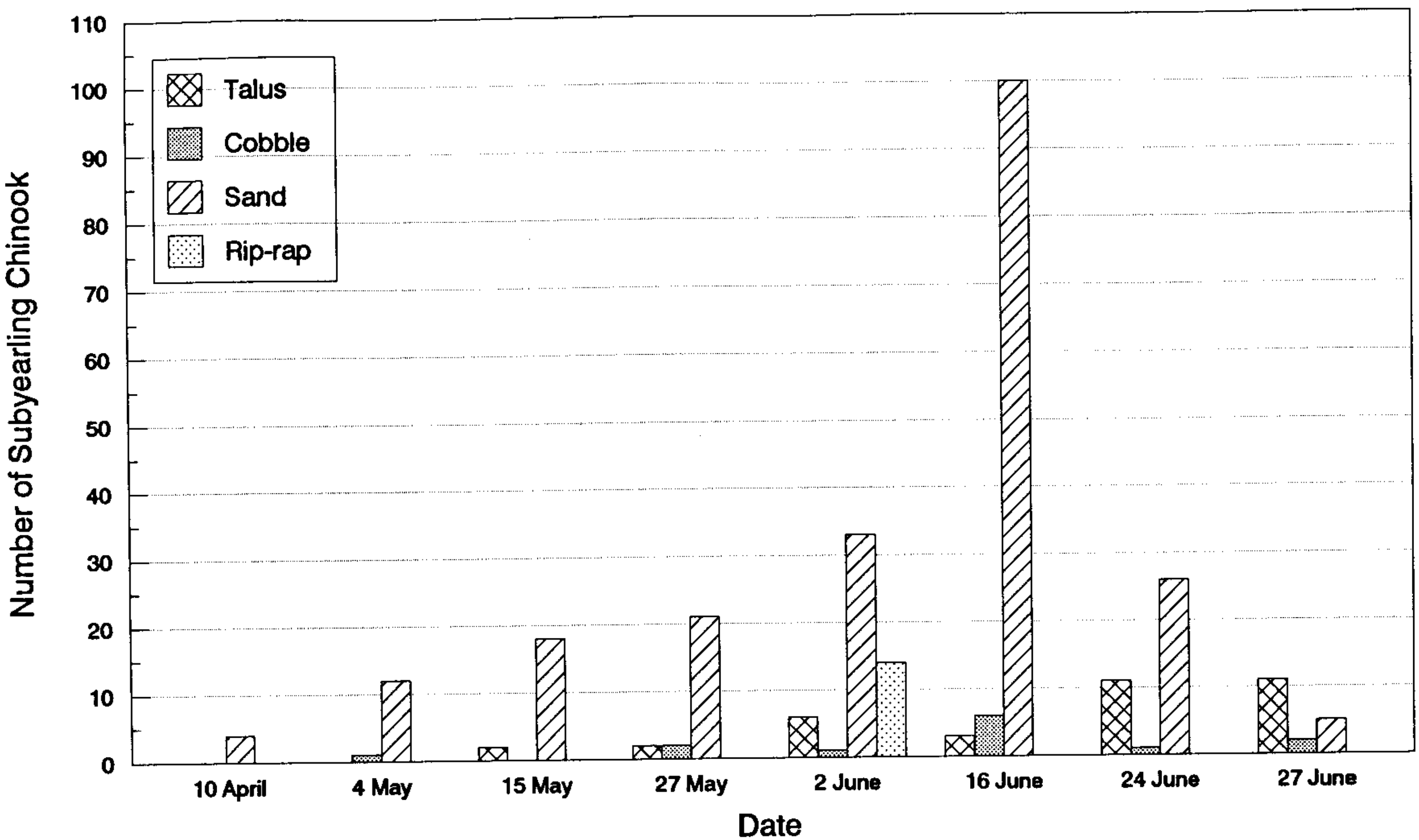


Figure 110. Habitat use and number of subyearling chinook salmon sampled by beach seining during 1993 in Lower Granite Reservoir.

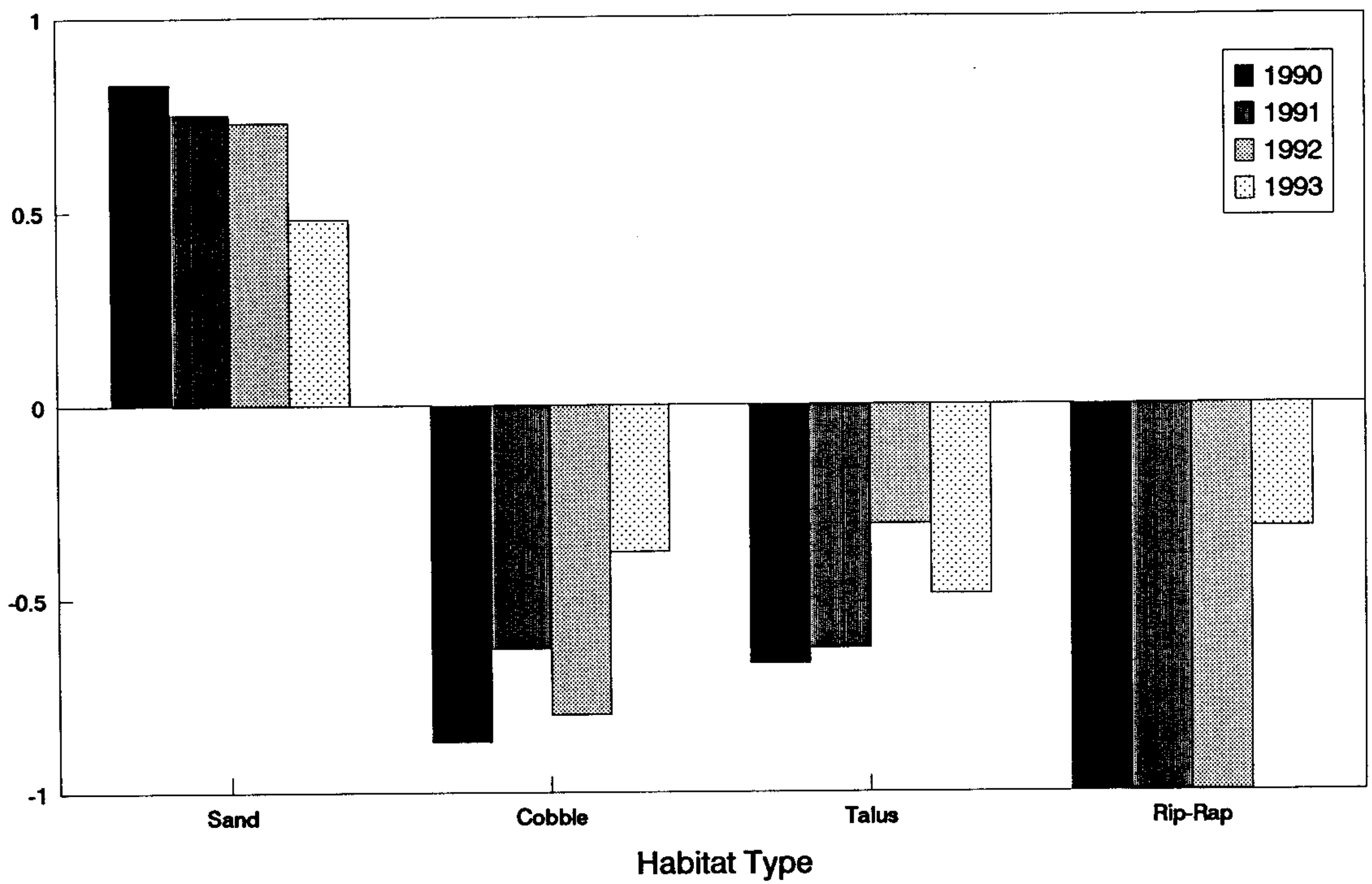


Figure 111. Substrate selected by subyearling chinook salmon during 1990, 1991, 1992 and 1993 in Lower Granite Reservoir as determined by Jacobs Utilization Index.

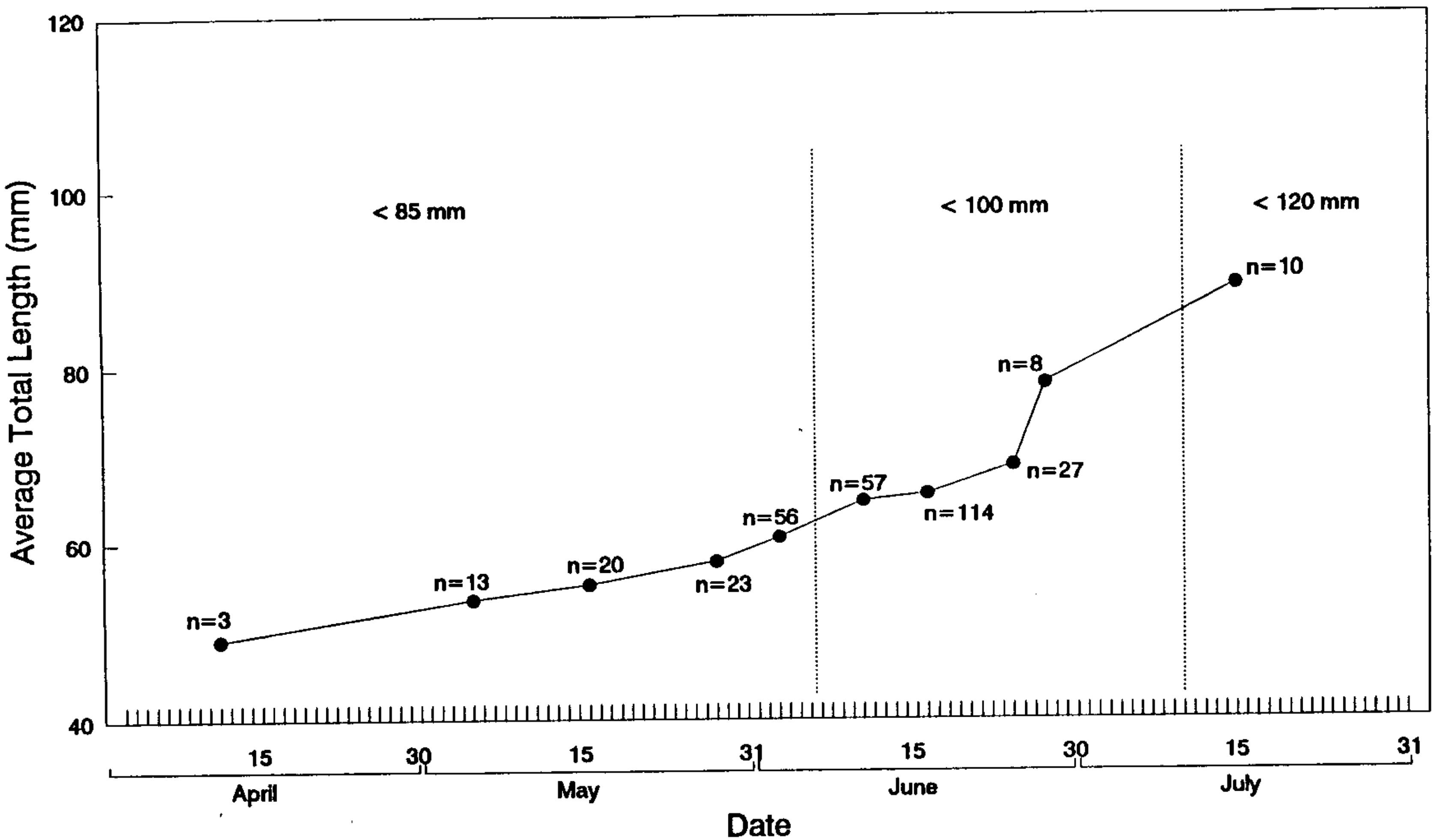


Figure 112. Mean total length of subyearling chinook salmon sampled from mid-April to mid-July, 1993 in Lower Granite Reservoir.

The overall rearing period of subyearling chinook salmon in Lower Granite Reservoir during 1993 was 100 days compared to 75 days in 1992 and 112 days in 1991 (Figure 113). Littoral rearing of subyearling chinook was 96 days in 1993, considerably longer than 1991 and 1992. Subyearlings migrated from the shoreline at approximately 16°C in 1993.

DISCUSSION

A number of differences were found in the temporal and spatial distribution and abundance of subyearling chinook salmon in 1993. The estimated abundance of subyearling chinook salmon was highest (6,346) in 1993 of all years sampled. Estimated abundance along the shoreline in previous years averaged about 4,500 subyearling chinook.

Also interesting in 1993 was that peak catches differed among years. During 1987 and 1992, two similar low flow years, peak abundance occurred on 16 May. During 1993, one of the higher flow years in recent years, peak abundance occurred on 17 June. Comparison of temperatures during 1987, 1990, 1991, 1992 and 1993 indicate subyearlings migrate from the shoreline once shoreline temperatures approach and remain above 18°C. In 1993, that migration occurred at approximately 16°C. Shoreline residence during these years is related directly to water temperature and flows. Higher flows, as in 1993, result in lower water temperatures that increases the shoreline rearing period of subyearling chinook salmon.

Although shoreline rearing duration varies with flow year, the total time in Lower Granite seems to be similar among years. Relating

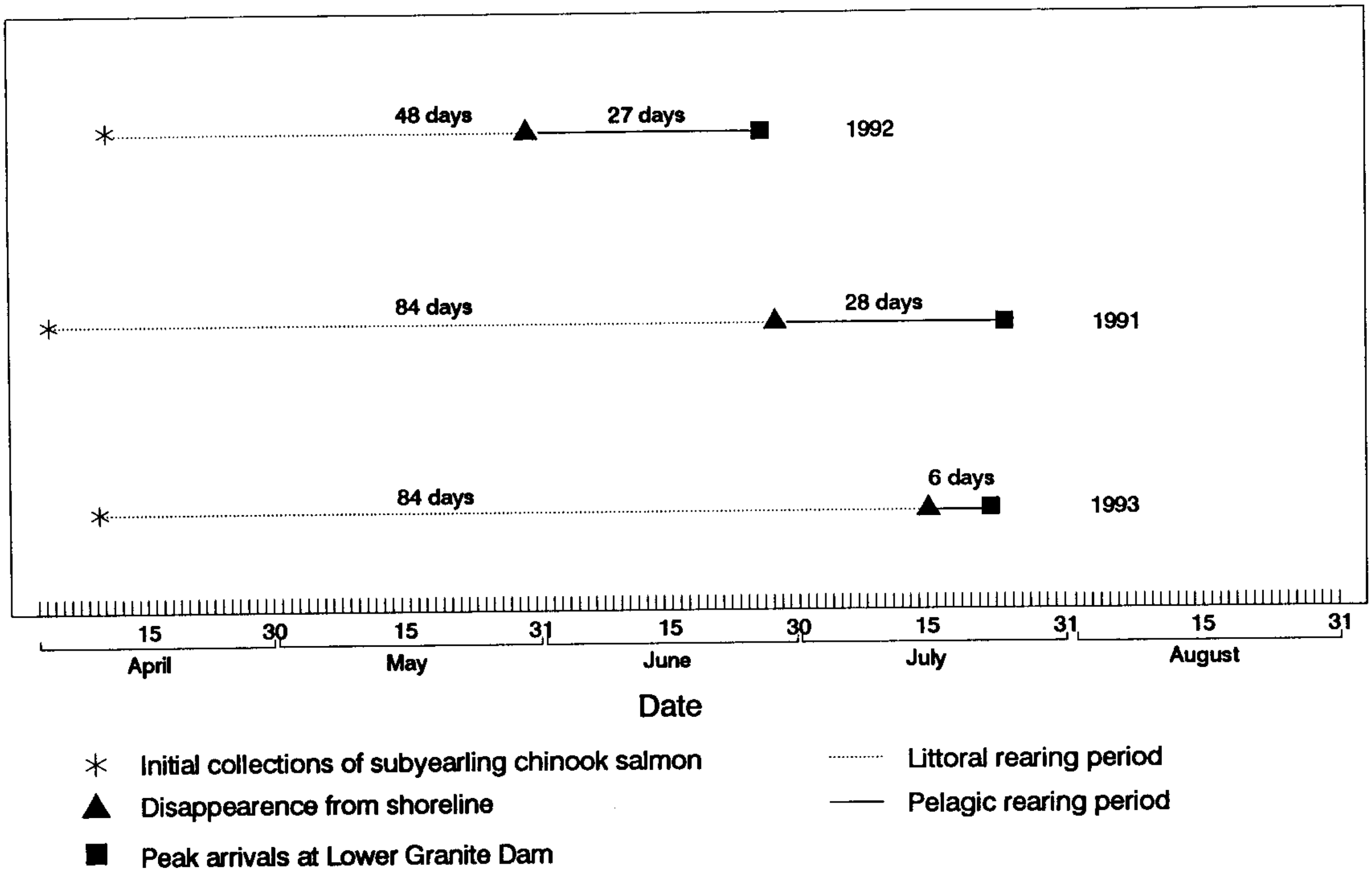


Figure 113. Estimated overall, littoral and open water rearing periods of subyearling chinook salmon during 1991, 1992 and 1993 in Lower Granite Reservoir.

initial dates of shoreline collection of subyearling chinook salmon with peak abundance at Lower Granite Dam reveals the duration of residence in the reservoir. The duration of open water rearing was found by subtracting the time of disappearance from the shoreline with peak abundance at the dam. The duration of open water rearing was similar during 1991 and 1992 at about 27 days. During 1993, that duration was 6 days, although the timing of peak abundance at the dam was similar between 1991 and 1993. Temperature may play a significant role in the timing of downstream migration of subyearling chinook out of Lower Granite Reservoir.

Habitat use in 1993 also differed from previous years. Some subyearling chinook were collected over rip-rap in 1993, although their preference was strong for finer substrates. We found a moderate avoidance of rip-rap by subyearling chinook during 1993 compared to Curet (1994) who found a strong avoidance of rip-rap habitat for 1990 through 1992. Suitable habitat may change under different flows. During 1992, the lowest flow year of those examined, subyearling chinook strongly avoided rip-rap whereas in 1993, a more "average" flow year, the strength of avoidance was lessened. Timing may also be contributing to substrate preference, as some of the fish sampled along the rip-rap may have been migrating through Lower Granite and were sampled more as chance than exhibiting a preference.

Comparison of total lengths of subyearling chinook salmon sampled during 5 years of collections along the shoreline in Lower Granite Reservoir showed high similarity. Although water temperatures were higher during lower flow years, size of captured subyearlings were not highly different. A tendency existed between slightly larger sizes in early to mid-May during the low flow years of 1987 and 1992 but during 1990, 1991 and 1993, 3 years of similar flow conditions, size at capture was not highly different.

Objective 6. To assess biotic components associated with in-water disposal including macrophyte development including utilization and interactions with fish and zooplankton abundance.

Subobjective 1. To assess the extent of macrophyte development at disposal sites and evaluate utilization and interactions with fish and biota; and

Subobjective 2. To assess zooplankton community structure and abundance.

METHODS

Macrophytes

We determined the extent of macrophyte growth in 1993 associated with the in-water disposal by snorkeling and Shipek dredge. Snorkeling was conducted by swimming the entire length of each station along two transects at 1.5 (5 ft) and 3.1 m (10 ft) depth. The species composition and density of macrophyte development at depths > 3.1 m was assessed by taking 10 grab samples from four randomly selected quadrants in each of three depth zones (<1 m, 1-3 m and >3.6 m) for a total of 40 grabs/depth. Standing crops of macrophytes were estimated by weighing (dry weight) dried (105°C ca. 8 hours) samples. Ash free weights were determined by incinerating samples in a muffle oven for 12 hours at 510°C. Samples were removed from the oven, placed in a desiccator to cool for 1 to 2 hours and weighed.

Zooplankton

Paired, half-meter plankton nets, 2.134 m (6.9 ft) in length with 0.5 m (1.6 ft) diameter opening and 1 mm (0.04 inch) mesh, were used to assess zooplankton abundance at shallow disposal (1 and 2) and reference

(5 and 11) stations and mid-depth disposal station 4 in Lower Granite Reservoir at weekly intervals from 23 May through 10 September, 1993. Paired plankton nets were towed at night approximately 1.6 m/s (5.25 ft/s) below the surface and 1.0 m (3.3 ft) deep for 3 minutes at each depth. Three paired hauls were taken at each station providing six/samples/station/sampling effort.

All zooplankton samples were preserved in a 10% buffered formalin solution for later identification. Zooplankton were separated in the laboratory from debris, larval fishes and insects with the aid of a WILD 6.5 x 40 power microscope. All zooplankton were enumerated to genus using standard dilution and subsampling techniques (Edmondson and Winberg 1971). Zooplankton identification was aided by the use of dichotomous keys developed by Pennak (1987), Brooks (1957) and Ward and Whipple (1963).

Estimates of zooplankton density were determined using a quadrant sampling scheme (Scheafer et al. 1986) for plankton net samples. Mean density (M) was determined by the following:

$$\text{Density } M = N/a;$$

where: N = mean number of fish among samples (n=6), and
a = area of 1 half-meter plankton net.

Total density (T) was determined by multiplying the mean density by total volume sampled (318.08 m^3):

$$T = M * A;$$

where: M = mean density and
A = total volume.

The variance (V(T)) was determined by

$$V(T) = A_2 * M/a*N;$$

where: M = mean density,
A_2 = square of total volume,
a = volume of one sample, and
N = number of samples.

The bound (β) was (β = 0.05) was calculated by

$$\beta = 2 * A * M/a*N.$$

Upper and lower bounds were determined by adding and subtracting the bound (β) from the mean density (M).

RESULTS

Macrophytes

Macrophytes were first observed in early July and peaked in abundance in mid-August. Densities in 1993 were low at all stations. Two species, *Potamogeton crispus* and *P. filiformis*, were collected from Lower Granite Reservoir in 1993. Macrophytes were distributed between 0.76 (2.4 ft) and 1.0 m (3.28 ft) deep exclusively, and none were found in water > 1.0 m. Macrophytes were collected at shallow disposal stations 1 and 2 and reference stations 3, 10 and 11. Dredge samples provided an indication of the spotty macrophyte growth at low densities at disposal and reference stations in 1993. Although 30 samples were taken at various stations and during various times during the growth cycle of macrophytes in Lower Granite Reservoir, many samples did not contain macrophytes (Figure 114). At both stations 1 and 11, early to mid-July samples contained about the same biomass as those in mid-August. Variances among samples were high and account for wide confidence intervals around our biomass estimates. Highest biomass was

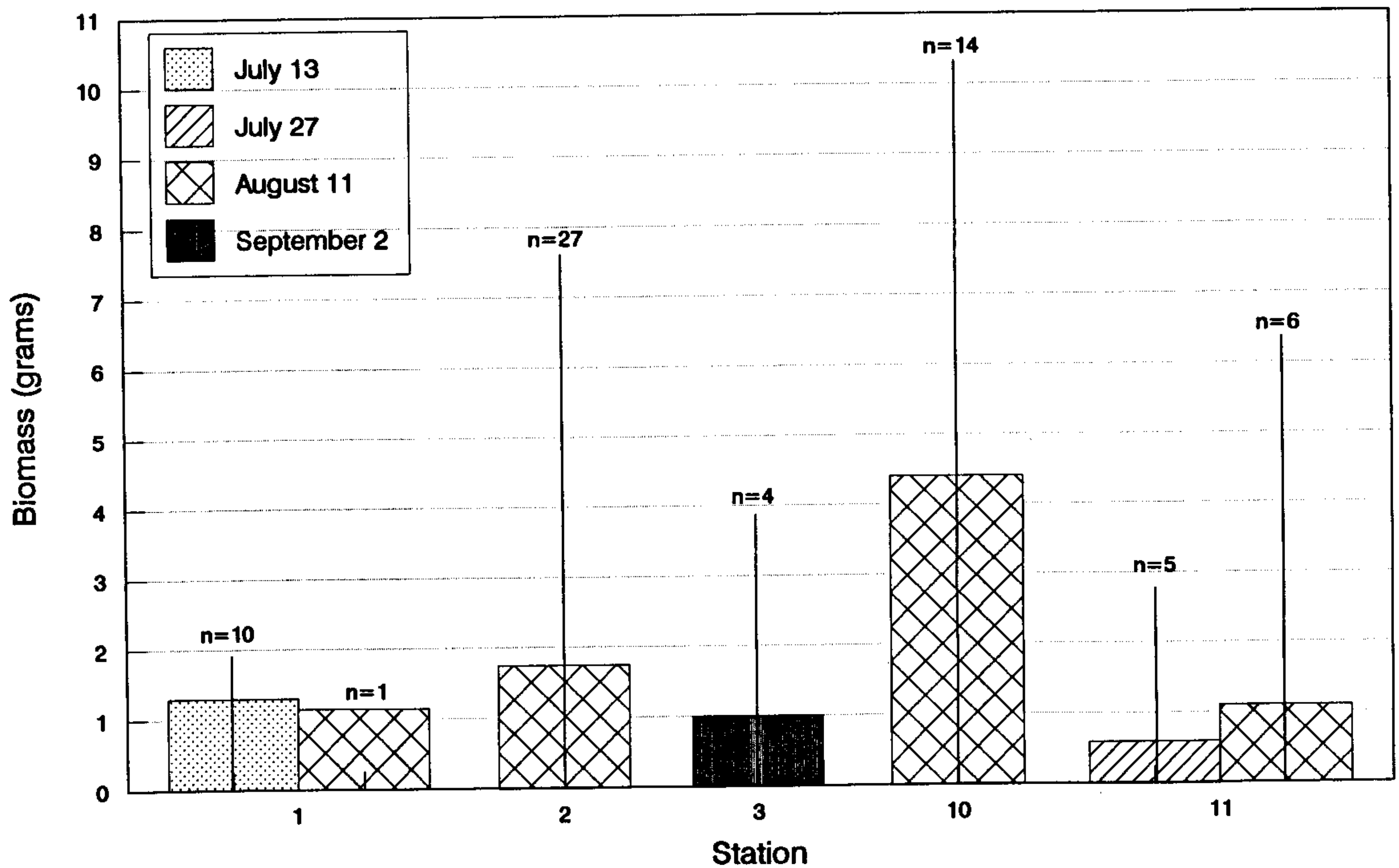


Figure 114. Biomass of macrophyte samples collected at stations 1, 2, 3, 10 and 11 on various dates during July through September, 1993 in Lower Granite Reservoir.

collected at reference station 10 followed by disposal station 2. Wide confidence intervals indicate that no significant differences in mean biomass were found between reference and disposal stations.

Zooplankton

A total of 14 zooplankton genera was collected at disposal (1, 2 and 4) and reference (5 and 11) stations in Lower Granite Reservoir during 1993 (Appendix Table 3). Highest densities (no./L) of zooplankters collected occurred on sampling dates 27 August and 4 September for all stations, with the exception of shallow reference station 11 (10 September; Figure 115). Zooplankton densities during early sampling dates (23 May through 3 August) were low at all disposal and reference stations (1, 2, 4, 5 and 11). Highest zooplankton densities were observed at shallow (1 and 2) and mid-depth (4) disposal stations on 27 August and 4 September. Estimated zooplankton densities during 27 August were 845.6/L at station 1, followed by station 4 (686.3/L) and station 2 (381.3/L). Zooplankton densities exhibited the same trend on 4 September, as the highest densities were observed at station 1 (915.7/L) followed by station 4 (344.1/L) and station 2 (334.1/L). Zooplankton densities at reference stations 5 and 11 were low over the entire sampling effort.

High *Daphnia* spp. densities were observed at shallow (1) and mid-depth (4) disposal stations during 27 August and 4 September (Figure 116). *Daphnia* spp. densities at shallow disposal station 1 ranged from 0.0/L to 467.2/L followed by mid-depth disposal station 4 (0.0/L-

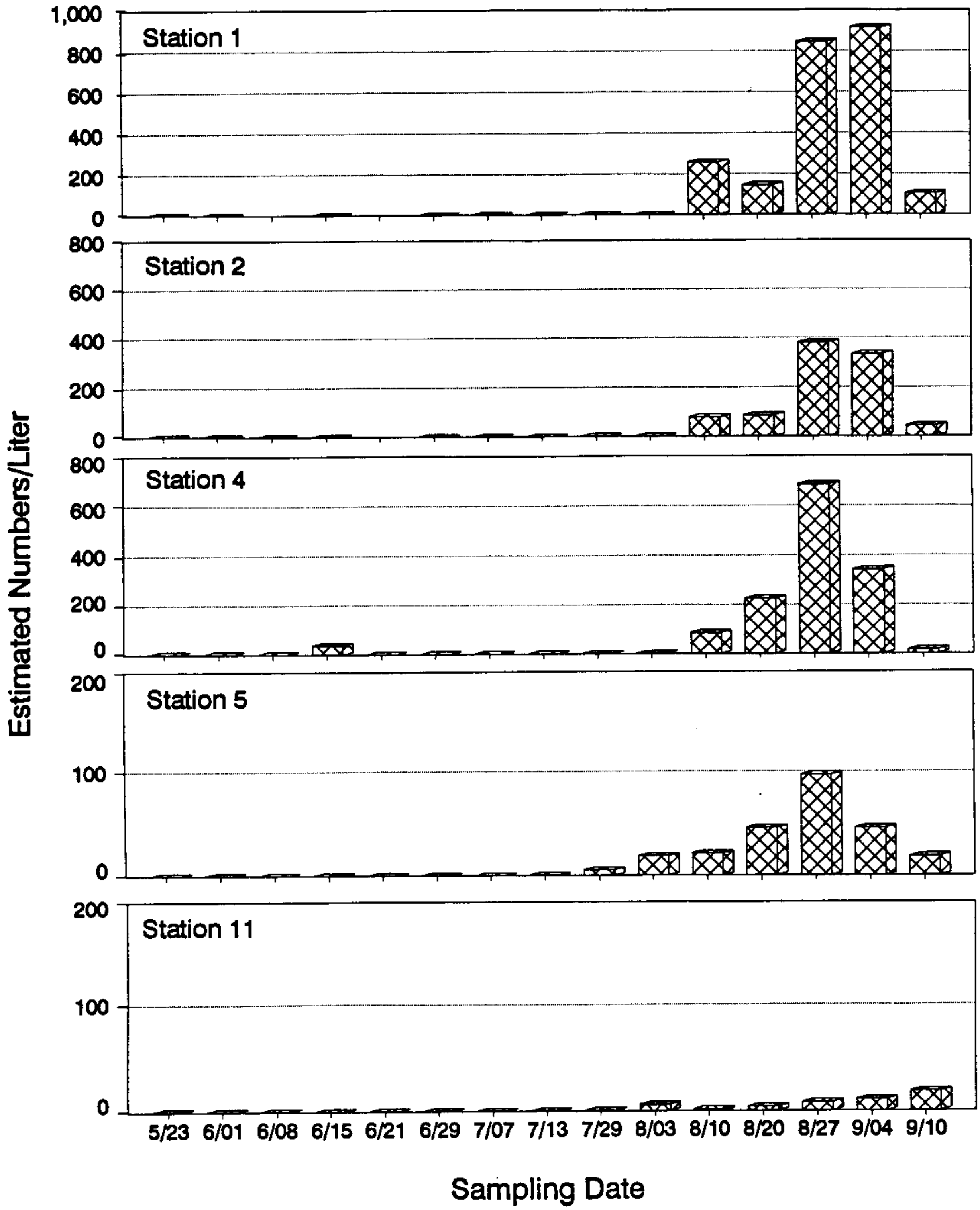


Figure 115. Estimated number/liter of zooplankton sampled from May to September, 1993 in Lower Granite Reservoir.

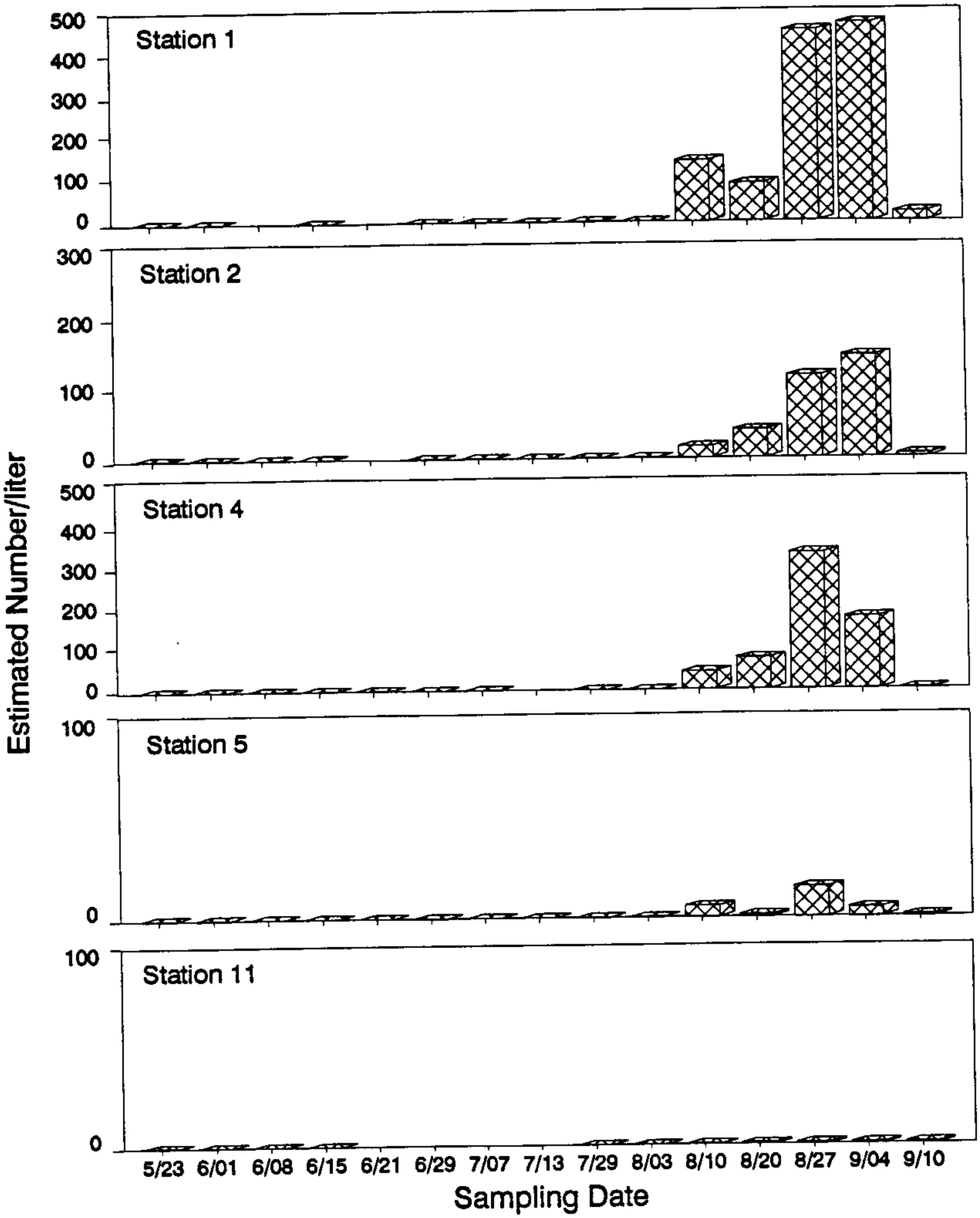


Figure 116. Estimated number/liter of Daphnia spp. sampled from May to September, 1993 in Lower Granite Reservoir.

321.2/L) and station 2 (0.0/L-142.6/L). *Daphnia* spp. densities were low at reference stations 5 and 11. Densities at shallow reference station 5 ranged from 14.7/L on 27 August to 0.01/L on 7 July. Estimated zooplankton densities at station 11 were low ranging from 0.0/L to 0.87/L.

Leptodora spp. densities were high during 27 August and 4 September at all stations (Figure 117). The two highest estimated densities were observed at shallow and mid-depth disposal stations 1 and 4 (Appendix Table 3). *Leptodora* spp. densities at station 1 ranged from 0.0/L to 446.2/L and at station 4 from 0.0/L to 363.7/L. *Leptodora* spp. densities at stations 5 and 11 were low.

Densities of other zooplankters collected in Lower Granite Reservoir were low and ranged from 0.0/L to 5.24/L (Figures 118-123). Generally, high densities of other zooplankton species were observed between 10 August and 4 September with the exception of *Latona* spp., which had high densities on 10 September for stations 4, 5 and 11 (Figure 119). Other dominant zooplankton densities were generally high at shallow (1 and 2) and mid-depth (4) disposal stations with the exception of *Sida crystallina* (station 5; Figure 118) and *Latonopsis* spp. at station 11 (Figure 120). Estimates densities for other zooplankton were generally < 0.5/L (Appendix Table 3).

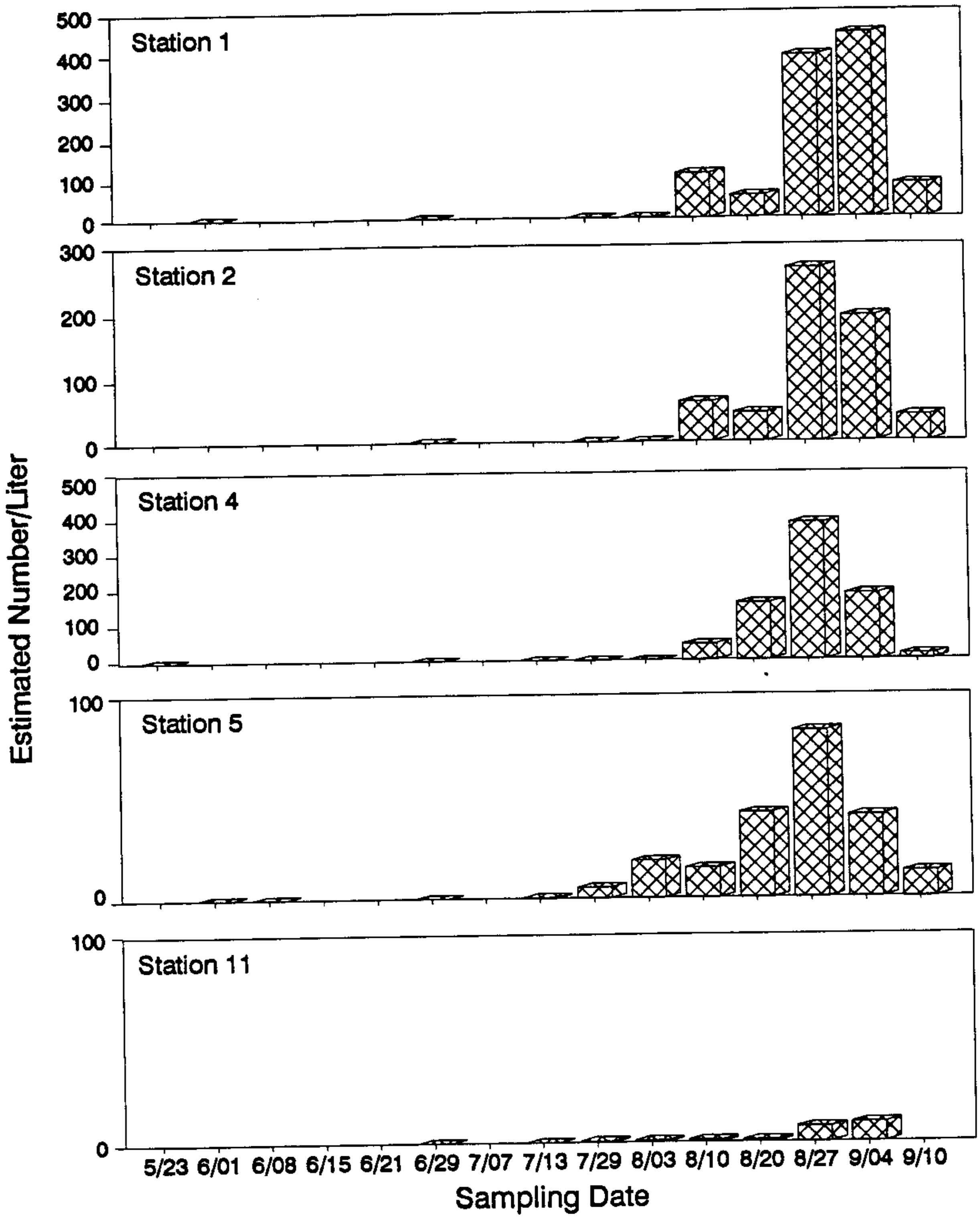


Figure 117. Estimated number/liter of Leptodora spp. sampled during May through September, 1993 in Lower Granit Reservoir.

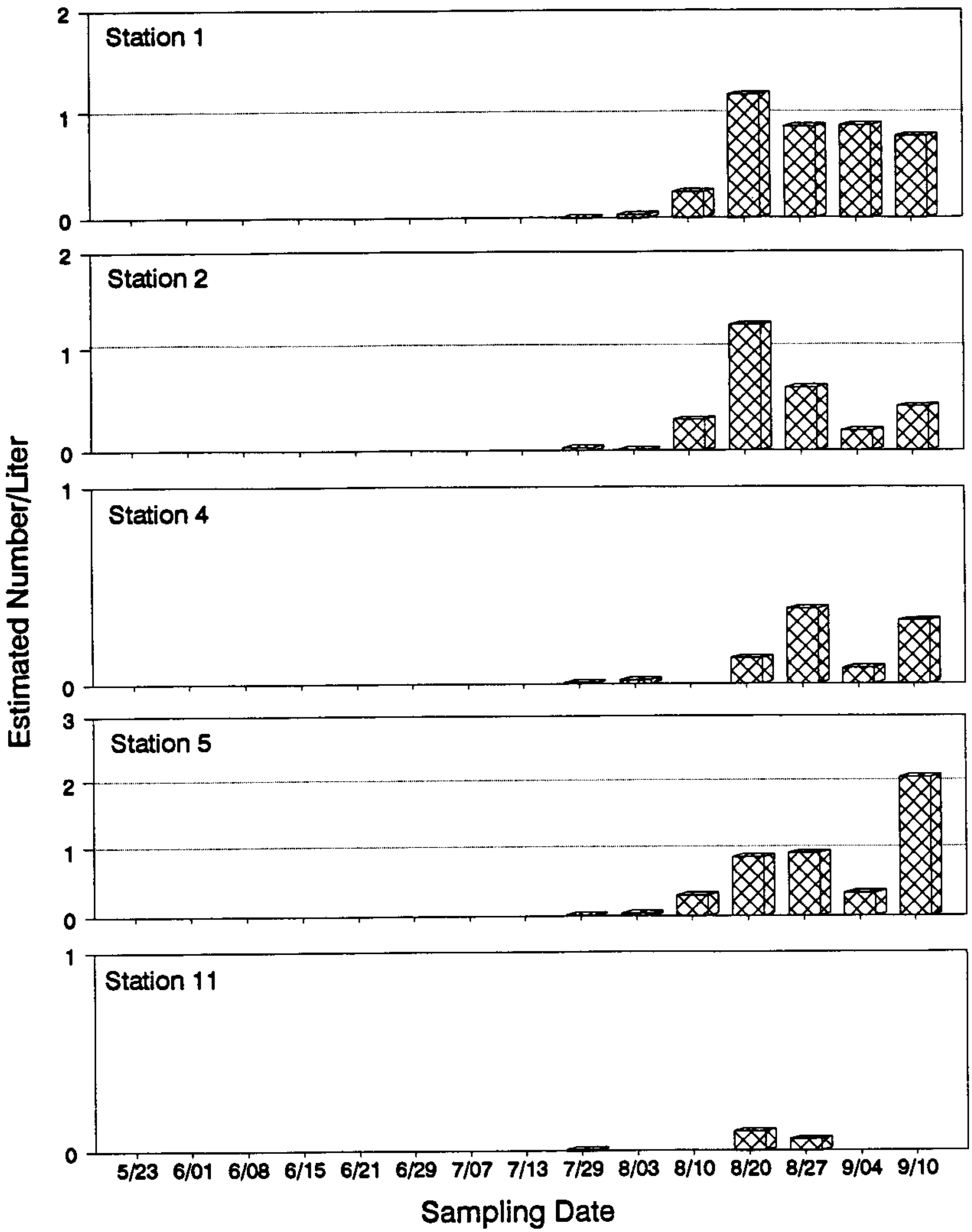


Figure 118. Estimated number/liter of Sida crystallina sampled from May to September, 1993 in Lower Granite Reservoir.

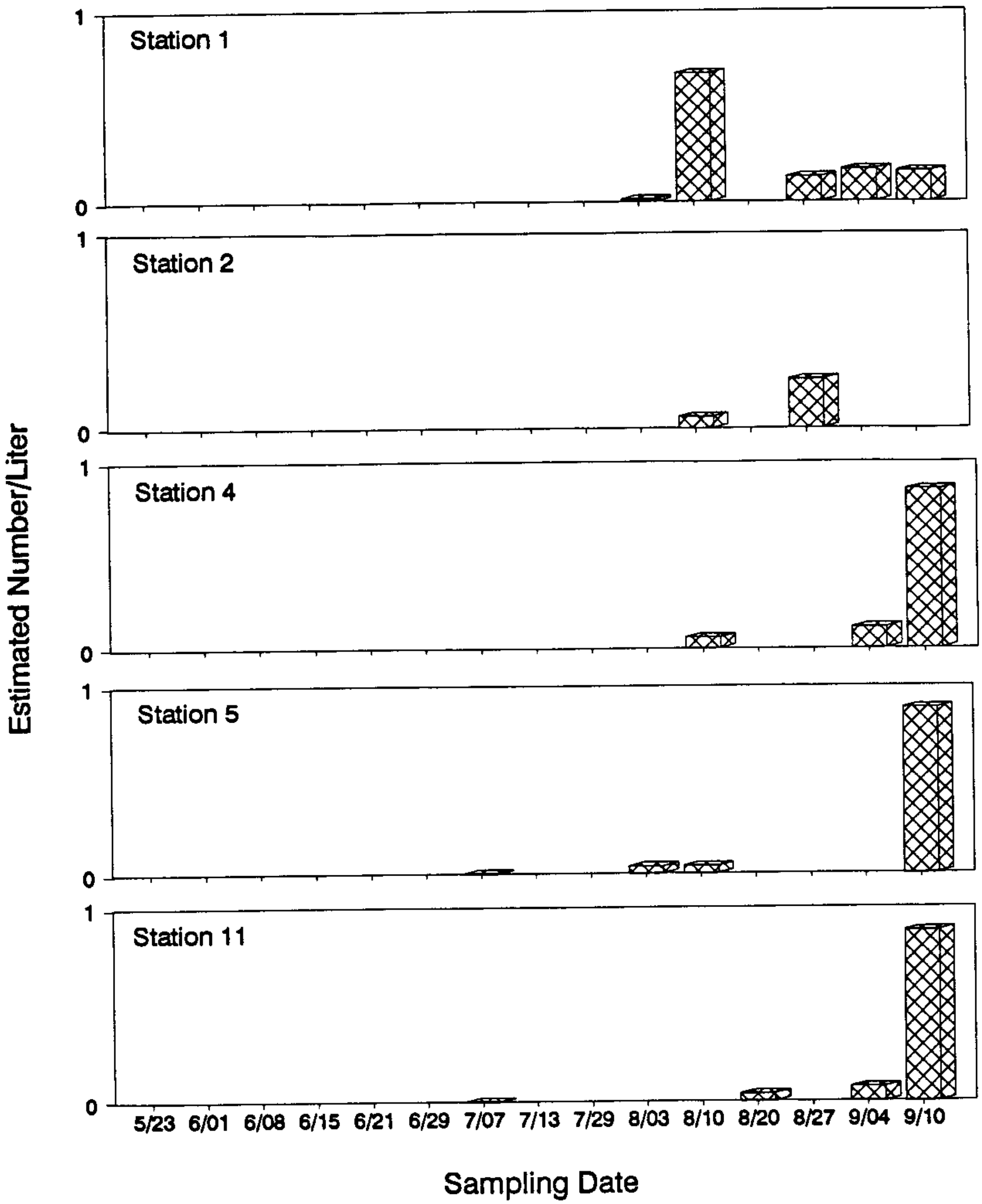


Figure 119. Estimated number/liter of Latona spp. sampled from May to September, 1993 in Lower Granite Reservor.

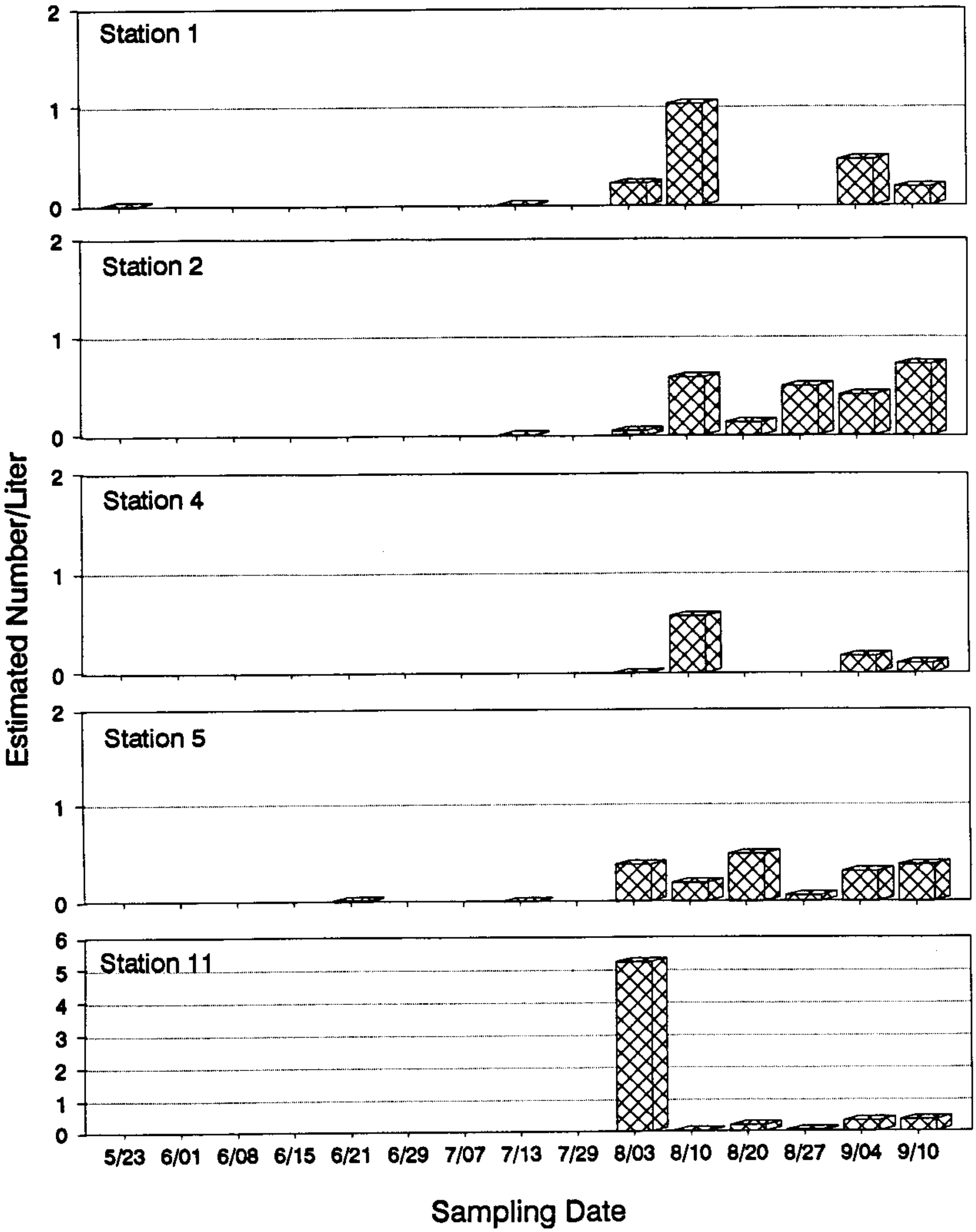


Figure 120. Estimated number/liter of Latonopsis spp. sampled from May to Septmeber, 1993 in Lower Granite Reservoir.

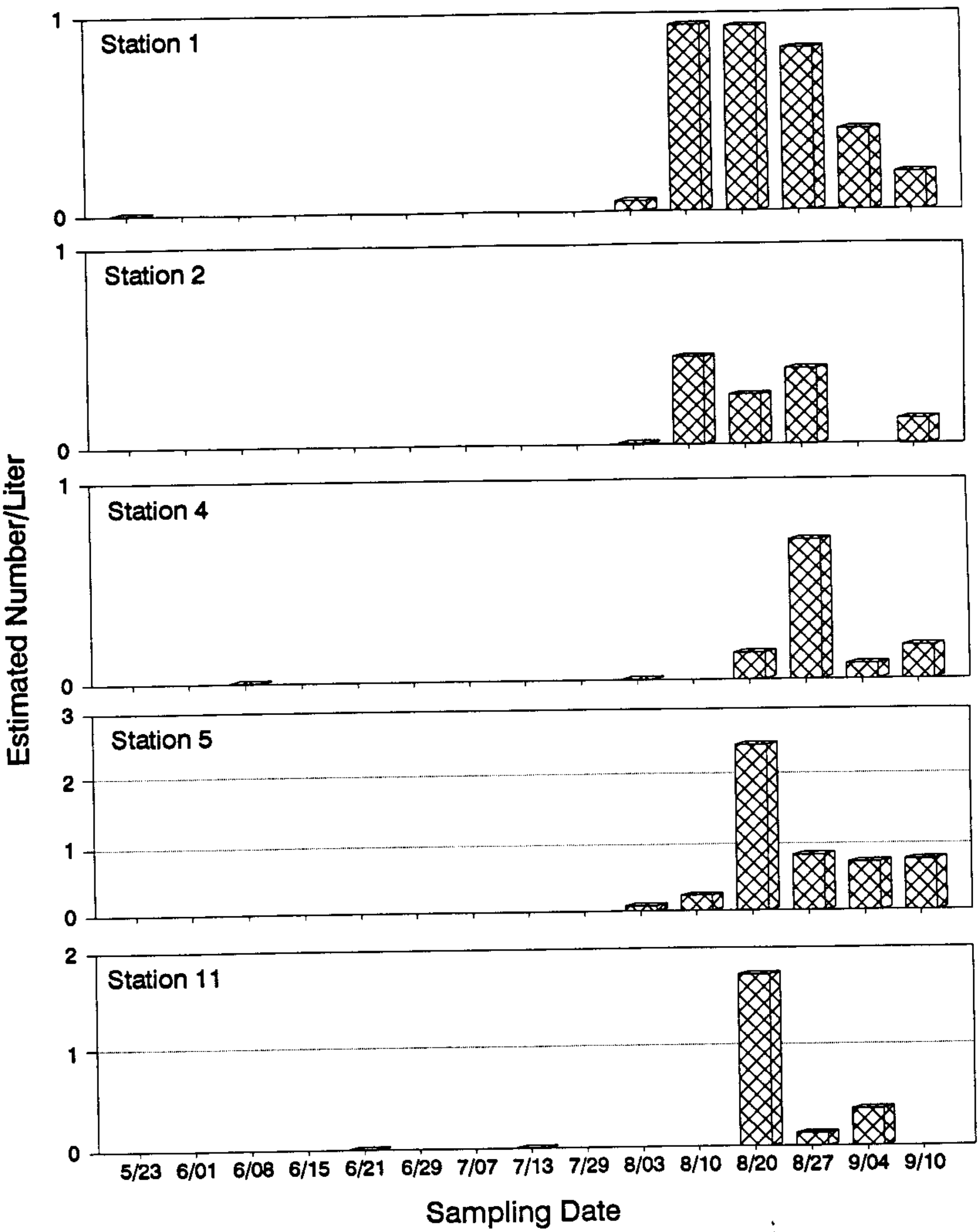


Figure 121. Estimated number/liter of Eurycerus spp. sampled from May to September, 1993 in Lower Granite Reservoir.

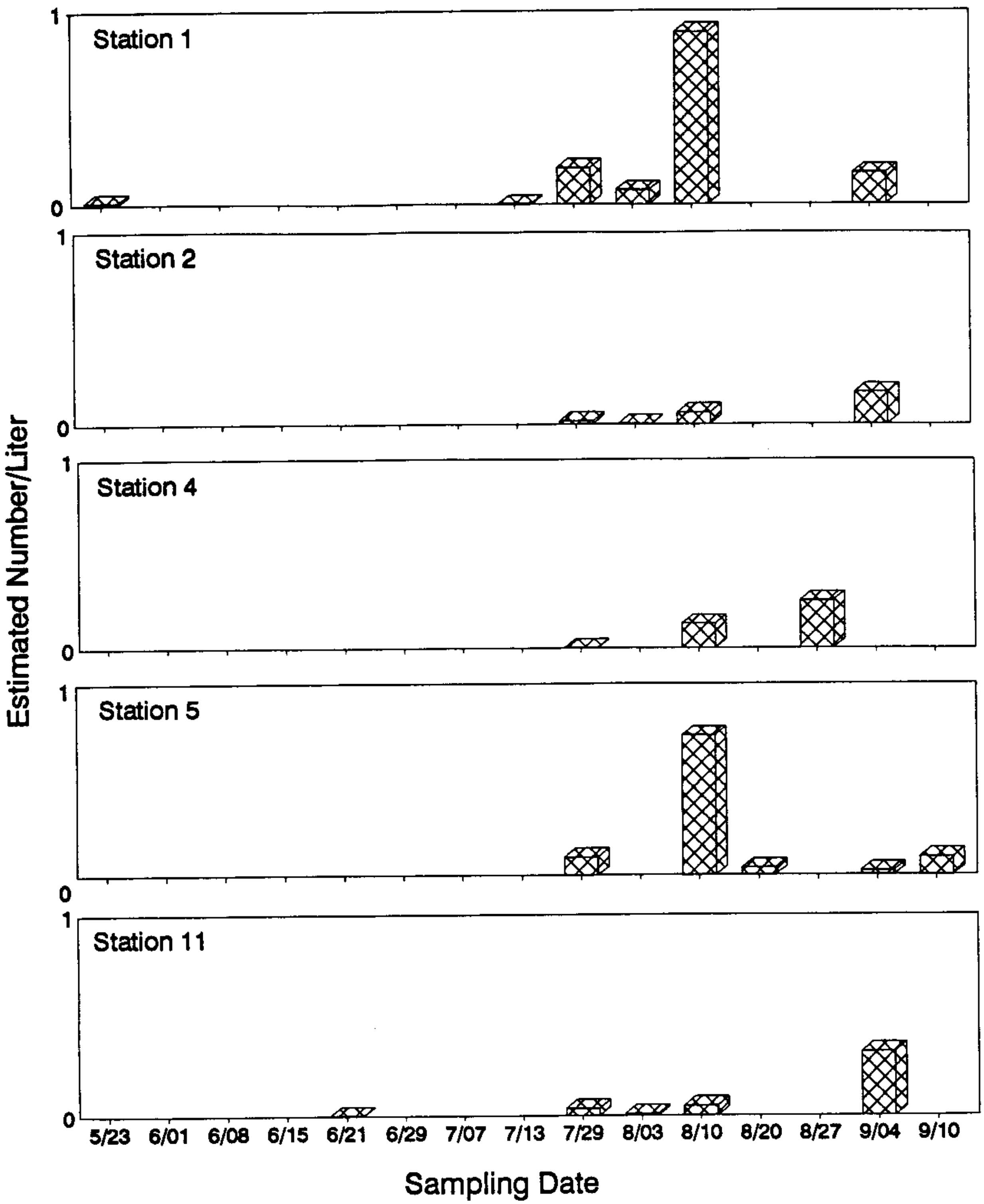


Figure 122. Estimated number/liter of Eurycerus lamellatus sampled from May to September, 1993 in Lower Granite Reservoir.

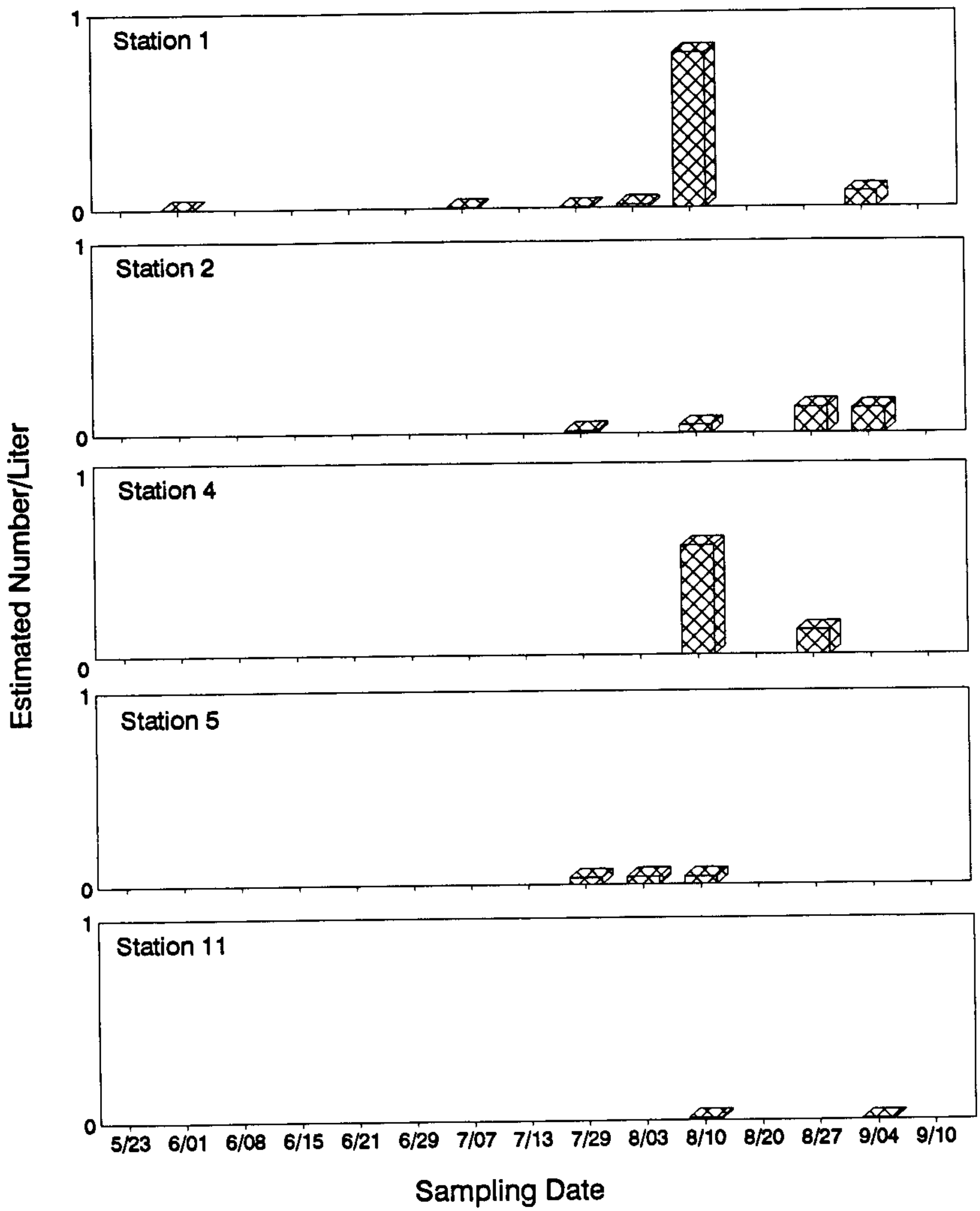


Figure 123. Estimated number/liter of Cyclop spp. sampled from May to September, 1993 in Lower Granite Reservoir.

DISCUSSION

Macrophytes

Macrophyte densities in 1993 were low at all stations. Two species, *P. crispus* and P. filiformis, were the only species collected from Lower Granite Reservoir in 1993. Macrophytes were distributed between 0.76 and 1.0 m (2.5-3.28 ft) exclusively, and none were found in water > 1.0 m.

Macrophytes were first observed in early July and peaked in abundance in mid-August. The apparent late growth of macrophytes in Lower Granite Reservoir may be also related to low water temperatures (Bennett et al. 1994c, 1994e) associated with high 1993 flows and high apparent turbidities associated with high inflows. Also, low biomass may be related to minimal recovery from the 1992 experimental drawdown. Regardless of the cause, macrophyte growths in 1993 were spotty, low in diversity and biomass.

Zooplankton

Zooplankton densities at all stations were low during 1993. Highest densities occurred in the end of summer (27 August and 4 September), except at the shallow reference station 11 when high numbers were collected on 10 September. Samples collected in May, June, July and early August all showed low abundance. Highest numbers (845.6/L) of zooplankton were collected at disposal station 1.

Daphnia spp. densities were highest in late August and early September and like all zooplankton, were highest at disposal station 1.

Densities at other stations were considerably lower, and those at reference stations 5 and 11 were < 20/L throughout the sampling period.

Densities of other zooplankton were generally low throughout all sampling stations in Lower Granite Reservoir. *Leptodora* spp. densities were similar to those of *Daphnia* spp. at stations 1 and 2, but also were low at reference stations 5 and 11.

The reason for the seemingly low densities of zooplankton in Lower Granite Reservoir are not known. During 1993, average inflows were experienced but these were considerably higher than previous low flow years. Water temperatures were lower (Bennett et al. 1994c, 1994e) in 1993 as a result of high flows. Stations with high densities of zooplankton were located furthest down-reservoir which may have contributed to the low abundance. Our observations of zooplankton abundance during previous years while sampling for larval fish indicated considerably higher zooplankton abundance in low flow years. Zooplankton has been so dense in Lower Granite Reservoir that duration of larval fish tows were reduced from 3 to 1 minute at the surface and 1 m depth samples. High zooplankton densities were observed in 1992 which was a low flow year.

Objective 7. To assess patterns of fish community abundance and composition in Lower Granite Reservoir from 1985 through 1993.

BACKGROUND

Fish assemblages exhibit, to varying degrees, properties of resistance and resilience (Connell and Sousa 1983), when faced with naturally occurring disturbances (i.e. floods, droughts, etc; Moyle and Vondracek 1985; Ross et al. 1985; Erman 1986; Matthews 1986; Meffe and Minckley 1987; Freeman et al. 1988; Meffe and Sheldon 1988). The structure of many fish assemblages is believed to result from biotic processes (e.g. interactive segregation) which operate to prevent competitive exclusion (Grossman et al. 1982; Rahel et al. 1984; Yant et al. 1984). Notwithstanding the relative role of biotic factors affecting community structure, severe floods, droughts, habitat alterations and other disturbances can have destabilizing effects on fish assemblages (Harrell 1978; Quinn 1980; Matthews 1986; Meng et al. 1994). In general, fish community persistence and/or stability (Connell and Sousa 1983) is believed to be greater in benign environments than in more variable environments (Ross et al. 1985; Schlosser 1982, 1987).

The purpose of this analysis was to summarize patterns of fish community abundance at sediment disposal stations and reference stations in Lower Granite Reservoir during 1989 through 1993. Additionally, we examined persistence and stability of the resident fish assemblage using fish abundance data collected during 1985 through 1993. The study encompassed 2 to 4 generations in the populations of most resident species which enabled us to evaluate community stability of the fish assemblage in Lower Granite Reservoir (Connell and Sousa 1983).

Several perturbations occurred within the reservoir in addition to disposal of in-water sediments. These alterations included: 1) variable temperatures created by upstream releases of cold water from Dworshak Reservoir (Bennett et al. 1994c, 1994e; Figure 124); 2) operation of Lower Granite Reservoir at minimum operating pool (Bennett et al. 1994a); 3) the 1992 experimental test drawdown (Bennett et al. 1994b; Figure 125), and 4) variable flow years (Figure 126).

We addressed environmental disturbances in Lower Granite Reservoir by examining patterns in fish community abundance. Fish community attributes are widely used in many types of environmental assessments (i.e. the index of biotic integrity; Karr 1981) and can provide a more holistic interpretation of biological response to environmental alterations. Specifically, we asked the following questions related to fish community composition in Lower Granite Reservoir: 1) Were patterns in feeding guild abundance similar at disposal and reference stations and did these patterns change through time? 2) Did disposal and reference stations show similar trends in species association patterns during 1989 through 1993? 3) Was fish community structure in Lower Granite Reservoir persistent during 1985 through 1993 given the array of environmental variation that occurred? and 4) What factors appear to have more affect on species composition and overall abundance of resident fishes in Lower Granite Reservoir?

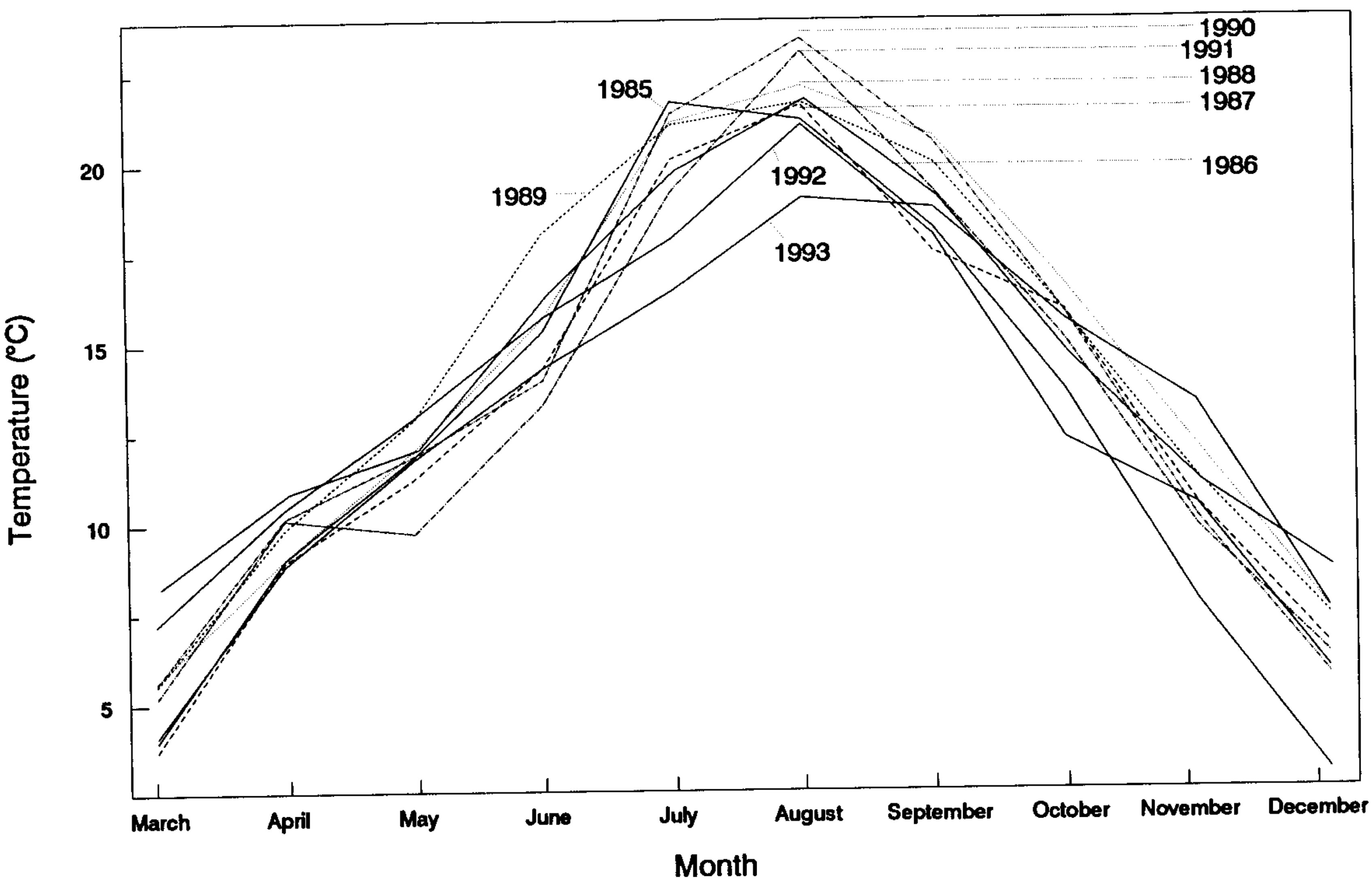


Figure 124. Mean monthly temperatures during 1985-1993 in Lower Granite Reservoir.

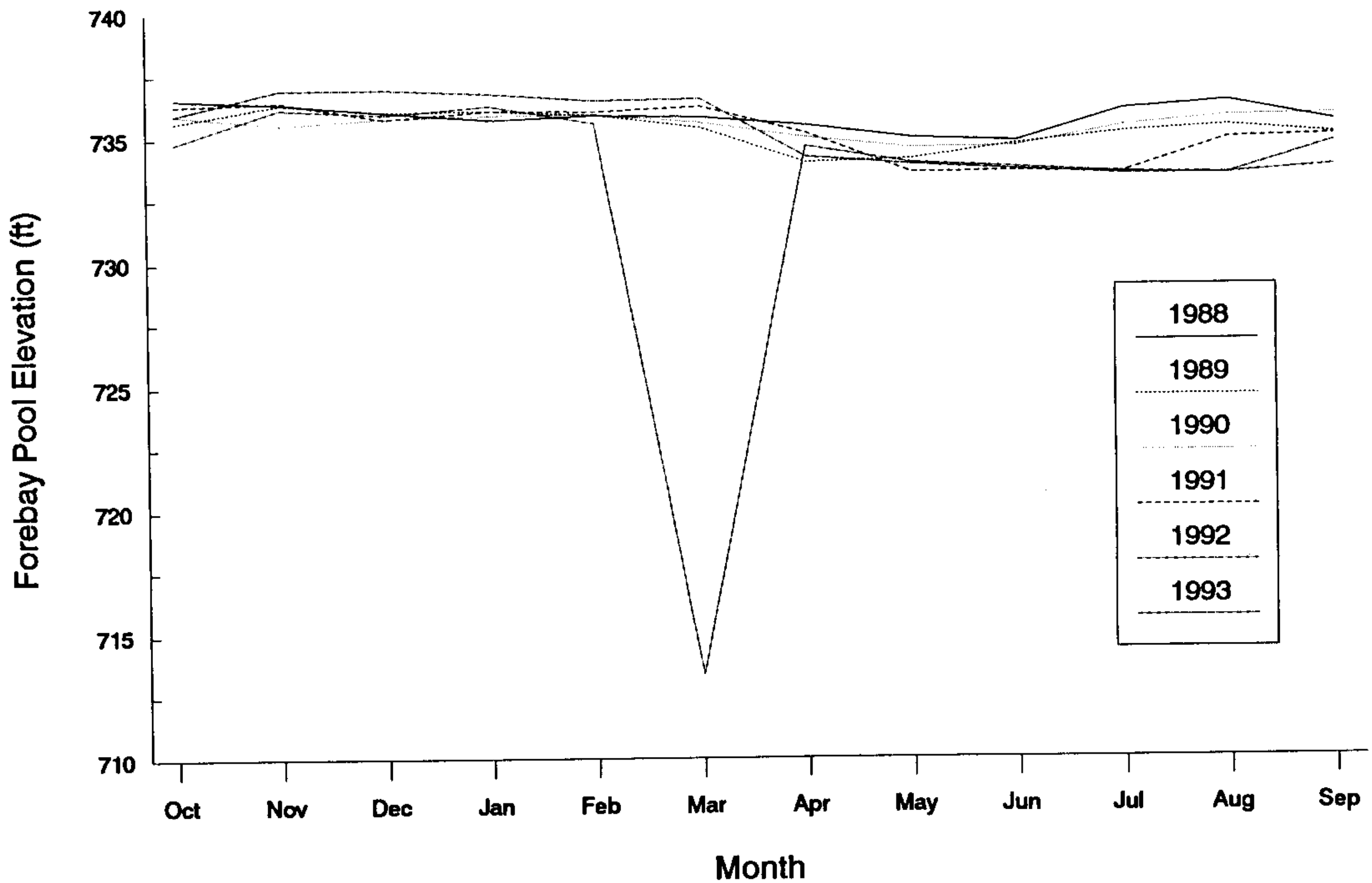


Figure 125. Forebay pool elevations during 1988-1993 in Lower Granite Reservoir. Note experimental test draw-down during March 1992.

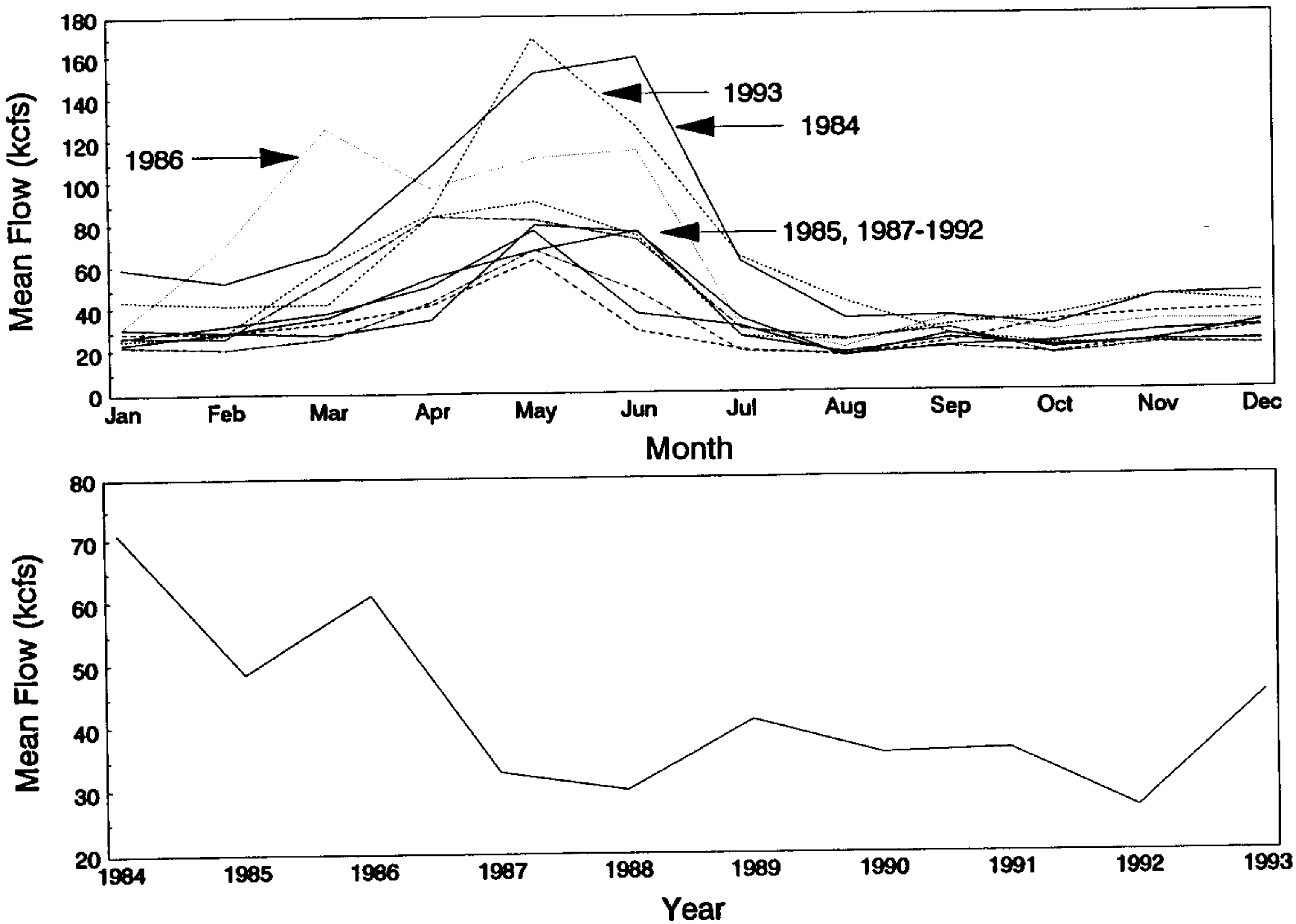


Figure 126. Mean monthly and yearly flows during 1984-1993 in Lower Granite Reservoir.

METHODS

Relative Gear Selectivity

Several gear types were used during the study to reduce gear bias and increase collection efficiency of fishes in various habitats. Detailed descriptions of gears used are given in Bennett and Shrier (1986) and Bennett et al. (1989, 1990, 1991, 1993a, 1993b, 1994d). However, since we were interested in community composition (all species), we wanted to ensure fishes were caught in relative proportion to their abundance in the reservoir. To evaluate this, we examined catch data from six gear types used during spring 1988. Gill netting (mean no./hour), electrofishing (no./5 min pass), beach seining (mean no./haul), surface trawling (no./m), bottom trawling (no./m) and purse seining (no./m) were used simultaneously throughout the reservoir during 1988, mostly in an attempt to evaluate collection efficiency for salmonid smolts. Although the preferred approach in evaluating the effectiveness of any gear(s) would be to conduct mark-recapture studies (Arthaud 1992), this would be unrealistic in community studies since extensive amounts of effort and time would be required to mark-recapture all species with all gear types. Rather, we evaluated the relative selectivity of each gear type by comparing its catch to the total combined catch for all gear types (Yeh 1977). Mean species catch/effort for each gear type was summed across stations as a measure of reservoir-wide catch. This allowed for a comparison with total catch since total catch represented the total number of a given species collected throughout the reservoir (all stations combined) during spring 1988.

This simple correlation analysis provides a relative measure of which gear types, or combinations of gear types, more closely resemble the total catch. The major assumption of this approach, however, and one which we could not specifically address, is total catch (all gear types combined) is representative of the relative abundance of all species in the assemblage. Although most researchers rely on a single gear when comparing time series trends in species abundance (Meng et al. 1994) and simply accept the biases that are assumed, we evaluated single and combined relative abundance (three gear combinations) in an effort to discover which gear (or gear combinations) were more representative of community composition (higher correlation with total catch). We also examined relationships between size-frequency distributions (20 mm size classes) from gear types used in spring 1988 with size-frequency distributions from the total catch.

Community Comparisons, Disposal vs. Reference Stations from 1989 through 1993

We established two objectives for comparing fish communities at disposal stations to fish communities at reference stations. The first objective was to compare trophic group (feeding guilds) abundance patterns at disposal and reference stations. Our goal was to evaluate whether patterns in guild abundance and structure were similar at disposal and reference stations among years.

The second objective was to evaluate similarities between stations and species association patterns using multivariate ordination techniques. These techniques do not generate a test statistic but rather enable one to reduce the dimensionality of multivariate data into a series of orthogonal axes. Stations (or species) are positioned along the axes based on similarities in community composition (or years). Stations positioned close to each other are more similar in terms of species abundance and composition than stations positioned farther apart.

Feeding Guilds

We restricted our analyses to resident fishes because of their obligate use of the reservoir and the sampling variability (e.g. timing) associated with collecting anadromous species. Additionally, we attempted to restrict analyses to predominantly adult fishes since young of year (YOY) fishes often introduce significant sampling error in community analysis (Angermeier 1987). In attempts to exclude the majority of YOY fishes, we used only samples collected in the spring of each year (April-June) since YOY fishes become increasingly abundant during summer and fall. Moreover, if YOY fishes survived and were recruited into the population, their contribution to the abundance of their species would be observed in the following spring(s) data set and ultimately included in the analysis.

After excluding salmonids, other anadromous species (shad and sturgeon) and omitting categories of unidentified fishes (young sunfishes clumped into a single genus, *Lepomis* spp.), we identified 13 resident fishes that occurred throughout the reservoir during 1985 through 1993 (Table 6).

We assigned species to feeding guilds based on published literature accounts of diets and feeding habits (Table 6; Scott and Crossman 1990; Schlosser 1982). Among the 13 common resident fishes, four feeding guilds were identified (Table 7).

We used repeated measures analysis of variance with two grouping factors (guild and disposal versus reference) and one within factor (year) to address the following questions: 1) Did guild abundance show similar trends through time at disposal and reference stations? and 2) Was abundance of all guilds similar across years? We used shallow stations (disposal versus reference) as replicates and performed the analysis on log-transformed electrofishing catches (see Table 14 for fishes and guilds represented in electrofishing catches). We summarized spring electrofishing catch/efforts by year and station.

Station and Species Associations

We used principal components analysis and correspondence analysis to examine similarities among stations sampled during 1989 through 1993 (species*station data matrices). Species association patterns were evaluated at shallow stations (disposal versus reference) to assess whether these associations changed or remained similar at disposal and reference stations (species*year data matrices). An index of relative abundance was obtained by combining catch/efforts for all gears consistently used at a given station during 1989 through 1993 for the

Table 6. Species codes and trophic classification for resident fishes in Lower Granite Reservoir.

Species	Code	Trophic group
chiselmouth *Acrocheilus alutaceus*	AAL	Herbivore
carp *Cyprinus carpio*	CCA	Omnivore
bridgelip sucker *Catostomus columbianus*	CCO	Omnivore
largescale sucker *Catostomus macrocheilus*	CMA	Omnivore
brown bullhead *Ictalurus nebulosus*	INE	Omnivore
pumpkinseed *Lepomis gibbosus*	LGI	Insectivore
peamouth *Mylocheilus caurinus*	MCA	Insectivore
redside shiner *Richardsonius balteatus*	RBA	Insectivore
channel catfish *Ictalurus punctatus*	IPU	Insectivore-piscivore
smallmouth bass *Micropterus dolomieu*	MDO	Insectivore-piscivore
white crappie *Poxomis annularis*	PAN	Insectivore-piscivore
yellow perch *Perca flavescens*	PFL	Insectivore-piscivore
northern squawfish *Ptychocheilus oregonensis*	POR	Insectivore-piscivore

Table 7. Feeding guild classification scheme (after Schlosser 1982).

Diet	Feeding guild
>90% plant detritus <10% invertebrates	herbivores
25-90% detritus 10-75% invertebrates	omnivores
>90% invertebrates	insectivores
>10% fish and remainder invertebrate	insectivore-piscivore

station comparisons. For example, shallow stations 1, 2, 3 and 5 were consistently sampled (1989-1993) by gill netting, electrofishing and beach seining. Shallow stations 9 and 10 were consistently sampled by electrofishing and beach seining whereas mid and deep stations (4, 6 and 8) were sampled by gill nets. We pooled electrofishing catches among shallow disposal stations and among shallow reference stations and summarized catches by year, 1989 through 1993, for the species association comparisons (species*year data matrices).

Principal components analysis was performed on log-transformed relative abundance indices to reduce heteroscadasticity (Gauch 1982). Correspondence analysis was also performed on the species*station data matrix as verification that station loadings along the first and second principal component axes from principal components analysis were similar or dissimilar. The use of more than one ordination technique is recommended (Gauch 1982; Hinch et al. 1991) since similar results often indicate inherent variability in the data. Patterns observed from the use of a single technique may be an artifact of the methodology chosen (Ludwid and Reynolds 1988).

Stability and Persistence of the Fish Community from 1985 through 1993 in Lower Granite Reservoir

We used fish abundance data collected at shallow reference stations 5 and 9, hereafter referred to as upper and lower, respectively, to address the question of assemblage persistence and stability in Lower Granite Reservoir during April through June 1985 through 1993. An index of relative abundance was obtained by combining catch/efforts for all gears consistently used at a station. The upper station was sampled using gill netting, electrofishing and beach seining whereas the lower station was consistently sampled using electrofishing and beach seining. Since time series comparisons within stations and not between stations were made, any bias from the combined index would be consistent throughout the period of interest.

We used a nonparametric statistic, Kendall's concordance W, to analyze community stability. We ranked the abundance of each species by year and tested for association among years. This approach has been applied and misapplied in several fish community studies (Grossman et al. 1982; Matthews 1986; Moyle and Vondracek 1985; Hansen and Ramm 1994). Rejecting the null hypothesis provides evidence of association (stability) in community composition though failure to reject the hypothesis does not necessarily indicate instability (as other authors have suggested i.e. Grossman et al. 1982; Freeman et al. 1988), since it is impossible to accept a null hypothesis (Strong 1980; Yant et al. 1984). Additionally, since Kendall's W is sensitive to sample size (positive correlation between W and n), we used resampling techniques to select fewer and fewer species from the original data. From this, we examined effects of small n (i.e. few species) on conclusions drawn from the original test with all species. Moreover, although assemblage structure (composition) may not exhibit significant change, overall fish abundance may vary in response to perturbation. We evaluated changes in overall abundance at both stations using analysis of variance on log-transformed relative abundance indices (Ho: total catch 85= total catch 87=...total catch 93). Sample dates within a station, spring samples, were used as replicates for this analysis.

RESULTS

Relative Gear Selectivity

Eighteen species were represented in reservoir samples collected during spring 1988 (Table 8). Catch rates from all gear types were positively correlated with the total catch, with the exception of purse seining (Table 9). Electrofishing and beach seining had the highest correlation with total catch whereas purse seining and surface trawling exhibited the lowest correlations with total catch.

As expected, combined relative abundance for three gear combinations were more highly correlated to total catch than individual gears alone (Table 10). The three gear combination of gill netting, electrofishing and bottom trawling for resident fishes had the highest correlation ($r=0.825$, $P<0.01$) whereas gill netting, surface trawling and purse seining had the lowest correlation with total catch ($r=0.51$, $P<0.05$; Figure 127). The three gear combination of gill netting, electrofishing and beach seining, which was used consistently during this study at several stations, was also highly correlated ($r=0.798$) with total catch (Figure 127).

These comparisons indicate only relative differences between individual gears and three gear combinations. Since total catch was a function of combined catches from all gear types, we cannot assume

Table 8. Catch rates during April through June 1988 for fishes in Lower Granite Reservoir. Gear types[a] are: GN=gill netting, ST=surface trawling, EF=electrofishing, BS=beach seining, PS=purse seining and BT=bottom trawling.

Species	GN	ST	EF	BS	PS	BT	Total catch
AAL	0.077	0	4.26	0.25	0	0.0013	140
ATR	0.106	0	0	0	0	0	30
CCA	0.292	0	0.15	0.42	0	0.002	106
CCO	0.064	0.0002	2.16	0.11	0	0.0065	112
CMA	1.527	0	25.85	4.21	0	0.4595	3796
INE	0.042	0	0.08	0.06	0	0.0012	21
IPU	0.089	0	0	0	0	0.0002	35
LGI	0.035	0	0.46	0.66	0	0.015	99
MCA	0.018	0	0.04	0	0	0	9
MDO	0.0940	0	15.63	7.05	0.0004	0.0028	569
OMY	0.477	0.0763	9.96	15.26	2.159	0.001	8842
ONE	0.004	0	0.15	0.12	0.001	0.0003	15
OTS	0.097	0.0073	6.5	18.77	0.392	0.0101	2129
PAN	0.133	0.0005	1.1	0.11	0.001	0.0122	132
PFL	0.17	0	0.3	0.12	0	0.0031	75
POR	0.339	0	2.3	1.32	0.001	0.005	216
PWI	0	0	0.08	0.06	0	0.0051	28
RBA	0.041	0	1.09	0.06	0	0	41

[a]Effort for gear types as follows: gill netting (mean catch/hour), surface trawling (mean catch/meter), electrofishing (catch/5 min pass), beach seining (mean catch/haul), purse seining (mean catch/meter) and bottom trawling (mean catch/meter).

Table 9. Correlations of catch rates for individual gear types with total catch. Data represent catches for April through June 1988 in Lower Granite Reservoir.

Gear type	Correlation coefficient (Spearman's)	P (r)=0
Gill net	0.69	0.002
Surface trawl	0.51	0.03
Electrofishing	0.91	0.0001
Beach seining	0.84	0.0001
Purse seining	0.48	0.05
Bottom trawl	0.60	0.01

Table 10. Ranked correlations (Kendall's tau) of relative abundance for three-gear combinations with total catch for spring 1988 in Lower Granite Reservoir.

Three-gear combination	r
Gill net, surface trawl, electrofishing	0.684
Gill net, surface trawl, beach seine	0.708
Gill net, surface trawl, purse seine	0.516
Gill net, surface trawl, bottom trawl	0.661
Gill net, electrofishing, beach seine	0.798
Gill net, electrofishing, purse seine	0.696
Gill net, electrofishing, bottom trawl	0.825
Gill net, beach seine, purse seine	0.696
Gill net, beach seine, bottom trawl	0.788
Gill net, purse seine, bottom trawl	0.673
Surface trawl, electrofishing, beach seine	0.794
Surface trawl, electrofishing, purse seine	0.708
Surface trawl, electrofishing, bottom trawl	0.743
Surface trawl, beach seine, purse seine	0.744
Surface trawl, beach seine, bottom trawl	0.751
Surface trawl, purse seine, bottom trawl	0.614
Electrofishing, beach seine, purse seine	0.782
Electrofishing, beach seine, bottom trawl	0.786
Electrofishing, purse seine, bottom trawl	0.766
Beach seine, purse seine, bottom trawl	0.751

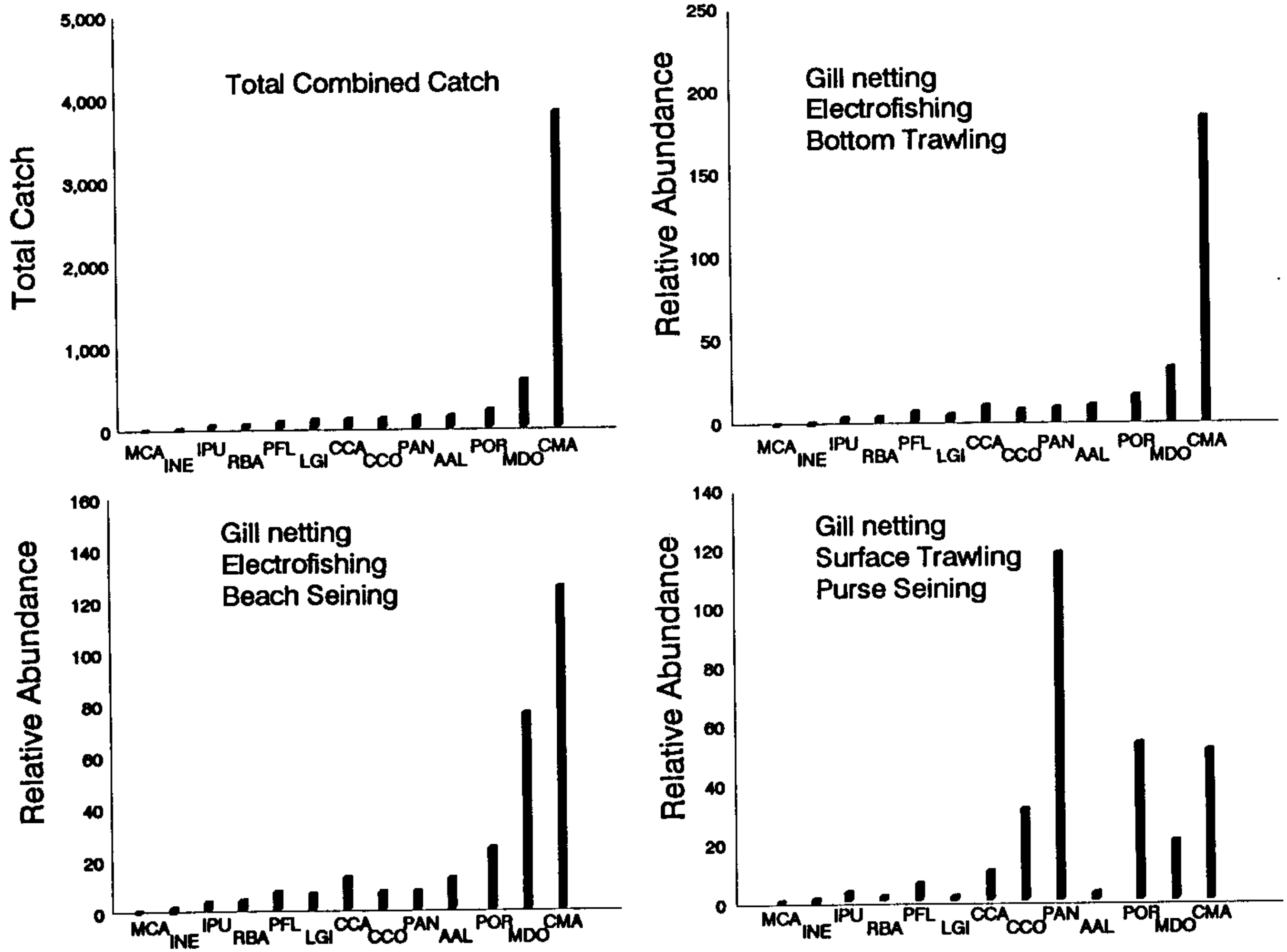


Figure 127. Catch distributions for total catch and three gear combinations for resident fishes collected during spring 1988 in Lower Granite Reservoir.

independence. Consequently, we were interested in evaluating the combined gill netting, electrofishing and beach seining index with an independent measure of fish abundance. The lack of similar data on fish abundance from Lower Granite Reservoir during 1988 precluded this attempt, although we did observe, using the remainder of our data (the other three gear combination) a significant correlation ($r=0.63$, $P<0.05$) between the combined gill net, electrofishing and beach seine index and the combined bottom trawl, surface trawl and purse seine catch for the 13 resident fishes (Figure 128).

Rank correlations (Kendall's Tau) among size class frequencies for individual gear types and size class frequencies observed in the total catch were analyzed for each resident species. As a relative measure of size-class 'bias', we ranked gears from high (highest correlation with total catch) to low (lowest correlation with total catch; Table 11). Ranks were then summed to provide a total ranked score indicating which gear was least bias (high score) and which gear most bias (low score). Similar to the abundance comparisons, electrofishing catches were least size-selective across all resident species whereas purse seining and beach seining were most size-selective (Table 11). Again, similar to the abundance comparisons, the three gear combination of gill netting, electrofishing and bottom trawling provided the least biased samples for size-class frequencies (total rank score=115) whereas gill netting, electrofishing and beach seining (total rank score=101) provided the second 'best' three-gear combination for resident fishes in Lower Granite Reservoir.

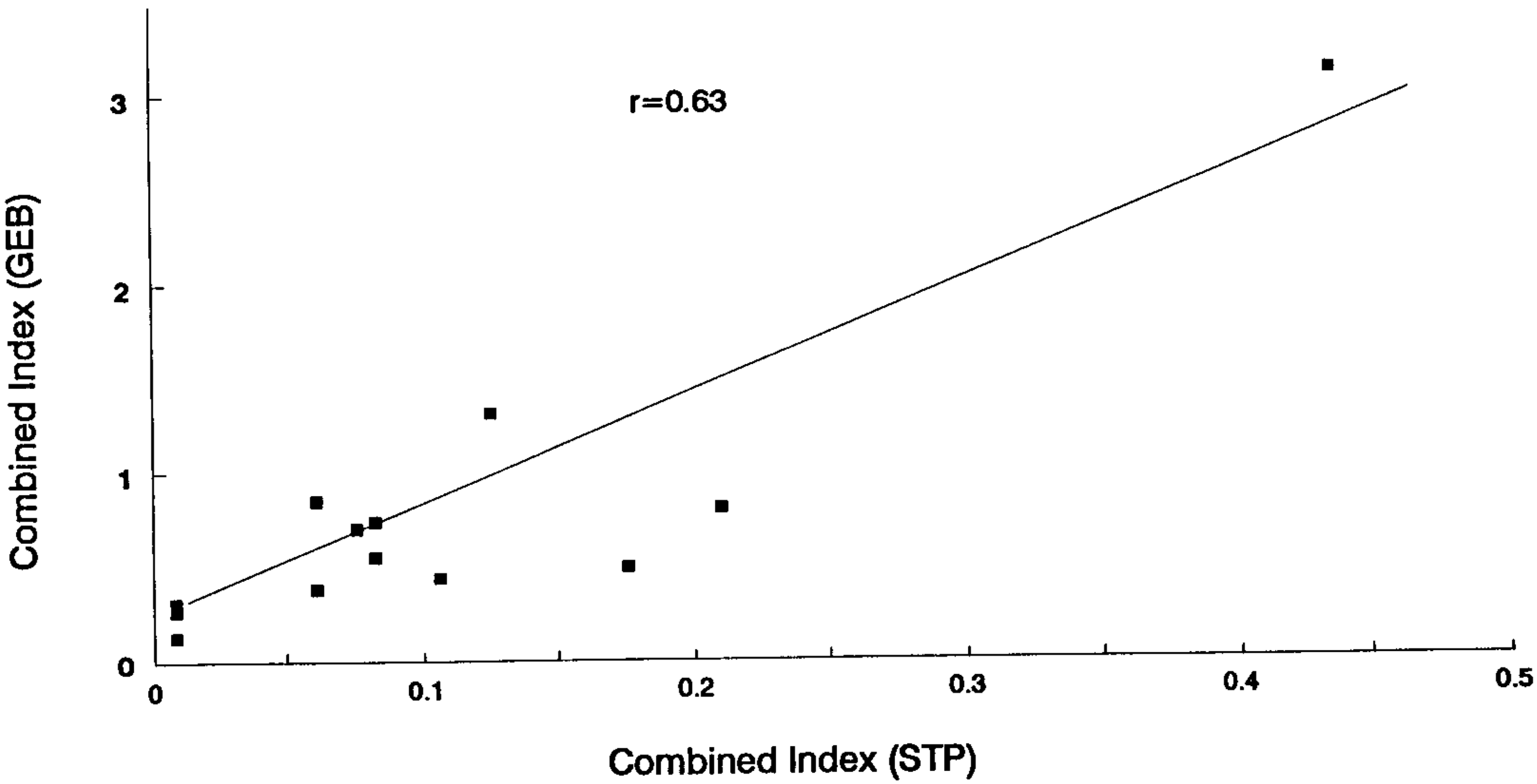


Figure 128. Comparison of combined index for gill nets, electrofishing and beach seining (GEB) with combined index for surface trawling, bottom trawling and purse seining (STP) for 13 resident fishes from April through June, 1988. Spearman's correlation coefficient is given.

Table 11. Rank correlations (Kendall's tau) among size-class frequencies for individual gear types and total catch. Size-class frequency data for resident (nonanadromous) fishes in Lower Granite Reservoir. Dash lines indicate sample sizes were too low for comparisons. Ranks across gear types are in parentheses. GN=gill netting, EF=electrofishing, BS=beach seining, ST=surface trawling, BT=bottom trawling and PS=purse seining.

Species	GN	EF	BS	ST	BT	PS
AAL	0.217 (2)	0.894 (4)	0.091 (1)	----	0.471 (3)	----
CCA	0.939 (4)	0.518 (2)	0.455 (1)	----	0.576 (3)	----
CCO	0.133 (1)	0.745 (4)	0.296 (2)	----	0.530 (3)	----
CMA	0.227 (1)	0.573 (4)	0.302 (2)	----	0.317 (3)	----
INE	0.874 (5)	0.462 (3)	0.388 (2)	----	0.592 (4)	0.348 (1)
IPU	0.965 (2)	----	----	----	0.064 (1)	----
LGI	0.683 (1)	0.899 (4)	0.843 (2)	----	0.844 (3)	----
MDO	0.529 (3)	0.926 (5)	0.860 (4)	----	0.491 (2)	0.310 (1)
PAN	0.436 (3)	0.725 (4)	0.222 (1)	0.025 (*)	0.765 (5)	0.313 (2)
PFL	0.786 (4)	0.640 (3)	0.246 (1)	----	0.618 (2)	----
POR	0.313 (2)	0.342 (3)	0.535 (5)	----	0.412 (4)	0.210 (1)
PWI	----	0.560 (2)	0.424 (1)	----	0.980 (3)	----
RBA	0.653 (2)	0.978 (3)	0.296 (1)	----	----	----
Total rank score	34	42	25	----	39	5

* Not used to compute a total rank score.

From these comparisons, we concluded that the gear types used during 1985 through 1993, predominantly electrofishing, gill netting and beach seining, provided reasonable estimates of species relative abundance.

Community Comparisons, Disposal vs. Reference Stations from 1989 through 1993

As a means of comparing fish assemblages at disposal and reference stations during 1989 through 1993, we first examined basic properties associated with community response to habitat degradation. For example, we evaluated trends in species richness, including anadromous species and percent tolerant species at disposal and reference stations for evidence of community changes. We presumed degraded habitat quality would likely result in loss of species richness and diversity and increased abundance of tolerant species (Karr 1981). We compared trends in species richness and percent tolerant fishes among disposal and reference stations. We found no significant difference in species richness for the years 1989 through 1993 (t-test; P=0.439) at shallow disposal and reference stations (Figure 129). Similarly, we found no significant difference between mid-water disposal or reference stations (P=0.401) or deep disposal or reference stations (P=0.08; Figure 129).

We identified carp *Cyprinus carpio* and brown *Ictalurus nebulosus* and yellow *I. natalis* bullhead as tolerant species based on published literature accounts of life history traits for these fishes (Scott and Crossman 1990). Although several species have varying degrees of

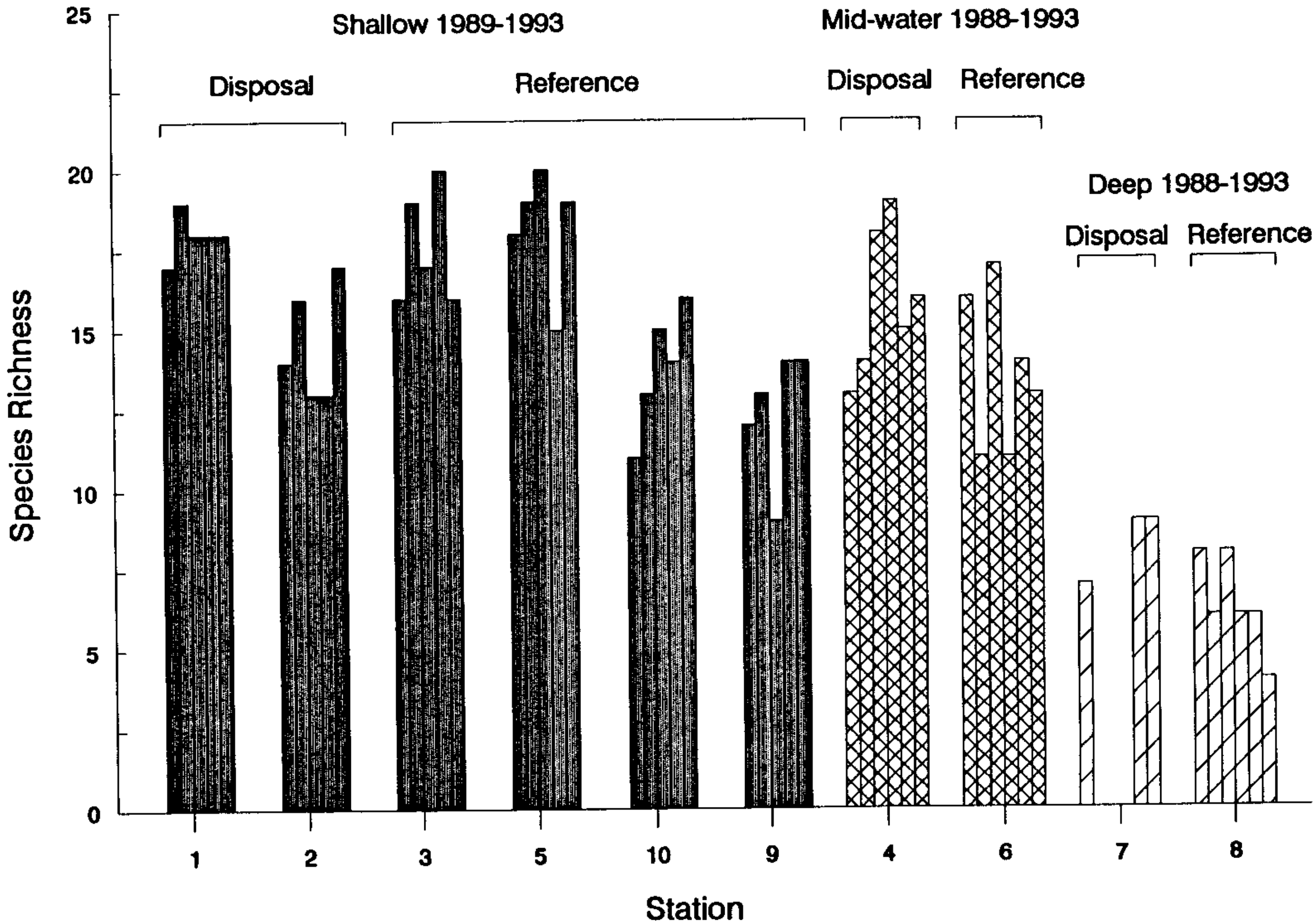


Figure 129. Time series trends in species richness (including anadromous fishes) at disposal and reference stations during 1989-1993 in Lower Granite Reservoir.

tolerance to disturbed conditions, carp and bullhead exhibit high degrees of tolerance relative to other species. We evaluated the proportion (%) of carp and bullhead in samples collected at each station during 1989 through 1993. Statistical comparisons were not made, rather we visually analyzed serial correlations for evidence of increased/decreased proportion of these species at disposal and reference stations (Figure 130).

Trends in percent tolerant fishes were similar among shallow disposal and reference stations during 1989 through 1993. We observed a relatively high proportion (27%) of tolerant species at deep disposal station 7 in 1993. This increase was predominantly due to high catch rates of carp in 1993. We did not observe an increase at reference station 8 in 1993, but did observe increased proportion of tolerant species at mid-depth reference station 6. We believe the relatively close proximity of reference station 6 and disposal station 7 are areas preferred by carp and bullhead because of depths, velocities or other localized characteristics. Additionally, trends in percent tolerant for station 7 were difficult to interpret since 3 years of data were not collected at this station, as station 7 was not created until 1992.

Feeding Guilds

Repeated measures analysis of variance indicated overall fish abundance varied significantly from year to year ($P=0.0006$; Table 12; Figure 131). Feeding guilds varied differently through time ($P=0.0002$; Table 12; Figure 132). Insectivores (I; $P=0.53$) and omnivores (O;

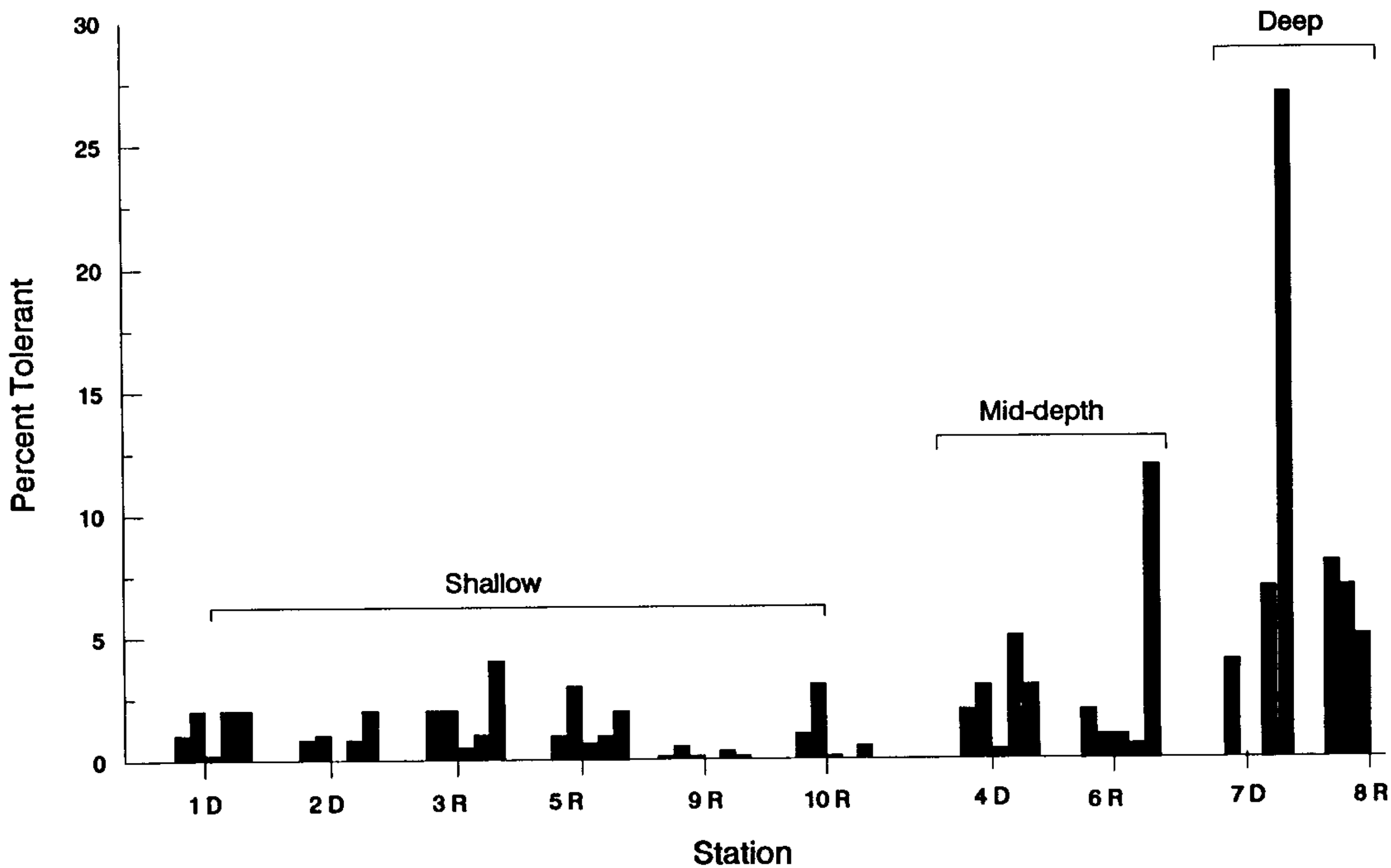


Figure 130. Trends in the relative abundance of tolerant species (carp and brown bullhead) at reference (R) and disposal (D) stations during 1989-1993 in Lower Granite Reservoir.

Table 12. Summary statistics of repeated measures analysis of variance. Grouping factors included guilds and station type (i.e. disposal vs. reference) whereas yearly trends in guild abundance was used as a within subject factor. See tables 6 and 7 for species and guilds.

Source	df	F	P
Between subject effects			
Guild	3	21.6	0.0002
Type	1	12.6	0.0003
Type x guild	3	4.4	0.019
Between subject contrasts			
H versus I	1	24	0.0002
H versus IP	1	4.2	0.06
H versus O	1	0.5	0.49
I versus IP	1	8.05	0.01
I versus O	1	31.4	0.0001
IP versus O	1	7.68	0.01
H disposal versus reference	1	12.14	0.025
I disposal versus reference	1	0.46	0.53
IP disposal versus reference	1	120.8	0.0004
O disposal versus reference	1	2.13	0.21
Within subject effects			
Year	4	6.4	0.0006
Year x guild	12	0.55	0.84
Year x type	4	1.6	0.18
Year x type x guild	12	0.81	0.62
Within subject contrasts			
Year x H versus I	4	0.57	0.65
Year x H versus IP	4	0.84	0.48
Year x H versus O	4	0.28	0.85
Year x I versus IP	4	0.53	0.67
Year x I versus O	4	0.49	0.71
Year x IP versus O	4	0.62	0.61
H year x disposal versus reference	4	1.14	0.37
I year x disposal versus reference	4	0.19	0.94
IP year x disposal versus reference	4	0.21	0.92
O year x disposal versus reference	4	1.34	0.29

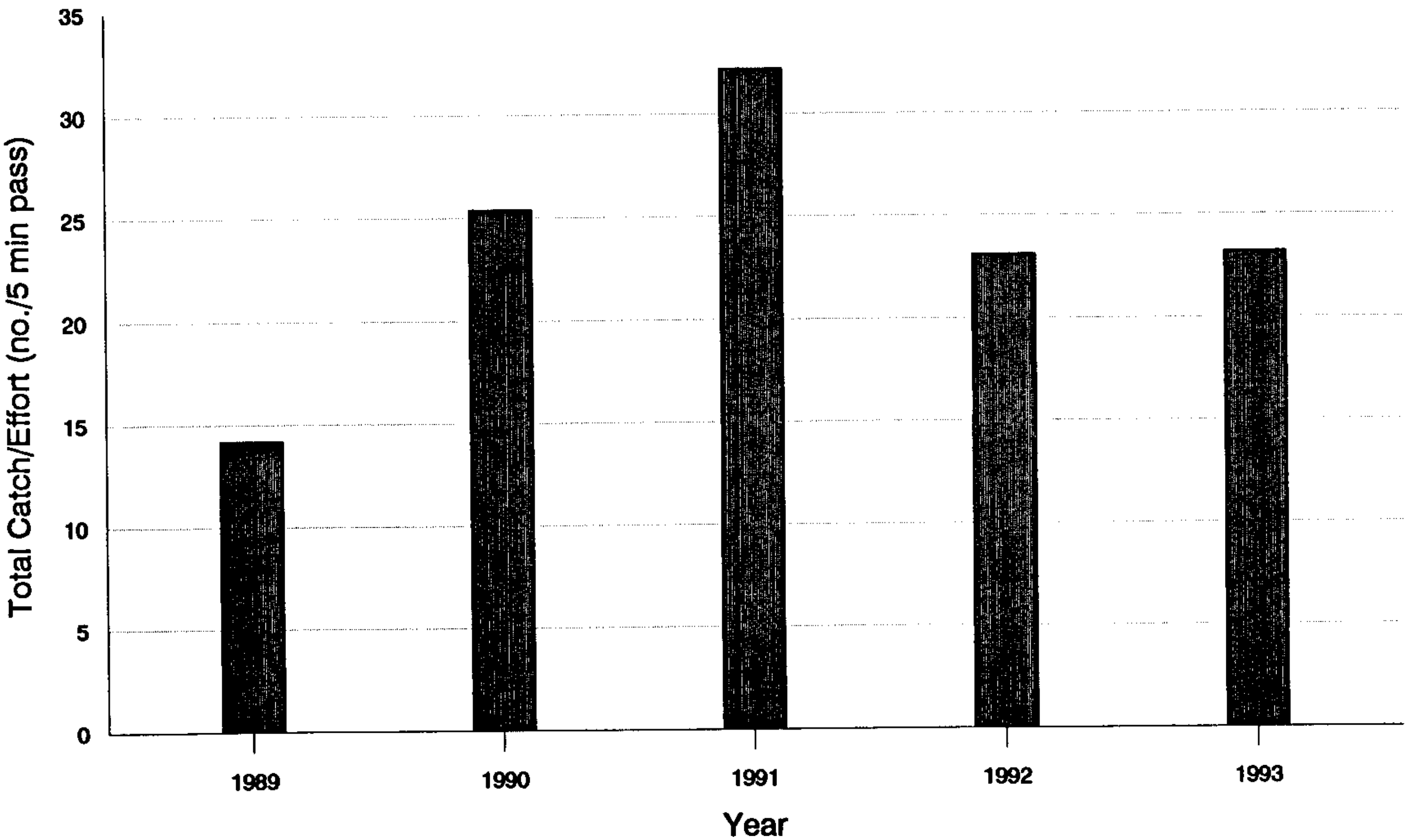


Figure 131. Trends in pooled fish abundance among shallow stations during 1989-1993 in Lower Granite Reservoir. Total catch/effort represents summed electrofishing catches (fish/5 min. pass) from mean spring species abundance at each station.

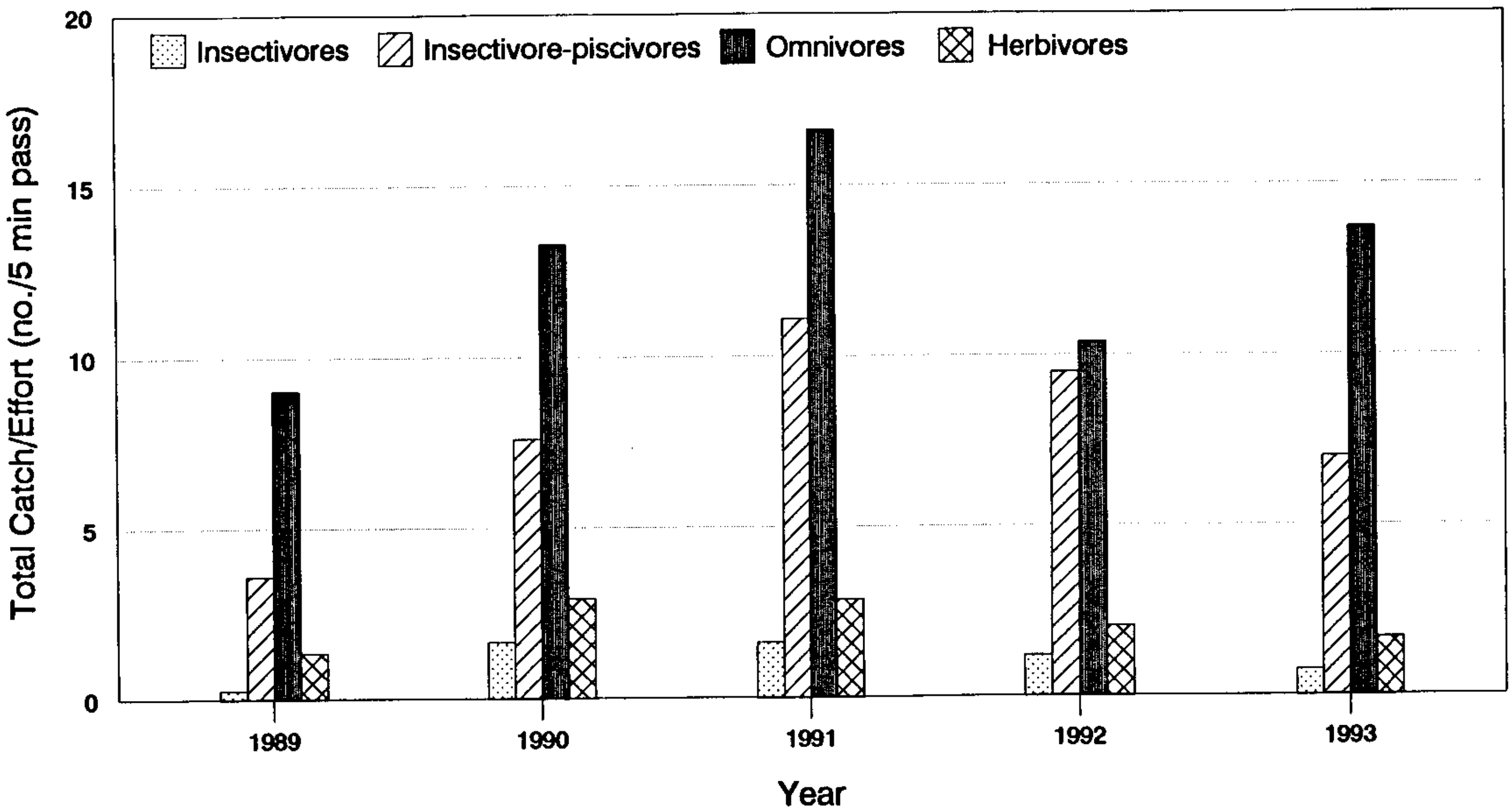


Figure 132. Trends in feeding guild abundance among shallow stations during 1989-1993 in Lower Granite Reservoir. Total catch/effort represents summed electrofishing catches from mean spring guild abundance at each station.

P=0.21) showed no selection for disposal or reference stations whereas herbivores (H; P=0.025) and insectivore-piscivores (IP; P=0.0004) were collected more frequently at reference stations than at disposal stations (Table 12). Higher combined abundance of herbivores and insectivore-piscivores at reference stations was responsible for an overall station effect (disposal versus reference; P=0.0003) but we observed no station effect through time (P=0.18). More importantly, we found no evidence of a year*station*guild interaction (P=0.62) indicating individual guilds showed no variation within years comparing disposal versus reference stations (Table 12; Figures 133-136). These results indicated that individual feeding guilds varied similarly across years at disposal and reference stations.

Station and Species Associations

The first principal component from the principal component analysis of the 1989 (species*station) data matrix accounted for 60% of the total variation in species abundance patterns (Table 13). Loadings along the first axis indicated that among shallow stations, station 10 and station 2 were most dissimilar based on species abundance patterns (Figure 137). Disposal station 4 was similar to reference stations 6 and 8 based on species abundance data. Station loadings generated from correspondence analysis indicated nearly identical patterns of station similarities, thus accounting for 21% of the total variation. We are reporting results from the principal components analysis since more of the variation was explained among sampling stations. Principal

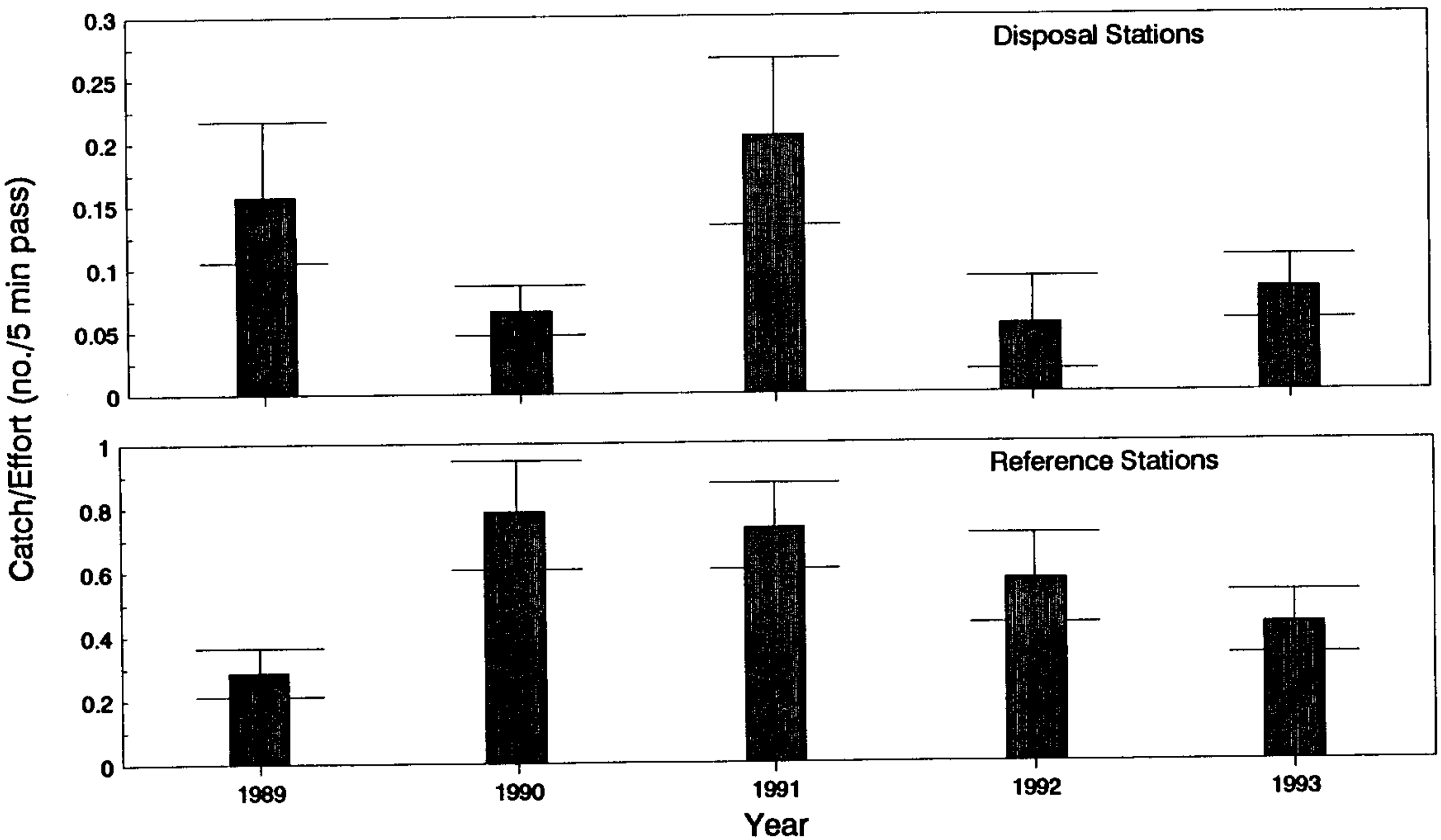


Figure 133. Trends in mean abundance of herbivores (chiselmouth) sampled by electrofishing at shallow disposal and reference stations during 1989-1993 in Lower Granite Reservoir. Horizontal lines represent ±1 standard error.

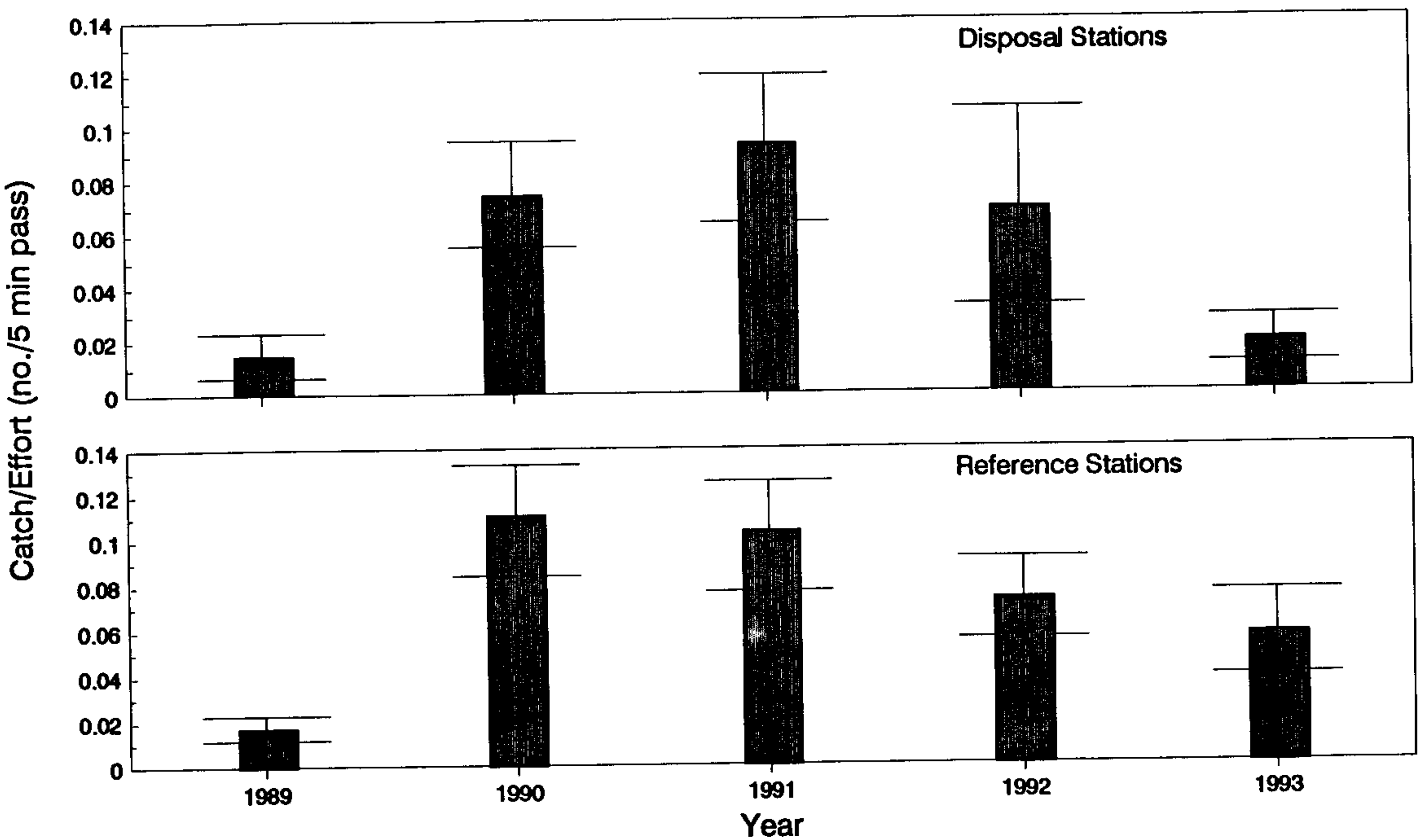


Figure 134. Trends in mean abundance of insectivore fishes at shallow disposal and reference stations sampled by electrofishing during 1989-1993 in Lower Granite Reservoir. Horizontal lines represent ± 1 standard error.

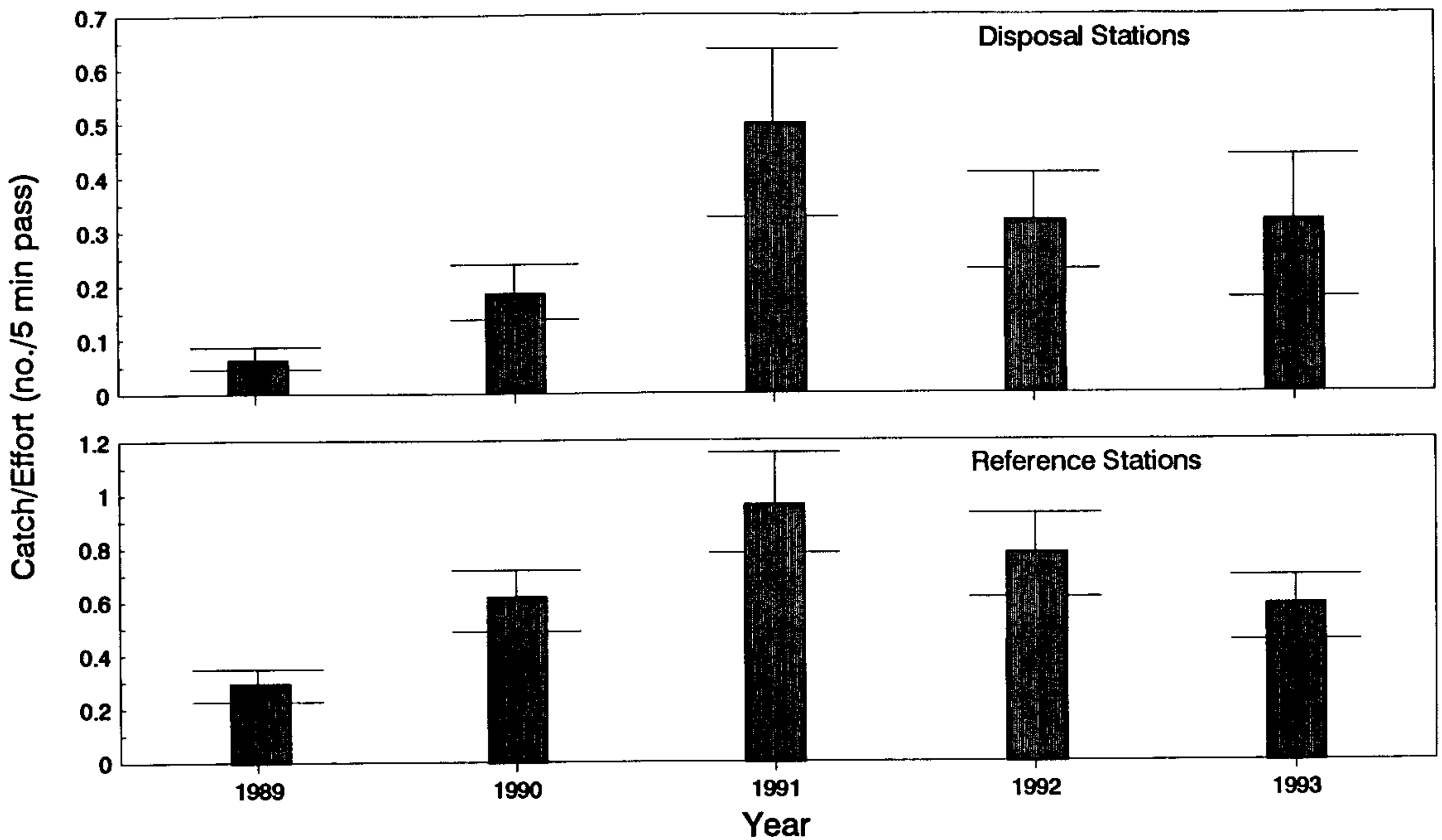


Figure 135. Trends in mean abundance of insectivore-piscivore fishes sampled by electrofishing at shallow disposal and reference stations during 1989-1993 in Lower Granite Reservoir. Horizontal lines represent ±1 standard error.

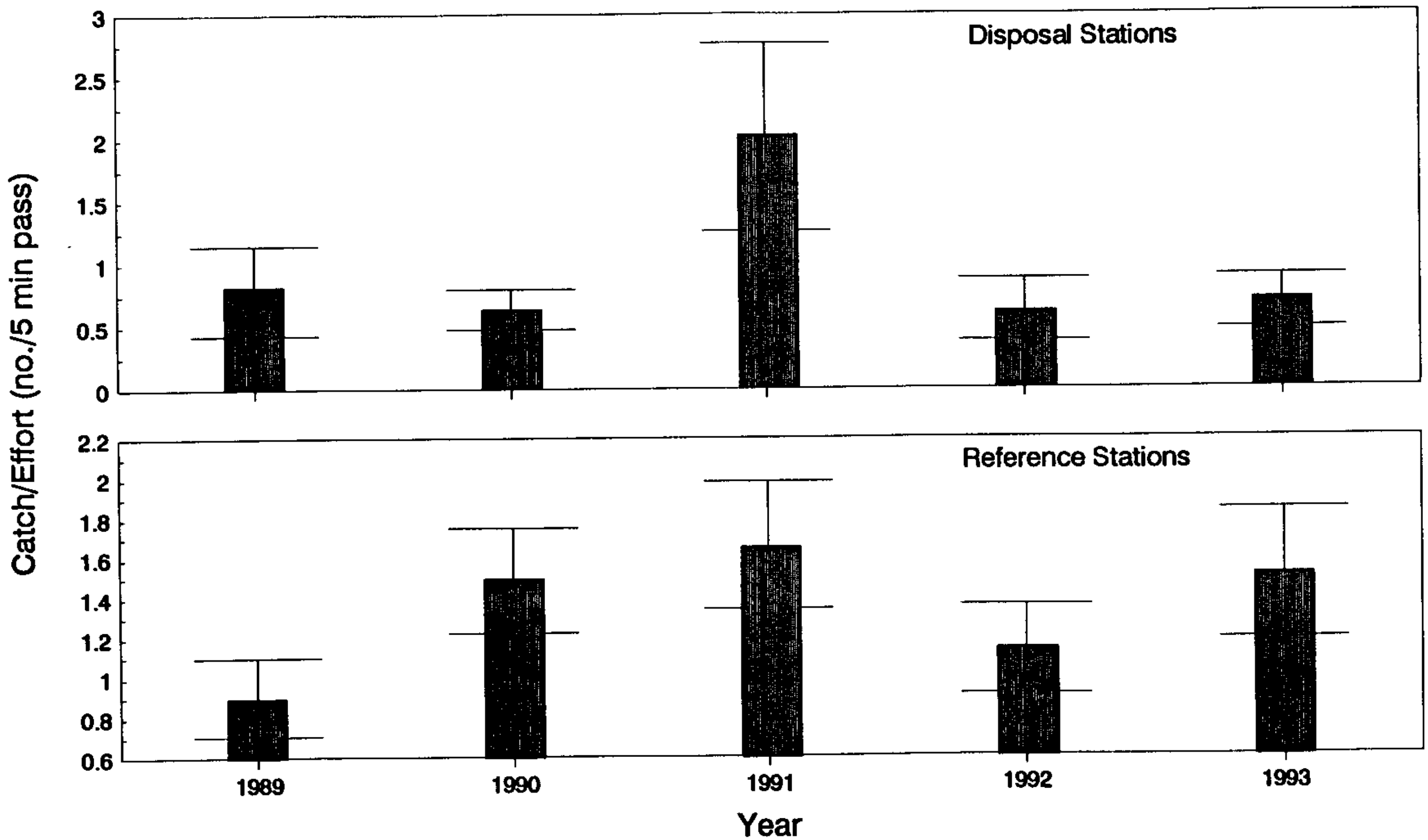


Figure 136. Trends in mean abundance of omnivore fishes sampled by electrofishing at shallow disposal and reference stations during 1989-1993 in Lower Granite Reservoir. Horizontal lines represent ±1 standard error.

Table 13. Loadings from the first principal component of a principal components analysis (PCA) of species assemblages for nine stations during 1989-1993 in Lower Granite Reservoir. Percent variation explained by first principal component in parentheses.

			PCA scores		
Station	1989 (60%)	1990 (47.9%)	1991 (49.3%)	1992 (44.2%)	1993 (44.2%)
1	0.089	0.110	0.412	0.179	1.655
2	-0.309	-0.383	-0.353	-0.007	-0.080
3	0.097	0.547	0.588	0.955	0.696
4	-0.712	-0.808	-0.928	-1.084	-0.824
5	0.182	0.390	1.324	0.887	0.652
6	-0.908	-0.889	-1.021	-0.898	-0.857
8	-1.020	-1.176	-1.121	-1.174	-1.222
9	0.297	0.682	0.167	0.633	-0.103
10	2.283	1.526	0.921	0.510	0.082

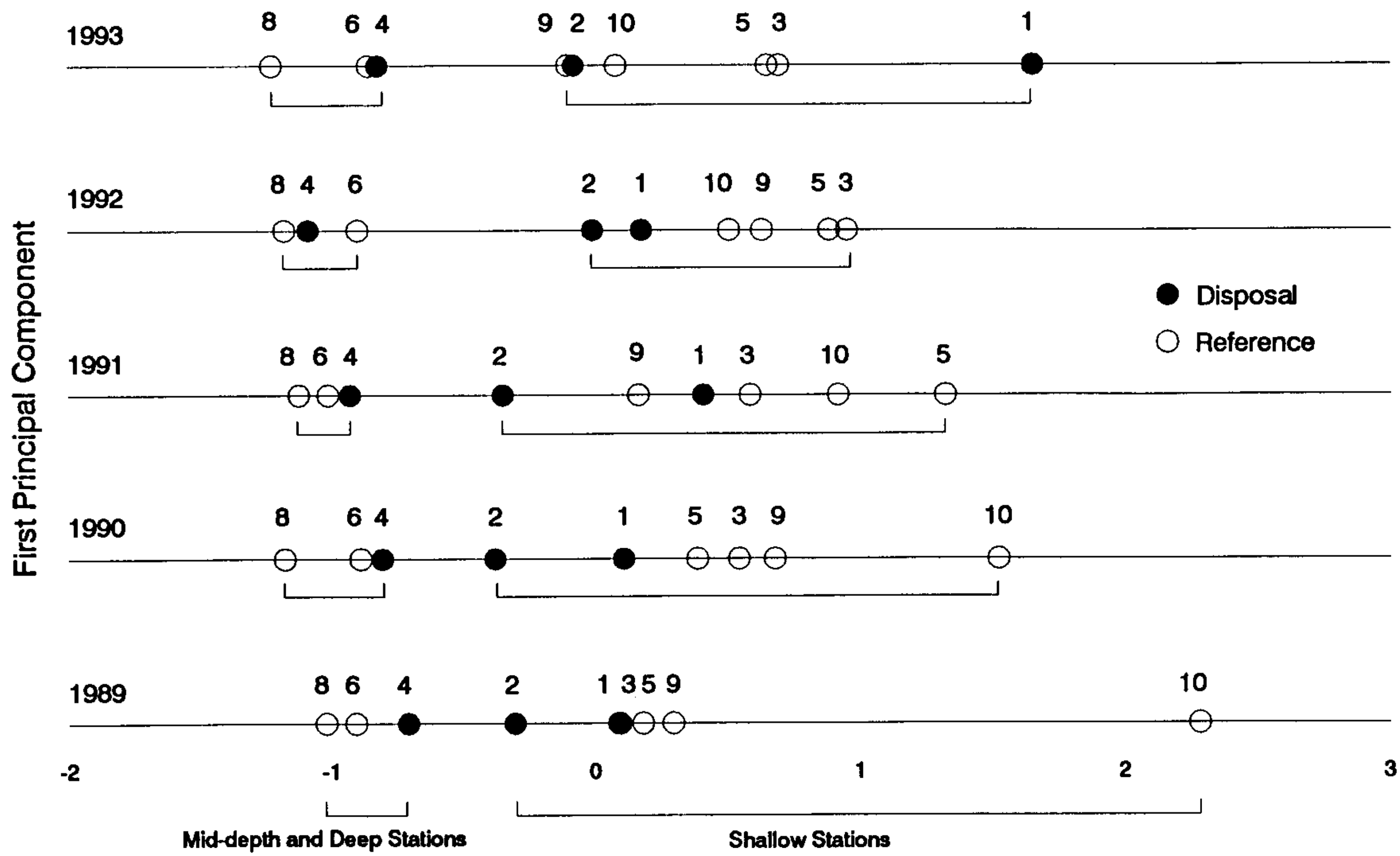


Figure 137. Sampling unit (station) loadings along the first principal (PC1) generated from each yearly species*station data matrix from sampling during 1989-1993 in Lower Granite Reservoir.

components ordination of the 1990 data matrix indicated patterns similar to 1989 in station loadings along the first PC, which accounted for 48% of the total variation in species abundance and composition (Table 13; Figure 137). Shallow disposal and reference stations were positively ordered along the first axis whereas mid-depth (disposal and reference) and deep stations were negatively positioned along the axis. Shallow stations 2 and 10 were most dissimilar in terms of species abundance and composition. The first principal component generated from the 1991 data matrix accounted for 49.3% of the total variation (Table 13). Station 10 was more similar to other shallow reference and disposal stations in 1991 than in 1989 and 1990, and station 5 was positively positioned along the right side of the axis (Figure 137). We observed increased abundance of several species in 1991 at station 5 compared to 1989 and 1990 (Figure 138). Increased abundance of largescale sucker, chiselmouth, peamouth *Mylocheilus caurinus*, smallmouth bass and northern squawfish were particularly notable.

The first principal components from the 1992 and 1993 data sets accounted for 44.2% (each) of the total variation in species abundance patterns (Table 13). We observed a different pattern of shallow station loadings for both years with stations 10, 9 and 1 accounting for most of the rearrangement in loadings along the first principal component axis (Fig. 137). Stations 9 and 10 were more similar during 1992 and 1993 than other years, though tended to 'shift' to the left, negatively, along each axis whereas station 1 was positively positioned along the first principal component axis in 1993. Overall, we observed more

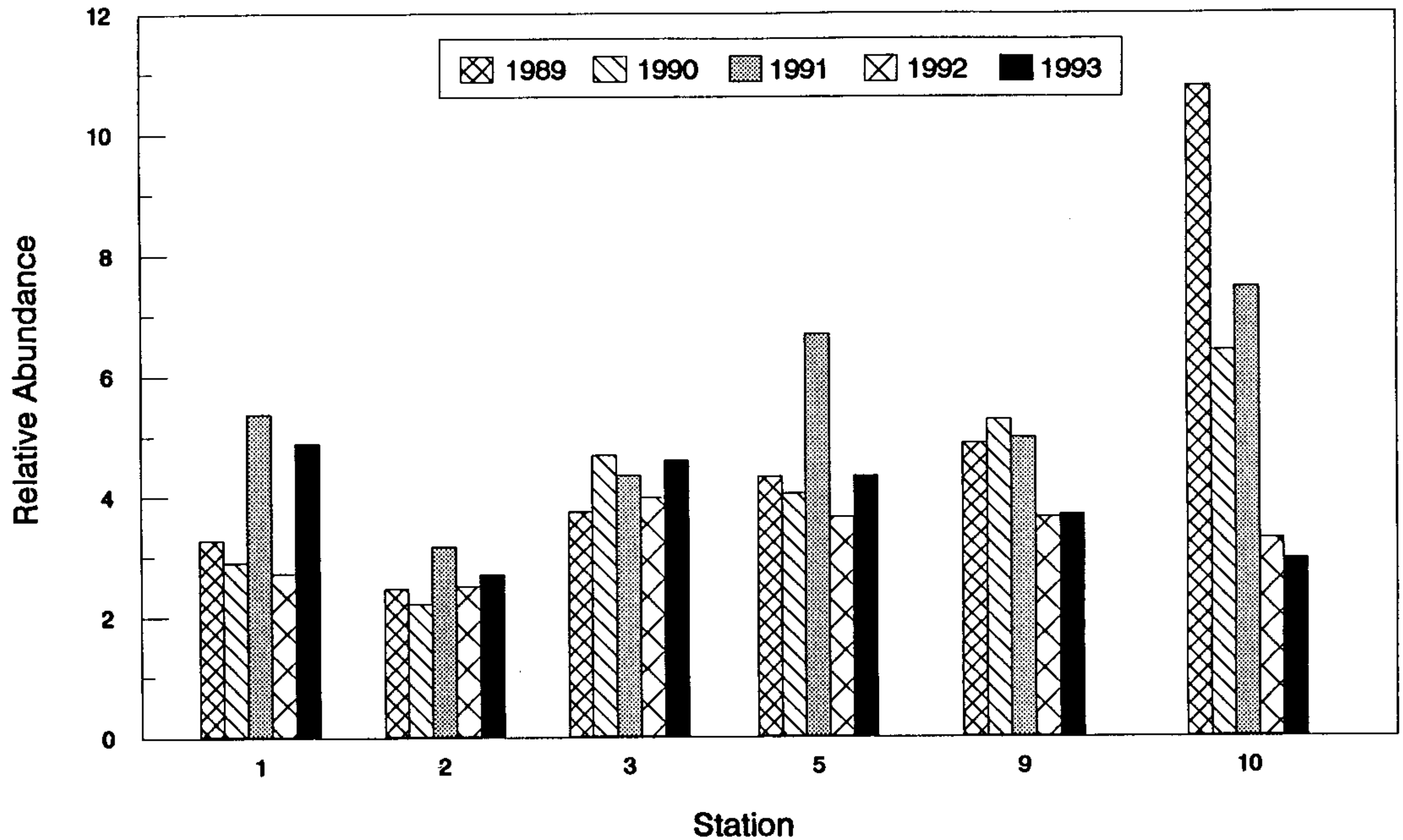


Figure 138. Pooled catch for resident fishes at shallow reference and disposal stations during 1989-1993 in Lower Granite Reservoir. The y-axis represents summed catch of log-transformed species relative abundances. The relative abundance index was derived by combining mean catch/efforts of spring beach seining and electrofishing.

variability among fish assemblages sampled at shallow stations (1, 2, 3, 5, 9 and 10) than mid or deep stations (4, 6, and 8; Figure 137). Among shallow stations sampled with the same gears, those positioned along the right of each principal component axis tended to have more species and higher overall fish abundance than stations positioned along the left of each axis.

We interpreted the variation in principal component loadings among shallow stations to be related to declines in overall fish abundance at stations 9 and 10 (Figure 138). Stations 1, 3 and 5 exhibited similar patterns of overall species abundance and tended to shift to the right along each axis during 1989 through 1993. Deep and mid-depth disposal and reference stations exhibited similar patterns in species composition and abundance throughout the study period.

After ordering stations for each yearly data set, station loadings appeared to be related to an underlying gradient of station depths. We examined this relationship by constructing bivariate plots of principal components analysis scores from the first principal component versus mean log-transformed station depths (ft). Although station depths likely changed with operational changes among years, relative differences should remain the same. From these comparisons, we observed significant correlations of station depths with principal component loadings for each yearly data set (Figures 139-143). These plots support patterns observed in species abundance in that yearly variability among fish assemblages seems to increase as stations become more shallow. This was particularly noticeable among stations 10 (the

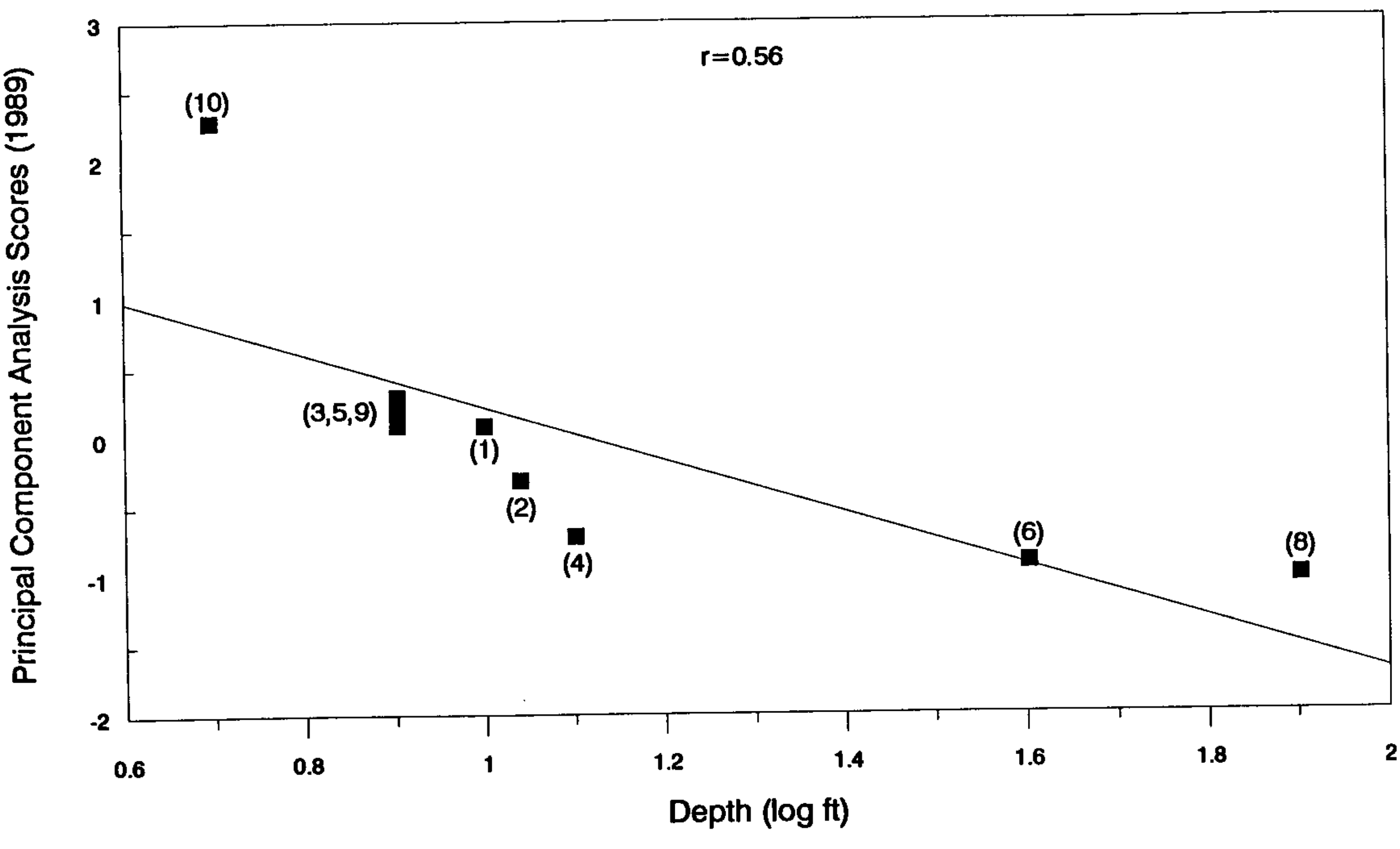


Figure 139. Relationship between station depths and community composition based on 1989 principal component analysis loadings from the first principal component. The X-axis represents mean log-transformed station depths. Stations indicated in parentheses.

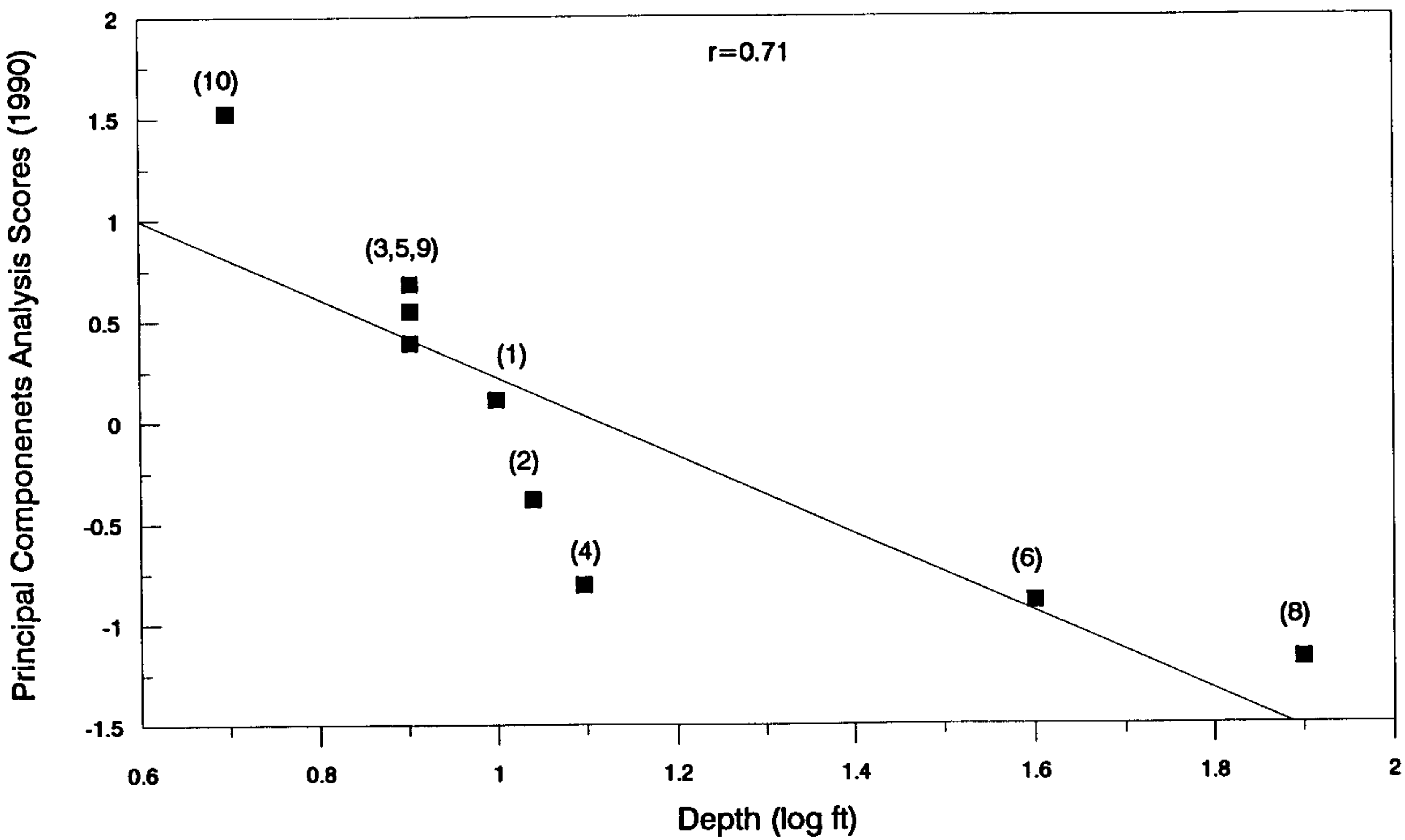


Figure 140. Relationship between station depths and community composition based on 1990 principal components analysis loadings from the first principal component. The X-axis represents mean log-transformed station depths. Stations indicated in parentheses.

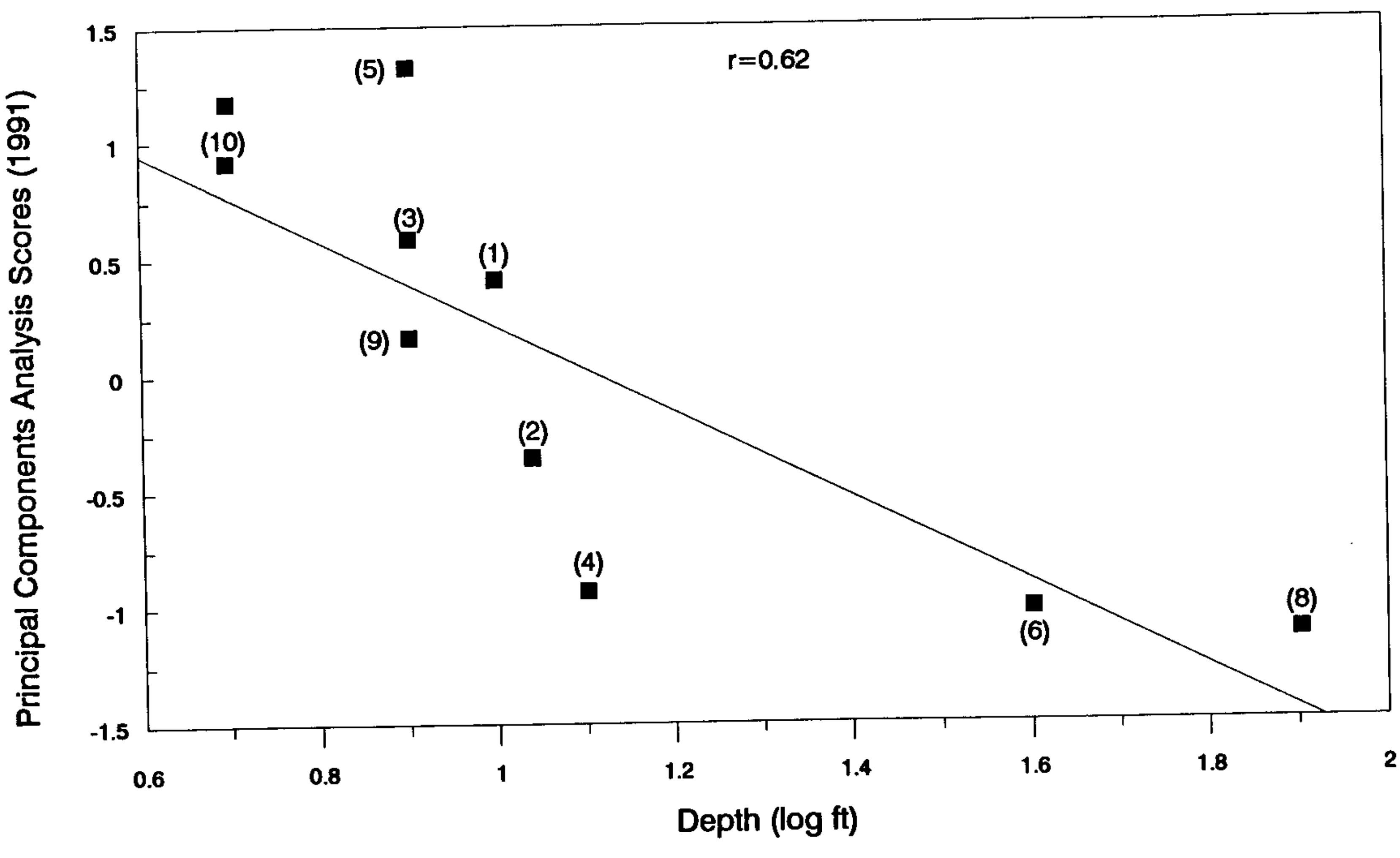


Figure 141. Relationship between station depths and community composition based on 1991 principal components analysis loadings from the first principal component. The x-axis represents mean log-transformed station depths. Stations indicated in parentheses.

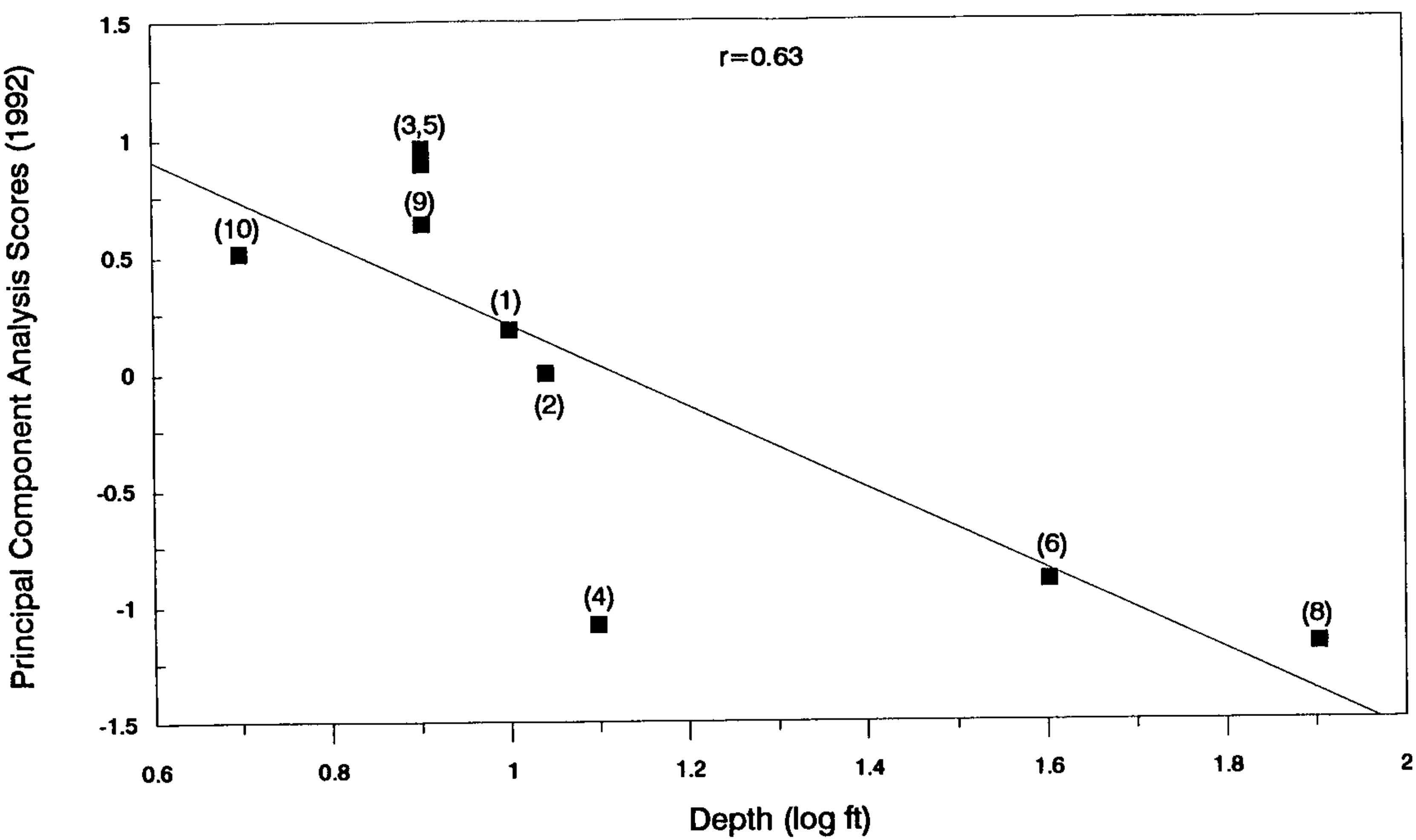


Figure 142. Relationship between station depths and community composition based on 1992 principal components analysis loadings from the first principal component. The X-axis represents mean log-transformed station depths. Stations indicated in parentheses.

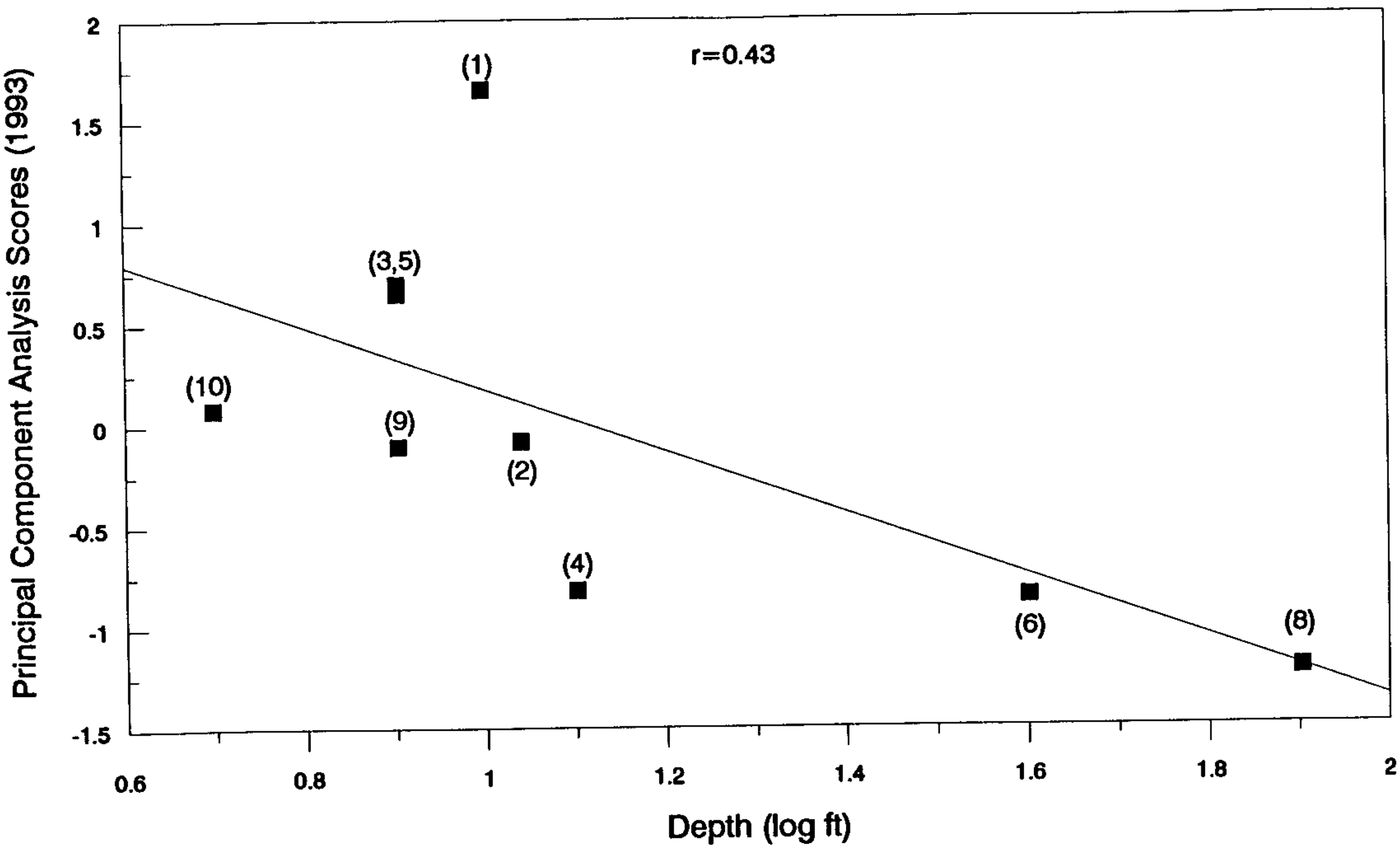


Figure 143. Relationship between station depths and community composition based on 1993 principal components analysis loadings from the first principal component. The X-axis represents mean log-transformed station depths. Stations indicated in parentheses.

shallowest station), 5 and 9. Similarly, fish assemblages at deep and mid-depth stations exhibited a higher degree of stability in species composition and abundance across years. However, stations 5 and 9 had fewer species and lower overall total catches compared to shallow stations (Bennett et al. 1989, 1990, 1991, 1993b, 1994d).

We evaluated species associations at shallow disposal and reference stations by creating two (disposal and reference) species*year data matrices. We pooled electrofishing catch rates for each species by station type (disposal or reference) and summarized catches by year. We wanted to evaluate whether species associations at disposal stations were similar to those at reference stations from 1989 through 1993. A total of nine resident species were represented in electrofishing collections from shallow stations during 1989 through 1993 (Table 14). We omitted yellow perch because of low frequency of occurrence (2 of 5 years) at both disposal and reference stations.

The first principal component from each data matrix indicated species associations were similar across years (Table 15). Largescale sucker, pumpkinseed, smallmouth bass and northern squawfish were positively correlated with the first principal component generated from each data set (disposal and reference). Chiselmouth were more frequently encountered at reference stations during the study whereas peamouth appeared to be a more important assemblage member at disposal stations during 1989 through 1993 (Table 15). Bivariate plots of the first principal component from each data set were significantly correlated ($r=0.76$, $P=0.015$) indicating species associations at disposal

Table 14. Nine resident fishes represented in electrofishing catches at shallow disposal and reference stations during 1989-1993 in Lower Granite Reservoir.

Species	Code	Feeding guild
Chiselmouth	AAL	Herbivore
Bridgelip sucker	CCO	Omnivore
Largescale sucker	CMA	Omnivore
Pumpkinseed	LGI	insectivore
Peamouth chub	MCA	insectivore
Redside shiner	RBA	insectivore
Smallmouth bass	MDO	insectivore-piscivore
Northern squawfish	POR	insectivore-piscivore
White crappie	PAN	insectivore-piscivore

Table 15. Species correlations with the first and second principal component (PC) from an ordination of species abundance * year for shallow disposal and reference stations. Asterisk indicates significant correlations along first principal component.

	Disposal stations		Reference stations	
Species	PC 1	PC 2	PC 1	PC 2
AAL	0.56	-0.13	0.96*	-0.23
CCO	0.15	-0.94	0.63	-0.50
CMA	0.91*	-0.24	0.76*	-0.14
LGI	0.87*	-0.46	0.90*	0.26
MCA	0.89*	0.41	0.47	0.62
MDO	0.79*	-0.25	0.91*	0.28
PAN	-0.44	-0.82	-0.33	0.34
POR	0.71*	0.50	0.91*	0.35
RBA	-0.36	0.10	0.38	-0.90

stations were similar to those at reference stations during 1989 through 1993. Additionally, principal components analysis comparisons among years indicated similar trends in overall fish abundance at disposal and reference stations (Table 16). Loadings for 1991 (disposal and reference) were positively positioned along the right of each axis, indicative of the high catch rates observed throughout the reservoir during that year (Table 16). These trends indicate fish abundance and composition responded similarly at disposal and reference stations among years.

Stability and Persistence of the Fish Community from 1985 through 1993 in Lower Granite Reservoir

We observed significant concordance ($P<0.001$) of ranked species abundance across years for both the upper and lower reservoir stations (Tables 17 and 18). The original data sets contained 13 resident species. We randomly selected five and three species from each station to evaluate the effects of decreased sample sizes. Concordance of species abundance for the reduced number of species were also significant ($P<0.01$, for $n=5$ and $n=3$ at both stations) indicating similarities in species abundance across years were likely inherent in the data, and concordance observed in the original data ($n=13$) was less likely an artifact of the Kendall's test statistic.

Resident fish assemblages at upper and lower stations exhibited stability in ranked species abundance during 1985 through 1993. Although these assemblages appeared to be highly structured and

Table 16. Loadings of years along the first principal component from an ordination of species abundance * year for shallow disposal and reference stations.

Year	Disposal stations	Reference stations
1989	-0.68	-1.7
1990	-0.72	0.66
1991	1.71	1.08
1992	0.18	0.38
1993	-0.49	-0.42

Table 17. Ranked abundance of resident fishes at the upper station (station 5) in Lower Granite Reservoir during April through June, 1985-1993.

	Year							
Species	85	87	88	89	90	91	92	93
AAL	9	11	7	12	11	11	10	11
CCA	8	7	8	8	5	1.5	4	5
CCO	5	4.5	6	3	9	7	7	6
CMA	10	13	13	13	13	13	13	13
INE	1.5	2.5	2.5	4	8	4	5	4
IPU	1.5	2.5	2.5	2	1	1.5	2	2
LGI	3	1	4	6	4	9	6	7
MCA	11	8.5	9	5	2	5	2	2
MDO	7	6	12	10	12	10	12	12
PAN	6	12	5	9	7	8	9	9
PFL	4	4.5	10	7	6	6	8	8
POR	13	10	11	11	10	12	11	10
RBA	12	8.5	1	1	3	3	2	2

Table 18. Ranked abundance of resident fishes at the lower station (station 9) in Lower Granite Reservoir during April through June, 1985-1993.

	Year							
Species	85	87	88	89	90	91	92	93
AAL	9	10	10	11	11	11	11	10.5
CCA	5	6	2	6	7.5	3.5	3	7
CCO	7	6	11	10	10	9	7	8
CMA	11	13	13	13	13	13	13	13
INE	2	1.5	5.5	4	5	3.5	6	3
IPU	1	1.5	2	2	2.5	3.5	3	3
LGI	3.5	3	8.5	8	9	10	10	10.5
MCA	10	4	2	5	2.5	3.5	3	3
MDO	8	12	12	12	12	12	12	12
PAN	6	9	5.5	7	6	8	8	9
PFL	3.5	8	5.5	2	2.5	3.5	3	3
POR	12	11	5.5	9	7.5	7	9	6
RBA	13	6	8.5	2	2.5	3.5	3	3

persistent throughout the study period, we did observe significant variation in total relative abundance from year to year (station 5 P=0.05; station 9 P=0.002; Figure 144). Total fish abundance was significantly higher in 1985 than in other years at both stations (P<0.05, Duncan's multiple comparison test). Total fish abundance at both stations was similar for the years 1987 through 1993 (Figure 144). Since total relative abundance represents the summed abundance of all 13 resident species, the decline from 1985 may be weighted by one or more species. To evaluate which species exhibited the largest declines, we constructed bivariate plots of species abundance by year for each gear type used at each station. We observed negative correlations of species abundance with years for nearly all species for the beach seining data (Tables 19 and 20). We looked for species that declined significantly at both stations for a given gear type in attempts to reveal consistent patterns. Since the stations were separated spatially, we assumed these patterns would be indicative of a reservoir-wide decline among similar habitat types. Carp, peamouth, northern squawfish, redside shiner *Richardsonius balteatus* and to a lesser degree bridgelip *Catostomus columbianus* sucker and largescale sucker abundances, decreased significantly (P<0.03) at both stations in beach seine catches (Tables 19 and 20). Similarly, gill net catches from station 5 indicated highly significant declines (P<0.002) in redside shiner, carp, and northern squawfish abundance (Table 21). Electrofishing catches at both stations were more variable with some species exhibiting significant increases in abundance (Tables 22 and 23). Largescale sucker, smallmouth bass, white

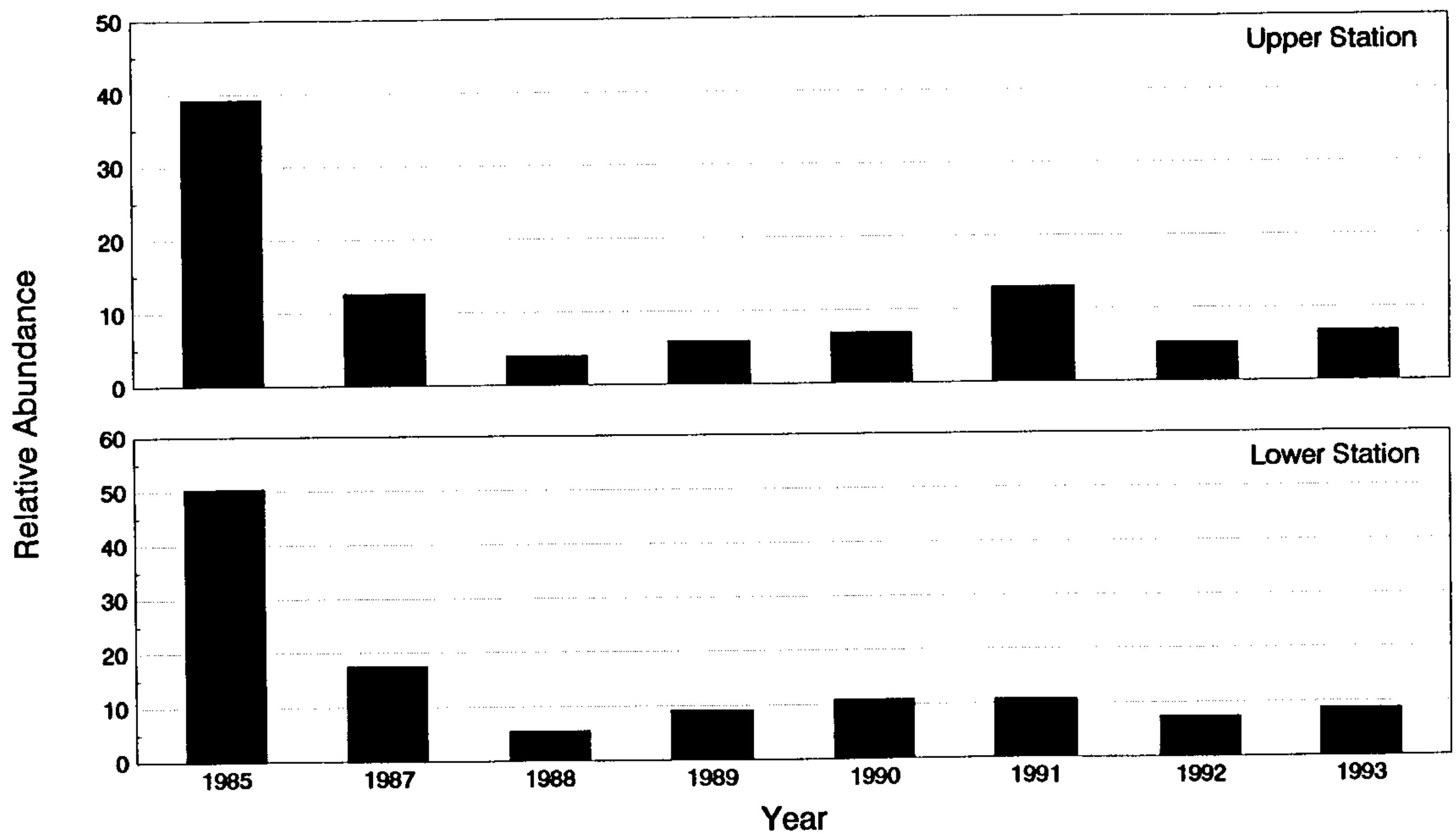


Figure 144. Pooled catch for 13 resident fishes in the upper (station 5) and lower (station 9) sections of Lower Granite Reservoir during 1985-1993. The y-axis represents summed relative abundance from combined gear types used consistently at each station. No collections were made during spring 1986.

Table 19. Correlations of beach seine catches (n=50) with years (1985-1993) for the upper station (5) in Lower Granite Reservoir. * indicates significant correlations.

Species	Correlation (Spearman's)	P (R)=0
AAL	-0.132	0.3608
CCA	-0.368	0.0085*
CCO	-0.323	0.020*
CMA	-0.323	0.021*
INE	----	----
IPU	----	----
LGI	----	----
MCA	-0.517	0.0001*
MDO	-0.012	0.932
PAN	-0.199	0.165
PFL	-0.061	0.671
POR	-0.335	0.017*
RBA	-0.450	0.001*

Table 20. Correlations of beach seine catches (n=42) with years (1985-1993) for the lower station (9) in Lower Granite Reservoir. * indicates significant correlations.

Species	Correlation (Spearman's)	P (R)=0
AAL	-0.515	0.0005*
CCA	-0.374	0.0145*
CCO	-0.484	0.001*
CMA	-0.679	0.0001*
INE	----	----
IPU	----	----
LGI	-0.293	0.06
MCA	-0.652	0.0001*
MDO	-0.063	0.690
PAN	-0.538	0.0002*
PFL	-0.436	0.003*
POR	-0.710	0.0001*
RBA	-0.630	0.0001*

Table 21. Correlations of gill net catches (n=34) with years (1985-1993) for the upper station (5) in Lower Granite Reservoir. * indicates significant correlations.

Species	Correlation (Spearman's)	P (R)=0
AAL	0.049	0.780
CCA	-0.665	0.0001*
CCO	0.073	0.678
CMA	0.513	0.0019*
INE	0.238	0.173
IPU	0.111	0.530
LGI	0.118	0.502
MCA	0.013	0.938
MDO	0.170	0.335
PAN	0.057	0.747
PFL	-0.171	0.331
POR	-0.585	0.0003*
RBA	-0.530	0.0012*

Table 22. Correlations of electrofishing catches (n=39) with years (1985-1993) for the upper station (5) in Lower Granite Reservoir. * indicates significant correlations.

Species	Correlation (Spearman's)	P (R)=0
AAL	0.417	0.008*
CCA	0.001	0.999
CCO	0.179	0.274
CMA	0.376	0.018*
INE	0.083	0.612
IPU	----	----
LGI	0.276	0.088
MCA	0.002	0.986
MDO	0.415	0.008*
PAN	0.327	0.041*
PFL	0.012	0.938
POR	0.135	0.411
RBA	0.001	0.999

Table 23. Correlations of electrofishing catches (n=36) with years (1985-1993) for the lower station (9) in Lower Granite Reservoir. * indicates significant correlations.

Species	Correlation (Spearman's)	P (R)=0
AAL	0.002	0.989
CCA	----	----
CCO	-0.447	0.006*
CMA	0.612	0.0001*
INE	-0.091	0.596
IPU	----	----
LGI	0.605	0.0001*
MCA	-0.153	0.371
MDO	0.179	0.295
PAN	0.507	0.001*
PFL	-0.205	0.228
POR	0.020	0.907
RBA	-0.507	0.0016*

crappie *Poxomis annularis* and pumpkinseed *Lepomis gibbosus* abundances generally have increased in electrofishing catches since 1985. Patterns in species abundance are somewhat obscured by size and species-selectivity of the different gear types. However, we identified five species that were most likely responsible for the overall decreased catch observed in the comparisons of total catch for 1985 through 1993. Overall, redside shiner, peamouth, bridgelip sucker, northern squawfish and carp abundances were significantly lower during 1987 through 1993 than 1985. These declines are particularly noticeable in beach seine catches, although for some species the pattern is also observed in gill net, and to a lesser degree, electrofishing catches.

Abundances of feeding guilds for the upper and lower stations indicated general increases in omnivorous species following 1985 whereas the abundances of insectivore and insectivore-piscivore guilds have declined since the mid-1980s (Figure 145). Trends in relative abundance of herbivores and omnivores were variable during 1985 through 1993 and did not exhibit similar patterns of overall decline at both stations (Figure 145).

DISCUSSION

Community Comparisons, Disposal vs. Reference Stations from 1989 through 1993

Feeding Guilds

Feeding guild abundance at disposal and reference stations varied from year to year. We observed higher abundance of herbivores and

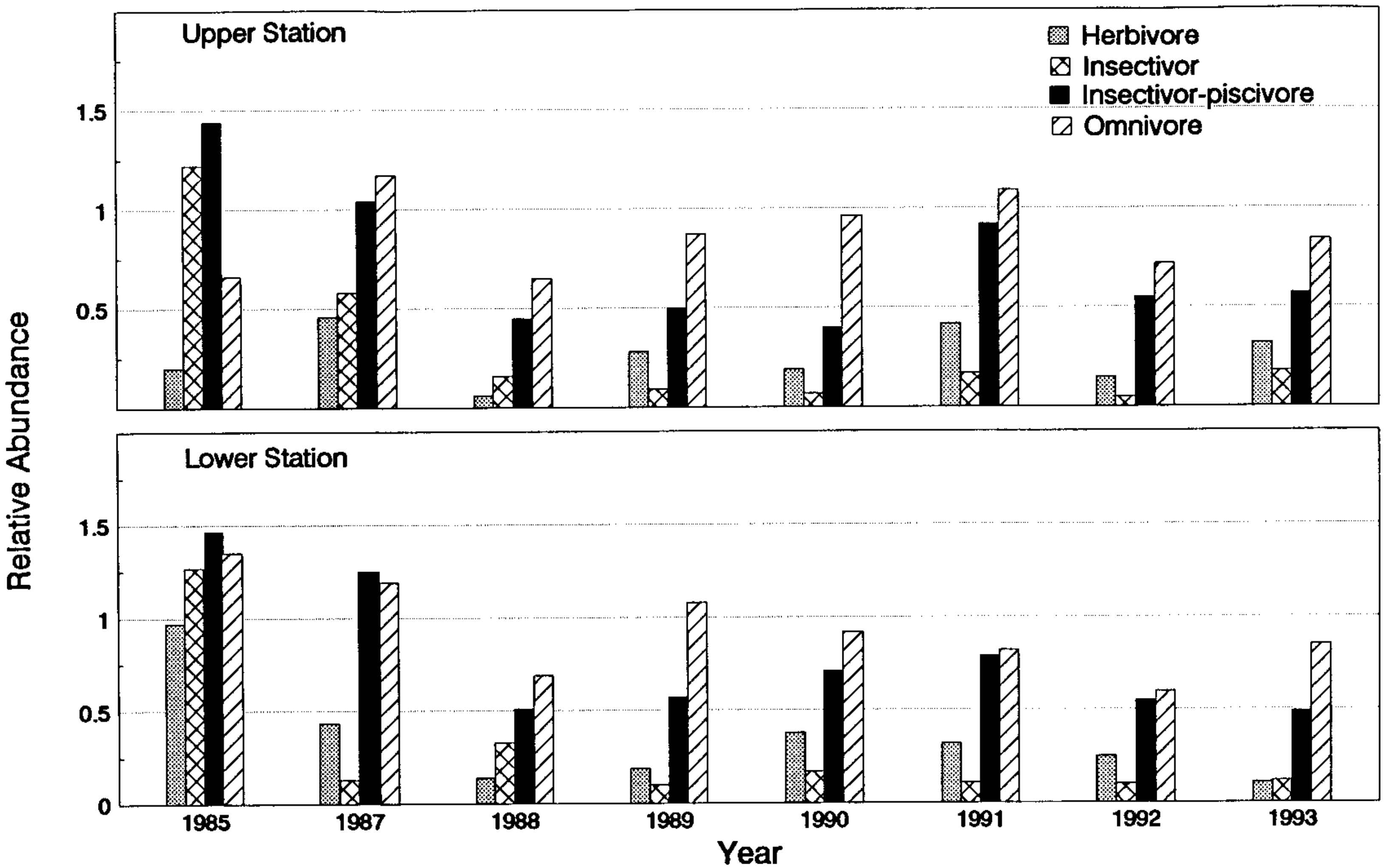


Figure 145. Relative abundance of feeding guilds in upper (station 5) and lower (station 9) sections in Lower Granite Reservoir during April to June, 1985-1993. The y-axis represents log-transformed feeding guild abundances from gear types used consistently at each station.

insectivore-pisivores at reference stations during 1989 through 1993. The herbivore guild was represented by a single species, chiselmouth, and hence is weighted solely by changes in the abundance of this species. Chiselmouth were frequently collected at reference stations 9 and 10, the two shallowest stations sampled. Because chiselmouth feed on attached algae, their occurrence and abundance may be related to an underlying depth gradient (e.g. occur more frequently at shallower stations). Additionally, since guild comparisons were made using electrofishing data, higher catch rates of chiselmouth may be related to higher gear susceptibility in shallow water. Similarly, members of the insectivore-piscivore guild (smallmouth bass, northern squawfish, crappie) may be more susceptible to electrofishing at shallower reference stations (stations 5, 9 and 10) than at relatively deeper disposal stations (stations 1 and 2). Since water depth is an important factor regulating both community composition and gear efficiency, variability in overall guild abundance (disposal versus reference) might be expected given the disparity in station depths. Consequently, to test the hypothesis of equal abundance among feeding guilds at stations (disposal versus reference) where water depths could not be controlled is not realistic. A more reasonable hypothesis, from the standpoint of disposal versus reference stations, is to examine trends in guild abundance through time comparing disposal to reference stations (e.g. the goal of the repeated measures analysis of variance). Testing this hypothesis, we found guild abundance at disposal stations varied similarly to guild abundance at reference stations through time (no significant difference). We found no evidence that insectivore-piscivores, for example, increased at disposal stations while they decreased at reference stations across time. Rather, we observed responses which appeared to be regulated by reservoir-wide factors that affected guild abundance at disposal and reference stations equally.

Station and Species Associations

We found no evidence that fish assemblages at disposal stations had lower species richness or higher percent tolerant species than reference stations. Rather, we observed variable community composition as a function of average station depths. Colonization and resulting community structure near the disposal island, stations 1 and 2, were similar to reference stations (3 and 5) with similar depths. Species associations at disposal stations were also similar to those at reference stations during 1989 through 1993. Moreover, these associations responded similarly through time indicating reservoir-wide effects were more important in regulating year-to-year variation in community composition than localized habitat characteristics. We hypothesize that fish assemblages among shallow stations may be more susceptible to environmental factors (e.g. flows, drawdowns, etc.) and exhibit more variable responses to reservoir perturbations than those in deeper waters.

Stability and Persistence of the Fish Community from 1985 through 1993 in Lower Granite Reservoir

Ranked species abundance at upper and lower stations in Lower Granite Reservoir was persistent throughout the study despite a wide array of environmental influences. However, the abundance of several species, particularly cyprinids, declined through time. The reduced abundance of cyprinids (insectivore fishes) occurred early in the study, between 1985 and 1987, before several environmental changes occurred (minimum operating pool, Bennett et al. 1994a; increased cold water releases from upstream, Bennett et al. 1994c, 1994d; and the 1992 experimental test drawdown, Bennett et al. 1994b). Species ranks were similar from 1987 through 1993 exhibiting little variation and hence accounted for the significant association observed across years.

Although community structure was generally persistent throughout the study, we did observe significant declines in overall relative abundance from 1985. These declines were related to reduced abundance of juvenile and adult redside shiners, peamouth, carp and northern squawfish. Conversely, centrarchid fishes exhibited increased abundance and were positively correlated with years at stations 5 and 9. These species included smallmouth bass, pumpkinseed and crappie. Additionally, electrofishing catch rates for largescale sucker have increased significantly since 1985.

The insectivore and insectivore-piscivore feeding guilds dominated community composition in 1985 but quickly diminished by 1987. Feeding guild structure has been fairly constant from 1987 through 1993, dominated by omnivorous species (e.g. suckers, carp, bullhead, etc.). This pattern has prompted several hypotheses related to patterns in feeding guild abundance in Lower Granite Reservoir and implications thereof. First several system-wide disturbances have occurred in Lower Granite Reservoir since 1985. With the exception of station depths, we found no apparent relationships between environmental variables (e.g. water temperatures, forebay elevations, etc.) and patterns of community composition. In the case of reservoir inflows, we observed an interesting, although not definitive, pattern between total relative abundance and previous mean yearly inflows (Figure 146). Bivariate plots of mean yearly inflows (1985-1993) and species relative abundance (one year later) indicated that redside shiner, bridelip sucker and northern squawfish abundance which accounted for most of the decline from 1985 to 1987 were positively correlated to flows at both stations (Figures 147-149). It is also interesting to note negative correlations between pumpkinseed abundance and mean yearly inflows at both stations (upper r=-0.71, P=0.04; lower r=-0.27, P=0.50).

High average yearly flows were correlated with water turbidity (r=0.97; Figure 150). Turbid conditions in Lower Granite Reservoir might relate into reduced predator efficiency during late spring/early summer when YOY fishes begin to forage, hence reducing mortality on YOY fishes and increasing their abundance in the following spring catch. Additionally, increased flows might relate into short-term increases in habitat volume (e.g. more wetted area) resulting in more shallow water rearing environment and better summer/fall survival.

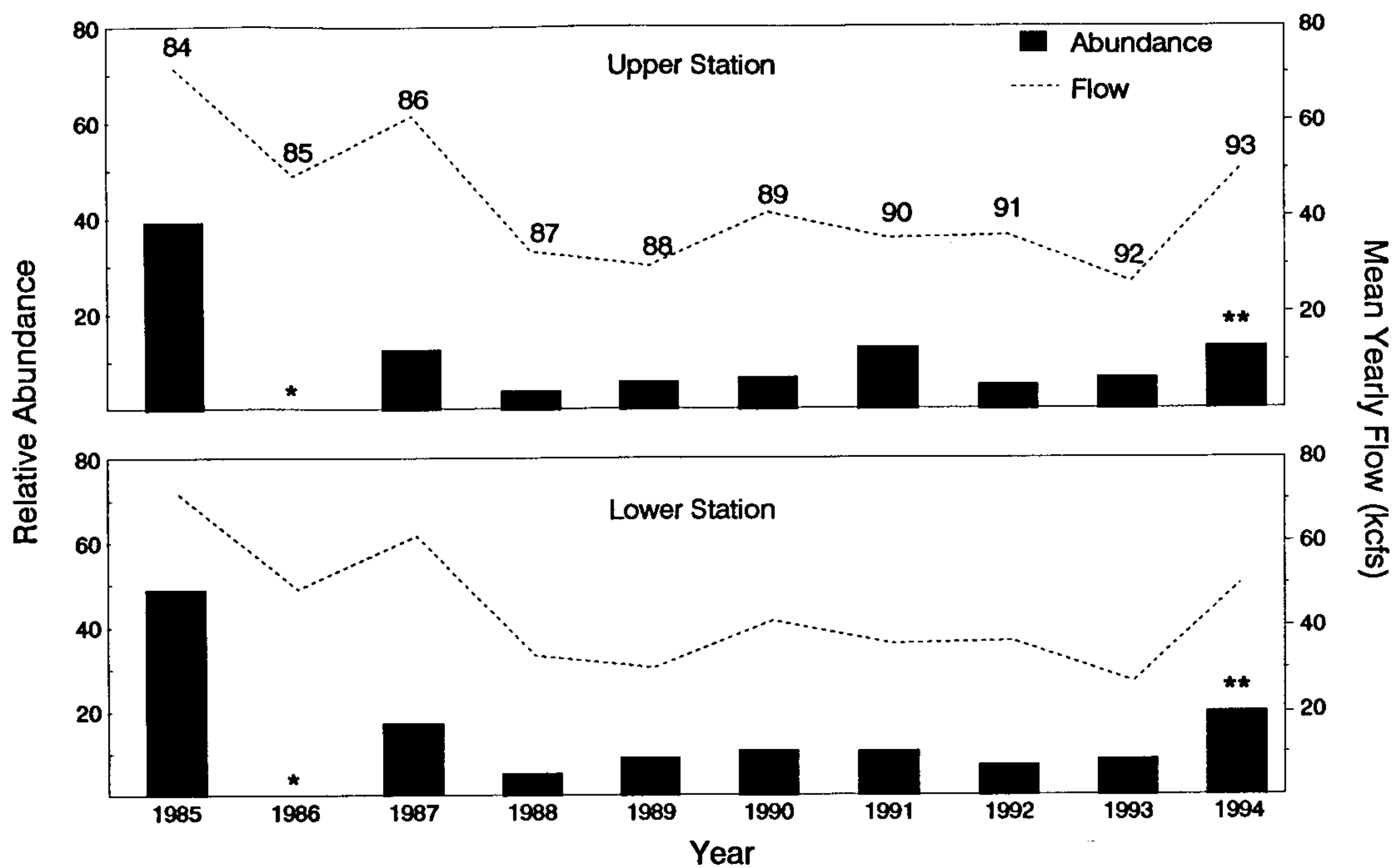


Figure 146. Patterns of reservoir inflows and relative abundance (one year later) at two stations (upper, 5; lower, 9) during 1985-1994 in Lower Granite Reservoir. * no collections were made in 1986. ** relative abundance in 1994 represents electrofishing data, not a combined index as other years, and likely underestimates relative abundance compared to other years.

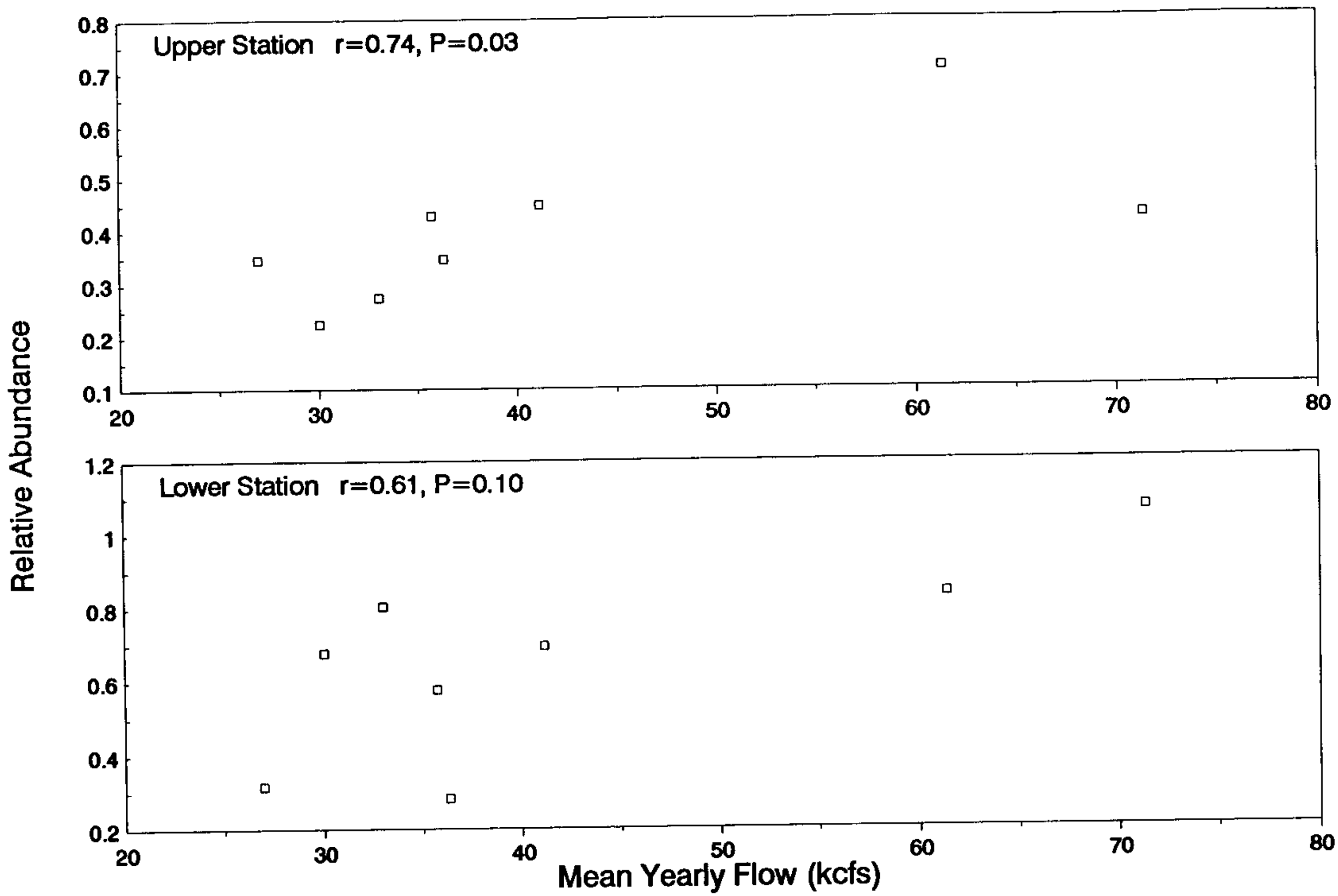


Figure 147. Bivariate plot of mean yearly inflow versus relative abundance for bridgelip sucker (1 year later) at upper (station 5) and lower (station 9) stations in Lower Granite Reservoir during 1985-1993.

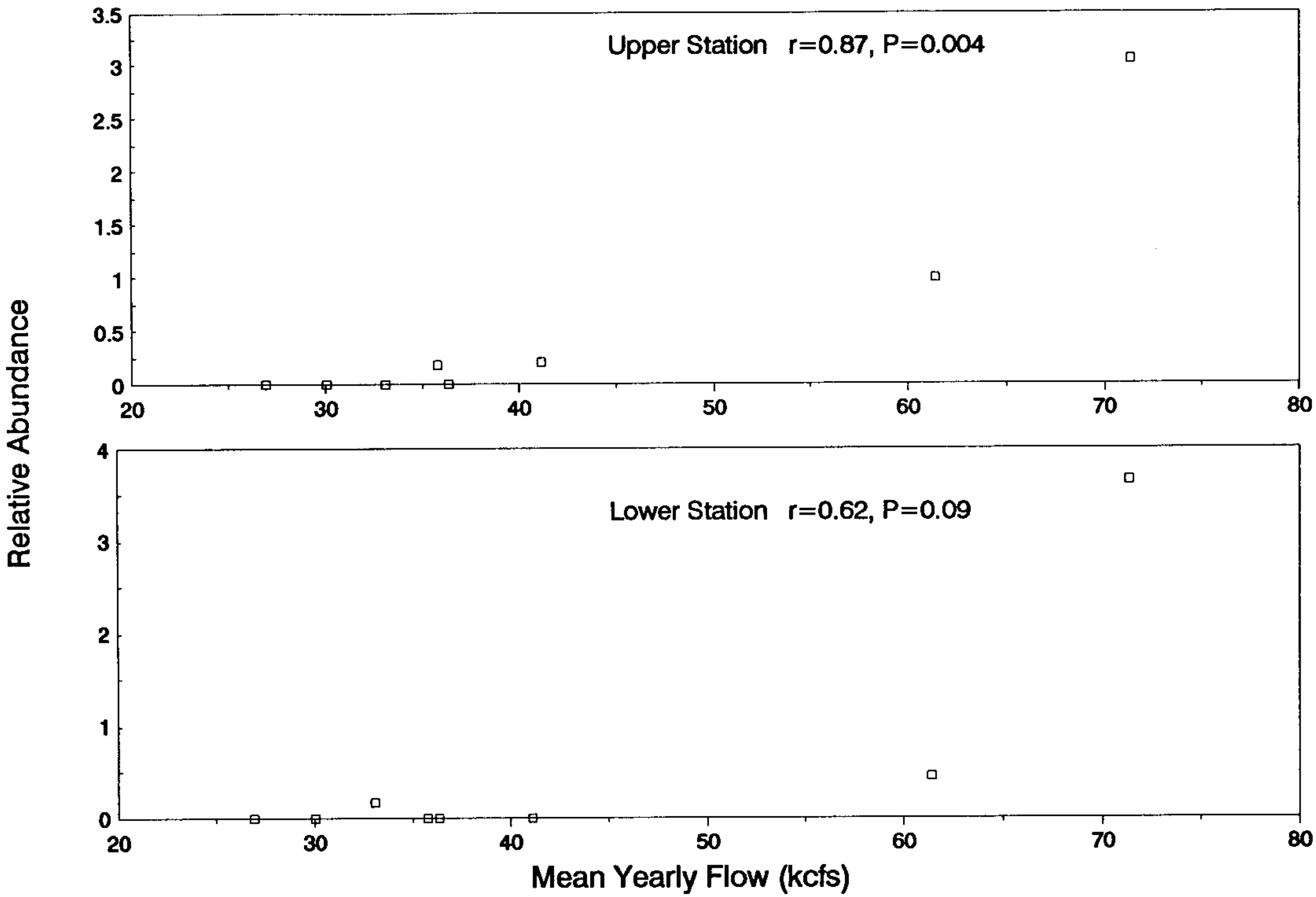


Figure 148. Bivariate plot of mean yearly inflow versus relative abundance for redside shiner (1 year later) during 1985-1993 at upper (5) and lower (9) stations in Lower Granite Reservoir.

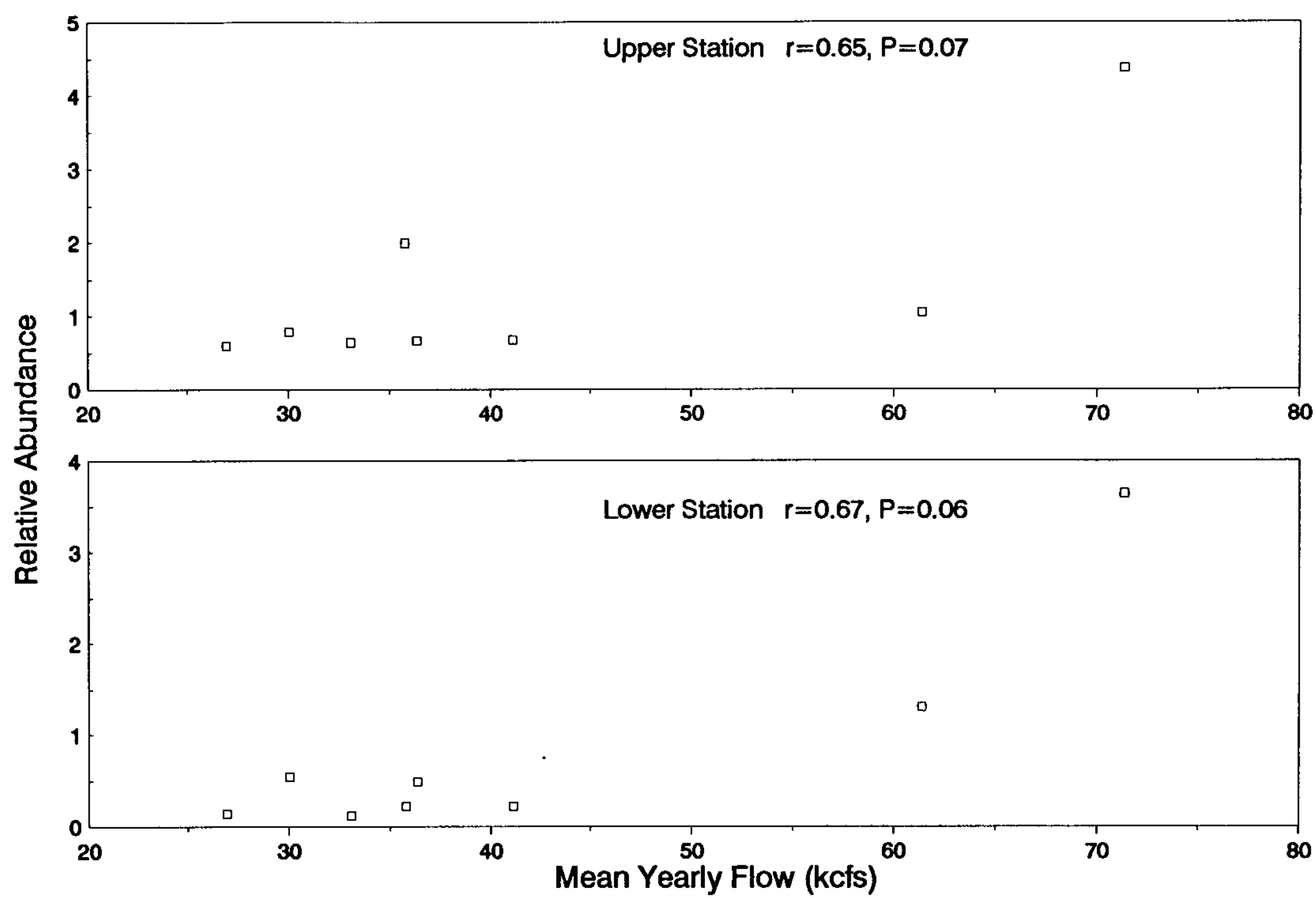


Figure 149. Bivariate plot of mean yearly inflow versus relative abundance for northern squawfish (1 year later) during 1985-1993 at upper (5) and lower (9) stations in Lower Granite Reservoir.

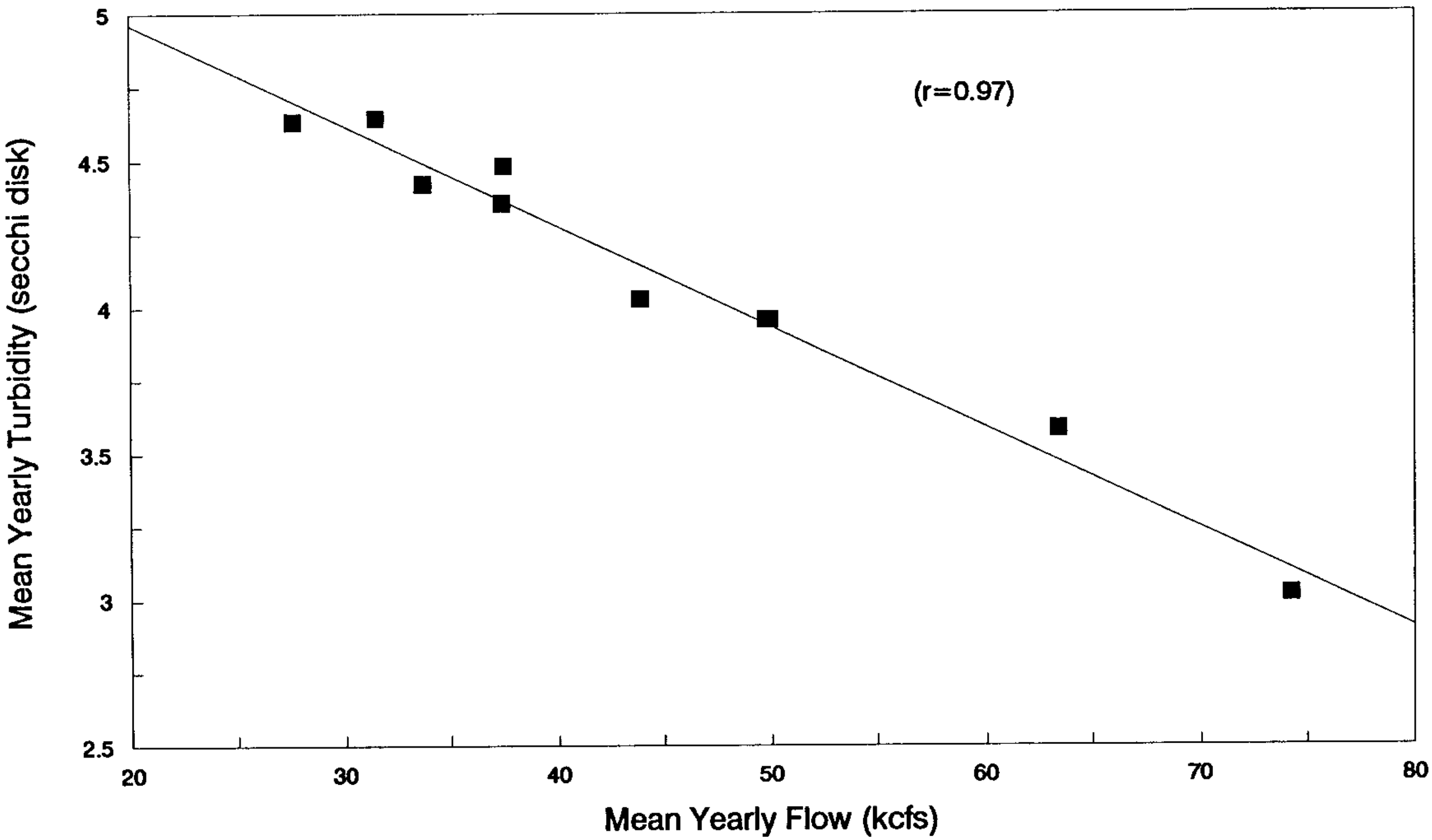


Figure 150. Correlation between mean yearly inflows and turbidity during 1984-1993 in Lower Granite Reservoir.

Another hypothesis related to this pattern might be changes in the distribution (i.e. downstream movements) of several resident species in response to high flow conditions. For example, during high flow years some fishes may seek refuge in the reservoir by moving downstream, particularly during early/late spring, using the more stable Lower Granite Reservoir pool as spawning habitat. Estimates of home range size and seasonal distribution, particularly for cyprinids, might strengthen this hypothesis although there is little information in the literature concerning distributional patterns for many fishes. Also, this relationship may have no cause and effect associated with the abundance of resident fishes. Hypotheses such as reservoir aging and subsequent changes in community composition might explain shifts in community composition and abundance from 1985 to 1987. In any case, large-scale changes occurring after 1985 such as operating Lower Granite Reservoir at minimum operating pool, coldwater releases from Dworshak Reservoir, and the 1992 experimental test drawdown did not appear to significantly 'destabilize' the resident fish assemblages at stations 5 and 9. The fish assemblages at these stations have been persistent and highly structured since 1987.

OVERALL DISCUSSION

Fish and habitat monitoring conducted from 1985 through 1993 has provided fishery managers with a clearer understanding of the dynamics and habitat use of resident fishes and outmigrating salmonids in Lower Granite Reservoir. Our findings have provided decision makers with a clearer understanding of the dynamics of predation on juvenile salmonids (Chandler 1993; Curet 1994), dynamics and habitat use by white sturgeon (Lepla 1994), abundance and dynamics of potential food items (Bennett et al. 1988, 1989, 1990, 1991, 1993a, 1993b, 1994d), importance of food items for resident fishes (Bennett and Shrier 1986) and juvenile salmonids (Curet 1994) and overall fish community characteristics (Bennett et al. 1988, 1989, 1990, 1991, 1993a, 1993b, 1994d).

During 1985 through 1993, we monitored for changes in the fish and fish food communities in Lower Granite Reservoir. These efforts have showed year to year variation in numbers of fishes sampled ranging from 7,512 (1993) to 42,085 (1988; Tables 2-4, Appendix Tables 4-21). However, we have not seen dramatic changes in fish community composition, and persistence of fishes has been strong as changes in the Lower Granite fish community have been relatively consistent through time.

Deposition of dredged material into Lower Granite Reservoir in 1988, 1989 and 1992 altered the habitat and changed the fish community to that inhabiting similar habitats in reference sites. Guild abundance at disposal stations varied similarly to guild abundance at reference stations. We found no evidence insectivore-piscivore fishes increased at disposal stations while decreasing at reference stations. Reservoir wide factors affected guild abundance equally at reference and disposal stations based on our guild analysis.

Comparisons of species richness between disposal and reference stations showed no differences and no difference in "tolerant" species occurred. Community composition seemed to be variable as a function of average depth. Species colonization and associations differed similarly between reference and disposal stations with similar water depths and changed similarly from 1989 through 1993. These associations responded similarly through time indicating reservoir-wide effects were more important than localized habitat characteristics.

Persistence of species was generally similar among years, although the abundance of several species, especially cyprinids, declined through time. The reduced abundance of insectivorous fishes occurred between 1985, our first general survey (Bennett and Shrier 1986), and 1987, before several "high impact" environmental changes (minimum operating pool, Bennett et al. 1994a; increased input of cold water, Bennett et al. 1994c, 1994e; 1992 experimental test drawdown, Bennett et al. 1994b) occurred. Species abundances changed little from 1987 through 1989.

Interestingly, high impact environmental changes such as inflows of low temperature water, the 1992 test drawdown, and operating at minimum operating pool did not destabilize the resident fish community. The fish assemblages at shallow stations 5 and 9 have been persistent and well structured since 1987.

Although community structure was generally stable, abundance of some species changed. Reduced abundances in juvenile and adult redside shiners, peamouth, carp and northern squawfish were found along with increases in smallmouth bass, pumpkinseed and crappie. The only relationship between species abundance and environmental factors was station depth. The pattern of reservoir inflows the previous year and total relative abundance was interesting. Abundances of certain species (redside shiner, bridgelip sucker and northern squawfish) were positively correlated with inflows, while that of pumpkinseed was negative. High average flows were correlated with water turbidity which could alter species distribution, reduce predation efficiency and increase habitat volume.

The decrease in the northern squawfish population has probably been a result of the Sport Reward Program. Our catch/efforts by gill netting for 1992 and 1993 were the lowest of all years sampled indicating a reduction in population abundance. At the initiation of the Sport Reward Program, some biologists predicted compensation could occur resulting in increased survival of juvenile squawfish and an increase in abundance. We have not seen increased catch/efforts of northern squawfish by beach seining and electrofishing, both techniques have shown success in sampling small squawfish (Arthaud 1992). Although the number of salmonid smolts consumed by squawfish in Lower Granite Reservoir was similar to that in John Day Reservoir our results indicated predation was not a major source of mortality in the reservoir (Chandler 1993).

The smallmouth bass population has increased in recent years and seems to provide the largest predatory threat to chinook salmon in Lower Granite Reservoir (Curet 1994). Curet (1994) reported high consumption rates of subyearling chinook salmon in Lower Granite Reservoir by smallmouth bass for 1992, although his study was conducted during spring following the experimental test drawdown. A similar study to Curet's is currently examining bass predation on subyearling salmon with similar preliminary results (Anglea and Bennett, unpublished data). Abundance of smallmouth bass in Lower Granite Reservoir seems to be directly correlated with low flow conditions. Early spawning and large age-0 smallmouth bass entering the winter are probably the mechanism controlling year class strength.

Several concerns expressed at the inception of the dredging and in-water disposal have been allayed from our monitoring. A principal concern was over creating habitat highly favorable for predators, such as smallmouth bass and northern squawfish. As indicated, the squawfish population has not increased as a result of the disposal events; it actually has decreased. The abundance of smallmouth bass has increased in Lower Granite Reservoir, although not as a function of in-water disposal but from changes in flow characteristics. Our data does not indicate the habitat created by in-water disposal contributed to changes in predator abundance.

Another concern of dredging and disposal was that the habitat created could become too favorable and result in residualization of smolts. Comparisons of catch/effort by beach seining, electrofishing and two-boat trawling has indicated smolts do not concentrate in the newly constructed habitats and any residualization in the reservoir is probably attributed to other factors (i.e. low flows as with juvenile steelhead in 1992 and 1987).

Use of dredged material has potential to create more shallow water habitat in Lower Granite Reservoir. Creating more shallow water habitat could increase fish species richness, increase availability of food items to outmigrating yearling salmonids, and increase available rearing habitat for subyearling chinook. If managers have concerns for increased species richness, dredged material can be disposed of in mid to deep habitats with no apparent ill effects. These disposal stations were represented by few species and low overall abundance.

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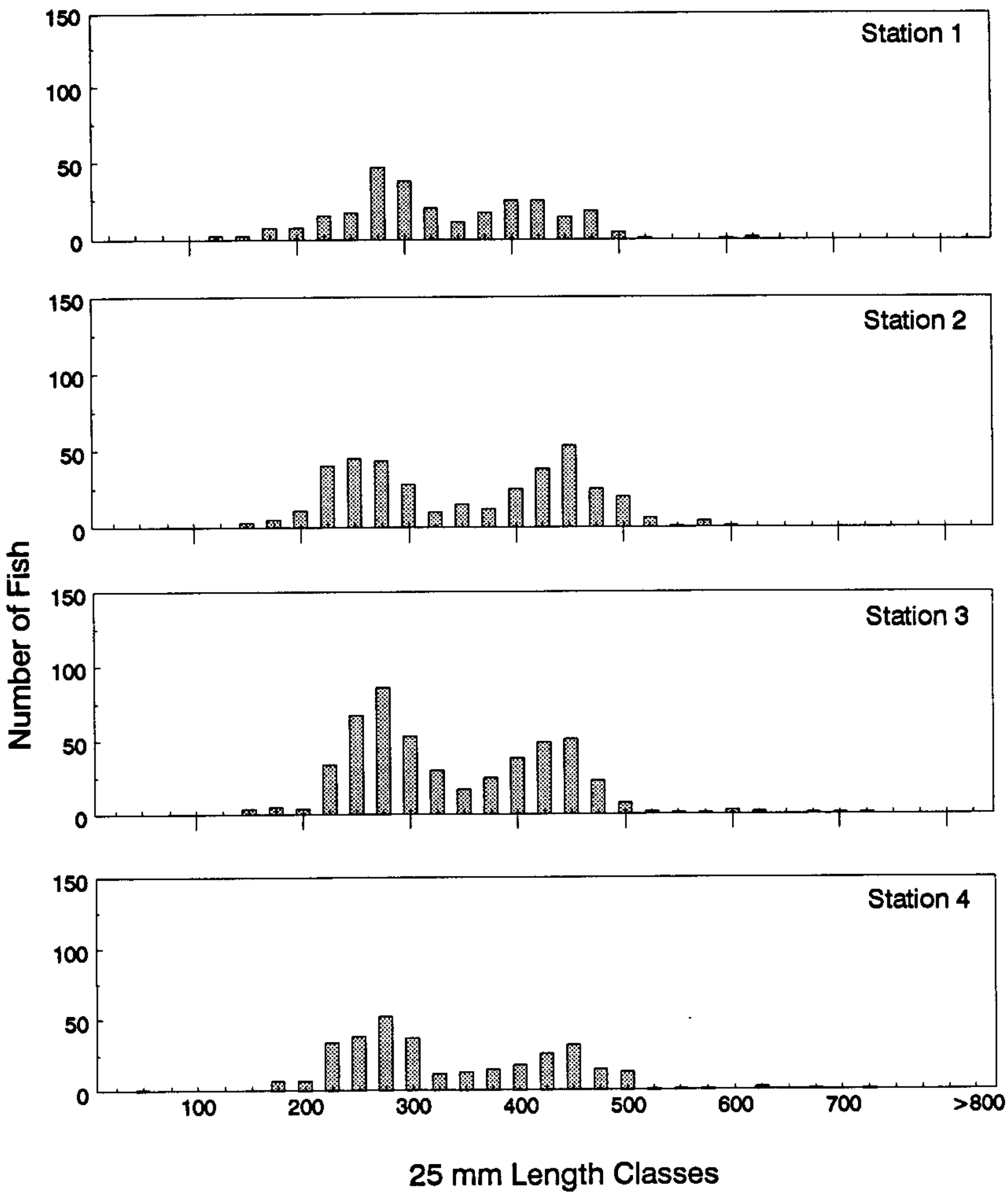
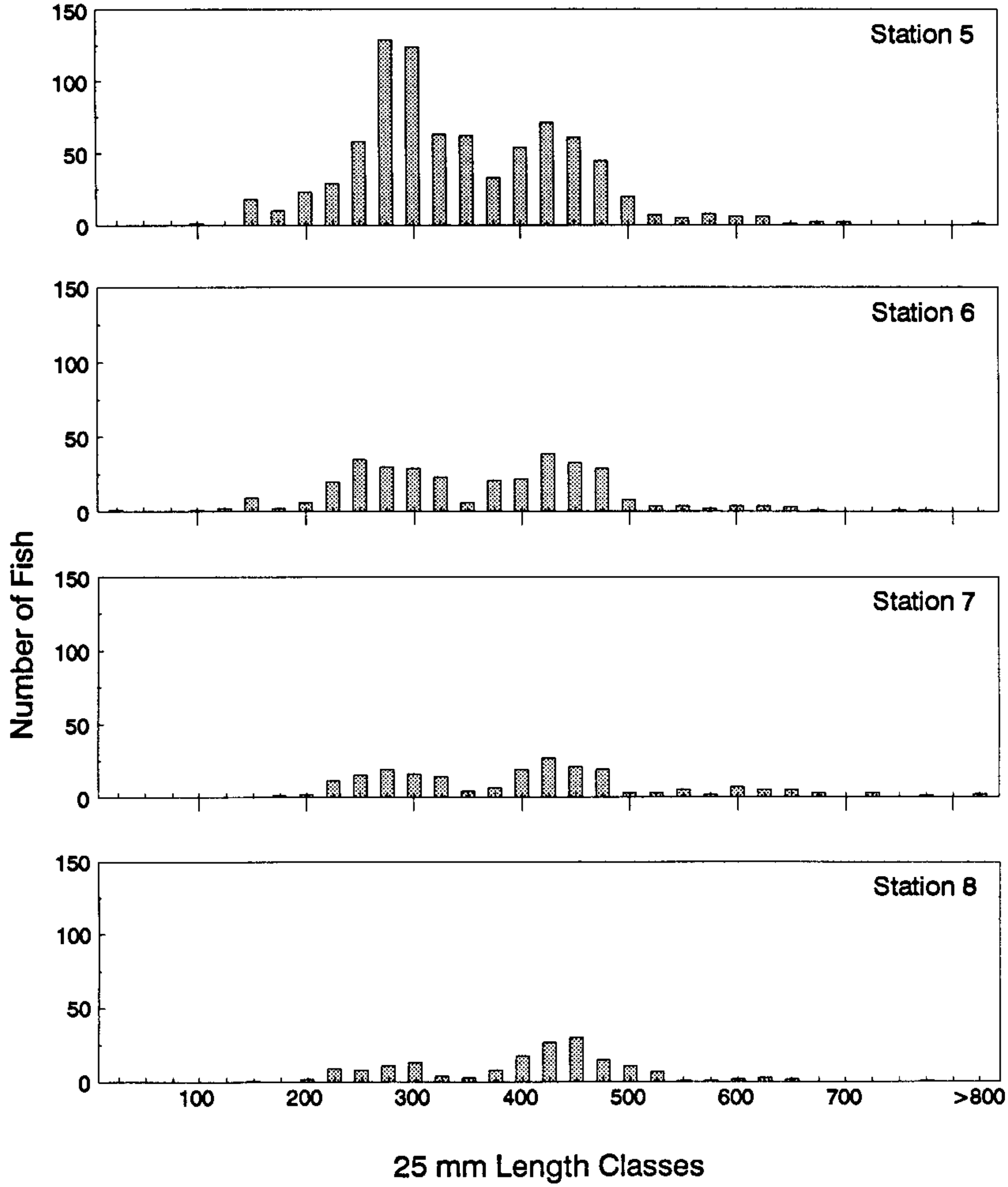
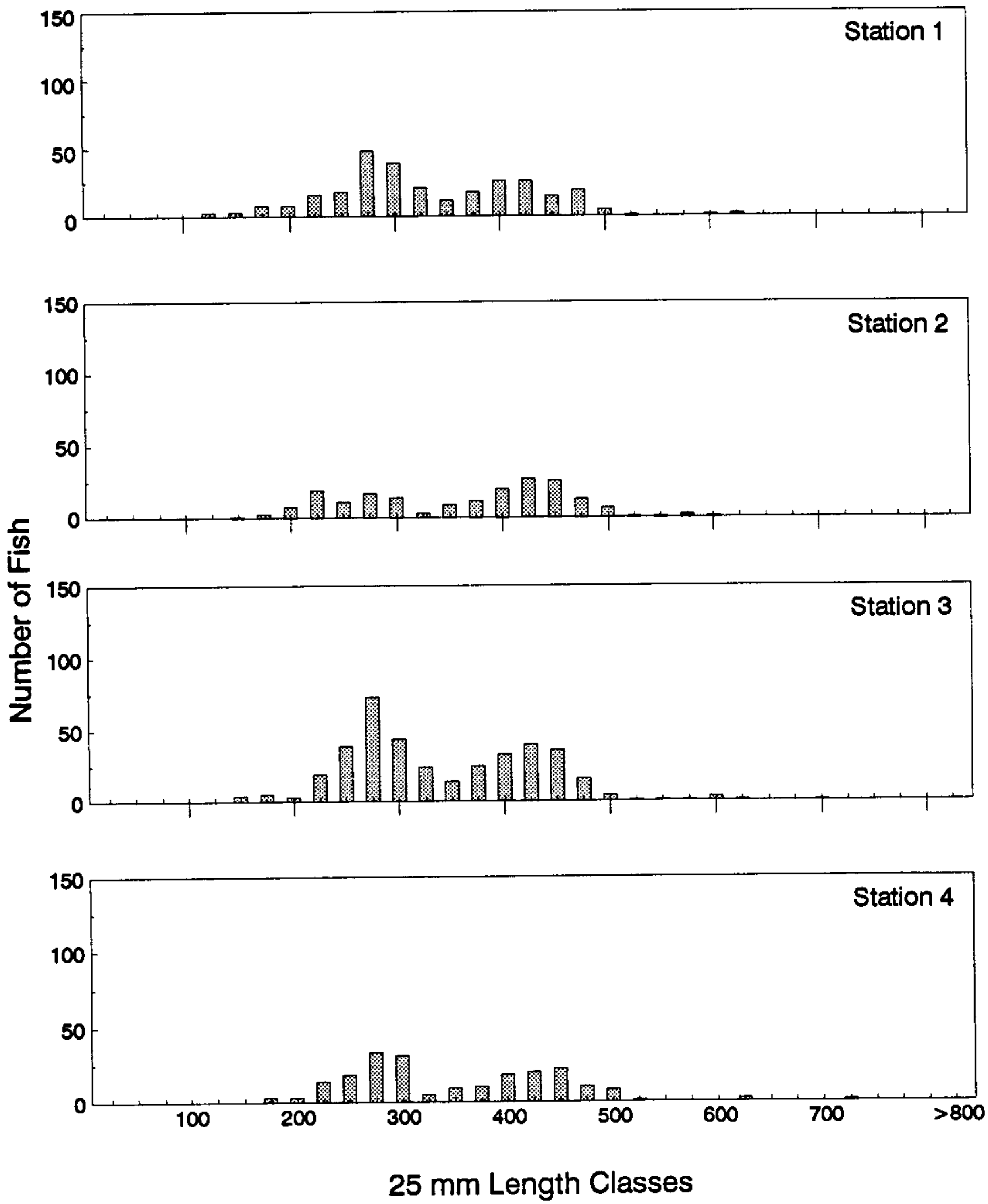


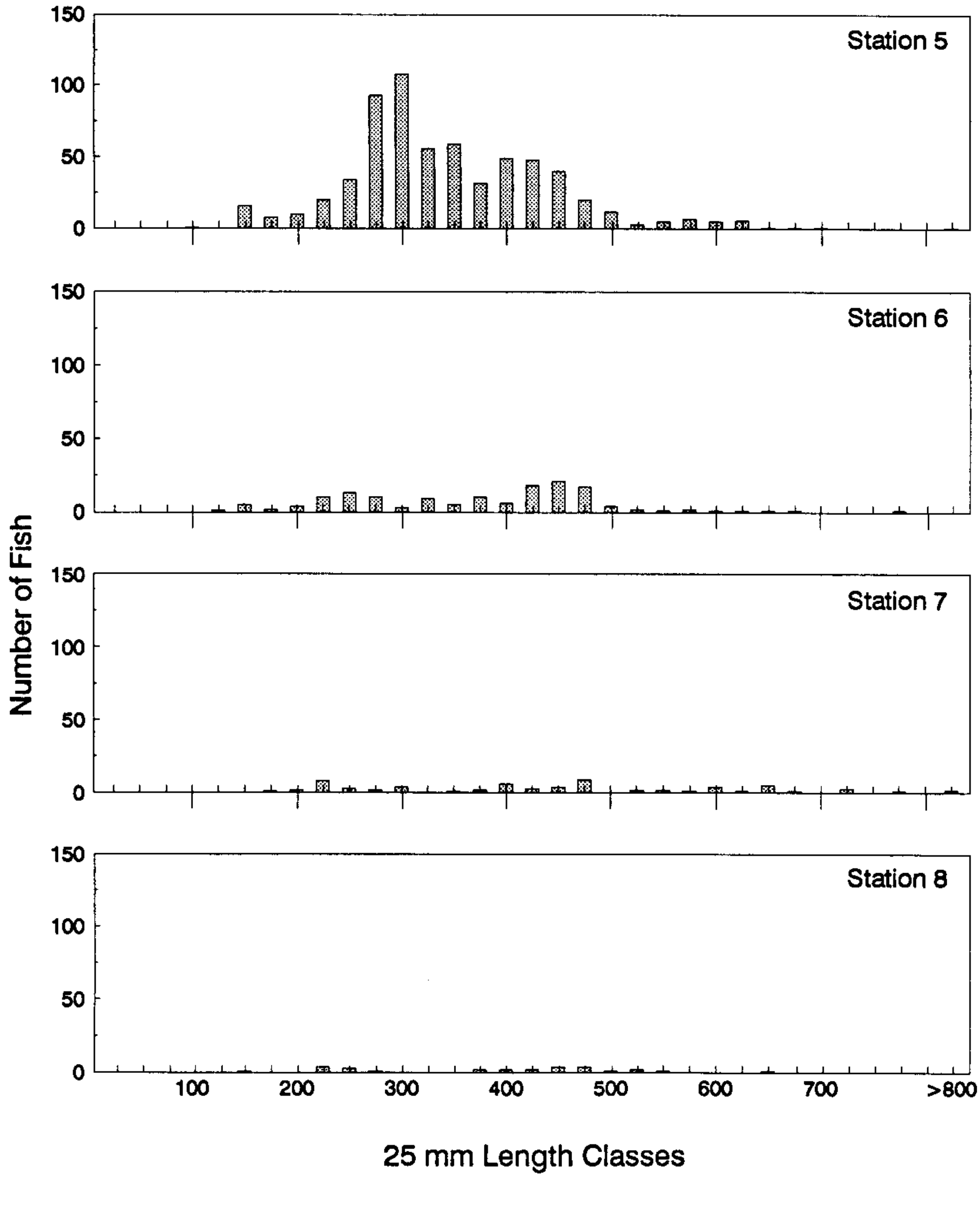
Appendix Figure 1. Length distributions of fishes sampled by gill netting at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during 1993 in Lower Granite Reservoir.



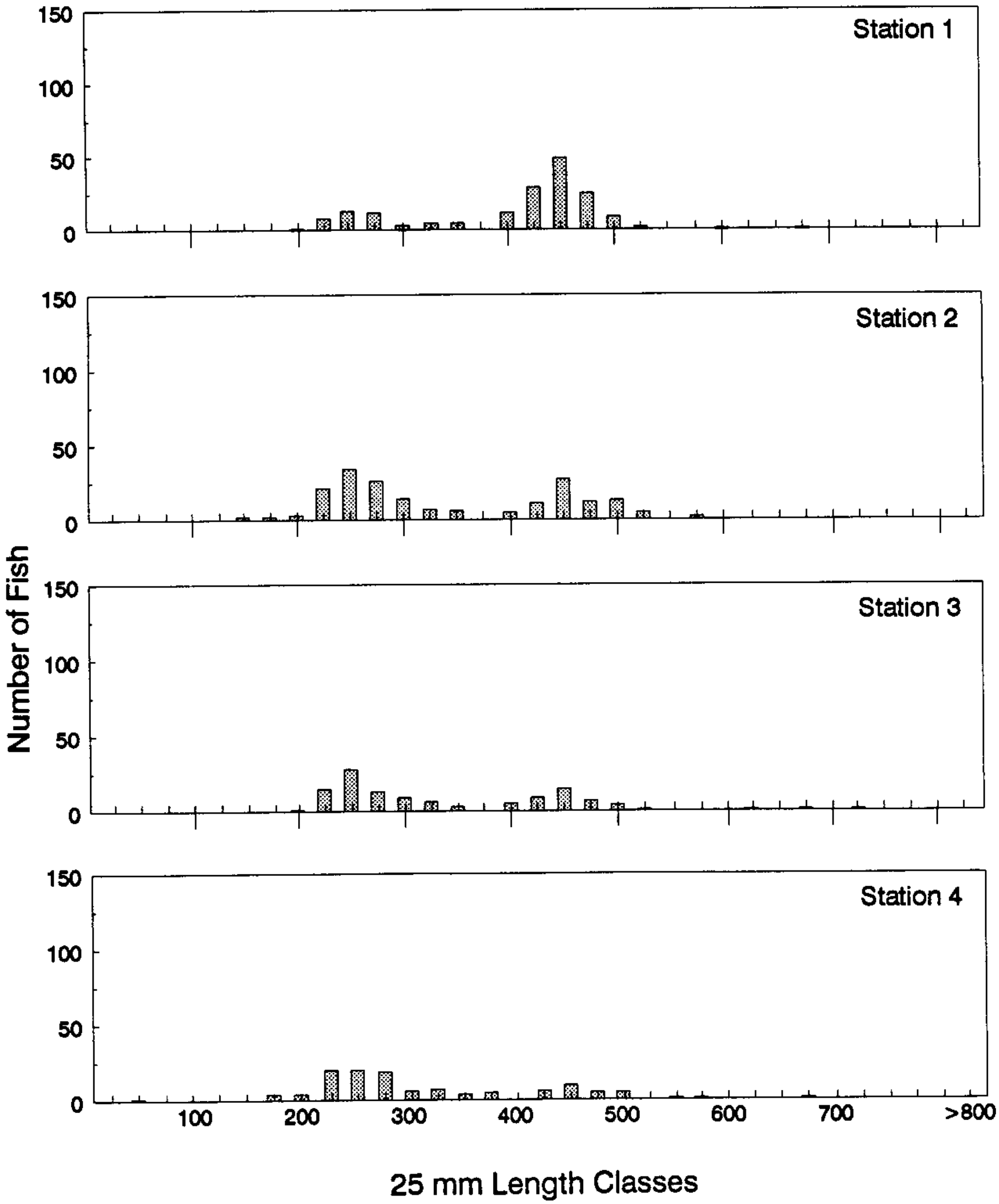
Appendix Figure 2. Length distributions of fishes sampled by gill netting at shallow (5), mid-depth (6) and deep (8) reference stations and deep disposal station 7 during 1993 in Lower Granite Reservoir.



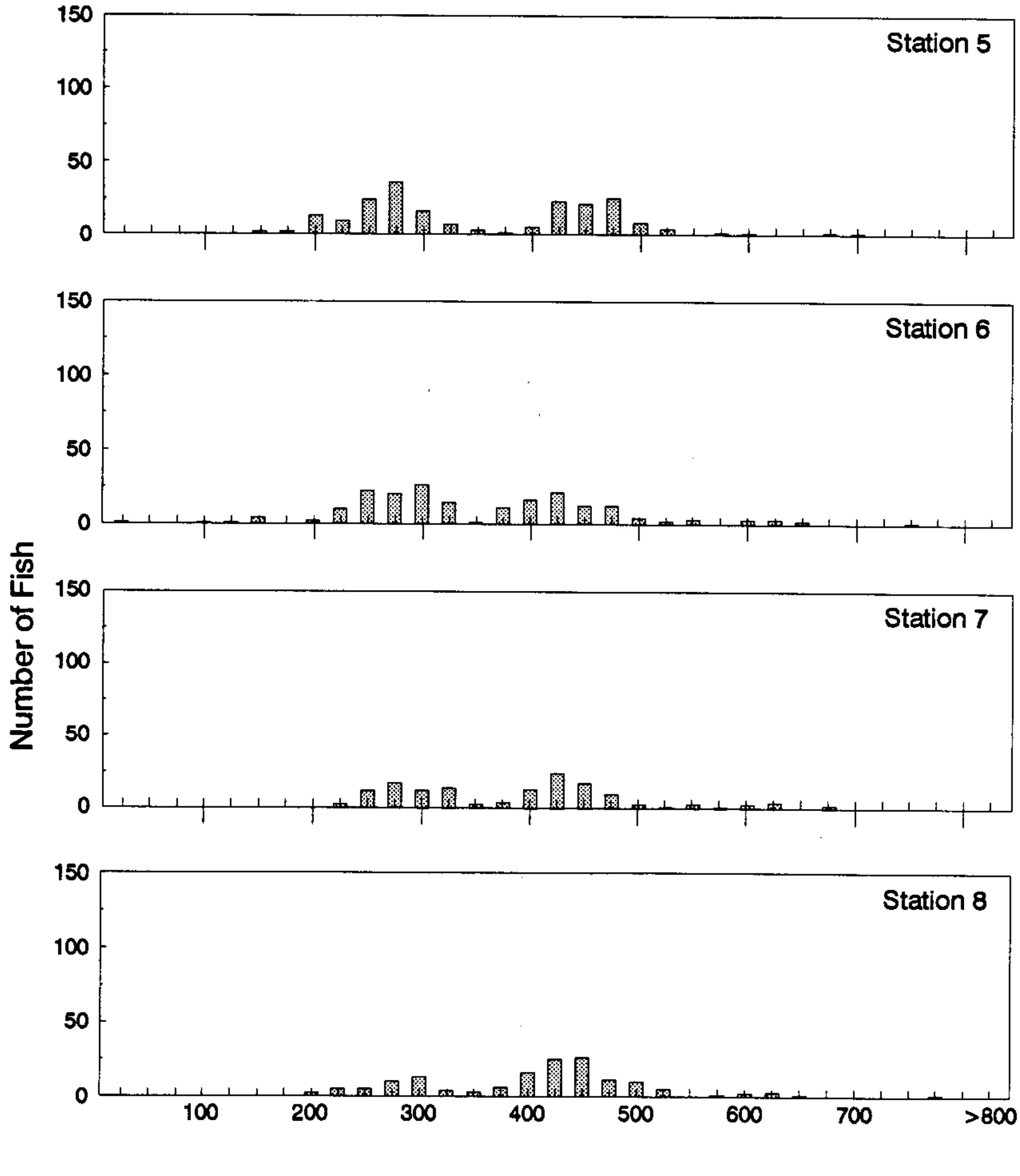
Appendix Figure 3. Length distributions of fishes sampled by gill netting at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during spring 1993 in Lower Granite Reservoir.



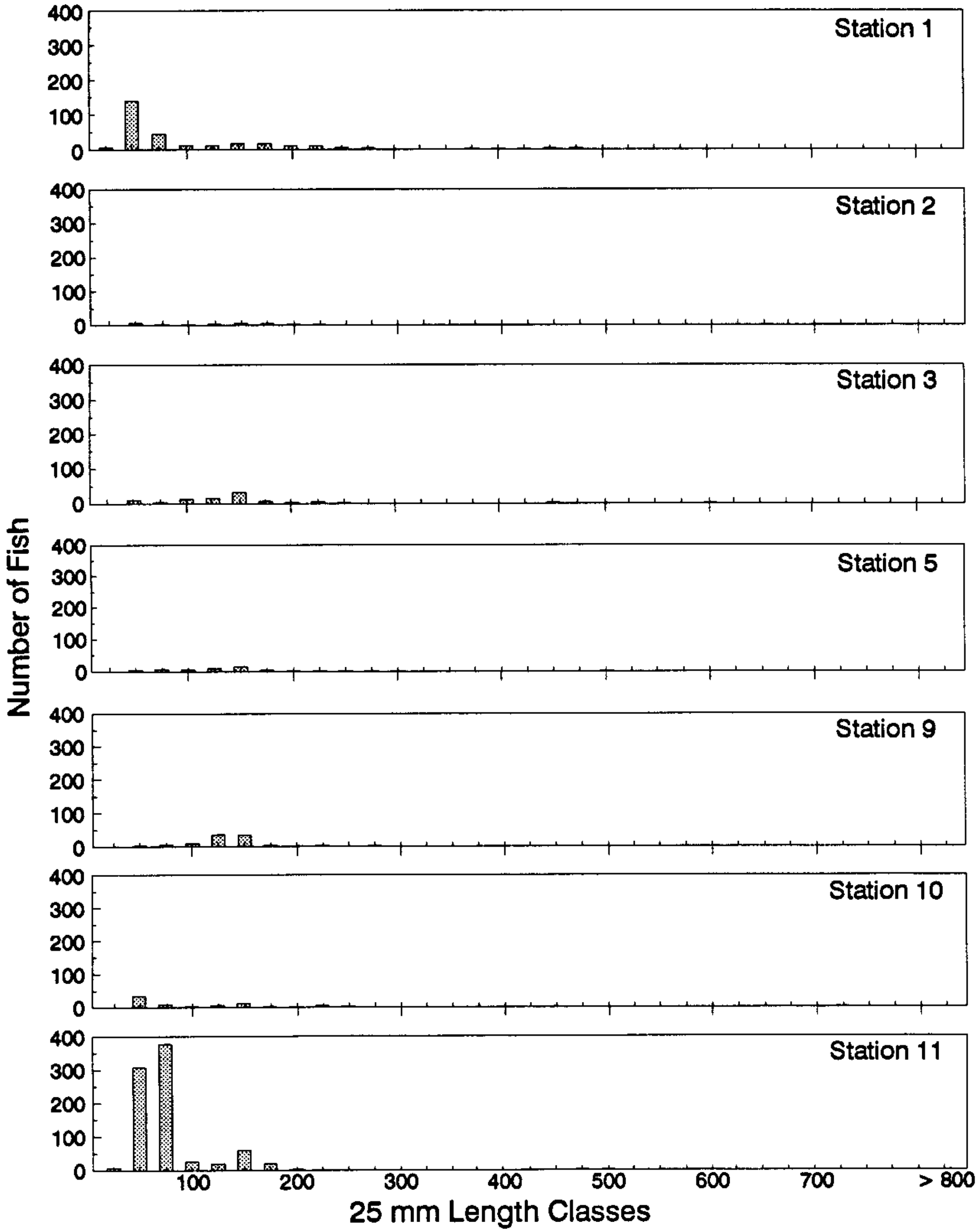
Appendix Figure 4. Length distributions of fishes sampled by gill netting at shallow (5), mid-depth (6) and deep (8) reference stations and deep disposal station 7 during spring 1993 in Lower Granite Reservoir.



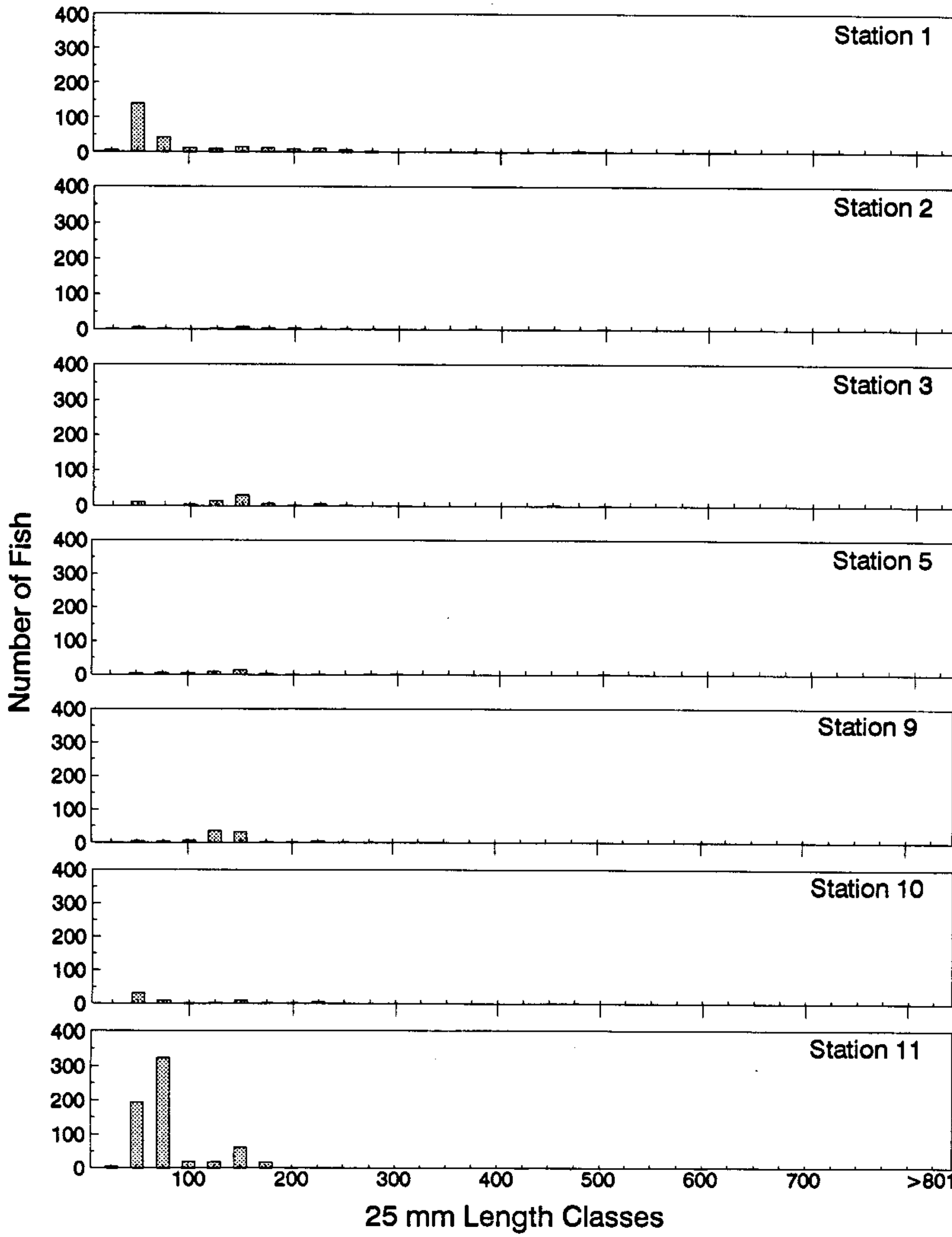
Appendix Figure 5. Length distributions of fishes sampled by gill netting at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during fall 1993 in Lower Granite Reservoir.



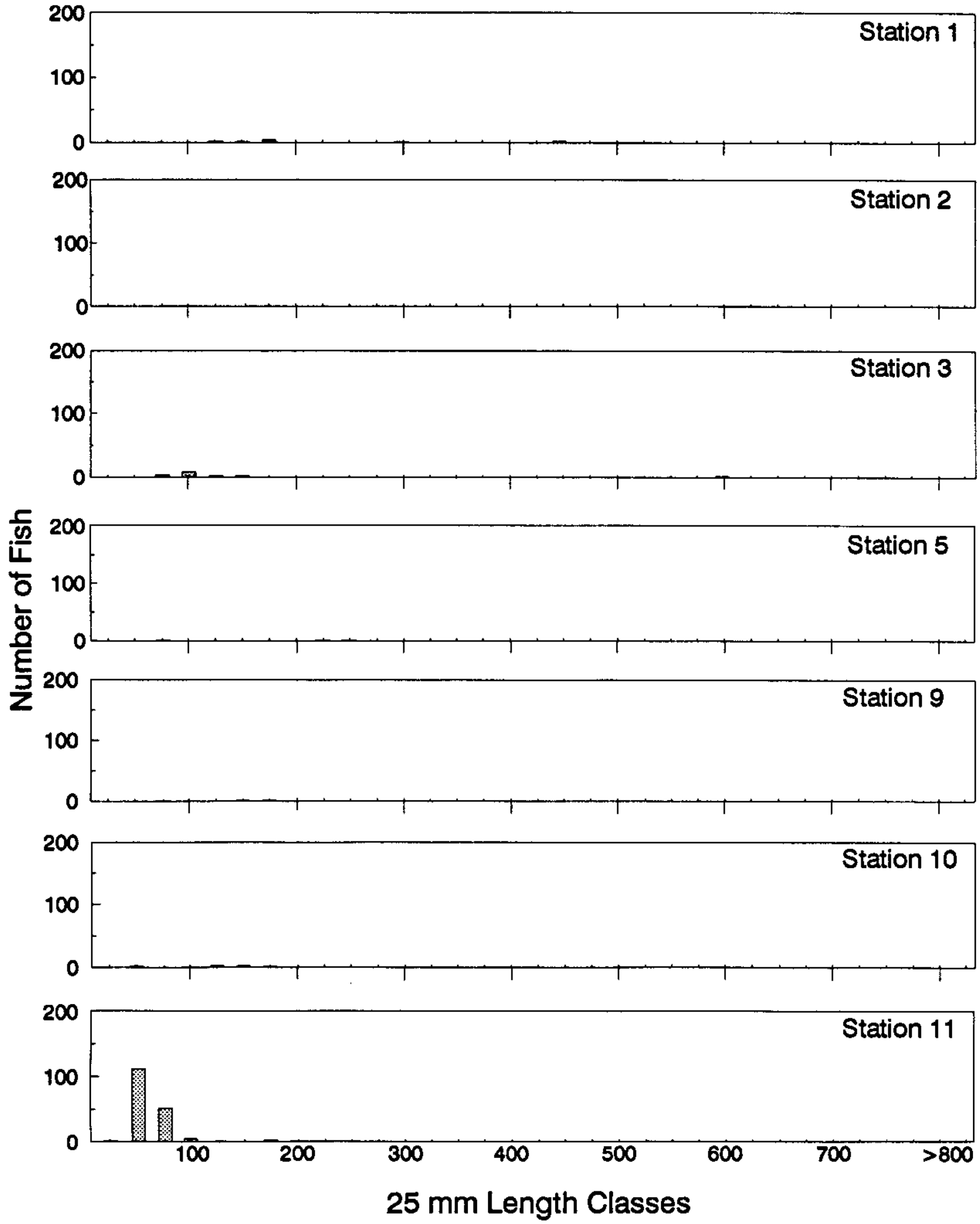
Appendix Figure 6. Length distributions of fishes sampled by gill netting at shallow (5), mid-depth (6) and deep (8) reference stations and deep disposal station 7 during fall 1993 in Lower Granite Reservoir.



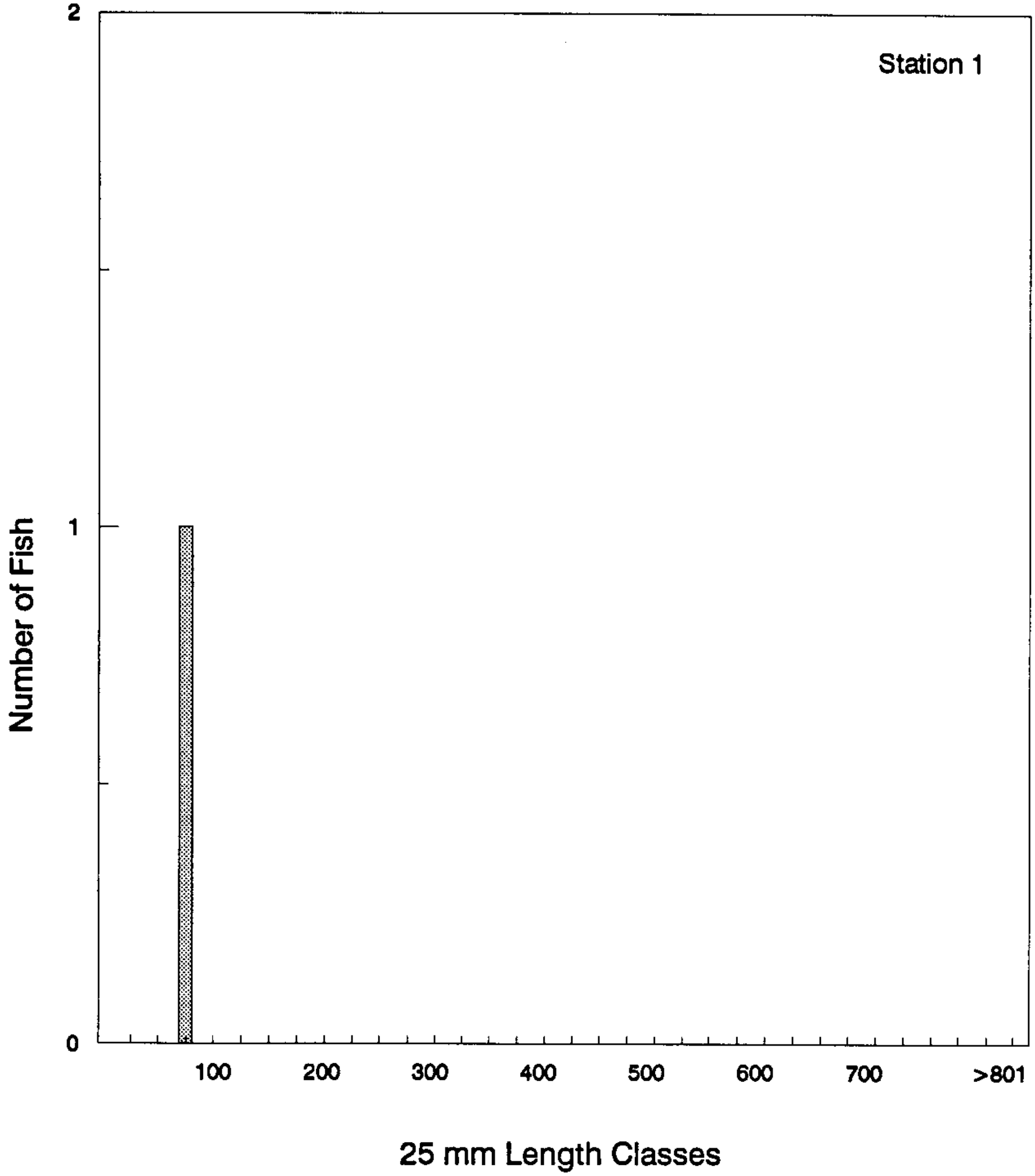
Appendix Figure 7. Length distributions of fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during 1993 in Lower Granite Reservoir.



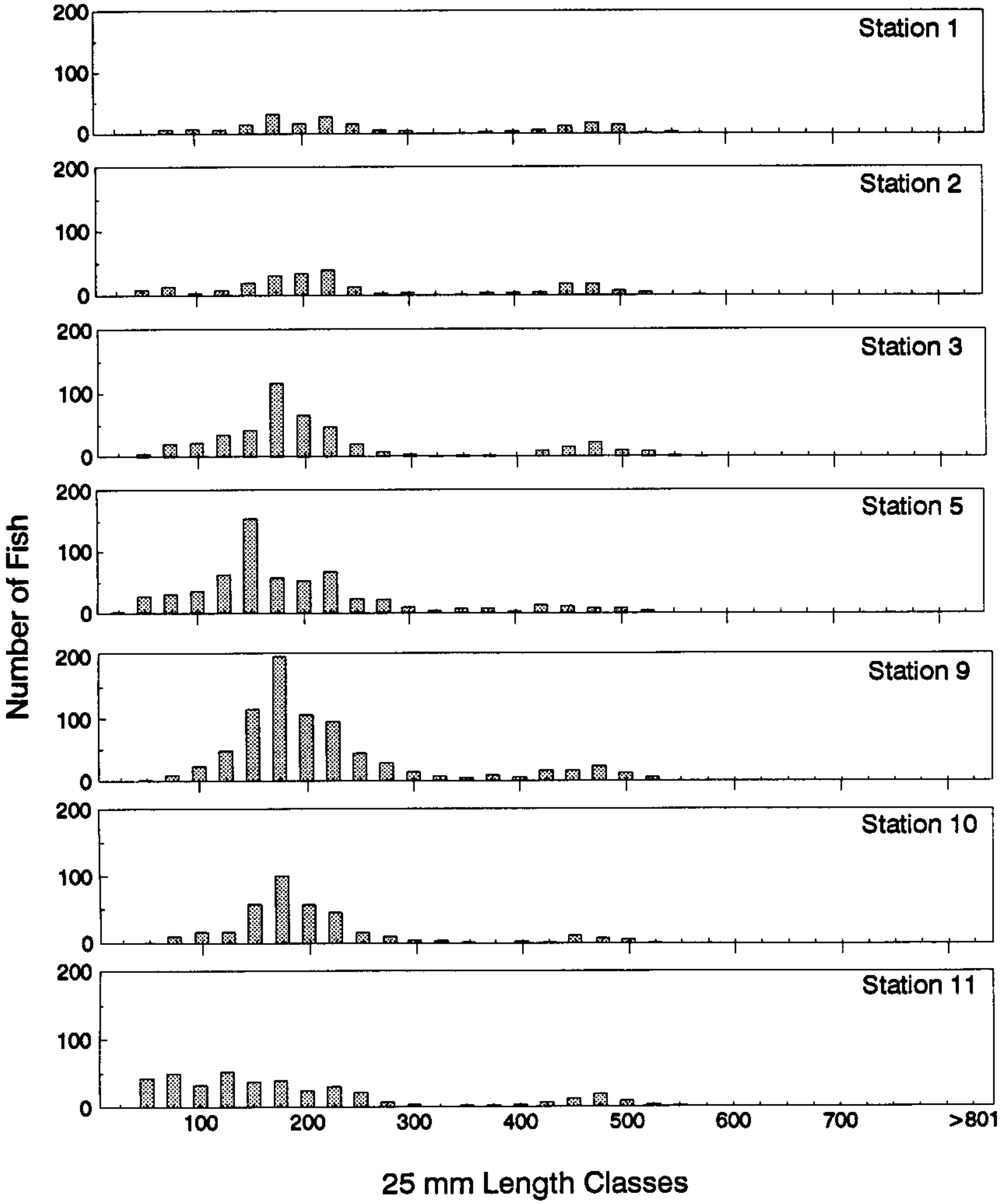
Appendix Figure 8. Length distributions of fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during spring 1993 in Lower Granite Reservoir.



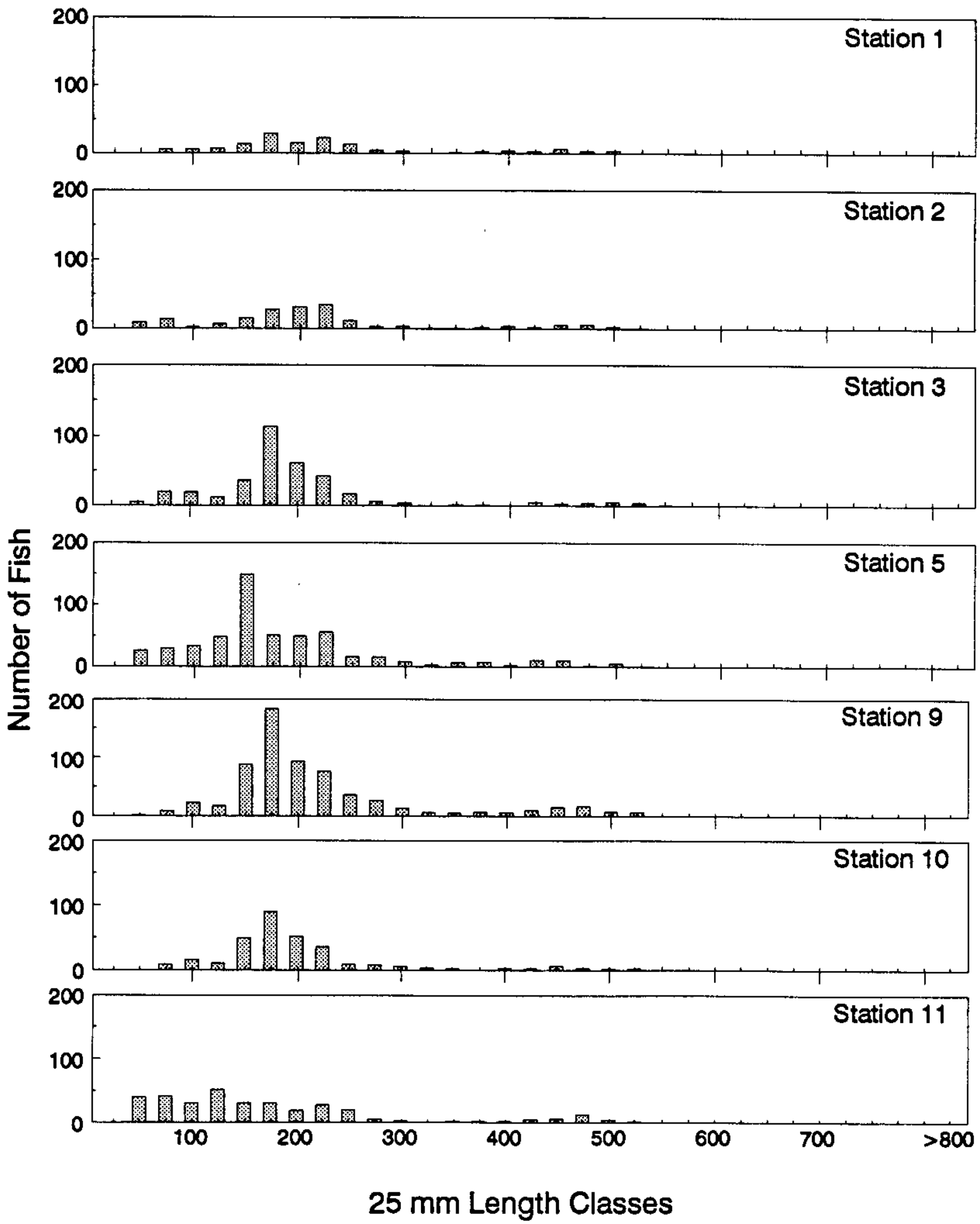
Appendix Figure 9. Length distributions of fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during summer 1993 in Lower Granite Reservoir.



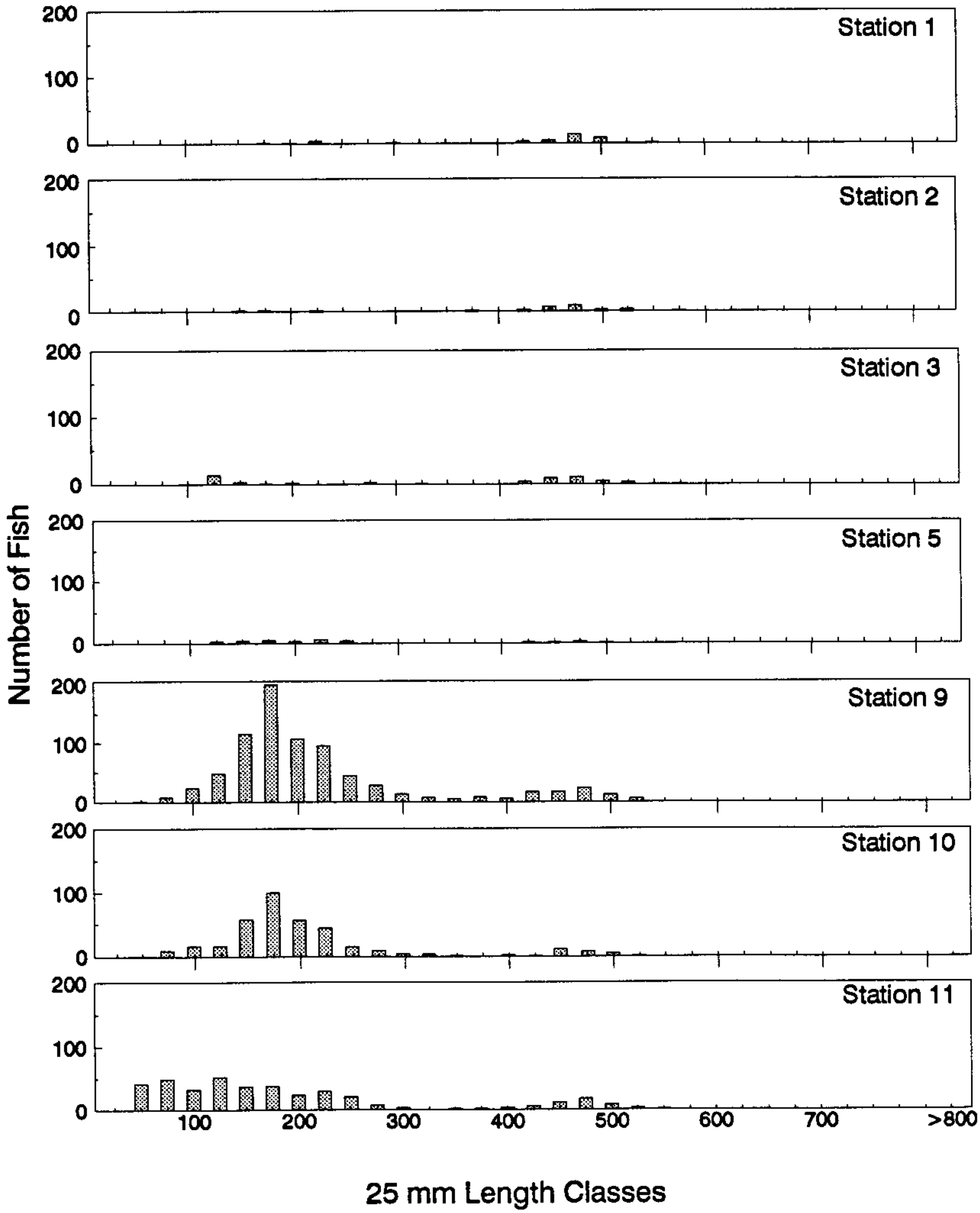
Appendix Figure 10. Length distributions of fishes sampled by beach seining at shallow disposal station 1 during fall 1993 in Lower Granite Reservoir.



Appendix Figure 11. Length distributions of fishes sampled by electrofishing at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during 1993 in Lower Granite Reservoir.



Appendix Figure 12. Length distributions of fishes sampled by electrofishing at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during spring 1993 in Lower Granite Reservoir.



Appendix Figure 13. Length distributions of fishes sampled by electrofishing at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations during fall 1993 in Lower Granite Reservoir.

Appendix Table 1. Catch/volume of water filtered (No./10,000 m^3) for 0.5-meter plankton net samples during 1993 in Lower Granite Reservoir. Upper and lower refer to bounds. Abbreviation: PWI-mountain whitefish.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	PWI Mean	PWI Upper	PWI Lower	Total Mean	Total Upper	Total Lower
23 May	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	5.24	28.67	0.00	21	90	0
1 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				5	29	0
	4	180	1.5	0.196	53.014				5	29	0
	5	180	1.5	0.196	53.014				26	118	0
	11	180	1.5	0.196	53.014						
15 June	1	180	1.5	0.196	53.014				94	253	0
	2	180	1.5	0.196	53.014				362	637	86
	4	180	1.5	0.196	53.014				26	118	0
	5	180	1.5	0.196	53.014				702	1421	14
	11	180	1.5	0.196	53.014				178	447	0
21 June	1	180	1.5	0.196	53.014				68	135	1
	2	180	1.5	0.196	53.014				42	133	0
	4	180	1.5	0.196	53.014				26	121	0
	5	180	1.5	0.196	53.014				335	899	0
	11	180	1.5	0.196	53.014				26	119	0
29 June	1	180	1.5	0.196	53.014				58	151	0
	2	180	1.5	0.196	53.014				414	1035	0
	4	180	1.5	0.196	53.014				105	240	0
	5	180	1.5	0.196	53.014				1058	1836	281
	11	180	1.5	0.196	53.014				293	788	0

Appendix Table 1. (Continued) Abbreviation: PWI-mountain whitefish.

Date	Station	Duration	Speed	Area	Volume	PWI			Total		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
7 July	1	180	1.5	0.196	53.014				21	76	0
	2	180	1.5	0.196	53.014				31	111	0
	4	180	1.5	0.196	53.014				57	174	0
	5	180	1.5	0.196	53.014				147	330	0
	11	180	1.5	0.196	53.014				94	280	0
13 July	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014				5	29	0
	4	180	1.5	0.196	53.014				10	40	0
	5	180	1.5	0.196	53.014				246	908	0
	11	180	1.5	0.196	53.014				356	1108	0
21 July	1	180	1.5	0.196	53.014				21	68	0
	2	180	1.5	0.196	53.014				26	109	0
	4	180	1.5	0.196	53.014				42	144	0
	5	180	1.5	0.196	53.014				959	3146	0
	11	180	1.5	0.196	53.014				162	425	0
29 July	1	180	1.5	0.196	53.014				47	168	0
	2	180	1.5	0.196	53.014				68	194	0
	4	180	1.5	0.196	53.014				79	205	0
	5	180	1.5	0.196	53.014				220	460	0
	11	180	1.5	0.196	53.014				320	720	0
3 August	1	180	1.5	0.196	53.014				10	57	0
	2	180	1.5	0.196	53.014				0	0	0
	4	180	1.5	0.196	53.014				79	321	0
	5	180	1.5	0.196	53.014				136	341	0
	11	180	1.5	0.196	53.014				351	554	0

Appendix Table 1. (Continued) Abbreviation: PWI-mountain whitefish.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	PWI			Total		
						Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014				293	839	0
	2	180	1.5	0.196	53.014				131	384	0
	4	180	1.5	0.196	53.014				283	922	0
	5	180	1.5	0.196	53.014				314	1011	0
	11	180	1.5	0.196	53.014				278	684	0
20 August	1	180	1.5	0.196	53.014				236	809	0
	2	180	1.5	0.196	53.014				115	436	0
	4	180	1.5	0.196	53.014				173	710	0
	5	180	1.5	0.196	53.014				131	320	0
	11	180	1.5	0.196	53.014				147	253	0
27 August	1	180	1.5	0.196	53.014				31	125	0
	2	180	1.5	0.196	53.014				16	69	0
	4	180	1.5	0.196	53.014				31	155	0
	5	180	1.5	0.196	53.014				37	121	0
	11	180	1.5	0.196	53.014				26	143	0
4 September	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				5	29	0
	11	180	1.5	0.196	53.014				5	29	0
10 September	1	180	1.5	0.196	53.014				5	29	0
	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						

Appendix Table 1. (Continued) Abbreviations: ASA-American shad; CYP-Cyprinus spp.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	ASA			CYP		
						Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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						
15 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				26	118	0
	5	180	1.5	0.196	53.014				26	83	0
	11	180	1.5	0.196	53.014						
21 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				16	64	0
	4	180	1.5	0.196	53.014				10	57	0
	5	180	1.5	0.196	53.014				58	142	0
	11	180	1.5	0.196	53.014				5	29	0
29 June	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014	5	29	0			
	4	180	1.5	0.196	53.014				5	29	0
	5	180	1.5	0.196	53.014				21	90	0
	11	180	1.5	0.196	53.014				37	121	0

Appendix Table 1. (Continued) Abbreviations: ASA-American shad; CYP-cyprinid.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	ASA Mean	ASA Upper	ASA Lower	CYP Mean	CYP Upper	CYP Lower
7 July	1	180	1.5	0.196	53.014				16	47	0
	2	180	1.5	0.196	53.014				16	47	0
	4	180	1.5	0.196	53.014				47	134	0
	5	180	1.5	0.196	53.014				100	222	0
	11	180	1.5	0.196	53.014				42	111	0
13 July	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	5	29	0	16	64	0
	11	180	1.5	0.196	53.014				26	70	0
21 July	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				10	40	0
	4	180	1.5	0.196	53.014				31	104	0
	5	180	1.5	0.196	53.014				231	676	0
	11	180	1.5	0.196	53.014				68	153	0
29 July	1	180	1.5	0.196	53.014				31	104	0
	2	180	1.5	0.196	53.014				47	126	0
	4	180	1.5	0.196	53.014				52	122	0
	5	180	1.5	0.196	53.014				26	69	0
	11	180	1.5	0.196	53.014				110	189	31
3 August	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014	5	29	0			
	4	180	1.5	0.196	53.014				5	29	0
	5	180	1.5	0.196	53.014				21	90	0
	11	180	1.5	0.196	53.014				37	121	0

Appendix Table 1. (Continued) Abbreviations: ASA-American shad; CYP-cyprinid.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	ASA			CYP		
						Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	5	29	0	220	566	0
	2	180	1.5	0.196	53.014				94	230	0
	4	180	1.5	0.196	53.014				168	504	0
	5	180	1.5	0.196	53.014	5	29	0	178	560	0
	11	180	1.5	0.196	53.014						
20 August	1	180	1.5	0.196	53.014				110	395	0
	2	180	1.5	0.196	53.014				63	241	0
	4	180	1.5	0.196	53.014				10	57	0
	5	180	1.5	0.196	53.014				121	263	0
	11	180	1.5	0.196	53.014				136	196	77
27 August	1	180	1.5	0.196	53.014				10	57	0
	2	180	1.5	0.196	53.014				5	29	0
	4	180	1.5	0.196	53.014				10	40	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014				5	29	0
4 September	1	180	1.5	0.196	53.014				31	104	0
	2	180	1.5	0.196	53.014				47	126	0
	4	180	1.5	0.196	53.014				52	122	0
	5	180	1.5	0.196	53.014				26	69	0
	11	180	1.5	0.196	53.014				110	189	31
10 September	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014	5	29	0			
	4	180	1.5	0.196	53.014				5	29	0
	5	180	1.5	0.196	53.014				21	90	0
	11	180	1.5	0.196	53.014				37	121	0

Appendix Table 1. (Continued) Abbreviations: AAL-chiselmouth; POR-northern squawfish.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	AAL Mean	AAL Upper	AAL Lower	POR Mean	POR Upper	POR Lower
23 May	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						
1 June	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						
15 June	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						
21 June	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						
29 June	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				5	29	0

Appendix Table 1. (Continued) Abbreviations: AAL-chiselmouth; POR-northern squawfish.

Date	Station	Duration	Speed	Area	Volume	AAL			POR		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
7 July	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						
13 July	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						
21 July	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	5	29	0			
29 July	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				5	29	0
3 August	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	16	64	0			

Appendix Table 1. (Continued) Abbreviations: AAL-chiselmouth; POR-northern squawfish.

Date	Station	Duration	Speed	Area	Volume	AAL			POR		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	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	5	29	0			
	11	180	1.5	0.196	53.014						
20 August	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				10	57	0
27 August	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						
4 September	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				5	29	0
	11	180	1.5	0.196	53.014						
10 September	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						

Appendix Table 1. (Continued) Abbreviations: MCA-peamouth; CSP-catostomid.

Date	Station	Duration	Speed	Area	Volume	MCA			CSP		
		Second	m/s	m²	m³	Mean	Upper	Lower	Mean	Upper	Lower
23 May	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				21	90	0
1 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				5	29	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				26	118	0
	11	180	1.5	0.196	53.014						
15 June	1	180	1.5	0.196	53.014				94	253	0
	2	180	1.5	0.196	53.014				362	637	86
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				676	1338	14
	11	180	1.5	0.196	53.014				178	447	0
21 June	1	180	1.5	0.196	53.014				68	135	1
	2	180	1.5	0.196	53.014				26	69	0
	4	180	1.5	0.196	53.014				16	64	0
	5	180	1.5	0.196	53.014				278	757	0
	11	180	1.5	0.196	53.014				21	90	0
29 June	1	180	1.5	0.196	53.014				52	122	0
	2	180	1.5	0.196	53.014				409	1006	0
	4	180	1.5	0.196	53.014				100	211	0
	5	180	1.5	0.196	53.014				1037	1745	330
	11	180	1.5	0.196	53.014				252	637	0

Appendix Table 1. (Continued) Abbreviations: MCA-peamouth; CSP-catostomid.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MCA Mean	MCA Upper	MCA Lower	CSP Mean	CSP Upper	CSP Lower
7 July	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014				16	64	0
	4	180	1.5	0.196	53.014				10	40	0
	5	180	1.5	0.196	53.014				47	107	0
	11	180	1.5	0.196	53.014				42	111	0
13 July	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014				5	29	0
	4	180	1.5	0.196	53.014				10	40	0
	5	180	1.5	0.196	53.014	21	9	0	204	725	0
	11	180	1.5	0.196	53.014	5	29	0	320	982	0
21 July	1	180	1.5	0.196	53.014				21	68	0
	2	180	1.5	0.196	53.014				5	29	0
	4	180	1.5	0.196	53.014				10	40	0
	5	180	1.5	0.196	53.014	5	29	0	681	2238	0
	11	180	1.5	0.196	53.014	5	29	0	79	186	0
29 July	1	180	1.5	0.196	53.014				16	64	0
	2	180	1.5	0.196	53.014				21	68	0
	4	180	1.5	0.196	53.014				26	83	0
	5	180	1.5	0.196	53.014				194	391	0
	11	180	1.5	0.196	53.014	26	143	0	178	358	0
3 August	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				68	281	0
	5	180	1.5	0.196	53.014				126	284	0
	11	180	1.5	0.196	53.014				210	269	150

Appendix Table 1. (Continued) Abbreviations: MCA-peamouth; CSP-catostomid.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MCA			CSP		
						Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				16	86	0
	4	180	1.5	0.196	53.014				52	182	0
	5	180	1.5	0.196	53.014				121	365	0
	11	180	1.5	0.196	53.014				278	684	0
20 August	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				31	127	0
	4	180	1.5	0.196	53.014				105	380	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
27 August	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	10	57	0			
4 September	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						
10 September	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						

Appendix Table 1. (Continued) Abbreviations: CMA-largescale sucker; INE -brown bullhead.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CMA			INE		
						Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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						
15 June	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						
21 June	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						
29 June	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						

Appendix Table 1. (Continued) Abbreviations: CMA-largescale sucker; INE- brown bullhead.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CMA			INE		
						Mean	Upper	Lower	Mean	Upper	Lower
7 July	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						
13 July	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	5	29	0			
21 July	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						
29 July	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						
3 August	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						

Appendix Table 1. (Continued) Abbreviations: CMA-largescale sucker; INE-brown bullhead.

Date	Station	Duration	Speed	Area	Volume	CMA			INE		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	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 August	1	180	1.5	0.196	53.014				16	47	0
	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						
27 August	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						
4 September	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						
10 September	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						

Appendix Table 1. (Continued) Abbreviations: CEN-Centrarchid; PSP-Pomoxis spp.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CEN			PSP		
						Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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						
15 June	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						
21 June	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						
29 June	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						

Appendix Figure 1. (Continued) Abbreviations: CEN-Centrarchid; PSP-Pomoxis spp.

Date	Station	Duration	Speed	Area	Volume	CEN			PSP		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
7 July	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	10	57	0			
13 July	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						
21 July	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	10	40	0			
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	31	146	0			
	11	180	1.5	0.196	53.014	5	29	0			
29 July	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						
3 August	1	180	1.5	0.196	53.014	10	57	0			
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	5	29	0			
	11	180	1.5	0.196	53.014						

Appendix Table 1. (Continued) Abbreviations: CEN-Centrarchid; PSP-Pomoxis spp.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	CEN Mean	CEN Upper	CEN Lower	PSP Mean	PSP Upper	PSP Lower
10 August	1	180	1.5	0.196	53.014	68	244	0			
	2	180	1.5	0.196	53.014	21	68	0			
	4	180	1.5	0.196	53.014	63	237	0			
	5	180	1.5	0.196	53.014	5	29	0			
	11	180	1.5	0.196	53.014						
20 August	1	180	1.5	0.196	53.014	110	366	0			
	2	180	1.5	0.196	53.014	21	68	0			
	4	180	1.5	0.196	53.014	42	203	0	5	29	0
	5	180	1.5	0.196	53.014	10	57	0			
	11	180	1.5	0.196	53.014						
27 August	1	180	1.5	0.196	53.014	21	68	0			
	2	180	1.5	0.196	53.014	10	40	0			
	4	180	1.5	0.196	53.014	21	115	0			
	5	180	1.5	0.196	53.014	37	121	0			
	11	180	1.5	0.196	53.014	10	57	0			
4 September	1	180	1.5	0.196	53.014				5	29	0
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	5	29	0			
	11	180	1.5	0.196	53.014						
10 September	1	180	1.5	0.196	53.014	5	29	0			
	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						

Appendix Table 1. (Continued) Abbreviations: MDO-smallmouth bass; UNK-unknown.

Date	Station	Duration	Speed	Area	Volume	MDO			UNK		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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	29	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
15 June	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						
21 June	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						
29 June	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						

Appendix Table 1. (Continued) Abbreviations: MDO-smallmouth bass; UNK-unknown.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MDO Mean	MDO Upper	MDO Lower	UNK Mean	UNK Upper	UNK Lower
7 July	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						
13 July	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						
21 July	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	10	57	0			
	11	180	1.5	0.196	53.014						
29 July	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						
3 August	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						

Appendix Table 1. (Continued) Abbreviations: MDO-smallmouth bass; UNK-unknown.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MDO			UNK		
						Mean	Upper	Lower	Mean	Upper	Lower
10 August	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 August	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				10	40	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
27 August	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						
4 September	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						
10 September	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						

Appendix Table 2. Catch/volume of water filtered (No./10,000 m^3) for larval handbeam trawl samples in shallow (S; 0.5 m) and deep (D; 10 m) waters along the shoreline during 1993 in Lower Granite Reservoir. Upper and lower refer to bounds. Abbreviations: ASA-American shad.

Date	Station	Depth	ASA Mean	ASA Upper	ASA Lower	Total Mean	Total Upper	Total Lower
2 June	1	D				49	187	0
		S						
	2	D				97	373	0
		S				390	1493	0
	5	D				244	620	0
		S				195	746	0
	11	D				195	746	0
		S				390	941	0
9 June	1	D				292	860	0
		S	97	373	0	97	373	0
	2	D				49	187	0
		S				195	746	0
	5	D				146	385	0
		S				1072	3755	0
	11	D				14815	1131	0
		S				4483	11172	0
16 June	1	D						
		S				682	1785	0
	2	D				49	187	0
		S				3606	12261	0
	5	D	49	187	0	49	187	0
		S				390	1493	0
	11	D				828	2168	0
		S	390	1493	0	4483	14274	0
22 June	1	D				195	746	0
		S				1559	5970	0
	2	D				146.2	560	0
		S				2144	4774	0
	5	D						
		S	97	373	0	97	373	0
	11	D				97	373	0
		S				585	1590	0
1 July	1	D						
		S				97	373	0
	2	D				926	3545	0
		S				2144	7801	0
	5	D				1121	3896	0
		S				97	373	0
	11	D				439	1541	0
		S	292	770	0	74659	117760	32605

Appendix Table 2. (Continued) Abbreviations: ASA-American shad.

Date	Station	Depth	ASA			Total		
			Mean	Upper	Lower	Mean	Upper	Lower
8 July	1	D				292	877	0
		S				3801	13739	0
	2	D				49	187	0
		S				195	746	0
	5	D						
		S				682	1884	0
	11	D	439	1679	0	34064	79808	3899
		S	1072	3329	0	184503	305176	65540
14 July	1	D						
		S				292	770	0
	2	D				97	373	0
		S						
	5	D				390	1143	0
		S				292	1119	0
	11	D				7602	18276	0
		S				165789	311823	23808
23 July	1	D	147	587	0	342	1222	0
		S	487	1481	0	1365	3663	107
	2	D						
		S	1365	2823	0	3801	10498	0
	5	D				2242	7171	0
		S				1170	4083	0
	11	D	49	187	0	585	2239	0
		S	31287	116073	0	32943	118833	991
27 July	1	D	98	98	98	831	3030	98
		S	195	746	0	390	1493	0
	2	D				49	187	0
		S	97	373	0	585	2239	0
	5	D				1559	5179	0
		S				975	2629	0
	11	D				12573	20928	5821
		S	585	1848	0	41423	93129	2809
6 August	1	D	49	187	0	391	1555	0
		S						
	2	D						
		S						
	5	D				5701.76	19092.83	0.00
		S	97	373	0	584.8	2238.84	0.00
	11	D	49	187	0	25779.71	47957.06	4616.44
		S	7797	29439	0	82163.74	194885.75	13702.99

Appendix Table 2. (Continued) Abbreviation: ASA-American shad.

			ASA			Total		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D				3606	9052	0
		S				292	1119	0
	11	D				49	187	0
		S	97	373	0	4191	13154	0
28 August	1	D						
		S						
	2	D						
		S						
	5	D				49	187	0
		S				97	373	0
	11	D				49	187	0
		S				195	746	0
4 September	1	D						
		S						
	2	D						
		S						
	5	D				390	1294	0
		S				585	1412	0
	11	D						
		S				97	373	0
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: CYP-Cyprinus; AAL-chiselmouth.

			CYP			AAL		
Date	Station	Depth	Mean	Upper	Lower	MEAN	UPPER	LOWER
2 June	1	D	49	187	0			
		S						
	2	D						
		S						
	5	D	97	235	0			
		S	97	373	0			
	11	D	97	373	0			
		S	195	471	0			
9 June	1	D						
		S						
	2	D						
		S	97	373	0			
	5	D						
		S	97	373	0			
	11	D	49	187	0			
		S	1852	4650	0			
16 June	1	D						
		S	585	1412	0			
	2	D	49	187	0			
		S	1559	5970	0			
	5	D						
		S						
	11	D	49	187	0			
		S	2437	8919	0			
22 June	1	D	195	746	0			
		S	195	746	0			
	2	D	97	373	0			
		S						
	5	D						
		S						
	11	D	97	373	0			
		S	487	1217	0			
1 July	1	D						
		S						
	2	D						
		S						
	5	D	97	373	0	48.73	186.57	0.00
		S						
	11	D	341	1306	0			
		S	7505	11024	3985	292.40	1119.20	0.00

Appendix Table 2. (Continued) Abbreviations: CYP-Cyprinus spp.; AAL-chiselmouth.

Date	Station	Depth	CYP			AAL		
			Mean	Upper	Lower	Mean	Upper	Lower
8 July	1	D	292	877	0			
		S	195	746	0			
	2	D	49	187	0			
		S	97	373	0			
	5	D						
		S	682	1884	0			
	11	D	4825	14752	0	634	2425	0
		S	26316	37894	14737	975	1969	0
14 July	1	D						
		S						
	2	D						
		S						
	5	D	146	385	0			
		S	97	373	0			
	11	D	5653	12348	0	49	187	0
		S	20370	31397	9343	1949	7055	0
23 July	1	D						
		S	585	1062	107			
	2	D						
		S	2047	6182	0			
	5	D						
		S	682	2217	0			
	11	D	536	2052	0			
		S	1267	1543	991			
27 July	1	D	49	196	0			
		S						
	2	D	49	187	0			
		S						
	5	D				49	187	0
		S				97	373	0
	11	D	8480	11138	5821	3119	7451	0
		S				6823	15849	0
6 August	1	D						
		S						
	2	D						
		S						
	5	D	146	560	0			
		S						
	11	D	19883	35603	4162	1023	1978	68
		S	32749	51794	13703	3509	13433	0

Appendix Table 2. (Continued) Abbreviations: CYP-Cyprinus spp.; AAL-chiselmouth.

			CYP			AAL		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	49	187	0			
		S	97	373	0			
4 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: CCA-carp; MCA-peamouth.

			CCA			MCA		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
2 June	1	D						
		S						
	2	D				97	373	0
		S				97	373	0
	5	D						
		S						
	11	D						
		S						
9 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
16 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
22 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S				97	373	0
1 July	1	D						
		S						
	2	D				926	3545	0
		S				2144	7801	0
	5	D				682	2217	0
		S						
	11	D				97	235	0
		S				1754	3836	0

Appendix Table 2. (Continued) Abbreviations: CCA-carp; MCA-peamouth.

Date	Station	Depth	CCA Mean	CCA Upper	CCA Lower	MCA Mean	MCA Upper	MCA Lower
8 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				5702	7504	3899
		S				5263	7744	2782
14 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	49	187	0			
		S				2437	5234	0
23 July	1	D						
		S						
	2	D						
		S				97	373	0
	5	D						
		S						
	11	D						
		S				195	471	0
27 July	1	D				196	782	0
		S						
	2	D						
		S				292	1119	0
	5	D				49	187	0
		S						
	11	D				536	1265	0
		S				7115	11421	2809
6 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				2388	4390	386
		S				14230	36961	0

Appendix Table 2. (Continued) Abbreviations: CCA-carp; MCA-peamouth.

			CCA			MCA		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
4 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: POR-northern squawfish; RBA-redside shiner

			POR			RBA		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
2 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
9 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
16 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
22 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
1 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: POR-northern squawfish; RBA-redside shiner.

			POR			RBA		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
8 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
14 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				97	235	0
		S				195	746	0
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
27 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
6 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: POR-northern squawfish; RBA-redside shiner.

			POR			RBA		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	3899	12035	0			
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
4 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: CSP-Catostomid spp.; CMA-largescale sucker.

Date	Station	Depth	CSP Mean	CSP Upper	CSP Lower	CMA Mean	CMA Upper	CMA Lower
2 June	1	D						
		S						
	2	D						
		S	292	1119	0			
	5	D	146	385	0			
		S						
	11	D	97	373	0			
		S	195	471	0			
9 June	1	D	146	292	0	97	373	0
		S						
	2	D				49	187	0
		S				97	373	0
	5	D				146	385	0
		S	682	2612	0			
	11	D	14620	385	0	146	560	0
		S	2534	6150	0	97	373	0
16 June	1	D						
		S	97	373	0			
	2	D						
		S	2047	6291	0			
	5	D						
		S	390	1493	0			
	11	D	780	1981	0			
		S	1657	3862	0			
22 June	1	D						
		S	1267	4851	0			
	2	D	49	187	0			
		S	2144	4774	0			
	5	D						
		S						
	11	D						
		S						
1 July	1	D						
		S	97	373	0			
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	64815	101010	28619			

Appendix Table 2. (Continued) Abbreviations: CSP-Catostomid spp.; CMA-largescale sucker.

Date	Station	Depth	CSP Mean	CSP Upper	CSP Lower	CMA Mean	CMA Upper	CMA Lower
8 July	1	D						
		S	3314	11873	0			
	2	D						
		S	97	373	0			
	5	D						
		S						
	11	D	22466	53447	0			
		S	150390	252759	48021	487	1481	0
14 July	1	D						
		S	292	770	0			
	2	D						
		S						
	5	D	146	385	0			
		S	195	746	0			
	11	D	1754	5320	0			
		S	140741	267017	14464	97	373	0
23 July	1	D	49	196	0			
		S	97	373	0			
	2	D						
		S	195	746	0			
	5	D						
		S	195	746	0			
	11	D						
		S						
27 July	1	D						
		S						
	2	D						
		S	195	746	0			
	5	D						
		S	97	373	0			
	11	D	390	887	0			
		S	4483	13697	0	97	373	0
6 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	2388	5612	0			
		S	23294	61020	0	195	746	0

Appendix Table 2. (Continued) Abbreviations: CSP-Catostomid spp.; CMA-largescale sucker.

			CSP			CMA		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	97	373	0			
4 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: IPU-channel catfish; CEN-Centrarchid spp.

Date	Station	Depth	IPU			CEN		
			Mean	Upper	Lower	Mean	Upper	Lower
2 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
9 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S	292	770	0			
	11	D						
		S						
16 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
22 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
1 July	1	D						
		S						
	2	D						
		S						
	5	D				97	373	0
		S				97	373	0
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: IPU-channel catfish; CEN-Centrarchid spp.

Date	Station	Depth	IPU Mean	IPU Upper	IPU Lower	CEN Mean	CEN Upper	CEN Lower
8 July	1	D						
		S				97	373	0
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
14 July	1	D						
		S						
	2	D				97	373	0
		S						
	5	D						
		S						
	11	D						
		S						
23 July	1	D						
		S						
	2	D						
		S						
	5	D				2242	7171	0
		S				292	1119	0
	11	D						
		S				195	746	0
27 July	1	D				489	1955	0
		S						
	2	D						
		S						
	5	D				1413	4619	0
		S				780	1882	0
	11	D				49	187	0
		S						
6 August	1	D				342	1369	0
		S						
	2	D						
		S						
	5	D				2583	7152	0
		S				292	1119	0
	11	D						
		S				195	746	0

Appendix Table 2. (Continued) Abbreviations: IPU-channel catfish; CEN-Centrarchid spp.

			IPU			CEN		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D				3606	9052	0
		S				292	1119	0
	11	D						
		S				97	373	0
28 August	1	D						
		S						
	2	D						
		S						
	5	D				49	187	0
		S						
	11	D						
		S						
4 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S				585	1412	0
	11	D						
		S				97	373	0
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PSP-Pomoxis spp.; MDO-smallmouth bass.

Date	Station	Depth	PSP			MDO		
			Mean	Upper	Lower	Mean	Upper	Lower
2 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
9 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
16 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
22 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
1 July	1	D						
		S						
	2	D						
		S						
	5	D	146	559	0	49	188	0
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PSP-Pomoxis spp.; MDO-smallmouth bass.

			PSP			MDO		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
8 July	1	D						
		S	195	746	0			
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
14 July	1	D						
		S						
	2	D						
		S						
	5	D				97	373	0
		S						
	11	D						
		S						
23 July	1	D						
		S				97	373	0
	2	D						
		S	97	373	0			
	5	D						
		S						
	11	D						
		S						
27 July	1	D						
		S				195	746	0
	2	D						
		S						
	5	D				49	187	0
		S						
	11	D						
		S						
6 August	1	D						
		S						
	2	D						
		S						
	5	D				2973	11381	0
		S				195	746	0
	11	D	49	187	0			
		S						

Appendix Table 2. (Continued) Abbreviations: PSP-Pomoxis spp.; MDO-smallmouth bass.

Date	Station	Depth	PSP Mean	PSP Upper	PSP Lower	MDO Mean	MDO Upper	MDO Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S				97	373	0
	11	D						
		S						
4 September	1	D						
		S						
	2	D						
		S						
	5	D	390	1294	0			
		S						
	11	D						
		S						
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PAN-white crappie; PFL-yellow perch.

			PAN			PFL		
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
2 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
9 June	1	D	49	195	0			
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
16 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
22 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
1 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PAN-white crappie; PFL-yellow perch.

Date	Station	Depth	PAN			PFL		
			Mean	Upper	Lower	Mean	Upper	Lower
8 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
14 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
27 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
6 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S				195	746	0

Appendix Table 2. (Continued) Abbreviations: PAN-white crappie; PFL-yellow perch.

Date	Station	Depth	PAN			PFL		
			Mean	Upper	Lower	Mean	Upper	Lower
21 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
4 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 September	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviation: UNK-unknown.

			UNK		
Date	Station	Depth	Mean	Upper	Lower
2 June	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
9 June	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
16 June	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
22 June	1	D			
		S	97.47	373.14	0.00
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
1 July	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			

Appendix Table 2. (Continued) Abbreviation: UNK-unknown.

			UNK		
Date	Station	Depth	Mean	Upper	Lower
8 July	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
14 July	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
23 July	1	D	147	440	0
		S	97	373	0
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
27 July	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
6 August	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			

Appendix Table 2. (Continued) Abbreviation: UNK-unknown.

Date	Station	Depth	UNK		
			Mean	Upper	Lower
21 August	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D	49	187	0
		S	97	373	0
28 August	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
4 September	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			
11 September	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			

Appendix Table 3. Catch/volume of filtered water (No/L) for 0.5 meter pairedplankton nets during 1993 in Lower Granite Reservoir. Upper and lower refer to 95% bounds.

Date	Station	Duration	Speed	Area	Volume	Daphnia spp.			Total		
		Second	m/s	m²	m³	Mean	Upper	Lower	Mean	Upper	Lower
23 May	1	180	1.5	0.196	53.014	0.1382	0.8819	0	0.1570	1.3491	0
	2	180	1.5	0.196	53.014	0.0691	0.5949	0	0.0691	0.5949	0
	4	180	1.5	0.196	53.014	0.0534	0.5156	0	0.0565	0.6308	0
	5	180	1.5	0.196	53.014	0.0754	0.6246	0	0.0754	0.6246	0
	11	180	1.5	0.196	53.014	0.1351	0.8702	0	0.1351	0.8702	0
1 June	1	180	1.5	0.196	53.014	0.0471	0.4813	0	0.0533	0.7117	0
	2	180	1.5	0.196	53.014	0.2451	1.2352	0	0.2451	1.2352	0
	4	180	1.5	0.196	53.014	0.0251	0.3422	0	0.0251	0.3422	0
	5	180	1.5	0.196	53.014	0.0490	0.4918	0	0.0528	0.6184	0
	11	180	1.5	0.196	53.014	0.0189	0.2935	0	0.0189	0.2935	0
8 June	1	180	1.5	0.196	53.014	0.0000	0.0000	0	0.0000	0.0000	0
	2	180	1.5	0.196	53.014	0.0189	0.2935	0	0.0220	0.4087	0
	4	180	1.5	0.196	53.014	0.0566	0.5322	0	0.0659	0.8778	0
	5	180	1.5	0.196	53.014	0.0408	0.4450	0	0.0439	0.5602	0
	11	180	1.5	0.196	53.014	0.0282	0.3646	0	0.0282	0.3646	0
15 June	1	180	1.5	0.196	53.014	0.0094	0.2036	0	0.0125	0.3188	0
	2	180	1.5	0.196	53.014	0.0126	0.2368	0	0.0157	0.3520	0
	4	180	1.5	0.196	53.014	0.0031	0.1152	0	37.0031	66.1152	7
	5	180	1.5	0.196	53.014	0.0031	0.1152	0	0.0031	0.1152	0
	11	180	1.5	0.196	53.014	0.0094	0.2036	0	0.0094	0.2036	0
21 June	1	180	1.5	0.196	53.014	0.0000	0.0000	0	0.0000	0.0000	0
	2	180	1.5	0.196	53.014	0.0000	0.0000	0	0.0000	0.0000	0
	4	180	1.5	0.196	53.014	0.0094	0.2036	0	0.0031	0.1152	0
	5	180	1.5	0.196	53.014	0.0471	0.4813	0	0.0533	0.7117	0
	11	180	1.5	0.196	53.014	0.0000	0.0000	0	0.0062	0.2304	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Daphnia spp.			Total		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	1	180	1.5	0.196	53.014	0.05	0.52	0	0.06	0.68	0
	2	180	1.5	0.196	53.014	0.08	0.67	0	0.10	0.93	0
	4	180	1.5	0.196	53.014	0.04	0.43	0	0.04	0.54	0
	5	180	1.5	0.196	53.014	0.05	0.48	0	0.06	0.75	0
	11	180	1.5	0.196	53.014	0.00	0.12	0	0.01	0.40	0
7 July	1	180	1.5	0.196	53.014	0.01	0.24	0	0.02	0.35	0
	2	180	1.5	0.196	53.014	0.17	0.99	0	0.17	0.99	0
	4	180	1.5	0.196	53.014	0.03	0.34	0	0.03	0.34	0
	5	180	1.5	0.196	53.014	0.01	0.24	0	0.02	0.35	0
	11	180	1.5	0.196	53.014	0.00	0.12	0	0.01	0.23	0
13 July	1	180	1.5	0.196	53.014	0.02	0.32	0	0.03	0.64	0
	2	180	1.5	0.196	53.014	0.03	0.36	0	0.03	0.53	0
	4	180	1.5	0.196	53.014	0.00	0.12	0	0.01	0.23	0
	5	180	1.5	0.196	53.014	0.31	1.42	0	0.68	3.10	0
	11	180	1.5	0.196	53.014	0.05	0.50	0	0.10	1.29	0
29 July	1	180	1.5	0.196	53.014	1.00	3.00	0	1.70	6.91	0
	2	180	1.5	0.196	53.014	0.15	0.94	0	0.59	3.85	0
	4	180	1.5	0.196	53.014	0.08	0.65	0	0.77	3.85	0
	5	180	1.5	0.196	53.014	0.13	0.85	0	5.55	13.16	0.6
	11	180	1.5	0.196	53.014	0.02	0.32	0	0.71	3.52	0
3 August	1	180	1.5	0.196	53.014	0.11	0.77	0	1.74	7.92	0
	2	180	1.5	0.196	53.014	0.10	0.73	0	0.79	4.18	0
	4	180	1.5	0.196	53.014	0.06	0.53	0	0.21	2.01	0
	5	180	1.5	0.196	53.014	0.30	1.40	0	19.28	31.90	9.8
	11	180	1.5	0.196	53.014	0.07	0.59	0	6.04	32.15	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Daphnia spp.			Total		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	146.3321	170.5257	122.14	259.7200	315.7000	209.9900
	2	180	1.5	0.196	53.014	16.1998	24.2495	0.00	78.2500	107.2600	44.9700
	4	180	1.5	0.196	53.014	42.4160	55.4415	29.39	86.0900	116.8400	58.6700
	5	180	1.5	0.196	53.014	5.3978	10.0448	0.75	21.8100	40.1700	7.8500
	11	180	1.5	0.196	53.014	0.2922	1.3733	0.00	1.3200	5.3800	0.0000
20 August	1	180	1.5	0.196	53.014	90.7900	109.8500	71.73	145.7000	183.5200	109.9900
	2	180	1.5	0.196	53.014	39.4000	51.9500	26.85	84.7700	114.5000	57.3500
	4	180	1.5	0.196	53.014	74.5300	91.7900	57.26	225.5900	268.8400	183.5100
	5	180	1.5	0.196	53.014	1.1200	3.2400	0.00	46.7400	68.6200	28.8200
	11	180	1.5	0.196	53.014	0.6000	2.1600	0.00	3.8100	12.7400	0.0000
27 August	1	180	1.5	0.196	53.014	451.1200	493.6000	408.64	845.5600	932.7600	761.5100
	2	180	1.5	0.196	53.014	115.0600	136.5100	93.60	381.3000	441.2200	325.4500
	4	180	1.5	0.196	53.014	321.1700	357.0100	285.33	686.2600	764.8400	608.8300
	5	180	1.5	0.196	53.014	14.7000	22.3700	7.04	98.6600	128.7000	71.0400
	11	180	1.5	0.196	53.014	0.8700	2.7400	0.00	8.4900	17.4300	1.9500
4 September	1	180	1.5	0.196	53.014	467.1841	510.4130	423.96	915.7445	1,008.7393	827.9316
	2	180	1.5	0.196	53.014	142.6058	166.4893	118.72	334.0623	389.2561	281.6658
	4	180	1.5	0.196	53.014	168.2989	194.2449	142.35	344.1415	399.7288	291.2009
	5	180	1.5	0.196	53.014	4.4615	8.6860	0.24	46.4409	69.1120	27.7413
	11	180	1.5	0.196	53.014	0.7949	2.5781	0.00	11.0689	22.5448	3.3003
10 September	1	180	1.5	0.196	53.014	21.8700	31.2200	12.52	104.3100	135.9800	75.6300
	2	180	1.5	0.196	53.014	4.2100	8.3100	0.11	44.4000	64.7100	26.5300
	4	180	1.5	0.196	53.014	0.7900	2.5700	0.00	16.3400	30.6300	6.5400
	5	180	1.5	0.196	53.014	0.8200	2.6200	0.00	18.9100	35.3700	5.5700

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Leptodora spp.			Diaphanosoma spp.		
		Second	m/s	m²	m^3	Mean	Upper	Lower	Mean	Upper	Lower
23 May	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014	0.0031	0.1152	0			
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
1 June	1	180	1.5	0.196	53.014	0.0031	0.1152	0			
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	0.0038	0.1266	0			
	11	180	1.5	0.196	53.014						
8 June	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	0.0031	0.1152	0			
	11	180	1.5	0.196	53.014						
15 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				0.0031	0.1152	0
	4	180	1.5	0.196	53.014				37.0000	66.0000	7
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
21 June	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Leptodora spp.			Daiphansoma spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	1	180	1.5	0.196	53.014	0.0063	0.1648	0			
	2	180	1.5	0.196	53.014	0.0157	0.2664	0			
	4	180	1.5	0.196	53.014	0.0031	0.1152	0			
	5	180	1.5	0.196	53.014	0.0157	0.2664	0			
	11	180	1.5	0.196	53.014	0.0063	0.1648	0	0.0031	0.1152	0
7 July	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						
13 July	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014	0.0031	0.1152	0			
	5	180	1.5	0.196	53.014	0.3645	1.5719	0			
	11	180	1.5	0.196	53.014	0.0346	0.4064	0			
29 July	1	180	1.5	0.196	53.014	0.5059	1.9283	0	0.1320	0.8585	0
	2	180	1.5	0.196	53.014	0.2985	1.3912	0	0.0817	0.6533	0
	4	180	1.5	0.196	53.014	0.6315	2.2209	0	0.0440	0.4635	0
	5	180	1.5	0.196	53.014	5.1496	9.6880	0.6110	0.1131	0.7857	0
	11	180	1.5	0.196	53.014	0.6252	2.2067	0	0.0063	0.1648	0
3 August	1	180	1.5	0.196	53.014	1.1751	3.3431	0	0.0219	0.3186	0
	2	180	1.5	0.196	53.014	0.6064	2.1640	0	0.0126	0.2368	0
	4	180	1.5	0.196	53.014	0.1257	0.8347				
	5	180	1.5	0.196	53.014	18.4117	26.9935	9.8299			
	11	180	1.5	0.196	53.014	0.7101	2.3954	0	0.0063	0.1648	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Leptodora spp.			Diaphanosoma spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	108.7000	129.5600	87.8500			
	2	180	1.5	0.196	53.014	60.5300	76.0900	44.9700			
	4	180	1.5	0.196	53.014	42.2900	55.3000	29.2800			
	5	180	1.5	0.196	53.014	14.7900	22.4800	7.1000			
	11	180	1.5	0.196	53.014	0.9400	2.8800	0			
20 August	1	180	1.5	0.196	53.014	52.7800	67.3100	38.2500			
	2	180	1.5	0.196	53.014	43.7400	56.9600	30.5100			
	4	180	1.5	0.196	53.014	150.8100	175.3700	126.2500			
	5	180	1.5	0.196	53.014	41.7436	54.6655	28.8200			
	11	180	1.5	0.196	53.014	1.0714	3.1416	0			
27 August	1	180	1.5	0.196	53.014	392.4895	432.1122	352.8700			
	2	180	1.5	0.196	53.014	264.3617	296.8802	231.8400			
	4	180	1.5	0.196	53.014	363.6466	401.7857	323.5100			
	5	180	1.5	0.196	53.014	82.1300	100.2551	64.0000			
	11	180	1.5	0.196	53.014	7.3867	12.8224	1.9500			
4 September	1	180	1.5	0.196	53.014	446.2243	488.4724	403.9763	0.1634	0.9718	0
	2	180	1.5	0.196	53.014	190.5516	218.1597	162.9435			
	4	180	1.5	0.196	53.014	175.3305	201.8130	148.8480	0.0817	0.6533	0
	5	180	1.5	0.196	53.014	40.1821	52.8600	27.5042	0.1100	0.7732	0
	11	180	1.5	0.196	53.014	9.4478	15.5952	3.3003	0.0094	0.2036	0
10 September	1	180	1.5	0.196	53.014	81.1246	99.1384	63.1107			
	2	180	1.5	0.196	53.014	38.8971	51.3706	26.4236			
	4	180	1.5	0.196	53.014	14.0256	21.5157	6.5354			
	5	180	1.5	0.196	53.014	12.6934	19.8189	5.5678			

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Latona spp.			Latonopsis		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
23 May	1	180	1.5	0.196	53.014				0.0031	0.1152	0
	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						
1 June	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						
8 June	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						
15 June	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						
21 June	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				0.0126	0.2368	0
	11	180	1.5	0.196	53.014						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Latona spp.			Latonopsis		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	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						
7 July	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	0.0031	0.1152	0			
	11	180	1.5	0.196	53.014	0.0031	0.1152	0			
13 July	1	180	1.5	0.196	53.014				0.0094	0.2036	0
	2	180	1.5	0.196	53.014				0.0063	0.1648	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				0.0031	0.1152	0
	11	180	1.5	0.196	53.014						
29 July	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						
3 August	1	180	1.5	0.196	53.014	0.0126	0.2368	0	0.2262	1.1775	0
	2	180	1.5	0.196	53.014				0.0471	0.4813	0
	4	180	1.5	0.196	53.014				0.0031	0.1152	0
	5	180	1.5	0.196	53.014	0.0377	0.4260	0	0.3770	1.6051	0
	11	180	1.5	0.196	53.014				5.2398	28.6727	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Latona spp.			Latonopsis		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	0.6700	2.3000	0	1.0300	3.0600	0
	2	180	1.5	0.196	53.014	0.0600	0.5600	0	0.5900	2.1300	0
	4	180	1.5	0.196	53.014	0.0600	0.5600	0	0.5700	2.0700	0
	5	180	1.5	0.196	53.014	0.0400	0.4300	0	0.1900	1.0600	0
	11	180	1.5	0.196	53.014				0.0200	0.2900	0
20 August	1	180	1.5	0.196	53.014				0.0000	0.1200	0
	2	180	1.5	0.196	53.014				0.1300	0.8300	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				0.4900	1.9000	0
	11	180	1.5	0.196	53.014	0.0400	0.4300	0	0.1900	1.0600	0
27 August	1	180	1.5	0.196	53.014	0.1300	0.8300	0			
	2	180	1.5	0.196	53.014	0.2500	1.2500	0	0.5000	1.9200	0
	4	180	1.5	0.196	53.014				0.0000	0.0000	0
	5	180	1.5	0.196	53.014				0.0600	0.5600	0
	11	180	1.5	0.196	53.014				0.0400	0.4600	0
4 September	1	180	1.5	0.196	53.014	0.1650	0.9772	0	0.4697	1.8404	0
	2	180	1.5	0.196	53.014				0.4147	1.7027	0
	4	180	1.5	0.196	53.014	0.1131	0.7857	0	0.1665	0.9827	0
	5	180	1.5	0.196	53.014				0.3111	1.4265	0
	11	180	1.5	0.196	53.014	0.0754	0.6246	0	0.3393	1.5044	0
10 September	1	180	1.5	0.196	53.014	0.1571	0.9498	0	0.1885	1.0569	0
	2	180	1.5	0.196	53.014				0.7226	2.4228	0
	4	180	1.5	0.196	53.014	0.8546	2.7035	0	0.0943	0.7083	0
	5	180	1.5	0.196	53.014	0.8797	2.7556	0	0.3770	1.6051	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Cyclops spp.			Eurycerus Lamellatus		
		Second	m/s	m²	m³	Mean	Upper	Lower	Mean	Upper	Lower
23 May	1	180	1.5	0.196	53.014				0.0126	0.2368	0
	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						
1 June	1	180	1.5	0.196	53.014	0.0031	0.1152	0			
	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						
8 June	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						
15 June	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						
21 June	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				0.0031	0.1152	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Cyclops spp.			Eurycerus Lamellatus		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	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						
7 July	1	180	1.5	0.196	53.014	0.0031	0.1152	0			
	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						
13 July	1	180	1.5	0.196	53.014				0.0031	0.1152	0
	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						
29 July	1	180	1.5	0.196	53.014	0.0031	0.1152	0	0.0189	0.2935	0
	2	180	1.5	0.196	53.014	0.0126	0.2368	0	0.0157	0.2664	0
	4	180	1.5	0.196	53.014				0.0031	0.1152	0
	5	180	1.5	0.196	53.014	0.0346	0.4064	0	0.0943	0.7083	0
	11	180	1.5	0.196	53.014				0.0377	0.4260	0
3 August	1	180	1.5	0.196	53.014	0.0157	0.2664	0	0.0754	0.6246	0
	2	180	1.5	0.196	53.014				0.0031	0.1152	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	0.0377	0.4260				
	11	180	1.5	0.196	53.014				0.0094	0.2036	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Cyclops spp.			Eurycerus Lamellatus		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	0.7900	2.5700	0	0.8900	2.7800	0
	2	180	1.5	0.196	53.014	0.0400	0.4600	0	0.0600	0.5600	0
	4	180	1.5	0.196	53.014	0.5700	2.0700	0	0.1300	0.8300	0
	5	180	1.5	0.196	53.014	0.0400	0.4300	0	0.7300	2.4400	0
	11	180	1.5	0.196	53.014	0.0100	0.2000	0	0.0500	0.5200	0
20 August	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				0.0400	0.4600	0
	11	180	1.5	0.196	53.014						
27 August	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	0.1300	0.8300	0			
	4	180	1.5	0.196	53.014	0.1300	0.8300	0	0.2500	1.2500	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
4 Septmeber	1	180	1.5	0.196	53.014	0.0754	0.6246	0	0.1634	0.9718	0
	2	180	1.5	0.196	53.014	0.1257	0.8347	0	0.1634	0.9718	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				0.3236	1.4614	0
	11	180	1.5	0.196	53.014	0.0031	0.1152	0	0.0220	0.3186	0
10 September	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				0.0943	0.7083	0
	5	180	1.5	0.196	53.014				1.3196	3.6171	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Sida Crystallina			Eurycerus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
23 May	1	180	1.5	0.196	53.014				0.0031	0.1152	0
	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						
1 June	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						
8 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				0.0031	0.1152	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
15 June	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						
21 June	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				0.0031	0.1152	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Sida Crystallina			Eurycerus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	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						
7 July	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						
13 July	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				0.0031	0.1152	0
29 July	1	180	1.5	0.196	53.014	0.0031	0.1152	0			
	2	180	1.5	0.196	53.014	0.0283	0.3646	0			
	4	180	1.5	0.196	53.014	0.0063	0.1648	0			
	5	180	1.5	0.196	53.014	0.0189	0.2935	0			
	11	180	1.5	0.196	53.014	0.0094	0.2036	0			
3 August	1	180	1.5	0.196	53.014	0.0346	0.4064	0	0.0471	0.4813	0
	2	180	1.5	0.196	53.014	0.0063	0.1648	0	0.0063	0.1648	0
	4	180	1.5	0.196	53.014	0.0189	0.2935	0	0.0031	0.1152	0
	5	180	1.5	0.196	53.014	0.0377	0.4260	0	0.0754	0.6246	0
	11	180	1.5	0.196	53.014						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Sida Crystallina			Eurycerus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	0.2500	1.2400	0	0.9400	2.8800	0
	2	180	1.5	0.196	53.014	0.3100	1.4400	0	0.4400	1.7700	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	0.3100	1.4400	0	0.2300	1.1800	0
	11	180	1.5	0.196	53.014						
20 August	1	180	1.5	0.196	53.014	1.1900	3.3800	0	0.9300	2.8700	0
	2	180	1.5	0.196	53.014	1.2600	3.5000	0	0.2500	1.2500	0
	4	180	1.5	0.196	53.014	0.1300	0.8300	0	0.1300	0.8300	0
	5	180	1.5	0.196	53.014	0.8800	2.7600	0	2.4600	5.5900	0
	11	180	1.5	0.196	53.014	0.1000	0.7500	0	1.7300	4.3600	0
27 August	1	180	1.5	0.196	53.014	0.8800	2.7600	0	0.8200	2.6200	0
	2	180	1.5	0.196	53.014	0.6300	2.2100	0	0.3800	1.6100	0
	4	180	1.5	0.196	53.014	0.3800	1.6100	0	0.6900	2.3500	0
	5	180	1.5	0.196	53.014	0.9400	2.8800	0	0.8200	2.6200	0
	11	180	1.5	0.196	53.014	0.0600	0.5600	0	0.1300	0.8300	0
4 September	1	180	1.5	0.196	53.014	0.8845	2.7654	0	0.4147	1.7027	0
	2	180	1.5	0.196	53.014	0.2011	1.0979	0			
	4	180	1.5	0.196	53.014	0.0754	0.6246	0	0.0754	0.6246	0
	5	180	1.5	0.196	53.014	0.3362	1.4958	0	0.7164	2.4091	0
	11	180	1.5	0.196	53.014				0.3770	1.6051	0
10 September	1	180	1.5	0.196	53.014	0.7855	2.5580	0	0.1885	1.0569	0
	2	180	1.5	0.196	53.014	0.4399	1.7663	0	0.1257	0.8347	0
	4	180	1.5	0.196	53.014	0.3205	1.4527	0	0.1634	0.9718	0
	5	180	1.5	0.196	53.014	2.0737	4.9537	0	0.7541	0.0000	0

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Ceriodaphnia spp.			Holopedium spp.		
		Second	m/s	m²	m³	Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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						
8 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	0.0031	0.1152	0			
	4	180	1.5	0.196	53.014	0.0031	0.1152	0	0.0031	0.1152	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						
15 June	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						
21 June	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Ceriodaphnia spp.			Holopedium spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	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						
7 July	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						
13 July	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						
29 July	1	180	1.5	0.196	53.014	0.0283	0.3646	0			
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014	0.0031	0.1152	0			
	5	180	1.5	0.196	53.014	0.0094	0.2036	0			
	11	180	1.5	0.196	53.014						
3 August	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014	0.0031	0.1152	0			
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014	0.0031	0.1152	0			

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Ceriodaphnia spp.			Holopedium spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	1	180	1.5	0.196	53.014	0.11	0.79	0			
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014	0.06	0.56	0			
	5	180	1.5	0.196	53.014	0.09	0.68	0			
	11	180	1.5	0.196	53.014	0.00	0.12	0			
20 August	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						
27 August	1	180	1.5	0.196	53.014	0.13	0.83	0			
	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						
4 Septmeber	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						
10 September	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Alona spp.			Simocephalus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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						
8 June	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						
15 June	1	180	1.5	0.196	53.014				0.0031	0.1152	0
	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						
21 June	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Alona spp.			Simocephalus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	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						
7 July	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						
13 July	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						
29 July	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	0.0031	0.1152	0			
	11	180	1.5	0.196	53.014						
3 August	1	180	1.5	0.196	53.014	0.0189	0.2935	0			
	2	180	1.5	0.196	53.014	0.0031	0.1152	0			
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Alona spp.			Simocephalus spp.		
		Second	m/s	m²	m³	Mean	Upper	Lower	Mean	Upper	Lower
10 August	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 August	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	0.04	0.43	0	0.04	0.43	0
27 August	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						
4 September	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						
10 September	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume		Argulus spp.	
		Second	m/s	m^2	m^3	Mean	Upper	Lower
23 May	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			
1 June	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			
8 June	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			
15 June	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			
21 June	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			

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Argulus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower
29 June	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			
7 July	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			
12 July	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			
29 July	1	180	1.5	0.196	53.014	0.0031	0.1152	0
	2	180	1.5	0.196	53.014			
	4	180	1.5	0.196	53.014	0.0031	0.1152	0
	5	180	1.5	0.196	53.014	0.0031	0.1152	0
	11	180	1.5	0.196	53.014	0.0094	0.2036	0
3 August	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			

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Argulus spp.		
		Second	m/s	m^2	m^3	Mean	Upper	Lower
10 August	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 August	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			
27 August	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			
4 September	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			
10 September	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			

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Ostracoda			Nauplius Larvae		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
23 May	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						
1 June	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						
8 June	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						
15 June	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						
21 June	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Ostracoda			Nauplius Larvae		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
29 June	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						
7 July	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						
13 July	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	0.0157	0.2664	0			
29 July	1	180	1.5	0.196	53.014				0.0031	0.1152	0
	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						
3 August	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						

Appendix Table 3. (continued)

Date	Station	Duration	Speed	Area	Volume	Ostracoda			Nauplius Larvae		
		Second	m/s	m^2	m^3	Mean	Upper	Lower	Mean	Upper	Lower
10 August	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 August	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						
27 August	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						
4 September	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						
10 September	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						

Appendix Table 4. Number of fishes sampled by all gear types during spring 1987 in Lower Granite Reservoir.

Species	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S	Total
white sturgeon	1			3	2		6
chinook salmon	4	3	7	11	11	61	97
steelhead trout	3	9	41	53	63	96	265
chiselmouth	2	3	16	6	11	87	125
carp	2	4	20	22	29	35	112
peamouth			2	1		4	7
northern squawfish	2	5	13	19	21	43	103
redside shiner	3	8	6	2	6	48	73
bridgelip sucker			3	7	7	40	57
largescale sucker	2	8	26	77	52	197	362
brown bullhead			1	1		1	3
channel catfish	1	4		18	3	2	28
pumpkinseed				1			1
smallmouth bass			1	2		35	38
white crappie			1		2	2	5
black crappie					3	18	21
yellow perch					21	43	64
Total	20	44	137	223	231	712	1,367

Appendix Table 5. Numbers of fishes sampled by all gear types during summer 1987 in Lower Granite Reservoir.

Species	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S	Total
white sturgeon	8	4		1		5	18
chinook salmon	1					1	2
steelhead trout	16	21	47	22	19	10	135
chiselmouth	1		2		2	6	11
carp	10	10	10	16	17	134	197
peamouth			2		2	3	7
northern squawfish	1	5	6	13	16	6	47
redside shiner			1	1			2
bridgelip sucker		1					1
largescale sucker	7	58	38	87	124	192	506
brown bullhead	1	1	1				3
channel catfish			4	12	3		19
pumpkinseed			1	1	3		5
bluegill						1	1
smallmouth bass		1	1	3	13	58	76
white crappie				1	2	2	5
black crappie			7		1	1	9
yellow perch			40	5	29	13	87
Total	45	101	160	162	231	432	1,131

Appendix Table 6. Number of fishes sampled by all gear types during fall 1987 in Lower Granite Reservoir.

Species	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S	Total
white sturgeon	2	3		1			6
American shad		1				1	2
sockeye salmon				1			1
chinook salmon	1	1	4	1		6	13
steelhead trout	13	12	52	23	9	23	132
chiselmouth		3	5	3	7	12	30
carp	15	14	19	7	21	11	87
peamouth			5	16	4	2	27
northern squawfish	11	7	17	20	10	31	96
redside shiner			3	1		12	16
bridgelip sucker			1	1	1	2	5
largescale sucker	4	29	37	34	23	95	222
brown bullhead						2	2
channel catfish	3	4	5	8	1	4	25
pumpkinseed						1	1
bluegill						2	2
smallmouth bass			6	2	3	19	30
white crappie		1	35	6	39	15	96
black crappie	1		15	5	6	2	29
yellow perch			17	2	67	18	104
Total	50	75	222	130	191	258	926

Appendix Table 7. Number of fishes sampled by all gear types during spring 1988 in Lower Granite Reservoir.

Species	Stations								Total
	3	4	5	6	7	8	9	10	
white sturgeon	1	3	3		5	18			30
sockeye salmon	2		2	6			2	3	15
chinook salmon	160	27	542	1,169		4	160	67	2,129
steelhead trout	144	98	2,752	5,509	8	5	143	183	8,842
mountain whitefish		8	13	5				2	28
chiselmouth	48	1	23	2			38	28	140
carp	15	11	40	26	4	5		5	106
peamouth	2	1	6						9
northern squawfish	64	20	92	16	2	11	2	9	216
redside shiner	23	2	4				2	10	41
bridgelip sucker	13	4	17	33		1	35	9	112
largescale sucker	251	77	578	2,418	80	10	218	164	3,796
brown bullhead	2	1	15	1			1	1	21
tadpole madtom				1					1
channel catfish	3	7	4	3	8	10			35
pumpkinseed	6		79				2	12	99
bluegill	1		106	9			3	34	153
smallmouth bass	90	15	92	10			185	177	569
largemouth bass	1								1
white crappie	36	5	60	22	1		1	7	132
black crappie			1	1					2
yellow perch	6	6	60				1	2	75
Total	868	286	4,489	9,231	108	64	793	713	16,552

Appendix Table 8. Number of fishes sampled by all gear types during summer 1988 in Lower Granite Reservoir.

Species	Stations								Total
	3	4	5	6	7	8	9	10	
white sturgeon	3	2	2		7	30			44
chinook salmon			4	3					7
steelhead trout	4	4	75	104	7	1	6	11	212
mountain whitefish			3	3					6
chiselmouth	3	2	9	1			1		16
carp	41	31	53	3	1	5	3	31	168
peamouth		2	6	1					9
northern squawfish	15	12	484	16	11	5	1	5	549
redside shiner				2				3	5
bridgelip sucker	4			2			9	5	20
largescale sucker	455	303	4,703	774	98	77	101	48	6,559
brown bullhead	12	2	12	2		1			29
channel catfish	23	12	17	73					125
Lepomis spp.		171	7,965	28					8,164
pumpkinseed	12	2	34	2			6	6	62
bluegill		19	1,322	5			1	1	1,348
smallmouth bass	146	6	57	11			146	62	428
largemouth bass	2		1						3
white crappie	135	8	1,178	550				2	1,873
yellow perch	16	5	57	4					82
Total	871	581	15,982	1,584	124	119	274	174	19,709

Appendix Table 9. Number of fishes sampled by all gear types during fall 1988 Lower Granite Reservoir.

Species	Stations								Total
	3	4	5	6	7	8	9	10	
white sturgeon				1		21			22
American shad		1							1
chinook salmon		1	1	1	1				4
steelhead trout	9	3	15	1			1	1	30
mountain whitefish	3		2						5
chiselmouth	5	3	14	1					23
carp	3	1	16	12	4	9		2	47
peamouth		2	3						5
northern squawfish	26	15	148	47	8	9	1	1	255
redside shiner			1					1	2
bridgelip sucker	6	5	10	2				1	24
largescale sucker	234	72	490	549	11	25	2	21	1,404
brown bullhead	6	1	6	3				2	18
channel catfish	6	3	7	8		10			34
Lepomis spp.		5	2,527	135					2,667
pumpkinseed		4	18	151				7	180
bluegill		1	8	11				3	23
smallmouth bass	9	2	1	2			12	14	40
white crappie	53	20	567	348	1				989
black crappie				1					1
yellow perch	4	1	33	11				1	50
Total	364	140	3,867	1,284	25	74	16	54	5,824

Appendix Table 10. Number of fishes sampled by all gear types during spring 1989 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon							36			36
sockeye salmon						1				1
chinook salmon	172	406	370	172	2,640	594		477	145	4,976
steelhead trout	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
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
smallmouth bass	23	19	76	6	46	3		185	119	477
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
Cottid spp.			1							1
Total	865	948	991	551	3,970	1,113	98	1,128	1,243	10,907

Appendix Table 11. Number of fishes sampled by all gear types during summer 1989 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon		1		1			54			56
chinook salmon						1				1
steelhead trout			3		2		3	2	8	18
chiselmouth	5	5	11		1			28	126	176
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
smallmouth bass	25	198	446	8	152	4		250	299	1,382
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
Cottid spp.			1		2					3
Total	683	848	855	75	786	30	97	529	711	4,614

Appendix Table 12. Number of fishes sampled by all gear types during fall 1989 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon							7			7
chinook salmon			1		4					5
steelhead trout	4	1	3	6	12	1	1	1	2	31
moutain whitefish	2		1		2					5
chiselmouth	6	10	18	4	4	1		44	58	145
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
bluegill								2	1	3
smallmouth bass	8	54	173		77	2		130	88	532
white crappie	2	5	1		23	11		1		43
black crappie	3	1			18					22
yellow perch		4	3	2	29	1				39
Cottid spp.			1		1					2
Total	180	198	371	37	445	77	36	354	348	2,046

Appendix Table 13. Number of fishes sampled by all gear types during spring 1990 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
Pacific lamprey						1				1
white sturgeon					1		16			17
sockeye salmon	1				3	3		1		8
chinook salmon	42	62	61	296	532	473	2	186	50	1,704
steelhead trout	15	105	48	22	90	200	9	43	10	542
mountain whitefish	41	17	15	7	5	2		2	5	94
chiselmouth	38	11	66	11	98	12		110	93	439
carp	2	1	5	9	16	5	4	1	16	59
peamouth	7	2	3	1	1					14
northern squawfish	41	29	61	48	42	27	10		6	264
speckled dace				1						1
redside shiner	18	12	24	5	3				1	63
bridgelip sucker	21	5	17	7	39	7		42	15	153
largescale sucker	215	227	383	101	800	59	16	317	239	2,357
black bullhead				1	2					3
yellow bullhead	2		1		2	2				7
brown bullhead	5	4	15	8	27	3	1		1	64
channel catfish	1	2	6	1	4	12	34			60
Lepomis spp.			3							3
pumpkinseed	5	5	36	1	20				21	88
bluegill			3		9				11	23
smallmouth bass	34	43	106	7	25	4		9	133	361
white crappie	6	17	24	8	43	10			3	111
black crappie	13	6	32	7	6	7			23	94
yellow perch			16	19	49	1				85
sculpin	1									1
Total	508	548	925	560	1,817	828	92	711	627	6,616

Appendix Table 14. Number of fishes sampled by all gear types during summer 1990 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon	1				4		5			10
American shad					3					3
steelhead trout			2			1			2	5
chiselmouth	1	2			6				4	13
carp	9	9	23	9	50	1	5	1	1	108
peamouth			13		1					14
northern squawfish	61	21	227	11	78	4	1	2	2	407
redside shiner			1							1
bridgelip sucker	2		3	1	2			6		14
largescale sucker	372	292	352	127	835	52	49	79	35	2,193
yellow bullhead	1		2		6	11		1		21
brown bullhead	39	5	18	2	14	7			1	86
channel catfish	13	10	17	4	24	6	2			76
Lepomis spp.	15	8	3	1,367		6			131	1,527
pumpkinseed	7	4	35	5	51	1		23	8	134
bluegill			3					2	12	17
smallmouth bass	144	230	325	4	108	10		304	353	1,478
Pomoxis spp.	37	20	146		8					211
white crappie	14	52	62	4	56	32		2		222
black crappie	1	3	14		2	3		3	2	28
yellow perch		5	5	2	45	5			1	63
Total	717	661	2,615	169	1,299	133	62	423	552	6,631

Appendix Table 15. Number of fishes sampled by all gear types during fall 1990 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon							4			4
American shad		1		1						2
chinook salmon	1				2					3
mountain whitefish		3	3	1						7
steelhead trout	2	4	8	2	4	1				21
chiselmouth	4	4	5	11	2	2		1	7	36
carp	1	1	1		1	3	1			8
peamouth	5	7		1	1	3				17
northern squawfish	38	27	23	12	68	17	7	3	5	200
redside shiner		1								1
bridgelip sucker	4	4	2	2		1		4	1	18
largescale sucker	350	246	186	55	132	123	32	48	18	1,190
yellow bullhead	2	2	1	2	2	3				12
brown bullhead	2	1	2		1	11	1			18
channel catfish	2		1	1	11	1	5			23
Lepomis spp.	10	12	19		75					116
pumpkinseed	1	2			3	2		6		14
bluegill					1			1	1	3
smallmouth bass	8	19	59	1	23	7		68	21	206
Pomoxis spp.	3									3
white crappie	2		8	1	15	20			1	47
black crappie	1	1	3							5
yellow perch	5	2		7	8	9				31
Total	441	339	321	97	349	203	50	131	57	1,988

Appendix Table 16. Number of fishes sampled by all gears during 1991 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon							1			1
sockeye salmon	1							7		8
chinook salmon	70	163	113	376	996	78		194	8	1,998
steelhead trout	39	64	41	16	279	73	1	43	9	565
mountain whitefish	29	10	11	7	4					61
chiselmouth	46	37	77	78	146	7	1	77	85	554
carp			4		5	3				12
peamouth	30	1	6	7	10					54
northern squawfish	37	30	66	251	295	32	13	4	45	773
redside shiner	2		1		1				3	7
bridgelip sucker	2	6	17	11	16	1		26	8	87
largescale sucker	313	331	415	317	539	15	10	421	309	2,670
black bullhead				3	4					7
yellow bullhead			1	1	2				1	5
brown bullhead	2			1	7					10
channel catfish	1				1	6	3			11
Lepomis spp.	13	5	20	12	12			9	357	428
pumpkinseed	5	1	11	25	29	1		23	89	184
bluegill	5		2	1	1			4	10	23
smallmouth bass	104	71	121	128	131	1		262	325	1,143
Pomoxis spp.	1		1						7	9
white crappie	4	4	10	2	12	5		6	5	48
black crappie	7	9	11	9	12			3	11	62
yellow perch	1	1	3	7	10					22
sculpin				4	4			1		9
Total	712	733	931	1,256	2,516	222	29	1,080	1,272	8,751

Appendix Figure 17. Number of fishes sampled by all gear types during summer 1991 in Lower Granite Reservoir.

Species	Stations						Total
	1	2	3	5	9	10	
steelhead trout					1		1
chiselmouth	6		7	10	3	3	29
carp	5		8		2		15
peamouth	12	1	10	9	2		34
northern squawfish	253	10	115	91	25	49	543
bridgelip sucker			1	1	11	12	25
largescale sucker	91	62	278	32	124	53	640
yellow bullhead			5	1	8		14
brown bullhead	6		1				7
Lepomis spp.	25		1,356	5	1	3	1,390
pumpkinseed	13	4	30	19	52	25	143
bluegill	1	1	6	5	12	8	33
smallmouth bass	142	123	225	173	384	258	1,305
Pomoxis spp.	14	2	497	30		1	544
white crappie	7	16	78	3	7	3	114
black crappie	1		11	3			15
Total	576	219	2,628	382	632	415	4,852

Appendix Table 18. Number of fishes sampled by all gear types during fall 1991 in Lower Granite Reservoir.

Species	Stations									Total
	1	2	3	4	5	6	8	9	10	
white sturgeon		1					2			3
chinook salmon		1			1					2
steelhead trout	1	7	4	3	3	1		2	1	22
chiselmouth	2	3	5	4	7	1				22
carp			5	3	1	1	5			15
peamouth	6	1		4	3	2				16
northern squawfish	76	23	65	10	63	19	15	7	15	293
brigdelip sucker	18	3	6		3	1		11	4	46
largescale sucker	162	114	119	30	143	49	29	41	29	716
black bullhead	2									2
yellow bullhead	2	3	2		1					8
brown bullhead	3	5	5	1	7	7				28
channel catfish	4				4	4	9			21
Lepomis spp.	77	4	224		21			4	49	379
pumpkinseed		1	22	1	8			12	3	47
bluegill								2		2
smallmouth bass	21	29	187	5	70	6		63	19	400
white crappie	5	2	25	1	13					46
black crappie					3	7			1	11
yellow perch					5	2				7
Total	379	197	669	62	356	100	60	142	121	2,086

Appendix Table 19. Number of fishes sampled by all gear types during spring 1992 in Lower Granite Reservoir.

Species	Stations 1	2	3	4	5	6	7	8	9	10	Total
white sturgeon	7		1	3	2	1	8	9			31
sockeye							1				1
chinook	63	191	151	47	713	496			78	132	1,871
steelhead trout	13	108	34	60	429	420	10	12	210	161	1,457
mountain whitefish	4		5		1						10
chiselmouth	9	5	18	1	32			1	57	48	171
carp	3	3	3	7	5	2	5				28
peamouth	15	1	7			1				4	28
porthern squawfish	20	8	55	8	33	10	2	7	17	24	184
redside shiner	2		2								4
bridgelip sucker			8		11				6	5	30
largescale sucker	88	183	193	24	267	47	46	72	199	200	1,319
yellow bullhead	1		1	1	2	1			1		7
brown bullhead	4	2	3		11	4	1		2		27
channel catfish	5		3	3	3	6	1	12			33
Lepomis spp.			1								1
pumpkinseed	16	4	29	1	18	1			18	10	97
bluegill			2		1				5		8
smallmouth bass	72	42	150	2	99				199	147	711
white crappie	5	6	7	3	9	6				1	37
black crappie	2	4	26	3	12	1	1		7	5	61
yellow perch	2	4	2	2	15	5					30
Total	331	561	701	165	1,663	1,001	75	113	799	737	6,146

Appendix Table 20. Number of fishes sampled by all gear types during summer 1992 in Lower Granite Reservoir.

Species	Stations						Total
	1	2	3	5	9	10	
steelhead trout		2	2	4	10	25	43
chiselmouth	3						3
carp	1		4		1	4	10
northern squawfish	2	1		6		2	11
redside shiner			1				1
largescale sucker	2		3	1			6
yellow bullhead			1				1
brown bullhead			1				1
madtom		1					1
Lepomis spp.	2		996			48	1,046
pumpkinseed	25		7	3	1	24	60
bluegill			32			11	43
smallmouth bass	32	6	155	7	5	26	231
Pomoxis spp.			6				6
black crappie			2			1	3
yellow perch			4				4
Total	67	10	1,214	21	17	141	1,470

Appendix Table 21. Number of fishes sampled by all gear types during fall 1992 in Lower Granite Reservoir.

Species	Stations										Total
	1	2	3	4	5	6	7	8	9	10	
white sturgeon					7	1	3	3			14
American shad	8				3						11
steelhead trout	17	15	37	3	4	3		1	35	63	178
mountain whitefish	1										1
chiselmouth	19	15	5	2	20	4			1	5	71
carp				2	12	3	4	12			33
peamouth	10	4	2		4	10	1		2	2	35
northern squawfish	14	5	24	3	24	9	2	8	6	17	112
redside shiner										1	1
Catostomus spp.		10									10
bridgelip sucker	4	1		1	4	1			3		14
largescale sucker	366	167	180	81	253	72	46	59	92	71	1,387
black bullhead			3								3
yellow bullhead			4		1						5
brown bullhead	21	2	8		7	7		2			47
channel catfish	2	3	2	3	71	6	2	6			95
Lepomis spp.	298	1	111		7				2	182	601
pumpkinseed	2	5	3	4	6	7			27	88	142
bluegill	1		1						3	46	51
smallmouth bass	39	22	107	5	35	3			74	72	357
largemouth bass									1		1
white crappie	3	3			8						14
black crappie	2	3	2	10	1	24	1		7	3	53
yellow perch	35	23	14	15	53	5					145
Total	842	279	503	129	520	155	59	91	253	550	3,381