US Army Corps
of Engineers
Walla Walla District

Monitoring Fish Community Activity at Disposal and Reference Sites in Lower Granite Reservoir, Idaho - Washington Year 5 (1992)

Report By:
David H. Bennett
Melissa A. Madsen
Thomas J. Dresser, Jr.
Thomas S. Curet

Department of Fish & Wildlife Resources
College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, Idaho 83844-1136

September 1995

MONITORING FISH COMMUNITY ACTIVITY AT DISPOSAL AND REFERENCE SITES IN LOWER GRANITE RESERVOIR, IDAHO-WASHINGTON YEAR 5 (1992)

by

David H. Bennett

Melissa A. Madsen

Thomas J. Dresser, Jr.

Thomas S. Curet

Department of Fish & Wildlife Resources
College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, Idaho 83844-1136

September 1995

TABLE OF CONTENTS

Item Page

ACKNOWLEDGMENTS

We thank all of the numerous people who contributed to successful completion of this project. Teri Barila and Chris Pinney provided very helpful and personal contract supervision and challenging discussion. Thanks to Ed Buettner, Idaho Department of Fish and Game, for use of the barge and Dennis Rondorf, National Biological Service, for use of the two-boat trawl. Numerous University students contributed valuable field time, well beyond what they were paid, especially Tim Curet and Brad Johnson. Dasu Bagarathi conducted the data analysis.

List of Figures

Page

Page

Page

Page

Page

Page

Page

List of Appendix Tables

List of Tables

List of Appendix Figures

Page

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. Sediment inflows from upstream sources contribute nearly 1.75 million cubic meters (2.3 million cubic yards) of material annually to the Lower Granite system. Deposition of a large amount of this material has necessitated dredging of the confluence area 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 initiated in 1988. Two in-water disposal sites were examined; in 1988 a mid-depth site originally 6.1-12.1 m (20-40 ft) deep was modified to a depth of 1.8-3.6 m (6-12 ft) thereby creating an underwater plateau, and in 1989 an island was created immediately downstream of the underwater plateau. 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 1992. This report provides information on the results of monitoring the fish and benthic macroinvertebrate communities and utilization of these habitats in year-5 (1992).

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 assess 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;*
5. *To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir;*
6. *To assess subyearling chinook salmon abundance, habitat utilization and migration in Lower Granite Reservoir; and*
7. *To assess biotic components associated with in-water disposal including macrophyte development, utilization and interactions with fish and benthic invertebrate abundance.*

STUDY AREA

Ten sampling stations were used to monitor fish abundance during 1992 in Lower Granite Reservoir. Stations sampled to evaluate the use of dredged material to enhance habitat included stations 1, 2 and 4. Stations 3, 5, 9 and 10 were shallow reference stations; one additional reference station (11) was sampled for larval predator abundance. Twenty-two stations were sampled to assess subyearling chinook salmon *Oncorhynchus tshawytscha* abundance and habitat use, and nine additional stations between RM 108.0 and RM 137.1 were selected to assess white sturgeon *Acipenser transmontanus* abundance.

Objective 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.

We used several gear types during 1992 to make representative fish collections in Lower Granite Reservoir. Gear types included gill nets, beach seines, electrofishing, surface trawling, half-meter plankton nets and a handbeam trawl. Gill nets were used to assess the relative abundance of potential predators and white sturgeon in pelagic waters. Surface trawling was used to sample 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. All fish larger than larval size were identified to species and measured to total length (mm). Most fish collected were released immediately after data collection, while northern squawfish *Ptychocheilus oregonensis* were sacrificed for assessment of salmonid smolt predation (Objective 3). Adult salmonid fishes were released immediately without being removed from the water to comply with the Endangered Species Permit.

A total of 10,997 fishes representing 25 species and 3 genera was collected at disposal (1, 2, 4 and 7) and reference (3, 5, 6, 8, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during 1992. The highest number of adult and subadult fishes collected was from 1 April through 30 June, the spring sampling interval, when a total of

6,146 fishes was collected. A total of 1,470 fishes was collected during summer and 3,381 during fall 1992.

Juvenile chinook salmon were the most abundant species sampled during spring 1992 accounting for 30.4% (n=1,871) of the fishes collected. Next in abundance was juvenile steelhead *Oncorhynchus mykiss* (23.7%, n=1,457) followed by largescale sucker *Catostomus macrocheilus* (21.4%, n=1,319), smallmouth bass *Micropterus dolomieu* (11.4%, n=711), northern squawfish (2.9%, n=184) and chiselmouth *Acrocheilus alutaceus* (2.7%; n=171).

The highest number of adult and subadult predators, smallmouth bass and northern squawfish, sampled during spring by all gear types was collected from shallow reference station 9 (n=216) followed by shallow reference stations 3 (n=205) and 10 (n=171). Abundance of smallmouth bass (station 1, 21.7%; station 2, 7.4%) and northern squawfish (station 1, 6.0%; station 2, 1.4%) at shallow disposal stations 1 and 2 was generally low.

During the summer sampling interval, 1 July through 30 September, 1992, a total of 1,470 fishes was sampled by all gear types. *Lepomis* spp. dominated the catch (71.1%, n=1,046) followed by smallmouth bass (15.7%, n=231) and pumpkinseed *Lepomis gibbosus* (4.0%, n=60). No juvenile salmon were sampled during summer and the abundance of juvenile steelhead sampled was 2.9% (n=43). The number of predators collected at disposal station 2 during the summer was low (n=7).

A total of 3,381 fishes was collected by all gear types during the fall 1992 sampling interval (1 October through 31 October). Largescale sucker (41.0%, n=1,387) dominated the catches followed by *Lepomis* spp. (17.7%, n=601), smallmouth bass (10.5%, n=357) and juvenile steelhead (5.2%, n=178). Abundance of predators at shallow disposal stations 1 (6.2%, n=53) and 2 (9.6%, n=27) was low.

The abundance of channel catfish *Ictalurus punctatus* based on gill net collections varied among stations during 1992 but was low at disposal stations. The abundance of channel catfish, based on comparisons of catch/effort, indicated significantly ($P < 0.05$) higher abundance at reference stations 5 and 6 than other reference and disposal stations.

Night and daytime catches of smallmouth bass by electrofishing and beach seining were generally low at disposal stations 1 and 2, however little statistical significance was found among stations. Since 1989, few statistical differences in catch/effort have been found among stations and years. Abundance of larger smallmouth bass based on gill net collections was high at disposal stations 1 and 2.

White sturgeon were collected at reference and disposal sampling stations in 1992. The abundance of white sturgeon, based on comparison of catch/effort was similar among stations, except at deep disposal station 7 where abundance was significantly ($P < 0.05$) higher. The population estimate for sturgeon was similar to previous years.

The abundance of larval fishes was monitored during 1992. As in previous years, the highest catches were at shallow reference station 11. High numbers of larval fishes collected in 1991 and 1992 were attributed to reservoir operations at minimum operating pool and not the in-water disposal. Density of larval northern squawfish was highest at shallow reference station 11 and low at the disposal stations.

Objective 2. To assess fish utilization and characterize habitat at the newly constructed deep water disposal site.

Gill netting was used to sample the newly constructed in-water deep disposal station 7 (RM 119.0) during April, May, June, August and October (Objective 1). Sampling was conducted in the evening and night with experimental gill nets.

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 redrawn to scale from the NOAA nautical chart and depths recorded at points along each transect where an appreciable change in depth occurred. Lines representing 3 m (10 ft) contour intervals were drawn by hand and then digitized for final plotting.

Habitat created by disposal of dredged material in late winter 1992 resembled an underwater island. Dredged material was positioned adjacent to a steep shoreline (about 20% grade) that decreased in depth about 24 m in 120 m (80 ft in 400 ft). Depths at the site were reduced from the original river channel at approximately 24-30 m (80-100 ft) to as shallow as 15 m (50 ft) at the top of the disposed material. The area where the bulk of the disposal occurred was about 240 m x 135 m (800 ft x 450 ft).

Catch/efforts for northern squawfish, smallmouth bass, channel catfish and white sturgeon by gill netting were similar between deep reference station 8 and deep disposal station 7 in 1992. Catch/efforts were higher at deep reference station 8 for northern squawfish and channel catfish than those at deep disposal station 7, although these differences were not significant (P > 0.05). Catch/efforts for white sturgeon and smallmouth bass were higher at disposal station 7 than reference station 8, although these differences also were not significant (P > 0.05).

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

Two-boat trawling was used to compare abundance of salmonid fishes at shallow disposal station 2 and mid-depth disposal station 4 with shallow reference station 5 and mid-depth reference station 6. Two hauls per site were taken using a 10 m (32.8 ft) surface trawl. Sampling was conducted for 3 days during peak downstream smolt migration to obtain relative estimates of smolt abundance at the sampling stations, and at biweekly intervals in April, May and June.

Differences in catch/effort for juvenile chinook salmon by surface trawling among stations were not significant (P > 0.05) during spring 1992. Catch/effort for juvenile chinook was lowest at shallow disposal station 2, while that at mid-depth reference station 6 was highest. Differences in catch/effort by surface trawling for juvenile chinook salmon generally were similar among stations from 1989 through 1992. Catch/efforts were significantly ($P < 0.05$) higher at reference stations 5 and 6 compared to disposal stations 4 and 2.

Comparisons of catch/effort by surface trawling for juvenile steelhead indicated no significant ($P > 0.05$) differences among stations. Catch/effort was highest at mid-depth reference station 6 followed by shallow reference station 5.

Comparisons of catch/effort for juvenile steelhead by surface trawling from 1989 through 1992 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/efforts were highest at station 5 and lowest at station 4.

Objective 4. To assess movements and habitat utilization of white sturgeon Acipenser transmontanus in Lower Granite Reservoir.

White sturgeon sampling was conducted in Lower Granite Reservoir from February through early November 1992. Gill netting was the primary technique used to assess white sturgeon abundance, although setline sampling was also conducted in 1992. All captured sturgeon were measured for length, weighed, marked and released.

Approximately 2,565 gill net and 1,000 setline hours of effort were employed to capture 312 white sturgeon in Lower Granite Reservoir. Approximately 81% of all sturgeon (n=254) collected were located in the upper portion of Lower Granite Reservoir between RM 127.0 and RM 137.1. Total lengths of white sturgeon sampled by gill netting ranged from 21.7 cm to 159.5 cm with a mean length of 74.9 cm. Approximately 99% of the sturgeon sampled were < 122 cm.

A total of 66 sturgeon was recaptured from 2 February to 3 November, 1992. Fifteen of the 66 sturgeon were initially tagged during the 1990 tagging effort. Net movement of sturgeon initially marked and recaptured in 1992 ranged from 0.0 to 18.5 river kilometers (0.0-11.5 river miles) with five fish traveling > 17 km (> 10 miles) since their last recorded capture. Mean travel distance during the study was 12.5 river kilometers (7.8 river miles) downstream and 12.3 river kilometers (7.7 river miles) upstream.

A modified Schnabel estimate was used to compute a population estimate for white sturgeon based on captures and recaptures from February to May, 1992. The estimate yielded 1,804 individuals and a 95% confidence interval of 816 to 7,219 white sturgeon, based on a 2% recapture rate. This estimate was similar to those in previous years, although the confidence intervals were wider.

Depth of main channel areas sampled ranged from 14 to 36 m (46-118 ft) with adjacent bench areas typically ranging from 8 to 13 m (29.5-42.6 ft) deep. Sturgeon were collected at depths ranging from 6 to 36 m (19-118 ft) with a mean depth of 19.1 m (62.75 ft). Sturgeon > 40 cm were sampled throughout Lower Granite Reservoir, while sturgeon < 40 cm were collected in upper reservoir locations in depths < 18 m (<59.0 ft).

Objective 5. To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir.

Stomachs of 63 northern squawfish (>250 mm) collected by all gear types between river mile (RM) 107.5 and 137.1 from 1 April through 30 June, 1992 were examined for food items. Captured squawfish were measured by total length to the nearest millimeter (mm), anesthetized and the entire digestive tract removed and frozen for later analysis in the laboratory.

The majority (47%) of northern squawfish was captured at mid-reservoir stations (RM 112-126) followed by upriver (38%, RM 127-137.1) and lower reservoir locations near mid-depth reference station 6 (14%, RM 111). Squawfish (72%) ranged in length between 350-449 mm with a mean length of 380 mm.

Abundant food items of northern squawfish were insects, fish and crayfish. Crayfish were the dominant item by weight followed by fish while insects were most abundant numerically. Of the fish eaten, salmonids and centrarchids were most abundant.

Total daily ration for northern squawfish sampled during spring was 22.84 mg/g/d for all prey fishes. The daily ration estimate for squawfish that consumed juvenile chinook salmon was 11.64 mg/g/d and the ration of juvenile steelhead was 1.45 mg/g/d. Mean monthly total daily ration estimates varied by month. Mean monthly total daily ration of juvenile chinook salmon by northern squawfish was higher (2.44 mg/m/d) than that of juvenile steelhead (1.89 mg/m/d), and total daily ration of all salmonids was 16.45 mg/m/d.

Seasonal total daily ration of salmonids by northern squawfish indicate the ration of all salmonids combined was higher in 1992 than both 1990 and 1991. The daily ration of juvenile chinook salmon was six times higher in 1992 than 1990 and 1991. The consumption estimate of all prey fishes by northern squawfish > 250 mm during spring was 4.73 prey/predator/day. Based on an estimated population size for northern squawfish of 7,500 from RM 112.0 to RM 132.0, approximately 214,424 juvenile chinook and 3,743 steelhead were consumed. Combined losses for both identified and unidentified salmonids to squawfish during spring 1992 was estimated at 254,623 salmonid smolts.

Objective 6. To assess subyearling chinook salmon abundance, habitat utilization and migration in Lower Granite Reservoir.

Subyearling chinook were collected by beach seining and electrofishing during 1992 using identical methods employed for juvenile predator sampling (Objective 1). Areas of concentration of subyearling chinook were identified and measurements of macrohabitat characteristics were taken. Stomach contents of subyearling chinook salmon > 40 mm were evacuated using a modified gastric lavage following anesthetization with M.S. 222. A 5 cc syringe with a protected hypodermic needle was inserted through the mouth, down the esophagus to the fish's stomach.

A total of 330 subyearling chinook salmon was captured by beach seining between 10 April through 28 May, 1992 in Lower Granite Reservoir. No subyearling chinook salmon were collected in littoral areas after 28 May, 1992. One hundred and fourteen of the 146 (78%) subyearlings sampled on 15 May occurred at river miles 137.5, 132.0, 130.5 and 123.0. No subyearling chinook salmon were sampled downstream of RM 120.

A total of 305 subyearling chinook salmon (92%) was captured over substrates that consisted of > 75% fines (< 2 mm in diameter). Three years of beach seining data indicate 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. Subyearling chinook salmon exhibited a strong avoidance of rip-rap habitat.

A total of 292 subyearling chinook salmon stomachs sampled during April through July 1991 and 1992 was examined from Lower Granite and Little Goose reservoirs. Thirty-one different prey items were identified. Four prey items accounted for 87% of all prey items occurring in the stomachs by weight (dry weight, mg) and calorically: Ephemeroptera, Diptera, larval fishes and Cladocera.

We calculated the estimated average proportion of maximum consumption (P-value) as 0.274 using a bioenergetics model fitted to observed monthly growth for the combined April to July 1991 and 1992 samples. The P-value for a maintenance ration (zero growth) was estimated at 0.20 using the same prey caloric values and water temperatures, indicating maximum food consumption, was barely higher than maintenance.

Objective 7. To assess biotic components associated with in-water disposal including macrophyte development, utilization and interactions with fish and benthic invertebrate abundance.

We used a Shipek dredge (1,072 cm^2) to sample at disposal stations 1, 2 and 4 and reference stations 3, 5, 6 and 8 during July 1992. Four dredge samples were taken along three evenly spaced transects at each station providing a sample size of 12 per station. Collected organisms were identified to the lowest taxon possible and enumerated and wet weights were measured.

Benthic invertebrate community standing crop estimates ranged from 0.65 g/m^2 at shallow reference station 10 to 8.73 g/m^2 at mid-depth reference station 6. High standing crops of benthic invertebrates were at deep reference station 8 (5.37 g/m^2), mid-depth disposal station 4 (4.37 g/m^2), deep disposal station 7 (4.08 g/m^2) and shallow reference station 5 (3.42 g/m^2). Standing crop estimates of benthic invertebrates at disposal stations 1 and 2 and reference stations 3, 9 and 11 were statistically similar (1.43 to 1.91 g/m^2).

Standing crop estimates of chironomid biomass during July, 1992 ranged from 0.44 g/m^2 at shallow reference station 10 to 3.64 g/m^2 at mid-depth reference station 6. Chironomid biomass was highest at mid-depth station 6 (3.64 g/m^2), followed by mid-depth disposal station 4 (3.34 g/m^2), deep reference station 8 (2.88 g/m^2) and shallow reference station 5 (2.65 g/m^2). Estimates of chironomid biomass at disposal (1 and 2) and reference stations (3 and 11) were similar. The standing crop estimate at deep disposal station 7 was 2.17 g/m^2 compared to 2.88 g/m^2 at reference station 8. Statistical differences were scattered among stations.

During July 1992, the standing crop estimate of oligochaete biomass at mid-depth reference station 6 was highest (3.8 g/m^2) followed by deep reference station 8 (2.48 g/m^2) and deep disposal station 7 (1.72 g/m^2). Disposal (1 and 2) and reference stations (3, 9 and 11) had similar standing crop estimates of oligochaetes.

Comparisons of benthic invertebrate community standing crop estimates indicate a decline at stations 1, 3, 5 and 6 from 1989 to 1992. Station 6 had consistently the highest biomass of all stations and was significantly ($P < 0.05$) different among the 3 years of study.

Comparisons of chironomid biomass among 1989, 1991 and 1992 showed decreases at stations 1 and 3 and increases at mid-depth disposal station 4 (3.34 g/m^2) and deep reference station 8 (2.88 g/m^2) above 1989 levels (1.03 g/m^2 and 1.53 g/m^2). Statistically, chironomid biomass was significantly ($P < 0.05$) higher in 1989 than 1992 and 1991 at station 1.

Aquatic macrophyte growth and development was first observed at shallow station 1 (RM 120.0) during mid-June, but this initial sampling effort did not include other disposal (2 and 4) and reference stations (3, 5, 9, 10 and 11). Information collected by snorkeling indicated aquatic macrophyte growth and development occurred below 0.76 m and 3.5 m (2.5 and 12 ft) relative to 733 ft elevation, or minimum operating pool in Lower Granite Reservoir. No macrophytes were found at mid-depth disposal station 4 or mid-depth reference station 6. Shallow reference stations 5 and 9 were devoid of aquatic macrophytes throughout the entire sampling season (mid-June through August).

Potomogeton crispus was the dominant aquatic macrophyte found at all disposal and reference stations in Lower Granite Reservoir during 1992, with the exception of station 11 that was dominated by *P. filiformis*.

Mean biomass (g/m^2 dry weight) of aquatic macrophytes increased at all shallow disposal and reference stations from mid-July through August. Mean biomass ranged from 0.0 g/m^2 at station 11 to 1.75 g/m^2 at station 1 on 7 July, 1992. Variability in macrophyte density was high among and within stations. As a result, confidence intervals of biomass generally encompassed zero.

Taxonomic diversity of macroinvertebrates among stations with aquatic macrophytes was similar as chironomids accounted for 89%, followed by Ephemeroptera (4.4%) and Pelecypoda (3.3%) of the total number of macroinvertebrates collected at all stations. Chironomids dominated samples at all stations. The highest density of all taxonomic groups was at shallow reference station 10, with the exception of the order Plecoptera, which was observed only at reference station 3. Total standing crop estimates of macroinvertebrates in macrophyte beds ranged from 4.46 g/m^2 at station 3 to 12.85 g/m^2 at station 10.

DISCUSSION

The experimental in-water disposal alternatives that resulted from the two dredging workshops were completed in 1992. Results from previous monitoring efforts were easier to interpret because dredging and in-water disposal was the principal perturbation on the reservoir system. However in 1992, Lower Granite Reservoir was an aquatic ecosystem altered by a number of perturbations including release of upstream flows to decrease water temperatures and the experimental physical drawdown of the reservoir in March 1992. Effects of these perturbations on fishes and benthic invertebrates have been significant with alterations in the food chain and emigration of fishes downstream.

Collections of fishes and benthic macroinvertebrates during spring, summer and fall following the March 1992 test drawdown have shown that some changes have occurred in these communities. For example, the total number of fishes collected in 1992 (10,997) was considerably lower than in previous years. In spring 1992, juvenile anadromous salmonids comprised over 54% of all fishes sampled. The more abundant resident fishes, largescale suckers, smallmouth bass and northern squawfish, accounted for about 35% of the fish community compared to 1991 when they comprised about 54%.

Juvenile anadromous salmonids were not collected at any one station in higher abundance than others in 1992, including the forebay. This should alleviate concern that was expressed at one of the planning workshops that the in-water disposal areas become overly attractive to salmonids that they might inhibit "normal" migration. In 1992, Lower

Granite Reservoir reared many non-migrating juvenile steelhead. Juvenile steelhead were so abundant in the reservoir in 1992 that they accounted for 5% of all fishes sampled compared to other years when few were collected.

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

Channel catfish abundance was also lower at the disposal stations. Catch/effort was significantly higher at reference stations 5 and 6 than at Centennial Island (station 1) and the underwater plateau (deep water disposal station 7).

The deep in-water disposal station 7 was attractive to white sturgeon in 1992. Catch/effort of white sturgeon was highest at station 7 than the other reference and disposal stations. In previous years, highest catches of white sturgeon at sampling stations has occurred at deep reference station 8. The attractiveness of station 7 may be related to the heterogeneity of bottom substrate or the potential for higher food abundance following disposal.

Abundance of the more abundant resident fishes since 1989 has shown few changes. Numbers of northern squawfish have not increased in Lower Granite Reservoir as a result of the in-water disposal. During that 4 year period, adult numbers, based on gill net captures, were significantly ($P < 0.05$) higher at reference stations. Numbers of squawfish collected by beach seining have generally declined since 1989. Smallmouth bass abundance at the disposal stations has been generally stable; beach seining data showed no changes in abundance of smaller bass. Abundance of adult sized bass has generally stayed constant. Channel catfish abundance in 1992 was similar to that found in 1989. Lowest captures of channel catfish during the 1989-1992 period have occurred at the disposal stations.

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 and 1992 compared to 1989 and 1990. Larval fish abundance at disposal stations, however, has consistently been low. We attribute the increase in abundance to the more stable water levels that occurred as a result of operating at minimum operating pool.

Predation of salmonids by northern squawfish has been monitored since 1987. In 1992, daily ration of salmonids, especially juvenile chinook salmon, by northern squawfish was about 6 times higher than in 1990 and 1991. Also during 1992, smallmouth bass consumed nearly 32,000 subyearling chinook salmon. We attribute this high level of consumption indirectly to the 1992 drawdown that reduced the crayfish population. The higher incidence of predation on juvenile salmonids by northern squawfish and smallmouth bass was probably a result of decreased crayfish availability; crayfish are the most important food item of predators based on stomach analysis.

Subyearling chinook salmon abundance in Lower Granite Reservoir in 1992 was generally similar to previous years. Subyearlings exhibited strong preference for finer substrata with about 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 rearing habitat for them in the lower reservoir.

Food of subyearlings was primarily insects, zooplankton and fish. Cladocera, Diptera, Ephemeroptera and larval fishes accounted for about 87% of the food items by weight and calorically. Food availability for subyearling chinook salmon seems to be important in Lower Granite Reservoir, especially since prey consumption was only slightly above that required for maintenance based on use of a bioenergetics model. Migration from shoreline areas occurs at about 18°C, the water temperature the bioenergetics model predicted would result in a cessation of weight gain.

The benthic macroinvertebrate sampling in 1992 indicated the community was relatively simple consisting primarily of oligochaetes and chironomids. The total benthic invertebrate community biomass was similar among disposal and reference stations, although mid-depth reference station 6 exhibited the highest community biomass.

Macrophyte densities were low in comparison to other systems with abundant aquatic vegetation. Our observations suggested that the drawdown earlier in the spring adversely affected macrophytes; some areas that previously supported relatively dense stands of macrophytes contained none throughout the 1992 growing season.

The importance of macrophytes in the Lower Granite system is related to cover and food abundance. We found that invertebrate diversity and standing crops were higher in macrophytes than in similar areas without macrophytes.

In summary, the 1992 monitoring in Lower Granite Reservoir revealed a number of changes in the system, all related to other perturbations and changes in operations. We attributed several positive effects from the in-water disposal of sediment in the reservoir but no negative effects. Increased benthic invertebrate abundance in disposal areas, possibly increased availability to fishes, and an increase in rearing habitat for subyearling chinook salmon are apparent benefits to the system. Increased availability of potential food items appears highly important because of the apparent food limitation for subyearling chinook salmon and possibly yearlings within Lower Granite Reservoir.

INTRODUCTION

The Lower Granite Project provides electrical power generation, flood control, navigation and recreation. However, the inflow of sediment during spring runoff is adversely affecting these uses and the safety of the project by threatening the integrity of the levee system.

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. Estimates of sediment deposition by U.S. Army Corps of Engineer personnel have indicated that nearly 1.75 million cubic meters (2.3 million cubic yards) annually enter the confluence of the Snake and Clearwater rivers at the upper end of Lower Granite Reservoir.

Sediment dredging was initiated in 1986 with land disposal. In 1988, 1989 and 1992 experimental in-water disposal of sediment was made approximately 20 miles downstream in Lower Granite Reservoir. Three in-water disposal options have been employed including a mid-depth plateau, and island and deep water disposal. Since 1988, monitoring of fish and benthic communities have been conducted (Bennett et al. 1991).

A number of alternatives are being evaluated to alleviate the accumulation of sediment, although dredging and in-water disposal are immediate solutions. Experimental in-water disposal approximately 19 miles (30.6 km) downstream of the confluence of the Snake and Clearwater rivers was conducted during 1988 and 1989. Dredge material was used to create an Centennial Island and an underwater plateau at mid-depth (20-60 ft) located at river mile 119 (RM 119).

Historically, dredged material has been considered a liability. Use of dredged material, however, can be beneficial under the right conditions. 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). 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 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 that 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). A majority of the larval squawfish rearing occurs in the upper part 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).

As a result of these concerns over potential habitat and aquatic community changes, this project was funded as a continuation of the in-water disposal evaluation.

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 assess 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;*
5. *To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir;*
6. *To assess subyearling chinook salmon abundance, habitat utilization and migration in Lower Granite Reservoir; and*
7. *To assess biotic components associated with in-water disposal including macrophyte development, utilization and interactions with fish and benthic invertebrate abundance.*

STUDY AREA

Ten sampling stations in Lower Granite Reservoir were used to monitor fish abundance during 1992 (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 and 10 were classified as reference stations; one additional reference station (11) was sampled for larval predator abundance. Not all stations were sampled to fulfill each stated objective. Also, 22 stations were sampled to assess the relative abundance of subyearling chinook salmon (Objective 6; Figure 2). 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);

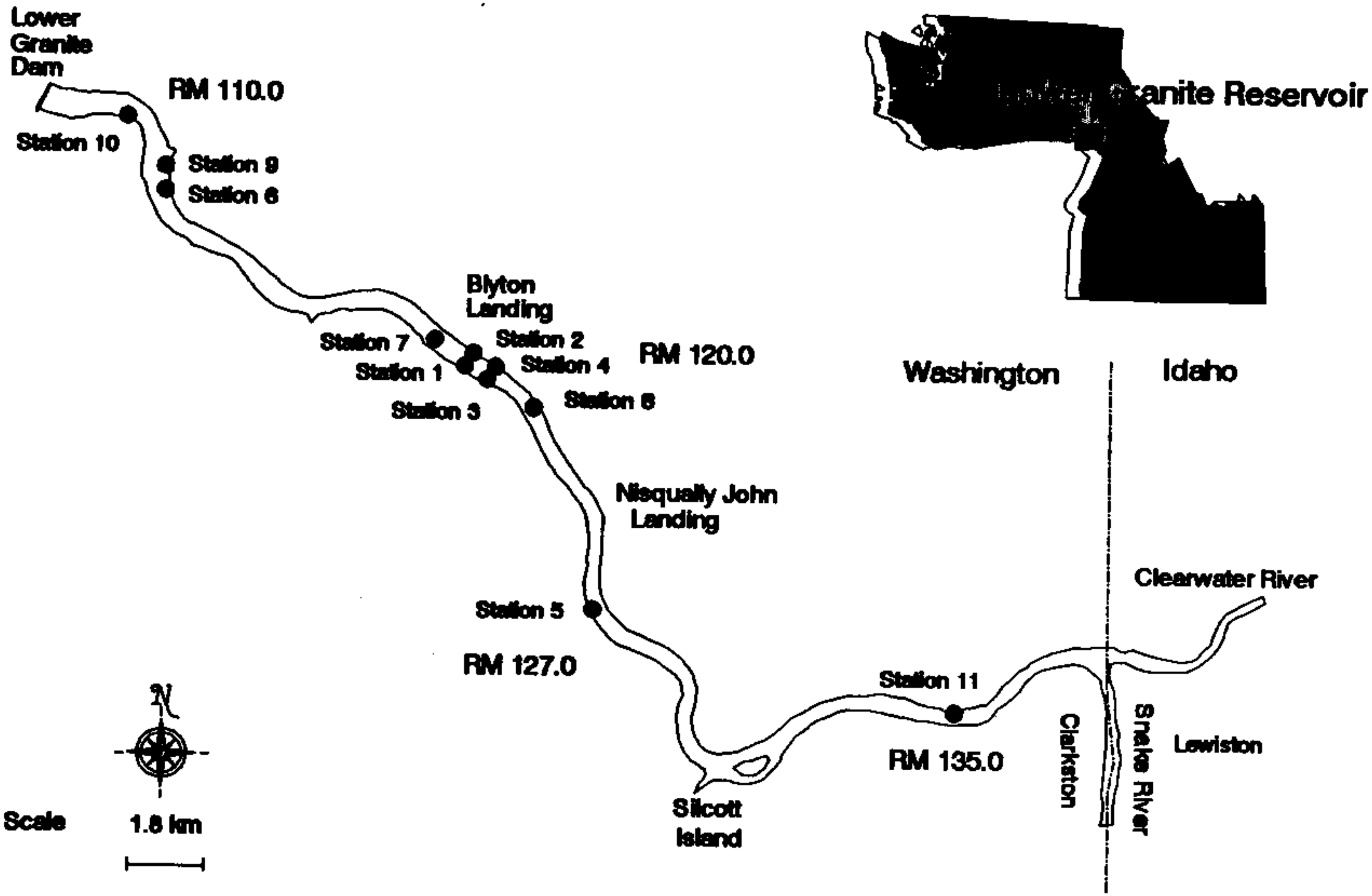


Figure 1. Map of sampling locations in Lower Granite Reservoir, Idaho-Washington where adult, subadult, juvenile and larval fish abundance was assessed during spring, summer and fall 1992.

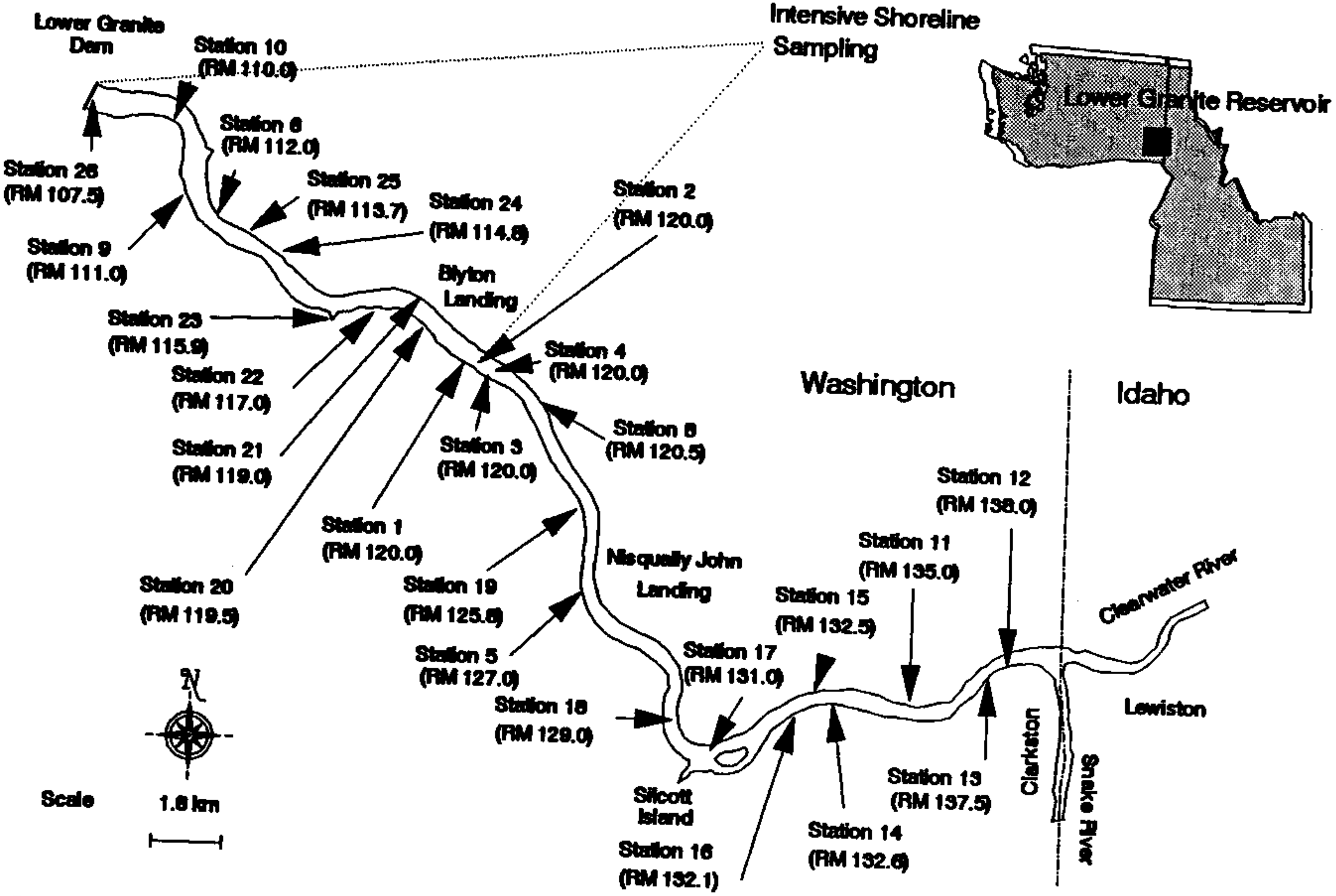


Figure 2. Map of juvenile chinook sampling stations during 1992 in Lower Granite Reservoir, Idaho-Washington.

10 RM 110.0: shallow water reference site on the south side of the reservoir;

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

12 RM 138.0: south shoreline 1 mile upstream from Red Wolf Crossing; subyearling chinook salmon beach seining station;

13 RM 137.5: south shoreline 0.5 miles upstream of the Red Wolf Bridge crossing; subyearling chinook salmon beach seining station;

14 RM 132.6: south shoreline 1.6 miles upstream from Silcott Island; subyearling chinook salmon beach seining station;

15 RM 132.5: rip-rap north shoreline; subyearling chinook salmon beach seining station;

16 RM 132.1: south shoreline; subyearling chinook salmon beach seining station;

17 RM 131.0: Silcott Island (Chief Timothy State Park); subyearling chinook salmon beach seining station;

18 RM 129.0: 1 mile upstream from Steptoe Canyon embayment; subyearling chinook salmon beach seining station;

19 RM 123.25: west shoreline 2.0 miles downstream from Nisqually John Landing; subyearling chinook salmon beach seining station;

20 RM 119.5: west shoreline 0.5 miles downstream and across from Blyton Landing; subyearling chinook salmon beach seining station;

21 RM 119.0: upstream shoreline adjacent to Blyton Landing; subyearling chinook salmon beach seining station;

22 RM 117.0: Keith Canyon 1.1 miles upstream from Knoxway Canyon Bay; subyearling chinook salmon beach seining station;

23 RM 115.9: Knoxway Canyon Bay; subyearling chinook salmon beach seining station;

24	RM 114.8: Crum boat landing 0.9 miles upstream from Granite Point; subyearling chinook salmon beach seining station;
25	RM 112.75: northeast shoreline 0.75 miles downstream from Granite Point; subyearling chinook salmon beach seining station; and
26	RM 107.5: Lower Granite Dam and Lock; subyearling chinook salmon beach seining station.

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 sampled to assess relative white sturgeon abundance. 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 110.5 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 3).

Transect	Location
R1S11	RM 110.5: transect 0.5 miles downstream of Wawawai Landing;
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;
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;
R3S4	RM 129.2: transect 3.7 miles upstream of Nisqually John Landing;

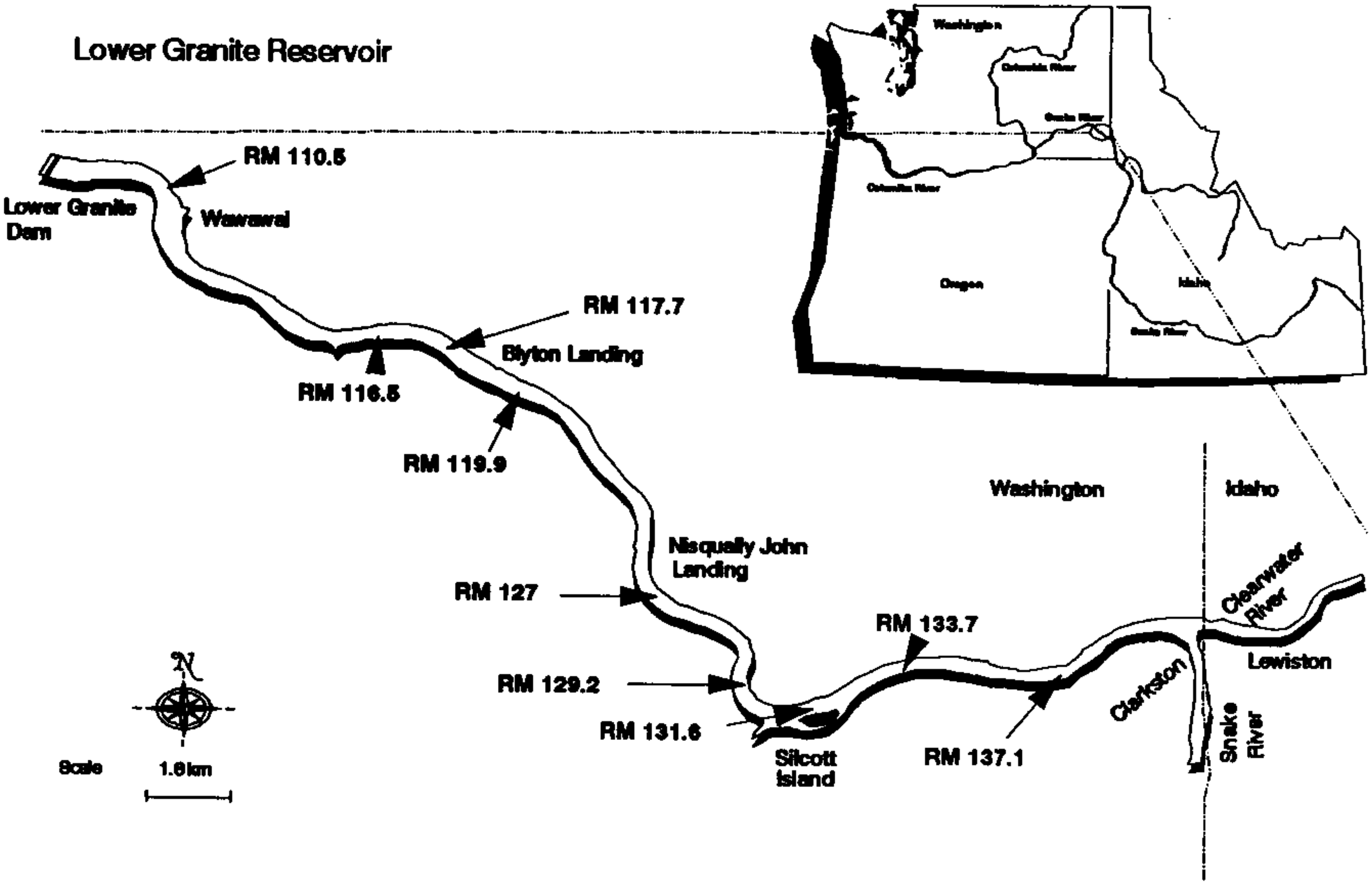


Figure 3. Sampling locations for white sturgeon during 1992 in Lower Granite Reservoir.

R3S7	RM 131.6: transect 2.4 miles downstream from Port of Wilma;
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 juvenile and adult predators with special emphasis on northern squawfish Ptychocheilus oregonensis *at in-water disposal sites and compare with those of reference sites.*

METHODS

To compare abundance of juvenile and adult fishes, reduce sampling gear bias and make representative collections, several gear types were used during 1992 in Lower Granite Reservoir. Gill netting, beach seining, electrofishing and surface trawling (see Objective 3 for surface trawling methods, results and discussion) were employed in addition to half-meter plankton nets and a handbeam trawl. Gill nets were used to assess the relative abundance of potential predators and white sturgeon in pelagic waters. Beach seining and electrofishing were used to sample shallow stations during diurnal and nocturnal hours, respectively. Surface trawling was used to sample pelagic salmonid abundance. Paired plankton nets and a handbeam trawl were used to estimate 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 5.08 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 during April, May, June, August and October. Horizontal, multifilament gill nets 762 m x 1.8 m (250 ft x 6 ft) consisting of 5 graded panels with bar measurements of 5.08, 7.6, 10.1, 12.7 and 15.24 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 the deep disposal (7) station and mid-depth (6) and deep reference (8) stations because few salmonids have ever been collected at these stations. As in 1991, 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 12.1 m^3 (8 ft^3) bag constructed of 0.64 cm (0.25 inch) mesh was used to sample fish along the shoreline at stations 1, 2, 3, 5, 9 and 10 (Figure 1) at biweekly intervals during the daytime in April, May and June and at monthly intervals in July, August, September and October. 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 454 m^2 (5,000 ft^2) was sampled each haul.

Standardized nighttime electrofishing was conducted by paralleling the shoreline, as close as possible, at shallow stations 1, 2, 3, 5, 9 and 10 (Figure 1). Biweekly sampling efforts were conducted during April, May and June and at monthly intervals during July through October. Electrofishing effort generally consisted of three periods of 5 minutes at each station. Two periods of 5 minutes at each station were used at 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 to comply with the Endangered Species Permit.

Larval fish sampling was conducted at weekly intervals from mid-June through mid-September during the time of maximum larval abundance (Bennett et al. 1993a, 1993b). Paired, half-meter plankton nets, 2.134 m (6.9 ft) length with 0.5 m (1.6 ft) diameter opening and 1 mm (0.04 inch) stretched mesh, were used to assess larval predator abundance in pelagic waters at disposal stations (1, 2 and 4) and shallow reference stations (5 and 11). 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. A custom built, hand-drawn beam trawl was used to assess larval predator abundance in the littoral regions of the shallow disposal and reference stations (LaBolle et al. 1985). The beam trawl was pulled at a constant rate parallel to the shoreline over a standard distance of 15.2 m (50 ft). Three hauls were taken in shallow (<1 m) and deep (>1 m) water for a total of six samples/station/sampling effort.

All plankton net and handbeam trawl samples were preserved in a 10% buffered formalin solution for later identification. Larval fishes were separated by hand with the aid of a 3-diopter binocular magnifier in the laboratory from debris, plankton and insects. All larval fishes were identified to the lowest possible taxon using a dichotomous key developed for the lower Snake River reservoirs (Bratovich 1985). Larval development regulated the taxonomic level to which larval fishes could be identified.

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:

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

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 318.08 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 ($\beta = 0.05$) calculated by

$$B = 2 * A *M/a*N.$$

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

RESULTS

Relative Abundance

A total of 10,997 fishes representing 25 species and 3 genera was collected at disposal (1, 2, 4 and 7) and reference (3, 5, 6, 8, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during 1992 (Tables 1-4). The highest number of adult and subadult fish collected was from 1 April through 30 June, the spring sampling interval, when a total of 6,146 fishes was collected (Table 2). A total of 1,470 fishes was collected during summer (Table 3) and 3,381 during fall 1992 (Table 4).

Juvenile chinook salmon were the most abundant species sampled during spring 1992 accounting for 30.4% (n=1,871) of the fishes collected (Table 2). Next in abundance was juvenile steelhead (23.7%, n=1,457) followed by largescale sucker *Catostomus macrocheilus* (21.4%, n=1,319), smallmouth bass *Micropterus dolomieu* (11.4%, n=711), northern squawfish (2.9%, n=184) and chiselmouth *Acrocheilus alutaceus* (2.7%, n=171).

The highest number of adult and subadult predators, smallmouth bass and northern squawfish, sampled during spring by all gear types was collected from shallow reference station 9 (n=216) followed by shallow reference stations 3 (n=205) and 10 (n=171; Table 2). Abundance of smallmouth bass (station 1, 21.7%; station 2, 7.4%) and northern

Table 1. List of species codes, scientific names and common names for fishes sampled during 1992 in Lower Granite Reservoir.

Codes	Scientific Name	Common Name
LTR	Entosphenus tridentatus	Pacific lamprey
ASA	Alosa sapidissima	American shad
ATR	Acipenser transmontanus	white sturgeon
ONE	Oncorhynchus nerka	sockeye salmon
OTS	Oncorhynchus tshawytscha	chinook salmon
PWI	Prosopium williamsoni	mountain whitefish
OMY	Oncorhynchus mykiss	rainbow trout
AAL	Acrocheilus alutaceus	chiselmouth
CCA	Cyprinus carpio	carp
MCA	Mylocheilus caurinus	peamouth
POR	Ptychocheilus oregonensis	northern squawfish
RBA	Richardsonius balteatus	redside shiner
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
LGI	Lepomis gibbosus	pumpkinseed
LMA	Lepomis macrochirus	bluegill
LSP	Lepomis spp.	misc. juv. sunfish
PNI	Pomoxis nigromaculatus	black crappie
PAN	Pomoxis annularis	white crappie
PSP	Pomoxis spp.	misc. juv. crappie
MDO	Micropterus dolomieu	smallmouth bass
MSA	Micropterus salmoides	largemouth bass
PFL	Perca flavescens	yellow perch
COT	Cottus spp.	sculpin

Table 2. Number of fishes sampled by all gear types during spring (1 April - 30 June) 1992 in Lower Granite Reservoir.

Species	Stations										Total
	1	2	3	4	5	6	7	8	9	10	
White sturgeon	7		1	3	2	1	8	9			31
Mountain whitefish	4		5		1						10
Sockeye/Kokanee							1				1
Chinook	63	191	151	47	713	496			78	132	1,871
Rainbow trout	13	108	34	60	429	420	10	12	210	161	1,457
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
Northern 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
Pumpkinseed	16	4	29	1	18	1			18	10	97
Bluegill			2		1				5		8
Lepomis spp.			1								1
Black crappie	2	4	26	3	12	1	1		7	5	61
White crappie	5	6	7	3	9	6				1	37
Smallmouth bass	72	42	150	2	99				199	147	711
Yellow perch	2	4	2	2	15	5					30
Total	331	561	701	165	1,663	1,001	75	113	799	737	6,146

Table 3. Number of fishes sampled by all gear types during summer (1 July - 30 September) 1992 in Lower Granite Reservoir.

Species	Stations						Total
	1	2	3	5	9	10	
Rainbow 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
Pumpkinseed	25		7	3	1	24	60
Bluegill			32			11	43
Lepomis spp.	2		996			48	1,046
Black crappie			2			1	3
Pomoxis spp.			6				6
Smallmouth bass	32	6	155	7	5	26	231
Yellow perch			4				4
Total	67	10	1,214	21	17	141	1,470

Table 4. Number of fishes sampled by all gear types during fall (1 October - 31 October) 1992 in Lower Granite Reservoir.

Species	Stations 1	2	3	4	5	6	7	8	9	10	Total
American shad	8				3						11
White sturgeon					7	1	3	3			14
Mountain whitefish	1										1
Rainbow trout	17	15	37	3	4	3		1	35	63	178
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
Pumpkinseed	2	5	3	4	6	7			27	88	142
Bluegill	1		1						3	46	51
Lepomis spp.	298	1	111		7				2	182	601
Black crappie	2	3	2	10	1	24	1		7	3	53
White crappie	3	3			8						14
Smallmouth bass	39	22	107	5	35	3			74	72	357
Largemouth bass									1		1
Yellow perch	35	23	14	15	53	5					145
Total	842	279	503	129	520	155	59	91	253	550	3,381

squawfish (station 1, 6.0%; station 2, 1.4%) at shallow disposal stations 1 and 2 was generally low and similar, except smallmouth bass abundance was higher at station 1 than station 2 and higher than northern squawfish abundance. Fishes collected during spring were sampled by gill netting, beach seining, electrofishing and surface trawling.

During the summer 1992 sampling interval, 1 July through 30 September, a total of 1,470 fishes was sampled by all gear types. *Lepomis* spp. dominated the catch (71.1%, n=1,046) followed by smallmouth bass (15.7%, n=231) and pumpkinseed *Lepomis gibbosus* (4.0%, n=60; Table 3). No juvenile salmon were sampled during summer and the abundance of juvenile steelhead sampled was 2.9% (n=43).

The highest number of smallmouth bass was collected at shallow reference station 3 (12.7%, n=155), however no northern squawfish were collected at this station (Table 3). The highest number of both smallmouth bass and northern squawfish collected at a station occurred at shallow disposal station 1 (50.7%, n=34); the relative abundance of smallmouth bass was 47.7% (n=32) while northern squawfish was 2.9% (n=2). The number of predators collected at disposal station 2 during the summer was low (n=7). Fishes collected during the summer sampling interval were collected by daytime beach seining and nighttime electrofishing; no gill netting was conducted.

A total of 3,381 fishes was collected by all gear types during the fall 1992 sampling interval (1 October through 31 October; Table 4). Largescale sucker (41.0%; n=1,387) dominated the catches followed by

Lepomis spp. (17.7%, n=601), smallmouth bass (10.5%, n=357) and juvenile steelhead (5.2%, n=178).

Numbers of smallmouth bass and northern squawfish collected during fall were highest at shallow reference station 3 (n=131) followed by shallow reference stations 10 (n=89) and 9 (n=80; Table 4). Abundance of predators at shallow disposal stations 1 (6.2%, n=53) and 2 (9.6%, n=27) was low. Fishes collected during fall were sampled by daytime beach seining, nighttime electrofishing and gill netting.

Length Comparisons

Spring

The majority of fishes sampled in Lower Granite Reservoir during spring 1992 was between 75-500 mm (Figures 4 and 5). Length distributions at shallow disposal stations 1 and 2 were similar to those at shallow reference stations 3 and 5 and mid-depth reference station 6, as the modal length was 150 mm for each station. Length distributions at mid-depth (4) and deep (7) disposal and reference (8) stations were similar and ranged from 125 mm to > 801 mm. Catches at deep reference station 8 were low and lengths ranged from 125 mm to 675 mm.

Summer

The majority of fishes sampled during summer 1992 was between 25-300 mm (Figure 6). Shallow disposal and reference stations generally had an abundance of fish between 25-75 mm. Modal lengths at shallow disposal stations 1 and 2 were 75 mm and 50 mm during summer whereas during spring the modal length for both stations was 150 mm. Modal

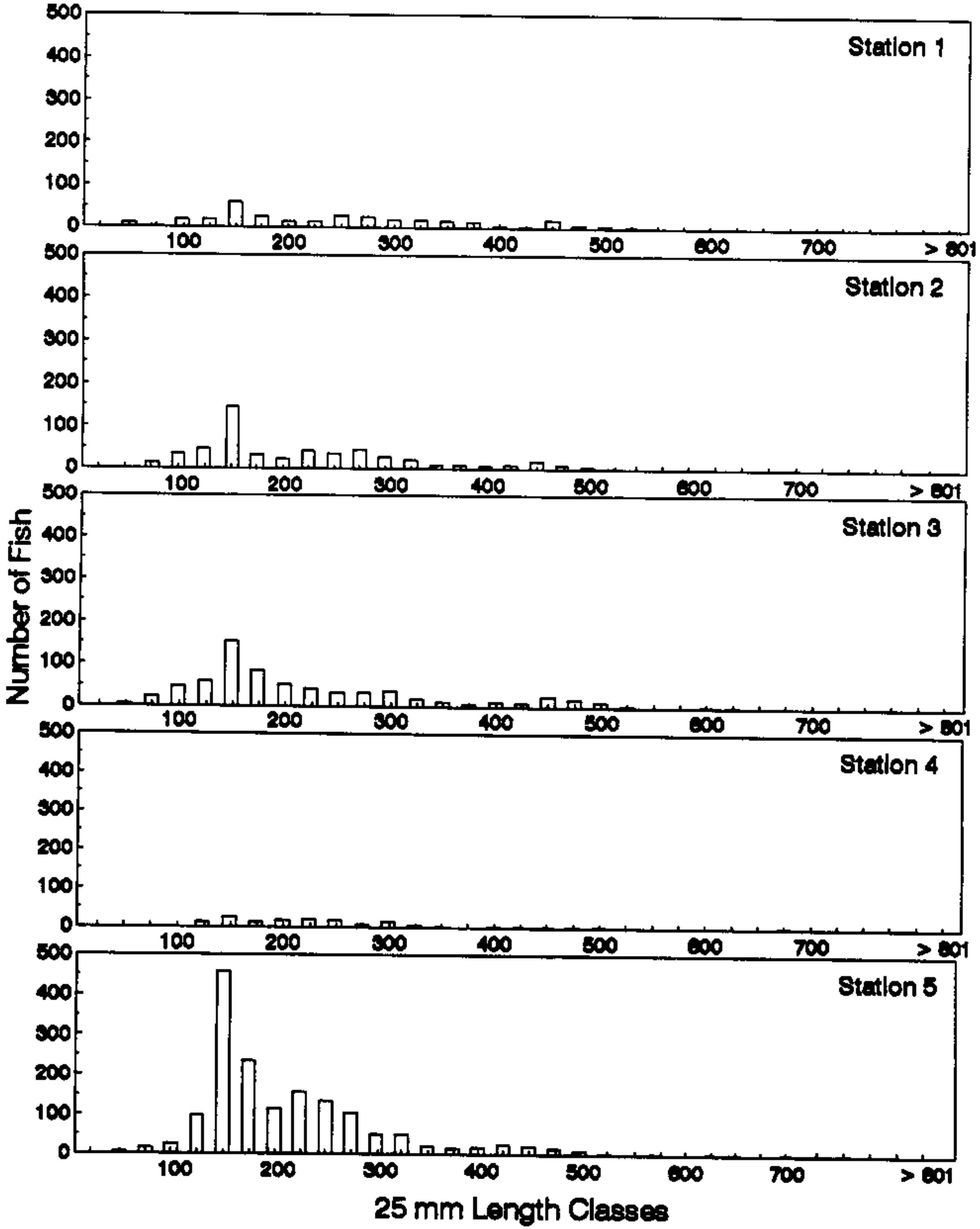


Figure 4. Length distributions of fishes sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow (3 and 5) reference stations during spring 1992 in Lower Granite Reservoir.

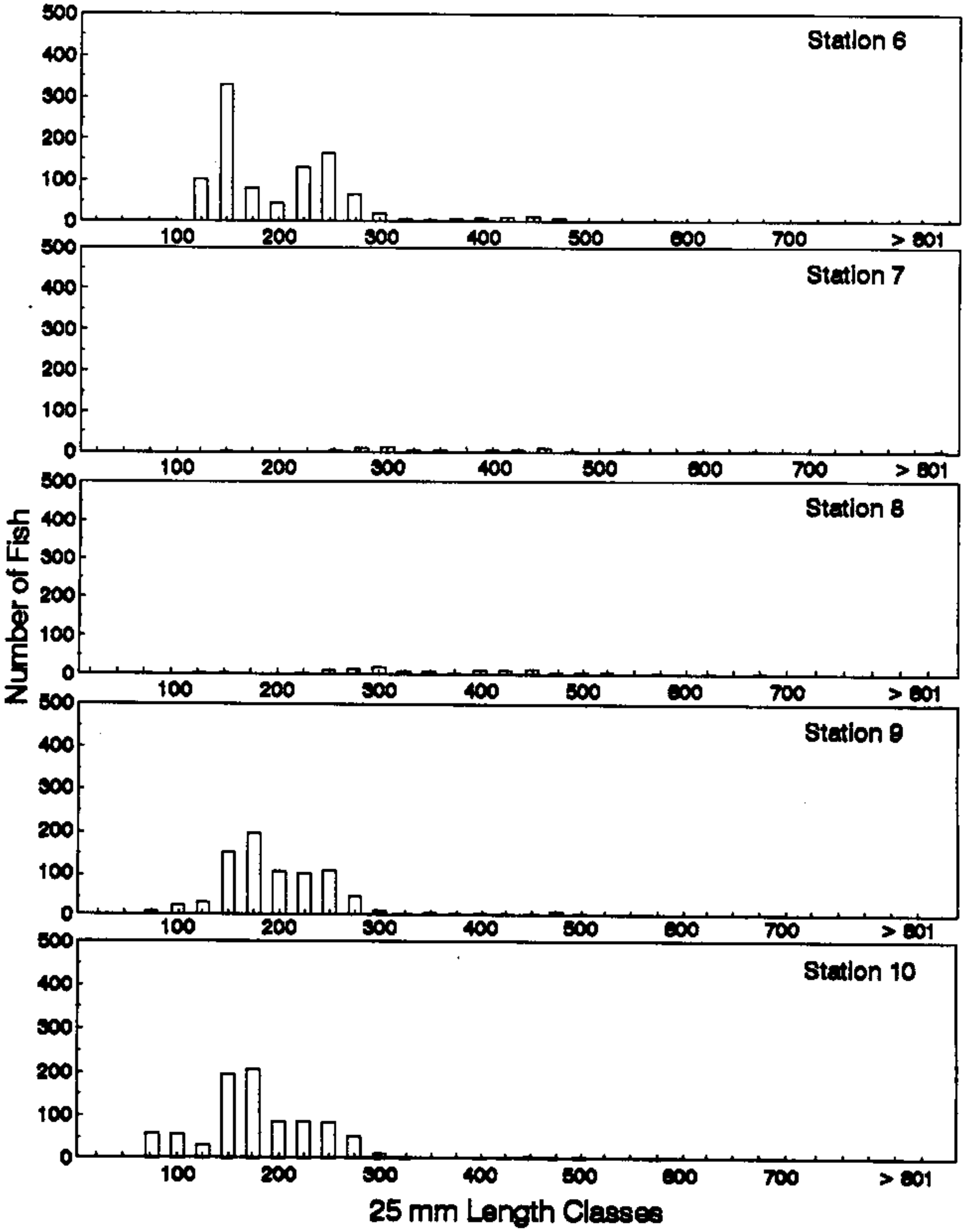


Figure 5. Length distributions of fishes sampled by all gear types at shallow (9 and 10), mid-depth (6) and deep (8) reference and disposal (7) stations during spring 1992 in Lower Granite Reservoir.

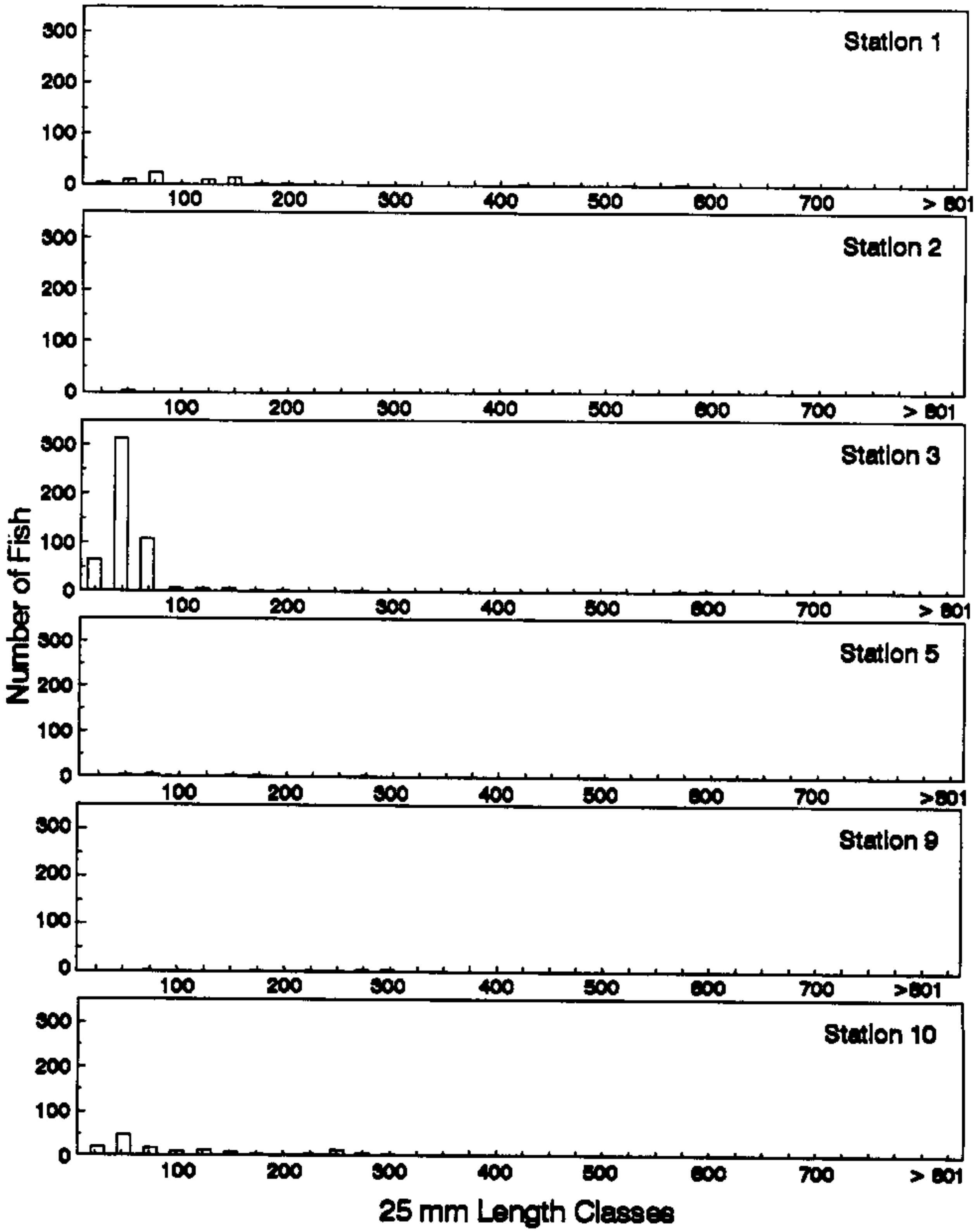


Figure 6. Length distributions of fishes sampled by all gear types at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during summer 1992 in Lower Granite Reservoir.

lengths at reference stations 9 and 10 were 275 mm and 50 mm, respectively, but catches at station 9 were low. Mid-depth disposal (4) and mid-depth (6) and deep (8) reference stations were not sampled during summer 1992.

Fall

The majority of fishes sampled in Lower Granite Reservoir during fall 1992 were between 25-525 mm and few fish > 800 mm were sampled (Figures 7 and 8). Shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations had generally similar length distributions. The modal length at stations 1, 3 and 10 was 50 mm and the modal length at mid-depth disposal (4) and reference (6) stations was 300 mm. Deep reference station 8 had the largest modal length at 450 mm. Smaller fish were generally not sampled at stations 6, 7 and 8, possibly because gill nets were the only gear type used to sample these stations.

Length Structure

Length structures of the key fish species in Lower Granite Reservoir; yearling and subyearling chinook salmon, steelhead trout, northern squawfish, smallmouth bass, channel catfish *Ictalurus punctatus* and white sturgeon *Acipenser transmontanus* were compared among stations for all gear types combined. Length structures of fishes sampled during 1992 were compared within season and gear types (Appendix Figures 1-15).

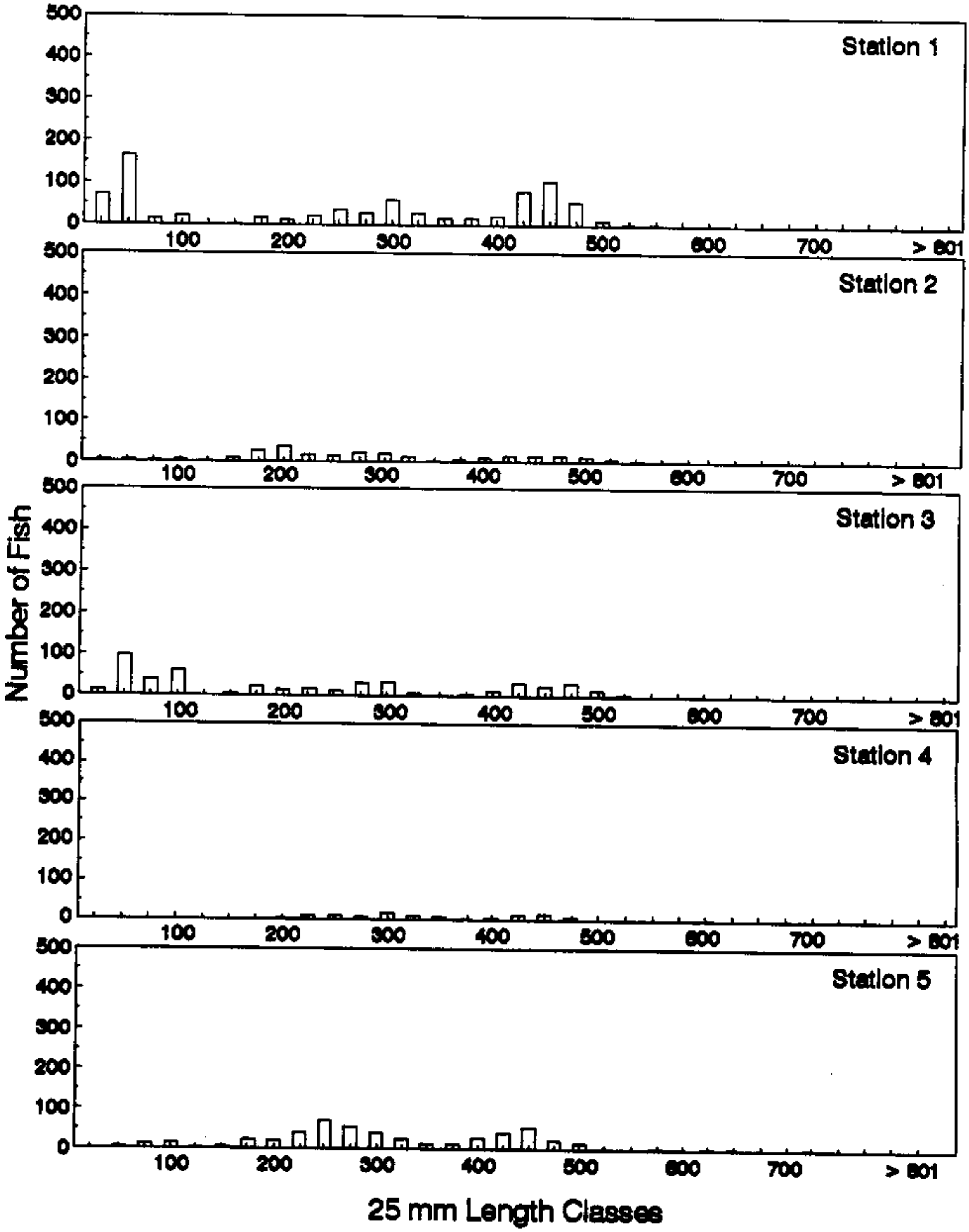


Figure 7. Length distributions of fishes sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow (3 and 5) reference stations during fall 1992 in Lower Granite Reservoir.

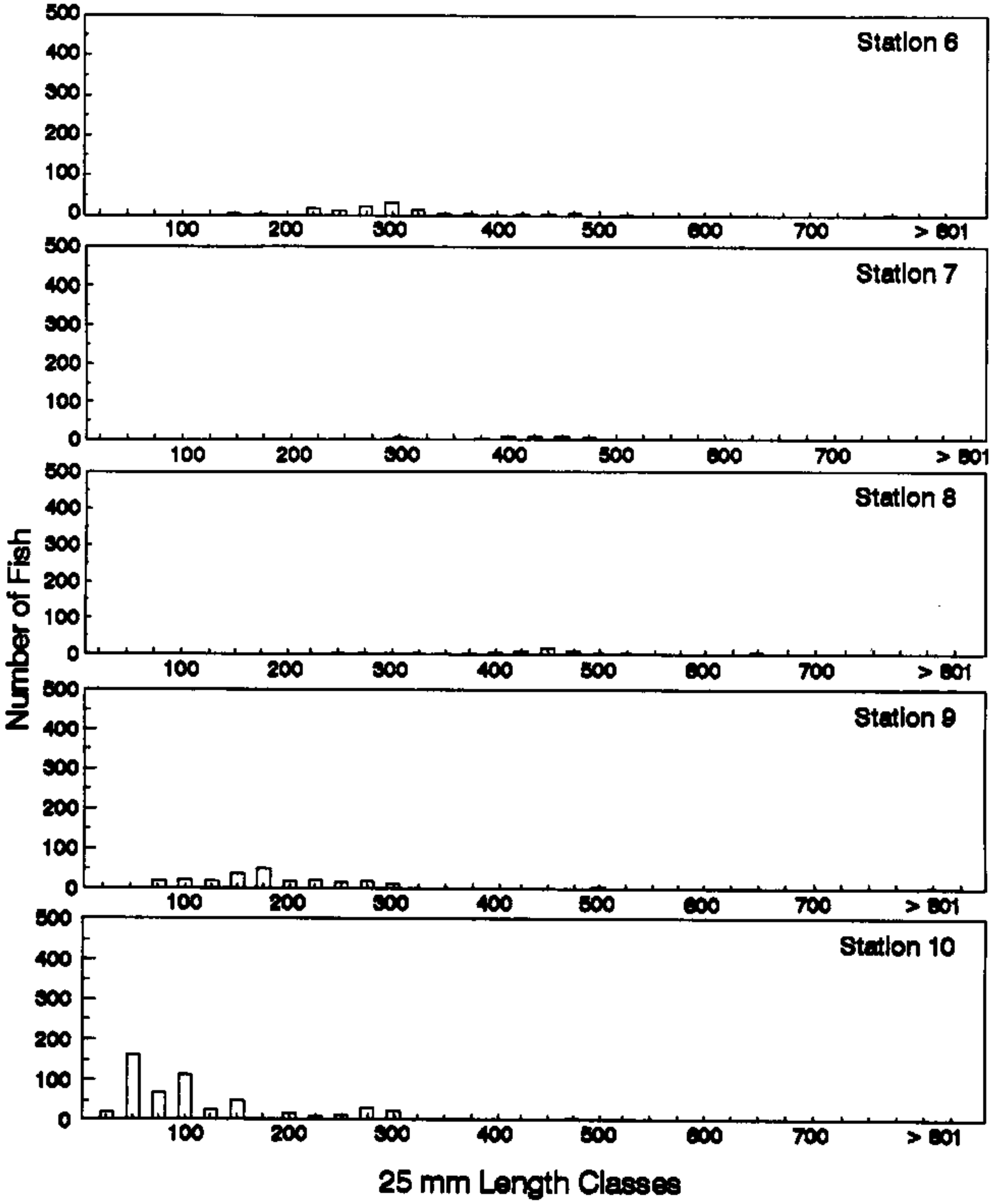


Figure 8. Length distributions of fishes sampled by all gear types at shallow (9 and 10), mid-depth (6) and deep (8) reference and disposal (7) stations during fall 1992 in Lower Granite Reservoir.

Spring

Chinook salmon.— During spring 1992, the modal length of yearling and subyearling chinook salmon collected by all gear types was 150 mm (Figures 9 and 10). Although numbers varied among stations, lengths of juvenile chinook salmon were similar and ranged from 50 mm to 250 mm.

Steelhead.— Juvenile steelhead collected by all gear types during spring ranged in length from 125 mm to 425 mm (Figures 11 and 12). Modal lengths were 225 mm at stations 2, 3, 4, 5, 250 mm at stations 1, 6, 9 and 10, and 275 mm at station 8. Small juvenile steelhead (125 mm) were collected at stations 4, 5, 6 and 9 and the largest (425 mm) was collected at station 6.

Northern squawfish.— Length distributions of northern squawfish during spring were generally similar at shallow disposal (1 and 2) and reference (3 and 5) stations (Figures 13 and 14). The range of length classes collected by all gear types was 75-500 mm. The smallest modal length was 75 mm at shallow disposal station 5 and the largest was 400 mm at mid-depth disposal station 4. The model length was 175 mm at stations 1, 9 and 10.

Smallmouth bass.— Length distributions of smallmouth bass collected by all gear types during spring 1992 were generally similar between disposal (1 and 2) and reference (3, 5, 9 and 10) stations (Figures 15 and 16). Lengths of smallmouth bass ranged from 50 mm at disposal station 1 to 500 mm at disposal station 2. The modal lengths were 175 mm at stations 3, 9 and 10, 200 mm at station 2, and 275 mm at station 5. Length distributions at stations 2 (200 and 275 mm) and 5

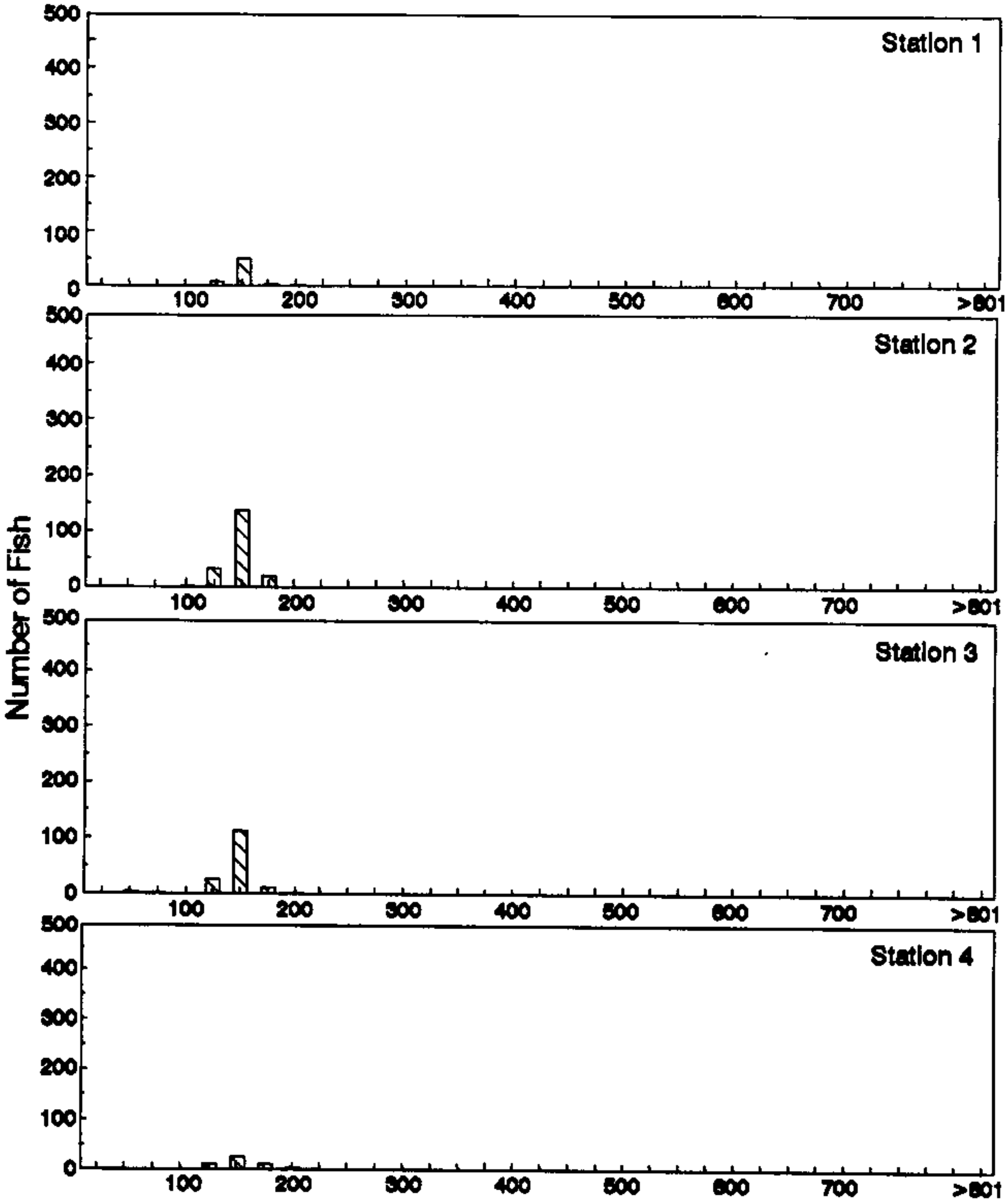


Figure 9. Length distributions of juvenile chinook salmon sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during spring 1992 in Lower Granite Reservoir.

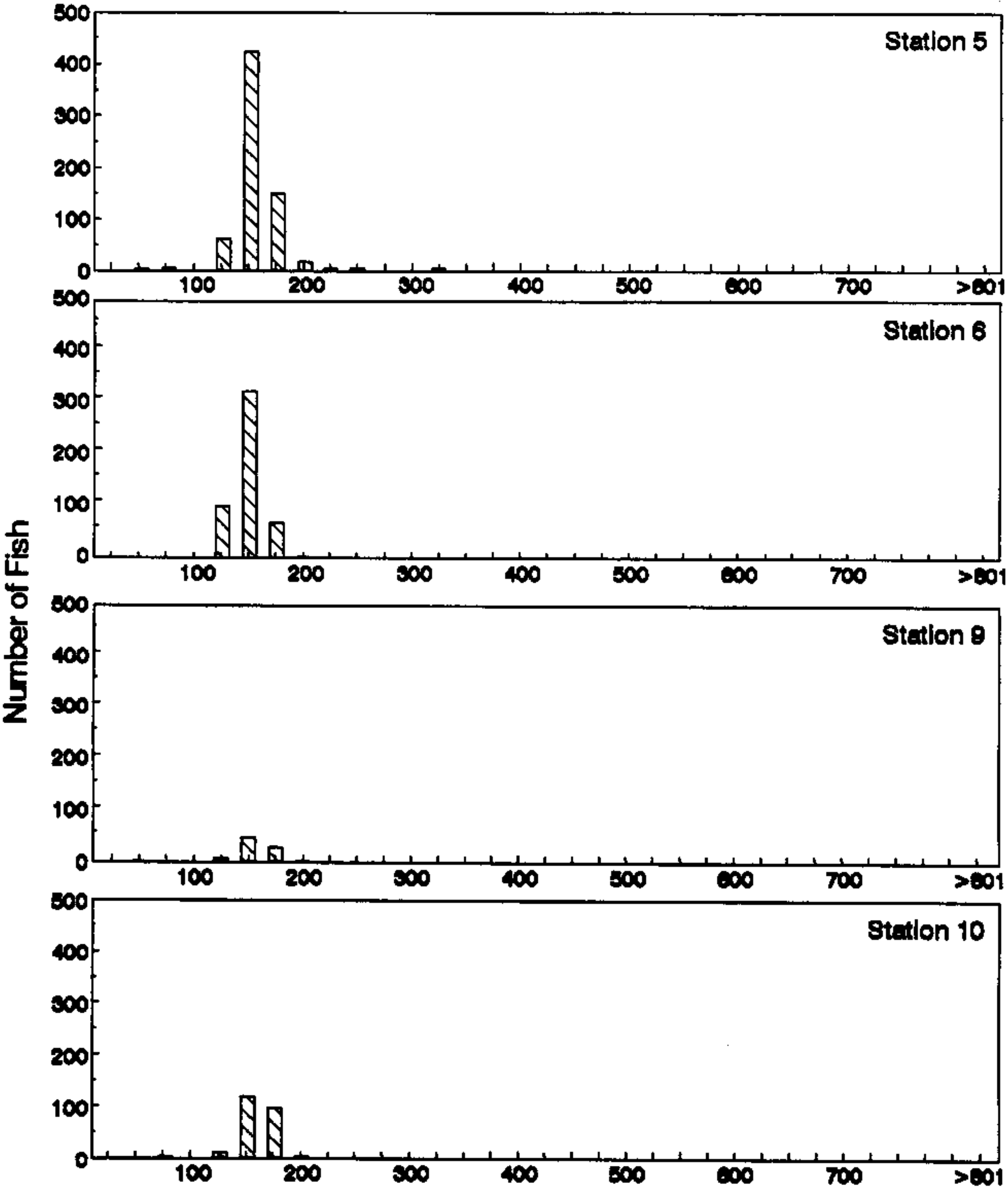


Figure 10. Length distributions of juvenile chinook salmon sampled by all gear types at shallow (5, 9 and 10) and mid-depth (6) reference stations during spring 1992 in Lower Granite Reservoir.

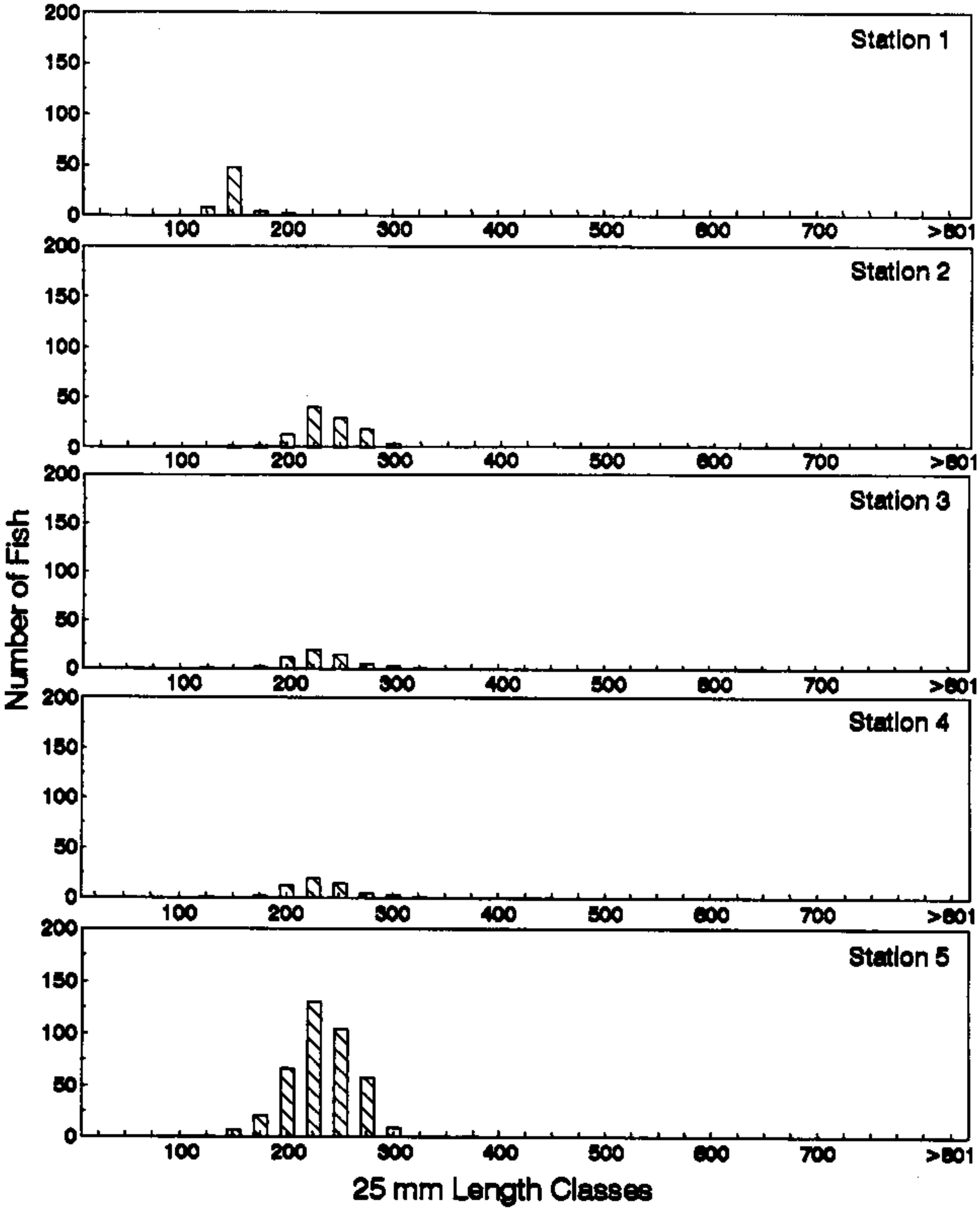


Figure 11. Length distributions of juvenile steelhead sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference (3 and 5) stations during spring 1992 in Lower Granite Reservoir.

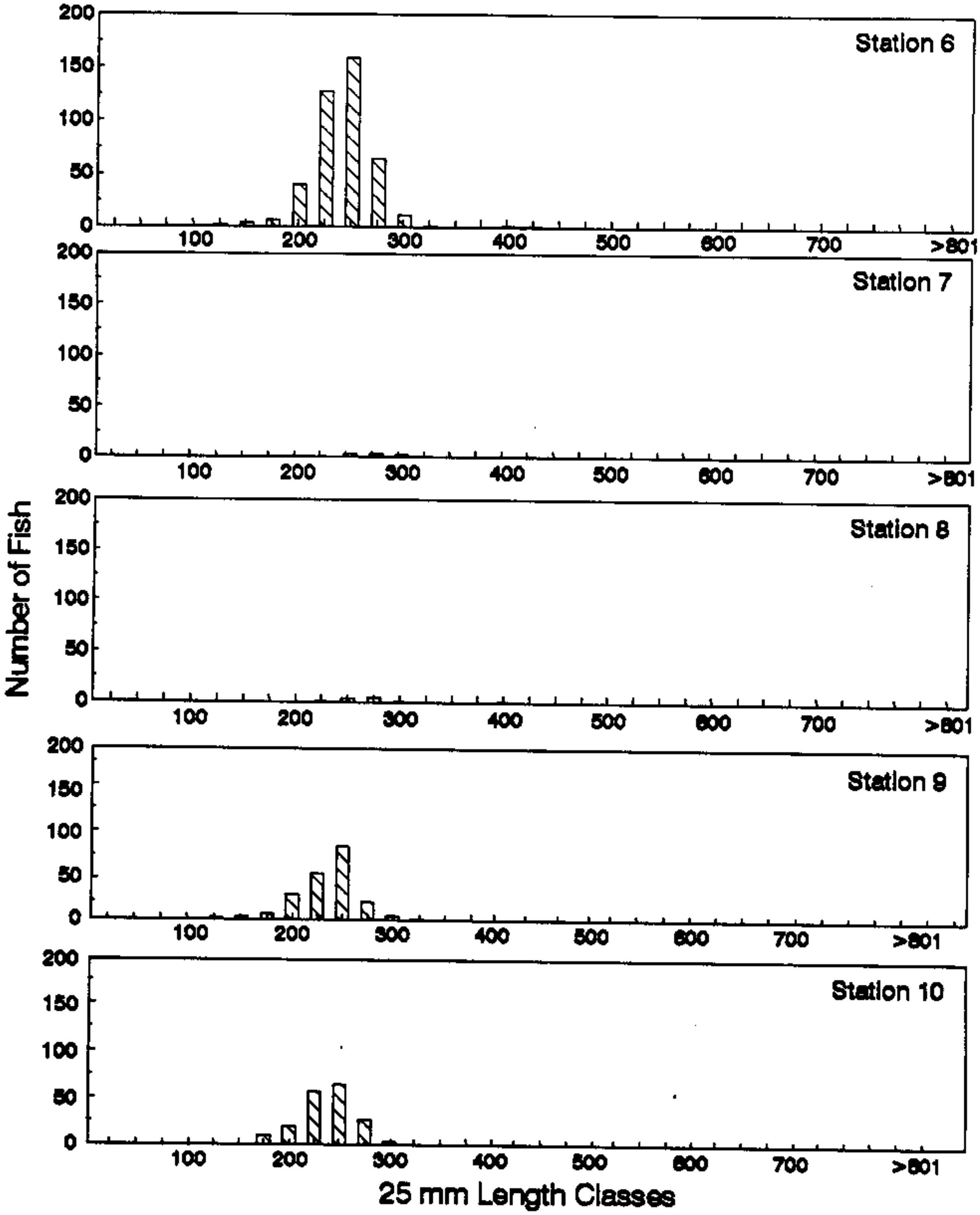


Figure 12. Length distributions of juvenile steelhead sampled by all gear types at shallow (9 and 10), mid-depth (6) and deep (8) reference and disposal (7) stations during spring 1992 in Lower Granite Reservoir.

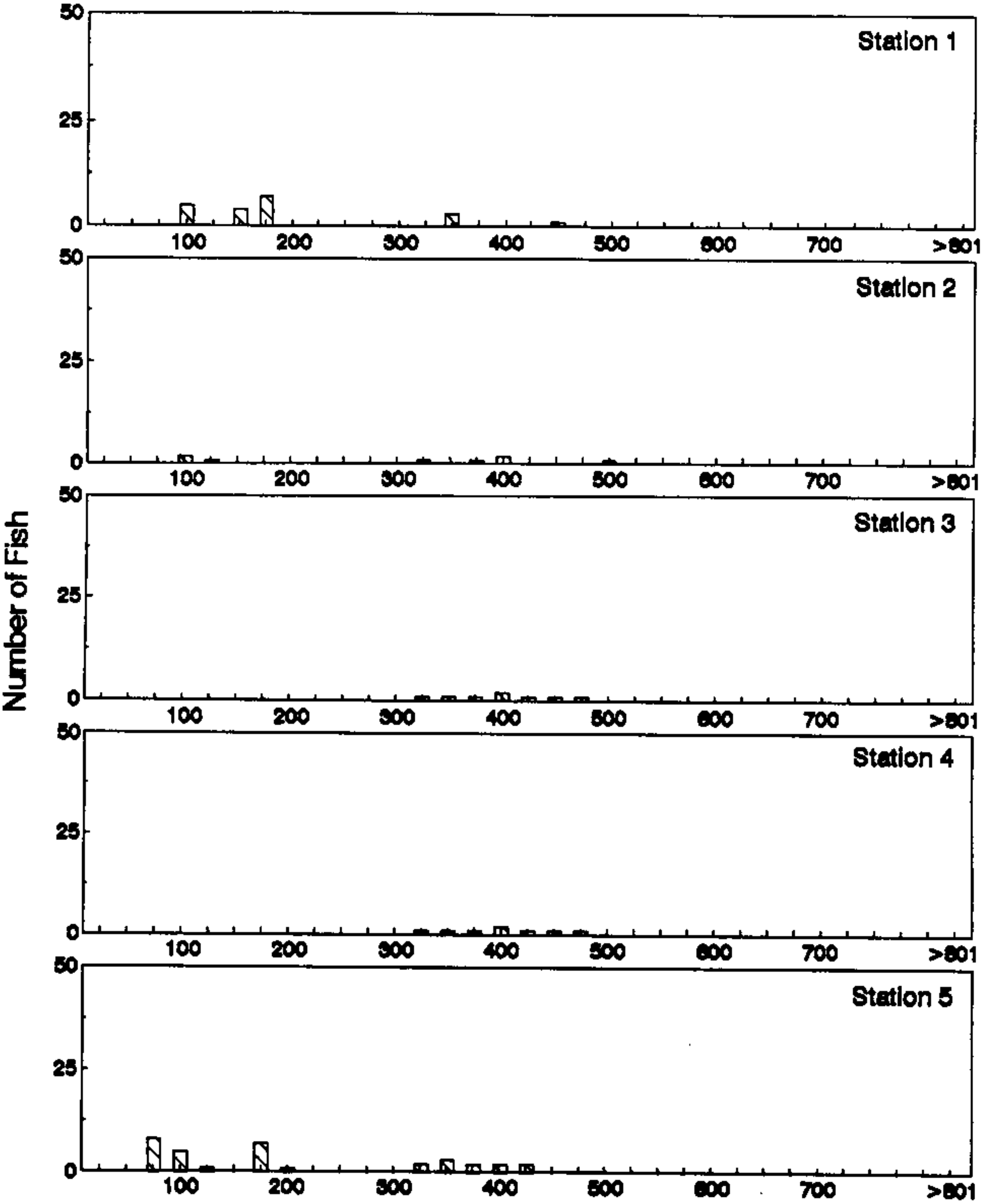


Figure 13. Length distributions of northern squawfish sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference (3 and 5) stations during spring 1992 in Lower Granite Reservoir.

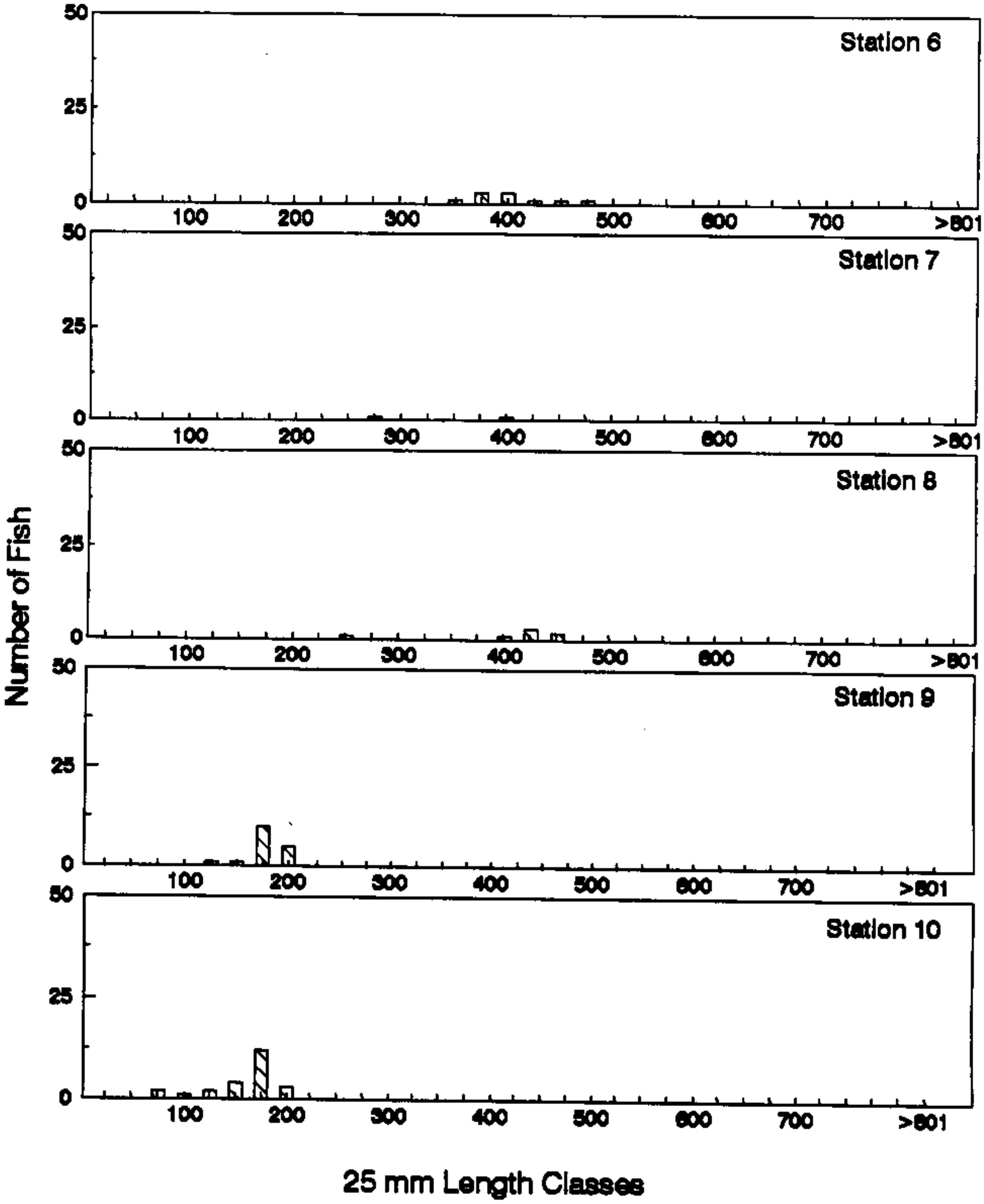


Figure 14. Length distributions of northern squawfish sampled by all gear types at shallow (9 and 10), mid-depth (6) and deep (8) reference and disposal (7) stations during spring 1992 in Lower Granite Reservoir.

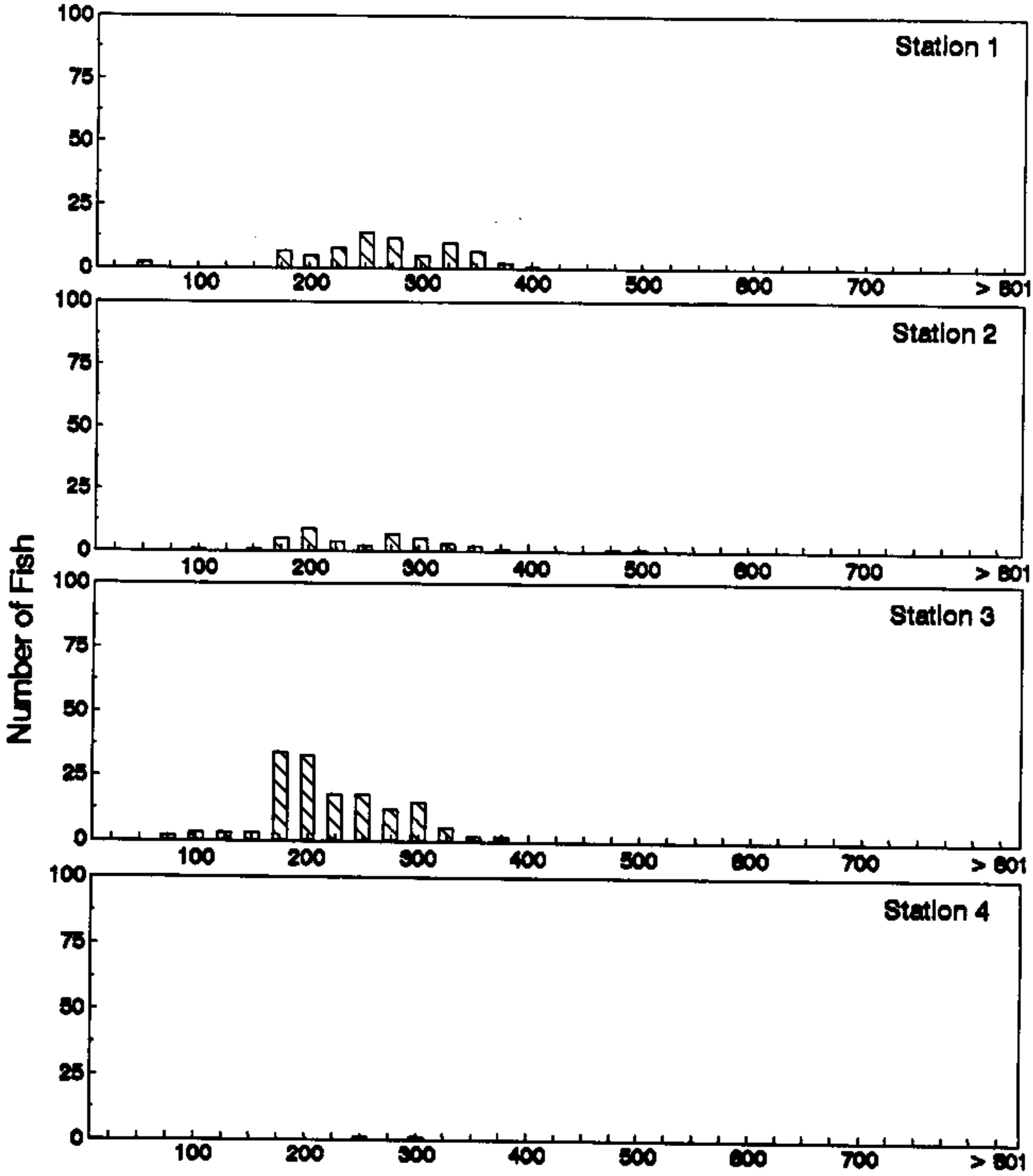


Figure 15. Length distributions of smallmouth bass sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during spring 1992 in Lower Granite Reservoir.

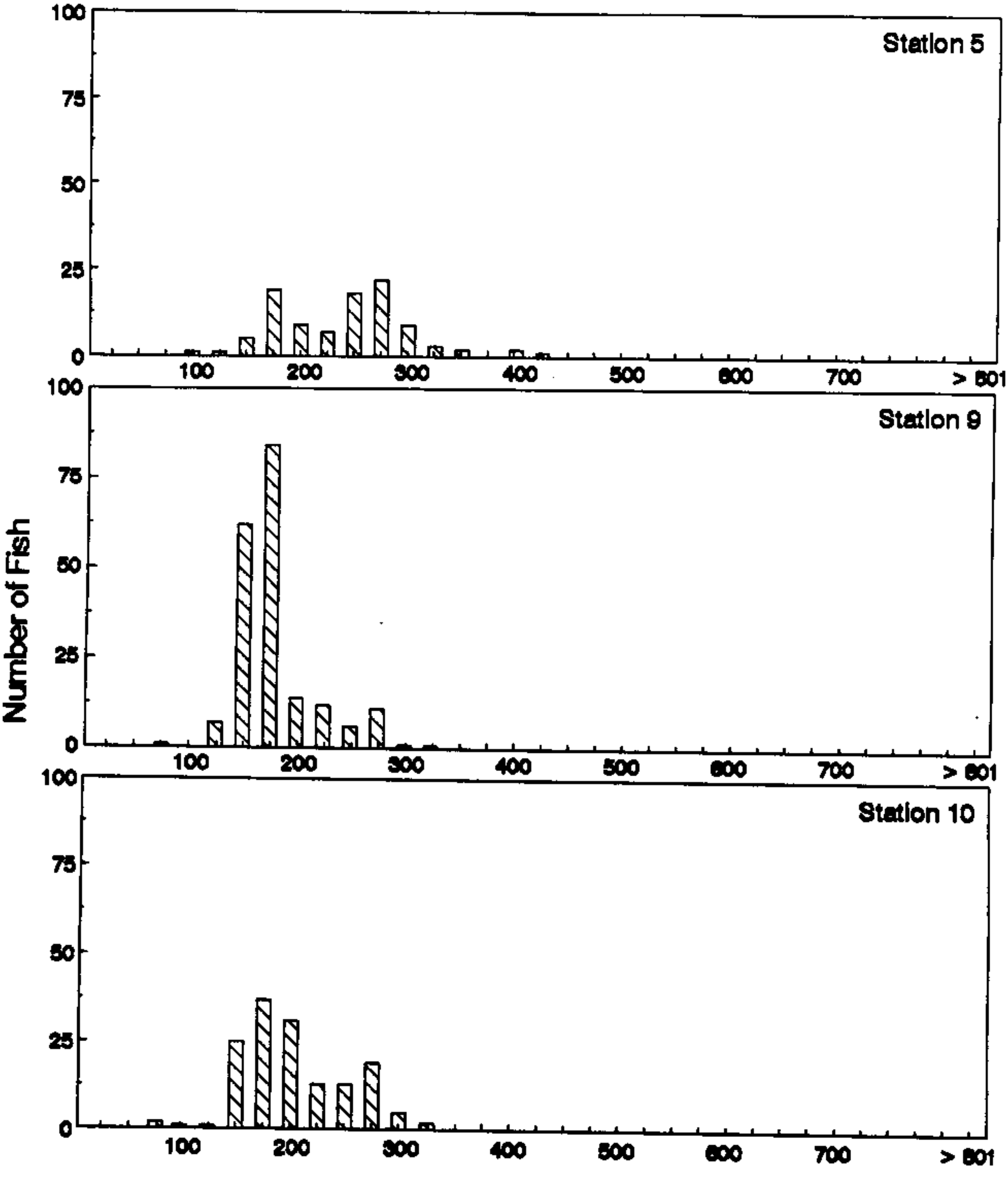


Figure 16. Length distributions of smallmouth bass sampled by all gear types at shallow reference stations 5, 9 and 10 during spring 1992 in Lower Granite Reservoir.

(175 and 275 mm) were clearly bimodal. Few smallmouth bass were collected at mid-depth disposal station 4.

Channel catfish.— Few channel catfish were collected during spring 1992 and most were collected at stations 6 and 8 (Figures 17 and 18). Lengths ranged from 125 to 600 mm and model lengths ranged from 175 to 500 mm. One channel catfish was sampled at disposal station 7.

White sturgeon.— Length distributions of white sturgeon sampled during spring 1992 ranged from 325 mm at station 8 to > 801 mm at stations 1, 3, 4, 6 and 7 (Figures 19 and 20). Modal lengths were > 800 mm at stations 1, 3 and 6, and 575 mm at station 8. Few (n=1) sturgeon were sampled at stations 3 and 6, and the majority (n=17) was sampled at deep disposal (7) and reference (8) stations. Length frequencies of white sturgeon were similar between stations 7 and 8.

Summer

Chinook salmon.- No juvenile chinook salmon were collected during summer 1992.

Steelhead.— Lengths of juvenile steelhead collected during summer 1992 ranged from 200 mm at station 5 to 350 mm at station 10 (Figure 21). The modal length was generally 275 mm, except at station 10 where it was 250 mm. The majority of steelhead sampled in the summer was at station 10.

Northern squawfish.— Lengths of northern squawfish sampled during summer by electrofishing and beach seining ranged from 50 to 150 mm (Figure 22). The modal length was 75 mm at shallow disposal station 1

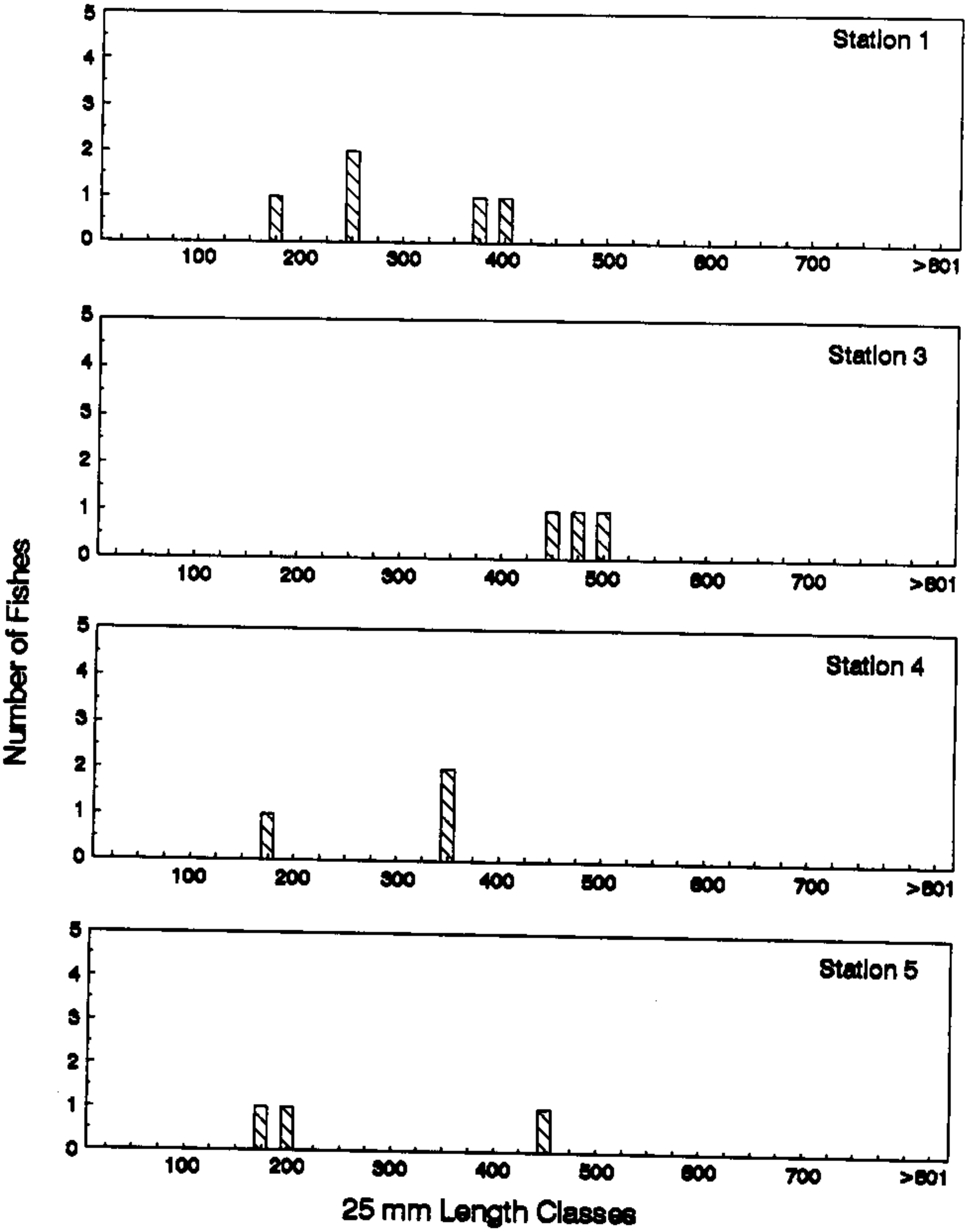


Figure 17. Length distributions of channel catfish sampled by all gear types at shallow (1) and mid-depth (4) disposal stations and shallow (3 and 5) reference stations during spring 1992 in Lower Granite Reservoir.

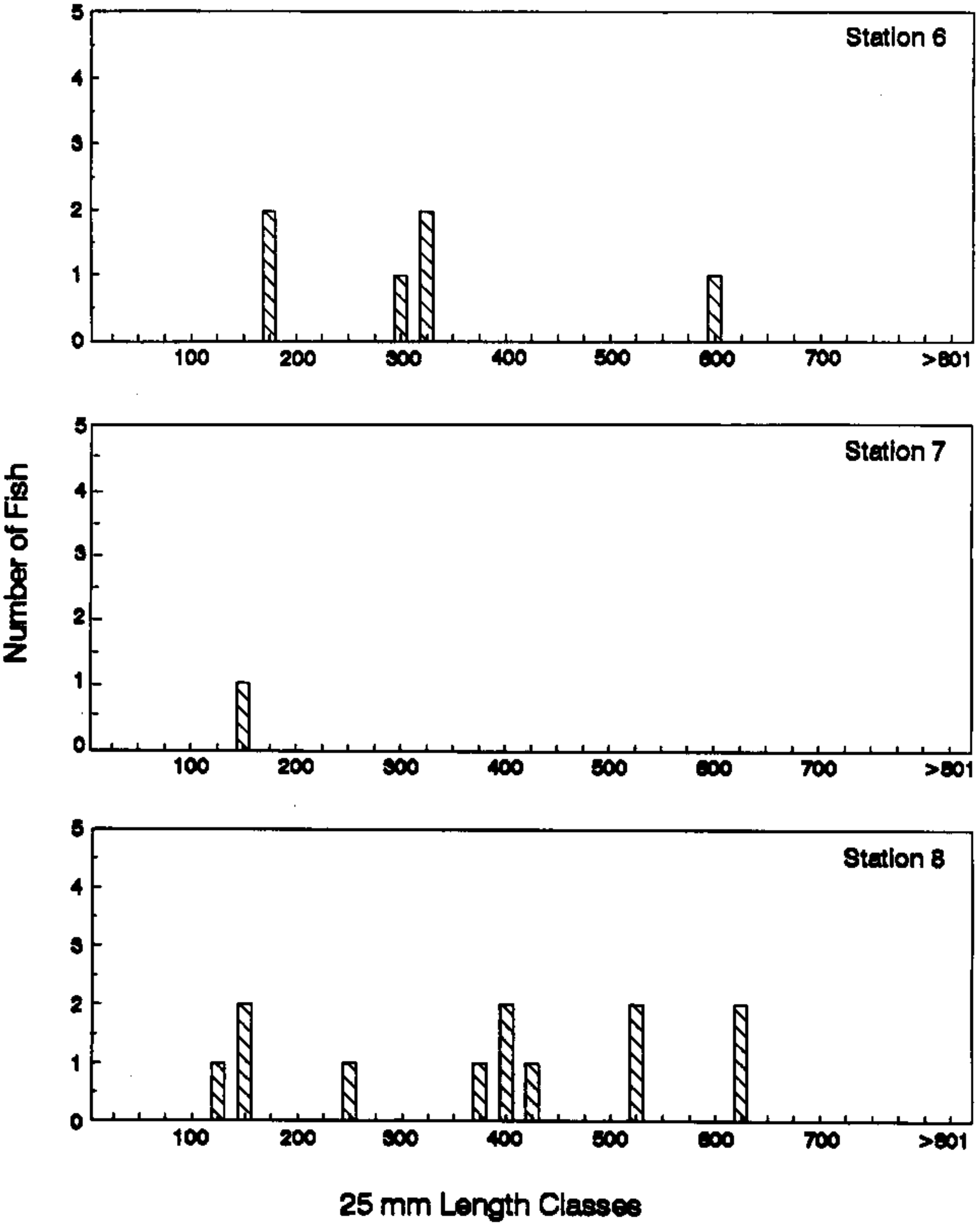


Figure 18. Length distributions of channel catfish sampled by all gear types at mid-depth (6) and deep (8) reference and disposal (7) stations during spring 1992 in Lower Granite Reservoir.

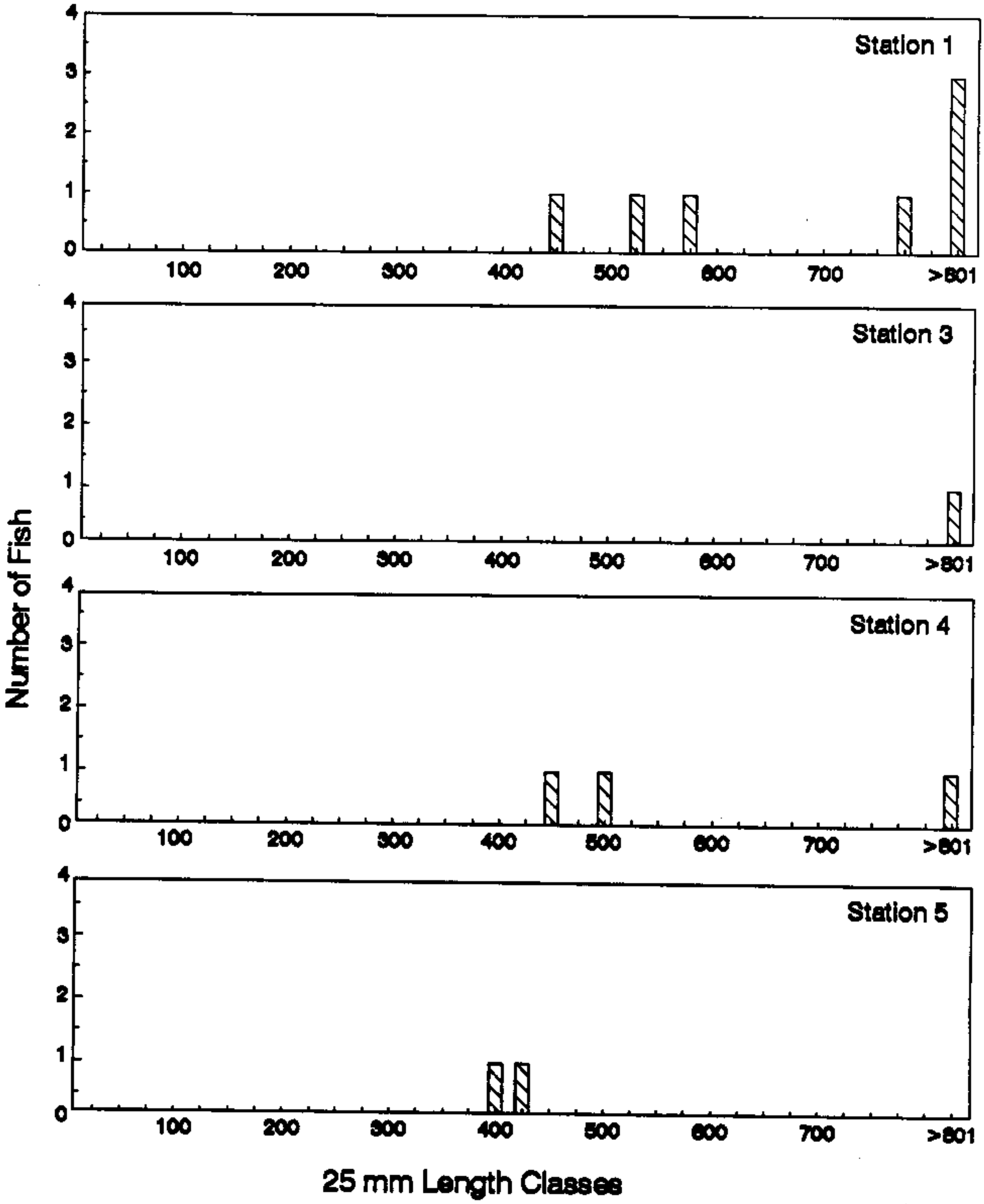


Figure 19. Length distributions of white sturgeon sampled by gill netting at shallow (1) and mid-depth (4) disposal stations and shallow (3 and 5) reference stations during spring 1992 in Lower Granite Reservoir.

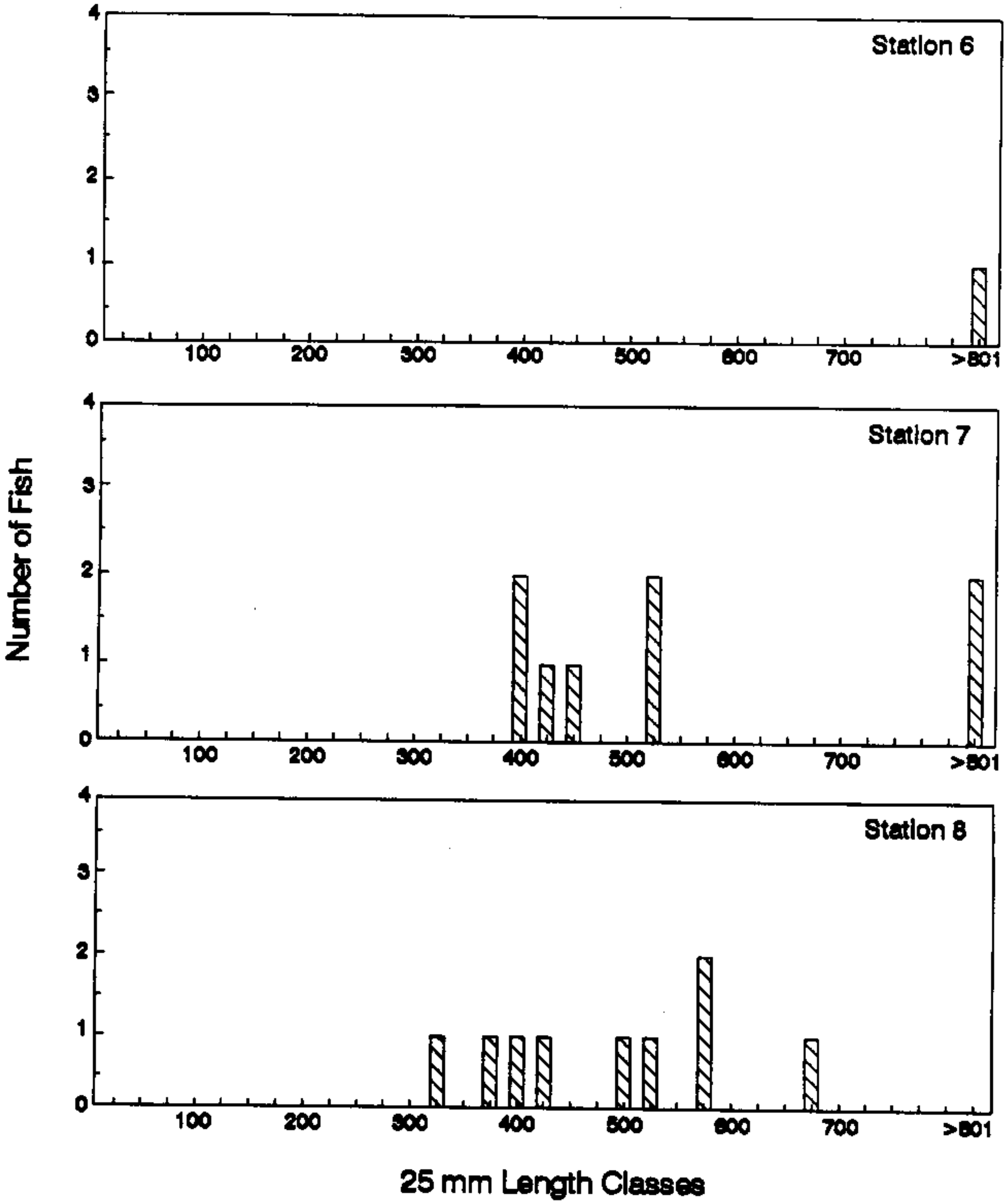


Figure 20. Length distributions of white sturgeon sampled by gill netting at mid-depth (6) and deep (8) reference and deep (7) disposal stations during spring 1992 in Lower Granite Reservoir.

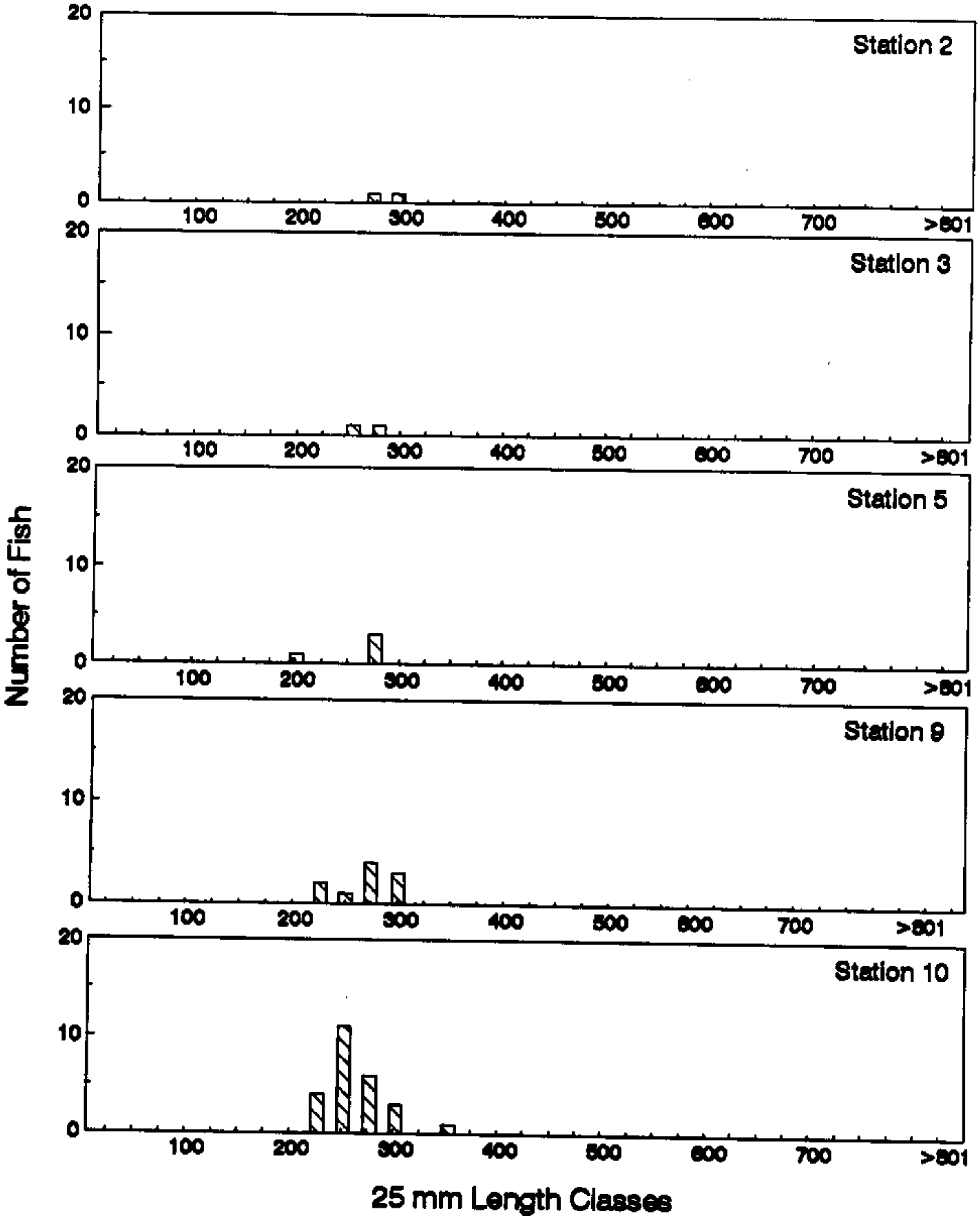


Figure 21. Length distributions of juvenile steelhead sampled by all gear types at shallow disposal (2) and reference (3, 5, 9 and 10) stations during summer 1992 in Lower Granite Reservoir.

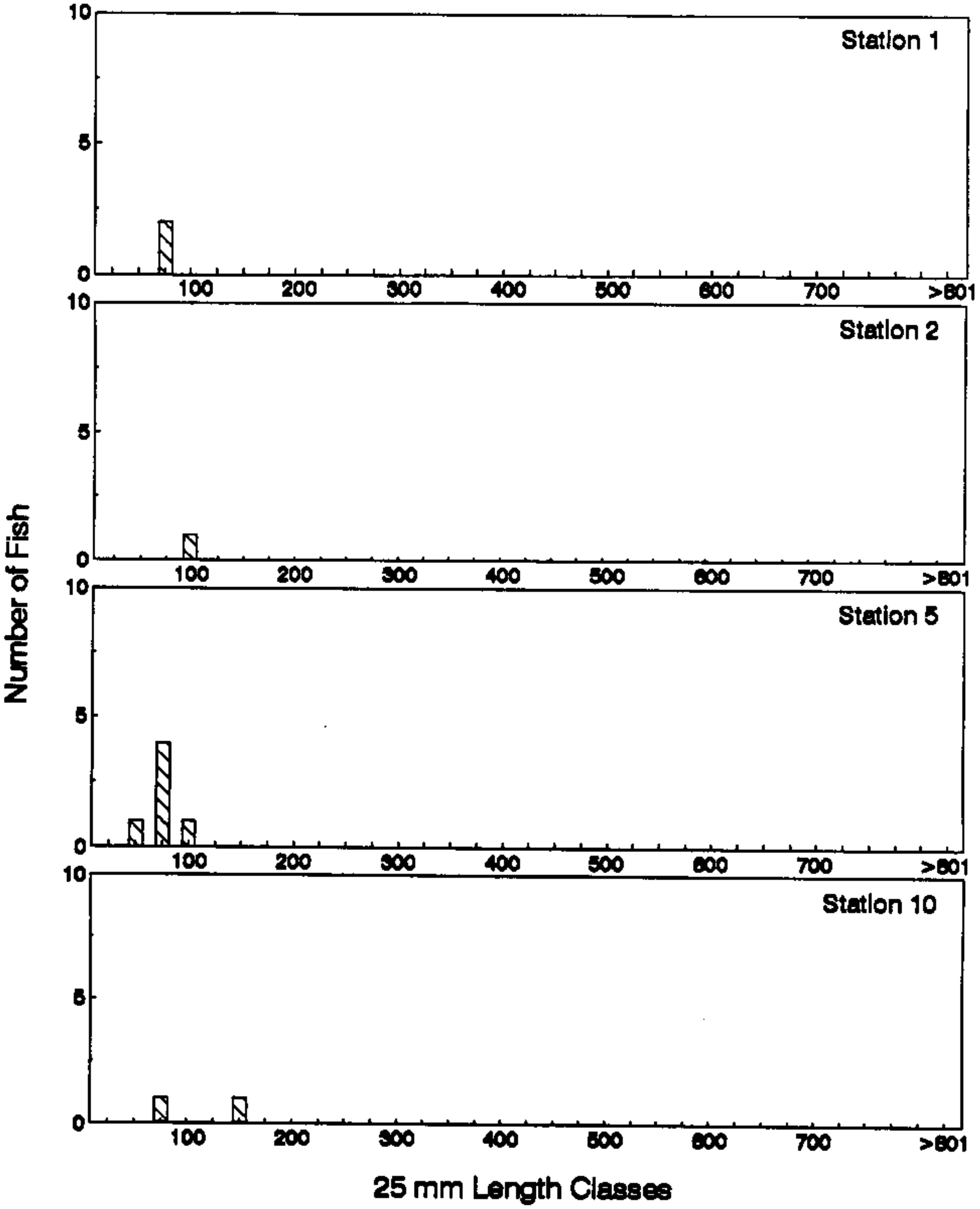


Figure 22. Length distributions of northern squawfish sampled by all gear types at shallow disposal (1 and 2) and reference (5 and 10) stations during summer 1992 in Lower Granite Reservoir.

and reference station 5. Low numbers of squawfish were generally collected at all stations sampled.

Smallmouth bass.— Lengths of smallmouth bass collected during summer 1992 ranged from 25 to 225 mm (Figure 23). Length distributions at shallow disposal stations were similar; modal lengths were 50 mm at stations 2 and 10, and 75 mm at stations 1 and 3. The majority of smallmouth bass was sampled at shallow reference station 3.

Channel catfish and white sturgeon.— No channel catfish or white sturgeon were sampled during summer 1992 as gill netting was not employed.

Fall

Steelhead.— Length distributions of juvenile steelhead sampled in Lower Granite Reservoir during fall ranged from 175 mm at station 10 to 350 mm at station 5 (Figure 24). Modal lengths of steelhead were 300 mm at stations 1, 2 and 3, and 275 mm at station 10. The majority of steelhead was sampled at shallow reference station 10.

Northern squawfish.— Length distributions of northern squawfish sampled during fall by all gear types ranged from 75 to 425 mm and modal lengths varied among stations (Figures 25 and 26). Modal lengths were 150 mm at stations 2, 5 and 10, and 425 mm at station 8.

Smallmouth bass.— Length distributions of smallmouth bass collected at shallow disposal (1 and 2) and reference (3, 5 and 10) stations during fall 1992 were similar (Figures 27 and 28). The modal length at these stations was 100 mm. Length frequencies at stations 1,

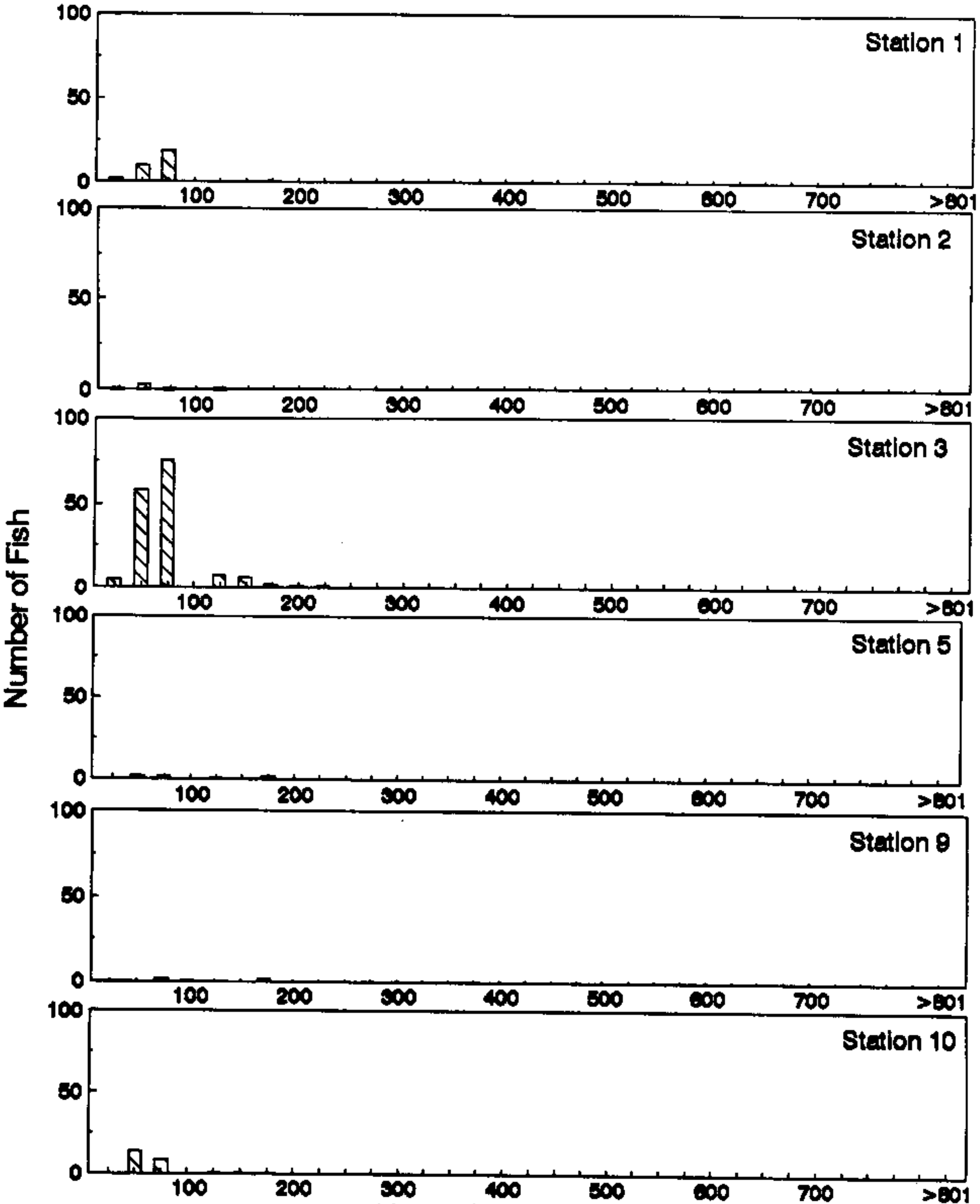


Figure 23. Length distributions of smallmouth bass sampled by all gear types at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during summer 1992 in Lower Granite Reservoir.

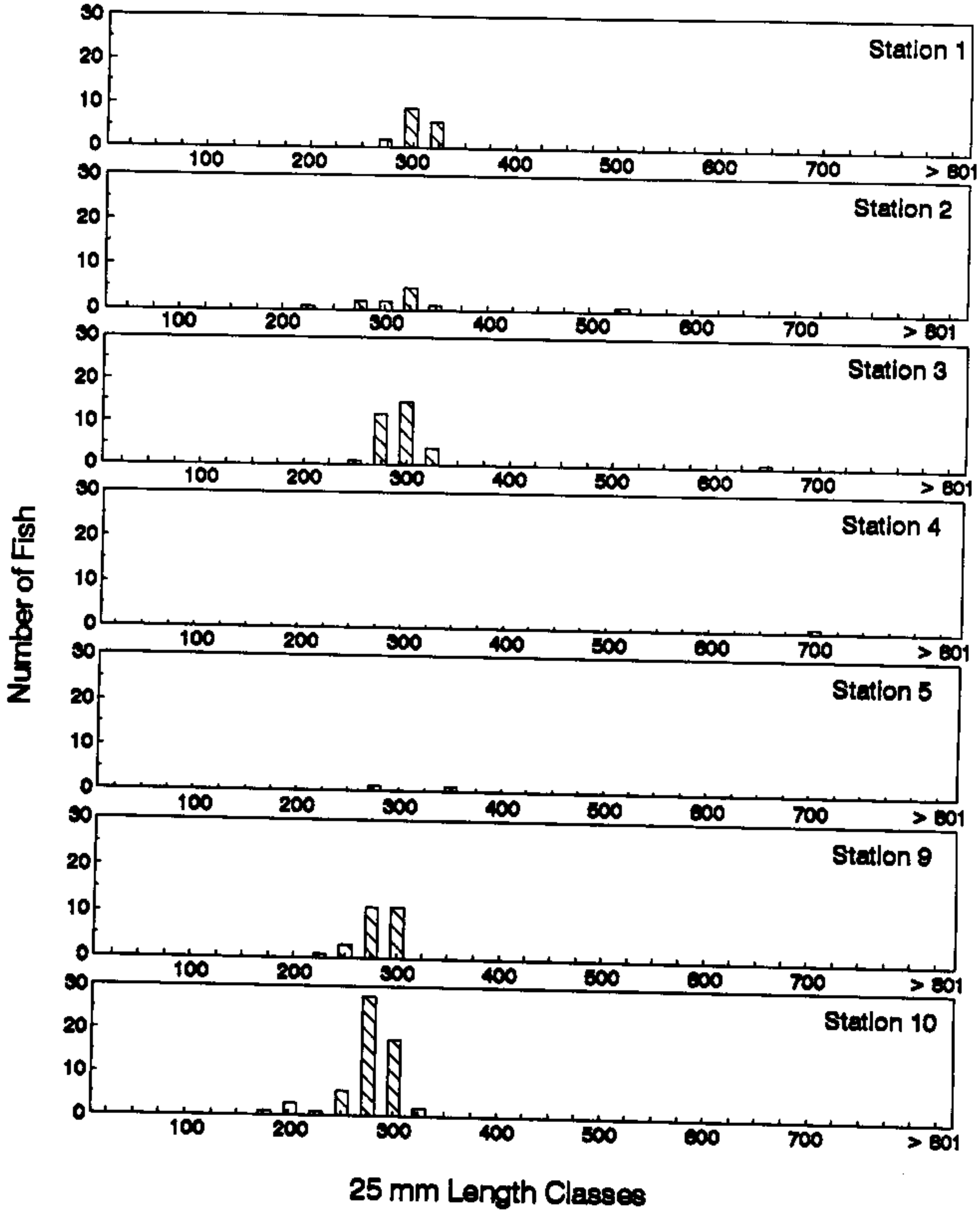


Figure 24. Length distributions of juvenile steelhead sampled by all gear types at shallow (1 and 2) disposal and reference (3, 5, 9 and 10) stations and mid-depth disposal station 4 during fall 1992 in Lower Granite Reservoir.

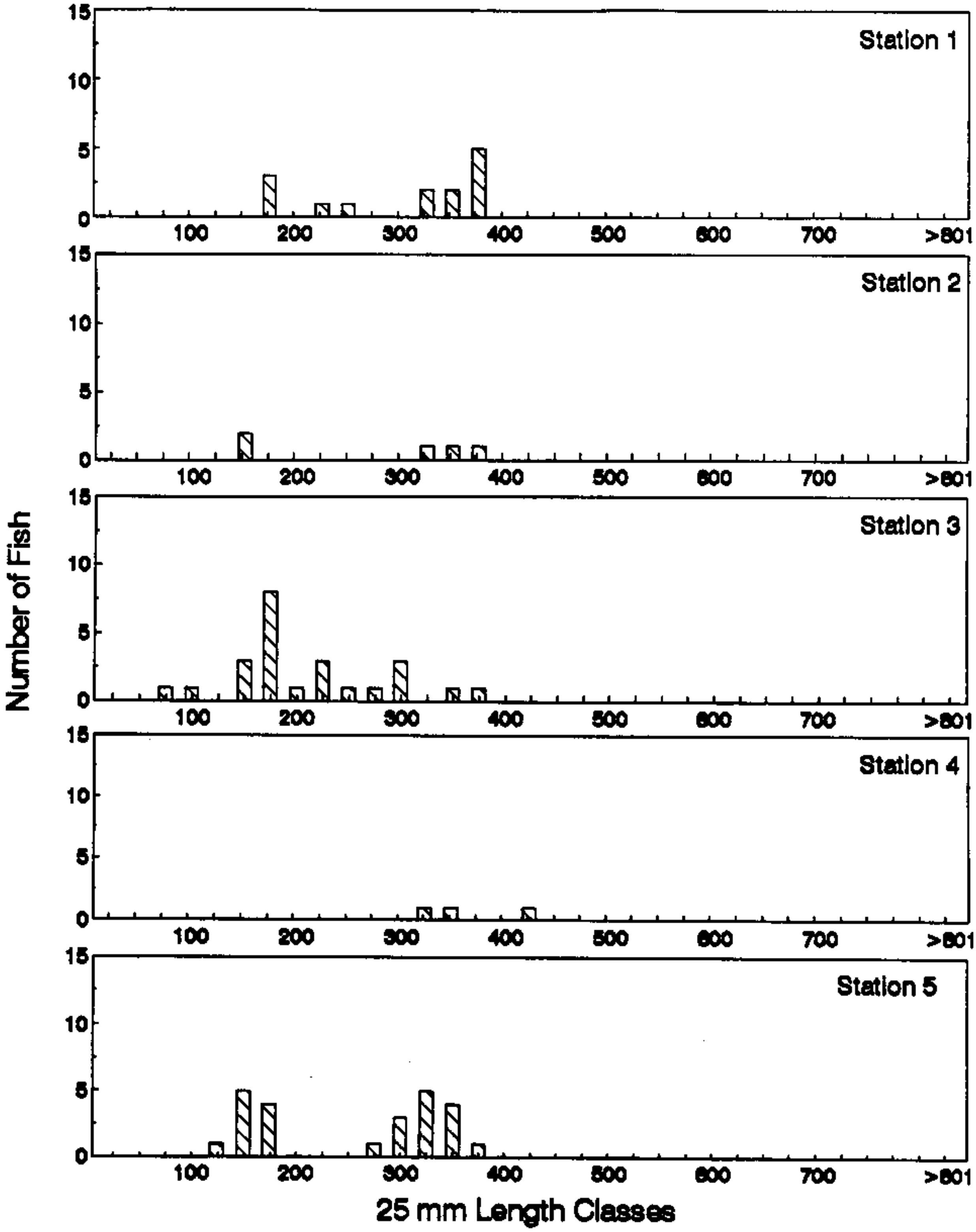


Figure 25. Length distributions of northern squawfish sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference (3 and 5) stations during fall 1992 in Lower Granite Reservoir.

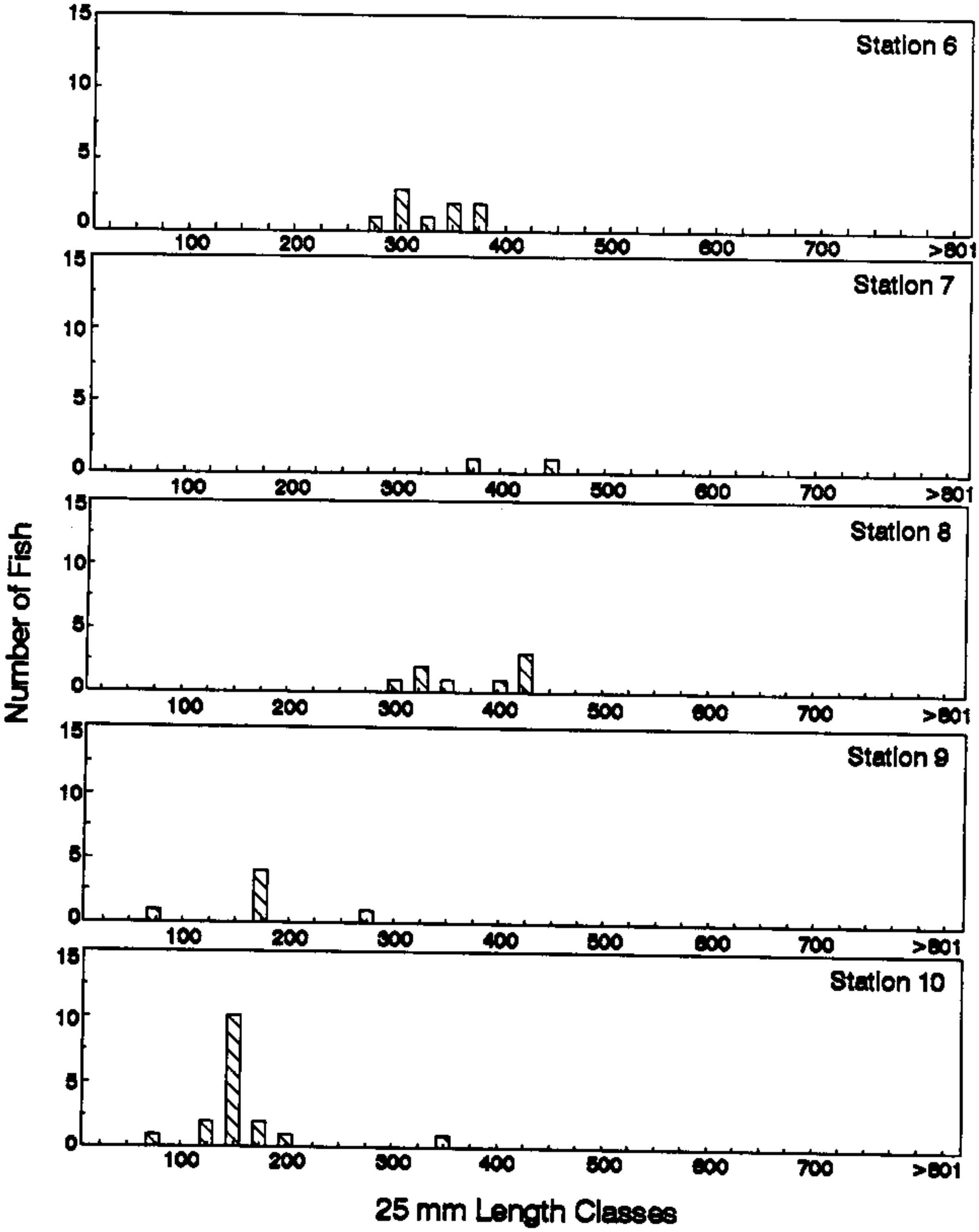


Figure 26. Length distributions of northern squawfish sampled by all gear types at shallow (9 and 10), mid-depth (6) and deep (8) reference and disposal (7) stations during fall 1992 in Lower Granite Reservoir.

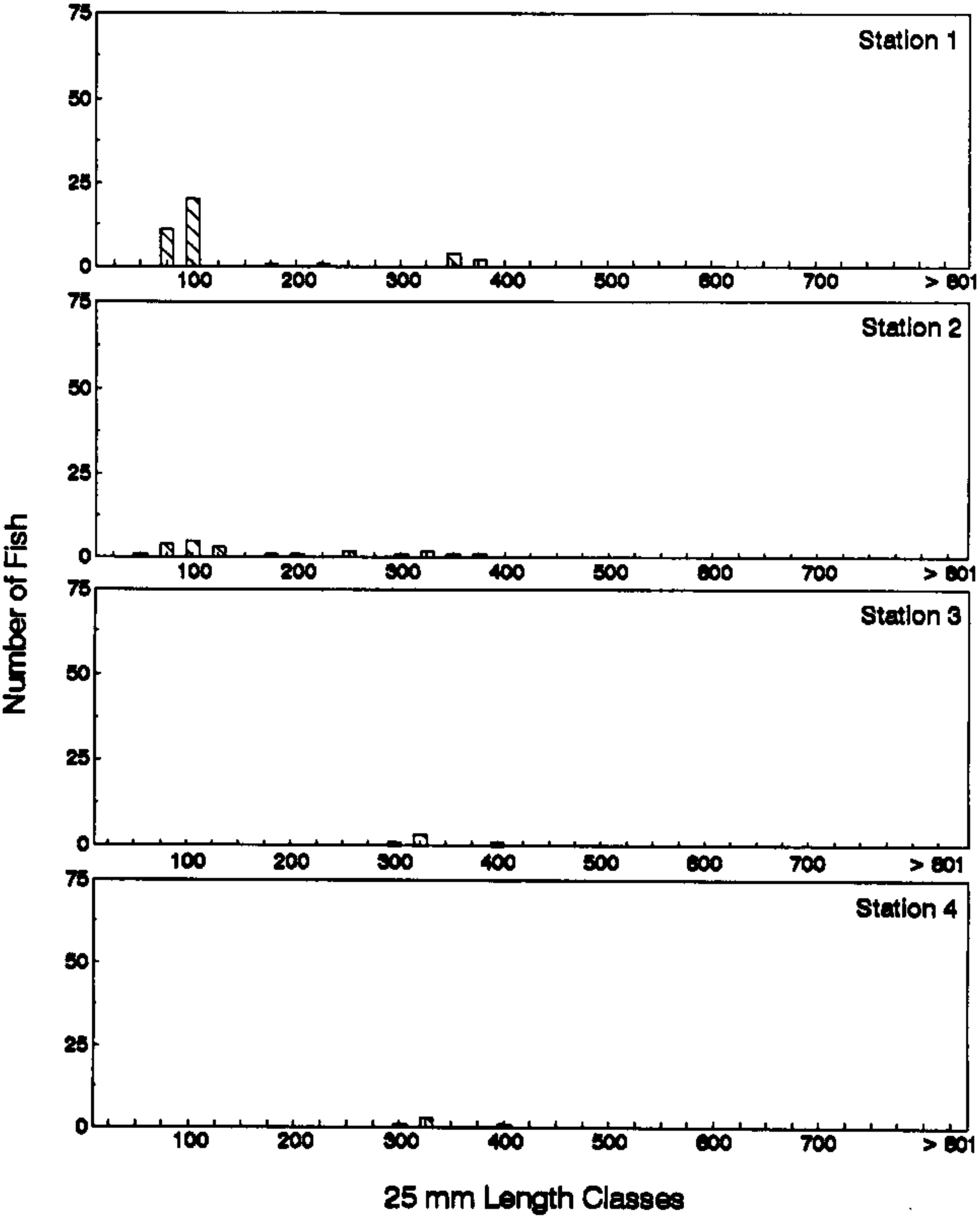


Figure 27. Length distributions of smallmouth bass sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during fall 1992 in Lower Granite Reservoir.

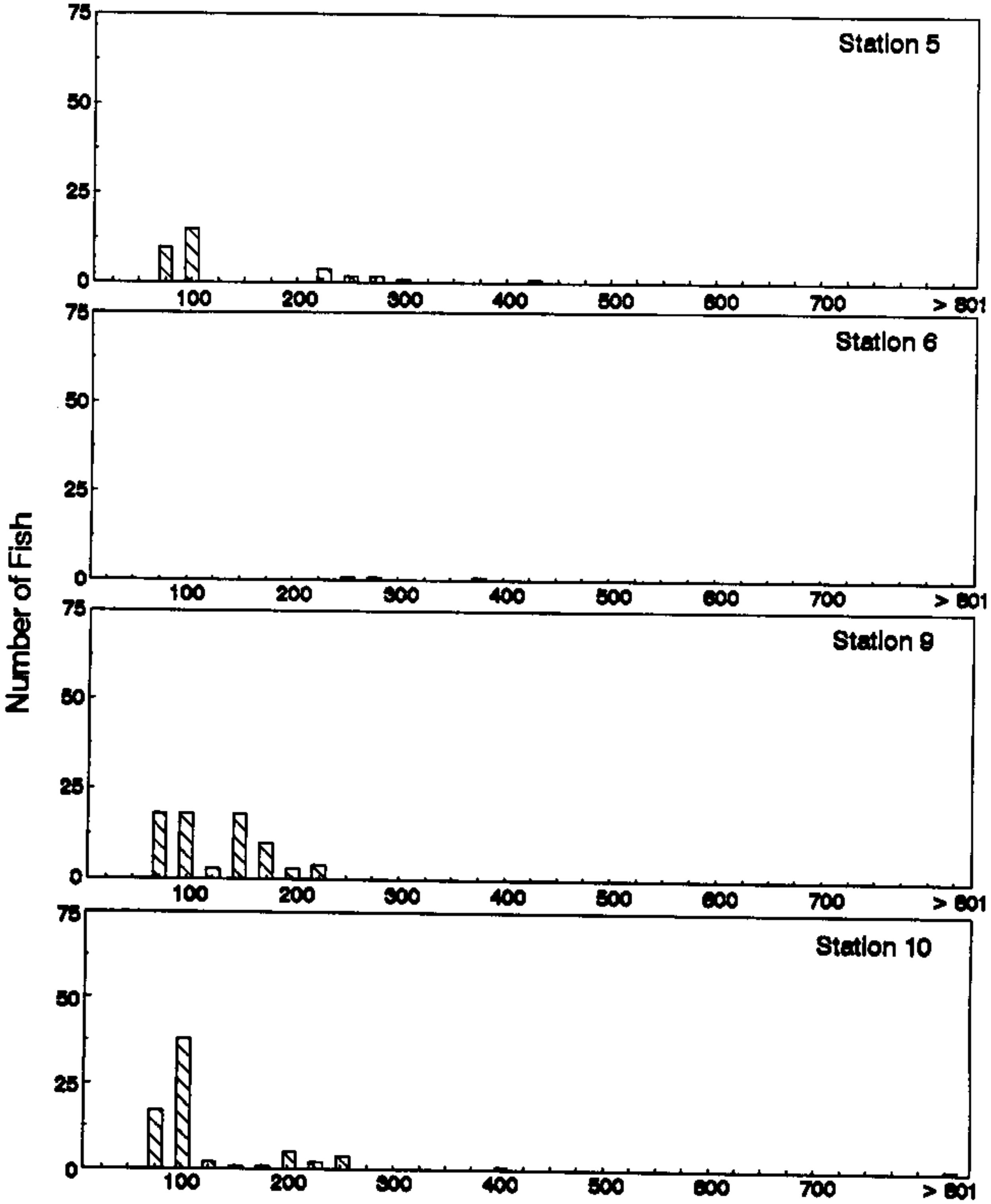


Figure 28. Length distributions of smallmouth bass sampled by all gear types at shallow (5, 9 and 10) and mid-depth (6) reference stations during fall 1992 in Lower Granite Reservoir.

2 and 5 suggested bimodal distributions, but numbers of fish sampled were low, thus limiting comparisons. Lengths ranged from 75 to 425 mm at station 5. The majority of the smallmouth bass was sampled at stations 3 and 10 while few were sampled at stations 4 and 6.

Channel catfish.– All channel catfish collected during fall 1992 ranged in length between 200 mm at station 5 and 600 mm at station 3 (Figures 29 and 30). Numbers sampled at all stations were low, however collections at station 5 were highest.

White sturgeon.– Length distributions of white sturgeon collected during fall 1992 ranged from 425 mm at shallow reference station 5 to > 801 mm at deep disposal station 7 (Figure 31). The model length was 475 mm at stations 5, 6 and 8, although numbers collected were low.

Abundance of Fishes by Gear Type

1992

Chinook salmon.- Comparisons of catch/efforts for juvenile chinook salmon by beach seining during 1992 indicated no significant ($P > 0.05$) differences among stations (Figure 32). Catch/effort was highest at shallow reference station 9 followed by station 5 and shallow disposal stations 1 and 2 were low.

Catch/effort for juvenile chinook salmon by nighttime electrofishing was highest at shallow reference station 5 followed by station 3 (Figure 33). Shallow reference station 11 had the lowest catch/effort. Differences in catch/effort among stations were not

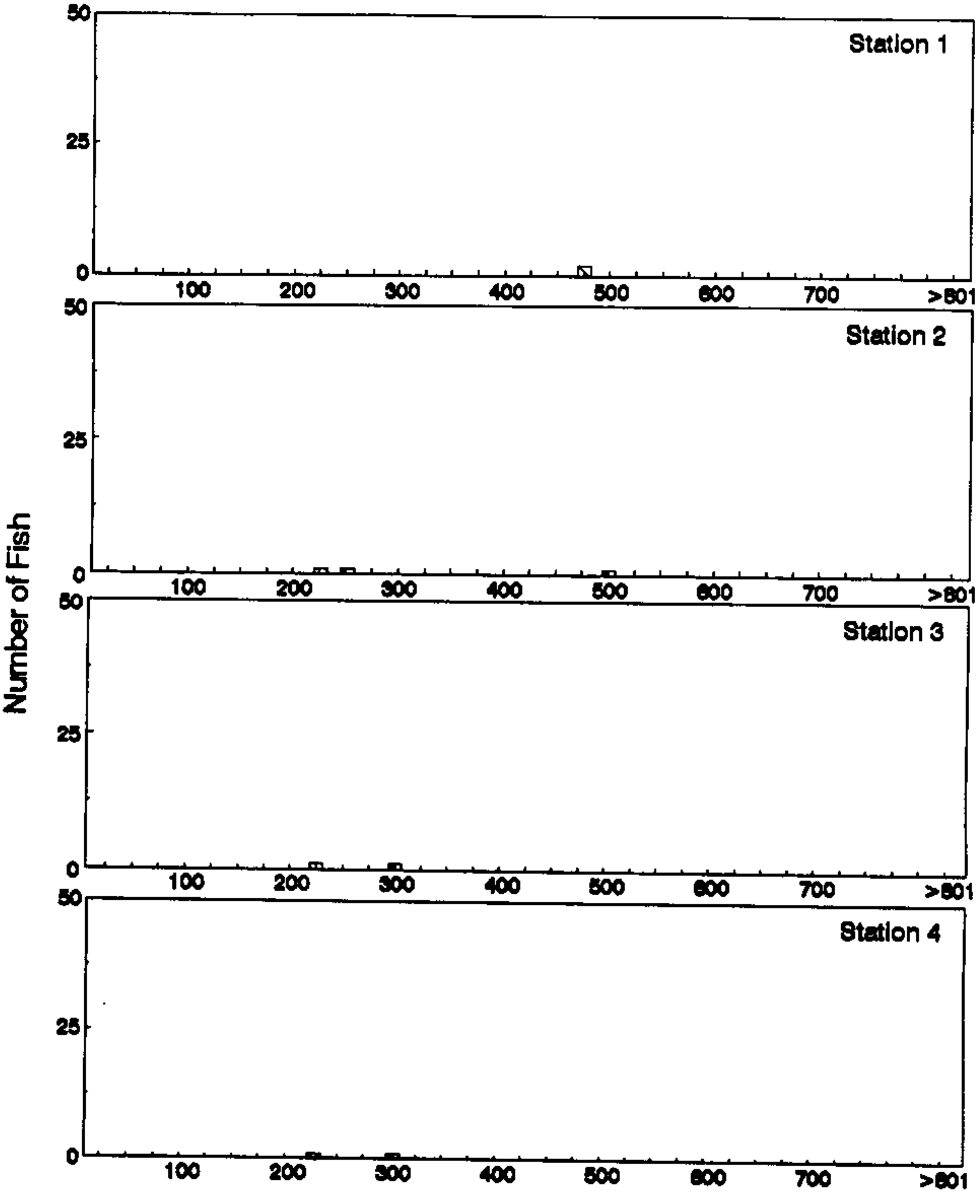


Figure 29. Length distributions of channel catfish sampled by all gear types at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during fall 1992 in Lower Granite Reservoir.

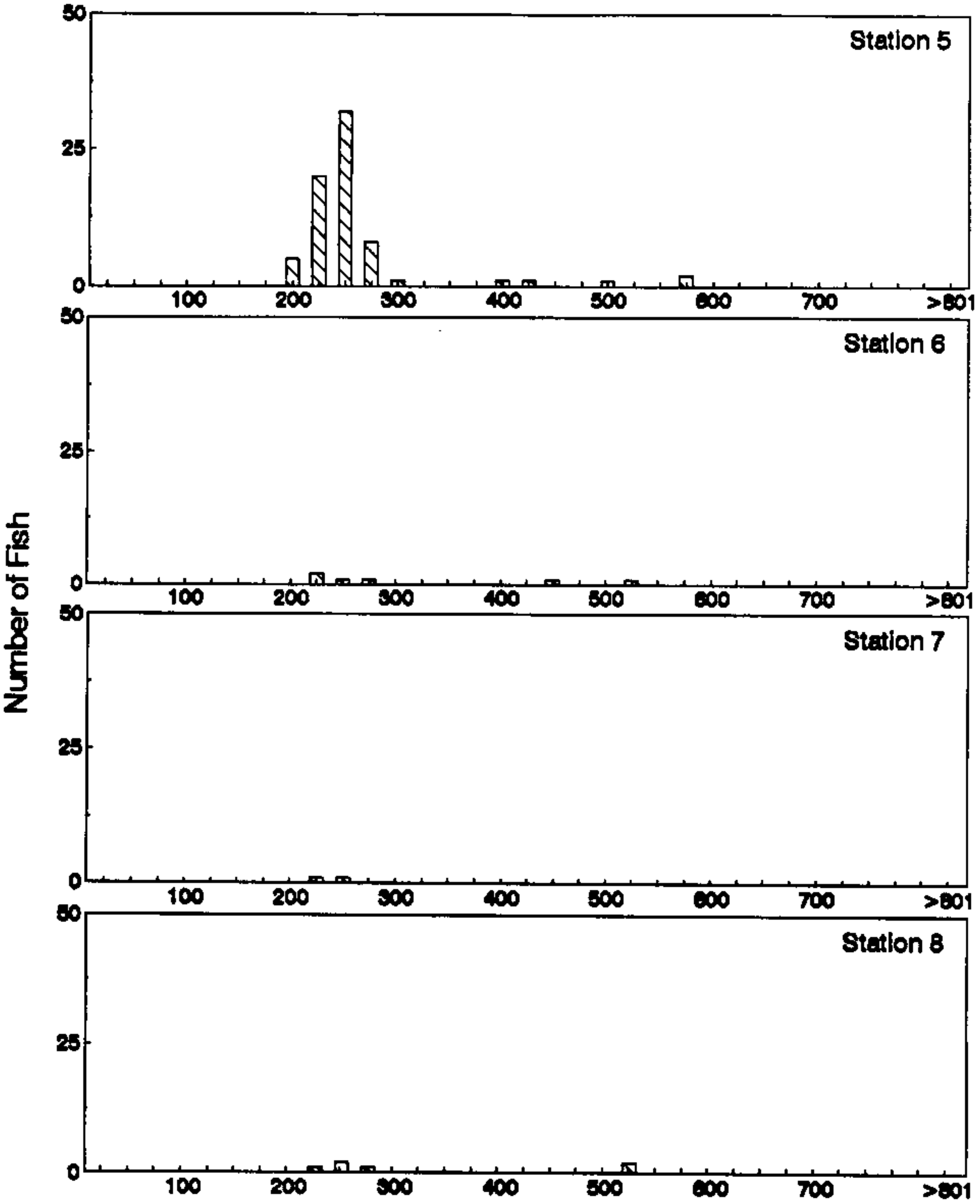


Figure 30. Length distributions of channel catfish sampled by all gear types at shallow (5), mid-depth (6) and deep (8) reference and disposal (7) stations during fall 1992 in Lower Granite Reservoir.

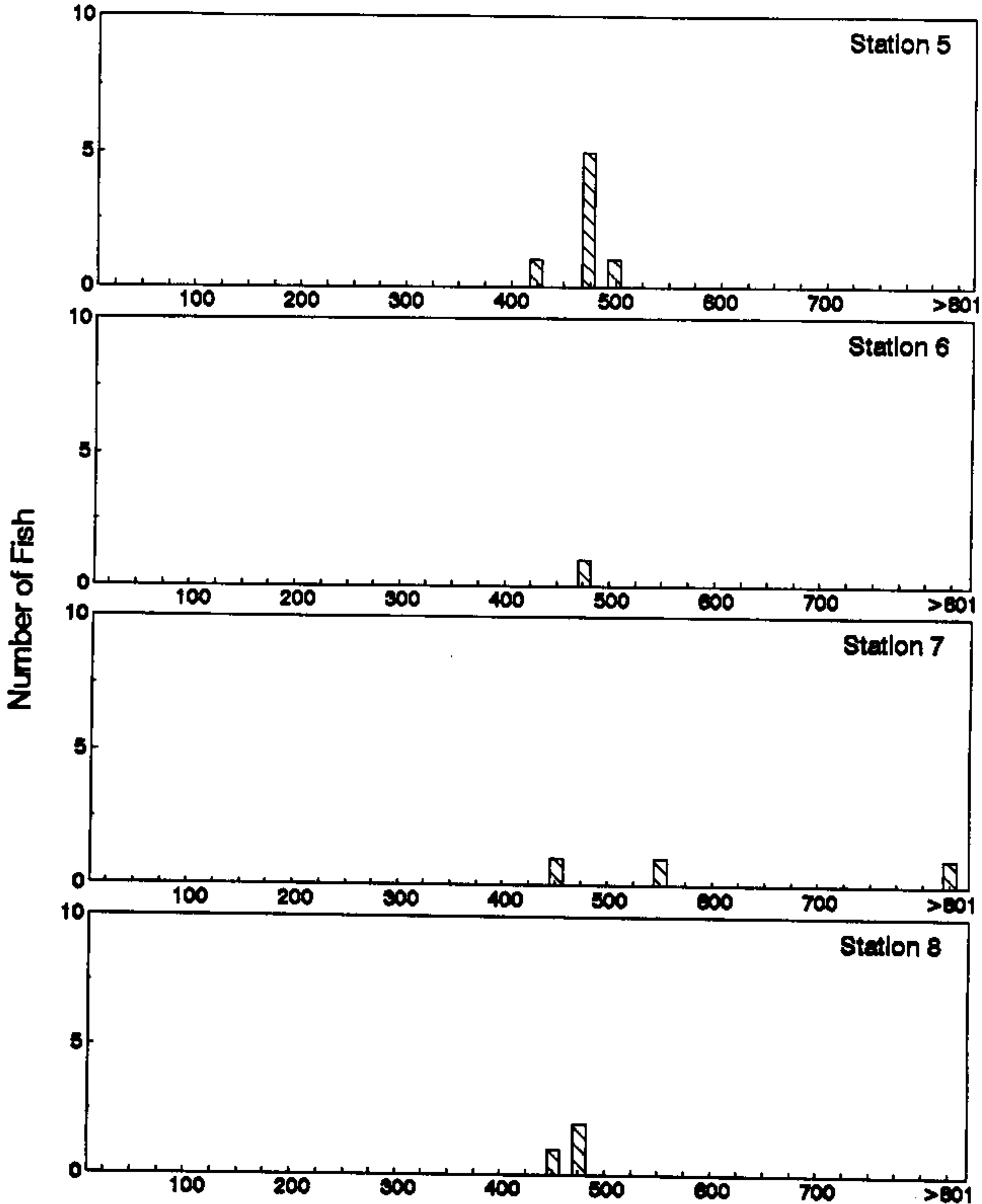
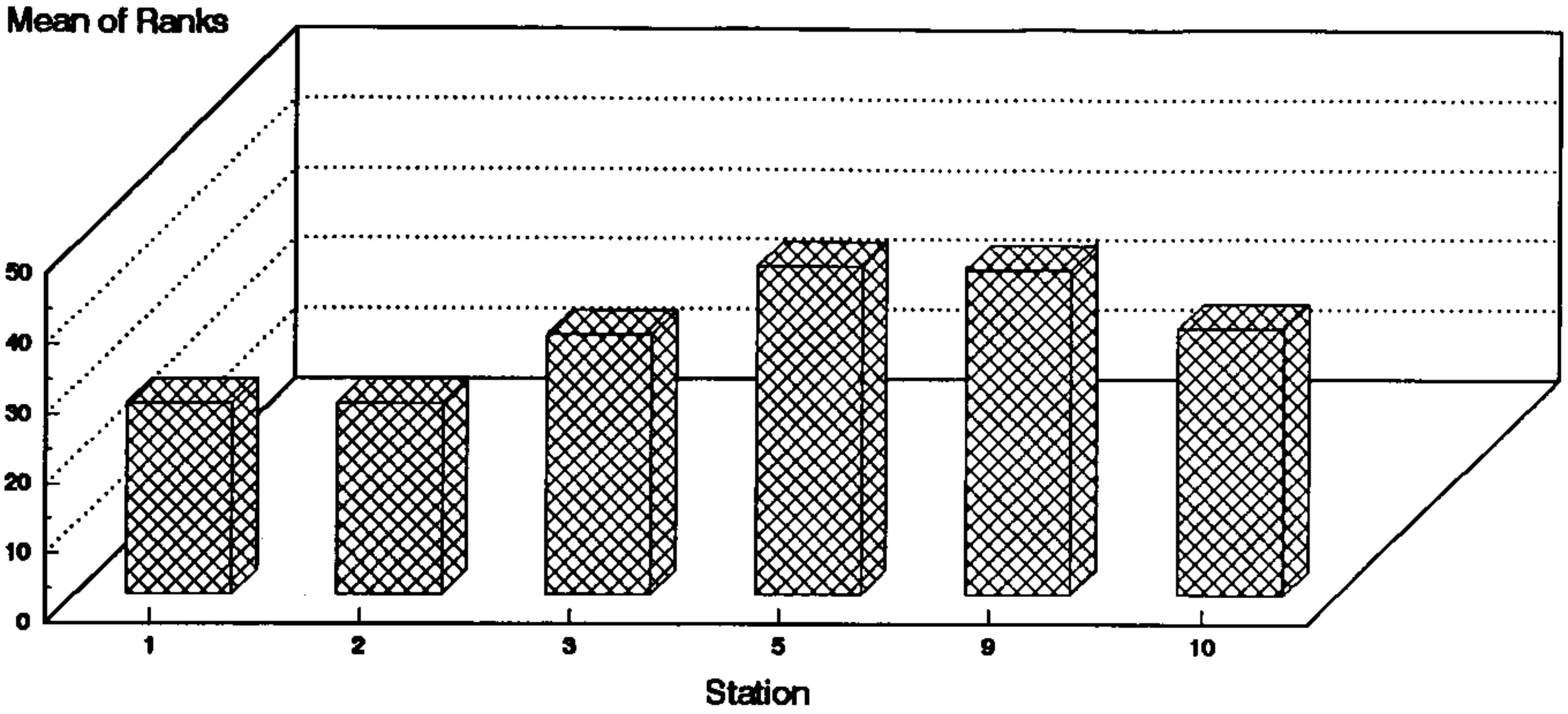


Figure 31. Length distributions of white sturgeon sampled by gill nets and set lines at shallow (5), mid-depth (6) and deep (8) reference and disposal (7) stations during fall 1992 in Lower Granite Reservoir.



Station Comparison

9 5 10 3 1 2

Figure 32. 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 stations indicates statistical nonsignificance (P > 0.05).

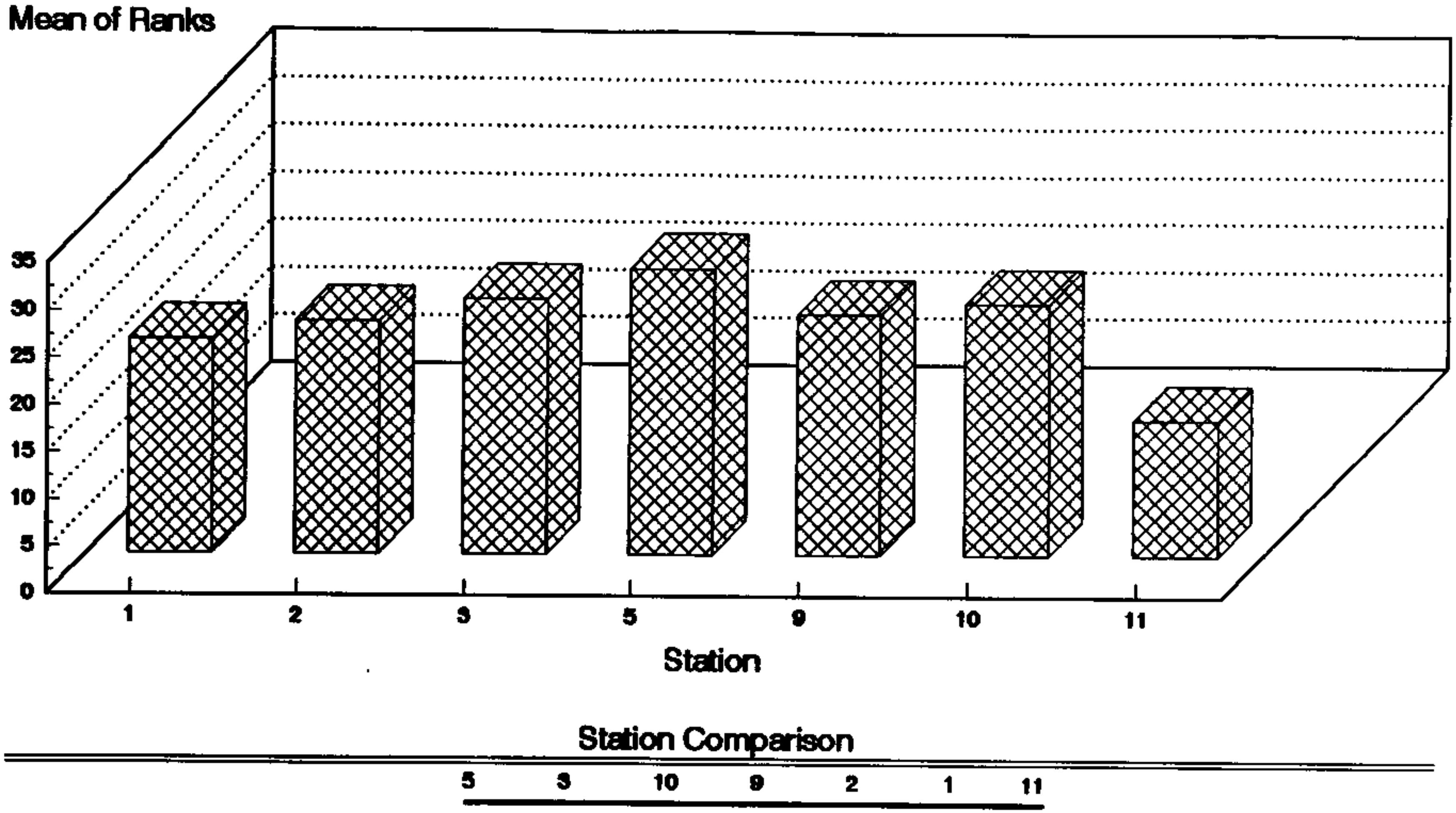


Figure 33. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by electrofishing during 1992 in Lower Granite Reservoir. The horizontal line under stations indicates statistical nonsignificance (P > 0.05).

significant ($P > 0.05$) suggesting similar levels of abundance between reference and disposal stations.

Results of comparisons of catch/effort for juvenile chinook salmon by surface trawling are discussed under Objective 3.

Steelhead.- Statistical differences in catch/effort for juvenile steelhead by beach seining were found among stations during 1992 (Figure 34). The highest catch/effort was at shallow reference station 10 followed by shallow reference station 9 and shallow disposal station 2. Catch/efforts among these stations were similar. Shallow disposal station 1 had the lowest catch/effort, however it was not statistically different from mid-depth and shallow reference stations 3 and 5 and shallow disposal station 2.

Spring and summer had the highest seasonal differences in catch/effort followed by fall (Figure 34). Catches during fall were significantly ($P < 0.05$) lower than spring, while differences between spring and summer and summer and fall were not significant ($P > 0.05$). These comparisons indicate the high abundance of juvenile steelhead in Lower Granite Reservoir in 1992.

Catch/effort for juvenile steelhead by electrofishing was highest at shallow reference station 10 followed by station 9 (Figure 35). The lowest catch/effort occurred at shallow reference station 11. Catch/efforts at shallow disposal (1) and reference (11) stations were significantly ($P < 0.05$) lower than catches at shallow reference stations 9 and 10.

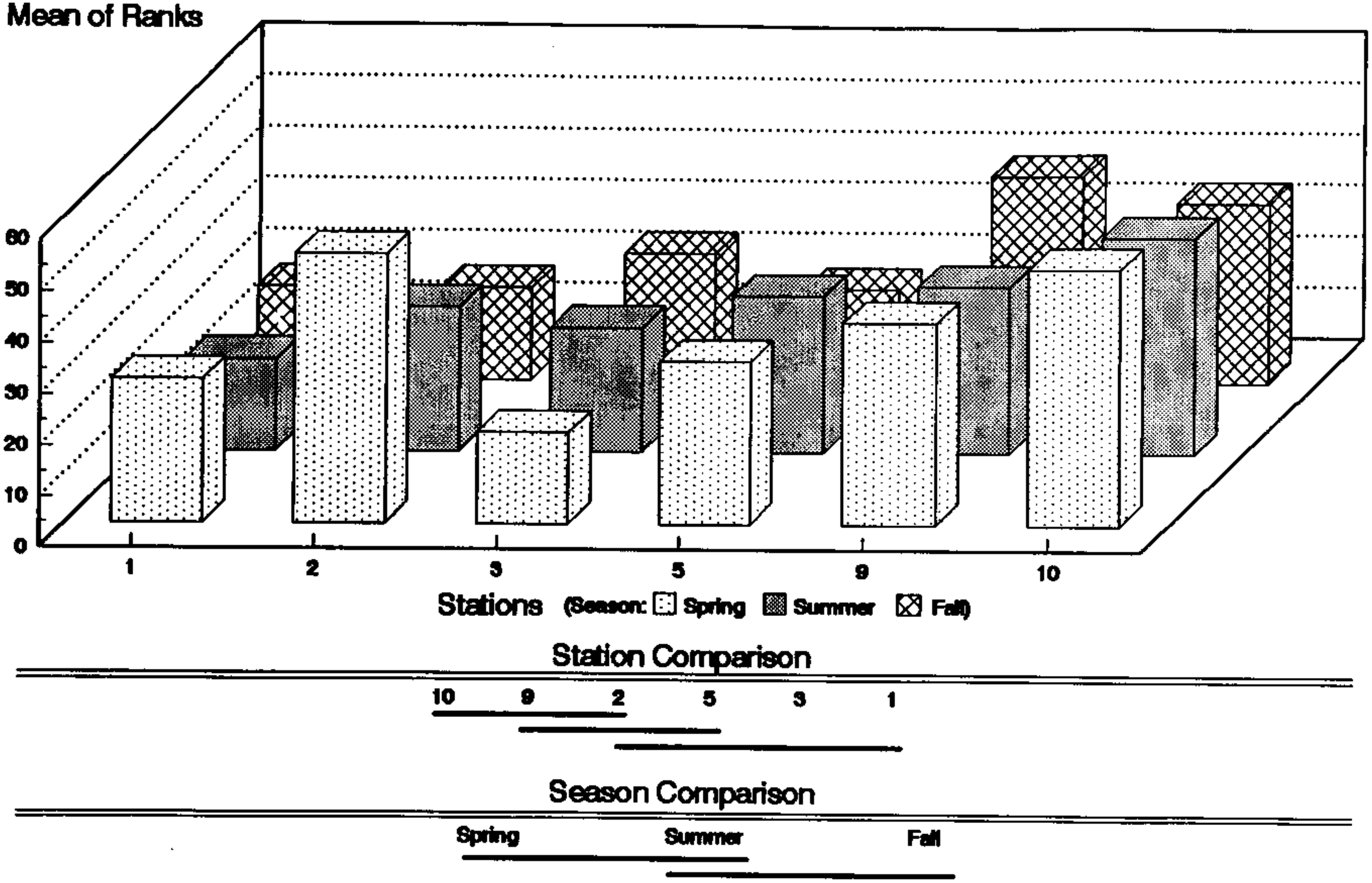


Figure 34. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by beach seining during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

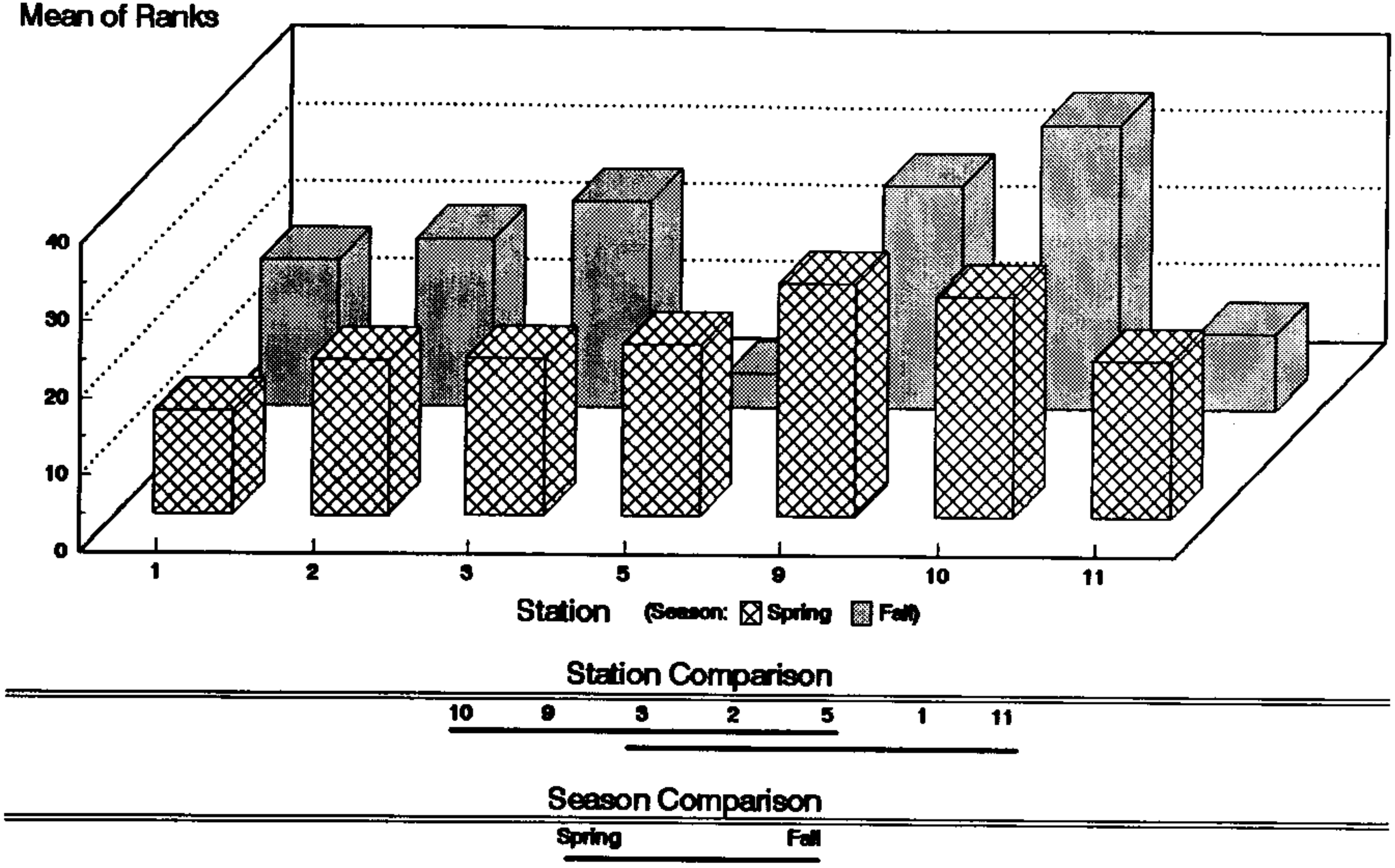


Figure 35. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by electrofishing during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

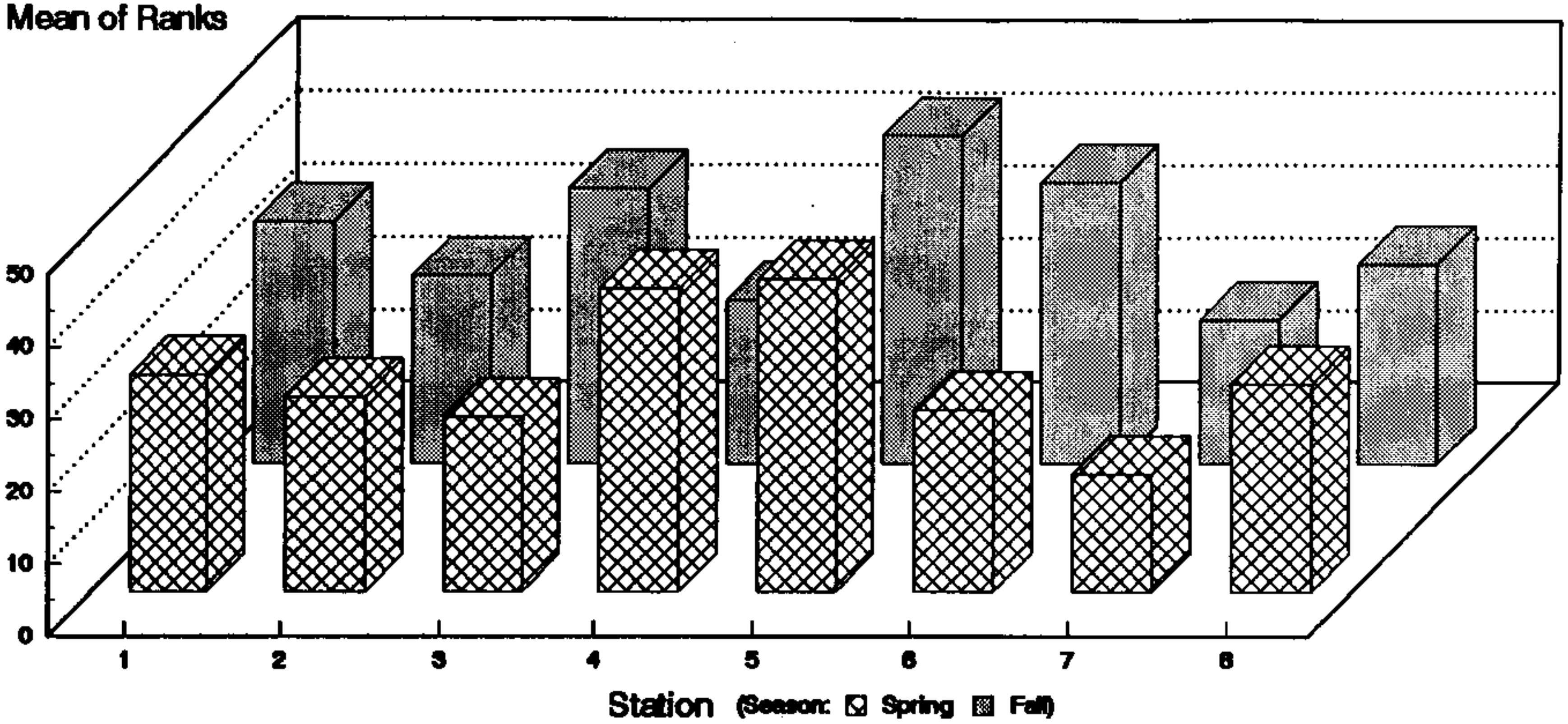
We did not observe seasonal differences in catch/effort for juvenile steelhead by electrofishing (Figure 35). Catch/effort was higher during spring than fall, although these differences were not statistically significant ($P > 0.05$).

Results of comparisons of catch/effort for juvenile steelhead sampled by surface trawling are discussed under Objective 3.

Northern squawfish.- Abundance of northern squawfish based on comparisons of catch/effort by gill netting during 1992 was highest at shallow reference station 5 followed by mid-depth and shallow disposal stations 4 and 1 (Figure 36). The lowest catch/effort for squawfish was at deep disposal station 7. Significant ($P < 0.05$) statistical differences in catch/effort were observed between the highest catch/effort at station 5 and the lowest at station 7, however differences between the other stations were not significant.

We found no significant ($P > 0.05$) seasonal differences between spring and fall in catch/effort for northern squawfish sampled by gill netting during 1992 (Figure 36). Catch/effort increased in the fall at mid-depth reference stations 3 and 6 above those observed during spring. Differences in catch/effort from spring to fall for northern squawfish were at mid-depth disposal station 4. Differences in catch/effort between spring and fall for other stations were slight.

Catch/effort for northern squawfish by beach seining was highest at shallow reference station 5 followed by station 10 (Figure 37). Shallow reference station 9 had the lowest catch/effort and differences



Station Comparison

5 4 1 6 3 8 2 7

Season Comparison

Spring Fall

Figure 36. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

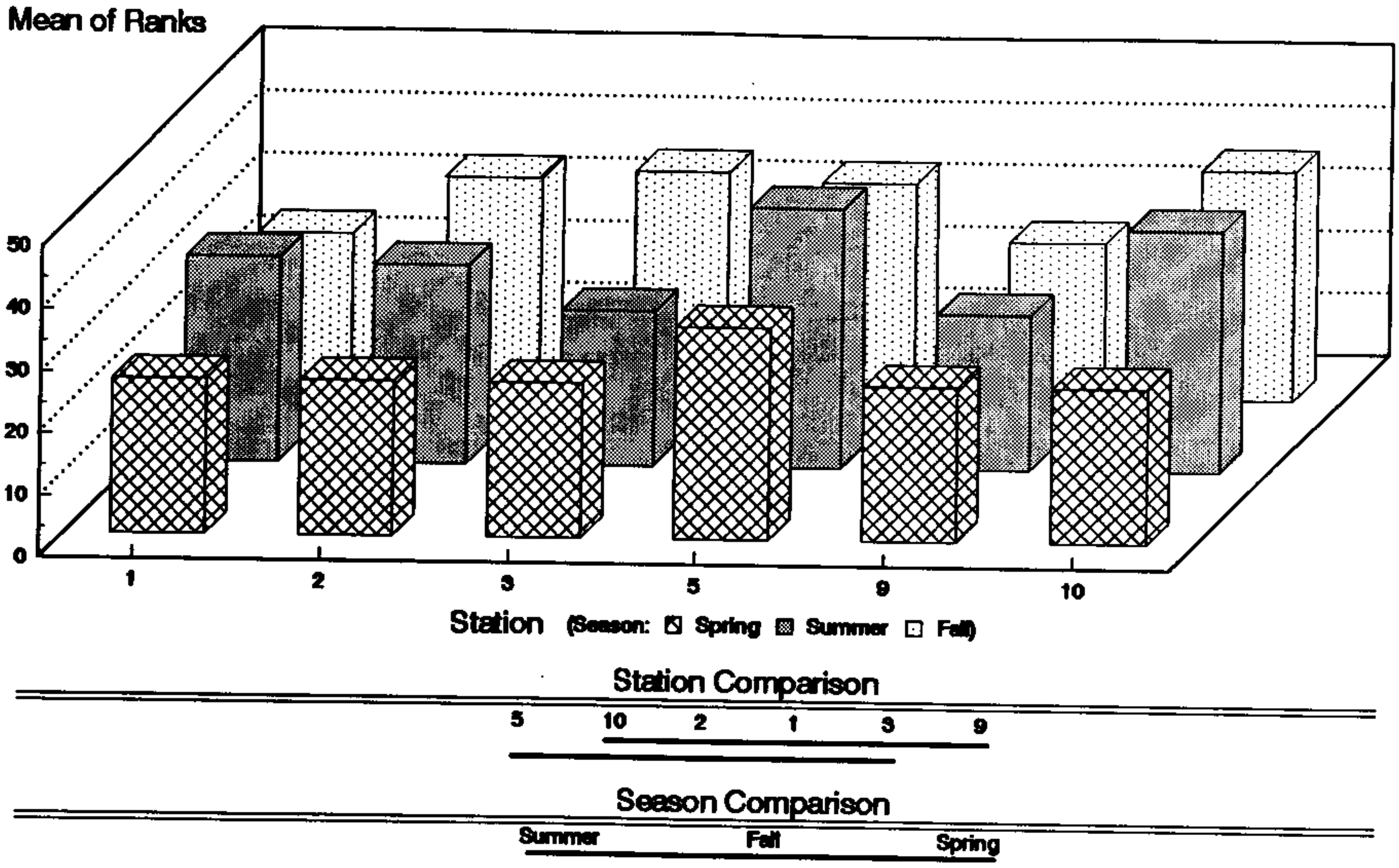


Figure 37. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by beach seining during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).

between stations 9 and 5 were significant ($P < 0.05$). Catch/efforts among other stations were not different.

No seasonal differences were found in catch/effort for northern squawfish by beach seining (Figure 37). The highest catch/effort for squawfish occurred during summer followed by fall and spring, although these differences were not significant ($P > 0.05$).

Catch/effort for northern squawfish by electrofishing was highest at shallow reference station 3 followed by shallow reference station 5 (Figure 38). Statistically, differences in catch/effort for squawfish were generally similar among disposal and reference stations. The only statistical difference in catch/efforts was between the highest at station 3 and the lowest at shallow disposal station 2. Comparisons of catch/effort at other stations were not statistically ($P > 0.05$) different.

No statistically significant ($P > 0.05$) seasonal differences in catch/effort for northern squawfish by electrofishing were found (Figure 38). Catch/effort was highest in the spring and lowest in the fall.

Smallmouth bass.- Catches of smallmouth bass by gill netting varied among stations (Figure 39). Catches were generally higher at shallow stations. During spring, catch/effort was highest at shallow disposal station 1 whereas during fall catch/effort was highest at shallow disposal station 2. In general, catch/effort was highest in the spring at the shallow reference and disposal stations whereas it was significantly higher in the fall at mid-depth disposal and reference stations 4 and 6.

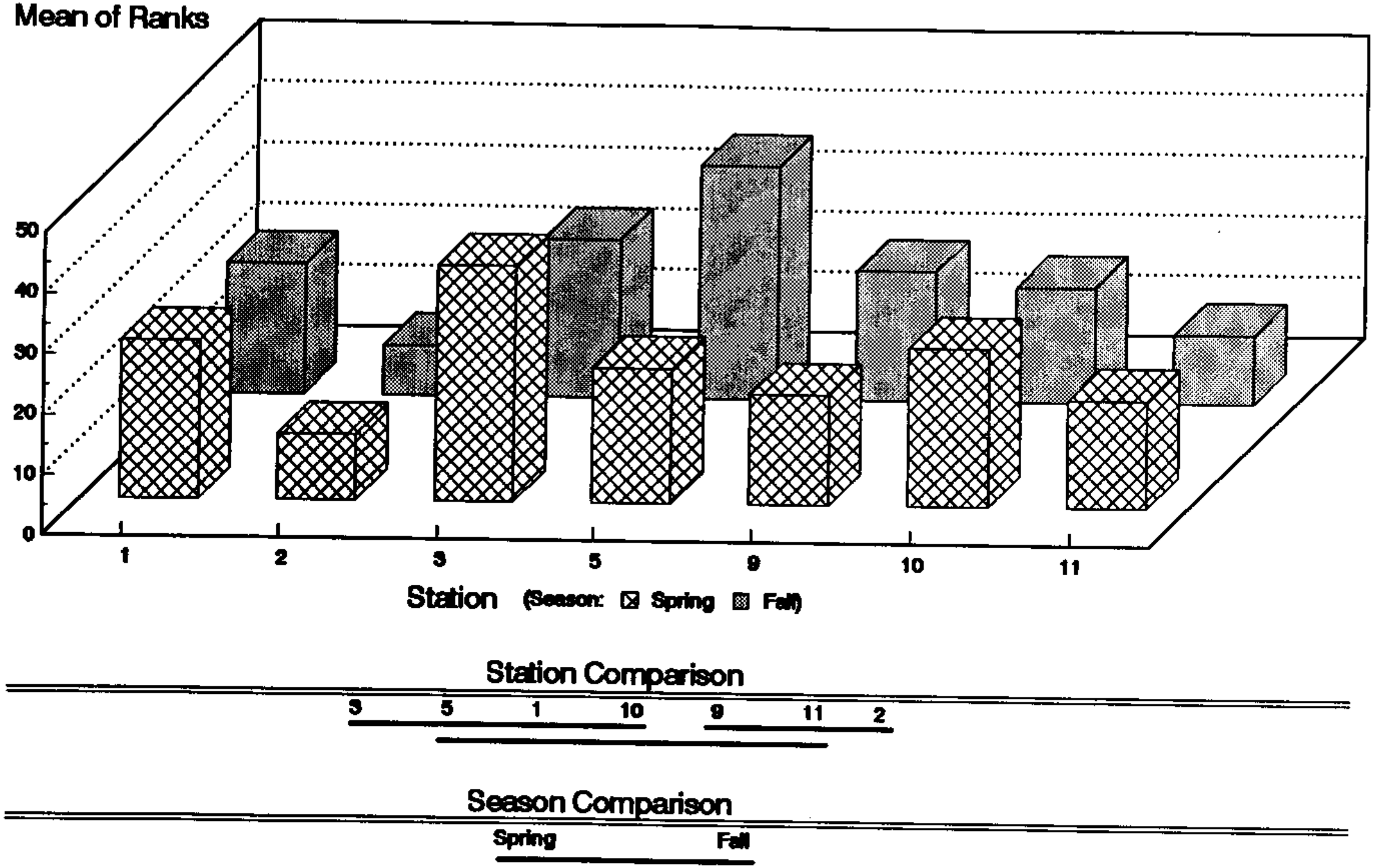


Figure 38. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by electrofishing during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).

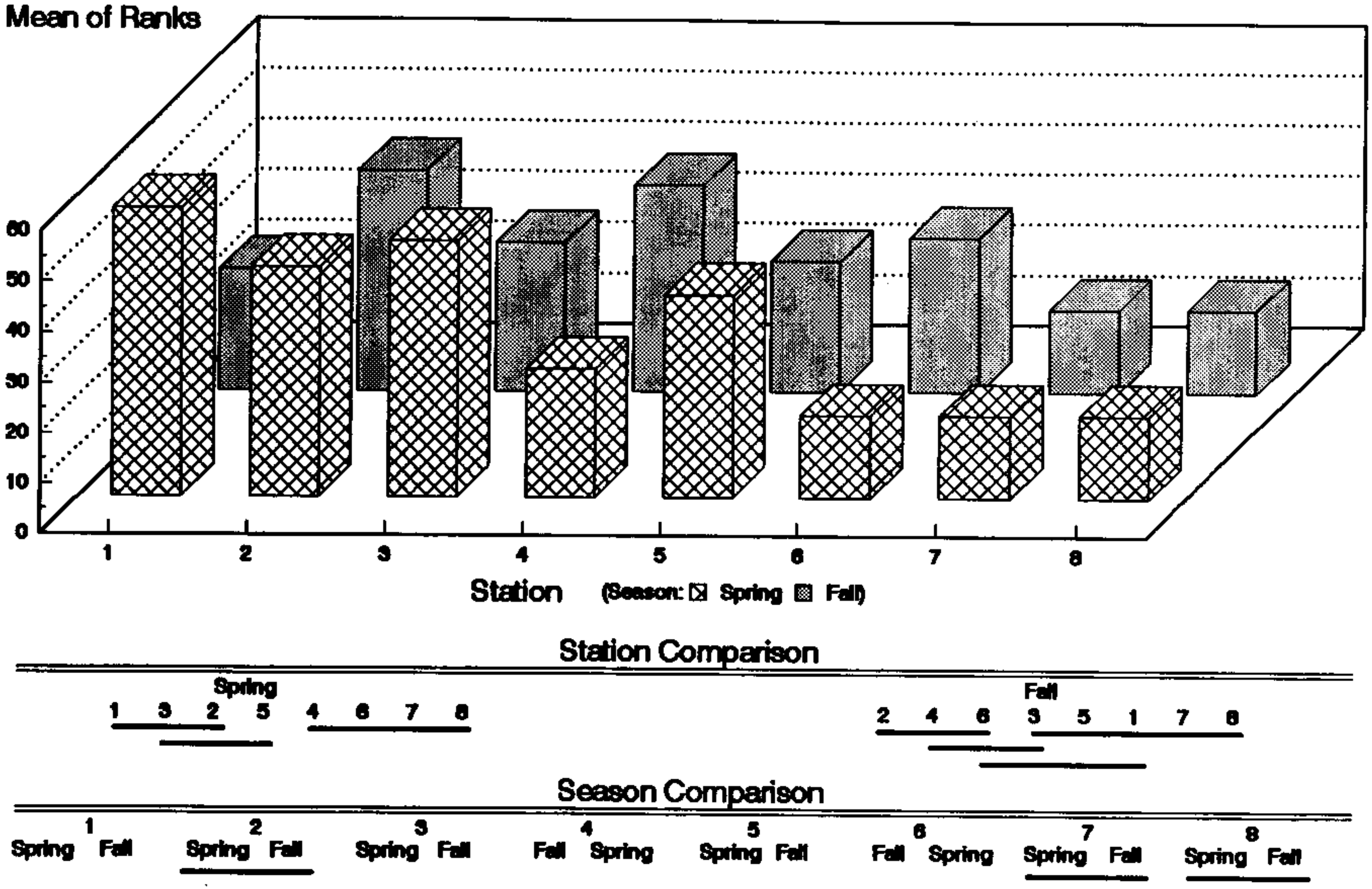


Figure 39. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

Catch/efforts for smallmouth bass by gill netting varied seasonally within shallow and mid-depth stations (Figure 39). Within the spring and fall seasons, a number of significant ($P < 0.05$) differences in catch/effort were found. Catch/efforts for smallmouth bass between spring and fall were not significantly ($P < 0.05$) different at stations 2, 7 and 8 while those at other stations were different.

Smallmouth bass were collected by beach seining at stations 1, 2, 3, 5, 9 and 10 during 1992 (Figure 40). Highest abundance at a station varied seasonally, although catch/effort was highest at shallow reference station 3 followed by shallow reference and disposal stations 10 and 1. Abundance among stations was not significantly ($P > 0.05$) different during 1992.

We found seasonal differences in catch/effort for smallmouth bass by beach seining among spring, summer and fall (Figure 40). Catch/effort data were significantly ($P < 0.05$) higher in summer than in either fall or spring. However, differences in catch/effort between fall and spring were not significant ($P > 0.05$).

Comparisons of catch/effort for smallmouth bass by electrofishing indicated few differences in abundance between reference and disposal stations (Figure 41). Catch/effort of smallmouth bass was highest at shallow reference station 9 followed by station 3. Shallow disposal stations 1 and 2 had low catch/efforts and these were significantly ($P < 0.05$) lower than those at stations 9 and 3. Catch/efforts from the other stations were generally similar.

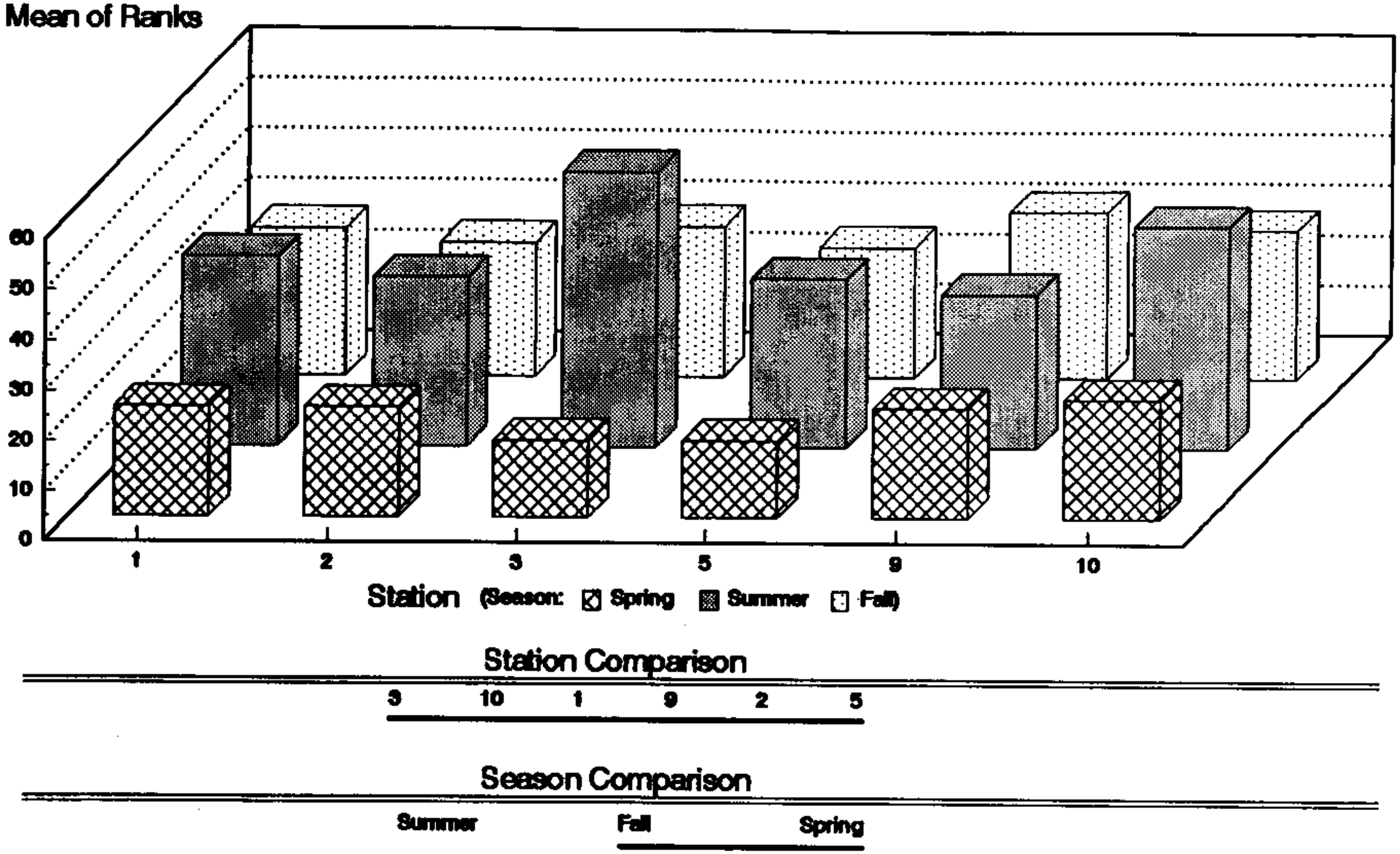


Figure 40. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by beach seining during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

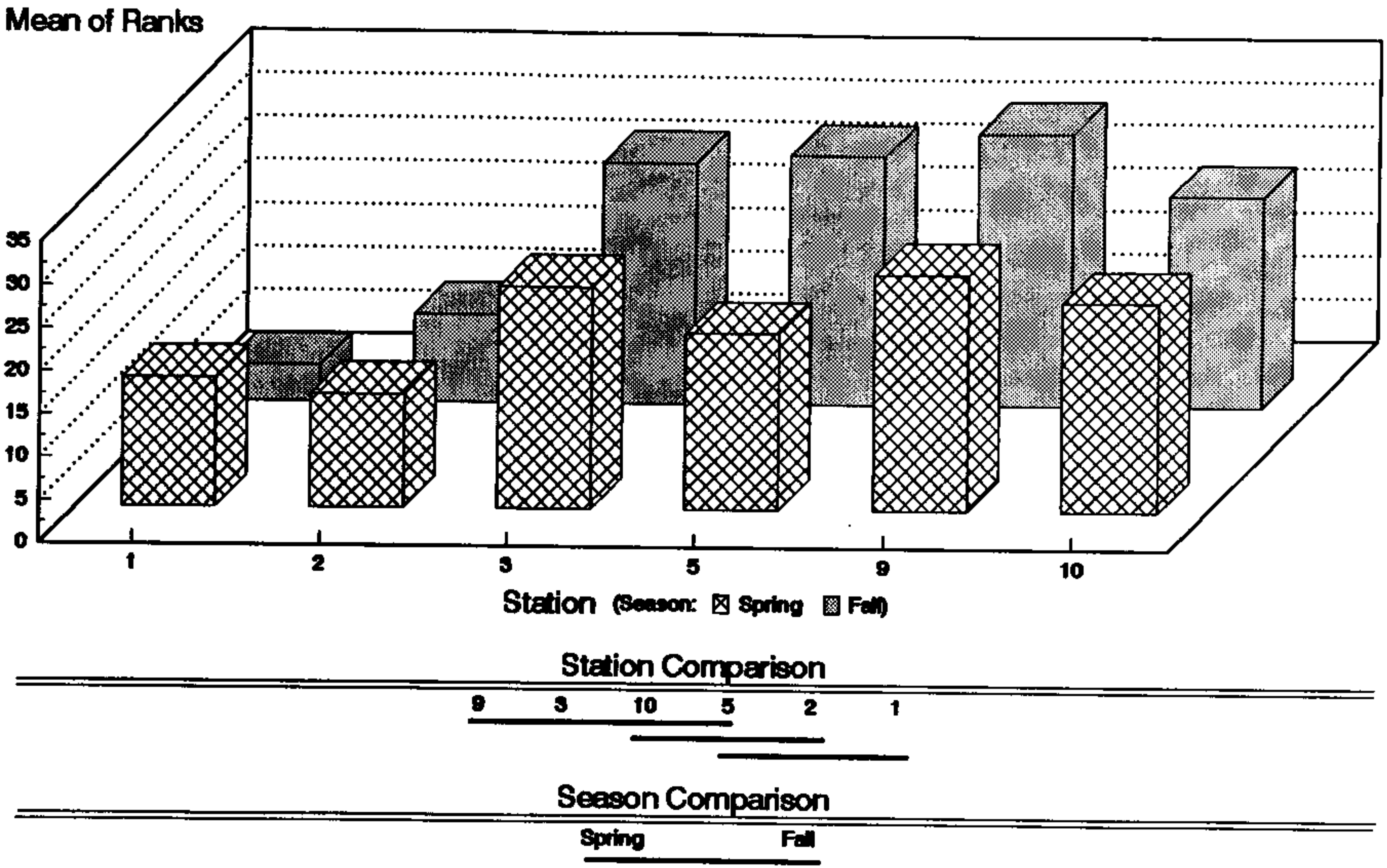


Figure 41. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

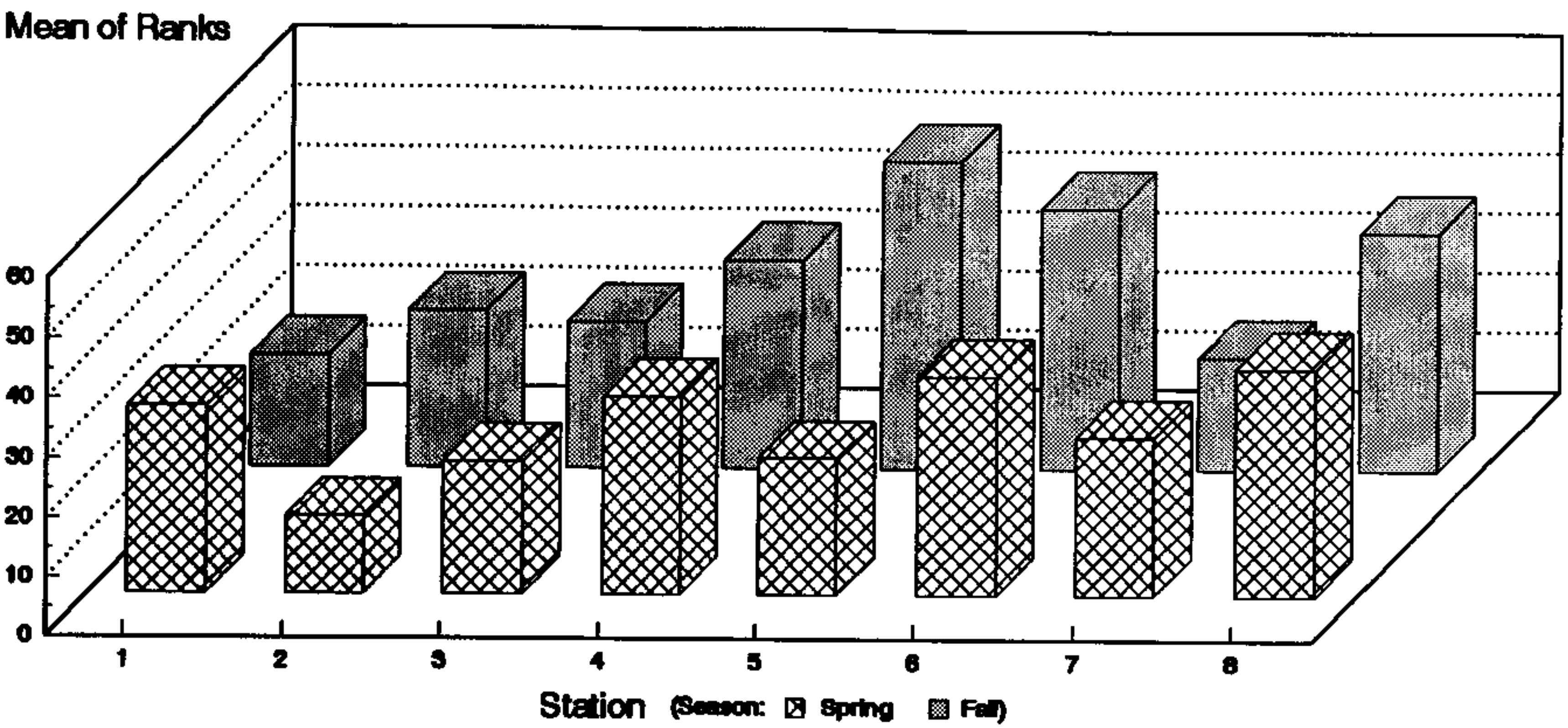
Comparisons of catch/effort among seasons for smallmouth bass by electrofishing were statistically ($P < 0.05$) similar (Figure 41). Catch/efforts were highest in the spring, although these differences were not sufficient to show a seasonal change in abundance.

Channel catfish.- During 1992, we collected channel catfish by gill netting at eight sampling stations. Catch/effort was highest at reference station 5 followed by stations 6 and 8. The lowest catch/effort was at disposal station 2 (Figure 42). Comparisons of catch/effort at the four disposal stations were not significantly ($P > 0.05$) different while those at reference stations 5 and 6 were significantly higher than the shallow and deep disposal stations.

We found no seasonal differences in catch/effort for channel catfish by gill netting during 1992 (Figure 42). Catch/efforts of catfish at reference stations 5 and 6 were higher in the fall and that at disposal station 2 was the lowest in the spring.

White sturgeon.- During 1992, statistical differences in catch/effort of white sturgeon sampled by gill netting among stations were few (Figure 43). The highest overall catch/effort was at deep disposal station 7. The lowest catch/effort was at disposal station 2 which was significantly ($P < 0.05$) different from disposal station 7 and reference stations 5 and 8.

Seasonal differences in catch/effort by gill netting for white sturgeon between spring and fall 1992 were not statistically different ($P > 0.05$; Figure 43). Catches at shallow stations were generally higher in the spring than fall, although catches at deep disposal and



Station Comparison

5 6 8 4 1 3 7 2

Season Comparison

Fall Spring

Figure 42. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).

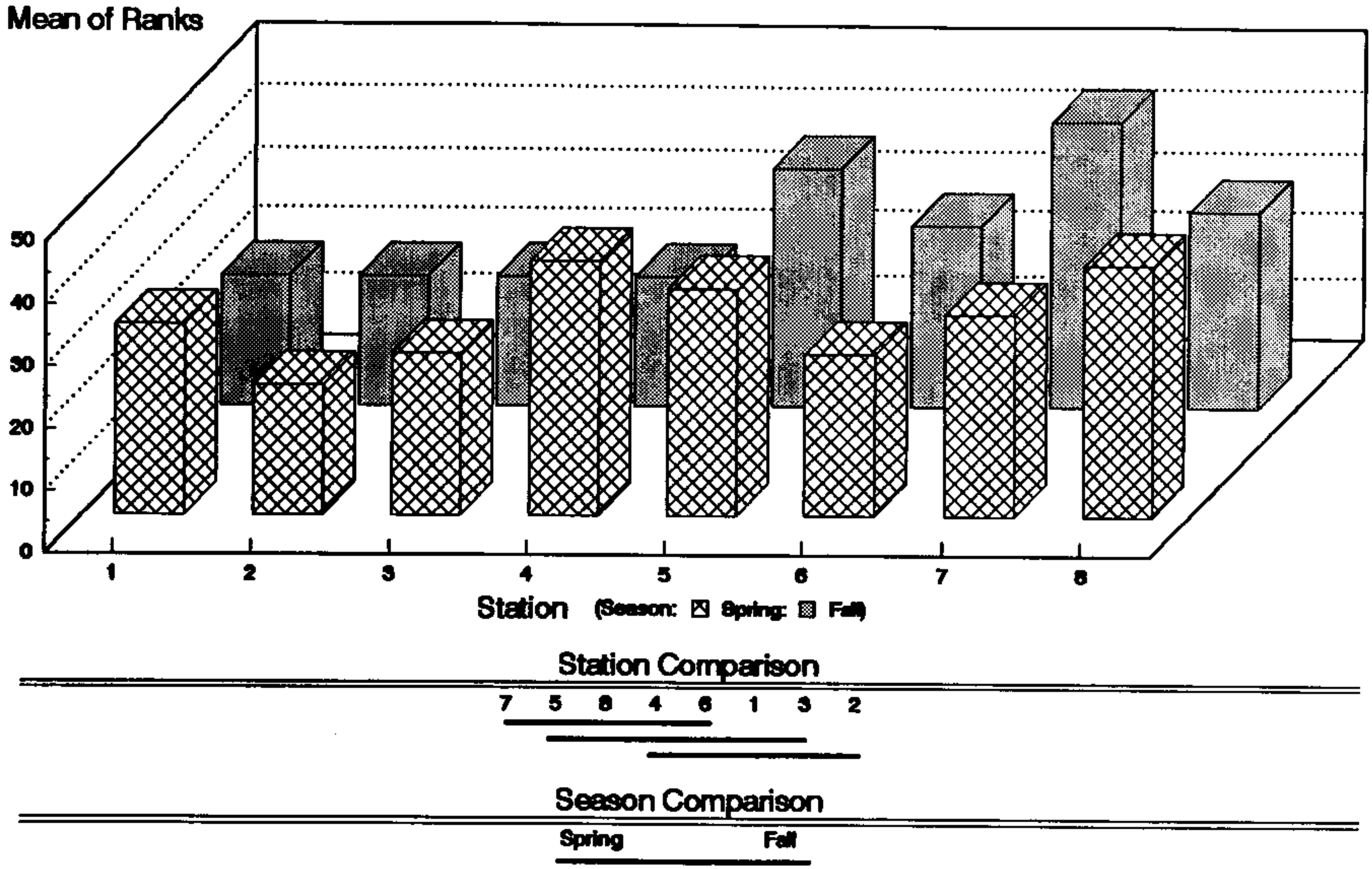


Figure 43. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

reference stations 7 and 8 were generally higher than shallow and mid-depth stations for both seasons.

1989-1992

Chinook salmon.- During 1989 to 1992 comparisons of catch/effort by beach seining for chinook salmon were not significantly ($P < 0.05$) different among reference and disposal stations (Figure 44). Catch/effort was highest at reference station 5 and lowest at disposal station 2 during these 4 years. Yearly comparisons of catch/effort were not significantly different among 1989-1991, although 1992 catches were significantly ($P < 0.05$) lower than 1989-1991 (Figure 44).

During the period from 1989 to 1992, we found no significant ($P > 0.05$) differences in catch/effort of chinook salmon by electrofishing among stations and years (Figure 45). Catch/efforts were highest at reference station 5 followed by station 3 and disposal stations 1 and 2. Reference station 9 had the lowest catch/effort. Although no annual differences in catch/effort were found, the highest catch/effort was in 1989 followed by 1990. Catch/effort in 1991 was the lowest (Figure 45).

Steelhead- During 1989 to 1992, we found some differences in catch/effort of juvenile steelhead by beach seining for stations and years (Figure 46). Catch/effort was highest at shallow reference station 9 followed by station 10. Catch/efforts at these stations were significantly ($P < 0.05$) higher than catches at disposal station 2 and reference stations 5 and 3. Catch/effort was significantly ($P < 0.05$) lower at disposal station 1 than all other stations.

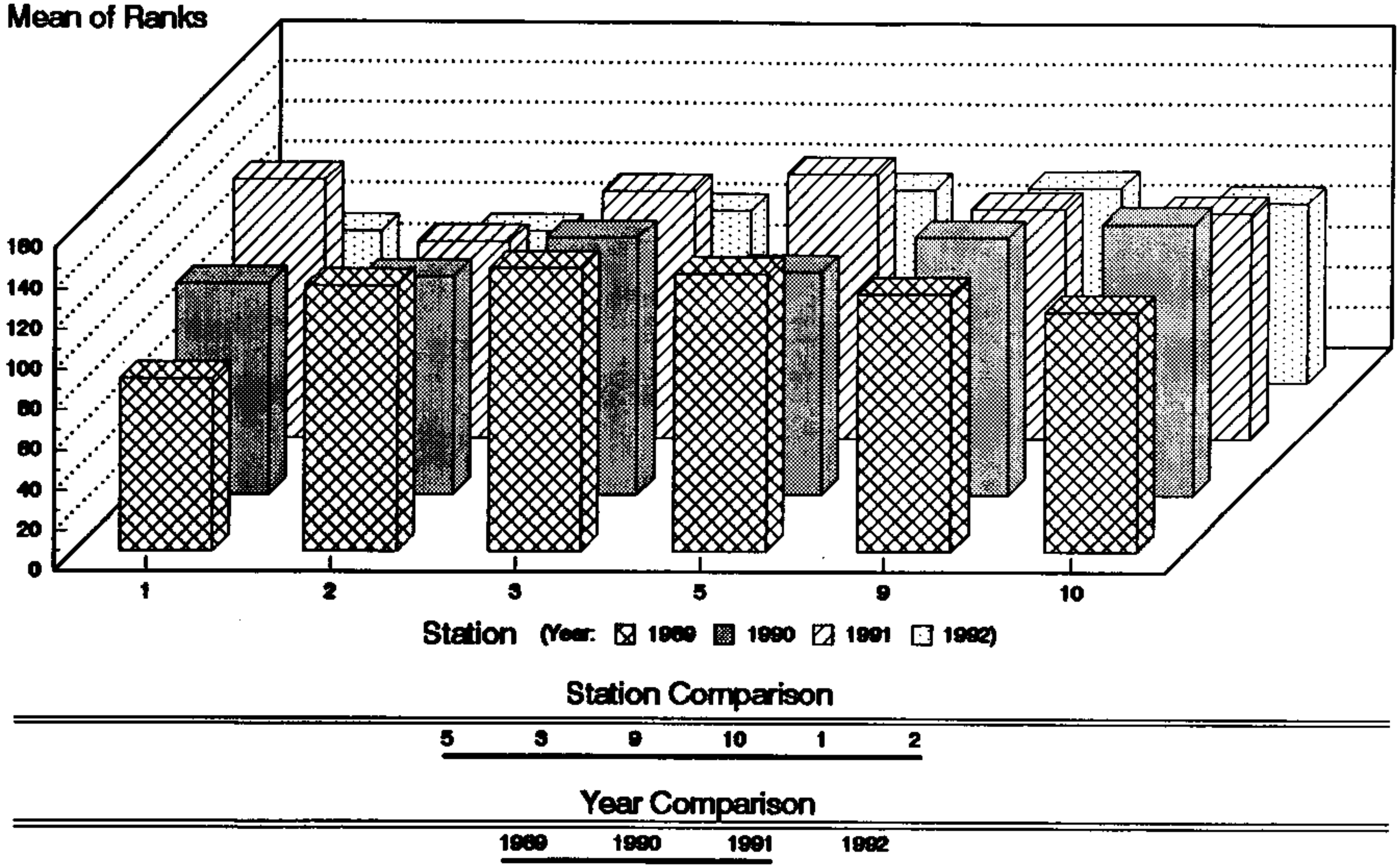


Figure 44. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by beach seining during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

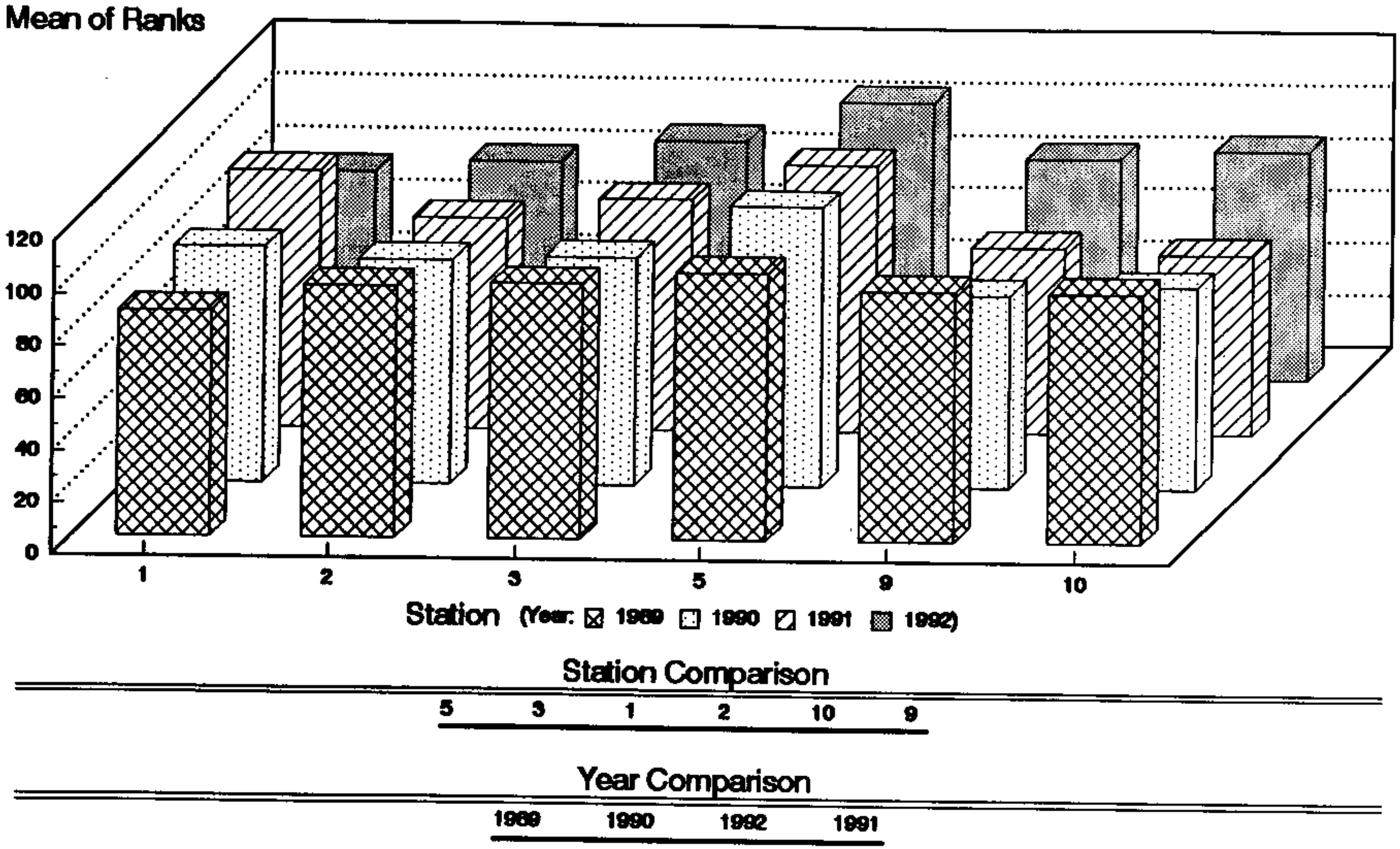


Figure 45. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

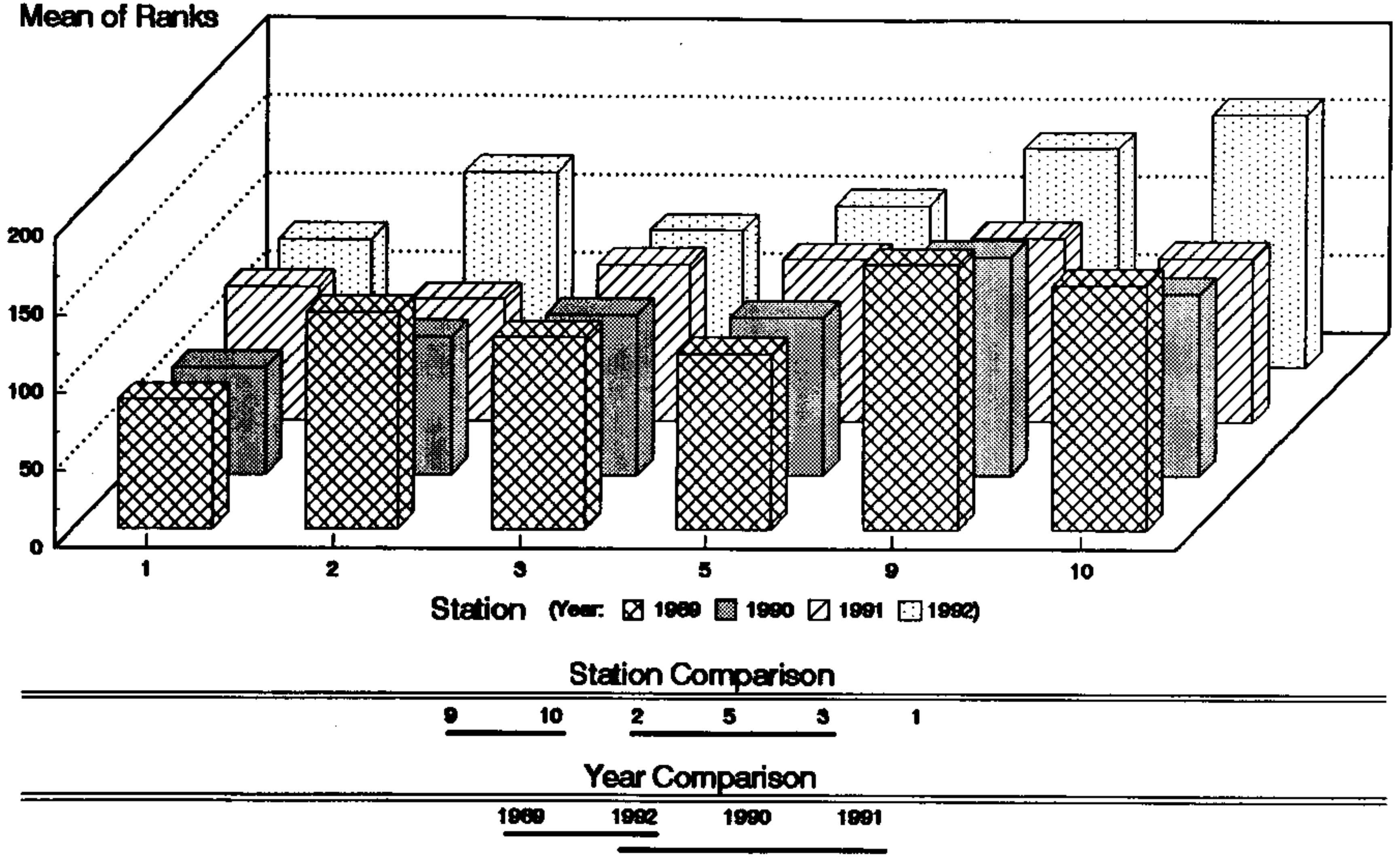


Figure 46. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by beach seining during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance ($P > 0.05$).

Yearly catch/efforts by beach seining for juvenile steelhead were highest in 1989 followed by 1992, although 1992 was not significantly ($P < 0.05$) different from 1990 and 1991 (Figure 46). Catch/effort for 1989 was significantly higher than those for 1990 and 1991.

During 1989 to 1992, catch/effort for juvenile steelhead by electrofishing was highest at shallow reference station 9 followed by shallow stations 10 and 2 (Figure 47). Catch/effort at disposal station 1 was lowest. Catch/efforts within years were generally similar, except catch/effort for 1992 was significantly ($P < 0.05$) higher than those for 1990, 1991 and 1989.

We also found significant interactions in catch/effort for juvenile steelhead by electrofishing between seasons and years (Figure 48). Differences in catch/effort between fall and spring were similar for all years except 1990 when spring was significantly ($P < 0.05$) higher than fall. Within spring and fall, differences in catch/effort by electrofishing were generally similar among years. Catch/effort was highest in 1992 during both spring and fall, although during spring the annual difference was statistically significant ($P < 0.05$).

Northern squawfish.- Since 1989 we found few station differences in catch/effort for northern squawfish by gill netting (Figure 49). Catch/effort was significantly ($P < 0.05$) higher at reference stations 5 and 6 than shallow disposal stations 2 and 1 and shallow and deep reference stations 3 and 8. The lowest catch/effort for northern squawfish since 1989 occurred at mid-depth disposal station 4.

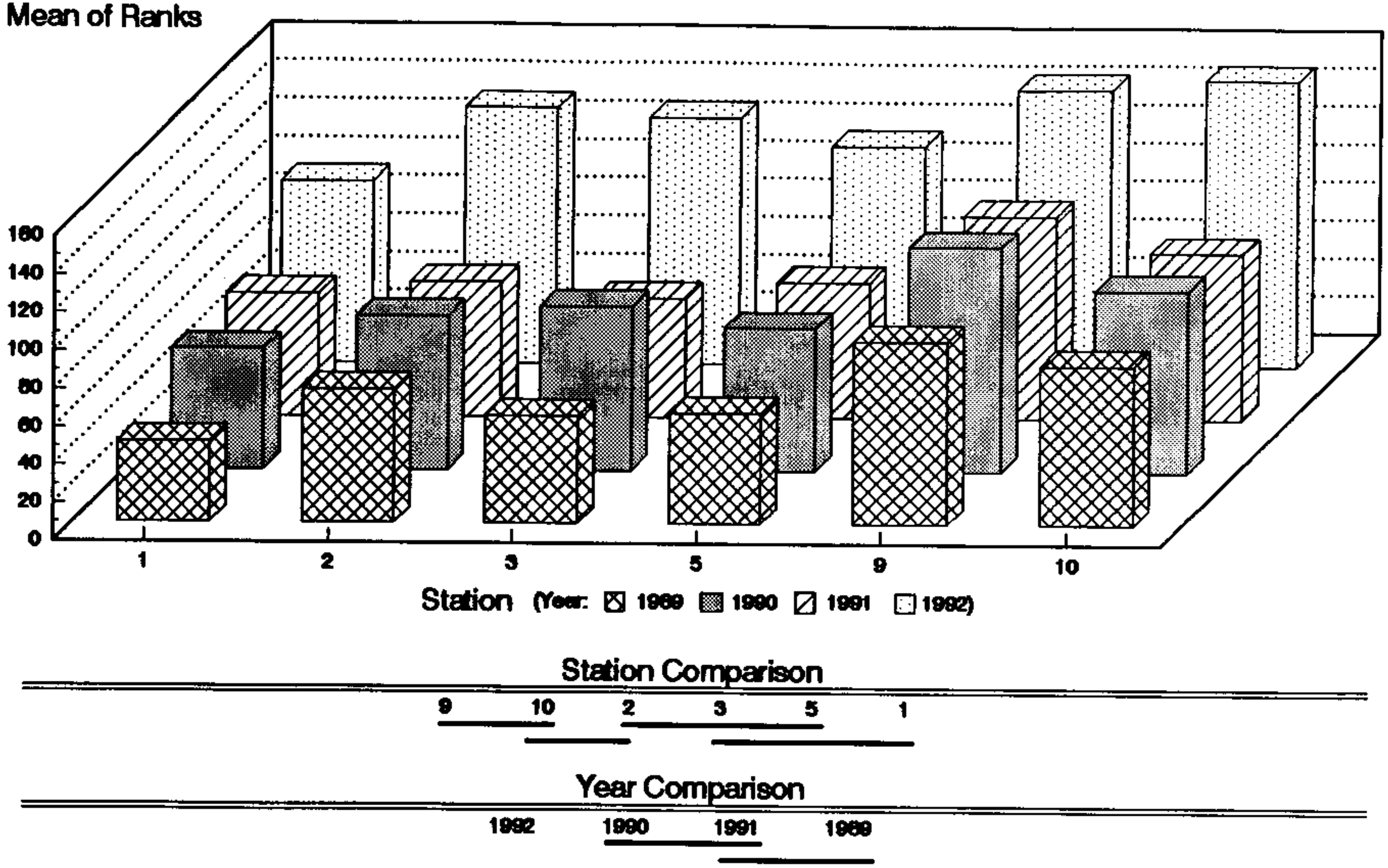


Figure 47. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

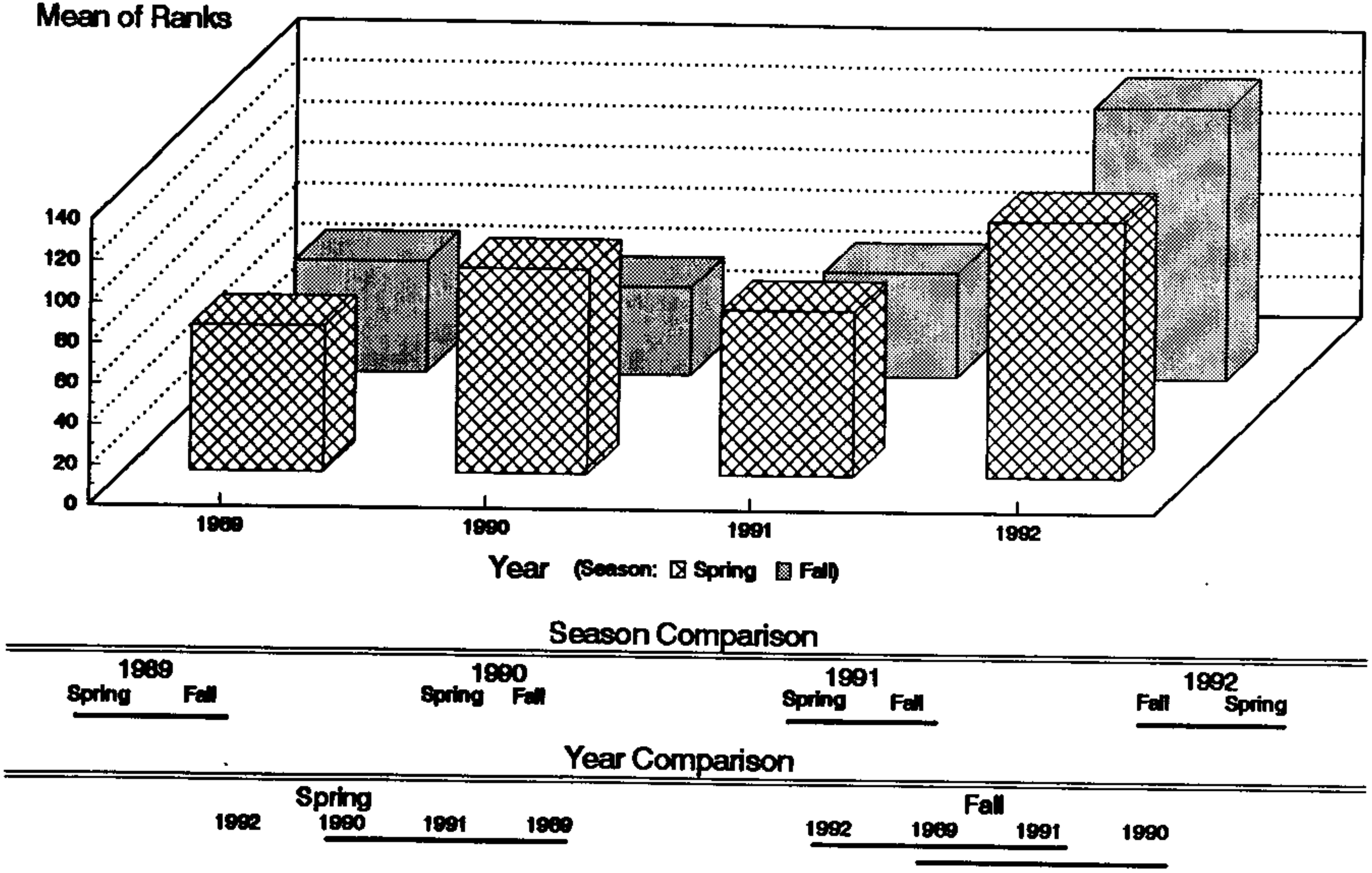
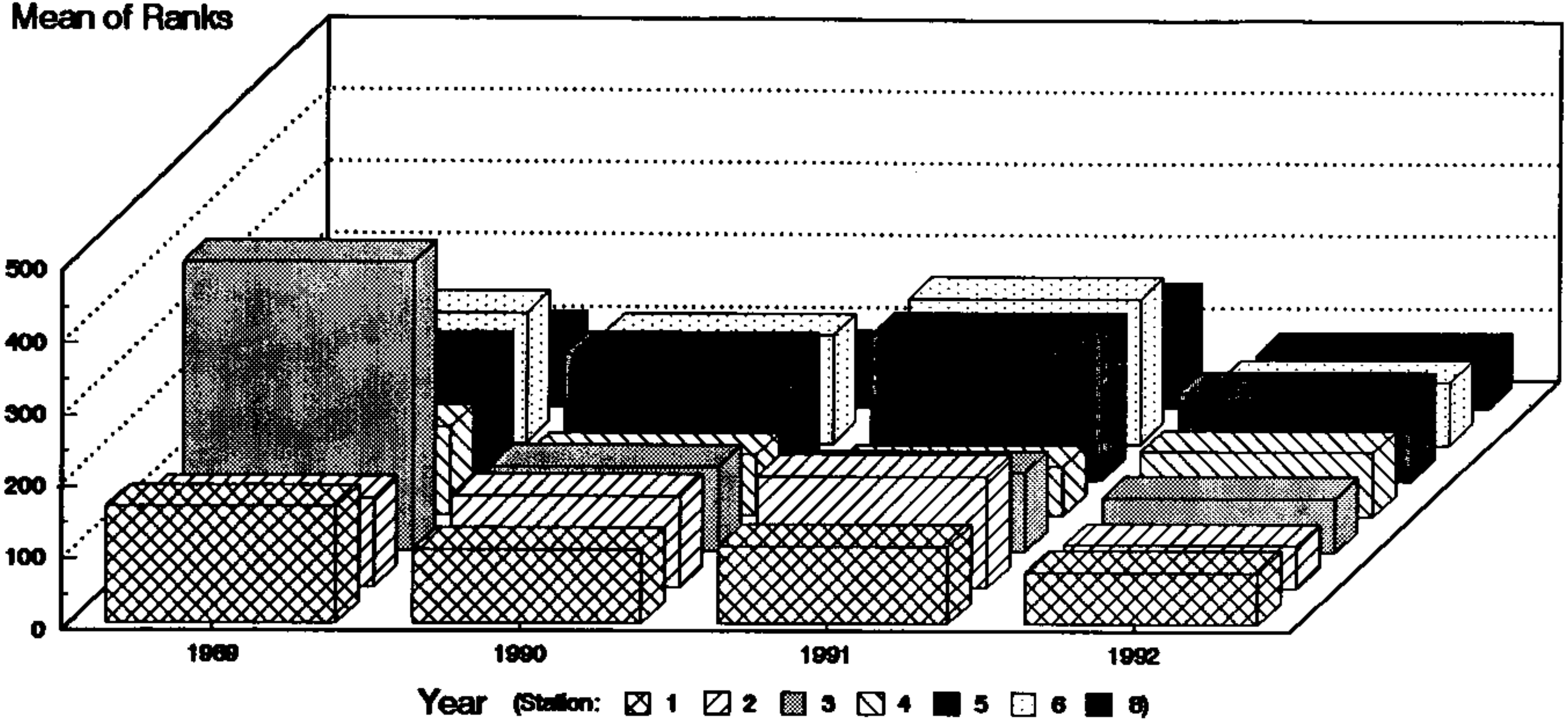


Figure 48. Graphical and statistical comparisons of the mean of ranks for juvenile steelhead abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under seasons and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

5 6 2 1 3 8 4

Year Comparison

1991 1989 1990 1992

Figure 49. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by gill netting during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance ($P > 0.05$).

Differences in catch/effort by gill netting among years 1989-1992 were limited (Figure 49). Highest catch/effort was in 1991 followed by 1989 and 1990. The lowest catch/effort occurred in 1992. Differences in catch/effort between 1989, 1990 and 1991 were significantly higher ($P > 0.05$) than that of 1992.

From 1989 to 1992 we found significant differences ($P < 0.05$) in catch/effort by beach seining for northern squawfish between stations and years, and seasons and years (Figures 50 and 51). Statistical differences in catch/effort for northern squawfish among stations were scattered (Figure 50); catch/effort by beach seining was highest at reference station 10 and lowest at reference station 9. Disposal stations 1 and 2 had significantly ($P < 0.05$) lower catch/efforts than station 10. Catch/effort was highest during 1989 followed by 1991 and was lowest in 1992 (Figure 50). Comparisons between 1989 with 1990 and 1992 were statistically different ($P > 0.05$).

Few seasonal differences in catch/effort by beach seining for northern squawfish were found from 1989 to 1992 (Figure 51). Within these years, seasonal differences were limited and no trends were found. Seasonally, comparisons of catch/effort were generally highest in 1990 in the spring and summer while during fall catches were highest in 1989. Seasonal differences in catch/effort were generally few.

Differences in catch/effort by electrofishing for northern squawfish were found between some reference and disposal stations (Figure 52). The highest catch/effort was found at reference station 3 followed by station 5, disposal station 1 and reference station 10.

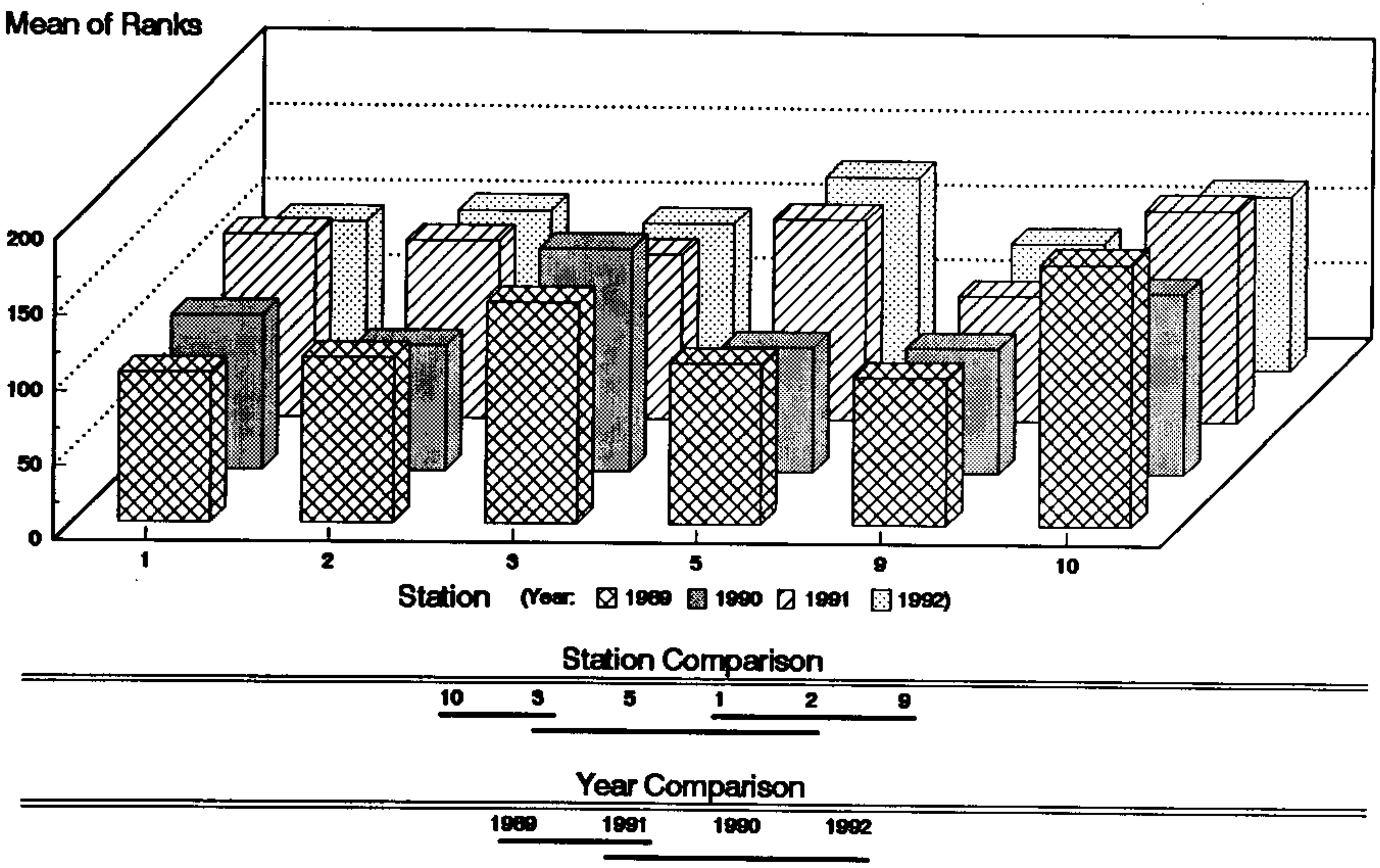


Figure 50. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by beach seining during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance ($P > 0.05$).

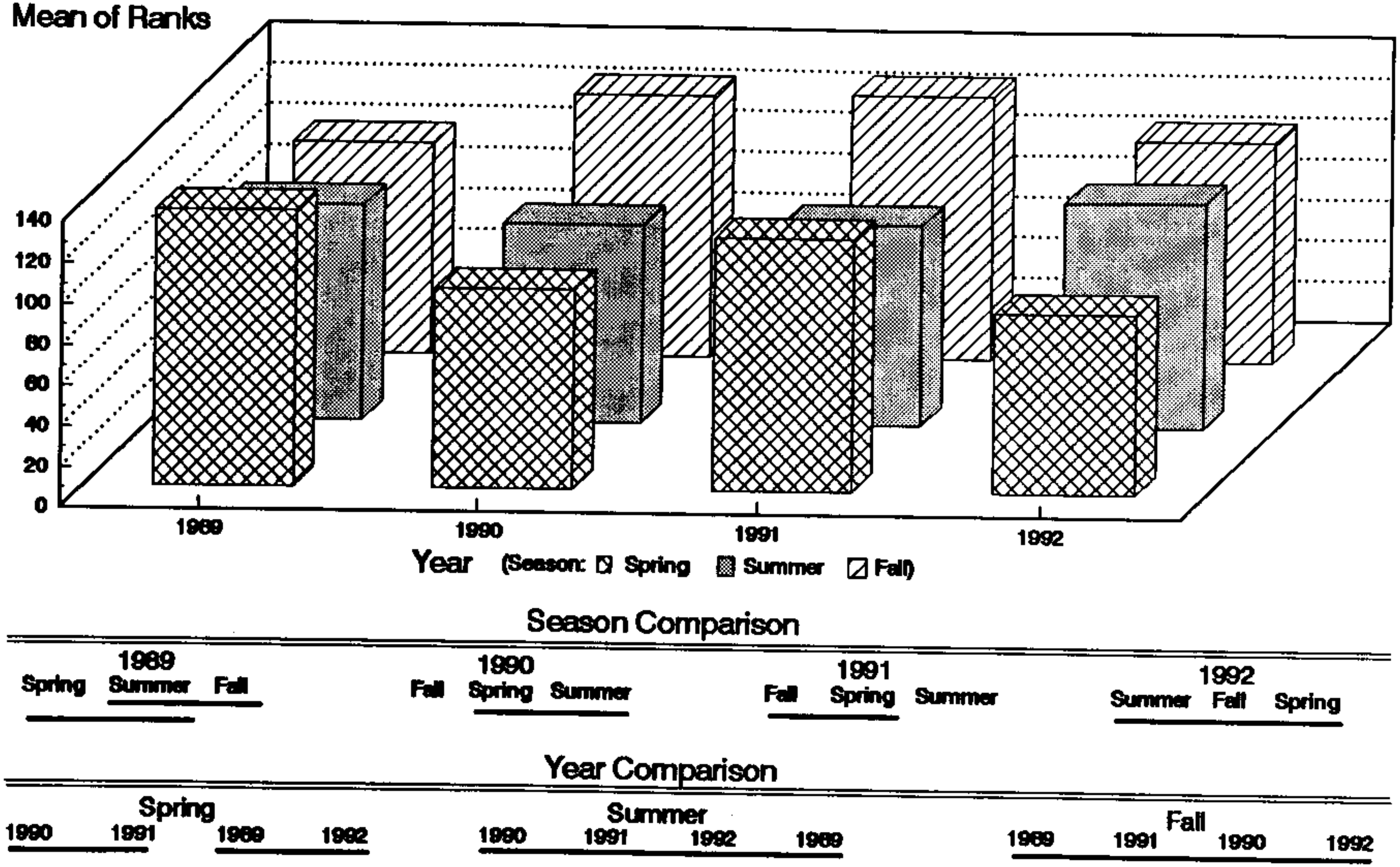


Figure 51. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by beach seining during 1989-1992 in Lower Granite Reservoir. Horizontal lines under seasons and years indicate statistical nonsignificance (P > 0.05).

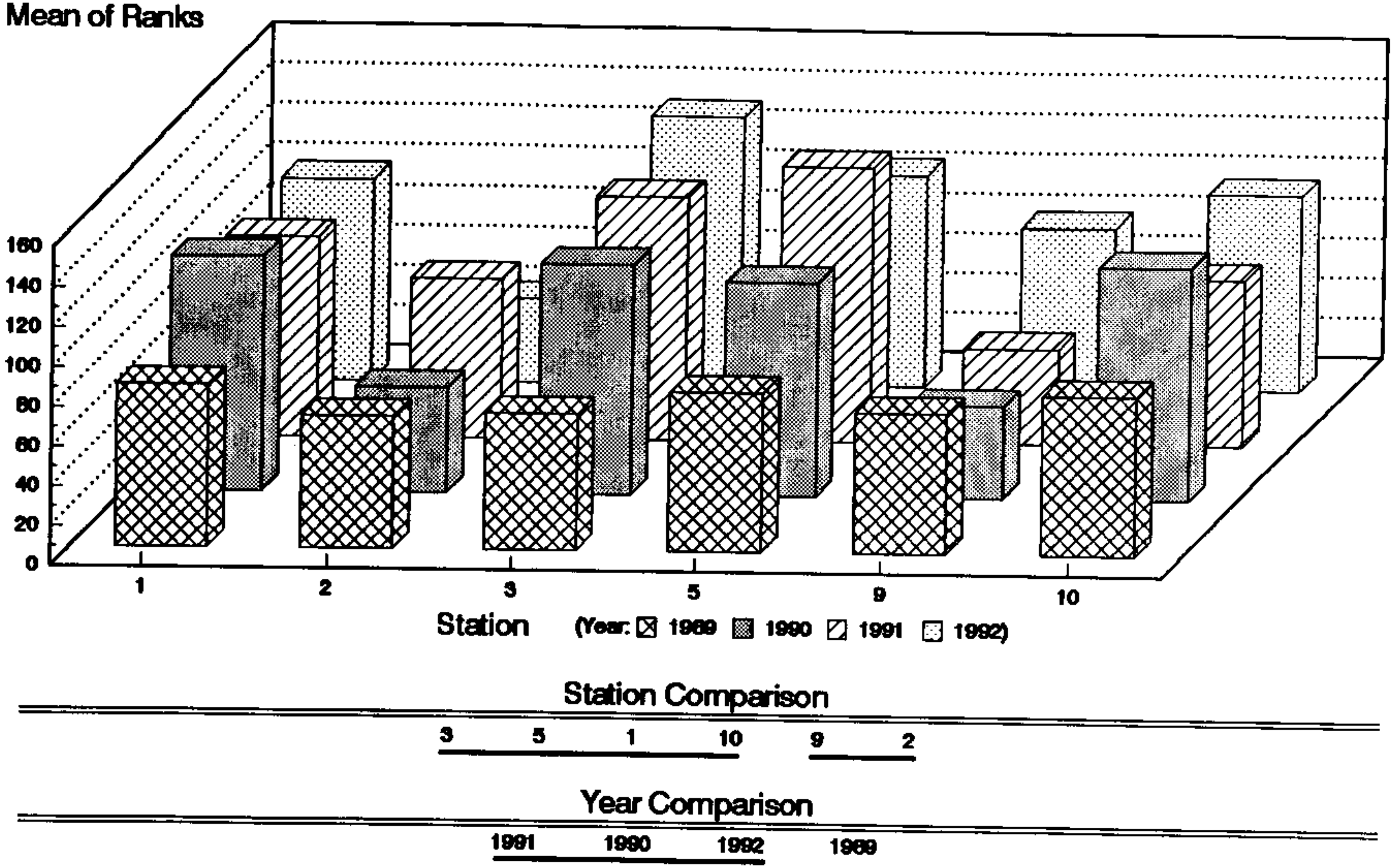


Figure 52. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

Catch/efforts at all of these stations were significantly ($P < 0.05$) higher than those at reference station 9 and disposal station 2.

Annual differences in catch/effort by electrofishing for northern squawfish indicated catch rates were significantly ($P < 0.05$) higher in 1991, 1990 and 1992 compared to 1989 (Figure 52).

Significant ($P < 0.05$) seasonal differences in catch/effort for northern squawfish sampled by electrofishing were only found in 1989 (Figure 53). Within the spring and fall seasons, none of the comparisons of catch/effort were significant among years.

Smallmouth bass.- We found significant interactions between stations and seasons, and years and stations for smallmouth bass sampled by gill netting during 1989 through 1992 (Figures 54 and 55). Comparisons of stations and seasons resulted in the highest catch/effort at shallow reference station 3 followed by shallow reference station 5 and disposal stations 1, 2 and 4 during spring (Figure 54). During fall, catch/effort for smallmouth bass by gill netting was highest at mid-depth reference station 6 followed by disposal station 2; these catch rates were significantly ($P < 0.05$) higher than the lowest at deep reference station 8. Seasonally catch/efforts within each station were highest in spring except mid-depth reference station 6 that had higher catch/effort in the fall, although no differences were significant ($P > 0.05$).

Station differences in catch/effort by gill netting for smallmouth bass within years were scattered (Figure 55). Stations with high catch/efforts were disposal stations 1 and 2 and reference stations 3

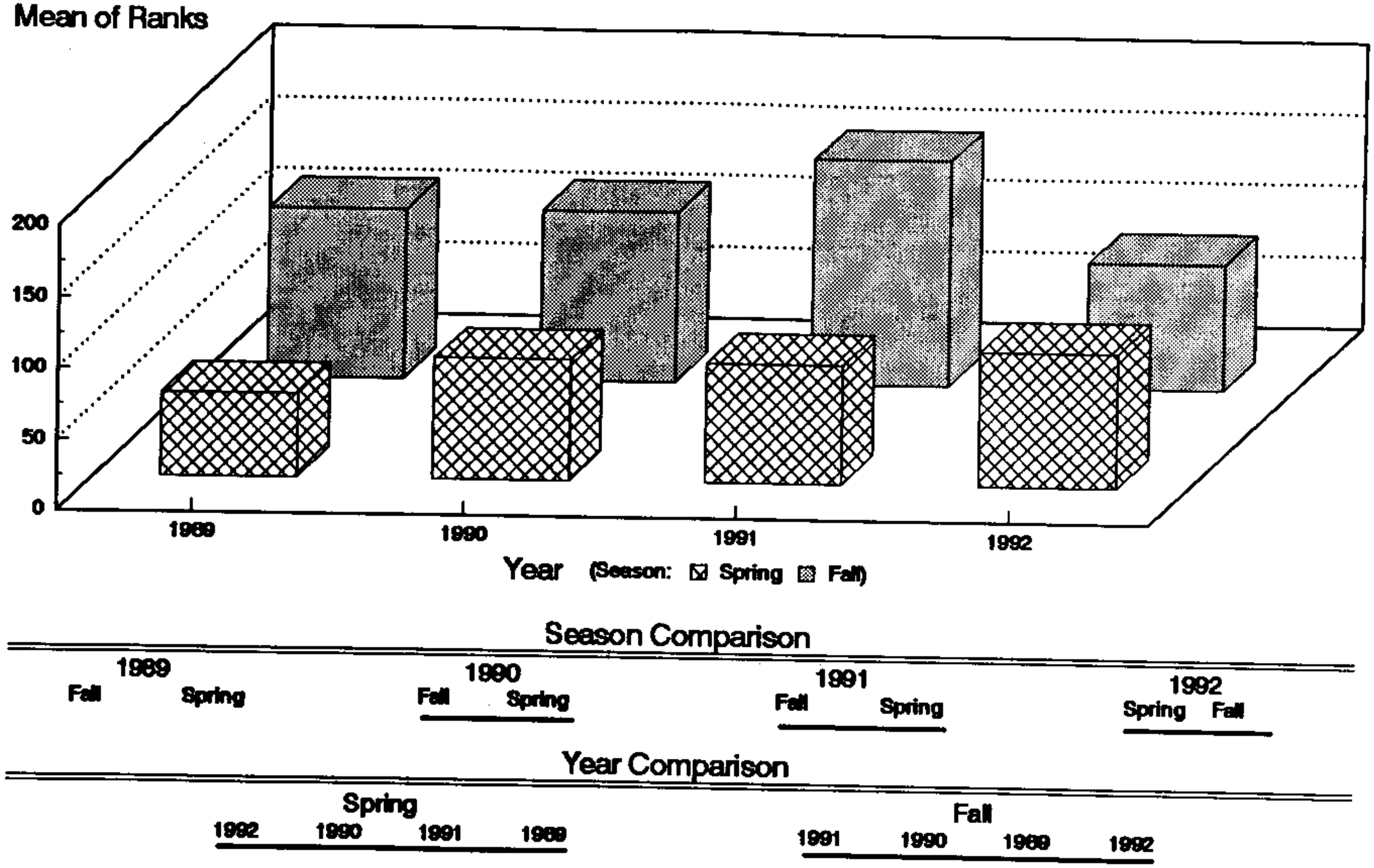


Figure 53. Graphical and statistical comparisons of the mean of ranks for northern squawfish abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under seasons and years indicate statistical nonsignificance (P > 0.05).

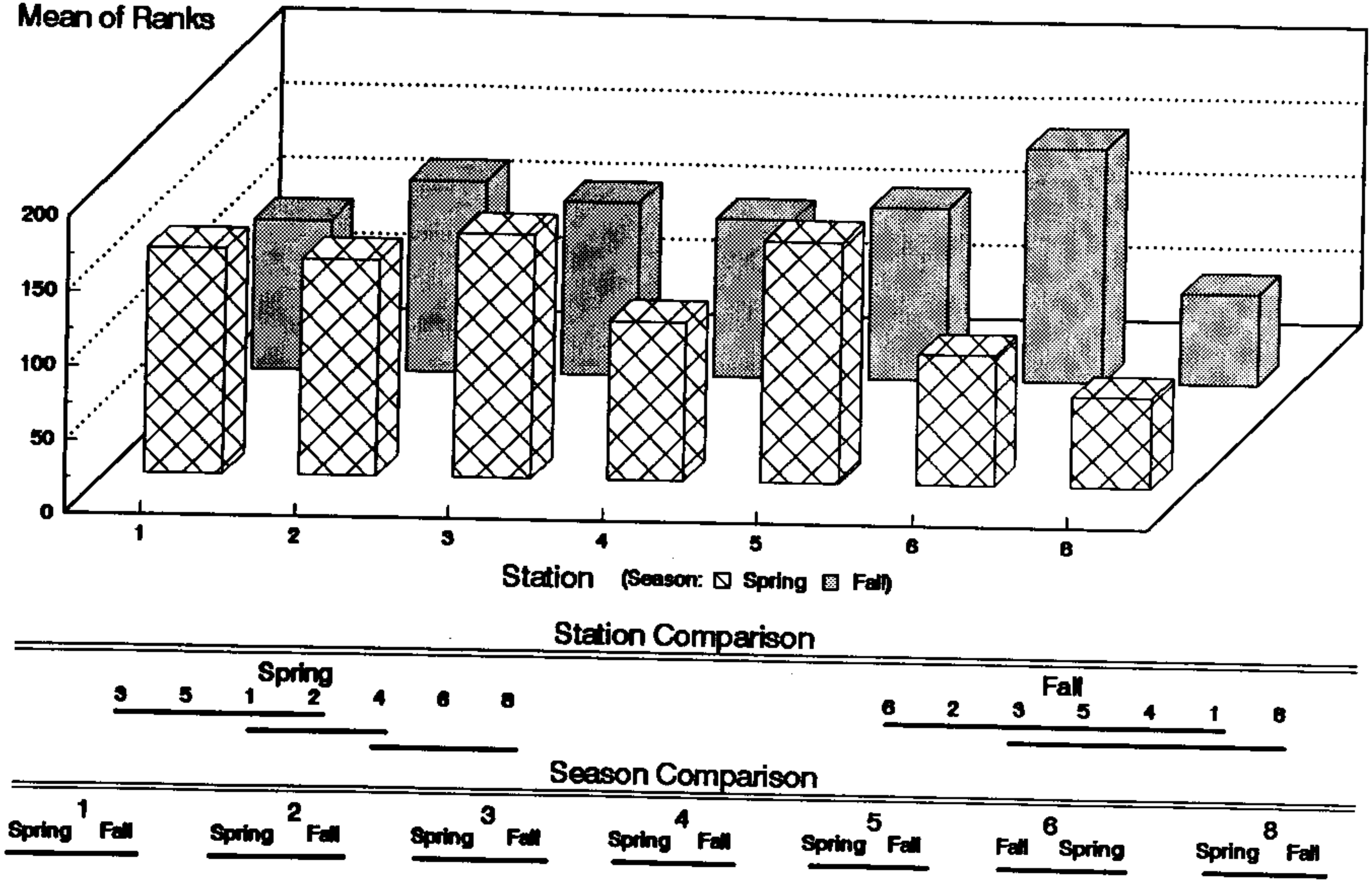


Figure 54. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance ($P > 0.05$).

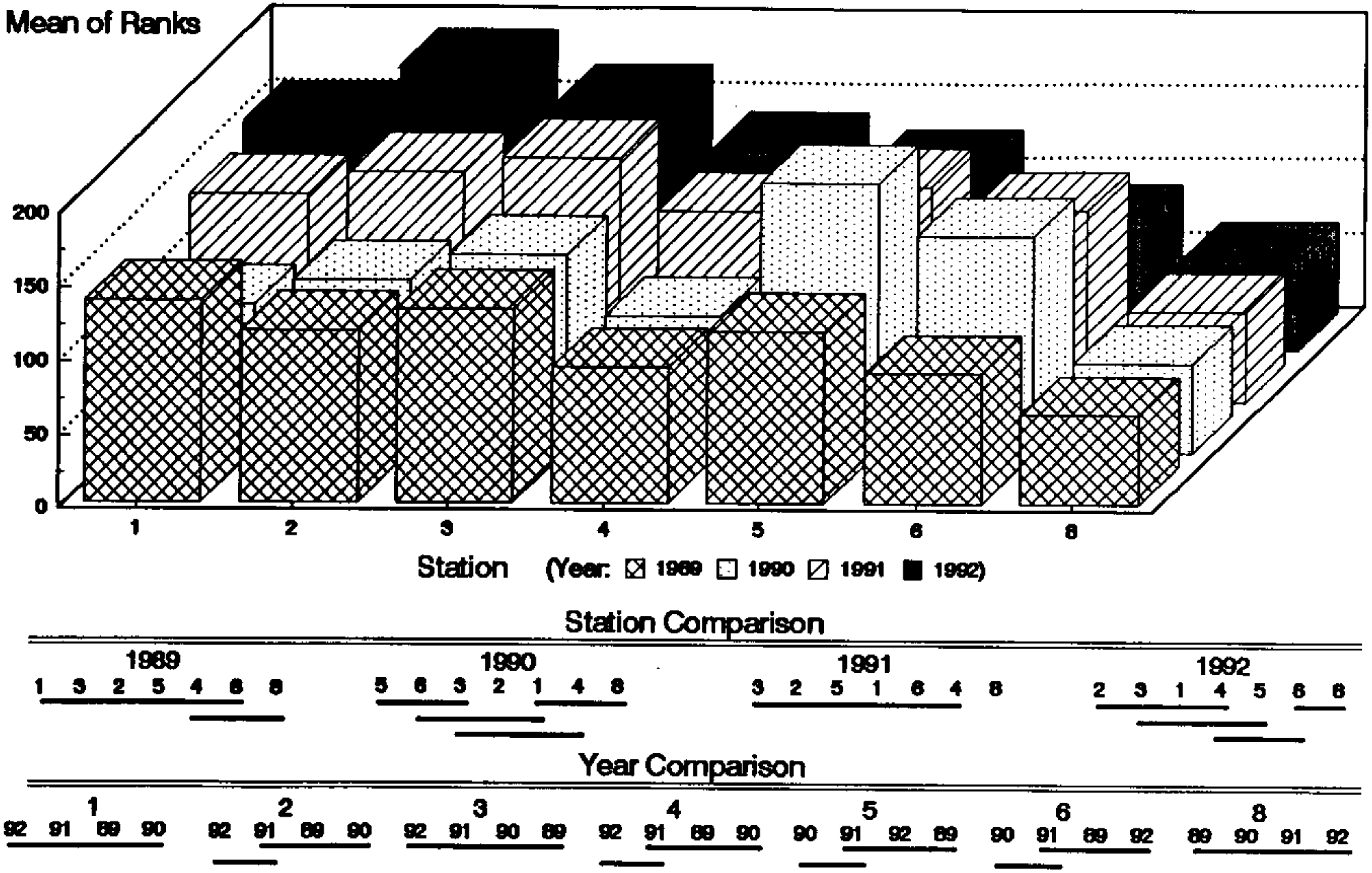


Figure 55. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

and 5. Deep reference station 8 consistently had the lowest catch/effort. Yearly differences in catch/effort within stations indicated that at reference station 3 and disposal stations 1, 2 and 4, the highest catch/effort occurred during 1992, although few of these were significant.

Comparisons of catch/effort for smallmouth bass by beach seining varied significantly ($P < 0.05$) among stations but not years (Figure 56). During the 4 year period from 1989 to 1992, catch/effort for smallmouth bass was highest at reference station 10 followed by station 9 and was lowest at reference station 5. Catch/effort of smallmouth bass was significant between the two highest stations and the two lowest. Catch/effort was highest in 1990 and lowest in 1989, although annual differences were not significant ($P > 0.05$).

During 1989 to 1992, we found significant ($P < 0.05$) interactions of catch/effort by beach seining for smallmouth bass between seasons and years (Figure 57). Highest catch/effort varied within years among seasons. Comparisons of catch/effort for 1992 and 1990 were significantly ($P < 0.05$) different among spring, summer and fall. Comparisons of catch/effort within seasons were generally similar among years as catch/effort in 1992 among seasons was generally lower compared to 1989, 1990 and 1991.

Station differences in catch/effort for smallmouth bass by electrofishing from 1989 through 1992 were varied (Figure 58). During these years, catch/effort by electrofishing was highest at shallow reference station 9 followed by shallow reference station 10.

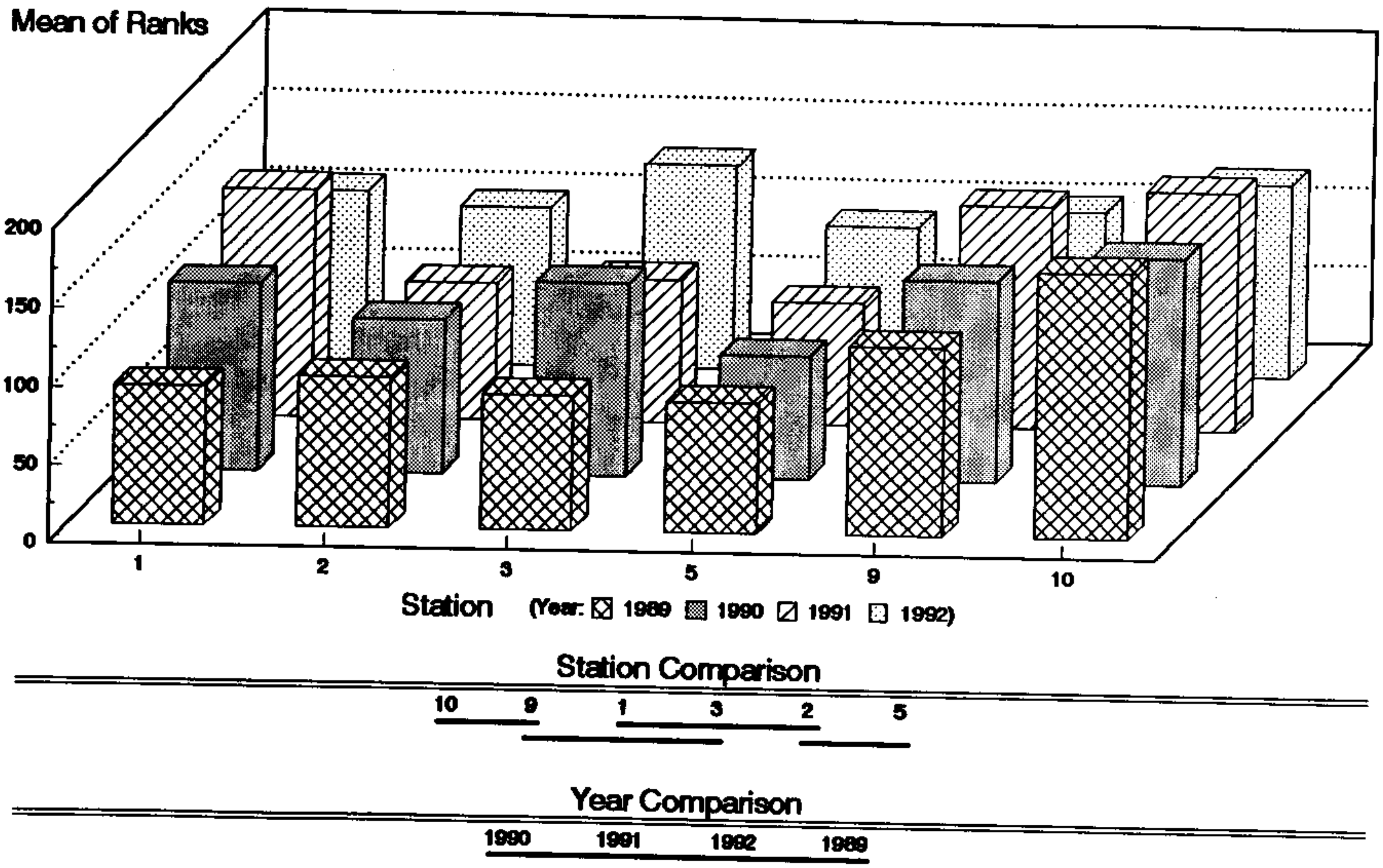


Figure 56. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by beach seining during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

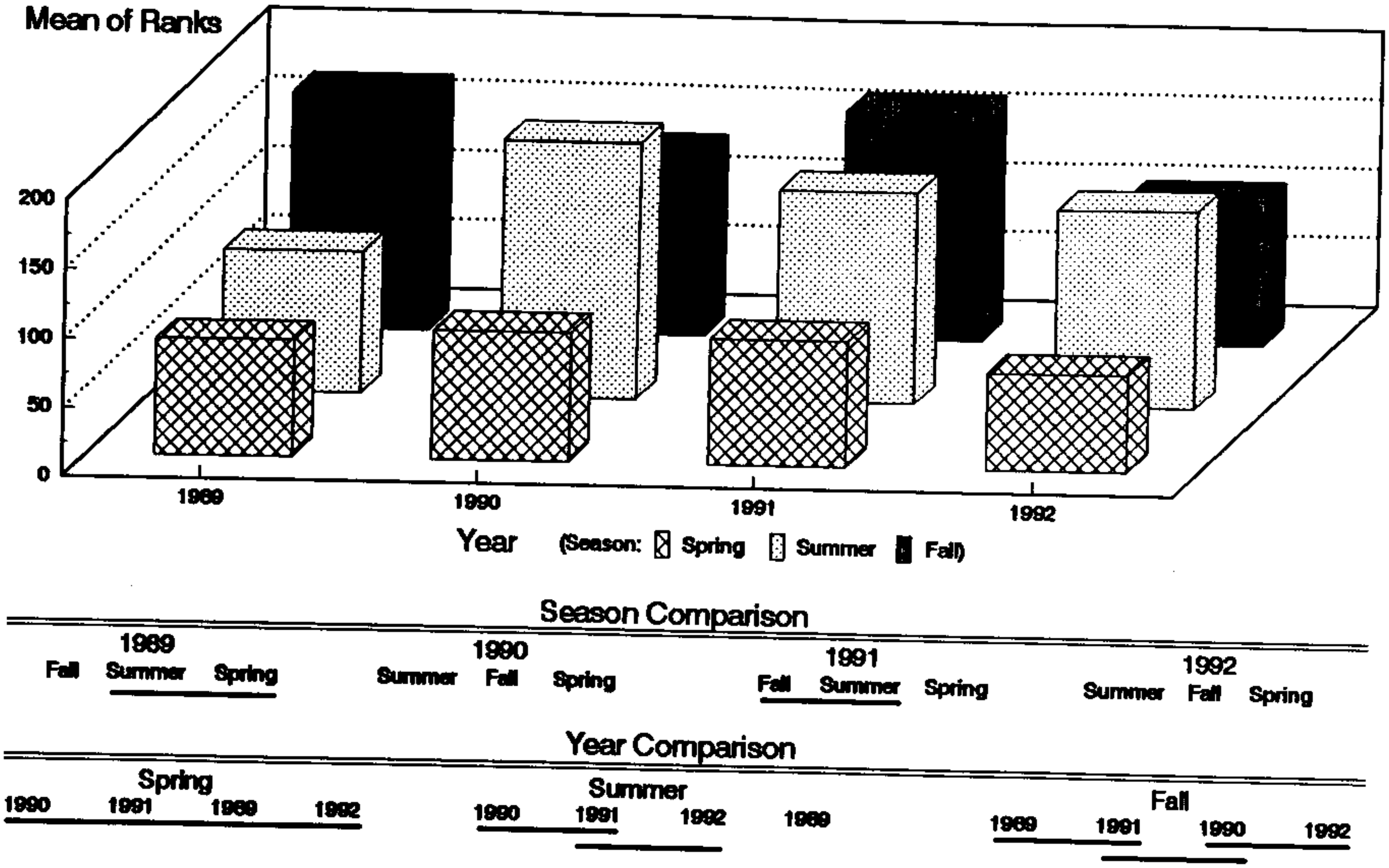


Figure 57. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by beach seining during 1989-1992 in Lower Granite Reservoir. Horizontal lines under seasons and years indicate statistical nonsignificance (P > 0.05).

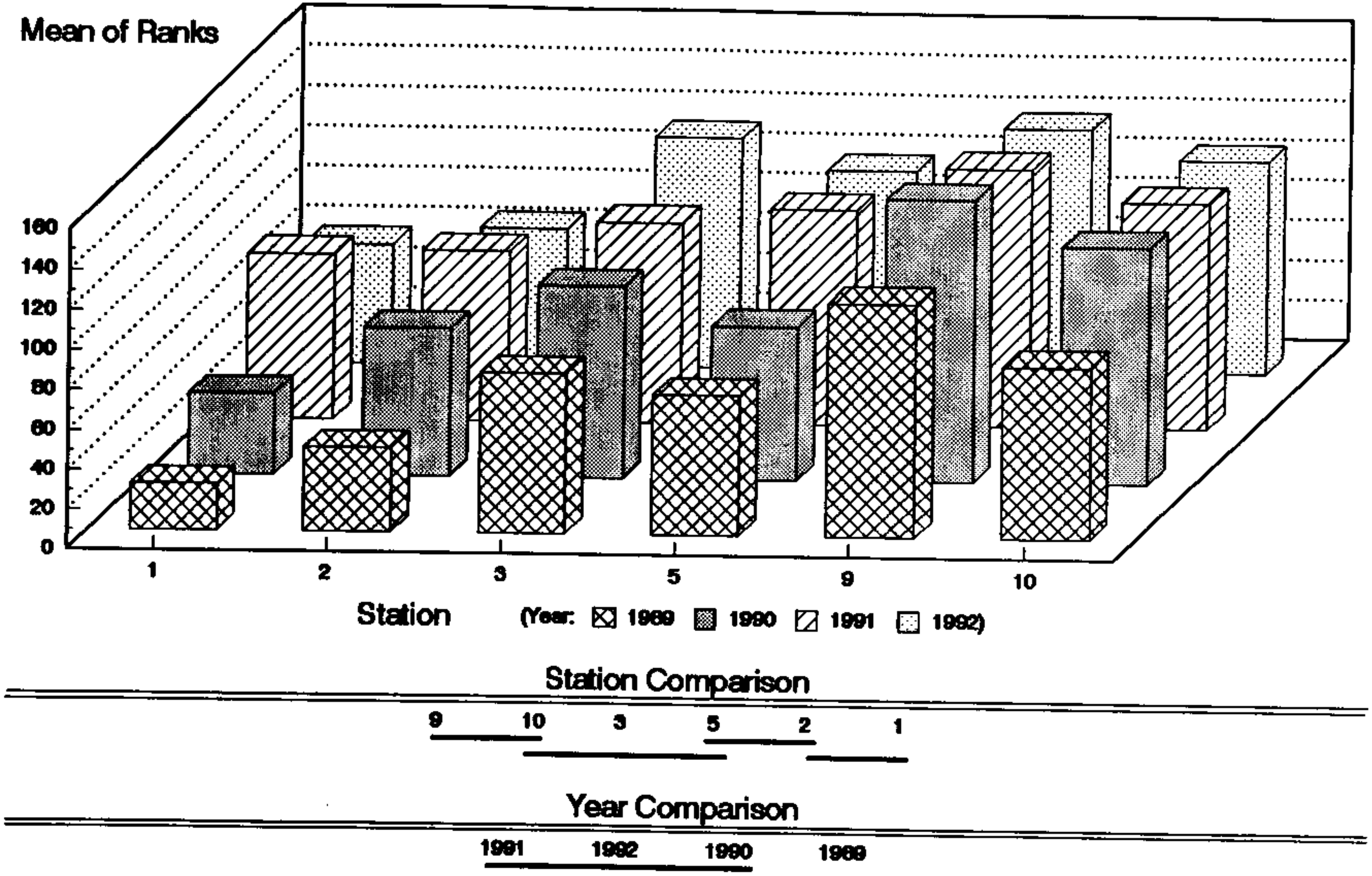


Figure 58. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance ($P > 0.05$).

Catch/effort at disposal station 1 was lowest during 1989-1992 and it was significantly ($P < 0.05$) lower than the reference stations sampled.

Differences in catch/effort by electrofishing for smallmouth bass among years were few (Figure 58). Catch/effort was highest in 1991 followed by 1992 and 1990; these differences were not significant ($P < 0.05$). The lowest catch/effort occurred in 1989 and was significantly lower than the other years.

Interactions between catch/effort by electrofishing for smallmouth bass within stations and seasons, and seasons and years were varied (Figures 59 and 60). Within seasons, catch/effort was highest at disposal station 1 followed by station 2 for both spring and fall, although significance was limited to differences from the highest to the lowest in both seasons (Figure 59). At all stations except disposal station 1, seasonal comparisons of catch/effort were highest in the spring, although only at station 3 were these comparisons significant ($P < 0.05$; Figure 59).

Catch/effort for smallmouth bass by electrofishing was generally similar among seasons during 1989 through 1992 (Figure 60). For 1989-1991, catches during spring were highest, although the differences were not significant ($P > 0.05$). However, fall catch/effort during 1992 was significantly ($P < 0.05$) higher than spring.

Catch/effort within years was variable (Figure 60). During spring, catch/effort was significantly higher in 1989 than 1990, 1991 and 1992. During fall, the only annual significant ($P < 0.05$) difference in catch/effort was between the highest in 1992 and the

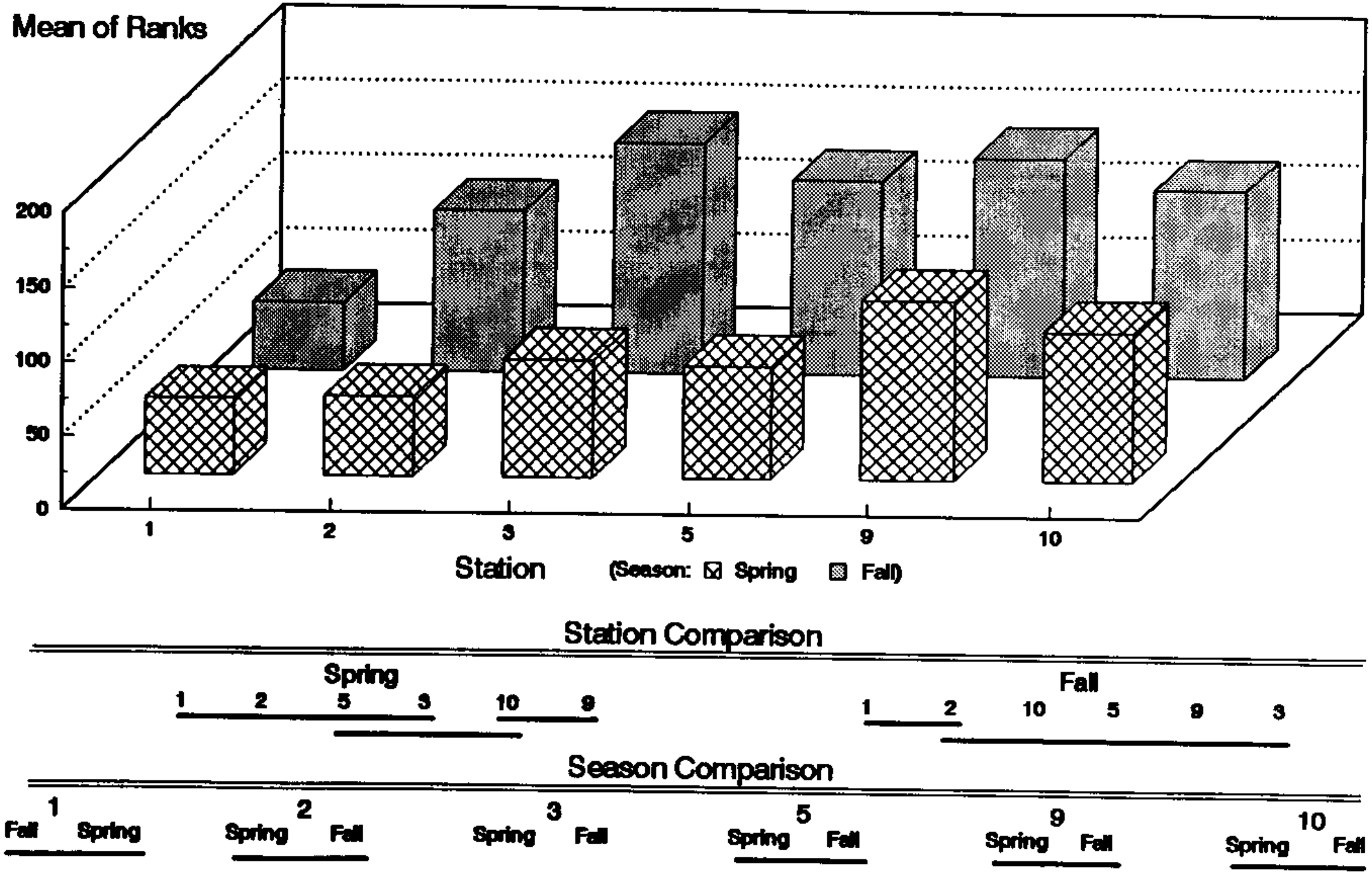


Figure 59. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).

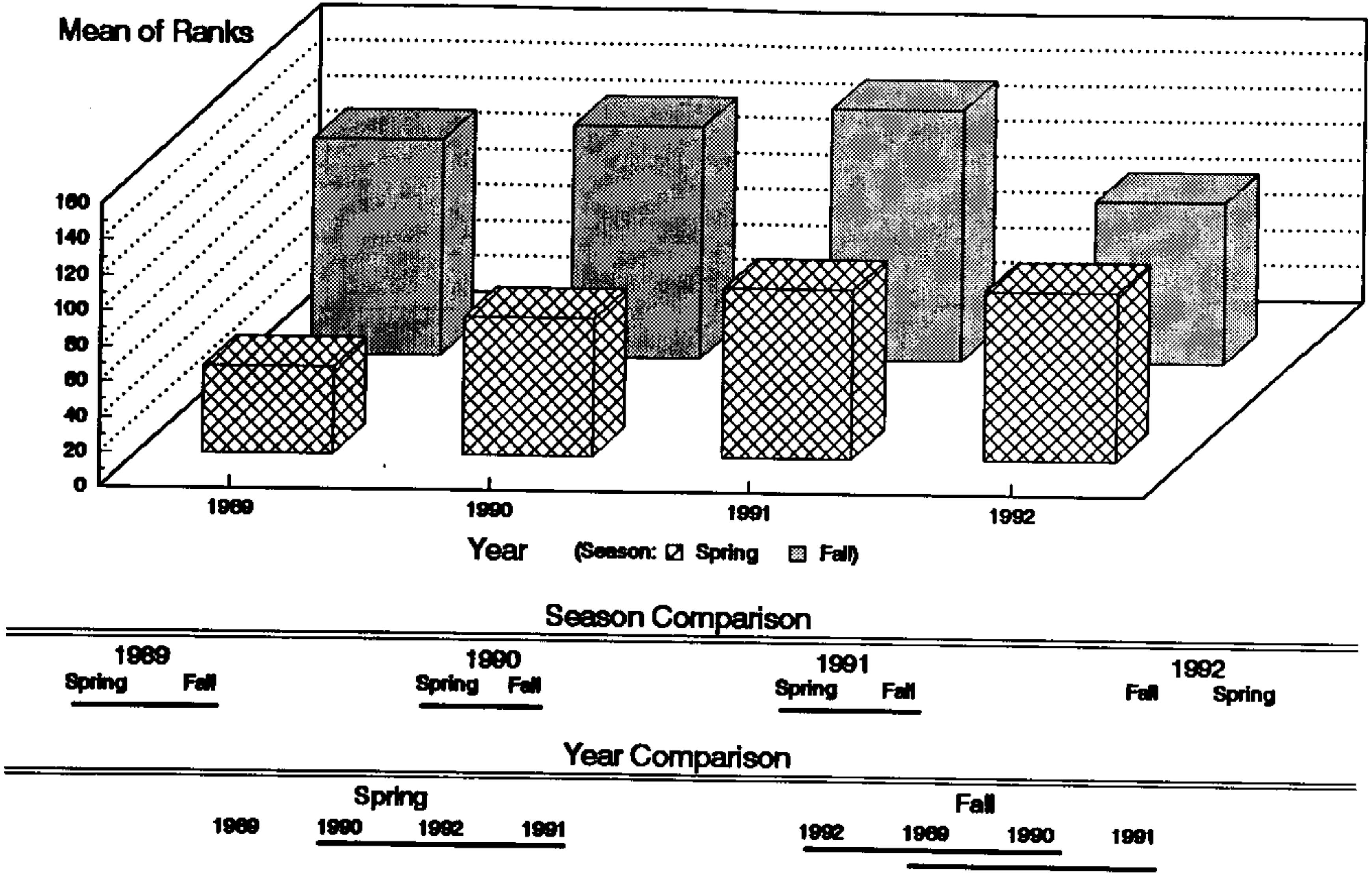


Figure 60. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by electrofishing during 1989-1992 in Lower Granite Reservoir. Horizontal lines under seasons and years indicate statistical nonsignificance (P > 0.05).

lowest in 1991. Catch/effort of smallmouth bass was lowest in 1991 during both spring and fall.

Channel catfish.- Several significant differences in catch/effort for channel catfish by gill netting were found among stations (Figure 61). Comparisons of catch/efforts during 1989 through 1992 were highest at reference station 8 followed by reference stations 5 and 6. Disposal station 2 had the lowest catch/effort.

Yearly comparisons of catch/effort for channel catfish by gill netting were highest in 1992 and lowest in 1991; these differences were significant ($P < 0.05$; Figure 61). Other yearly differences in catch/effort were not significant ($P > 0.05$).

A significant interaction between seasons and stations was found for channel catfish by gill netting during 1989 through 1992 (Figure 62). Catch/effort within spring was highest at deep reference station 8 followed by station 6 while it was lowest at disposal station 2. During fall, the highest catch/effort was at station 8 and lowest at reference station 3; these differences were significant ($P < 0.05$) while others were not. Catch/effort at disposal stations 1, 4 and 2 was intermediate to the other reference stations during fall. No seasonal differences among stations were statistically significant ($P > 0.05$).

White sturgeon.- Catch/effort for white sturgeon by gill netting among stations was variable among years 1989-1992 (Figure 63). Differences in catch/effort among stations were largely highest during 1989 to 1991 at deep reference station 8 and shallow reference station 5. During 1989, 1990 and 1991, catch/effort at station 8 was

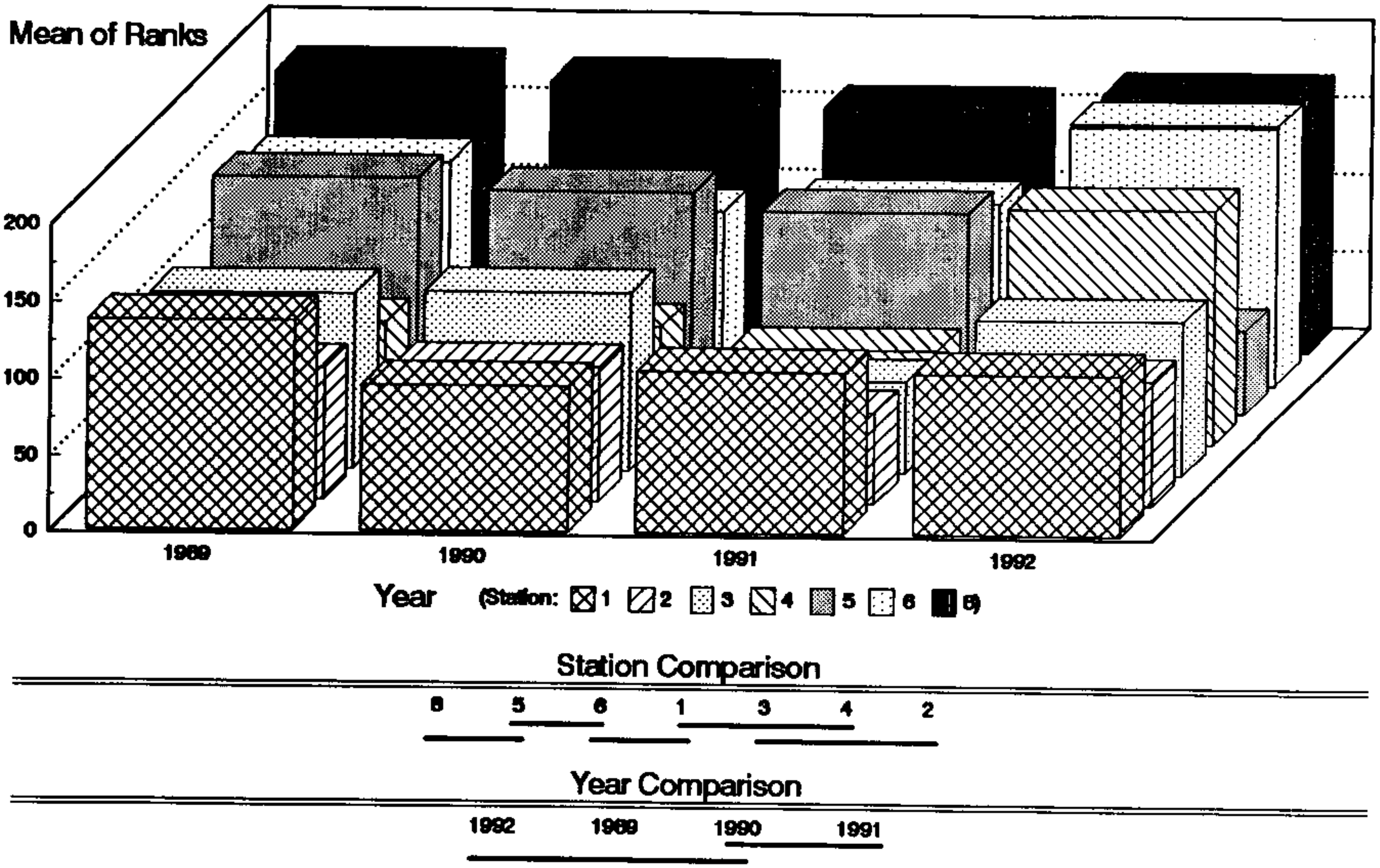


Figure 61. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

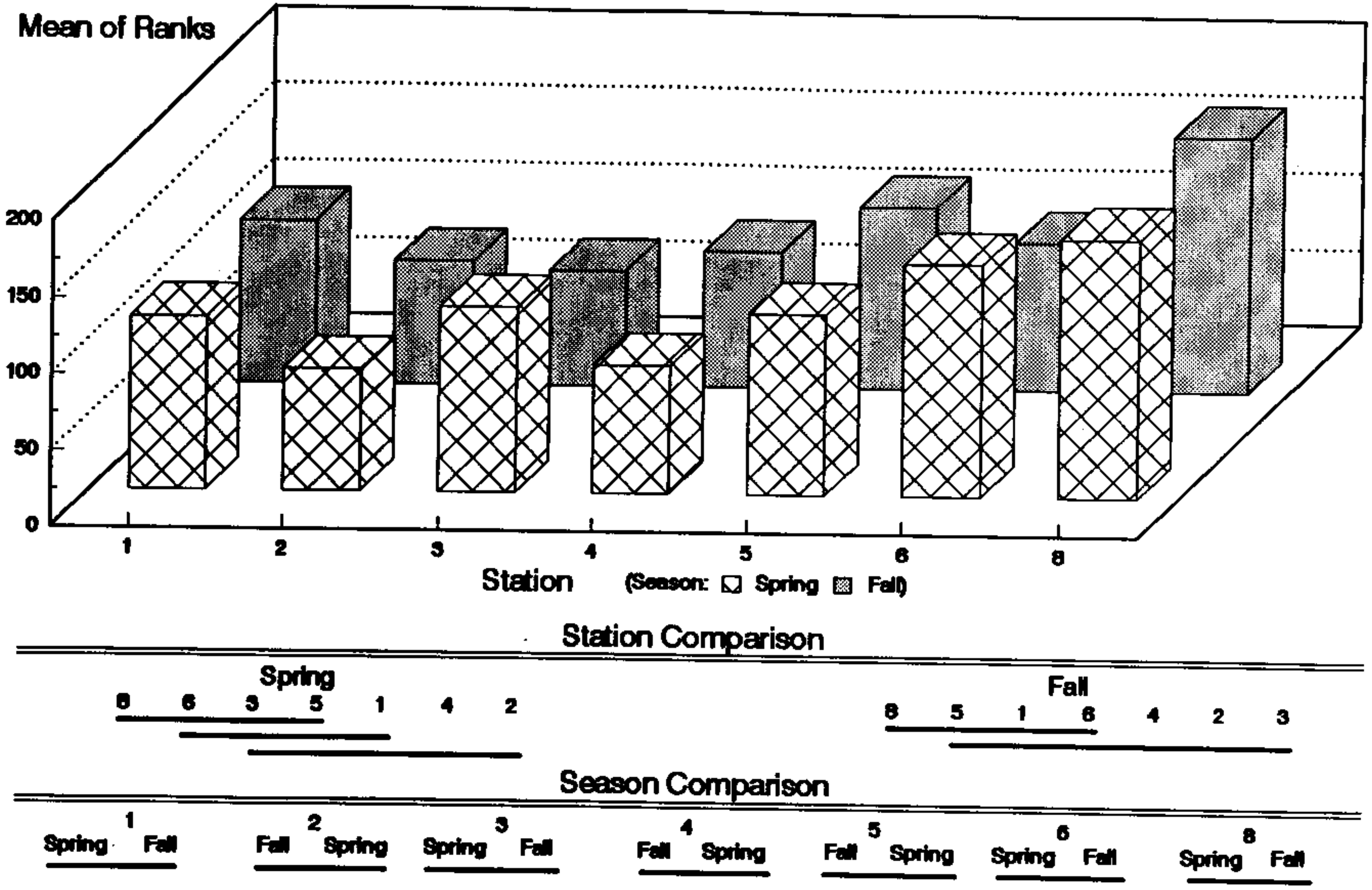


Figure 62. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by gill netting during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).

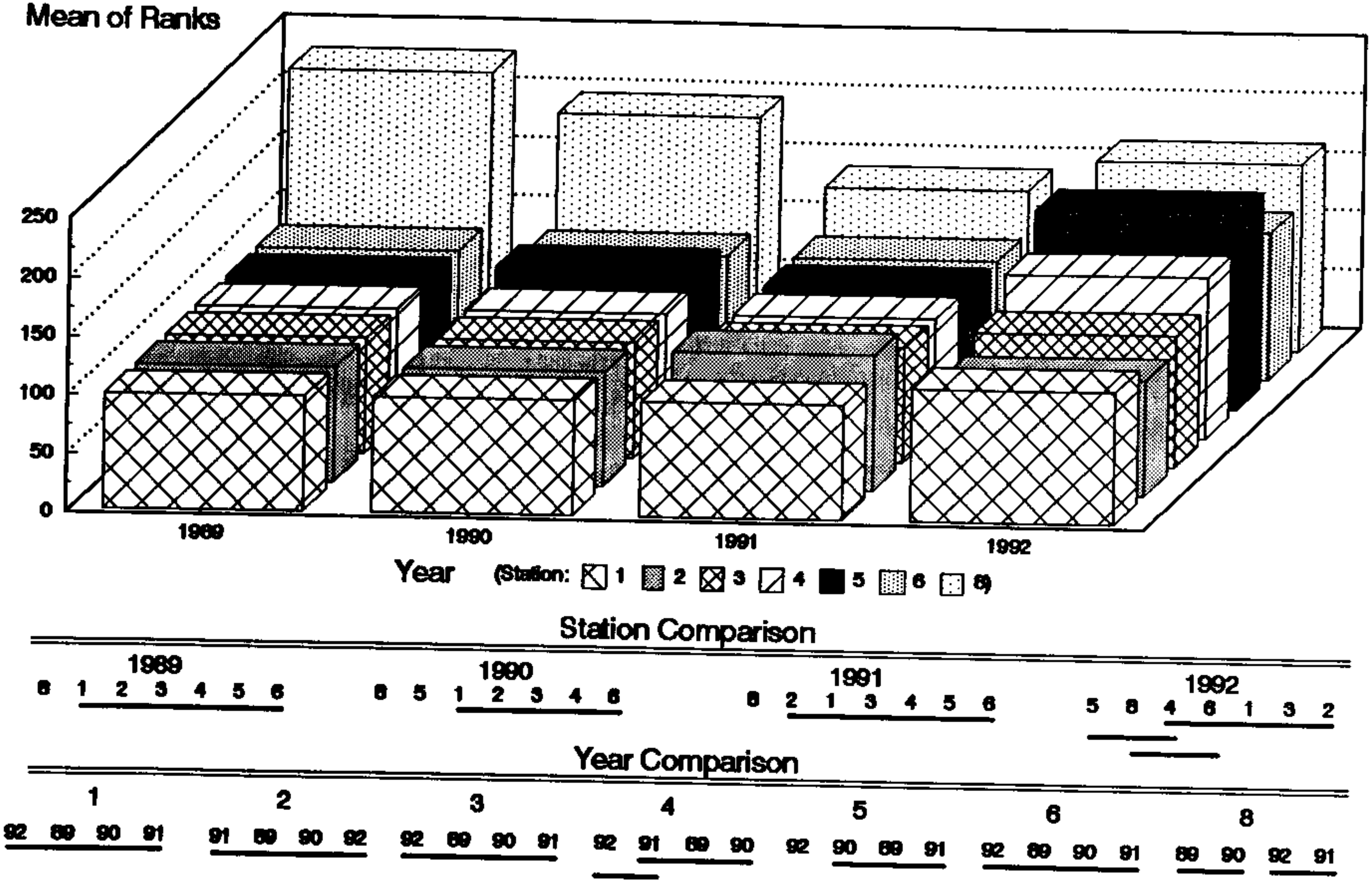


Figure 63. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance (P > 0.05).

significantly ($P < 0.05$) higher than other stations. Catch/effort for white sturgeon was highest during 1992 at shallow reference station 5 followed by deep reference station 8.

Yearly comparisons of catch/effort within stations for white sturgeon by gill netting were varied and significance was limited to stations 4, 5 and 8 (Figure 63). Differences in catch/effort at station 5 during 1992 were significantly ($P < 0.05$) higher than those for 1989 through 1991. Our comparisons suggest no major changes have occurred in white sturgeon abundance since 1989.

Larval Fishes

A total of 8,688 larval fishes was collected by paired, half-meter plankton nets and a hand-drawn beam trawl during 1992 in Lower Granite Reservoir, Idaho-Washington (Table 5; Appendix Tables 1 and 2). Fourteen species and five genera representing seven families were collected. Ninety-two percent (n=8,025) of the total number of larval fishes sampled were collected by handbeam trawl and the remaining 8% (663) were collected by plankton nets. Centrarchids generally dominated handbeam trawl and plankton net catches during June, August and September, however in July catch rates were highest for cyprinids (Figure 64). Six families were represented during August. Relative abundance of catostomids, percids, clupeids, cottids and ictalurids in the larval samples was low for all months.

The abundance of larval predators sampled by handbeam trawl and plankton nets varied spatially and temporally (Figures 65-68). Larval

Table 5. Larval fish collected by paired plankton nets and a handbeam trawl during 1992 in Lower Granite Reservoir.

Species	Month				Total
	June	July	August	September	
American shad		13	2		15
Chiselmouth		52			52
Carp		2			2
Peamouth	1	160			161
Northern squawfish		1,242	6		1,248
Redside shiner	1	12			13
Cyprinid spp.	81	1,903	5		1,989
Largescale sucker		1			1
Catostomid spp.	38	22	4		64
Channel catfish			1		1
Pumpkinseed			1		1
Bluegill		1	140		141
Lepomis spp.		27	277	282	586
Black crappie		8	17		25
White crappie		196	15		211
Pomoxis spp.		11	375	24	410
Smallmouth bass	356	138	4		498
Centrarchid spp.	172	1,659	1,271	141	3,243
Yellow perch			17		17
Cottus spp.	1	1			2
Unknown spp.	1	5	1	1	8
Total	651	5,453	2,136	448	8,688

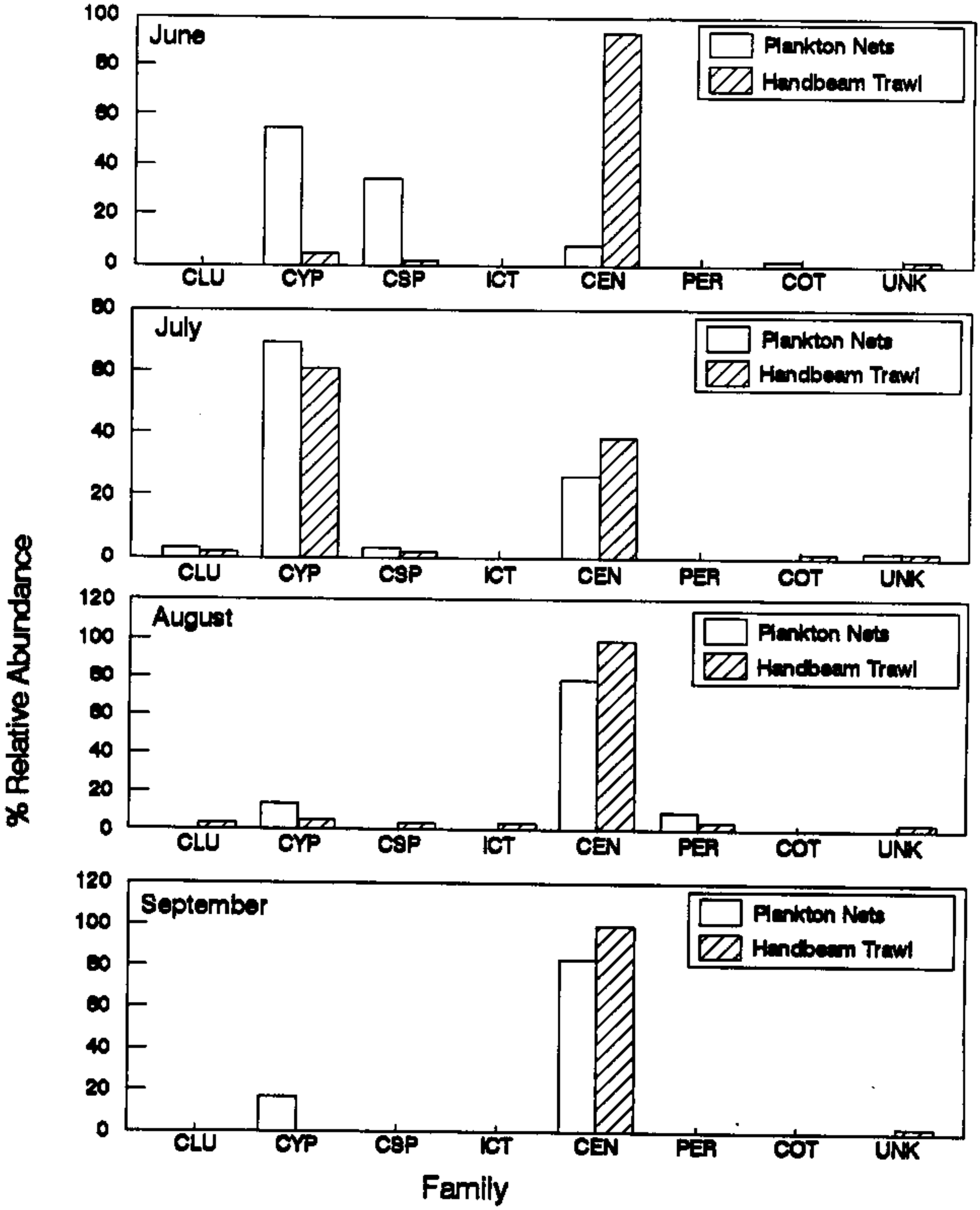


Figure 64. Larval abundance sampled by half-meter plankton nets and handbeam trawl during 1992 in Lower Granite Reservoir. Family abbreviations include: CEN-Centrarchid, CLU-Clupeidae; COT-Cottidae; CSP-Catostomid; CYP-Cyprinid; ICT-Ictalurid; PER-Percid; UNK-unknown.

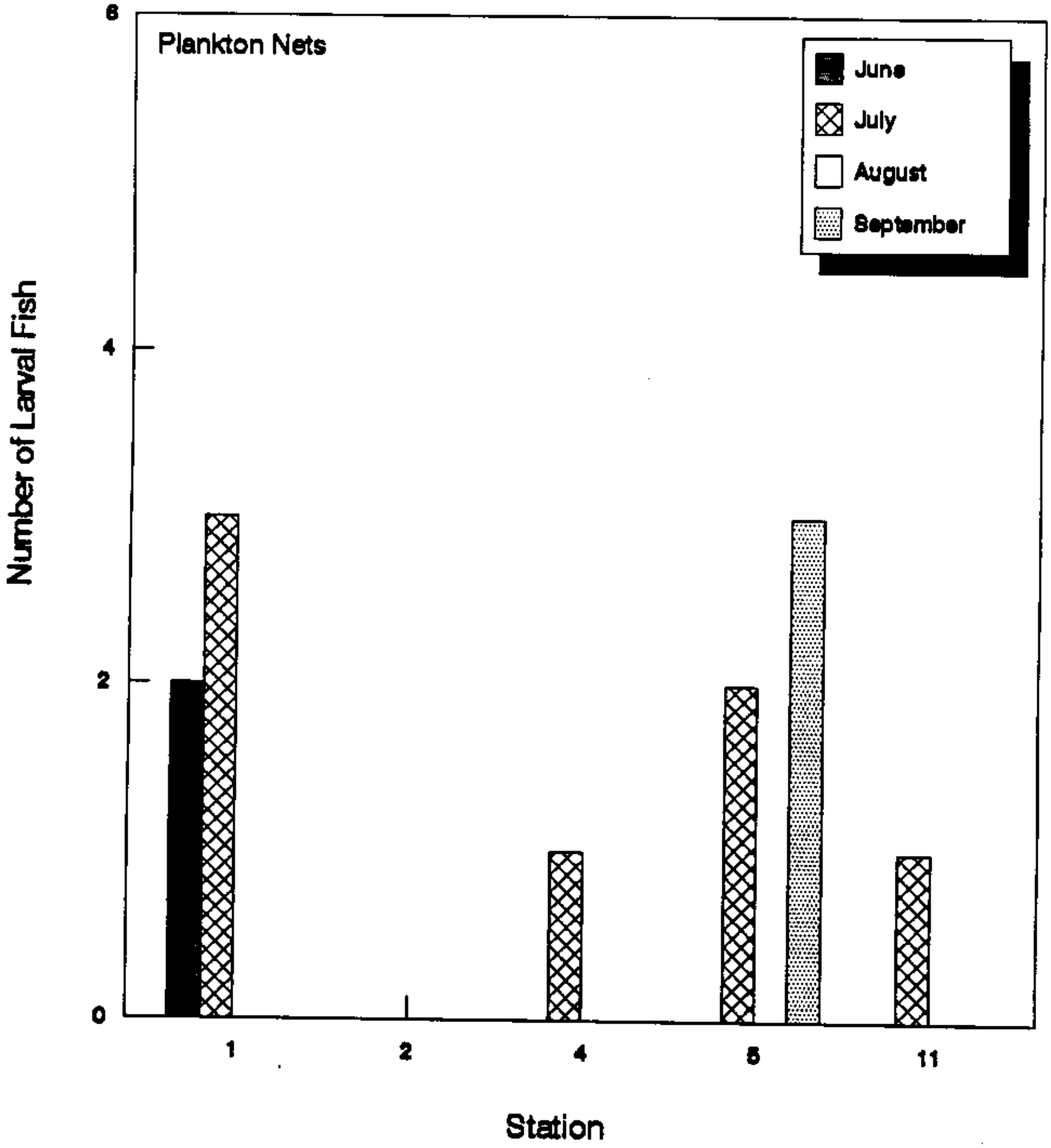


Figure 65. Larval smallmouth bass abundance sampled by half-meter plankton nets during 1992 in Lower Granite Reservoir.

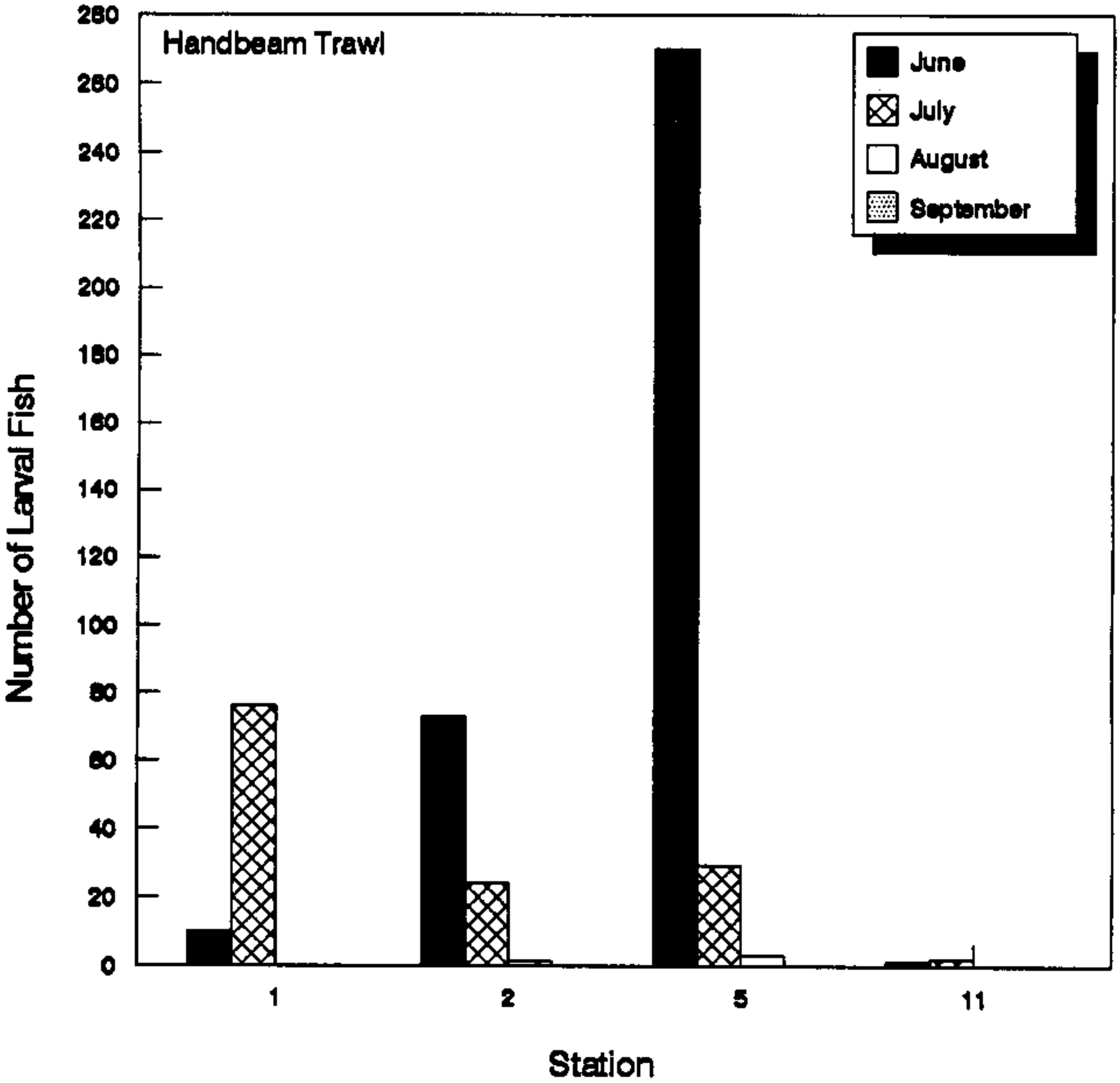


Figure 66. Larval smallmouth bass abundance sampled by a hand-drawn beam trawl during 1992 in Lower Granite Reservoir.

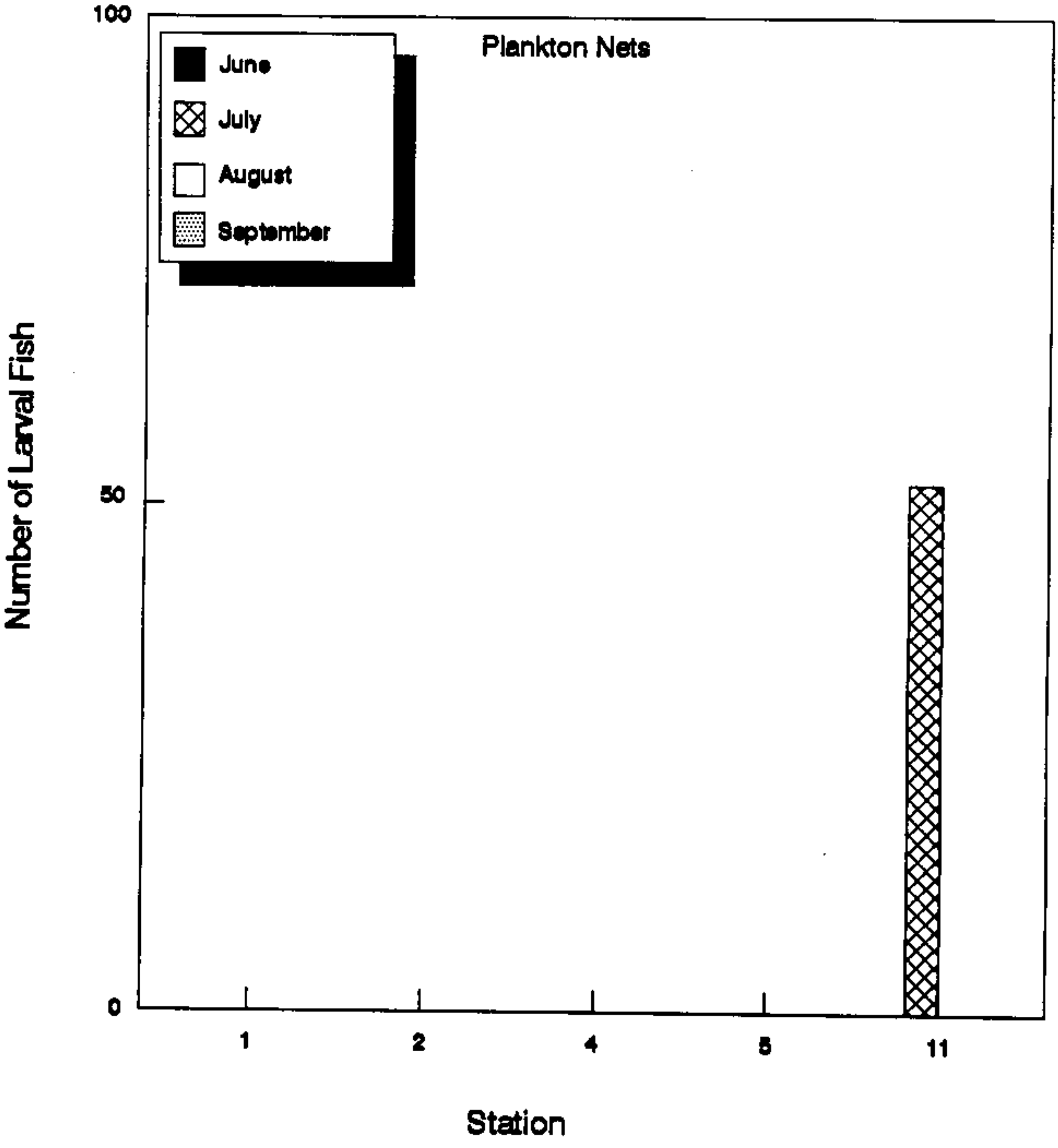


Figure 67. Larval northern squawfish abundance sampled by half-meter plankton nets during 1992 in Lower Granite Reservoir.

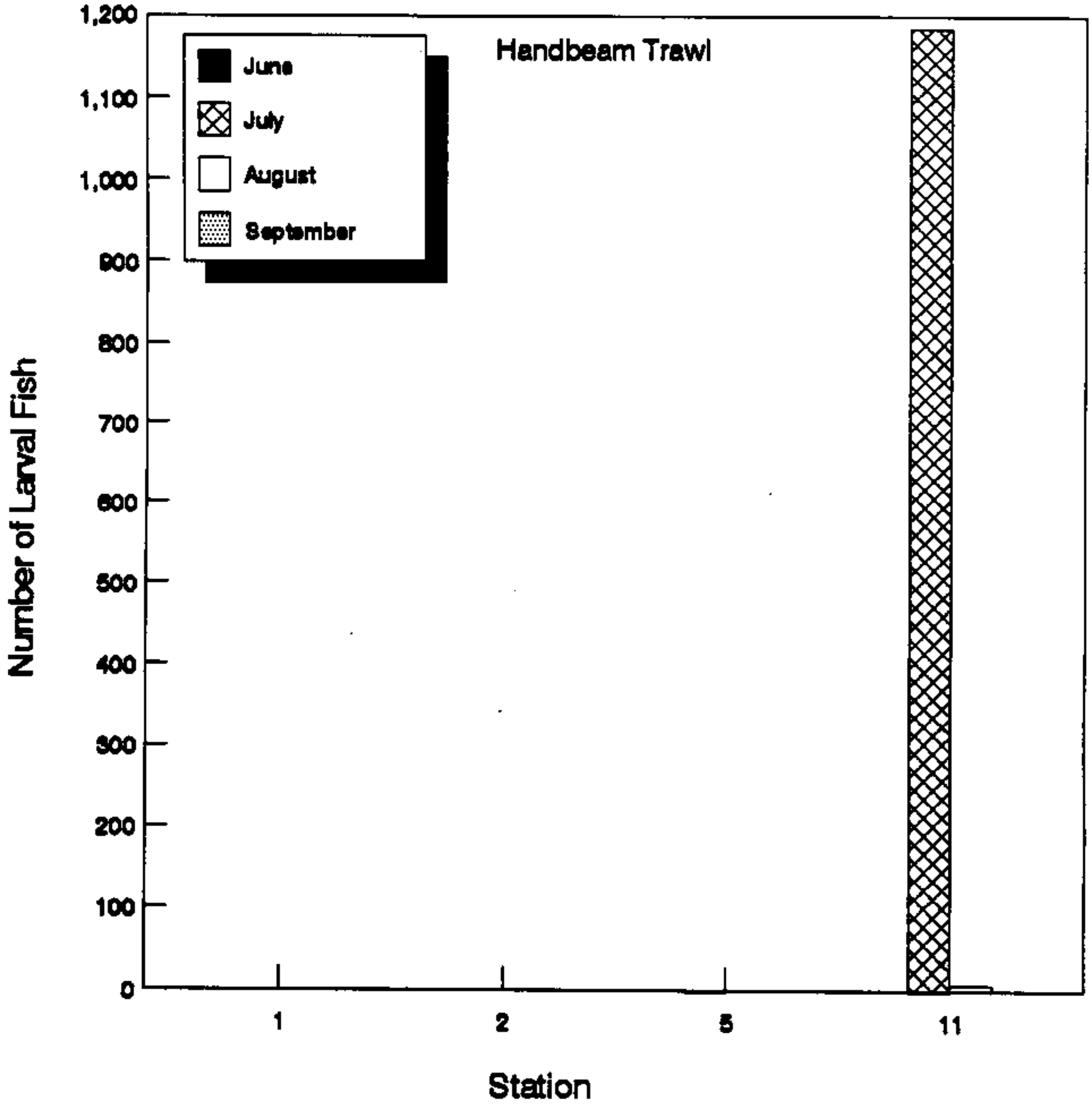


Figure 68. Larval northern squawfish abundance sampled by a hand-drawn beam trawl during 1992 in Lower Granite Reservoir.

smallmouth bass were collected at all stations during June and July by handbeam trawl (Figure 66). The highest total number of smallmouth bass collected by handbeam trawl occurred during June at shallow reference station 5. No larval smallmouth bass were collected during August and few were collected in September.

Catches of larval smallmouth bass sampled by paired plankton nets were low (Figure 65). During July the highest number of larval smallmouth bass were collected (n=3) at shallow disposal station 1, while the highest catches during September (n=3) were made at shallow reference station 5. No larval smallmouth bass were collected by plankton nets at disposal station 2.

Larval northern squawfish were collected in high abundance by handbeam trawl at shallow reference station 11 (Figure 68). Few larval squawfish were sampled at reference station 5. The highest number of larval squawfish was caught in the shallowest water. Expanded mean density estimates exceeded 30,000-40,000/10^4 m^3 of water (Appendix Tables 1 and 2). Larval squawfish were sampled at station 11 during July and August and the highest number was clearly collected in July.

Larval northern squawfish were sampled by paired plankton nets only at shallow reference station 11 during July (Figure 67). No larval squawfish were collected in the pelagic regions of shallow (1 and 2) and mid-depth disposal (4) stations or shallow reference station 5.

DISCUSSION

Differences in catch/effort of juvenile anadromous fishes were few among stations. Catch/effort of juvenile chinook salmon for all gear types did not differ among stations in 1992. A number of statistical differences was found in catch/effort for juvenile steelhead along the shoreline but not pelagically in 1992. Based on catch/effort, juvenile steelhead abundance was highest along the shoreline in the lower reservoir at reference stations 10 and 9 both at night (Figure 35) and during the daytime (Figure 34). Juvenile steelhead abundance based on catch/effort was generally lowest at disposal station 1.

Overall catch/effort of juvenile chinook salmon along the shoreline by beach seining was significantly ($P < 0.05$) lower in 1992 than in other years (Figure 44) which may relate to travel time and duration of habitation in Lower Granite Reservoir. Comparisons among years of catch/effort for juvenile steelhead indicated in-reservoir abundance since 1989 was highest in 1992.

Seasonal comparisons of catch/effort within years indicated the overall abundance of juvenile steelhead in Lower Granite Reservoir. Spring comparisons indicated juvenile steelhead abundance was highest in 1992 since 1989 (Figure 48). Low flows during the steelhead smolt migration, as in 1992, result in high abundance and high catch/effort that can continue into the fall. During years of high catch/effort throughout the summer and fall, juvenile steelhead residualization is high.

One change imposed on the reservoir fish community is the Sport Reward Program for Northern Squawfish. This program has removed a large number of squawfish, although the majority has been removed upstream of the sampling stations, but has also probably increased incidental harvest of sport fishes like crappies, channel catfish and smallmouth bass. However, Smith (unpublished data, Washington Department of Fish and Wildlife, Pullman) found that the incidental harvest of sport fishes has not increased as a result of the Sport Reward Program.

In 1992, few station differences in catch/effort for smallmouth bass were found (Figures 40 and 41). Catch/effort by beach seining, a technique that samples primarily ages 0-1 smallmouth bass, indicated similar abundance among shallow reference and disposal stations. Electrofishing, a technique that catches both juvenile and larger smallmouths (Arthaud 1992), indicated that few station differences in abundance were found; in general, reference stations during 1992 generally had higher abundance of smallmouth bass (Figure 41).

Gill netting results indicated that larger smallmouth bass were collected in shallow water in the spring and deeper water in the fall (Figure 39). Station differences in abundance based on catch/effort using gill nets indicated smallmouth abundance at disposal stations was generally as high as that at reference station 3.

Based on comparison of catch/effort, overall changes in abundance of smallmouth bass have not occurred since 1989. Abundance of age-0 to age-1 smallmouth bass based on beach seining has been highest in the lower reservoir at reference stations 10 and 9, and it has not differed among 1989-1992 (Figure 56). Abundance of older smallmouths, based on comparisons of catch/effort by electrofishing and gill netting, has been similar to those of younger fish (Figures 58 and 55). During the years of 1989-1992, a number of seasonal differences in abundance was found within stations. Smallmouth bass are widely distributed in Lower Granite Reservoir and generally have changed little in abundance at the various sampling stations during this 4 year period.

Comparisons of catch/effort of northern squawfish among gear types in 1992 indicated high abundance occurred in Lower Granite Reservoir at reference stations 3 and 5 (Figures 36-38), although few differences were statistically significant. During 1992, no seasonal differences in catch/effort were found.

During the years from 1989-1992 a number of factors has affected the overall abundance of northern squawfish in Lower Granite Reservoir. Two significant factors are the test drawdown in spring 1992 and the second year of the Sport Reward Program. Analysis of the catch by gear types indicates that juvenile squawfish abundance has generally decreased; although few statistical differences among years have been found (Figures 49, 50 and 52). Abundance of younger squawfish has been the highest at reference station 10 and lower at disposal stations 1 and 2. During years 1989-1992, Centennial island was not a highly favorable habitat for ages 0-1 northern squawfish. Nighttime electrofishing, a technique that collects the smaller to medium sized squawfish, has generally supported this interpretation of squawfish abundance (Figures 52 and 53). Gill netting results indicate that since 1989, the population of larger squawfish has generally declined and abundance in 1992 was significantly lower than in the previous 3 years (Figure 49). Differences in abundance of larger squawfish were found within stations among the years of 1989-1992 as significantly higher catch/effort was found at reference stations 5 and 6, while those at disposal and other reference stations were lower. The habitation of the larger squawfish at disposal station 4, the underwater plateau, is the lowest of all stations based on results of gill netting. Our results indicate the disposal of dredged material has not increased the suitable habitat of squawfish in Lower Granite Reservoir.

During 1992, higher catch/effort of channel catfish occurred at reference stations 5, 6 and 8 (Figure 42). Catch/effort by gill netting for channel catfish was low at deep disposal station 7 and shallow and mid-depth disposal stations 1 and 4. Since 1989, catch/effort was highest in 1992 although only statistically different from that in 1991 (Figure 61). Highest overall catch/effort from 1989-1992 has consistently been at deep reference station 8.

White sturgeon abundance has fluctuated little among stations since 1989 based on differences in catch/effort (Figure 63). Only in 1992 was the catch/effort not highest at reference station 8. In 1992 the highest catch/effort of sturgeon was at disposal station 7 followed by shallow and deep reference stations 5 and 8 (Figure 43). Based on sampling results from 1992, white sturgeon were inhabiting the deep disposal site at station 7.

Larval fish abundance in 1992 showed a substantial increase from 1989 and 1990. Shallow reference station 11, at Port of Wilma, in 1992 had the highest abundance of larval northern squawfish by several orders of magnitude (Figures 67 and 68). The majority of larval squawfish was collected in July and few were collected in August (Table 5). Larval centrarchid fishes dominated the catches from June through August in Lower Granite Reservoir. Early larval catches were smallmouth bass, followed by crappies and bluegill/pumpkinseed. We have observed major changes in abundance of larval predator fishes since 1989 that probably have been related to the reservoir operating regimen (Bennett et al. 1994a). In 1991 and 1992, water levels have generally been maintained at minimum operating pool within 0.305 m (1 ft) operating range. Increases in abundance of primarily larval northern squawfish in Lower Granite Reservoir seem to be more closely related to the operating regimens than the experimental disposal of dredged materials. Larval fish abundance at disposal stations has been consistently low in comparison to that at reference station 11.

Objective 2. To assess 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, August and October (Objective 1). 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 5.08 cm (1.5, 1.75 and 2.0 inches; Webb et al. 1987). Gill nets were set for 3-4 nights on the bottom for a total of approximately 6 hours and checked at 1-3 hour intervals to preclude destructive sampling to all fishes, especially salmonids. All fish captured were measured to total length and released alive immediately after processing.

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. Resolution of our mapping procedure is difficult to state explicitly; the depth measurements were accurate within 0.3 m (1 ft), although the source of potential error lies in the ability to follow designed transects. The "horizontal" resolution and resulting maps concur with our working knowledge of this site and provide a description of site morphometry. Shoreline morphometry and reservoir width was obtained from the National Oceanic and Atmospheric Administration (NOAA) Nautical Chart 18548 (Washington - Idaho Snake River, Lower Granite Reservoir). We measured depth profiles while traveling at a constant speed along transects between known points. Six to 12 transects were run parallel and perpendicular to the newly created disposal site.

Shorelines were redrawn to scale from the NOAA nautical chart and depths recorded at points along each transect where an appreciable change in depth occurred. Lines representing 3 m (10 ft) contour intervals were drawn by hand and then digitized for final plotting.

RESULTS

Habitat created by disposal of dredged material in late winter 1992 resembled an underwater island (Figure 69). Dredged material was positioned adjacent to a steep shoreline (about 20% grade) that decreased in depth about 24 m in 120 m (80 ft in 400 ft). Depths at the site were reduced from the post-reservoir river channel at approximately 24-30 m (80-100 ft) to as shallow as 15 m (50 ft) at the top of the disposed material. The area where the bulk of the disposal occurred was about 240 m x 135 m (800 ft x 450 ft).

Catch/efforts for northern squawfish, smallmouth bass, channel catfish and white sturgeon by gill netting were similar between deep reference station 8 and deep disposal station 7 in 1992 (Figures 70-73). No significant ($P > 0.05$) differences in catch/effort were found at these two stations during the spring and fall seasons. Catch/efforts were higher at deep reference station 8 for northern squawfish and channel catfish than those at deep disposal station 7, although these differences were not significant (Figures 70 and 72). Catch/efforts for white sturgeon and smallmouth bass were higher at disposal station 7

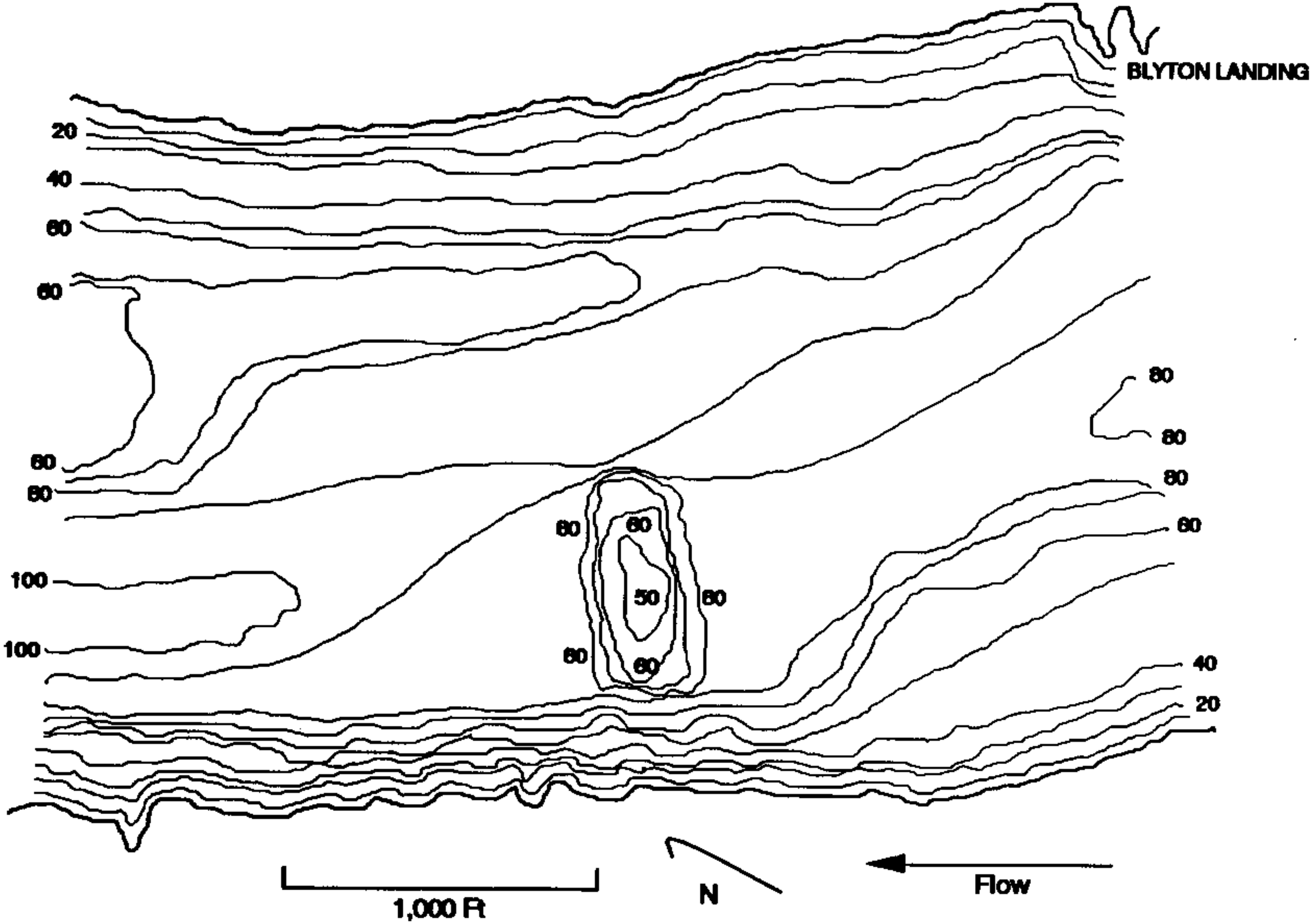
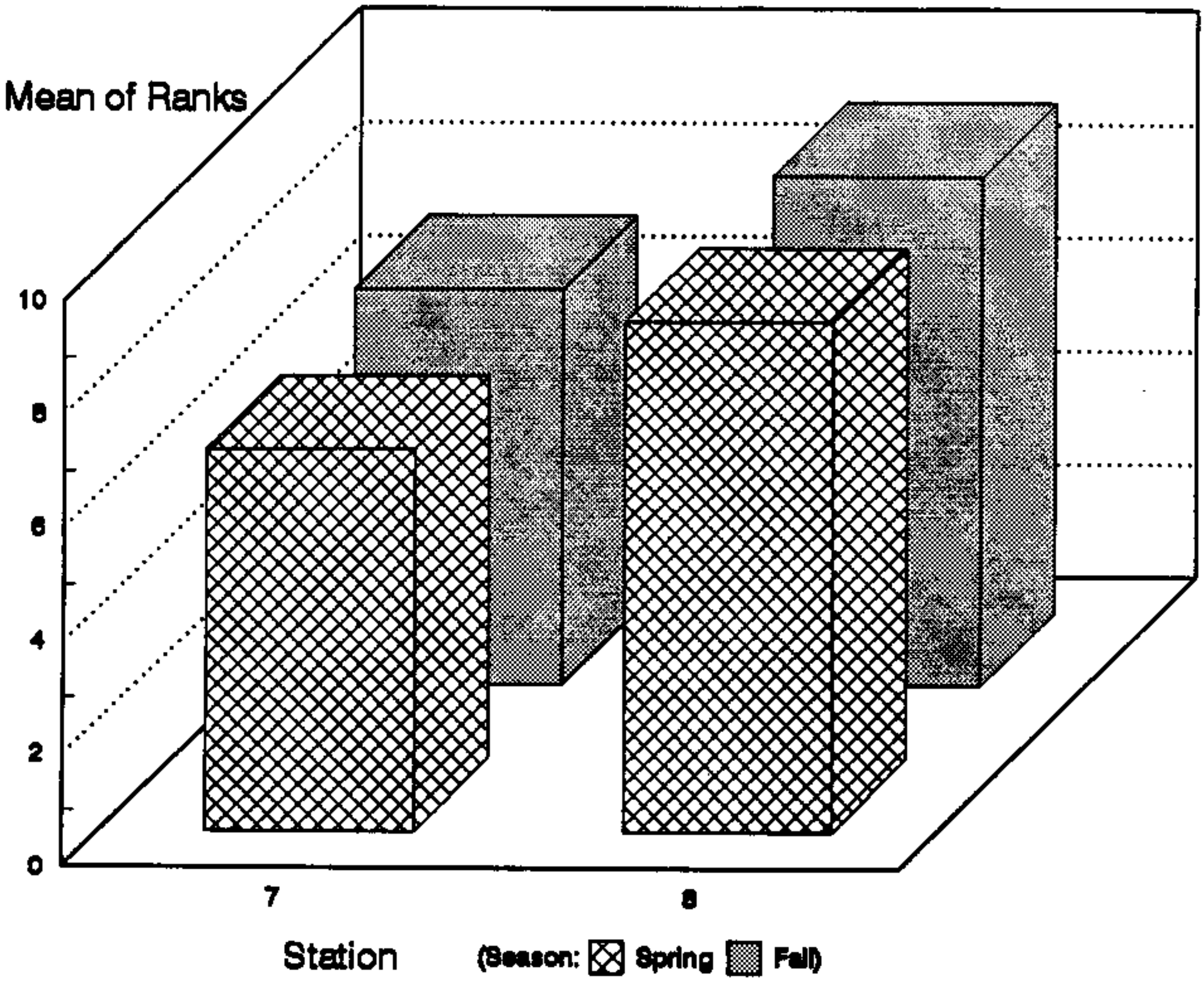


Figure 69. Map of the newly created deep water disposal station 7 at river mile 119.0 in Lower Granite Reservoir.



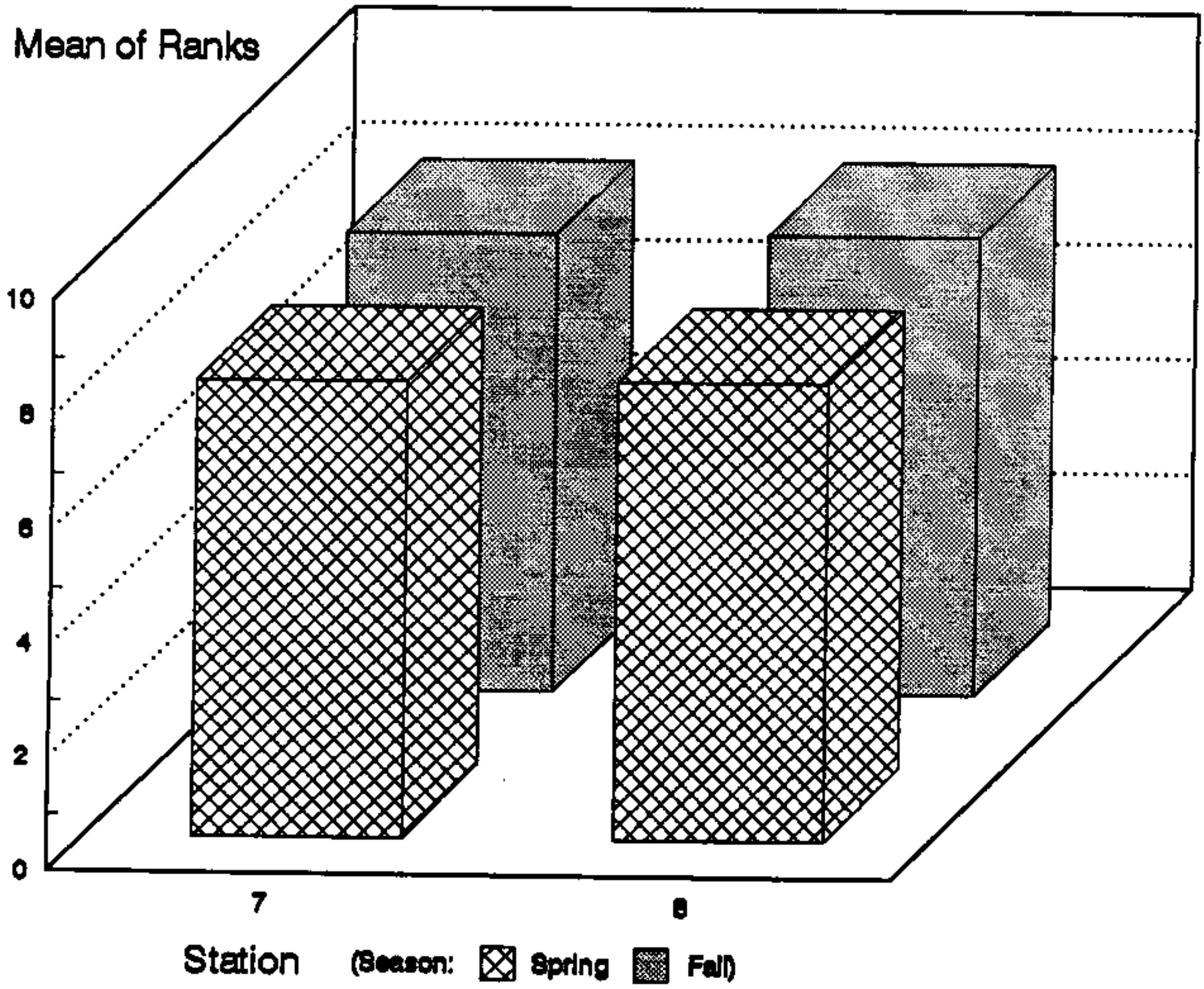
Station Comparison

8 7

Season Comparison

Fall Spring

Figure 70. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).



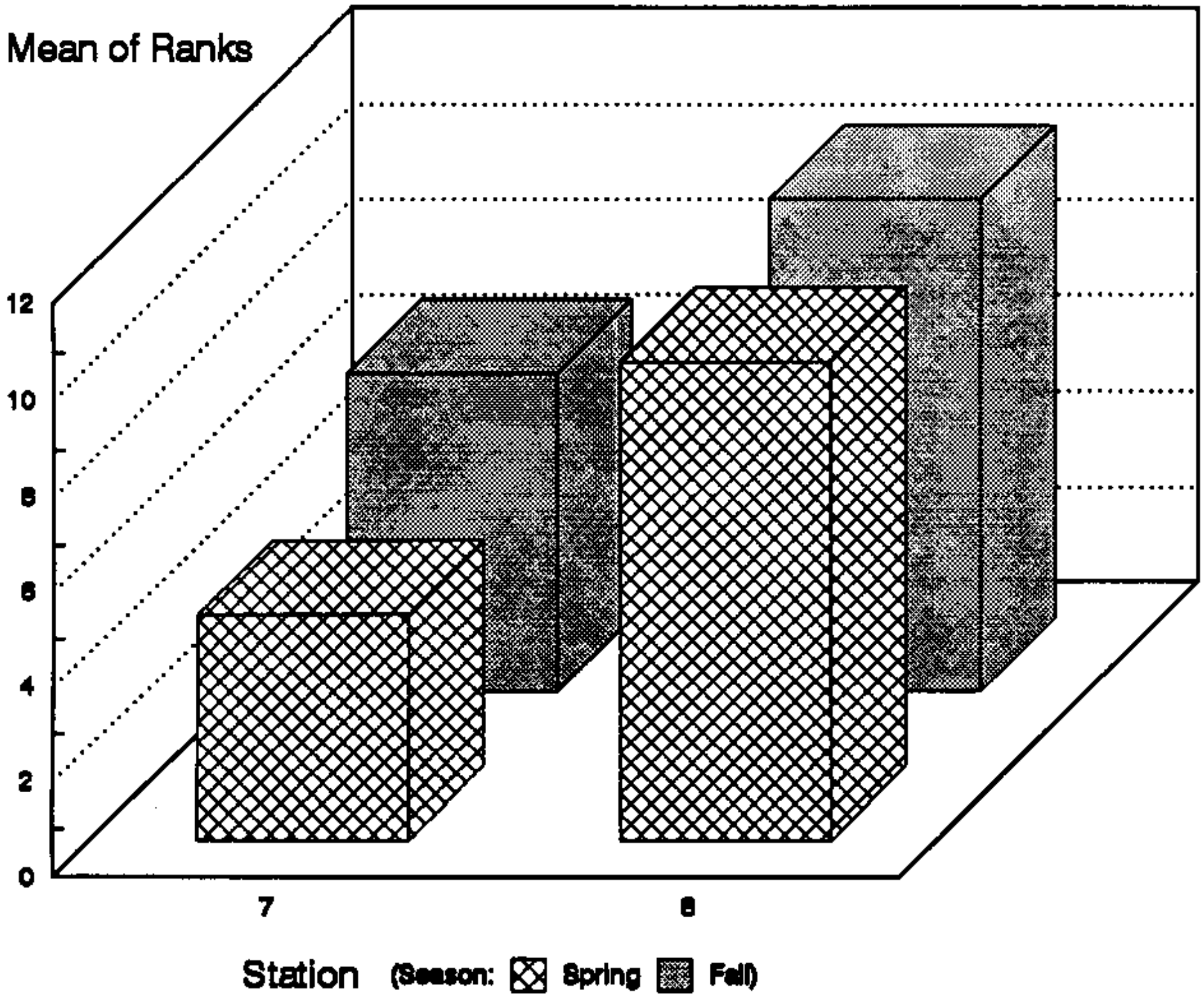
Station Comparison

7 8

Season Comparison

Spring Fall

Figure 71. Graphical and statistical comparisons of the mean of ranks for smallmouth bass abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).



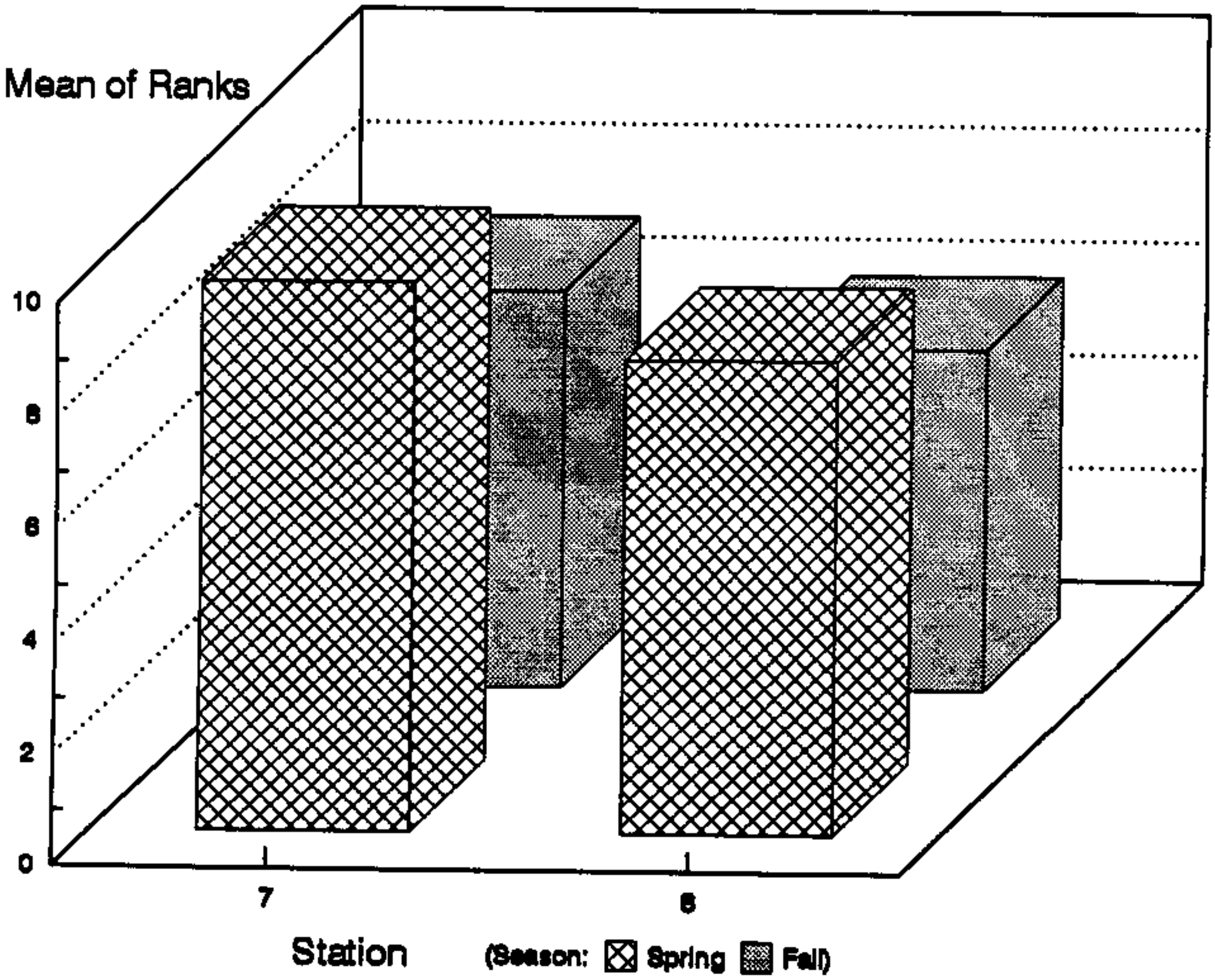
Station Comparison

8 7

Season Comparison

Fall Spring

Figure 72. Graphical and statistical comparisons of the mean of ranks for channel catfish abundance sampled by beach seining during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).



Station Comparison

7 8

Season Comparison

Spring Fall

Figure 73. Graphical and statistical comparisons of the mean of ranks for white sturgeon abundance sampled by gill netting during 1992 in Lower Granite Reservoir. Horizontal lines under stations and seasons indicate statistical nonsignificance (P > 0.05).

than reference station 8, although these differences also were not significant (Figures 71 and 73). Catch/effort for white sturgeon was generally higher in the fall and catch/effort for smallmouth bass was higher in the spring; these differences were not statistically significant ($P > 0.05$).

DISCUSSION

Disposal of dredged material in the river channel at approximately RM 119.0 created some heterogeneity to an apparent homogeneous channel bottom. The disposal, based on acoustical soundings, resembled an underwater structure similar to Centennial Island.

Changes in catch/effort for the species of interest as a result of the deep water disposal were not found in 1992, the first year following disposal. No significant differences in catch/effort were found between deep disposal station 7 and deep reference station 8, the deep control station. Catch/effort for white sturgeon was higher at station 7 than station 8, but these differences were not statistically significant ($P > 0.05$). No significant seasonal differences were found in catch/efforts between the deep water stations for northern squawfish, smallmouth bass, channel catfish or white sturgeon.

Higher catches of white sturgeon at station 7 may be related to the "newness" of the disposal material. Food organisms may have been more plentiful or accessible and may have attracted sturgeon to the disposal site. The abundance of benthic invertebrates, potential food organisms, at disposal station 7 was high based on our 1992 survey and generally similar to that at reference station 8 (Objective 7). Regardless of the higher abundance of white sturgeon and similar abundance of channel catfish, northern squawfish and smallmouth bass between disposal (7) and reference (8) stations, we have not observed concentrations or an absence of fishes that we could attribute to the deep water disposal of dredged material in Lower Granite Reservoir.

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

METHODS

Two-boat trawling was used to compare abundance of salmonid fishes at shallow disposal station 2 and mid-depth disposal station 4 with shallow reference station 5 and mid-depth reference station 6 (Figure 1). Two hauls per site were taken using a 10 m (32.8 ft) surface trawl consisting of 3.8 cm (1.5 inch) mesh netting with a cod end of 0.64 cm (0.25 inch) mesh. The surface trawl was towed between two boats, approximately 44 m (145 ft) apart, the length of each station at an average speed of approximately 0.36 m/s (1.2 ft/s). Sampling was conducted for 3 days during peak downstream smolt migration to obtain relative estimates of smolt abundance at the sampling stations, and at biweekly intervals in April, May and June. Peak migration for spring and summer chinook salmon usually occurs during the third week in April and the second to third week in May for steelhead. No summer, fall or winter sampling was conducted because results from previous years have indicated catch/effort with this gear type is low and not cost effective during those seasons.

Daytime beach seining and nighttime electrofishing were conducted at stations 1, 2, 3, 5, 9 and 10 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 and electrofishing during April, May and June at each of the stations and at monthly intervals from July through October.

All fish collected were identified to species and measured to total length (mm) and released, except adult salmonids were released immediately without being removed from the water to comply with the Endangered Species Permit.

RESULTS

Chinook Salmon

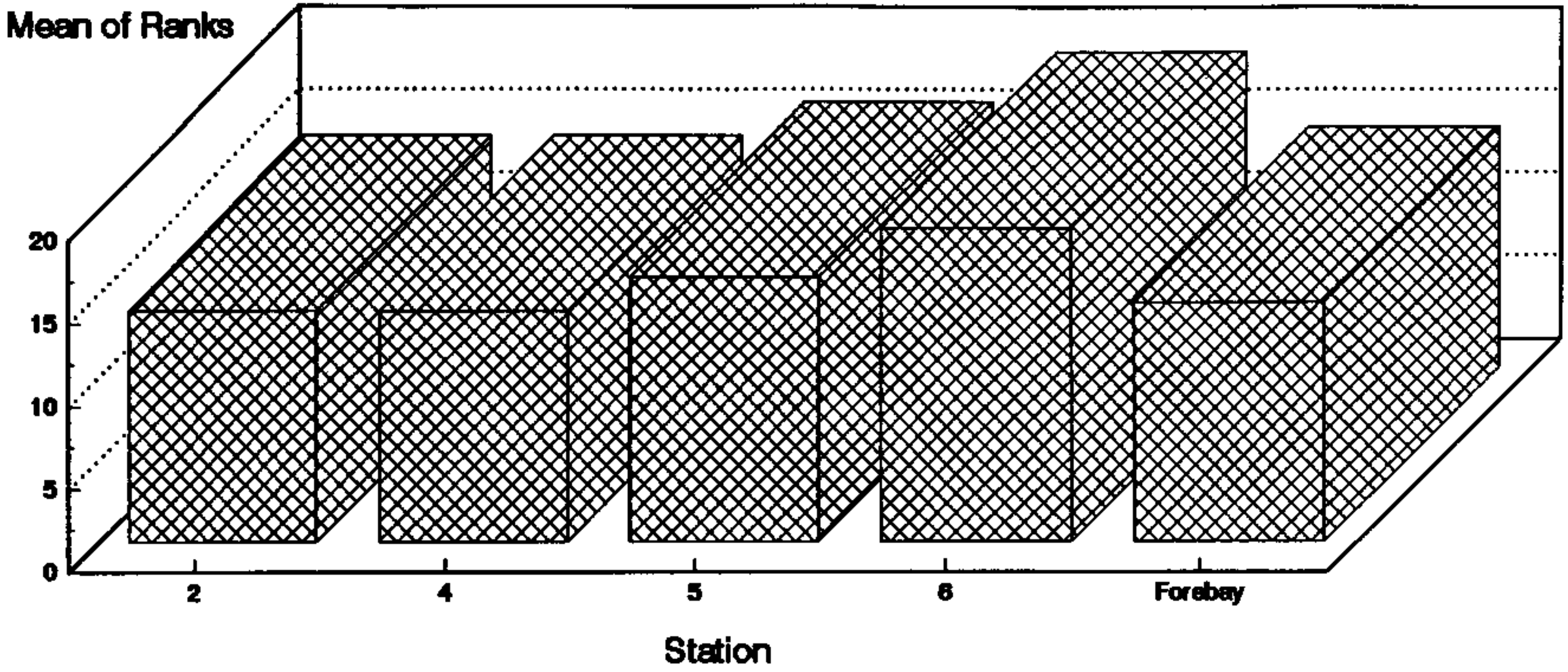
1992

Differences in catch/effort for juvenile chinook salmon by surface trawling among stations were not significant ($P > 0.05$) during spring 1992 (Figure 74). 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 75). 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 75). 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.



Station Comparison

6 5 Forebay 4 2

Figure 74. 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 stations indicates statistical nonsignificance ($P > 0.05$).

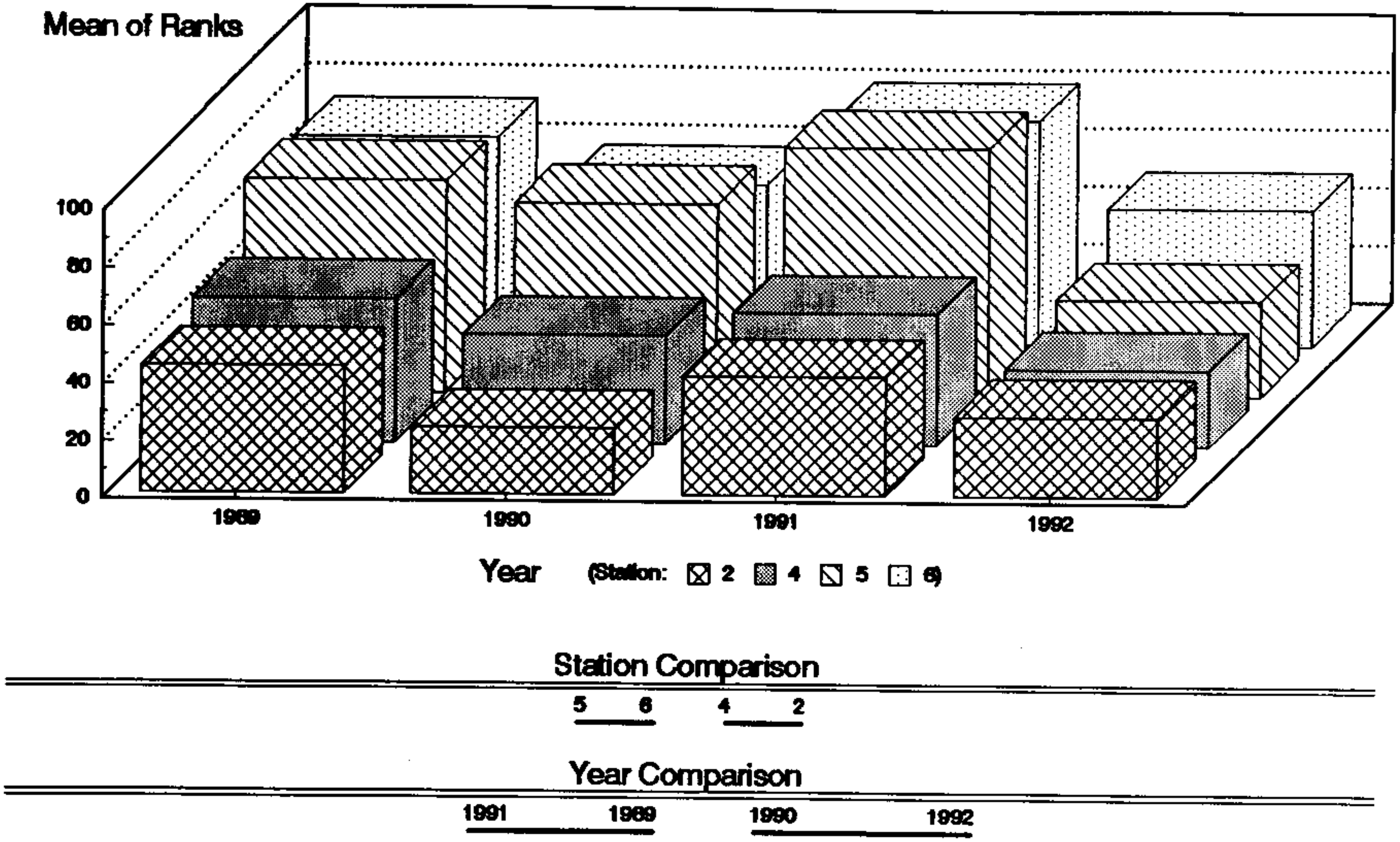


Figure 75. Graphical and statistical comparisons of the mean of ranks for juvenile chinook salmon abundance sampled by surface trawling during 1989-1992 in Lower Granite Reservoir. Horizontal lines under stations and years indicate statistical nonsignificance ($P > 0.05$).

Steelhead

1992

Comparisons of catch/effort by surface trawling for juvenile steelhead indicated no significant ($P > 0.05$) differences among stations (Figure 76). 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.

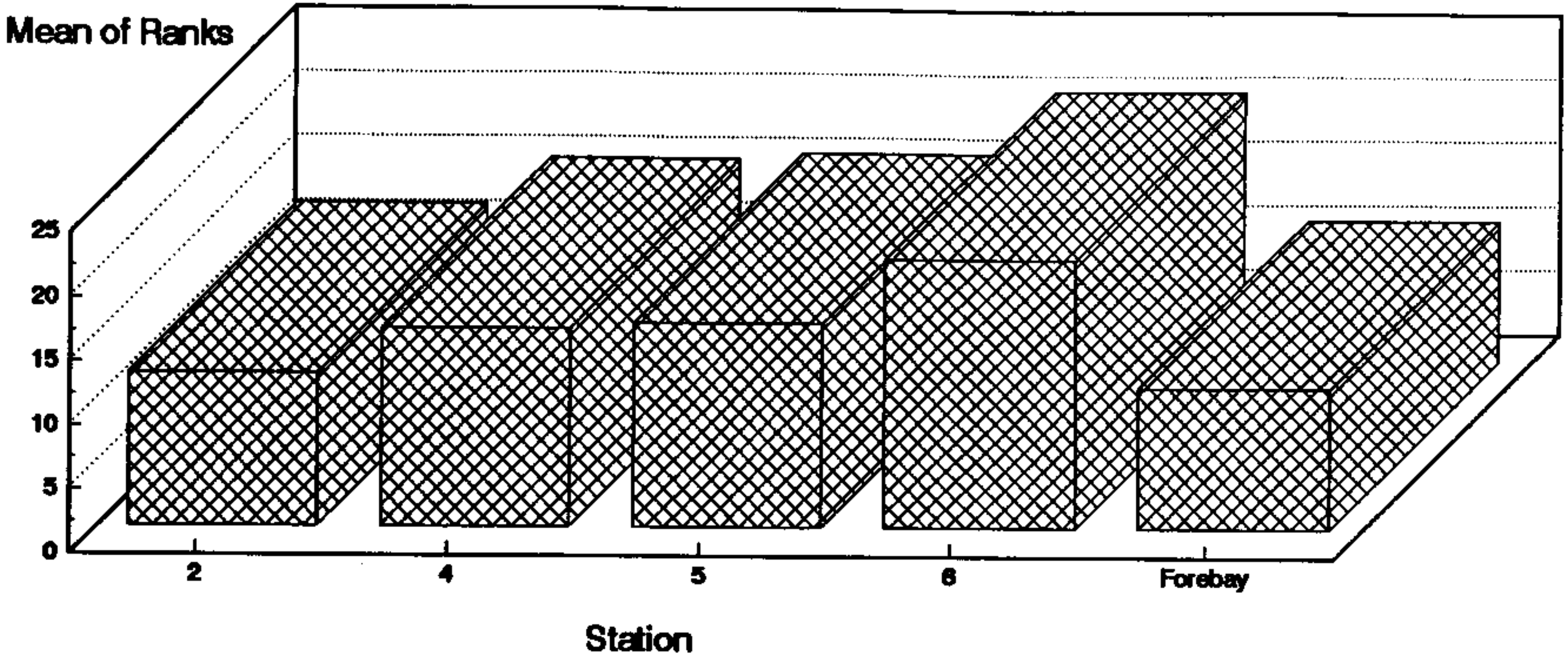
1989-1992

Comparisons of catch/effort for juvenile steelhead by surface trawling from 1989-1992 indicated significant ($P < 0.05$) differences among stations and years (Figure 77). 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 77). Catch/efforts for 1991 and 1992 were significantly ($P < 0.05$) higher than those in 1989 and 1990.

DISCUSSION

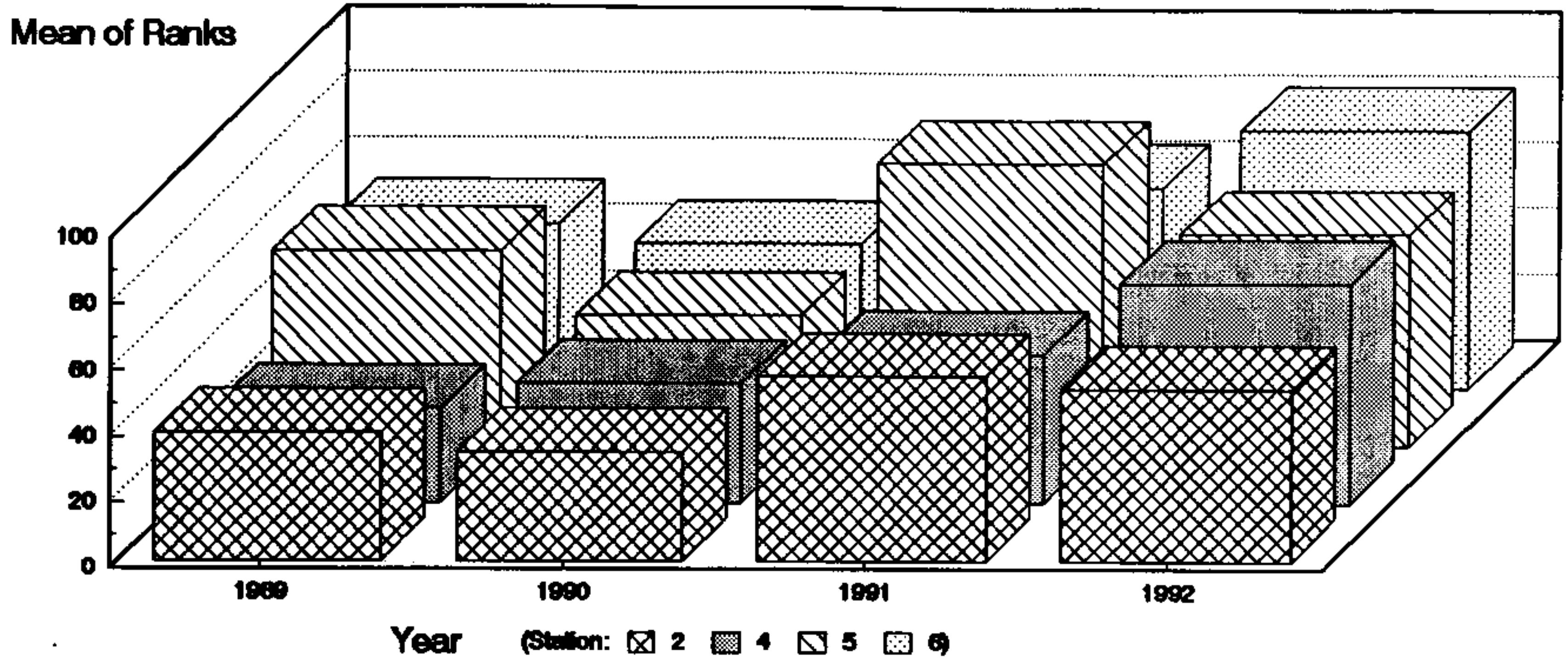
Catches by surface trawling, a technique that samples pelagic abundance, indicated juvenile chinook salmon abundance was generally similar among stations including the forebay area of Lower Granite Dam



Station Comparison

6 5 4 2 Forebay

Figure 76. 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 stations indicates statistical nonsignificance ($P > 0.05$).



Station Comparison

5 6 2 4

Year Comparison

1992 1991 1989 1990

Figure 77. 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 stations and years indicate statistical nonsignificance (P > 0.05).

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 75). Overall catch/efforts of juvenile chinook salmon along the shoreline by beach seining and pelagically by surface trawling was lower in 1992 than in other years (Figures 32 and 75). Although overall flows were lower in 1992 than some other years, peak flows in early May helped move juvenile chinook through Lower Granite Reservoir (Figures 78, 79, 80 and 81). In general, years with lower flows result in longer residence in the reservoir and higher catch/effort.

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.

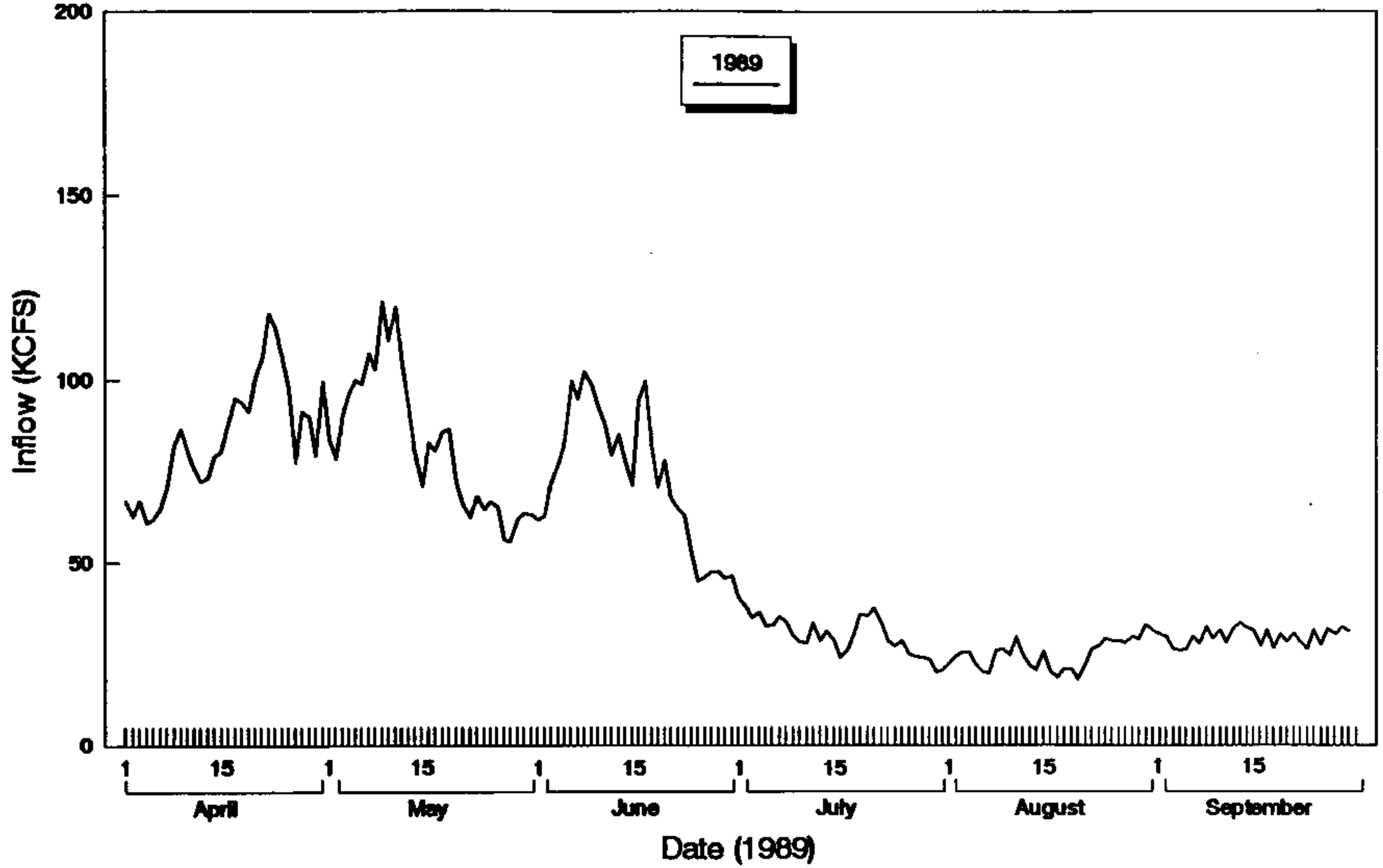


Figure 78. Daily average inflows during 1989 into Lower Granite Dam.

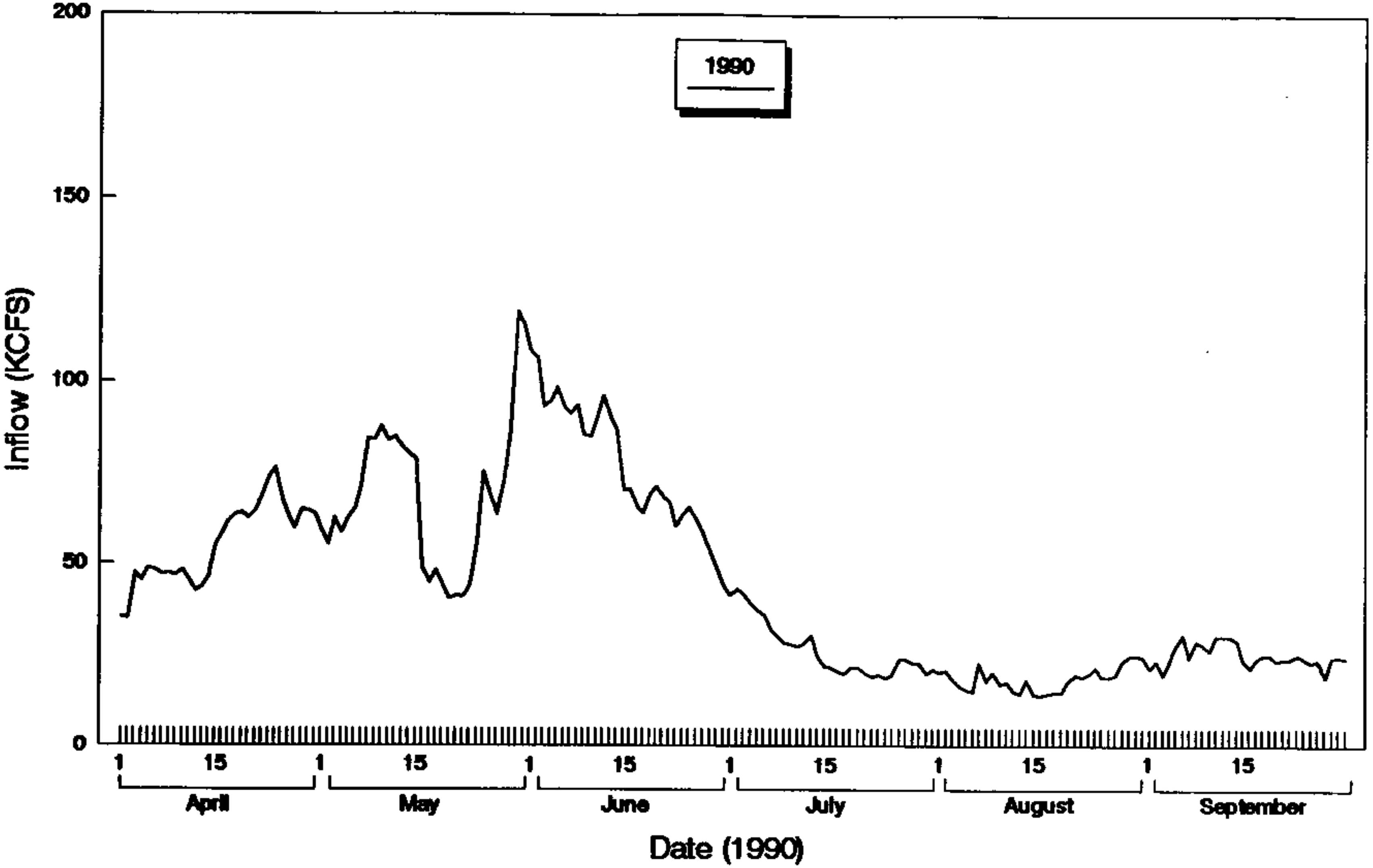


Figure 79. Daily average inflows during 1990 into Lower Granite Dam.

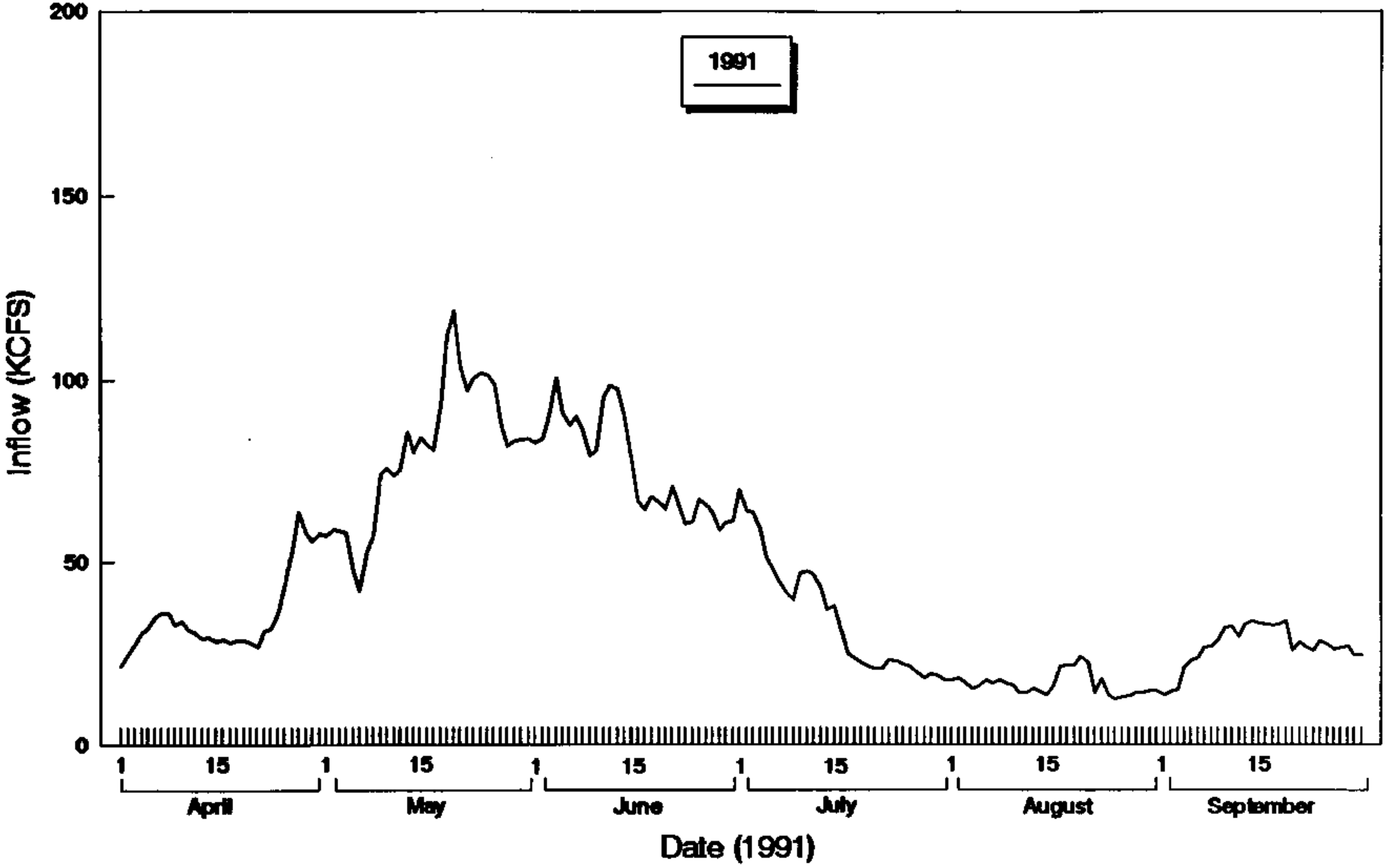


Figure 80. Daily average inflows during 1991 into Lower Granite Dam.

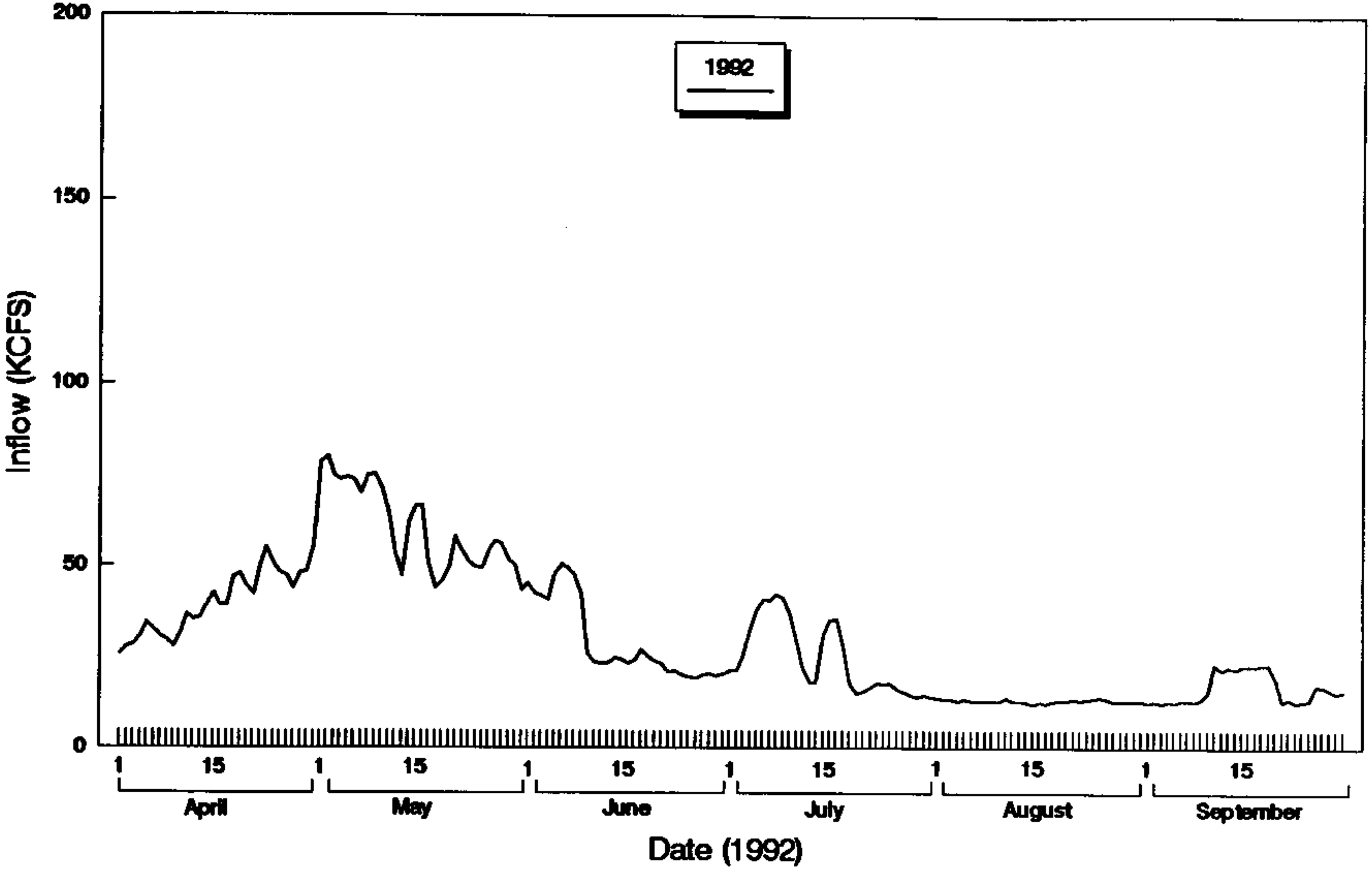


Figure 81. Daily average inflows during 1992 into Lower Granite Dam.

Objective 4. To assess movements and habitat utilization of white sturgeon Acipenser transmontanus in Lower Granite Reservoir.

METHODS

Spring (20 February to 22 May) and fall (1 September to 3 November) sampling efforts were conducted in Lower Granite Reservoir for white sturgeon during 1992 (Figure 3). Nine transects were sampled throughout Lower Granite Reservoir using eight experimental gill nets (1.8 x 75 m, 6 x 250 ft) with bar mesh ranging in size from 2.54 cm 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 fish species.

Setline sampling was also conducted to supplement gill net effort and reduce potential gear bias. Setlines were fished for approximately 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 100-250 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 inches) from mainline to a hook and was rigged onto the mainline in random order. Hooks were primarily baited with Pacific lamprey *Entosphenus tridentatus* and largescale suckers. 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 for total length (cm), 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.

Water depth was measured at all locations sampled for sturgeon. Water depth was recorded with a Lowrance Mach 1 Eagle echosounding chart recorder. Hydroacoustic transects were conducted at approximately 1,020 m (3,400 ft) intervals across channel to assess macrohabitat characteristics at the sites.

RESULTS

Approximately 2,565 gill net and 1,000 setline hours of effort were employed to capture 312 white sturgeon in Lower Granite Reservoir from 2 February to 3 November, 1992. All 312 sturgeon were collected by gill nets. No sturgeon were captured with setlines.

Approximately 81% of all sturgeon (n=254) collected were located in the upper portion of Lower Granite Reservoir between RM 127.0 and RM 137.1 (Figure 82). The highest catch/effort of white sturgeon during the spring was 0.51 at RM 133.7 (transect R3S9) followed by 0.18 at RM 127.0 (transect R2S17; Figure 83). The catch/effort at RM 110.5 (transect R1S11) was low (0.0026) during spring. During the fall, catch/effort was highest at RM 127.0 (0.22) followed by RM 133.7 (0.19). Catch rates at RM 110.5, RM 116.5 (transect R1S29) and RM 119.9 (transect R2S8) were low and similar (0.04).

Total lengths of white sturgeon sampled by gill netting ranged from 21.7 cm to 159.5 cm with a mean length of 74.9 cm (Figure 84). Approximately 99% of the sturgeon sampled were < 122 cm.

A total of 66 sturgeon was recaptured from 2 February to 3 November, 1992 (Table 6). Fifteen sturgeon were initially tagged during the 1990 tagging effort. Net movement of sturgeon initially marked and recaptured in 1992 ranged from 0.0 to 11.5 river miles with five fish traveling > 17 km (> 10 miles) since their last recorded capture. The longest movement was by a fish that was originally tagged on 7 July, 1990 at RM 119.9, recaptured on 7 April, 1992 at RM 129.7 and then recaptured again on 17 September, 1992 at RM 127.0 for a net downstream movement of 2.7 river miles. This same fish was captured 2 days later, 19 September, 1992, approximately 10.1 river miles upstream at RM 137.1. Mean travel distance during the study was 7.8 river miles downstream and 7.7 river miles upstream.

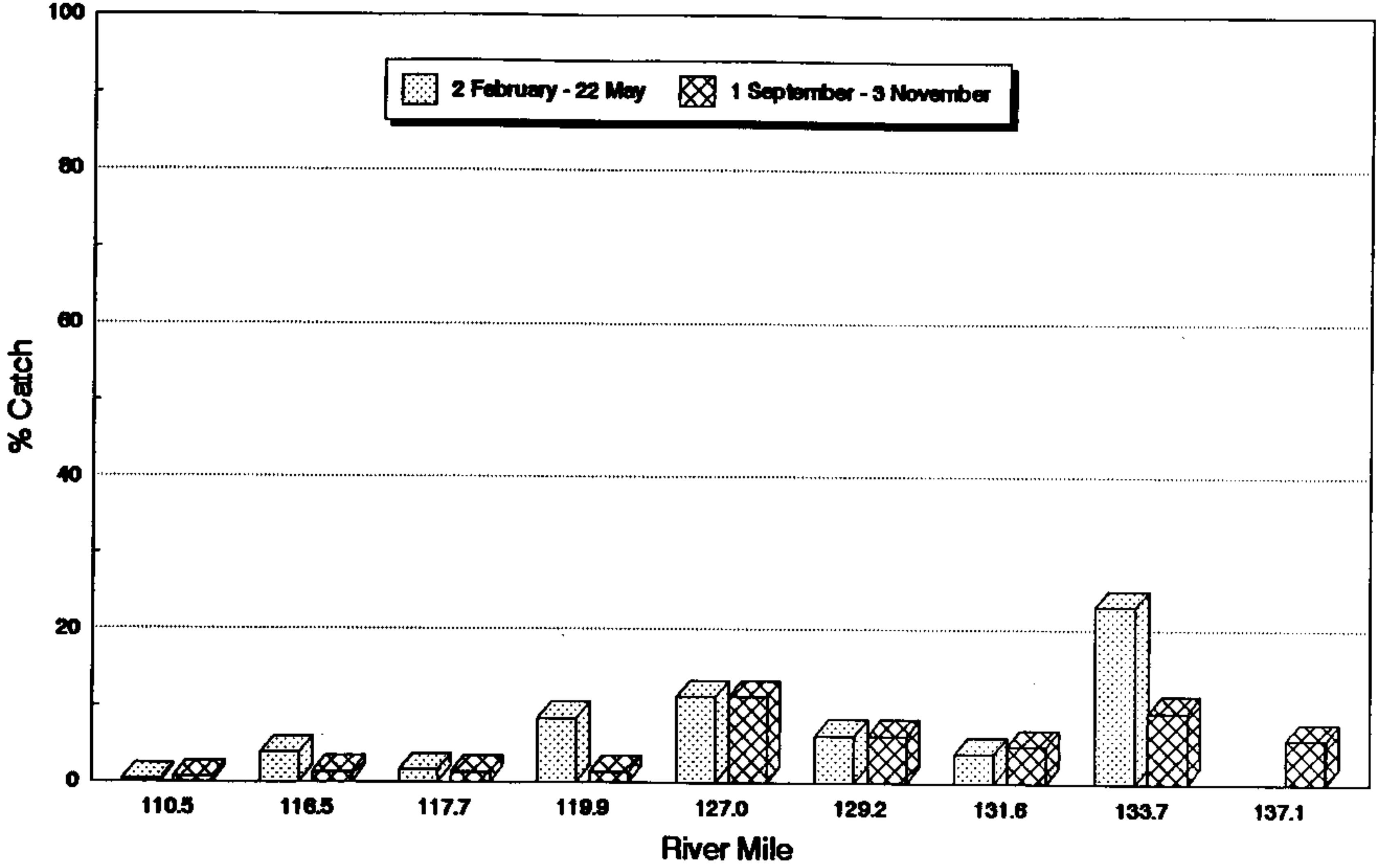


Figure 82. Percent catch of white sturgeon sampled by gill netting during spring and fall sampling during 1992 between river miles 110.5 and 137.1 in Lower Granite Reservoir.

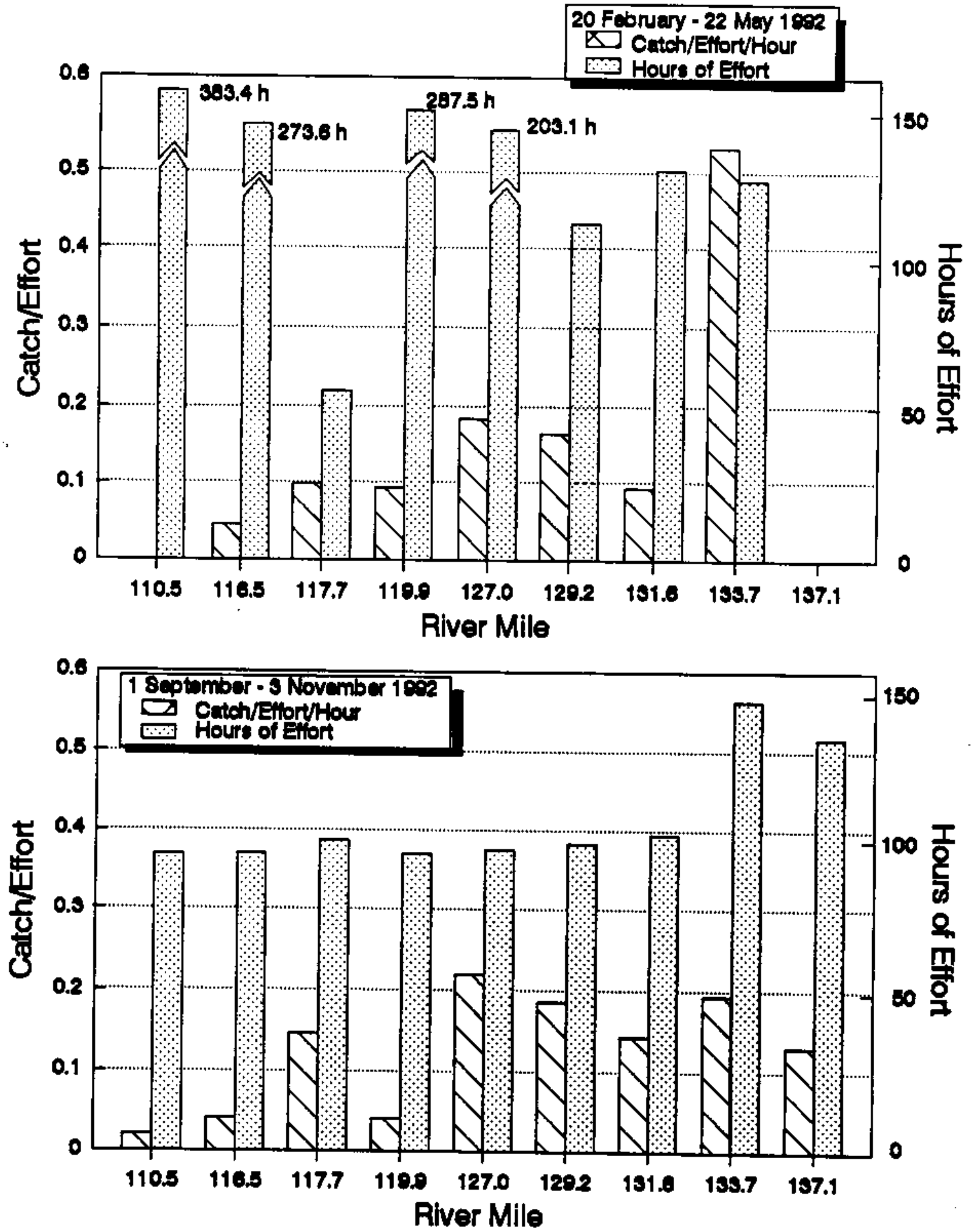


Figure 83. Catch/efforts for white sturgeon captured by gill nets during spring and fall, 1992 sampling in Lower Granite Reservoir.

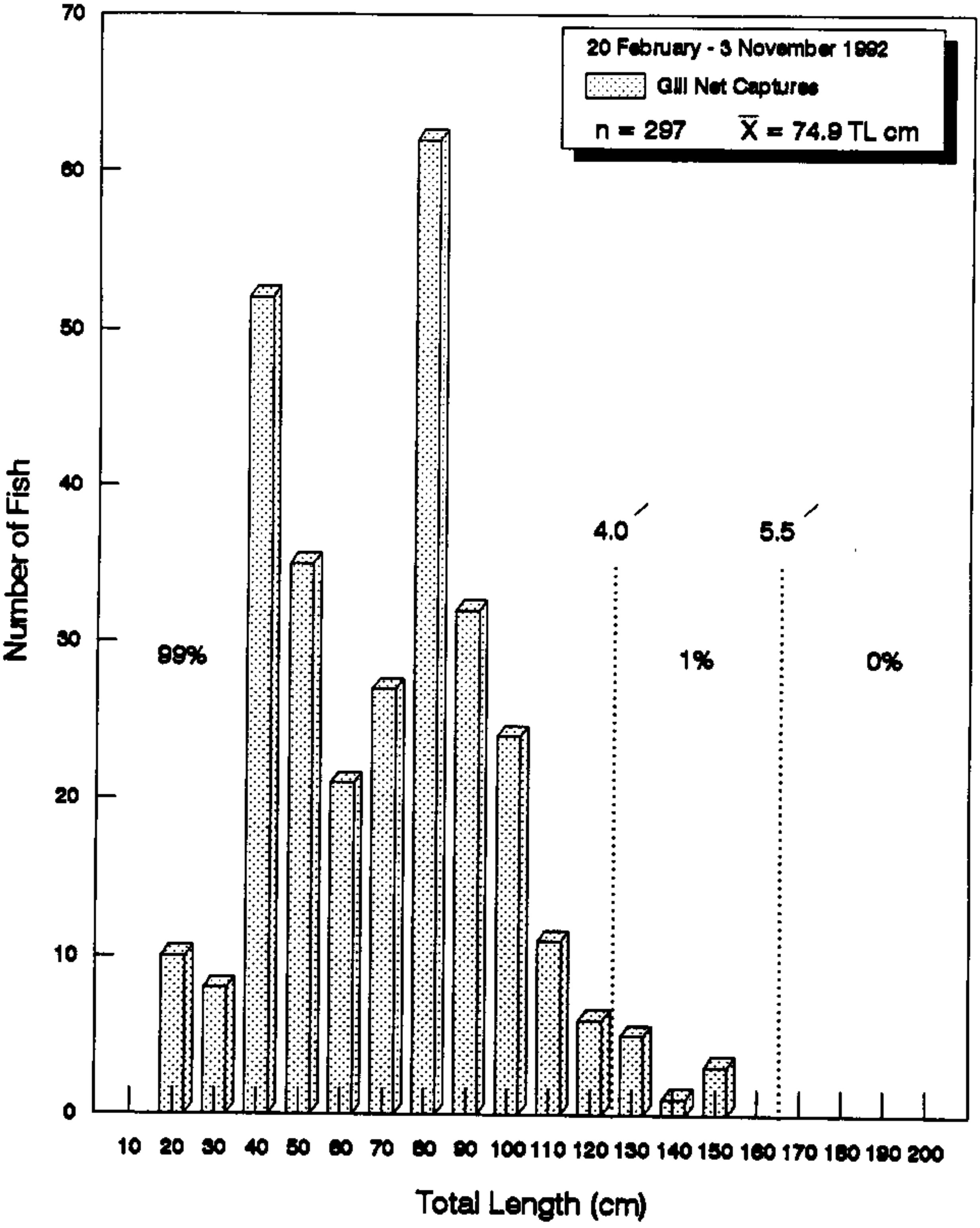


Figure 84. Length distributions of white sturgeon sampled during spring and fall 1992 sampling seasons in Lower Granite Reservoir.

Table 6. Location and net movement of white sturgeon recaptured during spring and fall, 1992 sampling in Lower Granite Reservoir.

P.I.T. Tag	Metal Tag	Initial Capture		Recapture		Recapture		Recapture		Net Movement (RM)
		Date	RM	Date	RM	Date	RM	Date	RM	
7F7F762017	890	10/07/91	133.7	3/04/92	133.7	·······		·······		0.0
7F7F762821	858	4/01/92	133.7	9/19/92	137.1	·······		·······		3.4
7F7F775A54	643	9/11/91	133.7	4/01/92	133.7	·······		·······		0.0
7F7F767726	900	10/01/91	119.9	3/10/92	129.2	3/15/92	117.7	·······		20.8
·······	819	6/05/90	110.5	3/04/92	133.7	·······		·······		23.2
7F7D024FOD	521	6/22/91	133.7	9/19/92	127.0	·······		·······		6.7
7F7F7606F	763	10/17/91	137.1	9/21/92	133.7	·······		·······		3.4
7F7D024030	456	4/23/91	126.1	9/05/92	127.0	·······		·······		0.9
·······	926	6/10/90	130.6	9/05/92	127.0	·······		·······		3.6
7F7D016249	547	6/22/91	133.7	4/01/92	133.7	·······		·······		0.0
·······	374	10/23/90	133.7	3/04/92	133.7	·······		·······		0.0
7F7D016206	906	4/23/91	126.1	5/20/92	119.9	·······		·······		6.2
·······	130	6/21/90	127.0	2/20/92	133.7	·······		·······		6.7
7F7F75642	794	10/17/91	137.1	4/12/92	120.5	·······		·······		16.6
7F7D015512	467	4/21/91	122.6	4/01/92	133.7	·······		·······		11.1
7F7E775E56	184	6/26/90	113.6	6/11/91	117.7	9/19/92	137.1	·······		19.4
7F7F762C3B	191	7/03/90	119.9	4/07/92	129.7	9/17/92	127.0	9/19/92	137.1	22.6
·······	200	7/03/90	119.9	4/01/91	134.5	2/20/92	133.7	·······		18.0
·······	217	6/16/90	133.7	7/01/91	137.1	4/01/92	133.7	·······		6.8
·······	224	6/16/90	133.7	9/21/92	133.7	·······		·······		0.0
7F7F767244	166	7/14/90	117.7	10/06/91	116.6	5/22/92	129.7	·······		14.2
7F7D017106	149	7/16/90	127.0	11/17/90	133.7	5/31/91	133.7	9/10/92	133.7	6.7
·······	22	5/27/90	114.6	4/01/91	134.5	9/05/92	127.0	·······		27.4
·······	286	10/23/90	133.7	3/26/92	127.0	·······		·······		6.7
·······	333	11/17/90	133.7	4/12/92	120.5	·······		·······		13.2

Figure 6. Continued

P.I.T. Tag	Metal Tag	Initial Capture		Recapture		Recapture		Recapture		Net Movement (RM)
		Date	RM	Date	RM	Date	RM	Date	RM	
7F7F7F255F	447	4/20/91	134.5	9/01/91	129.2	2/20/92	133.7	·······		9.8
7F7D015204	452	5/31/91	133.7	4/07/92	129.2	·······		·······		4.5
7F7D015C29	487	4/23/91	126.1	4/07/92	129.2	5/17/92	127.0	·······		5.3
7F7D015E4E	523	6/22/91	133.7	9/08/92	137.1	9/17/92	127.0	·······		13.5
7F7F7F1C15	553	6/21/91	116.5	10/07/91	133.7	9/13/92	110.5	·······		40.4
7F7D017D6B	579	6/03/91	110.5	9/08/92	129.2	·······		·······		18.7
7F7F7F260C	587	5/31/91	133.7	4/03/92	131.6	·······		·······		2.1
7F7F767346	599	9/11/91	133.7	2/20/92	133.7	·······		·······		0.0
7F7F762B7D	602	10/07/91	133.7	9/19/92	137.1	·······		·······		3.4
7F7F76253A	605	10/07/91	133.7	2/20/92	133.7	·······		·······		0.0
7F7F766A19	614	8/15/91	137.1	4/03/92	131.6	·······		·······		5.5
7F7F775976	616	9/11/91	133.7	3/04/92	133.7	·······		·······		0.0
7F7F775E10	619	9/22/91	110.5	9/08/92	137.1	9/19/92	137.1	·······		26.6
7F7F775F67	651	8/04/91	127.0	4/08/92	127.0	·······		·······		0.0
7F7F766E24	655	8/01/91	129.2	10/07/91	133.7	4/01/92	133.7	·······		4.5
7F7F763641	671	10/07/91	133.7	4/08/92	127.0	·······		·······		6.7
7F7F762C56	672	10/07/91	133.7	9/21/92	133.7	·······		·······		0.0
·······	673	7/08/91	133.7	2/20/92	133.7	·······		·······		0.0
7F7F81C70	678	7/08/91	133.7	9/21/92	133.7	·······		·······		0.0
7F7D01630E	676	6/07/91	116.5	7/08/91	119.9	5/18/92	127.0	·······		10.5
7F7F767E37	773	10/18/91	110.5	3/19/92	116.5	·······		·······		6.0
7F7F766666	800	10/17/91	137.1	5/18/92	127.0	·······		·······		10.1
·······	824	2/27/92	116.5	3/15/92	127.0	·······		·······		10.5
7F7D015F1C	922	4/23/91	126.1	5/20/92	119.9	·······		·······		6.2
·······	926	4/07/92	129.2	5/20/92	119.9	·······		·······		9.3

Table 6. Continued

P.I.T. Tag	Metal Tag	Initial Capture		Recapture		Recapture		Recapture		Net Movement (RM)
		Date	RM	Date	RM	Date	RM	Date	RM	
7F7F7E4430	353	N/A		6/04/91	129.2	4/03/92	131.2	......		2.0
7F7D017446	386	4/30/91	131.6	10/07/91	133.7	9/10/92	133.7	......		2.1
7F7F761F3A	934	4/06/92	127.0	9/14/92	117.7	......		......		10.7
......	***SP00350	N/A		5/20/92	127.0	......		......		N/A
7F7D02392E	942	6/18/91	129.2	4/03/92	131.6	......		......		2.4
7F7F767277	990	N/A		9/22/91	110.5	9/22/92	131.7	......		21.2
7F7F76392D	1039	9/17/92	127.0	9/21/92	133.7	......		......		6.7
7F7D025135	1060	5/09/91	129.2	6/22/91	133.7	9/17/92	127.0	......		11.2
7F7F7D7D72	1108	4/01/91	134.5	9/07/92	117.7	......		......		16.8
7F7F7D7B39	1131	5/18/92	127.0	9/05/92	127.0	......		......		0.0
7F7F775A39	1160	8/15/91	137.1	5/18/92	127.0	......		......		10.1
7F7F7D321E	1194	4/13/91	116.3	9/07/92	117.7	......		......		1.4
......	1177	N/A		9/05/92	127.0	......		......		N/A
......	1189	N/A		5/20/92	119.9	......		......		N/A
......	456	N/A		5/18/92	127.0	......		......		N/A
......	5	5/27/90	114.6	4/01/91	134.5	9/05/92	127.0	......		27.4

A modified Schnabel estimate was used to compute a population estimate for white sturgeon based on captures and recaptures from February to May, 1992. The estimate yielded 1,804 individuals and a 95% confidence interval of 816 to 7,219, based on a 2% recapture rate.

Depth of main channel areas sampled between RM 110.5 and RM 137.1 ranged from 14 to 36 m (46-118 ft) with adjacent bench areas typically ranging from 8 to 13 m (29.5-42.6 ft) deep. Sturgeon were collected at depths ranging from 6 to 36 m (19-118 ft) with a mean depth of 19.1 m (62.75 ft). Sturgeon > 40 cm were sampled throughout Lower Granite Reservoir while fish < 40 cm were collected in upper reservoir locations in depths < 18 m (<59.0 ft).

DISCUSSION

The importance of Lower Granite Reservoir to rear smaller white sturgeon was found again in 1992. Large sturgeon (>40 cm) were collected throughout Lower Granite Reservoir, while smaller sturgeon were collected in the upper portion of the reservoir. Mean size was generally similar to previous years and averaged about 75 cm total length. Over 99% of the sturgeon sampled were < 120 cm (4 ft; Figure 84). Although we have shown in previous years that gill nets are size selective (Bennett et al. 1993b), our efforts to sample larger fish with set lines failed to collect any sturgeon.

Effort was generally similar at each transect (Figure 83), although catch/efffort of white sturgeon was highest at RM 133.7 from February to May. From September to early November, with similar effort, catch/effort was generally similar from RM 127 upstream. The proportion of marked sturgeon captured in 1992 was about 2%, considerably lower than in previous years (Lepla 1994). We attribute the decreased proportion of marked fish to the migration of smaller fish into the reservoir and emigration of larger fish. Our original hypothesis that young sturgeon were migrating into Lower Granite Reservoir, rearing and probably migrating upstream to the lotic sections of the Snake River is supported by the decreased number of marked sturgeon in the population. Lower Granite Reservoir seems to have an open population of sturgeon. Although we have found that sturgeon were entrained during the experimental March 1992 drawdown of Lower Granite Reservoir (Bennett et al. 1994b), the proportion of marked sturgeon lost to Little Goose Reservoir should have been similar to that of the population. Our population estimate for 1992 was similar to that from previous years, even though we had a low number of recaptures.

Movements of white sturgeon in 1992 were about similar upstream and downstream. The average upstream and downstream movements were 12.3 and 12.5 km (7.7 and 7.8 miles). Five fish moved > 17 km (10 miles) and the longest movement between successive captures was 65 river kilometers (40.4 river miles). One fish was recaptured 2 days apart and moved over > 17 km (>10 miles) between those 2 days.

Objective 5. To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir;

METHODS

Stomachs of northern squawfish (> 250 mm) collected by all gear types between river mile (RM) 107.5 and 137.1 from 1 April through 30 June, 1992 were examined for food items. Captured squawfish were measured by total length to the nearest millimeter (mm), anesthetized and the entire digestive tract removed and frozen for later analysis in the laboratory.

Stomach samples were sorted, enumerated and identified to the lowest possible taxon. Crustaceans were identified to genus or family and insects were identified to order. Undigested fish were identified to species, when possible, and measured to the nearest mm (fork length). Unidentified materials, parasites and nonfood items were blotted dry and weighed (mg).

Bone morphology identification techniques (Hansel et al. 1988) were used to identify partially digested fish. For those with advanced digestion, fork lengths were estimated from standard or nape to tail lengths or bone lengths using regression equations.

Partially digested fish remains from more than one prey fish were weighed together and apportioned to the weight of an individual prey fish based on the relative weight and degree of digestion. When only digested fish parts remained and the relative size of each prey fish could not be determined, the total weight of the parts were divided equally among fish in the stomach (Vigg et al. 1988).

When diagnostic bones were found in squawfish stomachs from unknown salmonids (i.e. juvenile chinook salmon or juvenile steelhead), the species identification was determined by comparing the range of lengths of salmonids captured by our sampling (Objective 1) within 7 days of the squawfish capture. When prey lengths overlapped those captured by our sampling, species identification was not possible and prey were pooled into a category of salmonids.

RESULTS

A total of 63 northern squawfish was captured during 1992 in Lower Granite Reservoir. The majority (47%) were captured at mid-reservoir stations (RM 112-126) followed by upriver (38%, RM 127-137.1) and lower reservoir locations near mid-depth reference station 6 (14%, RM 111; Figure 85). One northern squawfish was captured near the confluence (RM 139.5) of the Snake and Clearwater rivers. The majority of squawfish (72%) sampled ranged in length between 350-449 mm with a mean length of 380 mm (Figure 86).

Abundant food items of northern squawfish were insects, fish and crayfish (Table 7). Crayfish were the dominant item by weight followed by fish while insects were most abundant numerically. Of the fish eaten, salmonids and centrarchids were most abundant.

Daily Ration

Total daily ration for northern squawfish sampled during spring was 22.84 mg/g/d for all prey fishes (Figure 87). Total daily ration

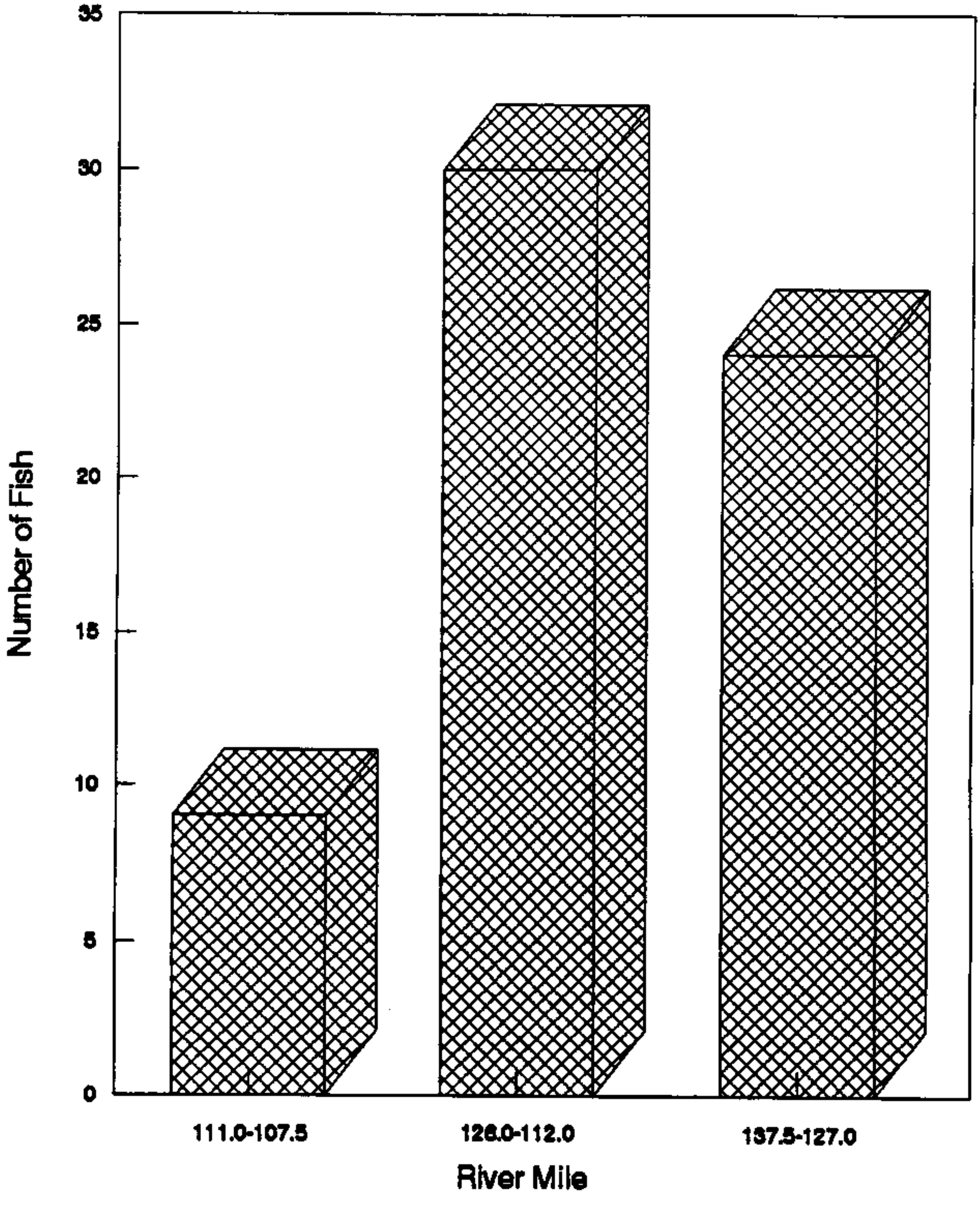


Figure 85. Number of northern squawfish captured during spring 1992 in Lower Granite Reservoir.

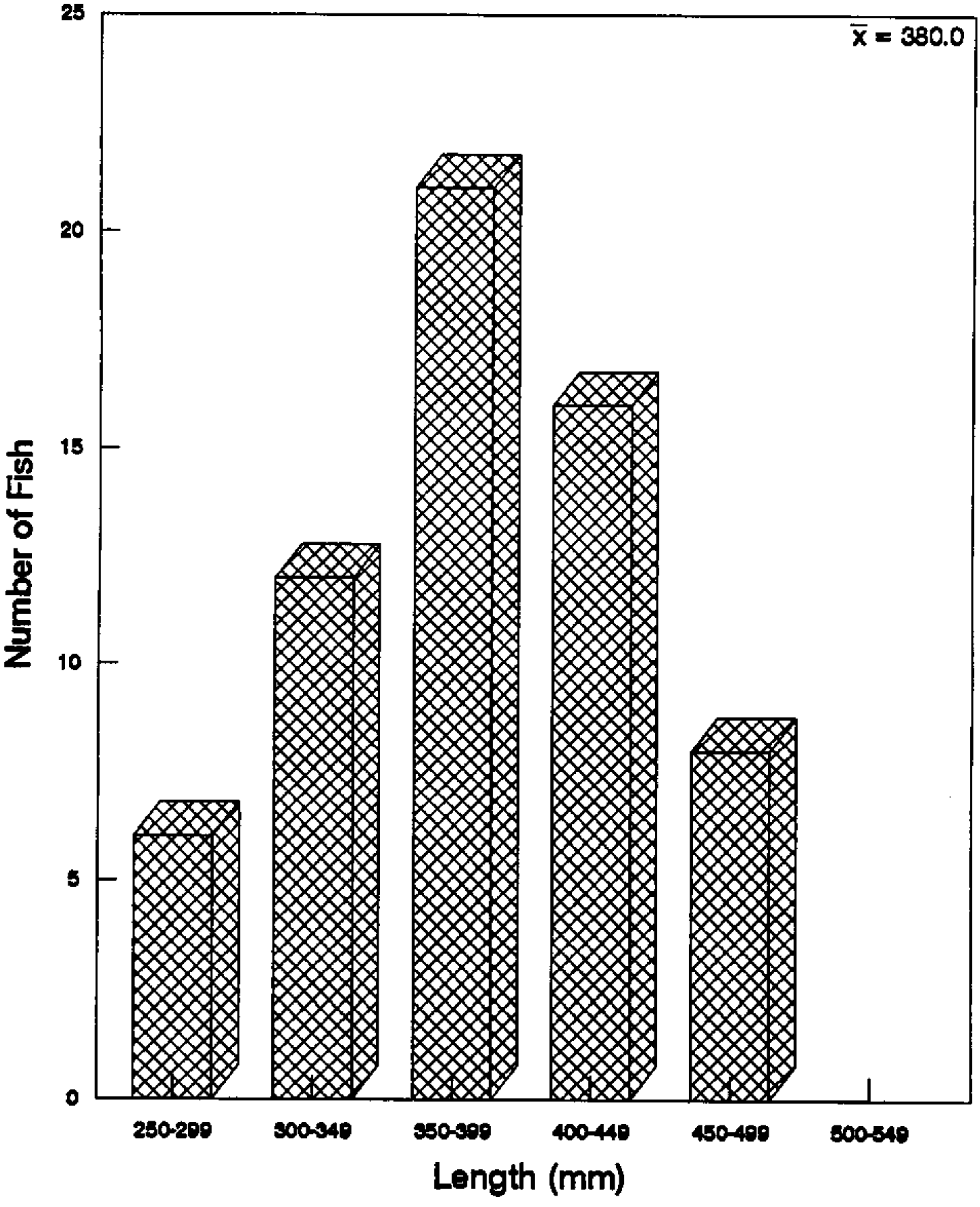


Figure 86. Length distributions of northern squawfish captured during spring 1992 between river miles 107.5 and 137.1 in Lower Granite Reservoir.

Table 7. Stomach contents of 63 northern squawfish collected during spring (1 April - 30 June), 1992 in Lower Granite Reservoir.

Prey Group	Number	Frequency	% Number	Dry Wt. Grams	% Dry Wt.
Crustaceans					
Decapods	23	16	8.4	132.7	48.1
Insecta					
Hymenoptera	30	2	11.0	0.7	0.2
UNID. Insects	18	2	6.6	N/A	N/A
Insect parts	135	6	49.6	3.3	1.2
Osteichthes					
Salmonidae (unident.)	10	10	3.6	86.5	31.3
Chinook	5	4	1.8	16.7	6
Steelhead	1	1	0.3	5.4	1.9
Castostomidae	1	1	0.3	0.8	0.3
Centrarchidae	1	1	0.3	10.1	3.6
Non-salmonidae	3	3	1.1	5	1.8
Unident. fish	3	3	1.1	7.6	2.7
Other Items					
Grain, rodents, ect.	42	5	15.3	6.4	2.2

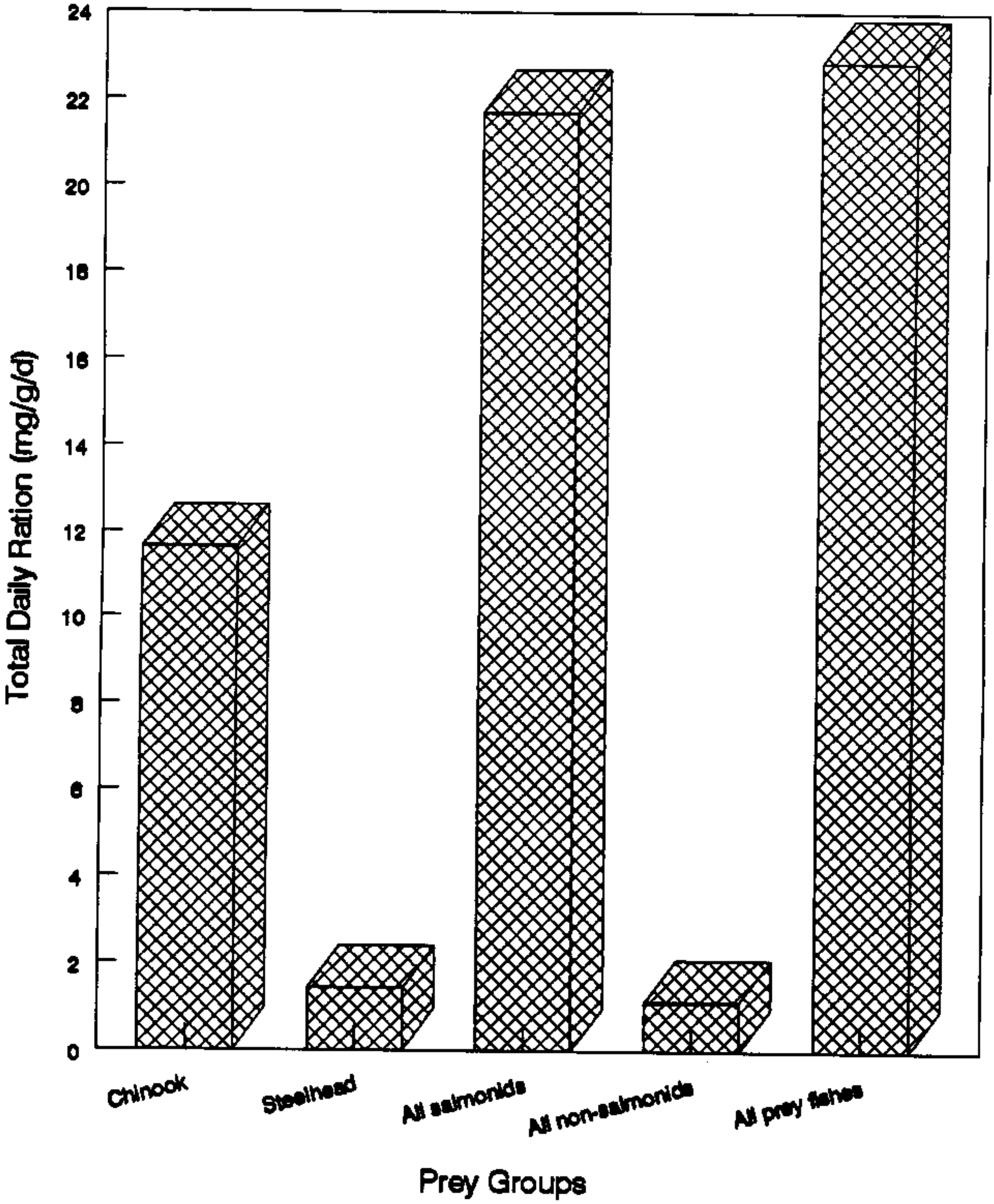


Figure 87. Total daily ration of fishes consumed by northern squawfish during spring 1992 in Lower Granite Reservoir.

was lowest for non-salmonids (1.14 mg/g/d, castostomids and unidentified non-salmonids). The daily ration estimate for squawfish that consumed juvenile chinook salmon was 11.64 mg/g/d and the ration of juvenile steelhead was 1.45 mg/g/d.

Mean monthly total daily ration estimates during April of juvenile chinook salmon (20.5 mg/g/d), all salmonids and all prey fishes by northern squawfish were high and similar (Figure 88). Mean monthly total daily ration estimates during April of juvenile steelhead and all non-salmonids were low.

Mean monthly total daily ration estimate of all prey fishes consumed by northern squawfish in May was 18.31 mg/g/d (Figure 89). Mean monthly total daily ration of juvenile chinook salmon was higher (2.44 mg/m/d) than that of juvenile steelhead (1.89 mg/m/d) and total daily ration of all salmonids was 16.45 mg/m/d. During May the total daily ration of non-salmonids was low and similar to the total daily ration for steelhead.

Daily Ration 1990-1992

Seasonal total daily ration of salmonids by northern squawfish indicate the ration of all salmonids combined was higher in 1992 than both 1990 and 1991 (Figure 90). The daily ration of juvenile chinook salmon was six times higher in 1992 than 1990 and 1991. Daily consumption of steelhead in 1992 was lower than 1990 and similar to 1991. Total daily ration of salmonids during April and May, 1992 was substantially higher than other years with the exception of June

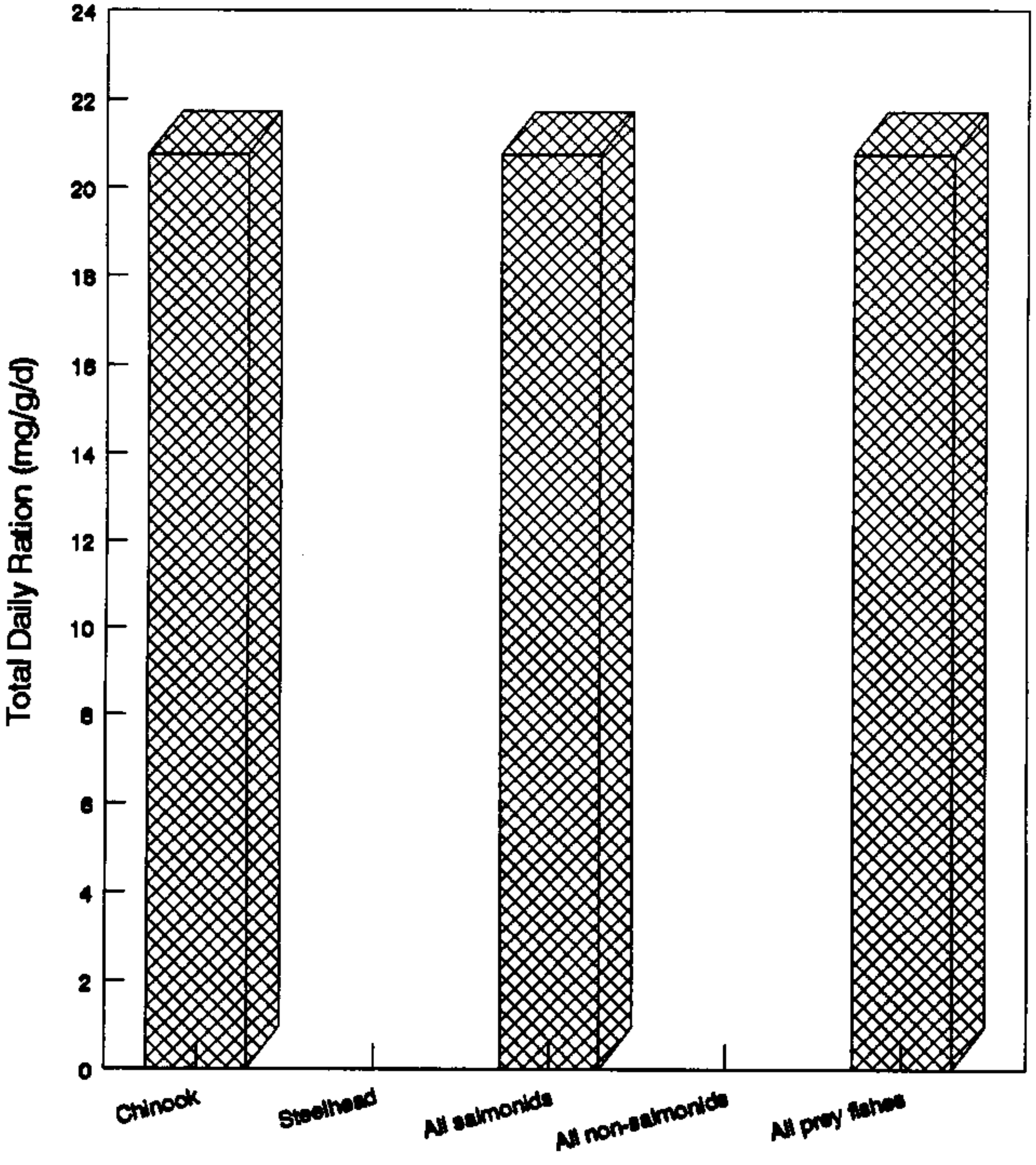


Figure 88. Total daily ration of fishes consumed by northern squawfish during April 1992 in Lower Granite Reservoir.

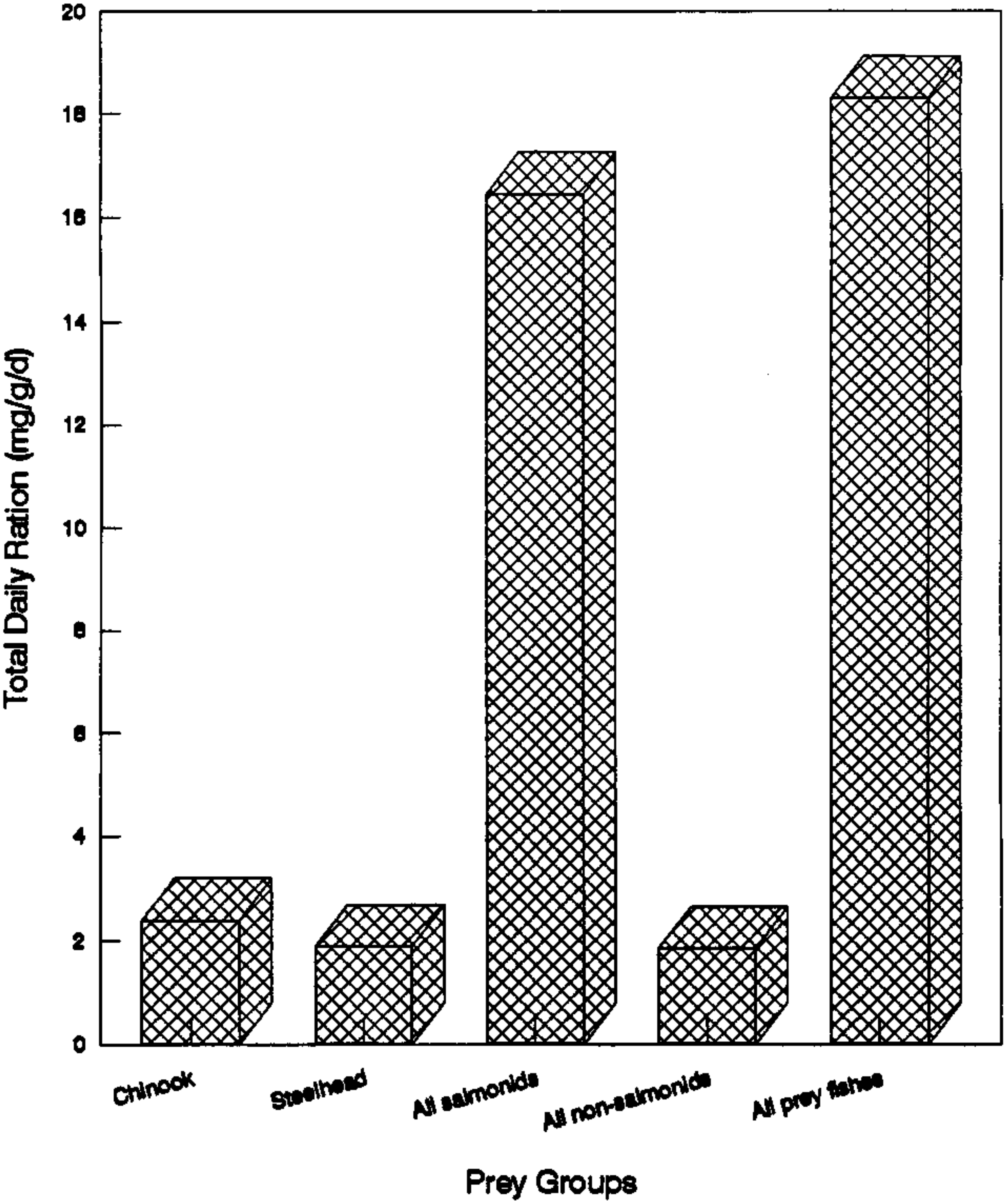


Figure 89. Total daily ration of fishes consumed by northern squawfish during May 1992 in Lower Granite Reservoir.

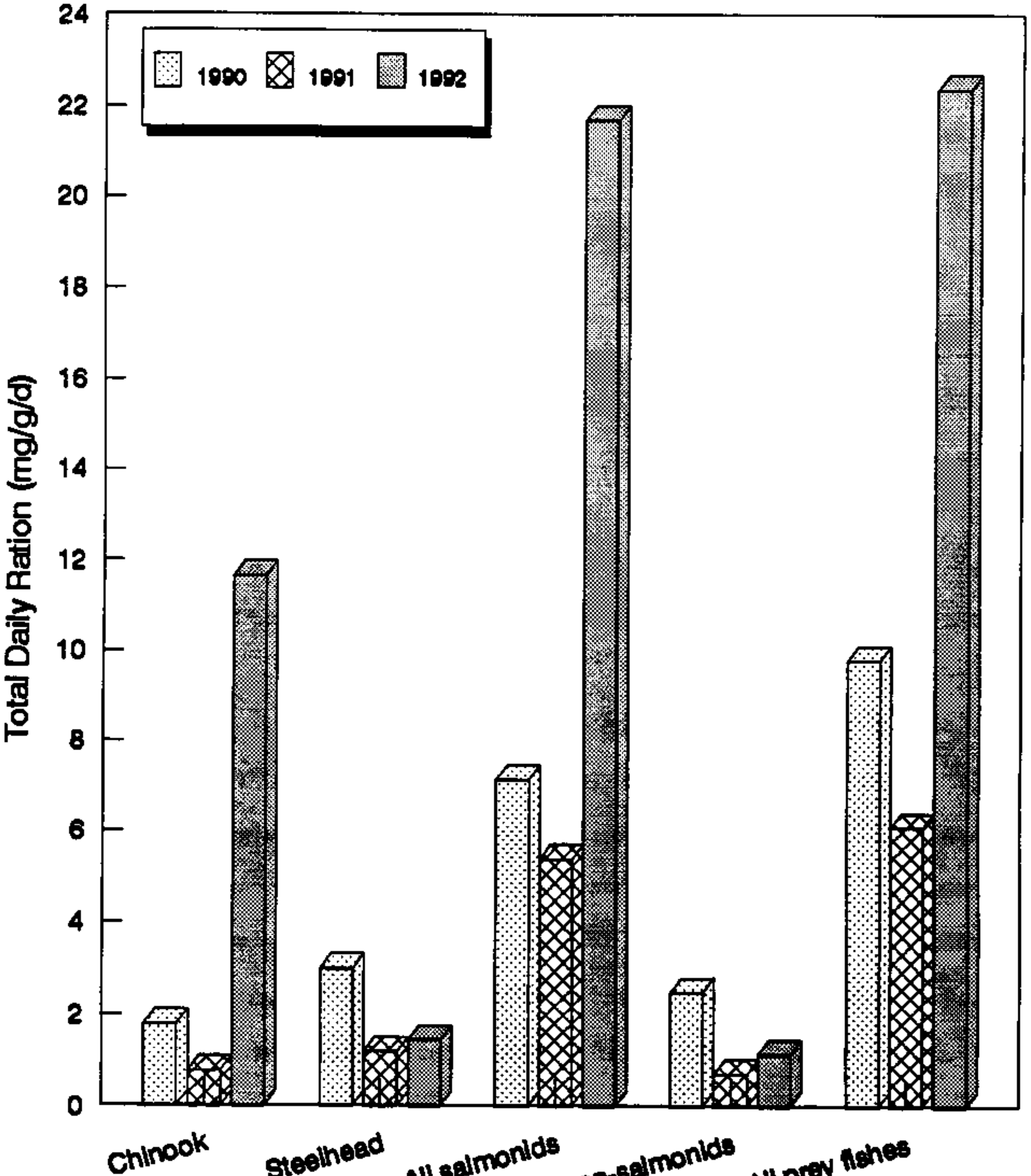


Figure 90. Total daily ration of fishes consumed by northern squawfish during spring 1990-1992 in Lower Granite Reservoir.

(Figures 91-93). The total daily ration of juvenile chinook consumed by squawfish during May was similar during 1990 and 1992 (Figure 92). No northern squawfish stomachs were sampled during June 1992.

Consumption Estimates

The consumption estimate of all prey fishes by northern squawfish > 250 mm during spring was 4.73 prey/predator/day (Figure 94). Mean seasonal consumption rates during spring of juvenile chinook salmon and steelhead by squawfish were 3.65 prey/predator/day and 0.13 prey/predator/day. The spring consumption rate of all prey fishes by squawfish was 4.03 prey/predator/day and that of non-salmonids was 0.94 prey/predator/day.

The highest mean monthly consumption rate of juvenile salmonids by northern squawfish was in April (0.88 prey/predator/day; Figure 95). The mean monthly consumption rates of juvenile chinook salmon (0.87 prey/predator/day) and all salmonids by squawfish were highest in April. Mean monthly consumption rates of juvenile steelhead and non-salmonids by squawfish were low during April, 1992 suggesting the majority of salmonids in the diet were probably juvenile chinook salmon.

The mean monthly consumption rate of all prey fishes by northern squawfish decreased during May (0.32 prey/predator/day; Figure 96). Northern squawfish had a mean monthly consumption rate in May of 0.07 prey/predator/day for juvenile chinook salmon. The mean monthly consumption rate of juvenile steelhead by northern squawfish was highest in May at 0.016 prey/predator/day.

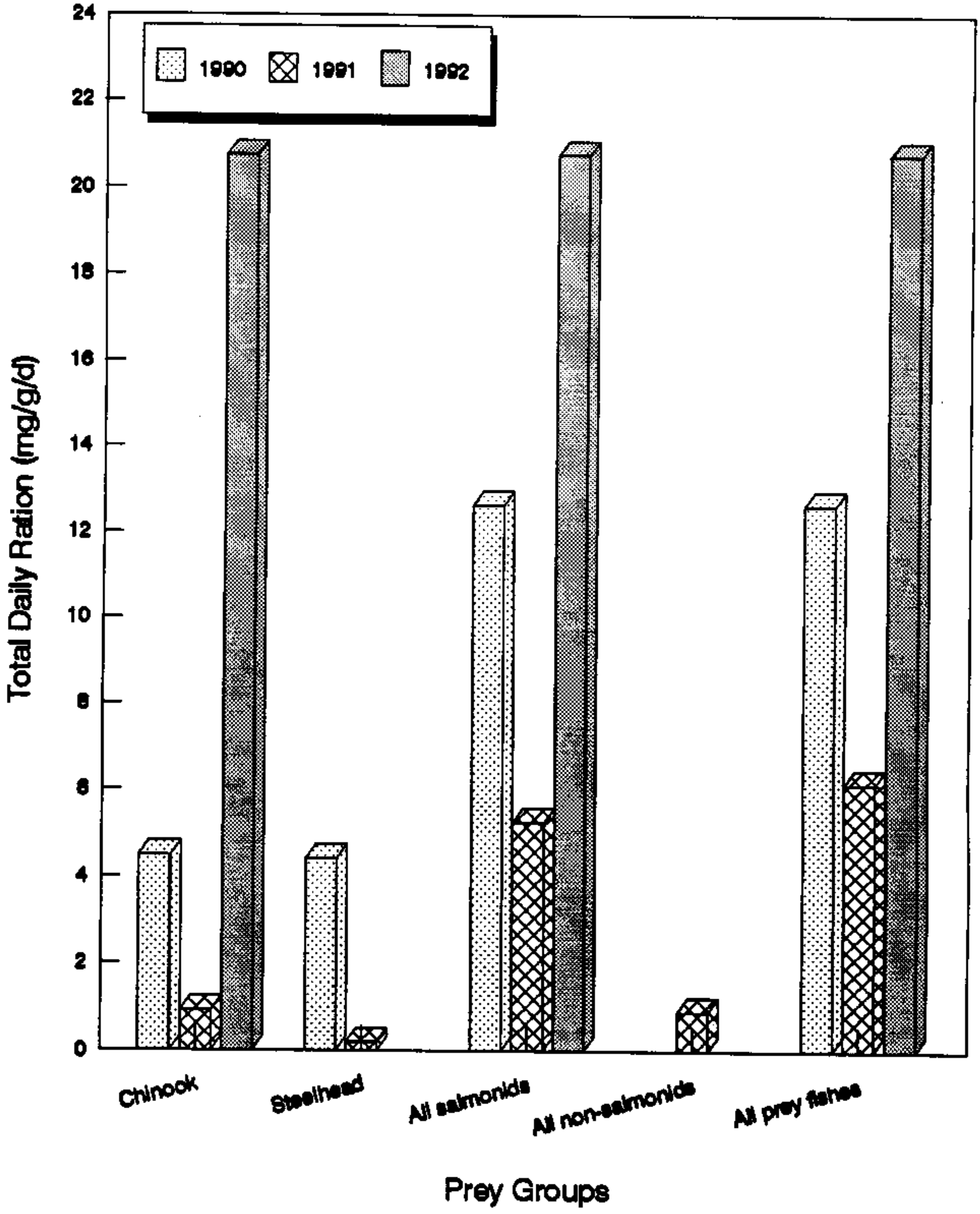


Figure 91. Total daily ration of fishes consumed by northern squawfish during April 1990-1992 in Lower Granite Reservoir.

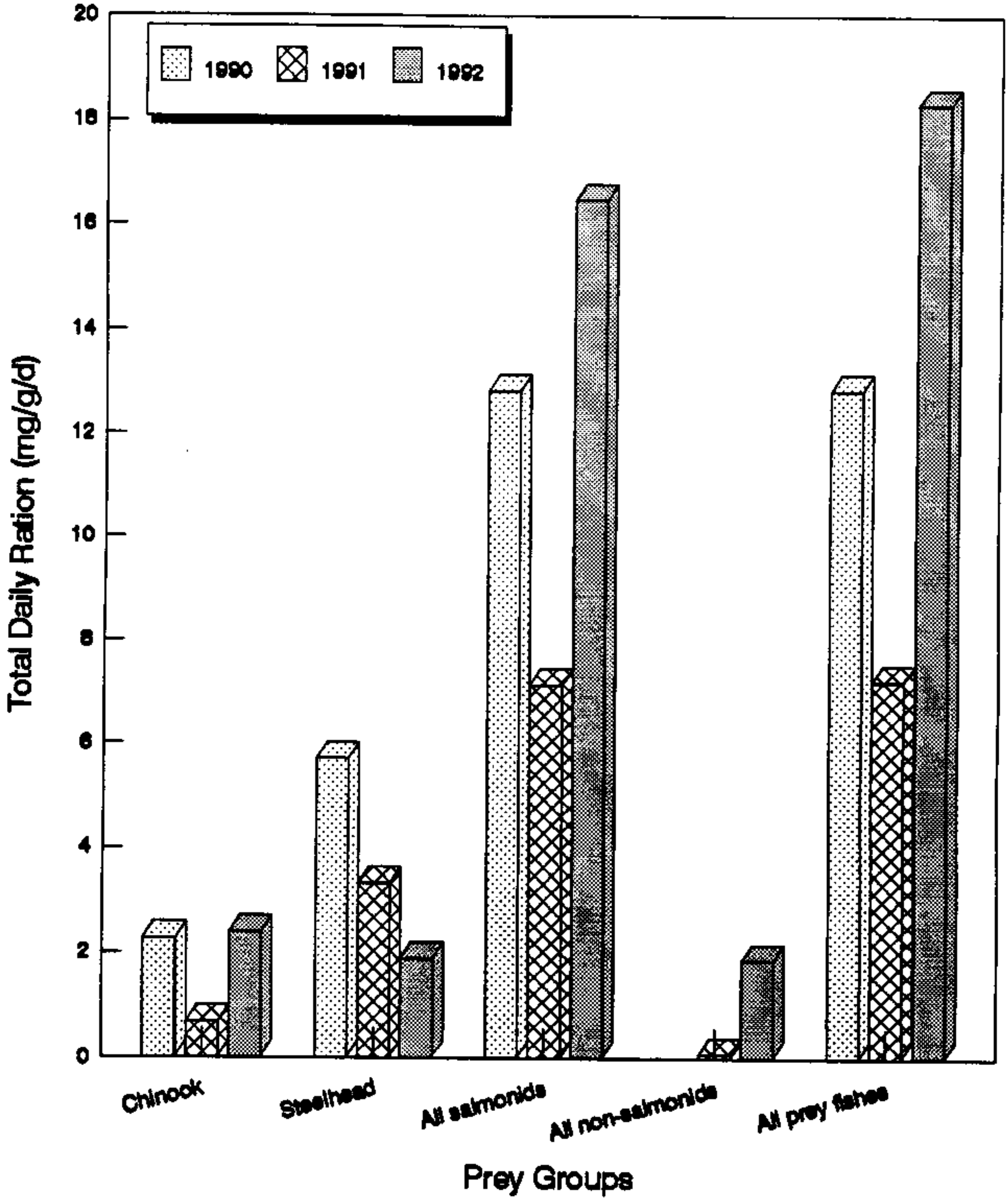


Figure 92. Total daily ration of fishes consumed by northern squawfish during May 1990-1992 in Lower Granite Reservoir.

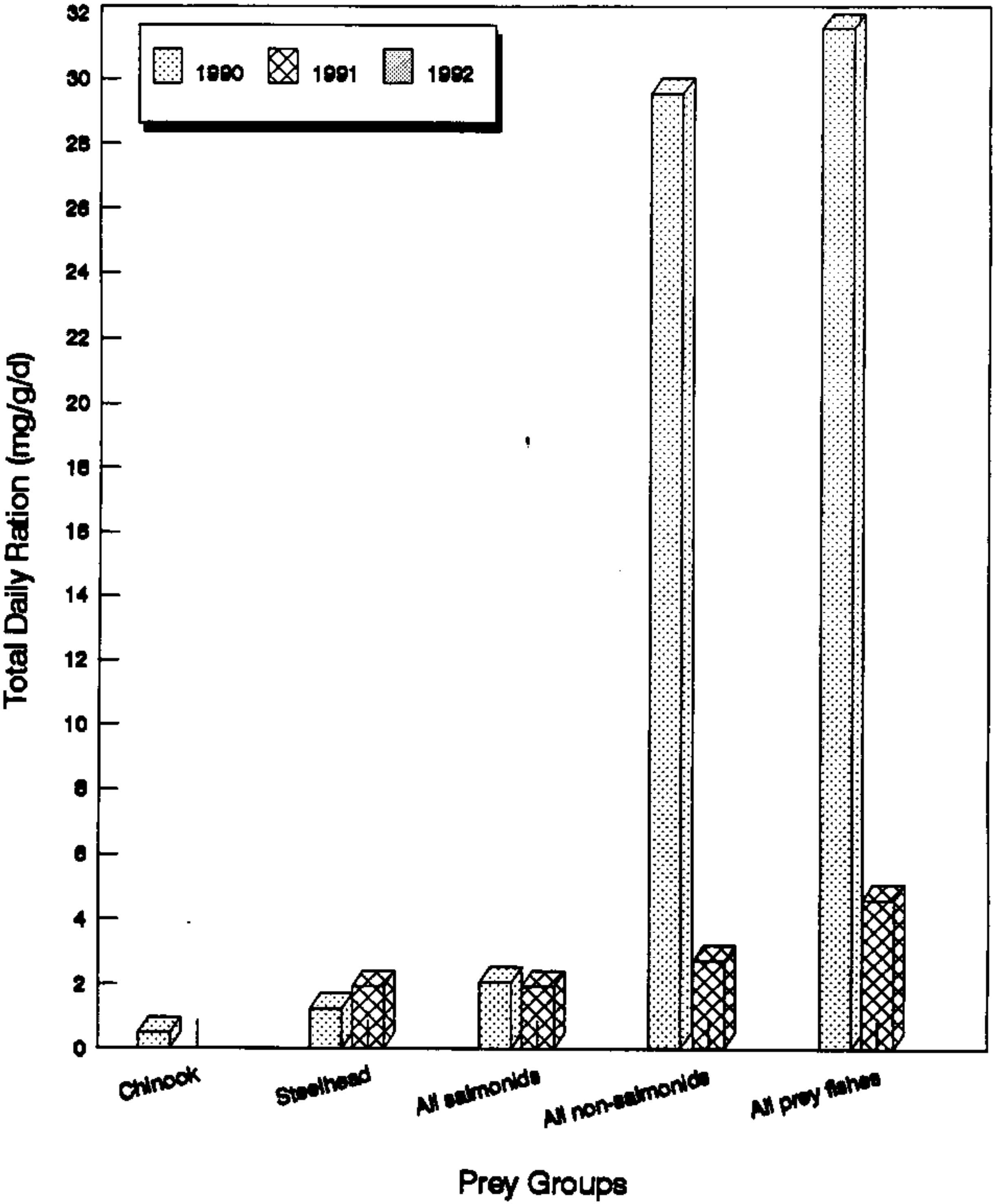


Figure 93. Total daily ration of fishes consumed by northern squawfish during June 1990-1991 in Lower Granite Reservoir.

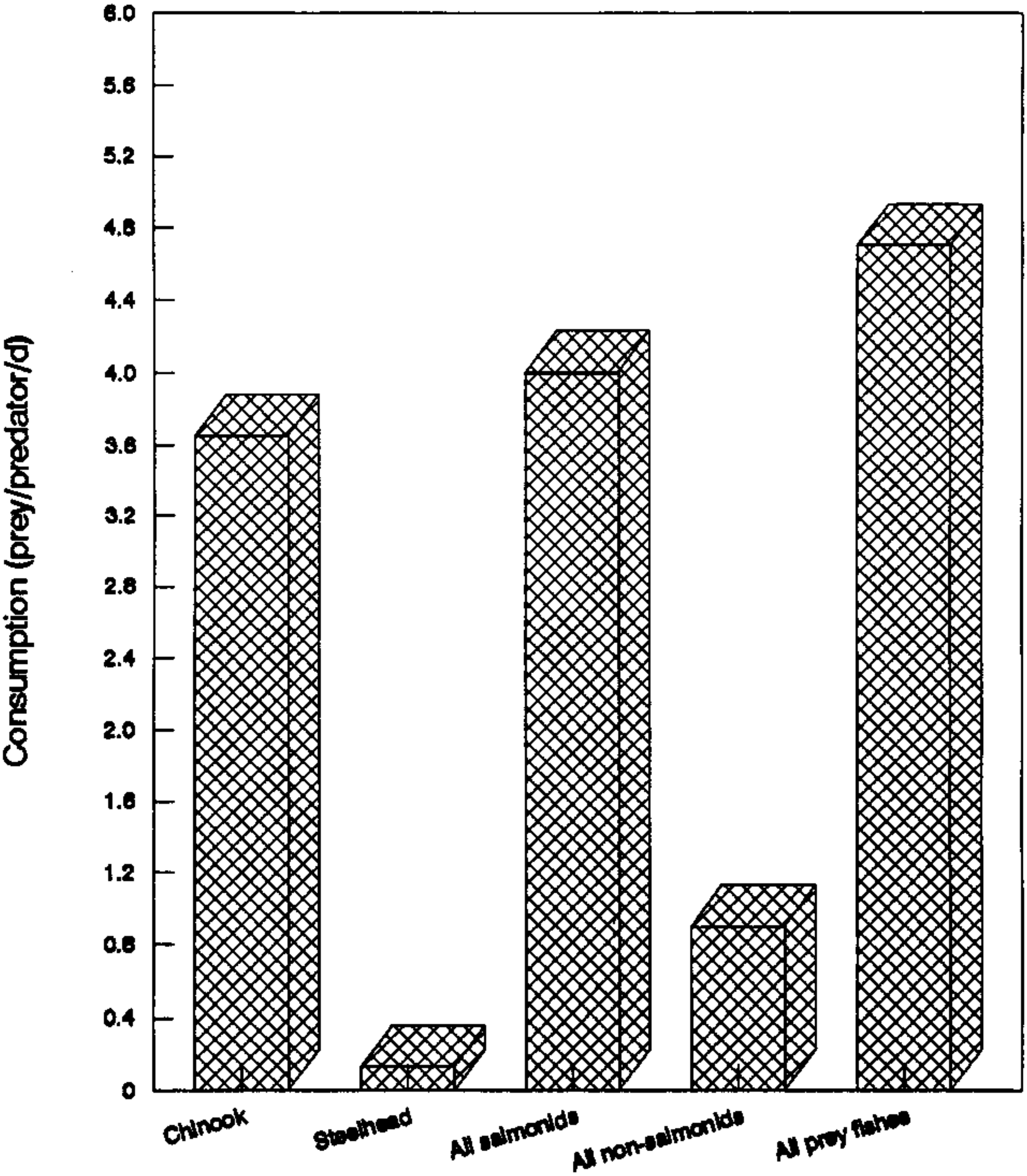


Figure 94. Consumption rates of fishes by northern squawfish during spring 1992 in Lower Granite Reservoir.

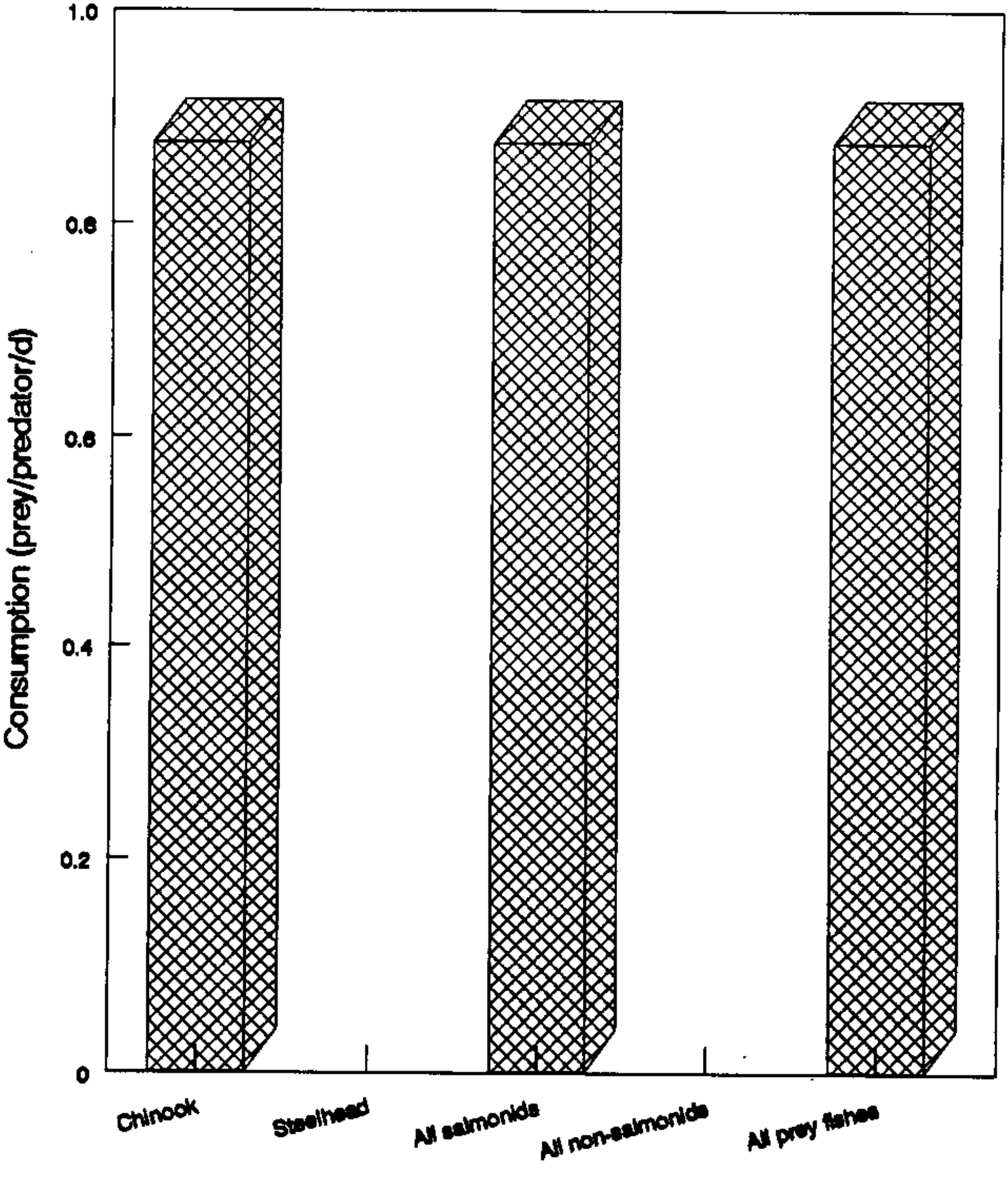


Figure 95. Consumption rates of fishes by northern squawfish during April 1992 in Lower Granite Reservoir.

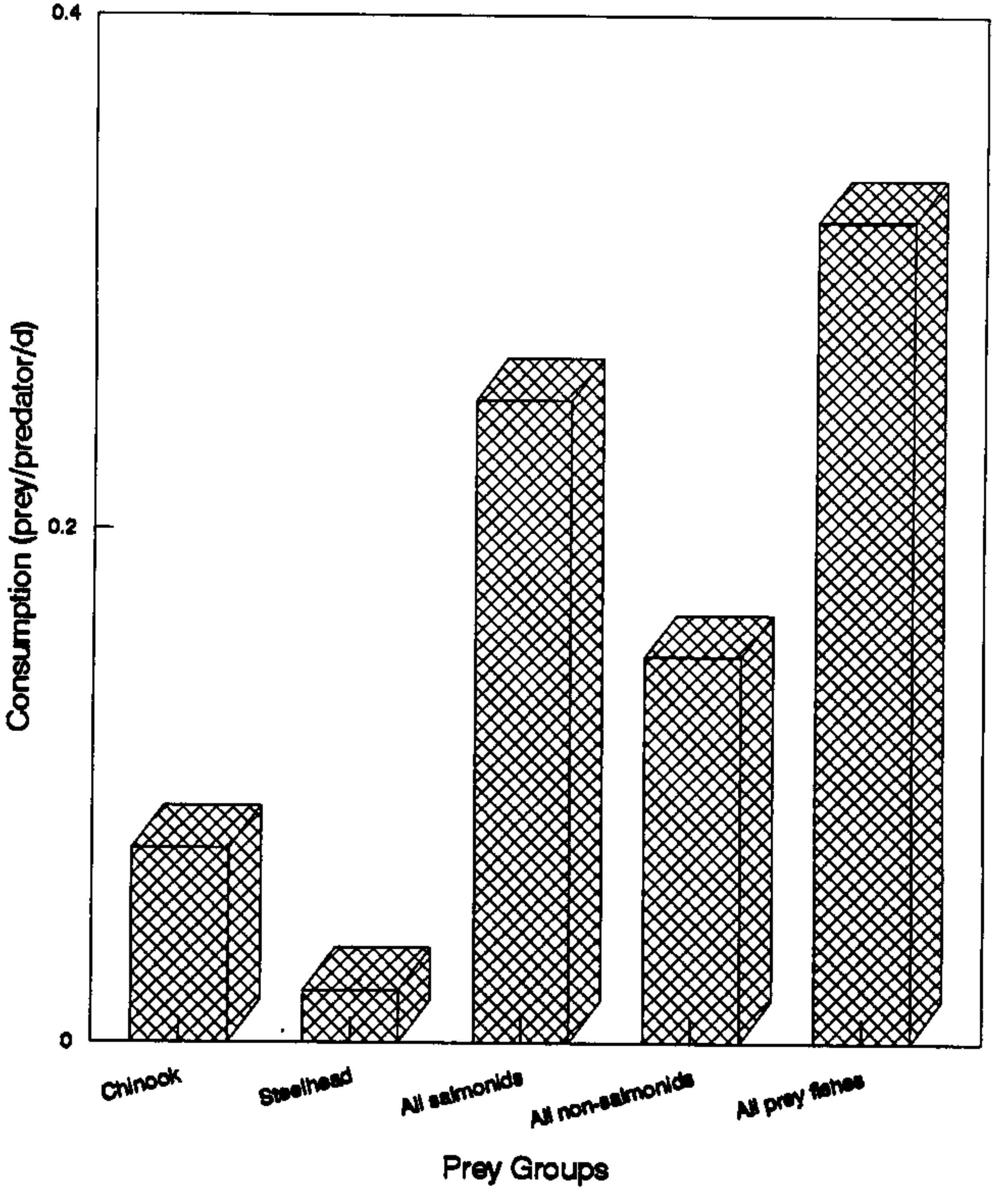


Figure 96. Consumption rates of fishes by northern squawfish during May 1992 in Lower Granite Reservoir.

Based on comparisons of catch/effort with similar gear types from John Day Reservoir (Beamsderfer and Rieman 1988), we used a population size for northern squawfish of 7,500 from RM 112.0 to RM 132.0 to estimate the number of smolts consumed. Using 7,500 squawfish, approximately 197,010 juvenile chinook salmon were consumed during April and approximately 17,414 juvenile chinook salmon were consumed in May. Numbers of steelhead consumed were low in April while an estimated 3,743 steelhead were consumed in May. Combining monthly estimates, the total loss of juvenile chinook salmon and steelhead to northern squawfish consumption during spring 1992 in Lower Granite Reservoir from RM 112.0 to RM 132.0 was 214,424 and 3,743; respectively. Combined losses for both identified and unidentified salmonids to squawfish during spring 1992 was estimated at 254,623 salmonid smolts.

DISCUSSION

Northern squawfish sampled for the presence of salmonids in their stomachs during 1992 were nearly identical in size to those sampled during 1990 and 1991. Mean total length was 390 mm in 1990 compared to 388 mm in 1991 (Bennett et al. 1993b) and 380 mm in 1992. The modal length class of northern squawfish was 350-400 mm for all 3 years. Although the size of predators was similar between 1990, 1991 and 1992, substantial differences were found in overall consumption of salmonids.

Our estimates of salmonid consumption by northern squawfish for 1992 were substantially higher because of differences in the total daily ration. The reason for higher consumption may be attributed to differences in flows through Lower Granite Reservoir (Figures 79-81). Bennett et al. (1994a) reported that during 1990, a year of higher consumption than 1991, flows were generally < 70 KCFS through April, increased in early May, decreased to 40 KCFS during mid-May and then increased substantially in early June (120 KCFS; Figure 79). During spring 1991, when salmonid consumption by northern squawfish was lower than 1990, flows during April were generally < 60 KCFS, increased in mid-May to 80 KCFS and remained at > 70 KCFS through June (Figure 80). However, consumption estimates of salmonids by northern squawfish during 1992 was the highest of the 3 years and may be related to the relatively low flows during April (25 to < 60 KCFS) and May (40 to 70 KCFS; Figure 81).

Objective 6. To assess subyearling chinook salmon abundance, habitat utilization and migration 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 1992. We stratified the reservoir into habitat types based on shoreline characteristics (rip rap, cobble, sand, talus, etc.) and location in the reservoir (up or downstream) and beach seined these similar to methods employed under Objective 1 for juvenile predator sampling. At each of the stations, we determined macrohabitat characteristics (depth, gradient, substrate, cover) associated with abundance of subyearling chinook salmon.

Stomach contents of subyearling chinook salmon > 40 mm were evacuated using a modified gastric lavage (Foster 1977; Dunsmoor 1990) following anesthetization with M.S. 222. A 5 cc syringe with a protected hypodermic needle was inserted through the mouth, down the esophagus to the fish's stomach. Distilled water was then pumped into the stomach flushing the stomach contents out through the mouth where food items were collected in a plankton mesh funnel. The technique enabled collection of food items without sacrificing the fish. Subyearling chinook salmon processed for food habits were retained in an aerated live well for 2 hours to assess mortality. All prey items were preserved in 10% buffered formalin.

Prey items were identified to the lowest practical taxonomic level and classified according to their developmental stage. Prey items were enumerated and individual weights for organisms determined using length-weight relationships (Dunsmoor 1990), or estimates of mean weight per individual (Gains et al. 1992; Hall et al. 1970). Live weight estimates were adjusted for ash and water content, and estimates of calories/g ash free dry weight for individual prey items were used to determine caloric values for food items (Cummins and Wuycheck 1971).

Stomach items were analyzed using an index of caloric importance (ICI) developed by Dunsmoor (1990). The ICI was calculated as follows:

ICI = C x F, where:

C = the percentage that a food category contributed to the total calories of food items in all stomachs, and

F = frequency of occurrence.

Estimates of caloric importance were calculated for all taxonomic groups identified when analyzing stomach contents and for consolidated prey groups. Consolidated prey groups were Diptera, Cladocera, larval fishes, Ephemeroptera, other insects and other items.

A bioenergetics model (Hewett and Johnson 1987) was used to estimate the proportion of maximum ration consumed by the fish over the sample season (P-value). If the P-value is 1, the fish is feeding at its maximum rate based on its size and the water temperature (Hewett and Johnson 1987). Average monthly total length (mm), weights (g), prey caloric values and water temperatures (°C) were used in the model.

RESULTS

A total of 330 subyearling chinook salmon was captured by beach seining between 10 April through 28 May, 1992 in Lower Granite Reservoir. No subyearling chinook salmon were collected in littoral areas after 28 May, 1992. The highest catch/effort by beach seining in 1992 occurred on 15 May. One hundred and fourteen of the 146 (78%) subyearlings sampled on 15 May occurred at river miles 137.5, 132.0, 130.5 and 123.0 during four of the 42 beach seine hauls. A majority of the subyearling chinook salmon collected in Lower Granite was captured in the upper portion of the reservoir (Figure 97). No subyearling chinook salmon were sampled downstream of RM 120.

A total of 305 subyearling chinook salmon (92%) was captured over substrates that consisted of > 75% fines (< 2 mm in diameter), whereas 100% of subyearling chinook salmon were captured over substrates that consisted of > 75% fines and gravels/talus and fines/cobble (< 50 mm in diameter). All subyearling chinook collected throughout Lower Granite Reservoir were associated with either a sand (92%), sand/talus (5.5%), or sand/cobble substrate (2.5%; Figure 98). Three years of beach seining data indicate 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 (Figure 99). Juvenile chinook salmon exhibited a strong avoidance of rip-rap habitat.

A total of 292 subyearling chinook salmon stomachs was examined from Lower Granite and Little Goose reservoirs during 1991 and 1992.

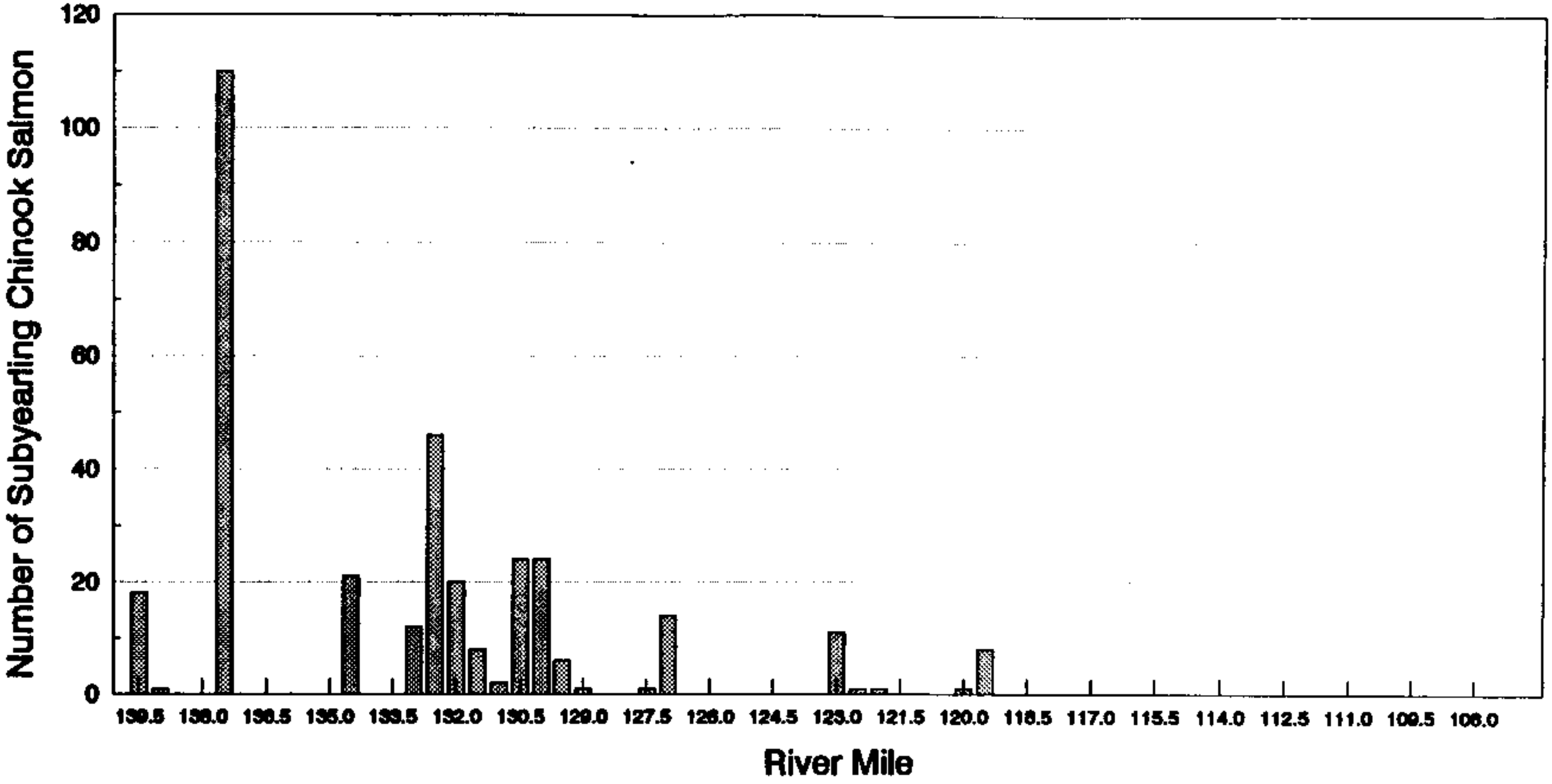


Figure 97. Number of subyearling chinook salmon collected at various locations during 1992 in Lower Granite Reservoir.

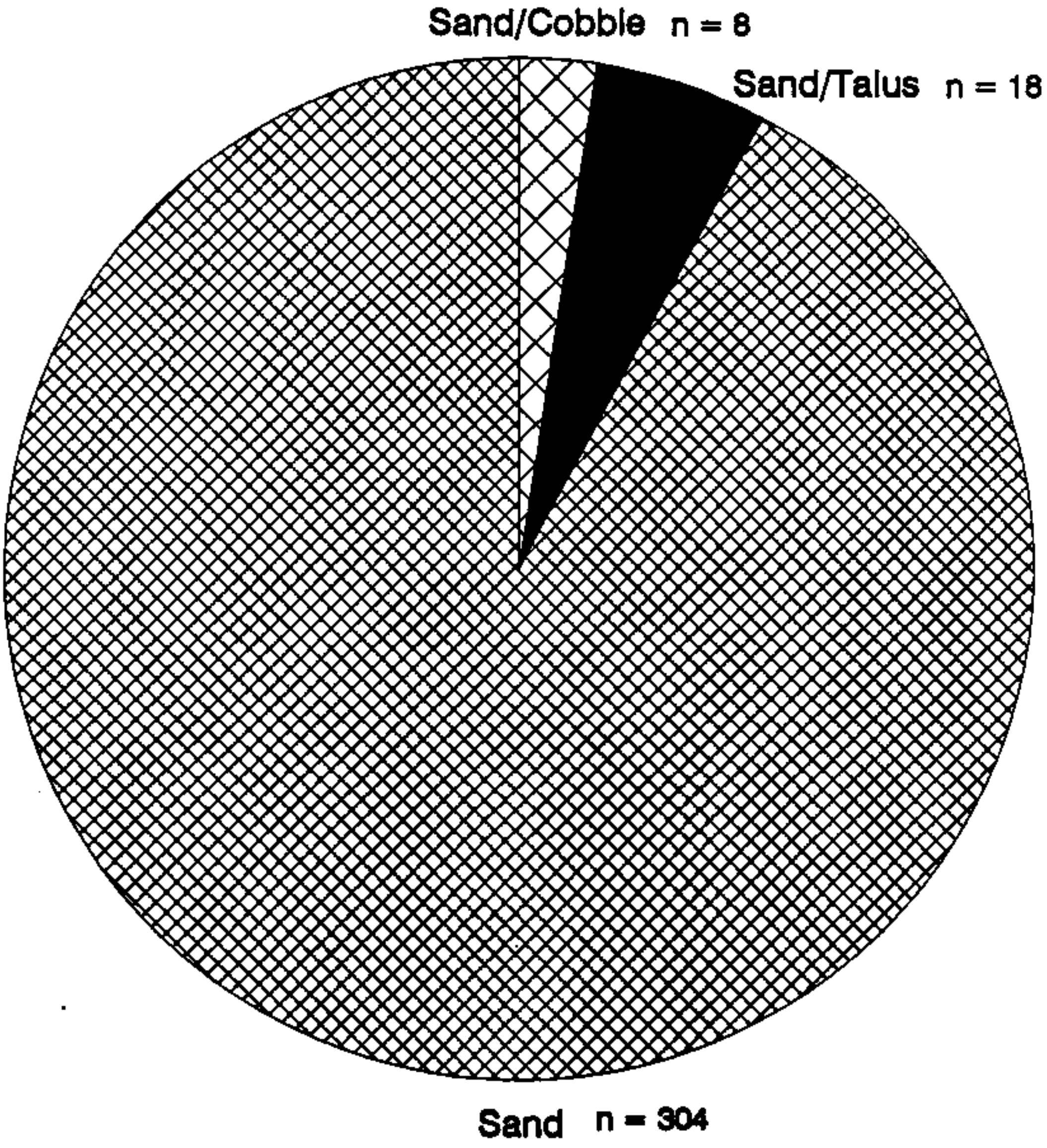


Figure 98. Habitat use and abundance of subyearling chinook salmon sampled by beach seining during 1992 in Lower Granite Reservoir.

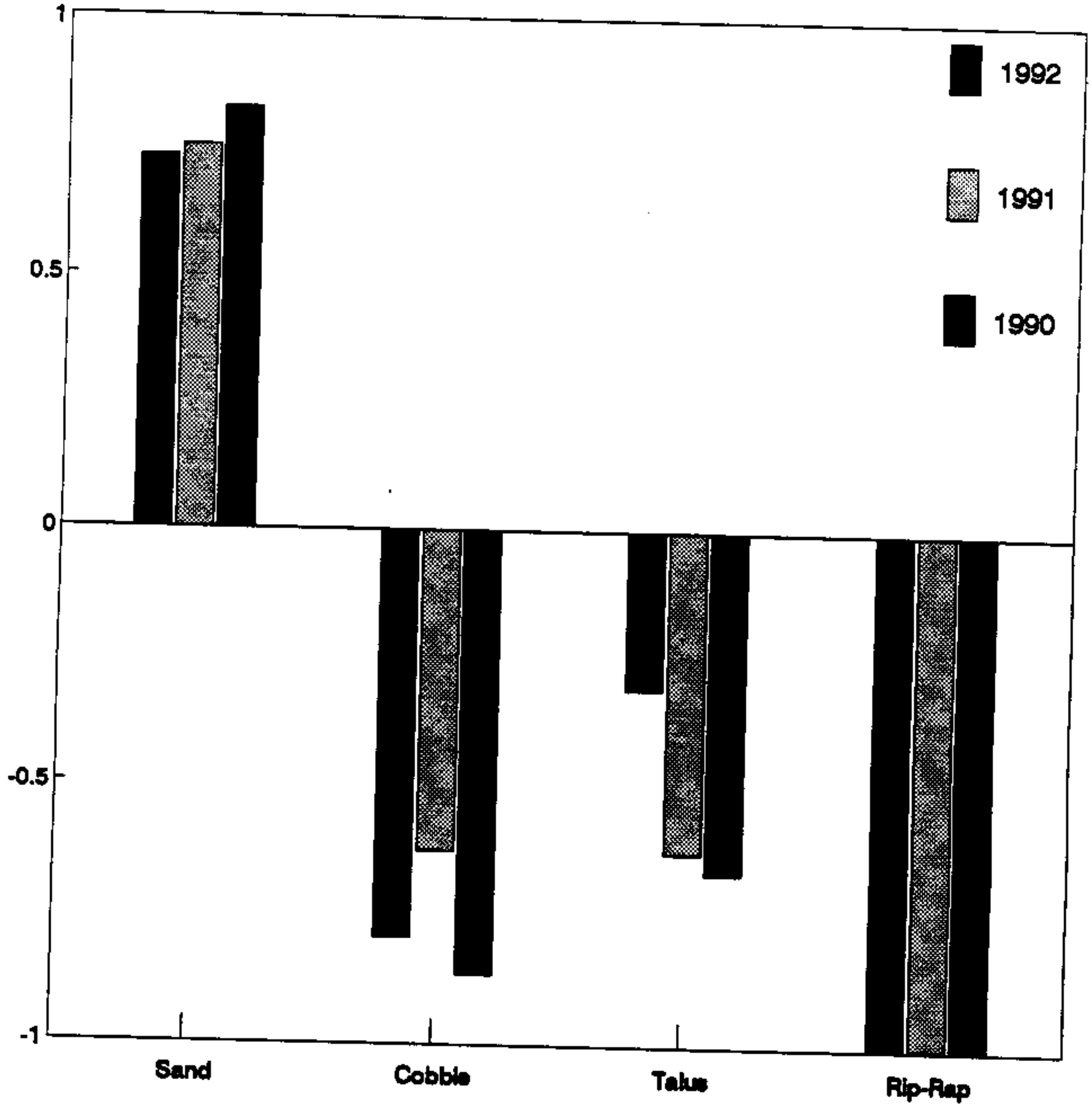


Figure 99. Selectivity of habitats by subyearling chinook salmon sampled by beach seining in Lower Granite Reservoir as determined using Jacob's utilization index.

Stomachs that were sampled from Lower Granite and Little Goose reservoirs during 1991 and 1992 were combined due to low numbers sampled within years and reservoirs.

Thirty-one different prey items were identified (Table 8). Four prey items numerically accounted for 96% of all prey items that occurred in the stomachs. Cladocera, primarily Daphnia, were the dominant food items (46%) ingested and occurred in 43% of the stomachs followed by Diptera, primarily Chironomidae and Simulidae, which accounted for 38% of the prey items and occurred in 84% of the stomachs. Ephemeroptera, primarily Baetidae, and Homoptera, primarily Aphididae, accounted for 7% and 4% of the ingested prey items occurring in 35% and 33% of the stomachs, respectively (Table 8).

Four prey items accounted for 87% of all prey items occurring in the stomachs by weight (dry weight, mg). Ephemeroptera and Diptera accounted for 33% and 25% of the prey items, respectively. Larval fishes accounted for 21% of the prey items by weight occurring in 4% of the stomachs, while Cladocera accounted for 11% of all prey items (Table 8).

Four prey items accounted for 89% of the total calories ingested by subyearling chinook. Ephemeroptera, Diptera, Cladocera and larval fishes provided 37%, 24%, 10% and 18% of the total calories ingested, respectively. Estimates of caloric importance indicate that Chironomidae/Simulidae, Ephemeroptera and Cladocera are the most important contributors to the diet of subyearling chinook salmon (Table 9). The mean value of caloric intake exhibited by subyearling chinook

Table 8. Stomach contents of 292 subyearling chinook salmon collected during the spring 1991-1992 in Lower Granite and Little Goose reservoirs.

Prey Group	Number	Frequency	% Number	Dry Weight (mg)	% Dry Weight	Calories	% Calories
Collembola	6	5	0.0006	1.0636	0.0012	6.1	0.0012
Chironomidae/Simuliidae	4,516	246	0.3841	232.8146	0.2523	1,190.1	0.2428
Cecidomyiidae	46	19	0.0039	0.5260	0.0006	2.5	0.0005
Ceratopogonidae	3	1	0.0003	0.0210	0.0000	0.1	0.0000
Coleoptera	1	1	0.0001	0.4700	0.0005	2.2	0.0004
Drosophilidae	2	1	0.0002	0.0400	0.0000	0.2	0.0000
Empididae	1	1	0.0001	0.0100	0.0000	0.0	0.0000
Sciaridae	1	1	0.0001	0.0060	0.0000	0.0	0.0000
Ephemeroptera	858	101	0.0730	307.3715	0.3331	1,849.2	0.3773
Homoptera	482	97	0.0410	31.3687	0.0340	159.9	0.0326
Cicadellidae	12	9	0.0010	0.6620	0.0007	3.4	0.0007
Isoperla	4	4	0.0003	0.2500	0.0003	1.3	0.0003
Hodotermitidae	1	1	0.0001	0.0100	0.0000	0.1	0.0000
Odonata	1	1	0.0001	0.8500	0.0009	4.7	0.0009
Hymenoptera	22	16	0.0019	4.2996	0.0047	24.4	0.0050
Plecoptera	3	3	0.0003	1.8800	0.0020	9.8	0.0020
Psocoptera	1	1	0.0001	0.0200	0.0000	0.1	0.0000
Thysanoptera	16	8	0.0014	0.3110	0.0003	1.6	0.0003
Thripidae	4	4	0.0003	0.0290	0.0000	0.1	0.0000
Trichoptera	20	14	0.0017	6.3360	0.0069	30.4	0.0062
Uknown Insects	38	11	0.0032	1.1174	0.0012	5.6	0.0011
Insect Parts	72	65	0.0061	14.8000	0.0160	74.6	0.0152
Amphipoda	10	6	0.0009	3.4296	0.0037	13.4	0.0027
Annelida	10	6	0.0009	3.0600	0.0033	14.2	0.0029
Araneae	5	4	0.0004	0.5700	0.0006	2.7	0.0005
Copepoda	11	9	0.0009	1.1660	0.0013	6.4	0.0013
Cladocera	5,426	126	0.4616	102.3934	0.1110	503.9	0.1028
Hirudinea	1	1	0.0001	3.7800	0.0041	18.5	0.0038
Hydracarina	66	36	0.0056	0.2343	0.0003	1.2	0.0002
Isopoda	76	35	0.0065	31.7780	0.0344	90.1	0.0184
Larval Fish	41	11	0.0035	172.2000	0.1866	884.6	0.1805
Total				922.8575		4,901.4	

Table 9. Food habits and resulting index calculations from 292 subyearling chinook salmon stomachs collected during spring 1991-1992 in Lower Granite and Little Goose reservoirs.

Prey Group	Frequency	% Number	% Frequency	% Dry Weight	% Calories	I.C.I.	% I.C.I.
Collembola	5	0.0005	0.0059	0.0012	0.0012	7.38500E-06	0.0001
Chironomidae/Simuliidae	246	0.3841	0.2911	0.2523	0.2428	0.07089	0.5068
Cecidomyiidae	19	0.0039	0.0225	0.0006	0.0005	1.16860E-05	0.0001
Ceratopogonidae	1	0.0003	0.0012	0.0000	0.0000	2.50000E-08	0.0000
Coleoptera	1	0.0001	0.0012	0.0005	0.0004	5.20000E-07	0.0000
Drosophilidae	1	0.0002	0.0012	0.0000	0.0000	4.70000E-08	0.0000
Empididae	1	0.0001	0.0012	0.0000	0.0000	1.20000E-08	0.0000
Sciaridae	1	0.0001	0.0012	0.0000	0.0000	6.00000E-09	0.0000
Ephemeroptera	101	0.0730	0.1195	0.3331	0.3773	0.04510	0.3233
Homoptera	97	0.0410	0.1148	0.0340	0.0326	0.00375	0.0269
Cicadellidae	8	0.0010	0.0095	0.0007	0.0007	6.52100E-06	0.0000
Isoperla	4	0.0006	0.0047	0.0003	0.0003	1.23100E-06	0.0000
Hodotermitidae	1	0.0001	0.0012	0.0000	0.0000	1.20000E-08	0.0000
Odonata	1	0.0001	0.0012	0.0000	0.0000	1.12400E-06	0.0000
Hymenoptera	18	0.0019	0.0213	0.0047	0.0050	0.00011	0.0008
Plecoptera	3	0.0003	0.0036	0.0029	0.0020	6.94400E-06	0.0000
Psocoptera	1	0.0001	0.0012	0.0000	0.0000	2.50000E-08	0.0000
Thysanoptera	8	0.0014	0.0095	0.0003	0.0000	3.06300E-06	0.0000
Thripidae	4	0.0003	0.0047	0.0000	0.0000	1.43000E-07	0.0000
Trichoptera	14	0.0017	0.0166	0.0068	0.0062	0.00010	0.0007
Uknown Insects	11	0.0032	0.0130	0.0012	0.0011	1.49680E-05	0.0001
Insect Parts	65	0.0061	0.0769	0.0160	0.0152	0.00117	0.0084
Amphipoda	6	0.0009	0.0071	0.0037	0.0027	1.93890E-05	0.0001
Annelida	6	0.0009	0.0071	0.0033	0.0029	2.06030E-05	0.0001
Araneae	4	0.0004	0.0047	0.0006	0.0005	2.58800E-06	0.0000
Copepoda	9	0.0009	0.0107	0.0013	0.0013	1.40000E-05	0.0001
Cladocera	126	0.4618	0.1491	0.1110	0.1026	0.01533	0.1099
Hirudinea	1	0.0001	0.0012	0.0041	0.0036	4.46100E-06	0.0000
Hydracarina	36	0.0058	0.0426	0.0003	0.0002	1.01370E-05	0.0001
Isopoda	35	0.0065	0.0414	0.0344	0.0184	0.00076	0.0055
Larval Fish	11	0.0035	0.0130	0.1866	0.1805	0.00235	0.0168

increased substantially over the course of the sample period (April-July; Figure 100).

Estimates of caloric relative importance by group indicated that Dipterans, Ephemeropterans, and other insects were important prey items (Table 10). Monthly comparisons of percent caloric contribution of prey items to subyearling chinook diets indicated Dipterans contributed substantially to subyearling diets in April and became less important during the summer (Figure 101). Ephemeropterans increased in importance from April to June and constituted about half of the total ingested calories by June. Their importance decreased substantially in July, however, when larval fishes constituted 89% of the total calories ingested. Before July, larval fishes had contributed little to the total number of calories ingested. Cladocera was the dominant prey item present in stomachs in May, although they contributed only a small portion of the ingested calories during April, June and July. Dipterans were the most numerous prey item eaten during April, June and July.

Comparisons of percent caloric and numeric contribution of prey items to subyearling chinook salmon diets for four size classes of subyearling chinook salmon indicated that for 40-55 mm fish, Ephemeropterans were calorically the most important food item (43%) followed by Cladocera (28%; Figure 102). Ephemeropterans were important to subyearling diets for all size classes, although less for the largest subyearlings (<30%). Dipterans contributed substantially to the caloric intake of 56-70 mm and 71-85 mm size classes (27% and 39%, respectively), however they contributed to > 3% of the diets of 40-55 mm

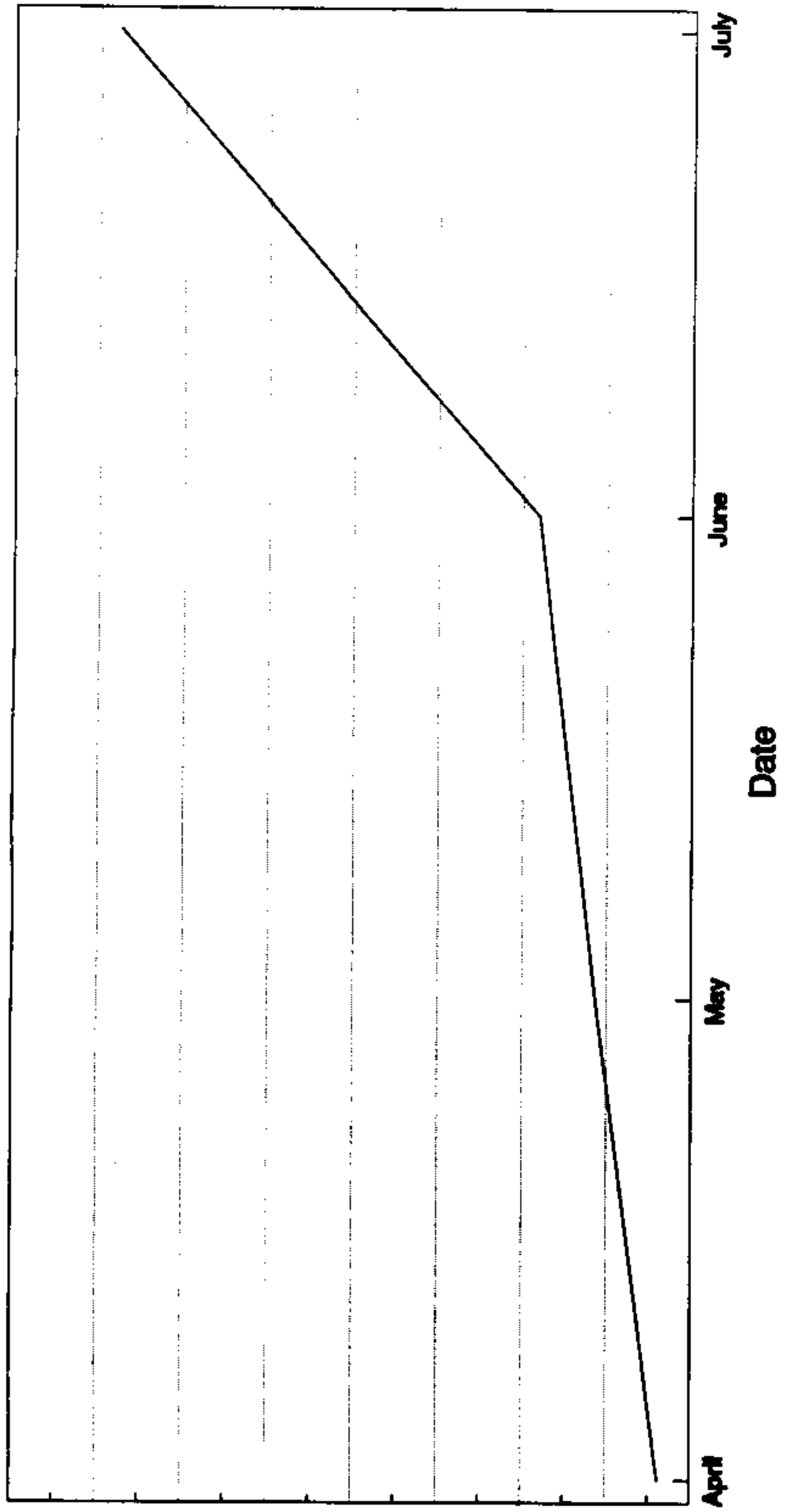


Figure 100. Mean monthly calories ingested by subyearling chinook salmon during spring 1991-1992 in Lower Granite and Little Goose reservoirs.

Table 10. Food habits and resulting index calculations after prey group consolidation from 292 subyearling chinook salmon collected during spring 1991-1992 in Lower Granite and Little Goose reservoirs.

	Number	Frequency	% Number	% Frequency	% Dry Weight	% Calories	I.C.I.	% I.C.I.
Diptera	4,589	269	0.3895	0.3168	0.2328	0.2433	0.0771	0.4781
Ephemeroptera	858	101	0.0730	0.1190	0.3329	0.3771	0.0449	0.2771
Larval Fish	41	11	0.0035	0.0130	0.1685	0.1804	0.0023	0.0144
Other *	184	101	0.0156	0.1190	0.0463	0.0304	0.0036	0.0224
Other Insects *	683	241	0.0581	0.2839	0.0697	0.0661	0.0188	0.1159
Cladocera	5,428	128	0.4614	0.1484	0.1109	0.1028	0.0153	0.0942
Totals	11,781	849						

* Other items were Amphipopds, Annelida, Araneae, Copepoda, Cladocera, Hirudinea, Hydracarina and Isopods. Other insects were Homopterans, Isoperla, Coleoptera, Odonata, Hymenoptera, Plecoptera, Thysanoptera, Collembola, Trichoptera, unknown insects and insect parts.

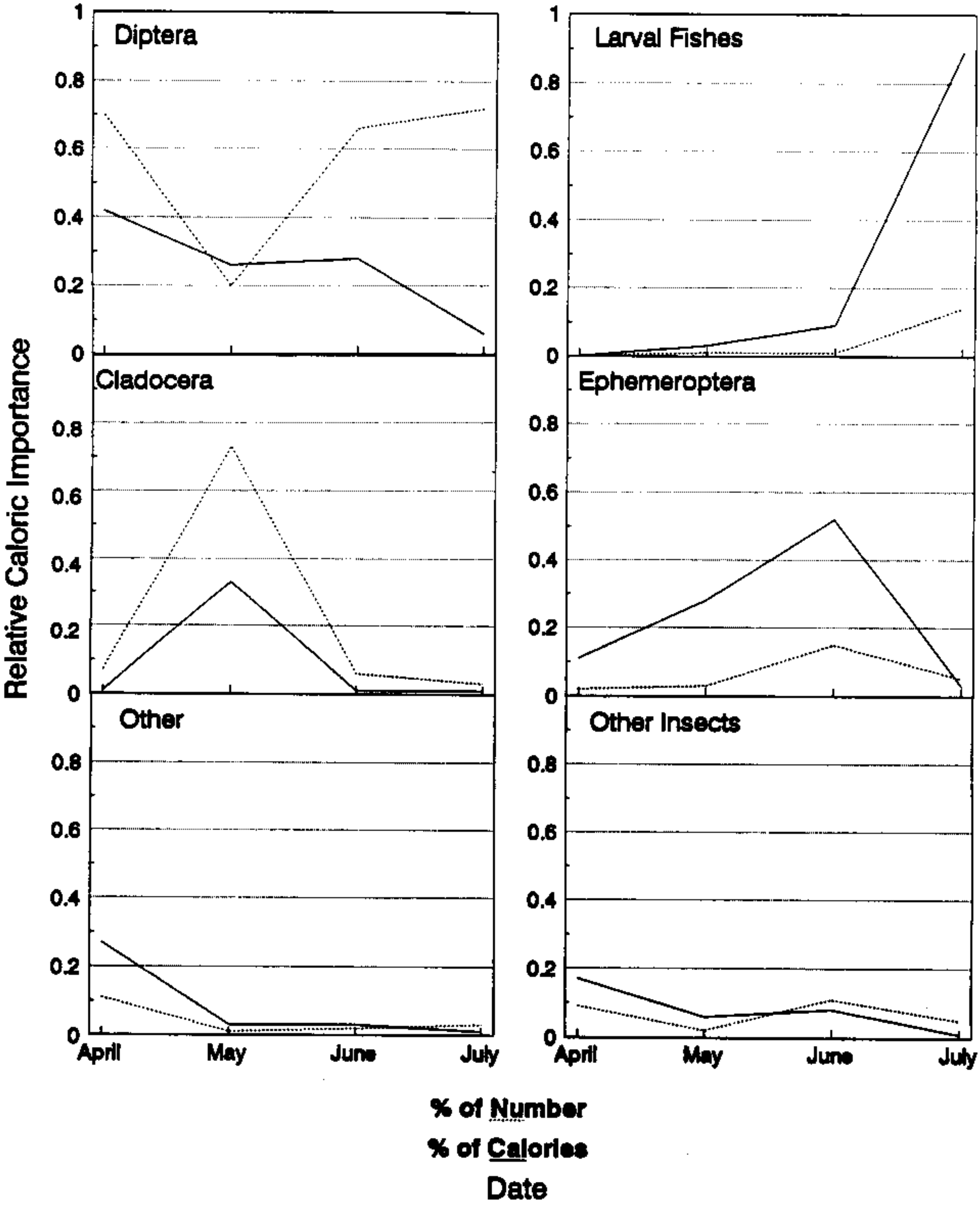


Figure 101. Relative caloric importance of major food items by month of subyearling chinook salmon collected during April through July, 1991-1992 in Lower Granite and Little Goose reservoirs.

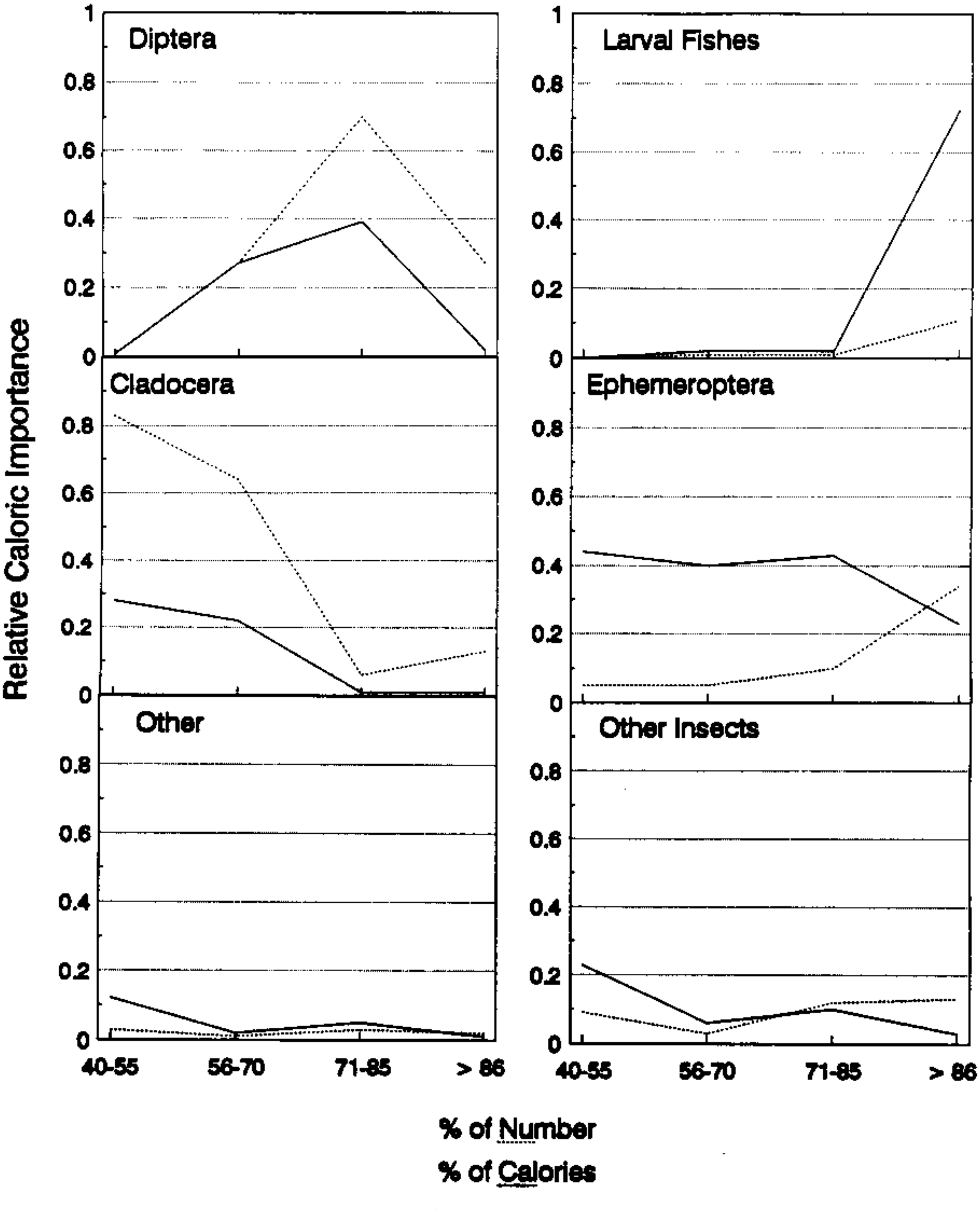


Figure 102. Relative caloric importance of major food items by size class for subyearling chinook salmon collected during April through July, 1991-1992 in Lower Granite and Little Goose reservoirs.

and > 86 mm size classes. Calorically, larval fishes were the most important prey item in the diet of fish > 86 mm constituting 72% of the diet. Cladocera contributed primarily to the diets of the 40-55 mm size class and their caloric importance consistently decreased for each of the larger size classes. Cladocera were the most numerically abundant prey item present in stomachs of 40-55 mm and 56-70 mm fish.

The estimated average proportion of maximum consumption (P-value) fitted to observed monthly growth was 0.274 for the combined April to July 1991-1992 samples. The P-value for a maintenance ration (zero growth) was estimated at 0.20 using the same prey caloric values and water temperatures.

DISCUSSION

A total of 330 subyearling chinook salmon was sampled by beach seining between 10 April through 28 May 1992. The highest catch/effort occurred on 15 May. No subyearling chinook were collected during June 1992 in Lower Granite Reservoir.

Abundance of subyearling chinook salmon varied among areas in Lower Granite Reservoir. No subyearlings were sampled along the shoreline downstream of RM 120. Abundance was highest in early May and differed little from late April through mid-May (Curet 1994). Our sampling on 27 May indicated few subyearlings remained along the shoreline. The early movement of subyearlings offshore in Lower Granite Reservoir does not appear to be size related (Figure 103). Curet (1994) found that lengths of subyearling chinook captured along the shoreline

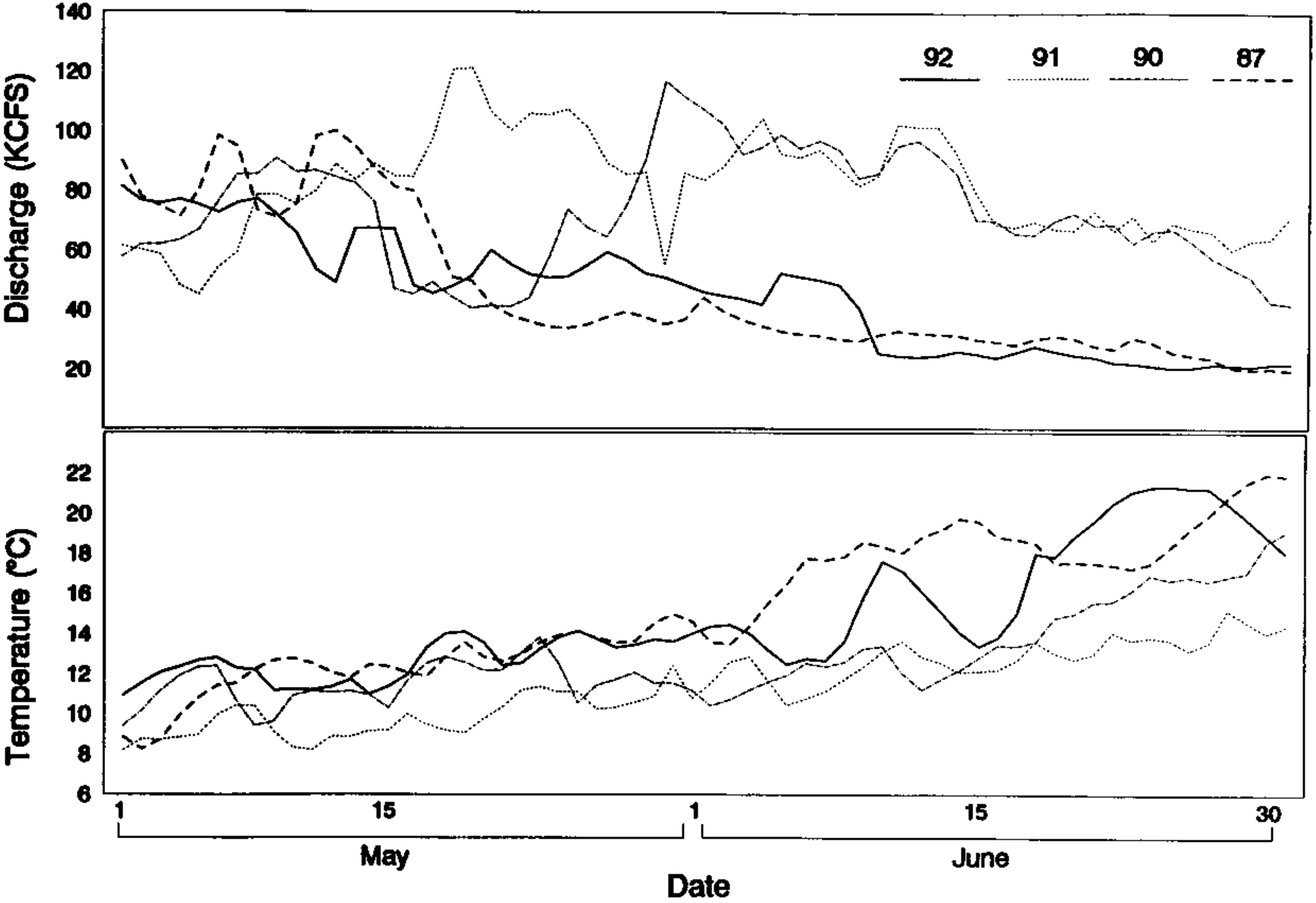


Figure 103. Weighted mean temperatures and discharges during 1987, 1990, 1991 and 1992 from the Snake and Clearwater rivers.

of the reservoir were similar during years of collection, although migration times were different suggesting size does not dictate or initiate movement.

The peak abundance and duration of rearing of subyearling chinook salmon along the shoreline of Lower Granite Reservoir appears to be related to both water temperature and discharges from the Snake and Clearwater rivers and to shoreline temperatures in the reservoir. During 1987 and 1992, years of low river discharge and higher water temperatures (Figure 104), earlier peaks in shoreline abundance and an earlier movement of subyearlings offshore occurred, possibly a result of excessively warm rearing conditions along the shoreline (Curet 1994). During 1990 and 1991, years of higher river discharge and lower water temperatures, rearing conditions along the shoreline appeared suitable until mid- to late June. Except for 1992, subyearling chinook migrated from the shoreline once shoreline reservoir temperatures approached and remained > 18°C (Figure 105). In 1992, subyearlings left the shoreline of the reservoir at 17°C, although temperatures declined to 16°C for a short period after their disappearance.

Sand and mud/sand were substrates over which subyearling chinook salmon were most commonly collected. Some subyearling chinook salmon were collected over cobble and talus but to a much lesser extent than either sand and mud/sand. The reason for high abundance of subyearling chinook salmon over sand and mud/sand substrates is not clear. Increased food availability may be important (Curet 1994). Also, sand and mud/sand substrates are characteristic substrates in areas of

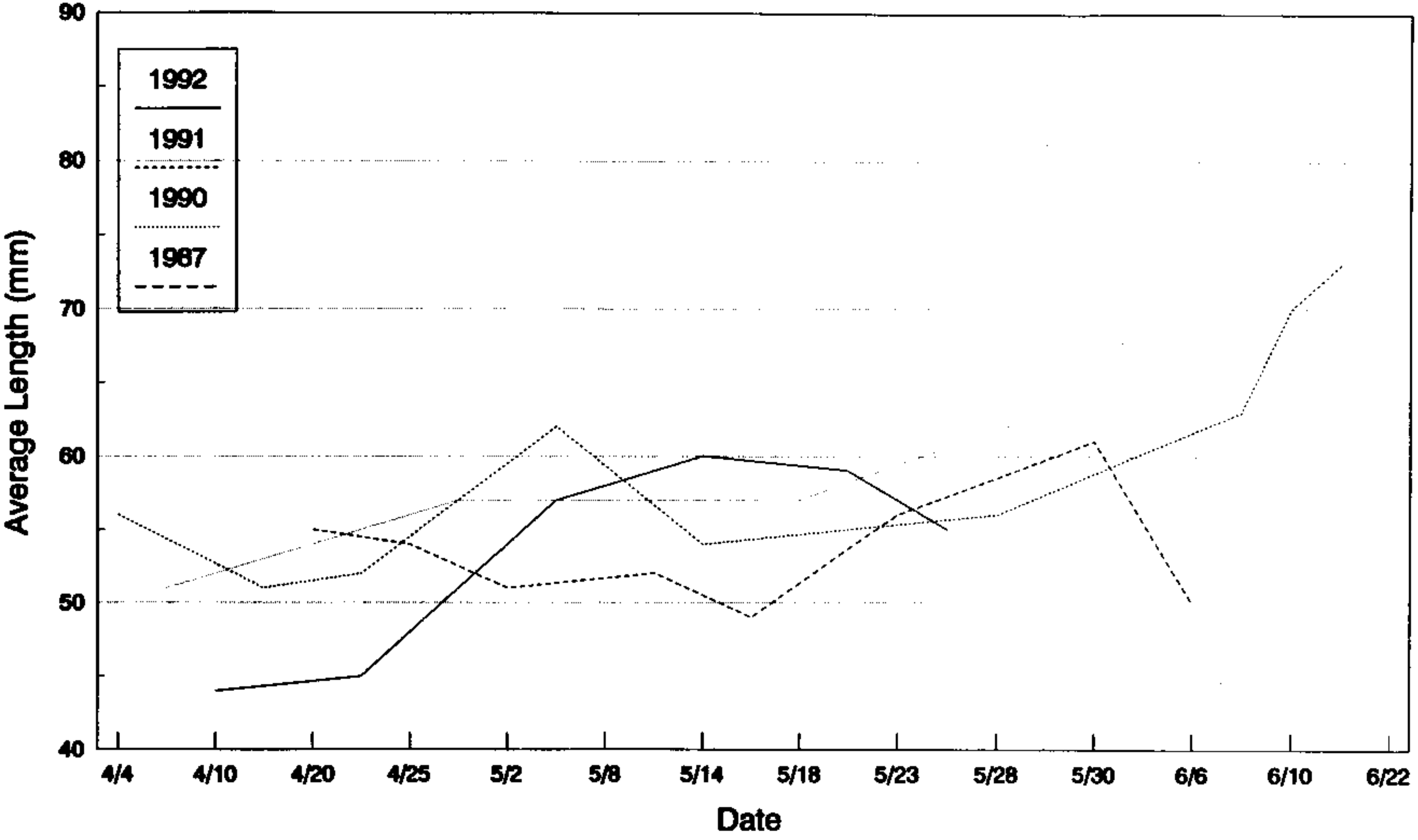


Figure 104. Average lengths of subyearling chinook salmon during 1987, 1990, 1991 and 1992 in Lower Granite Reservoir.

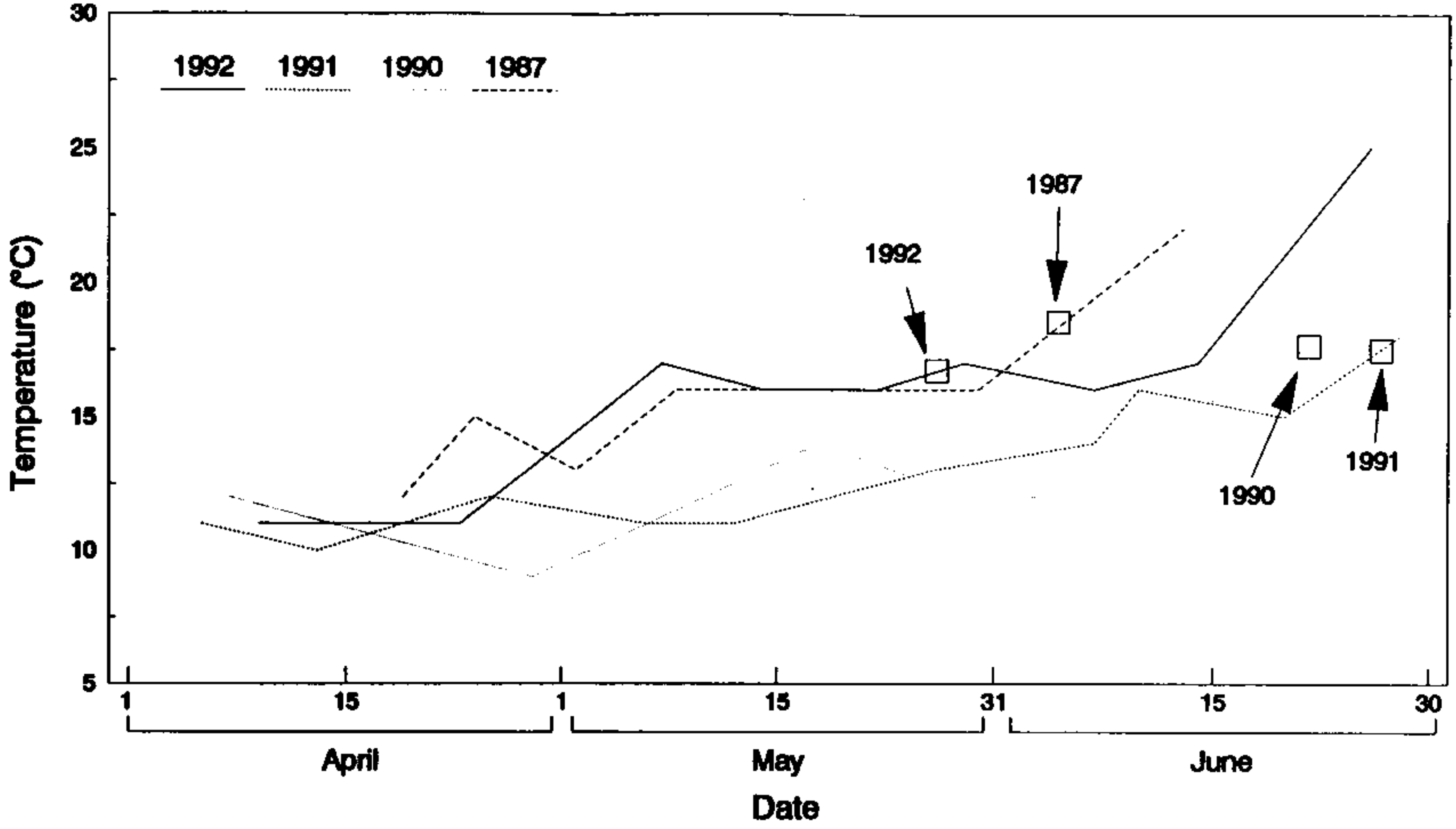


Figure 105. Mean shoreline temperatures during 1987, 1990, 1991 and 1992 in Lower Granite Reservoir. Squares depict disappearance of subyearling chinook salmon from the shoreline.

reduced velocities. The importance of low velocities may be actually more significant in influencing rearing potential than the prevailing substrate.

We found differences in the use of prey items by month and size of subyearling chinook salmon. These differences may be attributed to the abundance and availability of prey items, the size of prey items, and the size of the fish.

Availability of prey items has been suggested as an important factor in determining the utilization of specific prey items (Dauble et al. 1980). Rondorf et al. (1990) indicated the shift in diet by subyearlings to smaller, less preferred Daphnia species in embedments on Lake Wallula, Columbia River, Washington, may be a result of the Cladocerans' higher densities and ease of capture in embedments. In the lower Snake River reservoirs, the importance of Cladocera to subyearling chinook diets was most apparent in May and in the 40-55 mm length class. The almost complete absence of Cladocera in the diets of subyearlings in April may be a result of their reduced availability. In early spring relatively few Cladocerans are found in lakes and ponds, but as temperatures increase more reproduction occurs and larger populations result (Pennak 1978). Furthermore, the turbulence of water movement and grinding effect of suspended material generally precludes high zooplankton densities in free-flowing rivers (Funk et al. 1979), a situation that could occur in Lower Granite Reservoir during high April flows. Although conclusive evidence is lacking on the timing and abundance of zooplankton in the spring in Lower Granite Reservoir, recent sampling efforts (Bennett et al. 1993b, unpublished data) indicate an increase in zooplankton abundance during the spring and summer, coinciding with importance of Cladocera to subyearling diets in May.

The reduced importance of Cladocerans to subyearling salmon diets in June and July may be related to their body size. The maximum size a food particle consumed by a fish generally increases as the size of the fish grows (Becker 1970), so as the length of subyearlings during the spring increases, the larger migrants may consume larger prey with higher energy content.

The availability of the most important insects (Chironomids and Ephemeropterans) and larval fishes to the diets of subyearling chinook salmon generally coincided with the peak seasonal abundance of insects (Dorband 1980) and larval fishes (Bennett et al. 1993b). Chironomid species in Lower Granite Reservoir generally peak in the late spring or early summer with notable declines occurring between early May or June (Dorband 1980). Baetis, the most abundant ephemeropteran ingested by subyearlings, were most abundant in Dorband's (1980) samples during the spring and mainly in the upper portion of Lower Granite Reservoir where most of our stomach samples were collected. Peak abundance of larval fishes, primarily Cyprinids, occurred during July in Lower Granite Reservoir in 1990 (Bennett et al. 1993a) the same month larval fishes were an important food item to subyearling chinook. The importance of these organisms to subyearling chinook may partially be explained by their seasonal abundance.

Using the same prey grouping strategy as Rondorf et al. (1990), subyearlings in the lower Snake River reservoirs ingest prey items that differ in composition compared to diets of subyearlings in the Columbia River. Numerically, Dipterans contributed substantially to the diet (38%) of subyearlings in the lower Snake River, whereas in the Columbia River Dipterans constituted < 15% of the diet. The difference probably reflects differences in the diversity and availability of potential prey in the two systems. The more predominant terrestrial insects ingested as food items in the Columbia River (Homopterans and Hymenopterans) could result from the higher riparian vegetation there, which is lacking along the Lower Granite pool. This hypothesis is supported by the higher frequency of Homopterans ingested (65%) in Little Goose than in Lower Granite (35%). Little Goose Reservoir visually supports a more diverse and abundant riparian community than Lower Granite Reservoir.

The proportion of maximum consumption (P-value) for subyearling chinook was low (0.274) suggesting prey availability may be limiting as Poe (1992) suggested. P-values < 1 may also suggest competition, predator avoidance, disease (Hewett and Johnson 1987), or the influence of other biotic and abiotic factors. To determine the difference between our estimated P-value and the maintenance ration (zero growth) for subyearling chinook, we estimated the P-value for the maintenance ration by setting the ending weight equal to the initial weight for subyearling chinook. The estimated maintenance ration P-value for subyearling chinook was 0.2 suggesting subyearlings were feeding at slightly higher than maintenance levels.

Application of a bioenergetics model further suggests temperatures may dictate shoreline distribution and downstream migration. Both specific growth rates (calories/gram predator/day) and daily weight increments for subyearling chinook salmon declined once water temperatures exceeded 13°C (Figures 106 and 107). Brett (1952) found that chinook fingerlings preferred temperatures ranging from 12°C to 14°C. At temperatures exceeding this preferred range, the metabolic demands of subyearling chinook begin to exceed the fish's ability to consume adequate forage to maintain optimal growth. Migration from the shoreline of Lower Granite Reservoir (Figure 105) occurred once water temperatures exceeded 18°C coinciding with the models predicted cessation and reduction of weight gain and growth rates (Figures 106 and 107). Curet (1994) suggests reservoir and shoreline temperatures greatly influence the duration of shoreline and open water rearing period of subyearling chinook salmon and their residence time in Lower Snake River reservoirs.

The overall impact of the altered river environment to a lentic environment on fish communities and their associated prey bases cannot be adequately addressed when observing the food habits of a single group of fish. These results suggest, however, that the nutritional need of subyearling chinook is probably not being satisfied during their brief migratory and rearing period in Lower Granite Reservoir.

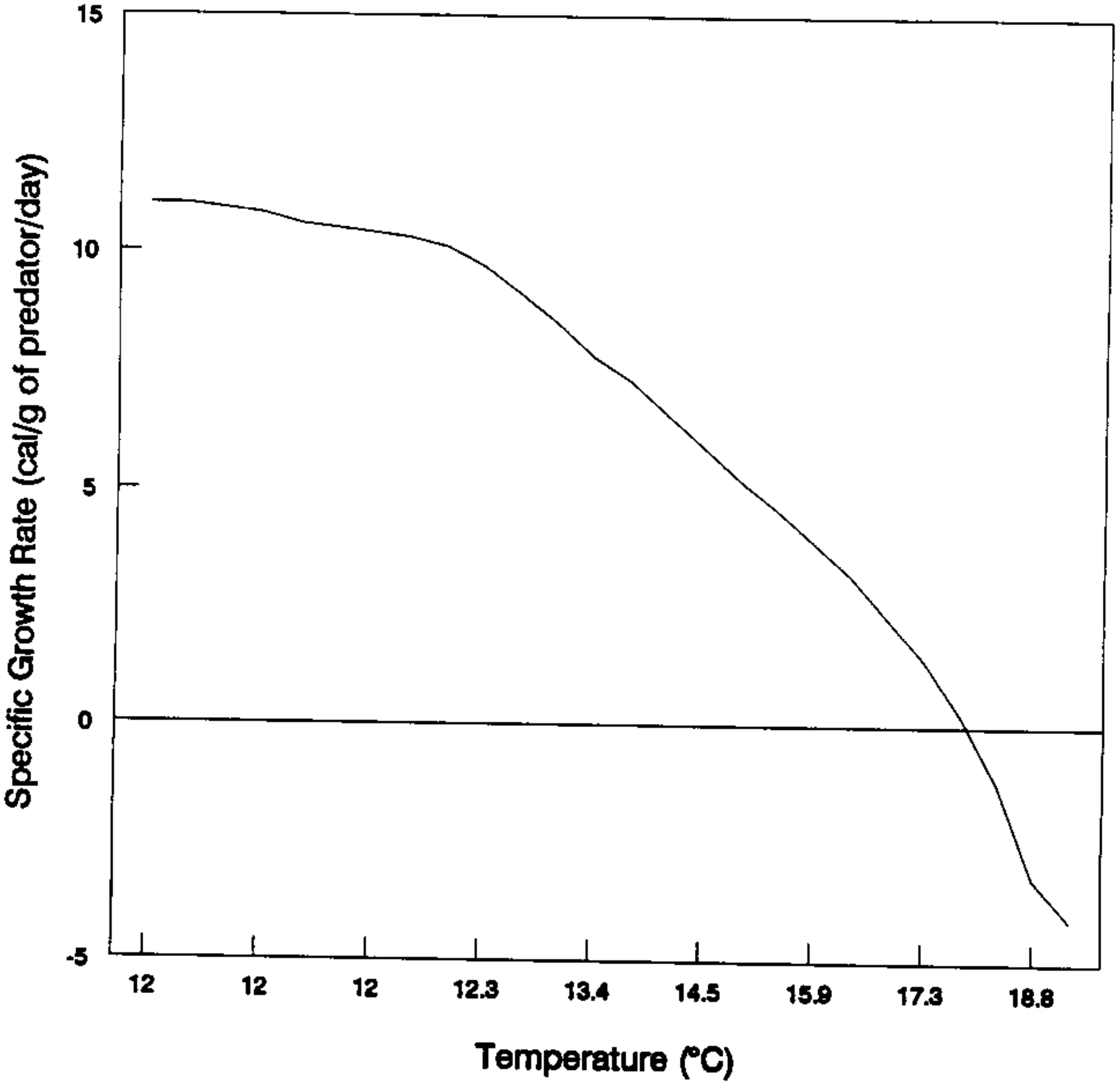


Figure 106. Estimated specific growth rates for subyearling chinook salmon during 1991-1992 in Lower Granite Reservoir.

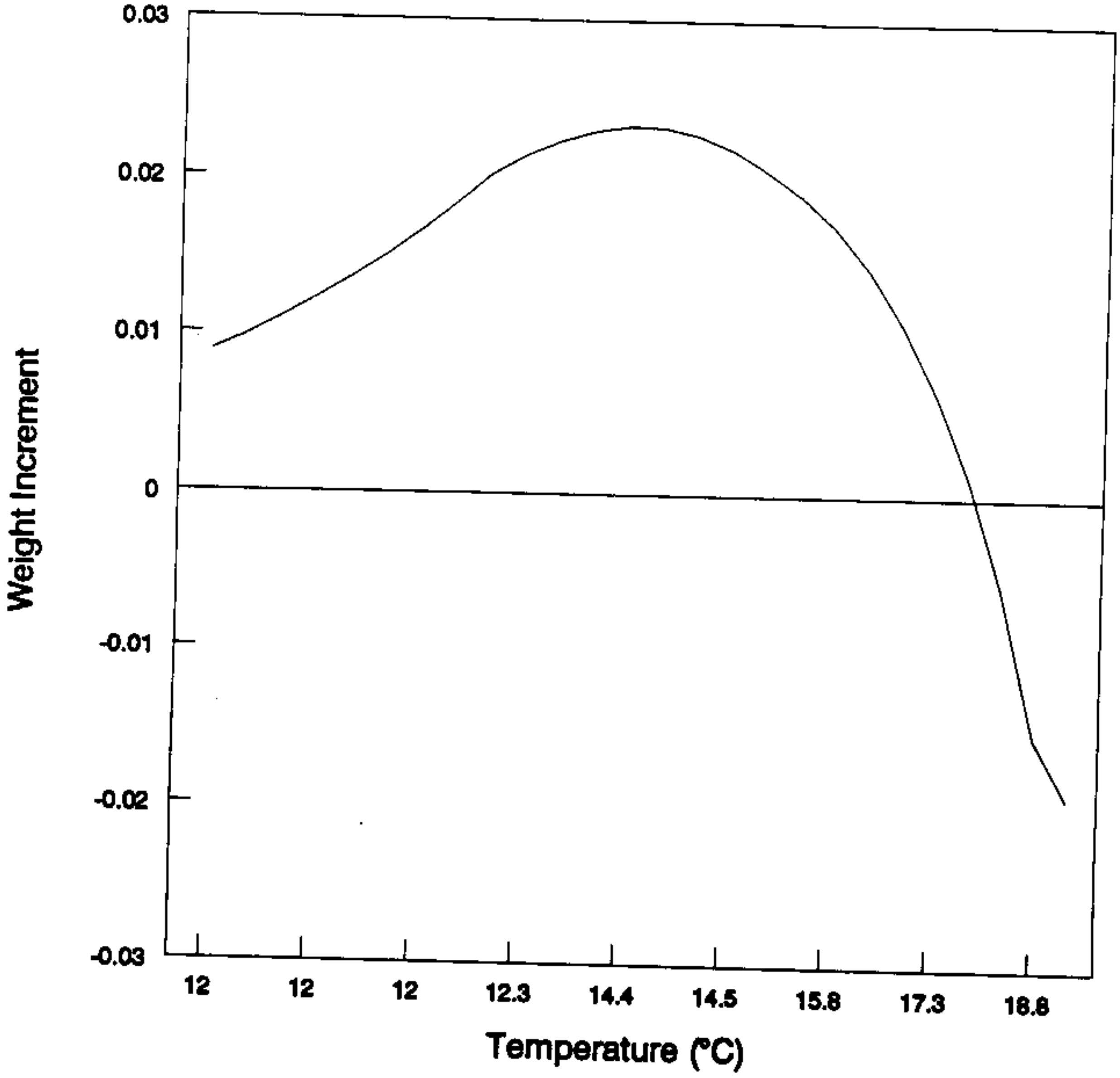


Figure 107. Estimated daily weight increments for subyearling chinook salmon during 1991-1992 in Lower Granite Reservoir.

Objective 7. To assess biotic components associated with in-water disposal including macrophyte development, utilization and interactions with fish and benthic invertebrate abundance.

METHODS

Benthic Invertebrate Samples

A Shipek dredge (1,072.5 cm^2) was used to collect 12 benthic invertebrate samples each at shallow disposal (1 and 2) and reference stations (3, 5, 9, 10 and 11), mid-depth disposal (4) and reference (6) stations, and deep disposal (7) and reference (8) stations during July, 1992. Four dredge hauls were taken along three evenly spaced transects at each station.

Benthic invertebrate samples were washed through a 0.595 mm sieve bucket (#30) and immediately preserved in a 10% formalin solution for later laboratory analysis. Organisms were separated into major taxonomic groups (Pennak 1987), enumerated and weighed. Wet weights were determined by blotting organisms for 1 to 3 minutes in a tared, water filled, covered vessel to preclude variations associated with evaporative water loss. Sample weights and numbers were expanded (x 9.32) for density (number/m^2) and standing crop (g/m^2) estimates for a per meter squared area.

Macrophyte Samples

Aquatic macrophyte growth and development at shallow disposal (1 and 2) and reference (3, 5, 9, 10 and 11) stations were assessed by snorkeling the entire length of each station from the shoreline to depths of 3.1 m (10 ft). A Shipek dredge was used to determine distribution and abundance of macrophytes at mid-depth disposal (4) and reference (6) stations at depths > 3.6 m (12 ft). A total of 15 subsamples, 1 m^2 wire frame quadrant, was collected from macrophyte beds at each shallow water station. The 1 m^2 frame quadrant was randomly tossed into an area containing macrophytes. Using snorkels, we found the submerged quadrant and physically broke macrophyte stems even with the bottom substrate within the 1 m^2 frame. Samples were labeled and frozen for analysis in the laboratory to determine species composition and estimates of density and standing crops (+/- 95% confidence intervals).

Macroinvertebrate Samples

Ten macroinvertebrate samples were collected in macrophyte beds during 26 July, 1992 in Lower Granite Reservoir. Samples were randomly collected within aquatic macrophyte beds at shallow disposal (1) and reference (3 and 10) stations using a Ponar dredge (239.25 cm^2).

Aquatic vegetation was removed and placed immediately in 10% formalin. Sediment was washed through a 0.595 mm sieve bucket (#30). In the laboratory, organisms were separated from sediment and aquatic macrophytes, separated into major taxonomic groups (Pennak 1978), enumerated and weighed. Wet weights were determined by blotting organisms in each taxonomic group for 1 to 3 minutes and weighing in a tared, water filled, covered vessel. Sample numbers and weights were expanded for areal corrections (x 41.8) for density (number/m^2) and standing crop estimates (g/m^2).

RESULTS

Benthic Invertebrates

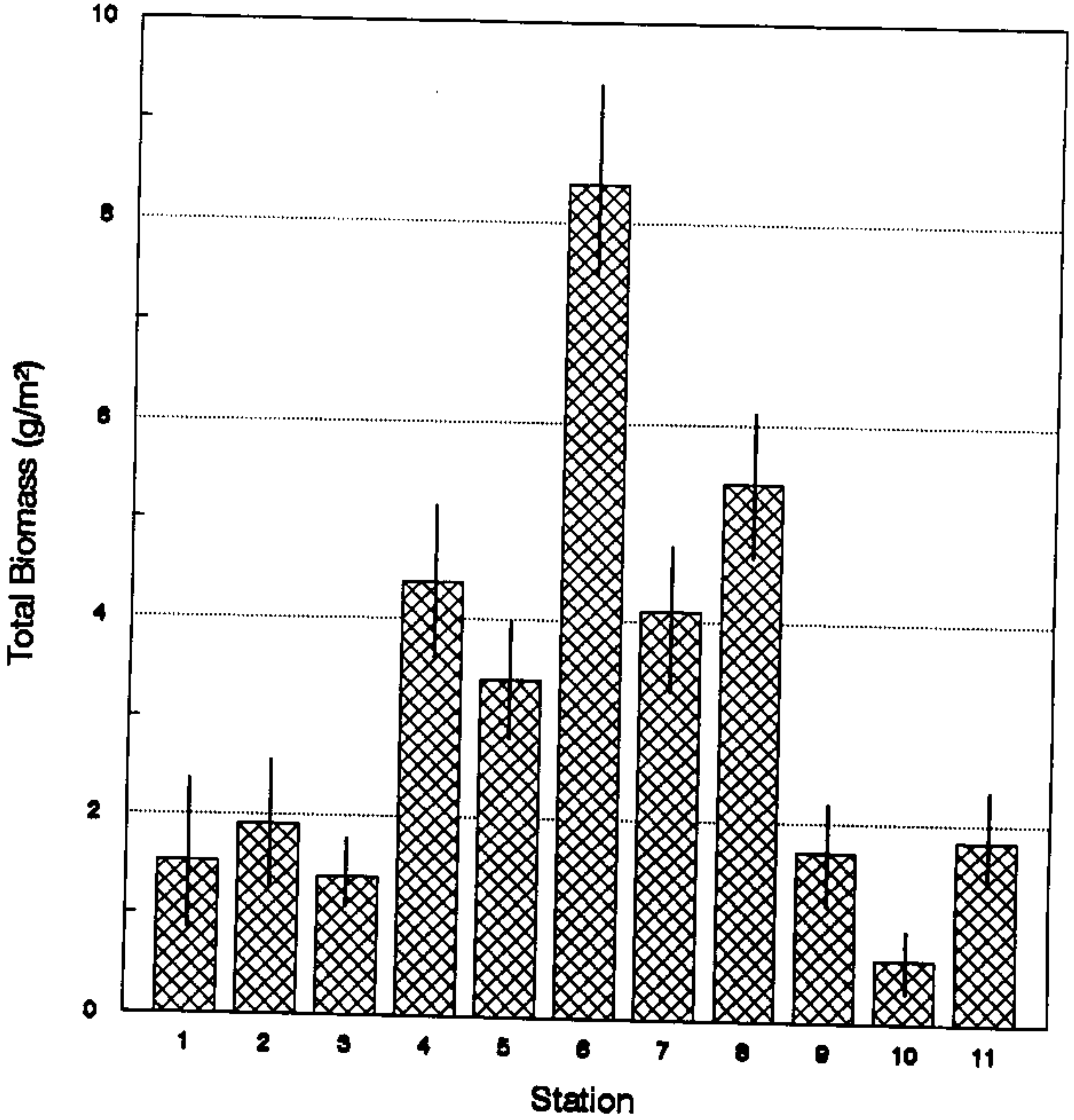
Total Biomass

Benthic invertebrate community standing crop estimates ranged from 0.65 g/m^2 at shallow reference station 10 to 8.73 g/m^2 at mid-depth reference station 6 (Figure 108). High standing crops of benthic invertebrates were at deep reference station 8 (5.37 g/m^2), mid-depth disposal station 4 (4.37 g/m^2), deep disposal station 7 (4.08 g/m^2) and shallow reference station 5 (3.42 g/m^2). Standing crop estimates of benthic invertebrates at disposal stations 1 and 2 and reference stations 3, 9 and 11 were similar (1.43 to 1.91 g/m^2).

Statistical comparisons of total benthic invertebrate community biomass in 1992 among stations indicated reference station 6 had significantly higher ($P < 0.05$) biomass than other stations (Figure 108). Comparisons of total biomass at disposal stations 1 and 2 were not significantly different from those at reference stations 3, 9, 10 and 11. No significant difference ($P > 0.05$) was found between benthic invertebrate standing crops at deep disposal (7) and reference (8) stations.

Chironomid Biomass and Density

Standing crop estimates of chironomid biomass during July, 1992 ranged from 0.44 g/m^2 at shallow reference station 10 to 3.64 g/m^2 at mid-depth reference station 6 (Figure 109). Chironomid biomass was highest at mid-depth station 6 (3.64 g/m^2), followed by mid-depth



Station Comparison

6 8 4 7 5 2 11 9 1 3 10

Figure 108. Standing crop estimates and statistical comparisons of total benthic invertebrate biomass sampled during July 1992 in Lower Granite Reservoir. Vertical lines on bars indicate 95% confidence intervals around the mean. Horizontal lines under stations indicate statistical nonsignificance ($P > 0.05$).

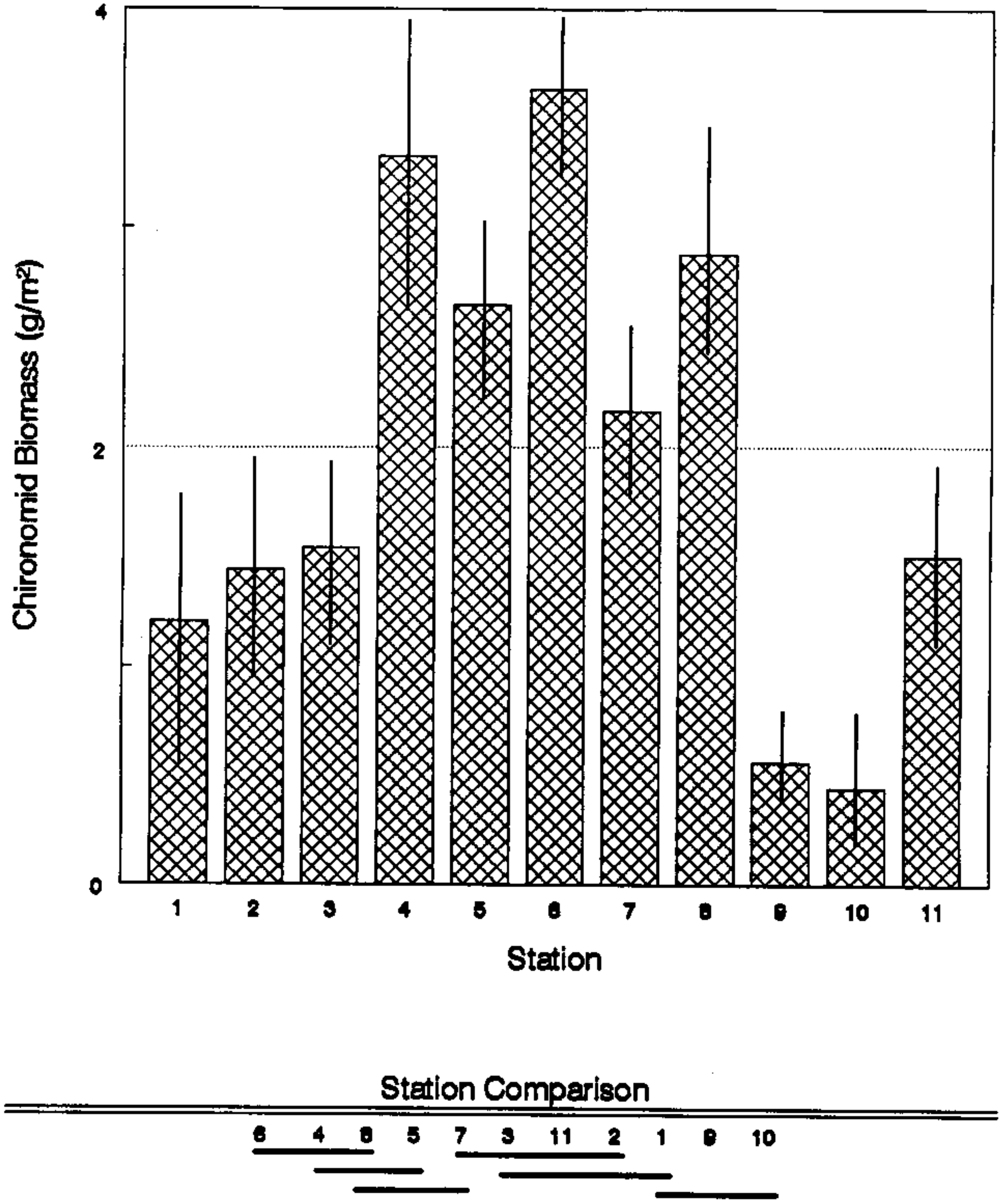


Figure 109. Standing crop estimates and statistical comparisons of chironomid biomass sampled during July 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confindence intervals around the mean. Horizontal lines under stations indicate statistical nonsignificance ($P > 0.05$).

disposal station 4 (3.34 g/m^2), deep reference station 8 (2.88 g/m^2) and shallow reference station 5 (2.65 g/m^2). Estimates of chironomid biomass at disposal (1 and 2) and reference stations (3 and 11) were similar. The standing crop estimate at deep disposal station 7 was 2.17 g/m^2 compared to 2.88 g/m^2 at reference station 8.

Statistical differences in chironomid biomass among stations during 1992 were scattered (Figure 109). Station 6 had the highest standing crop estimate followed by station 4; these were statistically ($P < 0.05$) different from the shallow reference and disposal stations. Stations 9 and 10 were similar and significantly ($P < 0.05$) lower than most other stations. Deep disposal station 7 was in the middle of the range and was significantly ($P < 0.05$) different from the highest (stations 6 and 4) and lowest (stations 1, 9 and 10) groups of stations.

The density estimate of chironomids was highest at deep reference station 8 (835.69/m^2) followed by reference stations 5 (830/m^2) and 6 (823.27/m^2; Figure 110). Statistically, the densities of chironomids were high and similar at reference stations 8, 5, 6 and 11 and disposal station 4 while other station differences were scattered (Figure 110). Estimated chironomid densities at shallow disposal stations 1 and 2 were generally similar to shallow reference stations.

Oligochaete Biomass

During July 1992, the standing crop estimate of oligochaete biomass at mid-depth reference station 6 was highest followed by deep reference station 8 (2.48 g/m^2) and deep disposal station 7 (1.72 g/m^2;

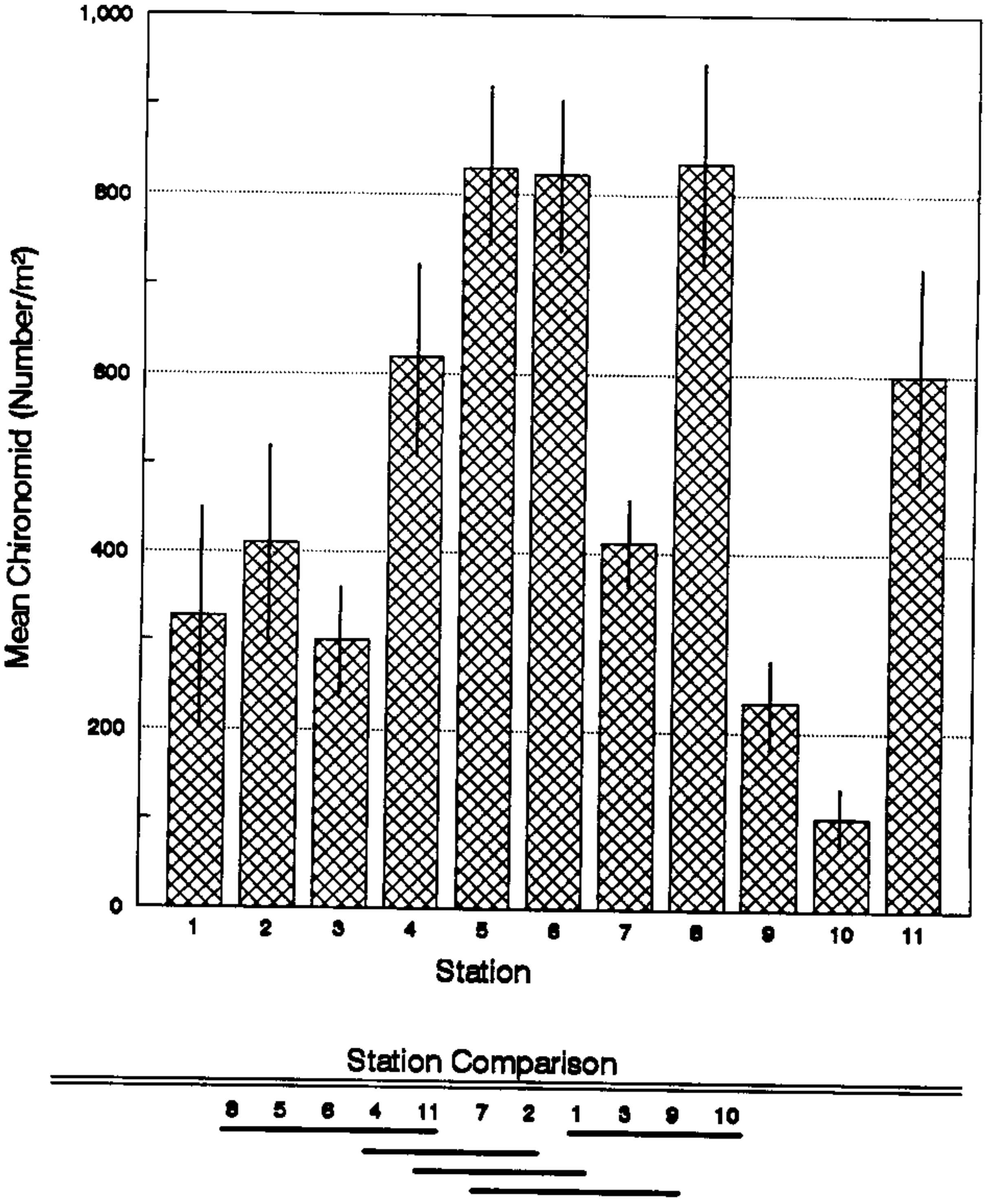


Figure 110. Numerical densities and statistical comparisons of chironomids sampled during 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under stations indicate statistical nonsignificance (P > 0.05).

Figure 111). Biomass estimates ranged from 0.01 g/m^2 at shallow reference station 10 to 3.93 g/m^2 at station 6. Disposal (1 and 2) and reference stations (3, 9 and 11) had similar standing crop estimates of oligochaetes. Mid-depth disposal station 4 (0.68 g/m^2) and shallow reference station 5 (0.76 g/m^2) also had similar standing crop estimates. Statistically, oligochaete biomass at reference station 6 was significantly higher ($P < 0.05$) than other disposal and reference stations, except at station 8 (Figure 111). Significant differences were not found at other disposal and reference stations (1, 2, 3, 4, 5, 7, 9, 10 and 11). Densities of oligochaetes at reference stations 3, 10 and 11 were low.

Numerical density of oligochaetes was not expressed, because of their propensity to fragment during sampling, sieving and sorting. We believe biomass is the best measure of their abundance.

1989 and 1991 vs. 1992

Total biomass.- Comparisons of benthic invertebrate community standing crop estimates indicate a decline at stations 1, 3, 5 and 6 from 1989 to 1992 (Figure 112). The highest decreases in standing crop estimates were among 1989 (8.67 g/m^2), 1991 (7.92 g/m^2) and 1992 (3.42 g/m^2) at shallow reference station 5. Deep reference station 8 exhibited the only increase in standing crop from 1991 (2.92 g/m^2) to 1992 (5.38 g/m^2), but the increase did not surpass the 1989 estimate (9.66 g/m^2). Standing crop estimates at shallow disposal station 2 were low and similar among July 1991 (1.93 g/m^2), 1992 (1.92 g/m^2) and 1989

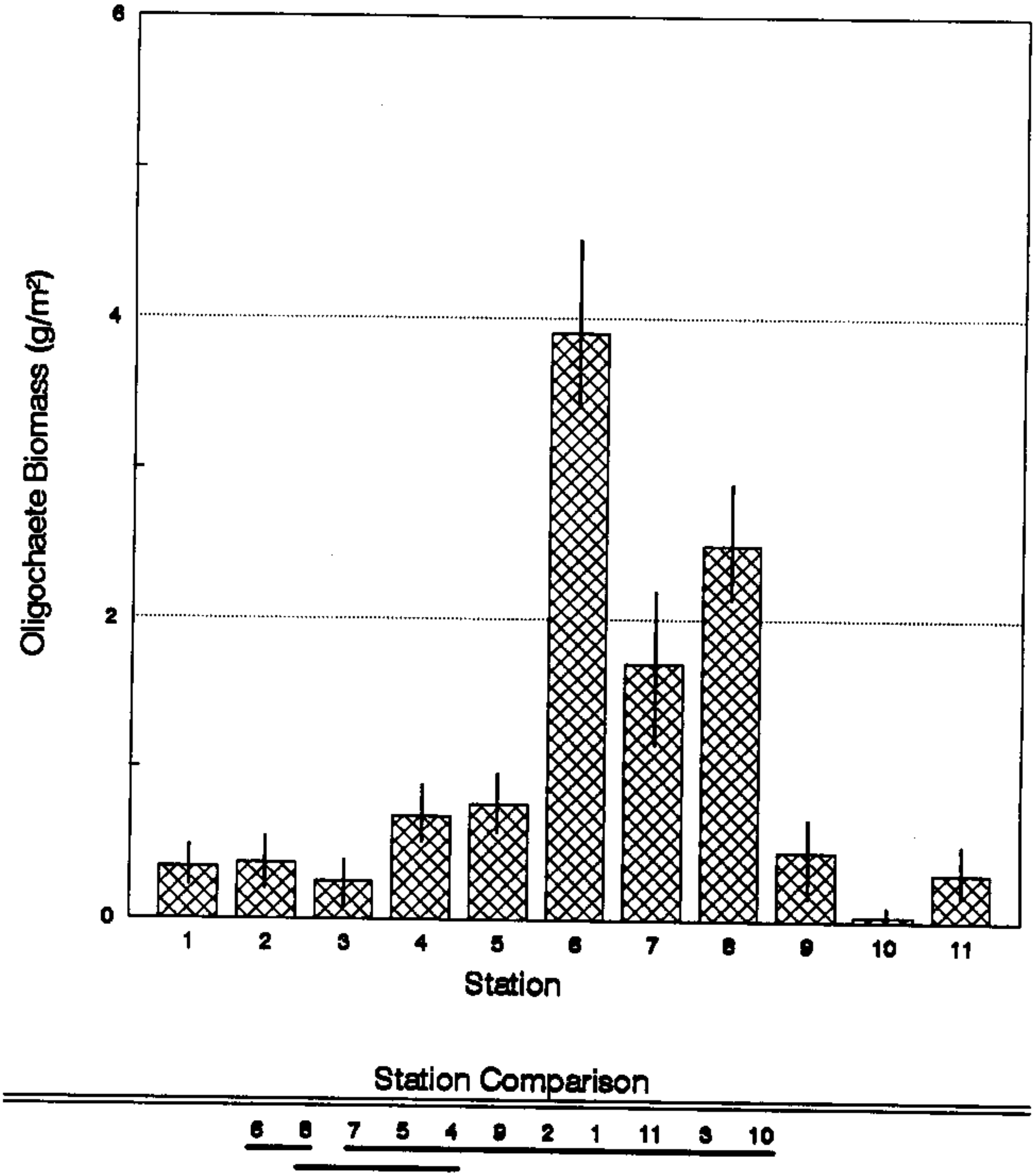


Figure 111. Standing crop estimates and statistical comparisons of oligochaete biomass sampled during July 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under stations indicate statistical nonsignificance ($P > 0.05$).

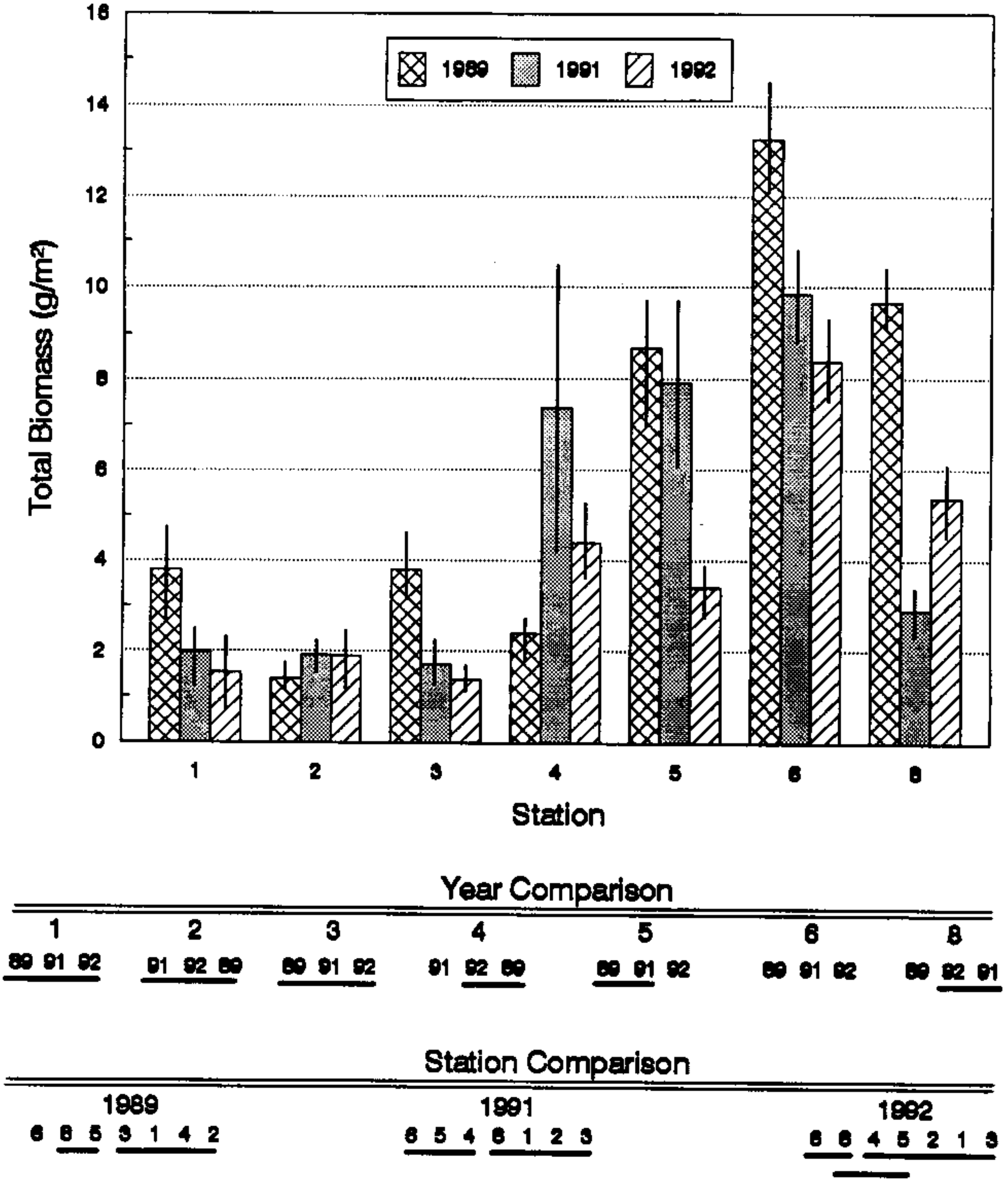


Figure 112. Standing crop estimates and statistical comparisons of total benthic invertebrate biomass sampled during 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance (P > 0.05).

($1.43\ g/m^2$). Statistical differences ($P < 0.05$) in total benthic invertebrate biomass between 1989, 1991 and 1992 were found at mid-depth reference station 6 (Figure 112). Station 6 had consistently the highest biomass of all stations and was significantly ($P < 0.05$) different among the 3 years of study. Statistical differences in community benthic invertebrate biomass were also found at stations 4, 5 and 8. Statistical differences in total benthic invertebrate biomass among years and stations were few. Station 6 consistently had the highest total biomass for 1989, 1991 and 1992.

Chironomid biomass and density.- Comparisons of chironomid biomass among 1989, 1991 and 1992 showed decreases at stations 1 and 3 and increases at mid-depth disposal station 4 ($3.34\ g/m^2$) and deep reference station 8 ($2.88\ g/m^2$) above 1989 levels ($1.03\ g/m^2$ and $1.53\ g/m^2$, respectively; Figure 113). During 1992, chironomid biomass decreased from 1991 levels at stations 5 and 6. Standing crop estimates of chironomid biomass at disposal station 2 ($1.45\ g/m^2$) were similar between 1991 and 1992 and both years were higher than that in 1989.

Statistically chironomid biomass was significantly ($P < 0.05$) higher in 1989 than 1992 and 1991 at station 1 (Figure 113). No significant differences ($P > 0.05$) among years were found at stations 2, 3, 4 and 8.

Density estimates (number/m^2) of chironomids for 1989 and 1991 indicated a general decrease at all stations except stations 4 and 8 (Figure 114). However, the 1992 comparison of densities indicates all stations increased from 1991 except reference station 3. Station 8

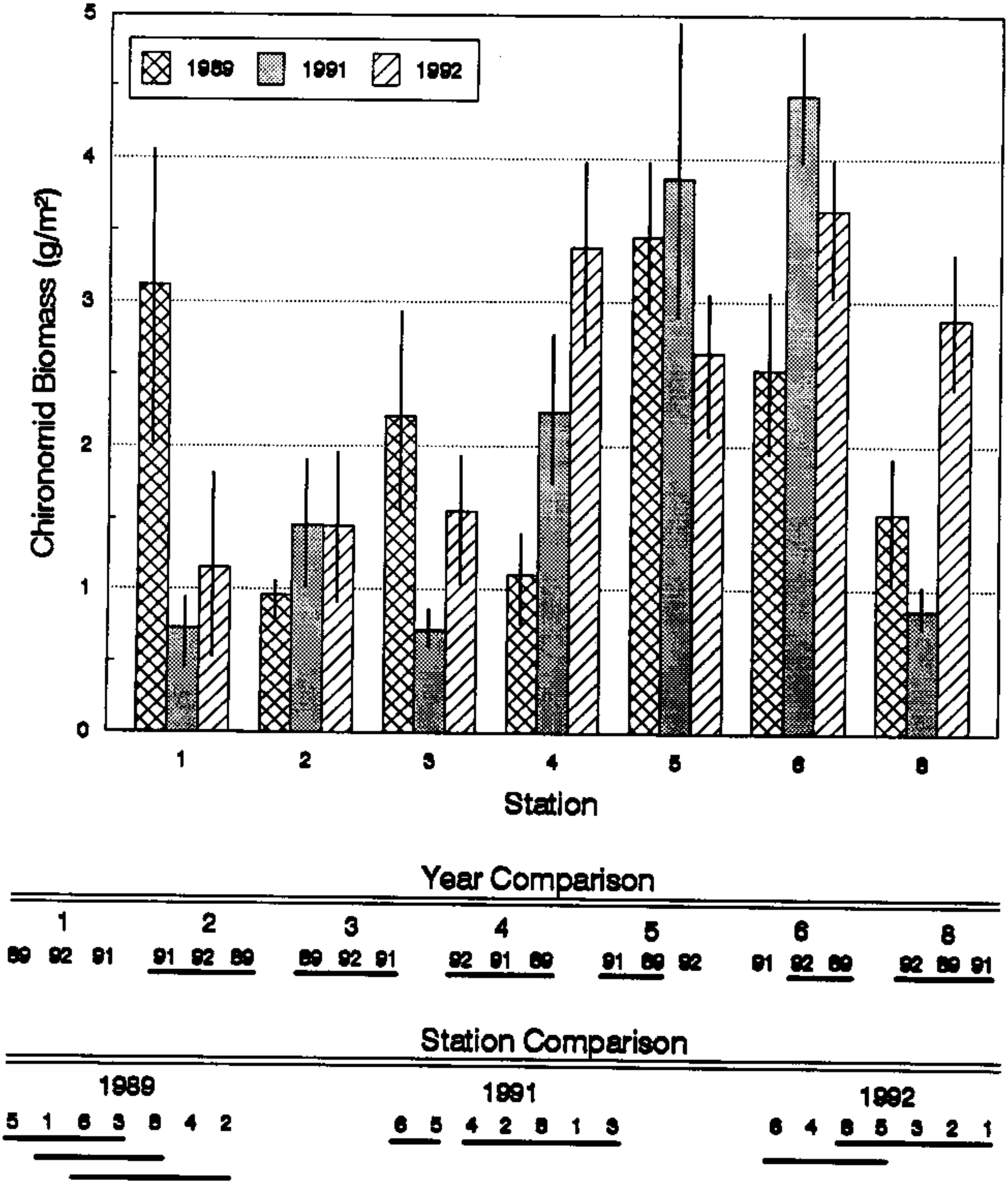


Figure 113. Standing crop estimates and statistical comparisons of chironomid biomass sampled during 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance (P > 0.05).

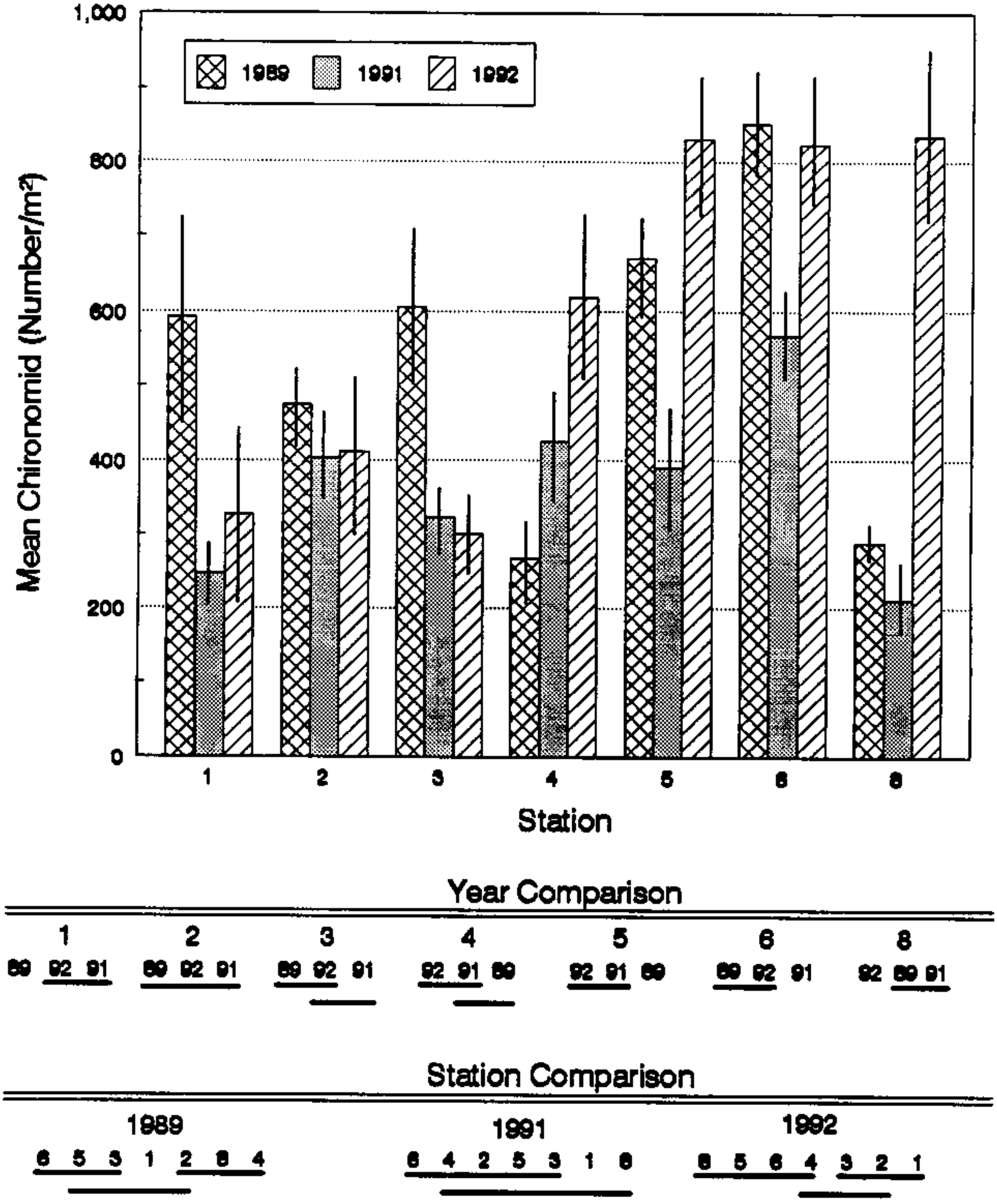
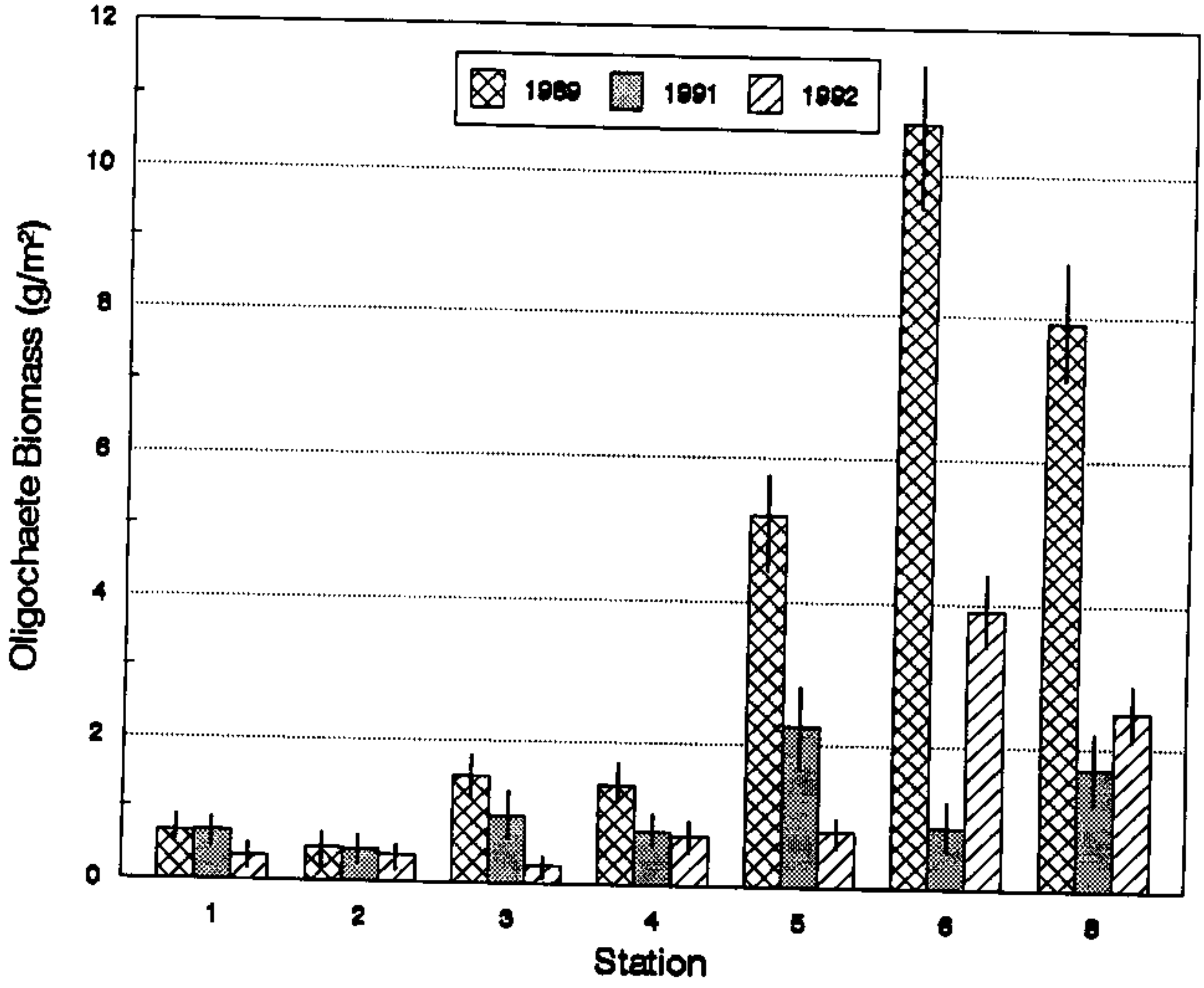


Figure 114. Numerical densities and statistical comparisons of chironomids sampled during 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance (P > 0.05).

showed the highest increase from $286.71/m^2$ in 1989, $209.70/m^2$ in 1991 to $835.69/m^2$ in 1992. Densities at station 5 increased from $389.89/m^2$ in 1991 to $830.27/m^2$ in 1992, while those at station 6 increased from $567.74/m^2$ in 1991 to $823.27/m^2$ in 1992. Significant ($P < 0.05$) interactions between numerical densities of chironomids and stations were indicated at stations 1, 3, 4, 5, 6 and 8 (Figure 114). The numerical density of chironomids at station 8 during 1992 was significantly higher ($P < 0.05$) than those in 1989 and 1991. Differences at other stations were scattered among years. No significant differences ($P > 0.05$) were found at shallow disposal station 2 among 1989, 1991 and 1992.

Oligochaete biomass.- Standing crop estimates of oligochaetes during 1989, 1991 and 1992 decreased at stations 1, 2, 3, 4 and 5 (Figure 115). The standing crop estimates at station 5 decreased from 2.24 g/m^2 in 1991 to 0.76 g/m^2 in 1992. The standing crop estimate at station 6 decreased from 10.69 g/m^2 in 1989 to 0.84 g/m^2 in 1991, and the estimate at station 8, which decreased between 1989 and 1991, showed a slight increase in 1992 but was significantly ($P < 0.05$) below the 1989 standing crop estimate (Figure 115). Estimates of oligochaete biomass at reference stations 5 and 6 during 1989 were significantly higher than 1991 and 1992. Differences in standing crop estimates within years among stations were slight, but reference stations 6 and 8 were generally significantly ($P < 0.05$) higher than other stations.



Year Comparison

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

Station Comparison

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

Figure 115. Standing crop estimates and statistical comparisons of oligochaete biomass sampled during 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance ($P > 0.05$).

1988 vs. 1989 vs. 1991 vs. 1992

Total biomass.- Total benthic invertebrate community biomass among 1988, 1989, 1991 and 1992 indicates a decrease in standing crop estimates at stations 3, 5 and 6 (Figure 116). Station 8 had the largest decrease from 1988 to 1991 (19.50 to 2.92 g/m^2) then increased in 1992 to 5.38 g/m^2. Community biomass at mid-depth disposal station 4 increased from 0.91 g/m^2 in 1988 to 7.36 g/m^2 in 1991 and then decreased in 1992 to 4.38 g/m^2.

Statistical differences in benthic invertebrate community standing crop estimates among these 4 years were found at stations 4, 5, 6 and 8 (Figure 116), while no significant differences ($P > 0.05$) was found at reference station 3. Comparisons of community biomass among stations within years indicate station 6 had the highest estimates during 1989, 1991 and 1992 and station 8 was highest in 1988. Reference station 3 had the lowest community biomass except in 1988.

Chironomid biomass and density.- Standing crop estimates of chironomids at reference station 5 were similar during 1989, 1991 and 1992, although biomass was much higher in 1988 (Figure 117). Chironomid biomass increased slightly at disposal station 4, however the increase was not statistically significant ($P > 0.05$; Figure 117). Estimates of biomass at mid-depth station 6 from 1988 to 1992 were generally similar. The standing crop estimate of chironomids at deep reference station 8 increased from 0.87 g/m^2 in 1991 to 2.88 g/m^2 in 1992. No significant difference in chironomid biomass was found at station 3 among years.

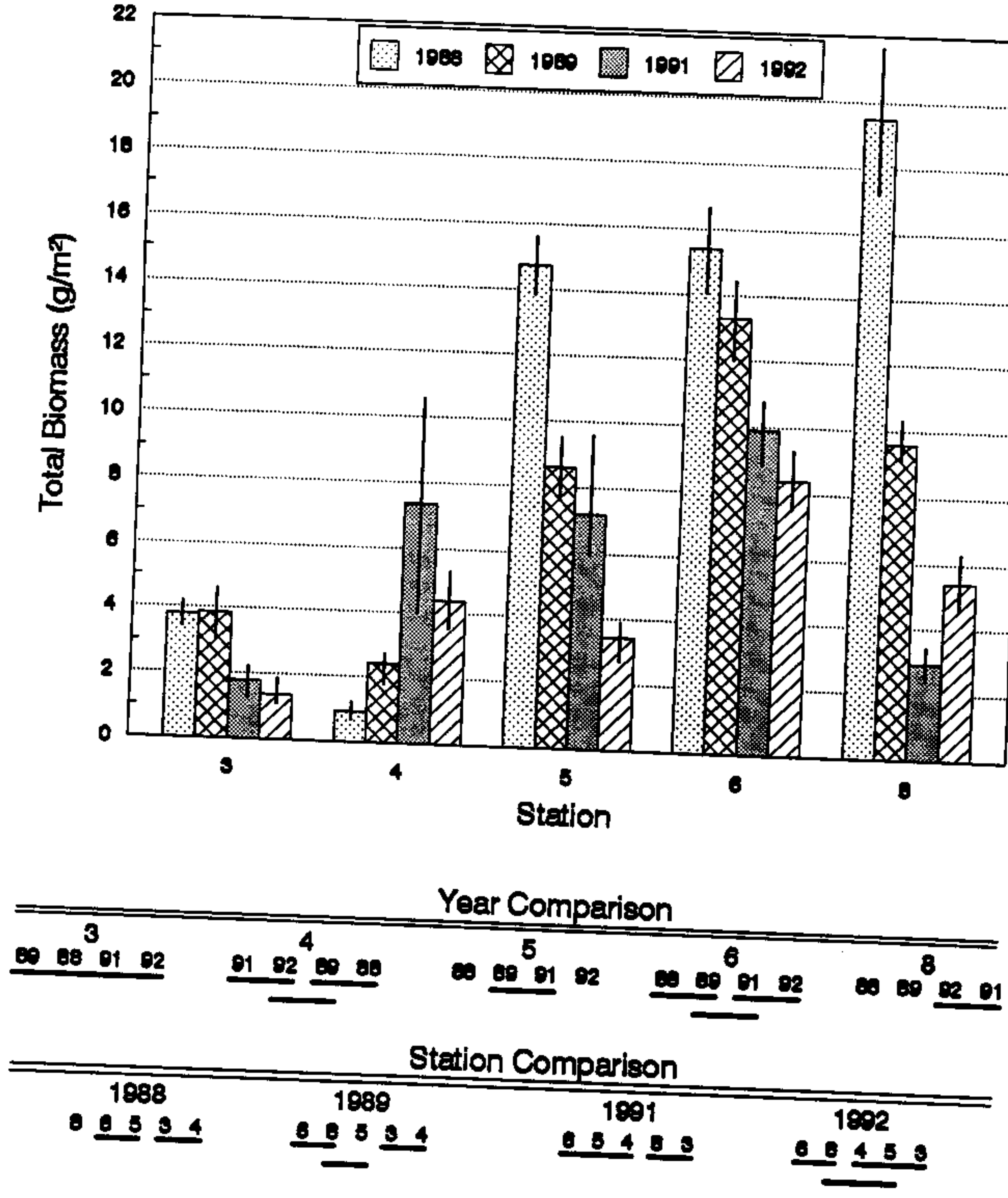


Figure 116. Standing crop estimates and statistical comparisons of total benthic invertebrate biomass sampled during 1988,1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance (P > 0.05).

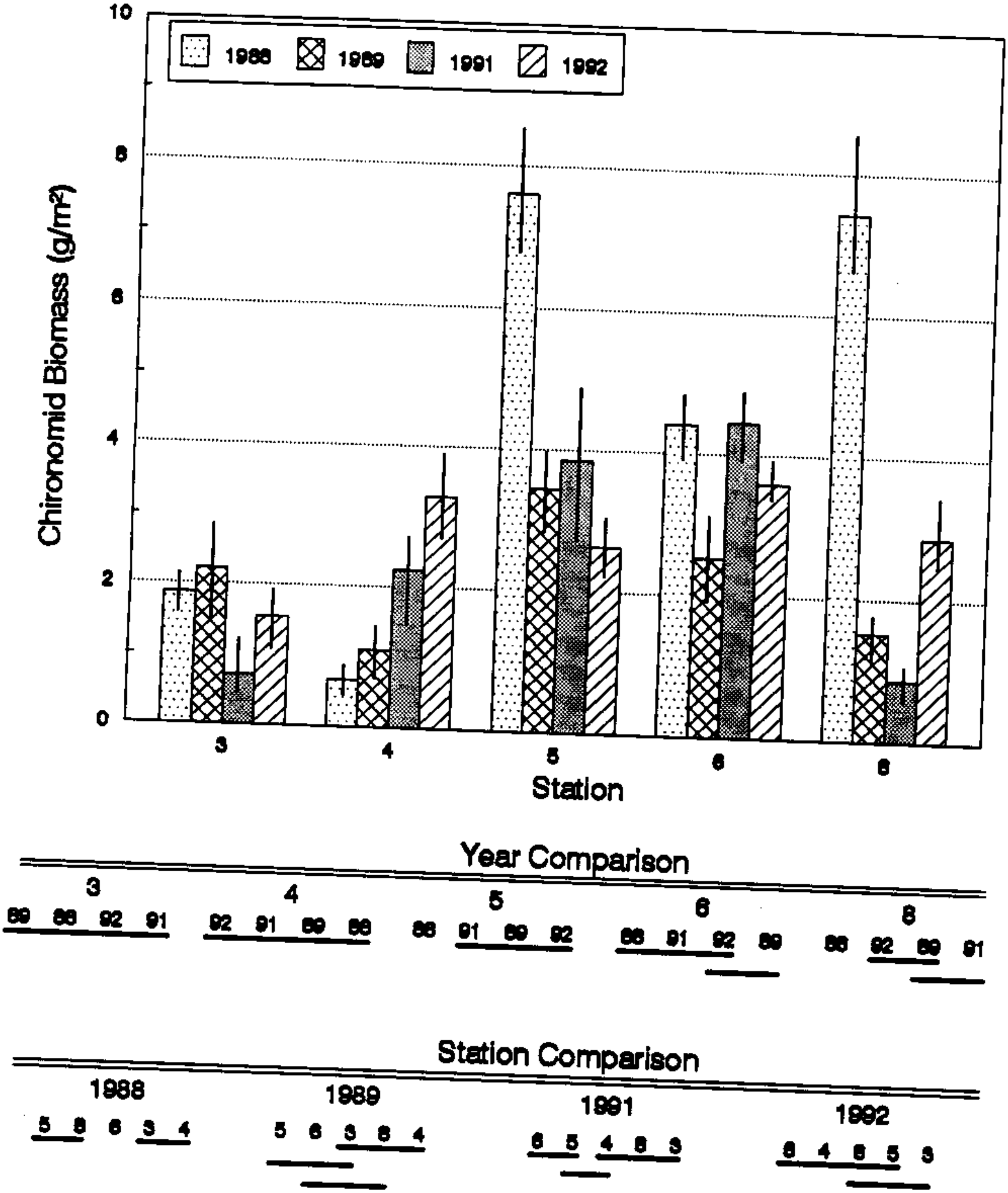


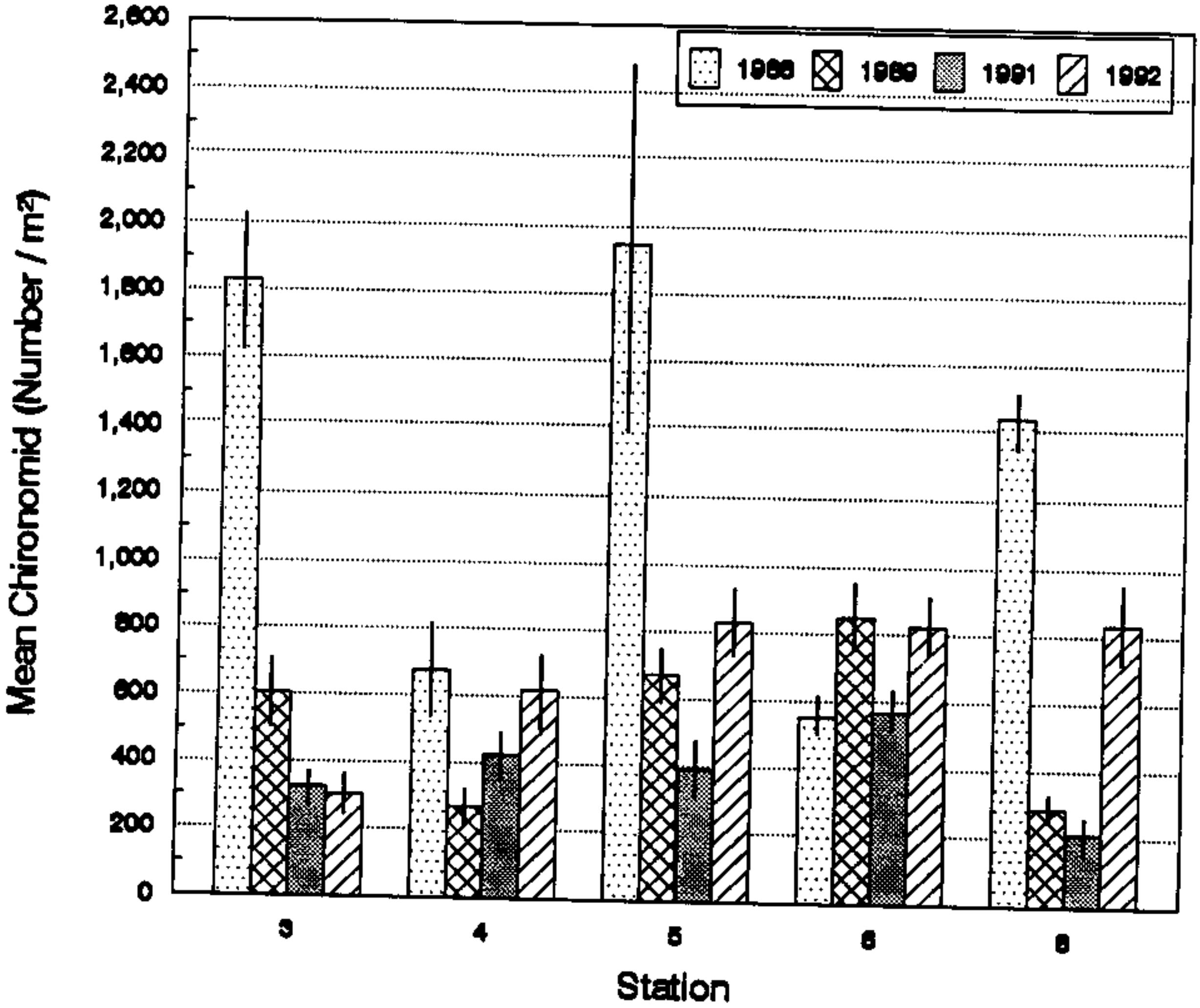
Figure 117. Standing crop estimates and statistical comparisons of chironomid biomass sampled during 1988, 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance (P > 0.05).

Mean densities of chironomids from 1988, 1989 and 1991 have decreased at all stations, except mid-depth disposal station 4 (Figure 118). However, during 1992 increases were measured at all stations, except reference station 3. The largest increase in density occurred at station 8 (209.70/m^2 in 1991 to 835/m^2 in 1992) and the large decreases were at stations 3 and 5. Densities of chironomids have generally been similar at stations 6 and 4 between 1988, 1989, 1991 and 1992.

Oligochaete biomass.- Standing crop estimates of oligochaete biomass decreased at reference stations 3 and 5, although these decreases were generally not significant ($P > 0.05$; Figure 119). Slight increases in estimates occurred at stations 6 and 8 from 1991 to 1992; that at station 6 was significant between years while that at station 8 was not. Significant ($P < 0.05$) differences in oligochaete biomass at other stations and among years were few.

Aquatic Macrophytes

Aquatic macrophyte growth and development was first observed at shallow station 1 (RM 120.0) during mid-June, but this initial sampling effort did not include other disposal (2 and 4) and reference stations (3, 5, 9, 10 and 11). Additional aquatic macrophyte sampling was initiated on 7 July, 1992 at stations 1, 2, 3, 10 and 11. Information collected by snorkeling indicated aquatic macrophyte growth and development occurred below 0.76 m and 3.5 m (2.5 and 12 ft) relative to 733 ft elevation, or minimum pool in Lower Granite Reservoir. No macrophytes were found at mid-depth disposal station 4 or mid-depth



Year Comparison

3
88 89 91 92

4
88 92 91 89

5
88 92 89 91

6
89 92 91 88

8
88 92 89 91

Station Comparison

1988
5 3 8 4 6

1989
6 5 3 8 4

1991
6 4 5 3 8

1992
8 5 6 4 3

Figure 118. Numerical densities and statistical comparisons of chironomids sampled during 1988, 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance ($P > 0.05$).

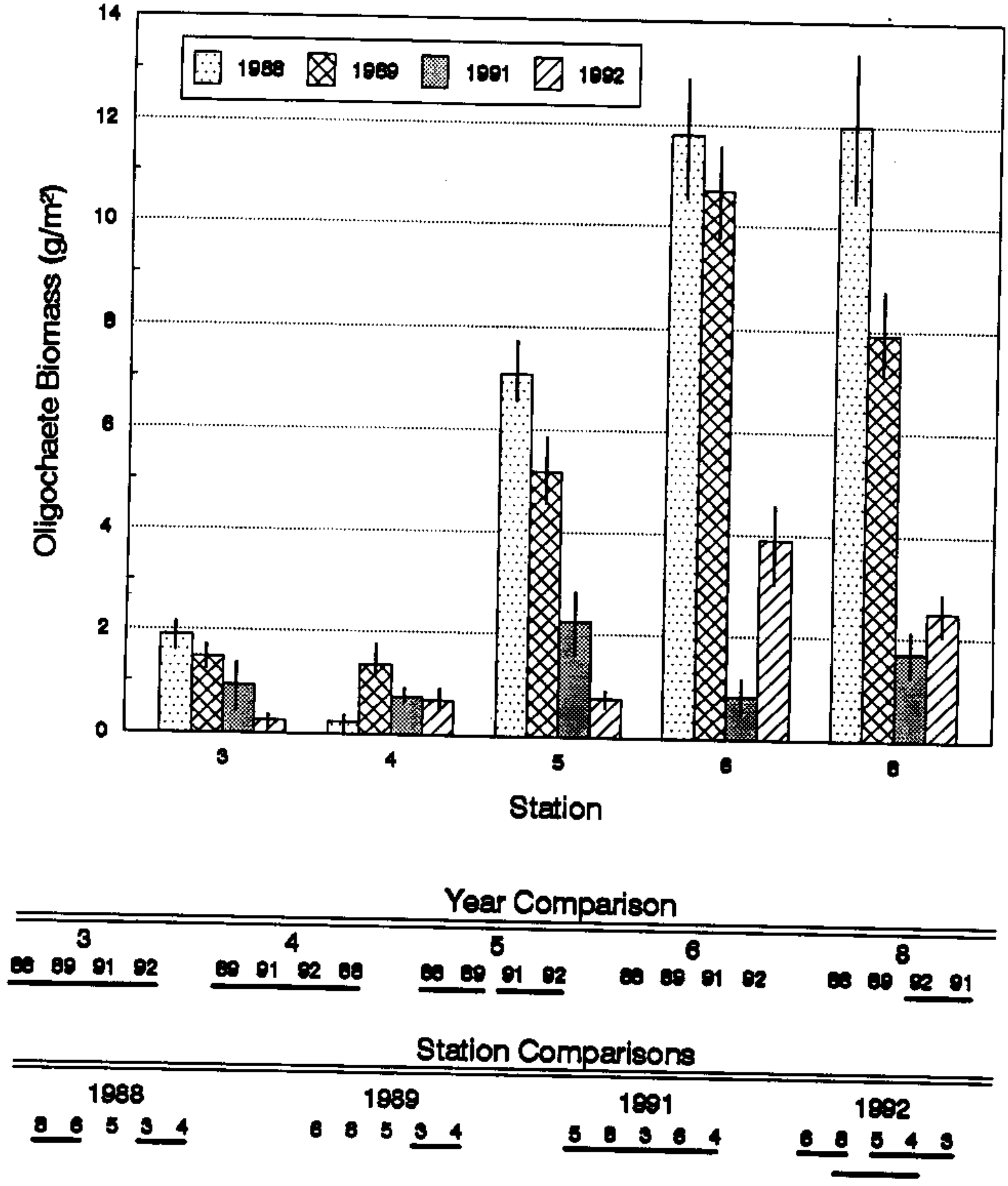


Figure 119. Standing crop estimates and statistical comparisons of oligochaete biomass sampled during 1988, 1989, 1991 and 1992 in Lower Granite Reservoir. Vertical lines on the bars indicate 95% confidence intervals around the mean. Horizontal lines under years and stations indicate statistical nonsignificance ($P > 0.05$).

reference station 6. Shallow reference stations 5 and 9 were devoid of aquatic macrophytes throughout the entire sampling season (mid-June through August).

Potomogeton crispus was the dominant aquatic macrophyte found at all disposal and reference stations in Lower Granite Reservoir during 1992, with the exception of station 11 that was dominated by *P. filiformis*. Shallow disposal stations 1 and 2 and shallow reference station 10 were dominated exclusively by *P. crispus*, while shallow reference station 3 had approximately equal densities of *P. crispus* and *P. filiformis*.

Mean biomass (g/m^2 dry weight) of aquatic macrophytes increased at all shallow disposal and reference stations from mid-July through August. Mean biomass ranged from 0.0 g/m^2 at station 11 to 1.75 g/m^2 at station 1 on 7 July, 1992 (Figure 120). Increases in mean biomass were observed at all shallow stations except station 11 on 15 July, 1992. The highest increase occurred at station 1 (4.11 g/m^2) and was followed by stations 10 (3.97 g/m^2) and 3 (3.45 g/m^2). Shallow reference station 11 had the lowest observed mean biomass (0.24 g/m^2) on 15 July, 1992. On 24 August, 1992 large increases in mean biomass were observed at stations 1, 3 and 10 and shallow disposal station 2 showed the only decrease (3.41 g/m^2 to 2.68 g/m^2). The largest increase in macrophyte standing crop estimates occurred at station 10 where biomass increased from 3.97 g/m^2 to 36.46 g/m^2. Biomass increased from 4.11 g/m^2 to 28.50 g/m^2 at shallow disposal station 1 and from 3.44 g/m^2 to 20.29 g/m^2 at shallow reference station 3.

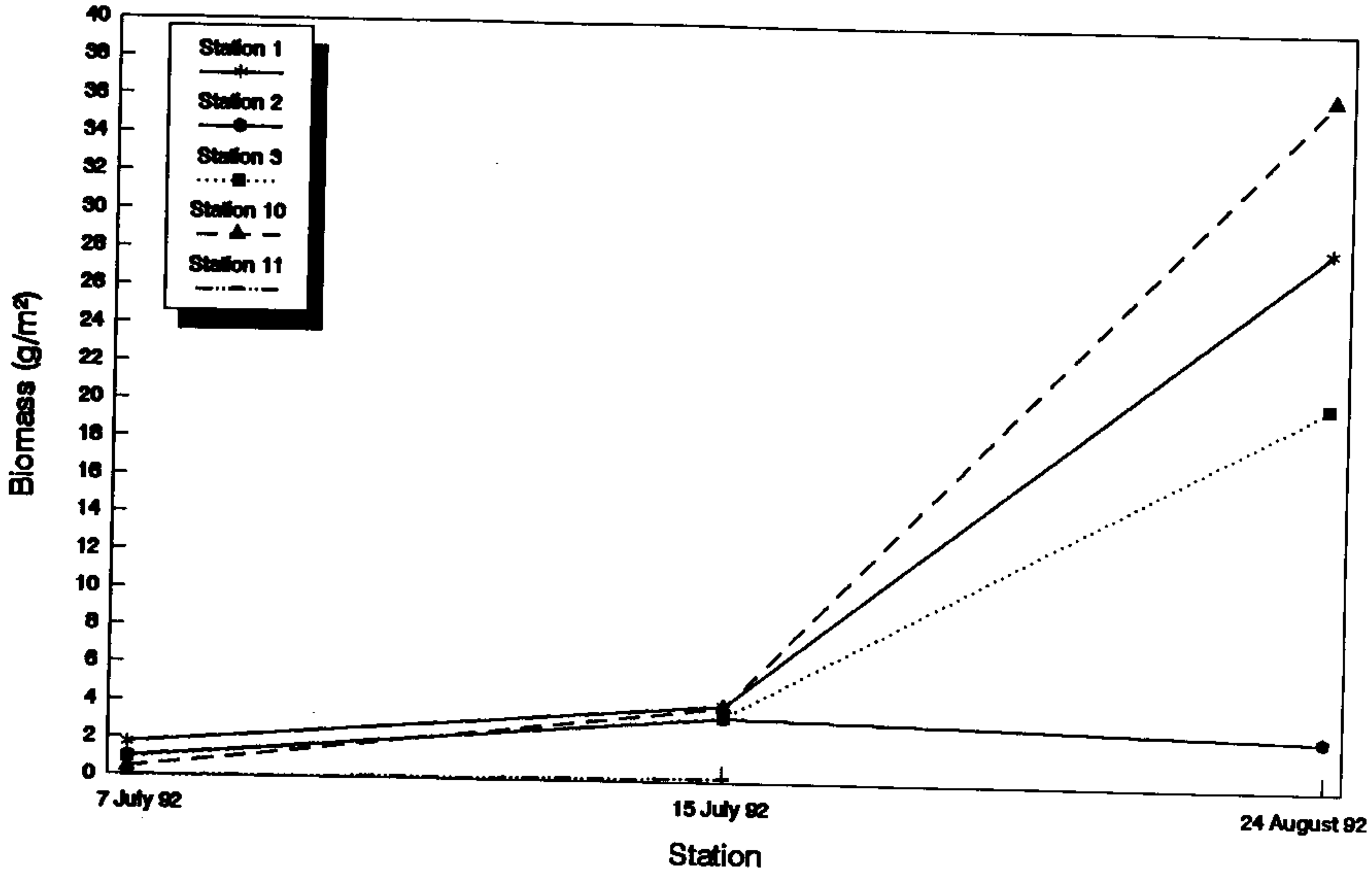


Figure 120. Mean biomass of aquatic macrophyte growth sampled during July through August, 1992 in Lower Granite Reservoir.

Variability in macrophyte density was high among and within stations. As a result, confidence intervals of biomass generally encompassed zero.

Macroinvertebrates in Macrophytes

Taxonomic diversity of macroinvertebrates among stations with aquatic macrophytes was similar (Table 11). Chironomids accounted for 89%, followed by Ephemeroptera (4.4%) and Pelecypoda (3.3%) of the total number of macroinvertebrates collected at all stations. Densities of macroinvertebrates varied among stations 1, 3 and 10 (Table 11; Figures 121 and 122). Chironomids dominated samples at all stations. The highest density of all taxonomic groups was at shallow reference station 10, with the exception of the order Plecoptera, which was observed only at reference station 3.

Total standing crop estimates of macroinvertebrates in macrophyte beds ranged from 4.46 g/m^2 at station 3 to 12.85 g/m^2 at station 10 (Figure 123). The highest standing crop estimate was of chironomids followed by Oligochaeta (5.7 g/m^2) and Ephemeroptera (3.2 g/m^2; Figures 124 and 125).

DISCUSSION

Benthic Invertebrates

The benthic invertebrate community data collected in 1992 generally supported previous years sampling (Bennett et al. 1991, 1993a, 1993b); the community is relatively simple and consists primarily of

Table 11. Taxons and densities of macroinvertebrates sampled during 1992 in Lower Granite Reservoir.

Taxon		Station		
		1	3	10
Nematoda	number/m^2	19 (1.4)	42 (1.4)	64 (4.4)
	g/m^2	0.002 (0.00001)	0.003 (0.00001)	0.01 (0.001)
Annelida				
Oligochaeta	number/m^2	N/A	N/A	N/A
	g/m^2	3.4 (0.05)	1.2 (0.07)	1.1 (0.06)
Crustacea				
Isopoda	number/m^2	11 (1.3)	9 (0.9)	25 (1.4)
	g/m^2	0.02 (0.003)	0.03 (0.003)	0.01 (0.001)
Insecta				
Arachnidae	number/m^2	23 (1.6)	74 (4.9)	121 (6)
	g/m^2	0.02 (0.001)	0.1 (0.01)	0.1 (0.01)
Plecoptera	number/m^2	N/A	102 (6.7)	N/A
	g/m^2	N/A	0.13 (0.02)	N/A
Ephemeroptera	number/^{2}	61 (2.5)	260 (12.6)	1145 (42.7)
	g/m^2	0.1 (0.003)	0.3 (0.02)	2.6 (0.07)
Trichoptera	number/m^2	4 (0.6)	33 (2.7)	105 (4.2)
	g/m^2	0.001 (0.0001)	0.1 (0.01)	0.6 (0.1)
Diptera				
Chironomidae	number/m^2	4706 (131.46)	5727 (177.11)	19132 (530.1)
	g/m^2	2.9 (0.06)	2.3 (0.06)	7.6 (0.2)
Gastropoda	number/m^2	N/A	9 (0.9)	305 (39.4)
	g/m^2	N/A	0.3 (0.04)	0.07 (0.01)
Pelecypoda	number/m^2	46 (5.9)	N/A	1076 (53.6)
	g/m^2	0.01 (0.001)	N/A	0.16 (0.01)

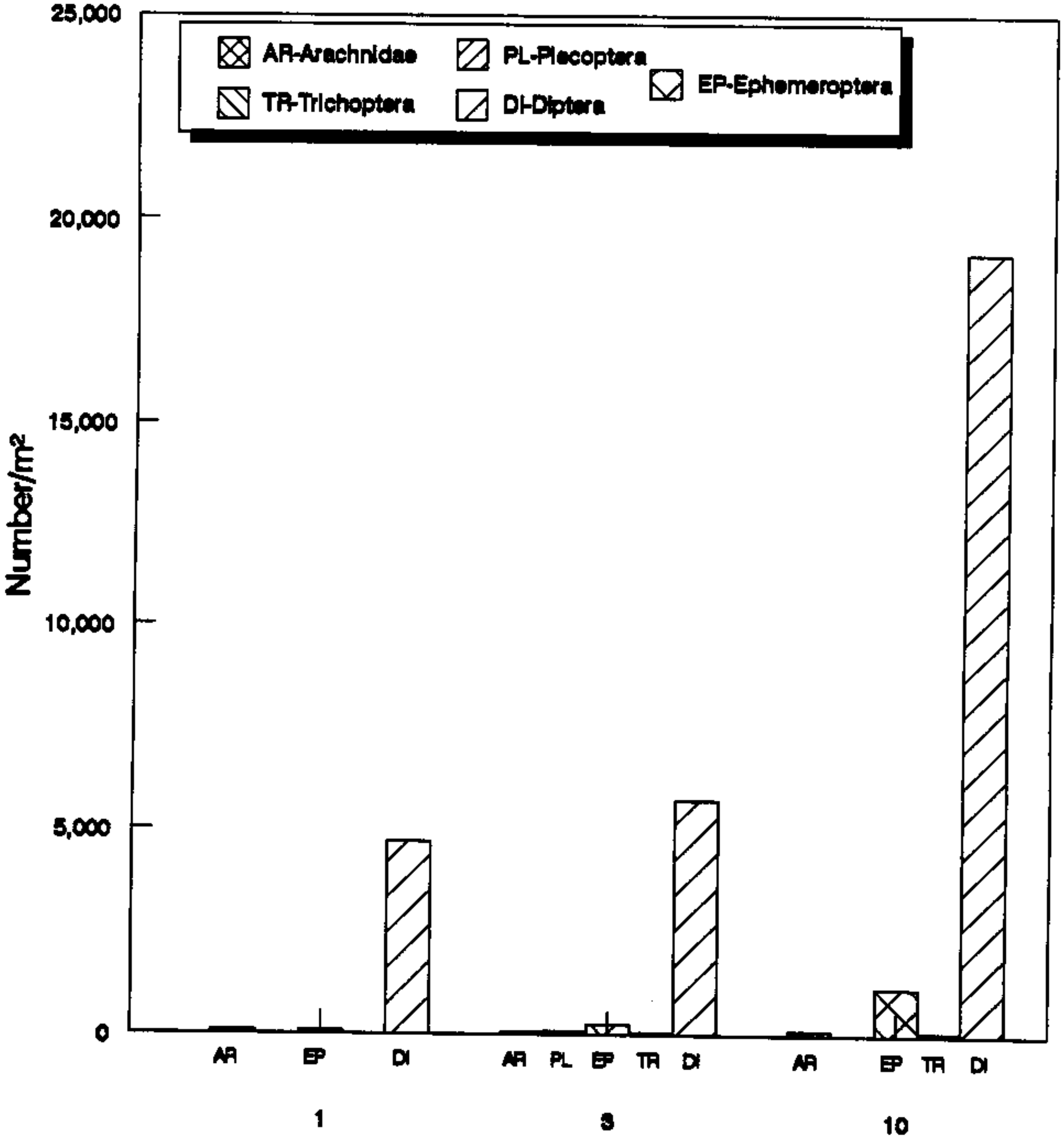


Figure 121. Numerical densities of macroinvertebrates sampled at shallow disposal (1) and reference (3 and 10) stations during 1992 in Lower Granite Reservoir.

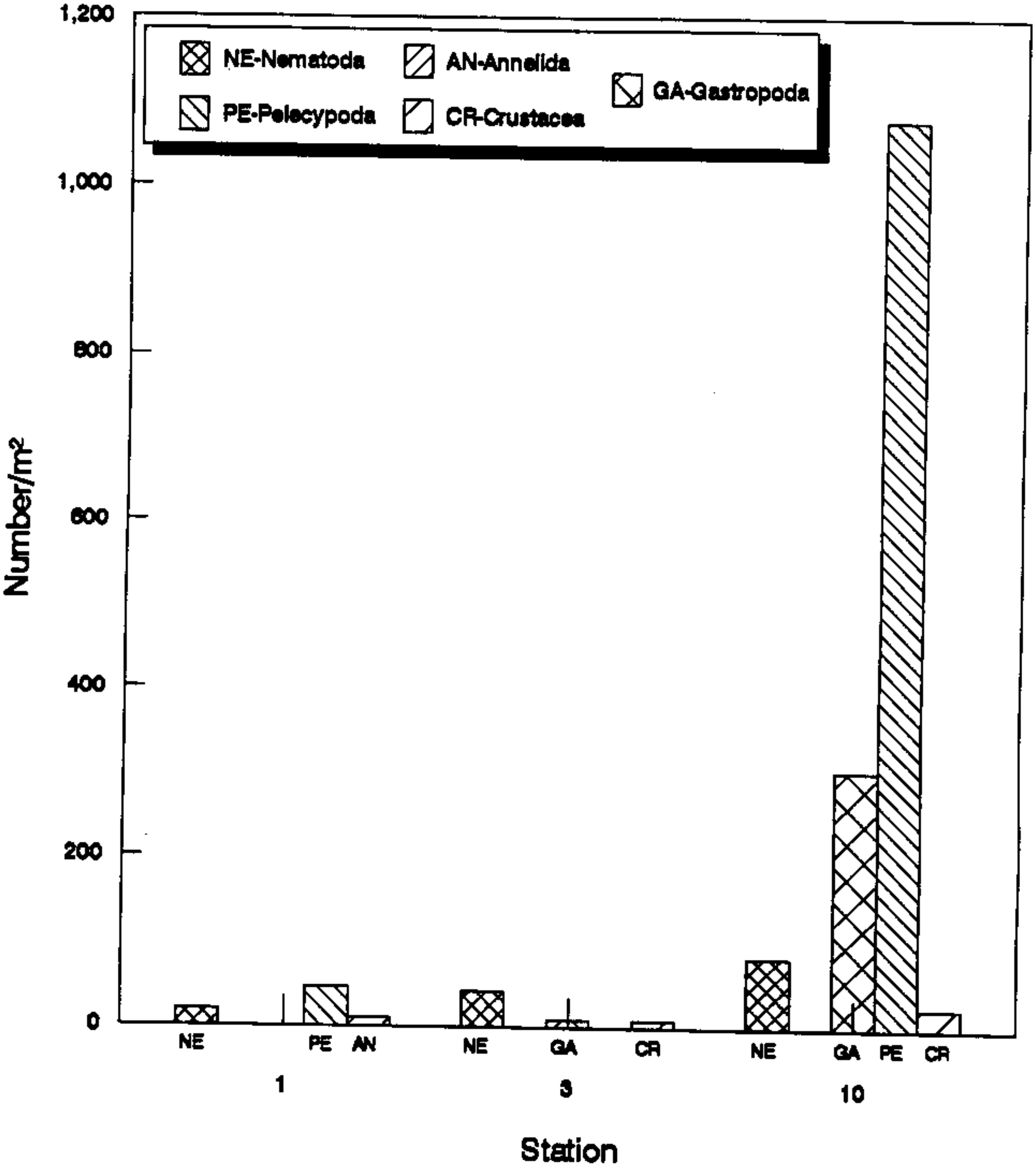


Figure 122. Numerical densities of macroinvertebrates sampled at shallow disposal (1) and reference (3 and 10) stations during 1992 in Lower Granite Reservoir.

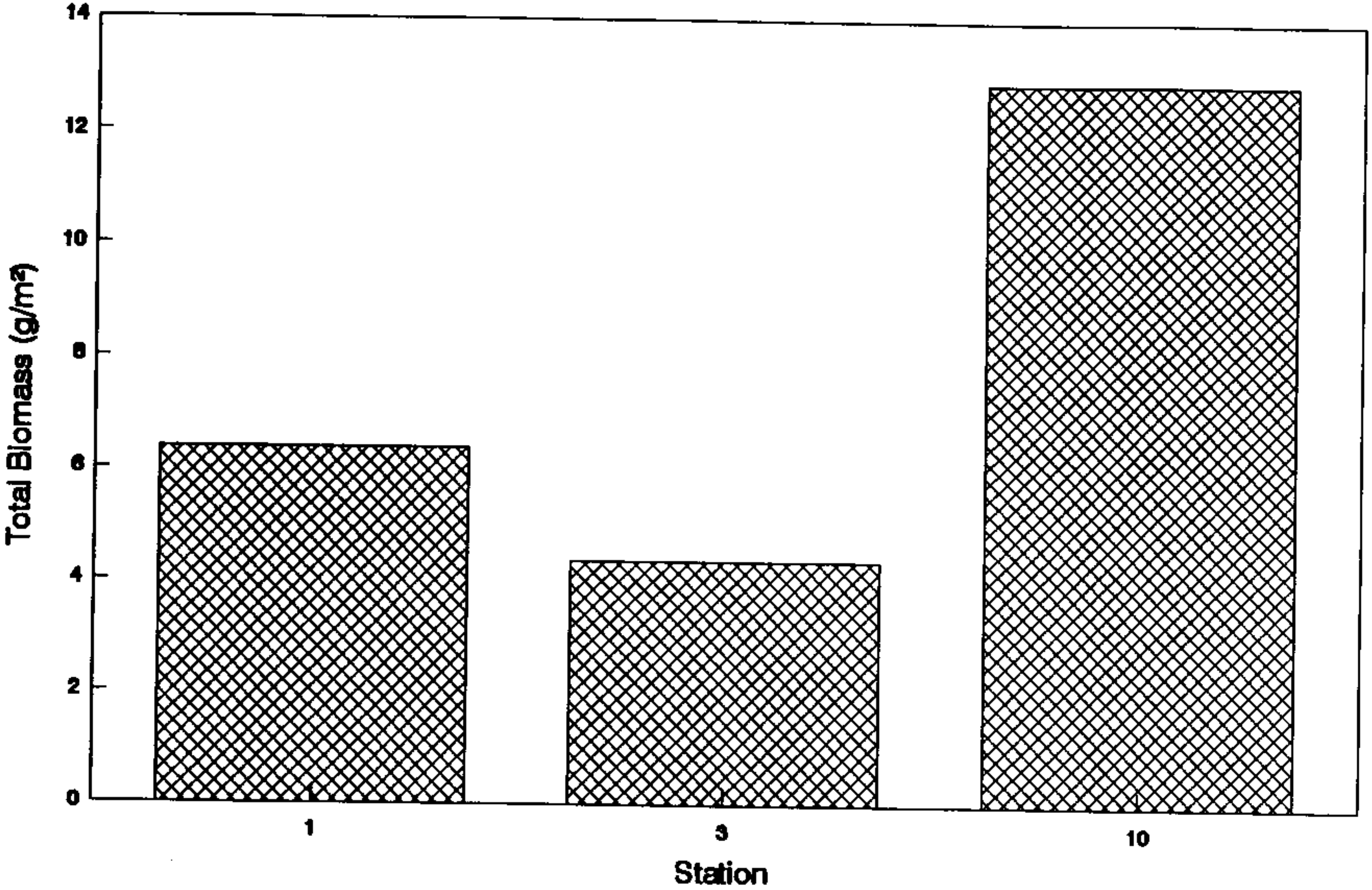


Figure 123. Total biomass of macroinvertebrates sampled at shallow disposal (1) and reference (3 and 10) stations during 1992 in Lower Granite Reservoir.

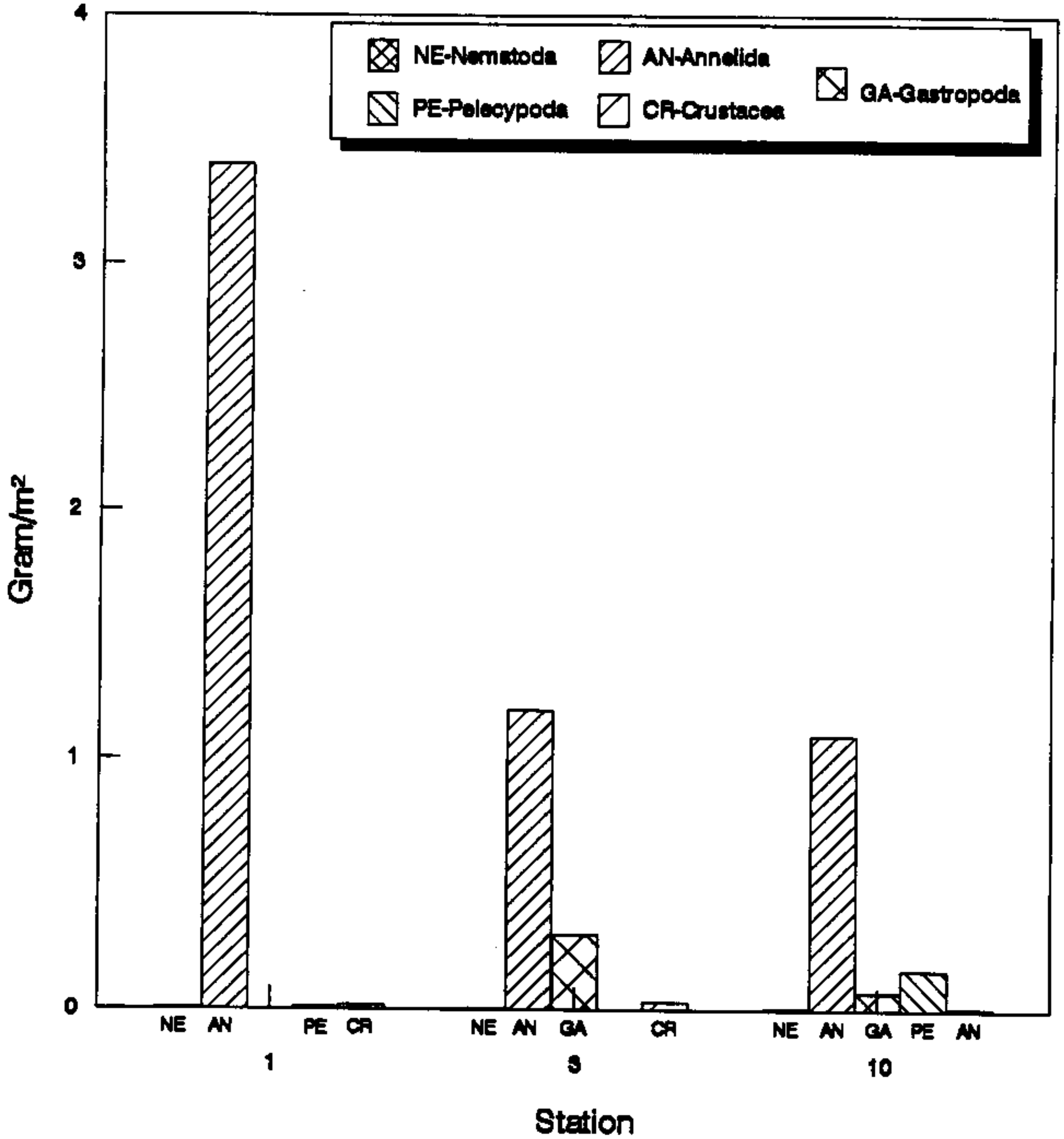


Figure 124. Total biomass of macroinvertebrates sampled at shallow disposal (1) and reference (3 and 10) stations during 1992 in Lower Granite Reservoir.

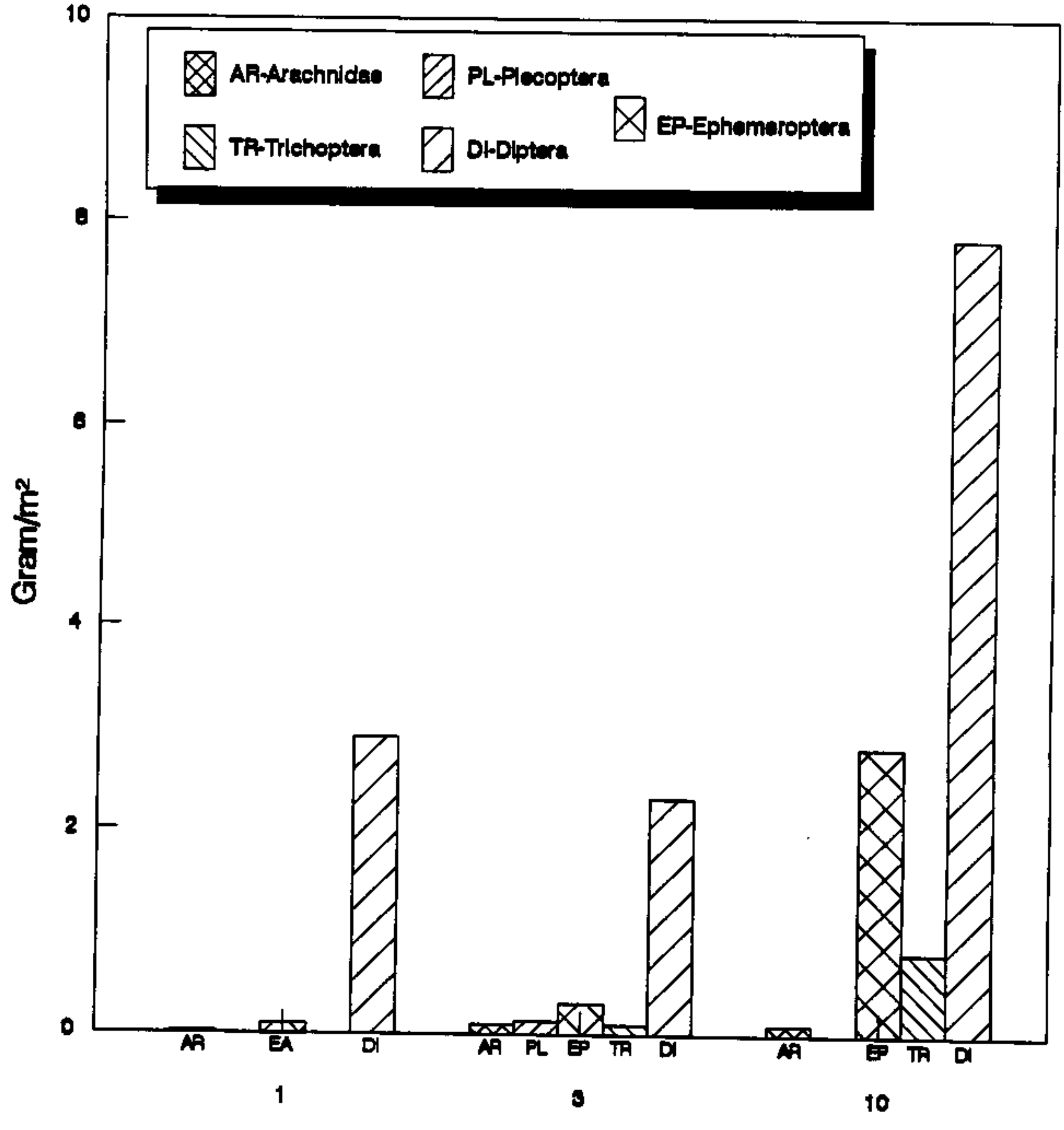


Figure 125. Total biomass of macroinvertebrates sampled at shallow disposal (1) and reference (3 and 10) stations during 1992 in Lower Granite Reservoir.

chironomids and oligochaetes. Standing crop estimates of the benthic invertebrate community ranged from > 8 g/m^2 to < 1.0 g/m^2. Shallow stations had the lowest biomass estimates, with the exception of reference station 5, followed by deep and mid-depth stations (Figure 108). Variances in the estimates were similar between stations with lower estimates and those with higher biomass estimates.

Total community biomass at shallow disposal stations 1 and 2 were similar to shallow reference stations. Total biomass at disposal station 4 was third highest of all stations sampled in 1992. Total community biomass and chironomid biomass were generally similar, whereas oligochaete biomass was highest at mid-depth and deep reference stations 6 and 8 and disposal station 7. Other stations, such as stations 4 and 5, that had higher biomass of chironomids were low in oligochaete biomass.

Interpretation of the benthic invertebrate community data is difficult because of the experimental drawdown in March 1992. Samples in 1992 were collected approximately 3 months following refill of Lower Granite Reservoir. Benthic invertebrate habitat in shallow and mid-depths were ostensibly affected by the drawdown, but the total invertebrate community and chironomid biomass estimates were generally similar to those in 1991. Densities of chironomids in 1992 were actually higher than those in 1989 and 1991 prior to the drawdown. Oligochate biomass was lower in 1992 than years prior to the drawdown. Our data suggest the levels of abundance of the total benthic invertebrate community were probably not adversely affected by the drawdown.

The apparent lack of more long-term effects on the benthic community is probably related to the relatively short duration of exposure and the burrowing capability of some of the organisms. We observed chironomids that had burrowed about 3.6 m (12 inches) below the surface during the drawdown to avoid desiccation. This strategy was successful for at least chironomids during the month drawdown in 1992. Oligochaetes were probably more adversely affected based on their consistent decline in abundance.

Macrophytes

Abundance of macrophytes in Lower Granite Reservoir was adversely affected by the 1992 drawdown. Macrophytes were slow to grow in the summer, were more patchy in their distribution, and provided less habitat for rearing fishes as a result of their lower abundance. Total biomass of macrophytes was low at all stations sampled in 1992; the highest abundance was at shallow reference station 10. Biomass at the island disposal station 1 and adjacent reference station 3 was about 50% of that at reference station 10. These estimates of macrophyte biomass were low compared to those from other reservoirs with more abundant macrophytes beds. For example, Box Canyon Reservoir, Pend Oreille River, Washington, has extensive macrophyte growths that exceed 1,000 g/m^2 (Falter 1991).

Macroinvertebrates in Macrophytes

The macroinvertebrate community in macrophyte beds is considerably more diverse than in soft substrate without macrophytes. Representatives of the orders Tricoptera, Plecoptera and Ephemeroptera were collected in the samples; organisms that are not commonly found in the soft substrate samples.

Standing crop estimates of macroinvertebrates within the macrophyte beds were also considerably higher than those in the open soft substrate. At station 10, dipteran biomass was generally higher than the total benthic invertebrate community biomass estimates for the most productive areas in Lower Granite Reservoir. These macrophyte areas provide a high abundance and greater diversity of potential food items for fishes in the reservoir.

Fishes are also abundant in the macrophyte beds. We observed young-of-the-year centrarchid and cyprinid fishes inhabiting these areas. These macrophyte areas provide cover and food for smaller fishes. The total fish community standing crop estimates could be increased by increased macrophytes in the reservoir. Future drawdowns will adversely affect fishes indirectly by exposing macrophytes to desiccation, thus reducing potential food and cover resources.

OVERALL DISCUSSION

The complete array of experimental in-water disposal options that resulted from the two dredging workshops outlined by Webb et al. (1987) was completed in 1992. In 1987, the underwater plateau or mid-depth disposal (station 4) was created followed by construction of Centennial Island in 1989. In 1992, the deep water disposal was completed. Monitoring for fish and benthic macroinvertebrates has occurred annually (Bennett et al. 1988, 1990, 1991, 1993a, 1993b). Results from previous monitoring efforts were easier to interpret because dredging and in-water disposal was the principal perturbation on the Lower Granite Reservoir system. However in 1992, Lower Granite Reservoir was altered by a number of perturbations including release of upstream flows from Dworshak Dam on the North Fork of the Clearwater River to decrease water temperatures and the experimental drawdown in March 1992 (Bennett et al. 1994a, 1994b, 1994c, 1994d). Effects of these perturbations on fishes and benthic invertebrates have been significant with alterations in the food chain and emigration of fishes downstream. We reported that entrainment of resident fishes, including white sturgeon, occurred as a result of the experimental drawdown (Bennett et al. 1994b). Our assessment was more qualitative than quantitative and the significance on these communities is not known. Data interpretations are therefore based on the knowledge that the Lower Granite system was significantly altered in 1992.

Collections of fishes and benthic macroinvertebrates during spring, summer and fall following the March 1992 drawdown have shown that some changes have occurred in these communities. For example, the total number of fishes collected in 1992 (10,997) was considerably lower than in previous years. In 1991, 15,689 fishes were sampled (Bennett et al. 1993b). In spring 1992, juvenile anadromous salmonids comprised over 54% of all fishes sampled. The more abundant resident fishes, largescale suckers, smallmouth bass and northern squawfish, accounted for about 35% of the fish community compared to 1991 when these species accounted for 54% of all fishes sampled.

Juvenile anadromous salmonids were not collected at any one station in higher abundance than others in 1992, including the forebay of Lower Granite Dam. Catch/efforts for juvenile steelhead and chinook salmon from 1989 through 1992 were significantly higher ($P < 0.05$) at reference stations 5 and 6 than at Centennial Island (station 2) and underwater plateau (station 4). The lower numbers of juvenile anadromous salmonids at the disposal stations should alleviate concern that was expressed at the workshop (Webb et al. 1987) that the in-water disposal areas could become overly attractive to salmonids and might inhibit "normal" migration. During this 4 year period, salmonids were significantly more abundant at upstream (station 5) and downstream (station 6) locations than the island. In 1992, Lower Granite Reservoir reared many non-migrating juvenile steelhead. Juvenile steelhead were so abundant in the reservoir in the fall of 1992 that they accounted for 5% of all fishes sampled compared to 1991 when < 1% were collected.

Shallow water predator numbers in 1992 were higher at reference stations than at disposal stations. Shallow reference stations 9, 3 and

10 supported the highest abundance of northern squawfish and smallmouth bass. Northern squawfish abundance, based on gill net captures, was highest at shallow reference station 5 and lowest at deep disposal station 7. Catch/effort for smaller northern squawfish by electrofishing and beach seining was highest at shallow reference stations. Smallmouth bass abundance was also lower at Centennial Island, based on electrofishing, whereas gill net data showed high abundance during the spring. We attributed this high number to the "armored" rock face that attracts prespawning smallmouth bass.

Channel catfish abundance in 1992 was also lower at the disposal stations than the reference stations. Channel catfish are considerably lower in abundance in Lower Granite than in Little Goose Reservoir (Bennett et al. 1983). Regardless, catch/effort was significantly higher at reference stations 5 and 6 than at the island, underwater plateau, and the deep disposal station.

The deep disposal station (7) was attractive to white sturgeon in 1992. Catch/effort of white sturgeon was higher at station 7 than the other reference and disposal stations. In previous years, highest catches of white sturgeon at sampling stations have consistently occurred at deep reference station 8 (Bennett et al. 1993b). The attractiveness of station 7 may be related to the heterogeneity of bottom substrates or the potential for higher food abundance following disposal.

Population abundance of the more abundant resident fishes since 1989 have shown few changes. Northern squawfish numbers have not increased in Lower Granite Reservoir as a result of the in-water disposal. During the 4 year period of 1989-1992, adult numbers, based on gill net captures, were significantly ($P < 0.05$) higher at reference stations. Numbers collected by beach seining have generally declined since 1989. Because of sampling efficiency, this may indicate a decrease in juvenile northern squawfish. Smallmouth bass abundance at the disposal stations has been generally stable as beach seining data showed no changes in smaller bass abundance. Abundance of adult sized bass has generally stayed constant. Channel catfish abundance is similar to that found in 1989. Lowest captures of channel catfish during the 1989-1992 period have occurred at the disposal stations.

Abundance of larval fishes has increased in Lower Granite Reservoir as a result of the operating regimen rather than in-water disposal. Larval fish abundance was extremely high in 1991 and 1992 compared to 1989 and 1990. Larval fish abundance at the disposal stations, however has consistently been low. We attribute the increase in abundance to the more stable water levels that occurred as a result of operating at minimum operating pool (Bennett et al. 1994a). High larval fish abundance in 1991 and 1992 seems to be related to the water level fluctuations that occur during the larval phase of the life cycle, primarily during May through July.

Predation of salmonids by northern squawfish in Lower Granite Reservoir has been monitored since 1987 (Chandler 1993). In 1992, daily ration of northern squawfish on salmonids, especially juvenile chinook salmon, was about 6 times higher than in 1990 and 1991. Also during

1992, smallmouth bass consumed an estimated 31,512 subyearling chinook salmon (Curet 1993). We attribute these high levels of consumption indirectly to the 1992 drawdown. Although crayfish comprised the highest biomass of any single food item of northern squawfish in 1992, crayfish abundance decreased substantially following the drawdown. Numerous crayfish were stranded and desiccated along the shoreline of Lower Granite Reservoir during the 1992 drawdown by the decreasing water levels. Since crayfish were the principal food item for many predatory fishes in Lower Granite Reservoir (Bennett and Shrier 1987), their decrease in abundance probably increased predation on juvenile salmonids in Lower Granite Reservoir immediately after the drawdown. Thus, the high incidence of predation on juvenile salmonids by northern squawfish and smallmouth bass in 1992 was probably a result of decreased crayfish availability.

Subyearling chinook salmon abundance in Lower Granite Reservoir in 1992 was generally similar to previous years (Bennett et al. 1993b; Curet 1993). Time of shallow water use in Lower Granite was similar to previous years, extending from early April through May. Subyearlings were found primarily over finer substrata as 100% were collected over substrata < 50 mm diameter. As in previous years, they exhibited strong preference for finer substrata with about 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.

Food of subyearlings was primarily insects, zooplankton and fish. Cladocera, Diptera, Ephemeroptera and larval fishes accounted for about 87% of the food items by weight and calorically. Monthly differences in food items probably related to food availability. Food availability for subyearling chinook salmon seems to be important in Lower Granite Reservoir, especially since prey consumption was only slightly above that required for maintenance (Curet 1993). Use of a bioenergetics model indicated that their maximum consumption was about 27.4%, slightly higher than the 20% maintenance ration. Based on our observations and use of the bioenergetics model, temperature may dictate shoreline distribution and timing of migration. Migration from shoreline areas occurs at about 18°C, the water temperature the bioenergetics model predicted would result in a cessation of weight gain.

The benthic macroinvertebrate sampling in 1992 indicated the Lower Granite community remains relatively simple consisting primarily of oligochaetes and chironomids. The total benthic invertebrate community biomass was similar among disposal and reference stations. The newly created deep water disposal station 7 exhibited the highest community biomass. Although many of the invertebrate stations in Lower Granite Reservoir were affected by the 1992 spring drawdown, the total community and chironomid biomasses were similar to those in 1991 prior to the drawdown. Densities of chironomids were higher than those in 1989 and 1991, although oligochaete biomass was low. The lack of more "long term" effects from the drawdown was probably related to the timing and relatively short exposure. March 1992 was overcast with some rain that helped alleviate the desiccation of the substrate and reduce mortality of the benthic invertebrates that could burrow.

Macrophyte densities were low in comparison to other systems with abundant aquatic vegetation. Our observations suggested that the drawdown in the spring of 1992 adversely affected macrophytes; some areas that previously supported relatively dense stands of macrophytes contained none throughout the 1992 growing season.

The importance of macrophytes in the Lower Granite system is obvious. Little cover exists for rearing fishes and food abundance is higher within macrophyte beds. We found that invertebrate diversity and standing crops were higher in macrophytes than in similar areas without macrophytes. Dipteran biomass was higher in the macrophytes than in the most productive benthic invertebrate areas of the reservoir.

In summary, the 1992 monitoring in Lower Granite Reservoir revealed a number of changes in that system, all seemingly related to other perturbations and changes in operations than the in-water disposal. We have found several positive effects from the in-water disposal of sediment in the reservoir but no negative ones. Increased benthic invertebrate abundance in disposal areas, possibly increased availability to fishes, and an increase in rearing habitat for subyearling chinook salmon are the apparent benefits to the system. Increased availability of potential food items appears important because of the apparent food limitation for subyearling chinook salmon and possibly yearlings within Lower Granite Reservoir. Our data suggest that increased shallow water habitat may be beneficial to fishes and the abundance of their food items. Resource managers should strongly consider solving the sedimentation problem in Lower Granite Reservoir with innovative approaches to habitat enhancement.

REFERENCES

Arthaud, D.L. 1992. Size selectivity and capture efficiency of electrofishing, gillnetting, and beach seining in Lower Granite Reservoir, Washington. Master's thesis. University of Idaho, Moscow.

Beamesderfer, R.C., and B.E. Rieman. 1988. Predation by resident fish on juvenile salmonids in a mainstem Columbia River reservoir; Part III. Abundance and distribution of northern squawfish, walleye and smallmouth bass. Pages 211-248 *in* T.P. Poe and B.E. Rieman, editors. Predation by resident fish on juvenile salmonids in John Day Reservoir: Volume 1. Final report (contracts DE-AI79-82BP34796 and DE-AI79-82BP35097) to Bonneville Power Administration, Portland, Oregon.

Becker, C.D. 1970. Feeding bionomics of juvenile chinook salmon in the Central Columbia River. Northwest Science, Volume 44, No. 2.

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

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

Bennett, D.H., and F.C. Shrier. 1987. Monitoring sediment dredging and overflow from land disposal activities on water quality, fish and benthos in Lower Granite Reservoir, Washington. Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

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

Bennett, D.H., L.K. Dunsmoor, J.A. Chandler, and T. Barila. 1989. Use of dredged material to enhance fish habitat in Lower Granite Reservoir, Idaho-Washington. Proceedings of the symposium on the effects of dredging on anadromous fishes in the Pacific Northwest. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

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

Bennett, D.H., J.A. Chandler, and G. Chandler. 1991. Lower Granite Reservoir in-water disposal test: Results of the fishery, benthic and habitat monitoring program-Year 2 (1989). Completion Report. U.S. Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., T.J. Dresser, T.S. Curet, K.B. Lepla, and M.A. Madsen. 1993a. Lower Granite Reservoir in-water disposal test: Results of the fishery, benthic and habitat monitoring program-Year 3 (1990). Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., T.J. Dresser, T.S. Curet, K.B. Lepla, and M.A. Madsen. 1993b. Lower Granite Reservoir in-water disposal test: Results of the fishery, benthic and habitat monitoring program-Year 4 (1991). Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., T.J. Dresser, Jr., and M.A. Madsen. 1994a. Effects of reservoir operations at minimum pool and regulated inflows of low temperature water on resident fishes in Lower Granite Reservoir, Idaho-Washington. Completion Report (Draft). U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., T.J. Dresser, Jr., and M.A. Madsen. 1994b. Evaluation of the 1992 drawdown in Lower Granite and Little Goose reservoirs. Completion Report. U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., M.H. Karr, and M.A. Madsen. 1994c. Thermal and velocity characteristics in the Lower Snake River reservoir, Washington, as a result of regulated upstream water releases. Completion Report (Draft). U.S. Army Corps of Engineers, Walla Walla, Washington.

Bennett, D.H., M.A. Madsen, and M.H. Karr. 1994d. Thermal characteristics in the Lower Snake River reservoir, Washington, as a result of regulated upstream water releases; Data Volume 1. Completion Report (Draft). U.S. Army Corps of Engineers, Walla Walla, Washington.

Bratovich, P.M. 1985. Reproduction and early life histories of selected resident fishes in Lower Snake River reservoirs. Master's thesis. University of Idaho, Moscow.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus Oncorhynchus. Journal, Fisheries Research Board of Canada, Volume 9, No.. 6, p. 265-323.

Chander, J.A. 1993. Consumption rates and estimated total loss of juvenile salmonids by northern squawfish in Lower Granite Reservoir, Washington. Master's thesis. University of Idaho, Moscow.

Cummins, K.W., and J.C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. International Association of Theoretical and Applied Limnology (Mittelungen) 18:1-158.

Curet, T.S. 1994. Habitat use, food habits and the influence of predation on subyearling chinook salmon in Lower Granite and Little Goose reservoirs, Washington. Master's thesis. University of Idaho, Moscow.

Dauble, D.D., R.H. Gray, and T.L. Page. 1980. Importance of insects and zooplankton in the diets of age-0 chinook salmon in the Central Columbia River. Northwest Science, Vol. 54, No. 4.

Dorband, W.R. 1980. Benthic macroinvertebrate communities in the lower Snake River reservoir system. Doctorate dissertation. University of Idaho, Moscow.

Dunsmoor, L.K. 1990. Relative prey importance and availability in relation to smallmouth growth in Brownlee Reservoir, Idaho, with notes on dietary indices. Master's thesis. University of Idaho, Moscow.

Falter, C.M., C. Baines, and J.W. Carlson. 1991. Water quality, fish and wildlife characteristics of Box Canyon Reservoir, Washington. Completion Report: Section 2. Pend Oreille County, Public Utility District, Newport, Washington.

Foster, J.R. 1977. Pulsed gastric lavage: an effective method of removing the stomach contents of live fish. Progressive Fish Culturist 39:166-169.

Funk, W.H., C.M. Falter, and A.J. Lingg. 1979. Limnology of an impoundment series in the lower Snake River. Final report of work. U.S. Army Corps of Engineers, Walla Walla, Washington. Contract Numbers DACW 68-75-C-0143 and 0144.

Gaines, W.L., C.E. Cushing, and S.D. Smith. 1992. Secondary production estimates of benthic insects in three cold desert streams. Great Basin Naturalist 52(1), pp 11-24.

Hall, D.J., W.E. Copper, and E.E. Werner. 1970. An experimental approach to the production dynamics and structure of freshwater animal communities. Limnology and Oceanography 15:839-928.

Hansel, H.C., S.D. Duke, P.T. Lofy, and G.A. Gray. 1988. Use of diagnostic bones to identify and estimate original lengths of ingested prey fishes. Transactions of the American Fisheries Society 117:55-62.

Hewett, S.W., and B.L. Johnson. 1987. A generalized bioenergetics model of fish growth for micro-computers. University of Wisconsin, Sea Grant Technical Report WIS-SG-87-245, Madison.

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

Pennak, R.W. 1978. Freshwater invertebrates of the United States. Second edition. John Wiley and Sons. New York, New York.

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

Poe, P. 1992. Research plan to determine timing, location, magnitude, and cause of mortality for wild and hatchery spring/summer chinook salmon smolts above Lower Granite Dam. U.S. Department of Energy, BPA Project No. 97-017.

Rondorf, D.W., G.A. Gray, R.B. Fairley. 1990. Feeding ecology of subyearling chinook salmon in riverine and reservoir habitats of the Columbia River. Transactions of the American Fisheries Society 119:16-24.

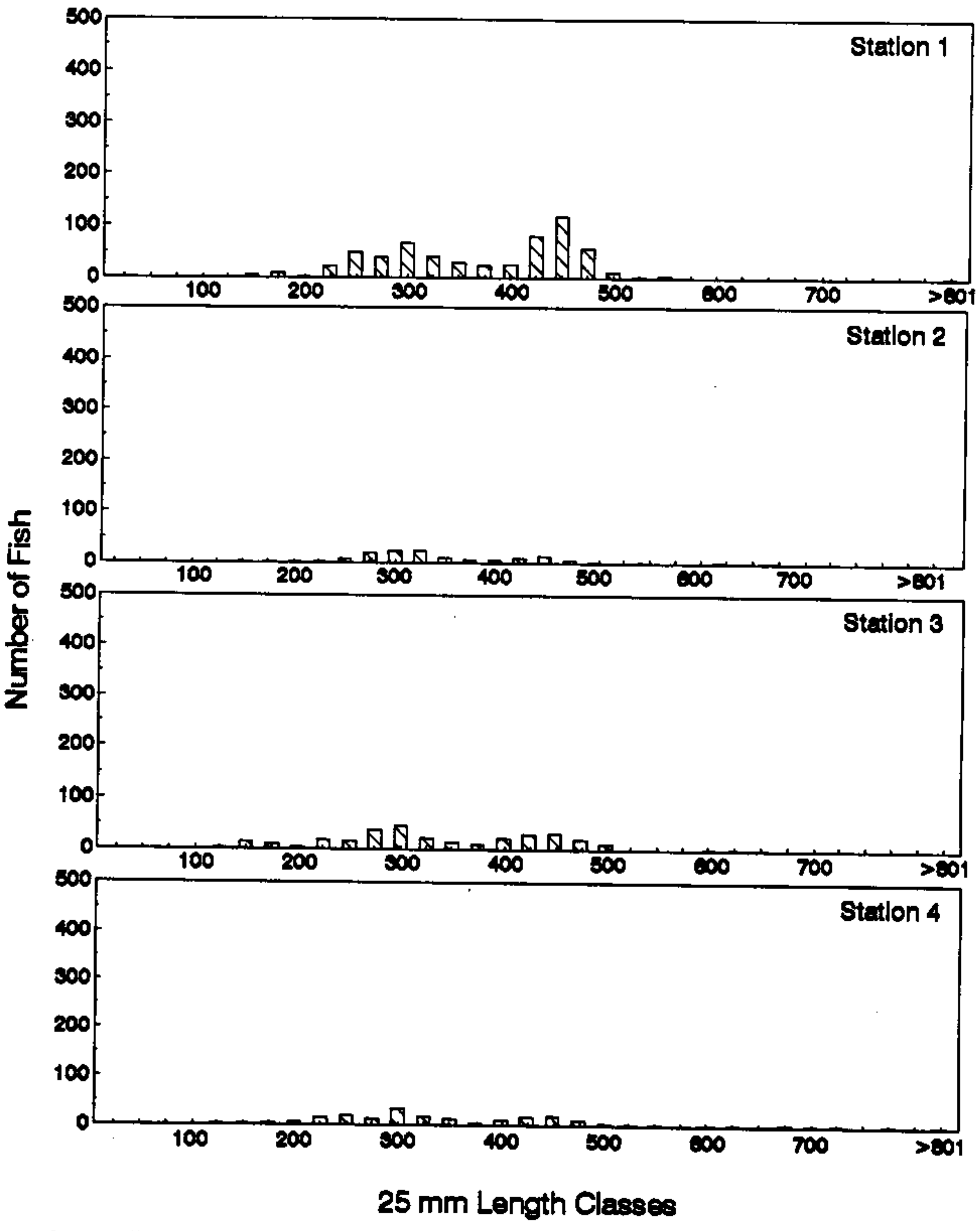
Scheafer, R.L., W. Mendenhall, and L. Ott. 1986. Elementary survey sampling. Duxbury Press, Boston, Massachusetts.

Thorne, R.E., C.J. McClain, J. Hedgepeth, E.S. Kuehl, and J. Thorne. 1992. Hydroacoustic surveys of the distribution and abundance of fish in Lower Granite Reservoir, 1989-1990. Final Report to U.S. Army Corps of Engineers, Walla Walla, Washington. Contract No. DAC 68-C-0022.

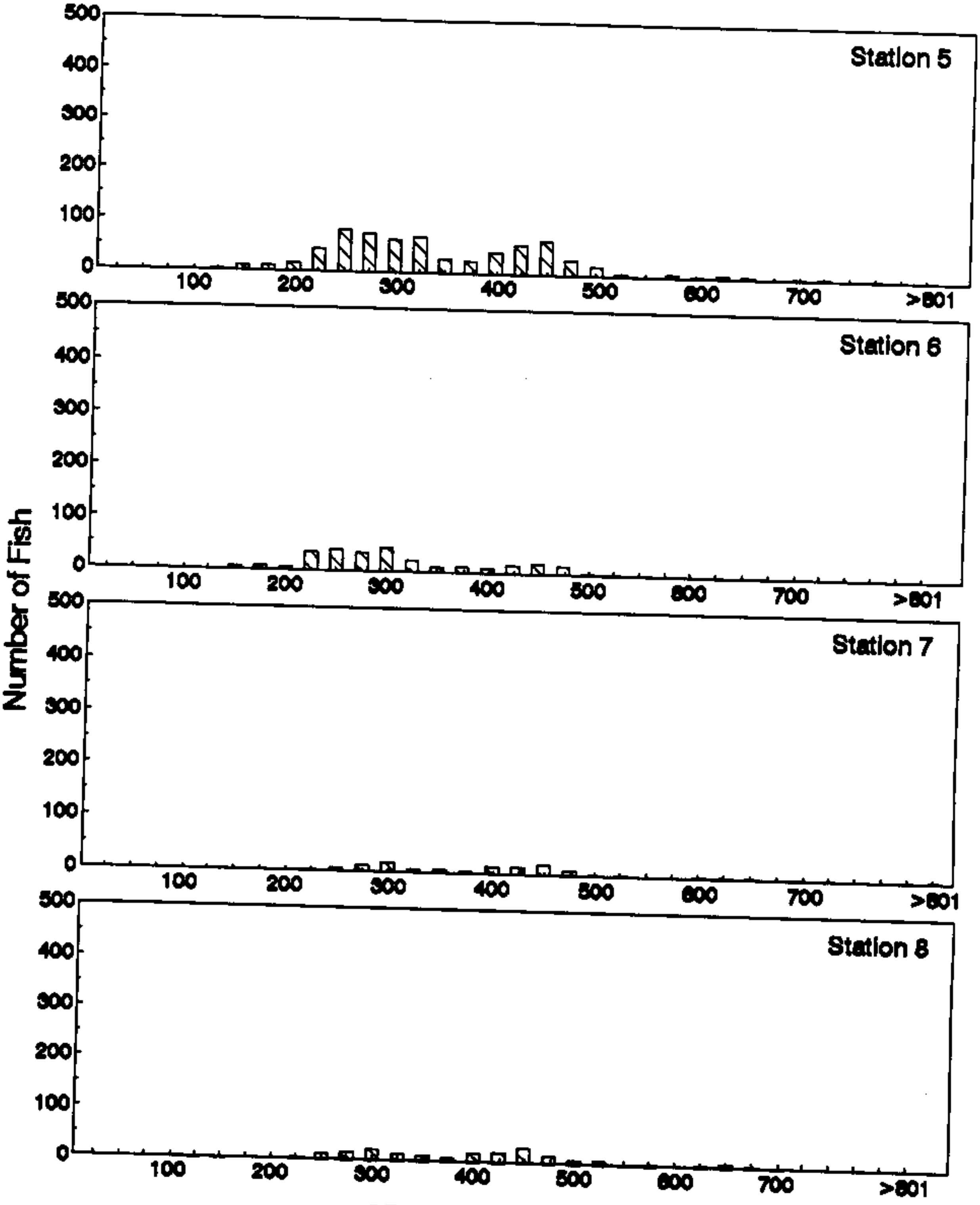
Vigg, S., T.P. Poe, L.A. Prendergast, and H.C. Hansel. 1988. Predation by resident fish on juvenile salmonids in a mainstem Columbia River reservoir: Part II. Consumption rates of northern squawfish, walleye, smallmouth bass, and channel catfish. Pages 56-115 *in* T.P. Poe and B.E. Rieman, editors. Predation by resident fish on juvenile salmonids in John Day Reservoir, 1983-86. Final Report (Contracts DE-AI79-82BP34796 and DE-AI79-82BP35097) to Bonneville Power Administration, Portland, Oregon.

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

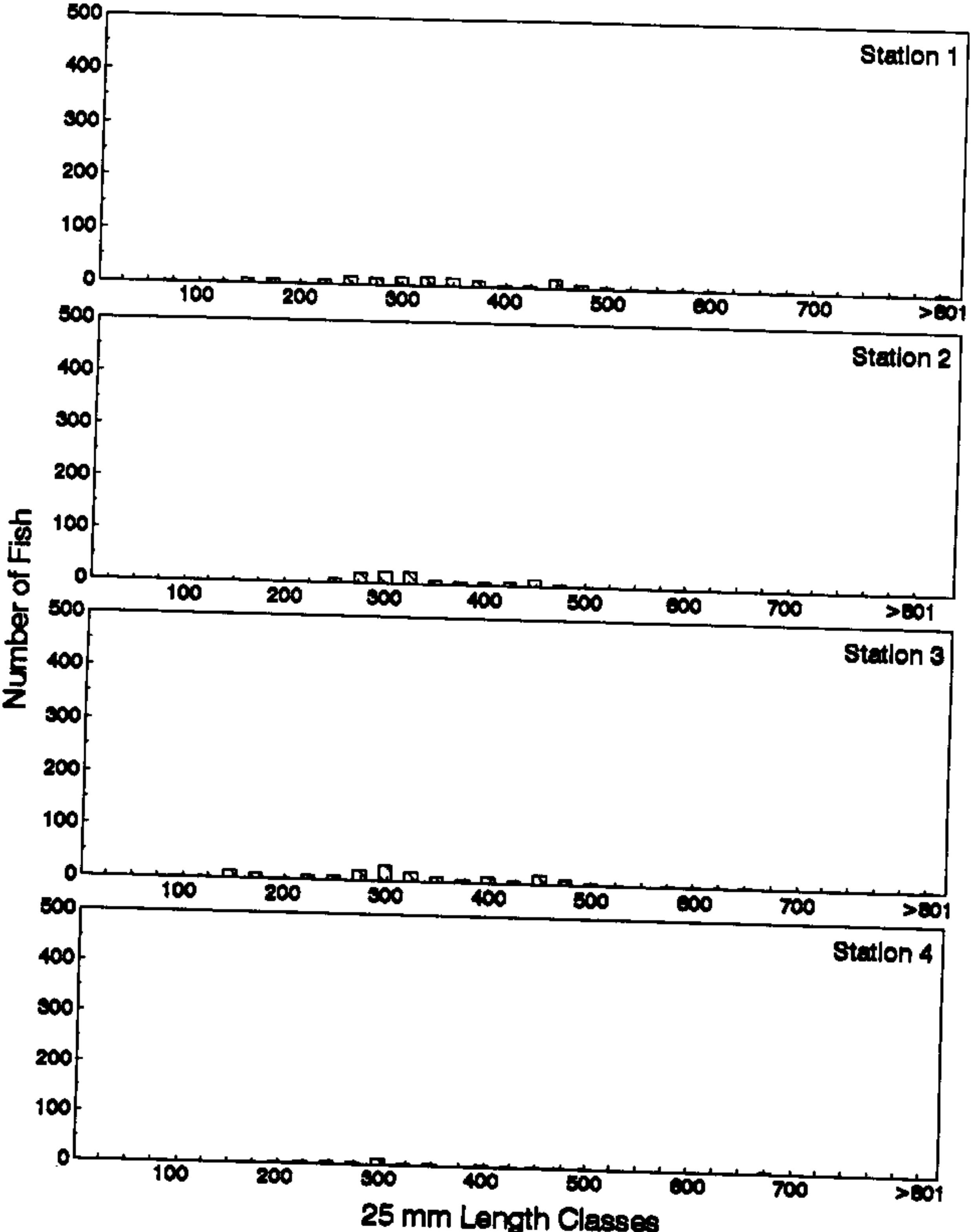
Appendix Figures and Tables



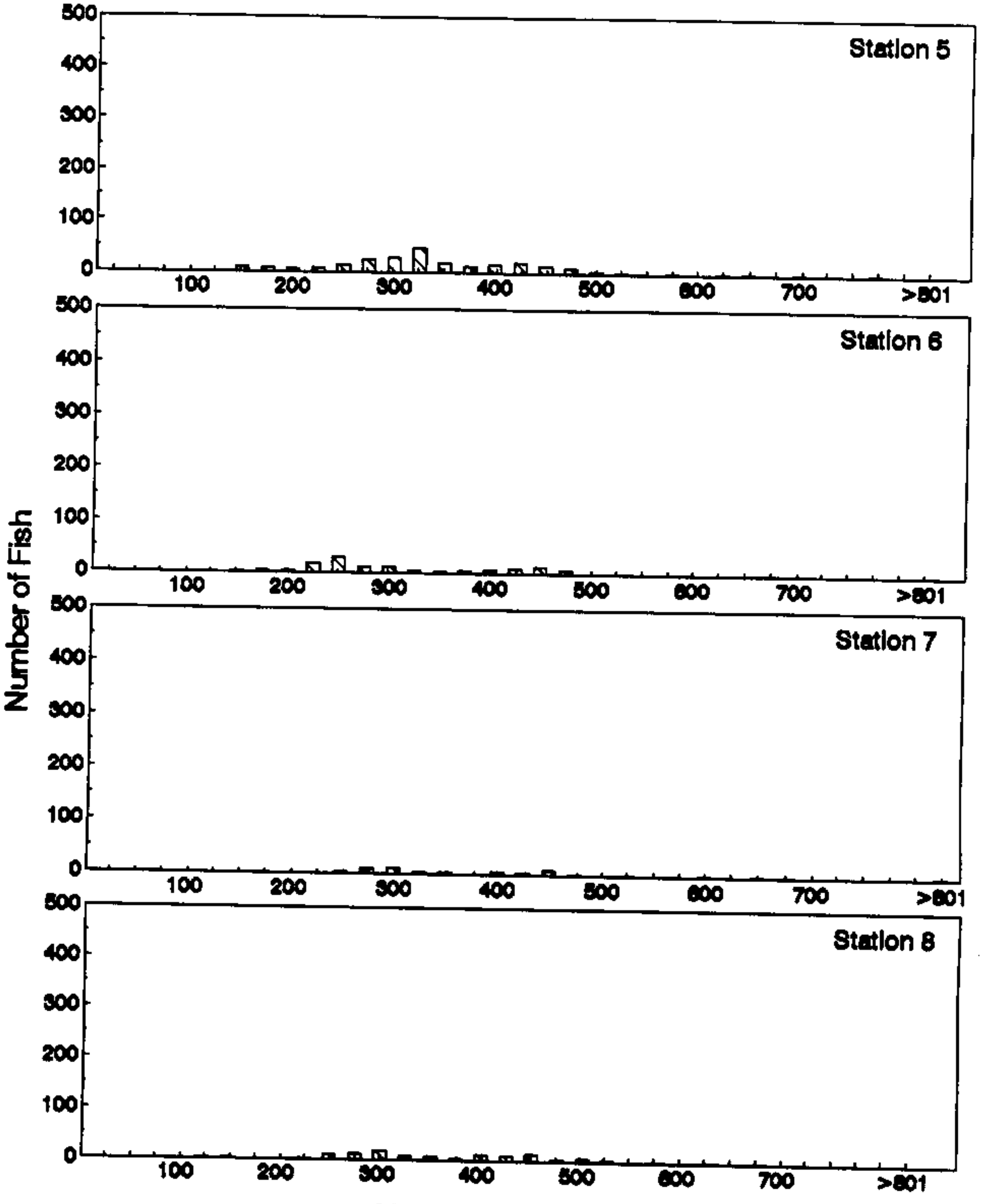
Appendix Figure 1. Length distributions of all fishes sampled by gill netting at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during 1992 in Lower Granite Reservoir.



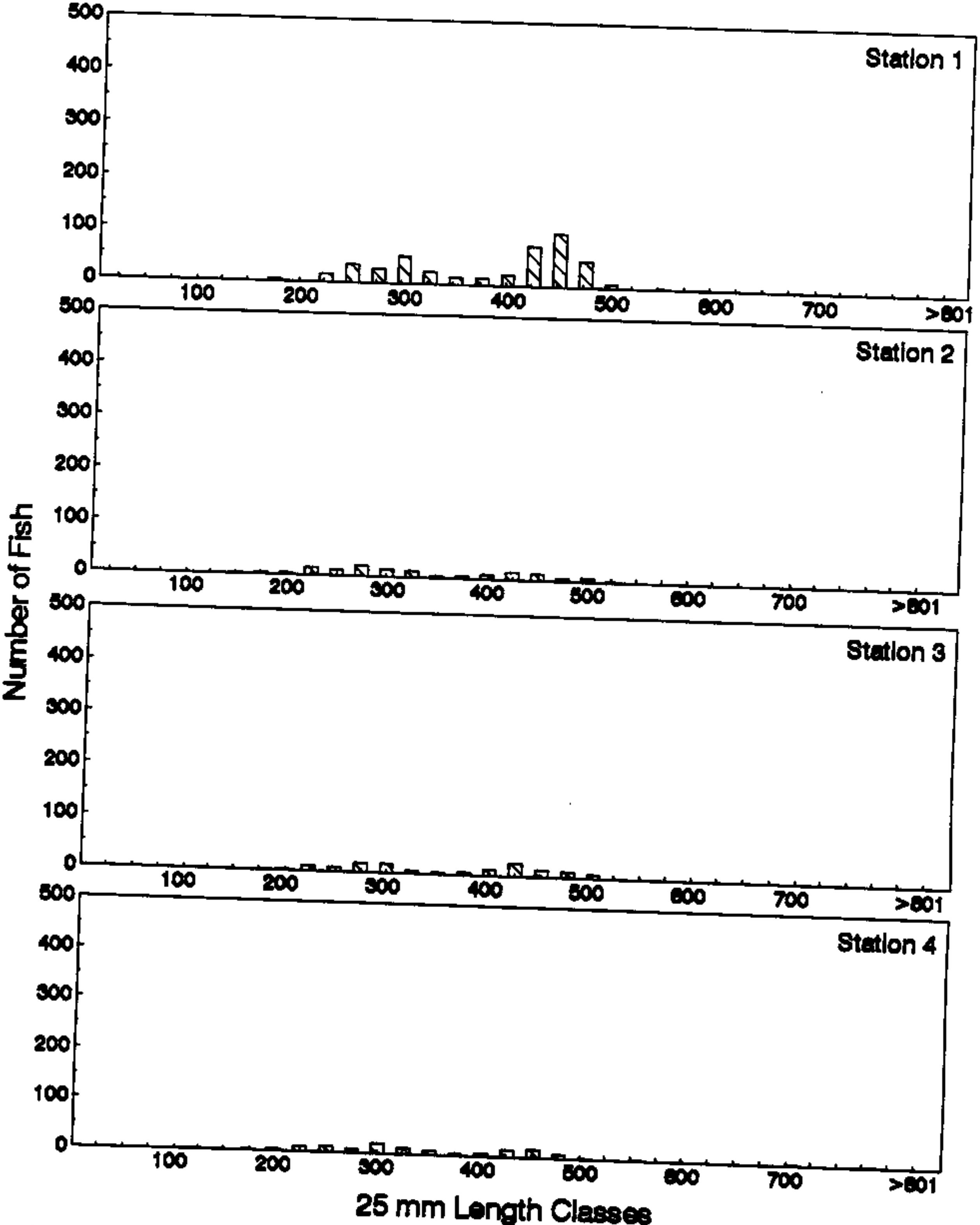
Appendix Figure 2. Length distributions of fishes sampled by gill netting at shallow (5), mid-depth (6) and deep (8) reference and disposal (7) stations during 1992 in Lower Granite Reservoir.



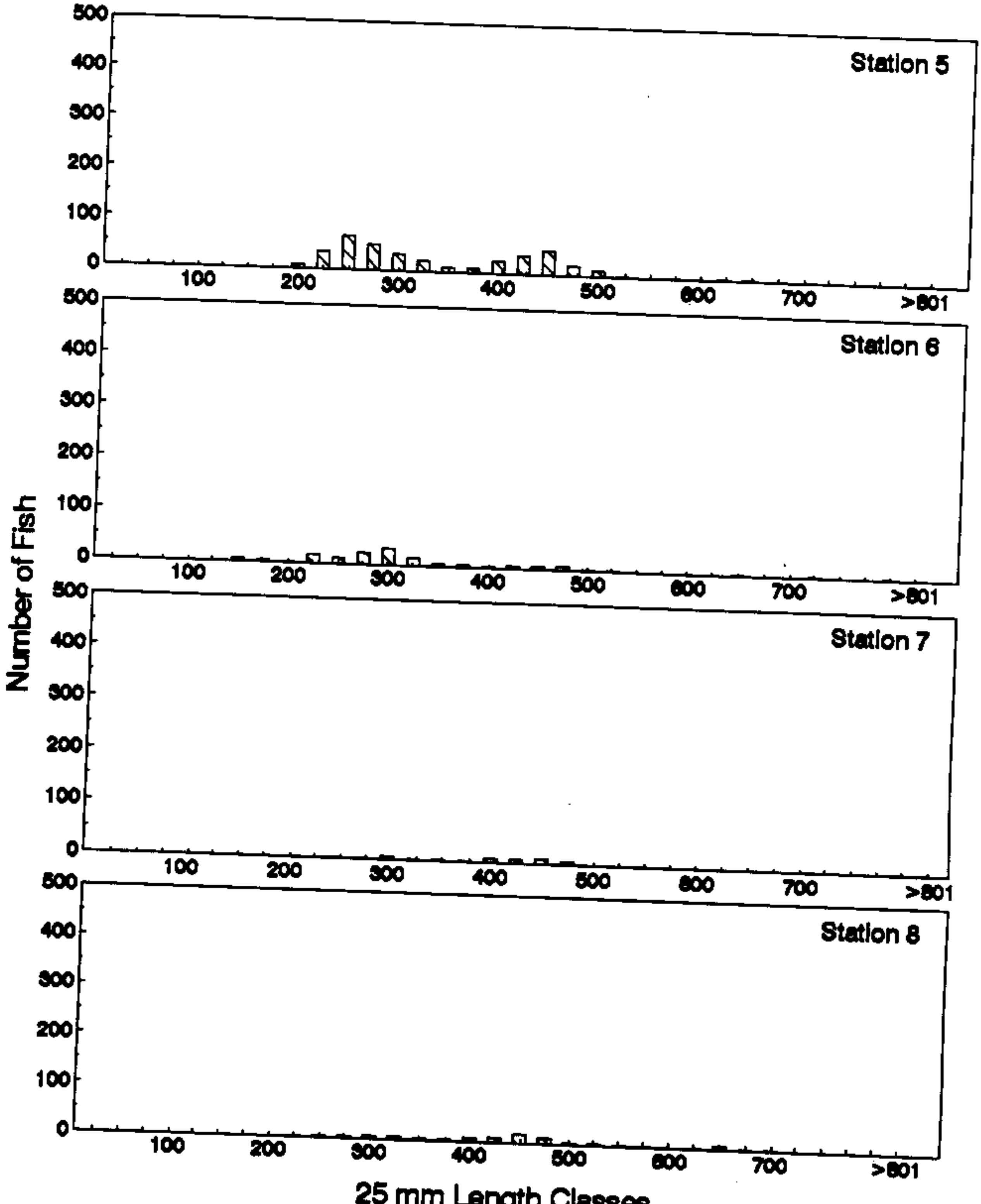
Appendix Figure 3. Length distributions of all fishes sampled by gill netting at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during spring 1992 in Lower Granite Reservoir.



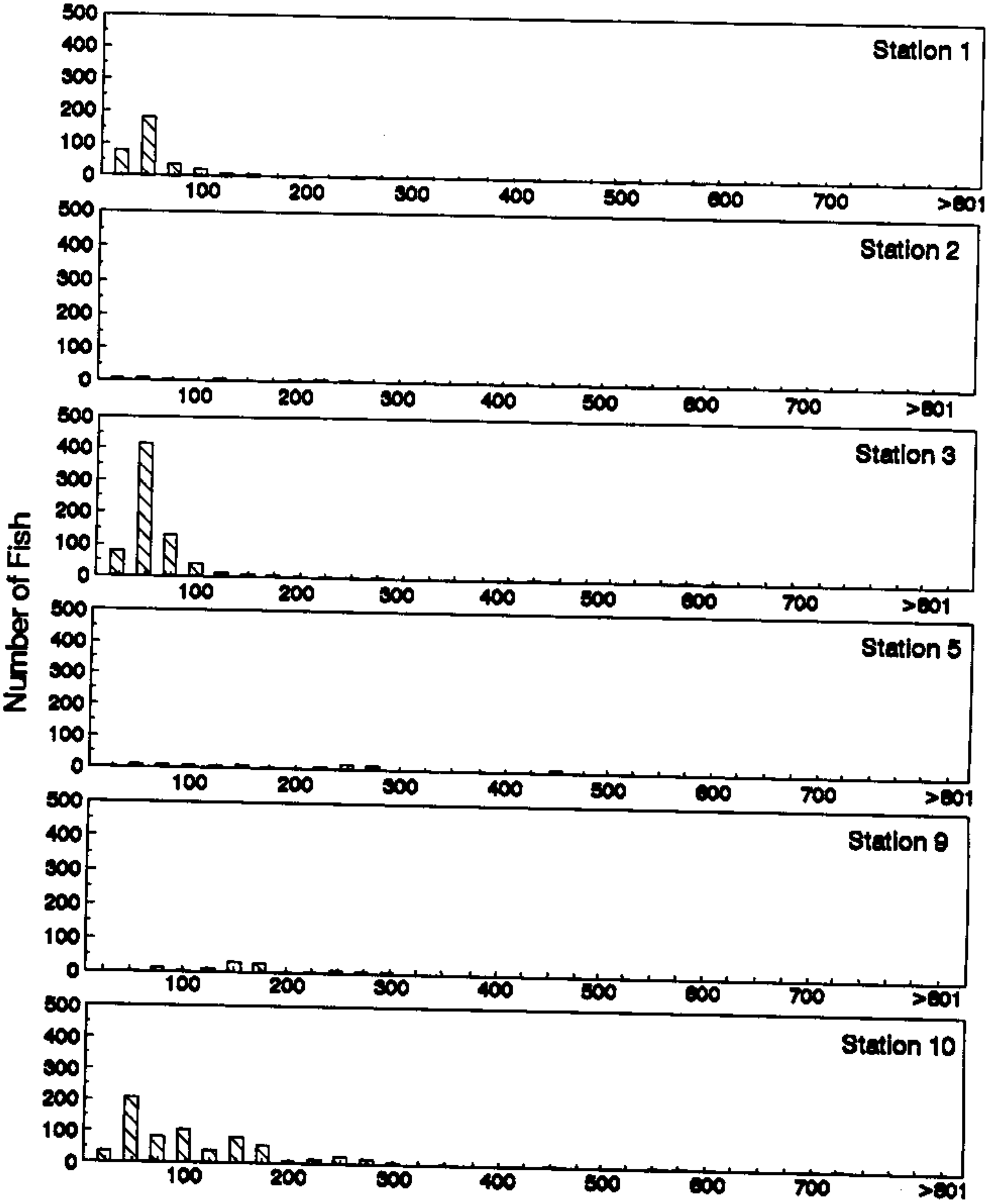
Appendix Figure 4. Length distributions of all fishes sampled by gill netting at shallow (5), mid-depth (6) and deep (8) reference and disposal (7) stations during spring 1992 in Lower Granite Reservoir.



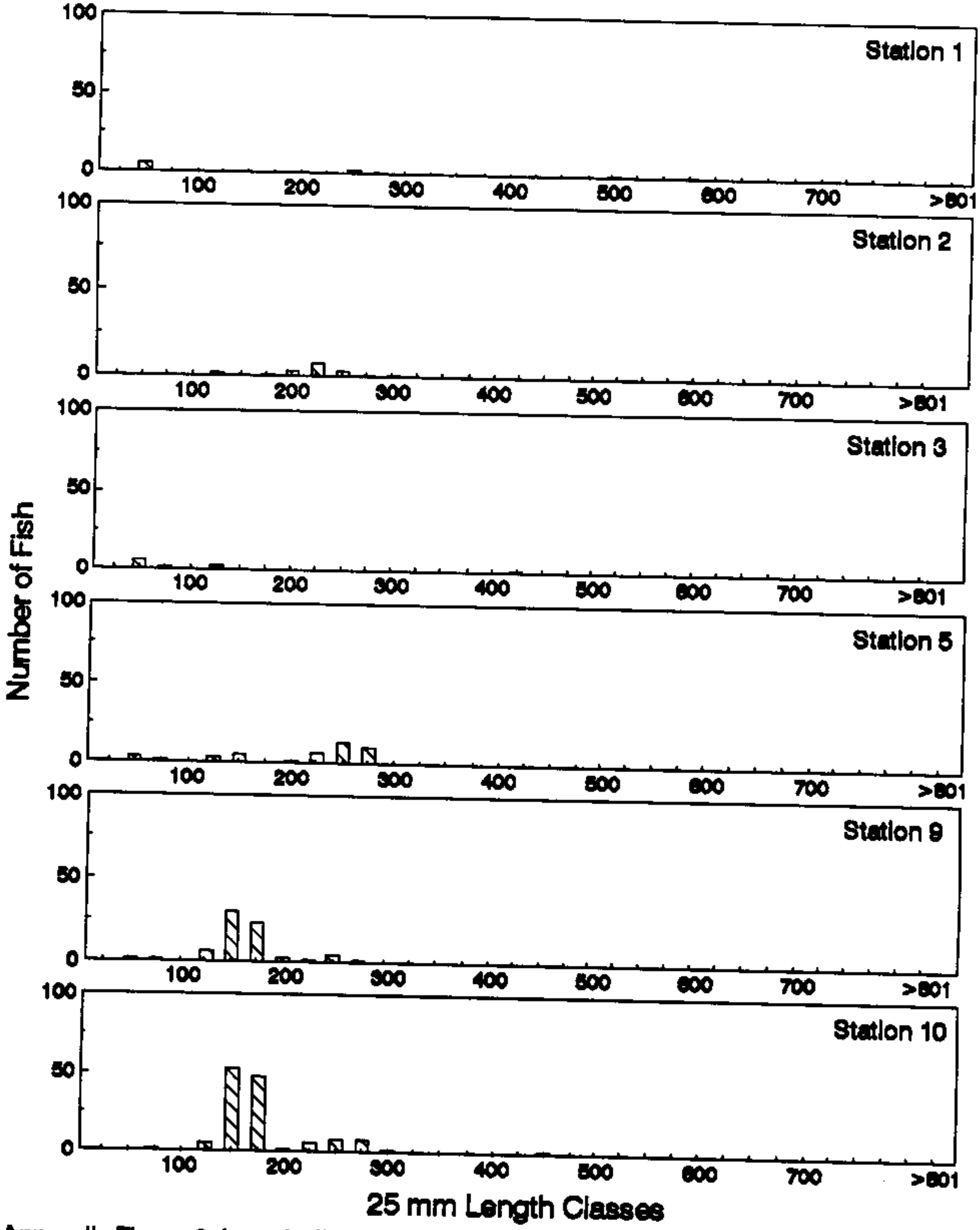
Appendix Figure 5. Length distributions of all fishes sampled by gill netting at shallow (1 and 2) and mid-depth (4) disposal stations and shallow reference station 3 during fall 1992 in Lower Granite Reservoir.



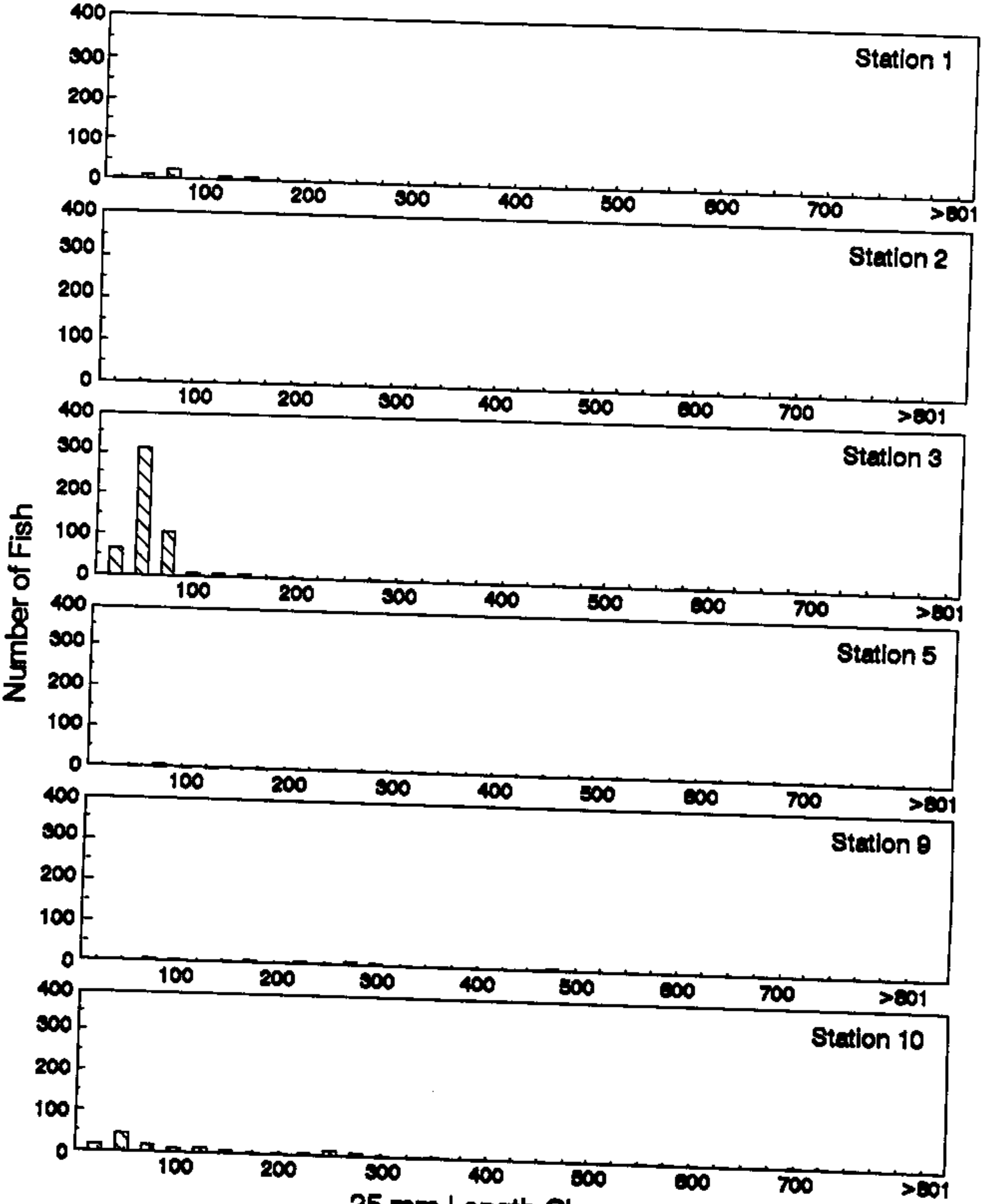
Appendix Figure 6. Length distributions of all fishes sampled by gill netting at shallow (5), mid-depth (6) and deep (8) reference and disposal (7) stations during fall 1992 in Lower Granite Reservoir.



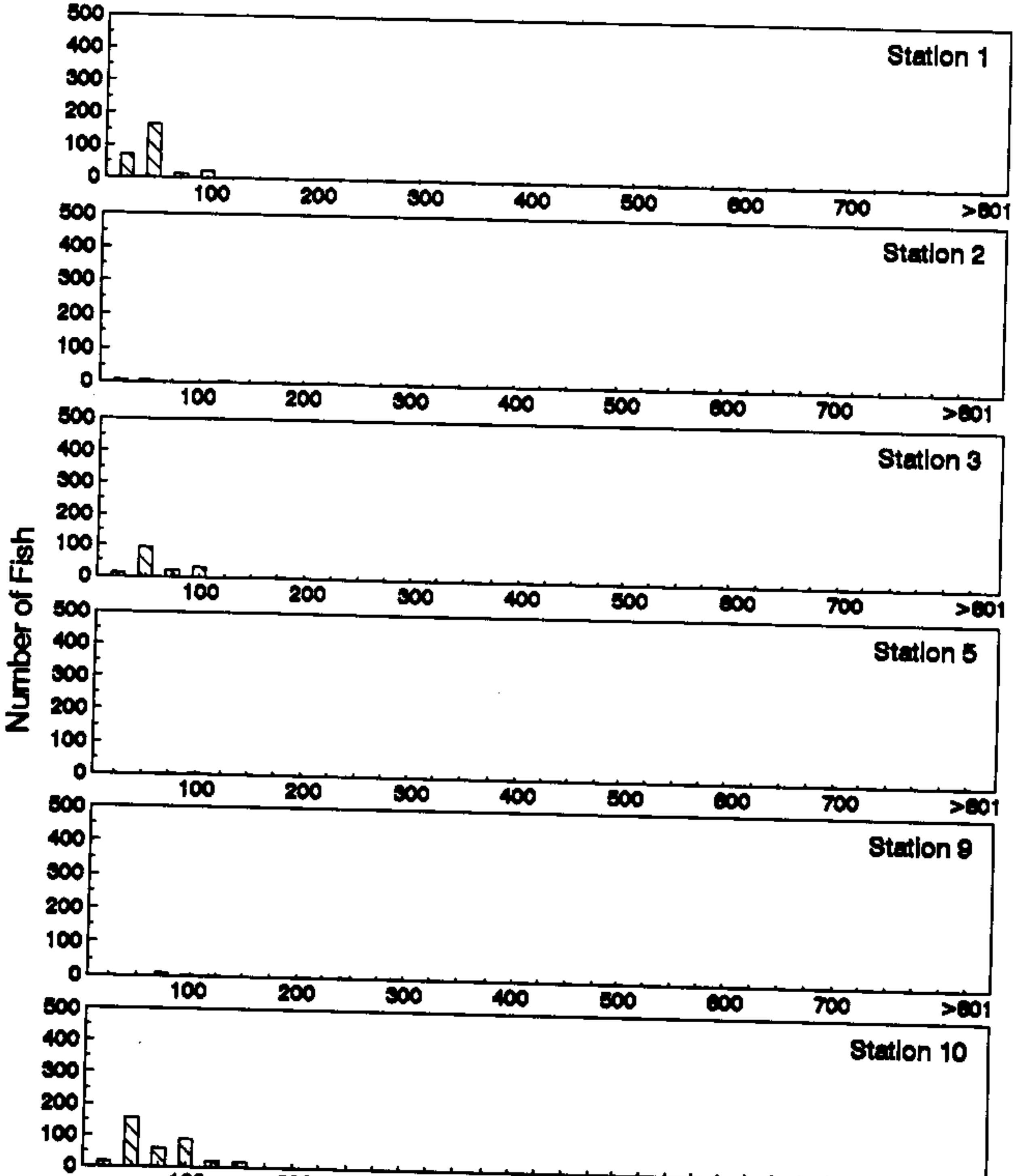
Appendix Figure 7. Length distributions of fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during 1992 in Lower Granite Reservoir.



Appendix Figure 8. Length distributions of all fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during spring 1992 in Lower Granite Reservoir.

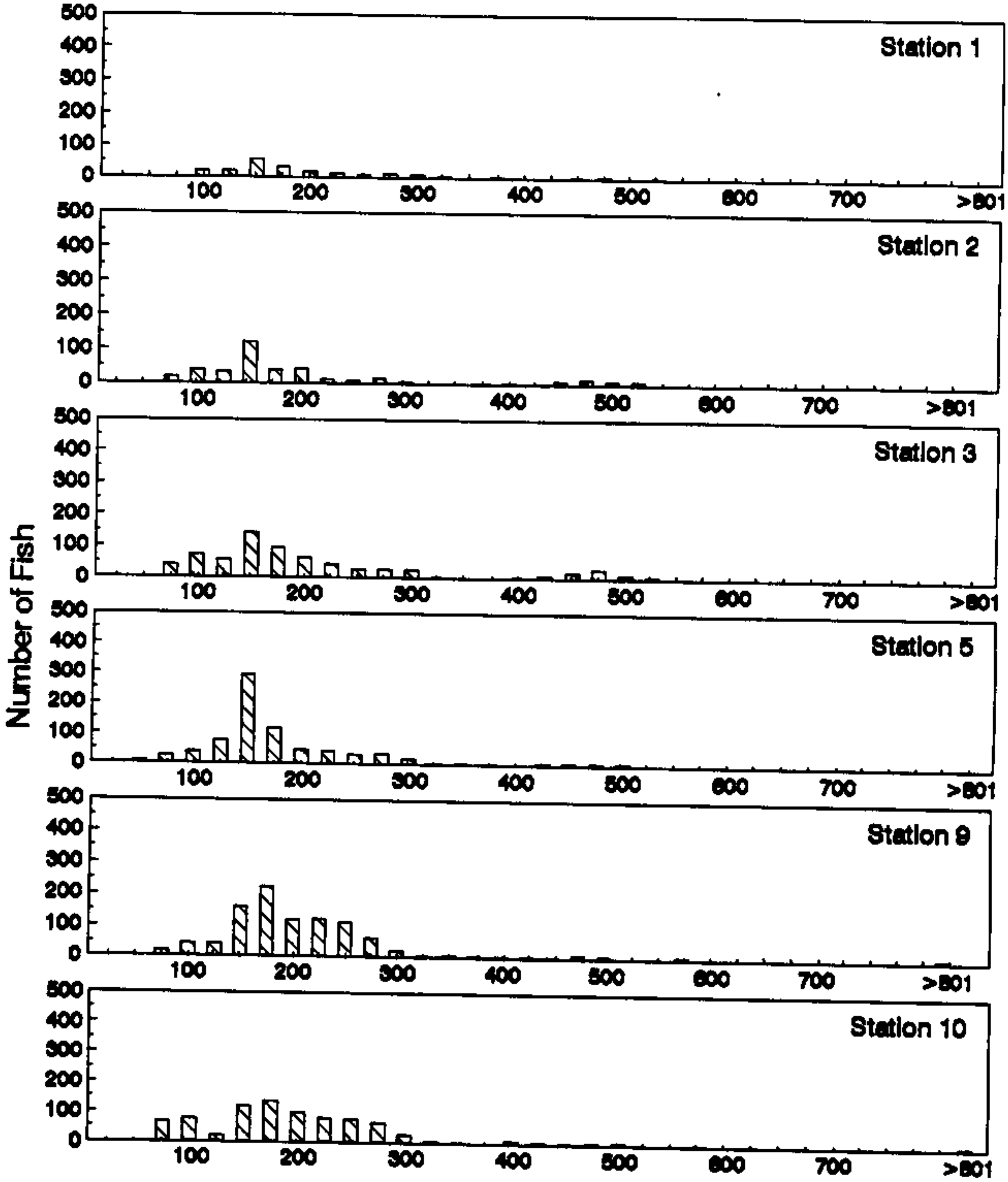


Appendix Figure 9. Length distributions of fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during summer 1992 in Lower Granite Reservoir.

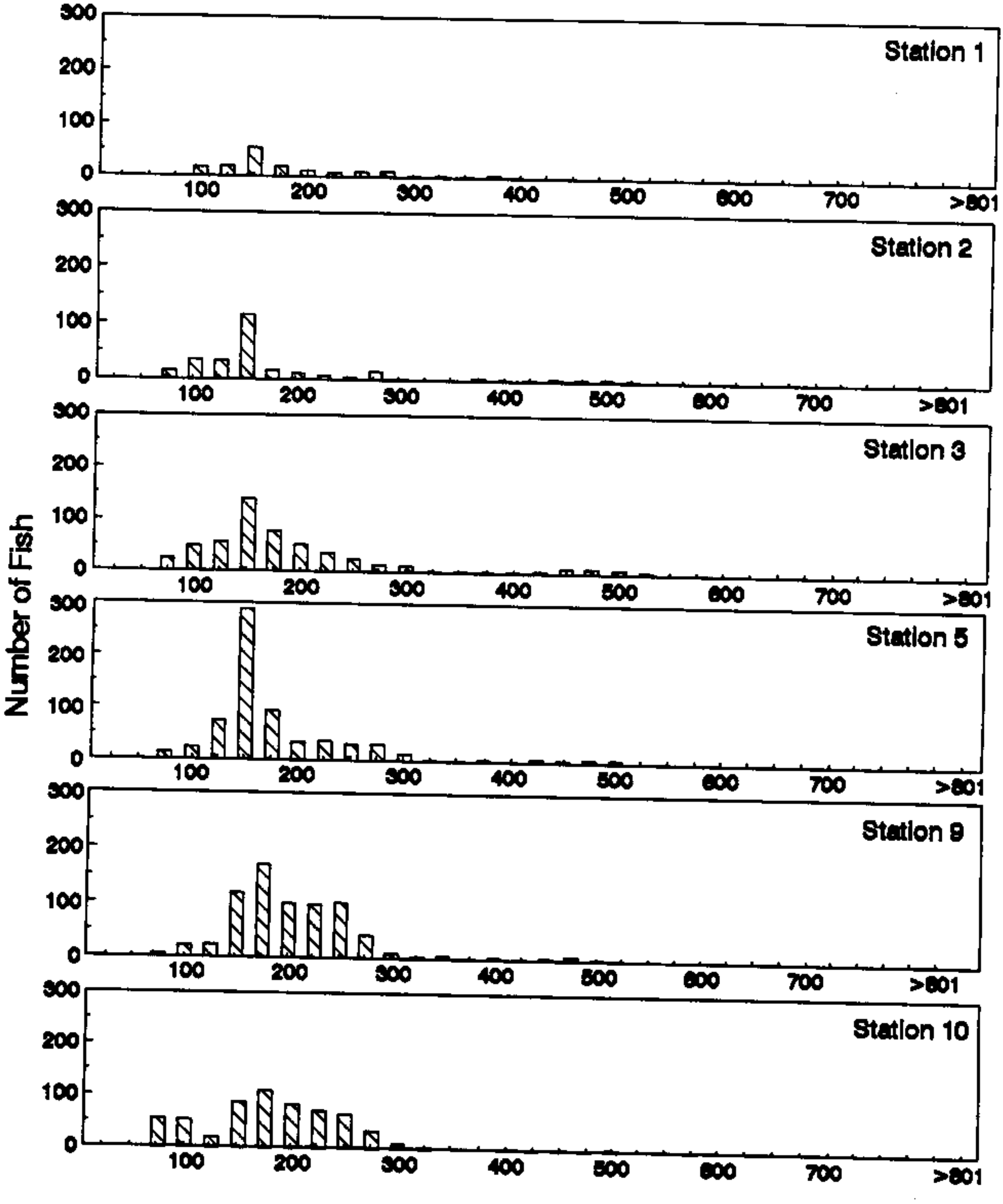


25 mm Length Classes

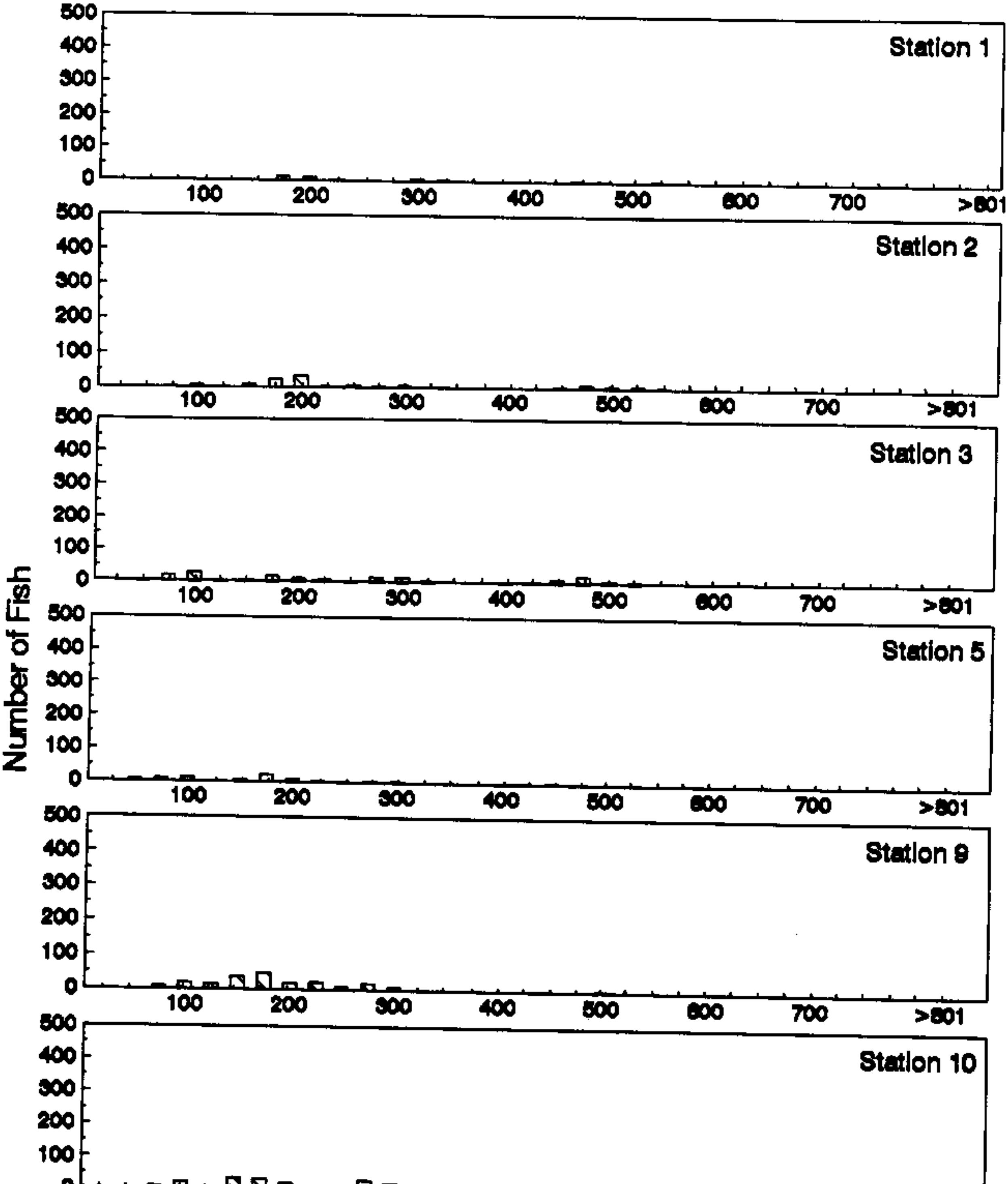
Appendix Figure 10. Length distributions of fishes sampled by beach seining at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during fall 1992 in Lower Granite Reservoir.



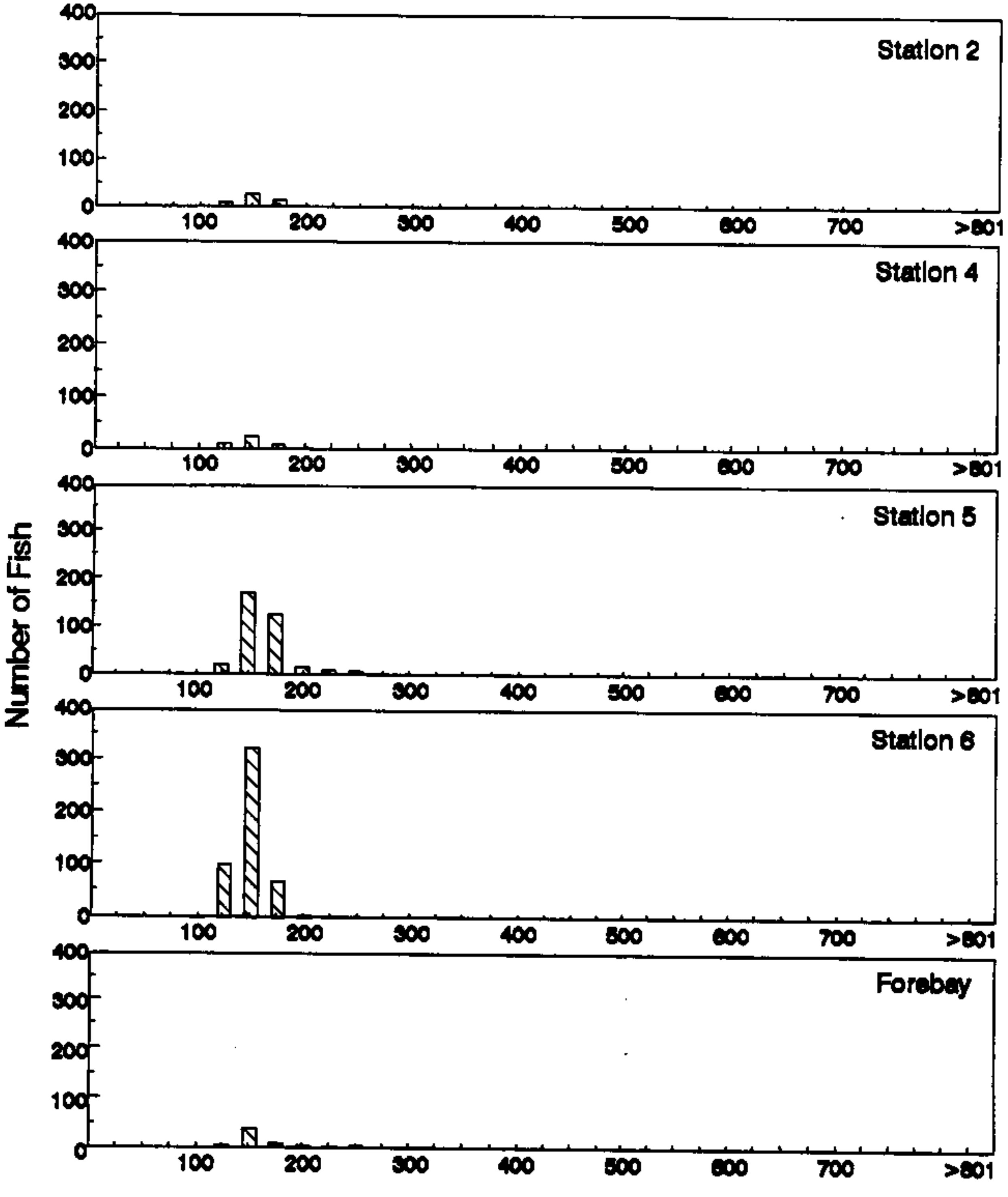
Appendix Figure 11. Length distributions of all fishes sampled by electrofishing at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during 1992 in Lower Granite Reservoir.



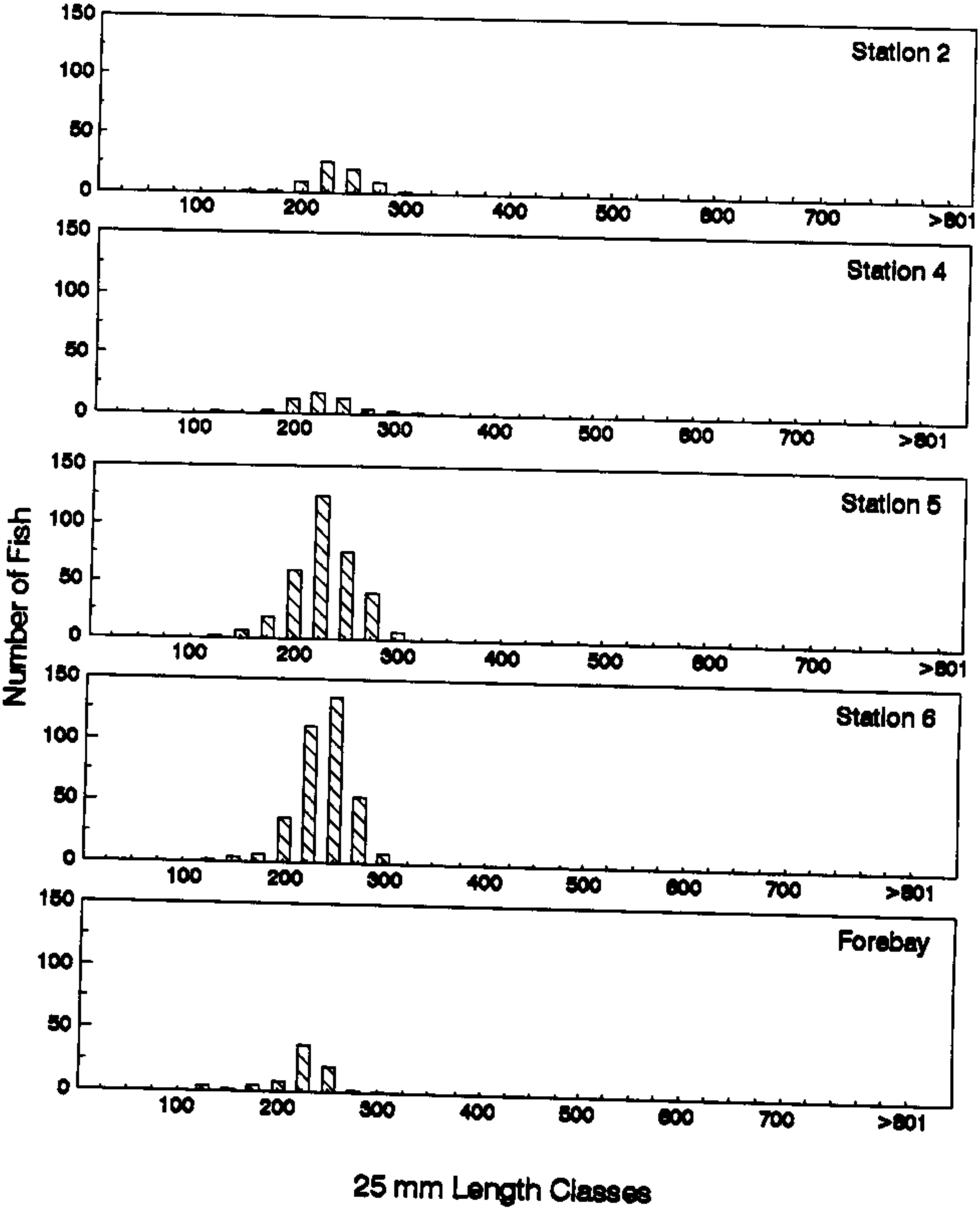
Appendix Figure 12. Length distrubutions of all fishes sampled by electrofishing at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during spring 1992 in Lower Granite Reservoir.



Appendix Figure 13. Length distributions of all fishes sampled by electrofishing at shallow disposal (1 and 2) and reference (3, 5, 9 and 10) stations during fall 1992 in Lower Granite Reservoir.



Appendix Figure 14. Length distributions of juvenile chinook salmon sampled by surface trawling at shallow (2) and mid-depth (4) disposal stations, shallow (5) and mid-depth (6) reference stations and the forebay during spring 1992 in Lower Granite Reservoir.



Appedix Figure 15. Length distributions of juvenile steelhead sampled by suface trawling at shallow (2) and mid-depth (4) disposal stations, shallow (5) and mid-depth (6) reference stations and the forbay during spring 1992 in Lower Granite Reservoir.

Appendix Table 1. Catch/volume of water filtered (No./10,000 m^3) for 1/2 m paired plankton net samples during 1992 in Lower Granite Reservoir. Upper and lower refer to bounds. Abbreviation: ASA-American shad.

							ASA			Total	
Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	Mean	Upper	Lower	Mean	Upper	Lower
05 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				76	203	0
	4	180	1.5	0.196	53.014				31	186	0
	5	180	1.5	0.196	53.014				6162	14231	0
	11	180	1.5	0.196	53.014				63	340	0
11 June	1	180	1.5	0.196	53.014				63	340	0
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				63	258	0
	5	180	1.5	0.196	53.014				314	1057	0
	11	180	1.5	0.196	53.014				31	185	0
19 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				31	186	0
	5	180	1.5	0.196	53.014				94	556	0
	11	180	1.5	0.196	53.014				723	1890	0
23 June	1	180	1.5	0.196	53.014				157	781	0
	2	180	1.5	0.196	53.014				31	185	0
	4	180	1.5	0.196	53.014				63	371	0
	5	180	1.5	0.196	53.014				157	598	0
	11	180	1.5	0.196	53.014				629	2153	0
01 July	1	180	1.5	0.196	53.014				2955	9558	0
	2	180	1.5	0.196	53.014				3301	7066	0
	4	180	1.5	0.196	53.014				1572	2795	0
	5	180	1.5	0.196	53.014				660	2216	0
	11	180	1.5	0.196	53.014				3395	9621	0

Appendix Table 1. (Continued) Abbreviation: ASA-American shad.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	ASA Mean	ASA Upper	ASA Lower	Total Mean	Total Upper	Total Lower
11 July	1	180	1.5	0.196	53.014				157	814	0
	2	180	1.5	0.196	53.014				849	3725	0
	4	180	1.5	0.196	53.014				94	556	0
	5	180	1.5	0.196	53.014				252	1370	0
	11	180	1.5	0.196	53.014				8394	28222	0
17 July	1	180	1.5	0.196	53.014				126	742	0
	2	180	1.5	0.196	53.014				94	556	0
	4	180	1.5	0.196	53.014				189	1113	0
	5	180	1.5	0.196	53.014				189	966	0
	11	180	1.5	0.196	53.014				1320	3907	0
24 July	1	180	1.5	0.196	53.014				409	1444	0
	2	180	1.5	0.196	53.014				288	1043	0
	4	180	1.5	0.196	53.014				63	258	0
	5	180	1.5	0.196	53.014	31	154	0	409	1688	0
	11	180	1.5	0.196	53.014				1717	9280	0
31 July	1	180	1.5	0.196	53.014				226	1203	0
	2	180	1.5	0.196	53.014				346	1198	0
	4	180	1.5	0.196	53.014				94	556	0
	5	180	1.5	0.196	53.014	63	195	0	464	2264	0
	11	180	1.5	0.196	53.014				220	990	0
05 August	1	180	1.5	0.196	53.014				94	556	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				94	556	0

Appendix Table 1. (Continued) Abbreviation: ASA-American shad.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	ASA			Total		
						Mean	Upper	Lower	Mean	Upper	Lower
12 August	1	60	1.5	0.196	17.672				396	1750	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 August	1	60	1.5	0.196	17.672				314	1515	0
	2	60	1.5	0.196	17.672				94	556	0
	4	60	1.5	0.196	17.672				94	556	0
	5	60	1.5	0.196	17.672				189	1113	0
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672				283	1329	0
	4	60	1.5	0.196	17.672				94	556	0
	5	60	1.5	0.196	17.672				189	773	0
	11	60	1.5	0.196	17.672						
05 Sept	1	180	1.5	0.196	53.014				126	595	0
	2	180	1.5	0.196	53.014				94	556	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						
12 Sept	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				3049	6535	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 1. (Continued) Abbreviation: AAL-chiselmouth; POR-northern squawfish.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	AAL			POR		
						Mean	Upper	Lower	Mean	Upper	Lower
05 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						
11 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						
19 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						
23 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						
01 July	1	60	1.5	0.196	17.672				94	556	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: 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
11 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672				3584	13017	0
17 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672				660	1773	0
24 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	31	186	0			
	11	180	1.5	0.196	53.014	692	4080	0	94	556	0
31 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				126	434	0
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

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

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	AAL			POR		
						Mean	Upper	Lower	Mean	Upper	Lower
12 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	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) Abbreviation: COT-Cottus spp.; UNK-unknown.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	COT Mean	COT Upper	COT Lower	UNK Mean	UNK Upper	UNK Lower
05 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						
11 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						
19 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	31	186	0			
23 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						
01 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: COT-Cottus spp.; UNK-unknown.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	COT			UNK		
						Mean	Upper	Lower	Mean	Upper	Lower
11 July	1	60	1.5	0.196	17.672				31	186	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
17 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
24 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						
31 July	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014				31	186	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						
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: COT-Cottus spp.; UNK-unknown.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	COT			UNK		
						Mean	Upper	Lower	Mean	Upper	Lower
12 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	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) Abbreviation: CSP-catostomid; CEN-centrarchid.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CSP Mean	CSP Upper	CSP Lower	CEN Mean	CEN Upper	CEN Lower
05 June	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	76	203	0			
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	786	1460	0			
	11	180	1.5	0.196	53.014	31	154	0			
11 June	1	180	1.5	0.196	53.014	31	154	0	31	186	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	31	154	0			
	11	180	1.5	0.196	53.014						
19 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	94	301	0			
23 June	1	180	1.5	0.196	53.014				94	410	0
	2	180	1.5	0.196	53.014				31	186	0
	4	180	1.5	0.196	53.014				31	186	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014	31	186	0			
01 July	1	60	1.5	0.196	17.672				472	1324	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672				63	258	0
	5	60	1.5	0.196	17.672	566	1806	0			
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: CSP-catostomid; CEN-centrarchid.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CSP Mean	CSP Upper	CSP Lower	CEN Mean	CEN Upper	CEN Lower
11 July	1	60	1.5	0.196	17.672	31	186	0	63	257	0
	2	60	1.5	0.196	17.672	189	1113	0	94	556	0
	4	60	1.5	0.196	17.672				94	556	0
	5	60	1.5	0.196	17.672	94	556	0	94	556	0
	11	60	1.5	0.196	17.672	943	2791	0			
17 July	1	60	1.5	0.196	17.672				1697	4407	0
	2	60	1.5	0.196	17.672				943	3589	0
	4	60	1.5	0.196	17.672				283	903	0
	5	60	1.5	0.196	17.672				283	1230	0
	11	60	1.5	0.196	17.672						
24 July	1	180	1.5	0.196	53.014				220	591	0
	2	180	1.5	0.196	53.014				157	528	0
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014				314	1164	0
	11	180	1.5	0.196	53.014						
31 July	1	180	1.5	0.196	53.014				38	203	0
	2	180	1.5	0.196	53.014						
	4	180	1.5	0.196	53.014				31	186	0
	5	180	1.5	0.196	53.014				126	742	0
	11	180	1.5	0.196	53.014						
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: CSP-catostomid; CEN-centrarchid.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CSP Mean	CSP Upper	CSP Lower	CEN Mean	CEN Upper	CEN Lower
12 August	1	60	1.5	0.196	17.672				113	609	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	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) Abbreviation: CYP-cyprinid; CCA-carp.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	CYP			CCA		
						Mean	Upper	Lower	Mean	Upper	Lower
05 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	31	186	0			
	5	180	1.5	0.196	53.014	5376	12771	0			
	11	180	1.5	0.196	53.014						
11 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	63	258	0			
	5	180	1.5	0.196	53.014	263	903	0			
	11	180	1.5	0.196	53.014	31	186	0			
19 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	31	186	0			
	5	180	1.5	0.196	53.014	94	556	0			
	11	180	1.5	0.196	53.014	597	1404	0			
23 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	31	186	0			
	5	180	1.5	0.196	53.014	157	598	0			
	11	180	1.5	0.196	53.014	565	1783	0			
01 July	1	60	1.5	0.196	17.672	2201	6565	0			
	2	60	1.5	0.196	17.672	3112	6293	0			
	4	60	1.5	0.196	17.672	1476	2352	0			
	5	60	1.5	0.196	17.672	94	410	0			
	11	60	1.5	0.196	17.672	3301	9265	0			

Appendix Table 1. (Continued) Abbreviation: CYP-cyprinid; CCA-carp.

							CYP			CCA	
Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	Mean	Upper	Lower	Mean	Upper	Lower
11 July	1	60	1.5	0.196	17.672	31	186	0			
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672	63	258	0			
	11	60	1.5	0.196	17.672	3301	9955	0			
17 July	1	60	1.5	0.196	17.672				31	186	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672	94	410	0			
	11	60	1.5	0.196	17.672	565	1578	0			
24 July	1	180	1.5	0.196	53.014	31	186	0			
	2	180	1.5	0.196	53.014	63	258	0			
	4	180	1.5	0.196	53.014						
	5	180	1.5	0.196	53.014	31	186	0			
	11	180	1.5	0.196	53.014	63	371	0			
31 July	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	63	371	0	126	321	0
	4	180	1.5	0.196	53.014	31	186	0			
	5	180	1.5	0.196	53.014	63	258	0			
	11	180	1.5	0.196	53.014	31	186	0			
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672	94	558	0			

Appendix Table 1. (Continued) Abbreviation: CYP-cyprinid; CCA-carp.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	CYP			CCA		
						Mean	Upper	Lower	Mean	Upper	Lower
12 August	1	60	1.5	0.196	17.672	189	584	0			
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	3016	6350	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 1. (Continued) Abbreviation: LSP-Lepomis spp.; PSP-Pomoxis spp.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	LSP			PSP		
						Mean	Upper	Lower	Mean	Upper	Lower
05 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						
11 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						
19 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						
23 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						
01 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: LSP-Lepomis spp.; PSP-Pomoxis spp.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	LSP Mean	LSP Upper	LSP Lower	PSP Mean	PSP Upper	PSP Lower
11 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
17 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
24 July	1	180	1.5	0.196	53.014	94	410	0	63	258	0
	2	180	1.5	0.196	53.014				63	258	0
	4	180	1.5	0.196	53.014				63	258	0
	5	180	1.5	0.196	53.014						
	11	180	1.5	0.196	53.014				113	609	0
31 July	1	180	1.5	0.196	53.014	63	258	0	126	742	0
	2	180	1.5	0.196	53.014	126	321	0			
	4	180	1.5	0.196	53.014	31	186	0			
	5	180	1.5	0.196	53.014	151	812	0			
	11	180	1.5	0.196	53.014						
05 August	1	60	1.5	0.196	17.672				94	556	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: LSP-Lepomis spp.; PSP-Pomoxis spp.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	LSP Mean	LSP Upper	LSP Lower	PSP Mean	PSP Upper	PSP Lower
12 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672	94	556	0			
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672	189	773	0			
	11	60	1.5	0.196	17.672						
05 Sept	1	180	1.5	0.196	53.014	31	186	0	94	410	0
	2	180	1.5	0.196	53.014	94	556	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						
12 Sept	1	180	1.5	0.196	53.014						
	2	180	1.5	0.196	53.014	31	186	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 1. (Continued) Abbreviation: MCA-peamouth; RBA-redside shiner.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MCA			RBA		
						Mean	Upper	Lower	Mean	Upper	Lower
05 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	31	186	0			
11 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						
19 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						
23 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				31	186	0
01 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: MCA-peamouth; RBA-redside shiner.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MCA Mean	MCA Upper	MCA Lower	RBA Mean	RBA Upper	RBA Lower
11 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672	566	24609	0			
17 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672	94	556	0			
24 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	597	2737	0	157	927	0
31 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	31	186	0	31	186	0
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: MCA-peamouth; RBA-redside shiner.

Date	Station	Duration Second	Speed m/s	Area M²	Volume m³	MCA			RBA		
						Mean	Upper	Lower	Mean	Upper	Lower
12 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	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) Abbreviation: MDO-smallmouth bass; PFL-yellow perch.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	MDO			PFL		
						Mean	Upper	Lower	Mean	Upper	Lower
05 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						
11 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						
19 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						
23 June	1	180	1.5	0.196	53.014	63	371	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						
01 July	1	60	1.5	0.196	17.672	189	1113	0			
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672	31	186	0			
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672	94	556	0			

Appendix Table 1. (Continued) Abbreviation: MDO-smallmouth bass; PFL-yellow perch.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	MDO Mean	MDO Upper	MDO Lower	PFL Mean	PFL Upper	PFL Lower
11 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
17 July	1	60	1.5	0.196	17.672	31	186	0			
	2	60	1.5	0.196	17.672	94	556	0			
	4	60	1.5	0.196	17.672	94	556	0			
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
24 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						
31 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	63	256	0			
	11	180	1.5	0.196	53.014						
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: MDO-smallmouth bass; PFL-yellow perch.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	MDO			PFL		
						Mean	Upper	Lower	Mean	Upper	Lower
12 August	1	60	1.5	0.196	17.672				94	556	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
23 August	1	60	1.5	0.196	17.672				31	186	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	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) Abbreviation: PNI-black crappie; PAN-white crappie.

Date	Station	Duration Second	Speed m/s	Area m^2	Volume m^3	PNI Mean	PNI Upper	PNI Lower	PAN Mean	PAN Upper	PAN Lower
05 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						
11 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						
19 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						
23 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						
01 July	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672				189	773	0
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: PNI-black crappie; PAN-white crappie.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	PNI			PAN		
						Mean	Upper	Lower	Mean	Upper	Lower
11 July	1	60	1.5	0.196	17.672				253	1028	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
17 July	1	60	1.5	0.196	17.672				63	371	0
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672				94	556	0
	5	60	1.5	0.196	17.672				94	556	0
	11	60	1.5	0.196	17.672						
24 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						
31 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						
05 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						

Appendix Table 1. (Continued) Abbreviation: PNI-black crappie; PAN-white crappie.

Date	Station	Duration Second	Speed m/s	Area m²	Volume m³	PNI Mean	PNI Upper	PNI Lower	PAN Mean	PAN Upper	PAN Lower
12 August	1	60	1.5	0.196	17.672	94	556	0			
	2	60	1.5	0.196	17.672						
	4	60	1.5	0.196	17.672						
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
22 August	1	60	1.5	0.196	17.672	94	556	0	189	773	0
	2	60	1.5	0.196	17.672				94	556	0
	4	60	1.5	0.196	17.672	94	556	0			
	5	60	1.5	0.196	17.672	94	556	0	94	556	0
	11	60	1.5	0.196	17.672						
26 August	1	60	1.5	0.196	17.672						
	2	60	1.5	0.196	17.672				189	773	0
	4	60	1.5	0.196	17.672				94	556	0
	5	60	1.5	0.196	17.672						
	11	60	1.5	0.196	17.672						
05 Sept	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 Sept	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 m³) for larval handbeam trawl samples in shallow (S; 0.5m) and deep (D; 10 m) waters along the shoreline during 1992 in Lower Granite Reservoir.

			ASA	Bound		Total	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S				195	690	0
	11	D				49	173	0
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D				292	1035	0
		S				98	345	0
	2	D				2973	8361	0
		S				3801	12716	0
	5	D				487	1726	0
		S						
	11	D				49	187	0
		S				195	749	0
24 June	1	D				1852	4705	0
		S				98	345	0
	2	D				927	2922	0
		S				974	3453	0
	5	D				3460	8267	0
		S				6238	15245	0
	11	D				195	642	0
		S				1170	3278	0
03 July	1	D				2095	4428	381
		S				293	788	0
	2	D				489	1754	0
		S				487	1886	0
	5	D				7184	10484	3994
		S				12282	27965	1102
	11	D				4338	13091	0
		S				73567	168961	448

Abbreviations: ASA-American shad.

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

Date	Station	Depth	ASA	Bound		Total	Bound	
			Mean	Upper	Lower	Mean	Upper	Lower
10 July	1	D				1316	3565	0
		S				1462	3498	0
	2	D				292	664	0
		S				3216	9056	0
	5	D				5604	11865	0
		S				18031	31102	5111
	11	D	98	345	0	97856	210691	0
		S	487	1725	0	6872	18173	0
18 July	1	D				3804	10434	0
		S				3022	8722	0
	2	D				2680	7674	0
		S				2534	7640	0
	5	D				21004	37295	5044
		S				44251	74402	16390
	11	D				3510	8756	56
		S				8675	20395	0
23 July	1	D				634	2243	0
		S				584	2070	0
	2	D				439	1008	0
		S				195	443	0
	5	D				1170	2576	0
		S				975	2054	0
	11	D	48	173	0	829	2306	0
		S	194	690	0	487	1411	0
01 August	1	D				2046	6776	0
		S				2338	7253	0
	2	D				292	722	0
		S						
	5	D	98	345	0	3996	10731	0
		S				4240	11826	0
	11	D				439	1396	0
		S				4240	11826	0
05 August	1	D				1706	5484	0
		S						
	2	D				536	1370	78
		S						
	5	D				1706	5484	0
		S				682	2070	0
	11	D				12525	34043	0
		S				390	1380	0

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

			ASA	Bound		Total	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
13 August	1	D				196	691	0
		S				293	1035	0
	2	D				439	1006	0
		S				98	345	0
	5	D				4874	10866	0
		S				22612	68938	0
	11	D				3022	7150	54
		S				10526	25842	0
20 August	1	D				878	2323	0
		S						
	2	D				49	173	0
		S						
	5	D				780	2637	0
		S				195	345	0
	11	D				5508	13249	0
		S				488	1390	0
28 August	1	D				3704	13094	0
		S				10917	43225	0
	2	D				9747	32100	0
		S						
	5	D				1268	3264	0
		S						
	11	D				14241	39266	0
		S						
03 Sept	1	D						
		S				146	518	0
	2	D				5167	18290	0
		S				16472	57212	0
	5	D				146	394	0
		S				1356	4467	0
	11	D				1024	3623	0
		S				1852	3914	0
11 Sept	1	D				195	690	0
		S						
	2	D						
		S						
	5	D				1852	6197	0
		S				4191	9520	0
	11	D				1852	6196	0
		S				3948	8658	0

Appendix Table 2. (Continued) Abbreviations: COT-Cottus spp.; UNK-unknown.

Date	Station	Depth	COT Mean	Bound Upper	Bound Lower	UNK Mean	Bound Upper	Bound Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 July	1	D						
		S						
	2	D						
		S						
	5	D	98	345	0			
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: COT-Cottus spp.; UNK-unknown.

			COT	Bound		UNK	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
10 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				98	221	0
		S						
18 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S				98	345	0
	11	D						
		S						
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
01 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S				98	345	0
05 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: COT-Cottus spp.; UNK-unknown.

			COT	Bound		UNK	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
13 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				49	173	0
		S						
20 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						
03 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D				49	173	0
		S						
	11	D						
		S						

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

Date	Station	Depth	CYP Mean	Bound Upper	Bound Lower	AAL Mean	Bound Upper	Bound Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D						
		S	292	1035	0			
	5	D						
		S						
	11	D						
		S	195	749	0			
24 June	1	D						
		S						
	2	D	98	345	0			
		S						
	5	D						
		S	390	1360	0			
	11	D	195	642	0			
		S	1170	3278	0			
03 July	1	D	487	1142	0			
		S	195	443	0			
	2	D	49	173	0			
		S	195	690	0			
	5	D	195	319	71			
		S	585	1014	157			
	11	D	633.53	1690	0	49	173	0
		S	25341	67154	0			

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

Date	Station	Depth	CYP Mean	Bound Upper	Bound Lower	AAL Mean	Bound Upper	Bound Lower
10 July	1	D	195	690	0			
		S	195	443	0			
	2	D	49	173	0			
		S	585	1720	0			
	5	D	390	637	0			
		S	6674	14139	3210			
	11	D	97563	209936	0	146	361	0
		S	4045	9522	0	1852	6191	0
18 July	1	D						
		S						
	2	D						
		S	98	345	0			
	5	D						
		S	98	345	0			
	11	D	1706	4680	0	98	345	0
		S	5263	11267	0			
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	585	1443	0	195	690	0
		S						
01 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	195	690	0			
05 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

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

Date	Station	Depth	CYP Mean	Bound Upper	Bound Lower	AAL Mean	Bound Upper	Bound Lower
13 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
20 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
26 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

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

Date	Station	Depth	IPU Mean	Bound Upper	Bound Lower	CEN Mean	Bound Upper	Bound Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D				1510	5349	0
		S						
	5	D						
		S						
	11	D						
		S						
24 June	1	D				1657	4210	0
		S				96	345	0
	2	D				731	2232	0
		S				292	1035	0
	5	D				1170	2671	0
		S				5556	13144	0
	11	D						
		S						
03 July	1	D				1316	2251	381
		S				96	345	0
	2	D				49	200	0
		S				292	1196	0
	5	D				6871	9820	3923
		S				6772	16596	945
	11	D				96	345	0
		S				1267	2773	0

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

Date	Station	Depth	IPU Mean	Bound Upper	Lower	CEN Mean	Bound Upper	Lower
10 July	1	D				877	2012	0
		S				1267	3055	0
	2	D				244	491	0
		S				1559	3540	0
	5	D				5214	11226	0
		S				9259	16618	1901
	11	D						
		S				390	637	142
16 July	1	D				1706	5674	0
		S				1852	5837	0
	2	D				828	2575	0
		S				292	721	0
	5	D				20468	35892	5044
		S				40156	64022	16390
	11	D				1462	2868	56
		S				3119	6360	0
23 July	1	D				390	1380	0
		S				195	690	0
	2	D				439	1006	0
		S						
	5	D				1170	2576	0
		S				975	2054	0
	11	D				49	173	0
		S				195	690	0
01 August	1	D				146	361	0
		S				292	721	0
	2	D				146	361	0
		S						
	5	D				3314	9137	0
		S				3265	9541	0
	11	D				146	361	0
		S				2242	4027	456
05 August	1	D				536	1550	0
		S						
	2	D				292	507	78
		S						
	5	D				1706	5484	0
		S				487	1380	0
	11	D				9844	26599	0
		S				195	690	0

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

Date	Station	Depth	IPU Mean	Bound Upper	Bound Lower	CEN Mean	Bound Upper	Bound Lower
13 August	1	D				49	173	0
		S				98	345	0
	2	D				439	1006	0
		S						
	5	D				4045	8676	0
		S				21150	64504	0
	11	D				487	1380	0
		S				10234	25121	0
20 August	1	D				49	173	0
		S						
	2	D						
		S						
	5	D				98	221	0
		S				195	345	0
	11	D				1652	4291	0
		S				390	1045	0
28 August	1	D				49	173	0
		S						
	2	D				7797	27237	0
		S						
	5	D	49	173	0	1023	2525	0
		S						
	11	D				11793	31549	0
		S						
03 Sept	1	D				146	518	0
		S						
	2	D						
		S						
	5	D				97	221	0
		S				1365	4467	0
	11	D				1462	2534	390
		S				195	690	0
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D				1754	5851	0
		S				3899	8485	0
	11	D				1754	5851	0
		S				3899	8485	0

Appendix Table 2. (Continued) Abbreviations: LMA-bluegill; PSP-Pomoxis spp.

Date	Station	Depth	LMA Mean	Bound Upper	Bound Lower	PSP Mean	Bound Upper	Bound Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: LMA-bluegill; PSP-Pomoxis spp.

Date	Station	Depth	LMA Mean	Bound Upper	Bound Lower	PSP Mean	Bound Upper	Bound Lower
10 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S				98	345	0
	11	D						
		S	195	443	0			
18 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
23 July	1	D				49	173	0
		S				97	345	0
	2	D						
		S						
	5	D						
		S						
	11	D						
		S				292	721	0
01 August	1	D				1413	5004	0
		S				1559	4807	0
	2	D				146	361	0
		S						
	5	D				536	1076	0
		S				975	2285	0
	11	D						
		S				195	690	0
05 August	1	D				1170	2576	0
		S						
	2	D				195	690	0
		S						
	5	D						
		S				195	690	0
	11	D				2632	7271	0
		S				195	690	0

Appendix Table 2. (Continued) Abbreviations: LMA-bluegill; PSP-Pomoxis spp.

Date	Station	Depth	LMA Mean	Bound Upper	Bound Lower	PSP Mean	Bound Upper	Bound Lower
13 August	1	D				98	345	0
		S				195	690	0
	2	D						
		S				98	345	0
	5	D				634	1500	0
		S				1462	4434	0
	11	D				390	1009	0
		S						
20 August	1	D				731	1605	0
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				3265	7577	0
		S						
26 August	1	D	1852	7590	0	98	345	0
		S	9942	40744	0			
	2	D				1852	4642	0
		S						
	5	D				98	221	0
		S						
	11	D				2339	7544	0
		S						
03 Sept	1	D				98	345	0
		S				195	690	0
	2	D				49	173	0
		S						
	5	D				49	173	0
		S						
	11	D				147	518	0
		S						
11 Sept	1	D				195	690	0
		S						
	2	D						
		S						
	5	D				49	173	0
		S				292	1035	0
	11	D				98	345	0
		S				49	173	0

Appendix Table 2. (Continued) Abbreviations: LSP-Lepomis spp.; LGI-pumpkin seed.

Date	Station	Depth	LSP Mean	Bound Upper	Bound Lower	LGI Mean	Bound Upper	Bound Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 July	1	D						
		S						
	2	D	96	345	0			
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: LSP-Lepomis spp.; LGI-pumpkin seed.

			LSP	Bound		LGI	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
10 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
16 July	1	D	49	173	0			
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
23 July	1	D	195	690	0			
		S	292	1035	0			
	2	D						
		S	195	443	0			
	5	D						
		S						
	11	D						
		S						
01 August	1	D	195	690	0			
		S	487	1725	0			
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
05 August	1	D						
		S						
	2	D	49	173	0			
		S						
	5	D						
		S						
	11	D				49	173	0
		S						

Appendix Table 2. (Continued) Abbreviations: LSP-Lepomis spp.; LGI-pumpkin seed.

Date	Station	Depth	LSP Mean	Bound Upper	Bound Lower	LGI Mean	Bound Upper	Bound Lower
13 August	1	D	49	173	0			
		S						
	2	D						
		S						
	5	D	195	690	0			
		S						
	11	D	1218	2399	37			
		S	292	721	0			
20 August	1	D						
		S						
	2	D	49	173	0			
		S						
	5	D	682	2416	0			
		S						
	11	D	49	173	0			
		S						
28 August	1	D	1754	5159	0			
		S	975	2481	0			
	2	D	98	221	0			
		S						
	5	D	98	345	0			
		S						
	11	D	49	173	0			
		S						
03 Sept	1	D	5020	17772	0			
		S	16277	56522	0			
	2	D						
		S						
	5	D	682	2415	0			
		S	390	1360	0			
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: MDO-smallmouth bass; PFL-yellow perch.

			MDO	Bound		PFL	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D	292	1035	0			
		S						
	2	D	1365	2657	72			
		S	3509	11681	0			
	5	D	487	1726	0			
		S						
	11	D	49	187	0			
		S						
24 June	1	D	195	495	0			
		S						
	2	D	98	345	0			
		S	682	2418	0			
	5	D	2290	5615	0			
		S	292	721	0			
	11	D						
		S						
03 July	1	D	292	1035	0			
		S						
	2	D	244	863	0			
		S						
	5	D						
		S	2827	10008	0			
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: MDO-smallmouth bass; PFL-yellow perch.

Date	Station	Depth	MDO Mean	Bound Upper	Bound Lower	PFL Mean	Bound Upper	Bound Lower
10 July	1	D						
		S						
	2	D						
		S	585	2071	0			
	5	D						
		S						
	11	D						
		S						
16 July	1	D						
		S						
	2	D						
		S	1267	3468	0			
	5	D						
		S						
	11	D						
		S						
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
01 August	1	D						
		S				292	721	0
	2	D						
		S						
	5	D	146	518	0			
		S						
	11	D						
		S				98	345	0
05 August	1	D				292	1035	0
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: MDO-smallmouth bass; PFL-yellow perch.

			MDO	Bound		PFL	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
13 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				49	173	0
		S						
20 August	1	D				98	345	0
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				98	345	0
		S						
28 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PAN-white crappie; PNI-black crappie.

			PAN	Bound		PNI	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
08 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 July	1	D						
		S						
	2	D				49	173	0
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PAN-white crappie; PNI-black crappie.

			PAN	Bound		PNI	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
10 July	1	D	244	863	0			
		S						
	2	D						
		S	487	1725	0			
	5	D						
		S						
	11	D						
		S						
16 July	1	D	2096	4760	0			
		S	1170	2885	0			
	2	D	1652	5099	0			
		S	877	3106	0			
	5	D	536	1403	0			
		S	3699	9690	0			
	11	D	244	863	0			
		S	195	423	0			
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
01 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
05 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: PAN-white crappie; PNI-black crappie.

Date	Station	Depth	PAN Mean	Bound Upper	Bound Lower	PNI Mean	Bound Upper	Bound Lower
13 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
20 August	1	D	244	863	0	585	1153	17
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	244	863	0			
		S				98	345	0
26 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: POR-northern squawfish; MCA-peamouth.

Date	Station	Depth	POR Mean	Bound Upper	Lower	MCA Mean	Bound Upper	Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S	98	345	0			
	11	D	2339	6282	0	49	173	0
		S	47271	96176	0	677	1306	448

Appendix Table 2. (Continued) Abbreviations: POR-northern squawfish; MCA-peamouth.

Date	Station	Depth	POR Mean	Bound Upper	Bound Lower	MCA Mean	Bound Upper	Bound Lower
10 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S				98	345	0
	11	D	487	1106	0	49	345	0
		S	19493	50115	0	6772	17382	162
18 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	928	2107	0			
		S	37622	95479	0	487	983	0
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D	244	690	0	98	221	0
		S				2144	2640	1649
01 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	585	1486	0			
05 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: POR-northern squawfish; MCA-peamouth.

			POR	Bound		MCA	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
13 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
20 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						
03 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: RBA-redside shiner; CSP-catostomid.

			RBA	Bound		CSP	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
06 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S				195	690	0
	11	D				49	173	0
		S						
12 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
17 June	1	D						
		S				98	345	0
	2	D						
		S				98	345	0
	5	D						
		S						
	11	D						
		S						
24 June	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
03 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: RBA-redside shiner; CSP-catostomid.

Date	Station	Depth	RBA Mean	Bound Upper	Bound Lower	CSP Mean	Bound Upper	Bound Lower
10 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	390	1380	0			
18 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S	98	345	0			
23 July	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
01 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S				390	885	0
05 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Appendix Table 2. (Continued) Abbreviations: RBA-redside shiner; CSP-catostomid.

			RBA	Bound		CSP	Bound	
Date	Station	Depth	Mean	Upper	Lower	Mean	Upper	Lower
13 August	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
20 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						
03 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
11 Sept	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						