US Army Corps of Engineers
Walla Walla District

For David Bennett

Fish and Benthic Community Abundance at Proposed In-Water Disposal Sites, Lower Granite Reservoir (1987).

Completion Report, with Addendum

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Fish and Benthic Community Abundance at Proposed In-Water Disposal Sites in Lower Granite Reservoir, Washington

Completion Report

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generally had flat bottoms and depth that varied from 80-120 ft. Structure at one deep station was abundant while scarce at the other.

Factors affecting velocity characteristics in Lower Granite Reservoir were a function of reservoir location. A model developed to predict channel and on-site velocities, indicated that the variables river mile/cross sectional area and total inflow were more significant in predicting upstream channel velocity ($R^2 = 0.70$), while river mile/cross sectional area and forebay pool elevation were most significant downstream ($R^2 = 0.58$). On-site velocities were less predictable than channel velocities.

We found no relationship between river mile and substrate particle size at deep and mid depth stations. Particles smaller than sand (< 0.061 mm) and sand dominated the sediment. Percent organic matter ranged from 7-15% and was significantly higher at one deep station (LG2D) than at the other mid depth and deep stations.

Seasonal differences in abundance in the benthic community were observed. As in previous surveys of the benthic community in Lower Granite Reservoir, oligochaetes and chironomids accounted for 99% of the number of organisms. Highest numbers and standing crops were collected in the summer. No significant differences in standing crops of benthos were found among deep and mid depth stations. Variability was similar among stations. Benthic community structure was generally more diverse at mid depth than deep stations.

Fish abundance and diversity varied among stations and seasons. Overall, white sturgeon abundance was low, especially at mid depth stations. Sturgeon abundance based upon gill net catches was similar to an earlier survey. Northern squawfish abundance was generally low especially predatory sized fish (> 250 mm).

Catches of northern squawfish at deep stations were consistent with those from a 1985 survey. Based on our catches residualization of rainbow trout was high in Lower Granite. During all seasons, rainbow trout provided high catch rates especially in gill nets. With the exception of rainbow trout, nongame fish dominated (redside shiners, northern squawfish, suckers and carp) the fish community in deep sites. Game fish abundance at mid depth sites was considerably higher than at deep sites. Largescale suckers clearly dominated the fish community biomass at all sites.

Fish densities based on hydroacoustical surveys indicated higher fish abundance at some mid depth sites than others. Fish activity varied by season. In the spring, higher numbers of fish were recorded at night as compared to the summer when highest records occurred during the day. Fish distribution at deep sites was generally in the upper third of the water column. We found little correlation ($P < 0.05$) between target abundance based on hydroacoustical surveys and catch rates in gill nets, which was probably a function of fish activity.

Smolts migrating through Lower Granite Reservoir during 1987 were preyed upon by channel catfish, northern squawfish and smallmouth bass. Squawfish and bass consumed predominantly chinook salmon, whereas channel catfish consumed mostly rainbow trout. This may reflect open water foraging by channel catfish and shoreline foraging by smallmouth bass and squawfish. Our results suggest a low incidence of predation on salmonid smolts in 1987 similar to results of the 1985 survey. A variety of food items are consumed in Lower Granite Reservoir, especially crayfish and zooplankton.

Acknowledgements

We wish to thank the U. S. Army Corps of Engineers for funding this project. Molly Spayde contributed greatly to this project both in the field and laboratory. We thank Ms. Teri Barila for interest, enthusiasm and supportive project supervision. Also, appreciation is extended to the numerous students of the University of Idaho who participated in data collection.

Executive Summary

Deposition of sediment in Lower Granite Reservoir has resulted in a number of alternatives to lessen the potential threat of flooding in the Lewiston, Idaho - Clarkston, Washington area. One alternative is to dredge and then dispose of the dredged materials in the reservoir. This proposal has caused concern among resource managers over the effects that could result to fishery resources in Lower Granite Reservoir. As a result this study was funded with the following objectives:

1. To characterize the physical habitat at six sites in Lower Granite Reservoir;
2. To assess seasonal dynamics of benthic community biomass in Lower Granite Reservoir;
3. To assess seasonal importance of selected disposal areas for fishes in Lower Granite Reservoir; and
4. To assess the occurrence of salmonid predation by resident fishes in selected habitats in Lower Granite Reservoir.

We established six sampling sites; three were mid depth (20-60 ft), one was shallow (< 20 ft) and two were in deep water (> 60 ft). The shallow station was located near RM 127 whereas the remaining stations were located downstream of RM 120, the location in Lower Granite Reservoir identified as being significant for dredge disposal. Sampling was initiated in April 1987 and continued through December 1987.

Substantial differences in bathmetry exist between mid depth and deep sites. Mid depth sites varied in depth from 30-50 ft with typically flat bottoms. All sites were structurally "simple" systems. Deep sites

Introduction

Sediment dredging and potential in-water disposal in Lower Granite Reservoir, Washington, has aroused concern among resource managers over possible deleterious affects on aquatic resources. Originally, hydraulic considerations were focused on shallow and deep water; with further study, however, the Army Corps of Engineers determined that disposal downstream from river mile (RM) 120 would not adversely affect flood profile at the Lewiston Levees. Therefore, emphasis on disposal was shifted to sites downstream of RM 120. Bennett and Shrier (1986) suggested shallow water habitat in Lower Granite Reservoir serves as foraging and resting areas for juvenile anadromous salmonid fishes and also as spawning and rearing for resident game fishes. In contrast, deep water habitats supported fewer fishes, a majority of which were nongame catostomid and cyprinid fishes. The principal species of concern in deep water was the white sturgeon (*Acipenser transmontanus*). Sturgeon abundance was deemed low although presence was documented.

The ecological significance of shallow water habitat and the limited quantity of shallow water sites below RM 120 shifted the focus to mid depth and deep water habitats in Lower Granite Reservoir which provided the impetus for this study. Use of mid depth sites for in-water disposal of dredge material to create additional shallow water habitat and possibly benefit the fishery resource was one reason for this study. Thus, possible beneficial uses could emanate from in-water disposal of dredge material. However, paucity of information on fish and benthic communities at mid depth habitats has made managers cautious of this approach without an adequate data base. Therefore, this study was funded to provide supplemental information to previous research (Bennett and Shrier 1986) and to provide background information on mid depth habitats.

Objectives

1) To characterize physical habitat at six sites in Lower Granite Reservoir;
2) To assess seasonal dynamics of benthic community biomass in Lower Granite Reservoir;
3) To assess seasonal importance of selected disposal areas for fishes in Lower Granite Reservoir;
4) To assess occurrence of salmonid predation by resident fishes in selected habitats in Lower Granite Reservoir.

Study Area

Six stations were selected for study in Lower Granite Reservoir (Figure 1). One shallow, (LG2S) three mid depth and two deep water stations were selected after thorough consultation with Corps of Engineer personnel involved with dredging and disposal activities. Sampling locations at deep and shallow water stations were identical to those previously sampled (Bennett and Shrier 1986) to provide for continuity of data and provide information on between year variation. Four additional shallow stations were sampled as part of another project to evaluate habitat utilization by salmonid fishes and predation (Bennett et al. 1988). Locations of these four additional shallow sites are shown in Figure 1. Ecological activity at the shallow station was believed to be similar to that for shallow water

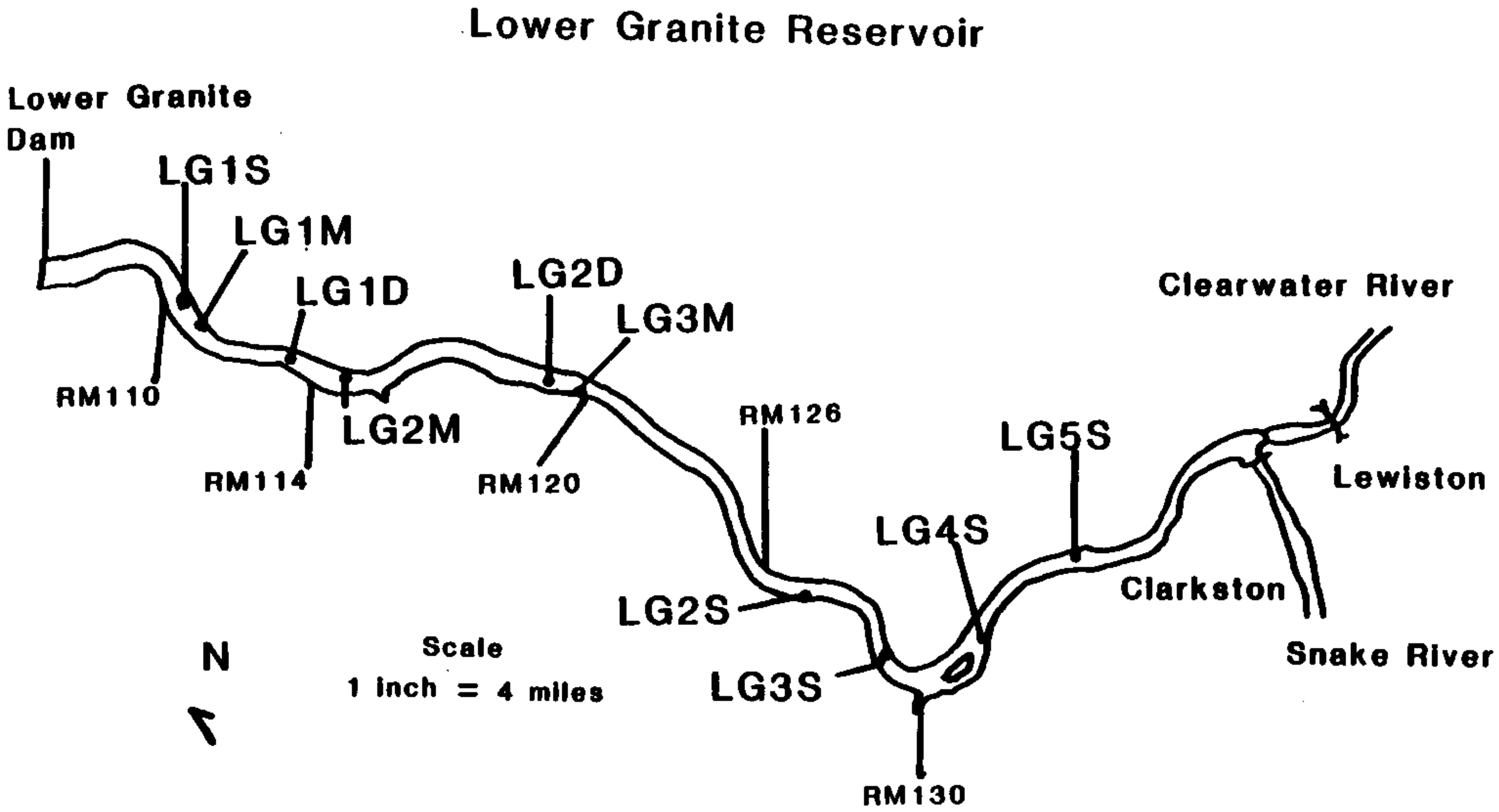

Figure 1. Fish sampling station locations on Lower Granite Reservoir. Letters at the end of station codes denote shallow-water (S), mid-water (M), or deep -water (D) habitat. Stations are numbered within each habitat type as they progress upstream.

created by disposal in the lower reservoir; however, direct comparisons should be made cautiously. General characteristics at each of the sites are shown in Table 1.

Objective 1: To characterize physical habitat at six proposed disposal sites in Lower Granite Reservoir.

Methods

Mapping

Morphometric maps of all six stations were constructed using an Eagle Mach I fish-finder (single transducer recording echosounder). Resolution of our mapping procedures is difficult to state explicitly. Our depth measurements were quite accurate (within 1 ft). Our main source of potential error lies in how well we were able to stay exactly on a designated transect. Our "horizontal" resolution is not perfect, but the resulting maps concur completely with our working knowledge of each site, and certainly provide adequate resolution for assessing 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 Lake). We measured depth profiles while travelling at constant speed along transects between known points located using the NOAA nautical chart. Six to twelve transects were run parallel and perpendicular to the channel at all stations. No attempt was made to map areas deeper than 60 ft at the mid depth stations, while the entire width of the reservoir was mapped at the deep stations.

Table 1. General characteristics of sampling stations on Lower Granite Reservoir, Washington.

	Station					
	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S
River Mile	114	119	111.8	114	120	127.3
Previous Station Designation[1]	SR2D	SR3D	--	--	--	SR2S
Maximum Reservoir Width (ft)	1520	2400	2880	2400	2080	1920
Maximum Channel Depth (ft)	120	100	120	120	98	89
Shoreline Composition						
North	--[2]	Riprap	Riprap	Riprap	--	--
South	Boulders	Cliffs	--	--	Sand	Talus

[1] Bennett and Shrier (1986)
[2] Site borders on one shoreline only

Station 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 10 ft contour intervals were drawn by hand and then digitized for final plotting.

Velocity

Velocity measurements were taken during 1987 when discharge ranged from high to low with a Swoffer Model 2100 velocity meter. We measured velocity at ten stations; four additional shallow stations were included in the analysis (see Bennett et al. 1988 for details). Because 1987 was a low-water year, "high" discharges were in the range considered "moderate" in a typical water year. Three profile locations were selected at each station. The "channel" profile was located at the deepest part of the channel on a transect perpendicular to the channel across the middle of the sampling station. Deep sites have only the channel profile which was also the "on-site" profile. The second location, the "midway" profile, was located where one half the depth between the "on-site" profile depth and channel profile depth occurred. The third location, the "on-site" profile was located on the middle of the site at a depth half way between depths describing the site (shallow 10 ft; mid depth 40 ft). At shallow stations, velocity measurements were recorded at the surface and then every 1 m in depth, whereas measurements at deep and mid depth stations were taken at the following depths: surface, 1, 5, 10, 15, 20, 25, 30, and 35 m.

We developed equations to predict velocities throughout Lower Granite Reservoir and to determine which morphometric and dam related activities influenced reservoir velocities. Predictive equations were derived based on two different dependent variables: average channel velocity and average on-site velocity. Average channel velocity is the mean of all measurements in the upper 15 m of the channel profile, which ensures an equal number of measurements (5) from all channel profiles regardless of total depth. All deep, mid depth and shallow stations were included in average channel velocity regressions. Average on-site velocity represents the mean of all readings taken from shallow and mid depth on-site profiles (i.e. 10 ft and 40 ft). Both deep stations were excluded from on-site equations because velocity measurements were taken only from the channel profiles.

Variables examined for relationships with channel and on-site velocities were related to morphometric and regulated characteristics of the reservoir. Morphometric variables were unique constants associated with each station including river mile, reservoir width, distance from channel to on-site profile, maximum depth, depths of channel, midway, and on-site profiles, and cross-sectional area. Regulated variables were variable as a result of dam-related activities and included confluence (Snake and Clearwater Rivers) and forebay pool elevations, total (turbine plus spillway) discharge at Lower Granite Dam, and inflow at the confluence. Variables within each category were mutually dependent which restricted us to use one variable from each category to avoid violating the least squares regression assumption of independence. When appropriate, we used ratios of variables (i.e. river mile/cross sectional area) within each category which incorporated effects of two colinear independent variables as one independent variable. We also transformed variables as needed to meet homogeneity of variance and normality assumptions of regression procedures.

Substrate

Substrate samples were collected with a ponar dredge and analyzed for particle size distribution and organic matter content. Samples were dried at 105°C for 32 hours and separated by dry sieving into three categories: particles larger than sand (> 2.00 mm), sand (0.061 mm-2.00 mm), and particles smaller than sand (< 0.061 mm). Because the fine sediments were caked, samples were gently crushed manually before sieving. After sieving, we measured the weight (g) of each substrate size category.

We analyzed organic matter content by drying the sediment in crucibles at 105°C for 21 hours followed by ignition at 550°C for 3.5 hours (APHA 1980). Samples were then wetted and re-dried at 105°C for 21 hours to re-hydrate particles smaller than sands. Samples were cooled in a dessicator after each drying period. Percent organic matter was determined as the difference between weights prior to and following ignition.

Results

Bathymetric sampling at both deep stations revealed the steep-sided nature of their southwest shores. At LG2D, this shoreline is actually a nearly vertical cliff (Figure 2). At LG1D, the channel is quite flat and regular at about 110 ft, with holes over 120 ft deep at either end of the station (Figure 3). In contrast, the channel at LG2D is wider and less regular, generally ranging from about 80-90 ft deep, with an area over 100 ft deep at the downstream end of the station. An area of shallower depth occurs just northeast of the channel of LG2D, as well as a 50-60 ft deep shelf southwest of the channel in the upstream portion of the station.

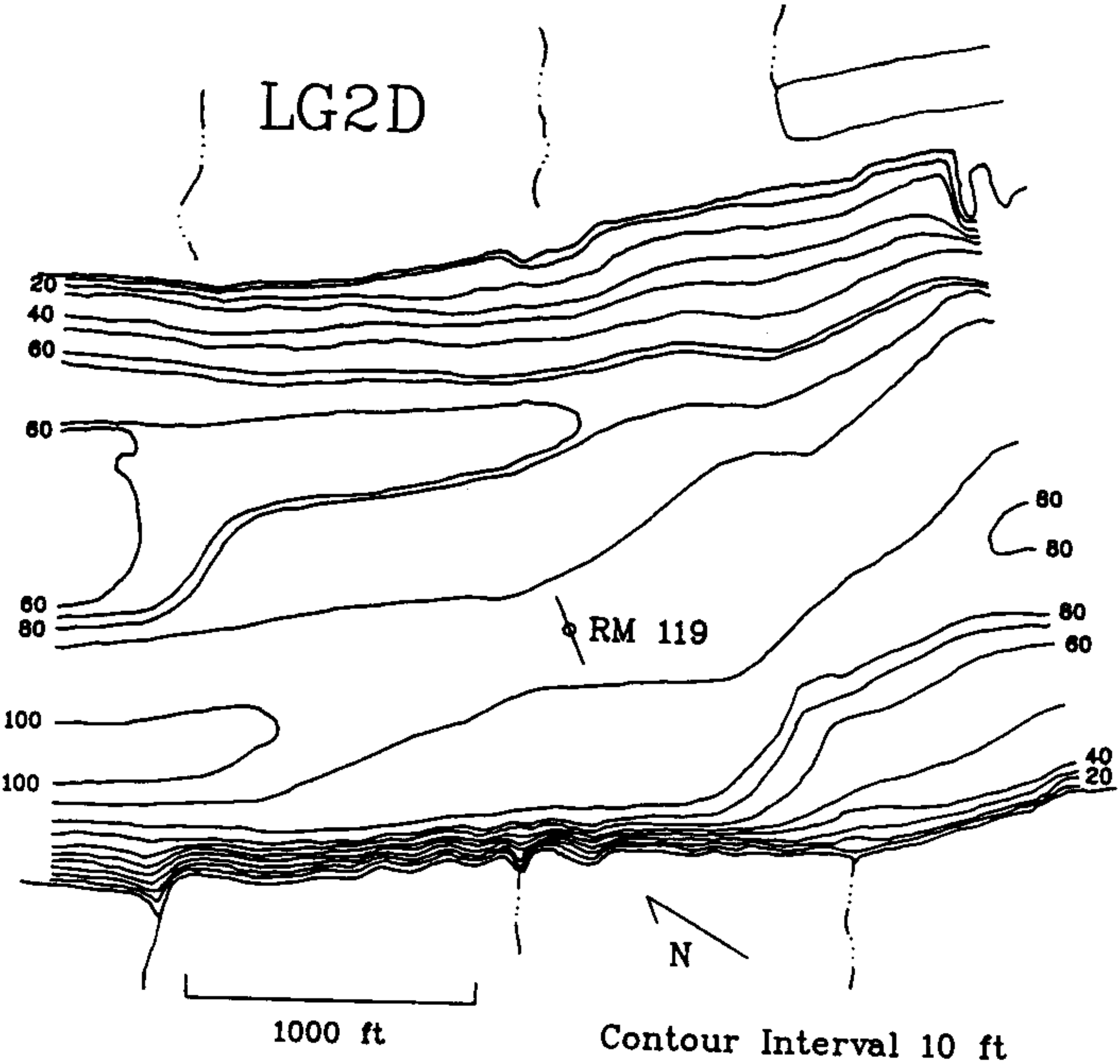

Figure 2. Morphometric map of station LG2D (RM 119) in Lower Granite Reservoir, Washington.

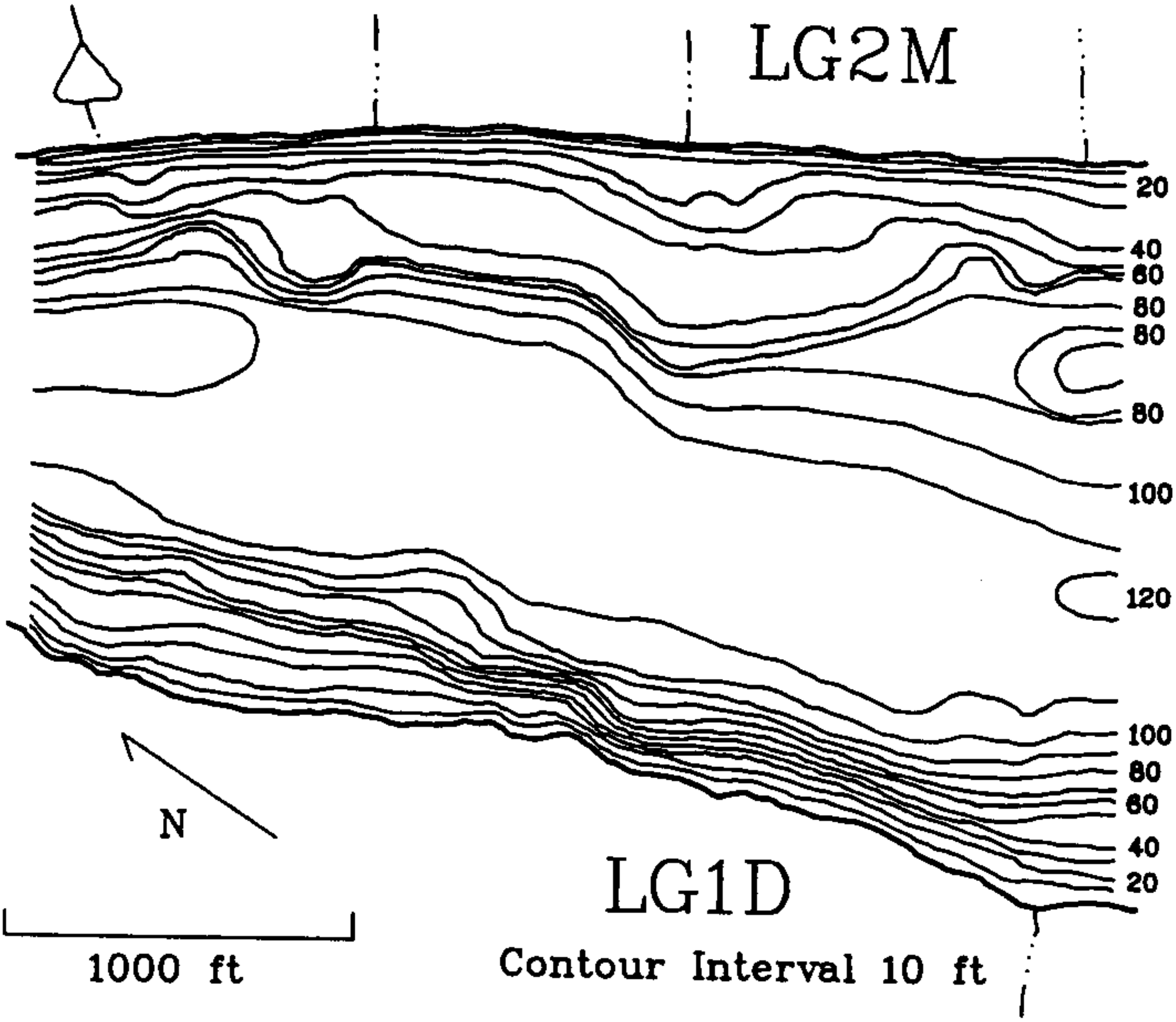

Figure 3. Morphometric map of stations LG2M and LG1D (RM 114) in Lower Granite Reservoir, Washington.

Depth information at mid depth stations revealed substantial differences among locations. The 60 ft depth contour at LG1M extended about half the width of the reservoir (~ 1500 ft) at the downstream limit but only about 500 ft at the upstream limit (Figure 4). An underwater ridge between the 30 and 40 ft contours rises to a depth of 10 ft and parallels the east shore about 200 ft from the waterline. At station LG2M, the 60 ft depth contour extended about 300-500 ft offshore; a shelf 40-60 ft deep and about 200 ft wide was the major feature at LG2M (Figure 3). At LG3M, the bottom was considerably flatter and shallower (Figure 5). Most of the shelf area occurred between 20 and 40 ft in depth. The 60 ft depth contour closely paralleled the southwestern shoreline, extending about 1000 ft toward the channel. Habitat mapping of LG2S is included in a comparison of shallow stations (Bennett et al. 1988).

Velocity

A graphical analysis of velocity readings from all depths, profiles and stations preceeded our regression analyses. No consistent depth-related velocity patterns emerged from plots of velocity profiles overtime (Appendix A); profiles at all stations varied widely among sample dates. We observed no strong relationship of velocity readings with total inflow at the confluence or total discharge at Lower Granite Dam. Figures 6 and 7 illustrate velocity patterns observed over river mile and profile at a depth of 5 m. River miles 134.7, 132.4, 129.2 and 127.3 (corresponding to stations LG5S, LS4S, LG3S and LG2S, respectively) show the strongest positive relationships with both total inflow (Figure 6) and total discharge (Figure 7) most likely a function of the "riverine" nature of the upper reservoir. As expected, velocity in up-reservoir areas is more responsive

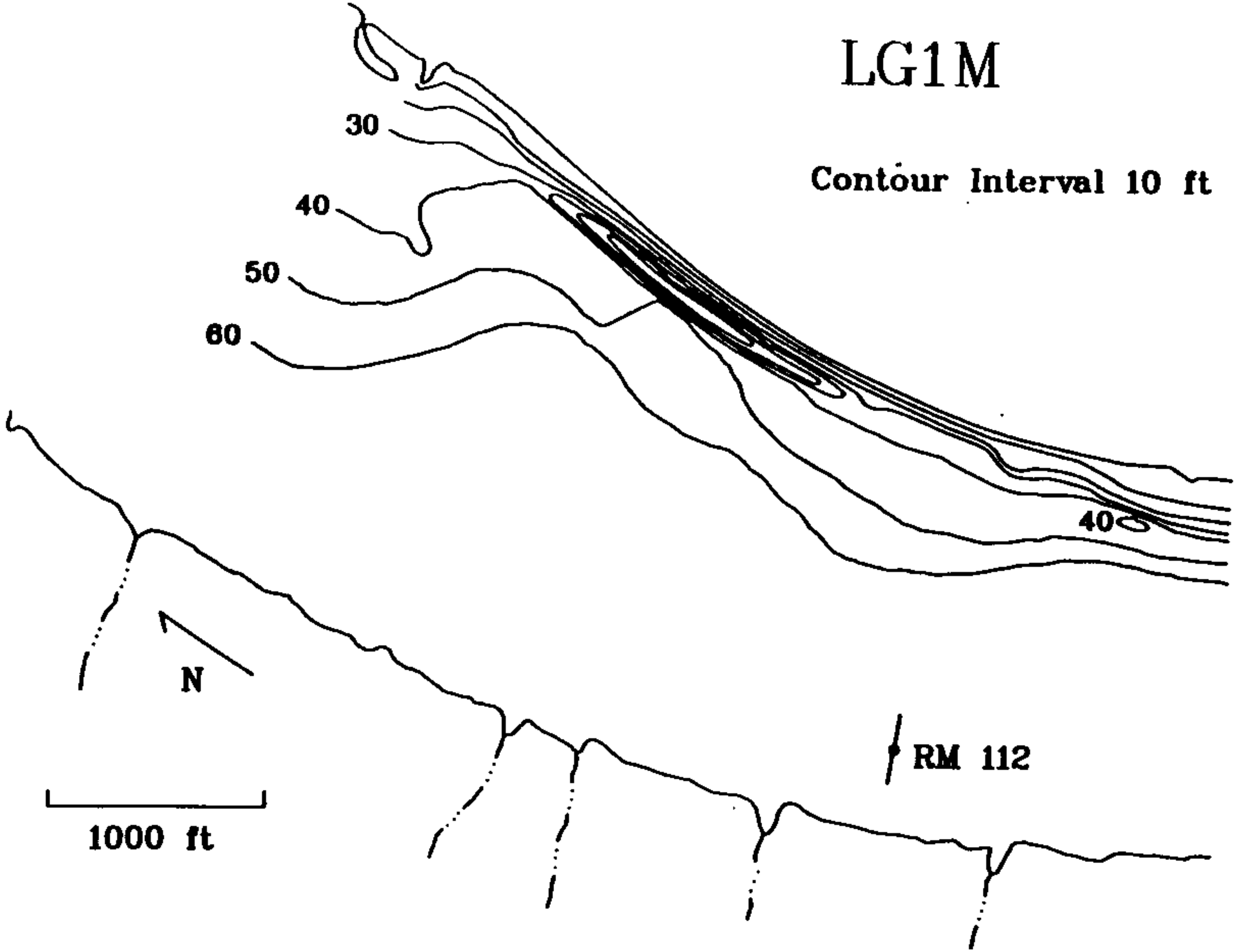

Figure 4. Morphometric map of station LG1M (RM 111.8) in Lower Granite Reservoir, Washington.

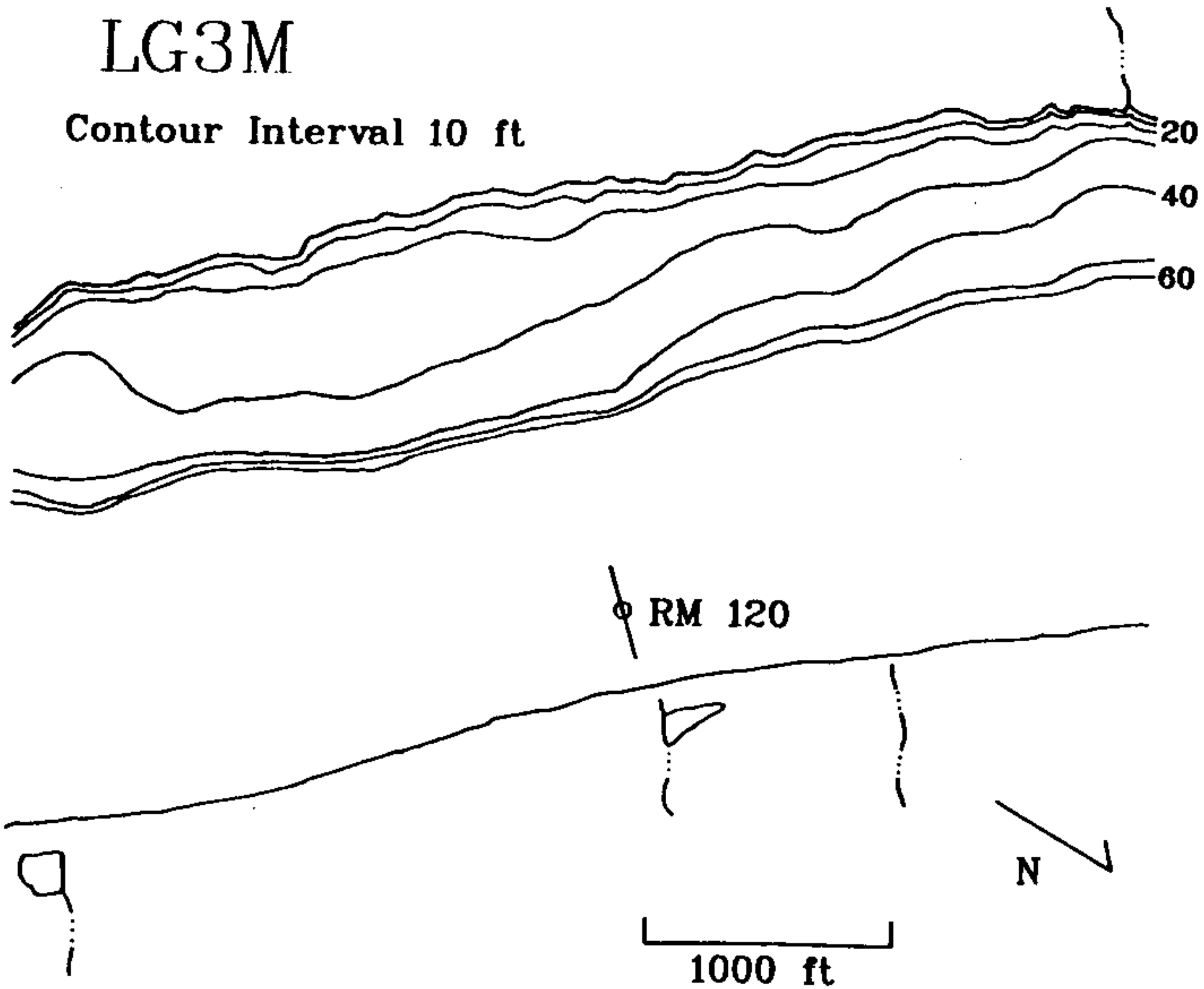

Figure 5. Morphometric map of station LG3M (RM 120) in Lower Granite Reservoir, Washington.

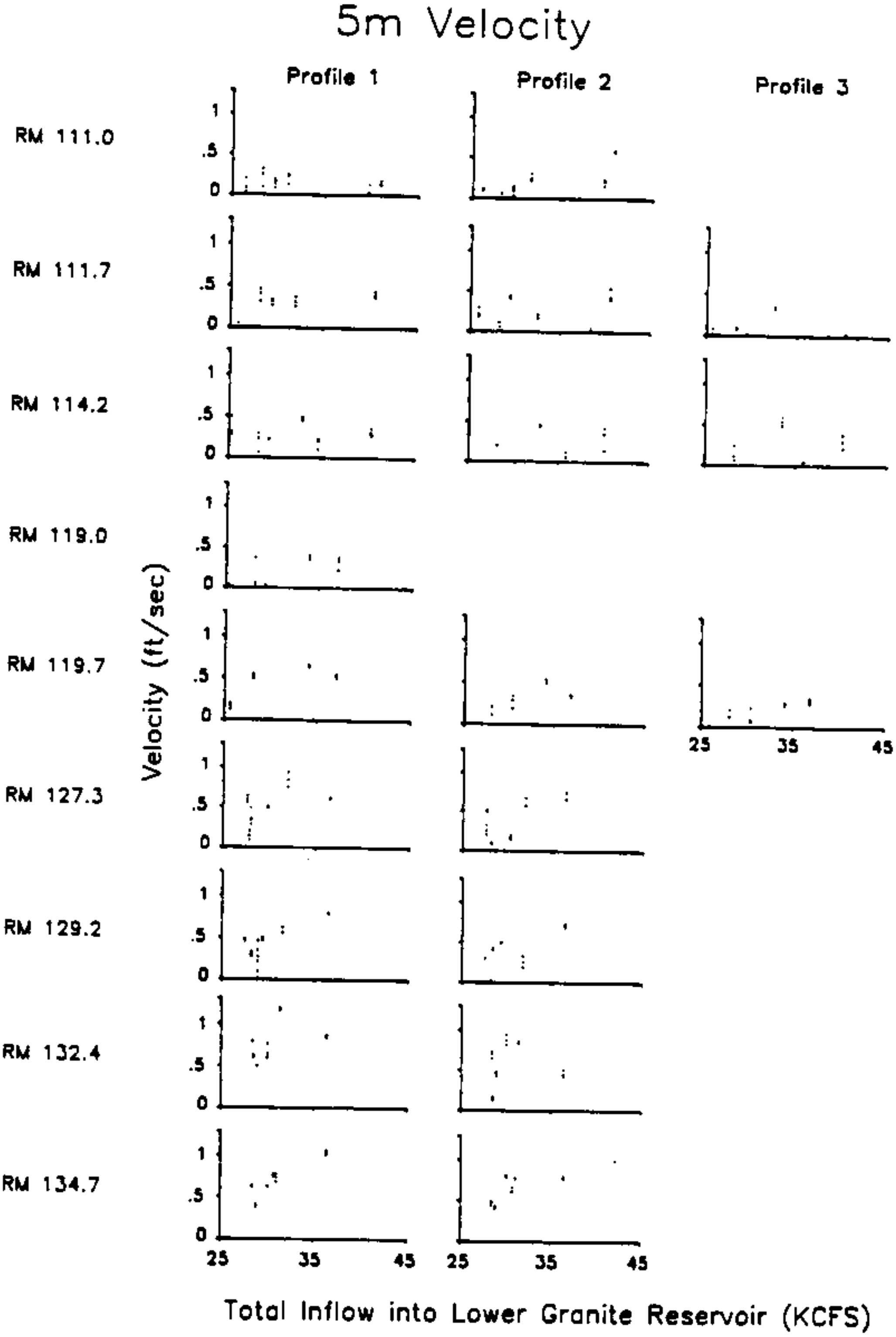

Figure 6. Relationship between velocity (ft/sec) at a depth of 5 m with river mile, profile location, and total inflow (KCFS) at the Snake and Clearwater River confluence. Profiles were located along a transect perpendicular to the channel; profile 1 was at the deepest point along the transect (channel profile), profile 3 was nearest to shore at 10 ft (shallow sites) or 40 ft (mid depth sites) in depth (on-site profile), and profile 2 was located at a depth which was half the difference in depths between profiles 1 and 3 (midway profile).

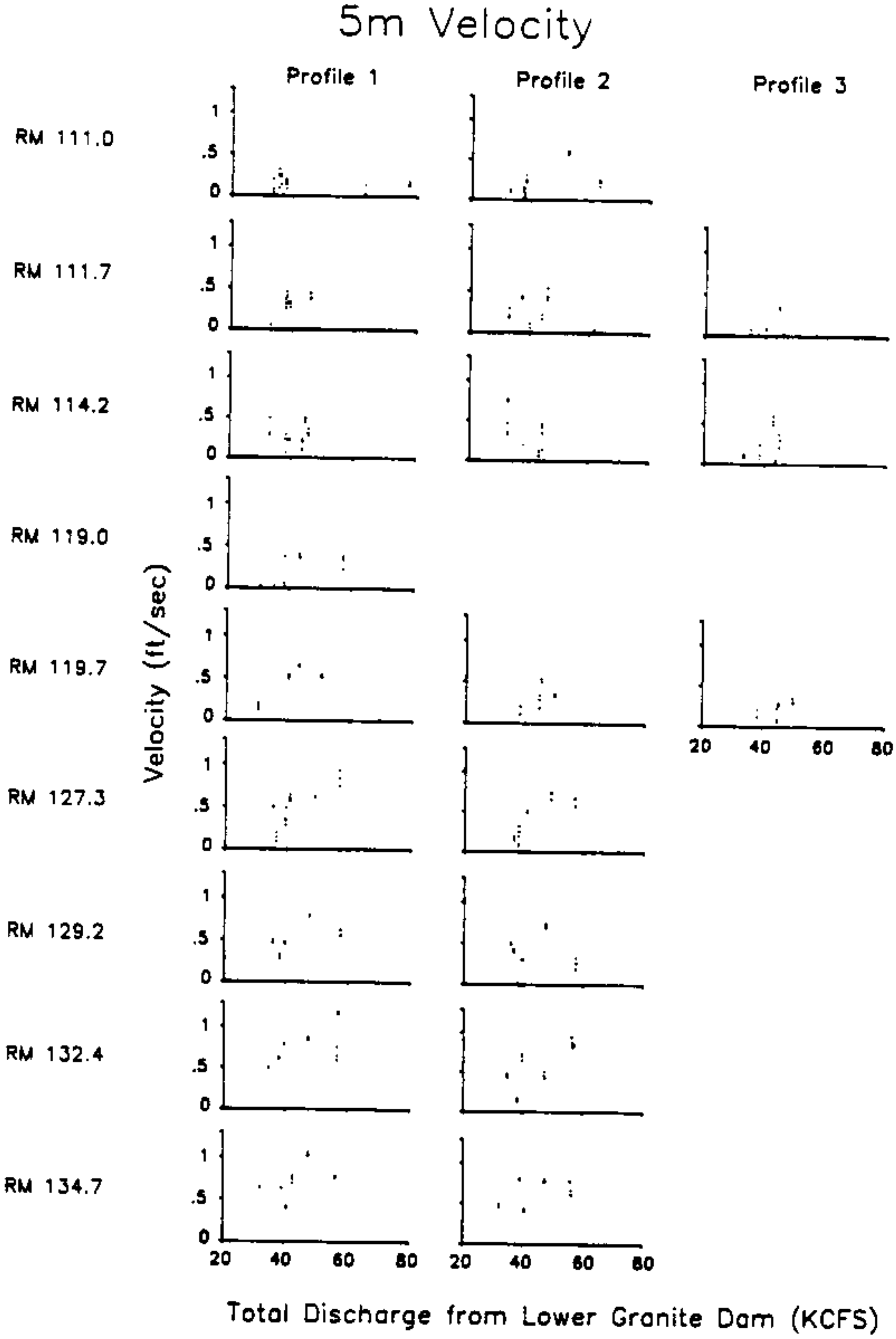

Figure 7. Relationship between velocity (ft/sec) at a depth of 5 m with river mile, profile location, and total discharge (KCFS) at Lower Granite Dam. Profiles were located along a transect perpendicular to the channel; profile 1 was at the deepest point along the transect (channel profile), profile 3 was nearest to shore at 10 ft (shallow sites) or 40 ft (mid depth sites) in depth (on-site profile), and profile 2 was located at a depth which was half the difference in depths between profiles 1 and 3 (midway profile).

to water "inputs" and "outputs" than in downstream areas where water volume is greater and less responsive to inflow and discharge.

Channel.-Average channel velocity over the length of Lower Granite Reservoir (RM 111 - 134) was best predicted by the ratio of river mile/cross sectional area and forebay pool elevation (adjusted $R^2 = 0.78$, $p = 0.0001$; Figure 8). Both variables were highly significant in contributing to the model ($p < .001$). Associated 95% confidence bounds for each predicted average velocity had a mean of ±0.219.

Regressions to predict upstream (RM 120 - 134) and downstream (RM 111 - 120) channel velocities within the reservoir demonstrated the importance of different variables in the two reservoir sections. The variables river mile/cross sectional area and total inflow were most important for predicting upstream channel velocity (adjusted $R^2 = .70$, $p = .0001$; Figure 9), while river mile/cross sectional area and forebay pool elevation were most important in the downstream section (adjusted $R^2 = 0.58$, $p = .0001$; Figure 10). We dropped one outlier from the upstream velocity data set because of its overriding effect on the analysis (R^2 with the outlier $= 0.64$). Confidence intervals (95%) for predicted values had an overall mean of ±0.242 in the upstream section and ±0.194 in the downstream section.

On-site.-We were not able to develop a reservoir-wide (RM 111 to 134) regression equation to predict average "on-site" velocities ($R^2 < 0.50$). Equations developed for the upstream and downstream portions of the reservoir indicate different variables were important in affecting site velocities. Log transformation of the average site velocities was necessary for both upstream and downstream sections to linearize the relationship. Polynomial transformations of the independent variables were necessary to

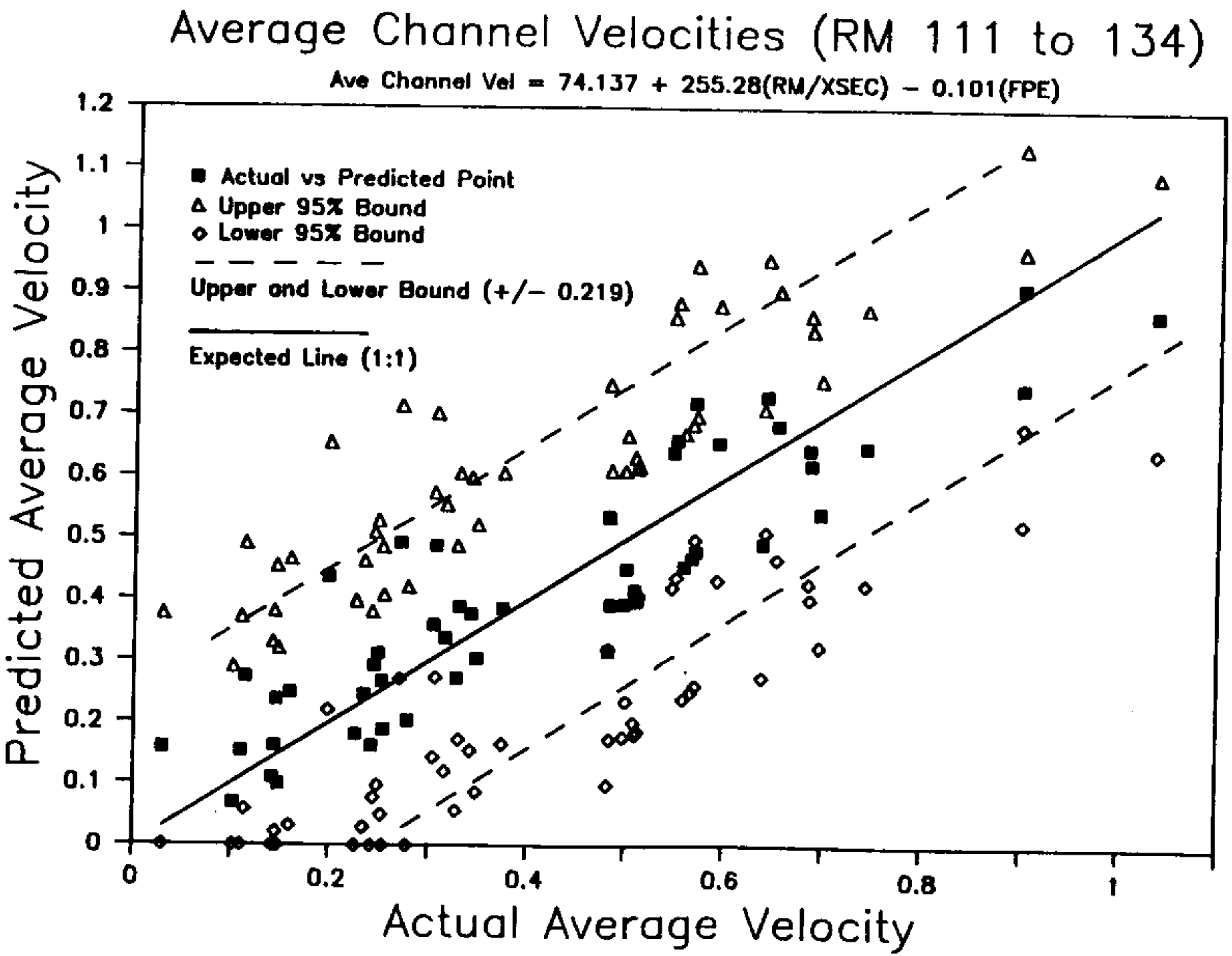

Figure 8. Actual vs. predicted values from regression (R^2=.78; p=.0001) relating average channel velocity (ft/sec) over the entire reservoir (RM 111 to 134) to the ratio of river mile / cross sectional area (ft^2; RM/XSEC) and forebay pool elevation (ft; FPE) at Lower Granite Dam. In the predictive regression equation, 74.137 is the intercept value while 255.28 and 0.101 are regression coefficients. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.219 ft/sec).

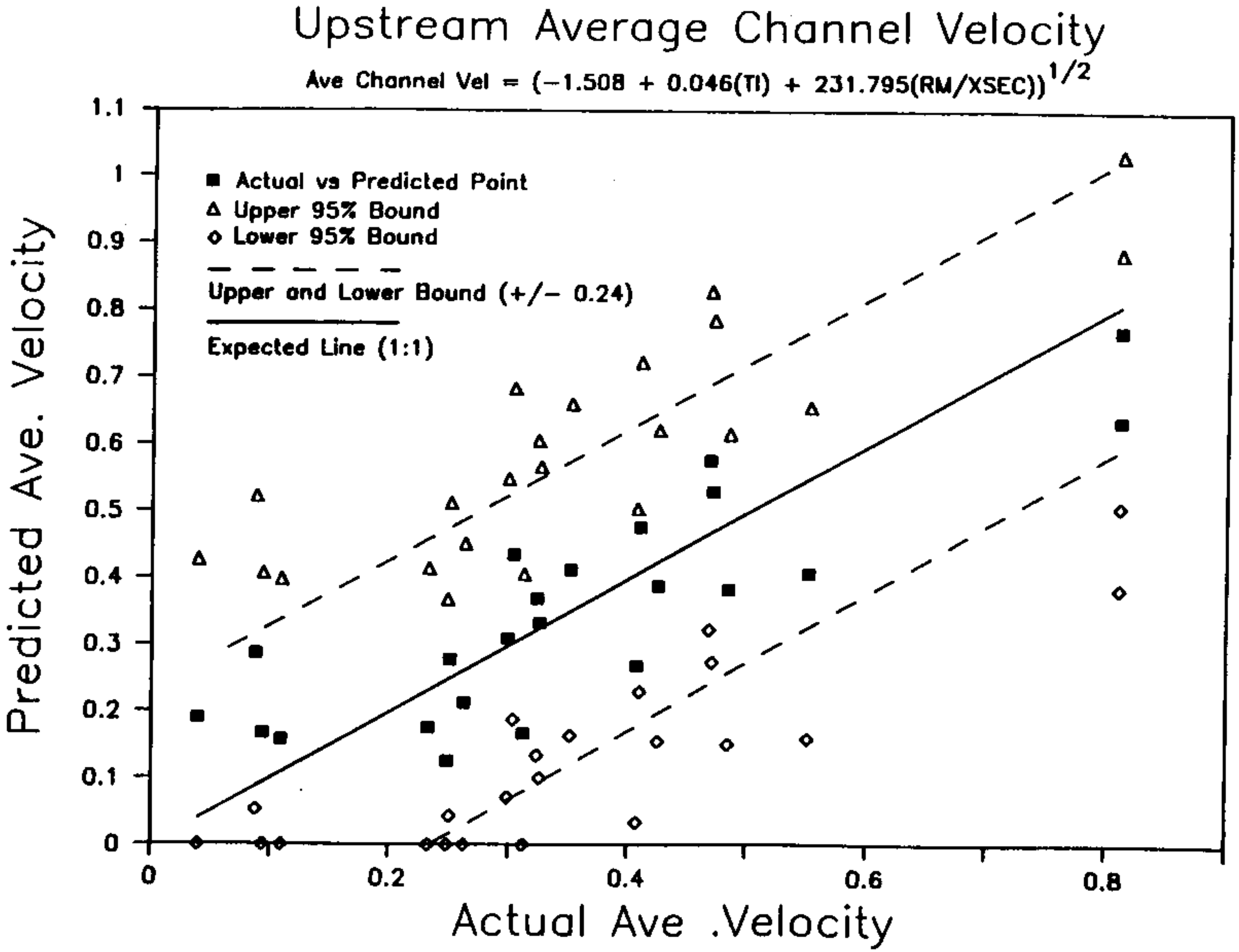

Figure 9. Actual vs. predicted values from regression (R^2=.70; p=.0001) relating average channel velocity (ft/sec) in the upstream (RM 120 to 134) portion of Lower Granite Reservoir to the ratio of river mile / cross sectional area (ft^2; RM/XSEC) and total inflow (KCFS; TI) at the confluence of the Snake and Clearwater Rivers. In the predictive regression equation, -1.508 is the intercept value while 0.046 and 231.795 are regression coefficients. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.240 ft/sec).

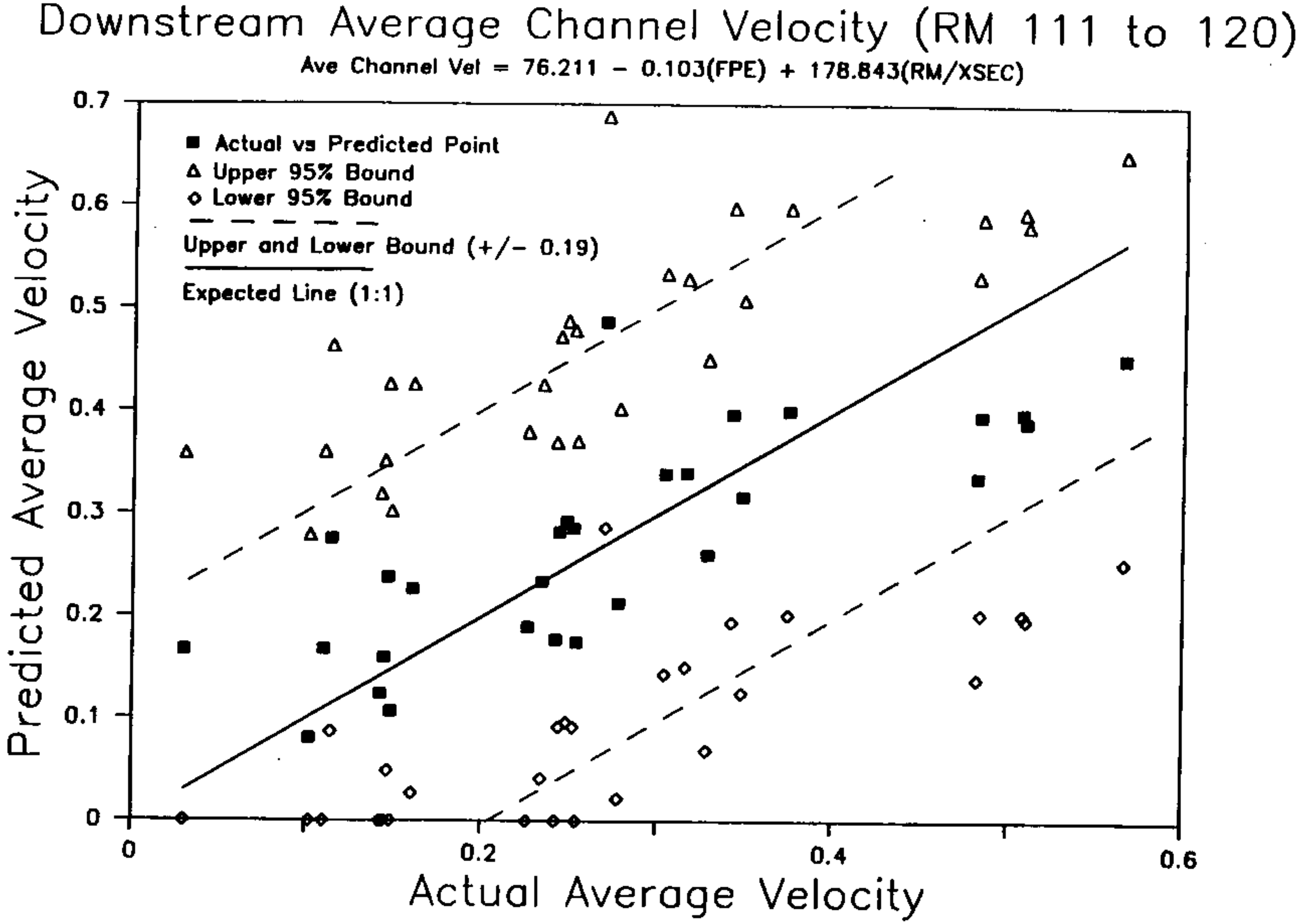

Figure 10. Actual vs. predicted values from regression (R^2=.58; p=.0001) relating average channel velocity (ft/sec) in the downstream (RM 111 to 120) portion of the reservoir to the ratio of river mile / cross sectional area (ft^2; RM/XSEC) and forebay pool elevation (ft; FPE) at Lower Granite Dam. In the predictive regression equation, 76.211 is the intercept value while 0.103 and 178.843 are regression coefficients. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.190 ft/sec).

normalize data and to control variance in both reservoir sections. Although regression coefficients associated with the polynomial transformation were not significantly different from 0 ($p > 0.05$), the resulting regressions were valid for predictive equations (personal communication, Dr. Dale Everson, Department of Applied Statistics, University of Idaho, Moscow). Therefore, we believe the equations developed do a reasonable job at predicting on-site velocities.

The best regression equation (adjusted $R^2 = 0.52$, $p = 0.0004$; Figure 11) developed for average on-site velocities for the upstream portion (RM 120-134) included confluence pool elevation and average midway velocity (the mean of of all measurements from the midway profile). Confidence intervals (95%) for the predicted values had an overall mean of ±0.215. The best regression equation for the downstream portion of the reservoir (adjusted $R^2 = 0.80$, $p = 0.0001$; Figure 12) included average channel velocity and site depth with a mean confidence interval (95%) for the predicted values of ±0.14.

Substrate

We found no relationship between particle size and river mile at deep and mid depth stations. Bounds on the estimates were relatively narrow. Particles smaller than sand (< 0.061 mm) dominated the fine sediment from ponar dredge collections (Figure 13). With the exception of LG2M, little variation was observed within or among stations. Particles less than 0.061 mm ranged from 66% (LG2M) to 87% (LG1M) of the sediment.

Percentage of sand (0.061 to 2.0 mm) in the fine sediments showed little variation within or among stations. Sand ranged from 13% (LG1M) to

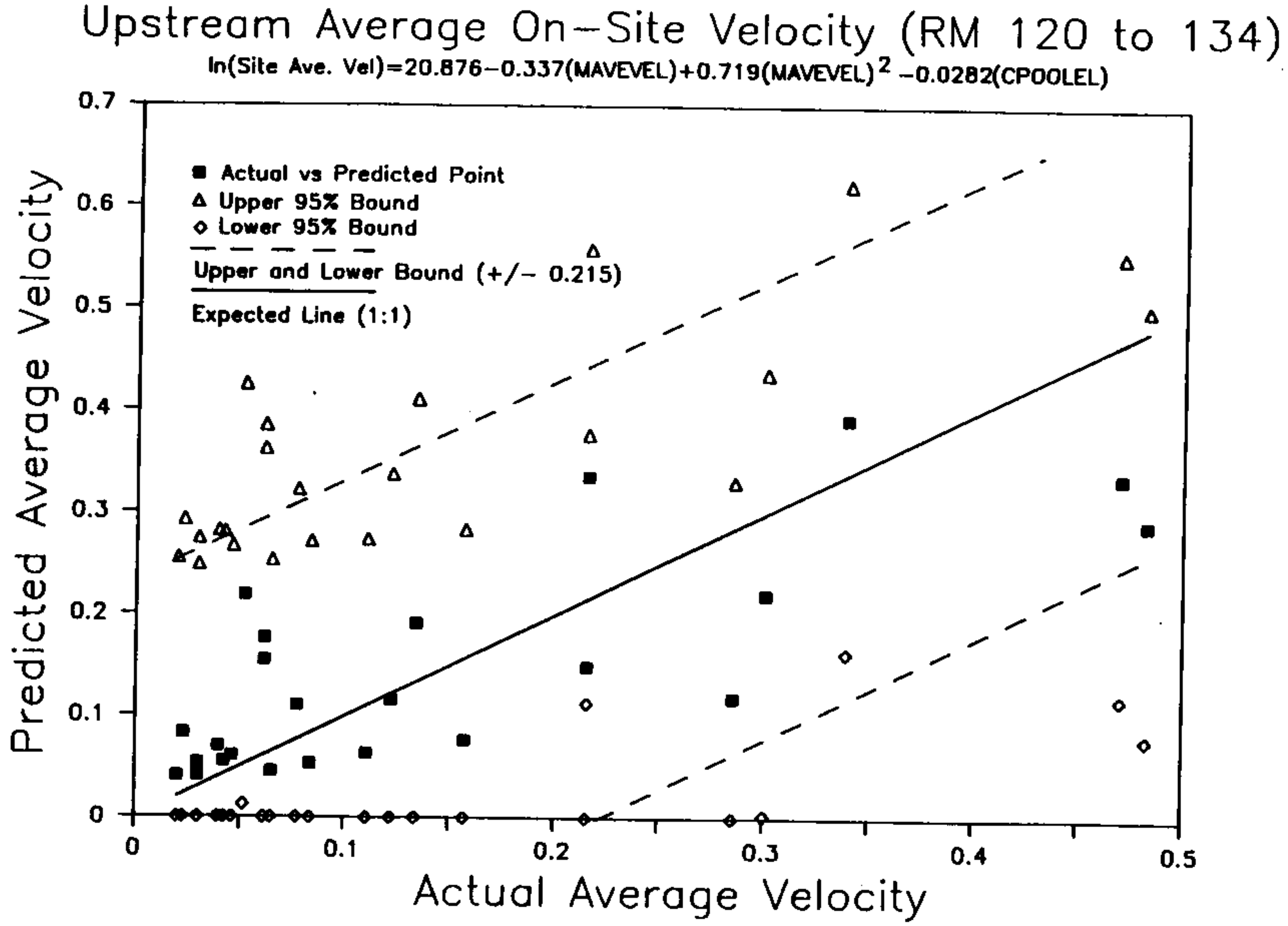

Figure 11. Actual vs. predicted values from regression (R^2=.52; p=.0004) relating average on-site velocity (ft/sec) in the upstream (RM 120 to 134) portion of Lower Granite Reservoir to average velocity at the midway profile (ft/sec; MAVEVEL) and pool elevation at the confluence of the Snake and Clearwater Rivers (ft; CPOOLEL). In the predictive regression equation, 20.876 is the intercept value while 0.337, 0.719, and 0.0282 are regression coefficients. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.215 ft/sec).

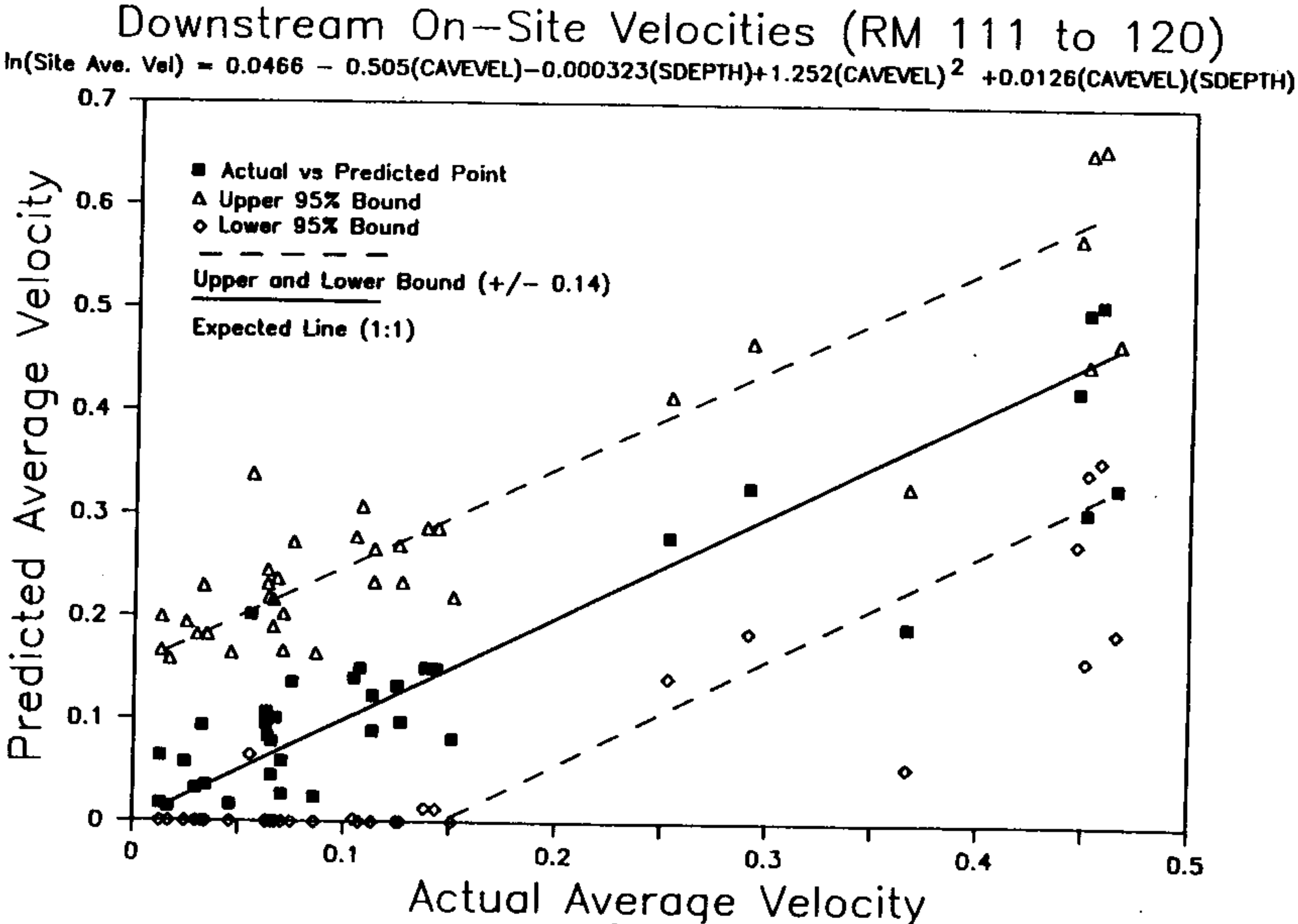

Figure 12. Actual vs. predicted values from regression (R^2=.80; p=.0001) relating average on-site velocity (ft/sec) in the downstream (RM 111 to 120) portion of Lower Granite Reservoir to average velocity at the channel profile (ft/sec; CAVEVEL) and depth (ft; SDEPTH) at the on-site profile. In the predictive regression equation, 0.0466 is the intercept value while 0.505, 0.000323, 1.252, and 0.0126 are regression coefficients. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence (bound) on predicted values (+/- 0.140ft/sec).

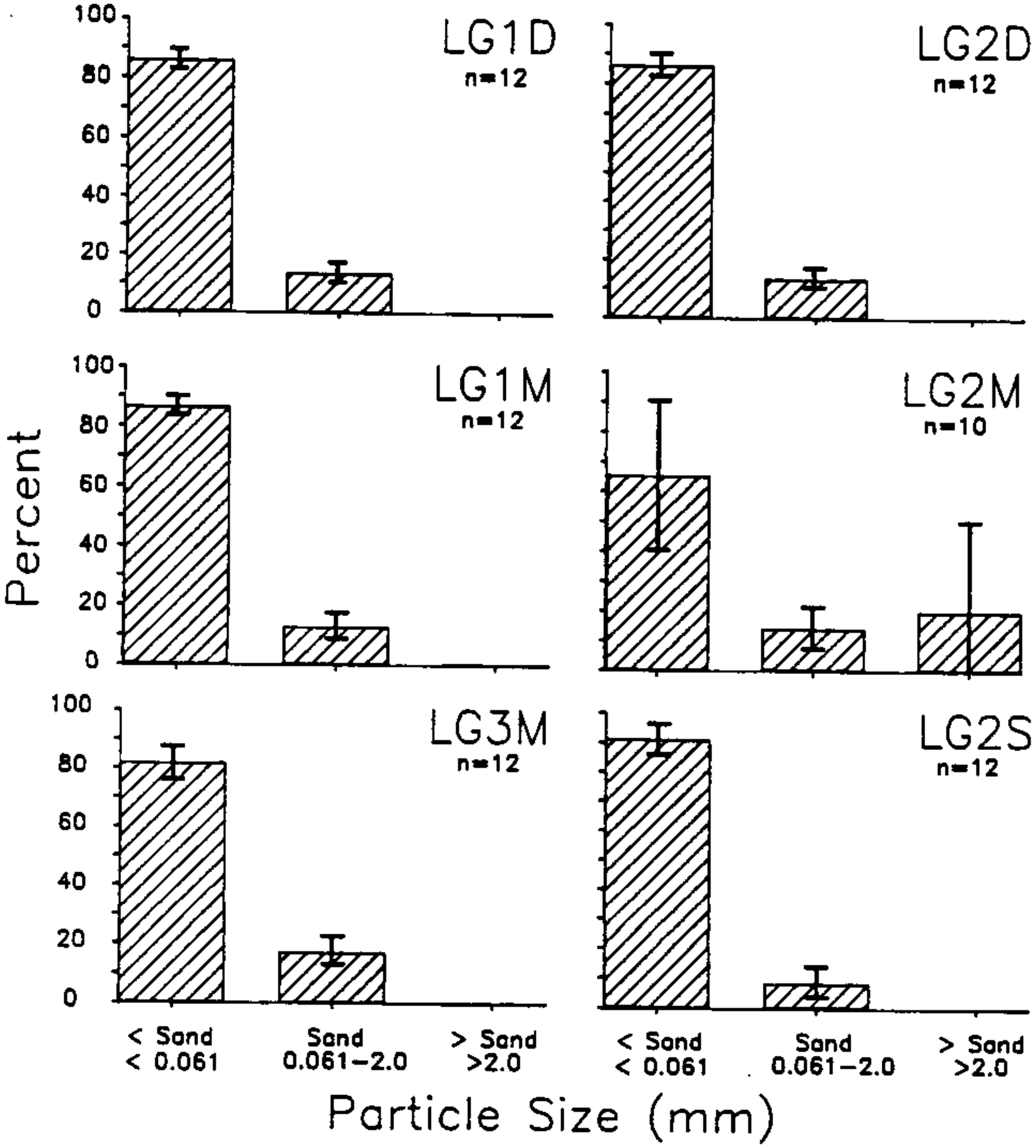

Figure 13. Composition of substrate larger than sand (> 2 mm), sand (0.061 to 2 mm), and less than sand (< 0.061 mm) from ponar dredge samples at shallow stations, Lower Granite Reservoir, Washington, 1987.

17.5% (LG3M) of the sediment. Particles greater than 2.0 mm were nonexistent with the exception of station LG2M which had a mean of 20% of the sediment larger than 2.0 mm. However, a relatively large variance is associated with this estimate (Figure 13).

Percent organic matter content of the sediment at the mid depth and deep stations ranged from 7.4% (LG1M) to 14.9% (LG2D; Figure 14). With the exception of LG2D, differences among the stations were slight. Substrate at LG2D had significantly higher organic matter than at mid depth stations and LG2S; however, overlap of 95% confidence bounds, although slight, suggest that organic matter at LG1D and LG2D may not significantly differ.

In addition to other physical habitat measurements, limited information on temperature and turbidity was collected, and is presented in Appendix Table A1.

Objective 2: To assess seasonal dynamics of benthic community biomass in Lower Granite Reservoir;

Methods

Eight benthic samples for statistical replication were collected during spring, summer and fall at each station using a Ponar dredge (239.25 cm^2). The particular location of sampling was at two sites along each of four transects at each station. Because of the size and/or the hard-packed nature of substrate at LG1S, no benthic samples could be taken.

The collected sediment was washed through a 0.595 mm sieve bucket (#30) and the collected organisms preserved in FAA (Pennak 1978). Organisms were separated into major taxonomic groups (Pennak 1978), enumerated and weighed. Wet weights were determined by blotting the organisms in each taxonomic

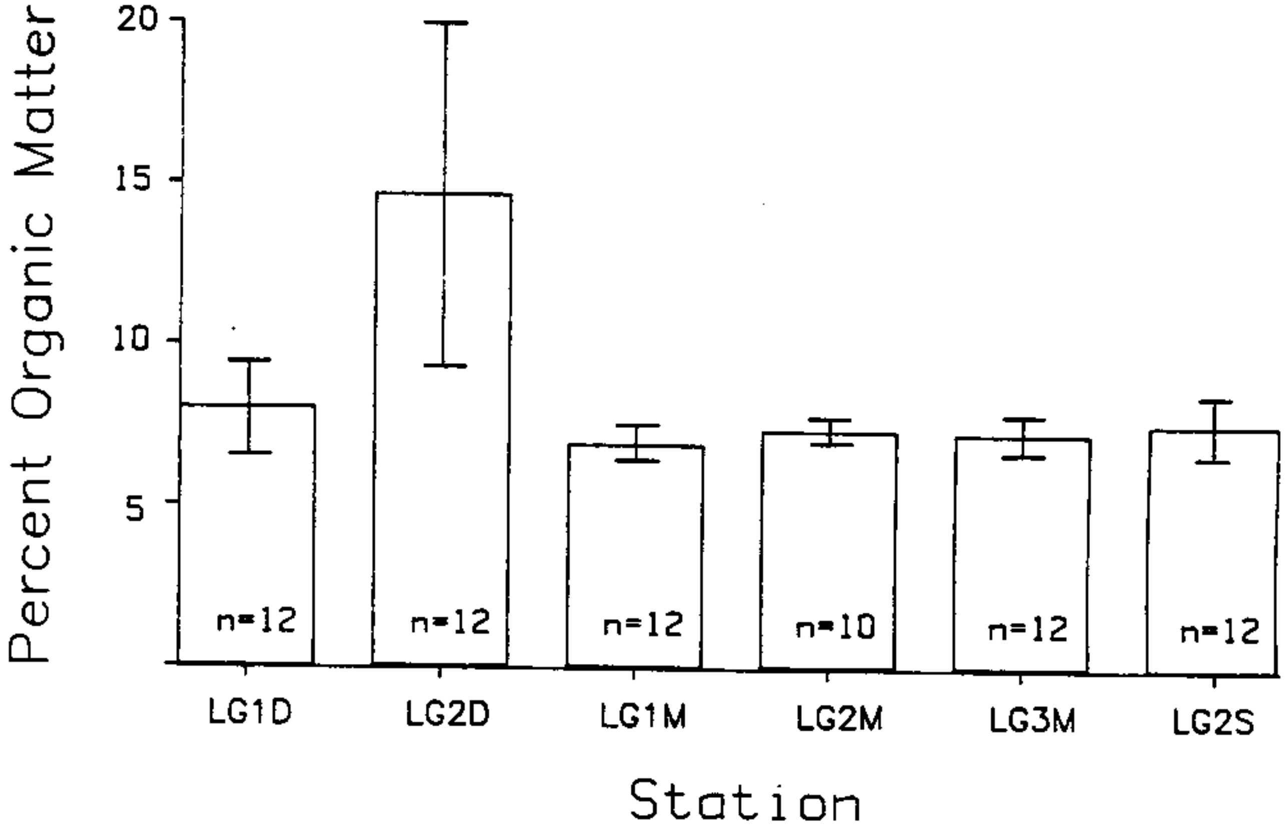

Figure 14. Mean organic content (%) at deep and mid depth stations, and LG2S during June, 1987, from Lower Granite Reservoir, Washington. Vertical bars delineate 95% confidence intervals on the means.

group for 1.0 to 3.0 minutes (depending upon the group size) and weighing in a tared, water-filled, covered vessel. Mean weights were used to calculate total weights of taxons which were summed over all taxons present to obtain a sample weight. Sample numbers and weights were expanded (x 41.8) for estimates per meter squared.

Results

Benthic community abundance varied among spring, summer and fall seasons. Oligochaetes and chironomids collectively accounted for more than 99% of the numbers of benthos samples (Tables 2-7). Taxa other than chironomids and oligochaetes from mid depth, deep, and shallow sites are enumerated in Appendix Tables A2 and A3. The highest number of taxa collected (8) was from LG5S and the lowest (2) was collected from four stations (LG1D, LG2D, LG3S, LG2S). Highest numbers and standing crops of benthos were collected in the summer (Tables 4 and 5). Oligochaetes consistently attained highest abundance at LG2D, while chironomids were most abundant at LG2M and LG3M among mid and deep sites. At shallow sites, oligochaetes were generally more abundant at LG4S and LG5S, while chironomids were more abundant at LG3S and LG4S.

Confidence intervals (95%) on mean estimates of standing crops overlapped among all deep and mid depth stations and among shallow stations for all seasons (Figures 15 and 16). Mean standing crop of benthos ranged from about 20 g/m^2 in the summer to a low of about 5 g/m^2 in the spring. In general, variation was directly proportional to the mean number and biomass.

<u>Objective 3</u>: To assess seasonal importance of selected disposal areas for fishes in Lower Granite Reservoir.

Table 2. Number of taxa and estimates of mean number/m^2 and mean biomass (g/m^2) of oligochaetes, chironomids, and other taxa from ponar dredge collections at shallow stations during spring, 1987, at Lower Granite Reservoir, Washington. Parenthetical numbers represent 95% confidence intervals (+/- the mean estimates).

Taxon	Station LG2S n=12	 LG3S n=8	 LG4S n=8	 LG5S n=7
Total Number	7	4	4	8
Oligochaete				
number/m^2	5,584 (4,335)	11,114 (3,588)	6,803 (6,284)	20,154 (11,699)
grams/m^2	2.8 (1.2)	4.5 (1.5)	4.3 (3.4)	5.9 (4.0)
Chironomidae				
number/m^2	1,149 (356)	512 (205)	1,097 (897)	1,194 (1,060)
grams/^{2}	3.6 (1.6)	1.1 (0.5)	2.5 (2.7)	0.8 (0.4)
Other				
number/m^2	21 (18)	16 (26)	31 (61)	107 (104)
grams/m^2	NA[1]	NA	NA	NA

[1] NA - not available

Table 3. Number of taxa and estimates of mean number/m^2 and mean biomass (g/m^2) of oligochaetes, chironomids, and other taxa from ponar dredge collections at mid depth and deep stations during spring, 1987, at Lower Granite Reservoir, Washington. Parenthetical numbers represent 95% confidence intervals (+/- the mean estimates).

Taxon	Station LG1D n=8	 LG2D n=8	 LG1M n=6	 LG2M n=8	 LG3M n=8
Total Number	3	2	5	3	4
Oligochaete					
number/m^2	1,144 (538)	3,339 (987)	2,083 (1,941)	2,247 (1,265)	1,327 (784)
grams/m^2	5.3 (2.9)	4.2 (1.0)	2.6 (0.9)	5.3 (1.7)	4.2 (2.9)
Chironomidae					
number/m^2	297 (143)	1,217 (186)	529 (257)	1,474 (534)	888 (609)
grams/m^2	3.6 (2.8)	2.7 (0.7)	2.2 (1.9)	3.4 (1.5)	1.6 (1.4)
Other					
number/m^2	10.5 (16.2)	-	21 (24)	37 (60)	21 (37)
grams/m^2	NA[1]	-	NA	NA	NA

[1] NA- not available

Table 4. Number of taxa and estimates of mean number/m^2 and mean biomass (g/m^2) of oligochaetes, chironomids, and other taxa from ponar dredge collections at shallow stations during summer, 1987, at Lower Granite Reservoir, Washington. Parenthetical numbers represent 95% confidence intervals (+/- the mean estimates).

Taxon	Station LG2S n=8	 LG3S n=8	 LG4S n=8	 LG5S n=8
Total Number	3	2	4	5
Oligochaete				
number/m^2	18,909 (5,434)	13,888 (5,428)	24,615 (4,080)	17,964 (6,712)
grams/m^2	7.4 (2.5)	5.5 (2.9)	8.5 (2.7)	7.4 (2.8)
Chironomidae				
number/m^2	1,677 (456)	1,980 (672)	2,085 (263)	1,709 (465)
grams/m^2	7.5 (4.7)	3.0 (1.6)	9.0 (2.5)	2.1 (1.7)
Other				
number/m^2	11 (25)	- -	31 (52)	16 (26)
grams/m^2	NA[1]	-	NA	NA

---

[1] NA - not available

Table 5. Number of taxa and estimates of mean number/m^2 and mean biomass (g/m^2) of oligochaetes, chironomids, and other taxa from ponar dredge collections at mid depth and deep stations during the summer, 1987, at Lower Granite Reservoir, Washington. Parenthetical numbers represent 95% confidence intervals (+/- the mean estimates).

Taxon	Station LG1D n=8	LG2D n=8	LG1M n=8	LG2M n=8	LG3M n=8
Total Number	2	3	3	3	3
Oligochaete					
number/m^2	4,614 (1,660)	10,560 (2,225)	4,196 (1,492)	6,354 (1,150)	8,627 (1,729)
grams/m^2	17.1 (7.8)	13.0 (3.4)	15.0 (7.9)	8.4 (5.6)	7.1 (2.2)
Chironomidae					
number/m^2	282 (148)	1,202 (290)	773 (165)	1,197 (249)	1,557 (230)
grams/m^2	2.8 (1.5)	7.0 (1.9)	4.3 (1.1)	5.1 (1.5)	7.6 (1.9)
Other					
number/m^2	-	5 (12)	5 (12)	5 (12)	5 (12)
grams/m^2	-	NA[1]	NA	NA	NA

[1] NA - not available

Table 6. Number of taxa and estimates of mean number/m^2 and mean biomass (g/m^2) of oligochaetes, chironomids, and other taxa from ponar dredge collections at shallow stations during fall, 1987, at Lower Granite Reservoir, Washington. Parenthetical numbers represent 95% confidence intervals (+/- the mean estimates).

Taxon	Station LG2S n=8	 LG3S n=8	 LG4S n=8	 LG5S n=8
Total Number	2	3	4	4
Oligochaete				
number/m^2	11,923 (3,533)	15,858 (8,783)	19,735 (9,131)	9,065 (1,780)
grams/m^2	9.4 (3.6)	4.9 (2.2)	8.0 (2.4)	5.1 (1.6)
Chironomidae				
number/m^2	1,238 (482)	1,980 (944)	1,583 (443)	998 (515)
grams/m^2	2.2 (0.8)	1.5 (0.8)	4.4 (2.3)	1.6 (1.1)
Other				
number/m^2	- -	10 (25)	37 (44)	16 (17)
grams/m^2	-	NA[1]	NA	NA

[1] NA - not available

Table 7. Number of taxa and estimates of mean number/m^2 and mean biomass (g/m^2) of oligochaetes, chironomids, and other taxa from ponar dredge collections at mid-depth and deep stations during the fall, 1987, at Lower Granite Reservoir, Washington. Parenthetical numbers represent 95% confidence intervals (+/- the mean estimates).

Taxon	Station LG1D n=8	 LG2D n=8	 LG1M n=8	 LG2M n=8	 LG3M n=8
Total Number	3	2	4	6	3
Oligochaete					
number/m^2	2,926 (595)	5,565 (2,404)	2,001 (739)	5,100 (1,733)	3,407 (1,723)
grams/m^2	15.2 (5.2)	13.4 (4.0)	9.8 (4.2)	13.2 (4.7)	9.2 (2.5)
Chironomidae					
number/m^2	627 (826)	559 (156)	412 (179)	460 (275)	376 (157)
grams/m^2	2.2 (1.2)	3.2 (0.7)	2.7 (1.1)	2.6 (2.1)	2.2 (0.6)
Other					
number/m^2	31 (41)	- -	16 (18)	26 (35)	5 (12)
grams/m^2	NA[1]	-	NA	NA	NA

[1] NA - not available

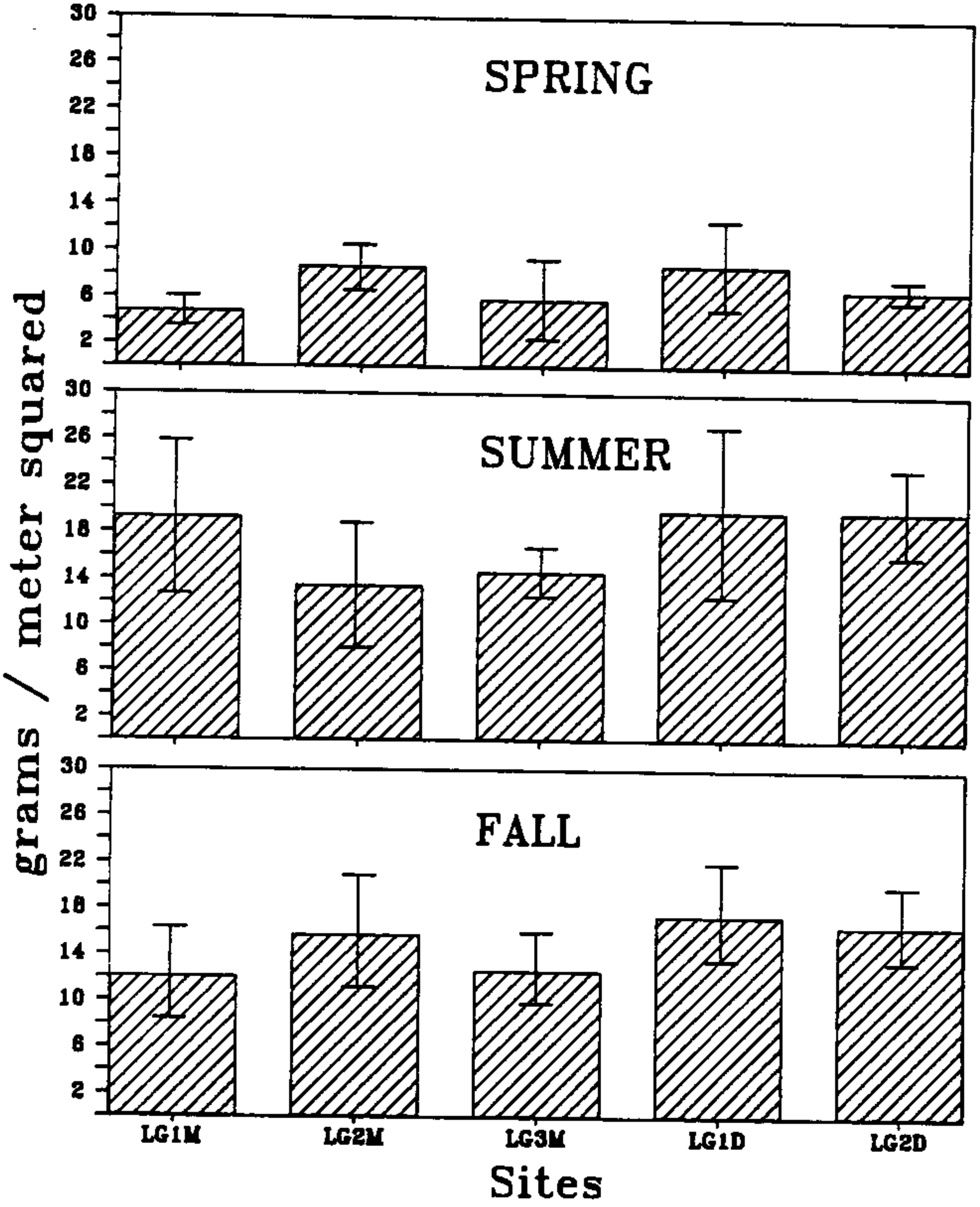

Figure 15. Mean biomass of benthic organisms and 95% confidence intervals collected from deep and mid depth stations during spring, summer, and fall, 1987 in Lower Granite Reservoir, Washington.

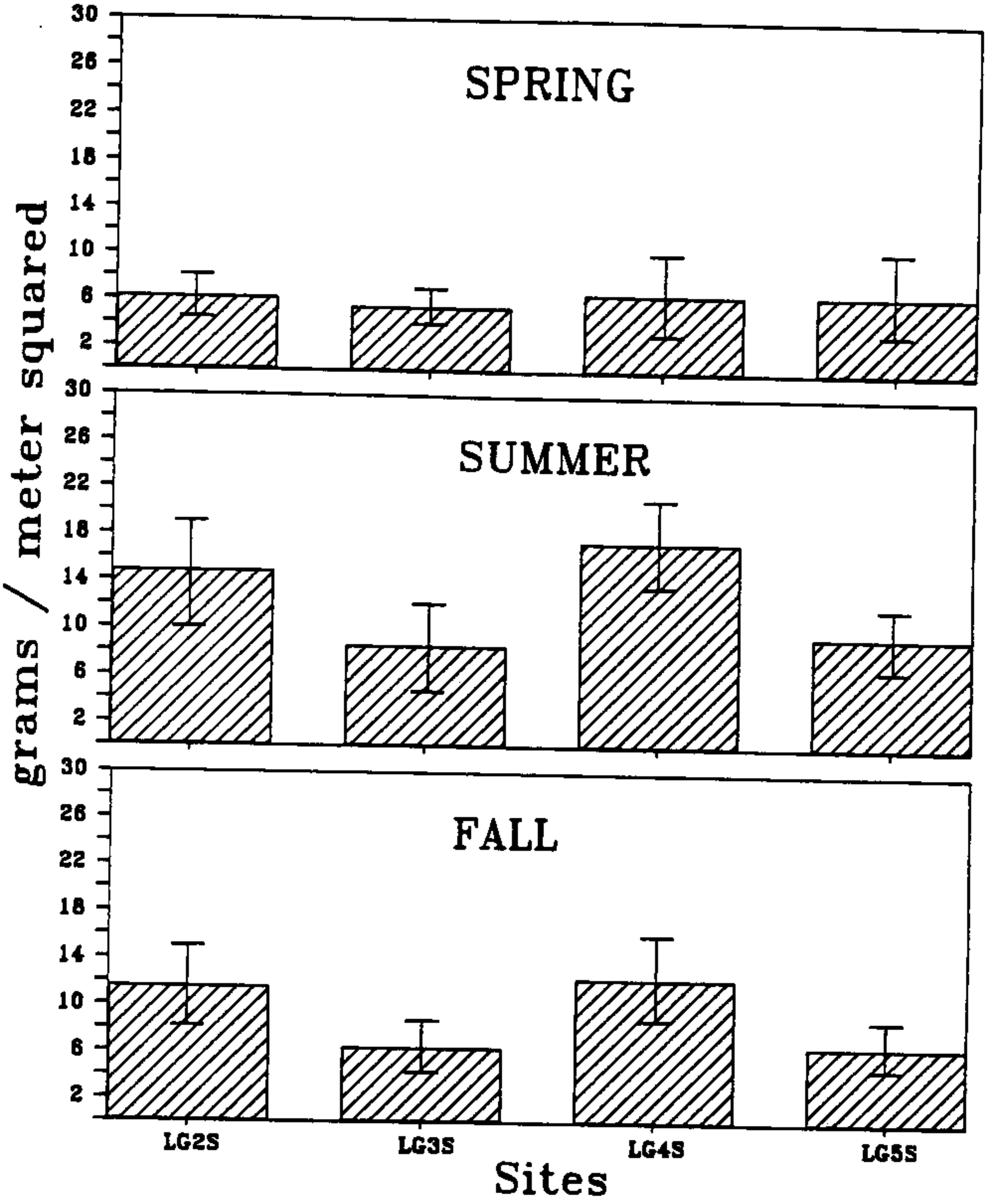

Figure 16. Mean biomass of benthic organisms with associated 95% confidence intervals collected from shallow water stations during spring, summer, and fall, 1987 in Lower Granite Reservoir, Washington.

Methods

To minimize sampling bias and make collections representative of the fish community, several gear types were used in Lower Granite Reservoir. Electrofishing by night and sometimes by day was used at the shallow water station (LG2S). An output of approximately 300 volts and 4-5 amps was found to adequately stun fish while causing virtually no mortalities or visual evidence of injury. Electrofishing was conducted by paralleling the shoreline for one 15 minute pass.

Gillnets were fished at each of the six stations. We used two types of experimental gillnets:

1. Monofilament - 61 m long x 1.8 m deep, 8 panels each 7.6 m long, at 1.25 cm, 2.54 cm, 3.81 cm, 5.08 cm, 6.35 cm, 7.62 cm, 8.89 cm, and 10.16 cm bar measurement.
2. Multifilament - same as horizontal monofilament (61 x 1.8 m).

At most stations, five horizontal gillnets (multi- and monofilament) were set perpendicular to the shoreline. Sets were floating, mid water or on the bottom. The mid water set was a floating net anchored about midway between the surface and the bottom that created a net "suspended" within the water column. Floating sets were checked at 1-2 hour intervals over approximately a 7-8 hour period. Bottom and mid water nets were checked at longer time intervals because of the difficulty in setting and that considerably fewer salmonids were collected at these depths. Short term effort in floating sets was used to prevent net mortality of anadromous fishes.

In addition to gillnetting, set lines were used at deep water stations. Each set line consisted of 12 m lines with six (4/0 size) hooks on each. Hooks were baited with cut bait and were fished for approximately 7-8 hours.

However, since limited catches were made (2 brown bullheads and 1 northern squawfish in 84 hours of effort), data collected were not used in this report.

Standardized beach seine hauls also were used at the shallow water station. Beach seining was conducted using a 30.5 x 2.4 m seine constructed of 6.35 mm knotless nylon mesh with a 2.4 x 2.4 x 2.4 m bag. A standard haul was made by setting the seine parallel to the shoreline using 15 m extension ropes. Three hauls were made at each station.

Fish collected with all gear types were identified to species and total lengths (mm) were taken (except adult anadromous fishes). All adult anadromous salmonids were released immediately and never removed from the water.

We used a commercial 'fish finder' (an Eagle Mach 1 single transducer recording echo-sounder made by Lowrance, Inc.) as another means of assessing overall fish abundance, depth distribution, and diel movements. All sonar sampling was conducted concurrently with gillnetting.

Sonar records (CPUE's) were calculated using estimates of total volume sampled per transect as effort. Although CPUE's were calculated, we <u>are not implying</u> a quantitative interpretation of the data. We realize the limitations of using an uncalibrated system and so make only qualitative interpretations. Lowrance, Inc. provided us with estimates of shape and size of the sonar beam at various depths, enabling us to calculate the volume sampled per transect as a function of transect length, average depth of the transect, and depth at which surface noise subsides. Shape of the sonar beam at any instant in time was assumed to be roughly conical. As a result of movement along a transect and loss of sonar readability at the surface because of noise, the functional volume sampled becomes a vertical truncated cone extended along the length of the transect.

We followed two strategies for sampling with the echosounder, both involving sampling while the gillnets were fishing. The first strategy involved sampling while actually setting each gillnet. During this procedure the boat was not travelling at a constant speed, but length of the sonar transect equals the length of the gillnet. The second strategy involved randomly driving the boat around our gillnet sets between net-checking times. Boat speed was standardized at low throttle on a 10 horsepower trolling motor, and every minute a mark was made on the sonar record, so length of each transect equaled the distance the boat travelled in one minute. Each transect can then be treated as a separate sample for CPUE estimates. In addition to providing CPUE information, hydroacoustic sampling enabled us to assess fish community depth distribution although we were unable to distinguish among species. Plotting the ratio of fish depth to total depth against time and average depth of each transect provided the most meaningful insights into diel and site-specific fish depth distribution.

Results

Total Catch

A total of 19 species consisting of 3653 individuals were collected at deep and mid depth sites and LG2S in Lower Granite Reservoir (Tables 8-11). Species names and codes used in figures and tables throughout this report are presented in Table 12. Highest number of fishes were collected in the spring followed by summer, fall and winter. Approximately equal numbers of

Table 8. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Idaho-Washington in spring 1987.

Species	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S	TOTAL
American shad							
white sturgeon	1			3	2		6
sockeye salmon							
chinook salmon	4	3	7	11	11	61	97
rainbow trout	3	9	41	53	63	96	265
chiselmouth	2	3	16	6	11	87	125
carp	2	4	20	22	29	35	112
peamouth			2	1		4	7
northern squawfish	2	5	13	19	21	43	103
redside shiner	3	8	6	2	6	48	73
bridgelip sucker			3	7	7	40	57
largescale sucker	2	8	26	77	52	197	362
brown bullhead			1	1		1	3
channel catfish	1	4		18	3	2	28
pumpkinseed				1			1
black crappie					3	18	21
white crappie			1		2	2	5
smallmouth bass			1	2		35	38
yellow perch					21	43	64
TOTALS	20	44	137	223	231	712	1367

Table 9. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Idaho-Washington in summer 1987.

Species	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S	TOTAL
American shad							
white sturgeon	8	4		1		5	18
sockeye salmon							
chinook salmon	1					1	2
rainbow trout	16	21	47	22	19	10	135
chiselmouth	1		2		2	6	11
carp	10	10	10	16	17	134	197
peamouth			2		2	3	7
northern squawfish	1	5	6	13	16	6	47
redside shiner			1	1			2
bridgelip sucker		1					1
largescale sucker	7	58	38	87	124	192	506
brown bullhead	1	1	1				3
channel catfish			4	12	3		19
bluegill						1	1
pumpkinseed			1	1	3		5
black crappie			7		1	1	9
white crappie				1	2	2	1
smallmouth bass		1	1	3	13	58	76
yellow perch			40	5	29	13	87
TOTALS	45	101	160	162	231	432	1131

Table 10. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Idaho-Washington in fall 1987.

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

Table 11. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Idaho-Washington in winter 1987.

Species	LG1D	LG2D	LG1M	LG2M	LG3M	LG2S	TOTAL
American shad	1						1
white sturgeon		1					1
sockeye salmon							
chinook salmon			1				1
rainbow trout	9	3	6	12	3	4	37
chiselmouth	1	1	19	16	2	24	63
carp	4		4	7	7		22
peamouth			10	2	3		15
northern squawfish	5	1	1	3	2	4	16
redside shiner				1		3	4
bridgelip sucker						2	2
largescale sucker	1		1	2	2	11	17
brown bullhead							
channel catfish							
pumpkinseed							
black crappie			3		1		4
white crappie			7		9	6	22
smallmouth bass							
yellow perch			2	1	5	1	9
TOTALS	21	6	54	44	34	55	216

Table 12. Species codes, and scientific and common names for fish collected in Lower Granite Reservoir, Washington. Species codes are used in figures and tables throughout this report.

Codes	Scientific Name	Common Name
ATR	*Acipenser transmontanus*	white sturgeon
ASA	*Alosa sapidissima*	American shad
ONE	*Oncorhynchus nerka*	sockeye salmon
OTS	*Oncorhynchus tshawytscha*	chinook salmon
PWI	*Prosopium williamsoni*	mountain whitefish
SGA	*Salmo gairdneri*	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
INE	*Ictalurus nebulosus*	brown bullhead
IPU	*Ictalurus punctatus*	channel catfish
LGI	*Lepomis gibbosus*	pumpkinseed
LMA	*Lepomis macrochirus*	bluegill
MDO	*Micropterus dolomieui*	smallmouth bass
PAN	*Pomoxis annularis*	white crappie
PNI	*Pomoxis nigromaculatus*	black crappie
PFL	*Perca flavescens*	yellow perch
COT	*Cottus* sp.	sculpin

species were collected at mid depth sites and LG2S but consistently deep stations.

Relative Abundance

During the spring, rainbow trout were high in abundance while fewer chinook salmon were collected at all stations except LG1D (Figure 17). At shiner, northern squawfish, carp and largescale sucker. Largescale suckers and rainbow trout dominated the catch at all mid depth stations. Highest species diversity in the spring was at station LG2S, possibly reflecting additional beach seining and electrofishing efforts.

In the summer, species diversity decreased and certain species dominated the catch (Figure 18). At deep and mid depth stations, largescale suckers and rainbow trout generally were highest in relative abundance. Yellow perch were abundant at LG1M and LG3M. Largescale suckers and carp attained highest relative abundance at LG2S in the summer. White sturgeon was third highest in relative abundance at LG1D, and present but less abundant at LG2D and LG2S.

During the fall, species diversity was highest of all seasons, with largescale suckers and rainbow trout dominating at most stations (Figure 19). Relative abundance of carp and northern squawfish increased at deep and mid depth stations, while relative abundance of game fishes (yellow perch and crappies) increased at mid depth stations.

In winter, rainbow trout dominated the catch with chiselmouth, while the relative abundance of largescale suckers decreased (Figure 20). Northern squawfish were common at both deep stations although few fish were

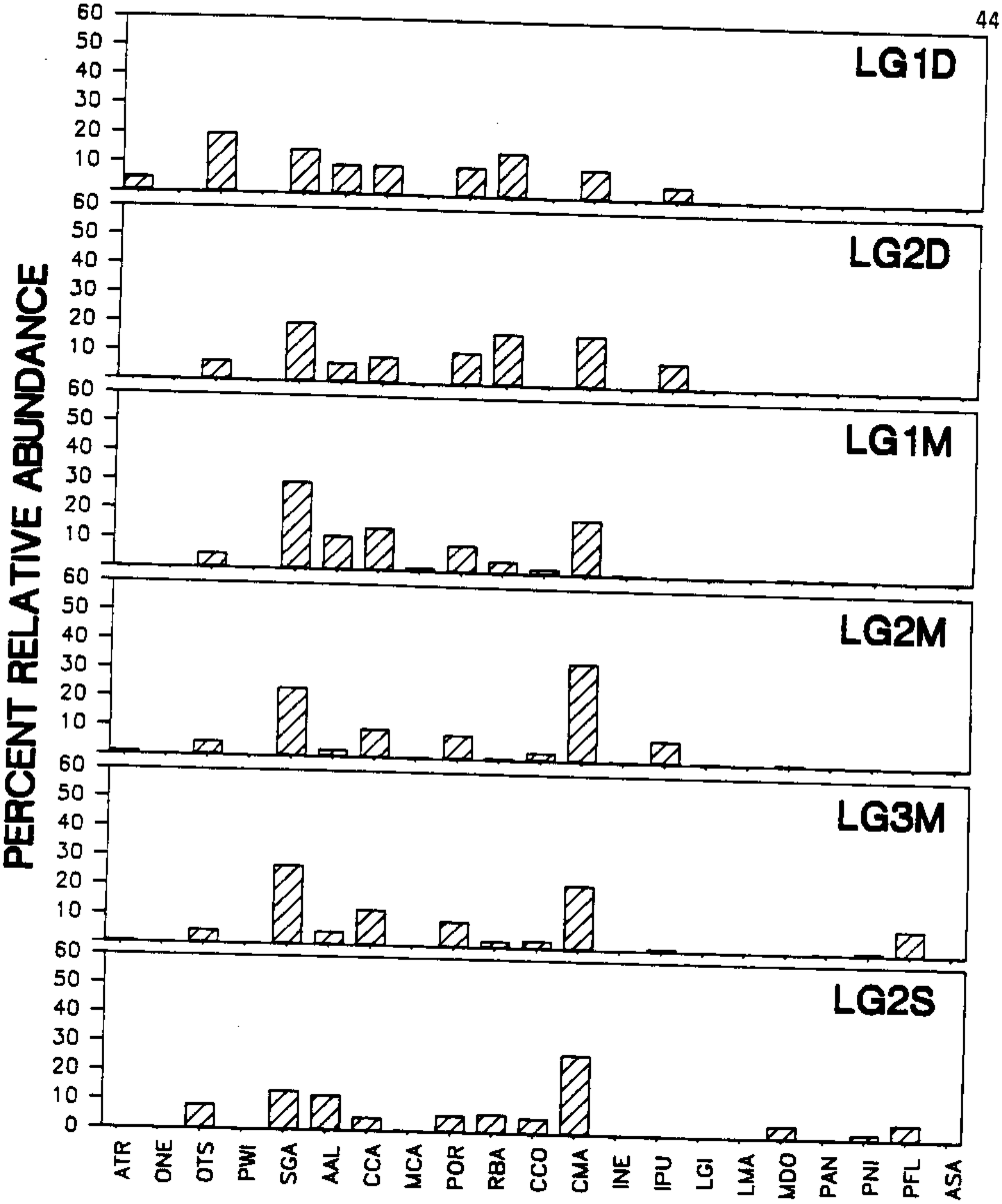

Figure 17. Relative abundance (%) of fishes based on sampling April through June, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

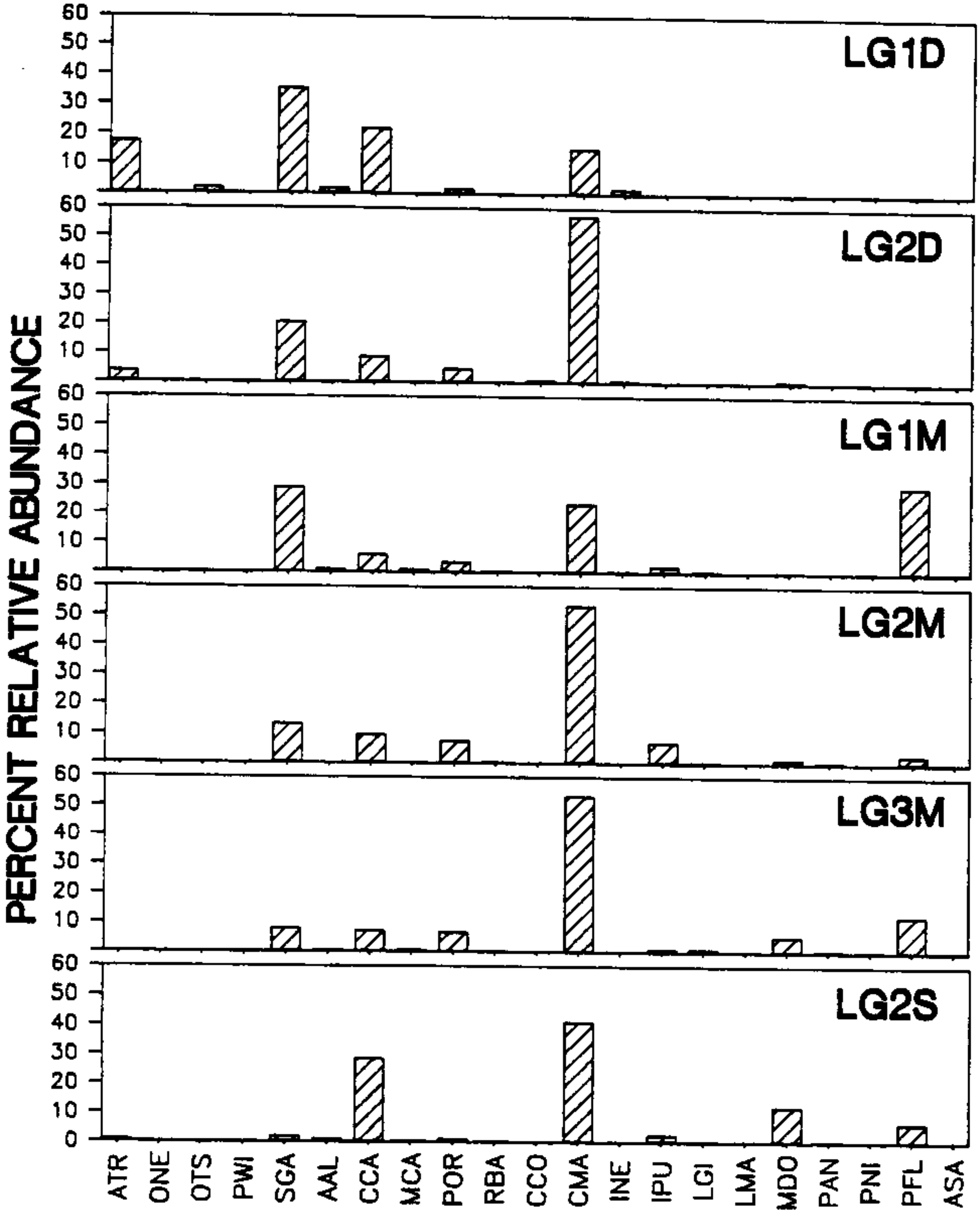

Figure 18. Relative abundance (%) of fishes based on sampling August through September, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

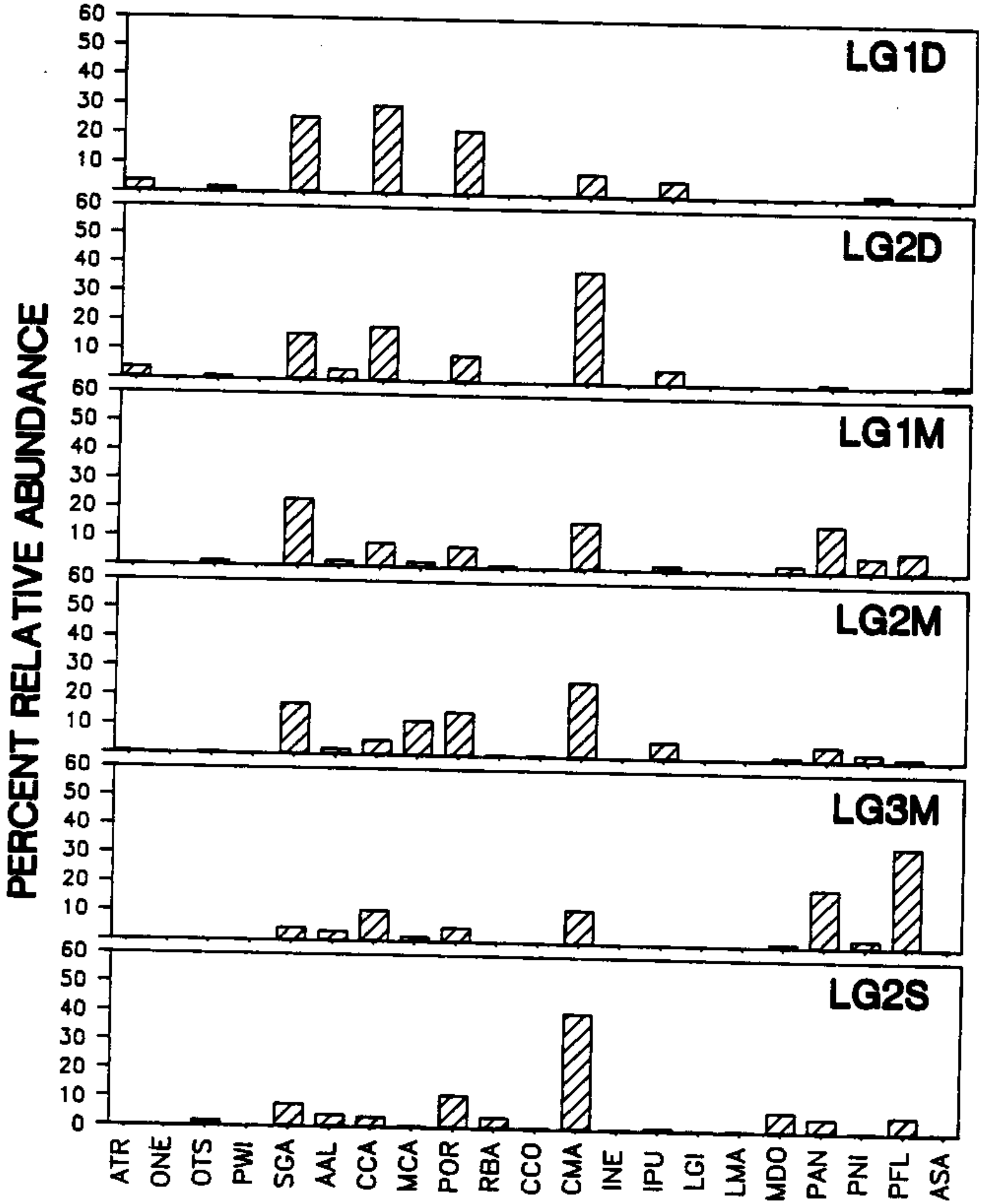

Figure 19. Relative abundance (%) of fishes based on sampling October through November 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

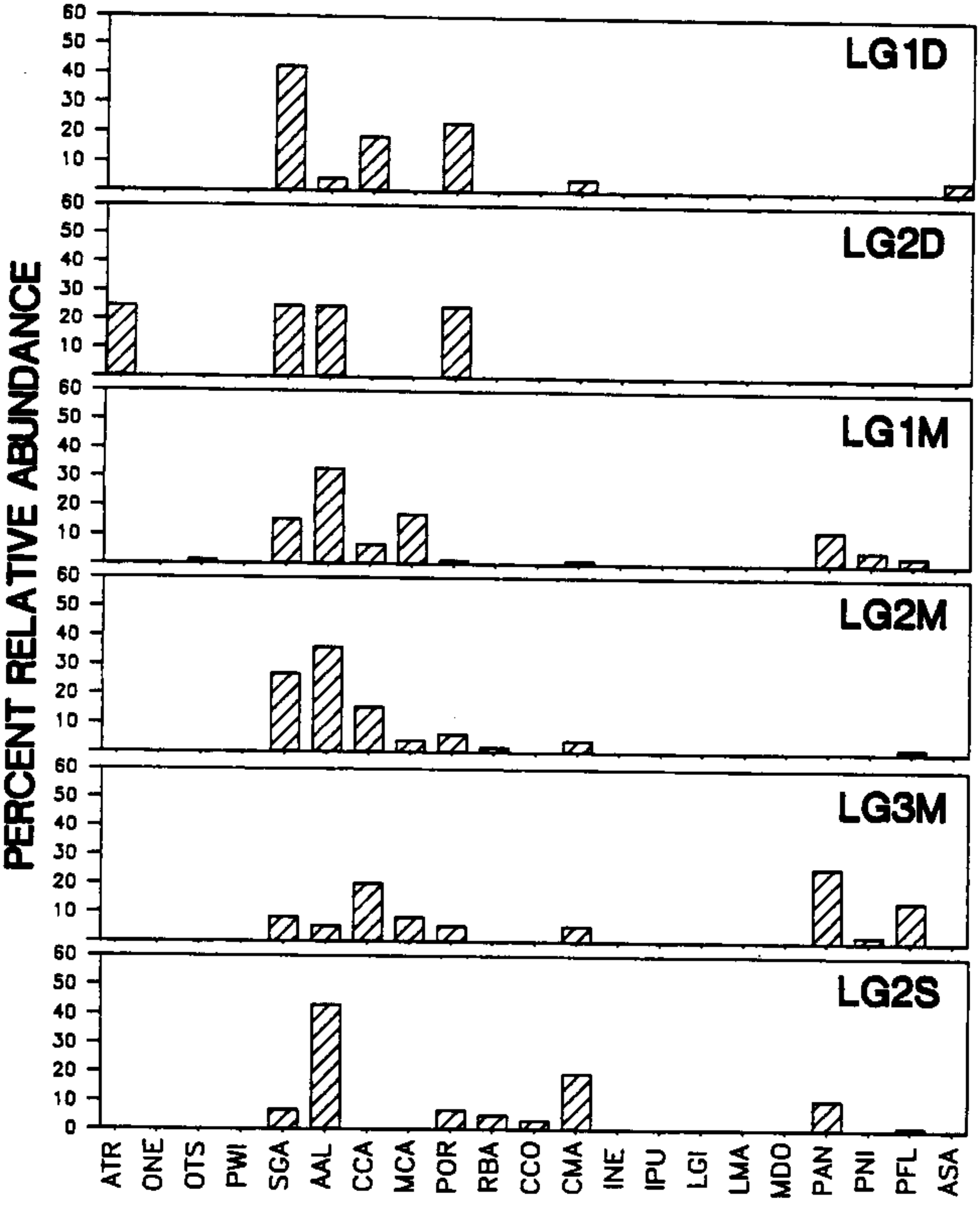

Figure 20. Relative abundance (%) of fishes based on sampling December, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

caught in winter at the deep stations, so high relative abundances may be deceptive.

Biomass

Largescale suckers dominated the biomass collected during the spring, summer, fall, and winter at all stations (Figures 21-24). Highest sucker biomass was collected at LG2S in all seasons. Sucker biomass peaked in the summer and was lowest in the winter.

Seasonal comparisons indicated that the highest biomass was collected in the spring at LG1M and at LG2S in the summer, whereas during the fall, biomass was similar among stations (Figure 25). Fish biomass captured during the winter was less than 10% of that collected during the spring. The majority of biomass was that of nongame fish (Figure 26).

Size Comparison

Sizes of fish collected ranged from less than 25 mm to over 800 mm (Figures 27-30). During the spring, sizes of fish sampled at mid depth stations were similar to, but generally larger than those collected at LG2S. Large numbers of small fish at LG2S reflects relatively intense spring beach seining and electrofishing efforts. Sizes were similar in the summer at deep and mid depth stations but shifted to larger sizes at LG2S. During fall and winter, size distributions were generally similar among stations and similar to those observed during the summer.

Catch Per Effort Abundance

Spring.-Fish abundance, based on gillnet catches at all 6 stations, exhibited differences among seasons, stations, sampling depth, and diel

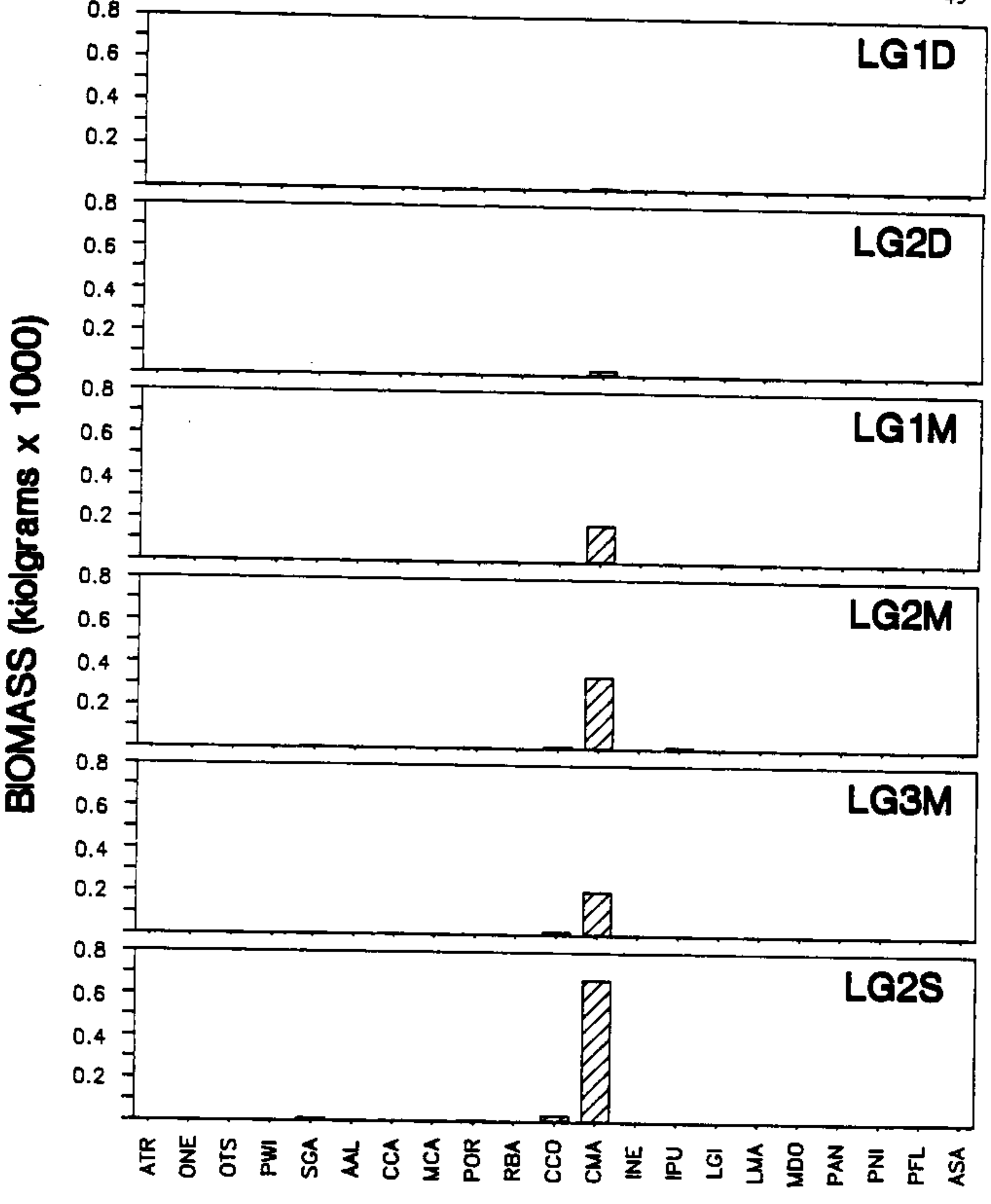

Figure 21. Biomass (kg) of fish sampled April through June, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

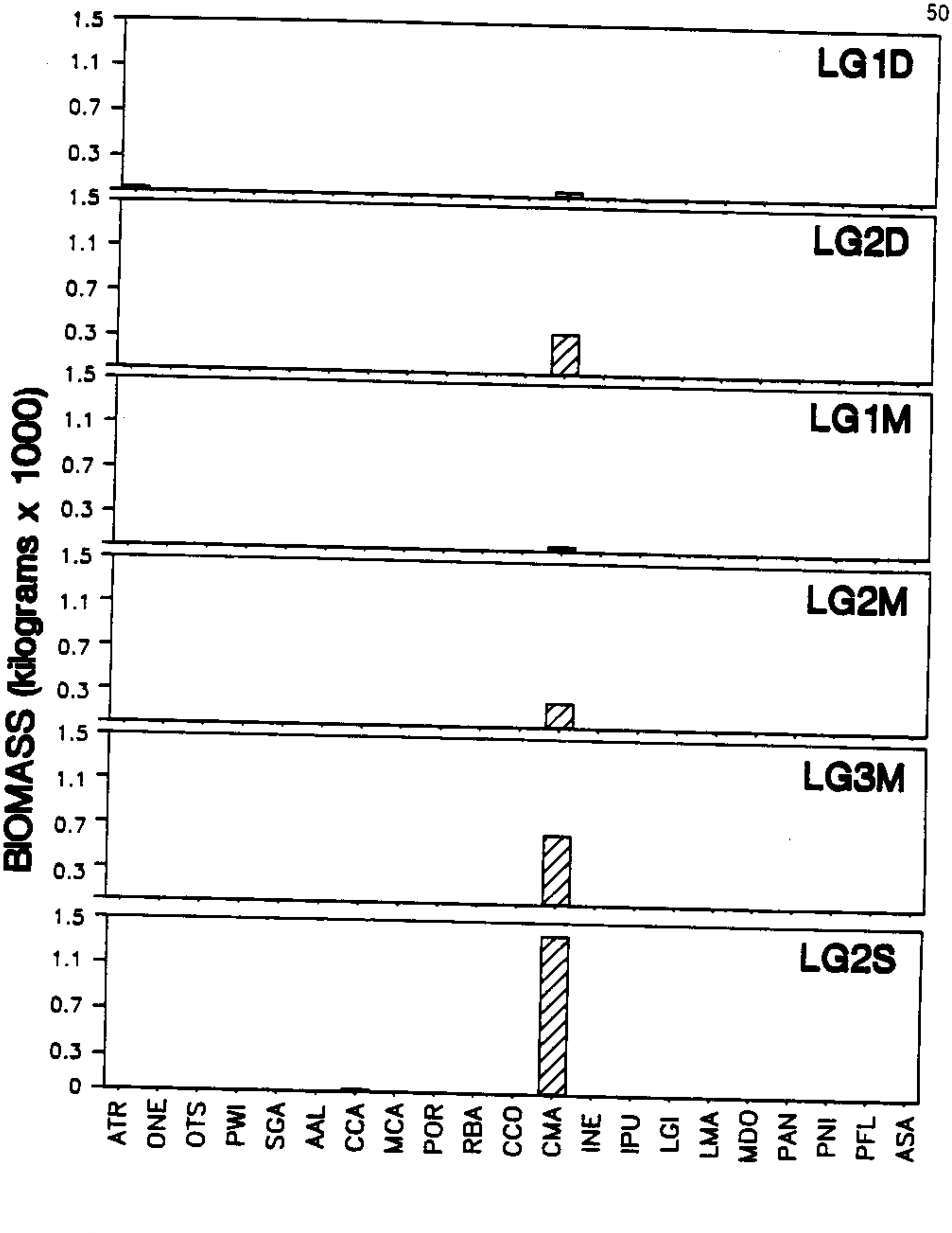

Figure 22. Biomass (kg) of fish sampled August through September, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

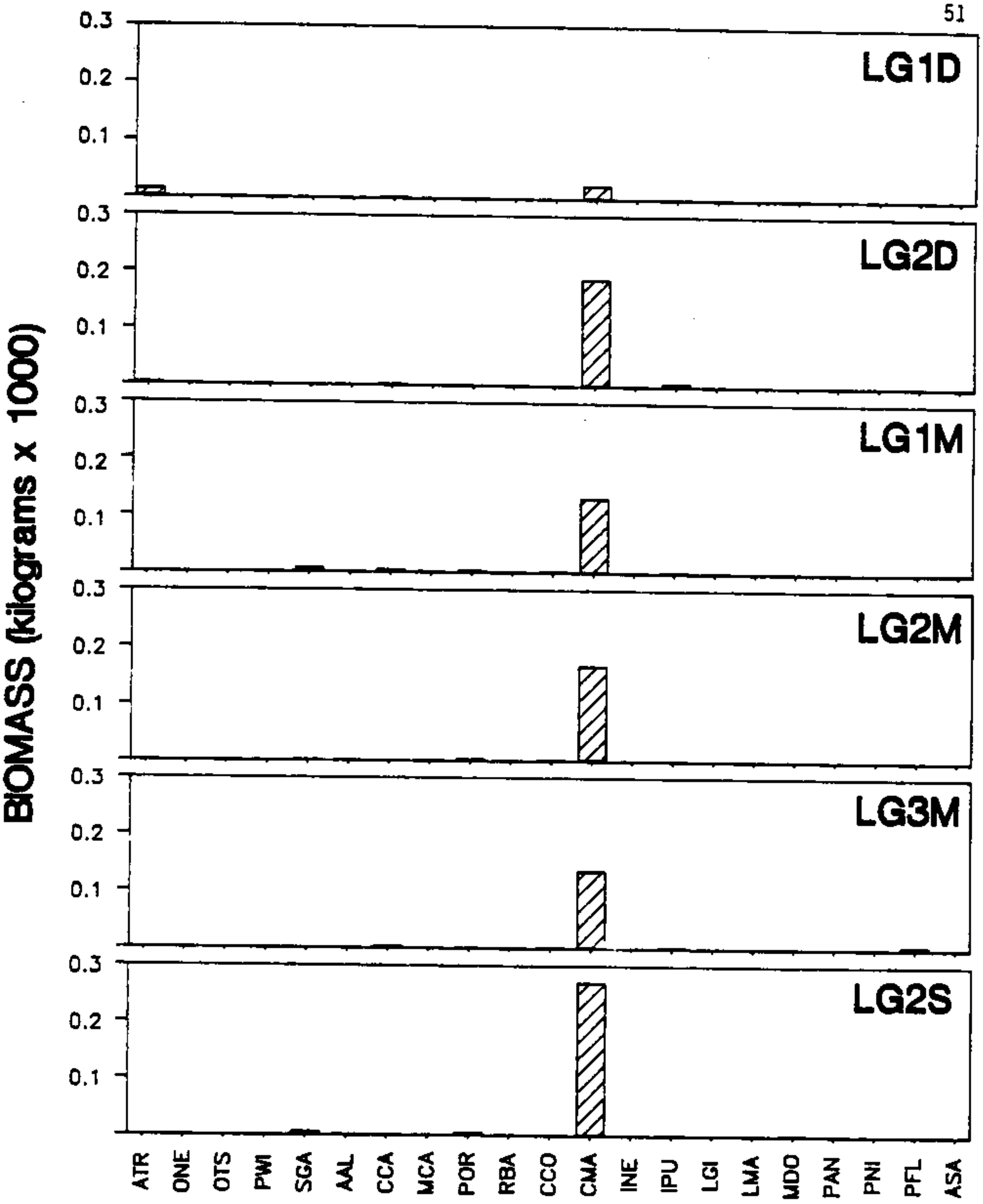

Figure 23. Biomass (kg) of fish sampled October through November, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

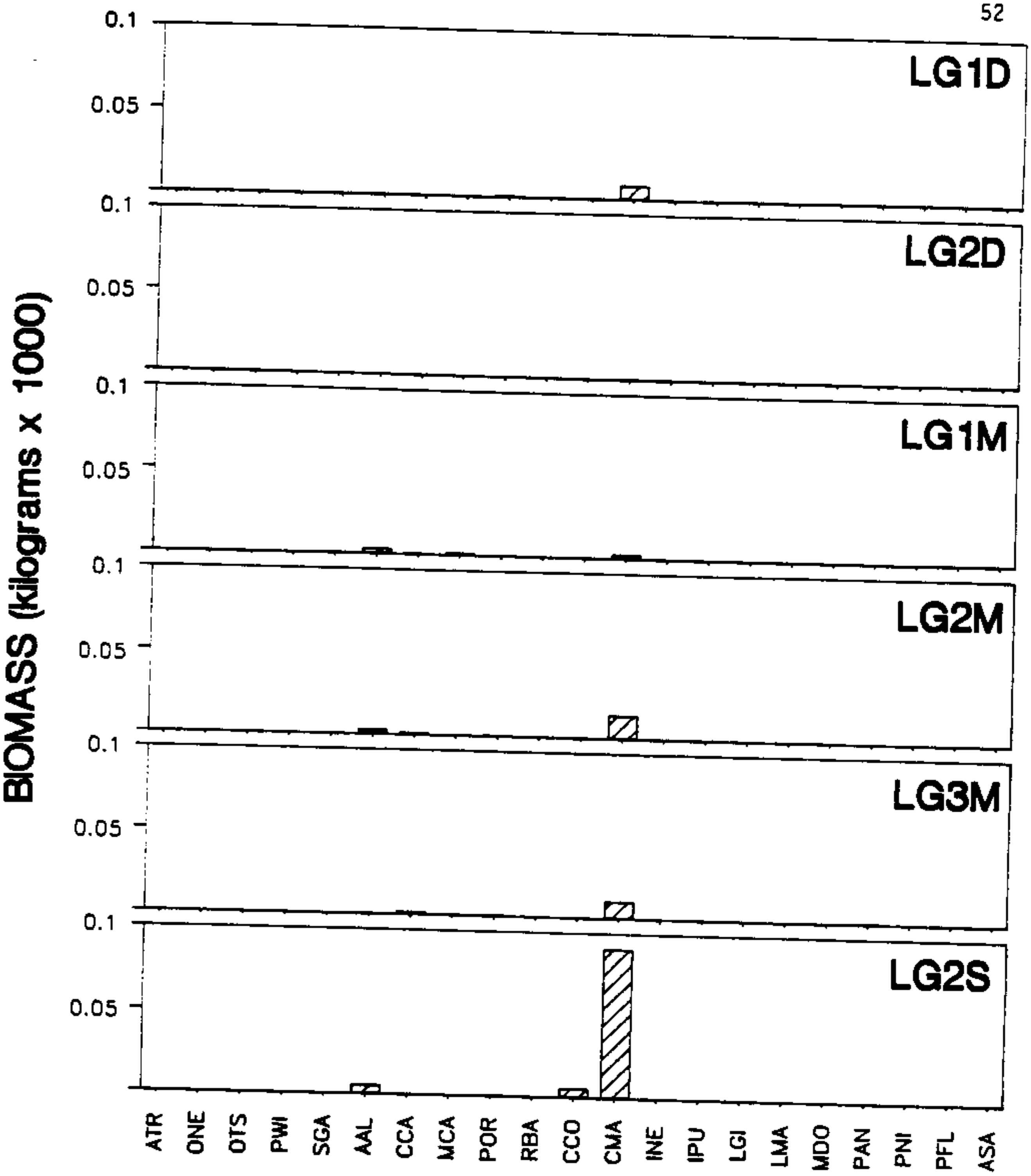

Figure 24. Biomass (kg) of fish sampled December, 1987 in Lower Granite Reservoir, Washington. See Table 12 for species codes. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

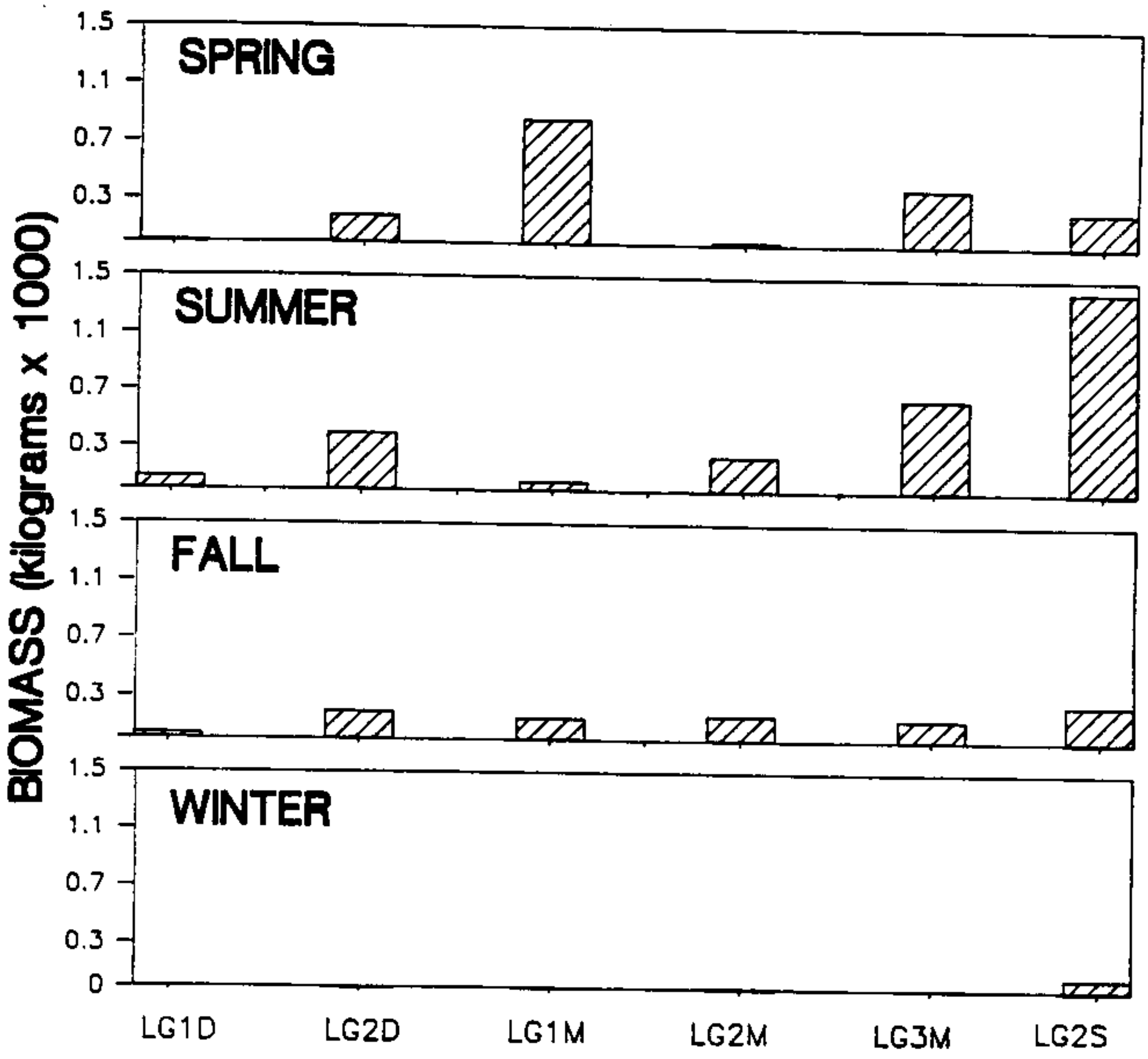

Figure 25. Summary of fish biomass (kg) collected by station and season from Lower Granite Reservoir, Washington, 1987. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

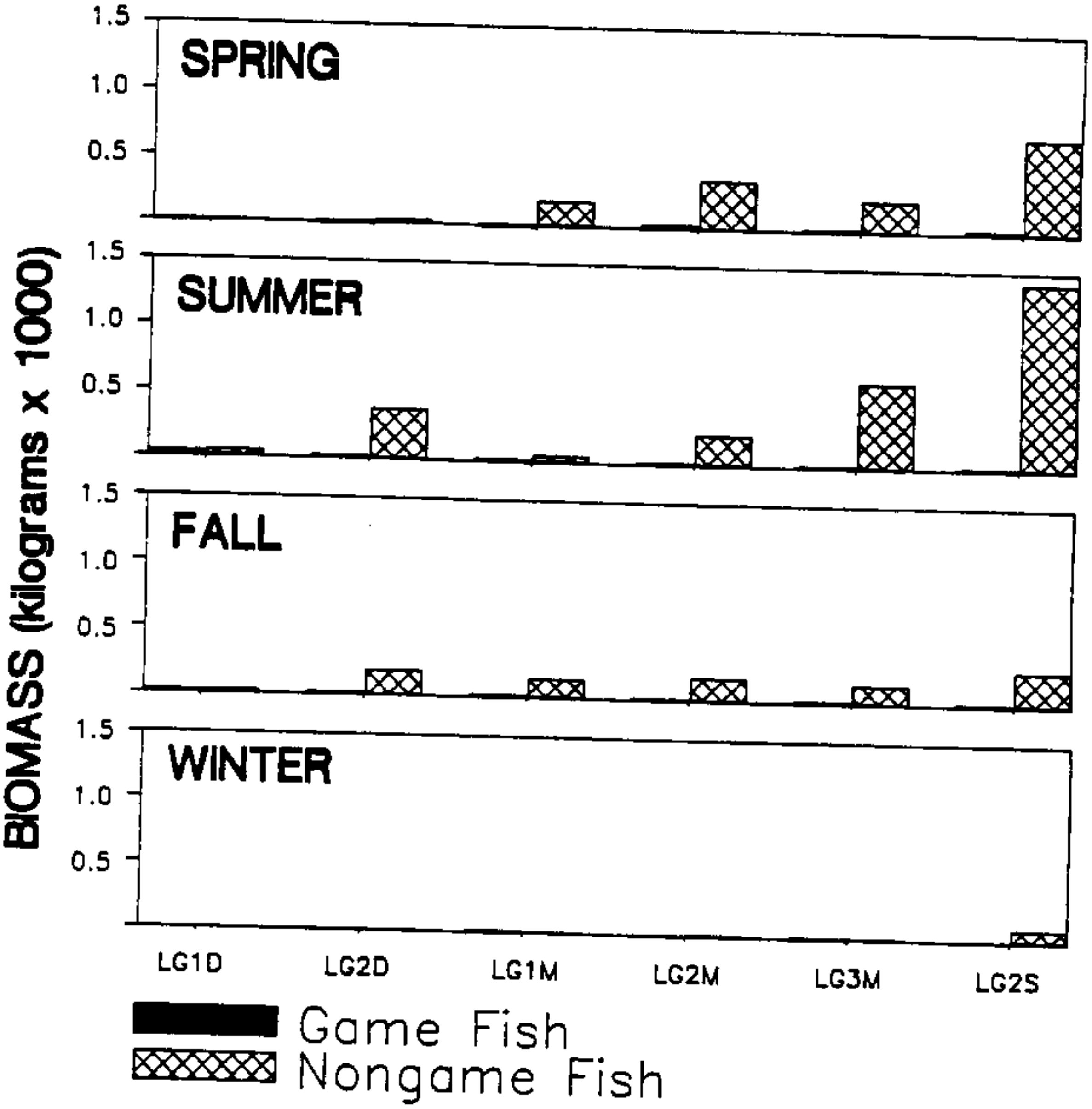

Figure 26. Comparison of game versus nongame fish biomass collected from various stations and seasons in Lower Granite Reservoir, Washington, 1987. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

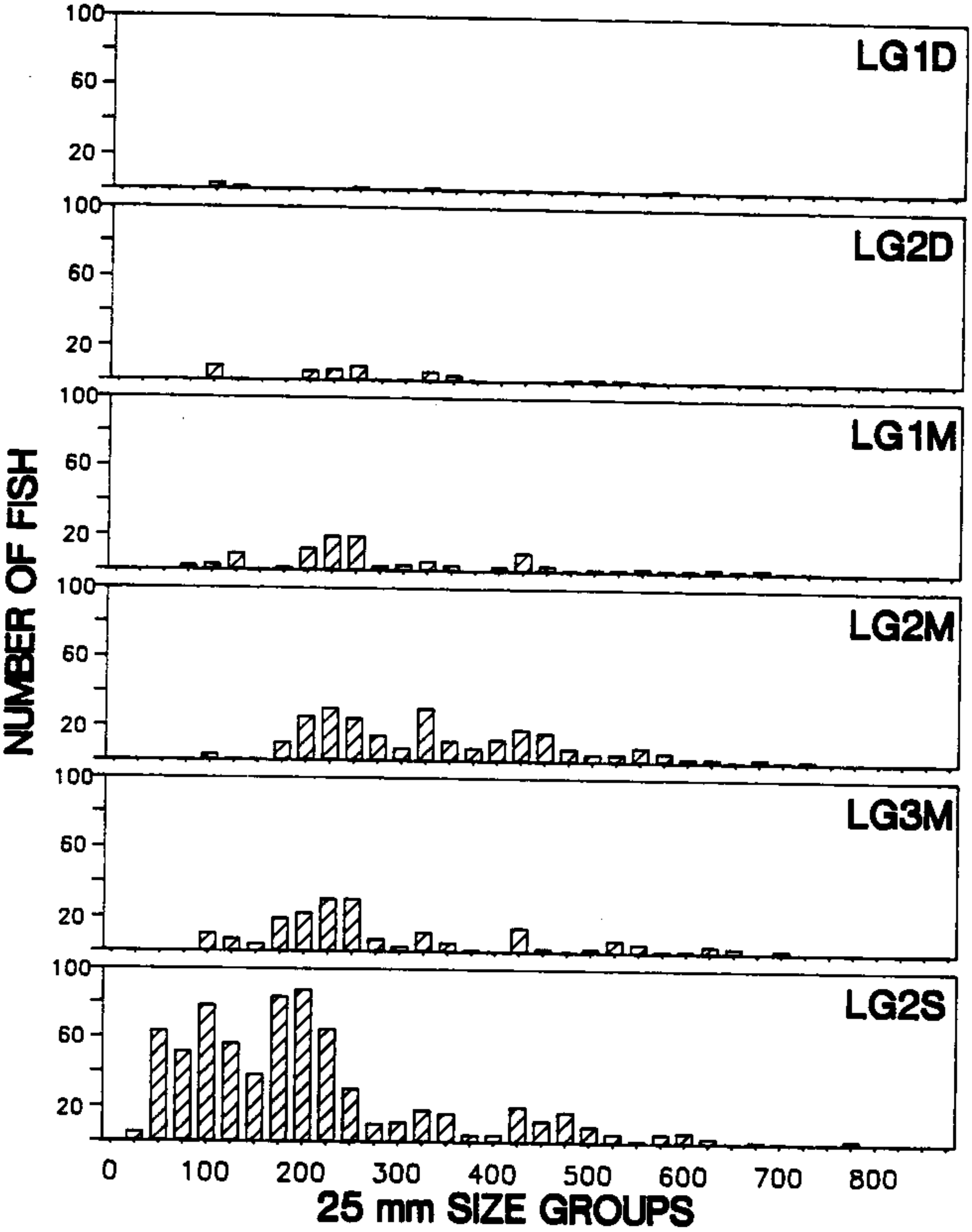

Figure 27. Length frequency distributions of all fishes collected from various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

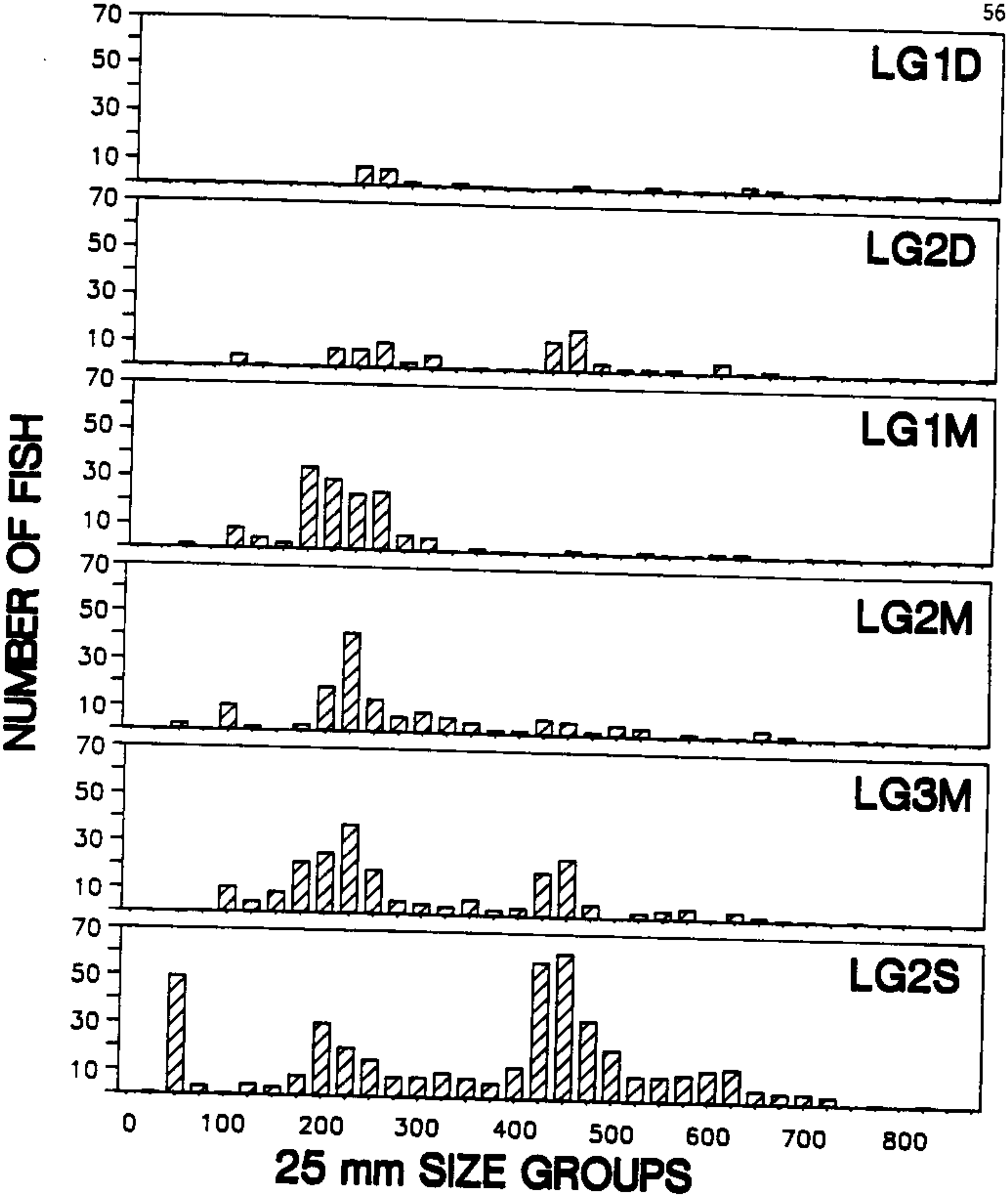

Figure 28. Length frequency distributions of all fishes collected from various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

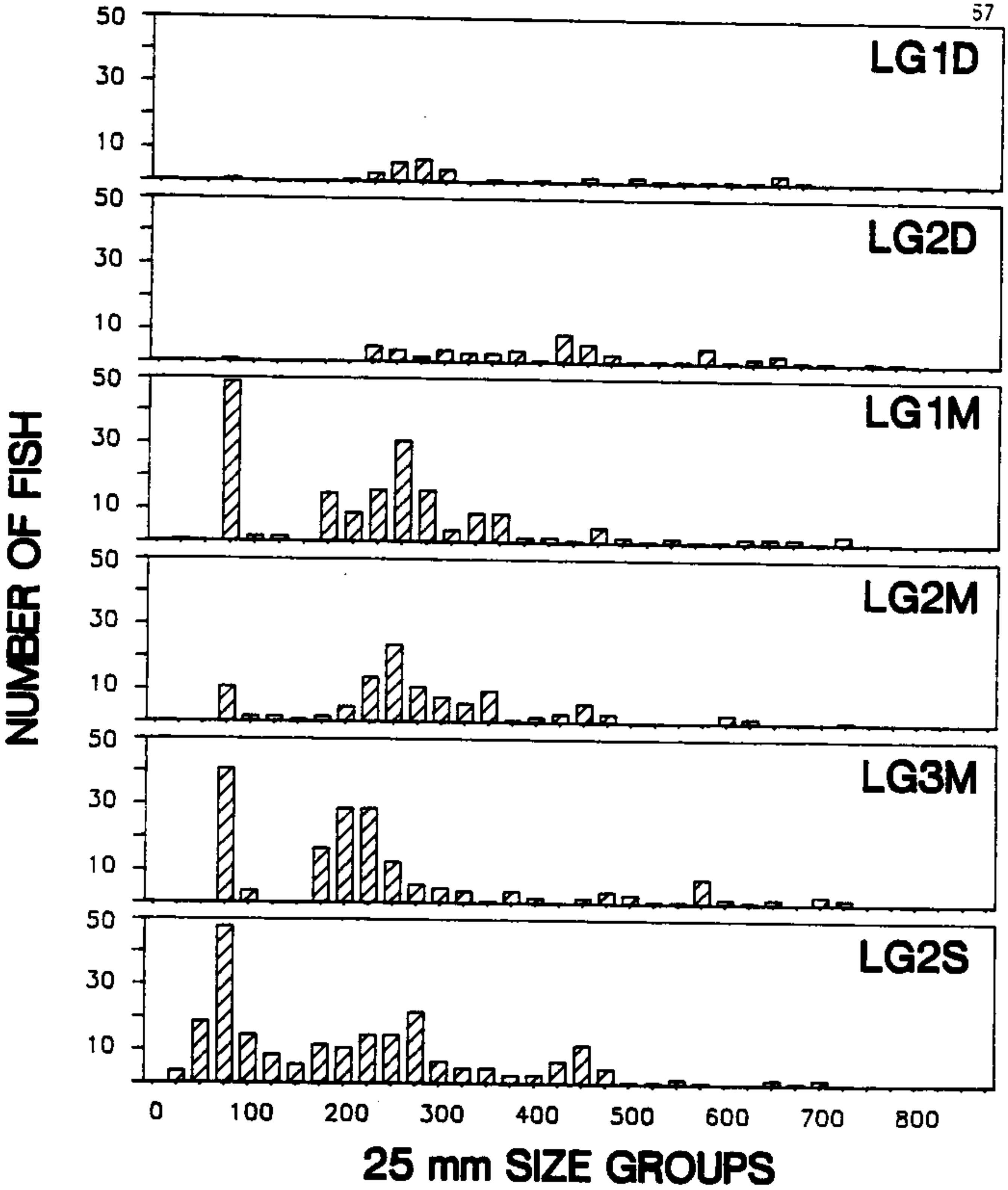

Figure 29. Length frequency distributions of all fishes collected from various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

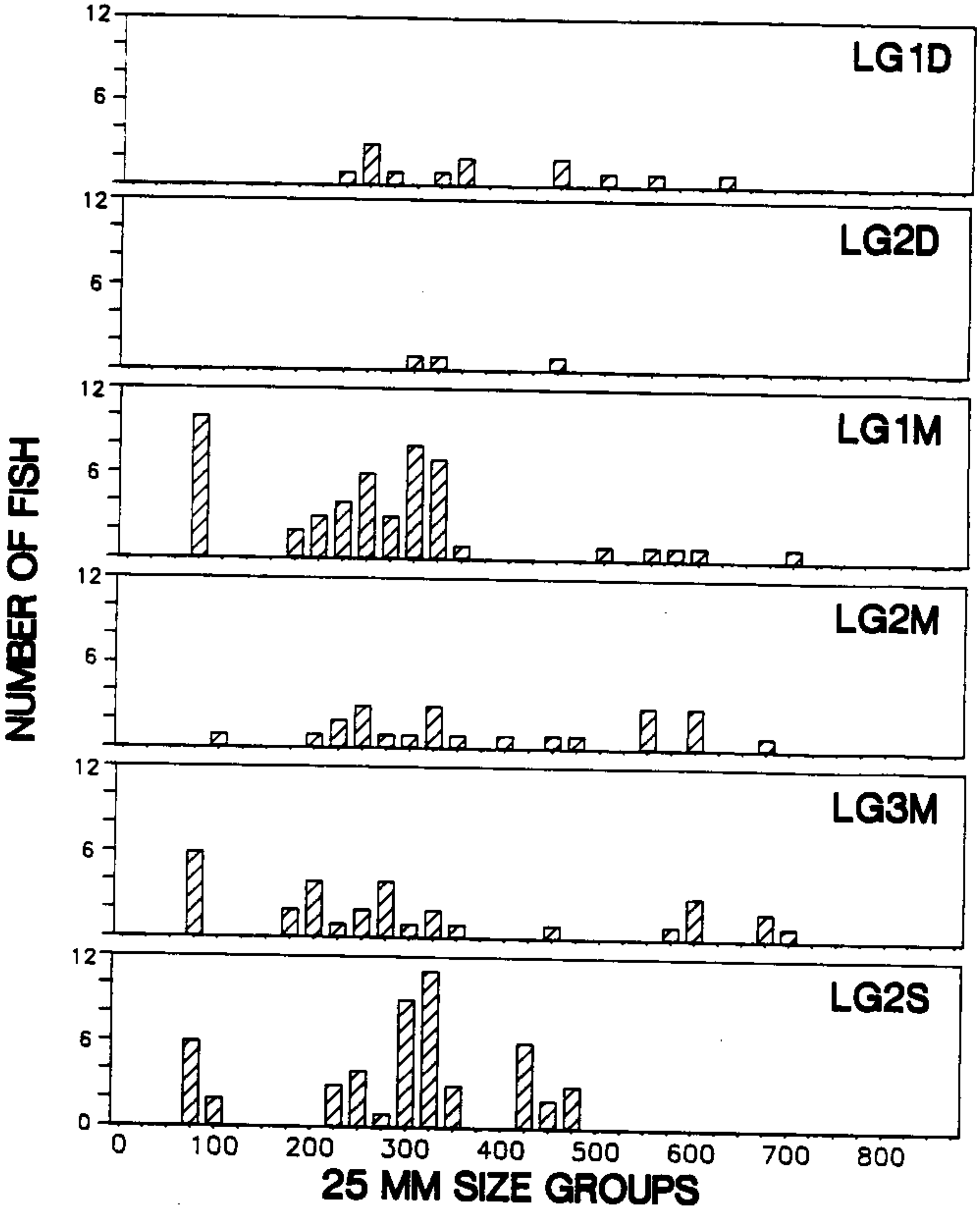

Figure 30. Length frequency distributions of all fishes collected from various sampling stations in Lower Granite Reservoir, Washington during December, 1987. Gillnets were used at all stations; beach seining and electrofishing were also used at LG2S.

sampling periods. Tables summarizing daily catch rates (catch/hour) from gillnets for each species by gillnet set types (bottom, mid water, and floating) and season are presented in Appendix B. Springtime CPUE's (catch per hour) were highest in daytime bottom sets, whereas nighttime mid water and floating sets generally produced higher CPUE's than daytime sets (Figures 31-36). Rainbow trout catch rates were consistently high in nighttime, floating sets at all sites (Figure 32). No mid water sets were made at LG2S because of its shallow (< 6 m) depth.

Few non-salmonid game fish were captured at any sites in spring. Chiselmouth, carp, largescale suckers, and redside shiners were non-game species captured most frequently at all stations. Chiselmouth were captured both day (mid depth and LG2S) and night (all sites), most frequently in floating followed by mid water sets. Few were captured in bottom sets at any station. In contrast, carp were caught most frequently in bottom and mid water sets at all stations; none were caught in floating sets at deep or mid depth sites, excepting LG3M where large numbers were caught in the day (Figure 31). Redside shiners, like chiselmouth, were most commonly captured in floating sets (especially at night at LG2S; Figure 32) and were seldomly captured at mid depth sites. Largescale suckers were captured in all types of net sets at all stations. Largescale sucker abundance was highest during daytime hours at the mid depth stations, where they were captured most frequently in bottom sets. Large numbers were captured at LG2S in floating sets (Figure 31).

Summer.-During summer, catches in floating nets were dominated by rainbow trout captured at night at deep and mid depth stations (Figures 37 and 38). Few rainbow trout were captured at LG2S, where floating sets were

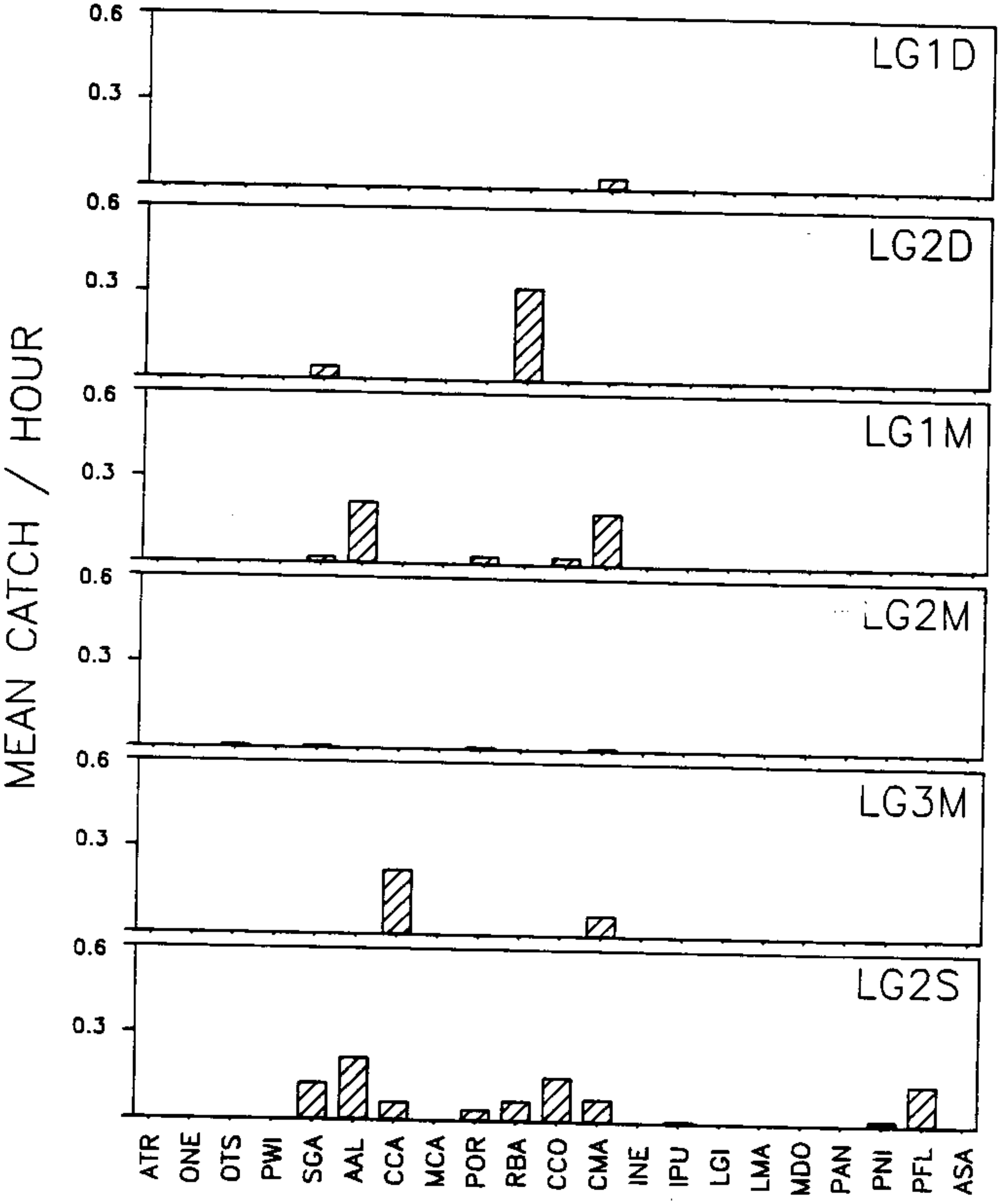

Figure 31. Mean catch per hour by species for floating gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. See Table 12 for species codes.

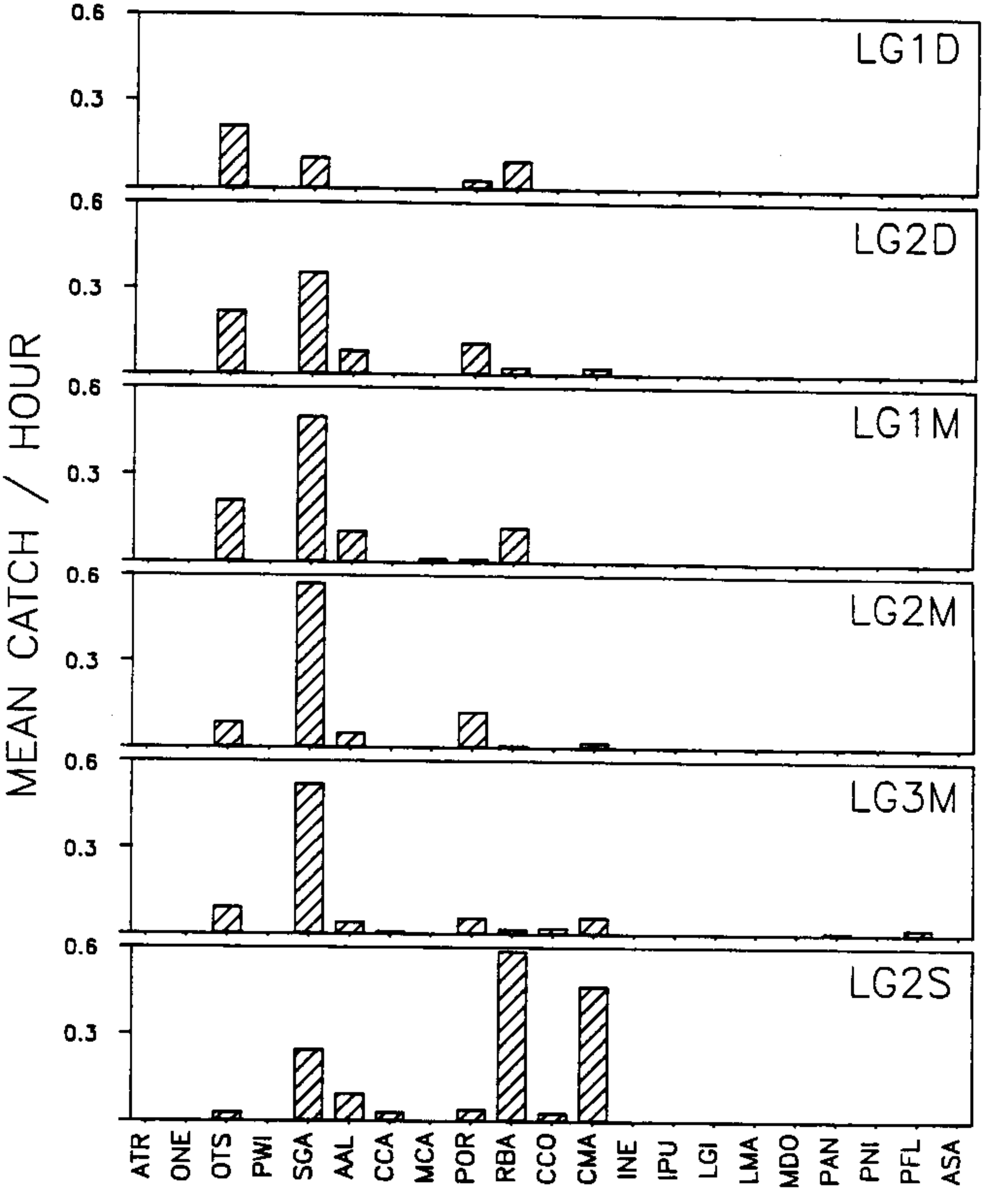

Figure 32. Mean catch per hour by species for floating gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. See Table 12 for species codes.

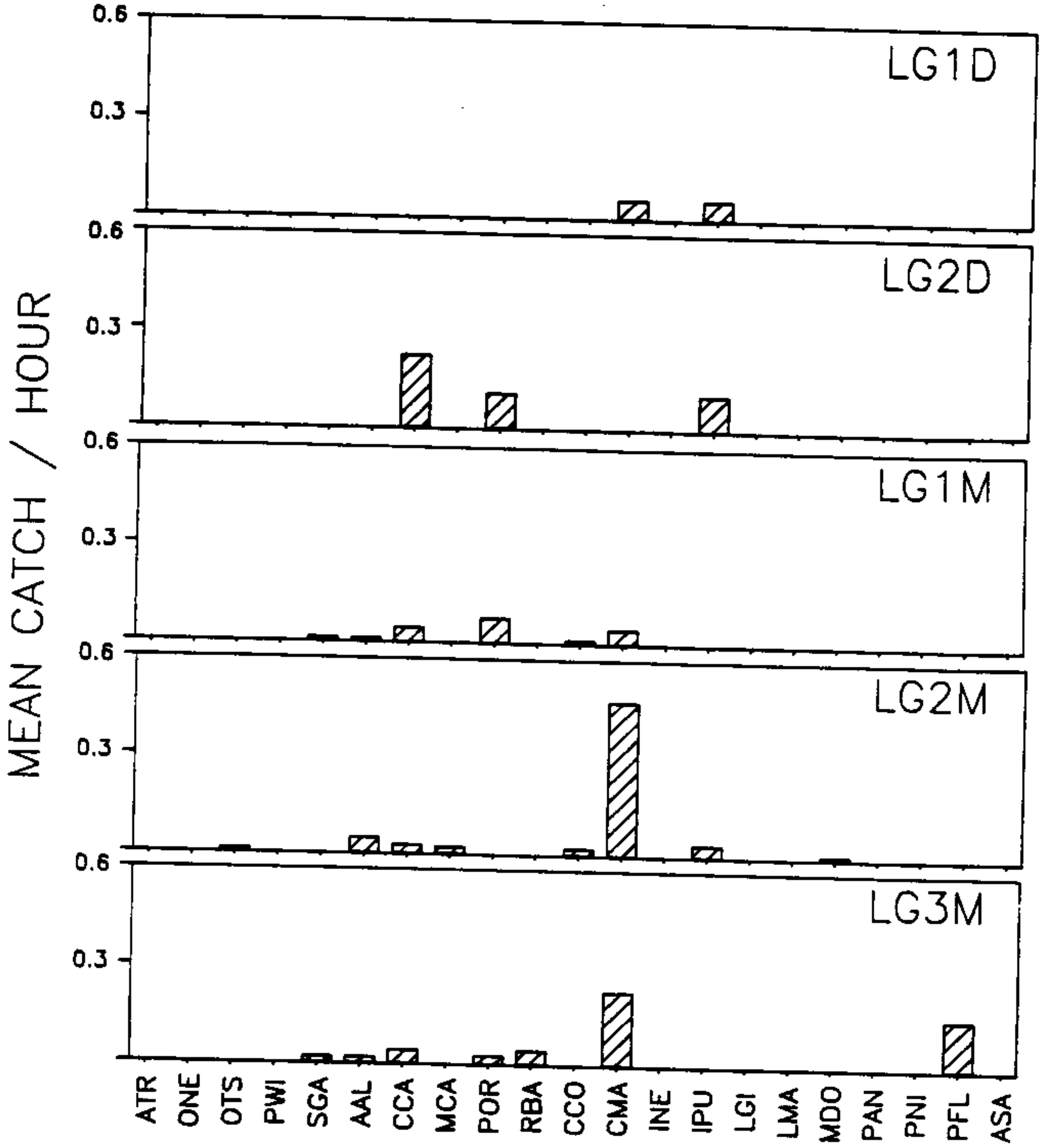

Figure 33. Mean catch per hour by species for mid water gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

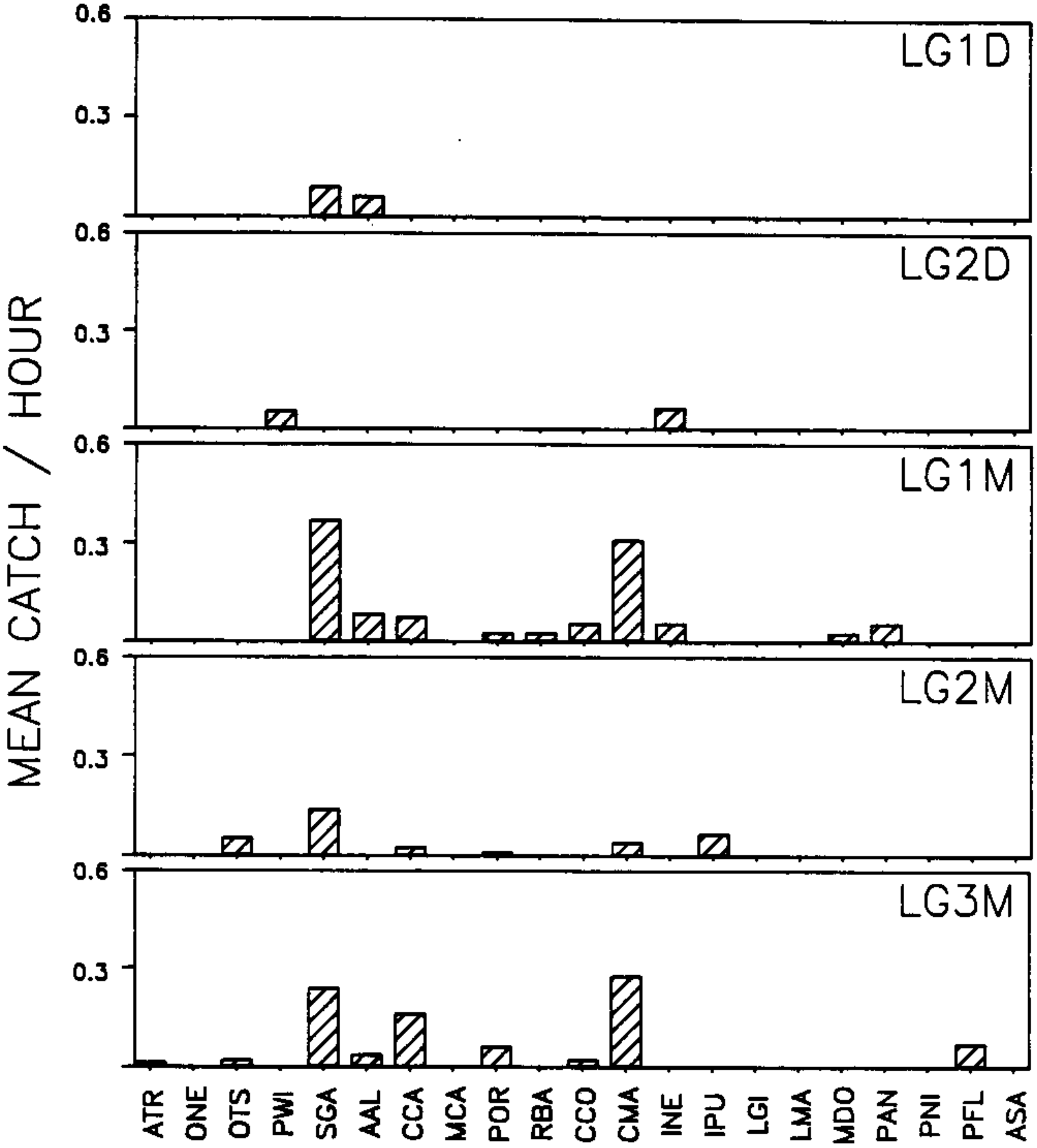

Figure 34. Mean catch per hour by species for mid-water gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

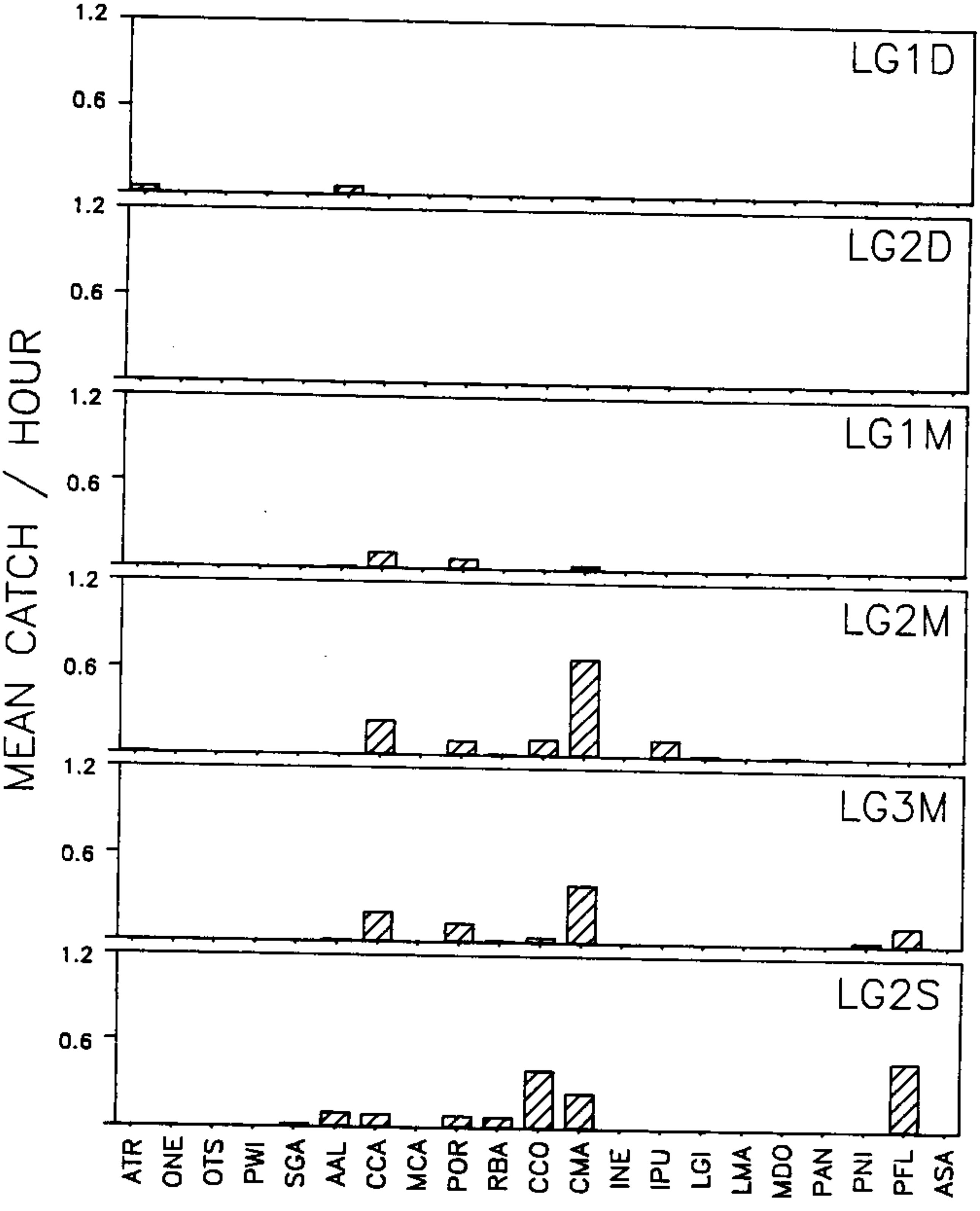

Figure 35. Mean catch per hour by species for bottom gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. See Table 12 for species codes.

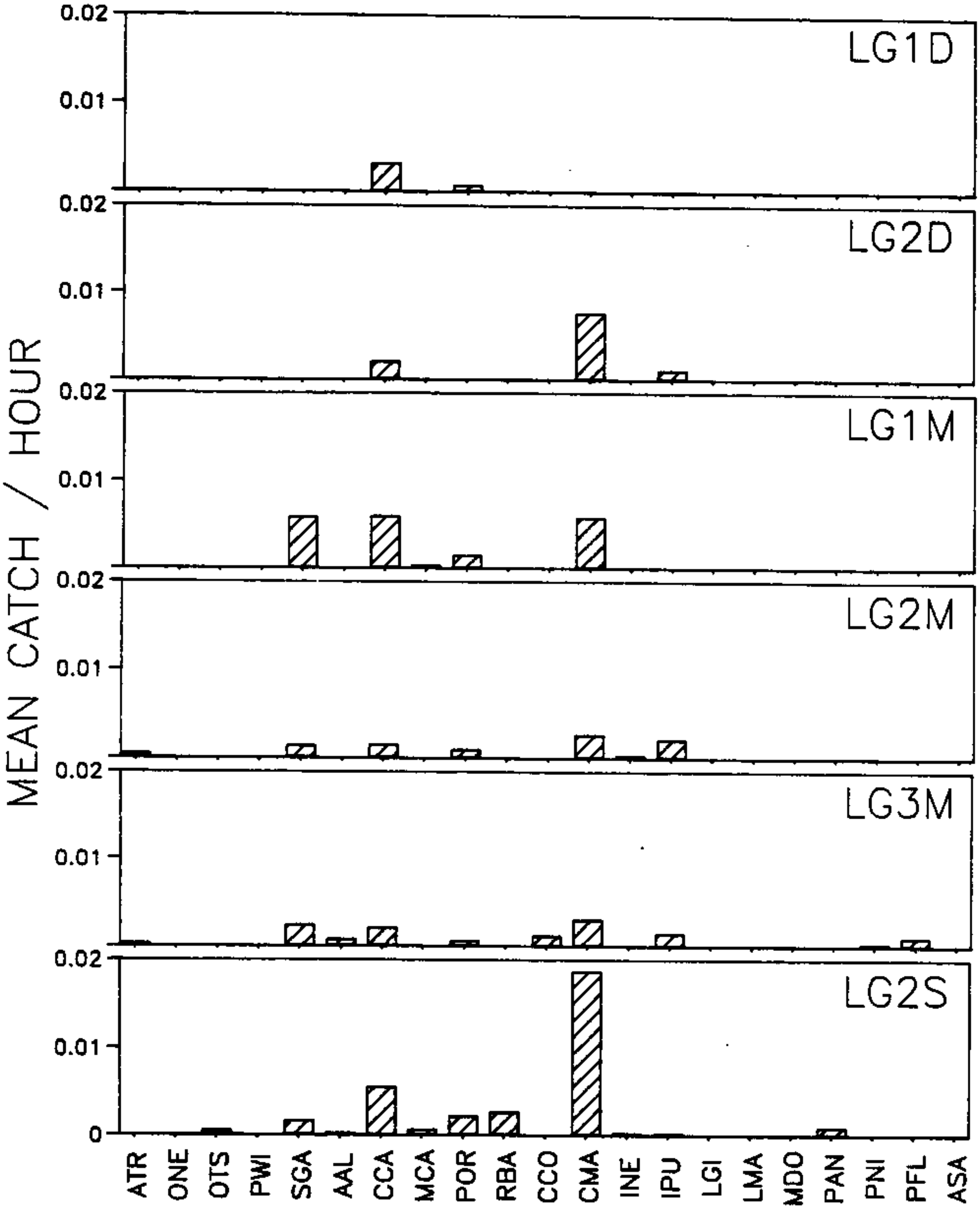

Figure 36. Mean catch per hour by species for bottom gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during April through June, 1987. See Table 12 for species codes.

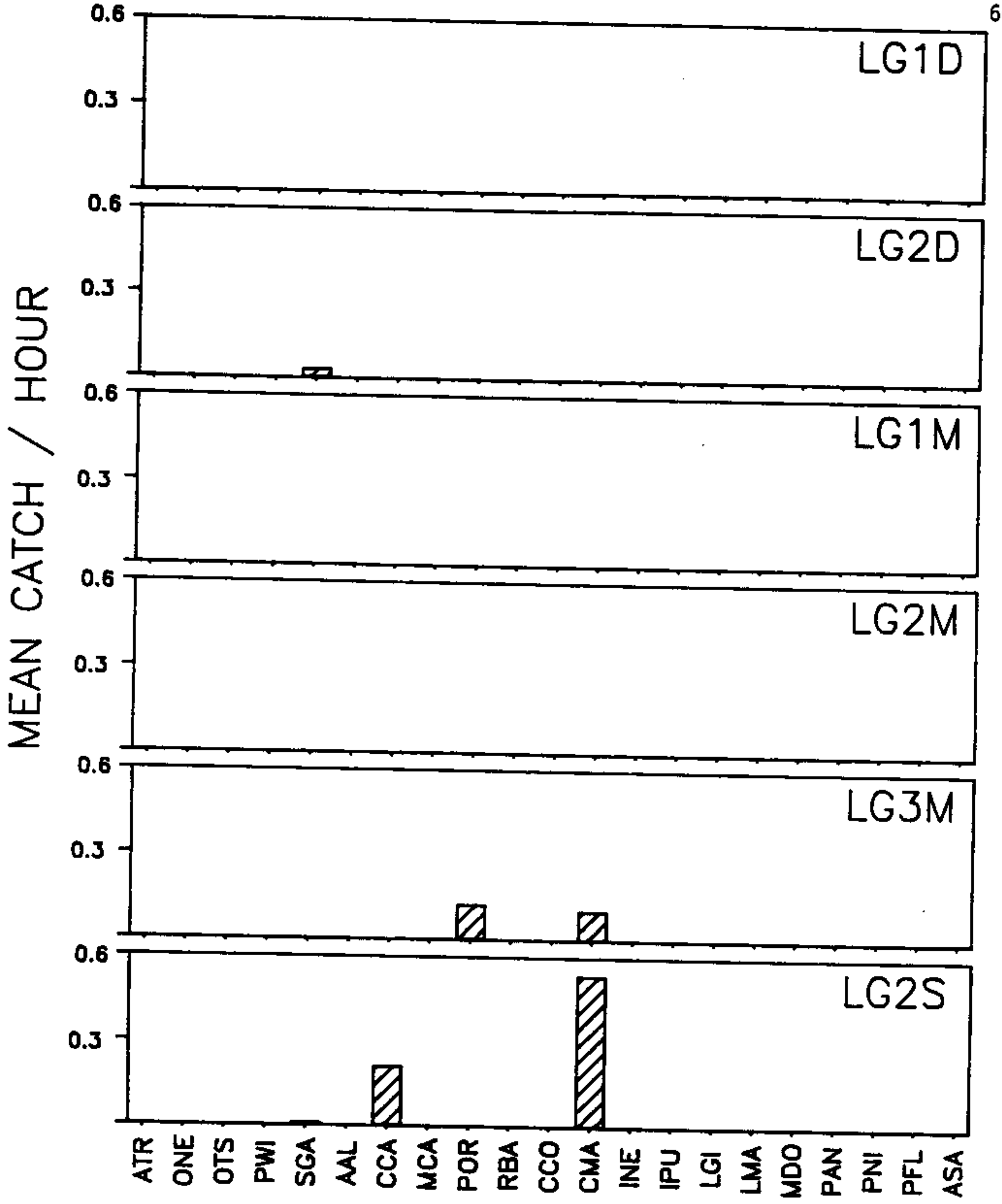

Figure 37. Mean catch per hour by species for floating gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. See Table 12 for species codes.

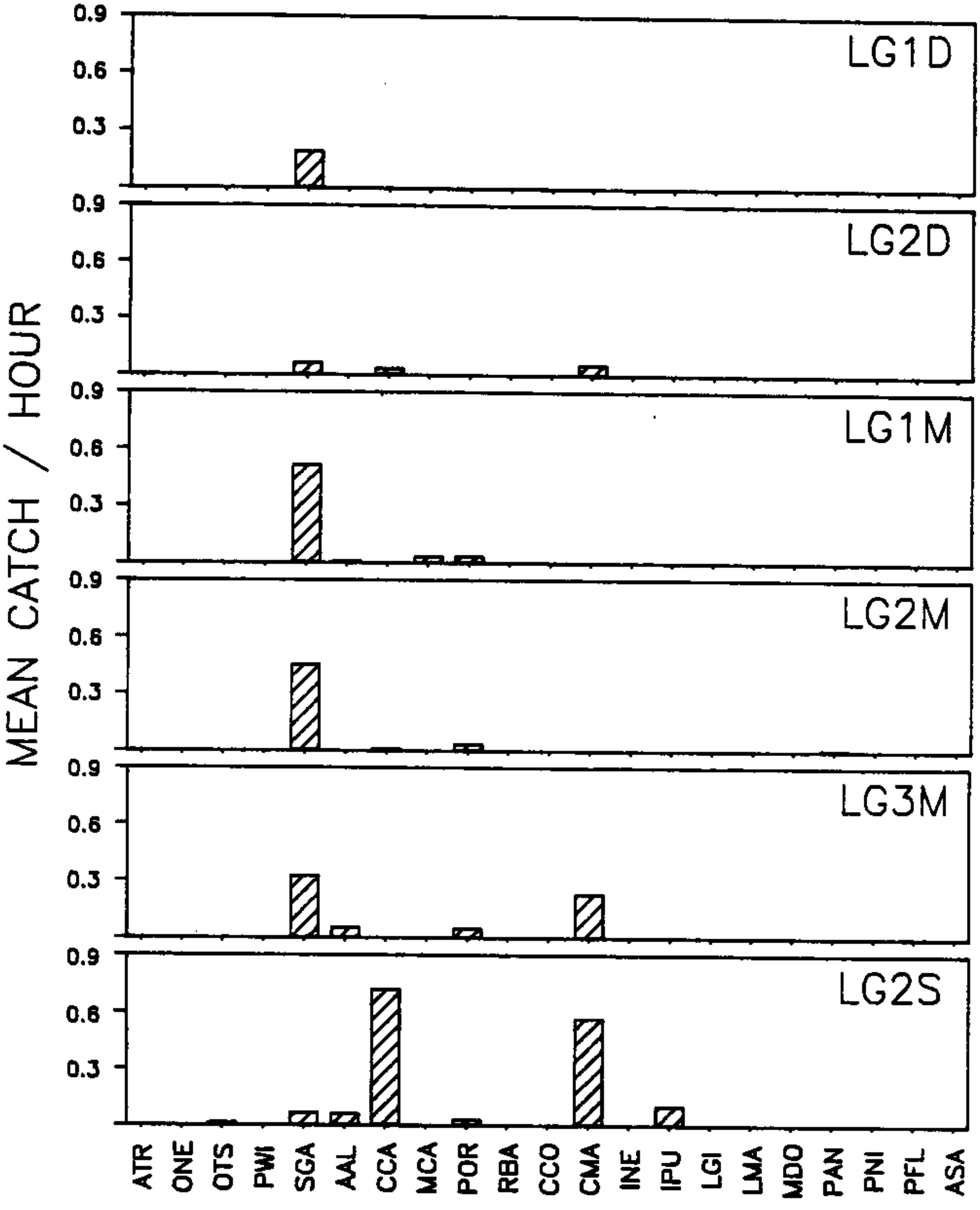

Figure 38. Mean catch per hour by species for floating gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. See Table 12 for species codes.

dominated by carp and largescale suckers, with carp catch rates increasing nearly 3 times from day to night and largescale sucker catch rates staying nearly constant (Figures 37 and 38).

As with floating sets, catch rates in mid water sets at deep stations were low for all species, except during the night for rainbow trout (Figures 39 and 40). Rainbow trout also dominated nighttime, mid water catch rates while largescale suckers dominated daytime catches at mid depth sites. LG3M produced relatively large numbers of yellow perch in daytime mid water sets (Figure 39).

Stations had markedly similar catch rates and species composition in both day and night bottom sets, excepting LG1D which produced few fish (Figures 41 and 42). Largescale suckers clearly dominated catches at all other sites both day and night, followed by yellow perch which occurred in high numbers except at LG2D and LG2M.

Fall.-Catch rates during fall sampling were generally lower than those from summer. Nighttime catch rates were generally higher than during the day in floating and mid water sets (Figures 43-46). Daytime, floating sets caught few fish, although large numbers of rainbow trout were caught at LG1M (Figure 43). Dominant species in nighttime, floating sets were rainbow trout and northern squawfish at all stations (Figure 44). Rainbow trout dominated nighttime, mid water sets as well, along with peamouth and northern squawfish (Figure 46).

Bottom sets during the day generally yielded more fish than night sets (Figure 47), with largescale suckers and carp accounting for most deep station fish, and largescale suckers, yellow perch, and centrarchids dominating catches from mid depth stations. Carp were caught more

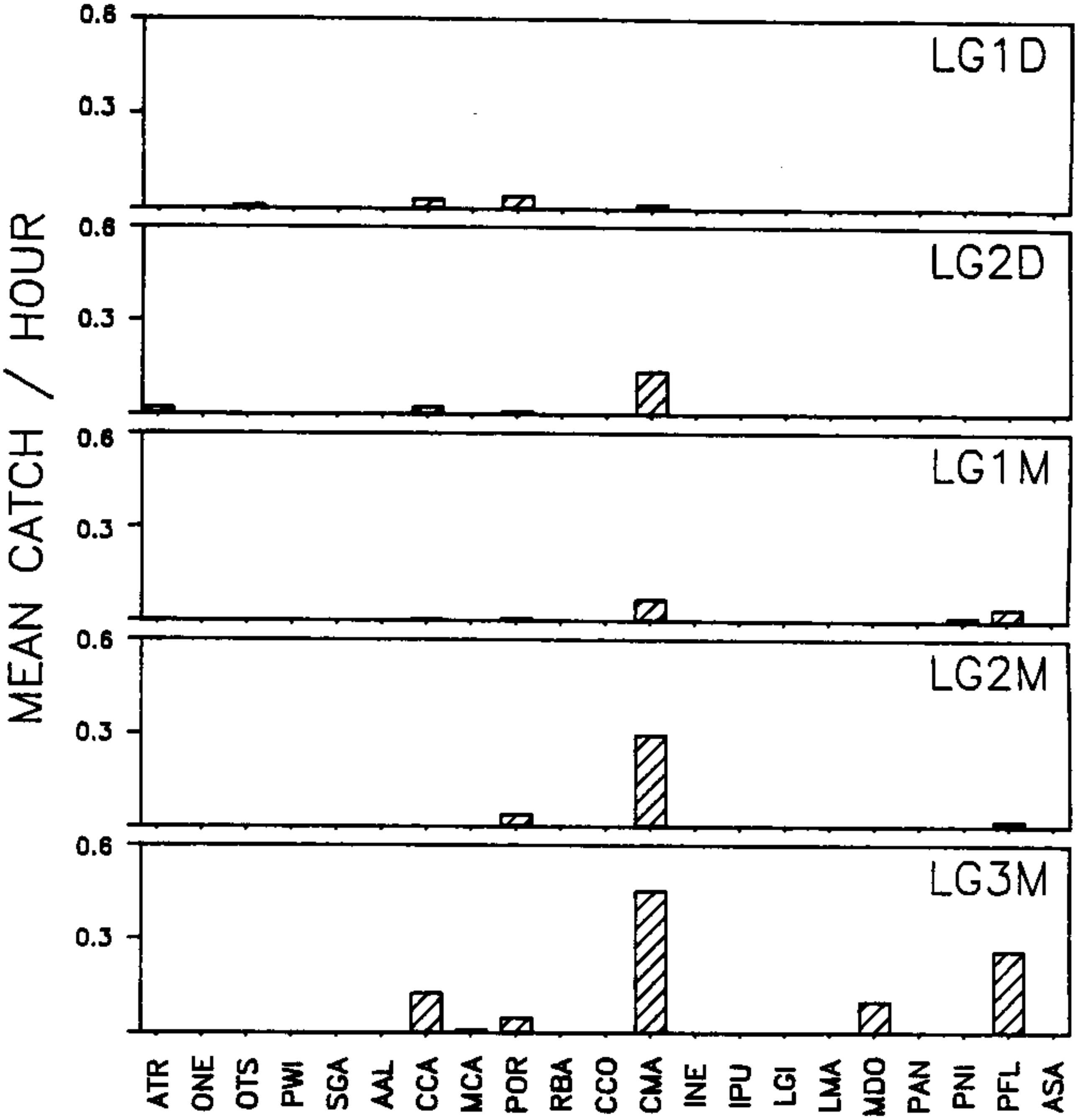

Figure 39. Mean catch per hour by species for mid water gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

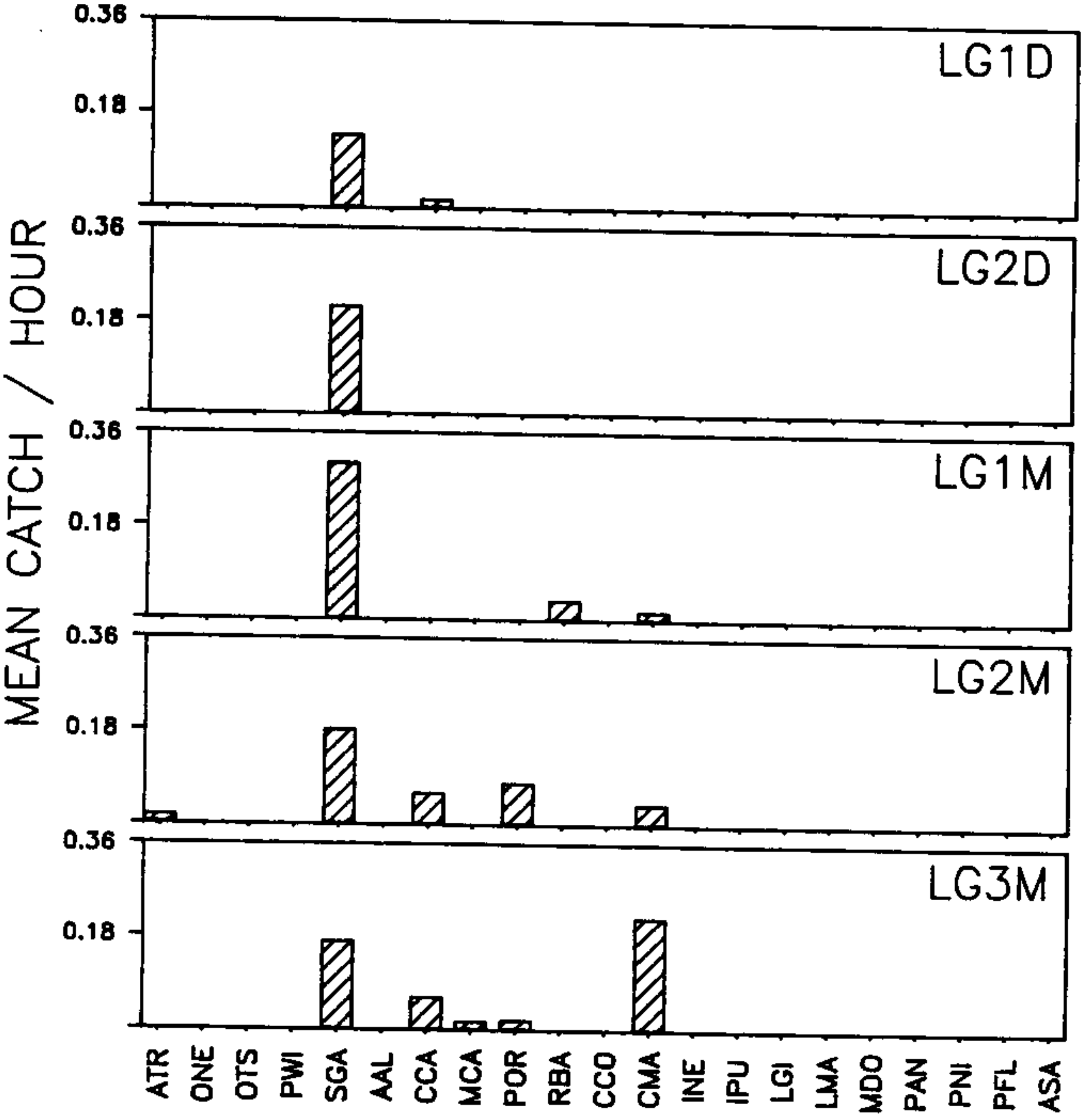

Figure 40. Mean catch per hour by species for mid water gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

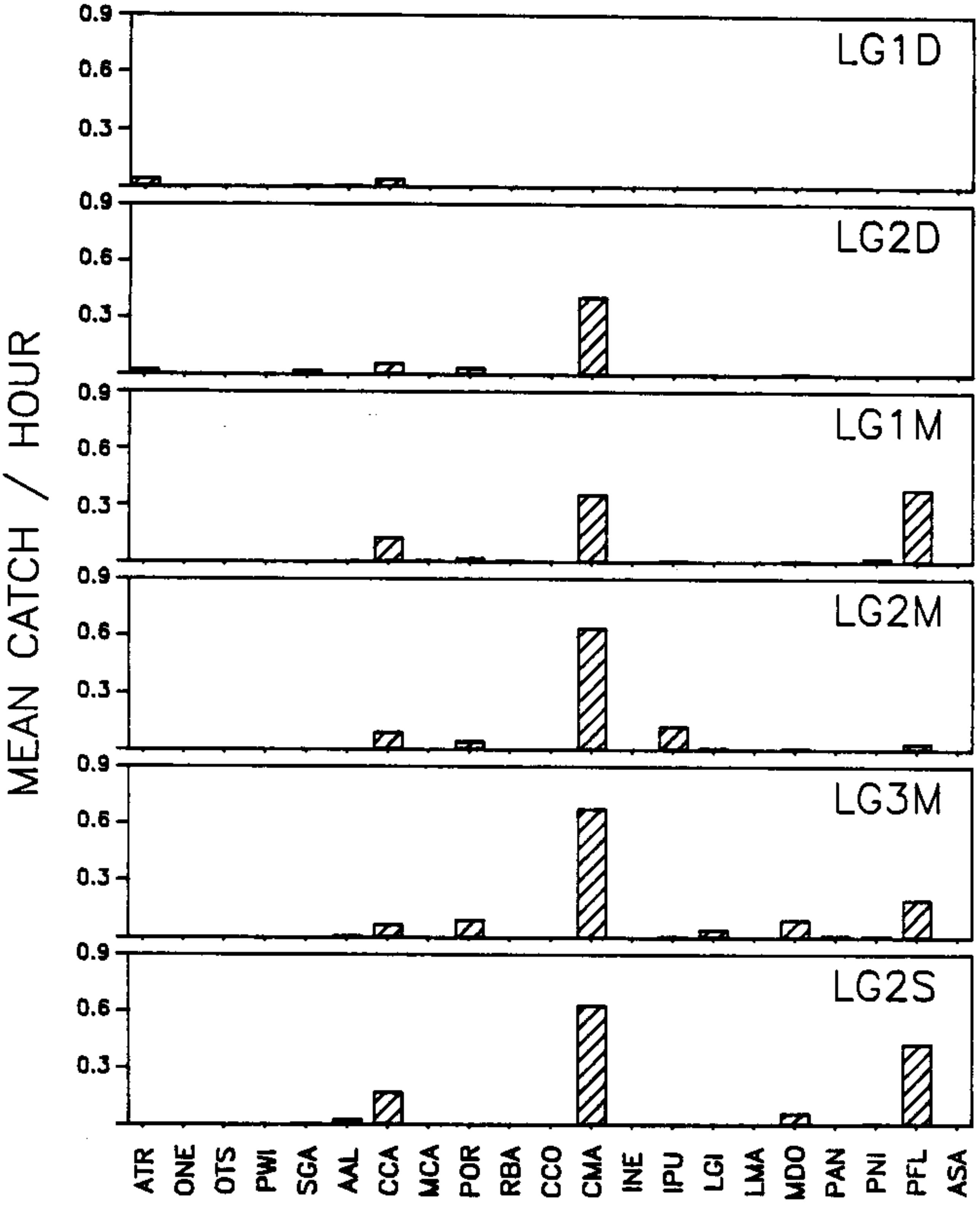

Figure 41. Mean catch per hour by species for bottom gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. See Table 12 for species codes.

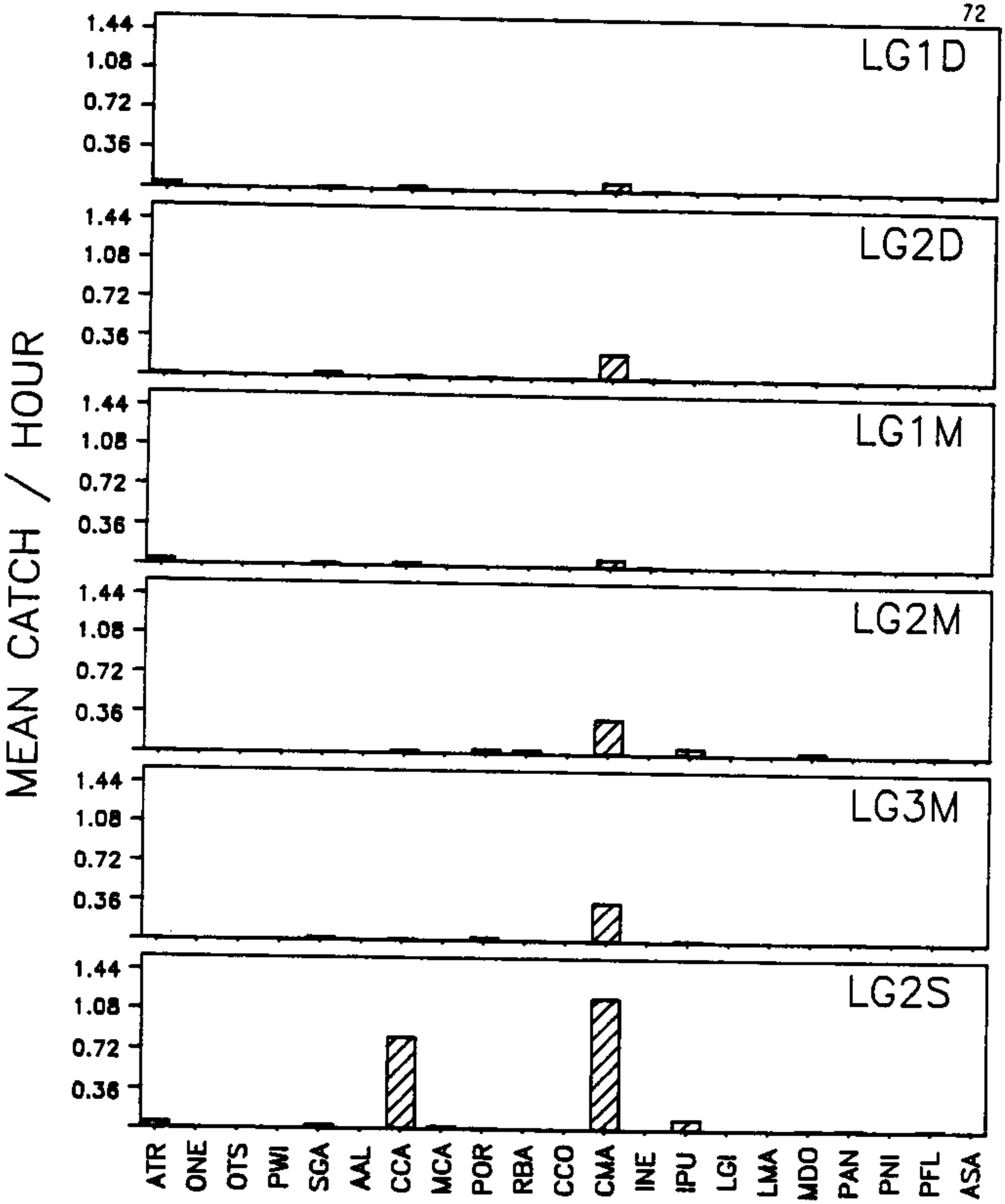

Figure 42. Mean catch per hour by species for bottom gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during August through September, 1987. See Table 12 for species codes.

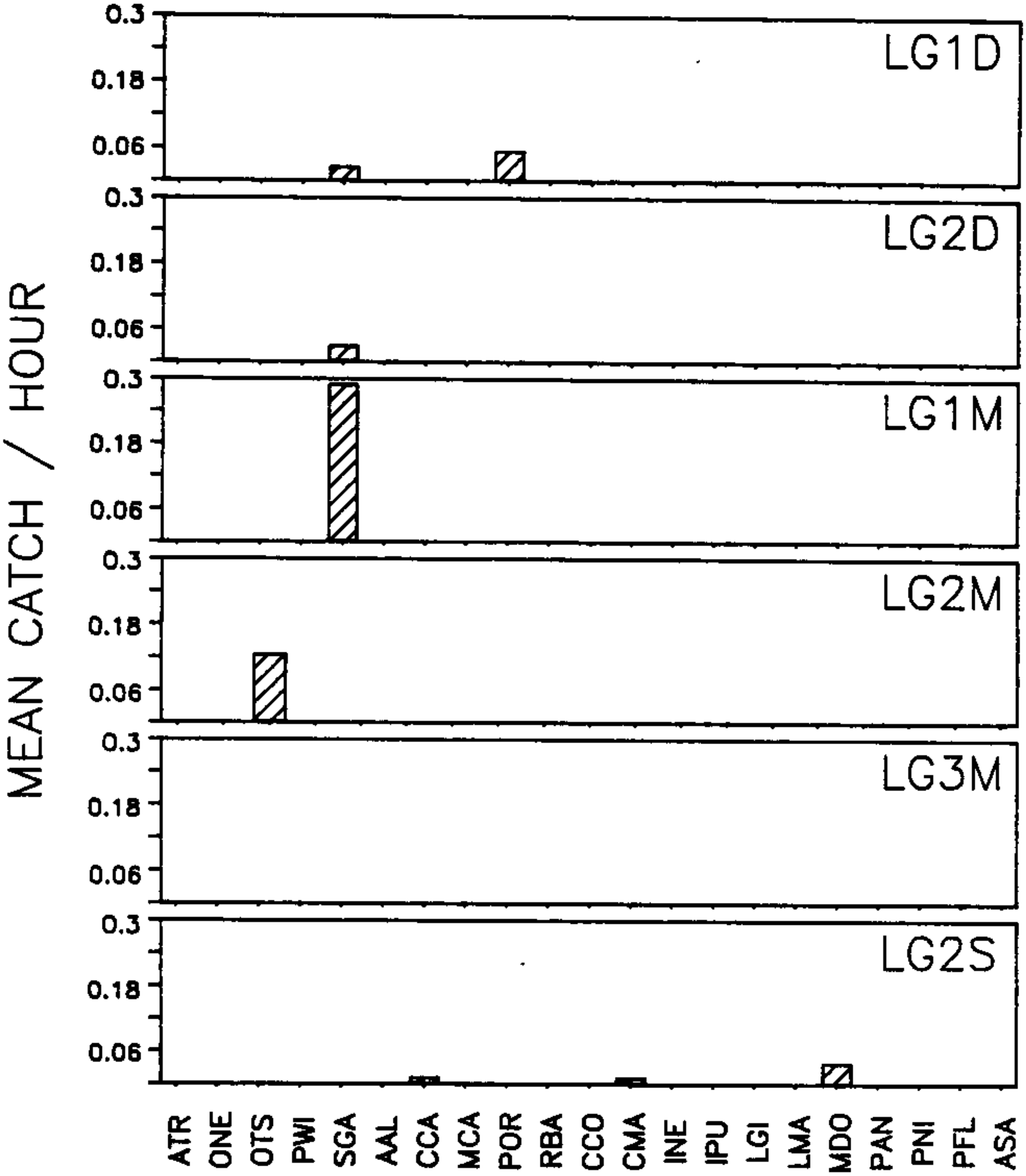

Figure 43. Mean catch per hour by species for floating gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. See Table 12 for species codes.

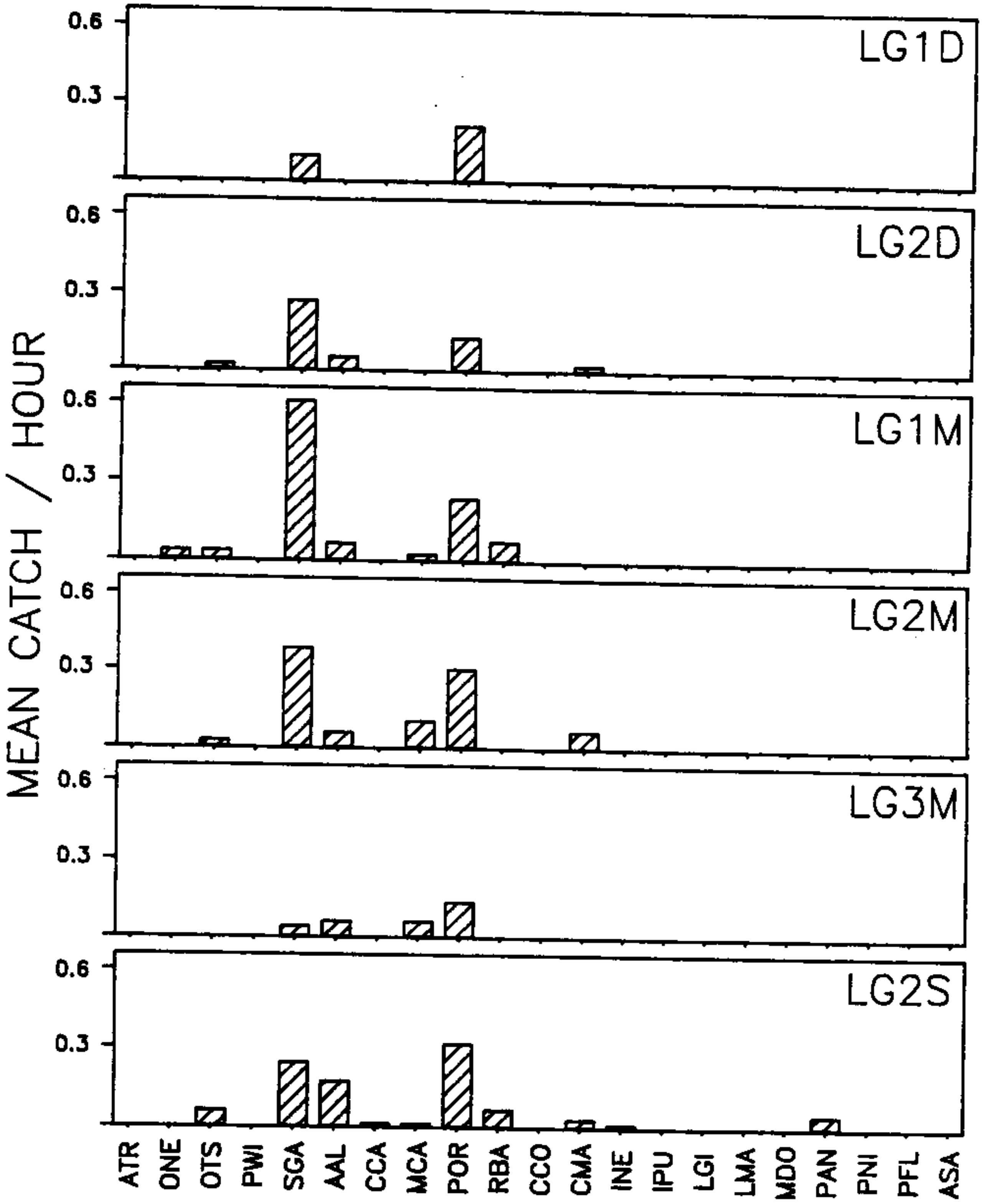

Figure 44. Mean catch per hour by species for floating gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. See Table 12 for species codes.

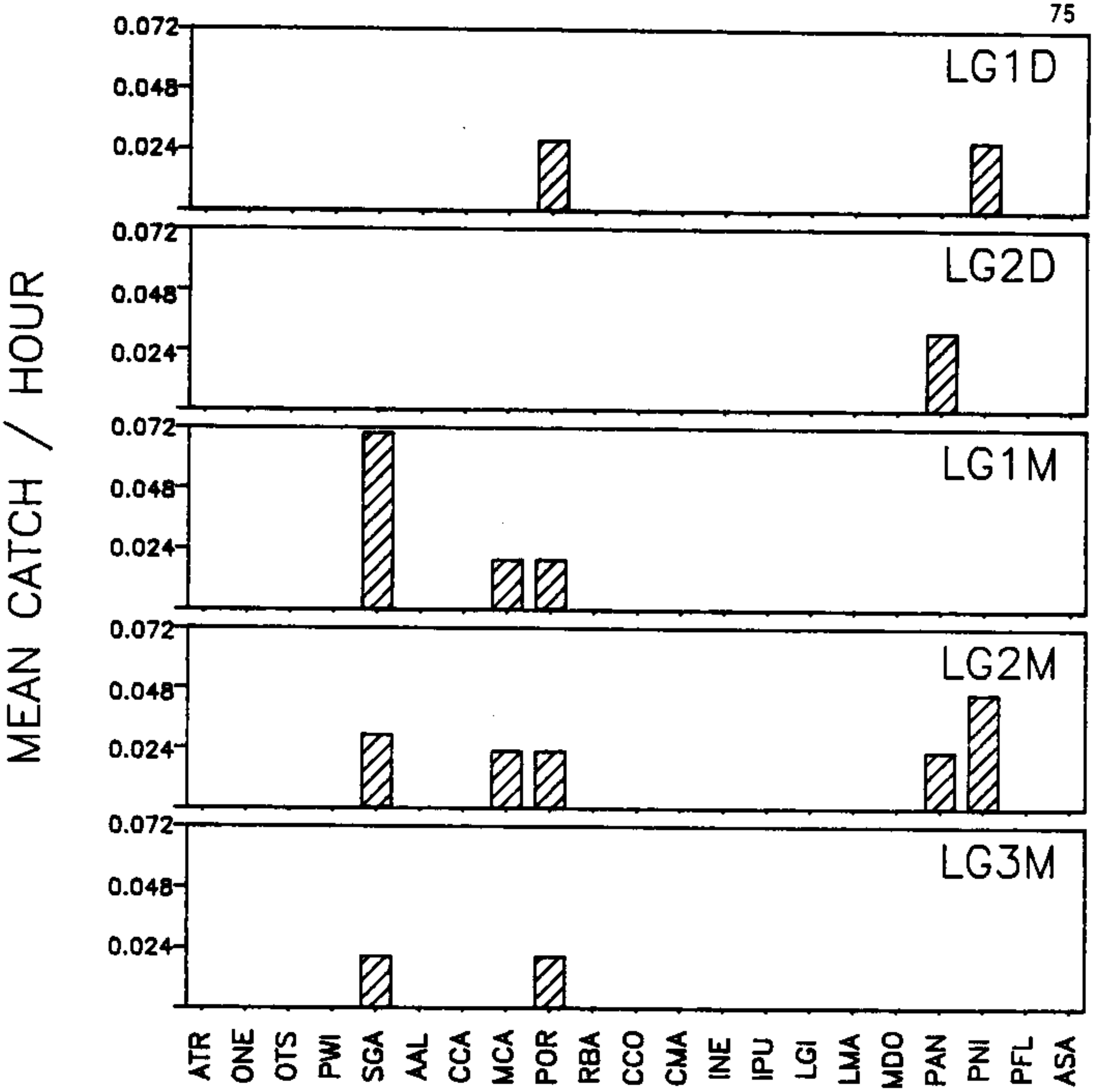

Figure 45. Mean catch per hour by species for mid water gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

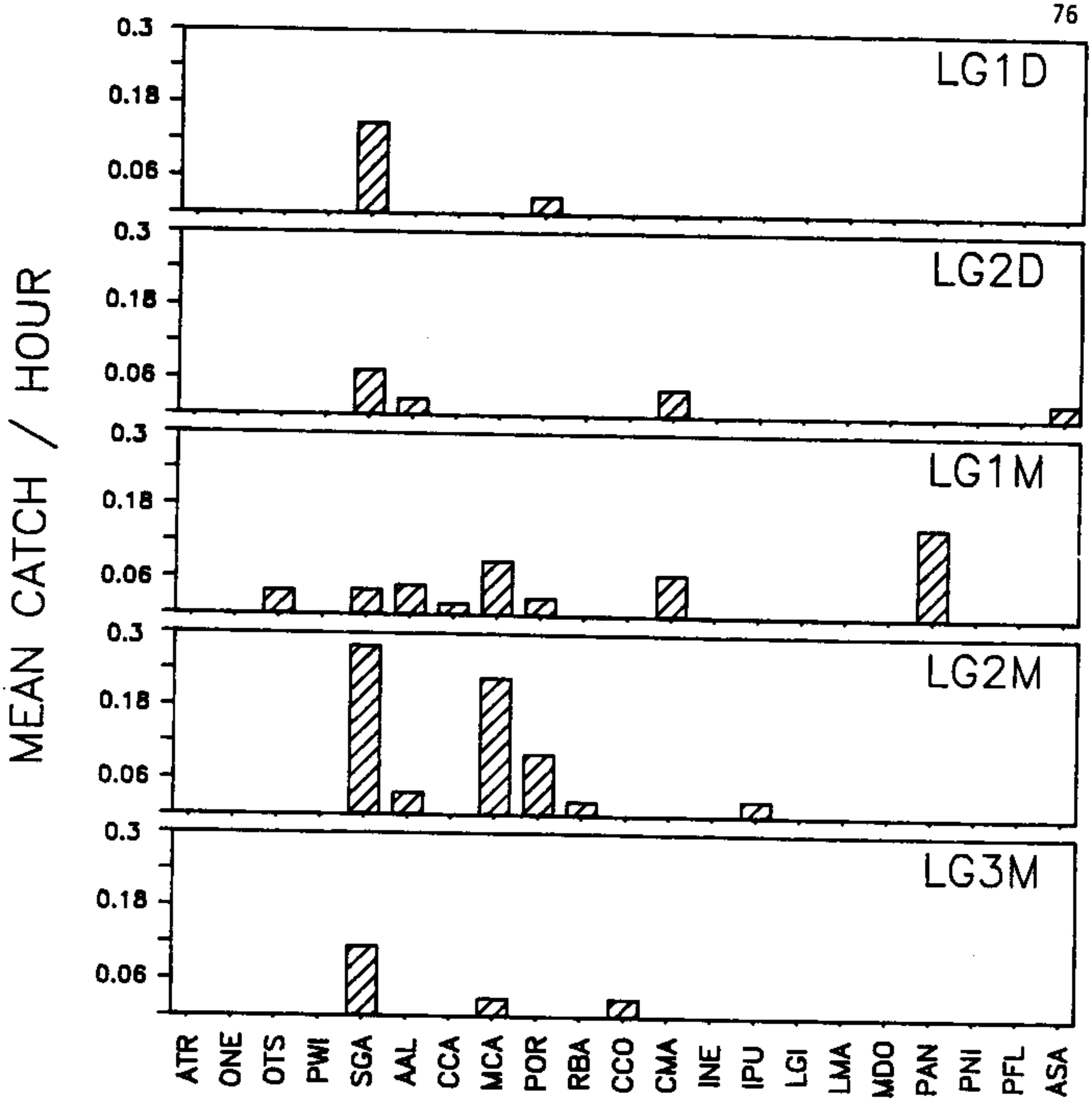

Figure 46. Mean catch per hour by species for mid water gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

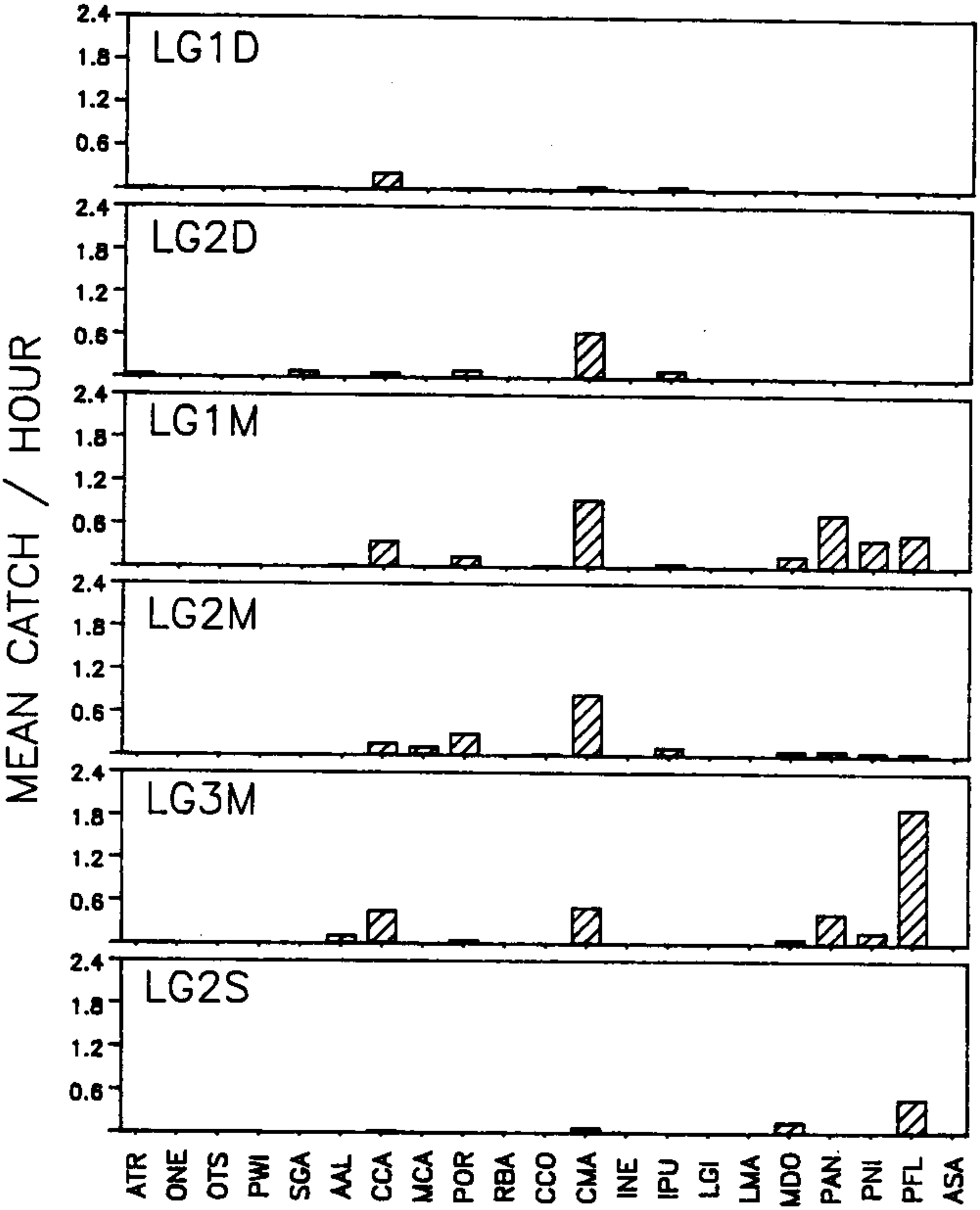

Figure 47. Mean catch per hour by species for bottom gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. See Table 12 for species codes.

frequently than other fish in nighttime bottom sets at deep stations, while crappies, largescale suckers, and carp dominated mid depth stations (Figure 48).

Winter.-Highest catch rates occurred in bottom sets followed by mid water and floating. Night catches in floating sets were dominated by rainbow trout and were higher than in the day (Figures 49 and 50). No fish were captured in daytime mid water sets; nighttime sets were dominated by rainbow trout and chiselmouth (Figure 51). Daytime, bottom set catch rates generally surpassed night rates, with carp, chiselmouth, and non-salmonid game fish forming the bulk of the daytime catch at mid depth sites (Figure 52). Crappies and yellow perch were captured at reasonably high rates day and night at the mid depth stations (Figures 52 and 53).

Seasonal Catches of Key Species

Certain species present in Lower Granite Reservoir are of special interest: chinook salmon and rainbow trout (steelhead) and their potential predators northern squawfish, channel catfish, and smallmouth bass, as well as white sturgeon. We prepared graphical analyses of gill-netting catch results specific to these key species to detect important relationships among species and habitat. Since predation on anadromous salmonid smolts is of interest, only subadult chinook salmon and rainbow trout were included in the following analysis.

Rainbow trout were captured at all stations in the spring, summer, and fall (Figures 54-59). Rainbow trout were captured much more frequently at night at all stations than during the day. Catch rates were highest at the three mid depth sites, with LG1M producing the most, followed by LG2D, LG1D,

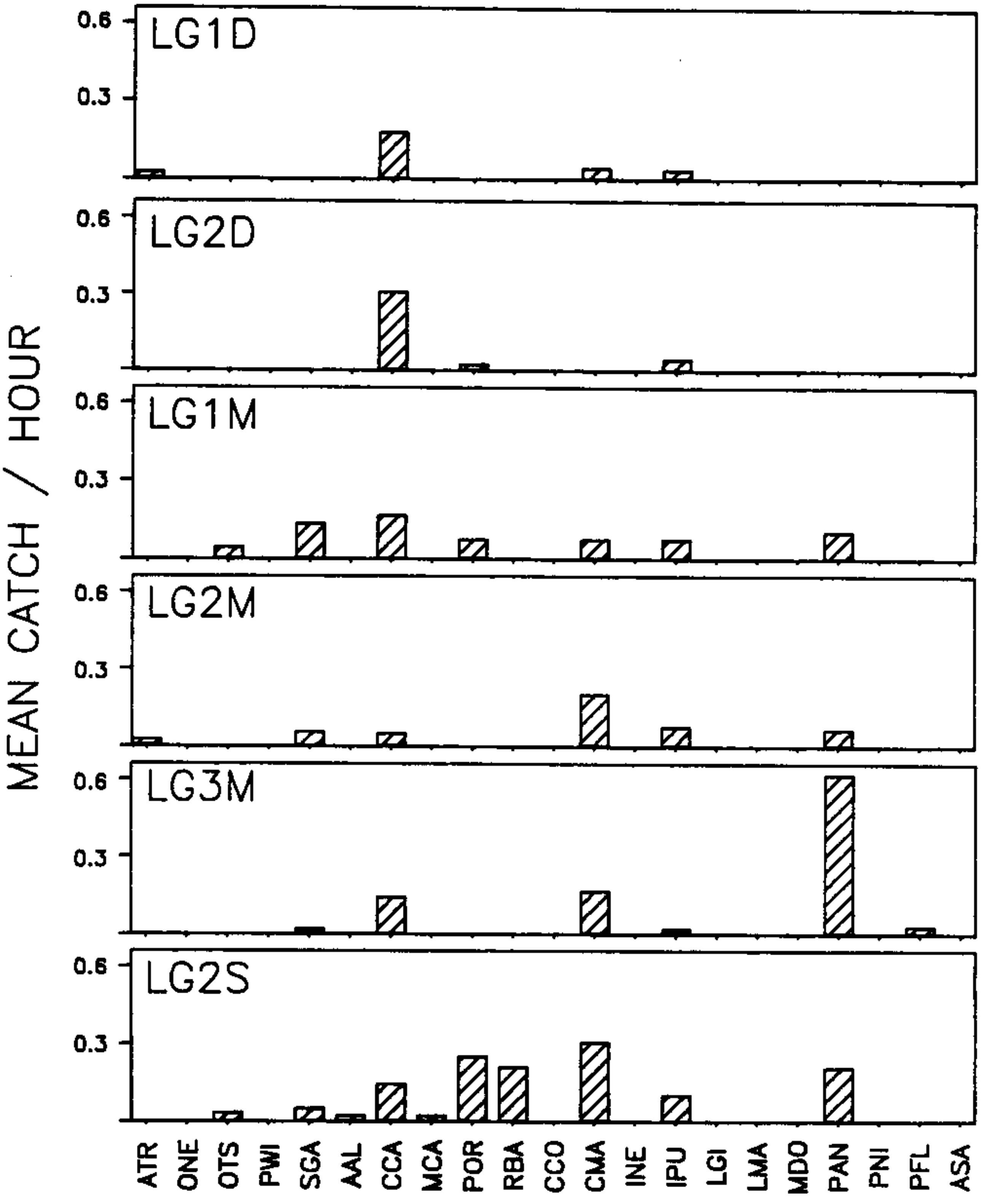

Figure 48. Mean catch per hour by species for bottom gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during October through November, 1987. See Table 12 for species codes.

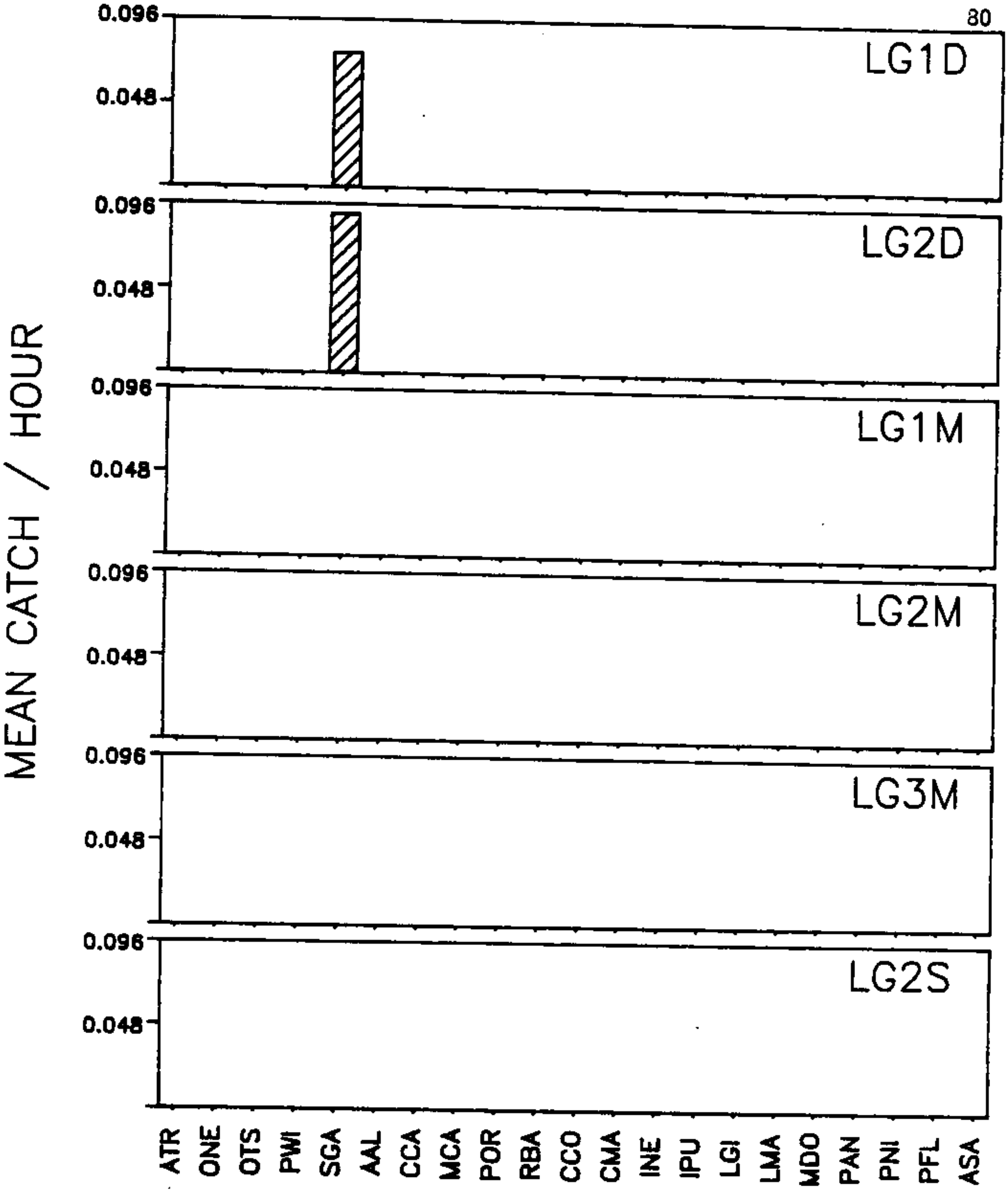

Figure 49. Mean catch per hour by species for floating gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during December, 1987. See Table 12 for species codes.

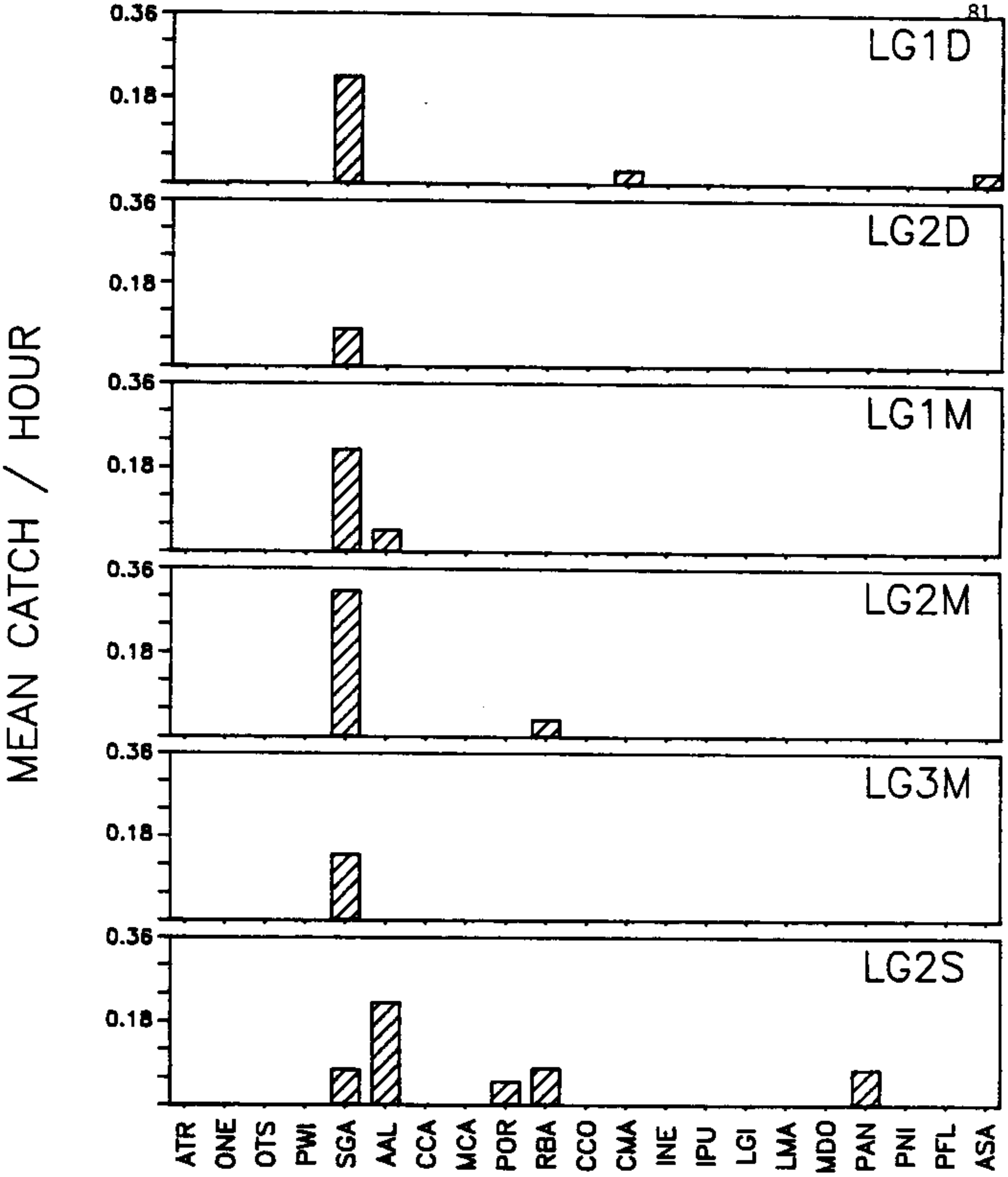

Figure 50. Mean catch per hour by species for floating gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during December, 1987. See Table 12 for species codes.

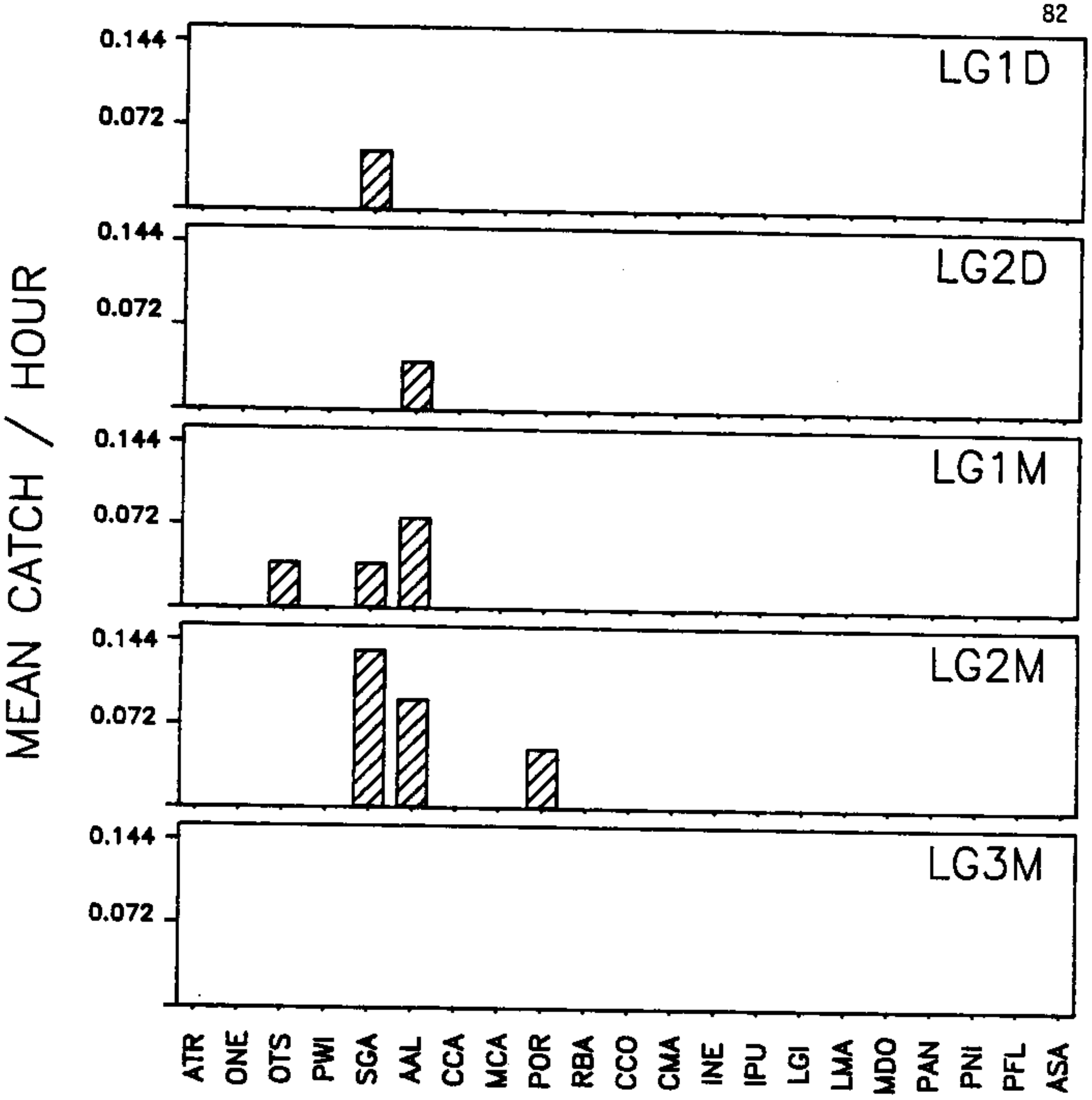

Figure 51. Mean catch per hour by species for mid water gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during December, 1987. See Table 12 for species codes. Because of depth limitations, no mid water sets were made at LG2S.

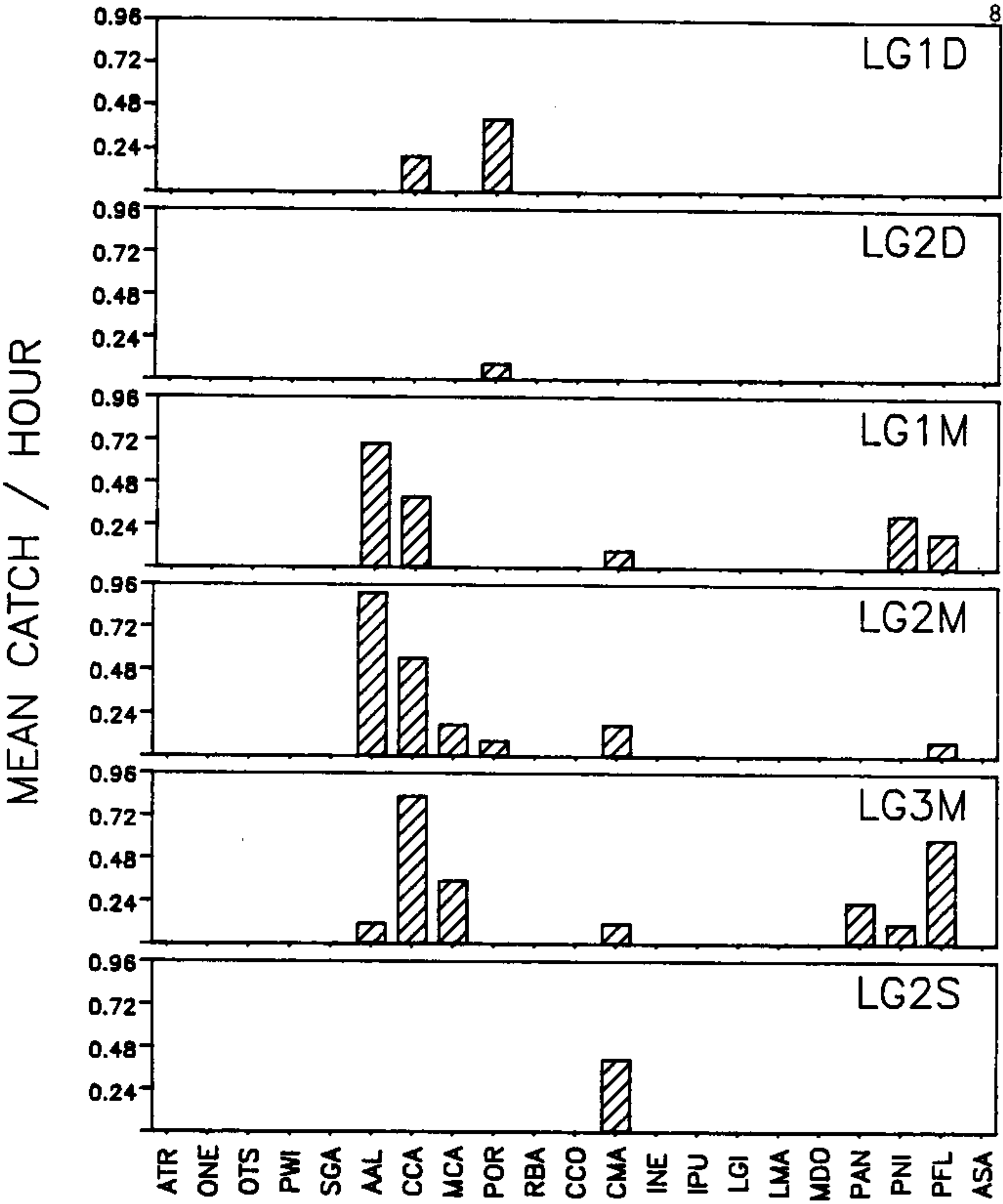

Figure 52. Mean catch per hour by species for bottom gillnets fished during the day at various sampling stations in Lower Granite Reservoir, Washington during December, 1987. See Table 12 for species codes.

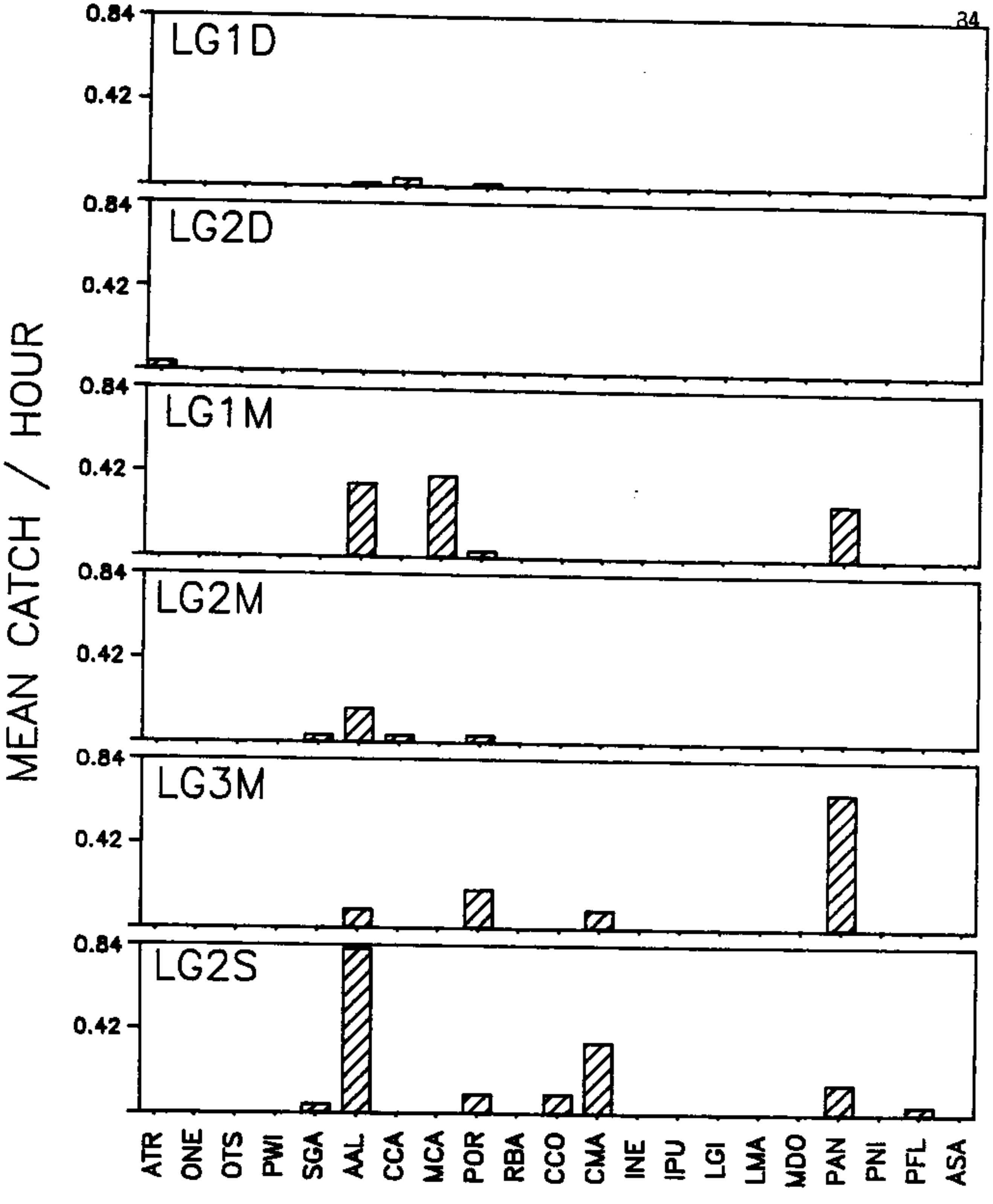

Figure 53. Mean catch per hour by species for bottom gillnets fished during the night at various sampling stations in Lower Granite Reservoir, Washington during December, 1987. See Table 12 for species codes.

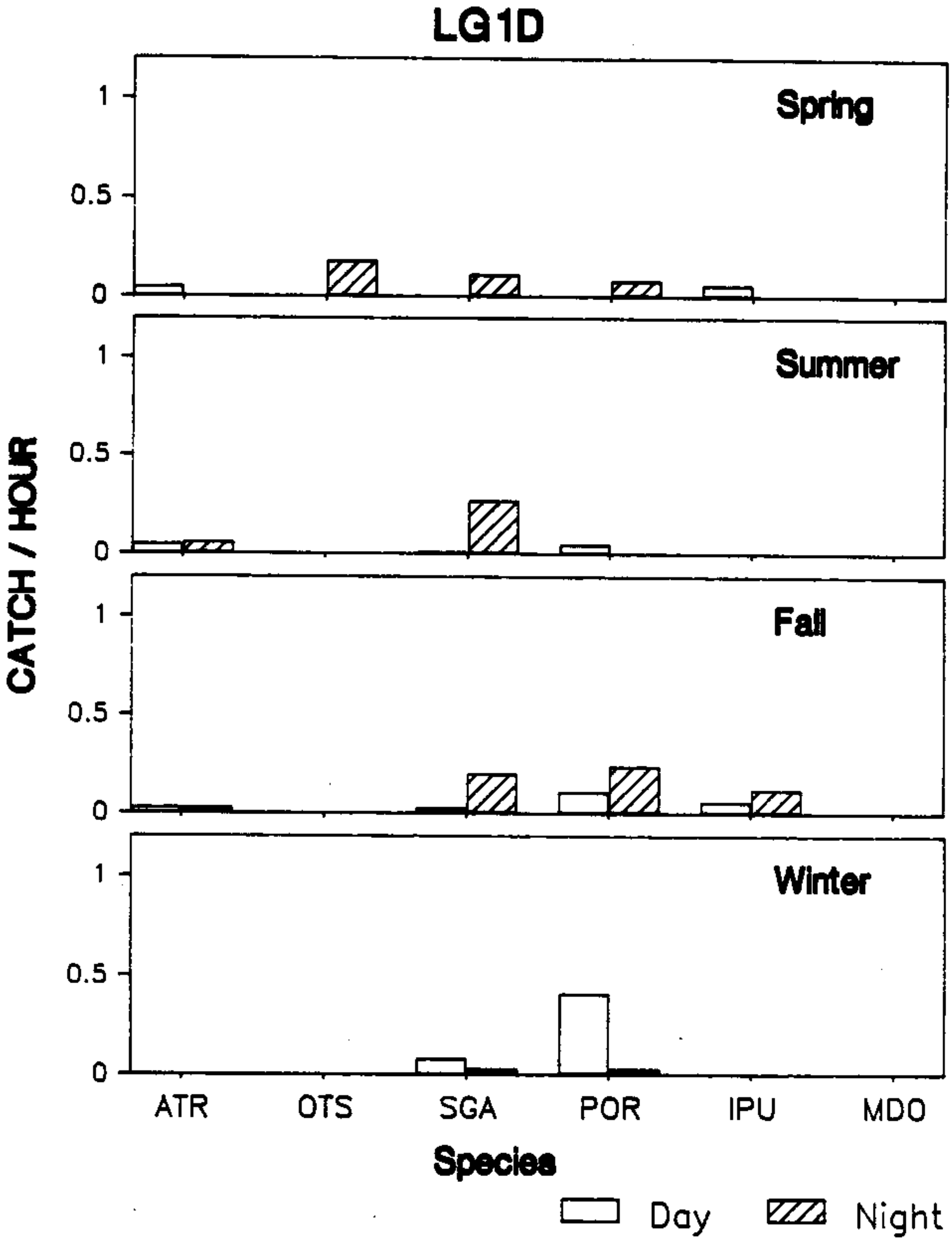

Figure 54. Catch rates for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) in gillnets fished at LG1D during 1987 in Lower Granite Reservoir, Washington. Seasonal catch rates were daily mean catch per hour summed over each season.

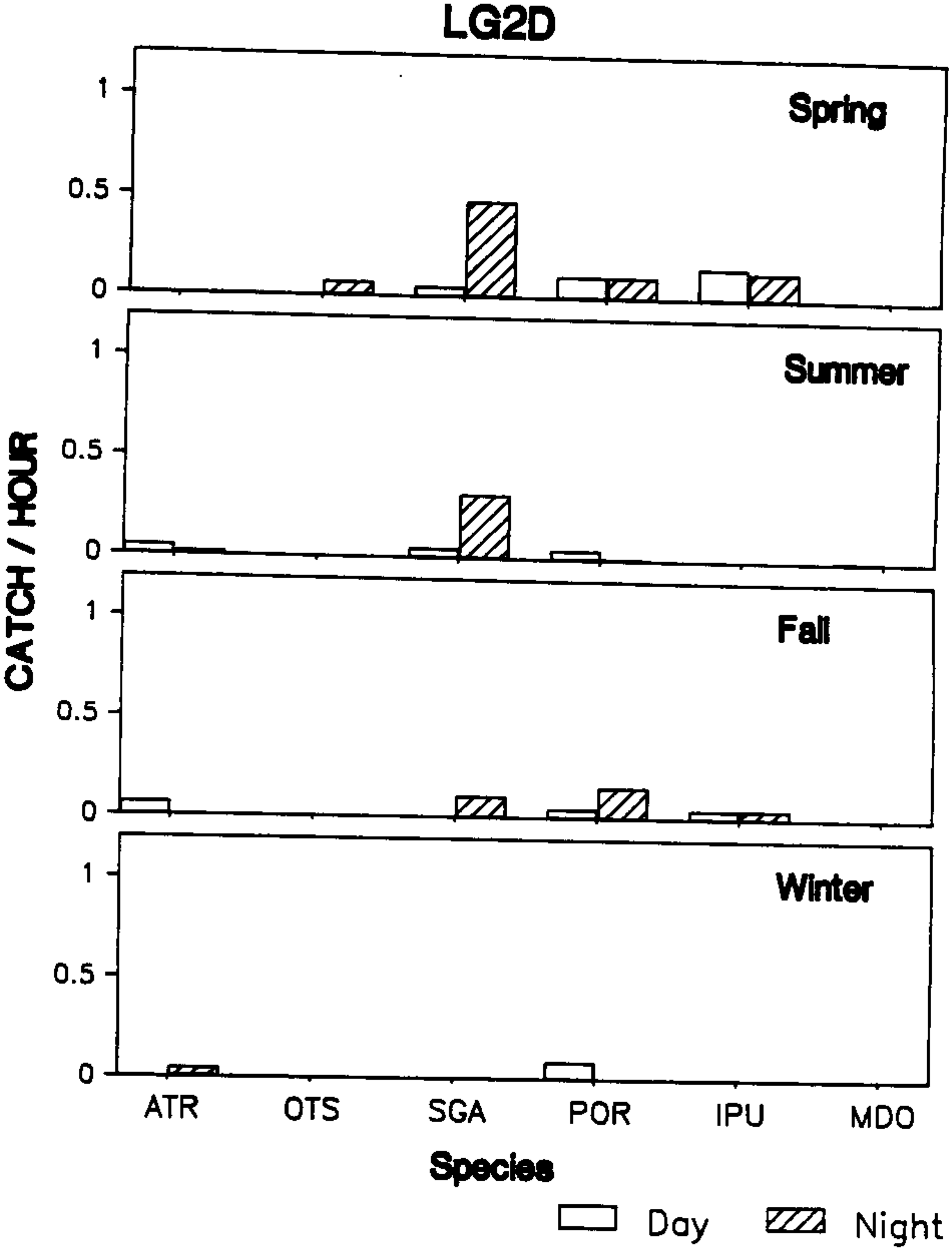

Figure 55. Catch rates for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) in gillnets fished at LG2D during 1987 in Lower Granite Reservoir, Washington. Seasonal catch rates were daily mean catch per hour summed over each season.

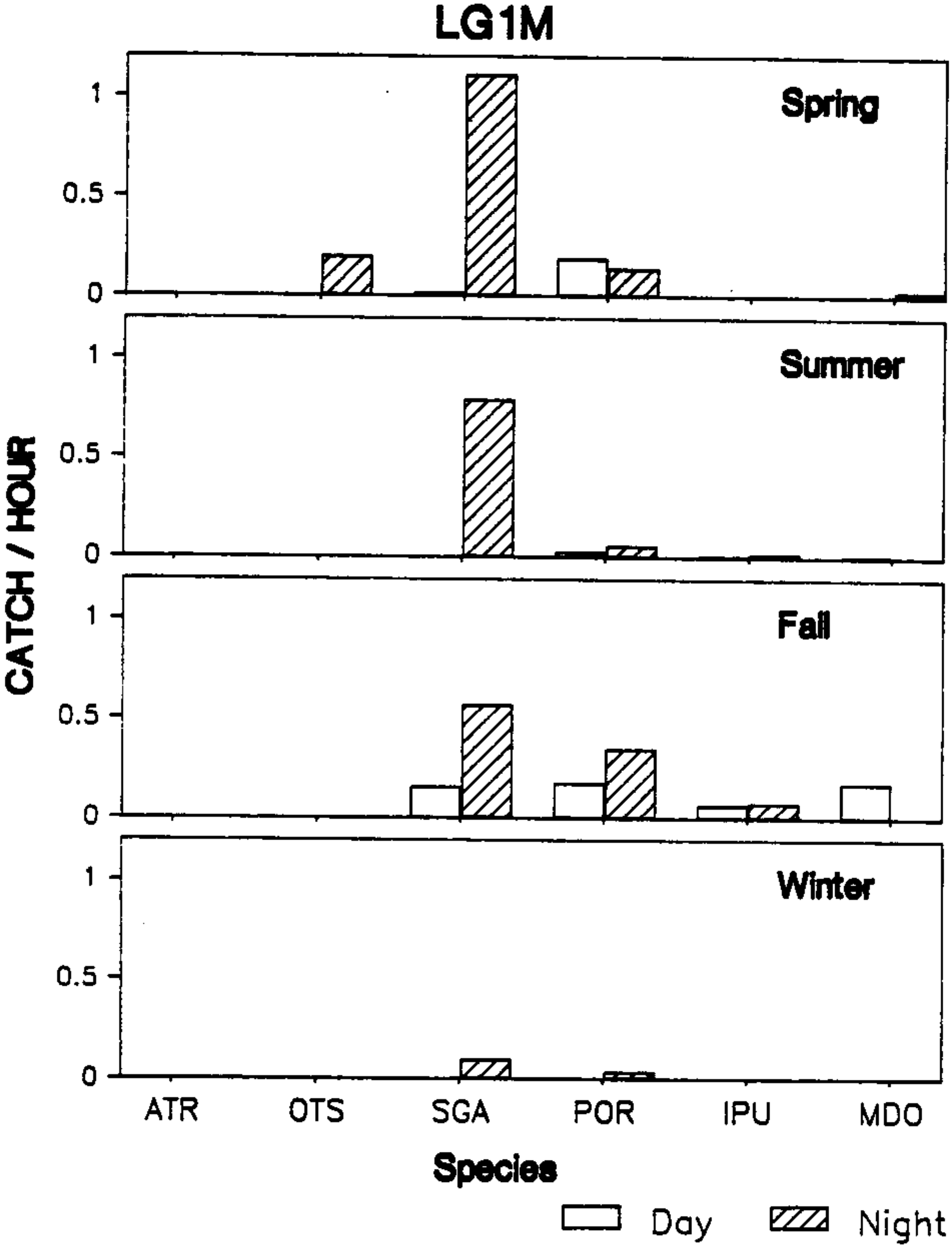

Figure 56. Catch rates for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) in gillnets fished at LG1M during 1987 in Lower Granite Reservoir, Washington. Seasonal catch rates were daily mean catch per hour summed over each season.

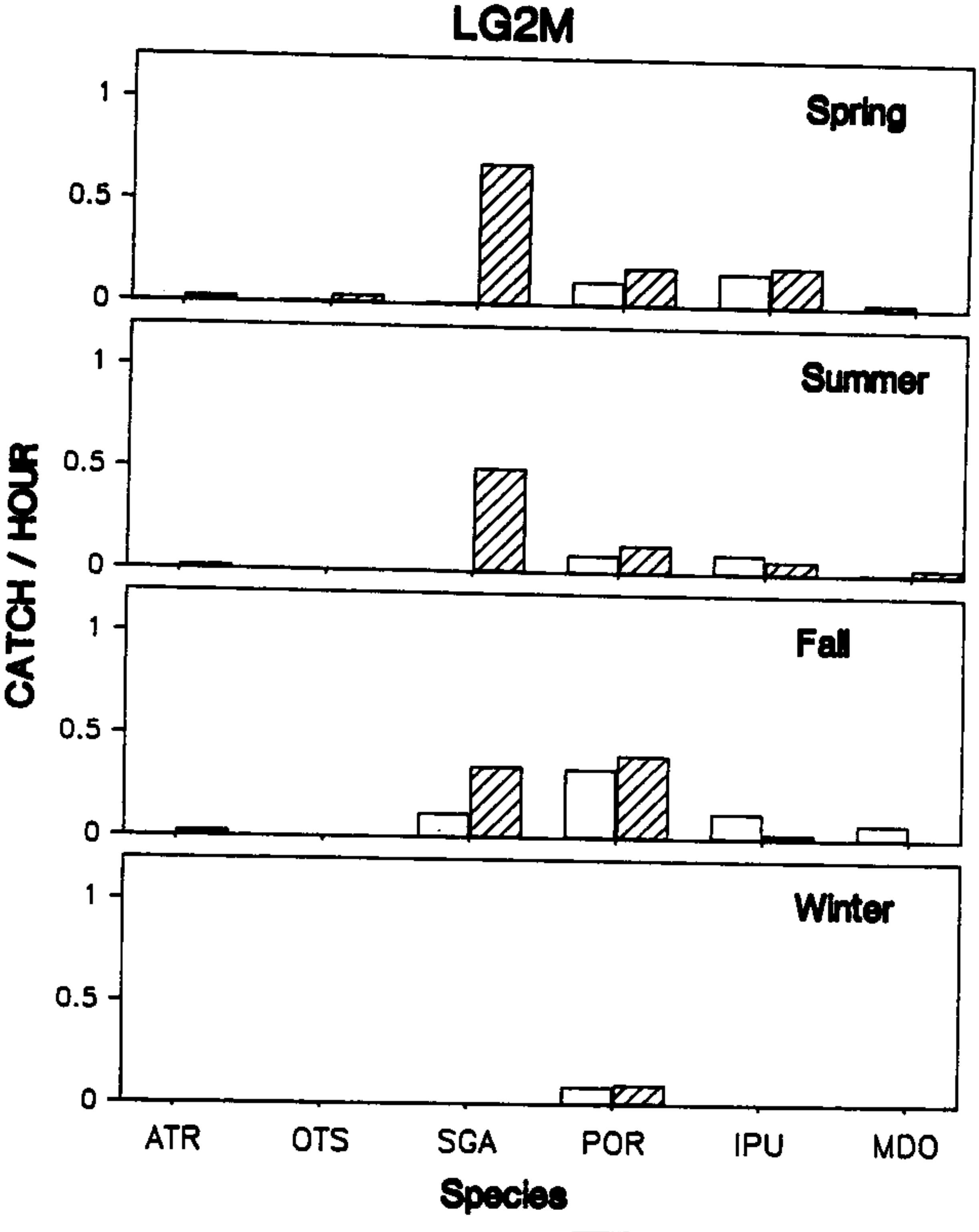

Figure 57. Catch rates for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) in gillnets fished at LG2M during 1987 in Lower Granite Reservoir, Washington. Seasonal catch rates were daily mean catch per hour summed over each season.

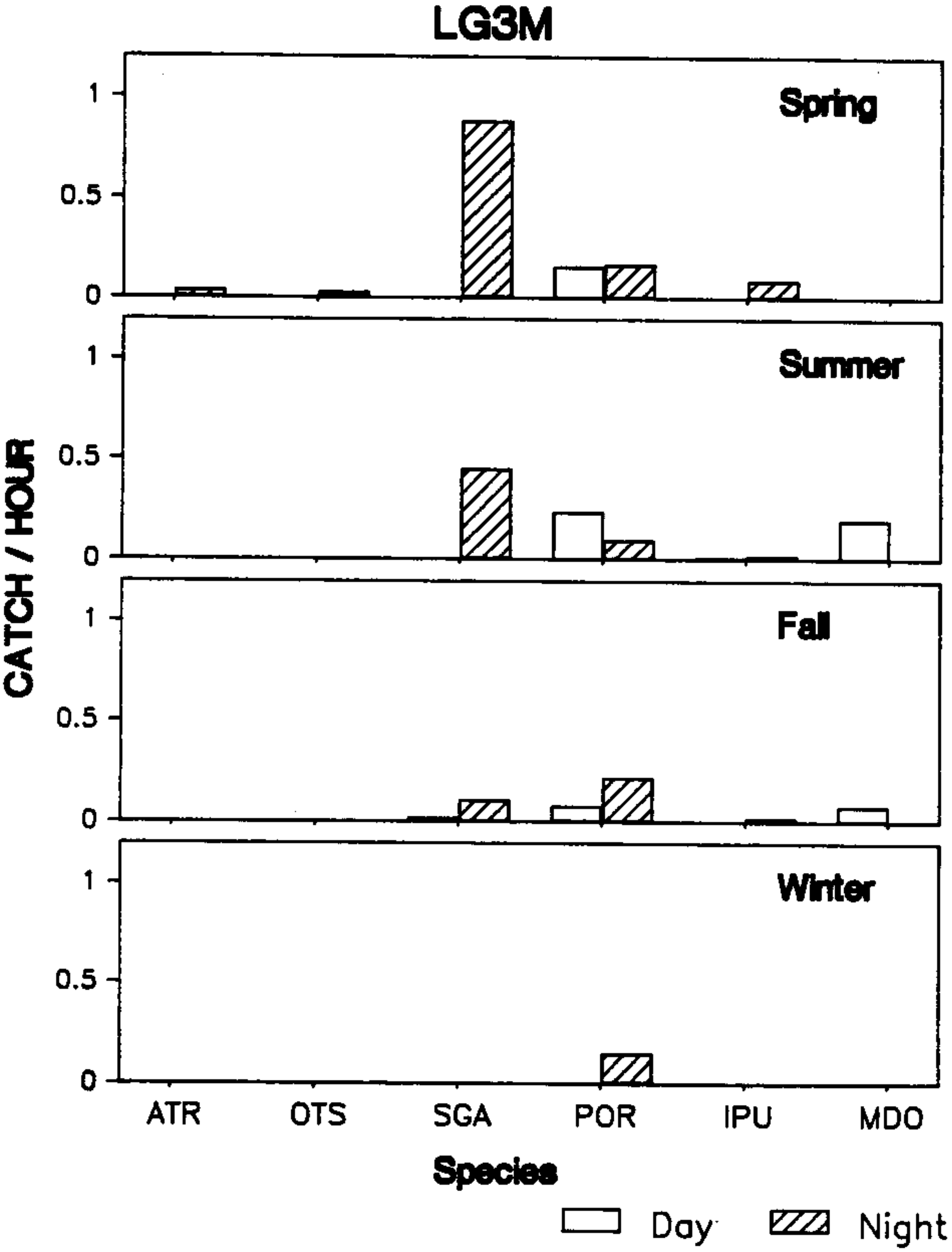

Figure 58. Catch rates for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) in gillnets fished at LG3M during 1987 in Lower Granite Reservoir, Washington. Seasonal catch rates were daily mean catch per hour summed over each season.

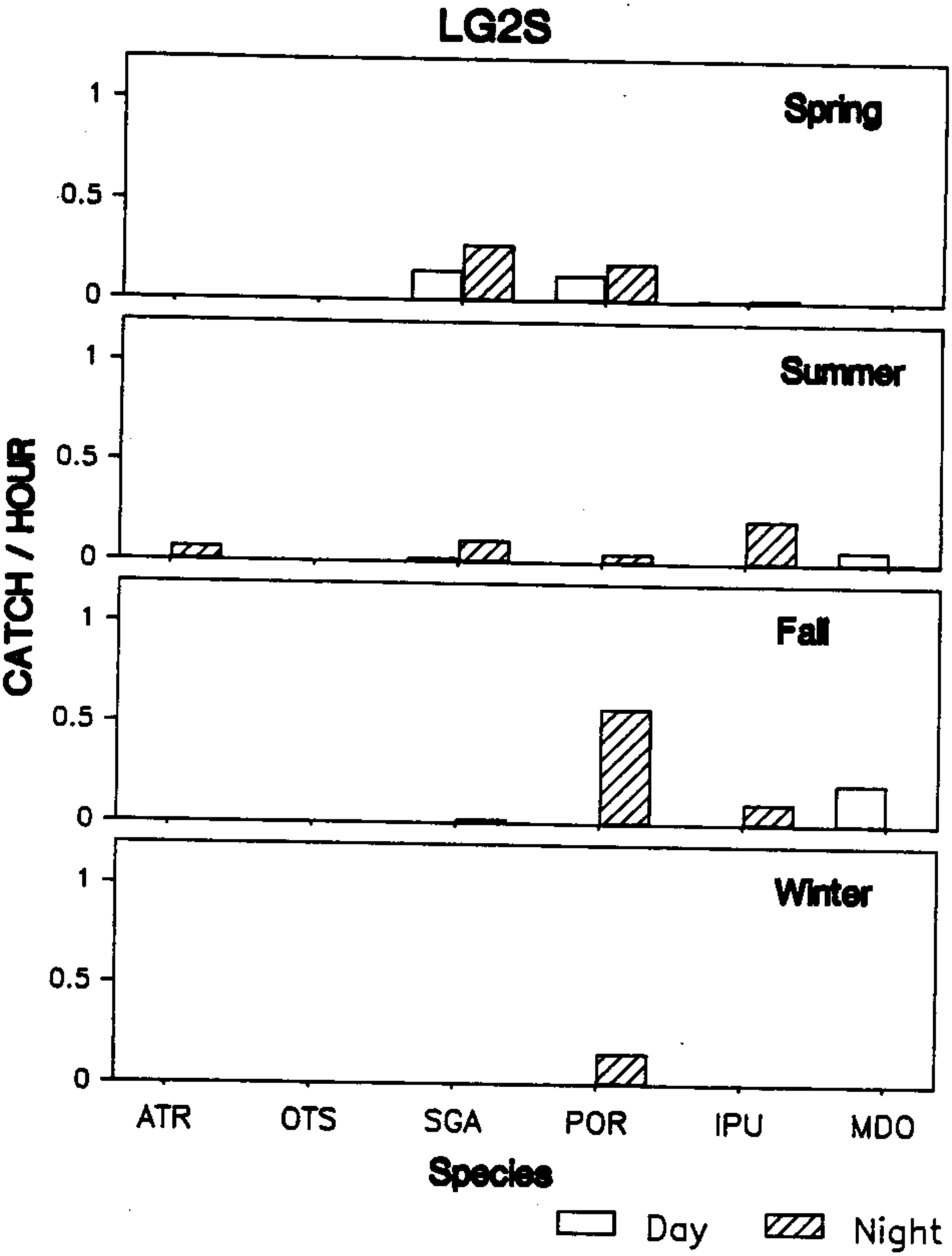

Figure 59. Catch rates for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) in gillnets fished at LG2S during 1987 in Lower Granite Reservoir, Washington. Seasonal catch rates were daily mean catch per hour summed over each season.

and LG2S. Catch rates were highest in the spring and decreasing season by season thereafter except at LG1D, where they were highest in summer for rainbow trout . Chinook salmon were captured only at night, and at much lower rates than rainbow trout. Chinook salmon occurred in low numbers at all stations (except LG2S).

Northern squawfish was the only key species to be captured every season at each site. Squawfish were generally caught both day and night at similar rates, although nighttime catch rates clearly dominated at LG2S, and daytime rates at LG1D (in the winter). Catch rates were highest in the fall at LG1M, LG2M, LG1D, and LG2S, while catch rates at LG2D and LG3M showed no substantial increase in the fall. No clear positive relationship between squawfish and rainbow trout catch rates existed. Squawfish catch rates were highest when catch rates of rainbow trout were low at several stations.

Catch rates of channel catfish were similar to those of northern squawfish. Catfish were captured both night and day, except at LG2S where they occurred mostly at night. At LG2S, catch rates of channel catfish were the highest of the key species in the summer (Figure 59). Unlike northern squawfish, catfish displayed no clear seasonal pattern, except for being totally absent from winter samples.

Smallmouth bass occurred only at mid depth and shallow stations. Catch rates were generally highest during daytime samples in the fall although few were captured in the spring, and none during winter.

Vertical Distribution of Key Species

In the spring, rainbow trout were caught mostly at the surface during the night at deep stations, whereas they were distributed throughout the water column at mid depth and LG2S (Figures 60-62). Northern squawfish were also distributed throughout the water column, while channel catfish were caught in mid water and bottom sets only. White sturgeon were captured in mid water or bottom sets.

As in the spring, rainbow trout were caught throughout the water column at mid depth and shallow stations during summer sampling, although they were more concentrated near the surface than in the spring (Figures 64 and 65). At deep stations, rainbows were also distributed at all net depths, which was different from spring. Northern squawfish were again caught throughout the water column, but seemed less frequent in surface sets than in the spring (Figure 63). Squawfish, channel catfish, and smallmouth bass did not seem to be keying on the same depth zones as rainbow trout. Both catfish and smallmouth were captured in mid water or bottom sets only. White sturgeon were captured in mid water or bottom sets at all stations but LG1M and LG2S.

Fall sampling showed no rainbow trout in bottom sets at deep stations (as in spring), although captures in mid water and floating nets suggest a wide distribution throughout the water column at the other stations (Figures 66-68). All predators showed generally increased catch rates in the fall at all stations, especially northern squawfish. Squawfish were more abundant at the surface than at other depths, although several stations showed high concentrations at the bottom also. Thus, rainbow trout and squawfish both showed highest catch rates at the surface, suggesting that the potential for

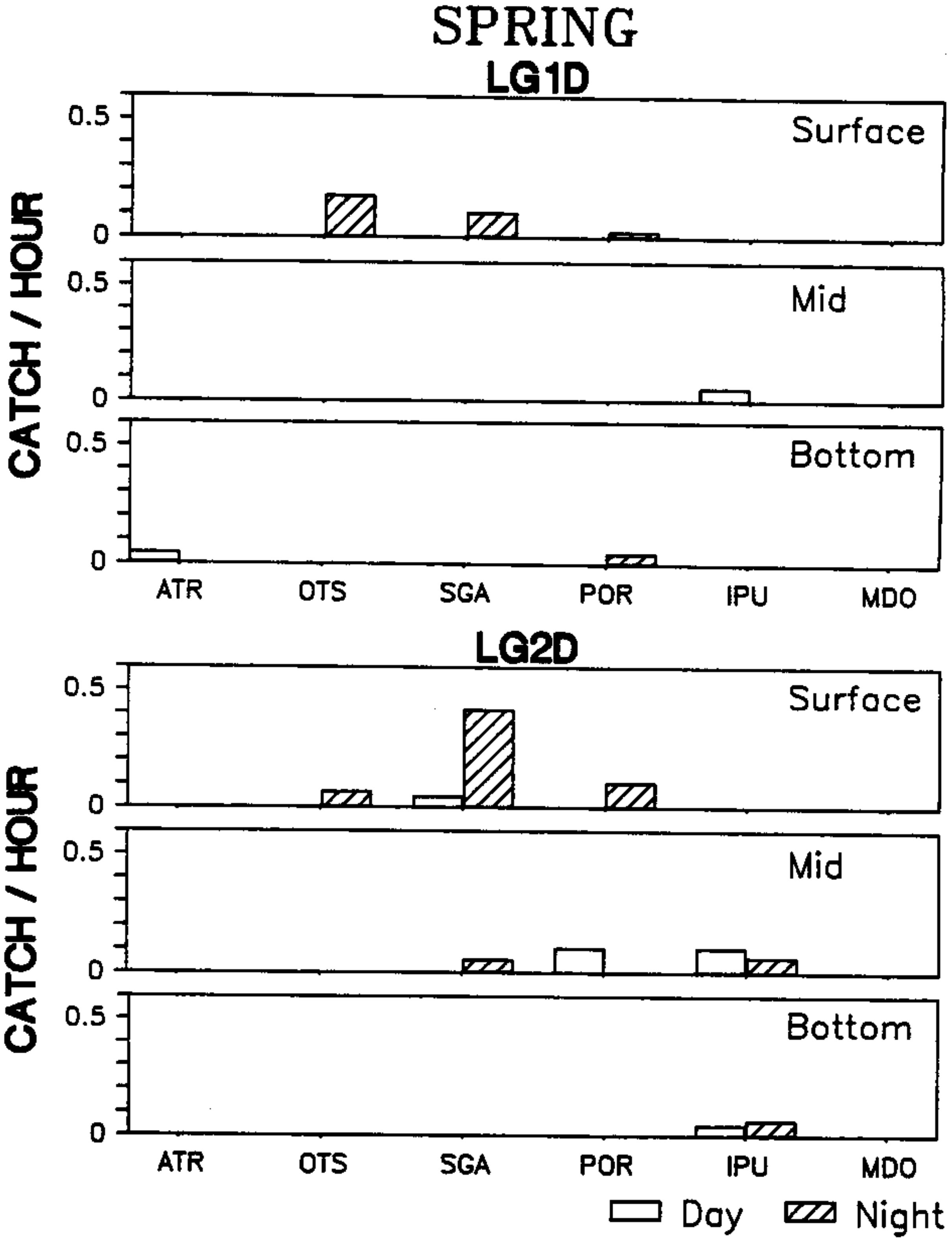

Figure 60. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1D and LG2D during spring, 1987 in Lower Granite Reservoir, Washington.

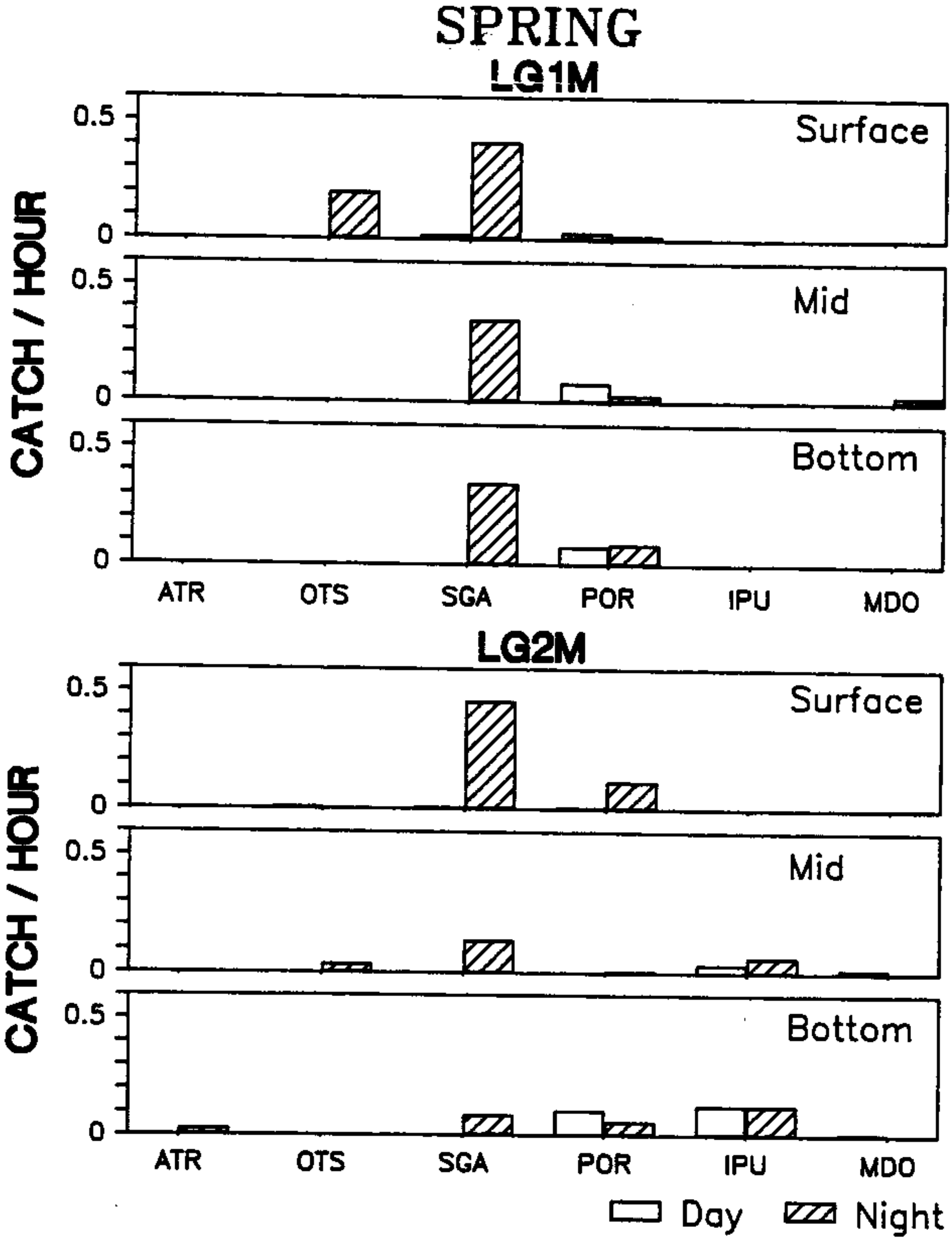

Figure 61. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1M and LG2M during spring, 1987 in Lower Granite Reservoir, Washington.

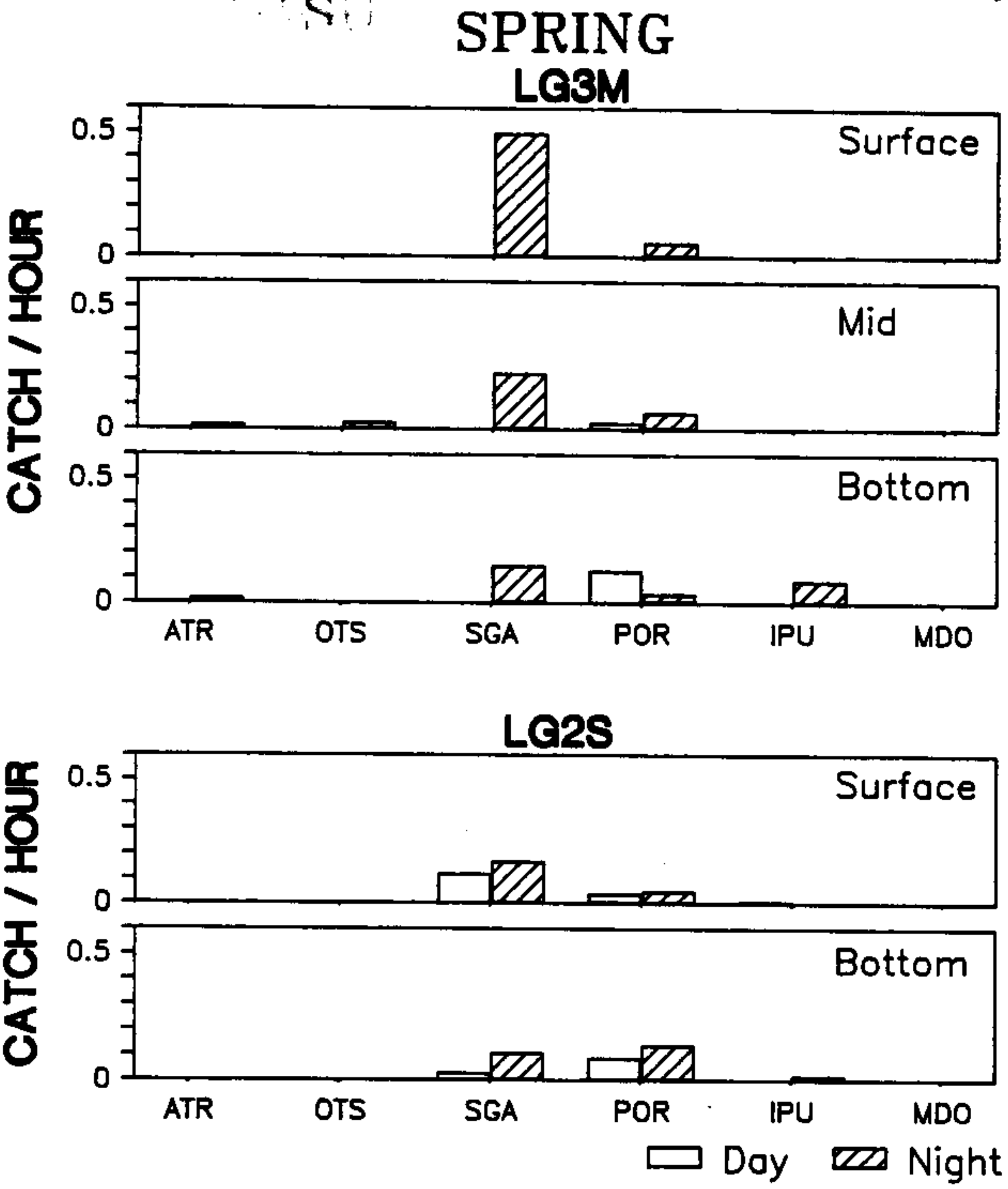

Figure 62. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG3M and LG2S during spring, 1987 in Lower Granite Reservoir, Washington.

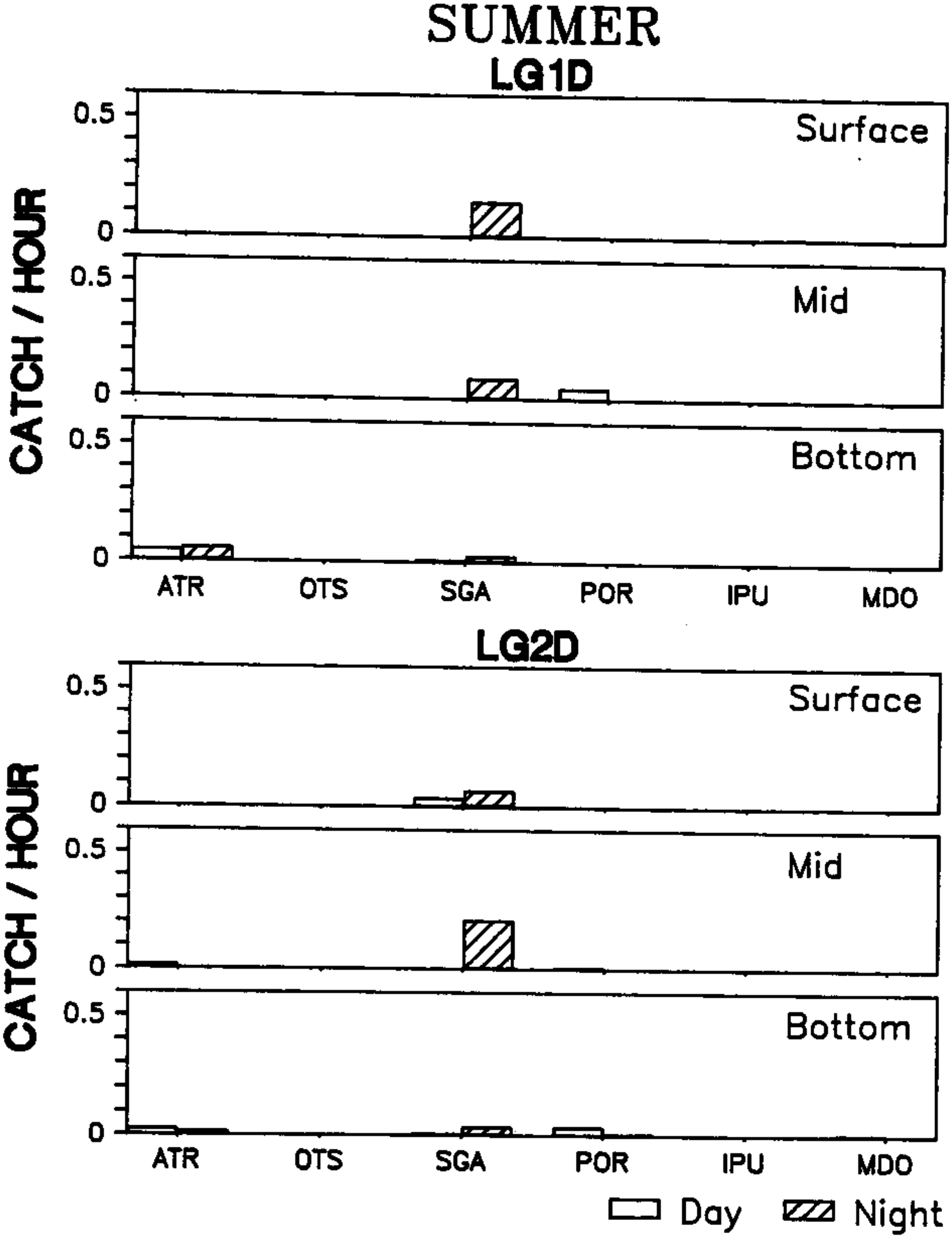

Figure 63. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1D and LG2D during summer, 1987 in Lower Granite Reservoir, Washington.

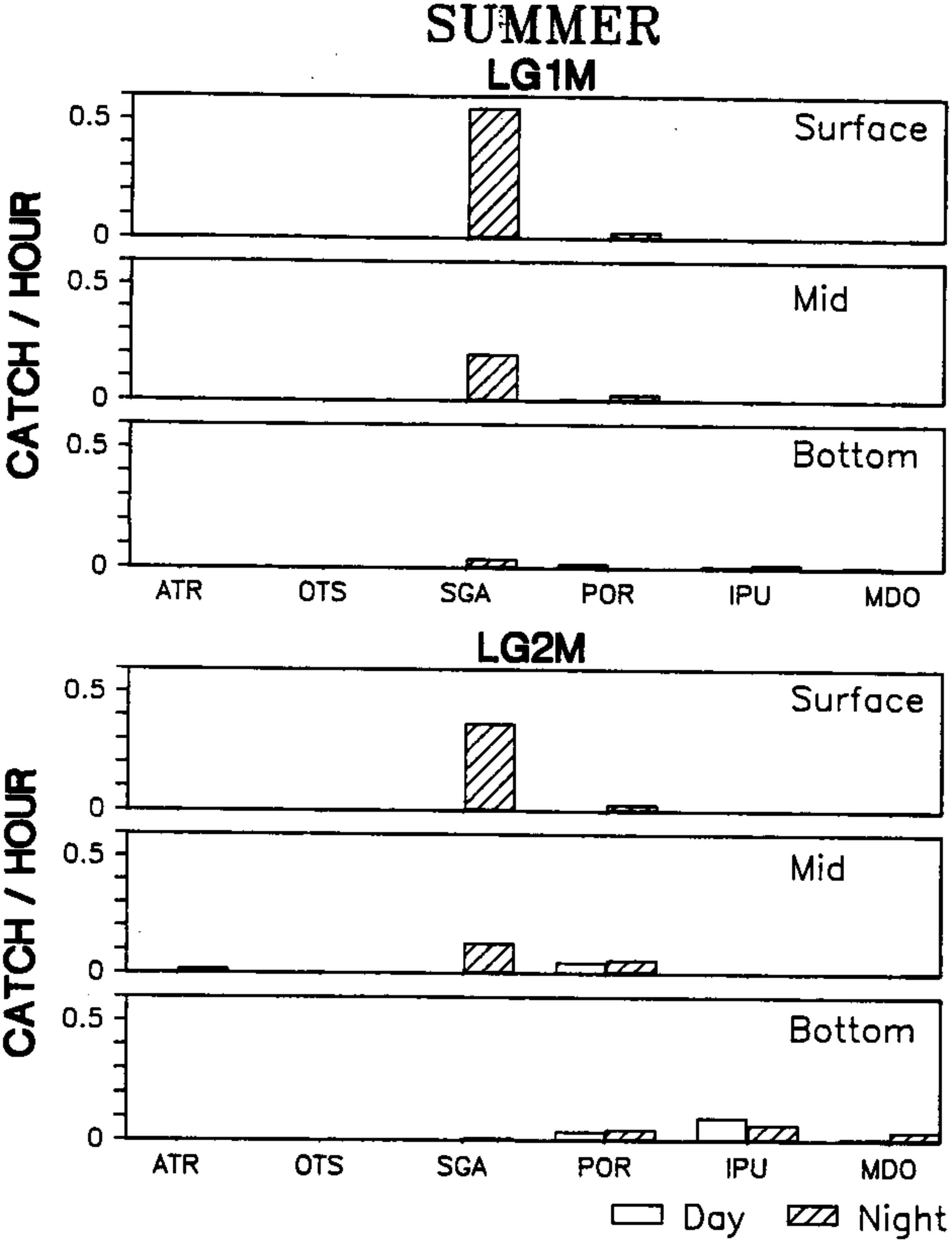

Figure 64. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1M and LG2M during summer, 1987 in Lower Granite Reservoir, Washington.

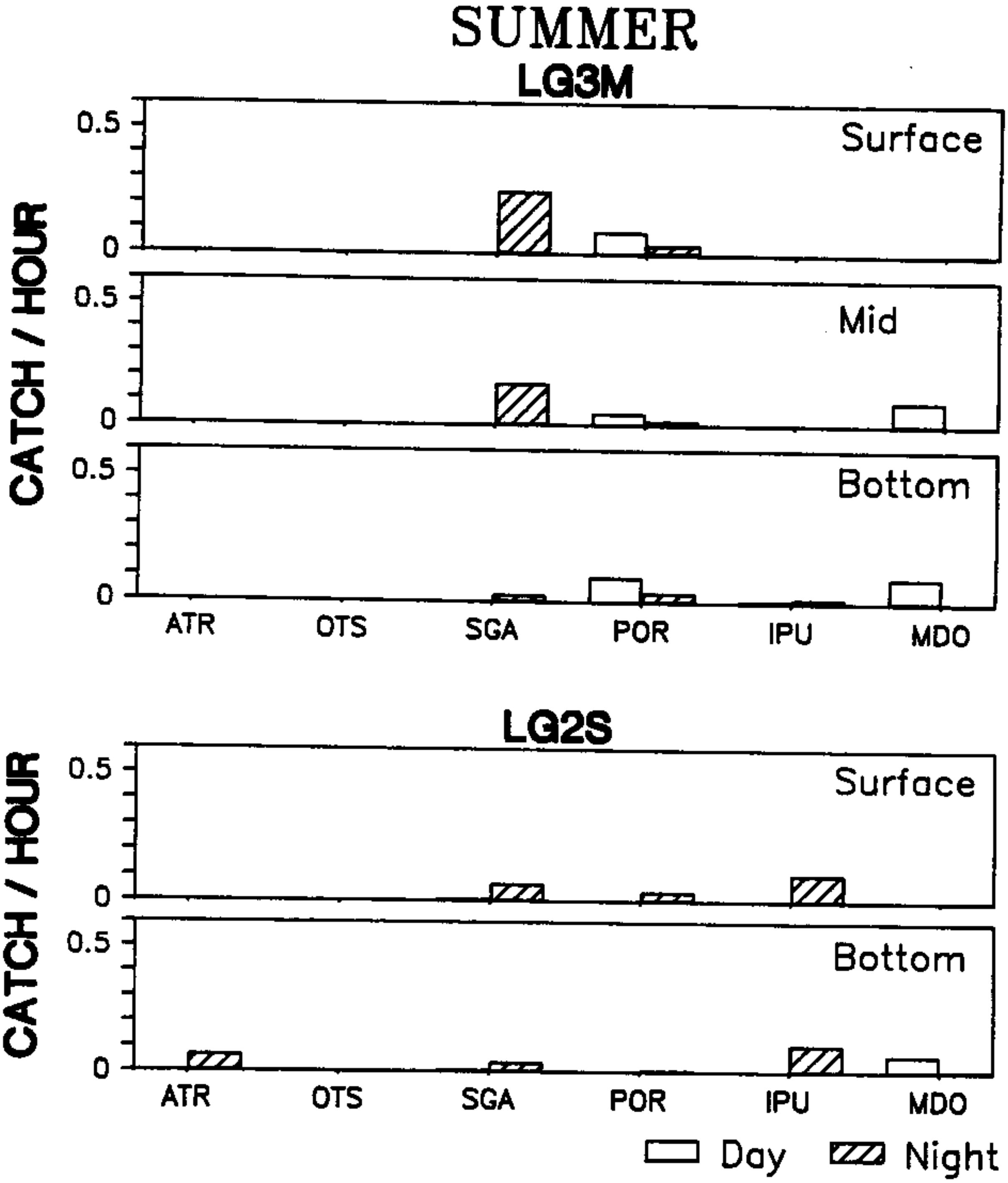

Figure 65. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG3M and LG2S during summer, 1987 in Lower Granite Reservoir, Washington.

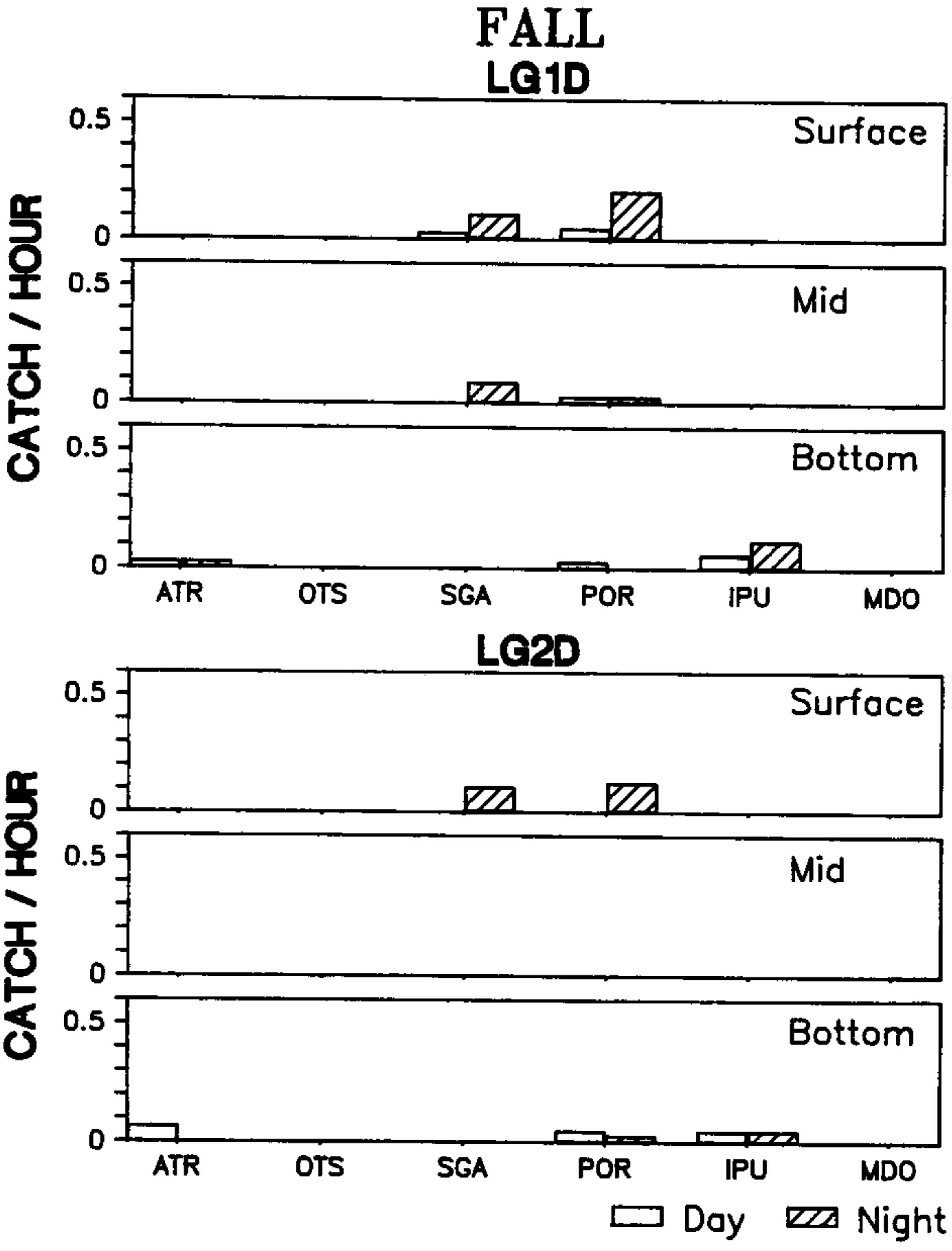

Figure 66. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1D and LG2D during fall, 1987 in Lower Granite Reservoir, Washington.

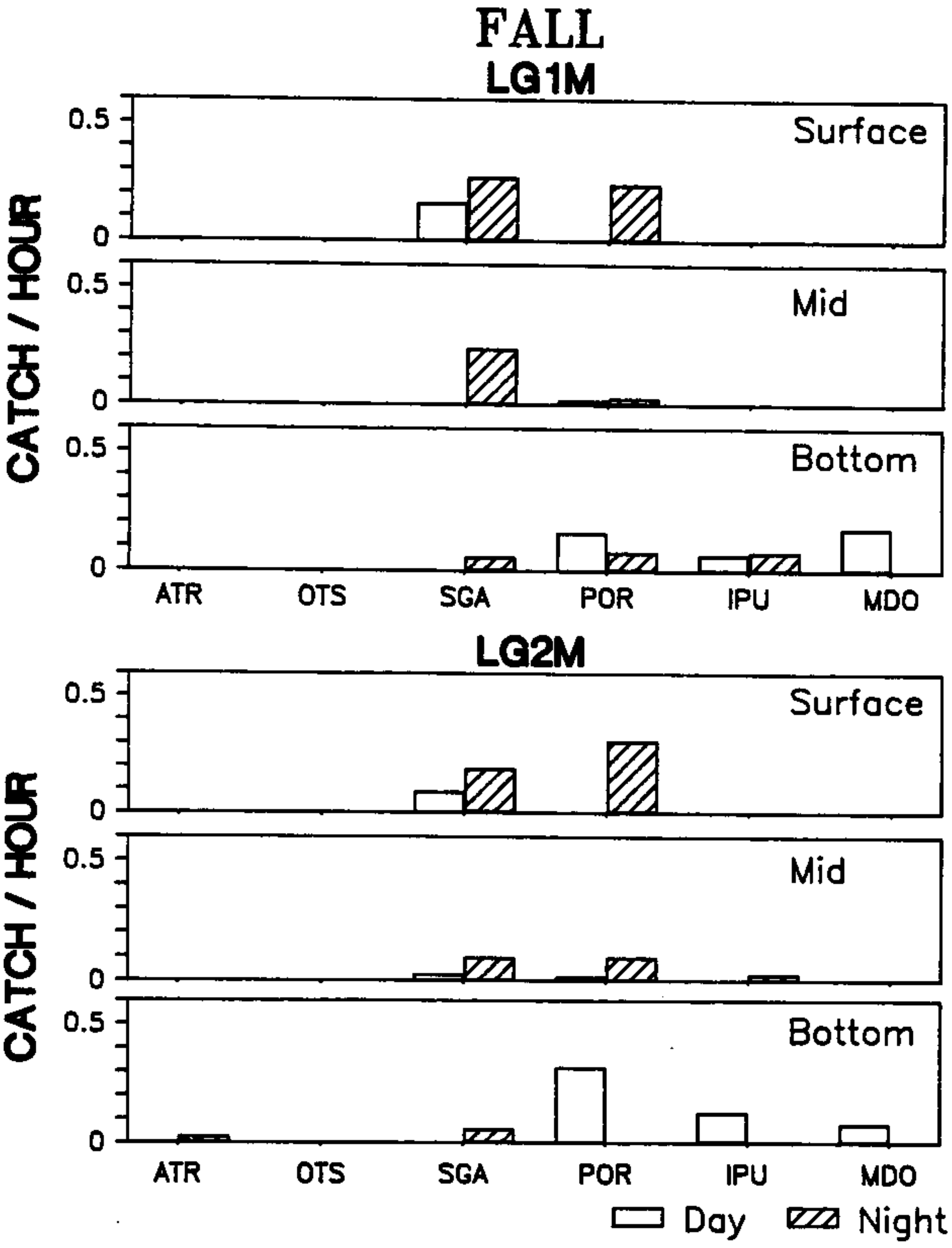

Figure 67. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1M and LG2M during fall, 1987 in Lower Granite Reservoir, Washington.

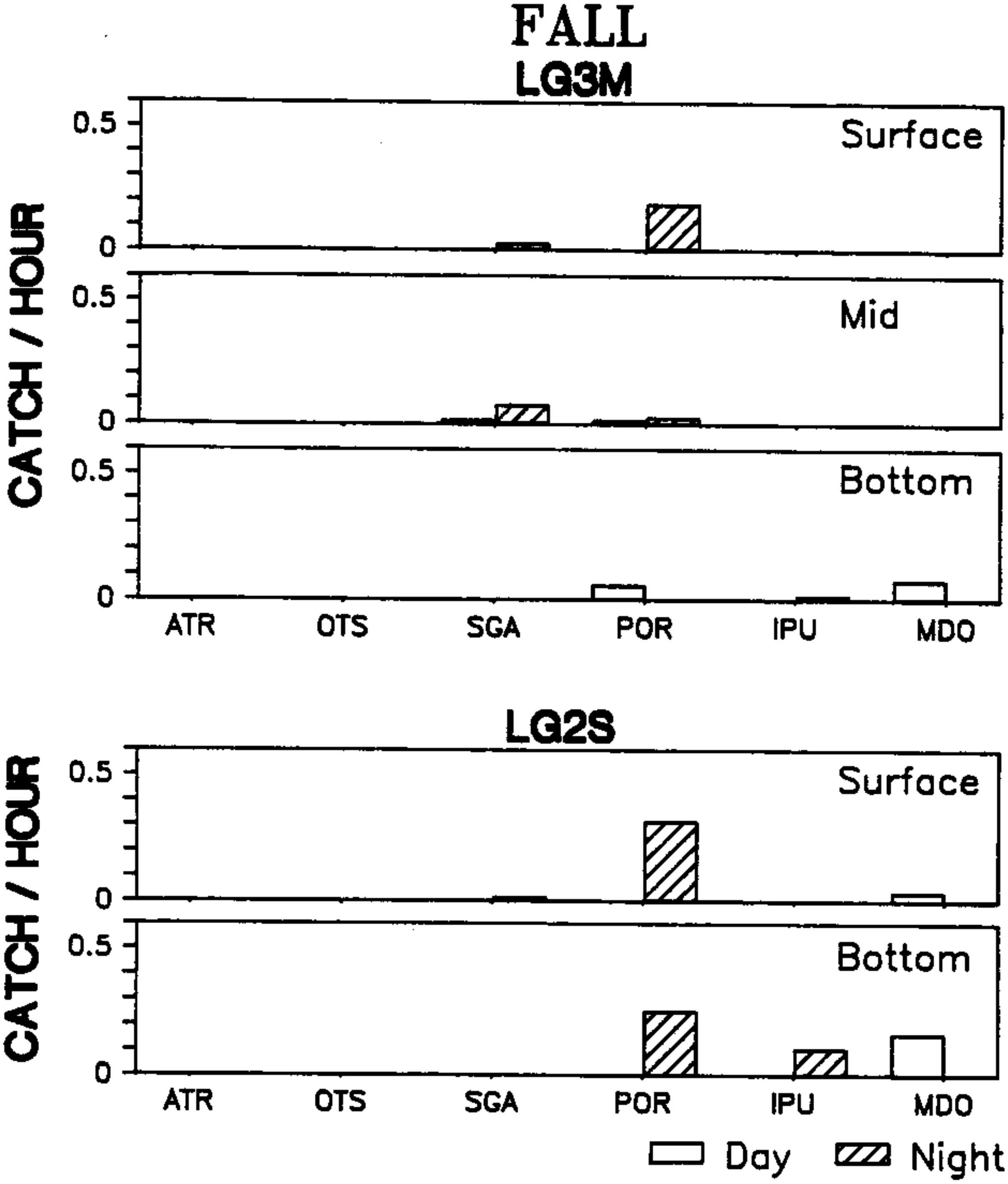

Figure 68. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG3M and LG2S during fall, 1987 in Lower Granite Reservoir, Washington.

the potential for predation may be greater in the fall than in other seasons. As in other seasons, channel catfish, smallmouth bass, and white sturgeon were captured almost exclusively in bottom sets.

The only key species caught in the winter were rainbow trout and northern squawfish (Figures 69-71). Northern squawfish were far more commonly caught at LG1D than other sites, with most of the fish caught during the daytime at the bottom and at the surface during the nighttime.

Hydroacoustics

Spring.-We weighted the total number of fish detected (catch) per transect by the volume sampled per transect which yielded a catch per unit effort (CPUE) in terms of fish numbers per cubic foot. As indicated earlier, because of gear limitations, our comparisons are purely qualitative and not meant to be quantitative. Roughly four times as many fish were recorded at LG3M (248) than LG1M (58), although only twice as many transects were sampled (102 compared to 48 transects; Table 13). Because volume sampled by hydroacoustic gear is directly related to depth (LG3M - 30 ft vs. LG1M - 35 ft), the magnitude of the difference between total numbers of fish recorded is even greater. Also, we found a large number of fish at LG3M at night (160) relative to the day (88), even though only half as much effort was expended during the night (34 out of 68 transects).

CPUE plots show considerably higher catch rates at LG3M than at LG1M (Figure 72). Night catch rates per transect were higher than day catch rates at LG3M. The difference may be attributable to multiple fish records per transect which offset the large number of zero CPUE transects recorded during the day. At LG1M, however, lower and roughly equal catch rates

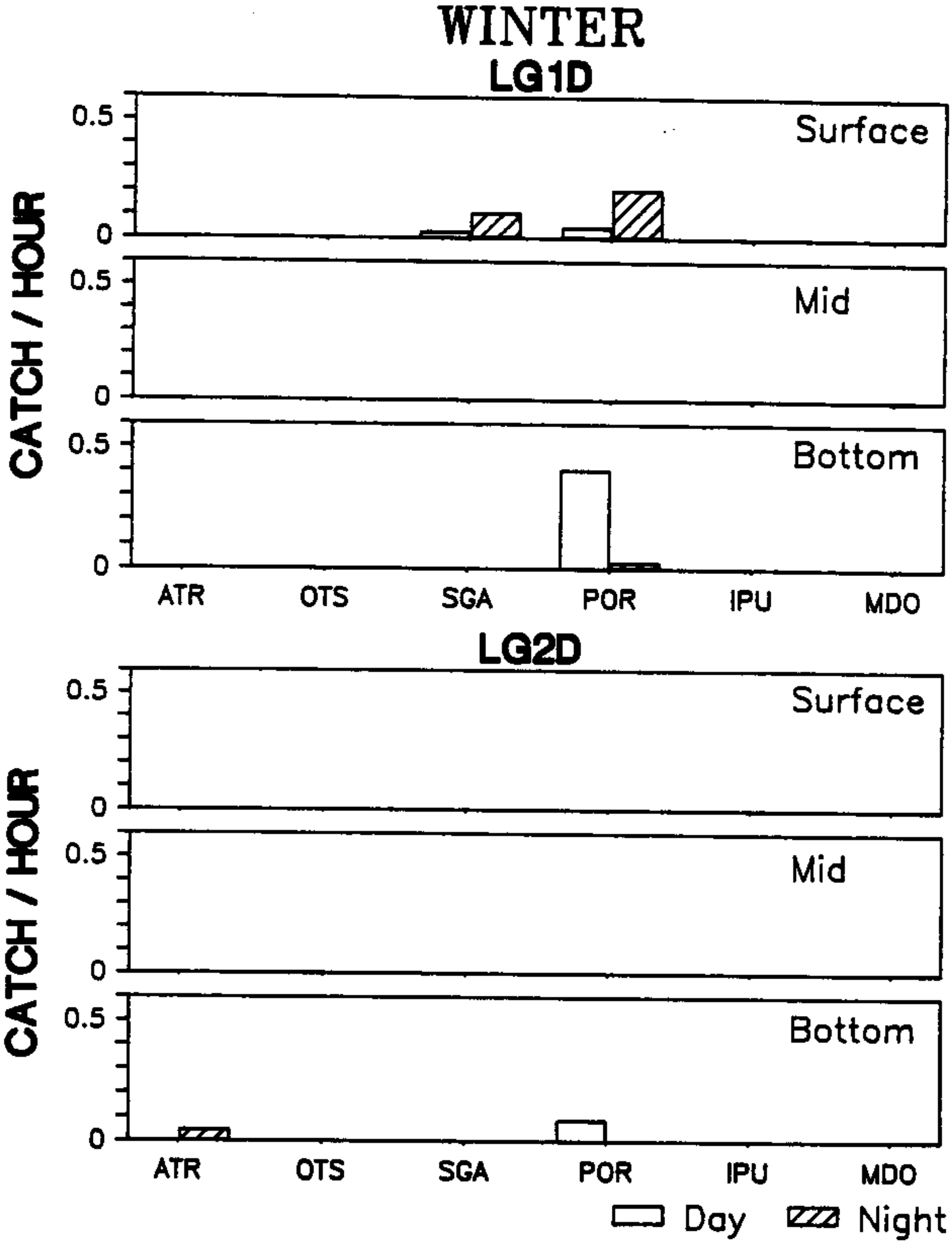

Figure 69. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG1D and LG2D during winter, 1987 in Lower Granite Reservoir, Washington.

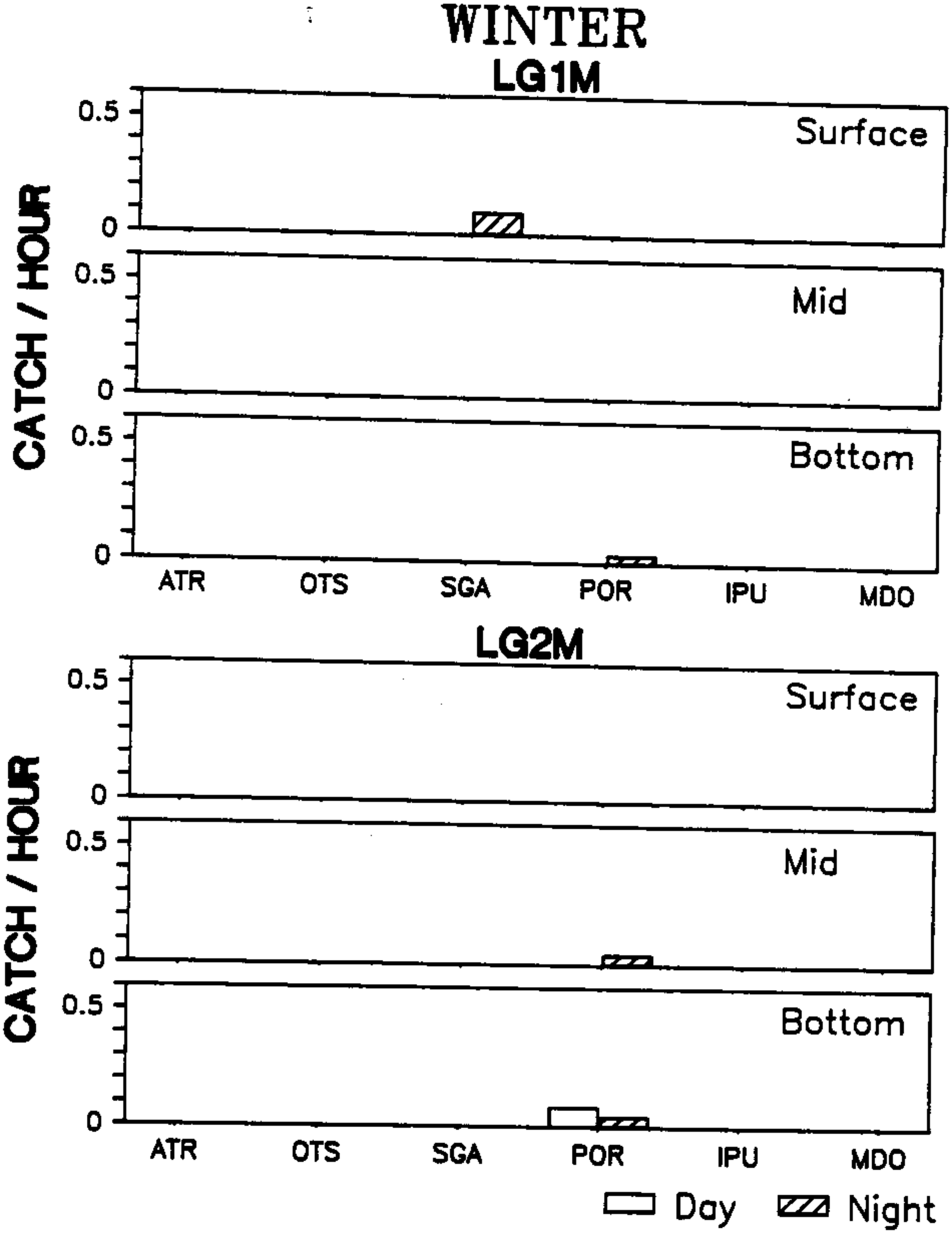

Figure 70. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gilnets fished at surface, mid water, and bottom at LG1M and LG2M during winter, 1987 in Lower Granite Reservoir, Washington.

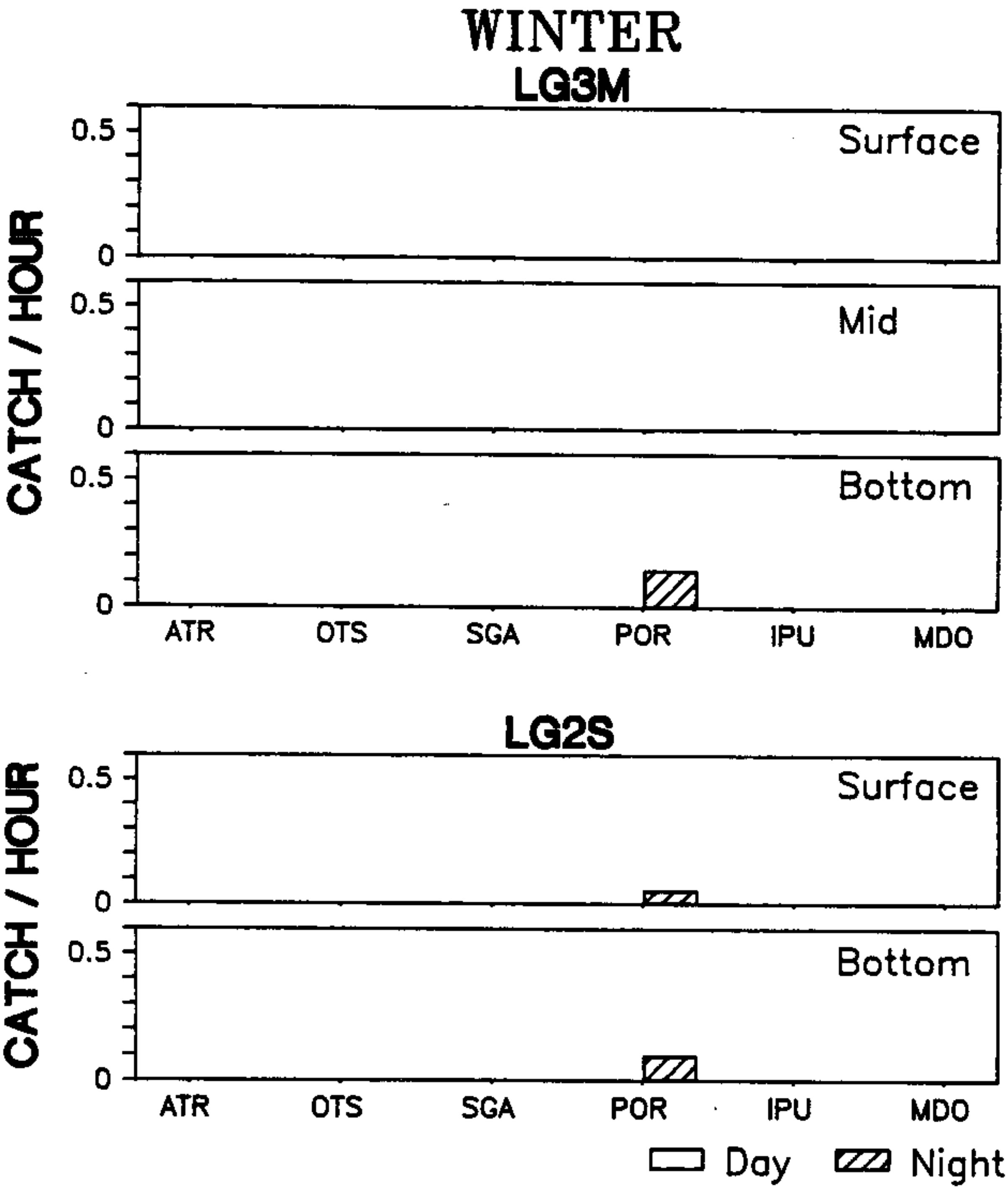

Figure 71. Mean catch per hour for white sturgeon (ATR), chinook salmon (OTS), rainbow trout (SGA), northern squawfish (POR), channel catfish (IPU), and smallmouth bass (MDO) from gillnets fished at surface, mid water, and bottom at LG3M and LG2S during winter, 1987 in Lower Granite Reservoir, Washington.

Table 13. Number of transects, average transect depth, and number of fish recorded during spring, summer, and fall (1987) hydroacoustic sampling on Lower Granite Reservoir, Washington. A transect represents the distance travelled by the boat in 60 seconds while travelling at a constant speed.

	SPRING					SUMMER					FALL				
	1D	2D	1M	2M	3M	1D	2D	1M	2M	3M	1D	2D	1M	2M	3M
No. of day transects	5	0	10	7	68	232	113	217	172	127	207	59	162	88	116
No. of night transects	1	3	38	16	34	107	73	150	74	123	78	16	101	95	72
Total no. of transects	6	3	48	23	102	339	186	367	246	250	285	75	263	183	188
Average transect depth (ft)	.	.	35	45	30	105	82	43	48	35	107	81	44	55	34
No. of day fish records	3	0	29	11	88	423	495	148	298	297	121	51	172	60	29
No. of night fish records	0	7	29	21	160	133	56	130	126	30	104	5	100	152	52
Total no. of fish records	3	7	58	32	248	556	551	278	424	327	225	56	272	212	81

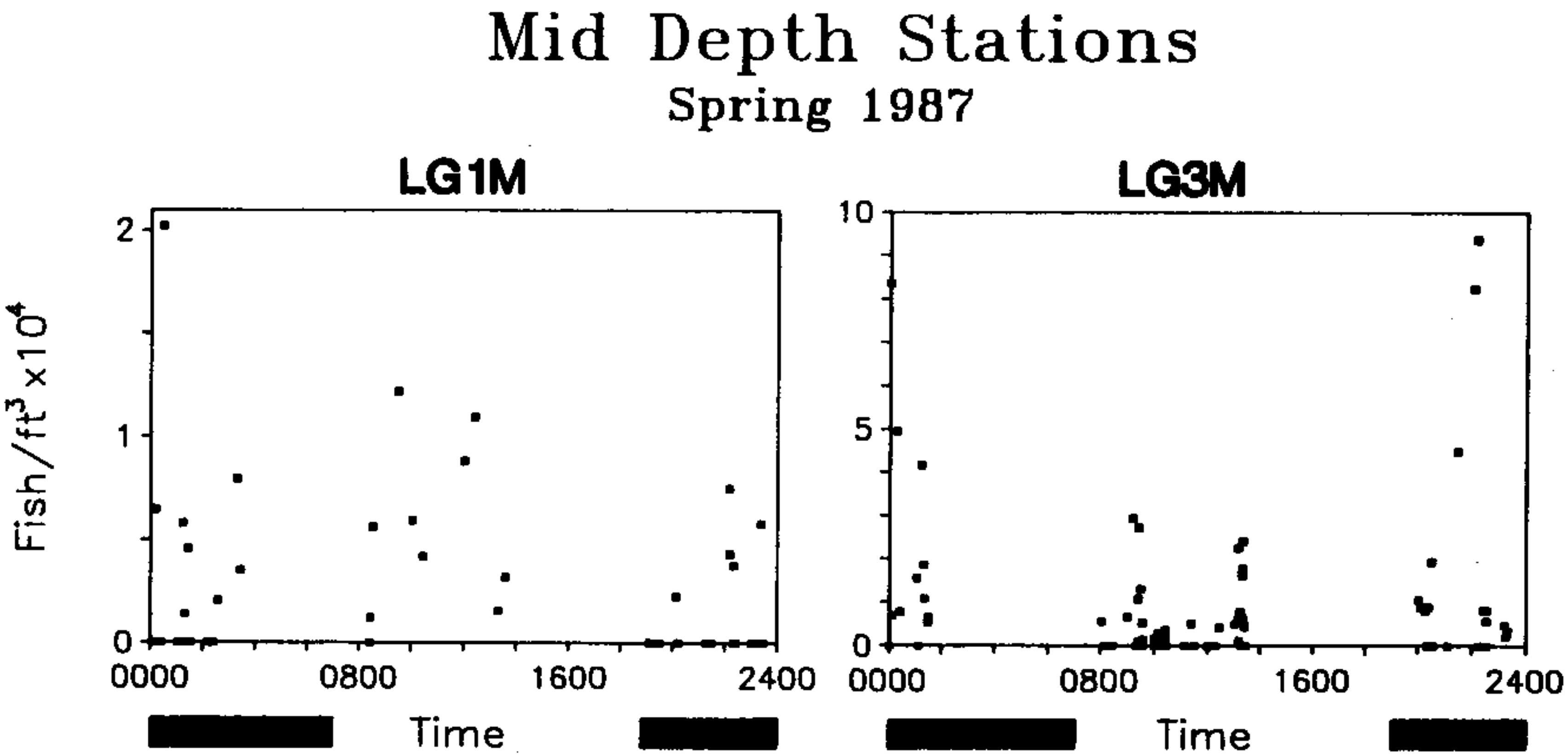

Figure 72. Diel fish density from spring, 1987 hydroacoustical samples at LG1M and LG3M in Lower Granite Reservoir, Washington. Horizontal black bars denote nighttime periods, and each point represents a single transect.

occurred between day and night periods, although the number of zero CPUE transects was less in the day. Fish recorded on transects 20 to 50 ft deep at LG1M were observed most frequently in areas off the bottom during day and night (Figure 73).

Fish depth distribution at LG3M (Figure 74) showed a higher tendency to use the bottom during the day compared to an open water distribution. Although fish depth distribution at night looks fairly uniform, the smaller volume sampled in the upper portion of the water column probably means fish were actually more common higher in the water column. Fish at LG3M do not seem to be selecting areas of specific depth.

Too few transects were sampled during the spring at deep stations to conclude much regarding fish distribution or density. As can be seen in Table 13, the number of fish records was less than 10.

Summer.-Mid depth stations received more effort during the summer than in spring as each station received more than 240 transects (Table 13). Daytime catch rates at LG3M were higher (as in the spring) than other mid depth stations, in contrast to the night catch rates which were the lowest of all the stations (Figure 75). Catch rates at LG3M were distinctly highest during the day, in contrast with the higher night catch rates observed in the spring. Stations LG1M and LG2M show roughly similar catch rates, although LG2M catch rates exhibited wider variation than at LG1M.

Diel fish depth distribution at LG1M was generally similar to that in the spring (Figure 76). Fish were more concentrated in the upper half of the water column day and night. The only notable difference between day and night periods at LG1M was that fish seem to be avoiding the area between the

LG1M

Spring 1987

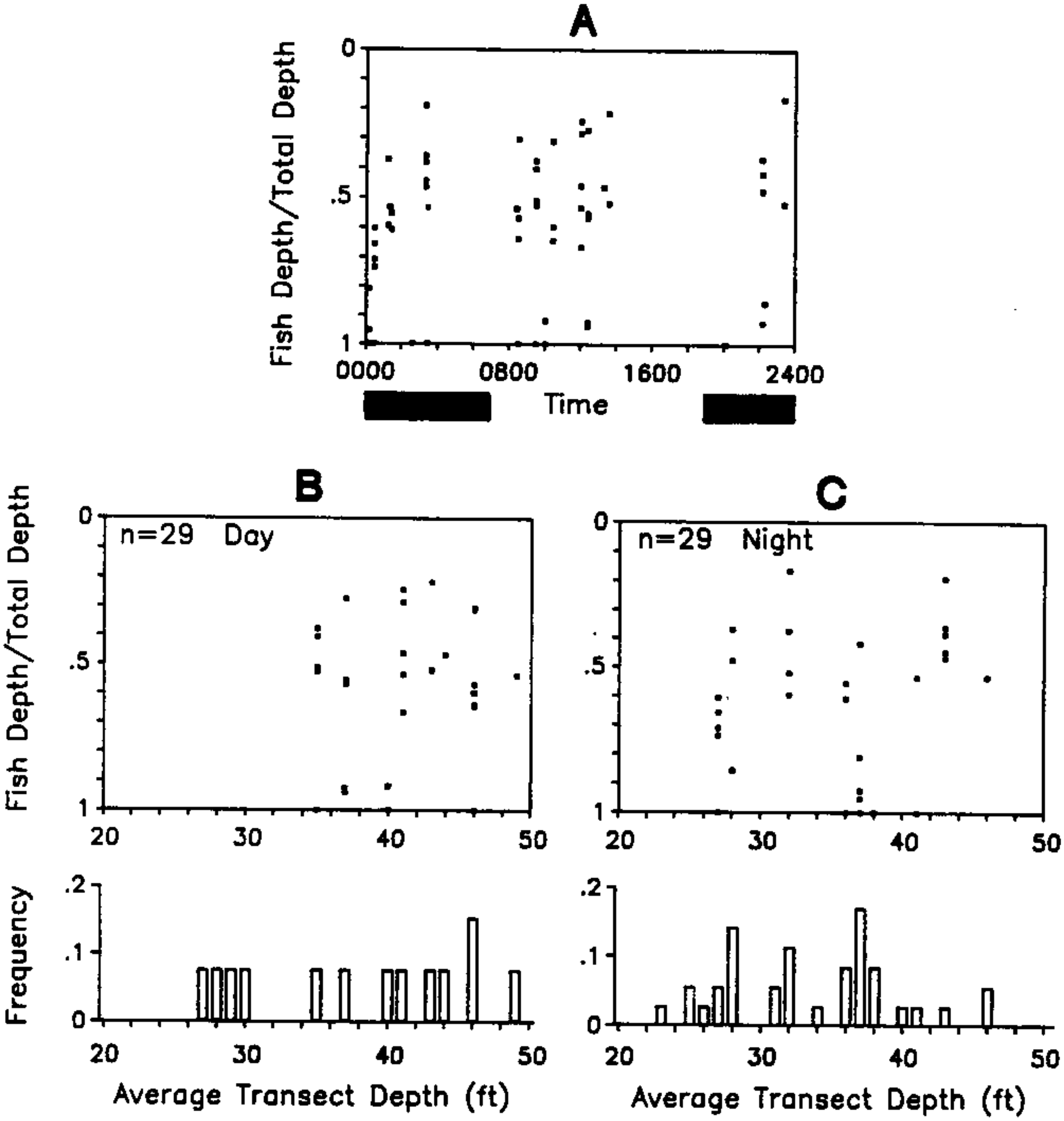

Figure 73. Fish depth distribution (fish depth / total depth) from spring, 1987 hydroacoustical samples on station LG1M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

LG3M
Spring 1987

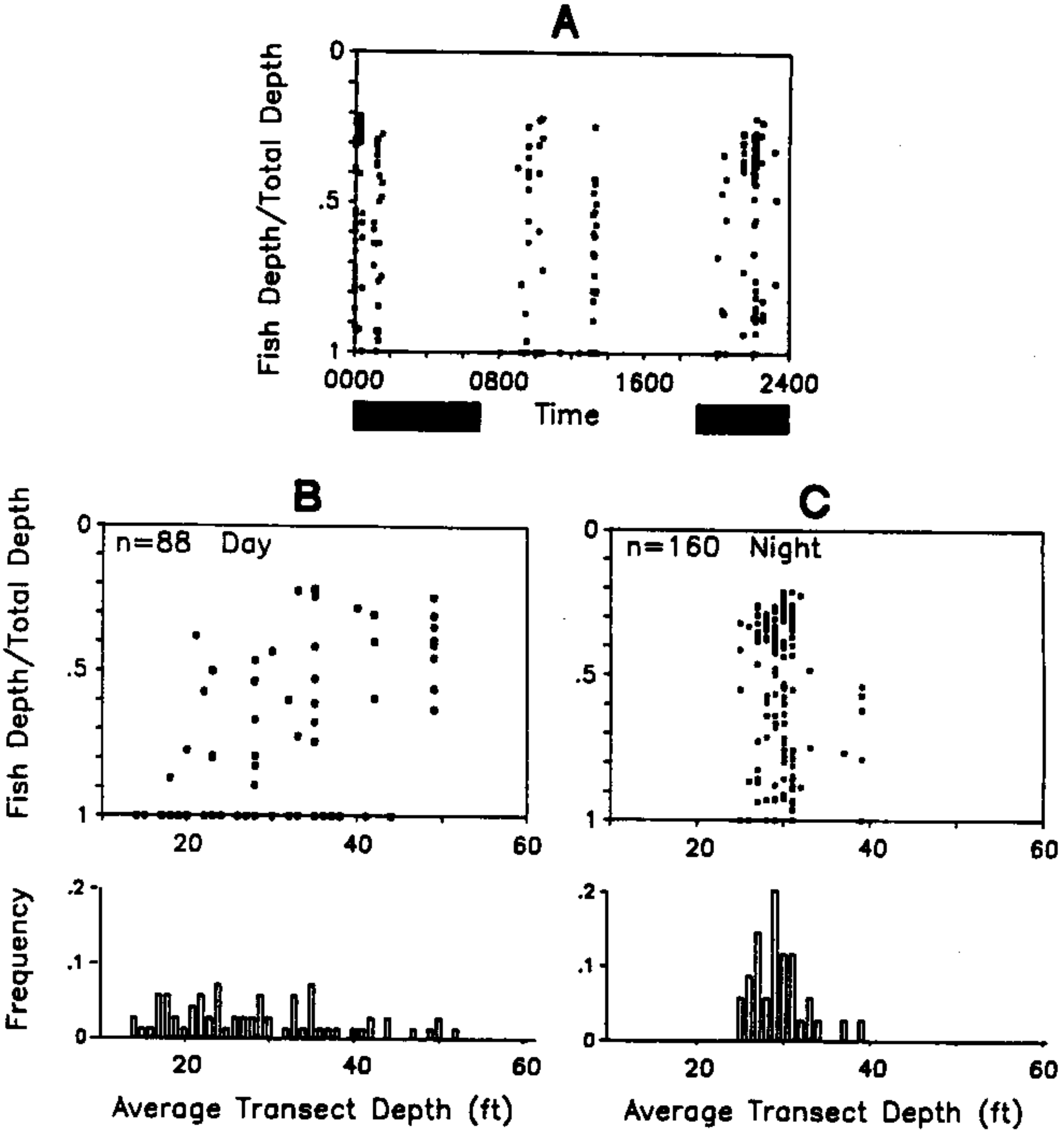

Figure 74. Fish depth distribution (fish depth / total depth) from spring, 1987 hydroacoustical samples on station LG3M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

Mid Depth Stations

Summer 1987

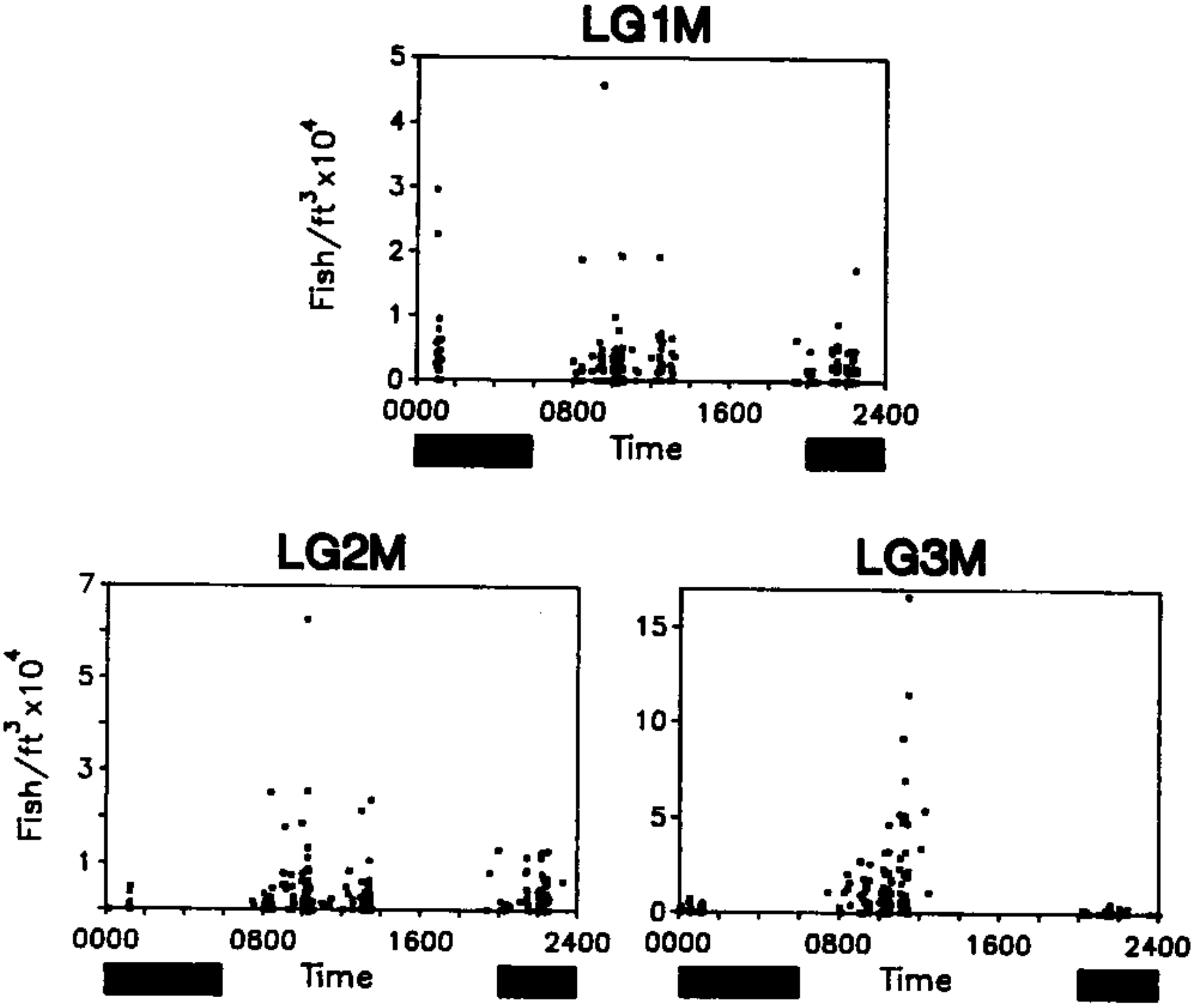

Figure 75. Diel fish density from summer, 1987 hydroacoustical samples at mid depth stations in Lower Granite Reservoir, Washington. Horizontal black bars denote nighttime periods, and each point represents a single transect.

LG1M
Summer 1987

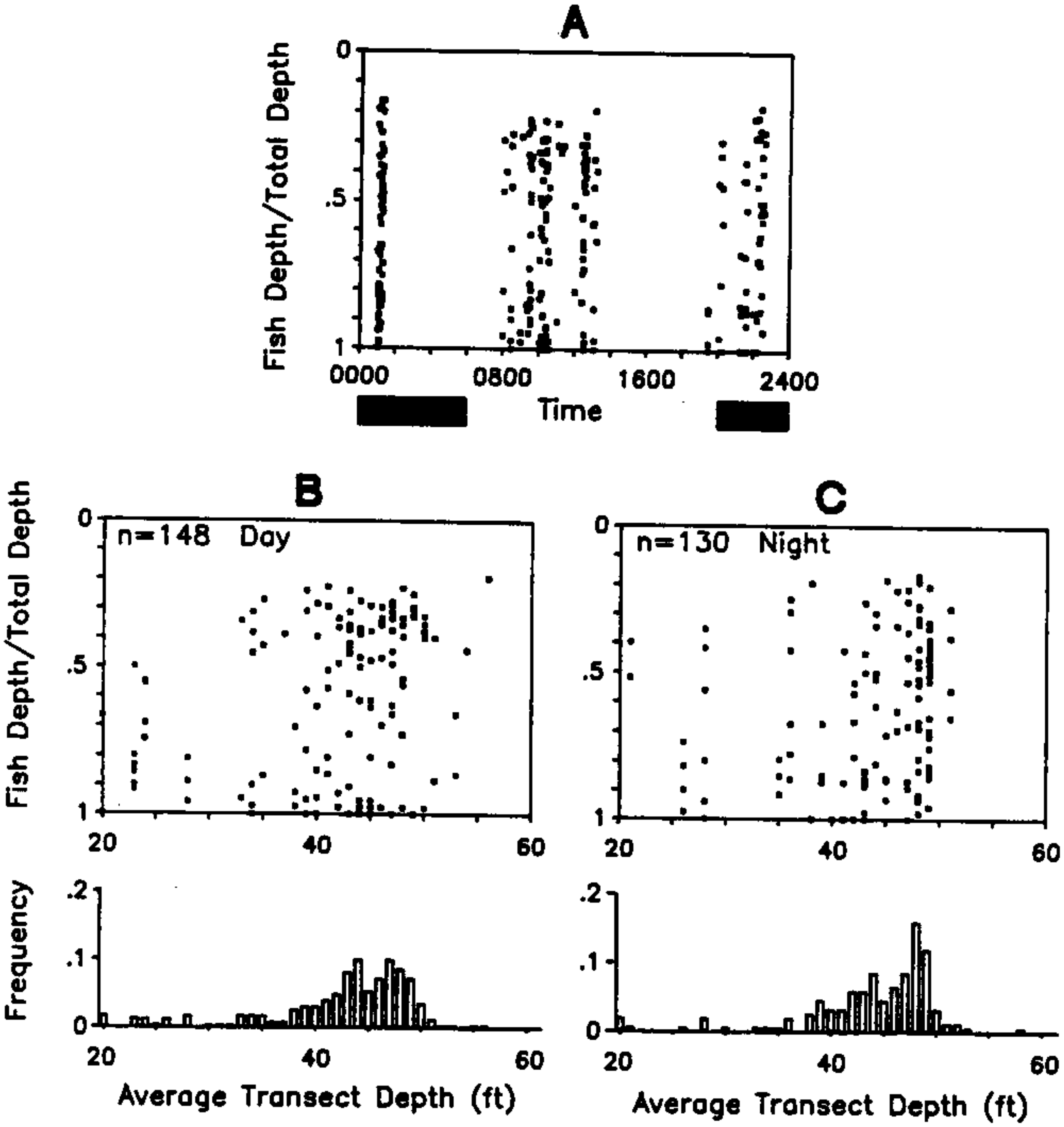

Figure 76. Fish depth distribution (fish depth / total depth) from summer, 1987 hydroacoustical samples on station LG1M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

bottom and upper water column during the day. As in the spring, fish show no preference for areas of specific depth.

Fish depth distribution at LG2M showed a strong diel pattern as fish were highly concentrated in the upper portion of the water column at night (Figure 77). Fish were more common in the upper water column also during the day but to a lesser extent than at night. As at LG1M, fish were detected infrequently between bottom and upper water column regions day and night, although the pattern was most pronounced at night.

The strongest diel pattern of fish abundance at the mid depth stations was observed at station LG3M. Many more fish were recorded in the day, although nearly equal effort was expended at night (Figure 78). Fish were densely scattered throughout the water column during the day, although they were again more concentrated in the upper water column. Apparently, fish were selecting areas of specific depth, avoiding the lower water column when depths exceeded 35 ft.

We sampled 339 transects at LG1D and 186 transects at LG2D during summer sampling (Table 13). Fish totals from deep stations were nearly identical, even though LG1D received over twice the effort. The most dramatic diel difference was observed at LG2D where only 56 out of 551 fish were recorded at night. Daytime catch rates were higher than nighttime rates at both deep stations (Figure 79), while catch rates at LG1D were higher than those at LG2D during both day and night.

Although catch rates differed between day and night at the deep stations, fish depth distribution did not. Fish recorded on transects 60 to 120 ft deep at LG1D were generally concentrated in the upper water column (Figure 80). Lack of fish records between the bottom and the upper half of

LG2M
Summer 1987

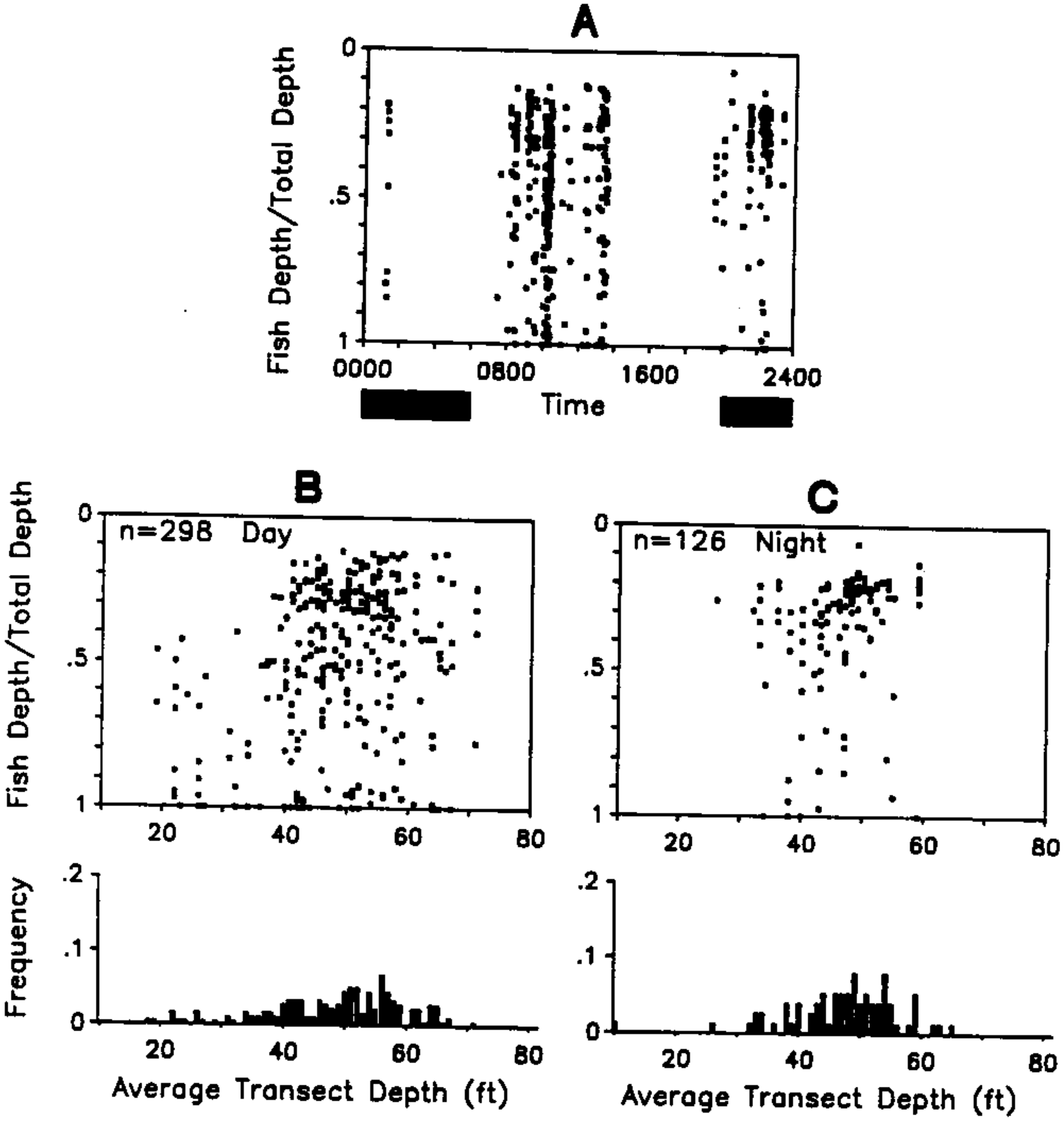

Figure 77. Fish depth distribution (fish depth / total depth) from summer, 1987 hydroacoustical samples on station LG2M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

LG3M
Summer 1987

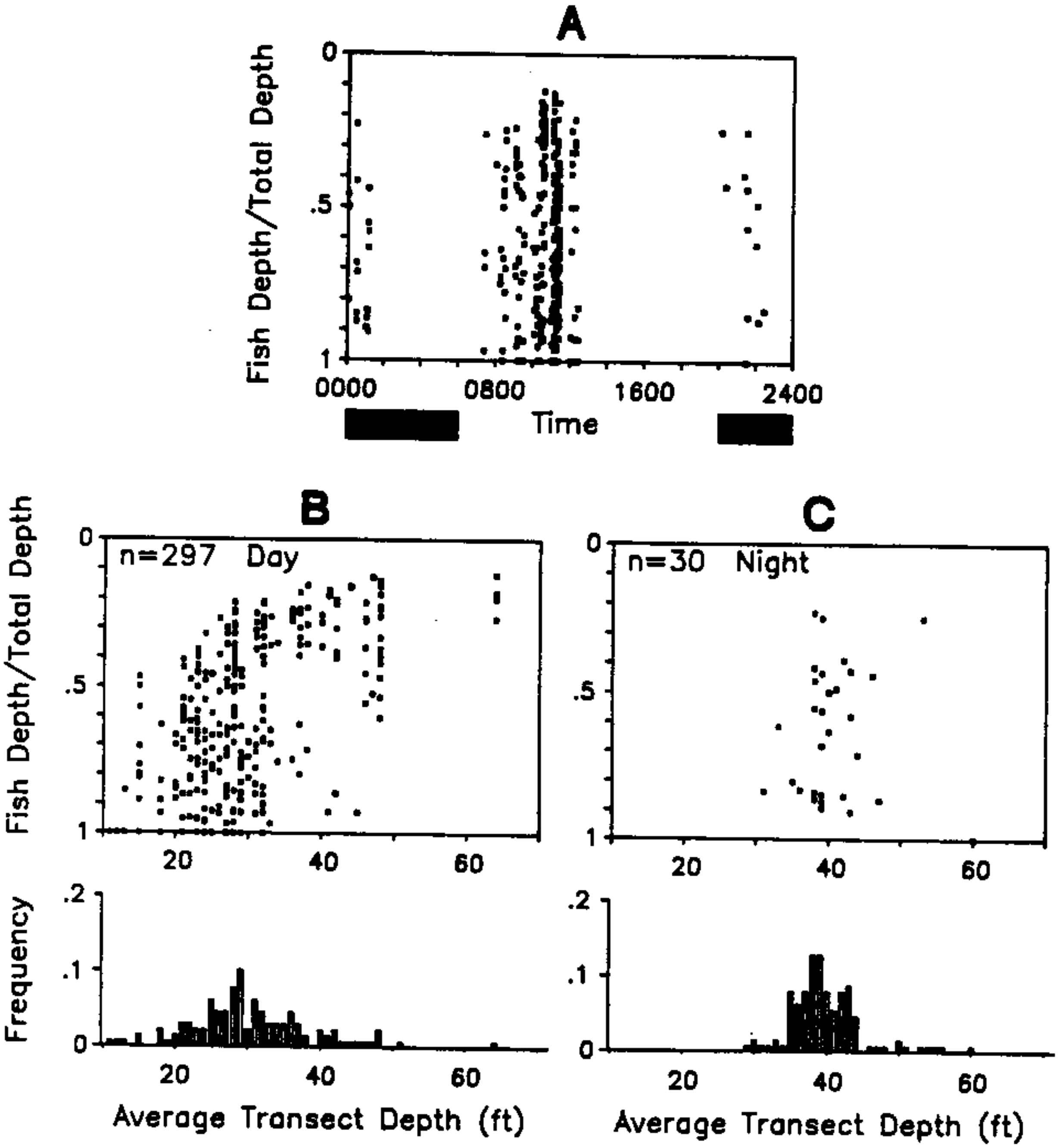

Figure 78. Fish depth distribution (fish depth / total depth) from summer, 1987 hydroacoustical samples on station LG3M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

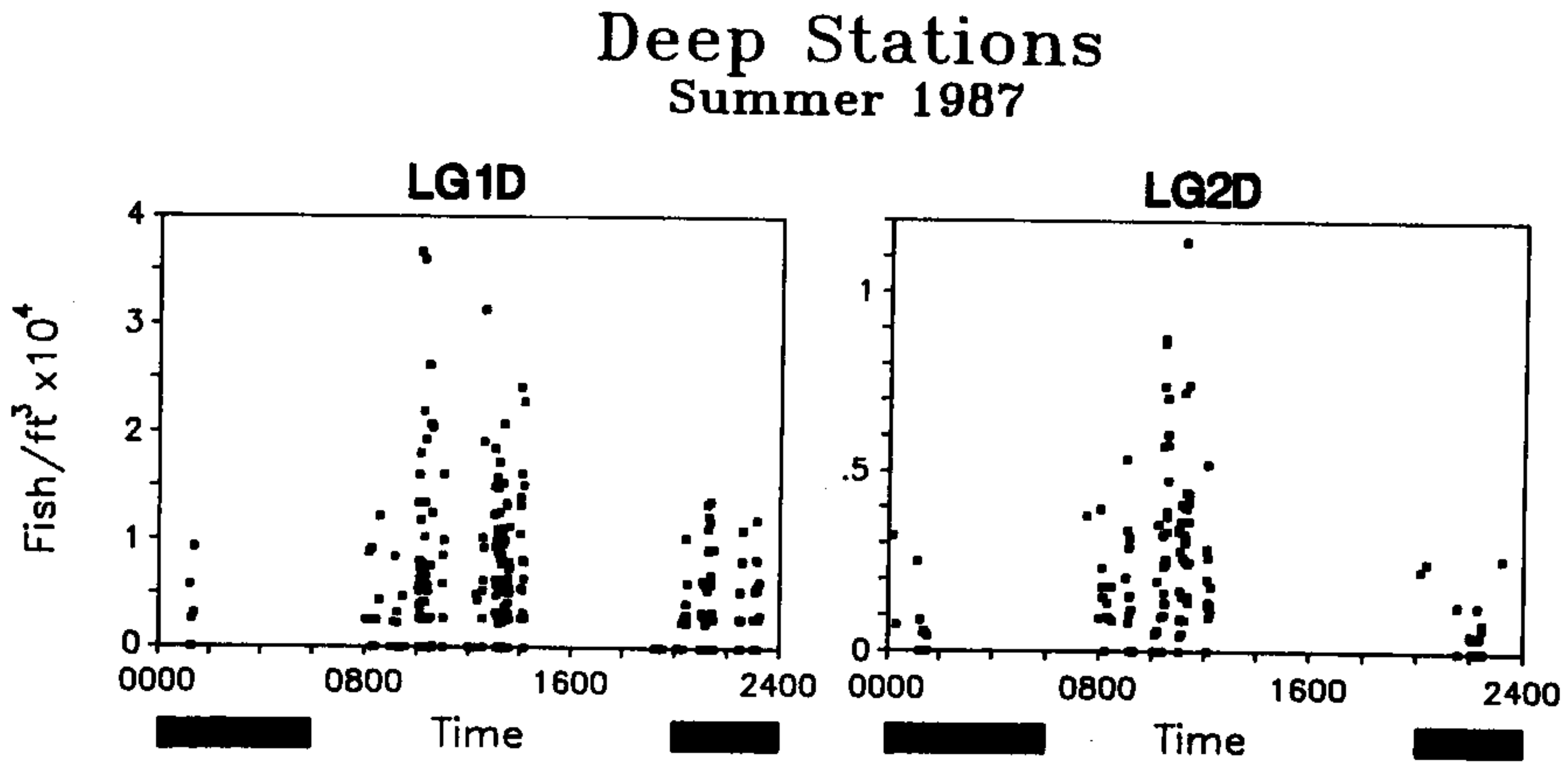

Figure 79. Diel fish density from summer, 1987 hydroacoustical samples at deep stations in Lower Granite Reservoir, Washington. Horizontal black bars denote nighttime periods, and each point represents a single transect.

LG1D
Summer 1987

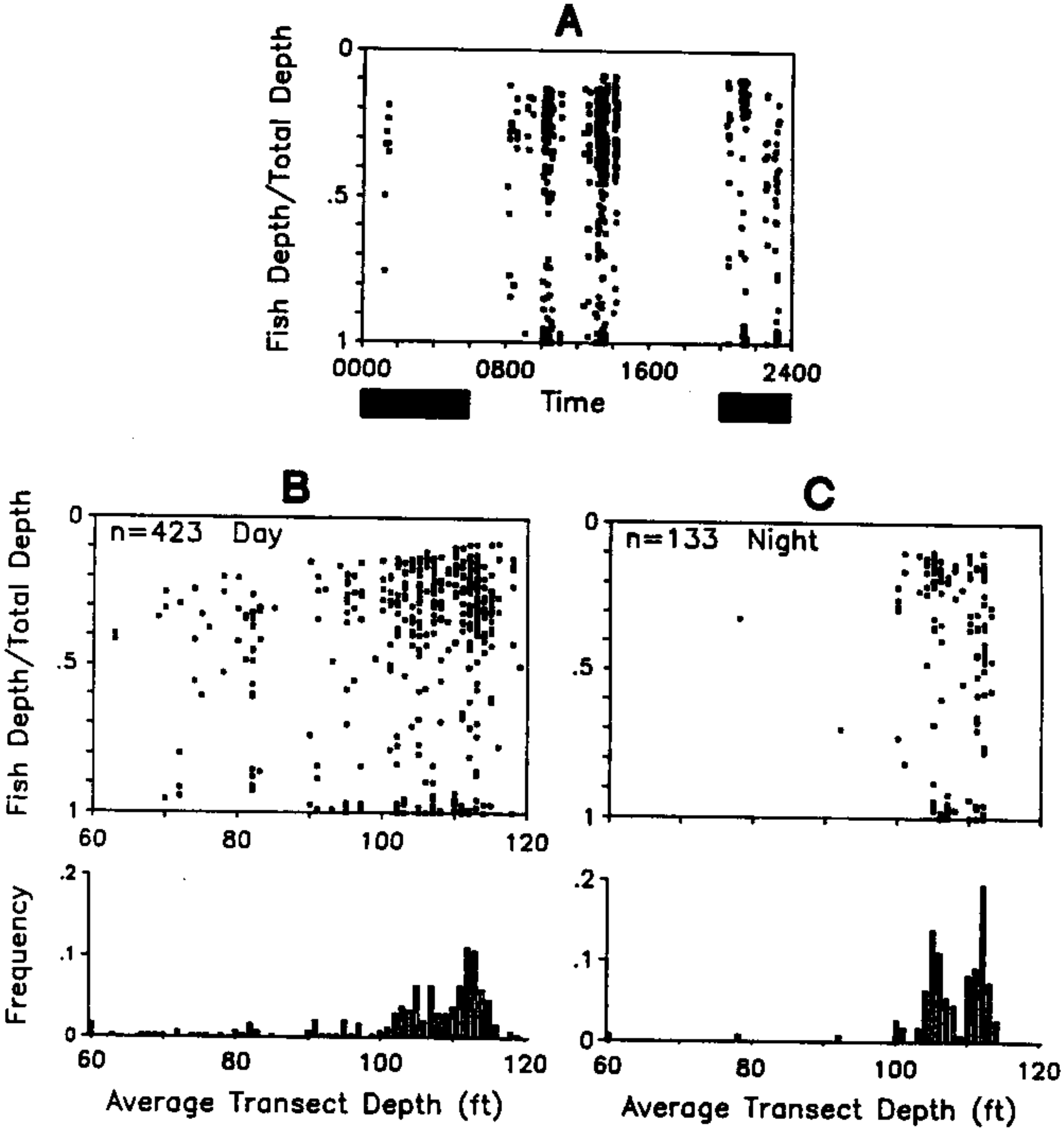

Figure 80. Fish depth distribution (fish depth / total depth) from summer, 1987 hydroacoustical samples on station LG1D at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

the water column reflects a true absence of fish. As at LG1D, fish at LG2D were concentrated in the upper third of the water column during the day and night (Figure 81). Few fish records were observed on or near the bottom.

Fall.-Number of transects conducted in the fall ranged from 75-285 (Table 13). Catch rates at LG1M and LG2M were approximately equal, while catch rates at LG3M were the lowest of the mid depth stations (Figure 82). Catch rates at LG2M and LG3M were slightly higher at night.

Fish at LG1M exhibited different diel depth distributions (Figure 83). During the day, fish were distributed approximately evenly throughout the water column. At night, fish were more concentrated in the upper water column than during the day, although the difference between fish occurrence in upper and lower portions of the water column at night was slight. As in the summer, fish showed no clear preference for areas of specific depth.

Fish records at LG2M were most abundant at night, and showed non-uniform diel depth distributions (Figure 84). Depth preference of fishes at night appeared to be inversely related to depth. Relatively few fish were recorded during the day, but those recorded indicated activity was within the upper water column. Fish at LG2M displayed no obvious preference for specific depth.

In contrast with the summer, fall transects at LG3M yielded the lowest catch rates of all mid depth stations, and showed a strong diel pattern in abundance and depth distribution (Figure 85). Fish were most abundant at night, and seemingly showed a strong preference for the upper water column. During the day, fish were concentrated near the bottom, although not in high abundance. Bottom fish did not seem to avoid the deeper shelf areas (35 - 45 ft) as strongly as in the summer.

LG2D
Summer 1987

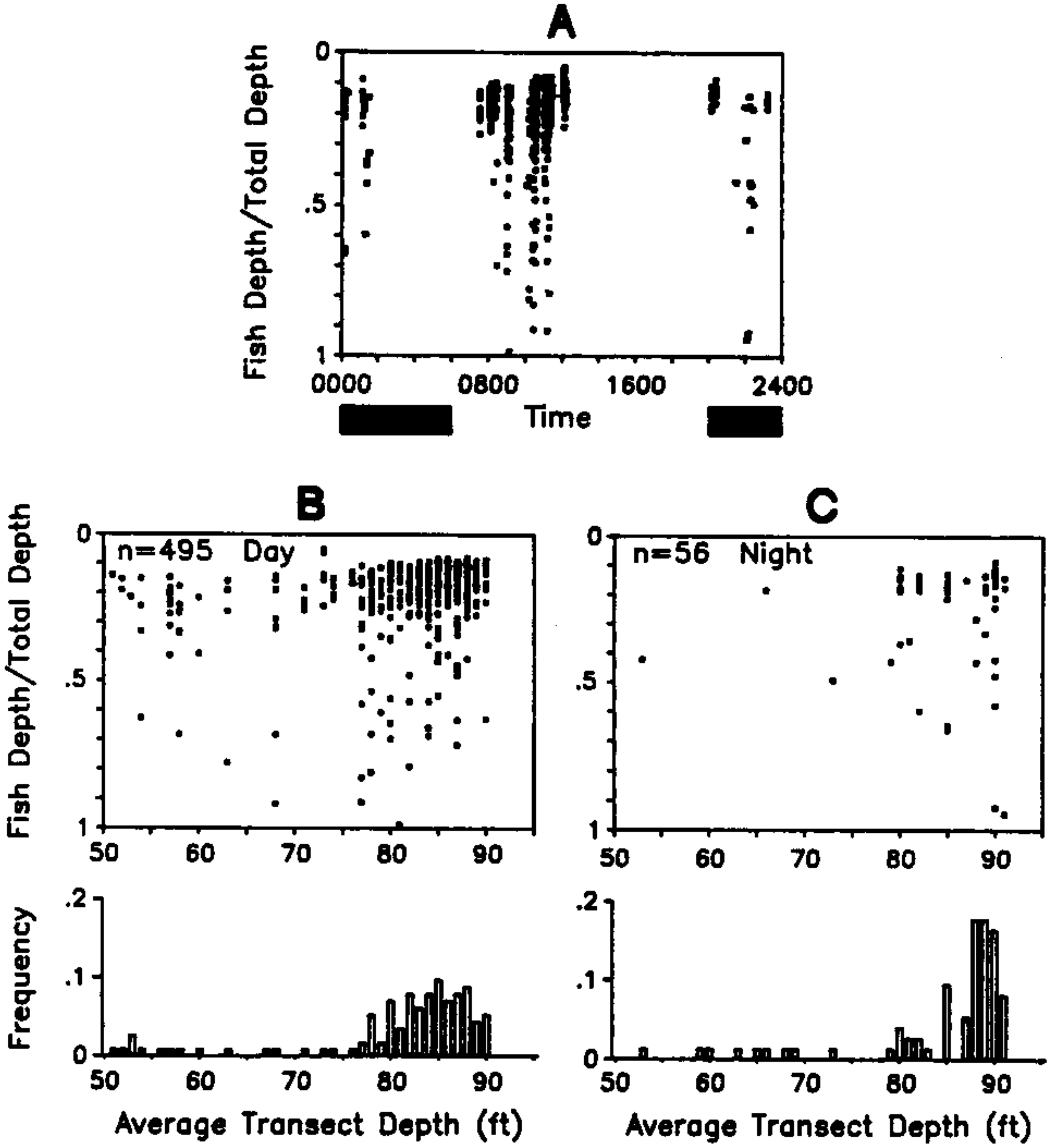

Figure 81. Fish depth distribution (fish depth / total depth) from summer, 1987 hydroacoustical samples on station LG2D at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

Mid Depth Stations

Fall 1987

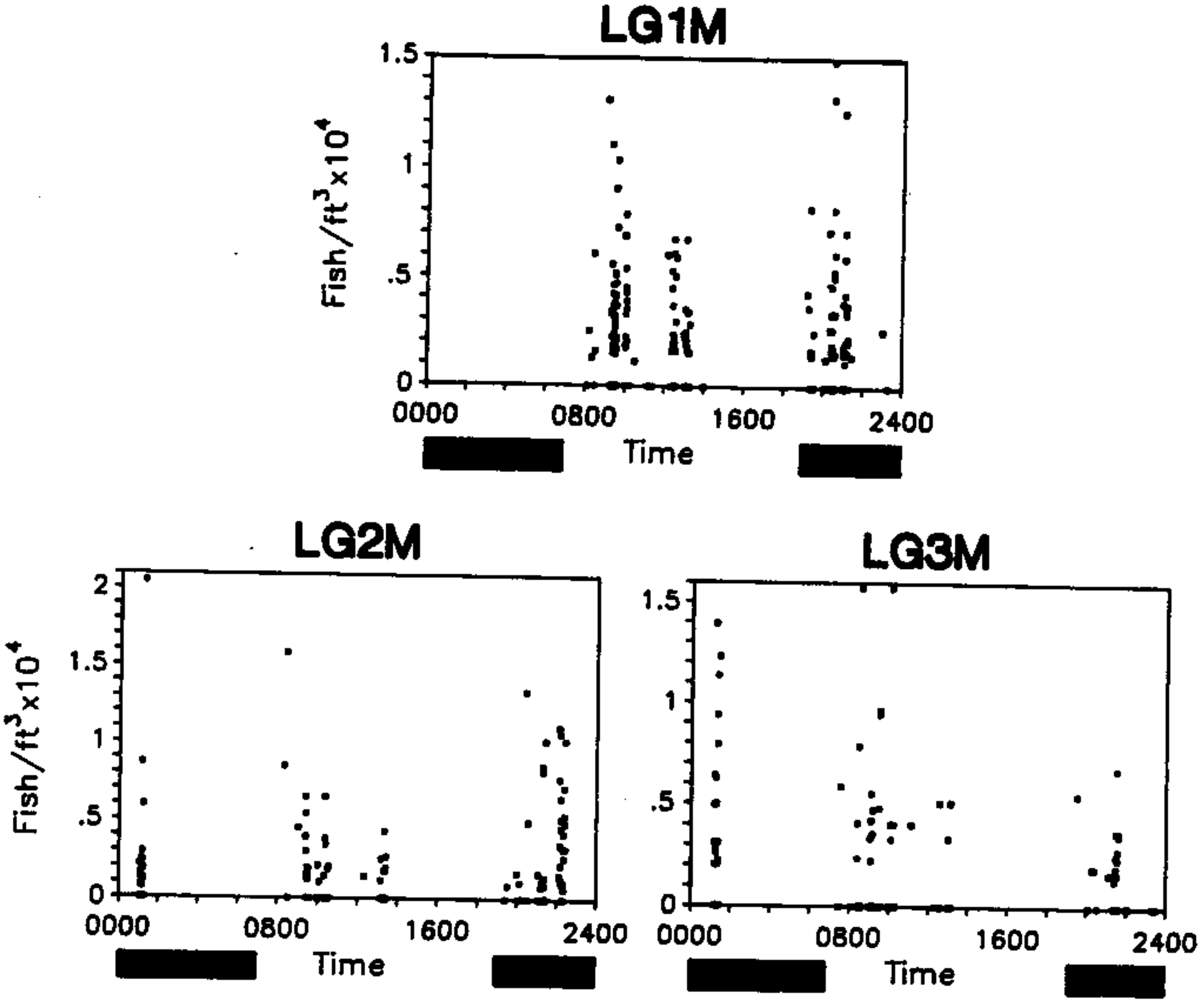

Figure 82. Diel fish density from fall, 1987 hydroacoustical samples at mid depth stations in Lower Granite Reservoir, Washington. Horizontal black bars denote nighttime periods, and each point represents a single transect.

LG1M
Fall 1987

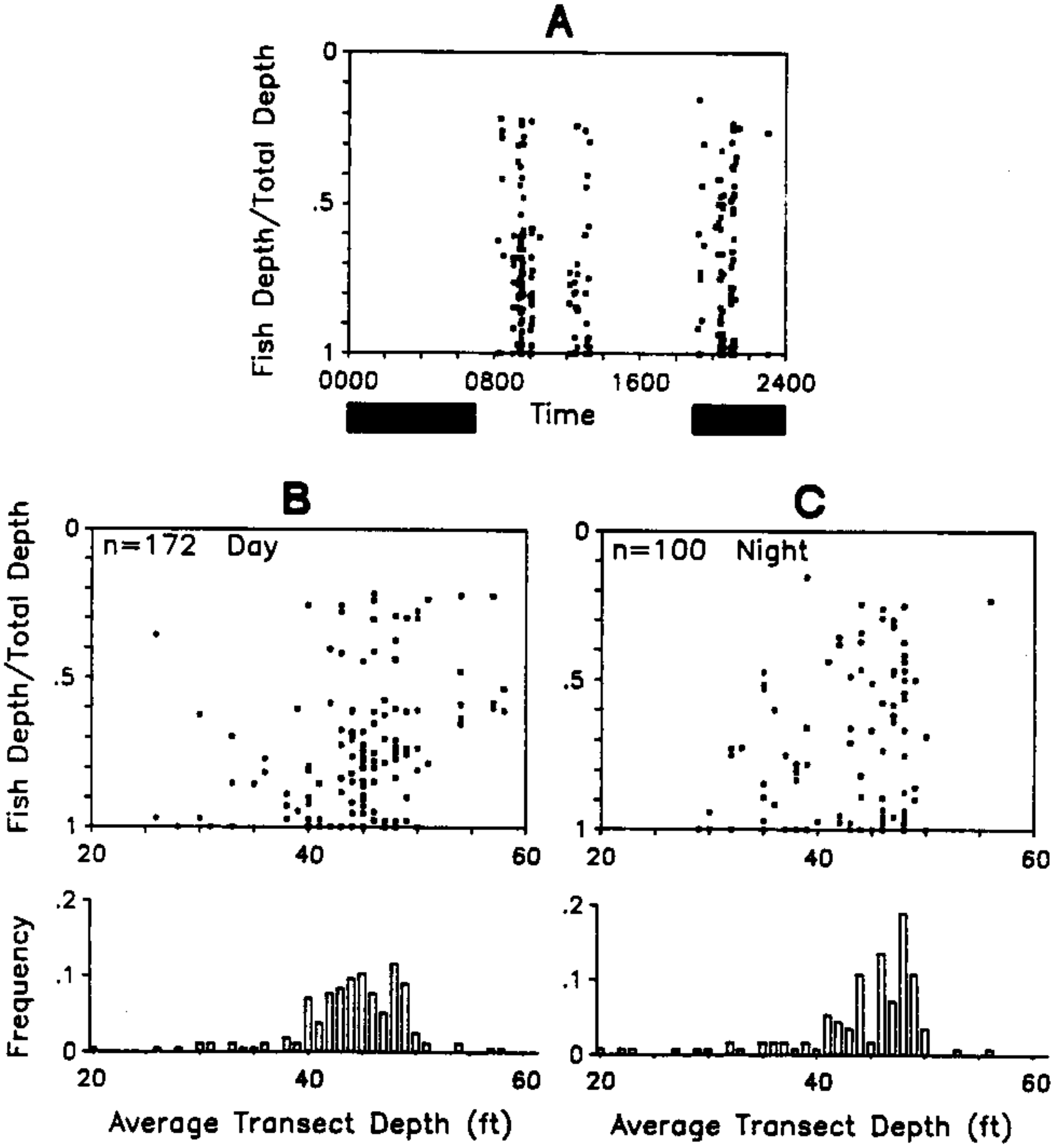

Figure 83. Fish depth distribution (fish depth / total depth) from fall, 1987 hydroacoustical samples on station LG1M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

LG2M
Fall 1987

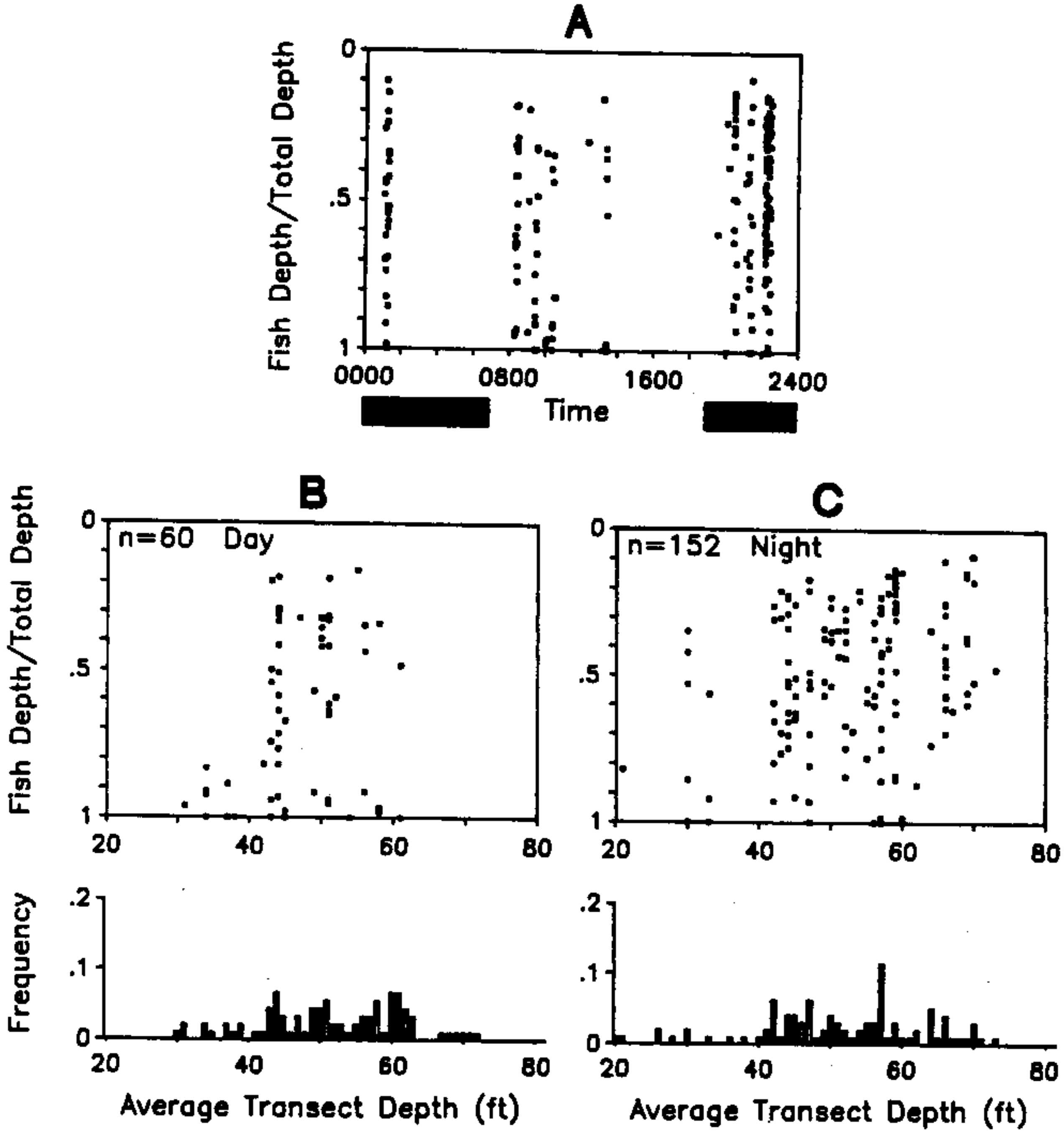

Figure 84. Fish depth distribution (fish depth / total depth) from fall, 1987 hydroacoustical samples on station LG2M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

LG3M
Fall 1987

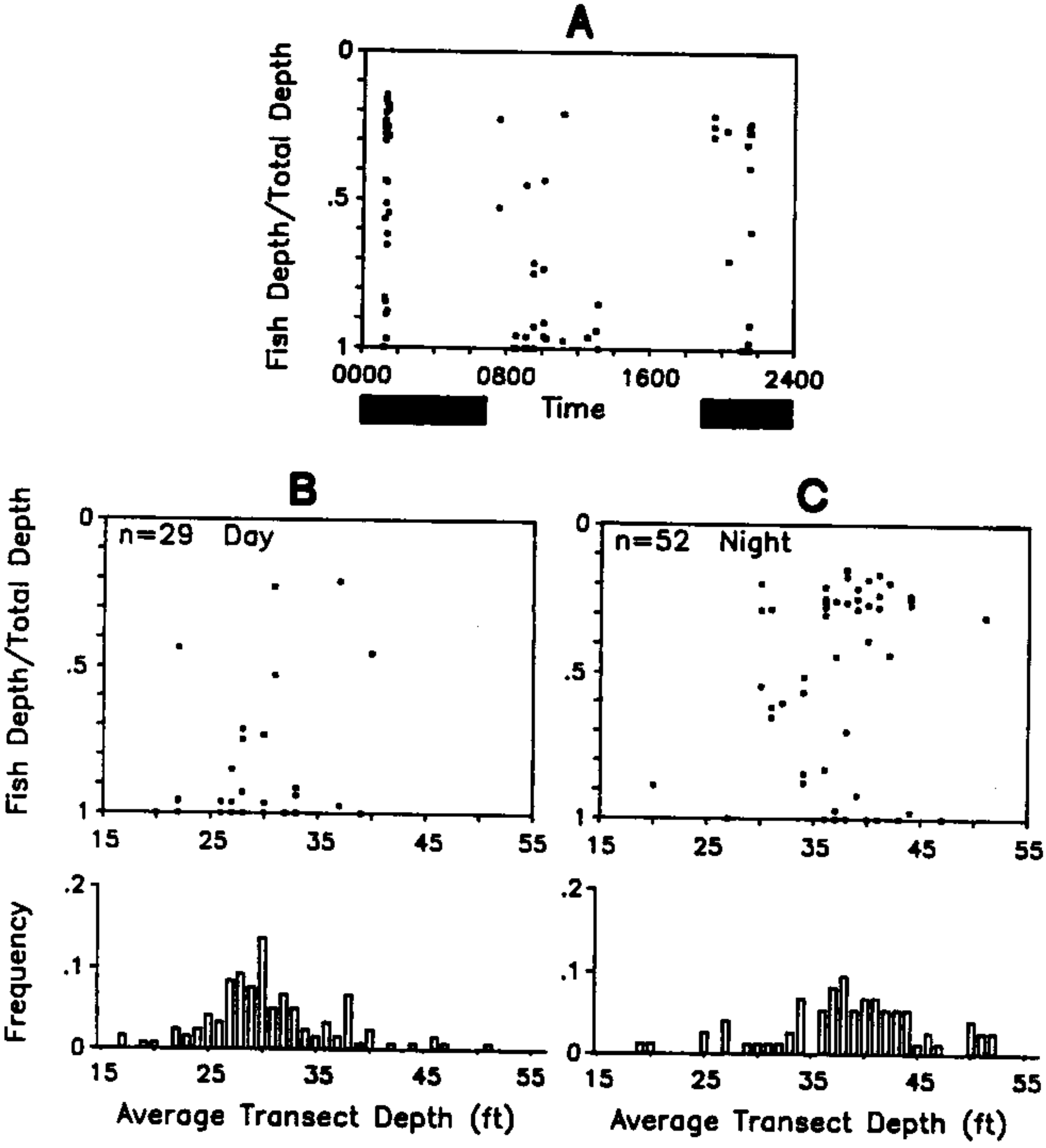

Figure 85. Fish depth distribution (fish depth / total depth) from fall, 1987 hydroacoustical samples on station LG3M at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

Station LG1D was sampled more heavily than was LG2D in the fall (285 vs. 75 transects; Table 13). Fish totals, however, followed the same pattern, with LG1D producing 225 records compared to 56 records from LG2D. Catch rates for the two deep stations were similar (Figure 86). Deep stations differed in that nighttime catch rates at LG1D were higher than daytime, whereas at LG2D, daytime catch rates were greater than nighttime rates.

Fall sampling at the deep stations suggested that fish depth distribution patterns were similar to those in the summer. Fish were concentrated in the upper portion of the water column at both LG1D (Figure 87) and LG2D (Figure 88) and to a lesser extent near the bottom, leaving an unoccupied region between these two areas.

Objective 4: To assess occurrence of salmonid predation by resident fishes at various sampling stations in Lower Granite Reservoir.

Methods

Seasonal food habits were determined by sampling fish stomachs at each of the six stations. In addition, fishes for food habits information were collected at four additional shallow stations (see Bennett et al. 1988 for specifics). Fishes were collected by beach seining, night and day electrofishing, and gillnetting. Diel food habits were determined from stomachs collected from both day and night sampling efforts as fish were available.

Lengths chosen for predator stomach analysis were based on previous smolt predation research conducted in John Day Reservoir. Gray et al.

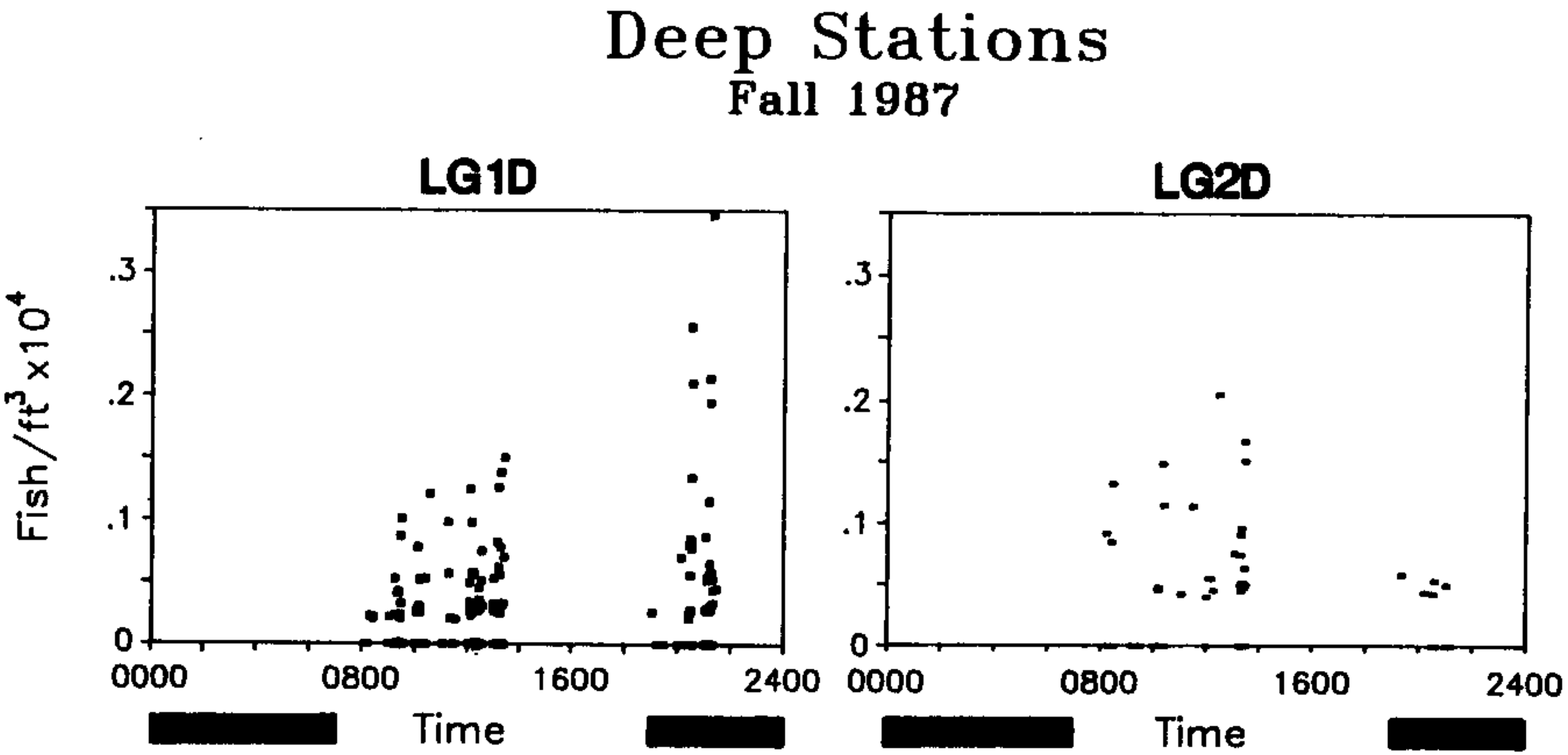

Figure 86. Diel fish density from fall, 1987 hydroacoustical samples at deep stations in Lower Granite Reservoir, Washington. Horizontal black bars denote nighttime periods, and each point represents a single transect.

LG1D

Fall 1987

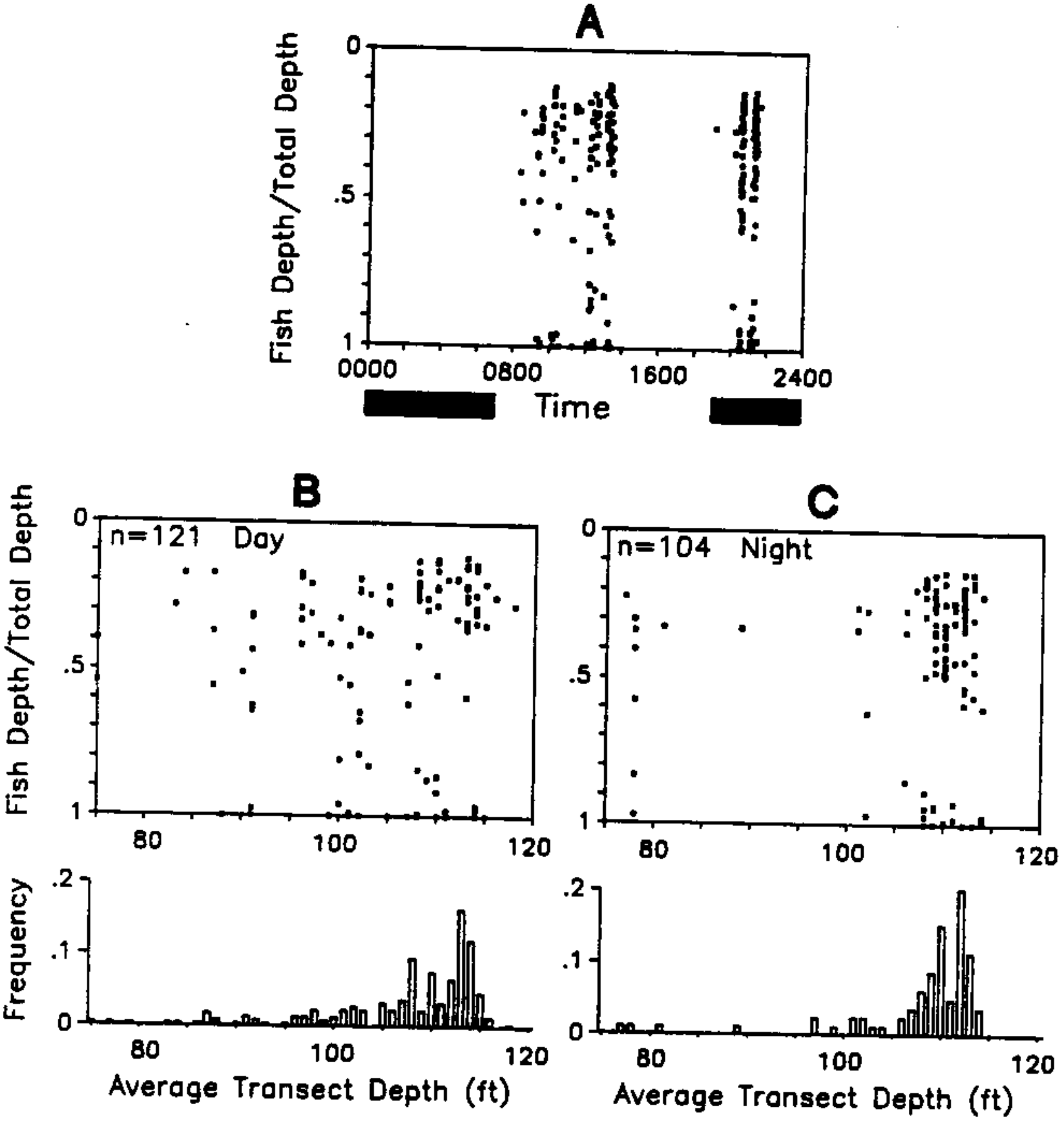

Figure 87. Fish depth distribution (fish depth / total depth) from fall, 1987 hydroacoustical samples on station LG1D at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) and night (C) periods. Histograms show sampling frequency for transects of varying depths during day (B) and night (C). Each point represents one fish; horizontal black bars denote nighttime periods.

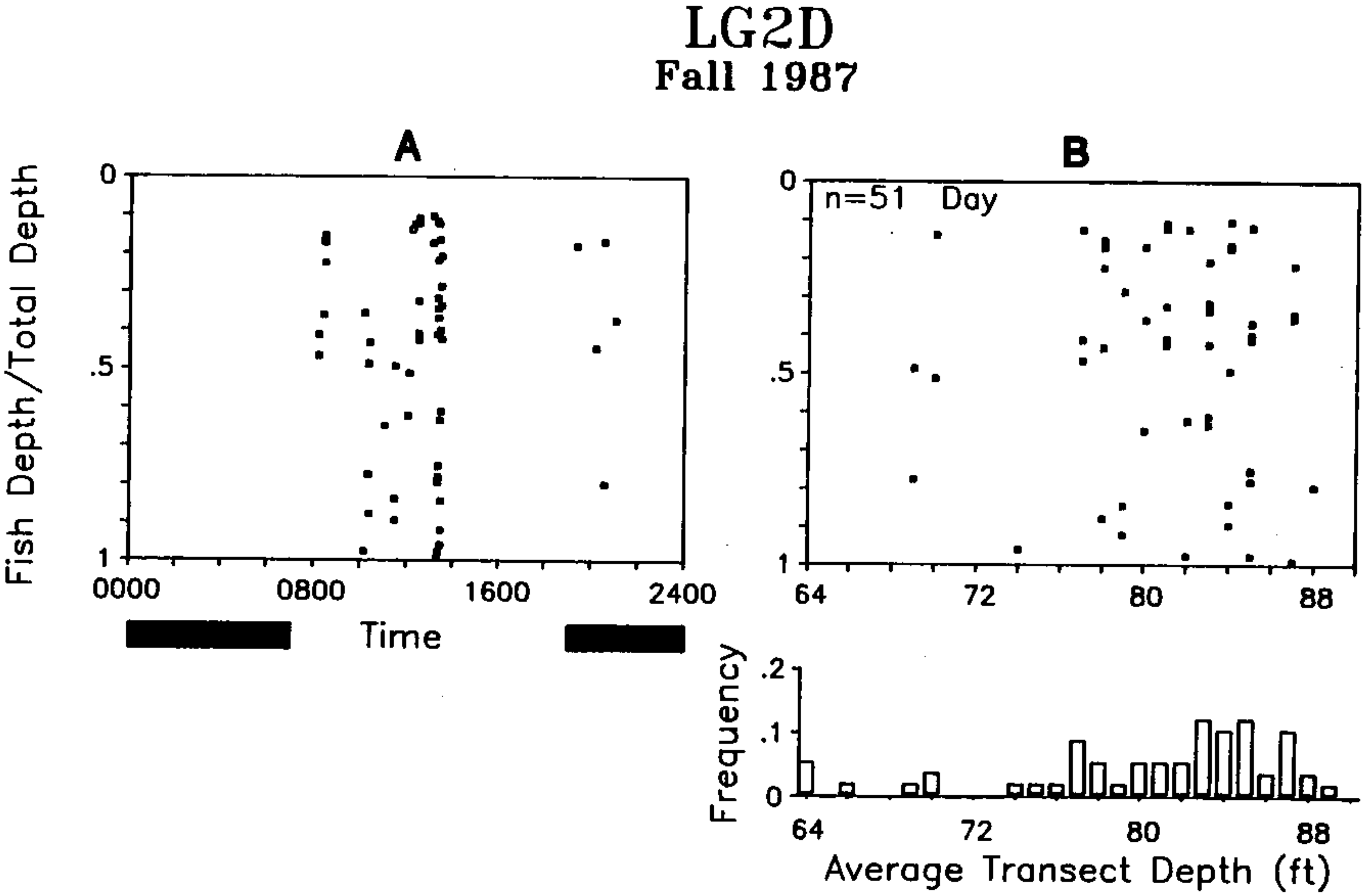

Figure 88. Fish depth distribution (fish depth / total depth) from fall, 1987 hydroacoustical samples on station LG2D at Lower Granite Reservoir, Washington. Observations in A (diel depth distribution) are subdivided into comparisons of fish depth / total depth with average transect depth (ft) during day (B) periods. Histogram shows sampling frequency for transects of varying depths during the day. Each point represents one fish; horizontal black bars denote nighttime periods.

(1984) reported that salmonids were found in the stomachs of 150 to 343 mm smallmouth bass; as a result our minimum length for smallmouth was 150 mm. Gray et al. (1984) further reported the high importance of fish in the diet of northern squawfish steadily increased with size after 300 mm. They found salmonids in squawfish as small as 324 mm. Based on this information, we imposed a minimum size of 250 mm for squawfish stomach collections. Salmonids were found in channel catfish ranging in size from 350-600 mm (Gray et al. 1985). An arbitrary size limit of 250 mm was imposed for analysis of both incidence of predation and a general food habits description.

Smallmouth bass, largemouth bass, crappies, and yellow perch were drugged using tricaine methylsulfonate (MS-222) and their stomach contents sampled. We used a lavage technique similar to that used by Light et al. (1983) and Seaberg (1957) except for the pump apparatus. We adapted a boat bilge pump (750 gph) to a pistol type garden hose shut-off and attached a modified flexible copper tube (1/4") that was inserted into the stomach of the fish through the esophagus. Stomach contents were flushed into a bucket, strained through plankton mesh (80 micron), and preserved in FAA. Stomachs of northern squawfish and channel catfish were surgically removed as a result of the inadequacies of the lavage technique to sample food habits from these species.

Stomach contents of fish were identified with dissecting and compound microscopes. All food items other than fish were identified to order. The origin of the organism (terrestrial or aquatic) also was noted. Keys used in identification were Pennak (1978), Merritt and Cummins (1978), and Borror et al. (1976). Fish were keyed to the lowest possible taxon. Bone identification keys and fish length/bone length regressions (unpublished data; USFWS, National Fishery Research Center - Willard Field Station) were used to identify and estimate lengths of heavily digested fish.

An index of relative importance (IRI; Pinkas et al. 1971; Bennett and Dunsmoor 1986) was used to compare seasonal and diel importance of prey items for each species and sampling station.

IRI = (N + W) x F, where

N = composition (%) of a food item by number

W = composition (%) of a food item by weight

F = frequency of occurrence

Weights used in the IRI were estimated live weights. All organisms (other than fish) that were visibly alike and in good condition were grouped and an average wet weight used to estimate the live weight for that group. Organisms were blotted dry for a standard drying time of 60 seconds, and then weighed. Fish weights were estimated by length-weight regressions developed for all fish species in Lower Granite Reservoir (Bennett and Shrier 1986).

Results

Contents of 326 smallmouth bass, 197 northern squawfish, and 55 channel catfish stomachs from Lower Granite Reservoir were analyzed over spring, summer, fall, and winter sampling periods.

Smallmouth Bass

Spring.-Contents of 261 smallmouth bass stomachs were analyzed. Most stomachs were from fish from shallow stations with the exception of three that were collected at stations LG1M and LG2M. The majority of the stomachs (48.6%) were collected from LG1S. Of the shallow stations, LG5S had the lowest number of bass represented (3.1%). Twenty-five percent (66) of the stomachs were empty. Bass examined for stomach contents during the spring season ranged from 127 to 475 mm (mean = 215 mm). The largest mean length of bass came from station LG2S (mean = 252 mm), whereas station LG4S had the smallest mean length (206 mm; Appendix Table C).

Chironomids, crayfish, and fish were the prey items of highest relative importance for smallmouth bass in Lower Granite Reservoir (Figure 89). Respective importance of chironomid life stages was pupae (73%), followed by adults (20%), and larvae (7%). Miscellaneous items (aquatic insects [Ephemeroptera, Trichoptera, and Plecoptera], microcrustaceans [Amphipoda *Corophium* spp.], Isopoda, Cladocera [*Daphnia*], and Copepoda, Hydracarina, fish eggs, and one rodent) were of little importance (Table 14).

Crayfish was the second most important prey item for bass during the spring season (Figure 89). Crayfish accounted for 26.2% of the total weight of food items, 5% of the total number, and occurred in 43% of the bass stomachs (Table 14).

Fish observed in the diet during the spring season included (in order of increasing relative importance): catostomids (species not distinguished), cyprinids (chiselmouth, northern squawfish, redside shiner, and peamouth), salmonids (chinook salmon, mountain whitefish, and rainbow trout [steelhead]), centrarchids, and cottids (Figure 89; Table 14). Catostomids accounted for 12.8% of the total weight of food items, 1.07% of the total number, and occurred in 8.7% of the stomachs which contained food

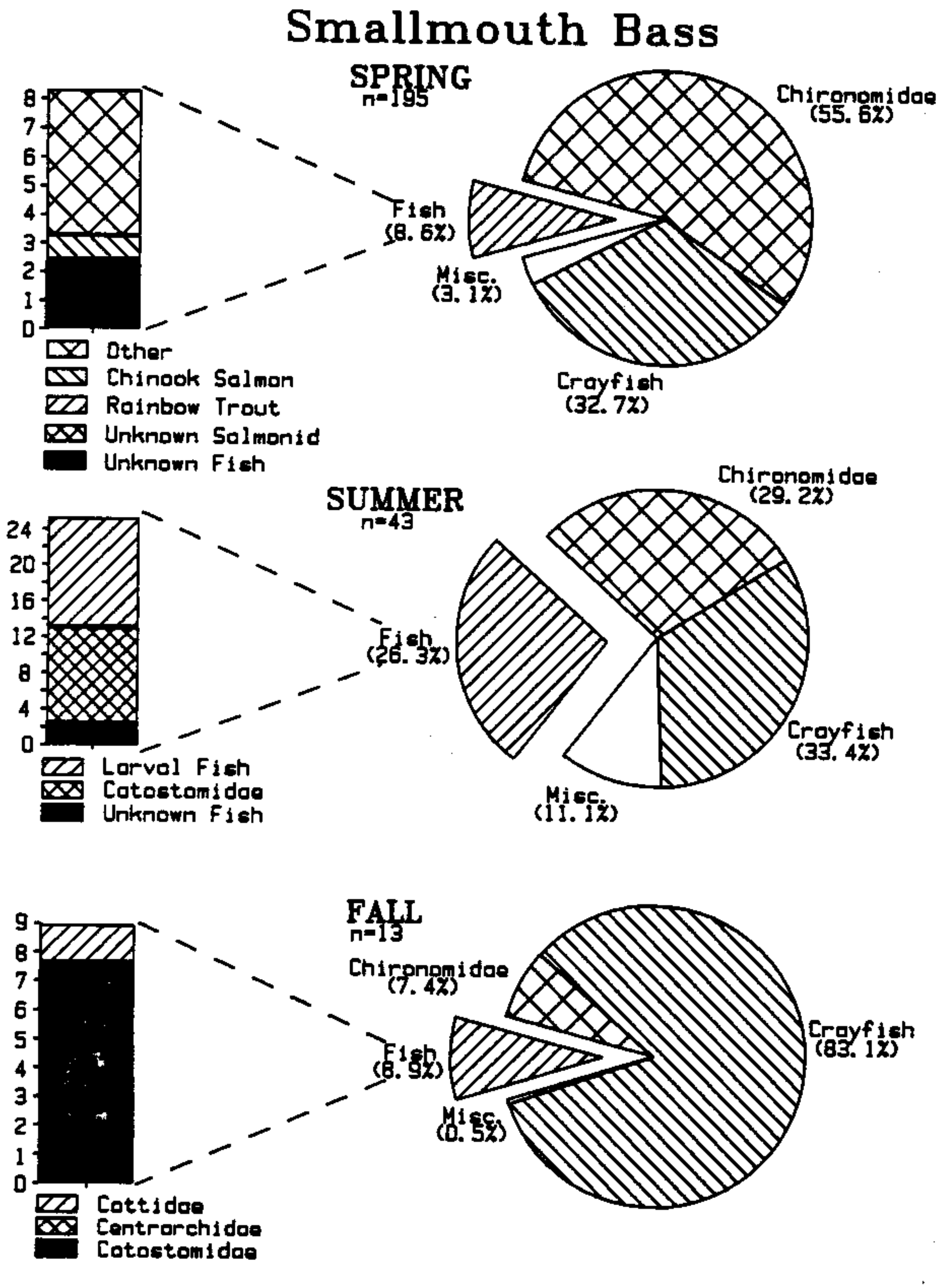

Figure 89. Percent of Index of Relative Importance (IRI) for food items of adult smallmouth bass (from all stations) in spring, summer, and fall, 1987 in Lower Granite Reservoir, Washington.

Table 14. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of smallmouth bass (n = 195) from Lower Granite Reservoir, Washington, during spring 1987.

Prey Item	Number of Prey	Weight of Prey	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Salmonidae							
Unknown Salmonidae	2	70.11	2	0.09	6.20	1.02	0.15
Salmo gairdneri	1	48.55	1	0.05	4.29	0.51	0.05
Oncorhynchus tshawytscha	7	193.64	4	0.33	17.11	2.04	0.85
Prosopium williamsoni	7	6.68	5	0.33	0.59	2.55	0.06
Catostomidae	23	145.98	17	1.07	12.90	8.67	2.88
Cyprinidae							
Unknown	3	6.07	2	0.14	0.54	1.02	0.02
Ptychocheilus oregonensis	19	26.43	15	0.89	2.34	7.65	0.59
Acrocheilus alutaceus	14	93.80	13	0.65	8.29	6.63	1.41
Mylocheilus caurinus	1	0.31	1	0.05	0.03	0.51	0.00
Richardsonius balteatus	4	3.48	3	0.19	0.31	1.53	0.02
Centrarchidae							
Micropterus dolomieui	2	79.00	1	0.09	6.98	0.51	0.09
Cottidae	3	4.50	3	0.14	0.40	1.53	0.02
Unknown Larval Fish	66	0.86	9	3.08	0.08	4.59	0.34
Unknown Fish	22	121.08	16	1.03	10.70	8.16	2.28
INSECTA							
Unknown Insect	9	0.08	6	0.42	0.01	3.06	0.03
Ephemeroptera	61	1.03	35	2.85	0.09	17.86	1.25
Trichoptera	7	0.11	6	0.33	0.01	3.06	0.02
Plecoptera	1	0.01	1	0.05	0.00	0.51	0.00
Coleoptera	2	0.01	2	0.09	0.00	1.02	0.00
Diptera							
Unknown Diptera	11	0.29	6	0.51	0.03	3.06	0.04
Chironomidae (Adult)	290	1.36	11	13.55	0.12	5.61	1.82
Chironomidae (Pupae)	1063	17.66	84	49.65	1.56	42.86	52.19
Chironomidae (Larvae)	99	0.82	27	4.62	0.07	13.78	1.54
Hemiptera							
Corixidae	1	0.00	1	0.05	0.00	0.51	0.00
Homoptera							
Cicadellidae	10	0.02	7	0.47	0.00	3.57	0.04
ARACHNIDA	65	0.05	1	3.04	0.00	0.51	0.04
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	108	296.99	86	5.04	26.24	43.88	32.65
Amphipoda							
Corophium spp.	45	0.17	32	2.10	0.01	16.33	0.82
Other	24	0.25	18	1.12	0.02	9.18	0.25
Isopoda	1	0.01	1	0.05	0.00	0.51	0.00
Cladocera							
Daphnia spp.	18	0.01	12	0.84	0.00	6.12	0.12
Copepoda	9	0.00	2	0.42	0.00	1.02	0.01
HYDRACARINA	71	0.00	4	3.32	0.00	2.04	0.16
MISCELLANEOUS	72	10.88	5	3.36	0.96	2.55	0.26

items. Chiselmouth was the most common cyprinid ingested by weight (8.3%), 0.65% of the total number, and occurred in 6.6% of the bass stomachs.

Salmonids contributed the most to the overall total weight of food items (28.2%) although their contribution to total number was low (0.8%). Collectively, anadromous salmonids occurred in 3.6% of bass with food. Of the bass stomachs containing salmonids, an average of 1.75 chinook salmon per stomach was observed. Only one rainbow trout was observed. Unidentifiable salmonids comprised 6.2% of the total weight of all prey items and 1% of bass stomachs with food (Table 14).

Summer.-Contents of 48 smallmouth bass were analyzed from the summer season. Nine (19.6%) stomachs were collected from the mid depth stations while the remaining were from shallow stations. Five (10.4%) of the 48 stomachs were empty. Total lengths of bass in the sample ranged from 145 to 351 mm. The overall mean length was 205 mm (Appendix Table C).

Summer diet composition was similar to that in the spring although the order of importance differed. Crayfish, chironomids, and fish were more abundant, followed by miscellaneous items (Figure 89). Crayfish accounted for 54% of the total weight of food items, 1.7% of the total number, and occurred in 32.5% of the stomachs (Table 15). Pupae dominated the chironomids in relative importance and percent total weight, although pupae and larval stages were equal in presence based on total number (13.6%). Chironomid pupae occurred in 20.2% of the stomachs containing food. Miscellaneous items (Ephemeroptera, Trichoptera, Amphipoda, Isopoda, Cladocera, and Hydracarina) accounted for less than 12% of the total IRI.

The relative importance of fish eaten by smallmouth bass in the summer sample increased to 26.3% of the total IRI from 8.6% in the spring season

Table 15. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of smallmouth bass (n = 43) from Lower Granite Reservoir, Washington, during summer 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Salmonidae							
Catostomidae	14	19.69	13	1.07	18.00	30.23	10.62
Cyprinidae							
Ptychocheilus oregonensis	3	1.06	3	0.23	0.97	6.98	0.15
Acrocheilus alutaceus	1	3.20	1	0.08	2.92	2.33	0.13
Mylocheilus caurinus	2	0.16	2	0.15	0.15	4.65	0.03
Centrarchidae							
Micropterus dolomieui	4	7.22	2	0.31	6.59	4.65	0.59
Unknown Larval Fish	220	3.88	14	16.79	3.55	32.56	12.20
Unknown Fish	9	9.72	6	0.69	8.88	13.95	2.46
INSECTA							
Unknown Insect	6	0.04	4	0.46	0.03	9.30	0.08
Ephemeroptera	40	0.52	7	3.05	0.48	16.28	1.06
Trichoptera	15	0.25	7	1.15	0.22	16.28	0.41
Diptera							
Chironomidae (Adult)	7	0.03	1	0.53	0.03	2.33	0.02
Chironomidae (Pupae)	178	2.96	29	13.59	2.70	67.44	20.24
Chironomidae (Larvae)	178	1.47	14	13.59	1.35	32.56	8.96
Hemiptera							
Notonectidae	2	0.00	2	0.15	0.00	4.65	0.01
Corixidae	13	0.02	4	0.99	0.02	9.30	0.17
Homoptera							
Aphididae	2	0.00	1	0.15	0.00	2.33	0.01
ARACHNIDA							
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	22	59.12	14	1.68	54.02	32.56	33.41
Amphipoda							
Corophium spp.	11	0.04	5	0.84	0.04	6.98	0.34
Isopoda	1	0.01	1	0.08	0.01	4.65	0.03
Cladocera							
Leptodora kindti	538	0.02	5	41.07	0.02	11.63	8.80
Daphnia spp.	34	0.01	3	2.60	0.01	6.98	0.34
Copepoda	4	0.00	2	0.31	0.00	4.65	0.03
HYDRACARINA	1	0.00	1	0.08	0.00	2.33	0.00

(Figure 89). Catostomids and larval fish dominated the diet during the summer season. Catostomids accounted for 18% of the total weight of all items and 44% of the total fish weight. Catostomids occurred in 30.2% of the bass stomachs which contained food. Larval fish accounted for 16.8% of the total number of food items and 3.3% of the total weight. Larval fish occurred in 32.5% of bass stomachs that contained food. Fish of lesser importance in the diet of bass during the summer months included (in order of IRI): centrarchids, northern squawfish, chiselmouth, and peamouth (Table 15). No salmonids were observed in bass stomachs during the summer months.

Fall.-Contents of 17 smallmouth bass were analyzed during the fall sampling season. Six of the stomachs were from mid depth stations; four (23.5%) stomachs were empty. The remaining stomachs were collected from shallow stations. Bass total length averaged 308 mm and ranged from 192 to 456 mm (Appendix Table C).

Crayfish dominated the relative importance (83.1%) of food items of smallmouth bass during the fall season (Figure 89). Crayfish accounted for 78.3% of the total weight of all food items, 43.6% of the total number and occurred in 77% of the bass stomachs (Table 16).

Relative importance of fish decreased in the fall to a level similar to the spring season (8.9%; Figure 89). Catostomids were the dominant fish, comprising 80% of the total fish weight and were present in 30.7% of the bass stomachs. Cottids occurred in two stomachs and accounted for 1.3% of the total IRI. Both bass which consumed cottids were captured at station LGIS. No salmonids were observed in bass stomachs examined during the fall season.

Table 16. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of smallmouth bass (n = 13) from Lower Granite Reservoir, Washington, during fall 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Catostomidae	4	17.49	4	10.26	17.11	30.77	7.47
Cottidae	2	4.50	2	5.13	4.40	15.38	1.30
INSECTA				0.00	0.00	0.00	0.00
Chironomidae (Pupae)	10	0.17	4	25.64	0.16	30.77	7.04
Chironomidae (Larvae)	2	0.02	1	5.13	0.02	7.69	0.35
Homoptera				0.00	0.00	0.00	0.00
Cicadellidae	1	0.00	1	2.56	0.00	7.69	0.18
ARACHNIDA	1	0.01	1	2.56	0.01	7.69	0.18
CRUSTACEA				0.00	0.00	0.00	0.00
Decapoda				0.00	0.00	0.00	0.00
Pacifastacus leniusculus	17	80.00	10	43.59	78.30	76.92	83.14
Copepoda	1	0.00	1	2.56	0.00	7.69	0.17

Relative importance of chironomids decreased substantially from spring and summer seasons to 7.4% in the fall (Figure 89). Chironomid pupae dominated, accounting for 83.3% of the total number of chironomids and 25.6% of all food items (Table 16). Miscellaneous items (Homoptera [Cicadellidae], Arachnida and Copepoda) collectively accounted for less than 1% of the total IRI.

Northern Squawfish

Spring.-Contents of 80 northern squawfish stomachs were analyzed during the spring season. Squawfish from all ten stations were represented in the analysis. Station LG2S had the largest number of stomachs collected (24), whereas the least represented station (LG3S) had one (Appendix Table D). Twenty one (26.3%) of the stomachs were empty. Total lengths of squawfish ranged from 137 to 550 mm; mean total length was 337 mm. Station LG1D had the longest mean length (414 mm; n = 2) while those from station LG4S had the smallest mean (242 mm; n = 2).

Chironomids, fish, miscellaneous insects, and crayfish comprised prey items of major importance to northern squawfish (Figure 90). Chironomids were the most important items accounting for 35.7% of the total number and occurring in 35.6% of all squawfish examined, although chironomids contributed only 0.6% of the total weight of all food items consumed (Table 17). Pupal instars comprised the majority of chironomids (94%). Miscellaneous insects (unknown dipterans, Coleoptera, Ephemeroptera, Trichoptera and Hymenoptera) were of minor importance.

Fish were the second most important group of prey for northern squawfish during the spring season (Figure 90). Fish eaten (in order of

Table 17. Number, weight, frequency of occurrence, and Index of Relative Importance (IR)I of food items of northern squawfish (n = 59) from Lower Granite Reservoir, Washington, during spring 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Salmonidae							
Unknown Salmonidae	2	70.12	2	0.25	8.92	3.39	1.00
Salmo gairdneri	7	273.11	7	0.86	34.76	11.86	13.54
Oncorhynchus tshawytscha	6	172.64	5	0.74	21.97	8.47	6.17
Catostomidae	5	11.69	5	0.62	1.49	8.47	0.57
Unknown Fish	3	77.91	3	0.37	9.91	5.08	1.68
INSECTA							
Unknown Insect	5	0.07	5	0.62	0.01	8.47	0.17
Ephemeroptera	30	0.38	3	3.69	0.05	5.08	0.61
Trichoptera	2	0.03	2	0.25	0.00	3.39	0.03
Coleoptera	29	0.16	16	3.57	0.02	27.12	3.12
Diptera							
Unknown Diptera	396	7.81	6	48.71	0.99	10.17	16.20
Chironomidae (Pupae)	273	4.54	21	33.58	0.58	35.59	36.96
Chironomidae (Larvae)	17	0.14	3	2.09	0.02	5.08	0.34
Hymenoptera							
Misc. Hymenoptera	1	0.00	1	0.12	0.00	1.69	0.06
Formicidae	3	0.00	3	0.37	0.00	5.08	0.01
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	19	156.73	14	2.34	19.95	23.73	16.95
Amphipoda							
Corophium spp.	13	0.05	5	1.60	0.01	8.47	0.44
MISCELLANEOUS	2	10.40	2	0.25	1.32	3.39	0.17

Northern Squawfish

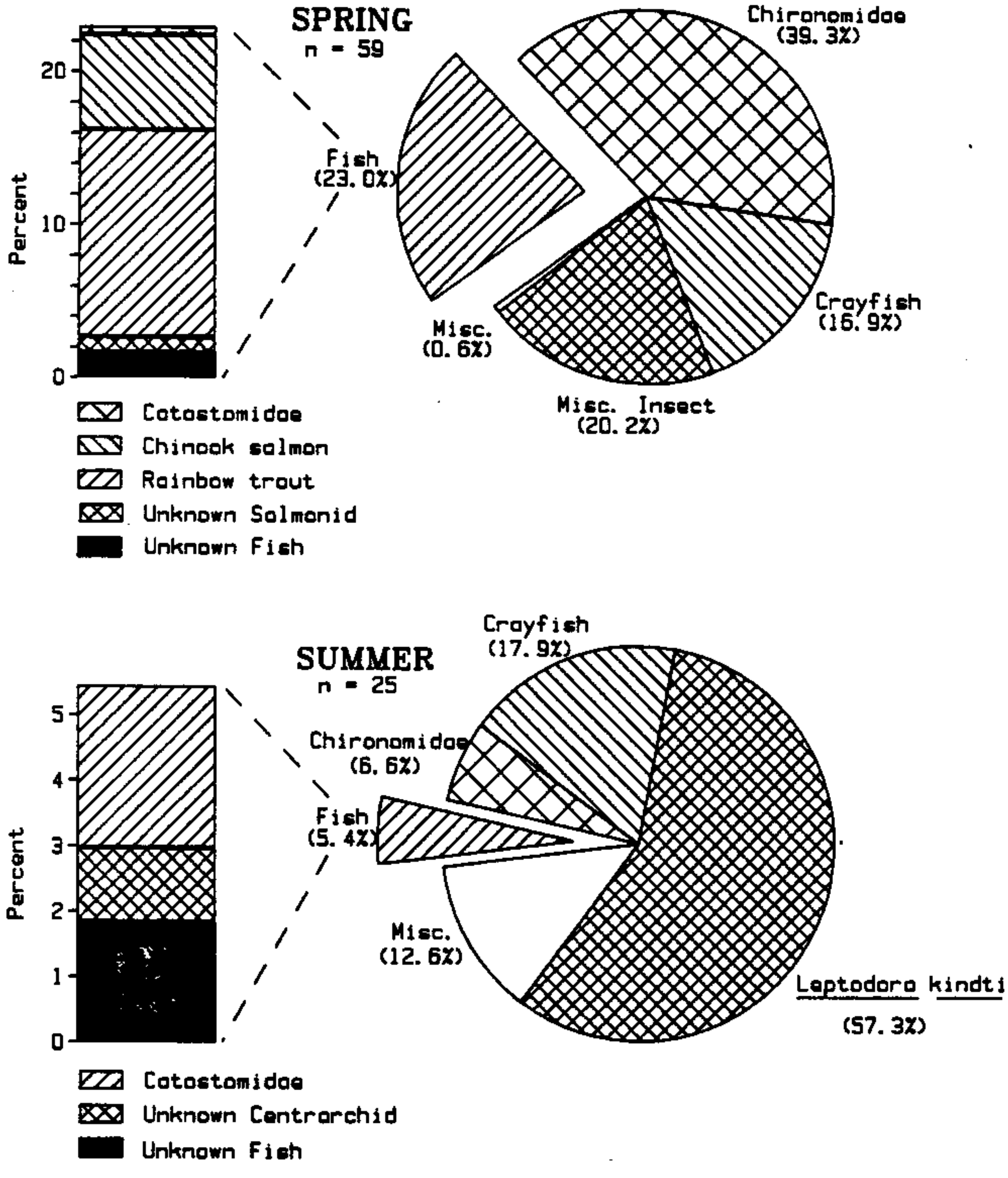

Figure 90. Percent of Index of Relative Importance (IRI) for food items of adult northern squawfish (from all stations) in spring and summer, 1987 in Lower Granite Reservoir, Washington.

relative importance) included: salmonids (rainbow trout [steelhead], chinook salmon) and catostomids. Salmonids comprised 65.7% of the total weight of all food items, and 1.9% of the total number (Table 17). Steelhead occurred in 10.2% of stomachs containing food items, and accounted for 61% of the total salmonid weight. Chinook salmon occurred in 8.5% of the stomachs with food. Collectively, salmonids occurred in 22% of all squawfish stomachs that contained food. Unknown salmonids occurred in 3.4% of squawfish stomachs. Catostomids accounted for 9.9% of the total weight and 0.37% of total number of all food items and occurred in 5% of squawfish stomachs with food. Unknown fish were of lesser importance.

Crayfish comprised 19.9% of the total weight, and 2.3% of the total number. Frequency of crayfish occurrence was 23.3% during the spring season (Table 17). Miscellaneous food items (Amphipod and <u>Corophium</u> spp.) occurred in 8.5% of the stomachs.

Summer.-Stomachs from 34 northern squawfish were collected during summer 1987. Nine (26.5%) of the stomachs collected were empty. Twenty-eight (82.4%) of the stomachs examined were from mid depth stations. Squawfish total lengths ranged from 230 to 495 mm and had a mean of 329 mm (Appendix Table D).

Summer food habits of northern squawfish differed dramatically from those during spring. Food items with higher relative importance were the cladoceran, <u>Leptodora</u> <u>kindti</u>, followed by crayfish, chironomids, and fish (Figure 90).

<u>Leptodora</u> <u>kindti</u> dominated food items during the summer season and accounted for 55.4% of the total number of prey items and 17.7% of the total

weight (Table 18). This cladoceran occurred in 32% of all squawfish examined in the summer.

Relative importance of crayfish was similar between spring and summer seasons (Figure 90). In the summer, crayfish accounted for 45.5% of the total weight of food items and occurred in 7.3% of the stomachs (Table 18).

Fish and chironomids decreased sharply in relative importance between spring and summer (Figure 90). Fish observed in stomachs during summer were catostomids, centrarchids, and unidentified individuals (Table 18).

Miscellaneous items in the summer were primarily cladocerans, (Daphnia), Hymenoptera (Formicidae), Coleoptera, Trichoptera, and Amphipoda. Daphnia occurred in 4.5% of the stomachs and accounted for 36.7% of the total number of prey items.

Fall.-Contents of 68 northern squawfish stomachs were examined; nineteen (27.9%) stomachs were empty. Fish from LG2S accounted for 27.9% of the stomachs while 33 (48.5%) were from mid depth stations. Total lengths of squawfish represented in the samples ranged from 252 to 532 mm, with an overall mean total length of 301 mm (Appendix Table D).

Relative importance of major food items during fall was similar to that of the spring season (Figure 91). Chironomids dominated, followed by crayfish, fish, and miscellaneous insects. The major difference between fall and summer seasons was the composition of fish prey. During the fall, catostomids comprised 99% of all fish observed in the stomachs, 39.1% of the total weight of prey items, and occurred in 6.4% of stomachs (Table 19). The miscellaneous category was comprised primarily of Daphnia spp. and Leptodora kindti (5.1%), and Coleoptera, Hemiptera, Homoptera, and Amphipoda.

Table 18. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of northern squawfish (n = 25) from Lower Granite Reservoir, Washington, during summer 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Catostomidae	11	10.82	2	0.19	12.42	8	2.47
Centrarchidae							
Unknown	1	10.00	1	0.02	11.47	4	1.13
Unknown Fish	5	5.41	3	0.09	6.21	12	1.85
INSECTA							
Unknown Insect	1	0.01	1	0.02	0.01	4	0.00
Trichoptera	1	0.00	1	0.02	0.00	4	0.00
Coleoptera	2	0.01	2	0.04	0.01	8	0.01
Diptera							
Unknown Diptera	1	0.013	1	0.02	0.01	4	0.00
Chironomidae (Adult)	3	0.01	1	0.05	0.02	4	0.01
Chironomidae (Pupae)	141	2.34	13	2.47	2.69	52	6.57
Chironomidae (Larvae)	2	0.02	2	0.04	0.02	8	0.01
Homoptera							
Aphididae	1	0.00	1	0.02	0.00	4	0.00
Hymenoptera							
Formimidae	39	0.05	5	0.68	0.06	20	0.36
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	5	39.69	4	0.09	45.53	16	17.87
Amphipoda							
Corophium spp.	1	0.00	1	0.02	0.00	4	0.00
Other	236	2.48	2	4.14	2.85	8	1.37
Cladocera							
Leptodora kindti	3156	15.42	8	55.38	17.69	32	57.25
Daphnia spp.	2092	0.88	3	36.71	1.01	12	11.08

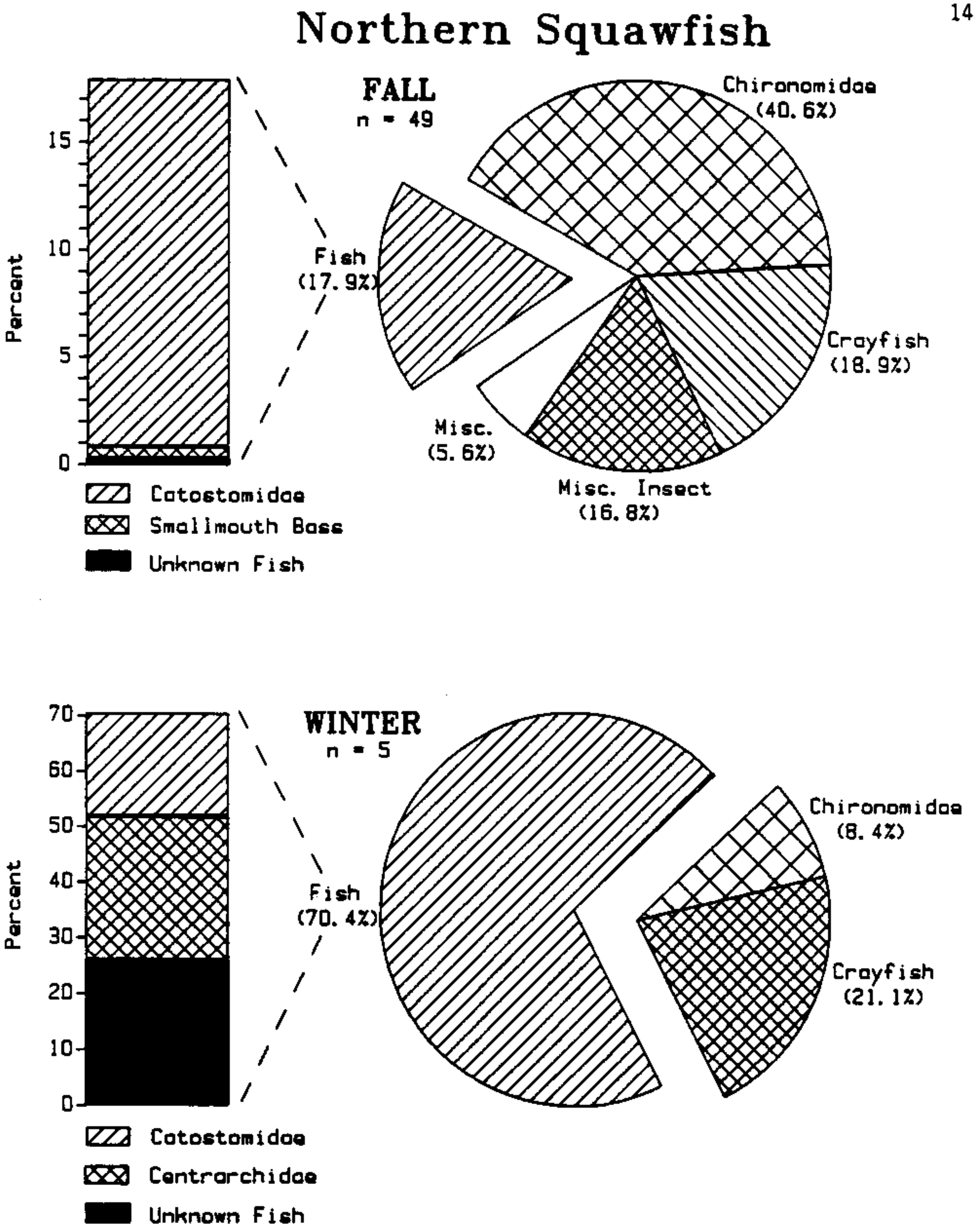

Figure 91. Percent of Index of Relative Importance (IRI) for food items of adult northern squawfish (from all stations) in fall and winter, 1987 in Lower Granite Reservoir, Washington.

Table 19. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of northern squawfish (n = 49) from Lower Granite Reservoir, Washington, during fall 1987.

Prey Item	Number of Prey	Weight of Prey	Frequency of Prey	Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Catosotomidae	9	86.01	8	0.11	39.15	16.33	17.07
Centrarchidae							
Micropterus dolomieui	14	10.32	2	0.18	4.70	4.08	0.53
Unknown Fish	3	12.54	1	0.04	5.71	2.04	0.31
INSECTA							
Unknown Insect	35	0.25	8	0.44	0.12	16.33	0.24
Trichoptera	1	0.00	1	0.01	0.00	2.04	0.00
Coleoptera	71	0.39	11	0.90	0.18	22.45	0.64
Diptera							
Unknown Diptera	5	0.04	3	0.06	0.02	6.12	0.01
Chironomidae (Adult)	3	0.01	2	0.04	0.01	4.08	0.00
Chiromonidae (Pupae)	1197	19.89	31	15.15	9.05	63.27	40.77
Chironomidae (Larvae)	1	0.01	1	0.01	0.00	2.04	0.00
Hemiptera							
Mesoveliidae	67	0.09	11	0.85	0.04	22.45	0.53
Homoptera							
Cicadellidae	531	0.86	15	6.72	0.39	30.61	5.80
Aphididae	1087	1.26	11	13.76	0.57	22.45	8.57
Hymenoptera							
Forcimidae	172	0.22	8	2.18	0.10	16.33	0.99
ARACHNIDA	31	0.17	4	0.39	0.08	8.16	0.10
CRUSTACEA							
Decapoda							
Pacifestacus leniusculus	14	76.11	10	0.18	34.65	20.41	18.92
Amphipoda							
Corophium spp.	68	0.25	6	0.86	0.12	12.24	0.32
Cladocera							
Leptodora kindti	2175	8.72	1	27.53	3.97	2.04	1.71
Daphnia spp.	2409	1.01	2	30.49	0.46	4.08	3.36
HYDRACARINA	1	0.00	1	0.01	0.00	2.04	0.00
MISCELLANEOUS	3	1.50	3	0.04	0.68	6.12	0.12

Winter.-Contents of 15 northern squawfish were collected. Ten (66.7%) of the stomachs were empty. Total lengths of fish examined ranged from 245 to 370 mm with a mean of 293 mm (Appendix Table D).

The three major food items were fish, crayfish, and chironomids (Figure 91). Crayfish importance, as in other seasons, was high; crayfish comprised 14.8% of the total weight, 16.7% of the total number, and occurred in two (40%) of the squawfish (Table 20). Fish importance (centrarchids, catostomids, and an unidentified fish) in winter increased although only five squawfish contained food.

Channel Catfish

Spring.-Contents of 20 channel catfish stomachs were analyzed during the spring season; two stomachs were empty. The highest number of catfish stomachs examined came from LG2M (70%). Only one catfish stomach was collected at the shallow stations (LG2S). Total lengths of catfish represented in the stomach sample ranged from 356 to 612 mm with a mean of 465 mm (Appendix Table E).

Food items of highest relative importance were fish, chironomids, and crayfish (Figure 92). Salmonids were the most important fishes present in the catfish diet. Rainbow trout (steelhead) accounted for 73.2% of the total weight of all food items, 1.5% of the total number of items, and occurred in 27.8% of the stomachs that contained food (Table 21). Only one chinook salmon was observed in catfish stomach samples. Collectively, salmonids contributed 38.9% of the total weight of all food items, 1.8% of the total number of prey items, and occurred in 38.9% of the stomachs sampled. Unknown fish contributed 2.7% of the total IRI.

Table 20. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of northern squawfish (n = 5) from Lower Granite Reservoir, Washington, during winter 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Catostomidae	2	5.89	2	16.67	10.97	40	18.55
Centrarchidae							
Unknown	1	10.00	1	8.33	18.62	20	9.05
Pomoxis spp.	2	17.89	1	16.67	33.32	20	16.78
Unknown Fish	2	11.89	2	16.67	22.15	40	26.05
INSECTA							
Diptera							
Chironomidae (Pupae)	3	0.05	1	25.00	0.09	20	8.42
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	2	7.97	2	16.67	14.84	40	21.15

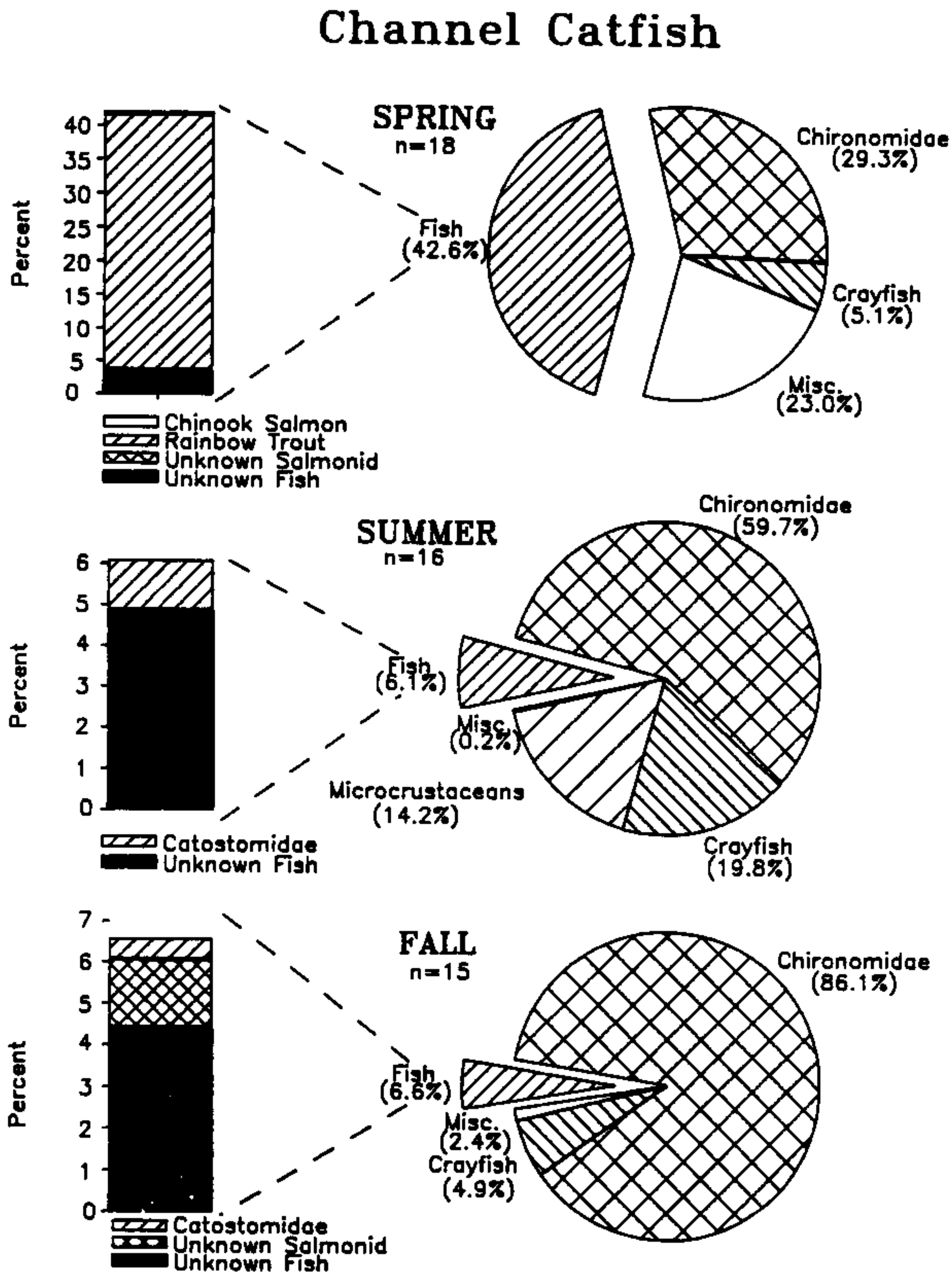

Figure 92. Percent of Index of Relative Importance (IRI) for food items of adult channel catfish (from all stations) in spring, summer, and fall, 1987 in Lower Granite Reservoir, Washington.

Table 21. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of channel catfish (n = 18) from Lower Granite Reservoir, Washington, during spring 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Salmonidae							
Unknown Salmonidae	1	96.24	1	0.16	6.78	5.56	0.73
Salmo gairdneri	9	1039.32	5	1.45	73.23	27.78	39.01
Oncorhynchus tshawytscha	1	30.04	1	0.16	2.12	5.56	0.24
Catosotomidae	1	3.66	1	0.16	0.26	5.56	0.04
Unknown Fish	2	175.65	2	0.32	12.38	11.11	2.65
INSECTA							
Unknown Insect	1	0.24	1	0.16	0.02	5.56	0.02
Trichoptera	2	0.03	1	0.32	0.00	5.56	0.03
Coleoptera	4	0.02	1	0.65	0.00	5.56	0.07
Diptera							
Chironomidae (Pupae)	239	3.97	7	38.55	0.28	38.89	28.39
Chironomidae (Larvae)	17	0.14	3	2.74	0.01	16.67	0.86
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	17	47.49	8	2.74	3.35	44.44	5.09
Amphipoda							
Corophium spp.	20	0.07	5	3.23	0.01	27.78	1.69
Other	1	0.01	1	0.16	0.00	5.56	0.02
MISCELLANEOUS	305	22.43	5	49.19	1.58	27.78	21.16

Chironomids were the second most important group of prey (Figure 92), with chironomid pupae comprising 93% of the chironomids examined. Crayfish occurred in 44.4% of the stomachs sampled, contributing 3.4% of the total weight, and 2.74% of the total number (Table 21). Miscellaneous items included fish eggs, a Pacific lamprey (Lampetra tridentata), a rodent, and organic matter.

Summer.-Contents of 17 channel catfish from four stations were analyzed from the summer season; one stomach was empty. Total lengths ranged from 259 to 528 mm with an overall mean length of 359 mm (Appendix Table E).

Major food items of importance were similar to the spring season (Figure 92). The major difference was a significant decrease in fish as an important food item during the summer season. Catostomids were the only identifiable fish observed (16.4% of the total weight, and less than 1% of the total number) and occurred in 1 (6.3%) stomach (Table 22). The remaining fish were unidentifiable, and occurred in two (12.5%) stomachs.

Crayfish increased in importance between the spring and summer seasons (Figure 92). Crayfish accounted for 33.3% of the total weight, 1.3% of the total number, and occurred in 50% of the stomachs in the sample (Table 22).

Miscellaneous items included Cladocera, Hymenoptera, Homoptera, Coleoptera, and Amphipoda. Of the Cladocera, Daphnia accounted for 12.7% of the total IRI, 42.6% of the total number, and occurred in 25% of the stomachs (Figure 92; Table 22).

Fall.-Three of the 18 (16.7%) channel catfish stomachs analyzed were empty. Fish were represented from all mid depth and deep stations and one shallow station (LG2S). Total lengths ranged from 208 to 583 mm with an overall mean of 355 mm (Appendix Table E).

Table 22. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of channel catfish (n = 16) from Lower Granite Reservoir, Washington, during summer 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Catostomidae	1	41.50	1	0.02	16.43	6.25	1.22
Unknown Fish	2	83.00	2	0.03	32.85	12.50	4.87
INSECTA							
Trichoptera	1	0.02	1	0.02	0.01	6.25	0.00
Coleoptera	41	0.22	1	0.65	0.09	6.25	0.05
Diptera							
Chironomidae (Pupae)	1992	33.10	13	31.66	13.10	81.25	43.07
Chironomidae (Larvae)	975	8.08	12	15.50	3.20	75.00	16.60
Homoptera							
Cicadellidae	1	0.00	1	0.02	0.00	6.25	0.00
Aphididae	14	0.02	1	0.22	0.01	6.25	0.02
ARACHNIDA	3	0.02	3	0.05	0.01	18.75	0.01
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	8	84.25	8	0.13	33.35	50.00	19.82
Amphipoda							
Corophium spp.	29	0.11	6	0.46	0.04	37.50	0.22
Isopoda	2	0.03	1	0.03	0.01	6.25	0.00
Cladocera				0.00	0.00	0.00	0.00
Leptodora kindti	531	0.01	2	8.44	0.00	12.50	1.25
Daphnia spp.	2680	1.12	4	42.60	0.45	25.00	12.74
MISCELLANEOUS	3	1.10	3	0.05	0.44	18.75	0.11

Chironomids dominated the relative importance of food items during the fall months followed by fish and crayfish (Figure 92). Chironomids accounted for 88.7% of the total weight of food items and 4.1% of the total number. Chironomid pupae occurred in 60% of the stomachs and chironomid larvae occurred in 14.5% of the stomachs (Table 23).

Salmonids (unidentified) comprised the majority of the fish, and accounted for 54.9% of the total weight, but less than one percent of the total number (occurred in one stomach). Catostomids and unknown fish comprised the remaining fish in the sample (Figure 92; Table 23).

Crayfish accounted for 14.2% of the total weight of prey items, 1.3% of the total number and occurred in 26.7% of the stomachs. Miscellaneous items (2.4% of IRI) in the fall diet included Homoptera, Ephemeroptera, Hymenoptera, Amphipoda, and Cladocera (Figure 92; Table 23).

Discussion

At the beginning of this research, participants at the scoping workshop (Webb et al. 1987) expressed interest in determining if "complex" mid depth habitat exists. Based on our soundings, none of the mid depth stations sampled were structurally complex. Although potential cover objects on the bottom were not specifically quanitified at mid depth stations, frequency was low and varied little among stations. A submerged ridge 200 ft from and parallel to the shoreline at LG1M was probably the most significant structural feature of all the mid depth sites. Station LG3M had a wide shelf sloping gradually from the 20 to 40 ft depth contours and a steep slope between 40-60 ft depth contours. Station LG2M had a moderately sharp drop-off and then also flattened somewhat at 40-60 ft depths. Shelf width

Table 23. Number, weight, frequency of occurrence, and Index of Relative Importance (IRI) of food items of channel catfish (n = 15) from Lower Granite Reservoir, Washington, during fall 1987.

Prey Item	Number of Prey	Weight of Prey (g)	Frequency of Prey	Total Number (%)	Weight (%)	Frequency (%)	IRI (%)
OSTEICHTHYES							
Salmonidae							
Unknown Salmonidae	2	70.11	1	0.50	54.90	6.67	4.43
Catostomidae	1	7.96	1	0.25	6.23	6.67	0.52
Unknown Fish	1	26.02	1	0.25	20.37	6.67	1.65
INSECTA							
Ephemeroptera	1	0.01	1	0.25	0.01	6.67	0.02
Coleoptera	2	0.01	2	0.50	0.01	13.33	0.08
Diptera							
Unknown Diptera	1	0.02	1	0.25	0.01	6.67	0.02
Chironomidae (Pupae)	282	4.69	12	71.03	3.67	80.00	71.65
Chironomidae (Larvae)	70	0.58	10	17.63	0.45	66.67	14.46
Homoptera							
Cicadellidae	12	0.02	5	3.02	0.02	33.33	1.21
Aphididae	2	0.00	2	0.50	0.00	13.33	0.08
ARACHNIDA	3	0.02	3	0.76	0.01	20.00	0.18
CRUSTACEA							
Decapoda							
Pacifastacus leniusculus	5	18.11	4	1.26	14.18	26.67	4.94
Amphipoda							
Corophium spp.	5	0.02	4	1.26	0.01	26.67	0.41
Other	1	0.01	1	0.25	0.01	6.67	0.02
Isopoda	1	0.14	1	0.25	0.11	6.67	0.03
Cladocera							
Daphnia spp.	7	0.00	2	1.76	0.00	13.33	0.28

differed considerably among mid depth stations as the shelf extended further into the channel at LG3M than at the other two mid depth stations.

While none of the mid depth stations provided structurally complex habitat, soundings at station LG1D showed a lot of bottom structure. Large rock slides form the shoreline at LG1D, and extend to the reservoir bottom. Soundings show an uneven bottom where boulders have accumulated as the gradient lessens at depths around 80 ft. Soundings in flat areas away from the base of the slope, however, showed no structure at all. Soundings at station LG2D showed no structure.

Water temperatures, dissolved oxygen (except during the summer), and substrate were all similar between mid depth and deep stations. Substrate was generally similar among sites as the majority of the bottom consisted of sand and particles smaller than sand. Substrate at LG2M was different in that only this site had a small percentage of substrate that was larger than sand. One difference between mid depth stations and deep station LG2D was the significantly higher proportion of organic matter in the substrate. Otherwise, the proportion of organic matter was similar among mid depth sites and LG1D.

Models developed to predict channel and on-site velocities indicated that different factors affect velocity in the upper reservoir than in the lower reservoir. Based on the coefficient of determination (R^2), more factors affect channel velocity in the lower reservoir than upstream. In both sections, however, an expression of reservoir "size" as a function of location on the reservoir (the ratio of river mile to cross sectional area) was important. Downstream (RM 111-120), forebay pool elevation was significant as compared to total inflow upstream (RM 120 to 134).

Logically, total discharge from Lower Granite Dam must be important in determining velocity patterns in the lower reservoir. However, discharge from the dam experiences large, shortterm flucuations. Velocity of the large mass of water in the lower reservoir cannot respond quickly to each change in discharge, resulting in obscured discharge-velocity relationships. Apparently, forebay pool elevations, which are also logically linked to discharge, smooth out discharge fluctuation effects enough to provide better predictive ability than discharge.

On-site velocities were less predictable than channel velocities when using predictor variables other than expressions of velocity from other profiles. On-site profiles were always near shore, generally a relatively large distance from the channel. As in a riverine environment, most water moving through Lower Granite travels downstream along the old river channel, while water along the shorelines frequently forms back-eddies and random currents. Velocity in such near shore areas shows no clear relationship to "inputs" or "outputs" of water into or from the reservoir. Instead, near shore areas are most strongly related to velocities in nearby deeper areas, suggesting a relatively predictable degree of velocity dissipation as distance from the channel increases and depth decreases.

In addition to similarities in physical habitat, the benthic community also was similar among sites. Similarities in composition and standing crops were found among all deep and mid depth stations. Standing crops were variable among the three seasons sampled but seasonal changes in abundance were similar among mid depth and deep stations. Also interesting was the finding that community structure was similar among mid depth stations. We did not see any trends in the abundance of different taxa at any one station, although mid depth stations were generally more diverse than deep stations. Benthic communities consisted predominantly of chironomids and oligochaetes, as was found in previous studies (Bennett and Shrier 1986; Bennett and Shrier 1987).

Benthic organisms were considerably more abundant in 1987 than in 1985, although seasonal trends were similar. In the 1985 surveys (Bennett and Shrier 1986), benthos abundance was several orders of magnitude lower at shallow stations and about one half as abundant at deep stations than in 1987. Unfortunately, 1985 benthos analyses did not include measures of standing crop. Counts of oligochaetes can vary widely because they often break into several pieces during sampling and sorting. However, chironomid abundance increased proportionally to oligochaetes which suggests that higher numbers of benthos in 1987 reflected actual increases in abundance. Based on the above discussion, clumped distributions, and widely variable abundances, benthic community abundance might not be an acceptable evaluation criterion for mid depth disposal activities. However, benthic community standing crops merit further investigation before a definitive assessment can be made.

Fish sampling at mid depth and deep stations was conducted principally by horizontal gillnets. At the inception of this project, we contemplated using vertical gillnets and set lines in addition to horizontal gillnets. After examination of catch rates from previous studies that utilized vertical nets on Lower Granite Reservoir (Bennett and Shrier 1986) and Little Goose Reservoir (Bennett et al. 1983), we concluded that higher catch rates and probably more information would be obtained from using horizontal nets exclusively. Although we did fish set lines in this project and throughout the earlier study (Bennett and Shrier 1986), we failed to catch any of the principal target species, the white sturgeon. Since catch rates in set lines were so low (only 2 bullheads and 1 squawfish were captured) we choose to omit this information from this report.

Gillnets seemed to provide an adequate assessment of fish habitation and activity at mid depth and deep stations. We attempted to use similar amounts of effort with mono and multifilament nets at each of the stations and, as a result, combined our captures between the two nets. As reported by Jester (1973) each of the nets are more effective at different times.

Fish collections at the deep and mid depth stations indicated that the abundance of white sturgeon was low at all of these stations. Highest catch rates for white sturgeon occurred at LG1D, where 11 fish were caught. Catch rates for white sturgeon were low at LG2D; none were collected at LG1M, while catch rates at LG2M and LG3M were lower than those at the deep stations. We tagged sturgeon throughout this project and recaptured none, suggesting a minimum population of 19 fish. In comparison, seven sturgeon were captured in 1985 (Bennett and Shrier 1986). Sturgeon collected in 1985 and 1987 were generally small (2-5 ft), suggesting possible recruitment from upstream lotic portions of the Snake River. Regardless of the source of recruitment, low catch rates suggest a low population density in Lower Granite Reservoir.

Catch rates were low for northern squawfish during spring and summer at all stations but increased at all stations during the fall. Increased catch rates could indicate greater activity and/or recruitment from shallow sites. Catches of northern squawfish at deep stations were low but consistent with those made in 1985 (Bennett and Shrier 1986). However, in 1987 sampling at mid depth stations, squawfish comprised a greater proportion of the fish community than at deep stations. Our sampling in 1987 and earlier (Bennett and Shrier 1987) has consistently shown that the majority of squawfish in Lower Granite Reservoir are juveniles and few are captured larger than 250 mm.

Juvenile rainbow trout that residualized in the reservoir as a result of low flows during spring 1987 provided the highest catch rates of all the key species. Unfortunately, we do not have sufficient data from previous years to compare catch rates to 1987. Only 1 rainbow trout was captured at a deep station during the 1985 survey (Bennett and Shrier 1986). Catch rates for rainbow trout were generally similar between LG2M and LG3M which were higher than those at LG2S. Highest catch rates of rainbow trout occurred at LG1M. Catch rates for rainbow at the deep stations differed as more rainbow were collected at LG2D. Catch rates for rainbow trout were similar between LG2S and LG1D. With the onset of the out-migration, we captured rainbow trout frequently in shallow waters and then, as the season progressed, continued collecting them predominantly at mid and deep stations. During the spring, many smolts had fungus infections. Trout that avoided the significant sport fishery in the reservoir generally improved in appearance and were collected in the summer, fall and into the winter season in reasonably good condition.

Our use of hydroacoustics greatly expanded our opportunity to "sample" mid and deep waters concurrently with gillnetting. A major drawback to the utility of sonar data was the inability to distinguish among different species and sizes of fish. Also, fish on the bottom were difficult to distinguish from the substrate. Another slight problem occurred when water disturbances and debris obliterated surface readings; this probably was not significant, however, because of the small sonar volume involved and the probable avoidance of the boat by fish at the surface. For these reasons, we are limited to drawing conclusions based on the entire fish community. A bias in sonar samples reflects the conical shape of the sonar beam. More volume is sampled per unit length along the transect at greater depths because sonar beam diameter increases with increasing depth. We adjusted for the bias by weighting total catch as a volumetric expression of effort (ft^3). We wish to emphasize that we do not equate this "catch rate" with a density estimate for the fish community. Our interpretations were exclusively qualitative and relative. Also, when we attempt to compare results from high in the water column to those near the bottom, or between stations, it is important to remember that more volume per transect is sampled in deeper areas.

Comparison of catch rates for gillnets and hydroacoustics indicated little correlation between methods at both mid depth and deep stations (Figures 93 and 94). In general, when gillnet catch rates were high, catch rates were low on the sonar. When catch rates were high on the echograms, gillnet catch rates were low. A number of possibilities could explain this disparity. First, fish could be distributed within the water column although their activity levels were low. Gill nets require fish movement to be effective. Also, fish could be changing levels quickly and, as a result, not be caught in the mid or deep nets although their signal is recorded on the echogram. Regardless of the reasons for the disparity, hydroacoustics provided a good technique to assess vertical distribution and differential activity patterns.

MID DEPTH STATIONS

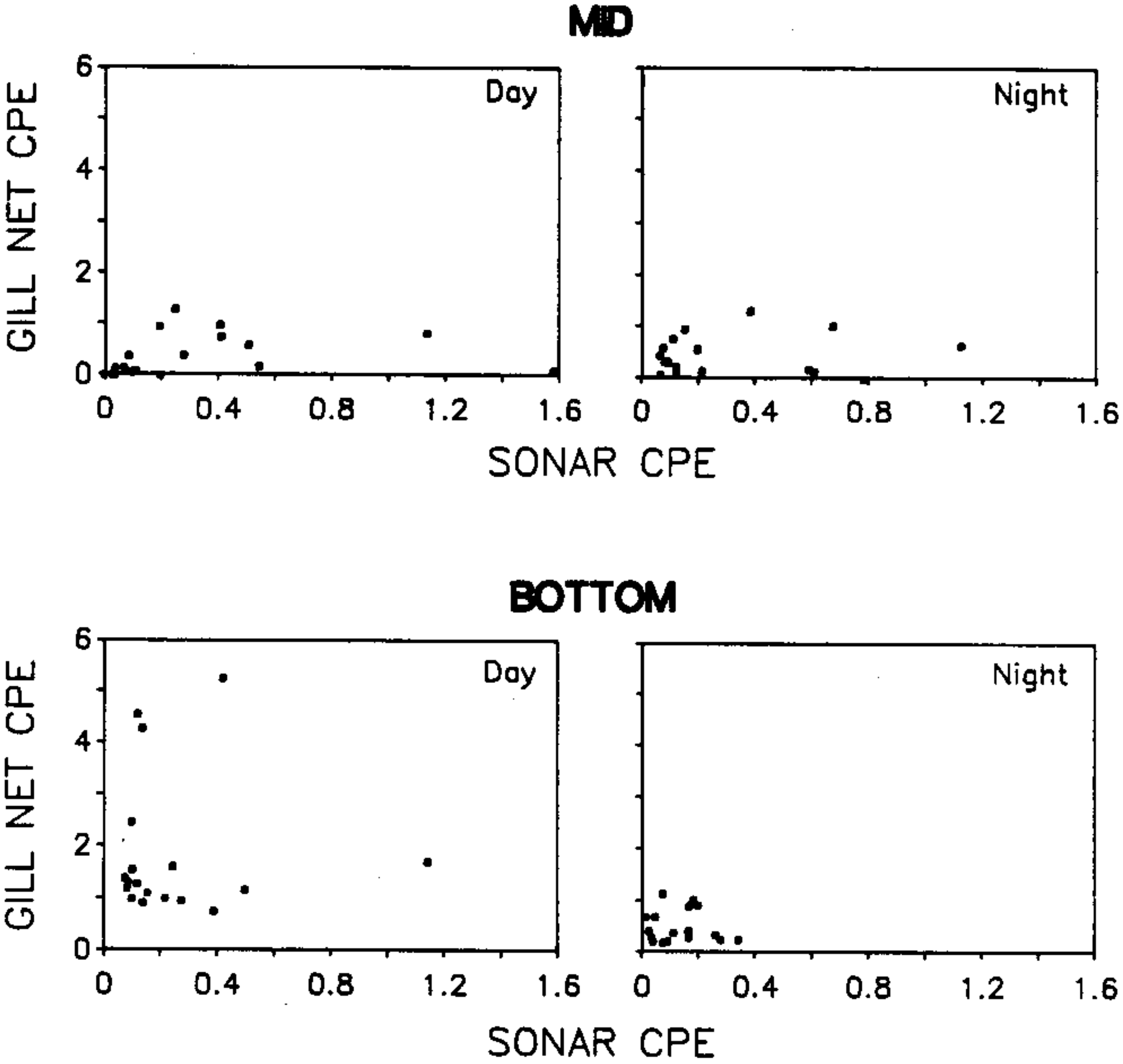

Figure 93. Comparison of gill net CPE (catch per hour) with sonar CPE (fish/ft^3 x 10^4) for day and night samples over all seasons in mid water and bottom regions of the mid depth stations in Lower Granite Reservoir, Washington.

DEEP STATIONS

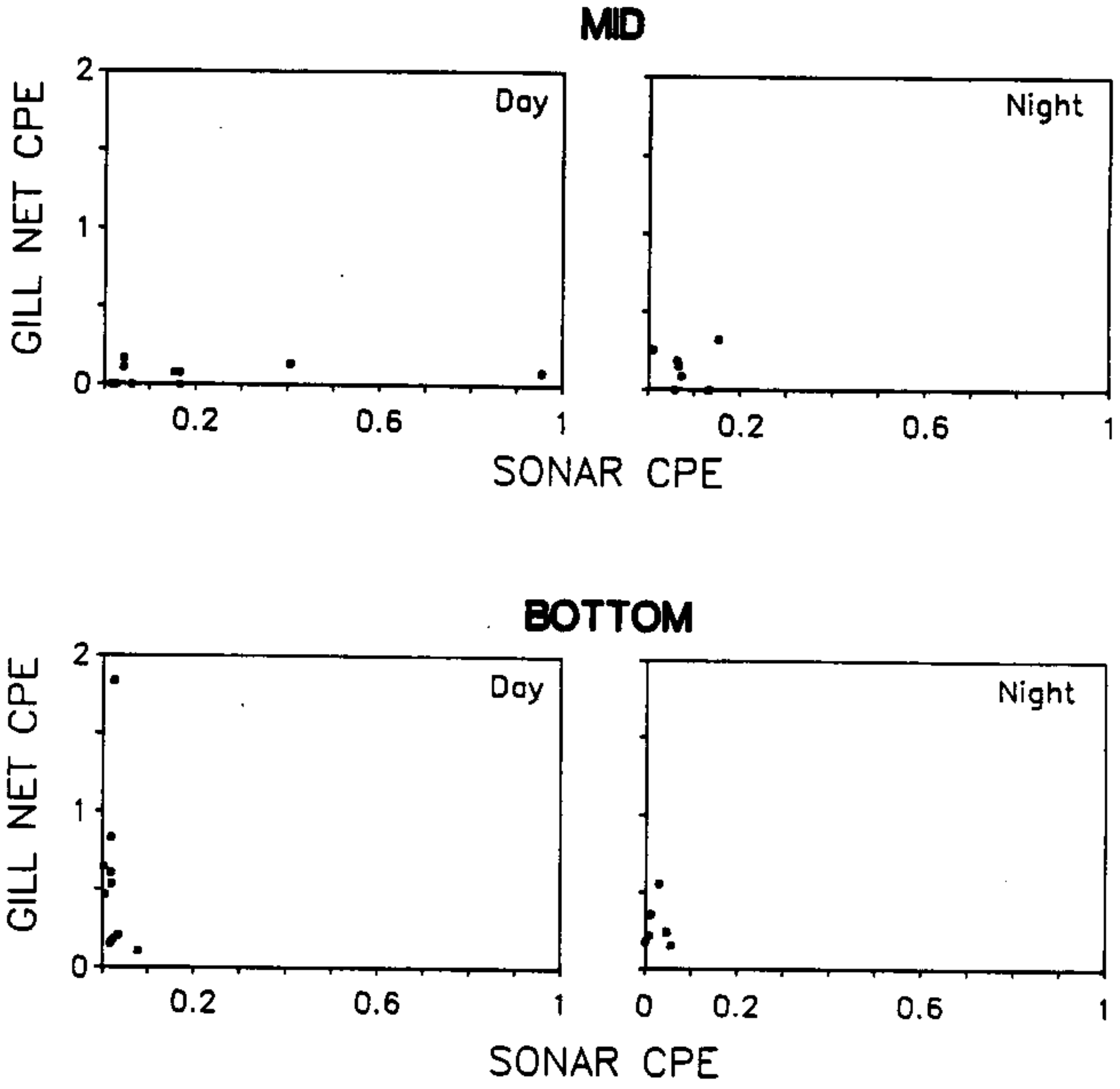

Figure 94. Comparison of gill net CPE (catch per hour) with sonar CPE (fish/ft^3 x 10^4) for day and night samples over all seasons in mid water and bottom regions of the deep stations in Lower Granite Reservoir, Washington.

One factor that affects fish distribution is morphometry. Morphometry at LG2M consists of a gently sloping shelf ending in an old river terrace which drops off rapidly at about 40 ft in depth. Fish occupying the deeper portions of the shelf were concentrated in the upper water column. Observed paucity of bottom fish at LG1D may reflect morphometry as well as fish habitat preference. LG1D slopes steeply down to depths around 80 ft, where the river channel bottom flattens. Large rock slides exist above full pool level, and a lot of this structure occurs at the base of the slope. Structure in such areas made fish record identification difficult; what appears to be structure on the bottom could also be fish. Bottom fish and structure records are probably intermingled, making it likely that the observed paucity of bottom fish could have been related to our inability to identify the records properly. However, density of fish in the upper water column at LG1D was so high that density off the bottom greatly exceeded that on the bottom even if all potential bottom fish records were counted.

Morphometry of LG2D consists of vertical cliffs down to 70 ft, where it flattens to the river channel. Little bottom structure was present; cliffs are old basaltic lava flows which decompose into relatively small pieces and fall right at the foot of the cliff. Thus, we were much more confident of detecting bottom fish records at LG2D than at LG1D, although few were present, with most fish occupying the upper water column at LG2D.

Food habits of potential smolt predators is always of interest in a reservoir like Lower Granite that receives millions of smolts annually. We found that smallmouth bass, northern squawfish, and channel catfish all contained salmonid smolts. Highest incidence occurred in channel catfish in the spring followed by northern squawfish and smallmouth bass. Crayfish and chironomids were major food items of smallmouth bass, channel catfish and northern squawfish throughout the year. Food habits of smallmouth bass and northern squawfish differed between 1985 and 1987. Based on the Index of Relative Importance, in the spring of 1987 chironomids comprised over 50% of the smallmouth bass diet, while in 1985 crayfish and fish were more common (Bennett and Shrier 1986). Crayfish dominated bass diets during the summers of 1985 and 1987, although fish were more prevalent in 1987 than in 1985. Northern squawfish diets were more diverse in 1987 than in 1985; in 1985 crayfish dominated squawfish diets (Bennett and Shrier 1986), while chironomids, insects, and zooplankton were important dietary items in 1987.

Of the fish found in stomach samples, smallmouth bass and squawfish contained predominantly chinook salmon, whereas channel catfish consumed mostly rainbow trout. This difference may reflect a difference where the predation occurred, or smaller chinook may be easier to consume for squawfish and bass, whose mouth size is smaller than channel catfish. During the summer, *Leptodora* was the dominant prey item of squawfish sampled. This probably indicates a paucity of available fish prey, since all squawfish sampled were larger than 250 mm, sizes at which they are generally piscivorous. Because northern squawfish from Lower Granite Reservoir are fairly small, they probably have trouble successfully attacking the large rainbow trout. Except at LG2S, channel catfish were always captured at mid or bottom depths, where rainbow trout catches were lowest. Seventy percent of the catfish caught for stomach sampling in the spring came from LG2M, where catfish were always caught on the bottom and trout catch rates at the surface were 4-5 times higher than on the bottom. Catfish are probably not altering their foraging patterns to coincide with the surface preference of trout, but are foraging on trout that venture into deeper areas, whereas northern squawfish and smallmouth may be foraging on the shoreline oriented chinook salmon. Our results suggest that the incidence of predation on salmonids was low in 1987, which agrees with previous reports on smolt predation in Lower Granite Reservoir during 1985 (Bennett and Shrier 1986).

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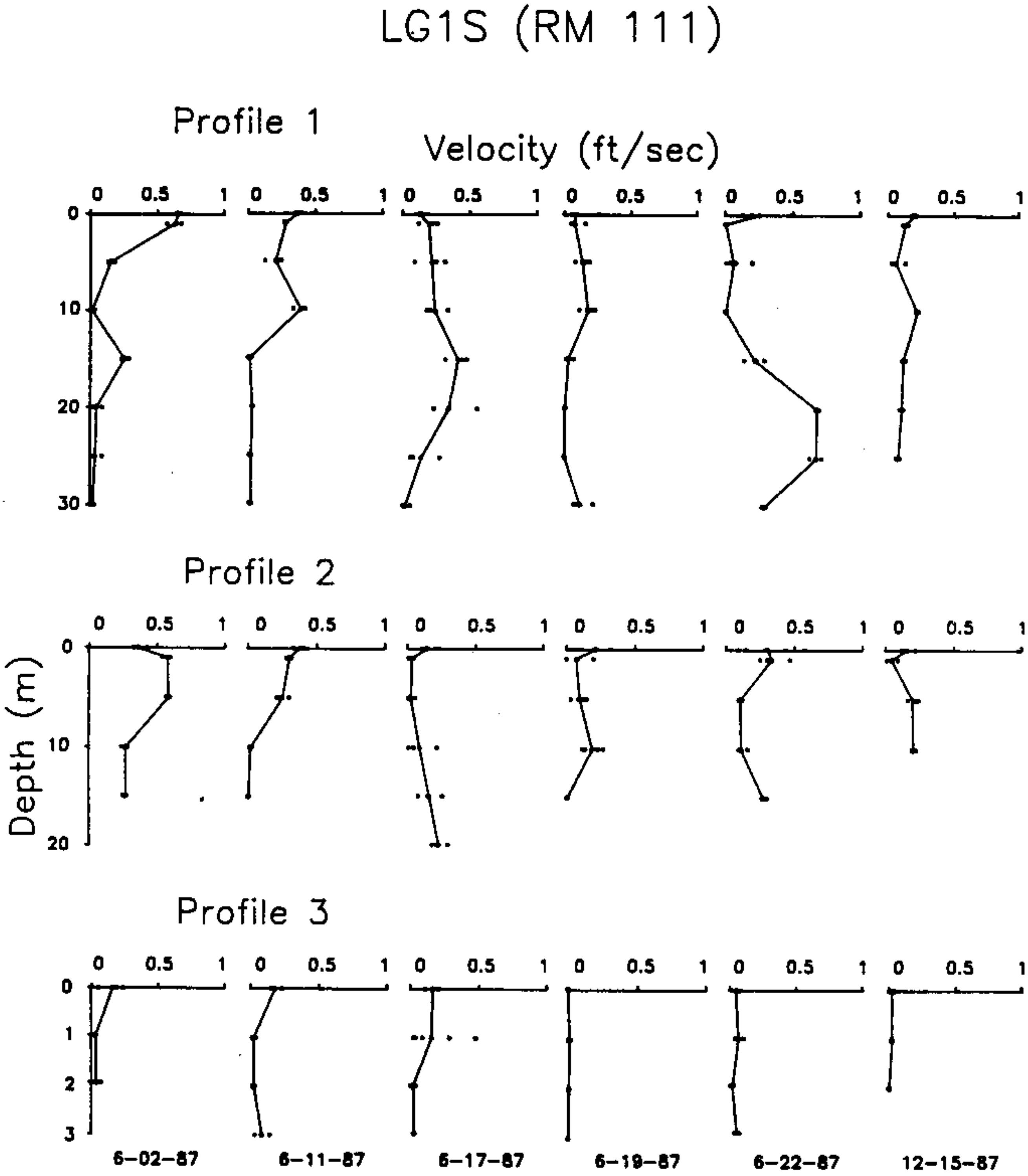
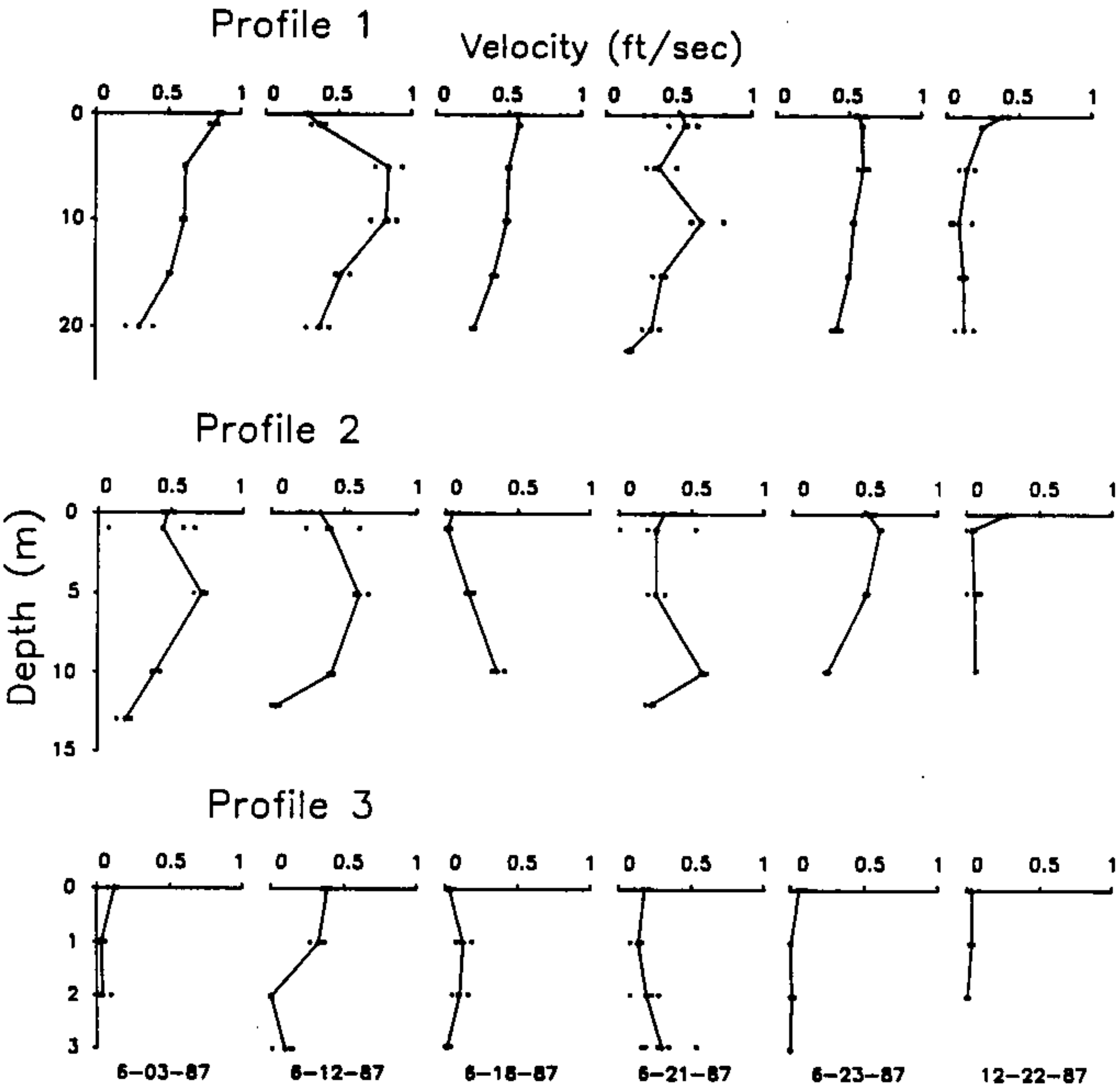
Appendix A. Velocity (ft/sec) profiles from June and December, 1987 sampling at all stations (deep, mid depth, and shallow) in Lower Granite Reservoir, Washington.

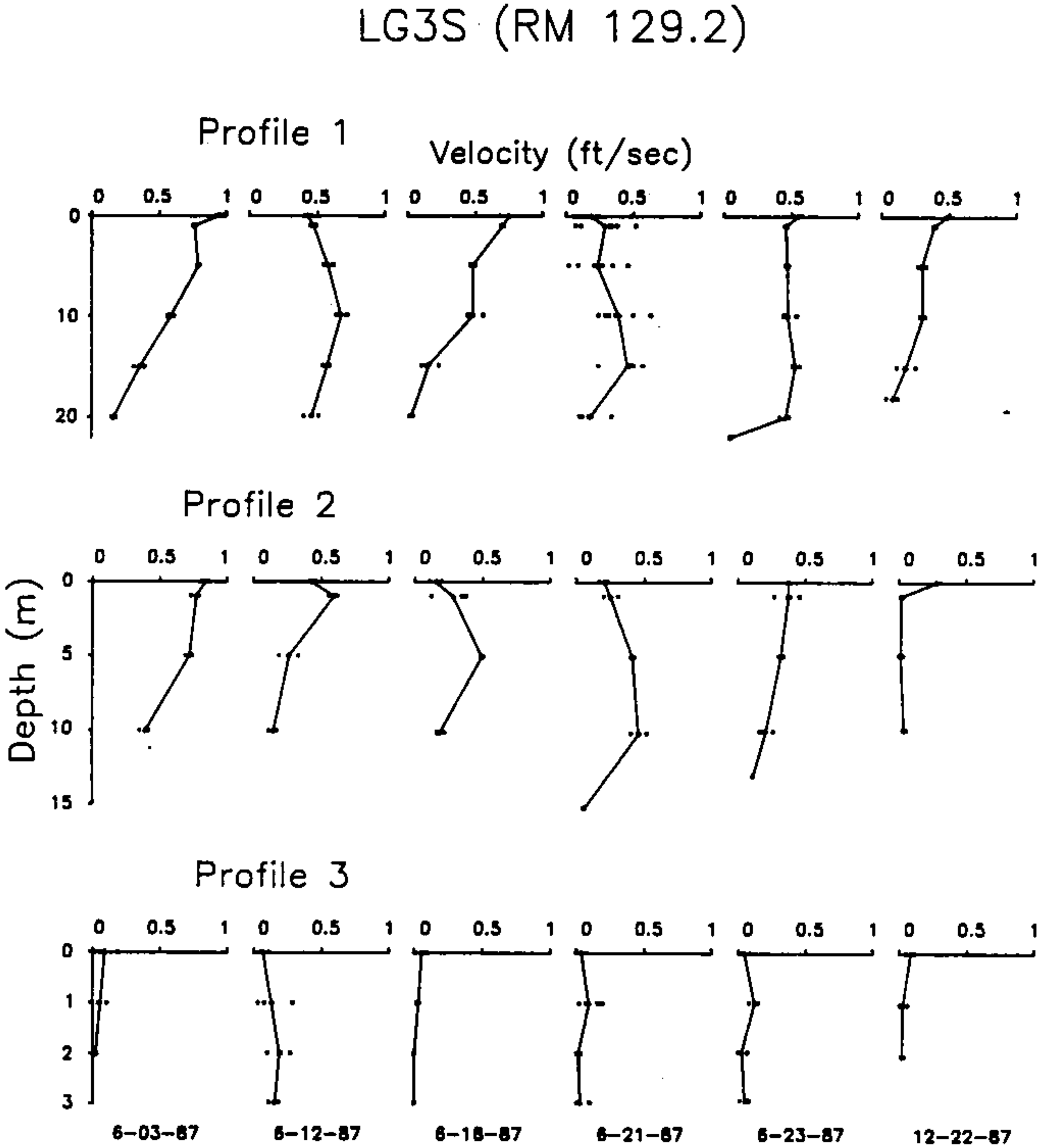


Appendix Figure 1. Velocity (ft/sec) profiles from June and December, 1987 sampling at station LG1S on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.

LG2S (RM 127.3)

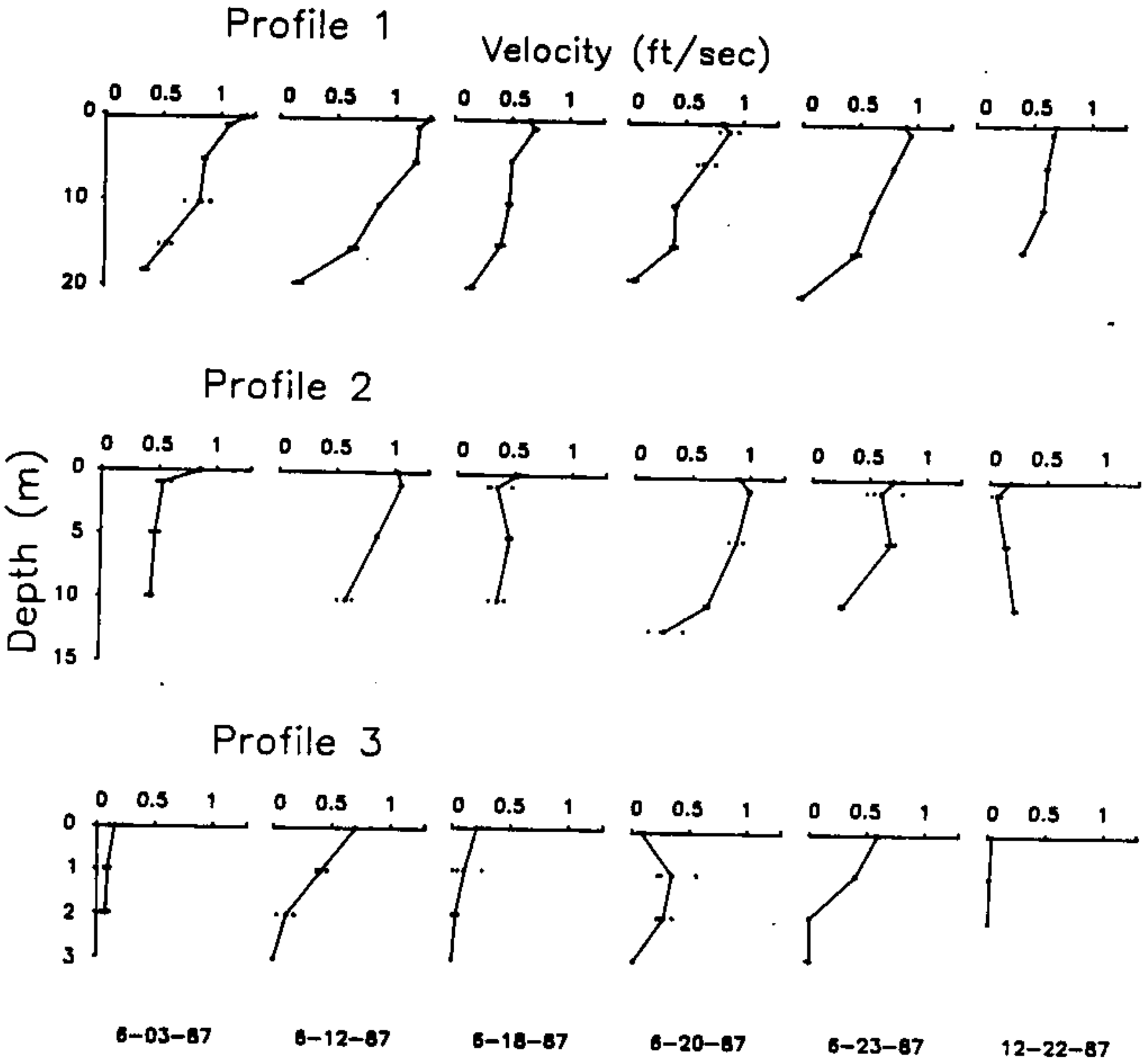


Appendix Figure 2. Velocity (ft/sec) profiles from June and December, 1987 sampling at station LG2S on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.

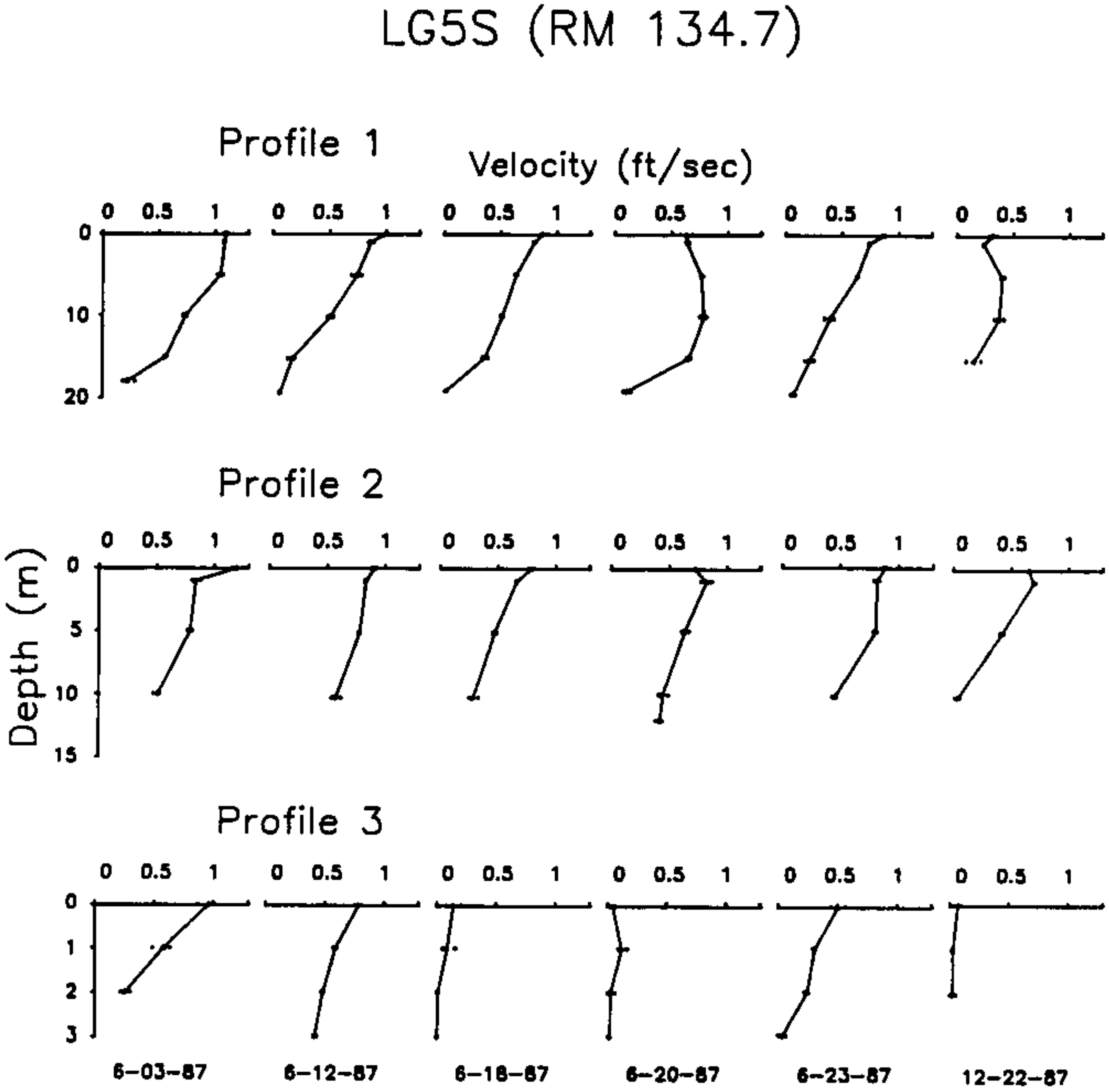


Appendix Figure 3. Velocity (ft/sec) profiles from June and December, 1987 sampling at station LG3S on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.

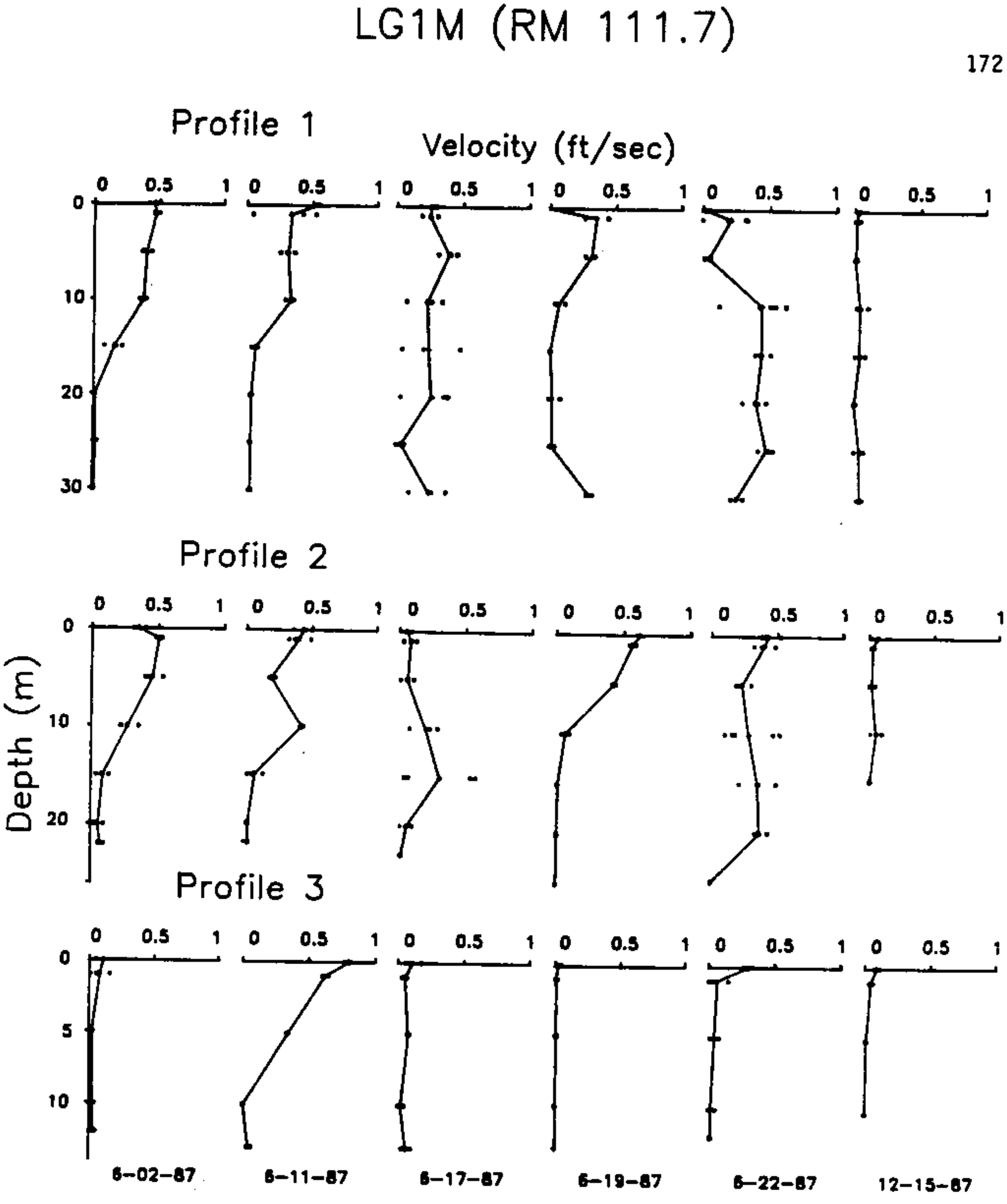
LG4S (RM 132.4)



Appendix Figure 4. Velocity (ft/sec) profiles from June and December, 1987 sampling at station LG4S on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.

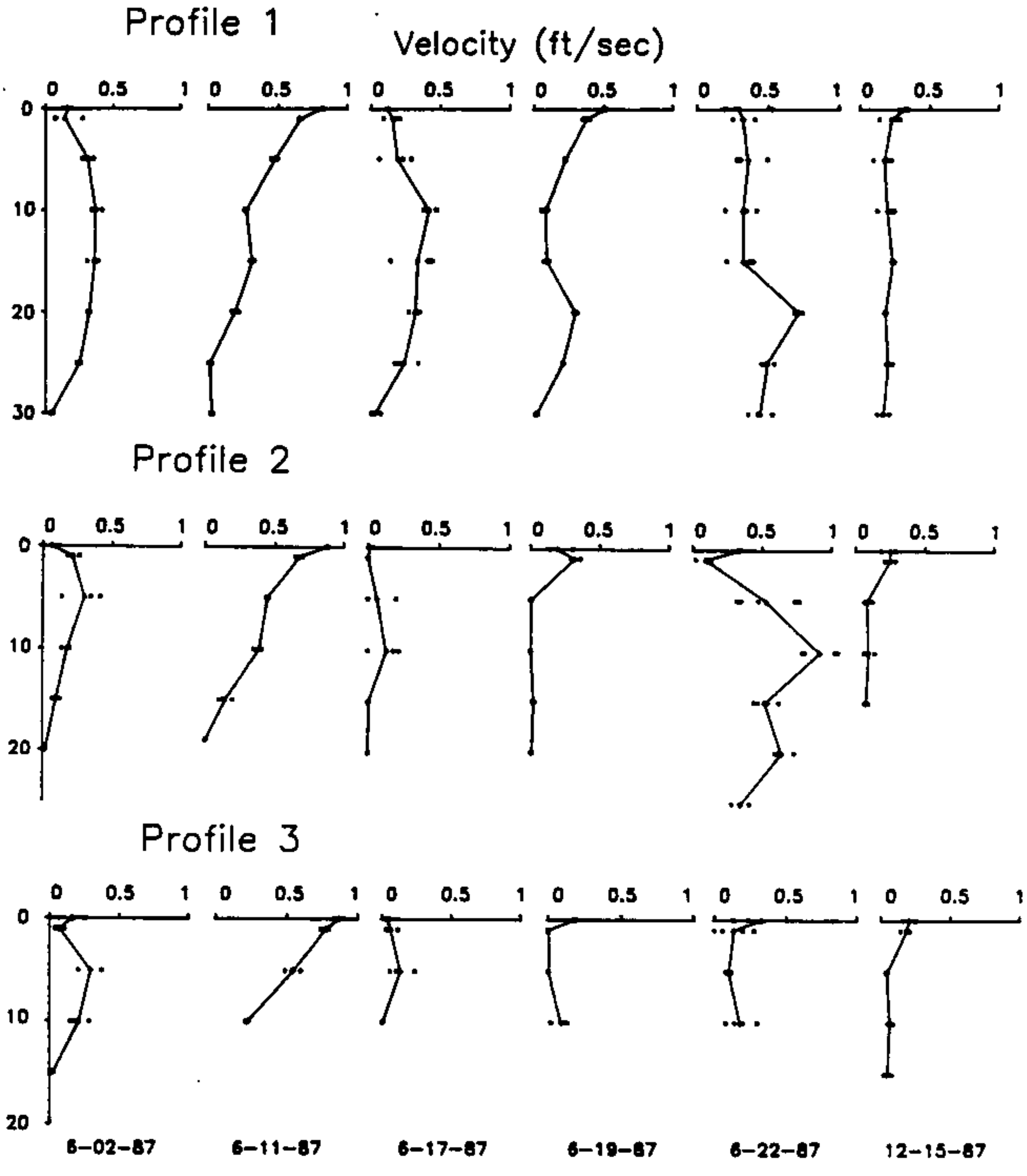


Appendix Figure 5. Velocity (ft/sec) profiles from June and December, 1987 sampling at station LG5S on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.

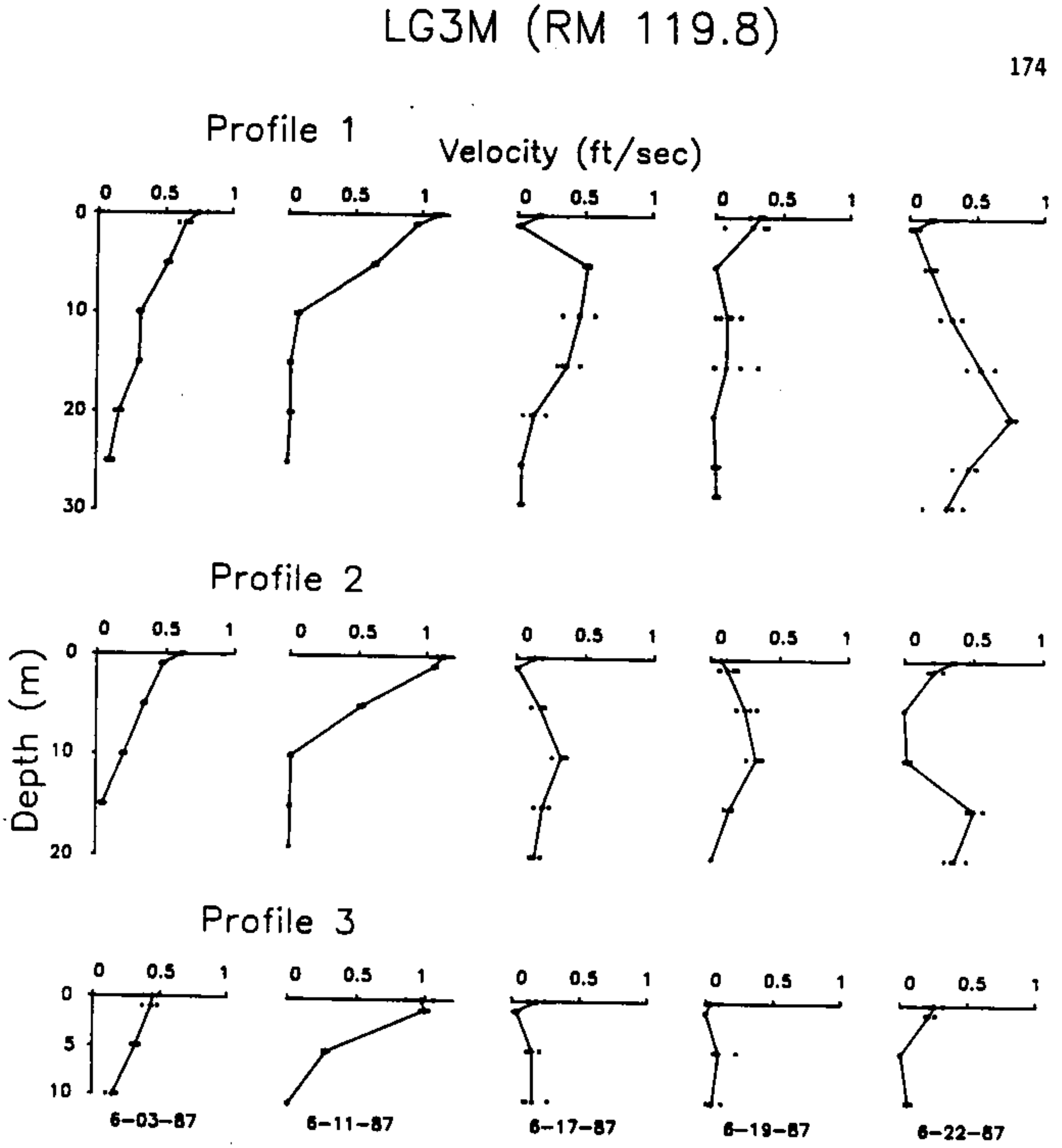


Appendix Figure 6. Velocity (ft/sec) profiles from June and December, 1987 sampling at station LGIM on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles I and 3. Velocities were measured every I m along profile 3, and at 0 m, I m, and 5 m, then every 5 m to the bottom along profiles I and 2.

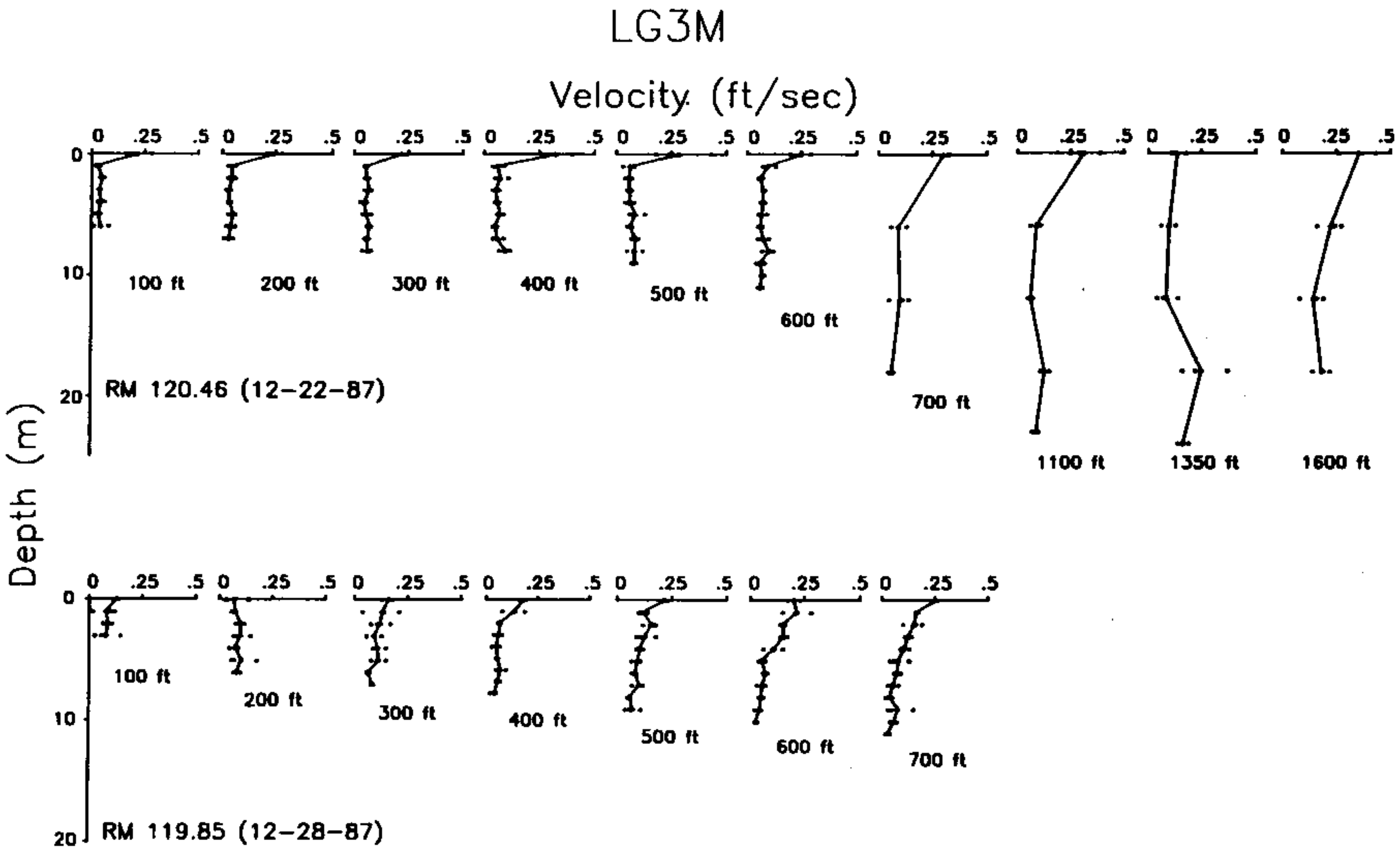
LG2M/1D (RM 114.2)



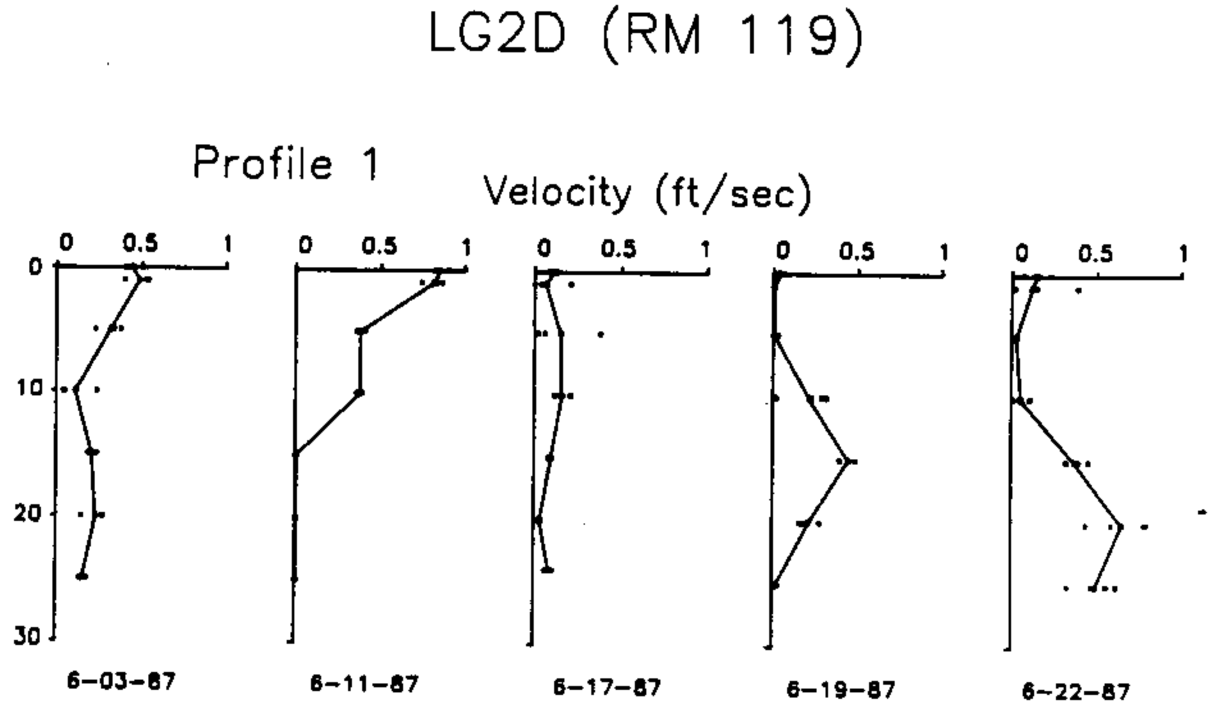
Appendix Figure 7. Velocity (ft/sec) profiles from June and December, 1987 sampling at stations LG2M and LG1D on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.



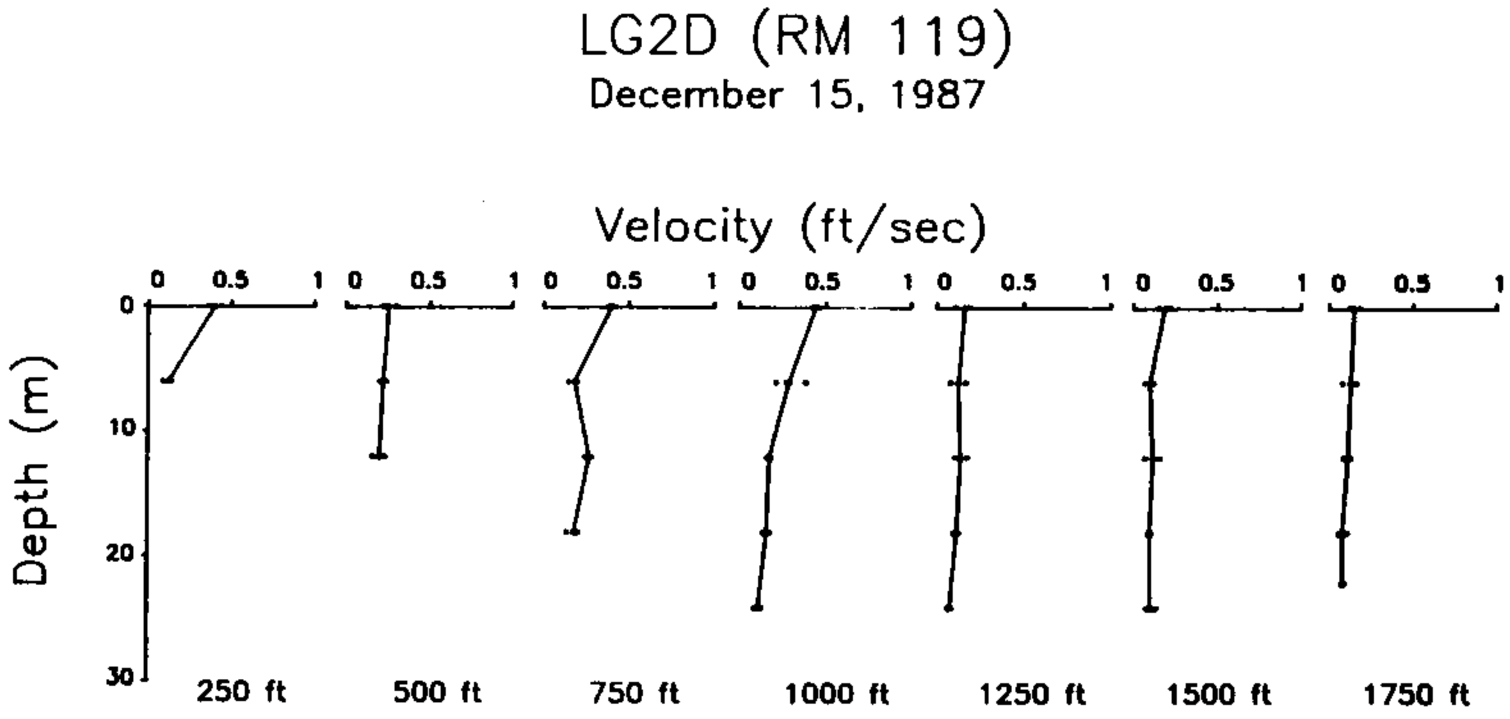
Appendix Figure 8. Velocity (ft/sec) profiles from June, 1987 sampling at station LG3M on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths (note depth scale differences). Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, profile 3 (on-site profile) was near shore in 10 ft of water, and profile 2 (midway profile) was at a depth equal to half the difference in depths between profiles 1 and 3. Velocities were measured every 1 m along profile 3, and at 0 m, 1 m, and 5 m, then every 5 m to the bottom along profiles 1 and 2.



Appendix Figure 9. Velocity (ft/sec) profiles from December, 1987 sampling at station LG3M on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths. Profiles were dropped from 2 transects (RM 120.46 and 119.85) running perpendicular to the channel. Profiles were dropped every 100 ft between the shoreline and the 60 ft contour (both transects), then at roughly equal intervals across the channel on the transect at RM 120.46. When total depth was greater than 60 ft, velocities were measured every 6 m along a profile; otherwise velocities were measured every 1 m.



Appendix Figure 10. Velocity (ft/sec) profiles from June, 1987 sampling at station LG2D on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths. Profiles were dropped from a transect running perpendicular to the channel; profile 1 (channel profile) was at the deepest point along the transect, and because LG2D is a deep station, no other profiles were dropped.



Appendix Figure 11. Velocity (ft/sec) profiles from December, 1987 sampling at station LG2D on Lower Granite Reservoir, Washington. Lines connect mean velocities for different depths. Seven profiles were dropped about every 250 ft from a transect running perpendicular to the channel. Velocities were measured every 6 m along each profile.

Appendix Table A1. Temperatures (C) and turbidities (NTU) from all stations measured throughout 1987 in Lower Granite Reservoir, Washington. Stations are presented in order based on river mile upstream to downstream.

Site	Day			Night		
	Date	Temperature	Turbidity	Date	Temperature	Turbidity
LG2S	5/11	15.5	3.1	5/17	14	
	5/20	15	2.3	5/28	15.5	2.5
	7/21		1	8/10	22.5	2.9
	8/10	24	3.3	8/18	22	3.5
	8/18	22	2.5	10/4	18	1.1
	10/3	16	2.6	10/14		1.6
	10/14	16	1.8	10/24	13	1.4
	10/24	14		12/6	8	0.8
	12/16	6				
LG3M	5/4	11	4.5	4/27	13	2.3
	5/14	14.5	1.8	5/8	13	2.3
	5/21	15	2.3	5/16		2.5
	5/26	16	2.3	5/20	14	1.9
	7/24		3	5/26		1.6
	8/4	23	1.8	8/4	23	
	8/12	23	2.5	8/12		1.7
	8/24	23.5	1.5	8/24	23	1.5
	10/7	17	1.1	10/7	17	1.1
	10/12	17	2	10/12	16	
	10/21	15	1.9	10/21	15	1.7
	12/2	8	2.2	11/30	8	2.7
				12/17	6	2.2
LG2D	5/14	14.5	2.3	4/27	13	2.8
	7/28		2	5/16	13.5	2
	7/29		1.9	5/26	15.5	1.8
	8/7	25	1.3	8/7	24	1.4
	8/19	22	1.8	8/19	22	1.2
	10/2	15.5	1.6	10/2		1
	10/17	16.5	1.5	10/17	15	
	10/23	14.5	1.5	10/23	14	
	12/4	8	1.1	12/3	7	1.9

Appendix Table A1 (continued).

Site	Day			Night		
	Date	Temperature	Turbidity	Date	Temperature	Turbidity
LG1D	4/27	15	3.9	4/24	12	2.8
	5/1	14	2.2	5/15	14	1.8
	5/5	13	3.4	5/27	15	2
	5/27	15.5	1.5	7/30		1.9
	7/30	23	2.2	8/6	23	1.8
	8/6	24	1.9	8/21	23	
	8/21	24	1.8	10/6	16	1
	10/6	16	1.4	10/13	16	1.8
	10/13	17	1.6	10/22	14	1.4
	10/22	15	2	12/4	8	
	12/7	8		12/16	6	
LG2M	4/27	15.5	3.8	4/24	12	2.8
	5/5	12	2.6	5/14	13	1.3
	5/12	15.5	2.1	5/15	14	2.1
	5/29	17	1.1	5/27		1.5
	7/23		1.5	8/3	23	
	8/3	23	1.5	8/13	23	
	8/13	24	2.2	8/17	23	
	8/17	23	2.6	10/5	17	1.3
	10/5	16.5	1.3	10/16		1.3
	10/16	17	2.6	10/20	15	
	10/20	16	2	12/5	8	2.2
				12/8	8	
LG1M	4/26		3.6	4/23	13	2.3
	5/7	14	2.2	5/7	13	3
	5/18	13	2.5	5/19	14	3
	7/22		1.5	8/5		1.7
	8/5	23	1.8	8/14	22	2.4
	8/14	23	1.6	8/20	23	1.5
	8/20	24	1.6	10/8	17	1.2
	10/8		1	10/15	17	2.2
	10/15	16	2	10/19	16	1.5
	10/19	16	1.9	12/2	9	
	12/3	8	1.2	12/19	5.5	

Appendix Table A2. Numbers of benthic organisms other than oligochaetes and chironomids from ponar dredge collections at mid-depth and deep stations during spring, summer, and fall, 1987, at Lower Granite Reservoir, Washington.

Taxon	Station LG1D	 LG2D	 LG1M	 LG2M	 LG3M
Spring	*n=8*	*n=8*	*n=8*	*n=8*	*n=8*
Nematoda	2	-	-	-	-
Mollusca					
Lamellibranchiata					
Pelecypoda	-	-	-	7	1
Arthropoda					
Aracnoidea					
Hydracarina	-	-	2	-	3
Insecta					
Ephemeroptera	-	-	1	-	-
Summer	*n=8*	*n=8*	*n=8*	*n=8*	*n=8*
Nematoda	-	1	-	-	5
Annelida					
Hirudinea	-	-	-	1	-
Arthropoda					
Arachnoidea					
Hydracarina	-	-	1	-	-
Fall	*n=8*	*n=8*	*n=8*	*n=8*	*n=8*
Nematoda	6	-	-	-	-
Annelida					
Hirudinea	-	-	-	1	-
Mollusca					
Lamellibranchiata					
Pelecypoda	-	-	1	2	-
Arthropoda					
Arachnoidea					
Hydracarina	-	-	-	1	1
Insecta					
Culicidae					
Chaoborus	-	-	2	1	-

Appendix Table A3. Numbers of benthic organisms other than oligochaetes and chironomids from ponar dredge collections at shallow stations during spring, summer, and fall, 1987, at Lower Granite Reservoir, Washington. Coarse substrate prevented us from effectively dredging LG1S with the ponar dredge.

	Station			
Taxon	LG2S	LG3S	LG4S	LG5S
Spring	*n=12*	*n=8*	*n=8*	*n=7*
Tardigrada	-	-	-	2
Nematoda	1	2	5	6
Annelida				
Polychaeta	2	-	1	3
Mollusca				
Lamellibranchiata				
Pelecypoda	1	-	-	2
Arthropoda				
Aracnoidea				
Hydracarina	1	1	-	2
Insecta				
Trichoptera	-	-	-	1
Coleoptera	1	-	-	-
Summer	*n=8*	*n=8*	*n=8*	*n=8*
Nematoda	2	-	-	-
Annelida				
Polychaeta	-	-	-	1
Arthropoda				
Arachnoidea				
Hydracarina	-	-	2	1
Fall	*n=8*	*n=8*	*n=8*	*n=8*
Nematoda	-	-	1	-
Arthropoda				
Arachnoidea				
Hydracarina	-	2	6	2
Insecta				
Trichoptera	-	-	-	1

Appendix B. Mean diel catch rates (catch per hour) from gillnetting for all species, gillnet types (bottom, mid water, and floating), stations, and seasons in Lower Granite Reservoir, Washington, 1987. Catch rates were calculated within length classes which differed among species. Length class 1 represents sub-adults for key species (ATR < 500 mm, ONE and OTS < 200 mm, SGA < 350 mm, POR and IPU < 250 mm, and MDO < 150 mm) and young-of-the-year (YOY) for all other species (< 100 mm). Length class 2 represents adults for key species and non-YOY for all other species. See Table 12 for species codes.

Appendix Table 1. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG10 Season - Spring

Date	Length Class	Species (Day)										Species (Night)									
		ATR	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO	ATR	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO
4/24	1	.	.	.	.	.	.	.	.	.	.		0.10								
	2	.	.	.	.	.	.	.	.	.	.						0.10	0.29			
	Total	.	.	.	.	.	.	.	.	.	.		0.10				0.10	0.29			
4/27	1											.	.	.	.	.	.	.	.	.	.
	2								0.12			.	.	.	.	.	.	.	.	.	.
	Total								0.12			.	.	.	.	.	.	.	.	.	.
5/05	1											.	.	.	.	.	.	.	.	.	.
	2											.	.	.	.	.	.	.	.	.	.
	Total											.	.	.	.	.	.	.	.	.	.
5/15	1	.	.	.	.	.	.	.	.	.	.			0.10							
	2	.	.	.	.	.	.	.	.	.	.		0.10								
	Total	.	.	.	.	.	.	.	.	.	.		0.10	0.10							
5/27	1												0.44	0.22							
	2																				
	Total												0.44	0.22							
Spring Mean									0.04				0.21	0.11			0.03	0.10			

Appendix Table 2. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG1D Season - Spring

		Species (Day)										Species (Night)									
Date	Length Class	ATR	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO	ATR	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO
4/24	1	.	.	.	.	.	.	.	.	.	.										
	2	.	.	.	.	.	.	.	.	.	.				0.19						
	Total	.	.	.	.	.	.	.	.	.	.				0.19						
4/27	1											.	.	.	.	.	.	.	.	.	.
	2								0.19	0.19		.	.	.	.	.	.	.	.	.	.
	Total								0.19	0.19		.	.	.	.	.	.	.	.	.	.
5/05	1											.	.	.	.	.	.	.	.	.	.
	2											.	.	.	.	.	.	.	.	.	.
	Total											.	.	.	.	.	.	.	.	.	.
5/15	1	.	.	.	.	.	.	.	.	.	.										
	2	.	.	.	.	.	.	.	.	.	.										
	Total	.	.	.	.	.	.	.	.	.	.										
5/27	1																				
	2													0.28							
	Total													0.28							
Spring Mean									0.06	0.06				0.09	0.06						

Appendix Table 3. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG1D Season - Spring

		Species (Day)										Species (Night)									
Date	Length Class	ATR	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO	ATR	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO
4/24	1	.	.	.	.	.	.	.	.	.	.										
	2	.	.	.	.	.	.	.	.	.	.										
	Total	.	.	.	.	.	.	.	.	.	.										
4/27	1											.	.	.	.	.	.	.	.	.	.
	2				0.19							.	.	.	.	.	.	.	.	.	.
	Total				0.19							.	.	.	.	.	.	.	.	.	.
5/05	1											.	.	.	.	.	.	.	.	.	.
	2											.	.	.	.	.	.	.	.	.	.
	Total											.	.	.	.	.	.	.	.	.	.
5/15	1	.	.	.	.	.	.	.	.	.	.										
	2	.	.	.	.	.	.	.	.	.	.						0.14				
	Total	.	.	.	.	.	.	.	.	.	.						0.14				
5/27	1																				
	2	0.15														0.58					
	Total	0.15														0.58					
Spring Mean		0.05			0.06											0.19	0.05				

Appendix Table 4. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2D Season - Spring

	Length	Species (Day)									Species (Night)								
Date	Class	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO
4/27	1	.	.	.	.	.	.	.	.	.		0.08			0.17				
	2	.	.	.	.	.	.	.	.	.	0.08		0.25		0.17	0.08	0.08		
	Total	.	.	.	.	.	.	.	.	.	0.08	0.08	0.25		0.34	0.08	0.08		
4/30	1		0.14								.	.	.	.	.	.	.	.	.
	2						0.97				.	.	.	.	.	.	.	.	.
	Total		0.14				0.97				.	.	.	.	.	.	.	.	.
5/14	1										.	.	.	.	.	.	.	.	.
	2										.	.	.	.	.	.	.	.	.
	Total										.	.	.	.	.	.	.	.	.
5/16	1	.	.	.	.	.	.	.	.	.		0.20							
	2	.	.	.	.	.	.	.	.	.	0.20								
	Total	.	.	.	.	.	.	.	.	.	0.20	0.20							
5/26	1										0.20	0.99							
	2																		
	Total										0.20	0.99							
Spring Mean			0.05				0.32				0.16	0.42	0.08		0.11	0.03	0.03		

Appendix Table 5. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG2D Season - Spring

Date	Length Class	Species (Day)									Species (Night)								
		OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO	OTS	SGA	AAL	CCA	POR	RBA	CMA	IPU	MDO
4/27	1	.	.	.	.	.	.	.	.	.		0.17							
	2	.	.	.	.	.	.	.	.	.									
	Total	.	.	.	.	.	.	.	.	.		0.17							
4/30	1										.	.	.	.	.	.	.	.	.
	2										.	.	.	.	.	.	.	.	.
	Total										.	.	.	.	.	.	.	.	.
5/14	1										.	.	.	.	.	.	.	.	.
	2										.	.	.	.	.	.	.	.	.
	Total										.	.	.	.	.	.	.	.	.
5/16	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.									
	Total	.	.	.	.	.	.	.	.	.									
5/26	1								0.23										
	2				0.45	0.23												0.20	
	Total				0.45	0.23			0.23									0.20	
Spring Mean					0.15	0.11			0.11			0.06						0.07	

Appendix Table 6. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2D Season - Spring

		Species (Day)									Species (Night)								
Date	Length Class	OTS	SGA	AAL	CCA	POR	RBA	CNA	IPU	MDO	OTS	SGA	AAL	CCA	POR	RBA	CNA	IPU	MDO
4/27	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.				0.17			0.17		
	Total	.	.	.	.	.	.	.	.	.				0.17			0.17		
4/30	1										.	.	.	.	.	.	.	.	.
	2								0.15		.	.	.	.	.	.	.	.	.
	Total								0.15		.	.	.	.	.	.	.	.	.
5/14	1										.	.	.	.	.	.	.	.	.
	2										.	.	.	.	.	.	.	.	.
	Total										.	.	.	.	.	.	.	.	.
5/16	1	.	.	.	.	.	.	.	.	.								0.21	
	2	.	.	.	.	.	.	.	.	.				0.21			0.42		
	Total	.	.	.	.	.	.	.	.	.				0.21			0.42	0.21	
5/26	1																		
	2																0.80		
	Total																0.80		
Spring Mean									0.05					0.13			0.46	0.07	

Appendix Table 7. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG1M Season - Spring

Date	Length Class	Species (Day)													Species (Night)												
		OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	INE	IPU	MDO	PAN	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	INE	IPU	MDO	PAN
4/23	1	.	.	.	.	.	.	.	.	.	.	.	.	.	0.5	0.6											
	2	.	.	.	.	.	.	.	.	.	.	.	.	.		0.1	0.1				0.1						
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.	0.5	0.7	0.1				0.1						
4/26	1														.	.	.	.	.	.	.	.	.	.	.	.	.
	2			0.65			0.09		0.09	0.56					.	.	.	.	.	.	.	.	.	.	.	.	.
	Total			0.65			0.09		0.09	0.56					.	.	.	.	.	.	.	.	.	.	.	.	.
5/07	1														0.09	0.52											
	2															0.09	0.09				0.17						
	Total														0.09	0.61	0.09				0.17						
5/18	1		0.07												.	.	.	.	.	.	.	.	.	.	.	.	.
	2														.	.	.	.	.	.	.	.	.	.	.	.	.
	Total		0.07												.	.	.	.	.	.	.	.	.	.	.	.	.
5/19	1	.	.	.	.	.	.	.	.	.	.	.	.	.		0.1				0.05							
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	0.05	0.1	0.14		0.05		0.1						
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.	0.05	0.2	0.14		0.05	0.05	0.1						
Spring Mean			0.02	0.22			0.03		0.03	0.19					0.21	0.5	0.11		0.02	0.02	0.12						

Appendix Table 8. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG1M Season - Spring

	Length	Species (Day)													Species (Night)												
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	MDO	PAN	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	MDO	PAN
4/23	1	.	.	.	.	.	.	.	.	.	.	.	.	.		0.52											
	2	.	.	.	.	.	.	.	.	.	.	.	.	.			0.17					0.17	0.87	0.17			0.17
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.		0.52	0.17					0.17	0.87	0.17			0.17
4/26	1														.	.	.	.	.	.	.	.	.	.	.	.	.
	2									0.15					.	.	.	.	.	.	.	.	.	.	.	.	.
	Total									0.15					.	.	.	.	.	.	.	.	.	.	.	.	.
5/07	1															0.52				0.09							
	2		0.05	0.05	0.15		0.1		0.05								0.09	0.09			0.09					0.09	
	Total		0.05	0.05	0.15		0.1		0.05							0.52	0.09	0.09		0.09	0.09					0.09	
5/18	1														.	.	.	.	.	.	.	.	.	.	.	.	.
	2						0.14								.	.	.	.	.	.	.	.	.	.	.	.	.
	Total						0.14								.	.	.	.	.	.	.	.	.	.	.	.	.
5/19	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.		0.07		0.15					0.07				
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.		0.07		0.15					0.07				
Spring Mean			0.02	0.02	0.05		0.08		0.02	0.05						0.37	0.09	0.08		0.03	0.03	0.06	0.31	0.06		0.03	0.06

Appendix Table 9. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG1M Season - Spring

	Length	Species (Day)													Species (Night)												
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	MDO	PAN	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	MDO	PAN
4/23	1	.	.	.	.	.	.	.	.	.	.	.	.	.		0.61											
	2	.	.	.	.	.	.	.	.	.	.	.	.	.				0.81		0.2			0.41				
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.		0.61		0.81		0.2			0.41				
4/26	1														.	.	.	.	.	.	.	.	.	.	.	.	.
	2														.	.	.	.	.	.	.	.	.	.	.	.	.
	Total														.	.	.	.	.	.	.	.	.	.	.	.	.
5/07	1															0.45											
	2				0.2		0.14			0.07								0.06									
	Total				0.2		0.14			0.07						0.45		0.06									
5/18	1						0.09								.	.	.	.	.	.	.	.	.	.	.	.	.
	2			0.05	0.14					0.05					.	.	.	.	.	.	.	.	.	.	.	.	.
	Total			0.05	0.14		0.09			0.05					.	.	.	.	.	.	.	.	.	.	.	.	.
5/19	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.				0.22	0.07	0.07			0.66				
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.				0.22	0.07	0.07			0.66				
Spring Mean				0.02	0.11		0.08			0.04						0.35		0.36	0.02	0.09			0.36				

Appendix Table 10. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2M Season - Spring

	Length	Species (Day)															Species (Night)													
Date	Class	ATR	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CMA	INE	IPU	LGI	NDO	Date	ATR	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CMA	INE	IPU	LGI	NDO
4/27	1			0.06												4/24			0.13											
	2							0.06			0.06							0.13					0.13							
	Total			0.06				0.06			0.06							0.13	0.13				0.13							
5/05	1		0.06													5/14			0.32											
	2																	0.16	0.11				0.05	0.05						
	Total		0.06															0.16	0.42				0.05	0.05						
5/12	1															5/15			0.57											
	2																						0.28							
	Total																		0.57				0.28							
5/27	1															5/24			1.04				0.05							
	2																	0.16	0.16	0.16			0.10							
	Total																	0.16	1.19	0.16			0.16							
5/29	1															5/27			0.22											
	2																		0.33	0.11						0.11				
	Total																		0.54	0.11						0.11				
Spring Mean			0.01	0.01				0.01			0.01							0.09	0.57	0.05			0.12	0.01		0.02				

Appendix Table 11. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG2M Season - Spring

		Species (Day)															Species (Night)													
Date	Length Class	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	LGI	MDO	Date	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	LGI	MDO
4/27	1															4/24		0.21	0.64											
	2				0.26		0.13			0.13	1.41		0.13															0.21		
	Total				0.26		0.13			0.13	1.41		0.13					0.21	0.64									0.21		
5/05	1															5/14			0.07									0.07		
	2										0.13							0.07			0.07		0.07					0.07		
	Total										0.13							0.07	0.07		0.07		0.07					0.13		
5/12	1												0.08			5/15														
	2		0.08								0.53				0.08															
	Total		0.08								0.53		0.08		0.08															
5/27	1															5/24														
	2																				0.07									
	Total																				0.07									
5/29	1															5/27														
	2					0.16					0.31															0.21				
	Total					0.16					0.31															0.21				
Spring Mean			0.02		0.05	0.03	0.03			0.03	0.48		0.04		0.02			0.06	0.14		0.03		0.01			0.04		0.07		

Appendix Table 12. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2M Season - Spring

	Length	Species (Day)															Species (Night)													
Date	Class	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	LGI	MDO	Date	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	LGI	MDO
4/27	1															4/24														
	2					0.41		0.14		0.41	1.24		0.14															0.36		
	Total					0.41		0.14		0.41	1.24		0.14															0.36		
5/05	1							0.13								5/14			0.13											
	2					0.13															0.07		0.07			0.07		0.07		
	Total					0.13		0.13											0.13		0.07		0.07			0.07		0.07		
5/12	1							0.08								5/15			0.14											
	2					0.38		0.08	0.08		0.68		0.08	0.08							0.14		0.14			0.14				
	Total					0.38		0.15	0.08		0.68		0.08	0.08					0.14		0.14		0.14			0.14				
5/27	1	0.08														5/24			0.17											
	2					0.23				0.08	0.53		0.30				0.17				0.17					0.17				
	Total	0.08				0.23				0.08	0.53		0.30				0.17		0.17		0.17					0.17				
5/29	1															5/27												0.11		
	2					0.05		0.11		0.11	0.95		0.11		0.05						0.11		0.11			0.45	0.11	0.11		
	Total					0.05		0.11		0.11	0.95		0.11		0.05						0.11		0.11			0.45	0.11	0.23		
Spring Mean		0.02				0.24		0.11	0.02	0.12	0.68		0.13	0.02	0.01		0.03		0.09		0.10		0.06			0.17	0.02	0.13		

Appendix Table 13. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG3M Season - Spring

	Length	Species (Day)															Species (Night)													
Date	Class	ATR	OTS	SGA	AAL	CCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL	Date	ATR	OTS	SGA	AAL	CCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL
																4/27			0.50											
																		0.10	0.10											
																		0.10	0.60											
4/30	1															4/30														
	2					1.15				0.38										0.07		0.07	0.07	0.15	0.30			0.07		0.15
	Total					1.15				0.38										0.07		0.07	0.07	0.15	0.30			0.07		0.15
5/04	1															5/08			0.39			0.10								
	2																	0.34		0.20		0.05	0.05							
	Total																	0.34	0.39	0.20		0.15	0.05							
5/14	1															5/16			0.75											
	2																	0.08				0.08								
	Total																	0.08	0.75			0.08								
5/21	1															5/20			0.20											
	2																	0.05				0.05								
	Total																	0.05	0.20			0.05								
5/26	1															5/26			1.13											
	2																		0.07		0.07				0.07					
	Total																		1.20		0.07				0.07					
Spring Mean						0.23				0.08								0.11	0.52	0.05	0.01	0.06	0.02	0.03	0.06			0.01		0.03

Appendix Table 14. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG3M Season - Spring

	Length	Species (Day)															Species (Night)													
Date	Class	ATR	OTS	SGA	AAL	CCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL	Date	ATR	OTS	SGA	AAL	CCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL
																4/27			0.19											
																			0.19											
4/30	1															4/30														
	2									0.92					0.46					0.15	0.44	0.15		0.15	0.44					0.44
	Total									0.92					0.46					0.15	0.44	0.15		0.15	0.44					0.44
5/04	1						0.16									5/08			0.28											
	2					0.08		0.08		0.08									0.09	0.09		0.09			0.09					
	Total					0.08	0.16	0.08		0.08									0.38	0.09		0.09			0.09					
5/14	1															5/16			0.15											
	2			0.12	0.12										0.25						0.15	0.15			0.45					
	Total			0.12	0.12										0.25				0.15		0.15	0.15			0.45					
5/21	1															5/20														
	2														0.09		0.10				0.10				0.10					
	Total														0.09		0.10				0.10				0.10					
5/26	1															5/26		0.15	0.74											
	2					0.16		0.16		0.16											0.30				0.59					
	Total					0.16		0.16		0.16								0.15	0.74		0.30				0.59					
Spring Mean				0.02	0.02	0.05	0.03	0.05		0.23					0.16		0.02	0.03	0.24	0.04	0.17	0.07		0.03	0.28					0.07

Appendix Table 15. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG3M Season - Spring

		Species (Day)															Species (Night)													
Date	Length Class	ATR	OTS	SGA	AAL	CCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL		ATR	OTS	SGA	AAL	CCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL
																4/27			0.38											
																										0.56				
																			0.38							0.56				
4/30	1															4/30														
	2					0.43			0.21	0.43					0.21					0.31	0.15	0.15		0.46	0.46				0.15	0.31
	Total					0.43			0.21	0.43					0.21					0.31	0.15	0.15		0.46	0.46				0.15	0.31
5/04	1						0.16									5/08			0.09											
	2					0.31	0.08			0.39												0.09								
	Total					0.31	0.23			0.39									0.09			0.09								
5/14	1															5/16														
	2									0.12					0.12						0.30		0.15					0.15		
	Total									0.12					0.12						0.30		0.15					0.15		
5/21	1															5/20														
	2					0.11				0.11					0.33						0.23				0.08					0.08
	Total					0.11				0.11					0.33						0.23				0.08					0.08
5/26	1						0.43									5/26	0.14		0.43											
	2				0.09	0.17		0.09		0.95				0.17											0.57					
	Total				0.09	0.17	0.43	0.09		0.95				0.17			0.14		0.43						0.57					
Spring Mean					0.02	0.20	0.13	0.02	0.04	0.40				0.03	0.13		0.02		0.15	0.05	0.11	0.04	0.03	0.08	0.19	0.09		0.03	0.03	0.07

Appendix Table 16. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2S Season - Spring

		Species (Day)															Species (Night)														
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	INE	IPU	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	INE	IPU	MDO	PAN	PNI	PFL
5/01	1		0.25				0.03					0.03			0.03		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2		0.03	0.56	0.06		0.06	0.22	0.47	0.16					0.03	0.06	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total		0.28	0.56	0.06		0.13	0.22	0.47	0.16		0.03			0.06	0.06	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5/11	1																.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2			0.09	0.14					0.09						0.37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total			0.09	0.14					0.09						0.37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5/17	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.07													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.07		0.20	0.07			1.18	0.07	0.85						
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.07	0.07	0.20	0.07			1.18	0.07	0.85						
5/20	1		0.11														.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2																.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total		0.11														.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5/28	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.26													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.17				0.09			0.09						
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.43				0.09			0.09						
Spring Mean			0.13	0.22	0.07		0.04	0.07	0.16	0.08		0.01			0.02	0.14	0.04	0.25	0.10	0.04		0.05	0.59	0.04	0.47						

Appendix Table 17.

Mean Catch/Hour

Gear - Bottom Gill Nets

Station - LG2S

Season - Spring

	Length	Species (Day)															Species (Night)														
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	INE	IPU	MDO	PAN	PNI	PFL
5/01	1		0.08						0.08								.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2			0.31	0.16		0.16	0.23	1.09	0.31						0.16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total		0.08	0.31	0.16		0.16	0.23	1.17	0.31						0.16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5/11	1															0.06	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2						0.06			0.18						0.60	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total						0.06			0.18						0.66	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5/17	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.04				0.04									
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.07		0.04	0.33		0.15	0.07		1.15	0.04	0.04		0.04		
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.07	0.04	0.04	0.33		0.19	0.07		1.15	0.04	0.04		0.04		
5/20	1																.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2				0.13		0.04		0.04	0.25						0.63	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total				0.13		0.04		0.04	0.25						0.63	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5/28	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.17					0.08								
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				0.34	0.08	0.08	0.17		1.10				0.08		
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		0.17		0.34	0.08	0.08	0.25		1.10				0.08		
Spring Mean			0.03	0.1	0.1		0.09	0.08	0.4	0.25						0.48	0.04	0.11	0.02	0.34	0.04	0.14	0.16		1.13	0.02	0.02		0.06		

Appendix Table 18. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG1D Season - Summer

Date	Length Class	Species (Day)										Species (Night)									
		ATR	OTS	SGA	AAL	CCA	POR	CMA	IME	IPU	MDO	ATR	OTS	SGA	AAL	CCA	POR	CMA	IME	IPU	MDO
7/27	1													0.37							
	2																				
	Total													0.37							
7/30	1																				
	2																				
	Total																				
8/06	1													0.22							
	2																				
	Total													0.22							
8/21	1																				
	2																				
	Total																				
Summer Mean														0.15							

Appendix Table 19. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG1D Season - Summer

Date	Length Class	Species (Day) ATR	OTS	SGA	AAL	CCA	POR	CMA	INE	IPU	MDO	Species (Night) ATR	OTS	SGA	AAL	CCA	POR	CMA	INE	IPU	MDO
7/27	1													0.19							
	2							0.08													
	Total							0.08						0.19							
7/30	1													0.09							
	2					0.08															
	Total					0.08								0.09							
8/06	1																				
	2						0.18							0.21							
	Total						0.18							0.21							
8/21	1													0.08							
	2		0.05			0.05										0.08					
	Total		0.05			0.05								0.08		0.08					
Summer Mean			0.01			0.03	0.05	0.02						0.14		0.02					

Appendix Table 20. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG1D Season - Summer

	Length	Species (Day)										Species (Night)									
Date	Class	ATR	OTS	SGA	AAL	CCA	POR	CNA	INE	IPU	NDO	ATR	OTS	SGA	AAL	CCA	POR	CNA	INE	IPU	NDO
7/27	1																				
	2	0.10			0.05	0.05										0.07		0.15			
	Total	0.10			0.05	0.05										0.07		0.15			
7/30	1			0.04								0.06		0.06							
	2	0.04				0.08						0.12									
	Total	0.04		0.04		0.08						0.18		0.06							
8/06	1													0.05							
	2																	0.15	0.05		
	Total													0.05				0.15	0.05		
8/21	1																				
	2	0.05				0.05						0.04				0.08		0.04			
	Total	0.05				0.05						0.04				0.08		0.04			
Summer Mean		0.05		0.01	0.01	0.05						0.06		0.03		0.04		0.09	0.01		

Appendix Table 21. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2D Season - Summer

Date	Length Class	Species (Day)										Species (Night)									
		ATR	OTS	SGA	CCA	POR	CCO	CMA	INE	IPU	NDO	ATR	OTS	SGA	CCA	POR	CCO	CNA	INE	IPU	NDO
7/28	1													0.18							
	2																				
	Total													0.18							
7/29	1			0.14										0.09							
	2																	0.05			
	Total			0.14										0.09				0.05			
8/07	1																				
	2																	0.19			
	Total																	0.19			
8/19	1																				
	2														0.16						
	Total														0.16						
Summer Mean				0.04										0.07	0.04			0.06			

Appendix Table 22. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG2D Season - Summer

		Species (Day)										Species (Night)									
Date	Length Class	ATR	OTS	SGA	CCA	POR	CCO	CNA	INE	IPU	NDO	ATR	OTS	SGA	CCA	POR	CCO	CNA	INE	IPU	NDO
7/28	1													0.33							
	2	0.09																			
	Total	0.09												0.33							
7/29	1																				
	2							0.14													
	Total							0.14													
8/07	1													0.19							
	2				0.1			0.26													
	Total				0.1			0.26						0.19							
8/19	1													0.31							
	2					0.05		0.16													
	Total					0.05		0.16						0.31							
Summer Mean		0.02			0.03	0.01		0.14						0.21							

Appendix Table 23. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2D Season - Summer

Date	Length Class	Species (Day)										Species (Night)									
		ATR	OTS	SGA	CCA	POR	CCO	CMA	INE	IPU	MDO	ATR	OTS	SGA	CCA	POR	CCO	CMA	INE	IPU	MDO
7/28	1																				
	2			0.06	0.06	0.12		0.42				0.09						0.09			
	Total			0.06	0.06	0.12		0.42				0.09						0.09			
7/29	1																				
	2	0.07						0.41										0.36			
	Total	0.07						0.41										0.36			
8/07	1			0.05							0.05			0.12		0.04					
	2				0.09	0.05		0.5									0.04	0.37			
	Total			0.05	0.09	0.05		0.5			0.05			0.12		0.04	0.04	0.37			
8/19	1													0.04							
	2	0.05			0.11			0.32							0.08			0.12	0.04		
	Total	0.05			0.11			0.32						0.04	0.08			0.12	0.04		
Summer Mean		0.03		0.03	0.07	0.04		0.41			0.01	0.02		0.04	0.02	0.01	0.01	0.24	0.01		

Appendix Table 24.

Mean Catch/Hour

Gear - Surface Gill Nets

Station - LG1M

Season - Summer

Date	Length Class	Species (Day)														Species (Night)													
		OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	INE	IPU	LGI	MDO	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	INE	IPU	LGI	MDO	PNI	PFL
7/22	1																0.63												
	2																	0.06											
	Total																0.63	0.06											
8/05	1																0.5												
	2																												
	Total																0.5												
8/13	1																												
	2																												
	Total																												
8/14	1																1.71												
	2																			0.16									
	Total																1.71			0.16									
8/15	1																												
	2																												
	Total																												
8/20	1																0.48												
	2																				0.16								
	Total																0.48				0.16								
Summer Mean																	0.55	0.01		0.03	0.03								

Appendix Table 25. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG1M Season - Summer

		Species (Day)														Species (Night)													
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	INE	IPU	LGI	MDO	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	INE	IPU	LGI	MDO	PNI	PFL
7/22	1																												
	2								0.18																				
	Total								0.18																				
8/05	1						0.06										0.5				0.08								
	2								0.11						0.22														
	Total						0.06		0.11						0.22		0.5				0.08								
8/13	1																												
	2																												
	Total																												
8/14	1																0.63												
	2								0.07												0.08		0.08						
	Total								0.07								0.63				0.08		0.08						
8/15	1																												
	2																												
	Total																												
8/20	1																0.08												
	2				0.05									0.09															
	Total				0.05									0.09			0.08												
Summer Mean					0.01		0.01		0.06					0.02	0.04		0.2				0.03		0.01						

Appendix Table 26.

Mean Catch/Hour

Gear - Bottom Gill Nets

Station - LG1M

Season - Summer

		Species (Day)														Species (Night)													
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	INE	IPU	LGI	MDO	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	INE	IPU	LGI	MDO	PNI	PFL
7/22	1																0.17												
	2								0.34						0.68								0.08						
	Total								0.34						0.68		0.17						0.08						
8/05	1																0.04												
	2																						0.08		0.08				0.08
	Total																0.04						0.08		0.08				0.08
8/13	1																												
	2				0.32				0.32																				
	Total				0.32				0.32																				
8/14	1																												
	2						0.07		0.57				0.07		0.28								0.12	0.04				0.08	0.04
	Total						0.07		0.57				0.07		0.28								0.12	0.04				0.08	0.04
8/15	1																												
	2				0.33	0.06			0.39		0.06				0.44														
	Total				0.33	0.06			0.39		0.06				0.44														
8/20	1						0.05							0.09			0.04								0.04				
	2			0.05				0.05	0.18					0.05	0.54			0.08					0.13			0.04			0.04
	Total			0.05			0.05	0.05	0.18					0.14	0.54		0.04	0.08					0.13		0.04	0.04			0.04
Summer Mean				0.01	0.11	0.01	0.02	0.01	0.3		0.01		0.01	0.02	0.32		0.04	0.01					0.07	0.01	0.02	0.01		0.01	0.03

Appendix Table 27. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2M Season - Summer

		Species (Day)												Species (Night)											
Date	Length Class	ATR	OTS	SGA	CCA	POR	RBA	CHA	IPU	LGI	MDO	PAN	PFL	ATR	OTS	SGA	CCA	POR	RBA	CHA	IPU	LGI	MDO	PAN	PFL
7/23	1															0.11									
	2																0.06							0.06	
	Total															0.11	0.06							0.06	
8/03	1															0.21									
	2																								
	Total															0.21									
8/13	1															1.02									
	2																	0.17							
	Total															1.02		0.17							
8/17	1															0.49									
	2																								
	Total															0.49									
8/23	1																								
	2																								
	Total																								
Summer Mean																0.37	0.01	0.03						0.01	

Appendix Table 28. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG2M Season - Summer

	Length	Species (Day)												Species (Night)											
Date	Class	ATR	OTS	SGA	CCA	POR	RBA	CNA	IPU	LGI	MDO	PAN	PFL	ATR	OTS	SGA	CCA	POR	RBA	CNA	IPU	LGI	MDO	PAN	PFL
7/23	1															0.08									
	2					0.08		0.42					0.08				0.25			0.08					
	Total					0.08		0.42					0.08			0.08	0.25			0.08					
8/03	1															0.08									
	2													0.08											
	Total													0.08		0.08									
8/13	1															0.17									
	2							0.1								0.08				0.08					
	Total							0.1								0.25				0.08					
8/17	1															0.32		0.16							
	2					0.08		0.68										0.16							
	Total					0.08		0.68								0.32		0.32							
8/23	1																								
	2																								
	Total																								
Summer Mean						0.05		0.24					0.02	0.02		0.15	0.05	0.06		0.03					

Appendix Table 29. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2M Season - Summer

Date	Length Class	Species (Day)												Species (Night)											
		ATR	OTS	SGA	CCA	POR	RBA	CMA	IPU	LGI	MDO	PAN	PFL	ATR	OTS	SGA	CCA	POR	RBA	CMA	IPU	LGI	MDO	PAN	PFL
7/23	1												0.11												
	2				0.05			0.75					0.05								0.16				
	Total				0.05			0.75					0.16								0.16				
8/03	1																								
	2					0.1		0.42	0.31		0.05						0.06			0.13					
	Total					0.1		0.42	0.31		0.05						0.06			0.13					
8/13	1									0.05															
	2					0.05		0.62	0.15											0.17					0.04
	Total					0.05		0.62	0.15	0.05										0.17					0.04
8/17	1															0.04									
	2				0.33	0.04		0.79	0.04								0.08	0.04		0.25					
	Total				0.33	0.04		0.79	0.04							0.04	0.08	0.04		0.25					
8/23	1																				0.21				
	2																	0.21	0.21	1.06			0.21		
	Total																	0.21	0.21	1.06	0.21		0.21		
Summer Mean					0.08	0.04		0.52	0.1	0.01	0.01		0.03			0.01	0.03	0.05	0.04	0.32	0.07		0.04		0.01

Appendix Table 30. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG3M Season - Summer

Date	Length Class	Species (Day)													Species (Night)												
		OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	LGI	NDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	LGI	NDO	PAN	PNI	PFL
7/24	1															0.14											
	2							0.13																			
	Total							0.13								0.14											
8/04	1															0.19											
	2																0.19				0.37						
	Total															0.19	0.19				0.37						
8/12	1															0.67											
	2						0.18													0.17	0.33						
	Total						0.18									0.67				0.17	0.33						
8/24	1																										
	2						0.19	0.19																			
	Total						0.19	0.19																			
Summer Mean							0.09	0.08								0.25	0.05			0.04	0.18						

Appendix Table 31. Mean Catch/Hour

Gear - Mid Gill Nets

Station - LG3M

Season - Summer

	Length	Species (Day)													Species (Night)												
Date	Class	OTS	SGA	AAL	CCA	NCA	POR	CNA	IPU	LGI	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	NCA	POR	CNA	IPU	LGI	MDO	PAN	PNI	PFL
7/24	1																										
	2				0.23		0.08	0.54			0.23			0.23				0.09			0.52						
	Total				0.23		0.08	0.54			0.23			0.23				0.09			0.52						
8/04	1															0.26											
	2				0.05	0.05		0.69			0.05			0.11							0.2						
	Total				0.05	0.05		0.69			0.05			0.11		0.26					0.2						
8/12	1															0.35											
	2				0.24			0.54						0.06				0.17		0.09	0.09						
	Total				0.24			0.54						0.06		0.35		0.17		0.09	0.09						
8/24	1						0.07									0.08											
	2						0.07	0.07			0.13			0.66					0.08		0.08						
	Total						0.13	0.07			0.13			0.66		0.08			0.08		0.08						
Summer Mean					0.13	0.01	0.05	0.46			0.1			0.27		0.17		0.07	0.02	0.02	0.22						

Appendix Table 32.

Mean Catch/Hour

Gear - Bottom Gill Nets

Station - LG3M

Season - Summer

Date	Length Class	Species (Day)													Species (Night)												
		OTS	SGA	AAL	CCA	NCA	POR	CMA	IPU	LGI	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	NCA	POR	CMA	IPU	LGI	MDO	PAN	PNI	PFL
7/24	1						0.05													0.08							
	2						0.1	0.26	0.05		0.15			0.1						0.08	0.54						
	Total						0.15	0.26	0.05		0.15			0.1						0.15	0.54						
8/04	1						0.05																				
	2				0.05			1.2			0.05			0.05				0.05			0.6	0.05					
	Total				0.05		0.05	1.2			0.05			0.05				0.05			0.6	0.05					
8/12	1						0.12															0.04					
	2			0.06	0.17			1.27			0.12										0.21				0.04		
	Total			0.06	0.17		0.12	1.27			0.12										0.21	0.04			0.04		
8/24	1						0.07									0.13											
	2				0.07					0.2	0.07	0.07	0.07	0.66							0.09						
	Total				0.07		0.07			0.2	0.07	0.07	0.07	0.66		0.13					0.09						
Summer Mean				0.02	0.07		0.1	0.68	0.01	0.05	0.1	0.02	0.02	0.2		0.03		0.01		0.04	0.36	0.02			0.01		

Appendix Table 33. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2S Season - Summer

		Species (Day)													Species (Night)												
Date	Length Class	ATR	OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL	ATR	OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL
7/21	1																										
	2								0.84									0.26	1.39		0.07	0.46	0.07				
	Total								0.84									0.26	1.39		0.07	0.46	0.07				
7/31	1																				0.08						
	2					0.86			0.94							0.08			0.94			1.33					
	Total					0.86			0.94							0.08			0.94		0.08	1.33					
8/10	1																						0.15				
	2																		0.15				0.15				
	Total																		0.15				0.3				
8/18	1			0.05													0.29										
	2								0.37										0.43			0.5	0.07				
	Total			0.05					0.37								0.29		0.43			0.5	0.07				
Summer Mean				0.01		0.22			0.54							0.02	0.07	0.07	0.73		0.04	0.57	0.11				

Appendix Table 34. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2S Season - Summer

Date	Length Class	Species (Day)													Species (Night)												
		ATR	OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL	ATR	OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL
7/21	1																0.05										
	2				0.09				1.32		0.19			0.94	0.05				0.81		0.05	0.96			0.05		
	Total				0.09				1.32		0.19			0.94	0.05		0.05		0.81		0.05	0.96			0.05		
7/31	1														0.06		0.06										
	2					0.15			0.62					0.15					0.99			0.41					
	Total					0.15			0.62					0.15	0.06		0.06		0.99			0.41					
8/10	1																						0.04				
	2				0.04	0.44					0.04		0.04	0.47					0.26	0.13		0.09	0.13	0.04	0.04		0.04
	Total				0.04	0.44					0.04		0.04	0.47					0.26	0.13		0.09	0.17	0.04	0.04		0.04
8/18	1			0.04											0.16		0.05						0.11				
	2					0.12			0.6		0.04			0.16					1.29			3.34	0.16				0.05
	Total			0.04		0.12			0.6		0.04			0.16	0.16		0.05		1.29			3.34	0.27				0.05
Summer Mean				0.01	0.03	0.18			0.64		0.07		0.01	0.43	0.07		0.04		0.84	0.03	0.01	1.2	0.11	0.01	0.02		0.02

Appendix Table 35. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG1D Season - Fall

	Length	Species (Day)									Species (Night)								
Date	Class	ATR	OTS	SGA	CCA	POR	CMA	IPU	MDO	PNI	ATR	OTS	SGA	CCA	POR	CMA	IPU	MDO	PNI
10/06	1												0.08		0.08				
	2					0.08													
	Total					0.08							0.08		0.08				
10/13	1			0.08									0.11		0.11				
	2					0.08													
	Total			0.08		0.08							0.11		0.11				
10/22	1												0.14		0.11				
	2											0.07	0.14		0.34				
	Total											0.07	0.28		0.45				
Fall Mean				0.03		0.05						0.02	0.16		0.21				

Appendix Table 36. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG1D Season - Fall

	Length	Species (Day)									Species (Night)								
Date	Class	ATR	OTS	SGA	CCA	POR	CNA	IPU	MDO	PNI	ATR	OTS	SGA	CCA	POR	CNA	IPU	MDO	PNI
10/06	1									0.08									
	2					0.08													
	Total					0.08				0.08									
10/13	1												0.18						
	2												0.09						
	Total												0.27						
10/22	1												0.09						
	2												0.09		0.09				
	Total												0.18		0.09				
Fall Mean						0.03				0.03			0.15		0.03				

Appendix Table 37. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG1D Season - Fall

Date	Length Class	Species (Day) ATR	OTS	SGA	CCA	POR	CMA	IPU	MDO	PNI	Species (Night) ATR	OTS	SGA	CCA	POR	CMA	IPU	MDO	PNI
10/06	1																0.12		
	2				0.26	0.09	0.18	0.09						0.12					
	Total				0.26	0.09	0.18	0.09						0.12			0.12		
10/13	1																		
	2	0.09			0.45									0.42		0.14			
	Total	0.09			0.45									0.42		0.14			
10/22	1																		
	2			0.09				0.09			0.09								
	Total			0.09				0.09			0.09								
Fall Mean		0.03		0.03	0.24	0.03	0.06	0.06			0.03			0.18		0.05	0.04		

Appendix Table 38. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2D Season - Fall

Date	Length Class	Species (Day)											Species (Night)										
		ATR	OTS	SGA	AAL	CCA	POR	CNA	IPU	NDO	PAN	ASA	ATR	OTS	SGA	AAL	CCA	POR	CNA	IPU	NDO	PAN	ASA
10/02	1														0.25								
	2														0.13			0.13					
	Total														0.38			0.13					
10/17	1																						
	2														0.1			0.1					
	Total														0.1			0.1					
10/23	1														0.09			0.09					
	2			0.09										0.09	0.26	0.17		0.09	0.09				
	Total			0.09										0.09	0.35	0.17		0.17	0.09				
Fall Mean				0.03										0.03	0.28	0.06		0.13	0.03				

Appendix Table 39. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG2D Season - Fall

		Species (Day)											Species (Night)										
Date	Length Class	ATR	OTS	SGA	AAL	CCA	POR	CMA	IPU	NDO	PAN	ASA	ATR	OTS	SGA	AAL	CCA	POR	CMA	IPU	NDO	PAN	ASA
10/02	1																						
	2														0.14				0.14				
	Total														0.14				0.14				
10/17	1																						
	2																						
	Total																						
10/23	1										0.1												
	2														0.09	0.09							0.09
	Total										0.1				0.09	0.09							0.09
Fall Mean											0.03				0.08	0.03			0.05				0.03

Appendix Table 40. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2D Season - Fall

		Species (Day)											Species (Night)										
Date	Length Class	ATR	OTS	SGA	AAL	CCA	POR	CMA	IPU	MDO	PAN	ASA	ATR	OTS	SGA	AAL	CCA	POR	CMA	IPU	MDO	PAN	ASA
10/02	1																						
	2	0.2				0.07	0.07	1.45	0.07								0.19			0.06			
	Total	0.2				0.07	0.07	1.45	0.07								0.19			0.06			
10/17	1																						
	2			0.09		0.19	0.09	0.38	0.09								0.57						
	Total			0.09		0.19	0.09	0.38	0.09								0.57						
10/23	1																						
	2							0.09									0.16	0.08		0.08			
	Total							0.09									0.16	0.08		0.08			
Fall Mean		0.07		0.03		0.09	0.05	0.64	0.05								0.31	0.03		0.05			

Appendix Table 41. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG1M Season - Fall

	Length	Species (Day)															Species (Night)														
Date	Class	ONE	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL	ONE	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL
10/08	1																0.12		0.23												
	2			0.08														0.12		0.12											
	Total			0.08													0.12	0.12	0.23	0.12											
10/15	1			0.38															0.57												
	2			0.23															0.57	0.08		0.08	0.41	0.25							
	Total			0.61															1.14	0.08		0.08	0.41	0.25							
10/19	1			0.09																											
	2			0.09															0.46				0.31								
	Total			0.18															0.46				0.31								
Fall Mean				0.29													0.04	0.04	0.61	0.07		0.03	0.24	0.08							

Appendix Table 42. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG1M Season - Fall

	Length	Species (Day)															Species (Night)														
Date	Class	ONE	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL	ONE	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL
10/08	1																		0.08												
	2																					0.16	0.08								
	Total																		0.08			0.16	0.08								
10/15	1																		0.22										0.44		
	2																		0.22	0.15	0.07					0.22					
	Total																		0.44	0.15	0.07					0.22			0.44		
10/19	1																		0.43												
	2			0.22			0.07	0.07										0.11	0.32			0.11									
	Total			0.22			0.07	0.07										0.11	0.75			0.11									
Fall Mean				0.07			0.02	0.02										0.04	0.42	0.05	0.02	0.09	0.03			0.07			0.15		

Appendix Table 43. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG1M Season - Fall

		Species (Day)															Species (Night)														
Date	Length Class	ONE	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CNA	IPU	NDO	PAN	PNI	PFL	ONE	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CNA	IPU	NDO	PAN	PNI	PFL
10/08	1													0.7	0.26														0.17		
	2				0.09	0.26		0.09		0.09	0.96		0.18			0.79					0.25		0.08			0.17	0.08				
	Total				0.09	0.26		0.09		0.09	0.96		0.18	0.7	0.26	0.79					0.25		0.08			0.17	0.08		0.17		
10/15	1							0.1				0.1		1.07	0.88				0.17										0.08		
	2					0.68		0.29			1.56	0.1	0.2	0.1		0.2		0.16	0.25				0.16			0.08	0.16				
	Total					0.68		0.39			1.56	0.2	0.2	1.17	0.88	0.2		0.16	[illegible]				0.16			0.08	0.16		0.08		
10/19	1													0.41															0.09		
	2					0.16					0.32		0.16		0.08	0.49					0.26										
	Total					0.16					0.32		0.16	0.41	0.08	0.49					0.26								0.09		
Fall Mean					0.03	0.37		0.16		0.03	0.95	0.07	0.18	0.76	0.41	0.49		0.05	0.14		0.17		0.08			0.08	0.08		0.11		

Appendix Table 44. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2M Season - Fall

		Species (Day)															Species (Night)														
Date	Length Class	ATR	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL	ATR	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL
10/05	1																		0.14				0.14								
	2																					0.14	0.27								
	Total																		0.14			0.14	0.41								
10/16	1			0.1															0.42												
	2			0.1															0.42				0.42			0.21					
	Total			0.21															0.84				0.42			0.21					
10/20	1			0.17																			0.09								
	2																	0.09	0.19	0.19		0.19									
	Total			0.17														0.09	0.19	0.19		0.19	0.09								
Fall Mean				0.13														0.03	0.39	0.06		0.11	0.31			0.07					

Appendix Table 45.

Mean Catch/Hour

Gear - Mid Gill Nets

Station - LG2M

Season - Fall

	Length	Species (Day)															Species (Night)														
Date	Class	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	IPU	MDO	PAN	PNI	PFL
10/05	1																														
	2																										0.09				
	Total																										0.09				
10/16	1							0.07						0.07	0.14				0.23												
	2						0.07												0.23	0.12		0.23	0.23								
	Total						0.07	0.07						0.07	0.14				0.47	0.12		0.23	0.23								
10/20	1			0.09															0.08				0.08								
	2																		0.3			0.45		0.08							
	Total			0.09															0.38			0.45	0.08	0.08							
Fall Mean				0.03			0.02	0.02						0.02	0.05				0.28	0.04		0.23	0.1	0.03			0.03				

Appendix Table 46. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2N Season - Fall

	Length	Species (Day)															Species (Night)														
Date	Class	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL	ATR	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	IPU	MDO	PAN	PNI	PFL
10/05	1												0.12				0.09		0.18										0.09		
	2					0.24		0.12			0.72		0.12								0.09					0.53	0.09				
	Total					0.24		0.12			0.72		0.24				0.09		0.18		0.09					0.53	0.09		0.09		
10/16	1													0.18													0.15				
	2					0.09		0.73		0.09	1.36	0.18			0.09	0.18					0.07					0.07					
	Total					0.09		0.73		0.09	1.36	0.18		0.18	0.09	0.18					0.07					0.07	0.15				
10/20	1											0.1		0.1	0.1														0.12		
	2					0.2	0.39	0.1			0.49	0.1																			
	Total					0.2	0.39	0.1			0.49	0.2		0.1	0.1														0.12		
Fall Mean						0.18	0.13	0.32		0.03	0.86	0.13	0.08	0.09	0.06	0.06	0.03		0.06		0.05					0.2	0.08		0.07		

Appendix Table 47. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG3N Season - Fall

Date	Length Class	Species (Day) OTS	SGA	AAL	CCA	NCA	POR	CCO	CMA	IPU	MDO	PAN	PNI	PFL	Species (Night) OTS	SGA	AAL	CCA	NCA	POR	CCO	CMA	IPU	MDO	PAN	PNI	PFL
10/07	1															0.08				0.08							
	2																0.15		0.15	0.15							
	Total															0.08	0.15		0.15	0.23							
10/12	1																			0.11							
	2															0.11	0.11		0.11	0.23							
	Total															0.11	0.11		0.11	0.34							
10/21	1																										
	2																										
	Total																										
Fall Mean																0.06	0.09		0.09	0.19							

Appendix Table 48.　　Mean Catch/Hour

Gear - Mid Gill Nets　　Station - LG3M　　Season - Fall

	Length	Species (Day)													Species (Night)												
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	CCO	CMA	IPU	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	CCO	CMA	IPU	MDO	PAN	PNI	PFL
10/07	1																										
	2																		0.09		0.09						
	Total																		0.09		0.09						
10/12	1		0.06													0.17											
	2						0.06									0.17											
	Total		0.06				0.06									0.35											
10/21	1																										
	2															0.08				0.08							
	Total															0.08				0.08							
Fall Mean			0.02				0.02									0.14			0.03	0.03	0.03						

Appendix Table 49. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG3M Season - Fall

	Length	Species (Day)													Species (Night)												
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	CCO	CMA	IPU	MDO	PAM	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	CCO	CMA	IPU	MDO	PAM	PNI	PFL
10/07	1											0.09															
	2			0.09	0.79				0.35					2.98				0.2				0.51			0.1		0.1
	Total			0.09	0.79				0.35			0.09		2.98				0.2				0.51			0.1		0.1
10/12	1											0.59	0.08												1.27		
	2				0.42		0.17		1.02		0.25	0.17		1.86		0.07		0.15					0.07		0.15		
	Total				0.42		0.17		1.02		0.25	0.76	0.08	1.86		0.07		0.15					0.07		1.42		
10/21	1											0.46	0.46												0.34		
	2			0.27	0.18				0.18					0.92				0.09									
	Total			0.27	0.18				0.18			0.46	0.46	0.92				0.09							0.34		
Fall Mean				0.12	0.46		0.06		0.52		0.08	0.44	0.18	1.92		0.02		0.15				0.17	0.02		0.62		0.03

Appendix Table 50. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2S Season - Fall

	Length	Species (Day)														Species (Night)													
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CNA	INE	IPU	MDO	PAN	PFL	ASA	OTS	SGA	AAL	CCA	MCA	POR	RBA	CNA	INE	IPU	MDO	PAN	PFL	ASA
10/03	1																0.05				0.11						0.11		
	2				0.04				0.04			0.12					0.17	0.16		0.05	0.05	0.22							
	Total				0.04				0.04			0.12					0.22	0.16		0.05	0.16	0.22					0.11		
10/14	1																				0.07								
	2															0.2	0.47	0.2			0.07								
	Total															0.2	0.47	0.2			0.13								
10/24	1																	0.06			0.06						0.06		
	2																0.06	0.11	0.06		0.61		0.11	0.06					
	Total																0.06	0.17	0.06		0.66		0.11	0.06			0.06		
Fall Mean					0.01				0.01			0.04				0.07	0.25	0.18	0.02	0.02	0.32	0.07	0.04	0.02			0.06		

Appendix Table 51. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2S Season - Fall

		Species (Day)														Species (Night)													
Date	Length Class	OTS	SGA	AAL	CCA	NCA	POR	RBA	CMA	INE	IPU	MDO	PAN	PFL	ASA	OTS	SGA	AAL	CCA	NCA	POR	RBA	CMA	INE	IPU	MDO	PAN	PFL	ASA
10/03	1									0.06											0.08				0.08		0.24		
	2				0.12				0.17			0.52		0.46				0.08	0.41	0.08	0.32	0.65	0.57		0.24		0.08		
	Total				0.12				0.17	0.06		0.52		0.46				0.08	0.41	0.08	0.41	0.65	0.57		0.32		0.32		
10/14	1																				0.05						0.2		
	2													0.93		0.05	0.1		0.05		0.05		0.3				0.05		
	Total													0.93		0.05	0.1		0.05		0.1		0.3				0.25		
10/24	1																										0.07		
	2								0.08					0.08	0.08	0.07	0.07				0.27		0.07						
	Total								0.08					0.08	0.08	0.07	0.07				0.27		0.07				0.07		
Fall Mean					0.04				0.08	0.02		0.17		0.49	0.03	0.04	0.06	0.03	0.15	0.03	0.26	0.22	0.31		0.11		0.21		

Appendix Table 52. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG1D Season - Winter

		Species (Day)									Species (Night)								
Date	Length Class	OTS	SGA	AAL	CCA	POR	CMA	IPU	MDO	ASA	OTS	SGA	AAL	CCA	POR	CMA	IPU	MDO	ASA
12/04	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.		0.27							
	Total	.	.	.	.	.	.	.	.	.		0.27							
12/07	1		0.08								.	.	.	.	.	.	.	.	.
	2										.	.	.	.	.	.	.	.	.
	Total		0.08								.	.	.	.	.	.	.	.	.
12/16	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.		0.32							
	Total	.	.	.	.	.	.	.	.	.		0.32							
12/17	1	.	.	.	.	.	.	.	.	.		0.09							
	2	.	.	.	.	.	.	.	.	.						0.09			0.09
	Total	.	.	.	.	.	.	.	.	.		0.09				0.09			0.09
Winter Mean			0.08									0.23				0.03			0.03

Appendix Table 53. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG10 Season - Winter

Date	Length Class	Species (Day)									Species (Night)								
		OTS	SGA	AAL	CCA	POR	CNA	IPU	NDO	ASA	OTS	SGA	AAL	CCA	POR	CNA	IPU	NDO	ASA
12/04	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.		0.07							
	Total	.	.	.	.	.	.	.	.	.		0.07							
12/07	1										.	.	.	.	.	.	.	.	.
	2										.	.	.	.	.	.	.	.	.
	Total										.	.	.	.	.	.	.	.	.
12/16	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.		0.08							
	Total	.	.	.	.	.	.	.	.	.		0.08							
12/17	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.									
	Total	.	.	.	.	.	.	.	.	.									
Winter Mean												0.05							

Appendix Table 54. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG10 Season - Winter

Date	Length Class	Species (Day)									Species (Night)								
		OTS	SGA	AAL	CCA	POR	CNA	IPU	MDO	ASA	OTS	SGA	AAL	CCA	POR	CNA	IPU	MDO	ASA
12/04	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.									
	Total	.	.	.	.	.	.	.	.	.									
12/07	1					0.1					.	.	.	.	.	.	.	.	.
	2				0.21	0.31					.	.	.	.	.	.	.	.	.
	Total				0.21	0.41					.	.	.	.	.	.	.	.	.
12/16	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.									
	Total	.	.	.	.	.	.	.	.	.									
12/17	1	.	.	.	.	.	.	.	.	.									
	2	.	.	.	.	.	.	.	.	.			0.09	0.18	0.09				
	Total	.	.	.	.	.	.	.	.	.			0.09	0.18	0.09				
Winter Mean					0.21	0.41							0.03	0.06	0.03				

Appendix Table 55. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2D Season - Winter

		Species (Day)							Species (Night)						
Date	Length Class	ATR	OTS	SGA	AAL	POR	IPU	MDO	ATR	OTS	SGA	AAL	POR	IPU	MDO
12/03	1	.	.	.	.	.	.	.							
	2	.	.	.	.	.	.	.							
	Total	.	.	.	.	.	.	.							
12/04	1								.	.	.	.	.	.	.
	2			0.09					.	.	.	.	.	.	.
	Total			0.09					.	.	.	.	.	.	.
12/07	1	.	.	.	.	.	.	.							
	2	.	.	.	.	.	.	.			0.17				
	Total	.	.	.	.	.	.	.			0.17				
Winter Mean				0.05							0.09				

Appendix Table 56. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG2D Season - Winter

	Length	Species (Day)							Species (Night)						
Date	Class	ATR	OTS	SGA	AAL	POR	IPU	MDO	ATR	OTS	SGA	AAL	POR	IPU	MDO
12/03	1	.	.	.	.	.	.	.							
	2	.	.	.	.	.	.	.							
	Total	.	.	.	.	.	.	.							
12/04	1								.	.	.	.	.	.	.
	2								.	.	.	.	.	.	.
	Total								.	.	.	.	.	.	.
12/07	1	.	.	.	.	.	.	.							
	2	.	.	.	.	.	.	.				0.08			
	Total	.	.	.	.	.	.	.				0.08			
Winter Mean												0.04			

Appendix Table 57. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG20 Season - Winter

	Length	Species (Day)							Species (Night)						
Date	Class	ATR	OTS	SGA	AAL	POR	IPU	MDO	ATR	OTS	SGA	AAL	POR	IPU	MDO
12/03	1	.	.	.	.	.	.	.	0.09						
	2	.	.	.	.	.	.	.							
	Total	.	.	.	.	.	.	.	0.09						
12/04	1								.	.	.	.	.	.	.
	2					0.09			.	.	.	.	.	.	.
	Total					0.09			.	.	.	.	.	.	.
12/07	1	.	.	.	.	.	.	.							
	2	.	.	.	.	.	.	.							
	Total	.	.	.	.	.	.	.							
Winter Mean						0.09			0.05						

Appendix Table 58.

Mean Catch/Hour

Gear - Surface Gill Nets

Station - LG1M

Season - Winter

	Length	Species (Day)												Species (Night)											
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PNI	PFL
12/02	1	.	.	.	.	.	.	.	.	.	.	.	.		0.2										
	2	.	.	.	.	.	.	.	.	.	.	.	.		0.09										
	Total	.	.	.	.	.	.	.	.	.	.	.	.		0.29	0.1									
12/03	1													.	.	.	.	.	.	.	.	.	.	.	.
	2													.	.	.	.	.	.	.	.	.	.	.	.
	Total													.	.	.	.	.	.	.	.	.	.	.	.
12/19	1	.	.	.	.	.	.	.	.	.	.	.	.												
	2	.	.	.	.	.	.	.	.	.	.	.	.		0.15										
	Total	.	.	.	.	.	.	.	.	.	.	.	.		0.15										
Winter Mean															0.22	0.05									

Appendix Table 59.

Mean Catch/Hour

Gear - Mid Gill Nets

Station - LG1M

Season - Winter

	Length	Species (Day)												Species (Night)											
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PNI	PFL
12/02	1	.	.	.	.	.	.	.	.	.	.	.	.												
	2	.	.	.	.	.	.	.	.	.	.	.	.	0.08		0.08									
	Total	.	.	.	.	.	.	.	.	.	.	.	.	0.08		0.08									
12/03	1													.	.	.	.	.	.	.	.	.	.	.	.
	2													.	.	.	.	.	.	.	.	.	.	.	.
	Total													.	.	.	.	.	.	.	.	.	.	.	.
12/19	1	.	.	.	.	.	.	.	.	.	.	.	.												
	2	.	.	.	.	.	.	.	.	.	.	.	.		0.08	0.08									
	Total	.	.	.	.	.	.	.	.	.	.	.	.		0.08	0.08									
Winter Mean														0.04	0.04	0.08									

Appendix Table 60. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG1N Season - Winter

Date	Length Class	Species (Day)												Species (Night)											
		OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PNI	PFL	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PNI	PFL
12/02	1	.	.	.	.	.	.	.	.	.	.	.	.					0.08							
	2	.	.	.	.	.	.	.	.	.	.	.	.			0.34		0.34							
	Total	.	.	.	.	.	.	.	.	.	.	.	.			0.34		0.42							
12/03	1											0.2		.	.	.	.	.	.	.	.	.	.	.	.
	2			0.7	0.4			0.1				0.1	0.2	.	.	.	.	.	.	.	.	.	.	.	.
	Total			0.7	0.4			0.1				0.3	0.2	.	.	.	.	.	.	.	.	.	.	.	.
12/19	1	.	.	.	.	.	.	.	.	.	.	.	.										0.56		
	2	.	.	.	.	.	.	.	.	.	.	.	.			0.4		0.4	0.08						
	Total	.	.	.	.	.	.	.	.	.	.	.	.			0.4		0.4	0.08				0.56		
Winter Mean				0.7	0.4			0.1				0.3	0.2			0.37		0.41	0.04				0.28		

Appendix Table 61. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2M Season - Winter

		Species (Day)											Species (Night)										
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	IPU	MDO	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	IPU	MDO	PFL
12/05	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.											
	Total	.	.	.	.	.	.	.	.	.	.	.											
12/08	1												.	.	.	.	.	.	.	.	.	.	.
	2												.	.	.	.	.	.	.	.	.	.	.
	Total												.	.	.	.	.	.	.	.	.	.	.
12/18	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.		0.63					0.08				
	Total	.	.	.	.	.	.	.	.	.	.	.		0.63					0.08				
Winter Mean														0.32					0.04				

Appendix Table 62.

Mean Catch/Hour

Gear - Mid Gill Nets

Station - LG2M

Season - Winter

Date	Length Class	Species (Day)											Species (Night)										
		OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	IPU	MDO	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	IPU	MDO	PFL
12/05	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.		0.1				0.1					
	Total	.	.	.	.	.	.	.	.	.	.	.		0.1	0.1			0.1					
12/08	1												.	.	.	.	.	.	.	.	.	.	.
	2												.	.	.	.	.	.	.	.	.	.	.
	Total												.	.	.	.	.	.	.	.	.	.	.
12/18	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.		0.17	0.08								
	Total	.	.	.	.	.	.	.	.	.	.	.		0.17	0.08								
Winter Mean														0.14	0.09			0.05					

Appendix Table 63.

Mean Catch/Hour

Gear - Bottom Gill Nets

Station - LG2M

Season - Winter

	Length	Species (Day)											Species (Night)										
Date	Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	IPU	MDO	PFL	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	IPU	MDO	PFL
12/05	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.			0.27			0.09					
	Total	.	.	.	.	.	.	.	.	.	.	.			0.27			0.09					
12/08	1												.	.	.	.	.	.	.	.	.	.	.
	2			0.92	0.55	0.18	0.09		0.18			0.09	.	.	.	.	.	.	.	.	.	.	.
	Total			0.92	0.55	0.18	0.09		0.18			0.09	.	.	.	.	.	.	.	.	.	.	.
12/18	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.		0.09	0.09	0.09							
	Total	.	.	.	.	.	.	.	.	.	.	.		0.09	0.09	0.09							
Winter Mean				0.92	0.55	0.18	0.09		0.18			0.09		0.05	0.18	0.05		0.05					

Appendix Table 64. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG3M Season - Winter

		Species (Day)													Species (Night)												
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PMI	PFL	ASA	OTS	SGA	AAL	CCA	MCA	POR	CMA	IPU	MDO	PAN	PMI	PFL	ASA
11/30	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.		0.29											
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.		0.29											
12/02	1														.	.	.	.	.	.	.	.	.	.	.	.	.
	2														.	.	.	.	.	.	.	.	.	.	.	.	.
	Total														.	.	.	.	.	.	.	.	.	.	.	.	.
12/17	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.		0.09					0.09						0.09
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.		0.09					0.09						0.09
Winter Mean																0.19					0.05						0.05

Appendix Table 65. Mean Catch/Hour

Gear - Mid Gill Nets Station - LG3M Season - Winter

		Species (Day)													Species (Night)												
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL	ASA	OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL	ASA
11/30	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.													
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.													
12/02	1														.	.	.	.	.	.	.	.	.	.	.	.	.
	2														.	.	.	.	.	.	.	.	.	.	.	.	.
	Total														.	.	.	.	.	.	.	.	.	.	.	.	.
12/17	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.													
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.													
Winter Mean																											

Appendix Table 66. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG3M Season - Winter

Date	Length Class	Species (Day) OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL	ASA	Species (Night) OTS	SGA	AAL	CCA	MCA	POR	CNA	IPU	MDO	PAN	PNI	PFL	ASA
11/30	1	.	.	.	.	.	.	.	.	.	.	.	.	.										0.49			
	2	.	.	.	.	.	.	.	.	.	.	.	.	.			0.1			0.2	0.1			0.2			
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.			0.1			0.2	0.1			0.68			
12/02	1										0.12				.	.	.	.	.	.	.	.	.	.	.	.	.
	2			0.12	0.83	0.36		0.12			0.12	0.12	0.59		.	.	.	.	.	.	.	.	.	.	.	.	.
	Total			0.12	0.83	0.36		0.12			0.24	0.12	0.59		.	.	.	.	.	.	.	.	.	.	.	.	.
12/17	1	.	.	.	.	.	.	.	.	.	.	.	.	.													
	2	.	.	.	.	.	.	.	.	.	.	.	.	.			0.09	0.18		0.09							
	Total	.	.	.	.	.	.	.	.	.	.	.	.	.			0.09	0.18		0.09							
Winter Mean				0.12	0.83	0.36		0.12			0.24	0.12	0.59				0.1	0.09		0.15	0.05	.		0.34			

Appendix Table 67. Mean Catch/Hour

Gear - Surface Gill Nets Station - LG2S Season - Winter

		Species (Day)											Species (Night)										
Date	Length Class	OTS	SGA	AAL	POR	RBA	CCO	CMA	IPU	MDO	PAM	PFL	OTS	SGA	AAL	POR	RBA	CCO	CMA	IPU	MDO	PAM	PFL
12/06	1	.	.	.	.	.	.	.	.	.	.	.										0.06	
	2	.	.	.	.	.	.	.	.	.	.	.		0.06	0.4	0.06	0.11						
	Total	.	.	.	.	.	.	.	.	.	.	.		0.06	0.4	0.06	0.11					0.06	
12/08	1	.	.	.	.	.	.	.	.	.	.	.										0.1	
	2	.	.	.	.	.	.	.	.	.	.	.		0.1	0.05	0.05	0.05						
	Total	.	.	.	.	.	.	.	.	.	.	.		0.1	0.05	0.05	0.05					0.1	
12/16	1												.	.	.	.	.	.	.	.	.	.	.
	2												.	.	.	.	.	.	.	.	.	.	.
	Total												.	.	.	.	.	.	.	.	.	.	.
Winter Mean														0.08	0.23	0.06	0.08					0.08	

Appendix Table 68. Mean Catch/Hour

Gear - Bottom Gill Nets Station - LG2S Season - Winter

		Species (Day)											Species (Night)										
Date	Length Class	OTS	SGA	AAL	POR	RBA	CCO	CMA	IPU	MDO	PAN	PFL	OTS	SGA	AAL	POR	RBA	CCO	CMA	IPU	MDO	PAN	PFL
12/06	1	.	.	.	.	.	.	.	.	.	.	.										0.31	
	2	.	.	.	.	.	.	.	.	.	.	.		0.1	1.15	0.1		0.21	0.42				
	Total	.	.	.	.	.	.	.	.	.	.	.		0.1	1.15	0.1		0.21	0.42			0.31	
12/08	1	.	.	.	.	.	.	.	.	.	.	.											
	2	.	.	.	.	.	.	.	.	.	.	.			0.5	0.1			0.3				0.1
	Total	.	.	.	.	.	.	.	.	.	.	.			0.5	0.1			0.3				0.1
12/16	1												.	.	.	.	.	.	.	.	.	.	.
	2							0.41					.	.	.	.	.	.	.	.	.	.	.
	Total							0.41					.	.	.	.	.	.	.	.	.	.	.
Winter Mean								0.41						0.05	0.83	0.1		0.11	0.36			0.16	0.05

Appendix Table C. Summary of smallmouth bass stomachs analyzed for food habits from Lower Granite Reservoir, Washington, 1987.

Season	Station	Total Number Collected	Total Number Empty	Total Number Stomachs	Total Length	
					Range (mm)	Mean (mm)
Spring	LG1S	127	38	89	127-356	205.5
	LG2S	25	3	22	161-475	251.7
	LG3S	71	17	54	150-460	217.6
	LG4S	27	7	20	171-280	212.5
	LG5S	8	1	7	178-320	220.5
	LG1M	1		1		270.0
	LG2M	2		2	189-296	239.0
	LG3M					
	LG1D					
	LG2D					
Summer	LG1S	5		5	145-251	196.0
	LG2S	9	2	7	174-287	205.0
	LG3S	11	2	9	164-353	205.7
	LG4S	9		9	162-256	201.0
	LG5S	5		5	154-234	187.8
	LG1M	1		1		293.0
	LG2M	3	1	2	189-351	249.3
	LG3M	5		5	174-206	189.0
	LG1D					
	LG2D					
Fall	LG1S	1		1		192.0
	LG2S	8		8	260-297	281.3
	LG3S					
	LG4S	2		2	438-441	439.5
	LG5S					
	LG1M	4	3	1	210-456	307.8
	LG2M					
	LG3M	2	1	1	270-413	341.5
	LG1D					
	LG2D					

Appendix Table D. Summary of northern squawfish stomachs analyzed for food habits from Lower Granite Reservoir, Washington, 1987.

Season	Station	Total Number Collected	Total Number Empty	Total Number Stomachs	Total Length	
					Range (mm)	Mean (mm)
Spring	LG1S	3	2	1	310-359	333.0
	LG2S	24	5	19	137-550	323.8
	LG3S	1		1		347.0
	LG4S	5	3	2	154-381	241.8
	LG5S					
	LG1M	9	3	6	253-499	356.0
	LG2M	17	5	12	230-510	366.5
	LG3M	14	2	12	243-472	343.9
	LG1D	2	1	1	335-493	414.0
	LG2D	5		5	233-365	310.6
Summer	LG1S					
	LG2S	1		1		360.0
	LG3S					
	LG4S					
	LG5S					
	LG1M	3	1	2	355-491	435.3
	LG2M	11	4	7	255-495	348.2
	LG3M	14	3	11	230-356	274.4
	LG1D	1		1		362.0
	LG2D	4	1	3	325-432	373.3
Fall	LG1S	1	1			331.0
	LG2S	19	8	11	261-420	269.5
	LG3S					
	LG4S	2	1	1	331-337	334.0
	LG5S					
	LG1M	15	1	14	260-532	316.9
	LG2M	11	4	7	252-427	324.2
	LG3M	7	1	6	256-498	314.9
	LG1D	7		7	255-375	293.6
	LG2D	6	3	3	255-358	294.2
Winter	LG1S					
	LG2S	3	2	1	273-370	336.7
	LG3S					
	LG4S					
	LG5S					
	LG1M	1		1		369.0
	LG2M	4	3	1	250-367	289.0
	LG3M	1	1			342.0
	LG1D	5	3	2	245-358	303.2
	LG2D	1	1			348.0

Appendix Table E. Summary of channel catfish stomachs analyzed for food habits from Lower Granite Reservoir, Washington, 1987.

Season	Station	Total Number Collected	Total Number Empty	Total Number Stomachs	Total Length Range (mm)	Total Length Mean (mm)
Spring	LG1S					
	LG2S	1		1		493.0
	LG3S					
	LG4S					
	LG5S					
	LG1M					
	LG2M	14	2	12	356-612	466.0
	LG3M	3		3	430-526	492.0
	LG1D	1		1		305.0
	LG2D	1		1		493.0
Summer	LG1S					
	LG2S	5		5	299-473	362.4
	LG3S					
	LG4S					
	LG5S					
	LG1M	2		2	259-528	394.0
	LG2M	8	1	7	268-435	345.5
	LG3M	2		2	323-409	366.0
	LG1D					
	LG2D					
Fall	LG1S					
	LG2S	1		1		302.0
	LG3S					
	LG4S					
	LG5S					
	LG1M	4		4	208-510	390.8
	LG2M	8	3	5	243-389	308.1
	LG3M	1		1		285.0
	LG1D	2		2	324-515	419.5
	LG2D	2		2	359-583	471.0

FISH AND BENTHIC COMMUNITY ABUNDANCE AT PROPOSED IN-WATER DISPOSAL SITES IN LOWER GRANITE RESERVOIR, WASHINGTON

ADDENDUM: Fish and habitat evaluation of shallow water habitats in Lower Granite Reservoir

by

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Acknowledgements

We wish to thank the United States Army Corps of Engineers for funding this project. Molly Hallock contributed greatly to this project, both in the laboratory and in the field. We thank Teri Barila for her interest, enthusiasm, and project supervision. Tevis Underwood was also helpful in lab and field work.

Executive Summary

Annual dredging and in-water disposal of dredge material has been proposed as an alternative to alleviate high sedimentation rates in Lower Granite Reservoir, Washington. This alternative may result in creation or destruction of shallow water habitats. The potential alteration in habitat has caused concern among resource managers as to the importance of shallow water habitats to native and introduced resident fishes as well as anadromous fishes residing in and moving through Lower Granite Reservoir. As a result of these concerns, this study was funded with the following objectives:

1. To characterize physical habitat conditions at selected shallow water sites;
2. To assess use of shallow water habitat by salmonid fishes and their potential predators; and
3. To evaluate incidence of predation on juvenile salmonid fishes in shallow water habitat.

Five shallow water (< 20 ft) stations were selected representing a wide divergence in habitat types especially substrate. Stations were scattered throughout the reservoir from RM 135 to RM 111. Sampling commenced April 1987 and continued through December 1987.

Intensive habitat sampling confirmed speculations from earlier studies about the characteristics of the physical habitat in Lower Granite Reservoir. Temperature, turbidity and water velocities were similar among the five shallow stations. Low velocities probably have little influence on resident fish distribution and habitat use. A systematic sample using snorkeling revealed significant differences in substrate, cover, mean depth, gradient, and shoreline diversity among the five stations. The

downstream station, LGIS, typically had gravel sized particles and highest amounts of organic and inorganic cover, while upstream stations had sandy substrate and little cover. Aquatic macrophyte abundance was low at all stations during the time of the survey.

Boat electrofishing and beach seining showed substantial differences in fish abundance among stations and seasons. During the spring, chinook salmon and rainbow trout (steelhead) were collected at all stations. Stations with primarily low gradient, fine substrate and negligible cover had higher abundances of fall chinook salmon (< 75 mm) in beach seine catches. In contrast, chinook salmon larger than 75 mm had highest abundance at the station with the most diverse physical habitat. Beach seine catches of rainbow trout were also highest at the station with the most diverse habitat. Significant Spearman rank correlations were found for abundance of chinook (< 75 mm) and wild rainbow trout and the proportions of inorganic cover, substrate, gradient, and no cover. The station with the highest diversity of physical habitat also was the most downstream station. Thus, fish distribution could have been related to habitat characteristics and/or reservoir location.

Smallmouth bass were the most abundant predator in beach seine and electrofishing catches. Predator size northern squawfish (> 250 mm) exhibited low catches at all shallow stations. No channel catfish were captured by beach seine or electrofishing at the shallow water stations.

The majority of fishes collected at the shallow water stations were young-of-the-year (YOY) or yearling. Summer beach seine catches at stations with fine substrates and low physical diversity had extremely high catches in YOY fish, predominantly largescale sucker, chiselmouth, northern squawfish, and smallmouth bass.

Stomach contents of the three major predators, northern squawfish, smallmouth bass and channel catfish, were collected to assess the incidence of predation. Channel catfish (n = 18) had the highest incidence of salmonids present in the stomach (38.9%), most of which were steelhead. Incidence of predation by northern squawfish was 22% (n = 59). An average of 1.2 rainbow trout and chinook salmon were observed per squawfish stomach which contained salmonids. Despite their apparent high abundance, only 3.6% of the bass contained salmonids, the majority of which were chinook. Bass predation on juvenile salmonids appears minor in shallow waters and channel catfish prefer deeper waters. Northern squawfish seem to be the dominant predators on salmonids in Lower Granite Reservoir although abundance of predator sized squawfish is low at shallow water stations.

Introduction

Since completion in 1975, Lower Granite Reservoir has been experiencing high rates of sedimentation. Without some action to alleviate the high sedimentation rates, flood control capabilities and navigational uses of the reservoir are threatened. Annual dredging and in-water disposal of about 800,000 cubic yards of sediment has been proposed as an alternative to alleviate high sedimentation rates. One disposal alternative currently being examined is in-water disposal of dredge material in one or more of the three major habitat types in Lower Granite Reservoir: deep water (> 60 feet), mid water (> 20-60 feet), and shallow water (< 20 feet). Much concern has been expressed by fishery managers as to the importance of these habitat types to both resident native and introduced fishes, as well as anadromous salmonids residing in and moving through the reservoir.

Knowledge of the importance of shallow water habitats for resident and anadromous fishes in Lower Granite Reservoir, Washington, is limited. Research by Bennett and Shrier (1986) showed that catches of juvenile chinook salmon (*Oncorhynchus tshawytscha*) and rainbow (steelhead) trout (*Salmo gairdneri*) in shallow water habitats in Lower Granite Reservoir were high during the winter and spring seasons. This research also demonstrated the presence of predators in shallow water habitats, principally northern squawfish (*Ptychocheilus oregonensis*), smallmouth bass (*Micropterus dolomieui*), and to a lesser extent channel catfish (*Ictalurus punctatus*). Thus, the potential for predation on juvenile salmonids exists in shallow water habitat.

Predation losses are often exaggerated in areas where migration is restricted at the dams or below turbines, where injured and disoriented fish are often highly susceptible to concentrations of predators. However, predation also occurs intensively throughout the body of a reservoir (Gray et al. 1984, Bennett et al. 1983). Reduced flows of a reservoir environment have been estimated to increase exposure of juvenile salmonids to predators as much as three times their original availability in a riverine environment (Ebel 1977). Exposure to high water temperatures as a result of extended out-migrations, and increase in slack water habitats that may be preferred by native and introduced potential predators also have been attributed causes of increased predation in impoundments (Gray et al. 1984).

With decreased flows and subsequent delays in migration through a reservoir, it is plausible that juvenile anadromous salmonids seek out preferred habitat. Bennett and Shrier (1986) suggest that shallow water habitat may be important for foraging and resting for juvenile salmonids. Areas with no apparent cover had high abundance of juvenile salmonids. They hypothesized that potential predators were less successful in capture of salmonids in areas of no cover.

A paucity of information exists on habitat use and preference of migrating juvenile anadromous salmonids and the causal mechanism of the habitat preference (i.e. food, cover, lack of cover, etc.). An understanding of the dynamics of predation, foraging, and preferred habitat characteristics may provide better insight for fishery managers to reduce predation by means of habitat alterations. This information may be especially important for the Lower Granite pool in view of the potential to create or fill shallow water areas as stated in the proposed in-water disposal plans. In theory, newly created shallow water areas may be beneficial for juvenile salmonids, if they provide areas with a low risk of predation. Conversely, the new areas could be a detriment if they attract potential predators and juvenile salmonids, and actually increase predation. The shallow areas may serve as rearing areas for juvenile predators and actually increase production of potential predators. Because certain aspects of these shallow water sites may be attractive to potential predators, it is equally important to determine habitat preferences of these fishes in Lower Granite Reservoir.

The current proposal by the U.S. Army Corps of Engineers to enhance habitat for salmonid fishes by disposing of dredge material at mid depth (20-60 ft) sites needs to be further evaluated. Their proposal would be to fill mid depth sites downstream of RM 120 and elevate the depth of these sites to create shallow water. One question that needs to be addressed is whether the habitat attributes at the elevated mid-depth sites would be attractive to salmonids and their predators. To adequately evaluate this question, more comprehensive data on shallow water sites were required. Specific objectives of this project were:

Objectives

1) To characterize physical habitat conditions at selected shallow water sites;
2) To assess use of shallow water habitat by salmonid fishes and their potential predators; and
3) To evaluate incidence of predation on juvenile salmonid fishes in shallow water habitat.

Study Area

Lower Granite Reservoir is the first in a series of four impoundments of the lower Snake River located in southeastern Washington (Figure 1). Lower Granite Reservoir is the longest of the four impoundments, with a total length of 39.2 miles (62.8 km). Total surface area of the reservoir is 8,900 acres (3,602 ha), with a maximum depth of 138 ft (42.1 m) and a mean depth of 55 ft (16.6 m). The Clearwater River is the only major tributary, which enters the reservoir near Lewiston, Idaho.

We sampled five (5) shallow water sites in Lower Granite Reservoir. Station locations were as follows (previous designation refers to Bennett and Shrier 1986):

Location	Coding	Previous Designation
RM 111	LG1S	SR1S
RM 127	LG2S	SR2S
RM 129	LG3S	--
RM 132	LG4S	--
RM 134	LG5S	SR3S

Station selection was based on habitat attributes at each of these sites and represents a wide divergence in habitat types with emphasis on substrate. A number of other habitat attributes also differ (e.g. shoreline gradient, depth and velocity) among stations but substrate differences were the most obvious. Specific characteristics of each station are shown in Appendix Table A.

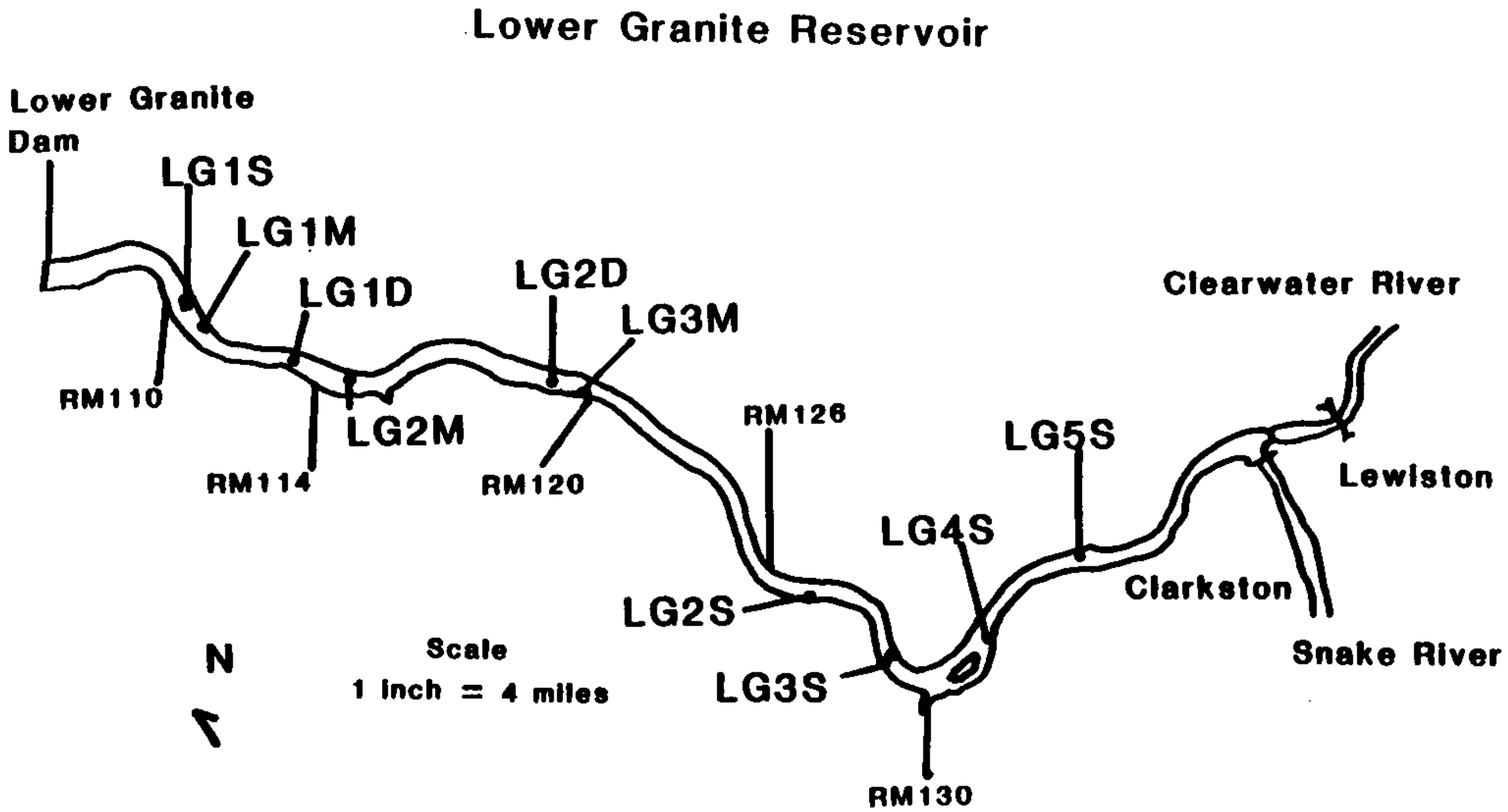

Figure 1. Fish sampling station locations on Lower Granite Reservoir. Letters at the end of station codes denote shallow-water (S), mid-water (M), or deep-water (D) habitat. Stations are numbered within each habitat type as they progress upstream.

Objective 1: **To characterize physical habitat conditions at selected shallow water sites.**

Methods

We characterized habitat at each shallow water site by quantifying selected habitat attributes. Habitat variables used to characterize each shallow water site were: turbidity, temperature, gradient, mean depth, velocity, shoreline diversity, total cover and cover type, substrate, and aquatic macrophyte distribution.

Temperature and Turbidity

Temperature (°C) was taken with a hand held thermometer at the surface following each fish sampling effort. Turbidity samples were collected at the surface in a 1 l bottle following each fish sampling effort. Water samples were transported to the University of Idaho where turbidity (NTU's) was measured using a Hach model 2100A Turbidimeter.

Velocity

Velocity measurements were taken during 1987 when discharge ranged from high to low with a Swoffer Model 2100 velocity meter. We measured velocity at ten stations; three additional mid depth and two deep stations were included in the analysis (see Bennett et al. 1988 for details). Because 1987 was a low-water year, "high" discharges were in the range considered "moderate" in a typical water year. Three profile locations were selected at each station. The "channel" profile was located at the deepest part of the channel on a transect perpendicular to the channel across the middle of the sampling station. Deep sites have only the channel profile which was also the "on-site" profile. The second location, the "midway" profile, was located where one half the depth between the "on-site" profile depth and channel profile depth occurred. The third location, the "on-site" profile, was located on the middle of the site at a depth half way between depths describing the site (shallow 10 ft; mid depth 40 ft). At shallow stations, velocity measurements were recorded at the surface and then every 1 m in depth, whereas measurements at deep and mid depth stations (Bennett et al. 1988) were taken at the following depths: surface, 1, 5, 10, 15, 20, 25, 30, and 35 m.

We developed equations to predict velocities throughout Lower Granite Reservoir and to determine which morphometric and dam-related activities influenced reservoir velocities. Predictive equations were derived based on two different dependent variables: average channel velocity and average on-site velocity. Average channel velocity is the mean of all measurements in the upper 15 m of the channel profile, which ensures an equal number of measurements (5) from all channel profiles regardless of total depth. All deep, mid depth and shallow stations were included in average channel velocity regressions. Average on-site velocity represents the mean of all readings taken from shallow and mid depth on-site profiles (i.e. 10 ft and 40 ft). Both deep stations were excluded from on-site equations because velocity measurements were taken only from the channel profiles.

Variables examined for relationships with channel and on-site velocities were related to morphometric and regulated characteristics of the reservoir. Morphometric variables were unique constants associated with each station including river mile, reservoir width, distance from channel to on-site profile, maximum depth, depths of channel, midway, and on-site profiles, and cross-sectional area. Regulated variables were variable as a result of dam-related activities and included confluence (Snake and Clearwater Rivers) and forebay pool elevations, total (turbine plus spillway) discharge at Lower Granite Dam, and inflow at the confluence. Variables within each category were mutually dependent which restricted us to use one variable from each category to avoid violating the least squares regression assumption of independence. When appropriate, we used ratios of variables within each category which incorporated effects of two colinear independent variables as one independent variable. We also transformed variables as needed to meet homogeneity of variance and normality assumptions of regression procedures.

Mapping

We constructed morphometric site maps which we used as a basis for systematically sampling physical attributes of the shallow stations. We mapped each shallow station using a transit and level rod to measure bearings and distances (estimated by stadia) between survey points along the full pool water line. Mean depth and bottom gradient calculations, and 2 m contour lines on our maps were based on depths measured at 10 m intervals along 10 parallel transects oriented nearly perpendicular to the shoreline. Depth determinations were made ±0.5 ft. Each station was divided into 10 equally spaced transects. Because stations were of different length, transects were unevenly spaced among stations. Transects extended 200 m from shore or to the 20 ft (6.1 m) depth contour, and were the same transects used for cover and substrate inventories.

Shoreline diversity was determined using an index similar to the shoreline development index described by Wetzel (1975). Total length of the shoreline was measured with a cartometer and then divided by the length of a straight line distance between the two most widely separated points.

Cover and Substrate

Diving.-We used the substrate classification system from Bovee (1982) ranging from fine particles (< 2 mm) to large boulders (> 600 mm; Appendix Table B) to inventory substrate at the shallow water sites. We established two main cover categories: organic and inorganic. Each cover category was broken into 6 size classes (Appendix Table B). Cover was defined as any object a fish could hide under or behind (Bovee 1982). Therefore, cover size classes did not necessarily reflect the absolute size of an object, but rather those dimensions of an object usable by a fish for cover. Because this survey was not specific in terms of what constitutes cover for different fish species, size classes in Appendix Table B were arbitrarily selected with the intent of bracketing any size of fish that could potentially use an object for cover.

Cover and substrate inventories were made along the same transects used for shallow station mapping. Transects were actually floating ropes with floats attached at 10 m intervals. Divers equipped with snorkeling gear dropped a 1 m^2 square plot every 10 m along each transect, then swam down to the bottom and made ocular estimates of cover and substrate attributes within the square plot. Ocular estimates consisted of estimating percent of the 1 m^2 area covered by dominant substrate and cover types and sizes. To facilitate estimates of percent coverage of dominant substrate and cover types within the 1 m^2 plot, a quartile ranking system was used and percent coverage expressed as: 1 (0-25%), 2 (26-50%), 3 (51-75%), and 4 (76-100%).

If a dominant substrate or cover size in a 1 m^2 plot was assigned a fourth quartile coverage (i.e. 76-100%), then a corresponding frequency of 1 was assigned. If the dominant substrate or cover size in a plot was assigned a third quartile coverage (i.e. 51-75%), then a frequency of .75 was assigned, etc.. The total proportion for each substrate size and cover size per cover type was then estimated for each station as the total frequency divided by the total number of plots in a station. Confidence intervals (95%) for each substrate and cover size were calculated as described by Schaeffer et al. (1986).

A Pearson's chi-square statistic for testing homogeneous proportions was used to identify significant differences among stations for proportions of no cover and inorganic cover. As a result of low frequencies of any one inorganic cover size, all inorganic cover sizes were pooled together to test for differences. Low observed frequencies precluded testing differences in organic cover among stations.

Grab Sampling.-Substrate samples were collected with a ponar dredge and analyzed for particle size distribution and organic matter content. Samples were dried at 105°C for 32 hours and separated by dry sieving into three categories: particles larger than sand (> 2.00 mm), sand (0.061 mm-2.00 mm), and particles smaller than sand (< 0.061 mm). Because the fine sediments were caked, samples were gently crushed manually before sieving. After sieving, we measured the weight (g) of each substrate size category.

We analyzed organic matter content by drying the sediment in crucibles at 105°C for 21 hours followed by ignition at 550°C for 3.5 hours (APHA 1980). Samples were then wetted and re-dried at 105°C for 21 hours to rehydrate particles smaller than sands. Samples were cooled in a dessicator after each drying period. Percent organic matter was determined as the difference between weights prior to and following ignition.

Aquatic Macrophytes

Aquatic macrophyte distribution was only of interest for the summer sample period as a result of their absence during other seasons. Their presence or absence was noted during the habitat survey, and the approximate area of coverage and average depth of their presence determined.

Results

Contour maps developed for each of the shallow water stations from the systematic survey showed LG1S was the narrowest of all shallow stations to a depth of 20 m (Figure 2). The southern part of the station was rip rap and provided the steepest gradient. In contrast, at LG2S a depth of 6 m begins approximately 200 m from shore. The largest area of habitat at LG2S was from 2-6 m deep (Figure 3). The shelf at depths less than 6 m at LG3S extended about 100 m from shore. Like LG2S, the largest amount of habitat at LG3S was from 2-6 m in depth (Figure 4). Depths less than 6 m extended offshore approximately 200 m at LG4S (Figure 5). Low shoreline gradient was obvious from the habitat mapping. At LG5S, the largest amount of habitat was from 2-4 m (Figure 6). As at LG4S, low shoreline gradient was apparent from the bathymetric surveys.

Temperature and Turbidity

Water temperature was similar among the five shallow stations (Table 1). Spring temperatures ranged from 11°C (April 15) to 23°C (June 13).

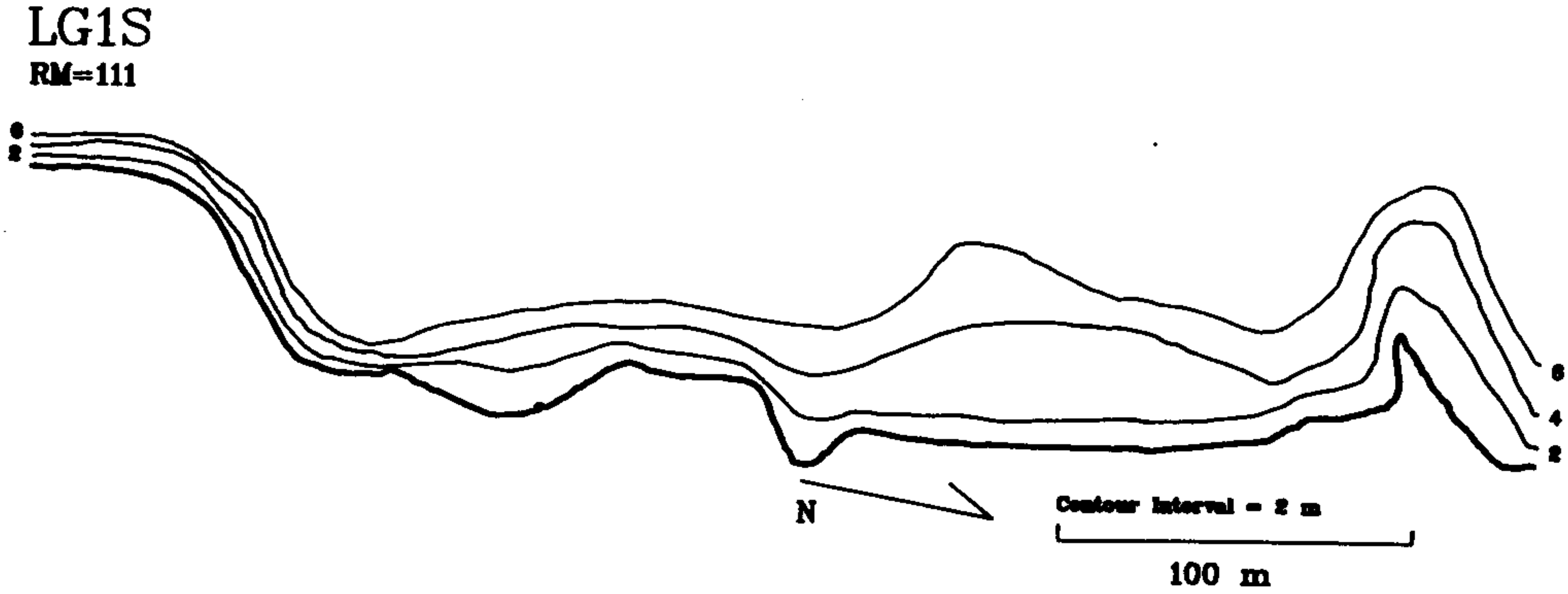

Figure 2. Morphometric map of shallow station LG1S (RM 111), Lower Granite Reservoir, Washington.

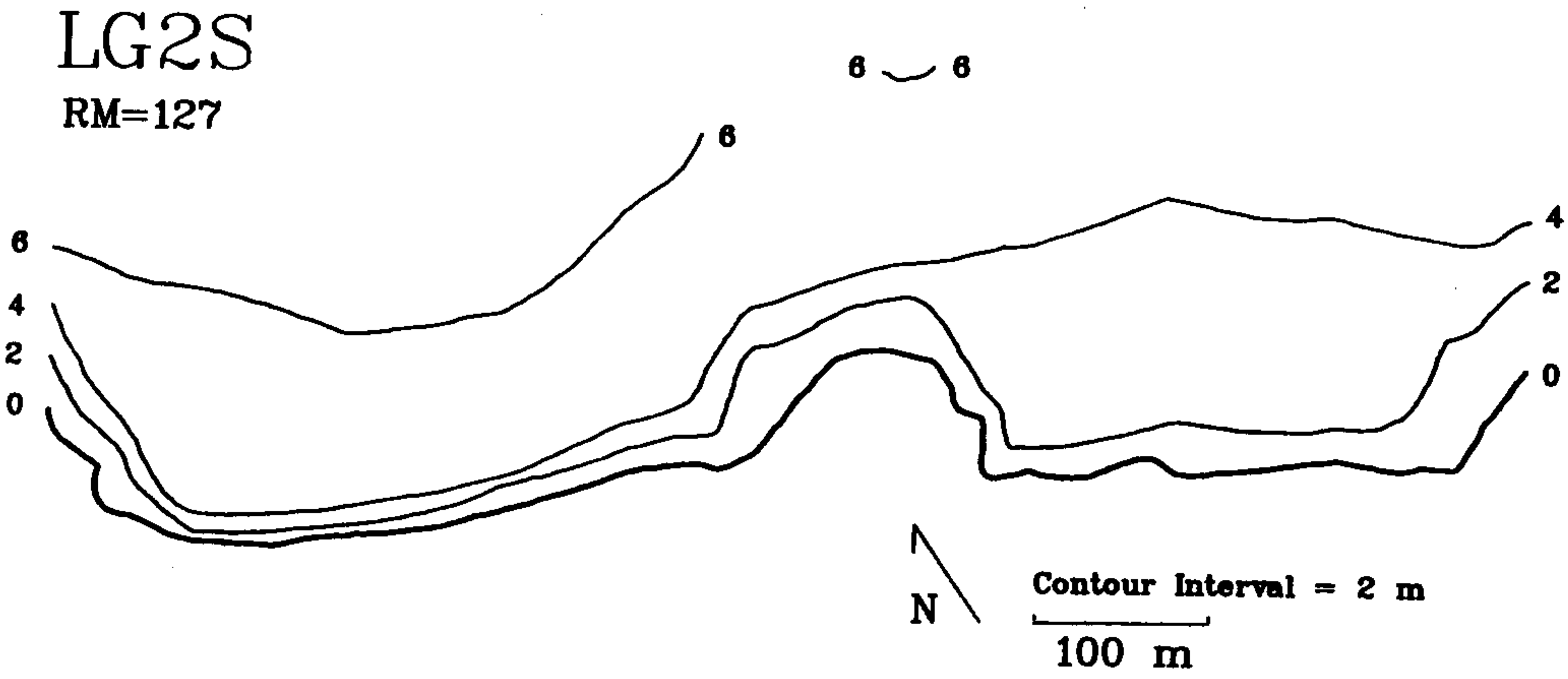

Figure 3. Morphometric map of shallow station LG2S (RM 127), Lower Granite Reservoir, Washington.

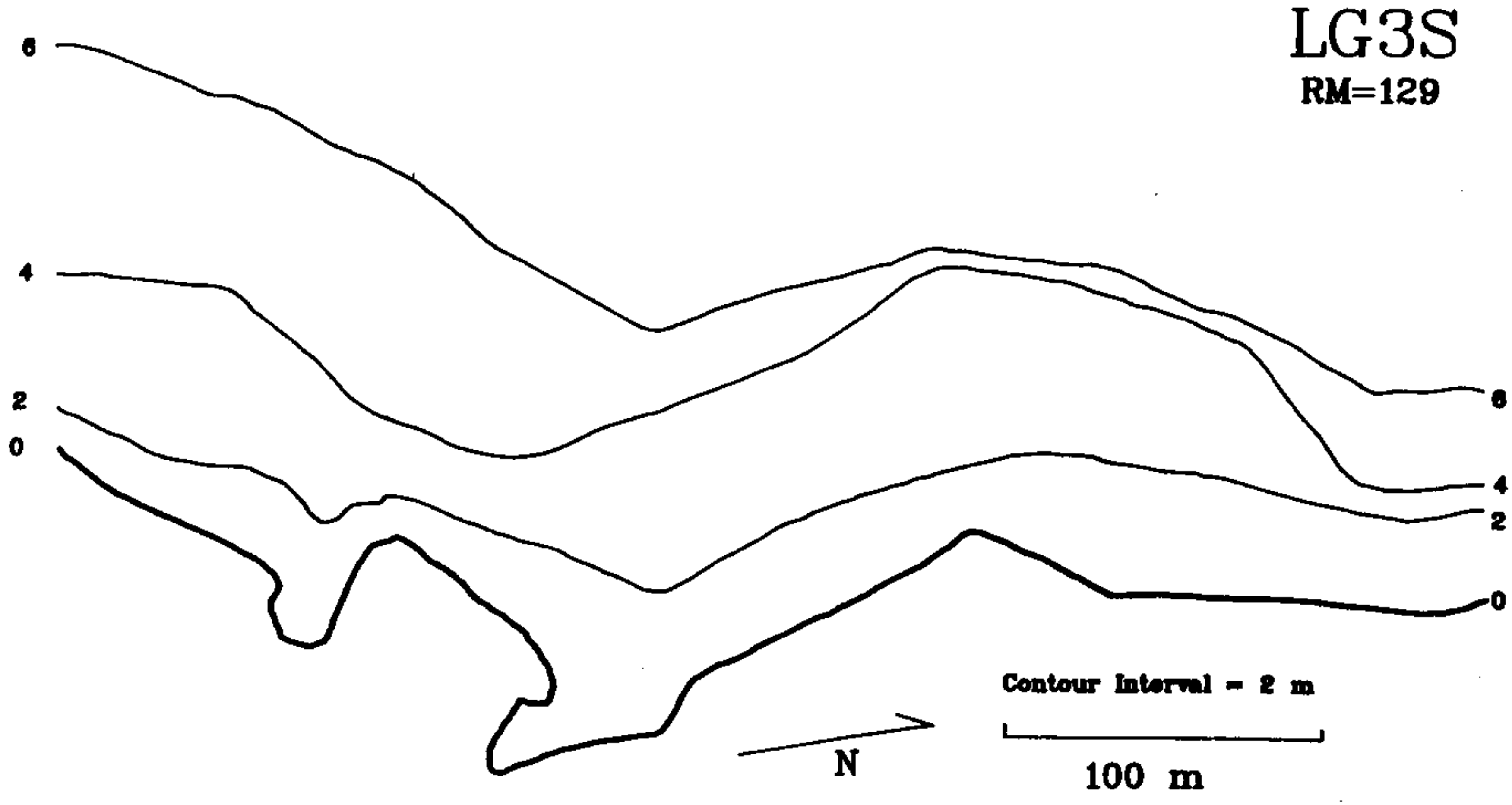

Figure 4. Morphometric map of shallow station LG3S (RM 129), Lower Granite Reservoir, Washington.

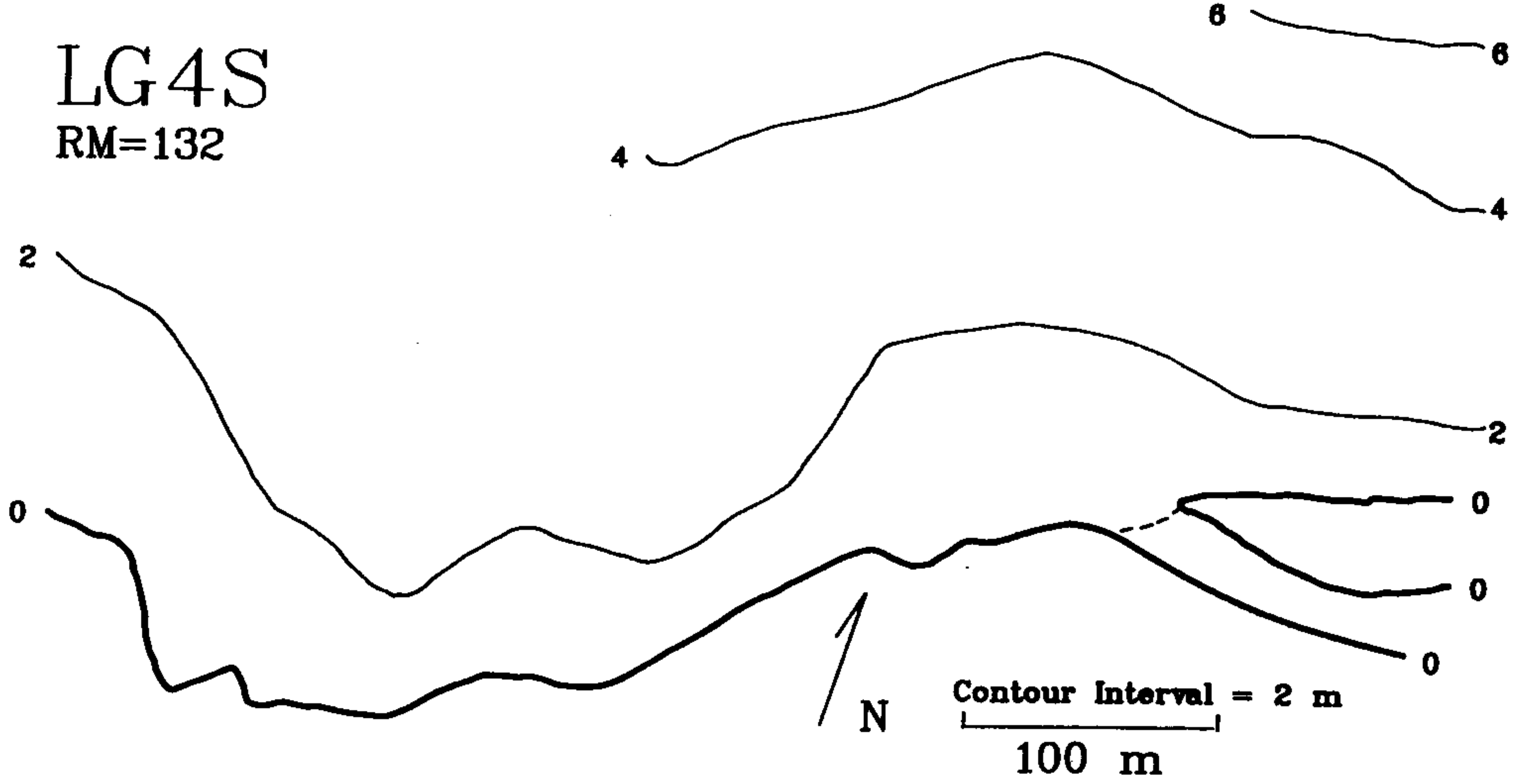

Figure 5. Morphometric map of shallow station LG4S (RM 132), Lower Granite Reservoir, Washington.

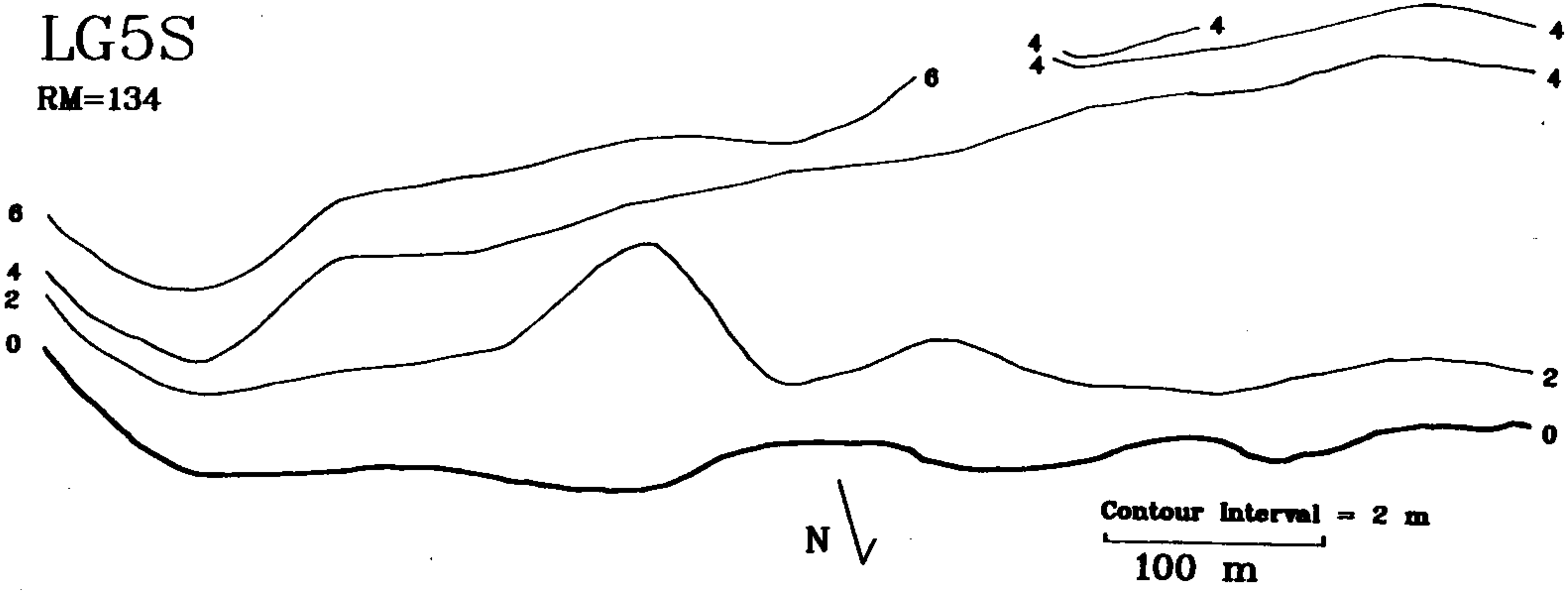

Figure 6. Morphometric map of shallow station LG5S (RM 134), Lower Granite Reservoir, Washington.

Table 1. Mean surface temperatures of shallow water stations, during the spring and fall, 1987, Lower Granite Reservoir, Washington.

Season		LG1S	LG2S	LG3S	LG4S	LG5S
Spring						
	Mean	14.2	14.8	14.8	14.6	15.2
	Variance	3.068	6.48	7.82	5.97	9.67
	(95% Bound)	1.1	1.1	0.98	1.2	1.3
	n	11	20	16	16	15
Fall						
	Mean	13.3	12.9	13.1	13.0	13.1
	Variance	2.86	2.88	2.91	2.92	3.01
	(95% Bound)	2.4	2.4	2.4	2.5	2.5
	n	8	8	8	8	8

Station LG5S had the highest overall mean spring seasonal temperature of 15.2°C. Temperatures ranged from 22 to 24°C throughout the summer period. Fall surface temperatures ranged from 17.5°C (October 11) to 11.5°C (November 11). The overall mean temperature in the fall also was similar among stations. Winter water temperatures during mid-December stayed relatively constant at 5°C.

Turbidity also was similar among the five shallow stations (Table 2). Mean surface turbidities (NTU) for the spring ranged from 2.5 (LG5S) to 4.2 (LG4S). The highest turbidity of 68 NTU'S was observed at LG2S during a gillnetting sample. However, because the other shallow stations were not sampled for turbidity that same day, this value was omitted from the mean and range determinations. Summer turbidities ranged from 1.8 (LG1S) to 3.0 (LG4S). Fall turbidities also were low, with no significant differences between stations; mean surface turbidities ranged from 1.2 (LG3S) to 1.4 (LG4S). Although no turbidity samples were collected during the winter sampling period, low inflows resulted in turbidities that were similar to the fall period.

Velocity

A graphical analysis of velocity readings from all depths, profiles and stations preceeded our regression analyses. No consistent depth-related velocity patterns emerged from plots of velocity profiles over time; profiles at all stations showed wide daily variation. We observed no strong relationship of velocity readings with total inflow at the confluence or total discharge at Lower Granite Dam. Figures 7 and 8 illustrate velocity patterns observed over river mile and profile at a depth of 5 m. River miles 134.7, 132.4, 129.2 and 127.3 (corresponding to

Table 2. Mean surface turbidities of shallow water stations, during spring and fall, 1987, Lower Granite Reservoir, Washington.

Season		LG1S	LG2S	LG3S	LG4S	LG5S
Spring						
	Mean	2.7	3.0	3.2	4.2	2.5
	Variance	0.83	1.98	1.32	1.57	1.18
	(95% Bound)	0.47	0.73	0.64	0.65	0.60
	n	15	15	13	15	13
Fall						
	Mean	1.3	1.3	1.2	1.4	1.3
	Variance	0.47	0.22	0.30	0.29	0.51
	(95% Bound)	0.36	0.17	0.23	0.23	0.39
	n	9	9	9	9	9

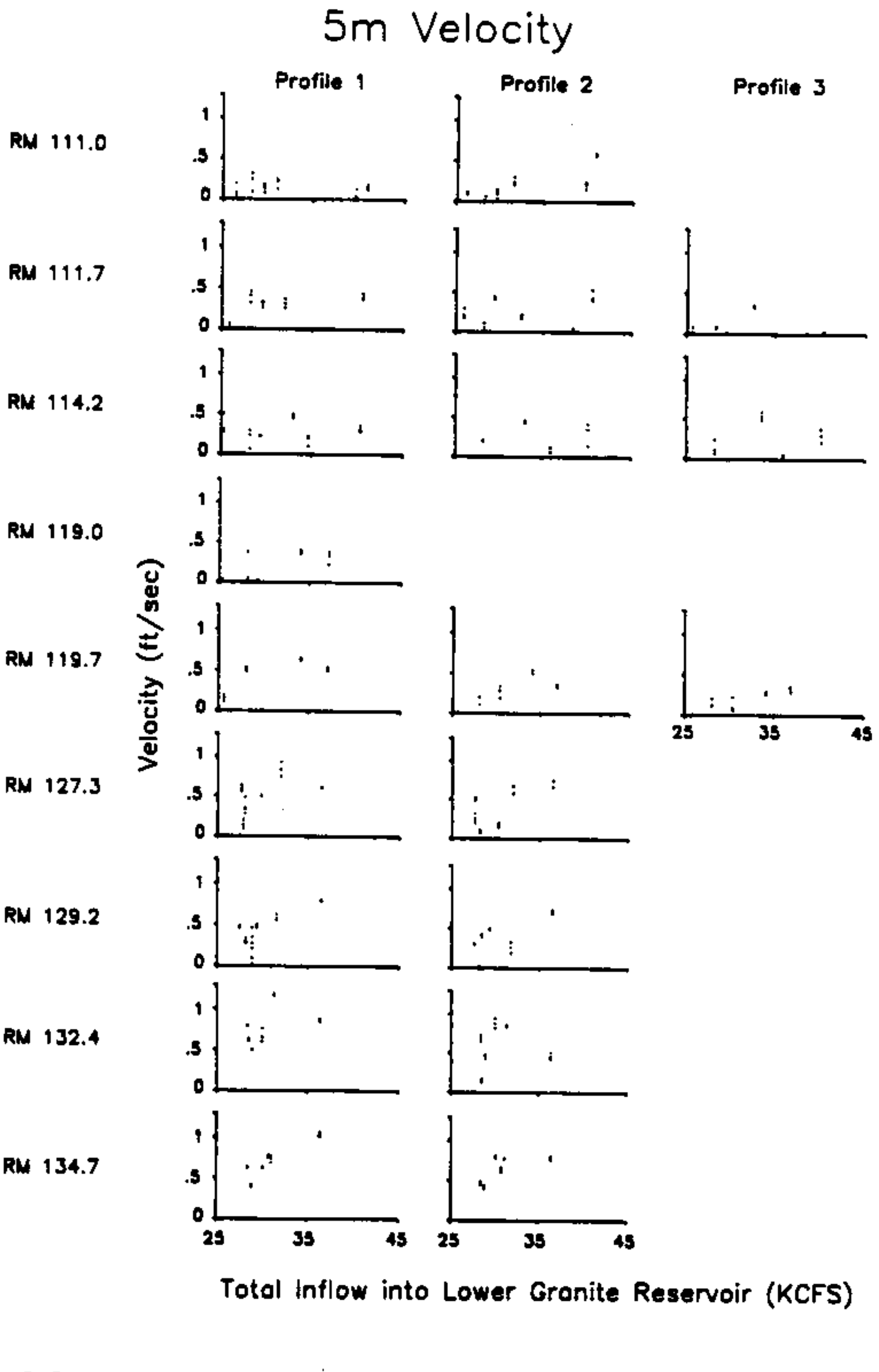

Figure 7. Relationship between velocity (ft/sec) at a depth of 5 m with river mile, profile location, and total inflow (KCFS) at the Snake and Clearwater River confluence. Profiles were located along a transect perpendicular to the channel; profile 1 was at the deepest point along the transect (channel profile), profile 3 was nearest to shore at 10 ft (shallow sites) or 40 ft (mid depth sites) in depth (on-site profile), and profile 2 was located at a depth which was half the difference in depths between profiles 1 and 3 (midway profile).

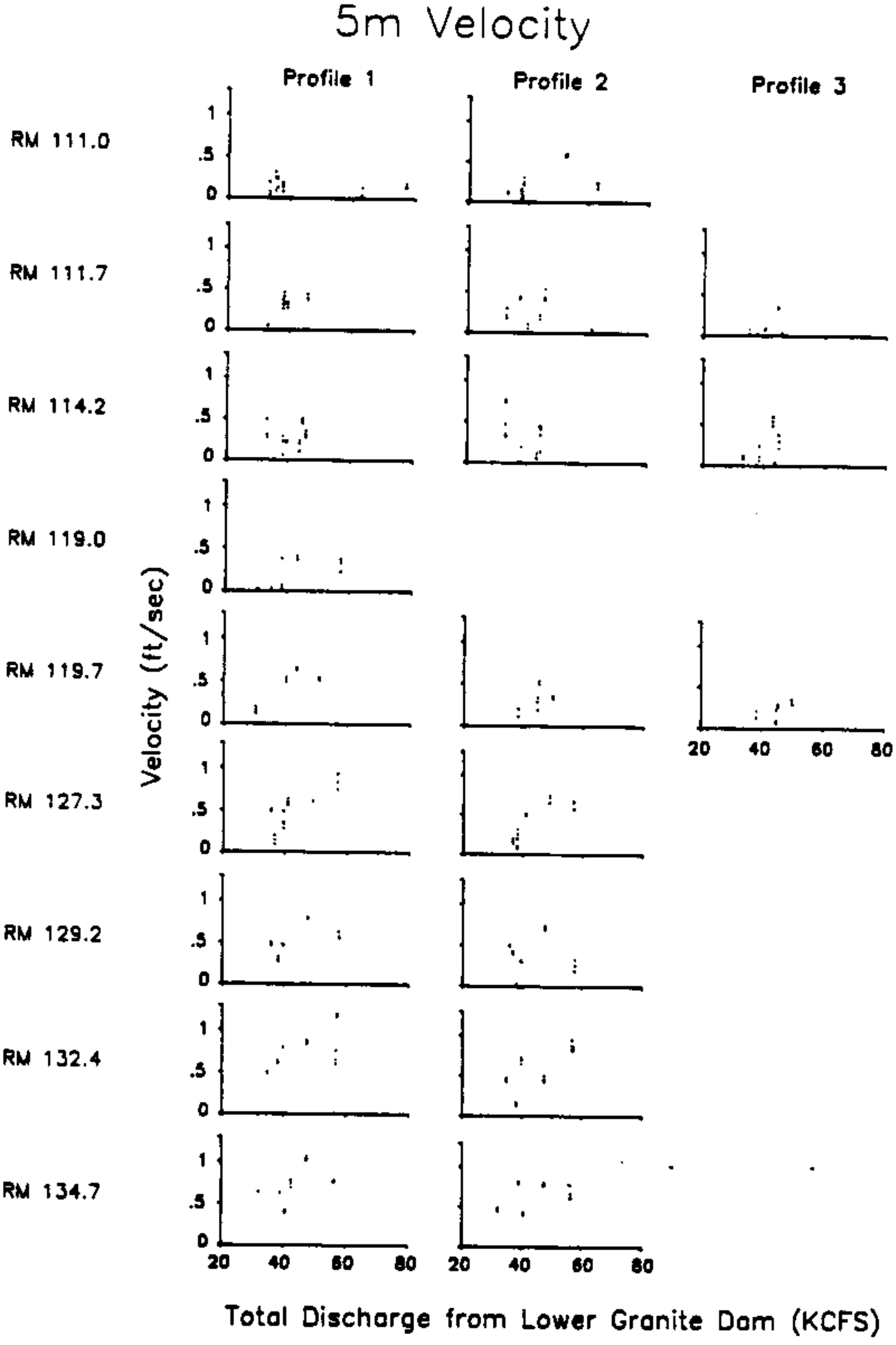

Figure 8. Relationship between velocity (ft/sec) at a depth of 5 m with river mile, profile location, and total discharge (KCFS) at Lower Granite Dam. Profiles were located along a transect perpendicular to the channel; profile 1 was at the deepest point along the transect (channel profile), profile 3 was nearest to shore at 10 ft (shallow sites) or 40 ft (mid depth sites) in depth (on-site profile), and profile 2 was located at a depth which was half the difference in depths between profiles 1 and 3 (midway profile).

stations LG5S, LS4S, LG3S and LG2S, respectively) show the strongest positive relationships with both total inflow (Figure 7) and total discharge (Figure 8), most likely a function of the "riverine" nature of the upper reservoir. As a result, velocity in up-reservoir areas is more responsive to water "inputs" and "outputs" than in downstream areas where water volume is greater and less responsive to inflow and discharge.

Channel.-Average channel velocity over the length of Lower Granite Reservoir (RM 111 - 134) was best predicted by the ratio of river mile/cross sectional area and forebay pool elevation (adjusted $R^2 = 0.78$, $p = 0.0001$; Figure 9). Both variables were highly significant in contributing to the model ($p < .001$). Associated 95% confidence bounds for each predicted average velocity had a mean of ±0.219.

Regressions to predict upstream (RM 120 - 134) and downstream (RM 111 - 120) channel velocities within the reservoir demonstrated the importance of different variables in the two reservoir sections. The variables river mile/cross sectional area and total inflow were most important for predicting upstream channel velocity (adjusted $R^2 = .70$, $p = .0001$; Figure 10), while river mile/cross sectional area and forebay pool elevation were most important in the downstream section (adjusted $R^2 = 0.58$, $p = .0001$; Figure 11). We dropped one outlier from the upstream velocity data set because of its overriding effect on the analysis (R^2 with the outlier $= 0.64$). Confidence intervals (95%) for predicted values had an overall mean of ±0.242 in the upstream section and ±0.194 in the downstream section.

On-site.-We were not able to develop a reservoir-wide (RM 111 to 134) regression equation to predict average "on-site" velocities ($R^2 < 0.50$).

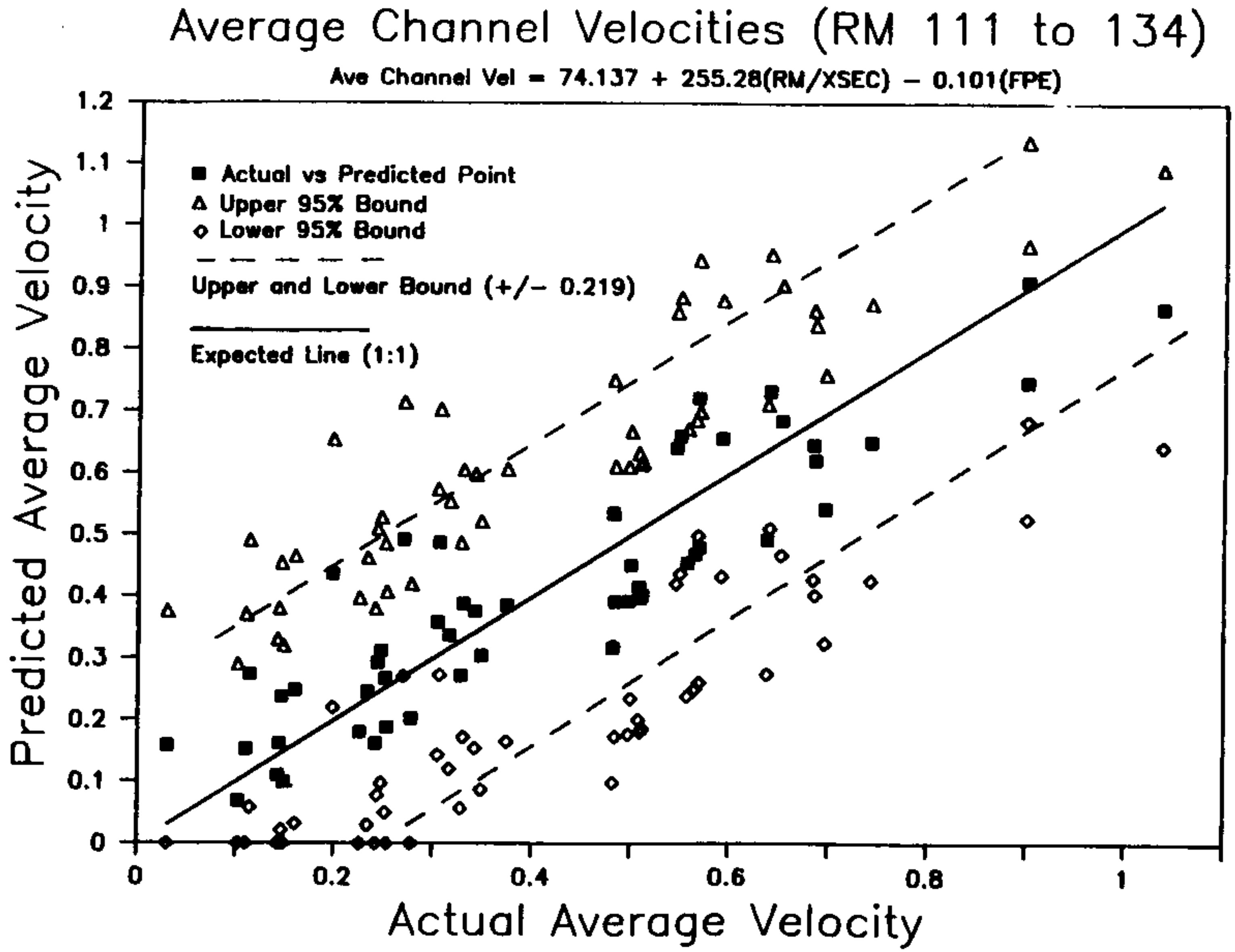

Figure 9. Actual vs. predicted values from regression (R^2=.78; p=.0001) relating average channel velocity (ft/sec) over the entire reservoir (RM 111 to 134) to the ratio of river mile / cross sectional area (ft^2; RM/XSEC) and forebay pool elevation (ft; FPE) at Lower Granite Dam. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.219 ft/sec).

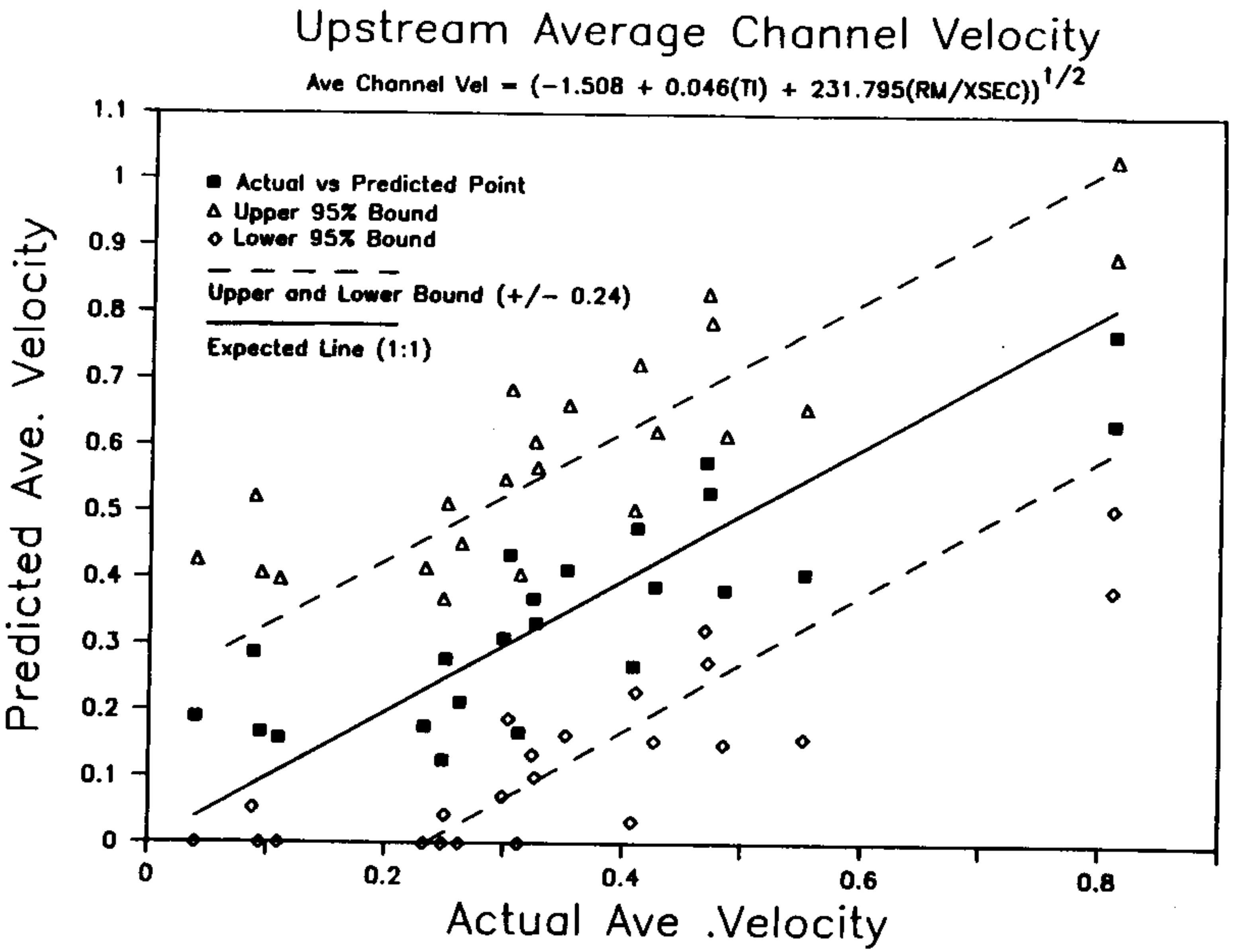

Figure 10. Actual vs. predicted values from regression (R^2=.70; p=.0001) relating average channel velocity (ft/sec) in the upstream (RM 120 to 134) portion of Lower Granite Reservoir to the ratio of river mile / cross sectional area (ft^2; RM/XSEC) and total inflow (KCFS; TI) at the confluence of the Snake and Clearwater Rivers. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.240 ft/sec).

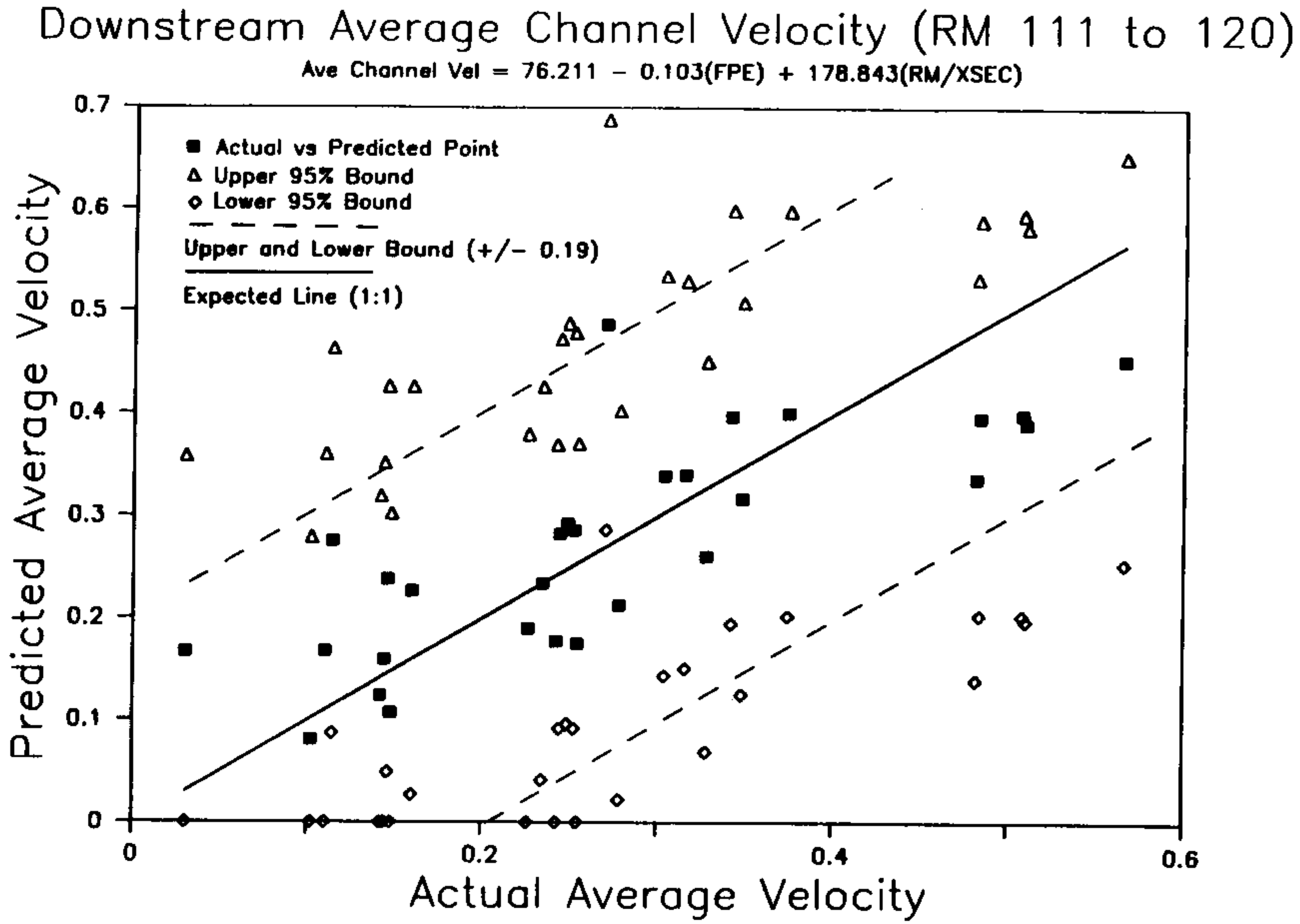

Figure 11. Actual vs. predicted values from regression (R^2=.58; p=.0001) relating average channel velocity (ft/sec) in the downstream (RM 111 to 120) portion of the reservoir to the ratio of river mile / cross sectional area (ft^2; RM/XSEC) and forebay pool elevation (ft; FPE) at Lower Granite Dam. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.190 ft/sec).

Equations developed for the upstream and downstream portions of the reservoir indicate different variables were important in affecting site velocities. Log transformation of the average site velocities was necessary for both upstream and downstream sections to linearize the relationship. Polynomial transformations of the independent variables were necessary to normalize data and to control variance in both reservoir sections. Although regression coefficients associated with the polynomial transformation were not significant ($p > 0.05$), the resulting regressions were valid for predictions (personal communication, Dr. Dale Everson, Department of Applied Statistics, University of Idaho, Moscow).

The best regression equation (adjusted $R^2 = 0.52$, $p = 0.0004$; Figure 12) developed for average on-site velocities for the upstream portion (RM 120-134) included confluence pool elevation and average midway velocity (the mean of of all measurements from the midway profile). Confidence intervals (95%) for the predicted values had an overall mean of ±0.215. The best regression equation for the downstream portion of the reservoir (adjusted $R^2 = 0.80$, $p = 0.0001$; Figure 13) included average channel velocity and site depth with a mean confidence interval (95%) for the predicted values of ±0.14.

Substrate

Diving.-A Pearson chi-square statistic for testing homogeneous proportions of all substrate size classes indicated significant differences among the five shallow water stations ($p < 0.005$). Station LG1S had a significantly lower proportion of finer (< 2 mm) substrates ($p < 0.005$) than the other four shallow stations (Figure 14; Table 3). No significant differences among the other four stations were found in the proportion of

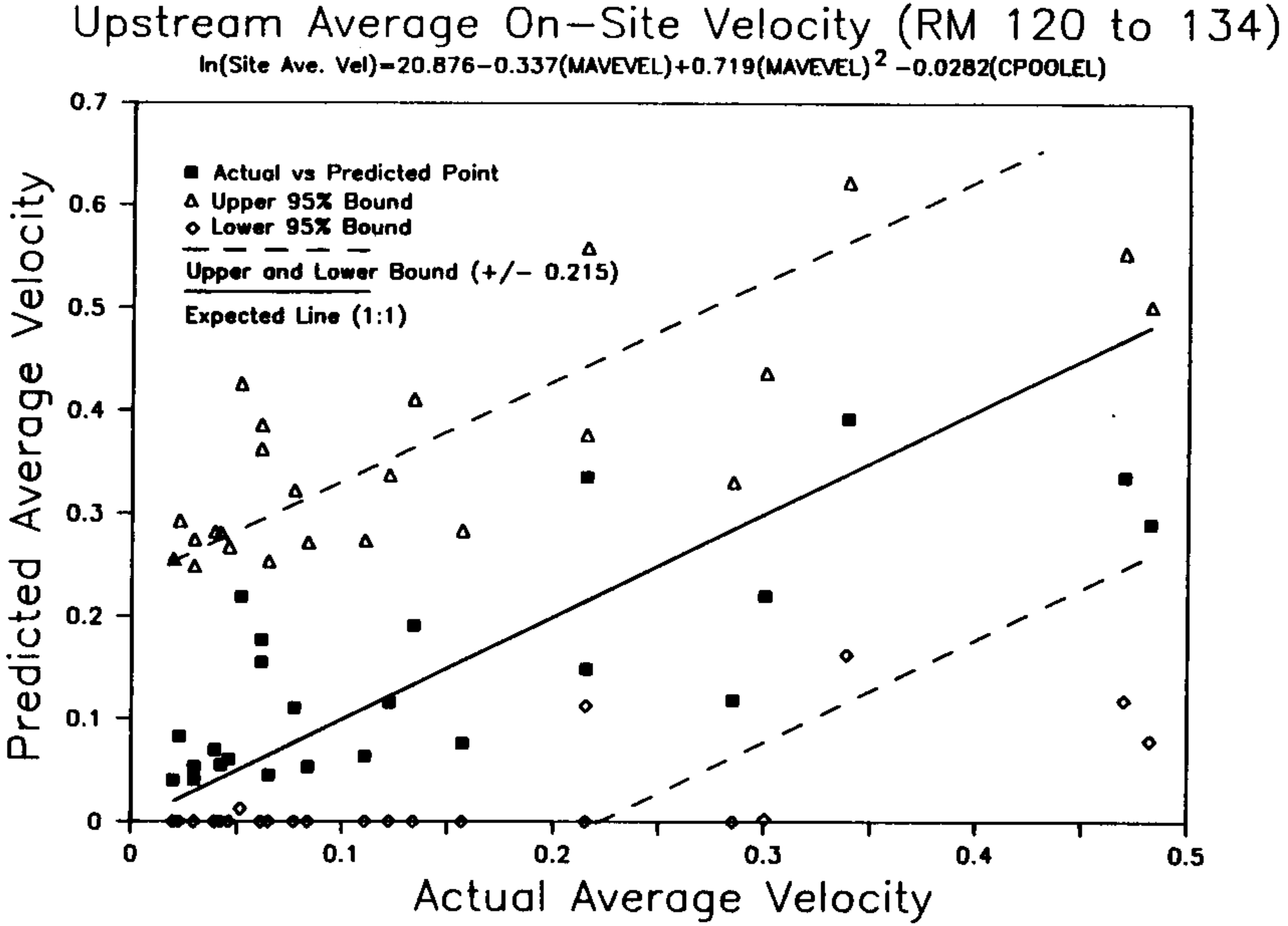

Figure 12. Actual vs. predicted values from regression (R^2=.52; p=.0004) relating average on-site velocity (ft/sec) in the upstream (RM 120 to 134) portion of Lower Granite Reservoir to average velocity at the midway profile (ft/sec; MAVEVEL) and pool elevation at the confluence of the Snake and Clearwater Rivers (ft; CPOOLEL). The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.215 ft/sec).

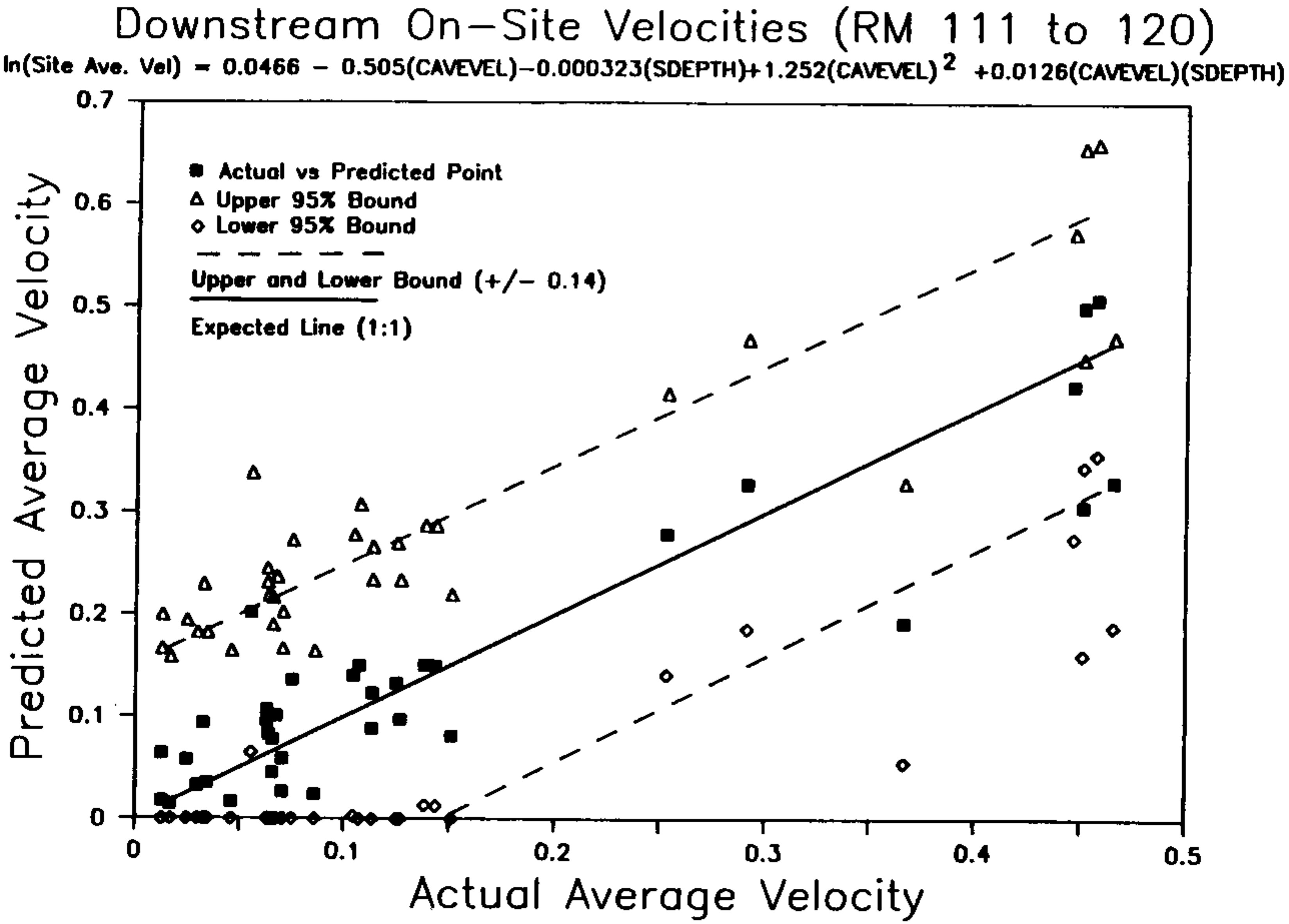

Figure 13. Actual vs. predicted values from regression (R^2=.80; p=.0001) relating average on-site velocity (ft/sec) in the downstream (RM 111 to 120) portion of Lower Granite Reservoir to average velocity at the channel profile (ft/sec; CAVEVEL) and depth (ft; SDEPTH) at the on-site profile. The solid line represents the expected 1:1 relationship (i.e. if R^2=1.0) and the dotted lines delineate the mean 95% confidence interval (bound) on predicted values (+/- 0.140 ft/sec).

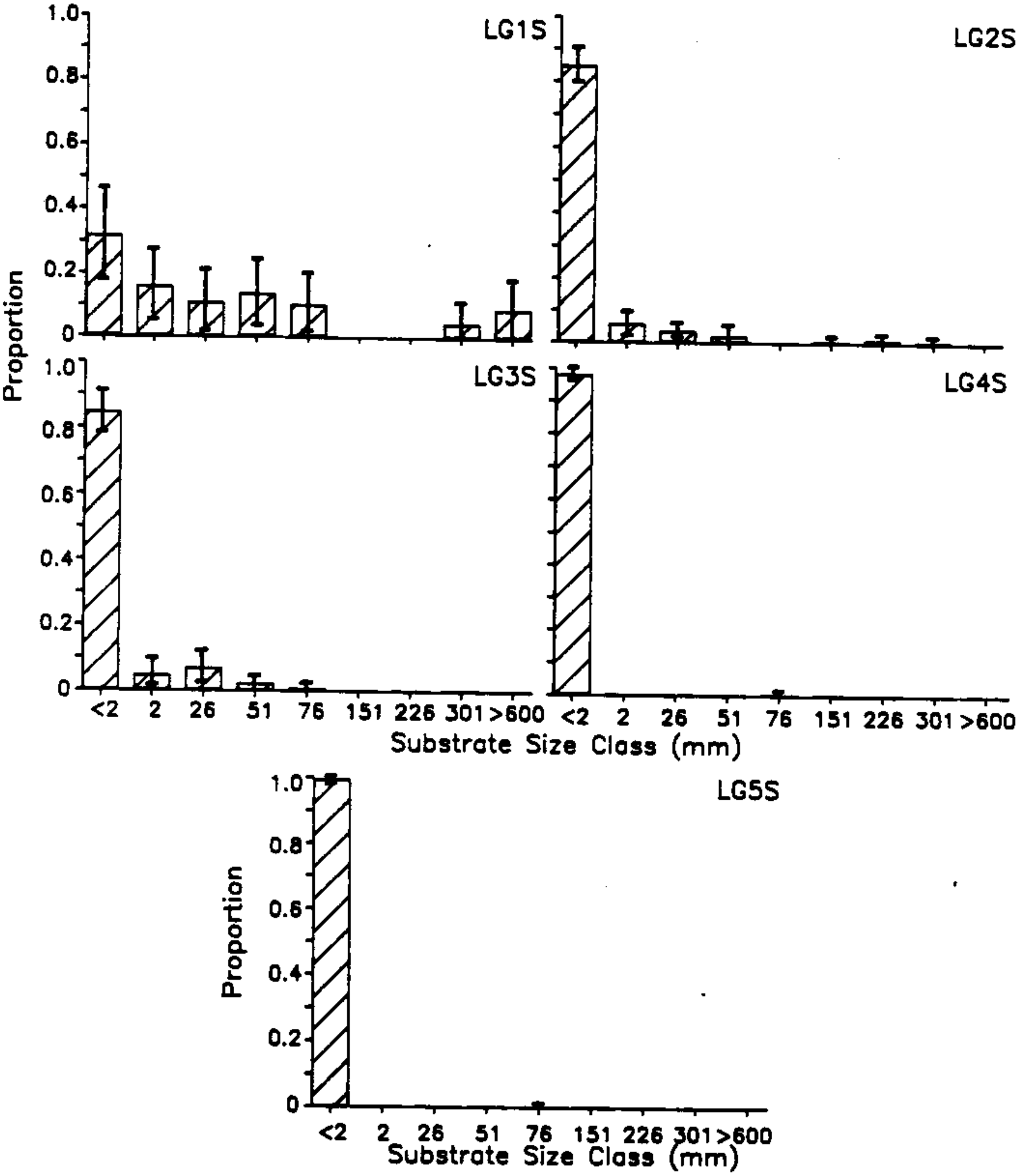

Figure 14. Substrate size composition estimated from an underwater systematic survey of all five shallow stations, Lower Granite Reservoir, Washington, 1987.

Table 3. Comparison of cover and substrate sizes based on snorkel surveys of shallow water stations, September 1987, Lower Granite Reservoir, Washington. Stations underlined indicate no significant differences ($P > 0.05$).

Inorganic Cover

LG1S	LG2S	LG3S	LG4S	LG5S
――				
	――――	――――		
			――――	――――

No Cover

LG1S	LG2S	LG3S	LG4S	LG5S
――				
	――――	――――	――――	――――

Substrate Size Fines (< 2 mm)

LG5S	LG4S	LG2S	LG3S	LG1S
――――	――――	――――	――――	
				――

Substrate Size 2-25 mm

LG1S	LG2S	LG3S	LG4S	LG5S
――				
	――――	――――		
			――――	――――

Substrate Size 26-50 mm

LG1S	LG2S	LG3S	LG4S	LG5S
――――	――――	――――		
			――――	――――

Substrate Size 51-75, 76-150, 151-225, 226-300, 301-600, >600 (pooled)

LG1S	LG2S	LG3S	LG4S	LG5S
――				
	――――	――――		
		――――	――――	
			――――	――――

fine substrate. Proportion of substrate from 2 to 25 mm was significantly higher at LG1S ($p < 0.01$; Table 3) than at the other four stations. No significant differences were found in the proportions of substrate 2 - 25 mm between stations LG2S and LG3S ($p > 0.10$) or between stations LG4S and LG5S (both 0). No differences in proportions were found among LG1S, LG2S, and LG3S ($0.10 > p > 0.05$) for size class 26 to 50 mm, whereas the proportional estimates in this class at stations LG4S and LG5S was 0 (Figure 14; Table 3).

The remaining six substrate size classes (51 mm to > 600 mm) were pooled for comparisons between the stations as a result of the overall low frequency of occurrence of individual size classes. Station LG1S had a significantly higher proportion ($p < 0.005$) of the combined substrate size classes. Stations LG2S vs. LG3S, LG3S vs. LG4S, and LG4S vs. LG5S were not significantly different ($p < 0.05$) in the quantity of the combined substrates (Table 3).

Our data for the pooled substrate size classes (51 - >600 mm) indicates that LG1S differs in the magnitude of proportions for each size class, as well as the high proportion of larger substrates not found at other stations (Figure 14). Stations LG2S and LG3S, though not significantly different in the 51 - >600 mm size classes appeared different in the proportions of larger substrate size. Station LG3S had no larger size classes represented in the survey, whereas most of the larger substrate observed at LG2S was near shore and around the alluvial fan present in the middle of the station (Figure 3).

Stations LG3S and LG4S were significantly different ($P < 0.10$) for the pooled comparisons of substrate (Table 3). This difference was primarily a result of the substrate from 51 to 75 mm being present at LG3S while absent at LG4S.

A relatively high degree of embeddedness was observed at all shallow water stations for smaller substrate sizes to 150 mm (Table 4). However, larger substrate sizes at LG1S and LG2S had relatively low embeddedness.

Dredging.-Fine sediment at the shallow stations was comprised primarily of particles smaller than sand (<0.061 mm; Figure 15). The proportion of particle sizes less than 0.061 mm show an apparent increase from upstream to downstream stations, ranging from 37.8% (LG5S) to 91.3% (LG2S). Relatively large variances are associated with the estimates for stations LG3S, LG4S, and LG5S, and therefore do not appear significantly different. However, LG2S shows a significantly higher percentage of sediments less than 0.061 mm than the other stations. A ponar dredge proved ineffective for sampling fine sediments at LG1S. Based on snorkeling observations, fine sediment at LG1S consisted of very fine hard packed material.

Percentage of sand (0.061 to 2.0 mm) in the fine sediments ranged from 10% (LG2S) to 56.7% (LG5S). Fine particle sizes greater than 2.0 mm were absent from LG2S, and ranged from 2.6 to 13.2% at the other stations (Figure 15).

Percent organic matter content of the sediments at the shallow water stations ranged from 5.2% (LG5S) to 8.8% (LG3S; Figure 16). Confidence bounds on the estimates suggest little significant difference among the shallow stations, with the possible exception of LG2S and LG5S being significantly different.

Table 4. Percent embeddedness of each substrate size observed at shallow water stations, September 1987, Lower Granite Reservoir, Washington.

Station	Embeddedness	Substrate Size (mm) 2-25	26-50	51-75	76-150	151-225	226-300	301-600	>600
LG1S									
	0-25%	43	40	29	20			100	100
	26-50%	28.5	40						
	51-75%		20	57	60				
	76-100%	28.5		14	20				
LG2S									
	0-25%	36.4	71	50		100	50	100	
	26-50%	27.2		50	100				
	51-75%	18.2							
	76-100%	18.2	29				50		
LG3S									
	0-25%	66.7		33.3					
	26-50%		22.2	33.3					
	51-75%		33.3	33.3					
	76-100%	33.3	44.4		100				
LG4S									
	0-25%				100				
	26-50%								
	51-75%								
	76-100%								
LG5S									
	0-25%								
	26-50%				100				
	51-75%								
	76-100%								

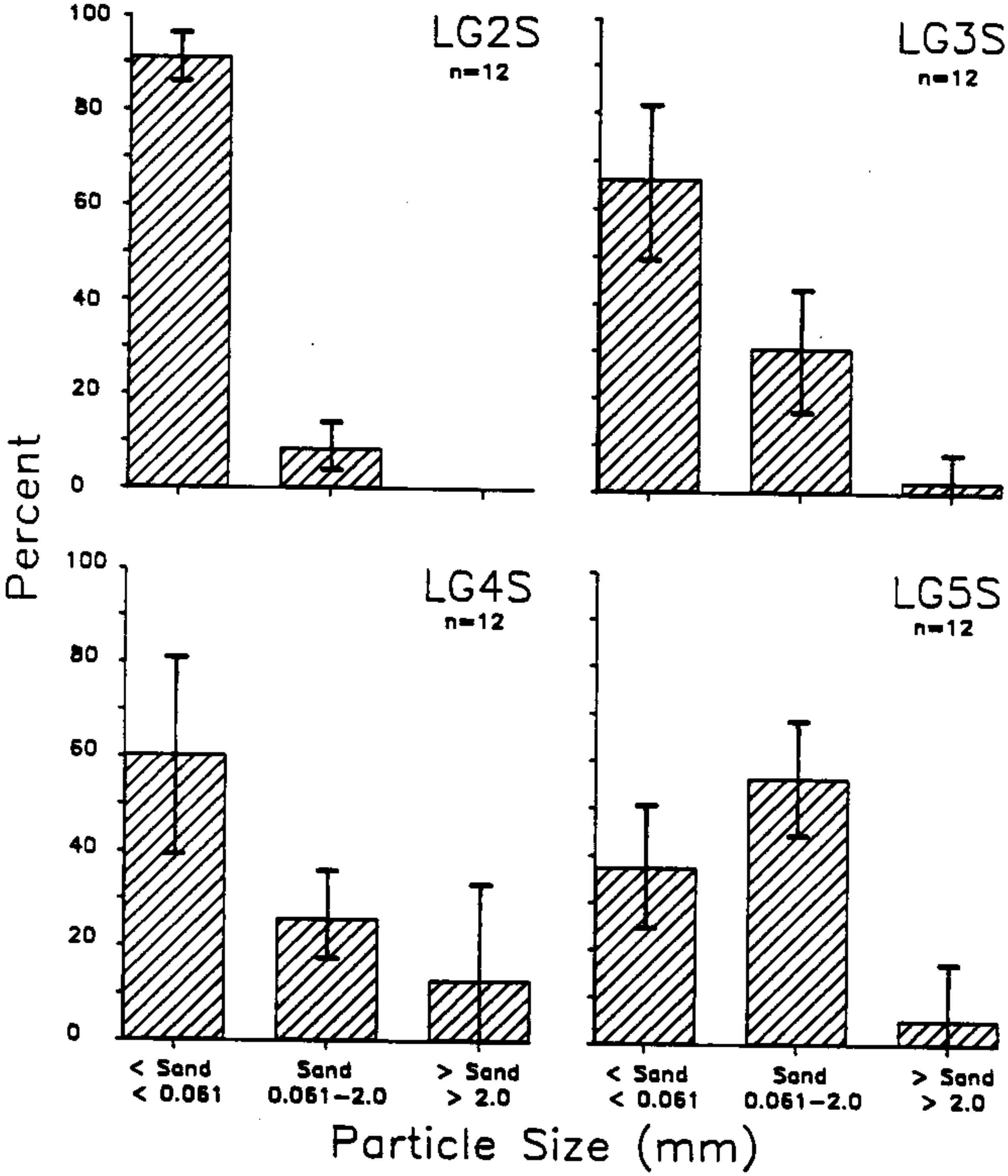

Figure 15. Composition of substrate larger than sand (> 2 mm), sand (0.061 to 2 mm), and less than sand (<0.061 mm) from ponar dredge samples at shallow stations, Lower Granite Reservoir, Washington, 1987.

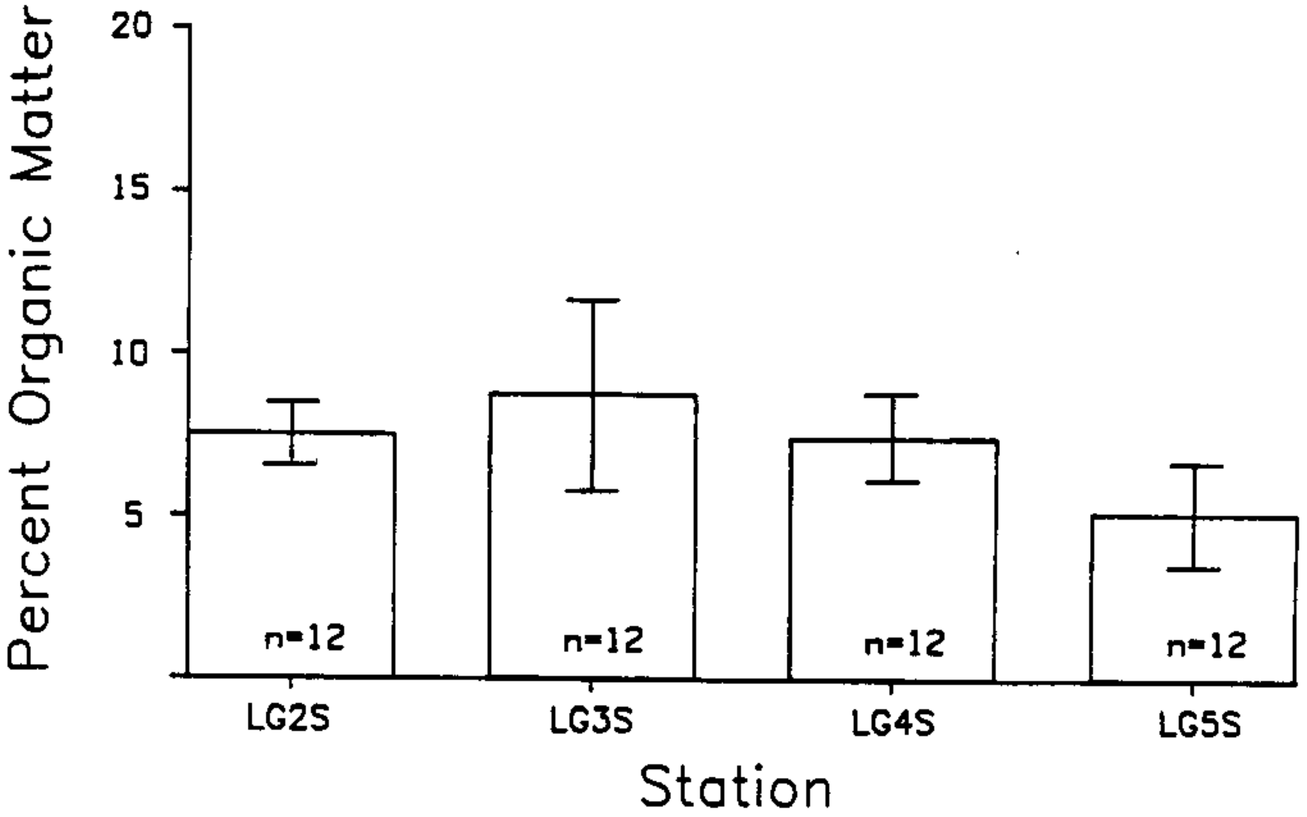

Figure 16. Percent organic content of fine sediments collected from ponar samples at shallow stations, Lower Granite Reservoir, 1987.

Cover

The pooled comparison for inorganic cover showed significant differences among stations ($p < 0.005$; Table 3). Multiple comparisons indicated that LG1S had a significantly higher proportion of inorganic cover than other shallow stations ($p < 0.005$). Comparisons of inorganic cover between stations LG2S and LG3S and stations LG4S and LG5S were not significantly different ($p > 0.10$; Table 3). The most obvious difference among size groups is the high proportion of larger inorganic cover at LG1S which are absent from other stations (Figure 17). Stations LG2S and LG3S were similar in the sizes of inorganic cover represented, whereas stations LG4S and LG5S have virtually no inorganic cover.

Station LG1S had the highest proportion of organic cover in the size range 51 to 100 mm. All remaining stations had less than 1% organic cover.

Significant differences were observed in the proportion of area with cover among stations ($p < 0.005$). LG1S had a significantly higher proportion of area with cover than other remaining stations ($p < 0.005$). No differences were observed in the proportion of area with cover among the remaining stations ($p > 0.05$; Table 3).

Morphometrics

Mean depths of the shallow water stations ranged from 2.4 (LG4S) to 3.7 m (LG2S; Appendix Table A). Shoreline lengths ranged from 0.5 km (LG1S) to 1.0 km (LG2S). The shoreline diversity index ranged from a high diversity of 1.35 (LG3S) to a low of 1.03 (LG5S). Total surface area of the stations at full pool ranged from 14,089 m^2 at LG1S to 136,187 m^2 at LG2S (based on either 200 m off-shore or a depth of 6.1 m; Figure 18). Total volumes at full pool ranged from 48,770 m^3 (LG1S) to 136,187 m^3

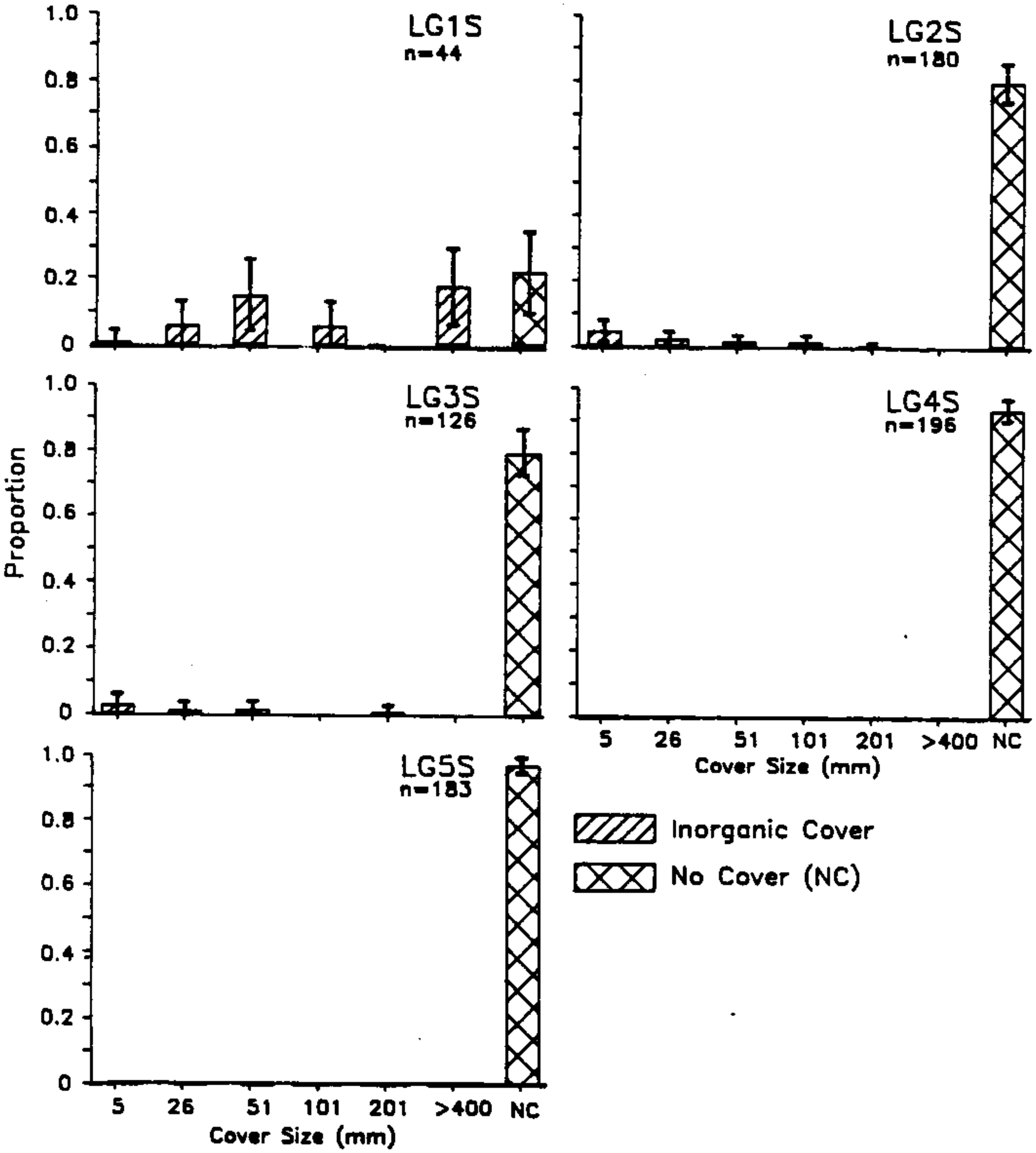

Figure 17. Proportions of cover sizes (inorganic) estimated from a systematic survey of all five shallow stations, Lower Granite Reservoir, Washington, 1987. The number of bottom observations for estimating cover is indicated (n).

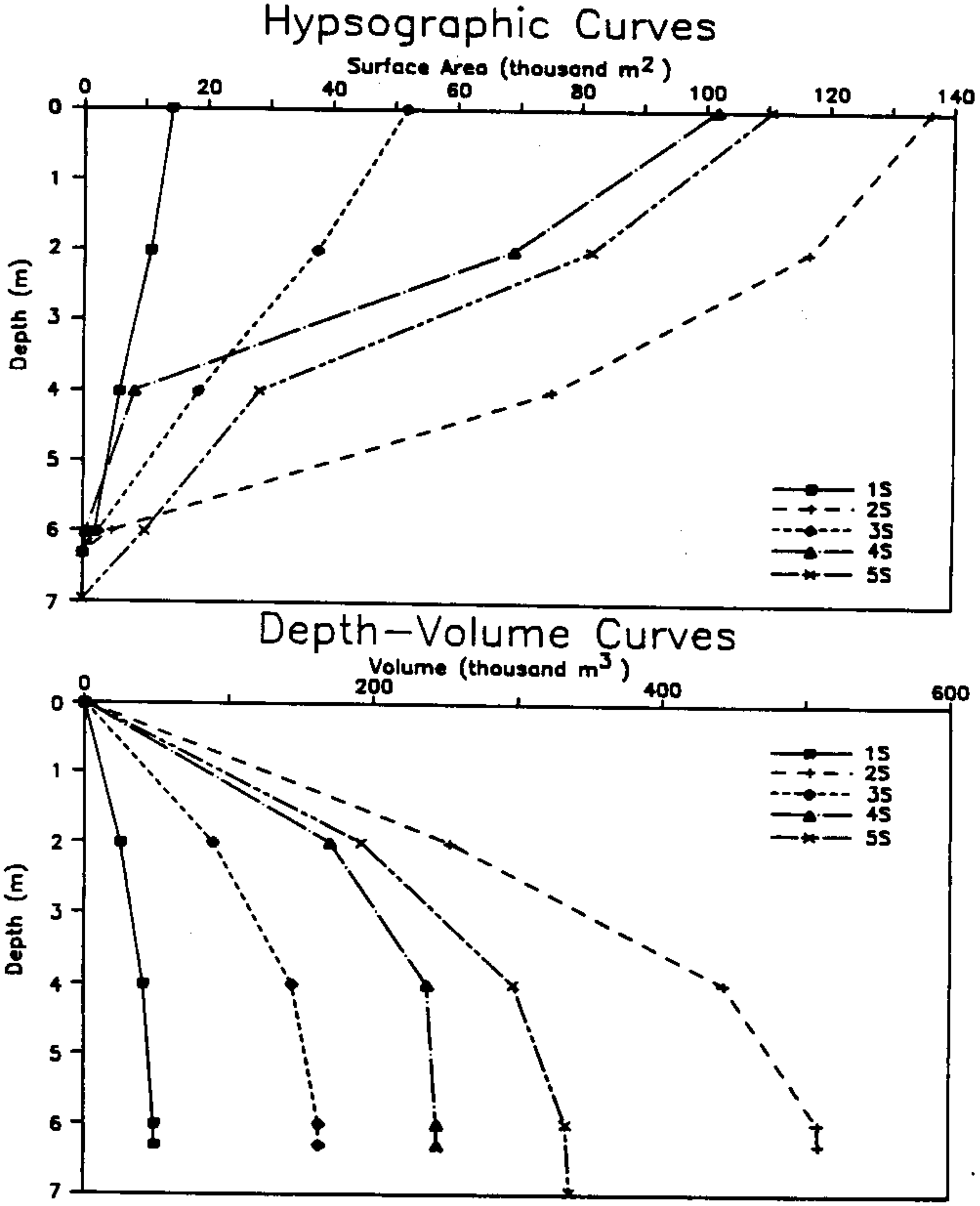

Figure 18. Hypsographic curves and depth-volume curves of all five shallow stations, Lower Granite Reservoir, Washington, 1987.

(LG2S). Mean bottom gradient between the 0 and 2 m contours ranged from a relatively steep slope (36.7%; LG1S) to a gentle slope (5.3%; LG5S). The mean bottom gradient between 2-4 m contours was lower than the 0-2 m gradient at each station and ranged from 29.1% (LG1S) to 2.7% (LG4S).

Aquatic Macrophytes

Aquatic macrophytes were observed at three (LG1S, LG3S, and LG5S) of the five shallow water stations in September. However, total area covered at each of the stations was relatively small. Station LG1S had the highest estimate of 3.4% of the area covered, followed by LG3S and LG5S at 2.6% and 2.0%. The depths at which aquatic macrophytes were observed ranged from 0.14 to 3.3 m, with an overall mean depth of 1.3 m. Species of macrophytes were predominantly Potamogeton crispus and Typha latifolia.

Objective 2. To assess use of shallow water habitat by salmonid fishes and their potential predators.

Methods

Fish were sampled during all four seasons in 1987. Fish sampling at the five shallow-water sites consisted of beach seining and boat electroshocking. The beach seine (30.5 x 2.4 m, 6.35 mm knotless mesh with a 2.4 x 2.4 m bag) was set approximately 50 feet from and parallel to the shoreline and pulled to shore. One unit of effort was one haul; three hauls per station were made each sampling day. The boat electroshocker was used both day night in the spring season and only at night in the fall. Spring daytime shocking was discontinued due to low catch rates and poor visibility. The boat electroshocker was equipped with a Coffelt model VVP-

15 attached to a 5 h.p. generator. One unit of electrofishing effort was a transect following the shoreline with current on for 15 minutes. Distances from shore varied with shoreline gradient, but shocking was conducted as close to the shoreline as possible.

In addition, gillnets were fished at LG2S as part of an overall assessment of the fish community at shallow, mid, and deep stations (Bennett et al. 1988). Fish collected by gillnet were included in the comparison of total fish catches, percent relative abundance, biomass, and size comparisons.

Weekly sampling efforts extended throughout the smolt out-migration in the spring, monthly during the summer, winter, and bi-weekly during the fall. Logistical problems and varying weather conditions precluded randomizing the order of sampling.

A Pearson's chi-square goodness of fit test was used to identify differences in catches of beach seine hauls and night electrofishing at the five shallow stations during the spring season. To evaluate the relationship between salmonid abundance and habitat characteristics we ranked the data and calculated Spearmans's rank correlation coefficient (Spearman's Rho). Specific habitat characteristics used included cover, gradient and substrate. Significant correlation for n=5 (p=0.95) are obtained if Spearman's Rho (r) exceeds 0.8 (Conover 1980).

Results

A total of 9,545 fish representing 22 species were collected from shallow stations in Lower Granite Reservoir (Tables 5-8). A list of scientific names and species codes used throughout this report is shown in Table 9. Highest numbers of fish were collected in the summer followed by

Table 5. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Washington in spring 1987.

Species	LG1S	LG2S	LG3S	LG4S	LG5S	TOTAL
Pacific lamprey					2	2
American shad						
white sturgeon						
sockeye salmon				1		1
chinook salmon	477	61	74	153	107	872
mountain whitefish			2	69		71
rainbow trout	142	96	108	97	50	493
chiselmouth	63	87	55	144	10	359
carp	14	35	38	10	3	100
peamouth	3	4	34	17	10	68
northern squawfish	47	43	154	161	18	423
redside shiner	8	48	21	75	4	156
bridgelip sucker	24	40	13	18	6	101
largescale sucker	332	197	128	110	36	803
brown bullhead		1				1
channel catfish		2				2
bluegill	1					1
pumpkinseed	1		2	1		4
black crappie	17		3		2	22
white crappie			2	4		6
smallmouth bass	309	35	105	39	10	498
yellow perch	11	43	1	7	2	64
TOTALS	1449	692	740	906	260	4047

Table 6. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Washington in summer 1987.

Species	LG1S	LG2S	LG3S	LG4S	LG5S	TOTAL
Pacific lamprey						
American shad						
white sturgeon		5				5
sockeye salmon						
chinook salmon		1				1
mountain whitefish						
rainbow trout	18	10	8			36
chiselmouth		6	12	8	623	649
carp		134	14		8	156
peamouth		3	4	4	233	244
northern squawfish	2	6	118	53	547	726
redside shiner			1		33	34
bridgelip sucker				1		1
largescale sucker	22	192	130	30	1495	1869
brown bullhead						
channel catfish						
bluegill		1	80	25	18	124
pumpkinseed	1		1		2	4
black crappie		1				1
white crappie		2				2
smallmouth bass	32	58	125	100	260	575
yellow perch		13		5		18
TOTALS	75	432	493	226	3219	4445

Table 7. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Washington in fall 1987.

Species	LG1S	LG2S	LG3S	LG4S	LG5S	TOTAL
Pacific lamprey						
American shad		1	1			2
white sturgeon						
sockeye salmon						
chinook salmon		6				6
mountain whitefish	1		5			6
rainbow trout	70	23	14	8	1	116
chiselmouth	2	12	2	4	2	22
carp		11	4	1		16
peamouth	1	2		3		6
northern squawfish	18	31	15	26	65	155
redside shiner	5	12	5	1	7	30
bridgelip sucker	21	2		2	3	28
largescale sucker	161	95	95	45	32	428
brown bullhead		2				2
channel catfish		4				4
bluegill	4	2	21	2	1	30
pumpkinseed	2	1				3
black crappie		2	7	1	2	12
white crappie	6	15		3		24
smallmouth bass	16	19		4		39
yellow perch		18		1		19
TOTALS	307	258	169	101	113	948

Table 8. Relative abundance of fishes sampled from stations in Lower Granite Reservoir, Washington in winter 1987.

Species	LG1S	LG2S	LG3S	LG4S	LG5S	TOTAL
Pacific lamprey						
American shad						
white sturgeon						
sockeye salmon						
chinook salmon						
mountain whitefish						
rainbow trout	3	4				7
chiselmouth		24				24
carp						
peamouth						
northern squawfish		4	1		2	7
redside shiner		3				3
bridgelip sucker		2				2
largescale sucker	6	11	2			19
brown bullhead						
channel catfish						
bluegill						
pumpkinseed						
black crappie						
white crappie		6			1	7
smallmouth bass						
yellow perch		1				1
TOTALS	9	55	3	0	3	56

Table 9. Species codes, and scientific and common names for fish collected in Lower Granite Reservoir, Washington. Species codes are used in figures and tables throughout this report.

Codes	Scientific Name	Common Name
ATR	*Acipenser transmontanus*	white sturgeon
ASA	*Alosa sapidissima*	American shad
ONE	*Oncorhynchus nerka*	sockeye salmon
OTS	*Oncorhynchus tshawytscha*	chinook salmon
PWI	*Prosopium williamsoni*	mountain whitefish
SGA	*Salmo gairdneri*	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
INE	*Ictalurus nebulosus*	brown bullhead
IPU	*Ictalurus punctatus*	channel catfish
LGI	*Lepomis gibbosus*	pumpkinseed
LMA	*Lepomis macrochirus*	bluegill
MDO	*Micropterus dolomieui*	smallmouth bass
PAN	*Pomoxis annularis*	white crappie
PNI	*Pomoxis nigromaculatus*	black crappie
PFL	*Perca flavescens*	yellow perch
COT	*Cottus* sp.	sculpin

the spring, fall and winter. Highest numbers of fish collected in the spring and fall were from LG1S and LG5S during the summer. The highest number of fish collected in the winter were from LG2S, probably because gillnets also were fished (Bennett et al. 1988).

Seasonal Abundance

During the spring, chinook salmon and rainbow trout (steelhead) were collected at all shallow stations (Figure 19). These species, along with smallmouth bass, were the most abundant game species. Highest salmon relative abundance was at LG5S and LG1S, while rainbow trout were about equally abundant at all shallow stations. Of the nongame species, largescale sucker, northern squawfish and chiselmouth were more abundant.

During the summer, smallmouth bass was the most abundant game species (Figure 20). Rainbow trout were most abundant at LG1S although present at LG2S and LG3S. As in the spring largescale suckers were abundant at all stations. Other nongame fish included high catches of carp at LG2S, northern squawfish at LG3S, LG4S, and LG5S, and chiselmouth at LG5S.

Relative abundance of rainbow trout during the fall season was similar to that of the summer season, with LG1S having the highest abundance. Nongame species were dominated by largescale sucker at all stations except LG5S, where northern squawfish dominated (Figure 21).

Fewer species were collected during the winter months. The only game fish represented in the winter months were rainbow trout at stations LG1S and LG2S and white crappie at LG5S and LG2S. Largescale suckers dominated the abundance at LG1S and LG3S. Chiselmouth dominated abundance at LG2S and northern squawfish were dominant at LG5S (Figure 22).

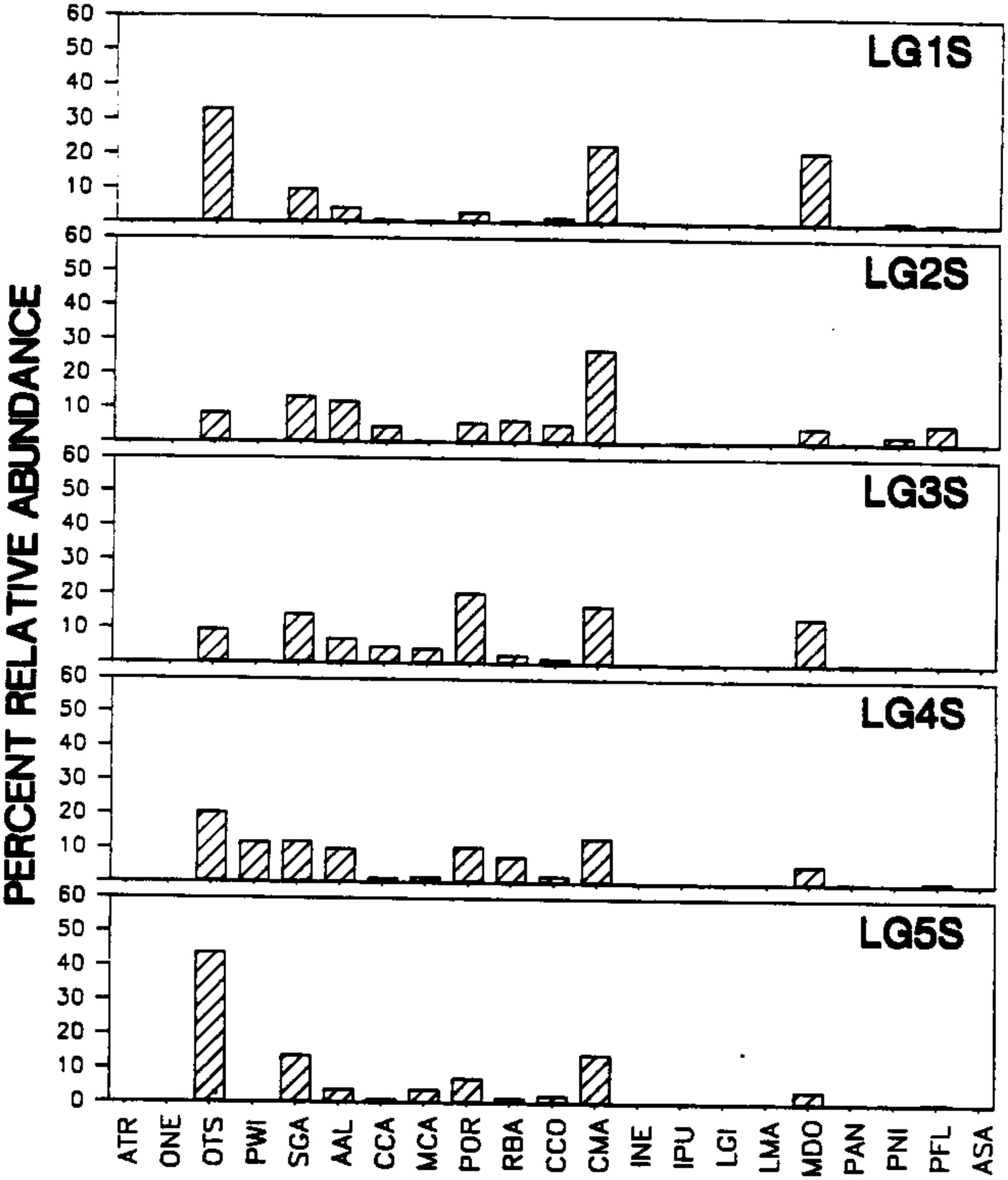

Figure 19. Percent relative abundance of all fish collected by beach seining and electrofishing during spring, 1987, Lower Granite Reservoir. Station LG2S includes catches from night and day gillnetting. See Table 9 for species codes.

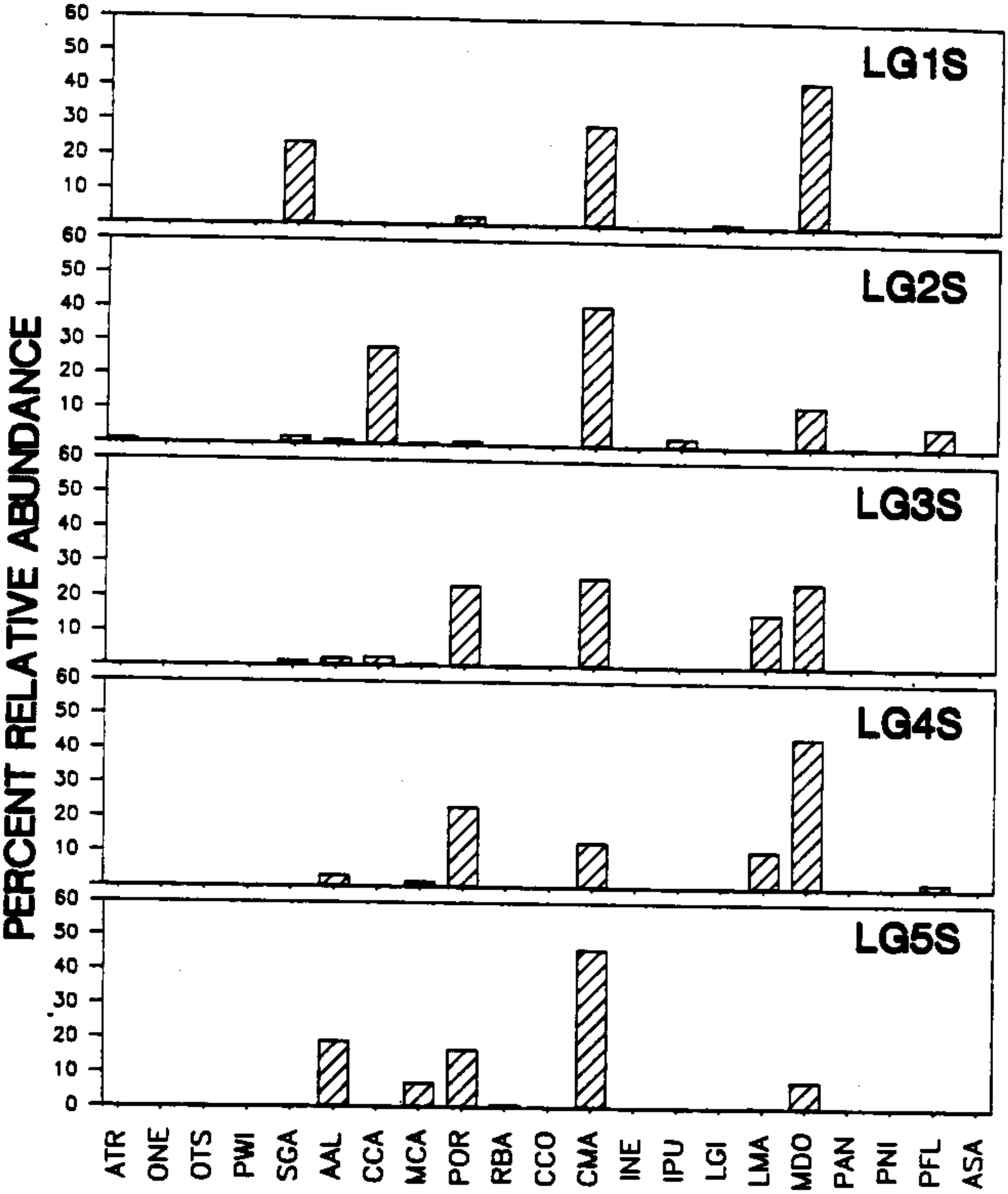

Figure 20. Percent relative abundance of all fish collected by beach seining and electrofishing during summer, 1987, Lower Granite Reservoir. Station LG2S includes catches from night and day gillnetting. See Table 9 for species codes.

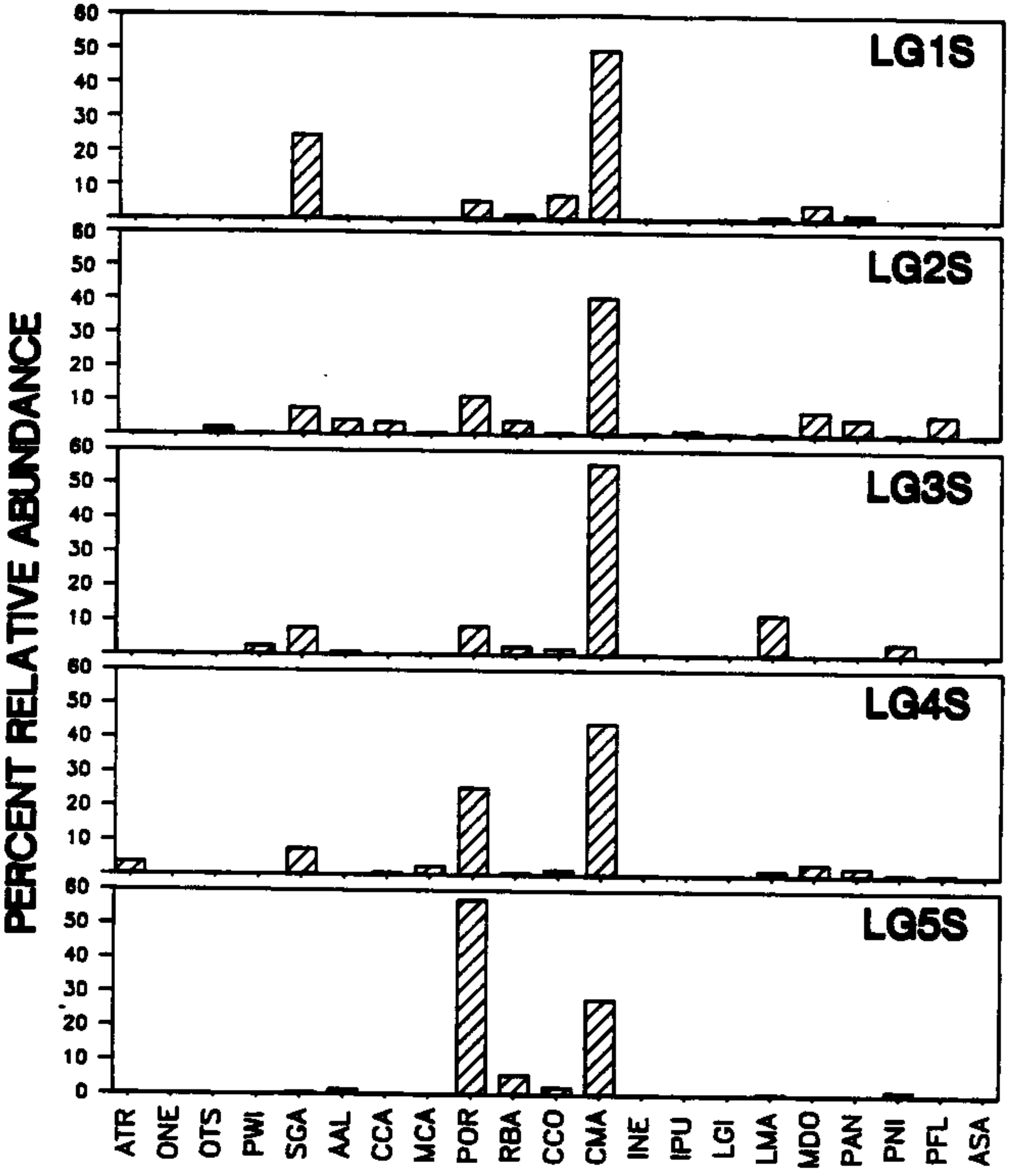

Figure 21. Percent relative abundance of all fish collected by beach seining and electrofishing during fall, 1987, Lower Granite Reservoir. Station LG2S includes catches from night and day gillnetting. See Table 9 for species codes.

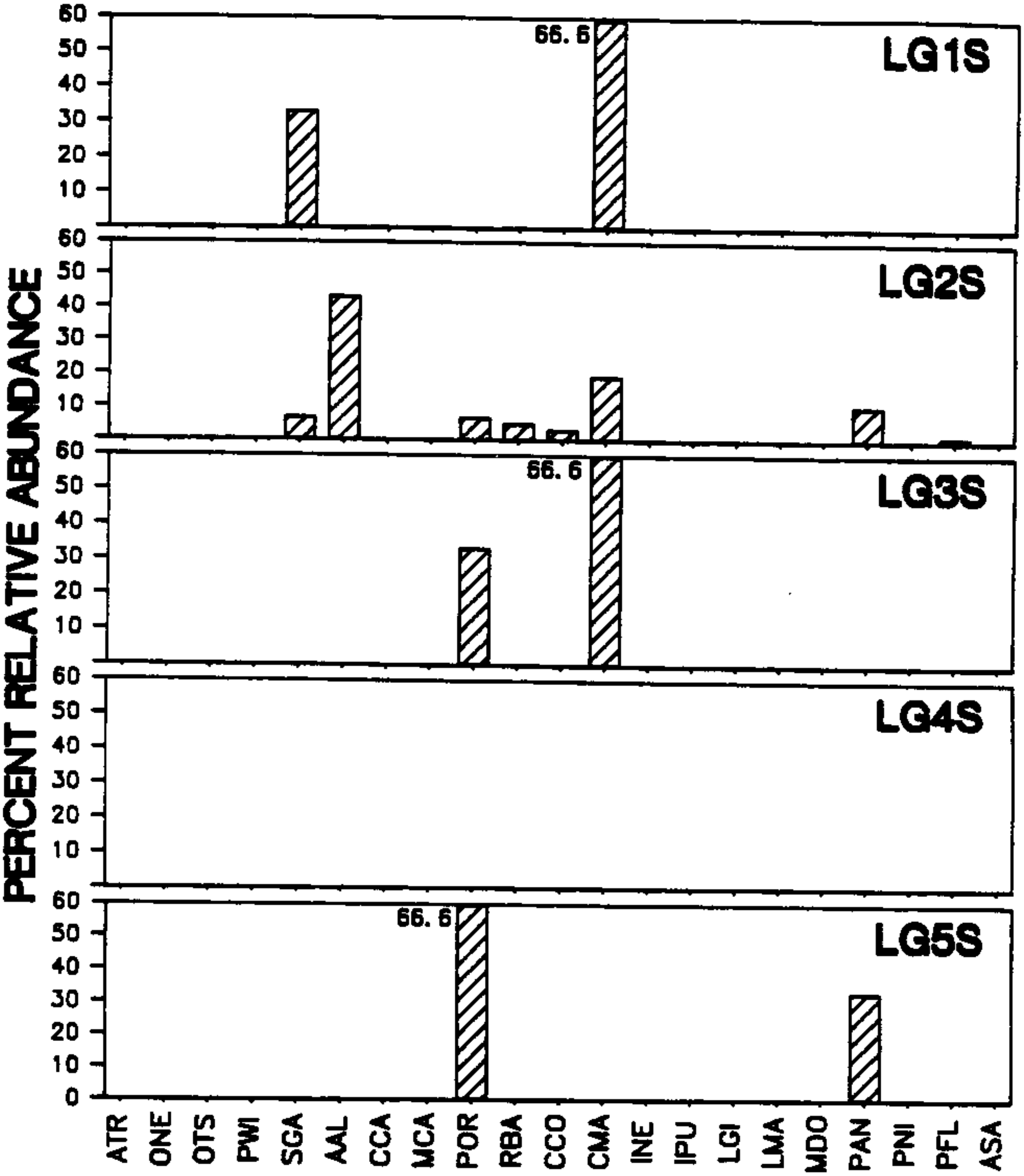

Figure 22. Percent relative abundance of all fish collected by beach seining and electrofishing during winter, 1987, Lower Granite Reservoir. Station LG2S includes catches from night and day gillnetting. See Table 9 for species codes.

Biomass

Seasonal comparison by station indicates that the highest biomass of fish flesh was collected during the summer at LG2S (Figure 23). Biomass sampled during the spring and fall was highest at LG1S. Subdividing fish biomass into game and nongame categories, however, indicates a dominance of nongame fish biomass (Figure 24). Game fish biomass was higher at all stations during the spring and summer but less than 10% of the biomass of nongame fish.

Of the species collected during all four seasons, largescale suckers clearly dominated the biomass (Figures 25-28). In the spring and fall, bridgelip suckers were followed by rainbow trout in biomass sampled. In the winter, suckers and chiselmouth were dominant although their biomass was about 10% of that during the spring.

Size Comparison

Individual daily catch per effort summaries for daytime and nighttime electrofising and beach seining are presented in Appendices C and D, respectively. Individual daily catch per effort summaries for gillnetting at LG2S are presented in Appendix B in Bennett et al. (1988).

Widest distribution of fish lengths was collected at station LG1S during the spring, and at LG2S during summer, fall, and winter (Figures 29-32). In general, the majority of fish collected during the summer were smaller than 100 mm except at LG2S where some fishes were larger than 500 mm. During fall and winter, fish collected at LG2S often exceeded 300 mm in length. However, gillnet captures included in this analysis shifted the size distribution to larger-sized fish. The majority of fish collected at LG3S, LG4S, and LG5S were less than 300 mm.

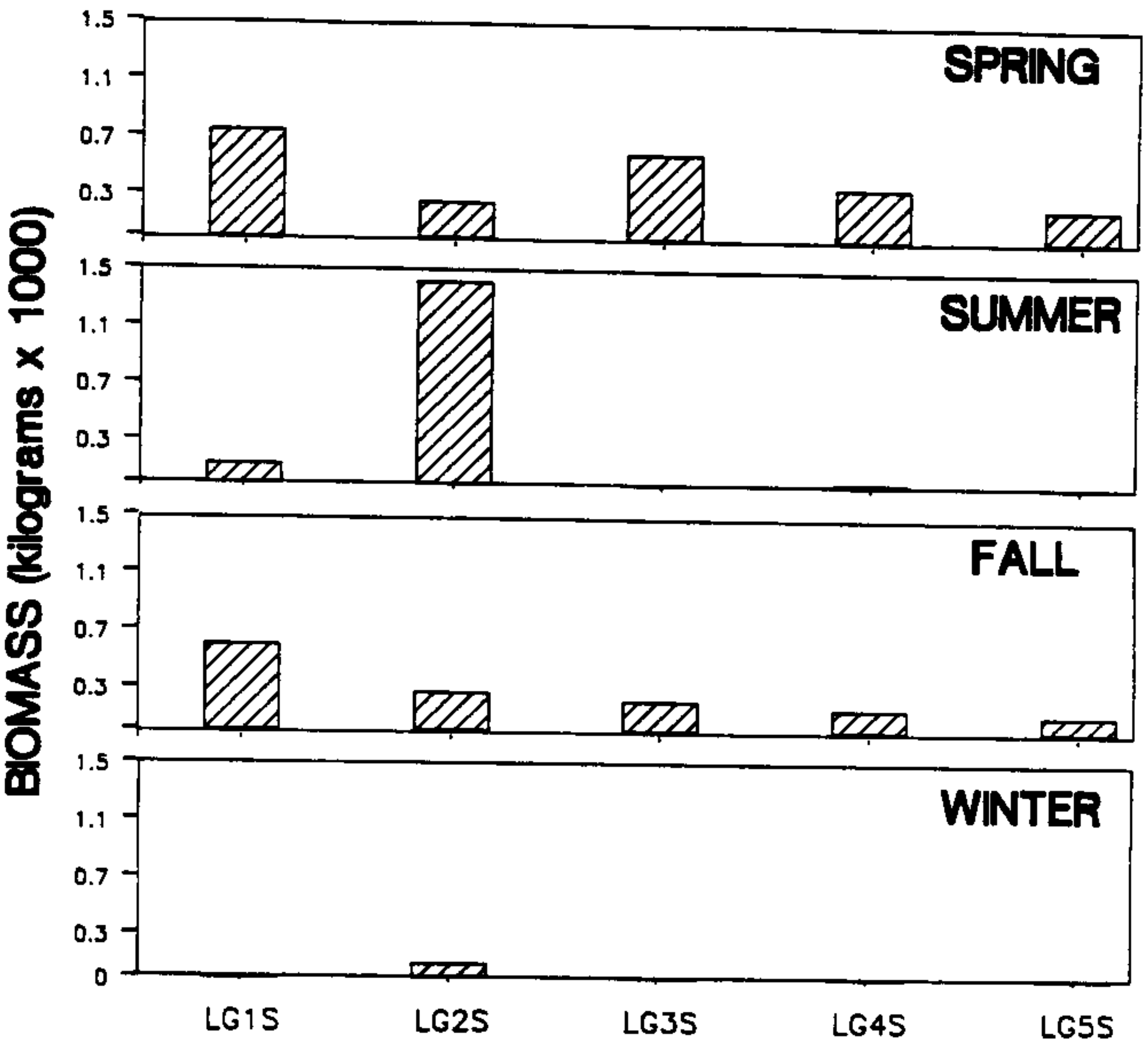

Figure 23. Total biomass (kilograms x 1000) of fish flesh collected by beach seining and electrofishing during all seasons, 1987, Lower Granite Reservoir, Washington. Station LG2S includes catches from night and day gillnetting.

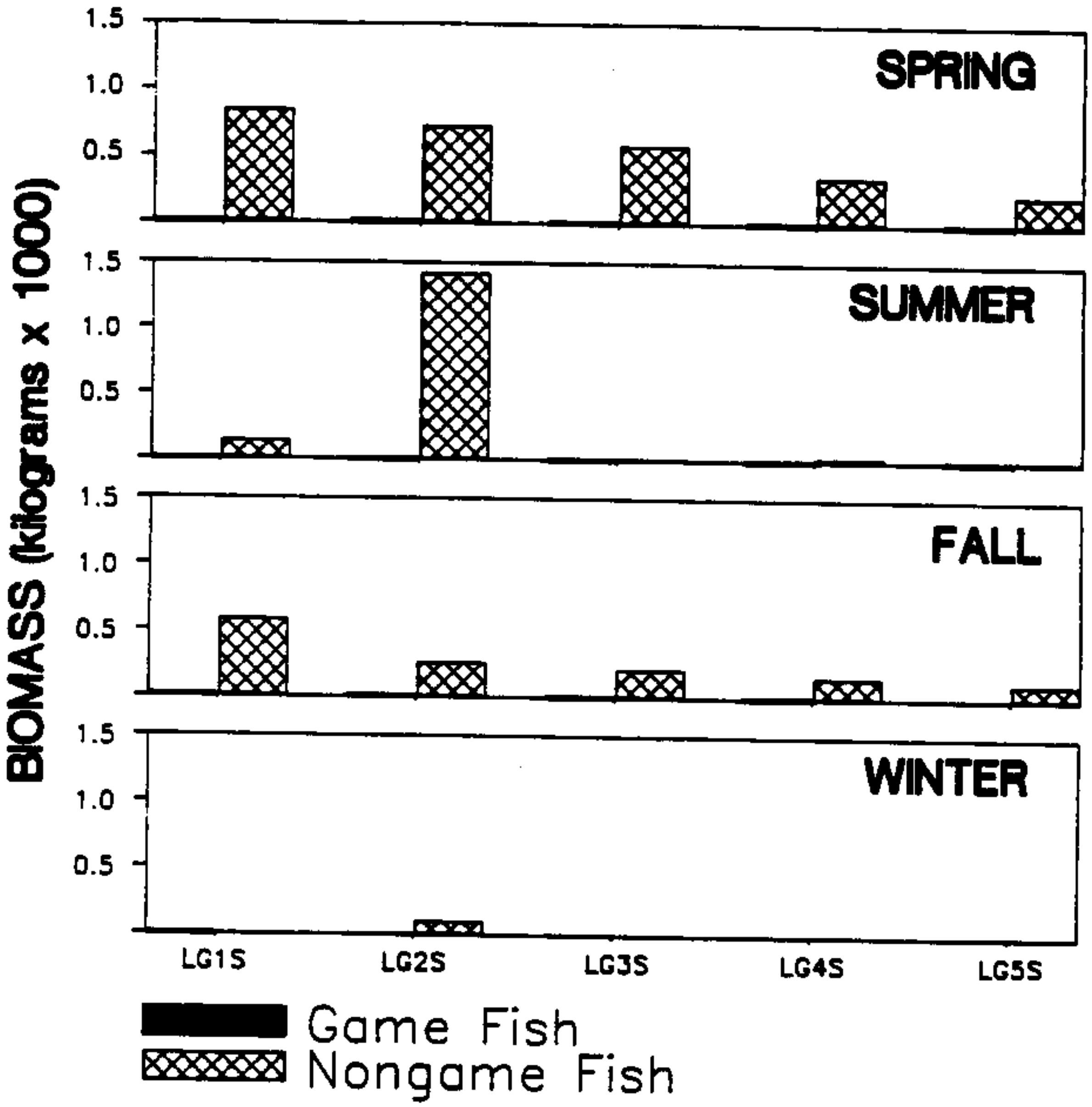

Figure 24. Total biomass (kilograms x 1000) of game and nongame fish collected by beach seining and electrofishing during all seasons, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting.

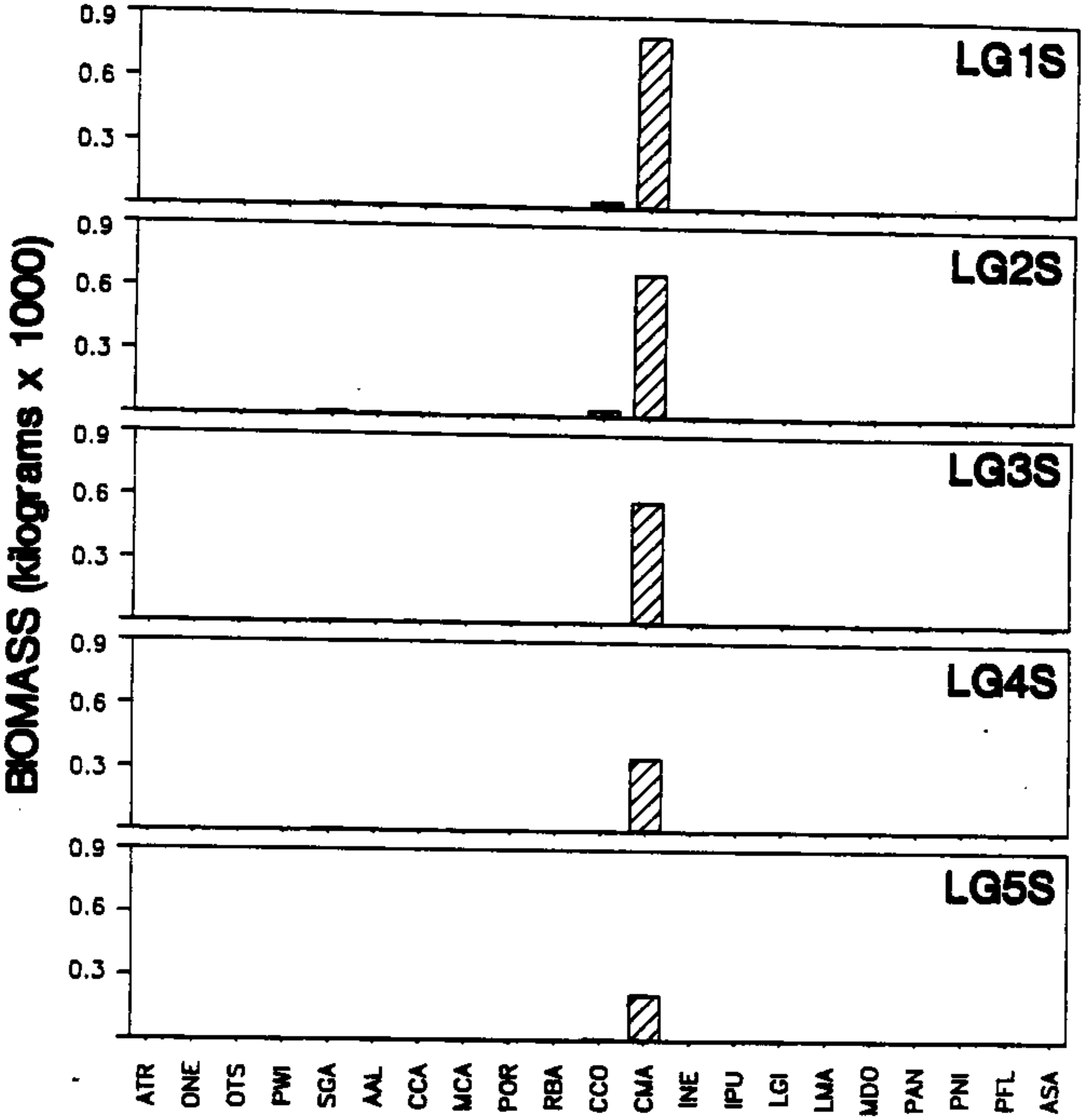

Figure 25. Total biomass (kilograms x 1000) of all species collected by beach seining and electrofishing during spring, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting. See Table 9 for species codes.

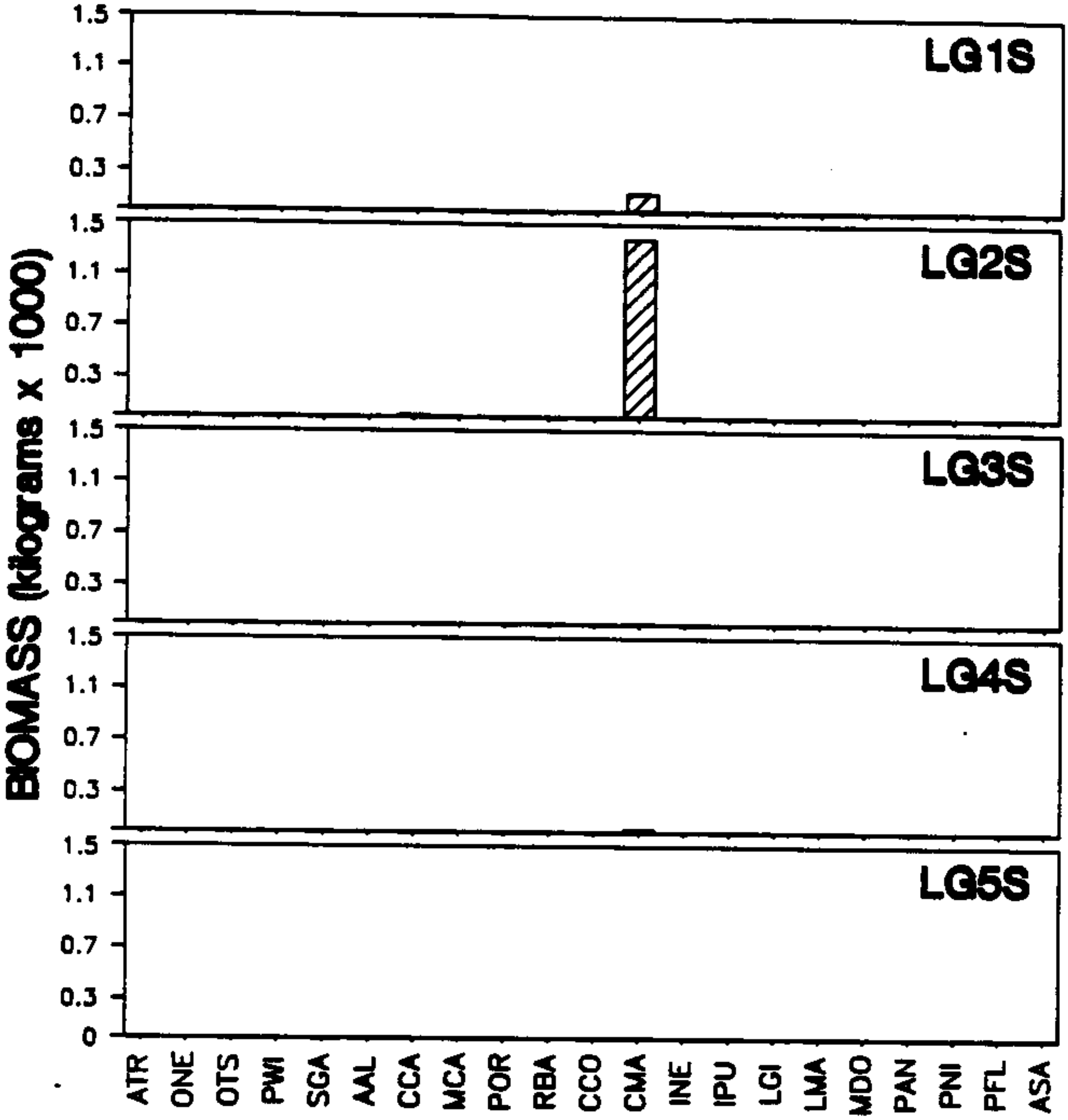

Figure 26. Total biomass (kilograms x 1000) of all species collected by beach seining and electrofishing during summer, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting. See Table 9 for species codes.

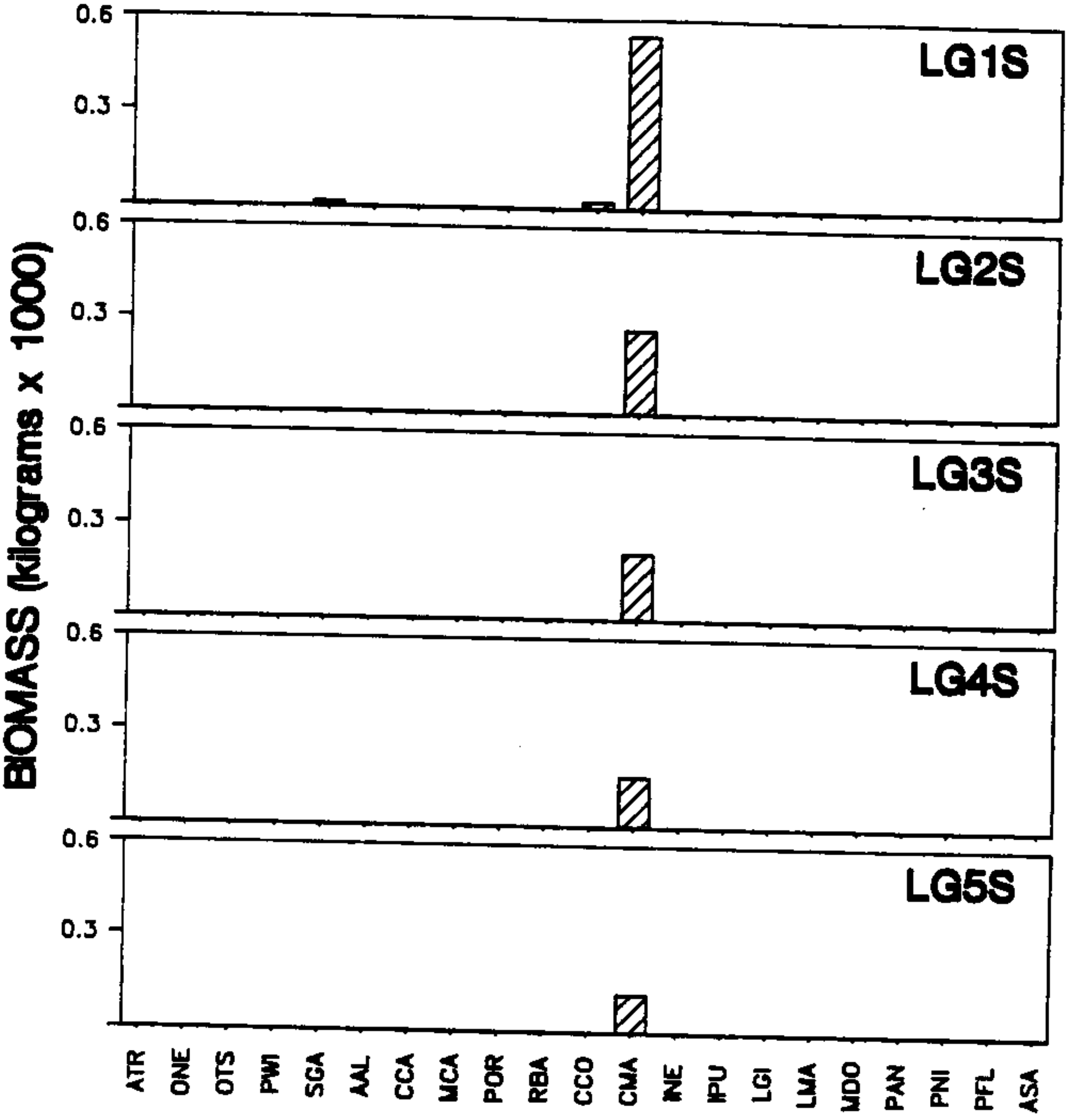

Figure 27. Total biomass (kilograms x 1000) of all species collected by beach seining and electrofishing during fall, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting. See Table 9 for species codes.

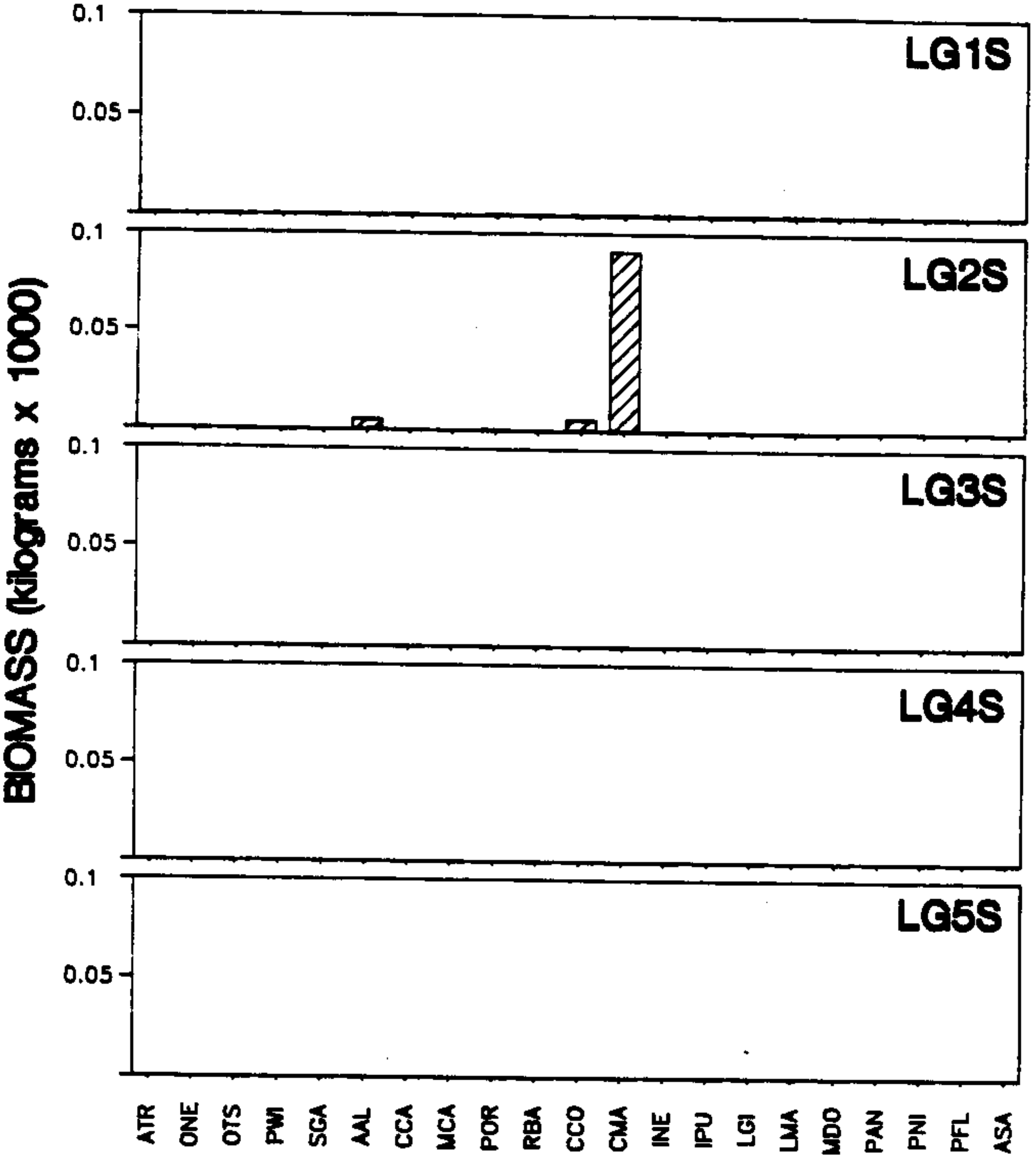

Figure 28. Total biomass (kilograms x 1000) of all species collected by beach seining and electrofishing during winter, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting. See Table 9 for species codes.

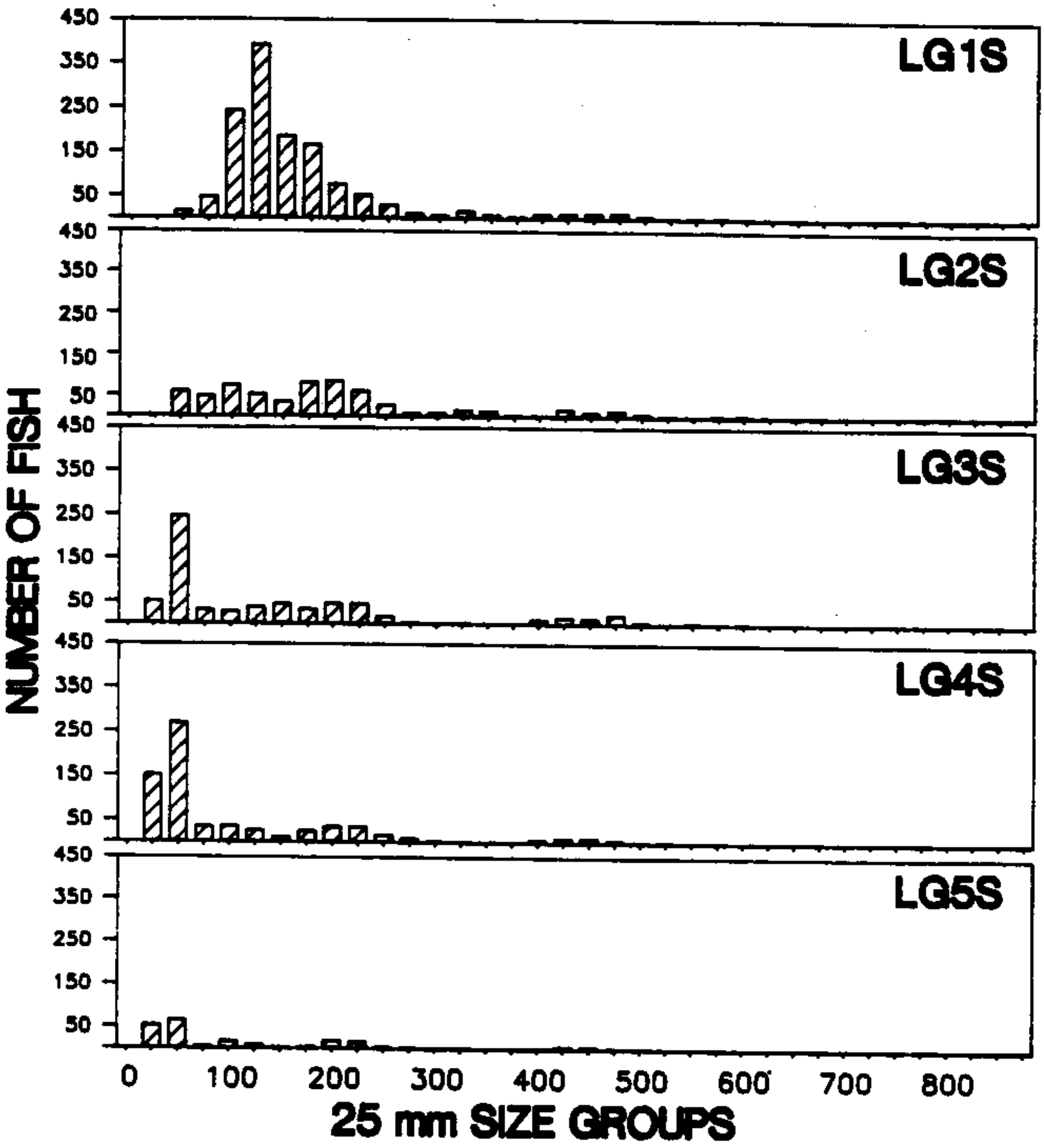

Figure 29. Length frequencies in 25 mm size groups of all fish collected by beach seining and electrofishing during spring, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting.

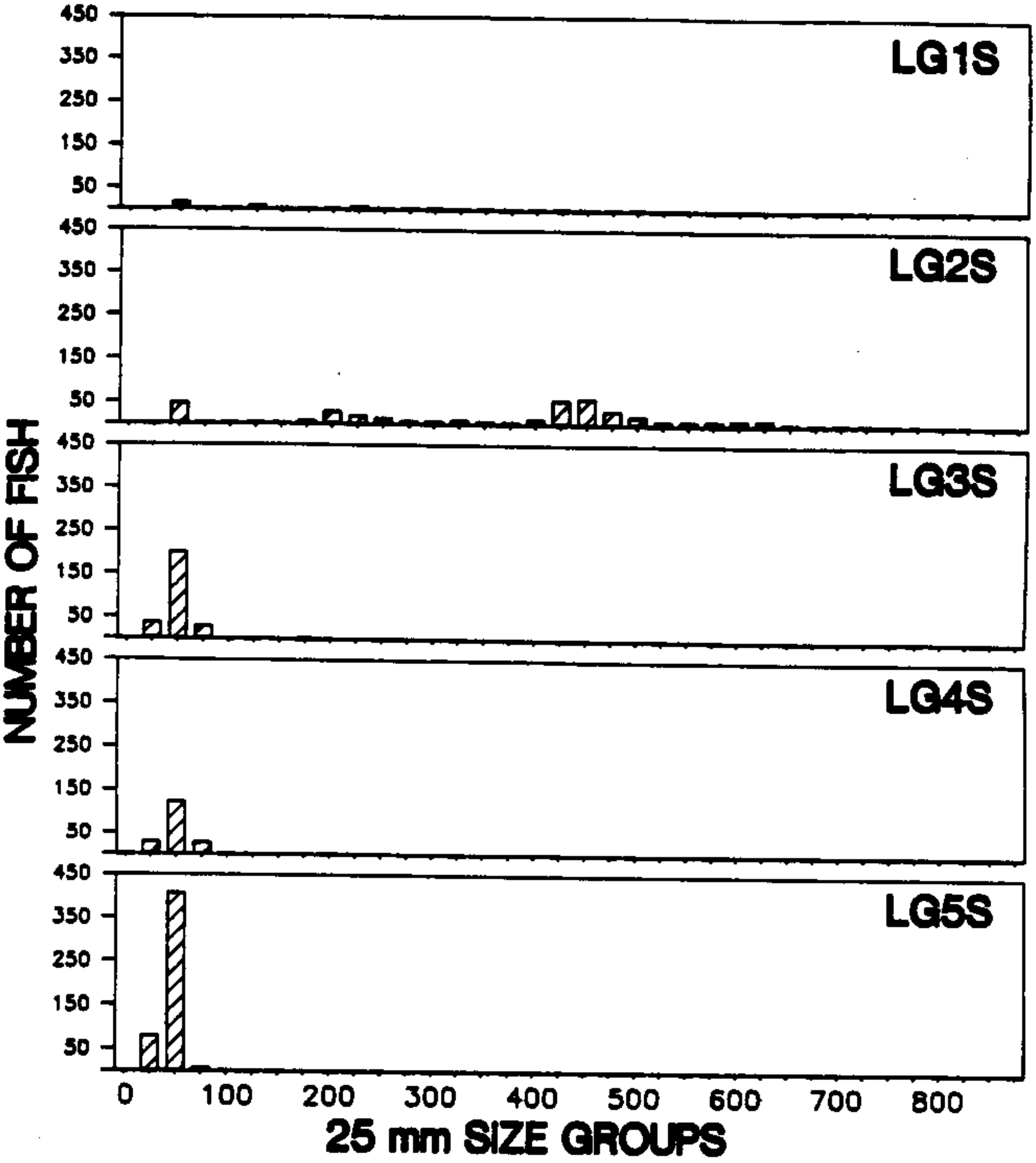

Figure 30. Length frequencies in 25 mm size groups of all fish collected by beach seining and electrofishing during summer, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting.

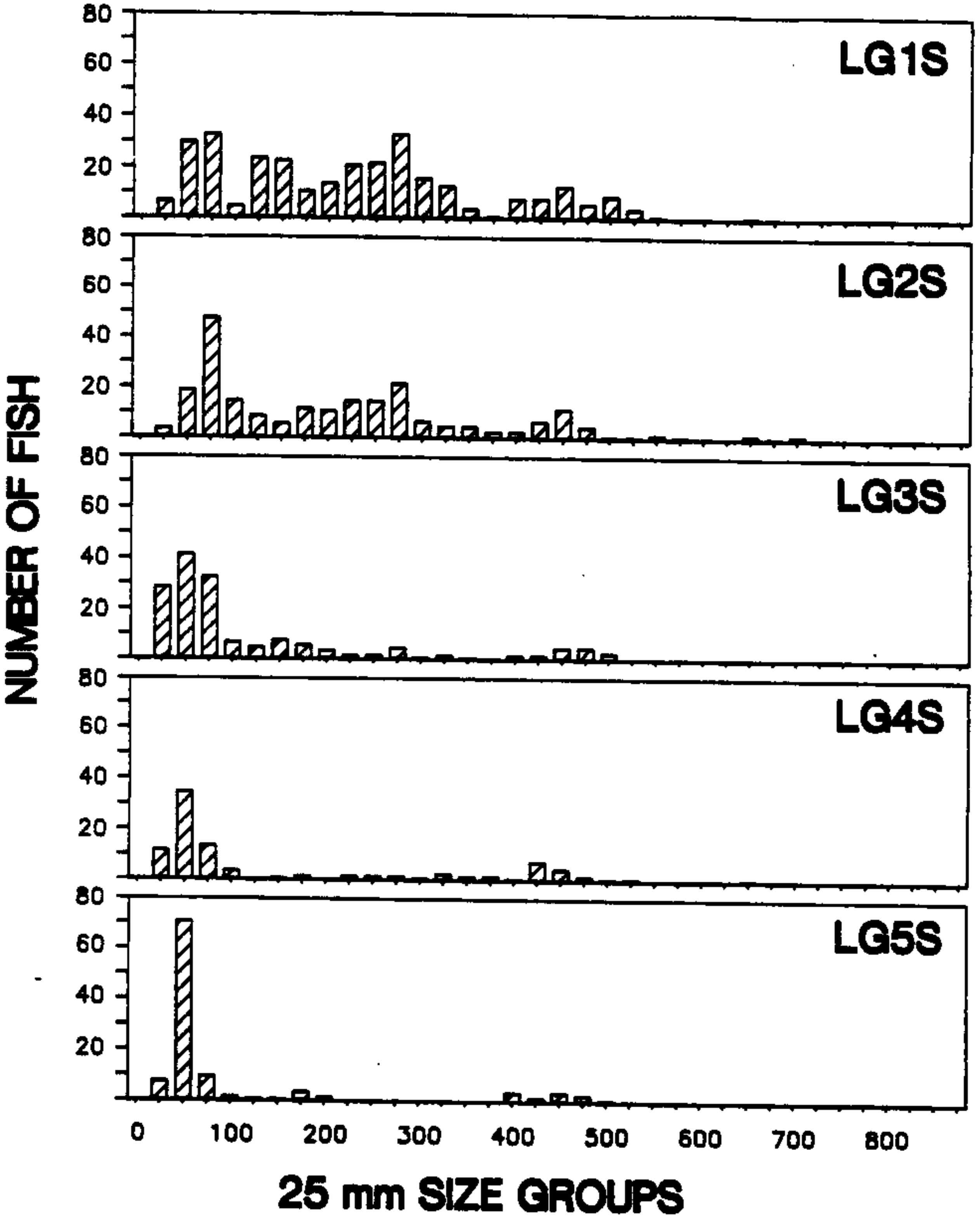

Figure 31. Length frequencies in 25 mm size groups of all fish collected by beach seining and electrofishing during fall, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting.

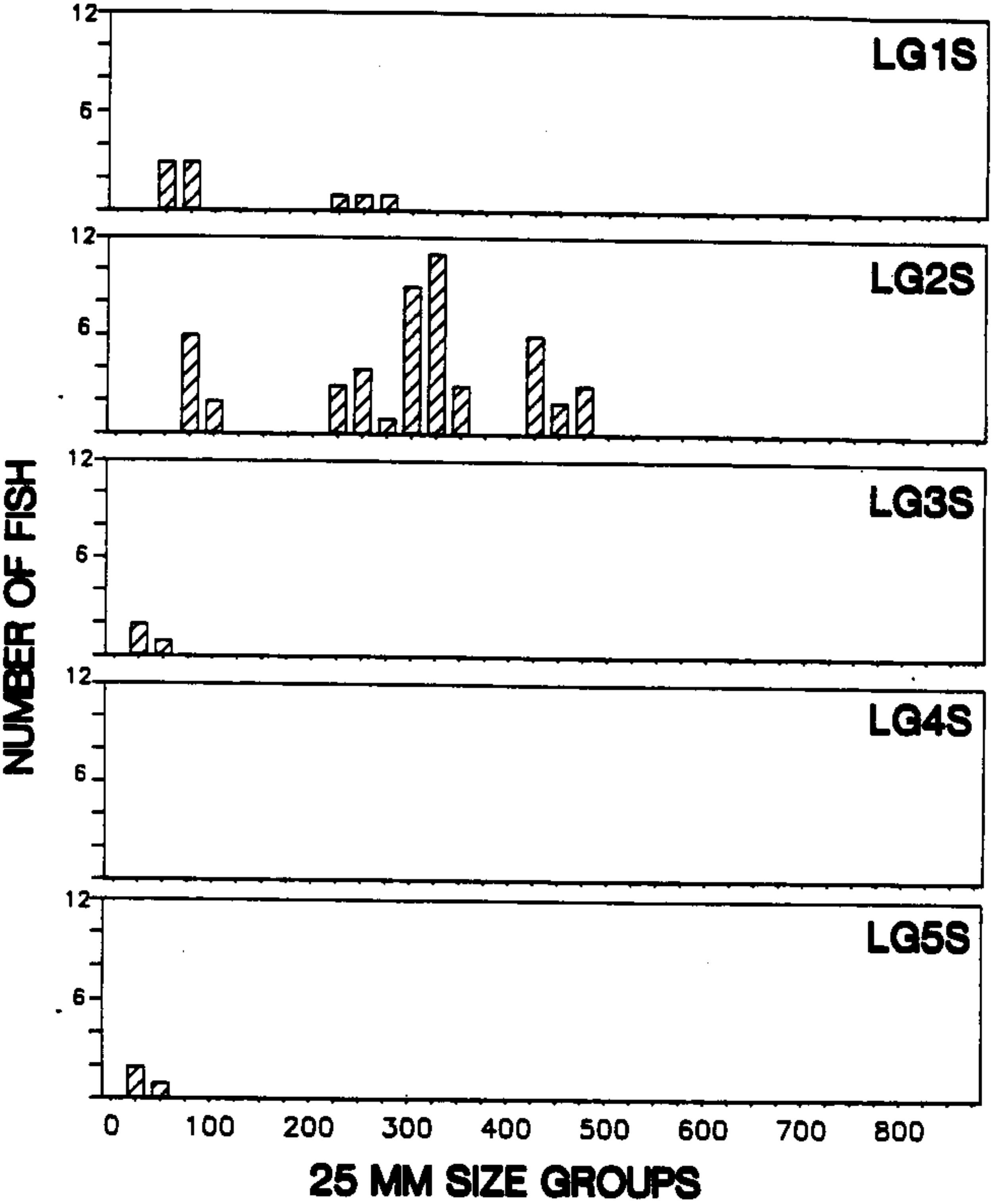

Figure 32. Length frequencies in 25 mm size groups of all fish collected by beach seining and electrofishing during winter, 1987, Lower Granite Reservoir, Washington. Station LG2S also includes catches from night and day gillnetting.

General CPUE Abundance

Abundance of various species at shallow stations based on electrofishing indicated a few dominant species were present in the spring. Daytime electroshocking in the spring yielded large catches of smallmouth bass per 15 minute transect at LG1S (Figure 33). Catch rates of salmonid fishes were relatively low at all stations. Station LG2S had the highest catch rates of rainbow trout and LG1S had the highest catch of chinook salmon. Largescale suckers dominated the nongame fish catches at all stations except LG5S.

Nighttime electrofishing in the spring yielded similar catch rates for smallmouth bass at LG1S as during the day (Figure 34). However, catch rates of bass at the other four stations were considerably higher at night than during the day. Rainbow trout catches were highest at LG3S and LG5S. Station LG2S had the highest catches of chinook salmon.

Abundance based on beach seining during the spring indicated high abundance of chinook salmon at shallow stations, especially LG1S, LG4S, and LG5S (Figure 35). Of the nongame species present, largescale suckers dominated at LG1S and LG2S, and northern squawfish dominated at LG3S and LG4S. Catch rates at LG5S were relatively low and no species was clearly dominant.

Summer beach seine catches were highest at LG5S and LG3S with fish in highest abundance being largescale suckers, northern squawfish, and chiselmouth (Figure 36). Catches at LG1S, LG2S, and LG4S were low in comparison to those at LG3S and LG5S.

Night electrofishing during the fall indicated that largescale suckers were the most abundant species (Figure 37). Catch rates for largescale

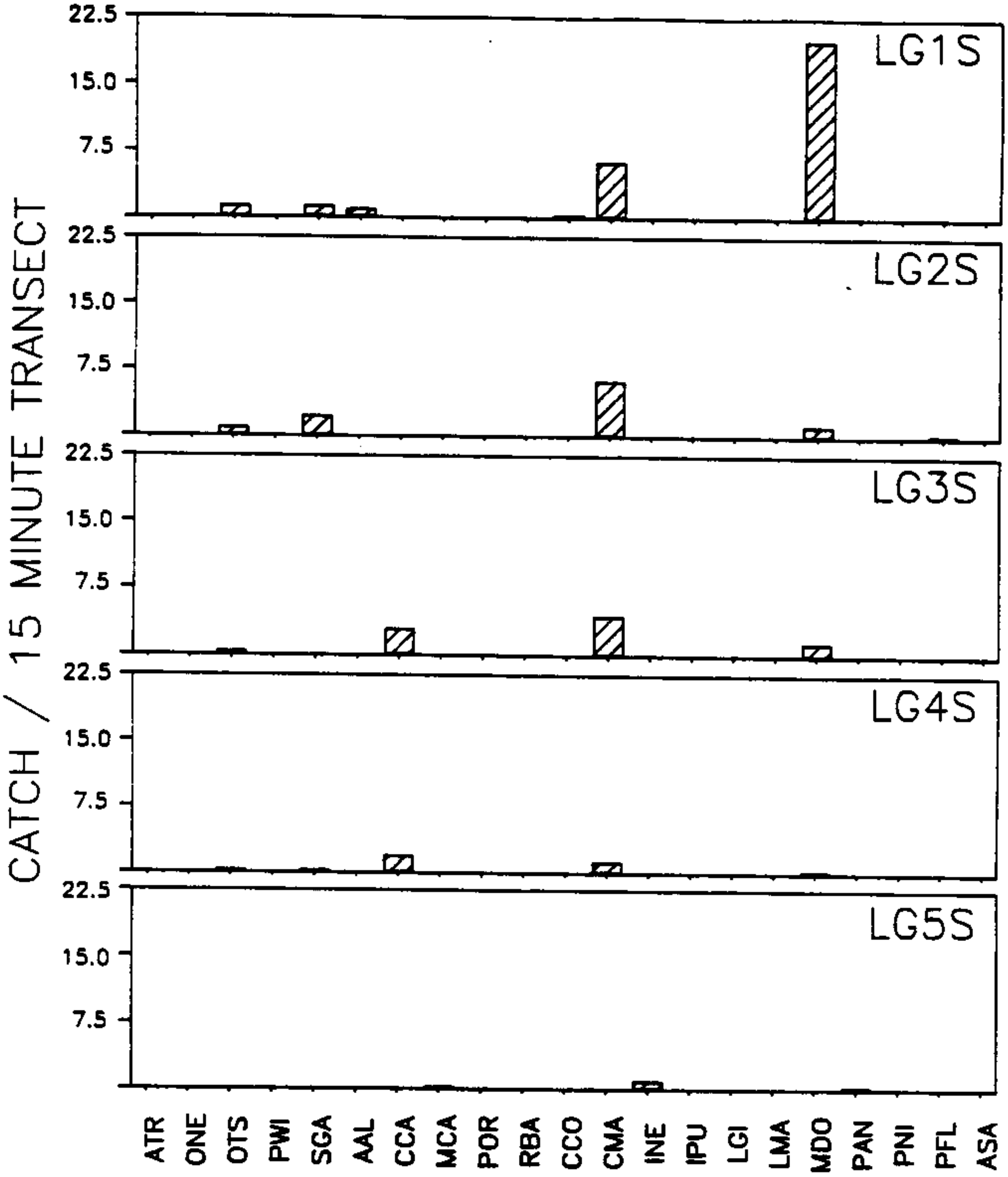

Figure 33. Catch per 15 minute transect of all species collected by daytime electrofishing during spring, 1987, Lower Granite Reservoir. See Table 9 for species codes.

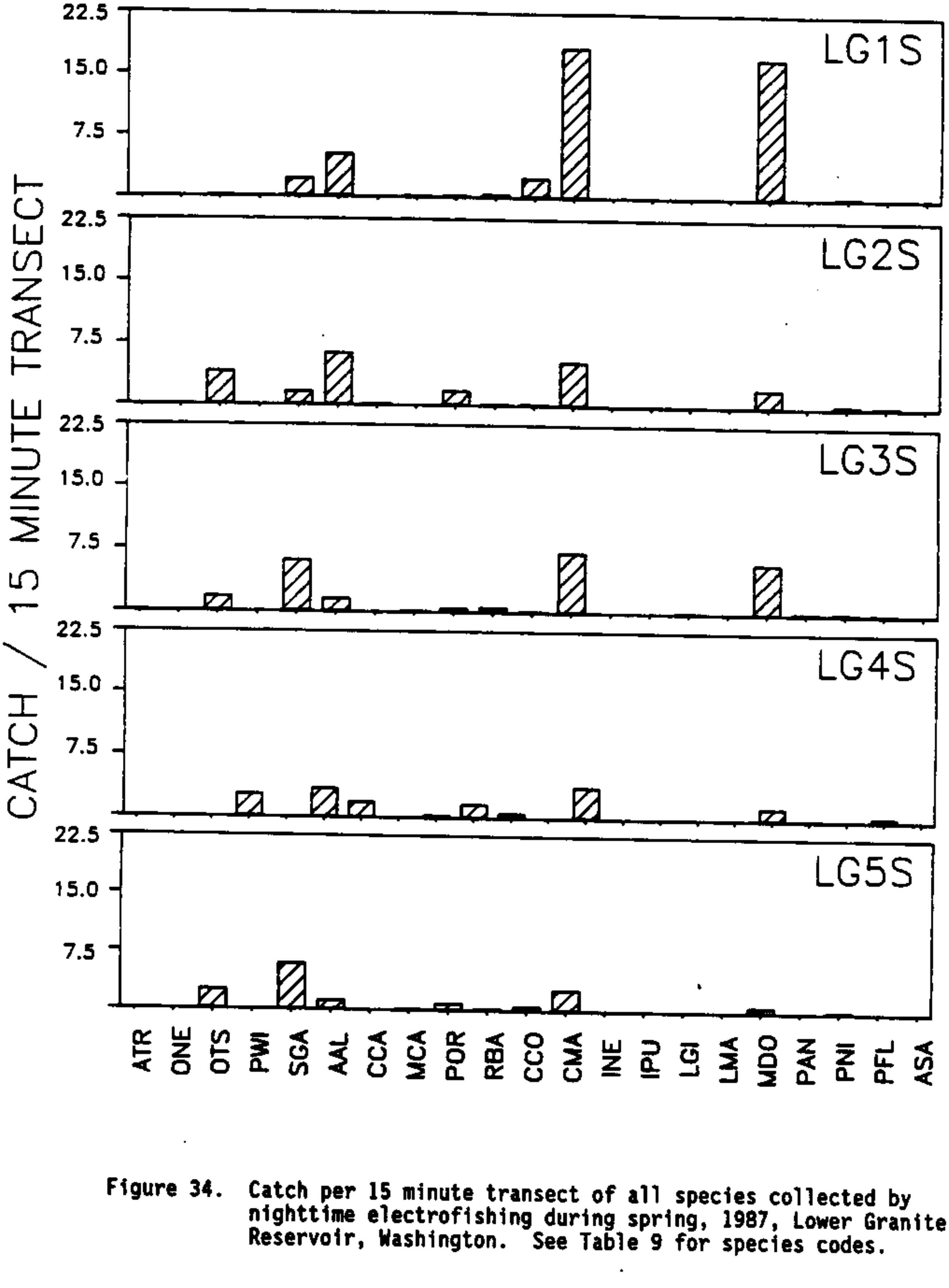

Figure 34. Catch per 15 minute transect of all species collected by nighttime electrofishing during spring, 1987, Lower Granite Reservoir, Washington. See Table 9 for species codes.

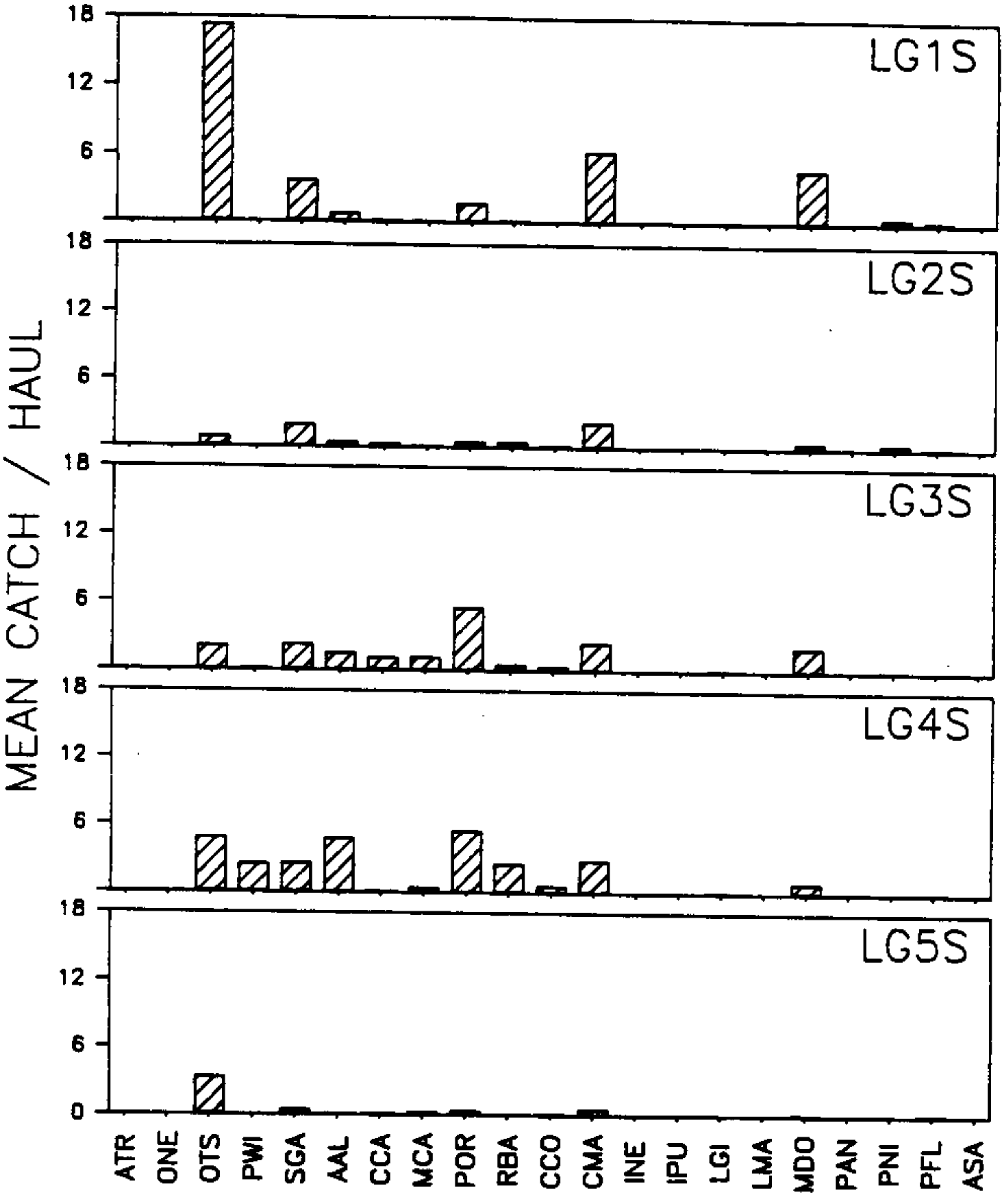

Figure 35. Mean catch per haul of all species collected by beach seine during spring, 1987, Lower Granite Reservoir, Washington. See Table 9 for species codes.

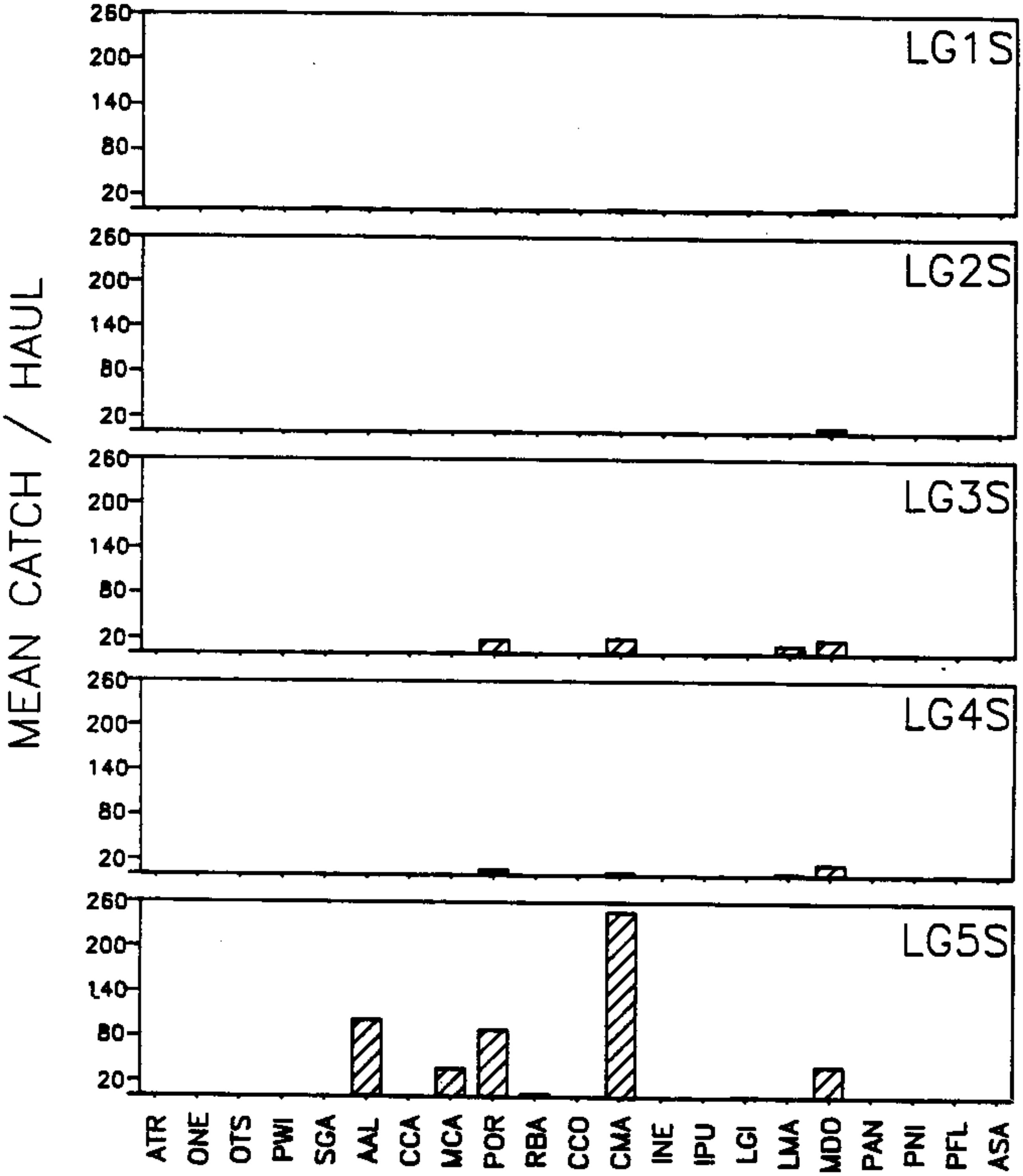

Figure 36. Mean catch per haul of all species collected by beach seine during summer, 1987, Lower Granite Reservoir, Washington. See Table 9 for species codes.

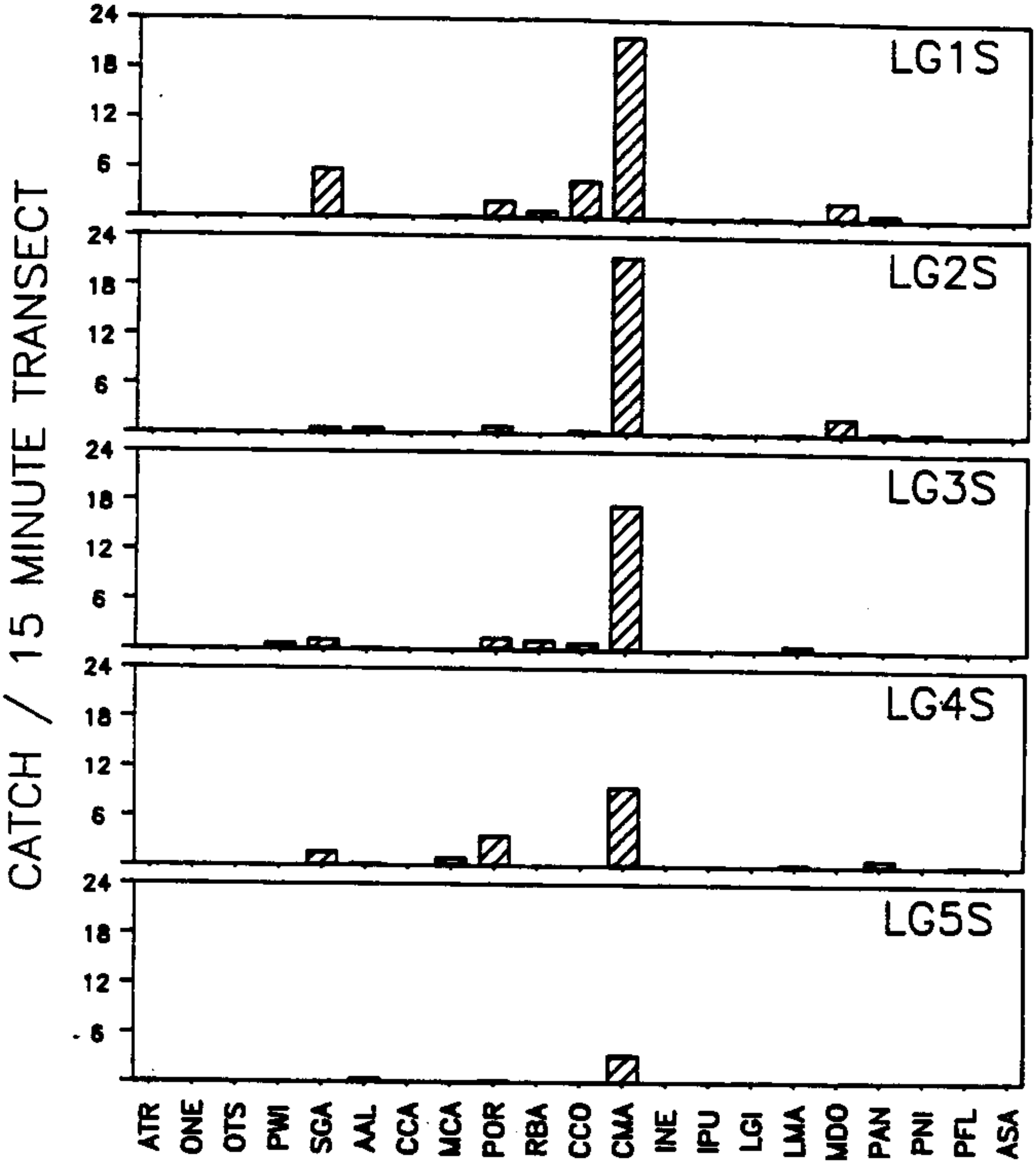

Figure 37. Catch per 15 minute transect of all species collected by nighttime electrofishing during fall, 1987, Lower Granite Reservoir, Washington. See Table 9 for species codes.

suckers were similar between LG1S and LG2S but lower at the other stations. Catch rates of residual rainbow trout, bluegill and smallmouth bass were next in abundance at those stations in the fall.

During fall and winter, catches from seining were low. Fall seine samples indicated rainbow trout and largescale suckers were abundant during the day at LG1S and northern squawfish were abundant at LG5S (Figure 38). Mean catch per haul was considerably lower at the other stations in the fall. During the winter, largescale suckers and rainbow trout were more abundant at LG1S, while white crappie and northern squawfish were also frequently caught at LG5S (Figure 39).

The majority of fishes collected at the shallow stations were young-of-the-year (YOY) or yearlings. For ease of separation, we considered anything less than 100 mm to be YOY, except for smallmouth bass (< 150 mm) and northern squawfish (< 250 mm). In the spring, YOY species abundance varied considerably by station. At LG1S, smallmouth bass and northern squawfish were more abundant (Figure 40). Northern squawfish yearlings were abundant at LG3S and LG4S. Chiselmouth and mountain whitefish also had relatively high catches at LG3S. In the summer, catch rates at LG5S relative to other stations were extremely high (Figure 41). Largescale sucker, chiselmouth, northern squawfish and smallmouth bass YOY predominated the catches. Although considerably lower than the summer, catches in the fall were highest at LG5S (Figure 42). Catches of black crappie, bluegill and smallmouth bass increased at LG1S, and LG3S compared to summer catches. At LG5S, northern squawfish and bridgelip suckers provided the highest catch rates. During the winter, catch rates were about half of that during the fall (Figure 43). Largescale suckers were abundant

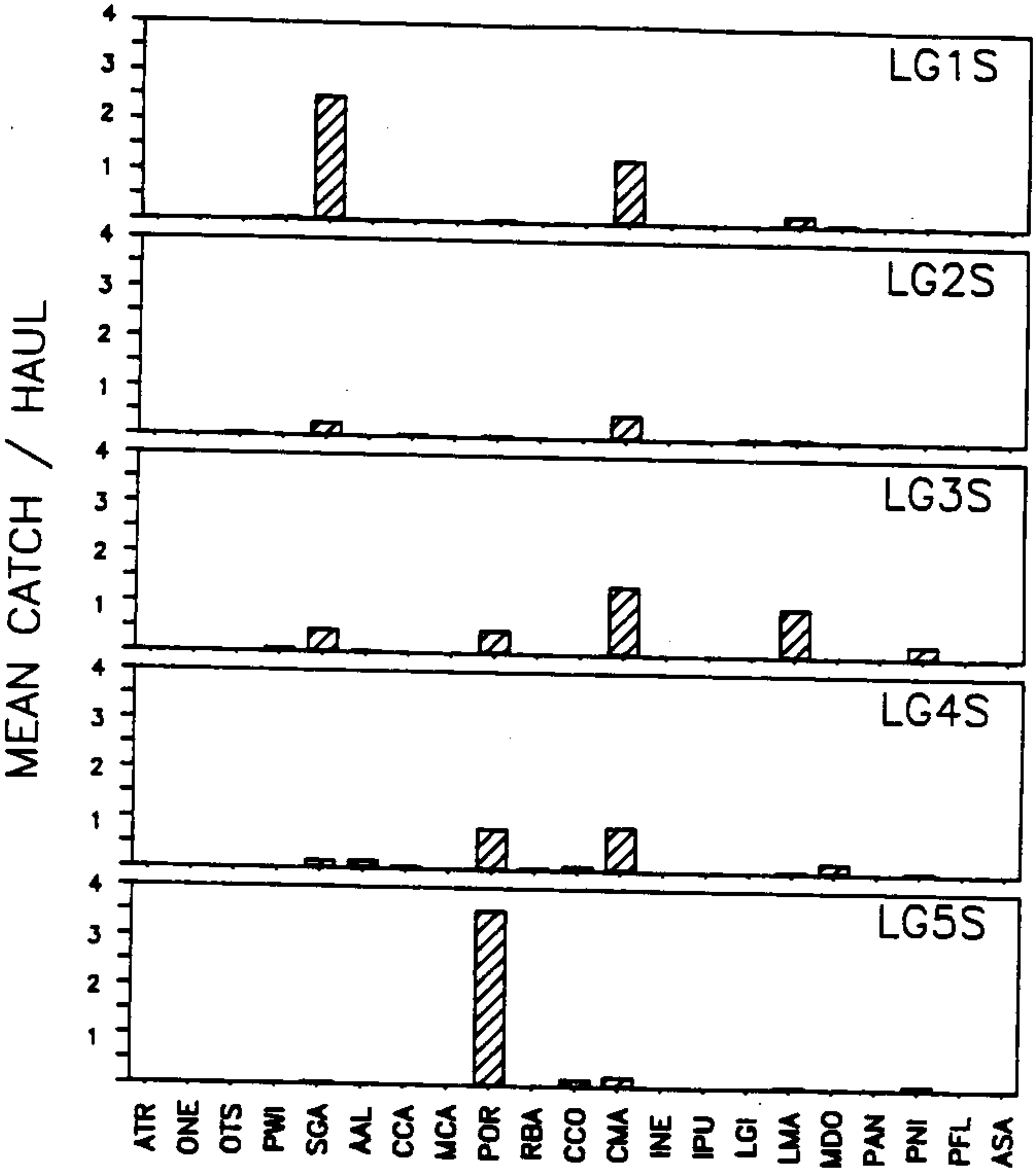

Figure 38. Mean catch per haul of all species collected by beach seine during fall, 1987, Lower Granite Reservoir, Washington. See Table 9 for species codes.

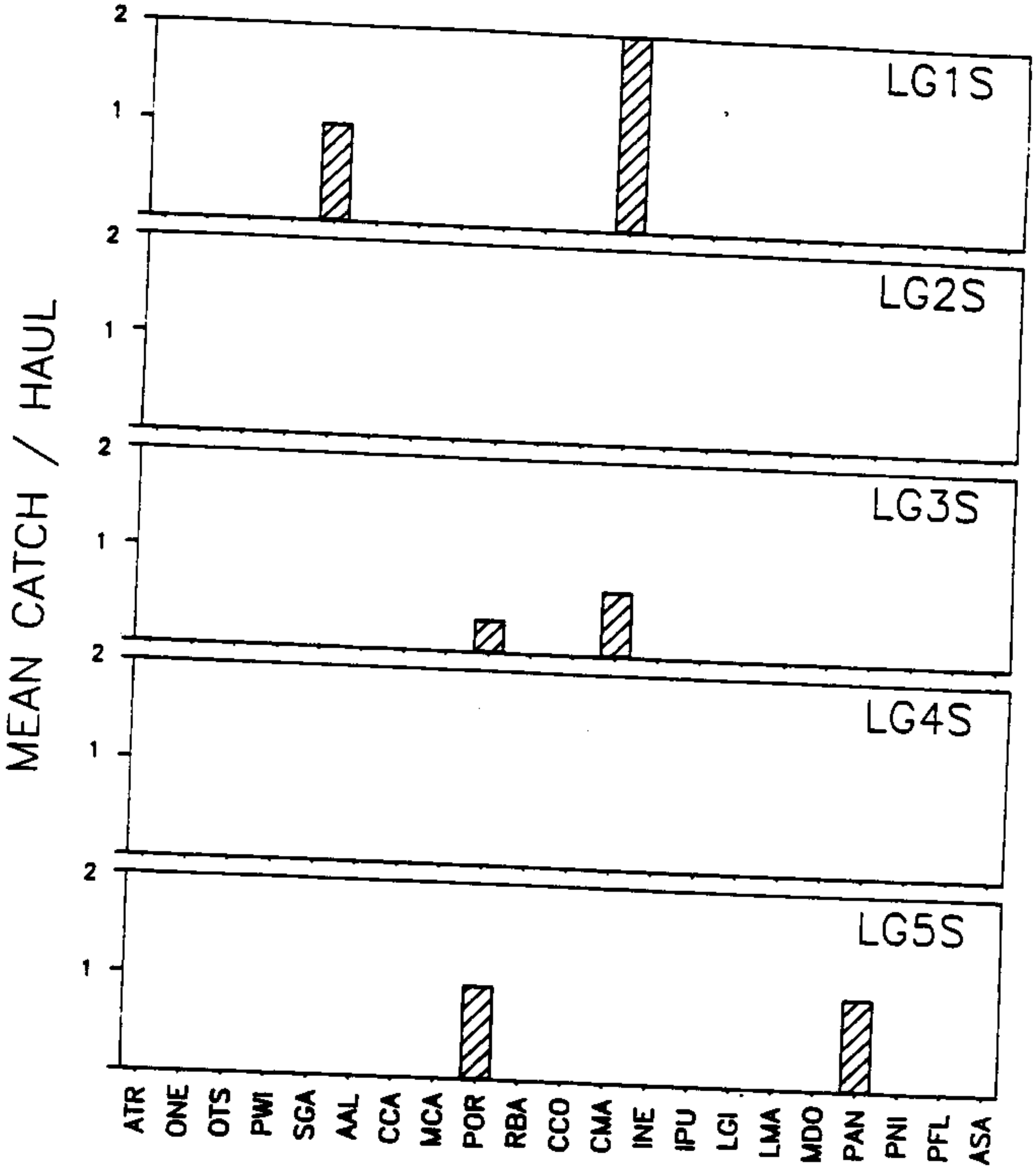

Figure 39. Mean catch per haul of all species collected by beach seine during winter, 1987, Lower Granite Reservoir, Washington. See Table 9 for species codes.

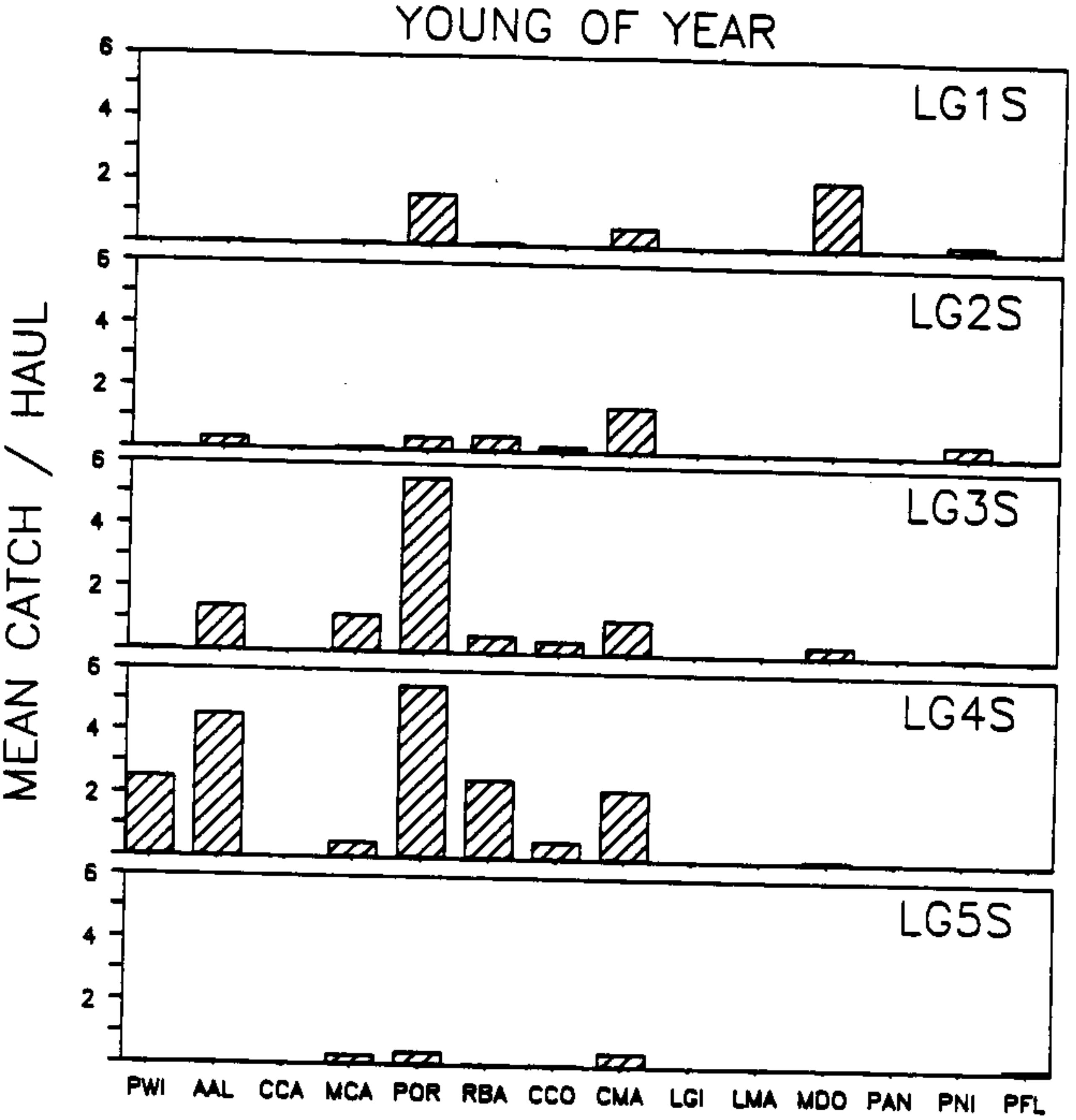

Figure 40. Mean catch per haul of resident species less than 100 mm total length, except MDO (< 150 mm) and POR (<250 mm), collected by beach seine during spring season, Lower Granite Reservoir, Washington. See Table 9 for species codes.

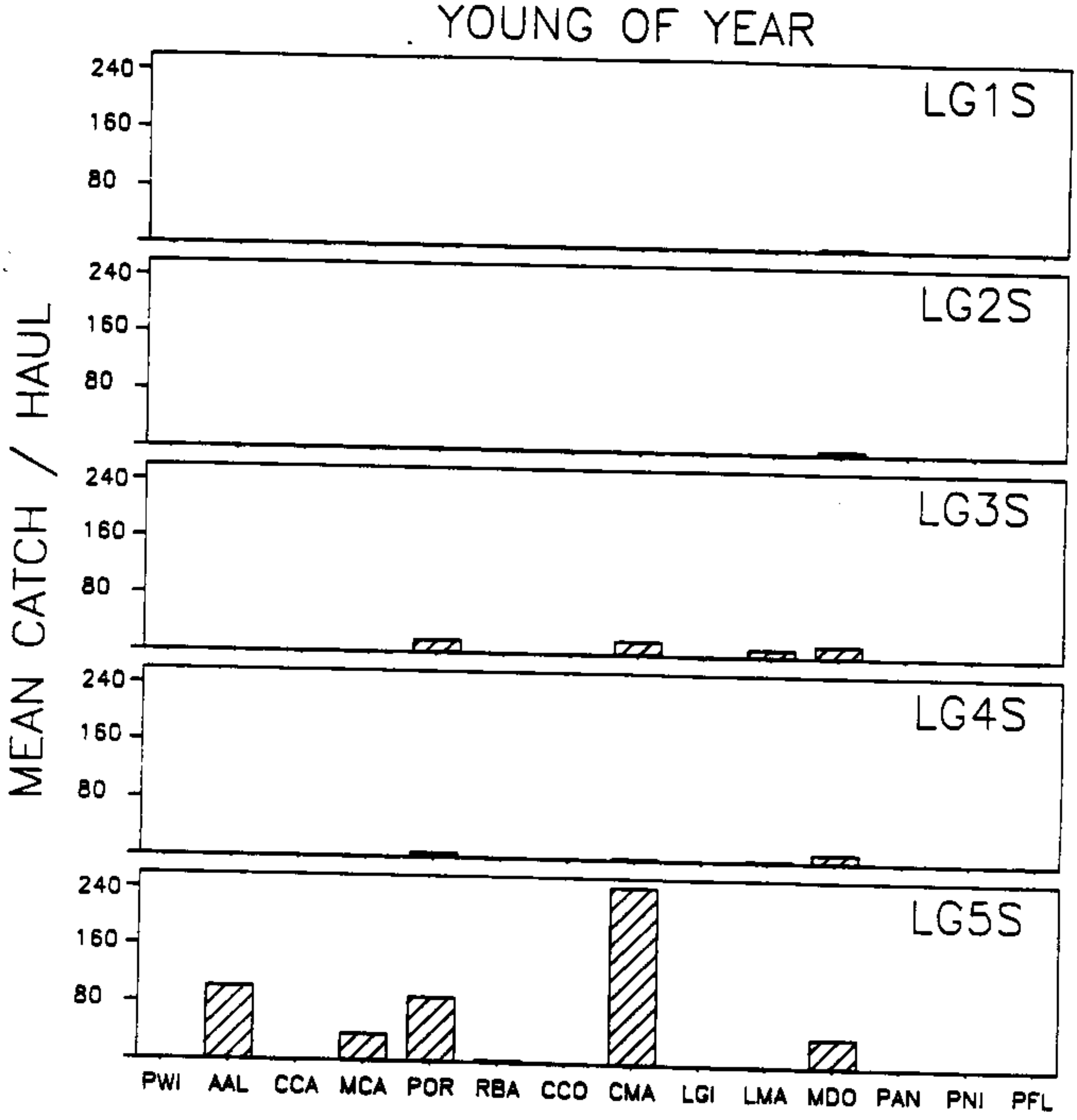

Figure 41. Mean catch per haul of resident species less than 100 mm total length, except MDO (< 150 mm) and POR (<250 mm), collected by beach seine during summer season, Lower Granite Reservoir, Washington. See Table 9 for species codes.

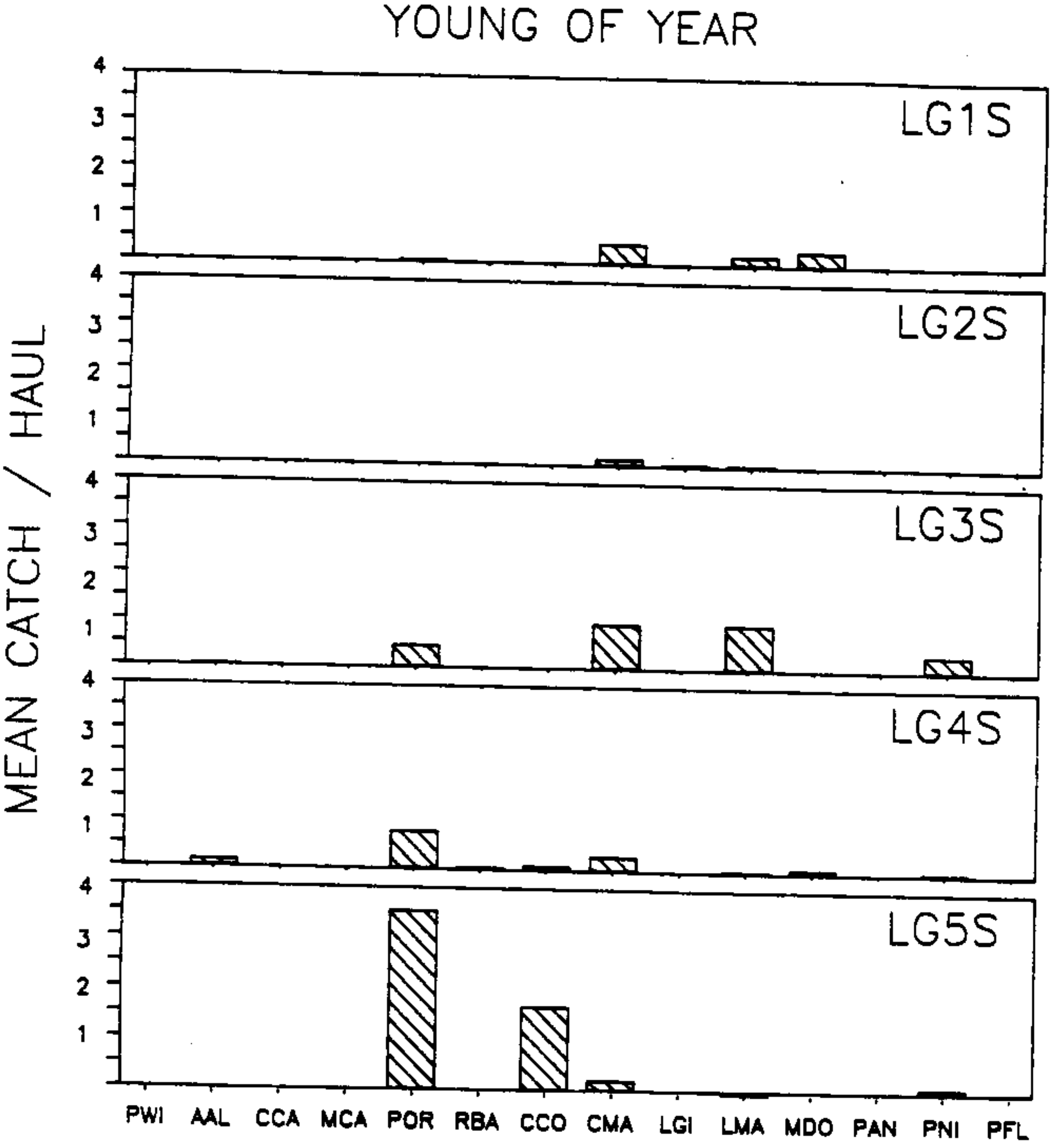

Figure 42. Mean catch per haul of resident species less than 100 mm total length, except MDO (< 150 mm) and POR (<250 mm), collected by beach seine during fall season, Lower Granite Reservoir, Washington. See Table 9 for species codes.

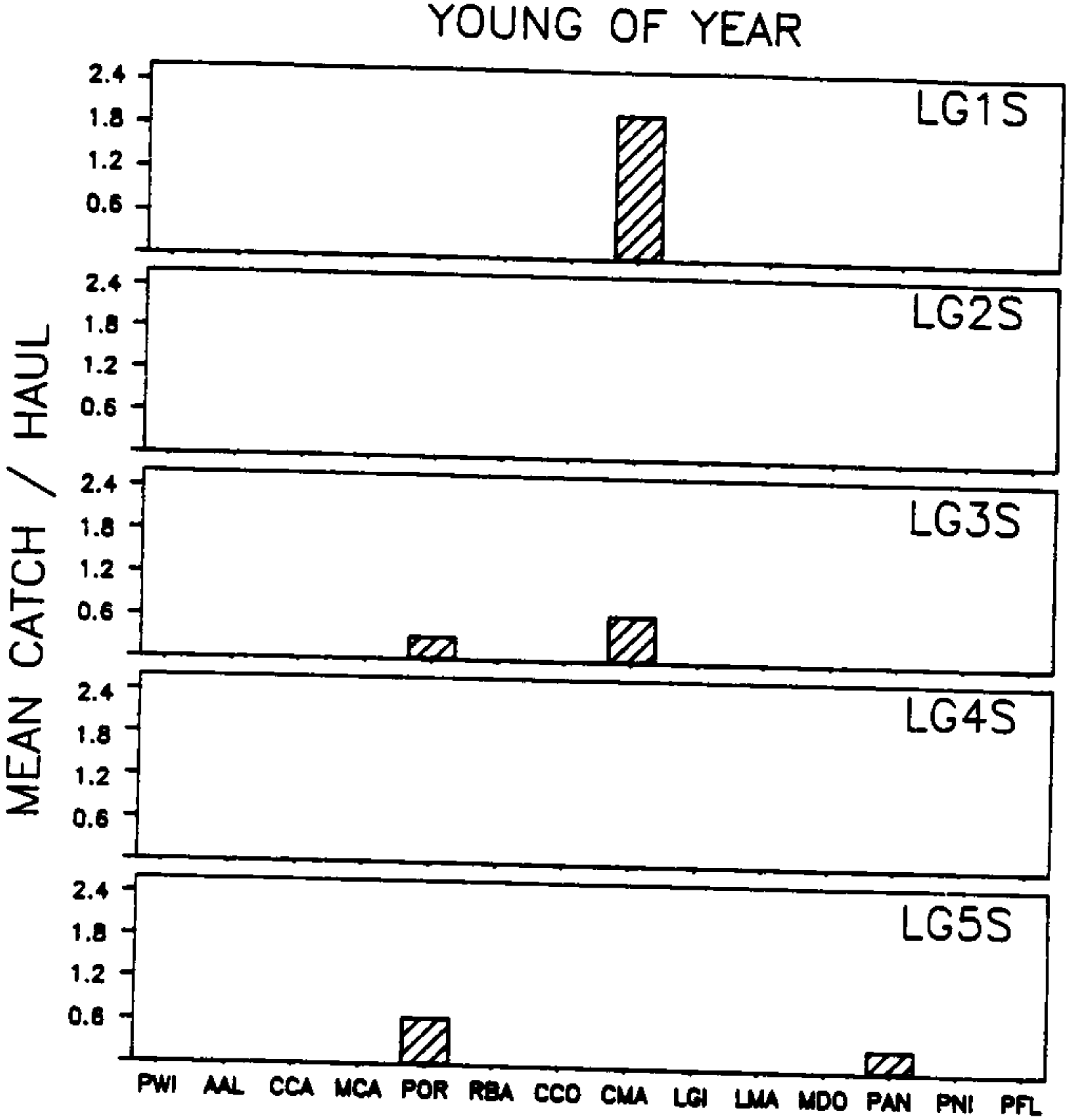

Figure 43. Mean catch per haul of resident species less than 100 mm total length, except MDO (< 150 mm) and POR (<250 mm), collected by beach seine during winter season, Lower Granite Reservoir, Washington. See Table 9 for species codes.

at LG1S and LG3S and northern squawfish were abundant at LG3S and LG5S. White crappie YOY also were abundant at LG5S.

CPUE Abundance - Key Species

Abundance of chinook salmon, rainbow trout, northern squawfish and smallmouth bass all differed throughout the spring beach seine collections. Chinook salmon peaked in abundance at LG1S the end of April to early May but were not abundant at the other stations (Figure 44). Later in the spring, fall chinook salmon ranging in length from 40 to 75 mm increased in abundance at the other stations with higher catch rates at LG4S and LG5S. Mean catch per haul for rainbow trout increased through early May and remained generally high at LG1S through mid June (Figure 45). Catch rates for rainbow trout at other stations were generally low during May but increased in early June. Northern squawfish were caught at LG1S and LG2S through early May (Figure 46). In contrast, catch rates of smallmouth bass generally increased at LG1S and LG3S but remained low at LG5S and LG2S throughout the spring (Figure 47).

In the summer, seine catches of rainbow trout and smallmouth bass were variable among stations. Rainbow trout were collected at LG1S in July and August and also at LG3S during July. Captures of smallmouth bass were similar among stations in mid July and predominantly at LG3S and LG4S the end of August (Figure 48).

In the fall, seine catch rates of rainbow trout generally increased from late October and peaked in late November at LG1S (Figure 49). Comparatively, catch rates were low at other stations at this time. Electrofishing provided information on nighttime use of shallow stations by chinook salmon, rainbow trout, northern squawfish and

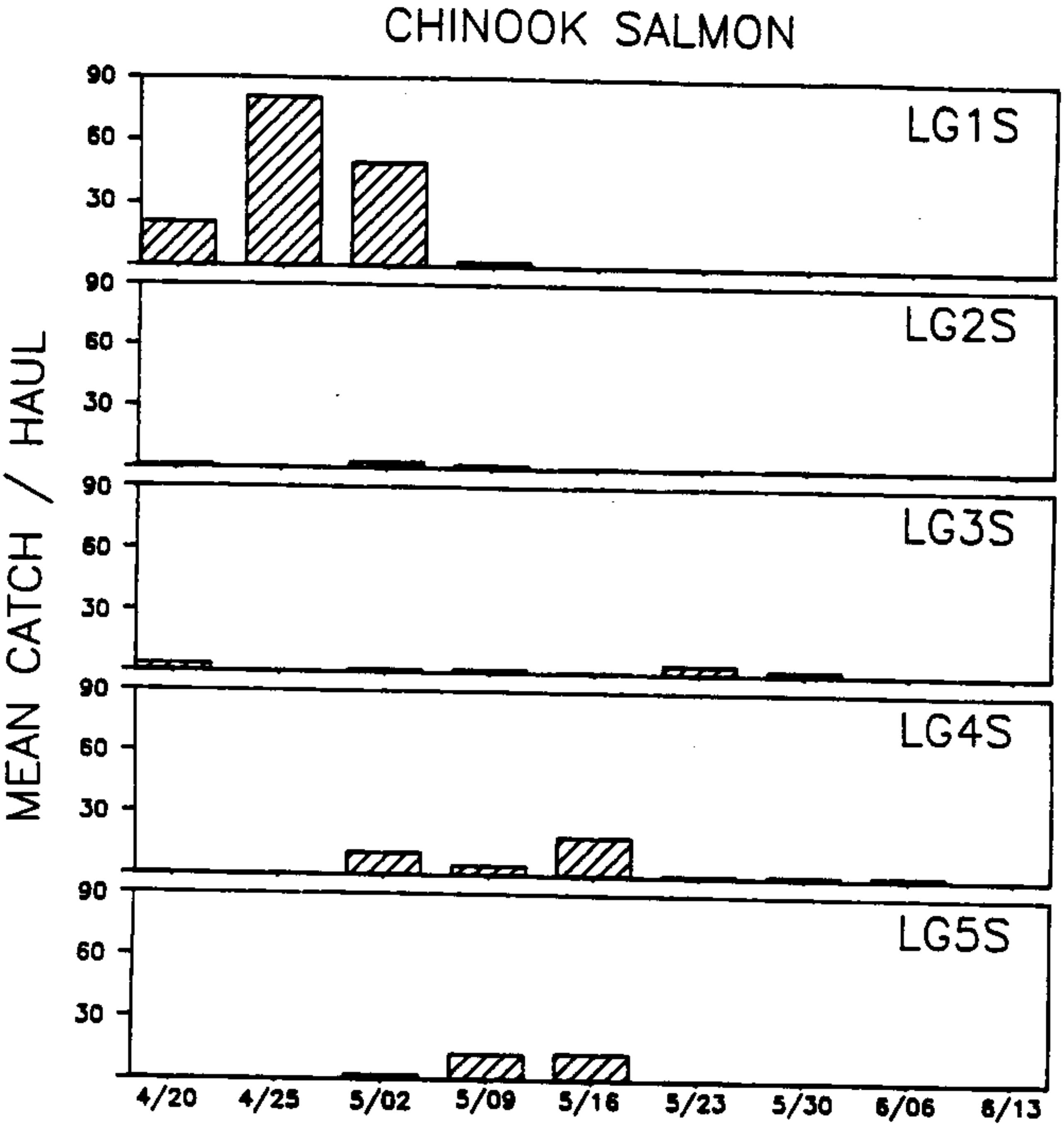

Figure 44. Mean catch per haul of chinook salmon less than 200 mm for each day of beach seining during spring, 1987, Lower Granite Reservoir, Washington.

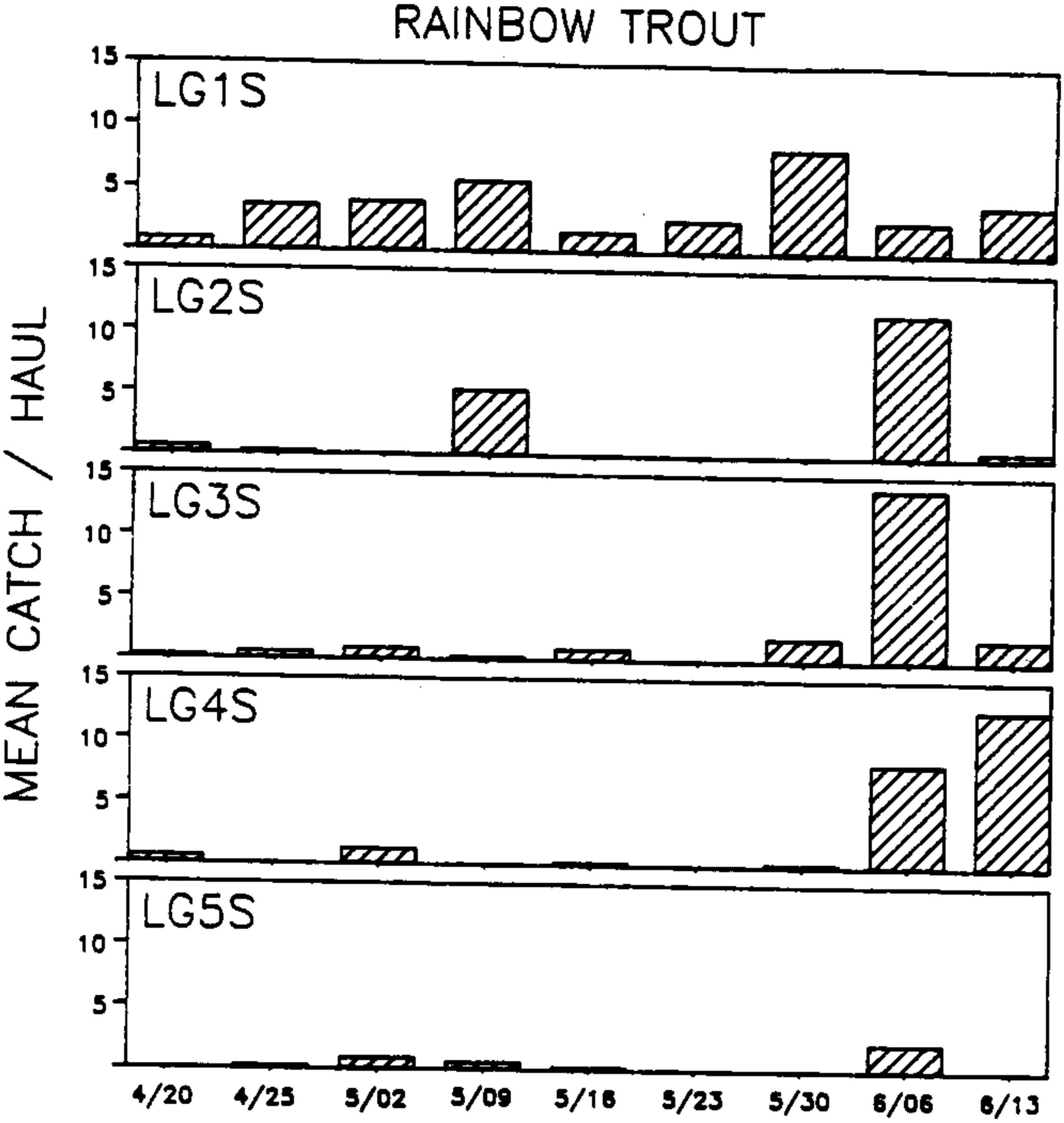

Figure 45. Mean catch per haul of rainbow trout less than 350 mm for each day of beach seining during spring, 1987, Lower Granite Reservoir, Washington.

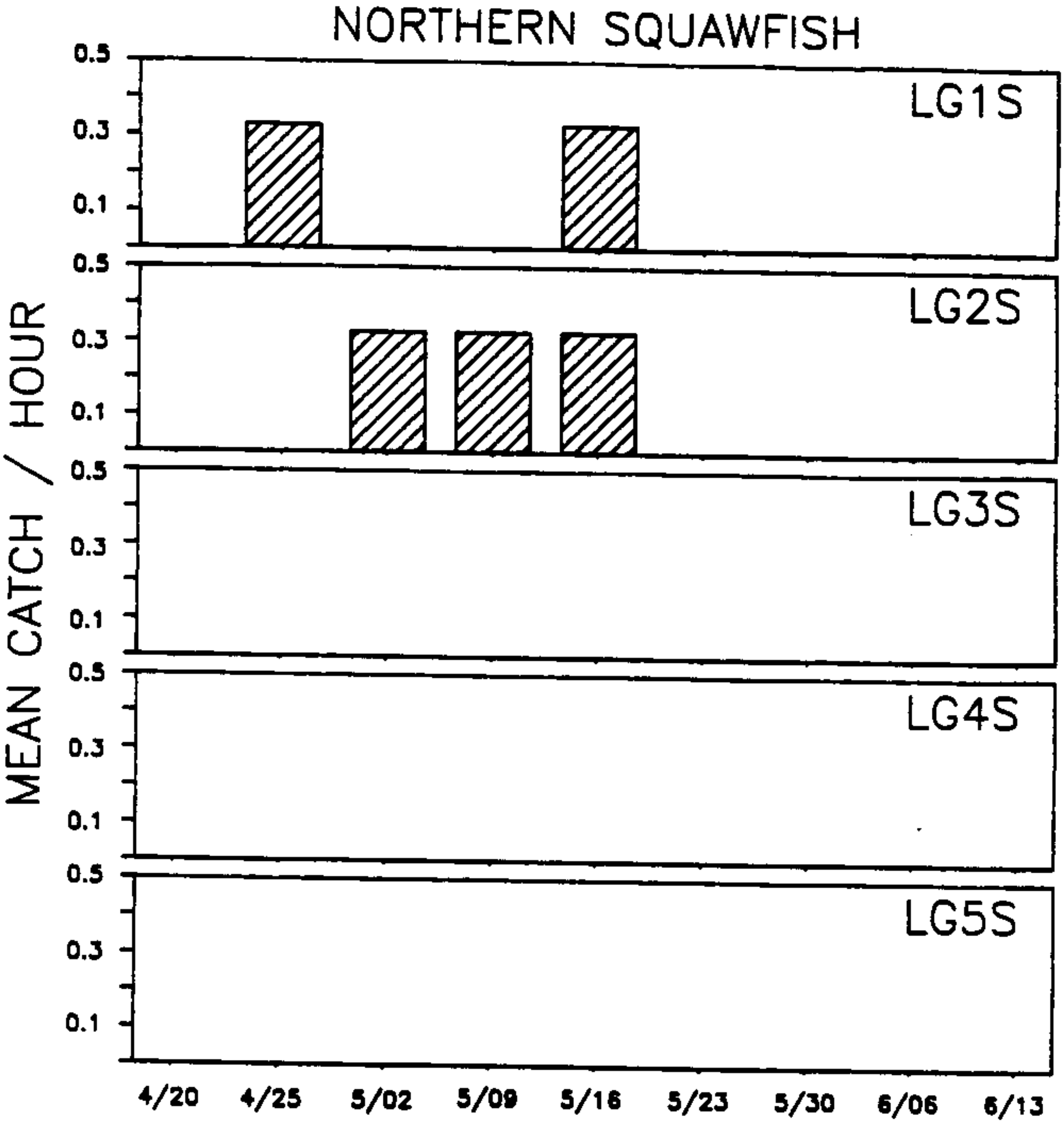

Figure 46. Mean catch per haul of northern squawfish greater than 250 mm for each day of beach seining during spring, 1987, Lower Granite Reservoir, Washington.

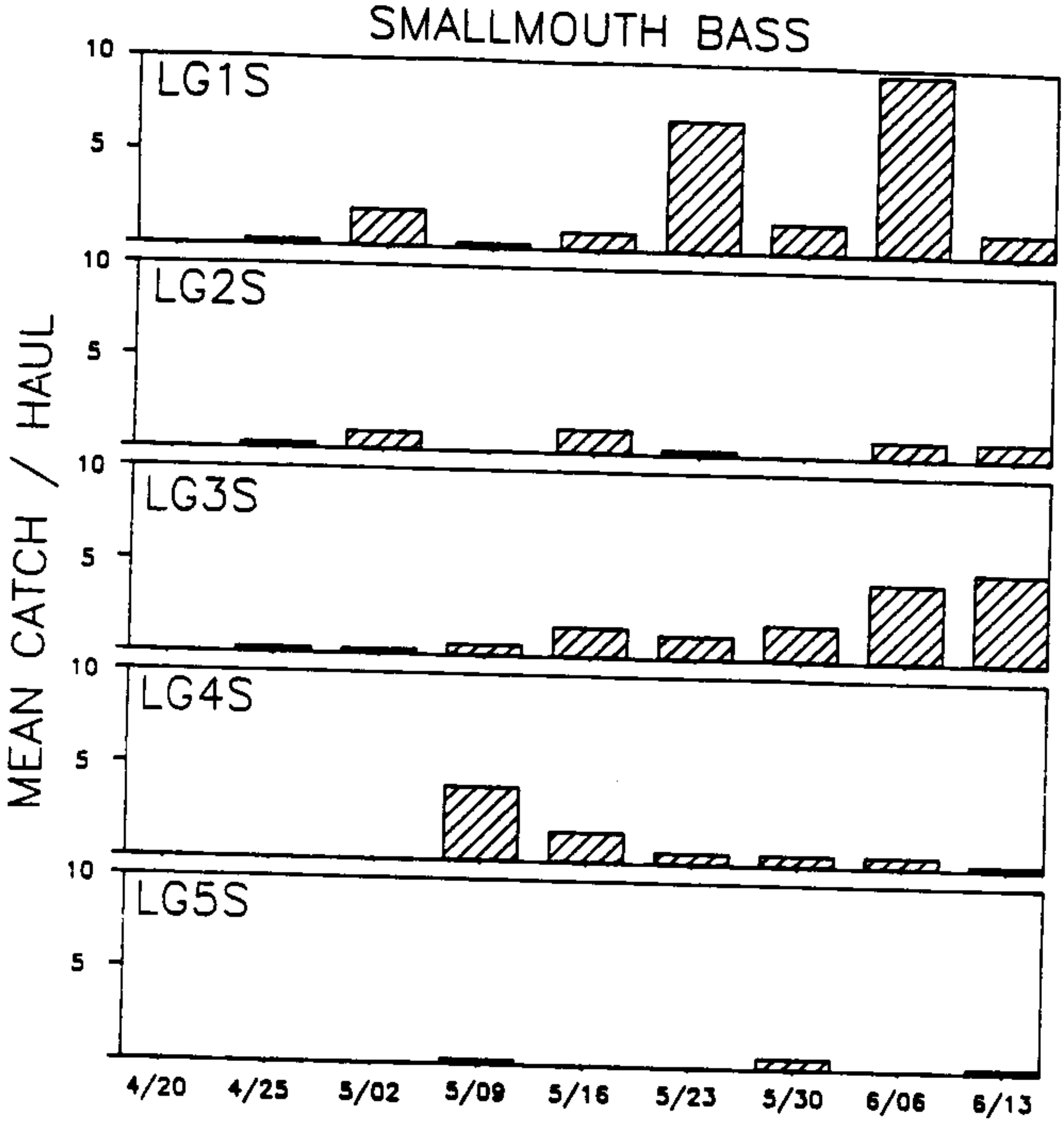

Figure 47. Mean catch per haul of smallmouth bass greater than 150 mm for each day of beach seining during spring, 1987, Lower Granite Reservoir, Washington.

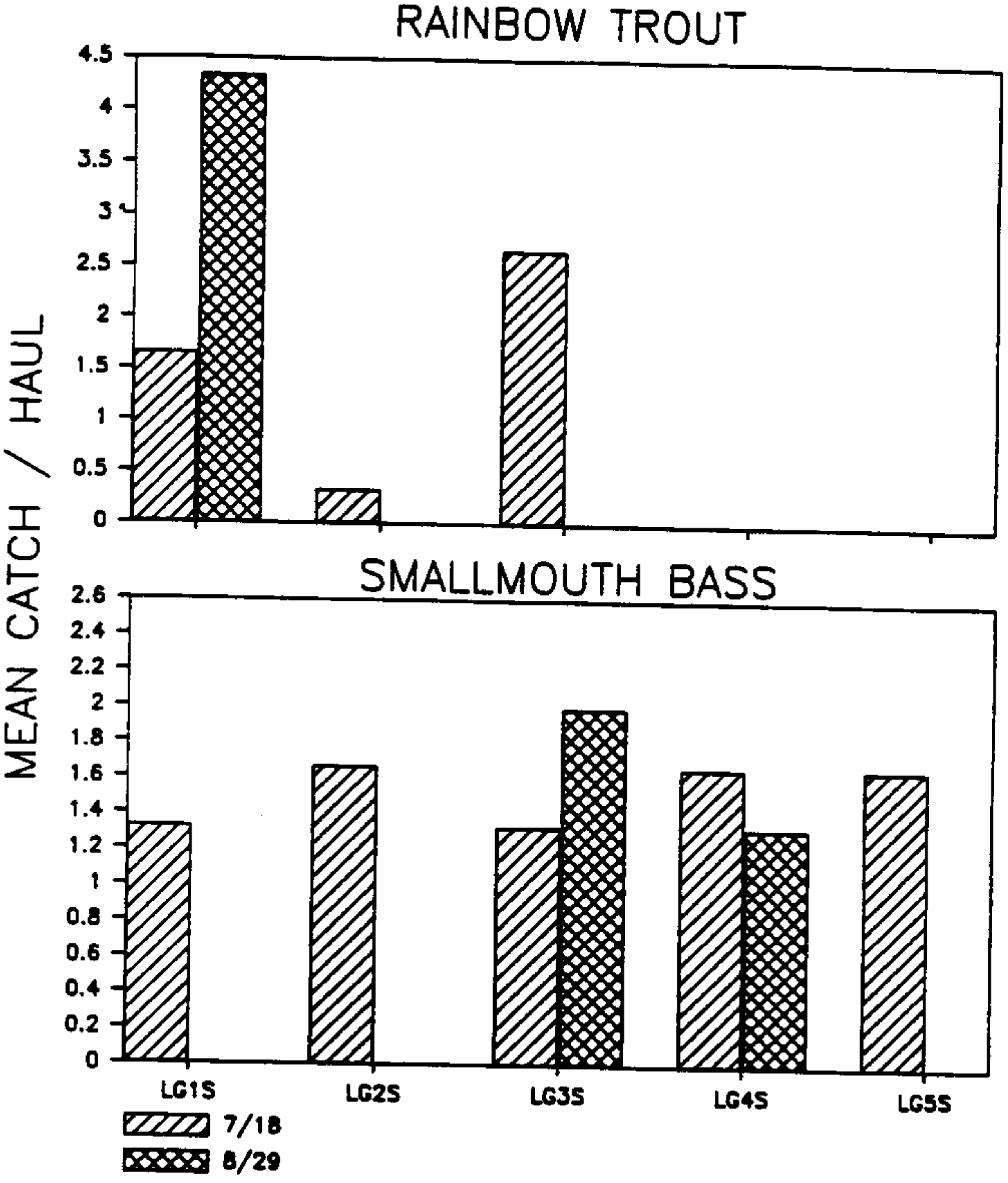

Figure 48. Mean catch per haul of rainbow trout less than 350 mm and smallmouth bass greater than 150 mm for each day of beach seining during summer, 1987, Lower Granite Reservoir, Washington.

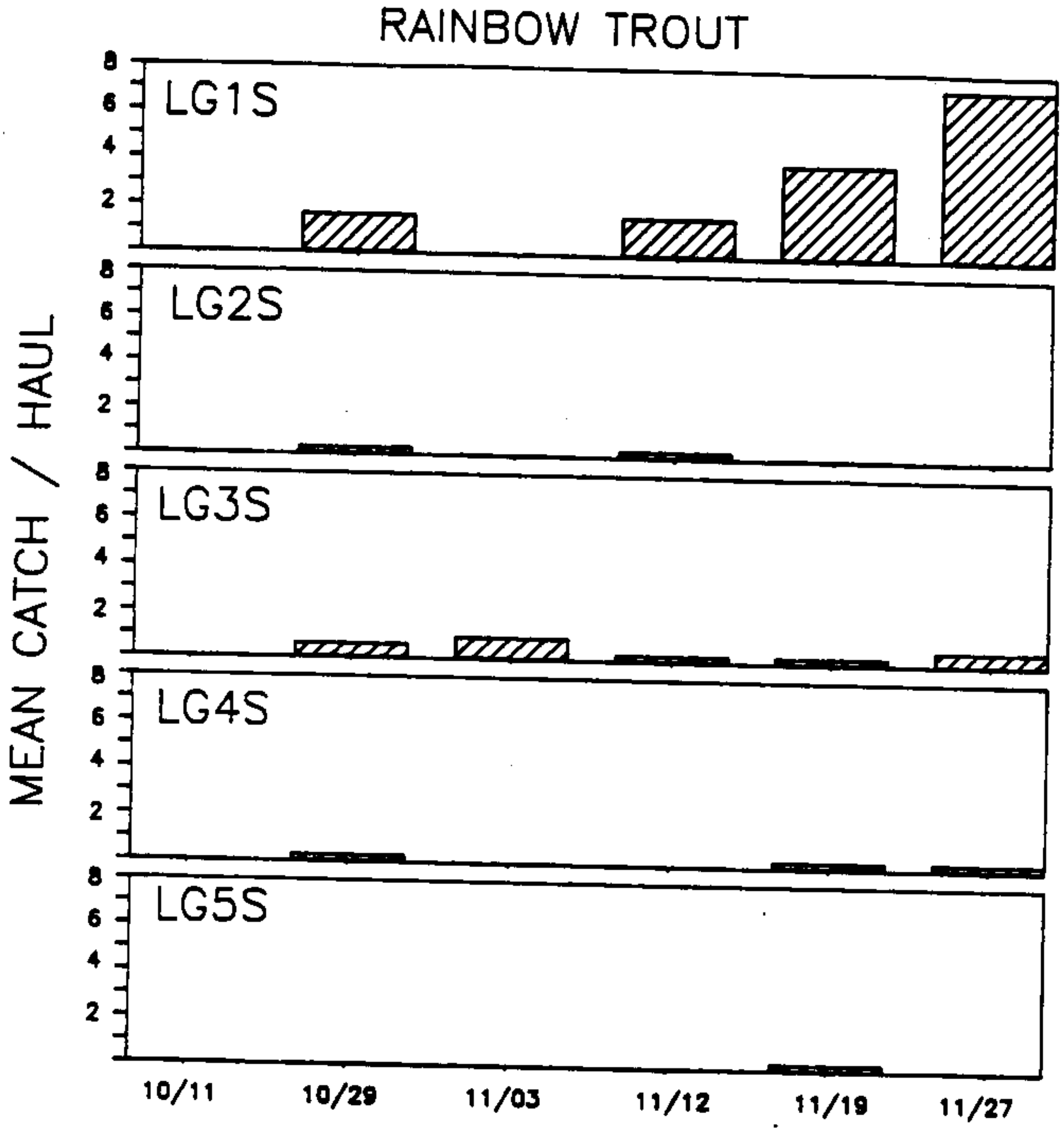

Figure 49. Mean catch per haul of rainbow trout less than 350 mm for each day of beach seining during fall, 1987, Lower Granite Reservoir, Washington.

smallmouth bass. During the spring, electrofishing indicated highest abundance of chinook salmon at LG2S followed by LG4S and LG3S (Figure 50). In contrast to day sampling, chinook salmon were not abundant at night at LG1S. Capture rates were highest in late April and early May and then decreased. Abundance of rainbow trout was highest at night at LG3S and LG5S and peaked during early June (Figure 51). Night abundance of northern squawfish varied widely among stations (Figure 52). The high abundance of smallmouth bass at LG1S was demonstrated by the highest catch rates in April, May and June of any station followed by catches at LG3S (Figure 53).

We compared total numbers of chinook salmon and rainbow trout captured at shallow stations throughout the spring to assess statistical differences (Table 10). This information indicates that fall chinook salmon (< 75 mm) were most abundant at LG4S and LG5S based on beach seining. In contrast, chinook salmon (> 75 mm) were most abundant at LG1S followed by LG4S, LG3S and LG2S. During the night, electrofishing captures indicated that rainbow trout were at similar levels of abundance at LG3S and LG5S followed by the other stations. During the day, however, beach seine catches were highest at LG1S.

Significant Spearman rank correlations were found between abundances of chinook salmon (< 75 mm; Figure 54) and wild rainbow trout (Figure 55) and the proportions of inorganic cover ($r=-0.9$), substrate (> 50 mm; $r=-0.9$), gradient ($r=-1.0$), and no cover ($r=0.9$). In contrast, no significant rank correlations were found for abundances of hatchery rainbows (Figure 56) or chinook (> 75 mm; Figure 57) with any of the habitat measurements.

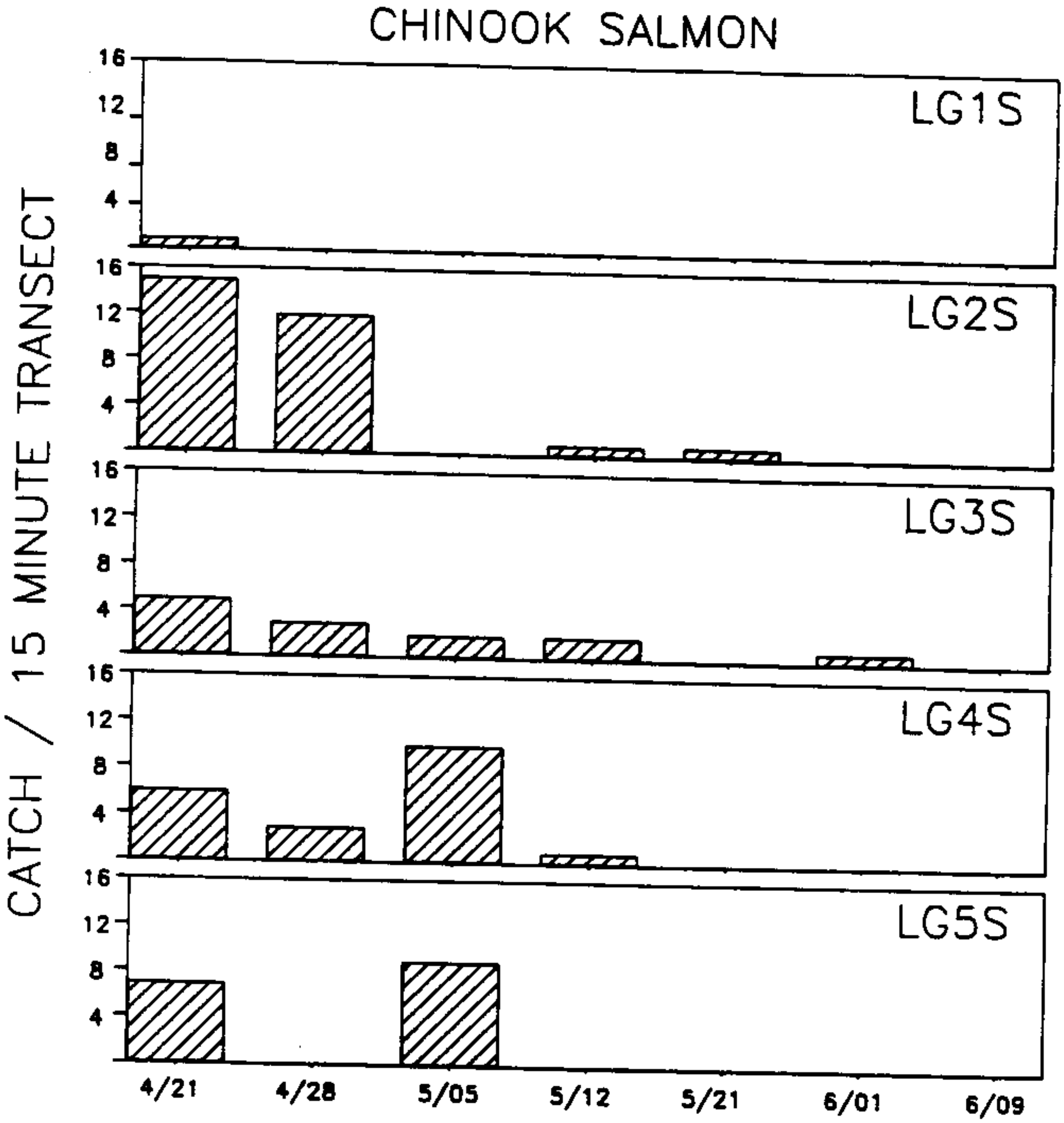

Figure 50. Catch per 15 minute transect of chinook salmon less than 200 mm for each night of electrofishing during spring, 1987, Lower Granite Reservoir, Washington.

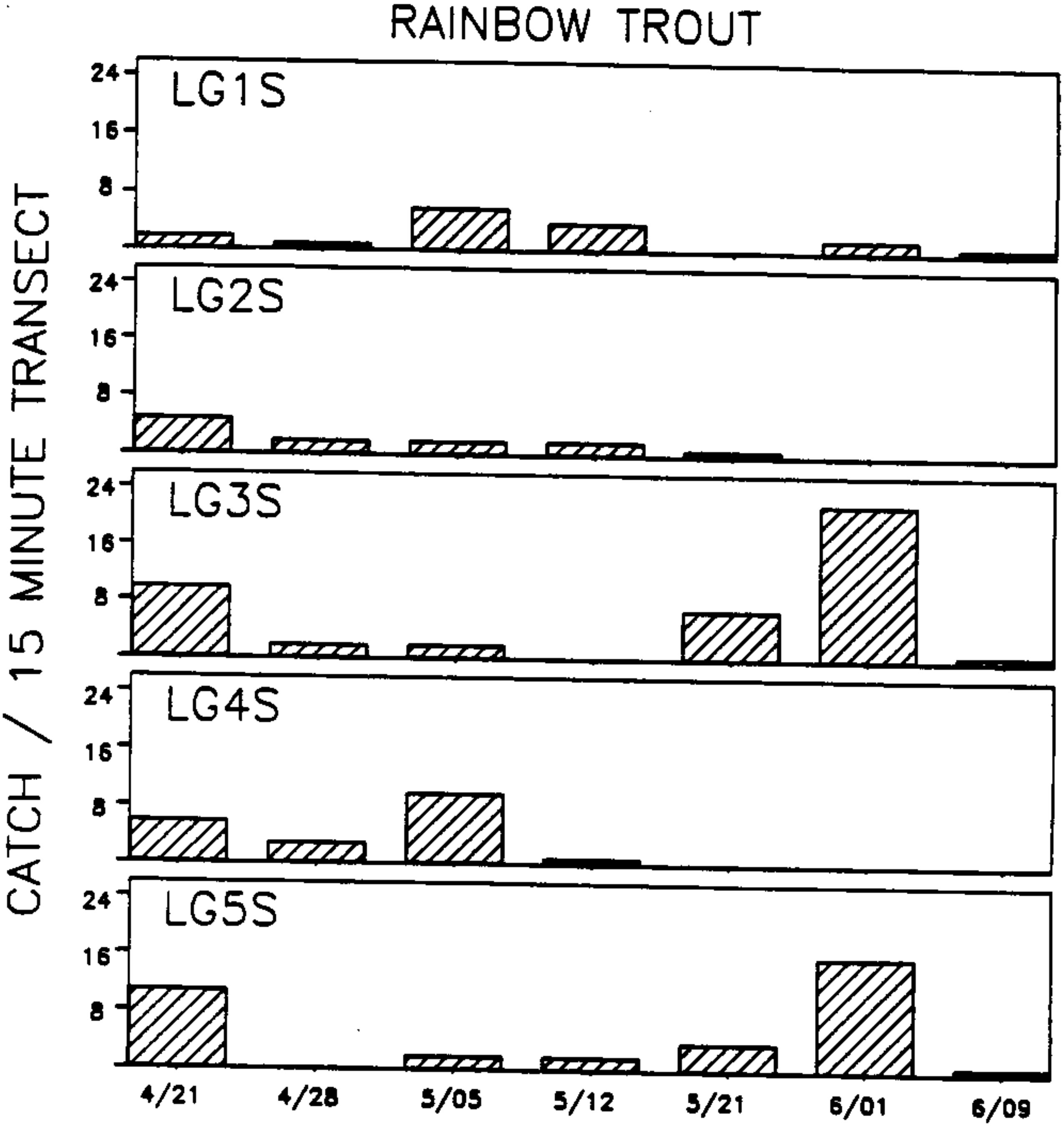

Figure 51. Catch per 15 minute transect of rainbow trout less than 350 mm for each night of electrofishing during spring, 1987, Lower Granite Reservoir, Washington.

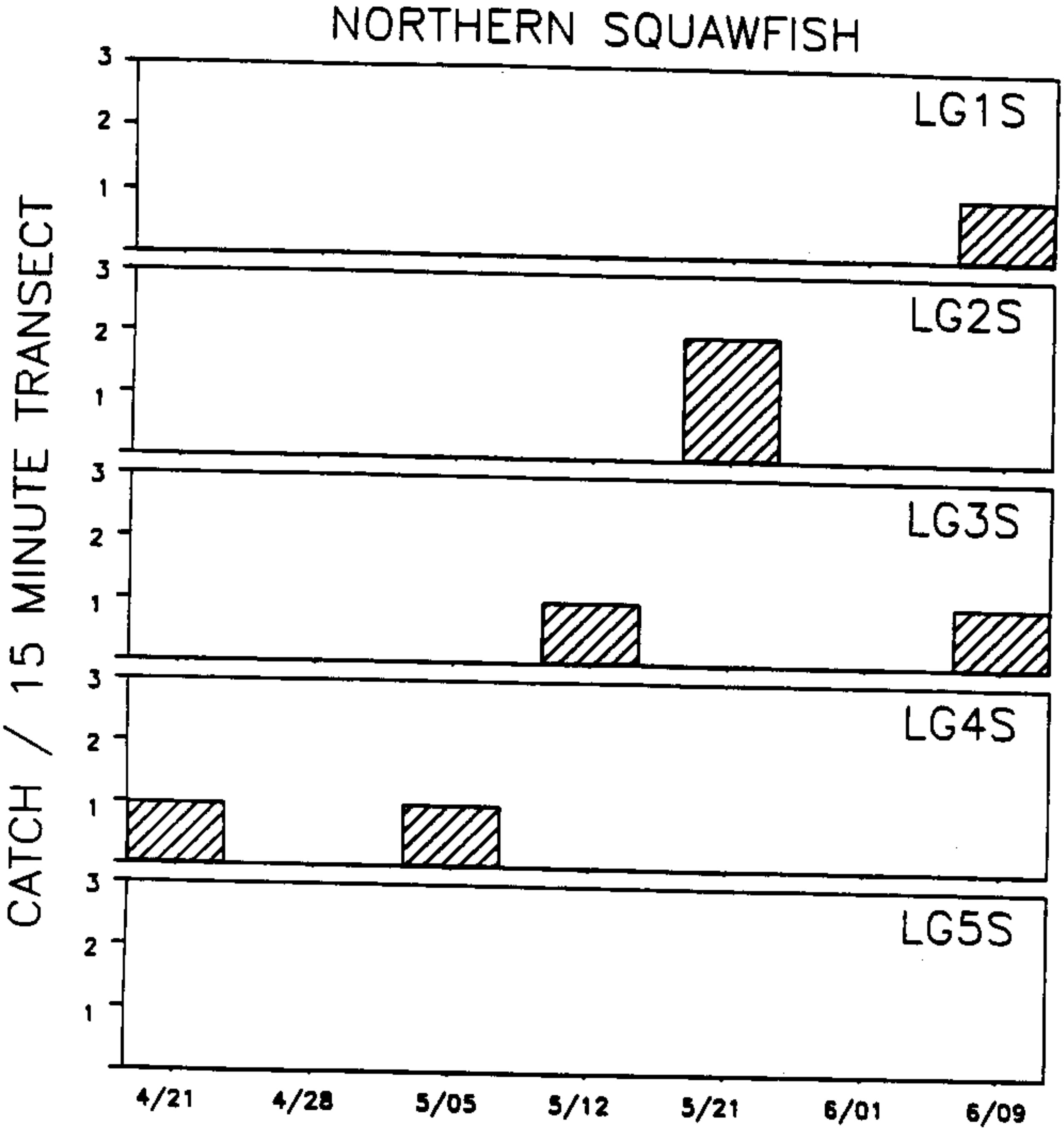

Figure 52. Catch per 15 minute transect of northern squawfish greater than 250 mm for each night of electrofishing during spring, 1987, Lower Granite Reservoir, Washington.

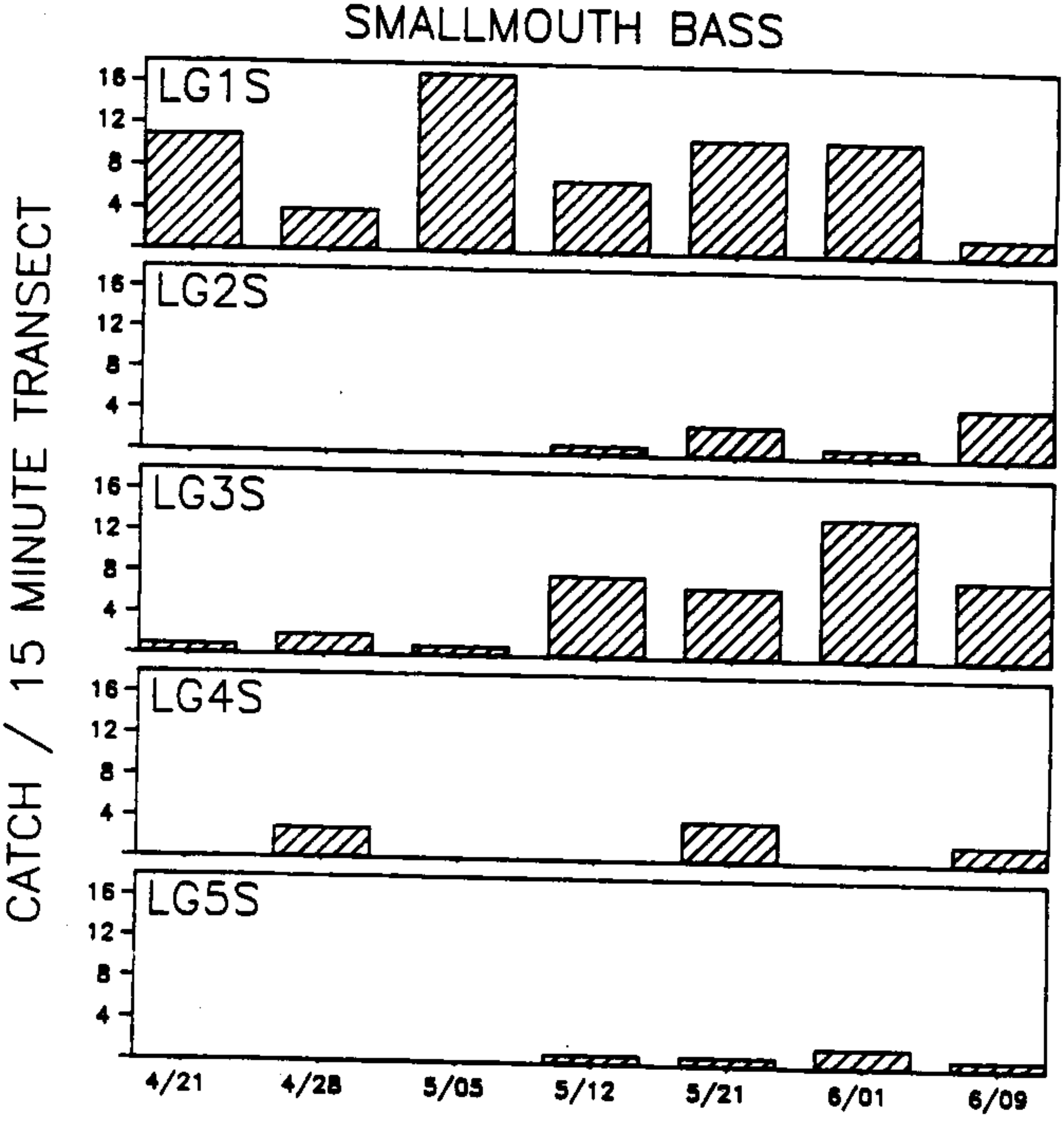

Figure 53. Catch per 15 minute transect of smallmouth bass greater than 150 mm for each night of electrofishing during spring, 1987, Lower Granite Reservoir, Washington.

Table 10. Statisical comparisons of abundance for chinook salmon (OTS) and rainbow trout (SGA) from the shallow stations in Lower Granite Reservoir, Washington during 1987. Stations underlined are not significantly different at $p < 0.05$. Day abundance was based on beach seining and night abundance based on electrofishing.

Species	Stastical Difference
OTS < 75 mm	LG4S LG5S LG3S LG2S LG1S
OTS > 75 mm	LG1S LG4S LG3S LG2S LG5S
SGA - night	LG3S LG5S LG4S LG1S LG2S
SGA - day	LG1S LG4S LG3S LG2S LG5S

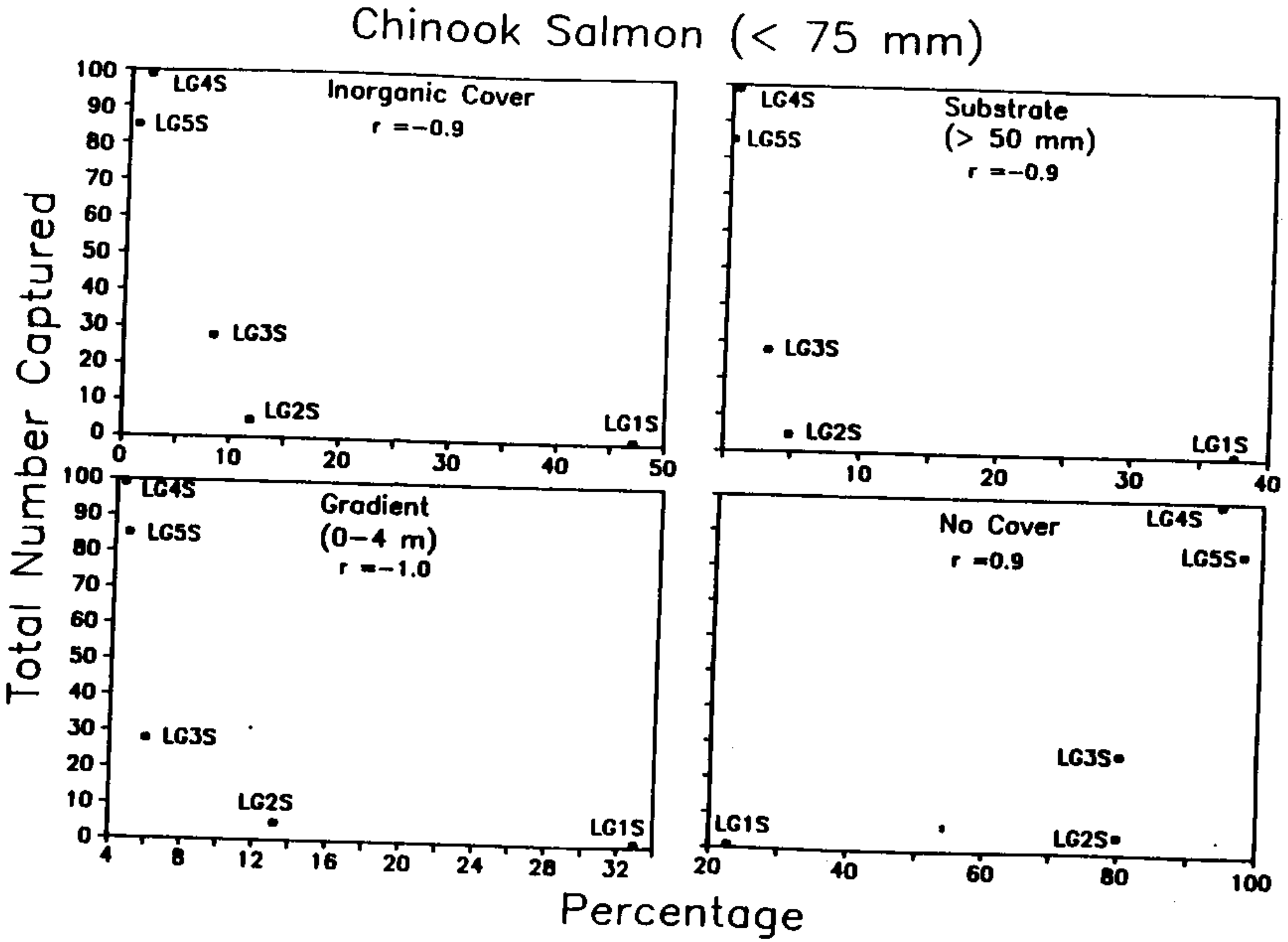

Figure 54. Chinook salmon (< 75 mm) abundance versus habitat charactersitics at shallow water stations during spring, 1987, Lower Granite Reservoir, Washington. The r^2 value represents the Spearman rank correlation coefficient.

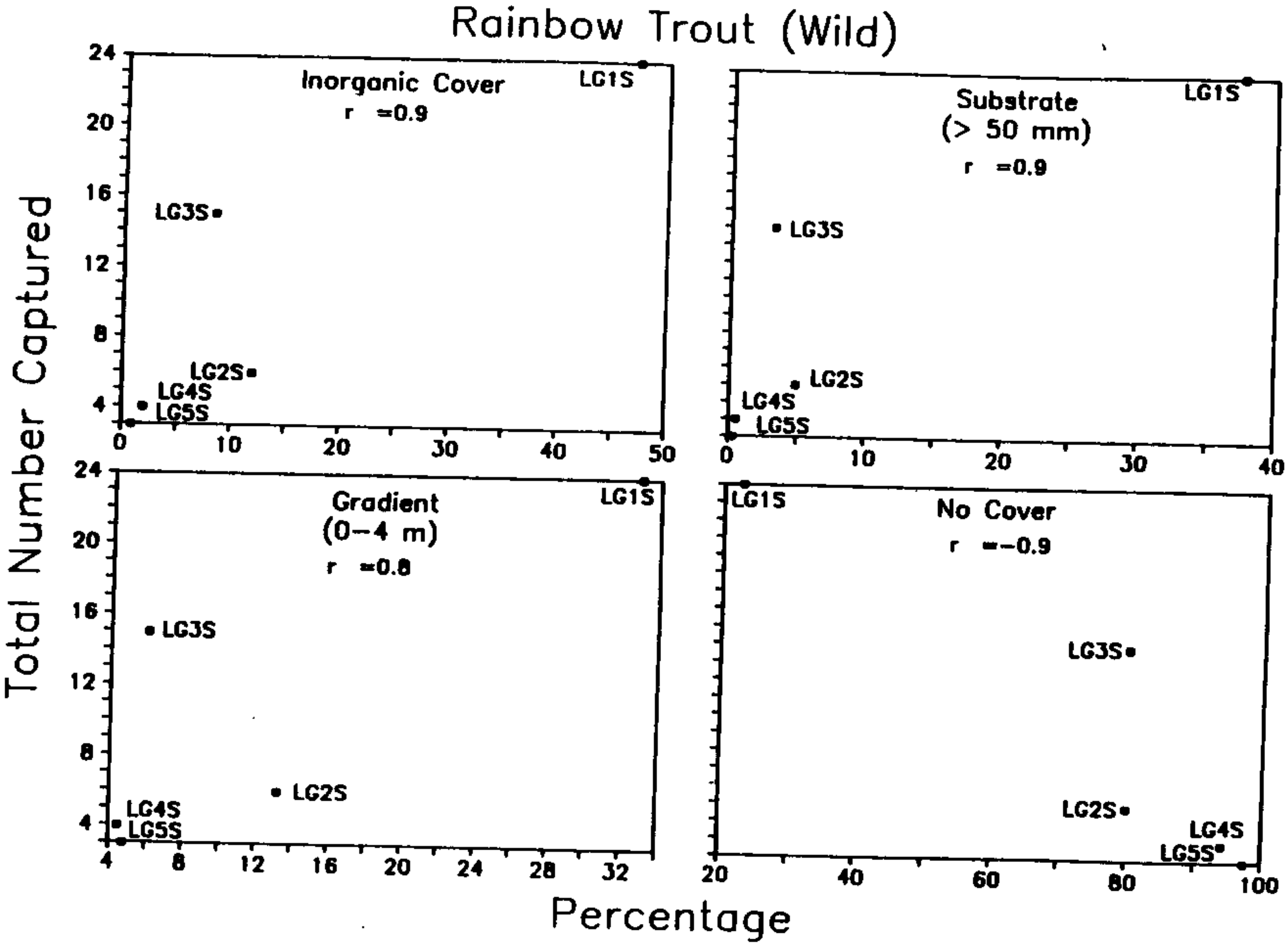

Figure 55. Rainbow Trout (wild) abundance versus habitat charactersitics at shallow water stations during spring, 1987, Lower Granite Reservoir, Washington. The r^2 value represents the Spearman rank correlation coefficient.

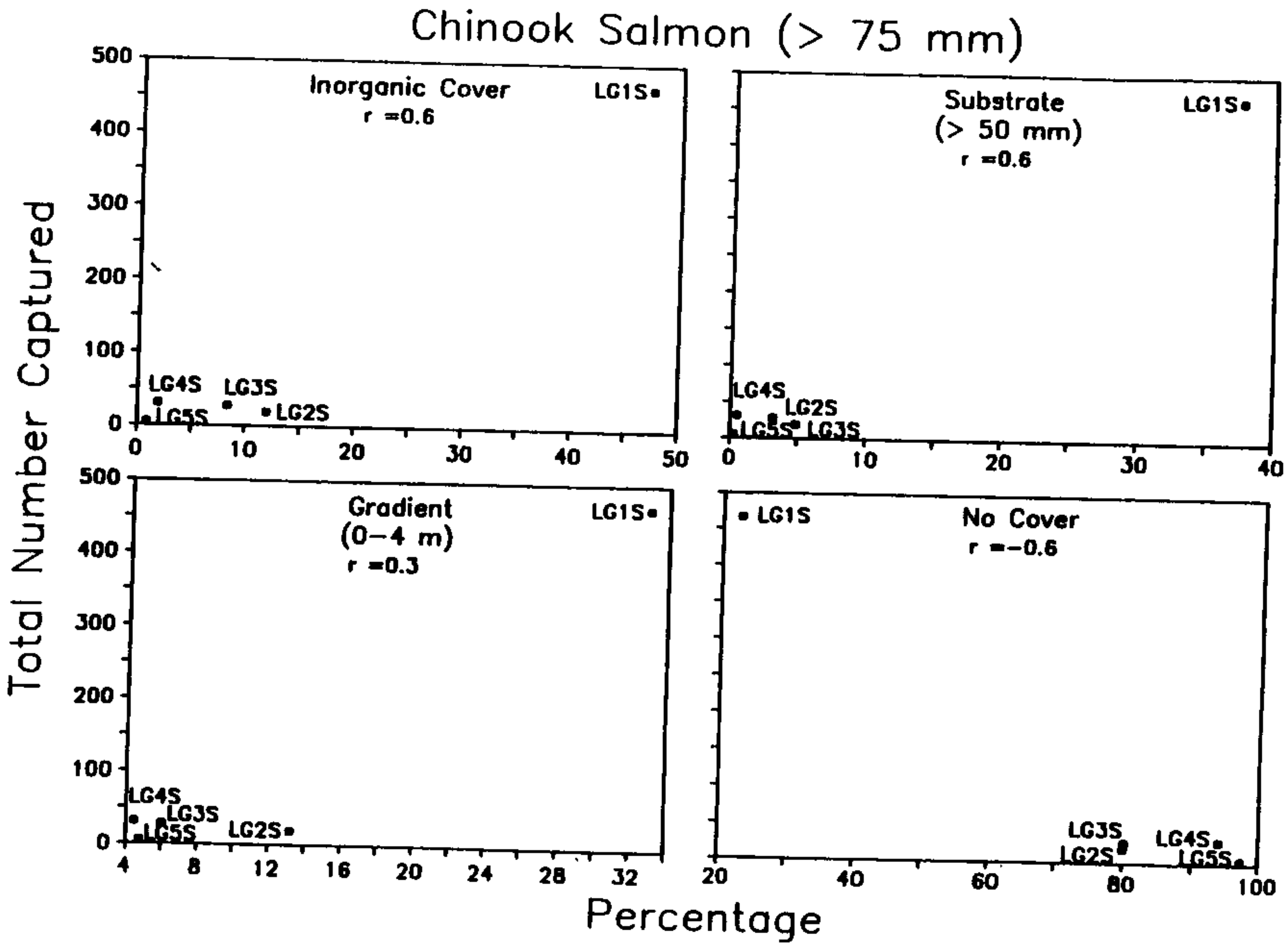

Figure 56. Chinook salmon (> 75 mm) abundance versus habitat charactersitics at shallow water stations during spring, 1987, Lower Granite Reservoir, Washington. The r^2 value represents the Spearman rank correlation coefficient.

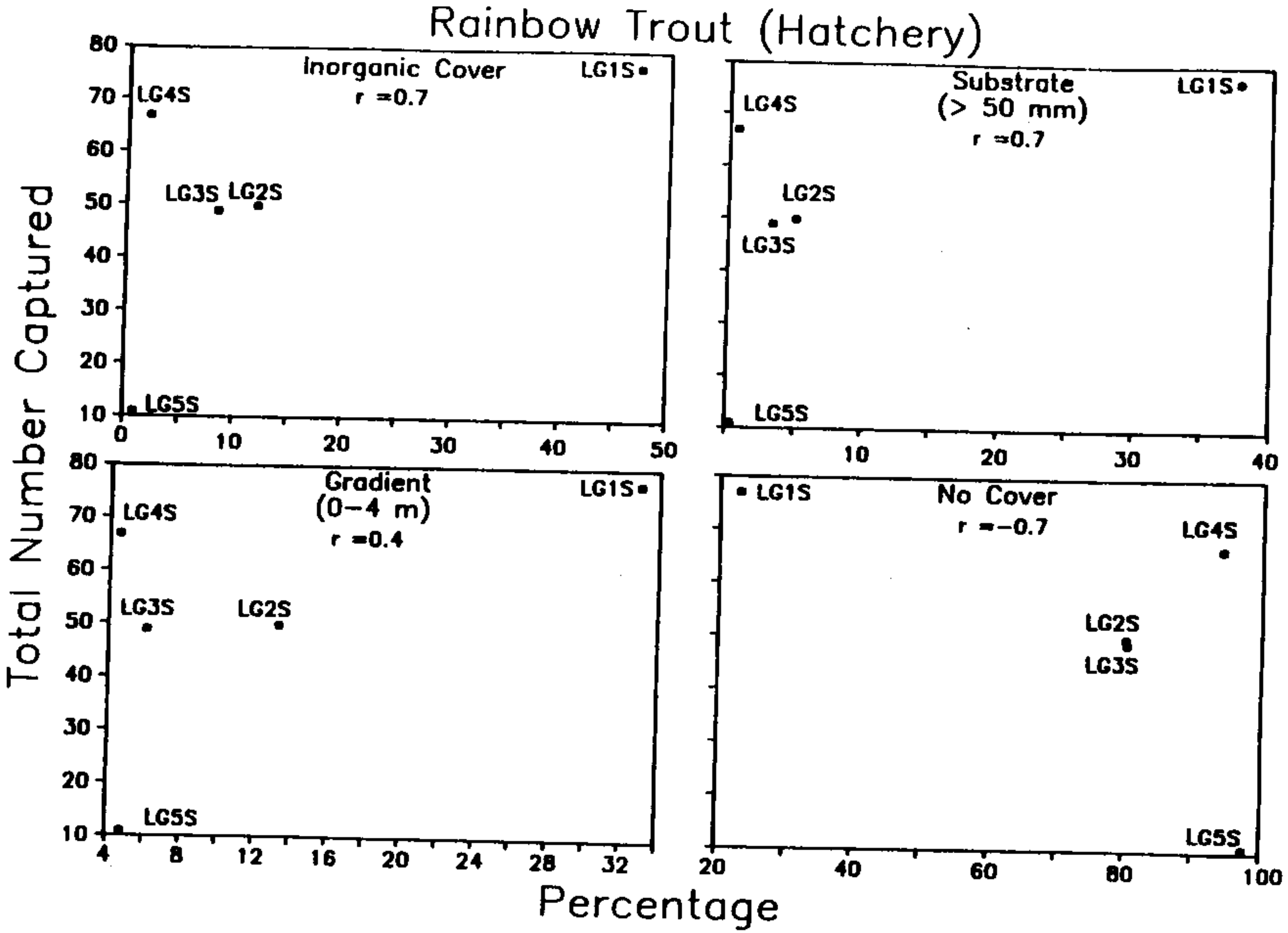

Figure 57. Rainbow Trout (hatchery) abundance versus habitat charactersitics at shallow water stations during spring, 1987, Lower Granite Reservoir, Washington. The r^2 value represents the Spearman rank correlation coefficient.

Objective 3. To evaluate incidence of predation on juvenile salmonid fishes in shallow water habitat.

Methods

Food habit information was collected seasonally. Fish collection in the five shallow water sites consisted of daytime beach seining, night and day electrofishing, and limited gillnetting at LG2S. Stomachs were sampled with a stomach lavage apparatus similar to that described by Seaberg (1957). This method had been proven effective for juvenile salmonids greater than 100 mm (Bennett and Shrier 1986), as well as smallmouth bass (Bennett and Dunsmoor 1986; Bennett et al. 1983; Gray et al. 1984). The apparatus flushes stomach contents out of the mouth where they were strained through a fine meshed net and preserved in FAA (10% Formalin, 40% Alcohol, 2% Acetic Acid, 48% Distilled Water). This apparatus is not effective for northern squawfish or channel catfish (Bennett et al. 1983, Gray et al. 1984). Digestive tracts of these fish were removed and preserved in FAA for later laboratory dissection.

Lengths chosen for predator stomach analysis were decided on from research conducted on John Day Reservoir. For smallmouth bass, Gray et al. (1984) reported that salmonids were found in the stomachs of smallmouth bass from 150 mm to 343 mm in length, so only fish greater than 150 mm were sampled. Gray et al. (1984) also reported that the importance of fish in the diet of northern squawfish steadily increases with size for squawfish exceeding 300 mm in length and found salmonids in squawfish as small as 324 mm. Based on this information, a size limit of 250 mm was imposed for sampling northern squawfish. Salmonids were found in channel catfish ranging in size from 350-600 mm (Gray et al. 1985). An arbitrary size limit of 250 mm was imposed on channel catfish collection for analysis of both incidence of predation and a general food habits description.

An index of relative importance (IRI; Pinkas et al. 1971; Bennett and Dunsmoor 1986) was used for each species to compare seasonal importance of prey items between fish species.

$IRI=(N + W) \times F$, where

N = composition (%) of a food item by number;

W = composition (%) of a food item by weight; and

F = frequency of occurrence.

All food items other than fish were identified to order. The origin of the organism (terrestrial or aquatic) also was noted. Fish were keyed to the lowest possible taxon. Bone identification keys and fish length/bone length regressions (Unpublished data; USFWS, National Fishery Research Center - Willard Field Station) were used when appropriate to identify and estimate lengths of heavily digested fish.

Weights used in the IRI were estimated live weights. All organisms (other than fish) that were visibly alike and in good condition were grouped and an average wet weight was used to estimate the live weight for that group. Organisms were blotted dry for a standard drying time of 60 seconds. Fresh fish weights were estimated by length-weight regressions on fish species from John Day Reservoir on the Columbia River (Palmer et al. 1986). Weights of partially digested fish were estimated by using length estimates from fish length/bone length regressions in length-weight regressions.

Results

Information on predation and general food habits is covered under Objective 4 in the report by Bennett et al. (1988).

Resident Predation on Juvenile Salmonids

During the spring smolt out-migration, stomachs of 261 smallmouth bass, 80 northern squawfish, and 20 channel catfish were examined to assess the incidence of predation on juvenile anadromous salmonids. Discarding the empty stomachs from the analysis, sample sizes were reduced to 195 smallmouth bass, 59 northern squawfish, and 18 channel catfish (Appendix Tables F-H).

Smallmouth Bass.-Seven (3.6%) of the bass contained salmonids. One bass contained rainbow trout, four (2.1%) contained chinook salmon, and two contained unidentifiable salmonids. An average of 1.75 chinook per stomach was observed for bass containing chinook, although this number was inflated as a result of one 475 mm bass which contained four chinook salmon smolts. Total lengths of bass containing salmonids ranged from 165 to 475 mm (Figure 58).

The bass containing rainbow trout was 297 mm total length and the ingested rainbow was 188 mm total length (Table 11). When compared to trout lengths captured by all sampling gear during the spring season, the ingested trout was smaller than the average length (Figure 59).

Ingested chinook salmon averaged 108 mm, ranged from 51 to 125 mm fork length, and were smaller than the average length of all chinook sampled during our survey (Figure 60). Bass ingesting chinook salmon had total lengths ranging from 185 to 475 mm (Table 11).

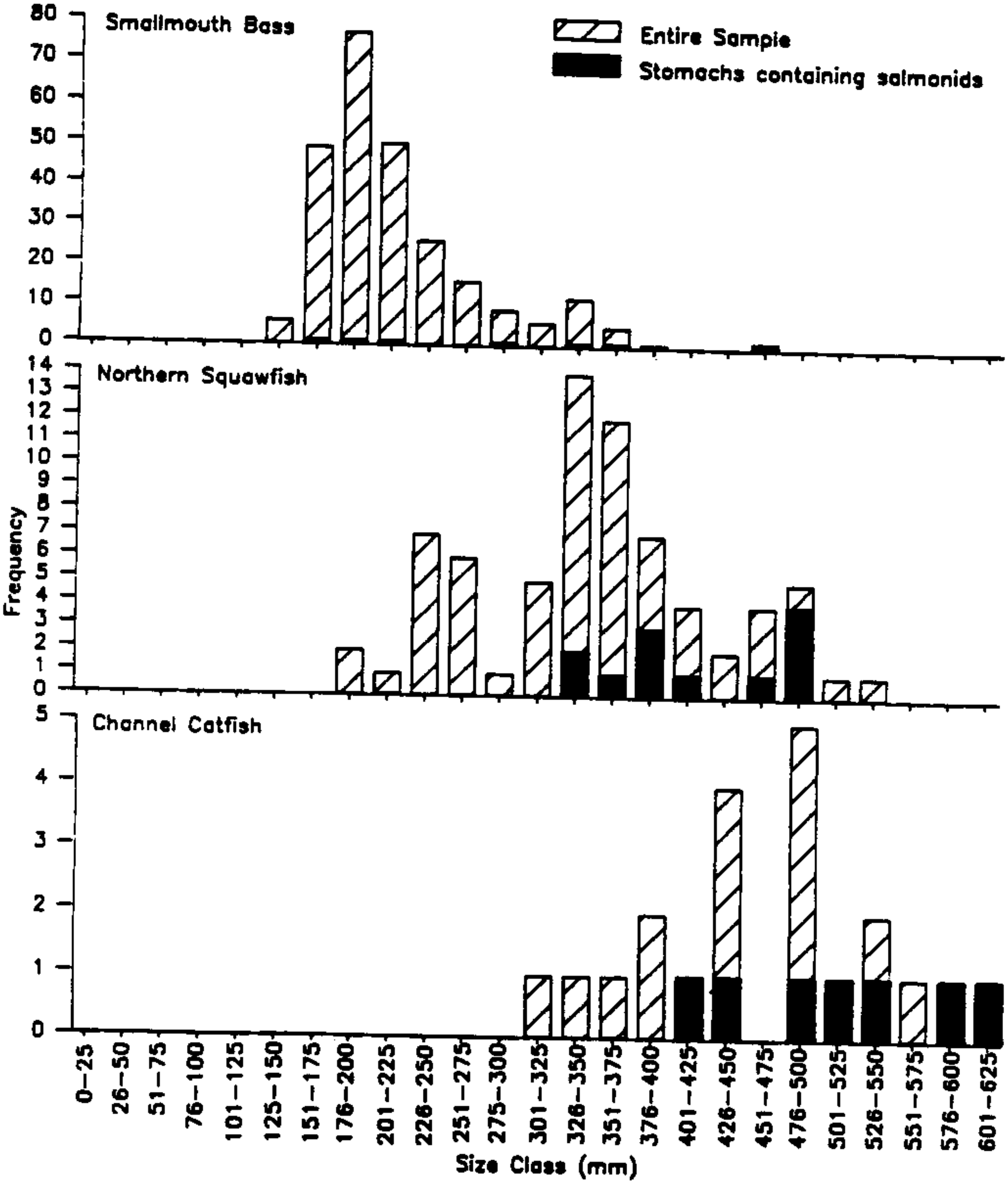

Figure 58. Length frequencies of predators examined for stomach analysis during spring, 1987, Lower Granite Reservoir. Black histograms represent length frequencies of predators that contained salmonids.

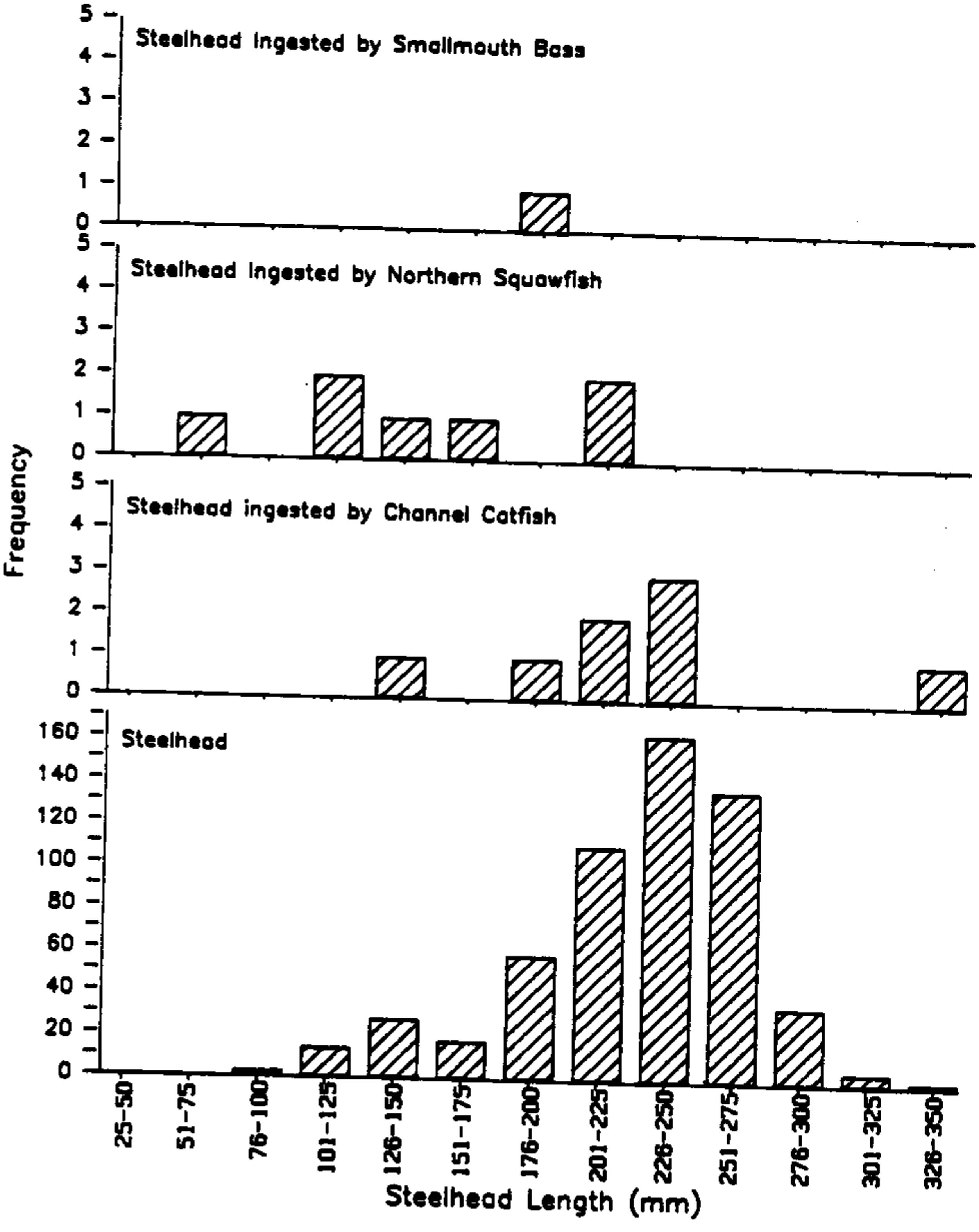

Figure 59. Length frequencies of rainbow trout collected by all sampling gear at deep, mid-depth, and shallow stations during spring, 1987, Lower Granite Reservoir, Washington, and those ingested by smallmouth bass, northern squawfish, channel catfish.

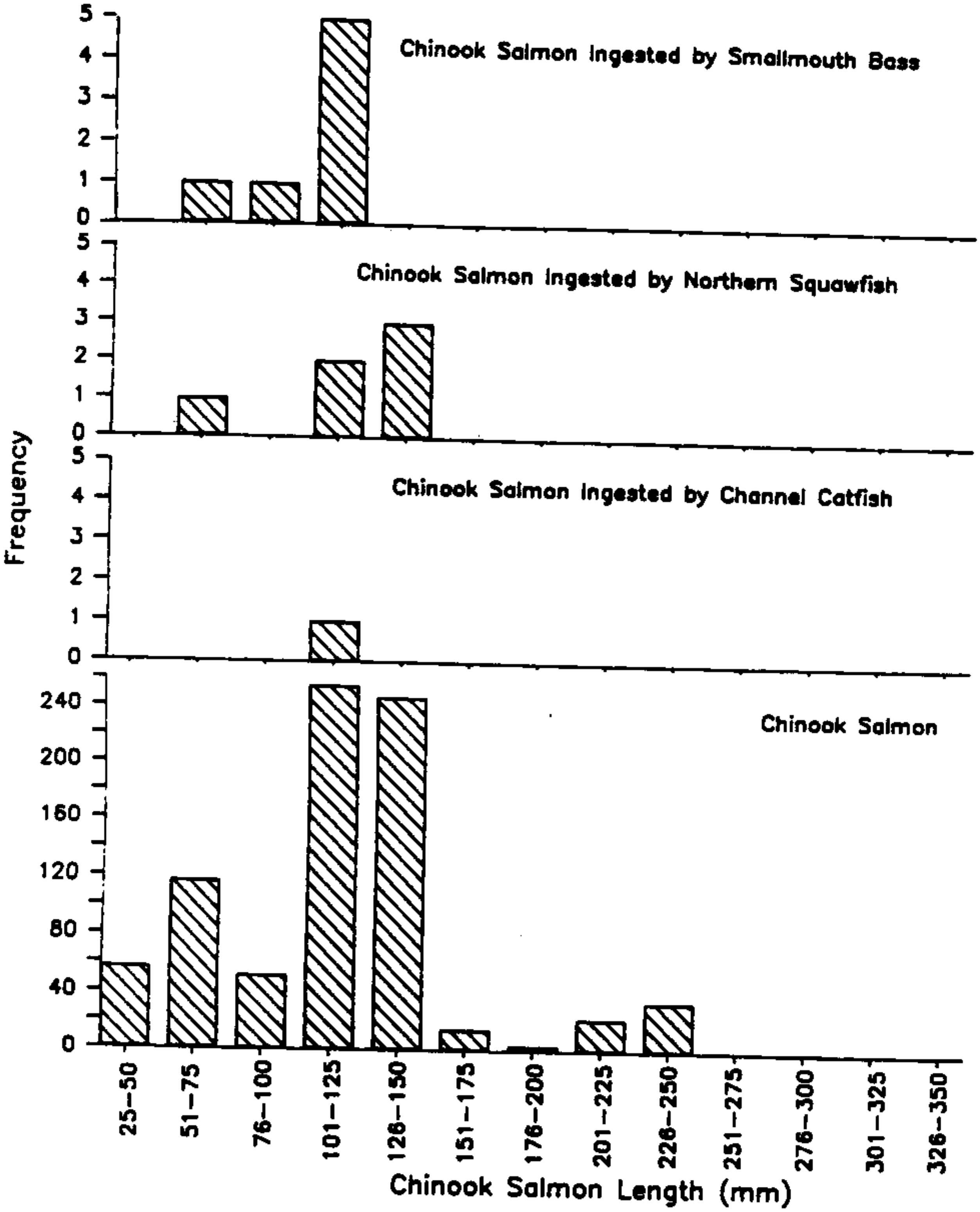

Figure 60. Length frequencies of chinook salmon collected by all sampling gear at deep, mid-depth, and shallow stations during spring, 1987, Lower Granite Reservoir, Washington, and those ingested by smallmouth bass, northern squawfish, channel catfish.

Table 11. Summary of salmonid predation observed in the spring stomach samples by predator, station, predator length, and ingested salmonid length.

Predator	Station[1]	Date Predator Captured	Day/Night	Predator Length (mm)	Ingested Chinook Length (mm)	Ingested Steelhead Length (mm)	Ingested Unknown Length (mm)
Smallmouth Bass							
	LG1S	6Jun87	N	330			*
	LG2S	15Apr87	D	368	125		
			D	475	121		
					101		
					131		
					128		
		6Jun87		297		188	
			N	165			*
	LG3S	23Apr87	D	340	129		
	LG4S	9May87		185			
Northern Squawfish							
	LG2S	1May87		490	131		
				387		138	
						121	
				393			*
				*		163	
	LG1M	4Apr87	N	361	131		
					138		
		7May87	D	499		210	
		19May87	N	415	138		
	LG2M	27Apr87		485	69		
		15May87				347	
		24May87		394	145		
	LG3M	5May87		332			*
		16May87		472		193	
	LG1D	15May87		493		95	
Channel Catfish							
	LG2M	24May87		402			*
				612		242	
		12May87	D	600		228	
		29May87		535		240	
						228	
	LG3M	4May87	N	430	120		
				521		245	
						344	
							*
	LG2D	5May87		493		199	
						146	

* no length available

[1] LG1M, LG2M, LG3M (mid depth), LG1D,LG2D (deep) stations (Bennett et al. 1988)

Northern Squawfish.-Thirteen (22%) northern squawfish contained one or more salmonids; 6 squawfish contained steelhead, 5 contained chinook salmon, and 2 contained unidentifiable salmonids. An average of 1.2 rainbow trout and chinook salmon were observed per stomach from squawfish containing salmonids. No squawfish with salmonids in their stomachs contained both salmonid species. In general, squawfish containing salmonids were large (331 to 499 mm; Figure 58).

Northern squawfish consuming rainbow trout ranged in length from 331 to 499 mm (Table 11). Trout ingested by squawfish averaged 155 mm and ranged from 89 to 214 mm in fork length and were below the overall average size of steelhead sampled during the spring (Figure 59).

Northern squawfish containing chinook salmon ranged in total length from 361 to 485 mm (Table 11). Ingested chinook averaged 120 mm and ranged from 67 to 132 mm in fork length, and were similar to the length distribution of chinook captured during spring sampling (Figure 60).

Channel catfish.-Seven (38.9%) channel catfish contained salmonids. Five (27.8%) contained rainbow trout, one (5.5%) contained a chinook, and one (5.5%) an unidentifiable salmonid. Lengths of channel catfish ingesting salmonids ranged from 402 to 612 mm (Figure 58). We observed an average of 1.8 trout per stomach in catfish containing rainbows.

Catfish containing rainbows ranged in total length from 493 to 612 mm (Table 11). Ingested trout averaged 232 mm and ranged from 138 to 328 mm in fork length (Figure 59); one was not measurable. The single chinook salmon (115 mm) was ingested by a 430 mm catfish (Table 11).

Discussion

Intensive habitat sampling of shallow stations during 1987 confirmed earlier speculations about the characteristics of the physical habitat in Lower Granite Reservoir. Use of snorkeling provided valuable information about the qualitative and quantitative aspects of cover and substrate.

On-site velocity profiles were always near shore, and generally a relatively large distance from the channel. As in a riverine environment, most water moving through Lower Granite travels downstream along the old river channel, while water along the shorelines frequently forms back-eddies and random currents. Velocity in such-near shore areas shows no clear relationship to "inputs" or "outputs" of water into or from the reservoir; rather, these areas show a clear relationship to velocities in nearby deeper areas (i.e. midway and channel velocity profiles) suggesting a relatively predictable degree of velocity dissipation as distance from the channel increases, coincident with a decrease in depth. Regardless of the regulating factors, observed velocities in Lower Granite Reservoir were relatively low. Such low velocities probably have little influence on resident fish distribution and habitat use. However, low velocities can significantly delay smolt out-migrations as well as increase exposure of juvenile salmonids to predators as much as three times their original availablilty in a riverine environment (Ebel 1977). We did not measure water velocities during the peak of the smolt outmigration. However, due to the nature of the "low water" year of 1987, we suspect lower than "normal" velocities occurred.

Substrate sampling with the ponar dredge provided information on substrate characteristics of the various shallow stations. Substrate was similar among LG2S, LG3S, LG4S and LG5S but rather different at LG1S.

Specifically, the proportion of sand decreased downstream to LG2S, while the proportion of particles smaller than sand increased from upstream to downstream. At LG1S, the predominance of gravel sized particles and hard packed fines explained our inability to sample effectively with a ponar dredge. LG1S had more inorganic and organic cover than any of the other shallow stations. Another feature of LG1S that possibly affected fish abundance was the relatively steep shoreline gradient. Proximity of deep water at LG1S, as demonstrated by morphometric maps and the hypsographic curves, possibly affected utilization by certain species of fish. Other features such as temperature, dissolved oxygen and turbidity were similar among stations.

Biologically, the shallow stations were similar in some respects and very different in others. Benthic community standing crops and composition were very similar among shallow stations as well as mid depth and deep stations in Lower Granite Reservoir (Bennett et al. 1988). However, because of substrate characteristics, we were unable to effectively sample LG1S. Substrate differences should affect benthic abundance and community structure (Wetzel 1975). Large substrates typically support attached organisms while the finer substrates support burrowing forms. Attached organisms are more readily available for consumption than burrowing forms.

Fish community differences among stations were significant. Fall chinook salmon (< 75 mm) seemed to prefer low gradient sandy shorelines, and attained highest abundance at stations that provided such habitat (LG4S and LG5S). The only significant positive correlation between abundance of fall chinook salmon (< 75 mm) and shallow station habitat attributes was provided by the proportion of no cover. Bennett and Shrier (1986) also noted that areas with no apparent cover had high abundances of juvenile chinook salmon. They hypothesized that predators were less successful in capturing salmonids in areas with no cover. Although we cannot make definitive statements about predator success, our collections of adult predators were lowest at stations with the least cover (LG4S and LG5S) in the spring when fall chinook juveniles are using these areas.

In contrast, spring and summer chinook salmon (> 75 mm) attained highest abundance at LG1S, the station with the greatest amount and diversity of cover. Bennett and Shrier (1986) also found spring and summer chinook to concentrate at LG1S. A question that needs further examination is why LG1S is such an attractive area for spring and summer chinook salmon. One possibility is that larger salmon are more able to evade predators and are available to fewer predators because of their size. As a result, larger chinook smolts may be willing to use more complex habitats where detection of predators may be less efficient.

Although we found significant correlations between habitat attributes of substrate, cover, and gradient and fall chinook salmon abundance, the question of factors affecting fish abundance remains. Is location in the lower reservoir the major factor affecting abundance of spring and summer chinook salmon in shallow water areas, or is it habitat? Because we do not have other shallow habitat types represented in the lower reservoir we can not answer this question. It was interesting, however, that day captures of chinook salmon were very high at LG1S but night captures were low. This could indicate that the lower reservoir is functioning as a staging area for out-migration and the majority of fish in this section leave in the evening. Chinook salmon at other stations may hold more at night until their motivation for out-migration increases. Regardless of why spring and summer chinook salmon inhabit LG1S, the important point is that the habitat appears to be attractive and fish are abundant.

We found several similarities in patterns of abundance between chinook salmon (>75 mm) and rainbow trout. Rainbow trout at station LG1S were significantly more abundant than at the remaining stations, whereas LG5S had the lowest abundance. However, differences observed for rainbow trout were not as dramatic as those for chinook salmon. Another similarity was that of apparent nighttime use of these areas. Stations LG1S dropped from the highest in chinook and trout abundance to fourth in abundance in nighttime catches. As with chinook salmon, is location in the reservoir the major factor determining abundance in shallow water areas, or is it habitat? Without a series of shallow stations in the lower reservoir, we can only speculate about habitat. We found no significant correlations (Spearman's Rho) between individual habitat parameters and hatchery steelhead abundance, although significant positive correlations were found for wild steelhead and proportions of inorganic cover and relatively large (> 50 mm) substrate. Again, decreased availability to predators may be one reason why the larger wild steelhead occupy more complex habitats as opposed to the tendency for smaller fall chinook to occupy areas with little cover.

A high number of rainbow trout residualized during the spring 1987 out-migration. Fish that survived into the summer provided highest catches at LG1S. At stations LG4S and LG5S, two stations with relatively low habitat diversity, residual rainbows were absent. This pattern of distribution was similar during the fall months as in the summer with LG1S also providing the highest catch rates of residual rainbow trout.

One rather different finding during 1987 was the lack of chinook salmon in the late fall and winter catches in Lower Granite Reservoir. In the 1985 survey, Bennett and Shrier (1986) reported that salmon pre-smolts were abundant in Lower Granite. In contrast, we captured only one chinook salmon (LG2S) in the fall and winter, although we only sampled into January. Flow differences or different hatchery release strategies may have accounted for the differences.

Predator abundance varied among the shallow stations. Of the three potential predator species on salmonids, only northern squawfish and smallmouth bass were present in shallow waters except at LG2S where channel catfish were caught in gillnets (Bennett et al. 1988). Bennett and Shrier (1986) also found channel catfish only at LG2S (SR2S), despite sampling with gillnets at four other shallow stations.

Smallmouth bass longer than 150 mm were captured at all shallow stations during the spring and summer seasons. During spring, stations LG1S consistently had the highest catches of bass followed by LG3S for both day and night. Abundance of riprap at LG1S provides attractive habitat for smallmouth. Numerous authors have reported that smallmouth bass prefer habitat with relatively large substrate, ample cover and near steep gradients (Coble 1975; Edwards et al. 1983; Scott and Crossman 1973; Becker 1983). Higher abundance of smallmouth bass at LG3S than at LG2S, LG4S, and LG5S during the spring was also probably related to habitat. Although habitat at LG3S was notably less diverse than LG1S, a moderate proportion of substrates between 2 to 75 mm occurred (Figure 14). These substrates were typically near shore between the 0-2 m contours. Abundance of smallmouths gradually increased from the middle of May to the middle of June at LG3S. During this time, water temperature were approaching 16°C, a temperature suitable for spawning (Scott and Crossman 1973). Bass prefer the type of substrate that occurs at LG3S for nest building (Coble 1975). Although LG2S also has similar proportions of substrate from 2 to 75 mm, lower bass abundance may be a result of the relatively steep gradient (14.6%), about double that at LG3S (7.8%). Paucity of gravel substrate at LG4S and LG5S may explain the relatively low numbers of larger bass at these stations.

Our catches of larger bass at shallow stations during the summer were similar. Highest captures were at LG3S (Figure 48). Based on available habitat, we expected higher abundance of larger bass at LG1S; however, catches at LG1S were lowest of all stations. Fishing mortality at LG1S may be responsible for this low number. LG1S is adjacent to a park and boat ramp that receives heavy fishing during the summer. Also, higher numbers of bass at upriver stations may reflect a foraging strategy on YOY forage fish. For example, catostomids contributed 26.3% of the total importance of prey items in the smallmouth bass diet (Bennett et al. 1988). Stations LG4S and LG5S have the highest abundance of YOY fishes.

Catches of smallmouth bass in the fall and winter were low at all shallow stations. Coble (1975) reported that bass typically move to deeper water as temperatures decrease below 15°C. Lower catches at this time are probably the result of reduced bass activity while in deeper waters.

Catches of adult northern squawfish (>250 mm) by beach seining and electrofishing were relatively low and variable at shallow stations during all seasons. However, gillnet catch rates at LG2S indicated that squawfish maintained relatively high species abundance in the offshore areas and catch rates were comparable to gillnet catches at mid depth stations (Bennett et al. 1988). Larger squawfish also were found in offshore areas of shallow stations in previous studies (Bennett and Shrier 1986, 1987) based on gillnet catches. Adult squawfish at shallow water stations may prefer offshore areas. However, except at LG2S, gear we used did not effectively sample offshore areas of the shallow stations, so definitive statements about habitat preferences are not possible.

Smallmouth bass was the dominant predator captured at shallow water stations. Highest numbers of smallmouth bass and salmonids during the spring season were both at LG1S. However, bass predation was apparently low as few salmonids appeared in stomachs from this or any other shallow station. Our findings showed a frequency of occurrence of 3.6% juvenile salmonids in stomachs that contained food. In Little Goose Reservoir, Bennett et al. (1983) reported a frequency of occurrence of juvenile salmonids in bass stomachs of 2.0%. Bennett and Shrier (1986) found that 26% of the weight of all prey items in bass stomachs were salmonids which was comparable to our findings (27.6%). Researchers at John Day Reservoir (lower Columbia River) reported variation in frequency of occurrences from 2.2% (April through December; Gray et al. 1984) to 3.7% (April through September; Gray et al. 1985). Although the weight of salmonids relative to other food items appears significant, our findings suggest that smallmouth bass do not appear to be a major predator on juvenile salmonid fishes in Lower Granite Reservoir.

Few predator-sized northern squawfish (>250 mm) were captured at shallow stations. Although LG2S was the only shallow station at which juvenile salmonids were observed in squawfish stomachs, this was also the only station where we gillnetted. Several larger squawfish captured at mid depth stations contained salmonids.

Frequency of occurrence of salmonids in stomachs of northern squawfish containing food items was 22% compared to 19% reported for Little Goose Reservoir (Bennett et al. 1983). Bennett and Shrier (1986) reported that 13.8% of the weight of prey items found in northern squawfish was salmonids, considerably lower than our findings (65.6%). Findings from John Day Reservoir reported that weight of salmonids in squawfish diets ranged from 30.9% (April through December; Gray et al. 1984) to 68.8% (April through September; Gray et al. 1986). Frequencies of occurrence for these years were 9.8% and 27% respectively. They also reported that salmonid predation increased with squawfish length. Squawfish longer than 400 mm consumed 4 to 5 times more salmonids than squawfish less than 400 mm.

Channel catfish predation on juvenile salmonids was not observed at shallow stations but was high at both mid depth and deep stations (Bennett et al. 1988). Frequency of occurrence (38.9%) was high relative to northern squawfish and smallmouth bass. Although our sample sizes were small, results are comparable to those in Little Goose reservoirs. Bennett et al. (1983) reported the frequency of occurrence of salmonids was 41% in Little Goose Reservoir. Reported percent frequencies of occurrence of salmonids in channel catfish from John Day Reservoir vary from a low of 1.5% (June through October; Gray et al. 1984) to 12.4% (April through September; Gray et al. 1986). Palmer et al. (1986) reported that only catfish larger than 400 mm were found to contain salmonids, which is similar to our data; the smallest catfish from Lower Granite Reservoir which contained a salmonid was 402 mm.

Measures of habitat and fish abundance at shallow stations may provide insight into the nature of shallow areas created by dredge fill. Due to the nature of the dredge material (i.e. sand and other fines), we expect the physical habitat (i.e. substrate and cover) of created shallow areas to resemble stations LG4S and LG5S. A few subtle difference may exist such as gradient and overall mean depth. Stations LG4S and LG5S appear to be valuable habitat for fall chinook salmon and resident YOY fish. Observed abundances of rainbow trout and spring and summer chinook salmon indicate a possible preference for a more complex habitat similar to LG1S. Careful monitoring of the created shallow areas in lower portions of the reservoir may help evaluate importance of habitat attributes vs. location in the reservoir in determining habitat use by salmonids.

Bass predation on juvenile salmonids appears minor in shallow areas, and channel catfish seem to prefer habitat provided by mid depth and deep stations (Bennett et al. 1988). Northern squawfish seem to be the dominant predator on salmonids in Lower Granite Reservoir. However, predation on juvenile salmonids and habitat use by northern squawfish in shallow water habitats is not fully understood. Careful monitoring may provide important insights into squawfish predation dynamics and habitat use in created shallow water habitats.

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Appendix Table A . A summary of the morphometric variables measured at the shallow stations, Lower Granite Reservoir, Washington.

Morphometric Variables	Station				
	LG1S	LG2S	LG3S	LG4S	LG5S
Shoreline Length (km)	0.51	1.0	0.6	0.6	0.7
Shoreline Diversity Index	1.19	1.18	1.35	1.14	1.03
Mean Depth (m)	3.46	3.74	3.14	2.40	3.04
Total Surface Area (m2)	14,089	136,187	51,744	101,691	110,511
Total Volume (m3)	48,770	509,143	162,278	243,945	336,299
Volume (0-2 m; m3)	24,741	252,620	88,822	169,606	191,375
Volume (2-4 m; m3)	16,289	190,299	54,797	67,326	105,214
Mean Percent Gradient (0-2 m)	36.7	14.6	7.8	6.2	5.3
Mean Percent Gradient (2-4 m)	29.1	11.8	4.2	2.7	4.2

Appendix Table B. Size delineations used in underwater systematic survey to quantify cover and substrate characteristics of shallow stations, Lower Granite Reservoir, Washington, 1987.

Substrate			Cover (Organic and Inorganic)	
No.	Description	Size (mm)	No.	Size(mm)
1	Fines	< 2	1	5 - 25
2	Small Gravel	2 - 25	2	26 - 50
3	Medium Gravel	26 - 50	3	51 - 100
4	Large Gravel	51 - 75	4	101 - 200
5	Small Cobble	76 - 150	5	201 - 400
6	Medium Cobble	151 - 225	6	> 400
7	Large Cobble	226 - 300		
8	Small Boulder	301 - 600		
9	Large Boulder	>600		

Appendix C. Catch per 15 minute transect from daytime electrofishing during spring, for all species and stations, in Lower Granite Reservoir, Washington, 1987. Catch rates were calculated within length classes which differed among species. Length class 1 represents sub-adults for key species (ATR < 500 mm, ONE and OTS < 200 mm, SGA < 350 mm, POR and IPU < 250 mm, and MDO < 150 mm) and young-of-the-year (YOY) for all other species (< 100 mm). Length class 2 represents adults for key species and non-YOY for all other species. See Table 9 for species codes.

Appendix Table 1. Catch / 15 Minute Transect

Gear - Day Electrofishing Station - LG1S Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	MDO	PNI
		Species										
4/15	1										5.00	
	2									8.00	6.00	
	Total									8.00	11.00	
4/23	1		2.00								9.00	
	2			1.00						1.00	6.00	
	Total		2.00	1.00						1.00	15.00	
4/28	1	4.00	2.00								16.00	
	2			2.00					1.00	10.00	18.00	
	Total	4.00	2.00	2.00					1.00	10.00	34.00	
Spring Mean		1.33	1.33	1.00					0.33	6.33	20.00	

Appendix Table 2. Catch / 15 Minute Transect

Gear - Day Electrofishing Station - LG2S Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	POR	RBA	CCO	CNA	MDO	PNI	PFL
		Species										
4/15	1	1.00	1.00									
	2								7.00	3.00		
	Total	1.00	1.00						7.00	3.00		
4/23	1	2.00	6.00							1.00		
	2								11.00			1.00
	Total	2.00	6.00						11.00	1.00		1.00
4/28	1											
	2								1.00			
	Total								1.00			
Spring Mean		1.00	2.40						6.30	13.33		3.33

Appendix Table 3. Catch / 15 Minute Transect

Gear - Day Electrofishing Station - LG3S Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	LGI	MDO	PAN	PNI	PFL
4/23	1	1.00													
	2				3.00					5.00		2.00			
	Total	1.00			3.00					5.00		2.00			
4/28	1														
	2				3.00					4.00		1.00			
	Total				3.00					4.00		1.00			
Spring Mean		0.50			3.00					4.50		1.50			

Appendix Table 4. Catch / 15 Minute Transect

Gear - Day Electrofishing Station - LG4S Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	MDO	PAN	PFL
4/15	1	1.00	1.00									
	2				4.00				2.00			
	Total	1.00	1.00		4.00				2.00			
4/23	1											
	2				2.00				2.00			
	Total				2.00				2.00			
4/28	1											
	2									1.00		
	Total									1.00		
Spring Mean		0.33	0.33		2.00				1.33	0.33		

Appendix Table 5. Catch / 15 Minute Transect

Gear - Day Electrofishing Station - LG55 Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	MDO	PNI
		Species										
4/15	1											
	2				1.00					1.00		
	Total				1.00					1.00		
4/23	1											
	2									2.00		
	Total									2.00		
4/28	1											
	2										1.00	
	Total										1.00	
Spring Mean					0.33					1.00	0.33	

Appendix D. Catch per 15 minute transect from nighttime electrofishing during spring and fall, for all species and stations, in Lower Granite Reservoir, Washington, 1987. Catch rates were calculated within length classes which differed among species. Length class 1 represents sub-adults for key species (ATR < 500 mm, ONE and OTS < 200 mm, SGA < 350 mm, POR and IPU < 250 mm, and MDO < 150 mm) and young-of-the-year (YOY) for all other species (< 100 mm). Length class 2 represents adults for key species and non-YOY for all other species. See Table 9 for species codes.

Appendix Table 1. Catch / 15 Minute Transect

Gear - Night Electrofishing Station - LG1S Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	MDO	PNI
4/21	1	1.00	2.00								6.00	
	2			8.00				1.00	1.00	27.00	11.00	
	Total	1.00	2.00	8.00				1.00	1.00	27.00	17.00	
4/28	1		1.00								2.00	
	2			10.00		1.00		2.00	5.00	39.00	4.00	
	Total		1.00	10.00		1.00		2.00	5.00	39.00	6.00	
5/05	1		6.00								9.00	
	2			7.00						21.00	17.00	1.00
	Total		6.00	7.00						21.00	27.00	1.00
5/12	1		4.00								11.00	
	2									12.00	7.00	
	Total		4.00							12.00	18.00	
5/21	1										5.00	
	2			2.00					2.00	4.00	11.00	
	Total			2.00					2.00	4.00	16.00	
6/01	1		2.00								22.00	
	2								5.00	11.00	11.00	
	Total		2.00						5.00	11.00	33.00	
6/09	1		1.00								1.00	
	2			2.00			1.00		4.00	14.00	2.00	
	Total		1.00	2.00			1.00		4.00	14.00	3.00	
Spring Mean		0.14	2.29	5.29		0.14	0.14	0.43	2.43	18.29	17.14	0.14

Appendix Table 2. Catch / 15 Minute Transect

Gear - Night Electrofishing Station - LG2S Season - Spring

		Species										
Date	Length Class	OTS	SGA	AAL	CCA	POR	RBA	CCO	CNA	MDO	PNI	PFL
4/21	1	15.00	5.00			3.00				1.00		
	2			9.00					11.00		3.00	
	Total	15.00	5.00	9.00		3.00			11.00	1.00	3.00	
4/28	1	12.00	2.00	2.00		3.00						
	2			6.00			1.00		4.00			2.00
	Total	12.00	2.00	8.00		3.00	1.00		4.00			2.00
5/05	1		2.00			2.00			1.00			
	2			5.00					5.00			
	Total		2.00	5.00		2.00			6.00			
5/12	1	1.00	2.00	3.00		1.00			2.00	1.00		
	2			10.00	1.00			1.00	8.00	1.00		
	Total	1.00	2.00	13.00	1.00	1.00		1.00	10.00	2.00		
5/21	1	1.00	1.00			1.00						
	2			6.00		2.00			1.00	3.00		
	Total	1.00	1.00	6.00		3.00			1.00	3.00		
6/01	1					1.00				1.00		
	2			3.00					4.00	1.00		
	Total			3.00		1.00			4.00	2.00		
6/09	1							1.00		2.00		
	2			1.00					2.00	5.00		
	Total			1.00				1.00	2.00	8.00		
Spring Mean		4.14	1.71	6.43	0.14	1.86	0.14	0.29	5.43	2.29	0.43	0.29

Appendix Table 3.   Catch / 15 Minute Transect

Gear - Night Electrofishing   Station - LG3S   Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	NCA	POR	RBA	CCO	CMA	LGI	MDO	PAN	PNI	PFL
4/21	1	5.00	10.00												
	2			4.00						6.00		1.00	1.00		
	Total	5.00	10.00	4.00						6.00		1.00	1.00		
4/28	1	3.00	2.00			1.00				1.00					
	2							1.00		5.00		2.00		1.00	
	Total	3.00	2.00			1.00		1.00		6.00		2.00		1.00	
5/05	1	2.00	2.00					1.00							
	2							2.00		6.00		1.00			
	Total	2.00	2.00					3.00		6.00		1.00			
5/12	1	2.00					1.00		1.00	3.00					1.00
	2			2.00			1.00	1.00		8.00	1.00	8.00			
	Total	2.00		2.00			2.00	1.00	1.00	11.00	1.00	9.00			1.00
5/21	1		7.00				1.00			5.00					
	2			1.00						7.00		7.00	1.00		
	Total		7.00	1.00			1.00			12.00		7.00	1.00		
6/01	1	1.00	22.00							2.00		1.00			
	2			3.00						4.00		14.00		1.00	
	Total	1.00	22.00	3.00						6.00		15.00		1.00	
6/09	1		1.00												
	2			2.00			1.00			4.00		8.00			
	Total		1.00	2.00			1.00			4.00		8.00			
Spring Mean		1.86	6.30	1.71		0.14	0.57	0.71	0.14	7.29	0.14	6.14	0.29	0.29	0.14

Appendix Table 4. Catch / 15 Minute Transect

Gear - Night Electrofishing Station - LG4S Season - Spring

		Species										
Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	MDO	PAN	PFL
4/21	1	6.00	18.00				2.00					
	2						1.00	1.00	9.00			
	Total	6.00	18.00				3.00	1.00	9.00			
4/28	1	3.00							2.00			
	2			1.00				1.00	3.00	3.00		1.00
	Total	3.00		1.00				1.00	5.00	3.00		1.00
5/05	1	10.00										
	2						1.00	1.00	1.00			
	Total	10.00					1.00	1.00	1.00			
5/12	1	1.00		1.00			1.00					
	2			2.00								1.00
	Total	1.00		3.00			1.00					1.00
5/21	1		3.00	1.00		1.00	2.00			1.00		
	2			3.00		1.00		2.00	5.00	4.00		
	Total		3.00	4.00		2.00	2.00	2.00	5.00	5.00		
6/01	1		1.00				2.00					
	2			4.00		1.00			5.00			
	Total		1.00	4.00		1.00	2.00		5.00			
6/09	1		3.00	1.00			3.00			1.00		
	2			1.00					2.00	2.00	1.00	2.00
	Total		3.00	2.00			3.00		2.00	3.00	1.00	2.00
Spring Mean		2.86	3.57	2.00		0.43	1.71	0.71	3.86	1.57	0.14	0.57

Appendix Table 5. Catch / 15 Minute Transect

Gear - Night Electrofishing Station - LGSS Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	MDO	PNI
		Species										
4/21	1	7.00	11.00									1.00
	2									1.00		
	Total	7.00	11.00							1.00		1.00
5/05	1	9.00	2.00				2.00					
	2									1.00		
	Total	9.00	2.00				2.00			1.00		
5/12	1		2.00									
	2			3.00							1.00	
	Total		2.00	3.00							1.00	
5/21	1		4.00	1.00		1.00	3.00	2.00	2.00	2.00		
	2			3.00					1.00	2.00	1.00	
	Total		4.00	4.00		1.00	3.00	2.00	3.00	4.00	1.00	
6/01	1		16.00									
	2								1.00	1.00	2.00	1.00
	Total		16.00						1.00	1.00	2.00	1.00
6/09	1		1.00				1.00			1.00		
	2			1.00						9.00	1.00	
	Total		1.00	1.00			1.00			10.00	1.00	
Spring Mean		2.67	6.00	1.33		0.17	1.00	0.33	0.67	2.83	0.83	0.33

Appendix Table 6. Catch / 15 Minute Transect

Gear - Night Electrofishing Station LG1S Season - Fall

Date	Length Class	SGA	MCA	POR	RBA	CCO	CMA	LGI	MDO	PAN
		Species								
10/09	1	4.00		1.00					1.00	
	2			1.00		6.00	26.00		4.00	
	Total	4.00		2.00		6.00	26.00		5.00	
10/28	1	2.00		1.00			21.00	1.00	8.00	4.00
	2			1.00		5.00		1.00		2.00
	Total	2.00		2.00		5.00	21.00	2.00	8.00	6.00
11/10	1	3.00					1.00			
	2		1.00		3.00	7.00	20.00			
	Total	3.00	1.00		3.00	7.00	21.00			
11/28	1	15.00								
	2					3.00	12.00			
	Total	15.00				3.00	12.00			
Fall Mean		6.00	0.25	1.00	0.75	5.25	20.00	0.50	3.25	1.50

Appendix Table 7. Catch / 15 Minute Transect

Gear - Night Electrofishing Station LG2S Season - Fall

Date	Length Class	SGA	AAL	POR	CCO	CMA	LMA	MDO	PAN	PNI
		Species								
10/09	1			2.00		7.00		2.00		
	2		1.00			15.00				
	Total		1.00	2.00		22.00		2.00		
10/28	1			1.00		16.00		4.00	1.00	
	2		2.00			9.00				
	Total		2.00	1.00		25.00		4.00	1.00	
11/10	1	3.00			1.00	15.00		2.00		2.00
	2			1.00	1.00	10.00				
	Total	3.00		1.00	2.00	25.00		2.00		2.00
11/28	1					9.00	1.00	1.00	1.00	
	2					5.00				
	Total					14.00	1.00	1.00	1.00	
Fall Mean		0.75	0.75	1.00	0.50	21.50	0.25	2.25	0.50	0.50

Appendix Table 8. Catch / 15 Minute Transect

Gear - Night Electrofishing Station LG3S Season - Fall

Date	Length Class	PWI	SGA	AAL	POR	RBA	CCO	CMA	LMA
		Species							
10/09	1				6.00			1.00	
	2					2.00		11.00	
	Total				6.00	2.00		12.00	
10/28	1		2.00			1.00		25.00	2.00
	2			1.00		1.00		11.00	
	Total		2.00	1.00		2.00		36.00	2.00
11/10	1		3.00				3.00	12.00	1.00
	2	3.00					1.00	5.00	
	Total	3.00	3.00				4.00	17.00	1.00
11/28	1					1.00		2.00	
	2							3.00	
	Total					1.00		5.00	
Fall Mean		0.75	1.25	0.25	1.50	1.25	1.00	17.50	0.75

Appendix Table 9. Catch 15 Minute Transect

Gear - Night Electrofishing Station LG4S Season -Fall

Date	Length Class	SGA	AAL	MCA	POR	RBA	CMA	LMA	PAN	PFL
		Species								
10/09	1		1.00	3.00	5.00		6.00	1.00	3.00	
	2				2.00		10.00			
	Total		1.00	3.00	7.00		16.00	1.00	3.00	
10/28	1		1.00		11.00	1.00	23.00		2.00	
	2					1.00	14.00		4.00	
	Total		1.00		11.00	2.00	37.00		6.00	
11/10	1	4.00			2.00		1.00			
	2						1.00			1.00
	Total	4.00			2.00		2.00			1.00
11/28	1	1.00			1.00		6.00			
	2				1.00		5.00			
	Total	1.00			2.00		11.00			
Fall Mean		1.25	0.25	0.75	2.75	0.50	7.25	0.25	2.25	0.25

Appendix Table 10.

Catch 15 / Minute Transect
Station LG5S

Gear-Night Electrofishing Season-Fall

Date	Length Class	AAL	POR	RBA	CMA
10/09	1	1.00	1.00		
	2				6.00
	Total	1.00	1.00		6.00
10/28	1				
	2	1.00			5.00
	Total	1.00			5.00
11/10	1				2.00
	2				6.00
	Total				8.00
11/28	1			6.00	5.00
	2			1.00	4.00
	Total			7.00	9.00
Fall Mean		0.50	0.25	1.75	7.00

Appendix E. Mean catch per haul from beach seining for all species, stations, and seasons in Lower Granite Reservoir, Washington, 1987. Catch rates were calculated within length classes which differed among species. Length class 1 represents sub-adults for key species (ATR < 500 mm, ONE and OTS < 200 mm, SGA < 350 mm, POR and IPU < 250 mm, and MDO < 150 mm) and young-of-the-year (YOY) for all other species (< 100 mm). Length class 2 represents adults for key species and non-YOY for all other species. See Table 9 for species codes.

Appendix Table 1. Mean Catch/Haul

Gear - Beach Seine Station - LG1S Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CMA	LGI	LMA	MDO	PNI	PFL
4/20	1	21.33	1.00			0.33					0.33	0.33		
	2													
	Total	21.33	1.00			0.33					0.33	0.33		
4/25	1	81.00	3.67	0.33		0.33	5.67							
	2				0.33		0.33					0.33		
	Total	81.00	3.67	0.33	0.33	0.33	6.00					0.33		
5/02	1	50.00	4.00	0.33			9.00	1.00	5.67			0.33	2.33	
	2			6.67				0.67	43.33			2.00	2.67	3.00
	Total	50.00	4.00	7.00			9.00	1.67	49.00			2.33	5.00	3.00
5/09	1	3.00	5.67									1.67		
	2								0.33			0.33		
	Total	3.00	5.67						0.33			2.00		
5/16	1		1.67											
	2				0.33		0.33					1.00		
	Total		1.67		0.33		0.33					1.00		
5/23	1		2.67									2.00		
	2				0.67				2.00			7.00		
	Total		2.67		0.67				2.00			9.00		
5/30	1	0.33	8.33									2.00		
	2								0.33			1.67		
	Total	0.33	8.33						0.33			3.67		
6/06	1		2.67									8.00		
	2											9.67		
	Total		2.67									17.67		
6/13	1	0.67	4.00									5.33		
	2								1.00	0.33		1.33		
	Total	0.67	4.00						1.00	0.33		6.67		
Spring Mean		17.37	3.74	0.82	0.15	0.07	1.70	0.19	5.85	0.04	0.04	4.78	0.56	0.33

Appendix Table 2. Mean Catch/Haul

Gear - Beach Seine Station - LG2S Season - Spring

Date	Length Class	Species											
		OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CNA	MDO	PNI	PFL
4/20	1	1.67	0.33			0.67			0.33	0.33			
	2		0.33							0.67			
	Total	1.67	0.67			0.67			0.33	1.00			
4/25	1		0.33	0.33		0.33	1.00			1.67			0.33
	2				0.33					0.67	0.33		
	Total		0.33	0.33	0.33	0.33	1.00			2.33	0.33		0.33
5/02	1	3.33		3.00			2.33	4.67	1.67	11.33		4.00	
	2			1.33	0.33		0.33			5.00	1.00	0.33	0.33
	Total	3.33		4.33	0.33		2.67	4.67	1.67	16.33	1.00	4.33	0.33
5/09	1	2.00	5.33				0.33						
	2						0.33						
	Total	2.00	5.33				0.67						
5/16	1	0.67											
	2				0.33		0.33				1.33		
	Total	0.67			0.33		0.33				1.33		
5/23	1												
	2									0.67	0.33		
	Total									0.67	0.33		
5/30	1	1.00					0.33						
	2				1.00								
	Total	1.00			1.00		0.33						
6/06	1		11.67										
	2				0.67						1.00		
	Total		11.67		0.67						1.00		
6/13	1		0.67										
	2				0.67					0.33	1.00		
	Total		0.67		0.67					0.33	1.00		
Spring Mean		0.96	2.07	0.52	0.37	0.11	0.56	0.52	0.22	2.30	0.56	0.48	0.07

Appendix Table 3.

Mean Catch/Haul

Gear - Beach Seine

Station - LG3s

Season - Spring

Date	Length Class	OTS	PWI	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	LGI	MDO	PNI
4/20	1	4.33		0.33			9.67	3.00	0.33	0.67				
	2	0.33				5.67	0.33				0.33			
	Total	4.67		0.33		5.67	10.00	3.00	0.33	0.67	0.33			
4/25	1	0.33		0.67	0.33			1.00	0.33					
	2												0.33	
	Total	0.33		0.67	0.33			1.00	0.33				0.33	
5/02	1	2.00		1.00	2.33		1.00	3.67	1.33	3.00	10.33			0.33
	2				0.67						5.33		0.33	
	Total	2.00		1.00	3.00		1.00	3.67	1.33	3.00	15.67		0.33	0.33
5/09	1	2.33		0.33				1.33					0.33	
	2					0.67					2.00		0.67	
	Total	2.33		0.33		0.67		1.33			2.00		1.00	
5/16	1	1.33		1.00						0.33			0.67	
	2				0.67						1.33	0.33	1.67	
	Total	1.33		1.00	0.67					0.33	1.33	0.33	2.67	
5/23	1	5.33						1.33	2.00					
	2										1.67		1.33	
	Total	5.33						1.33	2.00		1.67		1.33	
5/30	1	3.33	0.67	2.00	0.33			1.00					1.33	
	2					0.67					0.67		2.00	
	Total	3.33	0.67	2.00	0.33	0.67		1.00			0.67		3.33	
6/06	1	0.33		14.00	10.00			38.33	1.33				0.67	
	2										0.67		4.33	
	Total	0.33		14.00	10.00			38.33	1.33		0.67		5.00	
6/13	1			2.00				0.33					0.67	
	2					3.67					0.33		5.00	
	Total			2.00		3.67		0.33			0.33		5.67	
Spring Mean		2.19	0.07	2.37	1.60	1.19	1.22	5.56	0.59	0.44	2.52	0.04	2.19	0.04

Appendix Table 4.

Mean Catch/Haul

Gear - Beach Seine

Station - LG4S

Season - Spring

Date	Length Class	ONE	OTS	PWI	SGA	AAL	CCA	NCA	POR	RBA	CCO	CMA	LGI	MDO	PAN
4/20	1		1.00		0.67	0.33		0.33	0.33		0.33				
	2														
	Total		1.00		0.67	0.33		0.33	0.33		0.33				
4/25	1		1.00			1.00		0.33							
	2														
	Total		1.00			1.00		0.33							
5/02	1		11.33		1.33			2.00	7.33	1.33	1.33	8.00		0.67	
	2					0.67									0.67
	Total		11.33		1.33	0.67		2.00	7.33	1.33	1.33	8.00		0.67	0.67
5/09	1		5.33			37.00		1.00	35.67	17.67	3.33	11.00			
	2					0.33				0.33		0.33		4.00	
	Total	0.33	5.33			37.33		1.00	35.67	18.00	3.33	11.33		4.00	
5/16	1		19.33		0.33			1.00	1.00			0.33		0.33	
	2											0.33	0.33	1.67	0.33
	Total		19.33		0.33			1.00	1.00			0.67	0.33	2.00	0.33
5/23	1		1.67												
	2						0.33							0.67	
	Total		1.67				0.33							0.67	
5/30	1		2.00	9.33	0.33	0.33				1.00		0.33			
	2											0.33		0.67	
	Total		2.00	9.33	0.33	0.33				1.00		0.67		0.67	
6/06	1		2.33	13.67	8.33	2.33			3.67	3.00		0.67			
	2					1.33					0.33	3.33		0.67	
	Total		2.33	13.67	8.33	3.67			3.67	3.00	0.33	4.00		0.67	
6/13	1				12.67				1.67		0.33				
	2						1.00				0.33	1.67		0.33	
	Total				12.67		1.00		1.67		0.67	1.67		0.33	
Spring Mean		0.04	4.89	2.56	2.63	4.81	0.15	0.52	5.52	2.59	0.67	2.93	0.04	1.00	0.11

Appendix Table 5. Mean Catch/Haul

Gear - Beach Seine Station - LGSS Season - Spring

Date	Length Class	OTS	SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	MOO	PFL
4/20	1	0.33										
	2											
	Total	0.33										
4/25	1	0.33	0.33									
	2											
	Total	0.33	0.33									
5/02	1	2.67	1.00			0.33				0.33		
	2											
	Total	2.67	1.00			0.33				0.33		
5/09	1	13.00	0.67			0.67				0.33		
	2				0.33						0.33	
	Total	13.00	0.67		0.33	0.67				0.33	0.33	
5/16	1	13.67	0.33			2.00	3.67	0.67	0.33	0.67		
	2				0.33					1.00		0.67
	Total	13.67	0.33		0.33	2.00	3.67	0.67	0.33	1.67		0.67
5/23	1	0.67										
	2											
	Total	0.67										
5/30	1						0.33					
	2								0.33		0.67	
	Total						0.33		0.33		0.67	
6/06	1		2.33									
	2									2.00		
	Total		2.33							2.00		
6/13	1			0.67								
	2									1.00	0.33	0.67
	Total			0.67						1.00	0.33	0.67
Spring Mean		3.41	0.52	0.07	0.07	0.33	0.44	0.07	0.07	0.59	0.15	0.15

Appendix Table 6. Mean Catch / Haul

Gear - Beach Seine All Stations Summer Season

Station	Date	Length Class	Species											
			SGA	AAL	CCA	MCA	POR	RBA	CCO	CMA	LGI	LMA	MDO	PFL
LG1S	7/18	1	1.667										3.667	
		2								5	0.333		1.333	
		Total	1.667							5	0.333		5	
	8/29	1	4.333				0.667						5.667	
		2								2.333				
		Total	4.333				0.667			2.333			5.667	
	Summer Mean		3				0.33			3.67	0.17		5.33	
LG2S	7/18	1	0.333				0.333							
		2			1.667					1			1.667	
		Total	0.333		1.667		0.333			1			1.667	
	8/29	1					0.667			1		0.333	16	
		2												
		Total					0.667			1		0.333	16	
	Summer Mean		0.17		0.83		0.5			1		0.17	8.83	
LG3S	7/18	1	2.667										0.333	
		2			4.333					0.333	0.333		1.333	
		Total	2.667		4.333					0.333	0.333		1.667	
	8/29	1		4		1.333	39.33	0.333		43		26.67	38	
		2			0.333								2	
		Total		4	0.333	1.333	39.33	0.333		43		26.67	40	
	Summer Mean		1.33	2	2.33	0.67	19.67	0.17		21.67	0.17	13.33	20.83	
LG4S	7/18	1								1.333			1	
		2								0.667			1.667	
		Total								2			2.667	
	8/29	1		2.667		1.333	17.67		0.333	7.333		8.333	29.33	1.667
		2								0.667			1.333	
		Total		2.667		1.333	17.67		0.333	8		8.333	30.67	1.667
	Summer Mean			1.33		0.67	8.83		0.17	5		4.17	16.67	0.83
LG5S	7/18	1					0.333			0.333			1.333	
		2			0.333					0.333			1.667	
		Total			0.333		0.333			0.667			3	
	8/29	1		207.7	2.333	77.67	182	11		497.7		6	83.67	
		2									0.667			
		Total		207.7	2.333	77.67	182	11		497.7	0.667	6	83.67	
	Summer Mean			103.8	1.33	38.83	91.17	5.5		249.2	0.33	3	43.33	

Appendix Table 7. Mean Catch / Haul

Gear - Beach Seine Station LG1S Season - Fall

		Species					
Date	Length Class	PWI	SGA	POR	CMA	LMA	MDO
10/11	1			0.33		1.33	0.33
	2				0.67		
	Total			0.33	0.67	1.33	0.33
10/29	1		1.67				
	2						
	Total		1.67				
11/03	1						
	2				1.67		
	Total				1.67		
11/12	1		1.67		0.67		
	2				1.33		
	Total		1.67		2.00		
11/19	1		4.00		1.00		
	2	0.33	0.33		0.33		
	Total	0.33	4.33		1.33		
11/27	1		7.33		1.00		
	2				1.00		
	Total		7.33		2.00		
Fall Mean		0.06	2.50	0.06	1.30	0.22	0.56

Appendix Table 8. Mean Catch / Haul

Gear - Beach Seine Station LG2S Season-Fall

Date	Length Class	Species OTS	SGA	CCA	POR	CMA	LGI	LMA
10/11	1							
	2					0.33		
	Total					0.33		
10/29	1		0.33					
	2					1.00		
	Total		0.33			1.00		
11/03	1	0.33					0.33	
	2			0.33	0.33			
	Total	0.33		0.33	0.33		0.33	
11/12	1		0.33					0.33
	2		0.33			0.67		
	Total		0.67			0.67		0.33
11/19	1		0.33					
	2							
	Total		0.33					
11/27	1		0.33			1.00		
	2							
	Total		0.33			1.00		
Fall Mean		0.06	0.28	0.06	0.06	0.50	0.06	0.06

Appendix Table 9. Mean Catch / Haul

Gear - Beach Seine Station LG3S Season-Fall

Date	Length Class	Species						
		PWI	SGA	AAL	POR	CMA	LMA	PNI
10/11	1				0.67	0.33		
	2							
	Total				0.67	0.33		
10/29	1		0.67	0.33	0.33			2.33
	2	0.67						
	Total	0.67	0.67	0.33	0.33			2.33
11/03	1				0.67			
	2					1.00		
	3		1.00					
	Total		1.00		0.67	1.00		
11/12	1				0.67	0.33		
	2					1.00		
	3		0.33					
	Total		0.33		0.67	1.33		
11/19	1				0.33	0.33	1.00	
	2					0.33		
	3		0.33					
	Total		0.33		0.33	0.67	1.00	
11/27	1				0.33	5.00	5.00	
	2							
	3		0.67					
	Total		0.67		0.33	5.00	5.00	
Fall Mean		0.08	0.50	0.06	0.49	1.40	1.00	0.38

Appendix Table 10. Mean Catch / Haul

Gear - Beach Seine Station LG4S Season-Fall

Date	Length Class	Species SGA	AAL	CCA	POR	RBA	CCO	CNA	LMA	MDO	PNI
10/11	1		0.33		4.33	0.33		0.33		0.67	
	2										
	Total		0.33		4.33	0.33		0.33		0.67	
10/29	1	0.33					0.33				0.33
	2									0.67	
	Total	0.33					0.33			0.67	0.33
11/03	1										
	2							0.67			
	Total							0.67			
11/12	1						0.33	1.00	0.33		
	2							2.67			
	Total						0.33	3.67	0.33		
11/19	1	0.33	0.67		0.67			0.67			
	2			0.33							
	Total	0.33	0.67	0.33	0.67			0.67			
11/27	1	0.33									
	2										
	Total	0.33									
Fall Mean		0.17	0.17	0.06	0.83	0.06	0.11	0.89	0.06	0.22	0.06

Appendix Table 11. Mean Catch / Haul

Gear -Beach Seine Station LG5S Season - Fall

Date	Length Class	SGA	POR	CCO	CNA	LMA	PNI
10/11	1		18.33		0.67	0.33	
	2						
	Total		18.33		0.67	0.33	
10/29	1		1.00	0.67	0.33		0.67
	2						
	Total		1.00	0.67	0.33		0.67
11/03	1				0.33		
	2						
	Total				0.33		
11/12	1			0.33			
	2						
	Total			0.33			
11/19	1	0.33	1.67				
	2						
	Total	0.33	1.67				
11/27	1		0.33				
	2						
	Total		0.33				
Fall Mean		0.06	3.55	0.17	0.22	0.06	0.11

Appendix Table F. Summary of smallmouth bass stomachs analyzed for food habits from Lower Granite Reservoir, Washington, 1987.

Season	Station	Total Number Collected	Total Number Empty	Total Number Stomachs	Total Length	
					Range (mm)	Mean (mm)
Spring	LG1S	127	38	89	127-356	205.5
	LG2S	25	3	22	161-475	251.7
	LG3S	71	17	54	150-460	217.6
	LG4S	27	7	20	171-280	212.5
	LG5S	8	1	7	178-320	220.5
	LG1M	1		1		270.0
	LG2M	2		2	189-296	239.0
	LG3M					
	LG1D					
	LG2D					
Summer	LG1S	5		5	145-251	196.0
	LG2S	9	2	7	174-287	205.0
	LG3S	11	2	9	164-353	205.7
	LG4S	9		9	162-256	201.0
	LG5S	5		5	154-234	187.8
	LG1M	1		1		293.0
	LG2M	3	1	2	189-351	249.3
	LG3M	5		5	174-206	189.0
	LG1D					
	LG2D					
Fall	LG1S	1		1		192.0
	LG2S	8		8	260-297	281.3
	LG3S					
	LG4S	2		2	438-441	439.5
	LG5S					
	LG1M	4	3	1	210-456	307.8
	LG2M					
	LG3M	2	1	1	270-413	341.5
	LG1D					
	LG2D					

Appendix Table G. Summary of northern squawfish stomachs analyzed for food habits from Lower Granite Reservoir, Washington, 1987.

Season	Station	Total Number Collected	Total Number Empty	Total Number Stomachs	Total Length Range (mm)	Total Length Mean (mm)
Spring	LG1S	3	2	1	310-359	333.0
	LG2S	24	5	19	137-550	323.8
	LG3S	1		1		347.0
	LG4S	5	3	2	154-381	241.8
	LG5S					
	LG1M	9	3	6	253-499	356.0
	LG2M	17	5	12	230-510	366.5
	LG3M	14	2	12	243-472	343.9
	LG1D	2	1	1	335-493	414.0
	LG2D	5		5	233-365	310.6
Summer	LG1S					
	LG2S	1		1		360.0
	LG3S					
	LG4S					
	LG5S					
	LG1M	3	1	2	355-491	435.3
	LG2M	11	4	7	255-495	348.2
	LG3M	14	3	11	230-356	274.4
	LG1D	1		1		362.0
	LG2D	4	1	3	325-432	373.3
Fall	LG1S	1	1			331.0
	LG2S	19	8	11	261-420	269.5
	LG3S					
	LG4S	2	1	1	331-337	334.0
	LG5S					
	LG1M	15	1	14	260-532	316.9
	LG2M	11	4	7	252-427	324.2
	LG3M	7	1	6	256-498	314.9
	LG1D	7		7	255-375	293.6
	LG2D	6	3	3	255-358	294.2
Winter	LG1S					
	LG2S	3	2	1	273-370	336.7
	LG3S					
	LG4S					
	LG5S					
	LG1M	1		1		369.0
	LG2M	4	3	1	250-367	289.0
	LG3M	1	1			342.0
	LG1D	5	3	2	245-358	303.2
	LG2D	1	1			348.0

Appendix Table H. Summary of channel catfish stomachs analyzed for food habits from Lower Granite Reservoir, Washington, 1987.

Season	Station	Total Number Collected	Total Number Empty	Total Number Stomachs	Total Length Range (mm)	Total Length Mean (mm)
Spring	LG1S					
	LG2S	1		1		493.0
	LG3S					
	LG4S					
	LG5S					
	LG1M					
	LG2M	14	2	12	356-612	466.0
	LG3M	3		3	430-526	492.0
	LG1D	1		1		305.0
	LG2D	1		1		493.0
Summer	LG1S					
	LG2S	5		5	299-473	362.4
	LG3S					
	LG4S					
	LG5S					
	LG1M	2		2	259-528	394.0
	LG2M	8	1	7	268-435	345.5
	LG3M	2		2	323-409	366.0
	LG1D					
	LG2D					
Fall	LG1S					
	LG2S	1		1		302.0
	LG3S					
	LG4S					
	LG5S					
	LG1M	4		4	208-510	390.8
	LG2M	8	3	5	243-389	308.1
	LG3M	1		1		285.0
	LG1D	2		2	324-515	419.5
	LG2D	2		2	359-583	471.0