US Army Corps
of Engineers
Walla Walla District

Lower Granite Reservoir In-Water Disposal Test:

Results of the Fishery, Benthic and Habitat Monitoring Program-Year 3 (1990)

Completion Report

David H. Bennett
Thomas J. Dresser, Jr.
Thomas S. Curet
Kenneth B. Lepla
Melissa A. Madsen

January 1993

LOWER GRANITE RESERVOIR IN-WATER DISPOSAL TEST: RESULTS OF MONITORING THE FISH COMMUNITY ACTIVITY AT DISPOSAL AND REFERENCE SITES IN LOWER GRANITE RESERVOIR, IDAHO-WASHINGTON Year-3 (1990)

Completion Report

To:

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

David H. Bennett

Thomas J. Dresser Jr.

Thomas S. Curet

Kenneth B. Lepla

Melissa A. Madsen

Department of Fish and Wildlife Resources
College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, Idaho 83843

January, 1993

ACKNOWLEDGMENTS

Funding by the U.S. Army Corps of Engineers is greatly appreciated. Special thanks are extended to Teri Barila for contract supervision, rapid response to various requests and review of an earlier draft. Mr. Chris Penney also provided and in-depth review of an earlier draft. We also thank Mr. Ed Buettner of the Idaho Department of Fish and Game, Lewiston, Idaho for use of the barge. Field efforts by a myriad of students contributed to the quality of sampling. Data analysis was conducted very professionally by Dasarathi Baregala (Dasu).

TABLE OF CONTENTS

Item	Page Number
List of Figures	iii
List of Tables	xi
List of Appendix Figures	xiii
Executive Summary	xvi
Introduction	2
Objectives	4
Study Area	5
Objective 1: Assess Fish Abundance	8
Methods	8
Results	12
Total Catch	12
Relative Abundance	
Spring	12
Summer	13
Fall	14
Size Comparisons	
All Species	15
Size Structure	16
Spring 1990	16
Summer 1990	20
Fall 1990	22
Abundance of Key Species Among Stations	
1990	24
Comparison of Abundance of Key Species	
1989-1990	28
1988-1990	31
1987-1990	32
Larval Fishes	36
Discussion	38
Objective 2: Assess White Sturgeon Abundance	43
Methods	43
Results	45
Discussion	48
Objective 3: Juvenile Salmonid Fish Consumption	52
Methods	52
Results	53
Food Items	53
Daily Ration	54
Consumption Estimates	55
Discussion	57

Table of Contents Continued

Item	Page Number
Objective 4: Assess Age-0 Chinook Salmon Abundance	59
Methods	59
Results	60
Discussion	61
Overall Discussion	62
References	65
Figures	68-153
Tables	154-176
Appendix Figures	177-204

LIST OF FIGURES

Figure 1. Sampling locations in Lower Granite Reservoir, Idaho-Washington where adult, subadult, juvenile and larval fish abundance was assessed during spring, summer and fall 1990.

Figure 2. Locations where juvenile chinook salmon sampling was conducted at biweekly intervals in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Figure 3. Locations where white sturgeon sampling was conducted in Lower Granite Reservoir, Idaho-Washington during spring, summer and fall 1990.

Figure 4. Comparison of length frequencies for all gear types and fishes sampled at shallow water (1 and 2) and mid-depth (4) disposal stations and reference station 3 during spring 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 5. Comparison of length frequencies for all gear types and fishes sampled at shallow water reference stations (5, 9 and 10) and mid-depth (6) and deep water (8) reference stations during spring 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 6. Comparison of length frequencies for all gear types and fishes sampled at shallow water (1 and 2) and mid-depth (4) disposal stations and shallow water reference station 3 during summer 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 7. Comparison of length frequencies for all gear types and fishes sampled at shallow water (5, 9 and 10), mid-depth (6) and deep water (8) reference stations during summer 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 8. Comparison of length frequencies for all gear types and fishes sampled at shallow water (1 and 2) and mid-depth (4) disposal stations and reference station 3 during fall 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 9. Comparison of length frequencies for all gear types and fishes sampled at shallow water (5, 9 and 10), mid-depth (6) and deep water (8) reference stations during fall 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 10. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance ($P > 0.05$).

Figure 11. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance (P > 0.05).

Figure 12. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance (P > 0.05).

Figure 13. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 14. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 15. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance (P > 0.05).

Figure 16. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 17. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 18. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance (P > 0.05).

Figure 19. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance (P > 0.05).

Figure 20. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).

Figure 21. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).

Figure 22. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).

Figure 23. Graphical and statistical comparisons of the mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).

Figure 24. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).

Figure 25. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).

Figure 26. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).

Figure 27. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).

Figure 28. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).

Figure 29. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 30. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 31. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 32. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations, seasons and years indicate statistical nonsignificance (P > 0.05).

Figure 33. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and seasons indicate statistical nonsignificance (P > 0.05).

Figure 34. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 35. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.0).

Figure 36. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. The vertical line beside years indicates statistical nonsignificance (P > 0.05).

Figure 37. Graphical and statistical comparisons of the mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 38. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 39. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations and years indicated statistical nonsignificance (P > 0.05)

Figure 40. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).

Figure 41. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 42. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

Figure 43. Graphical and statistical comparison of the mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside years indicate statistical nonsignificance (P > 0.05).

Figure 44. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 45. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside years indicate statistical nonsignificance (P > 0.05).

Figure 46. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. The vertical line beside years indicates statistical nonsignificance (P > 0.05).

Figure 47. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 48. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 49. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. The vertical lines beside years indicates statistical nonsignificance (P > 0.05).

Figure 50. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).

Figure 51. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).

Figure 52. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside years indicate statistical nonsignificance (P > 0.05).

Figure 53. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

Figure 54. Graphical and statistical comparisons of mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).

Figure 55. Graphical and statistical comparisons of mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and seasons indicate statistical nonsignificance (P > 0.05).

Figure 56. Relative abundance of larval fish (by family and genera of game fishes) captured by paired plankton nets in Lower Granite Reservoir, Idaho-Washington from mid-June through September 1990. Family abbreviations are: CLU - Clupeidae; CYP - Cyprinidae; CAT - Catostomidae; ICT - Ictaluridae; CEN - Centrarchidae.

Figure 57. Relative abundance of larval fish captured by paired plankton nets in Lower Granite Reservoir, Idaho-Washington during mid-June through September 1990. Family abbreviations are: CLU - Clupeidae; CYP - Cyprinidae; CAT - Catostomidae; ICT - Ictaluridae; CEN - Centrarchidae.

Figure 58. Relative abundance of larval fishes captured by beam trawl in Lower Granite Reservoir, Idaho-Washington, mid-June through September 1990. Family abbreviations are: CLU - Clupeidae; CYP - Cyprinidae; CAT - Catostomidae; ICT - Ictaluridae; CEN - Centrarchidae.

Figure 59. Number of white sturgeon sampled during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling periods in Lower Granite Reservoir, Idaho-Washington.

Figure 60. Size distributions of white sturgeon sampled during spring-summer (April through July) and fall-winter (October through January) 1990-1992 in Lower Granite Reservoir, Idaho-Washington.

Figure 61. Mean catch rates and 95% confidence intervals for white sturgeon sampled by gill netting during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

Figure 62. Mean catch rates and 95% confidence intervals for white sturgeon sampled by gill netting during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

Figure 63. Net movement of recaptured white sturgeon during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 64. Lengths of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 65. Lengths of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 66. Lengths of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 67. Depth utilization frequencies of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 68. Current velocity utilization frequencies of white sturgeon sampled during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

Figure 69. Comparisons of length and focal point velocities of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 70. Temperature utilization frequencies of white sturgeon sampled during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

Figure 71. Comparisons of bottom temperatures, dissolved oxygen and focal point velocities at stations sampled for white sturgeon during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

Figure 72. Number of crayfish captured at stations sampled for white sturgeon during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

Figure 73. Number of northern squawfish captured in Lower Granite Reservoir, Idaho-Washington during 1990.

Figure 74. Number of fish consumed by different lengths of northern squawfish in Lower Granite Reservoir, Idaho-Washington during 1990.

Figure 75. Total daily ration of fishes by northern squawfish during 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 76. Total daily ration of fishes by northern squawfish during April 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 77. Total daily ration of fishes by northern squawfish during May 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 78. Total daily ration of fishes by northern squawfish during June 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 79. Consumption rates of fishes by northern squawfish during 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 80. Consumption rates of fishes by northern squawfish during April 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 81. Consumption rates of fishes by northern squawfish during May 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 82. Consumption rates of fishes by northern squawfish during June 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 83. Catch per unit effort of juvenile chinook salmon sampled by beach seining during spring-summer 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 84. Mean total lengths of juvenile chinook salmon captured by all gear types during spring-summer 1990 in Lower Granite Reservoir, Idaho-Washington.

Figure 85. Habitat utilization and abundance of juvenile chinook salmon sampled by beach seining and nighttime electrofishing during 1990 in Lower Granite Reservoir, Idaho-Washington.

LIST OF TABLES

Table 1. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington during spring 1990.

Table 2. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington during summer 1990.

Table 3. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington during fall 1990.

Table 4. List of common names, scientific names and species codes for fishes in Lower Granite Reservoir, Idaho-Washington during 1990.

Table 5. Catch/volume of water filtered (No./10,000 m^3) from 1/2 m larval tow nets during 1990. Upper and lower refer to bounds.

Table 6. Catch/volume of water filtered (No./10,000 m^3) for 1/2 m larval tow nets during 1990. Upper and lower refer to bounds. Abbreviations: ASA-American shad; AAL-chiselmouth; CCA-carp; POR-northern squawfish; RBS-redside shiner; CYP-cyprinid; CCO-bridgelip sucker; CMA-largescale sucker; CSP-catostomids; INA-brown bullhead; ISP-icturalid; LSP-*lepomis* spp.; PAN-white crappie; PNI-black crappie; PSP-*pomoxis* spp.; MDO-smallmouth bass; MSP-*micropterus* spp.

Table 7. Catch/volume of water (filtered No./10,000 m^3) for larval beam trawls sampled in shallow (S; 0.5 m) and deep (D; 1.0 m) waters along the shoreline during 1990. Abbreviations: POR-northern squawfish; CYP-cyprinid; CSP-catostomid; INE-brown bullhead; LSP-*lepomis* spp.; PAN-white crappie; PNI-black crappie; PSP-*pomoxis* spp.; MDO-smallmouth bass; MSP-micropterus spp.

Table 8. Location, size (mm) and net movement of white sturgeon recaptured during spring-summer (May through August) 1990 sampling interval in Lower Granite Reservoir, Idaho-Washington.

Table 9. Location, size (mm) and net movement of white sturgeon recaptured during fall-winter (October through January) 1990-1991 sampling interval in Lower Granite Reservoir, Idaho-Washington.

Table 10. Summary by food items consumed by northern squawfish in Lower Granite Reservoir during spring 1990.

LIST OF APPENDIX FIGURES

Appendix Figure 1. Length frequency distributions of juvenile chinook salmon sampled by surface trawling at shallow water disposal (2) and reference stations (5) and mid-depth disposal (4) and reference stations (6) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 2. Length frequency distributions of juvenile chinook salmon sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 3. Length frequency distributions of juvenile chinook salmon sampled by beach seining at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 4. Length frequency distributions of juvenile steelhead sampled by surface trawling at shallow water disposal (2) and reference stations (5) and mid-depth disposal (4) and reference stations (6) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 5. Length frequency distributions of juvenile steelhead sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 6. Length frequency distributions of juvenile steelhead sampled by beach seining at shallow water disposal (2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 7. Length frequency distributions of juvenile steelhead sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 8. Length frequency distributions of northern squawfish sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 9. Length frequency distributions of northern squawfish sampled by beach seining at reference stations (3 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 10. Length frequency distributions of northern squawfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 11. Length frequency distributions of channel catfish sampled by gill netting at shall water disposal (1) and reference (3 and 5) stations and mid-depth (6) and deep water (8) reference stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 12. Length frequency distributions of smallmouth bass sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 13. Length frequency distributions of smallmouth bass sampled by beach seining at shallow water disposal (1 and 2) and reference (3, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 14. Length frequency distributions of smallmouth bass sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations and mid-depth disposal (4) and reference (6) stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 15. Length frequency distributions of white sturgeon sampled by gill netting at shallow water (5) and deep water (8) reference stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.

Appendix Figure 16. Length frequency distributions of northern squawfish sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during summer 1990.

Appendix Figure 17. Length frequency distributions of northern squawfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir during summer 1990.

Appendix Figure 18. Length frequency distributions of channel catfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during summer 1990.

Appendix Figure 19. Length frequency distributions of smallmouth bass sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during summer 1990.

Appendix Figure 20. Length frequency distributions of smallmouth bass sampled by beach seining at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during summer 1990.

Appendix Figure 21. Length frequency distributions of smallmouth bass sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations and mid-depth disposal (4) and reference (6) stations in Lower Granite Reservoir during summer 1990.

Appendix Figure 22. Length frequency distributions of white sturgeon sampled by gill netting at shallow water disposal (2) and reference (5) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during summer 1990.

Appendix Figure 23. Length frequency distributions of northern squawfish sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during fall 1990.

Appendix Figure 24. Length frequency distributions of northern squawfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during fall 1990.

Appendix Figure 25. Length frequency distributions of channel catfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during fall 1990.

Appendix Figure 26. Length frequency distributions of smallmouth bass sampled by nighttime electrofishing at shallow water disposal (2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during fall 1990.

Appendix Figure 27. Length frequency distributions of smallmouth bass sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations and mid-depth disposal (4) and reference (6) stations in Lower Granite Reservoir, Idaho-Washington during fall 1990.

EXECUTIVE SUMMARY

Completion of the Lower Granite Lock and Dam Project on the Snake River in 1975 provided electrical power production, flood control, navigation and recreation to the eastern Washington-west central Idaho areas. Unfortunately, input and deposition of sediment from upstream sources are jeopardizing many of these uses. Estimates as high as 800,000 cubic yards (611,680 m^3) of material deposit annually in the upstream portion of Lower Granite Reservoir.

To alleviate some of the problems created by the deposition of sediment in the reservoir, dredging and in-water disposal are being evaluated. Disposal of dredged materials downstream of river mile 120 (RM 120) is considered necessary to benefit the flood profile in the reservoir.

Dredging began in 1986 with land disposal and dredging, and in-water disposal was initiated in 1988. Two in-water disposal options were examined. In 1988 a mid depth site (20-40 ft) was elevated to within 6-12 ft of the surface by creating an underwater plateau. In 1989, an island was created immediately downstream of the underwater plateau. Monitoring of fish and benthic community abundance began in 1988. This report provides information on the results of monitoring changes in the fish community and utilization of the newly created habitat in year-3 (1990).

OBJECTIVES

1) To assess abundance of larval, juvenile and adult predators with special emphasis on northern squawfish at two in-water disposal stations with those of reference stations;

2) To assess white sturgeon abundance and habitat factors associated with their abundance in Lower Granite Reservoir;

3) To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir; and,

4) To assess age-0 chinook salmon abundance in Lower Granite Reservoir and assess the potential suitability of the disposal stations for rearing of age-0 chinook salmon.

STUDY AREA

Ten sampling stations in Lower Granite Reservoir were used to monitor fish abundance during 1990 (Figure 1). Stations 1, 2 and 4 were created by in-water disposal of dredged material. Stations 3, 5, 9 and 10 were shallow water reference stations; one additional reference station (11) was sampled for larval predator abundance. An additional 22 stations were sampled to assess age-0 chinook salmon abundance, and nine additional stations between RM 108.0 and RM 137.1 were selected to assess white sturgeon abundance.

Objective 1: To access abundance of larval, juvenile and adult predators with special emphasis on northern squawfish at two in-water disposal stations with those of reference stations.

To reduce sampling gear bias, several gear types were used during 1990 to make representative collections in Lower Granite Reservoir. Gear types included; gill nets, beach seines, electrofishing, surface trawling, and plankton nets and a beam trawl. Gill nets were used to assess the relative abundance of potential predators in pelagic waters. Surface trawling was used to sample pelagic salmonid abundance. Beach seining and electrofishing were used to sample shallow water stations during diurnal and nocturnal hours, respectively. Plankton nets and a hand drawn beam trawl were used to estimate larval predator abundance.

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

Size of fish sampled in Lower Granite Reservoir, Washington during 1990 varied by gear type and season. Generally, larger fish were collected by gill nets, whereas smaller fish were consistently collected by beach seine. During spring, the majority of fish sampled in Lower Granite Reservoir were between 50-500 mm. Shallow water reference stations 3, 9 and 10 had an abundance of fish sampled during the summer between 50-100 mm that accounted for > 50% of all fish sampled. Length frequencies of all fishes sampled during fall differed from both spring and summer in that fewer fish 25-75 mm were present.

A total of 15,235 fish representing 26 species were collected at nine sampling stations by surface trawling, electrofishing, beach seining and gill netting in Lower Granite Reservoir, Washington during 1990. Higher numbers of fish were collected during the spring (n = 6,616) and summer (n = 6,636) followed by fall (n = 1,988). Spring and summer sampling efforts accounted for 86% of the total number of fish collected. The spring sample was represented by 25 species compared to 19 during the summer and 21 species in the fall.

Largescale suckers dominated total catches for all stations and all seasons. The highest abundance of largescale suckers (n = 800) was at shallow water reference station 5 during spring and summer. Juvenile chinook salmon were second in abundance in the spring, and the highest numbers were also collected at station 5 (n = 532). Surface trawling at disposal stations 2 and 4 and reference stations 5 and 6 accounted for the majority of juvenile chinook salmon (n = 1,704) and juvenile steelhead (n = 524) collected. Smallmouth bass were consistently high in abundance at shallow water reference stations 3 (n = 106) and 10 (n = 325). Northern squawfish were relatively high in abundance at all shallow water stations, except shallow water reference stations 9 and 10. The highest number of squawfish were collected in the summer and at reference station 3 (n = 61) followed by disposal stations 4 (n = 48) and 1 (n = 41). White sturgeon were collected only at reference stations 5 and 8; 25 of the 31 sturgeon sampled were collected at deep water reference station 8.

During 1990, catch rates of juvenile chinook salmon in open water were highest at reference station 5 followed closely by those at reference station 6. Daytime abundance of juvenile chinook salmon along the shoreline was similar among stations during 1990. During nighttime and daytime sampling, few differences in catch rates of juvenile chinook salmon and juvenile steelhead trout have been found between 1989 and

1990. During 1989 and 1990, catches of juvenile chinook salmon were significantly higher at reference station 5 than at disposal station 2.

Nighttime abundance of juvenile steelhead along the shoreline was generally similar among stations. Catches were highest at reference station 9 which were statistically higher ($P < 0.005$) than those at disposal stations 1 and 2 and reference stations 3 and 5. Daytime abundance of juvenile steelhead along the shoreline based on beach seining in 1990 was highest at reference station 9 followed by reference stations 3, 5 and 10. Abundance of juvenile steelhead in pelagic waters was highest at disposal station 4. Juvenile steelhead abundance at station 2 was similar to reference stations 5 and 6, although none of the differences were statistically ($P > 0.05$) significant. Daytime catches of juvenile steelhead were significantly ($P < 0.05$) higher in 1989 than in 1990.

Nighttime abundance of northern squawfish along the shoreline in 1990 was variable among stations. Reference station 9 and disposal station 2 had significantly ($P < 0.05$) lower catch rates than the other stations. Daytime abundance of northern squawfish along the shoreline was highest at reference stations 3 and 10 and lower at reference stations 5 and 9 and disposal stations 1 and 2. Significant differences in catch/effort of northern squawfish by gill netting were between reference stations 5 and 8 and disposal station 4. Daytime abundance of northern squawfish along the shoreline by beach seining indicated a significant ($P < 0.05$) decrease in abundance from 1989 to 1990. Most squawfish sampled by beach seining were juvenile fish.

The abundance of channel catfish based on gill net collections varied among stations. In general, the abundance of channel catfish was highest at reference station 8 in spring and shallow water reference station 5 in summer and fall during 1990. Channel catfish seem to inhabit deeper waters in spring and fall and shallow waters in summer.

Nighttime catches of smallmouth bass were higher at reference stations 3 and 10 followed by disposal stations 1 and 2. Daytime abundance of smallmouth bass along the shoreline was higher at reference stations 3 and 10, lower at disposal stations 1 and 2, and lowest at station 5. Differences in night and daytime catches along the shoreline for smallmouth bass were variable among stations and years. Catches of smallmouth bass at night along the shoreline were generally higher in 1989 than 1990 at all the reference stations, but were the opposite for the disposal stations.

The abundance of white sturgeon in 1990 was similar among stations, but catches were consistently higher at reference stations 5 and 8. Since 1987, few changes in the annual abundance of white sturgeon have been found.

Trends in the abundance of predator fishes have been variable among species. Catch rates of northern squawfish during the daytime were not significantly different between reference stations 5 and 9 from 1987 to 1990. Comparison of catch rates indicated highest abundance of squawfish in 1987 and 1989; these differences between 1987 and 1989, and 1988 and 1990 were significant ($P < 0.05$). Pelagic abundance of northern squawfish based on gill net catches from 1987 through 1990 was generally similar among years. The abundance of channel catfish in deep water since 1987 has not changed. Since 1987, catches of smallmouth bass along the shoreline have generally declined. Catches of smallmouth bass were significantly higher in 1987 and 1988 than in 1989 and 1990.

A total of 973 larval fishes were collected by paired plankton nets in Lower Granite Reservoir during 1990. These collections comprised five families and four genera. Cyprinids were highest in relative abundance in pelagic waters followed closely by catostomids and collectively accounted for approximately 85% of all larval fishes sampled. Members of the family cyprinidae were collected during July through September. Shallow water reference stations 5 and 11 generally had the highest total number of larval fishes. Density of larval northern squawfish was highest at shallow water reference stations 5 and 11.

A total of 1,274 larval fishes were collected from June through September, 1990 by beam trawl. Higher numbers of larval fishes collected by beam trawl indicated higher abundance in shallow water than in pelagic waters. The highest number of larval fishes collected occurred at reference stations 5 and 11. No larval northern squawfish were collected along the shoreline at either disposal station 1 or 2. The highest abundance of larval northern squawfish was found at reference station 11 and densities averaged > 25,000/10,000 m^3.

Objective 2: To assess white sturgeon abundance and habitat factors associated with their abundance in Lower Granite Reservoir.

Two-4 month sample intervals for white sturgeon were conducted in Lower Granite Reservoir, Washington-Idaho from 25 May to 23 August, 1990 (spring-summer) and 14 October, 1990 to 3 January, 1991 (fall-winter). Gill net sampling was the primary technique used to assess white sturgeon abundance, although setline sampling was conducted from 13 June to 20 July, 1990. All captured sturgeon were measured, weighed, marked and released.

A total of 407 white sturgeon were captured by gill net and setline sampling during 1990 in Lower Granite Reservoir. Highest white sturgeon abundance was at RM 137.1 and 133.7, and abundance progressively decreased with downstream distance from RM 133.7. Population abundance of white sturgeon > 45 cm total length was estimated at 813 individuals with 95% confidence intervals of 701 to 967.

A total of 42 white sturgeon were recaptured during the spring-summer and fall-winter sampling intervals. Net movement of recaptured sturgeon ranged from 0.0-20.6 river miles. Sturgeon migrated a mean distance of 11.3 river miles upstream and 3.4 river miles downstream during the spring-summer sample period. Sturgeon were captured at depths ranging from 19.6-118 ft (6-36 m) with a mean of 59 ft (17.9 m) during May to August and 57 ft (17.5 m) during October to January. Sampling in 1990 revealed a much higher population of white sturgeon in Lower Granite Reservoir than originally anticipated. Sturgeon were typically captured in the deepest micro-habitat available in main channel areas.

Objective 3. To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir.

Stomachs of northern squawfish (> 250 mm) collected from Lower Granite Reservoir during 1 April through 30 July, 1990 by all gear types between RM 112.5 and RM 132.0 were examined for food items. A total of 199 northern squawfish (> 250 mm) were captured during 1990.

Crayfish and fishes were dominant food items of northern squawfish in spring 1990 from Lower Granite Reservoir. Crayfish dominated food items in percent occurrence (47.5%) and numerically and were second to juvenile rainbow/steelhead in total weight. Salmonids represented the highest of all food items in weight, especially juvenile rainbow/steelhead trout.

Seasonal total daily ration for spring (all dates combined) was 9.808 mg/g/d for all prey fishes. Monthly ration estimate of northern squawfish was generally similar between April (12.605 mg/g/d) and May (12.805 mg/g/d), but was higher in June. Mean monthly total daily ration estimate for northern squawfish in June was 31.502 mg/g/d for all prey fishes. Juvenile chinook salmon had a total daily ration of 0.473 mg/g/d.

Consumption of all prey fishes by northern squawfish (> 250 mm) during the spring-summer season was 0.142 prey/predator/d. Mean seasonal consumption rate of squawfish with juvenile chinook salmon and steelhead was 0.0998 prey/predator/d and 0.021 prey/predator/d, respectively. Mean seasonal consumption rate of squawfish with all juvenile salmonids was 0.098 prey/predator/d.

The highest mean monthly consumption rate of juvenile salmonids by northern squawfish was in April at 0.206 prey/predator/d, as well as the mean monthly consumption rate of juvenile chinook salmon at 0.269 prey/predator/d. In April, mean monthly consumption rate of juvenile steelhead was 0.029 prey/predator/d. During May, mean monthly consumption rate of juvenile salmonids was 0.126 prey/predator/d and 0.109 of juvenile chinook salmon prey/predator/d. The highest mean monthly consumption rate of juvenile steelhead was 0.033 prey/predator/d in May. Mean monthly consumption rate for northern squawfish of all prey fishes was highest in June (0.55 prey/predator/d), and the highest consumption rate for non-salmonids was 0.729 prey/predator/d.

Based on comparison of catch/effort with similar gear type from John Day Reservoir, we estimated a population size of northern squawfish of 7,500 from RM 112.0 to RM 132.0. Using this estimate, approximately 60,458 juvenile chinook and 6,593 juvenile steelhead were consumed during April 1990. The estimated total loss of juvenile chinook and juvenile steelhead during spring 1990 in Lower Granite Reservoir from RM 112.0-132.0 was 89,852 and 16,559, respectively. Combined losses for both identified and unidentified salmonids during spring 1990 was estimated at 142,117 salmonid smolts.

Objective 4. To assess age-0 chinook salmon abundance in Lower Granite Reservoir and assess the potential suitability of the disposal stations for rearing of age-0 chinook salmon.

Age-0 chinook were collected by beach seining and electrofishing during 1990 using identical methods employed for juvenile predator sampling (Objective 1). Areas of concentration of age-0 chinook were identified and measurements of macrohabitat characteristics were taken.

A total of 264 age-0 chinook salmon were captured by beach seine and electrofishing between 8 April through 22 June, 1990. No age-0 chinook salmon were collected in littoral areas after 22 June, 1990. The highest catch-per-unit-effort by beach seining in 1990 occurred on 3 June which suggests the highest abundance of age-0 chinook in Lower Granite occurred during early June.

A total of 190 age-0 chinook (72%) were captured over substrates that consisted of > 75% fines (< 2 mm in diameter), whereas 225 age-0 chinook (85%) were captured over substrates that consisted of > 75% fines and gravels (< 50 mm in diameter). All age-0 chinook collected by beach seining and electrofishing were associated with either a sand (60%), sand/talus (36%), or sand/cobble substrate (4%). At RM 120.0, 28 fall chinook were captured at the disposal area (stations 1 and 2) which accounted for 11% of the age-0 chinook captured in 1990. Substrates at stations 1 and 2 consisted primarily of sands.

DISCUSSION

Based on our sampling, disposal of dredged materials in Lower Granite Reservoir has not altered the abundance of fishes since sampling was initiated in 1987. Numbers of fishes, catch/effort of species of interest, and overall abundance of younger life stages have changed little. Based on our collections, age-0 salmon use the shorelines at Centennial Island for rearing. Age-0 salmon densities near the island appear high relative to other areas, although direct comparisons of abundance are difficult. Habitation of age-0 chinook around the island may depend upon saturation of upstream habitats prior to the overflow of fish migrating downstream to the island or the lower part of Lower Granite Reservoir. In general, age-0 chinook salmon appear to rear at stations that typically have fines for substrate and generally low gradient shorelines.

Future considerations of using dredged material may consider shoreline or beach enhancement rather than island development. The benefit of this may be two fold: juvenile predators such as smallmouth bass and northern squawfish seem to utilize riprap shorelines for rearing and secondly, "less desirable" predator habitat appears highly desirable for rearing of juvenile chinook. Therefore, habitat suitable for salmonid predators may be decreased in area whereas, at the same time, suitable rearing habitat for subyearling chinook salmon may be increased. The beneficial use of dredged materials for creating/enhancing habitat for age-0 chinook salmon appears possible based on our preliminary results.

One concern in creating an island was that newly created habitat may be ideal rearing habitat for some stages of the life cycle for predator fishes. Based on subadult and adult abundance of predator fishes and results from larval fish sampling, both in shoreline and adjacent pelagic water abundance has not increased, and the dynamics of the fish community in Lower Granite Reservoir has changed little as a result of the in-water disposal of dredged materials.

INTRODUCTION

Sediment deposition has become a primary concern for flood control and navigation in Lower Granite Reservoir, Idaho-Washington. Accumulation of sediment has raised concern over the ability of the levee system on the Snake and Clearwater rivers to protect the cities of Lewiston, Idaho and Clarkston, Washington. Estimates by U.S. Army Corps of Engineer personnel have indicated that nearly 3 million cubic yards of sediment annually enter the confluence of the Snake and Clearwater rivers, which form the upper end of Lower Granite Reservoir.

A number of alternatives are being evaluated to alleviate the flooding potential; dredging and disposal are immediate solutions. As a result of limited land disposal sites and the effort required in finding and preparing suitable areas, the more feasible and immediate option is in-water disposal. Experimental in-water disposal was conducted during 1988 and 1989 approximately 19 miles (30.6 km) downstream of the confluence of the Snake and Clearwater rivers. Dredge material was used to create an island and an underwater plateau at mid-depth (20-60 ft; 6.1-12.2 m) at river mile 119.5 (RM 119.5).

One potential beneficial use of sediment is the creation of additional shallow water habitat. About 10% of the surface area of Lower Granite Reservoir is considered shallow water habitat. The importance of shallow waters for foraging, resting and feeding by juvenile anadromous salmonid fishes, such as chinook salmon *Oncorhynchus tshawytscha*, steelhead trout *O. mykiss* and resident gamefish was reported by Bennett and Shier (1986), Bennett et al. (1988) and Bennett et al. (1990). These reports include benefits of creating shallow water habitat, but concern has been expressed over the possibility of increased production of potential predators, primarily northern squawfish *Ptychocheilus oregonensis*. Initial findings have indicated that catch rates of larval and juvenile predators at experimental disposal sites have not been elevated above those at reference sites (Bennett et al. 1989, 1990, 1991).

Deep water disposal of sediment has also been considered another viable alternative. Bennett and Shrier (1986) showed that deep water habitat generally supported fewer fishes with a majority of those fish being nongame catostomids and cyprinids. Recent research suggests that white sturgeon *Acipenser transmontanus* abundance in Lower Granite Reservoir may be higher than originally anticipated which has elevated interest in deep water disposal (Bennett et al. 1989, 1990).

As a result of these concerns over potential habitat and aquatic community changes, this project was funded as a continuation of the in-water disposal evaluation. Anticipated conclusion of the field monitoring will be in 1994.

OBJECTIVES

1) To assess abundance of larval, juvenile and adult predators with special emphasis on northern squawfish at two in-water disposal stations with those of reference stations;

2) To assess white sturgeon abundance and habitat factors associated with their abundance in Lower Granite Reservoir;

3) To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir; and,

4) To assess age-0 chinook salmon abundance in Lower Granite Reservoir and assess the potential suitability of the disposal sites for rearing of age-0 chinook salmon.

STUDY AREA

Ten sampling stations in Lower Granite Reservoir were used to monitor fish abundance during 1990 (Figure 1). Stations 1, 2 and 4 were areas created by in-water disposal of dredged material. Stations 3, 5, 9 and 10 were classified as shallow water reference stations; one additional reference station (11) was sampled for larval predator abundance. Not all stations were sampled to fulfill each stated objective. Also, 22 stations were sampled to assess the relative abundance of age-0 chinook salmon (Figure 2). Specific locations of sampling stations are as follows:

Station	Location
1	RM - 120.48-120.19 - shoreline adjacent to the island created with dredge materials;
2	RM - 120.48-120.19 - open water shoreline adjacent to island created with dredge materials;
3	RM - 120.48-120.19 - reference station with shoreline area inside the mid-depth site (on-shore);
4	RM - 120.48-120.19 - mid-depth fill site that created the underwater bench;
5	RM - 127.0 - shallow water reference site (SR2S in Bennett and Shrier 1986; LG2S in Bennett et al. 1988);
6	RM - 114.0-114.92 - mid-depth reference site (LG1M in Bennett et al. 1988);
8	RM - 120.5 - deep water reference site;
9	RM - 111.0 - shallow water reference site (LG1S in Bennett et al. 1988);
10	RM - 110.0 - shallow water reference site on the south side of the reservoir;
11	RM - 135.0 - shallow water reference site on the north side of the reservoir (LG5S in Bennett et al. 1988);

12 RM - 138.0 - south shoreline 1 mile upstream from Red Wolf Crossing; age-0 chinook beach seining station;

13 RM - 137.5 - south shoreline 0.5 miles upstream of the Red Wolf Bridge crossing; age-0 chinook beach seining station;

14 RM - 132.6 - south shoreline 1.6 miles upstream from Silcott Island; age-0 chinook beach seining station;

15 RM - 132.5 - rip-rap north shoreline; age-0 chinook beach seining station;

16 RM - 132.1 - south shoreline; age-0 chinook beach seining station;

17 RM - 131.0 - Silcott Island (Chief Timothy State Park); age-0 chinook beach seining station;

18 RM - 129.0 - one mile upstream from Steptoe Canyon embayment; age-0 chinook beach seining station;

19 RM - 125.8 - west shoreline 2.0 miles downstream from Nisqually John Landing; age-0 chinook beach seining station;

20 RM - 119.5 - west shoreline 0.5 miles downstream and across from Blyton Landing; age-0 chinook beach seining station;

21 RM - 119.0 - upstream shoreline adjacent to Blyton Landing; age-0 chinook beach seining station;

22 RM - 117.0 - Keith Canyon 1.1 miles upstream from Knoxway Canyon Bay; age-0 chinook beach seining station;

23 RM - 115.9 - Knoxway Canyon Bay; age-0 chinook beach seining station;

24 RM - 114.8 - Crum boat landing 0.9 miles upstream from Granite Point; age-0 chinook beach seining station;

25 RM - 113.7 - northeast shoreline 1.2 miles downstream from Granite Point; age-0 chinook beach seining station; and

26 RM - 107.5 - Lower Granite Dam and Lock; age-0 chinook beach seining station.

In addition to the 22 stations sampled for age-0 chinook salmon, nine stations between RM 108.0 and RM 137.1 were selected to assess white sturgeon abundance (Figure 3). These stations were selected through a systematic sturgeon sampling survey along 20 transects based on hydroacoustic surveys conducted during 1989 (Thorne et al. 1992). The reservoir was divided into three reaches; each approximately 10 miles (16 km) long. Selection of sampling stations was based on low and high white sturgeon concentrations from the systematic survey.

Transect	Location
R1S2	RM - 107.5 - transect 0.5 miles upstream of Lower Granite Dam;
R1S11	RM - 110.5 - transect 0.5 miles downstream of Wawawai;
R1S20	RM - 113.6 - transect 2.6 miles upstream of Wawawai;
R1S29	RM - 116.5 - transect 1.4 miles upstream of Knoxway Canyon Bay;
R2S2	RM - 117.7 - transect 2.5 miles upstream of Knoxway Canyon Bay;
R2S8	RM - 119.9 - transect 0.5 miles upstream of Blyton Landing;
R2S17	RM - 127.0 - transect 1.5 miles upstream of Nisqually John Landing;
R3S9	RM - 133.7 - transect 0.3 miles downstream from Port of Wilma; and
R3S12	RM - 137.1 - transect 0.2 miles downstream from Red Wolf Bridge crossing.

Objective 1: To access abundance of larval, juvenile and adult predators with special emphasis on northern squawfish at two in-water disposal stations with those of reference stations.

METHODS

To reduce sampling gear bias, several gear types were used during 1990 to make representative collections in Lower Granite Reservoir. Gear types included: gill nets, beach seines, electrofishing, surface trawling, and plankton nets and a beam trawl. Gill nets were used to assess the relative abundance of potential predators in pelagic waters. Surface trawling was used to sample pelagic salmonid abundance. Beach seining and electrofishing were used to sample shallow water stations during diurnal and nocturnal hours, respectively. Plankton nets and a beam trawl were used to estimate larval predator abundance.

Eight horizontal multifilament gill nets 225 ft long x 6 ft (68.6 m x 1.2 m) in depth, consisting of three graded panels with bar measurements of 1.5, 1.75 and 2.0 inches (3.1, 4.1 and 5.1 cm), were fished at stations 1, 2, 3, 4, 5, 6 and 8 during April, May, June, August and October. Gill nets were set perpendicular to the shoreline and fished on the bottom for approximately 3 hours of daylight and 3 hours of dark for a total of 6 hours. We have found that catches are generally higher during the evening crepuscular period than other times during the day and night (Bennett et al. 1988). Gill nets were checked every 2 hours at stations 1, 2, 3, 4 and 5 to avoid destructive sampling to salmonids and other fish species. A 3-hour schedule was used at mid-depth (6) and deep water (8) reference stations because few salmonids were collected at these stations.

A 100 ft x 8 ft (30.5 m x 2.4 m) beach seine with a 8 x 8 x 8 ft (12.1 m^3) bag constructed of 0.25 inch mesh (0.64 cm) was used to sample fish along the shoreline. Shallow water stations 1, 2, 5, 9 and 10 (Figure 1) were sampled at biweekly intervals during April, May and June and at monthly intervals during July, August, September and October. Standardized beach seine hauls were made by setting the seine parallel and approximately 50 ft (15.2 m) from the shoreline with attachment lines and then drawn in perpendicular to the shoreline. An area equivalent to 1,489.5 ft^2 (454 m^2) was sampled during each haul.

Standardized nighttime electrofishing was conducted by paralleling the shoreline, as close as possible, at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations (Figure 1). Biweekly sampling efforts were conducted during April, May and June and at monthly intervals during July through October. Electrofishing effort generally consisted of three periods of 5 minutes at each station. At stations 1 and 2, two periods of 5 minutes at each station were used because of their small size. A constant output of 400 volts at 3-5 amps was found to adequately stun fish without causing mortality or visual evidence of injury.

Surface trawling was used to sample open water stations 2, 4, 5 and 6 (Figure 1) at biweekly intervals during April, May and June. Two hauls per site were taken using a 32.8 ft (10 m) surface trawl consisting of 1.5 inch (3.8 cm) mesh netting with a cod end of 0.25 inch

(0.64 cm) mesh. The surface trawl was towed between two boats approximately 145 ft (45 m) apart the entire length of each station at an average speed of approximately 1.2 ft/s.

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

Abundance of larval fishes was sampled from mid-June through September, 1990 at stations 1, 2, 4, 5 and 11 (Figure 1). Two conical plankton nets (0.5 m in diameter) were towed at the surface and at 3.3 ft (1 m) deep at a speed of approximately 4.9 ft/s (1.5 m/s). Larval towing was conducted at night to increase efficiency (Houde 1969; Isaacs 1964; Netsch et al. 1971). A total of three paired independent samples (n = 6) were taken at each site. Standard duration of each tow was 3 minutes at each depth. High plankton densities during July and August necessitated the reduction in tow durations to less than 3 minutes at each depth. All samples were filtered through a 0.004 inch mesh screen (1.0 mm) and preserved immediately in 10% formalin.

To assess larval fish abundance adjacent to the shoreline and during diurnal periods, a custom built beam trawl (LaBolle 1985) was used at shallow water stations 1, 2, 5 and 11 biweekly from mid-June through September, 1990. The beam trawl was drawn by hand over a standard distance of 50 ft (15.2 m). Three hauls were made at depths of 1.6 ft (0.5 m) and 3.3 ft (1.0 m) for a total of six samples/sampling location/sampling date. Each sample was preserved separately in 10% formalin.

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

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

$$M = \bar{N}/a$$

where: $\bar{N}$ = Mean number of fish among samples ($n = 3$ or $n = 6$),
a = Volume of 1 plankton or beam trawl.

Total density (T) was determined by multiplying the mean density by total volume sampled (plankton net 318.08 m^3 or beam trawl 68.4 m^3 or 34.2 m^3 depending on depth).

$$T = M * A$$

where: M = Mean density,
A = Total volume.

The variance (V(T)) was determined by the following:

$$V(T) = A^2 * M/a*\bar{N}$$

where: T = Mean density,
A^2 = Square of total volume,
a = Volume of one sample,
$\bar{N}$ = Number of samples.

The bound (β) was ($\alpha = 0.05$) calculated by the following:

$$\beta = 2 * A\sqrt{M/a*\bar{N}}$$

Upper and lower bounds were determined by adding and subtracting the bound from the mean density.

RESULTS

Total Catch

A total of 15,235 fish representing 26 species were collected at nine sampling stations by surface trawling, electrofishing, beach seining and gill netting in Lower Granite Reservoir during 1990 (Tables 1-3). Greater numbers of fish were collected during the spring and summer followed by fall. Spring and summer sampling efforts accounted for 86% of the total number of fish collected. The spring sample was represented by 25 species compared to 19 during the summer and 21 species in the fall. Scientific names, common names and species codes used throughout this report are presented in Table 4.

Relative Abundance

Spring

A total of 6,616 fish of all sizes were sampled in Lower Granite Reservoir by all gear types during spring, 1990 (Table 1). Largescale suckers dominated total catches for all stations. Beach seining, electrofishing and gill netting were all equally effective at capturing largescale suckers, although selectivity for larger fish was apparent. Shallow water reference station 5 had the highest abundance of largescale suckers (n = 800). Chinook salmon were next in abundance at station 5 (n = 532). Surface trawling at stations 2, 4, 5 and 6 accounted for the majority of juvenile chinook salmon (n = 1,704) and steelhead (n = 524) collected. Smallmouth bass were high in abundance at shallow water reference stations 3 (n = 106) and 10 (n = 133). Northern squawfish were relatively high in abundance at all shallow water stations, except stations 9 and 10. The highest number of squawfish were collected at station 3 (n = 61) followed by disposal stations 1 (n = 41) and 4 (n = 48). Other species common at shallow water stations during spring included chiselmouth, white crappie and black crappie.

White sturgeon were collected at stations 5 and 8 by gill netting during spring. Sixteen of the 17 sturgeon sampled were collected at deep water reference station 8.

Summer

A total of 6,631 fish were sampled during summer in Lower Granite Reservoir by all gear types (Table 2). Sampling at shallow water reference stations 3 and 5 accounted for 39% (n = 2,615) and 20% (n = 1,299) of all fish collected. Young-of-the-year (YOY) sunfishes, generally collected by beach seining, dominated the catches at station 3 (n = 1,367). Largescale suckers accounted for 64% (n = 835) of the catch at station 5 and generally dominated the catches at all stations, except station 3. Smallmouth bass catches were higher than those in the spring at all shoreline stations. Catches of smallmouth bass at shallow water reference stations 3 (n = 325), 9 (n = 304) and 10 (n = 353) were higher than those at other stations. Relative abundance of smallmouth bass at disposal stations were variable, being low at station 4 (n = 4) and high at station 2 (n = 230). No smallmouth bass were collected at deep water reference station 8. Catches of northern squawfish during summer were higher than spring catches. As in spring, the highest number of northern squawfish collected (n = 227) was at shallow water reference station 3. Catches at disposal stations 1 (n = 717) and 2 (n = 661) were similar during summer. White sturgeon were collected at stations 1, 5 and 8. The highest number of white sturgeon were collected at station 8 (n = 5) followed by station 5 (n = 4).

Fall

During fall, as in spring and summer, largescale suckers were highest in relative abundance at all stations followed by smallmouth bass and northern squawfish (Table 3). Abundance of smallmouth bass was highest at shallow water reference stations 3 (n = 59) and 9 (n = 68). Catch rates for smallmouth bass at disposal stations 1, 2 and 4 and reference stations 5, 6, 8 and 10 all were low compared to summer catch rates. Northern squawfish abundance varied among stations. Highest abundance of northern squawfish were collected at shallow water reference station 5 (n = 68) followed by disposal stations 1 (n = 38) and 2 (n = 27). White sturgeon were sampled by gill netting during fall only at station 8 (n = 4).

Size Comparisons

All Species

Size of fish sampled in Lower Granite Reservoir, Washington during 1990 varied by gear type. Generally, larger fish were collected by gill nets, whereas smaller fish were consistently collected by beach seine. A wide range of sizes of fish were collected by electrofishing.

Spring.- During spring, the majority of fish sampled in Lower Granite Reservoir were between 50-500 mm (Figures 4 and 5). Size distributions at disposal stations 1, 2 and 4 were generally similar to those at shallow water reference stations 3, 5, 9 and 10. Length frequencies at mid-depth reference station 6 ranged from 125-500 mm and were generally similar to those from shallow water stations, except for peaks at 125-150 mm. Deep water reference station 8 had primarily larger fish ranging from 200-950 mm. Smaller fish were probably present at station 8, but they were not sampled because gill nets were the only gear type fished.

Summer.- Length frequency distributions during summer were different from those of spring for most stations (Figures 6 and 7). Shallow water reference stations 3, 9 and 10 had an abundance of fish between 50-100 mm which accounted for > 50% of all fish sampled, while the 50-100 mm size classes for shallow water reference station 5 accounted for only 16% of the total number of fish collected (Figure 7). Length frequencies at disposal stations 1 and 2 during summer were similar to those of spring, although YOY fishes (< 100 mm) were abundant. Size frequencies at station 4 differed from stations 1 and 2 as smaller (50-175 mm) size classes were not sampled. The majority of fish sampled at mid-depth reference station 6 were 200-300 mm. Summer sampling differed from that of station 6 during spring where length classes 125 and 150 mm accounted for the majority of the fish (Figures 5 and 7). Size distributions at station 8 ranged from 275-950 mm and were similar to those of spring.

Fall.- Length frequencies of all fishes sampled during fall differed from both spring and summer in that fewer fish 25-75 mm were present (Figures 8 and 9). Generally, length frequencies at stations 1, 2, 3, 4, 5, 6 and 8 had modes at about 300 mm.

Size Structure

Size structure of key species; juvenile chinook salmon, steelhead trout, northern squawfish, channel catfish and smallmouth bass generally showed similarities among stations and within gear types in Lower Granite Reservoir. Analysis of size distributions generally show what sizes of the key species are utilizing various habitats.

Spring 1990

Chinook salmon.- The modal size of juvenile chinook salmon collected by surface trawling was 125 mm at all stations except station 2 where fewer fish were collected (Appendix Figure 1). Size distributions ranged from 25-175 mm. Size distributions of juvenile chinook salmon at disposal stations 2 and 4 and reference stations 5 and 6 were similar.

Size distributions of juvenile chinook salmon sampled along the shorelines by nighttime electrofishing were similar among stations, but smaller fish were more abundant than in trawl samples (Appendix Figure 2). Size classes of juvenile chinook salmon sampled ranged from 25-175 mm. The modal size of chinook salmon was 125 mm, identical to that seen by surface trawling. All stations had similar modal size classes of juvenile chinook salmon, with the exception of shallow water reference station 9 where few salmon were collected.

Size composition of juvenile chinook salmon sampled by beach seining varied among stations (Appendix Figure 3), and ranged from 25-150 mm at all stations with the majority of fish in 50-100 mm length classes. Generally, the modal size of juvenile chinook salmon sampled was smaller (50-100 mm) than those sampled by surface trawling (125 mm) and electrofishing (125 mm), and reflects the catches of age-0 chinook sampled by beach seining. Few juvenile salmon in the > 100 mm size class were collected at reference stations 3, 9 and 10.

Steelhead.- Size distributions of juvenile steelhead sampled by surface trawling were similar among all stations (Appendix Figure 4). Size classes ranged from 100-300 mm with a modal size of 175 mm at stations 2, 4 and 5 and 200 mm at station 6.

Modal size of juvenile steelhead sampled by electrofishing was 200 mm for all stations (Appendix Figure 5) and size distributions were similar among stations. Larger steelhead were collected at reference stations 9 and 10.

Size composition of juvenile steelhead captured by beach seining varied among stations (Appendix Figure 6), although numbers collected were low. Size classes ranged from 100-300 mm. Shallow water reference station 9 had the highest catch rates with the widest range of length classes (100-300 mm). Low frequencies of juvenile steelhead at stations 3 and 5 make size comparisons meaningless at those stations.

Size classes of juvenile steelhead collected by gill netting ranged from 175-400 mm (Appendix Figure 7). Captures at all stations were generally low which precludes depth comparisons. Generally, modal size of juvenile steelhead was larger than 200 mm and similar to those collected along the shoreline by beach seining and electrofishing.

Northern squawfish.- Length frequencies of northern squawfish sampled by nighttime electrofishing generally exhibited a modal size of 125 mm at all stations (Appendix Figure 8). The majority of squawfish collected were between 100-175 mm; few squawfish > 250 were sampled by electrofishing during spring.

Beach seining efforts for northern squawfish yield too few fish to provide an adequate comparison of size composition (Appendix Figure 9). A total of 10 squawfish were collected by beach seining which precludes meaningful comparisons among size classes. Length classes ranged from 50-400 mm.

Length frequencies of northern squawfish collected by gill netting during spring ranged from 300-625 mm (Appendix Figure 10). Little variation in modal size of northern squawfish was observed (325-400 mm) among stations. The largest fish was collected at shallow water disposal station 2. Low numbers of northern squawfish were collected from deep water reference station 8 and lengths ranged from 325-425 mm.

Channel catfish.- Low numbers of channel catfish were collected by gill netting at stations 1, 3, 5, 6 and 8 (Appendix Figure 11). Channel catfish at mid-depth and deep water reference stations were represented by a wide range of lengths. Size distributions ranged from 200-525 mm at station 8 and 300-625 mm at station 6. Generally, channel catfish numbers captured at shallow and mid-depth stations were low, although sizes at those stations were similar to those collected at station 8, the deep water reference station.

Smallmouth bass.- Length frequencies of smallmouth bass collected by nighttime electrofishing ranged from 25-350 mm with the majority of the fish sampled between 100-275 mm (Appendix Figure 12). Modal sizes were variable among stations with a higher number of larger fish collected at stations 2, 5 and 10.

Sizes of smallmouth bass varied by gear type. Low numbers of smallmouth bass were collected by beach seining during spring; length classes ranged from 50-350 mm and modal size varied among stations (Appendix Figure 13). For example, modal size was 50 mm at station 10 compared to 200 mm at station 1. Sizes captured at night by electrofishing were similar to those captured during the day by beach seining, although we captured larger bass by electrofishing.

Size composition of smallmouth bass sampled by gill netting ranged from 250-450 mm (Appendix Figure 14). Too few fish were sampled at disposal and reference stations to show trends in size distribution.

White sturgeon.- Length frequencies of white sturgeon collected by gill netting at reference stations during spring were characterized by low frequencies with a wide range in lengths (Appendix Figure 15). Although sampling was done in shallow water disposal (1, 2), shallow water reference (3, 5), mid-depth disposal and reference (4, 6) and deep water reference (8) stations, only one fish (650 mm) was captured at station 5 and the remaining white sturgeon were captured at station 8. Size classes at station 8 (RM 120.5) ranged from 350-1,000 mm. These sizes for sturgeon were collected during the fish stock assessment of the reference and disposal stations. More information on white sturgeon is presented under Objective 2.

Summer 1990

Chinook salmon.- No age-1 chinook salmon were collected in the summer of 1990 in Lower Granite Reservoir. Age-0 salmon collected are reported under Objective 4.

Steelhead.- A total of five juvenile steelhead ranging from 251-272 mm were sampled by all gear types at all stations during summer, 1990. Therefore, comparison of size composition during summer in Lower Granite Reservoir is not meaningful.

Northern squawfish.- A majority of northern squawfish collected by electrofishing were small, as modal sizes ranged from 25-50 mm (Appendix Figure 16). Juvenile squawfish were collected at disposal stations 1 and 2 and reference stations 3, 5 and 10. Northern squawfish sampled at station 9 were larger than those at other stations (125-200 mm). Northern squawfish in the 50 mm size class generally dominated electrofishing captures at disposal and reference stations, although numbers collected during summer were low (Appendix Figure 16).

Few northern squawfish were collected during summer by daytime beach seining. All were < 100 mm. Modal size of northern squawfish sampled by gill netting was 350 mm (Appendix Figure 17). Length frequencies of squawfish were similar among disposal stations 1, 2 and 4 and reference stations 3 and 5. No northern squawfish over 450 mm or less than 250 mm were collected by gill nets at any of the sampling stations. Captures of squawfish at stations 6 and 8 were low, although lengths were similar to those at shallow water stations.

Channel catfish.- Numbers of channel catfish collected at disposal stations 1 and 2 by gill netting increased during summer sampling season over that of the spring season. Size classes ranged from 225-650 mm (Appendix Figure 18) and modal size varied among stations. Numbers of channel catfish collected at the mid-depth (6) and deep water reference stations (8) were low. Size distributions generally were uniform from 250-500 mm.

Smallmouth bass.- Size composition of smallmouth bass sampled by nighttime electrofishing during summer, 1990 ranged from 25-350 mm (Appendix Figure 19). Although fewer bass were sampled at shallow water disposal stations 1 and 2, modal sizes (125-200 mm) generally were similar between disposal and reference stations.

Modal sizes of smallmouth bass collected by beach seining during summer ranged from 50-75 mm (Appendix Figure 20). Lengths ranged from

50-250 mm, although few bass > 100 mm were beach seined. Size compositions of bass collected from shallow water disposal stations 1 and 2 and reference stations 3, 9 and 10 were similar. Few bass were sampled at station 5 and these were in the 75 and 200 mm length classes.

Length frequencies of smallmouth bass captured by gill netting ranged from 200-450 mm (Appendix Figure 21). Numbers of smallmouth bass collected were low at disposal and reference stations, although size composition was similar among stations. No smallmouth bass were collected during summer at deep water reference station 8.

White sturgeon.- As with the spring sampling season, the summer gill netting effort for white sturgeon was characterized by a wide range (400-975 mm) of lengths (Appendix Figure 22). Deep water reference station 8 had the highest frequency of captures (n = 5), followed by shallow water reference station 5 (n = 4). One white sturgeon was captured at shallow water disposal station 1. Sizes of sturgeon captured at station 8 generally bracketed the sizes of sturgeon collected at stations 1 and 5. No sturgeon were collected at stations 2, 3, 4 and 6 during summer 1990.

Fall 1990

Salmonid fishes.- During fall 1990, 24 juvenile salmonids were collected in Lower Granite Reservoir (Table 3). About 66% of the salmonid fishes were steelhead.

Northern squawfish.- Two northern squawfish were collected by beach seining (60 and 71 mm) at stations 1 and 3 which was similar to the sizes collected by electrofishing (Appendix Figure 23). Few northern squawfish were collected in Lower Granite Reservoir by beach seining and electrofishing.

Frequencies of northern squawfish sampled by gill netting varied among stations and the size composition ranged from 200-525 mm (Appendix Figure 24). Squawfish numbers collected at disposal stations 1, 2 and 4 were low, although size distributions were similar to those at shallow (3 and 5) and mid-depth (6) reference stations. Low captures at deep water reference station 8 generally included larger squawfish (350-475 mm).

Channel catfish.- Lengths of channel catfish collected during fall by gill netting ranged from 200-675 mm (Appendix Figure 25). Captures were scattered throughout the disposal and reference stations with little trend in size composition. The largest channel catfish was collected at shallow water reference station 3.

Smallmouth bass.- The size composition of smallmouth bass collected during fall by electrofishing was similar among most stations (Appendix Figure 26). Length frequencies ranged from 25-300 mm, similar to size classes collected during summer. Modal size of bass during fall was 50-75 mm.

Few smallmouth bass were collected in Lower Granite Reservoir by beach seining during fall. Only one smallmouth bass (284 mm) was sampled by beach seine at shallow water reference station 10. Size of smallmouth bass sampled by gill netting ranged from 200-375 mm (Appendix Figure 27). The largest smallmouth bass (375 mm) was collected at shallow water disposal station 1. Low numbers of smallmouth bass collected during fall precluded meaningful size comparisons among stations.

White sturgeon.- White sturgeon size composition in the fall was similar to that of spring and summer gill netting sampling. White sturgeon were sampled exclusively at station 8 and sizes ranged from 450-775 mm.

Abundance of Key Species Among Stations

1990

Chinook salmon.- In open water, catch rates of juvenile chinook salmon by surface trawling in 1990 were highest at reference station 5 followed closely by those at reference station 6. Surface trawling catch rates at disposal stations 4 and 2 were lower than those at reference station 5, but not significantly lower (Figure 10).

Catch rates of juvenile chinook salmon during night by electrofishing were similar among stations. The highest catches occurred at disposal station 1, although these catches were not statistically higher than those at other stations ($P > 0.05$; Figure 11).

Daytime abundance of juvenile chinook salmon along the shoreline was similar among stations during 1990 based on comparison of catch rates. Although catch rates by beach seining were highest at reference stations 3, 9 and 10, these differences were not statistically significant ($P > 0.05$; Figure 12). Catches at disposal stations 1 and 2 were nearly identical.

Steelhead.- Nighttime abundance of juvenile steelhead along the shoreline sampled by electrofishing was generally similar among stations (Figure 13). Catches were highest at reference station 9 which were statistically higher ($P < 0.005$) than those at disposal stations 1 and 2 and reference stations 3 and 5. Few other statistical differences were found in nighttime catches of juvenile steelhead.

Daytime abundance of juvenile steelhead along the shoreline based on beach seining in 1990 varied between some reference and disposal stations (Figure 14). Highest catch rates occurred at reference station 9 followed by reference stations 3, 5 and 10. Generally, catch rates were not significantly different among stations, although rates at station 9 were significantly higher than those at disposal station 1.

Abundance of juvenile steelhead in pelagic waters was highest at disposal station 4 and similar among disposal station 2 with those from reference stations 5 and 6. However, none of the differences in catch rates were statistically ($P > 0.05$) significant (Figure 15).

Northern squawfish.- Nighttime abundance of northern squawfish along the shoreline sampled by electrofishing in 1990 was variable among stations. Of the reference stations, catches at stations 3 and 10 were the highest, and station 1 had the highest abundance of the disposal stations (Figure 16). Reference station 9 and disposal station 2 had significantly ($P < 0.05$) lower catch rates than the other stations.

Daytime abundance of northern squawfish along the shoreline based on beach seining was highest at reference stations 3 and 10 and lower at reference stations 5 and 9 and disposal stations 1 and 2 (Figure 17).

Of these differences, only catches of juvenile squawfish at station 3 were significantly higher than those at reference stations 5 and 9 and disposal stations 1 and 2. Other variations in abundance among stations were not statistically different.

Analysis of variance indicated a significant two-way interaction between season and station for gill netting of northern squawfish. Significant differences in catch/effort of northern squawfish by gill netting were between reference stations 5 and 8 and disposal station 4 (Figure 18).

Channel catfish.- The abundance of channel catfish based on gill net collections varied among stations (Figure 19). In general, the abundance of channel catfish in 1990 was highest at reference station 8 in spring, and shallow water reference station 5 in summer and fall. During summer few differences in abundance among stations were found. Generally, abundance of channel catfish at disposal station 4 was consistently low throughout 1990, while at disposal stations 1 and 2 abundance was seasonally variable but not significantly higher than at similar reference stations. Channel catfish seem to inhabit deeper waters in spring and fall and shallow waters in summer.

Smallmouth bass.- Nighttime catches of smallmouth bass sampled by electrofishing were higher at reference stations 3 and 10 followed by disposal stations 1 and 2 (Figure 20). Abundance of smallmouth bass at night was lowest at reference stations 5 and 9 and similar to daytime abundance of smallmouth bass at these stations.

During 1990, daytime abundance of smallmouth bass along the shoreline as determined by beach seining was higher at reference stations 10 and 3, lower at disposal stations 1 and 2, and lowest at station 5 (Figure 21). The only statistical difference ($P < 0.05$) was between the catches of smallmouth bass at reference stations 5 and 10.

Abundance of smallmouth bass in deeper waters as determined by gill netting was significantly different among stations during 1990 within seasons. The two-way interaction between station and season was significant ($P < 0.05$) which precluded an overall comparison of abundance. Ranked catches were highest in summer and fall, whereas spring catches were lower and mostly similar among stations. During summer 1990, abundance of smallmouth bass based on gill netting was similar among stations, except at station 8 where catches were significantly lower than at other stations (Figure 22). During fall, gill net catches were similar between some reference and disposal stations, although few significant differences were found.

White sturgeon.- The abundance of white sturgeon in 1990 was similar among stations, but catches were consistently higher at reference stations 5 and 8 (Figure 23). The two-way interaction between station and seasonal abundance of white sturgeon was significant. Abundance of sturgeon based upon gill net captures was generally low at all disposal, shallow and mid-depth reference stations.

Comparison of Abundance of Key Species

1989-1990

Chinook salmon.- During nighttime and daytime, the abundance of juvenile chinook salmon along the shoreline based on comparison of catches was similar among all shallow-water stations and between 1989 and 1990 (Figures 24 and 25). The interaction between year and station was significant ($P < 0.05$) for both beach seining and electrofishing. Trends in catches generally were similar between stations for 1989 and 1990, although catches were higher in 1989.

Catches of juvenile chinook salmon by surface trawling in pelagic waters were generally similar between 1989 and 1990, however catches were different among stations (Figure 26). Highest catches were at reference station 5. During 1989 and 1990, catches were significantly higher at reference station 5 than at disposal station 2.

Steelhead.- The abundance of juvenile steelhead along the shoreline has varied among years and stations. Daytime abundance sampled by beach seining varied among stations during 1989 and 1990. Catches of juvenile steelhead were significantly ($P < 0.05$) higher in 1989 than in 1990 (Figure 27). Between 1989 and 1990, catches were generally similar at reference stations 5 and 9, but were lower in 1990 at reference station 3 and disposal stations 1 and 2. From 1989 to 1990, beach seine collections of juvenile steelhead were significantly higher at station 9 than at reference station 5 and disposal station 1.

Nighttime abundance of juvenile steelhead based on electrofishing was similar to that of the daytime. As with beach seining, abundance was highest at station 9 and lowest at station 1 (Figure 28). Although catches were consistently higher in 1990, they were not significant.

The abundance of juvenile steelhead at various stations based on surface trawling for 1989 and 1990 was not significantly different among stations and between years (Figure 29). The station*year interaction was significant ($P < 0.05$) as catches generally were higher in 1989, although catches at station 4 were lower.

Northern squawfish.- Daytime abundance of northern squawfish along the shoreline as determined by beach seining indicated a significant ($P < 0.05$) decrease in abundance from 1989 to 1990 (Figure 30). Most squawfish sampled by beach seining were juvenile fish. Catches of squawfish by beach seining were consistently higher at all stations in 1989. Abundance at reference stations 3 and 10 was significantly higher than that at disposal stations 1 and 2 and reference stations 5 and 9 from 1989 to 1990.

Nighttime abundance of northern squawfish based on electrofishing was generally higher in 1989 than 1990 (Figure 31) and the two-way station*year interaction was significant ($P < 0.05$). In 1989, squawfish abundance was highest at station 1, although abundance was not significantly different among reference stations 3 and 5 and disposal station 2. However in 1990, abundance at disposal stations was low with disposal station 2 being about the lowest.

Abundance of larger northern squawfish based on gill netting differed among stations and seasons and between years 1989 and 1990 (Figure 32). The abundance of larger squawfish during 1989 and 1990 was highest in fall followed by spring and summer. Overall, the abundance of larger squawfish was intermediate at disposal stations 1, 2 and 4 during 1989 and 1990.

Channel catfish.- A three-way interaction between catches of channel catfish and season*year*station was found. In general, summer gill net catches were higher than other seasons, and catches were generally higher at shallow stations during summer and deeper stations during spring and fall (Figure 33). Catches were variable among years and seasons within a station.

Smallmouth bass.- Differences in daytime beach seine catches along the shoreline for smallmouth bass were variable among stations, but catches were not significantly different between 1989 and 1990 (Figure 34). During 1989 and 1990, beach seine catches of smallmouth bass were significantly higher at station 10 than at reference stations 3 and 5 and disposal stations 1 and 2.

Catches of smallmouth bass at night along the shoreline by electrofishing were generally higher in 1989 than 1990 at all the reference stations, but catches were just the opposite for the disposal stations (Figure 35). The year*station interaction was significant ($P < 0.05$) which required a comparison within a year and within a station. In general, catches of smallmouth bass were significantly lower in 1989 and 1990 at reference stations than those at the disposal stations 1 and 2.

Catches of smallmouth bass by gill netting were significantly different between 1989 and 1990 for spring and fall, but not summer

(Figure 36). The two-way interaction between year*season was significant ($P < 0.05$).

White sturgeon.- Catches of white sturgeon captured by gill netting were similar at all reference and disposal stations between 1989 and 1990, except at reference stations 5 and 8 where the abundance flip-flopped between 1989 and 1990 (Figure 37). The two-way interaction between station*year was significant ($P < 0.05$). Catches of white sturgeon at reference station 8 were significantly higher than those at other reference and disposal stations for both 1989 and 1990.

1988-1990

Chinook salmon.- The abundance of juvenile chinook salmon in open water within Lower Granite Reservoir has changed significantly from 1988 through 1990 based on comparison of catch rates by surface trawling (Figure 38). Catches were statistically lower in 1988 than in 1989 and 1990. During the period from 1988 to 1990, no significant difference was found among reference stations 5 and 6 and disposal station 4.

Steelhead.- Pelagic abundance of juvenile steelhead based on catches from surface trawling indicated no differences from 1988 to 1990 and no station differences (Figure 39). Catches at station 4 were the lowest, but they were not significantly different from reference stations 5 and 6.

Northern squawfish.- Catches of northern squawfish since 1988 by gill nets have generally been higher during fall (Figure 40). Station differences have been found with significantly higher catches of larger squawfish at reference station 5 than at other stations. Station 4 was the second from the lowest in squawfish abundance based on the catch rates from gill nets.

Channel catfish.- A significant three-way interaction was found between station*year*season for catches of channel catfish (Figure 41). Abundance at disposal station 4 was initially high based on catch rates of channel catfish by gill nets in spring and summer 1988. Since then, catches have declined.

Smallmouth bass.- Catch rates of smallmouth bass by gill netting have fluctuated seasonally since 1988 (Figure 42). Little consistency in catches of smallmouth bass were found from 1988 through 1990. During spring, catches of smallmouth bass were generally higher at disposal station 4, although they were highly variable. No real trends in season or station abundance of smallmouth bass were found.

White sturgeon.- The abundance of white sturgeon since 1988 has consistently been highest at reference station 8 (Figure 43). Catches of white sturgeon have been significantly lower at reference station 8 since 1989 and 1990. Catches at station 4 have not changed between 1988 and 1990.

1987-1990

Chinook salmon.- Abundance of juvenile chinook salmon along the shoreline based on beach seining has remained similar from 1987 to 1990 at reference stations 5 and 9 (Figure 44). Since 1987 daytime catches of juvenile chinook salmon along the shoreline have generally increased, yet they have remained statistically similar. Although open water abundance of chinook salmon was statistically different in 1988 from 1989 and 1990 (Figure 38), we found no difference in abundance along the shorelines at stations 5 and 9.

Nighttime catches of juvenile chinook salmon have generally increased since 1987 (Figure 45). Catches at stations 5 and 9 were significantly different with those at station 5 higher than station 9.

Steelhead.- Abundance of juvenile steelhead along the shoreline by beach seining has differed significantly ($P < 0.05$) at reference stations 5 and 9 from 1987 to 1990 (Figure 46). Catches of juvenile steelhead have been consistently about twice as high at station 9 than station 5.

Nighttime abundance of juvenile steelhead at reference stations 5 and 9 has differed among years (Figure 47). Catch rates were similar in 1987 and 1988, but were different in 1989 and 1990. Yearly differences in catch rates have been scattered within stations with little comparison except that catches were highest in 1988 and intermediate in 1990 at stations 5 and 9.

Northern squawfish.- Catch rates of northern squawfish sampled by beach seining during the daytime were not significantly different between reference stations 5 and 9 from 1987 to 1990. Comparison of catch rates indicated highest abundance in 1987 and 1989 followed by 1988 and 1990 (Figure 48). These differences between 1987 and 1989, and 1988 and 1990 were significant ($P < 0.05$).

Nighttime catches of northern squawfish by electrofishing indicated generally high abundance in 1989 and 1990 (Figure 49). Since 1987, no significant differences in the abundance of northern squawfish have been found, although during that time, their abundance has been significantly higher at station 5 than at station 9.

Pelagic abundance of northern squawfish based on gill net catches during 1987 through 1990 was generally similar among years (Figure 50). Catches of northern squawfish at reference station 5 have been the highest.

Channel catfish.- The abundance of channel catfish in deep water based on gill net collections since 1987 has not changed as a result of in-water disposal of dredged materials (Figure 51). No station differences have been observed, although numbers of channel catfish collected have averaged seasonally less than 100 fish. Differences in catches were variable and indicated no trend towards an increase in abundance. In general, catches have been highest in the summer and lower during spring and fall. Within seasons, catches of channel catfish have fluctuated in abundance from one year to the next.

Smallmouth bass.- Since 1987, catches of smallmouth bass along the shoreline by beach seining have generally declined (Figure 52). Catches of smallmouth bass were significantly higher in 1987 and 1988 than in 1989 and 1990. During this four year period, catches of smallmouth bass have been significantly higher at reference station 9 than at station 5.

After 1987, nighttime abundance of smallmouth bass along the shoreline at reference stations 5 and 9 increased in 1988 and 1989, but decreased in 1990 (Figure 53). Differences in abundance of smallmouth bass were slight between 1987 and 1990 at station 9, although abundance at station 5 was significantly higher during 1988 and 1989 than in either 1987 or 1990. Except for 1990 when no differences in abundance were found at reference stations 5 and 9, catches of smallmouth bass have been significantly higher at station 9.

Since 1987, catches of smallmouth bass in deeper waters sampled by gill netting have consistently been highest in summer (Figure 54). Abundance based on gill net catches has been significantly higher at reference station 5. Generally, catches during 1987 were significantly lower than those from 1989 and 1990.

White sturgeon.- White sturgeon abundance has remained relatively constant since 1987. The mean of ranks of catches indicates that the abundance of sturgeon in 1990 was not significantly ($P > 0.05$) different among years 1987 and 1990, although their abundance between 1988 and 1989 was significant ($P < 0.05$). Catches were significantly lower at both the shallow water and mid-depth reference stations than those at the deep water reference station 8. During the years of 1987-1990, few differences in seasonal abundance have been found (Figure 55). Station differences within the seasons also were few.

Larval Fishes

A total of 973 larval fishes were collected by paired plankton nets in Lower Granite Reservoir during 1990. These collections comprised five families and four genera (Figure 56). Larval cyprinids and catostomids could not be identified lower than the family level prior to median fin development.

Cyprinids were highest in relative abundance in pelagic waters followed closely by catostomids and collectively accounted for approximately 85% of all larval fishes collected by paired plankton nets (Figure 56). Centrarchids were the third highest family in relative abundance. *Lepomis* spp. dominated the catches of paired plankton nets at the genera level followed by *Ictalurus*, *Micropterus* and *Pomoxis* species (Figure 56). The genera *Micropterus*, *Ictalurus* and *Pomoxis* were about equally abundant in pelagic waters.

The most diverse and highest number of larval fishes were captured during July when five families were represented (Figure 57). Catostomids dominated June catches, whereas centrarchids dominated August and September catches. Members of the family cyprinidae were collected by paired plankton nets in July through September.

Shallow water reference stations 5 and 11 generally had the highest total number of larval fishes based on paired plankton net samples (Table 5). Of the disposal stations, station 2 had the highest number of larval fishes, whereas station 4 had the lowest.

Based on paired plankton net samples, density of larval northern squawfish was highest at shallow water reference stations 5 and 11

(Table 6). One larval squawfish was identified at the island, disposal station 2, whereas none were collected at disposal station 4.

Estimates of smallmouth bass densities, based on paired plankton net samples, were highest and generally similar at disposal stations 1 and 2 (Table 6). Larval smallmouth bass were not collected at any other station by paired plankton nets.

A total of 1,274 larval fishes were collected from June through September, 1990 by beam trawl. Higher numbers of larval fishes collected by beam trawl indicated higher abundance in shallow water than in pelagic waters. Relative abundance of cyprinids and catostomids was highest during June and decreased throughout summer (Figure 58). Larval cyprinid and centrarchid fishes were about equally abundant in July 1990, whereas larval centrarchids increased in abundance after June and dominated collections during August and September. Low numbers of larval cyprinids were collected by beam trawl in August and September, although numbers of larval centrarchids remained high.

The highest number of larval fishes collected by beam trawl occurred at reference stations 5 and 11 (Table 7). Larval fish numbers collected by beam trawl at shallow water disposal station 2 were higher than at disposal station 1. No larval northern squawfish were collected along the shoreline at either disposal station 1 or 2 (Table 7). The highest abundance of northern squawfish was found at reference station 11; densities averaged > 25,000/10,000 m^3. Larval smallmouth bass were collected by beam trawl at disposal stations 1 and 2, but they were generally low in abundance. Beam trawl samples also contained high numbers of *Lepomis* spp. and catostomids.

DISCUSSION

Over 15,000 fish were collected during 1990 in Lower Granite Reservoir as part of the monitoring. As in previous years, the highest number of species and individuals were collected during spring. The higher number of species in spring compared to summer was associated with the collection of several species of anadromous fishes during their out migration.

As in previous years, largescale suckers dominated the catch during spring followed by juvenile chinook salmon. Smallmouth bass and northern squawfish were high in abundance, but their numbers varied among stations. For example, reference stations 3 and 10 accounted for a high number of smallmouth bass while northern squawfish were relatively abundant at all shallow water stations except reference stations 9 and 10. Squawfish abundance was highest at disposal stations 1 and 4.

During summer, 1990, nearly 7,000 subadult and adult fish were collected. Largescale suckers were highest in abundance followed by smallmouth bass and northern squawfish. Catches of northern squawfish increased in summer over those of spring, and highest catches were made at shallow water reference station 5. Collections at shallow water reference stations 3 and 5 collectively accounted for nearly 60% of all fish sampled.

During fall, largescale suckers were highest in abundance followed by smallmouth bass and northern squawfish. Shallow water reference station 5 had the highest abundance of northern squawfish. Abundance of squawfish at the disposal stations was about half that of reference station 5.

Sizes of fishes collected between disposal and shallow water reference stations were generally similar. Wide ranges in sizes of fish were collected during spring. In summer, smaller fishes predominated catches; fish in the 50-100 mm range accounted for > 50% of all fishes sampled at the shallow water reference stations. Young-of-the-year fish were first recruited during summer and contributed to the smaller catch at the reference stations. Differences also occurred in sizes of fish collected at disposal stations 1 and 2 and disposal station 4, because smaller fish were not present in samples from station 4. Size distributions at station 4 were more similar to those at station 6, the mid-depth reference station. During fall, length frequency distributions were similar to those of spring and summer, except that smaller size classes were not present.

Northern squawfish collected during spring at shallow water stations were generally between 100-175 mm. Sizes of squawfish collected by gill netting were also similar among stations. Northern squawfish were generally similar in size to smallmouth bass.

During summer, squawfish collected at shallow stations were generally smaller than those collected during spring, probably demonstrating the influence of recruitment of YOY. Sizes of squawfish captured by gill netting were similar among reference and disposal stations. Collections of other species at shallow stations reflected the addition of juvenile fish.

During fall, larger squawfish (> 400 mm) were captured at disposal stations 2 and reference stations 3 and 5. The size composition of smallmouth bass was similar among most stations and similar to the size classes collected during summer.

Larval fishes were abundant at shallow water stations in Lower Granite Reservoir during 1990. Cyprinid fishes were highest in abundance followed closely by catostomids, both groups accounted for about 85% of all larval fishes collected by tow netting. Shallow water reference stations 5 and 11 had the highest total number of larval fishes collected by tow netting and hand trawl. Density of larval squawfish was highest at shallow water reference stations 5 and 11, but few were collected by tow nets at the disposal stations. Also, no larval squawfish were collected by hand trawl at disposal stations 1 and 2. In comparison, densities of larval squawfish averaged about 25,000/1000 m^3 at reference station 11. Other larval individuals of predator species collected in Lower Granite Reservoir were smallmouth bass. Although larval smallmouth bass were collected at disposal stations 1 and 2, their abundance was low.

Fish collections in 1990 showed abundance of juvenile salmonid fishes was similar at disposal and reference stations. Catches of juvenile chinook salmon and steelhead have been generally similar among island disposal stations and reference stations. Catches of juvenile steelhead were lower at station 1 than other reference and disposal stations sampled, but not for juvenile chinook salmon. Our sampling has indicated that juvenile chinook and steelhead seem to concentrate in certain locations of the reservoir. Juvenile steelhead abundance based on nighttime and daytime sampling was consistently higher at reference station 9 and often at station 10 than at other locations sampled in Lower Granite Reservoir (Figures 13 and 14). Catches of juvenile chinook salmon were higher at station 5 based on electrofishing and surface trawling than at other locations in the reservoir.

Although changes in abundance and apparent concentrations among stations were observed in 1990, only some of the same locations of concentrations were observed in 1989 and 1988. Juvenile steelhead abundance at station 9 was significantly higher than station 5 during 1989 and 1990 but not in 1987 and 1988. Catches of juvenile chinook salmon in pelagic waters were not significantly higher in 1988 and 1989 as they were at station 5.

Changes in predator abundance caused by in-water disposal has been a topic of concern for resource managers. As in previous years, subadult and adult predator catches and catch rates at disposal stations have been statistically similar to those at reference stations. Stations where salmonid abundance was high have generally had high abundance of subadult and adult predators. This generality seems to be true for shoreline oriented predators such as smallmouth bass and northern squawfish, but not for channel catfish. Channel catfish appear to migrate to shallower water during summer, possibly to coincide with their spawning activities rather than for feeding. In spring, channel catfish are more abundant at the deep water reference station, whereas during summer and fall, catch rates by gill nets were highest at shallow water reference station 5.

One concern about in-water disposal was the possible adverse affects on the dynamics of fishes in Lower Granite Reservoir. Comparison of catches of various species suggests abundance has changed little among species of interest. Abundance of northern squawfish has fluctuated since 1987, although no trends have existed. Smallmouth bass abundance also has been variable among years, but has generally remained higher at reference station 9 than at reference station 5, possibly related to the highway riprap at that station.

Initial analysis of the number of white sturgeon collected in Lower Granite Reservoir would suggest low abundance based on our sampling at the shallow, mid depth and deep water stations (Tables 1-3). Only catches at deep water reference station 8 were seasonally consistent; catches at other stations were low and variable. Sampling at other locations in Lower Granite Reservoir, specifically for white sturgeon (Objective 2), has indicated higher abundance than previously thought. Highest concentrations of sturgeon are in the upstream waters of Lower Granite Reservoir. Based on the relative abundance of white sturgeon in the reservoir and the need to deposit dredged material downstream of RM 120, our sampling has suggested abundance of sturgeon in shallow and mid-depth waters in Lower Granite Reservoir is low, and disposal activities at depths < 60 ft would probably have minimal affect on white sturgeon. For more detailed information on white sturgeon absolute and relative abundance in Lower Granite Reservoir, please see Objective 2.

Objective 2: To assess white sturgeon abundance and habitat factors associated with their abundance in Lower Granite Reservoir.

METHODS

Two-4 month sample intervals for white sturgeon were conducted from 25 May to 23 August, 1990 (spring-summer) and 14 October, 1990 to 3 January, 1991 (fall-winter). Gill net sampling was the primary technique used to assess white sturgeon abundance. Eight experimental gill nets, 200 ft long x 6 ft deep (61.2 m and 1.8 m), were set perpendicular to the shoreline at nine designated stations (Figure 3). Four nets with bar mesh measurements ranging from 1-6 inches (2.54-15 cm) were fished in the deepest part of the main channel, and the remaining four nets were fished adjacent to the main channel, typically on bench areas.

Gill nets were fished on the bottom for two to three 2-3 hour intervals totaling 6 hours of sampling time, and each station was sampled in sequence to complete one of five sampling passes. Each sampling pass required approximately 11 to 13 days to complete.

Setline sampling was conducted from 13 June to 20 July, 1990. Setlines were used to provide an additional collecting method-for sturgeon and minimize possible size selectivity of gill netting. Setlining consisted of four mainlines (1.4 inch cord rope) approximately

98 ft (30 m) long with gangen lines attached every 9.8 ft (3 m) for a total of six gangen lines per mainline. Gangen lines were constructed with a stainless steel mainline snap and 4/0 ball bearing swivel attached to 220-500 lbs test (100-250 kg) gangen twine. A stainless steel hog ring crimped onto a cadmium-tin coated circle tuna hook was tied to the gangen twine. Hooks were 16/0, 14/0 and 12/0. Each gangen line measured approximately 24 inches long (60 cm) from mainline to hook and was randomly rigged onto the mainline. Hooks were generally baited with dead rainbow trout obtained from various rearing facilities. Twenty four hours of setline effort per mainline was expended at each station to complete one sample pass.

All captured sturgeon were measured, weighed, marked and released. Sturgeon were marked with a numbered spaghetti tag below the posterior insertion of the dorsal fin, and an external aluminum lap seal was crimped around the leading right pectoral fin ray for ease of identification.

A modified Schnabel multiple mark recapture method was used to estimate population with 95% confidence intervals computed using normal approximation procedures.

Focal point velocity, water depth, dissolved oxygen and temperature were recorded at all locations sampled for sturgeon. A Swoffer digital current and YSI Model 54 oxygen-temperature meter were used to measure velocity, temperature and dissolved oxygen, respectively. Water depth was recorded with a Lowrance Mach I Eagle echosounding chart recorder. Surface and bottom current velocities, temperature and dissolved oxygen were measured at each station during both sampling periods to provide comparative data among stations.

RESULTS

A total of 407 white sturgeon were captured by gill net and setline sampling during 1990 in Lower Granite Reservoir. Approximately 3,568 hours of gill netting and 469 hours of setline effort were expended throughout the spring-summer and fall-winter sample periods. One white sturgeon was collected by setline during 1990.

Highest white sturgeon abundance was at RM 137.1 and 133.7, and abundance progressively decreased with downstream distance from RM 133.7 (Figure 59). Catches of sturgeon at RM 116.5 were higher than other mid-reservoir stations.

Population abundance of white sturgeon > 45 cm total length was estimated at 813 individuals with 95% confidence intervals of 701 to 967. A high ratio of recaptures to catch accounted for the relatively narrow confidence intervals.

Total lengths of white sturgeon collected in Lower Granite Reservoir ranged from 12.8-230 cm (0.4-7.5 ft) with a mean length of 67 cm (2.2 ft). Approximately 97% of the fish captured were less than 122 cm (4.0 ft) with 1.2% at 168 cm (5.5 ft) total length (Figure 60). Seven sturgeon ranging from 12.8-15.9 cm (0.4-0.5 ft) in total length were sampled near the Port of Wilma (RM 133.7), while sturgeon measuring 55-60 cm (1.8-1.9 ft) were infrequently caught which created a bi-modal distribution (Figure 60).

Mean catch rates at sampling stations were significantly ($P < 0.05$) higher during the spring-summer interval relative to the fall-winter interval. Mean catch rates for white sturgeon were highest during both spring-summer and fall-winter intervals at RM 133.7 followed by RM 137.1. Stations sampled downstream of RM 127.0 had low mean catch rates during the fall-winter interval (Figure 61). Mean catch rates were significantly higher ($P < 0.05$) at RM 133.7 and 137.1 than stations sampled downstream of RM 127.0 (Figure 62). Confidence intervals (95%) calculated around estimates of catch per effort at RM 108.0, 110.5, 113.6, 116.5, 117.7 and 119.9 overlapped, indicating no statistical differences in catch rates among stations (Figures 62).

A total of 42 white sturgeon were recaptured during the spring-summer and fall-winter intervals with 63% located upstream from their initial capture location (Figure 63). Net movement of recaptured sturgeon ranged from 0.0-20.6 river miles. Eight sturgeon migrated > 15 river miles since last recorded capture (Tables 8 and 9). Sturgeon migrated a mean distance of 11.3 river miles upstream and 3.4 river miles downstream during the spring-summer sample period. An average distance of 7.0 river miles was travelled upstream by recaptured sturgeon in the fall-winter period with no downstream movement recorded.

Sturgeon were generally located in the main channel regardless of upstream-downstream location in Lower Granite Reservoir. Approximately 30 fish were captured on bench areas during the spring-summer interval. No sturgeon were captured on bench areas during the fall-winter interval (Figures 64-66). Sturgeon measuring < 1.3 ft (< 40 cm) total length were primarily located at upper reservoir areas where maximum channel depth was < 62 ft (< 19 m). Sturgeon were captured at depths ranging from 19.6-118 ft (6-36 m) with a mean of 59 ft (17.9 m) during May to August and 57 ft (17.5 m) during October to January (Figure 67).

Bottom current velocities used by sturgeon ranged from 0.0-1.60 ft/s with a mean value of 0.25 ft/s for spring-summer interval and 0.10 ft/s for fall-winter sample interval (Figure 68). Range of lengths for sturgeon were fairly evenly distributed with respect to velocity (Figure 69).

Water temperatures where sturgeon were captured ranged from 2.0°C-22.0°C with a mean temperature of 18.2°C from May-August and 10.1°C during October-January (Figure 70). Water temperatures from main channel and bench areas were not significantly different within or among stations during sample intervals. Water temperatures in the fall were homothermous at 9.9°C by 10 November, 1990 (Figure 71).

Dissolved oxygen concentrations ranged from 5.9-9.8 mg/l during the sample intervals with no significant difference within or among stations (Figure 71). Dissolved oxygen was generally maintained at sufficient levels (> 5.0 mg/l) throughout the sample intervals with exception to low dissolved oxygen measured at RM 108.0, 110.5, 113.6, 116.5, 117.7 and 119.9. Instantaneous dissolved oxygen concentrations ranged from 3.4-5.0 mg/l near the water-substrate interface in the main channel on 6 August, 1990, but was near or above 6.0 mg/l by 20 August, 1990 throughout the reservoir.

Bottom focal point velocities measured at each station indicated upper reservoir areas maintained higher velocities throughout the spring-summer and fall-winter sample intervals (Figure 71). Main channel velocities were generally higher relative to bench areas, except at RM 113.6, 116.5 and 117.7 on 3 August, 1990 and RM 116.5 on 10 November, 1990. Fluctuation in velocities were more prevalent on bench areas.

Number of crayfish trapped at stations sampled for white sturgeon ranged from 0-167 with the highest number occurring consistently at RM 133.7. Main channel areas generally contained more crayfish than beach areas during both sample intervals (Figure 72).

DISCUSSION

Sampling in 1990 revealed a much higher population of white sturgeon in Lower Granite Reservoir than originally anticipated. Catches were significantly higher during spring-summer than fall-winter, and distribution of higher catches was generally similar between seasons. Over 400 white sturgeon were captured in Lower Granite Reservoir during 1990, and population estimates averaged about 800 fish > 40 cm. High catches were at RM 133 and 137, and although catches were lower downstream in the reservoir, they were comparably higher near Knoxway Bay at RM 116.

Sturgeon were typically captured in the deepest micro-habitat available in main channel areas. The majority of sturgeon were collected in the main channel, especially during fall and winter as none were collected on benches at that time. Sturgeon were caught in waters that ranged from about 20-118 ft and had bottom velocities that ranged from 0-1.6 ft/s. The mean velocity where fish were collected decreased from spring-summer to fall-winter from 0.25 to 0.10 ft/s. Deep (> 20 m) slack water areas that are characteristic of lower and mid-reservoir stations do not appear to provide suitable habitat, since mean depth utilized by sturgeon ranged from 57-59 ft (about 17 m). Water velocities in these areas were low (< 0.025 ft/s).

Eighty-six percent of the sturgeon (mean = 78.3 cm total length) marked at lower and mid-reservoir stations moved upstream throughout the spring, summer and late fall periods. During our sampling period from spring through late fall, downstream movement was minimal. Coon et al. (1977) reported a tendency for juvenile sturgeon to migrate downstream during the winter months.

Gill net sampling indicated that white sturgeon abundance was the highest in the upper reservoir, specifically at RM 133.7 and 137.1 during both sample intervals. Since mean catch rates were significantly higher ($P < 0.05$) at RM 133.7 and 137.1 than stations sampled downstream of RM 127.0, the upper reservoir areas seemed to provide more favorable habitat for sturgeon. Studies conducted on the Kootenai River, Idaho suggested that sturgeon were found at velocities between 0.10-1.83 ft/s (Apperson et al. 1990). Velocities this fast in Lower Granite Reservoir were found exclusively in the reservoir upstream of RM 137. Crayfish abundance was also highest in this area of Lower Granite Reservoir. We can not separate the influence of velocity and crayfish abundance on sturgeon abundance at this time, although crayfish are reportedly an important food item. Sturgeon diets include clams, mussels, crayfish, worms and fish eggs (Scott and Crossman 1973). As sturgeon grow, fish such as lamprey *Lampetra tridentadus*, shad *Alosa sapidissima* and salmon become more important in their diet (Anderson 1988). Coon et al. (1977) reported common food items for sturgeon 73 to 132 cm were crayfish, caddisfly and dipteran larvae, snails and clams. Sturgeon captured between Bliss and C.J Strike reservoirs on the Snake River, Idaho contained predominantly crayfish (Cochanuer 1983). Highest number of crayfish were trapped in Lower Granite at the upper reservoir stations which may have provided more accessible food resources for sturgeon. This food source may account, in part or totally, for the highest abundance of sturgeon in the upper part of the reservoir.

Range of temperatures reportedly utilized by white sturgeon were similar to the range recorded in Lower Granite Reservoir. Factors such as temperature may initiate activity and strongly influence seasonal migrations (Coon et al. 1977). Temperature was not considered a factor responsible for differences in sturgeon abundance from lower and mid-reservoir areas, since average seasonal temperatures differed little (< 3°C) among stations throughout Lower Granite Reservoir.

Dissolved oxygen generally remained sufficient (> 5 mg/l) for most fish during the sample intervals with exception to low dissolved oxygen occurring at the water-substrate interface about 3-5 miles upstream of Lower Granite Dam on 6 August, 1990. Water was released from Dworshak Reservoir at this time to enhance temperature conditions for fall chinook salmon (Teri Barila, U.S. Army Corps of Engineers, personal communication). Temperature monitoring in 1991 indicated cool water released from Dworshak Reservoir generally remains close to the bottom in Lower Granite Reservoir (Karr et al. 1992). These cooler waters coming into Lower Granite Reservoir are likely well oxygenated and therefore, probably accounted for the elevated oxygen levels after 6 August, 1990. The spatial distribution of sturgeon may have been influenced by low dissolved oxygen in the lower reaches of the reservoir.

Mean total length of white sturgeon in Lower Granite Reservoir was smaller than fish sampled from areas below Hells Canyon Dam, Idaho (Lukens 1985). A smaller mean length may be the result of size selection by gill nets, although setlines were generally unsuccessful in catching larger fish. Ninety seven percent of the sturgeon captured in Lower Granite Reservoir were < 4 ft. The largest sturgeon exceeded 7 ft (2.1 m) in length, although numbers of sturgeon > 6 ft (1.8 m) were low.

Capture of seven sturgeon that measured < 16 cm indicated successful reproduction was occurring in the Snake River. Our data suggests that juvenile sturgeon migrate downstream to Lower Granite Reservoir and rear in the upstream portion. Lukens (1985) suggested the upstream end of Lower Granite Reservoir may provide rearing habitat for juvenile sturgeon; this is supported by our results.

Deep slack water areas in Lower Granite Reservoir do not provide suitable habitat for rearing of sturgeon. Highest abundance of sturgeon was RM 133.7 and RM 137.1 at or upstream of the Port of Wilma which is more riverine habitat. The deep waters downstream of Wilma apparently provide less favorable rearing habitat than the more riverine upstream areas.

Objective 3. To estimate juvenile salmonid fish consumption by northern squawfish in Lower Granite Reservoir.

METHODS

Stomachs of northern squawfish (> 250 mm) collected from 1 April through 30 July, 1990 by all gear types between RM 112.5 and RM 132.0 were examined for food items. Captured squawfish were measured (total length mm) and anesthetized, and then the entire digestive tract was removed and frozen for later analysis.

Procedures developed by Vigg et al. (1988) were used to determine daily consumption rates of juvenile salmonids. Stomach contents were sorted, enumerated and identified to the lowest possible taxon. Unidentified materials, parasites and non-food items were recorded and excluded from dietary calculations. Prey items were blotted dry and weighed (mg). Crustaceans were identified to genus or family, while insects were identified to order. Undigested fish were identified to species, when possible, and measured (fork length-mm).

Bone morphology identification techniques described by Hansel et al. (1988) were used to identify partially digested fish. For advanced digested fishes, fork lengths were estimated from standard or nape to tail lengths or bone lengths using regression equations developed from known specimens.

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

When diagnostic bones for unknown salmonids (ie. juvenile chinook salmon or steelhead) were encountered, the species identification was determined by comparing the range of lengths of salmonids captured within 3 days of the capture. Lengths that overlapped from captured fish and prey fish precluded further identification beyond salmonids.

RESULTS

A total of 199 northern squawfish (> 250 mm) were captured in Lower Granite Reservoir in 1990. The majority (48%) were captured at up-river sampling stations (RM 127-138.1) followed by the disposal stations (25%) and the mid-depth reference station (14%; Figure 73). A majority of squawfish (81%) were between 300-450 mm with a mean length of 390 mm (Figure 74).

Food Items

Crayfish and fishes were dominant food items of northern squawfish in spring 1990 from Lower Granite Reservoir (Table 10). Crayfish dominated food items in percent occurrence (47.5%) and numerically and were second to juvenile rainbow/steelhead in total weight. Salmonids represented the highest of all food items in weight, especially rainbow/steelhead. Insects were high in frequency of occurrence but low in number and weight.

Daily Ration

Seasonal total daily ration for spring (all dates combined) was 9.808 mg/g/d for all prey fishes (Figure 75). Total daily ration was lowest for juvenile chinook salmon and intermediate for juvenile steelhead. Ration estimates for non-salmonids were intermediate between juvenile chinook and steelhead.

Monthly ration estimates of northern squawfish were generally similar between April and May, but were higher in June (Figures 76-78). Mean monthly total daily ration estimate of all prey fishes for April was 12.605 mg/g/d, while those of juvenile chinook salmon and steelhead were similar. Northern squawfish containing salmonids had a total daily ration of 12.606 mg/g/d; non-salmonids were not observed in squawfish during April indicating the concentration of predation on smolts (Figure 76).

Mean monthly total daily ration estimate of northern squawfish for May was 12.805 mg/g/d for all prey fishes. Squawfish total daily ration of juvenile chinook salmon was lower (2.276 mg/g/d) than that for juvenile steelhead (5.715 mg/g/d). Total daily ration of squawfish with all salmonids was 12.805 mg/g/d, and non-salmonids were not observed in squawfish during May (Figure 77).

Mean monthly total daily ration estimate for northern squawfish in June was 31.502 mg/g/d of all prey fishes. Juvenile chinook salmon had a lower total daily ration (0.473 mg/g/d) than steelhead (1.205 mg/g/d) and generally reflected lower salmonid consumption than in April and May. Squawfish had a total daily ration of 2.027 mg/g/d of all salmonids, probably a result of decreased smolt availability. Total daily ration for squawfish with all non-salmonids (catostomids and unidentified non-salmonids) was highest in June 29.474 mg/g/d (Figure 78).

Consumption Estimates

Consumption of all prey fishes by northern squawfish (> 250 mm) during the spring-summer season was 0.142 prey/predator/d (Figure 79). Mean seasonal consumption rates of squawfish with juvenile chinook salmon and steelhead were 0.0998 prey/predator/d and 0.021 prey/predator/d, respectively. Mean seasonal consumption rate of squawfish with all juvenile salmonids was 0.098 prey/predator/d. Mean consumption rate of non-salmonids during this period was 0.0582 prey/predator/d (Figure 79).

The highest mean monthly consumption rate of juvenile salmonids was in April at 0.206 prey/predator/d and coincided with the inception of downstream smolt migration in Lower Granite Reservoir (Figure 80). The mean monthly consumption rate of squawfish with juvenile chinook salmon was also highest in April (0.269 prey/predator/d). Mean monthly consumption rate of juvenile steelhead was 0.029 prey/predator/d. No non-salmonids were observed in squawfish digestive tracts during April.

The Mean monthly consumption rate of juvenile salmonids in May was 0.126 prey/predator/d (Figure 81). Northern squawfish had a mean monthly consumption rate of 0.109 juvenile chinook salmon/predator/d. Mean monthly consumption rate was highest of all months in May for juvenile steelhead at 0.033 prey/predator/d (Figure 81).

The mean monthly consumption rates for northern squawfish of all prey fishes was highest in June (0.55 prey/predator/d) and highest for non-salmonids (0.729 prey/predator/d). The lowest mean monthly consumption rates of juvenile chinook salmon and steelhead were 0.018 prey/predator/d in June and 0.010 prey/predator/d, respectively (Figure 82).

A majority (41%) of prey fishes were consumed by squawfish that ranged in length from 351-400 mm (Figure 74). Squawfish between 401-450 mm consumed the second highest (27%) proportion of prey fishes.

Based on comparison of catch/effort (similar gear type) from John Day Reservoir (Beamesderfer and Rieman 1988), we estimated a population size of northern squawfish of 7,500 from RM 112.0 to RM 132.0. Using this estimate, approximately 60,458 juvenile chinook and 6,593 juvenile steelhead were consumed during April. Approximately 25,389 juvenile chinook and 7,626 juvenile steelhead were consumed in May, and 4,005 chinook and 2,340 steelhead were consumed in June. Combining these monthly estimates, the total loss of juvenile chinook and steelhead during spring 1990 in Lower Granite Reservoir from RM 112.0-132.0 was

89,852 and 16,559, respectively. Combined losses for both identified and unidentified salmonids during spring 1990 was estimated at 142,117 salmonid smolts.

DISCUSSION

Between early April and late June 1990, we examined 199 northern squawfish stomachs for the presence of juvenile chinook salmon and steelhead. The majority of northern squawfish examined ranged in length from 300-450 mm; the size considered to be highly predatory. These squawfish were collected between RM 112.0 and RM 132.0, areas upstream from Lower Granite Dam and downstream of the confluence of the Snake and Clearwater rivers. Locations closer to the dams and the confluence areas have been tentatively identified as possible concentration areas for predators (Beamesderfer and Rieman 1991; Bentley and Dawley 1981; Bennett et al. 1983). Our samples describe predation in Lower Granite Reservoir in 1990 within the area from RM 112.5 to RM 132.0, outside of the areas of concentration for northern squawfish.

Presence of fish and other items in the stomachs of northern squawfish peaked in June. Non-salmonid fishes were not found in squawfish stomachs during April and May, but they were highly abundant in June.

Monthly daily ration of northern squawfish increased from April through June. Highest monthly mean daily ration of juvenile chinook salmon peaked in April (4.453 mg/g/d) and decreased in both May (2.276 mg/g/d) and June (0.473 mg/g/d). In comparison, highest mean monthly daily ration of juvenile steelhead peaked in May and was lower in April and June.

The highest mean monthly consumption rate for juvenile salmonids in Lower Granite Reservoir during 1990 was in April at 0.206 prey/squawfish/d. Highest consumption rate of salmonids was for juvenile chinook (0.269 prey/squawfish/d), nearly 10 times higher than that for juvenile steelhead (0.033 prey/squawfish/d), probably because of the size difference between juvenile chinook and steelhead.

Size of predator affected the rate of consumption on juvenile salmonid fishes. Northern squawfish from 351-400 mm in total length consumed over 40% of the prey fishes compared to 27% consumed by larger squawfish (401-450 mm). Chandler (1992) reported that consumption rates of squawfish were several orders of magnitude higher for predators > 349 mm compared to those < 349 mm.

Size and possibly behavior of prey also affected consumption. Juvenile chinook salmon are typically smaller than juvenile steelhead (Appendix Figures 1-7) which makes them available as prey to a wider range of sizes of northern squawfish. Larger size and possibly more rapid migration rates through Lower Granite Reservoir decrease the availability of juvenile steelhead. Consumption estimates of juvenile steelhead by northern squawfish are high because of their larger body size (Table 10).

Our consumption estimates for predation in Lower Granite Reservoir during 1990 are probably low relative to actual consumption because of the location and times of sampling. Predator sampling was conducted at disposal and reference stations. Sampling was conducted between the hours of late afternoon and evening. Chandler (1992) showed that consumption varied throughout the day and peaked in the late morning. However, his predator sampling in Lower Granite Reservoir throughout a 24-hour period provided estimates of predation that coincide with ours for 1990. Chandler estimated predation of juvenile salmon and steelhead in Lower Granite Reservoir for five years from 1987 to 1991, and although his estimates of consumption differ from year to year, they show about the same rate of consumption as ours for 1990.

Other predators also consume juvenile salmonids in Lower Granite Reservoir. Curet (1993) examined yellow perch, crappie and smallmouth bass consumption of juvenile salmonids. Preliminary results have indicated that smallmouth bass stomachs contained the highest incidence of juvenile salmonids. Curet's estimates of consumption along with those of Chandler (1992) provide a clearer picture of the significance of predation by the more abundant predators in Lower Granite Reservoir on both yearling and subyearling salmonids.

Objective 4. To assess age-0 chinook salmon abundance in Lower Granite Reservoir and assess the potential suitability of the disposal stations for rearing of age-0 chinook salmon.

METHODS

Age-0 chinook were collected by beach seining and electrofishing during 1990 using identical methods employed for juvenile predator sampling (Objective 1). Areas of concentration of age-0 chinook were identified and measurements of macrohabitat characteristics were taken. Instantaneous growth calculations were made using:

$$G = \ln L_t - \ln L_0$$

where: $\ln l_t$ = Natural log of length at time t and
$\ln l_0$ = Length (mm) at time of original capture.

RESULTS

A total of 264 age-0 chinook salmon were captured by beach seine and electrofishing between 8 April through 22 June, 1990 (Figure 83). No age-0 chinook salmon were collected in littoral areas after 22 June, 1990. The highest catch-per-unit-effort by beach seining in 1990 occurred on 3 June which suggests the highest abundance of age-0 chinook in Lower Granite Reservoir occurred during early June. Catches approximately two weeks later in June were lowest of all samples.

The average length of age-0 chinook salmon increased throughout the spring (Figure 84). Instantaneous growth calculations estimated growth at 0.51 mm/d between 8 April through 22 June; 0.10 mm/d in April, 0.09 mm/d in May and 0.13 mm/d in June. Mean lengths in June were from 72-84 mm.

A total of 190 age-0 chinook (72%) were captured over substrates that consisted of > 75% fines (< 2 mm in diameter), whereas 225 age-0 chinook (85%) were captured over substrates that consisted of > 75% fines and gravels (< 50 mm in diameter; Figure 85). At RM 120.0, 28 fall chinook were captured at the disposal area (stations 1 and 2) which accounted for 11% of the age-0 chinook captured in 1990. Substrates at stations 1 and 2 consisted primarily of sands. All age-0 chinook collected by beach seining and electrofishing throughout Lower Granite Reservoir were associated with either a sand (60%), sand/talus (36%), or sand/cobble substrate (4%; Figure 85).

DISCUSSION

Our first collection of age-0 chinook was in early April, and numbers generally increased along the shoreline of Lower Granite Reservoir into early June. Abundance peaked in early June and then decreased to a low in late June. Within two weeks, collections went from the highest to the lowest during the time age-0 chinook were sampled along the shoreline in the reservoir.

Over 75% of the age-0 chinook salmon sampled throughout Lower Granite Reservoir were collected over substrates that consisted of fines (< 2 mm) while nearly 90% were collected over substrates that were mixed gravels with fines. All age-0 chinook collected by beach seining and electrofishing were sampled over a combination of sand and other substrates. This type of substrate is typically found in the upstream portion of Lower Granite Reservoir and was deposited with construction of the island. These sandy shorelines are almost exclusively the habitat where age-0 chinook salmon are collected. Habitat created by island construction seems highly suitable for juvenile chinook, as 11% of the age-0 fish were collected at disposal stations 1 and 2. This high percentage could be misleading, as a very high proportion of the island was sampled as compared to other areas. Effort-per-unit area was higher at the island than at other locations within the reservoir. Regardless, the use of the island for rearing is high. Based on the 1990 collections, rearing habitat for age-0 chinook can be created by deposition of dredged materials because the suitability of the area seems to be high for rearing of juvenile chinook salmon.

OVERALL DISCUSSION

Based on our sampling, disposal of dredged materials in Lower Granite Reservoir has altered the abundance of fishes little since sampling was initiated in 1987. Numbers of fishes, catch/effort of species of interest and overall abundance of younger life stages have changed little. One area of interest was the potential to enhance and create suitable habitat for rearing age-0 chinook salmon in Lower Granite Reservoir. Based on our collections, age-0 salmon use the shorelines at the island for rearing. Age-0 salmon densities near the island appear high relative to other areas, although comparisons are difficult because of differential effort and the location of the island; about 20 miles downstream in the reservoir. Habitation of age-0 chinook around the island may depend upon saturation of upstream habitats prior to the overflow of fish migrating downstream to the island or the lower part of Lower Granite Reservoir. Regardless of the comparative densities, age-0 chinook salmon appear to rear at stations that typically have fines for substrate and generally low gradient shorelines. Future considerations of using dredged material may consider shoreline or beach enhancement rather than island development.

The benefit of this may be two fold: juvenile predators such as smallmouth bass and northern squawfish seem to utilize riprap shorelines for rearing and this "less desirable" habitat for rearing of juvenile chinook may be enhanced. Therefore, habitat suitable for salmonid predators may be decreased in area whereas, at the same time, suitable rearing habitat for subyearling chinook salmon may be increased. The beneficial use of dredged materials for creating/enhancing habitat for age-0 chinook salmon appears possible based on our preliminary results.

The other interest in creating an island was that newly created habitat may be ideal rearing habitat for some stages of the life cycle for predator fishes. Based on results from beach seining results and larval fish sampling both in shoreline and adjacent pelagic waters, predator abundance has not been increased, and the dynamics of the fish community in Lower Granite Reservoir has changed little as a result of the in-water disposal of dredged materials. One interesting finding is that the abundance of northern squawfish is not higher at the island, especially station 1, than we have currently determined. For example, shoreline habitat adjacent to the island is similar to that at reference station 11; substrate is similar, gradient is similar, and both shorelines have encroaching macrophytes. Locational differences may account for the low utilization by young squawfish at the island site. Northern squawfish may migrate downstream after incubating in the lotic reaches of the Clearwater and Snake rivers. Suitable rearing habitat at station 11 and at other stations is probably used prior to migrating further downstream. As the young squawfish rear and grow, movements motivated by density dependent factors may be away from the sandy shoreline habitat. If this interpretation were correct, one recommendation would be not to conduct beach enhancement in areas upstream of RM 120. Although these areas would probably be used by rearing juvenile chinook salmon, they would also be used by juvenile squawfish.

Deep water disposal is another option being considered. Based on our preliminary results, few white sturgeon would be affected if disposal were conducted downstream of RM 120. Results to date indicate > 70% of the white sturgeon in Lower Granite Reservoir are found upstream of RM 120. The majority of sturgeon have been collected upstream of Silcott Island. Low numbers were collected in the deep pool areas although sturgeon were collected in waters from 20-118 ft. Deep slack water habitat that is characteristic of the mid and lower reservoir does not provide desirable habitat. A mean depth of capture of 56 ft was found for white sturgeon and deeper areas did not support higher numbers of sturgeon. Based on our results from 1990 sampling and the sturgeon distribution, in-water disposal in deep waters of Lower Granite Reservoir would have minimal deleterious effects on white sturgeon.

REFERENCES

Anderson, R.S. 1988. Columbia River sturgeon. Washington Sea Grant, Marine Advisory Services. Columbia River Series WSG-AS 88-14.

Apperson, K.A. 1990. Kootenai River white sturgeon investigations and experimental culture. Annual progress report 1989 to Bonneville Power Administration (Project No. 88-65) Portland, Oregon.

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

Beamesderfer, R.C., and B.E. Rieman. 1991. Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447.

Bennett, D.H., P.M. Bratovich, W. Knox, D. Palmer, and H. Hansel. 1983. Status of the warmwater fishery and the potential of improving warmwater fish habitat in the lower Snake River reservoirs. Completion Report No. DACW68-79-C0057. U.S. Army Corps of Engineers, Walla Walla, Washington.

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

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

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

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

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

Bentley, W.W., E.M. Dawley. 1981. Effects of supersaturated dissolved atmospheric gases on northern squawfish, *Ptychocheilus oregonensis*. Northwest Science 55:50-61.

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

Chandler, J. 1992. Consumption rates and estimated total loss of juvenile salmonids by northern squawfish in Lower Granite Reservoir, Washington. Master's thesis. University of Idaho, Moscow.

Cochanuer, T.G. 1983. Abundance, distribution, growth and management of white sturgeon *Acipenser transmontanus* in the middle Snake River, Idaho. Doctoral dissertation. University of Idaho, Moscow.

Coon, J.C., R.R. Ringe, and T.C. Bjornn. 1977. Abundance, growth, distribution, and movements of white sturgeon in the mid-Snake River. Forest, Wildlife and Range Experiment Station, Contribution No. 97, University of Idaho, Moscow.

Curet, T.S. 1993. Habitat use, food habits and the influence of predation on subyearling chinook salmon in Lower Granite Reservoir, Washington. Master's thesis. University of Idaho, Moscow.

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

Houde, E.D. 1969. Distribution of larval walleyes and yellow perch in a bay of Oneida Lake and its relation to water currents and zooplankton. New York Fish Game Journal 16:184-205.

Isaacs, J.D. 1964. Night-caught larvae and day-caught larvae of the California sardine. Science, New York 144(3622):1132-113.

Karr, M., B. Tanovan, R. Rudder, and D. Bennett. 1992. Interim report: Model studies and 1991 operations. Completion Report. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

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

Lukens, J.R. 1985. Snake River stream investigations. Job Performance Report, Project No. F-73-R-7. Idaho Department of Fish and Game, Boise.

Netsch, N.G., A. Houser, and L.E. Vogele. 1971. Sampling gear for larval reservoir fishes. Progressive Fish-Culturist 33:175-179.

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

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa. Bulletin 184.

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

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

FIGURES

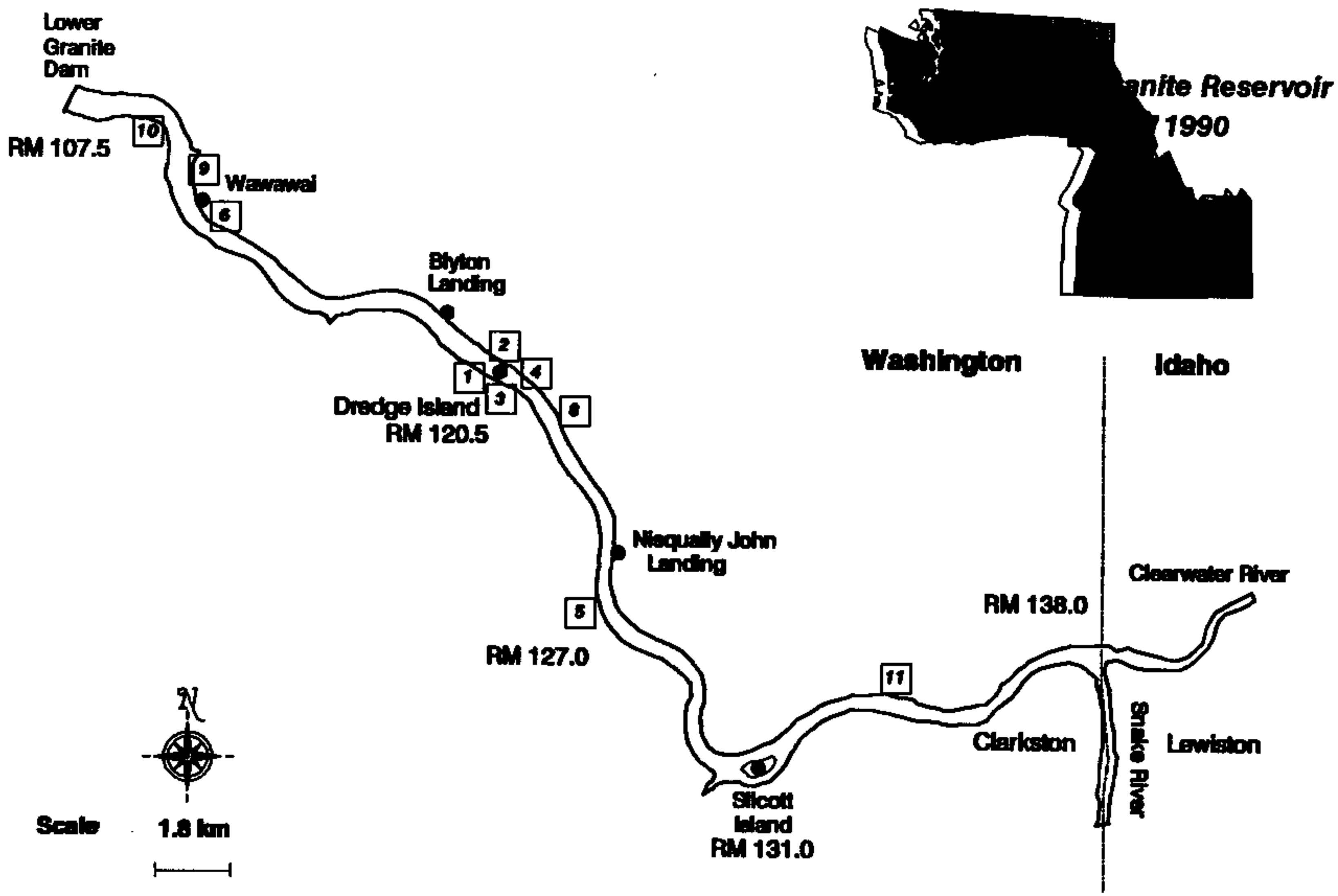


Figure 1. Sampling locations in Lower Granite Reservoir, Idaho-Washington where adult, subadult, juvenile and larval fish abundance was assessed during spring, summer and fall 1990.

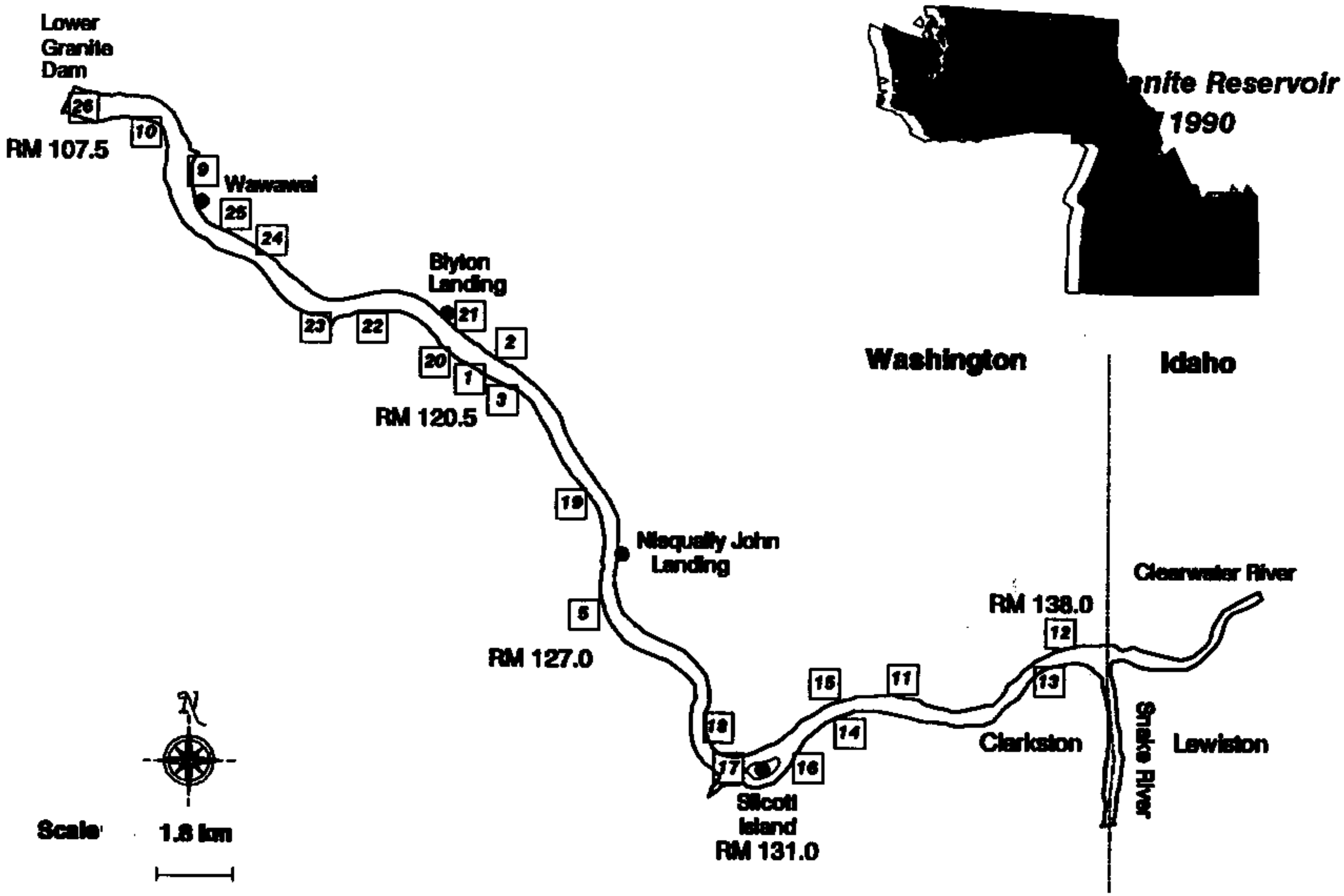


Figure 2. Locations where juvenile chinook salmon sampling was conducted at biweekly intervals in Lower Granite Reservoir, Idaho-Washington during spring 1990.

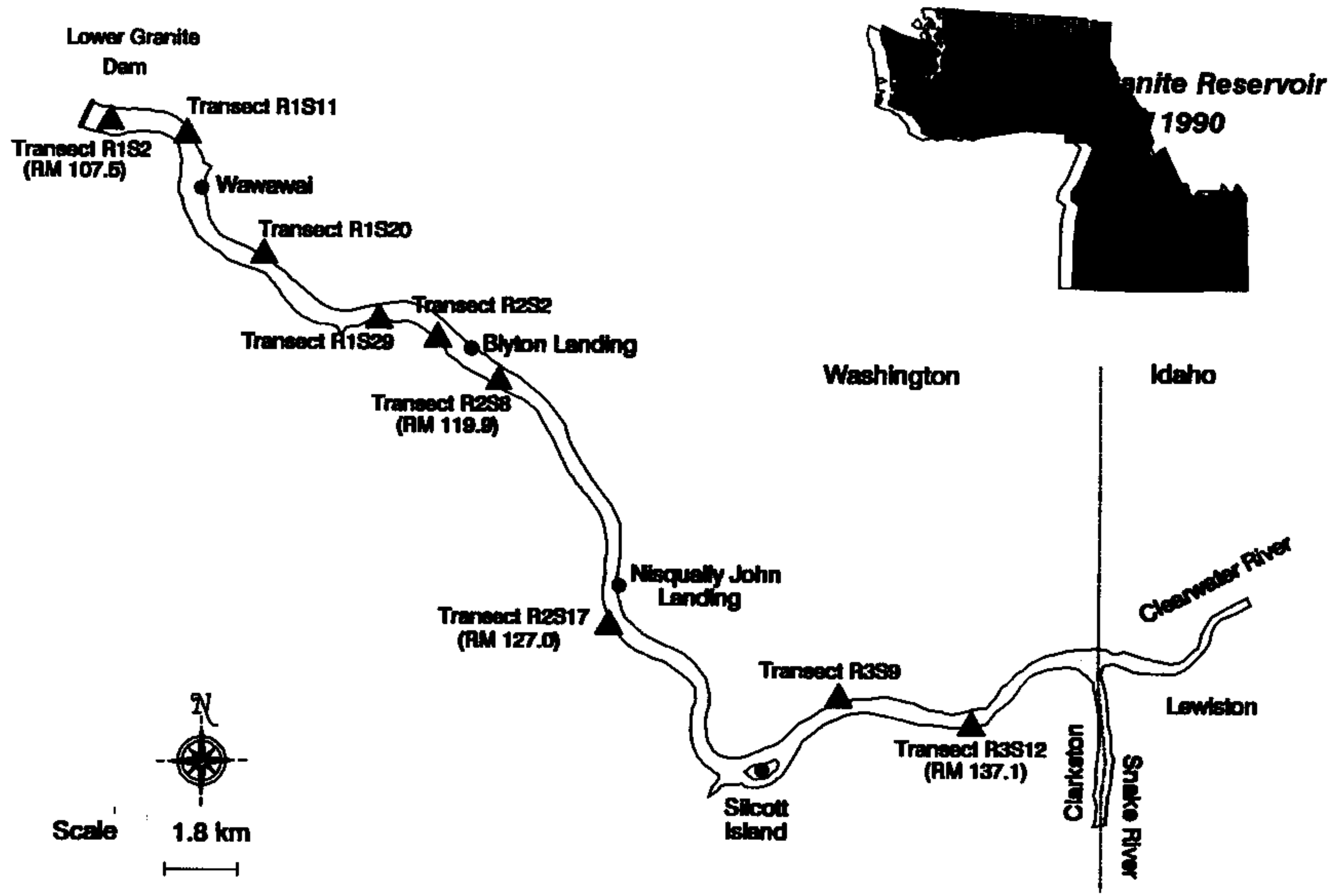


Figure 3. Locations where white sturgeon sampling was conducted in Lower Granite Reservoir, Idaho-Washington during spring, summer and fall 1990.

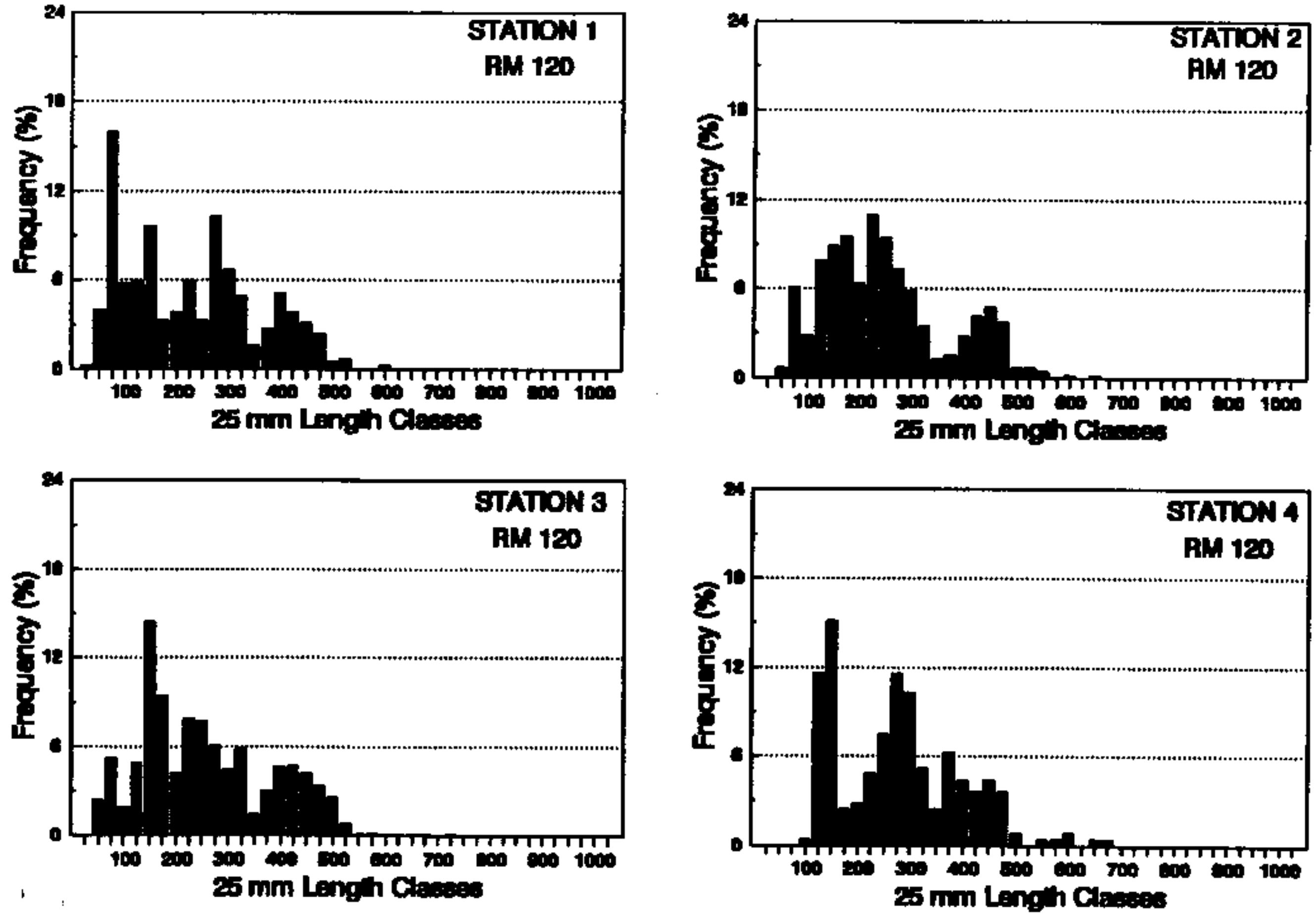


Figure 4. Comparison of length frequencies for all gear types and fishes sampled at shallow water (1 and 2) and mid-depth (4) disposal stations and reference station 3 during spring 1990 in Lower Granite Reservoir, Idaho-Washington.

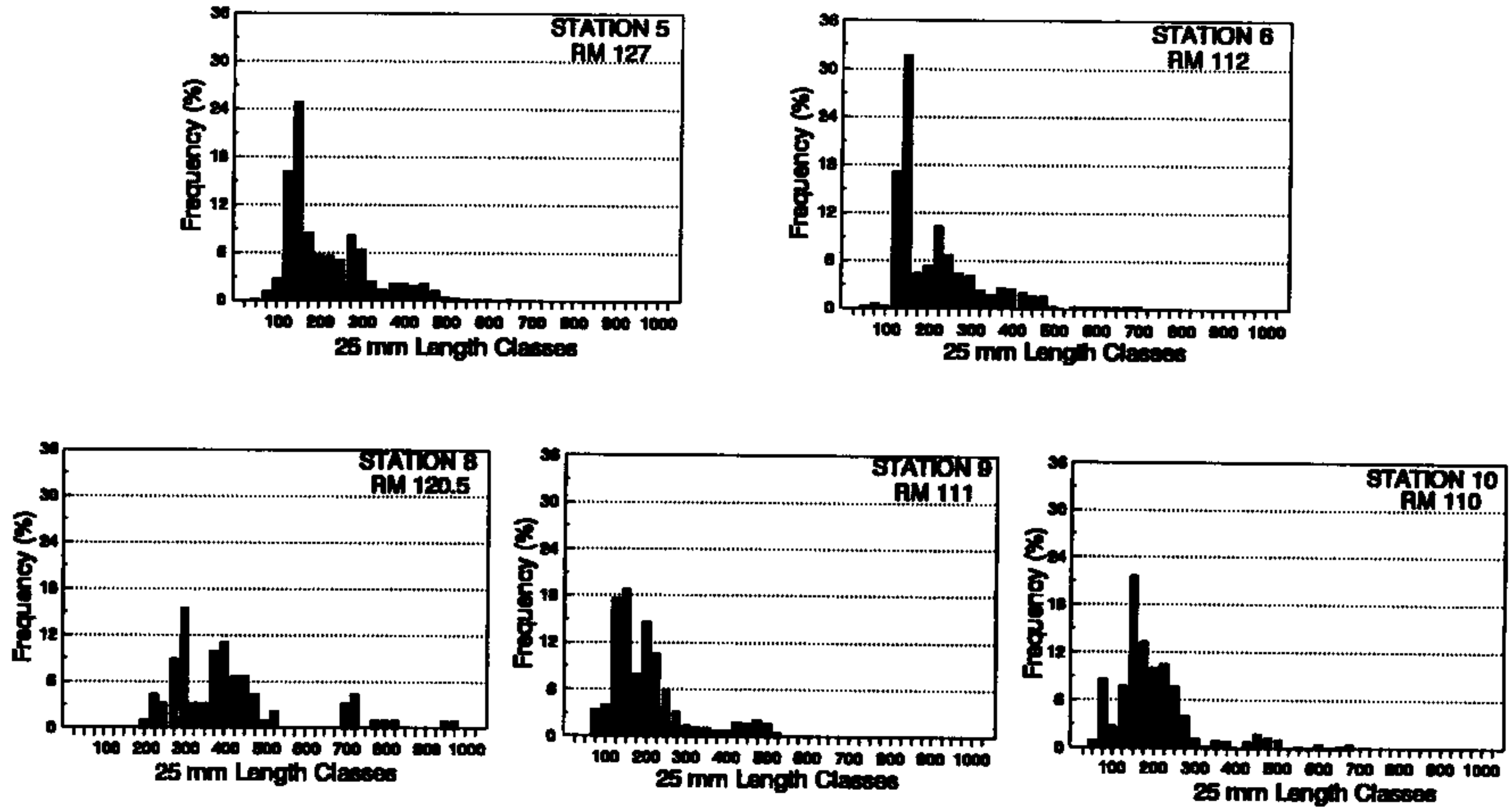


Figure 5. Comparison of length frequencies for all gear types and fishes sampled at shallow water reference stations (5, 9 and 10) and mid-depth (6) and deep water (8) reference stations during spring 1990 in Lower Granite Reservoir, Idaho-Washington.

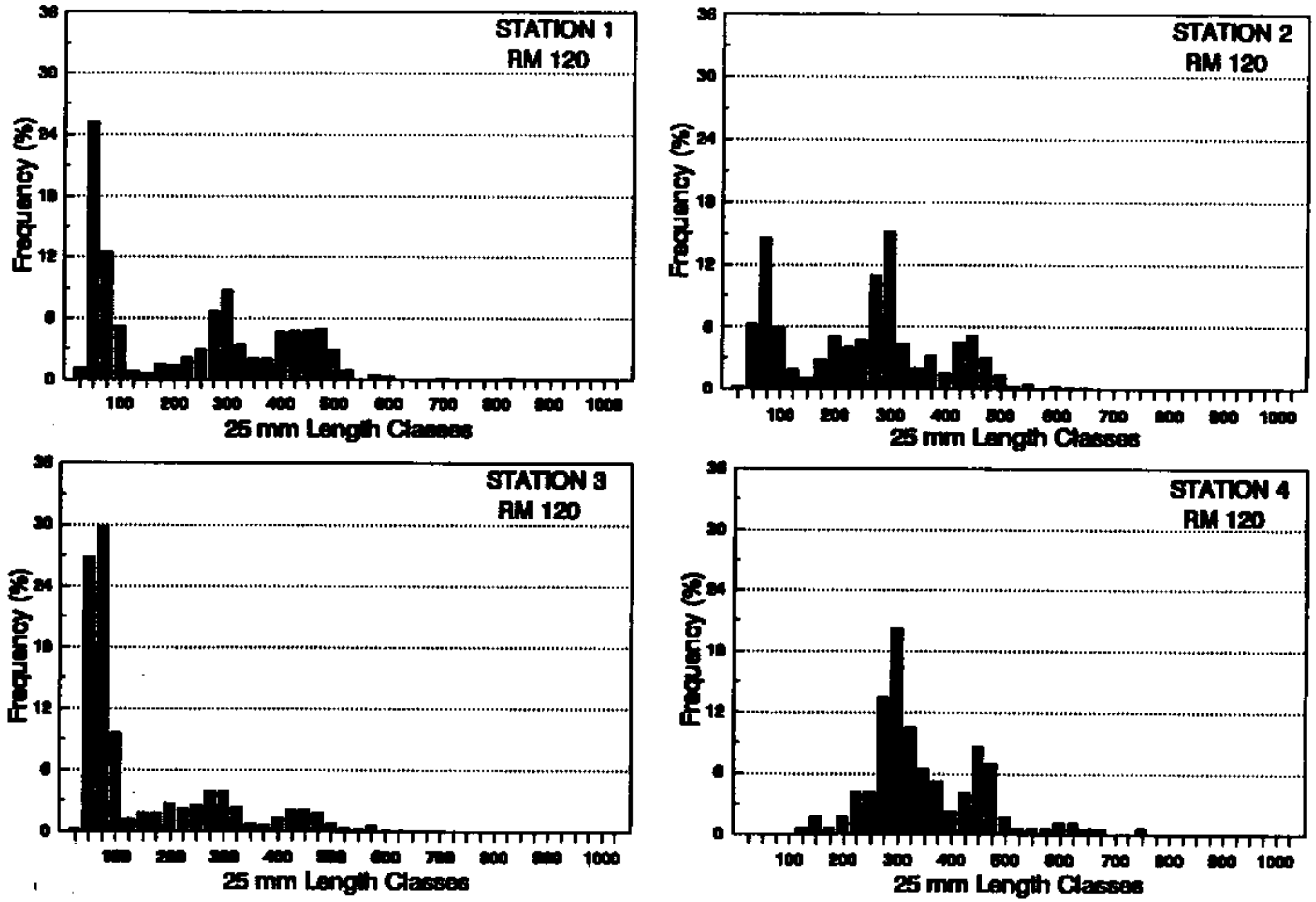


Figure 6. Comparison of length frequencies for all gear types and fishes sampled at shallow water (1 and 2) and mid-depth (4) disposal stations and shallow water reference station 3 during summer 1990 in Lower Granite Reservoir, Idaho-Washington.

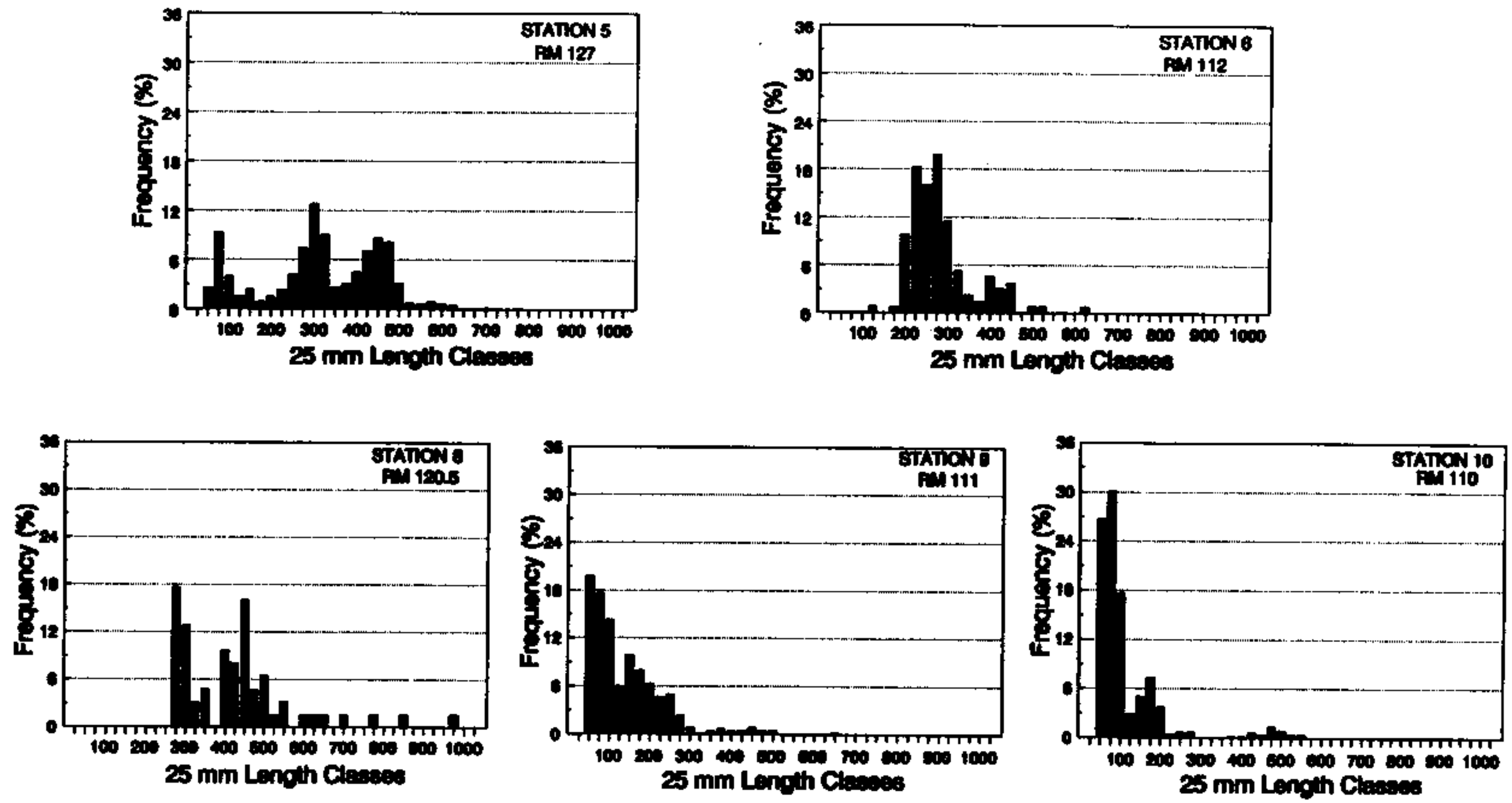


Figure 7. Comparison of length frequencies for all gear types and fishes sampled at shallow water (5, 9 and 10), mid-depth (6) and deep water (8) reference stations during summer 1990 in Lower Granite Reservoir, Idaho-Washington.

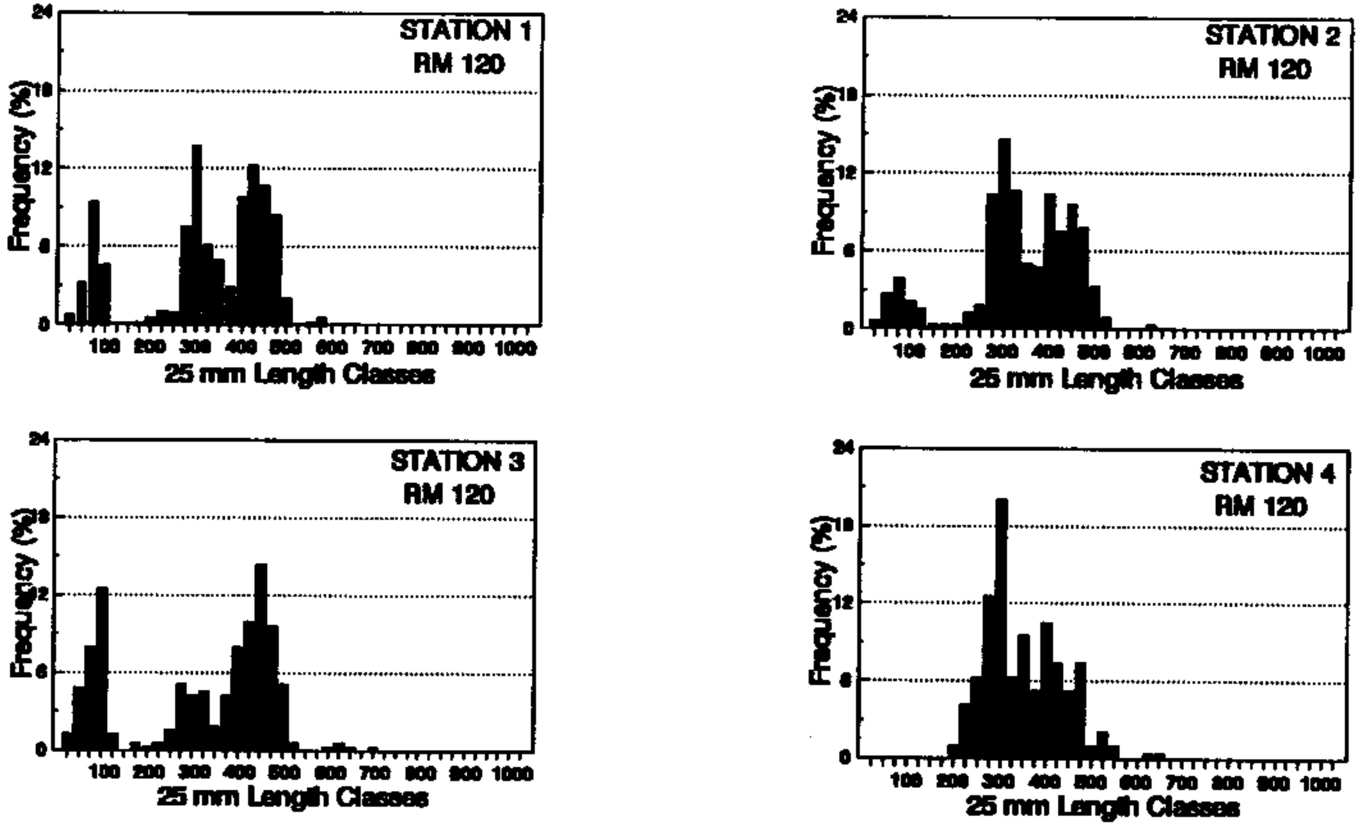


Figure 8. Comparison of length frequencies for all gear types and fishes sampled at shallow water (1 and 2) and mid-depth (4) disposal stations and reference station 3 during fall 1990 in Lower Granite Reservoir, Idaho-Washington.

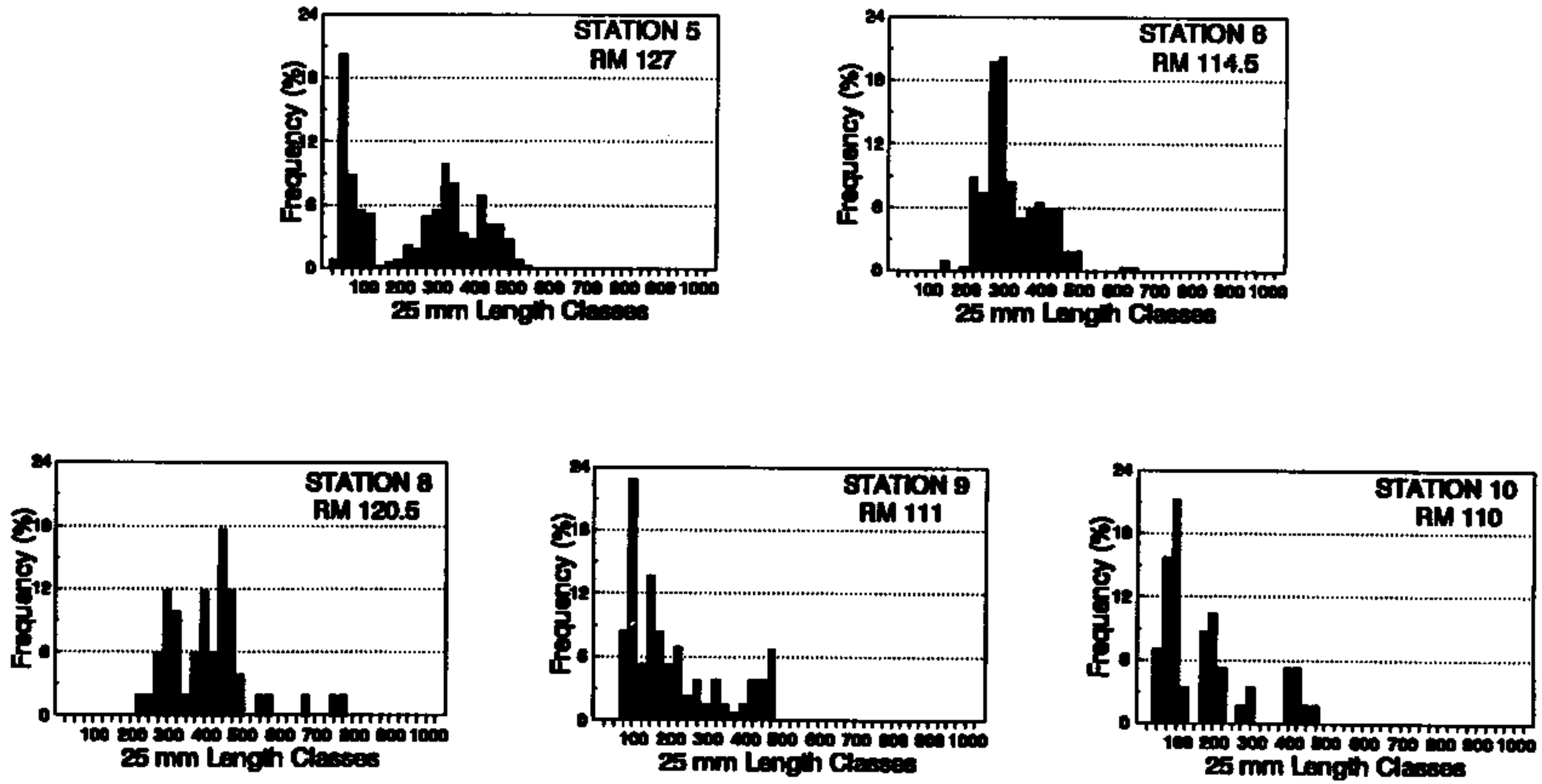


Figure 9. Comparison of length frequencies for all gear types and fishes sampled at shallow water (5, 9 and 10), mid-depth (6) and deep water (8) reference stations during fall 1990 in Lower Granite Reservoir, Idaho-Washington.

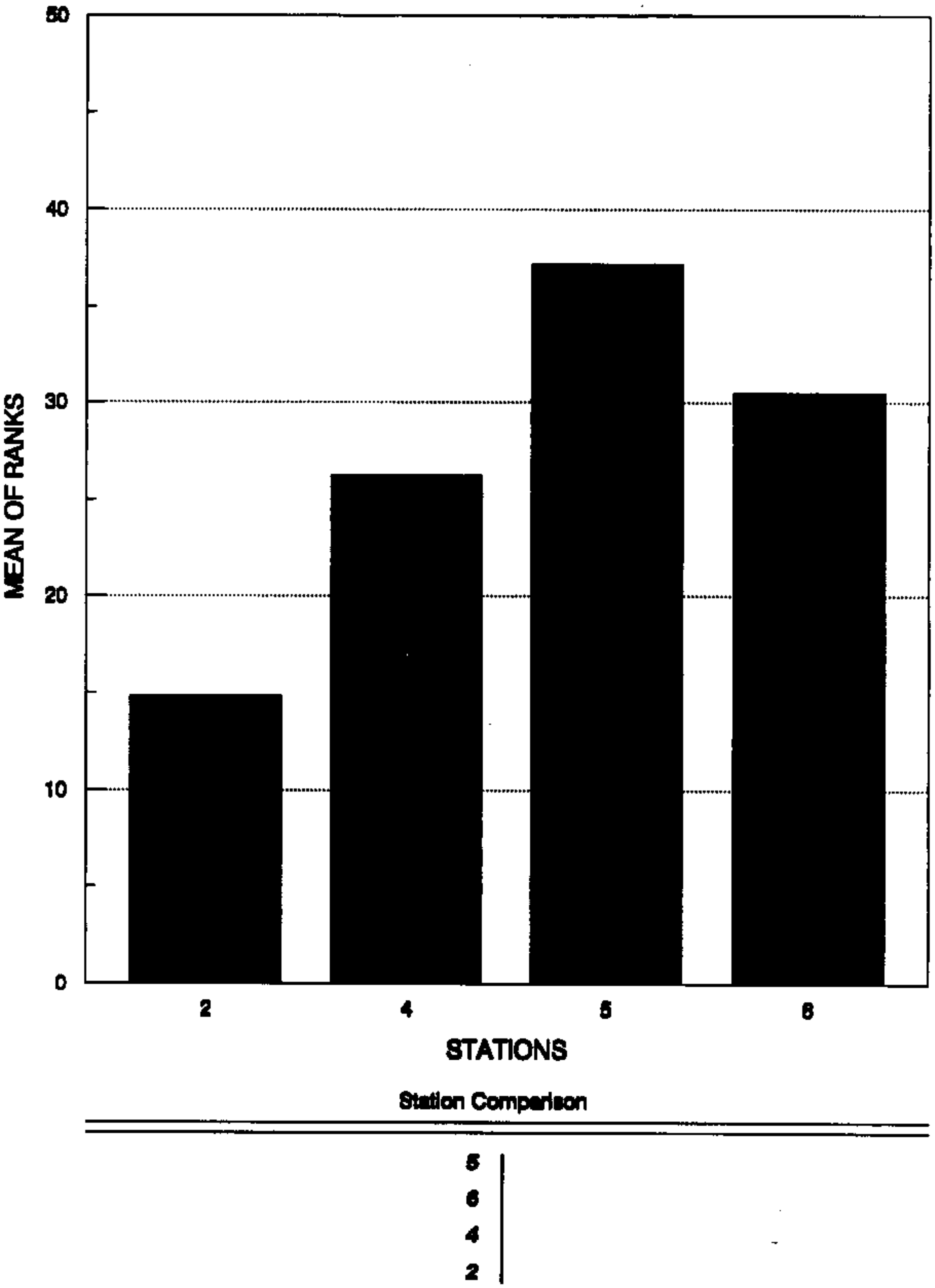
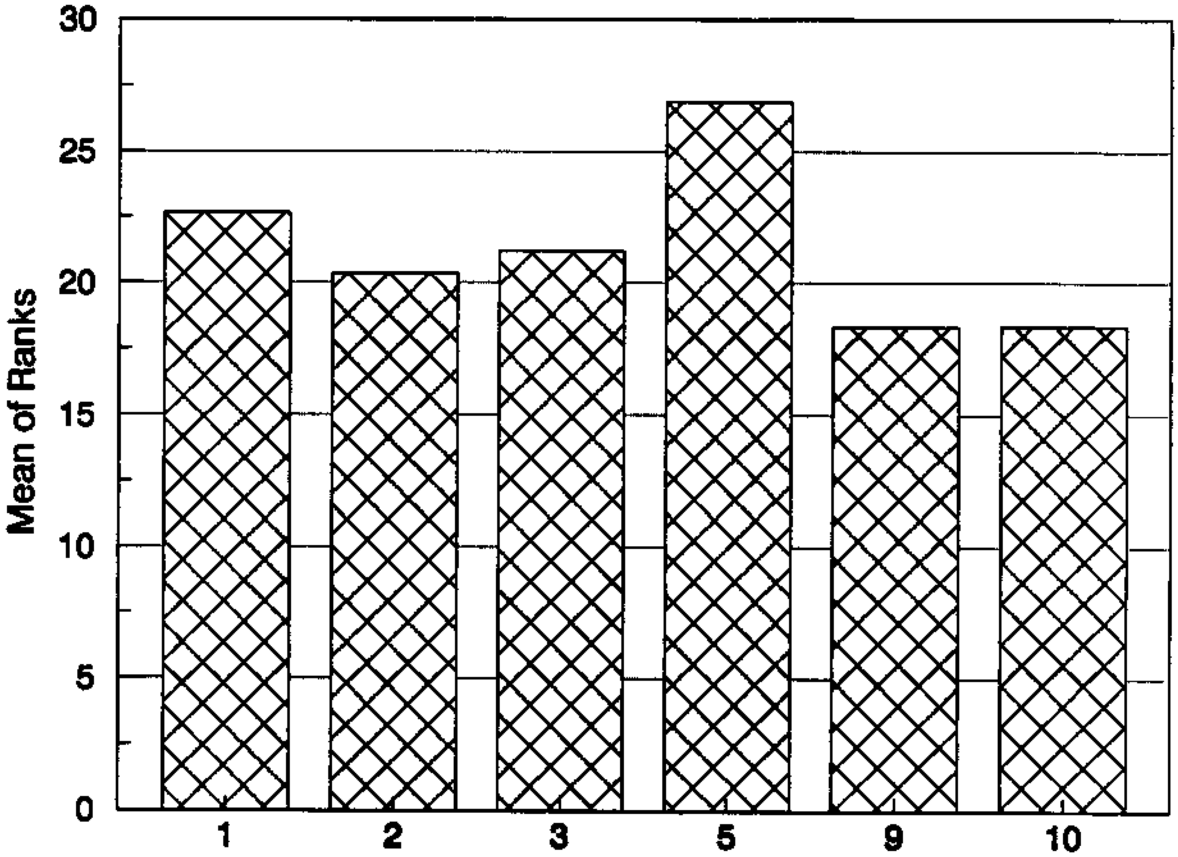


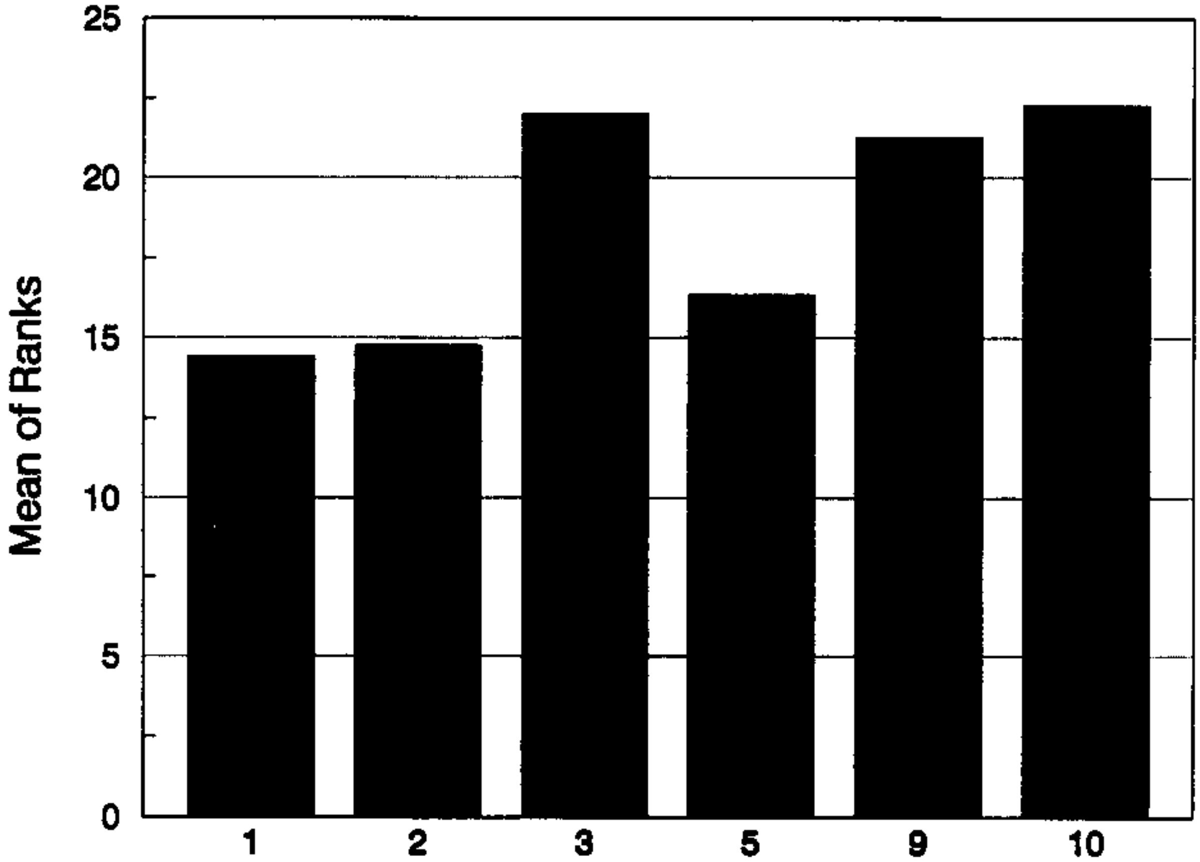
Figure 10. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance ($P > 0.05$).



Station Comparison

5
1
3
2
9
10

Figure 11. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance ($P > 0.05$).



Station Comparison

10
3
9
5
2
1

Figure 12. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance ($P > 0.05$).

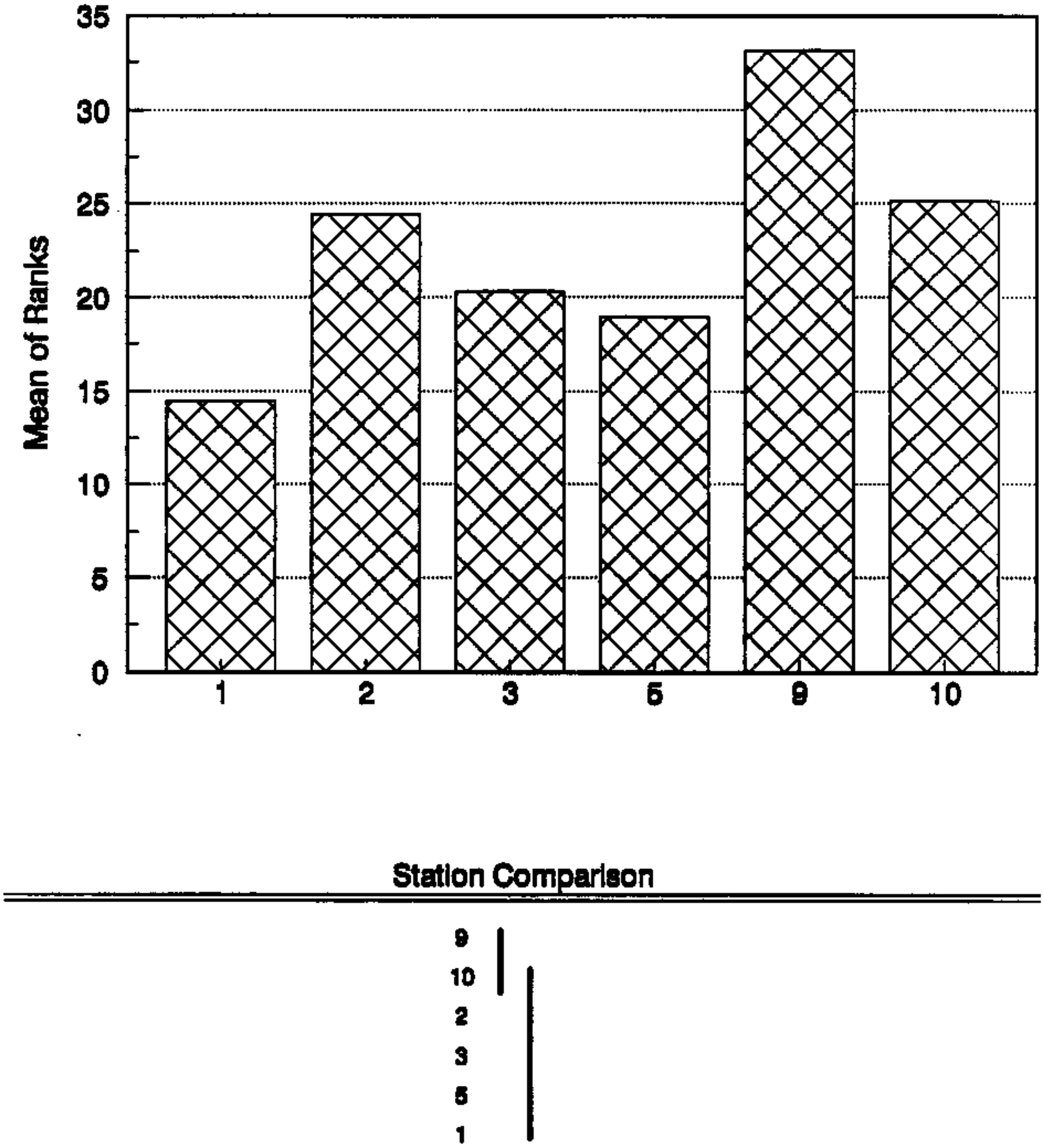
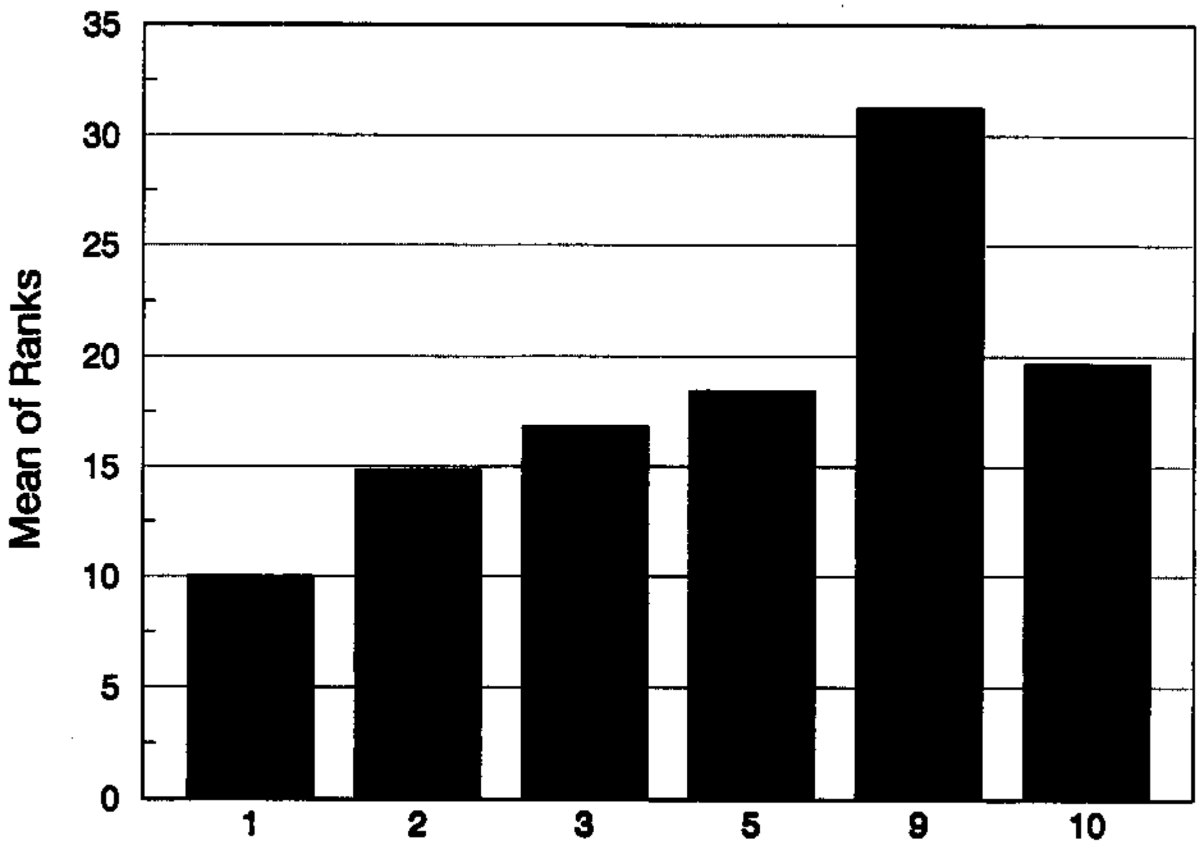


Figure 13. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).



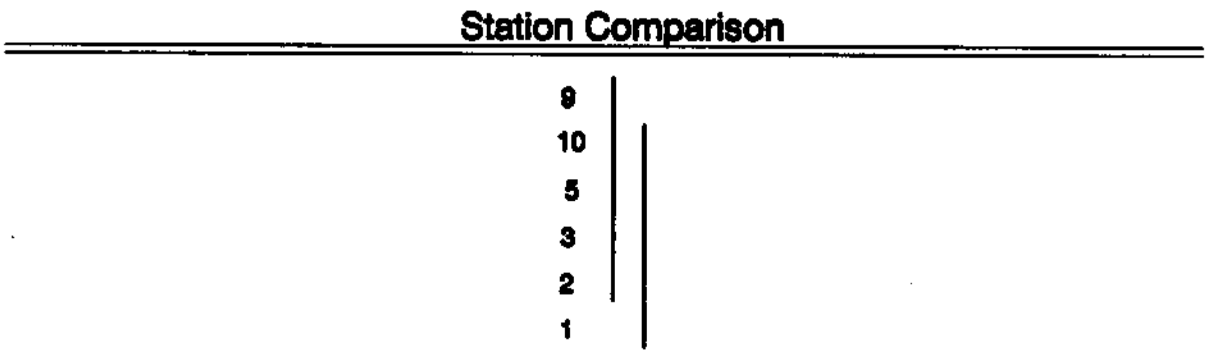


Figure 14. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).

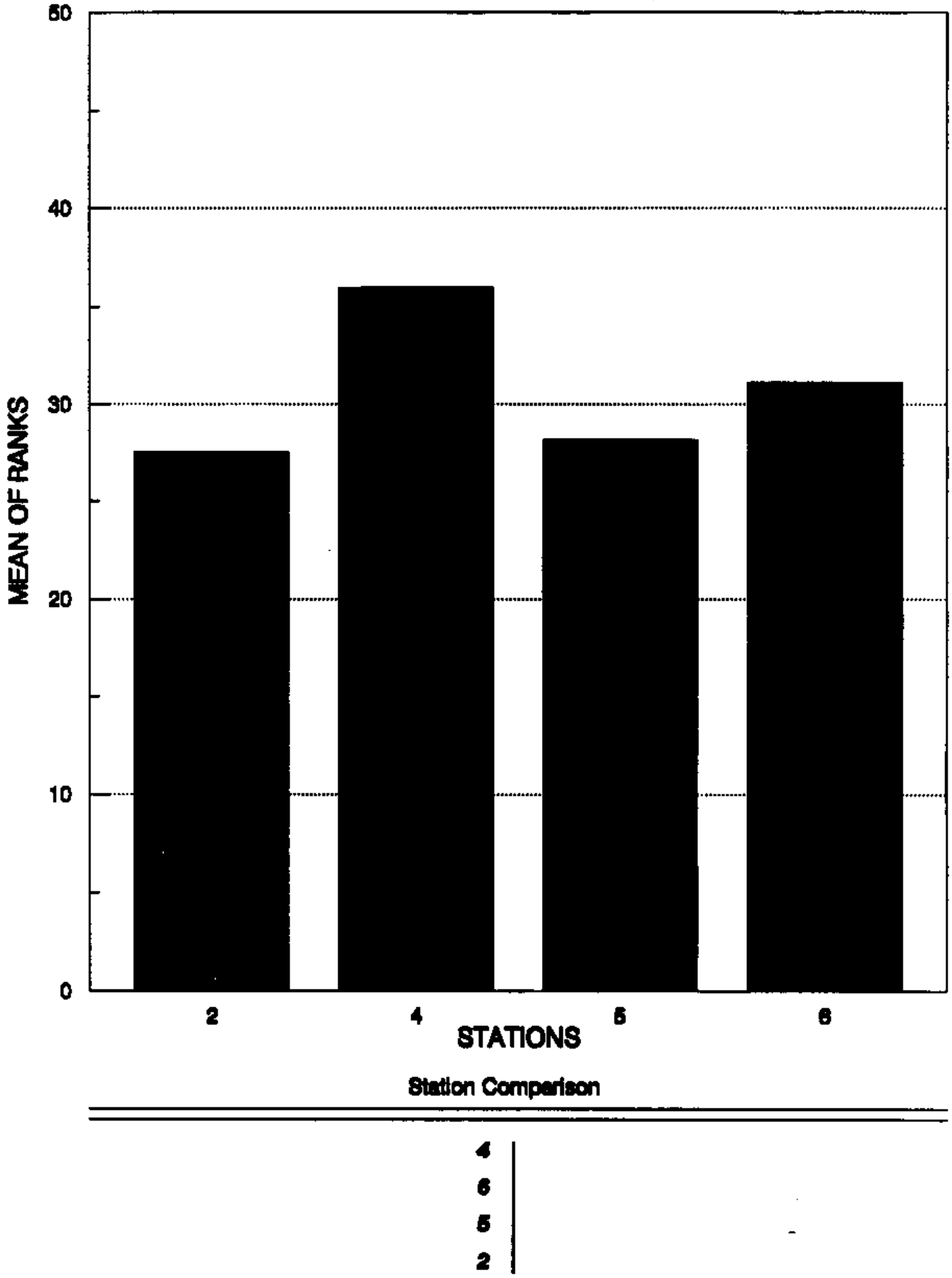
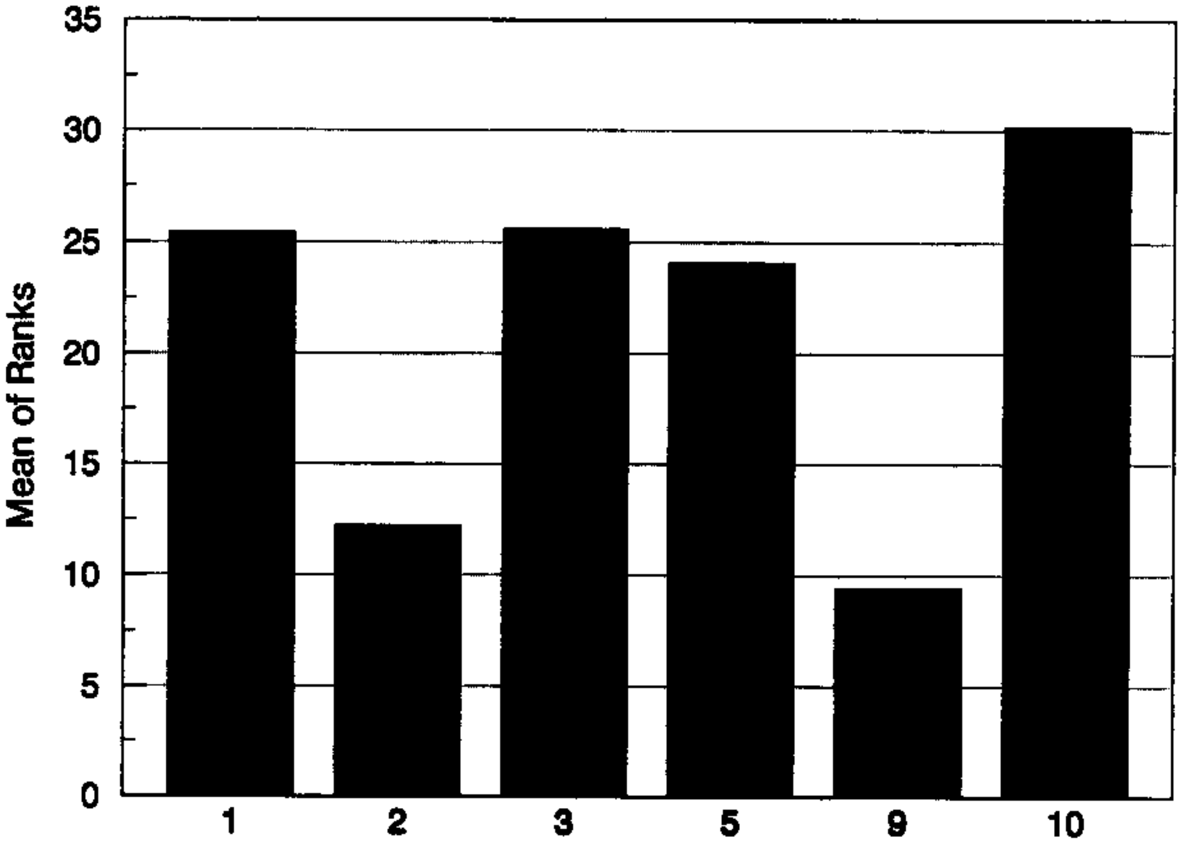


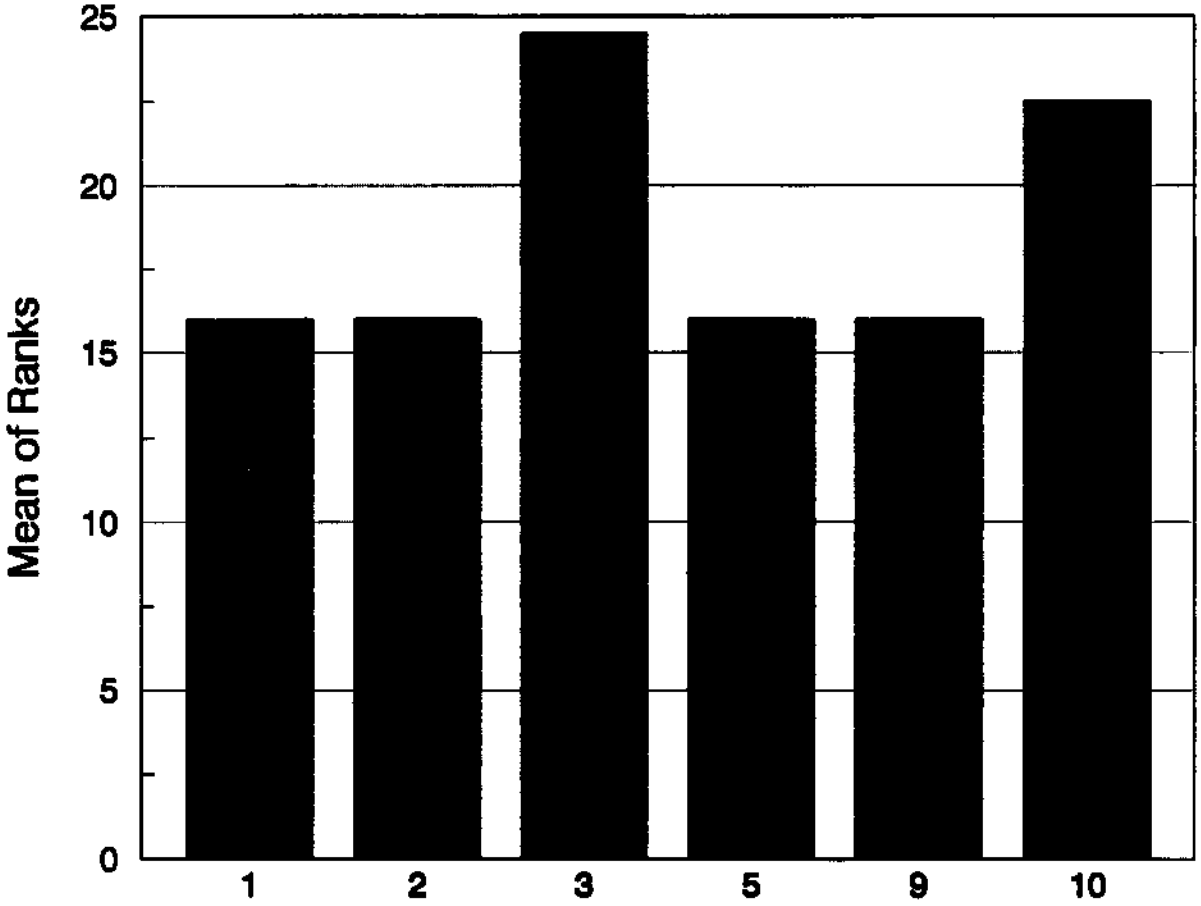
Figure 15. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1990. The vertical line beside stations indicates statistical nonsignificance ($P > 0.05$).



Station Comparison

Station	Group
10	A
3	A
1	A
5	A
2	B
9	B

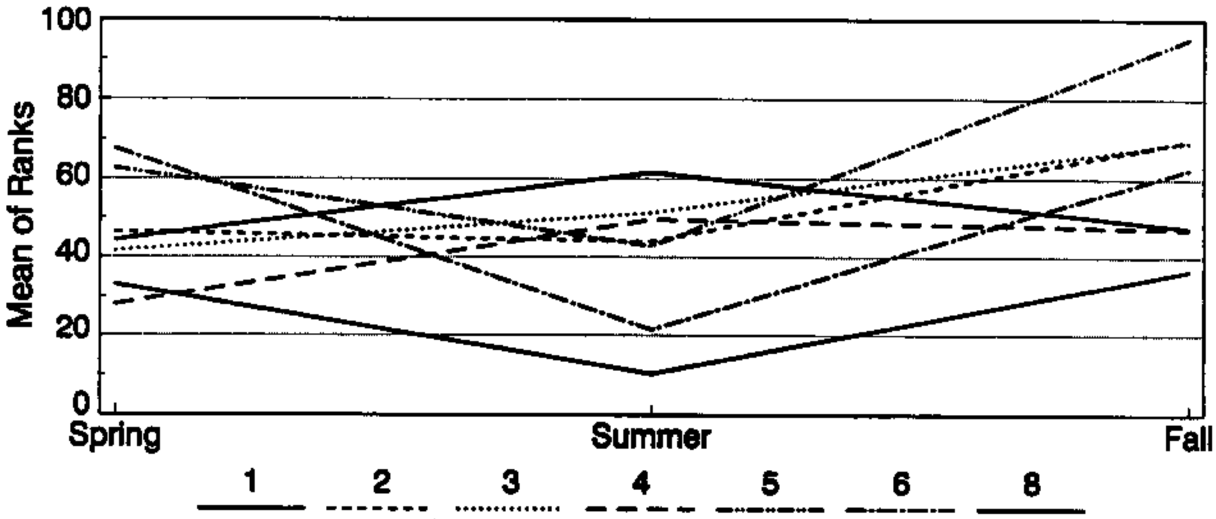
Figure 16. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

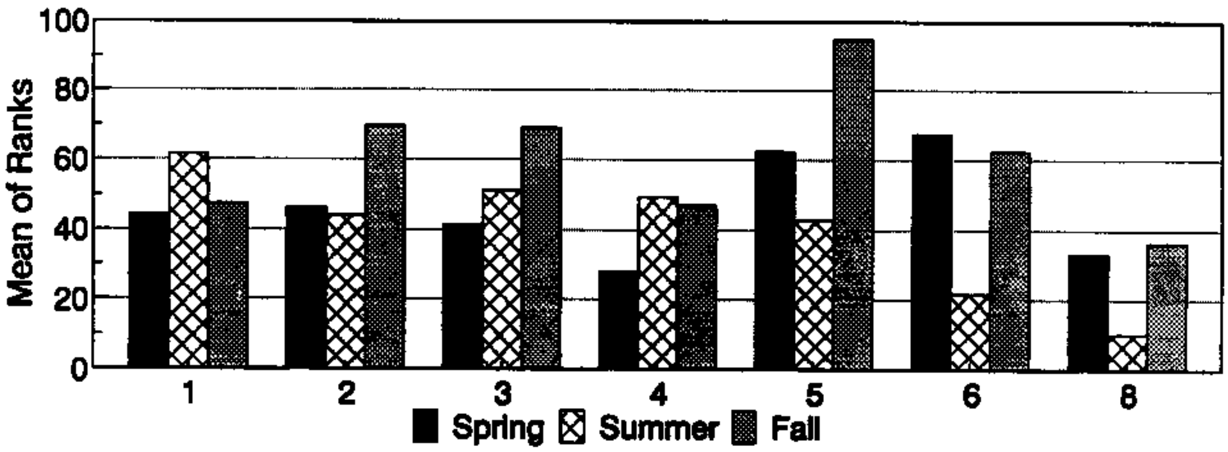
3
10
1
5
9
2

Figure 17. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

5
6
2
3
1
4
8



Season Comparison

Fa
Sp
Su

Figure 18. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).

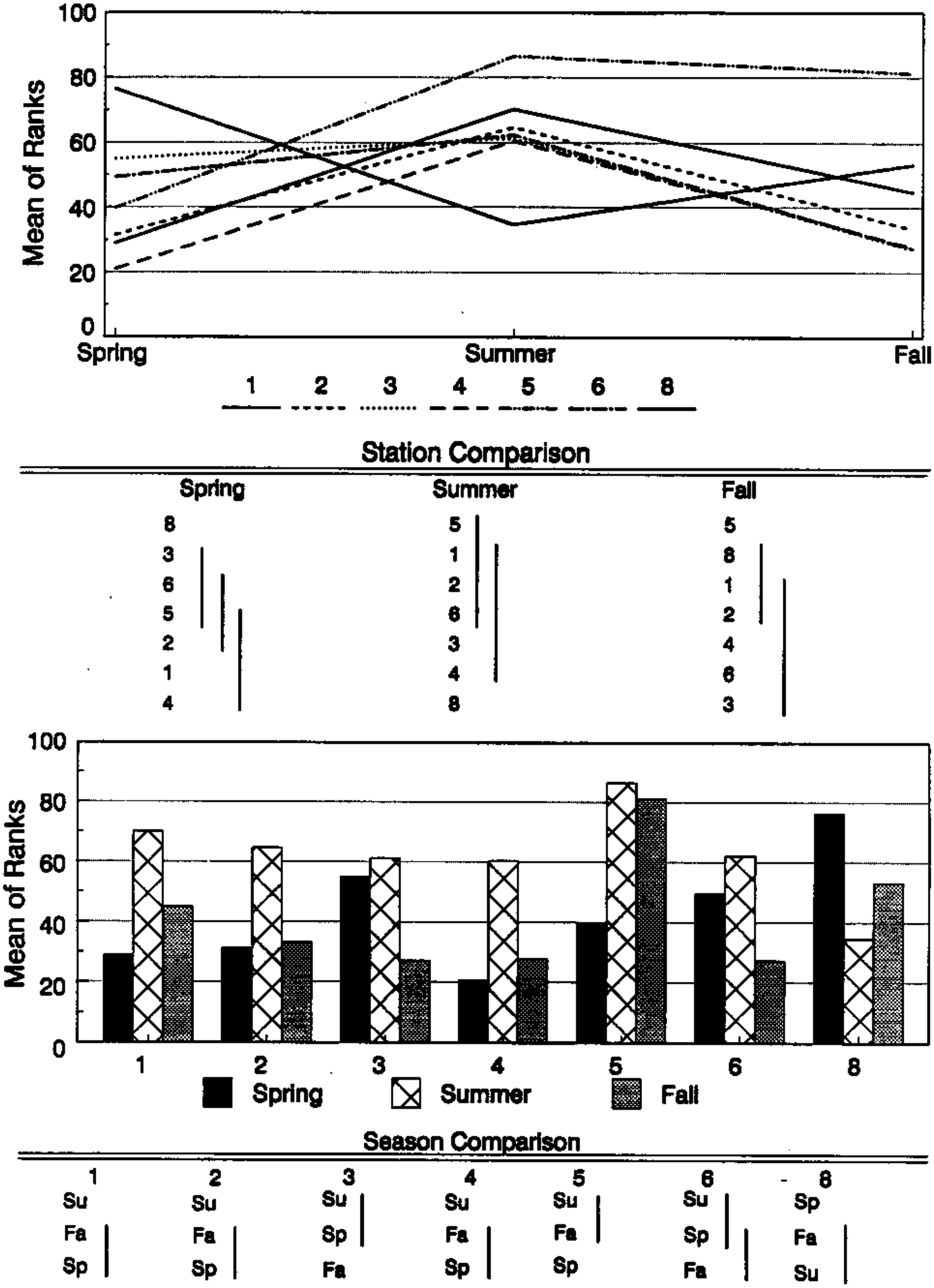
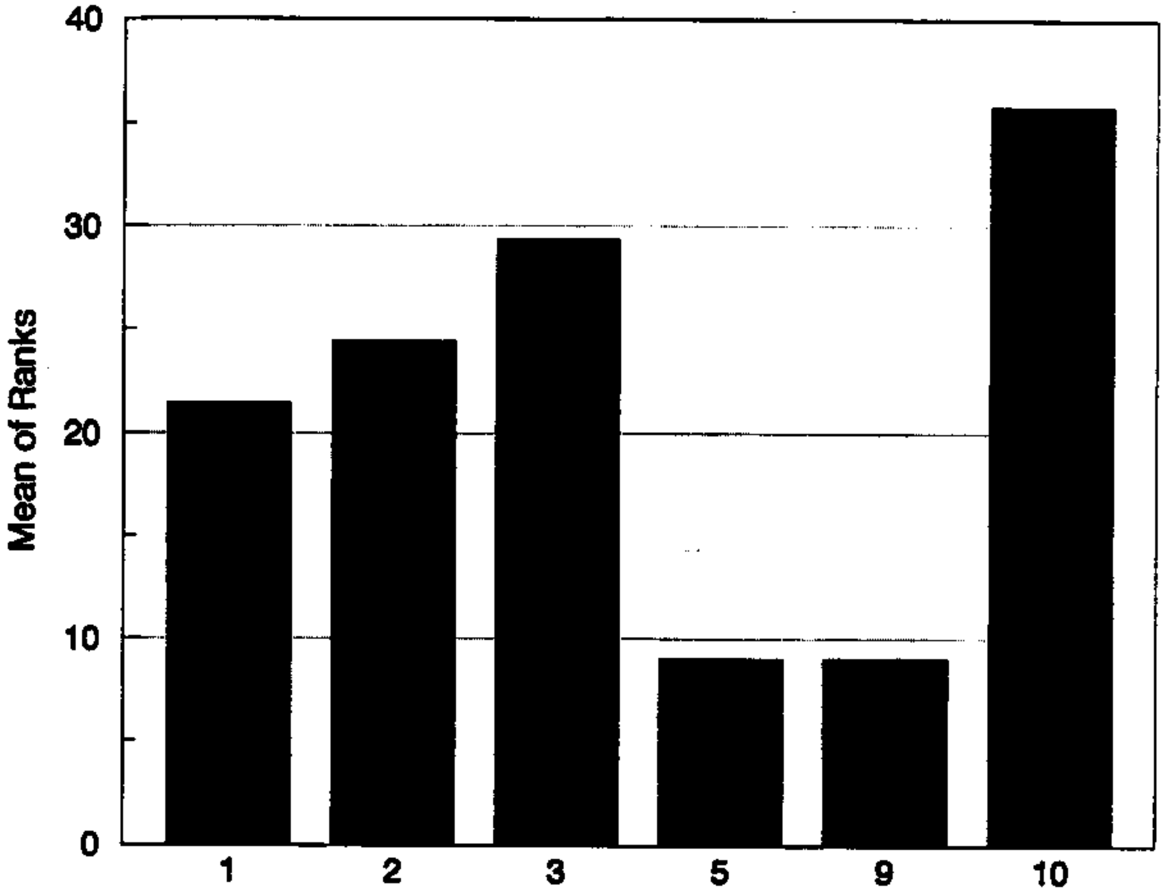


Figure 19. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).



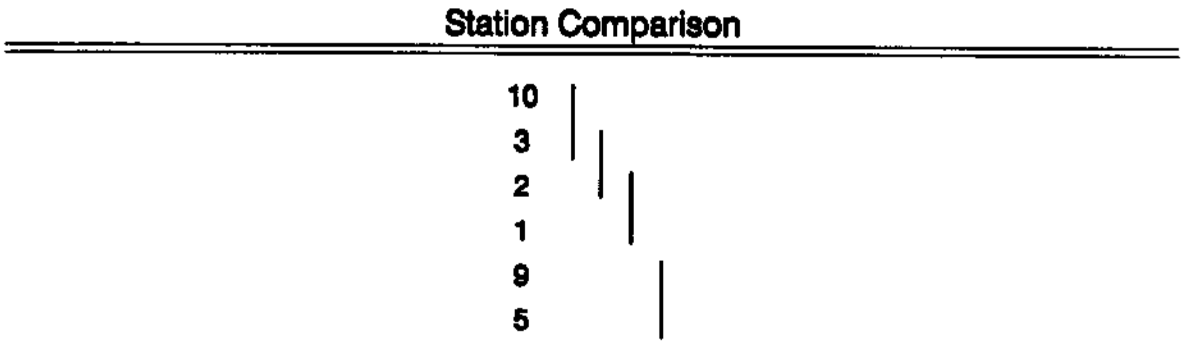
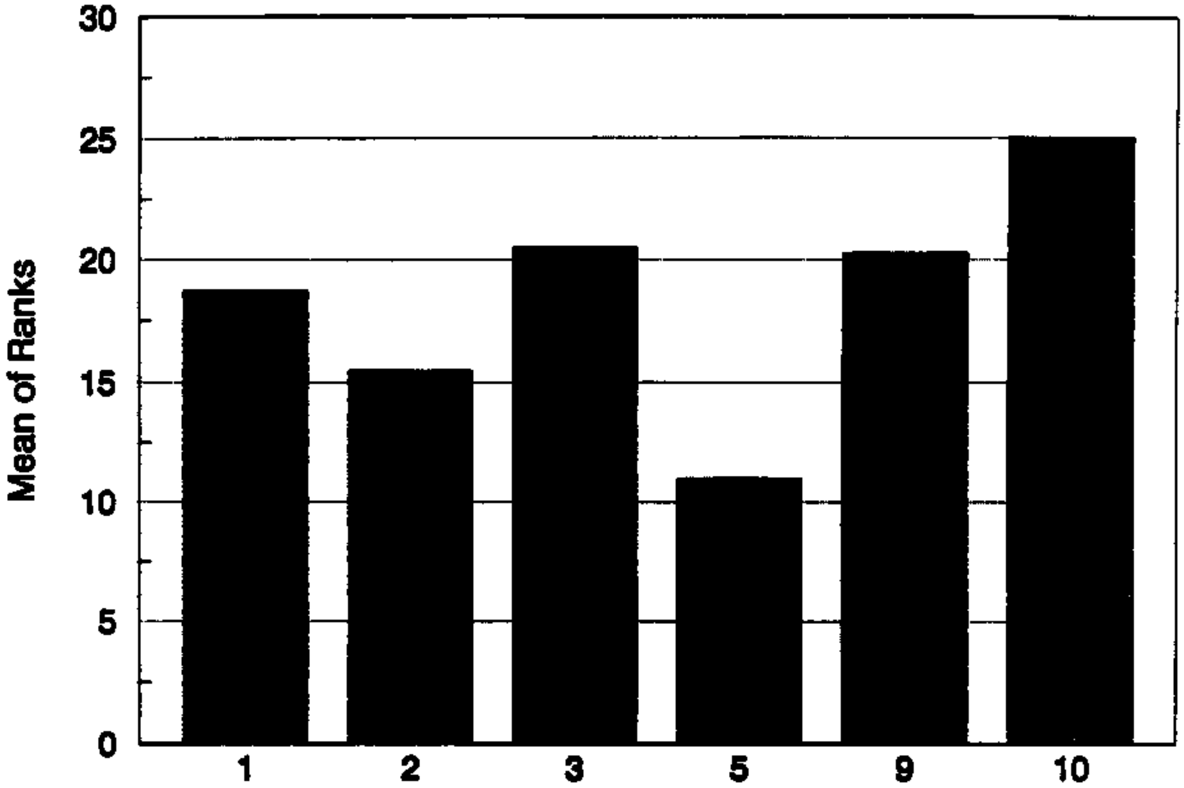


Figure 20. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).



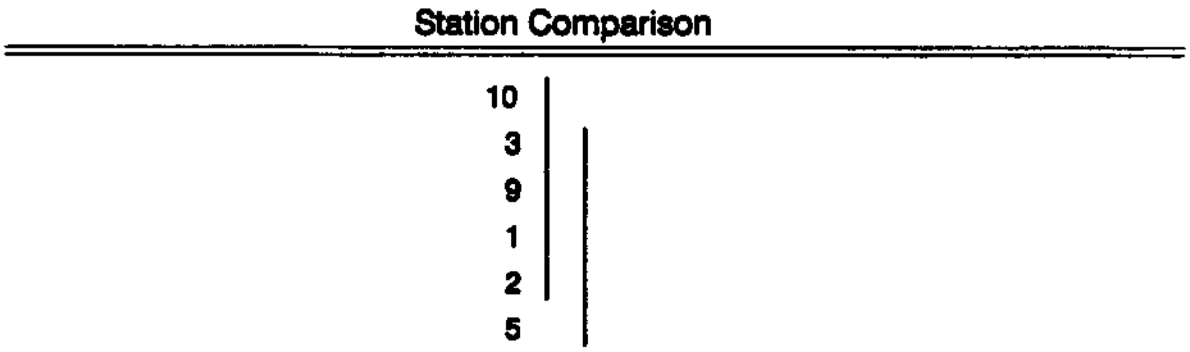


Figure 21. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

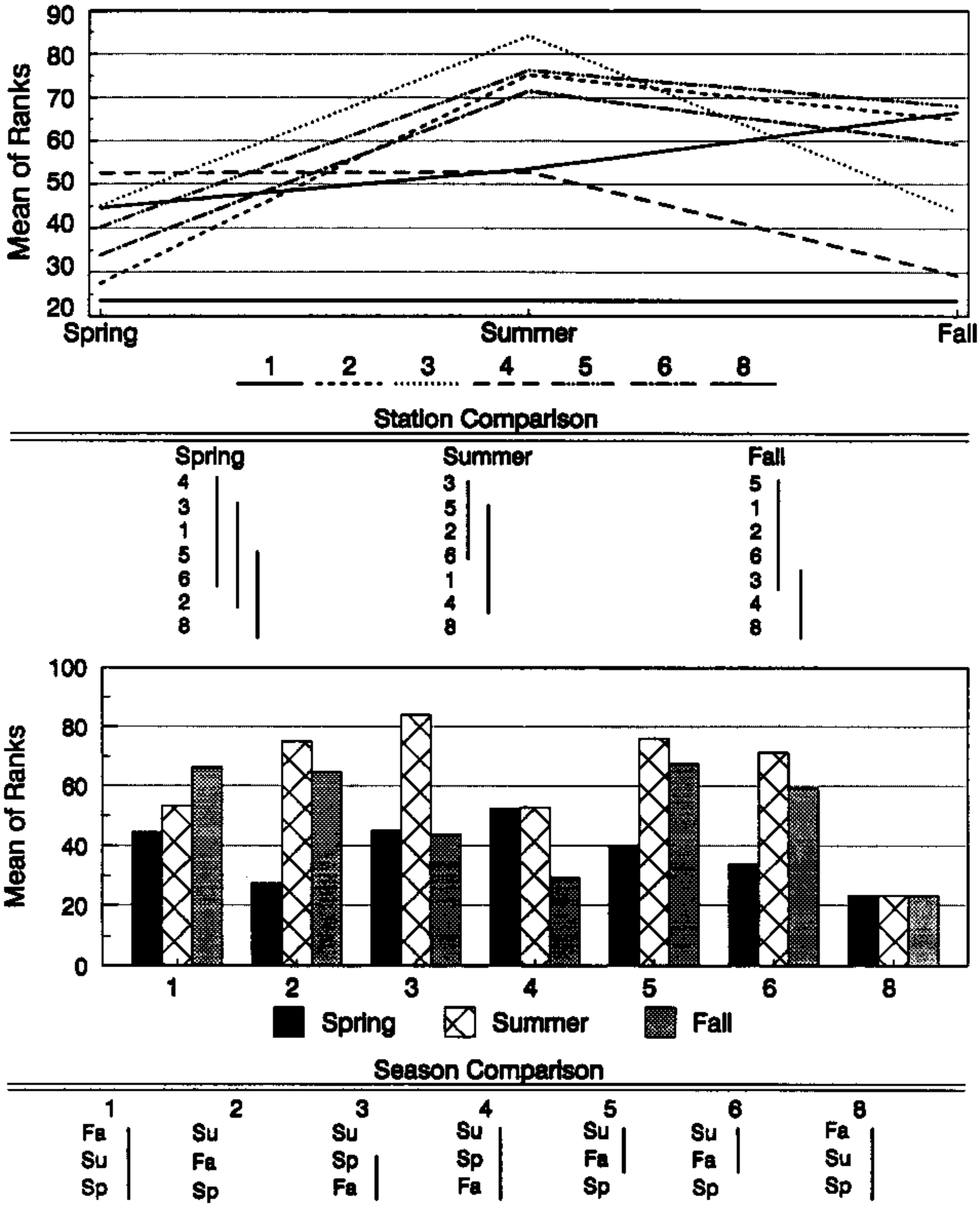


Figure 22. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Wasington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).

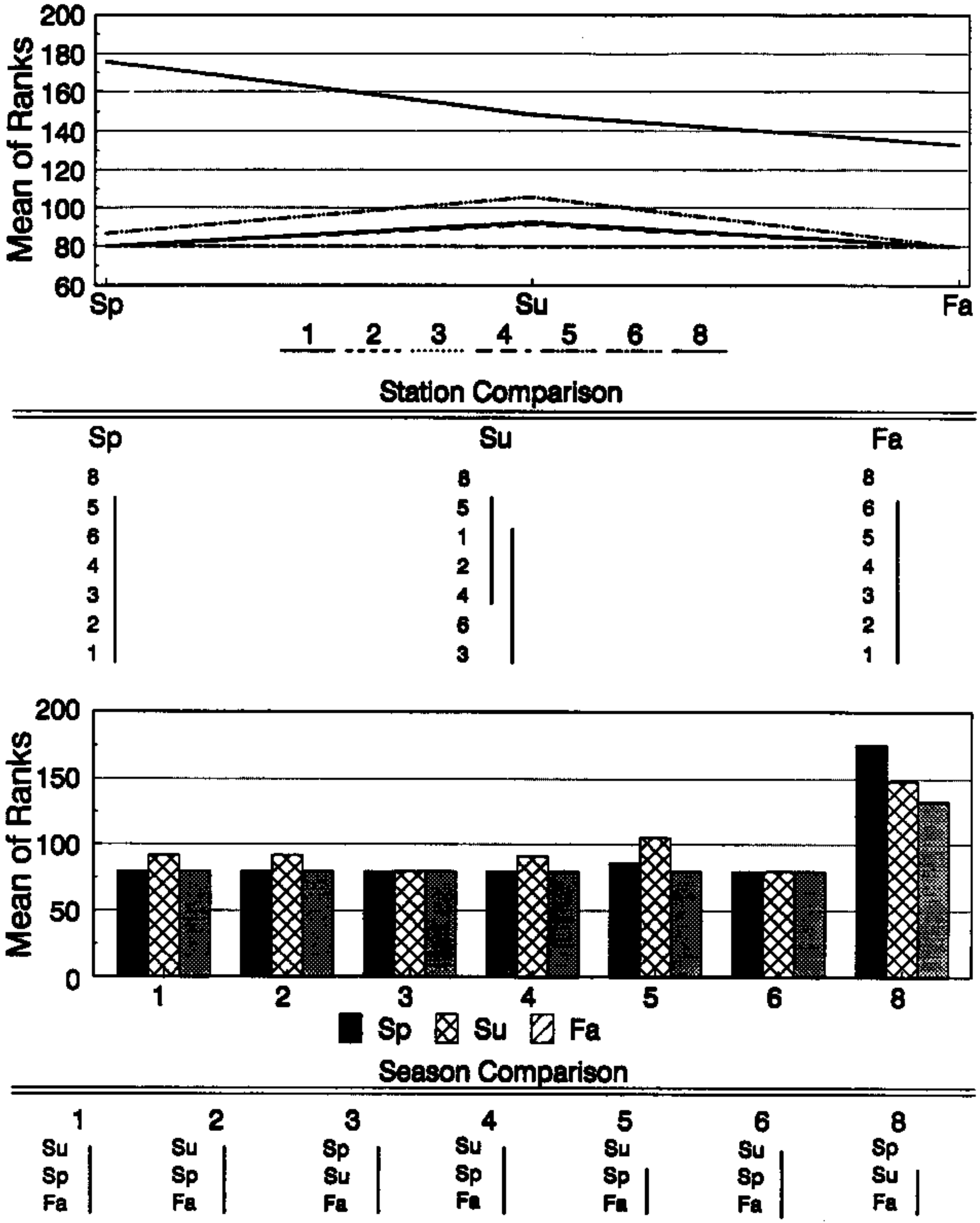
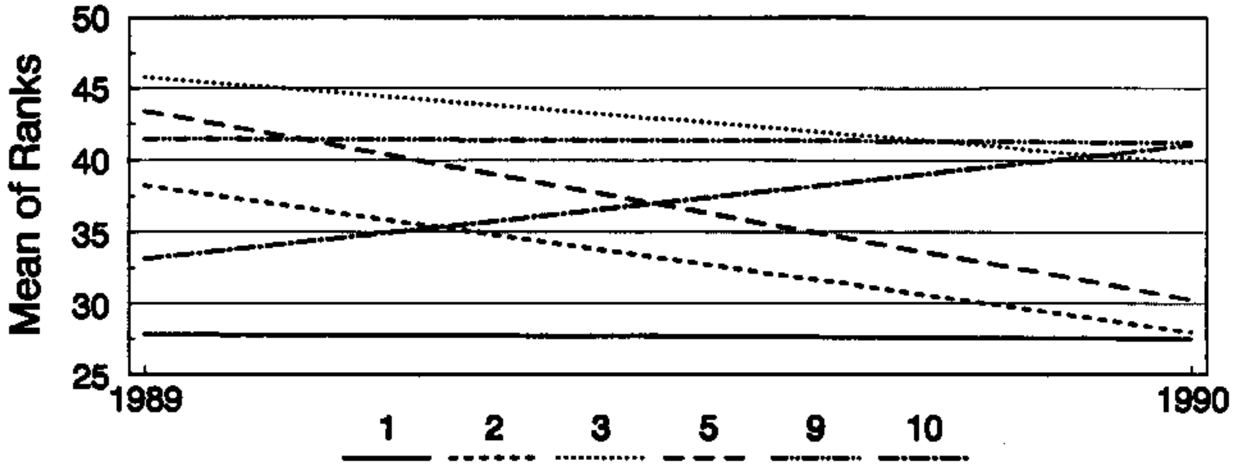
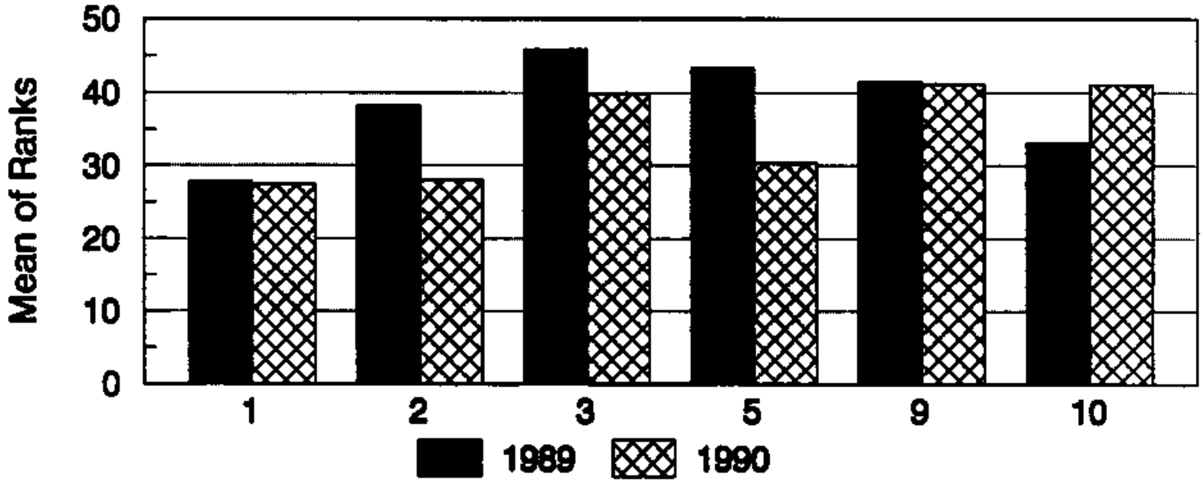


Figure 23. Graphical and statistical comparisons of the mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

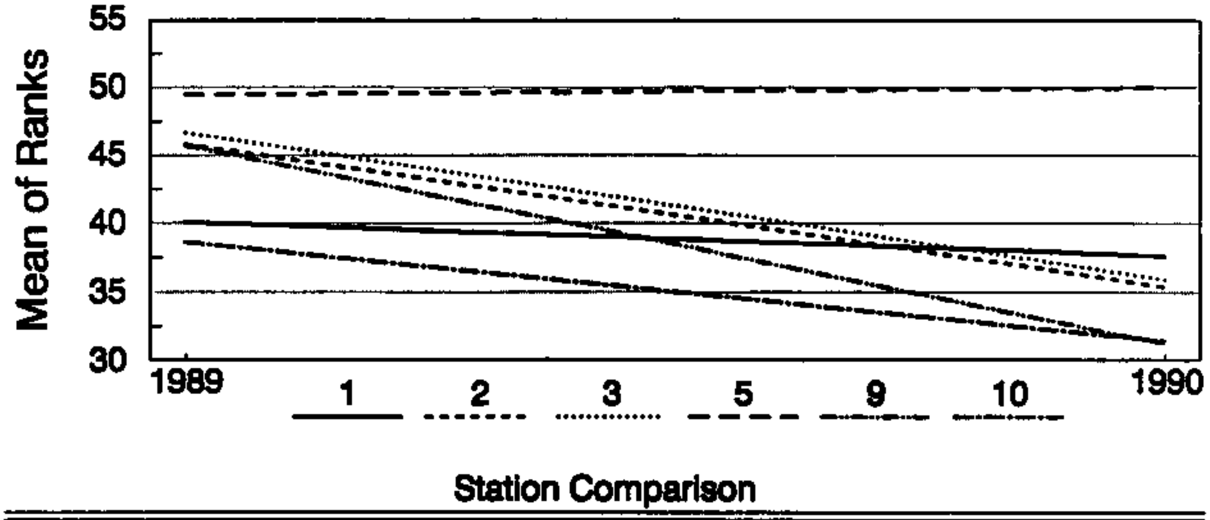
3
9
10
5
2
1



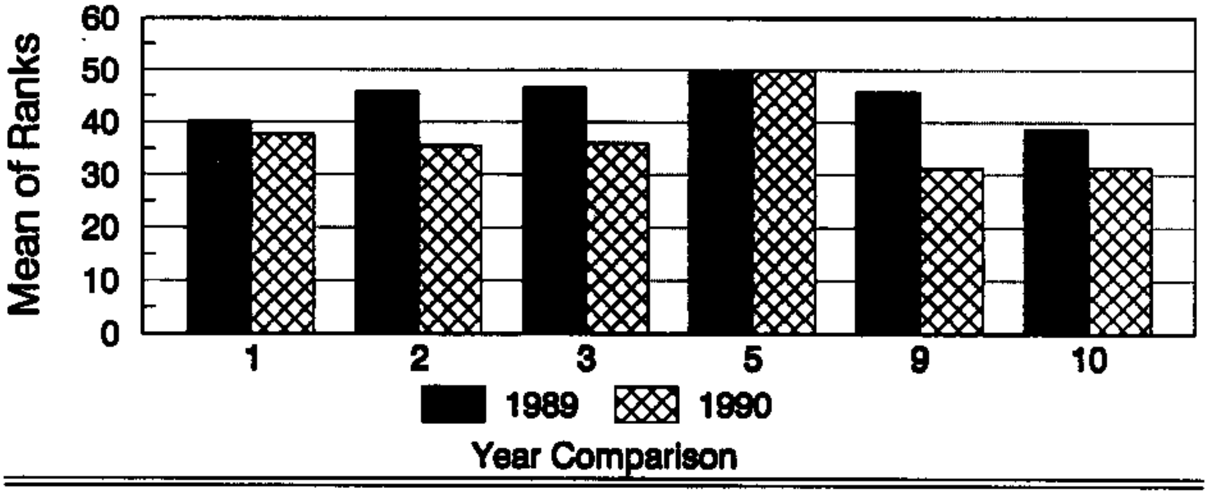
Year Comparison

1989
1990

Figure 24. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).



5
3
2
1
9
10



89
90

Figure 25. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

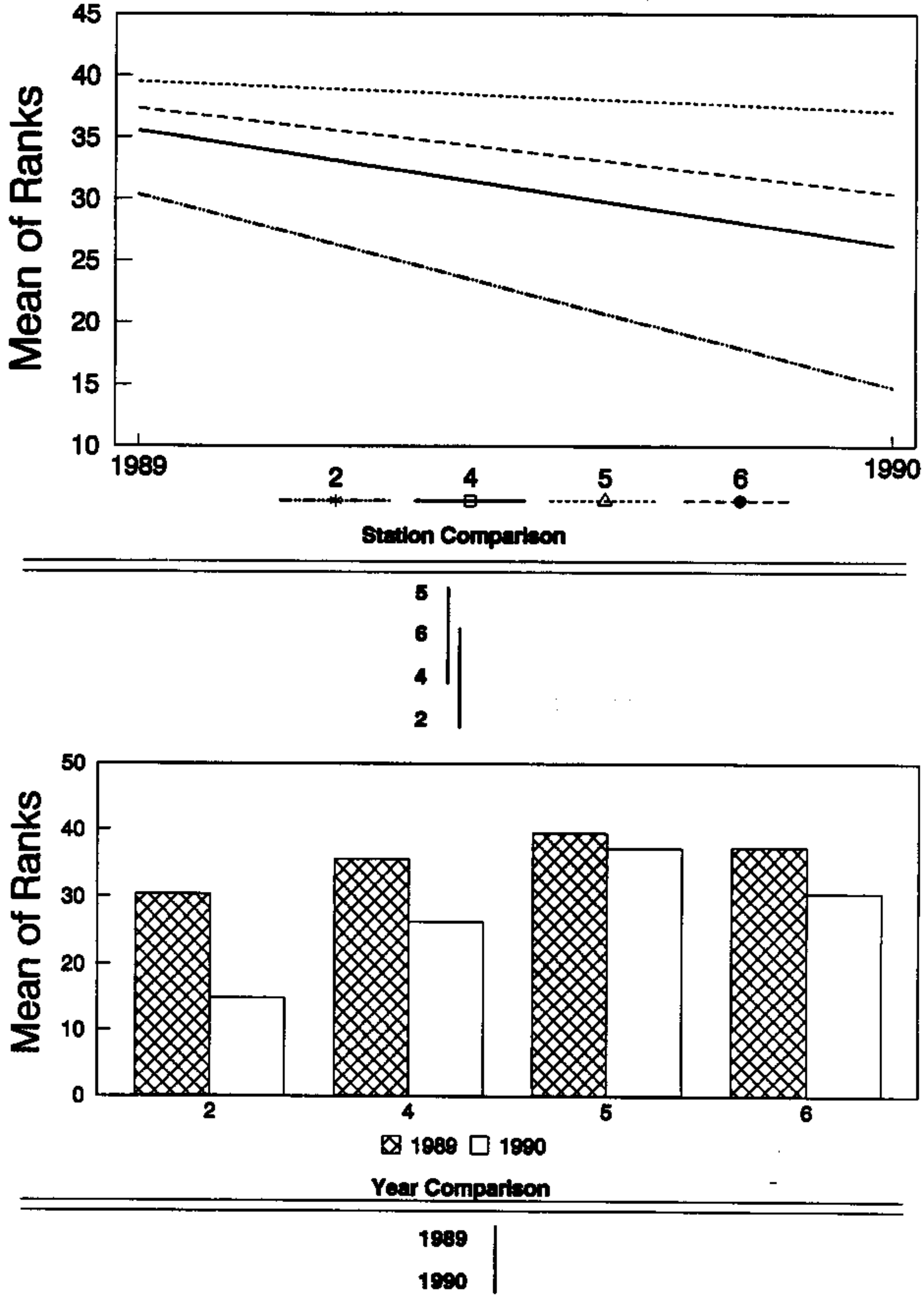
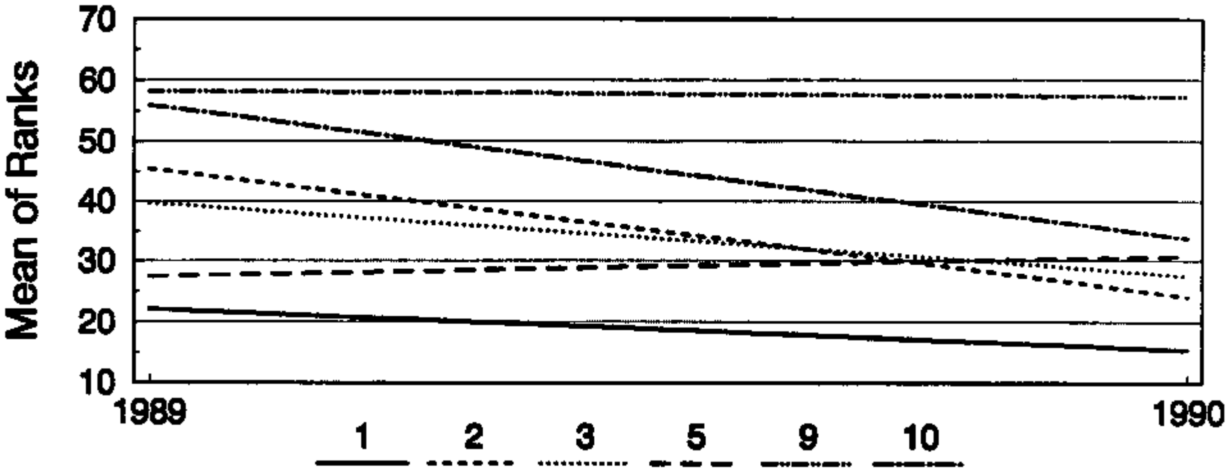
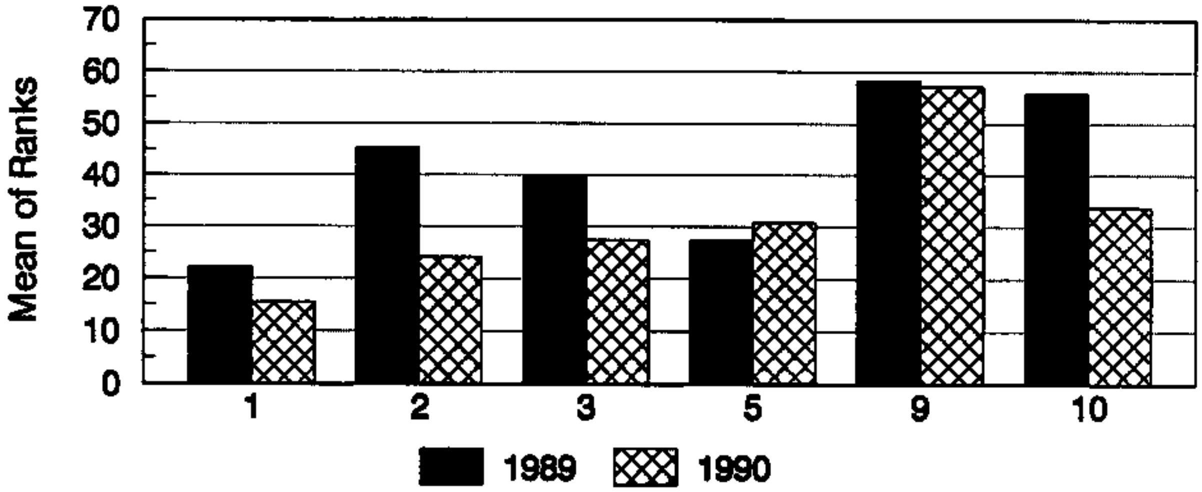


Figure 26. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

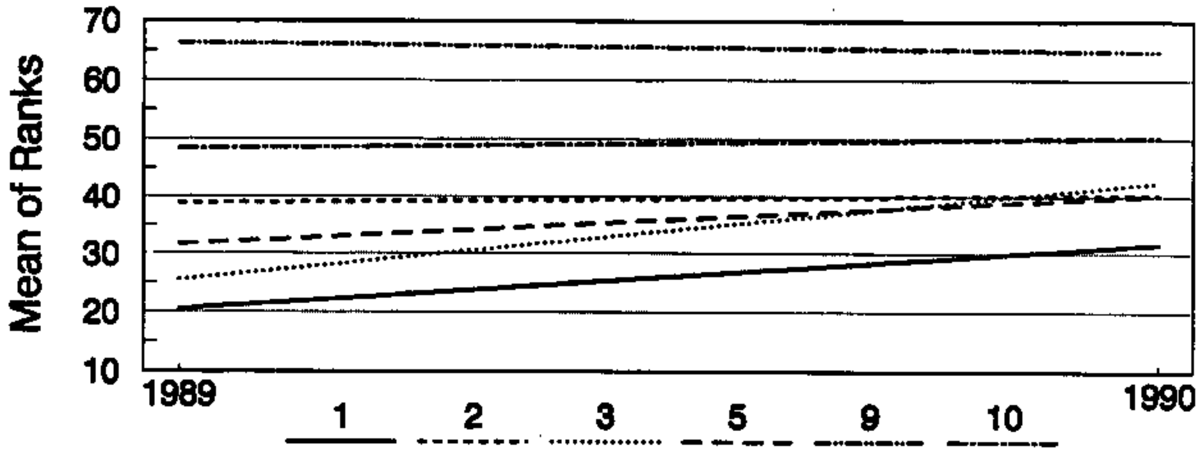
9
10
2
3
5
1



Year Comparison

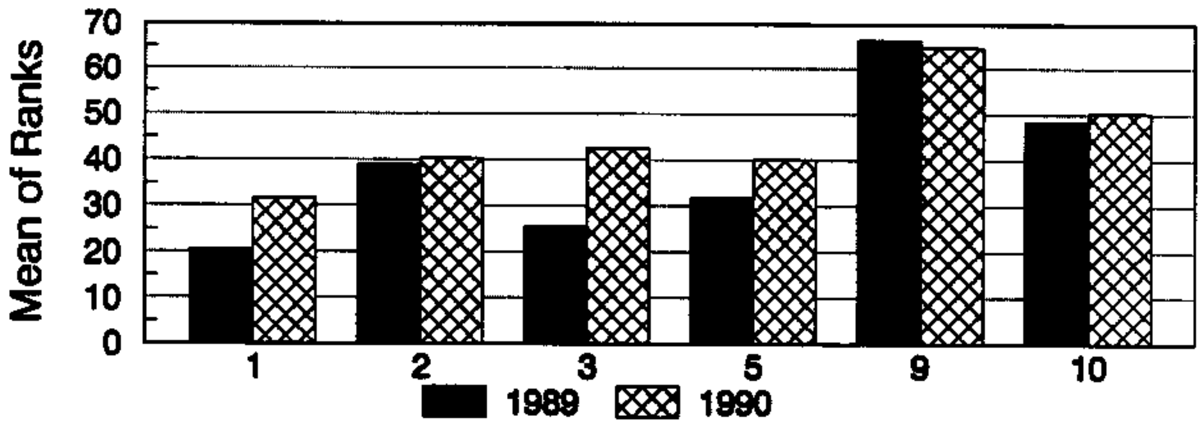
1989
1990

Figure 27. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

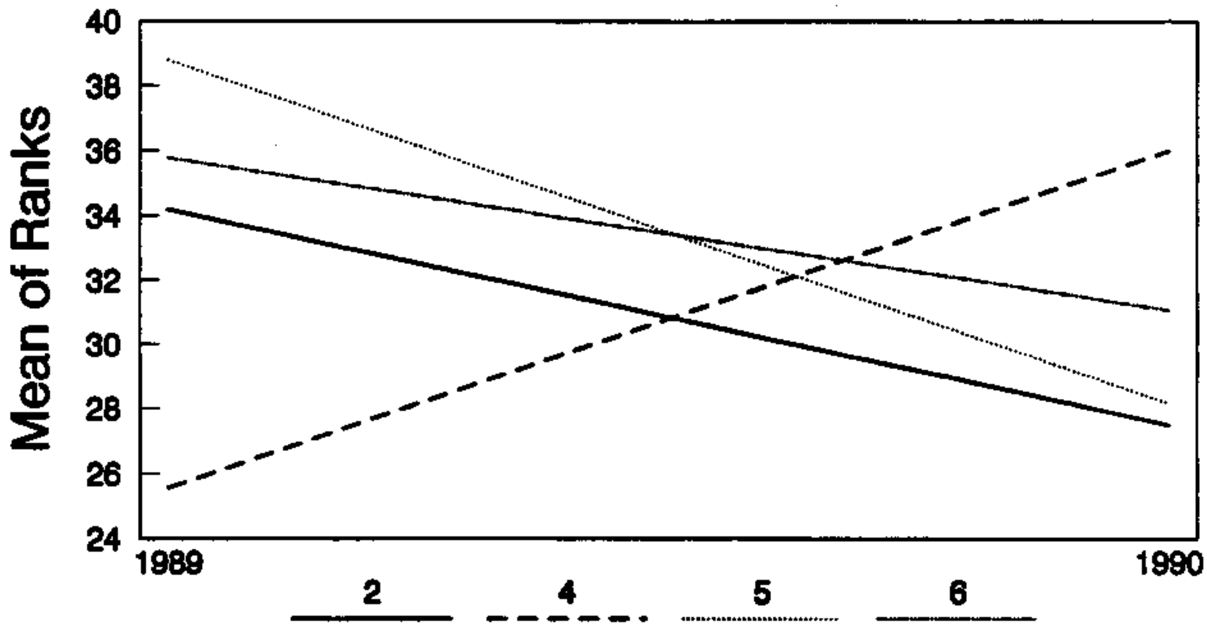
9
10
2
5
3
1



Year Comparison

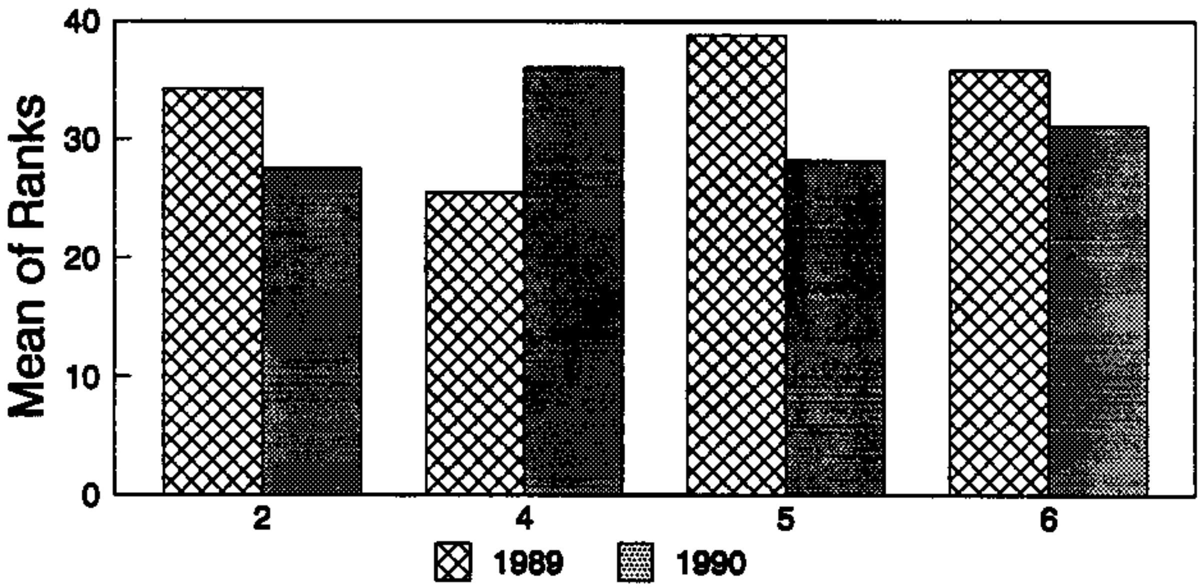
90
89

Figure 28. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

5
6
2
4



Year Comparison

1989
1990

Figure 29. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

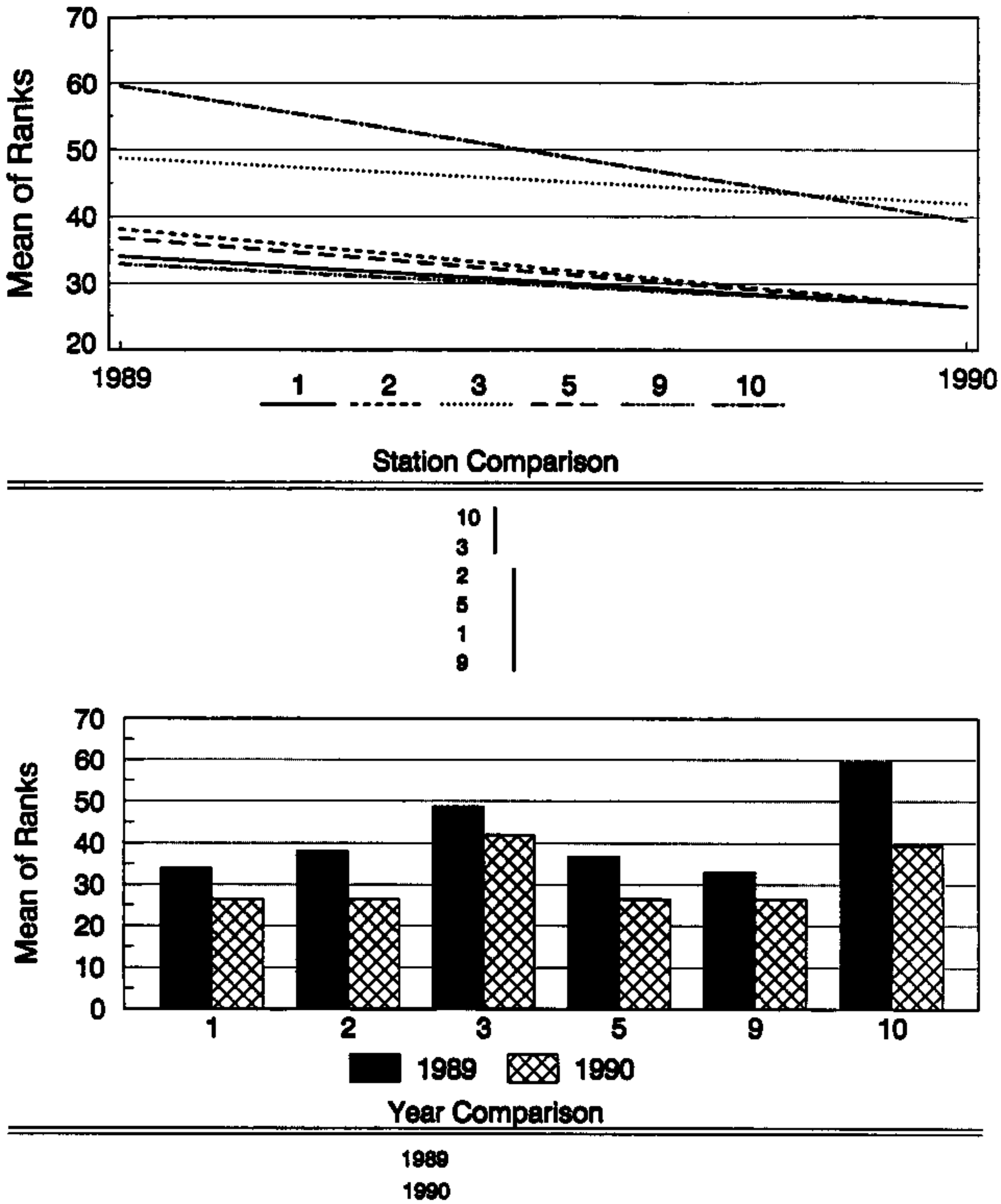


Figure 30. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

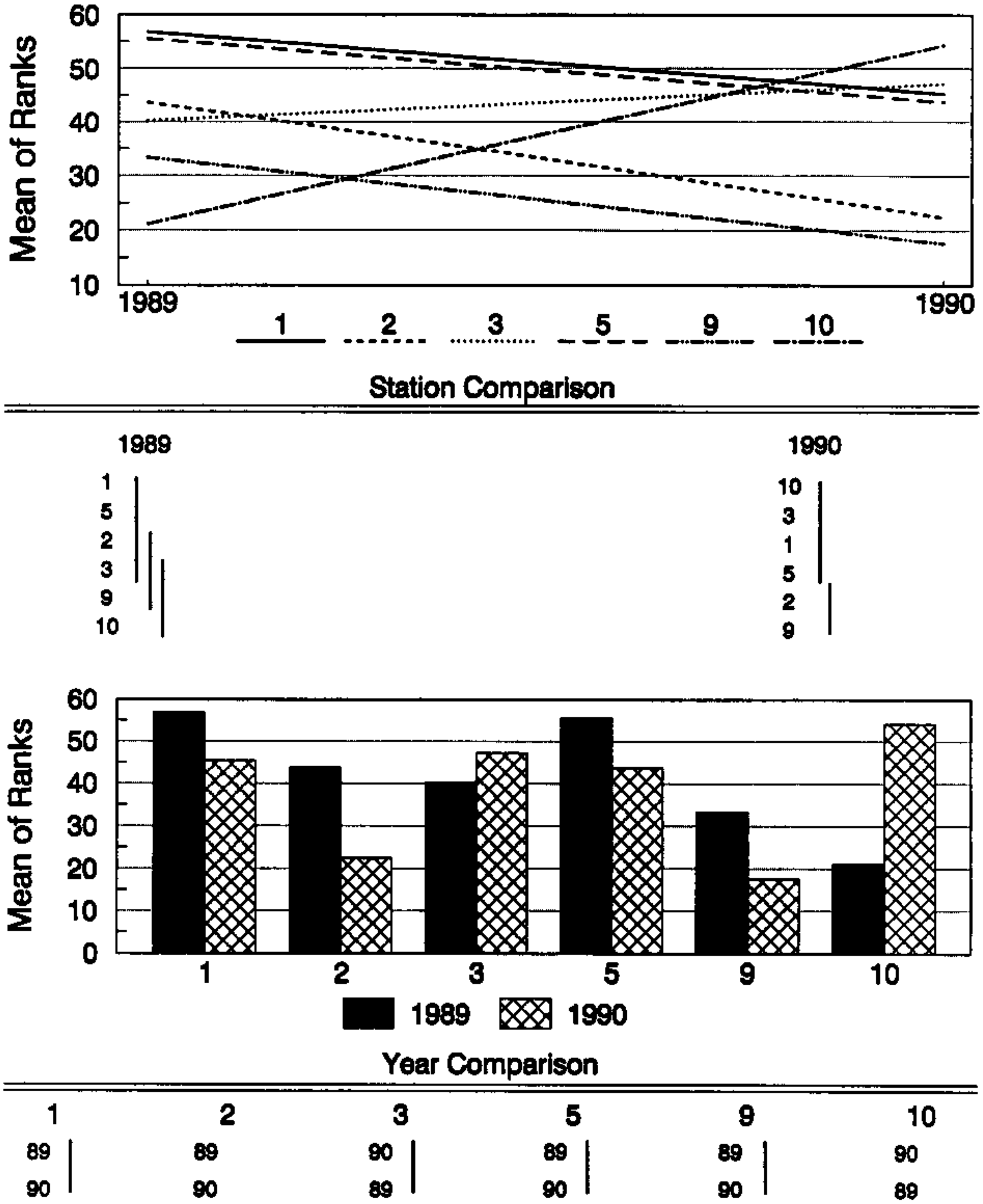


Figure 31. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

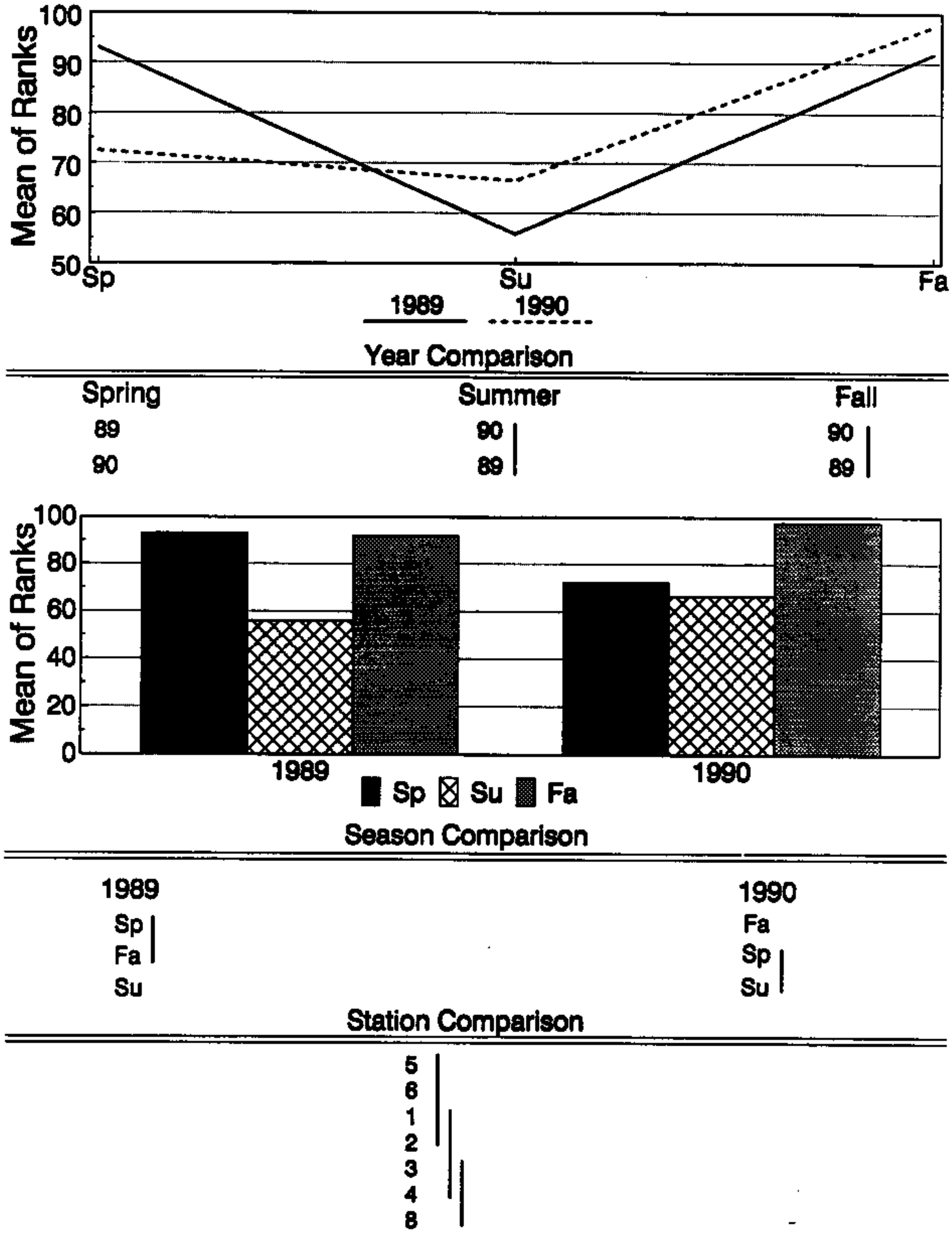


Figure 32. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations, seasons and years indicate statistical nonsignificance ($P > 0.05$).

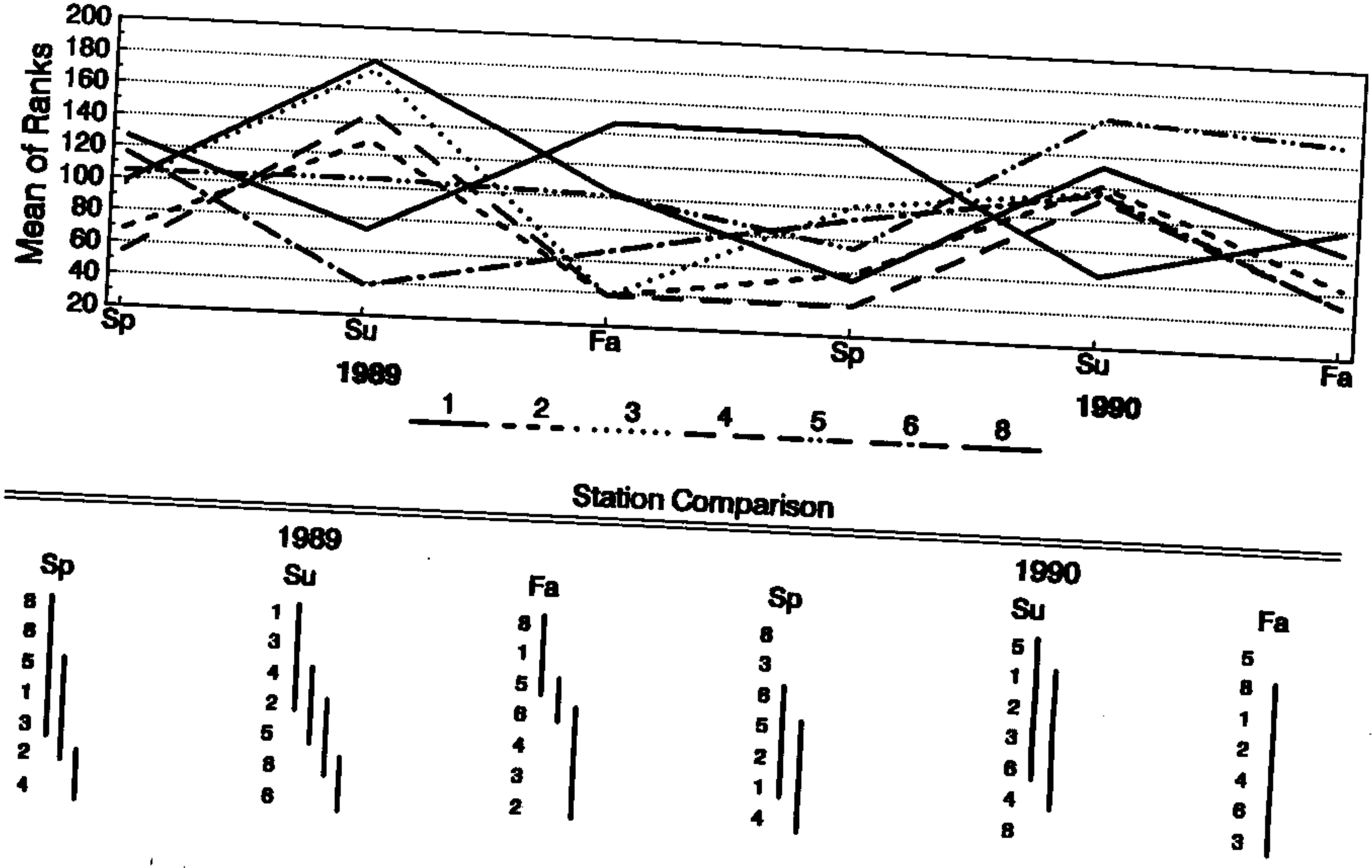
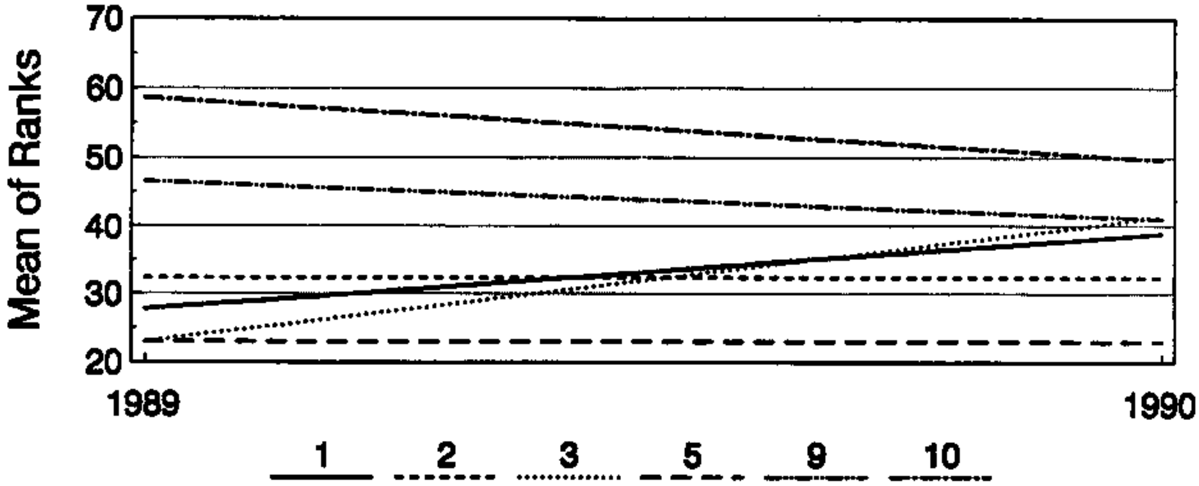
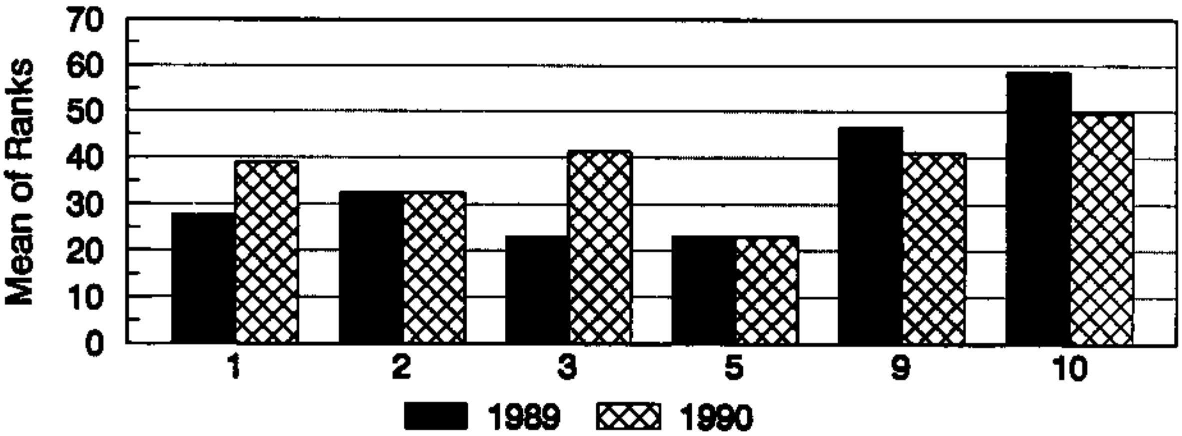


Figure 33. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and seasons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

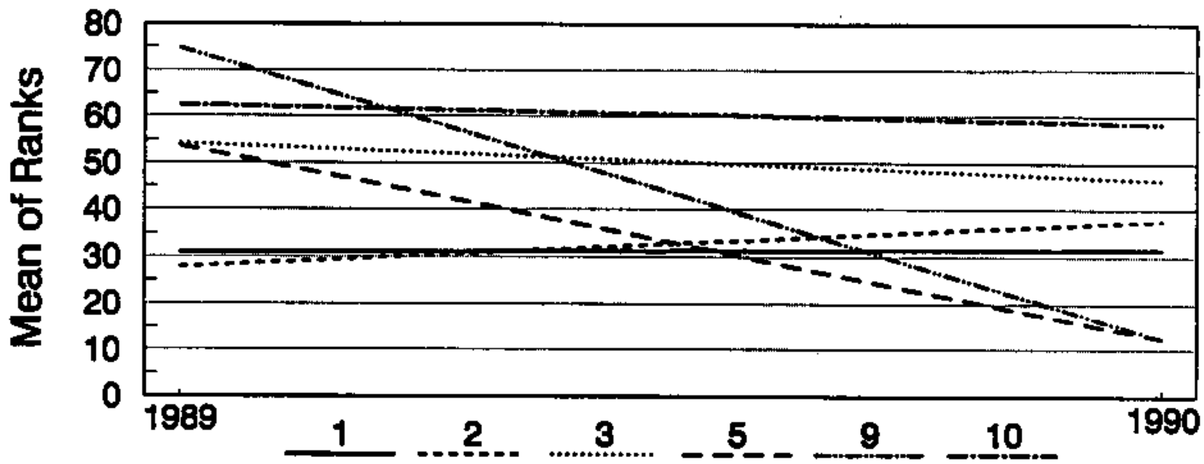
10
9
1
2
3
5



Year Comparison

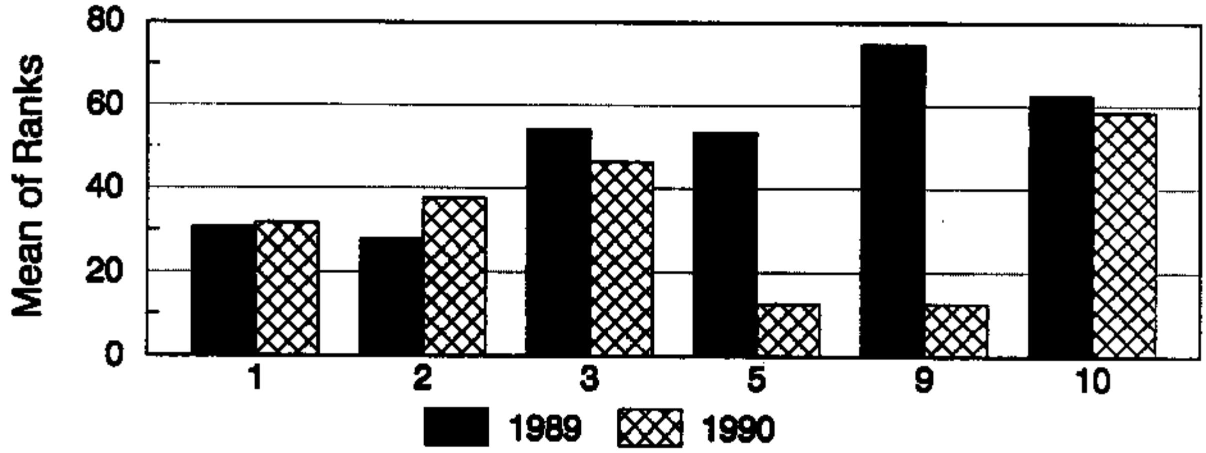
1990
1989

Figure 34. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

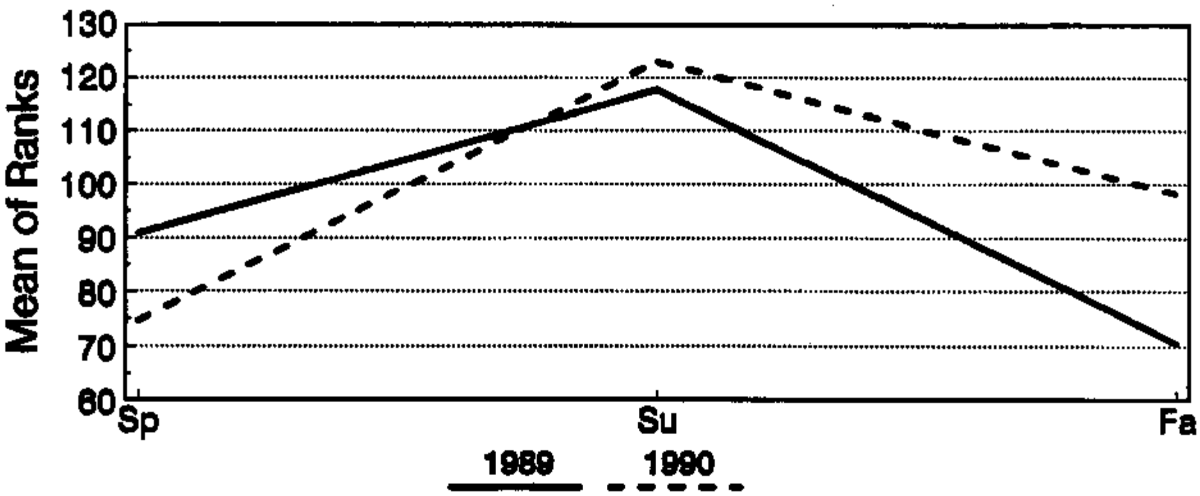
1989	1990
9	10
10	3
3	2
5	1
1	9
2	5



Year Comparison

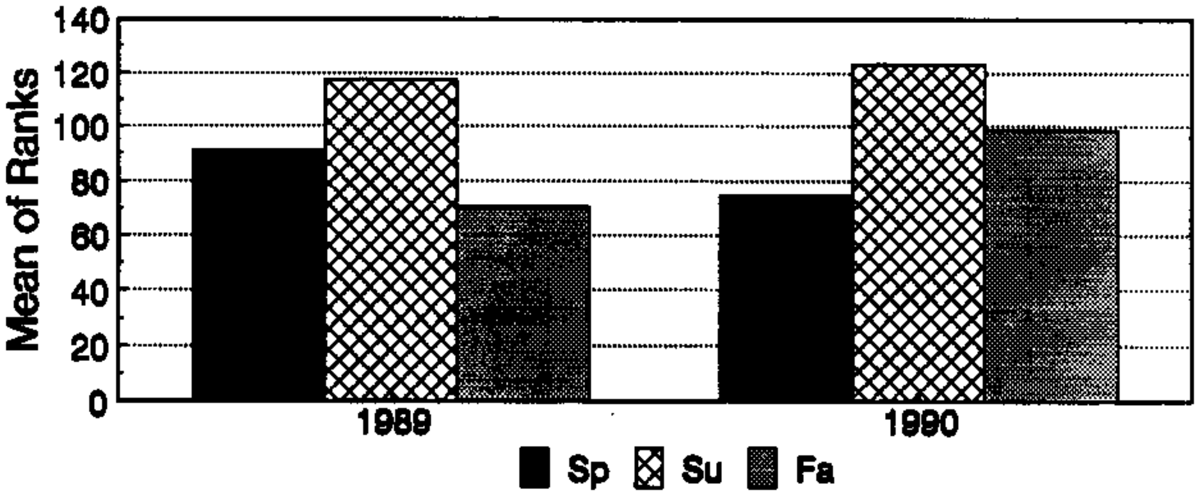
1	2	3	5	9	10
90	90	89	89	89	89
89	89	90	90	90	90

Figure 35. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P . > 0.0).



Year Comparison

Sp	Su	Fa
89	90 |	90
90	89 |	89



Season Comparison

1989	1990
Su	Su
Sp	Fa
Fa	Sp

Figure 36. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. The vertical line beside years indicates statistical nonsignificance ($P > 0.05$).

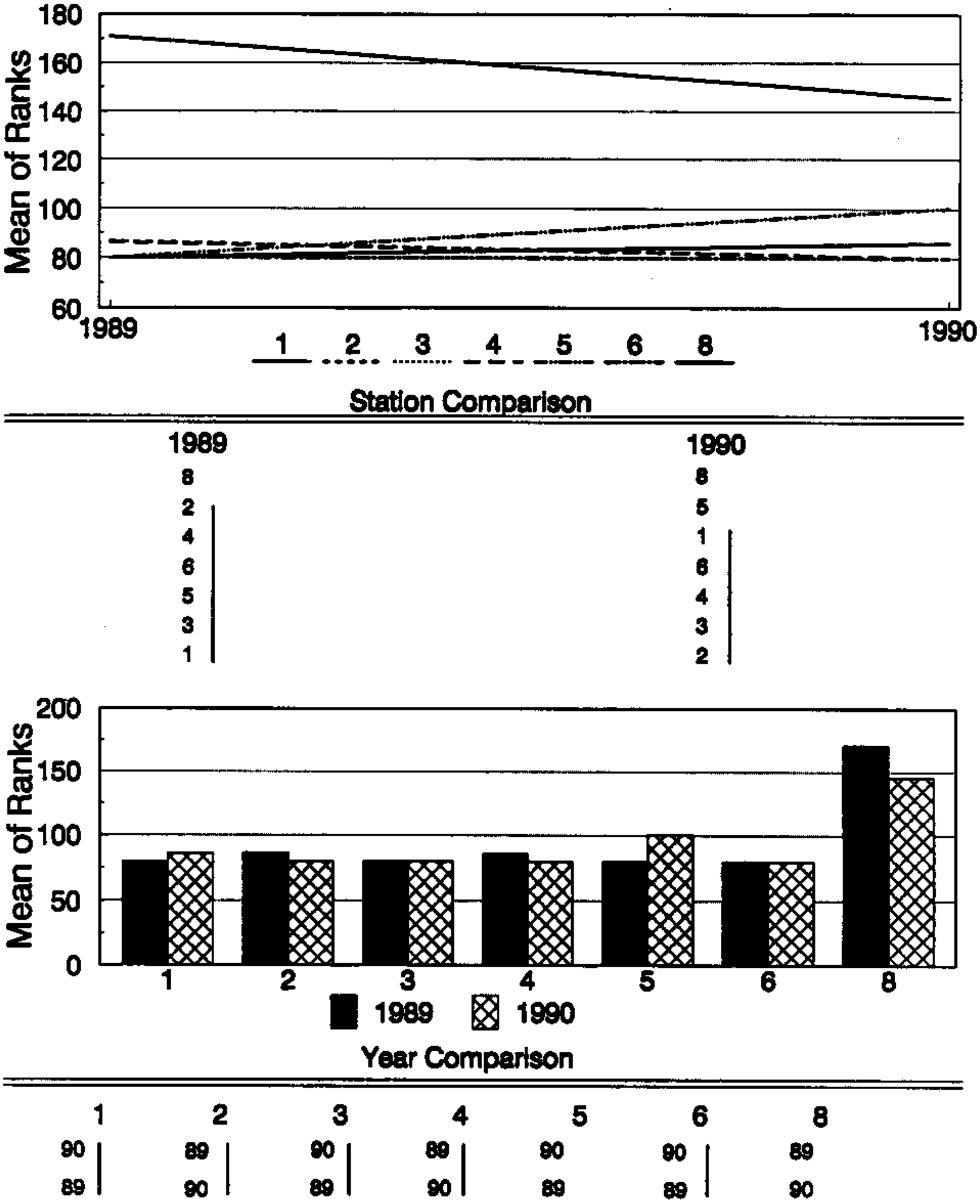
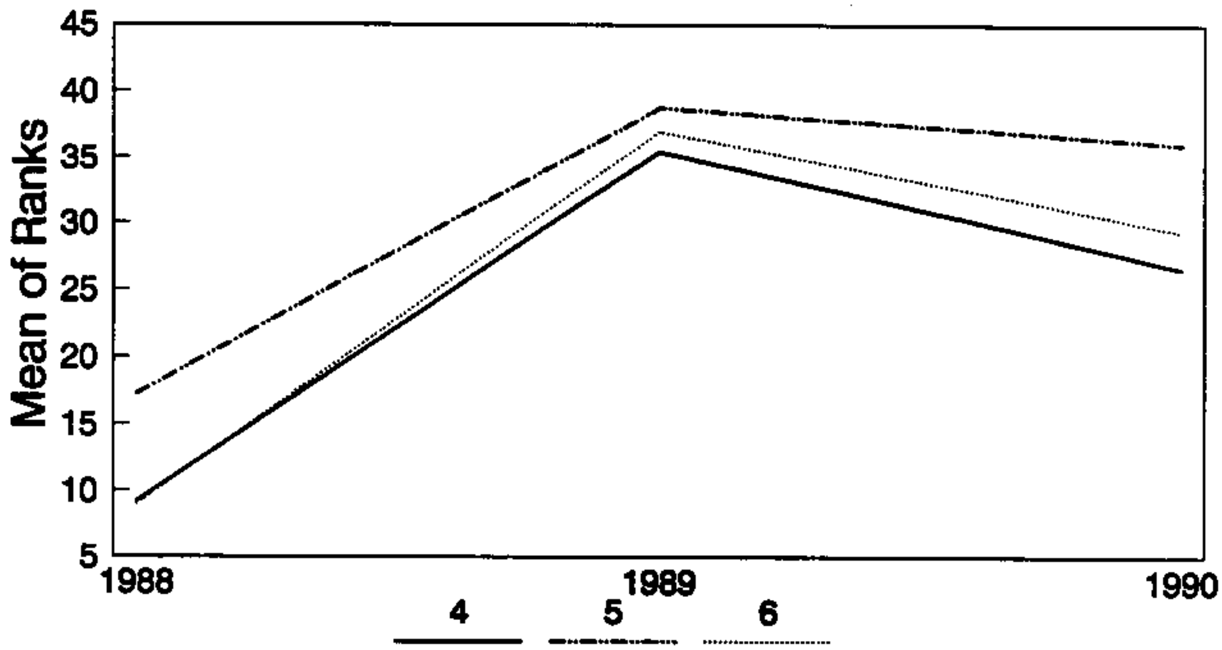
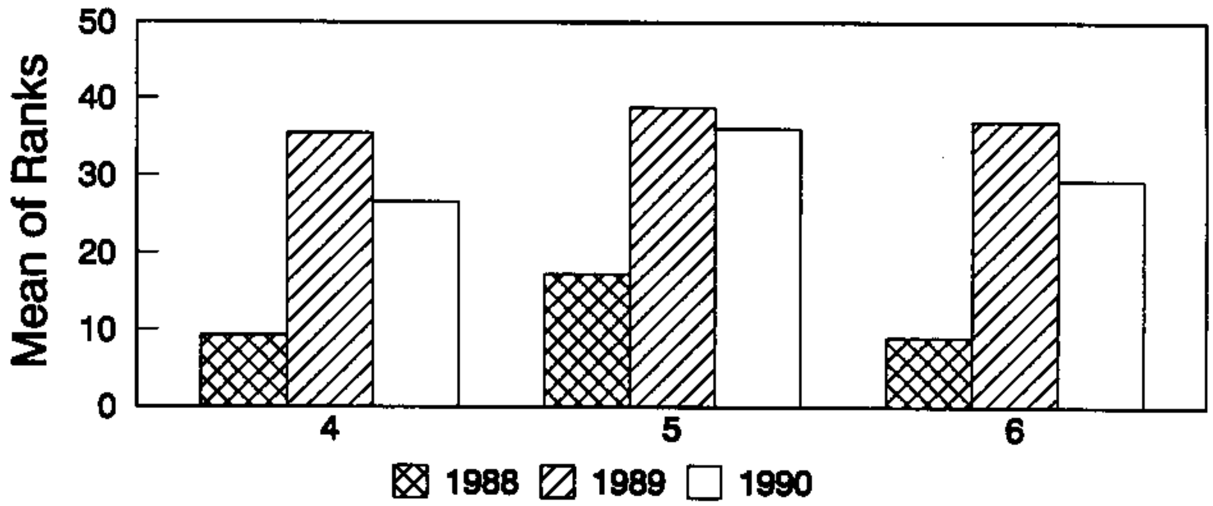


Figure 37. Graphical and statistical comparisons of the mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1989-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

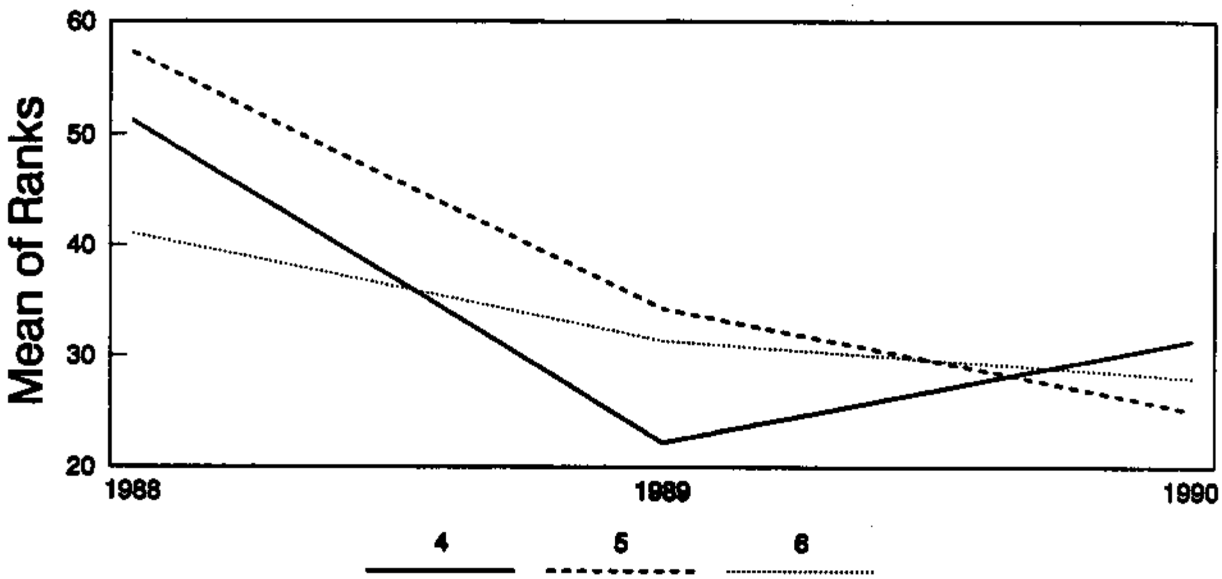
5
6
4



Year Comparison

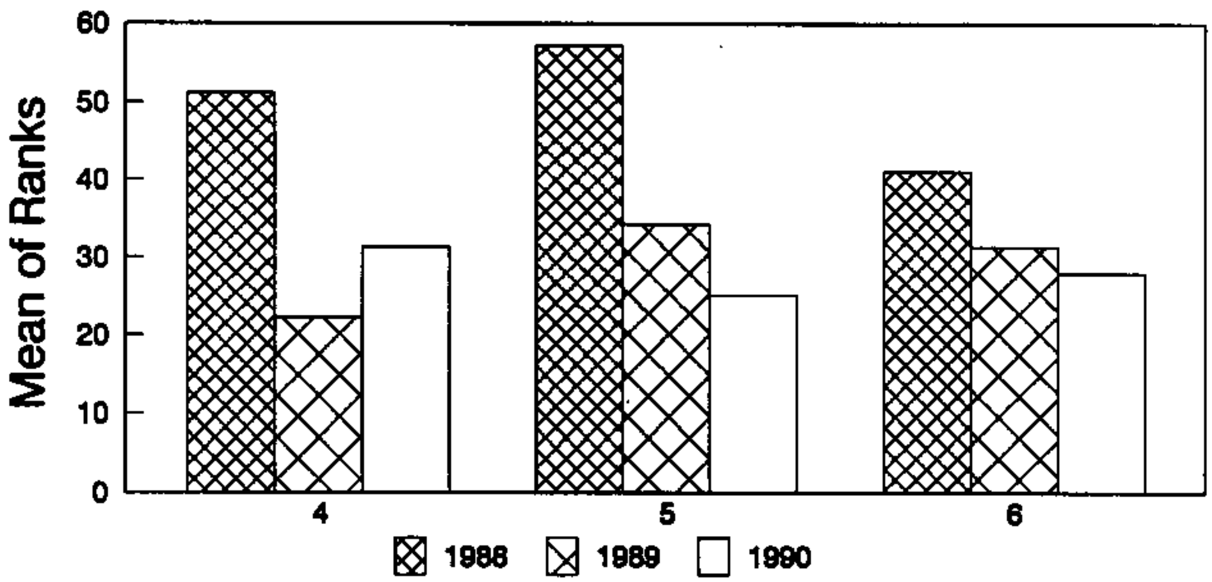
1989
1990
1988

Figure 38. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

5 |
6 |
4 |



Year Comparison

1988 |
1989 |
1990 |

Figure 39. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by surface trawling in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations and years indicated statistical nonsignificance (P > 0.05)

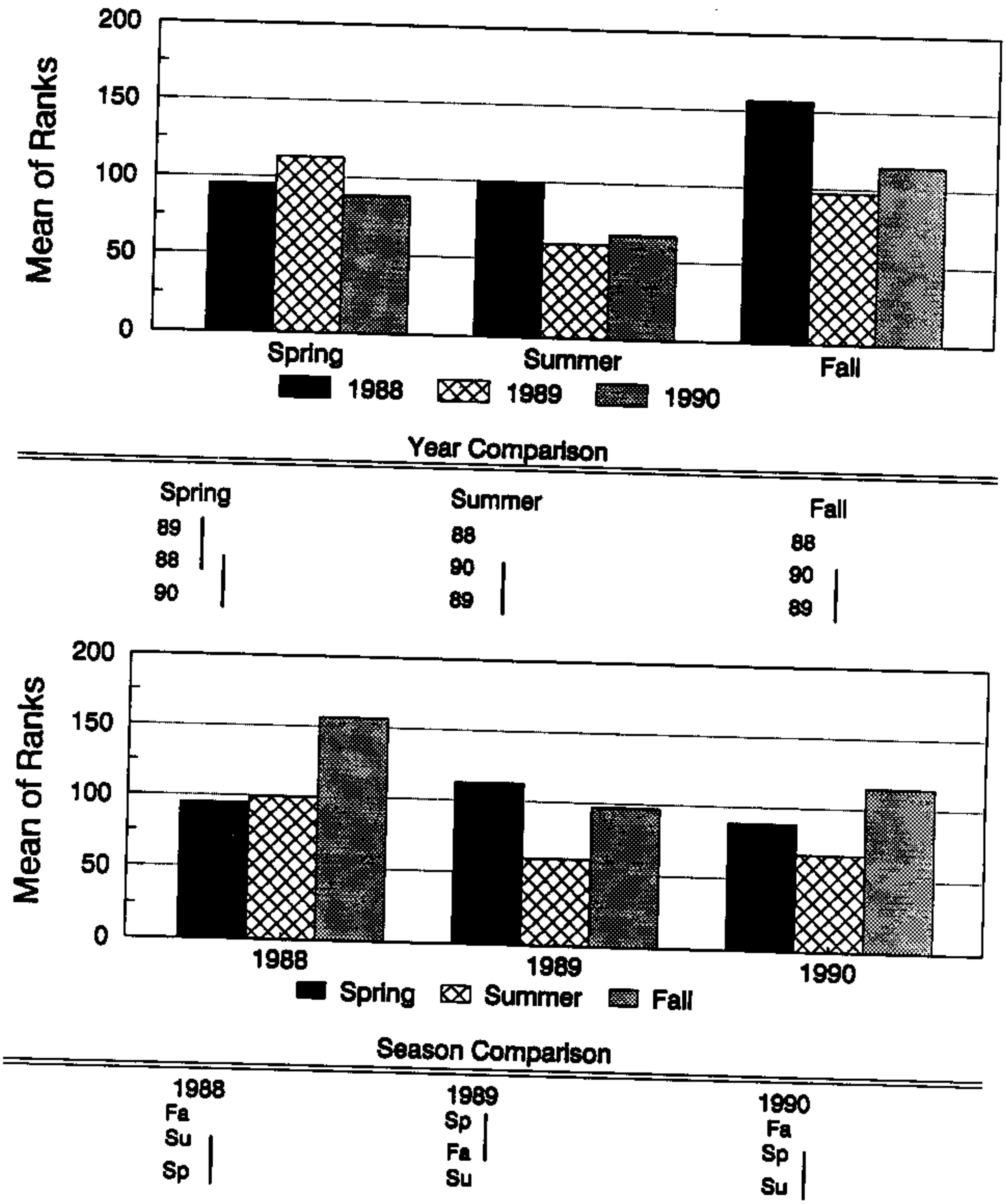
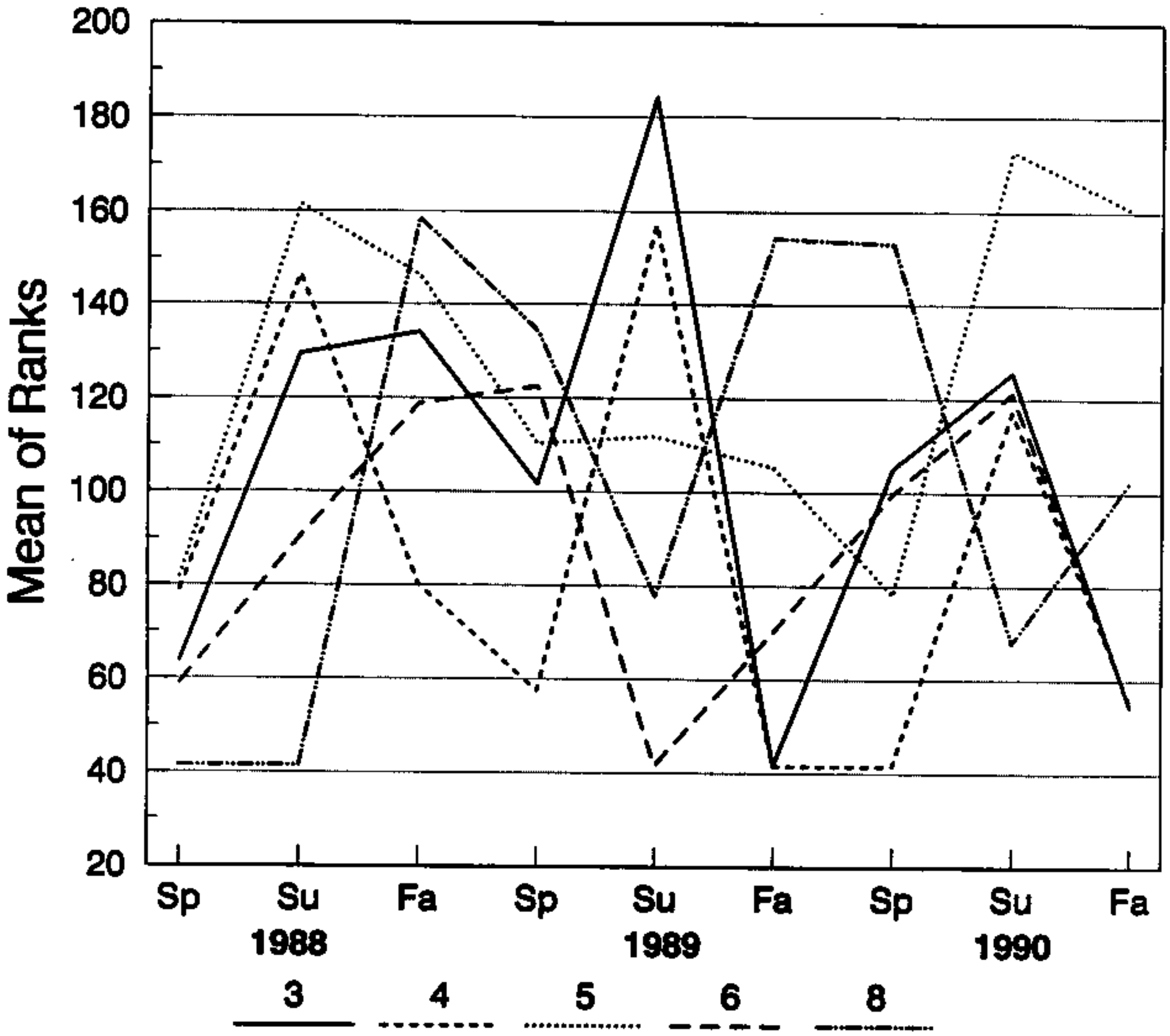


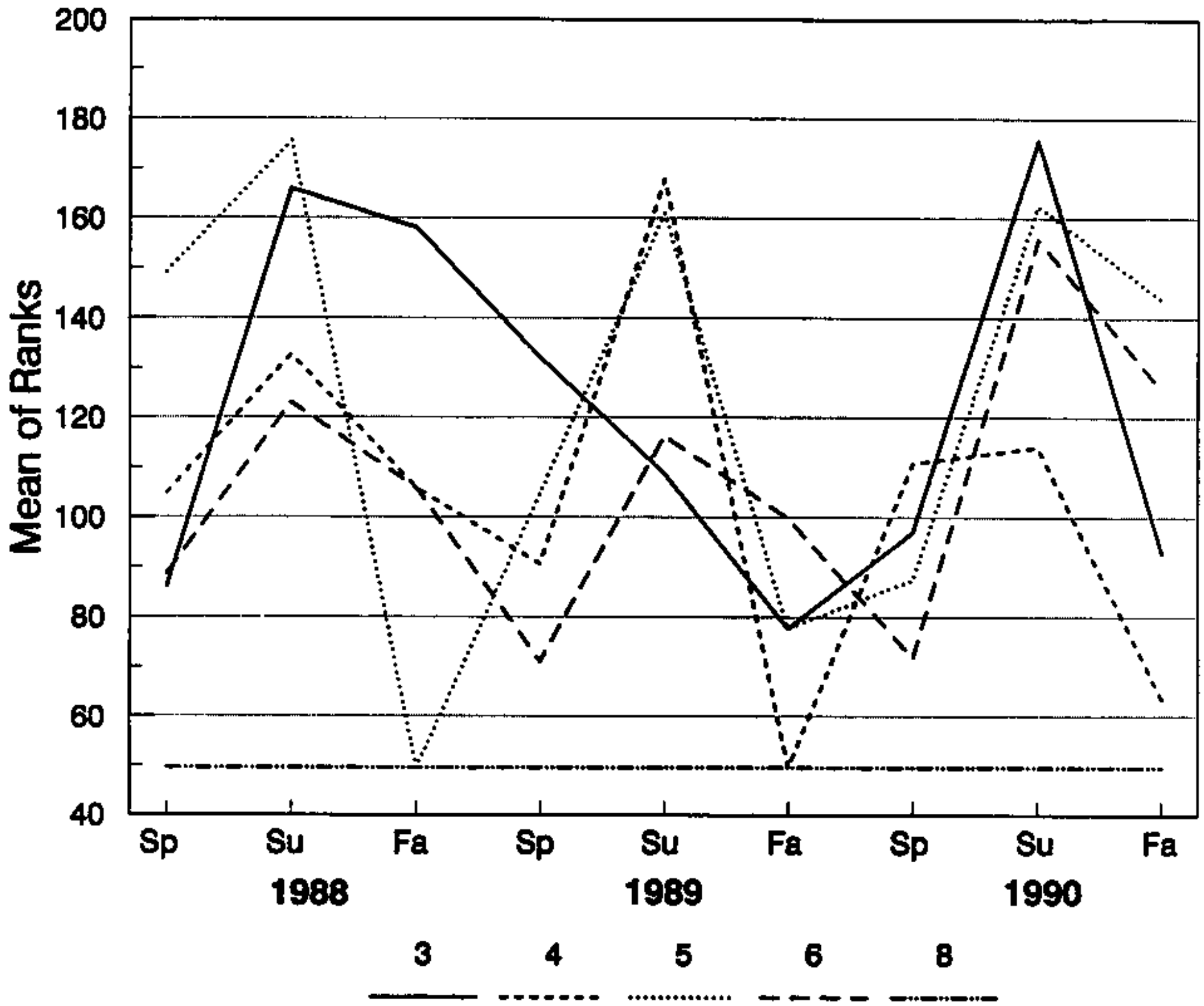
Figure 40. Graphical and statistical comparison of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside seasons and years indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

1988 Sp	1988 Su	1988 Fa	1989 Sp	1989 Su	1989 Fa	1990 Sp	1990 Su	1990 Fa
5	5	8	8	3	8	8	5	5
4	4	5	6	4	5	3	3	8
3	3	3	5	5	6	6	6	4
6	6	6	3	8	4	5	4	6
8	8	4	4	6	3	4	8	3

Figure 41. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).



Station Comparison

1988 Sp	1988 Su	1988 Fa	1989 Sp	1989 Su	1989 Fa	1990 Sp	1990 Su	1990 Fa
5	5	3	3	4	6	4	3	5
4	3	6	5	5	5	3	5	6
6	4	4	4	6	3	5	6	3
3	6	8	6	3	8	6	4	4
8	8	5	8	8	4	8	8	8

Figure 42. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside stations indicate statistical nonsignificance (P > 0.05).

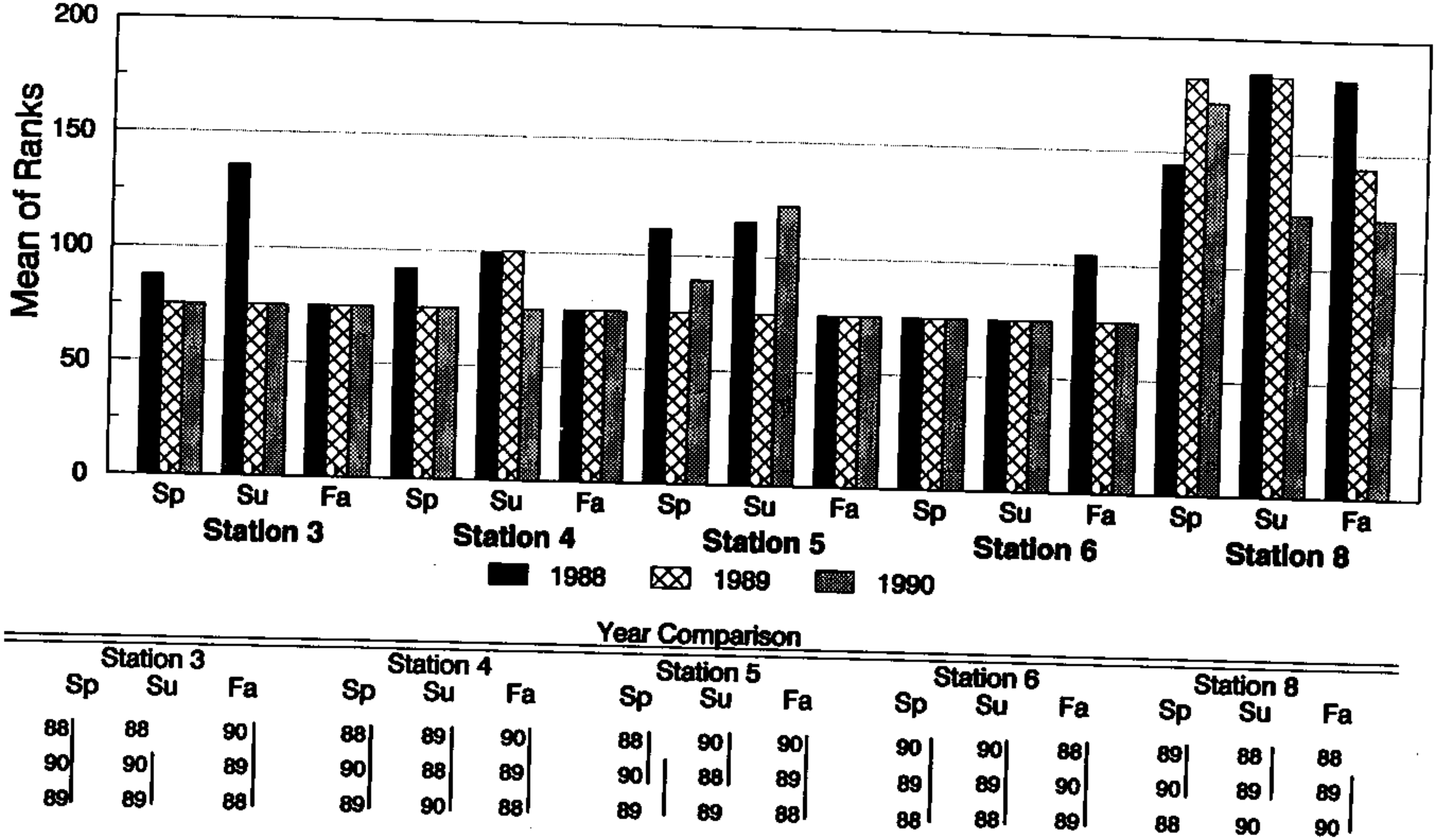


Figure 43. Graphical and statistical comparison of the mean of ranks of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1988-1990. Vertical lines beside years indicate statistical nonsignificance (P > 0.05).

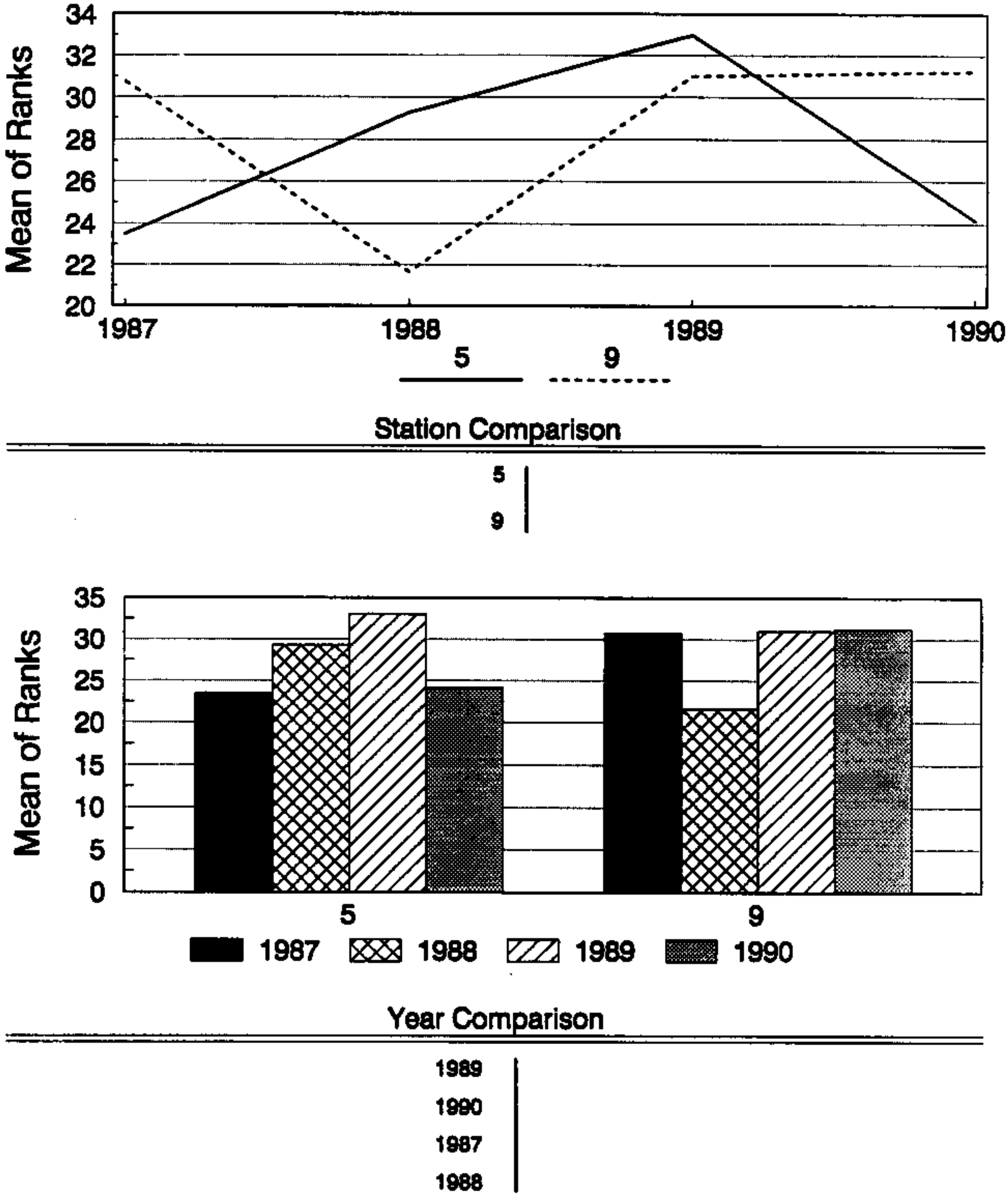
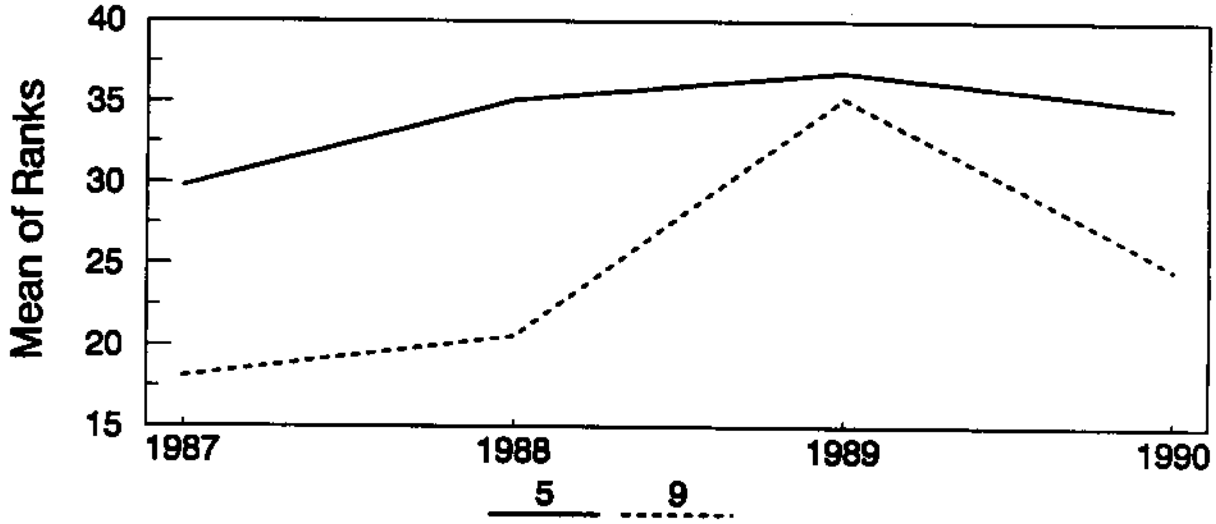
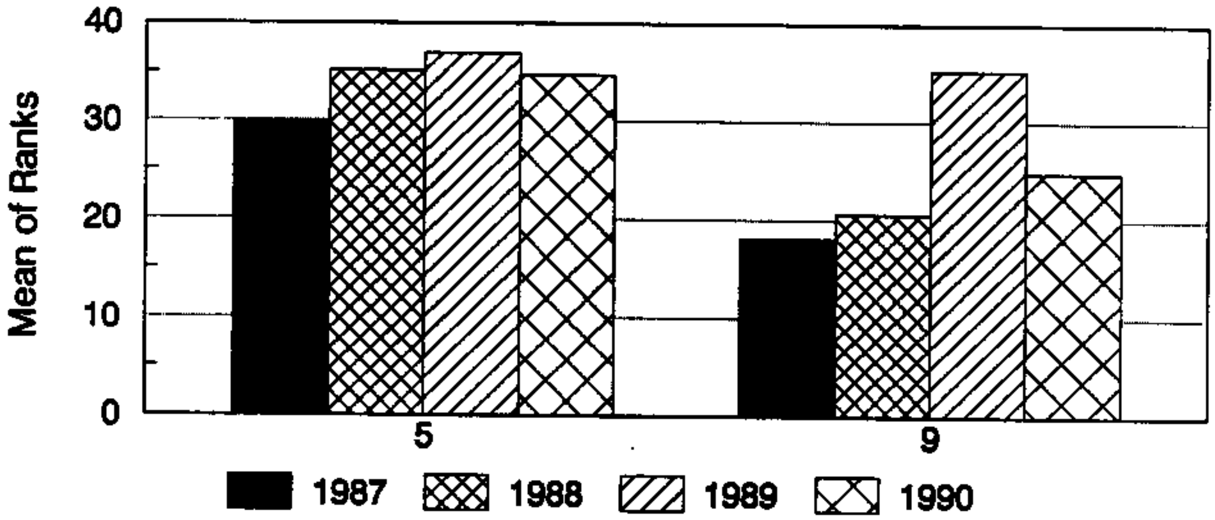


Figure 44. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

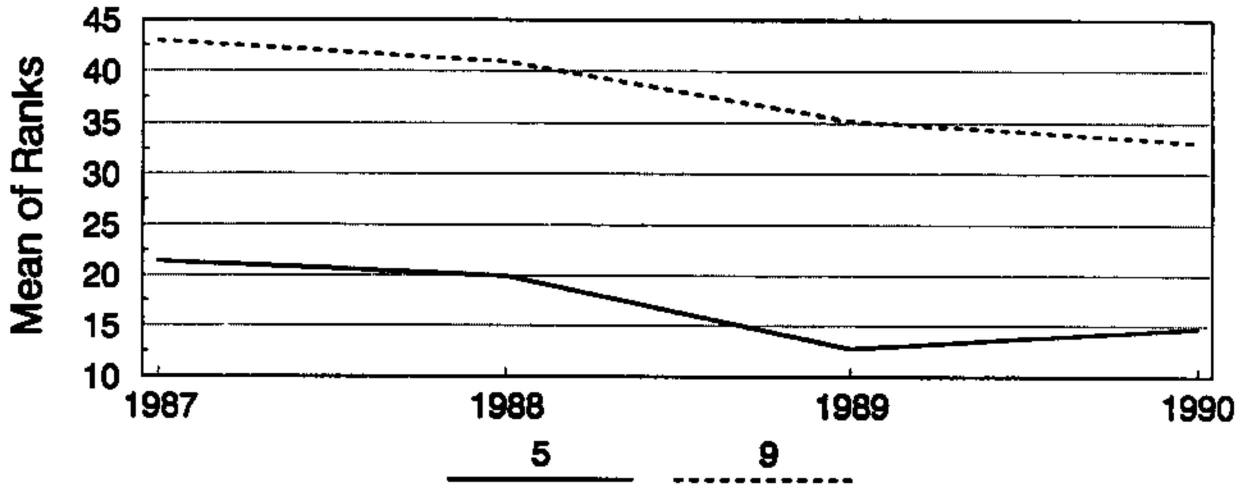
5
9



Year Comparison

1989
1990
1988
1987

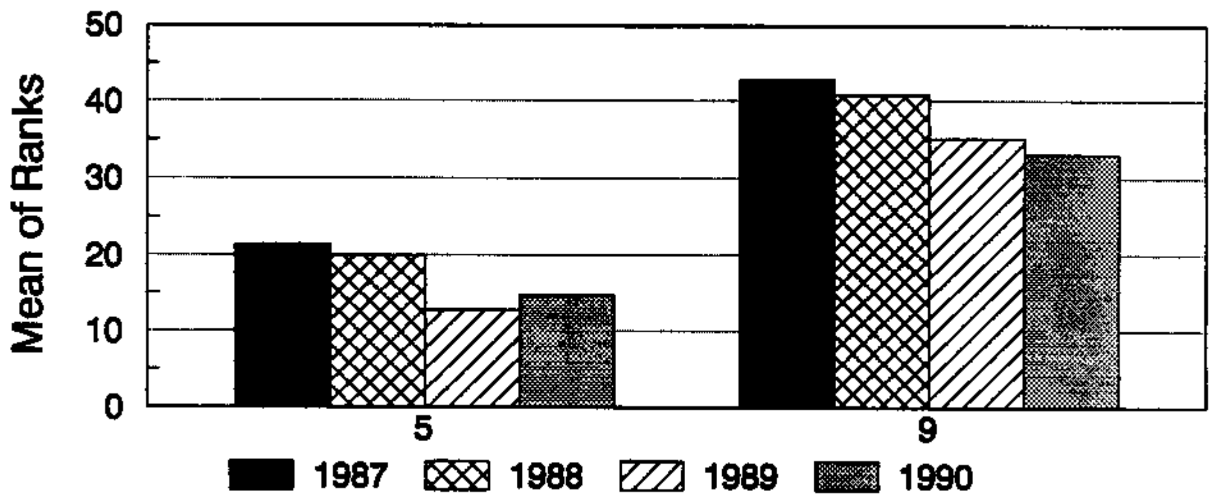
Figure 45. Graphical and statistical comparisons of the mean of ranks of juvenile chinook salmon abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside years indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

9

5



Year Comparison

1987
1988
1989
1990

Figure 46. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. The vertical line beside years indicates statistical nonsignificance ($P > 0.05$).

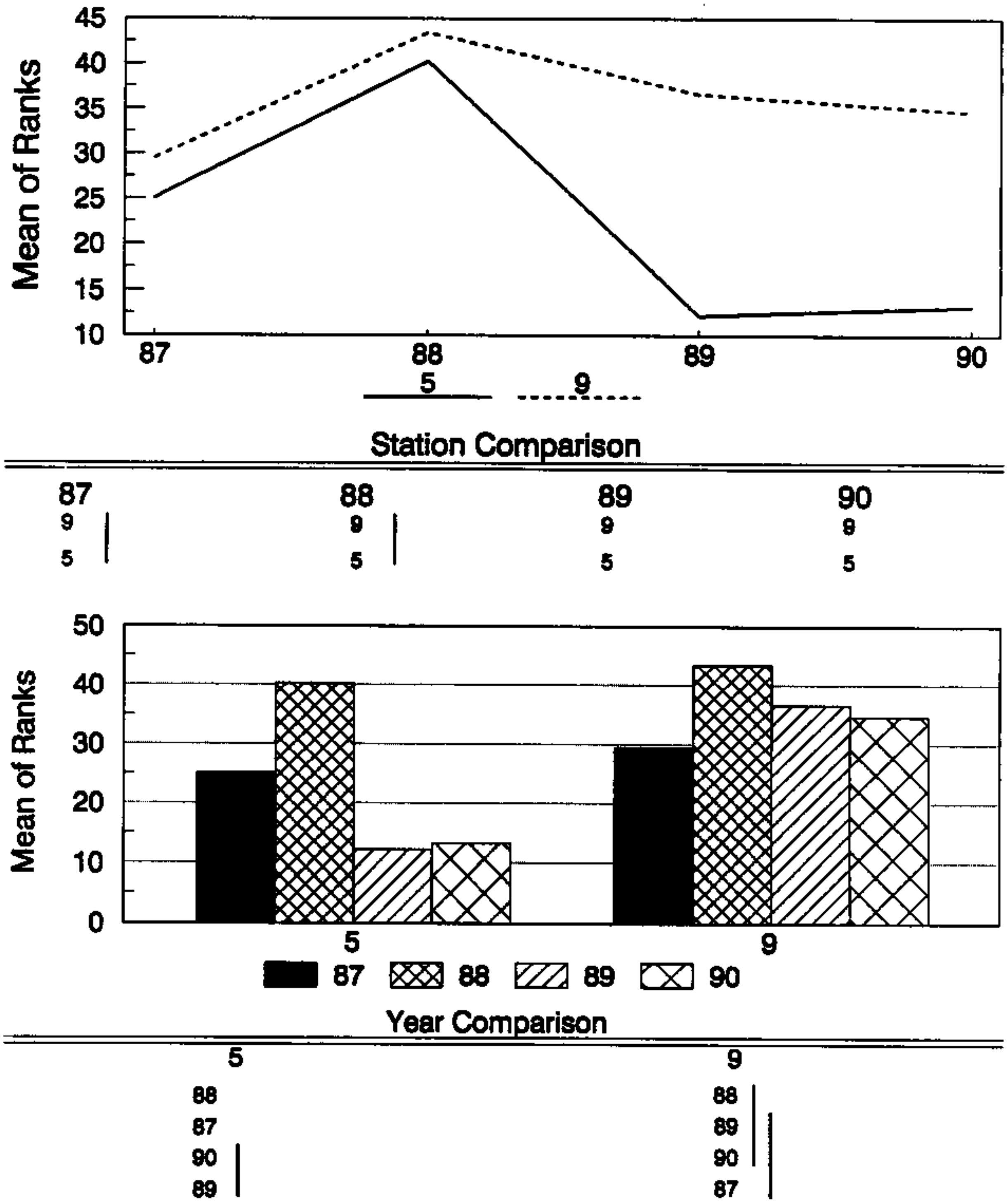
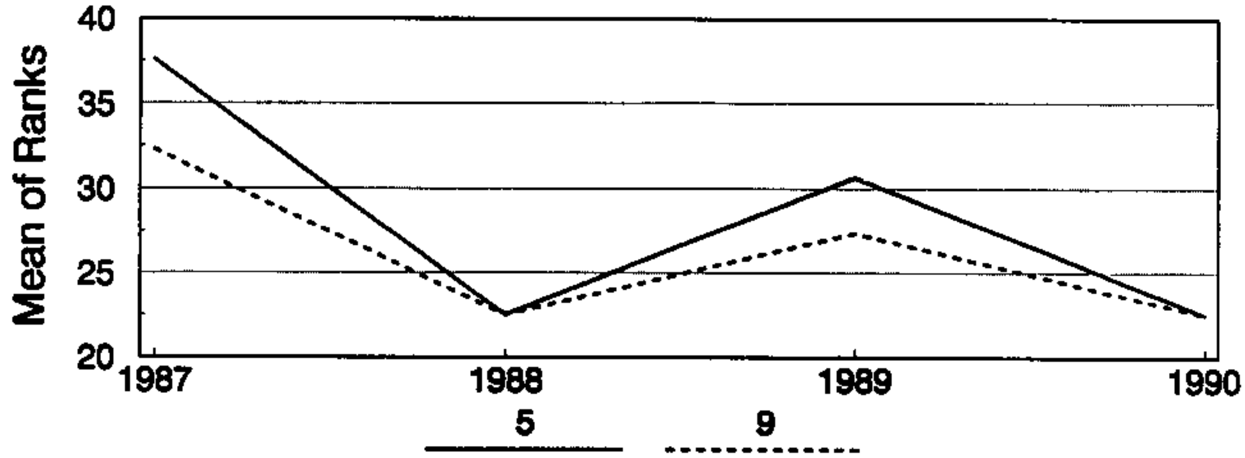
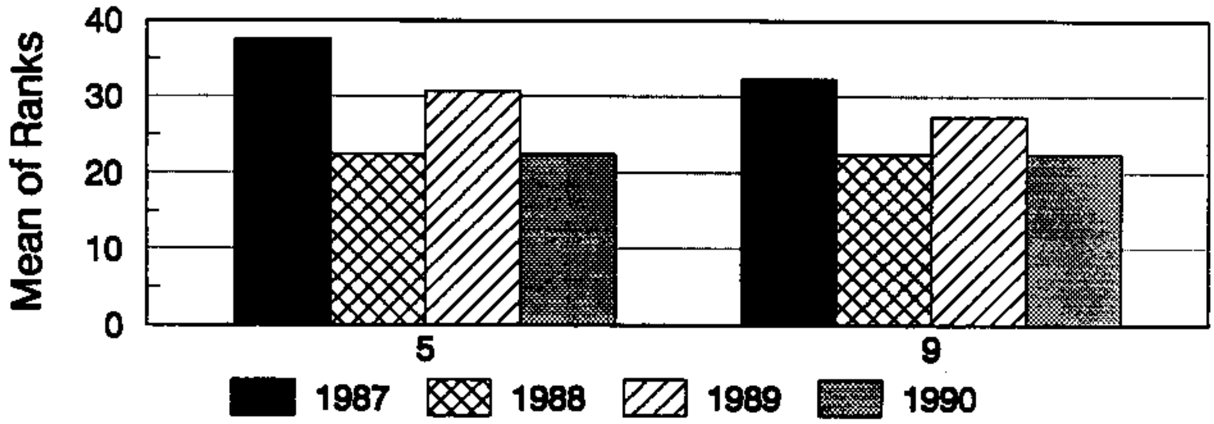


Figure 47. Graphical and statistical comparisons of the mean of ranks of juvenile steelhead abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

5 |
9 |

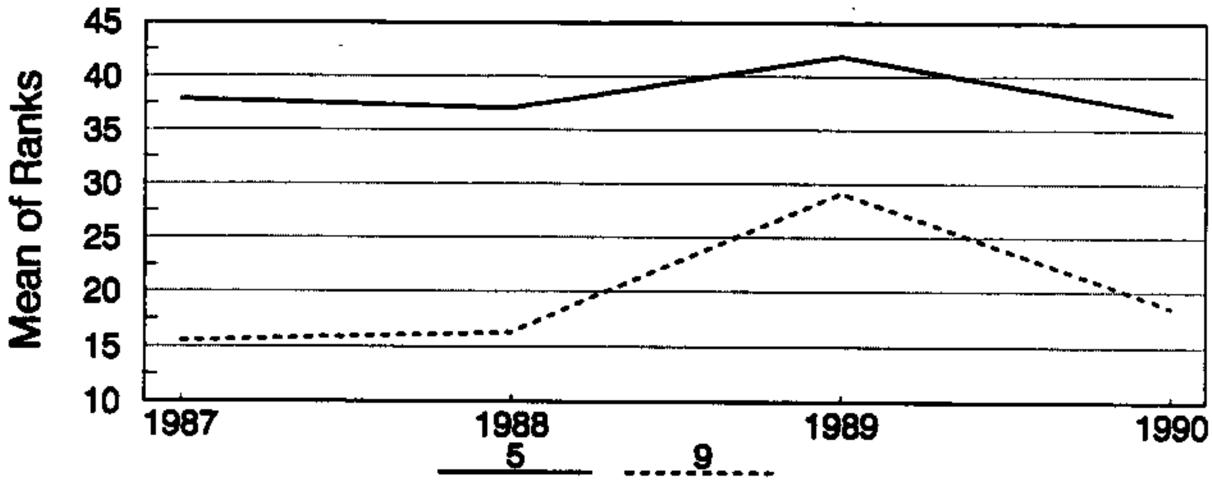


Year Comparison

1987 |
1989 |

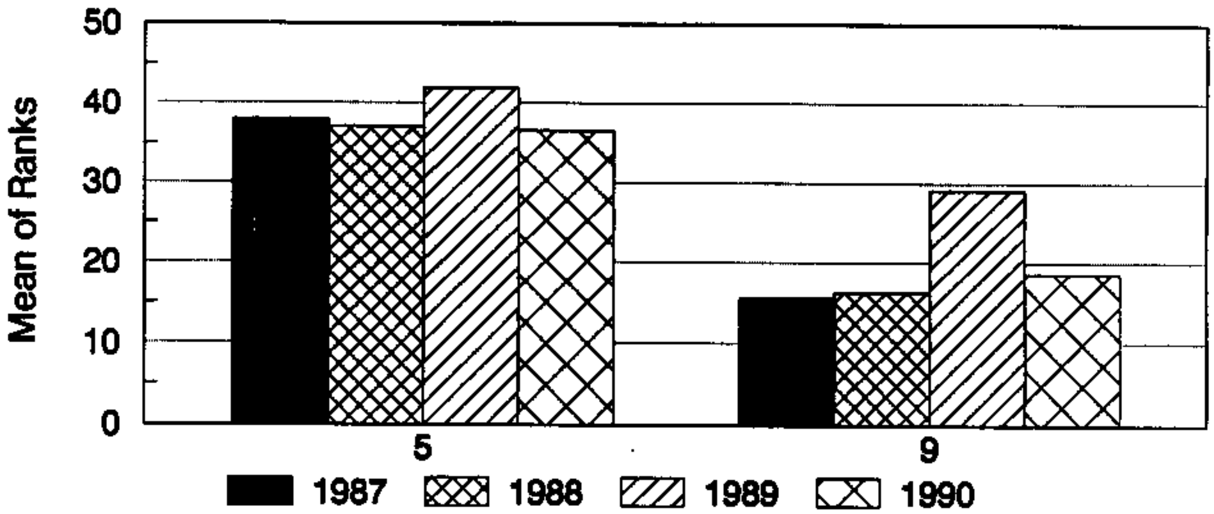
1988 |
1990 |

Figure 48. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

5
9



Year Comparison

89 |
90 |
88 |
87 |

Figure 49. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. The vertical line beside years indicates statistical nonsignificance ($P > 0.05$).

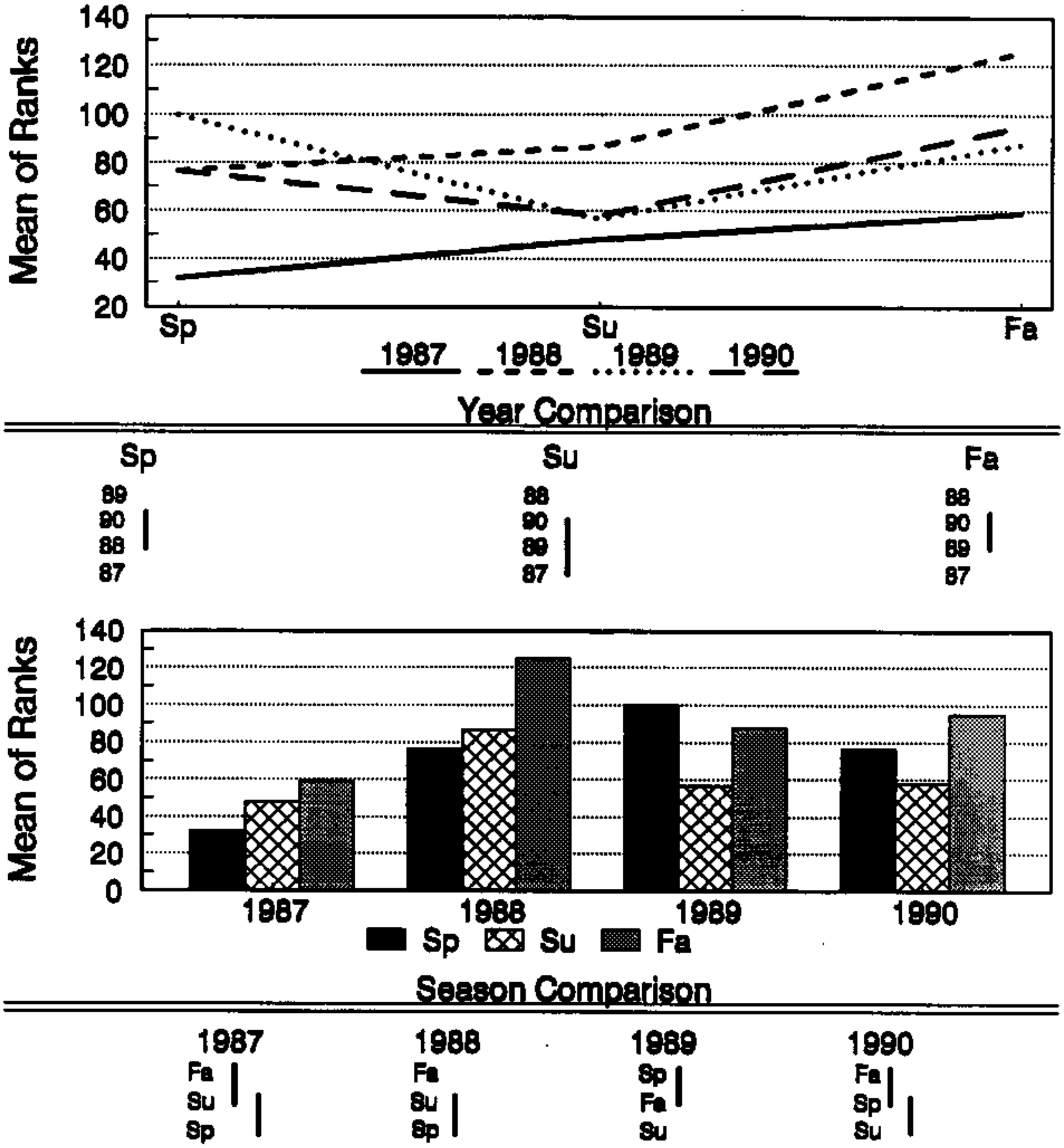


Figure 50. Graphical and statistical comparisons of the mean of ranks of northern squawfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).

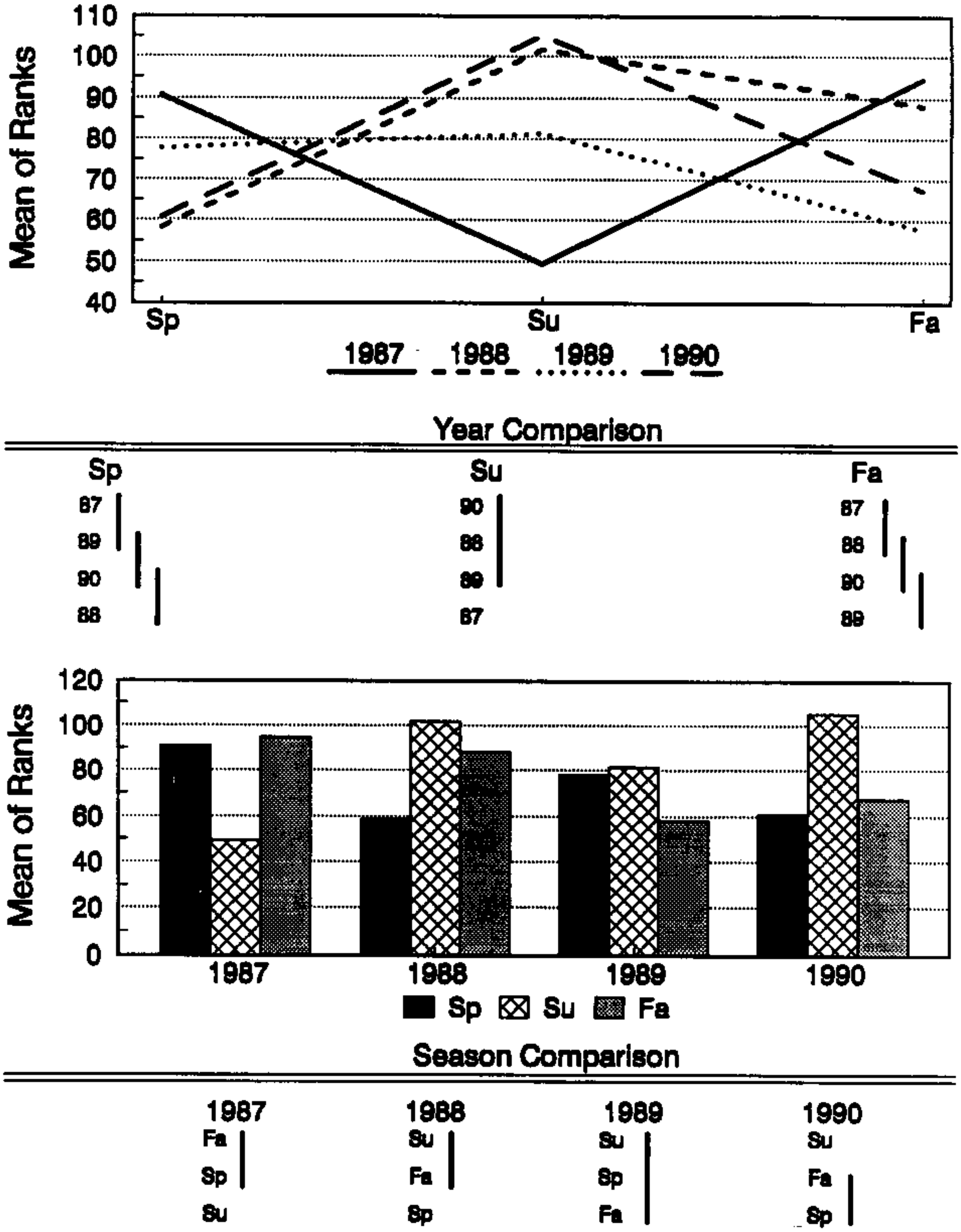


Figure 51. Graphical and statistical comparisons of the mean of ranks of channel catfish abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).

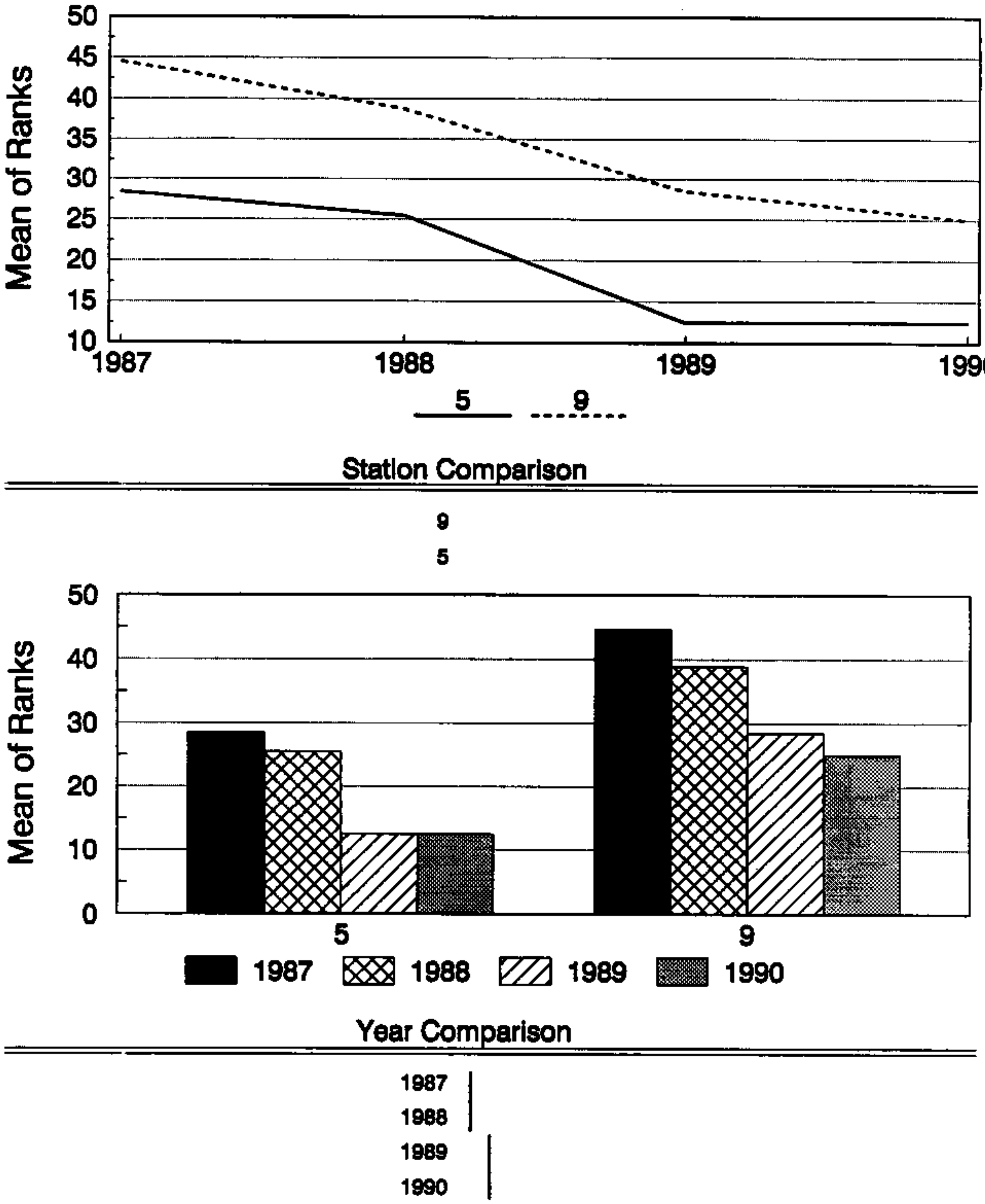
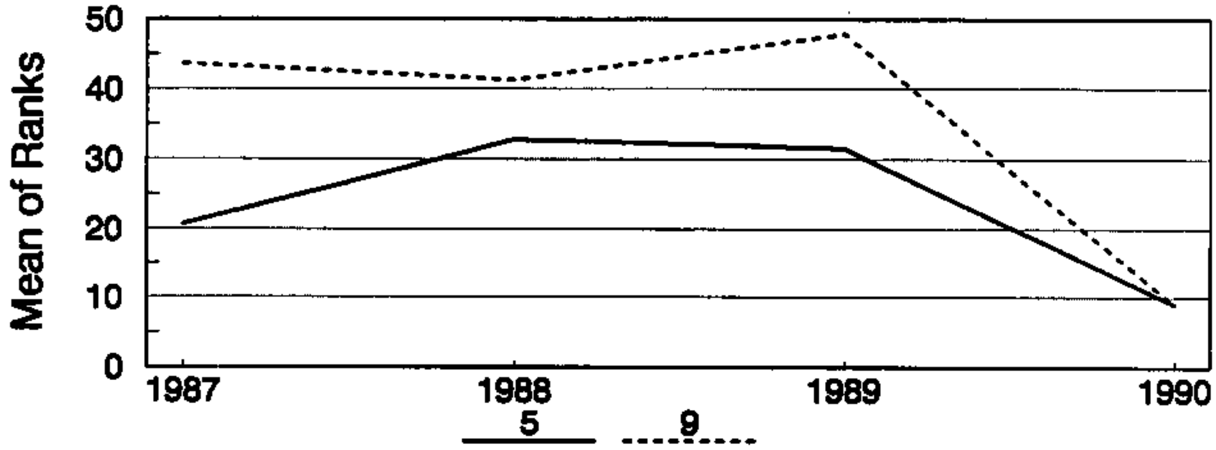
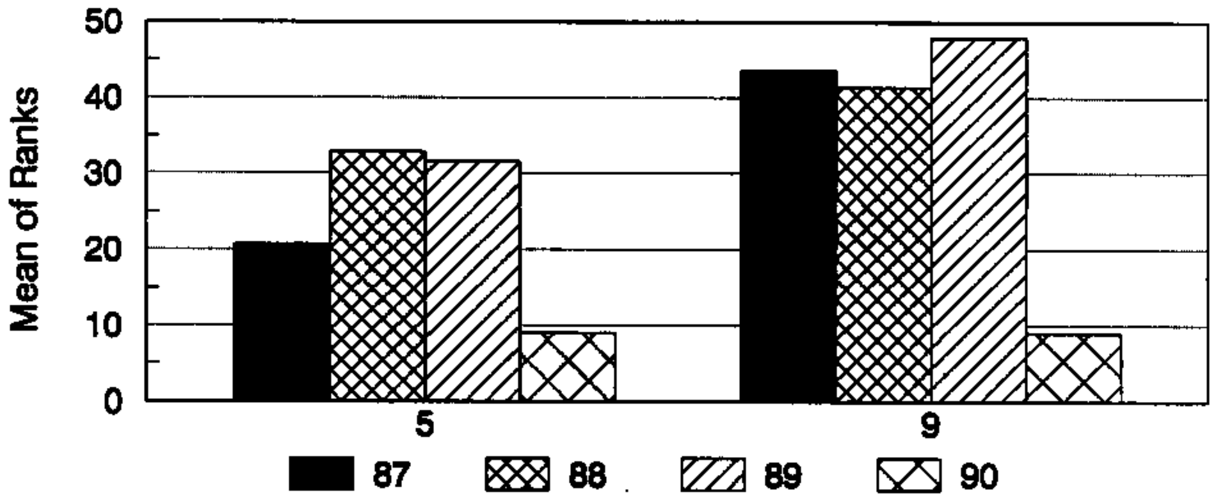


Figure 52. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by beach seining in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside years indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

1987	1988	1989	1990
9	9	9	9
5	5	5	5



Year Comparison

5	9
88	89
89	87
87	88
90	90

Figure 53. Graphical and statistical comparisons of the mean of ranks of smallmouth bass abundance sampled by nighttime electrofishing in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and years indicate statistical nonsignificance (P > 0.05).

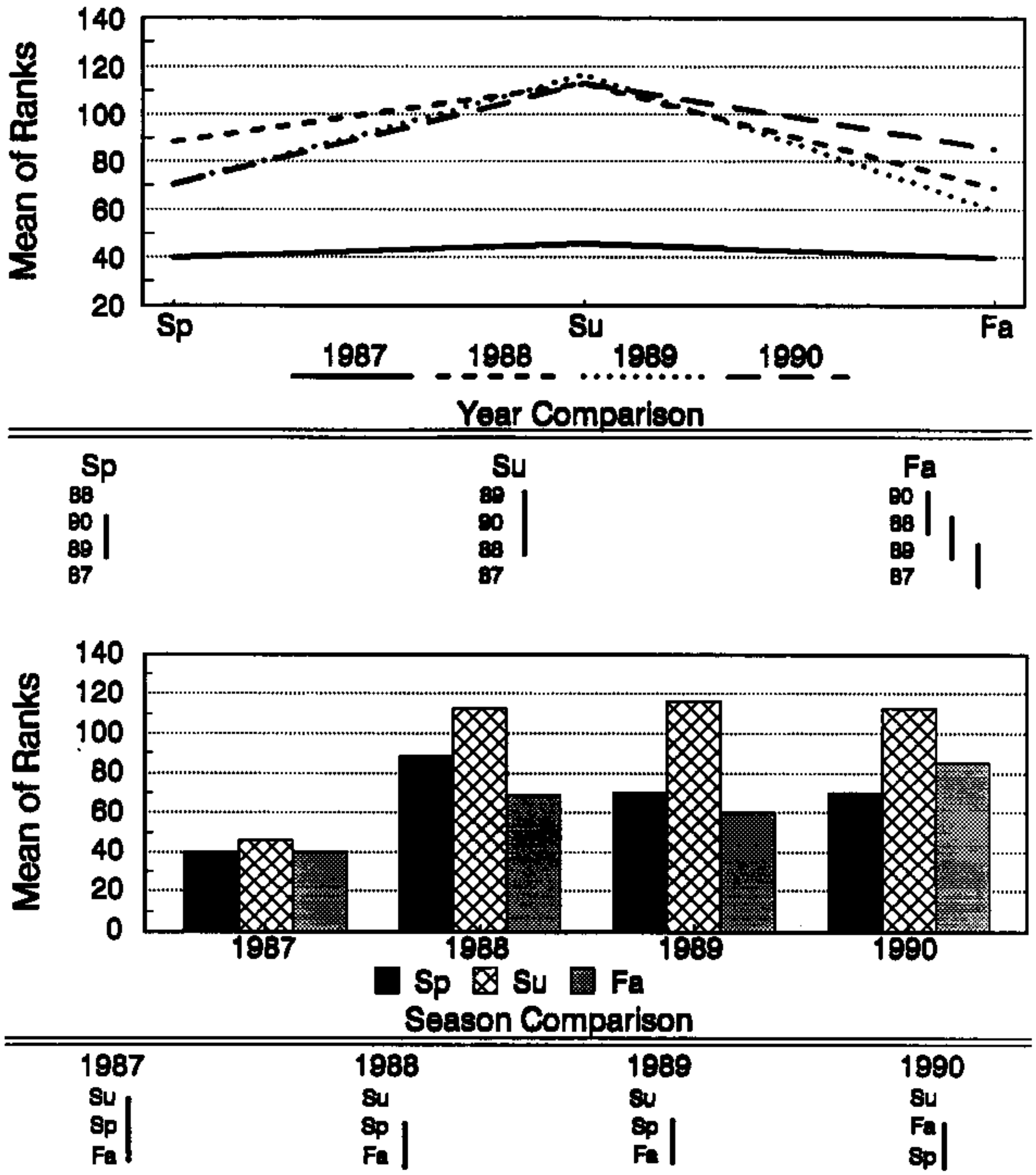
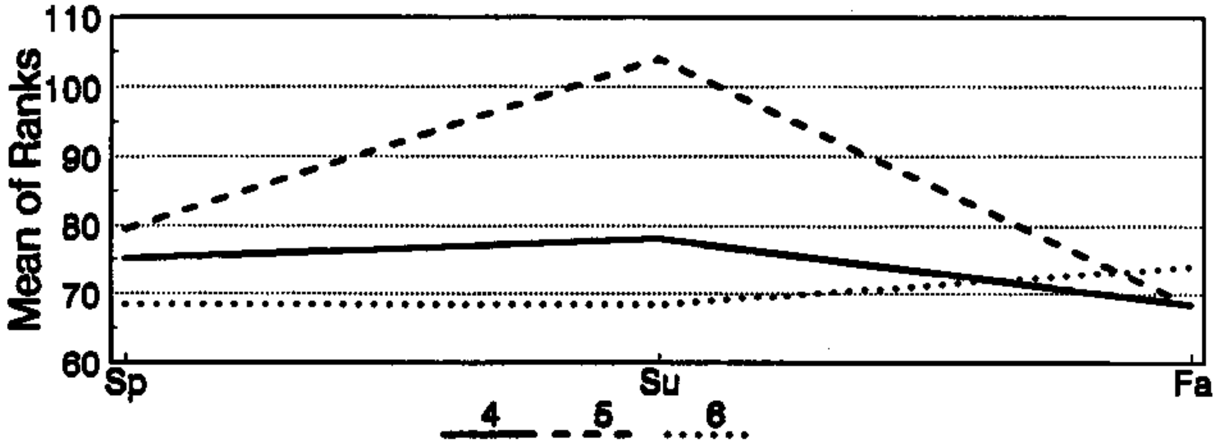
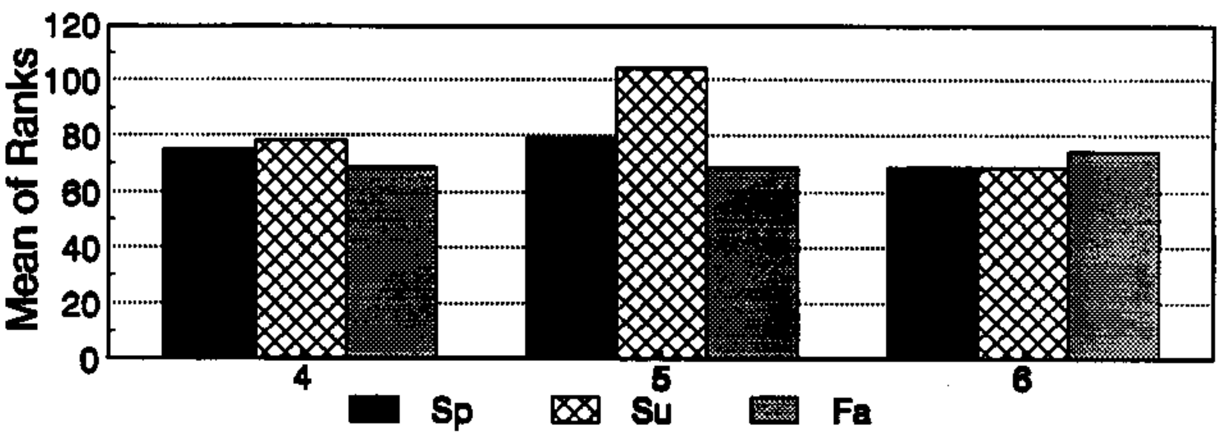


Figure 54. Graphical and statistical comparisons of mean of ranks of smallmouth bass abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside seasons and years indicate statistical nonsignificance (P > 0.05).



Station Comparison

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



Season Comparison

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

Figure 55. Graphical and statistical comparisons of mean of ranks of of white sturgeon abundance sampled by gill netting in Lower Granite Reservoir, Idaho-Washington during 1987-1990. Vertical lines beside stations and seasons indicate statistical nonsignificance (P > 0.05).

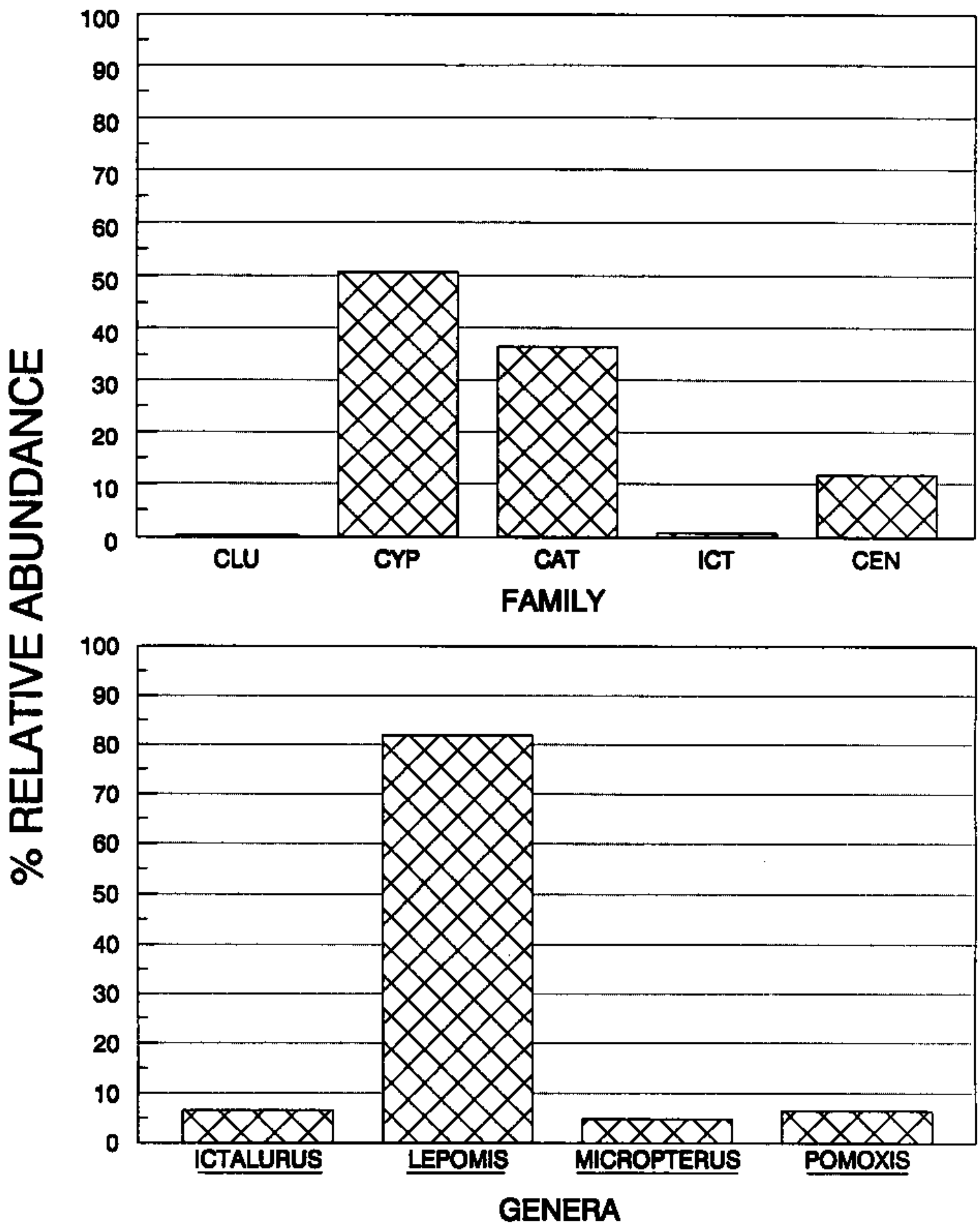


Figure 56. Relative abundance of larval fish (by family and genera of game fishes) captured by paired plankton nets in Lower Granite Reservoir, Idaho-Washington from mid-June through September 1990. Family abbreviations are: CLU - Clupeidae; CYP - Cyprinidae; CAT - Catostomidae; ICT - Ictaluridae; CEN - Centrarchidae.

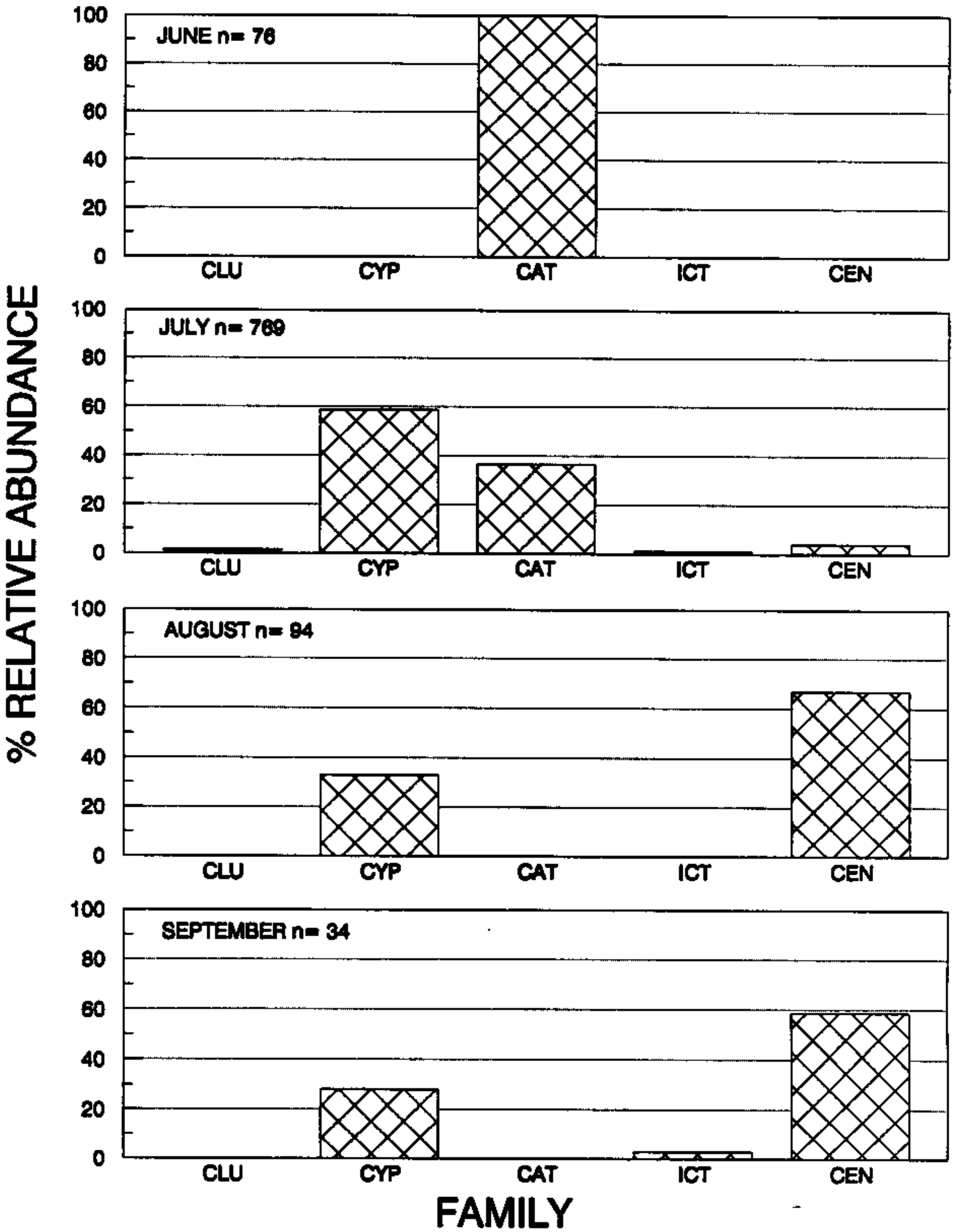


Figure 57. Relative abundance of larval fish captured by paired plankton nets in Lower Granite Reservoir, Idaho-Washington during mid-June through September 1990. Family abbreviations are: CLU - Clupeidae; CYP - Cyprinidae; CAT - Catostomidae; ICT - Ictaluridae; CEN - Centrarchidae.

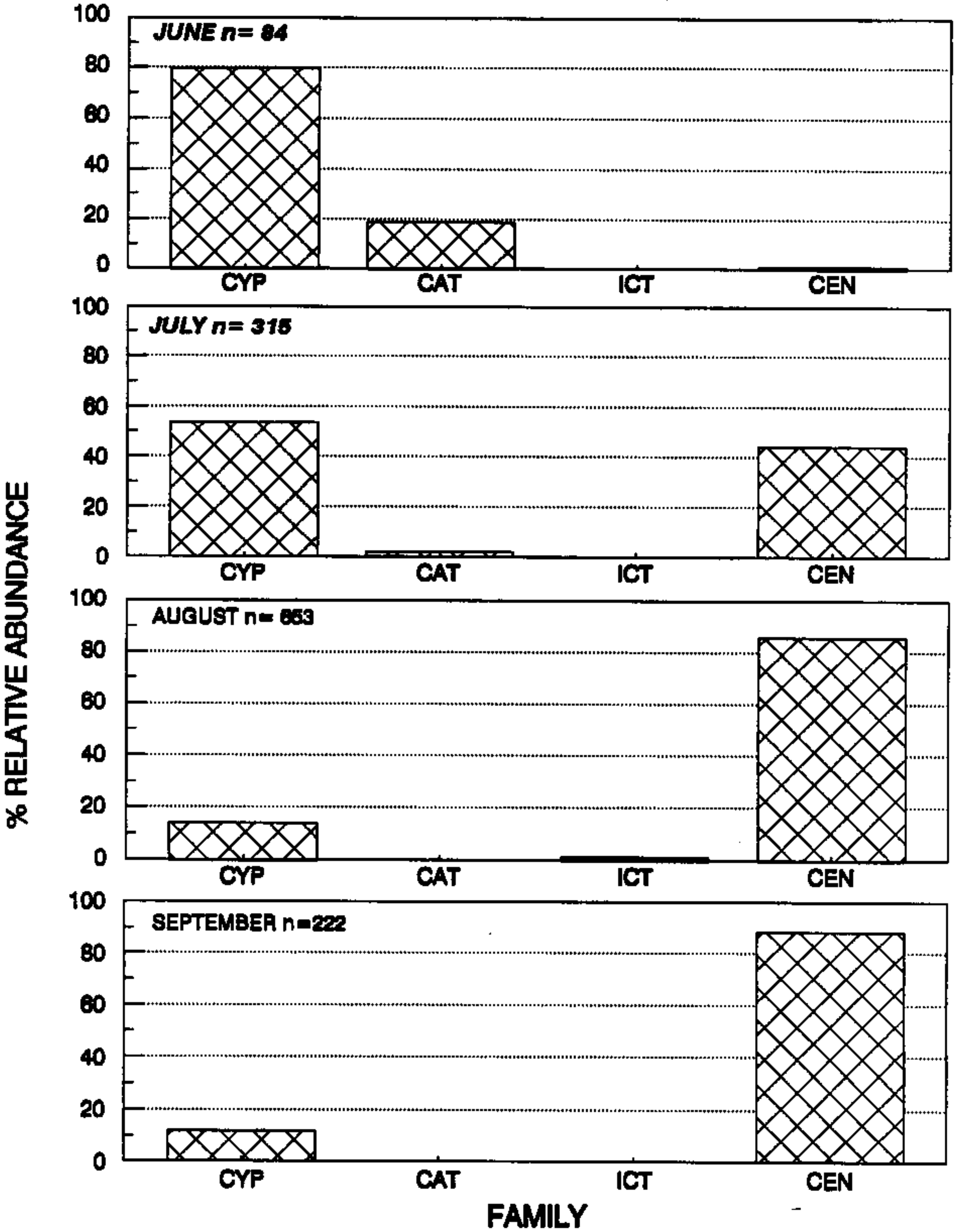


Figure 58. Relative abundance of larval fishes captured by beam trawl in Lower Granite Reservoir, Idaho-Washington, mid-June through September 1990. Family abbreviations are: CLU - Clupeidae; CYP - Cyprinidae; CAT - Catostomidae; ICT - Ictaluridae; CEN - Centrarchidae.

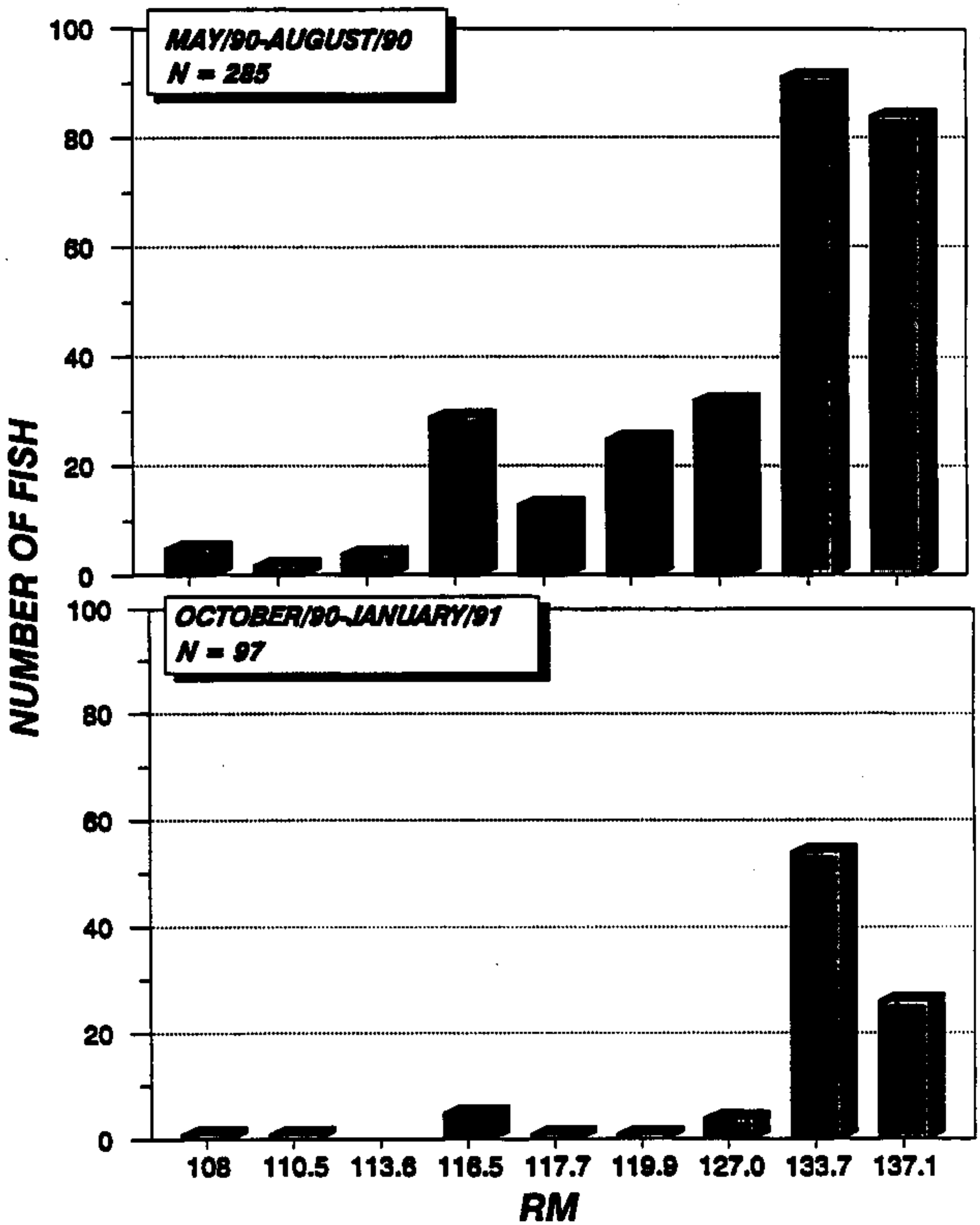


Figure 59. Number of white sturgeon sampled during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling periods in Lower Granite Reservoir, Idaho-Washington.

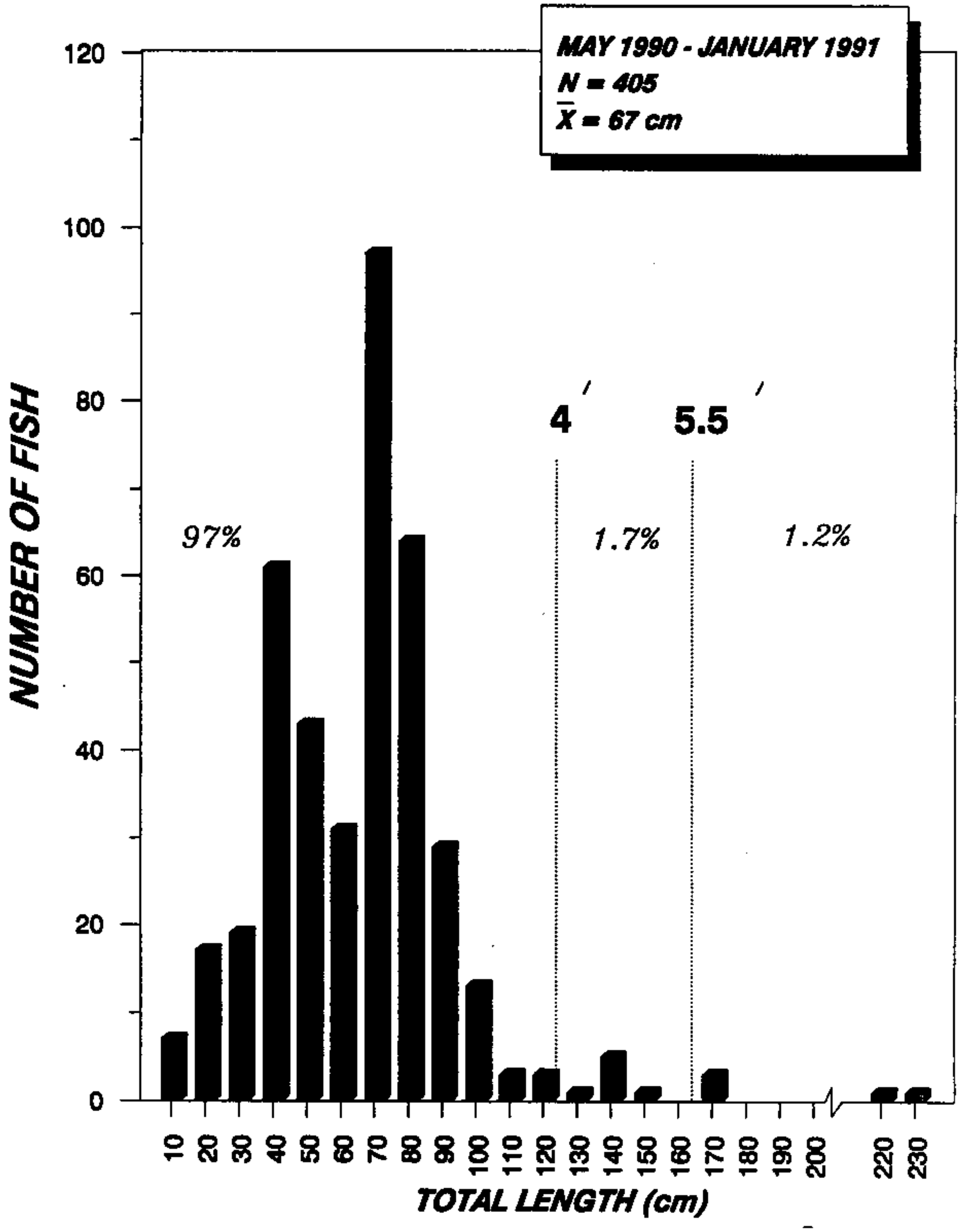


Figure 60. Size distributions of white sturgeon sampled during spring-summer (April through July) and fall-winter (October through January) 1990-1992 in Lower Granite Reservoir, Idaho-Washington.

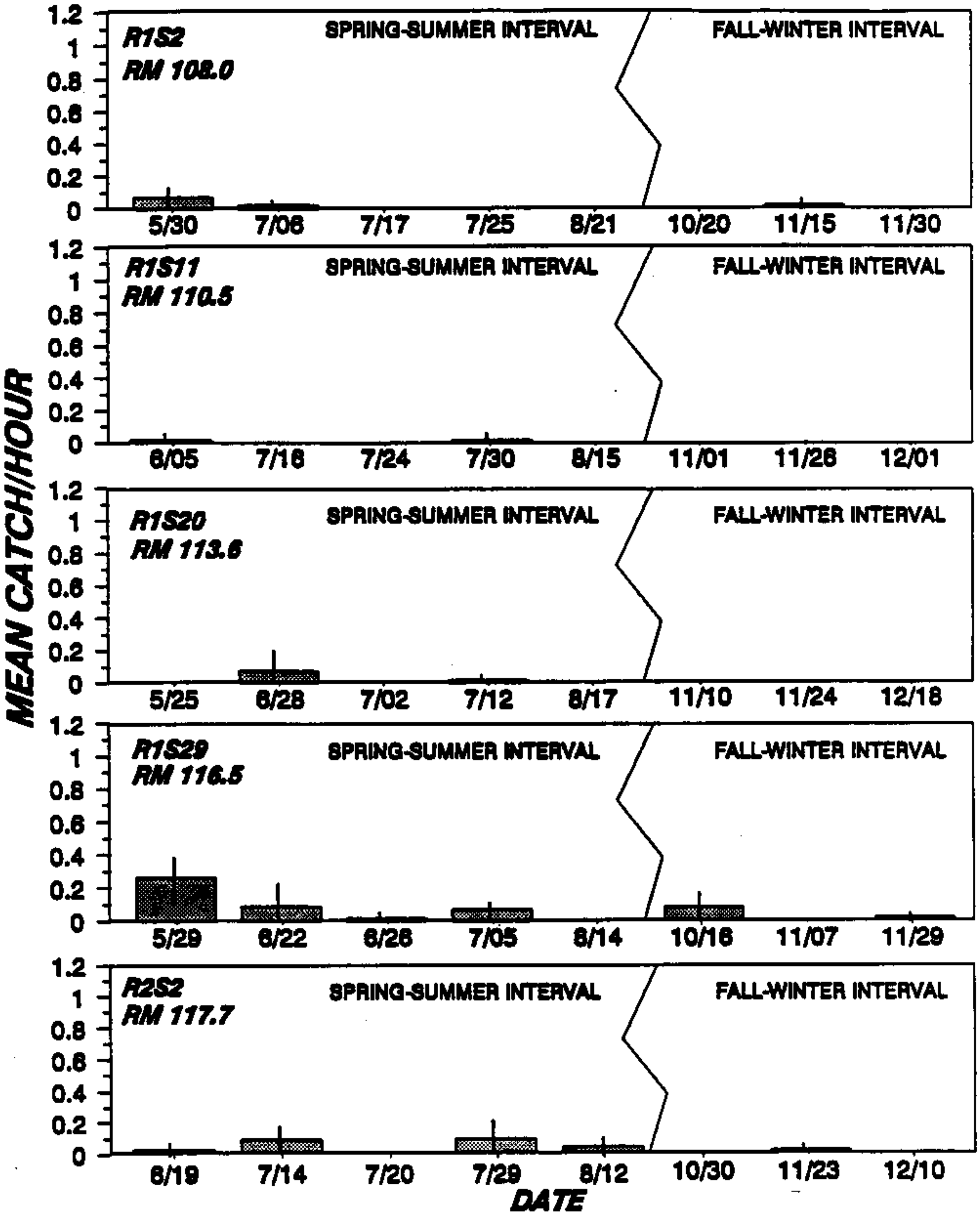


Figure 61. Mean catch rates and 95% confidence intervals for white sturgeon sampled by gill netting during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

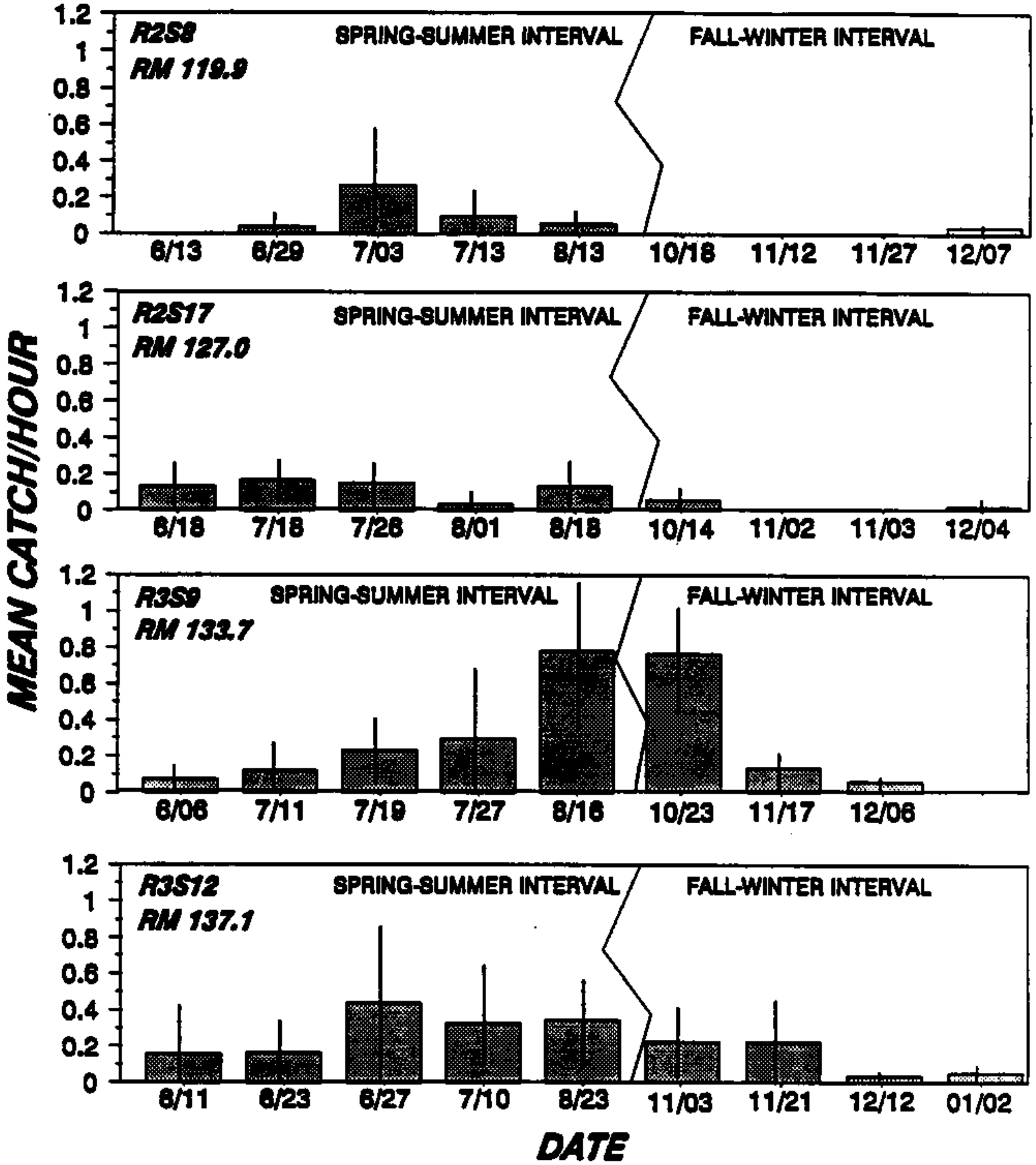


Figure 62. Mean catch rates and 95% confidence intervals for white sturgeon sampled by gill netting during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

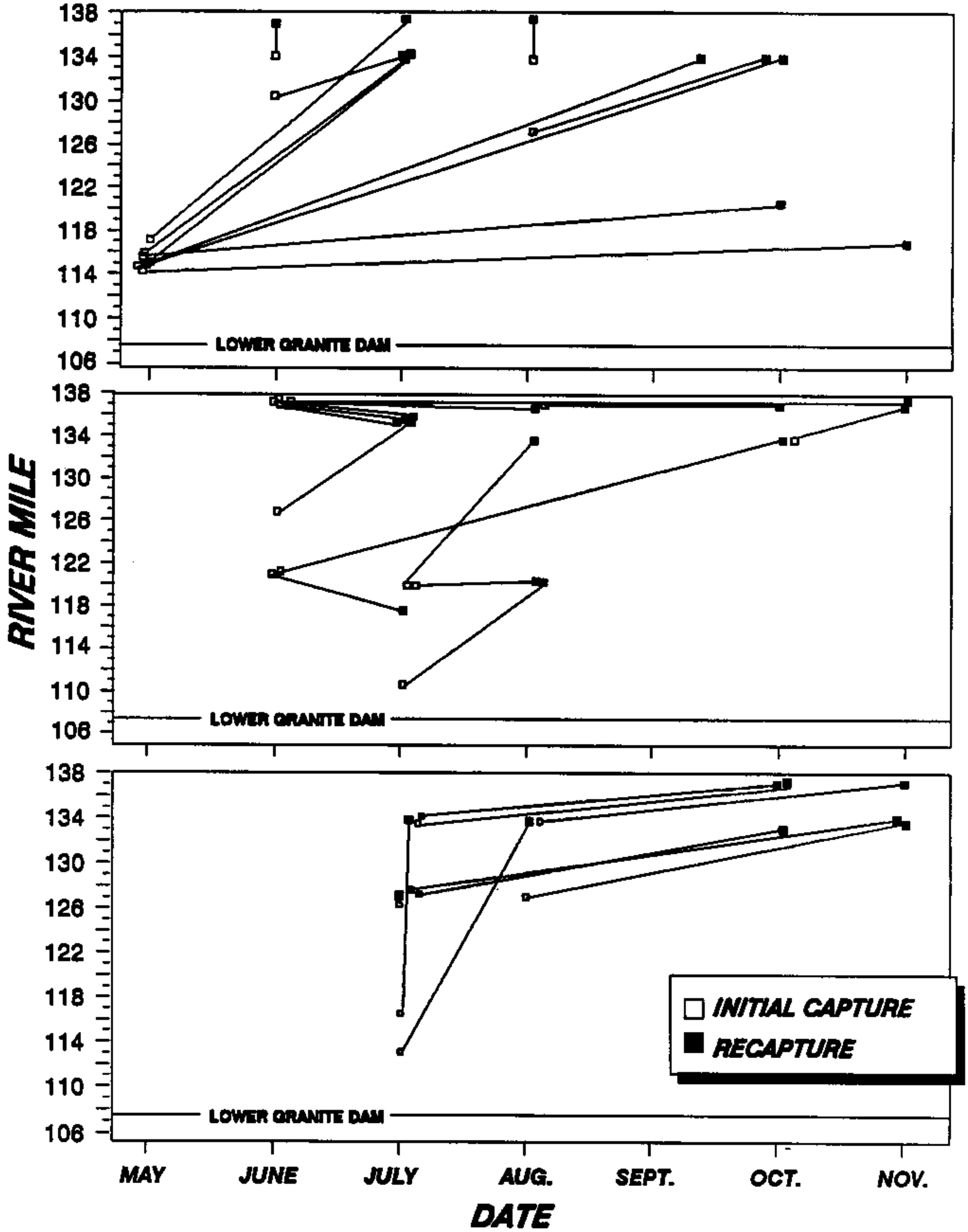


Figure 63. Net movement of recaptured white sturgeon during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

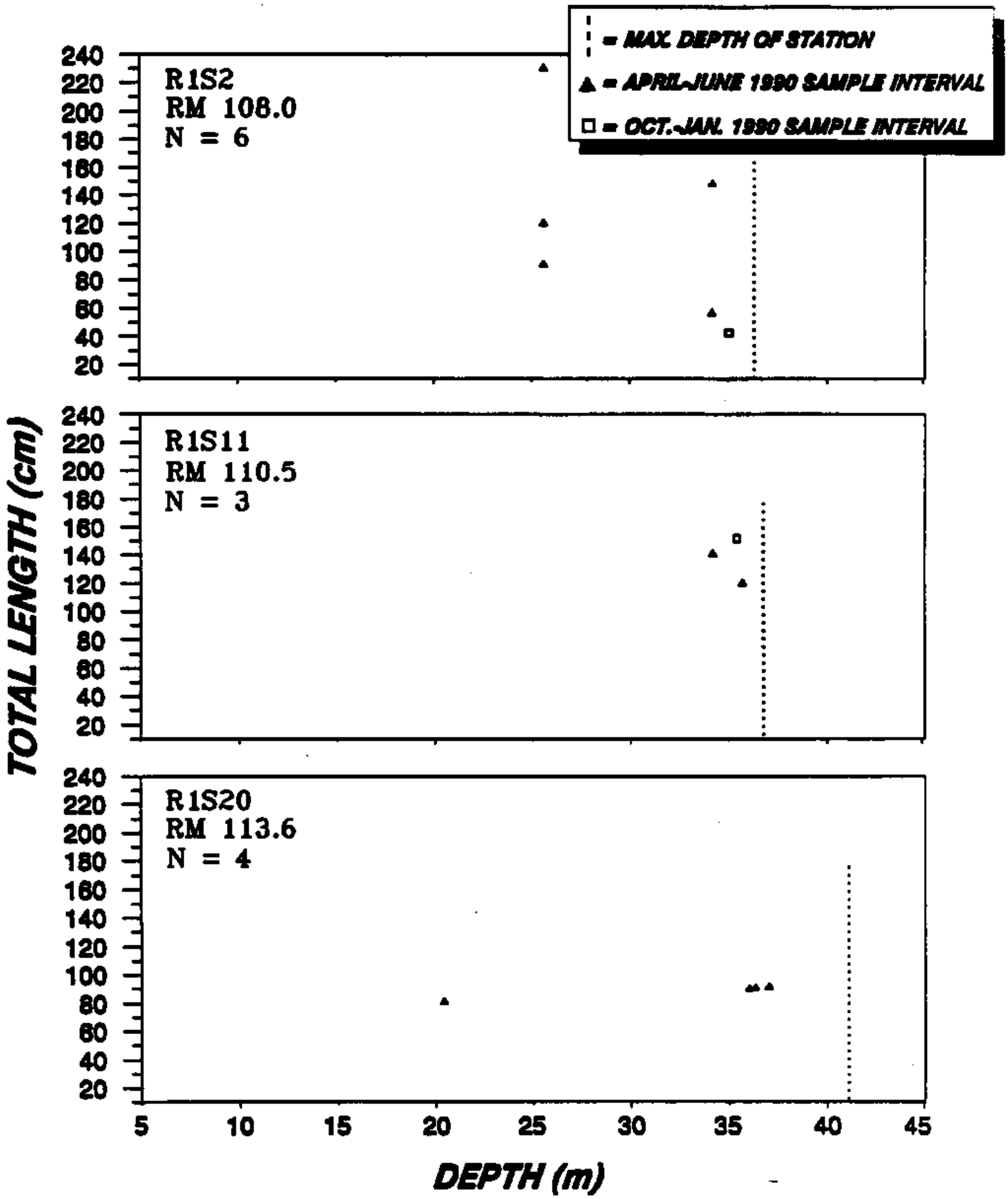


Figure 64. Lengths of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

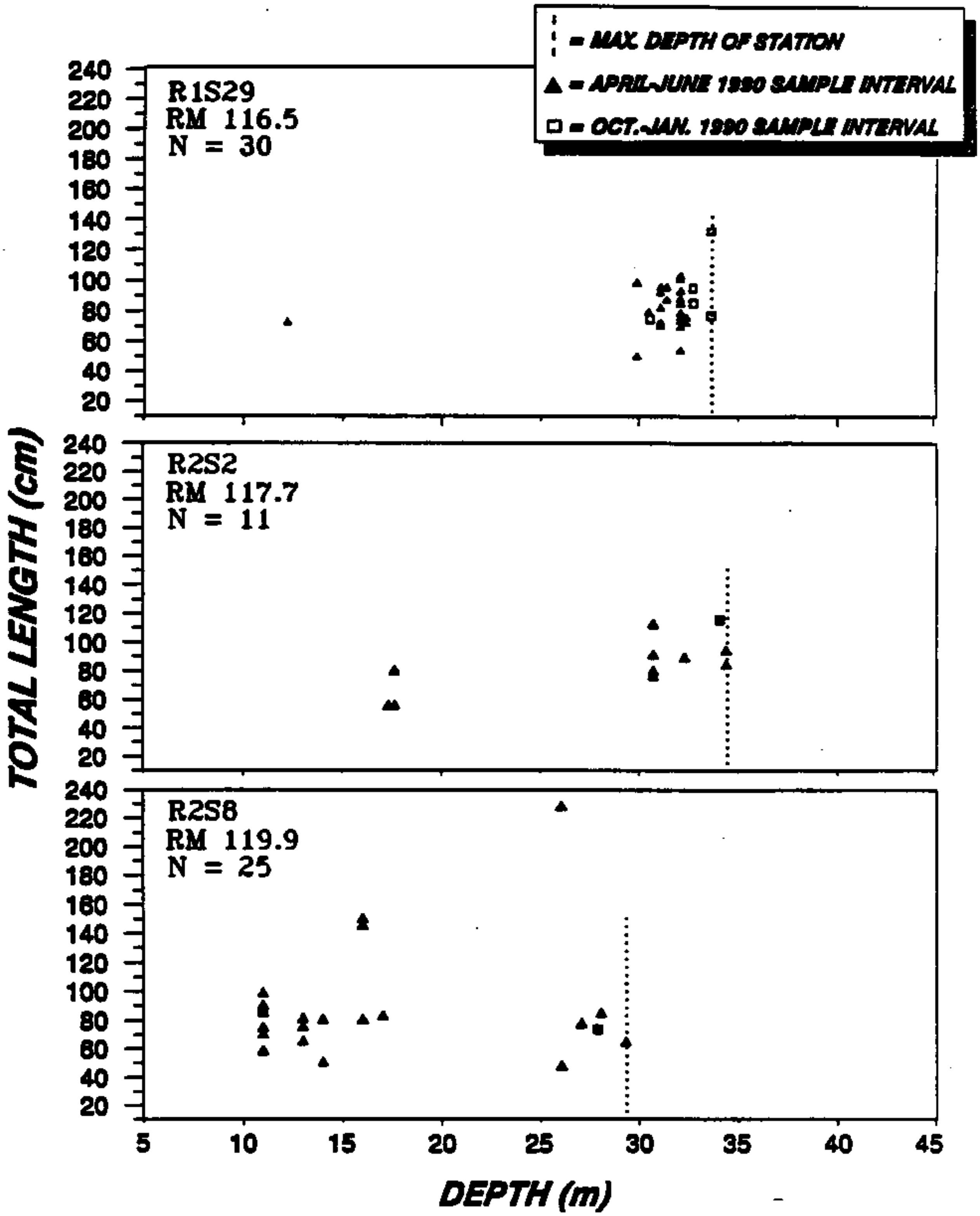


Figure 65. Lengths of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

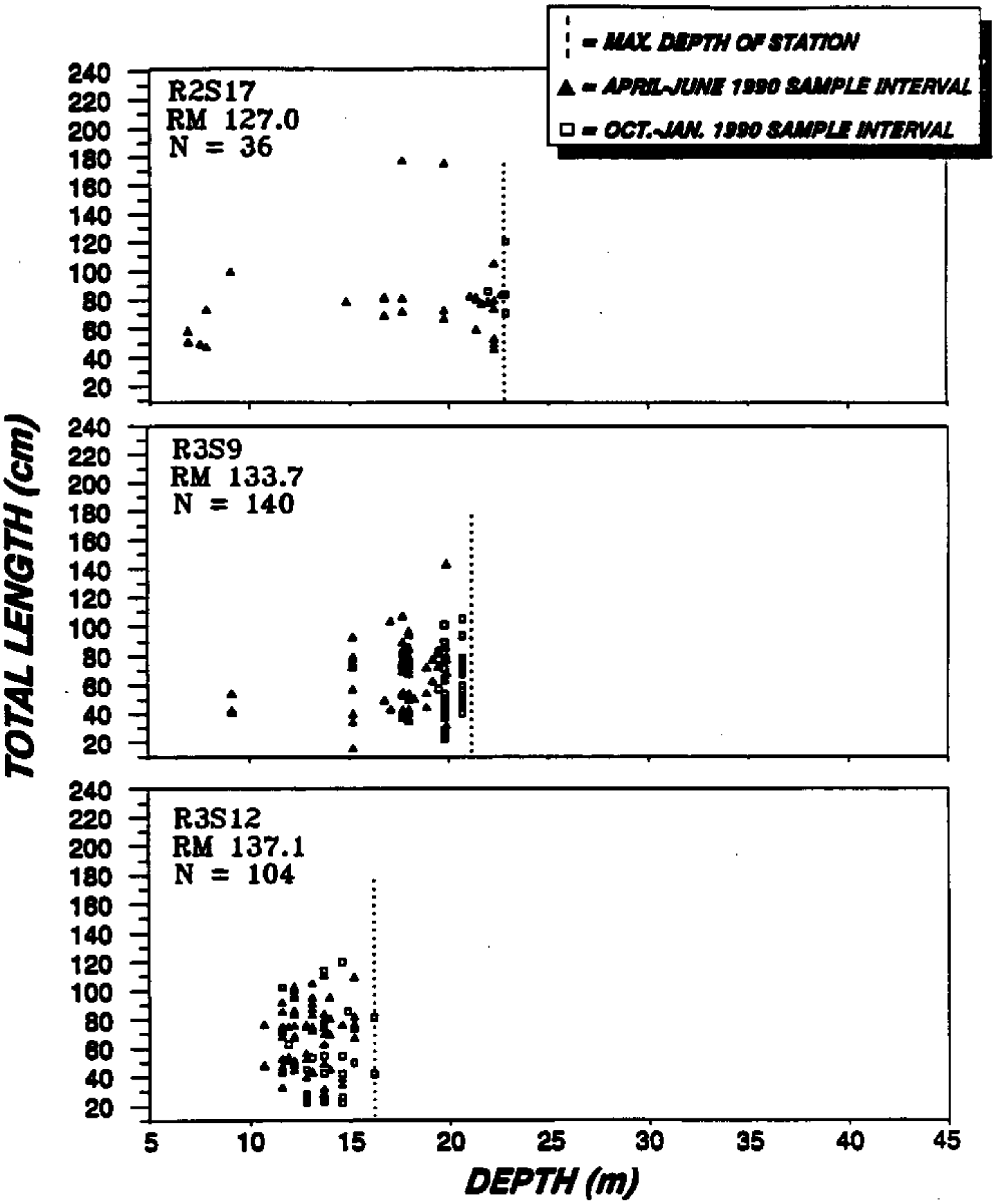


Figure 66. Lengths of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

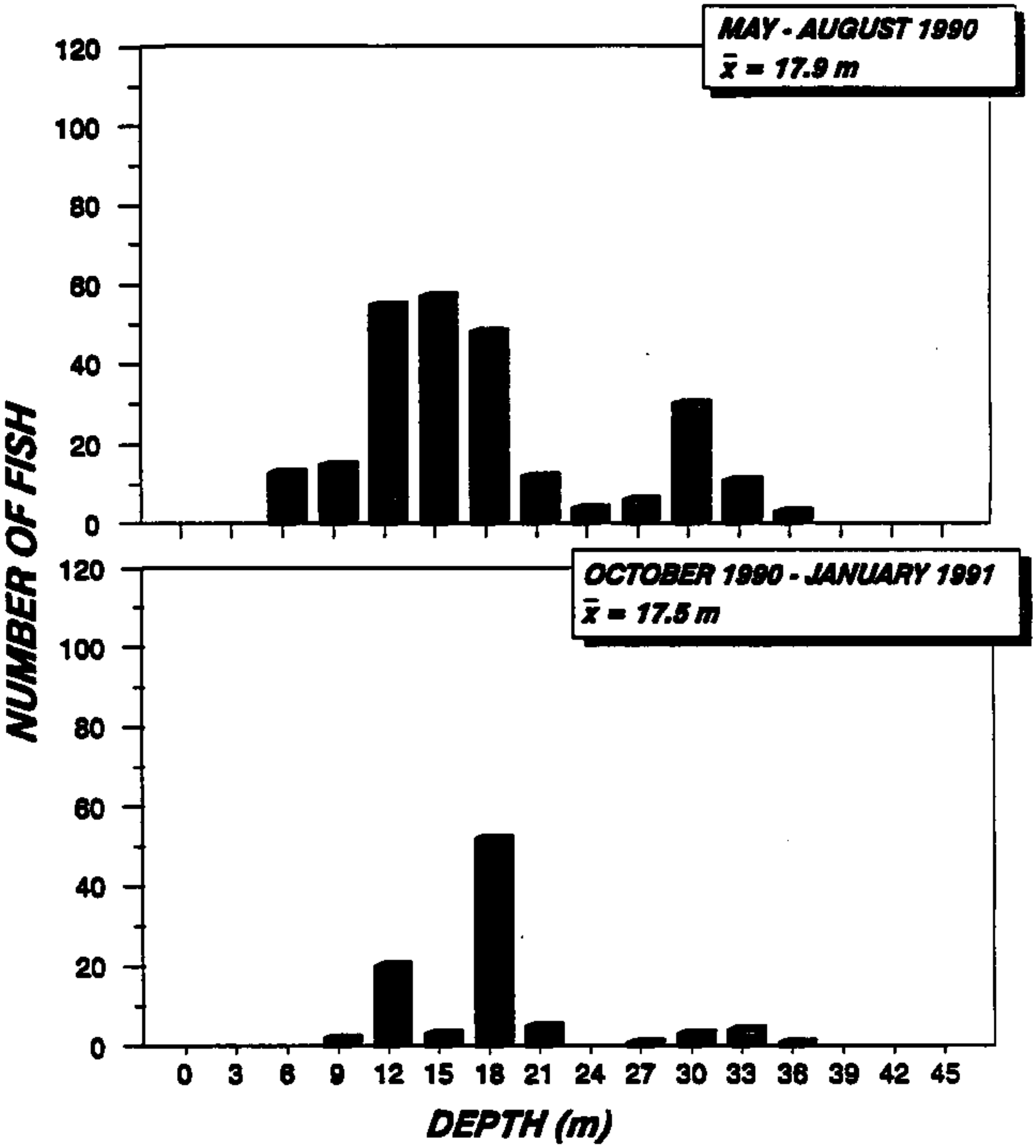


Figure 67. Depth utilization frequencies of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

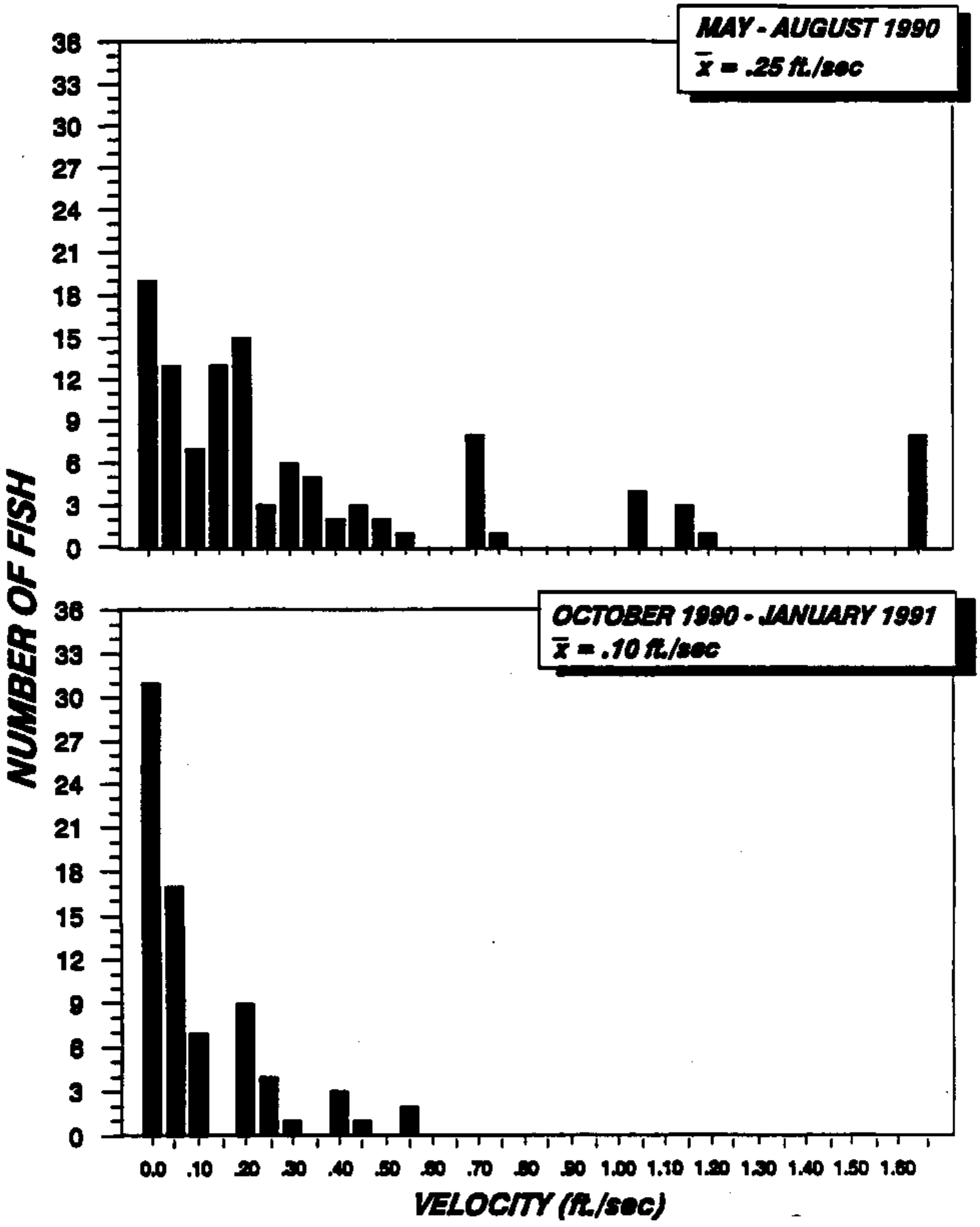


Figure 68. Current velocity utilization frequencies of white sturgeon sampled during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

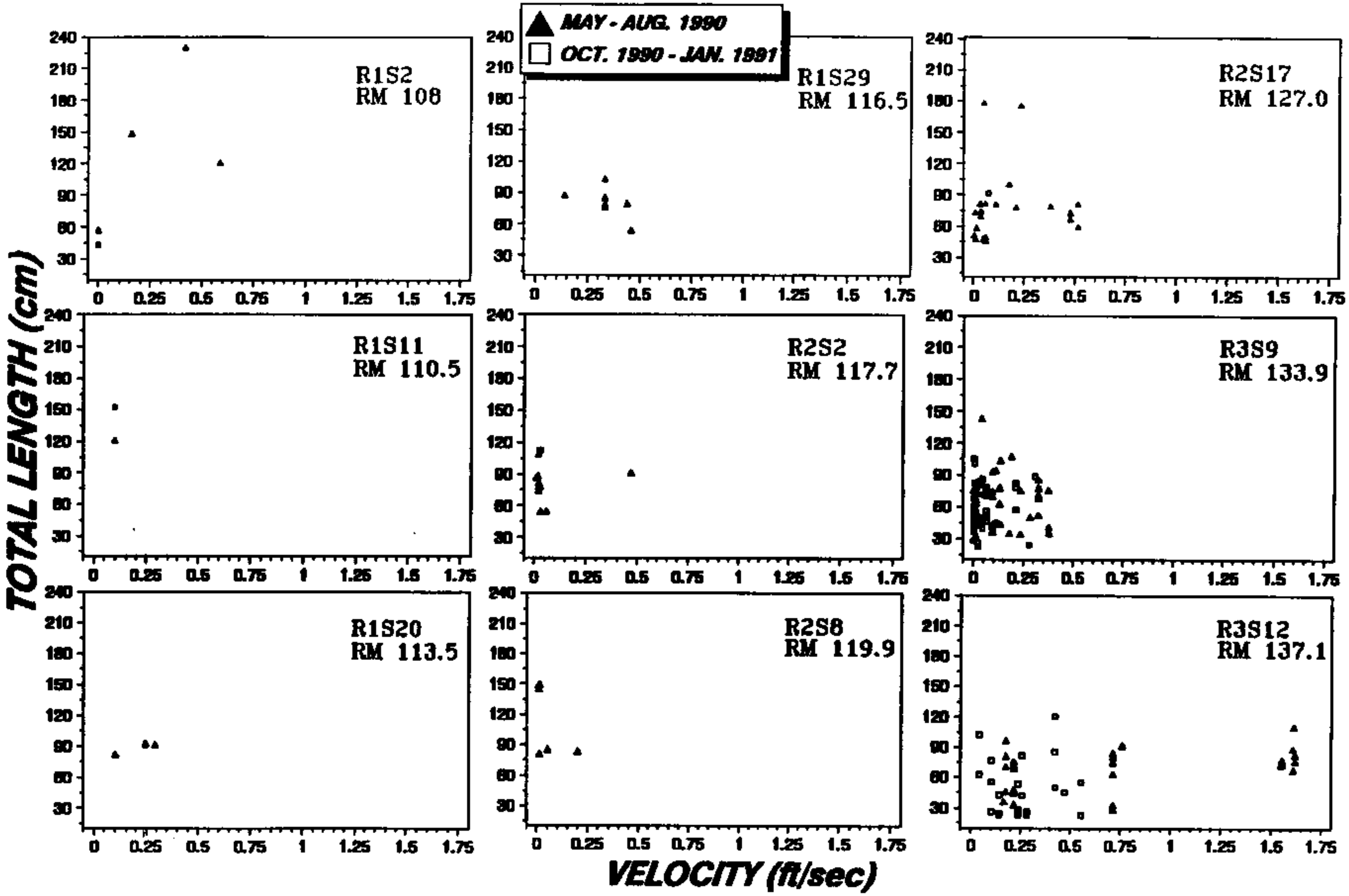


Figure 69. Comparisons of length and focal point velocities of white sturgeon captured during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

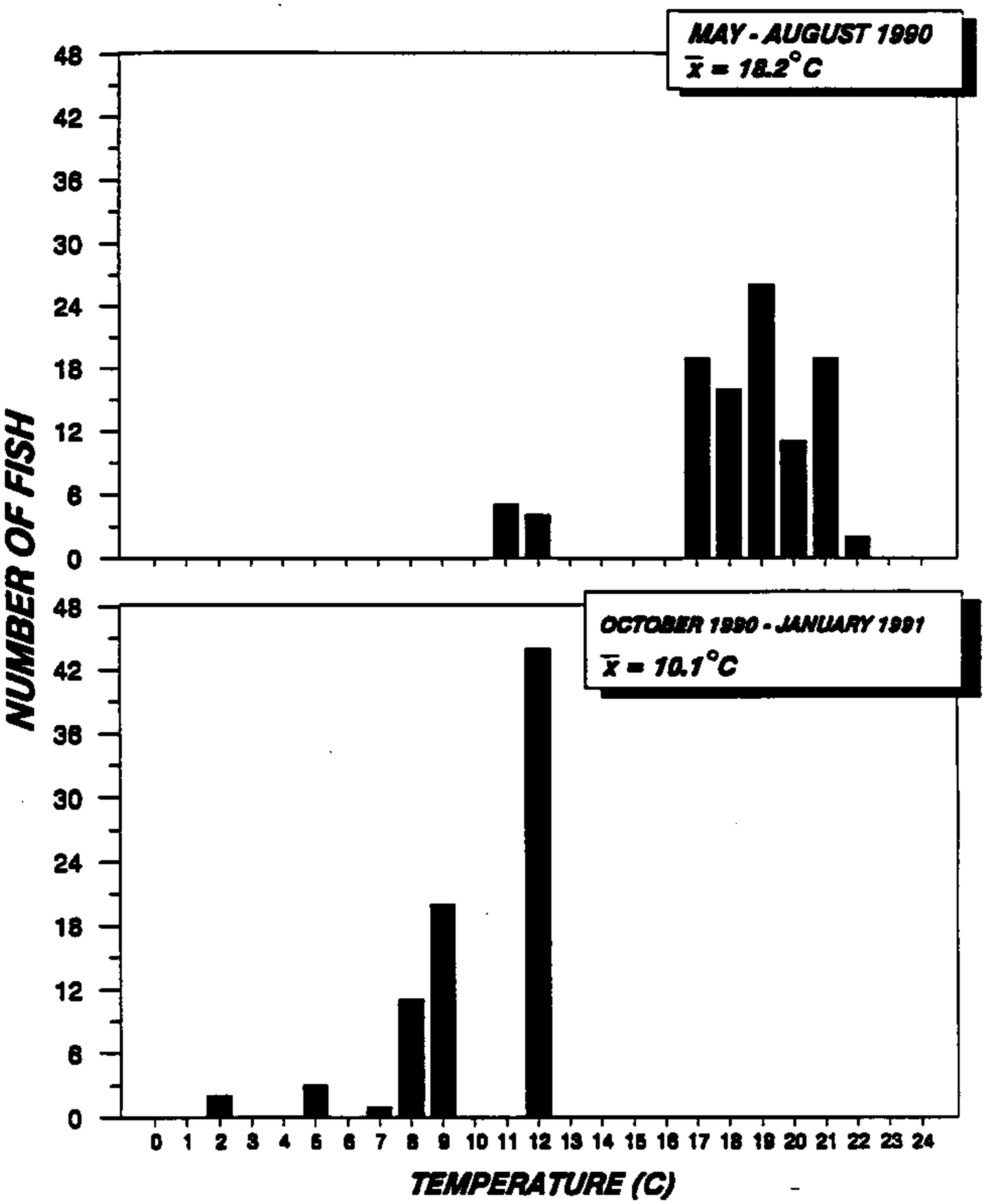


Figure 70. Temperature utilization frequencies of white sturgeon sampled during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

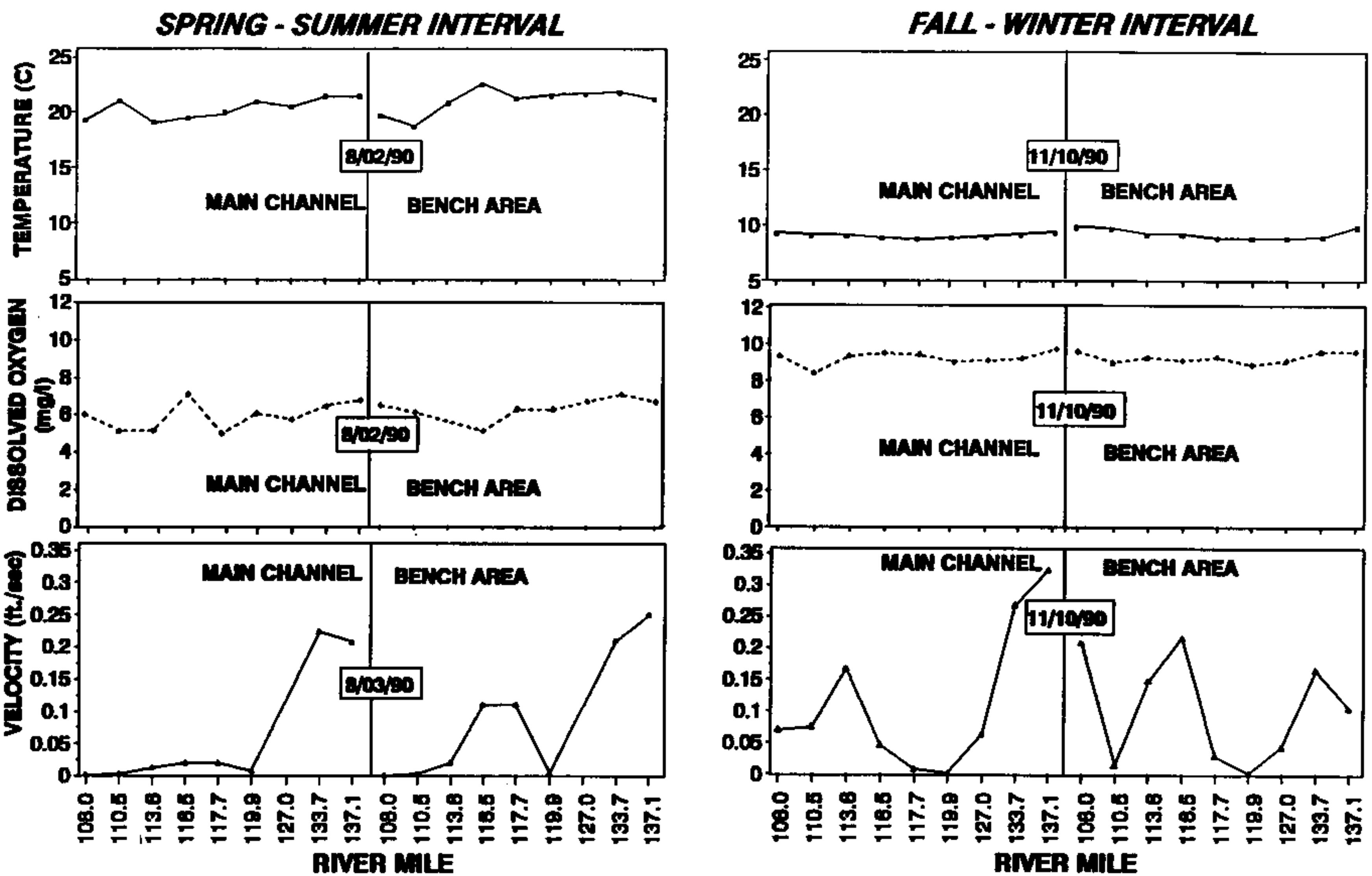


Figure 71. Comparisons of bottom temperatures, dissolved oxygen and focal point velocities at stations sampled for white sturgeon during spring-summer (May through August) and fall-winter (October through January) 1990-1991 sampling intervals in Lower Granite Reservoir, Idaho-Washington.

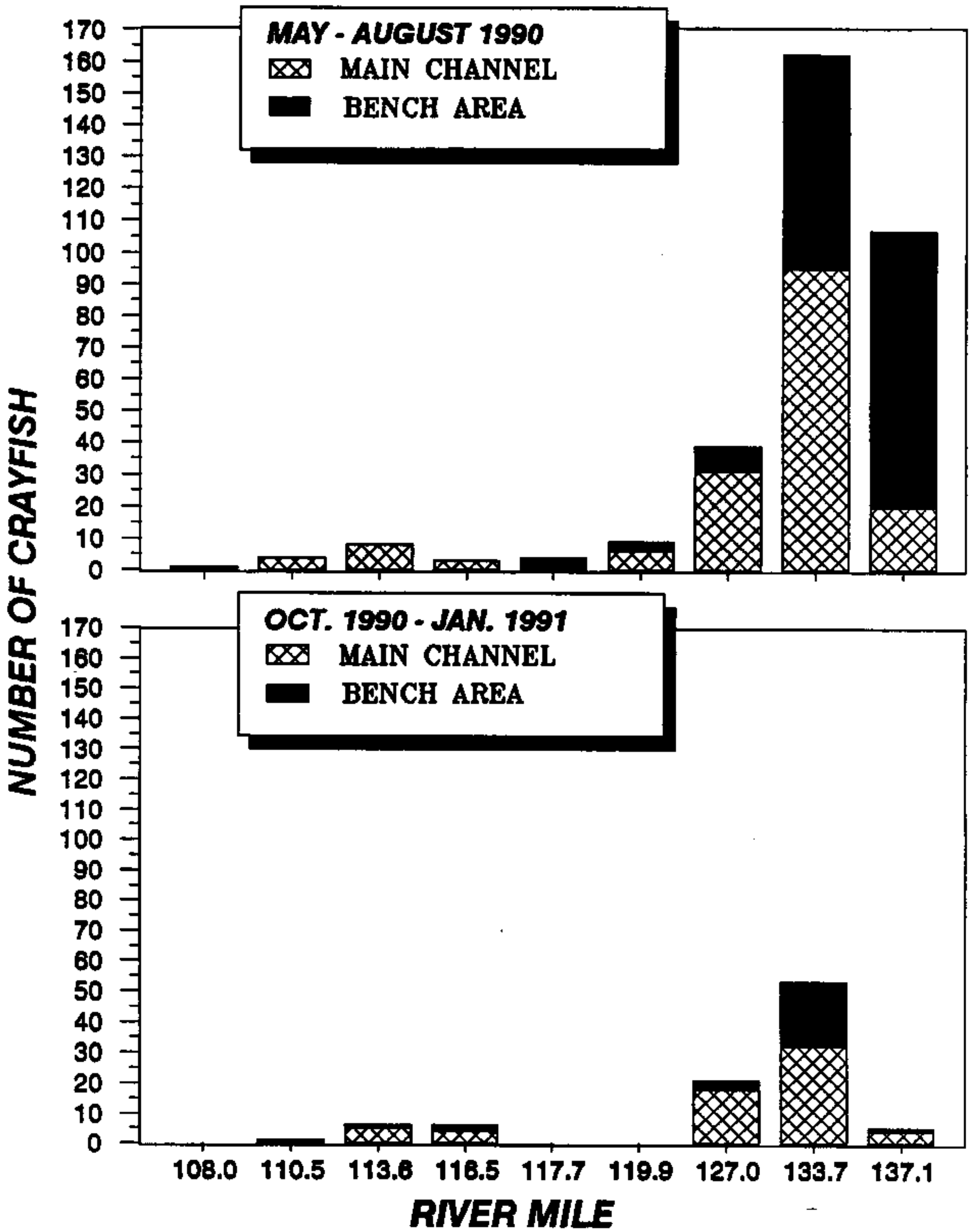


Figure 72. Number of crayfish captured at stations sampled for white sturgeon during spring-summer (May through August) and fall-winter (October through January) 1990-1991 in Lower Granite Reservoir, Idaho-Washington.

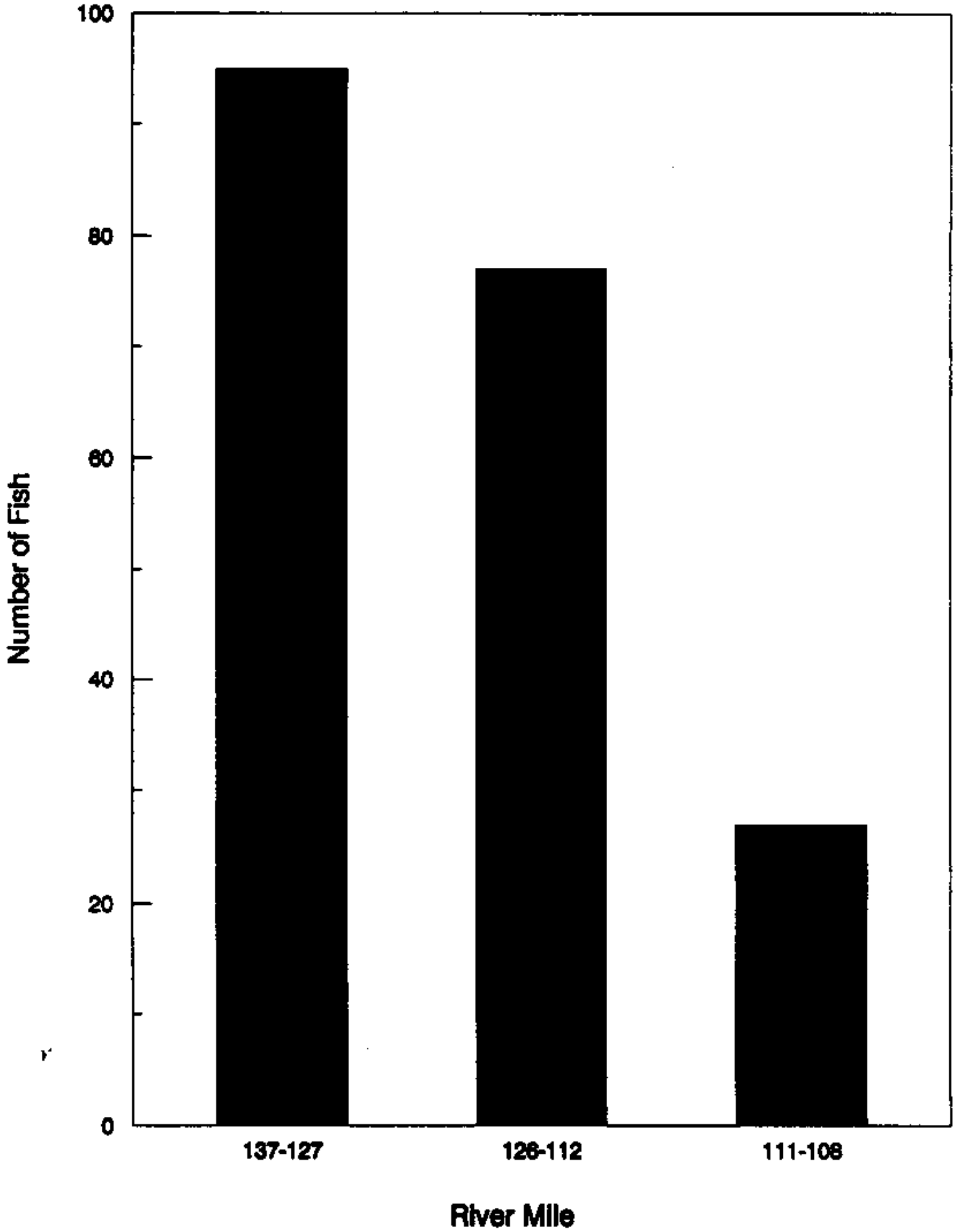


Figure 73. Number of northern squawfish captured in Lower Granite Reservoir, Idaho-Washington during 1990.

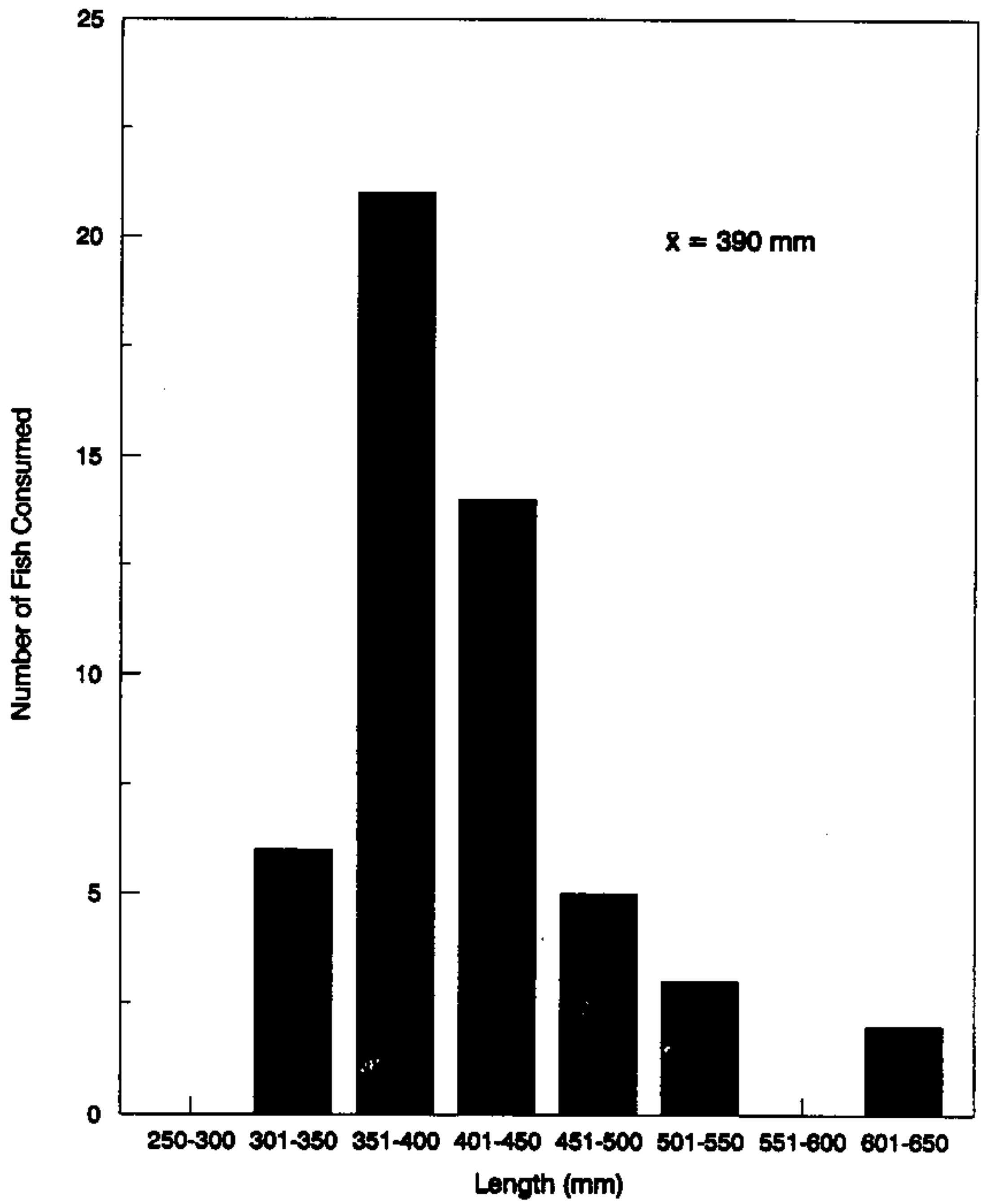


Figure 74. Number of fish consumed by different lengths of northern squawfish in Lower Granite Reservoir, Idaho-Washington during 1990.

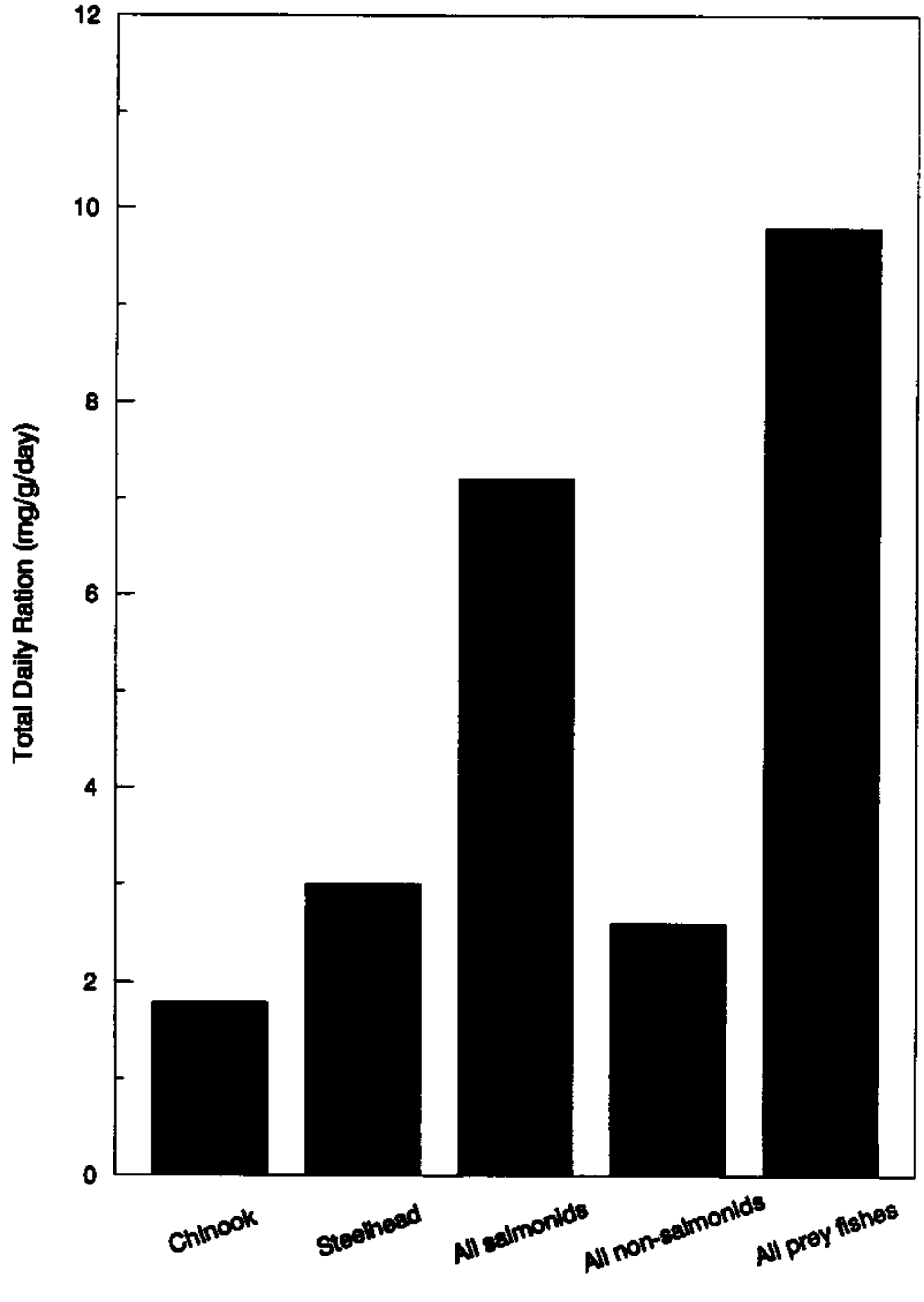


Figure 75. Total daily ration of fishes by northern squawfish during 1990 in Lower Granite Reservoir, Idaho-Washington.

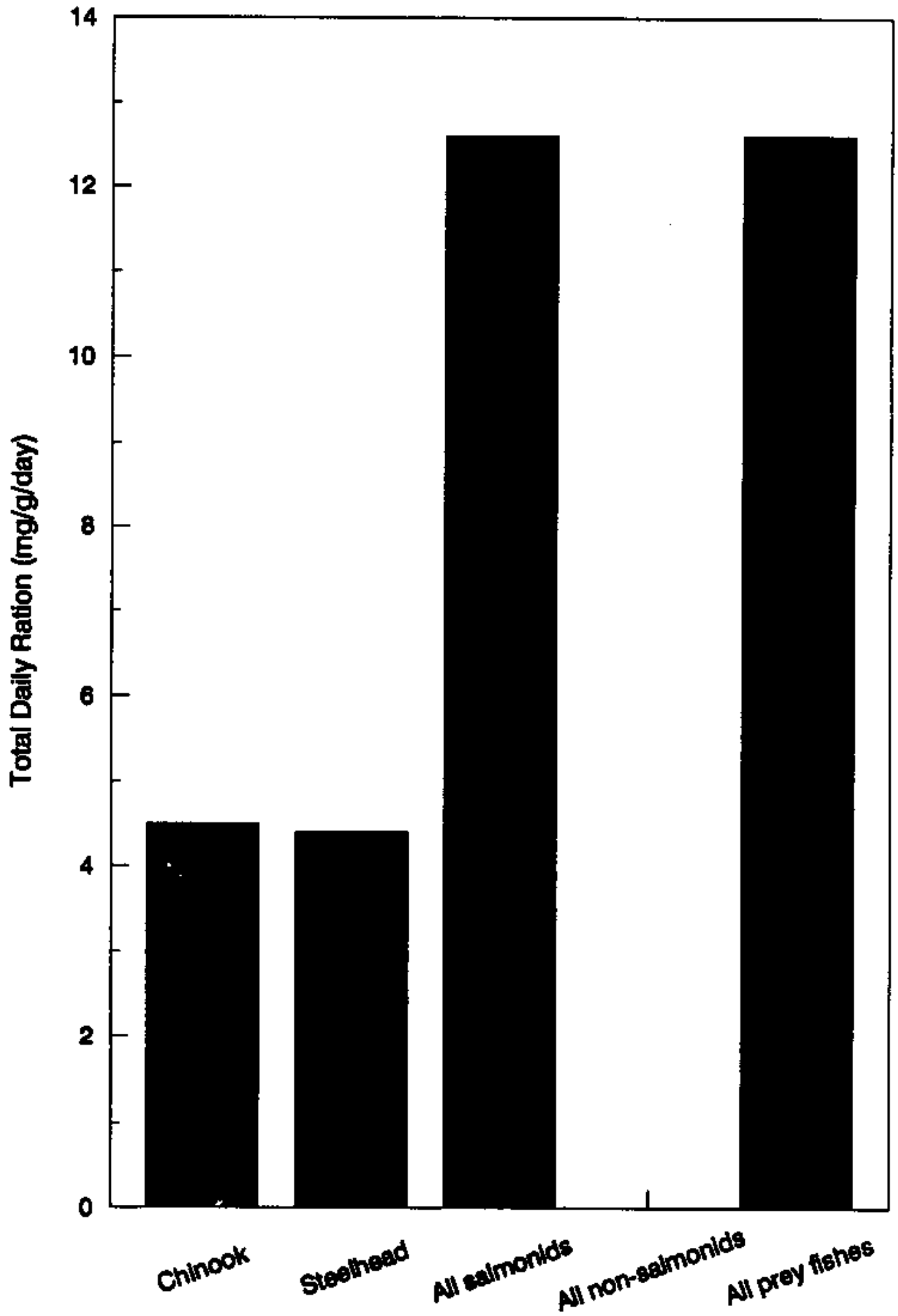


Figure 76. Total daily ration of fishes by northern squawfish during April 1990 in Lower Granite Reservoir, Idaho-Washington.

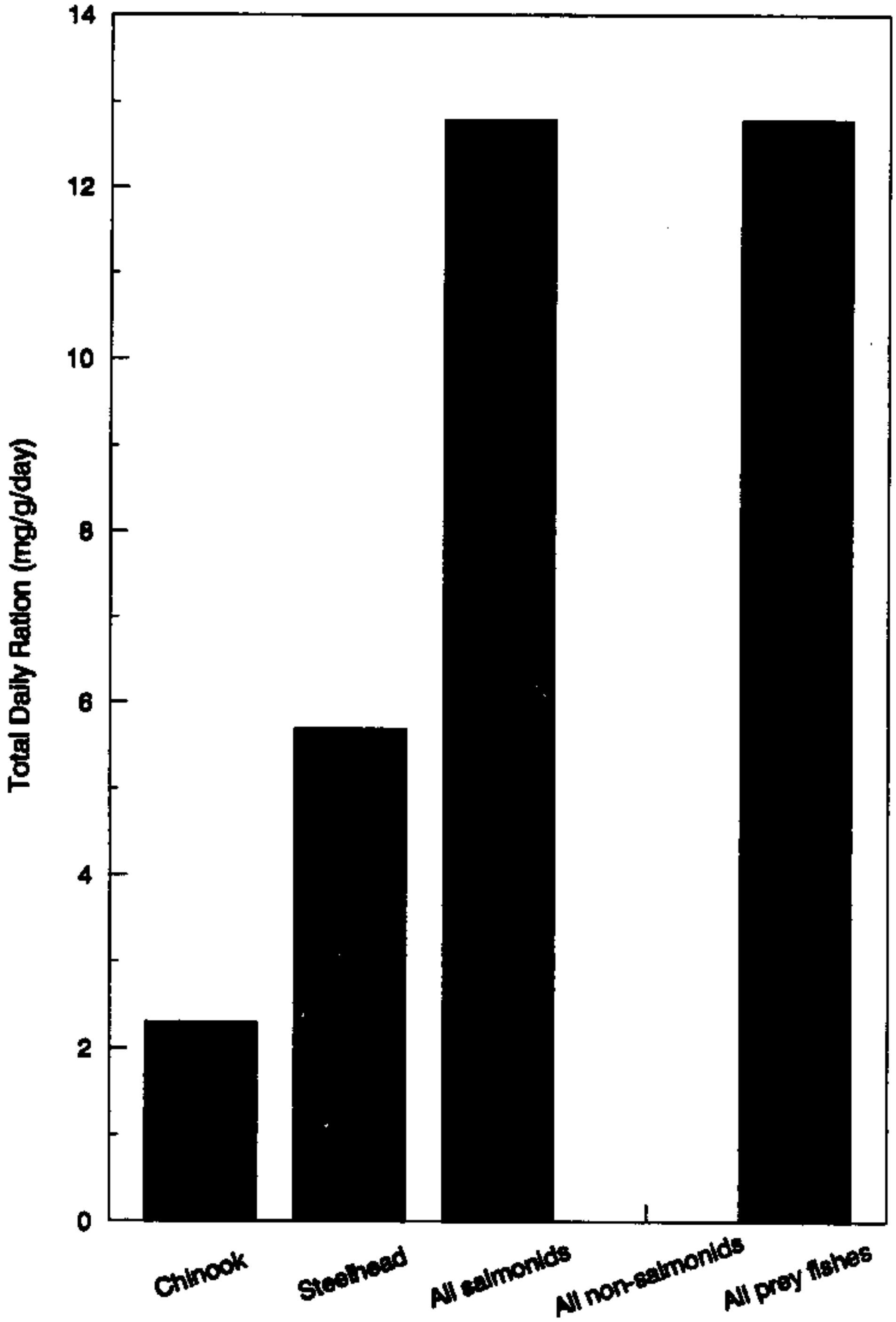


Figure 77. Total daily ration of fishes by northern squawfish during May 1990 in Lower Granite Reservoir, Idaho-Washington.

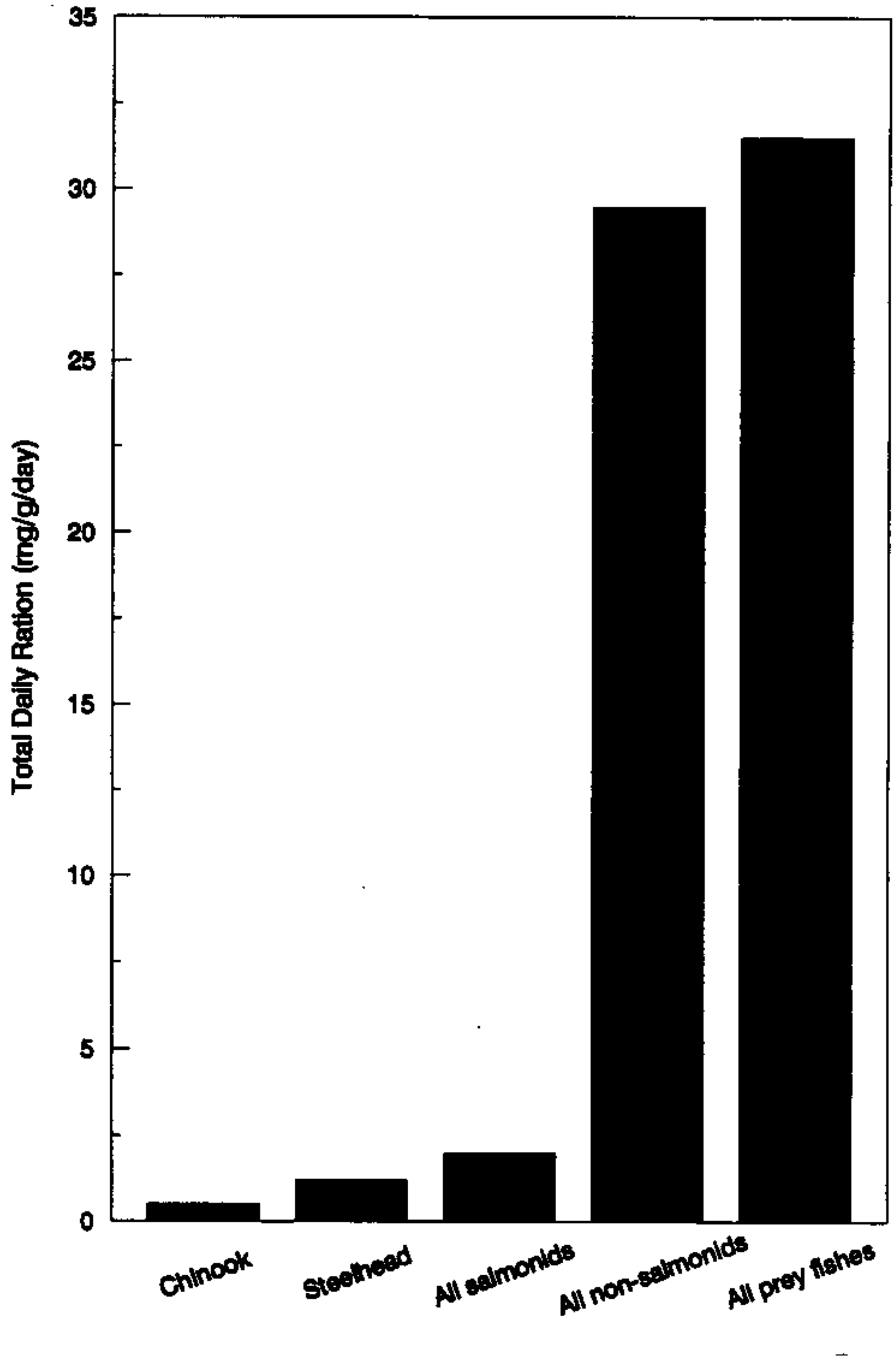


Figure 78. Total daily ration of fishes by northern squawfish during June 1990 in Lower Granite Reservoir, Idaho-Washington.

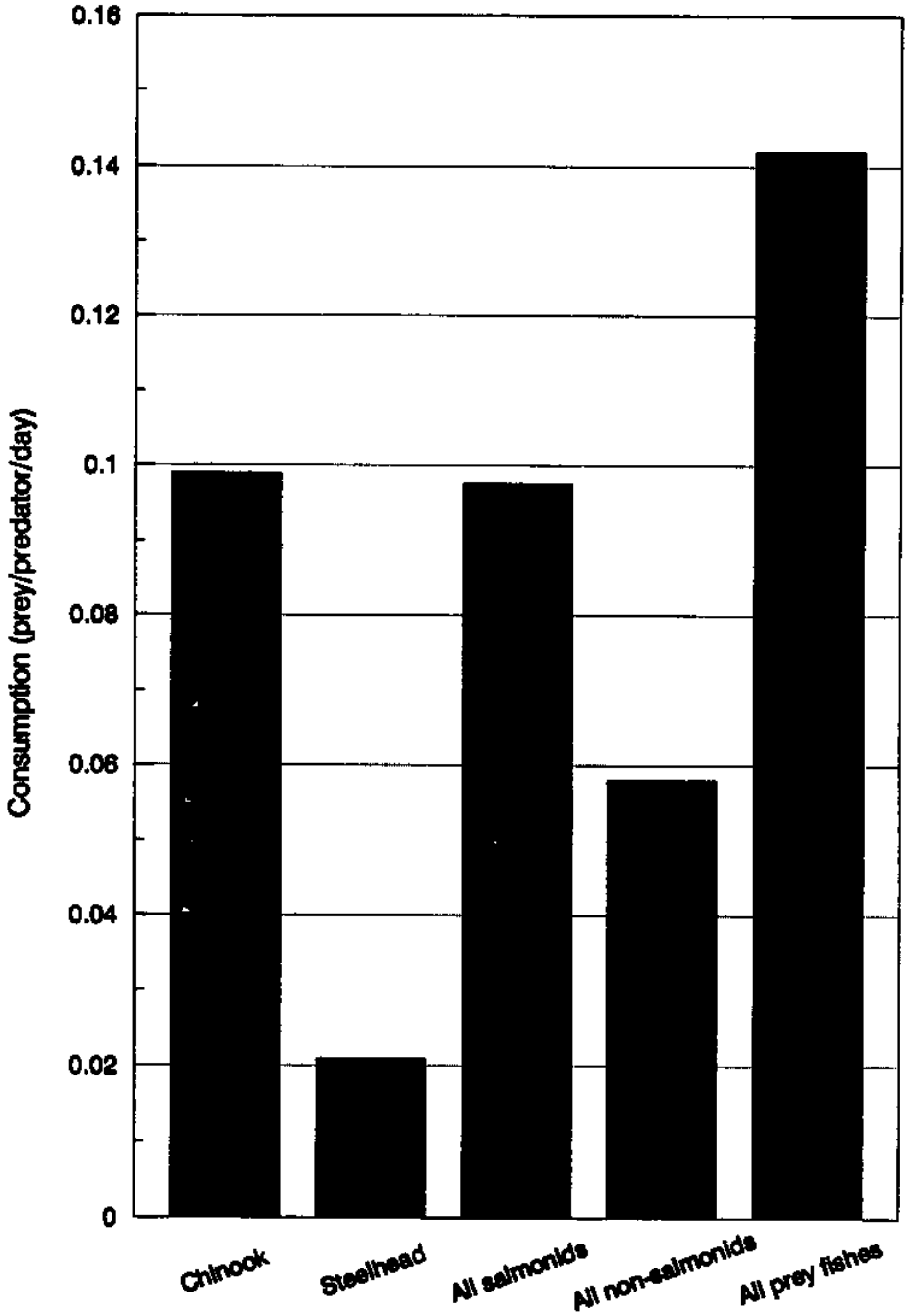


Figure 79. Consumption rates of fishes by northern squawfish during 1990 in Lower Granite Reservoir, Idaho-Washington.

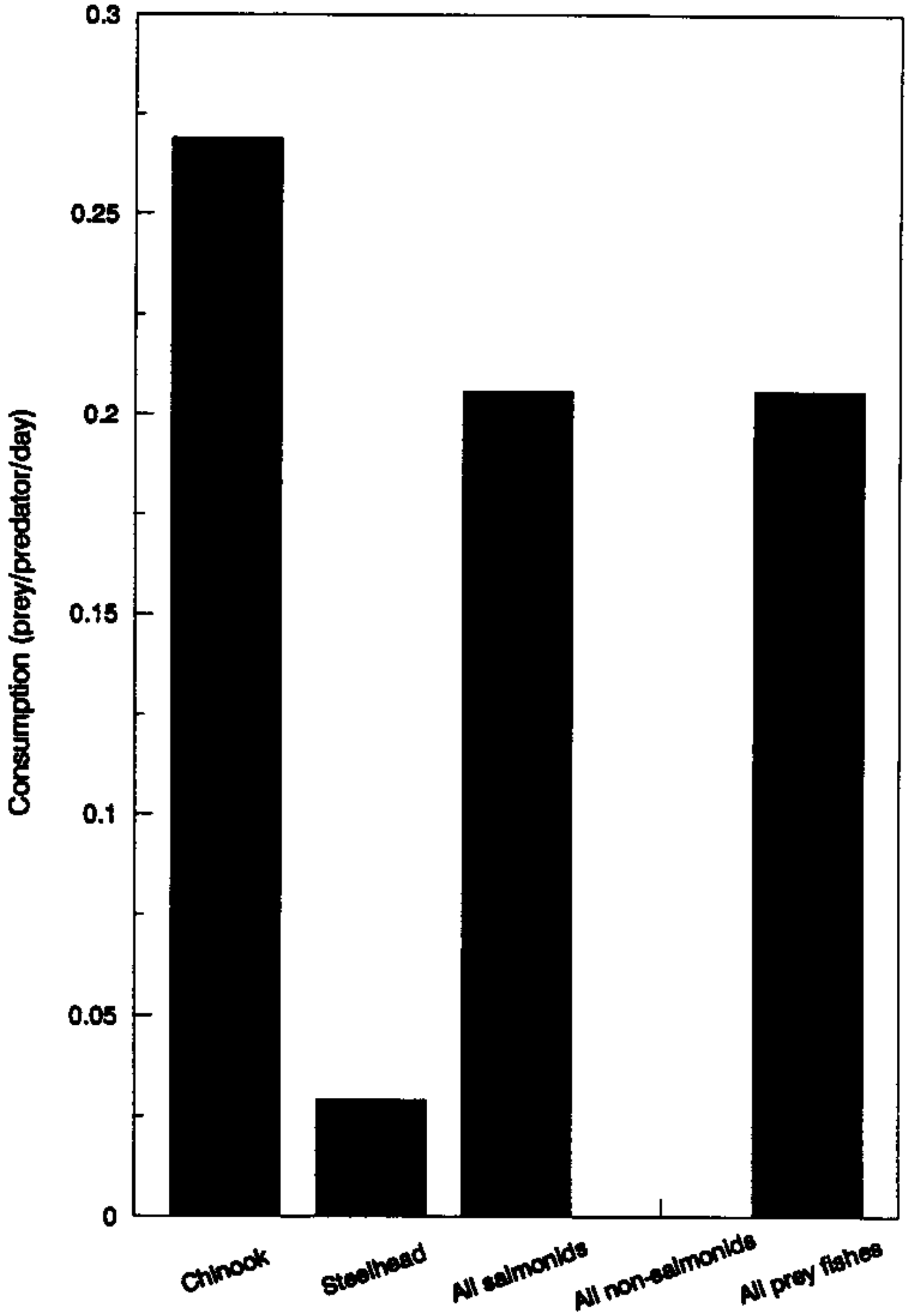


Figure 80. Consumption rates of fishes by northern squawfish during April 1990 in Lower Granite Reservoir, Idaho-Washington.

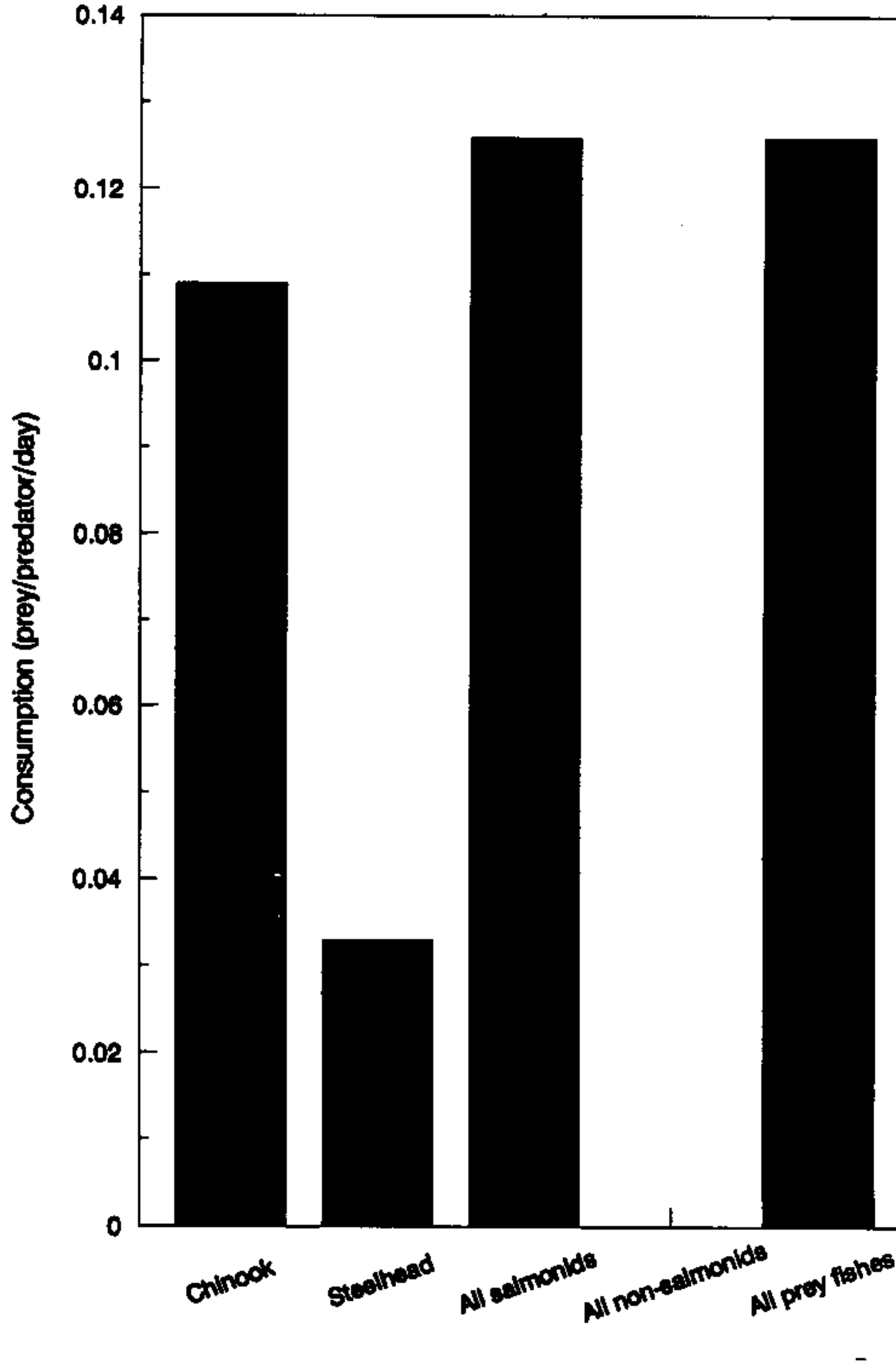


Figure 81. Consumption rates of fishes by northern squawfish during May 1990 in Lower Granite Reservoir, Idaho-Washington.

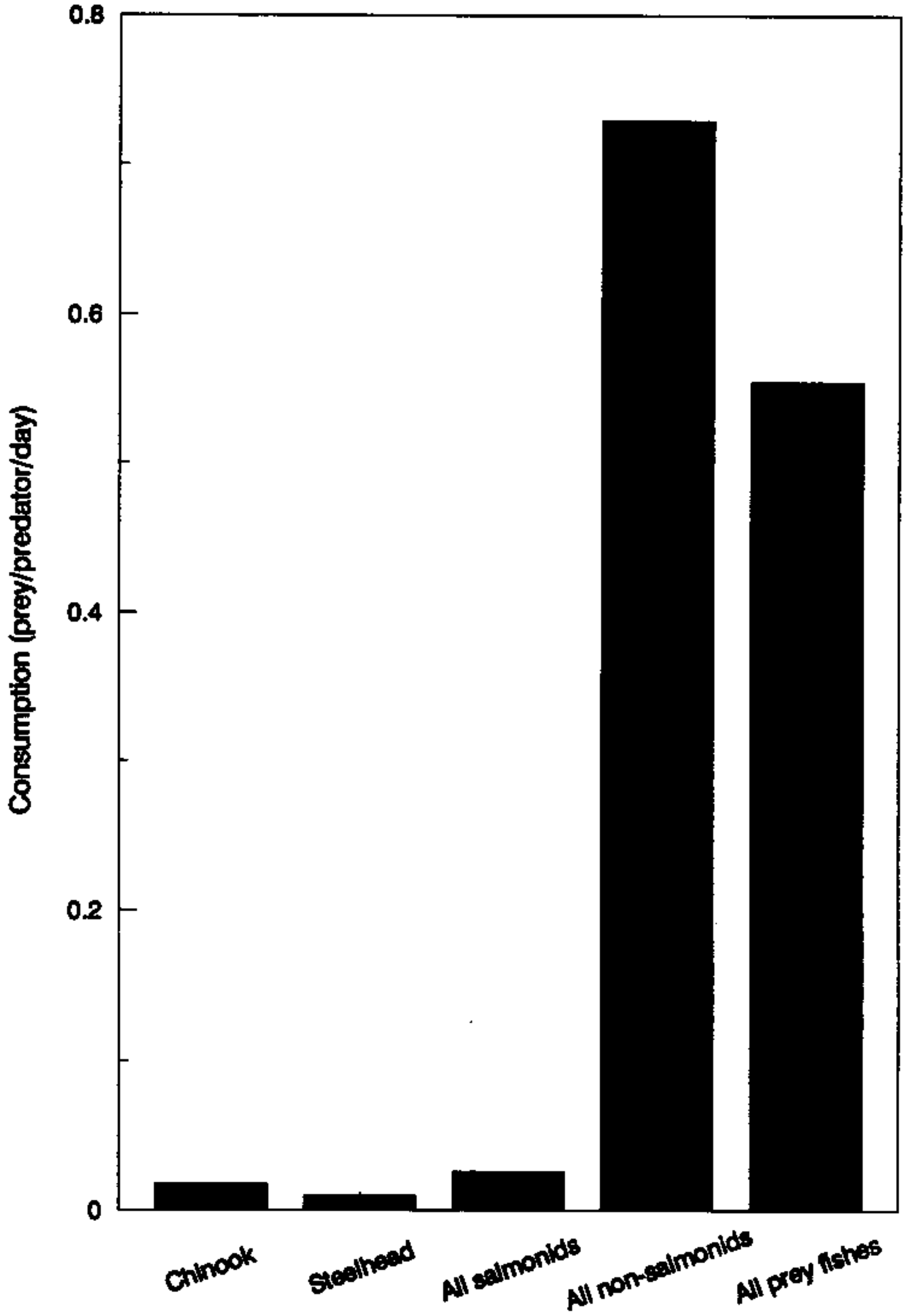


Figure 82. Consumption rates of fishes by northern squawfish during June 1990 in Lower Granite Reservoir, Idaho-Washington.

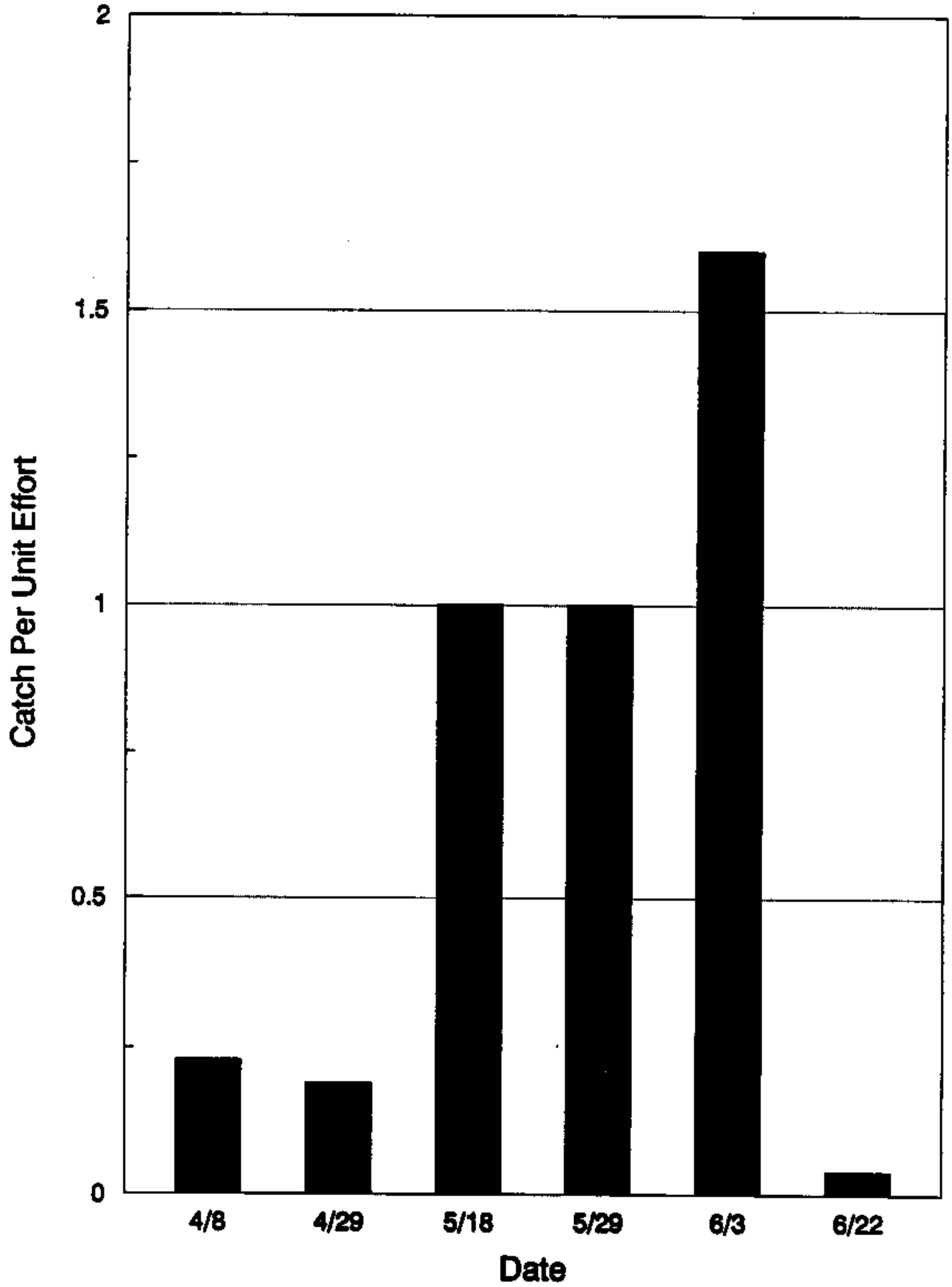


Figure 83. Catch per unit effort of juvenile chinook salmon sampled by beach seining during spring-summer 1990 in Lower Granite Reservoir, Idaho-Washington.

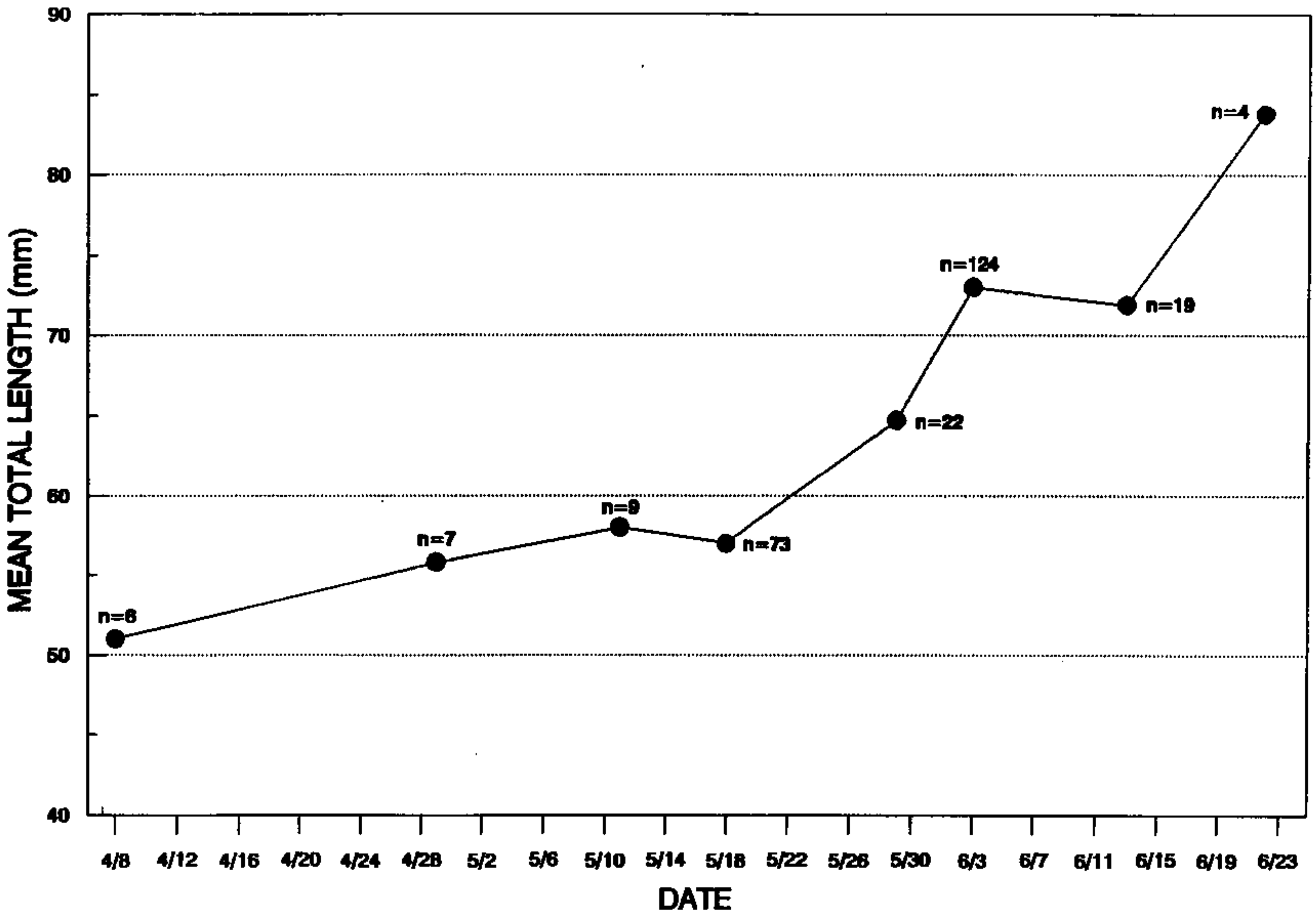


Figure 84. Mean total lengths of juvenile chinook salmon captured by all gear types during spring-summer 1990 in Lower Granite Reservoir, Idaho-Washington.

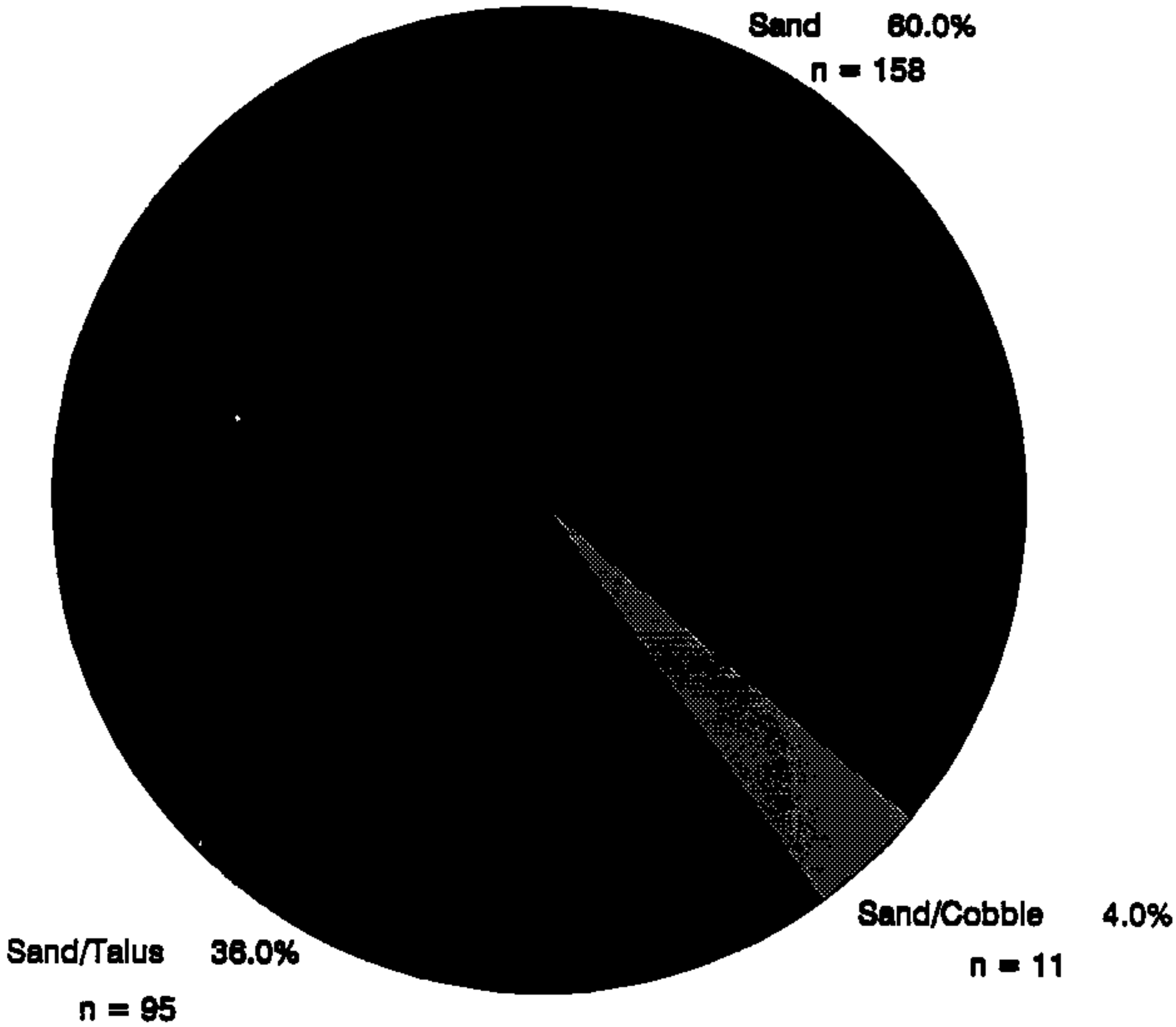


Figure 85. Habitat utilization and abundance of juvenile chinook salmon sampled by beach seining and nighttime electrofishing during 1990 in Lower Granite Reservoir, Idaho-Washington.

TABLES

Table 1. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington during spring 1990.

Species	Stations									TOTAL
	1	2	3	4	5	6	8	9	10	
Pacific lamprey						1				1
White sturgeon					1		16			17
Sockeye salmon	1				3	3		1		8
Chinook salmon	42	62	61	296	532	473	2	186	50	1,704
Mountain whitefish	41	17	15	7	5	2		2	5	94
Rainbow trout	15	105	48	22	90	200	9	43	10	542
Chiselmouth	38	11	66	11	98	12		110	93	439
Carp	2	1	5	9	16	5	4	1	16	59
Peamouth	7	2	3	1	1					14
Northern squawfish	41	29	61	48	42	27	10		6	264
Spectícled dace				1						1
Redside shiner	18	12	24	5	3				1	63
Brigdelip sucker	21	5	17	7	39	7		42	15	153
Largescale sucker	215	227	383	101	800	59	16	317	239	2,357
Yellow bullhead	2		1		2	2				7
Brown bullhead	5	4	15	8	27	3	1		1	64
Black bullhead				1	2					3
Channel catfish	1	2	6	1	4	12	34			60
Pumpkinseed	5	5	36	1	20				21	88
Bluegill			3		9				11	23
Lepomis sp.			3							3
Black crappie	13	6	32	7	6	7			23	94
White crappie	6	17	24	8	43	10			3	111
Smallmouth bass	34	43	106	7	25	4		9	133	361
Yellow perch			16	19	49	1				85
Sculpin	1									1
TOTALS	508	548	925	560	1,817	828	92	711	627	6,616

Table 2. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington during summer 1990.

	Stations									
Species	1	2	3	4	5	6	8	9	10	TOTAL
American shad					3					3
White sturgeon	1				4		5			10
Rainbow trout			2			1			2	5
Chiselmouth	1	2			6				4	13
Carp	9	9	23	9	50	1	5	1	1	108
Peamouth			13		1					14
Northern squawfish	61	21	227	11	78	4	1	2	2	407
Redside shiner			1							1
Bridgelip sucker	2		3	1	2			6		14
Largescale sucker	372	292	352	127	835	52	49	79	35	2,193
Yellow bullhead	1		2		6	11		1		21
Brown bullhead	39	5	18	2	14	7			1	86
Channel catfish	13	10	17	4	24	6	2			76
Pumpkinseed	7	4	35	5	51	1		23	8	134
Bluegill			3					2	12	17
Lepomis sp.	15	8	3	1,367		6			131	1,527
Black crappie	1	3	14		2	3		3	2	28
White crappie	14	52	62	4	56	32		2		222
Pomoxis sp.	37	20	146		8					211
Smallmouth bass	144	230	325	4	108	10		304	353	1,478
Yellow perch		5	5	2	45	5			1	63
TOTALS	717	661	2,615	169	1,299	133	62	423	552	6,631

Table 3. Number of fishes sampled by all gear types used within a station from Lower Granite Reservoir, Idaho-Washington during fall 1990.

	Stations									TOTAL
Species	1	2	3	4	5	6	8	9	10	
American shad		1		1						2
White sturgeon							4			4
Chinook salmon	1				2					3
Mountain whitefish		3	3	1						7
Rainbow trout	2	4	8	2	4	1				21
Chiselmouth	4	4	5	11	2	2		1	7	36
Carp	1	1	1		1	3	1			8
Peamouth	5	7		1	1	3				17
Northern squawfish	38	27	23	12	68	17	7	3	5	200
Redside shiner		1								1
brigdelip sucker	4	4	2	2		1		4	1	18
Largescale sucker	350	246	186	55	132	123	32	48	18	1,190
Yellow bullhead	2	2	1	2	2	3				12
Brown bullhead	2	1	2		1	11	1			18
Channel catfish	2		1	1	11	1	5			23
Pumpkinseed	1	2			3	2		6		14
Bluegill					1			1	1	3
Lepomis sp.	10	12	19		75					116
Black crappie	1	1	3							5
White crappie	2		8	1	15	20			1	47
Pomoxis sp.	3									3
Smallmouth bass	8	19	59	1	23	7		68	21	206
Yellow perch	5	2		7	8	9				31
TOTALS	441	339	321	97	349	203	50	131	57	1,988

Table 4. List of common names, scientific names and species codes for fishes in Lower Granite Reservoir, Idaho-Washington during 1990.

Codes	Scientific Name	Common Name
LTR	*Lampetra tridentatus*	pacific lamprey
ASA	*Alosa sapidissima*	americam shad
ATR	*Acipenser transmontanus*	white sturgeon
ONE	*Oncorhyncus nerka*	sockeye salmon
OTS	*Oncorhyncus tshawytscha*	chinook salmon
PWI	*Prosopium williamsoni*	mountain whitefish
OMY	*Oncorhyncus mykiss*	rainbow trout
AAL	*Acrocheilus alutaceus*	chiselmouth
CCA	*Cyprinus carpio*	carp
MCA	*Mylocheilus caurinus*	peamouth
POR	*Ptychosheilus oregonensis*	northern squawfish
ROS	*Rhinichthys osculus*	specticled dace
RBA	*Richardsonius balteatus*	redside shiner
CCO	*Catostomus columbianus*	bridgelip sucker
CMA	*Catostomus macrocheilus*	largescale sucker
INA	*Ictalurus natalis*	yellow bullhead
INE	*Ictalurus nebulosus*	brown bullhead
IME	*Ictalurus melas*	black bullhead
IPU	*Ictalurus punctatus*	channel catfish
LGI	*Lepomis gibbosus*	pumpkinseed
LMA	*Lepomis macrochirus*	bluegill
LSP	*Lepomis spp.*	misc. juv. sunfish
PNI	*Pomoxis nigromaciatus*	black crapple
PAN	*Pomoxis annularis*	white crapple
PSP	*Pomoxis spp.*	misc. juv. crapple
MDO	*Micropterus dolomieui*	smallmouth bass
PFL	*Perca flavescens*	yellow perch
COT	*Cottus spp.*	sculpin

Table 5. Catch/volume of water filtered (No./10,000 m^3) from 1/2 m larval tow nets during 1990. Upper and lower refer to bounds.

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	Mean	TOTAL Upper	Lower
21 June	1	180	1.5	0.19635	53.0145	2666.67	4508.66	824.68
	2	180	1.5	0.19635	53.0145	3666.67	5826.59	1506.74
	4	180	1.5	0.19635	53.0145	833.33	1863.04	0
	5	180	1.5	0.19635	53.0145			
	11	180	1.5	0.19635	53.0145	5500.00	8145.36	2854.64
6 July	1	180	1.5	0.19635	53.0145	333.34	1254.32	0
	2	180	1.5	0.19635	53.0145	333.34	1254.32	0
	4	180	1.5	0.19635	53.0145	666.67	1587.66	0
	5	180	1.5	0.19635	53.0145	7169.61	10262.74	4146.96
	11	180	1.5	0.19635	53.0145	34446.46	41367.14	27573.34
26 July	1	180	1.5	0.19635	53.0145	349.05	1136.43	0
	2	180	1.5	0.19635	53.0145	576.59	1662.43	0
	4	180	1.5	0.19635	53.0145	273.56	1102.83	0
	5	180	1.5	0.19635	53.0145	770.45	2391.83	0
	11	180	1.5	0.19635	53.0145	4760.58	7960.62	2107.16
31 July	1	60	1.5	0.19635	17.6715	1807.74	3336.62	581.34
	2	60	1.5	0.19635	17.6715	1610.99	3675.71	348.76
	4	60	1.5	0.19635	17.6715	2641.46	5746.66	0
	5	120	1.5	0.19635	35.3400	2573.19	6246.97	269.66
	11	120	1.5	0.19635	35.3400	9796.71	14486.26	5611.99
17 August	1	60	1.5	0.19635	17.6715	1633.33	2715.12	151.55
	2	60	1.5	0.19635	17.6715	2352.19	3436.43	1336.54
	4	60	1.5	0.19635	17.6715	1000.00	1651.24	348.76
	5	60	1.5	0.19635	17.6715	4166.67	5735.02	2967.52
	11	60	1.5	0.19635	17.6715	1166.67	1870.08	463.25
30 August	1	60	1.5	0.19635	17.6715	333.33	709.33	0
	2	60	1.5	0.19635	17.6715	166.67	432.54	0
	4	60	1.5	0.19635	17.6715	166.67	432.54	0
	5	60	1.5	0.19635	17.6715	1000.00	1860.37	238.83
	11	60	1.5	0.19635	17.6715	2666.67	3730.14	1603.19
11 September	1	180	1.5	0.19635	53.0145	333.34	1254.32	0
	2	180	1.5	0.19635	53.0145	666.67	2236.90	0
	4	180	1.5	0.19635	53.0145	500.00	1297.61	0
	5	180	1.5	0.19635	53.0145	1633.34	3972.69	0
	11	180	1.5	0.19635	53.0145	1333.34	3512.43	0
18 September	1	180	1.5	0.19635	53.0145			
	2	180	1.5	0.19635	53.0145	333.34	627.16	0
	4	180	1.5	0.19635	53.0145			
	5	180	1.5	0.19635	53.0145	333.34	627.16	0
	11	180	1.5	0.19635	53.0145	169.81	693.55	0

Table 6. Catch/volume of water filtered (No./10,000 m^3) for 1/2 m larval tow nets during 1990. Upper and lower refer to bounds. Abbreviations: ASA-American shad; AAL-chiselmouth; CCA-carp; POR-northern squawfish; RBS-redside shiner; CYP-cyprinid; CCO-bridgelip sucker; CMA-largescale sucker; CSP-catostomids; INA-brown bullhead; ISP-icturalid; LSP-*lepomis* spp.; PAN-white crappie; PNI-black crappie; PSP-*pomoxis* spp.; MDO-smallmouth bass; MSP-*micropterus* spp.

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	ASA Mean	ASA Upper	ASA Lower	AAL Mean	AAL Upper	AAL Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
28 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145				166.67	627.16	0
31 July	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	120	1.5	0.19635	35.3400	166.67	542.66	0			
	11	120	1.5	0.19635	35.3400						
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	CCA Mean	CCA Upper	CCA Lower	POR Mean	POR Upper	POR Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145				2666.67	4508.66	824.68
26 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145				500.00	1297.61	0
	11	180	1.5	0.19635	53.0145				4500.00	6692.82	2107.18
31 July	1	60	1.5	0.19635	17.6715	166.67	432.54	0			
	2	60	1.5	0.19635	17.6715	166.67	432.54	0			
	4	60	1.5	0.19635	17.6715	1000.00	1651.24	348.76			
	5	120	1.5	0.19635	35.3400	333.33	866.07	0	166.67	542.66	0
	11	120	1.5	0.19635	35.3400				7166.67	9632.23	4701.10
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715				166.67	432.54	0
	11	60	1.5	0.19635	17.6715				1166.67	1870.66	463.25
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715				833.33	1427.63	238.63
	11	60	1.5	0.19635	17.6715				2666.67	3730.14	1603.19
11 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145				666.67	1587.66	0
	11	180	1.5	0.19635	53.0145				666.67	1587.66	0
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145				166.67	627.16	0
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	RBA Mean	RBA Upper	RBA Lower	CYP Mean	CYP Upper	CYP Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145	166.67	627.16	0	3.14	66.4	0
	11	180	1.5	0.19635	53.0145	333.33	984.58	0	279.79	876.5	0
28 July	1	180	1.5	0.19635	53.0145				15.72	157.1	0
	2	180	1.5	0.19635	53.0145				78.59	394.8	0
	4	180	1.5	0.19635	53.0145				106.89	475.7	0
	5	180	1.5	0.19635	53.0145				103.75	467.1	0
	11	180	1.5	0.19635	53.0145				94.13	440.7	0
31 July	1	60	1.5	0.19635	17.6715				141.47	386.4	0
	2	60	1.5	0.19635	17.6715				94.13	294.3	0
	4	60	1.5	0.19635	17.6715				141.47	386.4	0
	5	120	1.5	0.19635	35.3400				306.52	816.4	0
	11	120	1.5	0.19635	35.3400	333.33	865.07	0	132.08	466.7	0
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715				18.86	108.3	0
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145	500.00	1297.61	0			
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145				3.14	66.4	0

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	CCO Mean	CCO Upper	CCO Lower	CMA Mean	CMA Upper	CMA Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145				166.67	627.2	0
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
26 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
31 July	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715	166.67	432.5	0			
	4	60	1.5	0.19635	17.6715						
	5	120	1.5	0.19635	35.3400						
	11	120	1.5	0.19635	35.3400						
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	CSP Mean	CSP Upper	CSP Lower	INA Mean	INA Upper	INA Lower
21 June	1	180	1.5	0.19635	53.0145	2666.67	4508.66	824.68			
	2	180	1.5	0.19635	53.0145	3666.67	5826.59	1506.74			
	4	180	1.5	0.19635	53.0145	833.33	1663.04	0			
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145	5500.00	8145.36	2854.64			
6 July	1	180	1.5	0.19635	53.0145	166.67	627.16	0			
	2	180	1.5	0.19635	53.0145	166.67	627.16	0			
	4	180	1.5	0.19635	53.0145	666.67	1587.66	0			
	5	180	1.5	0.19635	53.0145	7166.67	10166.35	4146.98			
	11	180	1.5	0.19635	53.0145	34166.66	40759.98	27573.34			
28 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
31 July	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715	166.67	432.54	0	166.67	432.54	0
	4	60	1.5	0.19635	17.6715	333.33	709.33	0	166.67	432.54	0
	5	120	1.5	0.19635	35.3400	1333.33	2396.81	269.86	333.33	709.33	0
	11	120	1.5	0.19635	35.3400	2166.67	3522.33	810.99	166.67	542.66	0
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	ISP Mean	ISP Upper	ISP Lower	LSP Mean	LSP Upper	LSP Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
26 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145				166.67	627.16	0
	11	180	1.5	0.19635	53.0145						
31 July	1	60	1.5	0.19635	17.6715				1333.33	2085.32	581.34
	2	60	1.5	0.19635	17.6715				1000.00	1651.24	348.76
	4	60	1.5	0.19635	17.6715				833.33	2289.55	0
	5	120	1.5	0.19635	35.3400				333.33	627.16	0
	11	120	1.5	0.19635	35.3400						
17 August	1	60	1.5	0.19635	17.6715				1633.33	2715.12	951.55
	2	60	1.5	0.19635	17.6715				2333.33	3328.12	1338.54
	4	60	1.5	0.19635	17.6715				1000.00	1651.24	348.76
	5	60	1.5	0.19635	17.6715				4000.00	5302.48	2697.52
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715				333.33	709.33	0
	2	60	1.5	0.19635	17.6715				166.67	432.54	0
	4	60	1.5	0.19635	17.6715				166.67	432.54	0
	5	60	1.5	0.19635	17.6715				166.67	432.54	0
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145				166.67	627.16	0
	2	180	1.5	0.19635	53.0145				166.67	627.16	0
	4	180	1.5	0.19635	53.0145				500.00	1297.61	0
	5	180	1.5	0.19635	53.0145				1166.67	2385.03	0
	11	180	1.5	0.19635	53.0145				166.67	627.16	0
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145				166.67	627.16	0
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145	166.67	627.16	0	166.67	627.16	0
	11	180	1.5	0.19635	53.0145				166.67	627.16	0

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	PAN Mean	PAN Upper	PAN Lower	PNI Mean	PNI Upper	PNI Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
28 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145				166.67	627.16	0
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
31 July	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	120	1.5	0.19635	35.3400						
	11	120	1.5	0.19635	35.3400						
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145				166.67	627.16	0
	2	180	1.5	0.19635	53.0145	166.67	627.16	0	333.33	984.58	0
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						

Table 6. Continued

DATE	STATION	Duration (Sec.)	Speed (m/Sec.)	Area (m2)	Volume (m3)	PSP Mean	PSP Upper	PSP Lower	MDO Mean	MDO Upper	MDO Lower
21 June	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
6 July	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145	166.67	627.16	0			
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
28 July	1	180	1.5	0.19635	53.0145				333.33	984.58	0
	2	180	1.5	0.19635	53.0145				500.00	1297.61	0
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
31 July	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	120	1.5	0.19635	35.3400	166.67	542.67	0			
	11	120	1.5	0.19635	35.3400						
17 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
30 August	1	60	1.5	0.19635	17.6715						
	2	60	1.5	0.19635	17.6715						
	4	60	1.5	0.19635	17.6715						
	5	60	1.5	0.19635	17.6715						
	11	60	1.5	0.19635	17.6715						
11 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						
18 September	1	180	1.5	0.19635	53.0145						
	2	180	1.5	0.19635	53.0145						
	4	180	1.5	0.19635	53.0145						
	5	180	1.5	0.19635	53.0145						
	11	180	1.5	0.19635	53.0145						

Table 7. Catch/volume of water (filtered No./10,000 m^3) for larval beam trawls sampled in shallow (S; 0.5 m) and deep (D; 1.0 m) waters along the shoreline during 1990. Abbreviations: POR-northern squawfish; CYP-cyprinid; CSP-catostomid; INE-brown bullhead; LSP-*lepomis* spp.; PAN-white crappie; PNI-black crappie; PSP-*pomoxis* spp.; MDO-smallmouth bass; MSP-*micropterus* spp.

			POR			CYP		
DATE	STATION	DEPTH	MEAN	UPPER	LOWER	MEAN	UPPER	LOWER
14 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
25 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D				5666.67	6911.82	4421.52
		S				16333.33	17828.12	14838.54
10 JULY	1	D						
		S						
	2	D						
		S						
	5	D				333.33	635.33	31.34
		S						
	11	D						
		S	1333.33	1760.42	906.25	32333.33	34436.47	30230.19
24 JULY	1	D						
		S						
	2	D				333.33	635.33	31.34
		S						
	5	D						
		S						
	11	D	5000.00	6169.62	3830.38	666.67	1093.75	239.58
		S	15333.33	16781.64	13885.02	1000.00	1369.86	630.14
7 AUGUST	1	D						
		S				1333.33	1760.42	906.25
	2	D						
		S						
	5	D						
		S						
	11	D	666.67	1093.75	239.58			
		S	15333.33	16781.64	13885.02	666.67	968.66	364.67
23 AUGUST	1	D						
		S						
	2	D						
		S						
	5	D						
		S	25333.33	27194.94	23471.72			
	11	D						
		S						
7 SEPTEMBER	1	D	6000.00	7281.23	4718.75			
		S	1333.33	1760.42	906.25			
	2	D						
		S						
	5	D						
		S	333.33	546.87	119.79			
	11	D						
		S						
28 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Table 7. Continued

DATE	STATION	DEPTH	CSP MEAN	CSP UPPER	CSP LOWER	INE MEAN	INE UPPER	INE LOWER
14 JUNE	1	D						
		S						
	2	D	1333.33	1760.42	906.25			
		S	1000.00	1523.07	476.93			
	5	D						
		S						
	11	D	1000.00	1523.07	476.93			
		S	333.33	546.87	119.79			
25 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S	333.33	546.87	119.79			
	11	D						
		S	1333.33	1760.42	906.25			
10 JULY	1	D	333.33	635.33	31.34			
		S	666.67	968.66	364.67			
	2	D	333.33	635.33	31.34			
		S	666.67	968.66	364.67			
	5	D						
		S						
	11	D						
		S						
24 JULY	1	D						
		S						
	2	D						
		S						
	5	D						
		S	333.33	546.87	119.79			
	11	D						
		S						
7 AUGUST	1	D						
		S						
	2	D				333.33	635.33	31.34
		S				333.33	546.87	119.79
	5	D						
		S						
	11	D						
		S						
23 AUGUST	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
7 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Table 7. Continued

DATE	STATION	DEPTH	LSP MEAN	LSP UPPER	LSP LOWER	PAN MEAN	PAN UPPER	PAN LOWER
14 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
25 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
10 JULY	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
24 JULY	1	D	666.66	1093.75	239.58			
		S						
	2	D						
		S						
	5	D	18333.33	20572.97	16093.69			
		S	8666.67	9755.52	7577.81			
	11	D						
		S	5333.33	6187.50	4479.17			
7 AUGUST	1	D	16333.33	18447.28	14219.37			
		S	32333.33	34436.47	30230.19			
	2	D	7000.00	8383.91	5616.09			
		S						
	5	D	61333.33	65429.77	57236.89			
		S	59666.66	62523.65	56809.67			
	11	D						
		S	333.33	546.87	119.79			
23 AUGUST	1	D						
		S						
	2	D	333.33	635.33	31.34			
		S						
	5	D						
		S	4333.33	5103.27	3563.40	666.66	968.66	364.67
	11	D						
		S	333.33	546.87	119.79			
7 SEPTEMBER	1	D	64333.33	68528.75	60137.90	333.33	635.33	31.34
		S	666.67	968.66	364.67			
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Table 7. Continued

DATE	STATION	DEPTH	PNI MEAN	PNI UPPER	PNI LOWER	PSP MEAN	PSP UPPER	PSP LOWER
14 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
25 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
10 JULY	1	D						
		S						
	2	D				333.33	635.33	31.34
		S						
	5	D				1333.33	1937.32	729.35
		S				4000.00	4739.73	3260.27
	11	D						
		S						
24 JULY	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
7 AUGUST	1	D						
		S	333.33	546.67	119.79			
	2	D						
		S						
	5	D	333.33	635.33	31.34			
		S						
	11	D						
		S						
23 AUGUST	1	D						
		S						
	2	D						
		S						
	5	D						
		S				2666.67	3270.65	2062.68
	11	D	3000.00	3905.98	2094.02			
		S						
7 SEPTEMBER	1	D	4666.67	5796.62	3536.71			
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Table 7. Continued

DATE	STATION	DEPTH	MDO MEAN	MDO UPPER	MDO LOWER	MSP MEAN	MSP UPPER	MSP LOWER
14 JUNE	1	D						
		S						
	2	D						
		S				333.33	546.87	119.79
	5	D						
		S						
	11	D						
		S						
25 JUNE	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
10 JULY	1	D						
		S						
	2	D						
		S				333.33	546.87	119.79
	5	D						
		S				333.33	546.87	119.79
	11	D						
		S						
24 JULY	1	D	12000.00	13811.96	10188.03			
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
7 AUGUST	1	D						
		S						
	2	D						
		S						
	5	D				333.33	635.33	31.34
		S						
	11	D						
		S						
23 AUGUST	1	D						
		S						
	2	D						
		S	3000.00	3640.62	2359.38			
	5	D						
		S						
	11	D						
		S						
7 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						
28 SEPTEMBER	1	D						
		S						
	2	D						
		S						
	5	D						
		S						
	11	D						
		S						

Table 7. Continued

DATE	STATION	DEPTH	MEAN	TOTAL UPPER	LOWER
14 JUNE	1	D			
		S			
	2	D	1,333.33	1,760.42	906.25
		S	1,333.33	2,069.94	596.72
	5	D			
		S			
	11	D	1,000.00	1,523.07	476.93
		S	333.33	546.87	119.79
25 JUNE	1	D			
		S			
	2	D			
		S			
	5	D			
		S	333.33	546.87	119.79
	11	D	5,666.67	6,911.82	4,421.52
		S	17,666.66	9,588.54	15,744.79
10 JULY	1	D	333.33	635.33	31.34
		S	666.67	968.66	364.67
	2	D	1,000.00	1,270.66	62.68
		S	1,000.00	1,515.53	466.46
	5	D	1,666.66	2,572.65	760.69
		S	4,333.33	10,206.60	3,390.06
	11	D			
		S	33,666.66	36,196.89	31,136.44
24 JULY	1	D	12,666.66	14,905.71	10,427.61
		S			
	2	D			
		S			
	5	D	18,333.33	20,572.97	16,093.69
		S	9,000.00	10,302.39	7,697.60
	11	D	5,666.67	7,263.37	4,069.96
		S	21,666.66	24,339.00	18,994.33
7 AUGUST	1	D	16,333.33	18,447.28	14,219.37
		S	33,999.99	36,743.76	31,256.23
	2	D	7,333.33	9,019.24	5,647.43
		S	333.33	546.87	119.79
	5	D	61,999.99	66,697.43	57,299.57
		S	59,666.66	62,523.65	56,809.67
	11	D	666.67	1,093.75	239.58
		S	16,333.33	18,297.17	14,369.48
23 AUGUST	1	D			
		S			
	2	D	333.33	635.33	31.34
		S	3,000.00	3,640.62	2,359.38
	5	D			
		S	32,999.99	36,537.52	29,462.47
	11	D	3,000.00	3,905.98	2,094.02
		S	333.33	546.87	119.79
7 SEPTEMBER	1	D	75,333.33	82,241.93	68,424.70
		S	1,999.99	2,729.06	1,270.92
	2	D			
		S			
	5	D			
		S	333.33	546.87	119.79
	11	D			
		S			
28 SEPTEMBER	1	D			
		S			
	2	D			
		S			
	5	D			
		S			
	11	D			
		S			

Table 8. Location, size (mm) and net movement of white sturgeon recaptured during spring-summer (May through August) 1990 sampling interval in Lower Granite Reservoir, Idaho-Washington.

Recapture		Initial capture					
Date	River mile	Date	River mile	Distance (Rm) moved	Total Length (mm)	Spaghetti no.	Metal no.
6/27/90	137.1	6/6/90	133.7	3.4 upstream	673	47	102
6/30/90	120.5	---	120.5	0	708	5/FY00429	6
7/10/90	137.1	6/27/90	137.1	0	446	143	---
7/10/90	137.1	---	---	---	1,025	72/IDFG-438	122
7/10/90	137.1	7/31/88	120.5	17.1 upstream	756	133/FY003616	155
7/10/90	137.1	5/29/90	116.5	20.6 upstream	522	17	41
7/14/90	117.7	6/14/90	121.1	3.4 downstream	664	95	72
7/19/90	133.7	6/10/90	130.4	3.3 upstream	681	52	103
7/19/90	133.7	5/27/90	114.6	19.1 upstream	791	27	25
7/19/90	133.7	6/11/90	137.1	3.4 downstream	722	45	57
7/26/90	127.0	7/18/90	127.0	0	604	126	126
7/27/90	133.7	6/11/90	137.1	3.4 downstream	697	44	104
7/27/90	133.7	6/18/90	127.0	6.7 upstream	623	86	94
7/27/90	133.7	7/15/90	116.5	17.2 upstream	773	173	150
7/27/90	133.7	6/27/90	137.1	3.4 downstream	940	99	109
8/11/90	120.5	7/03/90	119.9	0.6 upstream	481	114	166
8/13/90	119.9	7/30/90	110.5	9.4 upstream	1,410	221	15
8/16/90	133.7	7/18/90	127.0	6.7 upstream	737	128	143
8/16/90	133.7	5/27/90	114.5	19.2 upstream	645	20	9
8/16/90	133.7	6/23/90	137.1	3.4 downstream	727	92	63
8/16/90	133.7	5/28/90	115.5	18.2 upstream	771	32	27
8/16/90	133.7	7/03/90	119.9	3.8 upstream	658	122	212
8/23/90	137.1	6/27/90	137.1	0	764	106	113
8/23/90	137.1	8/16/90	133.7	3.4 upstream	534	212	247

Table 9. Location, size (mm) and net movement of white sturgeon recaptured during fall-winter (October through January) 1990-1991 sampling interval in Lower Granite Reservoir, Idaho-Washington.

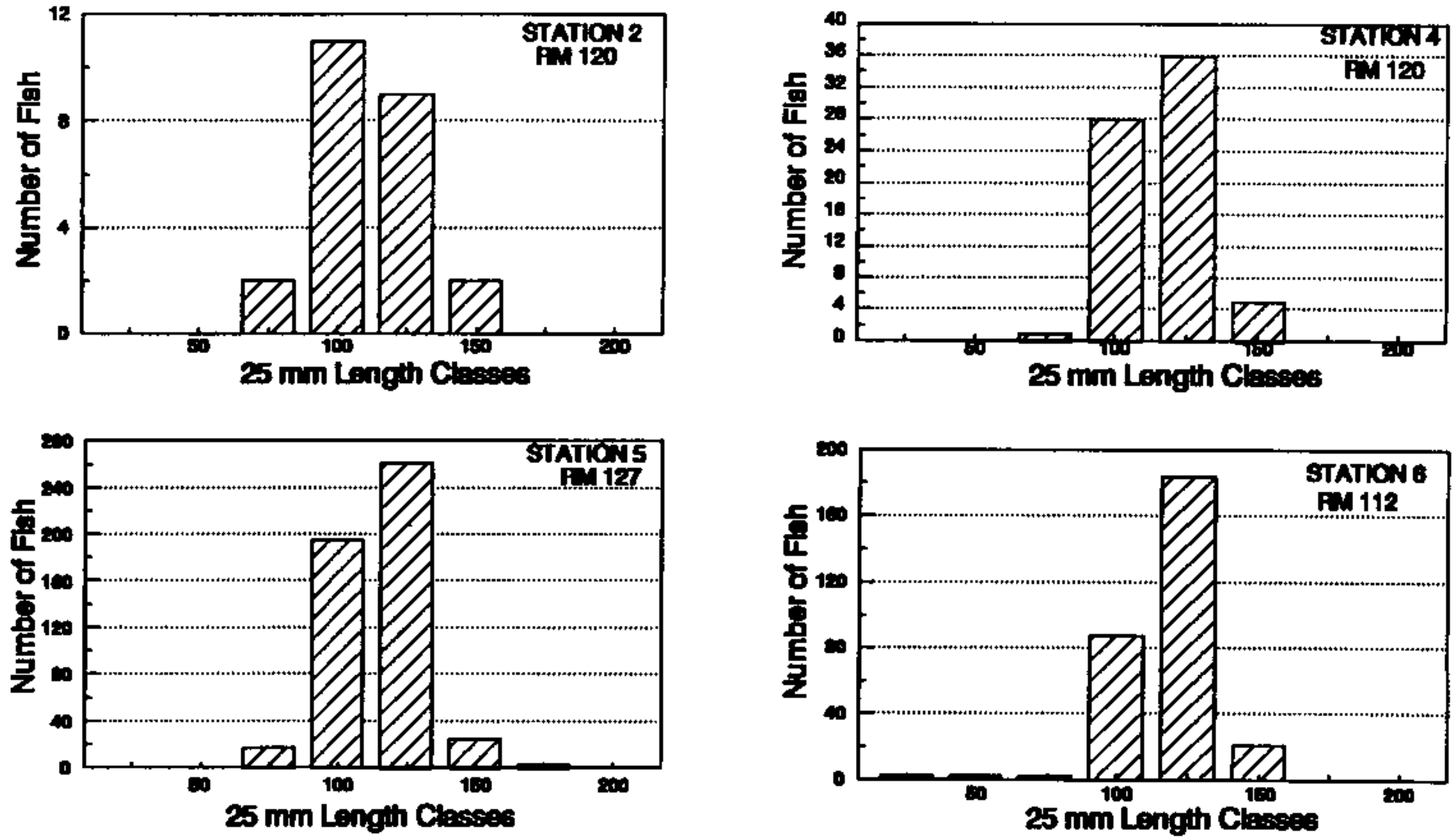
Recapture		Initial capture					
Date	River mile	Date	River mile	Distance (Rm) moved	Total Length (mm)	Spaghetti no.	Metal no.
10/12/90	120.5	5/29/90	115.5	5.0 upstream	774	31	28
10/23/90	133.7	8/14/90	121.1	12.6 upstream	791	98	95
10/23/90	133.7	7/27/90	133.7	0	780	—	123
10/23/90	133.7	8/28/90	127.0	6.7 upstream	484	07	—
10/23/90	133.7	5/29/90	115.5	18.2 upstream	850	42	32
10/23/90	133.7	7/18/90	127.0	6.7 upstream	800	137	158
11/03/90	137.1	7/27/90	133.7	3.4 upstream	563	198	—
✱✱ 11/03/90	137.1	8/23/90	137.1	0	785	108	113
11/17/90	133.7	7/18/90	127.0	6.7 upstream	828	130	149
11/17/90	133.7	8/16/90	127.0	6.7 upstream	780	191	272
✱✱ 11/21/90	137.1	11/03/90	133.7	0	563	198	—
11/21/90	137.1	8/16/90	133.7	3.4 upstream	503	202	368
11/29/90	116.5	5/27/90	114.6	1.9 upstream	757	21	22
12/12/90	137.0	8/11/90	137.1	0	114.2	25	93

✱✱ Double recapture

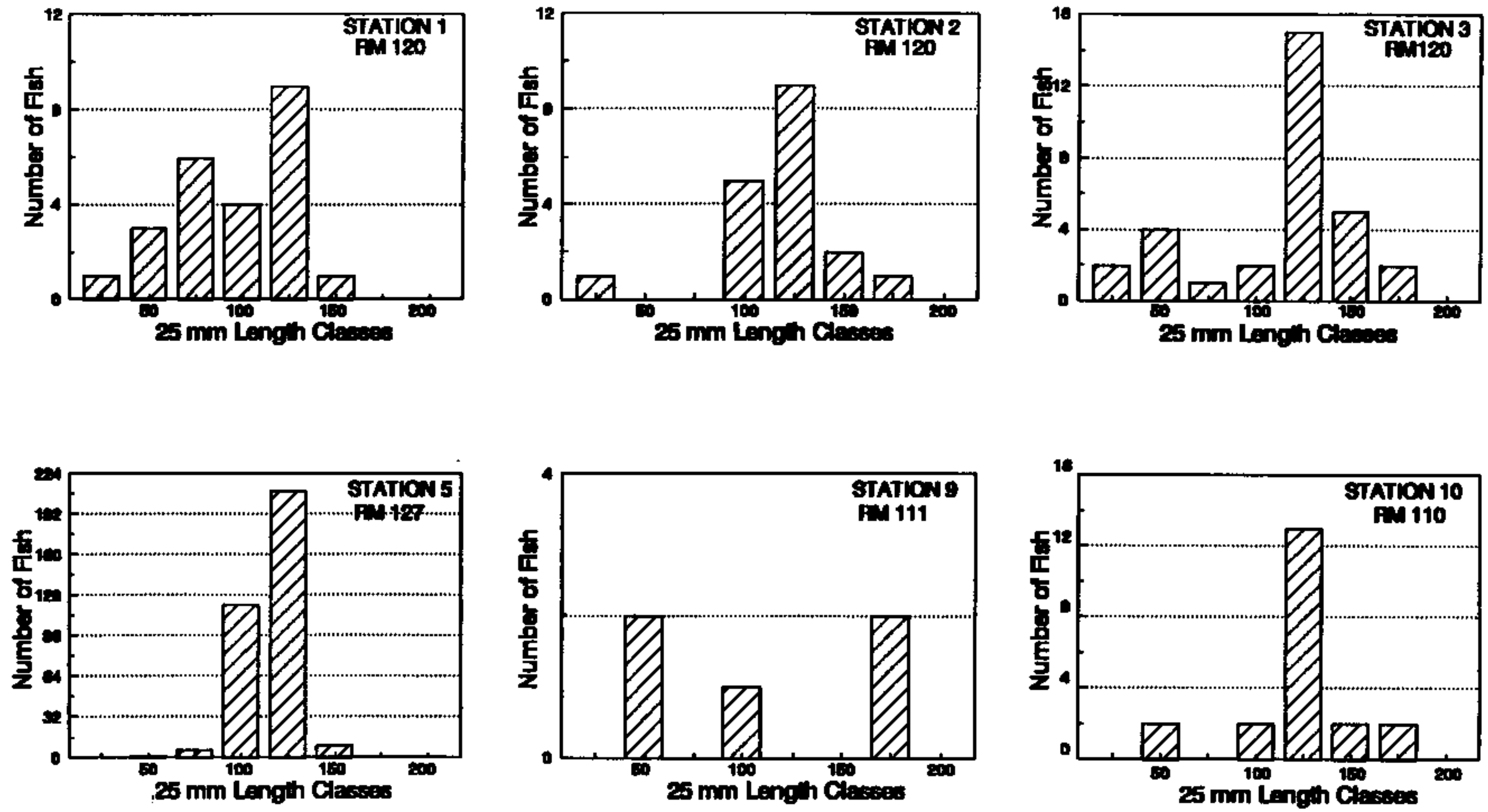
Table 10. Summary by food items consumed by northern squawfish in Lower Granite Reservoir during Spring 1990.

FOOD ITEM	OCCURRENCE			NUMBER			WEIGHT		
	# S.	%	%FREQ	TOT.	%	MEAN	TOT.	%	MEAN
DECAPODA	59	29.6	47.5	68	34.3	0.3	337.0	34.3	1.6
INSECT PARTS	12	6.0	9.6	0	0.0	0.0	6.2	0.6	0.0
COLEOPTERA	10	5.0	8.0	31	15.6	0.1	2.4	0.2	0.0
EPHEMEROPTERA	2	1.0	1.6	2	1.0	0.0	0.4	0.0	0.0
HEMIPTERA	1	0.5	0.8	1	0.5	0.0	0.0	0.0	0.0
HYMENOPTERA	17	8.5	13.7	40	20.2	0.2	7.4	0.7	0.0
ODONATA	1	0.5	0.8	1	0.5	0.0	0.0	0.0	0.0
ORTHOPTERA	1	0.5	0.8	1	0.5	0.0	0.0	0.0	0.0
PLECOPTERA	1	0.5	0.8	2	1.0	0.0	0.0	0.0	0.0
FISH (UID)	10	5.0	8.0	10	5.0	0.0	24.3	2.4	0.1
NON-SALMONIDAE (UID)	2	1.0	1.6	2	1.0	0.0	0.3	0.0	0.0
SALMONIDAE (UID)	16	8.0	12.9	17	8.5	0.0	79.5	8.1	0.3
Chinook	7	3.5	5.6	7	3.5	0.0	35.8	3.6	0.1
Rainbow/Sthd.	10	5.0	8.0	10	5.0	0.0	365.4	37.2	1.8
CATOSTOMIDAE	5	2.5	4.0	5	2.5	0.0	68.3	6.9	0.3
MISC. FOOD	1	0.5	0.8	1	0.5	0.0	14.6	1.4	0.0
PLANT (FOOD)	4	2.0	3.2	0	0.0	0.0	38.2	3.9	0.1

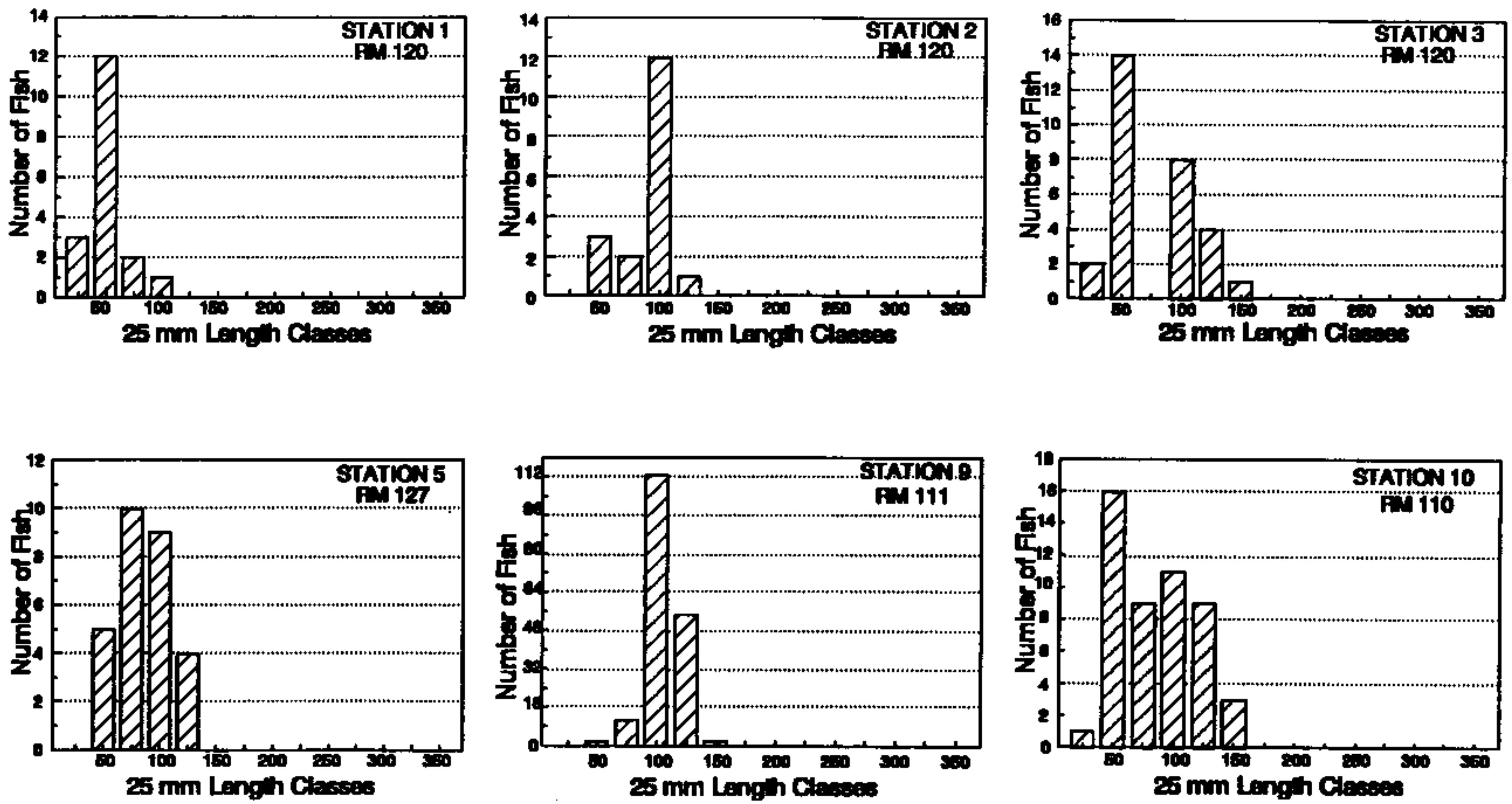
APPENDIX FIGURES



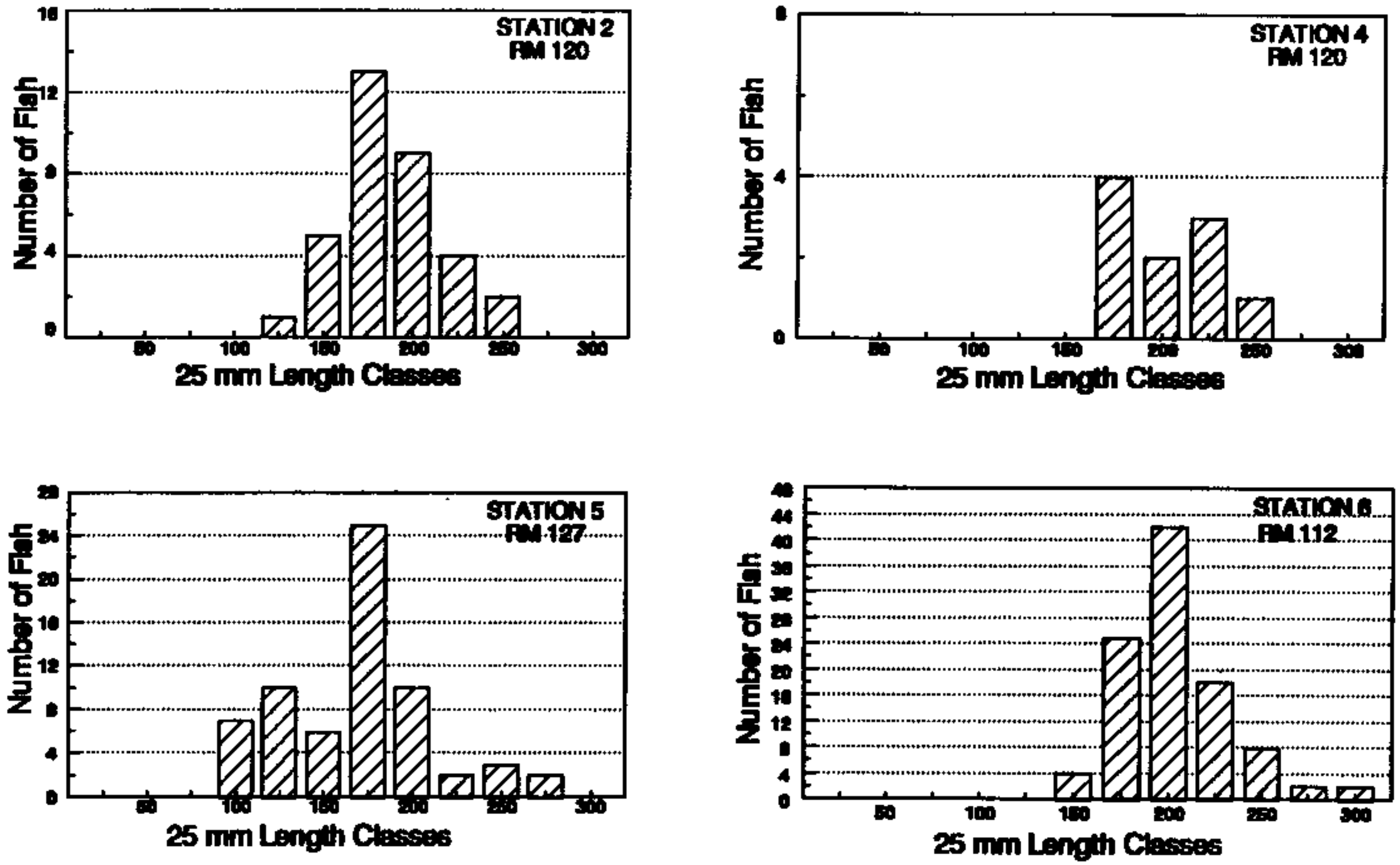
Appendix Figure 1. Length frequency distributions of juvenile chinook salmon sampled by surface trawling at shallow water disposal (2) and reference stations (5) and mid-depth disposal (4) and reference stations (6) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



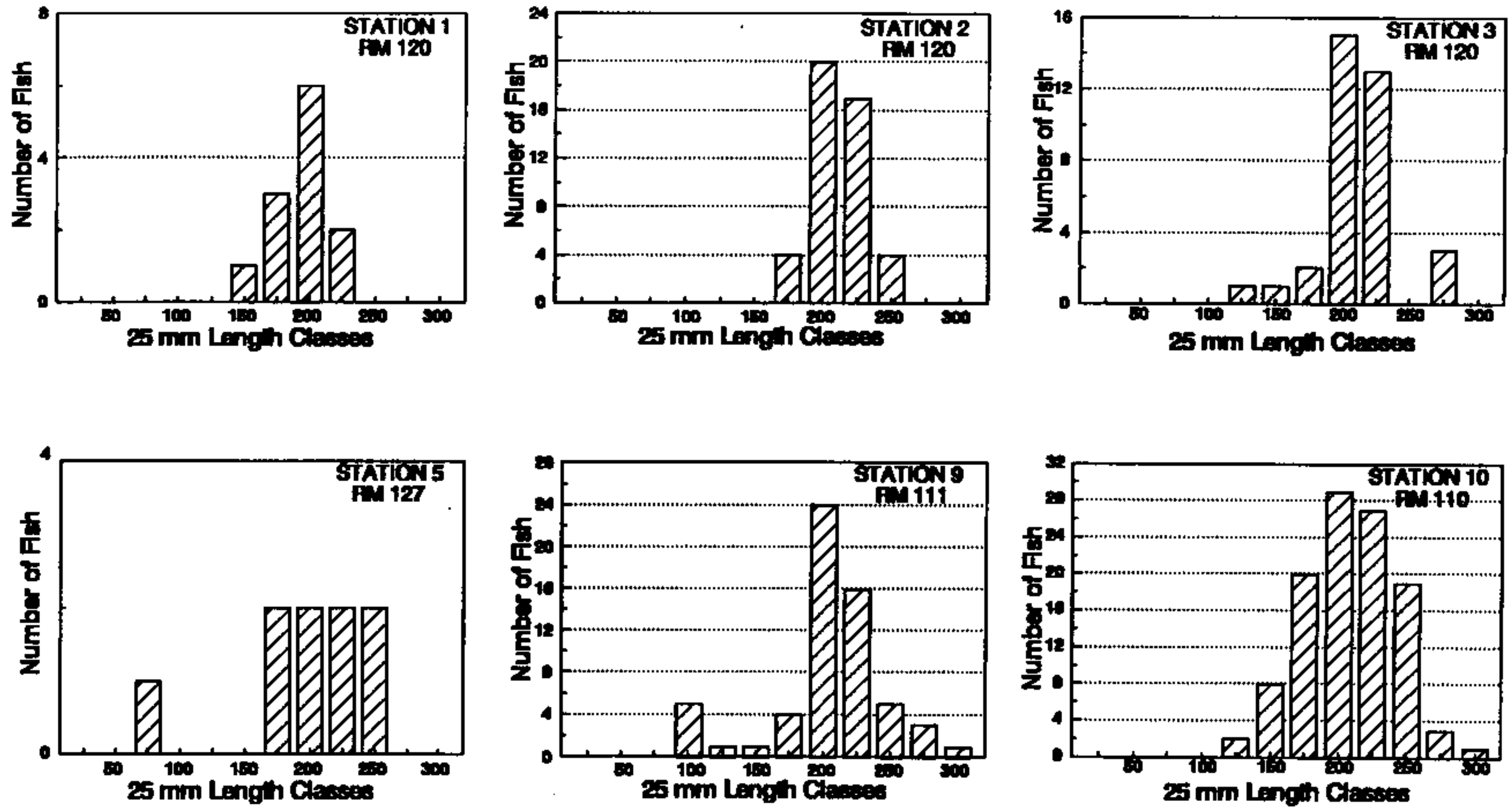
Appendix Figure 2. Length frequency distributions of juvenile chinook salmon sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



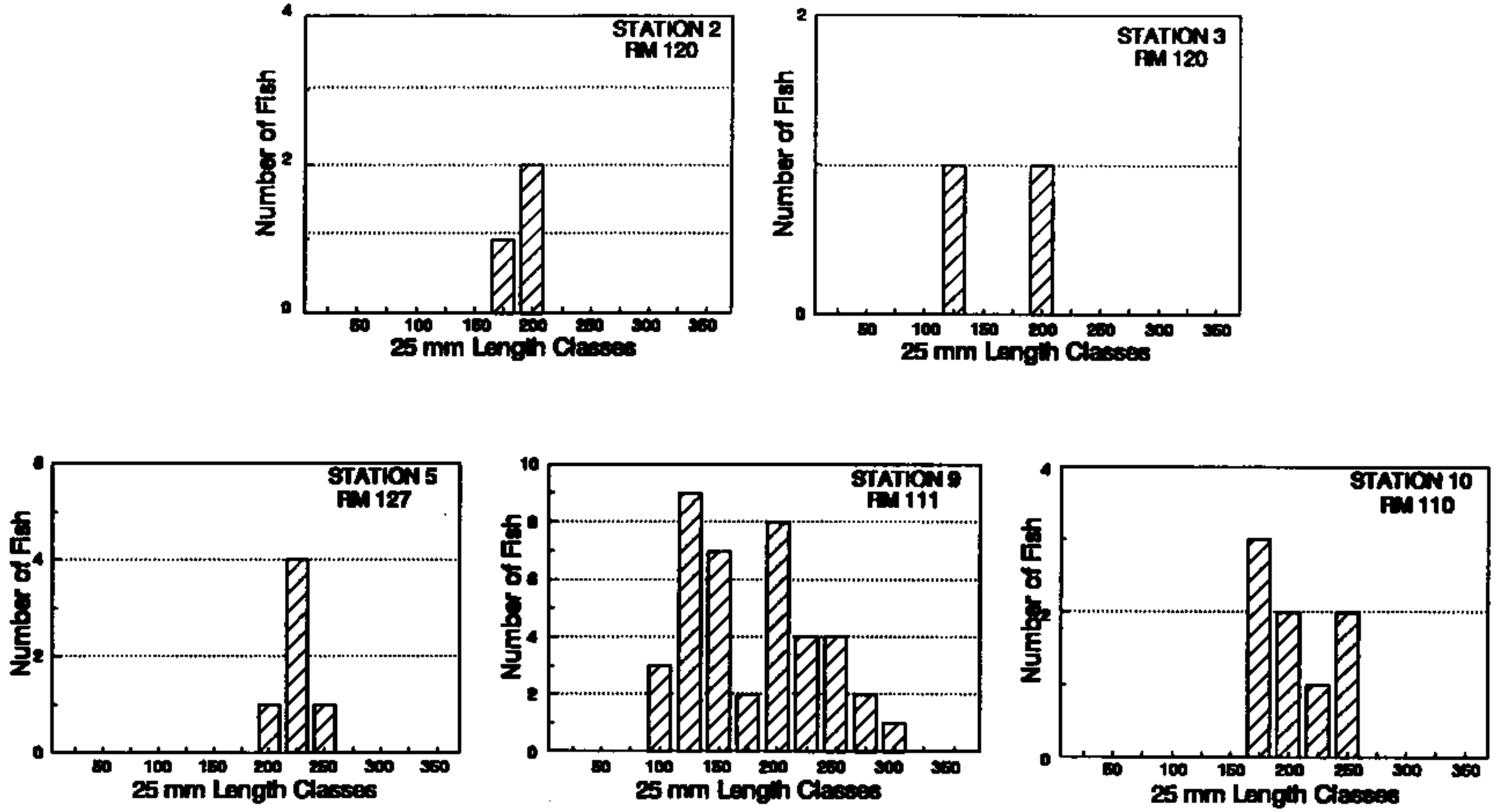
Appendix Figure 3. Length frequency distributions of juvenile chinook salmon sampled by beach seining at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



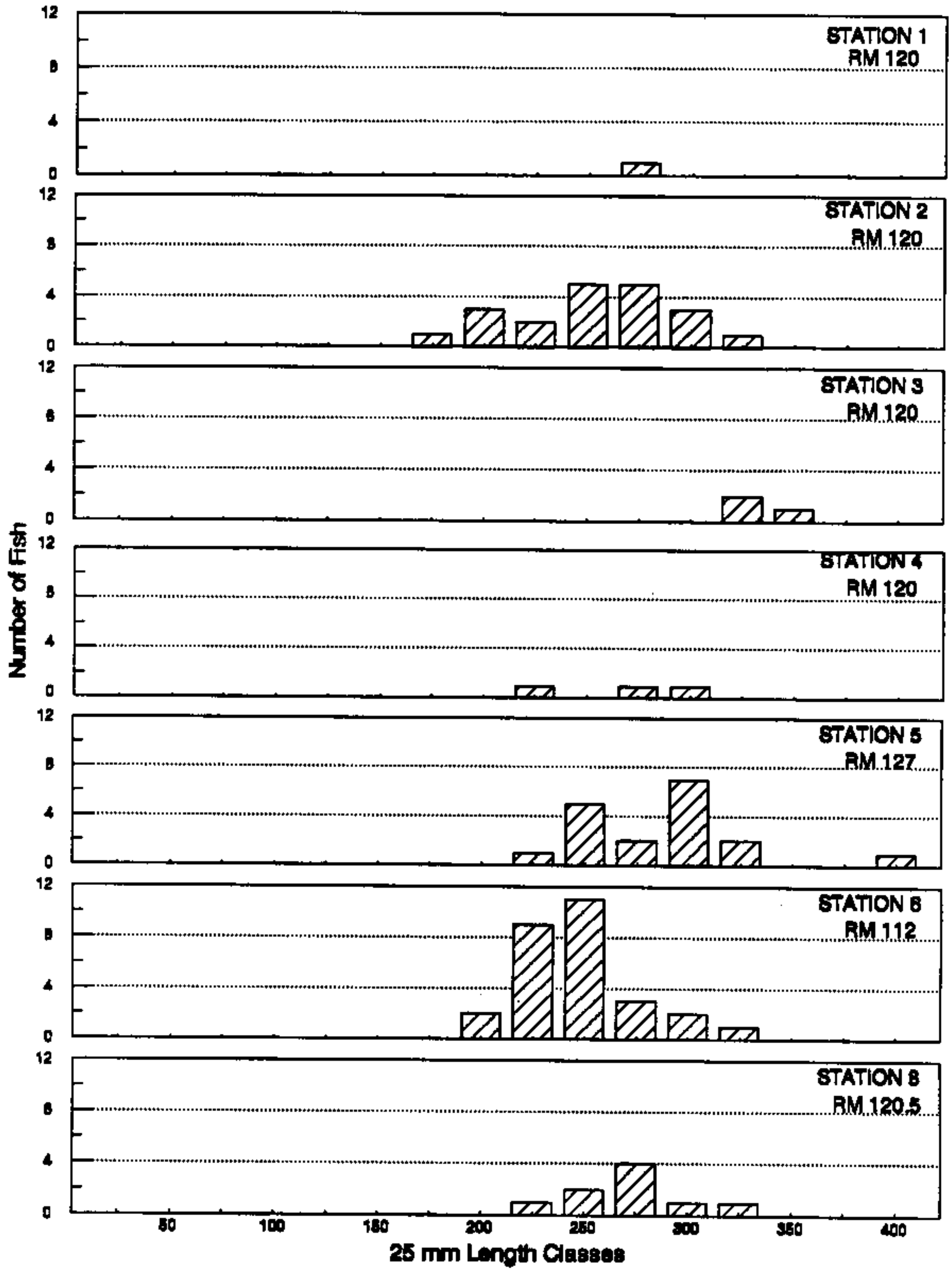
Appendix Figure 4. Length frequency distributions of juvenile steelhead sampled by surface trawling at shallow water disposal (2) and reference stations (5) and mid-depth disposal (4) and reference stations (6) in Lower Granite Reservoir, Idaho-Washington during spring 1990 .



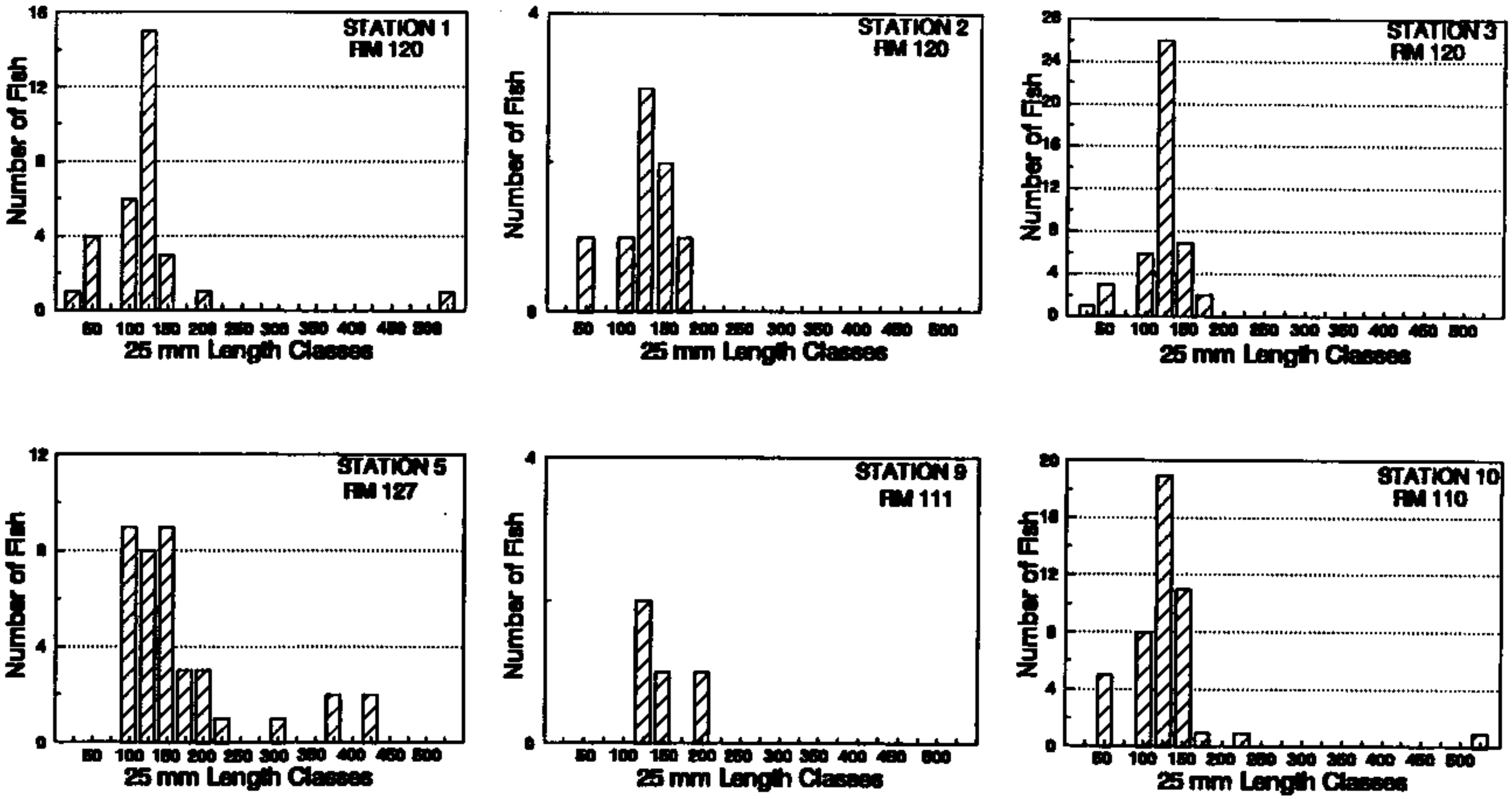
Appendix Figure 5. Length frequency distributions of juvenile steelhead sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



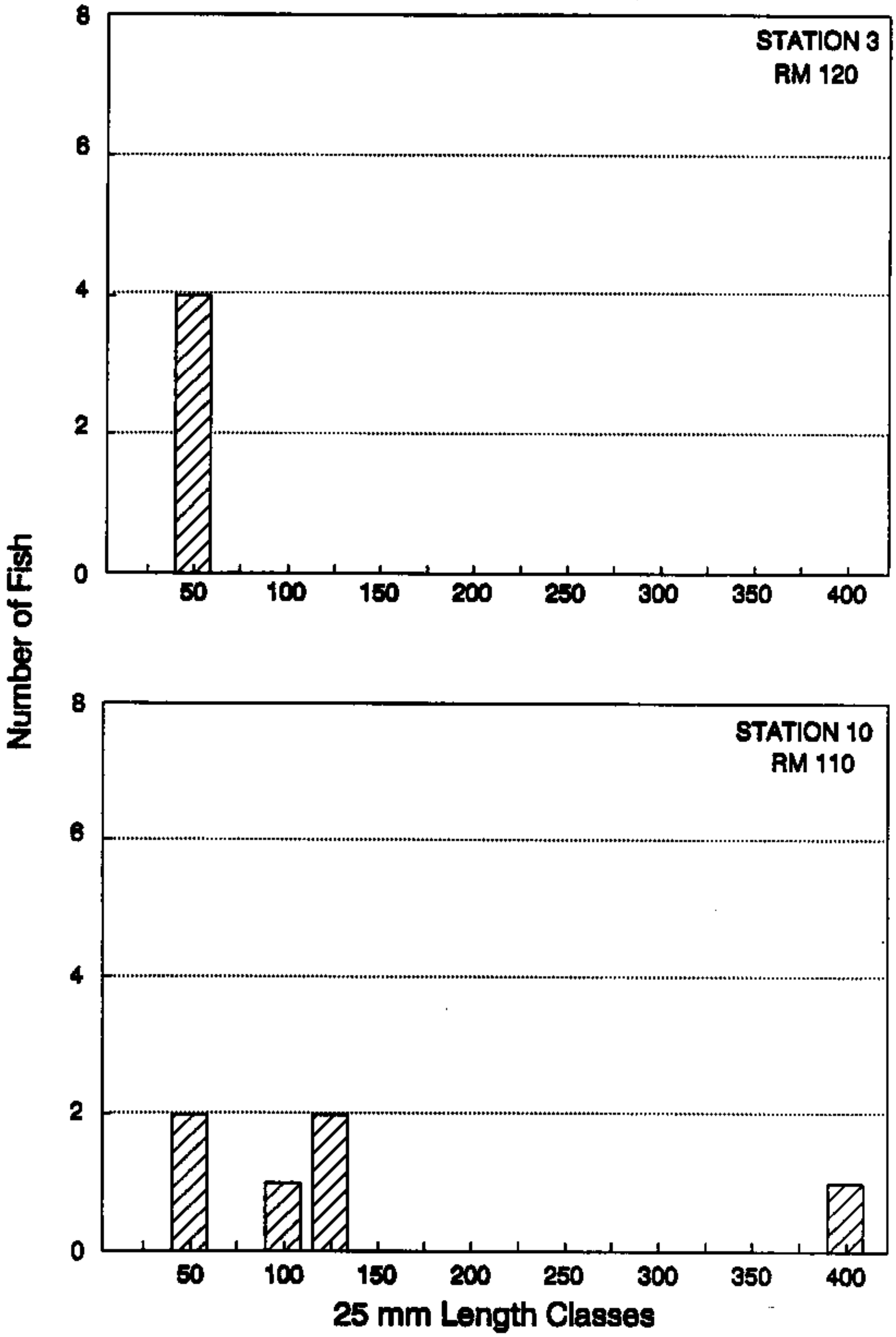
Appendix Figure 6. Length frequency distributions of juvenile steelhead sampled by beach seining at shallow water disposal (2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



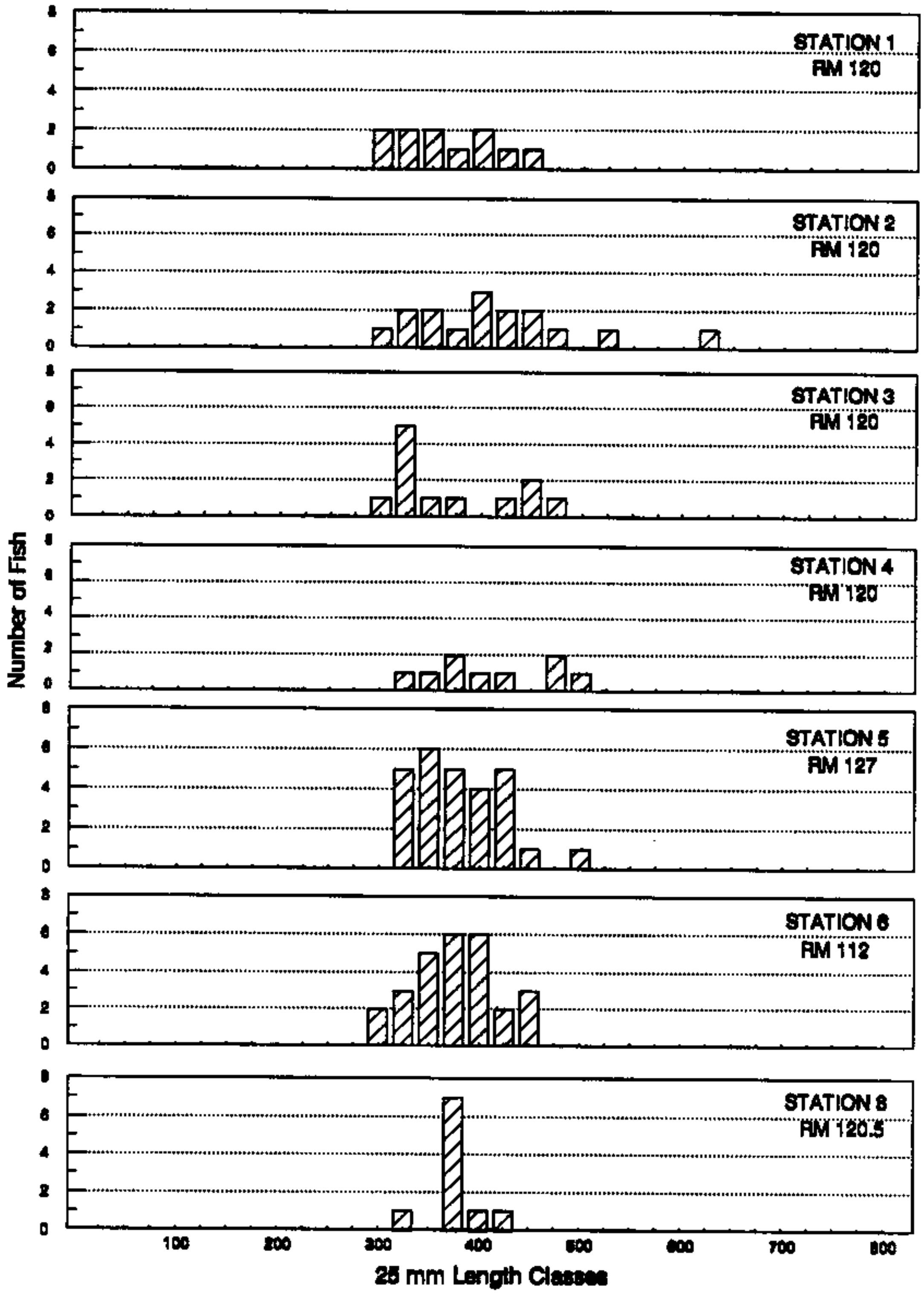
Appendix Figure 7. Length frequency distributions of juvenile steelhead sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during spring 1990.



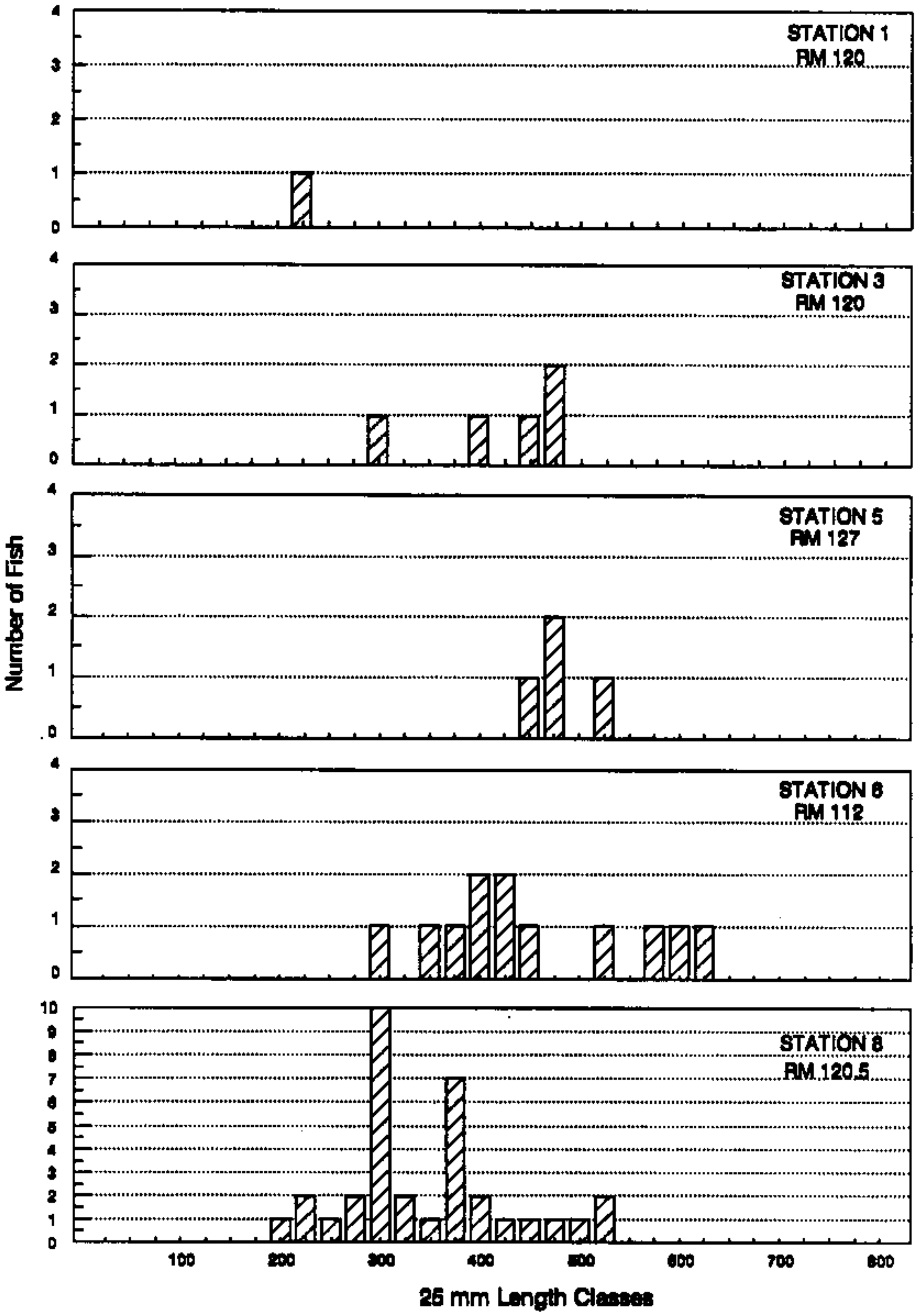
Appendix Figure 8. Length frequency distributions of northern squawfish sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference stations (3, 5, 9 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



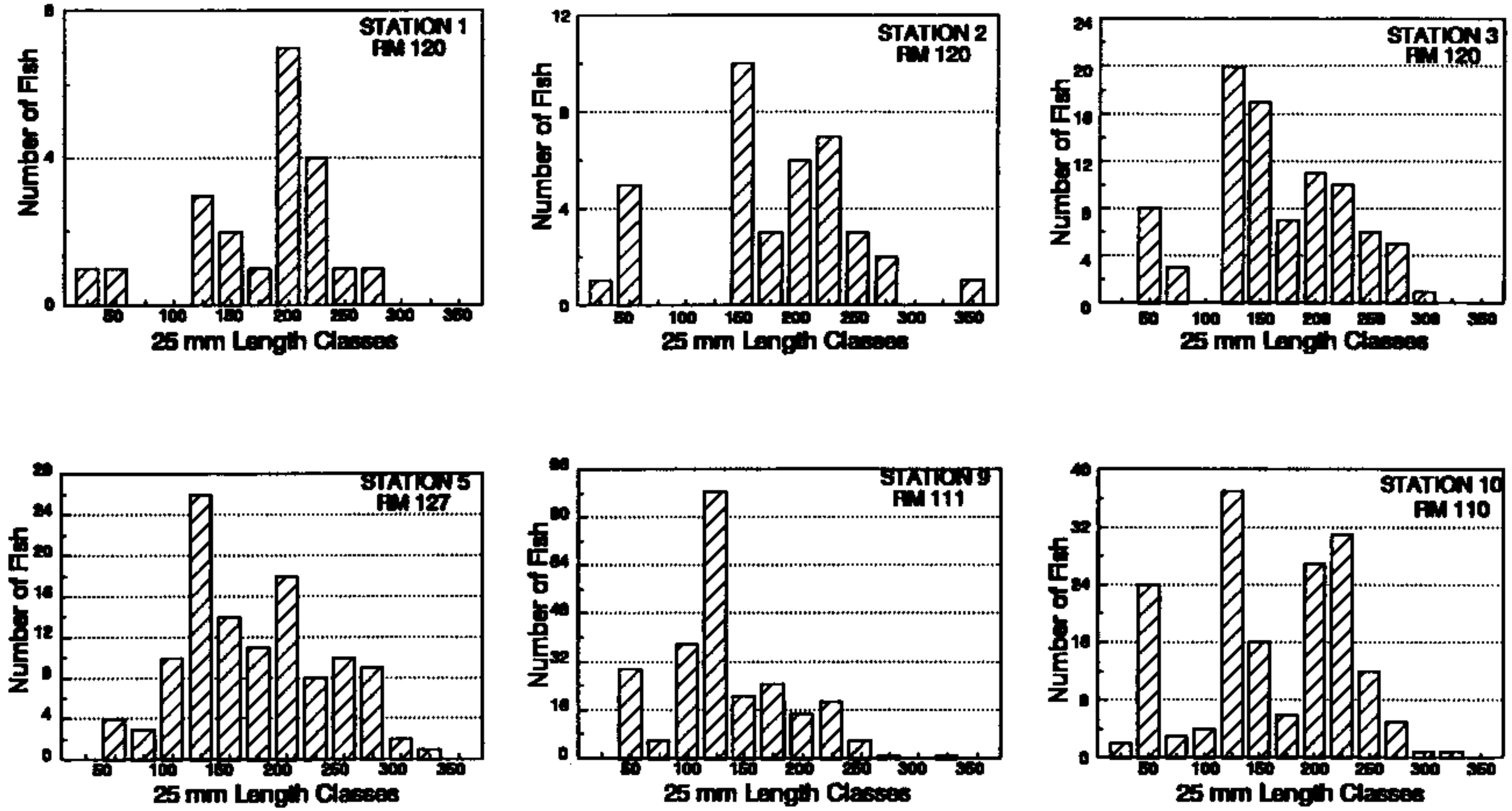
Appendix Figure 9. Length frequency distributions of northern squawfish sampled by beach seining at reference stations (3 and 10) in Lower Granite Reservoir, Idaho-Washington during spring 1990.



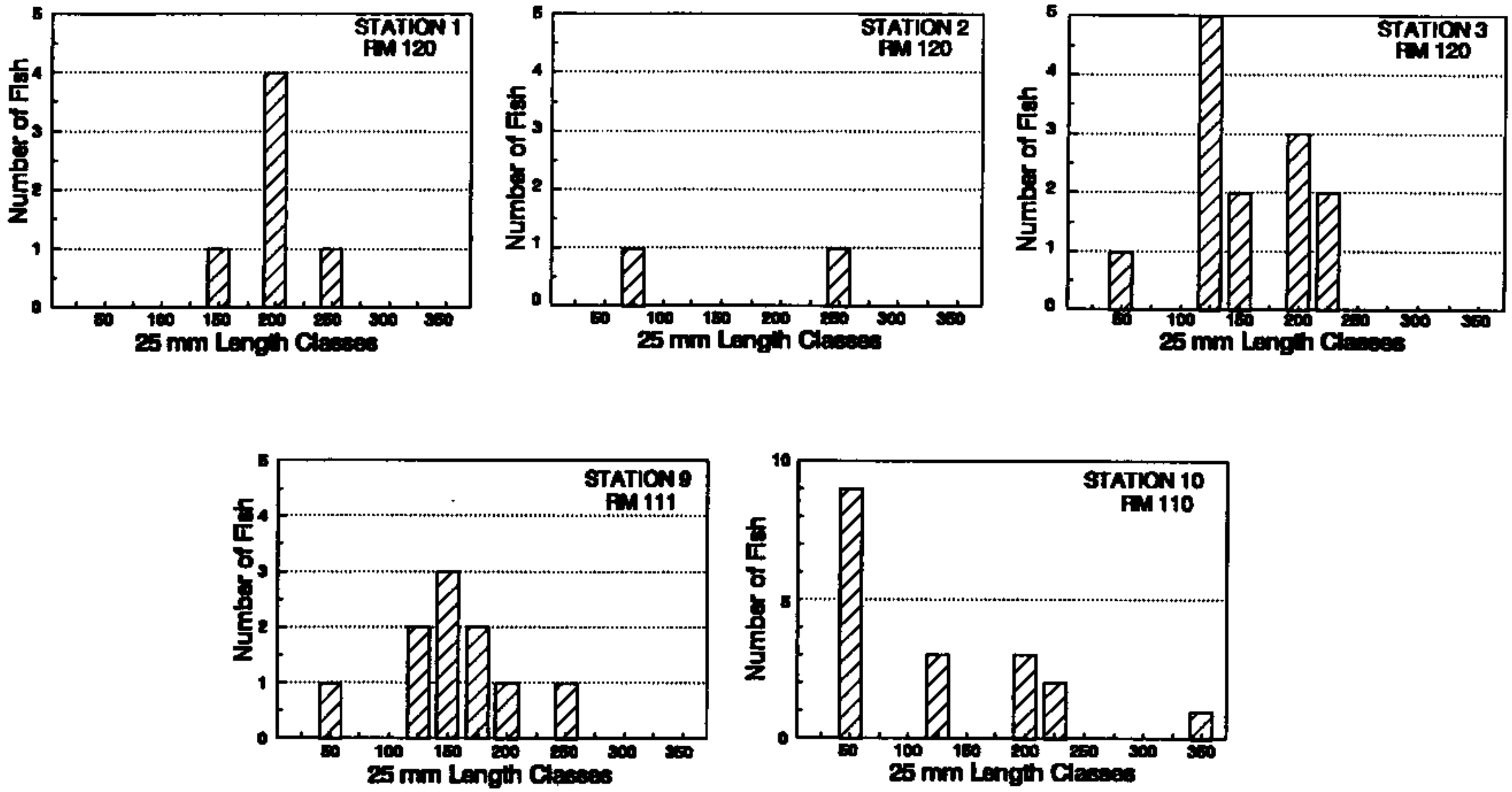
Appendix Figure 10. Length frequency distributions of northern squawfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during spring 1990.



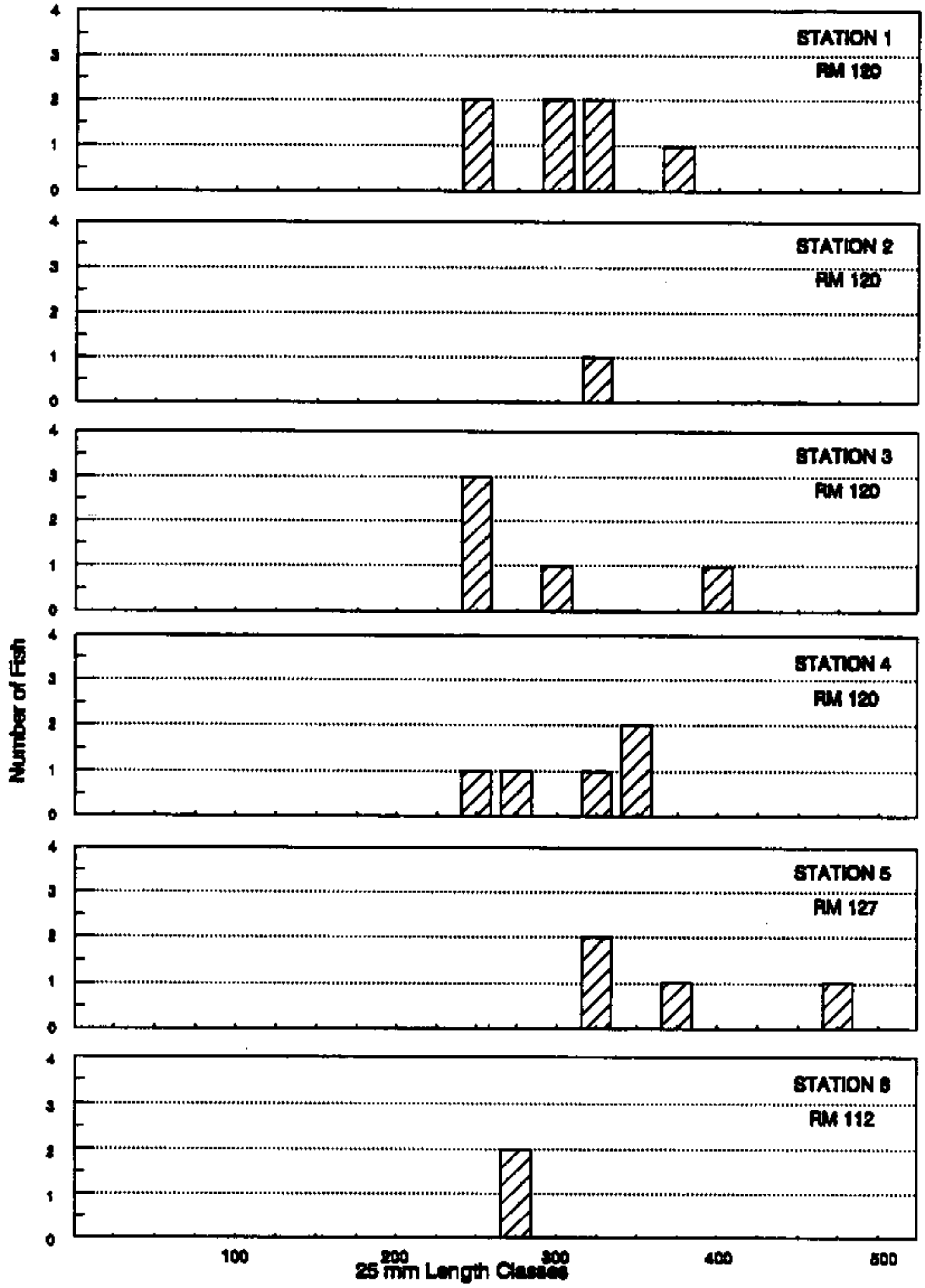
Appendix Figure 11. Length frequency distributions of channel catfish sampled by gill netting at shall water disposal (1) and reference (3 and 5) stations and mid-depth (6) and deep water (8) reference stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.



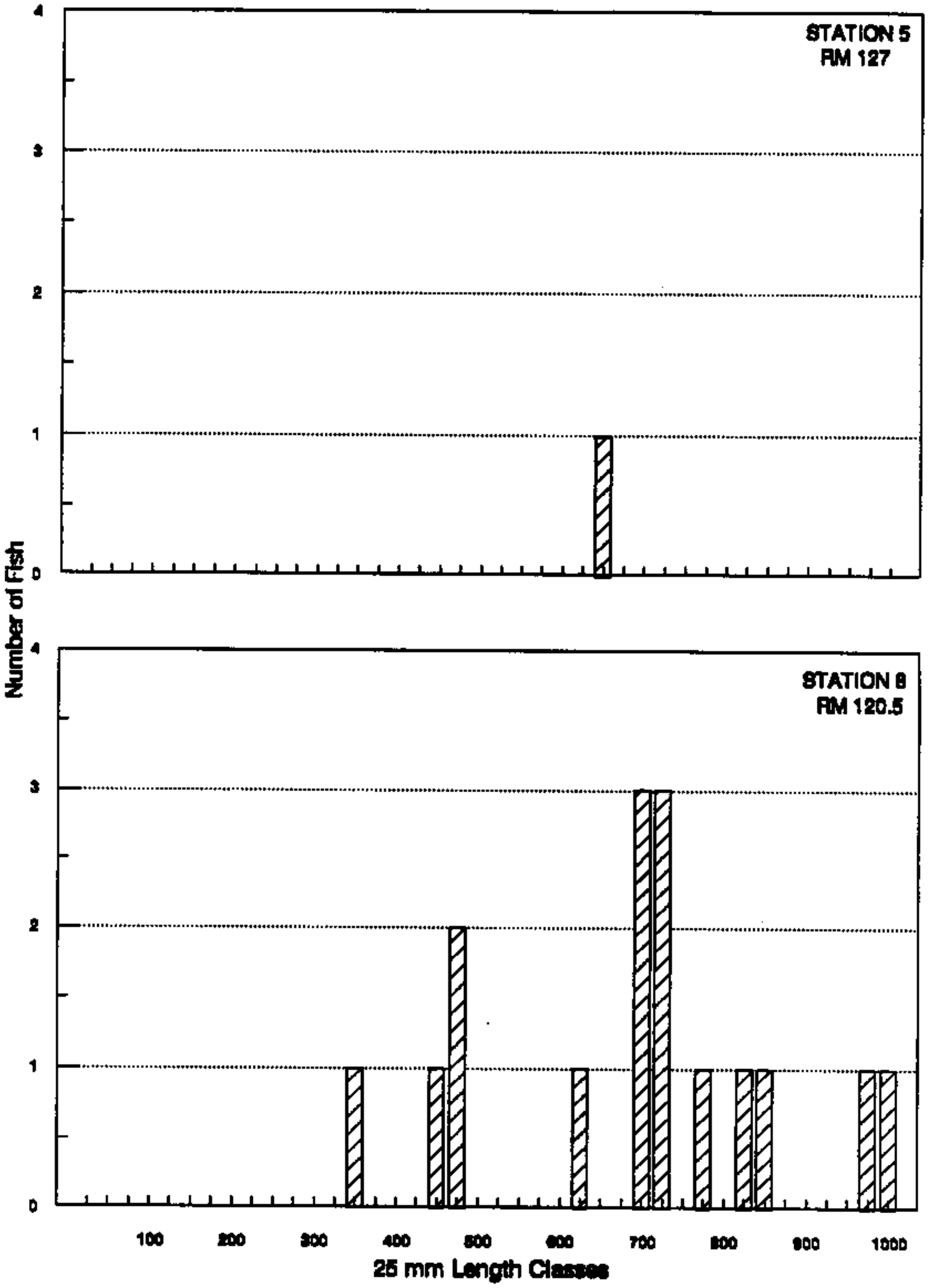
Appendix Figure 12. Length frequency distributions of smallmouth bass sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.



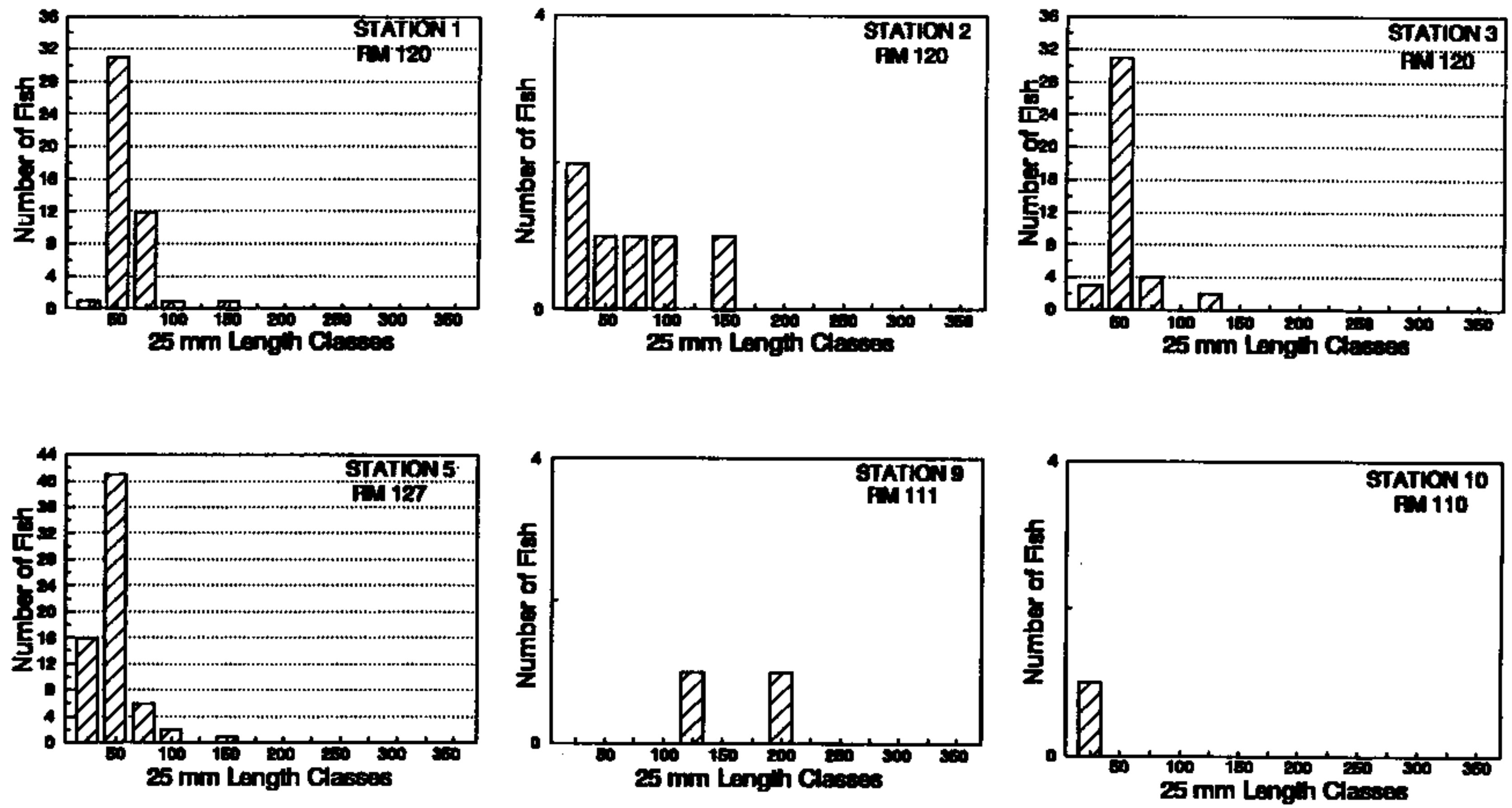
Appendix Figure 13. Length frequency distributions of smallmouth bass sampled by beach seining at shallow water disposal (1 and 2) and reference (3, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.



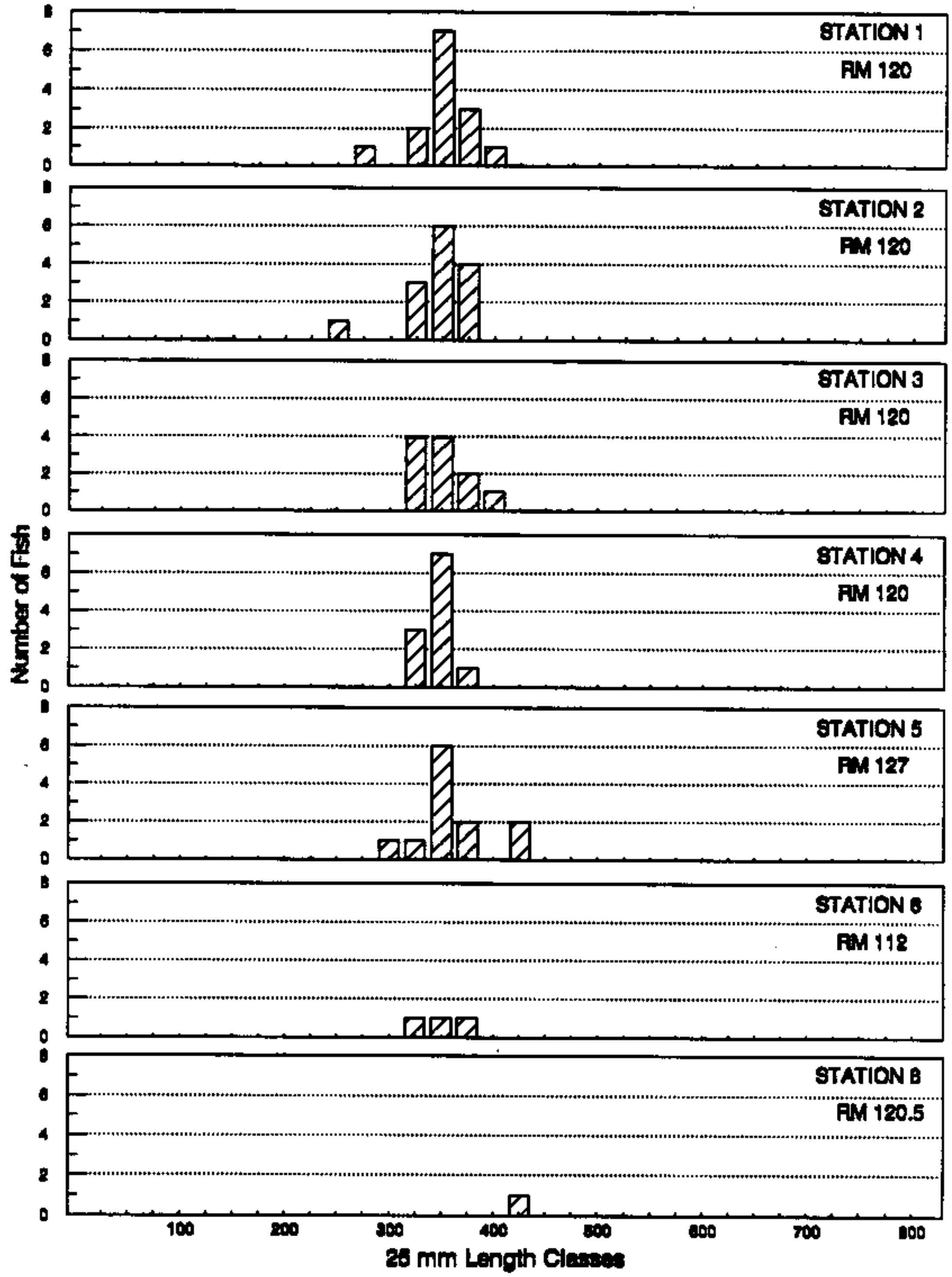
Appendix Figure 14. Length frequency distributions of smallmouth bass sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations and mid-depth disposal (4) and reference (6) stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.



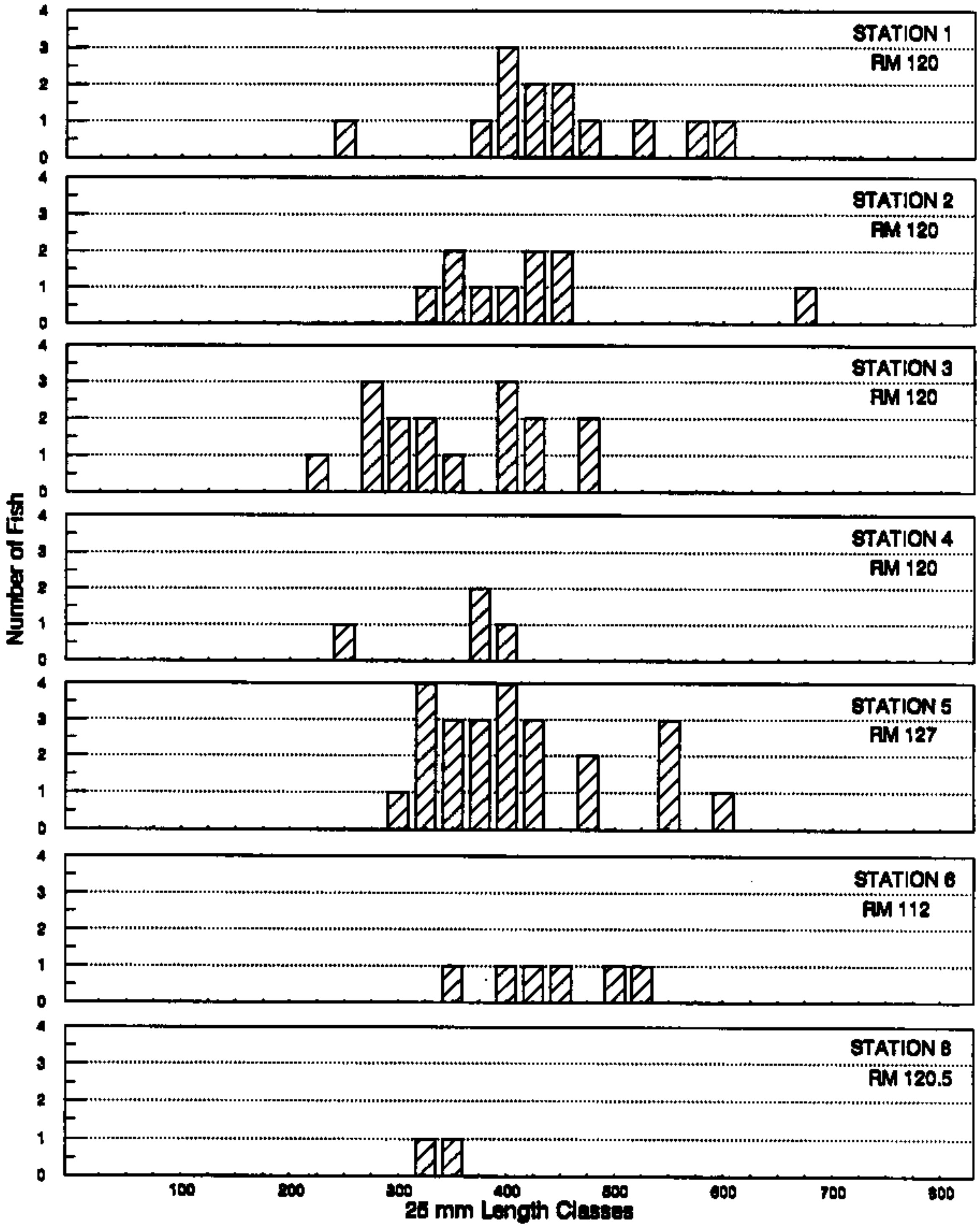
Appendix Figure 15. Length frequency distributions of white sturgeon sampled by gill netting at shallow water (5) and deep water (8) reference stations in Lower Granite Reservoir, Idaho-Washington during spring 1990.



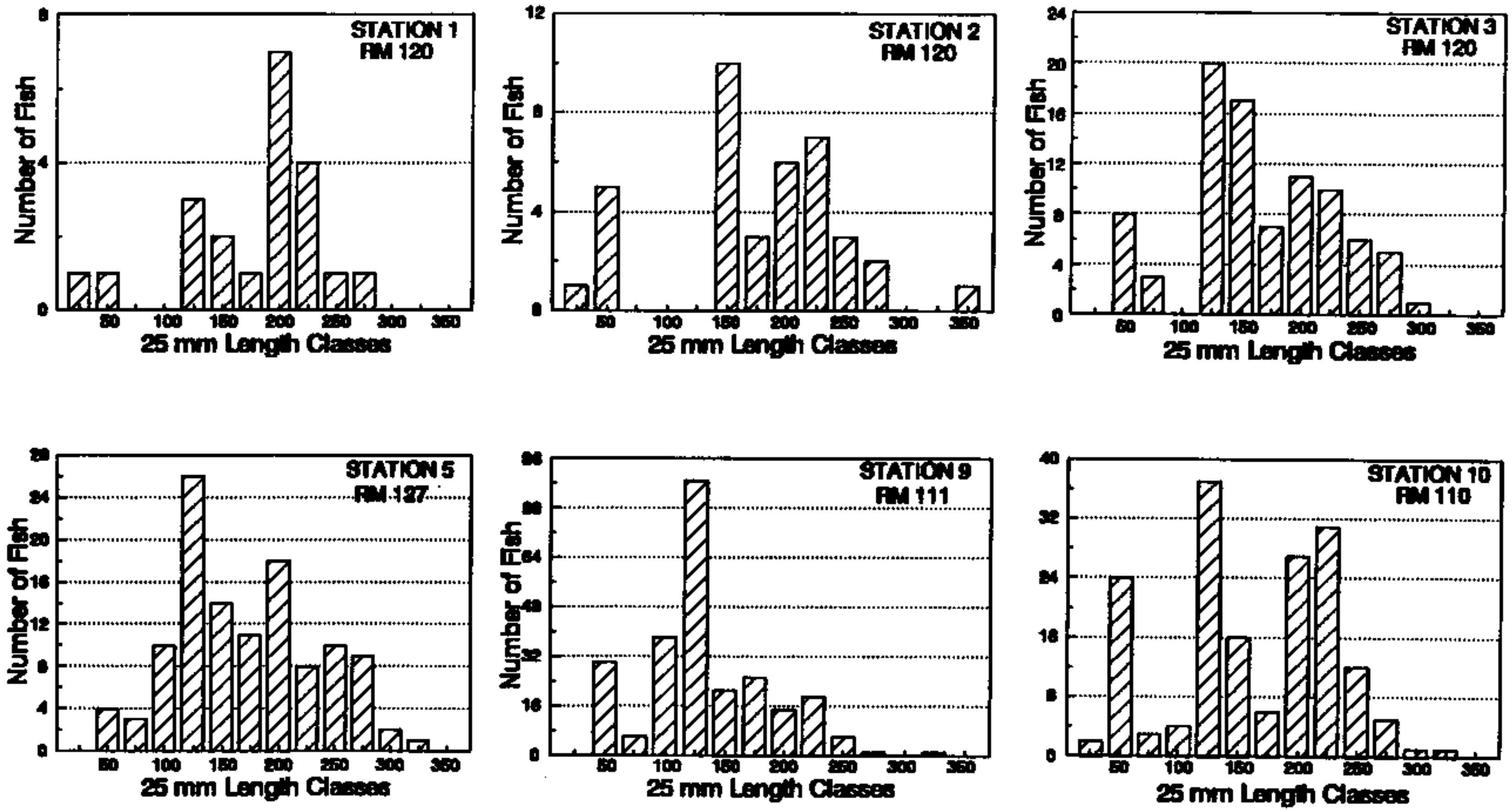
Appendix Figure 16. Length frequency distributions of northern squawfish sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during summer 1990.



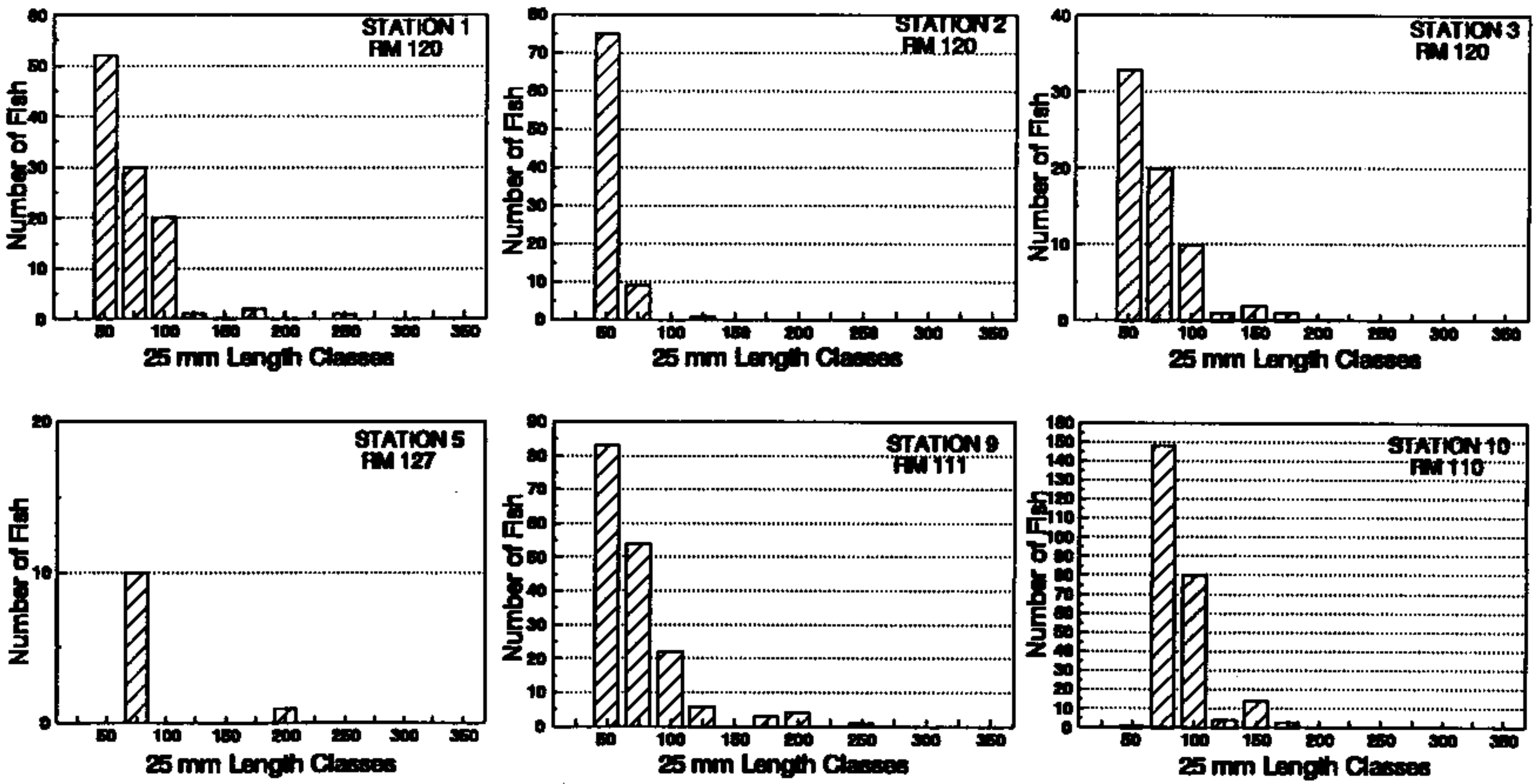
Appendix Figure 17. Length frequency distributions of northern squawfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir during summer 1990.



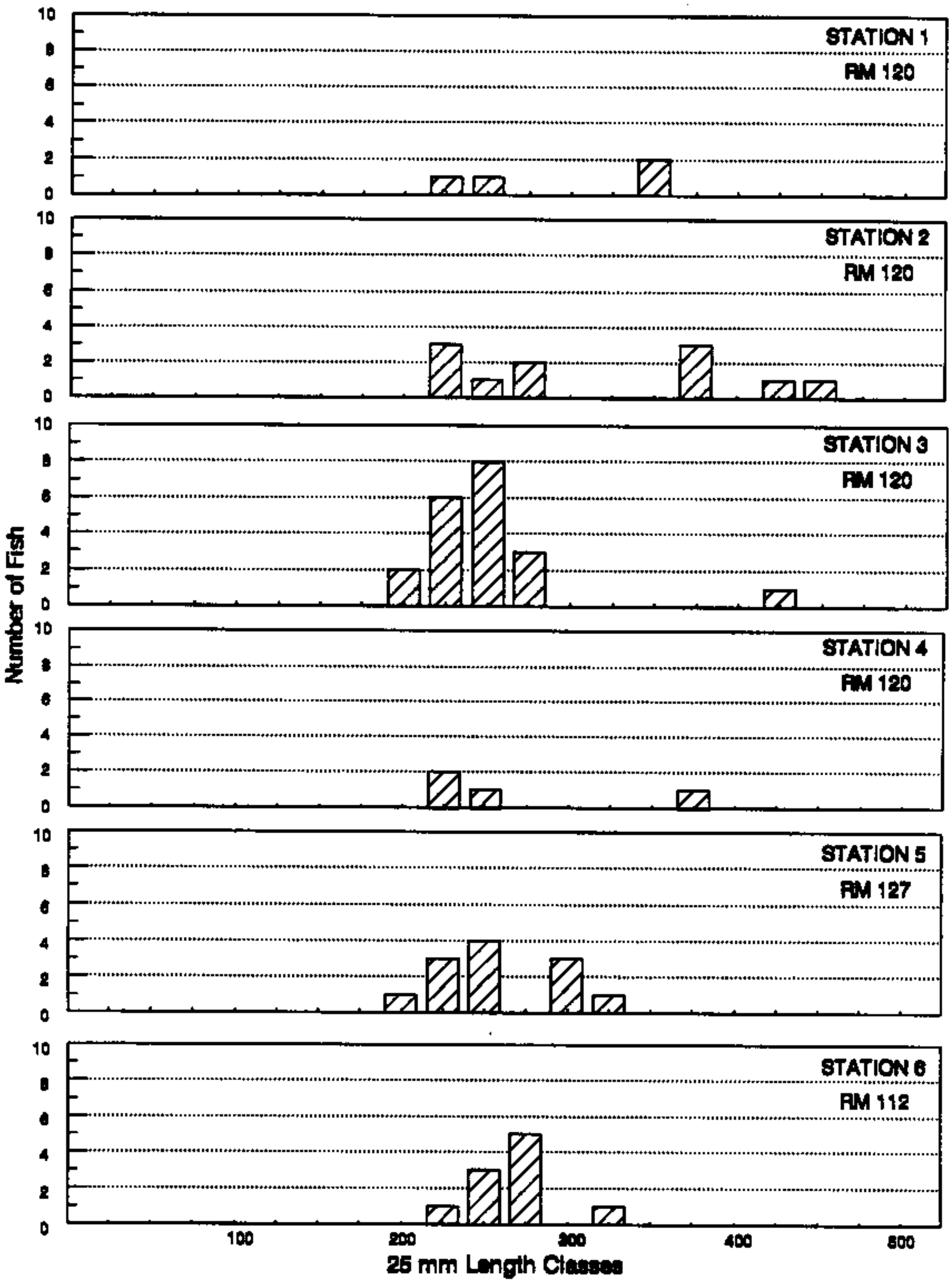
Appendix Figure 18. Length frequency distributions of channel catfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during summer 1990.



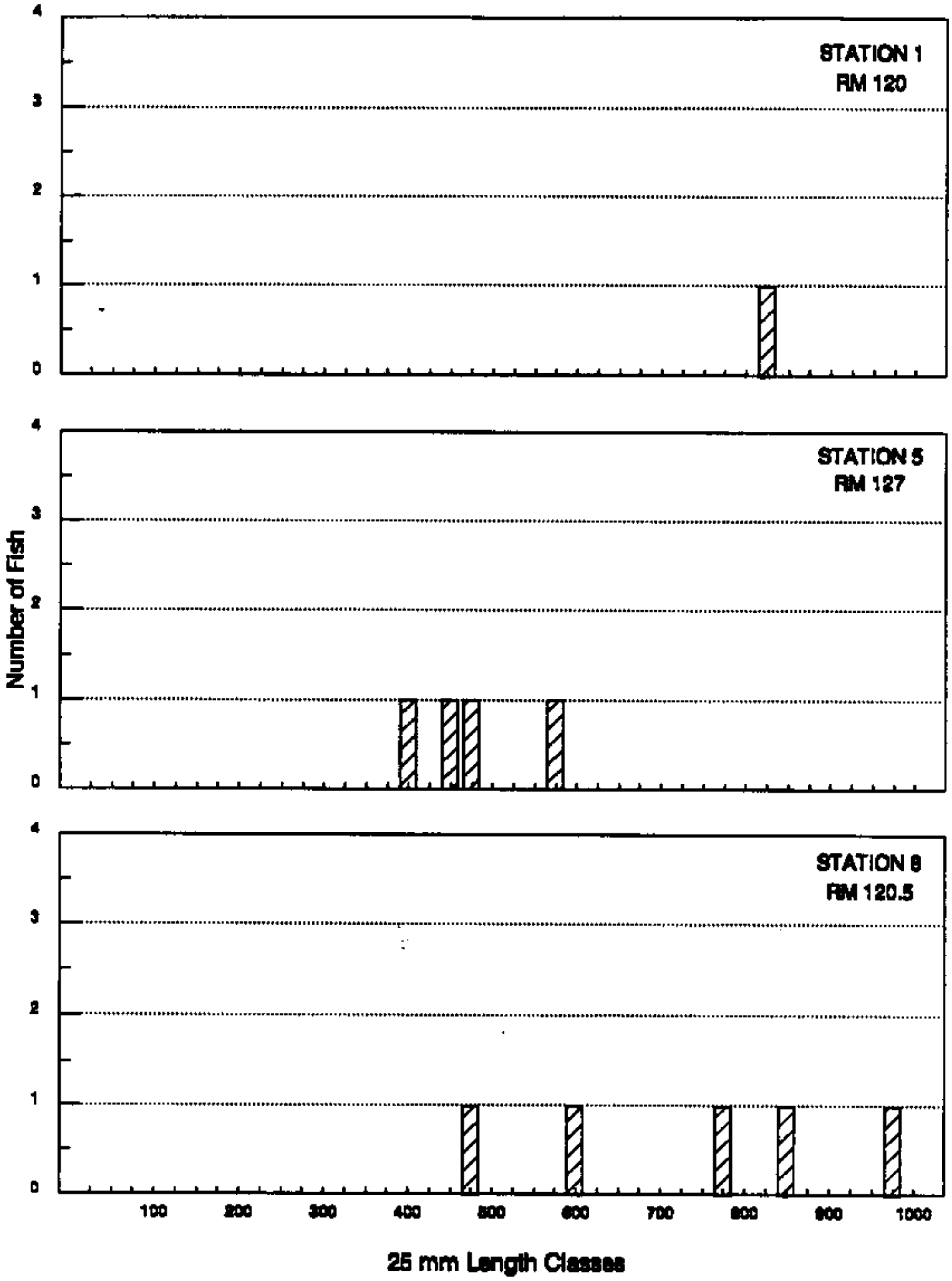
Appendix Figure 19. Length frequency distributions of smallmouth bass sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during summer 1990.



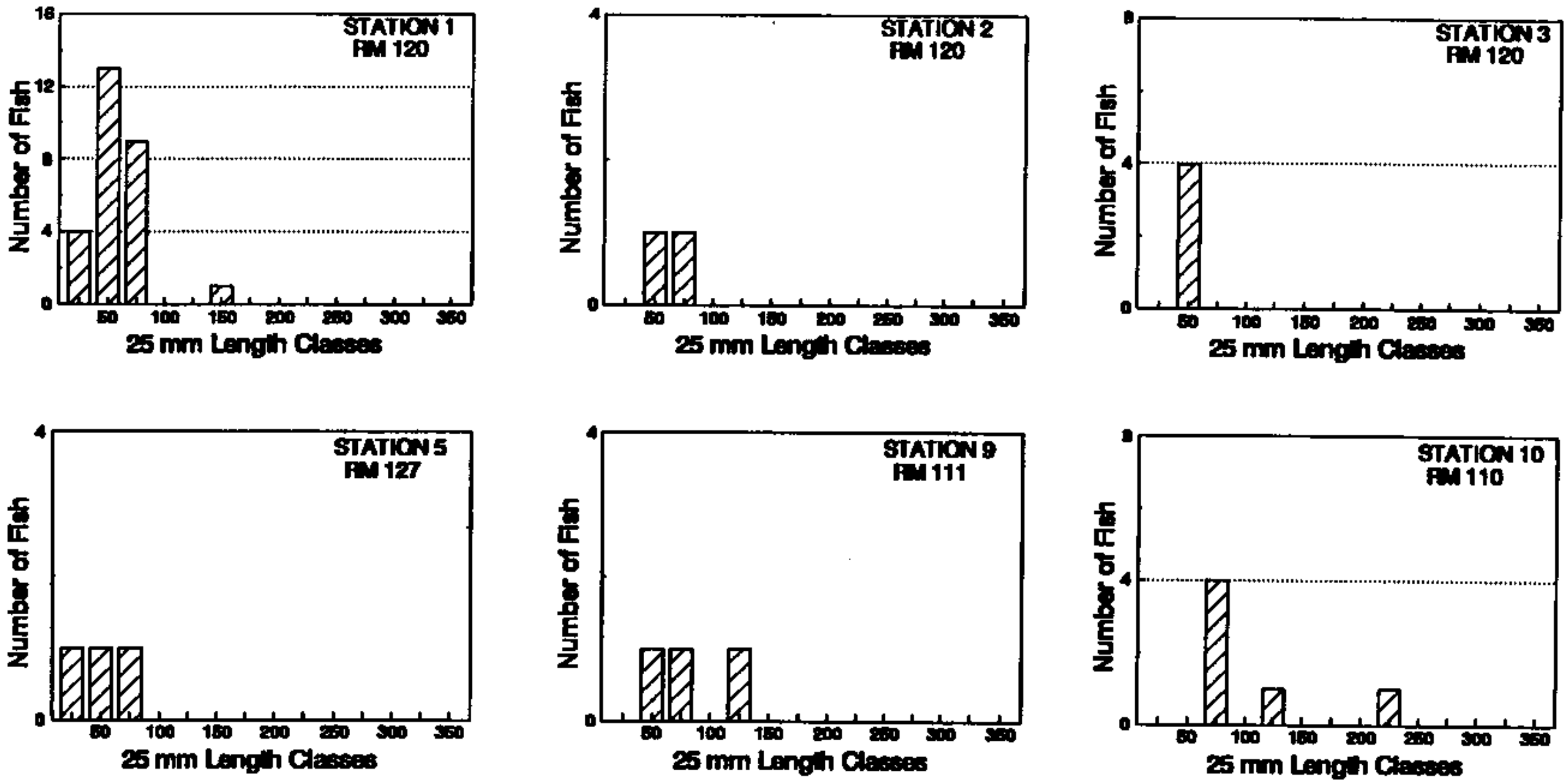
Appendix Figure 20. Length frequency distributions of smallmouth bass sampled by beach seining at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during summer 1990.



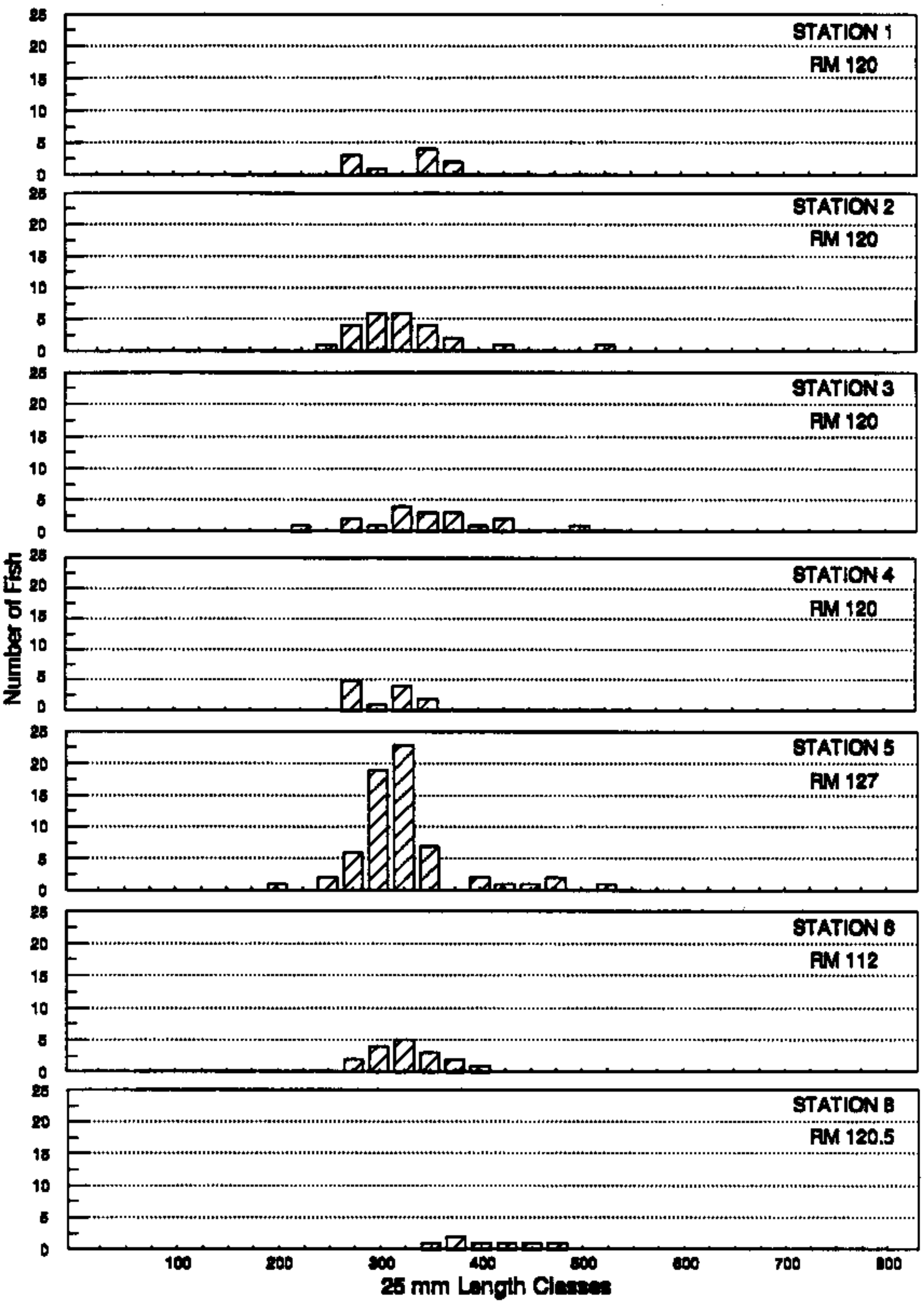
Appendix Figure 21. Length frequency distributions of smallmouth bass sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations and mid-depth disposal (4) and reference (6) stations in Lower Granite Reservoir during summer 1990.



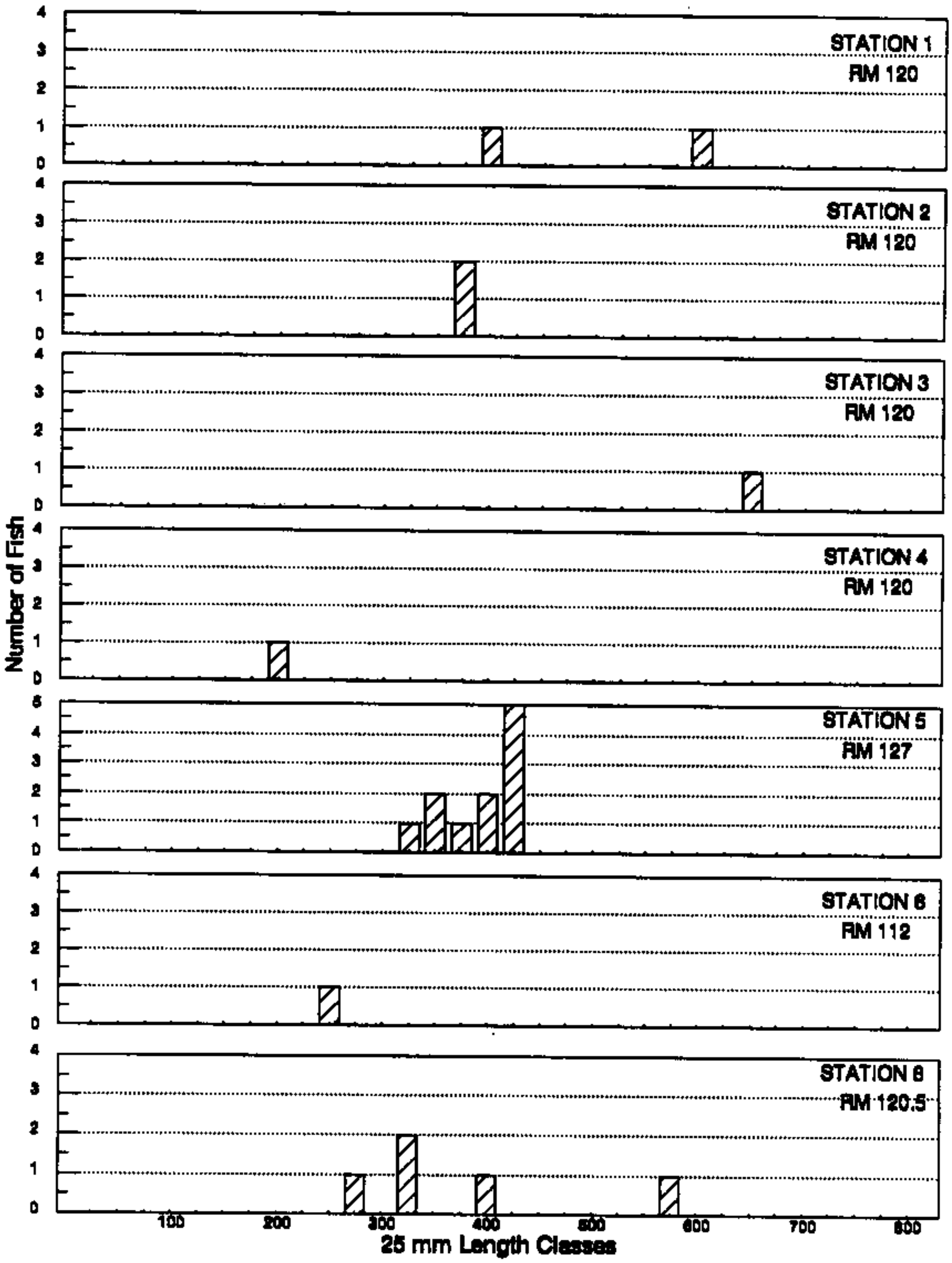
Appendix Figure 22. Length frequency distributions of white sturgeon sampled by gill netting at shallow water disposal (2) and reference (5) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during summer 1990.



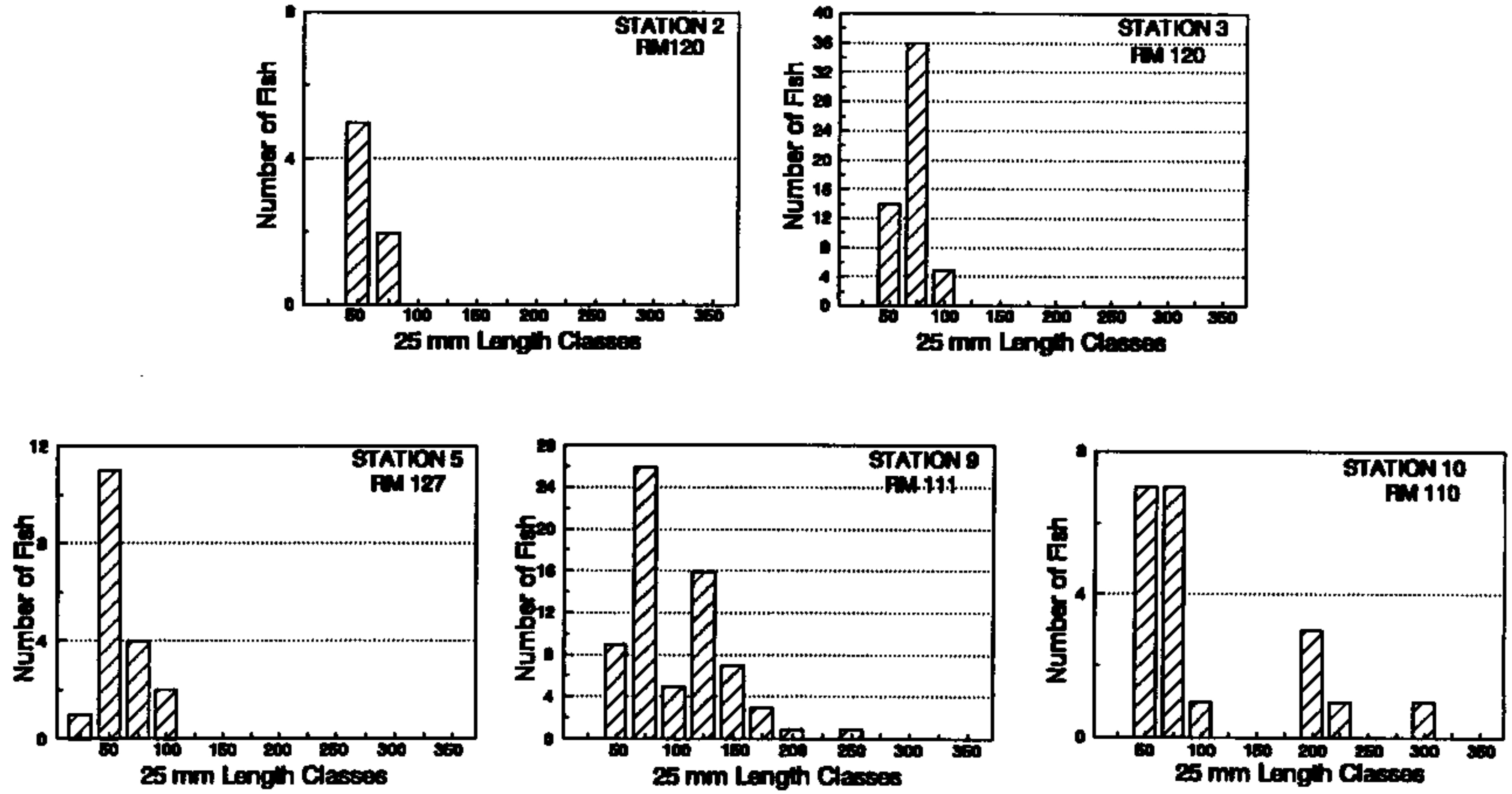
Appendix Figure 23. Length frequency distributions of northern squawfish sampled by nighttime electrofishing at shallow water disposal (1 and 2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during fall 1990.



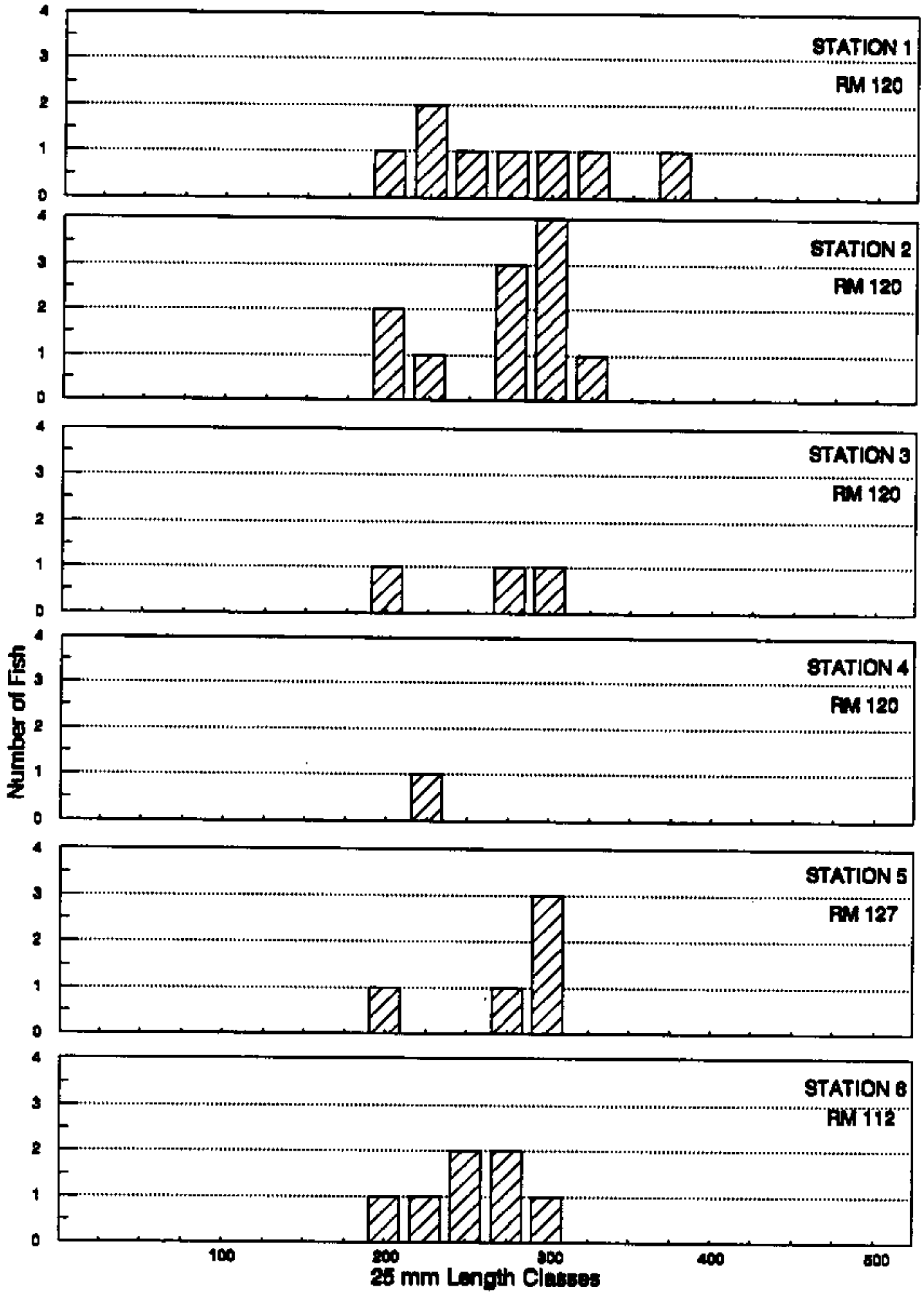
Appendix Figure 24. Length frequency distributions of northern squawfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during fall 1990.



Appendix Figure 25. Length frequency distributions of channel catfish sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations, mid-depth disposal (4) and reference (6) stations and deep water reference station 8 in Lower Granite Reservoir, Idaho-Washington during fall 1990.



Appendix Figure 26. Length frequency distributions of smallmouth bass sampled by nighttime electrofishing at shallow water disposal (2) and reference (3, 5, 9 and 10) stations in Lower Granite Reservoir, Idaho-Washington during fall 1990.



Appendix Figure 27. Length frequency distributions of smallmouth bass sampled by gill netting at shallow water disposal (1 and 2) and reference (3 and 5) stations and mid-depth disposal (4) and reference (6) stations in Lower Granite Reservoir, Idaho-Washington during fall 1990.