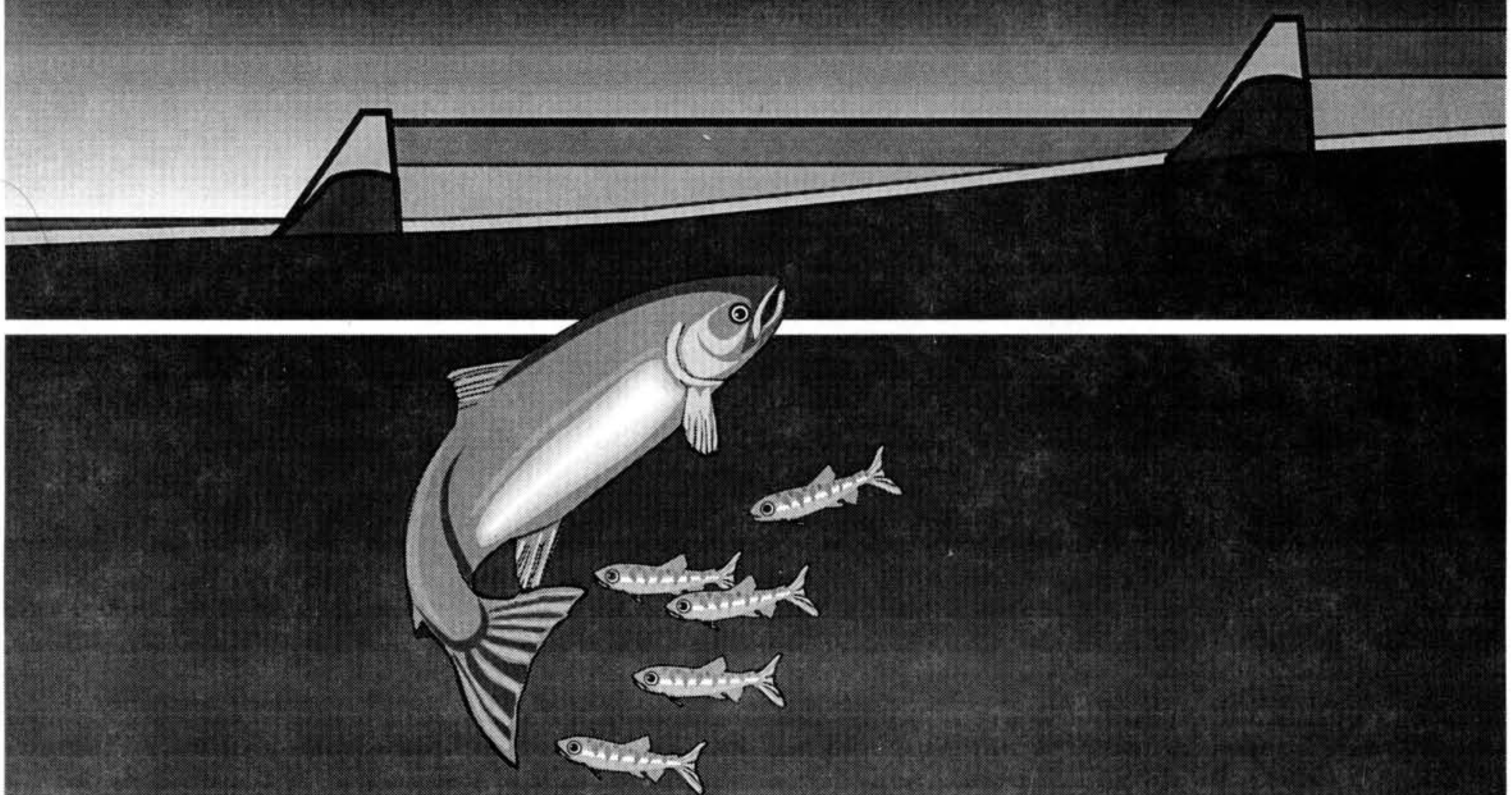
US Army Corps
of Engineers
Walla Walla District

1992 Reservoir Drawdown Test

Lower Granite and Little Goose Dams

Appendix P

Evaluation of the 1992 Drawdown in Lower Granite and Little Goose Reservoirs



December 1993

EVALUATION OF THE EFFECTS OF THE 1992 TEST DRAWDOWN

ON THE FISH COMMUNITIES IN

LOWER GRANITE AND LITTLE GOOSE RESERVOIRS, WASHINGTON

Completion Report

by

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EXECUTIVE SUMMARY

Fishery managers are considering new alternatives to enhance anadromous salmonid survival through reservoirs and dams on the Columbia River system. One alternative proposed at the 1991 Salmon Summit to improve survival of downstream migrating juvenile salmon was to draft one or more of the lower Snake River reservoirs below normal operating ranges during the migration period. During March 1992, the water levels in Lower Granite and Little Goose reservoirs were lowered for a physical test on the dams and associated structures.

The literature is replete with the effects of water-level changes on aquatic biota. Benthic communities are immediately reduced with drawdown, and large drawdowns can effectively concentrate prey species and benefit predators. Entrainment is another possible effect of massive water evacuation from a reservoir.

Two main purposes of this study were to: determine if there were any immediate impacts occurring to fish present in the reservoir at the time of the test drawdown, and to determine if potential future reservoir drawdown would have impacts on fish.

OBJECTIVES

1. To assess the presence of juvenile salmonids in Lower Granite Reservoir in winter/spring 1992, prior to the test drawdown and in Little Goose Reservoir following the drawdown;

2. To assess the occurrence of Gas Bubble Disease in juvenile salmonids in Little Goose Reservoir during and immediately following the test drawdown in 1992;

3. To assess the occurrence of outmigration/entrainment of anadromous and resident fishes from Lower Granite Reservoir associated with the test drawdown;

4. To assess the effects of the test drawdown on size and species composition of fishes in Lower Granite Reservoir;

5. To assess the effects of the test drawdown in Lower Granite Reservoir on white sturgeon *Acipenser transmontanus* distribution and abundance; and

6. To review existing reservoir fishery data and literature regarding reservoir drawdown, and to evaluate potential additional effects of reservoir drawdown, specifically predation and year-class strength of predators in Lower Granite Reservoir.

STUDY AREA

Lower Granite and Little Goose reservoirs are two run-of-river reservoirs constructed on the lower Snake River in 1975 and 1970, respectively. The surface areas of Lower Granite and Little Goose reservoirs are 8,900 acres (3,602 ha) and 10,025 acres (4,057 ha), respectively. Water levels can normally fluctuate 5 ft (1.5 m) in both reservoirs although the potential for drawdown to 710 ft (218 m) exists in Lower Granite Reservoir during flood circumstances when the Lewiston levees are in danger. Flows are typically low in March compared to later in the spring, but generally increase by the end of the month. Water temperatures remain low in March (< 45°F, < 7°C) and gradually warm after early April.

METHODS

We sampled shoreline and pelagic areas at random locations in Lower Granite Reservoir to assess the abundance of juvenile salmonids prior to the test drawdown in March 1992. All fish collected were identified, marked and released. White sturgeon were sampled by gill netting and tagged with an aluminum strap tag and a passive integrated transponder (P.I.T.).

Electrofishing was conducted along the shoreline in the tailwater of Lower Granite Dam following spill tests to assess the presence of Gas Bubble Disease (GBD). White sturgeon and other species collected from Little Goose Reservoir were closely examined for marks/tags originally applied in Lower Granite Reservoir. Statistical comparisons were made to assess changes in species relative abundance, mean catch/effort and size composition from 1989 through 1992. Statistical significance was determined by $P \leq 0.05$.

RESULTS and DISCUSSION

Population estimates made in Lower Granite Reservoir indicated salmonid numbers were low during late February 1992 prior to the test drawdown. We estimated that 95 +/- 51 (95% confidence intervals) juvenile hatchery steelhead *Oncorhyncus mykiss*, 176 +/- 63 wild juvenile steelhead, and 12 +/- 8 juvenile chinook salmon *O. tshawytscha* were present in Lower Granite Reservoir immediately before the March 1992 test drawdown. During the drawdown juvenile steelhead numbers decreased and numbers of juvenile chinook salmon increased substantially (12 to 515).

More than 2,200 salmonid and nonsalmonid fishes were examined for signs of gas bubble disease (GBD) from the tailwater immediately below Lower Granite Dam to downstream about 4.5 mi (7.2 km). Fish were examined within a few hours following spill tests and no external signs of GBD were found. Short duration of the spill tests and limited sampling may have affected these findings. Rainbow trout (steelhead), largescale suckers *Catostomus macrocheilus* and northern squawfish *Ptychocheilus oregonensis* were the more abundant species sampled and examined for GBD.

Recapture of a few marked largescale suckers (3) and juvenile steelhead (1) from Little Goose Reservoir indicated entrainment had occurred from Lower Granite Reservoir. Low numbers of recaptures in Little Goose Reservoir suggested outmigration/entrainment of the more abundant resident fishes from Lower Granite Reservoir was not high. We found no evidence that species composition and limited evidence that relative abundance changed in Lower Granite Reservoir as a result of the test drawdown. Numbers of largescale suckers, northern squawfish and chiselmouths collected in 1992, following refill, were considerably lower than catches in 1989 to 1991 suggesting possible entrainment. Comparisons of mean catch/effort from 1989 to 1992 showed few significant differences in abundance, although comparisons of largescale suckers and chiselmouths were significant ($P < 0.05$). Decreased mean catch/effort suggests possible entrainment from Lower Granite Reservoir.

Mean catch/efforts of white sturgeon in Lower Granite Reservoir increased significantly ($P < 0.05$) from 1989 to 1992. Higher mean catch/efforts suggested possible redistribution of sturgeon in Lower

Granite Reservoir. However, the ratio of recaptures in Lower Granite Reservoir did not change appreciably during 1992 suggesting immigration of sturgeon into Lower Granite Reservoir from upstream sources probably was not increased as a result of the test drawdown. Recaptures of sturgeon in the Lower Granite tailwater during fall 1992 following the drawdown indicated about 23% entrainment from Lower Granite Reservoir.

Comparison of the size composition of the catches from 1990, 1991 and 1992 indicated numerous statistical differences ($P < 0.05$) among years and species. None of these statistical differences were considered biologically significant and thus, no change in size structure could be attributed directly to the March 1992 test drawdown.

Findings from the literature and our results suggest future drawdowns to benefit smolts might have deleterious effects on smolt survival. Consolidation of predators and prey, reduced abundance of other vertebrate and invertebrate prey as a result of stranding, attraction of predators to tailraces, and increased year-class strength of predators could all result from drawdowns. Manipulation of Snake River reservoir levels could have several adverse affects to the resident and downstream migrating salmonid fish communities.

INTRODUCTION

The Columbia River system has been severely altered by construction of numerous dams. Navigation, electrical power generation, flood control and recreation are considered positive attributes of the dams, while negative effects have largely been attributed to the passage of juvenile and adult salmonid fishes. Salmonid populations had begun to decline from historic levels before construction of dams on the Columbia River system, however, with the advent of dams to the system, salmonid numbers continued to decline. Numbers of anadromous salmonids have declined so low that in 1991 and 1992 the sockeye salmon *Oncorhynchus nerka* and chinook salmon *O. tschawytscha* were classified as endangered and threatened under the Endangered Species Act of 1973. Although many efforts have been made to improve survival of salmon through the mainstem Columbia and Snake river dams and reservoirs, there is still a concern that survival of juvenile salmon is inadequate. While actual survival is unknown, new approaches to improve conditions for downstream migrants are being considered. Decreased water velocities due to increased crosssectional areas within the reservoirs and changes in the natural hydrograph have been linked to reduced success in fish passage (Raymond 1979).

An alternative proposed at the 1991 Salmon Summit to improve survival of downstream migrating juvenile salmon was to draft one or more of the lower Snake River reservoirs below the normal minimum operating pool level. Lowering the water surface elevation would reduce reservoir volumes and increase average in-reservoir velocities by decreasing the cross-sectional profiles. During March 1992, the water levels in Lower Granite and Little Goose reservoirs were lowered for a physical test of the dam and associated structures such as the road beds, levees, etc. Since juvenile salmonid numbers were expected to be low, a test of the physical structure could be conducted with minimal potential adverse affects to juvenile anadromous salmonids.

Two main purposes of this study were to: determine if there were any immediate impacts occurring to fish present in the reservoir at the time of the test drawdown, and to determine if potential future reservoir drawdown would have impacts on fish. To accomplish these purposes, the following objectives were addressed.

OBJECTIVES

1. To assess the presence of juvenile salmonids in Lower Granite Reservoir in winter/spring 1992 prior to the test drawdown and in Little Goose Reservoir following the test drawdown;

2. To assess the occurrence of Gas Bubble Disease in juvenile salmonids in Little Goose Reservoir during and immediately following the test drawdown in 1992;

3. To assess the occurrence of outmigration/entrainment of anadromous and resident fishes from Lower Granite Reservoir associated with the test drawdown;

4. To assess the effects of the test drawdown on size and species composition of fishes in Lower Granite Reservoir;

5. To assess the effects of the test drawdown in Lower Granite Reservoir on white sturgeon *Acipenser transmontanus* distribution and abundance; and

6. To review existing reservoir fishery data and literature regarding reservoir drawdown and to evaluate potential additional effects of reservoir drawdown, specifically predation and year-class strength of predators in Lower Granite Reservoir.

STUDY AREA

Lower Granite and Little Goose reservoirs are two run-of-river reservoirs constructed on the lower Snake River (Figure 1). The upper reservoir, Lower Granite, impounds water upstream into the Snake and Clearwater rivers near the cities of Clarkston, Washington and Lewiston, Idaho. The surface areas of Lower Granite and Little Goose reservoirs are 8,900 acres (3,602 ha) and 10,025 acres (4,057 ha), respectively. Little Goose Dam backs water to the base of Lower Granite Dam. Impoundment was completed in Little Goose Reservoir during 1970 and in Lower Granite Reservoir during 1975.

Lower Granite and Little Goose reservoirs have been operated with a maximum water level fluctuation of 5 ft (1.5 m). Water levels can fluctuate daily within this 5 ft zone from 733 to 738 ft (223 to 225 m) elevation, although during the last 3 years summer pool levels have been generally maintained at 734 ft (223.8 m). However, the potential for drawdown to 710 ft (216.5 m) exists in Lower Granite Reservoir during flood circumstances when the Lewiston levees are in danger (Dan Kenny, Army Corps of Engineers, Walla Walla, WA, personal communication).

The fish communities in both reservoirs have been surveyed (Bennett et al. 1983) with more recent and comprehensive information collected in Lower Granite Reservoir (Bennett and Shrier 1987; Bennett et al. 1988, 1989, 1990, 1991, 1993a, 1993b). During March, flows in the lower Snake River are typically low compared to later in the spring and generally increase by the end of the month. Water temperatures are typically < 45°F (<7°C) during March and gradually warm after early

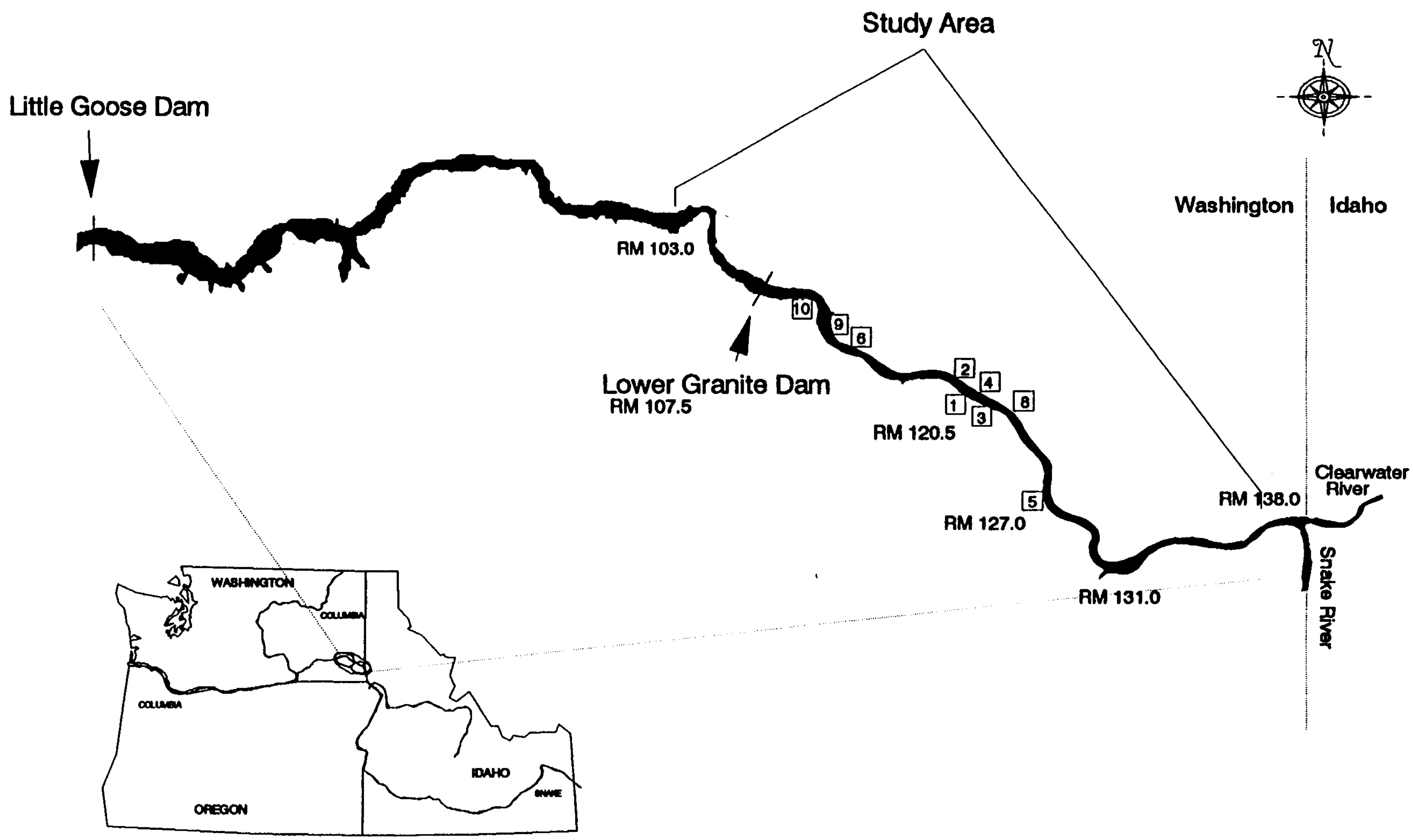


Figure 1. Map of Lower Granite and Little Goose reservoirs showing the locations of sampling in Lower Granite Reservoir. Numbers in boxes indicate sampling stations with location in river miles (RM).

April. Dissolved oxygen is near saturation (> 8 mg/L) in both reservoirs during spring.

Objective 1. To assess the presence of juvenile salmonids in Lower Granite Reservoir in winter/spring 1992 prior to the test drawdown and in Little Goose Reservoir following the test drawdown.

METHODS

Shoreline and pelagic areas throughout Lower Granite Reservoir were sampled at random locations to assess the abundance of juvenile salmonids by nighttime electrofishing, surface trawling and daytime beach seining prior to the test drawdown in March 1992. Lower Granite Reservoir was divided into 146-yd (133-m) transects on both the north and south shorelines yielding a total of 251 possible sampling transects. Five major habitat types were identified in Lower Granite Reservoir: talus, rip-rap, sand, embayment and cliff areas. A total of 81, 146-yd transects along the shoreline of Lower Granite Reservoir was sampled by standardized nighttime electrofishing (Bennett et al. 1993b) prior to and during the test drawdown. Nighttime electrofishing was conducted by paralleling the shoreline as close as possible for 400-450 seconds at each transect. An output of approximately 400 volts and 3-5 amps adequately stunned fish without causing mortalities or visual evidence (burns, extended vertebrae, etc.) of injuries. All fish collected were identified to species, measured to total length (TL-nearest mm), marked with a pectoral fin clip on either the right or left side depending on capture location (right side if captured upstream of river mile 127, RM 127; and left side if captured downstream of RM 127) and then released alive. The number of transects sampled within each habitat type was > 30% of the total habitat available (Table 1).

Table 1. Sampling units available and sampled in Lower Granite Reservoir during 1992.

Habitat Type	Units Available	Units Sampled	Proportion (%)
Talus	35	12	34
Rip-Rap	122	39	32
Sand	22	7	32
Embayment	2	1	50
Cliff	70	22	31

The tailwater region of Lower Granite Reservoir (RM 104.0-107.5) was divided into 0.5-mi (0.8-km) sections. Six, 0.5-mi transects were randomly selected from March 16 through March 23, 1992 for nighttime electrofishing. Standardized electrofishing effort was conducted similarly to that in Lower Granite Reservoir to assess the presence of salmonids in the Lower Granite tailwater region during drawdown and postdrawdown phases of water levels in Lower Granite Reservoir.

Surface trawling was used to assess abundance of pelagically oriented juvenile salmonids at 36 random locations throughout Lower Granite Reservoir prior to the test drawdown. Lower Granite Reservoir was divided into three strata: the upper stratum, riverine (RM 139-127); mid stratum, transition zone (RM 127-119); and lower stratum, reservoir/pool (RM 119-107.5). Each stratum was divided into 1-mi (1.6-km) transects. The number of transects sampled within each stratum was determined by the Proportional Allocation formula (Scheaffer et al. 1986).

The surface trawl was constructed of 1.5-in (3.8-cm) mesh netting, with a cod end of 0.25-in (0.64-cm) mesh. The trawl was towed between and behind two boats to avoid "scattering" fish from "prop wash" at approximately 148 ft (45 m) apart with 148 ft ropes. Tows were made downstream at speeds of approximately 5.25 ft/s (1.6 m/s) for 15 minutes at each transect.

Standardized daytime beach seining was used to sample 27 shoreline areas prior to the test drawdown in Lower Granite Reservoir. A 100 x 8-ft (30.5 x 2.4-m) seine constructed of 0.25 in (0.64-cm) knotless nylon mesh with a 8 x 8 x 8-ft^3 (2.4 x 2.4 x 2.4-m^3) bag was used to make 1-3 hauls at each randomly selected transect depending on suitability of available shoreline area. Beach seining was conducted by setting the seine parallel to and at a standard distance of approximately 50 ft (15 m) from the shoreline. A 50-ft (15-m) rope attached to each end of the seine was then drawn in perpendicular to the shoreline which sampled an area approximately 5,000 ft^2 (450 m^2).

RESULTS

Population estimates conducted prior to the test drawdown in March 1992 indicated low numbers of salmonids were present in Lower Granite Reservoir. Our estimates for juvenile hatchery steelhead along the shoreline prior to the drawdown were 95 +/- 51 (95% confidence intervals) and 176 +/- 63 for juvenile wild steelhead. Predrawdown estimates of juvenile chinook salmon along the shoreline were 12 +/- 8. Open water estimates based on two boat trawl samples were considerably lower than shoreline samples and indicated the majority of the salmonids were along the shoreline.

During the drawdown, population estimates were again made along the shoreline and numbers generally increased from predrawdown estimates. During the drawdown, 30 +/- 20 juvenile hatchery steelhead were estimated to be in Lower Granite Reservoir compared to 238 +/- 66 juvenile wild steelhead. Juvenile chinook salmon numbers increased during the drawdown to 515 +/- 279.

DISCUSSION

Our population estimates made prior to the March 1992 test drawdown indicated that salmonid abundance was low in Lower Granite Reservoir. Juvenile steelhead abundance was higher than juvenile chinook. Our shoreline and open water sampling indicated that during late February 1992 these juvenile salmonids were more abundant along the shoreline than in pelagic waters. During the drawdown, abundance of juvenile wild steelhead about doubled compared to predrawdown estimates and juvenile chinook abundance increased substantially (12 vs. 515). We believe these estimates are precise because of the relatively narrow confidence intervals, and gear avoidance was considered minimal at the low water temperatures (41°F, 5°C). Bennett et al. (1988) found that catches of salmonid fishes showed similar trends in abundance and had similar variances for the surface trawl and 492-ft (150-m) purse seine.

The number of juvenile salmon and steelhead sampled in Lower Granite Reservoir indicated numbers increased from prior to the test drawdown to during the drawdown. Initial collections prior to the drawdown corroborate those made during other years (D.H. Bennett, University of Idaho, Moscow, ID, unpublished data) that salmonid numbers are low in Lower Granite Reservoir during late winter. Population estimates made prior to the drawdown indicated juvenile steelhead were more abundant in Lower Granite Reservoir than juvenile chinook, and wild steelhead migrate earlier into the reservoir than hatchery steelhead. Thus, juvenile wild steelhead probably spend more rearing/resting time in the reservoir than hatchery fish that generally migrate rapidly through the reservoir. Numbers of juvenile chinook increased substantially during the drawdown from predrawdown abundance whereas juvenile steelhead numbers increased slightly or remained about the same.

Objective 2. To assess the occurrence of Gas Bubble Disease in juvenile salmonids in Little Goose Reservoir during and immediately following the test drawdown in 1992.

METHODS

The upstream portion of Little Goose Reservoir in the Lower Granite tailwater was sampled by nighttime electrofishing on March 16, 19, 21 and 23, 1992 immediately following spill tests at Lower Granite Dam. Sampling was conducted immediately downstream of Lower Granite Dam during the first two spill tests and further downstream on the evening following the third spill test. Six randomly selected 0.5-mi (0.8-km) sections between RM 104.0 and RM 107.5 were sampled by nighttime electrofishing along the shoreline. An output of 400 volts at 3-5 amps was used to stun fish without causing mortalities or evidence of injuries. All captured fishes, salmonids and nonsalmonids, were immediately examined for signs of Gas Bubble Disease (GBD; i.e. gas bubbles emanating from the lateral line pores and/or gas bubbles under the skin, in the fins, on the body, in the mouth and eyes, and/or exopthalmia; Bouck 1980). All fish were identified to species, measured to total length (nearest mm), examined for fin clips and released alive.

RESULTS

No external signs of GBD were observed in more than 2,200 salmonid and nonsalmonid fishes collected in the tailwater of Lower Granite Dam and several miles downstream (Table 2). Largescale suckers *Catostomus macrocheilus*, redside shiner *Richardsonius balteatus*, smallmouth bass *Micropterus dolomieu*, northern squawfish *Ptychocheilus oregonensis* and

Table 2. Number of fishes collected and examined for external signs of Gas Bubble Disease by river mile (RM) in Little Goose Reservoir, Washington during the March 1992 test drawdown.

Species	RM 103.0-103.5	RM 103.5-104.0	RM 104.0-104.5	RM 104.5-105.0	RM 105.0-105.5	RM 105.5-106.0	RM 106.0-106.5	RM 106.5 - 107.0	RM 107.0-107.5	Total
chinook salmon	0	0	3	1	0	1	0	1	0	6
sockeye salmon	0	0	1	1	0	1	2	1	14	20
steelhead	1	10	4	13	5	23	9	23	43	131
mountain whitefish	0	0	1	1	0	2	0	2	3	9
chiselmouth	8	23	5	16	2	21	2	42	35	154
peamouth	1	4	2	6	2	9	0	8	12	44
northern squawfish	19	73	11	114	21	89	5	39	126	497
redside shiner	2	4	0	9	0	17	0	2	6	40
bridgelip sucker	0	25	2	19	1	4	2	12	8	73
largescale sucker	4	161	91	262	17	66	10	119	96	826
brown bullhead	0	0	1	0	0	1	0	0	0	2
black bullhead	0	1	0	0	0	0	0	0	0	1
yellow bullhead	0	0	2	1	1	0	0	0	1	5
Lepomis spp.	0	1	0	0	0	0	0	0	0	1
pumpkinseed	0	6	0	2	1	19	1	2	1	32
bluegill	1	0	0	0	2	3	0	96	11	113
black crappie	0	0	0	1	0	0	0	1	0	2
smallmouth bass	9	85	16	61	25	47	11	9	39	302
Cottid spp.	1	8	0	7	4	3	3	9	3	38
Total	45	401	139	514	81	306	45	366	398	2,296

juvenile steelhead were collected in higher abundance in the Lower Granite tailwater than other species. These species represent fishes that are often distributed in littoral shoreline areas as well as pelagically and probably indicate that under similar conditions, such as flow, temperature and gas level, GBD may not adversely affect these fishes. The majority of juvenile steelhead examined for GBD in Little Goose Reservoir were wild (Figure 2).

DISCUSSION

Although we sampled more than 2,200 fishes in the tailwater of Lower Granite Dam, we did not find any external symptoms of GBD in either salmonid or nonsalmonid fishes. We sampled from immediately below the dam to downstream about 4.5 mi (7.2 km) at RM 103.5. Our sampling was conducted in the evening following decreased flow conditions to several hours following curtailment of the high flows. Although nitrogen gas supersaturation levels reportedly exceeded 115% presented by Weitkamp and Katz (1980) as the level of gas saturation that can adversely affect salmonid fishes, these levels were not maintained as a result of the short duration (2-3 hours) of the spill tests (Sarah Wik, U.S. Army Corps of Engineers, Walla Walla, WA, personal communication). Fish that were migrating or entrained out of Lower Granite Reservoir could have stayed with the "parcel" of water that was spilled, thus these fishes may not have been located during our sampling for GBD.

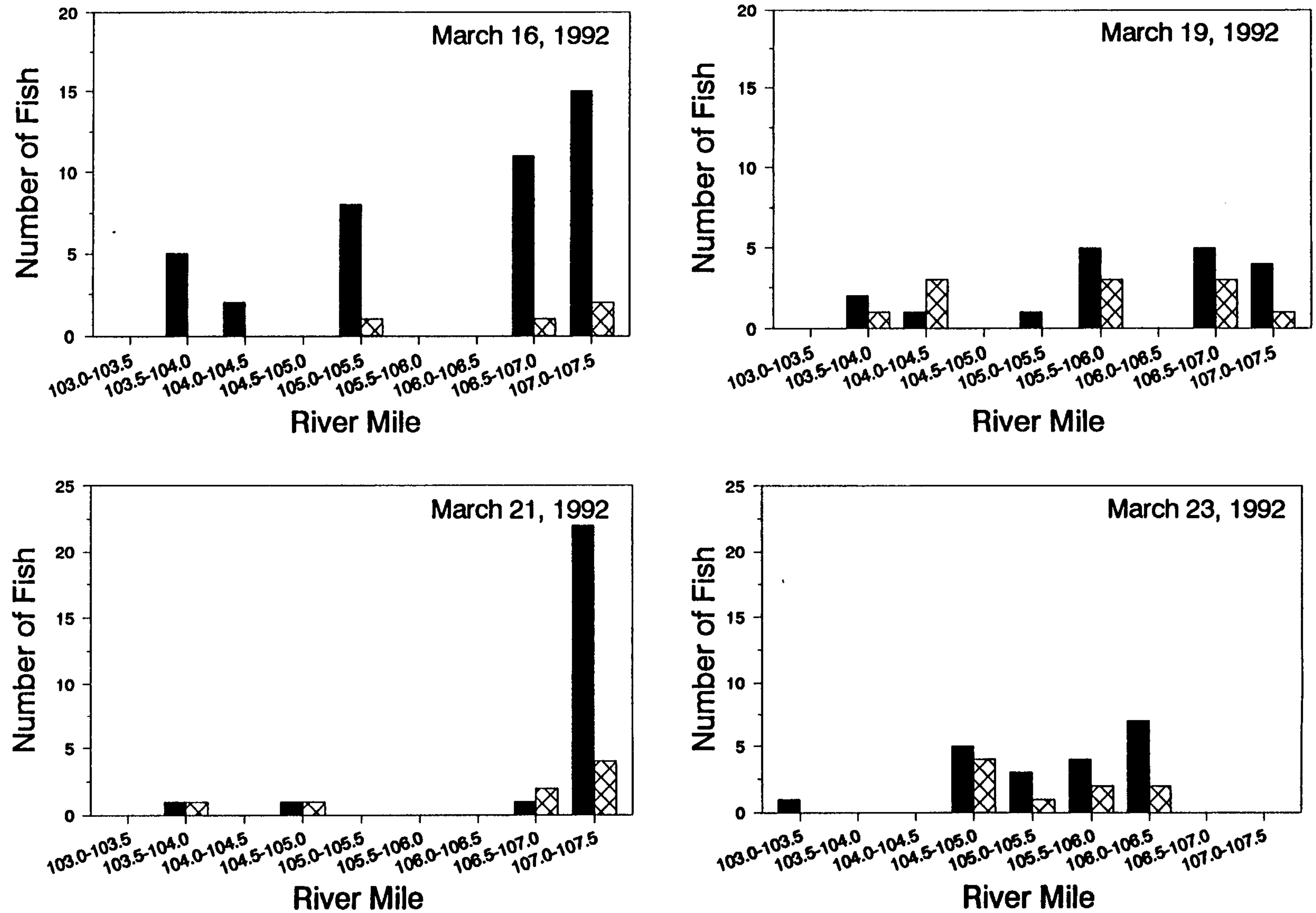


Figure 2. Comparisons of the number of wild (solid bars) and hatchery (checked bars) juvenile steelhead sampled in the tailwater of Lower Granite Dam during the March 1992 test drawdown.

Objective 3. To assess the occurrence of outmigration/entrainment of anadromous and resident fishes from Lower Granite Reservoir associated with the test drawdown.

METHODS

To assess the occurrence of outmigration/entrainment of resident and anadromous fishes, we marked all fish collected during our predrawdown sampling effort in Lower Granite and Little Goose reservoirs (Objective 1). All fish were given a pectoral fin clip on the left or right side depending upon the location of sampling. In addition, Arthaud (1992) conducted a study in Lower Granite Reservoir during spring to fall 1991 that provided approximately 15,000 fin-clipped fish from RM 109-114 in Lower Granite Reservoir. A large proportion of these marked fish were young-of-the-year and probably regenerated fins making them unrecognizable during spring 1992. The larger fish, however, should have remained identifiably marked for the post drawdown sampling.

To assess entrainment at the species level, we compared mean catch/efforts of fishes between predrawdown, spring 1989-1991, and postdrawdown, spring 1992. These comparisons were made by analysis of variance using ranks.

RESULTS

Recaptures from the Tailwater of Lower Granite Dam

Of all fish marked (except white sturgeon) in Lower Granite Reservoir, four were positively identified as being recaptured in Little Goose Reservoir. Three of the fin-clipped fish were largescale suckers and one was a juvenile steelhead. The juvenile steelhead and two largescale suckers were collected in the Lower Granite tailwater, whereas the third sucker was collected about 2-3 mi (3.2-4.8 km) downstream from Lower Granite Dam. One hundred thirty one juvenile steelhead were collected in the Lower Granite tailwater suggesting outmigration/entrainment from Lower Granite Reservoir could have been high (Table 2). However, we could not determine whether these steelhead entered Little Goose Reservoir as a result of "normal" migration, and may have been in the system prior to the drawdown as previously reported by Bennett et al. (1983), or drawdown.

Eleven additional recaptures of northern squawfish tagged by the Oregon Department of Fish and Wildlife were made in the Lower Granite tailwater from immediately downstream of the dam to RM 103, about 4 mi (6.4 km) downstream of the dam (D. Ward, Oregon Department of Fish and Wildlife, Clackamas, OR, personal communication). All of these fish were tagged in the tailwater of Lower Granite Dam and apparently exhibited no downstream movement as a result of the test drawdown.

Comparisons of Mean Catch/Efforts

Comparisons of mean catch/efforts between the predrawdown period of 1989-1991 and postdrawdown 1992 provided additional information on the possible outmigration/entrainment of fishes from Lower Granite Reservoir. Mean catch/efforts of fishes from spring 1992 were compared to those from spring 1989-1991 to assess changes in abundance.

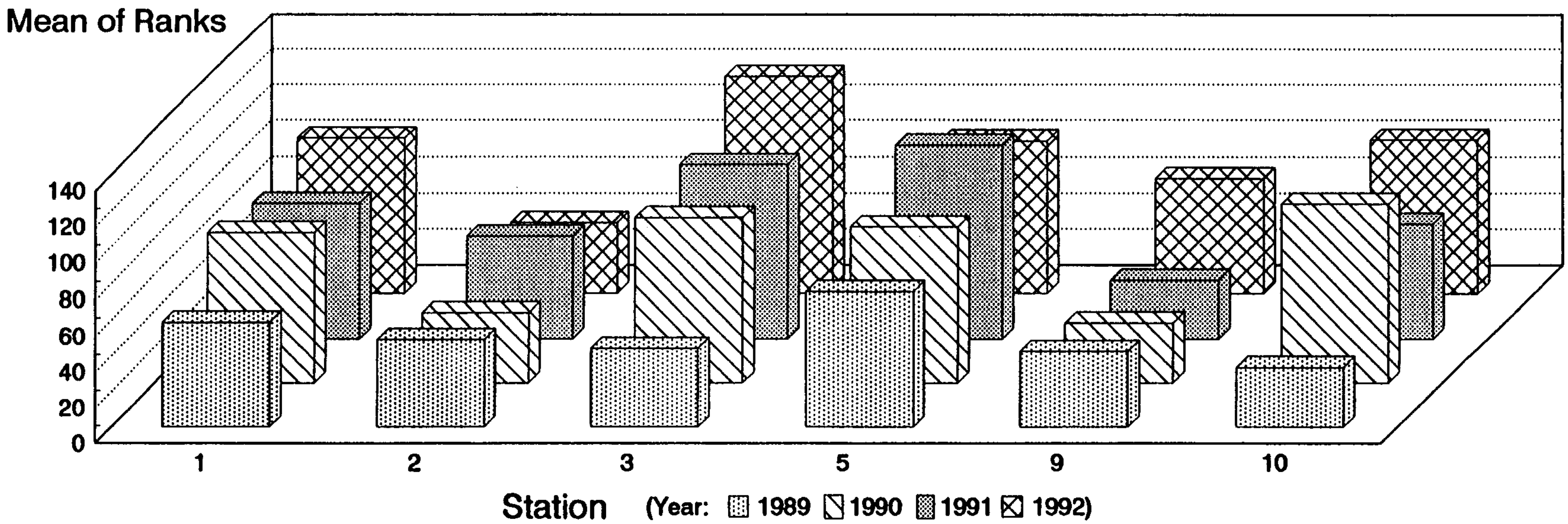
Northern squawfish.- Mean catch/efforts of northern squawfish sampled by electrofishing in Lower Granite Reservoir did not differ significantly ($P > 0.05$) among 1990, 1991 and 1992 (Figure 3). The mean catch/effort in 1989 was significantly ($P < 0.05$) lower than the other 3 years. Catch/effort generally decreased in mid-reservoir locations in 1992.

Mean catch/efforts of northern squawfish sampled by beach seining varied among years (Figure 4). Numbers collected in 1989 and 1991 were significantly ($P < 0.05$) higher than those in 1990 and 1992. Although the mean catch/effort was lowest in 1992, it was not significantly lower than that of 1990.

Mean catch/efforts of northern squawfish sampled by gill netting generally decreased at most stations from 1989 to 1992 (Figure 5). The mean catch/effort at station 8 (RM 120.5) was significantly ($P < 0.05$) lower in 1992 than in other years, while those at stations 1 and 3 (RM 120.48-120.19) increased but not significantly ($P > 0.05$) among years. Although mean catch/efforts varied among some sampling stations and years, the catch/effort at station 1 was statistically ($P < 0.05$) higher than other stations in 1992.

Smallmouth bass.- Mean catch/effort of smallmouth bass sampled by electrofishing in Lower Granite Reservoir in 1992 was highest of all years and that for 1989 was the lowest (Figure 6). During 1989-1992 few station differences were found.

The mean catch/effort of smallmouth bass sampled by beach seining in 1992 was lowest of all years (Figure 7). Differences between years were significant ($P < 0.05$) for 1990 and 1991 versus 1992 while those in 1989 were not.



Station Comparison

5 3 1 10 2 9

Year Comparison

1992 1990 1991 1989

Figure 3. Graphical and statistical comparisons of the mean of ranks of northern squawfish sampled by electrofishing in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

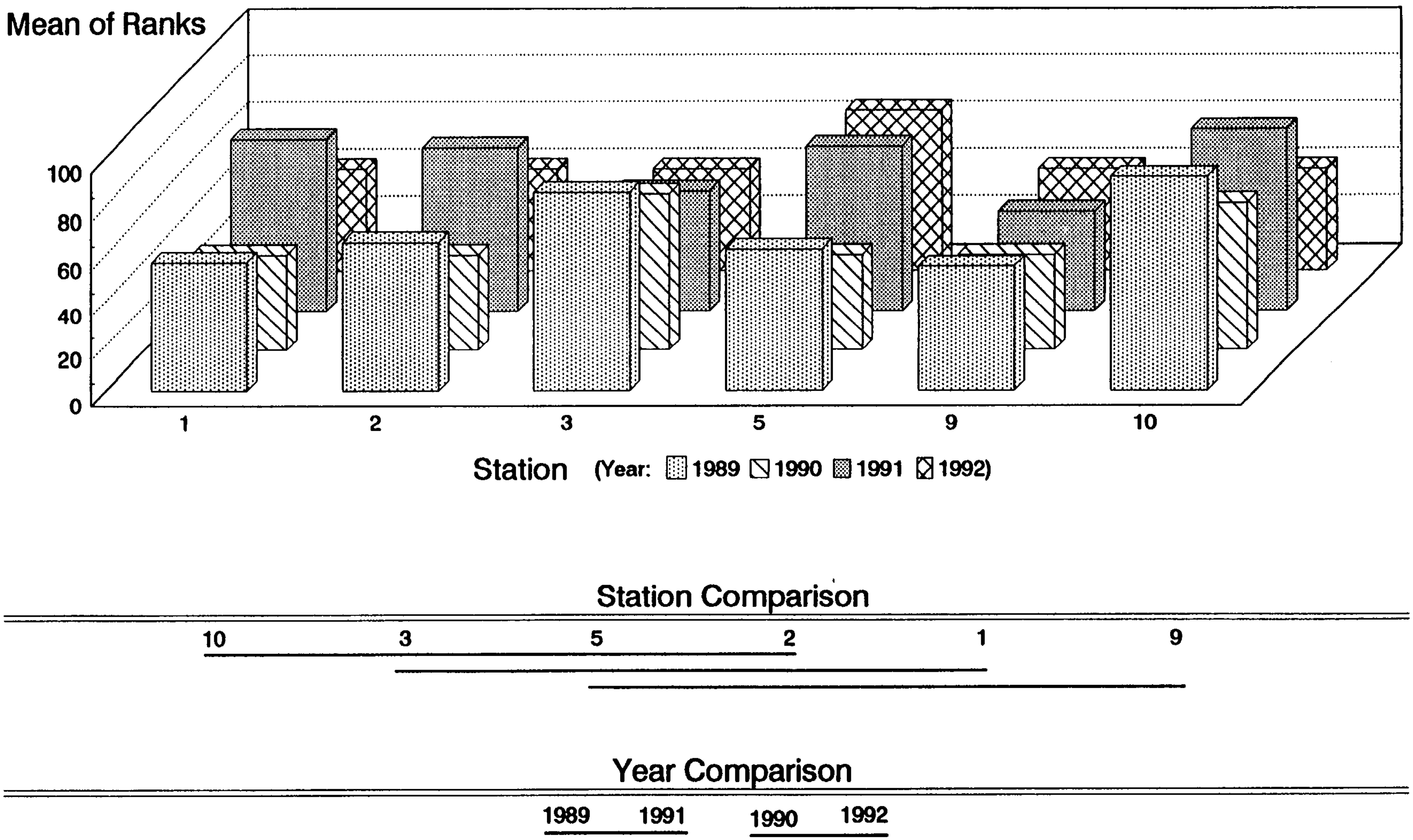
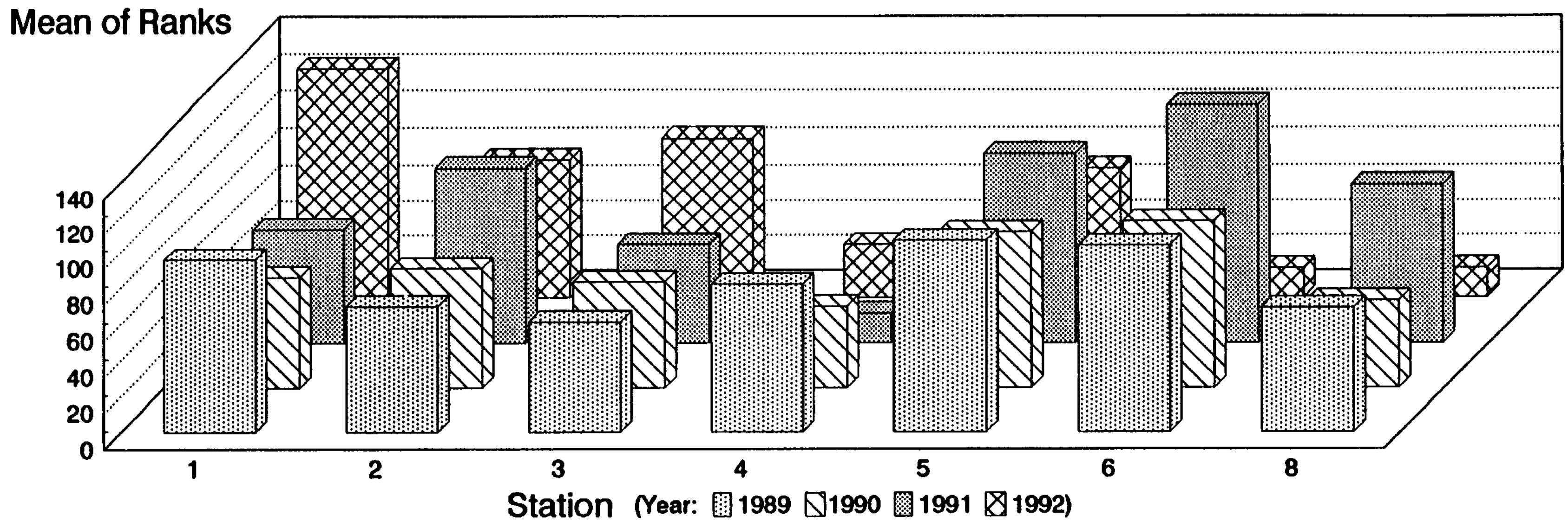


Figure 4. Graphical and statistical comparisons of the mean of ranks of northern squawfish sampled by beach seining in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



Station Comparison

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

Year Comparison

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

Figure 5. Graphical and statistical comparisons of the mean of ranks of northern squawfish sampled by gill netting in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

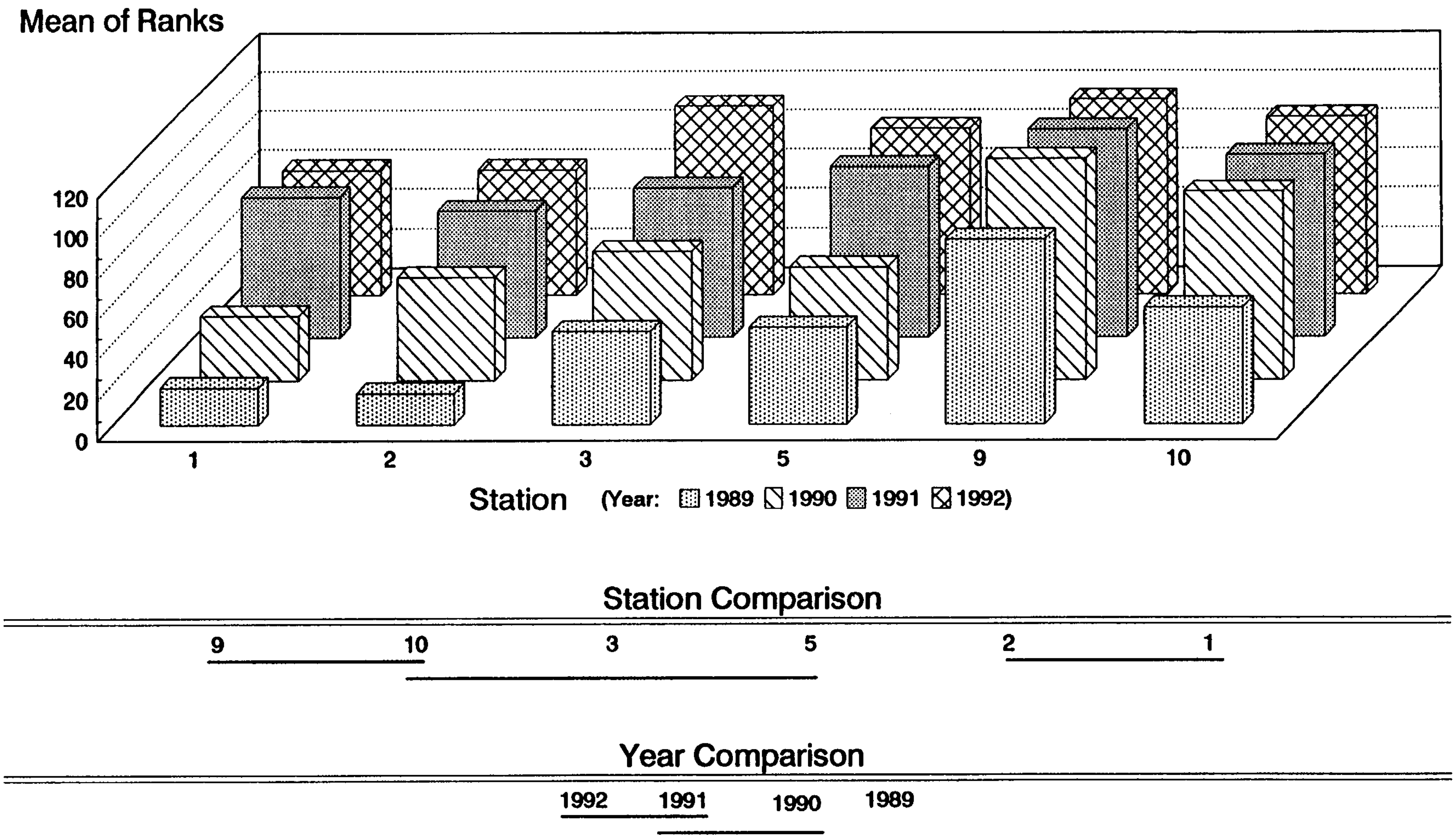
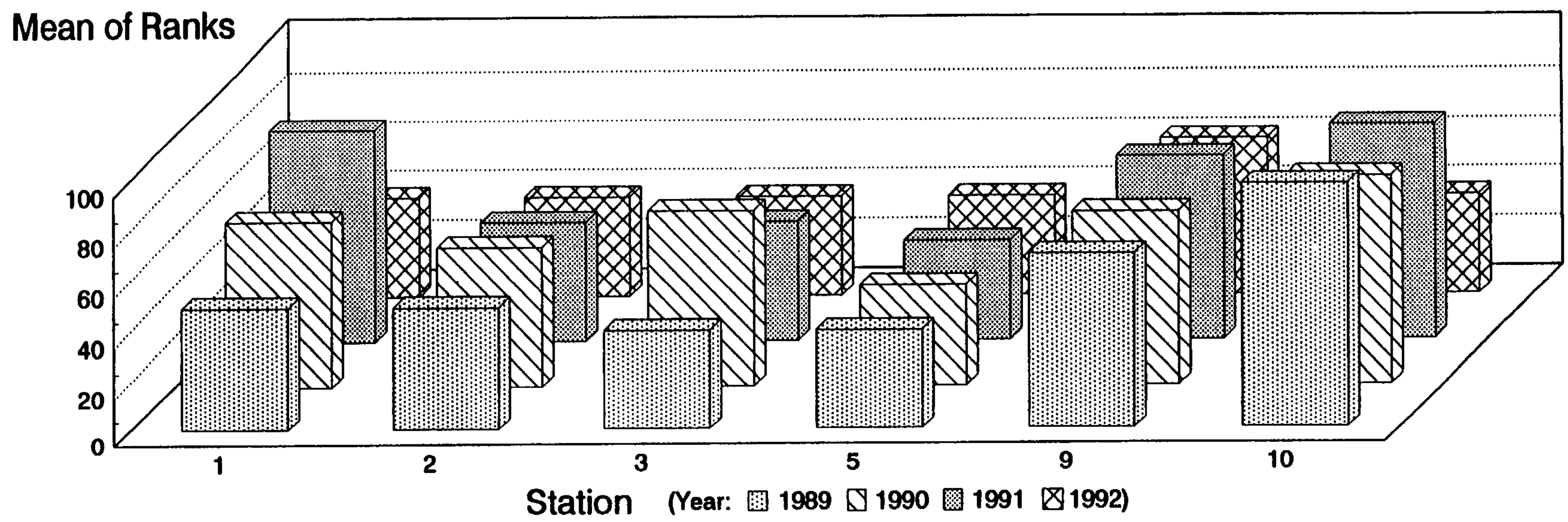


Figure 6. Graphical and statistical comparisons of the mean of ranks of smallmouth bass sampled by electrofishing in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

10 9 1 3 2 5

Year Comparison

1990 1991 1989 1992

Figure 7. Graphical and statistical comparisons of the mean of ranks of smallmouth bass sampled by beach seining in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).

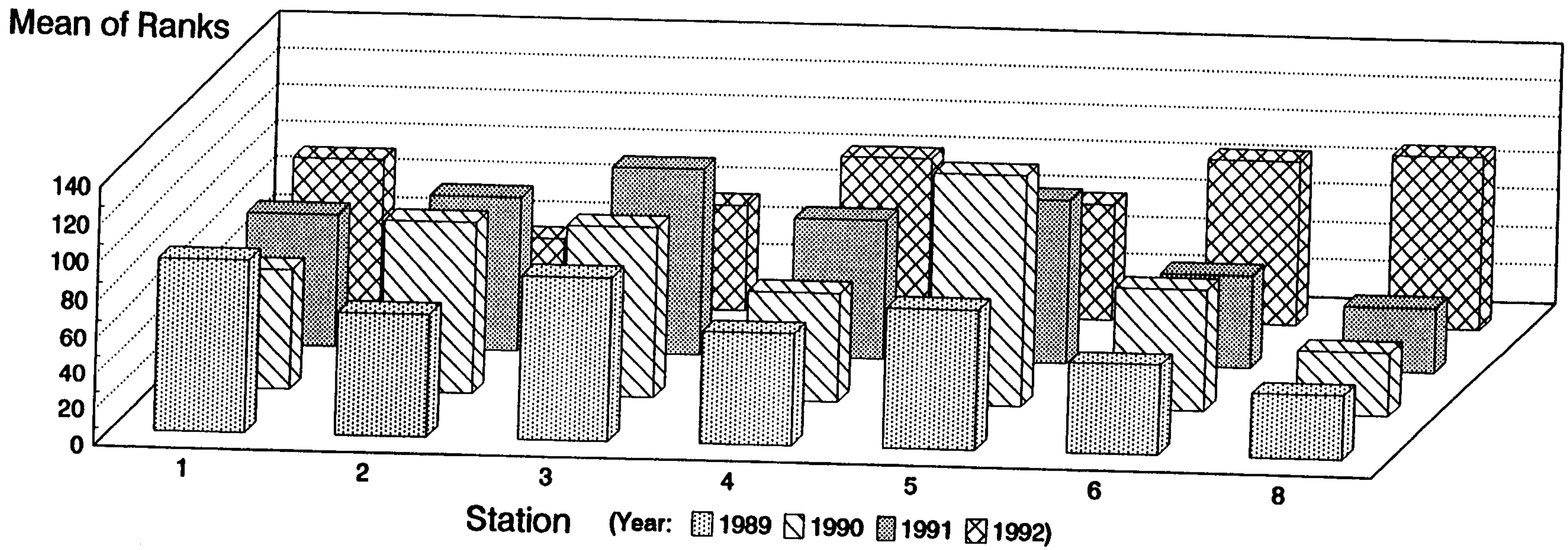
Comparisons of the mean catch/efforts of smallmouth bass by gill netting among years were affected by a year*station interaction (Figure 8). Mean catch/efforts were highest in 1992 at three of the seven stations sampled, although no consistent pattern in differences was found among years.

Channel catfish.- Comparisons of mean catch/efforts by gill netting of channel catfish *Ictalurus punctatus* in Lower Granite Reservoir resulted in several significant ($P < 0.05$) differences among years (Figure 9). The mean catch/effort in 1992 was significantly lower than other years.

White sturgeon.- Comparisons of mean catch/efforts by gill netting of white sturgeon sampled in Lower Granite Reservoir were obscured by a year*station interaction (Figure 10). The mean catch/efforts were highest in 1992 at five of seven stations sampled, although only station 4 (RM 120.48-120.19) was significantly ($P < 0.05$) higher.

Largescale sucker.- Mean catch/efforts of largescale suckers sampled by electrofishing in Lower Granite Reservoir fluctuated among years (Figure 11). The mean catch/effort of largescale suckers in 1992 was the third lowest of the four years sampled but it was not statistically different from 1989 or 1990.

Comparisons of mean catch/efforts of largescale suckers sampled by beach seining were affected by a year*station interaction (Figure 12). Although generally not significantly ($P > 0.05$) different, mean catch/efforts for each station were consistently the lowest in 1992.



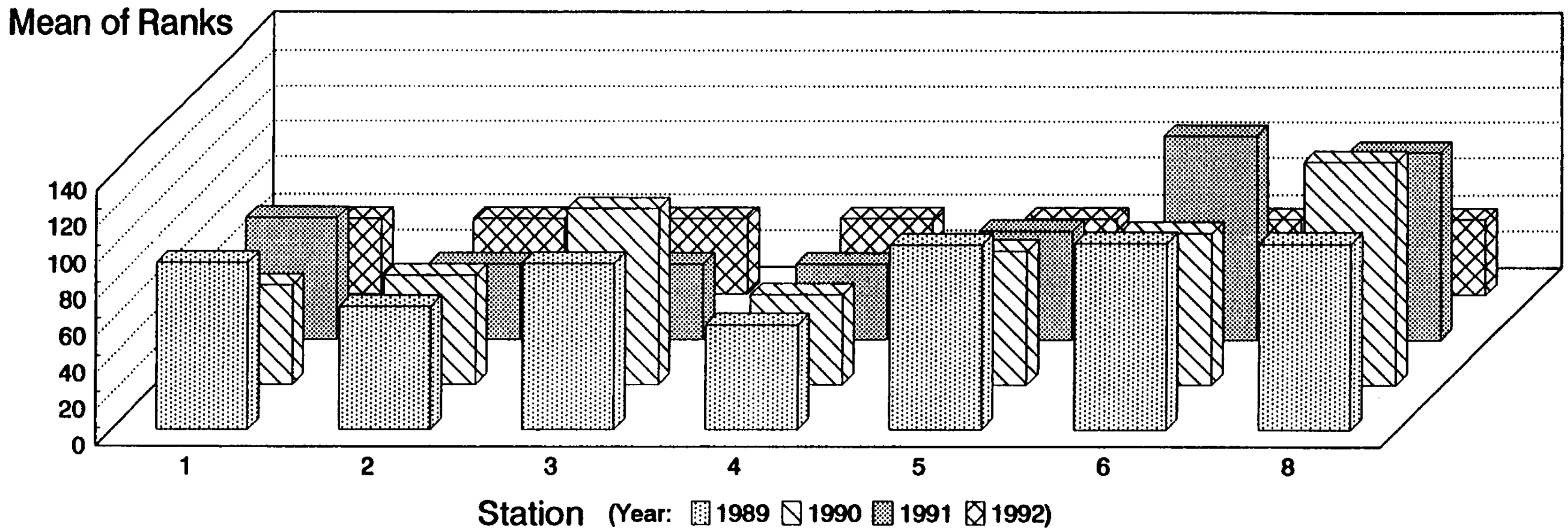
Station Comparison

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

Year Comparison

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

Figure 8. Graphical and statistical comparisons of the mean of ranks of smallmouth bass sampled by gill netting in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



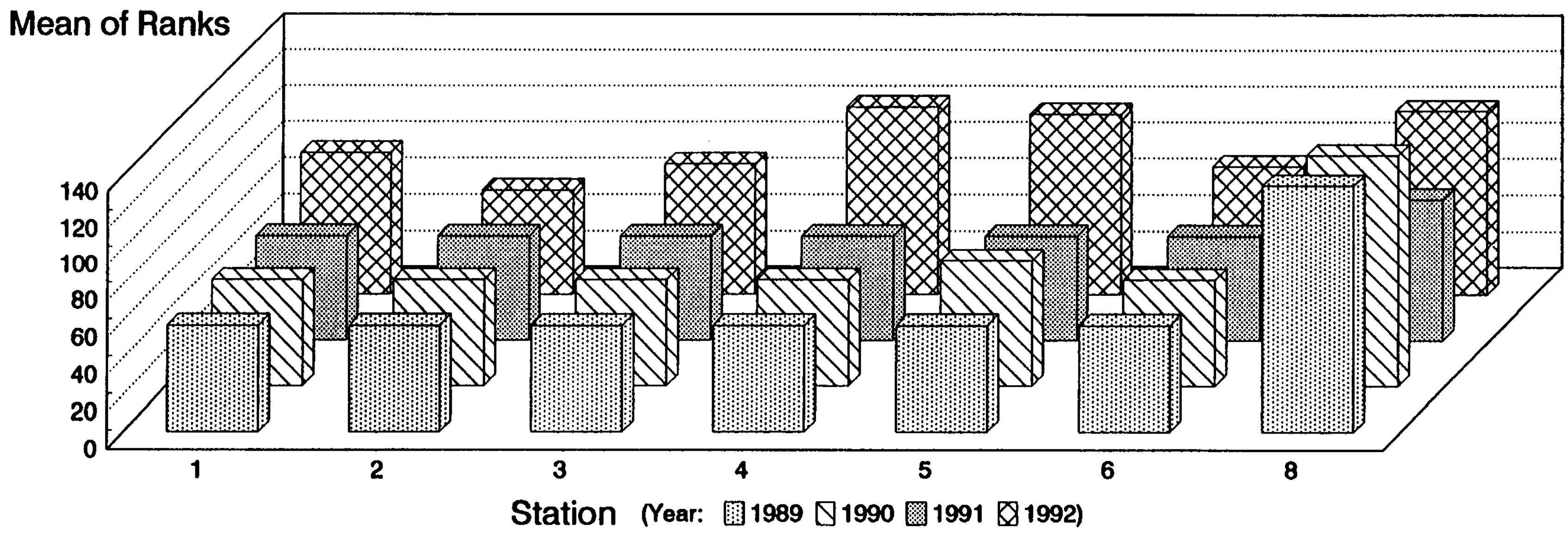
Station Comparison

8 6 3 5 1 2 4

Year Comparison

89 90 91 92

Figure 9. Graphical and statistical comparisons of the mean of ranks of channel catfish sampled by gill netting in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



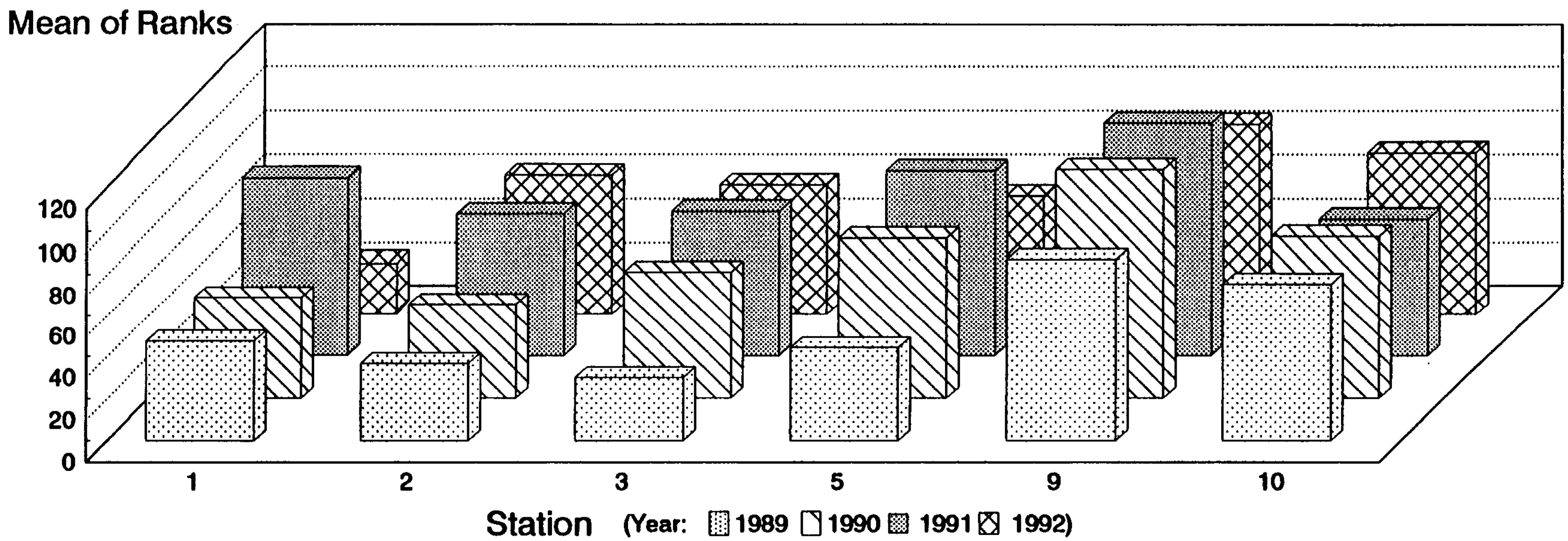
Station Comparison

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

Year Comparison

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

Figure 10. Graphical and statistical comparisons of the mean of ranks of white sturgeon sampled by gill netting in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

9 10 5 3 2 1

Year Comparison

1991 1990 1992 1989

Figure 11. Graphical and statistical comparisons of the mean of ranks of largescale suckers sampled by electrofishing in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).

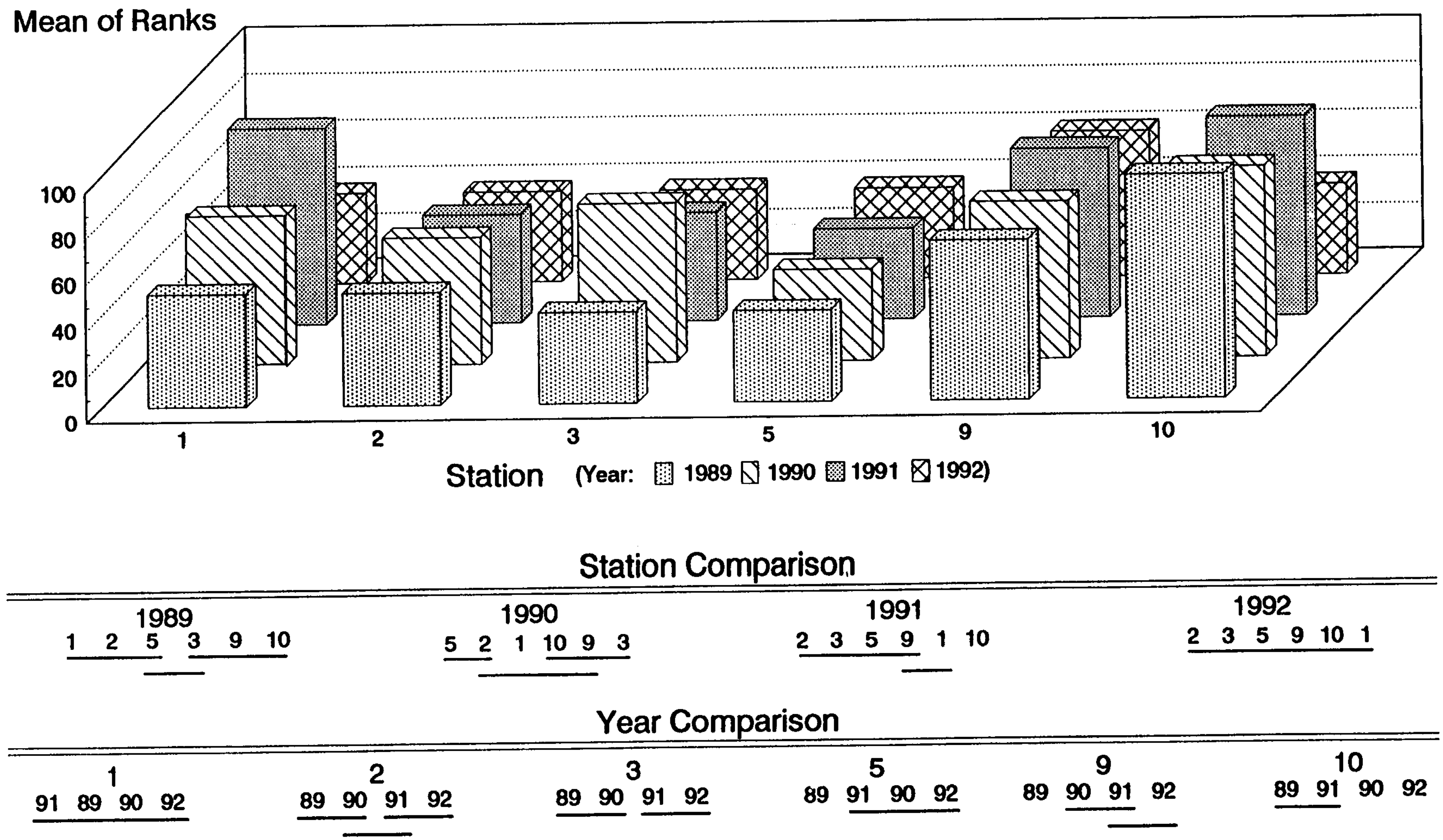


Figure 12. Graphical and statistical comparisons of the mean of ranks of largescale suckers sampled by beach seining in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).

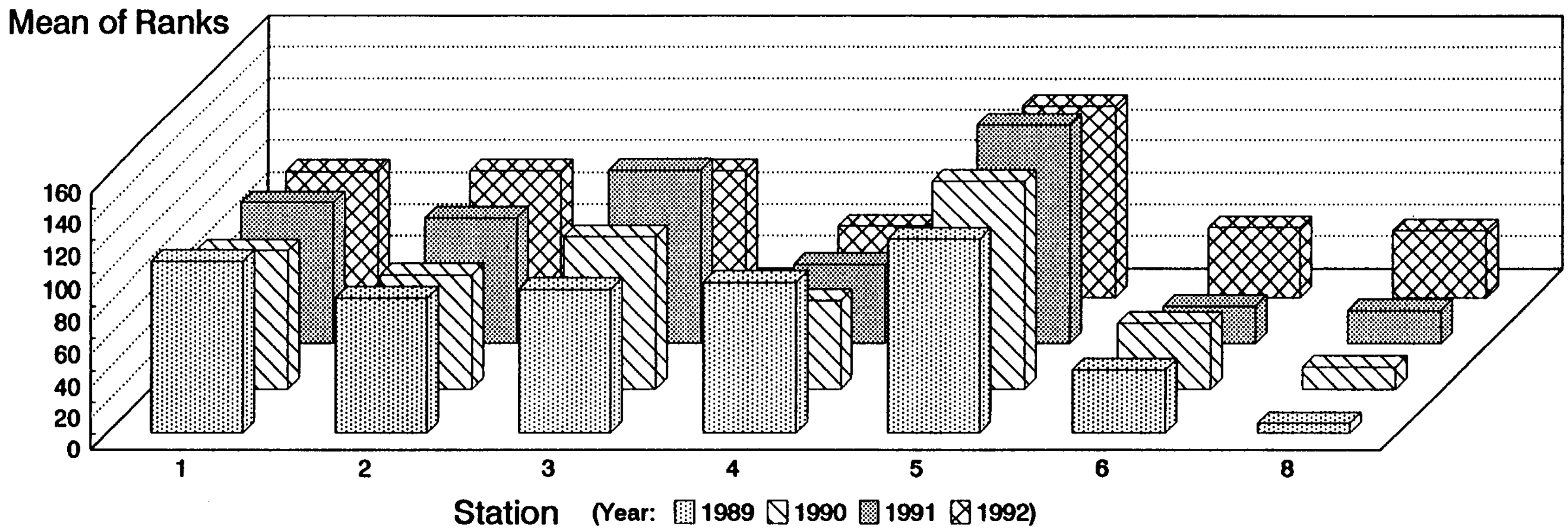
The mean catch/effort of largescale suckers sampled by gill netting was significantly ($P < 0.05$) lower in 1992 than other years sampled (Figure 13). Mean catch/effort from 1989 through 1992 at deeper stations (6, RM 114.0-114.92; and 8, RM 120.5) have been consistently low, while the highest mean catch/effort for largescale suckers was at station 5 (RM 127.0).

Chiselmouth.- Mean catch/effort for chiselmouths *Acrocheilus alutaceus* by electrofishing and beach seining generally showed little change among years (Figures 14 and 15). The mean catch/efforts of chiselmouths by both gear types were the lowest or second lowest in 1992 and these differences were not significant ($P > 0.05$).

The mean catch/effort by gill netting of chiselmouths decreased significantly ($P < 0.05$) in 1992 (Figure 16). Mean catch/efforts were similar among years 1989-1991 but that for 1992 was significantly ($P < 0.05$) lower.

DISCUSSION

We found limited evidence that outmigration/entrainment of fishes occurred from Lower Granite Reservoir associated with the March 1992 test drawdown. Largescale suckers and juvenile steelhead, fin clipped in Lower Granite Reservoir, were collected in Little Goose Reservoir. Although we had marked an additional 15,000 fish during fall 1991, many of these were young-of-the-year and their fin clips would have probably regenerated after 5-6 months. Everhart and Youngs (1975) reported



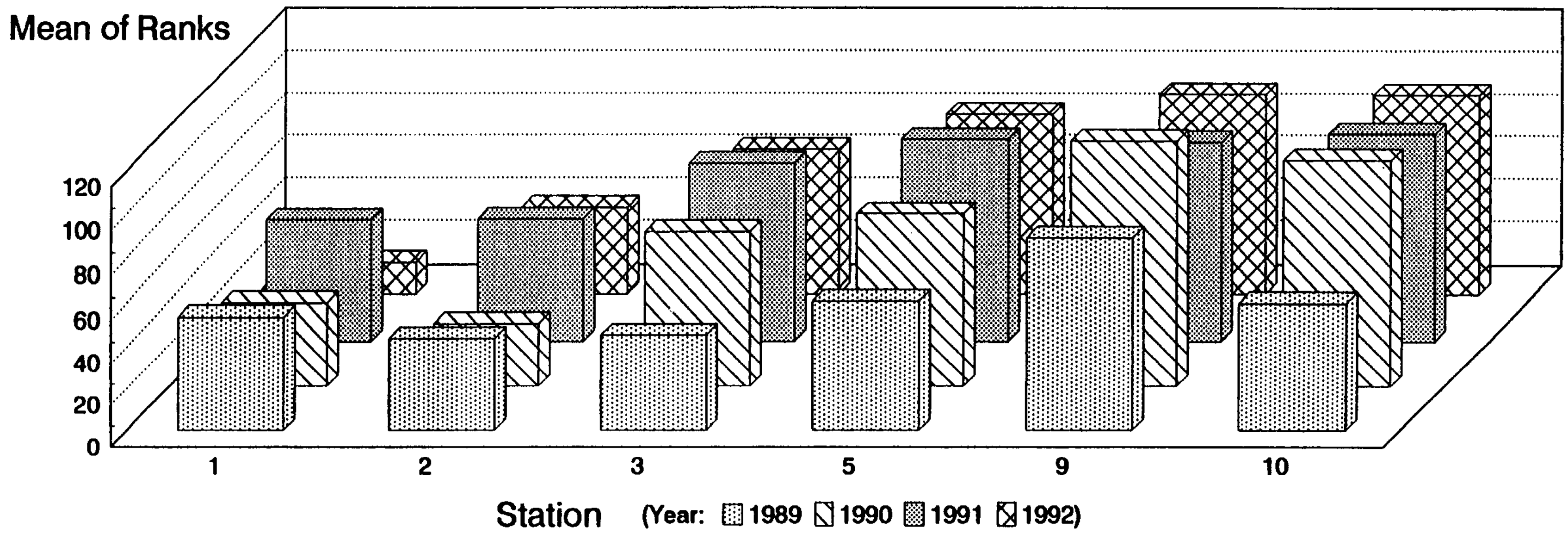
Station Comparison

5 1 3 2 4 6 8

Year Comparison

1989 1990 1991 1992

Figure 13. Graphical and statistical comparisons of the mean of ranks of largescale suckers sampled by gill netting in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



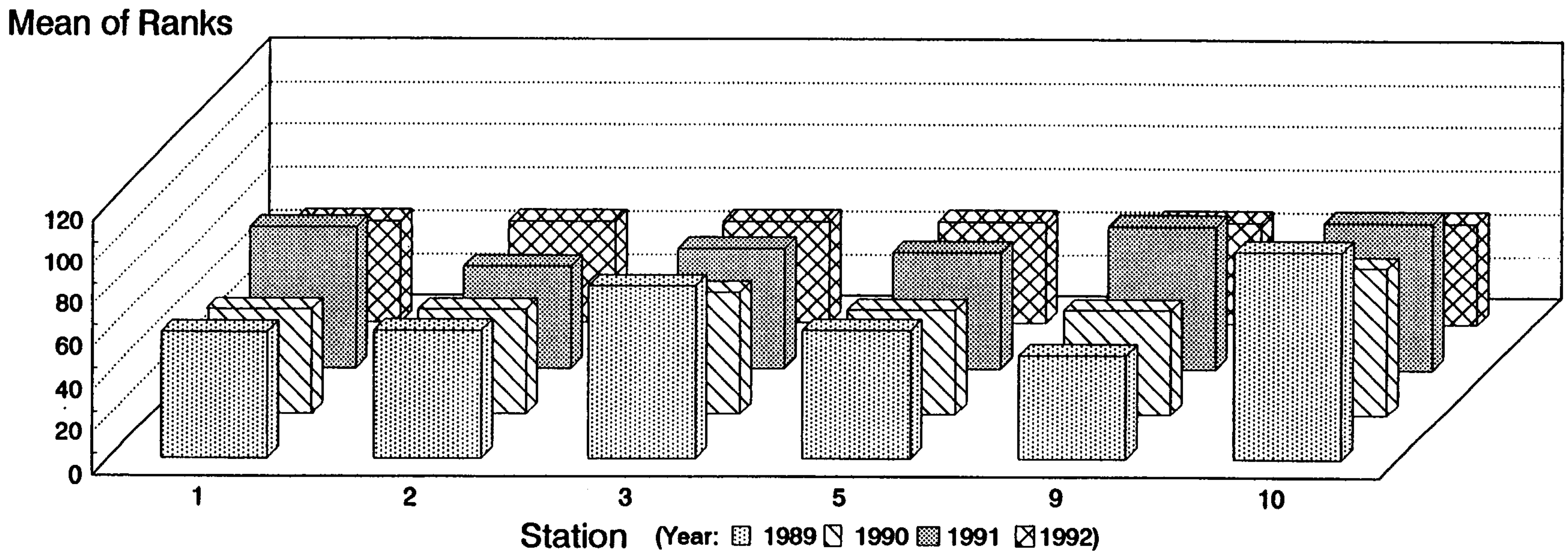
Station Comparison

9 10 5 3 2 1

Year Comparison

1991 1990 1992 1989

Figure 14. Graphical and statistical comparisons of the mean of ranks of chiselmouth sampled by electrofishing in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance (P > 0.05).



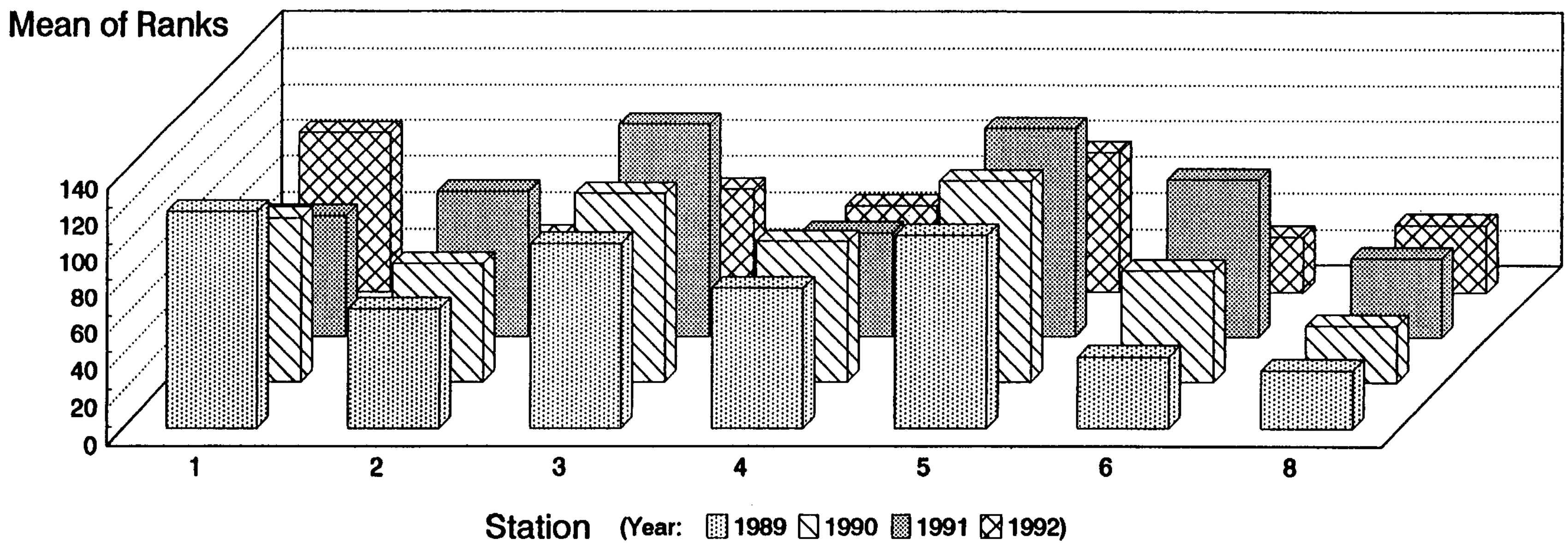
Station Comparison

10 3 1 9 5 2

Year Comparison

1989 1991 1990 1992

Figure 15. Graphical and statistical comparisons of the mean of ranks of chiselmouth sampled by beach seining in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignificance ($P > 0.05$).



Station Comparison

5 1 3 4 2 6 8

Year Comparison

1991 1990 1989 1992

Figure 16. Graphical and statistical comparisons of the mean of ranksof chiselmouth sampled by gill netting in Lower Granite Reservoir during spring 1989, 1990, 1991 and 1992. Horizontal lines under station and year comparisons indicate statistical nonsignficance (P > 0.05).

generally larger fish and spiny rayed fishes do not regenerate fin clips as fast as smaller individuals and soft rayed fishes. Partially regenerated fin clips are difficult to identify in the field and they might have been missed with the low ambient light under nighttime sampling conditions.

Our comparisons of mean catch/efforts between predrawdown 1989-1991 and postdrawdown 1992 provide indirect measures of fish entrainment. Of the six species compared, four species showed reductions in catch/effort. Northern squawfish, channel catfish, largescale suckers and chiselmouths showed significant reductions in mean catch/effort by gill netting following the drawdown. Gill nets generally sample the larger fishes and these data suggest entrainment of adult fishes could have occurred resulting in a reduced adult population. Comparisons of mean catch/efforts suggested smallmouth bass and white sturgeon abundance may have increased as a result of the drawdown.

Results of comparisons of mean catch/effort by electrofishing generally indicated few changes occurred in the fish community as a result of the test drawdown. Catches of smallmouth bass by electrofishing increased in 1992 although these differences were not statistically significant. Generally, subadult and adult fish are sampled by electrofishing.

Comparisons of the mean catch/efforts of the six species by beach seining generally showed similar results as the electrofishing. Most comparisons were not significant although numbers of smallmouth bass declined in 1992; 1992 was the lowest of all years. Beach seining catches primarily age 0 and age-1 fish. Our interpretation of these comparisons suggest that the smaller fishes generally remained at similar levels of abundance following the drawdown.

Objective 4. To assess effects of the test drawdown on size and species composition of fishes in Lower Granite Reservoir.

METHODS

To assess the effects of the test drawdown on the size and species composition of fishes in Lower Granite Reservoir, we sampled intensively throughout the reservoir during spring 1992. We have sampled at six sampling locations annually since 1989 and have established the size distribution of the fish community that is sampled by shoreline electrofishing at night, shoreline beach seining during the day and gill netting in pelagic waters. We sampled at these same locations following the drawdown using identical methods that were used in previous years and in 1992 (Bennett et al. 1989, 1991, 1993a, 1993b). Total length (mm) was measured on each of the fish sampled and length frequency distributions were generated from these collections.

To assess differences in species relative abundance among 1990, 1991 and 1992, we compared numbers of each species collected among years using the Kruskal-Wallis test, the nonparametric analog of the one-way analysis of variance (Conover 1971). Significance was determined by $P < 0.05$.

To assess differences in the size structure of fishes remaining in Lower Granite Reservoir following the test drawdown compared to those prior to the drawdown, chi-square analysis ($P < 0.05$) was used. Comparisons of size composition (0-75, 75-150, 150-225, > 225 mm, and additionally for bass 225-300 and > 300 mm) were made for smallmouth bass, northern squawfish, largescale suckers and chiselmouths collected during spring 1990 and 1991. If no significant ($P > 0.05$) differences were found in size composition, catches for 1990 and 1991 were combined and compared by chi-square analysis to catches made in 1992 (Dowdy and Wearden 1991). When significant ($P < 0.05$) differences were found between 1990 and 1991, comparisons were made between the size composition of catches from 1990 and 1992, and 1991 and 1992.

RESULTS

During spring 1992, we collected 21 species of fish in Lower Granite Reservoir. Numbers collected of each species were generally similar among years with few exceptions. Numbers collected in 1992 were lower than 1989, 1990 and 1991 in 10 species, whereas 2 species were collected in higher numbers in 1992 than in 1989, 1990 and 1991 (Table 3). Catch rates of largescale suckers, chiselmouths and northern squawfish declined in 1992 from 1989, 1990 and 1991 abundances. Statistically, changes in abundance of the fish community were not significantly ($P > 0.05$) different among years 1990, 1991 and 1992. Concordance (Kendall's Tau) among species catches was significant ($P < 0.05$) among all years including 1992.

Catch rates of smallmouth bass, northern squawfish, largescale suckers and chiselmouths during 1990 and 1991 throughout Lower Granite Reservoir differed significantly ($P < 0.001$) in size composition between years (Table 4). Comparison of size composition between 1990 and 1992, and 1991 and 1992 also were significantly ($P < 0.001$) different for smallmouth bass, northern squawfish, largescale suckers and chiselmouths.

Table 3. Number of fishes sampled by all gear types within Lower Granite Reservoir during spring (April 1 to June 20) 1989, 1990, 1991 and 1992 (April 1 to May 20).

Species	1989	1990	1991	1992
white sturgeon	36	17	1	141
sockeye salmon	1	8	8	0
chinook salmon	4,976	1,704	1,998	1,604
mountain whitefish	6	94	61	10
rainbow trout	695	542	565	1,352
chiselmouth	593	439	554	171
carp	94	59	12	23
peamouth	28	14	54	28
northern squawfish	352	264	773	182
redside shiner	8	63	7	4
brigdelip sucker	96	153	87	30
largescale sucker	2,820	2,357	2,670	1,268
yellow bullhead	0	7	5	7
brown bullhead	41	64	10	26
black bullhead	0	3	7	0
channel catfish	87	60	11	32
pumpkinseed	148	88	184	97
bluegill	2	23	23	8
Lepomis spp.	23	3	428	1
black crappie	10	94	62	60
white crappie	329	111	48	37
smallmouth bass	477	361	1,143	678
yellow perch	84	85	22	30
sculpin	1	1	9	0

Table 4. Chi-square analyses comparing size composition of catch by river mile (RM) from 1990, 1991 and 1992 in Lower Granite Reservoir[1]. Sampling in 1992 followed the March test drawdown. P values show level of significance while NS is not significant ($P > 0.05$).

Species	Sampling location	1990 vs 1991	1992 vs combined 1990/1991	1992 vs 1990	1992 vs 1991
chiselmouth	RM 120 (1)[2]	NS	NS		
	RM 120 (2)	NS	P=0.008		
	RM 120 (3)	P=0.01		P<0.01	NS
	RM 120 (4)	NS	NS		
	RM 127 (5)	P=0.04		P=0.005	P<0.001
	RM 114 (6)	P<0.001			
	RM 110 (10)	P<0.001		NS	P<0.001
largescale sucker	RM 120 (1)	P<0.001		P=0.002	P<0.001
	RM 120 (2)	P<0.001		P<0.001	P<0.001
	RM 120 (3)	P<0.001		P<0.001	P<0.001
	RM 120 (4)	NS	NS		
	RM 127 (5)	P<0.001		P<0.001	P<0.001
	RM 114 (6)	P=0.02		P<0.001	
	RM 110 (10)	P=0.02		P<0.001	P<0.001
smallmouth bass	RM 120 (1)	NS			
	RM 120 (2)	P=0.03		P=0.03	P=0.006
	RM 120 (3)	NS			
	RM 120 (4)	NS			
	RM 127 (5)	P<0.001		NS	P<0.001
	RM 114 (6)	P<0.001			
	RM 110 (10)	P=0.002		P<0.001	P<0.001
northern squawfish	RM 120 (1)	P<0.001		P=0.019	P<0.001
	RM 120 (2)	NS	NS		
	RM 120 (3)	P<0.001		P=0.051	P<0.001
	RM 127 (5)	P<0.001		P=0.001	P<0.001
	RM 114 (6)	P<0.001		NS	P=0.023
	RM 110 (10)	P<0.001		P=0.002	P<0.001

[1]Comparisons first made between 1990 and 1991; if not significant, then they were combined and compared to 1992. If significant, then annual comparisons were made to 1992.
[2]Number in parenthesis indicates sampling station.

Analysis of size composition by location in Lower Granite Reservoir generally showed greater differences between 1990 and 1991 than 1990 and 1991 combined and 1992 (Table 4). The incidence of smaller, medium sized and larger individuals within these species seems similar prior to and following the test drawdown of 1992. No trends were found in the size structure of the catch and location within Lower Granite Reservoir.

Comparison of size composition of northern squawfish captured at five stations in Lower Granite Reservoir indicated significant ($P < 0.001$) differences between 1990 and 1991. When the size structure of northern squawfish was compared between 1990 and 1991 and 1992, all differences were significant ($P < 0.002$).

The size structure of smallmouth bass following the 1992 test drawdown in Lower Granite Reservoir was generally different from the 2 years prior to the drawdown. Significant differences ($P < 0.03$) in the size composition of the catch between 1990 and 1991 was found at four of seven sampling stations. Of these differences, the size structure of the catch differed significantly between 1992 and 1990 and 1991 at all but one location. At the sampling locations where we found no significant differences in the size structure between 1990 and 1991, the combined catches of these years differed significantly at two of three locations with those in 1992.

The size composition of largescale suckers was significantly ($P < 0.001$) different between 1990 and 1991 at six of seven locations throughout Lower Granite Reservoir. At the one location where no differences were found between 1990 and 1991, we found no difference in the size composition of the catch between the combined sample of 1990 and 1991 with that of 1992.

We also found significant differences ($P < 0.04$) in the size composition of chiselmouths between 1990 and 1991 at four of seven sampling locations. At the three stations where no significant differences in the size composition of the catch was found, the combined 1990 and 1991 catches were not different between 1992 at two of the three stations.

These size comparisons demonstrate the size structure of the populations of smallmouth bass, northern squawfish, chiselmouths and largescale suckers based on our sampling has been different between years prior to and following the drawdown. We cannot attribute differences in the size composition of our catches to the 1992 test drawdown.

DISCUSSION

We observed no change in the species composition and relative abundance of fishes in Lower Granite Reservoir in spring 1992 following the March 1992 test drawdown. A total of 21 species were represented in our catches which is similar to previous years during the spring. Also, comparison of the numerical abundance of all fishes in our catches from 1992 with approximately the same amount of effort for 1990 and 1991 indicated no significant ($P > 0.05$) difference among years. Concordance was also found in numbers caught from 1989 through 1992 indicating no significant shift in relative abundance based on numbers sampled.

Although overall fish community composition prior to the 1992 test drawdown was similar to those following the drawdown, reduced numbers of certain species were found. Lower numbers of largescale suckers, chiselmouths and northern squawfish collected in 1992 indicated that these populations may have been affected by the March 1992 test drawdown. Other factors could have affected numbers sampled in 1992 including prespawning migrations and changes in habitat. Although short-term habitat changes occurred as a result of the drawdown, it is unlikely that these affected numbers caught in 1992 as a result of sampling in diverse habitat types following refill. Also, sampling was sufficient in 1992 and effort was similar to other years to make us believe the reduced catches probably reflected a reduction in numbers in Lower Granite Reservoir. These three species exhibited the widest decrease in numbers of the 21 species collected and they probably reflect decreased population size in Lower Granite Reservoir following the 1992 test drawdown. These findings are supported by the marking data that showed some of the marked largescale suckers were entrained by the drawdown.

Based on the evidence of changes in the relative abundance of different sizes sampled during a 3-year period, the March 1992 test drawdown had no apparent effect on the size structure of four of the more abundant resident fishes in Lower Granite Reservoir. We found no evidence to support the hypothesis that one or more year-classes were lost from the system. Our sampling results from 1990 and 1991, both years prior to the drawdown in Lower Granite Reservoir, indicated differences existed in the size composition between these 2 years. These differences in size composition were as great as those following the drawdown.

Chi-square analysis was highly sensitive to differences in the number of fishes collected by size group. As a result of this high sensitivity, differences in the size structure of the catch between years were commonly found. Assessing size composition based on sampling results is ostensibly variable, although gear types and effort were nearly identical among 1990, 1991 and 1992. Although statistical significance in size composition was found, these differences were not considered biologically significant.

Objective 5. To assess the effects of the test drawdown in Lower Granite Reservoir on white sturgeon distribution and abundance.

METHODS

We sampled white sturgeon prior, during and immediately following the test drawdown in Lower Granite Reservoir and during fall 1992 in the Lower Granite tailwater. Gill nets were set at previously sampled transects in Lower Granite Reservoir using established sampling protocols for white sturgeon (Bennett et al. 1993a, 1993b). Eight gill nets were set on the bottom and checked at 2-3 hour intervals. All fish were removed from the gill nets and sturgeon were measured, marked using an aluminum strap tag and a passive integrated transponder (P.I.T.) and released. All fish sampled were examined for the presence of a strap tag and/or signs of previous capture (tag scar and cut first ray of the pectoral fin).

During fall 1992, sampling for white sturgeon was conducted in the tailwater of Lower Granite Dam following the same procedures as predrawdown sampling. All sturgeon sampled were examined for the presence of a P.I.T. tag, an aluminum strap tag and/or a severed fin ray.

RESULTS

Twenty-one white sturgeon were captured immediately prior to the test drawdown in 4 days, February 20, 23, 26 and 27, 1992, of sampling in Lower Granite Reservoir. Of those 21 fish, one was recaptured yielding a recapture rate of 5%. During the drawdown, sampling was conducted for 22 days and 46 fish were captured. Of the 46 fish captured, 9 were recaptured yielding a recapture rate of 19%. Immediately following the drawdown, sampling was conducted from April 1 to May 20 and a total of 141 sturgeon were captured. Of these 141 sturgeon, 26 were recaptured yielding a recapture rate of 18%.

During summer 1992, one aluminum strap tag and P.I.T. tag were returned by an angler who caught a white sturgeon in the Lower Granite tailwater that was originally collected in Lower Granite Reservoir during 1990 and 1991. This fish was originally caught in August 1990 at RM 137 and then recaptured during 1991 at RM 130. The return of this tag indicates at least one white sturgeon emigrated from Lower Granite Reservoir between 1991 and July 1992.

During fall 1992, we sampled 105 white sturgeon in Lower Granite Reservoir; 8 of these were recaptures yielding a recapture rate of 7%. Also during fall 1992, we sampled 176 white sturgeon in the Lower Granite tailwater from September 28, 1992 to November 4, 1992. A total of 40 recaptures was made of sturgeon yielding a recapture rate of 23%. Several of these fish were originally tagged in Lower Granite Reservoir as far upstream as the Port of Whitman at RM 137. The recapture data clearly demonstrate movement of white sturgeon from Lower Granite to Little Goose Reservoir occurred but does not provide more specific information on the timing of that movement.

DISCUSSION

Our white sturgeon sampling in Lower Granite Reservoir shows a possible affect from the 1992 test drawdown. Sampling in the tailwater of Lower Granite Dam in the fall of 1992 provided verification that a number of sturgeon originally tagged in Lower Granite Reservoir passed the dam and were inhabiting the tailwater. Of the 176 sturgeon collected in the tailwater of Lower Granite Dam, 40 were originally collected and marked in Lower Granite Reservoir. We cannot confirm that these fish migrated downstream as a result of the 1992 test drawdown. However, we marked over 900 white sturgeon in Lower Granite Reservoir prior to the test drawdown and no tags were returned from the tailwater fishery prior to July 1992. We do not know whether the tagged sturgeon caught by an angler outmigrated during the March 1992 test drawdown or at some later time possibly during the 1992 spring runoff or prior, possibly a test spill conducted on June 1, 1991.

The magnitude and timing of sturgeon immigration into Little Goose Reservoir is not known. More intensive sampling in Little Goose Reservoir is necessary to assess whether sturgeon commonly migrate downstream from Lower Granite Reservoir possibly during runoff. The presence of nearly 1,000 permanently P.I.T. tagged sturgeon in Lower Granite Reservoir provides an easier and more cost efficient opportunity to assess the role Lower Granite Reservoir plays in the recruitment of sturgeon into Little Goose and possibly other lower Snake River reservoirs. Further sampling may show that sturgeon recruit to Little Goose Reservoir from spawning sites upstream of Lower Granite Reservoir. Several of the sturgeon that were recaptured in the Lower Granite tailwater were originally marked as far upstream as the Port of Whitman at RM 137.

Opportunities for sturgeon passage by Lower Granite Dam is limited. Possibilities include; spillways, turbines, juvenile by-pass system and navigation locks. Passage over the spillway was limited to a 1991 spill test on June 1 and the 1992 test drawdown in March. As indicated, the sturgeon that was tagged in Lower Granite in 1990 and caught by an angler in Little Goose Reservoir in early July 1992 could have moved downstream during either the 1991 spill test or the 1992 test drawdown. Also, small sturgeon (<10 in, < 245 mm, diameter) have occasionally been observed moving through the juvenile by-pass system. Turbine related mortality would probably be high; however, we have not observed any dead sturgeon in the tailwater of Lower Granite Dam or had any reports from anglers and agency biologists. The sturgeon that were sampled in the tailwater were not noticeably injured or bearing lesions. Regardless of the route, sturgeon have successfully moved from Lower Granite Reservoir to Little Goose Reservoir although their timing is not known.

Recapture rates of sturgeon have remained about 18% following the drawdown suggesting sturgeon immigration rates into Lower Granite Reservoir probably were not increased from upstream sources, although mean catch/effort was significantly ($P < 0.05$) higher in 1992 than 1991. If the more riverine conditions that existed in Lower Granite Reservoir upstream of Silcott Island during the test drawdown stimulated migration into the reservoir from upstream, we probably would have observed a decrease in the recapture rate.

Objective 6. To review existing reservoir fishery data and literature regarding reservoir drawdown and to evaluate potential additional effects of reservoir drawdown, specifically predation and year-class strength of predators in Lower Granite Reservoir.

The literature is relatively clear that drawdown can affect predator activity levels and prey abundance. Decreasing water levels that concentrate prey fish for at least 2-3 months at higher temperatures can increase predator foraging and growth (Aggus 1979). Increased feeding activity or growth by piscivores during or immediately after drawdown has been reported for northern pike (Beard and Snow 1970), smallmouth bass (Heisey et al. 1980), largemouth bass (Heman et al. 1969), white crappie and flathead catfish (Johnson and Andrews 1974). After prolonged drawdown, growth of predator fish decrease as prey and invertebrate abundance decreases (Ploskey 1986).

Although we collected more than 500 northern squawfish in the Lower Granite tailwater immediately following spill events (Figure 17), sampling was not conducted under no spill. Previous sampling results suggest a possible migration of squawfish to the tailwater as a result of increased flows. Such a migration was suggested by Bennett et al. (1983) for northern squawfish and channel catfish during spring 1979 and 1980 in Little Goose Reservoir. These data may be correlative but not represent cause and effect. Thus, high catches of northern squawfish in the tailwater of Lower Granite Dam may or may not represent a movement to the dam as a result of higher spill events.

Timing of the 1992 test drawdown in Lower Granite Reservoir coincided with low water temperatures (41-46°F, 5-8°C). Since fish are ectothermic vertebrates, their activity levels in this temperature range

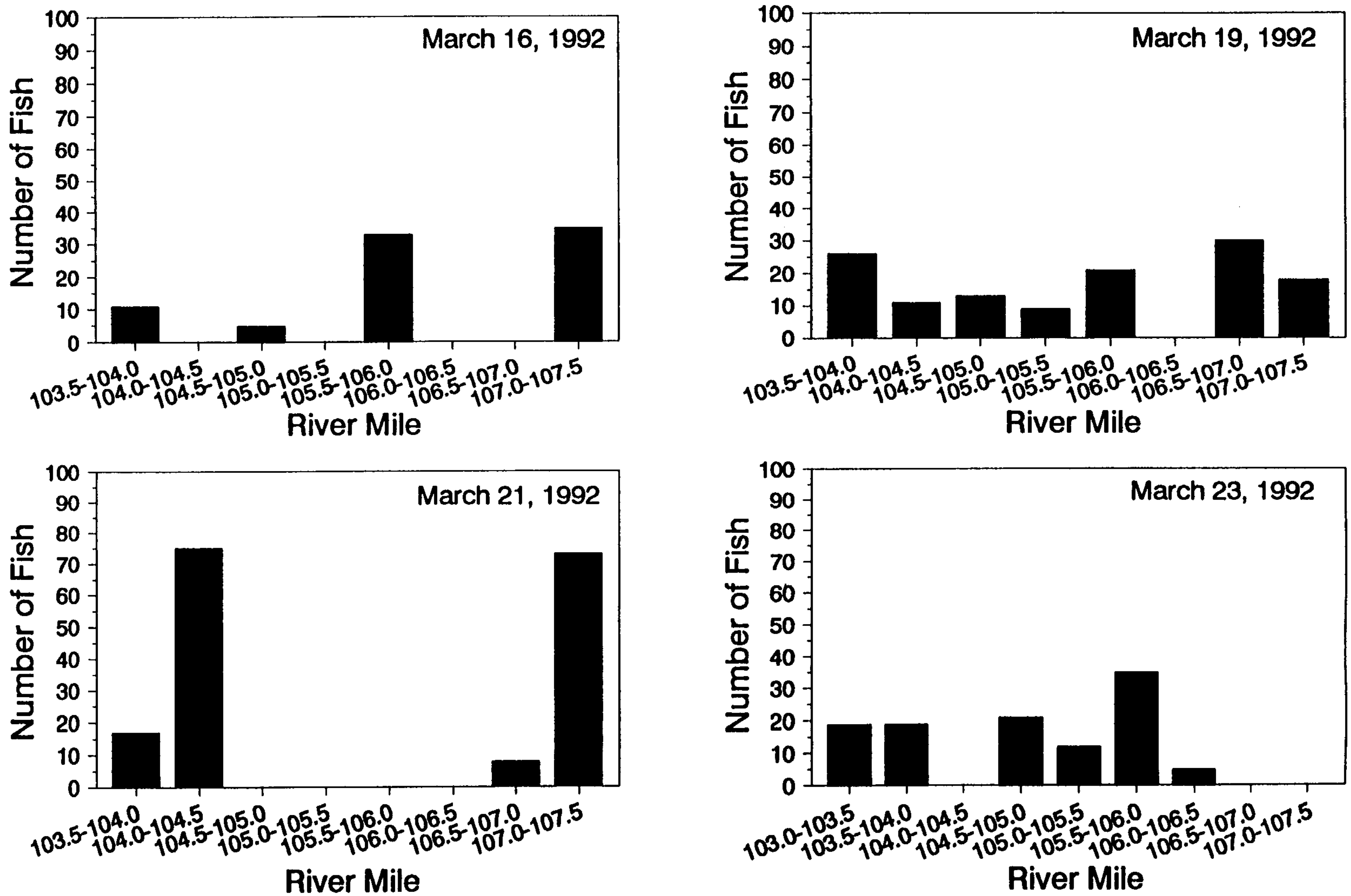


Figure 17. Numbers of northern squawfish collected by river mile in the tailwater of Lower Granite Dam following spill events associated with the March 1992 test drawdown.

are generally low. Feeding activity of smallmouth bass is directly linked to temperature as feeding is generally minimal at water temperatures < 50°F (<10°C; Coble 1975). Fairly extensive information currently indicates at 41°F (5°C) salmonid consumption by northern squawfish is nearly zero whereas at 59°F (15°C) the rate increases to 0.5 smolts/predator/day (Vigg and Burley 1991). Empirically, in John Day Reservoir, mean consumption rate of squawfish was four times higher at 66°F (19°C) than at 53°F (11.5°C; Vigg et al. 1991). It is obvious that at higher water temperatures, smolt consumption will increase dramatically.

We do not believe predation on salmonids by the two significant fish predators in Lower Granite Reservoir, northern squawfish (Chandler 1993) and smallmouth bass (Curet 1993), was substantial at the time of the 1992 test drawdown. Two factors contributed to the low levels of predation: low number of smolts in the reservoir and low water temperatures. The number of salmonids in Lower Granite Reservoir was low in March 1992 (Objective 1) and water temperatures were from 41-46°F (5-8°C). Although we did not examine predators internally, they did not exhibit signs of intense predation such as distended stomachs or smolt tails extending from their mouths. These are common sights in Lower Granite Reservoir during the active smolt migration period of mid-April to June. The combination of cool water temperatures and low salmonid abundance probably accounted for limited salmonid predation during the 1992 test drawdown.

We have limited evidence collected after refill following the 1992 test drawdown in Lower Granite Reservoir, however, that suggests changes in predation rates may have occurred as an indirect result of the drawdown. Curet (1993) reported a high incidence of chinook salmon in the diet of smallmouth bass immediately after refill. The high mortality of crayfish and smaller age-1 fish observed in the shallow waters of Lower Granite Reservoir during the drawdown probably reduced forage availability for smallmouth bass. Coble (1975) indicated that the diet of smallmouth bass is influenced greatly by abundance and availability of prey. Reduced forage may have caused a shift in the smallmouth bass diet to more of a fish diet in the spring. The number of age-0 chinook consumed by smallmouth bass in Lower Granite Reservoir during May 1992 exceeded that consumed by northern squawfish.

Although consumption has not been assessed during another year for comparison, we believe the high consumption rates determined following the 1992 test drawdown were probably not independent of forage abundance. We have previously shown that crayfish is the most important dietary item for northern squawfish, channel catfish and smallmouth bass (Bennett and Shrier 1986), and reduced crayfish abundance may have forced these predators to increase their consumption of juvenile chinook salmon.

Timing of a change in water levels is highly important in Lower Granite Reservoir as water temperatures are low in April (<50°F, <10°C) when spring and summer chinook are generally migrating through the reservoir. However, when water temperatures warm in May and June, age-0 chinook become highly susceptible to predation. Under drawdown conditions timed when water temperatures are higher, similar reductions in forage abundance may result in increased predation on downstream migrating salmonids.

Changes in fish communities have been associated with drawdowns. Under drawdown conditions, some fishes, such as those adapted to a lacustrine habitat, may not successfully spawn and their numbers would decline. Others that spawn under lotic conditions may be more successful and their numbers would increase. Timing of the drawdown and refill would ultimately affect the success of spawning and early rearing.

Strong year-classes of many freshwater fishes have been correlated with rising or high water levels during and after the spawning season (Ploskey 1986). Water levels also determine the quantity and quality of rearing habitat. During summer and early fall 1991, abundance of larval fishes in Lower Granite Reservoir was extremely high in comparison to previous years (Bennett et al. 1994). We do not know if this was a response to stable water levels associated with maintaining water levels at minimum operating pool. Benson (1976) and Nelson and Walburg (1977) and others have reported increased year-class strength associated with increased water levels in Missouri River reservoirs. Spawning success does not ensure a strong year-class but may increase its probability of occurring. Larval fish abundance in 1992 following the test drawdown was also high. In 1992, water levels were also generally maintained at minimum operating pool. As in 1991, we do not know whether this was a response to the stable water levels or a density dependent response to lower numbers of fishes. Based on literature and our data, strong year-classes of potential predators and competitors of salmonid fishes could occur in Lower Granite Reservoir as an indirect result of a drawdown. Thus, timing of any proposed drawdown and refill is extremely important. As indicated earlier, year-class strength of predators could increase and, in combination with the concentration of predators and downstream migrating smolts, the potential for predation may increase.

OVERALL DISCUSSION

Long-term water level changes have generally been associated with a reduction in benthos and fish standing crops (Ploskey 1986). Jenkins and Morais (1971) reported a negative correlation between total fish standing crop and annual vertical water level fluctuations in 70 U.S. reservoirs. Gaboury and Patalas (1984) reported reduced standing crops of predator and prey fishes in Cross Lake, Canada, as a result of a 49% reduction in average summer water levels. Reduced winter water levels also appear damaging to fish populations as Hatch (1991) reported high mortality rates of largemouth bass in Long Lake, Spokane River, Washington, following several years of drawdown to 23 ft (7 m). Bennett and DuPont (1993) also found annual mortalities of > 60% in adult-sized largemouth bass in the Pend Oreille River, Idaho associated with a 11.5 ft (3.5 m) late fall and winter drawdown. They believed high mortality may have been a result of the availability of limited overwintering habitat that may have increased downstream migration as an indirect result of water level reductions.

Based on these published findings, we hypothesize that changes occurred in the Lower Granite fish community as a result of the 1992 test drawdown. Our results, however, are far from conclusive as time constraints precluded exhaustive sampling and our data are contradictory, in part. Some data suggest minimal effects to the fish community while others show more significant effects.

The timing of the test drawdown limited sampling efficiency. Few fishes were active and present in shallow water during the predrawdown sampling. Based on the recovery of tagged fish, we found limited outmigration/entrainment in the fish community, as three marked largescale suckers and one juvenile rainbow trout/steelhead from Lower Granite Reservoir were collected in Little Goose Reservoir. Although we had marked about 15,000 fish in Lower Granite Reservoir in the spring-fall period of 1991, we collected few of those fish in Little Goose Reservoir. A high proportion of the marked fish were age 0 and fin clips would have been difficult to observe as a result of small fish size and high potential for fin regeneration, although many were larger and should have retained their marked identity. If outmigration/entrainment losses were high from Lower Granite Reservoir, we probably would have sampled higher numbers of marked fish downstream in Little Goose Reservoir. However, our sampling in Little Goose Reservoir was conducted only in the upstream 4 miles (6.4 km) from Lower Granite Dam, RM 107.5 downstream in Little Goose Reservoir to RM 104.0. Based on the recapture of marked fish, we conclude overall outmigration/entrainment of some resident fishes as a result of the March 1992 test drawdown was low. Also, because fish were marked in Lower Granite Reservoir in spring-fall, 1991, it was possible that some fish movement from Lower Granite to Little Goose occurred prior to the test drawdown.

Comparisons of mean catch/efforts and overall numbers of the more common resident fishes in the spring of 1992 with those from 1989-1991 suggests outmigration/entrainment from the drawdown could have been more significant than the marking-recovery data suggests. Although the species composition and relative abundance of fishes in Lower Granite

Reservoir was not altered based on the spring sampling results, numbers of largescale suckers, chiselmouths and northern squawfish sampled in 1992 were considerably lower than any year from 1989 through 1991. Lower numbers of northern squawfish could be related to the effects of the Sport Reward Program, or previous removals for dietary analysis (Chandler 1993) and not outmigration/entrainment losses from the test drawdown. Significant ($P < 0.05$) decreases in mean catch/effort by gill nets for large largescale suckers and chiselmouths suggest outmigration/entrainment from the test drawdown was high and their reduced abundances were observed in Lower Granite Reservoir during spring 1992. Gill nets generally sample large fish while electrofishing and beach seining collect small individuals (Atharud 1991; Bennett et al. 1991, 1993a, 1993b). Nonsignificance of mean catch/effort comparisons among years with electrofishing and beach seining suggest the larger fish may have been entrained in higher numbers than the smaller fish. However, comparisons of the size structure of various populations in Lower Granite Reservoir do not show a loss of larger fish from the reservoir.

The length frequency data were highly variable and, although significant differences were found, the data did not suggest any size related entrainment. We found about as many significant differences in the size composition of our catches from 1990 and 1991, 2 years prior to the drawdown, as we did between 1990 and 1992, and 1991 and 1992. The variability of the length data was high and accounted for the significant differences among years. With large sample sizes, Chi-square analyses are highly sensitive to detecting statistical differences, which we did. However, we do not consider these to be biologically significant. The relative abundance of size classes varied widely among years. Based on our sampling, we can confidently say size/age classes of the more abundant species were not entrained as a result of the 1992 test drawdown.

Our data suggest outmigration/entrainment of white sturgeon were probably significant to the Lower Granite population. Of the sturgeon that were recaptured during fall 1992 in Little Goose Reservoir, 23% were fish that were marked as long as 2 years prior to the test drawdown in Lower Granite Reservoir. These data suggest the outmigration/entrainment of white sturgeon in 1992 was high although timing is unknown. Entrainment may have occurred from a June 1, 1991 test spill. Because no sturgeon sampling was conducted between the June 1991 to fall 1992 period, we can not definitively say that entrainment of white sturgeon was a result of the 1992 test drawdown. The lack of returned tags from sturgeon fishermen prior to the drawdown provides limited evidence that outmigration/entrainment from Lower Granite Reservoir is not a common occurrence, although only one tag was returned after the drawdown.

Extrapolation of our findings from the March 1992 test drawdown to proposed drawdowns in the future to enhance smolt movement through the lower Snake River reservoirs is difficult. Water temperatures during the 1992 drawdown were 41-46°F (5-8°C), whereas a drawdown to enhance smolt movement through the reservoirs would occur when water temperatures range from < 50 to > 68°F (<10 to >20°C). Fish activity levels are accelerated at higher water temperatures and outmigration/entrainment and predation could be increased. We could not find any information in the literature that compared outmigration/entrainment losses at different times of the year. Smolt predation would be elevated with higher water temperatures (Vigg and Burley 1991) as reported in John Day (Vigg et al. 1991) and likely with a drawdown that consolidates predators and prey. Changes in abundance and availability of small fishes and invertebrate forage, such as crayfish and chironomids, may result in increased smolt predation.

Behavior modifications may result from changes in spill patterns. Our data, although limited, indicated a high abundance of northern squawfish in the tailwater of Lower Granite Dam. We have observed similar upstream migrations in Lower Granite Reservoir during the spring. These migrations may be related to a concentration and/or increased availability of food or reproduction. Also, Bennett et al. (1983) reported a similar migration of channel catfish to the Lower Granite tailwater in the spring of 1980. If these two predators migrate to the tailwater, the potential for increased smolt consumption exists in the tailwaters as a result of changes in spill patterns. We do not know whether this behavior would occur under drawdown conditions.

Results of this evaluation are considered preliminary. Our findings do suggest that if drawdown were conducted in the future, timing of refill of the reservoirs could affect year-class strength of fishes. Strong year-classes can result from reservoir refill. Based on the literature and our preliminary findings, the resident fish community, including white sturgeon, may be substantially changed by drawdown. Under drawdown conditions, fish behavior may be altered that could increase predation. Decision makers must exercise extreme caution to avoid creating conditions less favorable for salmonid smolts than currently exist in the Snake River reservoirs.

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