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DEVELOPMENT OF A SYSTEMWIDE PREDATOR CONTROL PROGRAM: STEPWISE IMPLEMENTATION OF A PREDATION INDEX, PREDATOR CONTROL FISHERIES, AND EVALUATION PLAN IN THE COLUMBIA RIVER BASIN

SECTION I: IMPLEMENTATION

1994 ANNUAL REPORT

Prepared by:

Charles F. Willis
S. P. Cramer and Associates, Inc.

Franklin R. Young
Columbia Basin Fish and Wildlife Authority

In Cooperation With

Washington Department of Wildlife
Pacific States Marine Fisheries Commission
Columbia River inter-Tribal Fish Commission
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of the Warm Springs Reservation
Nez Perce Tribe
Yakama Indian Tribe
Oregon Department of Fish and Wildlife

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
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Project Number 90-077
Contract Number 94B124514

September 1995

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SECTION II: EVALUATION

ANNUAL REPORT 1994

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EXECUTIVE SUMMARY

by Charles F. Willis

We report our results from the forth year of a basinwide program to harvest northern squawfish (*Ptychocheilus oregonensis*) *in an effort* to reduce mortality due to northern squawfish predation on juvenile salmonids during their emigration from natal streams to the ocean. Earlier work in the Columbia River Basin suggested predation by northern squawfish on juvenile salmonids may account for most of the 10-20% mortality juvenile salmonids experience in each of eight Columbia and Snake River reservoirs. Modeling simulations based on work in John Day Reservoir from 1982 through 1988 indicated it is not necessary to eradicate northern squawfish to substantially reduce predation-caused mortality of juvenile salmonids. Instead, if northern squawfish were exploited at a 10-20°/0 rate, reductions in numbers of larger, older fish resulting in restructuring of their population could reduce their predation on juvenile salmonids by 50°/0 or more.

Consequently, we designed and tested a sport-reward angling fishery and a commercial longline fishery in the John Day pool in 1990. We also conducted an angling fishery in areas inaccessible to the public at four dams on the mainstem Columbia River and at Ice Harbor Dam on the Snake River. Based on the success of these limited efforts, we implemented three test fisheries on a multi-pool, or systemwide, scale in 1991 -- a tribal longline fishery above Bonneville Dam, a sport-reward fishery, and a dam-angling fishery. Low catch of target fish and high cost of implementation resulted in discontinuation of the tribal longline fishery. However, the sport-reward and dam-angling fisheries were continued in 1992 and 1993. In 1992, we investigated the feasibility of implementing a commercial longline fishery in the Columbia River below Bonneville Dam and found that implementation of this fishery was also infeasible.

Although we were unable to implement an effective longline fishery, it was important to attainment of program objectives to attempt to substantially increase total annual exploitation. Estimates of combined annual exploitation rates resulting from the sport-reward and dam-angling fisheries remained at the low end of our target range of 10-20%. This suggested the need for additional, effective harvest techniques. During 1991 and 1992, we developed and tested a modified (small-sized) Merwin trap net. We found this floating trap net to be very effective at catching northern squawfish at specific sites. Consequently, in 1993 we examined a systemwide fishery using floating trap nets, but found this fishery to be ineffective at harvesting large numbers of northern squawfish on a systemwide scale.

In 1994, we investigated the use of trap nets and gill nets at site-specific locations where concentrations of northern squawfish were known or suspected to occur during the spring season (i.e., March through early June). In addition, we initiated a concerted effort to increase public participation in the sport-reward fishery through a series of promotional and incentive activities. Results of these efforts are subjects of this annual report under Section I, Implementation. In this section, we also report on the system we used to collect and dispose of harvested northern

squawfish. An evaluation of the cost effectiveness of a food-grade fish handling network is included.

Evaluation of the success of test fisheries in achieving our target goal of a 10-20% annual exploitation rate on northern squawfish is presented in Section II of this report. Overall program success in terms of altering the size and age composition of the northern squawfish population and in terms of potential reductions in loss of juvenile salmonids to northern squawfish predation is also discussed under Section II.

The fishery implementation and evaluation team includes the Columbia Basin Fish and Wildlife Authority (Authority), Pacific States Marine Fisheries Commission (PSMFC), S.P. Cramer and Associates, Inc. (SPCA), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), Columbia River Inter-Tribal Fish Commission (CRITFC), and the four lower Columbia River treaty tribes - the Confederated Tribes of the Umatilla Indian Reservation the Confederated Tribes of the Warm Springs Reservation, the Nez Perce Tribe, and the Yakama Indian Nation. The Authority and PSMFC, with assistance from SPCA, were responsible for coordination and administration of the entire program; PSMFC subcontracted various tasks and activities to ODFW, WDFW, CRITFC, and the four lower Columbia River treaty tribes based on expertise each brought to the tasks involved in implementing the program. Objectives of each cooperator related to program implementation were as follows,

1. WDFW (Report A): Implement a systemwide (i.e., Columbia River below Priest Rapids Dam and Snake River below Hells Canyon Dam) sport-reward fishery.

2. PSMFC (Report B): Process and provide accounting for reward payments to participants in the sport-reward fishery.

3. CRITFC (Report C): Implement a systemwide angling fishery at eight mainstem darns on the Snake and Columbia rivers.

4. CRITFC (Report D). Implement a fishery for removing northern squawfish near hatchery release sites and at other site-specific locations where concentrations of northern squawfish are known or suspected to occur.

5. SPCA ('Report E): Establish a private-sector operated system for collecting and disposing of harvested northern squawfish, coordinate system operations with fishery implementation activities, and evaluate the cost effectiveness of a food-grade fish handling network as a component of the overall fish handling system.

6. ODFW (Report F): Evaluate exploitation rate and size composition of northern squawfish harvested in the various fisheries implemented under the program together with an assessment of incidental catch of other fishes. Estimate reductions in predation on juvenile salmonids resulting from northern squawfish harvest. Evaluate changes in relative abundance, size and age structure, growth, and fecundity of northern squawfish and

consumption rates of juvenile salmonids by northern squawfish in lower Columbia and Snake River reservoirs and in the Columbia River below Bonneville Dam.

In addition to the activities listed above, ODFW conducted a limited lure trolling fishery for northern squawfish in the Bonneville Dam tailrace boat restricted zone from mid-June through mid-July 1994. A total of 75 hours of trolling produced a catch of 843 northern squawfish. No salmonids were intercepted.

Background and rationale for the Northern Squawfish Management Program study can be found in Report A of our 1990 annual report (Vigg et al. 1990). Highlights of results of our work in 1994 by report areas follows.

Report A
Implementation of the Northern Squawfish Sport-Reward Fishery in the Columbia and Snake Rivers

1. Objectives for 1994 were to implement the sport-reward fishery for northern squawfish in the lower Snake and Columbia rivers, to conduct a survey to assess impacts of the fishery on non-target fish species, to initiate an incentive and promotional program to increase angler participation and catch, and to report on the dynamics of the fishery and promotional program.

2. The northern squawfish sport-reward fishery was conducted from May 2 through September 25, 1994. Fourteen registration stations were located throughout the lower Snake and Columbia rivers.

3. A total of 129,434 northern squawfish equal to or greater than 11 inches in total length were returned to registration stations for reward vouchers during the 1994 season. These fish were caught during 20,795 successful angler days, which represented51% of the total number of angler days fished (40,783) by registered anglers. Harvest of northern squawfish increased by 24% over that observed in 1993, decreased by 3% compared to that observed in 1992, and decreased by 19'% compared to that observed in 1991, with a decrease in angler participation during 1994 compared to levels observed in any of the three prior years. Catch per unit effort (CPUE) in 1994 was 3.17 fish per angler day, and was significantly greater ($P<0.0001$) than any of the previous three years. An additional 7,707 northern squawfish under 11 inches total length were also returned to registration stations.

4. Lengths of northern squawfish over 250 mm fork length (i.e., 11 inches total length) averaged 335 mm in 1993 and in 1994, which represented a statistically significant decrease in mean fork length between 1992 (346 mm) and 1993. A statistically significant decrease in mean fork lengths was also observed between 1991 (350 mm) and 1992, suggesting a continuing trend in decreased average size of northern squawfish harvested in the sport-reward fishery during the initial years of the harvest program.

5. Registration station totals of harvested game fishes (22 species) other than northern squawfish and of unclassified fishes (six species) in 1994 indicated that no species was excessively harvested under the Northern Squaw-fish Management Program.

6. To obtain additional catch information, we conducted a phone survey of anglers who did not return to registration stations following their fishing trip. Harvest estimates for non-returning anglers included 1,730 northern squawfish that were 11 inches or larger and 5,840 northern squawfish that were less than 11 inches in total length. Catch estimates for other fish species included 1,320 smallmouth bass (*Micropterus dolomieui*), *500* walleye (*Stizostedion vitreum*), *80* steelhead (*Oncorhynchus mykiss*), 10 chinook salmon (*Oncorhynchus tschawytscha*), and 80 white sturgeon (*Acipenser transmontanus*).

7. Preliminary results from initiation of incentive and promotional activities were promising in terms of contributing to increased angler participation in special events and in terms of associated increase in harvest of northern squawfish.

8. An assessment of costs for implementing the sport-reward fishery in 1994 indicated a cost range from $1.36 (at The Fishery) to $24.57 (at Umatilla) per northern squawfish harvested at each of the 14 registration stations. The overall project cost per harvested northern squawfish was less in 1994 ($4.68) than in 1993 ($10.62) or 1992 ($9.68).

9. We recommend that the 1995 sport-reward fishery start in early May and extend through mid-September. Nine fill-time and 15 satellite registration stations should be operated with one shift per day extending from 1 p.m. to 9 p.m. seven days per week. Self registration during periods when stations are closed should continue. Registration stations should be operated throughout the area in which the fishery was implemented during 1991 through 1994. A phone survey should continue to provide information regarding total catch of target and non-target fishes, to evaluate satisfaction with the program, and to provide information needed to evaluate the effectiveness of incentive and promotional activities. An aggressive public relations program should be continued to increase awareness of, participation in, and efficiency of the sport-reward fishery.

Report B
Northern Squawfish Sport-Reward Fishery Payments

1. During 1994, a total of $396,364 was paid to anglers for 127,531 northern squawfish harvested in the sport-reward fishery.

2. A total of 13,434 vouchers were processed of which 13,141 were standard vouchers representing a harvest of 127,238 fish and 293 vouchers for tagged northern squawfish (one tagged fish per voucher). Non-tagged fish were processed with an award payment of $3 per fish while tagged fish were processed with an award value of $50 per fish. Not all vouchers issued to anglers were submitted for reward payment.

3. The mean catch was 9.7 northern squawfish per voucher.

4. Voucher processing proceeded smoothly with checks being cut and mailed to the angler within five days after receipt of the voucher.

5. Vouchers that had missing or incomplete information were returned to anglers for completion causing delay in payment. Vouchers that were not returned, or for which missing information was not provided, were rejected for payment.

6. The number of vouchers that were rejected totaled 93 with a combined potential reward of $726. There were a variety of reasons for vouchers being rejected, the most common being failure to complete the required questionnaire and submitting the voucher beyond the deadline for payment.

7. In addition to voucher processing, awards for weekly tournaments (246 prizes; $20,500), monthly drawings (25 prizes; $10,000), special tagged fish drawings (2 prizes; $10,000), G.I. Joe's tournaments (24 prizes; $5,000), and upper river tournaments (24 prizes; $4,000) were processed. Voucher payments and program award payments totaled $445,864 in 1994.

Report C
Controlled Angling for Northern Squawfish at Selected Dams on the Columbia and Snake Rivers

1. Dam angling at eight damson the lower Snake and Columbia rivers during 1994 resulted in a catch of 16,097 northern squawfish from May through early September. This was equivalent to 95% of the 1993 catch.

2. Total effort (10,002 hours) increased 3% compared to effort in 1993. Overall catch per angler hour (1.6) has remained relatively unchanged for the last three years (1992-1994). The mobile angling crew fished at Bonneville, The Dalles, and John Day dams, which yielded 25% of the total catch at a catch rate of 2.8 northern squawfish per angler hour.

3. Fishing effort at Snake River dams decreased by 43'% in comparison to 1993 effort because of continuing low catch rates of northern squawfish. However, Snake River catch rates did increase slightly over those observed in 1993. The catch rates of northern squawfish in 1994 at Columbia River dams decreased at Bonneville, John Day, and McNary dams and increased at The Dalles Dam compared to 1993 catch rates.

4. Incidental species caught as compared to the total catch decreased significantly from 5.5% in 1993 to 2.3°/0 in 1994. Bass comprised nearly half of the total bycatch with white sturgeon comprising another 20°/0 of the bycatch. Twelve juvenile and no adult salmonids were caught in 1994. Nine were released in good condition, two in poor condition, and one died.

5. We recommend that dam angling be continued at all eight lower Columbia and Snake River dams. Effort allocation adjustments should include an increase in effort at Bonneville and The Dalles dams using one crew whose effort is distributed between these dams based on weekly catch rates, and a decrease in effort at McNary Dam. Effort at John Day Dam should be maintained at the 1994 level. We also recommend continuing to use a mobile crew to fish at all four Snake River dams, focusing effort at Lower Granite Dam. The times and locations of daily effort at each dam should be distributed based on inseason monitoring of catch with a focus on dawn and dusk fishing periods. Boat crews should continue to be used in boat restricted zones (BRZs), particularly during high discharge periods, to catch northern squawfish in protected areas beyond the reach of dam-based anglers. A mobile crew should be employed below Bonneville Dam to conduct boat angling, lure trolling, and longlining in the BRZ. We include longlining on an experimental basis because its use may be effective when limited to BRZs. The volunteer angling effort should be expanded to 8-10 groups.

Report D

Site-Specific Removal of Northern Squawfish Aggregated to Feed on Juvenile Salmonids in the Spring in the Lower Columbia and Snake Rivers using Gill Nets and Trap Nets

1. Small-meshed gill nets and trap nets were used to catch 9,024 northern squawfish that were 250 mm fork length (FL) or longer during April through June 1994. Most of the catch was taken with gill nets (99.9%) and at locations in Bonneville Pool (98.5%). The mouth of the Klickitat River was the most productive fishing location. The most productive locations outside of Bonneville Pool were the mouths of the Umatilla and ClearWater rivers.

2. The total incidental catch of fishes for both gillnetting and trapping was 5,876 fish comprising approximately 20 species. Suckers (*Catostomus* spp.) were the predominate bycatch in gill nets. Salmonids comprised only 1% of total gill-net catches.

3. We recommend continuation of the site-specific fishery using gill nets only. Suitable site-specific fishery locations below Bonneville Dam should be investigated. The site-specific fishing season should be extended through the end of June, and daily fishing should be extended to one hour past sunrise. Other operational criteria should be reviewed and modified to increase operational efficiency while protecting against excessive interception of salmonids.

Report E
Handling and Transportation of Northern Squawfish Harvested under the Columbia River Northern Squawfish Management Program in 1994 and Evaluation of the Cost Effectiveness of a Food-Grade Fish Handling Network

1. Approximately 164,000 northern squawfish were harvested under the three fisheries implemented in 1994. We established a private-sector operated fish handling system to collect and transport harvested northern squawfish to end users, and we successfully coordinated activities among end users and fishery managers.

2. The 1994 fish handling system included a food-grade fish collection network located in the lower Columbia River. Operation of this network was less expensive than operation of a rendering-only network covering the same area would have been, based on handling of 111,536 pounds of northern squawfish harvested in the food-grade network area. Sale of food-grade fish generated $8,677 from 78,881 pounds of useable fish. Implementation of the food-grade network cost $38,927, which was $4,241 less than the cost for a rendering-only fish handling network. In addition, this project maintained the highest value end-use of the harvested resource. We, therefore, recommend continuation of the food-grade network as a component of the fish handling system.

3. The total spent for the fish handling system in 1994 was $156,881. With cost recovery from sale of food-grade fish, the net cost for the fish handling system was $148,204.

Report F
Development of a Systemwide Predator Control Program: Indexing and Fisheries Evaluation

1. Objectives in 1994 were to (1) evaluate exploitation rate, size composition and incidental catch of northern squawfish captured in the various fisheries and estimate reductions in predation on juvenile salmonids since implementation of the management program; and (2) evaluate changes through 1994 in relative abundance, smelt consumption rate, size and age structure, growth, and fecundity of northern squawfish in lower Columbia and Snake River reservoirs and in the Columbia River downstream from Bonneville Dam.

2. Systemwide exploitation of northern squawfish in 1994 was 10.9% for sport-reward, 1.1% for dam-angling, and 1. 1% for site-specific fisheries. Subsamples from each fishery indicated that the mean fork length was 344 mm in the sport-reward fishery, 401 mm in the dam-angling fishery, and 410 mm for gill nets in the site-specific fishery. ByCatch of salmonids was relatively low in all fisheries and was lowest in the dam-angling fishery relative to the tots! number of fish caught.

3. In general, relative abundance of northern squawfish in 1994 was similar to previous years in the Columbia River downstream from Bonneville Dam, but decreased in Columbia and Snake River reservoirs.

4. Potential predation on juvenile salmonids in 1995 maybe reduced 32% from pre-program levels. Eventual reductions in potential predation varied depending on estimates of sustained exploitation however, it appeared feasible to reduce overall predation by at least 40%. Smolt consumption indices decreased in Columbia Riverreservoirs and remained similar or increased in Snake River reservoirs and the Columbia River downstream from Bonneville Dam by approximately 30-60% in some areas.

5. Proportional stock density (PSD) of northern squawfish collected from the Bonneville Dam tailrace was lower in 1994 than in 1990. Estimates of PSD from 1991-1994 were generally below levels that would have been expected without implementation of the Northern Squawfish Management Program. Relatively strong recruitment in 1989 and 1990 will probably decrease PSD estimates in 1995 and 1996 as these relatively strong cohorts are recruited to "stock" size. Although length-age and fecundity-length relationships varied among years in some locations, we found no evidence of compensation by northern squawfish in any area.

SECTION 1. IMPLEMENTATION

Cooperators

Columbia Basin Fish and Wildlife Authority
S.P. Cramer and Associates, Inc.
Washington Department of Fish and Wildlife
Pacific States Marine Fisheries Commission
Columbia River Inter-Tribal Fish Commission

Report A

Implementation of the Northern Squawfish Sport-Reward Fishery in the Columbia and Snake Rivers

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1994 Annual Report

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ABSTRACT

Northern squawfish (*Ptychocheilus oregonensis*) harvest in 1994 totaled 129,434 fish returned to registration stations for payment ($3 per northern squawfish 11 inches or greater). Northern squawfish harvest was 24% greater than 1993 (104,536),31% less than 1992 (186,904) and 19°/0 less than 1991 (159, 162). A total of 40,783 angler days were spent fishing for northern

squawfish in 1994 and 5 1°/0 (20,795) of the registered anglers returned to registration stations for an exit interview. Effort in 1994 was lower than any of the three previous years. Catch per unit effort (CPUE) in 1994 was 3.17 (fish/angler day) and was significantly greater (1%0.0001) than any of the three previous years. An additional 7,707 northern squawfish under 11 inches were returned to registration stations.

Fork lengths were measured from 69,731 northern squawfish of which 66,498 were greater than or equal to 250 mm (approximately 11 inches total length). Mean fork length of northern squawfish greater than or equal to 11 inches total length, decreased from 1991 (350 mm) to 1994 (335 mm).

Registration station totals for game fish and unclassified fish species other than northern squawfish showed that no species of fish was excessively harvested by returning anglers. Of the total reported non-squawfish catch (4,269 fishes), anadromous salmonids (*Oncorhynchus* spp.) comprised 3.6'% (156 fish), all salmonids comprised 5.1% (216 fish), bass (*Micropterus* spp.) comprised 32.6% (1,393 fish), walleye (*Stizostedion vitreum*) comprised 11 .8% (502 fish), and channel catfish (*Ictalurus punctatus*) comprised 6.2% (263 fish). Many of these fish were being targeted when caught.

Non-returning angler estimates for harvest of game and unclassified fishes were obtained from a telephone survey. Harvest estimates included 1,730 northernsquawfishZ11 inches, 5,840 northern squawfish < 11 inches, 1,320 smallmouth bass (*Micropterus dolomieui*), *500 walleye,* 80 steelhead (*Oncorhynchus mykiss*), 10 chinook salmon (*Oncorhynchus tschawytscha*), and 80 white sturgeon (*Acipenser transmontanus*). *No* species of fish was found to be excessively harvested by non-returning anglers.

The promotional programs implemented in 1994 contributed to an increase in catch from 1993 and to the program achieving its highest exploitation rate to date. By increasing the reward paid for northern squawfish and by modifying select promotional activities, the 1995 fishery should be able to exceed the totals seen for 1994.

A total of 27,935 northern squawfish were returned to the registration station at The Fishery, which also achieved the lowest cost per fish ($1 .36) of any of the 14 registration stations. The registration station in Umatilla showed the highest cost per fish ($24.57). The overall cost per fish in 1994 was lower than for any of the previous years of the fishery.

INTRODUCTION

Northern squawfish (*Ptychocheilus oregonensis*) *are* the dominant predator ofjuvenile salmonids (*Oncorhynchus* spp.) in the lower Columbia and Snake River systems (Beamesderfer and Rieman 1991). Rieman andBeamesderfer(1990) demonstrated that predation on juvenile salmonids could be reduced by 50°/0 with limited, but sustained (1 0-20°/0) exploitation of northern squawfish greater than 275 mm fork length. The Columbia River Northern Squawfish

Management Program began in 1990 with the goal of achieving a 1O-2OVO annual exploitation of northern squawfish. The northern squawfish sport-reward fishery has the highest exploitation among fisheries in most areas (Knutsen et al. 1994). The sport-reward fishery encourages anglers to catch northern squawfish greater than or equal to 11 inches in total length by offering rewards and incentives.

Fourteen registration stations were operated on the Columbia and Snake rivers in 1994. Purposes of the registration stations were to register anglers, issue pay vouchers for northern squawfish greater than or equal to 11 inches, conduct exit interviews and to collect biological data on a subsample of fishes. Pay vouchers issued to anglers contained a questionnaire designed to collect harvest information and to determine angler satisfaction with the sport-reward fishery. Exit interviews provided additional harvest information from returning anglers. Anglers not returning to the registration station were surveyed by telephone.

New promotional and incentive programs were designed, implemented and evaluated in 1994. These programs were designed to boost angler participation and increase exploitation of northern squawfish greater than 11 inches.

Registration stations with limited hours of operation (satellite stations) were evaluated to determine their operational feasibility.

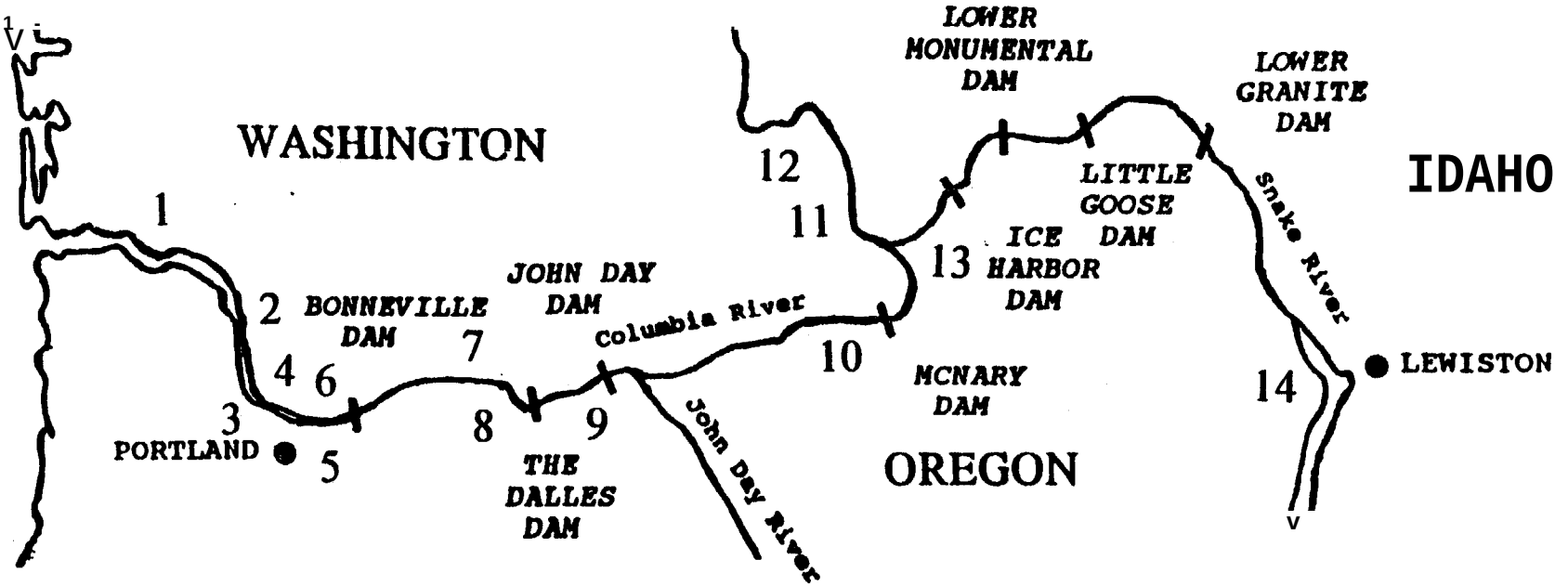
We examined the effectiveness of registration stations to identify and develop new operational methods that would lower costs. In doing so, we made a tremendous effort to ensure that our method of figuring costs was comparable to Susan Hanna's, who was responsible for the cost analysis following the 1992 and 1993 fishery seasons.

METHODS

Study Area

The northern squawfish sport-reward fishery was conducted from the mouth of the Columbia River to the boat restricted zone of Priest Rapids Dam, and from the mouth of the Snake River to the boat restricted zone of Hells Canyon Dam. Backwaters, sloughs and 400 feet inside the mouths of tributaries were also open for the harvest of northern squawfish for payment. Fourteen registration stations were located on the lower Columbia and Snake rivers (Figure 1).

A "tailrace" was defined as the section of river immediately below a dam. A "reservoir" was defined as the section of river from the tailrace of an upstream dam to the next downstream dam. The section of river below Bonneville Dam to the mouth of the Columbia River was defined as “downstream from Bonneville Dam. ”



1. **Cathalamet** Marina
2. **Kalama** Marina
3. M. **James** Gleason Boat Ramp
4. **Washougal** Boat Ramp
5. The Fishery at Covert's Landing
6. Hamilton Island
7. **Bingen** Marina
8. The **Dalles** Boat Ramp
9. **Giles** French Boat Ramp
10. **Umatilla** Marina
11. Columbia Point **Park**
12. **Vernita** Bridge
13. Hood Park
14. **Greenbelt** Boat Ramp

Figure 1. Location of the Northern **Squawfish** Sport-Reward Fishery registration stations on the Columbia and Snake rivers during the 1994 field season.

Participation Requirements

Angler compliance rules for 1994 were adopted as follows:

A) Each angler must register in person, prior to fishing, at one of the registration stations each fishing day. A fishing day is a 24-hour period from 9 p.m. through 9 p.m. of the following day.

B) Each angler, in person, must exchange his or her eligible northern squaw-fish for a voucher between the hours of 1 p.m. and 9 p.m. at the same registration station where the angler is registered during the same fishing day.

C) To be eligible for a voucher, each northern squawfish must be 11 inches or longer in total length and be presented in fresh condition or alive.

D) Anglers shall provide information regarding their harvest as requested by department personnel at the registration site and mail-in survey forms.

E) Anglers shall obtain a Washington Oregon or Idaho state fishing license to fish for northern squawfish and must use a single rod, reel and line with up to three hooks with no more than three points.

Registration interview

Washington Department of Fish and Wildlife (WDFW) technicians were present to register anglers from 1 p.m. to 9 p.m. daily. Anglers could self-register at a registration box near the site between 9 p.m. and 1 p.m. daily. A short registration form was completed to record information pertinent to the anglers fishing day.

Northern Squawfish Data

We compared overall harvest, harvest by registration station, effort and CPUE by year, 1991-1994. Fork lengths were compared by reservoir and year, 1991-1994, using SAS general linear model.

Northern Squawfish Processing

All reward-sized northern squawfish were tail-clipped to indicate processing by a WDFW technician. Each northern squawfish was graded (food grade sites only) according to guidelines provided by S.P. Cramer and Associates to determine whether a fish would be processed as "food-grade" or "fertilizer-grade." At the end of each shift, technicians delivered the fish to a designated facility for processing or storage by facility personnel.

Satellite Stations

Satellite stations were tested by intermittent scheduling of technicians to use existing vehicles for registration station operation. Satellite stations were operated daily for the following dates and times: (1) Boyer Park- June 20-July31 (5 p.m. to 7 p.m.), (2) Ridgefield - July 4 (12 p.m. to 4 p.m.), (3) Rainier- July 29-September 11 (12:30 p.m. to 2 p.m.), (4) Willow Grove - July 29-September 11 (2:30 p.m. to 4:30 p.m.), (5) Grays River- July 29-September 11 (5:30 p.m. to 7:30 p.m.), (6) Cascade Locks - July 18-September 11 (self-registration only 9 p.m. to 1 p.m.) and (7) Hood River - August 15-September 11 (self-registration only 9 p.m. to 1 p.m.). See Appendix A for satellite station locations.

RESULTS AND **DISCUSSION**

Harvest Data

The 1994 total harvest of northern squawfish eligible for payment was 129,434 fish and ranged from 19 fish in Ice Harbor Reservoir to 71,236 fish below Bonneville Dam (Figure 2). Northern squawfish harvest was 24% greater in 1994 than in 1993 (104,536),3 l% less than 1992 (186,904) and 19% less than 1991 (159, 162). Exploitation for the sport-reward fishery was greater in 1994 (10.9'XO) than in any previous year (Knutsen et al. 1995). An increased harvest in 1994 from 1993 may have been due to more favorable river conditions late in the sport-reward fishery season. Six registration stations (Cathlamet, Gleason, Camas, The Fishery, Vernita and Greenbelt) remained open for an additional two weeks yielding a harvest of 9,355 northern squawfish. These stations remained open due to increased northern squawfish harvest, continued participation from experienced anglers, and favorable river conditions. Northern squawfish harvest from the last five weeks (24,328), plus the two-week, six-site extension (9,355 fish), represented the major increase in harvest from 1993 (Figure 3). Anglers participating in the 1994 sport-reward fishery often complained to technicians that increased flow early in the season was decreasing their northern squawfish harvest. Low water conditions late in the season may have concentrated northern squawfish, making them more vulnerable. The systemwide mean weekly harvest in 1994 was 6,164 northern squawfish and ranged from 3,700 to 10,926 fish (Figure 3). Harvest varied by week from 1991-1994, but peak harvest occurred prior to July 15 in all years (Figure 3). Variation in spawning time could partially explain the difference in peak harvest among years. Northern squawfish aggregate in spawning areas prior to spawning (Patten and Rodman 1969). Anglers have informally reported to technicians that northern squawfish feed more aggressively prior to spawning, which could make them more vulnerable to angling prior to July 15. Variation in environmental factors such as water temperature and flow conditions also contributes to variation in peak harvest timing.

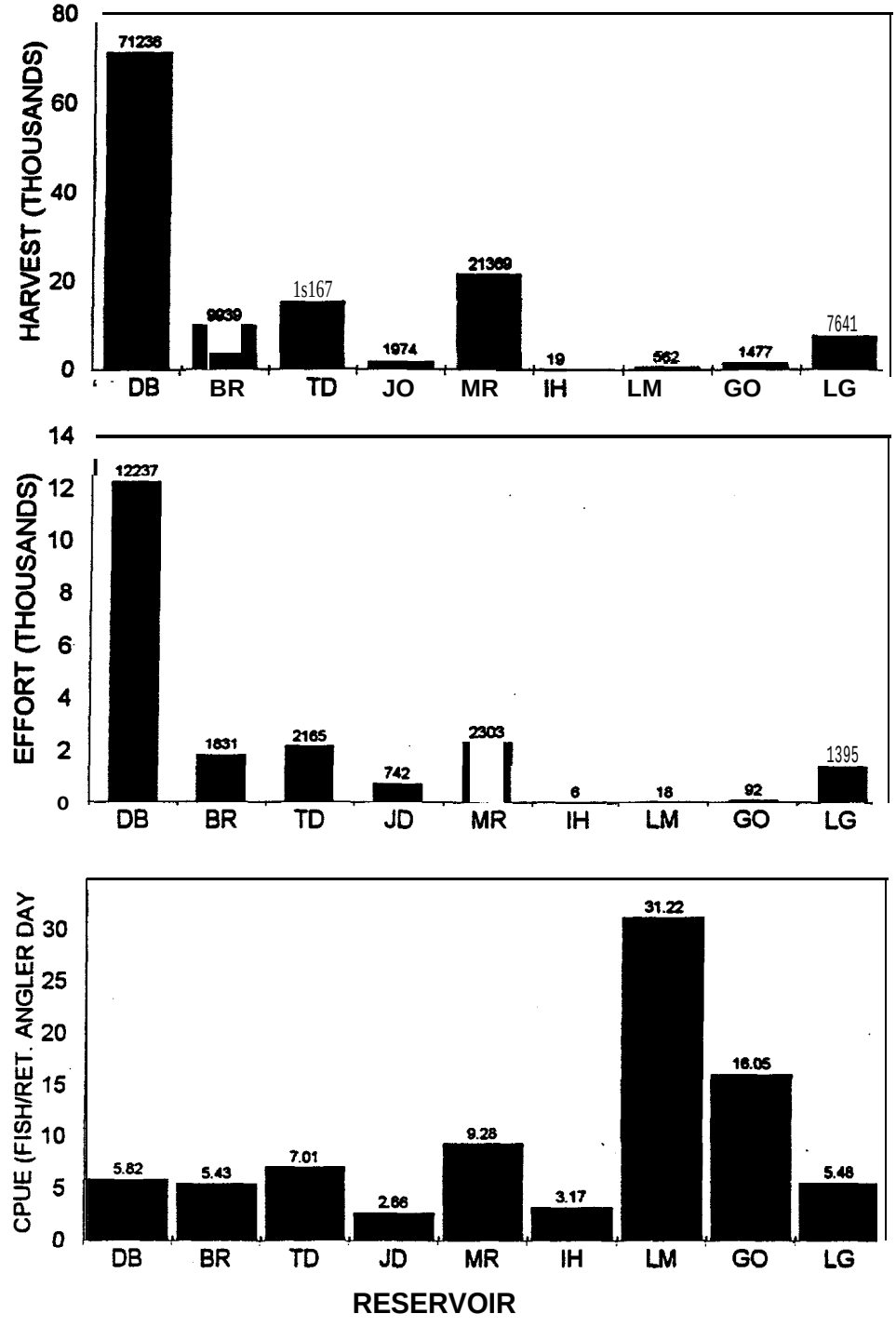


Figure 2. Northern squawfish harvest, effort (returning angler days) and CPUE (fish/returning angler day) by reservoir in 1994. DB - Downstream from Bonneville Dam, BR - Bonneville Reservoir, TD - The **Dalles** Reservoir, JD - John Day Reservoir, MR - **McNary** Reservoir, **IH** - Ice Harbor Reservoir, **LM** - Lower Monumental Reservoir, GO - Little Goose Reservoir, **LG** - Lower Granite Reservoir.

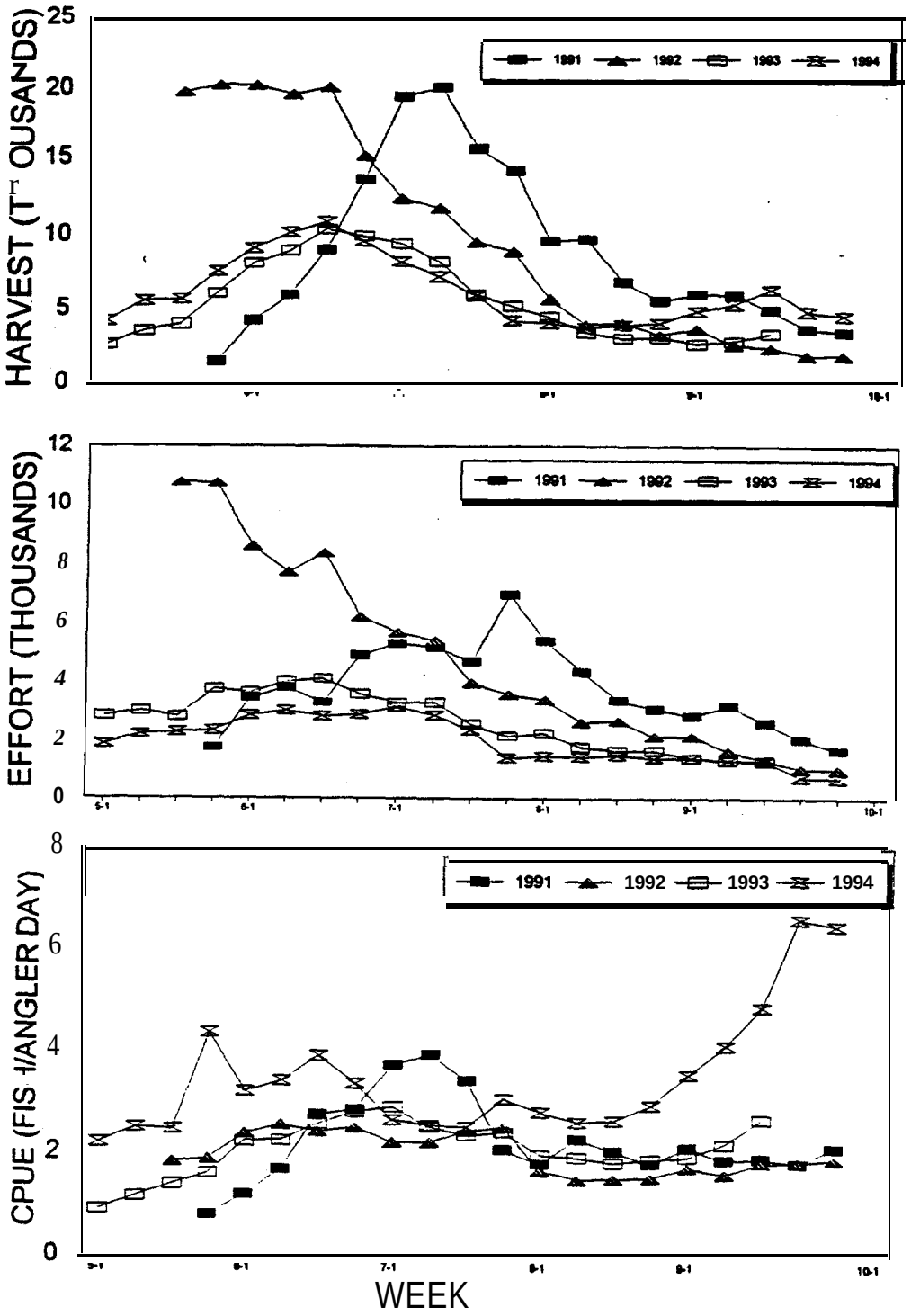


Figure 3. **Northern squawfish** harvest, effort (angler days) **and** CPUE (Fish/angler day) by week, 1991-1994.

Mean harvest of northern squawfish by registration station in 1994 was 9,129 fish and ranged from 1,586 fish at Umatilla Boat Ramp to 27,935 fish at The Fishery (Figure 4). Northern squawfish harvest in 1994 continued to be poor at Umatilla Boat Ramp in John Day Reservoir. Continued angler participation and lower program costs can be attained by converting this registration station to a satellite station. Twelve of the 14 registration stations in 1994 showed an increase in harvest of northern squawfish from 1993. Two registration stations, The Dalles and Umatilla[1], had greater harvests than in the three previous years, whereas The Fishery had a greater harvest than in 1993 or 1992. In comparison to 1993, The Fishery had the greatest percent increase in harvest (71%) of northern squawfish (Table 1).

Northern squawfish harvest was highest (43,846) in Fishing Location 10 (Table 2), which extends from Bonneville Dam downstream to Reed Island (Appendix Table A-2). Harvest from Fishing Locations 9 (14,264), 10 (43,846) and 16 (12,472; 6% of the fishing locations) accounted for approximately 55% of the total harvest (Table 2). The top 10 fishing locations (Table 2; 20% of the fishing locations) that produced the greatest harvest of northern squawfish ranged from 2,757 to 43,846 fish and accounted for 76% of the total harvest eligible for payment (Table 2).

In addition, 7,707 northern squawfish less than 11 inches were returned to registration stations for no payment.

Exit Interview Harvest Data for Game, Food and Unclassified Fish Species

The sampling method for returning angler harvest in 1994 was more complete than previous years. From 1991-1993, anglers were required to show their incidental catch to the technician before the fish could be recorded. Anglers often did not wish to take the time to show their catch and consequently many fish went unrecorded. In 1994, anglers were not required to show their catch at the exit interview, which resulted in a more complete census of angler harvest. The 1994 harvest estimates were approximately twice as high as any of the previous years estimates. Due to sampling differences, the annual harvest estimates should not be considered comparable (Table 3).

Exit interview data showed smallmouth bass to be the most frequently harvested fish other than northern squawfish (Table 3). American shad (*Alosa sapidissima*) were second followed by peamouth chub (*Mylocheilus caurinus*) and walleye (Table 3). All 561 peamouth chub were harvested incidentally (while targeting northern squawfish). Efforts will be made in 1995 to educate anglers on how to distinguish between peamouth and northern squawfish to reduce their incidental harvest. We also observed harvest of a suspected hybrid between northern squawfish and chislemouth (Columbia River chub). Data will be collected in 1995 on these suspected hybrids to verify their parentage, determine if they are piscivorous and then decide if they should be included in all reward programs.

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[1] Plymouth Boat Ramp harvest totals for 1991 and 1992 are used to represent Umatilla for this comparison.

Salmonid harvest was low for all species (Table 3). Beginning with the 1994 season, juvenile salmonids were distinguished from mature salmonids, but juvenile salmonids were not differentiated by species. Large numbers of juvenile hatchery steelhead pass through the Snake River near Clarkston in Lower Granite Reservoir. A portion of these juveniles residualize in the Snake River near Clarkston. In 1994, 85% of the 114 juvenile salmonids harvested came from Lower Granite Reservoir. Since these fish were not expected to survive, WDFW opened a fishery for these juveniles over 10 inches long. We cannot say with absolute certainty that 100% of the 1994 juvenile harvest consisted of juvenile hatchery steelhead, but the technicians who worked at the Clarkston registration station (Greenbelt) do not recall any of these fish being species other than juvenile hatchery steelhead. All juvenile salmonids will be classified to species in the 1995 northern squawfish sport-reward fishery and legally caught juveniles will be excluded from the harvest estimates.

Exit interview data is combined with voucher data in the harvest evaluation section of this report (Appendix F) to create a more accurate estimate of returning angler harvest. The 1995 returning angler sampling methods are discussed in Appendix F also.

Effort

Effort for 1994 was 40,783 angler days and ranged from six angler days in Ice Harbor Reservoir to 12,237 angler days in Bonneville Tailrace (Figure 2). There were no registration stations open in Ice Harbor or Lower Monumental Reservoirs in 1994, however, the reservoirs were open to participation. Effort was lower in 1994 than all previous years, indicating a need for increased participation coinciding with peak CPUE (Figure 3). Effort in 1994 was 18°/0 lower than 1993 (50,034), 54'% lower than 1992 (88,494) and 39% lower than 1991 (67,384).

Mean angler effort by week was 1,943 angler days and ranged from 704 to 3,102 angler days (Figure 3). Mean effort by registration station was 2,913 angler days and ranged from 1,359 at Columbia Point to 6,275 angler days at The Fishery (Figure 4). Effort (returning angler days) by fishing location (fishing location could only be recorded for anglers returning to the station) was highest in Locations 9 (3,346), 10 (5,927) and 16 (1,730; Table 2), which coincided with the top three harvest locations.

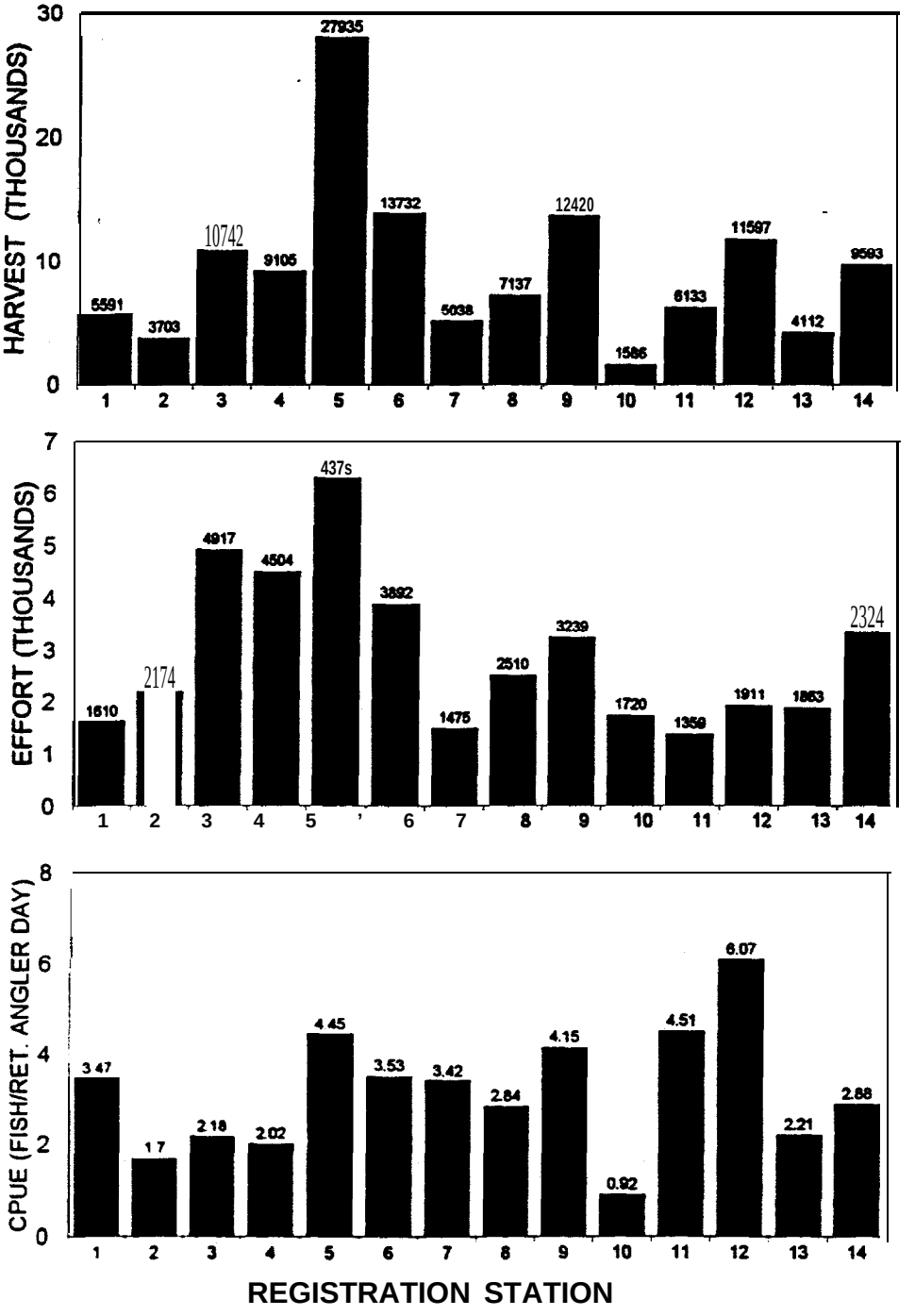

Figure 4. Northern **Squawfish** Harvest, **effort** and CPUE **(fish/** returning angler day) by **registration** location **in** 1994. 1 - **Cathlamet,** 2 - **Kalama,** 3 - Gleason, 4 - **Camas,** 5 - The Fishery, 6 - **Hamilton** Is., 7 - **Bingen,** 8 - The **Dalles,** 9 - **Giles** French, 10 - **Umatilla,** 11 - Columbia Point, **12** - **Vernita, 13** - Hood Park, 14 - **Greenbelt.**

Table 1. Number of NSF greater than or equal to 11 inches returned to registration stations, 1991-1994.

Station	1991	1992	1993	1994
Hamilton Island	18219	17048	9126	13732
The Fishery	40674	23851	16308	27935
Cascade Locks	9143	6779	1881	--
Bingen Marina	12711	12513	6408	5038
Dalles Boat Basin	3828*	6806	4338	7137
LePage Park	32141	16926	10643	--
Columbia Point Park	1104*	11148	5192	6133
Hood Park	3676*	9199	4119	4112
Lyons Ferry	4211*	3131	1466	--
Greenbelt Boat Ramp	17466	21333	10309	9593
Kalama Marina	--	6799	1605	3703
Gleason Boat Ramp	--	15494	9719	10742
Boyer Park	--	5875	1296	--
Cathlamet Marina	--	--	3960	5591
Rainier Boat Ramp	--	--	1561	--
Camas/Washougal Boat Ramp	--	--	5920	9105
Umatilla Boat Ramp	--	--	1000	1586
Vernita Rest Area	--	--	9765	11597
Maryhill State Park	1001*	5074	--	--
Plymouth Boat Ramp	5556	2414	--	--
Windust Park	919*	--	--	--
Central Ferry State Park	7845	--	--	--
Chief Timothy State Park	1048	--	--	--
Willow Grove Park	--	5676	--	--
Marine Park (Portco)	--	8637	--	--
Ringold	--	5139	--	--
Bayport Marina	--	1606	--	--
Giles French	--	--	--	13430

* Stations did not open until July 15, 1991.
-- Not in operation.

Table 2. Northern squawfish harvest (11 inches or greater), effort (returning angler days) and CPUE (fish/returning angler d by reservoir and fishing location, 1994.

RESERVOIR	FISHING LOCATION	NSF HARVEST	EFFORT	CPUE
Downstream from	1	1116	216	5.17
Bonneville Dam	2	3318	523	6.34
"	3	2079	347	5.99
"	4	610	123	4.96
n	5	1521	510	2.98
"	6	70	34	2.06
"	7	447	60	7.45
"	8	3965	1151	3.44
"	9	14264	3346	4.26
"	10	43846	5927	7.4
Bonneville Res.	11	481	111	4.33
"	12	1273	185	6.88
"	13	2757	673	4.1
"	14	5428	862	6.3
The Dalles Res.	15	2695	435	6.2
"	16	12472	1730	7.21
John DayRes.	17	35	28	1.25
"	18	0	0	0
W	19	0	0	0
"	20	0	0	0
"	21	437	27	16.19
"	22	539	273	1.97
"	23	963	414	2.33
McNaryRes.	24	21	16	1.31
"	25	1	4	0.25
"	26	19	16	1.19
"	27	75	55	1.36
"	28	546	185	2.95
"	29	2564	251	10.22
"	30	894	81	11.04
"	31	7176	305	23.53
"	32	4555	358	12.72
"	33	2851	472	6.04
W	34	0	0	0
"	35	2667	560	4.76
Ice Harbor Res.	36	4	3	1.33
"	37	0	0	0
"	38	15	3	5
Lower Monumental Res.	39	0	0	0
"	40	8	2	4
"	41	554	14	39.57
LittleGoose Res.	42	271	12	22.58
"	43	0	0	0
"	44	1206	80	15.08
LowerGraniteRes.	45	27	4	6.75
n	46	5	1	5
"	47	261	45	5.8
"	48	1415	394	3.59
"	49	2466	498	4.95
"	50	2724	420	6.49
W	51	743	33	22.52
	Totals	129384	20787	

Table 3. Total harvest of fishes, excluding NSF, that were reported during the exit interview.

Common Name	Code	1991	1992	1993	1994
American shad	AMs	6	54	28	776
Black crappie,	BC	44	3	0.	13
Blue catfish	BCF	0	0	0	2
Bluegill	BG	3	3	0	10
Bridgelip sucker	BRS	9	8	0	25
Brown bullhead	BBH	8	18	7	21
Bullhead (general)	BH	4	4	10	2
Bull trout	BLC	1	0	0	0
Carp	CP	6	19	7	15
Channel catfish	cc	453	141	202	263
Chinook Salmon	CK	0	7	5	9
Chiselmouth	CMO	106	139	87	38
Chum salmon	CH	0	1	0	0
Coho Salmon	co	0	0	1	3
Columbia River chub*	CRC	192	125	316	253
Crappie (general)	c	23	3	4	3
Cutthroat trout	CT	5	0	0	2
Cutthroat Lahontan	LCT	0	0	0	1
Juvenile salmonids	JVS	0	0	0	114
Kokannee	K	0	0	0	1
Largemouth bass	LMB	3	9	2	5
Longnose sucker	LNS	0	1	0	0
Largescale sucker	LRs	4	11	7	4
Peamouth	PMO	368	588	702	561
PumpkinSeed	Ps	1	2	1	1
Rainbow trout (res.)	RB	25	9	7	8
Rainbow trout (unk.)	RU	20	113	2	4
RedSide shiner	RS	1	2	0	0
Sandroller	SAN	0	0	1	0
Sculpin (general)	COT	2	10	1	21
Sculpin, Prickly	PRS	0	1	0	0
Sculpin, Torrent	TRS	0	0	1	0
Searun cutthroat	SCT	0	1	2	1
Smallmouth bass	SMB	770	693	493	1388
Sockeye salmon	SO	0	2	0	0
Starry flounder	SF	2	9	2	27
Steelhead (summer)	SS	10	40	20	25
Steelhead (unknown)	SH	18	9	3	4
Steelhead (winter)	Sw	1	13	0	0
Sucker (general)	SK	11	21	3	18
Tenth	TNC	1	0	0	0
Trout (unknown)	TR	0	0	5	25
walleye	WAL	184	231	121	502
Warmouth	WM	2	0	0	0
White crappie	Wc	20	0	1	3
Whitefish, mountain	WF	3	5	3	19
White sturgeon	WS	9	17	11	40
Yellow bullhead	YBH	0	0	9	5
Yellow perch	YP	43	36	16	57
Totals		2358	2349	2100	4269

* probable NSF/CMO hybrid; named columbia river chub for this report.

Catch per Unit Effort

Catch per unit effort (CPUE) in 1994 was 3.17 (fish/angler day) and ranged from 2.66 (fish/angler day) in John Day Reservoirto31.22 (fish/angler day) in Lower Monumental Reservoir (Figure 2). Overall CPUE was significantly higher (P<0.0001) in 1994 than in 1993 (2.09 fish/angler day), 1992 (2.11 fish/angler day) or 1991 (2.37 fish/angler day). The high CPUE in 1994 maybe due to a decrease in participation by inexperienced anglers along with experienced anglers becoming more successful at catching northern squawfish. The 1994 CPUE indicates that northern squawfish can be readily harvested by veteran anglers and that increasing the number of experienced anglers will increase harvest totals. Mean CPUE by week was 3.40 (fish/angler day) with a range of 2.21 to 6.46 (fish/angler day, Figure 3). Mean CPUE by registration station was 3.17 (fish/angler day) and ranged from 0.92 (fish/angler day) at Umatilla Boat Ramp to 6.07 (fish/angler day) at Vernita (Figure 4). CPUE (fish/returning angler day) was highest in fishing locations 31 (23.53),41 (39.57) and 42 (22.58; Table 2).

Fork Length Data

A total of 69,731 northern squawfish were sampled for fork length in 1994, of which 66,498 fish had a fork length greater than or equal to 11 inches. The mean fork length for northern squaw-fish greater than or equal to 250 mm was 335 mm and ranged from 323 mm in the Bonneville tailrace to 350 mm in The Dalles Reservoir (Table 4). Mean fork length of northern squawfish greater than 250 mm decreased significantly in 1994 (335 mm) from 1991 (350 mm; (1%0.0001), which concurred with the findings of the Oregon Department of Fish and Wildlife (Knutsen et al. 1995; Table 4). Ice Harbor and Lower Monumental reservoirs had lower mean fork lengths than Bonneville tailrace, but were not used in these comparisons due to a low sample size. Seven of nine reservoirs in 1994 showed a statistically significant decrease(P<O.0001) in mean fork length from 1991 (Table 4). Little Goose Reservoir showed a significant increase (P<0.0001) in mean fork length (345 mm) in 1994 over all previous years. Lower Granite Reservoir showed a significant decrease (P<0.0001) in mean fork length (349 mm) from 1993 (260 mm). An increase in harvest of northern squawfish in areas of the Snake River Canyon accessible by jet boat only may have been responsible for part of this decrease. We also believe that large numbers of illegally harvested northern squawfish have been turned in at Greenbelt Boat Ramp in past years, which may have biased previous mean fork lengths for Lower Granite Reservoir. Factors such as year-class strength and gear bias could also contribute to yearly changes in reservoir mean fork lengths.

Registration and Exit Times

Anglers registered most frequently in 1994 between 7 a.m. and 8 a.m. (4,264 anglers) and between 9 p.m. and 10 p.m. (4,106 anglers). Both time intervals show a similar number of anglers registering and indicate that the most popular registration times are early in the morning or late in the evening.

In 1994, the most popular times for anglers to return to the registration stations with their catch were 8 p.m. to 9 p.m. (6,647 anglers/51,312 squawfish) and 1 p.m. to 2 p.m. (2,600 anglers/1 6,710 squawfish).

Satellite Stations

Operation of seven satellite stations resulted in minimal costs and succeeded with the use of existing vehicles and technicians. Evaluation of operating cots was not a primary concern during the 1994 test period, however, costs should be evaluated during the 1995 sport-reward fishery. Implementation of additional satellite stations in 1995 could increase harvest and participation in areas where extended travel deters anglers. Communication with anglers at registration stations and by telephone survey during the 1994 northern squawfish sport-reward fishery indicated that anglers would participate more in certain areas if registration stations were more conveniently located.

Northern squawfish harvest and effort (angler days) totals for the seven satellite stations operated in 1994 were: Boyer Park (278 squawfish/72 angler days), Ridgefield (4 squawfish/42 angler days), Rainier (961 squawfish/212 angler days), Willow Grove (269 squawfish/180 angler days), Grays River (25 squawfish/17 angler days), Cascade Locks (O squawfish/8 angler days) and Hood River (95 squawfish/24 angler days) for a total harvest of 1,632 northern squawfish.

RECOMMENDATIONS FOR THE 1995 SPORT-REWARD FISHERY

1. Implement 15 satellite stations along the Snake and Columbia rivers (Table 5).

2. Convert Umatilla Boat Ramp to a satellite station. The station will operate from 6 p.m. to 8 p.m. daily as determined by the frequency of angler exits at Umatilla Boat Ramp during these hours in 1994.

3. Field operations should remain limited to one shift per day (e.g., 1 p.m. to 9 p.m.) seven days per week. Self-registration should continue to be available during non-staffed hours.

4. Location and number of registration stations should be placed systemwide at areas that will achieve highest harvest.

5. Continue a telephone survey to (1) evaluate incentive and promotional programs, (2) assess numbers of fish species harvested by non-returning anglers, and (3) evaluate program satisfaction.

Table 4. Mean fork length comparison by reservoir of **NSF** greater than 11 inches 1991-1994 **(P>f)** estimating the probability of the mean fork length being significantly different from 1991 to 1994.

Reservoir	Year	n	mean	P>F
Downstream from Bonneville Dam	1991	9698	341	
	1992	41842	334	0.0001
	1993	28047	321	
	1994	32577	323	
Bonneville	1991	7550	349	
	1992	8457	353	0.0001
	1993	6481	310	
	1994	4260	338	
The Dalles	1991	8563	371	
	1992	17043	364	0.0001
	1993	9101	364	
	1994	11564	350	
John Day	1991	2821	371	
	1992	2508	370	0.0001
	1993	956	365	
	1994	1746	343	
McNary	1991	4701	356	
	1992	17024	350	0.0001
	1993	13197	339	
	1994	10492	345	
Ice Harbor	1991	890	360	
	1992	4565	362	0.0001
	1993	45	350	
	1994	19	304	
Lower Monumental	1991	3642	319	
	1992	2897	309	**0.0141**
	1993	1586	313	
	1994	406	313	
Little Goose	1991	1902	337	
	1992	4748	330	**0.0001**
	1993	1147	337	
	1994	836	345	
Lower Granite	1991	19122	348	
	1992	19464	350	**0.0484**
	1993	9150	360	
	1994	6893	349	
Combined Totals	1991	59650	350	
	1992	119437	346	**0.0001**
	1993	68797	335	
	1994	68793	335	

Table 5. Satellite stations for the 1995 sport-reward program are shown along with the time of operation and the registration station responsible for their operation.

REGISTRATION STATIONS	SATELLITE STATIONS	TIME
1. CATHLAMET	JOHN DAY RAMP	8:00-9:00am
CATHLAMET	DEEP RIVER	9:30-10:30am
2. KALAMA	WILLOW GROVE	7:00-8:30am
KALAMA	RAINIER MARINA	9:00-10:00am
KALAMA	SCAPPOOSE BAY MARINA	10:30-11:30am
3. GLEASON	CHINOOK LANDING	7:00-8:30am
GLEASON	MARINE PARK (PORTCO)	9:00-10:00am
GLEASON	RIDGEFIELD MARINA	10:30-11:30am
4. THE FISHERY	BEACON ROCK	7:00-8:30am
THE FISHERY	HOME VALLEY	9:00-10:00am
THE FISHERY	CASCADE LOCKS	6:00-8:00pm
6. BINGEN	HOOD RIVER MARINA	7:00-8:00am
7. THE DALLES	MARYHILL STATE PARK	9:30-10:30am
8. HOOD PARK	UMATILLA	6:00-8:00pm
9. CLARKSTON	BOYER PARK	5:00-7:00pm

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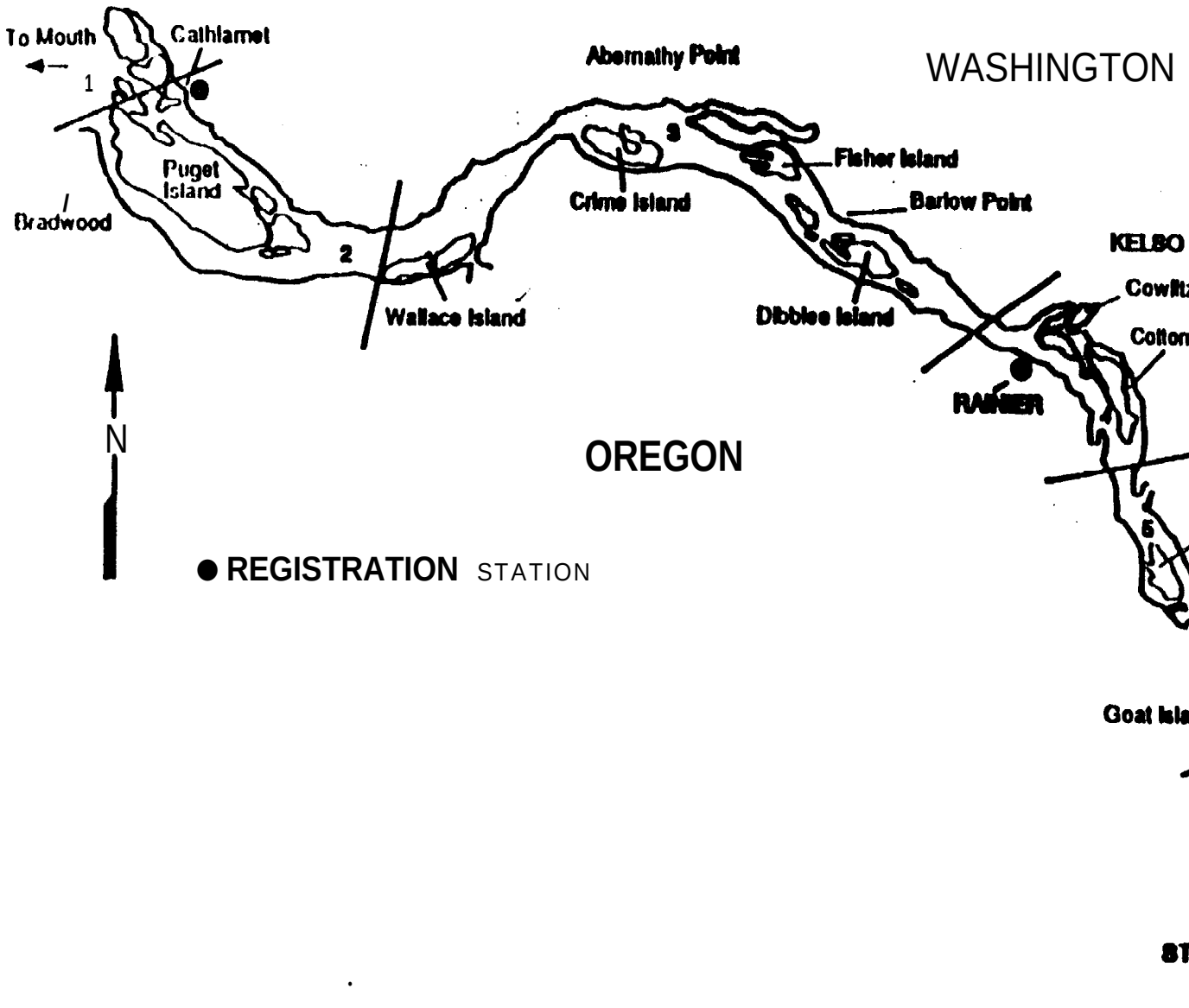
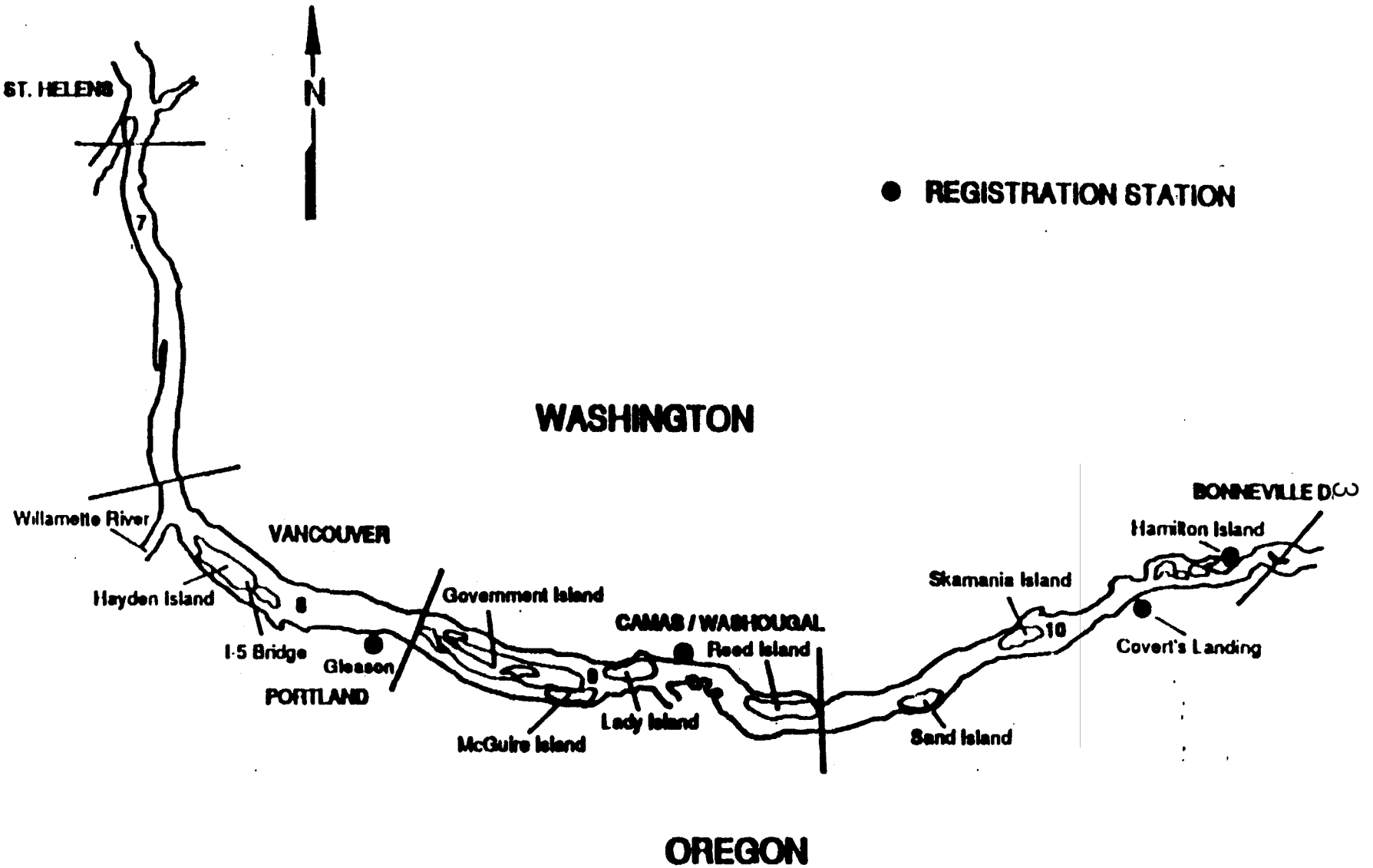
APPENDIX A

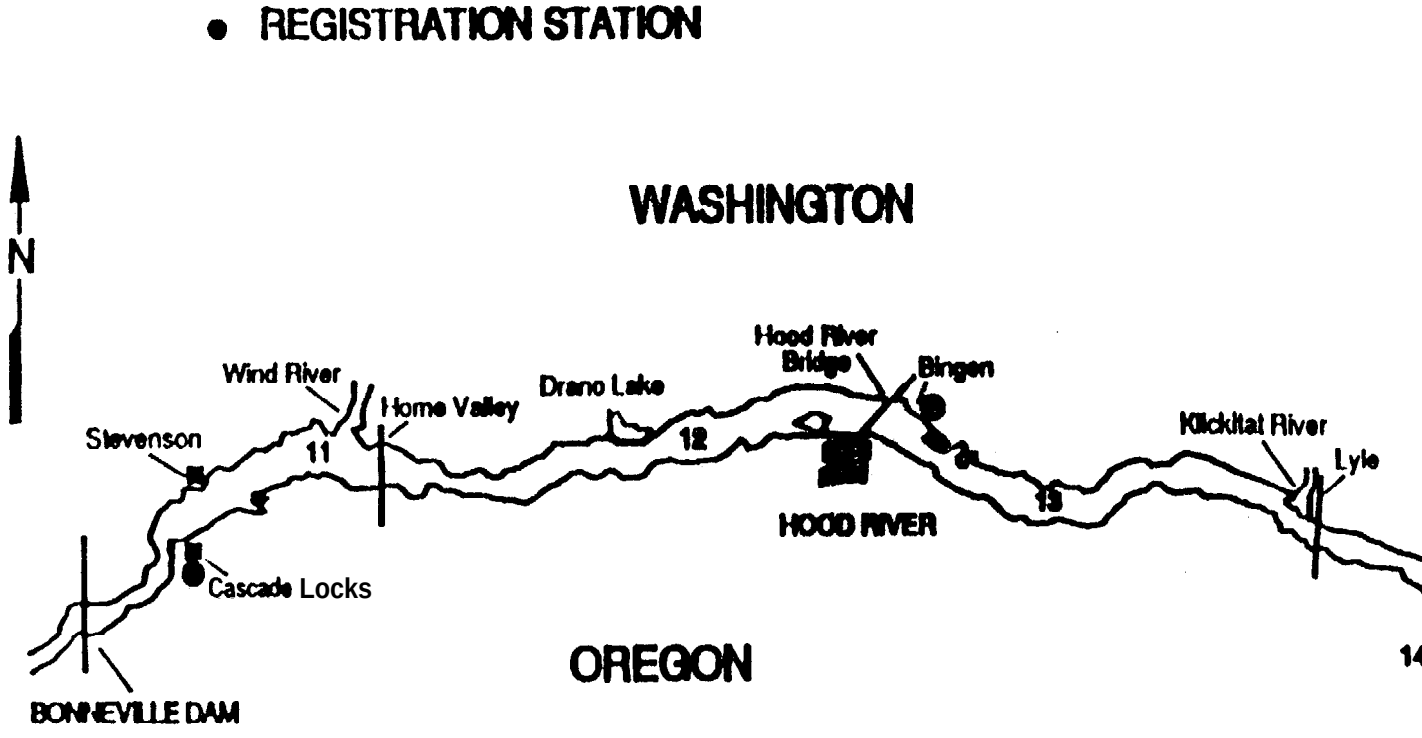
Maps Showing Fishing Locations and Codes for the 1994 Sport-Reward Fishery



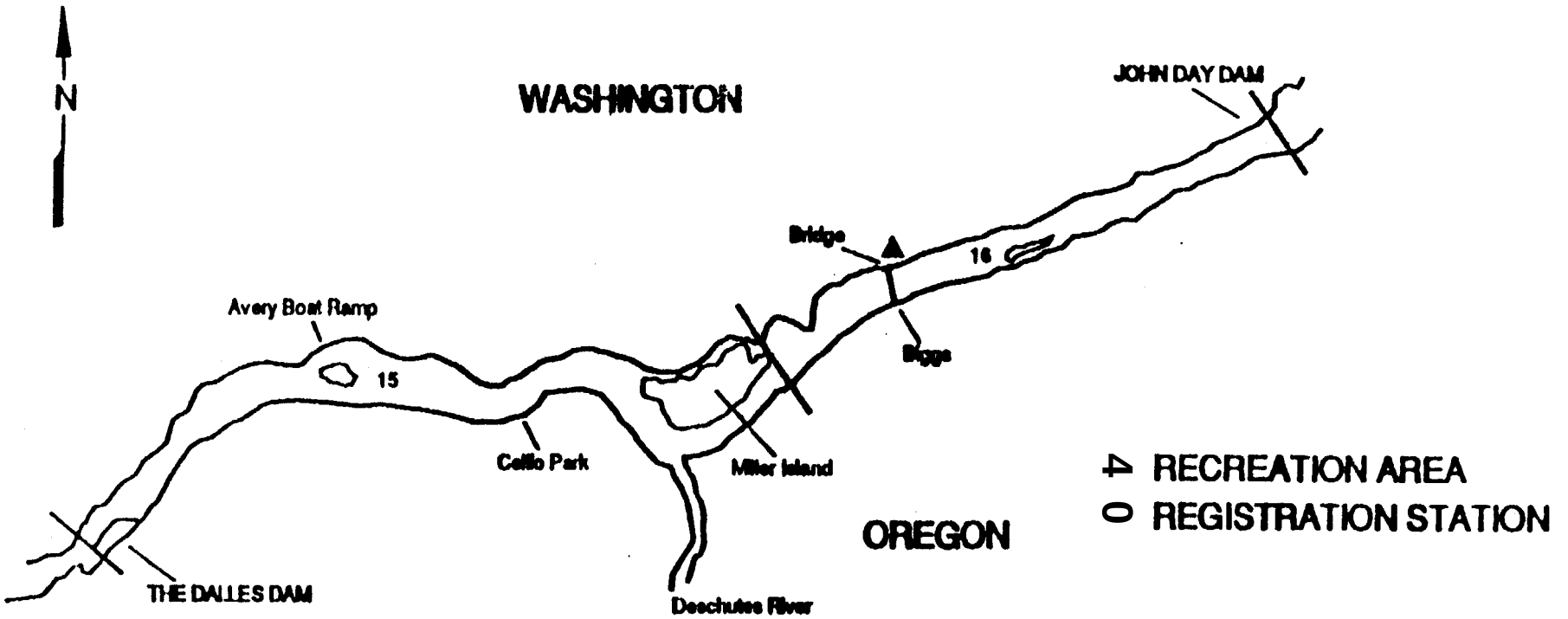
Appendix **A-1. 1994** Northern Squawfish Sport-Reward Fishery fishing location codes, mouth of Columbia Ri



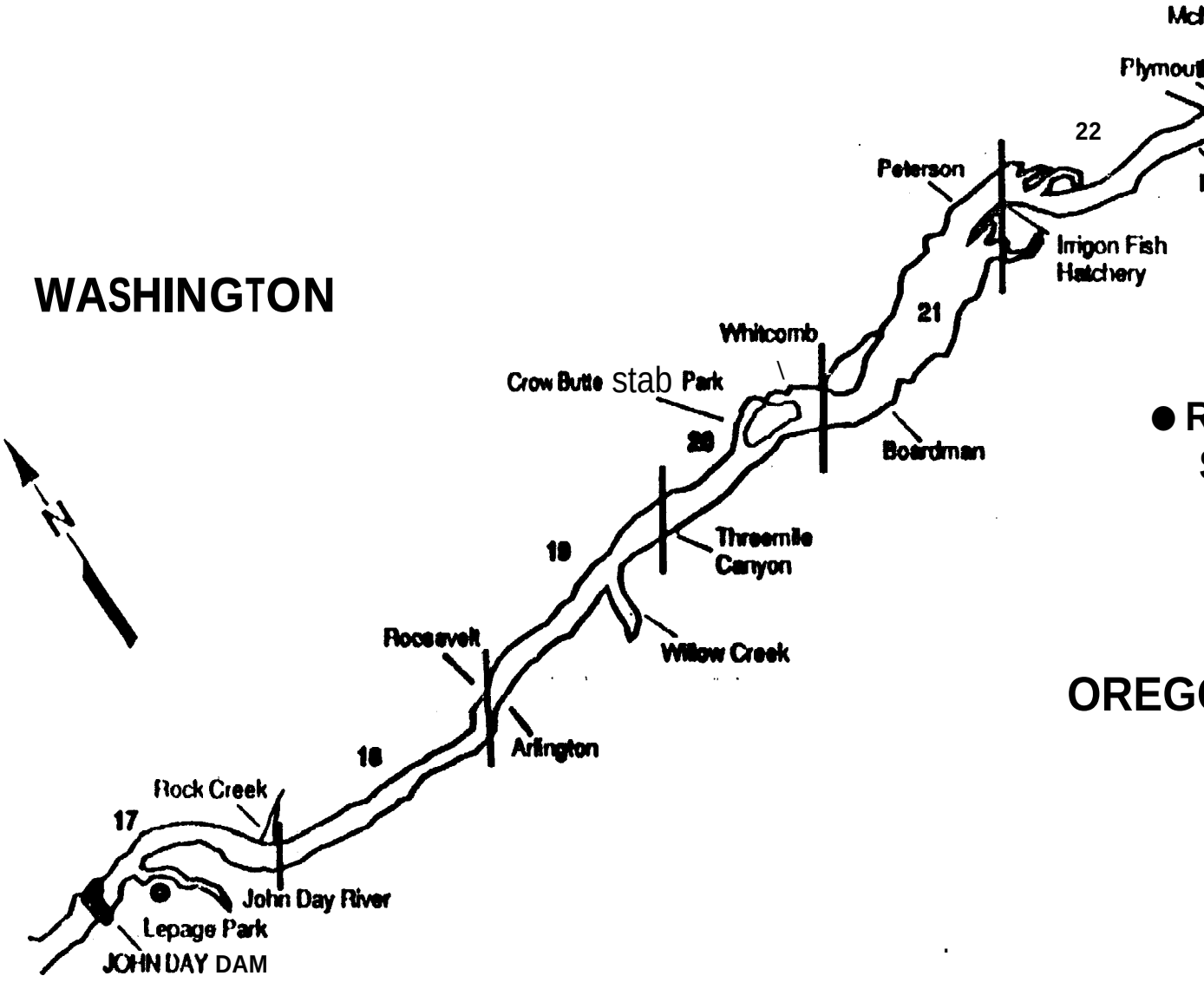
Appendix A-2. 1994 Northern Squawfish Sport-Reward Fishery fishing location codes, Lewis River to Bonneville Dam.



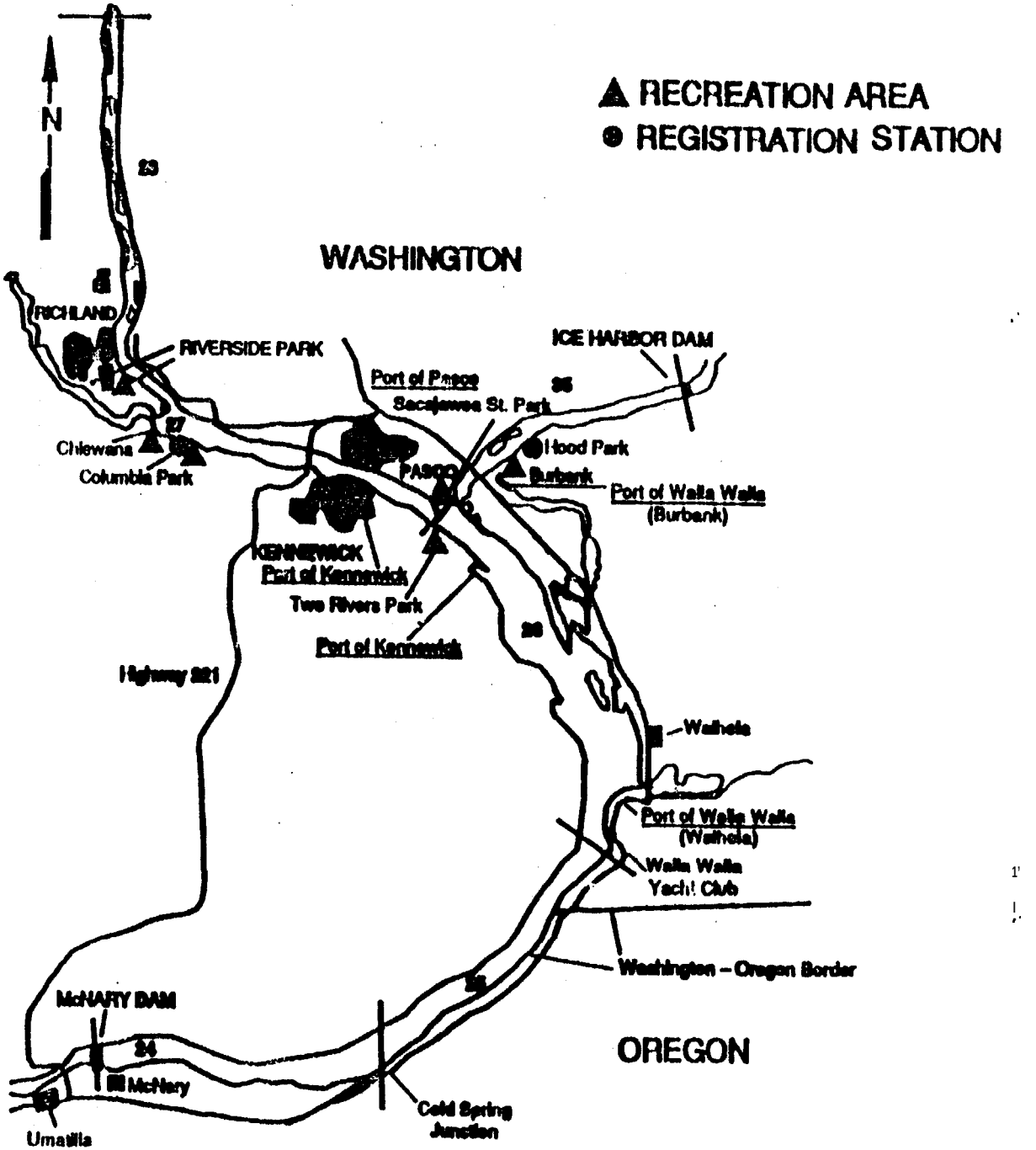
Appendix A-3. 1994 Northern Squawfish Sport-Reward Fishery fishing location codes, Bonneville Dam to T



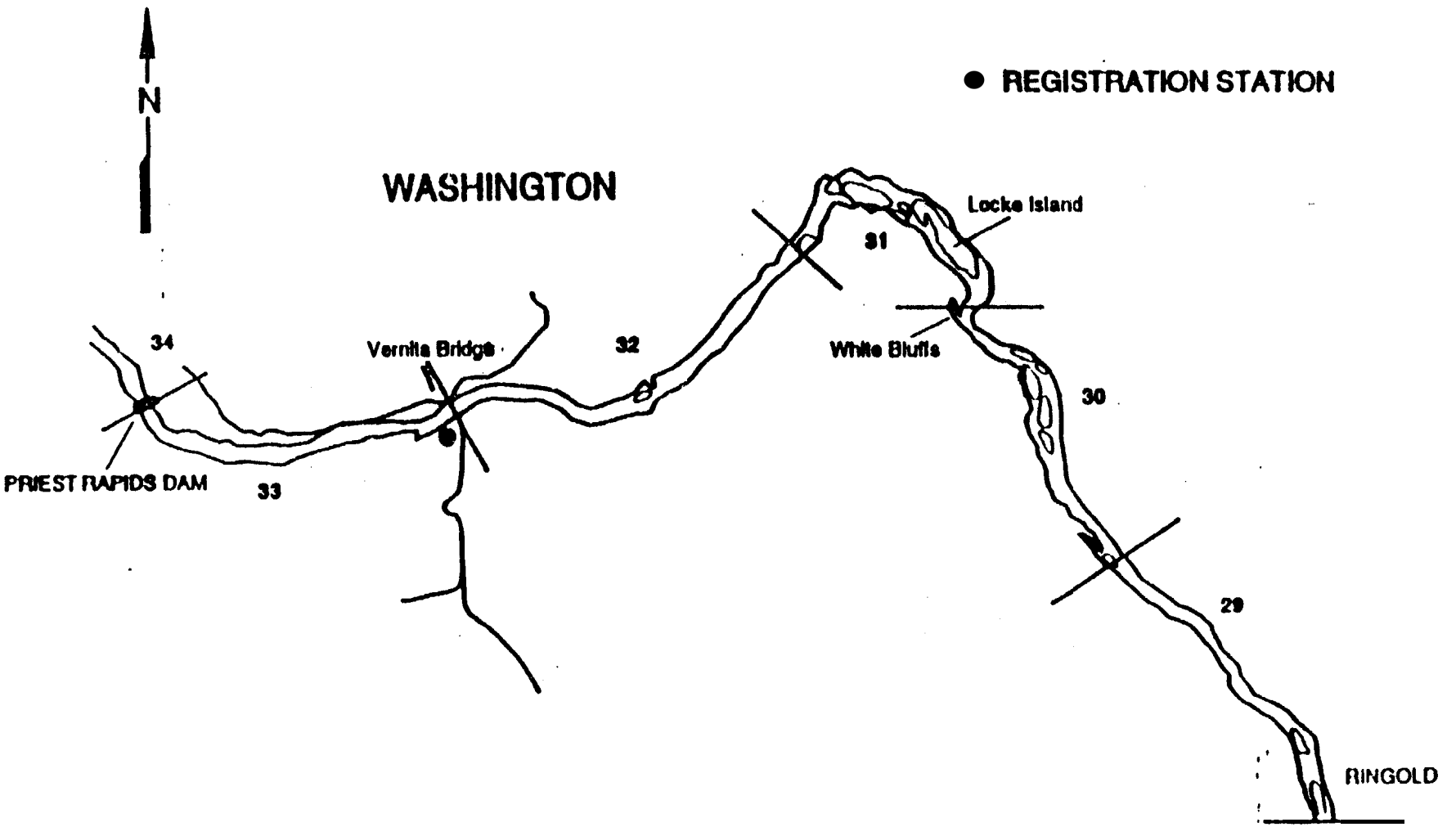
Appendix A-4. 1994 Northern Squawfish Sport-Reward Fishery fishing location codes, The Dalles Dam to John Day Dam.



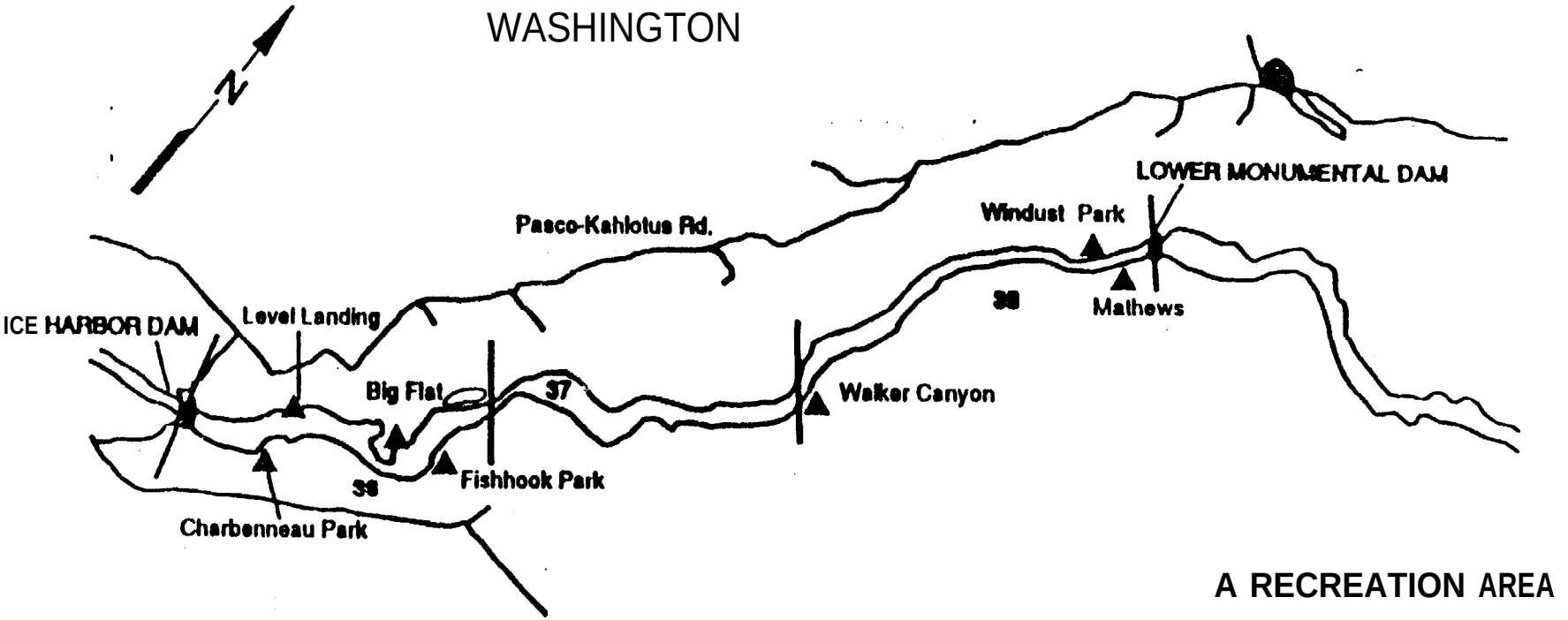
Appendix A-5. 1994 Northern **Squawfish** Sport-Reward **Fishery** fishing location codes, **John** Day **Dam** to **McN**



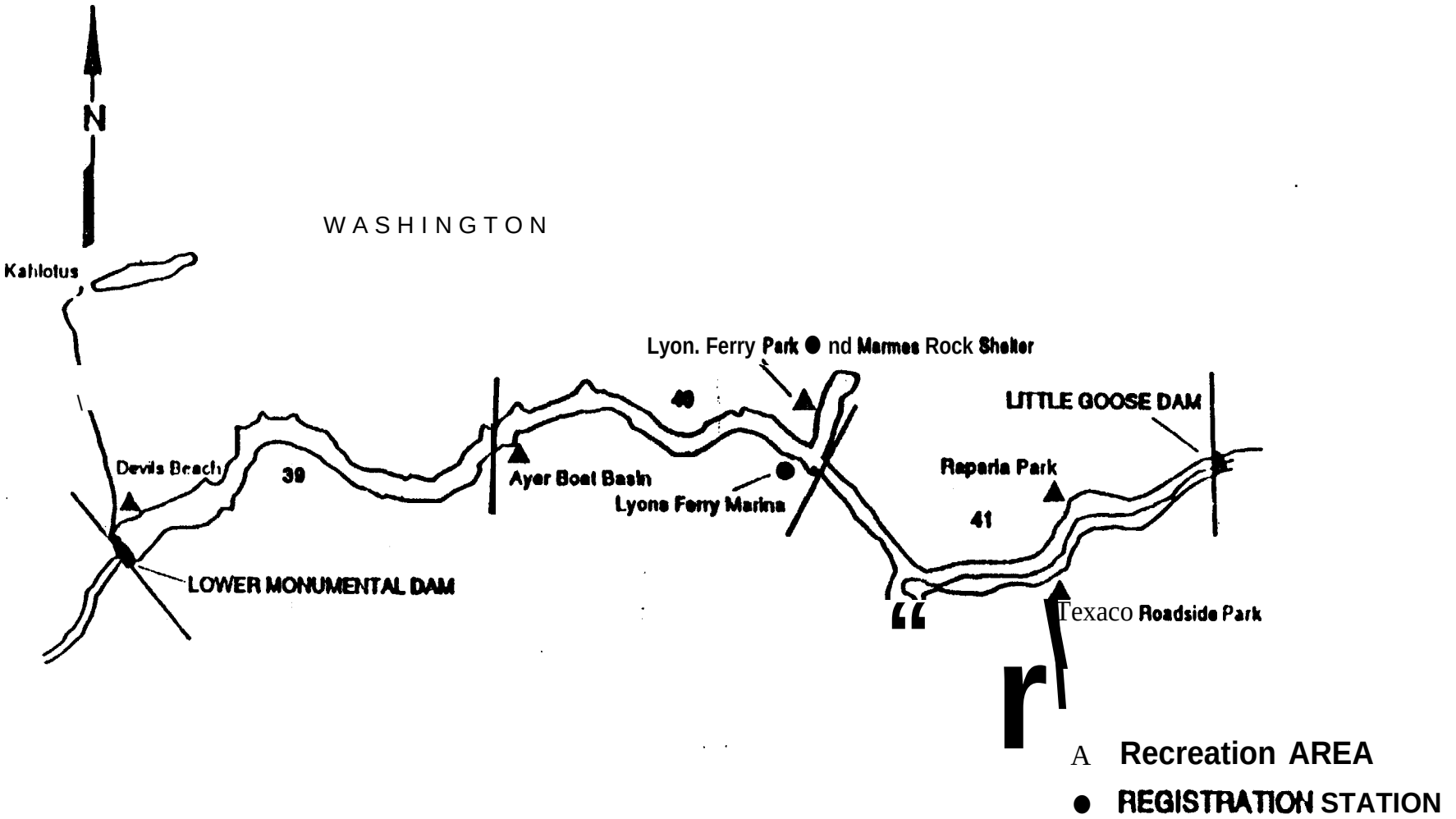
Appendix A-6. 1994 Northern Squawfish Sport-Reward Fishery fishing location codes, McNary Dam to Ringold Boat Ramp and mouth of Snake River to Ice Harbor Dam.



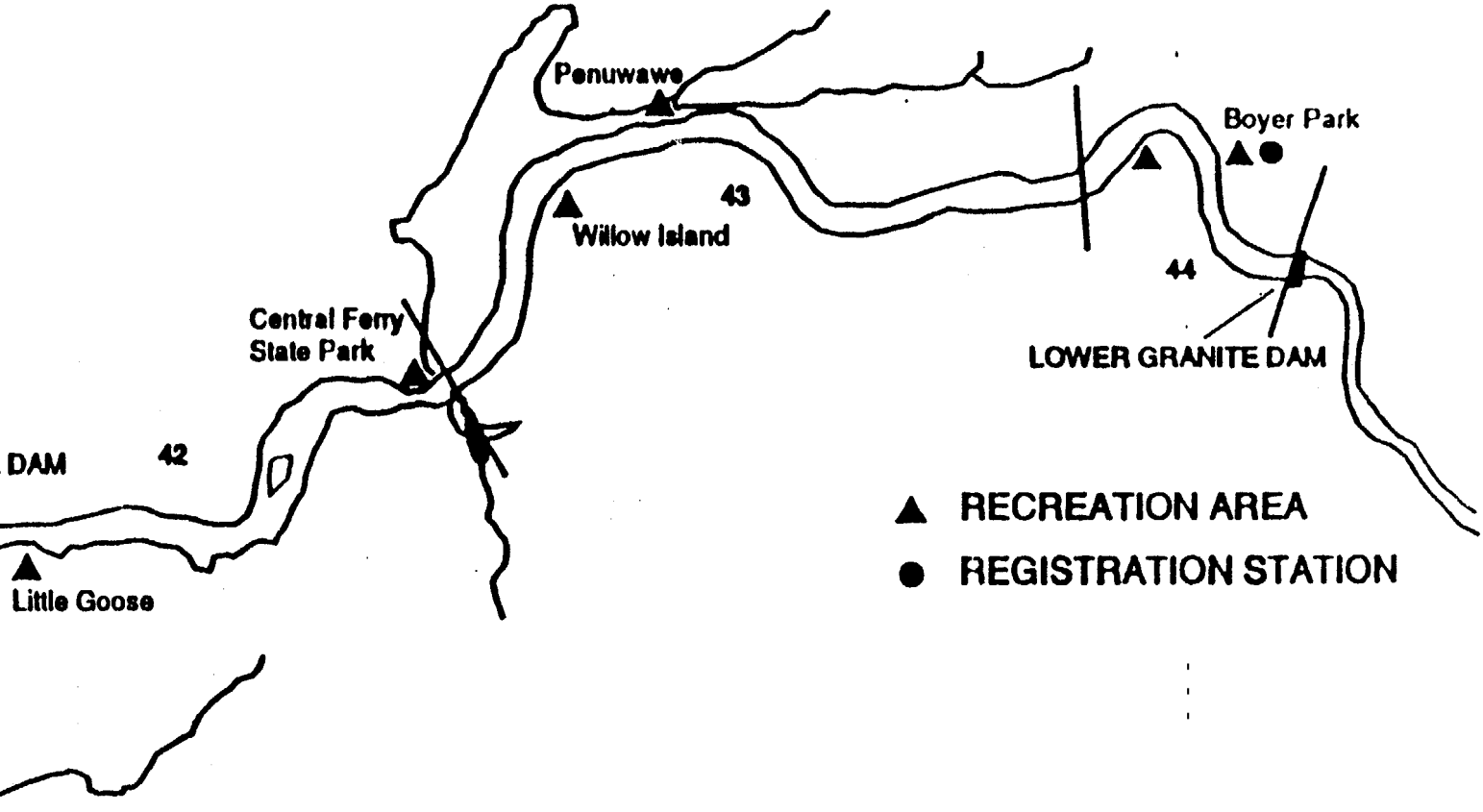
Appendix A-7. 1994 Northern Squawfi h Sport-Reward F h ry fishing location codes, Ringold Boat Ramp to Pri st Rapids Dam



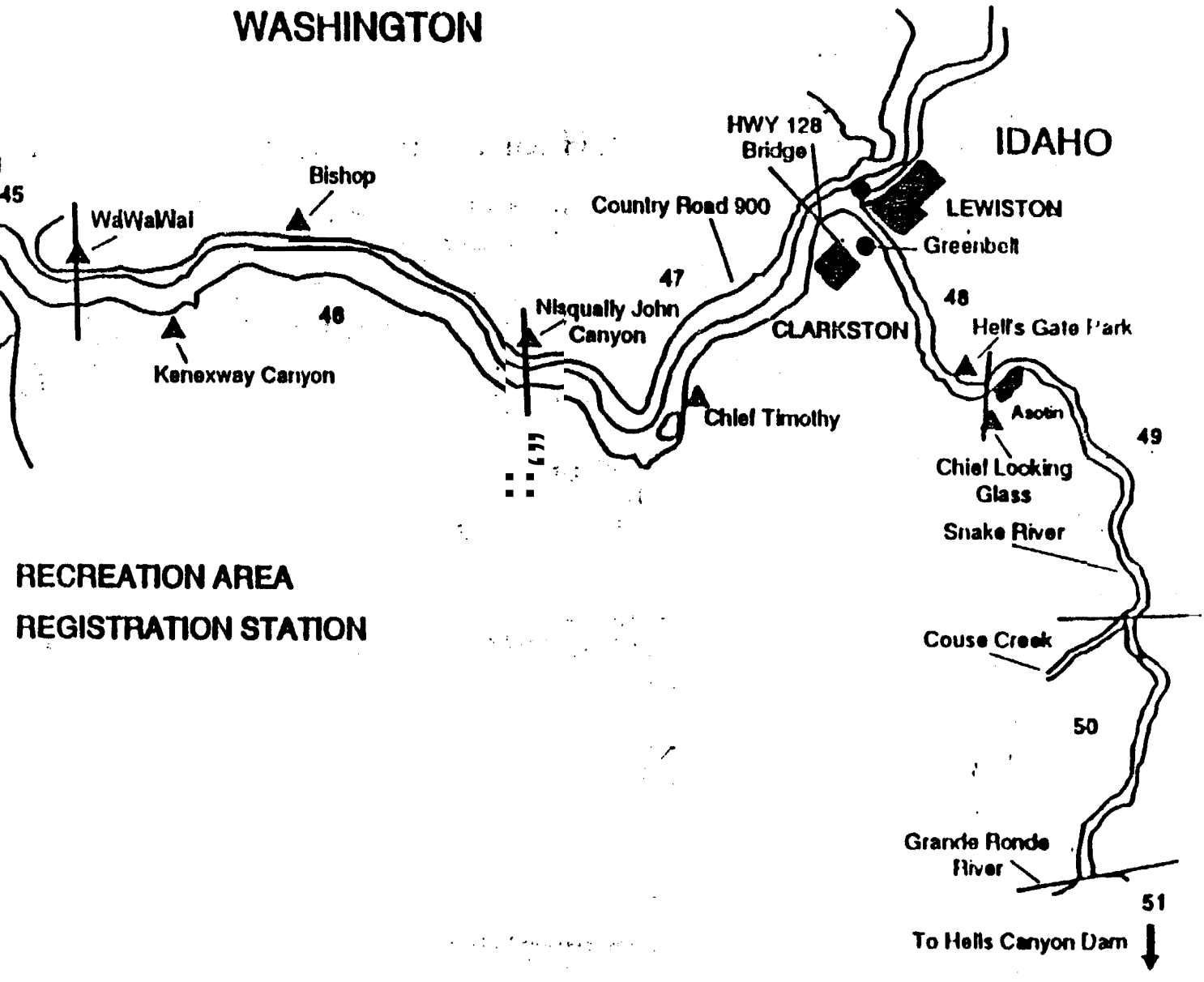
Appendix A-8. 1994 Northern **Squawfish** Sport-Reward Fishery fishing location codes, Ice Harbor Dam to Lower Monumental Dam.



Appendix A-9. 1994 Northern **Squawfish** Sport-Reward Fishery fishing location codes, Lower Monumental Dam to Little Goose Dam.



94 Northern Squawfish Sport-Reward Fishery fishing location codes, Little Goose Dam to Lower [illegible] Dam



4 Northern Squawfish Sport-Reward Fishery fishing location codes, Lower Granite Dam to Hell's Canyon Dam.

APPENDIX B

Fish Species Codes

Table B-1. Sport-Reward Fishery field species codes.

LMB	Bass, Largemouth
RKB	Bass, Rock
SMB	Bass, Smallmouth
BG	Bluegill
BH	Bullhead (Unknown)
YBH	Bullhead, Yellow
BBH	Bullhead, Brown
BLB	Bullhead, Black
CP	Carp
BCF	Catfish, Blue
cc	Catfish, Channel
FCF	Catfish, Flathead
CMO	Chiselmouth
CRC**	Columbia River Chub
c	Crappie (Unknown)
BC	Crappie, Black
Wc	Crappie, White
SF	Flounder, Starry
PMO	Peamouth
YP	Perch, Yellow
PS	Pumpkinseed
CK	Salmon, Chinook
CH	Salmon, Chum
co	Salmon, Coho
K	Salmon, Kokanee
SA	Salmon, Pacific (Unknown)
PK	Salmon, Pink
s o	Salmon, Sockeye
JCK*	Salmon, Chinook (Juvenile)
JCH*	Salmon, Chum (Juvenile)
JCO*	Salmon, Coho (Juvenile)
JPK*	Salmon, Pink (Juvenile)
JSO*	Salmon, Sockeye (Juvenile)
SAN	Sandroller
COT	Sculpin, (General)
AMs	Shad, American
RS	Shiner, Redside
NSF	Squawfish, Northern
SS	Steelhead, Summer
Sw	Steelhead, Winter
SH	Steelhead (Unknown)
JSA*	Steelhead, Juvenile (Adipose Absent)
JSP*	Steelhead, Juvenile (Adipose Present)
GRS	Sturgeon, Green
WS	Sturgeon, White
SK	Sucker (Unknown)
BRS	Sucker, Bridgelip
LRS	Sucker, Largescale
LNS	Sucker, Longnose
s	Sunfish, (Unknown)
TNC	Tenth
CT	Trout, cutthroat (Unknown)
CCT	Trout, Cutthroat Coastal
SCT	Trout, Cutthroat Searun
LCT	Trout, Cutthroat Lahontan
DB	Trout, Dolly/Bull (Unknown)
BLC	Trout, Bull (Char)
DVC	Trout, Dolly Varden (Char)
RB	Trout, Rainbow (Resident)
RU	Trout, Rainbow (Unknown)
TR	Trout, (Unknown)
WAL	Walleye
WM	Warmouth
WF	Whitefish, Mountain

* New codes for 1995
** Conventional naming for NSF Sport-Reward Program

APPENDIX C

Pay Voucher/Questionnaire

Methods

Registered anglers received a pay voucher/questionnaire each time they returned northern squawl%h>11 inches in total length to a registration station. The angler's name, address and social security number were recorded on the front of the voucher along with the number of northern squawfish received for payment, the registration station number and the corresponding document number. Once the angler signed the voucher in the presence of the technician, the exit interview process was completed. The angler was required to complete a questionnaire (Appendix Figure l-C), which was found on the back of the voucher, and send it to Pacific States Marine Fisheries Commission (PSMFC). PSMFC entered the information from the front of completed vouchers and returned incomplete vouchers to the angler for correction. Vouchers with technician errors were returned to Washington Department of Fish and Wildlife (WDFW) for verification of the number of fish, missing signatures and missing document numbers. After payment was issued, the voucher was returned to WDFW where information from the questionnaire was entered into a database.

Results and Discussion

Approximately 20% of the 13,046 vouchers received from PSMFC had incomplete or incorrect data. Anglers that returned vouchers with possible incorrect data were called by WDFW technicians and the data corrected when possible. Data that could not be reconciled was not included in our analysis. Part of the errors made by anglers were due to a misunderstood example given on the questionnaire concerning Questions 1, 2 and 3 (Appendix Figure 1-C). This example led anglers to believe they should record the same amount of fish in Question 1 as in Question 2 (Appendix Figure l-C). Many anglers were unsure of what was being asked of them for Question 3, which asked anglers to classify which fish were caught while targeting northern squawfish. Since the voucher questionnaires were generally not completed in the presence of a technician, confused anglers could easily record incorrect target data. The accuracy of the data concerning fish caught while targeting northern squawfish may therefore be inaccurate.

The number of fish reported caught on a particular day sometimes differed between the exit and voucher data. To reconcile problems with the voucher and exit data, the two sets were combined and a low and high estimate was generated in the harvest evaluation section of this report (Appendix F). Voucher, exit and phone survey data were also compared in Appendix F to establish the 1995 returning angler sampling method.

Eighty-nine percent of all fish harvested were northernsquawfish>11 inches (Appendix Table C-l), which shows the northern squawfish sport-reward fishery was successful in directing the majority of harvest to northern squawfish. A total of 28,673 northern squawfish under 11

inches were caught by returning anglers, but only 11,372 were harvested, which shows that most anglers return undersized northern squawfish to the water.

The top five fishes (other than northern squawfish) harvested by returning anglers were smallmouth bass (*Micropterus dolomieui; 2,063);* shad (*Alosa sapidissima; 885);* walleye (*Stizostedion vitreum*; *503);* peamouth (*Mylocheilus caurinus*; 452); and channel catfish (*Ictalurus punctatus;* 263; Appendix Table C-1). The same fishes top the list of frequently harvested while targeting northern squawfish (Appendix Table C-2). Peamouth were probably harvested due to misidentification as northern squawfish, but the other fishes were known to be popular food fish. The list noticeably changed when considering fish caught, as opposed to fish harvested while targeting northern squawfish. Smallmouth bass (6,371), peamouth (2,014), white sturgeon (*Acipenser transmontanus*; *1,568),* walleye (950) and suckers (*Catostomus* spp;.91 1) were the most susceptible to being caught on popular northern squawfish baits (Appendix Table c-2).

Approximately 75% of all fish caught while targeting northern squawfish (excluding northern squawfish) were returned to the river. This high percent of fish returned to the river dramatically lowers the sport-reward fishery's impact on fishes other than northern squawfish (Appendix Table C-2).

The voucher data reported 396 adult salmonids caught while targeting northern squawfish (Appendix Table C-2). The accuracy of this data was questioned since anglers were confused by the voucher question regarding targeted fish. The actual number of adult salmonids caught while targeting northern squawfish was probably considerably less. Juvenile salmonid catch while targeting northern squawfish was also high (201 fish). The 1995 returning angler sampling method will correct these problems and provide more reliable estimates of catch while targeting northern squawfish.

Anglers were asked to record how they found out about the northern squawfish sport-reward fishery in Question 4 (Appendix Figure 1-C). Word of mouth (7,890) was the most frequently cited way that anglers discovered the sport-reward fishery, followed by newspaper (3,785), radio (215), television (193) and club activity (100). Refer to Appendix D for further discussion of promotional activities.

Question 5 (Appendix Figure l-C) showed that 74% of returning anglers would not have taken their fishing trip if the sport-reward fishery had not existed. The same question was posed to non-returning anglers and showed only 28%. This discrepancy showed further differences between returning and non-returning anglers.

The majority of participating anglers were from Washington (52.7%) and Oregon (41.3%). The remaining anglers resided in Idaho and other states. Since the majority of northern squawfish sport-reward fishery waters bordered Washington and Oregon, participation was expected to be highest from these two states.

Question 7 addressed the possibility of conducting the sport-reward fishery in certain areas by offering anglers a higher reward ($20-$5,000) per fish for tagged northern squawfish only. Results indicated that 76% (9,993) of anglers would have decreased their participation by using this new system. Six percent *(785)* of anglers indicated their participation would increase, 17% (2,265) of anglers would not change their participation% and. 1 l% listed angler response as unknown. A sport-reward fishery based on paying only for tagged northern squawfish was not recommended.

Both voucher and questionnaire must be completed before payment will be made. An incomplete voucher or questionnaire will be returned to sender for completion. This will delay processing and payment.

PLEASE CIRCLE OR FILL IN THE APPROPRIATE ANSWER

1. Please iist the number of fish caught **that you kept in the boxes:**

Squawfish over 11 inches ☐

Squawfish under 11 inches ☐

Other **(specify)**

_____ ☐

_____ ☐

_____ ☐

2. Please list the number of fish you caught **that you released unharmed in the boxes.**

Squawfish over 11 inches ☐

Squawfish under **11** inches ☐

Other (specify)

_____ ☐

_____ ☐

_____ ☐

3. Please indicate for each type& size of fish whether you caught **them** while targeting **Northern Squawfish.**

Y **N**

Y N

Y N

Y N

Y N

EXAMPLE:

Squawfish over 11 inches 2

Squawfish under 11 inches 10

Other (specify)

Smallmouth Bass 4

Squawfish over 11 inches 2

Squawfish under 11 inches 10

Other (specify)

Smallmouth Bass 6

(Y) N

Y (N)

(Y) N

4. How did you **find** out about the Northern Squawfish Sport-Reward Fishery?
   A. Newspaper
   B. Radio
   C. T.V.
   D. **Word** Of **Mouth**
   E. Club Activity
   F. Other (specify)

5. Would you have taken this fishing trip if the Sport-Reward Fishery did not exist?.
   A. No
   B. Yea ,

6. State of Residence:
   A. Washington
   B. Oregon
   C. Idaho
   D. Other (specify)

7. If the Northern Squawfish Sport-Reward Fishery were to change the current reward system, **which** pays $3 per northern **squawfish** greater than 11", to anew system that paid $20-$5,(X)0, for only northern **squawfish** that were tagged, would this affect you participation?
   A. The new system would increase my participation.
   B. The new system would decrease my participation,
   C. The new system would not affect **my** participation.

Figure 1-C. Northern **Squawfish** Sport-Reward Fishery pay voucher questionnaire, 1994.

c-1. The number of fish recorded from voucher data as harvested or released for each species. All fish were included regardless of which species the angler targeted.

Species	Harvested	Released
American shad	885	508
Brown bullhead	--	
Black crappie	--	
Bluegill	28	56
Bullhead (general)	92	251
Bull trout	--	1
Bridgelip sucker	--	2
Crappie (general)	9	32
Channel catfish	267	187
Chum salmon	1	--
Chinook salmon	1	15
Chiselmouth	5	43
Coho salmon	--	2
Carp	37	190
Crayfish	--	5
Cutthroat (general)	--	3
Green sturgeon	1	--
Juvenile salmonid (general)	16	212
Largemouth bass	26	49
Northern squawfish (>11)	126778	275
Northern squawfish (<11)	11372	17301
Peamouth	452	1695
Redside shiner	6	--
Rainbow trout (unknown)	79	206
Sunfish	2	51
Salmon (general)	8	71
Searun cutthroat	2	--
Sculpin (general)	13	214
Smallmouth Bass	2063	6862
Starry flounder	49	550
Steelhead (unknown)	65	56
Sucker	154	845
Trout (unknown)	1	--
Torrent Sculpin	--	1
Walleye	503	954
Whitefish	26	30
White sturgeon	75	1950
Yellow bullhead	1	1
Yellow perch	203	170
TOTALS	143220	32794

Table C-2. The number of fish recorded from voucher data as caught or harvested for each species while targeting northern squawfish.

Species	Caught	Harvested
American shad	437	410
Brown bullhead	2	0
Bluegill	61	28
Bullhead (general)	285	65
Bull trout	1	0
Bridgelip sucker	1	0
Crappie (general)	38	8
Channel catfish	367	189
Chum salmon	1	1
Chinook salmon	15	1
Chiselmouth	46	4
Coho salmon	2	0
Carp	201	33
Crayfish	5	0
Cutthroat (general)	1	0
Green sturgeon	1	1
Juvenile salmonid (general)	201	12
Largemouth bass	48	19
Northern squawfish (>11)	118560	118292
Northern squawfish (<11)	23786	9027
Peamouth	2014	390
Rainbow trout (unknown)	234	66
Sunfish	51	1
Salmon (general)	62	8
Searun cutthroat	2	2
Sculpin (general)	195	8
Smallmouth Bass	6371	1590
Starry flounder	563	43
Steelhead (unknown)	77	42
Sucker	911	109
Trout (unknown)	1	1
Torrent Sculpin	1	0
Walleye	950	317
Whitefish	56	26
White sturgeon	1568	59
Yellow perch	265	119

APPENDIX D

Promotional Activities

Introduction

In 1994, the Bonneville Power Administration (BPA) increased its emphasis on advertising and promotional activities for the northern squawfish sport-reward fishery over that of previous years. Attempts to increase harvest were based on increasing angler effort. The goal of the incentive and advertising program for the 1994 sport-reward fishery was to increase the number of angler days spent by participants to 100,000. Prior to 1994, the highest number of angler days spent during the northern squawfish sport-reward fishery season was 88,000 in 1992.

To achieve that goal, several promotional activities and advertising options were implemented during the 1994 northern squawfish sport-reward fishery, which operated from May 2 through September 25. These included BPA-sponsored tournaments, weekly tournaments, $50 tagged northern squawfish, random drawings, and the use of advertising through newspaper and radio and by distributing printed materials.

Methods

Harvest and effort totals associated with promotional activities were monitored during the season on a weekly basis, and evaluated after the season to determine if the results produced positive contributions to the 1994 northern squawfish sport-reward fishery. Positive results were based on the ability of the incentive activity to generate increased effort or harvest for the northern squawfish sport-reward fishery.

Evaluation data for promotional programs were gathered using two methods. A question on the pay voucher asked returning anglers how they heard about the northern squawfish sport-reward fishery. Non-returning anglers were asked via telephone survey how the different promotional programs affected their participation. Based on these results, plans could be made for designing and implementing promotional activities for 1995.

Reward

The 1994 northern squawfish sport-reward fishery offered recreational anglers a $3 reward for each northern squawfish with a total length of 11 inches or longer that was turned into one of the sport-reward fishery's 14 registration stations.

BPA Tournaments

BPA sponsored two groups of northern squawfish tournaments during the 1994 season. The lower Columbia River group consisted of Tournament I (T1), which included Sites 1-6, and Tournament II (T2), which included Sites 7-9. The upper Columbia River group consisted of Tournament HI (T3), which included Sites 10-13 and Tournament IV (T4), which included only Site 14. T1 and T2 were conducted concurrently in the time period from July 9-16, while T3 and T4 took place during the July 16-24 time period.

BPA's advertising agency (Cole and Webber) solicited retail merchants of sporting goods to become co-sponsors of these tournaments. The G.I. Joe's retail chain was signed as a co-sponsor for T1 and T2. They contributed $5,000 in gift certificates and BPA added $4,000 cash for a total of $9,000 for T1 and T2.

For each tournament, prizes were awarded to anglers returning the longest three northern squawfish in each of four age categories (for their tournament area). These categories included 12 years and under, 13-17 years, 18-54 years and 55 and over.

A co-sponsor was not found for T3 and T4 so BPA acted as the sole sponsor and offered $4,000 to be evenly split between the two tournaments. Tournament rules and age categories for winners were the same as for T 1 and T2, although the prize amounts were lower since there was no co-sponsor.

Tournaments were evaluated by monitoring harvest and effort levels during tournament weeks at each registration station. Tournament week results were compared to results from the prior week in 1994 as well as from the same week in 1993 to determine what impact, if any, this activity had on the northern squawfish sport-reward fishery.

Weekly Tournaments

In August, WDFW proposed that a weekly tournament be implemented by BPA at all 14 sites as a way to boost effort and harvest. The "end-of-season" weekly tournament was designed to entice anglers who had regularly participated in the fishery earlier in the season, back to the northern squawfish sport-reward fishery. The tournament began on August 8 at all 14 sites for a four-week trial period with the option to extend it an additional week if harvest levels remained high. Cash prizes were awarded for the three longest northern squawfish turned in to each site over the course of each week. Each week a total of $3,500 was divided into $250 per site. Cash prizes were $125 for first, $75 for second and $50 for third.

Independent Tournaments

There were three independent tournaments held during the 1994 season. Independent tournaments are characterized as being non-BPA sponsored events that are planned, organized and promoted entirely by the sponsoring organization with a varying level of guidance from WDFW.

The Wahkiakum Conservation District held its Second Annual Squawfish Tournament from May 28-July 4 at the Cathlamet and Kalama registration stations. The tournament was open to the public for a $6 entry fee that was collected by local retailers involved in the tournament. Tournament organizers made two changes to their tournament (from 1993) in hopes of encouraging more participation in 1994. The entry fee was set at lower level than in 1993, and the Kalama station was added as an eligible site. Prizes were awarded by the Wahkiakum Conservation District to anglers with the longest northern squawfish turned in over the course of the tournament.

The Lower Columbia Walleye Club held a "squawfish roundup" in conjunction with their walleye tournament on July 9 and 10 at the Gleason station. Entry fees were $100 per two-person team or $25 per amateur. There were no prizes for northern squawfish, however tournament organizers made arrangements with WDFW so that all tournament entrants were registered with the northern squawfish sport-reward fishery so that the reward from any northern squawfish caught during the walleye tournament were donated to a local non-profit group for kids.

The Ridgefield Marina Tenants Association included northern squawfish in their July 4 fishing tournament at the Ridgefield Marina. The tournament operated from 12 p.m. until 4 p.m. and was open to the public. There was no registration station at this site so tournament organizers made arrangements with WDFW to operate a satellite registration station at the marina for the four hours of the tournament. Prizes were awarded to the angler catching the hugest or the most fish of any species; there were also prizes for the largest and the most northern squawfish.

Tagged Northern Squawfish

During the 1994 season, an additional monetary reward of $50 was offered for select tagged northern squawfish that were turned in to registration stations. Eligible tags were from work done by ODFW for northern squawfish exploitation estimates for the Northern Squawfish Management Program. To collect the $50 reward, anglers were required to turn in tagged northern squawfish with the tag still attached to the fish. WDFW technicians removed the tag, recorded data and issued the angler a separate tag voucher for their $50 reward. Anglers submitted the tag and tag voucher to ODFW for verification and verified vouchers were sent to PSMFC for payment.

Random Drawings

Successful anglers were also eligible for random drawings on a monthly and year-end basis. PSMFC held five random drawings each month, including one overall drawing for $1,000 and four regional drawings for $250 each. Each month, winners were selected from a list of anglers who had been issued payment checks by PSMFC during the previous month. Anglers received one chance in the drawing for each northern squawfish paid. Regions included the same sites as for the EPA tournaments. There was one end-of-season drawing for $5,000 that was open to all anglers who had been paid for northern squawfish before October 16, 1994.

Tagged Northern Squawfish Drawings

During 1994, PSMFC publicly held two random drawings of $5,000 each. A midseason drawing was held July 11 and included anglers who were paid for tagged northern squawfish up to July 8. An end-of-season drawing included anglers paid for tagged northern squawfish from July 9 through October 10, 1994. Anglers received one chance per tagged northern squawfish and multiple entries were used for those anglers who had turned in multiple tagged northern squawfish.

Season Extension

In August, harvest levels for the northern squawfish sport-reward fishery were rising and the overall CPUE was higher than any previous years at this time. WDFW proposed that the northern squawfish sport-reward fishery and the end-of-season weekly tournament be extended an additional two weeks. The recommendation was made to extend the season on a trial basis at six selected registration stations that were harvesting significant numbers of northern squawfish and where it was believed that anglers could maintain these harvest levels. WDFW checked with other members of the Northern Squawfish Management Program to verify that additional costs associated with extending the season were able to be absorbed within current budget levels and obtained approval for the extension on September 6.

Advertising

The advertising portion of the 1994 promotional program consisted of paid advertisements in newspapers and magazines, news releases and written articles, printed materials, and paid radio advertising. The voucher questionnaire asked successful anglers where they had heard about the northern squawfish sport-reward fishery. Results from the voucher were compiled to assist in determining the priority for 1995 advertising activities.

Advertisements for newspapers and magazines were used from early June to mid-August. These advertisements included graphics with text about the northern squawfish sport-reward fishery and generally targeted novice anglers from population centers located near registration stations. Advertisement size was usually one-fourth page and appeared once per week in daily newspapers and once per month in magazines.

News releases originated with BPA as information became available and were intended to generate written articles or television/radio coverage about the northern squawfish sport-reward fishery. Topics included general program information and rule changes, updated harvest and effort totals, and tournament and random drawing winners.

BPA produced several types of printed items to advertise or provide information about the sport-reward fishery such as pamphlets and posters.

The “Catch a Killer, Save a Salmon” pamphlet explained the guidelines of the northern squawfish sport-reward fishery and how to participate. A “How to Catch Them” pamphlet

covered tackle and techniques for catching northern squawfish and a one page insert explained the various incentive activities that were offered in 1994. Program personnel distributed and maintained supplies of these printed materials at retail businesses, bait and tackle shops, and information outlets where the public had access to them.

Informational packets called "Northern Squawfish Starter Kits" were designed to provide novice anglers with all the information that they would need to participate in the fishery. The kit was contained in an envelope with squawfish graphics; contents included BPA squawfish pamphlets, the incentive activities insert, maps with directions to registration stations and a lure for catching squawfish (a lead-head jig with plastic grub). The free kits were available at retail outlets belonging to the co-sponsor of the BPA tournaments or by calling BPA.

A 60-second radio spot was produced to promote the BPA sponsored tournaments, the northern squawfish sport-reward fishery and the availability of the free starter kits. The radio spot was run for a three-week period on multiple stations in the Portland/Vancouver, The Dalles/Hood River, Tri-Cities, and Lewiston/Clarkston markets. Coverage began two weeks prior to the BPA tournaments start date and ran until the end of tournament week for each area.

800 Hotline

The northern squawfish sport-reward fishery operated a toll-free hotline for anglers to use as a source of information about the program. The information on the hotline was accessed using touch-tone phones to select various menu topics. Information provided by the hotline included updated weekly harvest totals, program guidelines, voucher information, incentive information and "how to catch them" information. Rotary callers were forwarded to a customer service specialist for assistance.

Results/Discussion

Rewards

The 1994 northern squawfish sport-reward fishery generated 40,783 angler days and collected 129,434 northern squawfish over 11 inches. For the sport-reward fishery to increase harvest, it must increase angler effort, especially from experienced anglers. This maybe accomplished by targeting top anglers from previous seasons and providing them with incentives to fish longer and/or harder, and by recruiting new anglers into the fishery.

Money was the prime motivator for 40% of anglers participating in the northern squawfish sport-reward fishery and at least somewhat important to 77%, according to results from the 1993 phone survey (Klaybor et al. 1995). Effort jumped 178% when the reward for northern squawfish was increased from $1 to $3 in 1990; effort after the reward increase generally remained above that of the early season (Vigg et al. 1990). Harvest during the first week of the $3 reward (in 1990) increased 20 times the level of the prior week and also generally remained above earlier

levels. Based on this data, the best way for the northern squawfish sport-reward fishery to have a large impact on harvest and effort in 1995 is to increase the reward level.

BPA Tournament

Phone survey data indicated that tournaments increased participation in the northern squawfish sport-reward fishery for 43°A of surveyed anglers (Appendix Figure l-D). During periods of BPA-sponsored tournaments, overall effort for the northern squawfish sport-reward fishery increased by 8% over the period immediately preceding BPA tournaments (Appendix Figures 2-D and 3-D). Effort increased 4% for the lower Columbia River group of tournaments and 19°/0 for the upper Columbia River group of tournaments.

Effort increased at three of the four tournaments from the preceding time period. T1 sites showed an increase in effort of 10%. Four of the six sites showed increases ranging from 10?! to 50%. T2 was the least successful with all three sites, showing decreases in effort ranging from 2%to31%. T3 showed an overall increase in effort of 4% with increases at three of four sites ranging from 9°/0 at Site 13 to 25°/0 at Site 11. T4 was the most successful tournament from an effort standpoint with a 70°/0 increase seen over the previous period.

While overall effort increased during BPA tournament periods, harvest declined 26% for the northern squawfish sport-reward fishery with eight of the 14 sites showing declines, and one site remaining the same (Appendix Figures 2-D and 3-D).

Harvest declined 66% for the lower Columbia River group of tournaments when compared with the time period prior to the tournament. Harvest increased 9°/0 for the upper Columbia River group of tournaments from the prior period.

The overall decline in harvest for the sport-reward fishery was supported by the results of the individual tournaments where three of four showed declines in harvest from the prior period. Harvest declined 62% overall at T1 sites. Declines were seen at four of six sites and ranged from 31% at Site 6 to 77% at Site 2. One site stayed the same. Harvest declined 22% overall at T2 sites where all three sites showed declines ranging from 2°/0 at Site 9 to 66°/0 at Site 7. T3 was the only tournament in which harvest clearly increased (10% overall) over the preceding period. Harvest increased at three of four sites ranging from21% at Site 13 to 56’% at Site 10. T4 harvest increased by 5°/0 over the preceding period.

The BPA tournaments appear to be successful at increasing overall effort in the northern squawfish sport-reward fishery, but the results do not indicate an increase in harvest. This maybe due to the fact that the northern squawfish sport-reward fishery traditionally experiences declining harvest around this time of year. It is also possible that tournaments attract new anglers to the fishery who do not have the knowledge or experience to harvest large numbers of northern squawfish. T3 was the most successful of the four tournaments since both effort and harvest showed increases over the period prior to the tournament. T1 and T4 showed potential by being able to draw anglers from nearby population centers into the fishery. If the tournament is held earlier in the year in 1995, and if participants are trained to have better success at harvesting

northern squawfish, then this activity maybe able to generate increased northern squawfish harvest as well.

Weekly Tournaments

The first week of the "end-of-season" weekly tournament produced higher effort than the prior week at eight of the 14 registration stations (Appendix Figure 4-D). Harvest during that first week increased at seven of the 14 sites over the prior week.

As in previous seasons, effort and harvest levels began to decline by mid-July. Many regular anglers had already stopped participating for the season because they were unwilling to expend the increased effort required to catch "worthwhile" numbers of northern squawfish. The End-of-season tournaments successfully demonstrated that weekly tournaments can have positive results by bringing anglers back to the northern squawfish sport-reward fishery, even during traditionally slow times of year.

Independent Tournaments

The Wahkiakum Conservation District reported that its tournament attracted 30 anglers who harvested 634 northern squawfish in 1994. The number of tournament entrants increased 76% from that of the year before when the district reported that 17 anglers harvested 70 northern squawfish.

Participation for the Lower Columbia Walleye Club tournament produced 34% (65 anglers) of the Gleason site's total angler days and contributed 14%(18 northern squawfish) of the harvest at the Gleason site for the two-day tournament.

The Ridgefield Marina Tenants Association tournament harvested 40 northern squawfish that were under 11 inches long and only four that were eligible for the $3 reward. These northern squawfish were harvested by 42 anglers.

Small tournaments such as these offer the northern squawfish sport-reward fishery an inexpensive way to generate interest and excitement (in addition to effort and harvest) in a manner that is independent of the planned BPA tournaments. With additional guidance from WDFW, the sport-reward fishery may be able to translate the effort from this type of tournament into significant additional northern squawfish harvest.

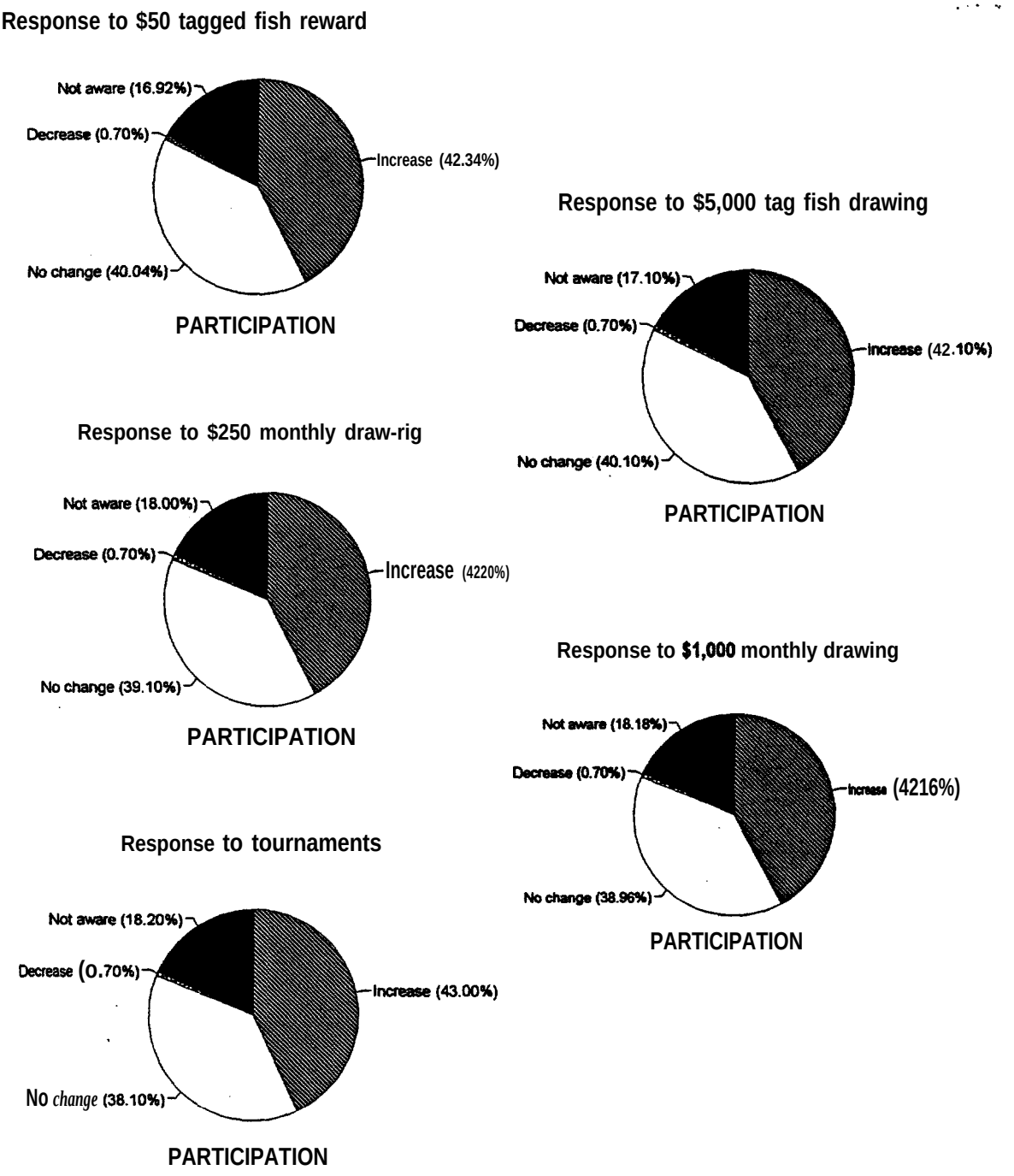


Figure 1-D. Angler responses to telephone survey question regarding how promotional activities affect participation.

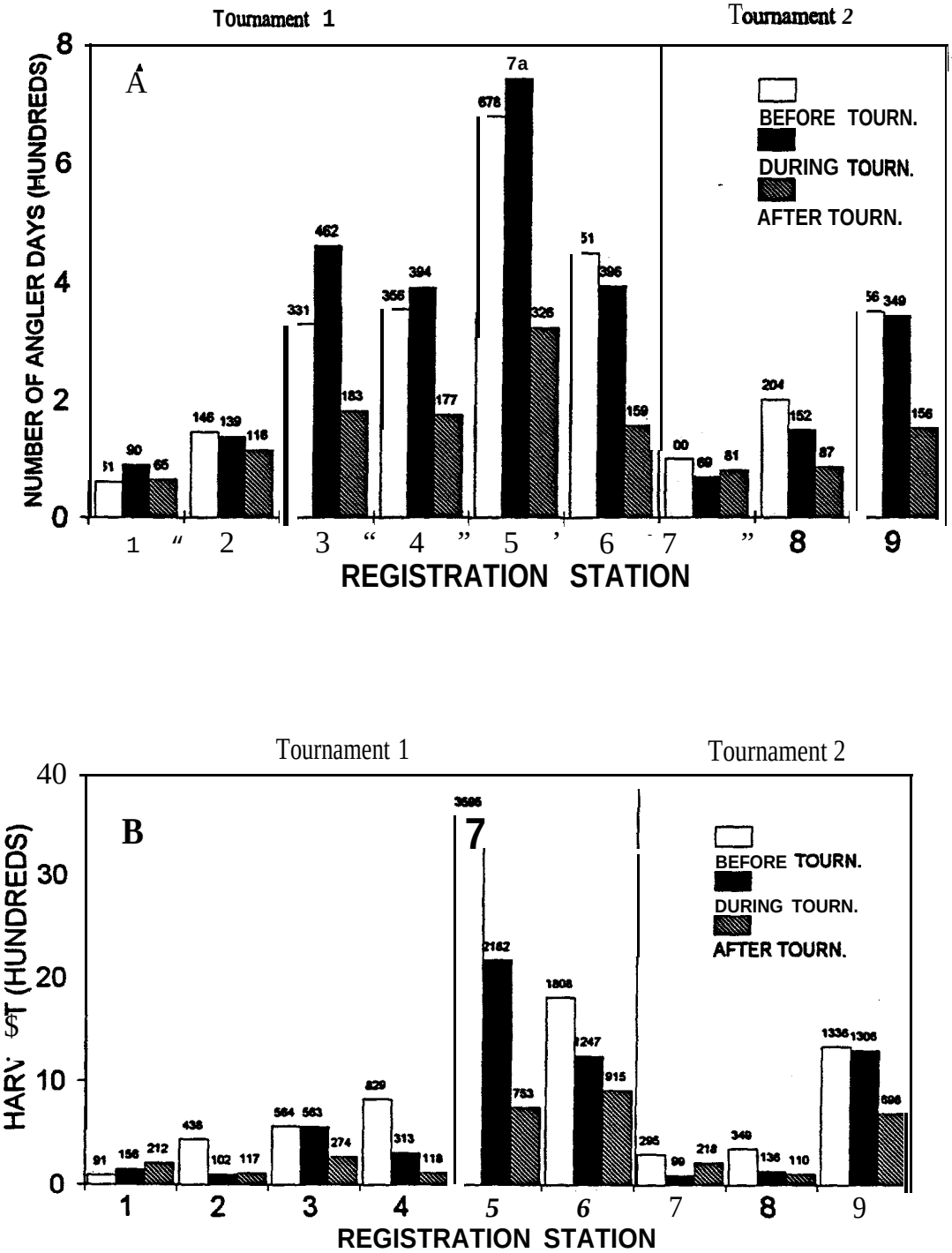


Figure 2-D. Angler effort and harvest for the Lower Columbia River during BPA tournaments.

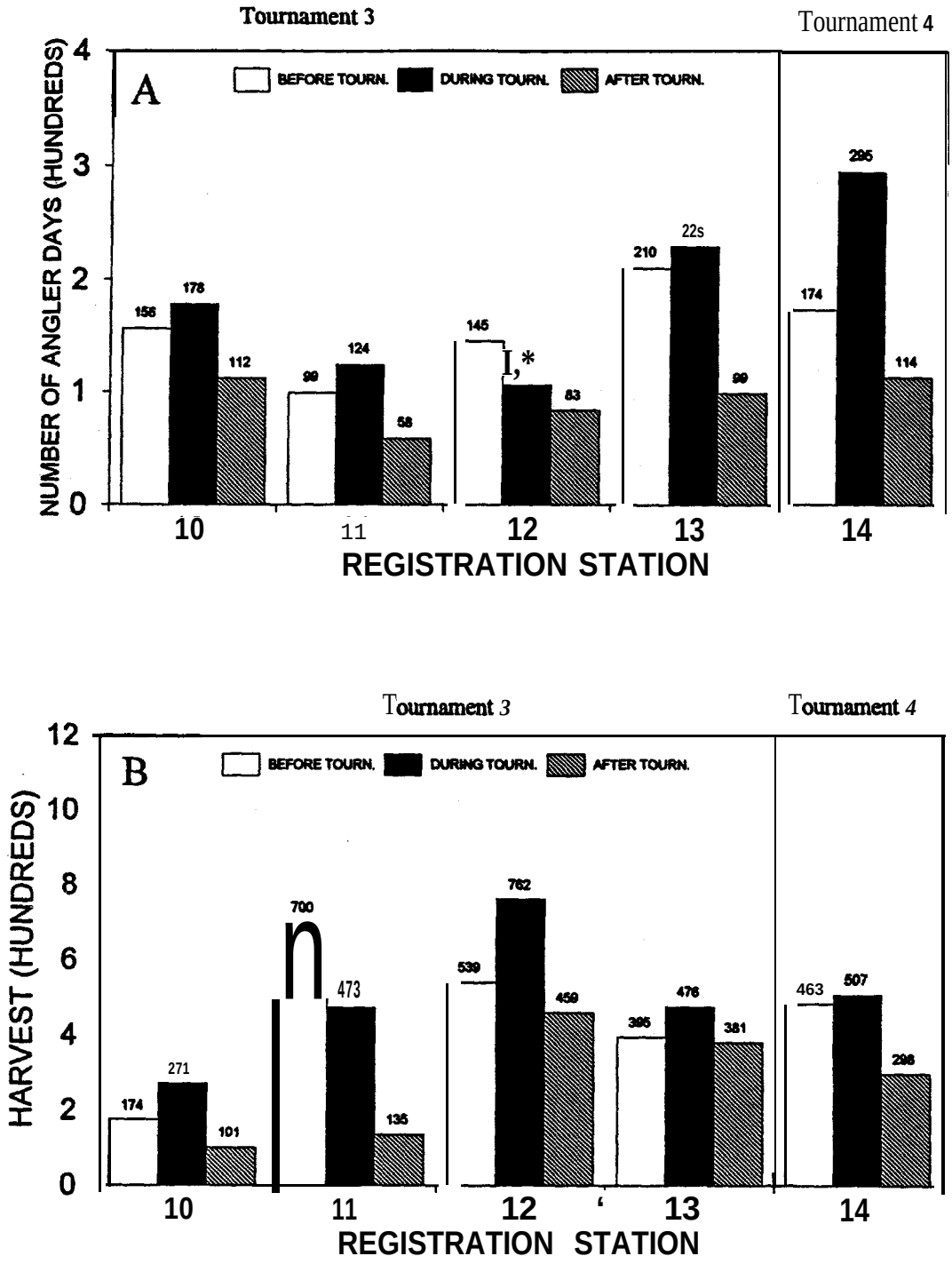


Figure 3-D. Angler effort and harvest for the Upper Columbia River during BPA tournaments.

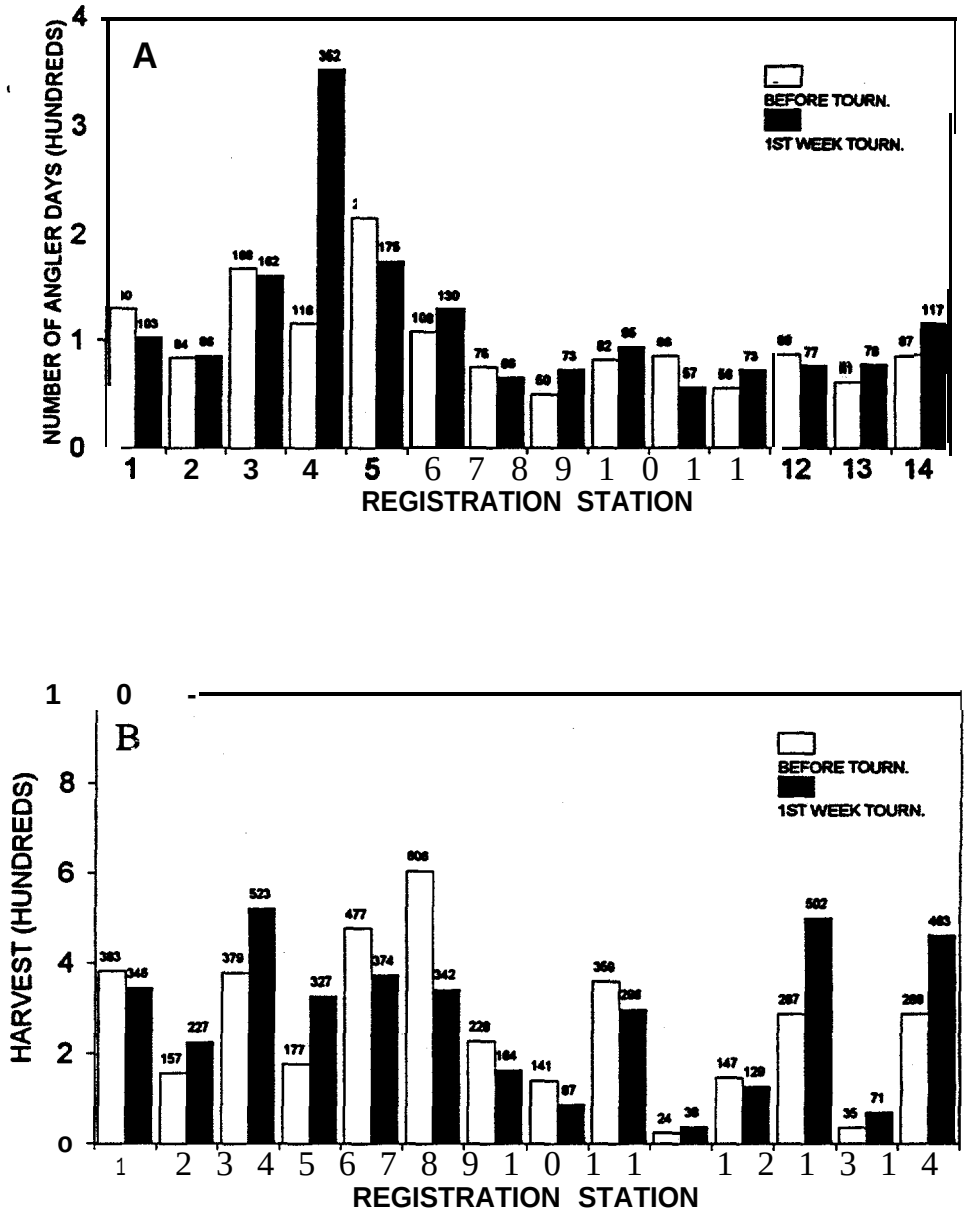


Figure 4-D. Angler effort and harvest for the first week of weekly tournaments versus prior week.

Tagged Northern Squawfish

Phone survey data showed that 42.3% of anglers indicated that "tagged northern squawfish" would increase their participation in the northern squawfish sport-reward fishery (Appendix Figure l-D). Anglers returned 381 tagged northern squawfish in 1994, of which the majority were spaghetti tags. The $50 reward was paid to 293 of these tags. Tags that did not qualify were often from radio tagged northern squawfish or from northern squawfish studies that were from areas outside the northern squawfish sport-reward fishery's boundaries.

Anglers harvesting tagged northern squawfish were spread out fairly evenly with most tags coming from areas with the highest effort, such as Portland/Vancouver. The most tags turned in by a single angler was six. Of the 14 registration stations in 1994, Site 5 processed the largest number of qualifying tags with 74 while Site 7 had the fewest tags turned in with only five (Appendix Figure 5-D). Most tagged squawfish were caught in May and June. The area below Bonneville Dam produced the most tagged northern squawfish of the nine reservoirs with 218. According to PSMFC, there were 185 different anglers involved in this promotion.

WDFW technicians reported that anglers indicated that the large number and wide distribution of tagged northern squawfish in the river made them feel that the $50 prizes were attainable and that this promotion increased their interest in the northern squawfish sport-reward fishery. Since eligible tags for this promotion came from northern squawfish studies that were conducted within the sport-reward fishery's boundaries, this incentive encouraged anglers to fish within program boundaries. The $50 reward may have also encouraged anglers to turn in tags from their fish.

Random Drawings

Phone survey data showed that 42.2% of anglers indicated that "random drawings" would increase their participation in the nonhero squawfish sport-reward fishery (Appendix Figure l-D). Of the 26 winners of random drawings over the course of the 1994 season, winners were evenly spread out within the sport-reward fishery's geographical area.

Anglers generally indicated to WDFW technicians that this incentive did not directly affect their participation in the fishery since most felt that they didn't have a good chance of winning. They would prefer to have more smaller drawings that would reward larger numbers of winners.

Tagged Northern Squawfish Drawings

Phone survey data showed that 42. 1% of anglers indicated that "tagged northern squawfish drawings" would increase their participation in the northern squawfish sport-reward fishery (Appendix Figure 1-D). Overall, there were 293 tags that were eligible for the two drawings. According to PSMFC, the midseason drawing included 170 entries from 121 people and the end-of-season drawing had 123 entries from 85 people. The most tags turned in by one person for either drawing was six. The public attendance for each drawing was 12-15 people.

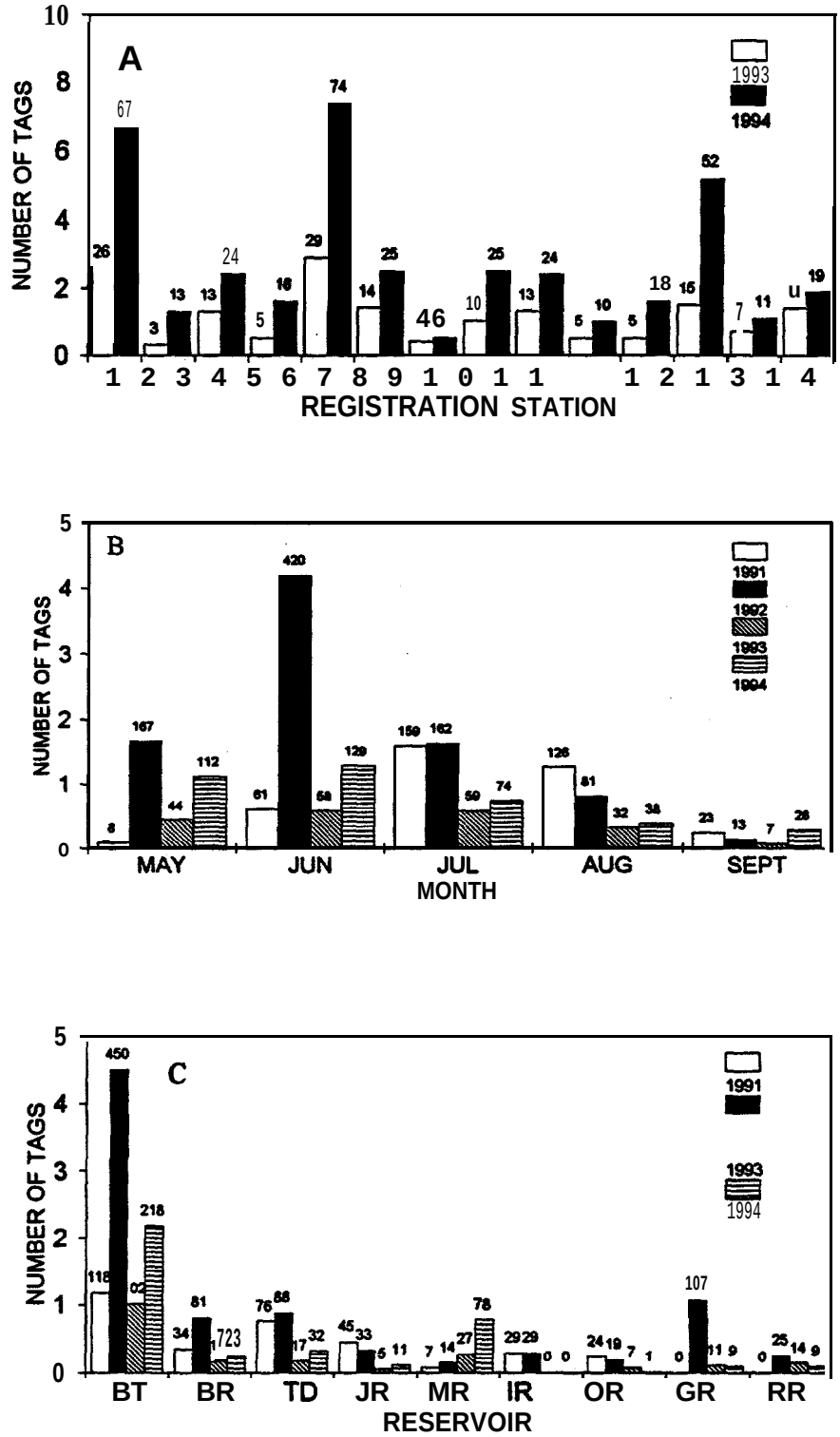


Figure 5-D. Tag recoveries by **registration** station **during** 1993 and 1994. Tag recoveries by month and reservoir during 1991-1994.

There was one eastern Washington winner and one western Washington winner for the two $5,000 drawings. Angler comments to technicians regarding this incentive were similar to those for the monthly random drawings. They would prefer to have more winners even ifit meant smaller reward amounts.

Season Extension

The two-week extension of the sport-reward fishery was responsible for generating 1,450 additional angler days, adding 9,349 northern squawfish to the yearly totals, and providing 32 additional winners for the end-of-season weekly tournament. The six sites that were selected for extension were able to maintain higher harvest and CPUE levels than the entire sport-reward fishery had for September in any previous year.

The results of the additional two-week season indicate that extending the northern squawfish sport-reward fishery on a selective basis can have a positive effect on the fishery's overall results. While the conditions that allowed these results in 1994 are not present every year, and extending all sites may not make sense, the sport-reward fishery should plan on keeping the end date for the fishery somewhat flexible to take advantage of high harvest and CPUE.

Advertising

Voucher data indicated that 26% of anglers questioned learned of the northern squawfish sport-reward fishery from the newspaper. This was the most-indicated category behind "word of mouth" at 63°/0 (Appendix Figure 3-C). There were 76 insertions in 10 daily newspapers within the program area. There were also a total of 10 insertions in weekly or monthly publications. While newspaper advertising may not influence and inform the majority of anglers, it is still an important medium for reaching a significant number of them.

Ten news releases about various aspects of the northern squawfish sport-reward fishery were produced over the course of the season and generated at least an equal number of articles in newspapers during the season, although the exact number is not available. An additional way to encourage articles about the northern squawfish sport-reward fishery in 1995 is to pro-actively provide program information to outdoor writers via a mailer prior to the start of the season.

BPA printed 50,000 "Catch a Killer," and 50,000 "How to Catch Them" pamphlets. WDFW technicians distributed approximately 30,000 of each to the public through our sites and to over 156 different retail outlets in Washington, Oregon and Idaho. A small number of posters were also distributed to outlets that received pamphlets.

There were over 3,800 "Northern Squawfish Starter Kits" given out during the 1994 season. Three thousand were distributed through the co-sponsor of BPA's lower Columbia River tournaments. BPA mailed the remaining kits to anglers per telephone request.

The number of northern squawfish starter kits distributed showed it to have potential for informing anglers about the sport-reward fishery. Unfortunately, there were no means for

demonstrating that this demand translated into increased effort or harvest for the northern squawfish sport-reward fishery.

Anglers responses from the voucher indicated that <1% learned about the northern squawfish sport-reward fishery from radio (Appendix Table 3-C). The radio spot was broadcast a combined total of 670 times among the four areas during the time periods that it was used. This total was split into 335 insertions between the Portland and The Dalles radio markets and 335 insertions between the Lewiston/Clarkston and the Tri-Cities radio markets.

Radio advertising did generate angler interest in the free northern squawfish starter kits as demonstrated by angler requests. It was difficult to demonstrate that radio added any positive results to the sport-reward fishery other than for distributing these kits. Continued use of this advertising medium in the future will require that the results be somehow documented.

The voucher questionnaire provided the only direct method for asking anglers how advertising affected them during the 1994 fishery. When the responses are broken down by type, it becomes apparent that to be successful, the sport-reward fishery must use methods of advertisement that stimulate word of mouth communication such as pre-season mailers and newspaper advertising. Data provided by the voucher gave us only a partial picture of how advertising affected anglers since it only surveyed successful anglers. The effect of advertising on the fishery's unsuccessful anglers is not known. Additional evaluation methods for determining the effect of advertising programs on unsuccessful anglers will be developed for the 1995 season to address this concern.

800 Hotline

The toll-free squawfish hotline was used by 5,478 users during the season with an average of about 1,100 people per month and peak usage in the month of June (Appendix Figure 6-D). According to AT&T, the average length of call was 2:32 minutes at a cost of $.44 per call. The busiest days of the week for usage were Monday through Thursday and most calls to the hotline were attempted during the day as opposed to evening or night. The largest number of calls came from the "503" area code, followed by "206," "509" and "208."

The 800 hotline number has generated usage that shows it to be an effective way to provide the public with regularly updated information about the northern squawfish sport-reward fishery. The relatively small average cost of $.44 per call shows that the hotline is also an efficient use of funds. In addition, the flexibility available to us with the hotline allows us to modify and improve the product that it provides to the public in response to demand.

Summary

The goal of the 1994 incentive programs for the northern squawfish sport-reward fishery was to increase effort to 100,000 angler days and to increase the harvest rate of northern squawfish so that our exploitation rate is closer to the upper end of the program's 10-20'%

exploitation goal. The promotional activities implemented in 1994 did result in a higher harvest level than the 1993 northern squawfish sport-reward fishery and our highest exploitation rate to date. To build on this foundation, the 1995 northern squawfish sport-reward fishery must continue to offer successful incentives from 1994 (with modifications if necessary) and add additional incentives if appropriate.

The goal for the 1995 northern squawfish sport-reward fishery should be broadened to aim for increases in both effort and harvest.

To boost effort, the 1995 incentives must accomplish three tasks: (1) entice top anglers from previous seasons to fish more often, (2) recruit new anglers that are experienced and well equipped to the northern squawfish sport-reward fishery, and (3) attract novice anglers.

To boost harvest, the northern squawfish sport-reward fishery must also accomplish three tasks: (1) provide incentives for top anglers to fish longer and/or harder; (2) provide information on northern squawfish angling to new, experienced anglers for them to become proficient squawfish anglers; (3) and provide direct training to novice anglers so that they will become competent northern squawfish anglers.

With the above mentioned goals in mind, the following recommendations are made regarding specific promotional and advertising programs for 1995.

1. Increase the reward paid for northern squawfish $\geq$ 11 inches.

2. Continue the BPA/co-sponsor tournament.

3. Use the weekly tournaments for slow periods.

4. Continue tagged northern squawfish promotion.

5. Modify random drawings to provide more winners.

6. Keep option of extending fishery.

7. Emphasize word-of-mouth advertising methods.

8. Use radio advertising to emphasize specific events.

9. Continue use of 800 hotline; modify as necessary.

10. Actively encourage independent tournaments.

Finally, evaluation methods for incentives should be strengthened prior to the start of the 1995 season.

By increasing the reward paid for northern squawfish and by modifying select promotional activities, the 1995 fishery should be able to exceed the totals seen for 1994.

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Vigg, S., C.C. Burley. D.L. Ward, C. Mallette, S. Smith, and M. Zimmerman. 1990. Report A in A.A. Nigro, editor. Development of a system-wide predator control program: stepwise implementation of a predation index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1990 Annual Report. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

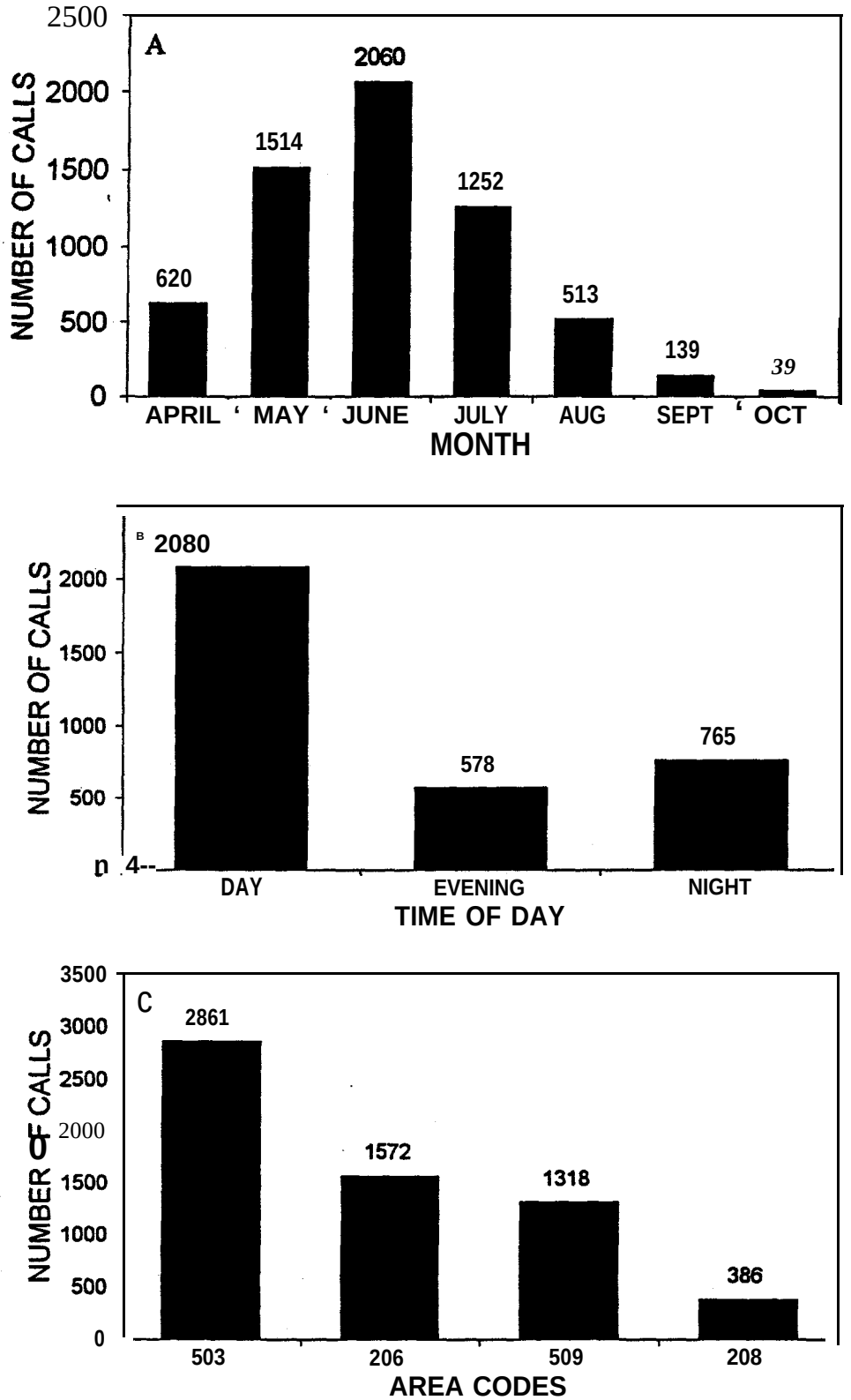

Figure 6D. Northern **squawfish** hotline usage by **month, time** of day and by area codes.

APPENDIX E

Phone Survey

Introduction

A telephone survey of non-returning anglers was conducted as part of the evaluation of the 1994 northern squawfish sport-reward fishery (Klaybor et al. 1995). Non-returning anglers are defined as anglers who registered to participate in the fishery, but did not return to the registration station to turn in fish and complete an exit interview.

The primary purpose of this study was to estimate non-returning angler harvest of northern squaw-fish and incidental harvest of other fish species. Other objectives were to determine how angler participation was impacted by various promotional programs or by changes in registration station location and hours of operation. The survey also allowed us to record and monitor technician interactions with anglers and other angler concerns with the northern squawfish sport-reward fishery.

Methods

Ten percent of non-returning anglers were surveyed from each of the 14 registration sites. Non-returning anglers were selected for survey using a systematic random sampling method. A randomly selected number between 1 and 5 was as a starting point in the weekly registration document files. Every fifth registered angler from that point (inclusive) was added to a potential survey list. Calls were made to non-returning anglers from that list until 10OA of the non-returning anglers from each site had been surveyed. This process was completed for each week of the fishery.

The calling protocol was adopted from Washington State University's Social Science Research Center (Dillman 1978). Up to five attempts were made to contact each angler selected for an interview. Three attempts were made on weekday afternoons or evenings and two attempts on weekend days, unless a family member of the angler recommended a specific time to call back.

Survey questions are listed in Appendix Table E-1. Computer programs checked the data for inappropriate values and inconsistencies. In addition, a minimum of 5% of each data file was extracted and checked for errors against the original documents.

Table E-1. Telephone questionnaire for non-returning anglers for the 1994 northern squawfish sport-reward fishery.

RESULTS CODES

CALL BACK CODES

BAM - ANSWERING MACHINE
BBz - BUSY
BCB - CALL BACK

DIRECTORY ASSISTANCE CODE

DWN - WRONG NUMBER
DDS - DISCONNECT
BNA - NO ANSWER

COMPLETED CODES

CCM - COMPLETE
CPC - PARTIAL COMPLETE

UNCOMPLETED CODES

IHC - HANDICAPPED
IOT - OTHER
IRN - NOT AVAILABLE
ITR - ABUSIVE
IDD - DECEASED
IDL - DEAF
IRF - REFUSAL
IDC - DON'T CALL AGAIN
IJV - JUVENILE

TIME CODES

WE - WEEK-END
WD - WEEK-DAY

D - DAY
E - EVENING

DAY CALL = 1:30 - 5:30
EVENING CALL = 5:30 - 9:00

DAY CODES

SUN - SUNDAY
MON - MONDAY
TUE - TUESDAY
WED - WEDNESDAY
THU - THURSDAY
FRI - FRIDAY
SAT - SATURDAY
suN - SUNDAY

ANGLER CALLING SCHEDULE

2 - WD E
1 - WD D
1 - WE D
1 - W E E

RESERVOIR CODES

1 - Below Bonneville
2 - Bonneville
3 - The Dalles
4 - John Day
5 - Mcnary
6 - Ice Harbor
7 - Lower Monumental
8 - Little Goose
9 - Lower Granite

TELEPHONE QUESTIONNAIRE FOR NON-RETURNING ANGLERS
NORTHERN SQUAWFISH SPORT—REWARD **FISHERY 1994**

A N G L E R NAME INTERVIEWER _____ **DATE** _____
DAY _____ **TIME** _____

My name is (Interviewer) and I am with the Washington State Northern Squaw Fish Program. Could I speak with (angler name)?

(Angler name) We are interviewing people who registered to fish for northern squawfish. This information will be kept confidential and only used to improve the efficiency of the program. Do you recall registering at (Check station) on (date)? (If no - Remind them with information from the registration form) I have a few questions *concerning your* fishing trip that I would like to ask you. It will only take about 10 minutes. Is this a good time to complete the questionnaire? (If no) When would be a good time to call back?

We have created maps that divide the Columbia and Snake Rivers into large sections. These maps will help us to determine the effect our program is having on the fish populations in those areas. We are not to trying to locate your favorite fishing hole. I just need to know approximately where you were fishing that day.

Q1. Reservoir Code _____

Q1A. Location Code _____

Q2. Did you catch any fish while you were fishing for northern squawfish?

1. YES 2. NO 3. CAN'T REMEMBER____

4. DIDN'T TARGET____

If yes: What species did you catch and how many of each? Please tell me one species at a time so that I can record them.

Were the northern squawfish over or under 11 inches? (>=11 inches NSF-G) (<11 inches NSF-L)

Q3. SPECIES	Q3A. QUANTITY	Q3B. FISH DISP.
_____	_____	_____
_____	_____	_____
_____	_____	_____

(9999-CAN'T REMEMBER)

Q3B. What did you do with the fish? Did you:

1. Return them to the water unharmed.

2* Kill them and return them to the water.

3. Keep them to eat.

4. Keep them for other uses.

5. Gave them to another angler to turn in.

6. Returned them to the station yourself
(Did you get a voucher?; Do you know the voucher#?; Do you know why you didn't get a voucher?) .

7. Other

Q3C. Memo

Q4 . Did you catch any fish while you were fishing for other species?

10 Y E s 2 . N O 3. CAN'T REMEMBER_____

4. DIDN'T TARGET_____

If ves: What species did you catch and how many of each? Please tell me one species at a time so that I can record them.

Were the northern squawfish over or under 11 inches?
(>=11 inches NSF-G) (<11 inches NSF-L)

Q5 . SPECIES	Q5A . QUANTITY	Q5B . FISH DISP.

(9999-CAN'T REMEMBER)

Q5B . What did you do with the fish? Did you:

1. Return them to the water unharmed.

2. Kill them and return them to the water.

3. Keep them to eat.

4. Keep them for other uses.

5. Gave them to another angler to turn in.

6. Returned them to the station yourself.
(Did you get a voucher?; Do you know the voucher#?; Do you know why you didn't get a voucher?)

7. Other

Q5C. Memo

Q6 . Are the checkstations conveniently located for you?

1. YES 2. NO

Q6A. If no: What new locations would you suggest?

_____

Q7 . Has the change in registration hours of operation (1) increased, (2) not changed, or (3) decreased your participation in the program?

Q8. Do you plan to register again with the program?

1. YES 2. *NO*

Q8A. If no: What is the main reason you do not plan to register with the program: (Wait for a response, then categorize.)

1. Poor success catching northern squawfish.

2* Registration is too much trouble.

3* Too far to registration site.

4. Other reasons: Q8B. Please explain: _____

Q9. Would you have taken this fishing trip if the Northern Squaw Fish Program did not exist?

1. YES 2. NO

Q10. Has this years promotional programs changed your participation in the Northern Squaw Fish Program, which are:

A. Tagged fish $50 reward program.

B. Tagged fish $5,000 reward program.

c. Monthly drawing by region-- $250.

D. Monthly drawing for total program--$1,000.

E. Derbies.

1. Increased 2. Not Change 3. Decreased

4. Were you not aware of the new program?

Q11. How would you rate your interaction with the technicians at the check station?

1. Very good

2. Good

3. Poor (Record comments on all number 3 responses)

4* No Interaction

Q12A. Comments

_____

Results and Discussion

Non-returning angler satisfaction with the northern squawfish sport-reward fishery was high, since more than 87% responded positively to questions related to their interaction with the program. Registration stations were conveniently located for 87.5% of the surveyed non-returning anglers (Appendix Table E-2). When asked to suggest other locations, less than 12°/0 of the non-returning anglers requested alternatives. Surveyed non-returning angler responses indicate that participation might be significantly increased by adding satellite registration stations at Chinook Landing, Vancouver, and possibly at LongView, since those sites were requested by 31.4%, 11. 1%, and 5.2%, respectively. Only 6.0% of surveyed non-returning anglers said their participation decreased as a result of the change in hours of operation during 1994 (Appendix Table E-2). This figure cannot include anglers who registered with the northern squawfish sport-reward fishery in prior years, but were unable to do so this year due to the changes in registration station location and hours of operation.

Non-returning anglers represented 47.6% of the total registered anglers for 1994 as compared to 56.7°A for 1993. The number of non-returning anglers decreased by 5,289 (26.7%) from 1993 while total registered anglers decreased by only 4,456 (12.8%) and returning registered anglers increased by 833 (5.5%). Even though overall participation was down, both number and percent of anglers that were successful increased from 1993. It maybe that the loss of participation occurred primarily among anglers who had low success in 1993 rather than as a result of the changes in registration locations and hours of operation.

Almost 97% of surveyed non-returning anglers said they planned to register with the northern squawfish sport-reward fishery again (Appendix Table E-2). From the 3. 1°/0 that would not, responses were evenly split between "poor success catching northern squawfish" (0.5%) and "too far to registration site" (0.6%) as reasons for not planning to register again. Miscellaneous "other reasons" (2.0%) included (1) too busy, (2) not interested, (3) fishing for other species, (4) leaving the area, and (5) one angler who didn't want to put his social security number on the voucher.

Approximately 17-18% (averaged over the whole season) of surveyed non-returning anglers were not aware of promotional programs. The programs were generally beneficial and about equally popular, with 42-43°/0 of surveyed non-returning anglers reporting that their participation increased as a result (Table E-2). Less than 1% of the responses to the promotional programs were unfavorable.

Non-northern squawfish species were not significantly impacted by the northern squawfish sport-reward fishery. For example, smallmouth bass (*Micropterus dolomieui*) and peamouth (*Mylocheilus caurinus*), the most frequently caught incidental species, represent only 7.47% and 3.97%, respectively, of the reported harvest while northern squawfish were being targeted (Appendix Table E-3). Over 78% (135) of the northern squawfish 11 inches or more in length that were harvested by surveyed non-returning anglers were targeted by those anglers (Appendix Table E-3). Over 94% (55 1) of northern squawfish less than 11 inches that were harvested by

surveyed non-returning anglers were targeted. "Harvest by target" data (Appendix Table E-3) could be somewhat misleading. One (1 OOYO) chinook salmon (*Oncorhynchus tshawytscha*), 79 (59.8%) smallmouth bass, 2 (25.0%) steelhead (*Oncorhynchus mykiss*), 16 (32.0%) walleye (*Stizeostedion vitreum*), and two (25.0%) white sturgeon (*Acipenser transmontanus*) were harvested by surveyed non-returning anglers while targeting northern squawfish. Although the percentages for these incidental species are large, the harvest quantities were low.

Approximately two-thirds (66.6%) of the surveyed non-returning anglers would have gone fishing even if the northern squawfish sport-reward fishery did not exist (Appendix Table E-2). Over 78% of non-northern squawfish species, 67.1'% of northern squawfish 11 inches or longer, and 84.8°/0 of northern squawfish less than 11 inches were harvested by these anglers (Appendix Table E-3). One (100%) chinook salmon, 111 (84.1%) smallmouth bass, seven (87.5%) steelhead, 45 (90.0°/0) walleye, and eight (100Yo) white sturgeon were harvested by surveyed non-returning anglers who would have gone fishing even if the sport-reward fishery did not exist. Nearly 75'% of commonly non-targeted species (COT, CP, LCH, NSF, PMO, SK) and over 85% of commonly targeted species (other species in Appendix Table E-4) were harvested by anglers who would have fished even if the northern squaw-fish sport-reward fishery did not exist. These anglers caught 79.3% of all fish harvested by surveyed non-returning anglers. The majority (80.7%) of northern squawfish harvested by surveyed non-returning anglers were caught by anglers who would have gone fishing even if the northern squawfish sport-reward fishery did not exist. Since these anglers would be targeting non-northern squawfish species if the northern squawfish sport-reward fishery did not exist, fishing pressure on other species is probably being reduced as a result of the northern squawfish sport-reward fishery. In addition, this factor may more than offset the number of non-northern squawfish species harvested by non-returning anglers who would not have gone fishing if the northern squawfish sport-reward fishery did not exist.

Fifteen surveyed non-returning anglers claimed to have returned northern squawfish to the registration station. Explanations for this discrepancy fell into three categories:

1. The registration station was closed when the anglers returned, so the fish were thrown away.

2. The anglers confused the date in question with another day when they did return to the registration station.

3. The fish were returned the next day.

Table E-2. Angler responses to categorized questions asked in the 1994 northern squawfish sport reward telephone survey.

	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Q2. Did you catch any fish while you were fishing for northern squawfish?				
1. YES	561	38.0	561	38.0
2. NO	702	47.6	1263	85.6
3. cAN'T REMEMBER	43	2.9	1306	88.5
4. DIDN'T TARGET	170	11.5	1476	100.0
Q4. Did you catch any fish while you were fishing for other species?				
1. YES	232	15.7	232	15.7
2. NO	476	32.2	708	48.0
3. CAN'T REMEMBER	22	1.5	730	49.5
4. DIDN'T TARGET	746	50.5	1476	100.0
Q6. Are the checkstations conveniently located for you?				
1. YES	1291	87.5	1291	87.5
2. NO	185	12.5	1476	100.0
Q7. Has the change in registration hours of operation increased, not changed, or decreased your participation in the program?				
1. INCREASED	40	2.7	40	2.7
2. NOT CHANGED	1348	91.3	1388	94.0
3. DECREASED	88	6.0	1476	100.0
Q8. Do you plan to register again with the program?				
1. YES	1430	96.9	1430	96.9
2. NO	46	3.1	1476	100.0
Q8A. If no: What is the main reason you do not plan to register with the program?				
0. Plan to register again.	1430	96.9	1430	96.9
1. Poor success catching northern squawfish.	8	0.5	1438	97.4
2. Registration is too much trouble.	9	0.6	1447	98.0
3. Too far to registration site.	29	2.0	1476	100.0
4. Other reasons.				

Table 2. (Cent.)

	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Q9. Would you have taken this fishing trip if the Northern Squawfish Program did not exist?				
1. YES	983	66.6	983	66.6
2. NO	493	33.4	1476	100.0
Q10. Has this year's promotional programs changed your participation in the Northern Squawfish Program, which are:				
A. Tagged fish $50 reward program.				
1. INCREASED	625	42.3	625	42.3
2. NOT CHANGED	591	40.0	1216	82.4
3. DECREASED	10	0.7	1226	83.1
4. NOT AWARE OF THE PROGRAM	250	16.9	1476	100.0
B. Tagged fish $5,000 reward program.				
1. INCREASED	621	42.1	621	42.1
2. NOT CHANGED	592	40.1	1213	82.2
3. DECREASED	10	0.7	1223	82.9
4. NOT AWARE OF THE PROGRAM	253	17.1	1476	100.0
C. Monthly drawing by region-- $250.				
1. INCREASED	623	42.2	623	42.2
2. NOT CHANGED	577	39.1	1200	81.3
3. DECREASED	10	0.7	1210	82.0
4. NOT AWARE OF THE PROGRAM	266	18.0	1476	100.0
D. Monthly drawing for total program--$1,000.				
1. INCREASED	623	42.2	623	42.2
2. NOT CHANGED	575	39.0	1198	81.2
3. DECREASED	10	0.7	1208	81.8
4. NOT AWARE OF THE PROGRAM	268	18.2	1476	100.0
E. Tournaments.				
1. INCREASED	635	43.0	635	43.0
2. NOT CHANGED	563	38.1	1198	81.2
3. DECREASED	10	0.7	1208	81.8
4. NOT AWARE OF THE PROGRAM	268	18.2	1476	100.0
Q11. How would you rate your interaction with the technicians at the check station?				
1. VERY GOOD	1044	70.7	1044	70.7
2. GOOD	243	16.5	1287	87.2
3. POOR	10	0.7	1297	87.9
4. NO INTERACTION	179	12.1	1476	100.0

This explanation can be further divided into two subgroups. The anglers may actually be confusing the dates of two different fishing trips (as in Number 2 above), or they may, in fact, have kept the fish on ice and returned them with the next day's catch.

Nearly 67% of all fish caught by surveyed non-returning anglers were returned to the water unharmed, including 76.9% of non-northern squawfish species. Only 5.5% (10) of the northern squawfish 11 inches or longer that were caught by surveyed non-returning anglers were returned to the water unharmed (Appendix Table E-5). Approximately 39% (376) of northern squawfish less than 11 inches that were caught by surveyed non-returning anglers were returned to the water unharmed. One (50.0%) chinook salmon, 909 (87.3%) smallmouth bass, 61 (88.4%) steelhead, 82 (62. 1°/0) walleye, and 454 (98 .3°/0) white sturgeon were returned to the water unharmed.

The estimated total catch by non-returning anglers (Appendix Table E-6) of northern squawfish ≥ 11 inches was 1,798 (+/- 1,154 fish -- 95'% confidence intervals), which was 39.4% less than the 2,968 estimated in 1993. The estimated total catch by non-returning anglers (Appendix Table E-7) of northern squawfish < 11 inches was 9,546 (+/- 2,317 fish -- 95% confidence intervals) in 1994, which was over 60°/0 less than the 24,731 estimated in 1993. These decreases are probably due primarily to the increase in number of successful anglers and the corresponding decrease in the number of non-returning anglers.

Table E-3. Telephone survey sample harvest and percent by species for anglers that targeted NSF and for anglers that targeted other species.

	NSF targeted		Non-NSF targeted		Totals	
SPECIES*	QTY	%	QTY	%	QTY	%
AMS	11	1.04%	346	61 .79%	357	22.06%
BH	31	2.93%	3	0.54%	34	2.1 o%
C	0	0.IDo%	11	1 .96%	11	0.68%
CC	19	1.IBO%	6	1 .07%	25	1 .55%
CK	1	0.I39%	o	0.00%	1	0.06%
COT	73	6.90%	0	0.00%	73	4.51%
CP	8	0.76%	o	0.00%	8	0.49%
CT	2	0.19%	o	0.00%	2	0.12%
LCH	15	1.42%	0	0.00%	15	0.93%
LMB	1	0.09%	o	0.00%	1	0.06%
NSF>=11	135	12.76%	38	6.79%	173	10.69%
NSF<11	551	52.08%	33	5.89%	564	36.09%
PMO	41	3.88%	1	0.18%	42	2.60%
RB	5	0.47 %	6	1 .07%	11	0.68%
RU	11	1 .04%	6	1 .07%	17	1 .05%
S	0	0.00%	7	1.25%	7	0.43%
SH	1	0.09%	2	0.36%	3	0.19%
SK	22	2.08%	1	0.18%	23	1.42%
SMB	79	7.47%	53	9.46'%	132	8.16%
SS	1	0.09%	4	0.71 %	5	0.31%
TR	3	0.28%	0	0.00%	3	0.19%
WAL	16	1.51%	34	6.07%	50	3.09%
WS	2	0.19%	6	1.0770	8	0.499'0
YP	30	2.84%	3	0.54%	33	2.04%
Totals	1058	100.00%	560	100.00%	1618	100.00%

*See Appendix B1.

Table E-4. Telephone survey sample harvest and percent by species for anglers that would not have fished without the NSSRF (NSSRF related) and for anglers that would have fished without the NSS (NSSRF unrelated).

	NSSRF related		NSSRF unrelated		Totals	
SPECIES*	QTY	%	QTY	%	QTY	%
AMS	31	9.25%	326	25.41 %	357	22.06%
BH	23	6.87%	11	0.86%	34	2.10%
C	0	0.00%	11	0.86%	11	0.68%
C C	5	1.499'0	20	1.56%	25	1 .55%
CK	0	0.00%	1	0.08%	1	0.06%
COT	61	18.21%	1 2	0.94%	73	4.51 %
CP	3	0.90%	5	0.39%	8	0.49%
CT	0	0.00%	2	0.16%	2	0.12%
LCH	3	0.90%	12	0.94%	15	13.93%
LMB	0	0.00%	1	0.08%	1	0.06%
NSF>=11	57	17.01%	116	9.04%	173	10.69%
NSF<11	89	26.57%	495	38.58%	584	36.09%
PMO	17	5.07%	25	1 .95%	42	2.60%
RB	0	n 00%	11	0.86%	11	0.68%
RU	2	0.60%	1	151?%	17	1 .05%
S	0	0.00%	7	0.55%	7	0.43%
SH	0	0.00%	3	0.23°A	3	0.19%
SK	2	0.60°A	21	1 .64%	23!	1.42%
SMB	21	6.27%	111	8.65%	132	8.16%
SS	1	0.309'0	4	0.31%	5	0.319'0
TR	0	0.00%	3	0.23%	3	0.19%
WAL	5	1 .49%	45	3.5170	50	3.099'0
WS	0	0.00%	8	0.62%	8	0.49%
YP	15	4.48%	18	1.40%	33	2.04%
Totals	335	100.00%	1283	100.00%	1618	100.00%

* See Appendix B1.

Table E-5. Questions Q3b and Q5b. Responses regarding how anglers disposed of selected game and sensitive fishes, with quantity and % by disposition within species for each target option.

Species	'Disposition"	NSF targeted #of fish	%	Non-NSF targeted #of fish	%	Totals #of fish	%
Chinook	1	0	0.00%	1	100.00%	1	50.00%
	3	1	100.00%	o	0.00%	1	50.00%
NSF >= 11	1	8	5.59%	2	5.00%	10	5.46%
	2	24	16.78%	3	7.50%	27	14.75%
	3	1	0.70%	o	0.00%	1	0.55%
	4	12	8.39%	31	77.50%	43	23.50%
	5	27	18.88%	o	0.00%	27	14.75%
	6	27	18.88%	1	2.50%	28	15.30%
	7	44	30.77%	3	7.50%	47	25.68%
NSF < 11	1	339	38.09%	37	52.86%	376	39.17%
	2	402	45.17%	23	32.86%	425	44.27%
	3	0	0.00%	2	2.86%	2	0.21%
	4	113	12.70%	8	11 .43%	121	12.60%
	6	29	3.26%	o	0.00%	29	3.02%
	7	7	0.79%	o	0.00%	7	0.73%
Smallmouth bass	1	534	87.11%	375	87.62%	909	87.32%
	3	79	12.89%	53	12.38%	132	12.68%
Steelhead**	1	46	95.83%	15	71 .43%	61	88.41 %
	3	2	4.17%	6	28.57%	8	11 .59%
Walleye	1	27	62.79%	55	61 .80%	82	62.12%
	3	15	34.88%	34	38.20%	49	37.12%
	7	1	2.33%	o	0.00%	1	0.76%
White Sturgeon	1	215	99.08%	239	97.55%	454	98.27%
	3	2	0.92%	6	2.45%	8	1 .73%

•Q3b and Q5b.

What did you do with the fish? Did you:

1. Return them to the water unharmed?
2. Kill them and return them to the water?
3. Keep them to eat?
4. Keep them for other uses?
5. Give them to another angler to turn in?
6. Return them to the station yourself?
7. Other?

** Includes SH and SS.

Table E-6. Total catch estimates of NSF over 11 inches by N/R anglers, along with confidence intervals and the percent of the catch returned to the water unharmed.

REGISTRATION STATIONS	NON RETURN TOTAL	NON RETURN SAMPLE	NUM.NSF CAUGHT OVER 11"	EST. NSF CAUGHT OVER 11"	OVER 11" VARIANCE	OVER 11" CONFIDENCE INTERVAL	NUM.NSF RETURNED OVER11	% of NSF RETURNED UNHARMED
CATHLAMET	810	81	7	70	0.59	131	0	0.00
KALAMA	1045	104	10	100	0.61	152	0	0.00
GLEASON	1614	161	52	621	15,86	961	0	0.00
WASHOUGAL	1669	166	8	80	0,38	162	0	0.00
FISHERY	1821	190	43	412	5.49	686	3	0.07
HAMILTON	1081	112	13	12s	0.42	125	5	0.38
BINGEN	394	39	2	20	0,24	59	0	0.00
DALLES	817	84	4	39	0.25	84	0	0.00
GILES FRENCH	839	83	6	61	0.21	80	1	0.17
UMATILLA	710	71	8	80	1,21	176	0	0.00
COLUMBIA P.	525	54	3	29	0.16	64	0	0.00
VERNITA	564	61	5	46	0.27	71	1	0.20
HOOD P.	891	95	4	38	0.17	71	0	0.00
GREENBELT	1705	175	18	176	2.25	366	0	0.00
TOTAL	14485	1476	183	1798	2.61	1164	10	0.06

Table E-7. Total catch estimates of NSF under 11 inches by N/R anglers, along with confidence intervals and the percent o the catch returned to the water unharmed.

REGISTRATION STATIONS	NON RETURN TOTAL	NON RETURN SAMPLE	NUM.NSF CAUGHT UNDER11	EST. NSF CAUGHT UNDERI 1	UNDER11 VARIANCE	UNDER11 CONFIDENCE INTERVAL	NUM.NSF RETURNED UNDER11	% of NSF RETURNED UNHARMED
CATHLAMET	810	81	113	1130	31.36	9S6	52	0.46
KALAMA	1045	104	163	1638	27.01	1o11	47	0.29
GLEASON	1614	161	256	2S66	31	1344	82	0.32
WASHOUGAL	1669	166	105	1056	7.24	662	35	0.33
FISHERY	1821	190	70	671	2.05	358	13	0.19
HAMILTON	1081	112	34	328	1.95	270	6	0.24
BINGEN	394	39	31	313	4.19	245	16	0.s2
DALLES	817	84	45	438	4.47	357	28	0.62
GILES FRENCH	839	83	44	44s	5,61	414	32	0.73
UMATILLA	710	71	21	210	3.56	302	12	0.67
COLUMBIA P.	525	54	32	311	14	506	8	0.2s
VERNITA	564	61	12	111	0.44	90	11	0.92
HOOD P.	891	95	5	47	0.11	57	3	0.60
GREENBELT	1705	175	29	283	0.89	230	29	1.00
TOTAL	14485	1476	960	9S46	10.51	2317	376	0 . 3 9

APPENDIX F

Harvest Evaluation

Introduction

The northern squawfish sport-reward fishery attracts thousands of anglers annually to fish for northern squawfish in the Columbia and Snake rivers. The harvest of fishes other than northern squawfish by these anglers is estimated by the Washington Department of Fish and Wildlife (WDFW) and used by the Oregon Department of Fish and Wildlife (ODFW) to ensure that no fishes are overharvested as a result of the northern squawfish sport-reward fishery. In the interest of brevity, harvest estimates discussed in this report are limited to smallmouth bass (*Micropterus dolomieui*), walleye (*Stizostedion vitreum*), steelhead (*Oncorhynchus mykiss*), white sturgeon (*Acipenser transmontanus*), chinook salmon (*Oncorhynchus tschawytscha*) and northern squawfish under 11 inches. Total harvest estimates, which includes returning angler and non-returning angler harvest, are made for each species.

If the harvest from non-returning anglers is similar to that of returning anglers, then sampling can be limited to either and harvest estimates obtained for both. Telephone survey estimates of non-returning angler harvest are used to estimate returning angler harvest and the results compared to harvest estimates derived from returning anglers. The comparison results as well as information from the voucher and exit interview data are used to create the most economical, practical and simple sampling method for estimating the 1995 incidental catch. The problems associated with defining incidental catch for the northern squawfish sport-reward fishery are also discussed and solutions proposed.

Methods

Anglers surveyed in the 1994 exit interview were asked how many fish they harvested (caught and kept only), but no data was recorded on total catch (includes released and kept fish). The incidental catch estimates in this report were therefore limited to total angler harvest and angler harvest while targeting northern squawfish.

We combined the voucher and exit data to achieve a more accurate estimate of returning angler harvest. If an angler reported harvesting a different number of fish in the exit interview and voucher data, then the highest number was recorded in a high data set (H) and the low recorded in a low data set (L). If an angler only recorded an exit or voucher questionnaire, then the recorded harvest value was used for both H and L values. Equal voucher and exit values were recorded as equal for both H and L values. The H estimate should be considered the highest possible harvest and the L estimate the lowest.

Phone survey (P) data for non-returning anglers were limited to harvested fish for comparison to returning angler data. The phone survey estimates for returning anglers were calculated by dividing the number of fish caught by all non-returning anglers sampled in each registration station by the number of angler days fished and then multiplying by the number of returning anglers for that registration station. The 10% sample of non-returning anglers was assumed to be representative of the non-returning angler population.

Harvest estimates were made for registered anglers (all anglers that participated in the program) by adding the P estimate to the H or L estimate.

Results and Discussion

P estimates for returning angler harvest were lower than L or H estimates for all fishes and four out of six P estimates were lower for returning angler harvest while targeting northern squawfish (Appendix Table F- 1). The P harvest estimates for smallmouth bass were approximately 50°/0 less than either L or H estimates and northern squawfish under 11 inches estimates were approximately 70°/0 less (Appendix Table F-l). The total P estimates were much closer to L or H estimates for white sturgeon, walleye, chinook and steelhead, but the P estimates were further from L or H estimates when compared by registration station (Appendix Table F-l). Differences between the P estimates and the L or H estimates may be due in part to differences in sampling design. The P estimates were derived from a 10% sample of non-returning anglers and the L and H estimates came from surveying approximately 96% of the returning anglers. The smaller sample size of the P estimates could cause greater variability among sample estimates, but the large number of P estimates that were lower than either L or H estimates (10 out of 12; Appendix Table F-1) leads us to conclude that non-returning anglers may in fact catch less fish than returning anglers. The data indicates that returning angler harvest cannot be accurately estimated from non-returning angler data, therefore, future estimates of returning and non-returning angler harvest should be derived from sampling each population separately.

The 1994 northern squawfish sport-reward fishery was the first year that harvest estimates were made for all anglers registered with the northern squawfish sport-reward fishery (Appendix Tables F-2 and F-3). Total harvest represents the harvest reported by all anglers irrespective of the type of fish the angler was targeting and should be considered the maximum fish mortality attributable to the northern squawfish sport-reward fishery, excluding hooking mortality from fish caught and released. Harvest while targeting northern squawfish represented a more reasonable estimate of northern squawfish sport-reward fishery's harvest, since targeted fish were excluded. Salmonids (chinook and steelhead) were harvested the least by anglers targeting northern squawfish, followed by white sturgeon and walleye (Appendix Tables F-2 and F-3). Anglers that target northern squawfish infrequently harvest steelhead, since they were responsible for only 12% of the estimated total steelhead harvest (Appendix Table F-3). Smallmouth bass and northern squawfish under 11 inches were the most vulnerable to harvest by northern squawfish sport-reward fishery anglers and were commonly harvested by anglers targeting northern squawfish (Appendix Tables F-2 and F-3).

Many fishermen that target fishes other than northern squawfish, such as smallmouth bass, register with the northern squawfish sport-reward fishery to collect the reward on incidentally caught northern squawfish. Reasonably, the fish caught by these anglers should not be counted as incidental catch for the northern squawfish sport-reward fishery. The 1995 northern squawfish sport-reward fishery will produce catch (includes harvested plus released fish) and harvest estimates only for anglers targeting northern squawfish, since these estimates provide the best measure of the northern squawfish sport-reward fishery's incidental harvest.

Returning anglers were sampled for harvest data in 1994 at the exit interview and on the voucher questionnaire. The voucher required additional time for anglers to complete and for the Pacific States Marine Fisheries Commission (PSMFC) to proof and return to angler if incomplete. Anglers frequently filled out the voucher incorrectly, partially due to its design and because no one was available for clarification. The exit interview delayed anglers slightly at the registration station, but the angler's memory of the day's catch was fresh and the technician was available to answer questions. Returning anglers will be surveyed in 1995 at the exit interview and the voucher questionnaire will be eliminated. Approximately 50°/0 of the returning anglers will be surveyed to obtain the highest sample size without excessively slowing down the exit interview process. Returning angler catch estimates from the exit interview will be added to the non-returning angler catch estimates from the telephone survey to derive total catch estimates for all registered anglers.

Table F-1. Estimated returning angler harvest and harvest while targeting northern squawfish by registration location and species.

Returning Angler Harvest

Location	Smallmouth Bass			White Sturgeon			Walleye			Chinook Salmon			Steelhead			NSF under 11"		
	H	L	P	H	L	P	H	L	P	H	L	P	H	L	P	H	L	P
Cathlamet	17	17	0	7	7	11	0	0	0	0	0	0	7	7	23	1154	1116	6S7
Kalama	12	12	0	2	2	7	3	3	0	0	0	7	7	7	14	1239	1216	'826
Gleason	431	405	172	3	3	0	44	44	30	0	0	0	0	0	0	2434	2255	1763
W	385	373	328	24	24	36	47	42	139	0	0	0	4	4	0	2734	259S	864
The Fishery	204	198	52	21	21	0	80	73	78	0	0	0	50	50	39	2925	2849	737
Hamilton	78	76	212	9	9	0	23	23	0	0	0	0	0	0	0	1613	1542	393
Bingen	122	115	67	0	0	0	1	1	0	0	0	0	3	3	0	609	594	251
The Dalles	192	183	71	8	8	0	131	122	18	1	1	0	4	4	0	997	S6S	152
Giles French	287	275	14	1	1	0	230	219	246	3	3	0	3	3	0	992	978	173
Umatilla	155	154	29	4	4	15	82	75	73	0	0	0	0	0	0	647	614	66
Columbia Point	S8	85	85	8	7	0	6	6	0	0	0	0	2	2	0	744	714	255
Vernita	52	52	0	2	2	0	16	16	13	4	4	0	7	7	0	616	615	13
Hood Park	36	34	43	0	0	5	4	4	0	0	0	0	0	0	0	387	38?	10
Greenbelt	489	463	311	1	1	0	0	0	0	0	0	0	3	3	6	1648	1576	0
Total	2546	2442	13S4	90	89	76	667	628	597	8	S	7	9	0	s 0 6 4	1S739	16025	6212

Returning Angler Harvest While Targeting Northern Squawfish

Location	Smallmouth Bass			White Sturgeon			Walleye			Chinook Salmon			Steelhead			NSF under 11"		
	H	L	P	H	L	P	H	L	P	H	L	P	H	L	P	H	L	P
Cathlamet	17	17	0	4	4	0	0	0	0	0	0	0	0	0	0	10$3	1058	6s7
Kalama	10	10	0	2	2	7	3	3	0	0	0	7	0	0	0	1074	1054	799
Gleason	394	377	132	3	3	0	15	15	30	0	0	0	0	0	0	206s	1907	1682
Washougal	318	315	303	17	17	0	17	17	63	0	0	0	1	1	0	2165	2092	806
The Fishery	1S5	183	52	1S	18	0	41	36	26	0	0	0	8	8	26	2783	2728	659
Hamilton	65	65	60	9	9	0	25	25	0	0	0	0	0	0	0	1407	1357	348
Bingen	96	91	33	0	0	0	3	3	0	0	0	0	0	0	0	531	519	251
The Dalles	138	134	27	4	4	0	62	59	16	1	1	0	0	0	0	857	831	152
Giles French	180	173	14	1	1	0	150	144	0	0	0	0	0	0	0	861	650	159
Umatilla	123	123	15	4	4	0	25	25	29	0	0	0	0	0	0	592	566	59
Columbia Point	52	52	64	4	4	0	6	6	0	1	1	0	1	1	0	661	641	255
Vernita	45	45	0	1	1	0	15	15	0	0	0	0	0	0	0	524	524	0
Hood Park	16	16	34	0	0	5	2	2	0	0	0	0	0	0	0	319	319	5
Greenbelt	276	271	10S	0	0	0	0	0	0	0	0	0	1	1	0	1464	1395	o
Totals	1915	1672	S43	67	67	12	364	350	166	2	2	7	11	11	26	1639S	15S41	5S64

H - Highest possible returning angler harvest estimate.
L - Lowest possible returning angler harvest estimate,
P - Telephone survey returning angler harvest estimate.

Table F-2. Estimated registered angler total harvest and harvest while targeting northern squawfish for smallmouth bass, white sturgeon and walleye by registration location.

Estimated Total Hawest

Location	Smallmouth Bass					White Sturgeon					Walleye				
	P	H	L	H t	u	P	H	L	Ht	Lt	P	H		H t	u
Cathlamet	o	17	17	17	17	10	7	7	17	17	0	0	0	0	0
Kalama	o	12	12	12	12	10	2	2	12	12	0	3		3	3 3
Gleason	170	431	406	601	575	0	3		3	3 3	30		44	44	74 74
Washougal	26	13	S5	37	36	46	63	4	30	24	24	54	54	111	47 42 156 163
The Fishery	3 s	2	04	16	62	42	23	s	o	21	21	21	21	5 s	s 0 7 3 136 131
Hamilton	135	7e	76	211	211	0	9	9	9	9	0	2	3	2	3 2 3 2 3
Bingen	40	122	115	162	155	0	0	0	0	0	0	1	1	1	1
The Dalles	7S	162	163	270	261	0	8	8	8	8	19	131	122	150	141
Giles French	10	287	275	267	2S5	0	1	1	1	1	172	230	219	402	361
Umatilla	40	155	154	165	164	20	4	4	24	24	100	62	75	1s2	175
Columbia Point	7	s	s	s	65 166 163	0	8	7	8	7	0	6	6	6	6
Vernita	0	5	2	52	52 52	0	2	2	2	2	9	16	16	25	25
Hood Park	6	4	3	6	34 120 118	9	0	0	9	9	0	4	4	4	4
Greenbelt	3	6	04	S6	46	36	49	82	3	0	1	1	1	0	0 0 0
Total	1294	2546	2442	3840	3736	79	90	88	169	168	499	667	628	1166	1127

Estimated Harvest While Targeting Northern Squawfish

Location	Smallmouth Base					White Sturgeon					Walleye				
	P	H	L	Ht	U	P	H	L	Ht	Lt	P	H	L	Ht	Lt
Cathlamet	0	17	17	17	17	0	4	4	4	4	0	0	0	0	0
Kalama	o	10	10	10	10	10	2	2	12	12	0	3	3	3	3
Gleason	130	364	377	524	607	0	3	3	3	3	30	15	15	45	45
Washougal	241	318	315	556	66S	o	17	17	17	17	50	17	17	67	67
The Fishery	36	185	183	223	221	0	18	18	16	18	19	41	3s	60	65
Hamilton	3 s	6	5	66	104 104	0	9	9	9	9	0	2	5	2 5 2 6 2 5	
Bingen	20	es	91	116	111	0	0	0	0	0	0	3	3	3	3
The Dalles	29	138	134	167	163	0	4	4	4	4	19	62	56	81	78
Giles French	10	1s0	173	160	1s3	0	1	1	1	1	0	150	144	160	144
Umatilla	20	123	123	143	143	0	4	4	4	4	4	0	2 5	2 5 6 5	S 5
Columbia Point	5 s	s	2	62	110 110	0	4	4	4	4	0		6	6 6	6
Vemits	o	4	5	4 6	4 5 4 5	o	1	1	1	1	.0		15	15 15	15
Hood Park	6S	16	16	82	S2	9	0	0	9	9	0	2	2	2	2
Greenbelt	127	276	271	403	36S	0	0	0	0	0	0	0	0	0	0
Total	778	1915	1872	2663	2S50	19	67	67	66	86	156	364	350	522	508

P - Non-returning angler harvest estimate.
H - Highest possible registered angler harvest estimate.
L - Loweat possible registered angler hervest estimate.
Ht = P+H
Lt = P+L

Table F-3. Estimated registered angler total harvest end harvest while targeting northern squawfish for chinook salmon, steelhead and NSF under 11-

Estimated Total Harvest

Location	Chinook Salmon					Steelhead					NSF under 11"				
	P	H	L	Ht	Lt	P		L	Ht	Lt	P	H	L	Ht	Lt
Cathlamet	0	0	0	0	0	2	0 7	7	27	27	610	1134	1116	1764	1726
Kalama	10	0	0	10	10	2	0 7	7	27	27	11SS	1239	1216	2405	2S62
Gleason	0	0	0	0	0	0	0	0	0	0	1744	2434	2235	4178	369e
Washougal	0	0	0	0	0	0	4	4	4	4	7042734259934363303				
The Fishery	0	0	0	0	0	29	50	50	79	79	546	2925	2849	3471	3395
Hamilton	0	0	0	0	0	0	0	0	0	0	251	1613	1S42	1864	1793
Bingen	0	0	0	0	0	0	3	3	3	3	152	609	594	761	746
The Dalles	0	1	1	1	1	0	4	4	4	4	165	S97	Sea	1162	1133
Giles French	0	3	3	3	3	0	3	3	3	3	121	992	97a	1113	lose
Umatilla	0	0	0	0	0	0	0	0	0	0	90	647	614	737	704
Columbia Point	0	0	0	0	0	0	2	2	2	2	233	744	714	977	e47
Vernita	0	4	4	4	4	0	7	7	7	7	9	616	61S	625	624
Hood Park	0	0	0	0	0	0	0	0	0	0	19	3s7	387	406	406
Greenbelt	0	0	0	0	0	10	3	3	13	13	O	1648	1578	1648	1578
Total	10	8	8	18	18	79	80	90	169	169	5810	18739	180252	454923	833

Estimated Harvest While Targeting Northern Squawfish

Location	Chinook Salmon					Steelhead					NSF under 11"				
	P	H	L	Ht	Lt	P	H	L	H	t	u	P	H	L	Ht	Lt
Cathlamet	0	0	0	0	0	0	0	0	0	0	0	810	109S	10S6	1703	16S6
Kalama	10	0	0	10	10	0	0	0	0	0	0	1125	1074	1034	2199	2179
Gleason	0	0	0	0	0	0	0	0	0	0	0	1664	2068	1907	3732	3571
Washougal	0	0	0	0	0	0	1	1	1	1	1	64321	65	2092	2808	2735
The Fishery	0	0	0	0	0	I	s	8	8	2	7	2 7	46S	2763	2728	3272	3217
Hamilton	0	0	0	0	0	0	0	0	0	0	0	222	1407	1357	162s	1579
Bingen	0	0	0	0	0	0	0	0	0	0	0	152	531	519	663	671
The Dalles	0	1	1	1	1	0	0	0	0	0	0	165	637	831	1022	e9a
Giles French	0	0	0	0	0	0	0	0	0	0	0	111	861	650	972	961
Umatilla	0	0	0	0	0	0	0	0	0	0	0	60	5 9 2	5 6 6	6 7 2	6 4 6
Columbia Point	0	1	1	1	1	0	1	1	1	1	23s	661	641	894	874
Vamita	0	0	0	0	0	0	0	0	0	0	0	524	524	324	524
Hood Park	0	0	0	0	0	0	0	0	0	0	9	319	319	32S	326
Greenbelt	0	0	0	0	0	0	1	1	1	1	0	1464	1395	1464	1395
Total	1	0	2	2	1	2	1	2	19	11	11	30	30	5503	16399	15841	21602	21344

P - Non-returning angler harvest estimate.
H - Highest possible registered angler harvest estimate.
L - Lowest possible registered angler harvest estimate.
Ht = P+H
Lt = P+L

APPENDIX G

Cost Analysis

Introduction

Evaluation of northern squawfish sport-reward fishery registration station costs was previously conducted by Dr. Susan Hanna, Oregon State University (Hanna et al. 1993). Cost evaluation was conducted for the 1994 northern squawfish sport-reward fishery by the Washington Department of Fish and Wildlife (WDFW). The total expenditures and the expenditures per northern squawfish were compared among registration stations. The average expenditures per northern squawfish were compared for 1992, 1993 and 1994. The data were used to determine the effect of cost saving measures implemented in 1994 and to influence management decisions for 1995.

Methods

Cost per registration station was calculated by (1) determining the portion of the supervising biologist's pay that is associated with each respective registration station, (2) totaling scientific technician 1's, 2's and intermittent technician pay for each registration station, and (3) determining breakdown of costs for field offices (rent, utilities, etc.) and vehicle rental and gasoline for each registration station. Appendix Table G-1 shows a sample breakdown of costs used to calculate the expenditures for each registration station.

Cost per northern squawfish by registration station was determined by dividing the total cost of the registration station by the total northern squawfish harvested at that registration station.

Harvest totals and operation costs associated with satellite stations were included in the cost for each parent registration station.

Results and Discussion

The average cost per registration station in 1994 was $43,292 and ranged from $32,793 at The Dalles to $50,431 at Cathlamet (Appendix Table G-2). The cost per registration station was predominantly influenced by travel costs and overtime pay associated with the distance technicians must travel from the field office to the registration station and fish processing facility. Busy registration stations also require more technician hours. The costs associated with the satellite station trial increased expenses for certain registration stations (Appendix Table G-2).

Appendix Table G-1. Sample breakdown of the costs used to calculate the total expenditure for each registration station, 1992-1994.

Item	Quantity	unit cost	Total COSt
PERSONNEL:			
Fisheries Biologist	2.5	$2,047.00	$5,117.50
Sci. Tech 2 (1 position)			
REG HOURS	994	$10.72	$10,655.68
O.T. HOURS	29	$16.08	$466.32
Sci. Tech 1 (1 position)			
REG HOURS	892	9.34	$8,331.28
O.T. HOURS	30	$14.01	$420.30
Sci. Tech 1 (Intermittent)			
REG HOURS	324.5	$9.34	$3,030.83
O.T. HOURS	4	$14.01	$56.04
SHIFT DIFF	584.5	$0.50	$292.25
SUBTOTAL:			$28,370.20
FRINGE BENEFITS			
Full-time Employees			$1,688.78
Part-time Employees			$2,948.69
SUBTOTAL:			$4,637.46
SUPPLIES:			$0.00
(Purchased from previous years. All items still in use.)			
OPERATION AND MAINTENANCE:			
Field office rental	5	$200.00	$1,000.00
Van rental (PER MONTH)	5	$949.00	$4,745.00
*Gas (PER MONTH)	5	$139.83	$699.15
SUBTOTAL:			$6,444.15
Indirect Costs:			
WDFW rate of 38.7 percent of salaries			$10,979.27
TOTAL			$50,431.08

*Varies by registration station.

Appendix Table G-2. Total expenditure, harvest and expenditure per northern squawfishS11 inches by registration location in 1994.

Registration station	Total expenditure	Total harvest	Expenditure per northern squawfish
Cathlamet	$50,431.08	5,591	$ 9.02*
Kalama	48,546.28	3,703	13.10 *
M.J. Gleason	48,878.52	10,742	4.55
Camas/Washougal	47,099.68	9,105	5.17
The Fishery	37,930.25	27,935	1.36
Hamilton Island	36,170.51	13,732	2.63
Bingen	35,816.95	5,038	7.10 *
The Dalles	32,793.04	7,136	4.59
Giles French	45,013.12	13,430	3.35
Umatilla	38,971.10	1,586	24.57
Columbia Point Park	38,289.33	6,133	6.24
Vemita	40,097.55	11,597	3.45
Hood Park	38,094.92	4,116	9.25
Greenbelt	45,779.22	9,593	4.77 *
AVERAGE	$43,292.78	9,245	$ 4.68

* Satellite station northern squawfish added to total catch.

The average cost per northern squawfish in 1994 was $4.68 and ranged from $1.36 per northern squawfish at The Fishery to $24.57 at Umatilla. The Fishery achieved the highest harvest (27,935 northern squawfish) and Umatilla the lowest (1,586 northern squawfish), which demonstrates how dramatically the cost per fish can be reduced by increasing the harvest per registration station.

The average cost per northern squawfish was highest in 1993 ($10.62; Appendix Table G-3). The total harvest in 1993 was also lower than any other year. A cost comparison of registration stations from 1992-1994 showed the highest cost per northern squawfish came from Umatilla ($24.57) in 1994, Umatilla ($63.19) in 1993 and St. Helens ($42.66) in 1992 (Appendix Table G-3). Variations in cost per northern squawfish by year and registration station occurred primarily due to (1) changes in northern squawfish harvest totals, (2) changes in the total number of registration stations, (3) equipment purchases, and (4) changes in the number of technicians used at registrations stations each year. The number of registration stations decreased from 20 in 1992 to 18 in 1992 and to 14 in 1994. The major costs for each registration station were similar regardless of the number of fish the station received, therefore stations with low harvest greatly increased the overall cost per fish. Registration station hours of operation in 1992 and 1993 were from 9 a.m. to 9 p.m. The hours of operation were decreased in 1994 to 1 p.m. to 9 p.m., which reduced technician hours and operation costs, but angler participation also dropped in 1994 to a level that was lower than any previous year. The reduction in hours of operation and the number of registration stations may have contributed to the decrease in participation.

The 1995 sport-reward fishery will expand the use of satellite stations to attract greater angler participation with minimal increases in cost. Satellite stations will be evaluated to determine if the additional fish were gained cost effectively.

References

Hanna, S., B. Anteneh, J. Pampush, M. Morrissey, D. Lin, and G. Foster. 1993. Economic, social, and legal feasibility of commercial, 'sport and bounty fisheries on northern squawfish. Report H *in* C.F. Willis, D.L. Ward, and A.A. Nigro, editors. Development of a systemwide predator control program: stepwise implementation of a predation index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1992 Annual Report. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Appendix Table G-3. Expenditure per northern squawfish>11 inches by registration station for 1992, 1993 and 1994.

Registration station	1992	1993	1994
Cathlament	- - -	12.22	*9.02*
Rainier	----	44.02	----
Kalama Marina	10.25	43.25	*13.10*
St. Helens	42.66	—-	----
Vancouver	8.70	- -	- - -
M.J. Gleason	4.61	7.88	*4.55*
Camas/Washougal	----	12.28	*5.17*
Hamilton Island	3.67	7.09	*2.63*
The Fishery	2.66	3.87	*1.36*
Cascade Locks	9.32	27.87	
Bingen	*5.56*	*9.38*	7.10
The Dalles	*8.71*	*13.67*	4.59
LePage Park	1.68	6.00	
Maryhill State Park	11.95	----	- - -
Giles French	—-	----	3.35
Plymouth	26.32	----	- -
Umatilla	- - -	63.19	24.57
Columbia Point	5.46	12.44	6.24
Ringold	9.93	- - -	
Vemita	----	6.30	3.45
Hood Park	6.46	12.07	9.25
Windust Park	39.23	- - -	- - -
Lyons Ferry State Park	17.46	39.54	----
Boyer Park	10.60	46.30	----
Greenbelt	3.40	5.33	*4.77*
AVERAGE PER YEAR	$6.86	$10.62	**$4.68**

REPORT B

Northern Squawfish Sport-Reward Fishery Payments

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INTRODUCTION

The Pacific States Marine Fisheries Commission (PSMFC) provided fiscal services for payment of rewards for northern squawfish harvested under the sport-reward fishery. Anglers registered and subsequently checked-in their catch at the Washington Department of Fish and Wildlife(WDFW) field stations where they received a voucher for all eligible fish. Standard vouchers were issued for all fish over 11 inches that were not tagged. The number of fish turned in were recorded on the voucher and verified by the creel clerk. Tagged fish received a special "tagged" voucher. Tagged vouchers were issued for each individual tagged fish turned in. The vouchers were then sent by the angler to our sport-reward post office box in Oregon City. Vouchers were received and paid during the fishery from May through September. A cut-off date of September 25, 1994, was established as the final date vouchers needed to be postmarked to receive payment from PSMFC. These dates were printed in bold on the vouchers. PSMFC allowed one month past the official cut-off date for receipt of the vouchers, then started rejecting late vouchers because of logistics and the need for Internal Revenue Service (IRS) reporting for the calendar year. Tagged vouchers were sent to the Oregon Department of Fish and Wildlife post office box by the angler for verification. The angler attached the tag to the voucher in a small envelope provided at the check station. Once verified or rejected by Oregon Department of Fish and Wildlife, all tag vouchers were delivered to PSMFC for payment. Verified tagged vouchers were paid at $50 per tag and rejected tagged vouchers were paid at the standard reward of $3. The following sections summarize the vouchers paid this year.

VOUCHER PAYMENTS

A total of 13,434 vouchers were processed and paid during the 1994 fishing season. They represented 127,531 fish and a total reward payment sum of $396,364 Of this total, 13,141 were "standard" vouchers representing 127,238 fish ($38 1,714). A total of 293 tagged vouchers was received for the 293 tagged fish caught. The payments for these fish totaled $14,650. Of all vouchers received, 93 vouchers for 242 fish ($726) remain unpaid. Rejected vouchers are addressed in a later section of this report. Table 1 displays the breakdown of the 13,434 vouchers processed.

Voucher processing proceeded smoothly. Depending on volume received, checks were cut and mailed to the angler within 5 days tier receipt of the voucher. Those vouchers that had missing or incomplete information were returned to the angler for completion, or to WDFW, as appropriate.

Table 1. Breakdown of the 13,434 vouchers processed in 1994.

# Vouchers	Voucher type	# Fish	$ Value	Mean fish/voucher
Standard ($3)	13,141	127,238	$381,714	9.68
Tagged ($50)	293	293	$14,650	**N/A**

REJECTED VOUCHERS/ MISCELLANEOUS PAYMENTS

Rejected vouchers represent vouchers that had missing data and were returned to the angler, but the angler chose not to complete them and send them back for payment. Therefore, these vouchers were not paid. The breakdown of rejected vouchers returned to the angler by reason for initial or subsequent submission is displayed in Table 2.

In addition to the voucher payments, a number of tournaments, drawings and prizes were awarded during the season. The amounts paid out for all parts of the program during 1994 are displayed in Table 3

Table 2. Breakdown of rejected vouchers in 1994.

Reason for rejection	# Vouchers	# Fish
Questionnaire not completed	64	180
Social Security # missing	12	20
Questionnaire not completed twice[1]	6	11
No angler signature	4	7
Submitted past deadline	7	24
Total	93	242

[1] Vouchers returned twice for missing questionnaire.

Table 3. Amounts paid out for the 1994 sport-reward fishery.

Program type	$ Paid
Standard vouchers	$381,714
Tagged fish vouchers	14,650
Weekly tournaments (246 prizes)	20,500
Monthly drawings (25 prizes)	10,000
Special tag drawings (2 prizes)	10,000
G.I. Joe tournaments (24 prizes)	5,000
Upper river tournaments (24 prizes)	4,000
Total	$445,864

Lists of the top 25 anglers with their name, address, standard and tag voucher payments, prize, tournament and drawings winnings were provided to the technical coordinator and Bonneville Power Administration.

MISCELLANEOUS WORK

All IRS Form 1099-Mist. statements were sent to the qualifying anglers for tax purposes the third week in January. Appropriate reports and copies were provided to the IRS by the end of February.

The last quarter of the current contract period work has centered on cleaning up the voucher data entry program and associated accounting cross-checks, reports and voucher tracking and editing routines. The program has become more sophisticated to allow nearly all options necessary by means of program menus without the need for special programming expense or computer program technical time. We now have the option to look at previous years' data and to carry forward certain files and angler data to shorten data entry time. We have also added the ability to carry forward suspense vouchers and those rejected or on hold, should they clear in the future for payment. Recent additions also allow for the carry forward of IRS or other agency garnishments that extend across two or more fishing seasons (years).

REPORT C

Controlled Angling for Northern Squawfish at Selected Dams on the Columbia and Snake Rivers

Prepared by

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ACKNOWLEDGMENTS

We thank Silas Whitman and Manuel Villalobos (Nez Perce Tribe); Gary James and Jed Volkman (Confederated Tribes of the Umatilla Indian Reservation); Lynn Hatcher, Steve Parker, and George Lee (Confederated Tribes and Bands of the Yakama Indian Nation); and Jim Griggs and Mark Fritsch (Confederated Tribes of the Warm Springs Reservation of Oregon) for implementing the work performed by tribal crews. Our deep appreciation goes to the technicians working for the Columbia River Inter-Tribal Fish Commission and tribal crews who fulfilled their duties admirably.

Personnel from the U.S. Army Corps of Engineers were invaluable in their cooperation and coordination: Jim Kuskie and Dennis Schwartz (Bonneville Dam); Jim Williams and Bob Dach (The Dalles and John Day dams); Peter Gibson and Brad Eby (McNary Dam); Bill Spurgeon (Ice Harbor and Lower Monumental dams); Rex Baxter and Rebecca Kalamasz (Little Goose Dam); and Jesse Smiley, Tim Wik, Mike Halter, and Ron Robson (Lower Granite Dam).

We give special thanks to the volunteer anglers from the Portland and Tom McCall chapters of Northwest Steelheaders, The Dalles Rod and Gun Club, and Mid-Columbia Bass Anglers, who have contributed to our efforts for two or more years.

Roy Beaty, Ken Collis, Jack McCormack, and Kathy McRae (alphabetical order) contributed to this report. We thank Blaine Parker, Keith Hatch, Dave Ward, Chris Knutsen, Mark Zimmerman, and Frank Young for their comments on an earlier draft of this report.

ABSTRACT

The 1994 field crews used hook-and-line angling for northern squawfish *(Ptychocheilus oregonensis)* at eight lower mainstem dams of the Columbia and Snake rivers from early May through early September. Total catch (16,097 fish) was 95% of the 1993 catch. Total effort (10,002 hours) was approximately 3% higher than in 1993. Yearly catch-per-angler-hour (CPM-I) has remained relatively constant for the last three years (1992: 1.7; 1993: 1.7; 1994: 1.6). On the Columbia River, catch rates decreased at Bonneville, John Day, and McNary dams and increased at The Dalles Dam compared to 1993. Because of continued low catch rates, effort on the Snake River was reduced 43°/0 from 1993 levels. However, the 1994 CPAH on the Snake River increased slightly compared to 1993.

As in past years, effort was focused at the most productive dams, and resident-crew effort was supplemented by volunteer, boat, and mobile angling. Four sport-angling groups donated their time at Bonneville, The Dalles, and McNary dams. The volunteers contributed 3.2% of the total catch. Most (83%) of boat-angling effort was spent at John Day and McNary dams with the

remainder at The Dalles, Ice Harbor, and Lower Monumental dams. Boat anglers contributed 7.7% of the total effort and caught 3.2% of the total northern squawfish. The mobile angling crew fished at Bonneville, The Dalles, and John Day darns, which yielded 24.8% of the total catch and a CPAH of 2.8.

Incidental catch in 1994 comprised 2.3% of the total catch -- less than half of that in 1993 (5.5%). Almost half of the incidental catch was bass (*Micropterus* spp.), and white sturgeon (*Acipenser transmontanus*) made up another 20%. There were 12 incidentally caught salmonids (*Oncorhynchus* spp.), all of which were juveniles; nine were released in good condition, two in poor condition, and one died.

Catch rates of northern squawfish were compared to outflow, smelt passage indices, and for different anglers, time periods, baits, and sites at each dam. These results are briefly discussed and were used in developing recommendations for future dam-angling activities.

INTRODUCTION

The eight hydroelectric dams on the lower Columbia and Snake rivers have converted a once free-flowing river into a series of reservoirs that prolong the seaward migration of juvenile salmonids (*Oncorhynchus* spp). The reservoir environment provides predatory fish with conditions more suitable for feeding, especially near dams (Raymond 1979; Rieman et rd. 1991). A principal predator, northern squawfish (*Ptychocheilus oregonensis*), has been targeted for control in the lower Columbia and Snake rivers by a multi-agency program aimed at reducing juvenile salmonid mortality due to northern squawfish predation. Northern squawfish can be effectively removed from the dams using hook-and-line angling techniques (Vigg et al. 1990; Beaty et al. 1993; Parker et al. 1993; CRITFC 1995). From 1990 to 1993, angling crews caught a total of 95,173 northern squawfish at eight dams on the lower Columbia and Snake rivers. In 1994, as in previous years, the Columbia River Inter-Tribal Fish Commission (CRITFC) and its member tribes endeavored to (1) remove northern squawfish from areas near darns; (2) minimize the incidental catch, particularly of salmonids and white sturgeon (*Acipenser transmontanus*); and (3) develop and implement more effective means of removing northern squawfish.

METHODS

Management Activities

In 1994, effort by angling crews was distributed among eight U.S. Army Corps of Engineer (USACE) damson the Columbia and Snake rivers (Table 1 and Figure 1). Most of this year's effort was focused at Columbia River dams, where catch rates in previous years have been consistently higher. Snake River dams were fished by a single crew that spent a majority of its time at Lower Granite and Little Goose dams. McNary Dam was fished by two crews who distributed their effort over seven days per week.

Table 1. Distribution of angling effort for resident crews at Columbia and Snake River darns in 1994.

Dam (river km)	Season	Number of days worked	crew supervised by[a]
COLUMBIA RIVER			
Bonneville (233)	May 31- Sept 1	52	CTws
The Dalles (310)	May 9 - Aug 31	6?	CTws
John Day (348)	June 14- Sept 6	40	YIN
McNary (470)	June 2 - Aug 31	89	CTUIR
SNAKE RIVER			
Ice Harbor (16)	Aug 15- Aug 31	7	NPT
Lower Monumental (68)	Aug 8- Aug 10	3	NPT
Little Goose (113)	June 7- July 28	11	NPT
Lower Granite (172)	May 23- Aug 30	33	NPT

[a] CTWS = Confederated Tribes of Warm Springs Reservation
YIN = Yakama Indian Nation
CT'UII/ = Confederated Tribes of Umatilla Indian Reservation
NPT = Nez Perce Tribe

Volunteer crews, boat-angling crews, and a mobile crew augmented effort at selected dams (Table 2). Volunteer anglers from four sport-angling groups were supervised by members of the mobile crew and fished at Bonneville, The Dalles, and McNary dams (Table 2). Members of resident crews at The Dalles, John Day, McNary, Ice Harbor, and Lower Monumental dams conducted boat angling, which was confined to tailrace boat restricted zones (BRZ). The mobile

crew fished at Columbia River dams when and where catch rates were high, and also contributed to boat-angling effort at John Day Dam.

Table 2. Supplemental angling activities used in 1994.

Supplemental angling method &personnel	Dam	Dates
MOBILE CREW		
CRITFC	Bonneville, The Dalles, & John Day	June 1 - Sept 8 (59 days total)
VOLUNTEER ANGLING		
Mid-Columbia Bass Anglers	McNary	June 17, 24; July 1,8, 15,22, 29; August 12
The Dalles Rod& Gun Club	The Dalles	June 23, 30; July 7,14,21,28
Portland Chapter - NW Steelheaders	Bonneville	June 25; July 16, 30; August 13,27
Tom McCall Chapter - NW Steelheaders	Bonneville	July 9,23
BOAT ANGLING		
CRITFC	John Day	August 17,24
YIN	The Dalles	June 30
	John Day	June 29, 30; July 13, 14,21, 22; August 16, 17, 18,22,23,24,30
NPT	Ice Harbor	August 15-18,22,23
	Lower Monumental	August 8,9, 10
CTUIR	McNary	June 30; July 4,5, 12, 13,18-21, 24,26,27, 31; August 1,19,21-31

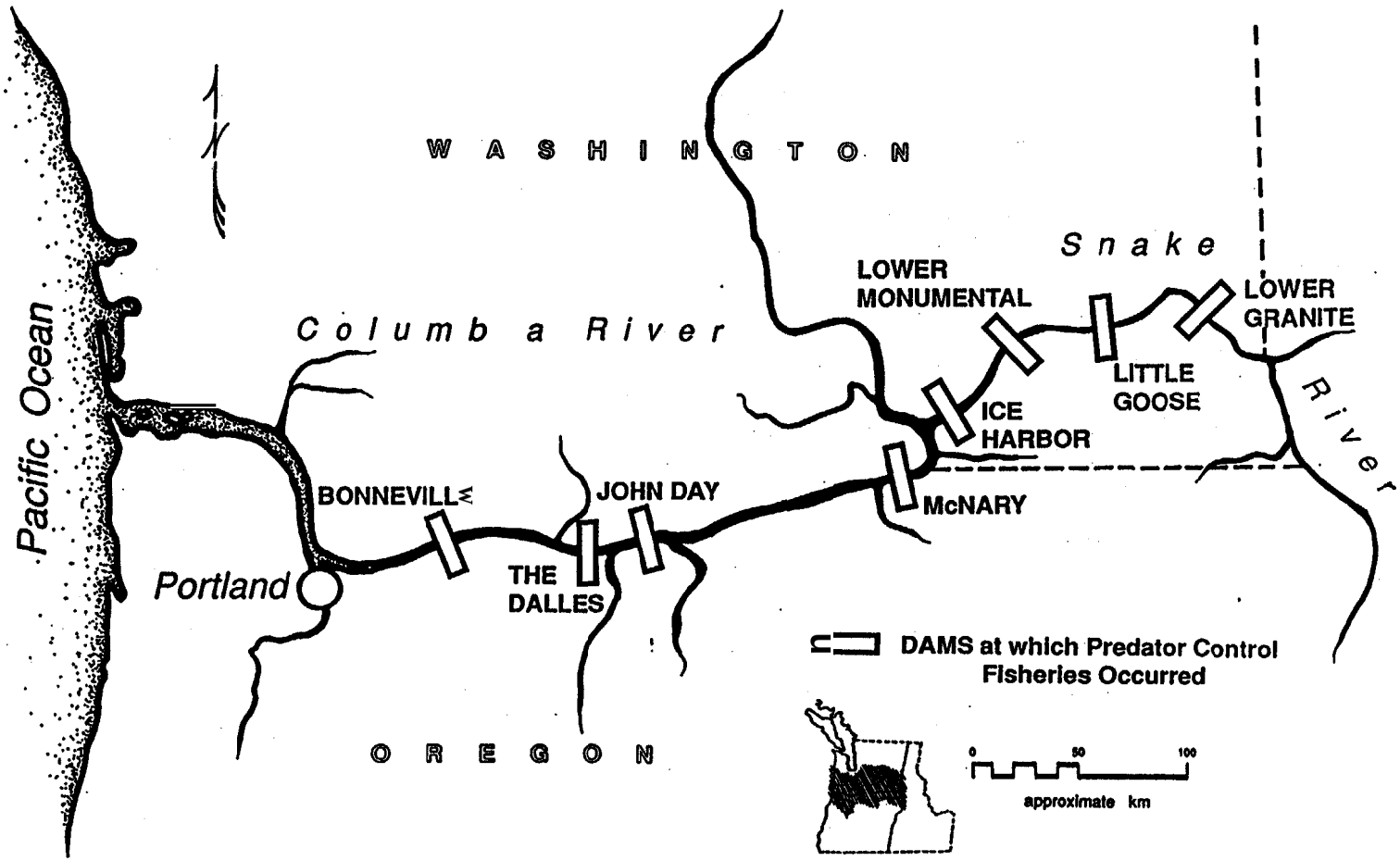


Figure 1. Dams where controlled angling operations were conducted in 1994.

Angling Methods

Anglers' equipment and techniques, including measures to minimize incidental catch, were similar to those used in the previous two years (see Parker et al. 1993). Once identified, all salmonids ≥ 0.50 m and sturgeon ≥ 0.75 m were immediately cut free to minimize stress and injury. Smaller salmon and sturgeon and all other species incidentally caught were reeled in, unhooked, and released immediately. Inmost cases, bronzed de-barbed hooks were used with a variety of baits (see Parker et al. 1993 for bait descriptions).

Data Collection and Analysis

As in previous years, data were collected using hand-held computers and transmitted daily via modem to CRITFC's Portland office (see Parker et al. 1993). Atypical data were identified using custom computer programs, then investigated and corrected if necessary. Weekly summary reports of catch and effort at each dam were provided to the Oregon Department of Fish and Wildlife (ODFW) via the Columbia Basin Fish and Wildlife Authority (CBFWA) bulletin board system (BBS).

Dam outflow and juvenile fish passage data were provided by the Fish Passage Center (FPC). Because daily values varied greatly, plots of CPAH on dam outflow and smelt passage indices are progressive averages for all variables. Progressive averages are calculated from the most current seven days' values.

RESULTS AND DISCUSSION

Northern Squawfish Catch

Spatial Effects

Anglers in 1994 caught 16,097 northern squaw-fish in 10,002 h of fishing, for an annual catch per angler hour (CPAH) of 1.6. Angling crews at Columbia River dams caught 15,270 northern squaw-fish in 8,911 h of effort for an overall CPAH of 1.7. Anglers at Snake River dams captured 827 northern squawfish in 1,092 h of effort, resulting in a CPAH of 0.8 (Table 3).

Table 3. Northern squawfish (NSF) catch, angling effort, and catch-per-angler hour (CPM) by dam for J991, 1992,1993, and 1994.

	1991			1992			1993			
Darn	NSF	Effort (h)	CPAH	NSF	Effort (h)	CPAH	NSF	Effort (h)	CPAH	NSF
COLUMBIA RIVER										
Bonneville	8,131	2,621	3.1	4,814	1,781	2.7	5,836	1,991	2.9	5,238
The Dalles	3,674	1,333	2.8	7.561	2,496	3.0	2,712	1,992	1.4	4,393
John Day	5,004	2,816	1.8	3,427	2,775	I.2	2,248	1,044	2.2	3,083
McNary	8,348	3,416	2.4	7,297	2,523	2.9	5,148	2,780	1.9	2,556
Season	25,1S7	10,187	2.s	23,099	9,s75	2.4	15,944	7,807	2.0	15,270
SNAKE RIVER										
Ice Harbor	1,486	2,052	0.7	278	298	0.9	122	404	0.3	23
Lower Monumental	3313	2,472	I.3	475	943	0.5	105	396	0.3	27
Little Goose	4,915	2,140	2.3	1,664	3,062	0.5	100	378	0.3	92
Lower Granite	4,480	2,448	1.8	2,352	2,881	0.8	678	734	0.9	685
Season	14,194	9,112	1.6	4,769	7,184	0,7	1,005	1,911	0.5	827
TOTALS	39,351	19,298	2.0	27,868	16,759	1.7	16,949	9,718	1.7	16,097

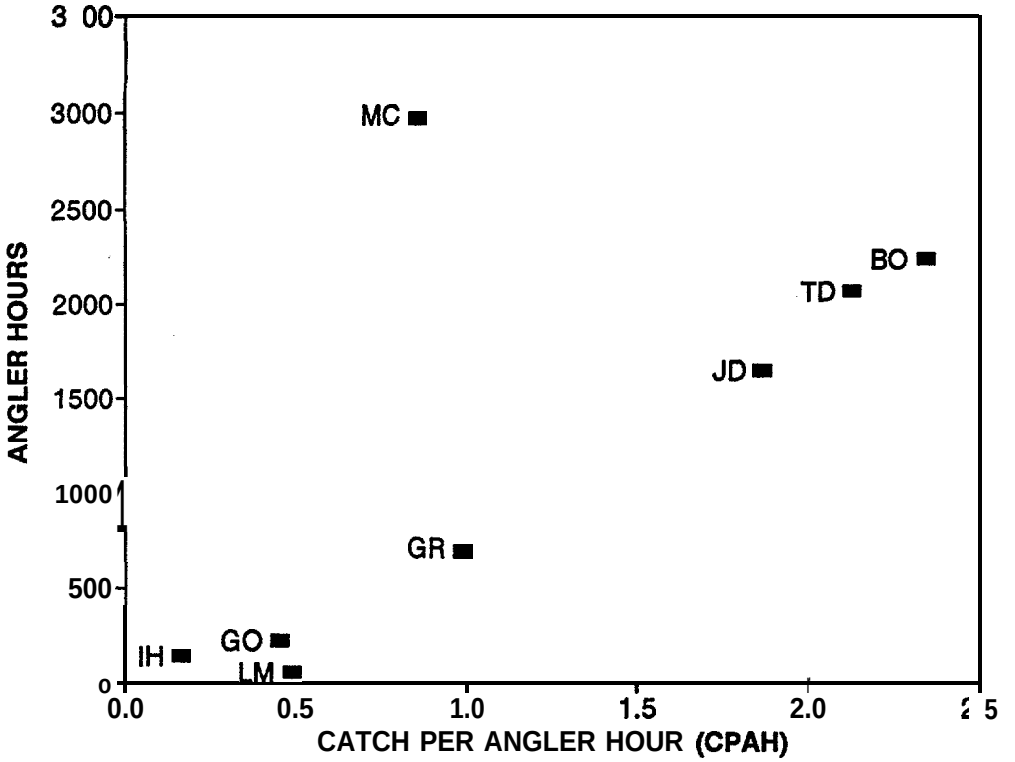


Figure 2. Annual catch per angler hour (CPAH) and total hours fished, by dam for 1994.

Among Columbia River dams, the largest catch (5,238) and CPAH (2.3) were at Bonneville Dam, followed by The Dalles, John Day, and MeNary dams (Table 3). The greatest amount of effort (2,966 h) was expended at McNary Dam based on high catch rates in previous years. This year, however, catch rates at McNary Dam did not warrant this level of effort (Figure 2). On the Snake River, Lower Granite Dam had the largest catch and highest CPAH, as was the case in previous years (Table 3).

Catch rates and percent of total catch of northern squawfish at various sites were highest in tailrace areas at most dams (Figures 3 through 10). Sites fished fewer than 10 angler-hours or contributing less than 1'% of the total northern squawfish catch are not shown on maps.

Temporal Effects

Total catch (16,097 fish) for the 1994 season was 95% of the 1993 catch, and total effort (10,002 h) was approximately 3% higher than in 1993 (Table 3). Yearly CPAHS for dam angling have remained relatively constant for the last three years, as has effort for the last two years (Table 3).

On the Columbia River, northern squawfish catch (15,270 fish) was 96% of the 1993 catch, despite a 14% increase in effort in 1994 (Table 3). The annual CPAH at Columbia River darns has continued to decline since 1991 (Table 3). The catch at Snake River dams was 82% of that in 1993, with 57% of the annual effort. Annual CPAH at Snake River dams was higher in 1994 (0.8) than in 1993 (0.5).

In 1994, catch rates declined at three of the four Columbia River dams (Bonneville, John Day, and McNary; Table 3), as compared to 1993. The greatest decline occurred at McNary dam (1993 CPAH: 1.9; 1994 CPAH: 0.9), which maybe explained by changes in flow at McNary Dam from previous years (B. Eby, USACE, personal communication). Conversely, CPAHS at Snake River dams increased at three out of four dams (Lower Monumental, Little Goose, and Lower Granite) this year as compared to last year (Table 3). The catch rate at Ice Harbor declined slightly from 1993. The significance of these changes is uncertain due to low levels of effort at these dams.

As in previous years, northern squawfish catch and CPAH at Columbia River dams were highest in July (Figures 11 and 12). Patterns in monthly catch and CPAH are less obvious at Snake River dams. However, peaks in catch and catch rate seemed to occur earlier in the year as compared to Columbia River dams (Figures 11 and 12).

Weekly totals of catch, effort, and CPAH for 1994 are listed in Appendix Tables A-1 and A-2. Plots of weekly CPAHS for 1994 indicate that an earlier start at the Dalles, McNary, and Lower Granite dams may have been productive (Figures 13 and 14).

Although differences among individual dams were apparent, the highest CPAH for both river systems was during the 1801-2400 hours time period (Table 4).

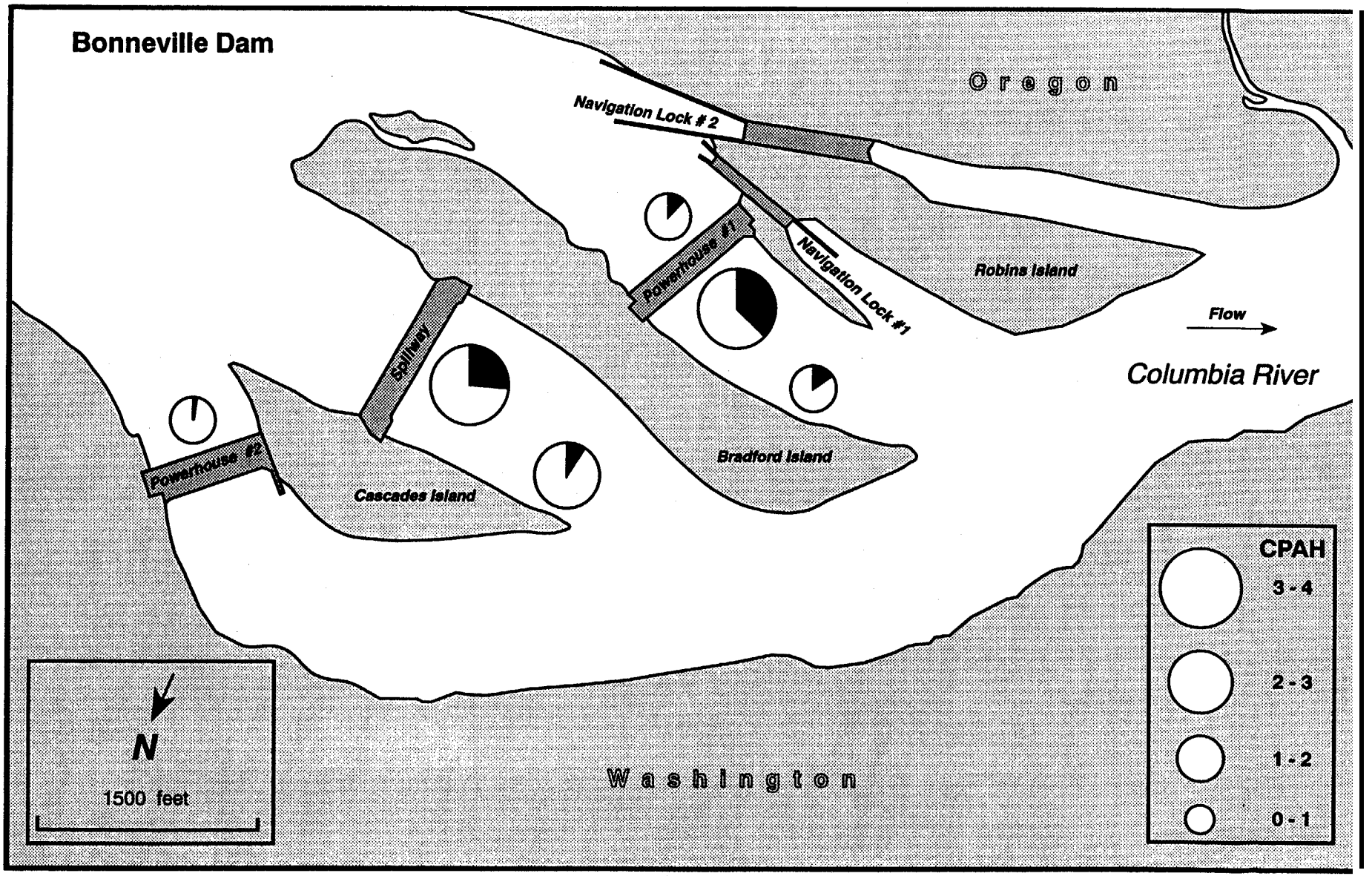


Figure 3. Catch-per-angler-hour **(CPAH)** of northern squawfish **in** various **sites** at Bonneville Dam, 1994. Dark shading **in** circles represents the percent of total catch caught at that site.

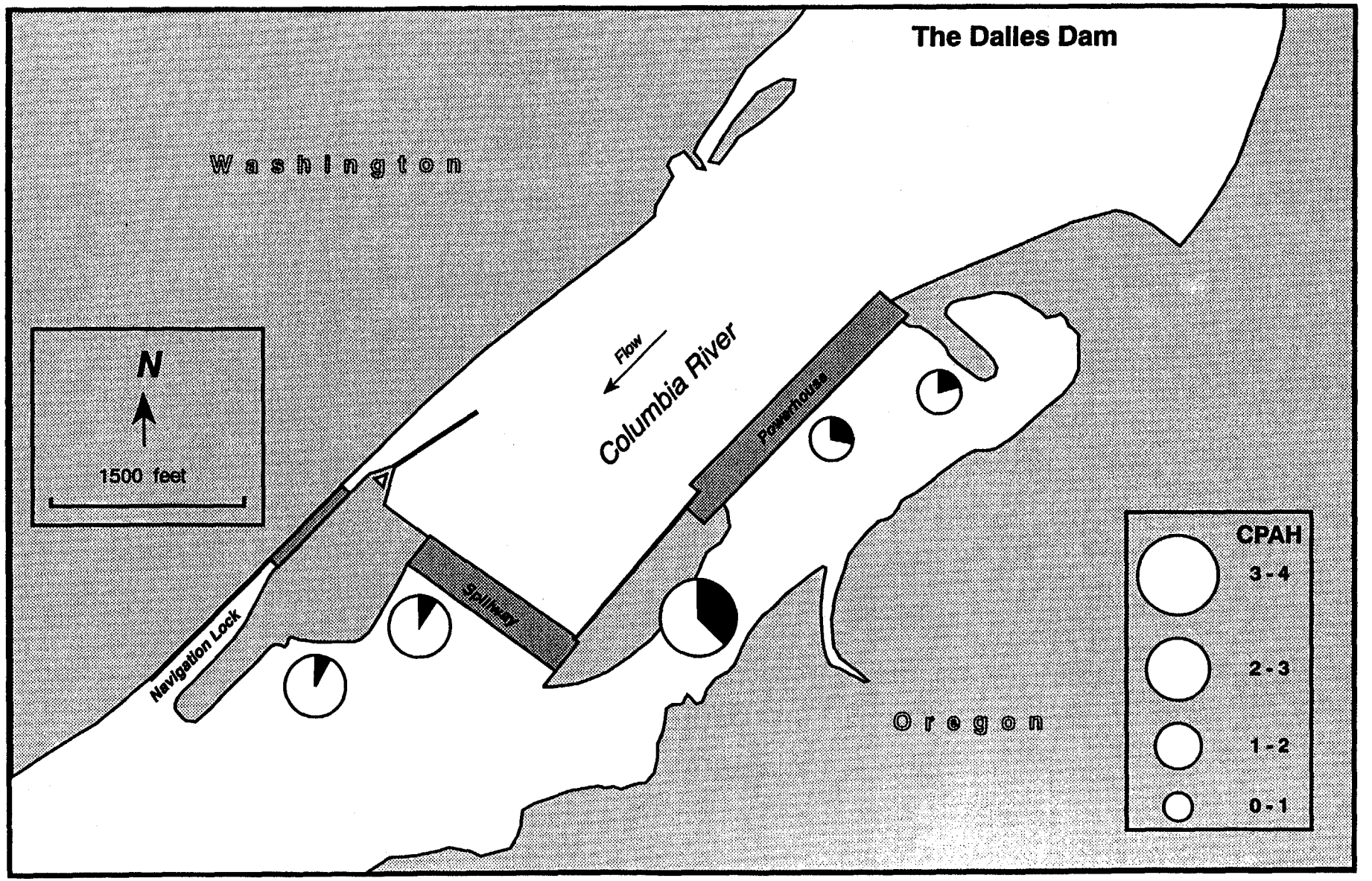


Figure 4. Catch-per-angler-hour **(CPAH)** of northern **squawfish in** various **sites** at The **Dalles** Dam, 1994. Dark shading **in** circles represents the percent of total catch caught at that site.

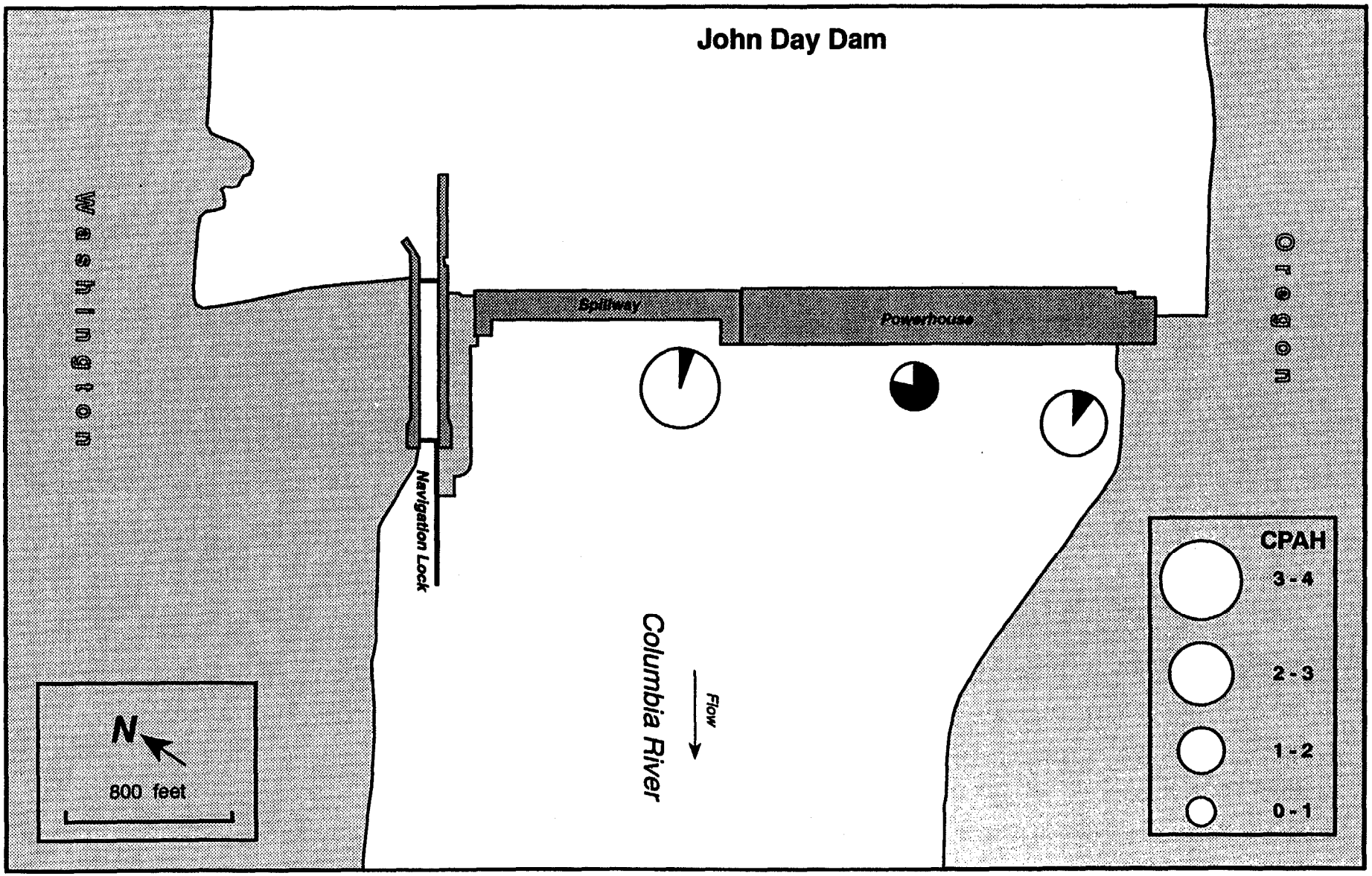


Figure 5. Catch-per-angler-hour **(CPAH)** of northern squawfish **in** various sites at John Day Dam, **1994.** Dark shading **in** circles **represents** the percent of total catch caught at that site.

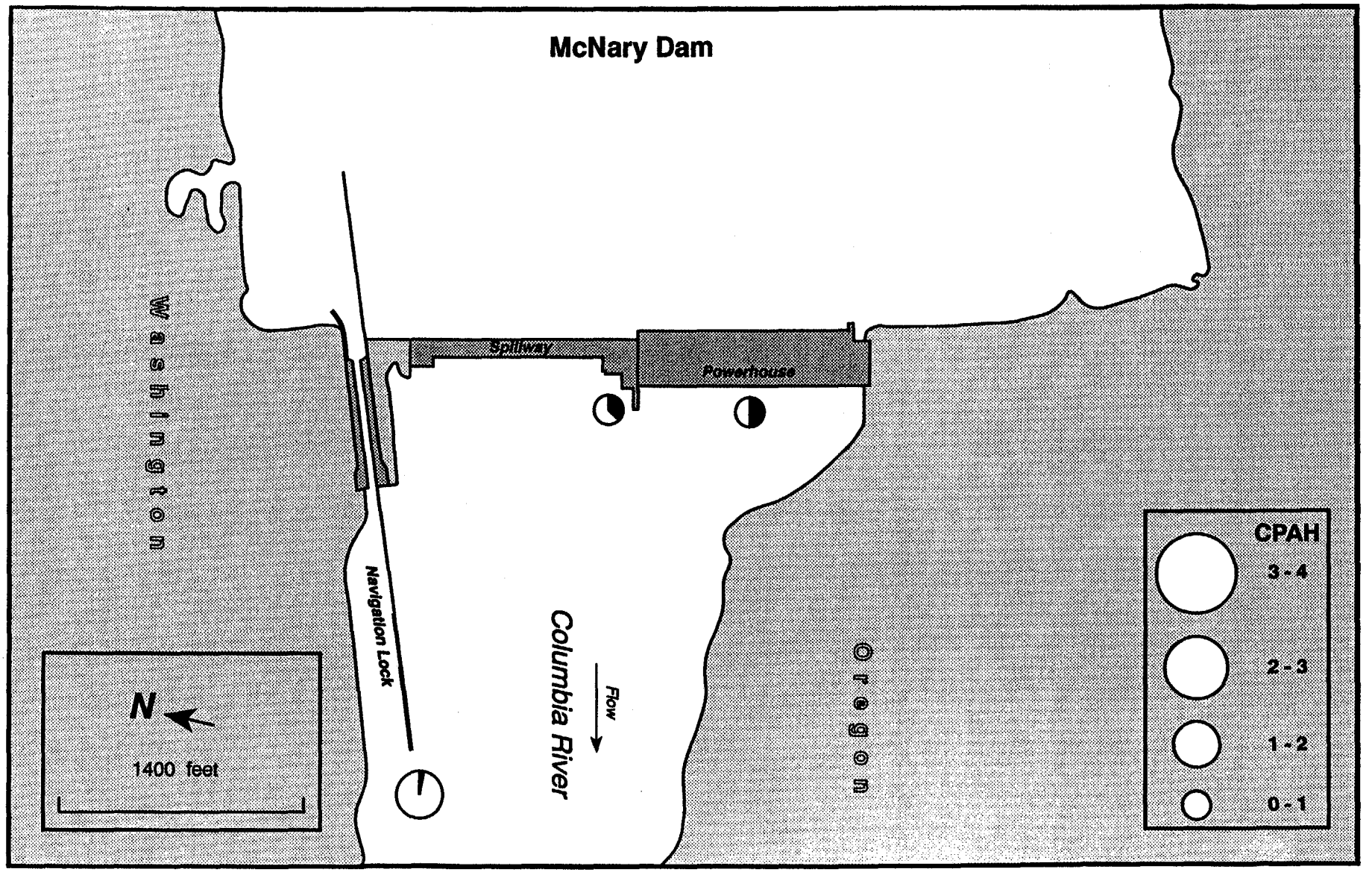


Figure 6. Catch-per-angler-hour (CPAH) of northern squawfish in various sites at McNary Dam, 1994. Dark shading in circles represents the percent of total catch caught at that site.

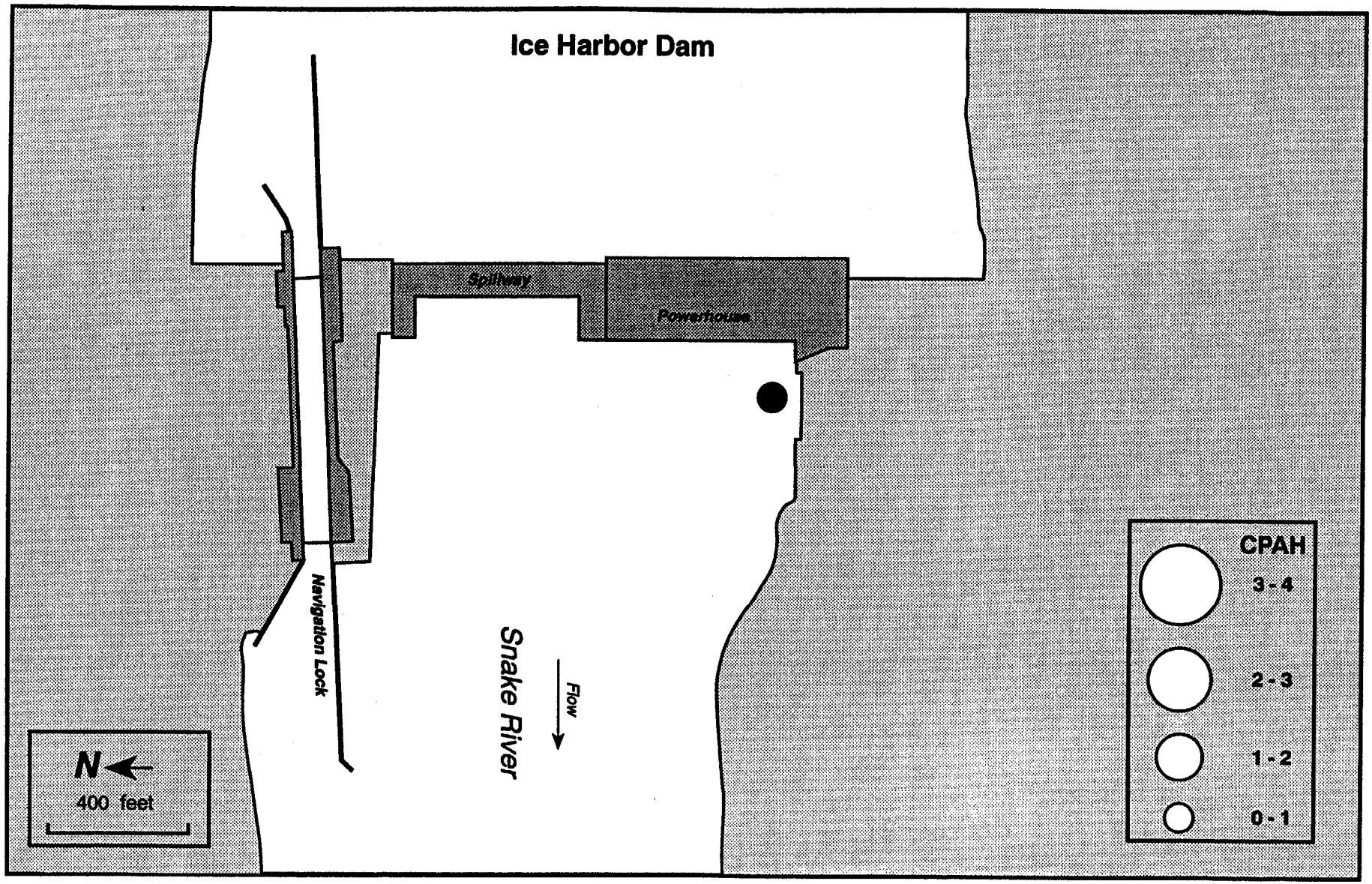


Figure 7 . Catch-per-angler-hour **(CPAH)** of northern **squawfish in** various **sites** at Ice Harbor Dam, 1994. Dark shading **in** circles represents the percent of total catch caught at that **site.**

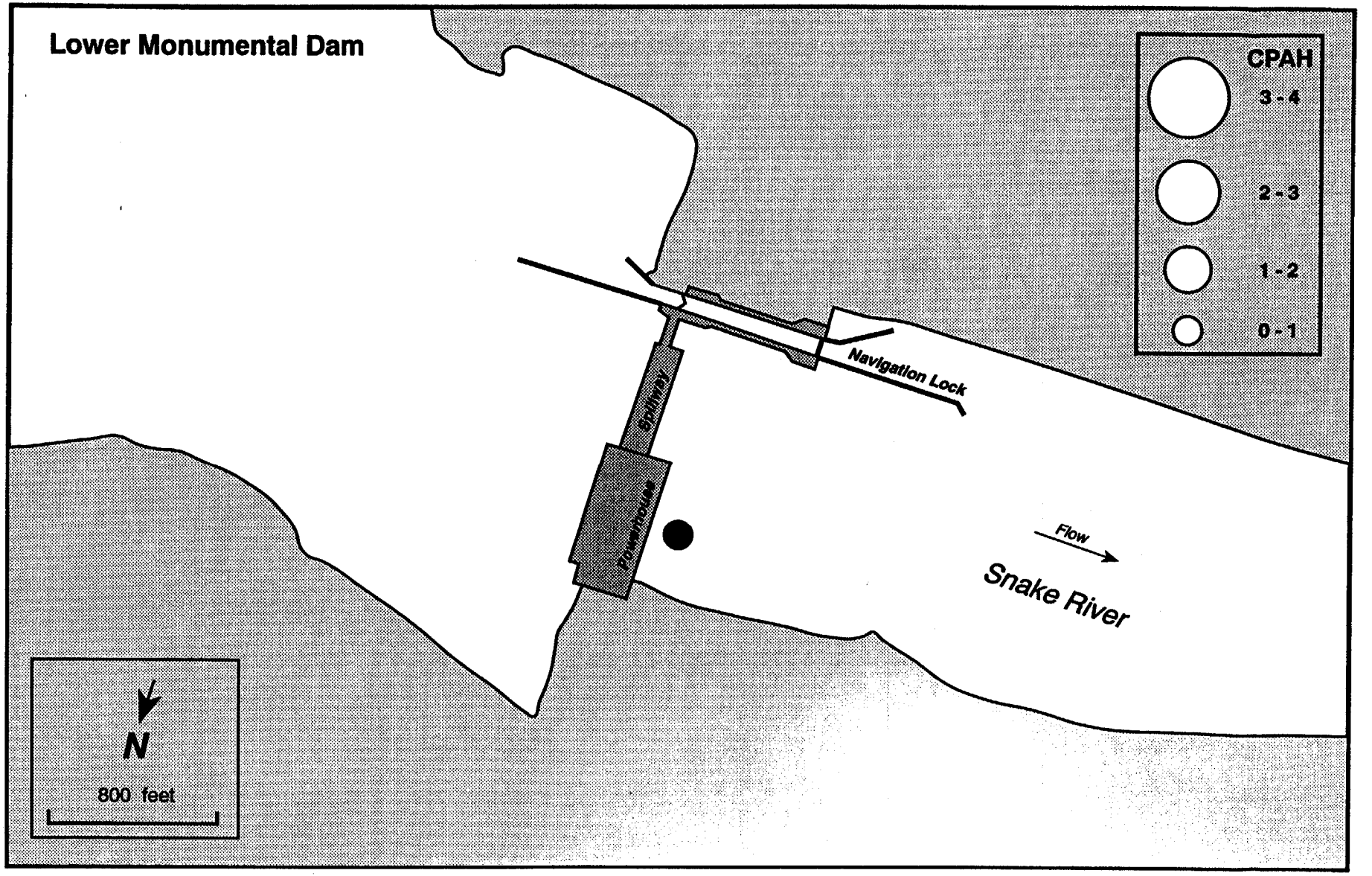


Figure 8 . Catch-per-angler-hour **(CPAH)** of northern **squawfish** in various **sites** at Lower Monumental Dam, 1994. Dark shading **in** circles represents the percent **of** total catch caught at that site.

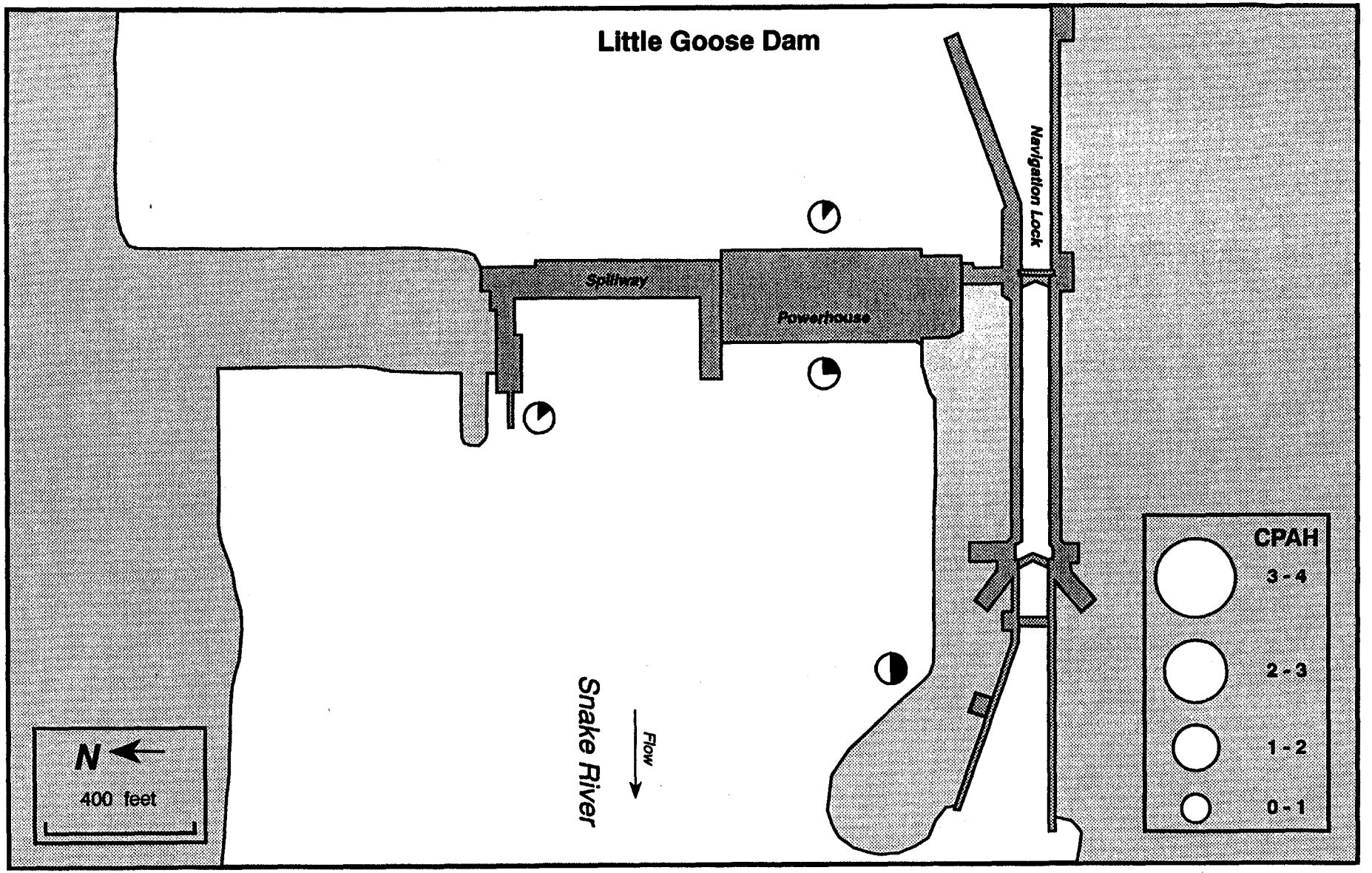
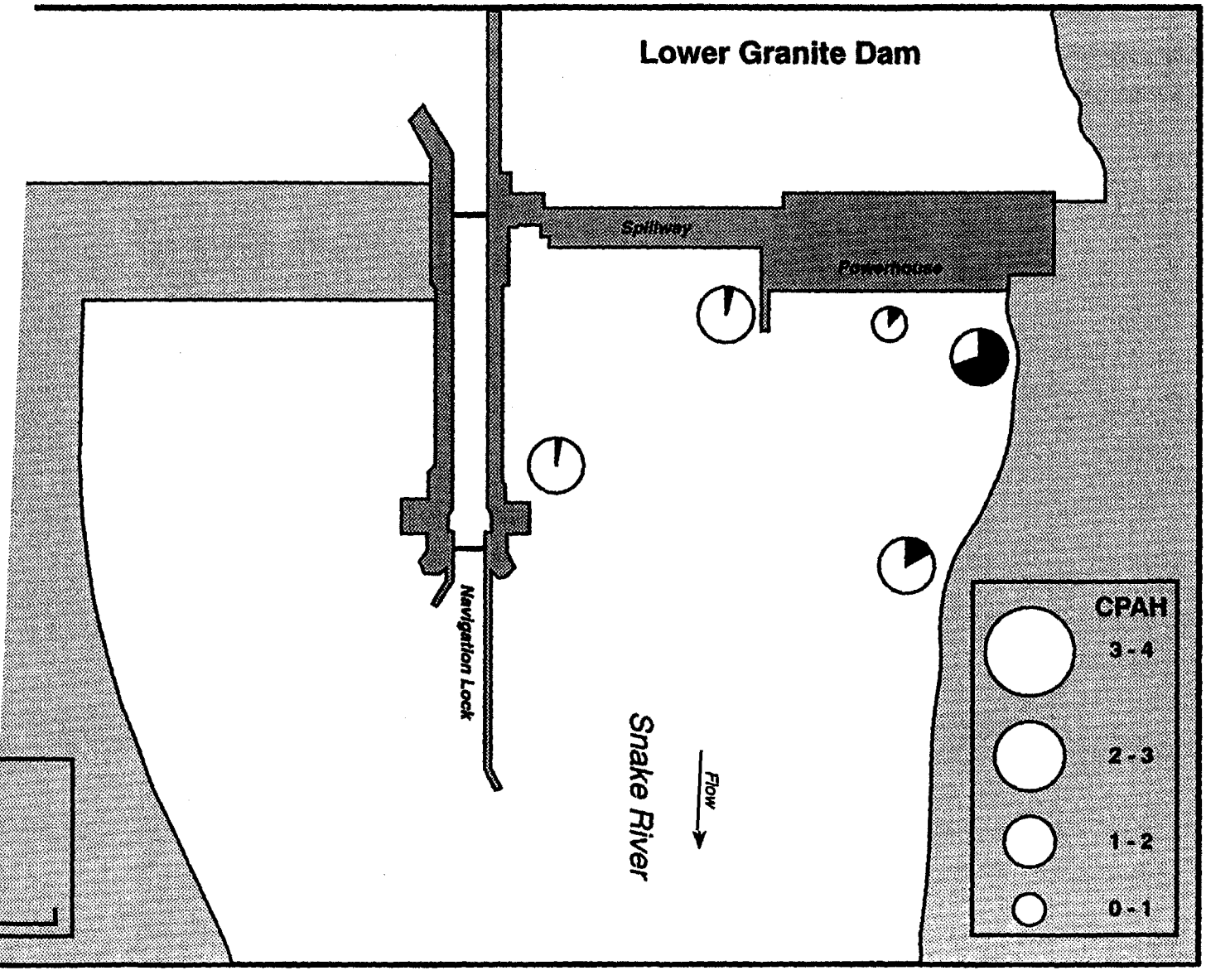
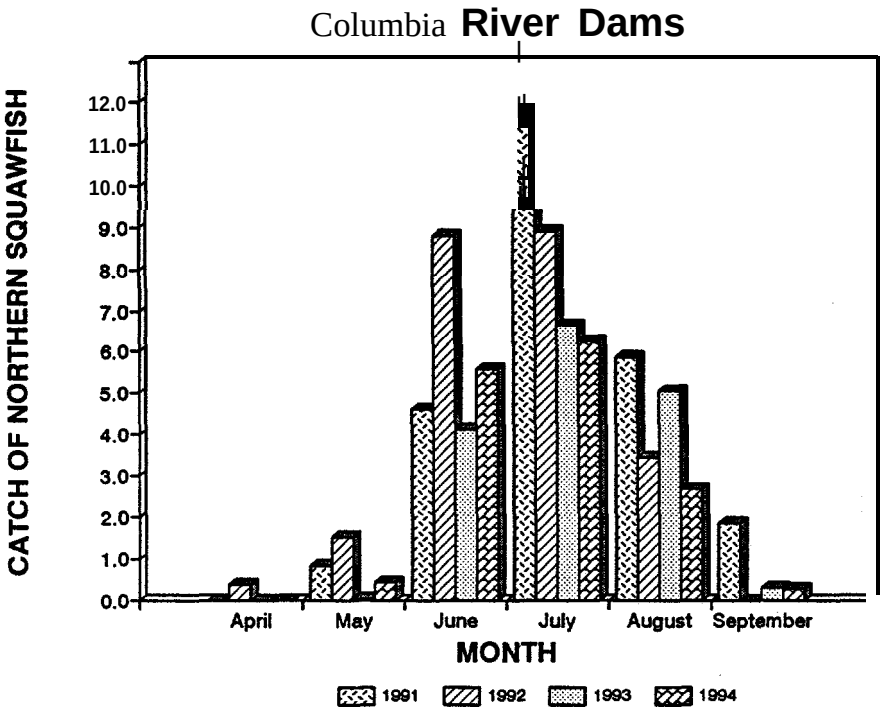
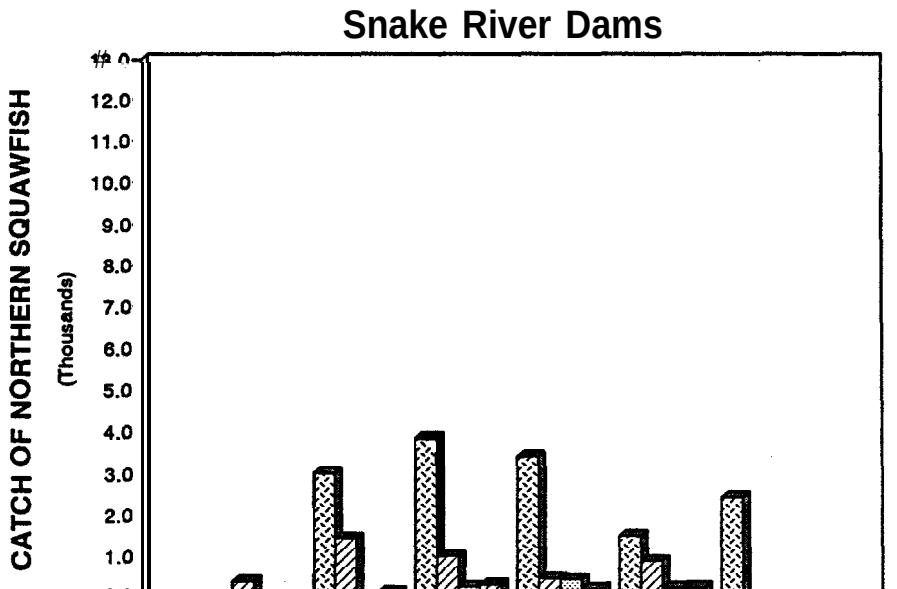


Figure 9. Catch-per-angler-hour (CPAH) of northern squawfish in various sites at Little Goose Dam, 1994. Dark shading in circles represents the percent of total catch caught at that site.

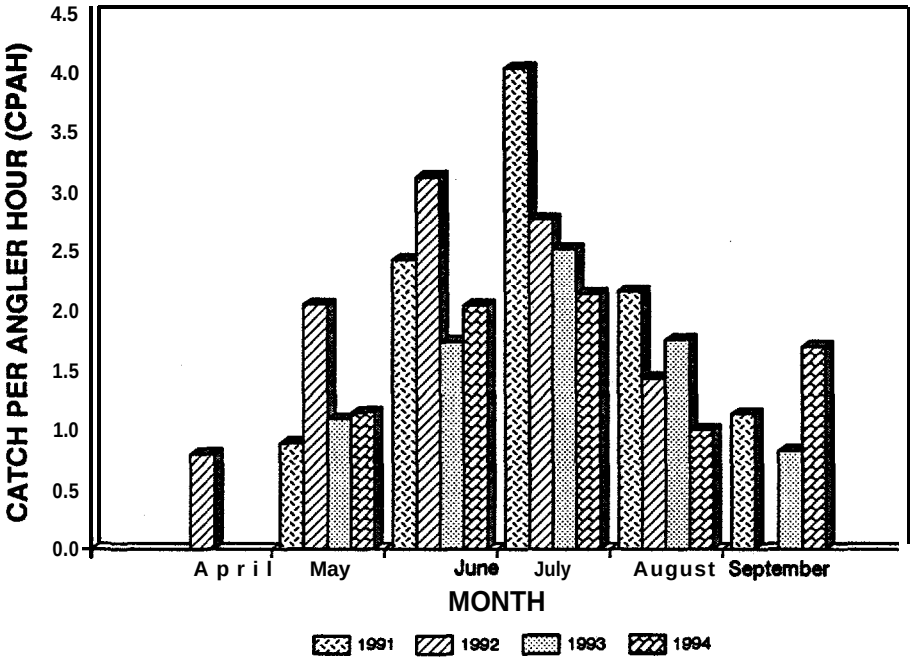


-per-angler-hour (CPAH) of northern squawfish in various sites at Lower
Dark shading in circles represents the percent of total catch caught at

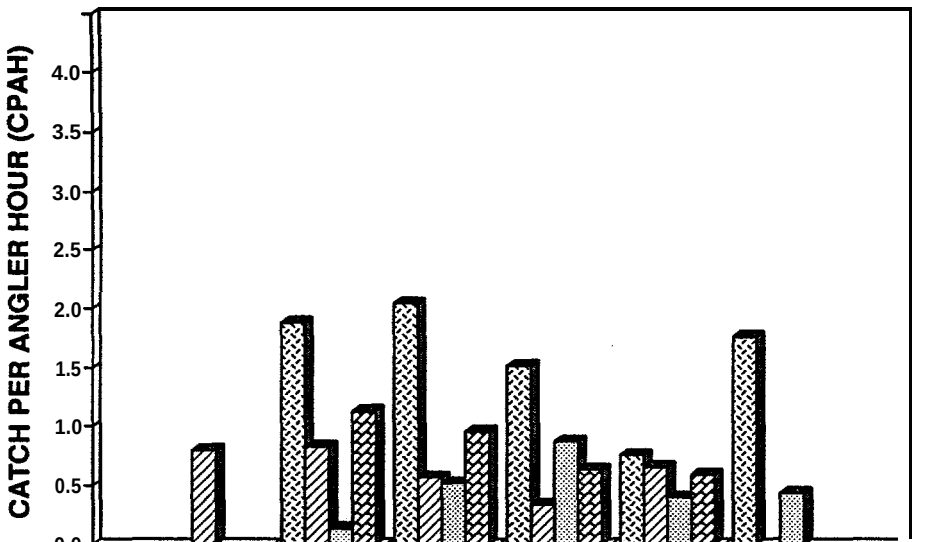

Columbia River Dams
CATCH OF NORTHERN SQUAWFISH
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
April
May
June
July
August
September
MONTH
1991
1992
1993
1994


Snake River Dams
CATCH OF NORTHERN SQUAWFISH
(Thousands)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

Columbia River Dams



Snake River Dams



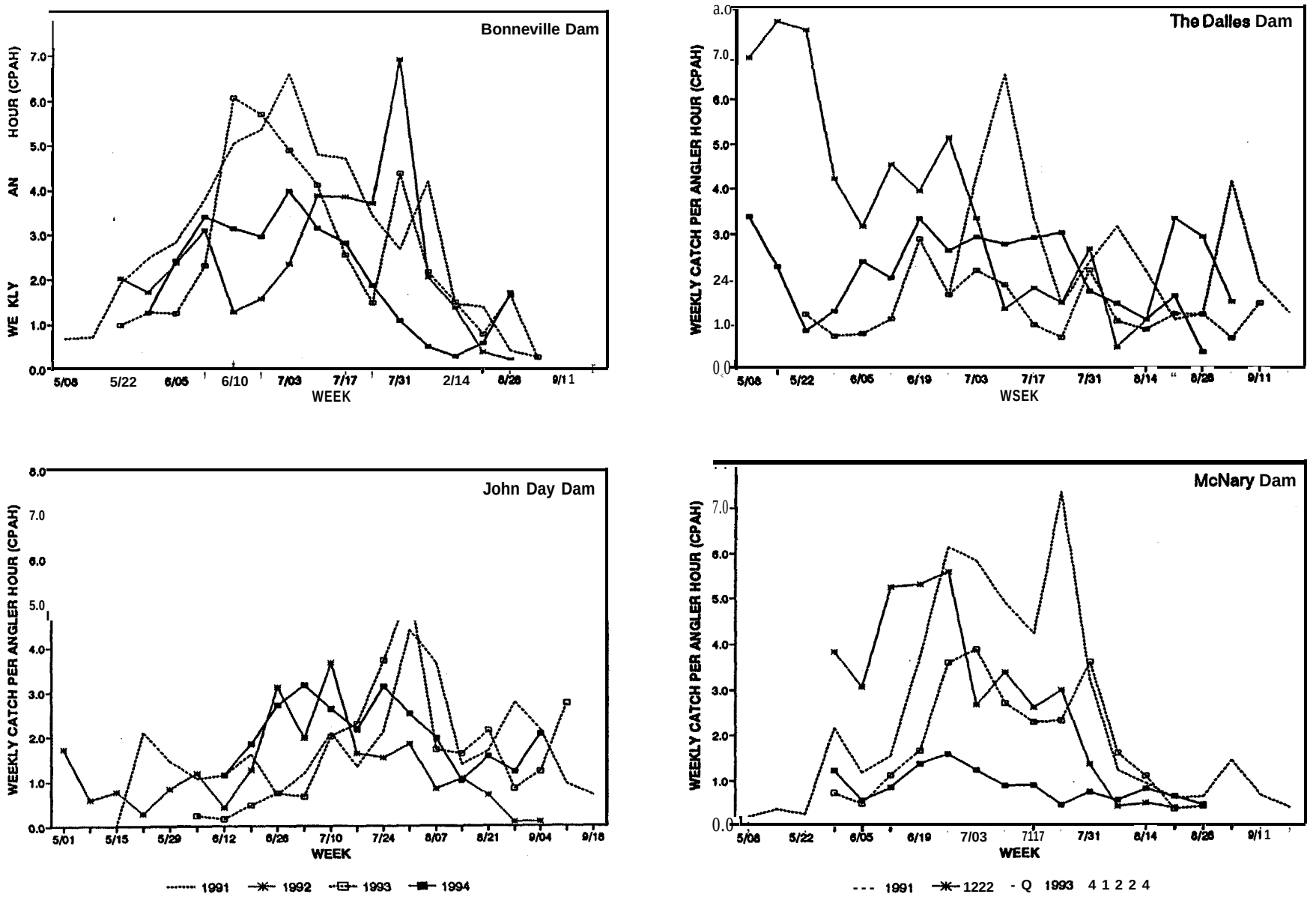


Figure 13. Weekly average catch per angler hour (CPAH) at Columbia River dams, 1991 through 1994.

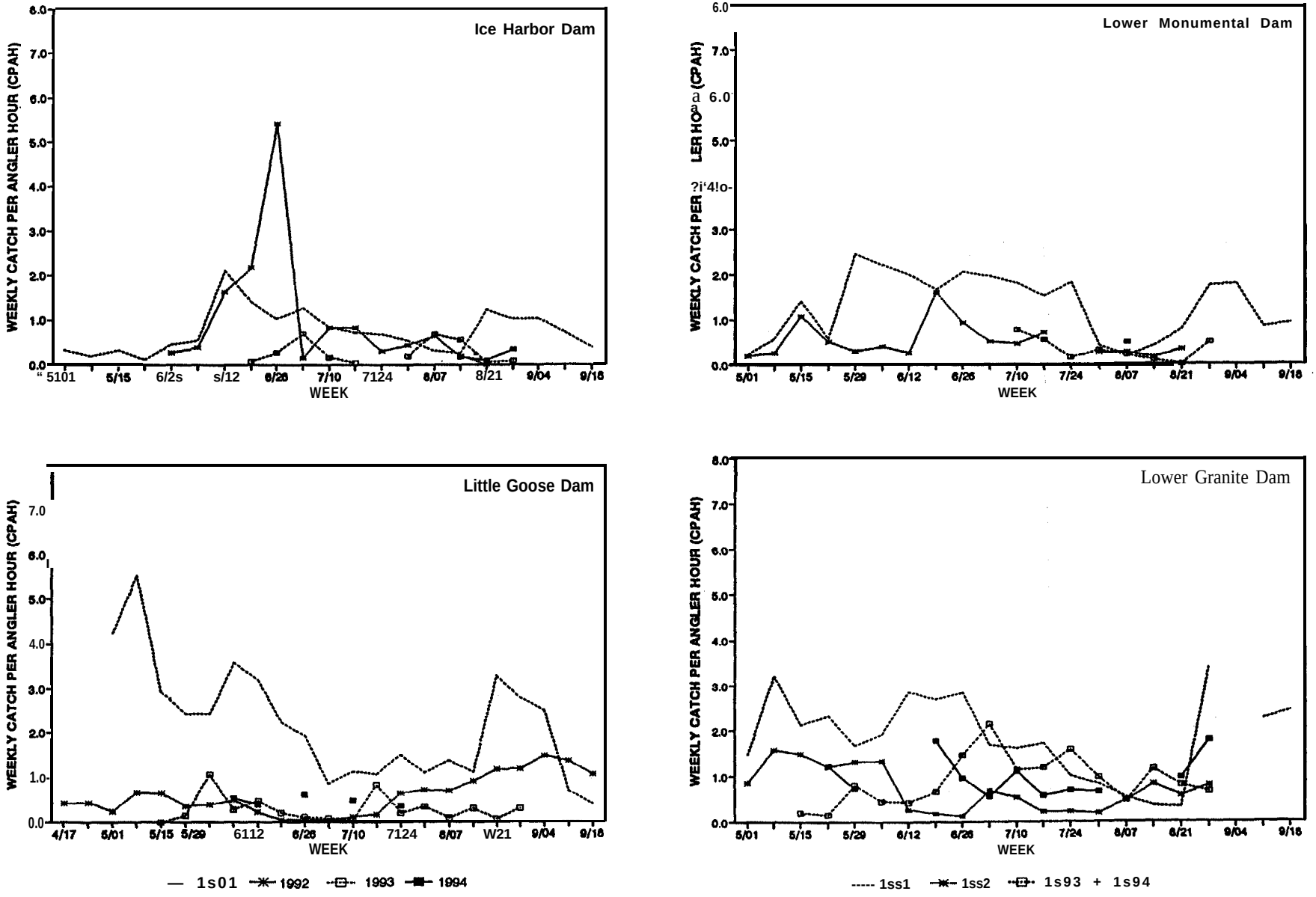


Figure 14. Weekly average catch per angler hour , (CPAH), at snake River dams. 1991 through 1994.

Table 4. Comparisons of catch and effort over four six-hour time periods for Columbia and Snake River dams, 1994.

Time Period:	0001-0600			0601-1200			1201-1800			1801-2400		
Dam	NSF	Effort (h)	CPAH	NSF	Effort (h)	CPAH	NSF	Effort (h)	CPAH	NSF	Effort (h)	CPAH
COLUMBIA RIVER												
Bonneville	363	242.03	1.5	1,787	464.88	3.8	1253	737.32	1.7	1,835	787.32	2.3
The Dalles	709	398.32	1.8	410	249.38	1.6	1,271	552.43	2.3	2,003	863.80	2.3
John Day	2,143	845.05	2.5	234	247.30	1.0	44	102.12	0.4	662	454.48	1.5
McNary	734	1,026.62	0.7	910	1,020.70	0.9	317	411.73	0.8	595	506.97	1.2
Season	3,949	2,512.02	1.6	3,341	1,982.26	1.7	2,885	1,803.60	1.6	5,09s	2,612.S7	2.0
SNAKE RIVER												
Ice Harbor				21	97.57	0.2	2	43.28	0.1			
Lower Monumental				22	41.37	0.5	5	14.08	0.4			
Little Goose	5	21.30	0.2	28	46.38	0.6	25	72.10	0.4	34	63.62	0,5
Lower Granite	155	171.50	0.9	214	267.48	0.8	187	151.08	1.2	129	101.92	1.3
Season	160	192.80	0.8	285	452.80	0.6	219	280.54	0.8	163	165.54	1.0
TOTALS	4,109	2,704.82	1.S	3,626	2,43S.06	1.5	3,104	2,084.14	1.5	5,2s8	2,778.11	1.9

Angling Techniques

Volunteer angling supplemented resident-crew angling at Columbia River dams by contributing 3.2%(5 17) of the northern squawfish catch in 1994. CPAHs for volunteer angling crews were consistently lower than resident crews, except at MeNary Dam (Table 5). Overall, boat-angling crews had a CPAH of 0.7; the resident-crew had aCPAH of 1.7. On the Columbia River, resident crews had the highest CPAH (1 .8), followed by volunteer angling (1 .5) and boat angling (0.8). At Snake River dams, where boat angling was the only supplemental technique used, the resident crew CPAH (0.8) was higher than that of boat angling (0.3).

Boat angling might have been more effective ifused earlier in the season (May through early June), when discharge rates were high. Boat-angling efforts were often used late in the season when catch rates had declined. If boat angling were used as a primary task, as opposed to an alternative when dam angling is poor, we expect this method could be more effective.

Angler ability is an important factor affecting our overall success at dams. Differences between volunteer- and resident-angler success at some dams maybe explained by differences in angler ability. Furthermore, success varies greatly among resident anglers working the same dams and schedules (Figure 15).

Catch rates varied among different baits chosen by anglers (Table 6). At Columbia River dams, soft plastic bait (SPO) was used most often by anglers (84% of the total hours fished) and was relatively effective as measured by CPAH (Table 6). At Snake River dams, anglers preferred combination lures (CLO, used 70°A of the total hours fished), which also produced high catch rates (Table 6). The bait having the highest CPAH at a dam was not always the one most often used. This may be explained by limited availability or convenience of some baits, or insufficient transfer of catch information to anglers regarding the relative success of different baits.

Hydrological Effects

Changes in flow affect the distribution of northern squawfish near dams (Faler et al. 1988; R. Shively, NBS, unpublished data). Specifically, in the spring and early summer when discharge rates are high, northern squawfish are found in protected areas away from dams. When flows decrease, they move closer to dams, presumably tofeed on outmigrating juvenile salmonids. Assuming dam angling catch rates area measure of northern squawfish density near dams, our data seem to support this hypothesis. There appears to be an inverse relationship between outflow and CPAH in the short term at many dams; that is, peaks in CPAH often coincide with declines in discharge (Figures 16 and 17). This supports a management approach that uses boats in the boat restricted zones during periods of high flow to target concentrations of northern squawfish out of reach of dam-based anglers.

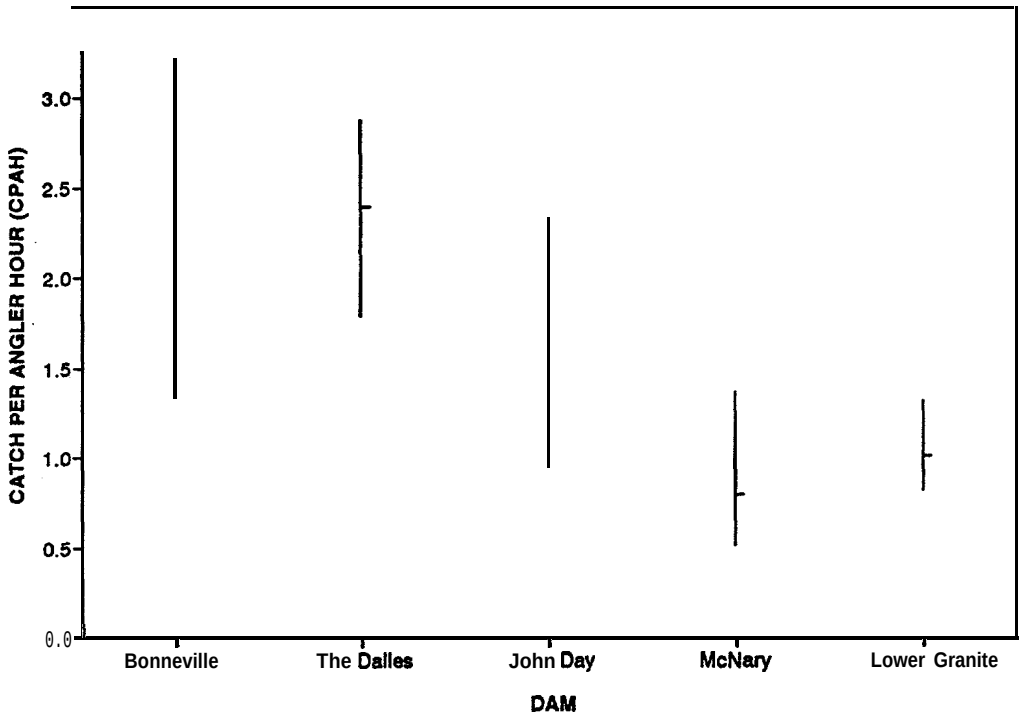


Figure 15. Range in angler effectiveness (CPAH) for each angling crew. Mobile crew, volunteer angling crews, and anglers who worked fewer than 100 hours are not included. Average CPAH for each crew is indicated by a horizontal mark.

Table 6. Comparisons of the effectiveness of baits used throughout the 1994 season at each dam. Baits are listed from highest to lowest CPAH.

Season totals by dam

Dam	Bait*	NSF	Effort (h)	CPAH
COLUMBIA RIVER				
Bonneville	HML	93	21.82	4.3
	SPO	4,788	1,809.57	2.7
	HPO	300	217.27	1.4
	NBo	57	182.08	0.3
	CLO	0	0.82	0.0
The Dalles	HPO	398	148.95	2.7
	SPO	3,909	1,854.82	2.1
	NBo	85	56.52	1.5
	HML	1	3.65	0.3
John Day	SPO	2,998	1,572.50	1.9
	HPO	69	52.05	1.3
	HML	7	9.22	0.8
	CLO	8	10.50	0.8
	NBo	1	4.68	0.2
McNary	NBo	693	649.52	1.1
	SPO	1,819	2,255.23	0.8
	CLO	26	32.20	0.8
	HPO	17	25.22	0.7
	HML	1	3.85	0.3
SNAKE RIVER				
Ice Harbor	NBo	1	2.05	0.5
	SPO	6	26.13	0.2
	CLO	16	103.40	0.2
	HPO	0	9.27	0.0
Lower Monumental	CLO	27	43.50	0.6
	NBo	0	1.57	0.0
	SPO	0	3.57	0.0
	HPO	0	6.82	0.0
Little Goose	SPO	5	9.00	0.6
	NBo	15	31.03	0.5
	CLO	66	138.28	0.5
	HPO	6	25.08	0.2
Lower Granite	NBo	144	131.97	1.1
	SPO	36	33.25	1.1
	CLO	481	482.37	1.0
	HPO	24	44.07	0.5
	HML	0	0.33	0.0

Season totals by river system

Bait*	NSF	Effort (h)	CPAH
COLUMBIA RIVER			
HML	102	38.54	2.7
SPO	13,514	7,492.12	1.8
HPO	784	443.48	1.8
NBo	836	892.80	0.9
CLO	34	43.52	0.8
SNAKE RIVER			
NBo	160	166.62	1.0
CLO	590	767.55	0.8
SPO	47	71.95	0.7
HPO	30	85.23	0.4
HML	0	0.33	0.0
TOTALS			
HML	102	38.87	2.6
SPO	13,561	7,564.07	1.8
HPO	814	528.72	1.5
NBo	996	1,059.42	0.9
CLO	624	811.07	0.8

•Bait descriptions

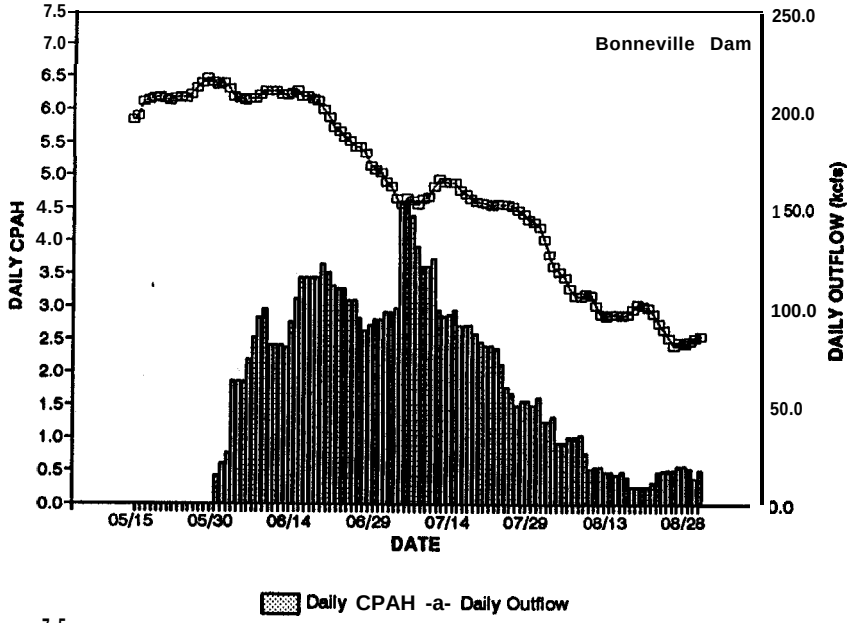
HML = Hard Metal Lures (such as spoons, spinners, Zonars)

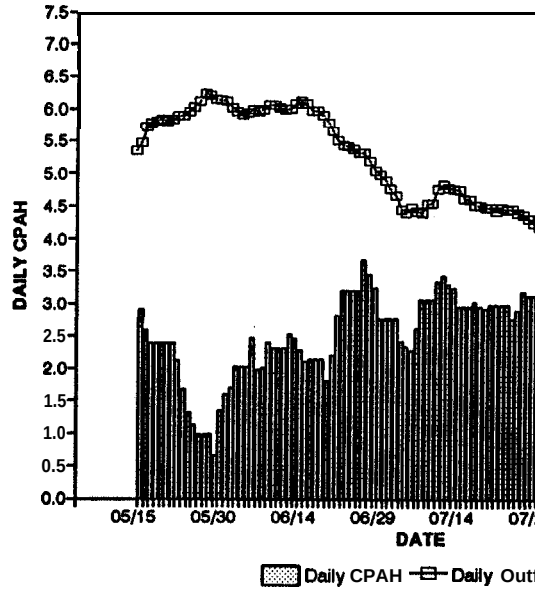
SPO = Soft Plastic (such as *grubs*, tubes, fish-like grubs)

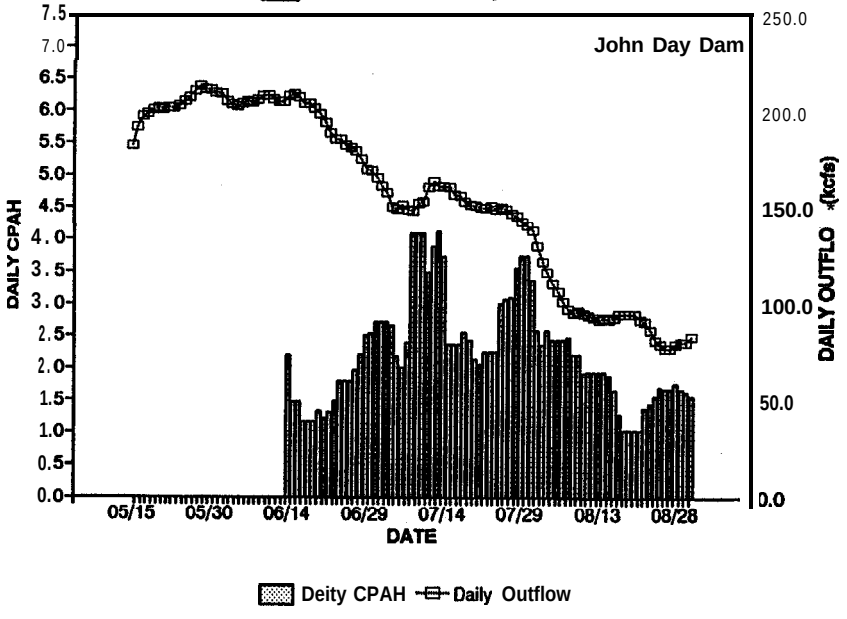
HPO = Hard Plastic (such as plugs, Rat-L-Traps, and Rapalas)

NBO = Natural Bait (such as worms, lamprey, and smelts)

CLO = Combination Lures (any combination of the classes listed above)







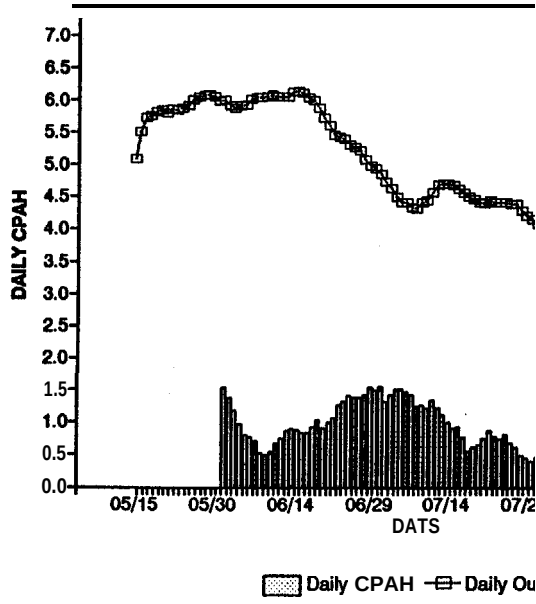
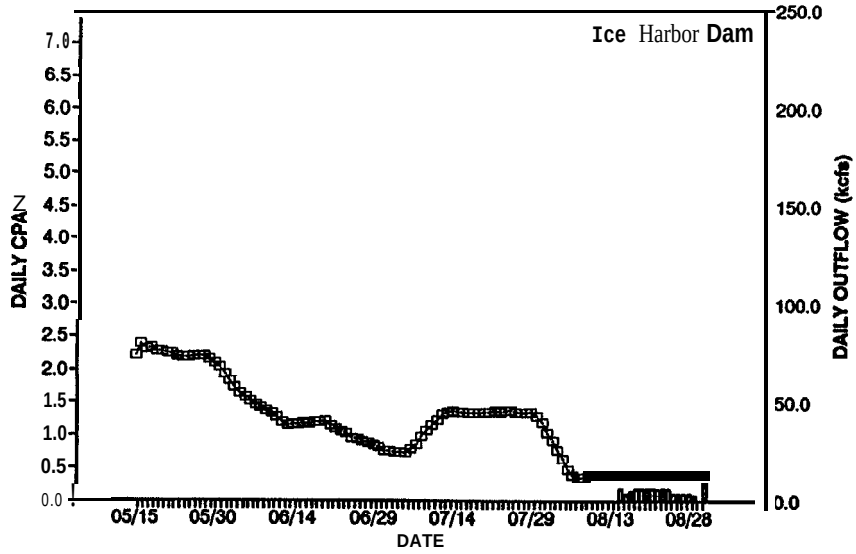
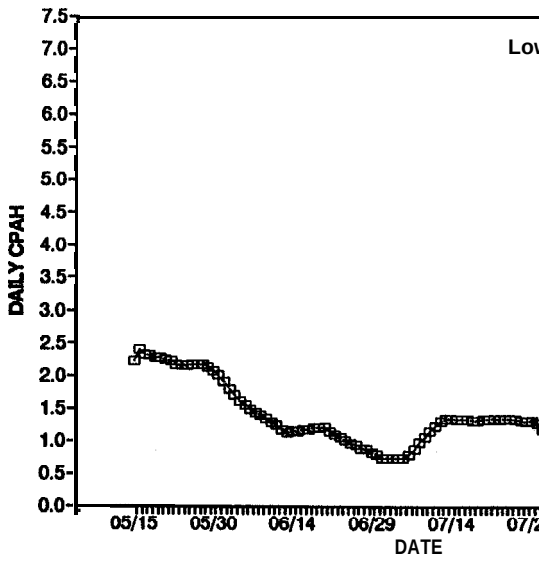
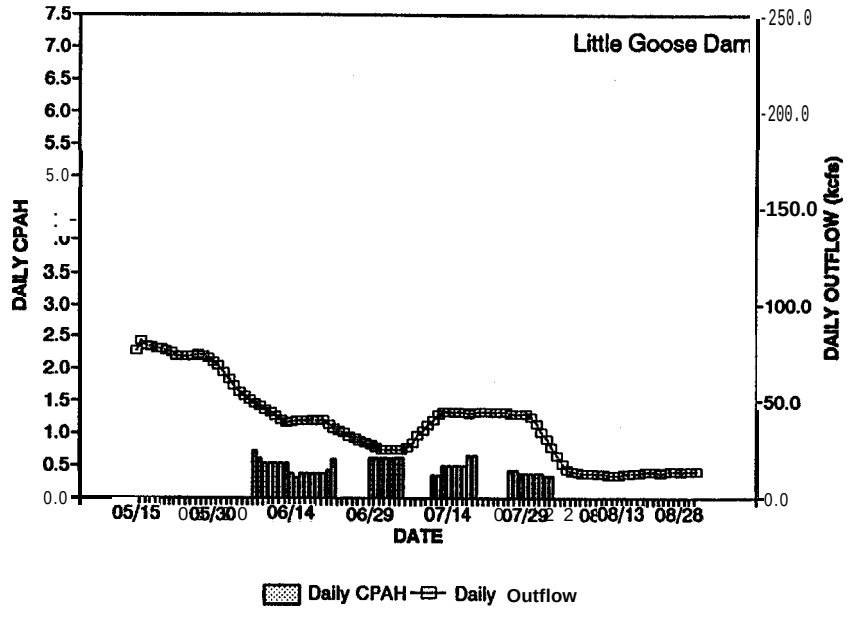


Figure 16. **Northern squawfish catch per angler hour (CPAH) and dam outflow at Columbia R**







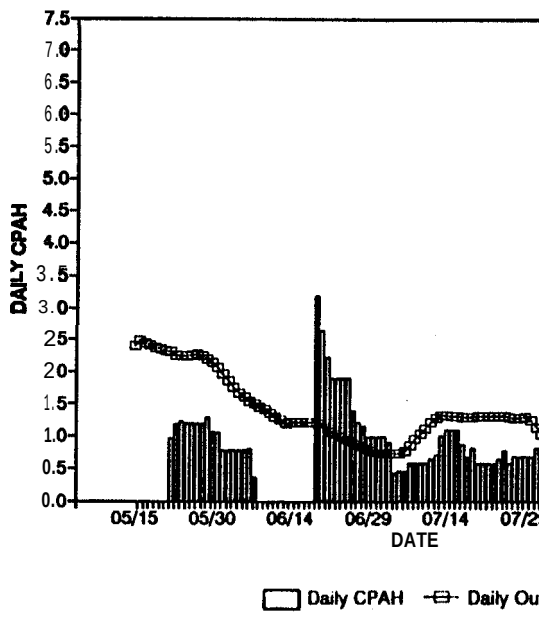


Figure 17. Northern **squawfish catch per angler hour (CPAH) and dam outflow at snake River**

Smelt Passage

Northern squawfish concentrate below Columbia River and Snake River dams to feed on juvenile salmonids that are injured or disoriented after passing the dam (Beamesderfer and Rieman 1991). A prediction of this hypothesis is that northern squawfish density near dams would be greatest during peak passage periods of juvenile salmonids. Our data seem to support this prediction. There appears to be a direct relationship between an index of juvenile salmonid passage and CPAH at dams in the short term (Figures 18 and 19). Furthermore, these data indicate angling at many dams started after the peak passage period for juvenile salmonids (Figures 18 and 19), suggesting that an earlier start of dam angling activities might have been more productive.

Incidental Catch

In 1994, 2.3% of the total catch was composed of incidental species (Figure 20; Appendix Tables A-3 through A-8), which was less than half of that in 1993 (5.5%). Of the 374 incidentally caught fish, there were 46°A bass, 20°A sturgeon, 11% catfish, 11°A walleye, 6'% other (e.g., sucker, peamouth), 3°/0 shad, and 3°/0 salmonids. Of the 12 incidentally caught salmonids (six unidentified and six steelhead; 0.07°/0 of all fish caught), all were juveniles; nine were released in good condition, two in poor condition, and one died. All incidentally caught salmonids were caught at Columbia River darns.

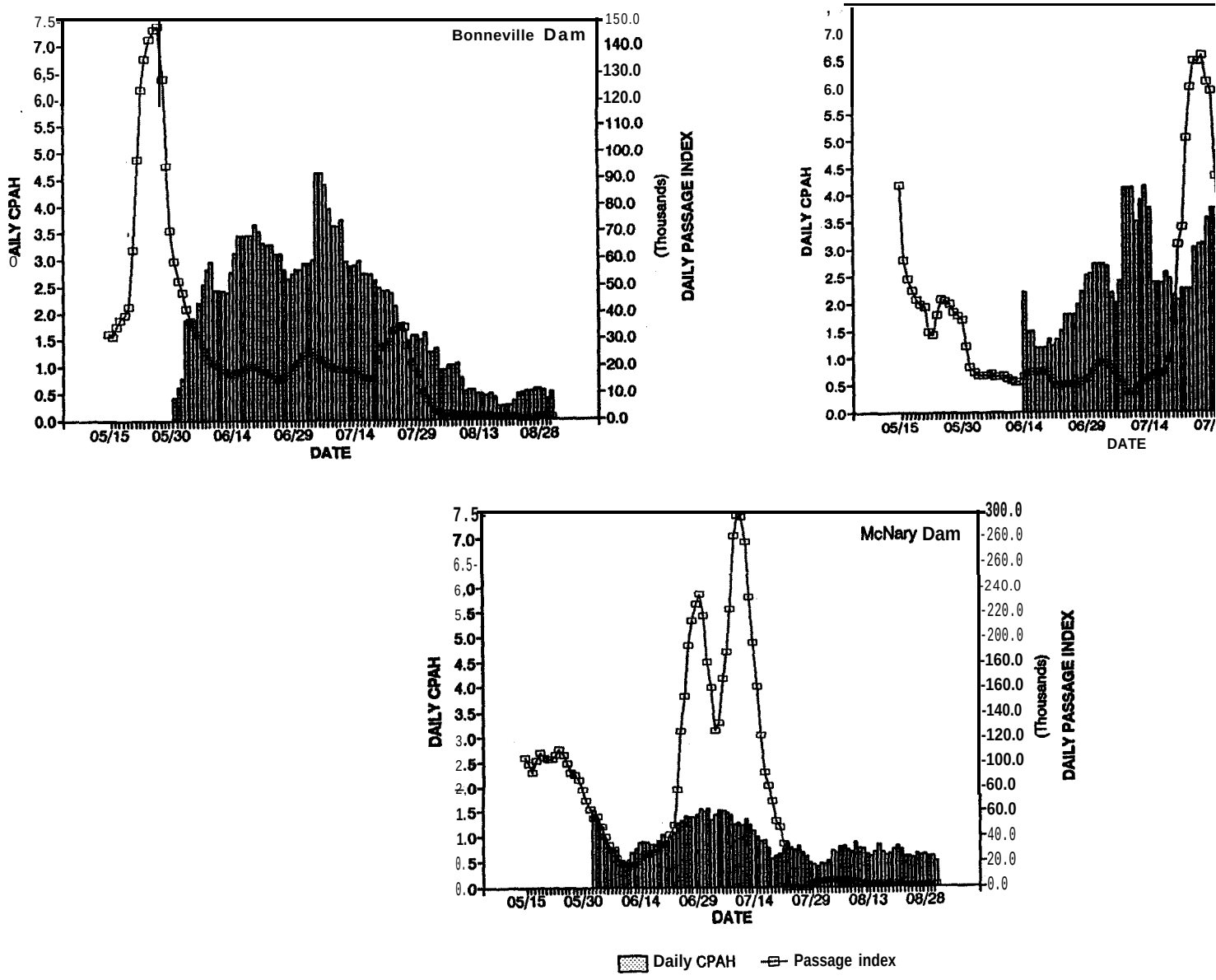


Figure 18. Northern squawfish catch per angler hour (cPAIi) and smelt passage indices at Colu
Passage information not available for The Dalles Dam. Note different scales for passage index.

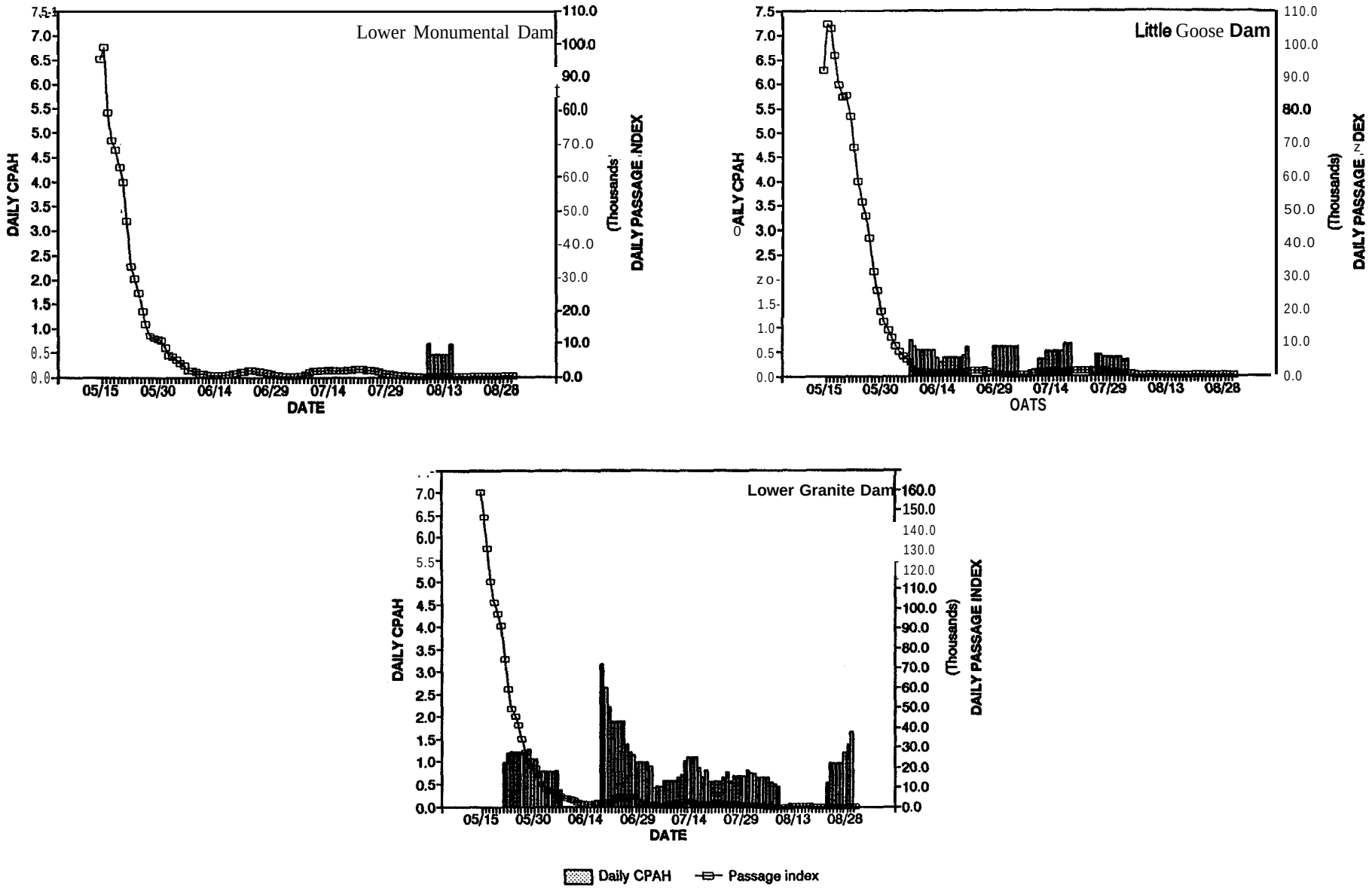


Figure 19. Northern squawfish catch per angler hour (CPAH) and smelt passage indices at Snake River dams, 1994. Passage information not available for Ice Harbor Dam. Note different scales for passage index.

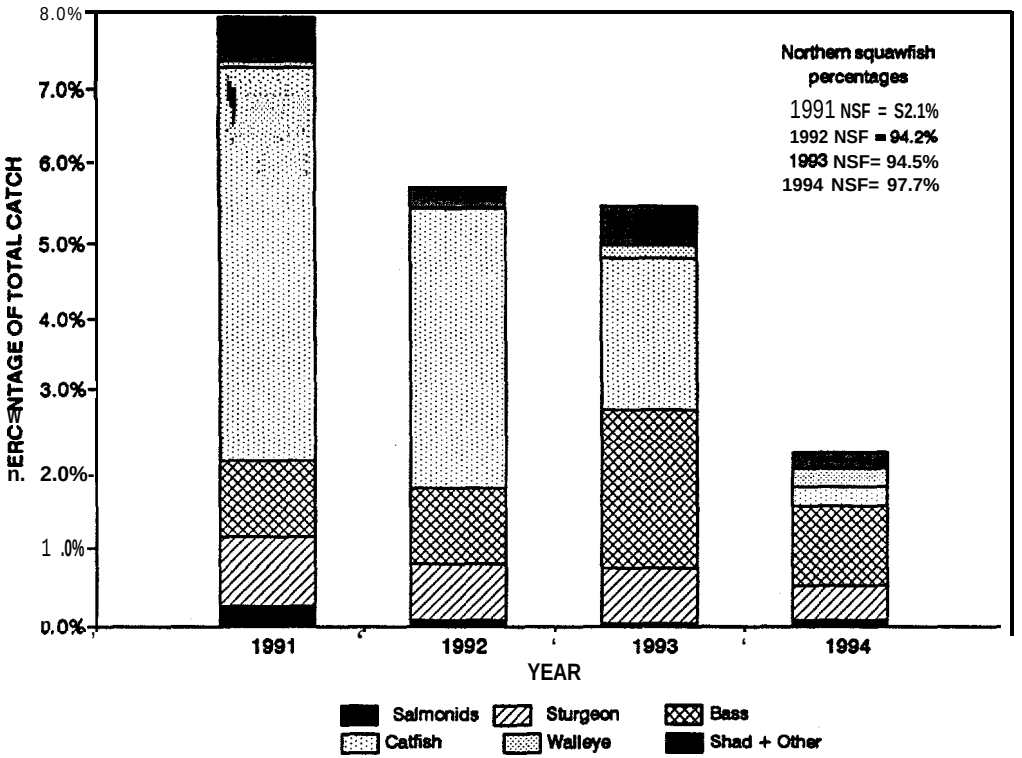


Figure 20. Percentage of total catch of all incidentally **caught fish and northern squawfish at Columbia and Snake River dams during 1991, 1992, 1993, and 1994.**

CONCLUSIONS AND RECOMMENDATIONS

L **Conclusion** - Hook-and-line angling at lower Columbia River and Snake River dams continues to be effective in removing predator-sized northern squawfish from areas where predation rates are high. Catch rates at Columbia River dams continue to be high at the lower-most dams (Bonneville and The Dalles), whereas MeNary Dam was less productive. At Snake River dams, Lower Granite Dam continues to be the most productive.

Recommendation - Continue controlled angling at all eight dams, concentrating most of the angling effort on the Columbia River. Specifically, increase effort (based on weekly catch rates) at Bonneville and The Dalles dams using one large crew whose effort is distributed between the two dams. Also, reduce effort at McNary Dam and maintain a level of effort at John Day Dam similar to that in 1994. Finally, continue to use one mobile crew at all Snake River dams with most of its effort directed at Lower Granite Dam.

2. Conclusion - In 1994, the most productive months at Columbia River and Snake River dams were July and May, respectively, which was consistent with results from previous years. Dawn and dusk continue to be the most productive time periods at most dams.

Recommendation - Distribute angling effort at each dam to improve efficiency. Daily effort should be distributed based on inseason monitoring of catch data and should encompass the most productive dams and time periods. Schedules and staffing levels should be:

Dam	Anglers	Season & effort patrn
Bonneville	6	May through August
The Dalles	6	May through August
John Day	4	Mid-June through early Sept.
McNary	5	June through August
Snake River dams	4	May through July; all dams staffed by a single crew

3. Conclusion - Results presented here suggest that dam outflow and catch rate of northern squawfish maybe inversely related. These results are consistent with radio-tagging data (R. Snively, NBS, personal communication) that show when discharge rates are high northern squawfish are mostly found in protected areas away from the dam.

Recommendation - Continue to use boats in the boat restricted zones near dams to target concentrations of northern squawfish beyond the reach of dam-based anglers, particularly during periods of high dam outflow. Expand these efforts below Columbia River dams to include a mobile crew whose primary responsibility will be to conduct boat-based angling, lure trolling, and longlining techniques. We include longlining on an experimental basis because its use may be effective when limited to boat restricted zones.

4. Conclusion - Volunteer angling efforts continue to be productive in catching northern squawfish at a low cost. Furthermore, the volunteer program provides participants with an opportunity to learn about the Northern Squawfish Management Program and to work cooperatively with other cultural groups.

Recommendation - Expand the volunteer angling effort at Columbia River dams (e.g., 8-10 volunteer groups). Two technicians will be dedicated to coordinating and overseeing these operations.

5. Conclusion - Angler expertise is a significant factor affecting catch rates of northern squaw-fish at dams.

Recommendation - When making hiring decisions for dam-angling positions, continue to consider past performance (i.e., angler catch and effort) for applicants previously employed on dam angling crews, and consider other hook-and-line angling experience for those not previously involved with the program.

6. Conclusion - Within-season evaluation of angling techniques and schedules is effective in maximizing catch rates of northern squawfish and minimizing the incidental catch of salmonids and sturgeon.

Recommendation - Continue analyzing data to better understand the factors affecting catch rates, and facilitate the timely transfer of that information to angling crews.

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APPENDIX A

1994 Tabular Data

Appendix Table A-1. Northern squawfish catch, effort, and catch per angler hour (CPAH), by statistical week, at Columbia River dams, 1994.

Statistical week #	Bonneville NSF	Bonneville Effort (h)	Bonneville CPAH	The Dalles NSF	The Dalles Effort (h)	The Dalles CPAH	John Day NSF	John Day Effort (h)	John Day CPAH	McNary NSF	McNary Effort (h)	McNary CPAH
20: 5108-5/14				77	22.73	3.4						
21: 5/15-5/21				105	46.47	2.3						
22: 5122-5/28				188	223.07	0.8						
23:5129-6104	138	108.25	1.3	140	110.37	1.3				92	76.57	1.2
24: 6/05-6/11	456	186.25	2.4	343	146.15	2.3				106	193.62	0.5
25:6112-6118	407	119.15	3.4	275	137.78	2.0	114	99.28	1.1	191	226.78	0.8
26:6119425	715	227.48	3.1	423	128.48	3.3	204	111.05	1.8	375	276.03	1.4
27: 6/26-7/02	530	178.73	3.0	639	247.33	2.6	274	101.57	2.7	346	222.57	1.6
28: 7/03-7109	979	246.48	4.0	455	157.65	2.9	214	67.97	3.1	313	259.88	1.2
29: 7/10-7116	688	219.15	3.1	383	140.82	2.7	276	104.87	2.6	213	244.43	0.9
30: 7/17-7/23	623	221.80	2.8	374	130.43	2.9	344	159.87	2.2	188	215.62	0.9
31:7124-7130	365	196.53	1.9	441	148.07	3.0	195	62.33	3.1	118	273.20	0.4
32: 7/31-8106	164	151.98	1.1	167	99.78	1.7	253	100.25	2.5	123	174.82	0.7
33:8107-8113	76	159.87	0.5	138	97.72	1.4	184	94.05	2.0	119	227.05	0.5
34: 8114-8/20	29	108.10	0.3	92	86.83	1.1	224	222.62	1.0	197	253.83	0.8
35:8121-8127	56	100.60	0.6	136	86.97	1.6	369	237.82	1.6	129	212.82	0.6
36: 8/28-9103	12	7.17	1.7	17	53.28	0.3	235	192.10	I .2	46	108.80	0.4
37:9104-9110							197	95.18	2.1			
Season	5,238	2,231.S5	2,4	4493	2,063.93	2.1	3,083	1,648.95	1.9	2,S56	2,966.02	0.9

Appendix Table A-2. **Northern squawfish** catch, effort, and catch per angler hour **(CPAH)**, by statistical week, at Snake River dams, 1994.

Statistical week #	Ice Harbor NSF	Ice Harbor Effort (h)	Ice Harbor CPAH	**Lower** Monumental NSF	**Lower** Monumental Effort (h)	**Lower** Monumental CPAH	Little Goose NSF	Little Goose Effort (h)	Little Goose CPAH	**Lower** Granite NSF	**Lower** Granite Effort (h)	**Lower** Granite CPAH
22: 5/22-5/28										93	76.65	1.2
23: 5129-6104										35	48.25	0.7
24: 6/05-6/11							29	56.02	0.5			
25:6112-6118							21	56.30	0.4			
26:6119-6125										160	90.33	1.8
27:6126-7102							12	19.80	0.6	62	64.85	1.0
28:7103-7109										36	64.12	0.6
29:7110-7116							17	35.82	0,5	52	47.17	1.1
30:7117-7123										38	66.42	0.6
31; 7/24-7130							13	35.47	0.4	32	46.57	0.7
32: 7/31-8/06										69	105,07	0.7
33: 8)07-8/13				27	55.45	0.5						
34: 8/14-8/20	14	84.37	0.2									
35: 8/21-8/27	4	41.57	0.1							46	47.72	1.0
36: 8128-9103	5	14.92	0.3							62	34.85	1.8
Season	23	140.85	0.2	27	55.45	0.5	92	203.4	0.5	68s	691.98	Lo

Appendix Table A-3. Monthly species composition of dam angling catch for Columbia and Snake River dams, 1994.

Month	Percent northern squawfish in total catch	Percent incidental species in total catch	Percent of total catch by species						
			Salmonids	Sturgeon	Bsas	Catfish	Walleye	shad	Other
COLUMBIA RIVER									
May	95.82%	4.18%	0.00%	0.00%	3.08%	0.00%	0.22%	0.00%	0.88%
June	98.28%	1.72%	0.07%	0.28%	0.91%	0.09%	0.07%	0.14%	0.16%
July	98.70%	1.30%	0.05%	0.19%	0.74%	0.19%	0.08%	0.05%	0.02%
August	95.24%	4.76%	0.18%	1.38%	1.85%	0.07%	1.03%	0.00%	0.25%
September	99.26%	0.74%	0.00%	0.00%	0.37%	0,00%	0.37%	0.00%	0.00%
Season	97.85%	2.15%	0.08%	0.43%	1.06%	0.12%	0.26%	0.07%	0.13%
SNAKE RIVER									
May	98.15%	1.85%	0.00%	0.00%	0.00%	1.85%	0.00%	0.00%	0.00%
June	98.39%	1.61%	0.00%	0.32%	0.00%	0.96%	0.00%	0.00%	0.32%
July	94.00%	6.00%	0.00%	1.00%	1.50%	3.50%	0.00%	0.00%	0.00%
August	92.28%	7.72%	0.00%	1.63%	0.41%	4.88%	0.00%	0.00%	0.81%
Season	95.61%	4.39%	0.00%	0.81%	0.46%	2.77%	0.00%	0.00%	0.35%
GRAND TOTALS									
May	96.27%	3.73%	0.00%	0.00%	2.49%	0,36%	0.18%	0.00%	0.71%
June	98.29%	1.71%	0.07%	0.28%	0.87%	0.13%	0.07%	0.13%	0.17%
July	98.55%	1.45%	0.05%	0.21%	0.76%	0.29%	0.08%	0.05%	0.02%
August	95.00%	5.00%	0.16%	1.40%	1.73%	0.46%	0.95%	0.00%	0.29%
September	99.26%	0.74%	0.00%	0.00%	0.37%	0.00%	0.37%	0.00%	0.00%
Season									

Appendix Table A-4. Monthly catch of incidental species by condition at release for Columbia and Snake river dams, 1994. Condition codes: 1) minimal injury, certain to survive, 2) moderate injury, may or may not survive, 3) dead, nearly dead, or certain to die, L) line cut or broken, fish not removed from the water.

Month	Total catch (all species)	Total incidental catch	Salmonids				Sturgeon				Bass			Cattish			Walleye			Shad	Other
			1	2	3	L	1	2	3	L	1	2	3	1	2	3	1	2	3		
COLUMBIA RIVER																					
May	455	19	0	0	0	0	0	0	0	0	14	0	0	0	0	0	1	0	0	0	4
June	5,698	98	4	0	0	0	7	0	0	9	52	0	0	5	0	0	4	0	0	8	9
July	6,367	83	2	1	0	0	9	0	0	3	45	2	0	12	0	0	4	1	0	3	1
August	2,817	134	3	1	1	0	9	1	0	29	50	1	1	2	0	0	28	1	0	0	7
September	269	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
Season	1S,606	336	9	2	1	0	25	1	0	41	162	3	1	19	0	0	38	2	0	11	21
SNAKE RIVER																					
May	108	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
June	311	5	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	1
July	200	12	0	0	0	0	0	0	0	2	3	0	0	7	0	0	0	0	0	0	0
August	246	19	0	0	0	0	0	0	0	4	1	0	0	12	0	0	0	0	0	0	2
Season	865	38	0	0	0	0	1	0	0	6	4	0	0	24	0	0	0	0	0	0	3
GRAND TOTALS																					
May	563	21	0	0	0	0	0	0	0	0	14	0	0	2	0	0	1	0	0	0	4
June	6,009	103	4	0	0	0	8	0	0	9	52	0	0	8	0	0	4	0	0	8	10
July	6,567	95	2	1	0	0	9	0	0	5	48	2	0	19	0	0	4	1	0	3	1
August	3,063	153	3	1	1	0	9	1	0	33	51	1	1	14	0	0	28	I	0	0	9
September	269	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
Season	16,471	374	9	2	1	0	26	1	0	47	166	3	1	43	0	0	38	2	0	11	24

Appendix Table A-5. Monthly species composition of dam angling catch for Columbia River dams, 1994.

Month	Percent northern squawfish in total catch	Percent incidental species in total catch	Percent of total catch by species						
			Salmonids	Sturgeon	Bass	Catfish	Walleye	Shad	Other
BONNEVILLE									
May	94. 12%	5.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.88%
June	99.29?4	0.71%	0.13%	0.18%	0.00%	0.00?4	0.00%	0.27%	0.13%
July	99.77%	0.23%	0.04%	o.ot3'%	0.08%	0.00%	0.00%	0.04%	0.00%
August	88.80%	11 ,20%	1.09?4	8.74%	0.27%	0.00%	0.55%	0.00%	0.55%
be	100.OOVO	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%'0	0,00%
Season	98.79%	1.21%	0.15%	0,72%	0.06%	0.00"/s	0.04%	0.13%	0.11%
THE DALLES									
May	95.89%	4.11%	0.00%	0.00%	3.20%	0.00%	0.23%	0.00'%	0.68%
June	96.99%	3.01%	0.00%	O.16%	2.52%	0,00%	0.22%	0.00%	0.1 1'%
July	97.41 %	2.59%	0.06%	0.06%	2.24%	0.00%	0.24%	0.00%	0.00%
August	89.72%	10.28%	0.00%	0.82%	7.50%	0.00%	1.79%	0.00%	0.16%
season	96.06"/.	3.94"/.	0.02%	0.20%	3.15%	0.00%	0.44%	0.00%	0.13%
JOHN DAY									
June	99.00%	1.00%	0.17%	0.17%	0.00%	0.00%	0.00%	0.33%	0.33%
July	98.47%	1.53%	0.10%	0.38%	0.67%'0	0.10%	0.10%	O.] 9%	0.00%
August	98<29%	1.71%	0.08%	0.08%	0.24%	0.00%	1.31%	0.00%	0.00%
September	99.22?40	0.78%	0.00%	0.00%	o.39%	0.00%	0.39?4	0.00%	0.00%
Season	98.56%	1.44%	0.10%	0,19"/0	0.35%	0.03"/0	0.58%	0.139'9	0.06%
McNARY									
June	97.96%	2.04%	0.00%	0.78%	0.58%	0.49%	0.00%	0.00%	0.19%
July	98,23%	1.77'%	0.00%	o.52%	0.00%	1.14%	0.00%	0.00%	0.10%
August	98.53'%	1.47%	0.00?40	0.16%	0.33%	0.33%	0.00%	0.00%	0.65%
					0.31 %	0.69%	0.00%	0.00%	0.27%

Appendix Table A-6. Monthly catch of incidental species by condition at release for Columbia River dams, 1994. Condition codes: 1) minimal injury, certain to survive; 2) moderate injury, mayor may not survive; 3) dead, nearly dead, or certain to die, L) line cut or broken, fish not removed from the water.

Month	Total catch (all species)	Total incidental catch	Salmonids				Sturgeon				Bass			Cattish			Walleye			Shad	Other
			1	2	3	L	1	2	3	L	1	2	3	1	2	3	1	2	3		
BONNEVILLE																					
May	17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
June	2,246	16	3	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	6	3
July	2,661	6	0	1	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	1	0
August	366	41	3	0	1	0	5	0	0	27	1	0	0	0	0	0	1	1	0	0	2
September	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Season	S,302	64	6	1	1	0	6	0	0	32	3	0	0	0	0	0	1	1	0	7	6
THE DALLES																					
May	438	18	0	0	0	0	0	0	0	0	14	0	0	0	0	0	1	0	0	0	3
June	1,825	55	0	0	0	0	1	0	0	2	46	0	0	0	0	0	4	0	0	0	2
July	1,697	44	1	0	0	0	1	0	0	0	37	I	0	0	0	0	3	1	0	0	0
August	613	63	0	0	0	0	3	0	0	2	44	1	1	0	0	0	11	0	0	0	1
Season	4,573	180	1	0	0	0	5	0	0	4	141	2	1	0	0	0	19	1	0	0	6
JOHN DAY																					
June	598	6	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2
July	1,047	16	1	0	0	0	4	0	0	0	6	1	0	1	0	0	1	0	0	2	0
August	1,226	21	0	1	0	0	0	1	0	0	3	0	0	0	0	0	16	0	0	0	0
September	257	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
Season	3,128	45	2	1	0	0	5	1	0	0	10	1	0	1	0	0	18	0	0	4	2
McNARY																					
June	1,029	21	0	0	0	0	4	0	0	4	6	0	0	5	0	0	0	0	0	0	2
July	962	17	0	0	0	0	4	0	0	1	0	0	0	11	0	0	0	0	0	0	1
August	612	9	0	0	0	0	1	0	0	0	2	0	0	2	0	0	0	0	0	0	4
Season	2,603	47	0	0	0	0	9	0	0	5	8	0	0	18	0	0	0	0	0	0	7

Appendix Table A-7. Monthly species composition of dam angling catch for Snake River dams, 1994.

Month	Percent northern squawfish in total catch	Percent incidental species in total catch	Percent of total catch by species						
			Salmonids	Sturgeon	Bass	Catfish	Walleye	Shad	Other
ICE HARBOR									
August	65.71 %	34.29%	0.00%	8.57%	2.86%	17.14%	0.00%	0.00%	5.71%
Season	65.71 %	34.29%	0.00%	8.57%	2.86%	17.14%	0.00%	0.00%	5.71%
LOWER MONUMENTAL									
August	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Season	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LITTLE GOOSE									
June	96.88%	3.13%	0.00%	0.00%	0.00%	3.13%	0.00%	0.00%	0.00%
July	85.71%	14.29%	0.00%	0.00%	8.57%	5.71%	0.00%	0.00%	0.00%
Season	92.93%	7.07%	0.00%	0.00%	3.03%	4.04%	0.00%	0.00%	0.00%
LOWER GRANITE									
May	98.15%	1.85%	0.00%	0.00%	0.00%	1.85%	0.00%	0.00%	0.00%
June	98.79%	1.21%	0.00%	0.40%	0.00%	0.40%	0.00%	0.00%	0.40%
July	95.76%	4.24%	0.00%	1.21%	0.00%	3.03%	0.00%	0.00%	0.00%
August	96.20%	3.80%	0.00%	0.54%	0.00%	3.26%	0.00%	0.00%	0.00%
Season	97.30%	2.70%	0.00%	0.57%	0.00%	1.99%	0.00%	0.00%	0.14%

Appendix Table A-8. Monthly catch of incidental species by condition at release for Snake River dama, 1994. Condition **codes: 1)** minimal injury, certain to **survive;** 2) moderate injury, mayor may not survive, 3) dead, nearly dead, or certain to die, L) line cut or broken, fish not removed from the water.

Month	Total catch (all species)	Total incidental catch	Salmonids				Sturgeon			Bass			Catfish			Walleye			Shad	Other
			1	2	3	L	1	2	3L	1	2	3	1	2	3	1	2	3		
ICE HARBOR																				
August	35	12	0	0	0	0	0	0	0	3	1	0	0	6	0	0	0	0	0	2
Season	35	12	0	0	0	0	0	0	0	3	1	0	0	6	0	0	0	0	0	2
LOWER MONUMENTAL																				
August	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Season	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LITTLE GOOSE																				
June	64	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
July	35	5	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0
Season	99	7	0	0	0	0	0	0	0	0	3	0	0	4	0	0	0	0	0	0
LOWER GRANITE																				
May	108	2	0	0	0	0	0	0	0	0	0	0	0	,2	0	0	0	0	0	0
June	247	3	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
July	165	7	0	0	0	0	0	0	0	2	0	0	0	5	0	0	0	0	0	0
August	184	7	0	0	0	0	0	0	0	1	0	0	0	6	0	0	0	0	0	0
Season	704	19	0	0	0	0	1	0	0	3	0	0	0	1A	0	0	0	0	n	1

APPENDIX B

Crew Questionnaire

In 1994, a questionnaire was given to resident-crew members to gain useful information about the dam-angling fishery from experienced fisheries technicians. The questionnaire contained two parts: (1) open-ended questions aimed at gathering detailed information on methods and equipment that were used successfully, and (2) a survey to rate components of the fishery (1=excellent through 5=poor) to identify areas needing improvement. The results of the questionnaire are summarized here.

Locating Northern Squawfish

To detect northern squawfish concentrations at dams, technicians utilized the following methods and cues:

- Previous knowledge of different sites at dams.
- Communication with other dam anglers and crews.
- Data summaries and feedback provided by project staff.
- Monitoring predator activity of the gulls and northern squawfish.
- Random fishing (prospecting) of different sites at dams.
- Sites having artificial light at night.
- Water conditions.

Changing water conditions at dams were identified by technicians as being particularly important in locating concentrations of northern squawfish. Specifically, technicians found catch rates of northern squawfish to be high in tailrace areas near turbine boils and back-eddies.

Catching Northern Squawfish

Equipment

Crews used a variety of rods, reels, lines, and baits with varying success (Appendix Table B-l). The majority of technicians used 7- and 8-foot fishing rods. The rigors of this fishery require that reels be extremely durable, and the majority of the reels performed well (Appendix

Scheduling

Technicians agree catch rates of northern squawfish are better during night and early morning hours and schedules should encompass these periods. Specific recommendations concerning schedules were:

- Crews fish additional hours from Mid-June to Mid-July when the "bite is on" to maximize catch. This includes increased weekend scheduling.

  Go to split-shifts toward the end of the dam-angling season when catch rates begin to decline; the first shift lasting from sundown to midnight, and the second shift from approximately 3 a.m. to 8 a.m.

- Begin season earlier on Snake River dams to improve catch rate.

- Work during periods of low tide at Bonneville Dam, at which time catch rates were observed to be relatively high by anglers at that darn.

Reducing Incidental Catch

To reduce incidental catch even further, supervisors and technicians with past dam-angling experience have suggested:

- Not fishing in forebay areas at some dams.
  Better supervision and training of inexperienced technicians.

Alternative Fisheries

Technicians recommended several alternative fisheries for northern squawfish. Longlining was suggested as an effective way to remove northern squawfish from tailrace areas. Also, an organized effort to render the northern squawfish incidentally caught by treaty salmon fishermen may result in the removal of large numbers of northern squawfish. The number of northern squawfish in gill-net catches, and traditional hoop nets and dip nets fished from scaffolds, is high during the spring and late August through September. Currently, northern squawfish caught by these methods are not eligible for reward in the sport-reward program. Technicians believe that if there were a reward for these fish, more northern squawfish might be recorded and accounted for under the Columbia River Northern Squawfish Management Program.

Conclusions

We believe that the information gained from the technician questionnaire can improve dam-angling effectiveness. Based on the information provided by technicians, we will work to:

Facilitate information exchange between project staff and crews regarding successful sites, times, baits, and methods.

Provide advanced information regarding tide, spill, and turbine schedules to each crew.

- Work with crews to set schedules that will be most productive.

- Investigate other opportunities to remove northern squawfish.

- Continue to solicit comments from technicians to improve existing and future fisheries.

Appendix Table B-1. Evaluation of dam angling equipment used by technicians in 1994.

Equipment	Make/Model	Recommendations For Use
Rods	Daiwa Black Widow	All models recommended
	Shakespeare Ugly Stik	7 ft. rods better suited for bank fishing and boat angling.
	Bass Pro Shop Power Stick	8 ft. rods cast more efficiently and do not rub fishing line against dam when reeling NSF to the top of the dam decks.
Reels	FenWick	Preferred, withstands rigors of fishery; Crank assembly lacks spring that fatigues in other reels.
	Penn	Not recommended, lacks power when reeling up to dam decks
Line	DuPont XT Solar	Highly visible, preferred when working at night.
	Spectra Spiderwire	Lack of stretch preferred for high velocity conditions.
	Berkley Trilene DuPont Stren	Good for all-around use.

REPORT D

Site-Specific Removal of Northern Squawfish Aggregated to Feed on Juvenile Salmonids in the Spring in the Lower Columbia and Snake Rivers Using Gill Nets and Trap Nets

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1994 Annual Report

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ABSTRACT

As part of a site-specific fishery, small-meshed gill nets and mobile Merwin traps caught 9,024 predator-sized (≥250 mm fork length) northern squawfish (*Ptychocheilus oregonensis*) from areas where they concentrate to feed on hatchery-released juvenile salmonids (*Oncorhynchus* spp.) in the lower Columbia and Snake rivers. Most of these fish were caught in gill nets (99.9%) and at locations in Bonneville Pool (98.5%). Merwin traps were ineffective (total catch of predator-sized northern squawfish = 6), despite the placement of traps in areas where gill-net catches of northern squawfish were high. The mouth of the Klickitat River was the most productive location fished in 1994 in terms of both total gill-net catch (6,253) and catch rate (catch-per-net-hour 10. 1), foIlowed by three other locations in Bonneville Pool (Drano Lake, Wind River, and Spring Creek). The most productive locations outside Bonneville Pool were the mouths of the Umatilla and Clearwater rivers, with a combined gill-net catch of 86 predator-sized northern squawfish and catch-per-net-hour of 1.1. Gill nets caught larger predators (average fork length = 410.4 mm), whereas Merwin traps were less size-selective (average fork length= 233.4 mm). The total incidental catch for both gill nets and Merwin traps was 5,876 fish, with suckers (*Catostomous* spp.) being the predominate species caught in gill nets, and salmonids (mostly juveniles) in Merwin traps. Innovations to Merwin traps to minimize impacts to juvenile

salmonids were developed and tested successfully. Further developments and changes to the site-specific fishery are recommended to improve our efficiency and productivity.

INTRODUCTION

In 1990, the Columbia River Northern Squawfish Management Program was implemented to reduce predation by northern squawfish (*Ptychocheilus oregonensis*) on outmigrating juvenile salmonids (*Oncorhynchus* spp.) in the lower Columbia and Snake rivers. The program goal is to sustain a 10-20°A annual exploitation rate on predator-sized (≥250 mm fork length) northern squawfish, which over several years may result in a 50°/0 or greater reduction in predation on juvenile salmonids (Rieman and Beamesderfer 1990). Various predator-control fisheries were implemented as part of the Squawfish Management Program, and after three years it was determined that further development of management alternatives was required to reach the desired exploitation rate.

In 1993, the Columbia River Inter-Tribal Fish Commission (CRITFC) and Yakama Indian Nation (YIN) investigated a site-specific predator control fishery that used small-meshed gill nets to remove northern squawfish from areas where they concentrate to feed on hatchery-released juvenile salmonids (Collis et al. 1995a). We hypothesized that by targeting feeding concentrations of northern squawfish, we would effectively remove large numbers of mostly predator-sized fish from areas where predation rates are high, thereby maximizing the survival benefits to out-migrating juvenile salmonids accruing from our fishing efforts. Furthermore, we believed that the timing and methodology of the proposed site-specific fishery would minimize incidental impacts to both juvenile and adult salmonids, particularly stocks listed as threatened or endangered.

Our 1993 results suggested that a site-specific fishery targeting northern squawfish near hatchery-release points in the spring could be productive, while keeping incidental impacts to salmonids to a minimum (Collis et al. 1995b). Catch rates of predator-sized northern squawfish more than doubled from before to after release at three locations where hatchery salmon were released in Bonneville Pool (Collis et al. 1995a). Northern squawfish caught after the release of juvenile salmonids had a significantly higher frequency of occurrence and mean number of juvenile salmonids in their diet compared to fish caught before release (Collis et al. 1995a). The average length of fish captured in the site-specific fishery was greater than in all other predator control fisheries in 1993, with the exception of dam angling (Wink and Ward 1995). Our data suggest that site-specific ‘removal of northern squawfish concentrated near hatchery release points could increase the current exploitation rate of northern squawfish. Furthermore, by targeting feeding concentrations of northern squawfish, this fishery has the advantage of removing larger predators from areas where predation rates on juvenile salmonids are high.

We investigated the step-wise implementation of a site-specific fishery using small-meshed gill nets and mobile Merwin traps to locate and target for removal concentrations of northern

squawfish near hatchery-release points in the lower Columbia and Snake rivers. Our objectives were to (1) expand the site-specific fishery to additional locations where northern squawfish might concentrate to feed on hatchery-released juvenile salmonids and (2) test the feasibility of an integrated sampling plan that uses both small-meshed gill nets and mobile Merwin traps to remove predator-sized northern squawfish from these areas, while minimizing impacts on salmonids.

METHODS

In 1994, three boat crews sampled at night in areas between the mouth of the Wind River and the head of Lake Wallula (McNary Pool) on the Columbia River, and the mouth of the ClearWater River on the Snake River (Figures 1 and 2; Table 1). Additionally, a separate crew operated a mobile Merwin trap in the cul-de-sac at The Dalles Dam (Figure 2). Sampling was conducted where northern squawfish were expected to concentrate to feed on juvenile salmonids, specifically below hatchery release points, near dams, and near the mouths of tributaries. The National Marine Fisheries Service (NMFS) Section 7 permitting process delayed commencement of this fishery for approximately 1.5 months. The ensuing season lasted from mid-April through early June, when operational criteria established to minimize impacts to salmonids were reached (i.e., A.5.c. and A.5.d., see Appendix A).

Tribal technicians were assisted by student volunteers enrolled in a cooperative education program at Mt. Hood Community College. Three volunteers worked one night a week for the duration of the season for college credit and work experience in fisheries science.

Sampling Design

An integrated sampling plan used small-meshed gill nets while mobile Merwin traps (Figure 3; for specifications see Mathews et al. 1991) were investigated as a way to increase the efficiency and productivity of the site-specific fishery. We hypothesized that Merwin traps would catch a greater number of northern squawfish per-unit-effort than small-meshed gill nets if deployed where these predators were concentrated (for discussion of Merwin trap effectiveness, see Lynch 1993). The integrated sampling plan involved three major steps:

1. Use current hatchery-release information and existing data on the seasonal patterns of northern squawfish density and abundance to construct a general sampling schedule (e.g., locations and times).

2. Set small-meshed gill nets (8 ft deep x 150 ft long constructed from 25-ft panels with the repeating mesh size sequence: 2“ and 13/4” bar measures) in these locations to find local concentrations of northern squawfish.

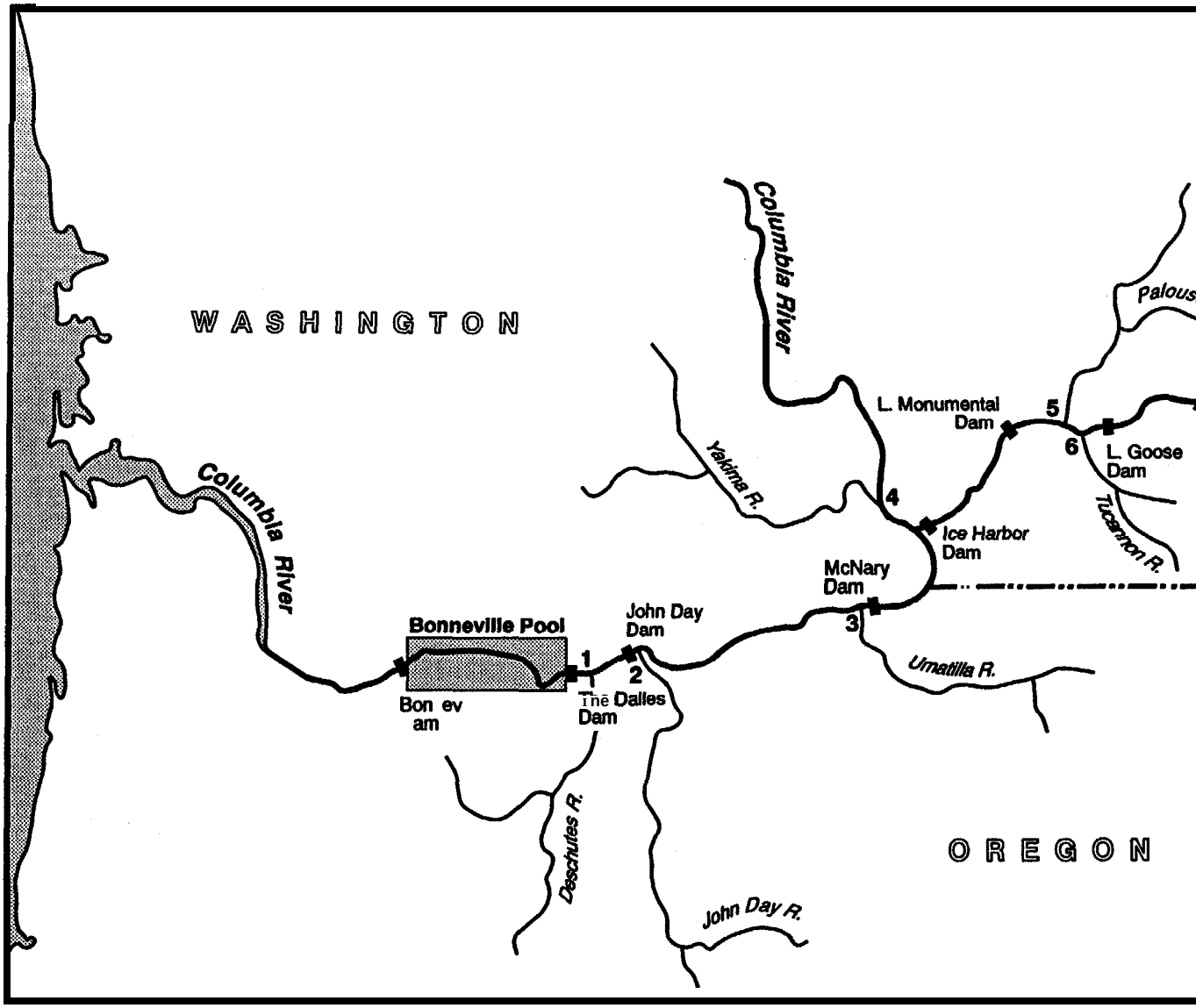

Figure 1. Sampling locations above Bonneville Pool (see **Figure 2-2** fo locations in Bonneville Pool), 1994. Locations are: 1 = **Miller** Island: **River;** 3 = **Umatilla** River; 4 = **Yakima River;** 5 = Lyons Ferry; 6 = **Tuca** and 7 = **Clearwater River.**

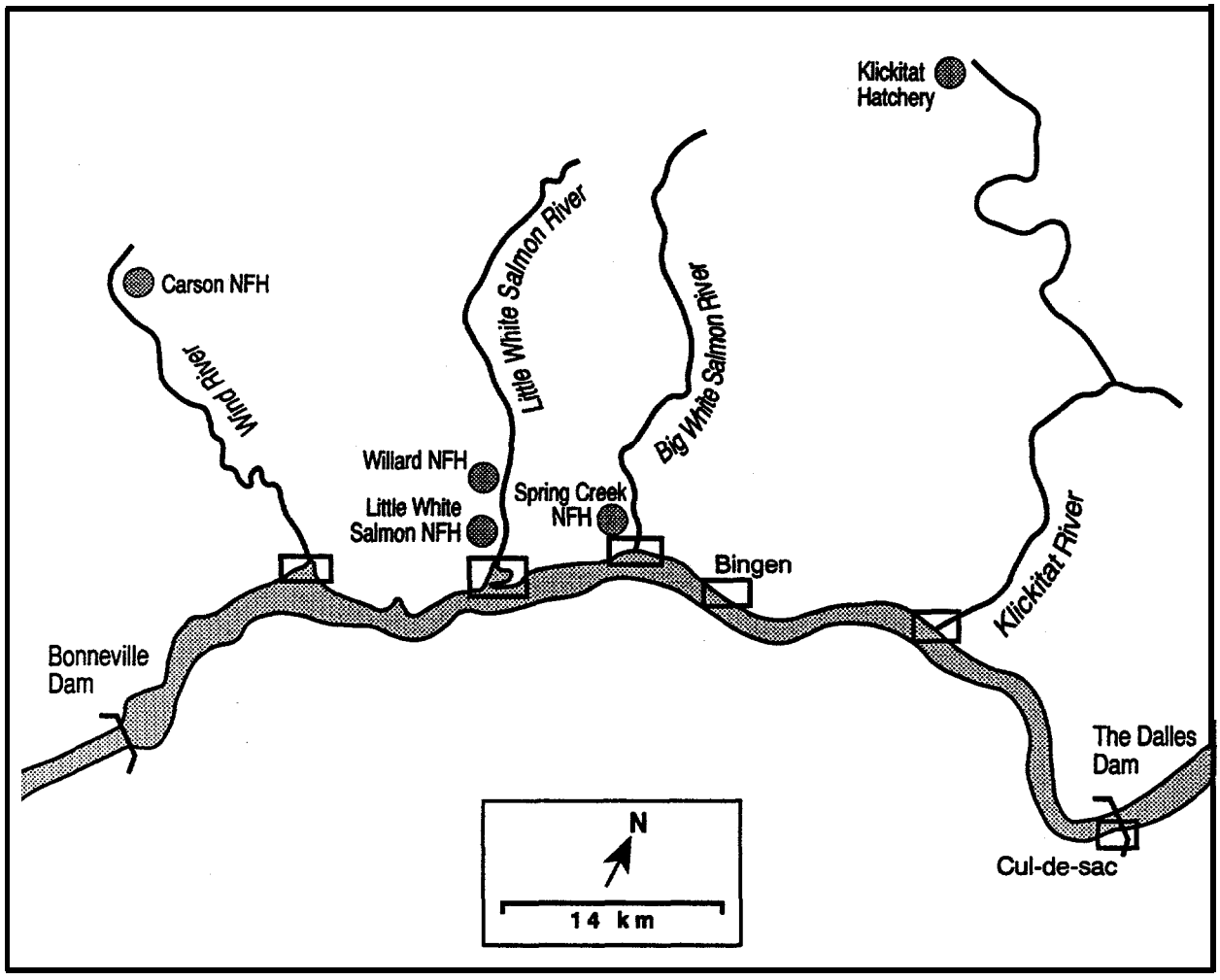

Figure 2. Sampling locations (shown **in** boxes) **in** Bonneville Pool, **1994.** Locations are (left to right): Wind **River;** Drano Lake; **Spring** Creek; **Bingen; Klickitat River;** and the Cul-de-sac at The **Dalles** Dam.

Table 1. Distribution of site-specific fishery effort at locations on the Columbia and Snake rivers in 1994.

Location	River mile	Dates worked - (crew nights fished)	Crew[a]
Bonneville Pool			
Wind River	154	4/25 - 5m4 (7)	CRITFC[b]
Drano Lake	162	4/19-5/31 (31)	CRITFC[c]
spMg creek	167	4/26, 5/19 (2)	CRITFC
Bingen	172	4123 (1)	CRITFC
Klickitat River	180	4/21 - 6/06[d] (43)	CRITFC[c]
The Dalles Dam (cul-de-sac)	192	5/05 - 5/23 (5)	CTWS
The Dalles Pool			
Miller Island	205	6/08 (1)	CRITFC
John Day Pool			
John Day River	218	6/02 (1)	YIN
Umatilla River	289	4120,5131 (2)	YIN
McNary Pool			
Yakima River	327	4/08 - 5/16 (6)	YIN
Lower Monumental Pool			
Lyons Ferry	59	4/21 (1)	NPT
Tucannon River	62	4/20 (1)	NPT
Little Goose Pool			
Lower Granite Dam (tailrace)	107	6/06 - 6/09 (4)	NPT
Lower Granite Pool			
Clearwater River	139	5/04 - 6ml (5)	NPT

[a] CRITFC = Columbia River Inter-Tribal Fish Commission; CTWS = Confederated Tribes of Warm Springs Reservation, YIN = Yakama Indian Nation; NPT = Nez Perce Tribe.
[b] CRITFC crew assisted by YIN crew.
[c] CRITFC crew assisted by YIN and NPT crews.
[d] Crew training occurred on one night in March (3/09). Roughly, 3 hr of gill-net sampling were done and those results are included in subsequent data summaries.

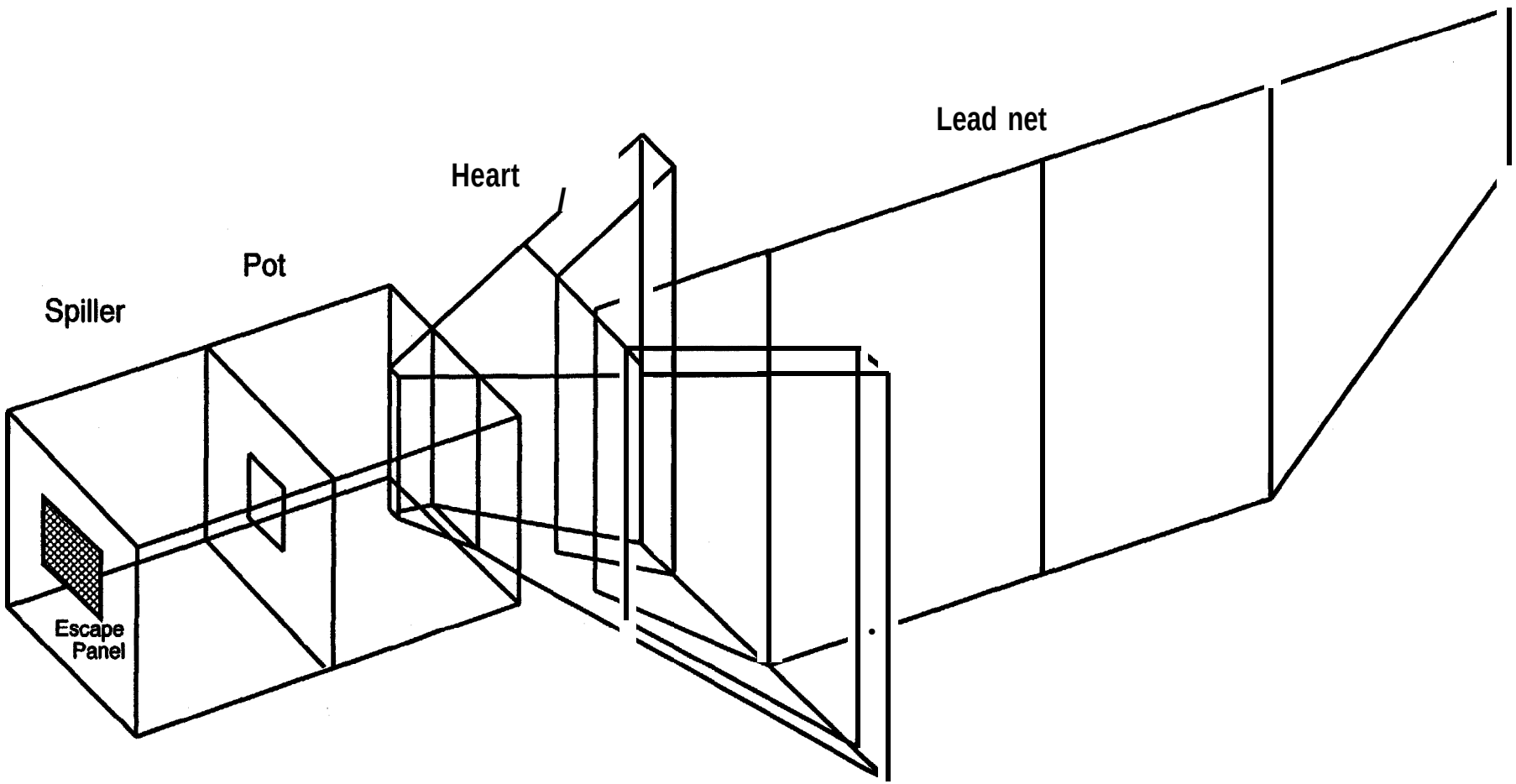

Figure 3. **Diagram** of the mobile **Merwin** traps used in the site-specific fishery in 1994. Escape panel constructed from 2-in (bar measurement) monofilament **gillnetting** affixed to the spiller just below the water line using velcro.

3. Deploy Merwin traps when and where gill-net catches are high, while, through careful monitoring, minimizing the incidental catch of other species, particularly salmonids.

Merwin traps were deployed when (1) ≥ 10 northern squawfish per-net-hour were caught in three consecutive gill-net sets (approximately 45 midset) and (2) gill-net catches of salmonids did not exceed operational criteria established for gillnetting (see Appendix A). An exception was the cul-de-sac at The Dalles Dam, where Merwin traps were deployed without previous gill-net sampling. Merwin traps were checked once every three hours. Concurrent gill-net sampling at other locations and sites within a location supplemented the Merwin trap sampling and was used in decisions to either relocate or discontinue trapping efforts. More effort was devoted to gillnetting when Merwin trapping proved to be relatively unproductive.

To minimize potential impacts of Merwin traps on juvenile sahnonids, an escape panel of a larger mesh size (2" bar measure) was sewn into the spiller (Figure 3) so that juveniles could escape the trap without having to be removed with a dip net. The impacts of gill nets to juvenile salmonids were negligible because the mesh size was large enough that juveniles could easily pass through the net. Additional information on the specifications of the gear used in this study and handling of the incidental catch can be found elsewhere (gill nets: Collis et al. 1995b; mobile Merwin traps: Iverson et al. 1992; also see Appendix A for Operational Criteria).

Data Collection and Analysis

We enumerated the catch of each net and trap and measured fork length from a random sample of up to five northern squawfish from each net or trap. Unless otherwise noted, subsequent data summaries and analyses include only predator-sized (≥ 250 mm fork length) northern squawfish. We compared catch and catch rate (catch-per-gillnet-hr or trap-hr; CPUE) for different gears, areas (e.g., pools, locations), and time periods (e.g., month, diel period, before and after release). Incidentally caught fish were identified and immediately released back into the river. Incidentally caught game fish were assigned one of three condition codes at the time of release: (1) minimal injury, certain to survive; (2) moderate injury, mayor may not survive; or (3) dead, nearly dead, or certain to die. Additionally, all salmonids caught were identified as either juvenile or adult and examined for external marks or fin clips. Also, we gathered specific information on the condition of each salmonid at release (i.e., Was the fish bleeding?, Did the fish free itself from the net?, How was the fish caught in the net?).

Statistical comparisons are by Student t-test (t) and Kendall rank correlation (r_t). All p values are two-tailed. Means are expressed as $\bar{X} \pm$ SE.

RESULTS AND DISCUSSION

Northern Squawfish Catch

Distribution of Catch and Effort

In 1994, we caught a total of 9,159 northern squawfish (Table 2). The majority (99.4%) of these fish were caught in gill nets and most (98.5%) were predator-sized (≥ 250 mm fork length). Overall, gill nets were fished for 1,375 net hours and caught 9,018 predator-sized northern squawfish, for a seasonal catch-per-net-hour (CPUE) of 6.6. Merwin traps were ineffective despite placing the traps in areas where gill-net catches of northern squawfish were high (see Gear Effectiveness). Mobile Merwin traps caught only six predator-sized northern squawfish in 67.4 hr of trap effort, for a seasonal catch-per-trap-hour (CPUE) of 0.1. Unless otherwise noted, data summaries that follow refer to gill-net catches of predator-sized northern squawfish.

Bonneville Pool was the most productive of the seven pools we fished in both total catch (Figure 4) and CPUE of northern squawfish (Figure 5). In Bonneville Pool, we caught 8,884 northern squawfish in 1,128 hr of effort, for a seasonal CPUE of 7.9. Of the remaining pools, Lower Granite and John Day were the most productive (Figures 4 and 5), with a combined catch of 96 northern squawfish in 96.5 hr of effort, for a seasonal CPUE of 1.0. The late stint, high flows, and regional concerns about incidental impacts to salmon at some locations precluded a thorough investigation of potentially productive sites outside of Bonneville Pool. Generally, gillnetting effort was distributed in pools and at locations that were most productive based on relative catch rates (Figure 5).

The mouth of the Klickitat River was the most productive location that we fished in 1994 (CPUE = 10. 1), followed by three other locations in Bonneville Pool (Table 2). The mouth of the Umatilla River (CPUE = 1.2) was the most productive location outside of Bonneville Pool, followed by the mouths of the Clearwater and John Day rivers (Table 2). There are several possible explanations for the higher catch rates of predator-sized northern squawfish at locations within Bonneville Pool relative to locations in other pools. First, it is likely that differences in the total number of hatchery fish released within a pool and at a location affect catch rates (Table 3). In 1994, approximately 22.6 million juvenile salmonids were released at locations we sampled in Bonneville Pool, compared to 11.9 million fish at all locations combined outside Bonneville Pooh (Table 3; Fish Passage Center, unpublished data). Furthermore, we found that catch rates of northern squawfish are positively correlated with the total number of hatchery fish released[1] at a given location (r_s = 0.62, p = 0.02; Figure 6). Second, although there were more releases at locations worked outside Bonneville Pool, most of those were small (8 l% of hatchery releases were <500,000 juvenile salmonids) compared to the releases at locations worked in Bonneville

[1] Does not include numbers of fish released after the closing of the fishery (June 9).

Pool (37% of hatchery releases were< 500,000 juvenile salmonids; Table 3). Third, higher flow velocities at some sampling sites in upriver locations, as compared to Bonneville Pool, sometimes precluded or limited gill-net sampling and could have reduced residence time of juveniles at those sites. Finally, due to limited time and resources, we were unable to thoroughly investigate locations outside Bonneville Pool.

May was the most productive month in both total catch and CPUE of northern squawfish (Figure 7). We expect that sampling in April would have been more productive if the fishery had not been delayed until April 192. Roughly 70°/0 of the April hatchery releases occurred before our sampling began at those locations (Table 3). Delays in the commencement of this fishery eliminated all sampling in March, with the exception of roughly 3 hr of crew training at the Klickitat River on March 9. Catch rates were high during this training period (CPUE = 11.1) indicating that March also might have been very productive.

Operational criteria (see Appendix A), established to minimize impacts to salmonids, were reached (i.e., A.5.c. and A.5.d., see Appendix A) in early June (June 8, 1995), which ended the fishery despite high catch rates of northern squawfish at some locations (e.g., CPUE = 7.9 at the Klickitat River in June). We estimate that approximately 6,000 more predator-sized northern squawfish might have been caught given a timely start of the fishery and less restrictive operational criteria.

The timing and duration of elevated catch rates of northern squawfish in a sampling location appear to be directly related to the release date and subsequent residence time of hatchery-released fish in the area (Collis et al. 1995a). To test this hypothesis, two locations (Drano Lake, Klickitat River) were sampled throughout a release period (i.e., before, during, and after release) in 1994. There is some evidence to support this hypothesis, because catch rates peaked during or immediately following hatchery releases at those locations (Figure 8).

Catch rates of northern squawfish were highest at sunset and sunrise, when catch rates of adult salmonids were lowest (Figure 9). Operational criteria in 1994, established to minimize impacts to salmonids, required that our sampling end no later than one hour before sunrise (i.e., A.2., see Appendix A). However, the dawn time period[3], seems to be the most effective in catching northern squawfish and avoiding salmonid by-catch (Figure 9; see Recommendations for suggested changes to criteria).

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[2] Sampling at the mouth of the Yakima River, which is not defined as critical habitat for listed species, began earlier (April 8), before the issuance of a biological opinion by the National Marine Fisheries Service.

[3] Sampling during this time period occurred because equipment (primarily boat) failure or high catch rates made it impossible to remove the nets from the water any earlier.

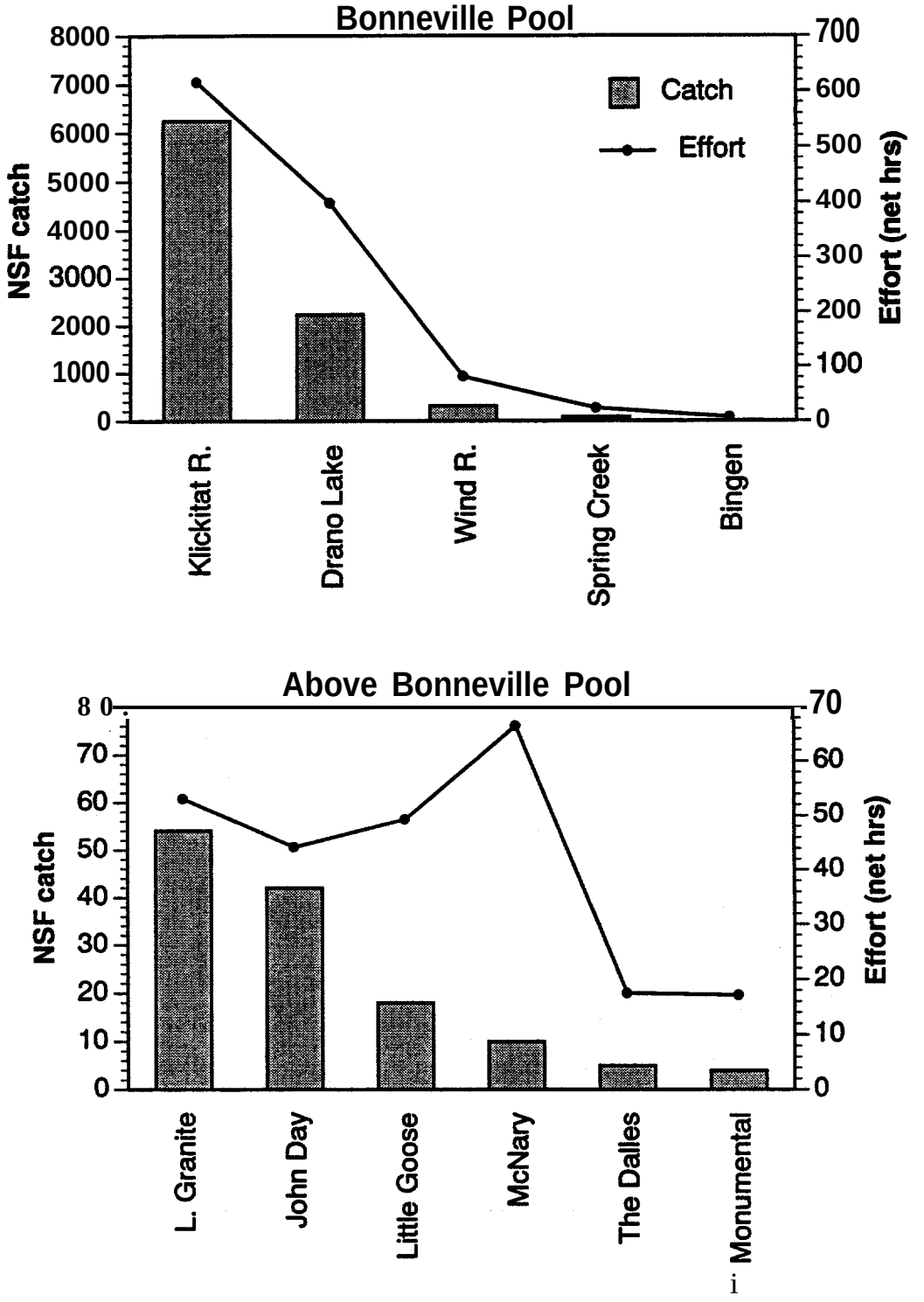

Figure 4. Northern squawfish (NSF) gillnet catch and effort at locations in Bonneville Pool and in pools above Bonneville Pool in 1994. Locations and pools arranged in order of highest to lowest catch (left to right).

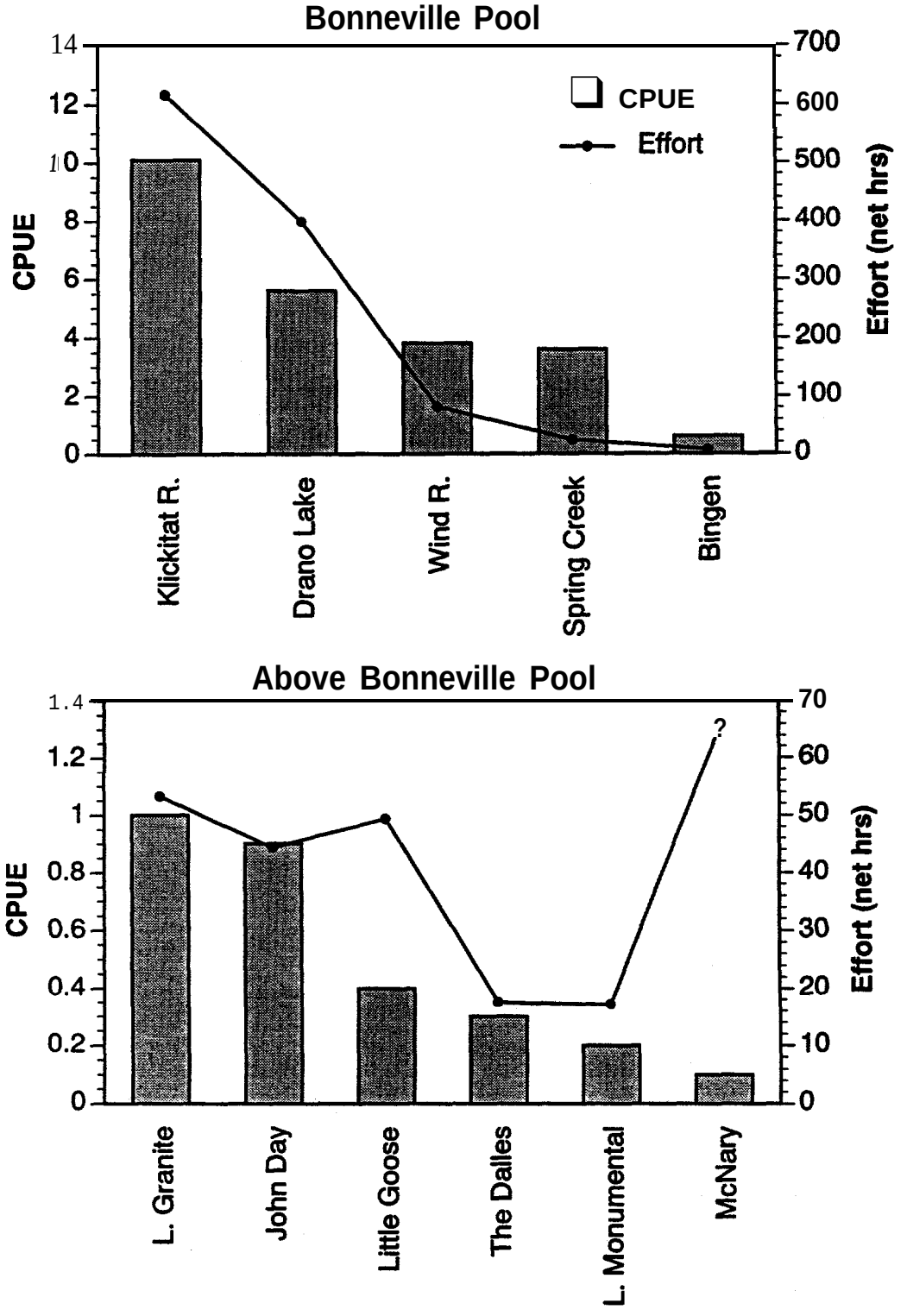

Figure 5. Northern **squawfish gillnet** catch-per-net-hr **(CPUE)** and effort at locations **in** Bonneville Pool and **in** pools above Bonneville Pool **in** 1994. Locations and pools arranged **in** order of highest to lowest CPUE (left to right).

Table 2. Northern squawfish (NSF) catch, effort, and catch-per-unit-effort (CPUE) for Merwin traps and gill nets at locations on the lower Columbia and Snake rivers in 1994.

	Merwin trap					Gill net				
Location	Crew nights fished	Effort[a]	Sm NSF[b]	Lg NSF[c]	CPUE[d]	Crew nights fished	Effort[e]	Sm NSF[b]	Lg NSF[c]	CPUE[d]
Klickitat R.	6	21.0	0	3	0	44	616.5	69	6,253	10.1
Drano Lake	3	9.9	0	0	0	31	399.1	9	2,231	5.6
Wind R.	—	—	—	—	—	7	81.6	0	3 2	3.8
Spring Creek	—	—	—	—	—	2	23.4	2	84	3.6
Umatilla R.	—	—	—	—	—	2	27.6	4	32	1.2
Clearwater R.	—	—	—	—	—	5	53.2	1	54	1.0
John Day R.	—	—	—	—	—	1	15.7	0	10	0.6
Bingen	—	—	—	—	—	1	7.1	0	4	0.6
Lyons Ferry	—	—	—	—	—	1	10.3	2	5	0.4
L. Granite Dam	—	—	—	—	—	4	49.3	0	18	0.4
Miller Is.	—	—	—	—	1		17.5	0	5	0.3
Yakima R.	—	—	—	—	1	6	66.5	0	0	0.1
Tucannon R.	—	—	—	—	—	1	6.8	0	0	0.0
The Dalles Dam	5	36.5	30	3	0.1	—	—	—	—	—
TOTAL	**14**	**67.4**	**48**	**6**	**0.1**	**106**	**1,374.6**	**87**	**9,018**	**6.6**

[a] trap hr.
[b] < 250 mm (fork length).
[c] ≥ 250 mm (fork length).
[d] CPUE for NSF ≥ 250 mm (fork length).
[e] net hr.

Table 3. Hatchery releases of juvenile salmonids from April-June at locations on the lower Columbia and Snake rivers in **1994.**

Location	Pool[a]	Total number released (million)	Number of releases	Date(s) of release[b] April	May
Wind R.	BO	2.1	2	**14-**, 22-	
Drano Lake	BO	8.2	6	**14**, **14**, **14**	19
Spring Creek	BO	7.6	2	**14**	**19**
Klickitat R.	BO	9.5	10	**11-**, **15**, **19-**, 25-,26-,29	**17**, 3
Umatilla R.	JD	4.8	10	1-, **4-**, 5-, 11, 13,15,19	12, **20**,
Yakima R.	MC	2.6	3	7-	1, **15**
Lyons Ferry	LM	0.7	2	**18-**, 26-	
Tucannon R.	LM	0.2	2	11-, 11-	
ClearWater R.	GR	3.6	14	8,9-, 13-,18-, 18-,18-,18,22, 25-,29-,29-	**2-**, 3,
TOTAL					

[a] BO = Bonneville Pool, JD = John Day Pool, MC = McNary Pool, LM = Lower Monumental Pool, GR = Lower Granite Pool

[b] Dates followed by a "-" are volitional releases that began on the date listed. Dates in bold and underlined represent releases of >500,000

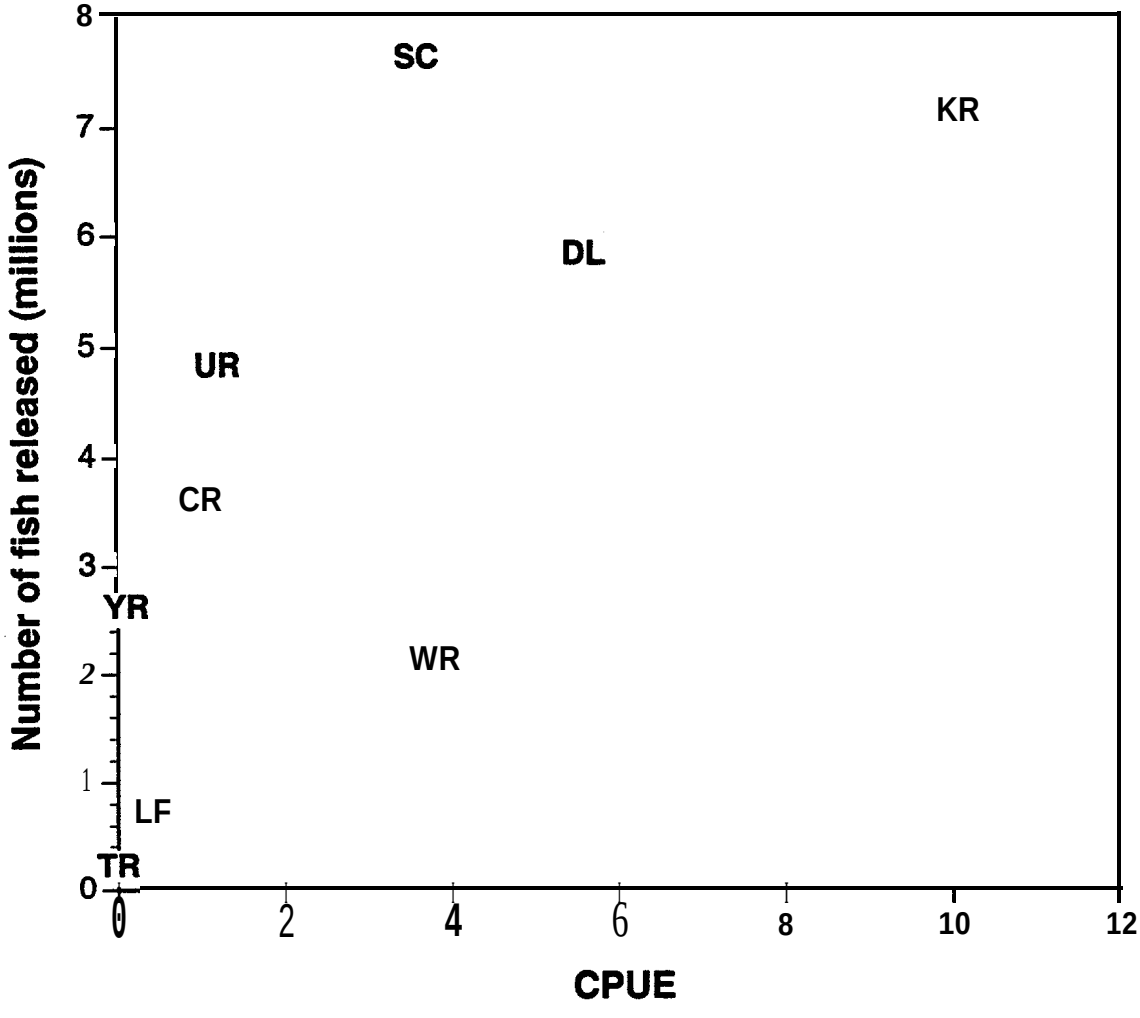

Figure 6. Catch-per-net-hr (CPUE) of northern squawfish in gillnets relative to the total number of hatchery-reared juvenile salmonids released at each location in 1994: KR = Klickitat River; DL = Drano Lake; WR = Wind River; SC = Spring Creek; UR = Umatilla River; CR = Clearwater River; LF = Lyons Ferry; YR = Yakima River; and TR = Tucannon River.

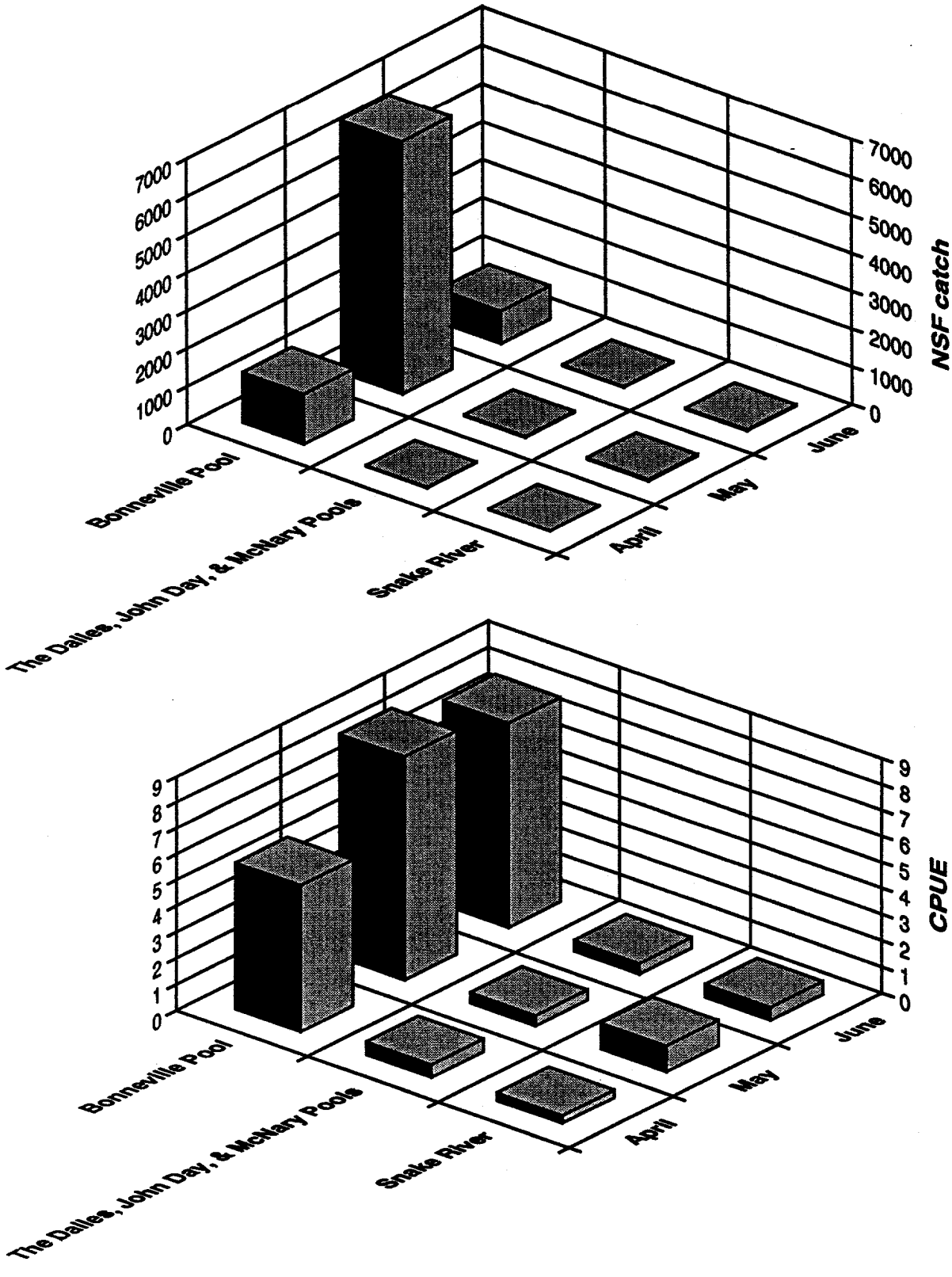

Figure 7. Monthly **gillnet** catch and **catch-per-net-hr (CPUE)** of northern squawfish (NSF) **in:** Bonneville Pool; The **Dalles,** John Day, and **McNary** Pools; and the Snake **River in 1994.**

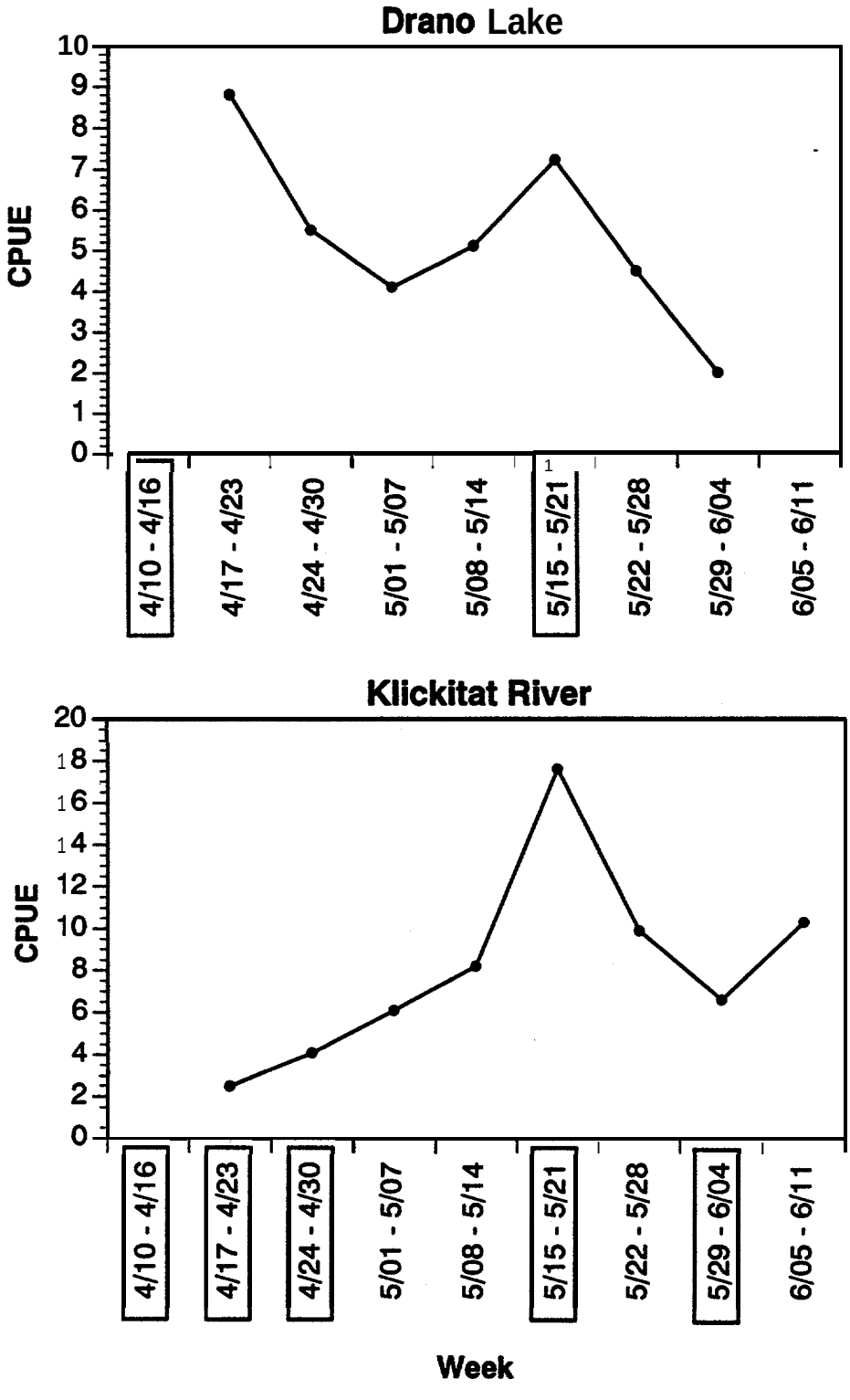

Figure 8. Weekly **gillnet catch-per-net-hr (CPUE)** of northern squawfish at **Drano** Lake and the **Klickitat River in** 1994. **Dates** shown **in** boxes represent weeks when **hatchery-**reared juvenile **salmonids** were released at that location.

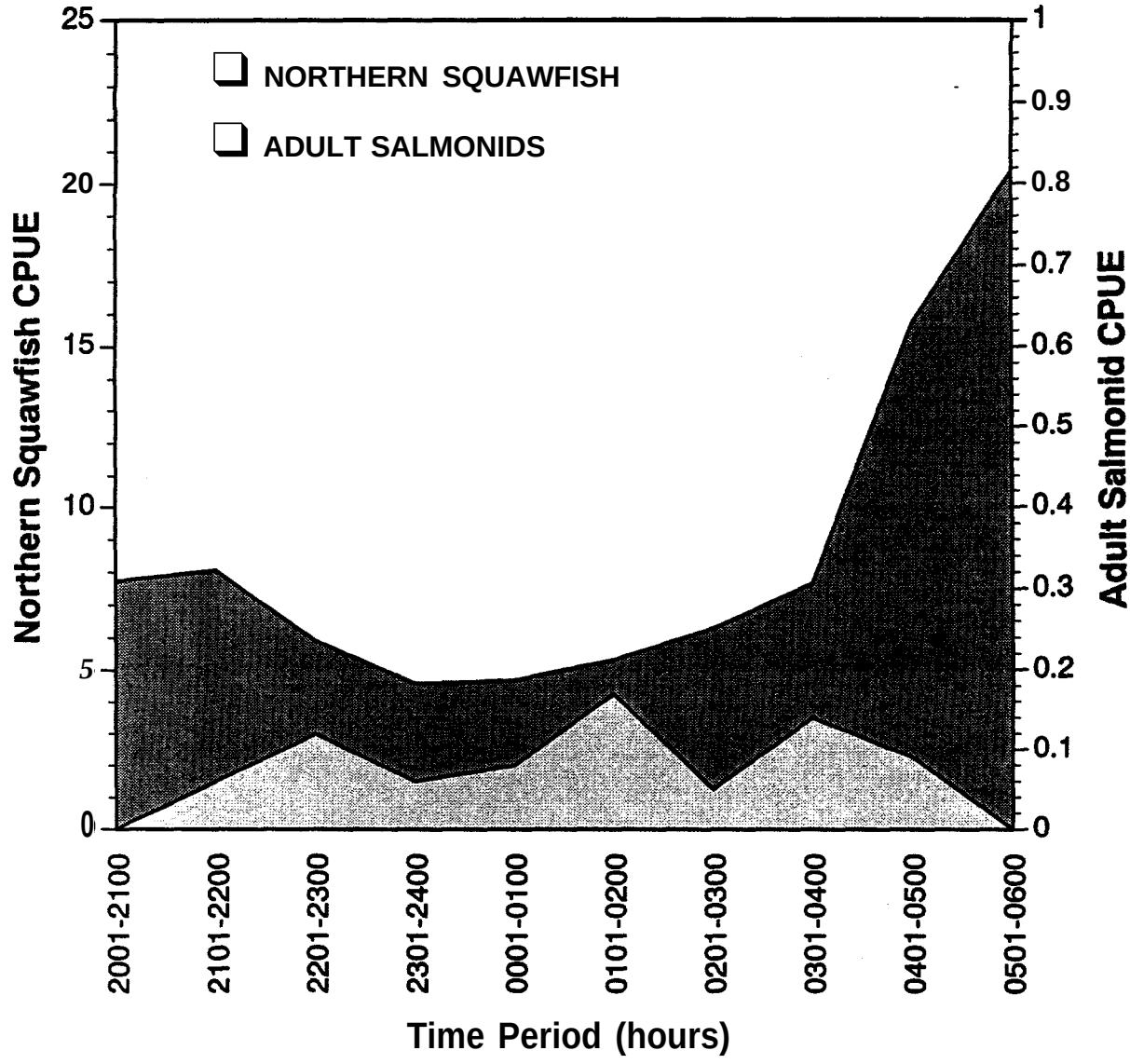

Figure 9. Catch-per-net-hour (CPUE) of northern squawfish and adult salmonids in gillnets during different time periods at all sampling locations in 1994. CPUE for earliest and latest time periods are based on a limited number of gillnet sets.

Gear Effectiveness

Small-meshed gill nets were more effective than mobile Merwin traps in this fishery for several reasons. First, the overall catch rate of northern squawfish with gill nets was considerably higher than with Merwin traps (Table 2). On seven nights when Merwin traps and gill nets were fished concurrently in the same sites, gill nets caught 653 predator-sized northern squawfish in 50.9 net hours of effort (CPUE = 12.8), compared to just one predator-sized northern squawfish caught in Merwin traps in 22.1 trap hours of effort (CPUE = 0.04).

Secondly, gill nets catch significantly larger (fork length) northern squawfish as compared to mobile Merwin traps (gill nets: $\bar{X}$ = 410.4 ± 0.7 mm, n = 4,602; Merwin traps: $\bar{X}$ = 233.4 ± 7.6 mm, n = 30, t = 19.3, p = .0001; Figure 10). In 1994, we improved the effectiveness of gill nets in catching larger predator-sized northern squawfish by eliminating the smallest mesh size (1 1/4" bar measure; Table 4) used in gill nets the previous year (Collis et al. 1995a). Furthermore, this change did not seem to negatively a.feet CPUE at the locations worked in both years (Table 4).

Finally, northern squawfish composed a greater percentage of the total catch in gill nets (62%) than they did in mobile Merwin traps (14%). This might be expected because small-meshed gill nets tend to target fish in the size range of predator-sized northern squawfish, whereas the mobile Merwin traps were less size-selective.

Past studies have shown that Merwin traps can be effective in catching northern squawfish in Columbia and Snake River reservoirs (Lemier and Mathews 1962; Sims et al. 1977; Mathews et al. 1992), particularly during the summer months when northern squawfish are presumed to be migrating to spawn. We hypothesized that Merwin traps could also be effective in catching northern squawfish in the spring if placed in areas where they are concentrated to feed on hatchery-released juvenile salmonids. Our data do not support this hypothesis. One possible explanation for this result might be that, while foraging, northern squawfish are less vulnerable to capture with Merwin traps than when they are migrating to spawn. Perhaps migrating fish, motivated to find a way around the lead net, can be led more easily into the trap than foraging fish, which may simply mill around and avoid the trap.

Incidental Catch

Species Composition

In 1994,5,876 fish (39% of the total catch) were incidentally caught in gill nets and Merwin traps combined (Table 5). Incidentally caught species composed 38% and 86'% of the total catch in gill nets and Merwin traps, respectively (Figure 11). Suckers (*Catostomous* spp.) were the most common incidentally caught species in gill nets, composing 69% of the incidental catch and 26% of the total catch (Table 5). Salmonids (mostly juveniles; see Salmonid By-Catch) composed the largest percentage of the total (40%) and incidental (47%) catch in Merwin traps (Table 5).

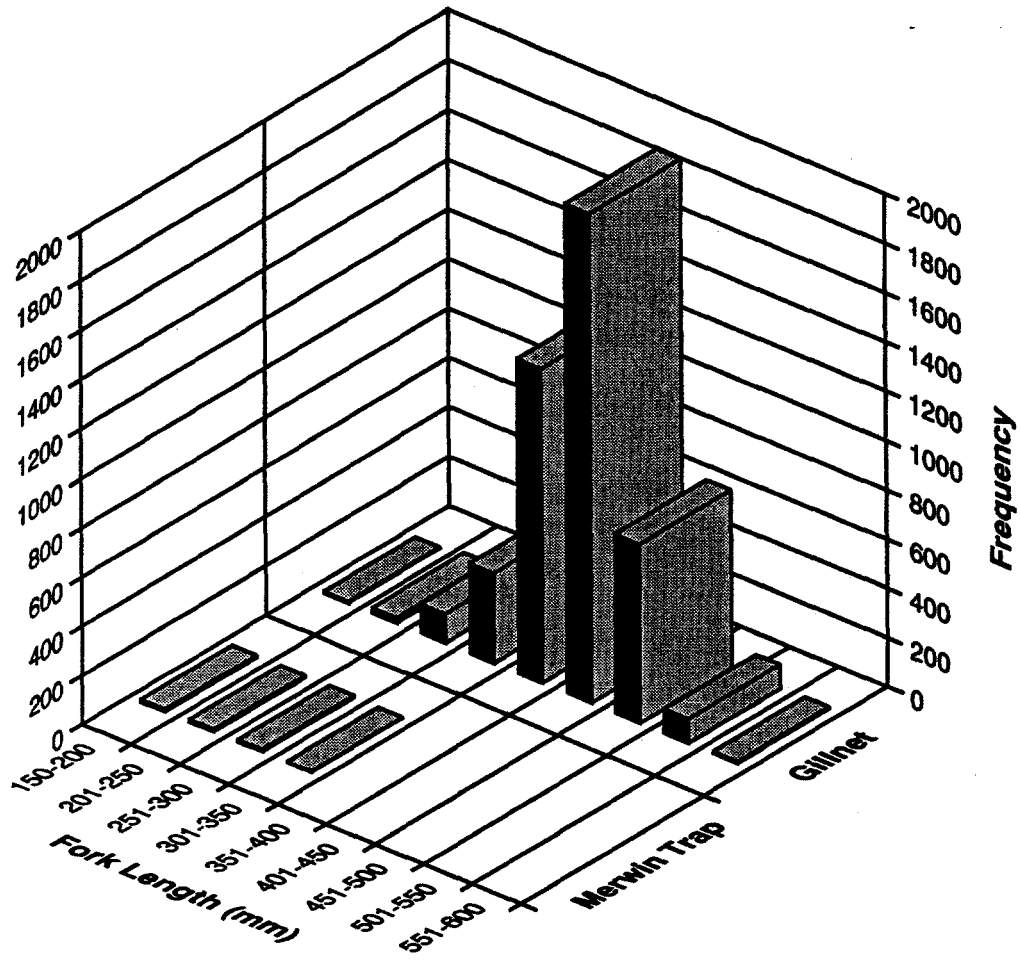

Figure 10. Size **distribution** of northern **squawfish** caught in Merwin traps and gillnets at all sampling locations in 1994.

Table 4. Comparisons of size (fork length) and catch rate (CPUE) of northern squawfish caught in gill nets having different mesh sizes in 1993 and 1994.

Location	1993[a] Average length (mm)	1993[a] % predator- size	1993[a] CPUE[c]	1994[b] Average length (mm)	1994[b] % predator-sized	1994[b] CPUE[c]
Wind River	381.0	99.39	4.6	407.1	100.00	3,8
Drano Lake	375.9	98.75	6.0	424.4	99.60	5,6
Spring Creek	346.5	96.24	2.7	396.8	97.67	3.6
Overall	370.7	98.36	4.4	410.4	99.58	5.2

[a] Gill nets were 8 ft deep x 150 ft long constructed from 25-ft panels with the repeating mesh size sequence: 2 in, 13/4 in, and 1 1/4 in bar measures.
[b] Gill nets were the same depth and length as in 1993; however. the smallest mesh size (1 1/4 in) was eliminated.
[c] Catoh-per-net-hour of predator-sized (≥ 250 mm fork length) northern squawfish.

Table 5. Species composition for site-specific gill-net and Merwin trap catches in 1994.

Species	Gill net	Merwin trap	TOTAL
Northern squawfish[a] *Ptychocheilus oregonensis*	9,105	*54*	9,159
Incidental catch			
Sucker *Catostomus* spp.	3,832	7	3,839
White sturgeon *Acipenser transmontanus*	401	0	401
Channel catfish *Ictalurus punctatus*	*376*	0	376
Salmonids[b] *Oncorhynchus* spp.	144	150	294
Common carp *Cyprinus carpio*	250	0	250
Peamouth *Mylocheilus caurinus*	140	49	189
Walleye *Stizostedion vitreum*	*98*	0	98
Chiselmouth *Acrocheilus alutaceus*	*47*	28	75
Redside shiner *Richardsonius balteatus*	0	69	69
Bass *Micropterus* spp.	51	14	65
Mountain whitefish *Prosopium williamsoni*	*46*	0	46
American shad *Alosa sapidissima*	*36*	0	36
Brown bullhead *Ictalurus nebulosus*	*23*	0	23
Pumpkinseed *Lepomis gibbosus*	11	0	11
Sculpin *Cottus* spp.	*2*	*3*	5
Crappie *Pomoxis* spp.	4	0	4
other	*4*	0	4
	91	0	91

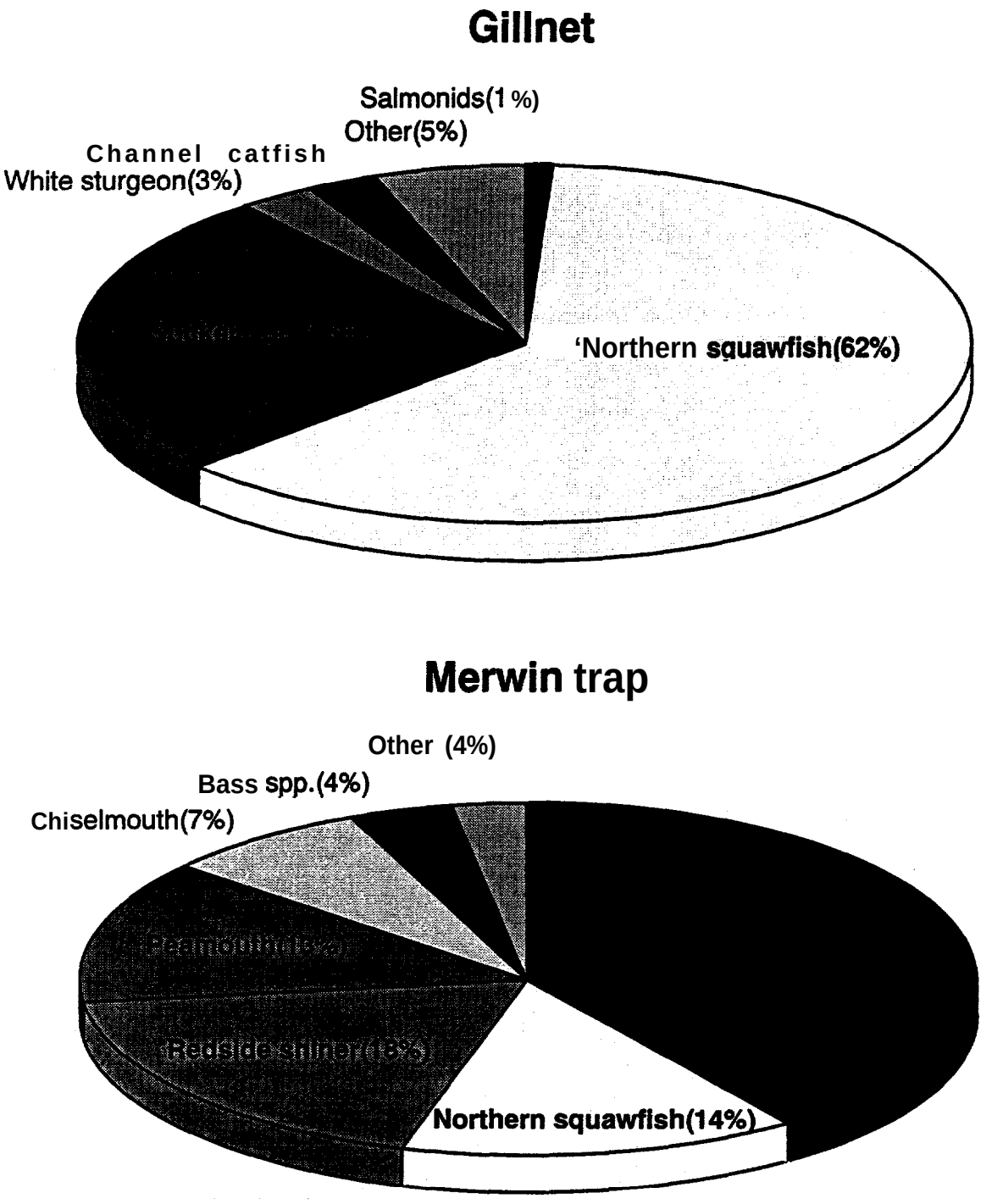

Figure 11. Percent of total catch of northern squawfish and incidentally caught species for gillnets and Merwin traps in 1994.

Salmonid By-Catch

A total of 294 salmonids (2% of total catch) were caught in both gill nets and Merwin traps combined in 1994 (Table 5). Salmonids composed 1% and 40% of the total catch in gill nets and Merwin traps, respectively (Table 5). The majority of the salmonid gill-net catch was adults (930A) and most (85%) were likely to survive at release (Table 6). Merwin traps captured a greater percentage of juvenile salmonids (98%) than adults (2%), all of which were released in good condition (Table 7).

An escape panel sewn into the spiller of the Merwin trap (Figure 3) allowed juvenile salmonids to escape the trap. In three trap sets wherein juvenile salmonids were caught and the escape panel was open, between 75% and 100% of the juveniles observed in the trap were able to escape through the panel. We feel that this was an important innovation to the Merwin trap and should be considered when using the trap in areas where there is a strong likelihood of catching juvenile salmonids.

RECOMMENDATIONS

1. **Continue developing the site-specific fishery to include additional locations where northern squawfish maybe concentrated to feed on juvenile salmonids, specifically below Bonneville Dam.**

ODFW biological evaluation crews working below Bonneville Dam in the spring have identified locations where northern squawfish catch rates have been relatively high. Incidental impacts to both salmon and sturgeon in these areas were no higher than in Bonneville Pool. It is likely that these areas would be productive sampling locations and the impacts to sensitive species would be as low as in other locations where the site-specific fishery has been implemented.

2. As part of the site-specific fishery, use small-meshed gill **nets exclusively to remove predator-sized northern squawfish. Also, test alternative gillnetting methods to increase effectiveness.**

Merwin traps were not effective in catching northern squawfish as part of this fishery. To maximize efficiency, only gill nets should be used in the site-specific fishery. Furthermore, alternative gillnetting methods should be tested to improve efficiency in catching predator-sized northern squawfish, specifically the use of gill nets of different dimensions (i.e., changes in length and width only; mesh size and line strength will not change) and the drifting of gill nets. There is no evidence to suggest that these kinds of changes might cause an increase in the incidental impacts to sensitive species.

Table 6. Gill-net salmonid catch and effort (net hr) by location, life stage, and condition at release in 1994. Condition codes: (1) minimal injury, certain to survive; (2) moderate injury, mayor may not survive; (3) dead, nearly dead, or certain to die.

		Condition at release					
		Juvenile salmonids[a]			Adult salmonids		
Location	Effort	1	2	3	1	2	3
Klickitat R.	616.4	1	0	0	35	5	4
Drano Lake	399.1	7	0	1	49	3	2
Wind R.	81.6	0	0	1	19	1	0
Richland	66.5	0	0	0	4	0	3
ClearWater R.	53.2	0	0	0	0	0	0
Lower Granite	49.3	0	0	0	1	0	0
Umatilla R.	27.6	0	0	0	0	0	0
Spring Creek	23.4	0	0	0	3	0	0
Miller Island	17.5	0	0	0	2	0	0
John Day R.	15.8	0	0	0	1	0	0
Lyons Ferry	10.3	0	0	0	1	1	0
Bingen	7.1	0	0	0	0	0	0
Tucannon R.	6.8	0	0	0	0	0	0
TOTAL	**1,374.6**	**8**	**0**	**2[b]**	**115[c]**	**10[d]**	**9[e]**

[a] Not identified to species.

[b] Juvenile salmonids were just-released hatchery smelts that got their teeth tangled in the net.

[c] 72 chinook salmon, 37 steelhead, 2 chinook salmon (jack), 2 cutthroat trout, 1 sockeye salmon, 1 rainbow trout.

[d] 2 chinook salmon, 7 steelhead, 1 cutthroat trout.

[e] 5 chinook salmon, 4 steelhead.

Table 7. Merwin trap salmonid catch and effort (trap hr) by location, life stage, and condition at release in 1994. Condition codes: (1) minimal injury, certain to survive; (2) moderate injury, may or may not survive; (3) dead, nearly dead, or certain to die.

		Condition at release					
		Juvenile salmonids[a]			Adult salmonids		
Location	Effort	1	2	3	1	2	3
The Dalles Dam Cul-de-sac	36.5	5	0	0	0	0	0
Klickitat R.	21.0	53	0	0	3'	0	0
Drano Lake	9.9	89	0	0	0	0	0
TOTAL	**67.4**	**147[b]**	**0**	**0**	**3[c]**	**0**	**0**

[a] Not identified to species.

[b] Approximately 155 juveniles exited the trap through an escape panel designed to minimize impacts due to handling. These fish were not considered "caught."

[c] Steelhead.

3. Extend the sampling season so that crews are working during the time that northern squawfish are concentrated to feed on hatchery released fish (March 1- June 30).

Other criteria that dictate cessation of the fishery (i.e., those based on water temperature, salmon by-catch, and sockeye passage over Ice Harbor Dam, see Appendix A) are sufficient to limit incidental capture and impacts to sensitive species. A criterion based on date alone may unnecessarily limit northern squaw-fish catch following hatchery releases in June.

4. Extend the fishing period to an hour past sunrise.

Based on data from the 1994 site-specific fishery, catch rates of northern squawfish remain high through the sunrise time period, while the incidental catch rate of salmonids does not increase and may decline (Figure 9). To increase effectiveness in catching northern squawfish, fishing should be allowed during this time period.

5. Identify operational criteria that adequately protect sensitive species from harm and do not limit the potential to catch northern squawfish.

The sockeye salmon criterion that determines cessation within a reach/reservoir on the Columbia River should be changed from the passage of ten or more over a given dam to the catch of one or more in a given reach/reservoir. The sockeye criterion that determines cessation of gillnetting on the Snake River (i.e., passage of one sockeye at Ice Harbor Dam) should remain unchanged. The proposed criterion is almost as conservative in minimizing the potential impacts to sockeye and will greatly simplify data handling and logistics.

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APPENDIX A

Operational Criteria for the 1994 Site-Specific Fishery -

Terms Used in Criteria

Caught (incidental species): For gillnetting, any fish known to have been detained by the gear, including those that free themselves when the net is being checked. For Merwin trapping, any fish that is detained in and removed from the gear.

Salmonid: Only the genera *Oncorhynchus* and *Salvelinus*. Excludes, for example, the genus *Prosopium* spp., which can also be caught incidentally during sampling in the Columbia and Snake River mainstems. All incidentally caught juvenile salmonids, regardless of species or origin, will be considered equal when applying operational criteria.

Adult: Salmonids greater than approximately51 cm (20 inches) in length, or as reported for dam passage.

Adult Equivalents: The number of adults represented by a larger number of juvenile salmonids, given an assumed survival rate to adulthood. Here we assume a general juvenile-to-adult survival rate of 0.02; hence, 50 juveniles= 1.0 adult equivalent.

Area: Generic spatial reference, may be synonymous with *location* or *site*.

Location: A moderate-sized reach of one shoreline and adjacent mainstem waters that extends approximately 3 km (2 mi) upstream and downstream from a landmark point (e.g., the mouth of a river into which smelts are released). One *location will* encompass several potential sampling *sites*.

Site: A relatively small reach (~ 400 m) within a *location* where sampling occurs.

A. Criteria Applicable to Both Gillnetting and Merwin Trapping

1. A general schedule of sampling times and a map of sampling locations will be provided to interested parties before these activities begin. Am schedule and description of locations will be provided to interested parties before sampling is conducted in a given week.

2. All sampling will take place at night, beginning one hour after sundown and ending one hour before sunrise.

3. Sampling will not take place when water temperatures exceed 68°F, as measured at the sampling site.

4. Sampling gears will not be operated within 500 feet of any fishway entrance.

5. All sampling will cease under the following conditions.

Condition	Cessation Duration and Area
a. 1 adult sockeye passes Bonneville Dam	Cease for 1994 in Bonneville tailrace.
b. 1 adult sockeye passes Ice Harbor Dam	Cease for 1994 in Snake River.
c. ≥ 10 adult sockeye/day pass nearest downstream dam (relevant only to Columbia River)	Cease for 1994 in reservoir upstream of dam.
d. 1 adult sockeye caught[1]	Columbia: Cease for 1994 in the reservoir where caught. Snake: Cease for 1994 in Snake River.
e. Cumulative incidental catch rate ≥ 3% of adult chinook salmon or steelhead	Cease in all reaches until cumulative catch declines (with the passage of additional fish) to 2.5% for the adults of the species causing the cessation.
f. 31 May 1994	Cease for 1994 in all reaches.

B. Criteria Applicable to Gillnetting

1. Gill nets will be pulled from the water and inspected for incidental take of adult salmonids at least once every 45 minutes.

2. Gill-net fishing will cease under the following conditions.

[1] This criterion is a fail-safe for the unlikely event that the three other sockeye criteria (a-c) are not sufficient to prevent the catch of any sockeye.

Condition	Cessation Duration and Area
a. ≥ 2 adult salmonids and/or adult equivalents of juvenile salmonids caught at 1 site, same night[2]	Cease for night at that site. .
b. ≥ 5 adult salmonids and/or adult equivalents ofjuvenile salmonids caught in 1 location, same night	Cease for night in that location.
c. No. juv. salmonids (fair or dead) ≥ 0.5. no. of northern squawfish (≥ 275 mm) caught at 1 site, same night.	Cease for night at that site.

C. Criteria Applicable to Merwin Trapping

1. Adult and juvenile salmonids will not be held longer than 3 hours.

2. Adult salmonids and other incidental species will be released over the cork line with soft-meshed shallow dip nets or by other methods that maybe judged to be less stressful to the fish than dipnetting.[3] We will develop and test whether escape panels (approximately 2“ bar mesh) sewn into the spiller will allow juvenile salmonids to volitionally leave the traps.

3. Merwin trap operation will cease under the following conditions.

[2] Neither juvenile nor adult chinook salmon or steelhead are gilled in the small mesh sizes used. Most are entangled with their mouth, and some adults free themselves before being lifted out of the water.

[3] UW researchers concluded that dip nets area more effective means of removing salmonids from Merwin traps than the other methods they tested: zipper, zippered escape holes, and a gated weir to exclude (large) adult salmonids from the spiller (Mathews et al. 1992).

Condition		Cessation Duration and Area
a.	No. adult salmonids > no. northern squawfish (≥ 275 mm) in any 3-h period at 1 site[4]	Cease for night at that site. .
b.	Adult salmonid catch rate ≥ 5/trap. h at 1 site	Cease for night at that site.
c.	≥ 25 juvenile salmonids per northern squawfish (≥ 275 mm) at 1 site	Cease for night at that site.
d.	Density of fish held in trap (when adult salmonids caught)> 1.0 lb/cu. ft[5]	Do not cease. Shorten period for checking and emptying trap by 1 h until criterion is met.

[4] The corresponding criterion in 1993 did not specify adult/juvenile salmonids or size of northern squawfish. Because we will count only predator-sized northern squawfish, the proposed criterion is much more conservative than that for 1993.

[5] This poundage criterion applies to a water temperature of 50°F. For each degree of water temperature below or above 50°F, the poundage will be increased or decreased 5°/0 respectively.

REPORT E

Handling and Transportation of Northern Squawfish Harvested under the Columbia River Northern Squawfish Management Program in 1994 and Evaluation of the Cost Effectiveness of a Food-Grade Fish Handling Network

Prepared by

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1994 Annual Report

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We thank the other Columbia River Northern Squawfish Management Program participants who were responsible for conducting fisheries on northern squawfish and whose cooperation in coordinating their activities with our own was essential to the success of this project. In particular, we thank Scott Smith and staff('Washington Department of Fish and Wildlife); Roy Beaty, Ken Collis, and staff (Columbia River Inter-Tribal Fish Commission); Manuel Villalobos and staff (Nez Perce Tribe); Jed Volkman and staff (Confederated Tribes of the Umatilla Indian Reservation); George Lee and staff (Confederated Tribes and Bands of the Yakama Indian Nation); and Mark Fritsch and staff (Confederated Tribes of the Warm Springs Reservation of Oregon).

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ABSTRACT

Three fisheries for harvesting northern squawfish (*Ptychocheilus oregonensis*) were implemented under the Columbia River Northern Squawfish Management Program during the spring and summer of 1994. Approximately 164,000 northern squawfish were harvested. Most harvested fish must be handled and transported from points of harvest to points of appropriate end-use or disposal to comply with state laws and social ethics prohibiting wanton waste of this resource.

We describe the fish handling and transportation system that we implemented in 1994. This system required cooperation and coordination of activities among private-sector end users of harvested northern squawfish and managers who were responsible for fishery implementation. The 1994 system included a food-grade fish collection network, established in a section of the lower Columbia River, that packaged and sold frozen northern squawfish to Stoner Fisheries, Inc. in Spirit Lake, Iowa. Fish harvested in other program areas were rendered. We conducted a cost comparison of the food-grade fish handling option with an alternative rendering-only option.

Actual cost of the 1994 food-grade fish handling network was compared to the cost for implementing a rendering-only network in the same area. Costs were based on handling of 111,536 pounds of northern squawfish harvested in the food-grade network area. Sale of food-

grade fish to Stoner Fisheries, Inc. generated $8,677 from 78,881 pounds of useable fish. Stoner also paid $3,642 in transportation charges that otherwise would have been borne by the program as rendering pick-up charges. Implementation of the food-grade network cost $38,927, which was $4,241 less than the cost for a rendering-only fish handling network.

The total spent for implementing the entire fish handling system in 1994 was $156,881. With cost recovery from sale of northern squawfish to Stoner Fisheries, Inc., the net cost for the fish handling system was $148,204.

The cost analysis among fish handling options indicated that a food-grade northern squawfish handling network in the lower Columbia River (from below The Dalles Dam to Vancouver, Washington), in combination with rendering of northern squawfish harvested elsewhere, was the most cost-effective mix of food-grade and rendering handling options for the Northern Squawfish Management Program. Aside from program cost considerations, this option preserves the highest value end-use of harvested northern squawfish.

INTRODUCTION

This report provides a description and cost summary of the 1994 northern squawfish handling system. This system included a food-grade collection network that packaged and sold frozen northern squawfish to Stoner Fisheries, Inc. in Spirit Lake, Iowa. A cost comparison of alternative handling options is provided. Field logistics, food-grade processing information and other end-uses are also discussed.

PROJECT DESCRIPTION

Fish Handling Options Available to the Program

In 1994, we examined the cost-effectiveness of two alternative options for handling northern squawfish harvested under the Columbia River Northern Squawfish Management Program. These options included rendering all the northern squawfish harvested by the program or selling some of the carcasses to Stoner Fisheries, Inc. and rendering the remaining volume. Rendering involves grinding whole fish and using the resulting product as an animal feed additive, fertilizer, etc., and is the lowest value end-use available to the program. The products of rendering are animal feed supplements and oil. Renderers do not pay for the carcasses. Rather, they charge a pick-up and disposal fee that is assumed by the handling project. Stoner Fisheries purchases food-grade "rough" fish, minces the flesh, and sells the product to processors of frozen fish products.

In September 1994, we provided to the program a cost comparison between these handling options and we demonstrated that a combination of food-grade handling and rendering is the least-cost fish handling option. Food-grade northern squawfish provides a cash return to the program, but more handling is required to maintain quality. Rendering requires less fish handling, but the project must pay for pick-up and disposal of the carcasses. Our assessment of handling options focused on whether the revenue generated from the sale of food-grade fish offsets the added cost for the additional fish handling required to maintain food-grade quality.

Fish Handling Requirements Common to Both Options

Both fish handling options require some basic services, facilities and equipment. Following is a review of the minimum handling requirements.

1. The carcasses must be removed from the field daily and stored in a secure cooler. Leaving barrels of carcasses outside overnight is unacceptable for sanitary and security reasons. Only very small quantities can be frozen in chest freezers and removed later. Large quantities must be collected and transported to storage centers on a daily basis.

2. The renderer in Portland requires carcasses in at least fair condition because the facility is located within the city limits and odor complaints are frequent. Consequently, large quantities of northern squawfish that are ultimately rendered in Portland must be handled with ice.

3. Labor is required to transport carcasses to central receiving locations and to assist with disposal or shipping to other destinations.

4. Central storage locations must have at least a walk-in cooler and cleaning facilities.

Description of the 1994 Food-Grade Fish Handling Network

In 1994, we implemented a limited food-grade collection network centered near Warrendale, Oregon. Larry Stoner of Stoner Fisheries, Inc. in Spirit Lake, Iowa, bought whole, frozen northern squawfish for $0.11 per pound and paid $0.04 per pound for transportation from the collection center in Oregon to his plant in lows. Food-grade fish were collected from Gleason, Washougal, The Fishery, Hamilton Island, Bingen, The Dalles and Giles French sport-reward fishery registration sites and from Bonneville and The Dalles dams (Figure 1).

The food-grade collection area was quite productive in terms of northern squawfish harvested. Although it represented only about 20% of the total program area, it produced 58% of the programwide harvest. The food-grade handling area was logistically favorable because most travel was along relatively short distances byway of Interstate 84. These two features combined to minimize fish handling and transportation costs.

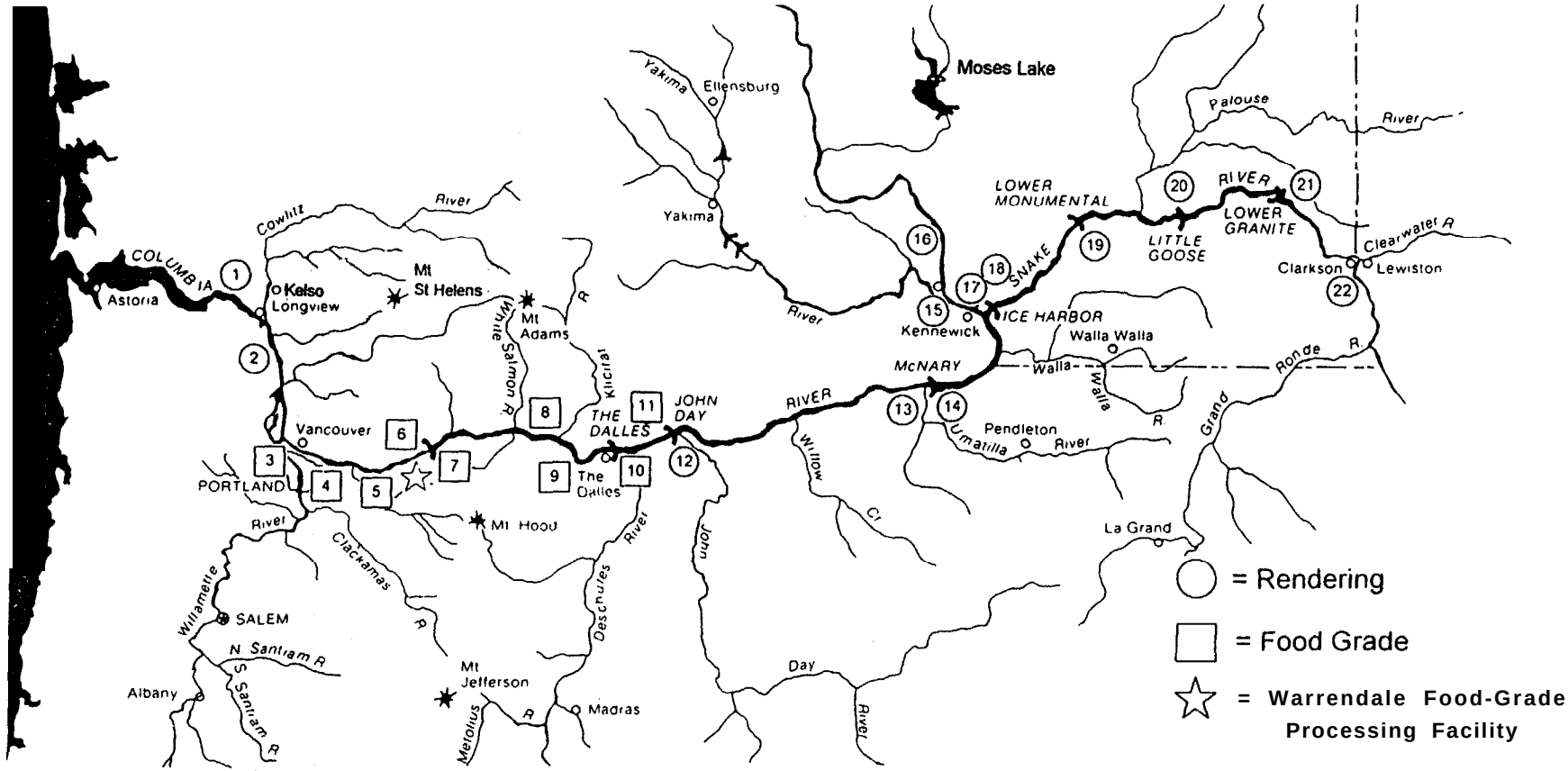
The fish handling network employed a driver who collected the iced northern squawfish from drop-off locations (Portland, Oregon; Bonneville Dam; The Dalles Dam; and Dallesport, Washington located across the Columbia River from The Dalles, Oregon) and delivered them to the Warrendale, Oregon, facility where they were packaged and frozen (Figure 1). This system greatly reduced the transportation responsibilities of dam-angling and sport-reward fishery technicians. Additional costs for food-grade packaging were minimized because the labor already in place for transporting fish was also used for packaging the fish. Further cost savings were realized because the dam-angling and sport-reward technicians did not need to clean coolers at the end of each day. This task was accomplished quickly with a steam cleaner at the Warrendale facility. Dam-angling and sport-reward technicians are now experienced fish handlers and provided very high yields of food-grade squawfish. Eighty-three percent (93,059 pounds) of the northern squawfish harvested from the food-grade area (1 12,700 pounds) were shipped to Stoner for processing.

Description of Rendering-Only Fish Handling Areas

The rendering-only locations included Kelso, Pasco (located across the Columbia River from Kennewick), and Clarkston, Washington (Figure 1). The rendering-only locations were facilities that provided walk-in coolers, disposal barrels and cleaning equipment. Sport-reward fishery technicians and dam anglers delivered northern squawfish carcasses to these locations, deposited them into barrels, and cleaned their coolers. The facility manager would provide assistance as needed to drivers who came to pick up fish to be rendered. Rendering-only northern squaw-fish harvest locations handled about 45,000 pounds of northern squawfish during the 1994 season.

Efforts were made in previous years to collect food-grade northern squawfish from the areas that are now rendering-only areas. However, relatively small numbers of fish harvested, difficult handling logistics, and the high cost of ice needed to preserve food-grade fish quality preclude cost-effective food-grade handling in these areas.

Due to cost restraints and transportation difficulties, no effort was made in 1994 to collect northern squawfish from the site-specific gill-net fishery or from McNary Dam.



Sport-Reward Sites

- 1 Cathlamet
- 2 Kalama
- 3 Gleason
- 4 Washougal
- 5 The Fishery
- 6 Hamilton Island
- 8 Bingen
- 9 The Dalles
- 11 Giles French
- 13 Umatilla
- 15 Columbia Point
- 16 Vernita
- 17 Hood Park
- 22 Greenbelt

Darns

- 1 Bonneville Dam
- 10 The Dalles Dam
- 12 John Day Dam
- 14 McNary Dam
- 18 Ice Harbor Dam
- 19 Lower Monumental Dam
- 20 Little Goose Dam
- 21 Lower Granite Dam

Figure 1. **Map of Northern Squawfish collection and processing network.**

METHODS

We compared the actual cost of the 1994 food-grade fish handling network with the cost that we would have had for rendering all the carcasses obtained from the food-grade collection area. The comparison is based on 111,536 pounds of northern squawfish handled in the food-grade collection area in 1994. The rendering-option cost information is based on the minimum needs of a process that would provide carcasses to the rendering facility in Portland, Oregon, in satisfactory condition so that they would be free from potential sanitation or negative public perception problems. The requirements for implementing each option are listed in Table 1 along with cost-recovery information.

Explanation of Fish Handling Requirements

This section explains the fish handling requirements listed in Table 1 and compares the differences, if any, between food-grade and rendering-only handling requirements.

Facility rental pays for the use of central storage facilities where harvested squawfish are collected and packaged for food-grade use or held until a renderer picks them up. These costs include space rental, use of fork lifts, scales, cleaning equipment, water and utilities. Facility rental costs are common to both fish handling options.

While a walk-in cooler can be used to hold fish for rendering a freezer is needed to preserve food-grade northern squawfish. The cost of renting freezer space was $300 per month more than the cost of renting cooler space. Likewise, less ice is necessary to maintain fish for rendering, and this cost difference was $567 per month in 1994.

On average, processing and packaging of food-grade fish required about 2.5 hours of additional labor each day beyond that required for a rendering only program. The monthly cost difference for the additional labor was $1,076.

Vehicle rental costs include rent, mileage and fuel for vehicles that transport the northern squawfish carcasses. These costs are the same among both handling options.

Only food-grade northern squawfish require packaging. The cost of packaging (i.e., waxed boxes and plastic liners) for the 1994 season was $1,329.

The food-grade project area did produce some low-quality northern squawfish that required rendering. The total cost for rendering the 18,477 pounds of low-quality northern squawfish in the food-grade area was $865 during the 1994 season. Rendering charges for the volume of fish handled in the food-grade collection area would have been $6,110 if food-grade fish had been rendered.

Table 1. 1994 northern squawfish food-grade collection network cost summary and rendering-only cost comparison in the food-grade collection area(Gleason, Washougal, The Fishery, Hamilton Island, The Dalles and Giles French sport reward sites; Bonneville and The Dalles dams).

RENDERING ONLY COSTS (projected)			FOOD-GRADE NETWORK COSTS (actual)		
Requirements	cost	4.5 Mo.	Requirements	cost	4.5 Mo.
Facility Rent	$800/mo	$3,600	Facility Rent	$800/mo	$3,600
cooler	$700/mo	$3,150	Freezer	$1,000/mo	$4,500
Ice	$1,100/mo	$4,950	Ice	$1,667/mo	$7,505
Labor	$14.50/hr 8 hrs/day	$16,820	Labor	$14.50/hr 10.5 hrs/day	$21,664
Vehicles	$1,897/mo	$8,538	Vehicles	$1,897/mo	$8,538
Packaging	$0	$0	Packaging	$1.00/box	$1,329
Rendering	111,536 lb		Rendering	18,477 lb	
Pick-up	$800/mo	$3,600	Pick-up	$100/mo	$450
Volume fee	$45/ton	$2,510	Volume fee	$45/ton	$415
			Crayfish Bait	1,200/lb	$0
Subtotal		$43,168	Subtotal		$48,001
Cost Recovery		$0	cost Recovery 93,059 lbs Shipped 78,881 lbs. processed[a] @ $0.11/lb		$8,677
			Stoner shipping refund		$397
Total Cost		$43,168	Total Cost (after sale)		$38,927
Food-Grade cost savings compared with rendering					$4,241

[a] Stoller rendered 14,178 pounds due to small size, freight damage or other quality reasons.

RESULTS AND DISCUSSION

Cost Recovery through Sale of Food-Grade Fish

Sale of food-grade northern squawfish to Stoner Fisheries, Inc. generated $8,677 in direct revenues (from 78,881 pounds of minceable northern squawfish). Stoner also paid $3,642 in transportation charges that otherwise would have been borne by the program as rendering pick-up charges. Table 2 summarizes Stoner's processing figures and payment totals for the 1994 season. Stoner received three shipments of northern squawfish from the program during 1994. Table 3 provides information concerning processing dates, food-grade yields and revenues generated from each shipment.

Results of Cost Comparison among Fish Handling Options

Table 1 presents the results of the comparison between the actual cost of the 1994 food-grade handling network and the projected cost of a rendering-only network. The food-grade network, including cost recovery ($3 8,927), was $4,241 less expensive than an alternative rendering-only network. The costs for a rendering-only network in the food-grade collection area during the 1994 season would have been $43,168.

1994 Overall Fish Handling System Cost Summary

The cost associated with the entire 1994 northern squawfish handling system is summarized in Table 4. The cost to operate the 1994 food-grade network (not including cost recovery from fish sales to Stoner Fisheries, Inc.) was $48,001. Total cost for the rendering-only areas (Kelso, Pasco, and Clarkston) during the 1994 season was $12,086. The projectwide direct handling cost for both the food-grade collection area and rendering-only locations was, therefore, $60,087. One-time charges of $2,600 were incurred for moving, storing and distributing equipment during the 1994 season.

The fixed cost for managing the project and for coordinating among participants was $94,194. Therefore, the total spent for the project was $156,881. With cost recovery (i.e., fish sales to Stoner Fisheries, Inc.), the net project cost was $148,204.

Other End Uses for Northern Squawfish Harvested in 1994

Scott Lewis from Oregon State University was given 1,164 pounds of low quality northern squawfish from the food-grade fish handling area for use as bait to facilitate his crayfish research.

Table 2. **Summary** of Stoner Fisheries, Inc. processing and payment information during 1994.

Total Fish Shipped:	93,059 pounds
Total Fish Processed:	78,881 pounds
% Processed	**85%**[a]
Total Reimbursement (78,881 pounds @ $0.1 l/pound)	**$8,677**[b]
Shipping paid by Stoner (91,050 pounds@ $0.04/pound)	$3,642[c]
Total sales value including shipping costs	**$12,319**[d]

[a] Fifteen percent of the northern **squawfish** received by Stoner were not food-grade quality due **to** small size, shipping damage or poor quality.
[b] Stoner paid cash for usable northern squawfish only (78,881 pounds).
[c] Stoner paid for shipping from Oregon to Iowa (except for 2,009 pounds). This **is in** lieu of alternative handling costs which the program would have had to pay.
[d] This total represents the total value of Stoner's contribution to the program (cash payment and shipping costs).

Table 3. Summary of processing and payments by shipment of northern squawfish to Stoner Fisheries, Inc. during 1994.

Shipment #1. Processed June 21, 1994:	
Total Fish received: 37,805 pounds	
Fish too small or of low quality:,	4,280 pounds
Net processed fish:	33,525 pounds
o/o processed (food-grade);	88.7'%
Total Production of Minced fish	11,160 pounds
Yield - All fish:	29.5%
Yield - Usable fish:	33.3%
Amount received (@ $0.1 1/pound):	$3,687.75
Shipment #2. Processed August 1, 1994	
Total Fish received: 43,33o pounds	
Fish too small or of low quality:	7,889 pounds
Net processed fish:	35,441 pounds
0/0 processed (food-grade);	81.8'%
Total Production of Minced fish:	13,453 pounds
Yield - All fish:	31.1%
Yield - Usable fish:	38.0%
Amount received (@ $0.1 1/pound):	$3,898.51
Shipment #3. Processed November 9, 1994.	
Total Fish received: 11,924 pounds	
Fish too small or of low quality:	2,009 pounds
Net processed fish:	9,915 pounds
% processed (food-grade);	83.1%
Total Production of Minced fish:	3,321 pounds
Yield - All fish:	31.1%
Yield - Usable fish:	33.5%
Amount received (@ $0.1 1/pound):	$1,090.65

Table 4. Summary of the total cost for the 1994 northern squawfish handling network.

Program component	Total cost
Food-Grade Collection	$48,001
Rendering-only Collection	$12,086
Equipment Handling and Storage	$2,600
Fixed Costs (Administration, contracts, negotiations, coordination and field supervision)	$94,194
Total	$156,881
Cost Recovery (Stoner sales) $8,677	
Total, after Cost Recovery	$148,204

CONCLUSIONS AND RECOMMENDATIONS

The cost analysis among fish handling options that we completed in 1994 indicated that a food-grade northern squawfish handling network in the lower Columbia River (from below The Dalles Dam to Vancouver, Washington) in combination with rendering of northern squawfish harvested elsewhere was the most cost-effective mix of food-grade and rendering handling options for the Northern Squawfish Management Program. Aside from program cost considerations, this option preserves the highest value end-use of harvested northern squawfish.

Our recommendation is for a continuation of a food-grade fish handling network, which should be implemented through cooperative efforts among private-sector concerns and which should be patterned after the 1994 food-grade fish handling network.

SECTION II. EVALUATION

Cooperators

Columbia Basin Fish and Wildlife Authority
S.P. Cramer and Associates, Inc.
Pacific States Marine Fisheries Commission
Oregon Department of Fish and Wildlife

REPORT F

Development of a Systemwide Predator Control Program: Indexing and Fisheries Evaluation

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A B S T R A C T

We are reporting progress on evaluation of the Northern Squawfish Management Program in 1994. Our objectives in 1994 were to (1) evaluate exploitation rate, size composition, and incidental catch of northern squawfish (*Ptychocheilus oregonensis)* captured in the various fisheries and estimate reductions in predation on juvenile salmonids since implementation of the management program, and (2) evaluate changes through 1994 in relative abundance, smolt consumption rate, size and age structure, growth, and fecundity of northern squawfish in lower Columbia and Snake River reservoirs and in the Columbia River downstream from Bonneville Dam.

Systemwide exploitation of northern squawfish in 1994 was 10.9% for sport-reward, 1.1% for dam-angling, and 1.1% for site-specific fisheries. Mean fork length was 344 mm in the sport-reward fishery, 401 mm in the dam-angling fishery, and 410 mm for gill nets in the site-specific fishery. Relative to the total number of fish caught, the dam-angling fishery reported the lowest percentage of incidental catch.

We estimate that potential predation on juvenile salmonids in 1995 may be reduced 32% from pre-program levels. Eventual reductions in potential predation varied depending on

estimates of sustained exploitation. However, it appeared feasible to reduce overall predation by at least 40%.

In general, relative abundance of northern squawfish in 1994 was similar to previous years in the Columbia River downstream from Bonneville Dam, but decreased in Columbia and Snake River reservoirs. Consumption indices decreased in Columbia River reservoirs and remained similar or increased in Snake River reservoirs and the Columbia River downstream from Bonneville Dam.

Proportional stock density (PSD) of northern squawfish collected from Bonneville Dam tailrace was lower in 1994 than in 1990. Estimates of PSD from 199 1- 1994 were generally below levels that would have been expected without implementation of the Northern Squawfish Management Program. Relatively strong recruitment in 1989 and 1990 will probably decrease PSD estimates in 1995 and 1996 as these relatively strong cohorts are recruited to "stock" size. Although length-age and fecundity-length relationships varied among years in some locations, we found no evidence of compensation by northern squawfish in any area.

INTRODUCTION

The goal of the Northern Squawfish Management Program is to reduce mainstem predation mortality on juvenile salmonids. From 1990 through 1992, we estimated the relative magnitude of northern squawfish (*Ptychocheilus oregonensis*) abundance, consumption, and predation in Columbia River impoundments (1990), Snake River impoundments (199 1), and the unimpounded lower Columbia River downstream from Bonneville Dam (1992). Those results established baseline levels of predation and described northern squawfish population characteristics throughout the lower basin before implementation of sustained predator control fisheries. In 1993, we again sampled Columbia River impoundments to evaluate changes from 1990. In 1994, we altered our sampling design to sample only areas where sufficient northern squawfish digestive tract samples could be collected to compare consumption indices among years: In this report, we describe our activities and findings in 1994 and, wherever possible, evaluate any changes from previous years.

Our objectives in 1994 were to (1) evaluate exploitation rate, size composition, and incidental catch of northern squawfish fisheries and estimate reductions in predation on juvenile salmonids since implementation of the management program, and (2) evaluate changes through 1994 in relative abundance, consumption, size and age structure, growth, and fecundity of northern squawfish in lower Columbia and Snake River reservoirs and in the Columbia River downstream from Bonneville Dam.

METHODS

Fishery Evaluation

Field Procedures

Three northern squawfish fisheries were conducted in 1994. The sport-reward fishery was implemented by the Washington Department of Fish and Wildlife (WDFW) from May 2 through September 25 throughout the lower Columbia and Snake rivers. The dam-angling fishery was implemented by the Columbia River Inter-Tribal Fish Commission (CRITFC), Confederated Tribes of the Warm Springs Reservation of Oregon, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes and Bands of the Yakama Indian Nation (YIN), and the Nez Perce Tribe (NPT) from May 9 to September 6 at Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. A site-specific fishery using both gill nets and Merwin traps was implemented by CRITFC, YIN, and NPT from April 8 through June 9 in Bonneville, The Dalles, John Day, McNary, Lower Monumental, Little Goose, and Lower Granite reservoirs.

We estimated exploitation rates of northern squawfish for each fishery based on recovery of fish tagged primarily before implementation of 1994 fisheries. We used electrotishing boats and bottom gill nets to collect northern squawfish from March 1 to May 3 1. Sampling effort was randomly allocated in all river kilometers (RKm) from RKm 71 through Priest Rapids Dam tailrace (RKm 639) on the lower Columbia River, and on the Snake River from RKm 0 through Lower Granite Reservoir (excluding Ice Harbor Reservoir). Fish greater than.225 mm fork length were tagged with a serially numbered "spaghetti" tag and given a secondary mark (right pelvic fin clip). Tags were recovered from each fishery from April 8 through September 25.

We measured fork lengths of northern squawfish from a subsample of fish harvested in sport-reward and dam-angling fisheries. Fork lengths from subsamples of fish harvested by the site-specific fishery were provided by CRITFC. Catch composition was provided for the respective fisheries by WDFW (sport reward) and CRITFC (dam angling and site-specific fishery).

Data Analysis

We used mark-and-recapture data to compare exploitation rates of northern squawfish among fisheries and reservoirs (Appendix A). Exploitation rates were calculated for one-week periods and summed to yield total exploitation rates for each fishery (Beamesderfer et al. 1987). We adjusted exploitation rates for tag loss (4.4%) during the season and calculated 90% confidence intervals for reservoir-specific and systemwide estimates.

We compared mean fork lengths of northern squawfish, length frequencies, and incidental catches in 1994 among fisheries. We also compared mean fork lengths of fish harvested by sport-reward and dam-angling fisheries among years (1990-l 994).

We used the Loss Estimate Spreadsheet Model (Zimmerman et al. 1995) to estimate reductions in predation relative to predation prior to implementation of the management program. The model incorporates age-specific exploitation rates on northern squawfish and resulting changes in age structure to estimate changes in predation. We used a lo-year "average" age structure (based on catch curves) for a pre-exploitation base, and assumed constant recruitment. Age-specific consumption of juvenile salmonids by northern squawfish is incorporated, however, potential changes in consumption, growth, and fecundity due to removals were not considered likely. The model therefore estimates changes in potential predation related directly to removals. This in effect allows us to estimate what the effects of removals would be if we were able to hold all variables except exploitation constant.

We estimated both the potential predation reduction in 1995 based on observed exploitation rates in 1994, and the eventual maximum potential- predation reduction assuming (1) continuing exploitation at 1994 levels, and (2) continuing exploitation at mean 1991-94 levels. In addition to reductions in overall predation, we estimated reductions in predation on juvenile salmonids originating in the Snake River upstream from Lower Granite Dam. We calculated 90% confidence intervals for all predation reduction estimates.

Biological Evaluation

Field Procedures

To evaluate changes in relative abundance and consumption, we used boat electrofishing to collect northern squawfish in the following areas: upper Lower Granite Reservoir (RKm 221-229), Lower Granite Dam tailrace, Little Goose Dam tailrace, John Day Reservoir, The Dalles Reservoir (excluding midreservoir), Bonneville Reservoir, Bonneville Dam tailrace, and three sections in the Columbia River downstream from Bonneville Dam tailrace (RKm 117-121, RKm 171-177, and RKm 190-196). The three sections sampled downstream of Bonneville Dam tailrace were selected to represent sections sampled in previous years (RKm 7 1- 12 1, RKm 122-177, and RKm 178-224). Sampling schedules, methods, and gear specifications were as described in previous reports (Vigg et al. 1990; Ward et al. 199 1; Parker et al. 1992; Zimmerman et al. 1995). We collected and preserved guts of all northern squawfish ≥250 mm fork length per methods of Petersen et al. (1991).

To evaluate changes in population structure, growth, and reproduction, we collected biological data from all northern squawfish collected by electrofishing, and from a subsample of northern squawfish caught in the sport-reward and dam-angling fisheries. We measured fork length (mm) and total body weight (g), determined sex (male, female, undetermined) and maturity (undeveloped or immature, developing, ripe, or spent), and collected gonad (ripe females only) and scale samples.

Laboratory Procedures

We examined gut contents of northern squawfish collected by electrofishing to measure consumption of juvenile salmonids by northern squawfish. Details of laboratory methods are given in Petersen et al. (1991). We used gravimetric quantification (Bagenal 1968) to estimate northern squawfish fecundity and used scale samples collected primarily by electrofishing for age determinations. Details of fecundity and aging procedures are given in Parker et al. (1995).

Data Analysis

We used catch per unit effort of standardized electrofishing runs as an index of northern squawfish density because it best reflected differences in northern squawfish abundance among areas and reservoirs (Ward et al. 1995). We compared density indices from 1990 through 1994 for all sampling areas. We calculated indices of northern squawfish abundance as the product of the northern squawfish density index'and reservoir or area-specific surface area (Ward et al. 1995), and compared indices among years for all sampling areas.

The following formula was developed as a consumption index (CI) by the NBS (Petersen et al. 1991):

$$CI = 0.0209 \cdot T^{1.60} \cdot MW^{0.27} \cdot (S \cdot GW^{-0.61})$$

where

T = water temperature (°C),
MW = mean predator weight (g),
S = mean number of salmonids per predator, and
GW = mean gut weight (g) per predator.

The consumption index is not a rigorous estimate of the number of juvenile salmonids eaten per day by an average northern squawfish. However, it is linearly related to the consumption rate of northern squawfish (Petersen et al. 1991). Spring (May - June) and summer (July-September) consumption indices were compared from 1990 through 1994 for all sampling areas except Snake River reservoirs, which were sampled only in the spring. To compare timing of consumption index sampling with concentrations of juvenile salmonids present in each area, we plotted the daily juvenile salmonid passage index for each lower Columbia and Snake River dam. We used the product of abundance and consumption indices to calculate predation indices for spring and summer periods in each year. We limited our comparison of predation indices to reservoir sections where data had been collected each year.

Because fishery exploitation rates increase with increasing size of northern squawfish (Zimmerman et al. 1995), sustained fisheries should decrease the abundance of large fish relative to the abundance of smaller fish. We used proportional stock density [PSD = 100 (number of fish at least quality length)/(number of fish at least stock length)] to compare size structure of northern squawfish populations among years from 1990 through 1994 in the Columbia River downstream

from Bonneville Dam, Bonneville Reservoir, and John Day Reservoir (Anderson 1980). Stock and quality sizes for northern squawfish have been defined as 250 mm and 380 mm fork length (Beamesderfer and Rieman 1988; Parker et al. 1995).

Comparisons of PSDs among years may be biased by (1) fluctuating year-class strengths that influence the number of stock-size fish (Mesa et al. 1990), and (2) size-selectivity of sampling gear (Beamesderfer and Rieman 1988). To help reduce bias, we used information on relative year-class strengths and natural mortality rates of northern squawfish to estimate PSDs that would be expected with and without program implementation (Appendix B). We also determined size selectivity of our sampling gear to adjust observed PSD estimates (Appendix B). We then compared observed and expected PSDs.

To evaluate changes in growth rate after implementation of the management program, we used length-at-age data from female northern squawfish to determine growth relationships for three areas: downstream from Bonneville Dam, Bonneville Reservoir, and John Day Reservoir. We determined regression parameters (slope and y-intercept) for fork length on age and compared relationships among years (1990-1994) for each area using joint 90% family confidence regions for estimates of parameter pairs (Neter et al. 1985). Parameter pairs were considered significantly different if point estimates (center-point of ellipse) were not within the confidence region for another year.

To evaluate changes in fecundity, we calculated mean fecundity (number of developed eggs per female) and mean relative fecundity (number of developed eggs per gram of body weight) from 199 1 through 1994 (fecundity data were not available for 1990) 'for three areas: downstream from Bonneville Dam, Bonneville Reservoir, and John Day Reservoir. We also determined regression parameters (slope and y-intercept) for the regression of fecundity on fork length and compared relationships among years (199 1- 1994) for each area using joint 90% family confidence regions for estimates of parameter pairs (Neter et al. 1985).

RESULTS

Fishery Evaluation

We tagged and released 2,476 northern squawfish throughout the lower Columbia and Snake rivers (Appendix A). A total of 282 marked northern squawfish were recaptured in the three fisheries: 236 by sport-reward anglers, 24 by dam anglers, and 22 by the site-specific gill-net fishery. Additionally, 12 tags were recovered during ODFW electrofishing and gill-net sampling, two were recovered by other ODFW crews, and eight were recovered by sport anglers not participating in the sport-reward fishery.

The sport-reward fishery had the highest exploitation rate of northern squawfish among fisheries in nearly all areas in 1994 (Figure 1; Appendix Table A-l). Sport-reward exploitation

was higher in 1994 than 1993 in all locations except McNary, Lower Monumental, and Lower Granite reservoirs (Appendix Table A-2). Dam-angling exploitation was lower in 1994 than 1993 in two of three areas where tags were recovered both years (Appendix Table A-3). Exploitation estimates were zero for dam angling in 1994 in The Dalles Reservoir although over 3,000 fish were caught because no tagged northern squawfish were recovered (Columbia River Inter-Tribal Fish Commission, unpublished data).- Exploitation estimates were also zero for dam angling in McNary, Lower Monumental, and Lower Granite reservoirs, but catch totaled only 136 fish in these reservoirs. The site-specific gill-net fishery had a relatively high exploitation rate in Bonneville Reservoir, where most of the effort (82%) was concentrated (K. Collis, Columbia River Inter-Tribal Fish Commission, personal communication).

Systemwide exploitation rate (all fisheries combined) of northern squawfish ≥250 mm during 1994 was 13.1% (Figure 1; Appendix Table A-l), which was higher than previous years (Table 1). Reservoir-specific exploitation rates were higher in 1994 than 1993 in Bonneville, The Dalles, and Little Goose reservoirs, and the Columbia River downstream from Bonneville Dam. Reservoir-specific exploitation rates are conservative because they exclude fish that were recaptured in reservoirs other than where marked, whereas systemwide exploitation rates include all recaptured northern squawfish. Confidence intervals for exploitation estimates were typically widest for reservoirs in which relatively few fish were tagged. However, bounds for systemwide exploitation estimates were relatively narrow. We did not estimate exploitation in Ice Harbor Reservoir from 1992 through 1994 because no northern squawfish were tagged.

As in previous years, the sport-reward and dam-angling fisheries harvested a disproportional number of large northern squawfish (Figure 2). Mean fork length was 344 mm in the sport-reward fishery and 401 mm in the dam-angling fishery. Mean fork length for northern squawfish captured in the site-specific fishery was 410 mm for gill nets and 233 mm for Merwin traps.

Mean size of northern squawfish harvested in each reservoir by dam angling in 1994 was generally within the range for previous years (Table 2). However, mean fork length increased in John Day Reservoir and decreased below Bonneville Dam. The size of fish harvested in 1994 by sport-reward anglers above John Day Dam varied considerably from previous years (Table 2). However, the significance of these changes is uncertain because of small sample sizes in John Day, Ice Harbor, Lower Monumental, and Little Goose reservoirs.

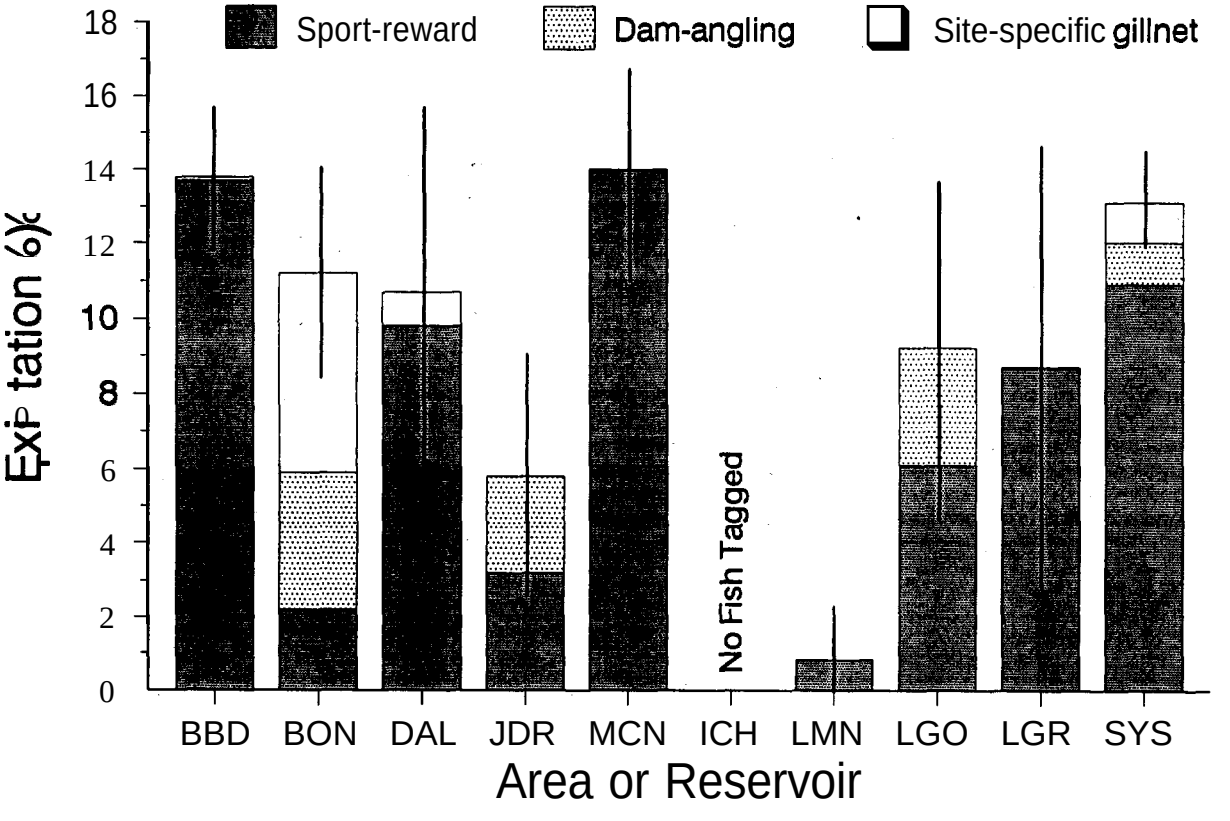

Figure 1. Exploitation rates (%) of northern squawfish ≥250 mm among areas and fisheries in 1994. BBD = Below Bonneville Dam, BON = Bonneville Reservoir, DAL = The Dalles Reservoir, JDR = John Day Reservoir, MCN = McNary Reservoir, ICH = Ice Harbor Reservoir, LMN = Lower Monumental Reservoir, LGO = Little Goose Reservoir, LGR = Lower Granite Reservoir, and SYS = Systemwide. Vertical bars represent 90% confidence intervals around total (all fisheries combined) exploitation estimates. The site-specific Merwin trap fishery is excluded because only six northern squawfish ≥250 mm fork length were caught.

Table 1. Total exploitation rates (all fisheries combined) of northern squawfish ≥250 mm, 1991-94

Area or reservoir	1991	1992	1993	1994
Downstream from				
Bonneville Dam	8.1	11.8	7.1	13.8
Bonneville	15.2	6.8	4.6	11.2
The Dalles	10.5	7.2	7.0	10.7
John Day	13.3	14.3	10.5	5.8
McNary	5.2	5.6	16.5	14.0
Ice Harbor	17.5	--	--	--
Lower Monumental	27.0	7.7	3.1	0.8
Little Goose	18.4	18.1	6.6	9.2
Lower Granite	16.8	14.6	12.6	8.1
Systemwide	11.3	12.2	8.5	13.1

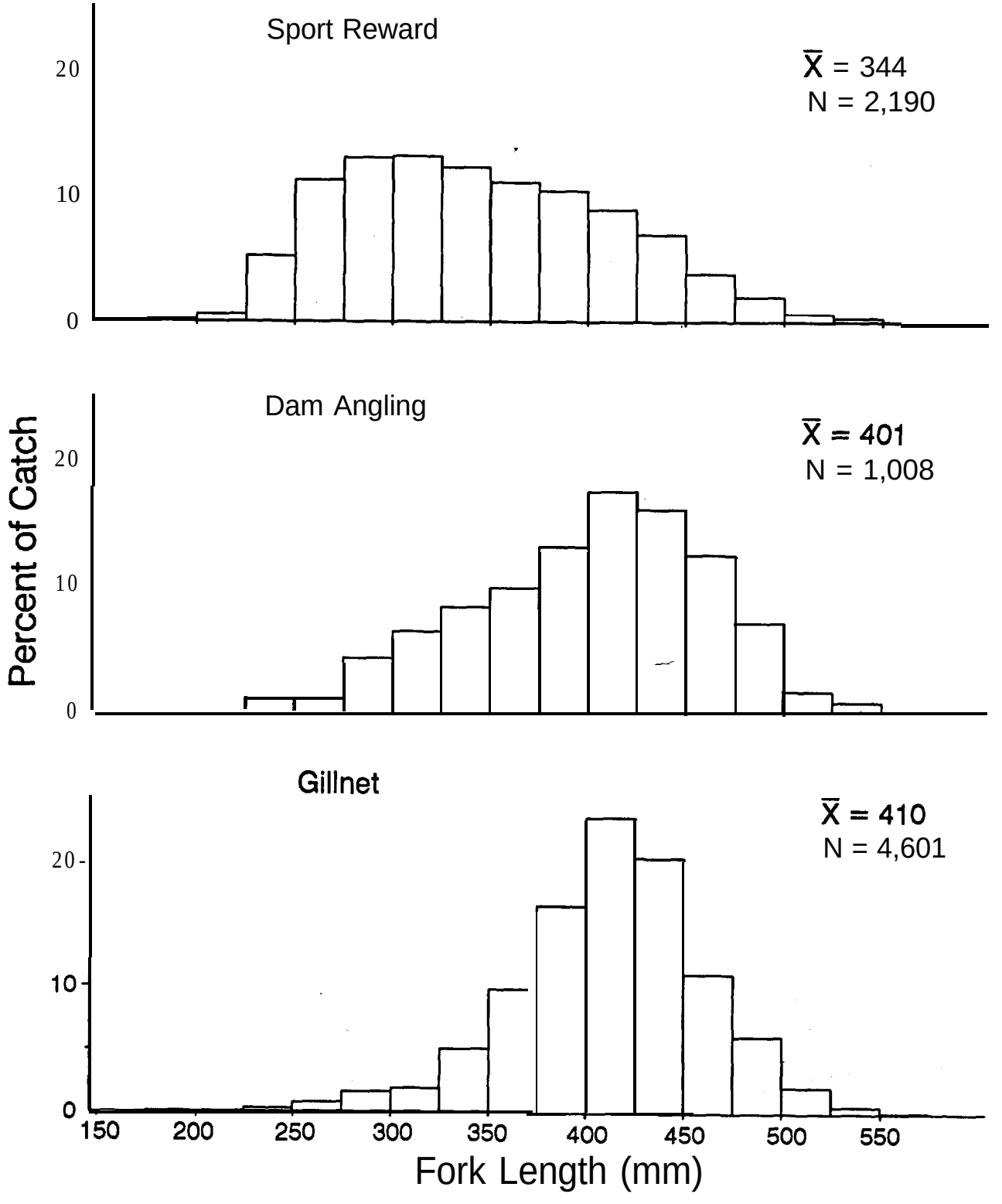

Figure 2. Size composition and mean fork length of northern **squawfish** in subsamples of fish harvested systemwide in sport-reward, dam-angling, and site-specific gill-net fisheries in 1994. N = subsample size.

Table 2. Mean fork length (mm) of northern squawfish harvested from 1990 through 1994 in sport-reward and dam-angling fisheries downstream from Bonneville Dam, and in each lower Columbia and Snake River reservoir.

Fishery: location	Mean fork length (mm)				
	1990	1991	1992	1993	1994
Dam Angling:					
Bonneville Dam Tailrace	414	417	388	390	376
Bonneville Reservoir	407	417	416	415	413
The Dalles Reservoir	421	404	380	420	390
John Day Reservoir	416	414	417	416	437
McNary Reservoir	393	393	375	408	--
Ice Harbor Reservoir	--	375	369	414	--
Lower Monumental Reservoir	--	325	309	341	--
Little Goose Reservoir	--	380	346	373	370
Lower Granite Reservoir	--	--	--	377	--
Sport Reward:					
Downstream from Bonneville Dam	--	332	337	316	337
Bonneville Reservoir	--	343	347	312	323
The Dalles Reservoir	--	344	369	369	358
John Day Reservoir	377	370	367	370	329
McNary Reservoir	--	354	356	358	366
Ice Harbor Reservoir	--	357	360	317	407
Lower Monumental Reservoir	--	338	330	307	428
Little Goose Reservoir	--	312	347	344	376
Lower Granite Reservoir	--	343	345	362	348

Incidental catch varied among fisheries (Table 3). Relative to the total number of fish caught, the dam-angling fishery reported the lowest incidental catch (2.3%). Sport-reward incidental catch was also relatively low (9.4%) and consisted mostly of smallmouth bass (*Micropterus dolomieui*). Incidental catch was highest in the site-specific fishery (37.9% for gill nets and 85.6% for Merwin traps) with suckers (*Catostomus* spp.) comprising the largest proportion (26%) of incidentally caught species. The proportion of predator-sized northern squawfish (≥250 mm fork length) relative to the total number of squawfish harvested was very low (11.1%) for Merwin traps. In contrast, most northern squawfish caught in sport-reward (94.4%), dam-angling (100.0%), and site-specific gill-net (99.0%) fisheries were ≥250 mm in fork length. .

Results from the Loss Estimate Spreadsheet Model indicate that potential predation on juvenile salmonids in 1995 may be reduced 32% from pre-program levels (Table 4). Predation on Snake River stocks will be similar to predation on other stocks. Eventual reductions in potential predation vary depending on estimates of sustained exploitation. However, based on observed exploitation rates, it appears feasible to reduce potential predation by approximately 40%.

Table 3. Number of northern squawfish and incidentally caught fish by species or family in each fishery in 1994. Sport-reward fishery incidental catch represents only those anglers returning to registration stations (S. Smith, Washington Department of Fish and Wildlife, personal communication).

Species or family	Sport reward	Dam angling	Site-specific	
			Gill net	Merwin trap
Northern squawfish				
≥ 250 mm fork length	129,434	16,097	9,018	6
< 250 mm fork length	7,707	0	87	48
Channel catfish	367	43	376	0
Smallmouth bass	6,371	170	51	14
Walleye'	950	40	98	0
White sturgeon'	1,568	74	401	0
American shad" (adult)	437	11	36	0
Salmonidae':				
Chinook (adult)	15	0	81	0
Chinook (juvenile)		0	0	0
Sockeye (adult)		0	1	0
Coho (adult)	2	0	0	0
Steelhead (adult)	77	0	48	3
Steelhead (juvenile)		0	0	0
Unknown (adult)	62	12	0	0
Unknown (juvenile)	201	0	10	147
Mountain Whitefish"	56	0	46	0
Other	239	0	4	0
Other cyprinidae[b]	2,060	--	437	146
Catostomidae[b]	912	--	3,832	7
Other	886	24	135	3
Total (all species)	151,344	16,471	14,661	374
Percent incidental catch	9.4	2.3	37.9	85.6

[a] Walleye = ***Stizostedion vitreum vitreum,*** white sturgeon = ***Acipenser transmontanus, american*** shad = ***Alosa sapidissima,*** salmonids = ***Oncorhynchus*** spp., mountain whitefish = ***Prosopium williamsoni.***

[b] All "non-game" fish caught by dam-angling are classified as "other."

Table 4. Comparison of predicted reductions in potential predation of juvenile salmonids relative to predation prior to implementation of the Northern Squawfish Management Program. Snake River stocks are juvenile salmonids originating upstream from Lower Granite Dam. Numbers in parenthesis represent 90% confidence intervals for estimates of potential predation reduction. Estimates from "Loss Estimate Spreadsheet" (Zimmerman et al. 1995)

	All stocks		Snake River stocks	
	Reduction in predation	Year reached	Reduction in predation	Year reached
Potential predation reduction in 1995	**32% (23-38%)**	--	**32% (23-38%)**	--
Maximum potential predation reduction with 1994 exploitation levels continued	**40% (32-46%)**	1999	**40% (3 2-46%)**	1999
Maximum potential predation reduction with mean 199 1 - 1994 exploitation levels continued	37% (28-43%)	2001	**38% (29-44%)**	**2002**

Biological Evaluation

From 1990 through 1994, density and relative abundance of northern squawfish ≥250 mm changed little in the Columbia River downstream from Bonneville Dam, but decreased in most Columbia and Snake River reservoirs (Appendix Tables C-l and C-2; Figure 3). Among Columbia River reservoirs, the percent change in relative abundance from 1990 to 1994 was highest in The Dalles Reservoir (-7 1%) and lowest in John Day Reservoir (-54%). The percent decrease in relative abundance from 1991 to 1994 was greatest in sections of Snake River reservoirs; -84% for Lower Monumental Reservoir tailrace, -75% for Little Goose Reservoir tailrace, and -71% for upper Lower Granite Reservoir.

Consumption indices for sections of Columbia River reservoirs sampled in 1994 were generally lower than those observed in previous years (Appendix Tables C-3 and C-4). This was

especially true in tailrace boat restricted zones (BRZs) of The Dalles and John Day reservoirs in summer. In the Columbia River downstream from Bonneville Dam and in sections of Snake River reservoirs, consumption indices were similar to or higher than those observed in past years. High spring flows precluded us from sampling in the tailrace BRZs of Bonneville and John Day reservoirs in 1993, and Bonneville, The Dalles, and Lower Monumental Reservoir BRZs in 1994. As a result, we were unable to calculate consumption indices for those areas. Sampling times typically coincided with peaks in downstream passage of juvenile salmonids, except at Bonneville Dam (Appendix D).

Decreased abundance or consumption indices for most areas in 1994 resulted in predation index values that were lower than previously observed, particularly in summer (Appendix Tables C-5 and C-6; Figure 4). The percent change from 1990 to 1994 in predation indices during summer was -47% at Bonneville Dam tailrace, -94% at The Dalles Reservoir (excluding midreservoir), and -89% at John Day Reservoir. The percent change from 1991 to 1994 at Snake River reservoirs in the spring was -73% at Lower Monumental Reservoir tailrace, -61% at Little Goose Reservoir tailrace, and -42% at upper Lower Granite reservoir. Predation index values for the three sections downstream from Bonneville Dam tailrace remained similar between 1992 and 1994 for the spring, but varied considerably in the summer (+228% at RKm 71-121; -72% at RKm 178-224).

Proportional stock density (PSD) expected without implementation of the Northern Squawfish Management Program increased from 1991 to 1994 in Bonneville Dam tailrace and John Day Reservoir (Figure 5). This increase was attributable to a relatively strong 1985 year class being recruited from stock- to quality-size from 1992 through 1994. Observed PSD decreased in Bonneville Dam tailrace and remained similar in Bonneville and John Day reservoirs from 1990 to 1994 (Figure 5). Observed PSDs were usually lower each year than would have been expected without the implementation of the Northern Squawfish Management Program. However, annual changes in observed PSDs did not always parallel expected values. Observed PSD estimates varied widely in Bonneville Reservoir between 1991 and 1994, but remained relatively similar each year in John Day Reservoir.

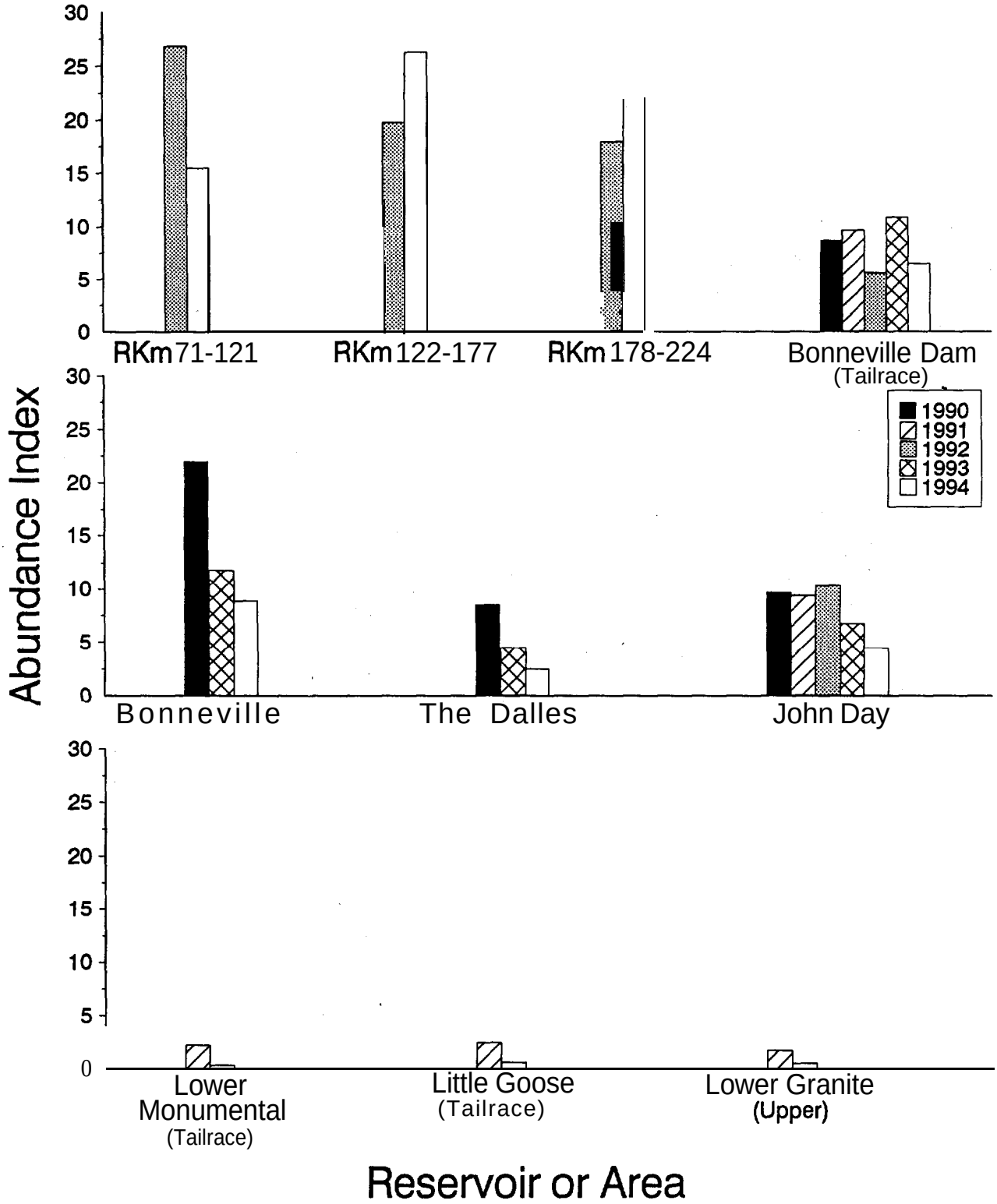

Figure 3. Index of northern squawfish abundance from 1990 through 1994 for sampling locations within the lower Columbia and Snake rivers.

Comparisons of confidence regions for joint estimates of parameters in length-age equations for female northern squawfish indicated that growth relationships in 1994 were not significantly different from most other years (Figure 6). In John Day Reservoir, parameter estimates did not differ significantly among any years from 1990 through 1994.

Comparisons of confidence regions for joint estimates of parameters infecundity-length equations for 1991 through 1994 indicated that relationships varied slightly among years in some areas (Figure 7). In Bonneville Reservoir and the Columbia River downstream from Bonneville Dam, differences in parameter estimates were significant between 1991 and some other years. However, in John Day Reservoir, parameter estimates did not differ significantly among any years. Estimates of mean fecundity and mean relative fecundity changed little or decreased between 1990 and 1994 in all three areas (Table 5).

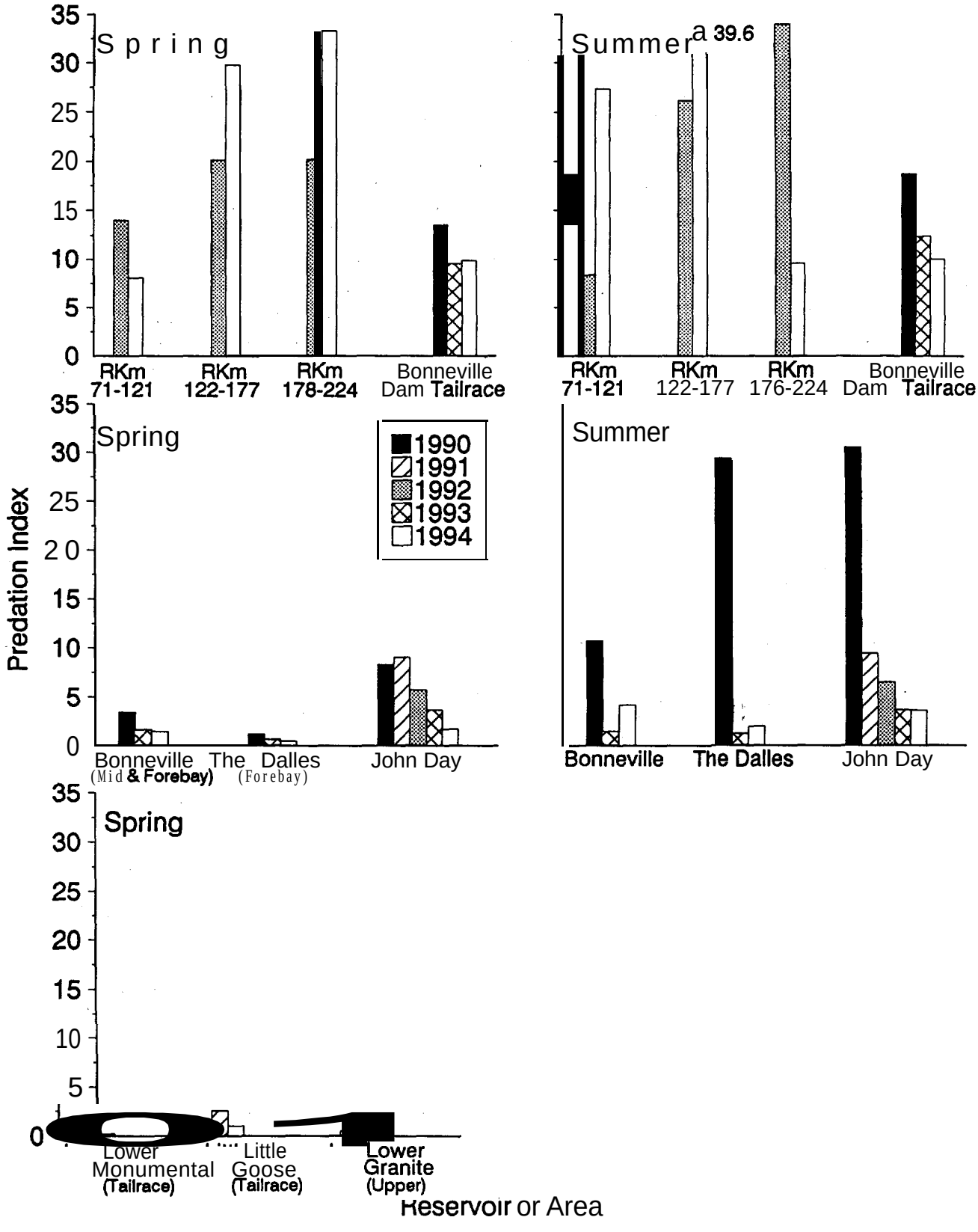

Figure 4. Index of northern squawfish predation for spring and summer from 1990 through 1994 for sampling locations within the lower Columbia and Snake rivers, Predation indices for The Dalles Reservoir in summer excludes the midreservoir section.

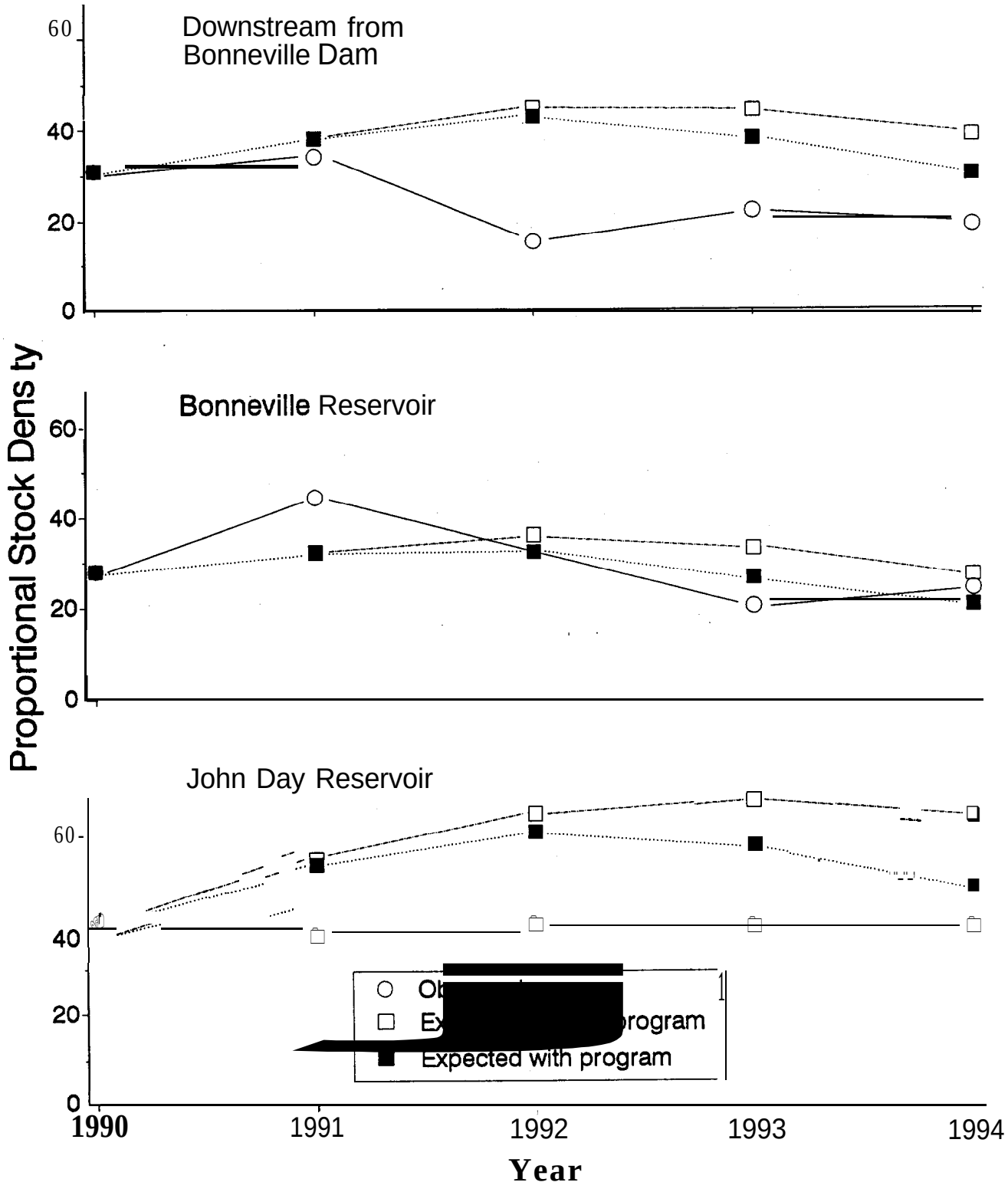

Figure 5. Observed and expected proportional stock density with and without implementation of the Northern Squawfish Management Program from 1990 through 1994 in the Columbia River downstream from Bonneville Dam, Bonneville Reservoir, and John Day Reservoir.

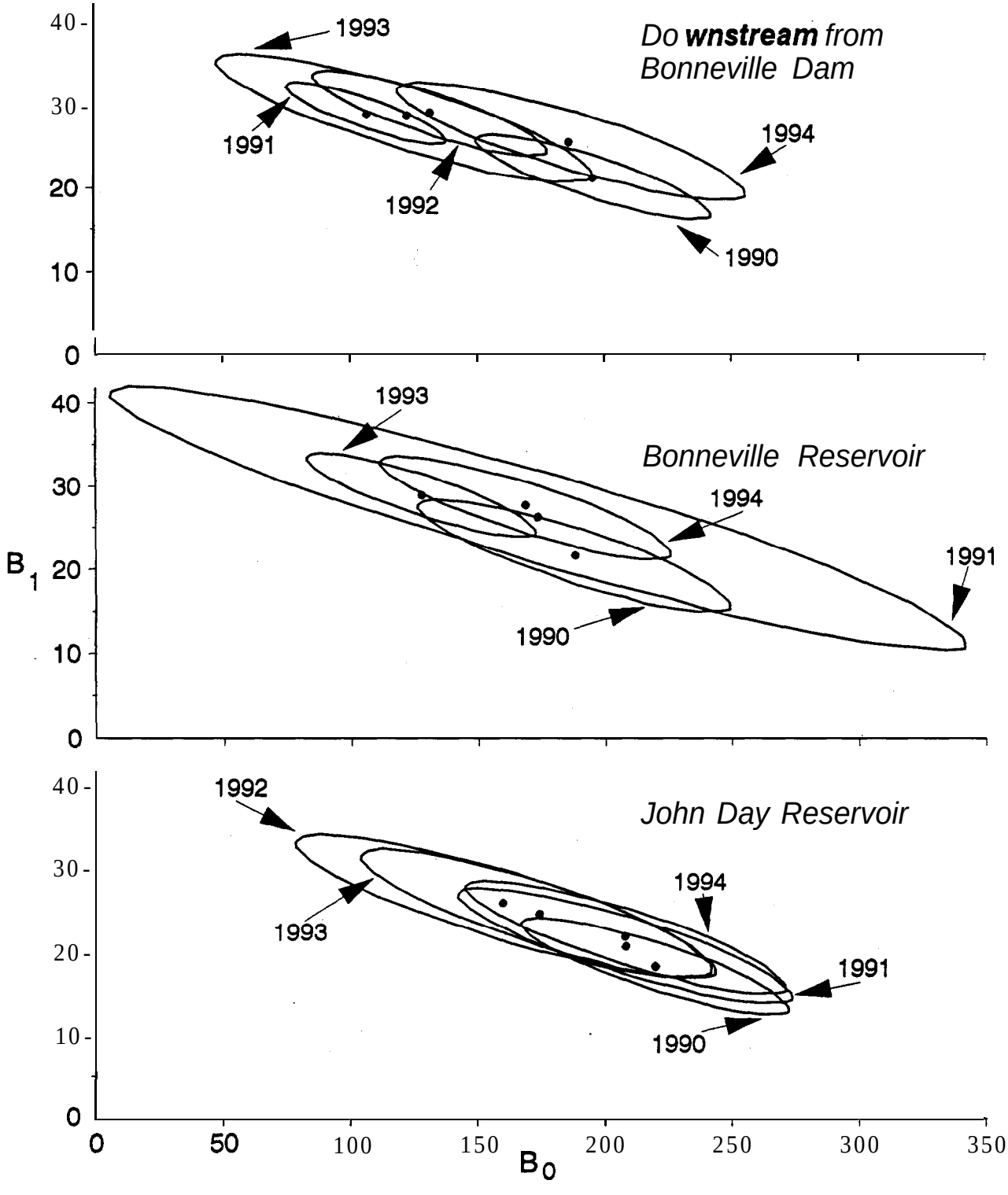

Figure 6. Joint 90% family confidence regions for estimates of length-age equation parameters (B, = slope and B_0 = y-intercept) for female northern squawfish in John Day Reservoir, Bonneville Reservoir, and the Columbia River downstream from Bonneville Dam for 1990 through 1994. No data were available for Bonneville Reservoir in 1992. Parameter pairs are considered significantly different if point estimates (solid circles) are not within the confidence region for another year.

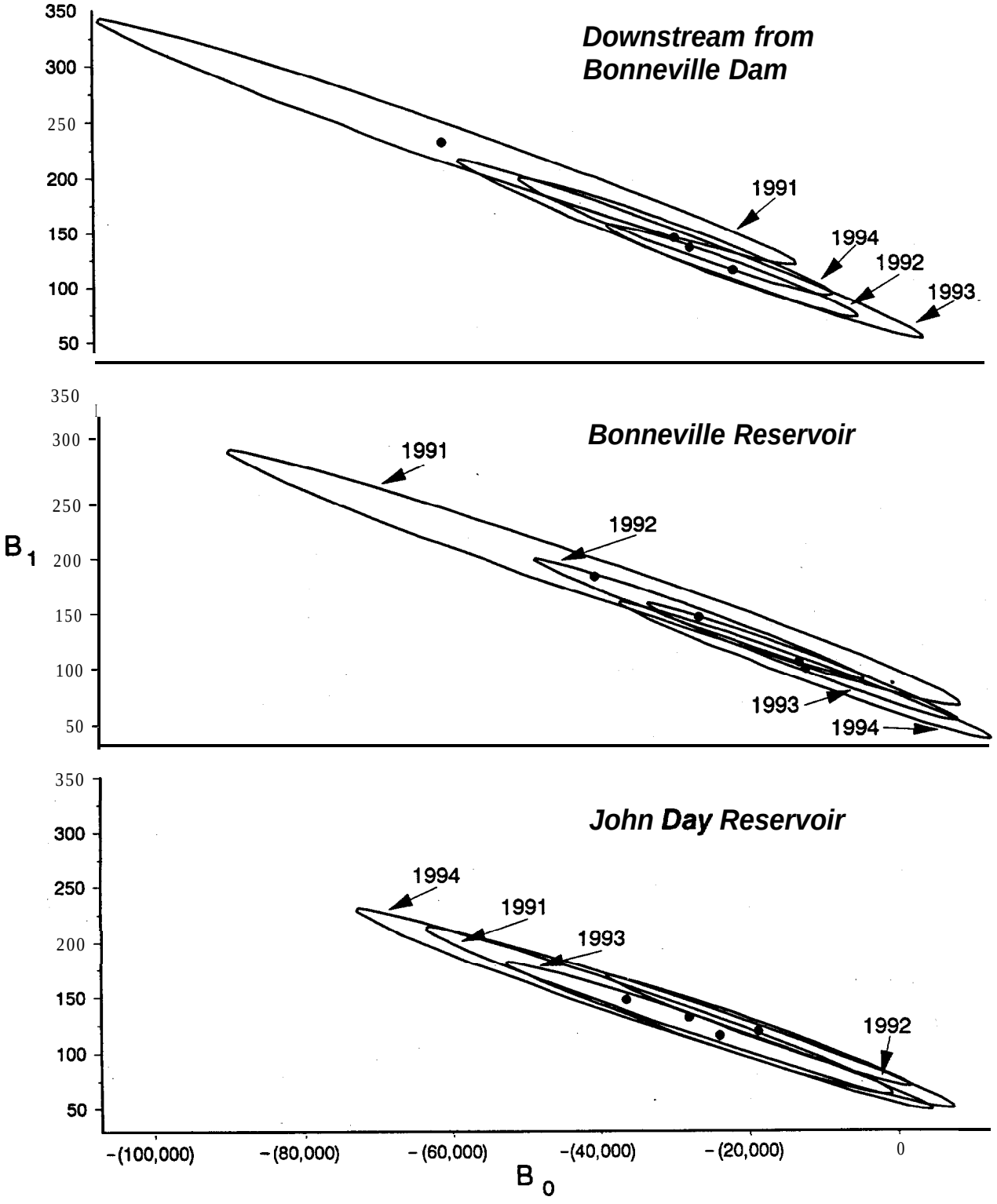

Figure 7. Joint 90% family confidence regions for estimates of fecundity-length equation parameters (B_1 = slope and B_0 = y-intercept) for northern squawfish in John Day Reservoir, Bonneville Reservoir, and the Columbia River downstream from Bonneville Dam for 199 1 through 1994. Parameter pairs are considered significantly different if point estimates (solid circles) are not within the confidence region for another year.

Table 5. Mean fecundity (number of developed eggs per female), mean relative fecundity (number of developed eggs per gram of body weight), and sample size (N) for northern squaw-fish in the Columbia River downstream from Bonneville Dam, Bonneville Reservoir, and John Day Reservoir from 199 1 through 1994.

Location, parameter	1991	1992	1993	1994
Downstream from Bonneville Dam				
Mean fecundity	34,806	23,437	24,288	27,812
Mean relative fecundity	36.58	30.59	34.41	36.47
N	52	77	33	75
Bonneville Reservoir				
Mean fecundity	**35,796**	33,338	30,405	28,688
Mean relative fecundity	43.52	34.94	31.86	31.91
N	45	110	103	101
John Day Reservoir				
Mean fecundity	30,619	3 1,504	26,088	27,638
Mean relative fecundity	28.11	31.62	24.83	**24.93**
N	81	119	96	60

DISCUSSION

Systemwide exploitation was higher in 1994 than in previous years, and well within the 10-20% target range. As in the past, the sport-reward fishery contributed the most to systemwide exploitation rates. Decreases in dam angling exploitation from 1991 through 1994 may be partially attributed to apparent declines in abundance of northern squawfish in tailrace BRZs. Additionally, high spring flows, cooler water temperatures, and associated spill at dams on the Columbia and Snake rivers may have decreased the relative effectiveness of the dam angling fishery over the past two years. Exploitation by dam-angling in The Dalles Reservoir was underestimated, probably because of incomplete mixing of tagged fish. However, systemwide mixing of fish tagged within and outside of BRZs is probably close to 100% (Zimmerman et al. 1995). The site-specific gill-net fishery appears to be a viable option for harvesting known

concentrations of northern squawfish. However, further removal efforts should continue to explore alternatives to help reduce numbers of incidentally caught salmonids.

Reductions in potential predation on stocks of outmigrating Snake River salmonids may reach 32% in 1995 and could reach 40% in the next five years if exploitation remains at past levels. The benefit of reduced predation to Snake River stocks may be particularly important over the next several years given record low escapement of adults in 1994. To reduce potential predation even further, every effort should be made to increase exploitation of northern squawfish. Increased promotional activities and incentives for participation in the sport-reward fishery, trolling.or casting lures from boats in restricted zones near dams as conducted by ODFW in 1994 (Appendix E), and expansion of the site-specific gill-net fishery could help enhance harvest in 1995.

Decreases in predation indices in reservoirs above Bonneville Dam were a result of lower abundance and consumption indices in those areas. Estimates of abundance may be affected by changing environmental conditions that influence vulnerability of 'northern squawfish to our sampling gear. However, incremental decreases in abundance indices each year in areas such as Bonneville and John Day reservoirs indicate that sustained removals may be affecting abundance. Furthermore, decreases in abundance indices for Bonneville and John Day reservoirs have corresponded to decreases in population estimates based on mark and recapture (Oregon Department of Fish and Wildlife, unpublished data). We are comfortable comparing consumption indices among years because (1) timing of sampling for nor-them squawfish digestive tracts usually coincided with peaks in smolt outmigration, (2) most actively feeding northern squawfish captured during peak smolt abundance were probably feeding at the upper end of the functional relationship between consumption rate and quantity of available prey, and (3) changes in consumption indices among years were not always directly related to changes in smolt abundance.

Decreases in proportional stock density were greater than could be explained by fluctuations in year-class strength, and indicate that sustained removals may be altering the size structure of predator-sized northern squawfish. Proportional stock densities will probably continue to decrease in 1995 and 1996 as a result of relatively strong recruitment years in 1989 and 1990, increasing the number of stock-sized fish. Observed PSDs did not always parallel expected values, but continued sampling will provide a more accurate picture of year-class strength, which should increase precision of expected PSD estimates.

We were unable to detect evidence of compensation among not-them squawfish to sustained removals, either in growth or fecundity. The magnitude of variation in growth and fecundity estimates observed from 1991 through 1994 indicates the difficulty in detecting a compensatory response of northern squawfish populations to sustained removals.

Our sampling approach in 1994 appeared adequate for collecting enough northern squawfish digestive tract samples to compare consumption indices among years. We believe that sampling through 1996 should provide sufficient information on changes in northern squawfish population characteristics, and the benefit of time-series analyses will allow us to better quantify annual variation among all population parameters.

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APPENDIX A

Exploitation of Northern Squawfish by Reservoir and Fishery: 1991 through 1994

Appendix Table A-l. Exploitation rates (%) of northern squawfish ≥250 mm among fisheries in 1994. The site-specific Merwin trap fishery is excluded because only six northern squawfish ≥250 mm fork length were caught.

Area or Reservoir	Sport Reward	Dam Angling	Site-specific Gillnet	Total
Downstream from Bonneville Dam	13.7	0.1	--	13.8
Bonneville	2.2	3.7	5.3	11.2
The Dalles	9.8	0.0[a]	0.9,	10.7
John Day	3.2	2.6	0.0[a]	5.8
McNary	14:o	0.0[a]	0.0[a]	14.0
Ice Harbor	--	--	--	--
Lower Monumental	0.8	0.0[a]	0.0[a]	0.8
Little Goose	6.1	3.1	0.0[a]	9.2
Lower Granite	8.7	0.0[a]	0.0[a]	8.7
System-Wide	10.9	1.1	1.1	13.1

[a] Northern squawfish harvested, but no tags recovered.

Appendix Table A-2. Exploitation rates (%) of northern squawfish ≥250 mm for the sport-reward fishery from 1991 through 1994.

Area or reservoir	1991	1992	1993	1994
Downstream from Bonneville Dam	7.9	11.5	6.1	13.7
Bonneville	13.4	4.1	2.1	2.2
The Dalles	6.1	6.3	7.0	9.8
John Day	4.3	3.5	2.4	3.2
McNary	3.3	5.6	16.0	14.0
Ice Harbor	3.9	--	--	--
Lower Monumental	10.0	1.8	3.1	0.8
Little Goose	5.0	12.0	3.3	6.1
Lower Granite	16.8	14.7	12.6	8.7
System-Wide	8.3	9.4	6.8	10.9

Appendix Table A-3. Exploitation rates (%) of northern squawfish ≥250 mm for the dam-angling fishery from 1991 through 1994.

Area or reservoir	1991	1992	1993	1994
Downstream from Bonneville Dam	0.2	0.2	0.0[a]	0.1
Bonneville	1.8	1.0	[illegible]	3.7
The Dalles	4.4	10.9	8.1	0.0[a]
John Day	9:o			2.6
McNary	1.9	--	0.5	0.0[a]
Ice Harbor	13.6	--	--	--
Lower Monumental	17.0	6.0	--	0.0[a]
Little Goose	13.4	6.1	3.3	3.1
Lower Granite	--	--	0.0[a]	0.0[a]
System-Wide	3.0	2.7	1.3	1.1

[a] Northern squawfish harvested, but no tags recovered.

Appendix Table A-4. Dates for each period in 1994.

Period	Dates	Period	Dates
1	before May 1	12	July 10 - July 16
2	May 1 - May 7	13	July 17 - July 23
3	May 8 - May 14	14	July 24 - July 30
4	May 15 - May 21	15	July 31 - August 6
5	May 22 - May 28	16	August 7 - August 13
6	May 29 - June 4	17	August 14 - August 20
7	June 5 - June 11	18	August 21 - August 27
8	June 12 - June 18	19	August 28 - September 3
9	June 19 - June 25	20	September 4 - September 10
10	June 26 - July 2	21	September 11 - September 17
11	July 3 - July 9	22	September 18 - September 24

Appendix Table A-5. Exploitation of northern squawfish downstream from Bonneville Dam in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time. period	T	Recaptures			M	Exploitation	
		Sport	Dam	Misc.		Sport	Dam
1	402	--	--	--	--	--	
2	632	3	--		402	0.0075	
3	--	3	--		1031	0.0029	
4	--	2	--	--	1028	0.0019	--
5	--	5	--	--	1026	0.0049	--
6	--	10		--	1021	0.0098	--
7	--	10		--	1011	0.0099	
8	--	16	--	1	1001	0.0160	
9	--	8	--	--	984	0.0081	
10	--	13		--	976	0.0133	--
11	--	14	1		963	0.0145	0.0010
12	--	7		1	948	0.0074	--
13	--	8	--	1	940	0.0085	
14	--	4	--	2	931	0.0043	
15	--	1	--	1	925	0.0011	--
16	--	1		--	923	0.0011	--
17		1		1	922	0.0011	--
18		5			920	0.0054	--
19	--	2			915	0.0022	
20	--	2	--		913	0.0022	
21	--	5	--		911	0.0055	
22	--	3	--		906	0.0033	
Total	1034	123	1	7	--	0.1309	0.0010
Adjusted for tag loss						0.1366	0.0010

Appendix Table A-6. Exploitation of northern squawfish in Bonneville Reservoir in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures				M	Exploitation		
		Sport	Dam	Net	Misc.		Sport	Dam	Net
1	407	--	--	1	--	--	--	--	0.0025
2	--	--	--		1	406	--	--	0.0074
3	--	1	--	3	4	402	0.0025	--	0.0075
4	--	--	--	10		394	--	--	0.0254
5	--	1	--	2	--	384	0.0026		0.0052
6	--	2	--	1	--	381	0.0052	--	0.0026
7	--	1	1	--	1	378	0.0026	0.0026	
8	--	2	2	--	4	375	0.0053	0.0053	
9	--	--	5	--	2	367	--	0.0136	
10	--	--	3	--	1	360	--	0.0083	--
		--	1	--	1	356	--	0.0028	
: :	II	--	--	--	1	354	--	--	--
13	--	--	1	--	1	353	--	0.0028	
					2	351	--	--	
: ;	II	--	--	--	1	349		--	
16	--	1	--	--		348	0.0029	--	--
	--	--	--	--	--	347	--	--	--
: ;	--	--	--	--	--	347	--	--	
19	--				1	347	--		
..	--					346	--	--	
;;	--					346	--		
22	--					346	--	--	
Total	407	8	13	20	20	--	0.0212	0.0356	0.0505
Adjusted for tag loss							0.0221	0.0371	0.0527

Appendix Table A-7. Exploitation of northern squawfish in The Dalles Reservoir in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures				M	Exploitation		
		Sport	Dam	Net	Misc.		Sport	Dam	Net
:	124					124			
3		1							
4			II		II	124 123	0.0081		
5		1				123	0.0081		
6						122			
7		1		1					
8	II		II		2	122 120	0.0082		0.0082
9		2				118	0.0169		
10									
11		2				116 114	0.0172 0.0088		
12		;				113	0.0088		
13					1				
14	II	1				111 110	0.0090		
15						110			
16									
17			II	II		110 110			
18						110			
19						110			
20									
21	II	1	II		II	110 110	0.0091		
22						109			
Total	124	11	0	1	3	--	0.0943	0.0000	0.0082
Adjusted for tag loss							**0.0984**	**0.0000**	**0.0086**

Appendix Table A-8. Exploitation of northern squawfish in John Day Reservoir in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures			M	Exploitation	
		Sport	Dam	Misc.		Sport	Dam
1	166		--	--	--		--
2				--	166	--	--
3	--	--	--	--	166	--	--
4	--	1	--	--	166	0.0060	--
5	--				165		--
6			1		165	--	0.0061
7	--	3	--	--	164	0.0183	--
8	--	--	--	--	161		--
9	--	--	2	--	161	--	0.0124
10	--	1		4	159	0.0063	
11	--			1	154	--	
12					153		
13			1		153		0.0065
14	--	--	--	--	152	--	--
15	--	--	--	--	152		--
16	--	--	--	2	152	--	--
17	--	--	--	--	150		--
18					150	--	--
19			--	1	150		--
20	--	--	--	--	149	--	--
21	--	--	--	--	149		--
22	--	--	--	--	149		--
Total	166	5	4	8		0.0306	0.0250
Adjusted for tag loss						0.0319	0.0261

Appendix Table A-9. Exploitation of northern squawfish in McNary Reservoir in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures			M	Exploitation	
		Sport	Dam	Misc.		Sport	Dam
1					--	--	
2	448	--	--	--	448	0.0067	--
3	--						
4	--	1	II	II	445 443	0.0045 0.0023	--
5	--	4	--	1	442	0.0090	--
6	--	4	--	1	437	0.0092	--
7	--	2	--	--	432	0.0046	--
8	--	4	--	--	430	0.0093	--
9	--	5	--	--	426	0.0117	--
10		4		1			
11	II	3	II	--	421 416	0.0095 0.0072	--
12	--						
13	--	44	--	-- 1	413 408	0.0097 0.0098	-- --
14		1	--	--			
15	II	2	--	--	404 403	0.0025 0.0050	--
16	--	2	--	--	401	0.0050	--
17	--	1		1			
18	--	2	II	--	399 397	0.0025 0.0050	--
	--	5					
: ;	--	2	II	II	395 390	0.0127 0.0051	--
21	--	--	--	--	388	--	--
22	--	1	--	--	388	0.0026	--
Total	448	56	0	5	--	0.1339	0.0000
Adjusted for tag loss						0.1397	0.0000

Appendix Table A-10. Exploitation of northern squawfish in Lower Monumental Reservoir in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures			M	Exploitation	
		Sport	Dam	Misc.		Sport	Dam
1	--			--	--		--
2	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--
5	130	--	--	--	--	--	--
6	--	--	--	--	130	--	--
7	--		--	--	130		
8	--		--	1	130		
9	--		--	--	129	--	
10	--	--	--	--	129	--	--
11	--	--	--	2	129	--	--
12	--		--	--	127		--
13	--		--	--	127		--
14	--		--	--	127	--	--
15	--	--	--	--	127		--
16	--	--	--	--	127	--	--
17	--	1	--	--	127	0.0079	--
18	--		--	--	126		--
19	--		--	--	126		--
20	--			--	126		--
21	--	--	--	--	126	--	--
22	--	--	--	--	126	--	--
Total	130	1	0	3	--	0.0079	0.0000
Adjusted for tag loss						0.0082	0.0000

Appendix Table A-11. Exploitation of northern squawfish in Little Goose Reservoir in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures			M	Exploitation	
		Sport	Dam	Misc.		Sport	Dam
1	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--
4		--	--	--	--		--
5	105	--	--	--	--	--	
6	--	--	1	--	105	--	0.0095
7	--	--	--	--	104		
8		5	--	--	104	0.0481	
9			1	--	99		0.0101
10			1	--	98	--	0.0102
11	--	--	--	--	97	--	--
12	--	--	--	--	97	--	
13	--	--	--	--	97		
14	--	--	--	--	97		
15			--	--	97		
16			--	--	97	--	--
17	--	--	--	--	97	--	--
18	--	--	--	--	97		--
19	--	--	--	--	97		--
20			--	--	97		--
21	--			--	97	--	--
22		1	--	--	97	0.0103	--
Total	105	6	3	0	--	0.0584	0.0298
Adjusted for tag loss						0.0609	0.0311

Appendix Table A-12. Exploitation of northern squawfish in Lower Granite Reservoir. in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures			M	Exploitation	
		Sport	Dam	Misc.		Sport	Dam
1			--	--			
2		--	--	--			--
3	15	--	--	--	--		--
4	47	--	--	--	15	--	--
5	--	1	--	--	62	0.0161	--
6			--	--	61	--	
7		2	--	--	61	0.0328	
8			--	--	59		
9			--	--	59		
10	--	--	--	--	59	--	--
11	--	1	--	--	59	0.0169	--
12		1	--	--	58	0.0172	--
13			--		57		
14			--	--	57		
15			--	--	57		
16	--	--	--	--	57	--	--
17	--	--	--	--	57	--	--
18	--		--		57	--	--
19			--	--	57		--
20	--		--	--	57	--	
21	--	--	--	--	57		--
22	--	--	--	--	57	--	--
Total	62	5	0	0	--	0.0831	0.0000
Adjusted for tag loss						0.0867	0.0000

Appendix Table A-13. Exploitation of northern squawfish system-wide in 1994. T = number marked. M = number marked at large. Misc. = marked fish recaptured in other fisheries or in other areas.

Time period	T	Recaptures				M	Exploitation		
		Sport	Dam	Net	Misc.		Sport	Dam	Net
1	1547	--	--	1	--	--	--		0.0006
2	632	7	--	3	--	1546	0.0045		0.0019
3	15	11	--	3	--	2168	0.0051	--	0.0014
4	47	4	--	10	--	2169	0.0018	--	0.0046
5	235	13	--	2	--	2202	0.0059		0.0009
6	--	17	2	1	--	2422	0.0070	0.0008	0.0004
7	--	20	1	2	--	2402	0.0083	0.0004	0.0008
8	--	28	2	--	7	2379	0.0118	0.0008	--
9	--	17	8	--	--	2342	0.0073	0.0034	--
10	--	21		--	4	2317	0.0091	0.0022	--
11	--	22	5		1	2287	0.0096	0.0009	--
12	--	14	--	--	3	2262	0.0062	--	--
13	--	14	2	--	1	2245	0.0062	0.0009	--
14	--	6	--	--	3	2228	0.0027	--	--
15	--	4	--	--	1	2219	0.0018		--
16	--	5	--	--	1	2214	0.0023	--	--
17	--	3	1	--	1	2208	0.0014	0.0005	--
18	--	7	--	--	--	2203	0.0032	--	--
19	--	8	1	--	--	2196	0.0036	0.0005	--
20	--	4	--	--	--	2187	0.0018	--	--
21	--	6	--			2183	0.0027		--
22	--	5	--			2177	0.0023		--
Total	2476	236	24	22	22	--	0.1046	0.0103	0.0107
Adjusted for tag loss							0.1092	0.0107	0.0112

APPENDIX B

Calculations of Northern Squawfish Year-Class Strengths, Size Selectivity, and Adjustment of PSD Estimates

Year-Class Strengths

To adjust expected proportional stock density (PSD) estimates for fluctuations in northern squawfish year-class strength, we modified the method of El-Zarka (1959) to index relative year-class strengths of northern squawfish cohorts produced between 1985 and 1990 in Bonneville Dam tailrace, Bonneville Reservoir, and John Day Reservoir. The El-Zarka (1959) procedure compared the relative abundance of each year class in catches from standardized sampling over a number of years However, the relative abundance of year classes in our catches were biased by exploitation rates that varied both among years and among ages within years. We therefore limited our comparisons to the relative abundance of northern squawfish large enough to be effectively sampled by our standardized electrofishing (ages 3 and older), but small enough to be excluded from the Northern Squawfish Management Program (ages 5 and younger). Limiting our comparisons to fish 3-5 years old also eliminated potential uncertainty caused by differences between sexes in growth after age 5 (Parker et al. 1995). Analysis indicated that cyclical variation in year-class strength of northern squawfish occurred in Bonneville Dam tailrace, Bonneville Reservoir, and John Day Reservoir between 1985 and 1990 (Appendix Figure B-l).

Size Selectivity

To adjust observed PSD estimates for size-selectivity of sampling gear, we compared the recapture rate among 50-mm size groups of marked northern squawfish. For each size group, we summed the number of fish marked for 1992 through 1994 evaluations of exploitation (Parker et al. 1992, Zimmerman et al. 1995), and the number of fish marked in John Day Reservoir from April through June, 1983-86 (ODFW, unpublished data). We then summed the number of marked fish recaptured during 1992-94 standardized electrofishing, and by electrofishing in John Day Reservoir from July through August, 1983-86. Only fish marked and recaptured in the same year were included. We pooled results to determine the overall recapture rate for each size group, and used regression analysis to determine the relationship between size (fork length) and recapture rate. Analysis indicated that vulnerability of northern squawfish to standardized electrofishing increased ($r^2 = 0.90$; $P < 0.05$) with increasing fork length (Appendix Figure B-2).'

Adjustment of PSD Estimates

We used age composition of our catches rather than size composition to incorporate year-class strength information and allow comparisons between observed and expected PSDs. We used pooled 1990-93 age-at-length data to (1) back-calculate age-specific lengths for female and

male northern squawfish, (2) estimate sex-specific age composition within 25-mm length intervals, and (3) estimate for each sex the proportion of each age (5 years) that were at least stock and quality size.

To estimate 1990-94 observed PSDs, we summarized sex-specific catch data into 25-mm length intervals to determine sex-specific age distributions. Sex-specific age distributions were corrected for size selectivity by dividing the observed frequency of each age by the recapture rate of the mean fork length of that age. The number of stock and quality size fish for each sex was estimated from the age distributions; observed PSDs were estimated by summing the total number of stock and quality size fish each year.

We calculated expected PSDs (with and without observed exploitation rates) for 1991-94, years subsequent to program implementation. Recruitment to age 5 varied as a function of relative year-class strength:

$$N_{5,i} = N_{5,0} \quad ((100 + Y_i) / (100 + Y_0))$$

where

$N_{5,i}$ = number of age 5 fish in year I,

$N_{5,0}$ = number of age 5 fish in 1990,

Y_i = relative year-class strength (percent deviation from mean) in year I, and

Y_0 = relative year-class strength (percent deviation from mean) in 1990.

Age composition varied as a function of natural survival rates and exploitation rates:

$$Ni,j = N_{i-1,j-1} \quad S(1 - E_{i-1,j-1})$$

where

$N_{i,j}$ = number of fish in year I of age j,

$N_{i-1,j-1}$ = number of fish in year I-l of age j-l,

S_{j-1} = natural annual survival fate

$E_{i-1,j-1}$ = exploitation rate in year I-l on fish of age j-l.

We used catch curves from 1990 data adjusted for size selectivity to estimate natural survival rates. Age distributions of the 1990 catch were estimated for each sex then combined into one catch curve. The expected number of stock and quality size fish for each sex was estimated from

expected age distributions (corrected for size selectivity), and observed PSDs were estimated by summing the total number of expected stock and quality size fish each year.

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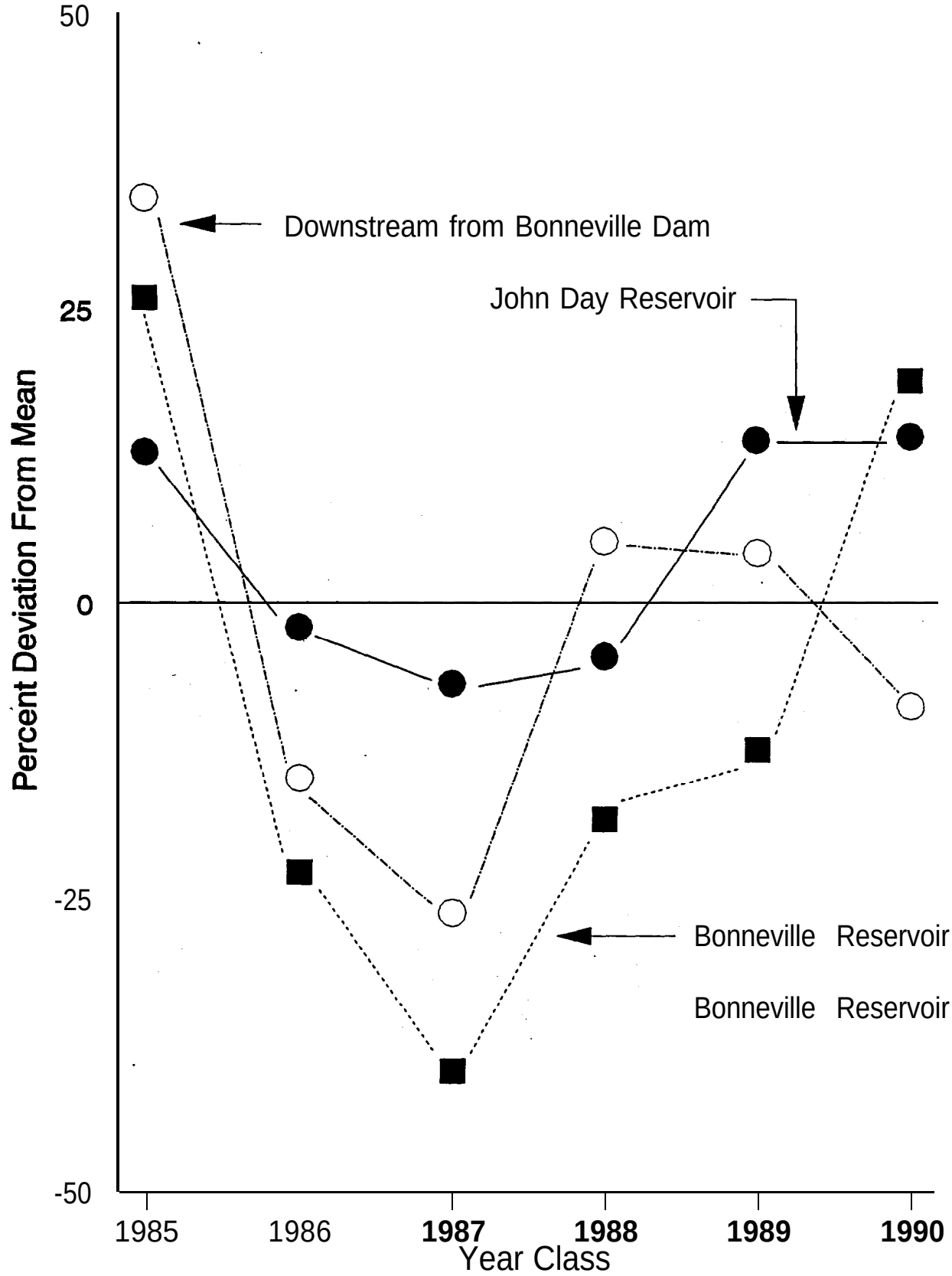
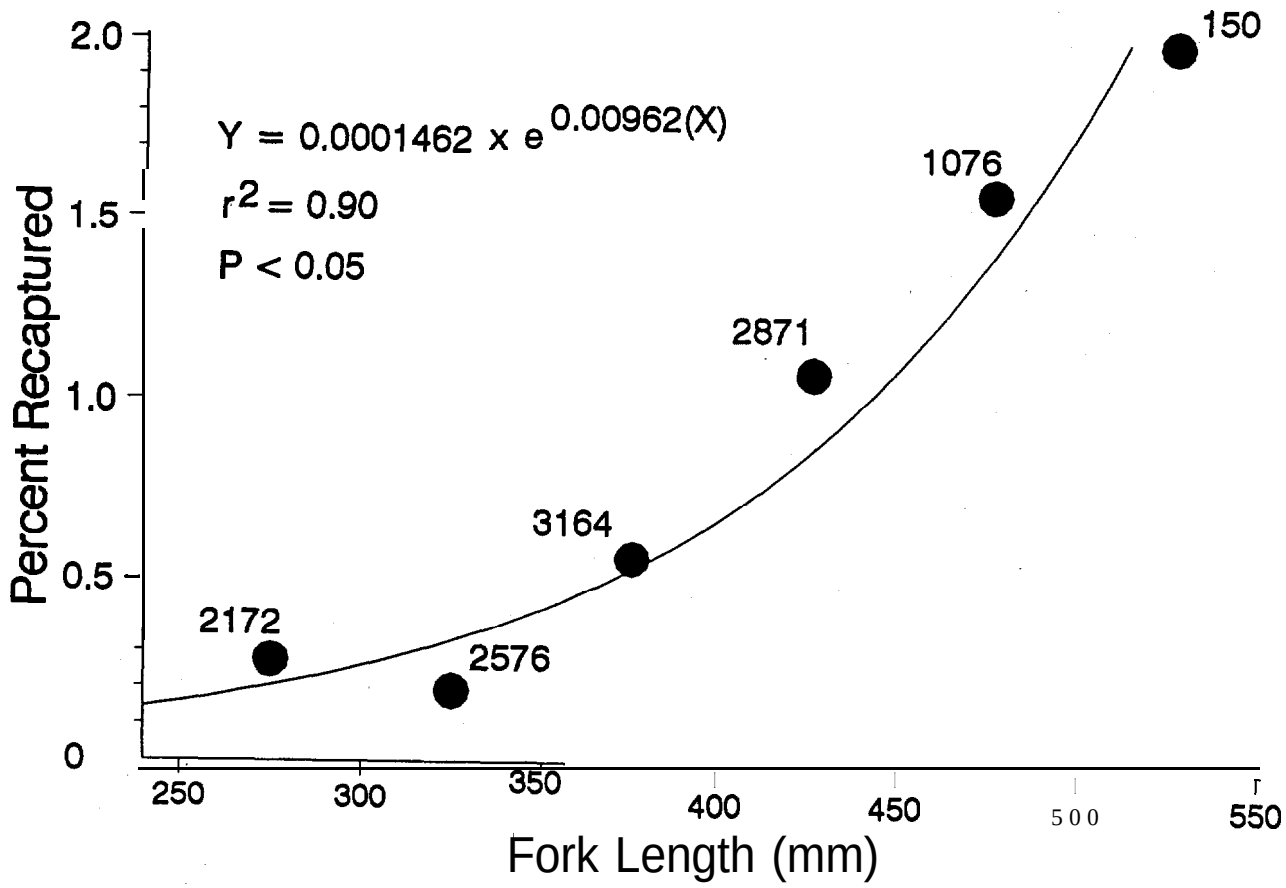


Appendix Figure B-l. Index of relative year-class strength of northern squawfish in the Columbia River downstream from Bonneville Dam, Bonneville Reservoir, and John Day Reservoir.



Appendix Figure B-2. Recapture rates for northern squawfish by 50-mm length intervals' from standardized electrofishing runs. Numbers of marked fish at large in each size group, are shown for each data, point.

APPENDIX C

Density, Abundance, Consumption, and Predation Indices from 1990 through 1994 for Sampling Locations in the Lower Columbia and Snake Rivers

Appendix Table C-l. Indices of northern squawfish density based upon catch per unit effort from standardized electrofishing runs from 1990 through 1994 for sampling zones within the Lower Columbia and Snake River. RKm = river kilometer. BRZ = boat restricted zone.

Location, zone	Density Index				
	1990	1991	1992	1993	1994
Below Bonneville Dam					
RKm 71-121	--	--	1.691	--	0.972
RKm 122-177	--	--	1.573	--	2.091
RKm 178-224	--		1.412	--	1.744
Tailrace	5.750	6,859	3.432	9.625	2.926
Tailrace BRZ	13.709	19.000	12.913	14.520	18.875
Bonneville Reservoir					
Forebay	5.711	--	i-	2.229	2.371
Mid-reservoir	2.102	--	--	1.179	0.690
Tailrace	0.512	--	--	1.103	0.600
Tailrace BRZ	5.465	--	--	1.500	6.750
The Dalles Reservoir					
Forebay	1.104	--	--	1.216	0.554
Tailrace	2.750	--	--	0.714	0.650
Tailrace BRZ	21.541	--	--	10.800	5.500
John Day Reservoir					
Forebay	0.715	0.656	1.252	0.634	0.692
Mid-reservoir	0.265	0.240	0.339	0.163	0.116
Tailrace	0.764	0.750	0.106	0.451	0.265
Tailrace BRZ	14.727	17.933	9.235	13.333	2.400
Lower Monumental Reservoir					
Tailrace	--	1.524	--	--	0.331
Tailrace BRZ	--	16.312	--	--	1.200
Little Goose Reservoir					
Tailrace	--	1.625	--	--	0.484
Tailrace BRZ	--	28.294	--	--	6.418
Lower Granite Reservoir					
Upper-reservoir	--	1.855	--	--	0.541

Appendix Table C-2. Indices of northern squawfish abundance from 1990 through 1994 for sampling locations in the Lower Columbia and Snake Rivers. RKm = river kilometer. BRZ = boat restricted zone.

Location, zone	Abundance Index				
	1990	1991	1992	1993	1994
Below Bonneville Dam					
RKm 71-121	--	--	26.8	--	15.4
RKm 122-177	--	--	19.7	--	26.2
RKm 178-224	--	--	17.9	--	22.1
Tailrace	4.5	5.4	2.7	7.6	2.3
Tailrace BRZ	3.0	4.1	2.8	3.1	4.1
Bonneville Reservoir					
Forebay	5.5	--	--	2.1	2.3
Mid-reservoir	15.2	--	--	8.5	5.0
Tailrace	0.4	--	--	0.8	0.5
Tailrace BRZ	0.9	--	--	0.2	1.1
The Dalles Reservoir					
Forebay	1.4	--	--	1.6	0.7
Tailrace	2.7	--	--	0.7	0.6
Tailrace BRZ	4.4	--	--	2.2	1.1
John Day Reservoir					
Forebay	1.4	1.3	2.5	1.2	1.4
Mid-reservoir	5.2	4.7	6.6	3.2	2.3
Tailrace	1.4	1.4	0.2	0.9	0.5
Tailrace BRZ	1.6	1.9	1.0	1.4	0.3
Lower Monumental Reservoir					
Tailrace	--	1.3	--	--	0.3
Tailrace BRZ	--	0.8	--	--	0.1
Little Goose Reservoir					
Tailrace	--	0.7	--	--	0.2
Tailrace BRZ	--	1.7	--	--	0.4
Lower Granite Reservoir					
Upper-reservoir	--	1.6	--	--	0.5

Appendix Table C-3. Indices of northern squawfish consumption of juvenile salmonids from 1990 through 1994 during spring in the Lower Columbia and Snake Rivers. RKm = river kilometer. BRZ = boat restricted zone.

Location, zone	Consumption Index				
	1990	1991	1992	1993	1994
Below Bonneville Dam					
RKm 71-121	--	--	0.5	--	0.5
RKm 122-177	--	--	1.0		
RKm 178-224	--	--	1.1	--	:::
Tailrace					3.2
Tailrace BRZ	:::	--	--	0.8	0.6
Bonneville Reservoir					
Forebay	0.6	--	--	0.7	0.2
Mid-reservoir	0.0	--	--	0.0	0.2
Tailrace	0.3	--	--	0.0	0.0
Tailrace BRZ	2.3	--	--	--	--
The Dalles Reservoir					
Forebay	0.8	--	--	0.1	0.1
Tailrace		--	--	0.0	--
Tailrace BRZ	Z	--	--	0.0	--
John Day Reservoir					
Forebay	1.5	1.9	1.9	1.5	1.0
Mid-reservoir	0.0	0.5	0.0	0.0	0.0
Tailrace	1.5	0.9	0.0	2:o	0.3
Tailrace BRZ	2.5	1.5	0.9	--	0.7
Lower Monumental Reservoir					
Tailrace	--	0.6	--	--	0.7
Tailrace BRZ	--	0.7	--	--	--
Little Goose Reservoir					
Tailrace	--	0.7	--	--	1.9
Tailrace BRZ	--	1.2	--	--	1.5
Lower Granite Reservoir					
Upper-reservoir	--	0.3	--	--	0.6

Appendix Table C-4. Indices of northern squawfish consumption of juvenile salmonids from 1990 through 1994 during summer in the Lower Columbia and Snake Rivers. RKm = river kilometer. BRZ = boat restricted zone.

Location, zone	Consumption Index				
	1990	1991	1992	1993	1994
Below Bonneville Dam					
RKm 71-121	--		0.3		1.8
RKm 122-177	--		1.3	--	1.5
RKm 178-224	--		1.9	--	0.4
Tailrace	0.5	--	--	1.2	0.4
Tailrace BRZ	5.5	--		1.0	2.1
Bonneville Reservoir					
Forebay	1.8			0.5	0.3
Mid-reservoir	0.0	--	--	0.0	0.0
Tailrace	0.0	--	--	0.0	0.0
Tailrace BRZ	0.8	--	--	1.0	3.2
The Dalles Reservoir					
Forebay	1.0			0.0	0.0
Tailrace	0.0			0.0	0.8
Tailrace BRZ	6.4	--	--	0.5	1.2
John Day Reservoir					
Forebay	2.4	3.1	0.7	0.6	1.2
Mid-reservoir	0.9	0.0	0.0	0.6	0.6
Tailrace	2.6	0.0	0.0	0.0	0.0
Tailrace BRZ	1137	2.8	4.6	0.6	1.9

Appendix Table C-5. Indices of northern squawfish predation on juvenile salmonids in the spring (May-June) from 1990 through 1994 for sampling locations in the Lower Columbia and Snake Rivers. RKm = river kilometer. BRZ = boat restricted zone.

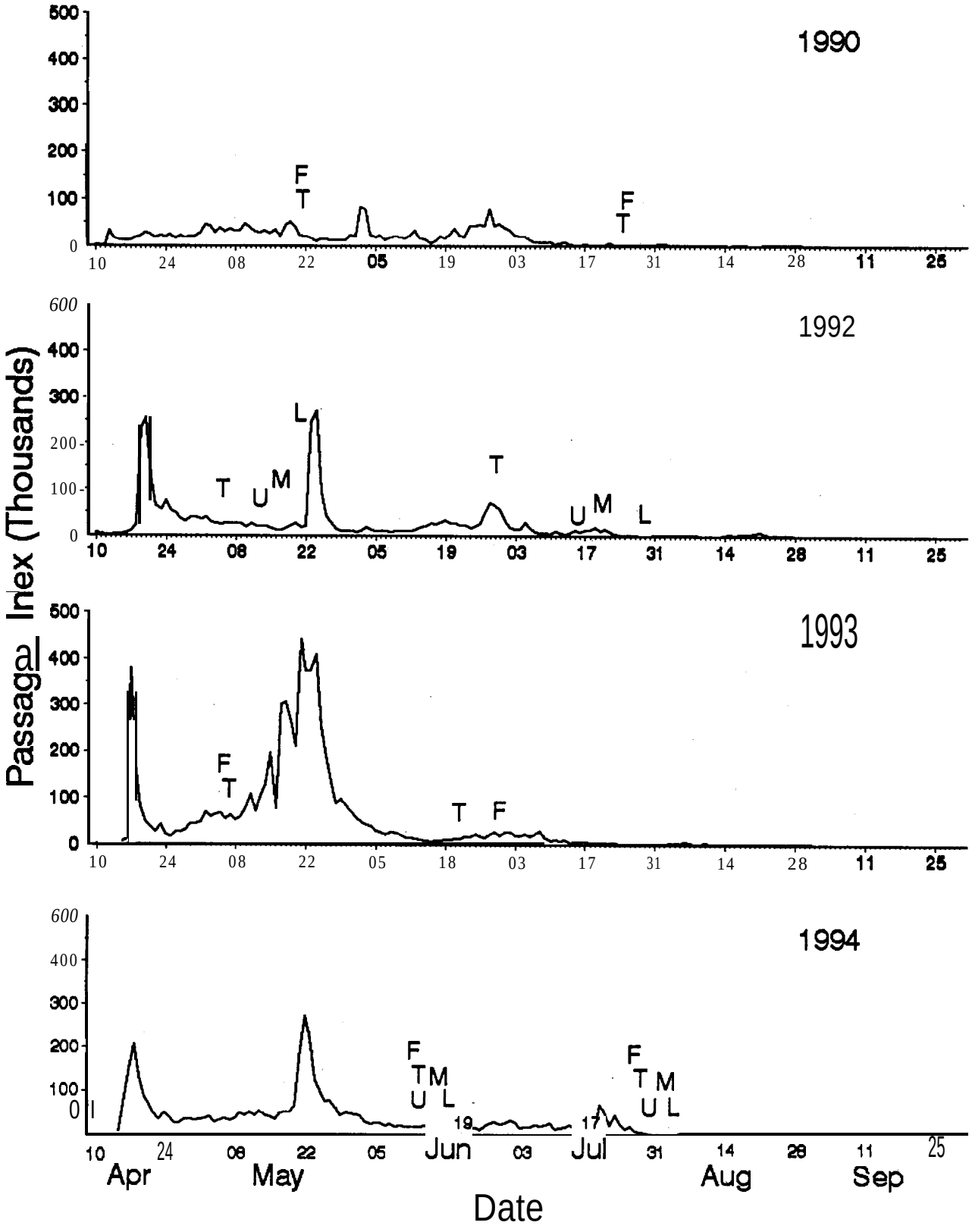
Location, zone	Predation Index				
	1990	1991	1992	1993	1994
Below Bonneville Dam					
RKm 71-121	--	--	14.0	--	8.0
RKm 122-177	--	--	20.1	--	29.7
RKm 178-224	--	--	20.2	--	33.3
Tailrace	5.5	--	--	6.1	7.4
Tailrace BRZ	8.0	--	--	3.5	2.5
Bonneville Reservoir					
Forebay	3.3	--	--	1.5	0.3
Mid-reservoir.	0.0	--	--	0.0	1.0
Tailrace	0.1	--	--	0.0	0.0
Tailrace BRZ	2.0	--	--	--	--
The Dalles Reservoir					
Forebay	1.1	--	--	0.2	0.1
Tailrace	1.9	--	--	0.0	--
Tailrace BRZ	3.9	--	--	0.0	--
John Day Reservoir					
Forebay	2.1	2.4	4.7	1.9	1.3
Mid-reservoir	0.0	2.4	0.0	0.0	0.0
Tailrace	1.9	1.3	0.0	1.7	0.2
Tailrace BRZ	3.9	2.9	0.9	--	0.2
Lower Monumental Reservoir					
Tailrace	--	0.8	--	--	0.2
Tailrace BRZ	--	0.6	--	--	--
Little Goose Reservoir					
Tailrace	--	0.5	--	--	0.4
Tailrace BRZ	--	2.0	--	--	0.6
Lower Granite Reservoir					
Upper-reservoir	- -	0.5	--	--	0.3

Appendix Table C-6. Indices of northern squawfish predation on juvenile salmonids in the summer (July-September) from 1990 through 1994 for sampling locations in the lower Columbia River. RKm = river kilometer. BRZ = boat restricted zone.

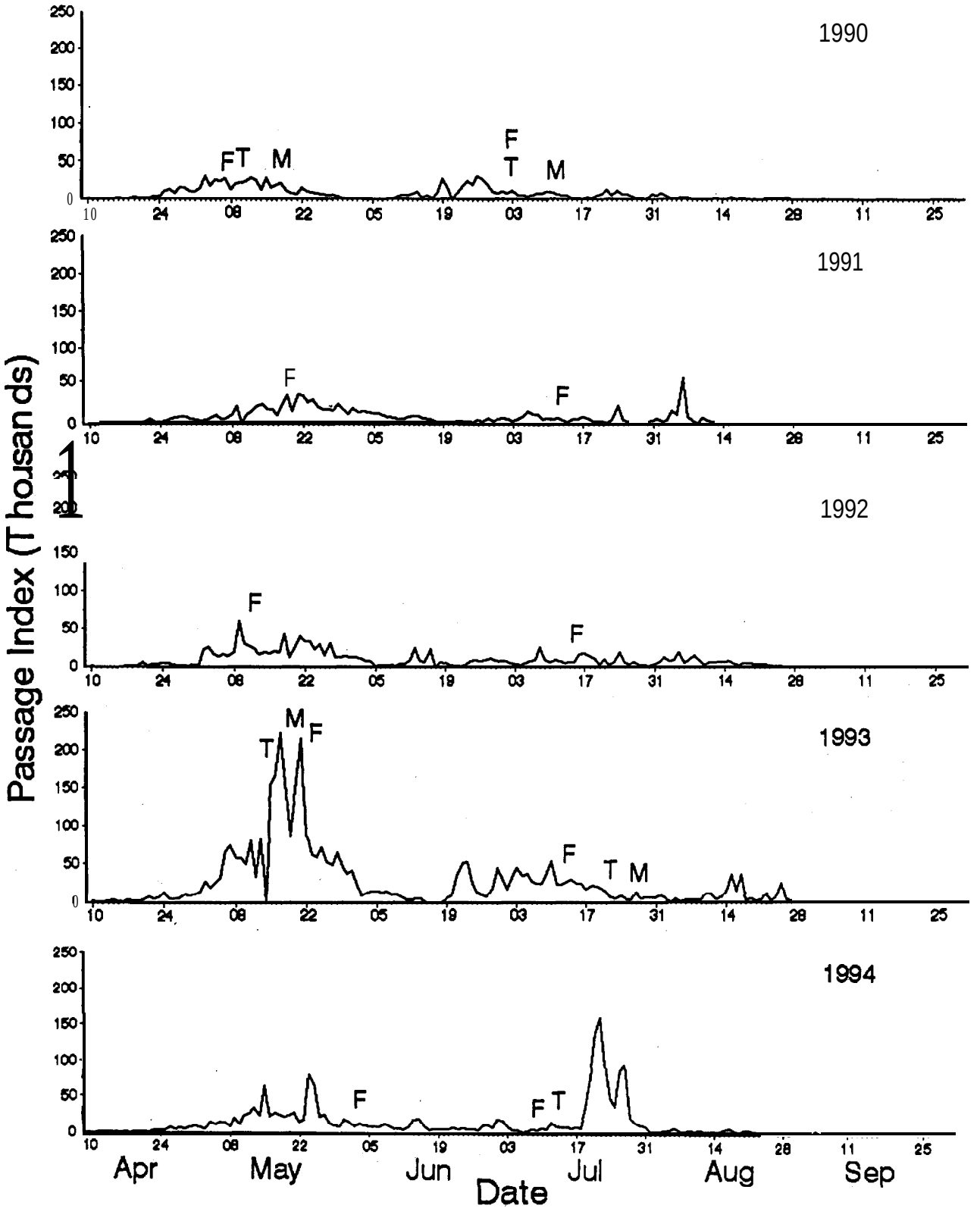
Location, zone	Predation Index				
	1990	1991	1992	1993	1994
Below Bonneville Dam					
RKm 71-121		--	8.3	--	27.3
RKm 122-177		--	26.1	--	39.6
RKm 178-224	--	--	33.9	--	9.5
Tailrace	2.3	--	--	9.1	1.0
Tailrace BRZ	16.4	--	--	3.2	8.9
Bonneville Reservoir					
Forebay	9.9			1.1	0.6
Mid-reservoir	0.0			0.0	0.0
Tailrace	0.0	--	--	0.0	0.0
Tailrace BRZ	0.7	--	--	0.2	3.5
The Dalles Reservoir					
Forebay	1.4			0.0	0.0
Tailrace	0.0			0.0	0.5
Tailrace BRZ	27.8	--	--	1.1	1.4
John Day Reservoir					
Forebay	3.4	4.0	1.7	0.7	1.6
Mid-reservoir	4.7	--		1.9	1.4
Tailrace	3.8	--	[illegible]	0.0	0.0
Tailrace BRZ	18.6	5.4	4.6	0.9	0.5

APPENDIX D

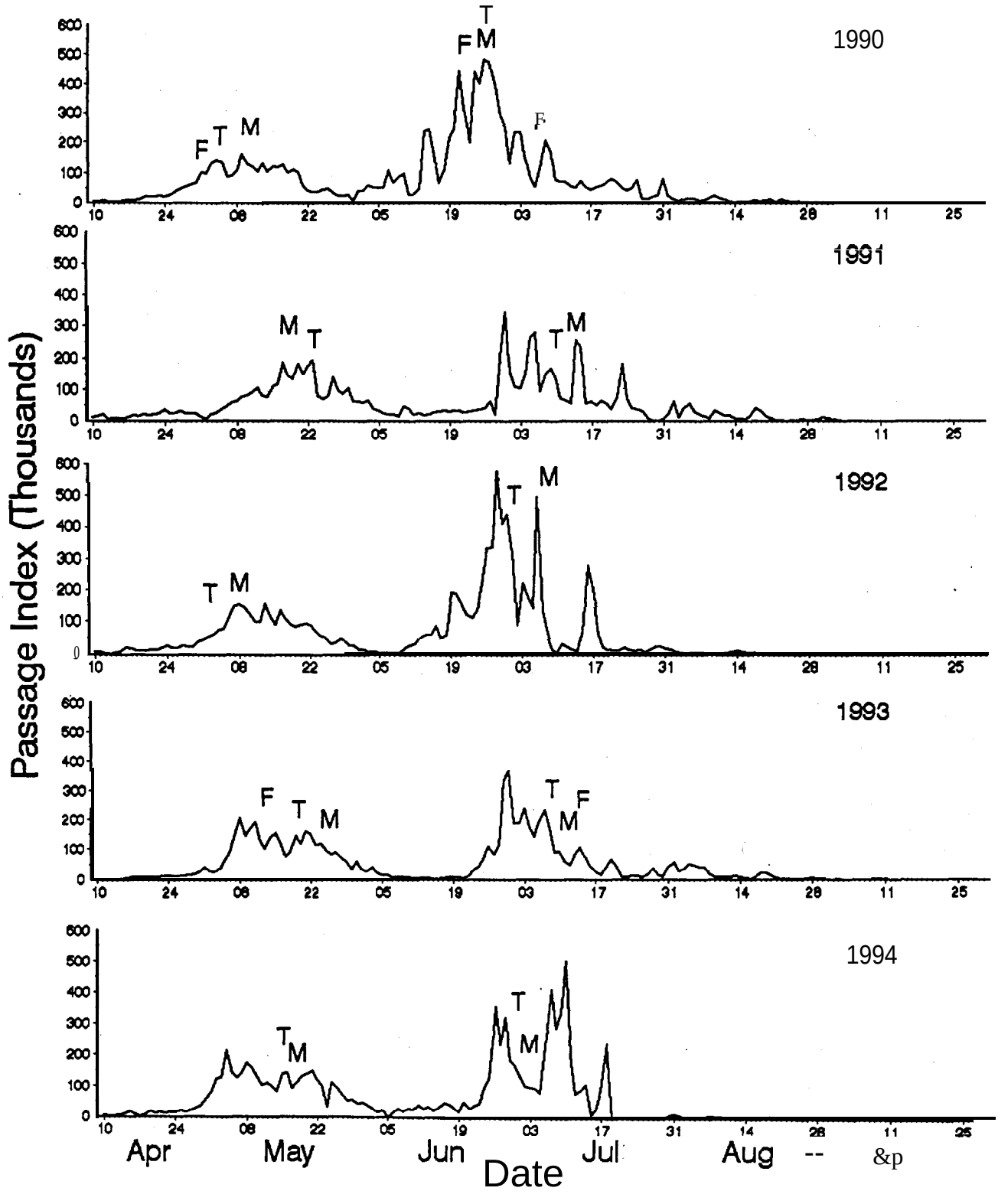
Timing of Consumption Index Sampling with Passage Indices at Lower Columbia and Snake River Dams



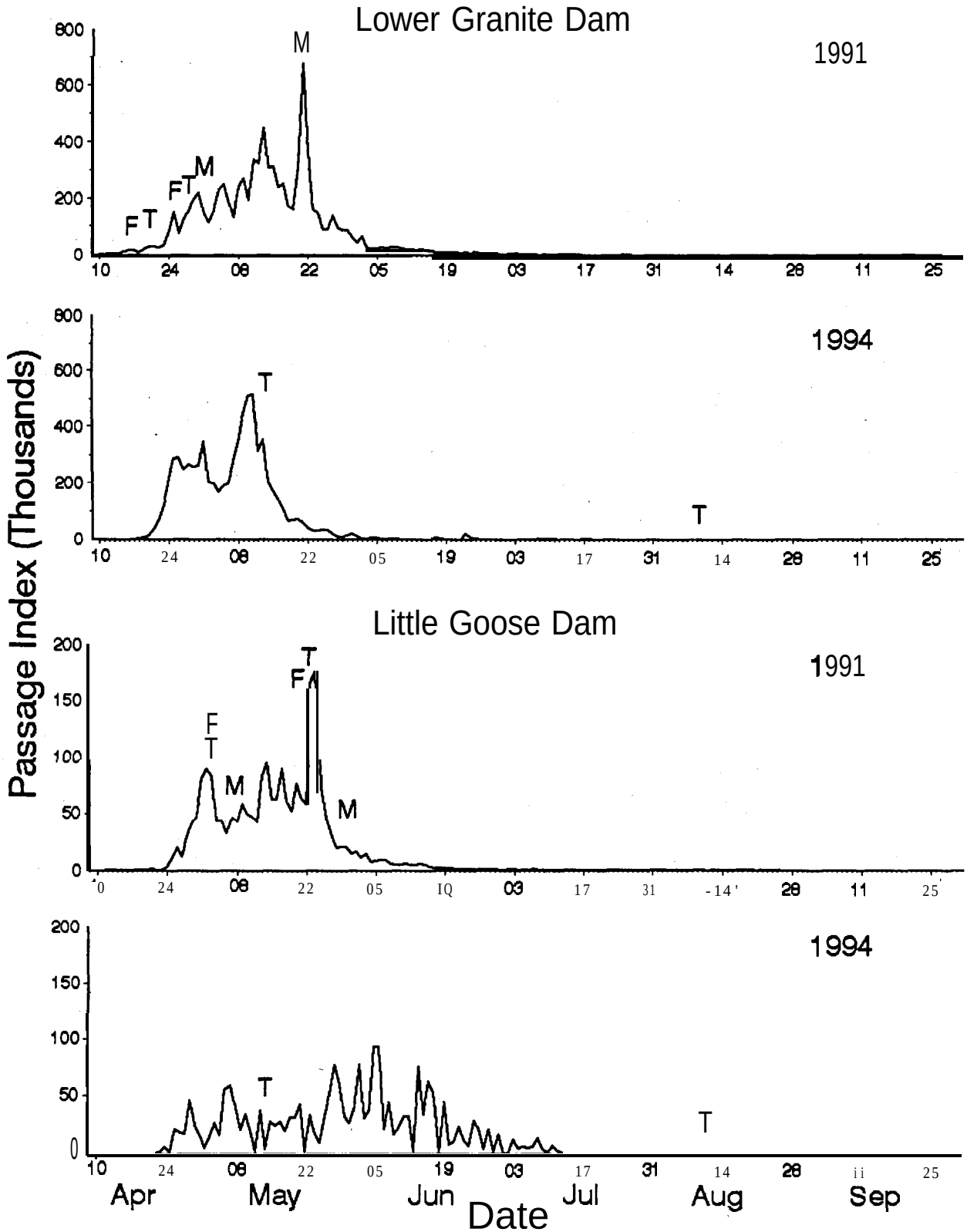
Appendix Figure D- 1. Timing of consumption index sampling with respect to juvenile salmonid passage indices at Bonneville Dam. Sample times for tailrace (T), forebay (F), and lower (L), middle (M), and upper (U) sections below Bonneville Dam are shown.



Appendix Figure D-2. Timing of consumption index sampling with respect to juvenile salmonid passage at John Day Dam. Sample times for tailrace (T), forebay (F), and the immediate downstream midreservoir (M) locations are shown.



Appendix Figure D-3. Timing of consumption index sampling with respect to juvenile salmonid passage at McNary Dam. Sample times for tailrace (T), forebay (F), and the immediate downstream midreservoir (M) locations are shown.



Appendix Figure D-4. Timing of consumption index sampling with respect to juvenile salmonid passage at Little Goose and Lower Granite dams. Sample times for tailrace (T), forebay (F), and the immediate downstream midreservoir (M) locations are shown.

APPENDIX E

Results of ODFW Lure Trolling in Bonneville Dam Tailrace Boat Restricted Zone in 1994

To further reduce predation on outmigrating juvenile salmonids in 1994, we evaluated the addition or expansion of various removal fisheries. ODFW experimented with lure trolling in 1991, and found it to be effective in limited areas of northern squawfish concentrations, such as Bonneville Dam tailrace. Over 1,100 northern squawfish were removed from this area in 1991, with a maximum catch rate of approximately 30 fish per hour (Ward et al. 1991). Incidental catch was minimal. We therefore implemented lure trolling in Bonneville Dam tailrace in 1994, designed specifically to benefit downstream migrating juvenile fall chinook salmon in June and July.

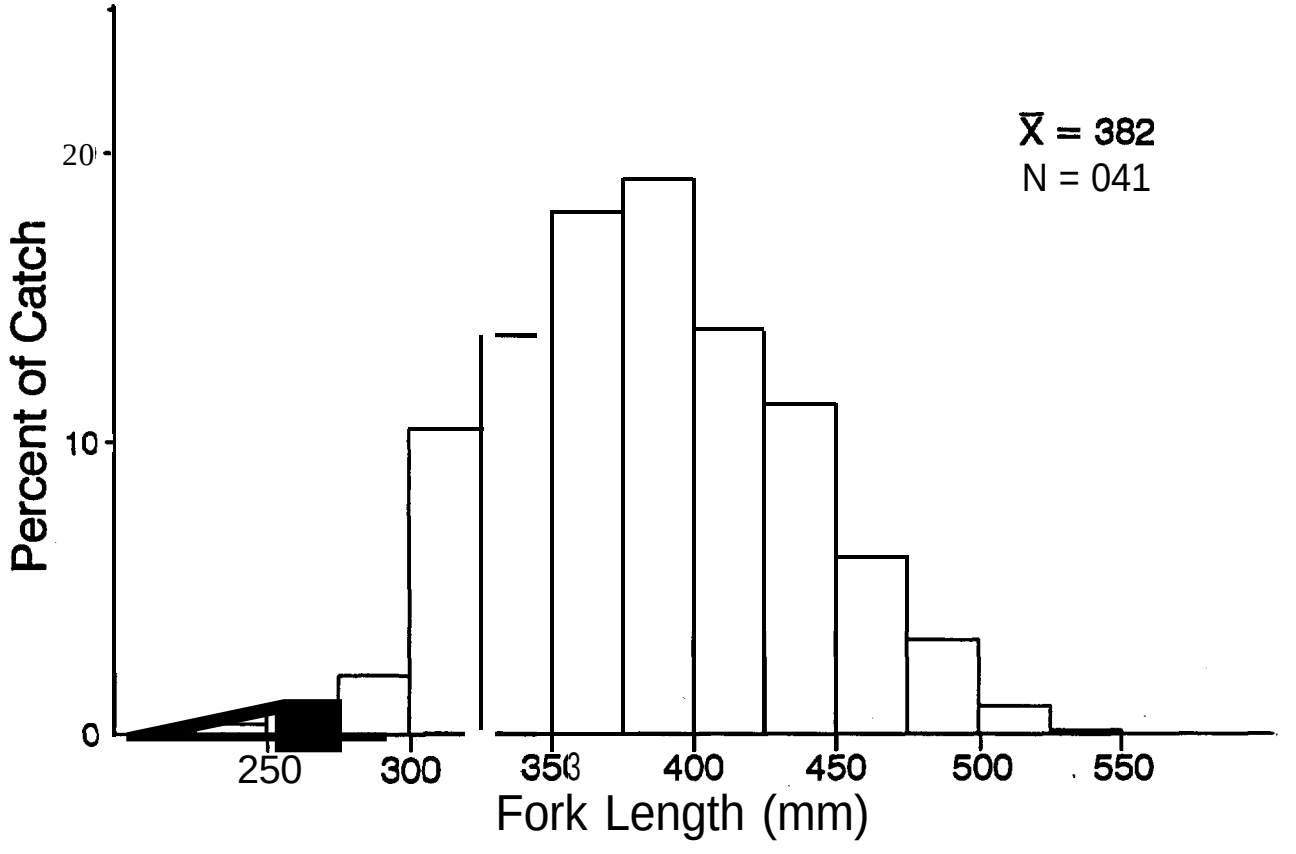
Lure trolling was conducted from June 14 to July 15 in the tailrace area of Powerhouses 1 and 2 at Bonneville Dam. Sampling gear and methods were described by Vigg et al. (1990). We measured fork length (mm) and determined sex and maturity from a subsample of northern squawfish caught.

We removed 841 northern squawfish in 76 hours for a catch rate of 11.1 fish per boat-hour. We found that casting lures from a stationary boat near juvenile bypass outfall areas was consistently more effective than trolling; casting accounted for approximately 95% of the northern squawfish catch. Fork length varied from 236 mm to 526 mm, with a mean of 382 mm (Appendix Figure E-l). No other species were captured during either trolling or casting.

References

Vigg, S., C.C. Burley, D.L. Ward, C. Mallette, S. Smith, and M. Zimmerman. 1990. Development of a system-wide predator control program: stepwise implementation of a predation index, predator control fisheries, and evaluation plan in the Columbia River basin. Oregon Department of Fish and Wildlife, Contract DE-BI79-90BP07084. 1990 Annual Report to Bonneville Power Administration, Portland, Oregon.

Ward D.L., M.P. Zimmerman, R.M. Parker, and S.S. Smith. 1991. Development of a system-wide predator control program: indexing, fisheries evaluation, and harvesting technology development. Oregon Department of Fish and Wildlife, Contract DE-BI79-90BPO7084. 199 1 Annual Report to Bonneville Power Administration, Portland, Oregon.



Appendix Figure E-l. Size composition and mean fork length of northern squawfish harvested while trolling and casting lures in Bonneville Dam **tailrace (BRZ)** in June and July, 1994.

APPENDIX F

Comparison of Digestive Tract Contents of Northern Squawfish and Smallmouth Bass Caught in the Lower Columbia and Snake Rivers in 1993 and 1994

We examined digestive tract contents of 2,077 northern squawfish and 1,365 smallmouth bass caught during standardized electrofishing in 1993 and 1994 (Appendix Tables F-l and F-2). We found salmonids in 15.2% of northern squawfish digestive tracts and 3.6% of smallmouth bass stomachs examined. Occurrence of salmonids in northern squawfish digestive tracts and smallmouth bass stomachs varied seasonally each year. Of locations for which data were collected each year, occurrence of ingested juvenile salmonids was highest for northern squawfish caught in Bonneville Dam tailrace (20.3%) and smallmouth bass caught in John Day Reservoir (4.7%).

Appendix Table F-l. Number of northern squawfish and smallmouth bass digestive tracts (N) examined from the lower Columbia River in 1993 that contained food, fish, and juvenile salmonids.

Period:	Northern squawfish				Smallmouth bass			
Reservior or area	N	Food	Fish	Salmonids	N	Food	Fish	Salmonids
Spring:								
Bonneville Dam tailrace	138	138	68	48	4	4	1	0
Bonneville	52	48	14	1	24	57	14	0
The Dalles	40	40	13	15	76	56	28	1
John Day	37	24	17		67		31	0
Summer:								
Bonneville Dam tailrace	142	139	25	15	10	9	4	1
Bonneville	163	163	28	13	53	31	17	0
The Dalles	160	168	15 67	9	148	67 119	65	0 12
John Day								

Appendix Table F-2. Number of northern squawfish and smallmouth bass digestive tracts (N) examined from the lower Columbia and Snake rivers in 1994 that contained food, fish, and juvenile salmonids. No samples were collected in Lower Granite Reservoir during the summer.

Period: Reservoir or area	Northern squawfish				Smallmouth bass			
	N	Food	Fish	Salmonids	N	Food	Fish	Salmonids
Spring:								
Below Bonneville Dam tailrace	90	51	27	18	33	28	22	2
Bonneville Dam tailrace,	152	72	33	25	7	6	4	
Bonneville	169	116	17	8	110	75	28	8
The Dalles	22	20	2	1	58	40	6	0
John Day	35	21	12	9	147	113	48	5
Lower Monumental	37	6		3	23	17	12	3
Little Goose	41	34	3:	28	8	5	3	1
Lower Granite		29	16	9	49	32	20	10
Summer:								
Below Bonneville' Dam tailrace	86	58	31	16	37	29	22	2
Bonneville Dam tailrace	80	29	21	16	14	10		0
Bonneville	204	151	18	28	117	100	40	3
The Dalles	97	61	30	13	106	76	32	0
John Day	97			24	191	146	55	9
				1	0	--	--	
Lower Monumental	20	19	14	9	0	--	--	II