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

2004 ANNUAL REPORT

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Project Number 199007700
Contract Number 00004477

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2004 EXECUTIVE SUMMARY

by
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This report presents results for year thirteen in a basin-wide program to harvest northern pikeminnow[1] (Ptychocheilus oregonensis). This program was started in an effort to reduce predation by northern pikeminnow on juvenile salmonids during their emigration from natal streams to the ocean. Earlier work in the Columbia River Basin suggested predation by northern pikeminnow on juvenile salmonids might account for most of the 10-20% mortality juvenile salmonids experience in each of eight Columbia River and Snake River reservoirs. Modeling simulations based on work in John Day Reservoir from 1982 through 1988 indicated that, if predator-size northern pikeminnow were exploited at a 10-20% rate, the resulting restructuring of their population could reduce their predation on juvenile salmonids by 50%.

To test this hypothesis, we implemented 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 system-wide 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.

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 trapnet. We found this floating trapnet to be very effective in catching northern pikeminnow at specific sites. Consequently, in 1993 we examined a system-wide fishery using floating trapnets, but found this fishery to be ineffective at harvesting large numbers of northern pikeminnow on a system-wide scale.

In 1994, we investigated the use of trap nets and gillnets at specific locations where concentrations of northern pikeminnow were known or suspected to occur during the

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[1] The common name of the northern squawfish was recently changed by the American Fisheries Society to northern pikeminnow at the request of the Confederated Tribes and Bands of the Yakama Indian Reservation.

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.

In 1995, 1996, and 1997, promotional activities and incentives were further improved based on the favorable response in 1994. Results of these efforts are subjects of this annual report.

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

Program cooperators include the Pacific States Marine Fisheries Commission (PSMFC), Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW). The PSMFC was responsible for coordination and administration of the program; PSMFC subcontracted various tasks and activities to ODFW and WDFW based on the expertise each brought to the tasks involved in implementing the program. Objectives of each cooperator were as follows.

1. **WDFW (Report A)**: Implement a system-wide (*i.e.* Columbia River below Priest Rapids Dam and Snake River below Hells Canyon Dam) sport-reward fishery and operate a system for collecting and disposing of harvested northern pikeminnow.

2. **PSMFC (Report B)**: Provide technical, contractual, fiscal and administrative oversight for the program. In addition, PSMFC processes and provides accounting for the reward payments to participants in the sport-reward fishery.

3. **ODFW (Report C)**: Evaluate exploitation rate and size composition of northern pikeminnow 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 pikeminnow harvest and update information on year-class strength of northern pikeminnow.

Background and rationale for the Northern Pikeminnow Management Program can be found in Report A of our 1990 annual report (Vigg et al. 1990). Highlights of results of our work in 2004 by report are as follows:

Report A

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

1. Objectives for 2004 were to: (1) implement a recreational fishery that rewards anglers who harvest northern pikeminnow ≥ 228 mm (9 inches) total length, (2) collect, compile, and report data on angler participation, catch and harvest of northern pikeminnow and other fish species, and success rtes of participating anglers during the season, (3) examine collected northern pikeminnow for the presence of external tags, PIT tags, and signs of tag loss, (4) collect biological data on northern pikeminnow and other fish species returned to registration stations, (5) scan northern pikeminnow for the presence of consumed salmonids containing PAIT tags, and (6) Survey non-returning fishery participants who were targeting northern pikeminnow to obtain catch and harvest data on all fish species caught.

2. The NPSRF was conducted from May 3 through September 26, 2004 from the Dalles dam downstream and from May 17 through September 26, 2004 from the Dalles dam upstream. Nineteen registration stations were operated throughout the lower Snake and Columbia rivers.

3. A total of 267,414 northern pikeminnow ≥ 9 inches in total length were harvested during the 2004 season with 35,211 angler days spent harvesting these fish. Catch-per-angler-day for all anglers during the season was 7.59 fish.

4. Anglers submitted 177 northern pikeminnow with external tags, and an additional 20 with fin-clip marks, but no tag. A total of 194,748 northern pikeminnow were individually scanned for the presence of salmonid PIT tags in their gut. A total of 149 salmonid PIT tags were detected and the codes recorded for transmittal to the PITAGIS database.

Report B

Northern Pikeminnow Sport-Reward Fishery Payments

1. For 2004 the rewards paid to anglers returned to the traditional amounts ($4, $5, and $6 per fish) for the three payment tiers during May. From June through September, the reward paid for the first 100 fish was $5 per fish. The reward for fish in the 101-400 fish range was $6 per fish and for all fish caught above 400 it was $8 per fish. The rewards for a tagged fish went up to $500 per fish.

2. During 2004, excluding tagged fish, rewards paid totaled $1,696,777 for 265,046 fish.

3. A total of 174 tagged fish vouchers were paid. During May (34 tags) the reward for tagged fish was $100. From June through September (140 tags), it increased to $500 per fish. The total season tag rewards paid totaled $73,400.

4. A total of 2,143 separate successful anglers received payments during the season.

5. The total for all payments for non-tagged and tagged pikeminnows in 2004 was $1,766,777. It was the highest catch and reward payments on record.

Report C

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

1. Objectives were to determine and evaluate: (1) northern pikeminnow exploitation rates; (2) reductions in northern pikeminnow potential predation on juvenile salmonids since program implementation; (3) spaghetti tag loss rates; (4) continuing age validation work for northern pikeminnow; (5) estimates of abundance, consumption, and predation indices for predator fishes within the study area, and (6) compensatory responses by the piscivore community.

2. System-wide exploitation in 2004 of northern pikeminnow 200 mm or greater in fork length was 17.0 which incorporated a tag loss of 11.3%.

3. Northern pikeminnow predation indices varied by season and area in 2004. The 2004 combined spring predation index for below Bonneville Dam (excluding the tailrace BRZ) was 32% lower than the average of the previous 3 years (1995, 1996, and 1999), and between 1992 and 2004 we observed an 88% drop in the overall spring predation index for below Bonneville Dam. The combined summer 2004 predation index for below Bonneville Dam was 89% less than in 1992.

4. A total of 542 scale and 186 opercle samples were aged from tagged, indexed, and recaptured northern pikeminnow in 2004. Complete agreement (i.e., zero discrepancy) on ages assigned by the three readers was 51.7% for scales, and 40.9% for opercles. The largest age discrepancy between corresponding scales and opercles for northern pikeminnow $\geq$ 350 mm was 11 years. Oxytetracycline (OTC) mark quality of fish recaptured in 2004 was not distributed randomly (χ^2 = 12.913, df = 2, $P < 0.05$), with marks more likely to be poor or fair than good. Northern pikeminnow OTC marked in 2002 and 2003 had an appropriate number

of annuli noted after the mark 55% and 64% of the time. When considering only fish with fair or good marks these increased to 63% and 90%.

5. The northern pikeminnow abundance index below Bonneville Dam (excluding the tailrace BRZ) was 40% lower than the average value of four previous years sampled (1994 – 1996, 1999), and the 2004 John Day Reservoir northern pikeminnow abundance index was an order of magnitude lower than the program average (1990-1996, 1999). Salmonidae composed the majority (69-89%) of fish remains identified to species in the digestive tracts of northern pikeminnow in all reaches of the study area. Northern pikeminnow consumption indices (CI) were generally lower in 2004 than program averages. The spring 2004 CI below Bonneville Dam (excluding the tailrace BRZ) was 69% lower than the mean CI for 1994 – 1996, and 1999. The summer 2004 CI value below Bonneville Dam (excluding the tailrace BRZ) was 62% lower than the 1994 – 1996, and 1999 mean.

6. Although consumption and predation indices were generally lower reservoir- and system-wide than previous years, the localized increases in these indices exhibited by remaining northern pikeminnow may be compensatory responses to prolonged exploitation by the NPMP. Smallmouth bass may also be exhibiting compensatory responses in localized areas. Though their consumption rates were similar to past years, 2004 relative densities (spring and summer) in the John Day Dam forebay were at least double the levels observed in 1990 and 1999. Increased smallmouth bass abundance can also indirectly influence juvenile salmonid predation. Competitive interactions with northern pikeminnow, which may shift their diets and habitat selection in the presence of smallmouth bass, could exacerbate juvenile salmonid predation. The multiple changes in the predator community witnessed in 2004 highlight the need for continued monitoring, and updated potential predation models.

REPORT A

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

2004 ANNUAL REPORT

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Acknowledgments

This project is funded by the Bonneville power administration (BPA), William Maslen, project manager and John Skidmore, COTR (contract de-bi719-94bi24514). We thank Carlene Stenehjem at BPA- public affairs; tom Friesen and his staff at the Oregon Department of Fish and Wildlife (ODFW); and Russell Porter and his staff at the Pacific States Marine Fisheries Commission (PSMFC) for their cooperation and coordination.

We are grateful to the city of rainier for the use of the rainier boat ramp; the city of Richland for the use of Columbia point park; the Cowlitz county parks and recreation department for the use of willow grove boat ramp; the port of Camas/Washougal for the use of the Camas/Washougal boat ramp; the port of Cathlamet for the use of Cathlamet marina; the port of Kalama for the use of Kalama marina; the port of The Dalles for the use of The Dalles boat basin; the Portland metro regional parks department for the use of the M.J. Gleason boat ramp and chinook landing; the u.s. army corps of engineers for the use of Giles French Park, and the greenbelt boat ramp; the u.s. forest service for the use of Bonneville trailhead; the Washington Department of transportation for the use of the Vernita bridge rest area; California land company for the use of Lyon's Ferry park; Dave and Linda Petersen for the use of Boyer park; and Sheila Cannon and Ken Beer for the use of the fishery at covert's landing.

We appreciate the efforts of, Beverly Buitenbos, Kathleen Byrd, Melissa Dexheimer, Paul Dunlap, Billie Embley, Bill Fleenor, Leif Fox, Josh Hede, Maria Holmes, Sean Hommestaad, Kurt Hubbard, Kara Kaelber, Sandra Kessler, Jeff Lesselyoung, Derrick Meaghers, Eric Meyer, Linda Moore, Sabrina Peters, Cole Shelton, Tracy Sobelman, Mark Thompson, Alyce Wells, DJ Werlau and Jessica Young for operating the sport-reward fishery registration stations.

We also recognize Diana Murillo for her excellent work in computer data entry and document verification, Fella Tanaka for her numerous phone survey interviews, Kathleen Moyer for serving as the lead technician for the PIT Tag recovery portion of the program, and Julie Memarian for producing our weekly field activity reports, overseeing the Sport-Reward hotline, operating a registration station, and helping to keep the Fishery operating smoothly throughout the season.

ABSTRACT

We are reporting on the progress of the Northern Pikeminnow *Ptychocheilus oregonensis* Sport-Reward Fishery (NPSRF) implemented by the Washington Department of Fish and Wildlife(WDFW) on the Columbia and Snake Rivers from May 3 through September 26, 2004. The objectives of this project were to (1) implement a recreational fishery that rewards anglers who harvest northern pikeminnow ≥228mm (9 inches) total length, (2) collect, compile, and report data on angler participation, catch and harvest of northern pikeminnow and other fish species, and success rates of participating anglers during the season, (3) examine collected northern pikeminnow for the presence of external tags, fin-clips, and signs of tag loss, (4) collect biological data on northern pikeminnow and other fish species returned to registration stations, (5) scan northern pikeminnow for the presence of consumed salmonids containing Passive Integrated Transponder (PIT) tags, and (6) obtain catch and harvest data on fish species caught by non-returning fishery participants who were targeting northern pikeminnow

A total of 267,414 northern pikeminnow ≥228mm and 4,859 pikeminnow < 228 mm were harvested during the 2004 season. There were a total of 5,614 different anglers who spent 35,211 angler days participating in the fishery. Catch per unit of effort for combined returning and non-returning anglers was 7.59 fish/angler day. The Oregon Department of Fish and Wildlife(ODFW) reported that the overall exploitation rate for the 2004 NPSRF was 17%

Anglers submitted 174 northern pikeminnow with external spaghetti tags, 8 with fin-clip marks but no tag, 7 with possible spaghetti tag wounds and a PIT tag present, and 10 with possible tag wounds and no fin clip recorded. A total of 155 PIT tags from consumed juvenile salmonids were detected and interrogated from northern pikeminnow received during the 2004 NPSRF.

Peamouth *Mylocheilus caurinus,* smallmouth bass *Micropterus dolomieui*, white sturgeon *Acipenser transmontanus* and channel catfish *Ictalurus punctatus* were the fish species most frequently harvested by NPSRF anglers targeting northern pikeminnow. The incidental catch of salmonids *Onchorhynchus spp*. by participating anglers targeting northern pikeminnow remained below established limits for the Northern Pikeminnow Management Program.

INTRODUCTION

Mortality of juvenile salmonids *Oncorhynchus spp.* migrating through the Columbia River system is a major concern of the Columbia Basin Fish and Wildlife Program, and predation is an important component of mortality (NPPC 1987a). Northern pikeminnow *Ptychocheilus oregonensis,* formerly known as northern squawfish (Nelson et al. 1998), are the primary piscine predator of juvenile salmonids in the Lower Columbia and Snake River systems (Rieman et al. 1991). Rieman and Beamesderfer (1990) predicted that predation on juvenile salmonids could be reduced by up to 50% with a sustained exploitation rate of 10-20% on northern pikeminnow >275 mm (11 inches) fork length (FL). The Northern Pikeminnow Management Program (NPMP) was formed in 1990, with the goal of implementing fisheries which achieve the recommended 10-20% annual exploitation on northern pikeminnow >275 mm FL within the program area (Vigg and Burley 1989). The Washington Department of Fish and Wildlife (WDFW) was enlisted to conduct the Sport-Reward Fishery (Burley et al. 1992) which provides monetary rewards to recreational anglers who harvest reward sized (≥ 9" Total Length) northern pikeminnow from within program boundaries on the Columbia and Snake rivers. Since 1991, the Northern Pikeminnow Sport-Reward Fishery (NPSRF) has been responsible for harvesting more than 2.5 million reward size northern pikeminnow and generating more than 575,000 angler days of effort in becoming the NPMP's most successful component for achieving the annual 10-20% exploitation rate on northern pikeminnow within the program boundaries (Klaybor et al. 1993; Friesen and Ward 1999). In 2000, NPMP administrators reduced the minimum size for eligible (reward size) northern pikeminnow to 228 mm (9 inches) in response to recommendations contained in a review of NPMP justification, performance, and cost-effectiveness (Hankin and Richards 2000).

The 2004 NPSRF continued to provide a tiered reward system (Hisata et al. 1995) that paid anglers a higher amount per fish based on achieving designated harvest levels and a separate bonus reward for returning northern pikeminnow that were spaghetti tagged by the Oregon Department of Fish and Wildlife (ODFW) as a part of the NPSRF's biological evaluation. All returning anglers, and 14.97% of non-returning anglers were surveyed in order to collect catch and harvest data needed to monitor the effect of the NPSRF on other fish species.

The objectives of the 2004 NPSRF were to (1) implement a recreational fishery that rewards anglers who harvest northern pikeminnow ≥228mm (9 inches) total length, (2) collect, compile, and report data on angler participation, catch and harvest of northern pikeminnow and other fish species, and success rates of participating anglers during the season, (3) examine collected northern pikeminnow for the presence of external tags, fin-clips, and signs of tag loss, (4) collect biological data on northern pikeminnow and other fish species returned to registration stations, (5) scan northern pikeminnow for the presence of consumed salmonids containing PIT tags, and (6) Survey non-returning fishery participants who were targeting northern pikeminnow to obtain catch and harvest data on all fish species caught.

METHODS OF OPERATION

FISHERY OPERATION

Boundaries and Season

The NPSRF was conducted on the Columbia River from the mouth to the boat-restricted zone below Priest Rapids Dam, and on the Snake River from the mouth to the boat-restricted zone below Hells Canyon Dam (Figure 1). In addition, anglers were allowed to harvest (and submit for payment) northern pikeminnow from backwaters, sloughs, and up to 400 feet from the mouth of tributaries within this area.

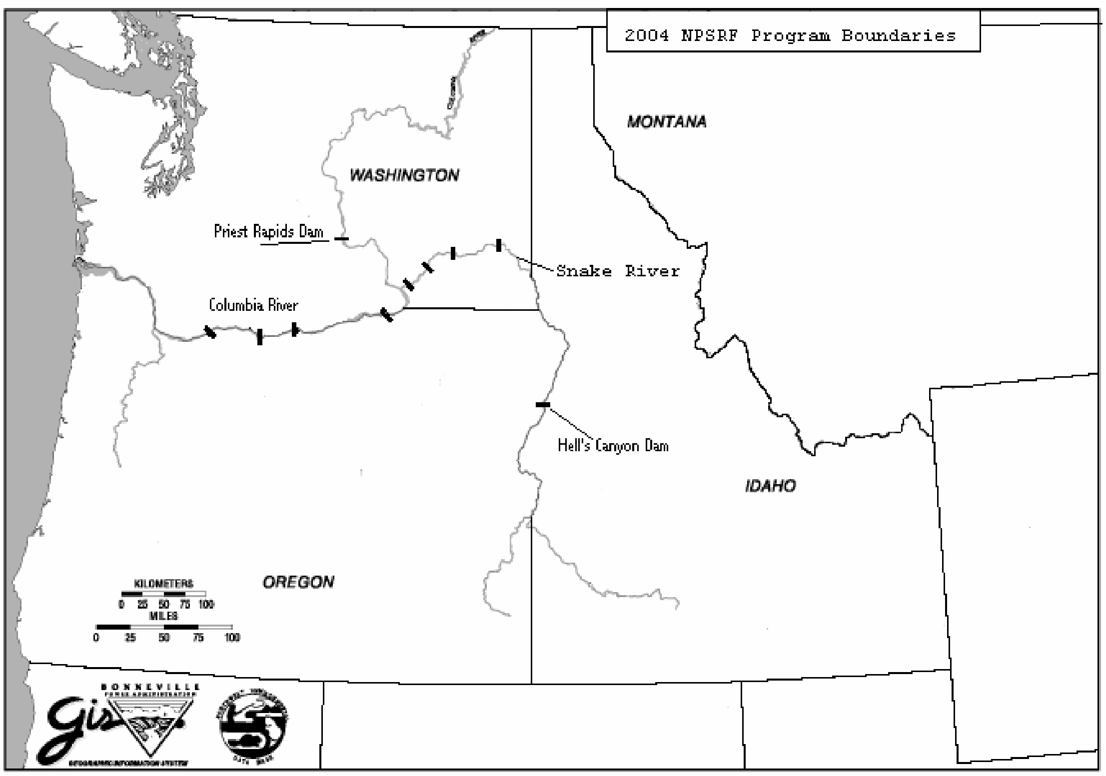
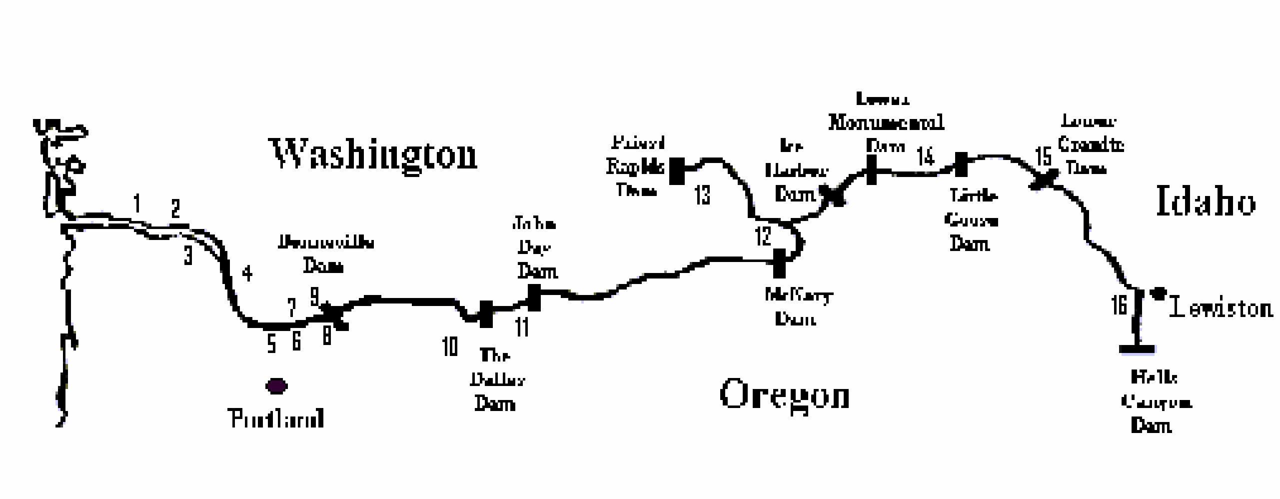


Figure 1. Northern Pikeminnow Sport-Reward Fishery Program Area

The NPSRF was fully implemented from May 17 through September 26, 2004. In addition, eleven stations below The Dalles Dam conducted a two week long "pre-season" beginning on May 3, 2004 in order to take advantage of favorable river conditions that provided anglers with an earlier opportunity to begin harvesting northern pikeminnow.



Registration Stations

1. Cathlamet Marina (12-4 pm)
2. Willow Grove Boat Ramp (5-8 pm)
3. Rainier Marina (4-8 pm)
4. Kalama Marina (11:30am-3 pm)
5. M. James Gleason Boat Ramp (12-8 pm)
6. Chinook Landing (7:30-10 am)
7. Washougal Boat Ramp (12-8 pm)
8. The Fishery (4-8:30 pm)

Registration Stations

9. Bonneville Trail Head (11am-4:00 pm)
10. The Dalles Boat Basin(12-8 pm)
11. Giles French (12-8 pm)
12. Columbia Point Park (11am-5:30 pm)
13. Vernita Bridge (3:30-7:30 pm)
14. Lyon's Ferry (9:30am-1 pm)
15. Boyer Park (11:30 am -2:30 pm)
16. Greenbelt (3:30-7:30 pm)

Figure 2. 2003 Northern Pikeminnow Sport-Reward Fishery registration stations.

Registration Stations

Sixteen registration stations (Figure 2) were located on the Columbia and Snake rivers to provide anglers with access to the Sport-Reward Fishery. WDFW technicians set up daily (seven days a week) registration stations at designated locations (normally public boat ramps or parks) which were available to anglers between two and eight hours per day during the season. Technicians registered anglers to participate in the NPSRF, collected creel information, issued pay vouchers to anglers returning with eligible northern pikeminnow, recorded biological data, scanned northern pikeminnow for the presence of PIT tags, and provided Sport-Reward Fishery information to the public. Self-registration boxes were located at each station so anglers could self-register when WDFW technicians were not present.

Reward System

The 2004 NPSRF rewarded anglers for harvesting northern pikeminnow $\geq$ 228mm (9 inches) total length (TL). The 2004 NPSRF continued to use a tiered reward system developed in 1995 (Hisata et al. 1995) that paid anglers a higher reward per fish once they had reached designated harvest levels over the course of the season. To receive payment, anglers returned their catch (daily) to the location where they had registered. Station technicians identified the angler's fish and issued a payment voucher for the total number of eligible northern pikeminnow. Anglers mailed payment vouchers to the Pacific States Marine Fisheries Commission (PSMFC) for redemption. Anglers returning with northern pikeminnow that were spaghetti-tagged by ODFW as part of the biological evaluation of the Fishery (Vigg et al. 1990), were issued a separate tag payment voucher that was mailed to ODFW for tag verification before payment was made by the PSMFC. During the first three weeks of the 2004 season, the NPSRF retained the reward levels in place at the beginning of the 2001 NPSRF (Winther et. al, 2001) which paid anglers $4 each for their first 100 northern pikeminnow, $5 each for numbers 101 – 400, $6 each for all fish over 400. Anglers received $100 each for returning eligible spaghetti-tagged northern pikeminnow. Beginning May 31, 2004, the reward increased to $5, $6, and $8 each respectively. The tagged pikeminnow increased to $500 each at this time as well. Bonneville Power funded the reward increase to compensate for the low 2004 summer flows that could impact salmon survival.

Angler Sampling

Angler data and creel data for the NPSRF were compiled from angler registration forms. One registration form represented one angler day. Angler data consisted of name, date, fishing license number, phone number, and city, state, zip code of participating angler. Creel data recorded by WDFW technicians included fishing location (Figure 3), and primary species targeted (Appendix B). Anglers were asked if they specifically fished for northern pikeminnow

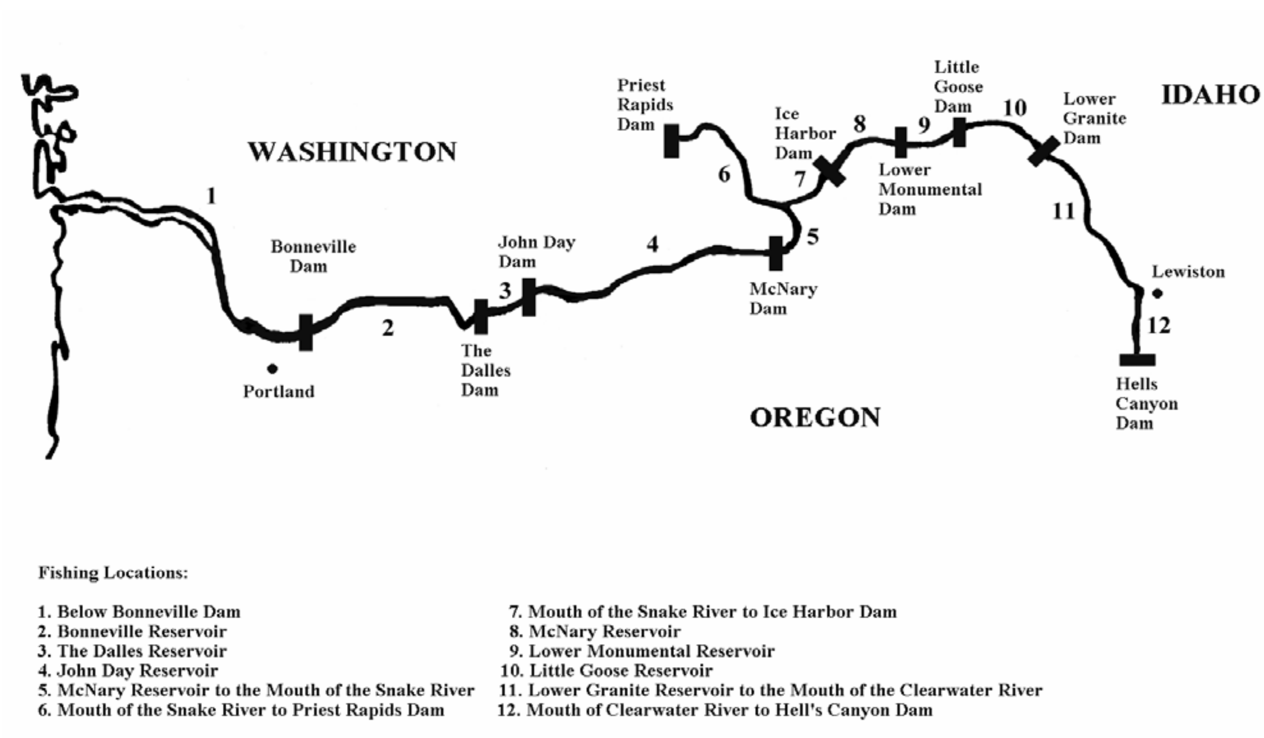


Figure 3. Fishing location codes used for the Northern Pikeminnow Sport-Reward Fishery

at any time during their fishing trip. A “No” response ended the exit interview. A “Yes” response prompted the technician to ask the angler, and record data on how many of each species of fish were caught, harvested or released while targeting northern pikeminnow. A fish was considered “caught” when the angler touched the fish, whether it was released or harvested. Fish returned to the water alive were defined as “released”. Fish that were retained by the angler or not returned to the water alive were considered “harvested”.

Returning Anglers

Technicians interviewed all returning anglers at each registration station to obtain any missing angler data, and to record creel data from each participant's angling day. Creel data from caught and released fishes were recorded from angler recollection. Creel data from all harvested fish species were recorded from visual observation.

Non-Returning Anglers

Non-returning angler data was compiled from the pool of anglers who had registered for the NPSRF and targeted northern pikeminnow, but did not return to a registration station to participate in an exit interview. WDFW technicians attempted to survey 20% of the NPSRF's non-returning anglers by telephone in order to obtain creel data from that segment of the NPSRF's participants. To obtain the 20% sample, non-returning anglers were randomly selected from each registration station for each week. A technician called anglers from each random sample until the 20% sample was attained. Non-returning anglers were surveyed with the same exit interview questions used for returning anglers. For the 2004 season, non-returning angler catch and harvest data were only recorded for the number and species of adult and/or juvenile salmonids, the number of $\geq$ 9" total length pikeminnow and the number of < 9" total length northern pikeminnow. Non-returning angler catch and harvest data for all other fish species (last obtained during the 2000 NPSRF) were not collected in 2004 since their catch and harvest rates tend to be less than 25% of the catch and harvest rates of returning anglers (Hisata et al. 1995). We anticipate collecting full creel data for all other fish species (in order to reconfirm this trend) again in 2005 per NPSRF protocol (Fox et al 1999).

NORTHERN PIKEMINNOW HANDLING PROCEDURES

Biological Sampling

Technicians examined all fishes returned to registration stations and recorded species as well as number of fish per species. Technicians examined all northern pikeminnow for the presence of external tags (spaghetti or dart), fin-clip marks, and signs of tag loss. Fork lengths and sex (determined by evisceration) of northern pikeminnow as well as fork lengths for any other harvested fish species were recorded whenever possible. All spaghetti tagged northern pikeminnow were scanned for PIT tags, measured for fork length, eviscerated to determine sex, and scale and opercle samples were taken. Data from tags, fin-clip marks or signs of tag loss were recorded on data forms and on a tag envelope. The tag was placed in the envelope, stapled to the tag payment voucher and given to the angler to submit to ODFW for verification.

PIT Tag Detection

Northern pikeminnow harvested by anglers participating in the NPSRF have been found to ingest juvenile salmonids carrying passive integrated transponder (PIT) tags (Glaser et al. 2000). PIT tags were also used for the first time as a secondary mark in all northern pikeminnow that were fitted with spaghetti tags as part of the 2003 NPMP's biological evaluation activities. The use of PIT tags rather than fin clips as a secondary mark in northern pikeminnow was intended to remove uncertainties regarding tag loss, and will result in a more accurate estimate of exploitation for the NPSRF. WDFW technicians sought to scan 100% of all northern pikeminnow returned to registration stations for Pit Tags using two types of PIT tag "readers". Northern pikeminnow were scanned using primarily Destron Fearing portable transceiver systems (model # FS2001F), to record information from PIT tag detections for submission to the Columbia Basin PIT Tag Information System (PTAGIS). The NPSRF also used Allflex ISO Compatible RF/ID Portable Readers (model # RS601) to scan northern pikeminnow and assist in recovery of initial PIT tag data when the Destron's were not available. Scanning began on the first day of the NPSRF pre-season and continued throughout the rest of the year. Technicians individually scanned all northern pikeminnow for PIT tag presence and complete biological data were recorded from pikeminnow with positive readings. All PIT tagged northern pikeminnow were labeled and preserved for later dissection and tag recovery. All data were verified after recovery of PIT tags and readers were downloaded regularly to a central laptop computer from which detection information was forwarded to PTAGIS via electronic mail.

Northern Pikeminnow Processing

During biological sampling, all northern pikeminnow were eviscerated (to determine sex), or caudal clipped as an anti-fraud measure intended to eliminate the possibility of previously processed northern pikeminnow being resubmitted for payment. In 2004, most northern pikeminnow were caudal clipped rather than eviscerated in order to facilitate accurate scanning for PIT tags. Sampled northern pikeminnow were iced and transported to cold storage facilities from which they were ultimately delivered to rendering facilities for final disposal.

RESULTS AND DISCUSSION

Northern Pikeminnow Harvest

The NPSRF harvested a record high catch total of 267,414 reward size northern pikeminnow ($\geq$ 228 mm TL) during the 2004 season. Of this total, 21,858 northern pikeminnow (8%) were caught during the two week pre-season which operated below The Dalles Dam from May 3 through May 16th. Total harvest for the 2004 NPSRF was 36% higher (70,859 fish) than for the 2003 NPSRF (Hone et al 2003), which harvested 196,555 northern pikeminnow (Figure 4). The 2004 NPSRF total harvest was 64% higher than mean 1991-2003, harvest. It should also be noted that in addition to reward size northern pikeminnow, the 2004 NPSRF also harvested 4,859 northern pikeminnow < 228 mm TL during the 2004 season.

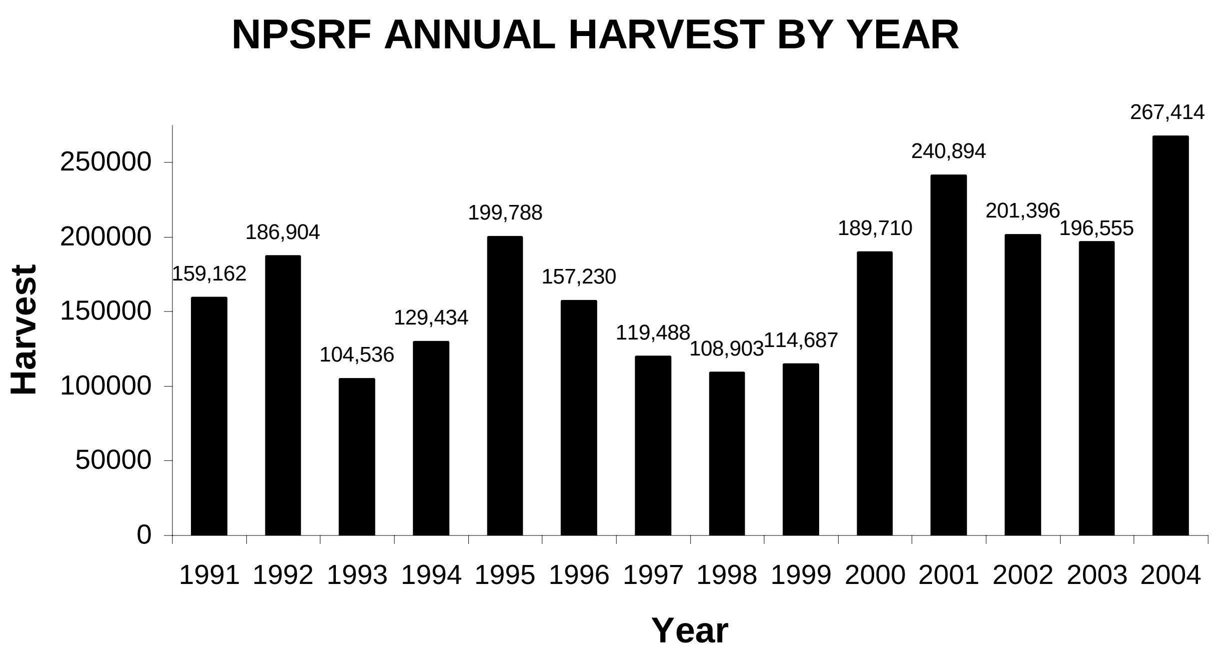


Figure 4. Annual Harvest totals for the Northern Pikeminnow Sport-Reward Fishery.

Mean weekly harvest for the 2004 NPSRF was 12,734 reward size northern pikeminnow and ranged from 7,304 in week 34 (August 23-29) to 21,460 in week 24 (June 14-20) (Figure 5). Mean weekly harvest for the pre-season was 10,929 NPM. Peak weekly harvest for the 2004 NPSRF occurred during the traditional June peak harvest period (Figure 6) seen from 1991-2003 (Fox et al. 1999). The 2004 overall weekly pattern mimics the trends of the 2003 NPSRF, (Figure 7) except for peaking one week earlier. It is also apparent the first four weeks of harvest during the 2004 season are higher than the corresponding weeks in 2004(Figure 7). These four weeks of 2004 harvest are the results of effort that occurred prior to the 2004 reward increase.

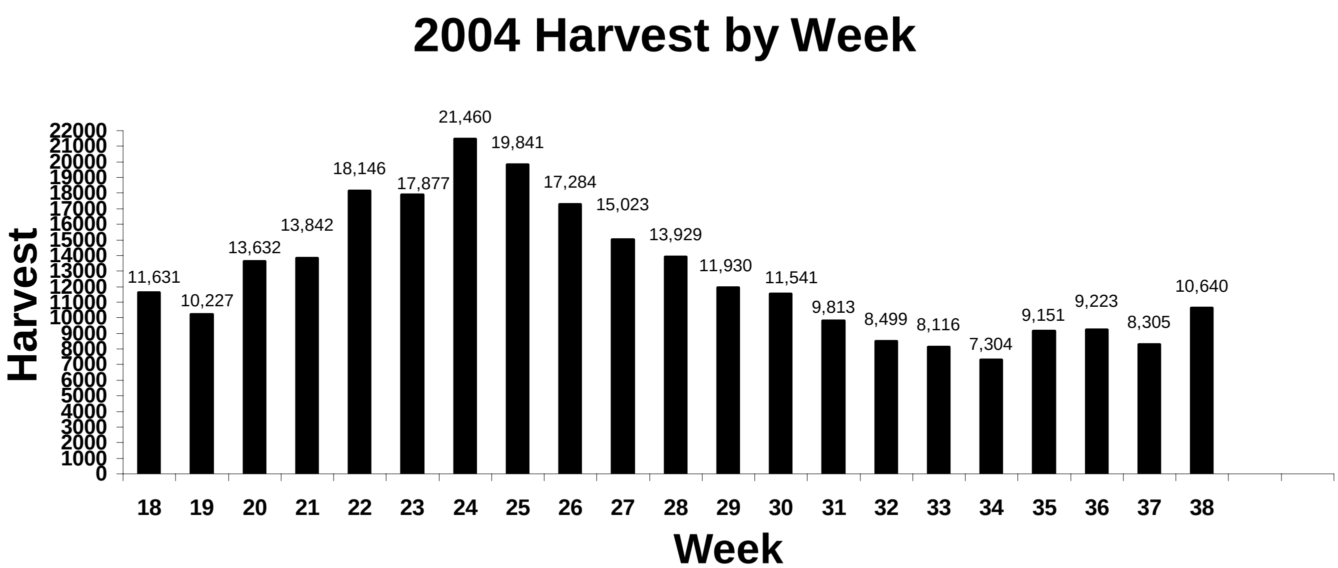


Figure 5. 2004 Northern Pikeminnow Sport-Reward Fishery Harvest by week.

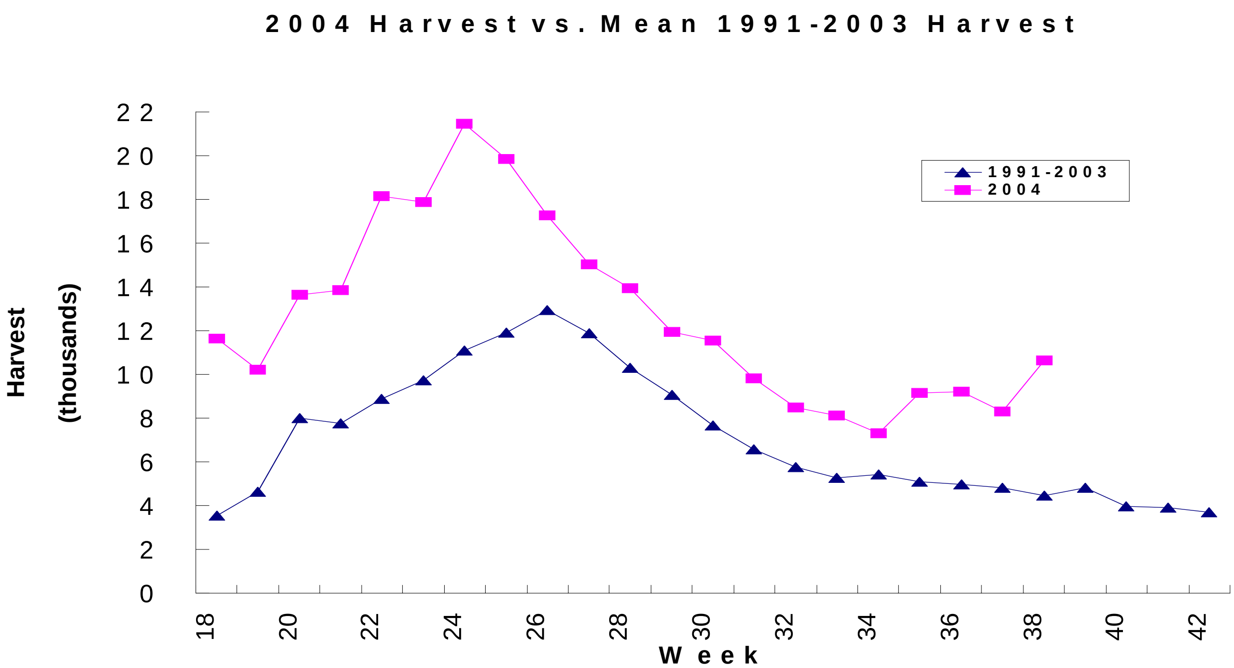


Figure 6. Comparison of 2004 NPSRF Weekly Mean Harvest to Mean 1991-2003 NPSRF Harvest.

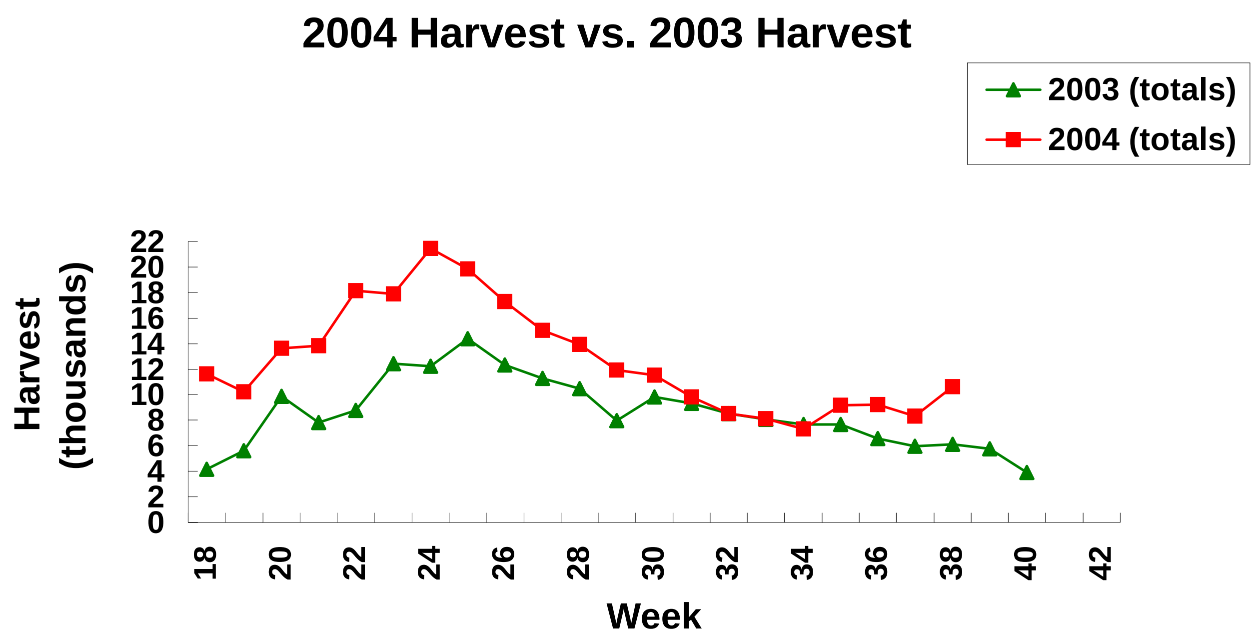


Figure 7. 2004 weekly Northern Pikeminnow Sport-Reward Fishery Harvest vs. 2003 weekly Harvest.

The mean harvest by fishing location was 22,285 northern pikeminnow and ranged from 94,710 reward size northern pikeminnow (36% of the total NPSRF season harvest) in fishing location 01, (downstream of Bonneville Dam) to 32 northern pikeminnow from fishing location 5 (McNary Dam to mouth of the Snake River) (Figure 8). Fishing location 01 was the NPSRF's top producing location for the fourteenth consecutive year. Harvest from fishing location 02 showed the greatest change from 2003, more than doubling the 37,005 NPM harvested in 2003.

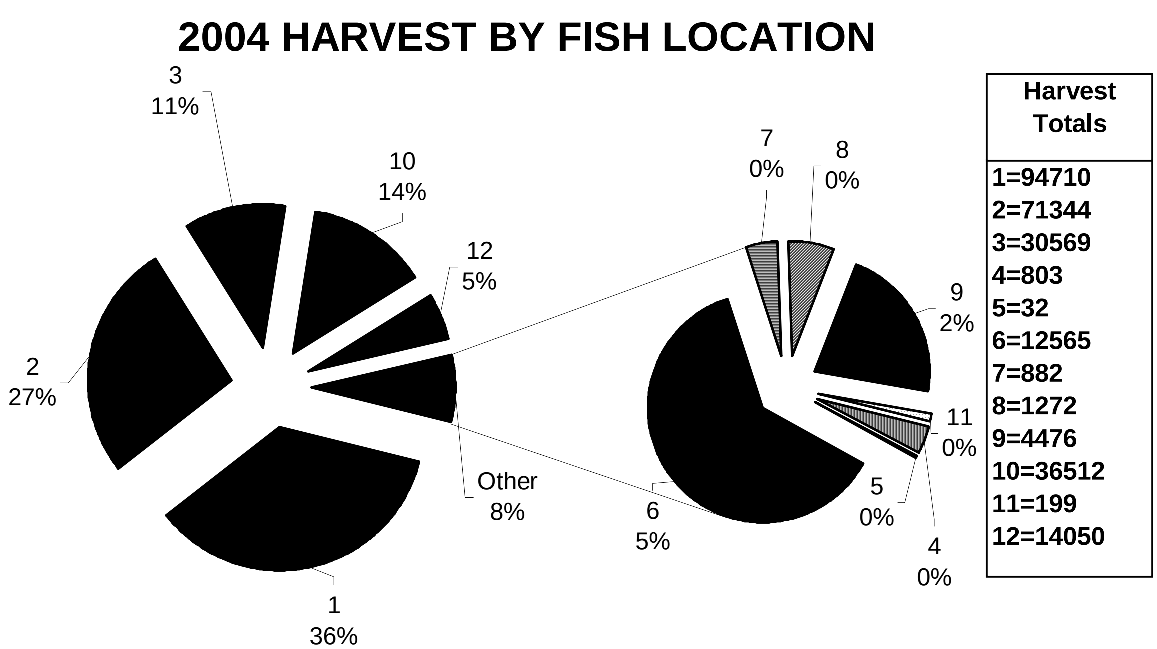


Figure 8. 2004 Northern Pikeminnow Sport-Reward Fishery Harvest by Fishing Location.

The mean harvest per registration station was 16,713 reward size northern pikeminnow and ranged from 54,469 northern pikeminnow at the Dalles station (20% of total 2004 NPSRF harvest) to 3,752 northern pikeminnow at the Lyon's Ferry station (Figure 9). Mean harvest per registration station was up substantially from 2003 (10,345). The Dalles site took the title of the top producing site from the top producer for the past three years, Greenbelt. The Dalles station (which receives most of it's harvest total from fishing location 02) showed the greatest change in harvest from 2003, also increasing by over 100% (30,508 NPM) of it's total from 2003. The dramatic increases in harvest from fishing location 02, and the Dalles station specifically, are primarily the result of changes in direction and velocity of water flow out of the Dalles dam.

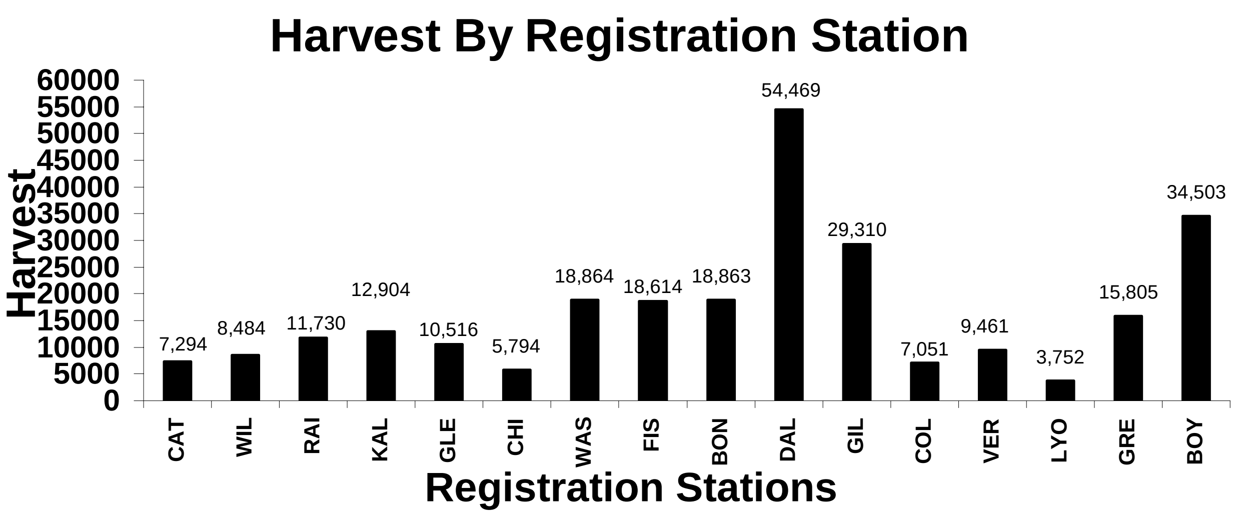


Figure 9. 2004 Northern Pikeminnow Sport-Reward Fishery Harvest by Registration station. CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, GLE-Gleason, CHI-Chinook, WAS-Washougal, FIS-The Fishery, BON-Bonneville Trailhead,, DAL-The Dalles, GIL-Giles French, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, GRE-Greenbelt, BOY-Boyer Park.

Incidental Catch/Harvest by Species

Returning Anglers

During the 2004 NPSRF, returning anglers reported that they caught or harvested the following salmonid species while targeting northern pikeminnow (Table 1). Harvested salmonids are most often fish that are incidentally caught and kept by anglers during a legal salmonid fishery. Released salmonids must be recorded based on angler recollection rather than identification by WDFW technicians. Instances where anglers report harvesting juvenile salmonids are most likely residualized hatchery steelhead smolts, and are sometimes reported as trout. Illegally harvested juvenile salmonids are reported to enforcement.

Table 1. Catch and harvest totals by returning anglers targeting northern pikeminnow during the 2004 Northern Pikeminnow Sport-Reward Fishery.

Salmonid Species		Caught	Harvest	Harvest Percent
Chinook (Adult)	*Oncorhynchus tshawytscha*	36	18	50.00%
Chinook (Jack)	*Oncorhynchus tshawytscha*	19	3	15.79%
Chinook (Juvenile)	*Oncorhynchus tshawytscha*	74	2	2.70%
Steelhead Adult (Hatchery)	*Oncorhynchus mykiss*	71	23	32.39%
Steelhead Adult (Wild)	*Oncorhynchus mykiss*	35	0	0
Steelhead Juvenile (Hatchery)	*Oncorhynchus mykiss*	71	7	9.86%
Steelhead Juvenile (Wild)	*Oncorhynchus mykiss*	31	0	0
Coho (Adult)	*Oncorhynchus kisutch*	0	0	0
Coho (Juvenile)	*Oncorhynchus kisutch*	1	0	0
Salmon Pacific (unknown)	*Oncorhynchus spp.*	1	0	0
Searun Cutthroat	*Oncorhynchus clarki*	4	3	75.00%
Coastal Cutthroat	*Oncorhynchus clarki*	1	0	0
Cutthroat (unknown)	*Oncorhynchus clarki*	2	0	0
Rainbow Trout	*Oncorhynchus mykiss*	10	7	70.00%
Trout (Unknown)		194	9	4.64%

As expected, returning anglers targeting northern pikeminnow most often caught and harvested northern pikeminnow. Other fish species incidentally caught by these anglers were mostly peamouth, smallmouth bass, white sturgeon, and channel catfish. This has been the case in each year that the NPSRF has been implemented. In addition to these species, returning anglers targeting northern pikeminnow also reported that they incidentally caught or harvested the non-salmonid species listed in Table 2.

Non-Returning Anglers Catch and Harvest Estimates

We surveyed 1,806 non-returning anglers (14.97% of all non-returning anglers) to record their catch and/or harvest of northern pikeminnow and salmonid species. Catch and harvest data for all other fish species caught by non-returning anglers (last obtained during the 2000 NPSRF) were not recorded in 2004 since their levels have been historically very low. We anticipate collecting full creel data for other fish species in order to determine whether trends have changed in 2005 per NPSRF protocol (Fox et al. 1999). Surveyed non-returning anglers targeting northern pikeminnow reported that they caught and/or harvested the species listed in column one during the 2004 NPSRF (Table 3). We applied a simple estimator to the catch and harvest totals obtained from the surveyed anglers to obtain a total catch and harvest estimate for all non-returning anglers. Estimated total catch and harvest of northern pikeminnow and salmonids for all non-returning anglers participating in the 2004 NPSRF is listed in column four and five (Table 3).

Table 2. 2004 Catch and harvest totals of non-salmonids by returning anglers during the 2004 NPSRF.

Species	Catch	Harvest	Percent Harvested
Northern Pikeminnow ≥ 228 mm	267,421	267,414	99.99%
Northern Pikeminnow < 228 mm	49,125	4,859	9.89%
Peamouth *Mylocheilus cauriuus*	55,309	8,612	15.57%
Smallmouth Bass *Micropterus dolomieui*	17,227	1,602	9.30%
Channel Catfish *Ictalurus punctatus*	8,726	1,507	17.27%
White Sturgeon *Acipenser Transmountanus*	9,339	217	2.32%
Sculpin *Cottus spp.*	5,873	771	13.13%
Yellow Perch *Perea flauesceno*	2,715	260	9.58%
Sucker (Unknown) *Castostomus spp.*	2,608	151	5.79%
Walleye *Stizostedion vitreum*	1,178	803	68.17%
Chiselmouth *Acrochilus alutaceus*	425	34	8.00%
Redside Shiner *Richarsonius balteatus*	92	14	15.22%
Carp *Cyprinus carpio*	658	56	8.51%
American Shad *Alosa sapidissima*	570	197	34.56%
Bullhead *Ictalurus spp.*	509	43	8.45%
Yellow Bullhead *Ictalurus natlis*	311	22	7.07%
Starry Flounder *Platichthys stellatus*	599	28	4.67%
Crappie (Unknown) *Pomoxis spp.*	135	42	31.11%
Bluegill *lepomis macrochirus*	131	8	6.11%
Largemouth Bass *Micropterus salmonids*	42	5	11.90%
Brown Bullhead *Ictalurus nebulosus*	26	0	0
Pumpkinseed *Leomis gibbosus*	37	6	16.22%
Mountain Whitefish *Prosopium williamsoni*	23	3	13.04%
Bridgelip Sucker *Catostomus columbianus*	23	3	13.04%
Black Bullhead *Ictalurus melas*	5	3	60.00%
Largescale Sucker *Catostomus macrocheilus*	13	3	23.08%
Longnose Sucker *Catostomus catostomus*	8	0	0
White Crappie *Promoxis annularis*	2	1	50.00%
Black Crappie *Pomoxis nigromaculatus*	1	0	0
Blue Catfish *Ictalurus punctatus*	2	0	0
Flathead Catfish *Pilodictis olivaris*	0	0	0

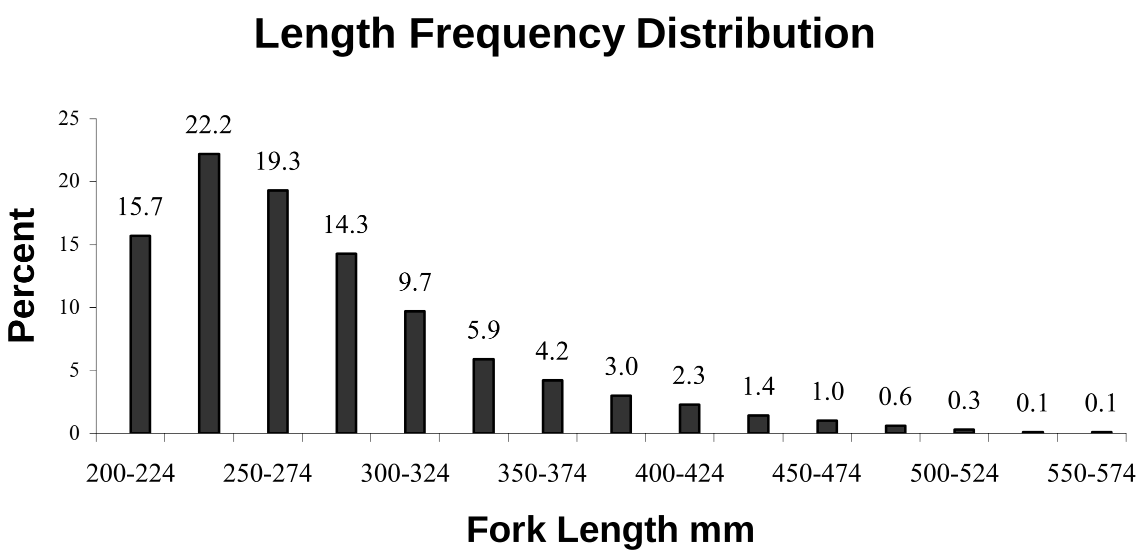
Table 3. Catch and harvest totals and estimates of catch and harvest for non-returning anglers.

Species	Caught	Harvested	%Harvested	Est. Catch	Est. Harvest
Northern Pikeminnow < 228 mm	63	57	90.48%	420	381
Chinook (Adult)	1	0	0	7	0
Chinook (Jack)	0	0	0	0	0
Chinook (Juvenile)	5	0	0	33	0
Steelhead Adult (Adipose absent)	0	0	0	0	0
Steelhead Adult (Adipose present)	1	0	0	7	0
Steelhead Juv. (Adipose absent)	0	0	0	0	0
Steelhead Juv.(Adipose present)	1	0	0	7	0
Rainbow Trout	0	0	0	0	0

N=12,062 n=1,806

Fork Length Data

A total of 77,933 northern pikeminnow ≥ 200 mm (28.6% of all returned to registration stations) were sampled for fork length in 2004. Of these, 75,014 had a fork length > 209 mm. The mean fork length for northern pikeminnow ≥ 200 mm was 279.5 mm with a standard deviation of 60.3 mm. The length frequency distribution of northern pikeminnow ≥ 200 mm is presented in Figure 10.



N = 77,933 Mean = 279.5 SD = 60.3

FIGURE 10. LENGTH FREQUENCY DISTRIBUTION OF NORTHERN PIKEMINNOW ≥ 200 MM TOTAL LENGTH SAMPLED IN 2004.

Angler Effort

The NPSRF recorded total effort of 35,211 angler days spent during the 2004 season. Of this total, we noted that 3,015 angler days (9%) were spent during the pre-season. This was an increase in total effort of 23% from the 2003 NPSRF (Figure 11). When total effort is divided into returning and non-returning angler days, 23,206 angler days (66%) were recorded by returning anglers. This is a slight increase from the 2003 NPSRF in which 65% of participating anglers returned for exit interviews. Of the 23,206 returning angler days spent during the 2004 NPSRF, 21,203 angler days (91%) were designated successful since they resulted in harvested NPM.

Mean weekly effort for the 2004 NPSRF increased to 1,677 angler days and ranged from 852 in week 37 (September 13-19) to 2,584 during week 24 (June 14-20) (Figure 12). Mean weekly effort for the pre-season was 1,508 angler days. Effort peaked during the NPSRF's traditional peak harvest period in mid-June. The NPSRF peak effort period was lower than the mean 1991-2003 peak, but continued to occur during the same week 21-25 time period seen from 1991-2003 (Figure 13).

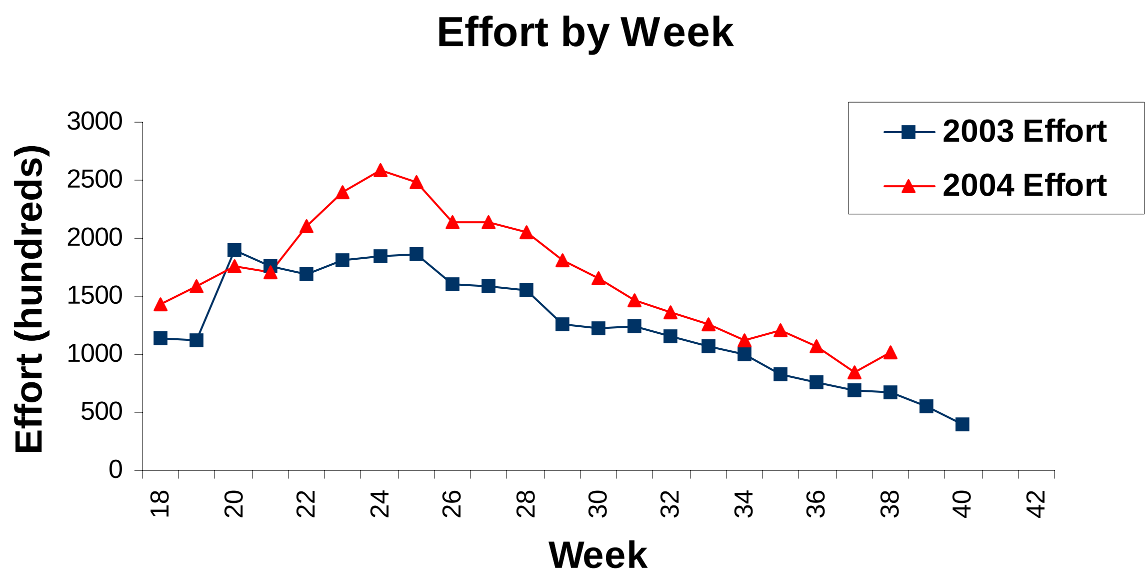


Figure 11. 2004 weekly Northern Pikeminnow Sport-Reward Fishery Effort vs. 2003 weekly Effort.

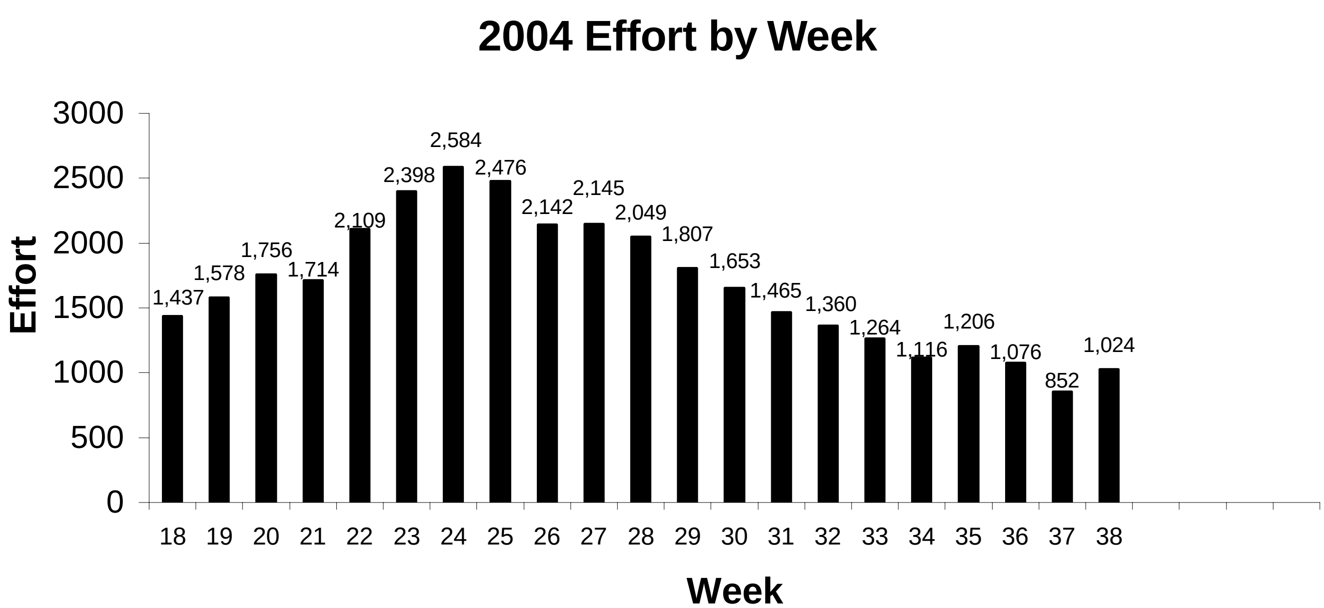


Figure 12. 2004 Northern Pikeminnow Sport-Reward Fishery Effort by week.

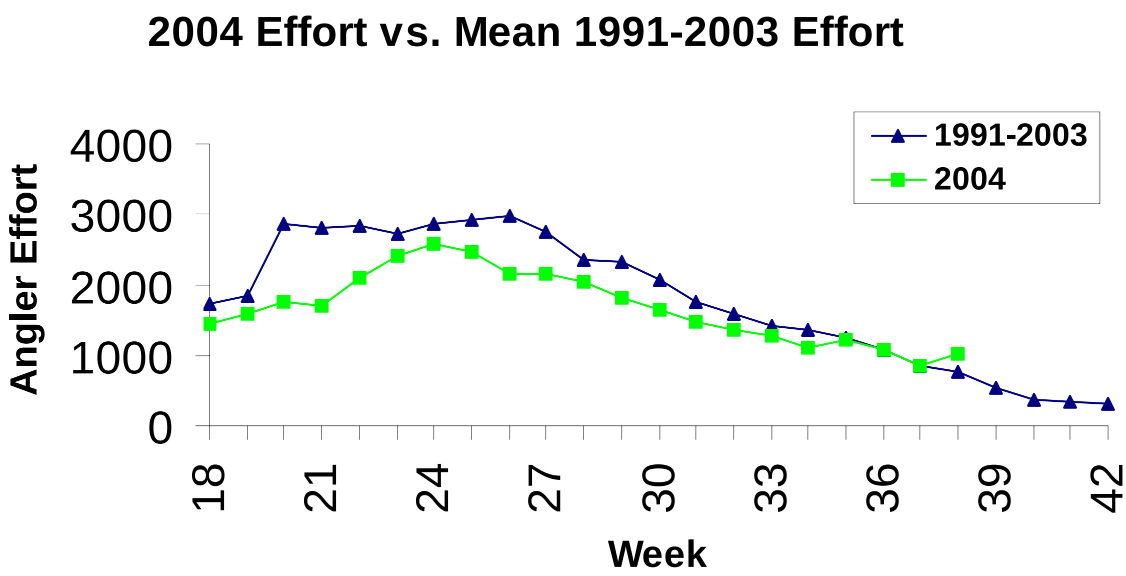


Figure 13. 2004 Northern Pikeminnow Sport-Reward Fishery weekly Effort vs. Mean 1991-2003 Effort.

Mean annual effort (returning anglers only) by fishing location was 1,933 angler days and ranged from 10,096 (44% of NPSRF total) in fishing location 01 (below Bonneville Dam) to 8 in fishing location 5 (McNary Dam to mouth of the Snake River) (Figure 14).

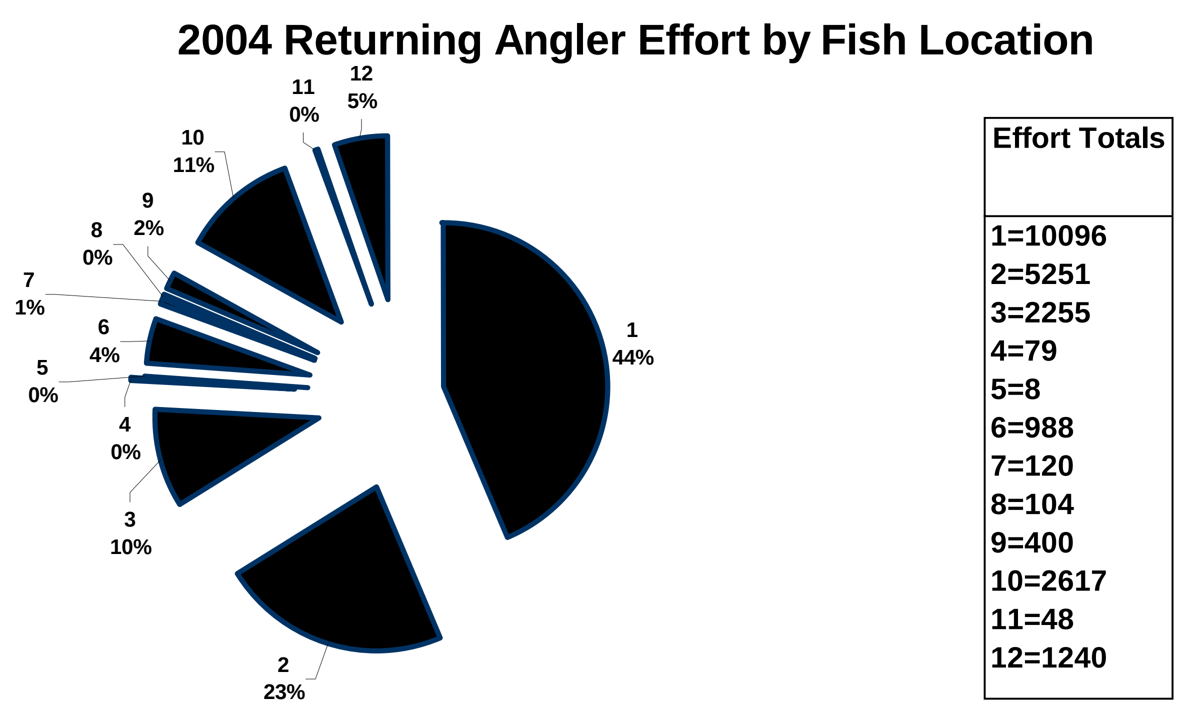


Figure 14. 2004 NPSRF Angler Effort by Fishing Location (returning anglers only).

Mean effort per registration station was 2,201 angler days and ranged from 6,369 angler days at the Dalles to 639 angler days at Lyon's Ferry (Figure 15). For the first time in seven years, Greenbelt was not the leader in effort. However, a large portion of Greenbelt's effort transferred to the site that was re-opened at Boyer Park in 2004. Effort at the Dalles increased from 3,062 angler days in 2003 to 6,369 angler days in 2004.

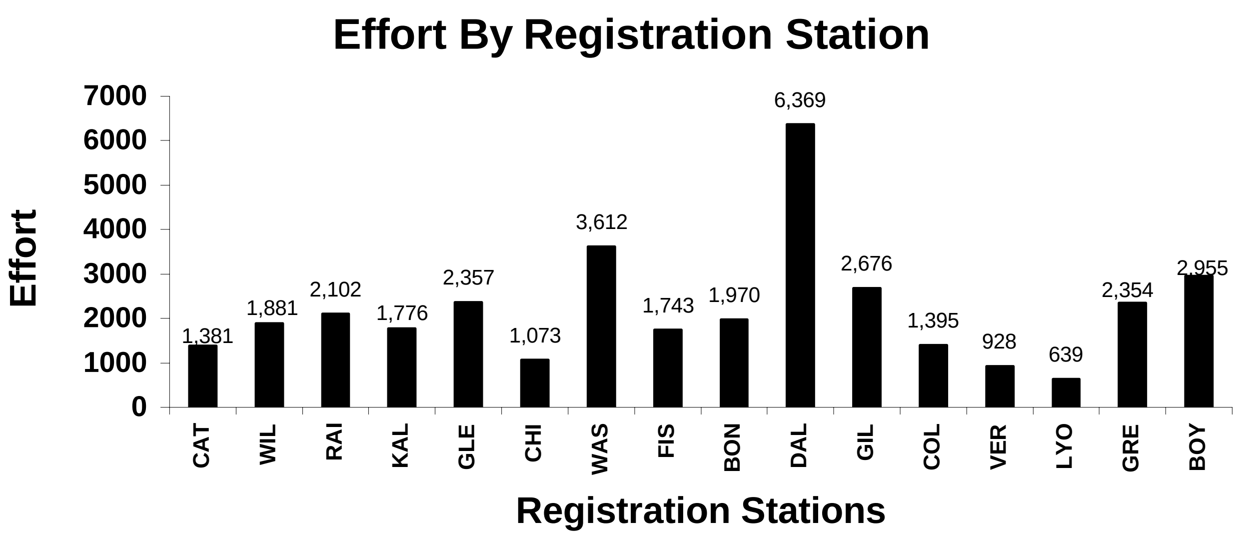


Figure 15. 2004 Northern Pikeminnow Sport-Reward Fishery Angler Effort by Registration Station. CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, GLE-Gleason, CHI-Chinook, WAS-Washougal, FIS-The Fishery, BON-Bonneville Trailhead, DAL-TheDalles, GIL-Giles French, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, GRE-Greenbelt, BOY-Boyer Park.

Catch Per Angler Day

The NPSRF recorded an overall catch per unit of effort (CPUE) of 7.59 northern pikeminnow harvested per angler day (returning + non-returning anglers) during the 2004 season. This catch rate was up from 6.85 in 2003 and once again set the standard for the highest CPUE in NPSRF history. The steady increase in CPUE from year to year is also consistent with the upward trend in CPUE seen in the NPSRF from 1991-2003 (Fox et al, 1999) (Figure 16). Returning angler CPUE was 11.52 northern pikeminnow per angler day and also set a NPSRF record as these anglers continued to develop their effectiveness at harvesting reward size northern pikeminnow. We estimated CPUE for non-returning anglers to be only .035 fish/angler day, illustrating a lack of angling success which is the most common reason given by non-returning anglers for not returning to their registration station after their angling day.

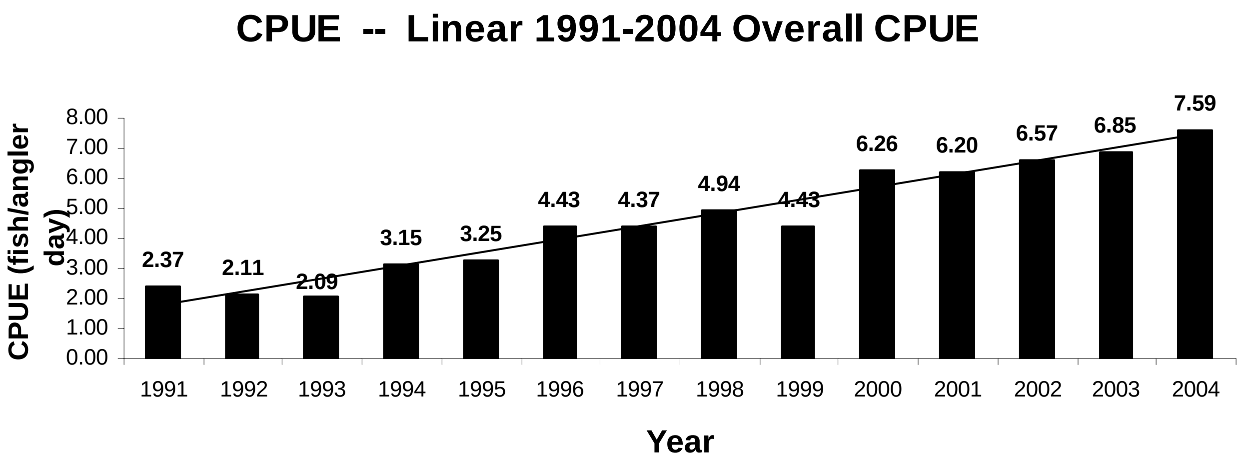


Figure 16. Annual CPUE totals for the Northern Pikeminnow Sport-Reward Fishery (return + non-return).

Mean weekly CPUE increased to 7.64 (from 7.25 in 2003), and ranged from 6.25 in week 32 (August 9-15) to a peak of 10.39 in week 38 (September 20-26) (Figure 17). Angling success (represented by CPUE), was much better during the 2004 NPSRF's pre-season (7.29 vs 4.34) than in 2003. The favorable fishing conditions persisted throughout the entire 2004 season as demonstrated by weekly CPUE rates > 6.0 for every week of the season. The 2003 NPSRF did not record weekly CPUE > 6.0 until week 23 (June 2-8, 2003).

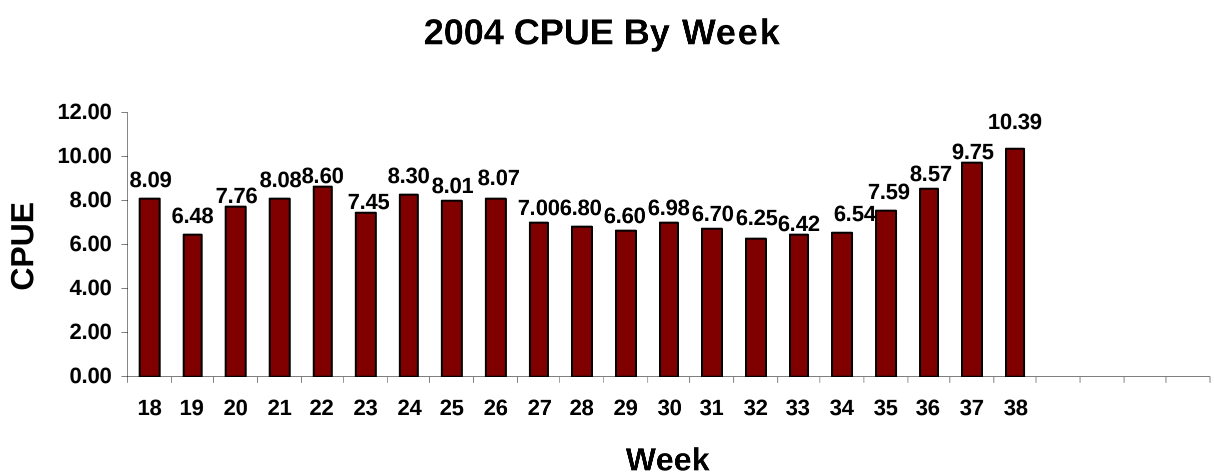


Figure 17. 2004 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Week.

The CPUE by fishing location during the 2004 NPSRF ranged from 13.95 northern pikeminnow per day in fishing location 10 (Little Goose Reservoir) to 4.00 in fishing location 5 (McMary Reservoir) (Figure 18). When compared to 2003, all fishing locations 1,2,3,4,7,9 and12 showed an increase in CPUE. The remaining five fishing locations showed a decrease in CPUE, notably in fishing location 10 which dropped from 19.00 in 2003 to 13.95 in 2004. The most likely reason for the drop in CPUE in location 10 was the increased participation generated by the decision of the NPSRF to re-establish a registration station at Boyer Park.

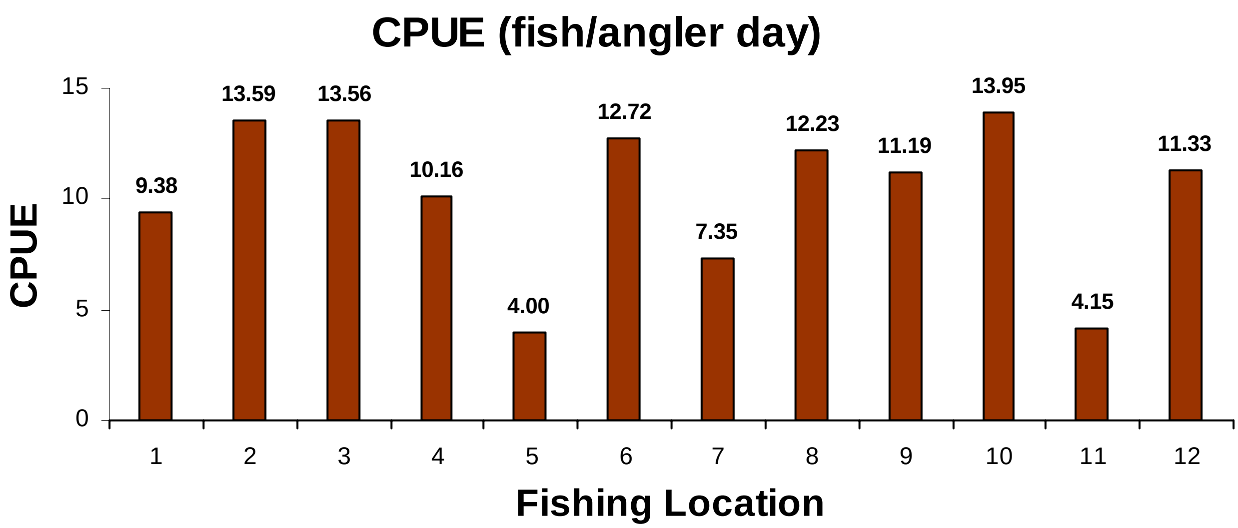


Figure 18. 2004 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Fishing Location.

The registration station that recorded the highest CPUE from the 2004 NPSRF was Boyer Park with 11.68 northern pikeminnow per angler day (Figure 19). The registration station with the lowest CPUE was Gleason with 4.46 northern pikeminnow per angler day. For the most part, changes in registration station CPUE were subtle for the 2004 NPSRF. The Fishery illustrated the largest change in CPUE with an increase from 6.67 in 2003 to 10.68 in 2004.

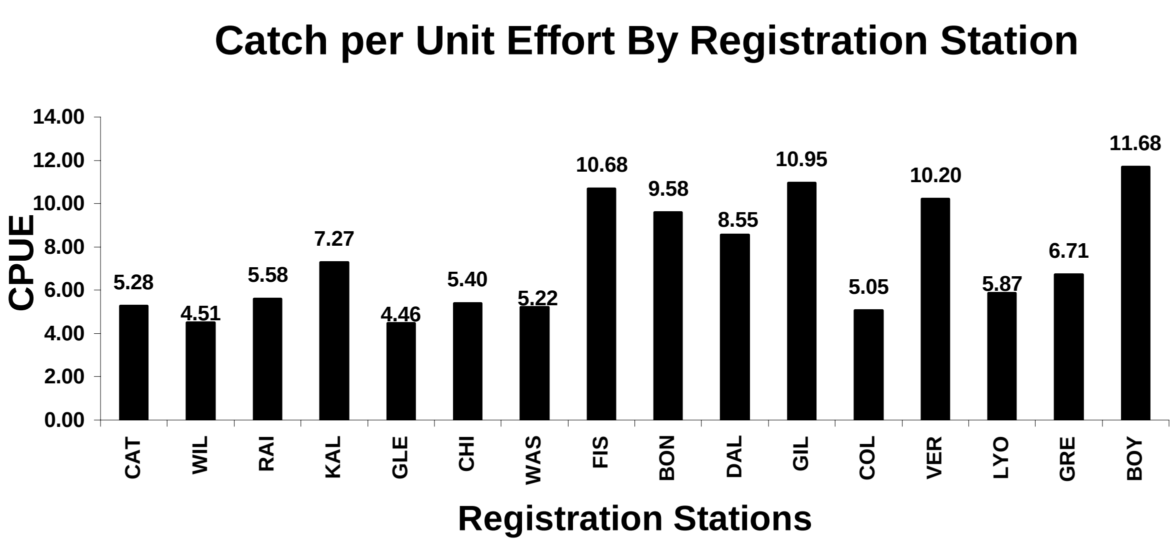


Figure 19. 2004 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Registration Station. CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, GLE-Gleason, CHI-Chinook, WAS-Washougal, FIS-The Fishery, BON-Bonneville Trailhead, DAL-The Dalles, GIL-Giles French, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, GRE-Greenbelt, BOY-Boyer Park.

Angler Totals

There were 5,614 separate anglers who participated in the 2004 NPSRF. Two thousand, five hundred and seventy nine of these anglers (46%) were classified as successful since they harvested at least one northern pikeminnow during the 2004 season. The average annual harvest of reward size northern pikeminnow per successful angler was 104 northern pikeminnow per season. When we break down the 2,579 successful anglers by tier, 83% (2,157 anglers) harvested less than 100 northern pikeminnow (Tier 1) during the 2004 season (Figure 20), with an average harvest of 15 northern pikeminnnow. Ten percent (250 anglers) harvested between 101 and 400 northern pikeminnow (Tier 2) during the 2004 season with an average harvest of 204 NPM. Seven percent (172 anglers) caught more than 400 northern pikeminnow (Tier 3) during the 2004 season and averaged 1,073 NPM.

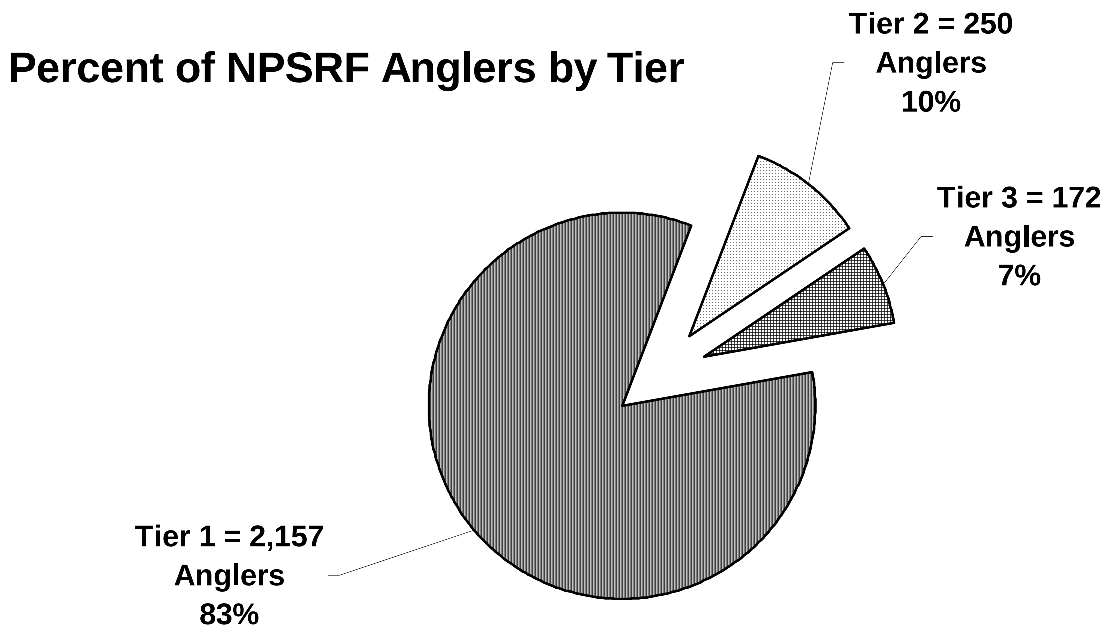


Figure 20. 2004 Northern Pikeminnow Sport-Reward Fishery Anglers based on number of fish harvested. Tier 1 anglers harvested ≤ 100 fish, Tier 2 anglers harvested 101-400 fish, and Tier 3 anglers harvested >400 fish during the 2004 Northern Pikeminnow Sport-Reward Fishery season.

Cumulative 2004 NPSRF harvest by angler tier was as follows. Tier 1 anglers harvested 12% (31,698 northern pikeminnow) of the total 2004 NPSRF harvest (Figure 21). This was down from 13% in 2003.). Tier 2 anglers harvested 19% (51,101 northern pikeminnow) of the total 2004 NPSRF harvest. Their total was also down from 20% of the harvest in 2003. As in past seasons, Tier 3 anglers were the most proficient anglers harvesting 69% (184,615 northern pikeminnow) of the total 2004 NPSRF harvest (up from 67% in 2003).

The average Tier 1 angler spent six days fishing during the 2004 NPSRF season, up from five in 2003 (Figure 22). Tier 2 anglers averaged 29 days fishing during the 2004 NPSRF, and Tier 3 anglers spent an average of 61 days fishing during the season. Angler effort by tier level has not varied much since first reported in the 2000 NPSRF Annual Report (Glaser et al 2000).

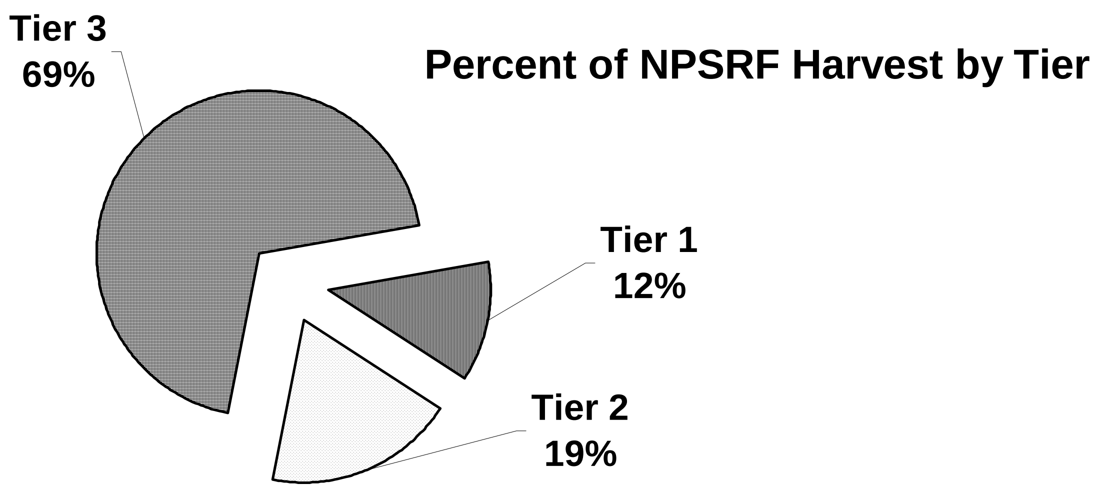


Figure 21. Percentage of 2004 Northern Pikeminnow Sport-Reward Fishery Harvest by Angler Tier. **Tier 1 anglers harvested $\leq$ 100 fish, Tier 2 anglers harvested 101-400 fish, and Tier 3 anglers harvested >400 fish during the 2004 Northern Pikeminnow Sport-Reward Fishery season.**

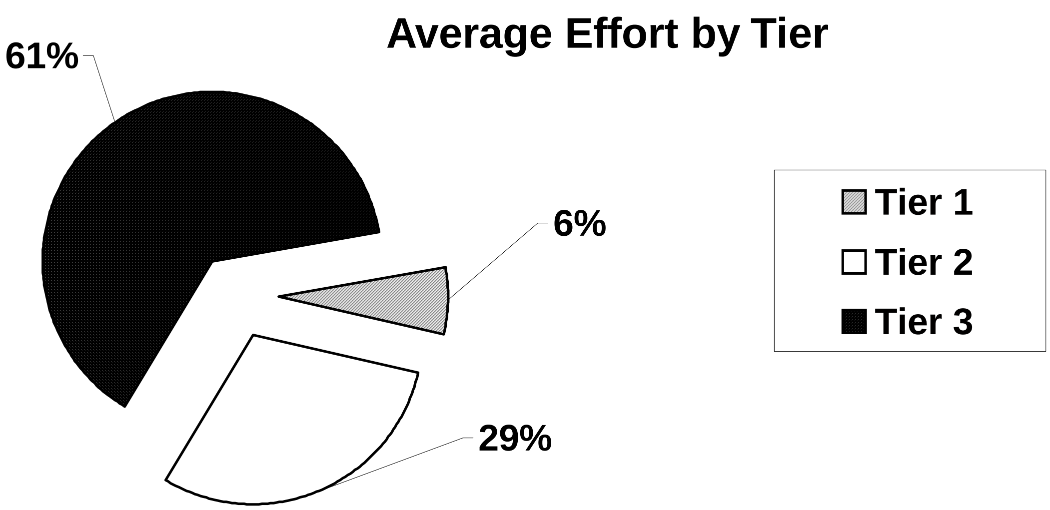


Figure 22. Average Effort of 2004 Northern Pikeminnow Sport-Reward Fishery Anglers by Tier. **Tier 1 anglers harvested $\leq$ 100 fish, Tier 2 anglers harvested 101-400 fish, and Tier 3 anglers harvested >400 fish during the 2004 Northern Pikeminnow Sport-Reward Fishery season.**

The CPUE for Tier 1 anglers was 2.44 northern pikeminnow per registered angling trip during the 2004 NPSRF (Figure 23). CPUE for Tier 2 anglers was 6.94 northern pikeminnow per trip, while Tier 3 angler CPUE was 17.52 northern pikeminnow per trip during the 2004 NPSRF. The 2004 NPSRF recorded increases in CPUE for angler in all three tiers, indicating that anglers were more successful at harvesting northern pikeminnow (regardless of their level of proficiency), than were anglers from 2003.

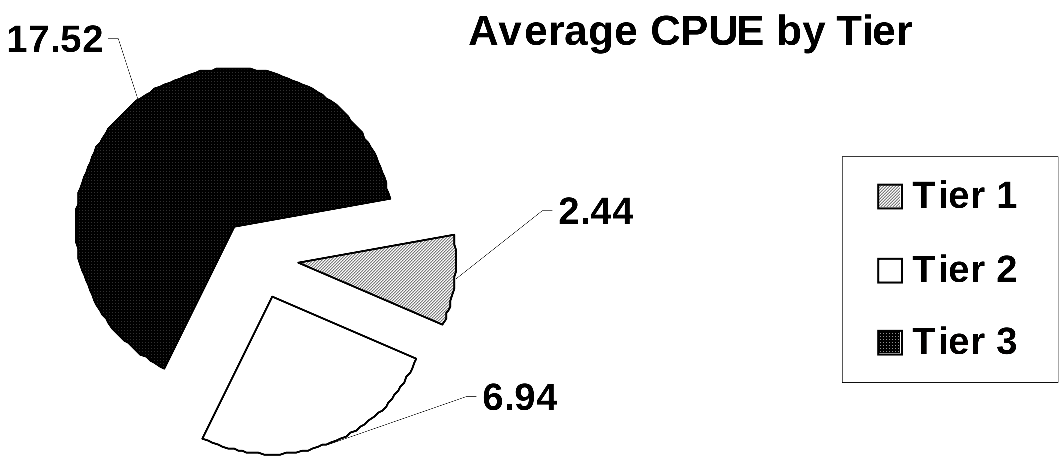


Figure 23. Average CPUE of 2004 Northern Pikeminnow Sport-Reward Fishery Anglers by Tier. Tier 1 anglers harvested < 100 fish, Tier 2 anglers harvested 101-400 fish, and Tier 3 anglers harvested >400 fish during the 2004 Northern Pikeminnow Sport-Reward Fishery season.

The top angler for the 2004 NPSRF harvested 4,664 NPM, which was 303 more fish than the number two angler harvested, and 665 more fish than last year's top angler who harvested 4,009 northern pikeminnow. The CPUE for this year's top angler was 40.6 northern pikeminnow (compared to the 2003 top angler's CPUE of 43.6), and he spent 115 angler days of effort during the 2004 season. By comparison, the top participating angler spent 145 days and harvested 4,077 northern pikeminnow.

Tag Recovery

Returning anglers recovered and turned in 174 northern pikeminnow tagged with external spaghetti tags during the 2004 NPSRF. This compares to the 2003 total of 177 tags turned in by NPSRF anglers (Hone et al., 2003). Of these, WDFW technicians identified 91spaghetti tagged northern pikeminnow that were also PIT tagged by ODFW in 2004 as a secondary mark. Technicians recorded an additional 7 northern pikeminnow with a fin-clip mark and/or wounds consistent with having lost a tag. The recovered tags and potential tag loss data was estimated by ODFW to equal a 17% exploitation rate for the 2004 NPSRF (2004 ODFW, personal communication).

A total of 267,590 northern pikeminnow were individually scanned for the presence of PIT tags. This represents 100% of the total harvest of reward-size fish handled by NPSRF technicians in 2004 (northern pikeminnow which did not qualify for reward were also scanned whenever possible). A total of 148 PIT tags from consumed smolts were located and successfully interrogated from the guts of these fish. There were also 6 PIT tags from unknown smolts recovered for an overall PIT tag recovery total of 154. This compares to the 2003 NPSRF which recovered 149 PIT tags from consumed smolts (Hone et al. 2003). We recorded PIT tag recoveries from May 3rd through September 23rd, with recoveries peaking on May 18th (13 recoveries) (Figure 24). PIT tag recoveries by fishing location showed that northern pikeminnow harvested from The Dalles Pool (fishing location 03), and Bonneville Pool (fishing location 02) yielded the majority of the NPSRF's PIT tag recoveries (Figure 25).

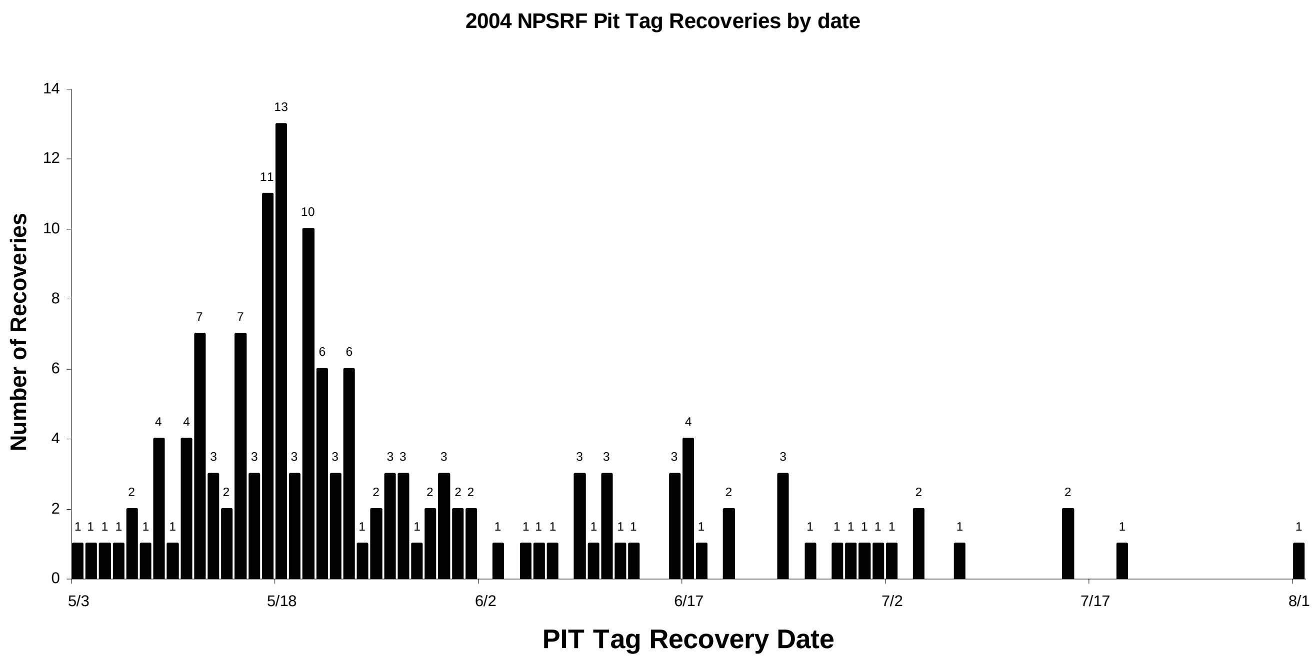


Figure 24. 2003 NPSRF PIT Tag Recoveries by Date (1 additional recovery on 9/23 not included in graph).

All 148 PIT tag recoveries were queried through the PTAGIS database and those queries yielded the following results. Fork lengths of smolts at release from PTAGIS were compared to fork lengths of the northern pikeminnow from which the PIT tag was recovered (Figure 26). Mean fork length for consumed smolts was 116 mm, while mean fork length for the "consuming" northern pikeminnow was 370 mm. The mean fork length of northern pikeminnow found to have consumed PIT tagged smolts was much larger than the overall mean fork length (279.5 mm) for all reward-size northern pikeminnow from the 2004 NPSRF. Species composition of PIT tagged smolts recovered from northern pikeminnow harvested in the 2004 NPSRF indicated that 135 (87.7%) of the PIT tags were from chinook smolts, 8 (5.2%) of the PIT tags were from

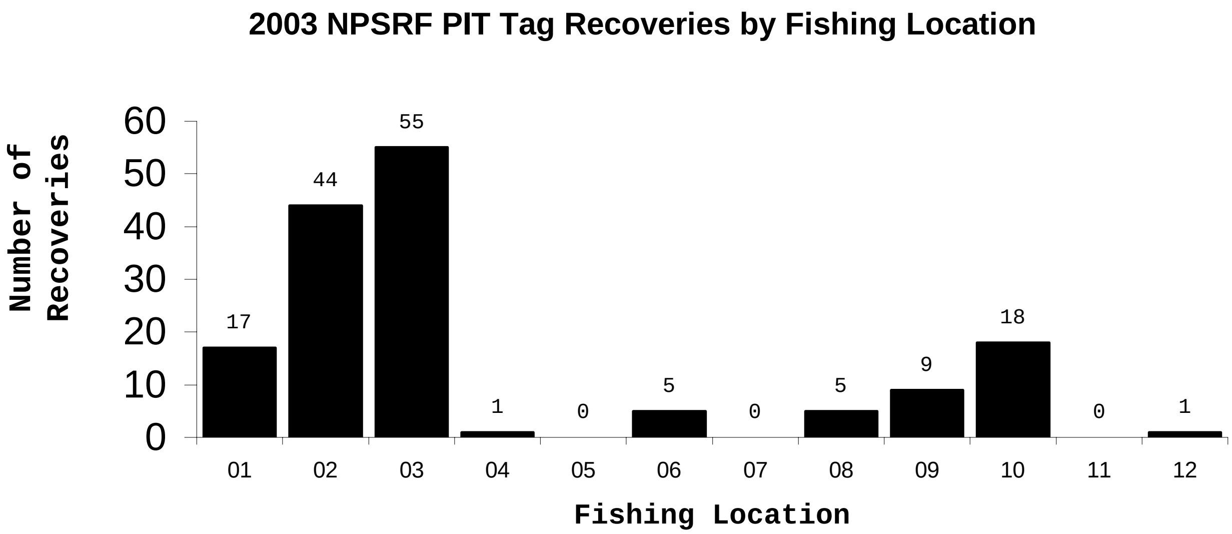


Figure 25. 2003 NPSRF PIT Tag Recoveries by Fishing Location.

steelhead smolts ,and 5 (3.2%) PIT tags were from coho smolts. We also recovered six unknown smolt that accounted for the remaining 3.9%. PIT tag queries of PTAGIS for the chinook smolts indicated that there were 14 (10.4%) of wild origin. PTAGIS queries also indicated that one of the 8 PIT tagged steelhead (12.5%), was of wild origin.

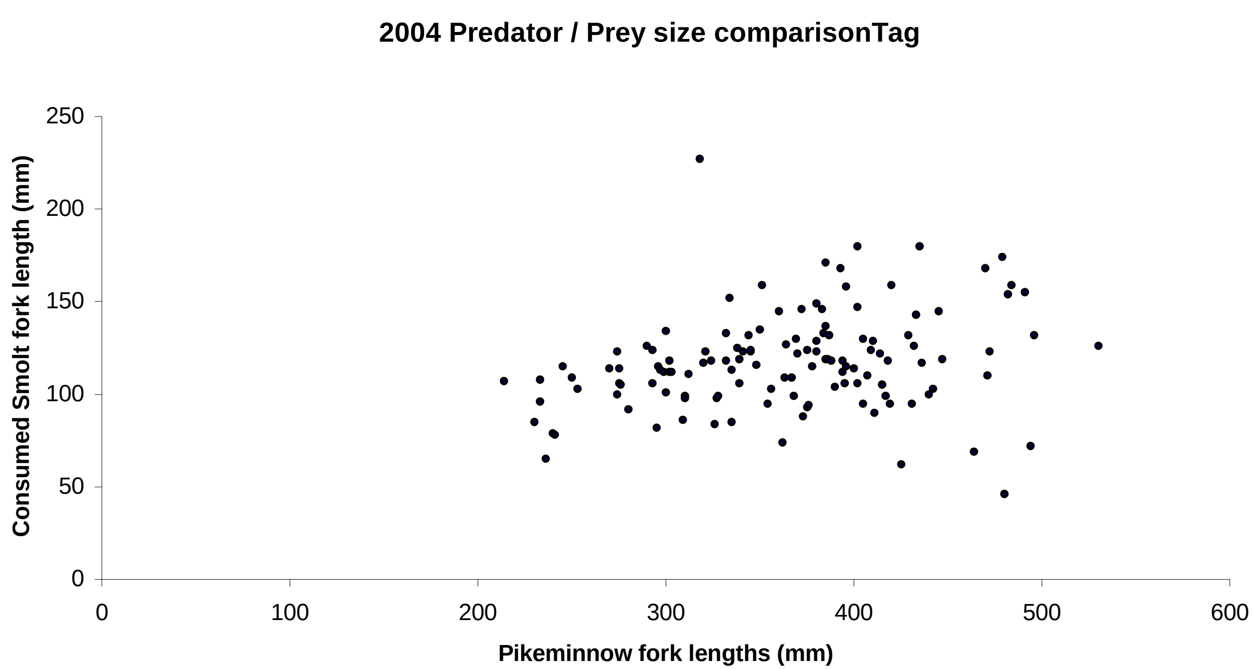


Figure 26. 2003 NPSRF Predator Prey Size Comparison (N=106).

Analysis of PIT tag recovery dates from the 2004 NPSRF continues to document northern pikeminnow predation on downstream migrating juvenile salmonids, primarily spring chinook. Our PIT tag recovery data also shows that northern pikeminnow consume chinook and steelhead smolts (including Snake River fish) most heavily during their peak migration month of May. Full implementation of the NPSRF throughout the month of May will continue to be needed in order to capture and document northern pikeminnow predation on these fish. Further data collection and analysis of PIT tag recoveries from juvenile salmonids consumed by northern pikeminnow harvested in the NPSRF may lead to a better understanding of northern pikeminnow predation on salmonids smolts migrating through the Columbia River system.

SUMMARY

The 2004 NPSRF not only succeeded in reaching the NPMP's 10-20% exploitation goal for the seventh consecutive year, but also set new single season records for harvest and exploitation rate (267,414 and 17% respectively). Harvest, effort and angler CPUE were all up from the 2003 NPSRF. River conditions at the start of the 2004 fishery were conducive to catching northern pikeminnow and the good fishing conditions resulted in an increase in harvest of northern pikeminnow, and also most likely an increase in effort. The increased reward levels which began in week five, attracted new and often inexperienced pikeminnow anglers to the NPSRF, but it also resulted in a short term dip in weekly CPUE. The increased reward did encourage anglers at all three tiers to increase their participation as seen in the increased average number of days spent fishing. The increased effort generated by the reward increase combined with favorable river conditions which allowed a higher angler CPUE, produced the record levels of harvest and exploitation seen by the NPSRF in 2004. The 2004 NPSRF increased participation from 2003 which was of note due to the NPSRF's downward trend in participation seen in recent years. While it is good to attract new anglers to the NPSRF through the use of increased angler rewards, the NPSRF must also continue to find ways to educate these anglers through the use of angler clinics, and "how to catch them" information/maps, etc. In addition, retention of reward levels similar to the current level in future NPSRF seasons will help retain our most effective and efficient anglers and also maintain or even increase their current levels of effort.

Detection of PIT tags retained in the gut of northern pikeminnow continues to show promise as a way to obtain additional data on northern pikeminnow predation on juvenile salmonids. Recovery of PIT tags from consumed juvenile salmonids peaked on May 18th in 2004 and species composition of recovered PIT tags showed that while the majority of northern pikeminnow predation on juvenile salmonids was on hatchery fish, there were also significant numbers of wild chinook and steelhead (including Snake River fish) being consumed. Peak PIT tag recoveries continued to coincide with the typical peak of the downstream smolt migration in May. PIT tags in northern pikeminnow were once again used as a secondary mark by ODFW in 2004 to eliminate uncertainties and document tag loss which will result in a more accurate estimate of pikeminnow exploitation by the NPSRF. PIT tag recoveries were also monitored to identify and document angler fraud from northern pikeminnow tagged outside NPSRF boundaries.

RECOMMENDATIONS FOR THE 2005 SEASON

1.) Begin full implementation of the 2005 NPSRF on May 2nd in order to take advantage of expected below average river flow which typically create river conditions conducive to harvesting northern pikeminnow.

2.) Strengthen and emphasize WDFW technician implementation of procedures for angler pre-registration to ensure standardization between registration stations and consistency with NPMP mandates.

3.) Review NPSRF Rules of participation as needed to adjust to the dynamics of the fishery and fishery participants, and to maintain NPSRF integrity.

4.) Develop angler education materials designed to improve efficiency of the NPSRF's new participants in order to help reach the NPMP's 10-20% exploitation goal.

5.) Provide information to the public about how to participate in the NPSRF and where and how to catch northern pikeminnow.

6.) Retain the option to extend the NPSRF season on a site-specific basis if harvest, angler effort and CPUE levels warrant.

7.) Continue to scan all northern pikeminnow for PIT tags from consumed juvenile salmonids, from the ODFW's biological evaluation, and as a means of identifying northern pikeminnow from outside NPSRF boundaries.

8.) Continue to develop additional measures to identify potential angler fraud and to deter anglers from fraudulently submitting northern pikeminnow to the NPMP for payment.

9.) Survey 20% of non-returning anglers to record total non-returning angler catch of all salmonids and other fishes and to estimate total non-returning angler catch and harvest.

10.) Investigate additional incentives for anglers to harvest northern pikeminnow from within program boundaries, i.e., spaghetti tagged fish.

REFERENCES

Burley, C. C., D. C. Klaybor, G. W. Short, and G.J. Hueckel. 1992. Evaluation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. Report B *in* C.F. Willis and A.A. Nigro editors. Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1991 Annual Report. Contract DE-B179-90-BP07084, Bonneville Power Administration, Portland, Oregon.)

Fox, L.G., J.J. Amren, B.G. Glaser, M.L. Wachtel, and E.C. Winther. 1999. Implementation of the northern pikeminnow sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Pikeminnow Management Program). 1999 Annual Report, project number 90-077. Bonneville Power Administration, Portland, Oregon.

Friesen, T.A. and D.L. Ward 1999. Management of northern pikeminnow and implications for juvenile salmonid survival in the lower Columbia and Snake rivers. North American Journal of Fisheries Management 19:406-420.

Glaser, B.G., J.J. Amren, L. G. Fox, M.L. Wachtel, and E.C. Winther. 2000. Implementation of the northern pikeminnow sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Pikeminnow Management Program). 2000 Annual Report, project number 90-077. Bonneville Power Administration, Portland, Oregon.

Hankin, D.G. and J. Richards. 2000. The northern pikeminnow management program: An Independent review of program justification, performance, and cost-effectiveness. Report to the Pacific Northwest Electric Power and Conservation Planning Council, Portland, Oregon.

Hisata, J.S., M.R. Petersen, D.R. Gilliland, E.C. Winther, S.S. Smith, and J. Suarez-Pena. 1995. Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. Report A *in* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 1995

Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Hone, J.D., R. Bruce, E.C. Winther, and J.A. Memarian. 2003. Implementation of the northern pikeminnow sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 2003 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Klaybor, D.C., C.C. Burley, S.S. Smith, E.N. Mattson, E.C. Winther, P.E. DuCommun, H.R. Bartlett, and S.L. Kelsey. 1993. Evaluation of the northern squawfish sport-reward fishery in the Columbia and Snake rivers. Report B in C.F. Willis and D.L. Ward, editors. 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. 1993 Annual Report, Volume 1. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Nelson, J.S., and five coauthors. 1998. Recommended changes in common fish names: pikeminnow to replace squawfish. Fisheries 23(9):37.

Northwest Power Planning Council. 1987a. Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council. Portland, Oregon.

Rieman, B.E., R.C. Beamesderfer, S. Vigg, and T.P. Poe. 1991. Predation by resident fish on juvenile salmonids in a mainstem Columbia reservoir: Part IV. Estimated total loss and mortality of juvenile salmonids to northern squawfish, walleye, and smallmouth bass. T. P. Poe and B. E. Rieman, editors. Resident fish predation on juvenile salmonids in John Day Reservoir, 1983-1986. Final Report (Contracts DE-AI79-82BP34796 and DE-AI79-82BP35097) to Bonneville Power Administration, Portland, Oregon.

Rieman, B.E., and R.C. Beamesderfer. 1990. Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241.

Smith, S.E., D.R. Gilliland, E.C. Winther, M.R. Petersen, E.N. Mattson, S.L. Kelsey, J. Suarez-Pena, and J. Hisata. 1994. (Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: Evaluation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. Washington Department of Fish and Wildlife, Contract

Number DE-BI79-90BP07084. 1994 Annual Report to Bonneville Power Administration, Portland, Oregon.)

Vigg, S. and C.C. Burley. 1989. Developing a predation index and evaluating ways to reduce salmonids losses to predation in the Columbia Basin. Report A in A.A. Nigro, editor. Developing a predation index and evaluating ways to reduce losses to predation in the Columbia Basin. Oregon Department of Fish and Wildlife, Contract Number DE-AI79-88BP92122. Annual Report to Bonneville Power Administration, Portland, Oregon.

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 number DE-BI79-90BP07084. 1990 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Winther, E.C., J.S. Hisata, M.R. Petersen, M.A. Hagen and R.C. Welling. 1996. Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 1996 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Winther, E.C., L.G. Fox, M.L. Wachtel, and B.G. Glaser. 2001. Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 2001 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Winther, E.C., L.G. Fox, J.D. Hone, and J.A. Memarian. 2002. Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 2002 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Appendix A

Northern pikeminnow sport-reward fishery rules and regulations

1. Present a valid fishing license and picture identification upon request by any authorized program representative.

2. Adhere to all applicable state fishing regulations for the area in which you fish. Contact your local state fishery agency for license requirements and current fishing regulations.

3. Register in person at one of the designated registration stations each day prior to fishing. Anglers may register during times when stations are unstaffed, by using the station's self-registration box. Anglers may not register at multiple stations on the same day.

4. Provide true and accurate information to authorized program representatives regarding the taking, possession, delivery, transportation, sale, transfer, or any other use of fish caught while participating in the northern pikeminnow sport-reward fishery program.

5. Comply with the directions of authorized program personnel related to the collection of sampling data and angler participation in the sport-reward fishery.

6. Mail in all reward vouchers within 30 days from the end of the season.

7. Fish must have been caught in the mainstem columbia river from the mouth up to the restricted zone below priest rapids dam, or in the snake river from the mouth up to the restricted zone below hell's canyon dam. The "mainstem" includes backwaters, sloughs, and up tributaries 400 feet from the tributary mouths. "tributary mouth" is as defined by state fishing regulations.

8. Fish must be returned to the same registration station where the angler registered. They must be returned on the same calendar day stamped on the angler's registration form, before that station closes for that day, and they must have been caught subsequent to that day's registration time.

9. Fish must have a total length greater than or equal to 9 inches. Fish less than 9 inches total length are not eligible for reward payment.

10. All fish to be redeemed for reward payment must have been personally caught solely by the angler submitting them for reward payment.

11. Fish must be alive or in fresh condition. Fish that are or were frozen, or that are in otherwise poor condition will not be accepted for payment. Technicians have the authority to determine whether northern pikeminnow submitted meet these standards.

12. Violation of any of the above rules may result in disqualification from the northern pikeminnow sport-reward fishery program.

[†]

[†] Rules were posted at all registration stations in 2003 and were printed on the back of all reward vouchers.

Appendix B

Species Codes

LMB	Bass, Largemouth
RKB	Bass, Rock
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
PK	Salmon, Pink
SO	Salmon, Sockeye
JAK	Salmon, Chinook (Jack)
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
NPM	Pikeminnow, Northern
SHP*	Steelhead (Adipose Present)
SHA*	Steelhead (Adipose Absent)
JSP	Steelhead, Juvenile (Adipose Present)
JSA	Steelhead, Juvenile (Adipose Absent)
GRS	Sturgeon, Green
WS	Sturgeon, White
SK	Sucker (Unknown)
BRS	Sucker, Bridgelip
LRS	Sucker, Largescale
S	Sunfish, (Unknown)
TNC	Tench
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

** Conventional naming for NPM Sport-Reward Program

REPORT B

NORTHERN PIKEMINNOW SPORT REWARD PAYMENTS – 2004

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March, 2005

INTRODUCTION

The **Northern Pikeminnow Predator Control Program** was administered by PSMFC in 2004. The program is a joint effort between the fishery agencies of the states of Washington and Oregon, and the Pacific States Marine Fisheries Commission (PSMFC). Washington ran the sport-reward registration/creel check stations throughout the river and handled all fish checked in to the program. Oregon provided fish tagging services, population studies, food habit and reproductive studies, as well as exploitation rate estimates. PSMFC provided technical administration, and fiscal and contractual oversight for all segments of the Program and processed all reward vouchers for the sport-reward anglers.

CATCH AND PAYMENTS

In 2004 a total of 267,213 fish were harvested in the sport-reward fishery, which is the largest annual catch on record. Vouchers for 265,186 fish were submitted for payment totaling rewards of $1,696,777. Rewards were paid at $5 for the first 100 fish caught during the season, $6 for fish in the 101-400 range, and $8 for all fish caught by an angler above 400 fish. PSMFC maintained an accounting system during the season to determine the appropriate reward amount due each angler for particular fish. A total of 2,143 anglers who registered were successful in catching one or more fish in 2004. The 2004 season ran from May 3, 2004 through September 26, 2004.

TAGGED FISH PAYMENTS

A total of 174 tagged fish were caught. Anglers were issued a special tagged fish voucher for all tagged fish brought to the registration station. The tag voucher was then sent in with the tag for verification and payment of the special $100 tagged fish reward during May (34 tagged fish turned in) and then it was increased to $500 in June (140 additional tags received from June-September). This resulted in tag reward payments of $73,400 in addition to the regular reward payments.

ACCOUNTING

Total payments for the season of regular vouchers, tagged fish, totaled $1,766,777. All IRS form 1099 Mis. Statements were sent to the qualifying anglers for tax purposes in the third week of January, 2005. Appropriate reports and copies were provided to the IRS by the end of February, 2005.

A summary of the catch and rewards paid is provided in table 1. For further information contact Russell Porter, PSMFC, field programs administrator at (503) 595-3100 or email at: russell_porter@psmfc.org.

2004 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of the vouchers received and paid as of November 23, 2004

	Fish	$ Paid	If still at old Tier	Difference
Fish paid @ tier 1 ($4.00 each):	24,500	$98,000	$98,000	N/A
Fish paid @ tier 2 ($5.00 each):	16,748	$83,740	$83,740	N/A
Fish paid @ tier 3 ($6.00 each):	7,749	$46,494	$46,494	N/A
Tags paid (@ $100.00 each):	34	$3,400	$3,400	N/A
Fish paid @ tier 1 ($5.00 each):	*47,143*	*$235,715*	$188,572	*$47,143*
Fish paid @ tier 2 ($6.00 each):	*60,774*	*$364,644*	$303,870	*$60,774*
Fish paid @ tier 3 ($8.00 each):	*108,098*	*$864,784*	$648,588	*$216,196*
Tags paid (@ $500.00 each):	*140*	*$70,000*	$14,000	*$56,000*
Total:	**265,186**	**$1,766,777**	$1,386,664	*$380,113*

Anglers @ tier 1	1,713
Anglers @ tier 2	254
Anglers @ tier 3	176
Number of separate anglers	2,143

Anglers with 10 fish or less:	991
Anglers with 2 fish or less:	398

	*Top Twenty Anglers **	TIER 1	TIER 2	TIER 3	TAGS	TOTAL FISH	BALANCE
1.	PAPST,THOMAS H	100	300	4,264	0	4,664	$34,526
2.	ZAREMSKIY, NIKOLAY N	100	300	3,961	1	4,362	$31,654
3.	ESSEX, JEAN E	100	300	3,956	2	4,358	$32,770
4.	CAGLE, CARL D	100	300	3,677	0	4,077	$30,284
5.	BROWN, JOHN G	100	300	3,097	2	3,499	$26,514
6.	WEBER, STEVEN A	99	300	2,745	1	3,145	$22,484
7.	HISTAND,TIMOTHY L	100	300	2,553	3	2,956	$21,834
8.	CALDWELL,TIMOTHY E	100	300	2,519	1	2,920	$21,226
9.	VASILCHUK, DAVID R	100	298	2,292	9	2,699	$23,948
10.	HASKETT,SHIRLEY M	100	300	2,129	1	2,530	$18,220
11.	LEMIEUX, WALTER E	100	300	2,104	0	2,504	$18,392
12.	STEVENS, TODD G	100	300	1,970	0	2,370	$18,035
13.	MILLER, EARL D	100	300	1,868	0	2,268	$16,796
14.	MUCK,JAMES E	100	300	1,762	4	2,166	$18,168
15.	OWRE, STEVEN H	100	300	1,750	2	2,152	$17,208
16.	MINGS, GLEN E	100	300	1,684	0	2,084	$15,724
17.	PLACHTA,REED N	100	300	1,656	0	2,056	$14,590
18.	VASILCHUK, ROMAN R JR	100	299	1,623	5	2,027	$17,119
19.	JENSEN, TED A JR	100	300	1,613	0	2,013	$14,938
20.	WILLIAMS, EDWARD R	100	300	1,608	0	2,008	$15,073
	* (by total fish caught)	1,999	5,997	48,831	31	56,858	$429,503

REPORT C

Development of a System-wide Predator Control Program: Indexing and Fisheries Evaluation

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SUMMARY

The Northern Pikeminnow Management Program (NPMP), a fishery aimed at reducing predation on juvenile salmonids by northern pikeminnow *Ptychocheilus oregonensis*, was implemented for the fourteenth consecutive year in the mainstem Columbia and Snake rivers. We report on (1) northern pikeminnow exploitation rates; (2) reductions in northern pikeminnow potential predation on juvenile salmonids since program implementation; (3) spaghetti tag loss rates; (4) continuing age validation work for northern pikeminnow; (5) estimates of abundance, consumption, and predation indices for predator fishes within the study area, and (6) compensatory responses by the piscivore community.

We tagged and released 644 northern pikeminnow ≥ 200 mm FL throughout the lower Columbia and Snake rivers in 2004, 518 of which were ≥ 250 mm FL. System-wide exploitation of northern pikeminnow ≥ 200 mm by the sport-reward fishery was 17.0% (95% confidence interval 13.4% - 24.4%); which incorporated a tag loss estimate of 11.3%. Modeling results estimated potential predation by northern pikeminnow on juvenile salmonids in 2004 at 79% of pre-program levels. If exploitation rates remained similar to mean 1996-2003 levels, further reductions in potential predation are likely to be minimal. Even if exploitation rates were maintained at 2004 levels long-term projections indicate further reductions in predation to be minimal.

We aged a total of 542 scale and 186 opercle samples from tagged, indexed, and recaptured northern pikeminnow in 2004. Complete agreement (i.e., zero discrepancy) on ages assigned by the three readers was 51.7% for scales, and 40.9% for opercles. The largest age discrepancy between corresponding scales and opercles for northern pikeminnow ≥ 350 mm was 11 years. Oxytetracycline (OTC) mark quality of fish recaptured in 2004 was not distributed randomly ($\chi^2 = 12.913$, df = 2, $P < 0.05$), with marks more likely to be poor or fair than good. Northern pikeminnow OTC marked in 2002 and 2003 had an appropriate number of annuli noted after the mark 55% and 64% of the time. When considering only fish with fair or good marks these increased to 63% and 90%.

The northern pikeminnow abundance index below Bonneville Dam (excluding the tailrace BRZ) was 40% lower than the average value of four previous years sampled (1994 – 1996, 1999), and the 2004 John Day Reservoir northern pikeminnow abundance index was an order of magnitude lower than the program average (1990-1996, 1999). Smallmouth bass *Micropterus dolomieu* relative densities in the John Day Reservoir forebay were substantially higher in 2004 than in 1999 and 1990.

Salmonidae composed the majority (69-89%) of fish remains identified to species in the digestive tracts of northern pikeminnow in all reaches of the study area. Thought the percentage of remains identified to species in smallmouth bass varied by study reach, cottids, salmonids, and catostomids were the most prevalent. Fish identified in walleye *Sander vitreus* stomach samples from below Bonneville Dam and lower Columbia River reservoirs were dominated by cyprinids, catostomids, cottids, and salmonids.

Northern pikeminnow consumption indices (CI) were generally lower in 2004 than program averages. The spring 2004 CI below Bonneville Dam (excluding the tailrace BRZ) was 69% lower than the mean CI for 1994 – 1996, and 1999. The summer 2004 CI value below Bonneville Dam (excluding the tailrace BRZ) was 62% lower than the 1994 – 1996, and 1999 mean.

Northern pikeminnow predation indices varied by season and area in 2004. The 2004 combined spring predation index for below Bonneville Dam (excluding the tailrace BRZ) was 32% lower than the average of the previous 3 years (1995, 1996, and 1999), and between 1992 and 2004 we observed an 88% drop in the overall spring predation index for below Bonneville Dam. The combined summer 2004 predation index for below Bonneville Dam was 89% less than in 1992.

Spring CI values for smallmouth bass in 2004 were greater than in 1995, 1996 and 1999 for rkm 190-197 and Lower Granite Reservoir. Summer CI values for rkm 190-197 were greater than those in 1996 and 1999, and summer CI values were greater in Bonneville and McNary Dam tailraces than any previous year.

Smallmouth bass predation indices were calculated for the first time in 2004 based on season specific catch per unit effort (CPUE) data. Below Bonneville Dam northern pikeminnow predation was much higher than smallmouth bass, except from rkm 190-197, where differences between smallmouth bass and northern pikeminnow predation were negligible. The last year that the John Day Reservoir spring northern pikeminnow predation indices were higher than the 2004 smallmouth bass predation index was 1992.

Northern pikeminnow year-class analysis downstream of Bonneville Dam showed considerable variation from year to year in the percentage of age 3 and 4 fish. The percentage of age five northern pikeminnow has been relatively stable since 1993, accounting for 15 – 17% of the total. Smallmouth bass year-class analysis downstream of Bonneville Dam indicated that a growing proportion of the population is composed of age four fish.

The 2004 northern pikeminnow proportional stock density (PSD) value for below Bonneville Dam was similar to previous years and a trend was not discernable; however, in Bonneville Reservoir the 2004 northern pikeminnow PSD value of 18 was less than half that seen in 1990. Median relative weight (W_r) differed significantly ($P < 0.01$) among years for male and female northern pikeminnow and for smallmouth bass; which had significantly higher W_r in 2004 than in the other 3 years analyzed (1990, 1996, and 1999).

Although consumption and predation indices were generally lower reservoir- and system-wide than previous years, the localized increases in these indices exhibited by remaining northern pikeminnow may be compensatory responses to prolonged exploitation by the NPMP. Smallmouth bass may also be exhibiting compensatory responses in localized areas. Though their consumption rates were similar to past years, 2004 relative densities (spring and summer) in the John Day Dam forebay were at least double the levels observed in 1990 and 1999. Increased smallmouth bass abundance can also indirectly influence juvenile salmonid predation. Competitive interactions with northern pikeminnow, which may shift their diets and habitat selection in the presence of smallmouth bass, could exacerbate juvenile salmonid predation. The multiple changes in the predator community witnessed in 2004 highlight the need for continued monitoring, and updated potential predation models.

INTRODUCTION

The Columbia and Snake rivers once supported large numbers of anadromous salmonids. Declines in adult returns have been attributed to many factors, including habitat degradation and overexploitation (Nehlsen et al. 1991; Wismar et al. 1994), hydroelectric and flood control activities during the 1970s (Raymond 1988), and predation (Rieman et al. 1991). The mean annual loss of juvenile salmonids to predators can be equivalent to mortality associated with dam passage (Rieman et al. 1991), which may approach 30 percent at a single dam (Long and Ossiander 1974). The Northern Pikeminnow Management Program (NPMP) is a targeted northern pikeminnow *Ptychocheilus oregonensis* fishery aimed at reducing predation on juvenile salmonids in the lower Columbia and Snake Rivers (Rieman and Beamesderfer 1990; Beamesderfer et al. 1996). The Oregon Department of Fish and Wildlife (ODFW) established baseline levels of predation and northern pikeminnow population characteristics prior to the implementation of northern pikeminnow control fisheries. Abundance, consumption, and predation were estimated in Columbia River reservoirs in 1990 and 1993, Snake River reservoirs in 1991, and the unimpounded lower Columbia River downstream from Bonneville Dam in 1992 (Ward et al. 1995). ODFW sampled northern pikeminnow from 1994 – 1996, and again in 1999 in areas where adequate sample sizes allowed comparisons among and between years (Zimmerman and Ward 1999; Zimmerman et al. 2000). This report describes our activities and findings for 2004, and wherever possible, evaluates changes from previous years.

Our 2004 objectives were to (1) evaluate the efficiency of the northern pikeminnow fishery by analyzing exploitation rates; (2) estimate reductions in northern pikeminnow predation on juvenile salmonids since program implementation; (3) estimate tag loss (%) for spaghetti tags; (4) validate aging methods for northern pikeminnow; and (5) estimate abundance, consumption, and predation indices for predator fishes within the study area. Objectives three and four were implemented in 2000 based on recommendations from an independent review of the NPMP (Hankin and Richards 2000). Objective five is a continuation of population monitoring studies conducted in 1990-1996 and 1999.

METHODS

FISHERY EVALUATION, PREDATION ESTIMATES, TAG LOSS, AND AGE VALIDATION

Field and Laboratory Procedures

The Washington Department of Fish and Wildlife (WDFW) administered the sport-reward fishery from 3 May (17 May upstream of The Dalles Dam) to 26 September 2004 throughout the lower Columbia and Snake rivers. Participating anglers received payment for northern pikeminnow 230-mm (9 in) total length (TL) and larger. This size limit is approximately equivalent to 200-mm fork length (FL). The payment schedule was modified beginning on 31 May 2004 in an effort to increase effort and harvest in the NPMP. Payments increased from $4 to $5 per fish for "Tier 1" anglers (< 100 fish caught), $5 to $6 per fish for "Tier 2" anglers (100-400 fish caught), and $6 to $8 per fish for "Tier 3" anglers (> 400 fish caught). Rewards for ODFW spaghetti-tagged fish rose from $100 to $500 per fish.

We began the 2004 tagging season recording our field data on paper. On 24 May we transitioned to computerized handheld data recorders. These consisted of personal digital assistants (PDA) programmed to allow us to record and download all sampling data to a personal computer. We tagged and released northern pikeminnow ≥ 200-mm FL with uniquely numbered spaghetti tags to estimate exploitation rates for the sport-reward fishery. To evaluate spaghetti tag retention, we also marked tagged northern pikeminnow with passive integrated transponder (PIT) tags; which were injected into the dorsal sinus area. After we started using the PDAs for data recording and storage, PIT tag codes were electronically sent from the scanner to the PDA via a hardwire link.

Tagging was completed before to the start of the fishery below Bonneville Dam and in Bonneville Reservoir in an effort to reduce bias in exploitation estimates (Styer 2003). However, in an effort to increase sample sizes, tagging operations ran concurrently with the fishery in The Dalles, John Day, McNary, and Lower Granite reservoirs. We used electrofishing boats and bottom gill nets to collect northern pikeminnow from 31 March to 30 June 2004. Parker et al. (1995) provides a detailed description of sampling gears and methods. We usually allocated three to four electrofishing runs or gill-net sets per sampled river mile; however, some deviation from this level of effort was necessary at times due to sampling logistics. In the Columbia River, we sampled from river kilometer (rkm) 78 (near Clatskanine, Oregon) upstream to rkm 634 (Priest Rapids Dam). We were unable to sample 51 rkm in this section due to mechanical problems or high winds. On the Snake River, we sampled above Lower Granite Dam from rkm 171 to rkm 246 (near the mouth of the Grande Ronde River). Tagging in Lower Monumental and Little Goose reservoirs was discontinued in 2001 due to historically low numbers of tagged and recaptured fish in these reservoirs.

We injected all northern pikeminnow tagged in 2004 with a solution of oxytetracycline (OTC) at a dosage of 50 mg OTC per kg fish weight (McFarlane and Beamish 1987) to leave a fluorescent mark on aging structures. Scale and opercle samples were collected from each tagged northern pikeminnow recaptured in the sport-reward fishery by WDFW personnel. We cleaned, mounted on cards, and pressed scales onto acetate sheets for viewing on a microfiche reader. Parker et al. (1995) described methods of age determination for northern pikeminnow. Two readers independently aged the scale samples. When readers disagreed on an age, they reviewed the scale in question together until they agreed on a final age.

We placed opercula, still in sample envelopes, into a bowl of water. Opercula were then heated in a microwave oven at high temperature for approximately 5 minutes (per group of five samples) to soften the skin and soft tissues covering the opercular bone. We then removed the tissue using a knife, fingernails, and a toothbrush. The thickened "ridge" radiating from the focus on the concave side of each opercle was ground down with a "Dremel Tool" (Robert Bosch Tool Corporation, Racine, Wisconsin) to enhance viewing of potential annuli near the focus

(Scoppettone 1988). Readers examined each opercle under a digital video microscope at 10x magnification using light transmitted from either above or below the opercle, whichever gave the best view of the annuli on a particular sample. Opercular images from the microscope were viewed on a computer monitor using imaging software. The same two readers who aged the WDFW scales also read the corresponding opercles, and resolved age differences in the same way that we had for scales. We checked opercles from each fish tagged between 2002-2004 in a dark room, under a dissecting microscope, and using a desk lamp fitted with a black light for fluorescent OTC marks.

Data Analysis

We used mark-and-recapture data to compare exploitation rates of northern pikeminnow ≥ 200 mm FL, 200-249 mm FL, and ≥ 250 mm FL among reservoirs. In areas where tagging was completed prior to the start of the fishery, we used a simple Peterson method (Ricker 1975) to compute annual exploitation rates. This is given by the equation

$$u = R/M$$

where

u = annual exploitation estimate,
M = the number of fish that are tagged in a season, and
R = the number of tagged fish that are recaptured in a season.

We calculated 95% confidence intervals for Peterson estimates using the formula

$$R \pm z(R/M)^{0.5}$$

where

z = the multiplier from the standard normal distribution,
M = the number of fish that are tagged in a season, and
R = the number of tagged fish that are recaptured in a season (Styer 2003).

We used a multiple sample approach to compute exploitation rates in areas where tagging and fishing occurred concurrently. Weekly estimates of exploitation were calculated by dividing the number of tagged northern pikeminnow recovered by the number of tagged fish at large. We then summed the weekly exploitation rates to yield total exploitation rates for the season (Beamesderfer et al. 1987).

We calculated 95% confidence intervals for exploitation estimates obtained by the multiple sample method by using the formula

$$u \pm t(k*s)^{0.5}$$

where

u = the annual exploitation estimate,
t = the multiplier from the Student's t-distribution,
k = the number of weeks in the fishing season, and
s = the standard deviation of the weekly exploitation estimates (Styer 2003).

We did not calculate exploitation rates for areas where the number of recaptures was less than four (Styer 2003), and exploitation estimates from previous years where fewer than four tags were recovered were excluded from this report.

All 2004 exploitation estimates and confidence intervals were adjusted for tag loss. To estimate the tag loss rate for spaghetti tags, we used the formula

$$L = [m / (m + r)] * 100$$

where

L = tag loss rate,
m = the number of northern pikeminnow recaptured with a secondary mark (PIT tag) and no spaghetti tag, and
r = the number of northern pikeminnow recaptured with year 2004 spaghetti tags intact.

To explore the effect of river flow on northern pikeminnow harvest, we plotted the annual system-wide sport-reward exploitation rate for fish ≥ 250 mm FL versus mean Columbia River stage during May-September below Bonneville Dam (USGS 2004). For this analysis, we used data from 1995-2004.

We used the model of Friesen and Ward (1999) to estimate predation on juvenile salmonids relative to predation prior to implementation of the NPMP. This model incorporates age-specific exploitation rates on northern pikeminnow and resulting changes in age structure to estimate changes in predation. We used a 10-year "average" age structure (based on catch curves) for a pre-exploitation base, and assumed constant recruitment. Age-specific consumption was incorporated, however potential changes in consumption, growth, and fecundity due to removals were not considered likely (Knutsen and Ward 1999). Therefore, the model estimates changes in potential predation related directly to removals and allows us to estimate the effects of removals if all variables except exploitation are held constant.

We estimated the potential relative predation in 2004 based on observed exploitation rates, and the eventual minimum potential predation assuming continuing exploitation at mean 1995-2004 levels. Because inputs to the model included three potential relationships between age of northern pikeminnow and consumption, as well as three estimates of exploitation (point estimate and confidence limits), we computed nine estimates of relative predation for each year (Friesen and Ward 1999). We report the maximum, median, and minimum estimates.

In 2004, the age validation study instigated by Takata and Ward (2001) focused on evaluating opercles as a viable alternative to scales for aging northern pikeminnow. We evaluated between-reader variation in ages assigned to both scales and opercles from northern pikeminnow. Two readers examined each scale or opercle, and aging discrepancies were calculated as

$$D = X_i - X_j$$

where

D = age discrepancy,
X_i = age assigned to a scale or opercle by reader X_i, and
X_j = age assigned to a scale or opercle by reader X_j.

We also continued to evaluate differences between ages assigned to opercles and ages assigned to scales collected from the same fish at the same time. We calculated discrepancies using the formula

$$D = A_O - A_S$$

where

D = age discrepancy,
A_O = age assigned to an opercle at recapture, and
A_S = age assigned to a scale at recapture.

We used t-tests when analyzing reader and opercle-scale discrepancies.

We checked opercles from northern pikeminnow tagged between 2002 and 2004 for OTC marks, and scored any discernable marks for quality. An easily observed and relatively wide fluorescent band along all or most of the opercle's edge was considered a "good" mark. If the fluorescent band was thin or patchy but still went around one-half or more of the opercle's edge, it was considered a "fair" mark. If fluorescent marking covered less than half of the opercle's edge then it was considered a "poor" mark. Additionally, for 2002 and 2003 opercles, we noted whether or not any annuli were visible after the OTC mark since one to two years had elapsed between tagging and recapture. Chi-squared tests were used to analyze OTC mark quality.

BIOLOGICAL EVALUATION

Field and Laboratory Procedures

We used boat-mounted electrofishing equipment to evaluate changes in northern pikeminnow and smallmouth bass *Micropterus dolomieu* relative abundance, consumption and predation indices, growth and population structure, condition, and feeding habits. Feeding habits of walleye *Sander vitreus* were also analyzed. Biological data was collected in the spring (3 May – 11 June) and summer (21 June – 30 July) of 2004 in the following areas: downstream from Bonneville Dam (rkm 114-120, rkm 170-179, and rkm 186-194), Bonneville Dam tailrace (rkm 224-232), Bonneville Dam forebay (rkm 233-238), mid-Bonneville Reservoir (rkm 272-283), The Dalles Dam tailrace (rkm 299-306), John Day Dam tailrace (rkm 339-346), John Day Dam forebay (rkm 347-352), mid-John Day Reservoir (rkm 386-397), McNary Dam tailrace (rkm 459-466), Little Goose Dam tailrace (Snake rkm 104-110), Lower Granite Dam tailrace (Snake rkm 163-170), and upper Lower Granite Reservoir (Snake rkm 218-227). About 1/3 of the original sampling goal was not completed due to mechanical problems, high winds, or lack of access to some transects (especially in or near boat restricted zones during spill). Sampling methods and gear specifications have been previously described (Ward et al. 1995; Zimmerman and Ward 1999). We only collected biological samples from smallmouth bass in the reach below Bonneville Dam and in Bonneville, John Day, and Lower Granite reservoirs. Smallmouth bass were only sampled every third electrofishing run in Lower Granite Reservoir.

We recorded biological data from all northern pikeminnow, smallmouth bass, and walleye collected by electrofishing, and from sub-samples of northern pikeminnow harvested by the sport-reward fishery. We measured FL of all target fish and collected scale samples from most of them. In areas where we had already obtained a sufficient number of samples, we sub-sampled scales from target fish. Digestive tract contents from northern pikeminnow, smallmouth bass, and walleye ≥ 200 mm FL were collected and preserved using methods described by Ward et al. (1995). All fish sampled for digestive-tract contents were weighed to the nearest gram on a spring balance. We also attempted to identify the sex (male, female, or undetermined) and maturity (undeveloped or immature, developing, ripe, or spent) of all northern pikeminnow sacrificed for digestive-tract sampling. As with our tagging study, we transitioned to the use of PDAs to record our field data on 24 May 2004. Fork-length data for northern pikeminnow harvested by the sport-reward fishery were provided by WDFW.

We examined digestive-tract contents of northern pikeminnow, smallmouth bass, and walleye to measure relative consumption rates of juvenile salmonids. Details of laboratory methods are given in Ward et al. (1995). Parker et al. (1995) described methods of age determination using scales. Other information regarding our aging protocol was previously noted in this report as part of the age validation study. The only difference between the age validation work and the biological sampling was that three readers examined scales collected during biological index sampling; individual scales were examined by two of the three readers.

Data Analysis

We used catch per unit effort (CPUE) of standardized (900 s) electrofishing runs for northern pikeminnow (Appendix Table C-1) to calculate abundance and predation indices. Abundance indices of northern pikeminnow were calculated as the product of CPUE and reservoir or area-specific surface area (Ward et al. 1995). We then compared abundance indices of northern pikeminnow in 2004 with those from 1990-1996 and 1999. We used transformed ($\log_{10}$(catch + 1)) as an index of smallmouth bass relative density.

The following formulas were developed as consumption indices (CI) for northern pikeminnow (Ward et al. 1995) and smallmouth bass (Ward and Zimmerman 1999):

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

and

$$CI_{SMB} = 0.0407 \cdot e^{(0.15)(T)} \cdot MW^{0.23} \cdot (S \cdot GW^{-0.29})$$

where

CI_{NPM} = consumption index for northern pikeminnow,
CI_{SMB} = consumption index for smallmouth bass,
T = water temperature (^{o}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 predator; however it is linearly related to the consumption rate of northern pikeminnow (Ward et al. 1995) and smallmouth bass (Ward and Zimmerman 1999). Spring (April-June) and summer (June-August) consumption indices were compared with those from 1990-1996 and 1999 for all sampling areas.

We used the product of abundance and consumption indices to calculate predation indices for northern pikeminnow for spring and summer periods, and compared northern pikeminnow predation among years for reservoirs and areas where data had been collected each year. The daily juvenile salmonid passage index at lower Columbia and Snake River dams was plotted to compare timing of index sampling with concentrations of juvenile salmonids present in each area (Appendix B; FPC 2004). We calculated a predation index for smallmouth bass for the first time in 2004 because of observed increases in smallmouth bass abundance in some areas. Because smallmouth bass relative densities vary by season in the Columbia and Snake rivers (Ward and Zimmerman 1999), predation indices were calculated using CPUE as a season-specific relative abundance index (Appendix Table C-2 and C-3). We multiplied the product of the season specific CPUE and reservoir or area-specific surface area by its corresponding consumption index to obtain a season specific predation index.

We examined the change in frequency of age 3-5 northern pikeminnow and age 4-5 smallmouth bass from 1990 – 1996, 1999, and 2004. Because the relative abundances of northern pikeminnow year classes in electrofishing catches were biased by exploitation rates that varied among years (Friesen and Ward 1999), we limited our comparisons to abundance of northern pikeminnow large enough to be effectively sampled and small enough to be excluded from the NPMP (ages 3-5). We constructed smallmouth bass electrofishing catch curves (ODFW, unpublished data) and concluded that younger smallmouth bass (ages 1-3) were not sampled in proportion to their abundance. We therefore limited our comparisons to ages 4 and 5 smallmouth bass. We back-calculated length at age of northern pikeminnow, and smallmouth bass using the Fraser-Lee method; intercept values were derived by regressing fork length at capture by the radius of the scale at capture.

Because northern pikeminnow exploitation rates are greater for larger fish than for smaller ones (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; Anderson 1980), where PSD = 100 • (number of fish ≥ quality length / number of fish ≥ stock length) to compare size structure of northern pikeminnow and smallmouth bass populations among years in the Columbia River downstream from Bonneville Dam, and in Bonneville and John Day reservoirs. Stock and quality sizes for northern pikeminnow are 250 and 380 mm FL (Beamesderfer and Rieman 1988; Parker et al. 1995). We also used stock-density indices to examine the smallmouth bass population. Stock, quality, and preferred size classes for smallmouth bass are 180 mm, 280 mm, and 350 mm TL respectively for smallmouth bass (Gabelhouse 1984).

Changes in body condition (e.g., "plumpness") may indicate a response to sustained exploitation. We used relative weight (W_r; Anderson and Gutreuter 1983) to compare the condition of northern pikeminnow and smallmouth bass in 2004 with previous years. We used the standard weight (W_s) equations for northern pikeminnow developed by Parker et al. (1995), $\log_{10}(W_s) = -4.886 + 2.986[\log_{10}(FL)]$; and for smallmouth bass developed by Kolander et al. (1993), $\log_{10}(W_s) = -5.329 + 3.2[\log_{10}(TL)]$ to calculate relative weight ($W_r = 100[\text{weight}]/W_s$). We combined data from areas sampled consistently during 1990-1996, 1999, and 2004 (below Bonneville Dam and Bonneville The Dalles, John Day, and Lower Granite reservoirs) to provide system-wide estimates of W_r. We calculated median W_r for male and female pikeminnow and all smallmouth bass, which were not sexed. To compare W_r among years, we used a Kruskal-Wallis one-way ANOVA on ranks; Dunn's test was applied to determine where pairwise differences occurred. An alpha level of 0.05 was established prior to data collection, and used to establish significance in all fishery and biological evaluations.

RESULTS

Fishery Evaluation, Predation Estimates, Tag Loss, and Age Validation

We tagged and released 644 northern pikeminnow ≥ 200 mm FL throughout the lower Columbia and Snake Rivers in 2004; 518 were ≥ 250 mm FL. The sport-reward fishery harvested 267,215 northern pikeminnow ≥ 200 mm (PSMFC 2005), including 86 of the northern pikeminnow marked in 2004. Fish tagged and recaptured in 2004 were at-large from 6 to 178 days, and more than 85% (n = 75) of the recaptures were ≥ 250 mm FL (Appendix Table A-1). However, based on actual sampled catch proportions, an estimated 165,673 (62%) of these fish were ≥ 250 mm FL and 101,542 were 200-249 mm FL. Average FL of northern pikeminnow harvested in the sport-reward fishery was 272.4 ± 60.3 mm (mean ± S.D.; R. Bruce, WDFW, personal communication).

Eleven northern pikeminnow with PIT tags and missing spaghetti tags were recaptured in the sport-reward fishery, yielding a tag loss estimate of 11.3%, and we adjusted 2004 exploitation rates to account for this tag loss. System-wide exploitation of northern pikeminnow ≥ 200 mm FL by the sport-reward fishery was 17.0% (95% confidence interval 13.4% - 24.4%). Reservoir/area-specific exploitation rates ranged from 11.7% in Bonneville Reservoir to 19.6% in the Lower Granite Reservoir. We did not calculate exploitation rates in The Dalles, John Day, or McNary reservoirs due to an insufficient number of recaptures per reservoir (n ≤ 4; Figure 1; Appendix Tables A-2, A-3; Styer 2003). For northern pikeminnow ≥ 250 mm FL, system-wide exploitation was 18.5% (95% confidence interval 14.5% - 26.6%), ranging from 9.3% in Bonneville Reservoir to 23.8% in Lower Granite Reservoir (Figure 2). System-wide exploitation rate for northern pikeminnow 200 – 249 mm FL was 10.9% (95% confidence interval 7.3% - 17.1%). Below Bonneville Dam (6.5%) and Bonneville Reservoir (13.5%) were the only areas where sufficient recaptures (n ≥ 4) of northern pikeminnow in this size class allowed for reach specific calculations of exploitation rates (Appendix Tables A-2, A-3). Weekly exploitation estimates for areas of concurrent tagging and fishing are given in Appendix A (Tables A-4 through A-7). Positive linear relationships exist between system-wide and below Bonneville Dam northern pikeminnow exploitation rates for both ≥ 250 mm (r = 0.89, P < 0.05) and ≥ 200 mm (r = 0.97, P < 0.05) size classes.

In previous years we found a significant inverse relationship (r^2 = 0.75; P < 0.05) between the system-wide sport-reward exploitation rate for northern pikeminnow ≥ 250 mm FL and mean Columbia River gage height measured below Bonneville Dam during the sport-reward season. In 2004 we found that this relationship, while still significant (r^2 = 0.56; P < 0.05), had weakened (Figure 3).

Modeling results indicated potential predation by northern pikeminnow on juvenile salmonids in 2004 ranged from 59% to 90% of pre-program levels, with a median estimate of 79% (Figure 4). Projections through 2010 indicate continued harvest at average 1995-2004 exploitation levels would result in minimal additional reductions in predation.

We aged a total of 542 scale and 186 opercle samples from tagged, indexed, and recaptured northern pikeminnow in 2004. Three readers aged scales for analysis. Complete agreement (i.e., zero discrepancy) on ages assigned by the three readers was 51.7%, and agreement within one year was 91.5% (Figure 5A). Two readers aged opercles. Complete opercle age agreement (40.9%) was lower than scales; agreement within one year was also lower (85.0%; Figure 5B). The largest age discrepancy among readers was four years, which occurred while aging both scale (n = 3) and opercle (n = 1) samples.

Corresponding scale and opercle age discrepancies were dependent on the size (fl) of northern pikeminnow (f = 15.38, p < 0.05). For fish < 350 mm fl, ages assigned to scales exactly matched ages assigned to corresponding opercles 42.9% of the time, and within one year 85.7% of the time (figure 6a). The largest discrepancy between scale and opercle ages in this size class was two years, and differences were not significantly different from zero (t = 0.143, p = 0.26). For fish ≥ 350 mm fl, scale ages matched exactly with corresponding opercle ages 23.2% of the time and within one year 55.4% of the time (figure 6b). The largest age discrepancy between scales and opercles for northern pikeminnow ≥ 350 mm was 11 years and the differences were significantly different from zero (t = 1.393, p < 0.05). The majority (58.0%) of these paired samples had older opercle ages than scale ages. There was a significant positive relationship between scale age and $\log_{10}$ transformed opercle age (f = 513.63, p > 0.01; r^2 = 0.75 (figure 7).

One hundred and sixty opercle samples from sport-reward tagged northern pikeminnow were examined in 2004 for OTC mark quality: 29 tagged in 2002, 45 tagged in 2003, and 86 tagged in 2004. There is insufficient evidence to conclude that mark quality of these 160 fish is dependent on the tagging year (χ^2 = 2.576, df=4, P > 0.05). However, mark quality of fish recaptured in 2004 was not distributed randomly (χ^2 = 12.913, df = 2, P < 0.05; Figure 8A), with OTC marks more likely to be of poor quality than good (χ^2 = 13.038, df = 1, P < 0.05), and more likely to be fair than good (χ^2 = 4.955, df = 1, P < 0.05). Mark quality for fish tagged in 2004 was dependent upon the number of days "at-large" before recapture (χ^2 = 11.429, df = 2, P < 0.05; Figure 8B). Differences in mark quality for fish at-large less than 60 days were inconclusive (χ^2 = 4.471, df = 2, P > 0.05); however, for northern pikeminnow at-large for more than 60 days, differences in the proportion of mark quality were detectible (χ^2 = 10.885, df = 2, P < 0.05; Figure 8B). Fish tagged in 2004 and at large for more than 60 days were significantly more likely to have an OTC mark of poor quality than either fair (χ^2 = 3.93, df = 1, P < 0.05) or good (χ^2 = 9.757, df = 1, P < 0.05) quality marks. Northern pikeminnow OTC marked in 2002 had two annuli after the mark noted on 55% of samples; this percentage increases to 63 when considering only those fish with either fair or good quality marks. One annulus after the OTC mark was noted in 64% of the 2003 northern pikeminnow. When considering only those fish with fair or good quality marks, this number increases to 90%; 100% of northern tagged in 2003 that exhibited a "good" quality mark in 2004 had one annulus visible after the mark.

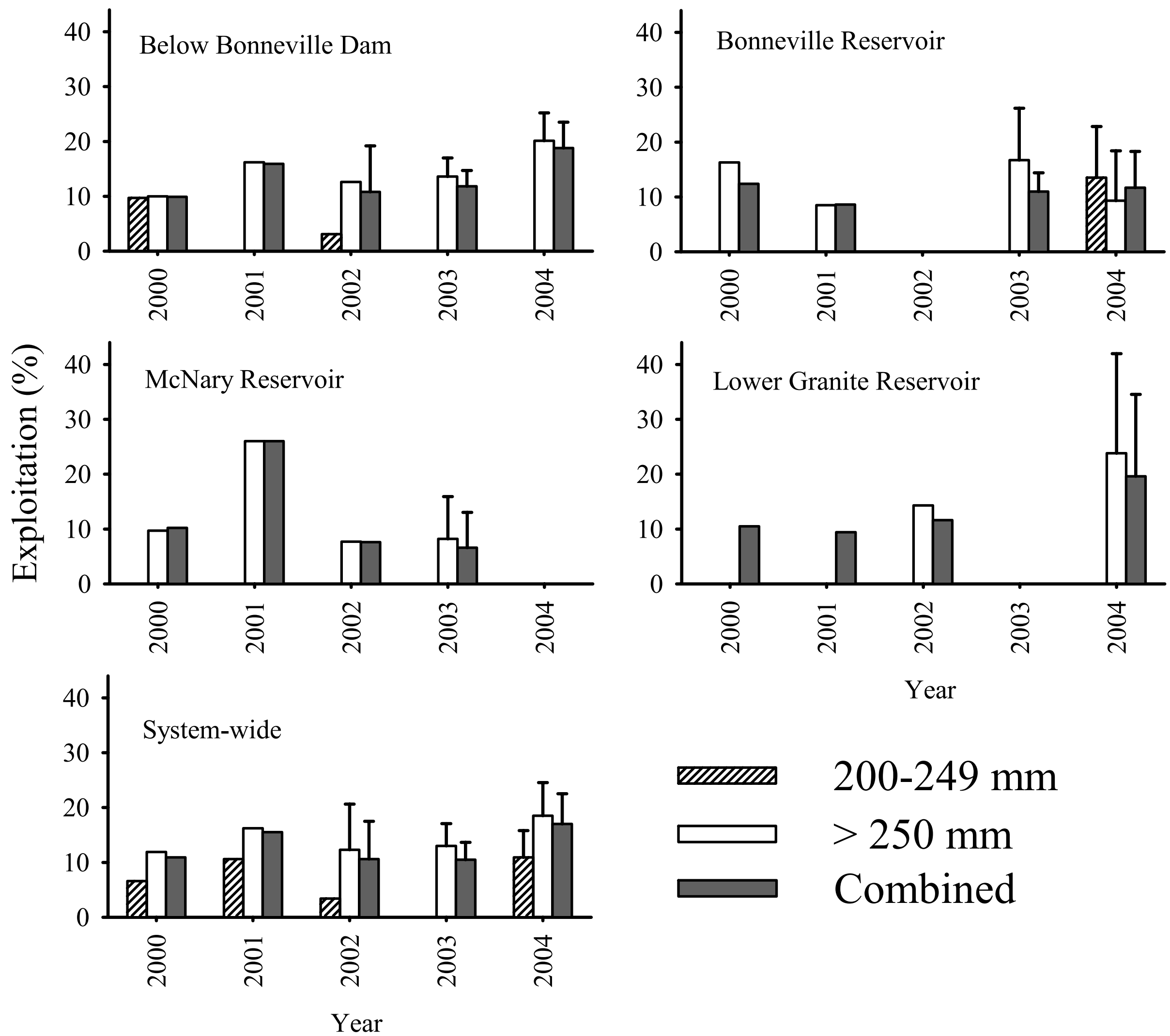


FIGURE 1.—Northern pikeminnow exploitation rates by reservoir or area for the sport-reward fishery (2000 – 2004). Exploitation rates for The Dalles, John Day, Lower Monumental and Little Goose Reservoirs are not shown due to insufficient (n ≤ 4) tag returns in these areas. Exploitation rates for 2000 – 2002 were not adjusted for tag loss. Error bars are the 95% upper confidence interval.

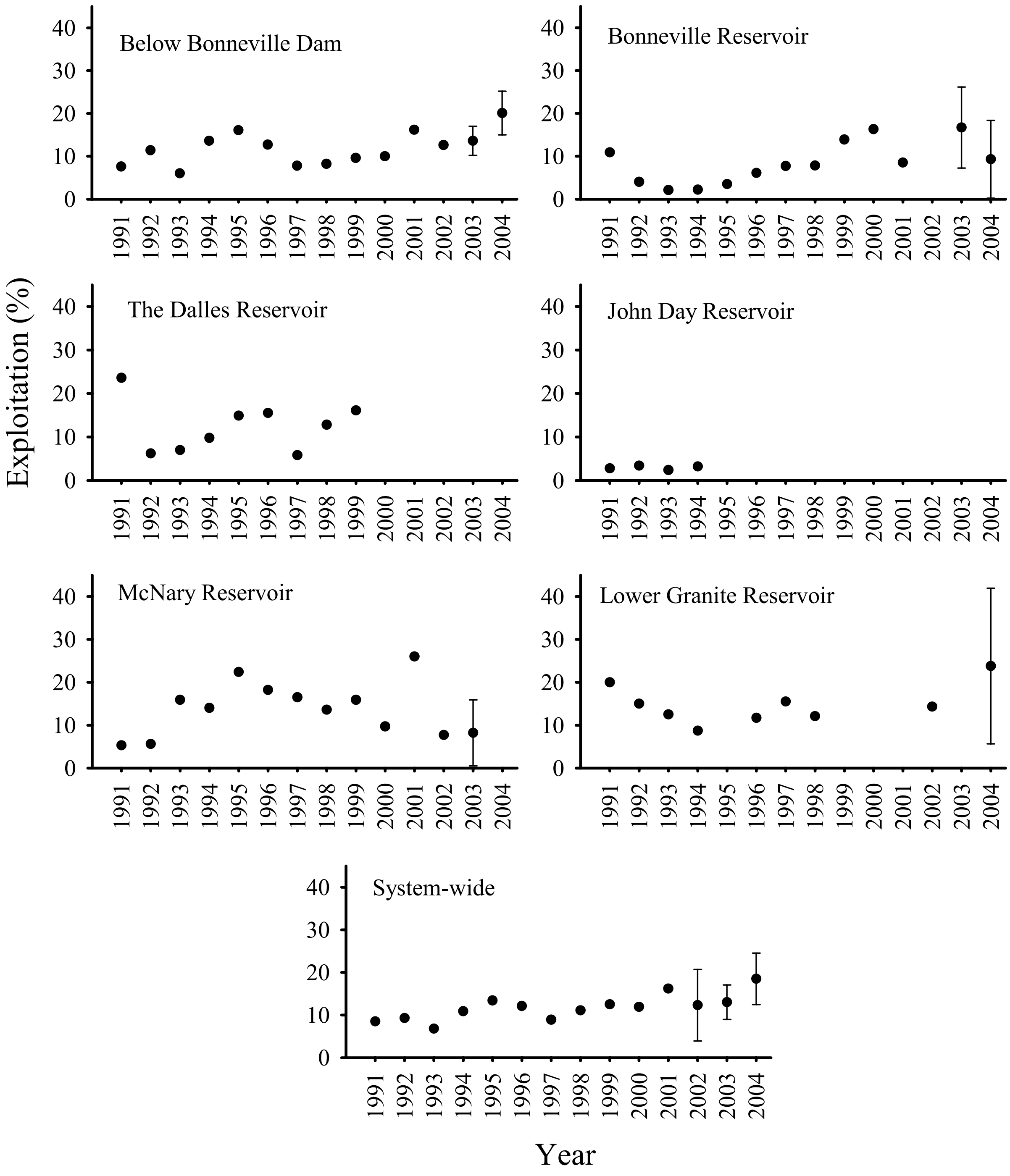


FIGURE 2.—Exploitation rates of northern pikeminnow ≥ 250 mm fork length by reservoir or area for the sport-reward fishery, 1991 – 2004. Exploitation rates for Lower Monumental and Little Goose reservoirs were not shown due to insufficient (n ≤ 4) tag returns in those areas. Exploitation rates for 2000 – 2002 were not adjusted for tag loss. Error bars are the upper and lower 95% confidence interval.

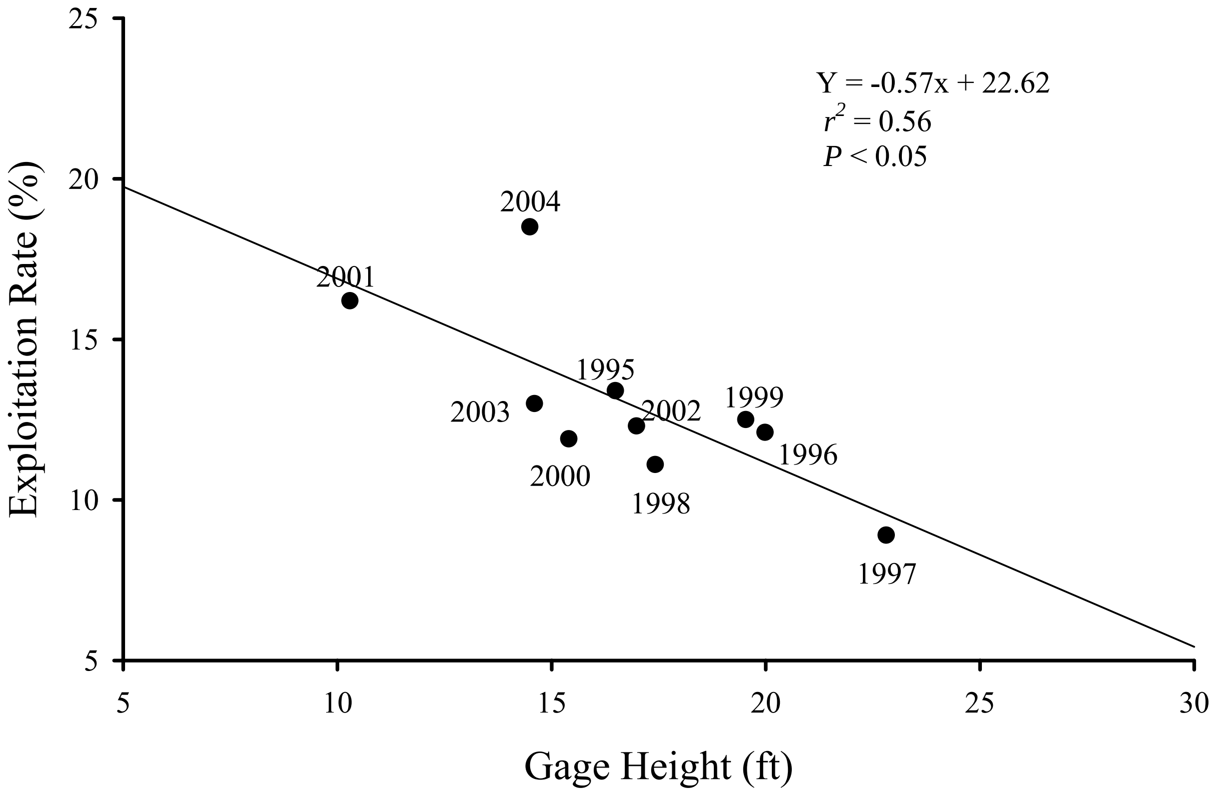


FIGURE 3.—Relationship between the system-wide sport-reward exploitation rate of northern pikeminnow ≥ 250 mm FL and mean Columbia River gage height (ft) below Bonneville Dam during the sport-reward season (May – September) for the period 1995 – 2004.

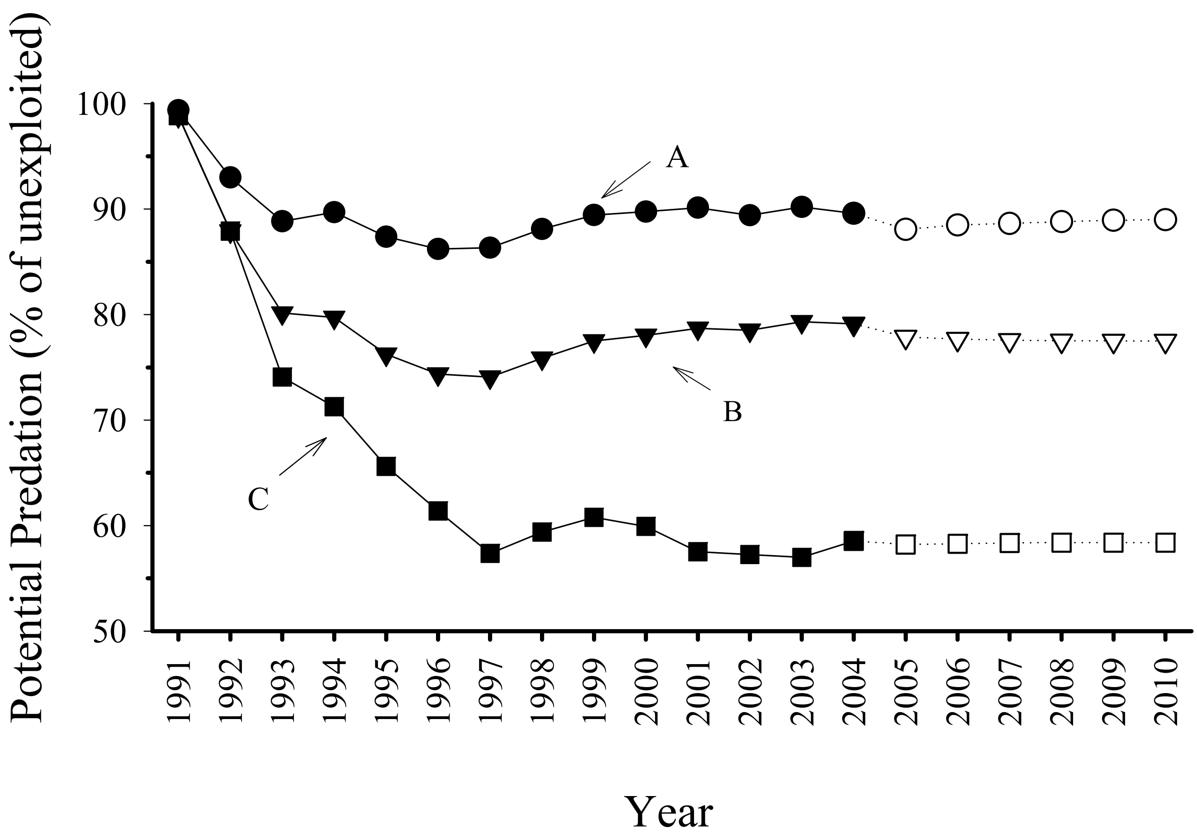


FIGURE 4.—Maximum (A), median (B), and minimum (C) estimates of potential predation on juvenile salmonids by northern pikeminnow relative to predation prior to implementation of the Northern Pikeminnow Management Program. Estimates of predicted predation after 2004 are based on the 1995 – 2004 ten-year average.

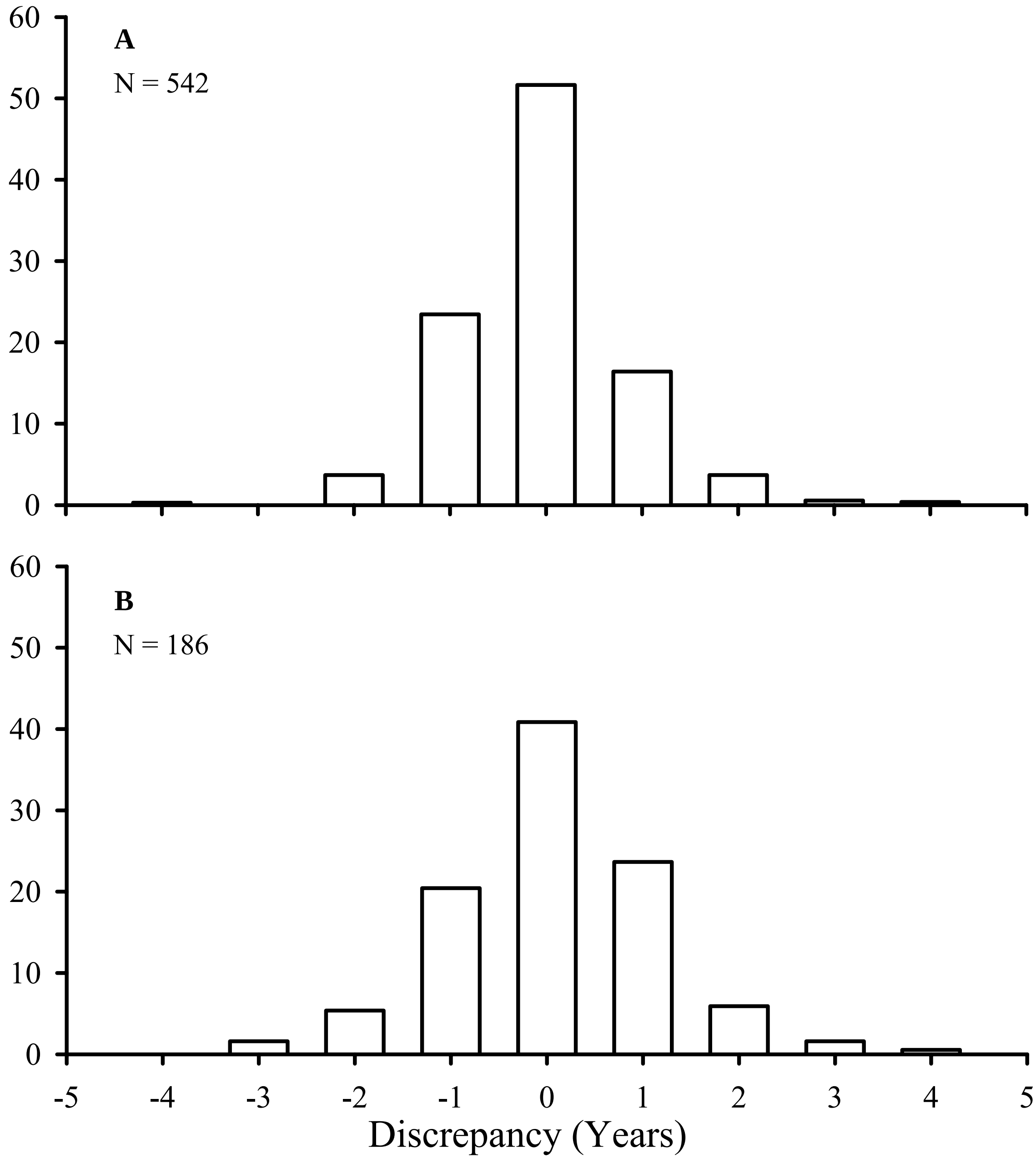


FIGURE 5.—Distribution of reader aging discrepancies for northern pikeminnow scales (A) and opercles (B) collected in 2004. An aging discrepancy is defined as Reader X_i age subtracted from Reader X_j age.

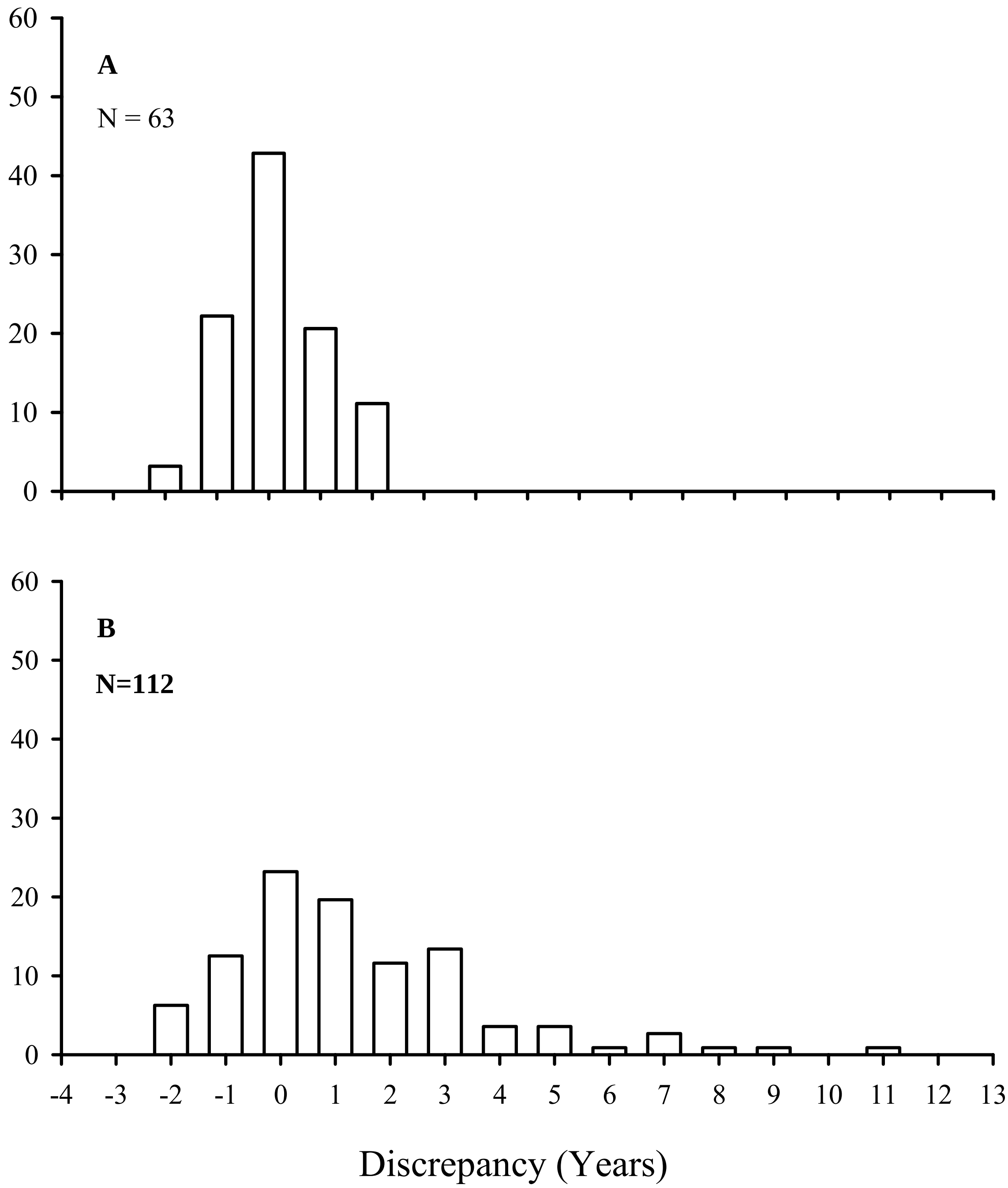


FIGURE 6.—Frequency distribution of aging discrepancies between scales and opercles taken from the same fish: northern pikeminnow < 350 mm fork length (A), northern pikeminnow ≥ 350 mm fork length (B). A discrepancy is defined as the scale age subtracted from the opercle age.

Biological Evaluation

Predator sampling near Columbia and Snake River dams generally coincided with peaks in juvenile salmonid passage indices (Appendix B). However, we were unable to sample within the boat-restricted zone at several dams because of high spill levels in 2004. With the exception of Bonneville and Little Goose reservoirs, northern pikeminnow abundance indices were the lowest to date (Table 1). The combined abundance index (excluding the tailrace BRZ) Below Bonneville Dam abundance was 40% lower than the average of the previous four years sampled (1994 – 1996, 1999), and the 2004 John Day Reservoir combined northern pikeminnow abundance index was an order of magnitude lower than the program average (1990-1996, 1999).

Spring smallmouth bass relative densities were similar in 2004 to previous years, except for the John Day Reservoir forebay, where they increased by an order of magnitude from 1999 and were double those of 1990 (Table 2). Summer smallmouth bass relative densities exhibited a similar pattern system-wide to spring relative densities, with the 2004 John Day Dam forebay relative density more than double the 1999 and 1990 levels (Table 3).

Salmonids composed the majority (69-89%) of fish remains identified to species in the digestive tracts of northern pikeminnow in all reaches of the study area (Table 4). Below Bonneville Dam and in the lower Columbia River reservoirs this represents increases of 6.6 and 10% from 1999 levels respectively. Although the overall percent of northern pikeminnow stomach samples that contained identifiable salmonid remains varied little by season in 2004 (Table 5), seasonal variations between 2004 and 1999 appeared to be sizeable. Spring 2004 percentages were less than one-half of spring 1999; conversely, summer 2004 percentages were more than three times higher than summer 1999. Cottids were consistently identified in northern pikeminnow stomachs from all study reaches, but never exceeded 11% of the total remains identified (Table 4). The importance of other prey species (e.g. centrarchids, cyprinids, and clupeids) appeared to vary by reach (Table 4).

The percentage of remains identified to species in smallmouth bass varied by study reach (Table 4). Below Bonneville Dam and in the lower Columbia River, cottids (62 – 64%) and salmonids (12 – 16%) were identified most often. In the Snake River, salmonids (60.5%) and catostomids (21.1%) were identified most often. The overall percentage of smallmouth bass stomachs that contained identifiable salmonids was 3% higher in the spring than the summer in 2004 (Table 5). The system-wide percentage of smallmouth bass stomachs that contained salmonids was higher in the spring (7%) and summer (4%) of 2004 than in the spring (4%) and summer (2%) of 1999 (Zimmerman et al. 2000).

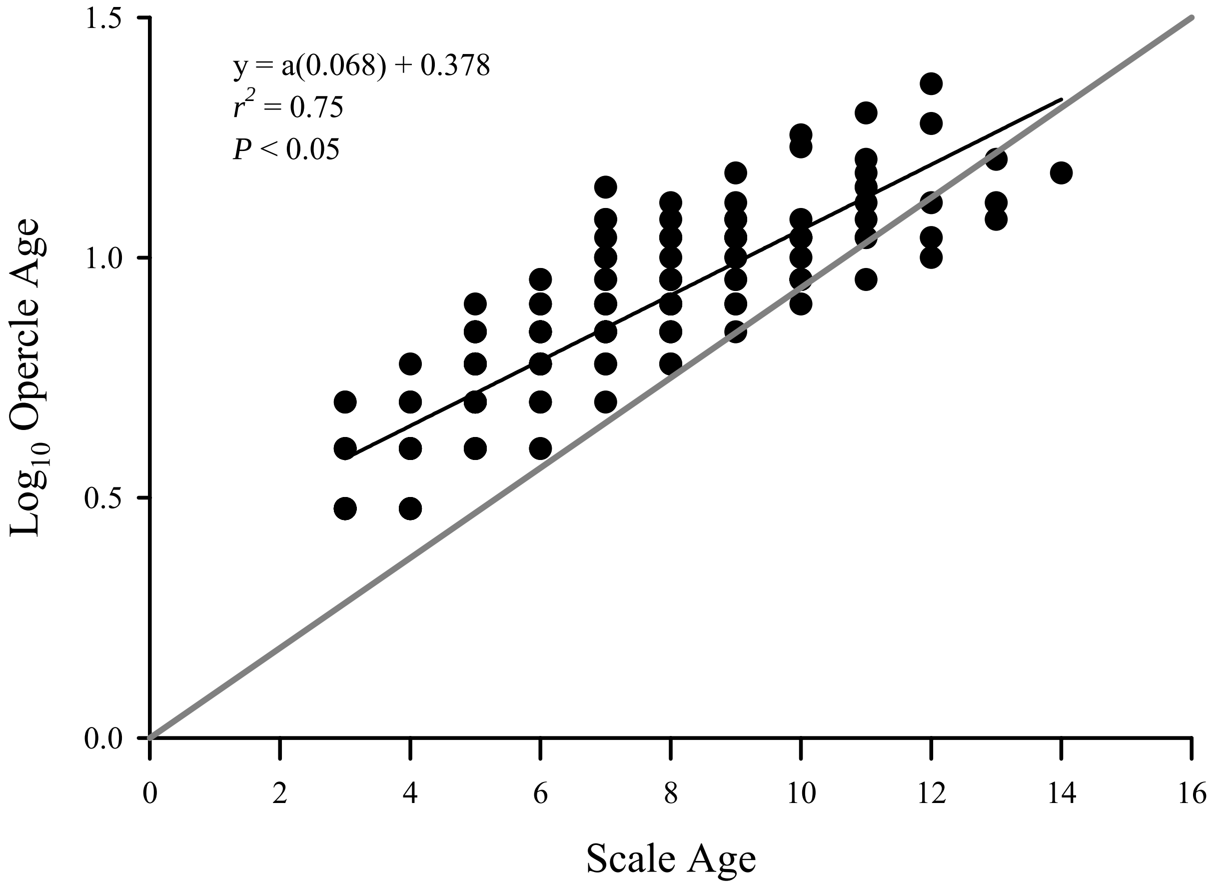


FIGURE 7.—Plot of ages assigned to scales and opercles from northern pikeminnow recaptured in 2004. Scale ages are plotted against corresponding Log_{10} transformed opercle ages. The diagonal line is a plot of the regression equation y = a(0.068) + 0.378. The grey-scaled reference line is where the regression line would be if there were no discrepancy.

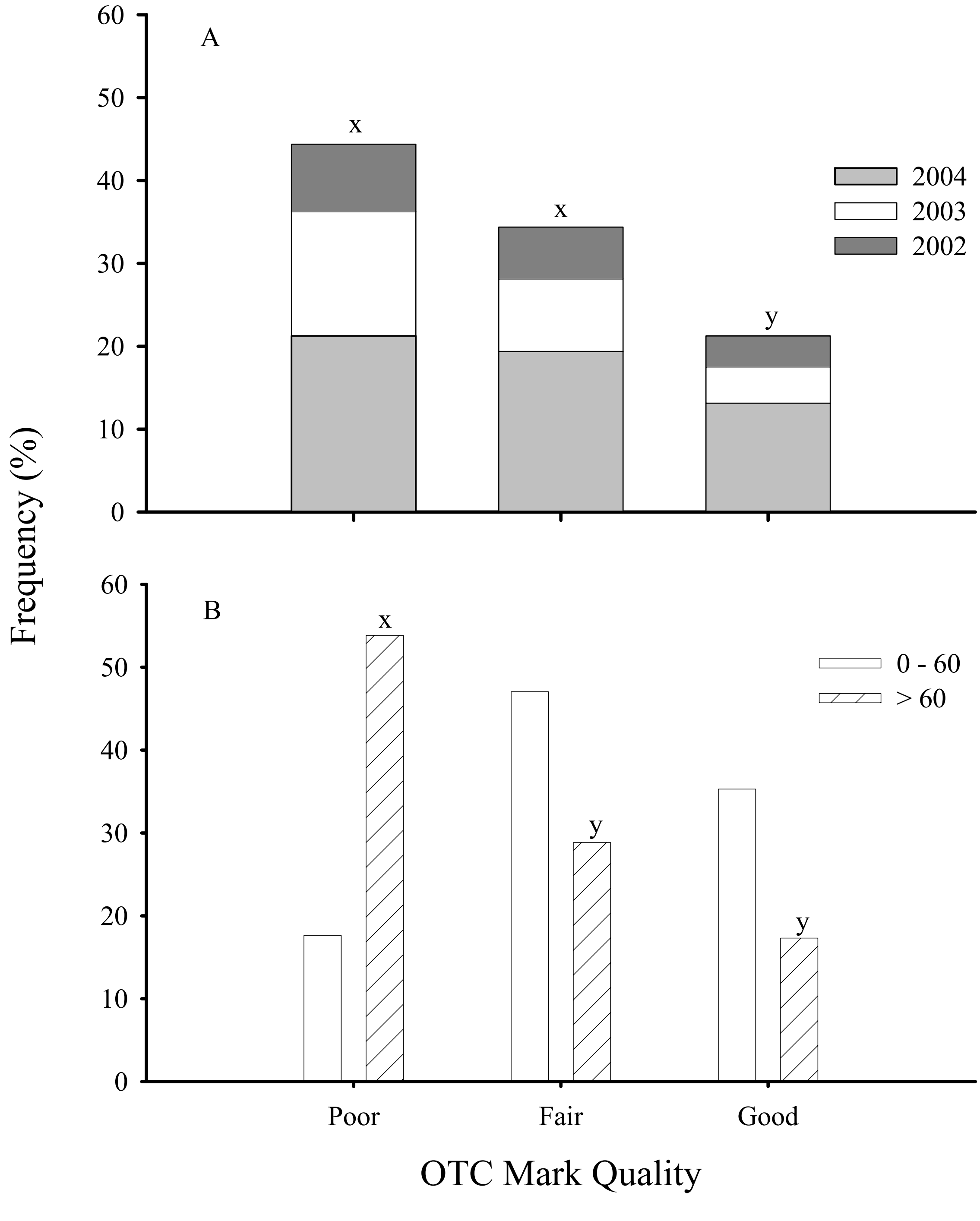


FIGURE 8.—Frequency distribution of OTC mark quality on opercles from northern pikeminnow tagged in 2002, 2003, and 2004: 2004 northern pikeminnow recaptures by tagging year (A), 2004 northern pikeminnow recaptures by number of days at large (B). Bars without a letter in common are significantly different ($P < 0.05$).

TABLE 1.—Abundance index values for northern pikeminnow ≥ 250 mm fork length in the lower Columbia and Snake rivers. rkm = river kilometer; BRZ = boat-restricted zone, and -- = not sampled.

Reservoir or Reach, area	Abundance Index								
	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	20.1	--	15.4	14.5	12.2	9.8	10.6
rkm 172-178	--	--	20.5	--	23.2	17.4	18.7	11.8	8.1
rkm 190-197	--	--	30.4	--	22.1	14.2	16.4	17.4	13.3
Tailrace	4.5	--	2.7	7.6	2.3	1.8	2.2	2.7	1.3
Tailrace BRZ	3.0	--	2.8	3.2	4.1	1.0	1.3	--	2.6
Bonneville									
Forebay	5.5	--	--	2.1	2.3	2.3	1.3	1.0	0.9
Mid-reservoir	15.1	--	--	8.5	5.0	7.4	4.9	2.2	2.3
Tailrace	0.4	--	--	0.8	0.5	0.8	0.7	1.1	1.3
Tailrace BRZ	0.9	--	--	0.2	1.1	--	--	--	--
The Dalles									
Forebay	1.4	--	--	1.6	0.7	0.5	0.6	--	--
Tailrace	2.7	--	--	0.7	0.6	1.5	3.6	0.8	0.4
Tailrace BRZ	4.4	--	--	2.2	1.1	0.7	0.7	--	--
John Day									
Forebay	1.4	1.3	2.4	1.2	1.4	0.5	0.6	0.3	0.1
Mid-reservoir	5.1	4.7	6.7	3.1	2.4	1.0	1.1	--	0.0
Tailrace	1.4	1.4	0.2	0.9	0.5	0.6	1.0	0.4	0.3
Tailrace BRZ	1.6	1.9	1.0	1.4	0.3	--	--	--	--
Lower Monumental									
Tailrace	--	1.3	--	--	0.3	0.1	0.1	0.0	<0.1
Tailrace BRZ	--	0.8	--	--	<0.1	0.2	0.1	0.0	<0.1
Little Goose									
Tailrace	--	0.7	--	--	0.2	<0.1	0.1	0.1	0.1
Tailrace BRZ	--	1.7	--	--	0.4	0.6	0.1	0.0	0.2
Lower Granite									
Upper reservoir	--	1.6	--	--	0.5	0.2	0.2	0.2	0.1

TABLE 2.—Spring relative density of smallmouth bass ≥ 200 mm fork length in the lower Columbia and Snake rivers, 1990-1996, 1999, and 2004. rkm = river kilometer; -- = not sampled. Relative density = mean transformed catch ($\log_{10}$(catch+1)) per 15-minute electrofishing run.

Reservoir or Reach, area	Relative Density								
	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	0.0	--	0.0	<0.1	0.0	0.0	0.0
rkm 172-178	--	--	0.2	--	0.2	0.5	0.3	0.1	0.3
rkm 190-197	--	--	0.1	--	0.1	0.4	0.1	<0.1	0.1
Tailrace	--	--	0.1	--	0.1	0.4	0.1	0.1	0.3
Bonneville									
Forebay	<0.1	<0.1	--	0.1	<0.1	0.1	0.1	0.1	0.2
Mid-reservoir	0.3	<0.1	--	0.1	0.3	0.3	0.2	0.1	--
Tailrace	0.3	0.3	--	0.7	0.5	0.4	0.6	0.4	0.5
John Day									
Forebay	0.5	0.3	0.4	--	0.3	0.4	0.3	0.1	1.0
Mid-reservoir	0.5	0.6	0.2	--	0.3	0.4	0.5	--	0.5
Tailrace	<0.1	0.1	0.2	--	0.1	0.1	<0.1	<0.1	--
Lower Granite									
Upper reservoir	0.6	--	--	--	0.6	0.3	0.4	0.3	0.2

TABLE 3.—Summer relative density of smallmouth bass ≥ 200 mm fork length in the lower Columbia and Snake rivers, 1990-1996, 1999, and 2004. rkm = river kilometer; -- not sampled. Relative density = mean transformed catch ($\log_{10}$(catch+1)) per 15-minute electrofishing run.

Reservoir or Reach, area	Relative Density								
	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	<0.1	--	0.1	<0.1	<0.1	0.0	<0.1
rkm 172-178	--	--	0.1	--	0.2	0.2	0.1	0.1	0.1
rkm 190-197	--	--	0.1	--	0.1	0.2	0.1	0.1	0.2
Tailrace	--	--	0.2	--	0.1	0.2	0.1	0.2	0.1
Bonneville									
Forebay	0.1	0.0	--	0.1	<0.1	0.1	<0.1	0.2	--
Mid-reservoir	0.1	0.1	--	0.2	0.2	0.1	0.1	0.1	0.3
Tailrace	0.2	0.4	--	0.4	0.4	0.5	0.2	0.4	0.4
John Day									
Forebay	0.4	0.3	0.3	0.4	0.5	0.4	0.3	0.4	0.9
Mid-reservoir	0.2	0.1	0.3	0.4	0.2	0.6	0.4	--	--
Tailrace	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.3
Lower Granite									
Upper reservoir	--	0.6	--	--	0.3	0.4	0.1	0.0	0.3

Fish identified in walleye stomach samples from below Bonneville Dam and lower Columbia River reservoirs were composed of species from Cyprinidae, Catostomidae, Cottidae and Salmonidae (Table 4). The percentage of walleye stomachs that contained identifiable salmonids decreased between spring 2004 and summer 2004 (Table 5). In summer 2004 only walleye sampled in the John Day Reservoir contained any identifiable salmonids. No walleye were sampled in the Snake River in 2004.

Spring 2004 mean CI values for northern pikeminnow between rkm 172-178 were greater in 2004 than 1995 and 1996, and greater in 2004 than 1999 for Bonneville Dam tailrace (Table 6). However, the combined spring 2004 CI below Bonneville Dam (excluding the tailrace BRZ) is 69% lower than the 1994 – 1996, 1999 four year mean CI. Spring CI values in the Bonneville Dam forebay were greater than those during 1994 – 1996 and 1999. Spring 2004 CI values were zero in both The Dalles Dam tailrace and the McNary Dam tailrace. In the remaining locations, too few northern pikeminnow ($n \leq 5$) were collected to calculate spring consumption indices.

The combined summer 2004 CI value below Bonneville Dam (excluding the tailrace BRZ) was 62% lower than the 1994 – 1996, 1999 mean (Table 7). However, 2004 consumption indices were greater than 1995, 1996, and 1999 for rkm 172-178 and greater than 1993-1996 and 1999 for the Bonneville Dam tailrace BRZ. Summer CI values for northern pikeminnow in 2004 were greater than any other study year in The Dalles and John Day Dam tailraces. We conducted summer index sampling in the lower Snake River for the first time in 2004; all consumption indices were zero except the Little Goose Dam tailrace BRZ (1.9).

TABLE 4.—Number and percent (%) of salmonids, cottids, and other fish families identified in northern pikeminnow, smallmouth bass, and walleye digestive tracts from the Columbia and Snake rivers, 2004. BBD = below Bonneville Dam, LCR = lower Columbia River reservoirs, and SNK = lower Snake River reservoirs.

	Northern pikeminnow			Smallmouth bass			Walleye	
	Percent			Percent			Percent	
Family	BBD (n=188)	LCR (n=37)	SNK (n=13)	BBD (n=48)	LCR (n=86)	SNK (n=38)	BBD (n=12)	LCR (n=23)
Salmonidae	74.5	89.2	69.2	12.5	15.3	60.5	16.7	17.4
Cottidae	10.6	10.8	7.7	62.5	64.0	5.3	0.0	8.7
Clupeidae	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinidae	2.1	0.0	15.4	10.4	10.5	7.8	69.7	8.6
Catostomidae	0.0	0.0	0.0	4.2	4.7	21.1	16.7	65.2
Ictaluridae	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
Percopsidae	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0
Gasterosteidae	3.2	0.0	0.0	4.2	2.3	0.0	0.0	0.0
Centrarchidae	0.0	0.0	7.7	0.0	1.2	5.3	0.0	0.0

TABLE 5.—Number (N) of northern pikeminnow, smallmouth bass, and walleye digestive tracts examined from the lower Columbia and Snake rivers in 2004, and percent that contained food, fish, and juvenile salmonids (Sal).

	Northern pikeminnow				Smallmouth Bass				Walleye			
		Percent				Percent				Percent		
Season, Reservoir or area	N	Food	Fish	Sal	N	Food	Fish	Sal	N	Food	Fish	Sal
Spring												
Below Bonneville Dam tailrace	59	51	12	9	19	95	79	11	0	0	0	0
Bonneville Dam tailrace	170	47	25	14	38	92	61	0	8	100	88	25
Bonneville	109	54	12	5	37	100	41	0	0	0	0	0
The Dalles	1	0	0	0	0	0	0	0	0	0	0	0
John Day	6	50	0	0	109	97	22	6	4	100	75	25
Lower Monumental	3	67	0	0	0	0	0	0	0	0	0	0
Little Goose	11	91	36	27	0	0	0	0	0	0	0	0
Lower Granite	8	75	25	38	60	97	33	17	0	0	0	0
All areas	367	52	19	11	263	97	37	7	12	100	83	25
Summer												
Below Bonneville Dam tailrace	56	73	18	5	23	96	78	9	1	100	100	0
Bonneville Dam tailrace	124	54	39	28	6	100	83	17	1	100	100	0
Bonneville	201	71	11	6	102	95	27	0	3	67	67	0
The Dalles	7	43	43	43	0	0	0	0	1	100	100	0
John Day	7	86	29	29	181	99	25	3	14	100	93	7
Lower Monumental	14	57	71	7	0	0	0	0	0	0	0	0
Little Goose	42	57	10	0	0	0	0	0	0	0	0	0
Lower Granite	14	71	0	0	76	99	36	12	0	0	0	0
All areas	465	65	19	12	388	98	31	4	20	95	90	5

TABLE 6.—Spring consumption indices for northern pikeminnow ≥ 250 mm fork length in the lower Columbia and Snake rivers, 1990-1996, 1999, and 2004. BRZ = boat-restricted zone; rkm = river kilometer; -- = not sampled, and X = no consumption index calculated ($n \leq 5$).

Reservoir or Reach, area	Consumption index								
	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	0.5	--	0.5	0.5	0.4	0.8	0.2
rkm 172-178	--	--	1.0	--	1.1	0.2	0.1	0.4	0.3
rkm 190-197	--	--	1.1	--	1.5	0.7	0.4	0.4	0.1
Tailrace	1.2	--	0.5	0.8	3.2	0.8	0.4	0.1	0.3
Tailrace BRZ	2.7	--	1.0	1.1	0.6	1.7	0.6	--	1.0
Bonneville									
Forebay	0.6	--	--	0.7	0.2	0.3	0.0	0.0	0.5
Mid-reservoir	0.0	--	--	0.0	0.2	0.0	0.1	0.6	--
Tailrace	0.3	--	--	0.0	0.0	0.2	0.0	0.2	0.0
Tailrace BRZ	2.3	--	--	--	--	--	--	--	0.0[a]
The Dalles									
Forebay	0.8	--	--	0.1	0.1	0.0	0.0	--	--
Tailrace	0.7	--	--	0.0	--	--	--	0.5	X
Tailrace BRZ	0.9	--	--	X	--	--	--	--	--
John Day									
Forebay	1.5	1.9	1.9	1.5	1.0	1.7	X	1.2	0.0[a]
Mid-reservoir	0.0	0.5	0.0	X	X	X	X	--	0.0[a]
Tailrace	1.5	0.9	0.0	2.0	0.3	0.8	0.5	1.7	0.0
Tailrace BRZ	2.5	1.5	0.9	--	0.7	--	--	--	--
Lower Monumental									
Tailrace	--	0.6	--	--	0.7	X	X	--	0.0[a]
Tailrace BRZ	--	0.7	--	--	--	1.3	X	--	0.0[a]
Little Goose									
Tailrace	--	0.7	--	--	1.9	X	0.7	X	X
Tailrace BRZ	--	1.2	--	--	1.5	1.6	--	--	X
Lower Granite									
Upper reservoir	--	0.3	--	--	0.6	1.2	0.2	1.9	X

[a]No northern pikeminnow collected.

TABLE 7.—Summer consumption indices for northern pikeminnow ≥ 250 mm fork length in the lower Columbia and Snake rivers 1990-1996, 1999, and 2004. BRZ = boat-restricted zone; rkm = river kilometer; -- = not sampled, and X = no consumption index calculated ($n \leq 5$).

Reservoir or Reach, area	Consumption index								
	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	0.3	--	1.8	1.5	0.0	1.0	0.4
rkm 172-178	--	--	1.3	--	1.5	0.4	0.0	0.0	0.7
rkm 190-197	--	--	1.9	--	0.4	1.2	0.0	0.5	0.2
Tailrace	0.5	--	2.1	1.2	0.4	0.9	0.6	0.2	0.2
Tailrace BRZ	5.5	--	7.8	1.0	2.1	1.3	3.1	--	4.0
Bonneville									
Forebay	1.8	--	--	0.5	0.3	0.0	0.3	0.0	--
Mid-reservoir	0.0	--	--	0.0	0.0	0.0	0.0	0.0	0.0
Tailrace	X	--	--	0.0	0.0	0.8	0.0	0.3	1.1
Tailrace BRZ	0.8	--	--	1.0	3.2	--	--	--	0.0[a]
The Dalles									
Forebay	1.0	--	--	0.0	0.0	0.0	0.0	--	--
Tailrace	0.0	--	--	0.0	0.8	0.0	0.7	0.0	5.5
Tailrace BRZ	6.4	--	--	0.5	1.2	2.2	X	--	0.0[a]
John Day									
Forebay	2.4	3.1	0.7	0.6	1.2	2.0	0.4	X	X
Mid-reservoir	0.9	X	0.0	0.6	0.6	X	X	--	--
Tailrace	2.6	0.0	X	0.0	X	0.6	0.3	0.0	X
Tailrace BRZ	11.7	2.8	4.6	0.6	1.9	--	--	--	--
Lower Monumental									
Tailrace	--	--	--	--	--	--	--	--	X
Tailrace BRZ	--	--	--	--	--	--	--	--	1.9
Little Goose									
Tailrace	--	--	--	--	--	--	--	--	0.0
Tailrace BRZ	--	--	--	--	--	--	--	--	0.0
Lower Monumental									
Upper reservoir	--	--	--	--	--	--	--	--	0.0

[a]No northern pikeminnow collected.

Spring CI values for smallmouth bass in 2004 were greater than in 1995, 1996 and 1999 for rkm 190-197 and Lower Granite Reservoir (Table 8). Summer CI values for rkm 190-197 were greater than those in 1996 and 1999 (Table 9), and summer CI values were greater in Bonneville and McNary Dam tailraces than any previous year. We collected smallmouth bass in Lower Granite Reservoir during summer indexing for the first time; the mean consumption index value was 0.2. In the remaining locations spring and summer CI values were low and similar to other years, or were not calculated due to insufficient sample size ($n \leq 5$).

Northern pikeminnow predation indices varied in both season and area in 2004. The Bonneville Dam tailrace BRZ spring predation index was more than three times higher than in 1996; however, this is still three times less than 1990 and similar to 1991 – 1995 (Table 10). The 2004 combined spring predation index for below Bonneville Dam (excluding the tailrace BRZ) is 32% lower than the average of the previous 3 years (1995, 1996, and 1999), and between 1992 and 2004 there has been an 88% drop in the overall spring predation index for below Bonneville Dam. The spring predation index in the Bonneville Dam forebay was higher in 2004 than in the previous two indexing years (1996 and 1999), where the predation index was zero, however, it is similar to several years prior to that (1993 – 1995), and 85% less than in 1990. All other Columbia River reservoirs/areas in spring 2004 were either not sampled, had sample sizes less than 5, or had predation indices of zero (Table 10). In the Snake River only the Lower Monumental tailrace had sufficient samples to calculate a spring predation index, and no salmonids were recovered from northern pikeminnow sampled in this area (Table 10).

Summer predation indices varied among areas. Below Bonneville Dam both the middle area (rkm 172-178) and the tailrace BRZ had predation indices higher than in 1999 and the tailrace BRZ had the highest predation index value since 1992 (Table 11). The other areas below Bonneville Dam exhibited decreases in predation index relative to 1999. The combined summer 2004 predation index for below Bonneville Dam was 89% less than in 1992. Predation indices in The Dalles and John Day Dam tailraces increased relative to 1999 and were the highest and second highest recorded. Snake River summer predation indices were calculated for the first time in 2004. The Little Goose tailrace BRZ was the only Snake River area to have a summer predation index (0.1). The other Snake River areas either had predation indices of zero, or insufficient sample sizes ($n \leq 5$; Table 11).

Smallmouth bass predation indices were calculated for the first time in 2004 based on season specific CPUE data (Appendix Table C-2 and C-3). Below Bonneville Dam northern pikeminnow predation was much higher than smallmouth bass, except from rkm 190-197, where differences between smallmouth bass and northern pikeminnow predation were negligible (Table 12). Smallmouth bass predation in Bonneville Reservoir was negligible. Comparisons between 2004 northern pikeminnow and smallmouth bass predation indices in the John Day and upper Lower Granite reservoirs were difficult due to small sample sizes of northern pikeminnow ($n \leq 5$). However, 1992 was the last year that had combined spring northern pikeminnow predation indices in the John Day Reservoir higher than combined spring 2004 smallmouth bass (Table 12).

TABLE 8.—Spring consumption indices for smallmouth bass ≥ 200 mm fork length in the lower Columbia and Snake rivers, 1990-1996, 1999, and 2004. BRZ = boat-restricted zone; rkm = river kilometer; -- = not sampled, and X = no consumption index calculated ($n \leq 5$).

	Consumption index								
Reservoir or Reach, area	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	X	--	X	X	--	--	0.0[a]
rkm 172-178	--	--	0.1	--	0.0	0.1	0.0	X	0.0
rkm 190-197	--	--	0.0[a]	--	0.3	0.0	0.0	X	0.2
Tailrace	--	--	X	--	0.0	0.0	0.0	X	0.0
Bonneville									
Forebay	0.0[a]	--	--	X	X	0.1	0.0	0.0	0.0
Mid-reservoir	0.0[a]	--	--	X	0.0	0.1	0.0	X	--
Tailrace	0.0	--	--	0.0	0.0	0.0	0.0	<0.1	0.0
John Day									
Forebay	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1
Mid-reservoir	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0
Tailrace	0.0[a]	X	X	X	0.0	0.0	0.0	X	0.0[a]
Lower Granite									
Upper reservoir	--	0.1	--	--	0.2	0.1	<0.1	0.1	0.2

[a]No smallmouth bass collected.

TABLE 9.—Summer consumption indices for smallmouth bass ≥ 200 mm fork length in the lower Columbia and Snake rivers 1990-1996, 1999, and 2004. BRZ = boat-restricted zone; rkm = river kilometer; -- = not sampled, and X = no consumption index calculated ($n \leq 5$).

	Consumption index								
Reservoir or Reach, area	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	0.0[a]	--	0.0	X	X	--	X
rkm 172-178	--	--	0.0	--	0.2	0.3	X	0.0	0.0
rkm 190-197	--	--	0.4	--	0.3	0.8	0.0	0.0	0.2
Tailrace	--	--	X	--	0.0	0.0	X	0.0	0.4
Bonneville									
Forebay	0.0[a]	--	--	X	0.4	0.0	0.0	0.2	--
Mid-reservoir	X	--	--	0.0	0.0	0.0	0.0	0.0	0.0
Tailrace	X	--	--	0.0	0.1	0.1	0.0	0.0	0.0
John Day									
Forebay	0.3	0.5	0.2	0.7	0.2	0.3	0.1	0.2	<0.1
Mid-reservoir	0.3	0.0	X	0.1	0.0	0.0	0.0	--	--
Tailrace	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Lower Granite									
Upper reservoir	--	--	--	--	--	--	--	--	0.2

[a]No smallmouth bass collected.

TABLE 10.—Spring predation indices for northern pikeminnow ≥ 250 mm fork length in the lower Columbia and Snake rivers, 1990-1996, 1999, and 2004. BRZ = boat-restricted zone; rkm = river kilometer; -- = not sampled, and X = no consumption index calculated ($n \leq 5$).

	Predation Index								
Reservoir or Reach, area	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	10.4	--	8.0	7.3	4.9	7.5	1.8
rkm 172-178	--	--	20.9	--	26.2	3.5	1.9	5.0	2.5
rkm 190-197	--	--	34.4	--	33.3	9.9	6.6	7.1	1.5
Tailrace	5.5	--	1.4	6.1	7.4	1.4	0.9	0.4	0.3
Tailrace BRZ	8.0	--	2.8	3.5	2.5	1.7	0.8	--	2.5
Bonneville									
Forebay	3.3	--	--	1.5	0.3	0.7	0.0	0.0	0.5
Mid-reservoir	0.0	--	--	0.0	1.0	0.0	0.5	1.3	--
Tailrace	0.1	--	--	0.0	0.0	0.2	0.0	0.2	0.0
Tailrace BRZ	2.0	--	--	--	--	1.5	--	--	--
The Dalles									
Forebay	1.1	--	--	0.2	0.1	0.0	0.0	--	--
Tailrace	1.9	--	--	0.0	--	--	--	0.4	X
Tailrace BRZ	3.9	--	--	0.0	--	--	--	--	--
John Day									
Forebay	2.1	2.5	4.7	1.9	1.3	0.9	0.4	0.4	--
Mid-reservoir	0.0	2.4	0.0	0.0	0.0	0.0	0.0	--	--
Tailrace	2.2	1.3	0.0	1.8	0.2	0.5	0.3	0.7	0.0
Tailrace BRZ	4.0	2.9	0.9	--	0.2	--	--	--	--
Lower Monumental									
Tailrace	--	0.8	--	--	0.2	0.0	0.0	--	0.0
Tailrace BRZ	--	0.6	--	--	--	0.3	0.0	--	0.0
Little Goose									
Tailrace	--	0.5	--	--	0.2	0.0	0.0	--	X
Tailrace BRZ	--	2.0	--	--	--	0.3	0.0	--	X
Lower Granite									
Upper reservoir	--	0.5	--	--	0.3	0.2	0.1	0.4	X

TABLE 11.—Summer predation indices for northern pikeminnow ≥ 250 mm fork length in the lower Columbia and Snake rivers, 1990-1996, 1999, and 2004. BRZ = boat-restricted zone; rkm = river kilometer; -- = not sampled, and X = no predation index calculated ($n \leq 5$).

	Predation Index								
Reservoir or Reach, area	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	6.2	--	27.3	14.5	0.0	9.4	4.7
rkm 172-178	--	--	27.0	--	35.0	7.0	0.0	0.0	5.8
rkm 190-197	--	--	57.8	--	9.5	17.0	0.0	9.5	2.3
Tailrace	2.3	--	5.7	9.1	1.0	1.6	1.3	0.6	0.3
Tailrace BRZ	16.4	--	21.9	3.2	8.9	1.2	4.0	--	10.2
Bonneville									
Forebay	9.9	--	--	1.1	0.6	0.0	0.4	0.0	--
Mid-reservoir	0.0	--	--	0.0	0.0	0.0	0.0	0.0	0.0
Tailrace	0.0	--	--	0.0	0.0	0.6	0.0	0.3	1.4
Tailrace BRZ	0.7	--	--	0.2	3.5	--	--	--	--
The Dalles									
Forebay	1.4	--	--	0.0	0.0	0.0	0.0	--	--
Tailrace	0.0	--	--	0.0	0.5	0.0	2.5	0.0	2.0
Tailrace BRZ	27.8	--	--	1.1	1.4	1.5	3.8	--	--
John Day									
Forebay	3.4	4.0	1.7	0.7	1.6	1.0	0.2	0.0	X
Mid-reservoir	4.6	0.0	0.0	1.9	1.4	0.0	0.0	--	--
Tailrace	3.7	0.0	0.0	0.4	0.0	0.4	0.2	0.0	X
Tailrace BRZ									
Lower Monumental									
Tailrace	--	--	--	--	--	--	--	--	X
Tailrace BRZ	--	--	--	--	--	--	--	--	0.1
Little Goose									
Tailrace	--	--	--	--	--	--	--	--	0.0
Tailrace BRZ	--	--	--	--	--	--	--	--	0.0
Lower Granite									
Tailrace BRZ	--	--	--	--	--	--	--	--	X

TABLE 12.—Spring and summer 2004 predation indices for Northern Pikeminnow ≥ 250 mm fork length and smallmouth bass ≥ 200 mm fork length and in the lower Columbia and Snake rivers. rkm = river kilometer; -- = not sampled, and X = no predation index calculated ($n \leq 5$).

	Predation Index			
	Northern Pikeminnow		Smallmouth Bass	
Reservoir or Reach, area	Spring	Summer	Spring	Summer
Below Bonneville Dam				
rkm 114-121	1.1	4.7	X	X
rkm 172-178	2.5	5.8	0.0	0.0
rkm 190-197	1.5	2.3	2.2	2.2
Tailrace[a]	2.8	10.5	0.0	0.2
Bonneville				
Forebay	0.5	--	0.0	--
Mid-reservoir	--	0.0	--	0.0
Tailrace	0.0	1.4	0.0	0.0
John Day				
Forebay	X	X	1.6	0.8
Mid-reservoir	X	--	2.3	--
Tailrace	0.0	X	X	0.5
Lower Granite				
Upper reservoir	X	X	0.2	0.4

[a] Represents combined tailrace and tailrace BRZ numbers.

Northern pikeminnow year-class analysis downstream of Bonneville Dam showed considerable variation from year to year in the percentage of age 3 and 4 fish (Figure 9). The percentage of age 5 northern pikeminnow has been relatively stable since 1993, accounting for 15 – 17% of the total. In Bonneville Reservoir, year-class strength was more variable than below Bonneville Dam; though the percentage of age-5 fish appears to be oscillating in a regular fashion (Figure 9).

Smallmouth bass year-class analysis downstream of Bonneville Dam indicates that a growing proportion of the population is composed of age 4 fish (Figure 10). In Bonneville Reservoir year-class strength appears to vary from year to year, although the percentages of age-5 fish in 1999 and 2004 were four to six times greater than between 1990 and 1995. Year-class strength of smallmouth bass in John Day and Lower Granite reservoirs is variable with no apparent trends (Figure 11).

The 2004 northern pikeminnow PSD value for below Bonneville Dam was similar to previous years and a trend was not discernable (Table 13). In the Bonneville Reservoir the 2004 northern pikeminnow PSD value of 18 was less than half that seen in 1990 (Table 13). PSD values were not calculated in 2004 for the John Day Reservoir because of an insufficient sample size ($n \leq 20$). Proportional and relative stock densities of smallmouth bass varied through time below Bonneville Dam, but do not appear to be trending up or down (Table 13). The Bonneville and John Day Reservoir smallmouth bass stock density indices were generally stable through time (Table 13).

Median W_r differed significantly ($P < 0.01$) among years for male and female northern pikeminnow (Figure 12). Both sexes exhibited a similar pattern; W_r was comparatively low in 1990-1992 and 1995-1996, and significantly higher in 1993-1994, 1999, and 2004. Median W_r was highest for male northern pikeminnow in 2004, and for female northern pikeminnow in 1999; however, these values did not differ significantly from those in 1993 and 1994.

Median W_r differed significantly ($P < 0.01$) among years for smallmouth bass (Figure 13); W_r was significantly higher in 2004 than in the other 3 years analyzed (1990, 1996, and 1999). Smallmouth bass median W_r was also significantly higher in 1990 and 1999 than 1996, and no trends were apparent.

DISCUSSION

System-wide exploitation of northern pikeminnow ≥ 250 mm FL (18.0%) by the sport-reward fishery in 2004 was greater than the average exploitation rate of 13.2% for the 5-year period 1999-2003. In the past, sport-reward harvest of large (≥ 250 mm FL) northern pikeminnow appeared to be driven by river flow, with exploitation increasing as river levels decreased. However, the amount of variability explained by river flow weakened from past years (Takata and Koloszar 2004), suggesting other factors also play a substantial role in explaining the variability of exploitation. The increase in 2004 exploitation may be related to the increased incentives applied to the reward structure of the sport-reward fishery. We expect the new reward structure to continue, and any models developed to predict exploitation should take this into account.

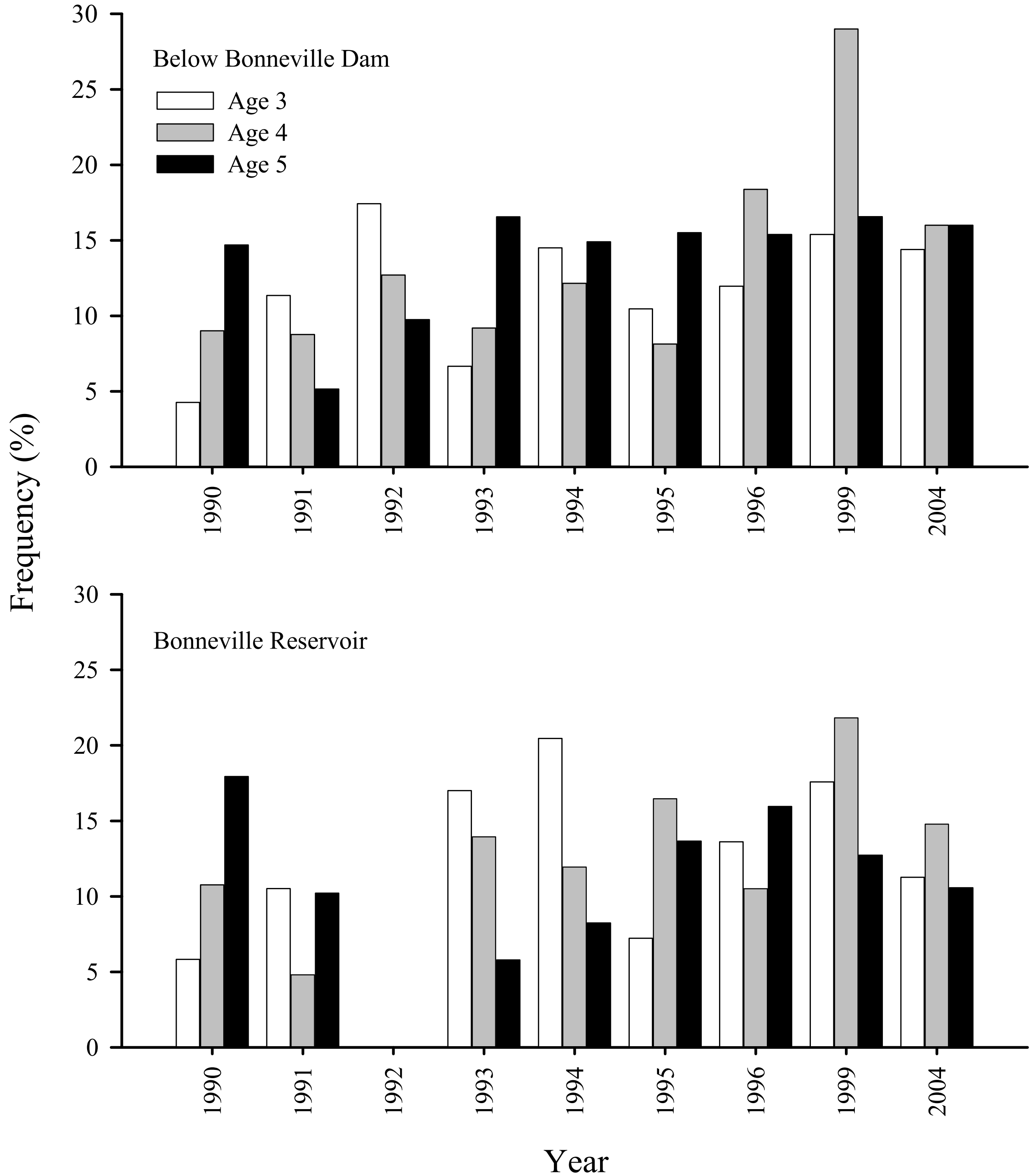


FIGURE 9.—Percent composition of age 3-5 northern pikeminnow, relative to the total sample, in the Columbia River downstream from Bonneville Dam and Bonneville Reservoir (1990 to 2004).

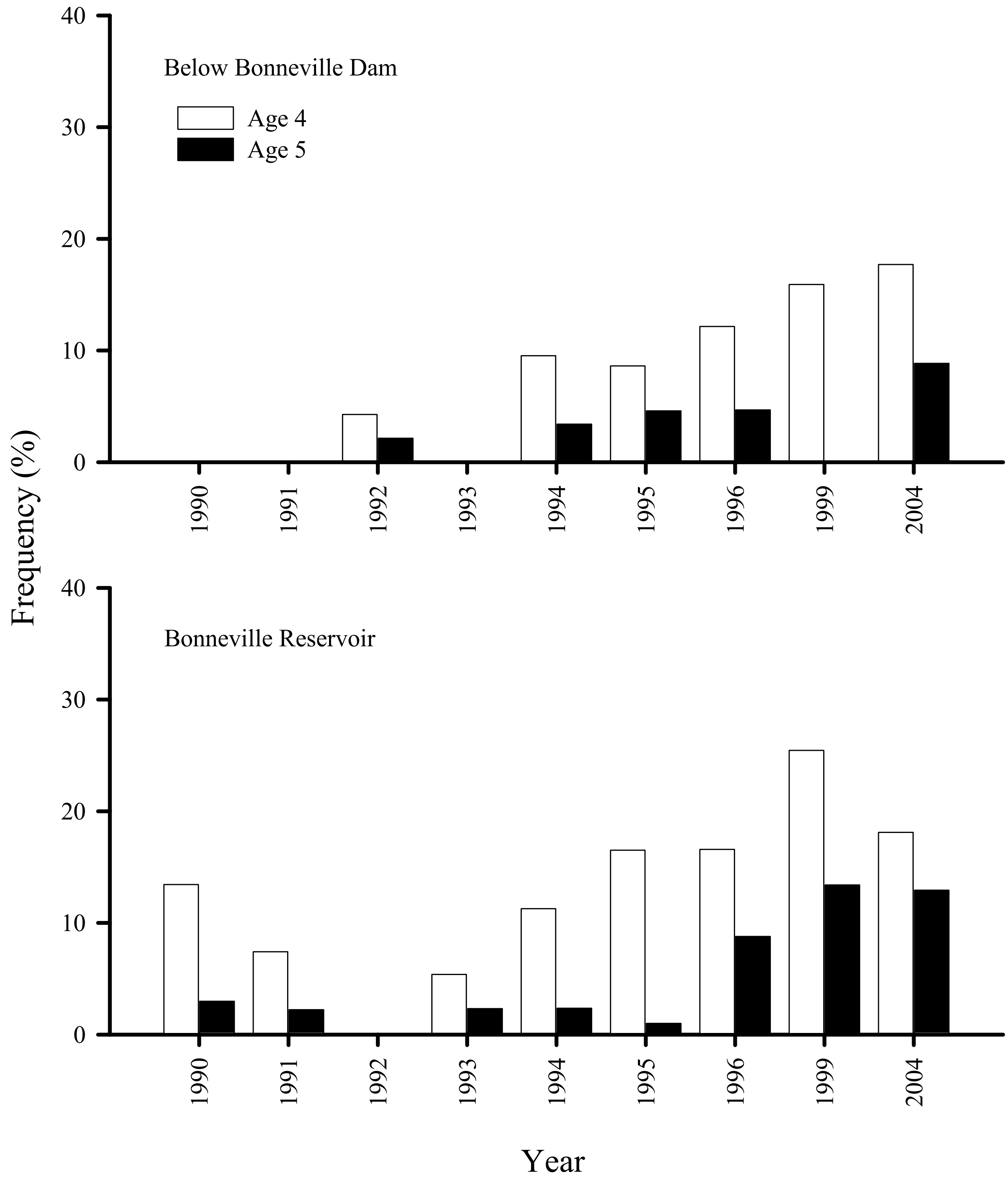


FIGURE 10.—Percent composition of age 4-5 smallmouth bass relative to the total sample in the Columbia River downstream from Bonneville Dam and Bonneville Reservoir from 1990 to 2004.

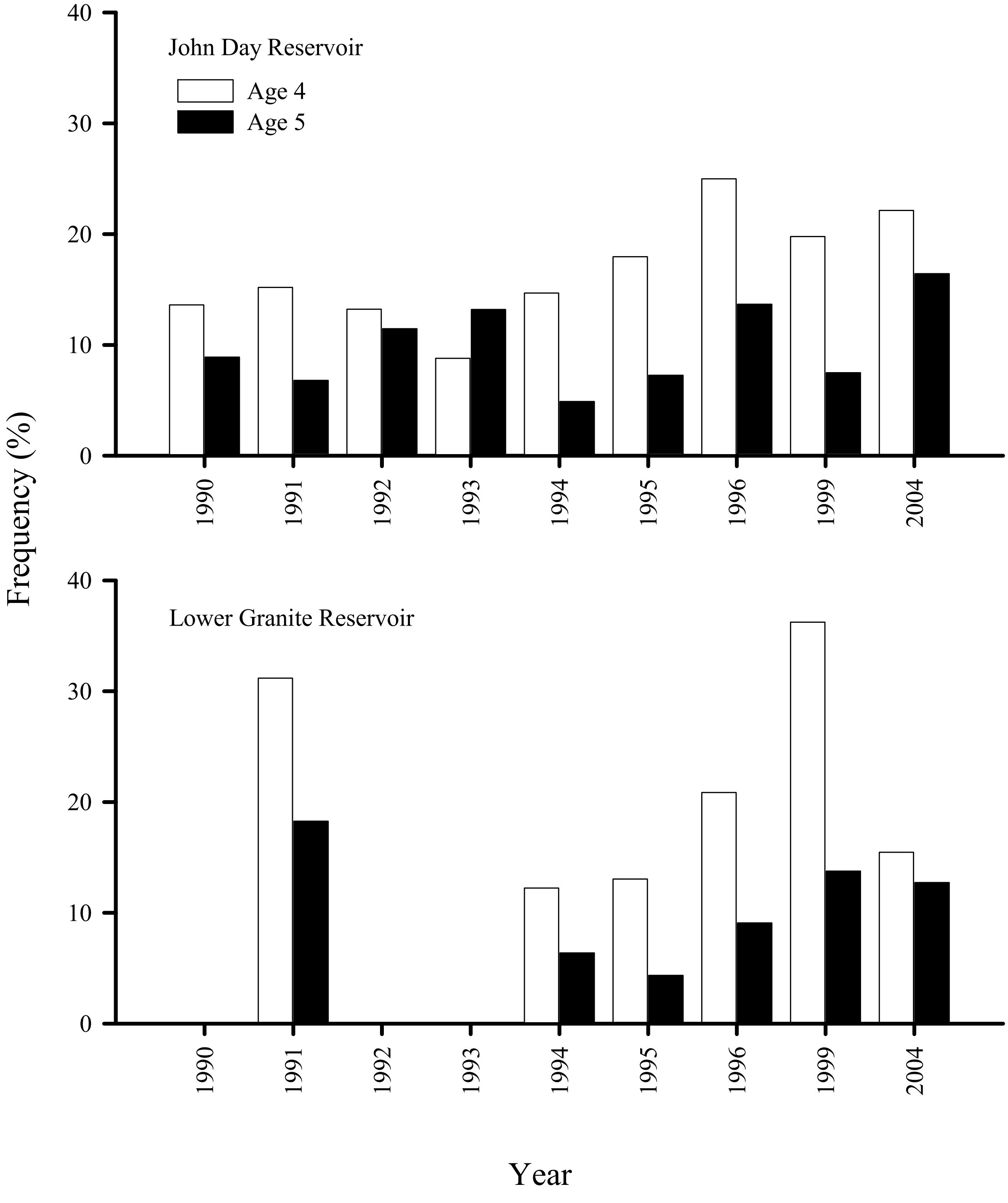


FIGURE 11.—Percent composition of age 4-5 smallmouth bass relative to the total sample in the Columbia River downstream from Bonneville Dam and Bonneville Reservoir from 1990 to 2004.

TABLE 13.—Proportional stock density (PSD), relative stock density (RSD-P), and sample size (*N*) of northern pikeminnow and smallmouth bass in the lower Columbia River (1990 – 1996, 1999, and 2004). -- = not sampled; X = Number (stock sized fish) ≤ 20, no stock density index calculated.

Location, Species, Parameter	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
Northern Pikeminnow									
PSD	--	--	29	--	33	41	33	39	35
(*N*)	--	--	(710)	--	(409)	(206)	(245)	(226)	(356)
Smallmouth Bass									
PSD	--	--	22	--	31	41	30	46	30
RSD-P	--	--	7	--	12	15	6	13	6
(*N*)	--	--	(153)	--	(141)	(181)	(83)	(54)	(172)
Bonneville Reservoir									
Northern Pikeminnow									
PSD	43	--	--	44	40	26	24	33	18
(*N*)	(245)	--	--	(213)	(378)	(319)	(199)	(169)	(136)
Smallmouth Bass									
PSD	39	--	--	26	37	33	58	46	44
RSD-P	15	--	--	10	12	11	14	13	17
(*N*)	(111)	--	--	(236)	(332)	(285)	(256)	(239)	(235)
John Day Reservoir									
Northern Pikeminnow									
PSD	60	66	65	64	71	43	53	62	X
(*N*)	(93)	(99)	(232)	(149)	(133)	(51)	(55)	(21)	(11)
Smallmouth Bass									
PSD	20	38	23	28	22	26	41	29	29
RSD-P	8	11	6	9	6	8	12	9	10
(*N*)	(330)	(175)	(324)	(156)	(427)	(625)	(234)	(106)	(581)

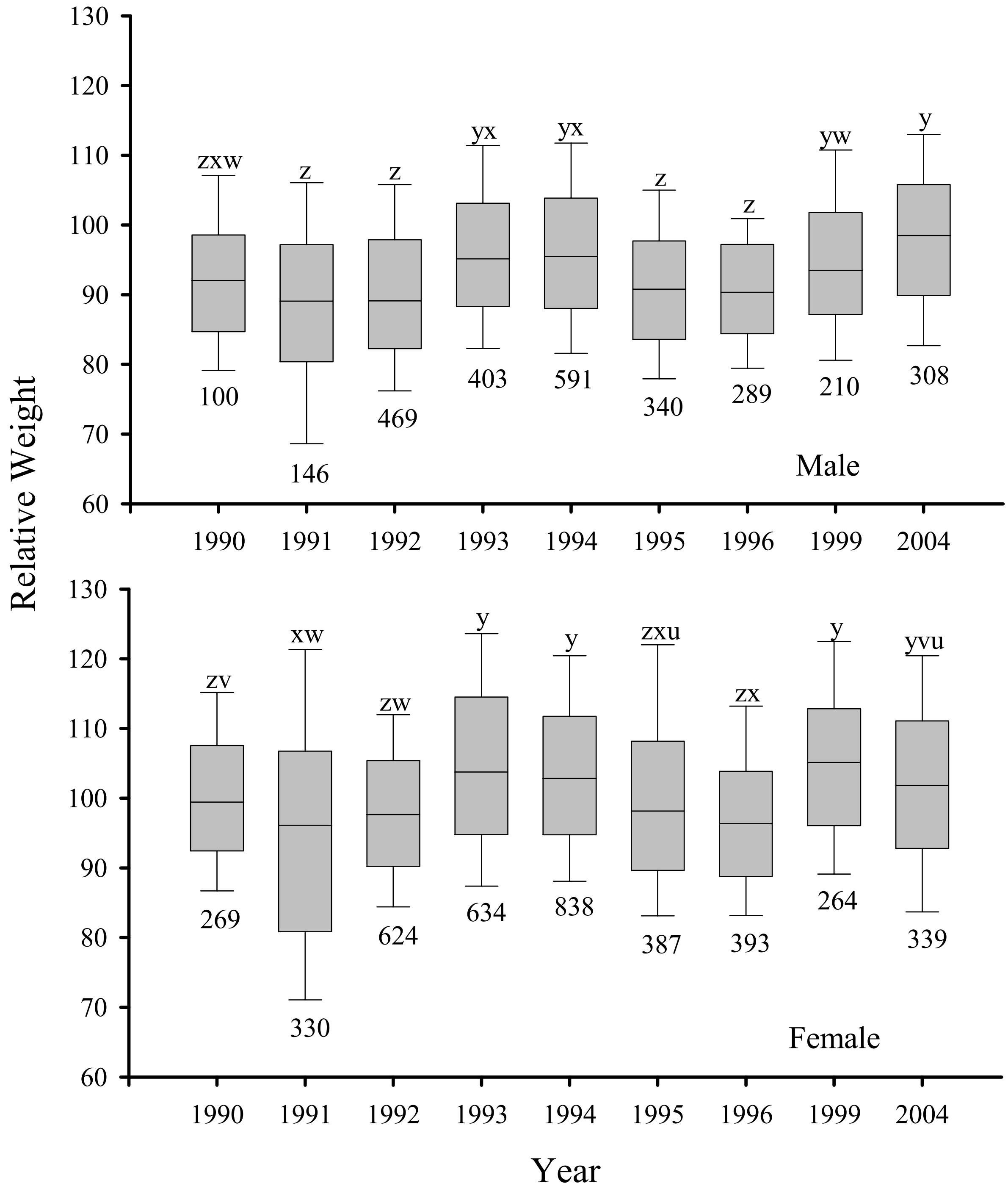


FIGURE 12.—Relative weight of male and female northern pikeminnow in the lower Columbia and Snake rivers for 1990-1996, 1999, and 2004. The horizontal line near the center of each bar is the median, the ends of the bar are the 25th and 75th percentiles, and

the whiskers are the 10th and 90th percentiles. Bars without a letter in common are significantly different ($P < 0.05$); numbers below the bars are the sample size.

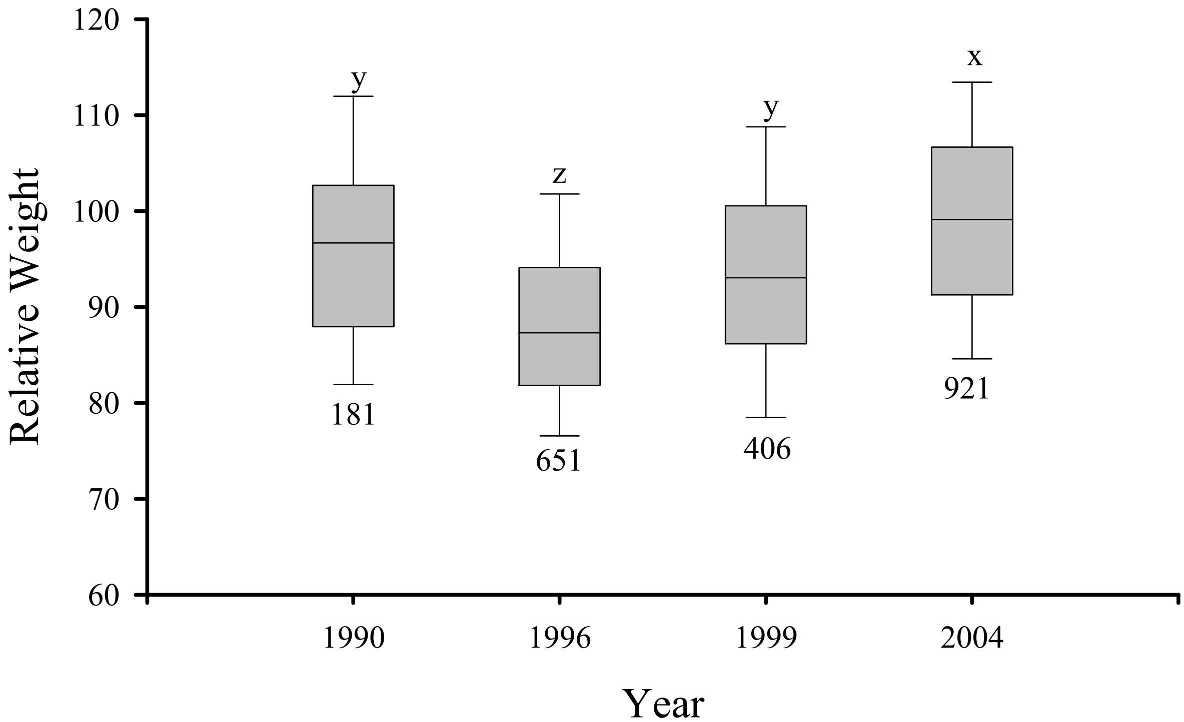


FIGURE 13.—smallmouth bass relative weight in the lower columbia and snake rivers in 1990, 1996, 1999, and 2004. The horizontal line near the center of each bar is the median, the ends of the bar are the 25th and 75th percentiles, and the whiskers are the 10th and 90th percentiles. Bars without a letter in common are significantly different ($p<0.05$); numbers below the bars are the sample size.

With the exception of 2004, exploitation rates for fish ≥ 250 mm FL have remained relatively stable over the course of the program. Exploitation rates for northern pikeminnow 200-249 mm have been much more erratic in the five years they have been targeted. It appears that smaller tagged fish may be less likely than their larger counterparts to be recovered in the fishery, limiting sample sizes and potentially biasing exploitation estimates. From 2000 to 2004 these smaller fish composed, on average, about 19% of the northern pikeminnow tagged and released each year. However, almost 40% of the northern pikeminnow harvested by the sport-reward fishery consisted of fish 200-249 mm FL. Higher mortality on smaller fish after tagging may prevent them from being recaptured in the fishery at a rate more consistent with their share of the overall catch (Takata and Koloszar 2004).

We calculated a tag loss estimate of 11.3% in 2004, which was higher than the 7.4% estimated in 2003 (Takata and Koloszar 2004) and the 4.2% used to adjust exploitation estimates prior to 2000 (Zimmerman et al. 2000). Although spaghetti tags are designed for a long retention time, they are prone to snagging due to their loop configuration (Guy et al. 1996), and 50% loss rates by 190 d have been noted in two catostomid species (Timmons and Howell 1995). Other mark recapture studies (using a variety of tag types) have reported loss rates of 5 – 25% (Ebener and Copes 1982; Muoneke 1992). The 11% tag-loss rate we observed in 2004 is within the range of loss rates in other tagging studies. Considering the habitat complexity of the system (e.g., pilings, snags, and riprap), and that spaghetti tags are prone to snagging, this seems like a reasonable estimate.

We were again able to utilize PIT tags as secondary marks for our tag loss study in 2004. The PDAs simplified the data transfer process for PIT tags; which increased their ease of use. We plan to employ PIT tags as our secondary mark again in 2005.

Based on the model of Friesen and Ward (1999) it appears most of the reduction in potential predation was realized in the first seven years of the NPMP. After slight increases in 1998 and 1999, predicted potential predation has stabilized at approximately 75-80% of pre-program levels. If exploitation rates remain similar to mean 1995-2004 levels, further reductions in potential predation are likely to be minimal. If exploitation rates are maintained at 2004 levels, long-term projections indicate further reductions in predation will be minimal (ODFW, unpublished data). Therefore, maintaining potential predation near the current levels may be a more realistic goal for the future rather than trying to gain additional large reductions in predation. In response to recommendations made in an audit of the NPMP (Hankin and Richards 2000), we are currently working on an updated predation model that takes into account size-at-age differences between males and females, and includes updated mortality estimates. We plan to use the new model once our aging and tag loss assessments are completed.

From 2001 to 2003 the readers in our aging study were the same two individuals. In 2004 three new readers aged northern pikeminnow scales. Complete agreement among the three readers was slightly higher than in 2002 and 2003 (about 50%). Agreement within one year improved from 2002 and 2003 when it was approximately 85% to over 90% in 2005. Two of the northern pikeminnow scale readers also read opercles. Although reader agreement for opercles remained lower than that for scales, there has been continuous improvement over the four years we have been reading them. Currently, complete agreement is about 40% and agreement within one year is approximately 85%. Aging precision may increase further as we continue to learn more about reading northern pikeminnow opercles and incorporate this knowledge into our aging protocols.

Comparisons between scale and opercle ages have been consistent among the three years we have conducted this analysis. Beyond 8-9 years of age, opercles are consistently aged older than corresponding scales. Studies by Campbell and Babaluk (1979), Scoppettone (1988), Donald et al. (1992), and the Washington Department of Fish and Wildlife (J. Sneva, WDFW, personal communication) also found that ages derived from opercles tended to be older than those from scales. For this reason, some investigators have suggested that opercles may provide more accurate ages than scales, particularly for older fish (Donald et al. 1992). We found a significant positive linear relationship between scale age and $\log_{10}$-transformed opercle ages; therefore, the age assigned to an opercle may be predicted with a certain margin of error. Given the lack of success that we have had in validating scale ages (Takata and Koloszar 2004), and that aging precision for opercles is currently lower than that for scales, we will continue to utilize both parts in our aging analysis.

In 2002, only 14% of the opercle samples had good quality fluorescent marks. After increasing the OTC dosage in 2003 we noted a higher (same year recoveries) percentage of good quality marks (35%) than in 2002. In 2004 the percentage of same year recoveries exhibiting a “good” mark decreased again to 24%. However, the purpose of this study is to determine the utility of OTC as an age validation tool. When we considered only those marks judged “good” or “fair,” we noted one annulus after the mark in 90% of fish tagged in 2003 and two annuli in 63% of fish tagged in 2002. “Good” and “fair” marks accounted for approximately 65% of the marks read in 2004. “Poor” quality marks included opercles that did not exhibit a mark at all, but should have. Again, considering that opercles may provide a more accurate representation of the true age of fish than scales (Donald et al. 1992), and our need for an opercle age validation tool, we plan to refocus future analysis, and re-analyze previously collected opercles to look at the percentage of opercles that fail to exhibit an OTC mark.

Reductions in the northern pikeminnow population may improve outmigrating salmonid survival, if an equal compensatory response by the remaining northern pikeminnow does not minimize the benefits (Beamesderfer et al. 1996; Friesen and Ward 1999). An increase in the population size structure or condition factor might be an indication of such a response (Knutsen and Ward 1999). Sustained exploitation should decrease the proportion of large fish to small fish (Zimmerman et al. 1995), and smaller northern pikeminnow consume fewer salmonids than their larger counterparts (Vigg et al. 1991). Northern pikeminnow stock-density indices have remained relatively stable within most reservoirs across years. However, PSD has decreased in Bonneville Reservoir through time, shifting to a population composed primarily of stock-sized fish. The long-term oscillations in year-class strength within Bonneville Reservoir do appear to explain the decrease in Bonneville Reservoir PSD. Therefore, the decreasing PSDs may indicate that the sport-reward fishery is having its desired effect, decreasing the size structure of northern pikeminnow in certain areas. However, when multiple-age spawning stocks with stable oscillations in year class strength are overexploited, reductions in population size and decreases in the amplitude and time period of the oscillation can occur (Everhart and Youngs 1981). Monitoring the northern pikeminnow population in Bonneville Reservoir for changes in stock density indices and year class strength should be continued. Stock density indices in the John Day Reservoir were not calculated in 2004 due to insufficient sample sizes. Though when looking at past years it seems that the majority of the northern pikeminnow sampled were in the quality (≥ 380 mm TL) size range, indicating potential recruitment problems. Average northern pikeminnow W_r varied significantly over time. However, these variations appear to be random in nature, trending neither up nor down. These random oscillations in W_r are possibly density independent in nature. Density independent factors, such as fluctuating numbers of migrating juvenile salmonids, unstable water levels, and changes in water temperature from year to year, are all factors unrelated to northern pikeminnow abundance that could affect the population (Van Den Avyle and Hayward 1999). When solely considering PSD and W_r data, a system-wide compensatory response does not seems apparent.

Other factors, such as increasing northern pikeminnow consumption and predation indices, might also be signs of compensation by remaining northern pikeminnow to prolonged exploitation by the NPMP (Zimmerman and Ward 1999). Although generally lower than previous years, northern pikeminnow consumption and predation indices have increased, relative to the last several years of indexing, within several localized reaches of the study area (e.g., rkm 172 – 178 and the tailraces of Bonneville, The Dalles, and John Day dams); the 2004 summer northern pikeminnow consumption index in The Dalles Dam tailrace was higher than any previous year. These increases in consumption correspond to increases in the percentage of stomach remains identified as salmonid. Two of these reaches, John Day and The Dalles dam tailraces, had the highest and third highest northern pikeminnow sport-reward harvests in 2004 (PSMFC 2005). Intra-specific competition for home range and forage resources can have deleterious effects on fish populations (Crowder 1990; Byorth and Magee 1998). Based on localized increases in northern pikeminnow consumption in high harvest areas, a localized reduction of intra-specific competition could be occurring, and is possibly compensatory response by remaining northern pikeminnow. Below Bonneville Dam spring and summer predation indices were 88 and 89% lower, reach-wide, in 2004 than in 1992, despite localized increases in consumption; it appears northern pikeminnow are not exhibiting a system-wide compensatory response. We collected northern pikeminnow digestive tracts during times of peak juvenile salmonid abundance at most sampling areas in 2004 (Appendix B); therefore we do not attribute lower predation indices to mistimed sampling. The predation index is composed of two components, consumption and abundance (Ward et al. 1995). Reductions in the system-wide northern pikeminnow predation are attributable to changes in abundance; which was generally lower in 2004 than in previous indexing years, and we observed an order of magnitude drop in northern pikeminnow abundance in the John Day Reservoir. Small sample sizes in several lower Columbia and Snake River reservoirs precluded the calculation of consumption and predation indices at many locations.

The efficacy of the NPMP also depends, in part, on the lack of response by other piscivores in the Columbia Basin to the sustained removal of northern pikeminnow (Ward and Zimmerman 1999). Smallmouth bass stock-density indices varied by reservoir, with the most balanced population occurring in Bonneville Reservoir. Stock density indices for below Bonneville Dam were variable but were frequently within ranges generally considered balanced for black bass populations in other systems (Green 1989). In the John Day Reservoir stock density indices indicated a population composed primarily of stock-sized fish (180 – 279 mm TL). However, there is no significant difference in salmonid consumption between smallmouth bass that are between 150 and 200 mm and those smallmouth bass greater than 200 mm (Zimmerman et al. 2000). A critical period during a fish's early life is thought to govern year class strength and recruitment (Van Den Avyle and Hayward 1999; Miranda and Hubbard 1994). It is unclear what factors may affect this critical period in John Day Reservoir smallmouth bass; however, the increasing percentage of age-4 fish over time alludes to increased early life survival. Average smallmouth bass W_r was highest in 2004, and varied significantly across years within the study period. These variations were without apparent trend, and like those of northern pikeminnow are likely the result of density-independent factors.

In the past, juvenile salmonids composed small but consistent portions of smallmouth bass diets in the Columbia and Snake rivers (Poe et al. 1991; Zimmerman 1999; Naughton et al. 2004). This was true again system-wide in 2004. Though consumption rates were similar to past years; smallmouth bass may be exhibiting a compensatory response in localized areas. The most notable of these areas is the John Day Dam forebay, where 2004 smallmouth bass relative densities (spring and summer) were at least double 1999 and 1990 levels. This increase corresponds to an order of magnitude drop in northern pikeminnow abundance within the same area. Because of this dramatic change in the piscivore community, we calculated a predation index for smallmouth bass for the first time in 2004. The last time that northern pikeminnow predation indices were greater than or equaled 2004 smallmouth bass levels was 1993 (spring) and 1995 (summer). Increases in smallmouth bass abundance may also influence salmonid predation in an indirect manner. Remaining northern pikeminnow may modify their diets and habitat selection in the presence of introduced piscivores (Poe et al. 1994), and in areas of high smallmouth bass abundance this behavior may be exacerbated. Smallmouth bass consumption indices have also increased above Lower Granite Dam, though less dramatically than in the lower Columbia reservoirs. These increases correspond to an increase in the percentage of stomach remains identified as salmonid (69.2); which is more than two and a half times the 1990 to 1996 frequency (25.8%; Zimmerman 1999), and three times more than the 1999 frequency (22.2%; Zimmerman et al. 2000). It is apparent that smallmouth bass are now a significant contributor to salmonid predation directly, and potentially indirectly as well, in some Columbia and Snake river areas.

Juvenile salmonids are an important component of Columbia River walleye diets (Poe et al. 1991; Vigg et al. 1991; Zimmerman 1999). Our diet analysis in 2004 corroborates this, and as previously documented (Zimmerman 1999), the number of juvenile salmonids present in walleye stomachs decreased substantially from spring to summer. Although salmonids do constitute an important component of walleye diets, cyprinids (below Bonneville Dam) and catostomids (lower Columbia reservoirs) were the most frequently identifiable prey items in their digestive tracts. Though walleye consume juvenile salmonids, their numbers continue to be low relative to northern pikeminnow and smallmouth bass (Beamesderfer and Rieman 1991), and their effects on salmonid populations are likely to be minimal. In 2004, we collected only 185 walleye system-wide; the majority of these (72%) were in the John Day and McNary reservoirs.

Previous evaluations of the NPMP have not detected responses by the predator community to the sustained removal of northern pikeminnow (Ward et al. 1995; Ward and Zimmerman 1999; Zimmerman and Ward 1999). Observable responses to fishery management programs can lag by more than 15 years from project inception (Hilborn and Winton 1993; Beamesderfer et al.1996), and it is possible that enough time had simply not elapsed for any response to be witnessed by previous studies. The John Day Reservoir was the site of the original northern pikeminnow test fishery fourteen years ago (Parker et al. 1995), so it would not be surprising if it were the first reservoir in the Columbia River system to exhibit a response to the NPMP. Considering the overall reductions in northern pikeminnow abundance and predation, the 20 – 25% reduction in potential predation predicted by Friesen and Ward's (1999) model may underestimate the true reduction juvenile salmonid predation by northern pikeminnow. With the continuation of the NPMP and the recent increase in the reward structure, a system-wide response from the predator community may be possible, emphasizing the need for continued monitoring of the piscivore community and an updated potential predation model.

ACKNOWLEDGMENTS

We are grateful to Michele Hughes, Kurt Karageorge, Mike Manky, Robin Miranda, Alena Pribyl, Steve Selser, and Chris Uraneck, who worked long hours in the field to capture and tag northern pikeminnow and collect the data in this report. In addition, we thank George Reed for his dedicated work with boat repair and maintenance, as well as his assistance in training our field crew.

This research was funded by the Bonneville Power Administration, John Skidmore, Project Manager (Contract DE-B1719-94BI24514). Russell Porter of the Pacific States Marine Fisheries Commission and David Ward of ODFW administered the contract. The Pacific States Marine Fisheries Commission provided PIT tags for our tag loss study.

We thank Eric Winther and his staff (WDFW) for their cooperation and help with project coordination. In addition, a special thanks to Kathleen Moyer for providing PIT tag recovery data and opercles. The U.S. Army Corps of Engineers was very cooperative regarding entry into boat-restricted zones near dams. In particular, we appreciate the assistance of John Bailey, Brad Eby, Mike Halter, Dick Hammer, Jon Rerecich, and Miro Zyndol. Finally, we thank Suzanne Miller of the U.S. Geological Survey for providing Columbia River hydrologic data.

REFERENCES

Anderson, R. O. 1980. Proportional stock density (PSD) and relative weight (W_r): interpretive indices for fish populations and communities. Pages 27-33 *in* S. Gloss and B. Shupp, editors. Practical fisheries management: more with less in the 1980s. New York Chapter American Fisheries Society, Bethesda, MD.

Anderson, R. O., and S. J. Gutreuter. 1983. Length, weight, and associated structural indices. Pages 280-300 *in* L. A. Nielsen and D. L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Beamesderfer, R. C., B. E. Rieman, J. C. Elliott, A. A. Nigro, and D. L. Ward. 1987. Distribution, abundance, and population dynamics of northern squawfish, walleye, smallmouth bass, and channel catfish in John Day Reservoir, 1986. Oregon Department of Fish and Wildlife, Contract number DE-AI79-82BP35097. 1986 Annual Report to Bonneville Power Administration, Portland, Oregon.

Beamesderfer, R. C., and B. E. Rieman. 1988. Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505-510.

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

Beamesderfer, R. C. P., D. L. Ward, and A. A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish (Ptychocheilus oregonensis) in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Byorth, P. A. and J. P. Magee. 1998. Competitive interactions between arctic grayling and brook trout in the Big Hole River drainage, Montana. Transactions of the American Fisheries Society 127:921-931.

Campbell, J. S., and J. A. Babaluk. 1979. Age determination of walleye, *Stizostedion vitreum vitreum* (Mitchill), based on the examination of eight different structures. Department of Fisheries and the Environment, Fisheries and Marine Service Technical Report number 849.

Crowder, L. B. 1990. Community ecology. Pages 609-632 *in* C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland.

Donald, D. B., J. A. Babaluk, J. F. Craig, and W. A. Musker. 1992. Evaluation of the scale and operculum methods to determine age of adult goldeyes with special reference to a dominant year-class. Transactions of the American Fisheries Society 121:792-796.

Ebener, M. P., and F. A. Copes. 1982. Loss of Floy anchor tags from lake whitefish. North American Journal of Fisheries Management 2:90-93.

Everhart, W. H., and W. D. Youngs. 1981. Principles of fishery science, 2nd edition. Cornell University Press, Ithaca, New York.

FPC (Fish Passage Center). 2004. Daily passage data for the smolt monitoring project, March – October 2004. Fish Passage Center. Available: www.fpc.or/smolt/SMP_queries.html. (December 2004).

Friesen, T. A., and D. L. Ward. 1999. Management of northern pikeminnow and implications for juvenile salmonid survival in the lower Columbia and Snake rivers. North American Journal of Fisheries Management 19:406-420.

Gabelhouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4: 273-285.

Green, D. M. 1989. N.Y.S. Bureau of Fisheries centrarchid sampling manual. Warmwater Fisheries Unit. Cornell Biological Field Station, Bridgeport, New York.

Guy, C. S., H. L. Blankenship, and L. B. Nielsen. 1996. Tagging and marking. Pages 353-383 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Hankin, D. G., and J. Richards. 2000. The northern pikeminnow management program: An independent review of program justification, performance, and cost-effectiveness. Report to the Pacific Northwest Electric Power and Conservation Planning Council, Portland, Oregon.

Hilborn, R., and Winton, J. 1993. Learning to enhance salmon production: lessons from the salmonid enhancement program. Canadian Journal of Fisheries and Aquatic Sciences 50:2043-2056.

Knutsen, C. J., and D. L. Ward. 1999. Biological characteristics of northern pikeminnow in the Lower Columbia and Snake Rivers before and after sustained exploitation. Transactions of the American Fisheries Society 128:1008-1019.

Kolander, C. J., D. W. Willis, and B. R. Murphy. 1993. Proposed revision of the standard weights (W_s) equation for smallmouth bass. North American Journal of Fisheries Management 13:398-400.

Long, C. W., and F. J. Ossiander. 1974. Survival of coho salmon fingerlings passing through a perforated bulkhead in an empty turbine bag and through flow deflectors (with and without dentates) on the spillways of Lower Monumental Dam, Snake River, April-May 1973. Final Report (Contract DACW68-84-H-0034) to U.S. Army Corps of Engineers, Portland, Oregon.

McFarlane, G. A., and R. J. Beamish. 1987. Selection of dosages of oxytetracycline for age validation studies. Canadian Journal of Fisheries and Aquatic Sciences 44:905-909.

Miranda, L. E., and W. D. Hubbard. 1994. Length-dependent winter survival and lipid composition of Age-0 largemouth bass in Bay Springs Reservoir, Mississippi. Transactions of the American Fisheries Society 123:80-87.

Muoneke, M. I. 1992. Loss of Floy anchor tags from white bass. North American Journal of Fisheries Management 12:819-824.

Naughton, G. P., D. H. Bennet, and K. B. Newman. 2004. Predation on juvenile salmonids by smallmouth bass in the Lower Granite Reservoir system, Snake River. North American Journal of Fisheries Management 24:534-544.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Parker, R. M., M. P. Zimmerman, and D. L. Ward. 1995. Variability in biological characteristics of northern squawfish in the lower Columbia and Snake rivers. Transactions of the American Fisheries Society 124:335-346.

Poe, T. P., H. C. Hansel, S. Vigg, D. E. Palmer, and L. A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in the John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.

Poe, T. P., R. S. Shively, and R. A. Tabor. 1994. Ecological consequences of introduced piscivorous fishes in the lower Columbia and Snake rivers. Pages 347-360 *in* D. J. Strouder, K. L. Fresh, and R. J. Feller, editors. Theory and application in fish feeding ecology. University of South Carolina Press, Columbia, South Carolina.

PSMFC (Pacific States Marine Fisheries Commission). 2005. 2004 northern pikeminnow catch data summary. Northern Pikeminnow Management Program. Available: www.pikeminnow.org/catch.html. (February 2005).

Raymond, H. L.. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer Chinook salmon and steelhead in the Columbia River basin. North American Journal of Fisheries Management 8:1-24.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Rieman, B. E., and R. C. Beamesderfer. 1990. Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241.

Rieman, B. E., R. C. Beamesderfer, S. Vigg, and T. P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Scoppettone, G. G. 1988. Growth and longevity of the cui-ui and longevity of other catostomids and cyprinids in western North America. Transactions of the American Fisheries Society 117:301-307.

Styer, P. 2003. Statistical consulting report to review computational methods in the northern pikeminnow management program. Report to the Oregon Department of Fish and Wildlife, Clackamas, Oregon.

Takata, H. K., and D. L. Ward. 2001. Development of a system-wide predator control program: fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 2000 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Takata, H. K., and J. A. Koloszar. 2004. Development of a system-wide predator control program: fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 2003 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Timmons, T. J., and M. H. Howell. 1995. Retention of anchor and spaghetti tags by paddlefish, catfishes, and buffalo fishes. North American Journal of Fisheries Management 15:504-506.

USGS (United States Geological Survey). 2004. NWISWeb data for Oregon 1995 – 2004. United States Geological Survey. Available: www.waterdata.usgs.gov/or/nwis. (November 2004).

Van Den Avyle, M. J., and R. S. Hayward. 1999. Dynamics of exploited fish populations. Pages 127-166 *in* C. C. Kohler and W. A. Hubert, editors. Inland fisheries management in North America, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Vigg, S., T. P. Poe, L. A. Prendergast, and H. C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:421-438.

Ward, D. L., J. H. Petersen, and J. J. Loch. 1995. Index of predation on juvenile salmonids by northern squawfish in the lower and middle Columbia River and in the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

Ward, D. L., and M. P. Zimmerman. 1999. Response of smallmouth bass to sustained removals of northern pikeminnow in the lower Columbia and Snake Rivers. Transactions of the American Fisheries Society 128:1020-1035.

Wismar, R. C., and five coauthors. 1994. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s-1900s). Northwest Science 68(Special Issue):1-35.

Zimmerman, M. P., C. Knutsen, D. L. Ward, and K. Anderson. 1995. Development of a system-wide predator control program: Indexing and fisheries evaluation. Oregon Department of Fish and Wildlife, Contract number DE-AI79-90BP07084. 1993 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Zimmerman, M. P. 1999. Food habits of smallmouth bass, walleyes, and northern pikeminnow in the lower Columbia River Basin during outmigration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:995-1007.

Zimmerman, M. P., and D. L. Ward. 1999. Index of predation on juvenile salmonids by northern pikeminnow in the lower Columbia River basin, 1994-1996. Transactions of the American Fisheries Society 128:995-1007.

Zimmerman, M. P., T. A. Friesen, D. L. Ward, and H. K. Takata. 2000. Development of a system-wide predator control program: indexing and fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 1999 Annual Report to the Bonneville Power Administration, Portland, Oregon.

APPENDIX A

Exploitation of Northern Pikeminnow, 2001-2004

APPENDIX TABLE A-1.—Number of northern pikeminnow tagged and recaptured in 2004.

Area or Reservoir	≥ 200 mm FL		200-249 mm FL		≥ 250 mm FL	
	Tagged	Recaptured	Tagged	Recaptured	Tagged	Recaptured
Below Bonneville	361	62	34	5	327	57
Bonneville	114	11	66	5	48	6
The Dalles	44	1	9	1	35	0
John Day	10	2	2	0	8	2
McNary	66	2	7	0	59	2
Lower Granite	49	8	8	0	41	8
All areas	644	86	126	11	518	75

APPENDIX TABLE A-2.—Exploitation rates (%) of northern pikeminnow ≥ 200 mm fork length (FL), 200-249 mm FL, and ≥ 250 mm FL for all fisheries combined, 2001-2004. Exploitation rates were not corrected for tag loss in 2001-2002.

Area or Reservoir	2001			2002			2003[b]			2004[b]		
	≥ 200	200-249	≥ 250	≥ 200	200-249	≥ 250	≥ 200	200-249	≥ 250	≥ 200	200-249	≥ 250
Below Bonneville	15.9	a	16.2	10.8	3.1	12.6	11.8	a	13.6	18.8	6.5	20.1
Bonneville	8.6	a	8.5	5.0	0.0	6.0	11.0	0.0	16.7	11.7	13.5	9.3
The Dalles	0.0	0.0	0.0	a	0.0	a	a	a	0.0	a	a	a
John Day	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	a	a	a
McNary	26.0	a	26.0	7.6	a	7.7	6.6	0.0	8.2	a	a	a
Lower Granite	9.4	a	a	11.6	a	14.3	a	0.0	a	19.6	a	23.8
All Areas	15.5	10.6	16.2	10.6	3.4	12.3	10.5	a	13.0	17.0	10.9	18.5

[a] Exploitation rate not calculated ($n \leq 4$).
[b] Sport-reward fishery only.

APPENDIX TABLE A-3.—Exploitation rates (%) of northern pikeminnow ≥ 200 mm fork length (FL), 200-249 mm FL, and ≥ 250 mm FL for the sport-reward fishery, 2001-2004. Exploitation rates were not corrected for tag loss in 2001-2002.

Area or Reservoir	2001			2002			2003			2004		
	≥200	200-249	≥250	≥200	200-249	≥250	≥200	200-249	≥250	≥200	200-249	≥250
Below Bonneville	15.9	a	16.2	10.8	3.1	12.6	11.8	a	13.6	18.8	6.5	20.1
Bonneville	8.6	a	8.5	5.0	0.0	6.0	11.0	0.0	16.7	11.7	13.5	9.3
The Dalles	0.0	0.0	0.0	a	0.0	a	a	a	0.0	a	a	a
John Day	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	a	a	a
McNary	26.0	a	26.0	7.6	a	7.7	6.6	0.0	8.2	a	a	a
Lower Granite	9.4	a	a	11.6	a	14.3	a	0.0	a	19.6	a	23.8
All areas	15.5	10.6	16.2	10.6	3.4	12.3	10.5	a	13.0	17.0	10.9	18.5

[a] Exploitation rate not calculated ($n \leq 4$).

APPENDIX TABLE A-4.—Weekly exploitation of northern pikeminnow ≥ 200 mm fork length system-wide in 2004. Exploitation rates were not adjusted where tagging was completed before fishing started. Blank cells indicate either no tagging effort, no recapture effort, or no exploitation calculated.

Sampling Week	Tagged	Recaptured	At-Large	Exploitation (%)
14	21		0	
15	114		21	
16	209		135	
17	131		344	
18	37		475	
19	36	5	512	0.977
20	13	3	543	0.552
21	4	9	553	1.627
22	27	2	548	0.365
23	2	8	573	1.396
24	9	5	567	0.882
25	1	8	571	1.401
26	0	8	564	1.418
27	39	5	556	0.899
28		8	590	1.356
29		6	582	1.031
30		5	576	0.868
31		3	571	0.525
32		2	568	0.352
33		4	566	0.707
34		0	562	0.000
35		0	562	0.000
36		3	562	0.534
37		1	559	0.179
38		0	558	0.000
39		1	558	0.179
Total	643	86		15.2

APPENDIX TABLE A-5.—Weekly exploitation of northern pikeminnow ≥ 250 mm fork length system-wide in 2004. Exploitation rates were not adjusted where tagging was completed before fishing started. Blank cells indicate either no tagging effort, no recapture effort, or no exploitation calculated.

Sampling Week	Tagged	Recaptured	At-Large	Exploitation (%)
14	21		0	
15	48		21	
16	187		69	
17	119		256	
18	37		375	
19	31	4	412	0.971
20	10	3	439	0.683
21	3	7	446	1.570
22	21	2	442	0.452
23	1	6	461	1.302
24	7	5	456	1.096
25	1	7	458	1.528
26	0	7	452	1.549
27	31	5	445	1.124
28		8	471	1.699
29		6	463	1.296
30		3	457	0.656
31		2	454	0.441
32		1	452	0.221
33		4	451	0.887
34		0	447	0.000
35		0	447	0.000
36		3	447	0.671
37		1	444	0.225
38		0	443	0.000
39		1	443	0.226
Total		75		16.600

APPENDIX TABLE A-6.—Weekly exploitation of northern pikeminnow ≥ 200 mm fork length in McNary Reservoir in 2004. Exploitation rates were not adjusted where tagging was completed before fishing started. Blank cells indicate either no tagging effort, no recapture effort, or no exploitation calculated.

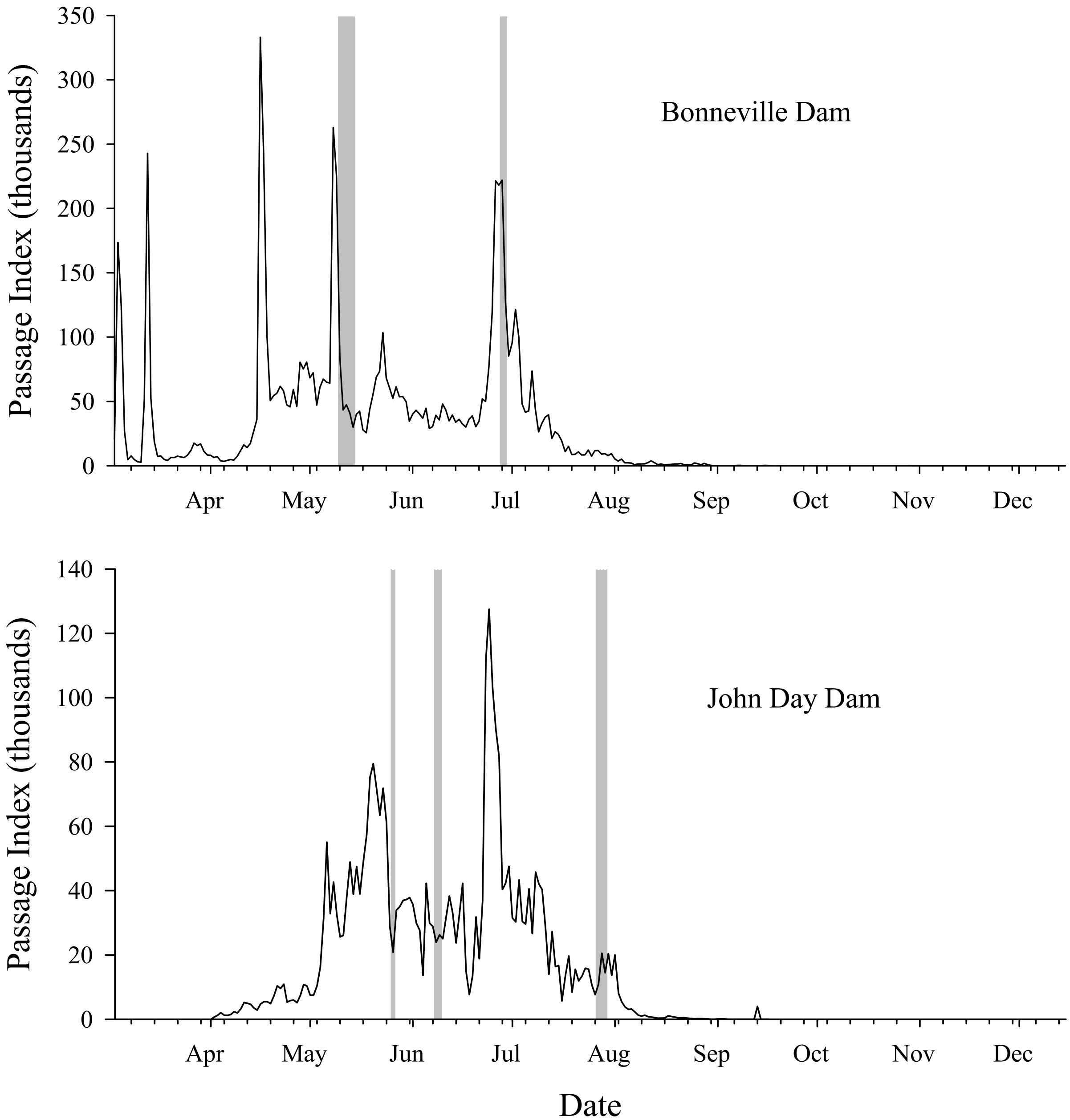
Sampling Week	Tagged	Recaptured	At-Large	Exploitation (%)
14	0		0	
15	0		0	
16	0		0	
17	0		0	
18	37		0	
19	0	0	37	
20	0	0	37	
21	0	0	37	
22	27	0	37	
23	2	0	64	
24	0	0	66	
25	0	0	66	
26	0	0	66	
27	0	0	66	
28		0	66	
29		1	66	1.515
30		0	65	
31		0	5	
32		0	65	
33		1	65	1.539
34		0	64	
35		0	64	
36		0	64	
37		0	64	
38		0	64	
39		0	64	
Total	66	2		3.010

APPENDIX TABLE A-7.—Weekly exploitation of northern pikeminnow ≥ 250 mm fork length in McNary Reservoir in 2004. Exploitation rates were not adjusted where tagging was completed before fishing started.

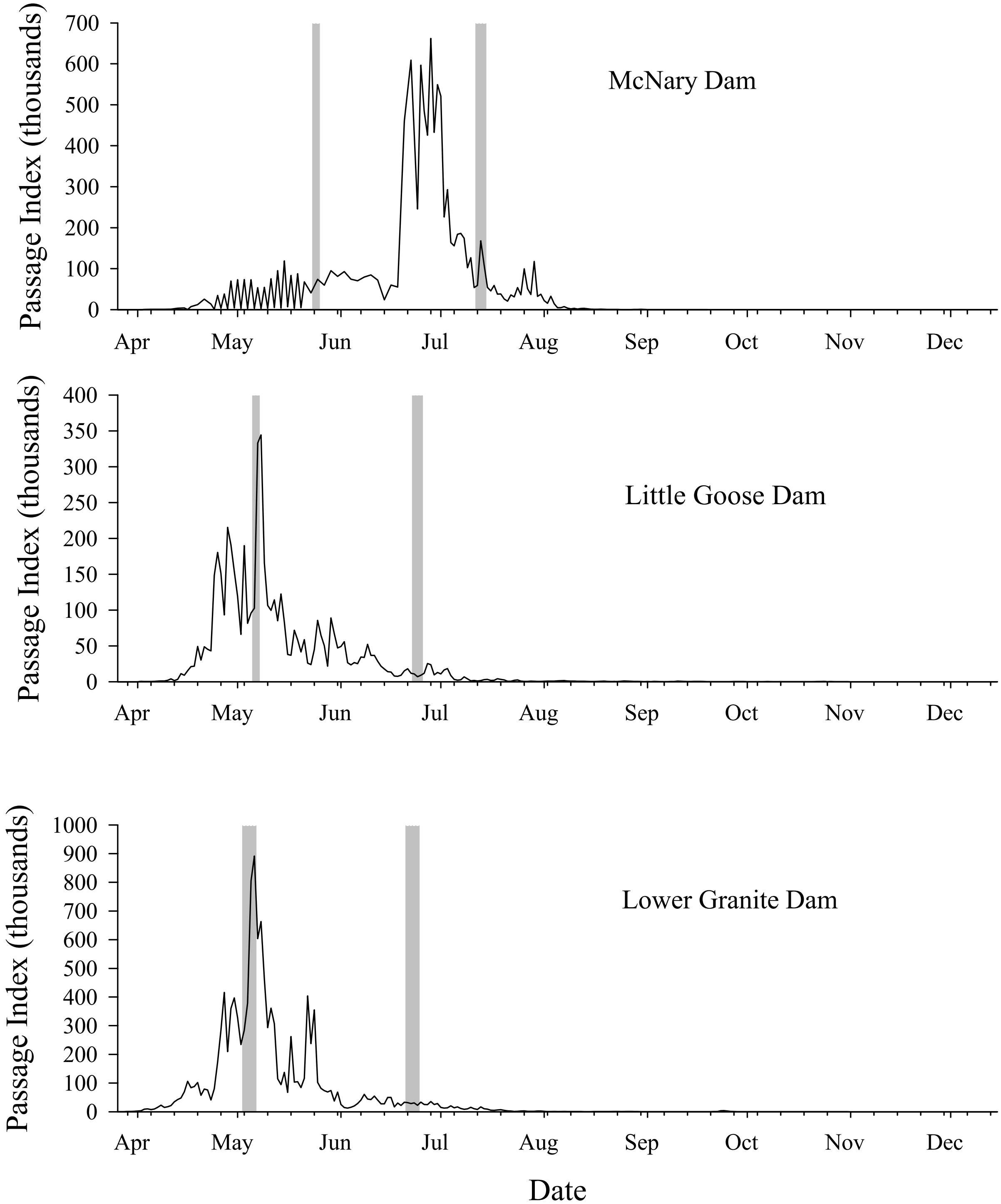
Sampling Week	Tagged	Recaptured	At-Large	Exploitation (%)
14			0	
15			0	
16			0	
17			0	
18	37		0	
19		0	37	
20		0	37	
21		0	37	
22	21	0	58	
23	1	0	59	
24		0	59	
25		0	59	
26		0	59	
27		0	59	
28		0	59	
29		1	59	1.695
30		0	58	
31		0	58	
32		0	58	
33		1	58	1.724
34		0	57	
35		0	57	
36		0	57	
37		0	57	
38		0	57	
39		0	57	
Total	59	2		3.420

APPENDIX B

Timing of 2004 Index Sampling in Relation to Juvenile Salmonid Passage Indices at Lower Columbia and Snake River Dams



APPENDIX FIGURE B-1.—Timing of index sampling with respect to juvenile salmonid passage indices at Bonneville and John Day dams in 2004. Shaded areas indicate dates when sampling occurred in the reservoir.



APPENDIX FIGURE B-2.—Timing of index sampling with respect to juvenile salmonid passage indices at McNary, Little Goose, and Lower Granite dams in 2004. Shaded areas indicate dates when sampling occurred in the reservoir.

APPENDIX C

Electrofishing Catch Per Unit Effort (CPUE) for Northern Pikeminnow in the Lower Columbia and Snake Rivers, 1990-1996, 1999, and 2004, and for Smallmouth Bass in Spring and Summer 2004

APPENDIX TABLE C-1.—CPUE of northern pikeminnow ≥ 250 mm fork length in the lower Columbia and Snake Rivers. rkm = river kilometer; BRZ = boat-restricted zone, -- = not sampled.

	CPUE								
Reservoir or Reach, area	1990	1991	1992	1993	1994	1995	1996	1999	2004
Below Bonneville Dam									
rkm 114-121	--	--	1.3	--	1.0	0.9	0.8	0.6	0.7
rkm 172-178	--	--	1.6	--	1.8	1.4	1.5	0.9	0.6
rkm 190-197	--	--	2.4	--	1.7	1.1	1.3	1.4	1.1
Tailrace	5.8	--	3.4	9.6	2.9	2.2	2.8	3.5	1.6
Tailrace BRZ	13.7	--	12.9	14.5	18.9	4.6	5.8	--	11.8
Bonneville									
Forebay	5.7	--	--	2.2	2.4	2.4	1.3	1.0	0.9
Mid-reservoir	2.1	--	--	1.2	0.7	1.0	0.7	0.3	0.3
Tailrace	0.5	--	--	1.1	0.6	1.1	0.8	0.8	1.7
Tailrace BRZ	5.5	--	--	1.5	6.8	--	--	--	--
The Dalles									
Forebay	1.1	--	--	1.2	0.6	0.6	0.4	--	--
Tailrace	2.8	--	--	0.7	0.7	1.6	3.7	0.8	0.4
Tailrace BRZ	21.5	--	--	10.8	5.5	3.5	1.0	--	--
John Day									
Forebay	0.7	0.7	1.3	0.6	0.7	0.3	0.3	0.2	<0.1
Mid-reservoir	0.3	0.2	0.3	0.2	0.1	0.1	0.1	--	0.0
Tailrace	0.8	0.8	0.1	0.5	0.3	0.3	0.5	0.2	0.1
Tailrace BRZ	14.7	17.9	9.2	13.3	2.4	--	--	--	--
Lower Monumental									
Tailrace	--	1.5	--	--	0.3	0.1	0.2	0.0	0.1
Tailrace BRZ	--	16.3	--	--	1.2	3.9	1.0	0.0	0.8
Little Goose									
Tailrace	--	1.6	--	--	0.5	0.1	0.3	0.3	0.3
Tailrace BRZ	--	28.3	--	--	6.4	10.3	1.0	0.0	3.3
Lower Granite									
Upper reservoir	--	1.9	--	--	0.5	0.2	0.3	0.2	0.1

APPENDIX TABLE C-2.— Spring and summer 2004 CPUE for smallmouth bass ≥ 200 mm fork length in the lower Columbia and Snake rivers. rkm = river kilometer; -- = not sampled.

Reservoir or Reach, area	CPUE	
	Spring	Summer
Below Bonneville Dam		
rkm 114-121	0.0	0.1
rkm 172-178	1.6	0.2
rkm 190-197	0.8	0.8
Tailrace	1.4	0.5
Bonneville		
Forebay	0.7	--
Mid-reservoir	--	1.6
Tailrace	2.9	2.0
John Day		
Forebay	11.3	8.8
Mid-reservoir	3.0	--
Tailrace	--	1.7
Lower Granite		
Upper reservoir	1.8	2.4

APPENDIX D

2004 Sampling dates

APPENDIX TABLE D-1.—Dates of each sampling week in 2004.

Sampling Week	Dates	Sampling Week	Dates
14	29 March – 4 April	27	28 June – 4 July
15	5 April – 11 April	28	5 July – 11 July
16	12 April – 18 April	29	12 July – 18 July
17	19 April – 25 April	30	19 July – 25 July
18	26 April – 2 May	31	26 July – 1 August
19	3 May – 9 May	32	2 August – 8 August
20	10 May – 16 May	33	9 August – 15 August
21	17 May – 23 May	34	16 August – 22 August
22	24 May – 30 May	35	23 August – 29 August
23	31 May – 6 June	36	30 August – 5 September
24	7 June – 13 June	37	6 September – 12 September
25	14 June – 20 June	38	13 September – 19 September
26	21 June – 27 June	39	20 September – 26 September