Document ID #P137011
Report was completed under BPA contract #61037

REPORT ON THE PREDATION INDEX, PREDATOR CONTROL FISHERIES, AND PROGRAM EVALUATION FOR THE COLUMBIA RIVER BASIN EXPERIMENTAL NORTHERN PIKEMINNOW MANAGEMENT PROGRAM

2013 ANNUAL REPORT

Prepared by:

Steve Williams

Pacific States Marine Fisheries Commission

In Cooperation with:

Oregon Department of Fish and Wildlife
Washington Department of Fish and Wildlife

Funded By:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621
Project Number 1990-077-00
Contract Number 56795

Table of Contents

List of Tables

Main Tables

Appendix Tables

List of Figures

2013 Executive Summary
by

Steve Williams

This report presents results for year twenty-four in the basin-wide Experimental Northern Pikeminnow Management Program to harvest northern pikeminnow[1] (Ptychocheilus oregonensis) in the Columbia and Snake Rivers. 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 long-line fishery in the John Day Pool in 1990. We also conducted an hook and line 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 long-line 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 long-line 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 long-line 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 trapnets and gillnets at specific locations where concentrations of northern pikeminnow were known or suspected to occur during the spring season (*i.e.*, March through early June). In addition, we initiated a concerted effort to increase public participation in the sport-reward fishery through a series of promotional and incentive activities. In 1995, 1996, and 1997, promotional activities and incentives were further improved based on the favorable

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

response in 1994. Results of these and other lessons learned over the 24 year period 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.

4. **WDFW (Report D)**: Dam angling at The Dalles and John Day dams.

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 2013 by report are as follows:

Report A

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

1. The objectives of the 2013 NPSRF were to (1) implement a public fishery that rewards recreational anglers for harvesting northern pikeminnow $\geq$ 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 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 Passive Integrated Transponder (PIT) tags implanted into northern pikeminnow by ODFW as secondary tags, and/or from northern pikeminnow containing consumed salmonids with PIT tags, and (6) survey non-returning fishery participants targeting northern pikeminnow in order to obtain catch and harvest data on fish species caught.

2. A total of 162,079 northern pikeminnow $\geq$ 228 mm were harvested during the 2013 NPSRF season. Of these, 162 northern Pikeminnow had both an external ODFW spaghetti tag and internal PIT tags and 101 that were found with ODFW PIT tags but missing spaghetti tags. An additional 74 PIT tags were recovered from juvenile Salmonids ingested by northern Pikeminnow received during the 2013 NPSRF. A total of 2,618 different anglers spent 20,082 angler days participating in the fishery during the 2013 season.

3.

Report B

Northern Pikeminnow Sport-Reward Fishery Payments

1. For 2013 the rewards paid to anglers were the same as in the 2012 season. Anglers were paid $4, $5, and $8 per fish for the three payment tiers (up to 100 fish, 101-400 fish and 401 and up) during the season. The rewards for a tagged fish were $500 per fish.

2. During 2013, excluding tagged fish, rewards paid totaled $1,052,171 for 160,596 fish.

3. A total of 161 tagged fish vouchers were paid. The total season tag rewards paid totaled $80,500.

4. The total value for all 160,757 northern pikeminnow submitted for payment in 2013 was $1,138,251.

5. A total of 874 separate successful anglers caught one or more fish and received payments during the season. A total of 2,618 separate anglers registered to fish, of which 33.4% returned vouchers for payment.

Report C

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

1. Primary objectives in 2013 were to: (1) evaluate exploitation rates of northern pikeminnow and potential reduction in predation on juvenile salmonids resulting from the targeted removal fisheries; (2) characterize population dynamics of northern pikeminnow, smallmouth bass *Micropterus dolomieu* and walleye *Sander vitreus* in the lower Snake River reservoirs; and (3) assess evidence of possible intra- and inter-specific compensatory responses by these predators related to the sustained removal of northern pikeminnow

2. After correcting for an observed rate of tag loss (1.1%), system-wide exploitation of northern pikeminnow greater than or equal to 250 mm fork length was 10.8% (95% confidence interval 6.9–14.7%).

2. Model-predicted reduction in predation was equivalent to a 35% from pre-program levels.

3. Biological indexing was conducted in areas of four the lower Snake River reservoirs (Ice Harbor, Lower Monumental, Little Goose and Lower Granite) to evaluate dynamics in select predator populations. We were able to evaluate (i.e., $n \geq 6$) consumption and predation for northern pikeminnow only in Lower Granite Reservoir during spring, where index values where the largest estimated since the early 1990s.

4. During spring and summer sampling events, smallmouth bass abundance was greatest in the mid-reservoir areas of the Snake River reservoirs sampled. Consumption index values for smallmouth bass were similar to those observed in preceding years. Across reservoirs, the most frequently occurring taxa observed in smallmouth diet samples were sand rollers ($\hat{p}_{max}$ = 0.56; Family: Percopsidae) and sculpins ($\hat{p}_{max}$ = 0.36; Family: Cottidae). Proportions of smallmouth bass diet samples containing juvenile salmon ranged from 0.08 to 0.18 across reservoirs. Proportional stock density values for smallmouth bass varied among reservoirs sampled (mean = 19 ± 7.1%) with the largest value occurring at Ice Harbor and Lower Monumental (24%) and the smallest at Lower Granite Reservoir (9%). Median relative weight values for smallmouth bass occupied a relatively narrow range (93 – 98).

5. As in previous years, walleye were encountered only in the mid-reservoir and tailrace areas of Lower Monumental Reservoir, where spring and summer abundance index values exceeded those calculated for 2010. Juvenile Pacific salmon generally were encountered infrequently in gut content samples of walleye in Lower Monumental Reservoir ($\hat{p}$ = 0.09) whereas minnows (Family: Cyprinidae) were encountered regularly ($\hat{p}$ = 0.64)

6. We evaluated 212 and 451 northern pikeminnow diet samples collected during angling activities at The Dalles and John Day dams, respectively. Fish were the primary prey type consumed by northern pikeminnow captured at both The Dalles and John Day dams.

Across months, juvenile salmon and American shad were encountered in the greatest number of northern pikeminnow diet samples ($\hat{p}_{max}$ = 0.74 and 0.84, respectively).

7. Increasing abundance index values for non-native piscivores in some areas of the Snake River reservoirs may be an early indication of a localized compensatory response to northern pikeminnow removal. Given the fragmented nature of these systems, we recommend monitoring efforts continue to assess localized trends in predator populations throughout the Columbia and Snake rivers to help elucidate potential net (system-wide) effects.

Report D

Dam angling at The Dalles and John Day dams

1. The 22 week fishery took place at The Dalles and John Day dams from May 1st to October 4th, 2013.

2. The project objectives were to: (a) implement a recreational-type hook and line fishery that harvests northern pikeminnow from within the boat restricted areas (BRZ) which are unavailable to the public at The Dalles and John Day dams, (b) allocate Dam Angler effort between The Dalles and John Day dams based on angler CPUE in order to maximize harvest of northern pikeminnow, (c) collect, compile and report data on angler harvest, CPUE, gear/techniques and incidental catch for each project, (d) scan, record and report Passive Integrated Transponder (PIT) tag data from all northern pikeminnow, smallmouth bass, walleye, and channel catfish caught by the angling crew, (e) Record the presence of any external spaghetti tags, fin-clips, or signs of tag loss from these fishes for use in coordination with other Oregon Department of Fish and Wildlife (ODFW) predation studies, (f) collect relevant biological data on all northern pikeminnow and other fishes caught by the 2013 Dam Angling crew.

3. Harvests for the 22 week fishery totaled 4039 northern pikeminnow at the two dams with 1,679 fish harvested at The Dalles dam and 2,360 fish at John Day dam. The total fishing time at the two dams was 1,472 hours for a combined overall average catch per angler hour of 2.74 fish. The catch at The Dalles dam was 2.95 fish per angler hour and at John Day dam, 2.62 fish per angler hour.

4. Back bouncing soft plastic lures were found to be the most effective method for harvesting northern pikeminnow from both dams.

5. Incidental species most frequently caught and released at both dams were smallmouth bass *Micropterus dolomieue*, white sturgeon *Acipenser transmontanus* and Sculpin *Cottus* spp.

6. The mean fork length of northern pikeminnow caught from The Dalles Dam was 324.2 mm and 352.5 mm at John Day dam.

REPORT A

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

2013 Annual Report

Prepared by

John D. Hone
Eric C. Winther
Paul V. Dunlap

Washington Department of Fish and Wildlife
600 Capital Way N
Olympia, WA 98501-1091

Funded by

U. S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
Portland, Oregon 97208-3621

Project No. 1990-077-00
Contract No. 00046941

March 2014

ACKNOWLEDGEMENTS

This project is funded by the Bonneville Power Administration (BPA), William Maslen, Project Manager, John Skidmore and David Roberts, COTR (Contract DE-BI719-94BI24514). We thank Erick VanDyke, Adam Storch and their 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 coordination.

We are thankful 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 City of Vancouver Parks and Recreation Department for the use of the Marine Park (PORTCO) boat ramp; the Cowlitz County Parks and Recreation Department for the use of the Willow Grove boat ramp; the Port of Bingen for the use of Bingen Marina; The Port of Camas/Washougal for the use of the Camas/Washougal boat ramp; the Port of Cascade Locks for the use of Marine Park; the Port of Cathlamet for the use of the Cathlamet Marina; the Port of Kalama for the use of the Kalama Marina; the Port of Ridgefield for the use of the Ridgefield boat ramp; the Port of The Dalles for the use of The Dalles Boat Basin; the Port of Umatilla for the use of the Umatilla Marina; 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 Washington Department of Transportation for the use of the Vernita Bridge Rest Area; Washington State Parks for the use of Beacon Rock and Maryhill State Parks; Jim MacArthur for the use of Lyon's Ferry Marina; and Dave and Linda Petersen for the use of Boyer Park.

We appreciate the efforts of Dick Buitenbos, Justin Burrus, Bryan Chambers, Kevin Clawson, Ryan Crane, Mark Flahaut, Bill Fleenor, Leif Fox, Roger Fox, Josh Fross, Travis Harwood, Jeff Lesselyoung, Steve Lines, Adam McCament, Eric Meyer, Glen Murray, Ruthanna Shirley, Mark Southern, Jason Swindle, Kathy Thompson, John Paul Viviano, Robert Warrington, Alyce Wells, Dennis 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, Mike Luepke for his rendering services, Kristine Hand for her numerous phone survey interviews, Kathleen Moyer for serving as the lead technician for the PIT tag recovery portion of the program, and Melissa Dexheimer for producing our weekly field activity reports, reconciling vouchers, and overseeing the Sport-Reward hotline throughout the season.

This project is funded by the Bonneville Power Administration (project number 1990-077-00) and the COTR is John Skidmore and David Roberts. Russell Porter of Pacific States Marine Fish Commission (PSMFC) administered the contract.

ABSTRACT

We are reporting on the progress of the Northern Pikeminnow Sport-Reward Fishery (NPSRF) implemented by the Washington Department of Fish and Wildlife (WDFW) on the Columbia and Snake Rivers from May 1 through September 30, 2013. The objectives of this project were to (1) implement a recreational fishery that rewards recreational anglers for harvesting northern pikeminnow $\geq$ 228mm (9 inches) total length (TL), (2) collect, compile, and report data on angler participation, catch and harvest of northern pikeminnow and other fish species, as well as success rates of participants 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 Passive Integrated Transponder (PIT) tags implanted into northern pikeminnow by ODFW as secondary tags, and/or from northern pikeminnow containing consumed salmonids with PIT tags, and (6) survey non-returning NPSRF participants targeting northern pikeminnow in order to obtain catch and harvest data on northern pikeminnow and other specified fish species.

A total of 162,079 northern pikeminnow $\geq$ 228 mm and 4,014 pikeminnow < 228 mm were harvested during the 2013 NPSRF season. There were a total of 2,618 different anglers who spent 20,082 angler days participating in the fishery during the 2013 season. Catch per unit effort for combined returning and non-returning anglers was 8.07 fish/angler day. The Oregon Department of Fish and Wildlife (ODFW) estimated that the northern pikeminnow harvest activities from the 2013 NPSRF resulted in an overall exploitation rate of 10.8% (Barr et. al. 2014).

Anglers submitted 162 northern pikeminnow with both external ODFW spaghetti tags and internal PIT tags. There were also 101 northern pikeminnow with ODFW PIT tags only, but missing spaghetti tags. An additional 74 PIT tags were recovered from juvenile salmonids (as well as our first ever recovery from a juvenile lamprey) ingested by northern pikeminnow received during the 2013 NPSRF.

Peamouth *Mylocheilus caurinus,* smallmouth bass *Micropterus dolomieue,* and sculpin *Cottus* spp, were the fish species most frequently caught by NPSRF anglers targeting northern pikeminnow. The incidental catch of salmonids *Oncorhynchus* spp, by participating anglers targeting northern pikeminnow continued to remain below established limits for the Northern Pikeminnow Management Program (NPMP).

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 FL (11 inches total length). The Northern Pikeminnow Management Program (NPMP) was created in 1990, with the goal of implementing fisheries to achieve the recommended 10-20% annual exploitation on northern pikeminnow >275 mm FL within the program area (Vigg and Burley 1989). In 2000, NPMP administrators reduced the minimum size for eligible (reward size) northern pikeminnow to 228 mm FL (9 inches total length) in response to recommendations contained in a review of NPMP justification, performance, and cost-effectiveness (Hankin and Richards 2000). Beginning in 1991, the Washington Department of Fish and Wildlife (WDFW) was contracted to conduct the NPSRF component of the NPMP (Burley et al. 1992). The NPSRF enlists recreational anglers to harvest reward sized ($\geq$9" total length) northern pikeminnow from within program boundaries on the Columbia and Snake Rivers using a monetary reward system. Since 1991, anglers participating in the NPSRF have harvested nearly 4 million reward sized northern pikeminnow and spent over 824,000 angler days of effort to become 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).

The 2013 NPSRF maintained the tiered angler reward system first implemented in 1995 (Hisata et al. 1995) which paid anglers higher rewards per fish based on achieving designated harvest levels and a separate bonus reward for returning northern pikeminnow spaghetti tagged by the Oregon Department of Fish and Wildlife (ODFW) as part of the NPSRF's biological evaluation. Catch and harvest data were collected from returning anglers, and non-returning anglers in order to monitor the effects of the NPSRF on other Columbia basin fishes.

The objectives of the 2013 NPSRF were to (1) implement a public fishery that rewards recreational anglers for harvesting northern pikeminnow $\geq$ 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 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 Passive Integrated Transponder (PIT) tags implanted into northern pikeminnow by ODFW as secondary tags, and/or from northern pikeminnow containing consumed salmonids with PIT tags, and (6) survey non-returning fishery participants targeting northern pikeminnow in order to obtain catch and harvest data on northern pikeminnow and other specified fish species.

METHODS OF OPERATION

Fishery Operation

Boundaries and Season

The 2013 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 caught in backwaters, sloughs, and up to 400 feet from the mouth of tributaries within this area. The NPSRF was fully implemented, with all stations except Gleason operating during a regular season from May 1 through September 30, 2013. The Gleason station did not open until week 28 due to boat ramp and park renovation.

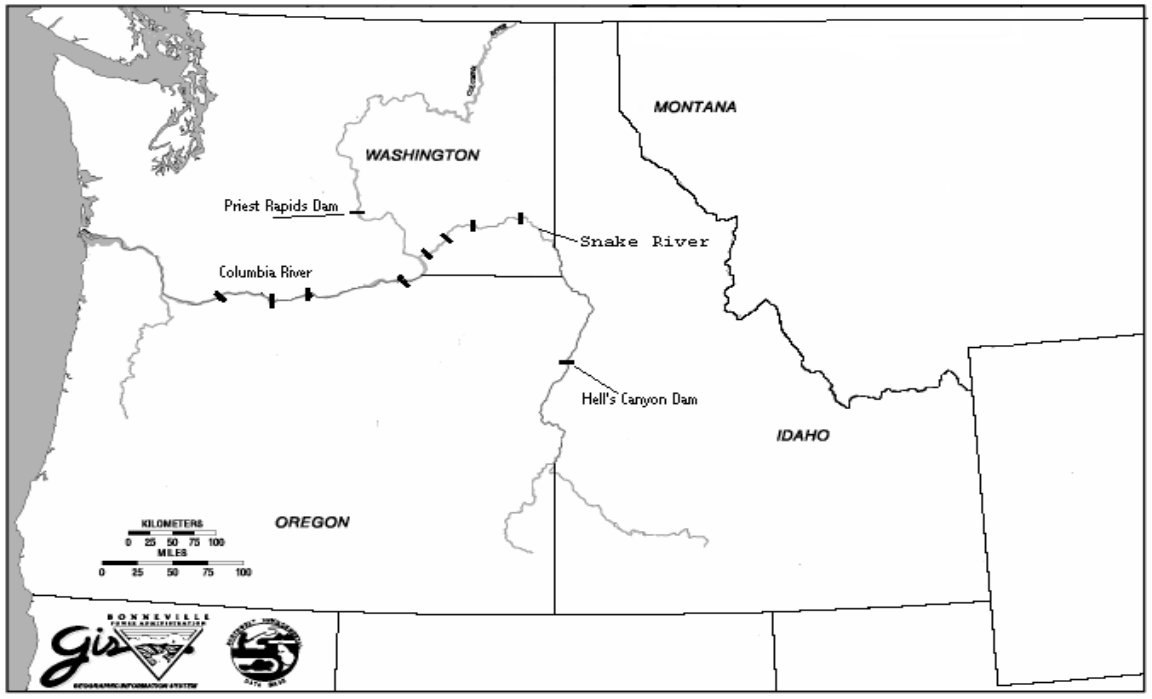


Figure 1. Northern Pikeminnow Sport-Reward Fishery Program Area

Registration Stations

Twenty-one 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 registration stations daily (seven days a week) at designated locations (normally public boat ramps or parks) which were available to anglers at specified times of between two and six hours per day during

the season. Technicians registered anglers to participate in the NPSRF, collected angler 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.

1. Cathlamet Marina (10am-1:30 pm)
2. Willow Grove Boat Ramp (2-5 pm)
3. Rainier Marina (9:30am-12:30 pm)
4. Kalama Marina (1pm-3 pm)
5. Ridgefield (3:30pm-5:30pm)
6. M. James Gleason Boat Ramp (12pm-5:30 pm)
7. Portco Boat Ramp (4pm-6pm)
8. Chinook Landing (9am-11:30am)
9. Washougal Boat Ramp (9:30am-3:30 pm)
10. Beacon Rock (9:30am-12:30pm)
11. Cascade Locks Boat Ramp (1pm-5:30 pm)
12. Bingen Marina (9am-12:30pm)
13. The Dalles Boat Basin (9am-3pm)
14. Maryhill (3:30pm-5:30pm)
15. Giles French (1:30pm-5:30 pm)
16. Umatilla Marina (4pm-6 pm)
17. Columbia Point Park (2pm-6:30 pm)
18. Vernita Bridge (10am-2:30 pm)
19. Lyon's Ferry (10:30am-12:30pm)
20. Boyer Park (10:30 am-2 pm)
21. Greenbelt (3:30pm-6:30 pm)

Figure 2. 2013 Northern Pikeminnow Sport Reward Fishery Registration Stations

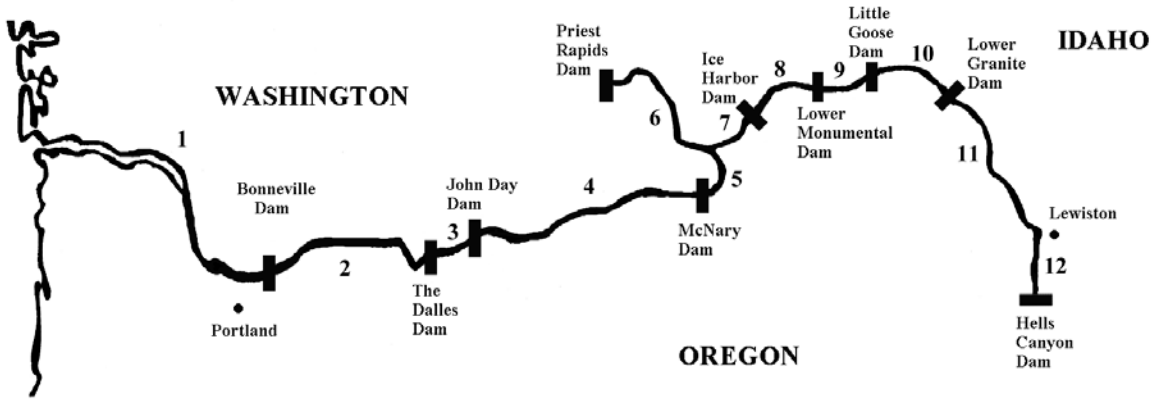
Reward System

The 2013 NPSRF rewarded anglers for harvesting northern pikeminnow $\geq$ 228mm TL (9 inches) and maintained the tiered angler reward system developed in 1995 (Hisata et al. 1995) which 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. WDFW 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 to the angler by PSMFC. During the 2013 season, the NPSRF retained the pay levels first used in 2004 (Hone et al. 2004) which paid anglers $4 each for their first 100 northern pikeminnow, $5 each for numbers 101-400, and $8 each for all fish over 400. Anglers were paid $500 for each northern pikeminnow which retained a valid spaghetti tag used by ODFW for the biological evaluation of the NPMP.

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. Anglers were asked if they specifically fished for northern pikeminnow at any time during their fishing trip. A "No" response ended the exit interview. A "Yes" response prompted technicians to ask the angler (and record data), 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".



Fishing Locations:

1. Below Bonneville Dam
2. Bonneville Reservoir
3. The Dalles Reservoir
4. John Day Reservoir
5. McNary Reservoir to the Mouth of the Snake River
6. Mouth of the Snake River to Priest Rapids Dam
7. Mouth of the Snake River to Ice Harbor Dam
8. McNary Reservoir
9. Lower Monumental Reservoir
10. Little Goose Reservoir
11. Lower Granite Reservoir to the Mouth of the Clearwater River
12. Mouth of Clearwater River to Hell's Canyon Dam

Figure 3. Fishing location codes used for the 2013 Northern Pikeminnow Sport-Reward Fishery

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 were 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 surveyed a minimum of 20% of the NPSRF's non-returning anglers using a telephone survey 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. Anglers were asked: "did you specifically fish for northern pikeminnow at any time during your fishing trip?" With a "Yes" response, anglers were asked to report the number and species of adult and/or juvenile salmonids and the number of reward size northern pikeminnow that were caught and harvested/released while they targeted northern pikeminnow. Angler catch and harvest data were not collected from non-returning anglers who did not target northern pikeminnow on their fishing trip. Non-returning angler catch and harvest data for non-salmonid species were not collected in 2013 because they were collected in 2010 and trends for these species have remained consistent over the NPSRF's previous 22 year history (Winther et al. 1996). These data will be collected again in 2015 to identify any variance from non-returning angler trends observed to date within the Sport-Reward Fishery.

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 checked all northern pikeminnow for the presence of external tags (spaghetti or dart), fin-clip marks, and signs of tag loss. Fork lengths (FL) and sex of northern pikeminnow as well as any other harvested fish species were recorded whenever possible. Complete biological data were collected from all tag-loss and spaghetti tagged northern pikeminnow including FL, sex (determined by evisceration), and scale samples (if specified). Spaghetti tagged and tag-loss northern pikeminnow carcasses were then labeled and frozen for data verification and/or tag recovery at a later date. Data from spaghetti tags were recorded on a tag envelope as well as on WDFW data forms. The spaghetti tag was then placed in the tag envelope, stapled to the tag payment voucher and given to the angler to submit to ODFW for verification.

PIT Tag Detection

All northern pikeminnow collected during the 2013 NPSRF were also scanned for passive integrated transponder (PIT) tags. Northern pikeminnow harvested by anglers participating in the NPSRF have been found to ingest juvenile salmonids which have been PIT tagged by other studies within the basin (Glaser et al. 2000). In addition, PIT tags have also been used by ODFW as a secondary mark in all northern pikeminnow fitted with spaghetti tags (beginning in 2003) as part of the NPMP's biological evaluation activities (Takata and Koloszar 2004). The use of PIT tags rather than fin clips as a secondary mark in northern pikeminnow was intended to improve the NPSRF's estimate of tag loss, and result in a more accurate estimate of exploitation for the NPSRF. WDFW technicians were required to scan 100% of all northern pikeminnow returned to registration stations for PIT tags using PIT tag "readers". Northern Pikeminnow submitted for payment to the NPSRF were scanned using 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). Scanning began on the first day of the NPSRF season and continued at all stations throughout the rest of the season. Technicians individually scanned all reward sized northern pikeminnow for PIT tag presence, and complete biological data were recorded from all 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 all PIT tag recovery data were provided to ODFW and the Pit Tag Information System (PTAGIS) on a regular basis.

Northern Pikeminnow Processing

During biological sampling, all northern pikeminnow were either eviscerated (to determine sex), or caudal clipped as an anti-fraud measure to eliminate the possibility of previously processed northern pikeminnow being resubmitted for payment. As in recent years, most northern pikeminnow harvested in 2013 were caudal clipped rather than eviscerated in order to facilitate more accurate recovery of 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 23 week NPSRF harvested a total of 162,079 reward size northern pikeminnow (≥ 228 mm TL) during the 2013 season. Because week 40 consisted of only one day (9/30/2013), the 2013 NPSRF was basically the same length as the 2012 NPSRF (Hone et al. 2012) and harvest was 3,920 fish higher than 2012 harvest (Figure 4). Harvest remained lower than the mean 1991-2012 harvest of 174,224 fish, but was above the season average for the five most recent years. 2013 NPSRF harvest achieved an exploitation rate of 10.8% (Barr et. al. 2014), which successfully reached the 10-20% exploitation target of NPMP. In addition to harvesting 162,079 reward size northern pikeminnow, the 2013 NPSRF also harvested 4,014 northern pikeminnow < 228 mm TL.

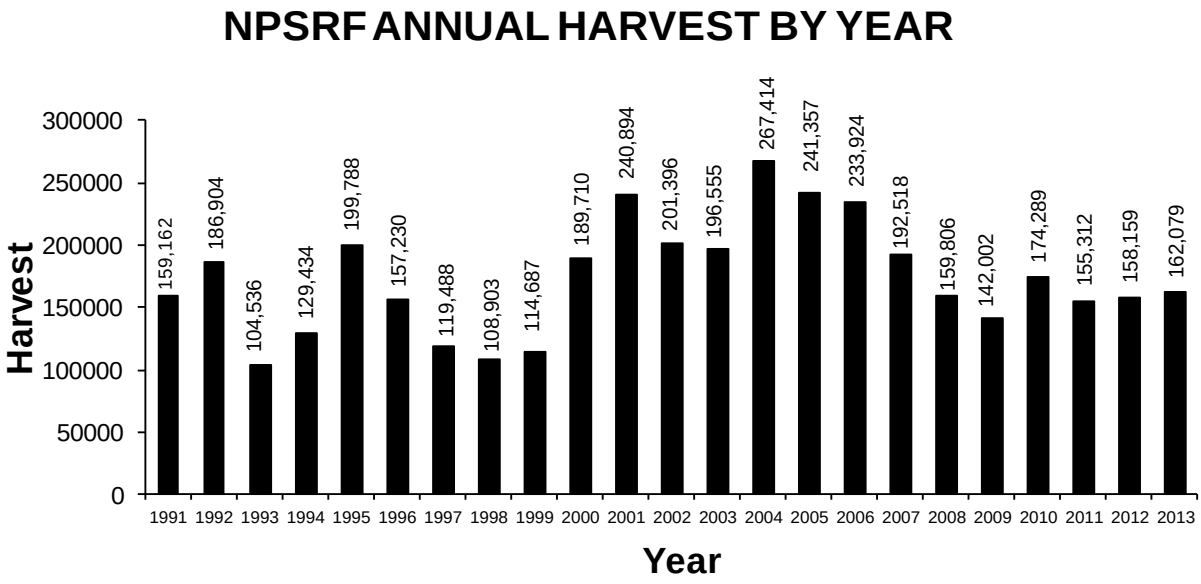


Figure 4. Annual Harvest Totals for the Northern Pikeminnow Sport Reward Fishery

Harvest by Week

Peak weekly harvest for the 2013 NPSRF was 11,423 fish which was higher than the 2012 peak weekly harvest of 10,163 and occurred during week 26 of the season (Figure 5). Mean weekly harvest was 7,047 fish which was down from the 2012 mean of 7,189. Peak harvest occurred the same week as 2012 and weekly harvest totals for the 2013 NPSRF were generally higher than the weekly totals for 2012 with the exception of the last 5 weeks of the season (Figure 6). Peak harvest matched the NPSRF's historical 1991-2012 peak in week 26 (Fox et al. 1999) and overall the 2013 weekly harvest followed the trend of the 1991-2012 weekly harvest levels (Figure 7).

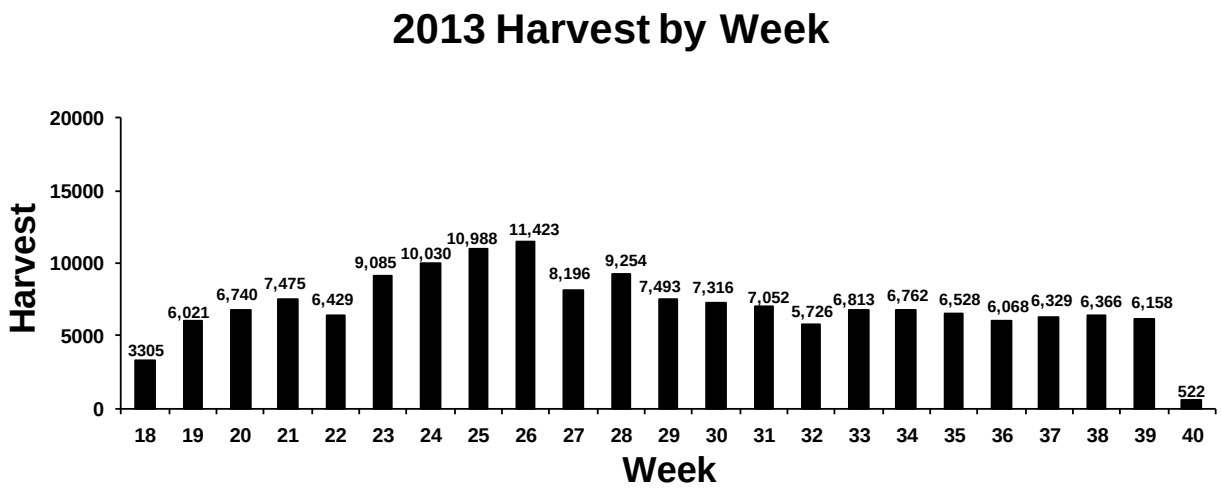


Figure 5. 2013 Weekly Northern Pikeminnow Sport-Reward Fishery Harvest.

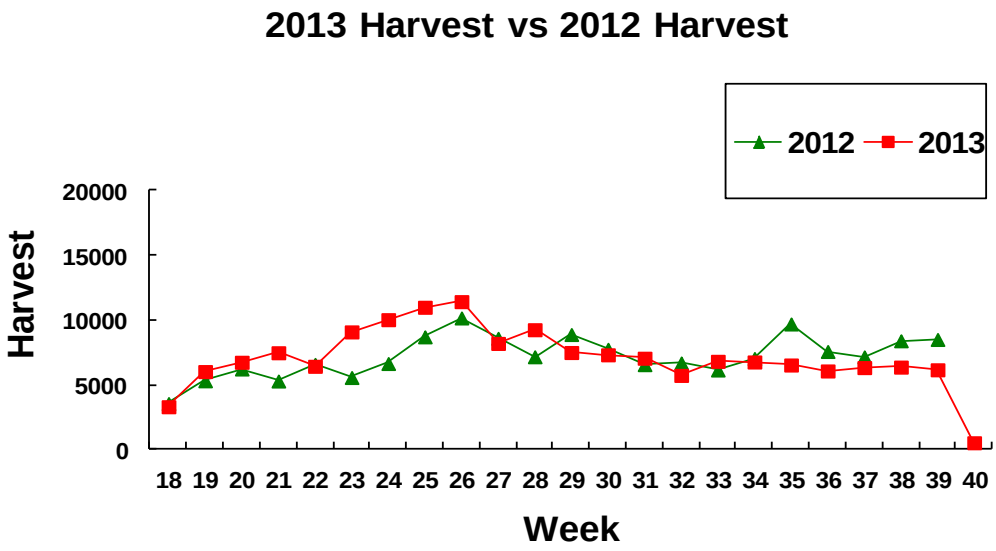


Figure 6. 2013 Weekly NPSRF Harvest vs. 2012 Weekly Harvest.

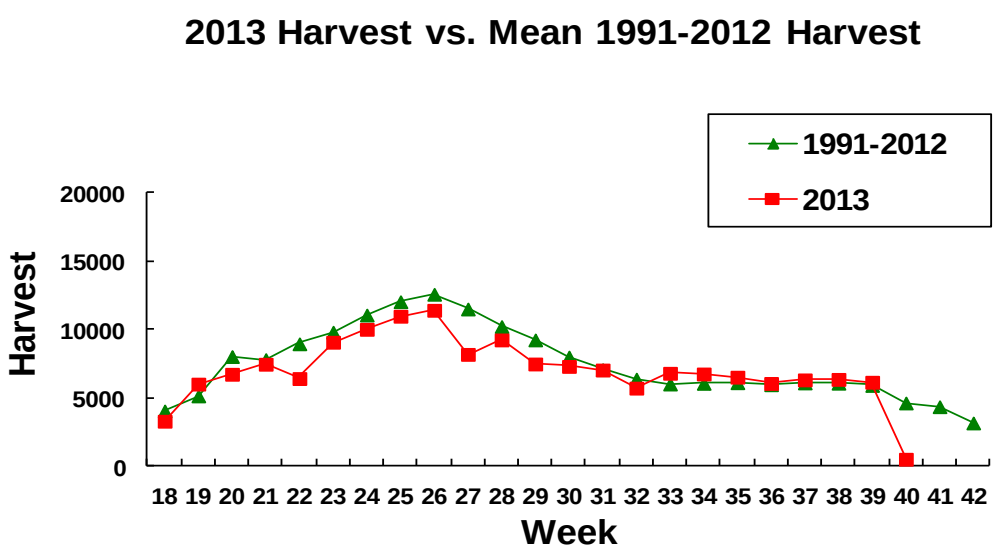


Figure 7. Comparison of 2013 NPSRF Weekly Harvest to 1991-2012 Mean Weekly Harvest.

Harvest by Fishing Location

The mean harvest by fishing location for the 2013 NPSRF was 13,507 northern pikeminnow and ranged from 55,530 reward size northern pikeminnow harvested from fishing location 01 (Below Bonneville Dam) to 48 northern pikeminnow harvested from fishing location 11 (Lower Granite Dam to the mouth of the Clearwater River) (Figure 8). Harvest from fishing location 01 (the Columbia River below Bonneville Dam) accounted for 34% of the total NPSRF harvest and has been the highest producing location for all but one season since the NPSRF was implemented in 1991. Fishing location 02 (Bonneville Reservoir) accounted for 21% of the total 2013 NPSRF harvest. Fishing location 10 (Little Goose Reservoir) accounted for 16% of the total 2013 NPSRF harvest and Fishing location 12 (Mouth of the Clearwater River to Hell's Canyon Dam) produced 9% of the total harvest.

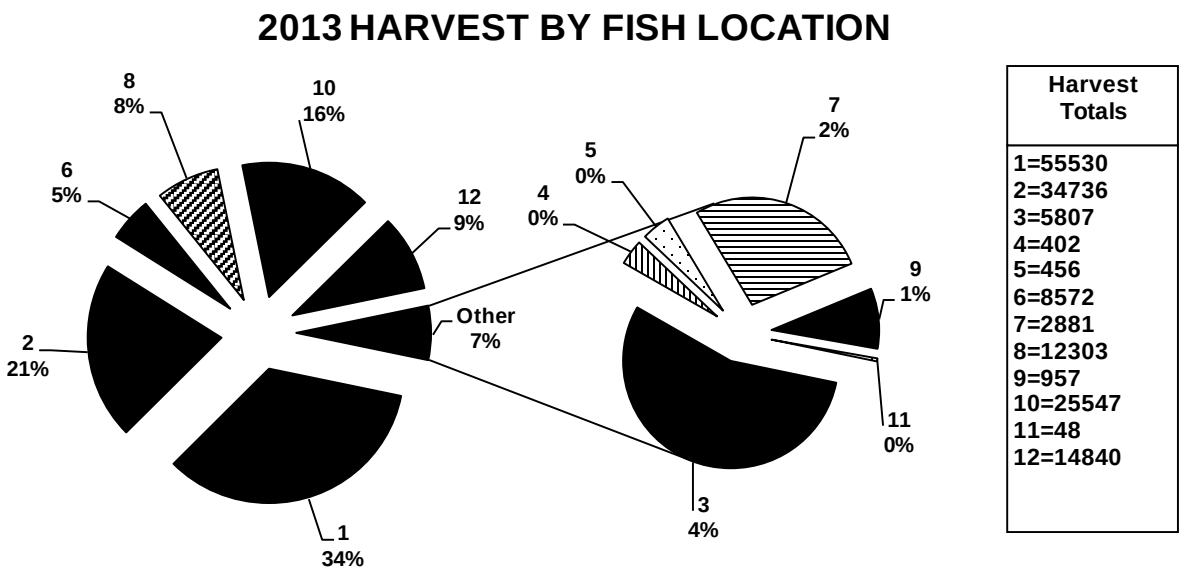


Figure 8. 2013 Northern Pikeminnow Sport-Reward Fishery Harvest by Fishing Location.*
*Fishing Location Codes for Columbia River; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the Snake River to Priest Rapids Dam. Fishing Location Codes for the Snake River; 7 = Mouth of the Snake River to Ice Harbor Dam, 8 = Ice Harbor Reservoir, 9 = Lower Monumental Reservoir, 10 = Little Goose Reservoir, 11 = Lower Granite Dam to the mouth of the Clearwater River, 12 = Mouth of the Clearwater River to Hell's Canyon Dam.

Harvest by Registration Station

Harvest in 2013 was up (from 2012 levels) at 10 of the 21 registration stations operated during the 2012 NPSRF. The Dalles registration station retained the title of the NPSRF's top producing station for a third season as anglers harvested 26,389 northern pikeminnow, equaling 16.3% of the total 2013 NPSRF harvest (Figure 9). Boyer Park, was a close second place with 24,986 northern pikeminnow harvested in 2013. The average harvest per registration station was 7,718 reward size northern pikeminnow, up from 7,531 per station in 2012. The registration station with the smallest harvest was Maryhill where anglers harvested 620 northern pikeminnow during the 2013 season. The Boyer Park registration station showed the largest increase in harvest with 24,986 reward size northern pikeminnow, up from 13,033 in 2012.

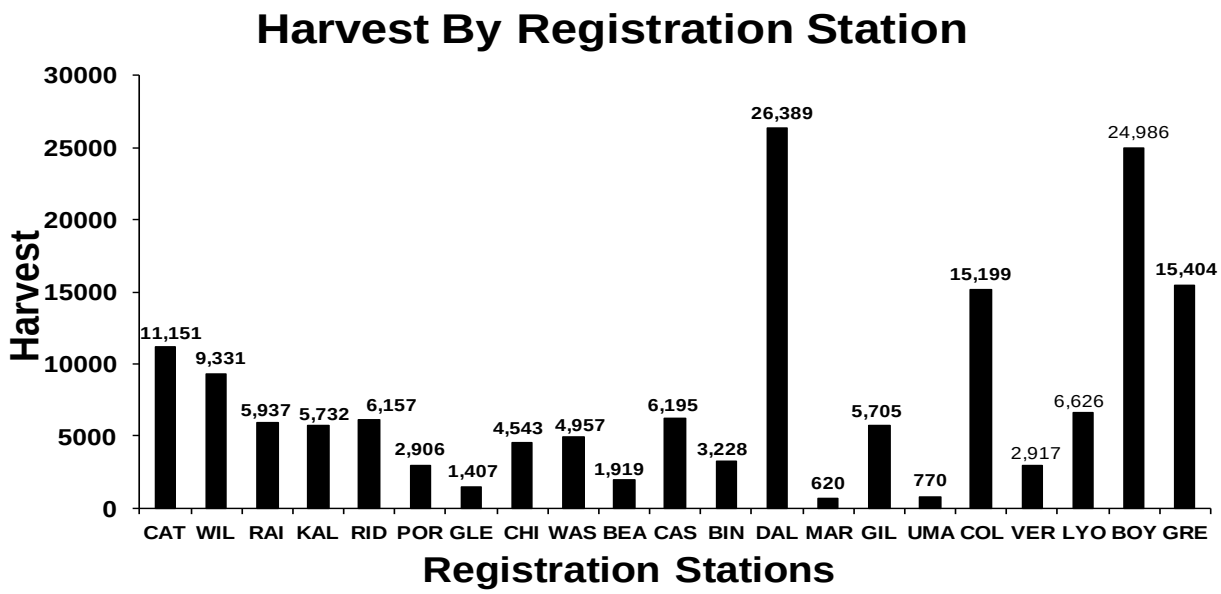


Figure 9. 2013 Northern Pikeminnow Sport-Reward Fishery Harvest by Registration Station.
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, POR-Portco, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL- The Dalles, MAR-Maryhill, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Harvest by Species/ Incidental Catch

Returning anglers

In addition to northern pikeminnow, returning anglers participating in the 2013 NPSRF reported that they incidentally caught the salmonids listed in Table 1. Incidental salmonid catch by returning NPSRF anglers consisted mostly of juvenile steelhead and juvenile chinook.

Table 1. Catch and Harvest of salmonids by Returning Anglers Targeting Northern Pikeminnow in 2013.

Salmon

Species	Caught	Harvest	Harvest Percent
Steelhead Juvenile (Hatchery)	150	0	0%
Steelhead Juvenile (Wild)	143	0	0%
Chinook(Juvenile)	82	0	0%
Trout(Unknown)	57	3	5.26%
Steelhead Adult (Wild)	40	0	0%
Steelhead Adult (Hatchery)	34	11	32.35%
Chinook (Adult)	30	2	6.76%
Chinook (Jack)	26	6	23.08%
Cutthroat(Unknown)	15	1	6.76%
Coho(Adult)	3	1	33.33%
Coho(Juvenile)	2	0	0%
Sockeye	2	0	0%

Anglers reported that all juvenile salmonids caught during the 2013 NPSRF were released. Technicians recorded all juvenile steelhead caught by NPSRF anglers (except those specifically reported as missing the adipose fin), as "wild". Harvested adult salmonids (hatchery fin-clipped chinook and steelhead with missing adipose fins) were caught incidentally during the 2013 NPSRF, but were only retained during legal salmonid fisheries. Instances where NPSRF anglers reported harvesting "trout" from the Snake River during a legal fishery are typically residualized hatchery steelhead smolts which are caught and kept by anglers and identified as "trout". Any NPSRF angler who reports illegally harvesting salmonids during the exit interview (whether juvenile or adult salmonids), are immediately reported to the appropriate enforcement entity by WDFW technicians.

Other fish species incidentally caught by returning NPSRF anglers targeting northern pikeminnow were most often peamouth, smallmouth bass, Sculpin, White Sturgeon, Yellow Perch, Channel Catfish, Suckers and Starry Flounder (Table 2).

Table 2. Catch and Harvest of non-salmonids by Returning Anglers Targeting Northern Pikeminnow in 2013.

Non-Salmonid

Species	Caught	Harvest	Harvest Percent
Northern Pikeminnow >228mm	162,108	162,079	99.98%
Northern Pikeminnow <228mm	44,366	4,014	9.05%
Peamouth	25,288	13,178	52.11%
Smallmouth Bass	8,953	917	10.24%
Sculpin (unknown)	7,474	4,895	65.49%
White Sturgeon	4,381	51	1.16%
Channel Catfish	2,291	430	18.77%
Yellow Perch	2,064	818	39.63%
Sucker (unknown)	1,337	249	18.62%
Starry Flounder	626	54	8.63%
Chiselmouth	378	53	14.02%
Walleye	269	177	65.80%
Carp	208	17	8.17%
Redside Shiner	125	20	16.0%
Catfish (unknown)	108	22	20.37%
Bluegill	79	50	63.29%
Bullhead (unknown)	67	10	14.93%
American Shad	62	24	38.71%
Sandroller	25	0	0%
Whitefish	14	0	0%
Largemouth Bass	12	3	25.0%
Pumpkinseed	4	2	50.0%

Non-returning Anglers Catch and Harvest Estimates

We randomly surveyed a total of 1,285 non-returning anglers (23% of all non-returning anglers) from participants at each of the NPSRF's 21 stations in order to survey and record their catch and/or harvest of reward sized northern pikeminnow and salmonid species. Catch and harvest data for other fish species caught by non-returning anglers were last collected in 2010 and were not collected in 2013 since harvest levels of those species by NPSRF anglers has been historically very low (Bruce et al. 2005). We anticipate once again collecting full catch and harvest data for all species from surveyed non-retuning anglers in 2015 to determine whether this trend has changed per NPMP protocol (Fox et al. 1999). Surveyed non-returning anglers targeting northern pikeminnow reported that they caught and/or harvested the fish species listed in column 1 of Table 3 during the 2013 NPSRF. A simple estimator was applied to the catch and harvest totals obtained from the surveyed anglers to obtain Total Catch and Total Harvest estimates for all non-returning anglers participating in the 2013 NPSRF. Estimated totals are listed in columns 4 and 5 of Table 3.

Table 3. 2013 NPSRF Non-returning Angler phone survey Catch results, Estimated Harvest, and expanded Total Catch and Harvest estimates for all Non-returning anglers.

Species	Caught	Harvest	%Harvested	Estimated Total Catch	Estimated Total Harvest
Northern Pikeminnow <228 mm	483	118	24.4%	2087	510
Northern Pikeminnow ≥ 228 mm	96	87	90.6%	415	376
Chinook Salmon (juvenile)	31	0	0%	134	0
Steelhead (juvenile)	23	0	0%	99	0
Chinook Salmon (adult)	2	2	100%	9	9
Chinook Salmon (jack)	0	0	na	0	0
Steelhead (adult)	0	0	na	0	0

N=5,553 n=1,285

Fork Length Data

The length frequency distribution of harvested northern pikeminnow (≥ 200 mm) from the 2013 NPSRF is presented in Figure 10. Fork length data for a total of 100,296 northern pikeminnow (62% of total) were taken during the 2013 NPSRF. The mean fork length for all measured northern pikeminnow (≥ 200 mm) in 2013 was 276.3 mm (SD= 62.5 mm), up from 275.1 in 2012.

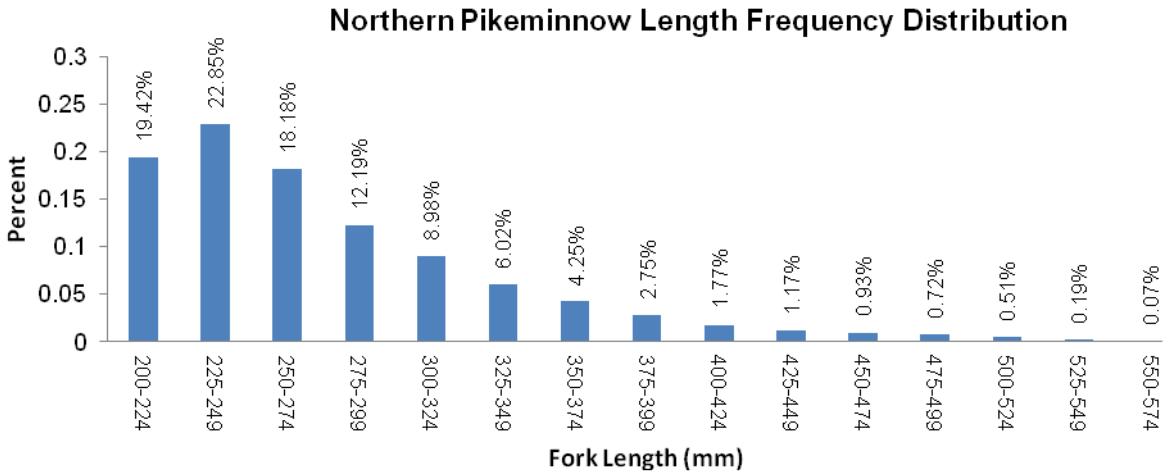


Figure 10. Length frequency distribution of northern pikeminnow ≥ 200 mm FL from 2013 NPSRF.

Angler Effort

The 2013 NPSRF recorded total effort of 20,082 angler days spent during the season, a decrease of 2,886 angler days from the effort total of the previous year (Hone et al. 2012) (Figure 11). When total effort is divided into returning and non-returning angler days, 14,529 angler days (72%) were recorded by returning anglers, and 5,553 were non-returns. The percentage of returning anglers showed a slight increase from 2012 (70%). In addition, 62% of total effort, and 85% of returning angler effort (12,405 angler days), was attributed to successful anglers who harvested at least 1 northern pikeminnow in 2013.

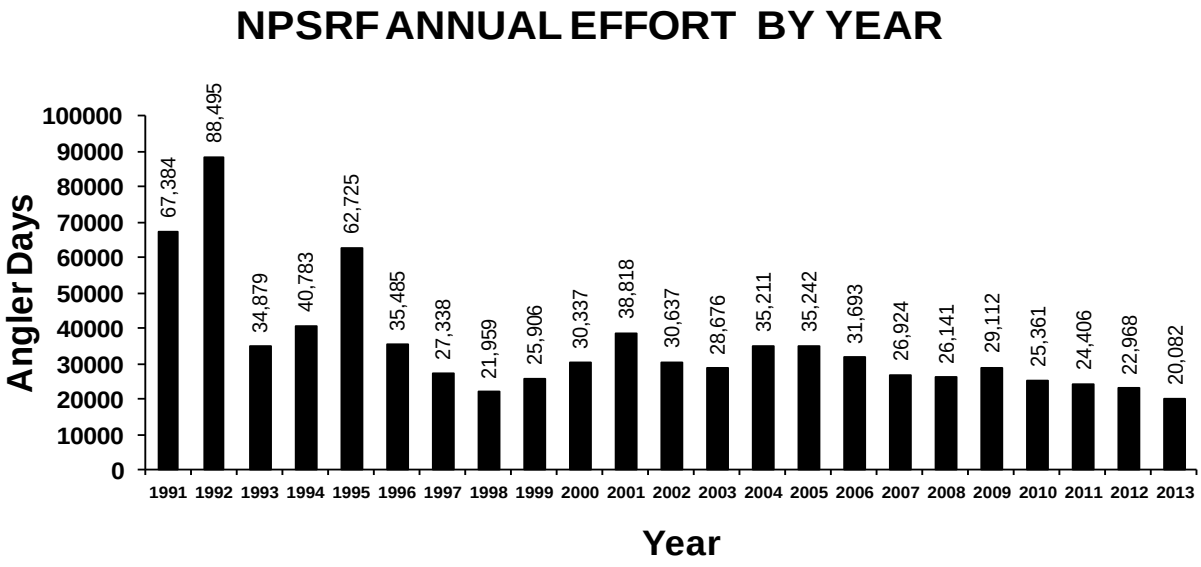


Figure 11. Annual Northern Pikeminnow Sport-Reward Fishery Effort.

Effort by Week

Mean weekly effort for the 2013 NPSRF was 873 angler days during the season, with the peak occurring in the sixth week of the season (Figure 12). Deviating from previous seasons, the peak effort (week 23) did not occur on the same week as peak harvest (week 26). Overall mean weekly effort decreased from 1,044 in 2012 to 873 in 2013 (Hone et al. 2012). The weekly effort totals for the 2013 NPSRF generally followed the pattern of previous seasons except that they were much lower than historical 1991-2012 effort levels which were buoyed by heavy participation in the first few years of the NPSRF (Figure 13).

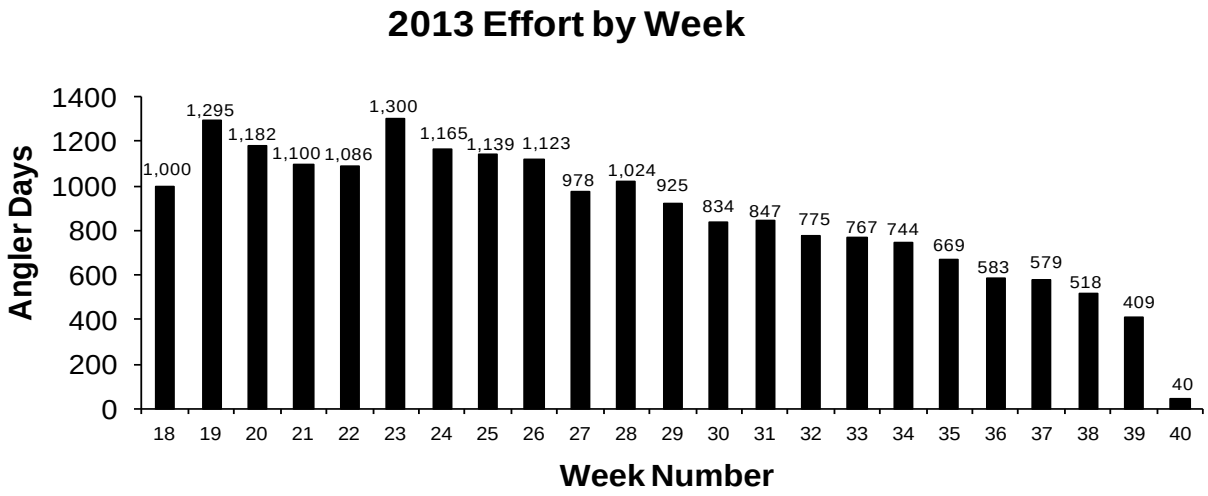


Figure 12. 2013 Weekly Northern Pikeminnow Sport-Reward Fishery Effort.

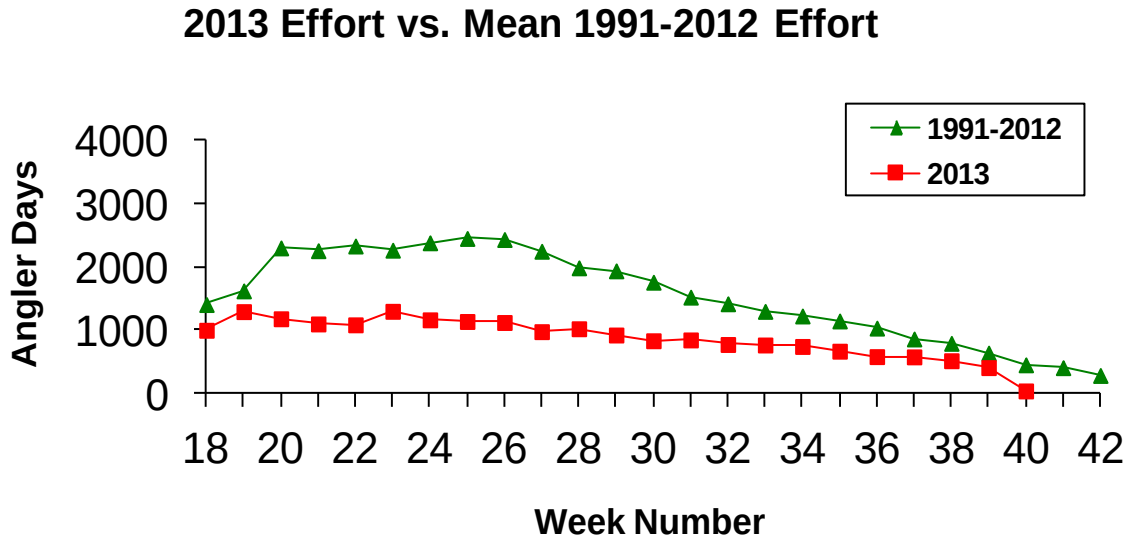


Figure 13. 2013 NPSRF Weekly Effort vs. Mean 1991-2012 Effort.

Effort by Fishing Location

Mean annual effort by fishing location for the 2013 NPSRF (returning anglers only) was 1,211 angler days compared to 1,333 angler days in 2012. Effort totals ranged from 5,182 angler days recorded below Bonneville Dam (fishing location 01) to only 12 angler days spent in fishing location 11 on the Snake River (Lower Granite Dam to the mouth of the Clearwater River) (Figure 14). Effort in all but five of the twelve NPSRF fishing locations decreased in 2013 causing the mean effort by fishing location to fall below that of the 2012 NPSRF. The most noteworthy change in effort was a decrease in SRF participation at fishing location 02 (Bonneville Reservoir), where 3,342 angler days were spent in 2013 compared to 4,280 angler days in 2012.

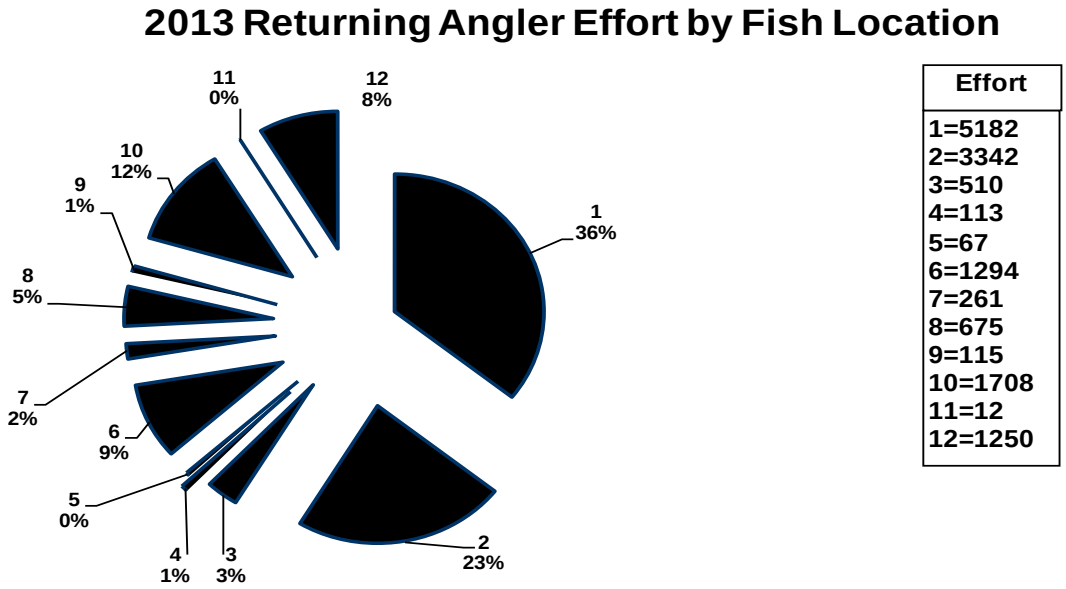


Figure 14. 2013 NPSRF Angler Effort by Fishing Location (returning anglers only).*
*Fishing Location Codes for Columbia River; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the Snake River to Priest Rapids Dam. Fishing Location Codes for the Snake River; 7 = Mouth of the Snake River to Ice Harbor Dam, 8 = Ice Harbor Reservoir, 9 = Lower Monumental Reservoir, 10 = Little Goose Reservoir, 11 = Lower Granite Dam to the mouth of the Clearwater River, 12 = Mouth of the Clearwater River to Hell's Canyon Dam.

Effort by Registration Station

Mean effort per registration station during the 2013 NPSRF was 956 angler days compared to 1,094 angler days in 2012. Effort totals ranged from 3,416 angler days at The Dalles station to 76 angler days at the Maryhill station (Figure 15). Effort during the 2013 NPSRF decreased at fifteen of the twenty one registration stations operated in 2012. Effort increased at six stations, most notably at the Boyer Park station where effort increased an additional 267 angler days in 2013. We also noted that the top 6 stations in terms of angler effort were also the top 6 harvest stations. We saw the largest decline in effort at the Cascade Locks station where there were 675 less angler days of effort spent than in 2012.

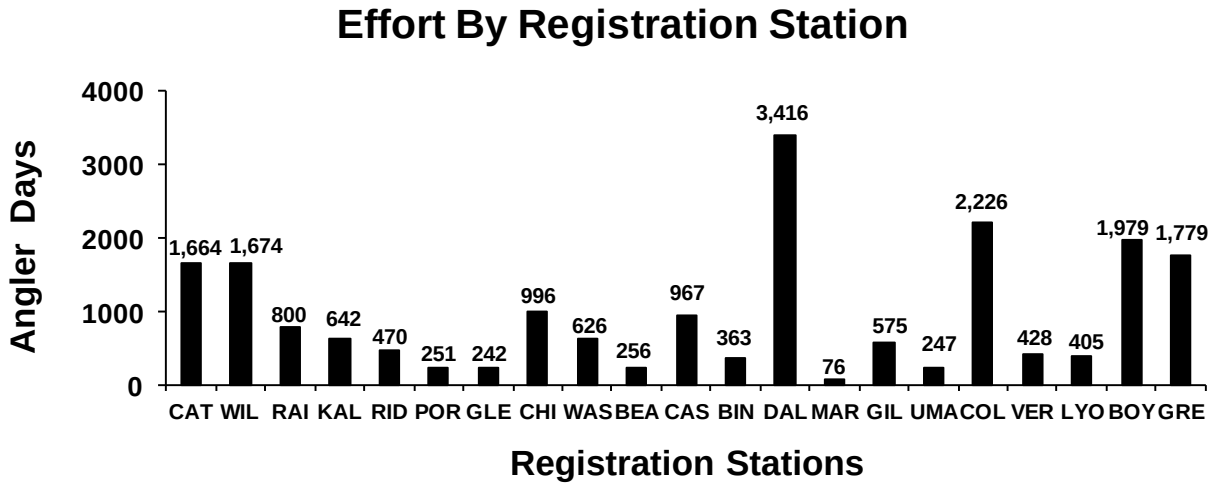


Figure 15. 2013 Northern Pikeminnow Sport-Reward Fishery Angler Effort by Registration Station.
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, POR-Portco, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, MAR-Maryhill, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Catch Per Angler Day (CPUE)

In 2013, NPSRF overall angler CPUE was 8.07 northern pikeminnow harvested per angler, per day and was the highest overall CPUE recorded in the NPMP's history (Figure 16). Overall CPUE (which includes both returning and non-returning anglers), was higher than in 2012 (Hone et al. 2012), and continued the upward trend seen throughout the NPSRF's 23 year history. Lower angler CPUE during the 2008 and 2009 seasons was due to an influx of new and/or inexperienced anglers attracted to the NPSRF by the Pikeminnow Angler Random Drawing incentives (Winther et al. 2008, Hone et al. 2009). The 2013 NPSRF, like the preceding three seasons, was conducted without the use of any random drawings or other incentives attracting inexperienced anglers. As a result, angler CPUE appears to have stabilized and returned to the upward trend seen prior to the drawings incentive. Returning angler CPUE during the 2013 NPSRF was 11.15 northern pikeminnow per angler day, up from the 2012 CPUE of 9.89. We estimate that CPUE for non-returning anglers is 0.07 reward size northern pikeminnow per angler day based on 2013 NPSRF phone survey results.

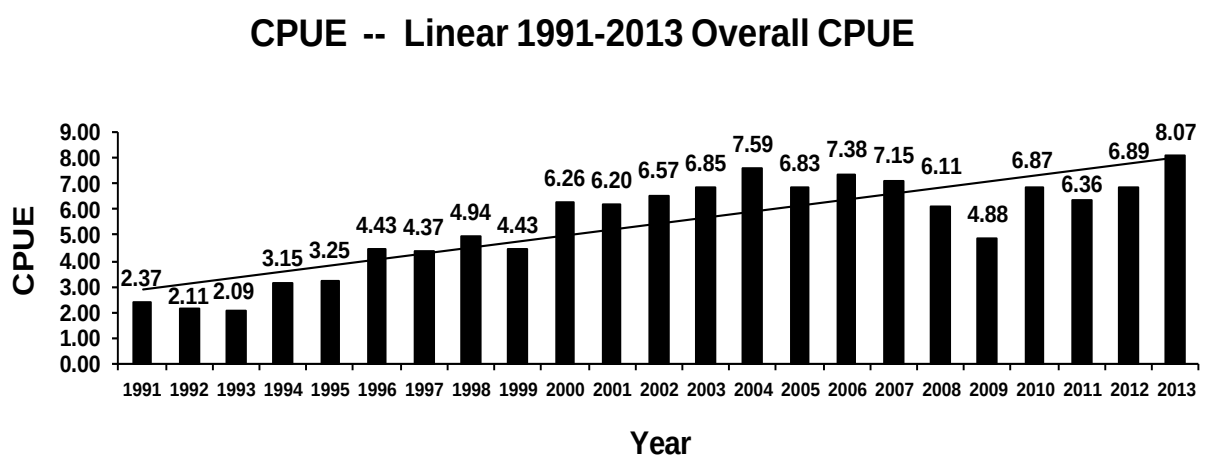


Figure 16. Annual NPSRF CPUE (returning + non-returning anglers) for the years 1991-2013.

CPUE by Week

Mean angler CPUE by week for the 2013 NPSRF was 8.75 fish per angler day compared to 7.40 in 2012. CPUE ranged from 3.31 in week 18 (May 1-May 5) to a peak of 15.06 in week 39 (September 23-September 29) (Figure 17). As has historically been the case, weekly CPUE for the 2013 NPSRF followed a two peak pattern where catch rates spike upward near peak harvest (week 26) and then again late in the season (Winther et al. 2010).

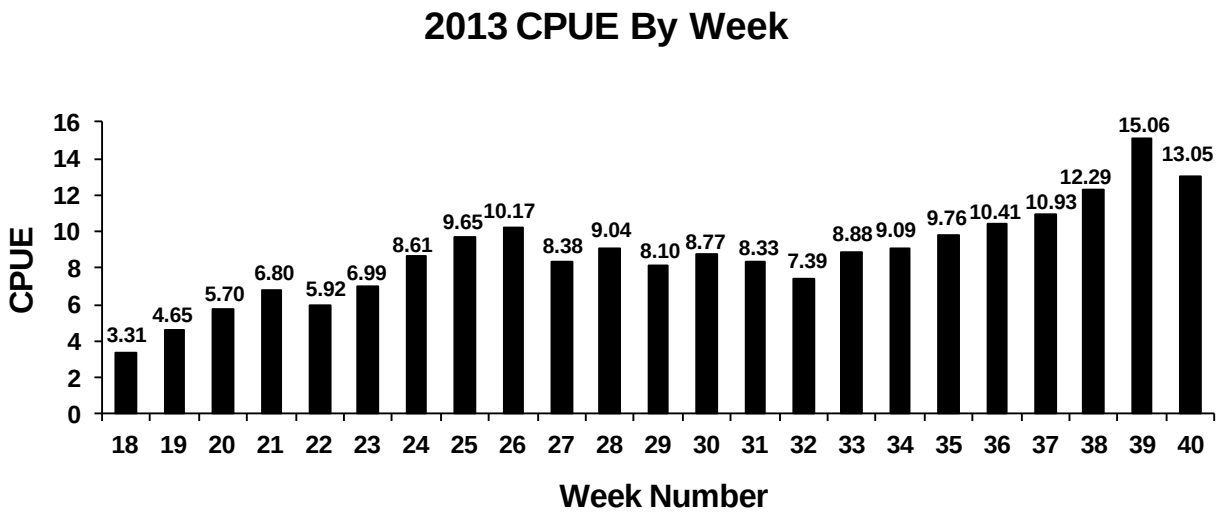


Figure 17. 2013 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Week.

CPUE by Fishing Location

Angler success rates for the 2013 NPSRF, as indicated by CPUE, are available for returning anglers only and varied by fishing location. Success rates ranged from a high of 18.23 fish per angler day in fishing location 08 (Ice Harbor Reservoir) to 3.56 fish per angler per day in fishing location 04 (John Day Reservoir) (Figure 18). Catch rates were up from 2012 at six of the twelve fishing locations (01, 02, 03, 05, 09 and 10). The average CPUE by fishing location was 9.83 northern pikeminnow per angler day in 2013 compared to 9.37 in 2012.

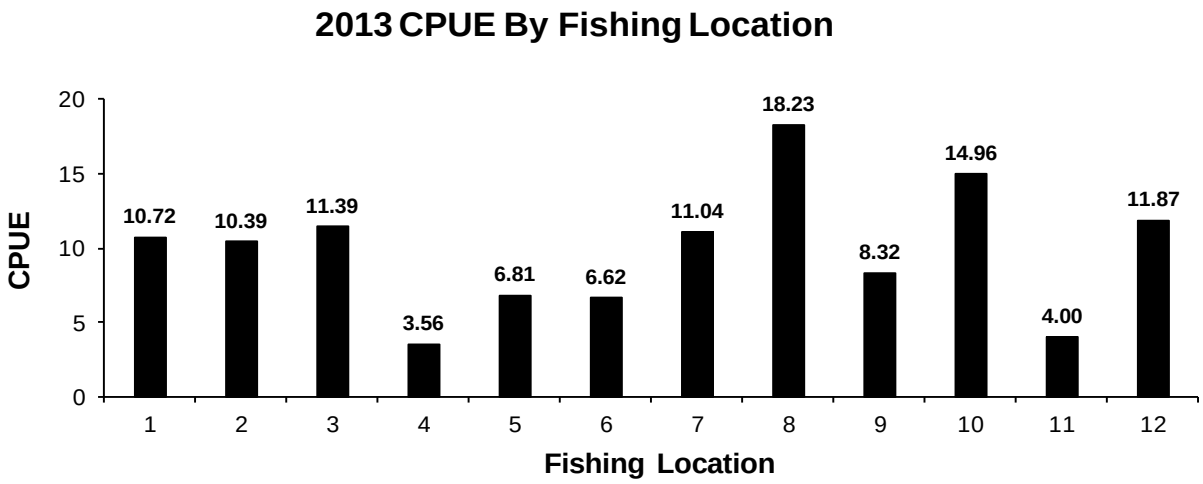


Figure 18. 2013 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Fishing Location.*
*Fishing Location Codes for Columbia River; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the Snake River to Priest Rapids Dam. Fishing Location Codes for the Snake River; 7 = Mouth of the Snake River to Ice Harbor Dam, 8 = Ice Harbor Reservoir, 9 = Lower Monumental Reservoir, 10 = Little Goose Reservoir, 11 = Lower Granite Dam to the mouth of the Clearwater River, 12 = Mouth of the Clearwater River to Hell's Canyon Dam.

CPUE by Registration Station

The registration Station with the highest CPUE during the 2013 NPSRF was the Lyon's Ferry station where anglers averaged 16.36 northern pikeminnow per angler day (Figure 19). The registration station with the lowest CPUE was the Umatilla station with a CPUE of 3.12 northern pikeminnow per angler day. The station average for angler CPUE was 8.31, up from 7.23 in 2012. Angler CPUE by registration station increased at sixteen stations during the 2013 NPSRF. The largest change in CPUE occurred at Boyer Park where the 2012 CPUE of 7.61 climbed to 12.63 in 2013.

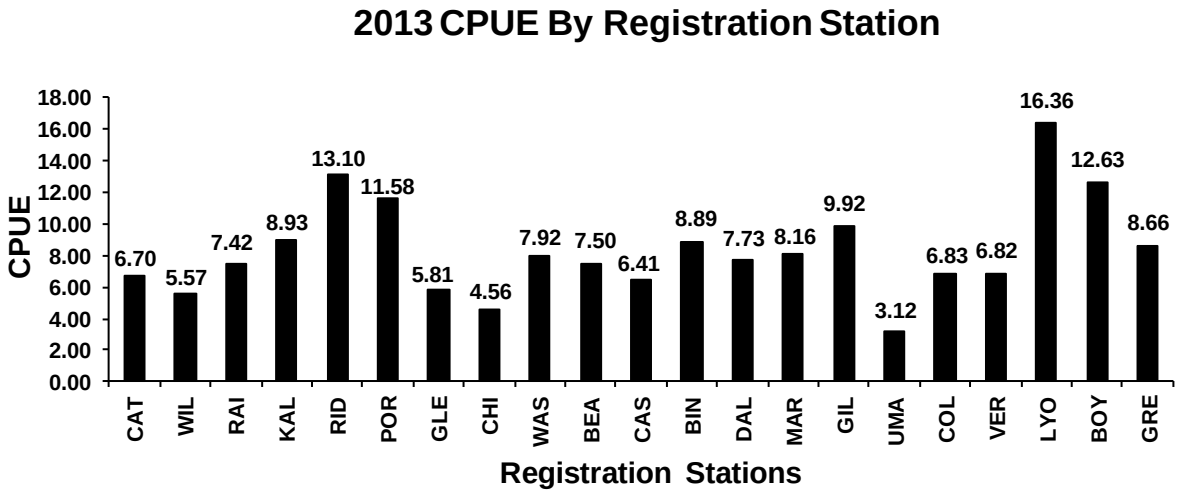


Figure 19. 2013 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Registration Station.
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, POR-Portco, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, MAR-Maryhill, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Angler Totals

There were 2,618 separate anglers who participated in the 2013 NPSRF, a decrease of 684 participants from 2012 (Hone et al. 2012). One thousand, one hundred and thirty of these anglers (43.2% of total vs. 38.9% in 2012) were classified as successful since they harvested at least one reward size northern pikeminnow (for which a voucher was issued) during the 2013 season. Of the successful anglers, 77% (874 anglers) sent in their vouchers to PSMFC for payment (PSMFC 11/06/13 Payment Summary) while 256 anglers (23%) did not. The average successful angler harvested 143 northern pikeminnow during the 2013 NPSRF, although when we break down the 1,130 successful anglers by tier, 83% (941 anglers) harvested fewer than 100 northern pikeminnow and were classified as Tier 1 anglers (Figure 20). Ninety seven anglers (9%) reached Tier 2 status by harvesting between 101 and 400 northern pikeminnow, and 92 anglers (8%) reached Tier 3 status by harvesting more than 400 northern pikeminnow in 2013. The 92 anglers who reached Tier 3 represented only 3.5% of all participants (both returning and non-returning anglers) during the 2013 NPSRF. The number of anglers reaching each of the three tiers during the 2013 NPSRF decreased for both Tier 1 and 3, but increased for Tier 2 when compared to 2012. Despite decreases in the number of Tier 1 anglers (from 1,097 in 2012 to 941 in 2013) and Tier 3 anglers (from 98 anglers in 2012 to 92 anglers in 2013), an increase in the number of Tier 2 anglers (from 90 in 2012 to 97 in 2013) surely aided in the improved 2013 NPSRF harvest.

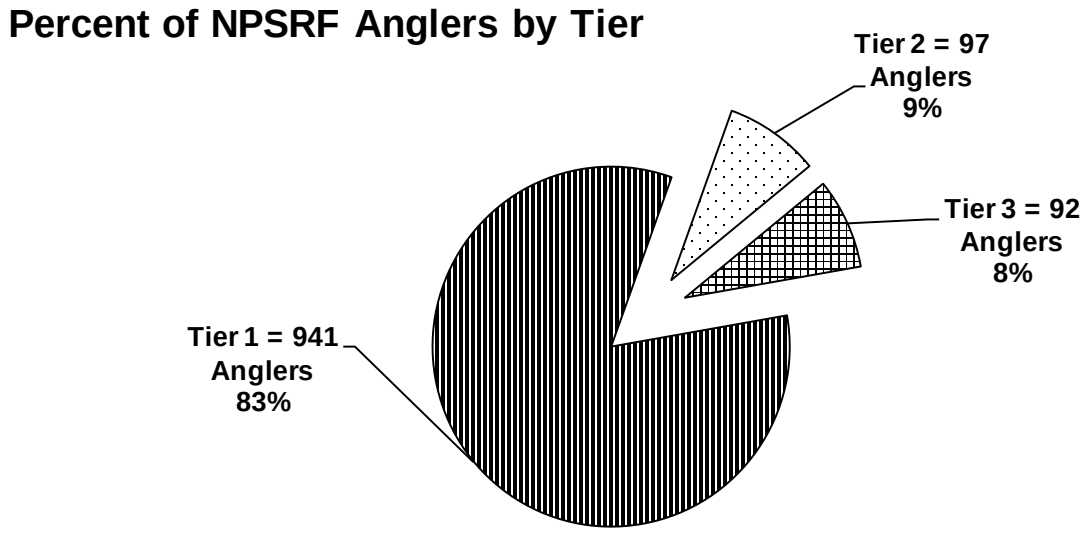


Figure 20. 2013 NPSRF Anglers by tier (returning only) based on total # of fish harvested.

While Tier 1 anglers made up 83% of all successful NPSRF participants in 2013, they accounted for only 7.4% of total NPSRF harvest (12,011 northern pikeminnow) (Figure 21). This translates to an average harvest of 13 fish per Tier 1 angler, per year. Tier 2 anglers harvested 20,104 northern pikeminnow equaling 12.4% of total 2013 NPSRF harvest and averaging 207 fish per angler, per year. Tier 3 anglers, (also known as "highliners"), harvested 129,964 northern pikeminnow equaling 80.2% of total 2013 NPSRF harvest and averaging 1,413 fish per angler, per year, up from 1,296 in 2012(Hone et al. 2012). Percentages of total NPSRF harvest for each of the three tiers were the same in 2013 as in 2012.

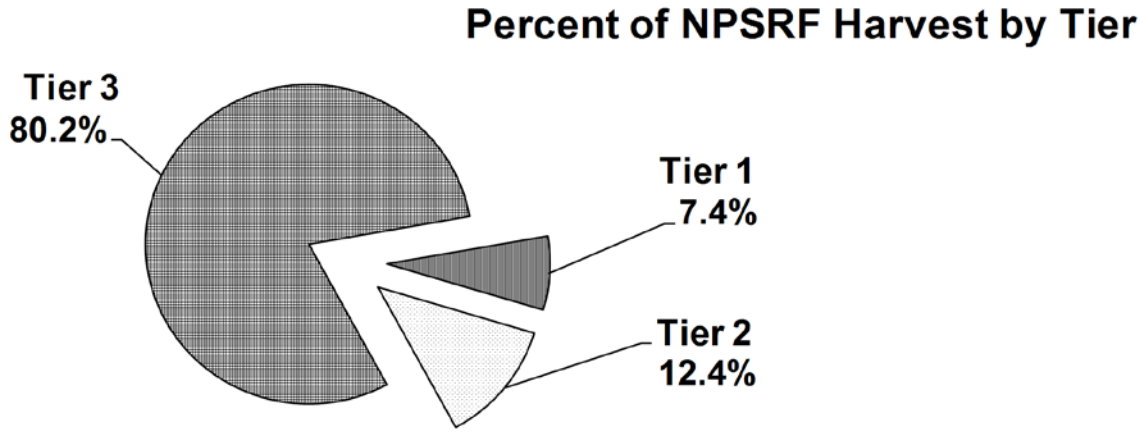


Figure 21. 2013 NPSRF Harvest by Angler Tier (Tier 1 = <100, Tier 2 =101-400, Tier 3 = > 400).

The average NPSRF participant (returning + non-returning anglers) expended more effort pursuing northern pikeminnow during the 2013 season than in 2012 (7.67 vs. 6.96 angling days of effort). When we look at successful anglers only, the overall average successful angler expended 10.97 angler days of effort during the 2013 NPSRF compared to 10.23 days in 2012 (Hone et al. 2012). Once again, as was first documented in 2002 (Winther et al. 2002), individual Tier 3 anglers expended more effort (on average) than individual Tier 2 anglers and individual Tier 2 anglers expended more effort (on average) than individual Tier 1 anglers. In 2013, Tier 3 anglers spent an average of 85 days fishing (up from 82 days in 2012), Tier 2 anglers spent an average of 35 days fishing (down from 43 in 2012), and Tier 1 anglers spent an average of only 7 days fishing, just as they had done in 2012 (Figure 22).

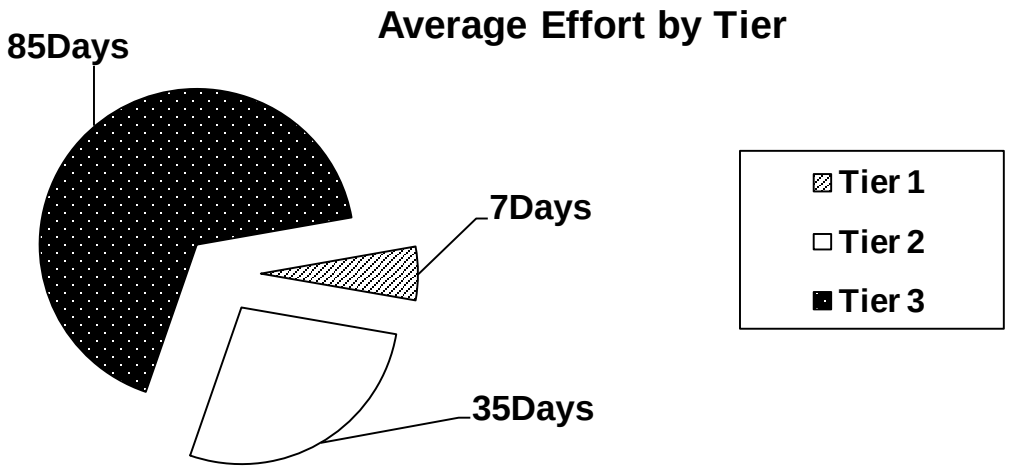


Figure 22. Average Effort of 2013 NPSRF Anglers by Tier (Tier 1 = <100, Tier 2 =101-400, Tier 3 = > 400) .

Overall angler CPUE for the 2013 NPSRF increased from 2012 and CPUE at each tier level increased as well. CPUE for anglers at Tier 1 increased from 1.68 in 2012 to 1.85 in 2013 (Figure 23). CPUE for Tier 2 anglers increased from 4.66 in 2012 to 5.90 in 2013, and CPUE for Tier 3 anglers went up from 15.78 in 2012 to 16.55 in 2013. This increase in CPUE at all three of the tier levels indicates that "fishing" (defined as the ability of SRF anglers to catch northern pikeminnow) was better in 2013 than in the previous season, regardless of the level of angler skill and/or experience.

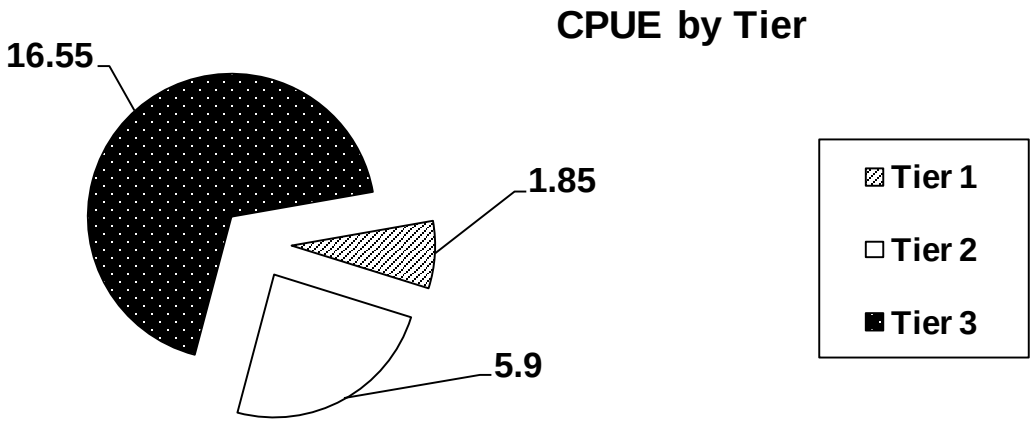


Figure 23. Average CPUE of 2013 NPSRF Anglers by Tier (Tier 1 = <100, Tier 2 =101-400, Tier 3 = > 400).

The top individual angler (based on number of fish caught) for the 2013 NPSRF harvested 9,229 northern pikeminnow with 8 spaghetti tagged northern pikeminnow worth a total earnings of $76,478 (PSMFC 11/06/2013 Sport Reward Payment Summary). The 2013 top angler caught 95 fewer fish than he did as the top angler in 2012 and almost twice the number of fish that the 2013 second place angler caught. The CPUE for this year's top angler (87.9 fish per angler day) was up from what he had as the top angler in 2012 (74.6 fish per angler day). The top angler for the 2013 season spent 20 less days (effort) fishing than he did in 2012 (as the top angler when he fished 125 days). By comparison, the top angler (in terms of participation rather than harvest) for the 2013 NPSRF fished 152 days and harvested 627 northern pikeminnow.

Tag Recovery

Northern Pikeminnow Tags

Returning anglers harvested 162 northern pikeminnow tagged by ODFW with external spaghetti tags during the 2013 NPSRF compared to 189 spaghetti tags paid in 2012 (Hone et al., 2012). Tag recoveries peaked in week 25, one week earlier than peak NPSRF harvest (Figure 24). All 162 of the spaghetti tagged northern pikeminnow were also PIT tagged by ODFW as a secondary mark. WDFW technicians also recovered an additional 101 northern pikeminnow which had ODFW PIT tags with wounds and/or fin-clips indicating that the fish had "lost" an ODFW spaghetti tag. The recovered spaghetti and PIT tags, as well as the potential tag loss data was estimated by ODFW to equal a 10.8% exploitation rate for the 2013 NPSRF (Barr, et al. 2013).

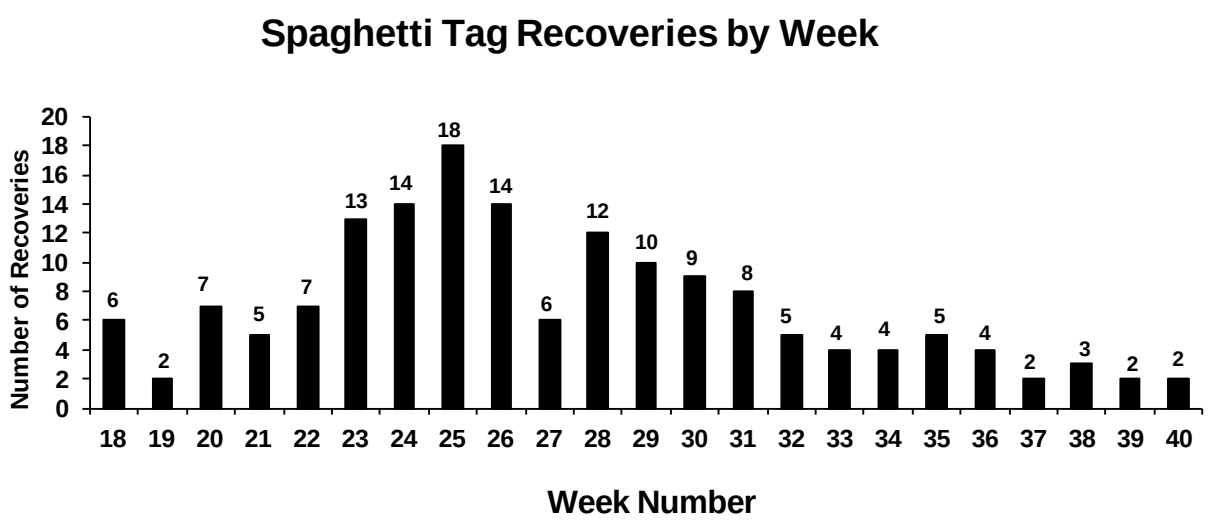


Figure 24. 2013 NPSRF Spaghetti Tag Recoveries by Week.

Ingested PIT Tags

A total of 162,079 northern pikeminnow were individually scanned for the presence of PIT tags. This represents 100% of the total harvest of reward-size fish for the 2013 NPSRF (northern pikeminnow not qualifying for rewards were also scanned whenever possible). Technicians recovered a total of 74 PIT tags from consumed smolts that had been ingested by northern pikeminnow harvested during the 2013 NPSRF, an overall occurrence rate of 1:2,190. In addition, one noteworthy recovery "first" for the 2013 NPSRF was the recovery of a PIT tag from a juvenile lamprey ingested by a northern pikeminnow turned in at the Boyer Park station on May 25, 2013. NPSRF technicians had for many years noted juvenile lamprey that had been regurgitated by northern pikeminnow after being caught and retained by anglers. This was the NPSRF's first documented recovery of a PIT tagged juvenile lamprey that was removed from the gut of a northern pikeminnow. Total ingested PIT tag recoveries in 2013 were lower (29 less) than the previous year and given that total harvest levels were similar, there ended up being a lower rate of occurrence (1:2,190 in 2013 versus 1:1,536 in 2012) (Hone et al., 2012) as well. PIT tag recoveries of salmonid smolts ingested by northern pikeminnow peaked during weeks 23 of the season (where 12 ingested smolts were recovered) and our final PIT tag recovery of the 2013 NPSRF occurred in week 30 near the end of July (Figure 25).

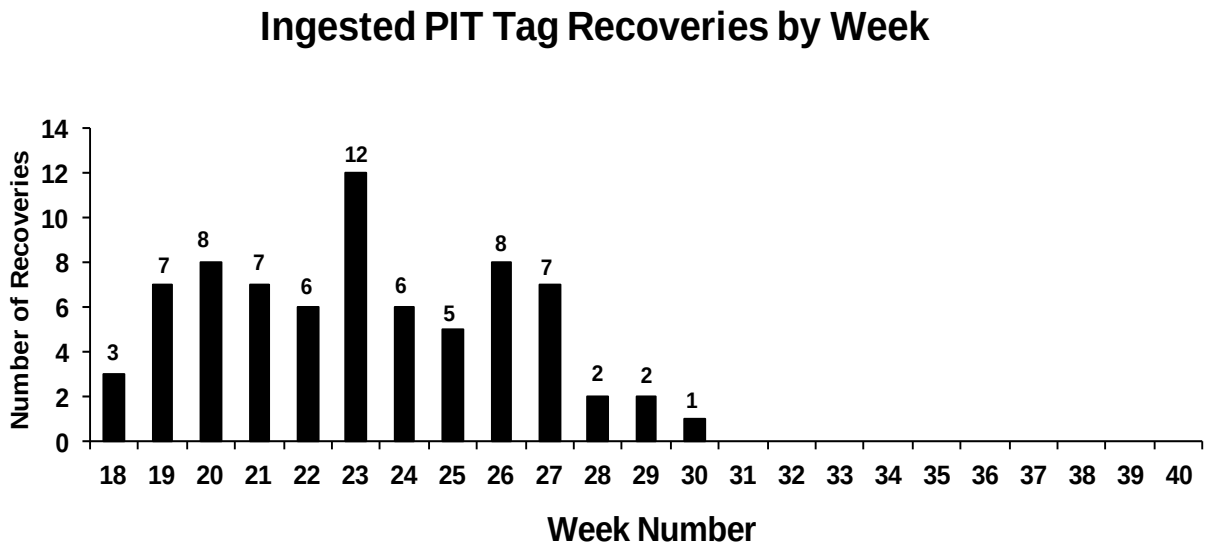


Figure 25. 2013 NPSRF PIT Tag Recoveries by Date.

Pit tag recoveries by fishing location during the 2013 NPSRF indicated that northern pikeminnow harvested from Fishing location 02 (Bonneville Reservoir) ingested the largest number of salmonid smolts containing PIT tags (Figure 26).

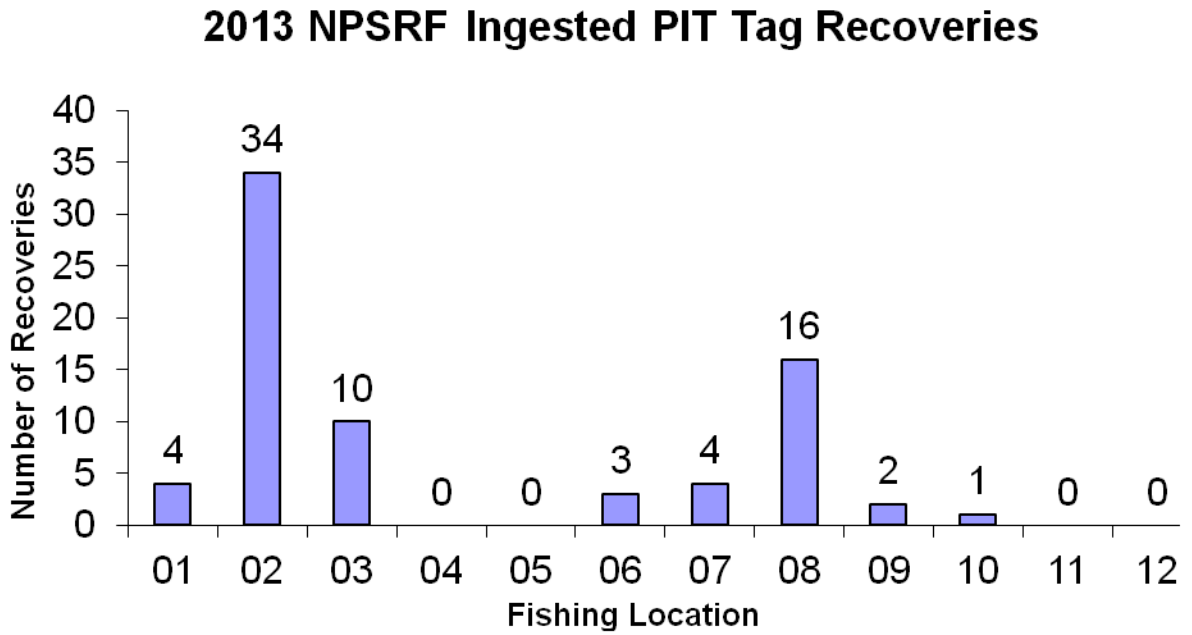


Figure 26. 2013 NPSRF ingested PIT Tag Recoveries by Fishing Location.
*Fishing Location Codes for Columbia River; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the Snake River to Priest Rapids Dam. Fishing Location Codes for the Snake River; 7 = Mouth of the Snake River to Ice

Harbor Dam, 8 = Ice Harbor Reservoir, 9 = Lower Monumental Reservoir, 10 = Little Goose Reservoir, 11 = Lower Granite Dam to the mouth of the Clearwater River, 12 = Mouth of the Clearwater River to Hell's Canyon Dam.

Species composition of PIT tagged smolts (recovered from northern pikeminnow harvested in the 2013 NPSRF) was obtained from PTAGIS and indicated that fifty-seven (77%) of the 74 ingested PIT tag recoveries were from chinook smolts. The other 17 PIT tags included 4 from coho, 3 from sockeye, 2 from steelhead, and 8 unknown species accounting for the remaining percentage (Figure 27). Most of the chinook PIT tags were recovered in May and June, as were all of the coho, sockeye, and steelhead recoveries. PTAGIS queries revealed that the PIT tag recoveries from chinook smolts consisted of 28 fall chinook, 19 spring chinook, 8 summer chinook and 2 unknown chinook). PIT tag queries of PTAGIS also indicated that 10 of the 74 recovered PIT tags (14%) were from salmonids of wild origin.

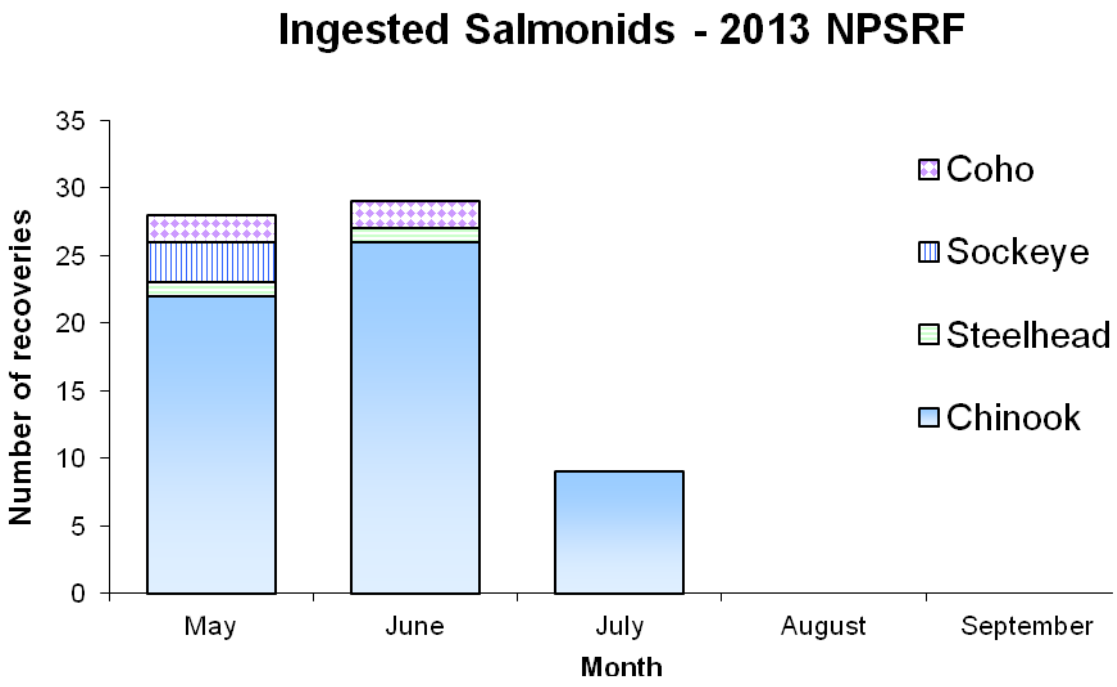


Figure 27. Recoveries of ingested salmonid PIT Tags from the 2013 NPSRF.

Analysis of PIT tag recovery data from the 2013 NPSRF continues to document actual northern pikeminnow predation on downstream migrating juvenile salmonids (as well as the NPSRF's first documented juvenile lamprey predation data). Further data collection and analysis of PIT tag recoveries from juvenile salmonids and/or lamprey consumed by northern pikeminnow harvested in the NPSRF may lead to a better understanding of northern pikeminnow predation including factors affecting the vulnerability of juvenile resident fishes migrating through the Columbia River. There may also be additional opportunities for using PIT tag recovery data to identify and document angler fraud as has been done in the past.

SUMMARY

The 2013 NPSRF succeeded in reaching the NPMP's 10-20% exploitation goal for the sixteenth consecutive year, achieving an estimated exploitation rate of 10.8%. NPSRF harvest in 2013 was up from 2012 while the number of angler days spent (effort) was down, resulting in an increase in overall angler CPUE. Peak weekly harvest occurred during week 26 (June 24-30) which corresponds to the 1991-2012 average peak week. The Dalles registration station was the SRF's top producing station in 2013 for a third consecutive season, with the station at Boyer Park reclaiming the number two spot after a year's absence. Anglers participating in the 2013 NPSRF recovered 162 northern pikeminnow spaghetti tagged by ODFW. An additional 101 northern pikeminnow with ODFW PIT tags, but missing spaghetti tags were also harvested. Mean fork length (FL) for northern pikeminnow harvested in the 2013 NPSRF was 276.3 mm, up from 275.1 mm in 2012, and 276 mm in 2011. NPSRF anglers reported that incidental catch consisted primarily of peamouth, smallmouth bass and sculpin (with most released), while juvenile steelhead were the most often caught salmonids (all of which were released).

The 2013 NPSRF continued to provide productive harvest opportunities for anglers throughout the program area, but certain locations stuck out as "Hot Spots" as indicated by high angler harvest rates (CPUE). These areas included Fishing location 08 (Ice Harbor Reservoir) on the Snake River where angler CPUE was 18.23 fish per angler day, the Lyon's Ferry and Ridgefield registration stations were angler CPUE was 16.36 and 13.10 fish per angler day respectively, and the NPSRF's top station (The Dalles) where anglers harvested 26,389 fish. The NPSRF's top angler caught 9,229 fish worth $76,478 in reward payments in 2013 (95 less than he did as the top angler in 2012).

Angler participation in the NPSRF (effort) continued the downward trend seen since 2004. All indicators, including overall NPSRF effort, mean effort per station, and mean effort per week declined from 2012 levels. The number of individual anglers participating in the NPSRF also dropped from 3,302 individual anglers in 2012 to 2,618 individual anglers in 2013 (which was a NPSRF all-time low). In addition, the average number of days spent participating in the 2013 NPSRF also declined for anglers at each of the three Tier levels. In past seasons, when participation drops, it has typically been due to poor catch rates caused by bad weather and/or poor fishing conditions. Given that angler CPUE was up at all Tier levels in 2013 (indicating that good numbers of northern pikeminnow were available to catch), the decline in NPSRF angler participation was likely due to factors other than angler success. Other possible factors that may have contributed to declining NPSRF participation include competition (for angler time) from activities other than fishing, competition from other fisheries (i.e., salmon fishing), and considerations related to the economics of recreational fishing for northern pikeminnow.

Detection of PIT tags from juvenile salmonids ingested and retained in the gut of northern pikeminnow continues to yield valuable data about northern pikeminnow predation on juvenile salmonids. Noteworthy in 2013, the NPSRF recovered a single PIT tag from a juvenile lamprey that had been consumed by a harvested northern pikeminnow as well as 74 PIT tag recoveries from consumed juvenile salmonids. Primary species consumed (according to PTAGIS) were chinook, followed by coho, sockeye, and steelhead. Fourteen percent of those 74 PIT tag recoveries were from salmonids of wild origin.

While there were many positive achievements accomplished during the twenty-third season of the NPSRF (reaching the NPMP's 10-20% harvest goal being the primary), there was also some cause for concern. The single biggest concern (as highlighted by results from the 2013 NPSRF) is the steady and continued decline in participation that the NPSRF has seen since 2004. The highest participation levels in NPSRF history occurred during the first two years of full implementation (1991-92), when the novelty and newsworthiness of paying recreational anglers to catch northern pikeminnow attracted more than 67,000 angler days of effort each season. In the time period since, NPSRF effort has continued to trend downwards to the record low of 2013. Throughout this history, there have also been a few peaks in effort where the gradual downward trend was interrupted by sudden spikes upwards. Upward spikes in effort were seen most notably in 1995, 2001, 2004-5, and 2008-09. When we reviewed NPSRF history, we found that these spikes coincided with certain NPMP Program changes or adjustments. In 1995, the NPMP implemented the Tiered reward system and both effort and harvest sharply increased. In 2001, rewards were temporarily increased and harvest and effort jumped up. In 2004-5 rewards increased and effort and harvest improved. The upticks in effort for 2008 and 2009 were a little different as effort increased while harvest continued to decline. Random angler drawings were the NPSRF promotional activity conducted in 2008-09 with the intent of attracting additional effort by enticing "new" anglers to participate in the NPSRF and/or incentivizing "additional" effort from existing anglers. This was done by giving each participant a chance in the drawing for every day they turned in northern pikeminnow. The results of the two random drawing years were an increase in the number of individual anglers and in the number of angler days of effort in 2009, and a sharp dip in CPUE for both years. Since NPSRF harvest rates did not respond to the influx of angler effort in 2009, we believe that what likely happened was that existing anglers split their catch with friends or other family members (in order to get more chances in the drawings), as opposed to the NPSRF attracting new, successful anglers. The point is that after 23 seasons, our NPSRF historical data indicates that while promotional activities like random drawings, tournaments, freebies, etc. may be nice "perks" for rewarding participating anglers, they are not enough to stop angler attrition. Our data makes the case that if the NPMP is really serious about improving angler effort and maintaining NPSRF viability, the one proven way to do that is by updating the current tiered reward system.

RECOMMENDATIONS

1.) Continue use of standardized season dates (May 1st-Sept 30th) for implementation of the 2014 NPSRF in order to create promotional opportunities, build angler familiarity, and further develop the NPSRF brand.

2.) Continue to develop program incentives designed primarily to increase angler harvest and incentivize new anglers (preferably experienced) to participate in the 2014 NPSRF.

a) Review NPSRF station times and routes for efficiencies which may allow adding additional stations or provide additional angler opportunities for participation.

b) Continue to pursue feasibility of paying for tag-loss NPM retaining ODFW PIT tags in response to repeated angler requests and to improve NPSRF public relations.

c) Continue use of angler clinics, coupons, and sport show booths as tools to recruit new anglers and promote NPSRF brand.

d) Investigate expanded use of internet and social media for advertising NPSRF as well as for angler recruitment and education.

e) Develop strategies for engaging experienced angler groups and recruiting them to the NPSRF for fund raising, conservation, or public service purposes.

3.) Review NPSRF rules of participation, adjusting to the dynamics of the fishery and fishery participants, in order to maintain NPSRF integrity (update OAR's and WAC's).

4.) Retain option to extend the NPSRF season on a site-specific basis if warranted by high harvest, angler effort, and/or CPUE levels.

5.) Scan all harvested northern pikeminnow for PIT tags from ingested juvenile salmonids or lamprey, from northern pikeminnow tagged by ODFW as part of the biological evaluation of the NPMP, and as a way to deter NPSRF angler fraud.

6.) Survey a minimum of 20% of non-returning NPSRF anglers to record non-returning angler catch of northern pikeminnow, all salmonids and other fishes per NPMP protocol. Estimate total catch of non-returning anglers and analyze and monitor data to identify and record changes in non-returning angler catch trends.

REFERENCES

Barr, C., E. Tinus, M. Gardner, C. Mallette, and A. Storch. 2014. Report [C] - System-wide predator control program: fisheries and biological evaluation. Oregon Department of Fish and Wildlife, Contract Number 56795. 2013 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Bruce, R.C., E.C. Winther, J.D. Hone, and P.V. Dunlap. 2005. 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). 2005 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, OR.

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 (Northern Pikeminnow Management Program). 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 90-007. Bonneville Power Administration, Portland, Oregon.

Friesen, T.A., and D.L. Ward 1999. Management of northern pikeminnow and implications for juvenile salmonid survival in 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. Peterson, D.R. Gilliland, E.C. Winther, S.S. Smith, and J. Saurez-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, J. Memarian, and E.C. Winther. 2004. 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). 2004 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Hone, J.D., P. Dunlap, K. Moyer, and E.C. Winther. 2009. 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). 2009 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Hone, J.D., E.C. Winther, and P. Dunlap. 2012. 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). 2009 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 predator 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 co-authors. 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. Beamsderfer, 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-A179-82 BP34796 and DE-A179-82BP35097) 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.

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.

Vigg, S. and C.C. Burley. 1989. Developing a predation index and evaluating ways to reduce salmonid 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-A179-88BP92122. 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, Contact number DE-B179-90BP07084. 1990 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Winther, E.C., J.S. Hisata, M.R. Peterson, 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., J.D. Hone, P.V. Dunlap, and K.C. Moyer. 2008. 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). 2006 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Winther, E.C., J.D. Hone, P.V. Dunlap, and K.C. Moyer. 2010. 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). 2010 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

REPORT B

Northern Pikeminnow Sport Reward Payments – 2013

Prepared by

Steve Williams
Craig Miller

Pacific States Marine Fisheries Commission
205 S.E. Spokane St. Suite 100
Portland, OR 97202

March, 2014

INTRODUCTION

The **Northern Pikeminnow Predator Control Program** was administered by PSMFC in 2013. 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, handled all fish checked in to the program and conducted dam angling at John Day Dam and The Dalles Dam. Oregon provided fish tagging services, population studies, and food habit studies, as well as exploitation rate estimates. PSMFC provided technical administration, and the fiscal and contractual oversight for all segments of the Program and processed all reward vouchers for the sport-reward anglers.

CATCH AND PAYMENTS

In 2013 a total of 161,917 fish were harvested in the sport-reward fishery. Of this total, 162 were tagged fish and 161,755 were untagged. Vouchers for 160,596 of the untagged fish were submitted for payment totaling rewards of $1,052,171. Rewards were paid at $4 for the first 100 fish caught during the season, $5 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 874 anglers who registered were successful in catching one or more fish in 2012. The 2013 season ran from May 1, 2013 through September 30, 2013. Prior to the opening of the season, coupons were issued to all anglers in the pikeminnow database and to those who signed up for our mailing list at the various sportsmen's shows. In addition, all the newspaper ads announcing the opening of the season contained the coupon. The 2013 Coupon was worth a $10 bonus when attached to a voucher for a qualifying pikeminnow caught and turned in for the reward payment

TAGGED FISH PAYMENTS

A total of 162 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 $500 tagged fish reward. Of this total, 161 tagged vouchers were submitted for payment. This resulted in tag reward payments of $80,500 in addition to the regular reward payments above.

ACCOUNTING

Total payments for the season of regular vouchers, coupons, and tagged fish, totaled $1,138,251. All IRS Form 1099-MISC Statements were sent to the qualifying anglers for tax purposes in the fifth week of January, 2014. Appropriate reports and copies were provided to the IRS by the end of February, 2014.

A summary of the catch and rewards paid is provided in Table 1. For further information contact Steve Williams, PSMFC, Field Programs Administrator at (503) 595-3100 or email at: swilliams@psmfc.org.

2013 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of all vouchers received and paid as of December 13, 2013

	Fish	Incentives	$ Paid
Fish paid @ tier 1 ($4 each):	29,614	N/A	$118,456
Fish paid @ tier 2 ($5 each):	38,047	N/A	$190,235
Fish paid @ tier 3 ($8 each):	92,935	N/A	$743,480
Tags paid (@ $500 each):	161	N/A	$80,500
Coupons issued (@ $10 each)	N/A	558	$5,580
Total:	**160,757**	**558**	**$1,138,251**

Anglers @ tier 1	686		
Anglers @ tier 2	96	Anglers with 10 fish or less:	416
Anglers @ tier 3	92	Anglers with 2 fish or less:	202
Total	874		

Top Twenty Anglers (by total fish caught)

	TIER 1	TIER 2	TIER 3	TAGS	TOTAL FISH	COUPONS	BALANCE
1.	100	300	8,821	8	9,229	$10	$76,478
2.	100	300	4,292	4	4,696	$10	$38,246
3.	100	300	4,031	4	4,435	$10	$36,158
4.	100	300	3,394	0	3,794	$10	$29,062
5.	100	300	3,363	5	3,768	$10	$31,314
6.	100	300	3,166	5	3,571	$10	$29,738
7.	100	300	2,950	3	3,353	$10	$27,010
8.	100	300	2,946	4	3,350	$10	$27,478
9.	100	300	2,787	2	3,189	$0	$25,196
10.	100	300	2,759	3	3,162	$10	$25,482
11.	100	300	2,421	0	2,821	$10	$21,278
12.	100	300	2,389	1	2,790	$10	$21,522
13.	99	300	1,940	5	2,344	$10	$19,926
14.	100	300	1,941	1	2,342	$10	$17,938
15.	100	300	1,800	1	2,201	$10	$16,810
16.	100	299	1,767	1	2,167	$10	$16,541
17.	100	300	1,675	2	2,077	$10	$16,310
18.	100	300	1,570	0	1,970	$10	$14,470
19.	100	300	1,460	0	1,860	$0	$13,580
20.	100	300	1,401	0	1,801	$10	$13,118
	1,999	5,999	56,873	49	64,920	$180	$517,655

Report C

System-wide Predator Control Program: Fisheries and Biological Evaluation

Prepared by

Charles M. Barr
Eric Tinus
Matthew Gardner
Christine Mallette
Adam J. Storch

Oregon Department of Fish and Wildlife
Columbia River Coordination Program
17330 S.E. Evelyn Street
Clackamas, Oregon 97015

Funded by

U. S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
Portland, Oregon 97208-3621

Project No. 1990-077-00
Contract No. 61037

March 2014

SUMMARY

The Northern Pikeminnow Management Program (NPMP), with its fisheries aimed at reducing predation on juvenile Pacific salmon *Oncorhynchus spp.* by northern pikeminnow *Ptychocheilus oregonensis* in the Columbia and Snake rivers, was assessed for the 2013 season (1 May–30 September 2013). We report on 1) northern pikeminnow exploitation rates and relative predation estimates; 2) population parameters of northern pikeminnow, smallmouth bass *Micropterus dolomieu*, and walleye *Sander vitreus* in select Snake River reservoirs; and 3) possible intra- and inter-specific compensatory responses to the sustained removal of northern pikeminnow.

To evaluate exploitation during 2013, we tagged and released 1,125 northern pikeminnow greater than or equal to200 mm fork length (FL) throughout the lower Columbia and Snake rivers. Of these fish, 714 were greater than or equal to 250 mm FL, the size-class used to monitor trends in system-wide exploitation and predation reduction since inception of the NPMP in 1990. System-wide exploitation of northern pikeminnow during the Sport-Reward fishery was 10.8% (95% confidence interval; 6.9–14.7%). Exploitation rates were adjusted using an estimated tag loss of 1.1%. Using the model of Friesen and Ward (1999), we estimated that 2013 predation levels were 35% (range: 20–53%) lower than pre-program levels.

Biological evaluation of northern pikeminnow, smallmouth bass and walleye was conducted in Ice Harbor, Lower Monumental, Little Goose and Lower Granite reservoirs during 2013. Abundance index values for northern pikeminnow in these reservoirs ranged from 0.00 to 0.17, whereas estimates varied between 0.05 and 2.94 during the first year of the NPMP in 1990. Juvenile salmon were encountered in the stomach contents of northern pikeminnow only in Lower Granite Reservoir ($\hat{p}$ = 0.57). Across reservoirs, other taxa common in diet samples included sculpins ($\hat{p}_{max}$= 0.14; Family: Cottidae), sunfishes ($\hat{p}_{max}$= 0.33; Family: Centrarchidae) and lampreys ($\hat{p}_{max}$= 0.33; Family: Petromyzontidae). We were unable to calculate consumption index values – and consequently predation index values – for northern pikeminnow in all areas within reservoirs due to sample size constraints.

Smallmouth bass abundance index values generally were greatest in the mid-reservoir areas of the Snake River reservoirs sampled in both spring and summer periods. Estimates exceeded those of all previous years (1991–2012) in mid-reservoir areas of Lower Monumental Reservoir during summer and Little Goose Reservoir during both spring and summer sampling events. Smallmouth bass consumption index values for the Snake River reservoirs were similar to those observed in preceding years. Across reservoirs, the most frequently occurring taxa observed in smallmouth diet samples were sand rollers ($\hat{p}_{max}$ = 0.56; Family: Percopsidae) and sculpins ($\hat{p}_{max}$ = 0.36; Family: Cottidae). Proportions of smallmouth bass diet samples containing juvenile salmon ranged from 0.08 to 0.18 across reservoirs. Although diet composition and consumption index values varied relatively little among years, predation index values calculated for smallmouth bass in mid-reservoir areas during the summer sampling period commonly were the highest calculated since monitoring began in 1991, likely an artifact of elevated abundances of smallmouth bass (i.e., abundance index values) in these areas.

As in previous years, walleye were encountered only in the mid-reservoir and tailrace areas of Lower Monumental Reservoir, where spring and summer abundance index values exceeded those calculated for 2010. Throughout the broader time series (i.e., 1999–2013) abundance

index estimates varied considerably, displaying no obvious monotonic trend. Juvenile Pacific salmon generally were encountered infrequently in gut content samples of walleye in Lower Monumental Reservoir ($\hat{p}$ = 0.09) whereas minnows (Family: Cyprinidae) were encountered regularly ($\hat{p}$ = 0.64).

During 2013, we evaluated 212 and 451 northern pikeminnow diet samples collected during angling activities at The Dalles and John Day dams, respectively. Fish were the primary prey type consumed by northern pikeminnow captured at both The Dalles and John Day dams. Across months, juvenile salmon and American shad were encountered in the greatest number of northern pikeminnow diet samples ($\hat{p}_{max}$ = 0.74 and 0.84, respectively).

Increasing abundance index values for non-native piscivores in some areas of the Snake River reservoirs may be an early indication of a localized compensatory response to northern pikeminnow removal. Given the fragmented nature of these systems, we recommend monitoring efforts continue to assess localized trends in predator populations throughout the Columbia and Snake rivers to help elucidate potential net (system-wide) effects.

INTRODUCTION

The Columbia and Snake rivers once supported large numbers of naturally produced anadromous Pacific salmon (*Oncorhynchus* spp.). 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 (Raymond 1988), and predation (Rieman et al. 1991; Collis et al. 2002). The mean annual loss of juvenile salmon to predators can be equivalent to mortality associated with dam passage (Rieman et al. 1991), which has approached 30% at a single dam (Long and Ossiander 1974). The Northern Pikeminnow Management Program (NPMP) is a set of targeted fisheries aimed at reducing predation on juvenile salmon by northern pikeminnow *Ptychocheilus oregonensis* in the lower Columbia and Snake rivers (Rieman and Beamesderfer 1990; Beamesderfer et al. 1996). Prior to the implementation of these fisheries, the Oregon Department of Fish and Wildlife (ODFW) quantified baseline levels of predation on juvenile salmon by select piscivorous fishes as well as northern pikeminnow population characteristics. Abundance, consumption, and predation were estimated in Columbia River reservoirs in 1990 and 1993, Snake River reservoirs in 1991, and the lower Columbia River downstream from Bonneville Dam in 1992 (Ward et al. 1995). We continue to sample northern pikeminnow populations in standardized areas, and to compare results among years when sample sizes are adequate to produce unbiased estimates (Zimmerman and Ward 1999; Zimmerman et al. 2000; Takata et al. 2007). This report describes activities and findings for 2013, and wherever possible, evaluates temporal changes.

Primary objectives in 2013 were to: (1) estimate rates of exploitation of northern pikeminnow exploitation and potential predation reduction resulting from the targeted removal fisheries; (2) define population parameters of northern pikeminnow, smallmouth bass *Micropterus dolomieu* and walleye *Sander vitreus* in the lower Snake River reservoirs; and (3) assess evidence of possible intra- and inter-specific compensatory responses by these predators related to the sustained removal of northern pikeminnow.

METHODS

Fishery Evaluation and Predation Reduction

Field Procedures

To address the first objective, we tagged northern pikeminnow and estimated exploitation rates with tag recovery data from the Sport-Reward fishery. Northern pikeminnow were collected using boat electrofishing in the Columbia River from river kilometer (rkm) 76 (near Clatskanie, Oregon) upstream to rkm 639 (Priest Rapids Dam) and in the Snake River from rkm 112 (Little Goose Dam) to rkm 248 (Figure 1). Four, 15-minute electrofishing transects were conducted in each river mile (i.e., 1.6 rkm). Sampling occurred between 2 April and 19 June 2013 between the hours of 1800 and 0400, except in the Hanford Reach of the Columbia River (rkm 557–639), where river navigation necessitated daytime sampling.

We tagged, and subsequently released northern pikeminnow greater than or equal to 200 mm in fork length (FL) with uniquely numbered Floy FT-4 lock-on loop tags. Each loop tag was inserted through the pterygiophores just below the midpoint of the dorsal fin. Due to logistical constraints, we were unable to complete tagging activities prior to the start of the Sport-Reward and Dam Angling fisheries. All fish captured downstream of The Dalles Dam (rkm 306) were tagged prior to the start of the fisheries, whereas all tagging conducted upstream of The Dalles Dam was performed concomitant with the fisheries. To provide an annual estimate of tag loss, all loop-tagged fish were marked secondarily with a 134.2 MHz ISO passive integrated transponder (PIT) tag inserted into the dorsal sinus.

We worked in cooperation with the Washington Department of Fish and Wildlife (WDFW) to acquire tag recovery information from the Sport-Reward and Dam-Angling fisheries. The fishery occurred between 1 May and 30 September 2013 (Hone et al. 2014, this report). Participating anglers received payment for all harvested northern pikeminnow greater than or equal to230 mm (9 in) total length (TL). This size criterion for total length corresponds approximately to the minimum fork length (i.e., 200 mm) of northern pikeminnow marked during tagging operations. The payment schedule consisted of three tiers (Porter 2014, this report), and anglers were eligible for a $500 reward for each loop-tagged fish that was returned to a check station.

In addition to the Sport Reward fishery, a NPMP-administered Dam-Angling fishery (Dunlap et al. 2014, this report) was conducted between 1 May and 4 October 2013 in the powerhouse tailraces of The Dalles and John Day dams. For this effort, a team of anglers used hook and line to remove northern pikeminnow greater than or equal to 230 mm TL. Loop-tagged fish captured by the dam anglers were accounted for when estimating exploitation rates for the Sport-Reward fishery (see *Data Analysis* below).

Data Analysis

The proportion of the northern pikeminnow population removed during program fisheries was quantified using mark-recapture data for continuous zones separated by dams (area-specific) and the entire area sampled (system-wide). To account for a reduction in the minimum length of northern pikeminnow eligible for Sport-Reward payment from 11 inches TL (≥278 mm TL;

≥250 mm FL) to 9 inches TL (≥230 mm TL; ≥200 mm FL) in 2000, rates of exploitation were calculated for three size-classes: 1) ≥200 mm FL (all fish tagged), 2) 200 – 249 mm FL, and 3) ≥250 mm FL. The subset of fish greater than or equal to 250 mm FL was used for temporal comparisons.

To control the introduction of known bias into area-specific estimates of annual exploitation, we applied two different models: one for areas where northern pikeminnow were tagged prior to the beginning of the Sport-Reward fishery and a second for areas where tagging occurred during the fishery (Styer 2003). Under each of these scenarios, rates of exploitation were estimated only for those areas where the number of recaptured northern pikeminnow was greater than three. When tagging was completed before the start of the fishery, we calculated the rate of exploitation (u) of the population using the Petersen estimator (Ricker 1975) coupled with a correction for tag retention as

$$u_j = \frac{\frac{R_j}{M_j}}{1-\left(\frac{m}{m+r}\right)}, \quad (1)$$

where R_j is the number of tagged fish recaptured during the season in area j, M_j is the number of fish tagged in area j, m is the number of northern pikeminnow marked during 2013 and recaptured with a PIT tag but no loop tag, and r is the number of northern pikeminnow marked during 2013 and recaptured with loop tags intact.

Confidence intervals (95%) for exploitation estimates were calculated using the normal approximation to a Poisson random variable as

$$u_j \pm \frac{z \cdot \sqrt{R_j}}{M_j}, \quad (2)$$

Where z is multiplier from the standard normal distribution, and R_j and M_j are as described above.

When tagging and fishing efforts occurred concomitantly, each week was treated as a separate sampling period according to the function:

$$u_{weekly_j} = \frac{\frac{R_{ij}}{M_{ij}}}{1-\left(\frac{m}{m+r}\right)}, \quad (3)$$

where R_{ij} is the number of tagged fish recaptured in area j during the i^{th} week, M_{ij} is the number of marked fish at large in area j at the beginning of the i^{th} week of the sport reward fishery, and m and r are as above.

The magnitude of negative bias associated with exploitation rates calculated using the Petersen estimator can be ambiguous when tagging and fishing are conducted concurrently (Styer 2003). To minimize uncertainty surrounding estimates of system-wide annual rates of exploitation, we applied a multiple sample approach as follows:

$$u_{annual_j} = \sum_{i=1}^{n_j} \frac{\frac{R_{ij}}{M_{ij}}}{1-\left(\frac{m}{m+r}\right)}, \quad (4)$$

where R_{ij}, M_{ij}, m and r are as above and n_j is the number of weeks in the season in area j.

We calculated 95% confidence intervals for estimates of annual exploitation using the formula

$$u_{annual_j} \pm t \cdot \sqrt{n_j} \cdot s_j, \quad (5)$$

where t is a multiplier from the Student's t-distribution for $k - 1$ degrees of freedom, s_j is the standard deviation of the weekly exploitation estimates for area j, and n_j is as above. Specific sampling weeks considered in the multiple sample approach can be found in Table B-1.

We used a model based on Friesen and Ward (1999) to estimate current predation on juvenile salmon relative to predation before the implementation of the program. The model estimates potential predation reduction from pre-program levels by incorporating: (1) population structure before removals by fisheries, (2) consumption of juvenile salmon by northern pikeminnow, (3) fish size (i.e., length), (4) size-specific exploitation rates, and (5) annual mortality. A ten-year mean age structure (based on catch curves) was applied for a pre-program baseline and static recruitment was assumed. Since its development, the model has been updated to include fork length increments derived from annual mark-recapture growth observations rather than growth estimates obtained from length and age data. Given these inputs, the model predicts changes in potential predation that were directly related to removals, if all other variables remain constant. We estimated the potential predation during 2013 based on observed exploitation rates and predicted future predation rates using the mean level of exploitation observed during current program rules (2001; 2004–2013). See Friesen and Ward (1999) for additional model documentation.

To test for differences in the size of northern captured in the 2013 sport reward versus the dam angling fisheries (Hone et al. 2014 and Dunlap et al. 2014, respectively, this report), using the R programming environment (R Core Team 2013), we applied area-specific ordinary least-squares models ('lm' in package 'stats'; R Core Team 2013) to fork length data. In this way, fork lengths of northern pikeminnow captured in the dam angling fishery at The Dalles Dam were compared those of fish collected in the sport reward fishery in Bonneville Reservoir and lengths of northern pikeminnow captured at John Day Dam were compared with those of fish collected in The Dalles Reservoir. A review of model assumptions ('lm.modelAssumptions' in package 'lmtest'; Zeileis and Hothorn 2002) showed residuals from each model were non-normal and suffered from heteroscedasticity. Data were log transformed to correct for non-normality and to account for non-constant variance, we applied corrected variance-covariance matrices ('hccm' in package 'car'; Fox and Weisberg 2011).

Biological Evaluation

Field Procedures

We used standardized boat electrofishing techniques described in Ward et al. (1995) and Zimmerman and Ward (1999) to evaluate northern pikeminnow, smallmouth bass, and walleye population parameters in four lower Snake River reservoirs (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) during 2013. Early morning (0200–1200) sampling was conducted during spring (9 May–3 June) and summer (25 June–1 July) in three areas (forebay, mid-reservoir, and tailrace) of each reservoir. The areas contained 20 to 24 transects, each approximately 500 m in length, along both shores of the river. Effort at each transect consisted of a 15 minute electrofishing period with continuous output of approximately 4 amperes. During the summer season, we were unable to sample the forebay and tailrace areas Lower Monumental reservoir as well as the forebay and mid-reservoir areas of Ice Harbor because shoreline water temperatures exceeded 18°C; an environmental threshold specified in scientific collection permits.

We recorded catch and biological data for all northern pikeminnow, smallmouth bass and walleye collected during sampling. Length (FL; nearest mm) and mass (nearest 10 g) were measured for all fish greater than or equal to 200 mm FL. Scales were removed from 25 fish per 25 mm FL increment for the three species by reservoir and season. All untagged northern pikeminnow greater than or equal to 200 mm FL were sacrificed to collect digestive tracts for diet analysis. Digestive tracts were removed by securing both ends with hemostats and pulling free the connective tissue. External tissue was then removed and digestive tracts were placed in sample bags for storage. Whenever possible, we recorded sex and stage of maturity for each sacrificed fish. Stomach contents from smallmouth bass and walleye greater than or equal to 200 mm FL or were collected by gastric lavage using a modified Seaburg sampler (Seaburg 1957). Contents from the foregut of fish were flushed into a 425 µm sieve and then transferred into individual sample bags. All samples were stored on ice while in the field, and then transferred to a freezer until analysis in the laboratory.

Using the protocol described above, we also collected digestive tracts from northern pikeminnow captured during the dam angling portion of the NPMP (Dunlap et al. 2014, this report). Digestive tracts were collected from a representative subsample of catches at each dam weekly from 28 May through 21 August 2013 (generally four days per week). In addition, morphometric (length and mass), sex and maturity data were collected for each fish sampled.

Laboratory Procedures

We examined the contents of digestive tracts from northern pikeminnow, smallmouth bass, and walleye collected during biological evaluation and northern pikeminnow collected during the Dam-Angling fishery to quantify relative consumption of juvenile salmon. Each sample was thawed in the laboratory and the contents sorted into general prey categories (fish, crayfish, other crustaceans, mollusks, insects, and vegetation). Material was weighed (blotted wet mass) to the nearest 0.01 g according to prey category. Stomach contents were then returned to the original sample bags. To digest soft tissues, a solution of pancreatin and sodium sulfide nonahydrate (Na_2O_9S) – mixed at 20 g and 10 g per liter of tap water, respectively – was added to each

sample. Sample bags were then sealed and placed in a desiccating oven at approximately 48°C for 24 hours. After removal from the oven, a sodium hydroxide solution (30g $NaOH \cdot 1\ l\ H_2O^{-1}$) was added to samples to dissolve remaining fats. Contents of each bag were then poured into a 425 µm sieve and rinsed with tap water. The remaining bones were identified to the lowest possible taxon (Hansel et al. 1988, Frost 2000, and Parrish et al. 2006) under a dissecting microscope.

Data Analysis

Following the methods of Ward et al. (1995), we calculated seasonal abundance index values for each predator species by multiplying catch per unit of effort (CPUE; fish·900 second electrofishing run^{-1}) by the surface area of specific sampling locations in each reservoir. We then applied the models of Ward et al. (1995) and Ward and Zimmerman (1999) to calculate consumption index values for northern pikeminnow (CI_{NPM}) and smallmouth bass (CI_{SMB}) as follows:

$$CI_{NPM} = 0.0209 \cdot T^{1.60} \cdot W^{0.27} \cdot (S \cdot GW^{-0.61}), \quad (6)$$

And

$$CI_{SMB} = 0.0407 \cdot e^{(0.15)(T)} \cdot W^{0.23} \cdot (S \cdot GW^{-0.29}), \quad (7)$$

Where

T = mean water temperature per season-area stratum (°C),
W = mean predator mass (g),
S = mean number of juvenile salmon per predator, and
GW = mean gut mass (g) per predator.

These consumption indices do not provide direct estimates of the number of juvenile salmon eaten per day by an average predator; however, output values have been shown to be correlated with consumption rates of northern pikeminnow (Ward et al. 1995) and smallmouth bass (Ward and Zimmerman 1999).

We used the product of seasonal abundance and consumption index values to generate period- and location-specific predation index estimates for northern pikeminnow and smallmouth bass.

Rates of exploitation of northern pikeminnow are believed to increase with increasing fish size (Zimmerman et al. 1995). Thus, sustained fisheries should decrease the abundance of larger fish in the population. With this in mind, we applied a model describing proportional stock density (PSD_i; Anderson 1980) to characterize variation in size structure for northern pikeminnow, smallmouth bass, and walleye populations as follows:

$$PSD_i = 100 \cdot (FQ_i / FS_i), \quad (8)$$

where

FQ_i = number of fish ≥ quality length for species i, and

FS_i = number of fish ≥ stock length for species *i*

Where possible, we also calculated relative stock density ($RSD\text{-}P_i$) for smallmouth bass and walleye (Gabelhouse 1984) using the equation

$$RSD\text{-}P_i = 100 \cdot (FP_i / FS_i), \quad (9)$$

Where

FP_i = number of fish ≥ preferred length for species *i*, and
FS_i = number of fish ≥ stock length for species *i*

Stock and quality minimum length categories used for northern pikeminnow were 250 and 380 mm FL, respectively (Beamesderfer and Rieman 1988; Parker et al. 1995). Stock, quality, and preferred minimum length categories for smallmouth bass were 180, 280, and 350 mm TL, respectively. For walleye, stock, quality, and preferred minimum length categories were 250, 380, and 510 mm TL, respectively (Willis et al. 1985). To standardize data, fork lengths were converted to total length using species-specific models (smallmouth bass: $TL_{SMB} = FL_{SMB} \cdot 1.040$; walleye: $TL_{WAL} = FL_{WAL} \cdot 1.060$).

Like shifts in size-structure, changes in body condition may indicate a response by remaining predators to the sustained exploitation of pikeminnow. We used relative weight (W_r; Anderson and Neumann 1996) to compare the condition of northern pikeminnow, smallmouth bass, and walleye in 2013 with previous years. Length-specific standard weights predicted by a length-mass regression model ($[\log_{10}(W_s) = a' + b \cdot \log_{10}(L)]$), for northern pikeminnow (Parker et al. 1995), smallmouth bass (Kolander et al. 1993), and walleye (Murphy et al. 1990) were used to calculate relative weight [$W_r = 100 \cdot (W/W_s)$]. To account for potential sexual dimorphism, we calculated median W_r separately for male and female northern pikeminnow. Because sampling methodologies preclude diagnosis of sex for smallmouth bass and walleye in the field, we did not calculate separately median W_r for males and females. To assess temporal trends in median W_r for northern pikeminnow we applied a Mann-Kendall test (Mann 1945) wherever possible for each reservoir. To account for serial dependence, trends were evaluated using a block bootstrap technique (Davidson and Hinkley 1997; McLeod 2011). Where feasible, missing data were estimated using linear interpolation. Analyses were conducted in the R programming environment using the 'Kendall' (McLeod 2011) and 'boot' (Fox and Weisberg 2011) packages. All tests were considered significant at $\alpha = 0.05$.

RESULTS

Fishery Evaluation and Predation Estimates

We tagged and released 1,125 northern pikeminnow greater than or equal to 200 mm FL throughout the lower Columbia and Snake rivers during 2013, of which 714 were greater than or equal to 250 mm FL (Table 1). A total of 166,023 northern pikeminnow greater than or equal to 200 mm FL were harvested in removal fisheries during 2013. Of this total, 162,084 fish were removed during the Sport-Reward fishery (Hone et al. 2014, this report) and 4,039 during the Dam-Angling fishery (Dunlap et al. 2014, this report). Ninety-one northern pikeminnow tagged in 2013 were recaptured during the Sport-Reward fishery and one was recovered in the dam angling fishery. Fish tagged in 2013 that were subsequently recaptured in the sport reward fishery were at large from 2 to 151 days (mean = 60 days). Seventy-four percent of Sport-Reward Fishery recaptures were greater than or equal to 250 mm FL (Table 1), whereas 58% of the total measured harvest (tagged and untagged) consisted of northern pikeminnow within this size class. The median fork length of the Sport-Reward fishery catch was 259 mm FL (J. Hone, WDFW, personal communication). One tagged northern pikeminnow (PIT tag and spaghetti tag) recaptured in the 2013 Sport-Reward fishery was captured with a PIT tag present but no loop tag; thus, exploitation was adjusted to reflect a 1.1% rate of tag loss.

System-wide exploitation of northern pikeminnow greater than or equal to 200 mm FL by the Sport-Reward fishery was 9.6% (95% confidence interval 6.1–13.2%; Tables B–1 and B–2). Tag returns were sufficient ($n \geq 4$) to calculate area-specific exploitation estimates for all areas except The Dalles and John Day reservoirs. Area-specific exploitation rates ranged from 4.7 to 12.6% across the other reservoirs sampled (Table B–2). For northern pikeminnow within the 200–249 mm FL size class, the system-wide exploitation rate was 7.7% for the Sport-Reward fishery (95% confidence interval 4.2–11.1%; Table B–2). Area-specific rates of exploitation could be estimated for the Columbia River below Bonneville Dam (6.7%), and Bonneville (10.1%) and McNary (5.8%) reservoirs (Table B–2). The estimated system-wide exploitation rate (10.8%, 95% confidence interval 6.9–14.7%; Figure 2; Table B–2) for northern pikeminnow ≥250 mm FL exceeded those of the other size classes . Area-specific exploitation rates were 9.6% for the Columbia River below Bonneville Dam, 11.2% in Bonneville Reservoir, 26.5% in McNary Reservoir, and 11.4% in Lower Granite Reservoir (Table B–2).

Based on our 2013 estimate of exploitation, the model-predicted reduction in northern pikeminnow consumption of juvenile salmon relative to pre-program levels was 35% (range: 19–53%; Figure 3). Model projections based on the current fishery and population structure suggest predation on juvenile salmon by northern pikeminnow may remain relatively static through 2017.

Biological Evaluation

We conducted 19 to 65 electrofishing runs in non-Boat Restricted Zone sampling areas to collect fish for biological evaluation (Table A-1). Spring index sampling generally coincided with the peak of juvenile salmon migration through Lower Granite, Little Goose, Lower Monumental, and Ice Harbor reservoirs (Figure 4). Across all sample sites, spring CPUE ranged from 0.00 to 0.20 fish·run^{-1} for northern pikeminnow, 1.13 to 11.88 fish·run^{-1} for smallmouth bass, and 0.00

to 0.19 fish·run^{-1} for walleye (Table 2). Summer CPUE ranged from 0.00 to 0.21 fish·run^{-1} for northern pikeminnow, 1.10 to 8.70 fish·run^{-1} for smallmouth bass, and 0.00 to 0.21 fish·run^{-1} for walleye. Across areas, catch rates for northern pikeminnow were the greatest in the upper section of Lower Granite Reservoir and the mid-reservoir area of Lower Monumental Reservoir during spring and summer, respectively. For smallmouth bass, CPUE was highest in the tailrace area of Lower Monumental during both spring and summer seasons, with the greatest CPUE occurring during spring sampling. Walleye were encountered only in Lower Monumental reservoir during 2013, where CPUE was comparable in the mid-reservoir and tailrace areas during spring and marginally greater in the mid-reservoir area compared to the tailrace during the summer (Table 2).

Abundance index values calculated for northern pikeminnow in 2013 ranged from 0.00 to 0.03 in Ice Harbor Reservoir, 0.00 to 0.17 in Lower Monumental Reservoir and 0.00 to 0.01 in Little Goose Reservoir. In the upper reach of Lower Granite Reservoir, annual abundance index was estimated to be 0.10 (Table C–1). Across all sites, abundance index values continue to remain lower than those calculated in 1991 (Figure 5).

Across all areas sampled during 2013, smallmouth bass abundance index values were greatest in the mid-reservoir area of Little Goose Reservoir and lowest in the tailrace area of the same reservoir during both spring and summer. Within reservoirs and across seasons, smallmouth bass abundance index values generally were greatest at the mid-reservoir locations, exceeding all values reported since 1991 in Lower Monumental Reservoir during summer and all values reported since 1991 in Little Goose Reservoir during both seasons. In Lower Granite Reservoir, the abundance index estimate for the spring season exceeded that of summer and was the greatest observed since 1991 in that sampling area (Table C–2).

The abundance index value for walleye sampled during 2013 in the middle section of Lower Monumental Reservoir – the only lower Snake River reservoir where walleye were observed – was approximately twice that of the tailrace section during both spring and summer seasons. The greatest abundance index value (0.32) for walleye occurred in the mid-reservoir stratum of Lower Monumental Reservoir during summer. Conversely, the lowest abundance index values occurred in the tailrace area of Lower Monumental Reservoir, where spring and summer estimates were comparable (0.16 and 0.17, respectively; Table C–3).

We examined 65 northern pikeminnow digestive tracts from Ice Harbor (n=3), Lower Monumental (n=22), Little Goose (n=23) and Lower Granite (n=17) reservoirs to characterize consumption. Across reservoirs and seasons, a majority of the digestive tracts examined contained food items (range = 0.57–1.00). During the spring season, the proportion of northern pikeminnow digestive tracts containing fish exceeded that of summer ($\hat{p}$ = 0.50 and 0.06, respectively). Among reservoirs, only stomach samples collected in Lower Granite during spring contained juvenile salmon (Table 3). When prey fish could be identified, salmon were encountered in the greatest number of gut content samples in Lower Granite Reservoir ($\hat{p}$ = 0.57). In Lower Monumental and Little Goose reservoirs, members of the families Centrarchidae ($\hat{p}$ = 0.33) and Petromyzontidae ($\hat{p}$ = 0.33), respectively, were encountered in the greatest number of gut content samples (Table 4).

During the spring and summer of 2013, we collected 842 and 578 smallmouth bass diet samples, respectively; large proportions of which contained prey items (range: 0.85–0.95). Across reservoirs and seasons, relatively large proportions smallmouth bass diets samples contained fish (range = 0.29–0.77). The proportions of smallmouth bass stomach samples containing salmon generally were low (<0.14) across seasons and reservoirs, with the largest proportion occurring in Lower Granite Reservoir during summer ($\hat{p}$ = 0.13; Table 3). In Little Goose and Lower Granite reservoirs, sand rollers (Family: Percopsidae) were encountered in the greatest number of diet samples ($\hat{p}_{max}$= 0.56), followed by salmon and trout ($\hat{p}_{max}$= 0.18; Family: Salmonidae) and sculpins ($\hat{p}_{max}$= 0.18; Family: Cottidae). In Ice Harbor and Lower Monumental reservoirs, sculpins ($\hat{p}_{max}$ = 0.36) or minnows ($\hat{p}_{max}$ = 0.24; Family: Cyprinidae) were encountered most frequently in gut content samples followed by salmon ($\hat{p}$ = 0.12) in Ice Harbor Reservoir and sunfishes ($\hat{p}$ = 0.16; Family: Centrarchidae) in Lower Monumental Reservoir (Table 4).

During the spring and summer seasons of 2013, we collected 7 and 9 walleye diet samples, respectively from Lower Monumental Reservoir, all of which contained prey items (Table 3). Among seasons, approximately equivalent proportions of diet samples collected contained fish material (spring, 0.86; summer, 0.89). Members of the family Cyprinidae were encountered in a relatively large proportion of walleye diet samples collected in Lower Monumental Reservoir ($\hat{p}$ = 0.64), whereas prey fishes belonging to Catostomidae and Salmonidae were observed in a disproportionately smaller number of samples (0.18 and 0.09, respectively; Table 4).

Where sampling occurred in 2013, we were able to evaluate (i.e., $n \geq 6$) consumption and predation for northern pikeminnow only in Lower Granite Reservoir during spring. In terms of consumption, the index value calculated for the spring of 2013 in Lower Granite Reservoir is the highest for that reservoir since 1991; the inception of biological evaluation in the lower Snake River. The time series of predation estimates displays a similar trend, where the index value calculated for 2013 is the largest calculated since 1994 (5.10 and 0.86, respectively; Tables C–4 and C–5).

Where estimable, consumption index values varied relatively little among areas or seasons (range: 0.00 – 0.03). The highest consumption index value for smallmouth bass occurred during spring in the upper section of Lower Granite Reservoir (Table C–6). Among reservoirs, predation index values were greatest in mid-reservoir area of Little Goose Reservoir during spring and summer (Table C–7). The spring and summer predation index values calculated for this location are the highest to date (1.52 and 2.05, respectively). Further, despite largely consistent diet composition and consumption among years, the predation index value calculated for smallmouth bass in the mid-reservoir area of Little Goose Reservoir during the summer season is the highest reported in the lower Snake River (Table C–7). This is presumably an artifact of greater than typical abundances of smallmouth bass in that area (Table C–2).

As in 2010, we were unable to calculate PSD for northern pikeminnow or PSD and RSP-P for walleye in any of the areas sampled during 2013 due to sample size constraints (i.e., $n < 20$; Table C–8). For smallmouth bass, PSD varied among reservoirs sampled (mean = 19 ± 7.1%) with the largest value occurring at Ice Harbor and Lower Monumental (24%) and the smallest at Lower Granite Reservoir (9%). In contrast, RSD-P values for smallmouth bass were relatively consistent across reservoirs (mean = 3 ± 1.4%; Table C–9).

Median W_r for male northern pikeminnow ranged from 87 to 113 in Ice Harbor, Lower Monumental, Little Goose and Lower Granite reservoirs, whereas values for female northern pikeminnow ranged from 95 to 135 (Figures 6–9; Table C–10). For smallmouth bass, median W_r values occupied a narrower range than northern pikeminnow (93 – 98; Figure 10; Table C–10). Since 1991, walleye have been collected only in Lower Monumental Reservoir. During 2013, the median W_r for walleye in that reservoir was 96 (Figure 11; Table C–10). Analyses of species-specific – and where applicable, gender-specific – W_r time series data within each reservoir identified only one significant trend. Specifically, W_r values for male northern pikeminnow in Lower Monumental Reservoir appeared to increase across years ($\tau = 0.4$, $p = 0.0410$).

During 2013, 1,742 northern pikeminnow digestive tracts were collected from fish removed by the Dam-Angling fishery at The Dalles and John Day dams. The fish from which digestive tracts were removed ranged in size from 208 to 578 mm FL (mean = 345 mm; Table D–1). Of the digestive tracts collected, a subsample of 663 were examined in the laboratory ($n_{\text{The Dalles}} = 216$, $n_{\text{John Day}} = 447$). During 2013 at both dams, large proportions ($\hat{p}_{\text{The Dalles}} = 0.77$ and $\hat{p}_{\text{John Day}} = 0.78$) of the digestive tracts examined contained food (Table D–2). Fish were observed in a greater proportion of diet samples than other prey types at both dams. Of fish prey encountered, across months, juvenile salmon and steelhead, American shad and lamprey at times occurred in the greatest number of diet samples. Juvenile salmon were observed in the greatest number of samples during July ($\hat{p} = 0.74$) but were observed less frequently than lamprey during May ($\hat{p}_{salmon} = 0.39$, $\hat{p}_{lamprey} = 0.72$) and June ($\hat{p}_{salmon} = 0.40$, $\hat{p}_{lamprey} = 0.55$). Occurrence of lampreys in diet samples was highest in May but decreased each subsequent month. Occurrence of salmon and steelhead in diet samples increased each month from May through July. American shad were encountered in the greatest number of northern pikeminnow diets during August ($\hat{p} = 0.84$; Table D–3).

The fork lengths of northern pikeminnow captured in the 2013 sport reward fishery in Bonneville Reservoir (mean = 292 ± 0.48–mm SE) differed significantly from those of fish captured in the dam angling fishery at The Dalles Dam (mean = 324 ± 1.64–mm SE; $p < 0.0001$). Similarly, the fork lengths of northern pikeminnow captured in the sport reward fishery in The Dalles Reservoir (mean = 340 ± 0.96–mm SE) were significantly smaller than those of fish captured in the dam angling fishery at John Day Dam (mean = 352 ± 1.65 mm SE; $p < 0.0001$).

DISCUSSION

Our 2013 estimate of the system-wide exploitation rate (10.8 ± 3.9%, 95% CI) for the NPMP is lower than estimates reported during the past fifteen years of sampling (Figure 2). This estimate falls towards the lower end of the target range of 10–20% required to maintain reduced predation on juvenile salmon (Rieman and Beamesderfer 1990).

Recaptures of northern pikeminnow 200–249 mm FL were inadequate ($n \leq 3$) to calculate area-specific rates of exploitation in all but three areas during 2013 (the Columbia River below Bonneville Dam, as well as Bonneville and McNary reservoirs; Table B–2). Ricker (1975) identified differential mortality and behavioral differences between marked and unmarked fish as violations of the assumptions of the Petersen mark-recapture methodology. Although we were able to calculate a system-wide estimate of exploitation for this subset of the population, disproportionate representation of the size class among areas within the system could influence the efficacy of our evaluation (Styer 2003). Inclusion of these smaller fish in estimates of exploitation rates for all northern pikeminnow greater than or equal to 200 mm FL could reduce the estimated proportion being exploited by NPMP fishery activities. Our evaluation has documented these concerns in previous reports (Takata and Koloszar 2004; Weaver et al. 2008; Weaver et al. 2009). For this reason, we continue to recommend using exploitation rates for northern pikeminnow greater or equal to 250 mm FL when comparing among years of program fisheries.

The 2013 Dam-Angling fishery accounted for 2.4% of the total northern pikeminnow harvest, a value slightly lower than that for 2012 (3.5%; Gardner et al. 2013). Seventeen tagged northern pikeminnow were recovered by dam anglers, one of which was tagged in 2013. Northern pikeminnow collected during the 2013 Dam-Angling fishery at The Dalles and John Day dams were significantly larger than those captured in the Sport-Reward fishery in Bonneville and The Dalles reservoirs, respectively. Vigg et al. (1991) found larger northern pikeminnow consumed disproportionately more smolts than smaller fish. Given the apparent discrepancy in length distributions among Dam-Angling and sport reward fisheries, dam anglers may have a better opportunity for harvesting larger, more predacious, northern pikeminnow than sport anglers (Martinelli and Shively 1997). Additionally, dam anglers harvest fish from the boat restricted zones, which are not accessible to sport-anglers. For these reasons, we support continued angling from the dams accompanied by concurrent monitoring of diet during future Dam-Angling activities.

Removals of larger individuals from northern pikeminnow populations may improve survival among migrating juvenile salmon if a compensatory response by remaining northern pikeminnow or other predatory fishes does not offset the net benefit of removal (Beamesderfer et al. 1996; Friesen and Ward 1999). Potential signs of a compensatory response by predators may be indicated by increased abundance, condition factor, consumption and predation indices, or a shift in population size structure toward larger individuals (Knutsen and Ward 1999). Sustained exploitation between 10 and 20% should bias size-structure toward smaller, less piscivorous, fish (Zimmerman et al. 1995; Vigg et al. 1991), effectively relaxing consumption of juvenile salmon by northern pikeminnow. Continued monitoring of the fisheries should provide the program with information necessary to identify any potential compensatory responses by these predatory fish populations.

The CPUE and abundance index data for 2013 are indicative of a continued and persistent decrease in the number of northern pikeminnow greater than or equal to 250 mm in the lower Snake River reservoirs since the early 1990s when the NPMP was implemented (Table C–1). This basic trend is also reflected in the total number of stock size northern pikeminnow we encounter during indexing years to calculate PSD values (Table C–8). During the last two periods of indexing in these reservoirs, we have been unable to calculate PSD for northern pikeminnow due to insufficient sample sizes ($n \leq 20$). Rieman and Beamesderfer (1990) proposed that a decreasing trend in PSD may reflect the effect of the Sport-Reward fishery as evinced by the direction of change in the size structure of northern pikeminnow. Neumann and Allen (2007) suggested PSD can be high in low-density populations. Proportional stock density values can be related to lower abundance index values. Everhart and Youngs (1981) found that overexploited fish populations may show oscillating patterns of year class strength. Changes in northern pikeminnow abundance and size structure may be related to exploitation, thus continued monitoring is needed to better understand the fisheries association with the functional dynamics of the population.

The efficacy of the NPMP depends on the lack of a compensatory response by other piscivores in the Columbia Basin to the sustained removal of northern pikeminnow (Ward and Zimmerman 1999). As reported in earlier work (Poe et al. 1991; Zimmerman 1999; Naughton et al. 2004), juvenile salmon comprised a small but consistent portion of smallmouth bass diets in the Columbia River. Our observations for 2013 are consistent with these findings (Table 3), with the primary prey fish species consumed by smallmouth bass being sculpins and sand rollers (Table 4). Ward and Zimmerman (1999) suggested the first evidence of a compensatory response by smallmouth bass would likely be a shift in diet towards greater proportions of juvenile salmon. While we did not observe an increase in the proportion of smallmouth bass diets containing juvenile salmon, abundance index values for this species at several locations sampled during 2013 were among the highest we have observed since monitoring began in 1991. The elevated abundance index estimates we observed for smallmouth bass during 2013 contribute to the highest predation index we observed in the lower Snake River reservoirs. We advocate for continued monitoring of smallmouth bass abundance to aid in the characterization of potential compensatory responses.

Like northern pikeminnow, abundance index values for walleye were considerably lower than those estimated for smallmouth bass (c.f., Tables C–2 and C–3) in certain areas of the lower Snake River. Past studies conducted throughout the Columbia River have identified juvenile salmon as an important diet component for walleye (Poe et al. 1991; Vigg et al. 1991; Zimmerman 1999). Takata et al. (2007) found juvenile salmon most often in walleye digestive tracts from The Dalles and John Day reservoirs. Yet, in reservoirs of the Snake River sampled during 2013, juvenile salmon were encountered infrequently in diet samples (Table 4). While abundance and diet data from the current study may suggest the predatory burden imposed by walleye on juvenile salmon is minimal, it is important to note these data are constrained in both space and time. Given evidence provided by others (e.g., diet composition, population dynamics, etc.) in different areas and over varying periods, it seems possible that relatively small shifts in population structure could result in an increased predatory impact of walleye in the lower Snake River system. In light of the predatory potential of walleye on juvenile salmon, and apparent variability therein, further monitoring of population parameters and diets is necessary to assess with greater precision long-term trends.

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). However, fishery management programs have been described as needing sustained annual sampling to effectively evaluate if a response has occurred (Beamesderfer et al. 1996). Therefore, it is critical to continue monitoring to assess the impact of the Northern Pikeminnow Management Program.

ACKNOWLEDGEMENTS

We are grateful to those who worked long hours in the field to collect the data presented in this report, particularly Emma Bell, Jonathan Cheek, Jeanette Grode, Jonathan LaTour, Mike Lovejoy, Kevin Rybacki, Gabe Sheer and Jason Westlund. We thank the following individuals for their cooperation and assistance: Ken Frisby (ODFW, The Dalles Screen Shop) and Mike Gribble (ODFW, Irrigon Hatchery) for providing boat storage facilities; Eric Winther, Kathleen Moyer, and other WDFW staff for providing PIT tag recovery and loop tag loss information; and John Bailey, Carl Dugger, Ben Hausmann, Paul Keller, Tammy Mackey, Andrew Traylor, and Miro Zyndol of the U.S. Army Corps of Engineers for coordination of access to project boat-restricted zones and powerhouse sampling sites.

This project is funded by the Bonneville Power Administration (project number 1990-077-00) and the Contracting Officer's Technical Representative (COTR) is John Skidmore. Christine Mallette of ODFW and Russell Porter of Pacific States Marine Fish Commission (PSMFC) administered the contract.

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 R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–482 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

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., 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.

Collis, K., D. D. Roby, D. P. Craig, S. Adamany, J. Y. Adkins, and D. E. Lyons. 2002. Colony size and diet composition of piscivorous water birds on the Lower Columbia River: Implications for losses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society 131:537–550.

Davidson, A.C. and D.V. Hinkley. 1997. Bootstrap methods and their application. Cambridge University Press.

Dunlap, P. V., J. D. Hone., and E. C. Winther. 2014. Report D – Northern Pikeminnow Dam Angling on the Columbia River. Project Number 199007700. 2013 Annual report to the Bonneville Power Administration, Portland, Oregon.

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

Fox J. and S. Weisberg. 2011. An {R} Companion to Applied Regression, Second Edition. Thousand Oaks CA: Sage.URL: http://socserv.socsci.mcmaster.ca/jfox/Books/Companion

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.

Frost, C. N. 2000. A key for identifying prey fish in the Columbia River based on diagnostic bones. U.S. Geological Survey Western fisheries Research Center, Cook WA. USA 50p.

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

Gardner, M., E. Tinus, M.H. Weaver, C. Mallette, and E.S. Van Dyke. 2013. System-wide predator control program, Report C, indexing and fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number 56795. 2012 Annual Report to the Bonneville Power Administration, Portland, Oregon.

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

Hone, J. D., P. V. Dunlap, and E. C. Winther. 2014. Report A – Implementation of the Northern Pikeminnow Sport-Reward Fishery in the Columbia and Snake Rivers. Project Number 199007700. 2013 Annual report to the Bonneville Power Administration, Portland, Oregon.

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.

Mann, H.B. 1945. Nonparametric tests against trend. Econometrica 12:245–259.

Martinelli, T. L., and R. S. Shively. 1997. Seasonal distribution, movements and habitat associations of northern squawfish in two lower Columbia River reservoirs. Regulated Rivers: Research and Management 6, pp 543–556, Nov–Dec 1997.

A.I. McLeod (2011). Kendall: Kendall rank correlation and Mann-Kendall trend test. R package version 2.2. http://CRAN.R-project.org/package=Kendall

Murphy, B. R., M. L. Brown, and T. A. Springer. 1990. Evaluation of the relative weight (W_r) index, with new applications to walleye. North American Journal of Fisheries Management 10:85–97.

Naughton, G. P., D. H. Bennett, 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 16:4–21.

Neumann, R. S. and M. S. Allen. 2007. Size structure. Pages 375–421 in C. S. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American fisheries Society, Bethesda, Maryland.

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.

Parrish, J.K., K. Haapa-aho, W. Walker, M. Stratton, J. Walsh, H. Ziel. 2006. Small-bodied and juvenile fishes of the Mid-Columbia Region including keys to diagnostic otoliths and cranial bones. Draft Version, March 2006. University of Washington, Seattle WA. USA 137p.

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.

Porter, R.G. 2014. Report B–Northern pikeminnow sport reward payments 2012. Pacific States Marine Fisheries Commission. 2013 Annual Report to the Bonneville Power Administration, Project 199007700, Portland, Oregon.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

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.

Seaburg, K. G. 1957. A stomach sampler for live fish. Progressive fish-Culturist 19:137–139.

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.

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.

Takata, H. K., M. J. Reesman, G. E. Reed, L. D. Layng, and T. A. Jones. 2007. Development of a system-wide predator control program: indexing and fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 2006 Annual Report to the Bonneville Power Administration, Portland, Oregon.

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.

Weaver, M. H., H. K. Takata, M. J. Reesman, L. D. Layng, G. E. Reed, and T. A. Jones. 2008. Development of a system-wide predator control program: fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 2007 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Weaver, M. H., H. K. Takata, M. J. Reesman, and E. S. Van Dyke. 2009. Development of a system-wide predator control program: fisheries evaluation. Oregon Department of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 2008 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Willis, D. W., K. D. McCloskey, and D. W. Gabelhouse, Jr. 1985. Calculation of stock density indices based on adjustments for efficiency of gill-net mesh size. North American Journal of Fisheries Management 5:126–137.

Wismar, R. C., J. E. Smith, B. A. McIntosh, H. W. Li, G. H. Reeves, and J. R. Sedell. 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.

Zeileis A. and Hothorn T. 2002. Diagnostic checking in regression relationships. R News 2(3), 7-10. URL http://CRAN.R-project.org/doc/Rnews/.

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., 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., 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.

TABLES
Main Tables

Table 1. Numbers of northern pikeminnow tagged and recaptured in the Sport-Reward fishery during 2013 used to calculate exploitation rates within various size classes.

	200–249 mm FL		≥ 250 mm FL		All combined	
Area	Tagged	Recaptured	Tagged	Recaptured	Tagged	Recaptured
Below Bonneville Dam	91	6	275	26	368[a]	32
Bonneville	70	7	171	19	241	26
The Dalles	15	0	27	2	42	2
John Day	13	0	10	0	23	0
McNary	109	6	186	15	295	21
Little Goose	38	3	8	1	46	4
Lower Granite	73	0	37	4	110	6
All areas combined	409	22	714	67	1,125	91[b]

[a]The total number of fish tagged is two greater than the sum of both size intervals because two fish were released prior to recording fork lengths.

[b]Two fish were not included in the area-specific exploitation calculations because they were captured in a reservoir other than the one in which they were released, and thus are not represented in the table.

Table 2. Catch per 15-minute boat electrofishing run (CPUE) of northern pikeminnow (≥250 mm FL), smallmouth bass (≥200 mm FL), and walleye (≥200 mm FL) captured during index sampling in the lower Snake River reservoirs during spring and summer 2013. FB = forebay, FB/BRZ = forebay boat restricted zone, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace boat restricted zone. "–" = no sampling conducted.

Species,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Season	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Northern pikeminnow,													
Spring	0.00	0.00	0.05	–	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00	0.20
Summer	–	–	–	–	–	0.21	0.10	–	–	0.00	0.05	–	0.03
Smallmouth bass,													
Spring	2.70	1.13	3.75	–	1.65	3.76	11.88	–	3.26	4.21	1.64	4.00	7.71
Summer	–	–	–	–	–	4.67	8.70	–	–	6.82	1.10	–	5.23
Walleye,													
Spring	0.00	0.00	0.00	–	0.00	0.19	0.19	–	0.00	0.00	0.00	0.00	0.00
Summer	–	–	–	–	–	0.21	0.20	–	–	0.00	0.00	–	0.00

Table 3. Number (n) of northern pikeminnow, smallmouth bass, and walleye (≥200 mm FL) digestive tracts examined from lower Snake River reservoirs during 2013, and proportion of samples containing food, fish, and salmonids (Sal). na = not applicable.

Season,	northern pikeminnow					smallmouth bass					walleye				
Reservoir	$n_{non\text{-}empty}$	n_{empty}	$\hat{p}_{Food}$	$\hat{p}_{Fish}$	$\hat{p}_{Sal}$	$n_{non\text{-}empty}$	n_{empty}	$\hat{p}_{Food}$	$\hat{p}_{Fish}$	$\hat{p}_{Sal}$	$n_{non\text{-}empty}$	n_{empty}	$\hat{p}_{Food}$	$\hat{p}_{Fish}$	$\hat{p}_{Sal}$
Spring,															
Ice Harbor	2	1	0.67	0.33	0.00	129	20	0.87	0.30	0.03	0	0	*na*	*na*	*na*
Lower Monumental	4	3	0.57	0.00	0.00	274	24	0.92	0.46	0.03	7	0	1.00	0.86	0.14
Little Goose	5	1	0.83	0.67	0.00	120	20	0.86	0.63	0.10	0	0	*na*	*na*	*na*
Lower Granite	13	1	0.93	0.71	0.57	242	13	0.95	0.67	0.09	0	0	*na*	*na*	*na*
All	24	6	0.80	0.50	0.27	765	77	0.91	0.52	0.06	7	0	1.00	0.86	0.14
Summer,															
Lower Monumental	9	6	0.60	0.00	0.00	261	24	0.92	0.29	0.01	9	0	1.00	0.89	0.00
Little Goose	14	3	0.82	0.12	0.00	125	12	0.91	0.77	0.04	0	0	*na*	*na*	*na*
Lower Granite	3	0	1.00	0.00	0.00	133	23	0.85	0.62	0.13	0	0	*na*	*na*	*na*
All	26	9	0.74	0.06	0.00	519	59	0.90	0.49	0.05	9	0	1.00	0.89	0.00

Table 4. Proportion of diet samples containing specific prey fish families for northern pikeminnow, smallmouth bass, and walleye in the lower Snake River reservoirs in 2013. Note: multiple families were represented in the gut contents of some fish. See Table 3 for sample sizes.

Common name (Family)	northern pikeminnow				smallmouth bass				walleye
	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Lower Monumental
suckers (Catostomidae)	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.02	0.18
sunfishes (Centrarchidae)	0.00	0.33	0.00	0.07	0.00	0.16	0.05	0.02	0.00
sculpins (Cottidae)	0.00	0.00	0.00	0.14	0.36	0.19	0.18	0.01	0.00
minnows (Cyprinidae)	0.00	0.00	0.00	0.00	0.24	0.20	0.03	0.01	0.64
catfishes (Ictaluridae)	0.00	0.00	0.00	0.00	0.05	0.02	0.01	0.00	0.00
sand rollers (Percospidae)	0.00	0.00	0.00	0.00	0.05	0.13	0.52	0.56	0.00
lampreys (Petromyzontidae)	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
salmon and trout (Salmonidae)	0.00	0.00	0.00	0.57	0.12	0.08	0.12	0.18	0.09
unidentified	1.00	0.67	0.67	0.29	0.26	0.28	0.22	0.24	0.18

Appendix Tables

Table A–1. Number of 15-minute (900 second) boat electrofishing runs conducted for biological indexing in the lower Snake River reservoirs for all sampling years. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ and Rkm = river kilometer.

Year	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
1991	57	58	49	18	66	61	40	16	58	55	40	17	55
1994	0	0	0	0	0	0	39	5	0	0	31	8	85
1995	0	0	0	0	0	0	38	8	0	0	32	8	89
1996	0	0	0	0	0	0	24	8	0	0	33	4	89
1999	0	0	0	0	0	0	11	3	0	0	28	1	63
2004	0	0	0	0	0	0	37	9	0	0	33	6	72
2007	37	40	40	0	40	36	37	0	40	48	40	0	96
2010	36	39	40	0	44	48	30	0	35	35	39	2	91
2013	20	24	20	0	20	45	36	0	19	31	31	1	65

Table B–1. System-wide weekly exploitation rates of northern pikeminnow (≥200 mm FL) for the Sport-Reward fishery in 2013. Dashes (–) indicate: no tagging effort, no recapture effort, or no exploitation calculated.

Sampling Week	Tagged	Recaptured	At-Large	Exploitation[a] (%)
04/01 - 04/06	17	–	0	–
04/07 - 04/13	241	–	17	–
04/14 - 04/20	80	–	258	–
04/21 - 04/27	271	–	338	–
04/28 - 05/04	46	5	609	0.8
05/05 - 05/11	22	0	650	0
05/12 - 05/18	183	3	672	0.5
05/19 - 05/25	19	5	852	0.6
05/26 - 06/01	0	3	866	0.3
06/02 - 06/08	90	6	863	0.7
06/09 - 06/15	110	11	947	1.2
06/16 - 06/22	46	11	1,045	1.1
06/23 - 06/29	–	8	1,080	0.7
06/30 - 07/06	–	4	1,072	0.4
07/07 - 07/13	–	7	1,068	0.7
07/14 - 07/20	–	6	1,061	0.6
07/21 - 07/27	–	2	1,055	0.2
07/28 - 08/03	–	7	1,053	0.7
08/04 - 08/10	–	1	1,046	0.1
08/11 - 08/17	–	2	1,045	0.2
08/18 - 08/24	–	3	1,043	0.3
08/25 - 08/31	–	2	1,040	0.2
09/01 - 09/07	–	2	1,038	0.2
09/08 - 09/14	–	2	1,036	0.2
09/15 - 09/21	–	0	1,034	0
09/22 - 09/28	–	1	1,034	0.1
09/29 - 10/05	–	0	1,033	0
Total	1,125	91		9.6

[a]Adjusted for tag loss (1.1%).

Table B–2. Exploitation rates (%) of northern pikeminnow, grouped by fork length and area, in the Sport-Reward fishery. ***a*** **= no exploitation rate calculated (n≤3) and dash (–) = not sampled.**

Group, Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Little Goose	Lower Granite	All areas
≥200 mm								
2000	9.9	12.4	*a*	*a*	10.2	*a*	10.5	10.9
2001	15.9	8.6	*a*	*a*	26.0	—	9.4	15.5
2002	10.8	5.0	*a*	*a*	7.6	—	11.6	10.6
2003	11.8	11.0	*a*	*a*	6.6	—	*a*	10.5
2004	18.8	11.7	*a*	*a*	*a*	—	19.6	17.0
2005	21.6	8.0	14.9	*a*	9.6	—	*a*	16.3
2006	14.6	10.5	22.4	*a*	10.7	20.0	*a*	14.6
2007	18.4	9.6	*a*	*a*	5.9	35.0	11.8	15.3
2008	20.6	9.6	13.8	*a*	14.1	8.3	4.1	14.8
2009	8.4	15.2	*a*	*a*	8.4	9	*a*	8.8
2010	17.2	10.1	*a*	*a*	9.2	15.0	63.1	15.9
2011	14.9	9.1	*a*	*a*	14.8	*a*	*a*	13.5
2012	15.4	8.6	*a*	*a*	8.8	*a*	*a*	11.0
2013	8.8	10.9	*a*	*a*	12.6	6.90	4.7	9.6
200–249 mm								
2000	9.7	4.1	*a*	*a*	*a*	*a*	*a*	6.6
2001	*a*	*a*	*a*	*a*	*a*	—	*a*	10.6
2002	3.1	*a*	*a*	*a*	*a*	—	*a*	3.4
2003	*a*	*a*	*a*	*a*	*a*	—	*a*	*a*
2004	*a*	13.5	*a*	*a*	*a*	—	*a*	10.9
2005	*a*	*a*	*a*	*a*	*a*	—	*a*	*a*
2006	9.6	6.7	*a*	*a*	*a*	17.4	*a*	9.9
2007	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*
2008	4.6	5.8	10.5	*a*	4.9	4.8	1.3	5.7
2009	*a*	*a*	*a*	*a*	*a*	5.6	*a*	1.8
2010	*a*	*a*	*a*	*a*	12.4	*a*	*a*	7.6
2011	17.9	*a*	*a*	*a*	11.0	*a*	*a*	9.8
2012	7.8	5.8	*a*	*a*	4.5	*a*	*a*	6.0
2013	6.7	10.1	*a*	*a*	5.8	*a*	*a*	7.7

Table B–2 (cont.). Exploitation rates (%) of northern pikeminnow, grouped by fork length and area, in the Sport-Reward fishery. *a* = no exploitation rate calculated (n≤3) and dash (–) = not sampled.

Group, Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Little Goose	Lower Granite	All areas
≥250 mm								
1991	7.6	10.9	23.6	2.8	5.3	2.4	20.0	8.5
1992	11.4	4.0	6.2	3.4	5.6	11.9	15.0	9.3
1993	6.0	2.1	7.0	2.4	15.9	3.3	12.5	6.8
1994	13.6	2.2	9.8	3.2	14.0	6.1	8.7	10.9
1995	16.1	3.5	14.9	0.0	22.4	2.9	6.4	13.4
1996	12.7	6.1	15.5	0.0	18.2	8.9	11.7	12.1
1997	7.8	8.0	5.8	0.0	16.5	0.0	15.5	8.9
1998	8.2	7.8	12.8	0.0	13.6	0.0	12.1	11.1
1999	9.6	13.9	16.1	3.7	15.9	0.0	6.1	12.5
2000	10.0	16.3	*a*	*a*	9.7	*a*	8.7	11.9
2001	16.2	8.5	*a*	*a*	26.0	—	*a*	16.2
2002	12.6	6.0	*a*	*a*	7.7	—	14.3	12.3
2003	13.6	16.7	*a*	*a*	8.2	—	*a*	13.0
2004	20.1	9.3	*a*	*a*	*a*	—	23.8	18.5
2005	23.1	8.2	18.0	*a*	13.0	—	*a*	19.0
2006	15.6	13.7	25.3	*a*	11.2	26.3	*a*	17.1
2007	19.4	11.1	*a*	*a*	7.5	*a*	17.3	17.8
2008	22.2	10.5	15.0	*a*	16.8	21.7	9.2	19.5
2009	11.3	15.9	*a*	*a*	11.6	25.8	*a*	12.8
2010	19.8	13.1	*a*	*a*	*a*	*a*	*a*	18.8
2011	14.5	10.4	*a*	*a*	17.8	*a*	*a*	15.6
2012	17.4	13.5	*a*	*a*	17.6	*a*	*a*	15.9
2013	9.6	11.2	*a*	*a*	26.5	*a*	11.4	10.8

Table C–1.Annual abundance index values (catch per 15-minute electrofishing run, scaled to surface area) for northern pikeminnow (≥ 250 mm FL) in the lower Snake River reservoirs during all sampling years. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ and dash (–) = not sampled.

	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
1991	0.05	0.99	0.32	0.15	0.54	2.94	1.29	0.83	1.25	1.74	0.72	1.67	1.56
1994	–	–	–	–	–	–	0.28	0.06	–	–	0.17	0.38	0.45
1995	–	–	–	–	–	–	0.09	0.20	–	–	0.03	0.60	0.19
1996	–	–	–	–	–	–	0.14	0.05	–	–	0.12	0.06	0.25
1999	–	–	–	–	–	–	0.00	0.00	–	–	0.14	0.00	0.23
2004	–	–	–	–	–	–	0.05	0.03	–	–	0.13	0.20	0.06
2007	0.04	0.00	0.12	–	0.03	0.26	0.00	–	0.04	0.00	0.01	–	0.10
2010	0.00	0.00	0.00	–	0.00	0.32	0.06	–	0.00	0.00	0.05	0.06	0.13
2013	0.00	0.00	0.03	–	0.00	0.17	0.05	–	0.00	0.00	0.01	0.00	0.10

Table C–2. Annual abundance index values (catch per 15-minute electrofishing run, scaled to surface area) for smallmouth bass (≥ 200 mm FL) in the lower Snake River reservoirs by season. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ and dash (–) = not sampled.

Season,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year,	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Spring,													
1991	1.31	11.30	2.74	0.02	1.34	3.81	3.26	0.31	3.47	11.94	1.08	0.15	0.70
1994	–	–	–	–	–	–	1.65	0.05	–	–	2.13	0.03	4.68
1995	–	–	–	–	–	–	0.89	0.05	–	–	1.52	0.25	1.68
1996	–	–	–	–	–	–	0.64	0.00	–	–	1.11	–	1.74
1999	–	–	–	–	–	–	2.70	0.09	–	–	0.80	0.06	1.42
2004	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	1.54
2007	1.79	6.50	3.84	–	2.65	5.36	5.04	–	6.81	5.99	0.42	–	3.80
2010	1.07	8.85	3.43	–	1.56	6.45	4.10	–	2.96	11.34	0.16	0.06	1.38
2013	3.86	4.04	2.52	–	1.72	5.76	10.08	–	4.83	15.53	0.72	0.24	6.49
Summer,													
1991	0.65	5.18	1.21	0.14	0.83	1.69	0.96	0.03	3.40	8.72	1.75	0.12	3.72
1994	–	–	–	–	–	–	2.25	0.10	–	–	0.93	0.12	1.10
1995	–	–	–	–	–	–	0.85	0.22	–	–	0.83	0.15	1.68
1996	–	–	–	–	–	–	1.06	0.05	–	–	0.35	0.06	0.46
1999	–	–	–	–	–	–	–	–	–	–	0.00	–	0.00
2004	–	–	–	–	–	–	9.01	0.23	–	–	0.47	0.30	2.01
2007	5.04	11.21	3.74	–	3.80	3.38	4.54	–	6.36	9.52	0.38	–	2.77
2010	3.84	8.07	2.83	–	3.45	6.51	13.16	–	2.96	11.73	0.68	1.77	3.25
2013	–	–	–	–	–	7.15	7.39	–	–	25.15	0.49	–	4.40

Table C–3. Annual abundance index values (catch per 15-minute electrofishing run, scaled to surface area) for walleye (≥200 mm FL) in the lower Snake River reservoirs by season. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ and dash (–) = not sampled.

Season,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year,	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Spring,													
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
1995	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
1996	–	–	–	–	–	–	0.00	0.00	–	–	0.00	–	0.00
1999	–	–	–	–	–	–	0.08	0.00	–	–	0.00	0.00	0.00
2004	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
2007	0.00	0.00	0.00	–	0.00	0.89	0.35	–	0.00	0.00	0.00	–	0.00
2010	0.00	0.00	0.00	–	0.00	0.00	0.05	–	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	–	0.00	0.29	0.16	–	0.00	0.00	0.00	0.00	0.00
Summer,													
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
1995	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
1996	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
1999	–	–	–	–	–	–	–	–	–	–	0.00	–	0.00
2004	–	–	–	–	–	–	0.00	0.00	–	–	0.00	0.00	0.00
2007	0.00	0.00	0.00	–	0.00	0.32	0.59	–	0.00	0.00	0.00	–	0.00
2010	0.00	0.00	0.00	–	0.00	0.26	0.14	–	0.00	0.00	0.00	0.00	0.00
2013	–	–	–	–	–	0.32	0.17	–	–	0.00	0.00	–	0.00

Table C–4. Spring and summer consumption index values for northern pikeminnow (≥250 mm FL) in the lower Snake River reservoirs during all sampling years. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ, dash (–) = not sampled, *a* = no consumption index calculated (n≤5) and *b* = no stomach data collected.

Season,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Spring													
1991	*a*	0.36	1.02	0.72	0.27	0.00	0.68	0.63	1.00	0.00	0.72	*a*	0.42
1994	–	–	–	–	–	–	0.77	ngs	–	–	2.32	*a*	0.77
1995	–	–	–	–	–	–	*b*	*a*	–	–	*b*	*a*	1.27
1996	–	–	–	–	–	–	*a*	*a*	–	–	0.71	–	0.31
1999	–	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	2.18
2004	–	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	*a*
2007	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*	*a*	*a*	–	0.97
2010	*a*	*a*	*a*	–	*a*	0.00	*a*	–	*a*	*a*	*a*	*a*	*a*
2013	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*	*a*	*a*	*a*	5.10
Summer													
1991	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
1994	–	–	–	–	–	–	*a*	0.00	–	–	*a*	*a*	*b*
1995	–	–	–	–	–	–	*a*	0.00	–	–	*a*	*a*	*a*
1996	–	–	–	–	–	–	*a*	0.00	–	–	*a*	*a*	*a*
1999	–	–	–	–	–	–	–	–	–	–	*a*	–	*a*
2004	–	–	–	–	–	–	*a*	0.00	–	–	0.00	*a*	*a*
2007	*a*	*a*	2.05	–	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*
2010	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*	*a*	*a*	*a*	1.70
2013	–	–	–	–	–	*a*	*a*	–	*a*	*a*	*a*	–	*a*

Table C–5. Spring and summer predation index values for northern pikeminnow (≥250 mm FL) in the lower Snake River reservoirs during all sampling years. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ, dash (–) = not sampled, *a* = no predation index calculated (n≤5) and *b* = no stomach data collected.

Season,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Spring													
1991	*a*	0.49	0.45	0.09	0.18	0.00	1.35	0.56	1.34	0.00	1.03	*a*	1.11
1994	–	–	–	–	–	–	0.31	*a*	–	–	1.03	*a*	0.71
1995	–	–	–	–	–	–	*b*	*b*	–	–	*b*	*a*	0.36
1996	–	–	–	–	–	–	*a*	*a*	–	–	0.18	–	0.14
1999	–	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	0.70
2004	–	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	*a*
2007	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*	*a*	*a*	–	0.19
2010	*a*	*a*	*a*	–	*a*	0.00	*a*	–	*a*	*a*	*a*	*a*	*a*
2013	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*	*a*	*a*	*a*	0.86
Summer													
1991	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
1994	–	–	–	–	–	–	*a*	0.00	–	–	*a*	*a*	*b*
1995	–	–	–	–	–	–	*a*	0.00	–	–	*a*	*a*	*a*
1996	–	–	–	–	–	–	*a*	0.00	–	–	*a*	*a*	*a*
1999	–	–	–	–	–	–	–	–	–	–	*a*	–	*a*
2004	–	–	–	–	–	–	*a*	0.00	–	–	0.00	*a*	*a*
2007	*a*	*a*	0.48	–	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*
2010	*a*	*a*	*a*	–	*a*	*a*	*a*	–	*a*	*a*	*a*	*a*	0.40
2013	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	–	*a*

Table C–6. Spring and summer consumption index values for smallmouth bass (≥200 mm FL) in the lower Snake River reservoirs during all sampling years. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ, dash (–) = not sampled, *a* = no consumption index calculated (n≤5) and *b* = no stomach data collected.

Season,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Spring													
1991	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.01	0.00	0.01	*a*	0.04
1994	–	–	–	–	–	–	0.03	*a*	–	–	0.02	*a*	0.03
1995	–	–	–	–	–	–	0.00	*a*	–	–	0.00	*a*	0.02
1996	–	–	–	–	–	–	0.00	*a*	–	–	0.00	–	0.01
1999	–	–	–	–	–	–	0.00	*a*	–	–	0.01	*a*	0.02
2004	–	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	0.02
2007	0.01	0.01	0.00	–	0.01	0.01	0.01	–	0.02	0.02	0.00	–	0.02
2010	0.01	0.00	0.01	–	0.01	0.00	0.00	–	0.01	0.01	0.00	*a*	0.05
2013	0.00	0.01	0.01	–	0.01	0.01	0.00	–	0.02	0.02	0.01	*a*	0.02
Summer													
1991	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
1994	–	–	–	–	–	–	*b*	*b*	–	–	*b*	*b*	*b*
1995	–	–	–	–	–	–	0.00	0.00	–	–	0.00	*a*	0.00
1996	–	–	–	–	–	–	0.00	a	–	–	0.00	*a*	0.00
1999	–	–	–	–	–	–	–	–	–	–	*a*	–	*a*
2004	–	–	–	–	–	–	*b*	*b*	–	–	*b*	*b*	0.01
2007	0.00	0.01	0.00	–	0.00	0.00	0.00	–	0.00	0.00	0.01	–	0.01
2010	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.01	0.01	*a*	0.01
2013	–	–	–	–	–	0.01	0.00	–	–	0.01	0.00	–	0.03

Table C–7. Spring and summer predation index values for smallmouth bass (≥200 mm FL) in the lower Snake River reservoirs during all sampling years. FB = forebay, Mid = mid-reservoir, TR = tailrace, TR/BRZ = tailrace BRZ, dash (–) = not sampled, *a* = no predation index calculated (n≤5), and *b* = no stomach data collected.

Season,	Ice Harbor				Lower Monumental				Little Goose				Lower Granite
Year	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	FB	Mid	TR	TR/BRZ	Rkm 222–228
Spring													
1991	0.00	0.10	0.00	0.00	0.31	0.00	0.00	0.00	0.12	0.10	0.03	*a*	0.08
1994	–	–	–	–	–	–	0.11	*a*	–	–	0.19	*a*	0.79
1995	–	–	–	–	–	–	0.00	*a*	–	–	0.00	*a*	0.13
1996	–	–	–	–	–	–	0.00	*a*	–	–	0.02	–	0.04
1999	–	–	–	–	–	–	0.04	*a*	–	–	0.01	*a*	0.08
2004	–	–	–	–	–	–	*a*	*a*	–	–	*a*	*a*	0.16
2007	0.13	0.26	0.03	–	0.18	0.22	0.16	–	0.52	0.40	0.00	–	0.30
2010	0.05	0.00	0.10	–	0.07	0.09	0.06	–	0.05	0.18	0.00	*a*	0.19
2013	0.00	0.12	0.11	–	0.09	0.24	0.19	–	0.41	1.52	0.03	*a*	0.60
Summer													
1991	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
1994	–	–	–	–	–	–	*b*	*b*	–	–	*b*	*b*	*b*
1995	–	–	–	–	–	–	0.00	0.00	–	–	0.00	*a*	0.00
1996	–	–	–	–	–	–	0.00	*a*	–	–	0.00	*a*	0.00
1999	–	–	–	–	–	–	–	–	–	–	*a*	–	*a*
2004	–	–	–	–	–	–	*b*	*b*	–	–	*b*	*b*	0.16
2007	0.26	0.59	0.05	–	0.00	0.00	0.00	–	0.34	0.00	0.05	–	0.53
2010	0.00	0.00	0.00	–	0.00	0.06	0.00	–	0.00	0.61	0.03	*a*	0.37
2013	–	–	–	–	–	0.43	0.00	–	–	2.05	0.00	–	0.88

Table C–8. Number of stock-sized fish (n) collected by boat electroshocking and proportional stock density (PSD, %) of northern pikeminnow in the lower Snake River reservoirs during all sampling years. Dash (–) = not sampled and *a* = no stock density index calculated (n≤20).

	Ice Harbor		Lower Monumental		Little Goose		Lower Granite	
Year	n	PSD (%)	n	PSD (%)	n	PSD (%)	n	PSD (%)
1991	116	29	473	12	621	29	102	42
1994	–	–	19	*a*	64	66	45	33
1995	–	–	35	23	84	60	20	30
1996	–	–	12	*a*	13	*a*	26	38
1999	–	–	0	*a*	9	*a*	17	*a*
2004	–	–	8	*a*	30	53	5	*a*
2007	8	*a*	7	*a*	2	*a*	11	*a*
2010	0	*a*	12	*a*	6	*a*	14	*a*
2013	1	*a*	7	*a*	1	*a*	7	*a*

Table C–9. Number of stock-sized fish (n) collected by boat electroshocking, proportional stock density (PSD, %), and relative stock density (RSD, %) of smallmouth bass in the lower Snake River reservoirs during all sampling years. Dash (–) = not sampled.

	Ice Harbor			Lower Monumental			Little Goose			Lower Granite		
Year	n	PSD	RSD	n	PSD	RSD	n	PSD	RSD	n	PSD	RSD
1991	499	21	4	460	21	3	640	21	3	249	8	3
1994	–	–	–	173	9	1	160	6	1	447	9	2
1995	–	–	–	74	12	3	131	14	5	275	17	6
1996	–	–	–	39	10	0	57	21	5	132	29	11
1999	–	–	–	42	62	2	30	70	0	83	37	6
2004	–	–	–	255	16	1	48	35	13	306	12	2
2007	671	13	3	542	14	3	520	18	5	519	14	3
2010	485	15	2	780	8	1	338	23	7	451	16	6
2013	220	24	3	661	24	1	408	20	4	731	9	2

Table C–10. Sample size (n), median relative weight (W_r), and 95% bootstrap confidence interval (CI; quantile) for northern pikeminnow (≥200 mm FL), smallmouth bass (≥200 mm TL), and walleye (≥200 mm TL) in the lower Snake River reservoirs during all sampling years. Dash (–) = not sampled.

Area,	Northern pikeminnow						Smallmouth bass			Walleye		
	Male			Female								
Year	n	W_r	CI	n	W_r	CI	n	W_r	CI	n	W_r	CI
Ice Harbor												
1991	33	90	4.7	35	92	12.4	240	87	4.4	0	*na*	*na*
1994	–	–	–	–	–	–	–	–	–	–	–	–
1995	–	–	–	–	–	–	–	–	–	–	–	–
1996	–	–	–	–	–	–	–	–	–	–	–	–
1999	–	–	–	–	–	–	–	–	–	–	–	–
2004	–	–	–	–	–	–	–	–	–	–	–	–
2007	9	97	16.2	12	91	17.3	408	90	2.3	0	*na*	*na*
2010	0	*na*	*na*	2	101	4.5	335	95	2.8	0	*na*	*na*
2013	1	87	*na*	1	135	*na*	155	94	2.3	0	*na*	*na*
Lower Monumental												
1991	121	93	3.2	124	95	5.0	225	91	3.3	0	*na*	*na*
1994	16	92	12.4	12	99	23.6	88	88	5.8	0	*na*	*na*
1995	15	94	9.6	24	101	12.0	60	87	5.9	0	*na*	*na*
1996	5	87	48.0	8	94	27.3	30	83	9.6	0	*na*	*na*
1999	0	*na*	*na*	0	*na*	*na*	40	100	7.4	1	105	*na*
2004	4	100	25.0	7	95	16.7	207	100	3.6	0	*na*	*na*
2007	5	91	10.8	6	103	39.6	420	91	2.6	33	91	7.4
2010	3	90	8.6	15	93	25.9	580	92	2.7	7	100	22.7
2013	7	97	12.8	13	95	17.4	586	93	1.7	16	96	6.8

Table C–10 (cont.). Sample size (n), median relative weight (W_r), and 95% bootstrap confidence interval (CI; quantile) for northern pikeminnow (≥200 mm FL), smallmouth bass (≥200 mm TL), and walleye (≥200 mm TL) in the lower Snake River reservoirs during all sampling years. Dash (–) = not sampled.

Area,	Northern pikeminnow						Smallmouth bass			Walleye		
	Male			Female								
Year	n	W_r	CI	n	W_r	CI	n	W_r	CI	n	W_r	CI
Little Goose												
1991	110	98	5.6	143	103	6.7	333	92	3.6	0	*na*	*na*
1994	19	94	16.6	53	114	10.5	60	92	4.2	0	*na*	*na*
1995	22	106	12.2	63	115	8.1	111	87	3.5	0	*na*	*na*
1996	5	86	25.7	9	113	32.2	54	87	6.1	0	*na*	*na*
1999	4	97	21.5	5	123	89.2	30	100	8.0	0	*na*	*na*
2004	6	101	22.5	33	106	10.3	37	95	11.4	0	*na*	*na*
2007	4	94	25.1	5	109	20.1	311	91	2.3	0	*na*	*na*
2010	1	88	*na*	7	99	27.6	243	97	2.7	0	*na*	*na*
2013	3	109	10.7	13	103	18.8	280	96	3.5	0	*na*	*na*
Lower Granite												
1991	38	92	9.5	54	100	8.2	586	91	2.3	0	*na*	*na*
1994	27	97	13.6	28	108	16.0	160	91	3.3	0	*na*	*na*
1995	10	99	17.6	10	106	28.5	178	91	3.8	0	*na*	*na*
1996	8	98	25.9	16	111	23.6	110	85	4.9	0	*na*	*na*
1999	3	133	20.5	10	127	29.5	82	95	3.7	0	*na*	*na*
2004	3	101	2.9	6	102	7.1	151	102	4.6	0	*na*	*na*
2007	0	*na*	*na*	8	131	34.1	373	96	2.6	0	*na*	*na*
2010	2	110	26.1	12	116	23.3	244	94	4.8	0	*na*	*na*
2013	4	113	28.7	8	101	33.2	416	98	2.3	0	*na*	*na*

Table D–1. Fork length characteristics of northern pikeminnow sampled annually from anglers' catches at Bonneville (2006), The Dalles (2006-2013), and John Day (2007-2013) dams for digestive tract evaluation.

Dam, Year	n	Minimum	Maximum	Mean	Median
Bonneville,					
2006	22	267	544	425	438
The Dalles,					
2006	129	212	549	360	342
2007	340	229	550	343	333
2008	209	200	518	356	350
2009	223	187	545	377	370
2010	395	185	545	366	364
2011	326	219	574	367	370
2012	324	210	525	332	314
2013	633	214	578	328	343
John Day,					
2007	453	230	553	366	358
2008	64	262	550	377	365
2009	224	251	572	403	394
2010	382	233	575	376	376
2011	288	230	515	362	363
2012	492	230	545	344	320
2013	1,109	208	565	355	376
All dams and years	5,613	185	575	357	355

Table D–2. Number (n) of northern pikeminnow (≥250 mm FL) digestive tracts examined from Bonneville (2006), The Dalles (2006-2013), and John Day (2007-2013) dams, and proportion of samples containing prey items (Sal=salmon, Lam=lamprey, Ash=American shad).

Dam, Year	$n_{non\text{-}empty}$	n_{empty}	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{crayfish}$	$\hat{p}_{other\ invert.}$	$\hat{p}_{misc.}$	$\hat{p}_{Sal}$	$\hat{p}_{Lam}$	$\hat{p}_{Ash}$	$\hat{p}_{other\ fish}$
Bonneville,											
2006	18	4	0.82	0.41	0.09	0.23	0.23	0.36	0.00	0.00	0.09
The Dalles,											
2006	46	83	0.36	0.21	0.08	0.04	0.11	0.04	0.17	0.00	0.05
2007	207	133	0.61	0.40	0.04	0.22	0.09	0.13	0.31	0.00	0.06
2008	132	77	0.63	0.44	0.04	0.33	0.05	0.11	0.31	0.00	0.12
2009	156	67	0.70	0.64	0.06	0.19	0.10	0.09	0.50	0.01	0.14
2010	245	150	0.62	0.49	0.06	0.14	0.17	0.16	0.18	0.15	0.18
2011	217	112	0.66	0.44	0.07	0.19	0.17	0.36	0.09	0.00	0.08
2012	212	63	0.77	0.57	0.09	0.19	0.25	0.15	0.18	0.00	0.00
2013	166	50	0.77	0.43	0.12	0.34	0.16	0.17	0.22	0.04	0.06
John Day,											
2007	263	190	0.58	0.37	0.02	0.27	0.03	0.13	0.08	0.11	0.21
2008	52	12	0.81	0.36	0.03	0.69	0.11	0.09	0.23	0.00	0.08
2009	137	87	0.61	0.56	0.08	0.31	0.04	0.11	0.40	0.00	0.14
2010	210	172	0.55	0.29	0.07	0.34	0.25	0.16	0.10	0.02	0.07
2011	198	85	0.70	0.22	0.06	0.56	0.04	0.15	0.07	0.00	0.02
2012	369	110	0.77	0.39	0.13	0.48	0.09	0.15	0.12	0.04	0.00
2013	349	98	0.78	0.47	0.22	0.34	0.04	0.23	0.16	0.09	0.05

Table D–3. Proportion of diet samples containing specific prey fish families for northern pikeminnow collected from The Dalles and John Day dams during May through August, 2013. Note: multiple families were represented in the gut contents of some northern pikeminnow.

Common name (Family)	May [a]	June	July	August	Total
lampreys (Petromyzontidae)	0.72	0.55	0.35	0.05	0.41
American shad (Clupeidae)	0.00	0.01	0.03	0.84	0.18
salmon and trout (Salmonidae)	0.39	0.40	0.74	0.16	0.48
mountain whitefish (Salmonidae)	0.00	0.03	0.00	0.00	0.01
minnows (Cyprinidae)	0.00	0.00	0.00	0.07	0.01
suckers (Catostomidae)	0.00	0.00	0.00	0.07	0.01
sunfishes (Centrarchidae)	0.00	0.00	0.01	0.09	0.02
walleye (Percidae)	0.00	0.01	0.00	0.02	0.01
unidentified	0.00	0.00	0.02	0.02	0.01

[a]Sampling began 28 May 2013

FIGURES

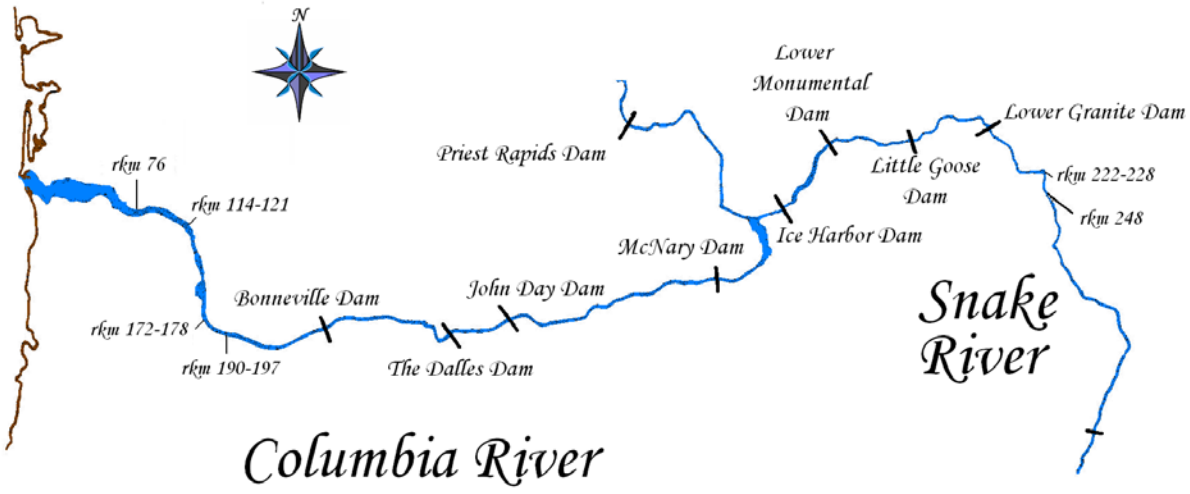


Figure 1. Study area in the Columbia and Snake rivers.

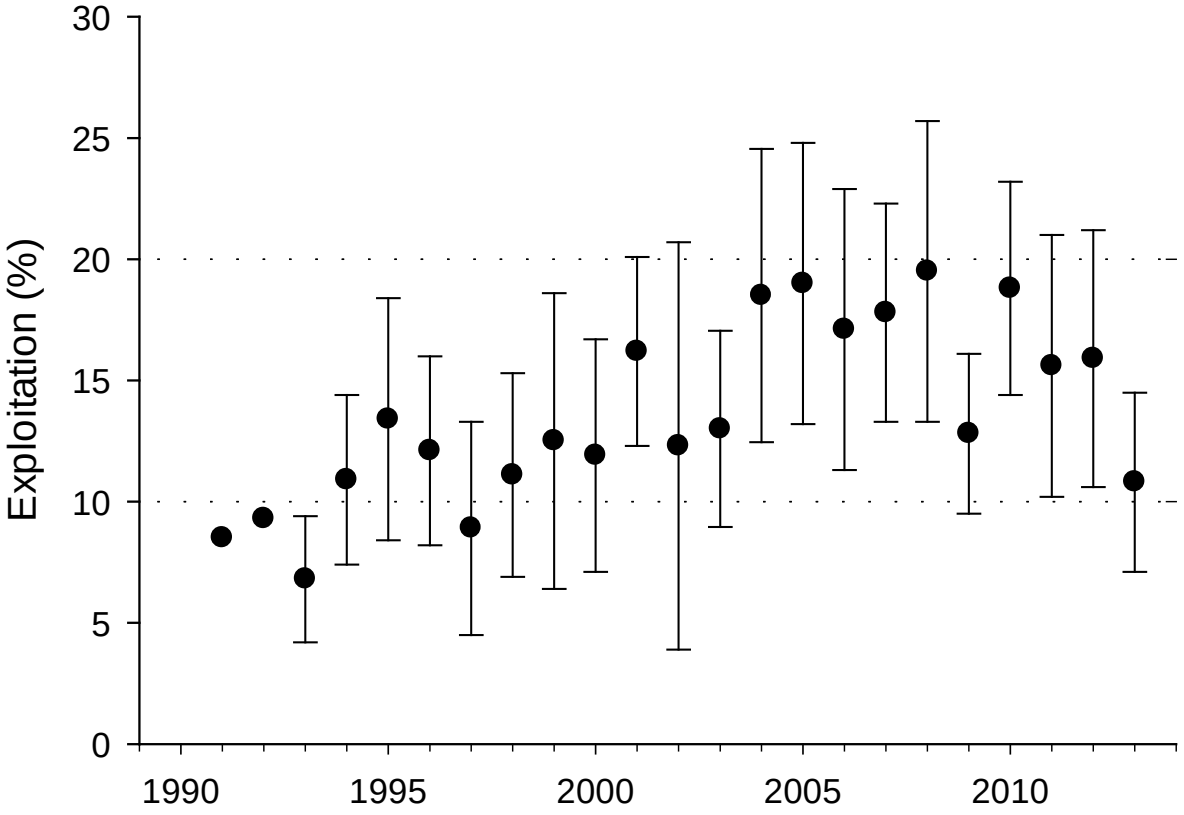


Figure 2. System-wide exploitation rates of northern pikeminnow (≥250 mm FL) for the Sport-Reward fishery, 1991–2013. Error bars represent the 95% confidence interval. Confidence intervals were not available for 1991–1992.

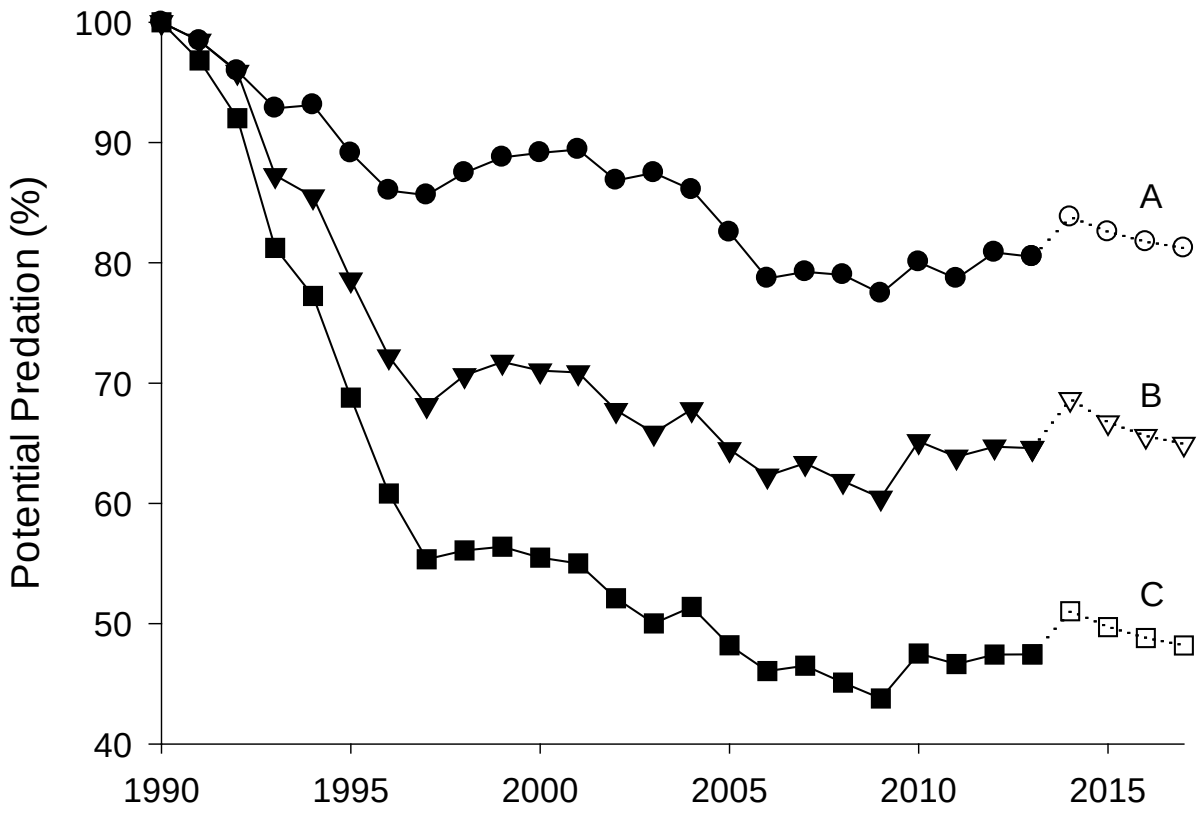


Figure 3. Maximum (A), median (B), and minimum (C) levels of potential predation estimated for northern pikeminnow on juvenile salmon relative to predation prior to implementation of the Northern Pikeminnow Management Program. Estimates of predicted predation after 2013 are based on 9-year average values.

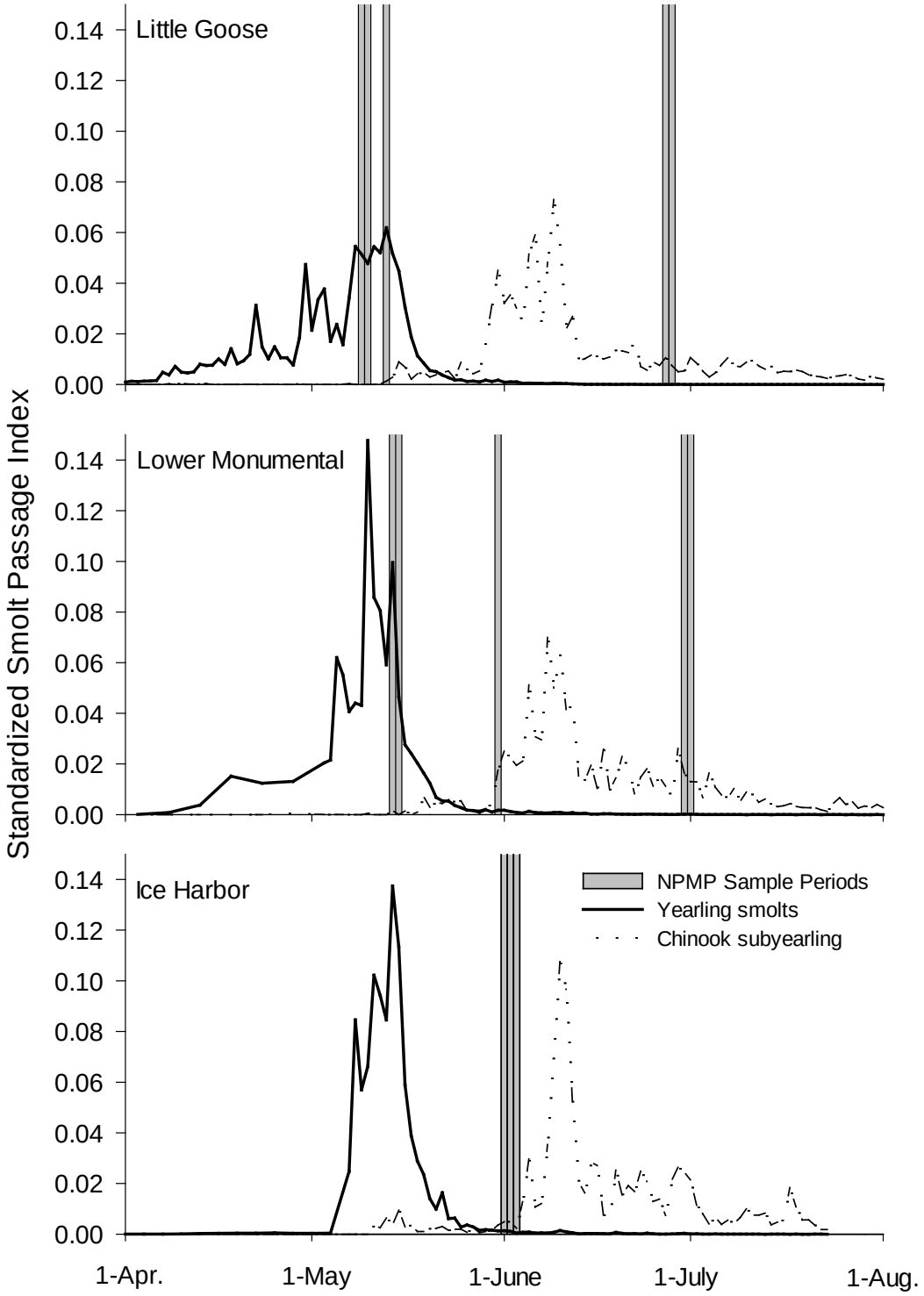


Figure 4. Periods of index sampling and index of juvenile salmon passing through Lower Granite, Little Goose and Lower Monumental dams 1 April–31 July 2013 (Source: Fish Passage Center, unpublished data). Passage data are daily smolt passage index values standardized to total passage throughout the period of interest. No comparable passage data exist for Lower Granite Reservoir.

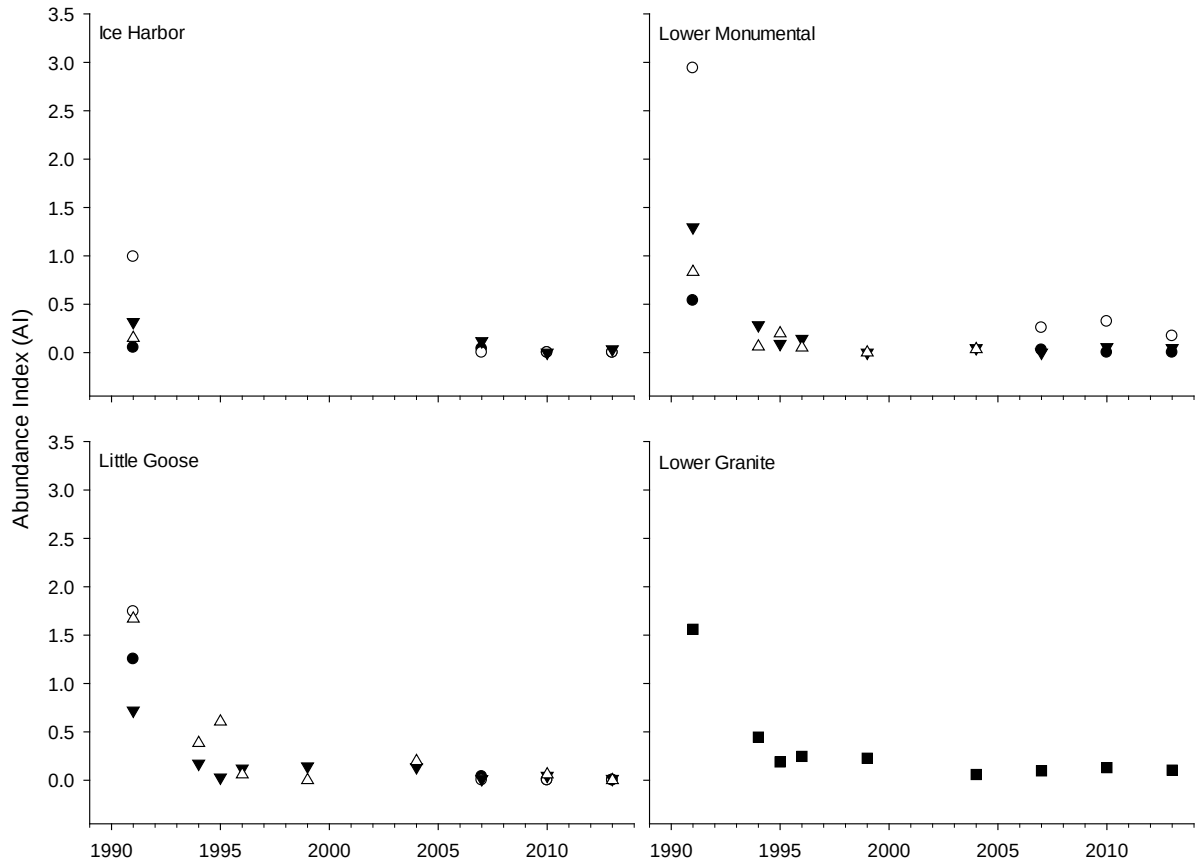


Figure 5. Abundance index values for northern pikeminnow in discrete reaches of Ice Harbor, Lower Monumental, Little Goose and Lower Granite reservoirs, 1991-2013.

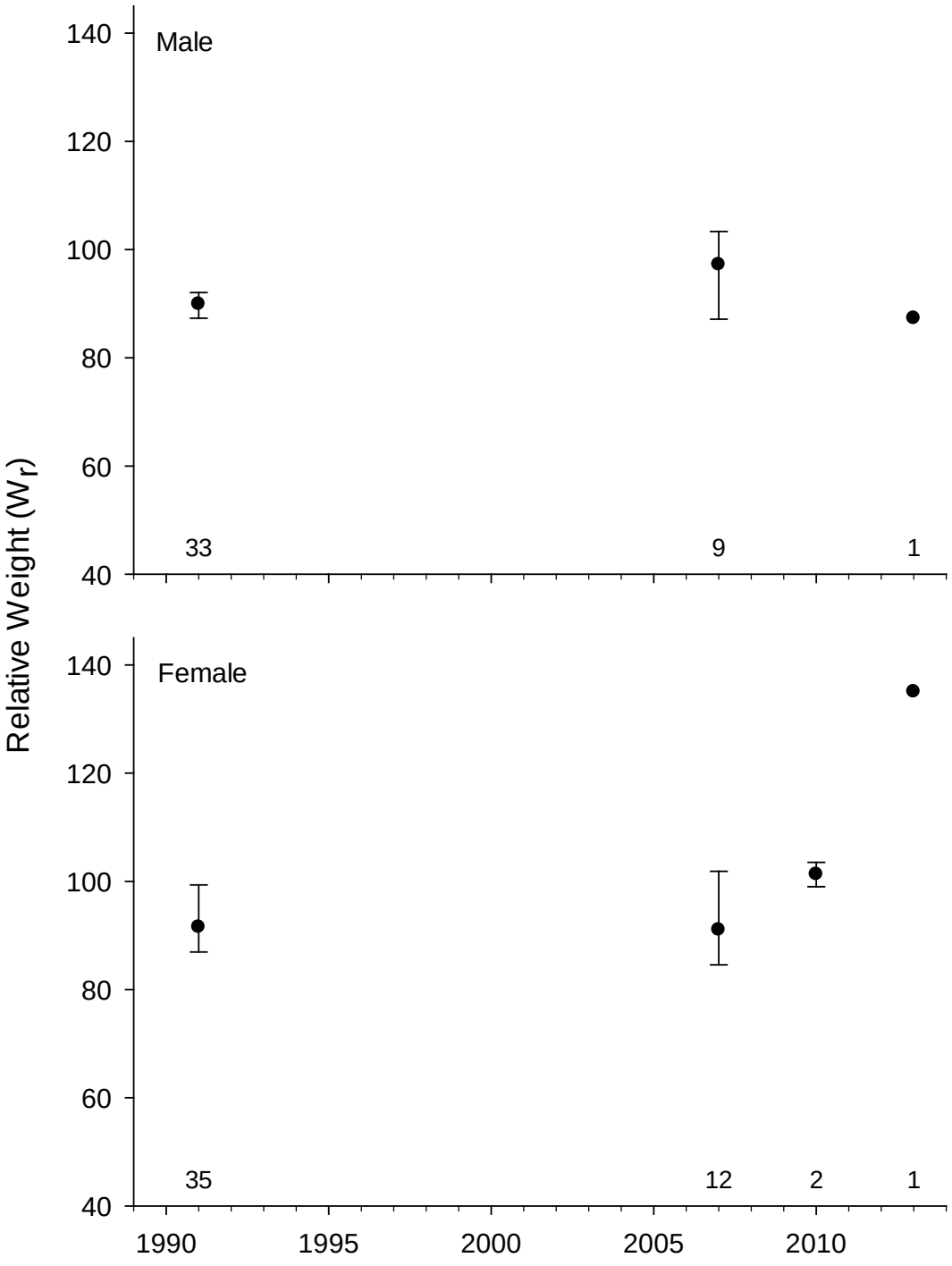


Figure 6. Median relative weight (W_r) for male and female northern pikeminnow in Ice Harbor Reservoir, 1991–2013. Error bars represent 95% bootstrap (quantile) confidence intervals. Sample sizes are presented above the independent axis. Years with no data indicate sampling was not conducted or no fish were collected.

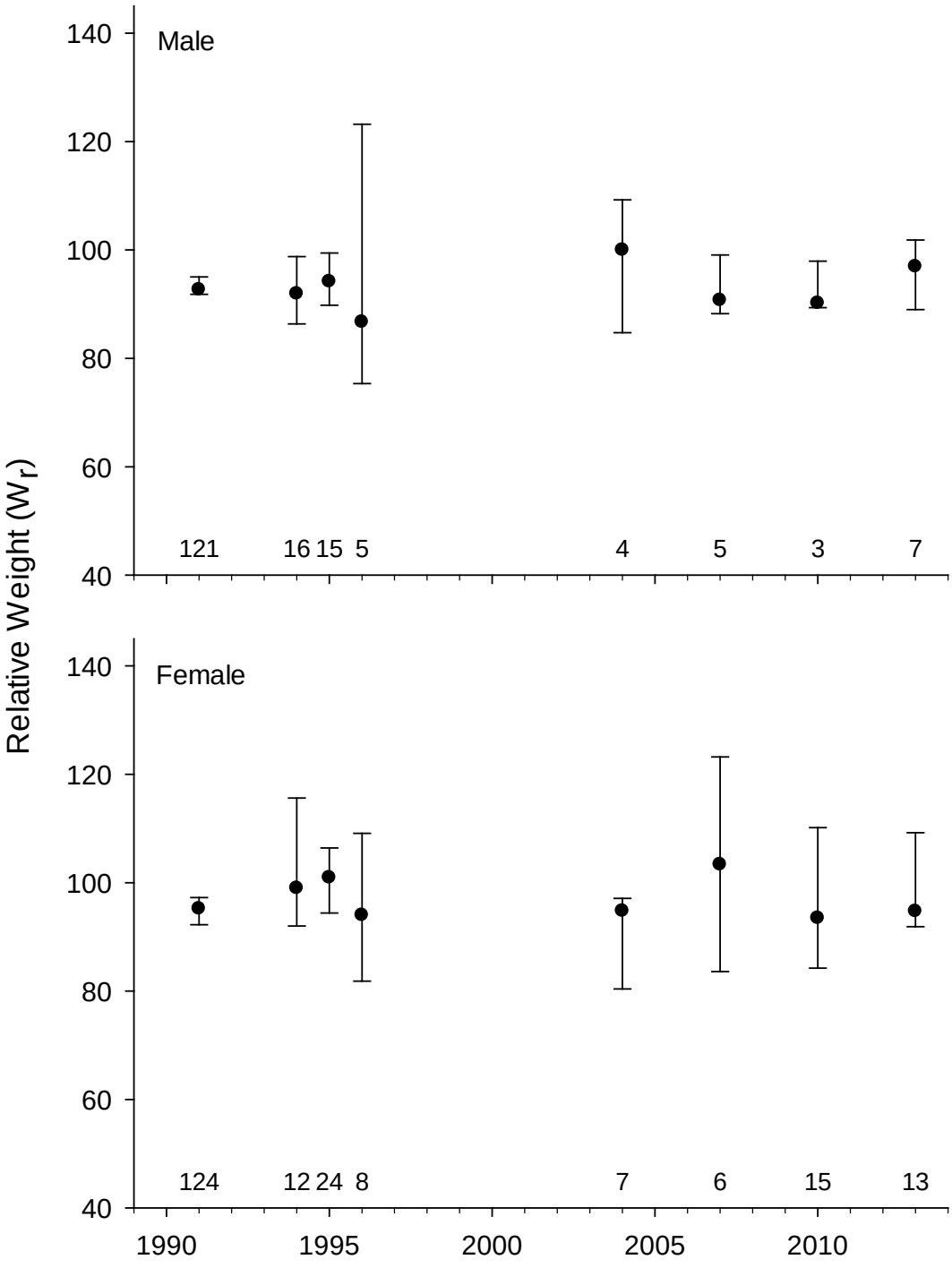


Figure 7. Median relative weight (W_r) for male and female northern pikeminnow in Lower Monumental Reservoir, 1991–2013. Error bars represent 95% bootstrap (quantile) confidence intervals. Sample sizes are presented above the independent axis. Years with no data indicate sampling was not conducted or no fish were collected.

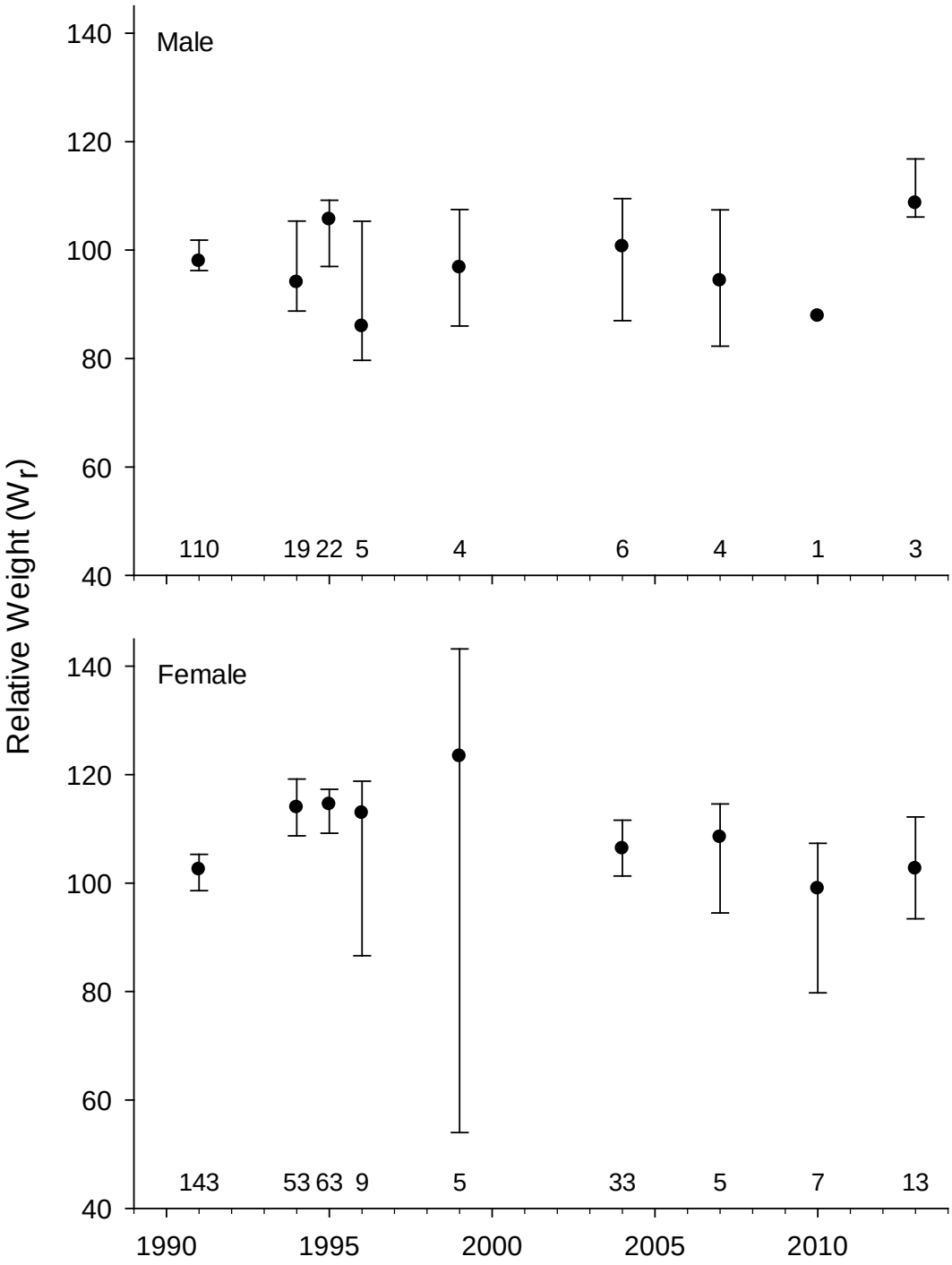


Figure 8. Median relative weight (W_r) for male and female northern pikeminnow in Little Goose Reservoir, 1991–2013. **Error bars represent 95% bootstrap (quantile) confidence intervals. Sample sizes are presented above the independent axis. Years with no data indicate sampling was not conducted or no fish were collected.**

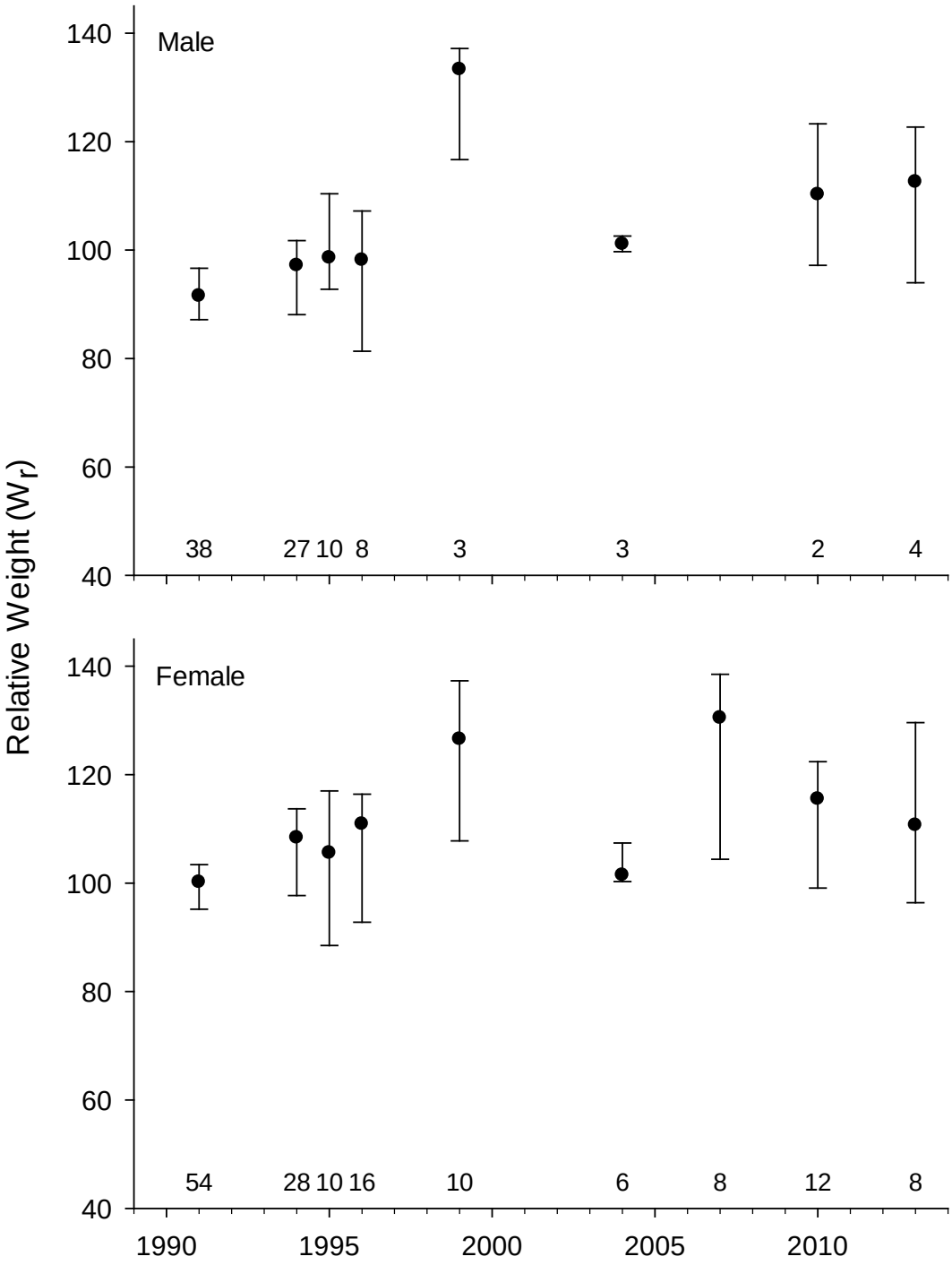


Figure 9. Median relative weight (W_r) for male and female northern pikeminnow captured in Lower Granite Reservoir, 1991–2013. Error bars represent 95% bootstrap (quantile) confidence intervals. Sample sizes are presented above the independent axis. Years with no data indicate sampling was not conducted or no fish were collected.

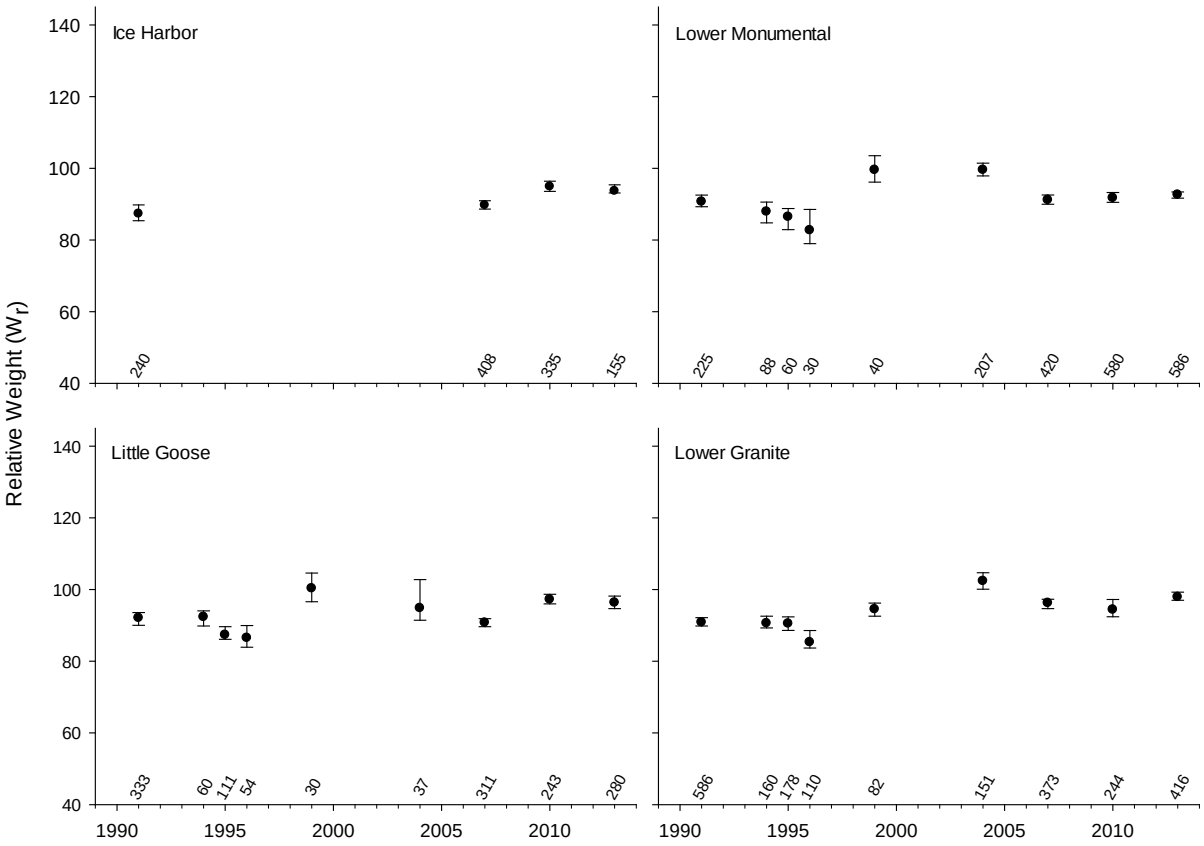


Figure 10. Median relative weight (W_r) for smallmouth bass captured in the lower Snake River reservoirs, 1991–2013. Error bars represent 95% bootstrap (quantile) confidence intervals. Sample sizes are presented above the independent axis. Years with no data indicate sampling was not conducted or no fish were collected.

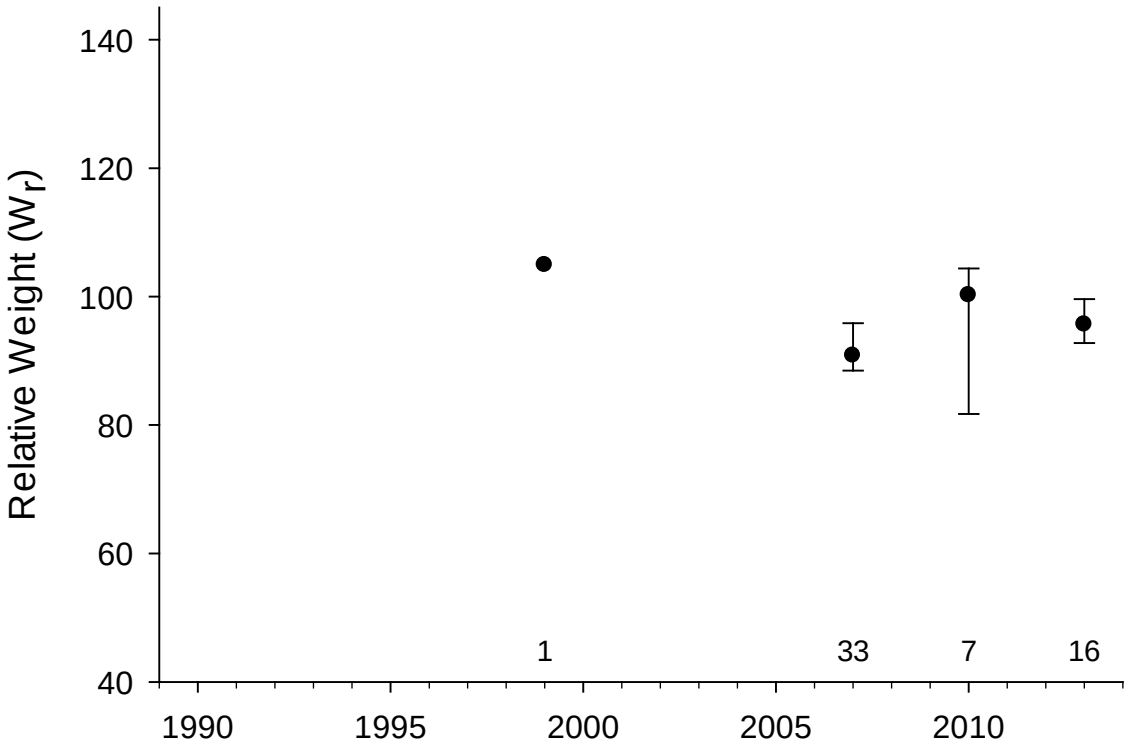


Figure 11. Median relative weight (W_r) for walleye captured in the lower Snake River reservoirs, 1991–2013. **Error bars represent 95% bootstrap (quantile) confidence intervals. Sample sizes are presented above the independent axis. Years with no data indicate sampling was not conducted or no fish were collected.**

Report D

Northern Pikeminnow Dam Angling on the Columbia River

Prepared by

Paul V. Dunlap
John D. Hone
Eric C. Winther

Washington Department of Fish and Wildlife
600 Capital Way N
Olympia, WA 98501-1091

Funded by

U. S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
Portland, Oregon 97208-3621

Project No. 1990-077-00
Contract No. 00046941

March 2014

ACKNOWLEDGEMENTS

This project is funded by the Bonneville Power Administration (BPA) as part of the Northern Pikeminnow Management Program (project number 1990-077-00), William Maslen, Environment, Fish & Wildlife Director and John Skidmore and David Roberts as Project COTR's. Russell Porter of Pacific States Marine Fisheries Commission (PSMFC) administered the contract. We would like to thank Tammy Mackey, Robert Cordie, Paul Keller, and Miroslaw Zyndol at the US Army Corps of Engineers (USACE), Erick Van Dyke 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 assistance and coordination in implementing this project in 2013.

We appreciate the efforts of Kevin Fox as the Dam Angler crew leader, along with Kyle Beckley, Rick Farris, Bob Mauldin, and Scott Mengis who served as our 2013 dam angler crew.

We also recognize Diana Murillo for her work on Dam Angler data entry and document verification, and Melissa Dexheimer for producing the Dam Angling Weekly Field Activity Reports throughout the 2013 season.

ABSTRACT

We are reporting on the 2013 Northern Pikeminnow Dam Angling component of the Northern Pikeminnow Management Program (NPMP) as implemented by the Washington Department of Fish and Wildlife (WDFW). Angling took place within the boat restricted tailrace areas of The Dalles and John Day dams for 23 weeks from May 1st to October 4th 2013. The objectives of this project were to (1) implement a recreational-type hook and line fishery that harvests northern pikeminnow from within the boat restricted areas (BRZ) unavailable to the public at The Dalles and John Day dams, (2) allocate Dam Angler effort between the The Dalles and John Day dams based on angler CPUE in order to maximize harvest of northern pikeminnow, (3) collect, compile and report data on angler harvest, CPUE, gear/techniques and incidental catch for each project, (4) scan, record and report Passive Integrated Transponder (PIT) tag data from all northern pikeminnow, smallmouth bass, walleye, and channel catfish caught by the angling crew and record with the presence of any external spaghetti tags, fin-clips, or signs of tag loss from these fishes for use in coordination with other Oregon Department of Fish and Wildlife (ODFW) predation studies, (5) collect relevant biological data on all northern pikeminnow and other fishes caught by the 2013 Dam Angling crew.

A Dam Angling crew of four anglers harvested 1,679 northern pikeminnow at The Dalles Dam and 2,360 northern pikeminnow at the John Day Dam for a total northern pikeminnow harvest of 4,039 in 2013. The crew fished a total of 1,472 hours during the 23 week fishery with a combined overall average catch per angler hour of 2.74, and the combined crew's average weekly catch equaling 176 fish. The Dam Angling crew averaged 2.95 fish per angler hour (CPUE), and cumulatively 34 northern pikeminnow per day at The Dalles Dam. The Dam Angling crew member CPUE was 2.62 with a cumulative crew total of 35 fish per day at the John Day Dam.

Based on the experience WDFW gained from implementing the Dam Angling project from 2010-12, the 2013 Dam Angling crew continued to use back bouncing soft plastic lures as the primary angling method for harvesting northern pikeminnow from The Dalles and John Day dams. Incidental species most frequently caught and released by the Dam Angling crew in 2013 were smallmouth bass *Micropterus dolomieue*, white sturgeon *Acipenser transmontanus*, and sculpin *Cottus* spp.

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 FL (11 inches total length). The Northern Pikeminnow Management Program (NPMP) was created in 1990, with the goal of implementing fisheries to achieve the recommended 10-20% annual exploitation on northern pikeminnow >275 mm FL within the program area (Vigg and Burley 1989). The primary component of the NPMP is the Northern Pikeminnow Sport-Reward Fishery (NPSRF) implemented by the Washington Department of Fish and Wildlife (WDFW) (Burley et al. 1992). Beginning in 2010, WDFW was also contracted to conduct the Dam Angling component of the NPMP (Hone et al. 2010, Dunlap et al. 2011, Winther et al. 2012) and 2013 marks the fourth consecutive year WDFW has implemented this component. The Dam Angling component of the NPMP utilized a four person crew of experienced anglers using recreational-type hook and line angling techniques to harvest northern pikeminnow from within the boat restricted zones (BRZ's) below The Dalles and John Day dams on the Columbia River.

The objectives of the 2013 Dam Angling component of the NPMP were to (1) implement a recreational-type hook and line fishery that harvests northern pikeminnow from within the boat restricted areas (BRZ) unavailable to the public at The Dalles and John Day dams, (2) allocate Dam Angler effort between the The Dalles and John Day dams based on angler CPUE in order to maximize harvest of northern pikeminnow, (3) collect, compile and report data on angler harvest, CPUE, gear/techniques and incidental catch for each project, (4) scan, record and report Passive Integrated Transponder (PIT) tag data from all northern pikeminnow, smallmouth bass, walleye and channel catfish caught by the angling crew and record the presence of any external spaghetti tags, fin-clips or signs of tag loss from these fishes for use in coordination with other Oregon Department of Fish and Wildlife (ODFW) predation studies, and (5) collect biological data on all northern pikeminnow and other fishes caught by the 2013 Dam Angling crew.

METHODS

Project Area

In 2013, northern pikeminnow removal activities utilizing a Dam Angling crew were once again conducted by WDFW at The Dalles and John Day Dams on the Columbia River as a supplemental component to the NPMP (Figure 1). Dam Angling activities in 2013 were planned for a five month period originally scheduled to be from May 1st (week 18) through the end of September (week 40). At both The Dalles, and John Day Projects, all angling activities were conducted within the tailrace boat restricted zones (BRZ) where no public angling was permitted. At The Dalles Dam, the Dam Angling crew fished primarily along the turbine wall and near the ice-trash sluiceway as indicated in Figure 2. At the John Day Dam, the crew fished exclusively along the turbine wall (Figure 3).

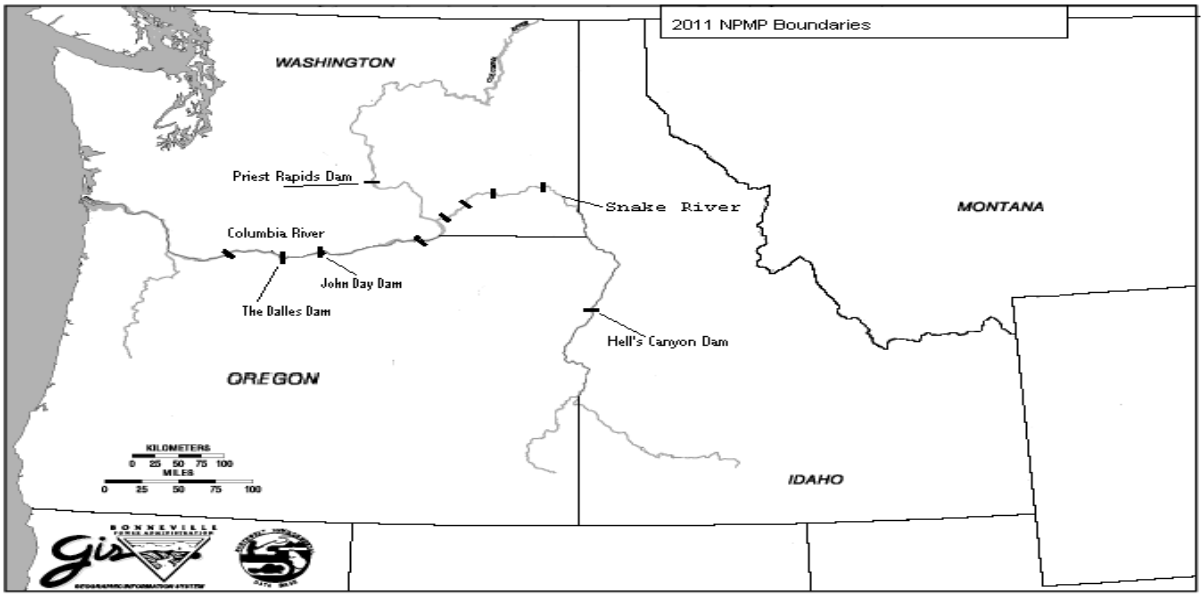


Figure 1. Northern Pikeminnow Management Program boundaries, including 2013 Dam Angling sites.

Figure 2. Angling locations for the 2013 Dam Angling crew at The Dalles Dam.

Figure 3. Angling locations for the 2013 Dam Angling crew at the John Day Dam.

The Dam Angling Season

In order to achieve the primary project objective of maximizing harvest of predatory northern pikeminnow, WDFW used the experience and knowledge gained from three previous seasons of conducting the Dam Angling component of the NPMP to formulate a Defined Angling Strategy (DAS) for use in conducting the 2013 Dam Angling season. The DAS consisted of two parts; (1) a defined CPUE goal (fish/angler hour) at which the Dam Angling crew would conduct full scale angling activities, and (2) a defined protocol for allocating Dam Angler effort in order to search for, and obtain the CPUE goal throughout the season. Based on data from the 2010-12 Dam

Angling seasons (Hone 2010, Dunlap 2011, and Winther 2012), the 2013 Dam Angler CPUE goal was set at 2.0 fish/angler hour. The protocol for allocating Dam Angler effort consisted of alternating the crew's angling days between The Dalles and John Day dams in a searching pattern until the CPUE goal was met, then concentrating all angling activities at that location. If Dam Angler CPUE were to slip below the goal, the crew's alternating location pattern would be resumed until the CPUE goal was reacquired. If angling conditions were such (at both projects) that the CPUE goal could not be met with reasonable effort, angling activities would be scaled back or suspended by the Project Leader until conditions improve. Any effort missed early in the season due to poor angling conditions would then be added to the end of the scheduled season.

The Dam Angling Crew

The four member angling crew typically worked four ten hour days a week, (usually Tuesday - Friday) during the 2013 season (Figure 4). Angling start times varied from approximately 4:30 am to 6:00 am at The Dalles Dam and from 5:00 am to 6:00 am at the John Day Dam. We also conducted a limited number of supplemental angling shifts in the evening at the John Day Dam (approximately 6:00 pm – 10:00 pm) during the 2013 fishery in order to determine if evening angling hours could be productive. In addition to the three or four person angling crew, a crew leader was also present each day for angler safety and supervision, to collect and record and compile data on northern pikeminnow harvest, other fish species caught, and to ensure that NPMP project protocols and Corps of Engineers (USACE) rules were adhered to.

Figure 4. The Dam Angling crew at The Dalles Dam.

Angling Gear

Dam anglers used Berkley Air IM8 Graphite 10'6" (2-8 oz. extra heavy casting) rods equipped with either Daiwa TD Luna 253 or Shimano Calcutta 400 series reels. Each reel was spooled with a 20# test braided main line (Power Pro), tied to a size 7 barrel swivel and a 24"-30" monofilament leader of 15-20# Maxima (Figure 5). For weight, a cannonball sinker was attached to the swivel using four to six inch dropper line of 12# monofilament leader. The cannonball sinker varied in weight from one to six ounces depending on river flow. Terminal gear consisted primarily of assorted soft plastic lures rigged with two octopus style hooks (size 1 to 1/0 Gamakatsu hooks) spaced 1 1/8" apart (Figure 6). Hook size varied in order to match the size of the soft plastic lure. Soft plastic lures used were in the 3-5" size range and included tubes, flukes, grubs and sassy shad.

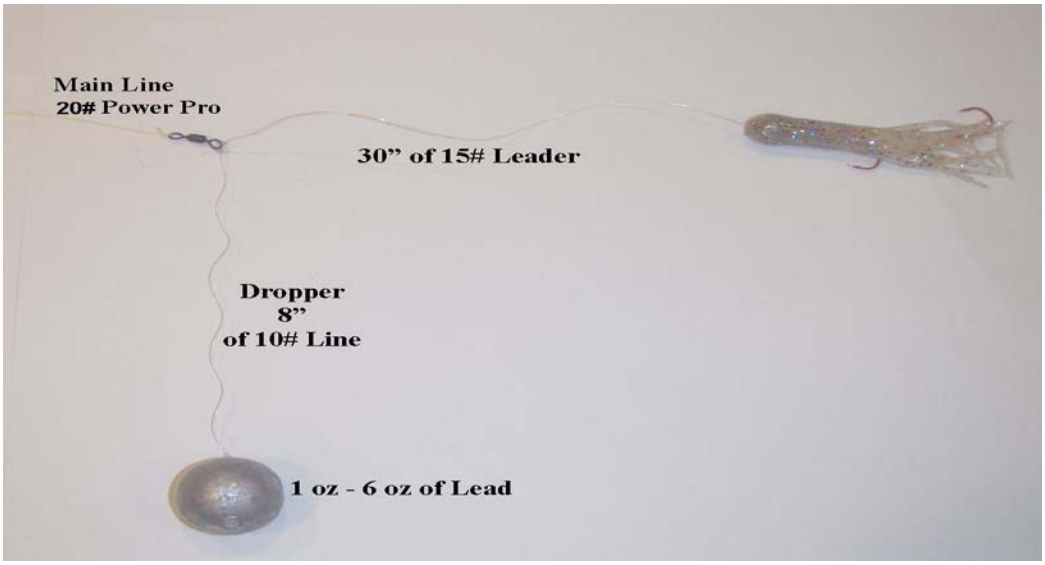


Figure 5. Example of typical rigging used by 2013 NPMP Dam Anglers.

Figure 6. Examples of soft Plastic lures and tube baits used by 2013 NPMP Dam Anglers.

Data collection

Creel data were recorded for each individual angler for their angling day and totals were combined and summarized daily with weekly totals submitted for both The Dalles, and John Day dams. Collected data included total angling hours of effort per angler, northern pikeminnow harvest per angler, incidental catch per angler, location and hour of all caught fishes by angler, as well as specific terminal gear (lure) used (and number of fish caught with that lure) by angler. Weekly catch and harvest totals (by project) for Dam Anglers were submitted to PSMFC using a Weekly Field Activity Report (WFAR) as is done for the NPSRF.

Biological Sampling

Fork lengths (FL) of all northern pikeminnow harvested by the Dam Angling crew were recorded on biological data sheets provided by the NPSRF. Technicians also examined all northern pikeminnow for the presence of external tags (spaghetti or dart), fin-clip marks, and signs of tag loss. Complete biological data were collected from all spaghetti tagged northern pikeminnow including FL, sex (determined by evisceration), and scale samples if specified. Spaghetti tagged northern pikeminnow carcasses were then labeled and frozen for data verification and/or tag recovery at a later date. Spaghetti tags from harvested northern pikeminnow along with biological data were recorded on a tag envelope provided by the NPSRF and all data were submitted to ODFW for verification.

PIT Tag Detection

All northern pikeminnow collected by Dam Anglers during 2013 were also scanned for passive integrated transponder (PIT) tags. Northern pikeminnow harvested by anglers participating in the NPSRF have been found to ingest juvenile salmonids which have been PIT tagged by other studies within the basin (Glaser et al. 2000). In addition, PIT tags have also been used by ODFW as a secondary mark in all northern pikeminnow fitted with spaghetti tags (beginning in 2003) as part of the NPMP's biological evaluation activities (Takata and Koloszar 2004). Dam Angling technicians were required to scan 100% of all harvested northern pikeminnow for PIT tags using Destron Fearing portable transceiver systems (model #FS2001F). Technicians were also asked to scan incidental catch for PIT tags whenever possible and all incidentally caught smallmouth bass per ODFW request. Scanning began on the first day of angling and continued throughout the duration of Dam Angling activities. Technicians individually scanned all northern pikeminnow for PIT tag presence, and complete biological data were recorded from all pikeminnow with positive readings. All northern pikeminnow with PIT tags were labeled and preserved for later dissection and tag recovery. All PIT tag data were verified after recovery of PIT tags by WDFW personnel and all data were provided to ODFW and the Pit Tag Information System (PTAGIS).

Northern Pikeminnow Processing

During biological sampling, all northern pikeminnow were caudal clipped as an anti-fraud measure to eliminate the possibility of previously processed northern pikeminnow being resubmitted to the Sport-Reward Fishery for payment. 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

Combined John Day/Dalles Dam Findings

2013 Dam Angling Season

The 2013 Dam Angling Season took place over a five month period from May through September. River Conditions were generally favorable early in the season as outflow was 30% lower than the previous two seasons. Dam Angling began in week 18 and total combined harvest was 4,039 northern pikeminnow in 1,472 hours of angling. Overall CPUE was 2.74 fish per angler hour and the crew first achieved the CPUE goal of 2.0 fish/angler hour (as established in our Defined Angling Strategy), in week 21 (Figure 7). Week 21 also represented the earliest week that our CPUE goal had been met in any of our four Dam Angling seasons (Winther et al. 2012, Dunlap et al. 2011, Hone et al. 2010). Fishing continued to be above our CPUE goal through week 31, with peak CPUE (5.7 fish/angler hour) achieved in week 26.

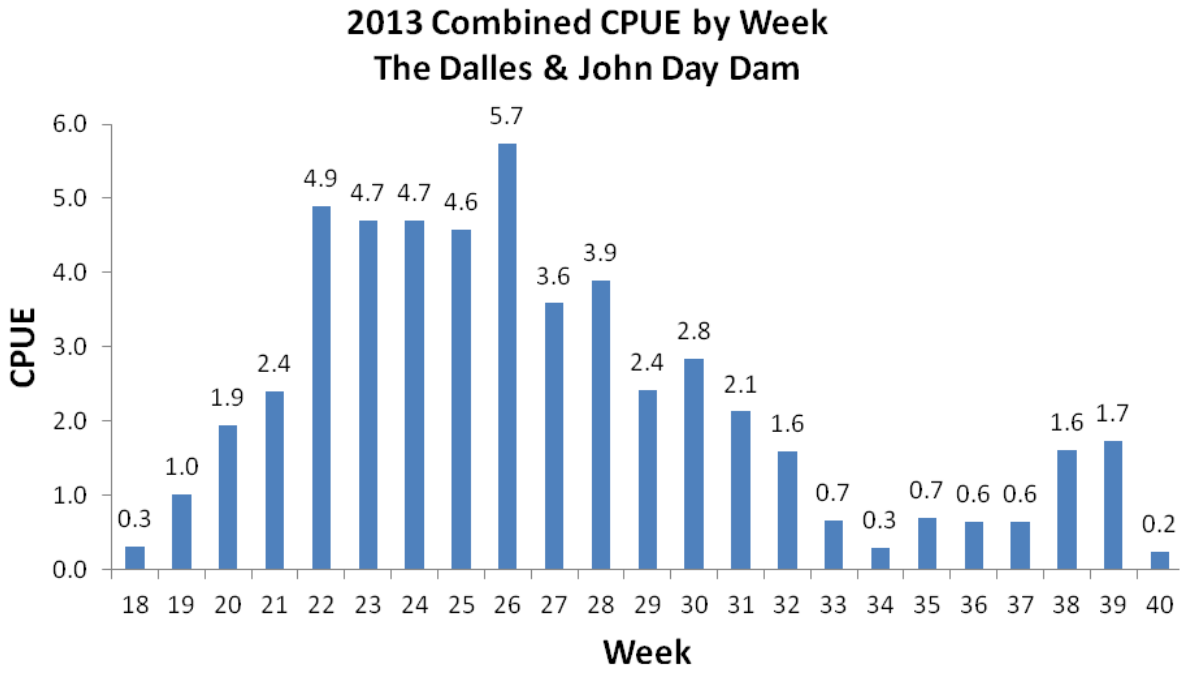


Figure 7. 2013 Weekly CPUE (fish/angler hour) of The Dalles (TD) and John Day (JD) dams combined.

Angling Gear and Technique

The 2013 Dam Angling crew primarily targeted fishing areas and fishing times at each dam that had been productive in the past (Winther 2012, Dunlap 2011, Hone 2010). Using the knowledge obtained during the three previous seasons in which WDFW had conducted the Dam Angling component of the NPMP, we believed that the majority of our angling success in 2013 would again come from fishing the turbine deck areas, back bouncing soft plastic lures. Our top producing lure was the 3.75" Gitzit tube in the Smoke/Black Copper Glitter color, which accounted for 2,496 harvested northern pikeminnow. The top 5 most productive soft plastic lures used by the Dam Angling crew in 2013 are listed in Table 1.

Table 1. Top 5 Northern Pikeminnow Lures used by 2013 WDFW Dam Angling Crew.

Northern Pikeminnow Lures

Brand/style	Size	Color	# N. Pikeminnow Caught
Gitzit/ tube bait	3.75"	Smoke/Black Copper Glitter	2,496
Gitzit/ tube bait	3.75"	Smoke Silver Glitter	696
Gitzit/ tube bait	3.75"	Dark Smoke Hologram	413
Gitzit tube bait	3.75"	Grey Shad	153
Gitzit/ tube bait	3.75"	Smoke\Green Gold Glitter	61

Angling Times

Time of day continued to make a difference in harvest success during the 2013 season. Dam Angler catch data from previous seasons had indicated that morning hours prior to 11 a.m. were consistently the most productive times for harvesting northern pikeminnow (Hone 2010, Dunlap 2011, Winther 2012). Results for 2013 Dam Angling season once again indicated that a majority of the northern pikeminnow harvest (80%) occurred prior to 11:00 am (Table 2).

Table 2. Combined 2013 WDFW Dam Angler Hourly Percentage of Northern Pikeminnow Harvest for The Dalles (TD) and John Day (JD) dams.

Hourly Northern Pikeminnow Harvest (combined TD and JD totals)

Time of day	% of Harvest
Prior to 6:00 a.m	17%
6:00 a.m - 7:00 a.m	13%
7:00 a.m. - 8:00 a.m.	14%
8:00 a.m. - 9:00 a.m	13%
9:00 a.m - 10:00 a.m	12%
10:00 a.m - 11:00 a.m.	11%
11:00 a.m. - 12:00 p.m.	8%
12:00 p.m. - 1:00 p.m.	5%
After 1 p.m.	6%

Table 3. 2013 WDFW Dam Angler Hourly Percentage of Northern Pikeminnow Harvest Comparison (TD vs JD).

	The Dalles Dam	John Day Dam
Time of day	% of Harvest	% of Harvest
5:00 a.m. - 6:00 a.m	18%	16%
6:00 a.m - 7:00 a.m	16%	11%
7:00 a.m. - 8:00 a.m.	14%	12%
8:00 a.m. - 9:00 a.m	13%	12%
9:00 a.m - 10:00 a.m	13%	11%
10:00 a.m - 11:00 a.m.	11%	10%
11:00 a.m. - 12:00 p.m.	8%	8%
12:00 p.m. - 1:00 p.m.	3%	7%
1:00 p.m. - 6:00 p.m.	2%	0%
6:00 p.m. - 7:00 p.m.	1%	1%
7:00 p.m. – 8:00 p.m.	1%	2%
8:00 p.m. – 9:00 p.m.	1%	2%
9:00 p.m. – 10:00 p.m.	0%	1%
10:00 p.m. – 2:00 a.m.	0%	0%

Incidental Catch

The Dam Angling crew incidentally hooked or caught the fish species listed in Table 4 while targeting northern pikeminnow at The Dalles and John Day dams in 2013. All incidentally caught fish species were immediately released. Incidental species most often caught were smallmouth bass *Micropterus dolomieue*, white sturgeon *Acipenser transmontanus*, and sculpin *Cottus* spp. . In addition, the Dam Angling crew once again noted large numbers of juvenile lamprey *Entosphenus* spp. and/or *Lampetra* spp. regurgitated by northern pikeminnow that they caught at The Dalles Dam and John Day Dam during May and June.

Table 4. 2013 WDFW Dam Angler Incidental Catch by project.

Incidental Catch		
Species	**The Dalles Dam**	**John Day Dam**
White Sturgeon	27	285
Smallmouth Bass	68	202
Sculpin	18	46
Walleye	1	15
Channel Catfish	0	16
American Shad	3	8
Peamouth	0	5
Chinook Salmon (adult)	1	0

Tag Recovery

All northern pikeminnow harvested by Dam Anglers in 2013 were visually examined for the presence of external spaghetti tags and 100% were individually scanned with PIT tag readers for the presence of any PIT tags. Three northern pikeminnow with external ODFW spaghetti tags were recovered by the Dam Angling crew in 2013. In addition, there were fourteen northern pikeminnow recovered that had lost spaghetti tags, but retained PIT tags implanted by ODFW as a secondary tag mark as part of ODFW's biological evaluation of the NPMP (Barr et al 2013). The 2013 Dam Angling crew also recovered 8 PIT tags from juvenile salmonid ingested by northern pikeminnow harvested at The Dalles and John Day dams. The overall occurrence rate for ingested PIT tagged salmonids in 2013 was one for every 505 northern pikeminnow (1:505), compared to 1:392 in 2012, and 1:2,190 from the 2013 NPSRF (Hone et al. 2013).

The Dalles Dam

Harvest

The Dam Angling crew harvested 1,679 northern pikeminnow in 19 weeks at The Dalles Dam in 2013, down from 3,122 fish in 2012 (Winther 2012). Weekly harvest for the Dam Angling crew averaged 88 fish per week and ranged from peak harvest of 306 northern pikeminnow in week 24 (June 11-13) to 4 fish in week 34 (Figure 8). Peak weekly harvest declined 44% from 2012 and occurred one week earlier than in 2012 and two weeks earlier than peak harvest for the Northern

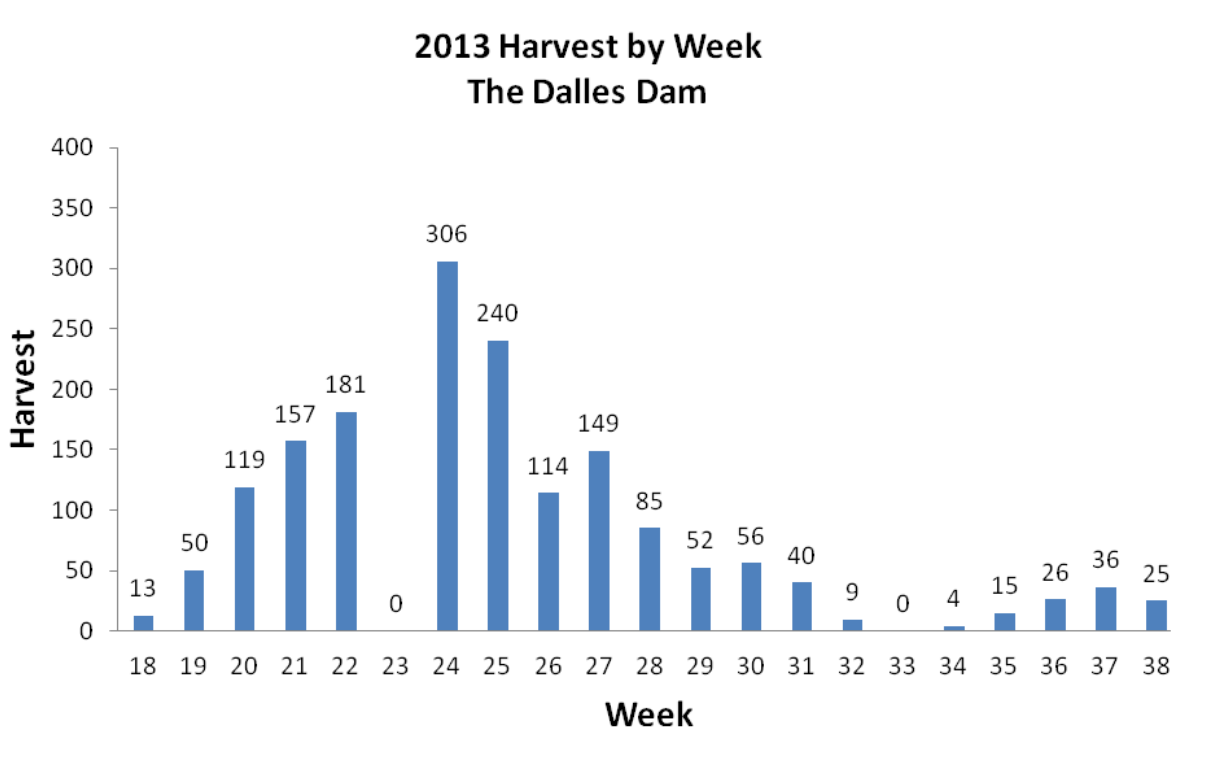


Figure 8. 2013 Weekly Dam Angler Harvest of Northern Pikeminnow at The Dalles Dam.

Pikeminnow Sport Reward Fishery (Hone et al. 2013). River outflows at The Dalles Dam early in 2013 were less than 175 kcfs which was considerably lower than in any of our three preceding years of Dam Angling (Winther 2012, Dunlap 2011, Hone 2010). This low flow created favorable river conditions during weeks 18-22 which resulted in higher early season northern pikeminnow harvest (Figure 9) than for that same period from any previous year. In addition to the 1,679 northern pikeminnow harvested at The Dalles Dam in 2013, the Dam Angling crew also harvested two spaghetti tagged, and 10 tag loss (PIT tag only) northern pikeminnow which were part of ODFW's biological evaluation of the NPMP. There were also 5 PIT tags recovered from juvenile salmonids that had been ingested by northern pikeminnow harvested by the Dam Angling crew.

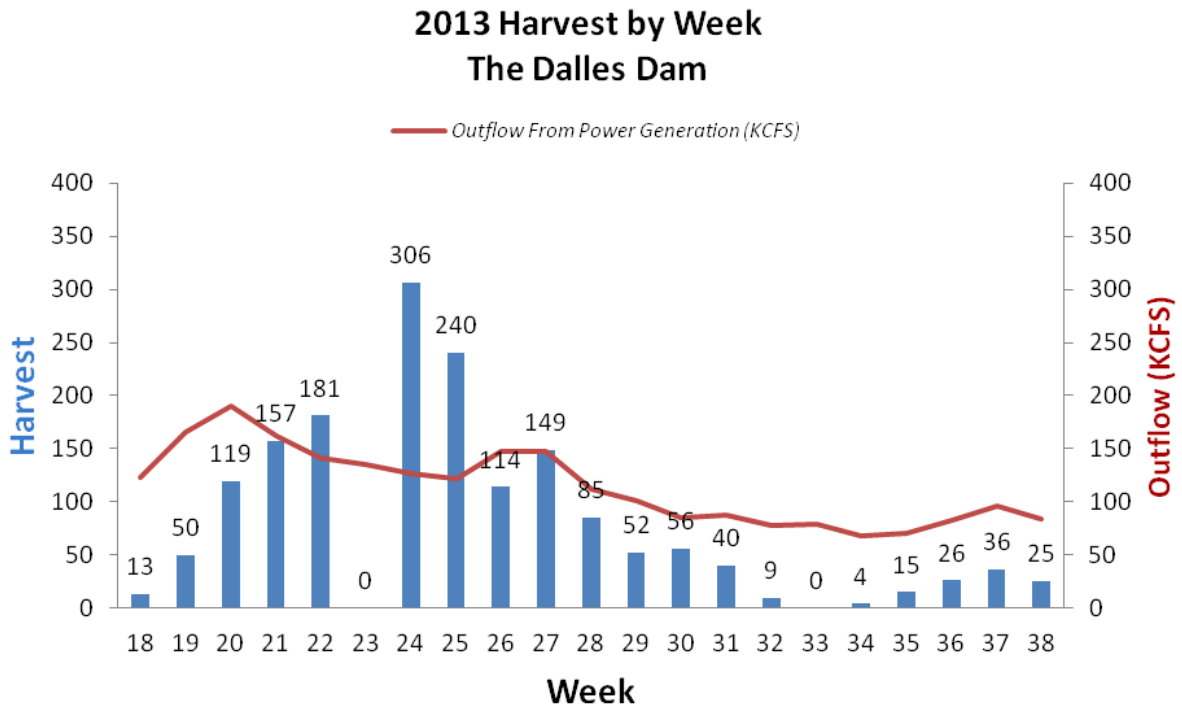


Figure 9. 2013 Weekly Northern Pikeminnow Harvest Compared to Outflow.

As was the case in past Dam Angling seasons, certain areas and/or turbines at The Dalles Dam produced better harvest than others. The bank area just upstream of the Ice/Trash Sluiceway really came on in 2013 and was the single top producing angling location, accounting for 50% of total harvest at The Dalles Dam in 2013 (Figure 10). Increased Dam Angler knowledge of technique and gear needed to proficiently fish this bank area were likely responsible for the large harvest percent increase at the Ice/Trash Sluiceway. The low river outflows also allowed the Dam Angling crew to access this area much earlier in the season than in past seasons when they could not safely do so until much later in the season (week 26 in 2012). As in past seasons the area between T9 and T14 also continued to be productive, accounting for 35% of total harvest at The Dalles Dam in 2013. This area has been a core area of northern pikeminnow harvest at The Dalles Dam accounting for 73% of harvest in 2012, 38% in 2011 and 49% in 2010 (Winther 2012, Dunlap 2011, Hone 2010).

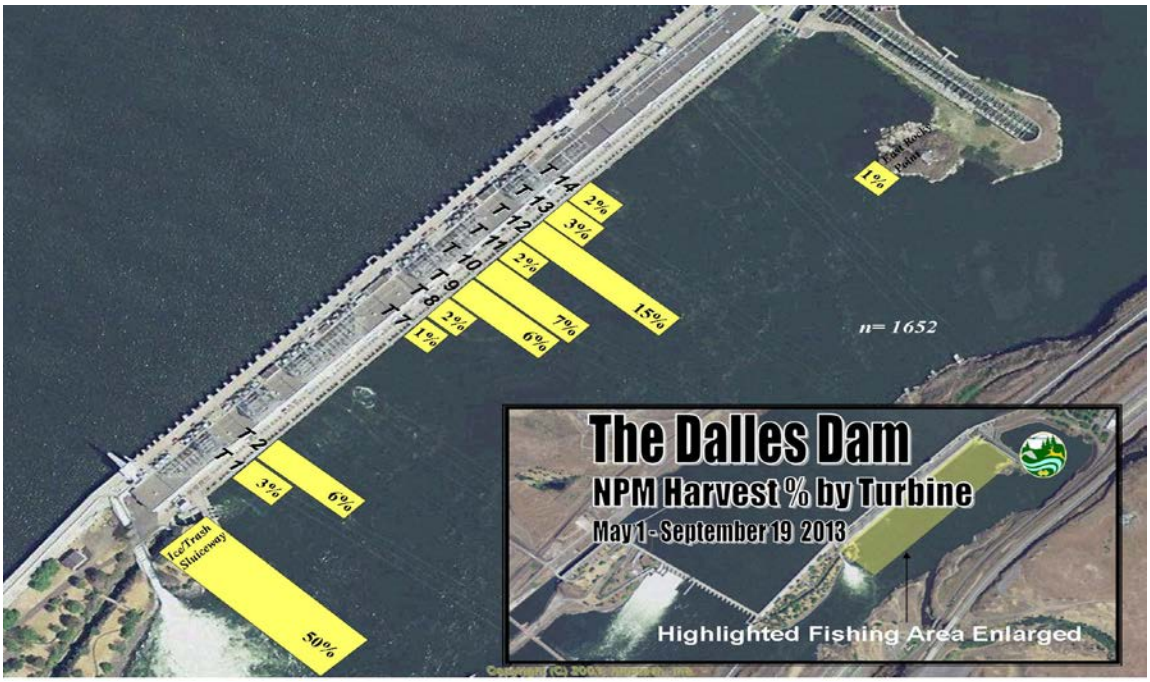


Figure 10. 2013 Overall Percent of Northern Pikeminnow Harvest by Area (T=turbine #, F = fishway).

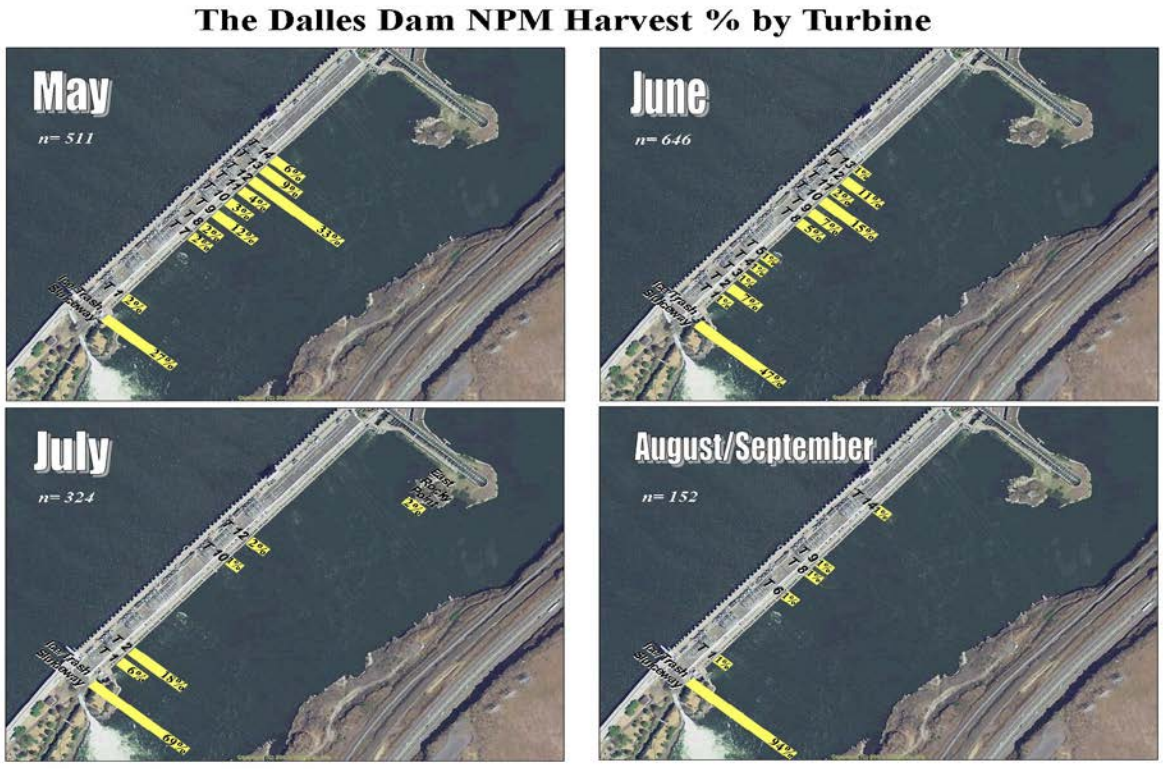


Figure 11. 2013 Monthly Harvest Percent by area (T=turbine# , F = fishway) at The Dalles Dam.

Incidental Catch

While the Dam Angling crew did not target other fish species in their angling activities during 2013, smallmouth bass (smb) were the most common species incidentally caught at The Dalles Dam. The Dam Angling crew caught 68 smallmouth bass at The Dalles Dam in 2013, compared to 59 in 2012. Most smallmouth bass were caught near the Ice/Trash sluiceway primarily in May and June (figure 12). As in past seasons, all smallmouth bass continued to be released.

Figure 12. 2013 Incidental catch of smallmouth bass by Dam Angling crew at The Dalles Dam.

Effort

Total angler hours of effort declined at The Dalles Dam to 570 hours in 2013, down from 1,161.1 hours in 2012(Winther 2012). Effort at The Dalles Dam accounted for 37% of total overall effort spent by the Dam Angling crew in 2013. In achieving that level of effort, the Dam Angling crew fished 50 days in 19 weeks at The Dalles Dam in 2013, compared to 41 days in 16 weeks in 2012.

CPUE

The Dam Angling crew harvested 1,679 northern pikeminnow in 570 angler hours at The Dalles Dam in 2013 for an overall average CPUE of 2.95 fish/angler hour. Overall CPUE at The Dalles Dam exceeded our 2.0 fish/angler hour DAS goal and was the Dam Angling crew's highest to date (Winther 2012, Dunlap 2011, Hone 2010). Weekly CPUE was above our 2.0 DAS goal for 13 of the 19 weeks fished (Figure 13) and ranged from 0.4 fish/angler hour in week 18 to 5.2 fish/angler hour (weeks 25 & 27).

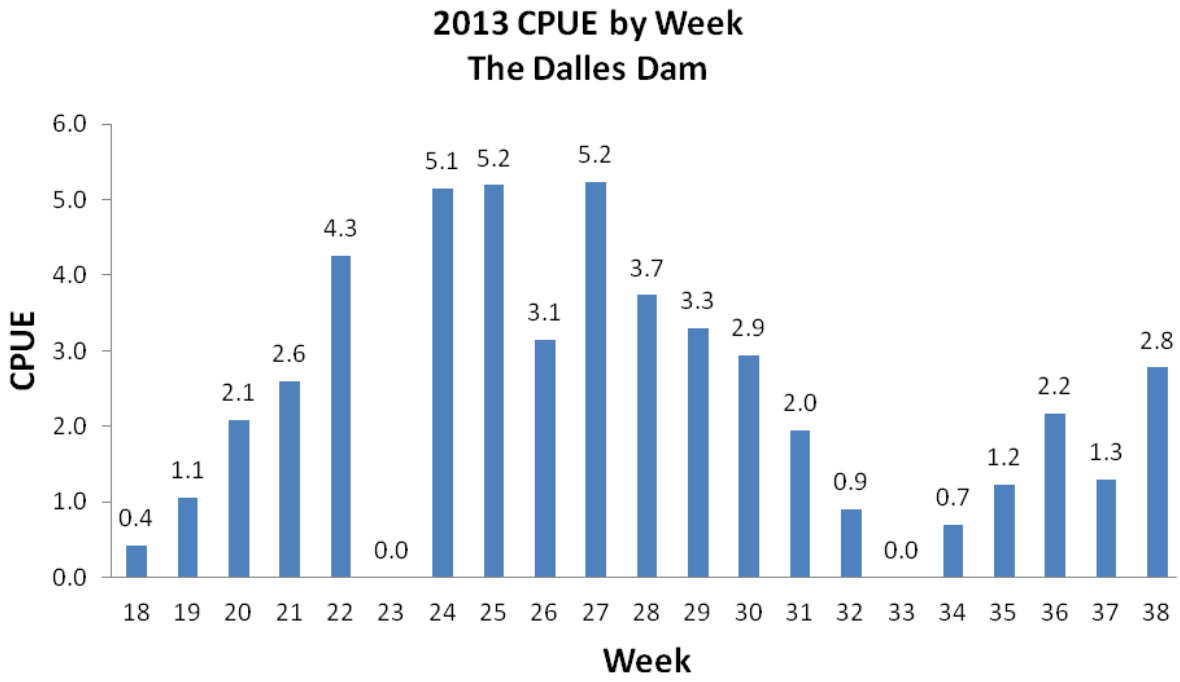


Figure 13. 2013 Weekly Dam Angler CPUE at The Dalles Dam.

Fork Length Data

Fork lengths were taken from 1,679 (100%) northern pikeminnow harvested by our Dam Angling crew at The Dalles Dam during the 2013 Season. The length frequency distribution of harvested northern pikeminnow from The Dalles Dam in 2013 is presented in Figure 14. Mean fork length for all measured northern pikeminnow at The Dalles Dam in 2013 was 324.2 mm, continuing the downward trend from 343.8 mm in 2012, 361.0 mm in 2011 and 365.5 mm in 2010 (Winther 2012, Dunlap 2011, Hone 2010).

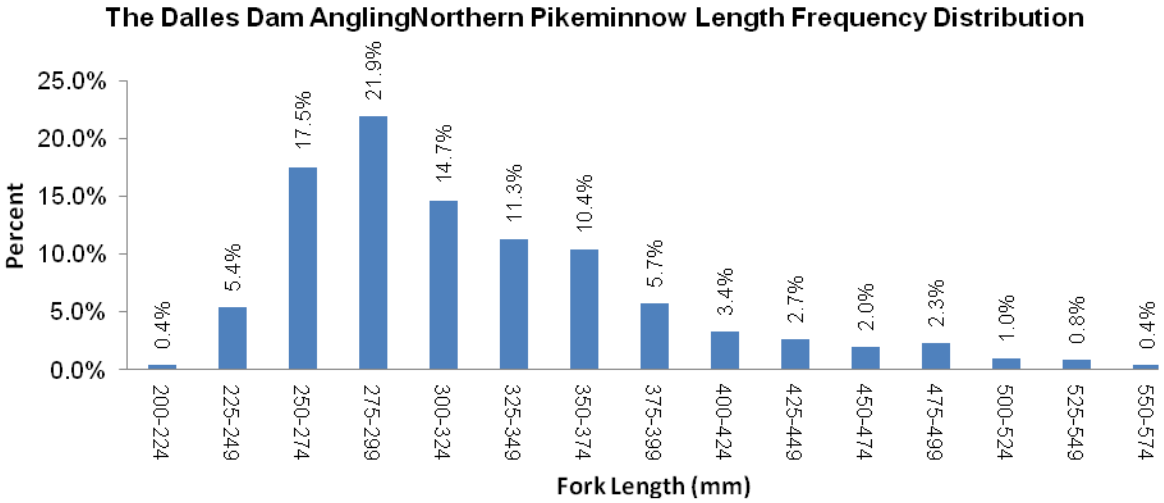


Figure 14. Northern pikeminnow Length Frequency Distribution at The Dalles Dam in 2013.

John Day Dam

Harvest

The Dam Angling crew harvested 2,360 northern pikeminnow during the 23 weeks that they fished at the John Day Dam in 2013. Weekly harvest averaged 103 fish per week and ranged from 371 in week 23 (June 4-7) to only 1 northern pikeminnow in week 19 (Figure 15). Peak harvest at the John Day Dam occurred 2 weeks earlier than for the Sport Reward Fishery and 16 weeks earlier than it had occurred during the 2012 Dam Angling season. In addition to the 2,360 harvested northern pikeminnow, the Dam Angling crew also recovered one spaghetti tagged, and 4 tag loss (PIT tag only) northern pikeminnow which were part of ODFW's biological evaluation of the NPMP (Barr et al. 2013). There were also 3 PIT tags recovered from juvenile salmonids that had been ingested by northern pikeminnow harvested by the Dam Angling crew. Contrary to previous Dam Angling seasons, harvest during weeks 22-26 was especially high, accounting for 52% of total harvest at the John Day Dam in 2013. Outflows at the John Day Dam during this time period were below 175 kcfs as indicated in (Figure 16) and coincided with good angling conditions and high harvest rates. The low outflow levels in effect during the early part of the 2013 season were also not present during the 2010-2012 Dam Angling seasons when outflow was above 200 kcfs (Winther 2012, Dunlap 2011, Hone 2010).

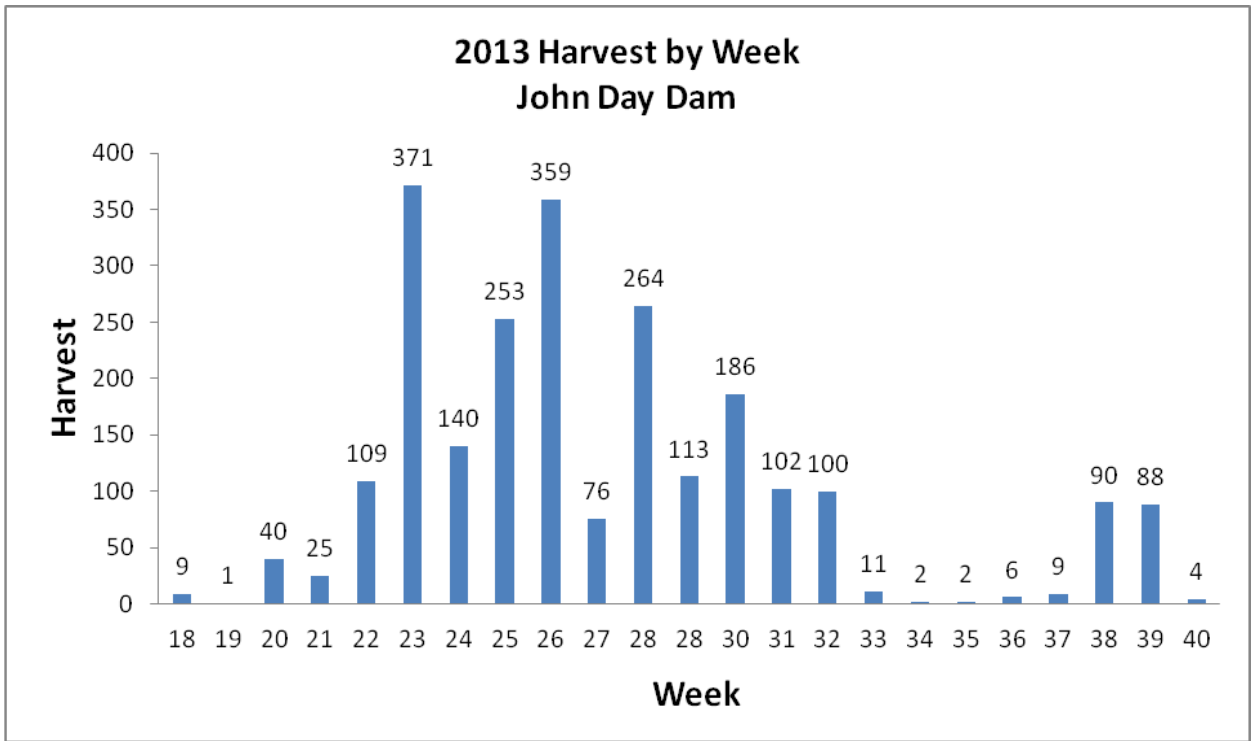


Figure 15. 2013 Weekly Dam Angler Harvest of Northern Pikeminnow at the John Day Dam.

The lower river out flows during 2013 may have also had a negative impact on late season Dam Angling harvest success. During weeks 33-40, only 212 (9% of total harvest) pikeminnow were harvested, compared to 49% of harvest in 2012 and 74% of harvest in 2011. Water temperatures also reached 70°F in week 30 and stayed above 70°F through week 38. Higher water temperatures were also present with the low flow and likely contributed to the loss of a late season harvest spike that we had encountered at the John Day Dam during the 2010-2012 seasons.

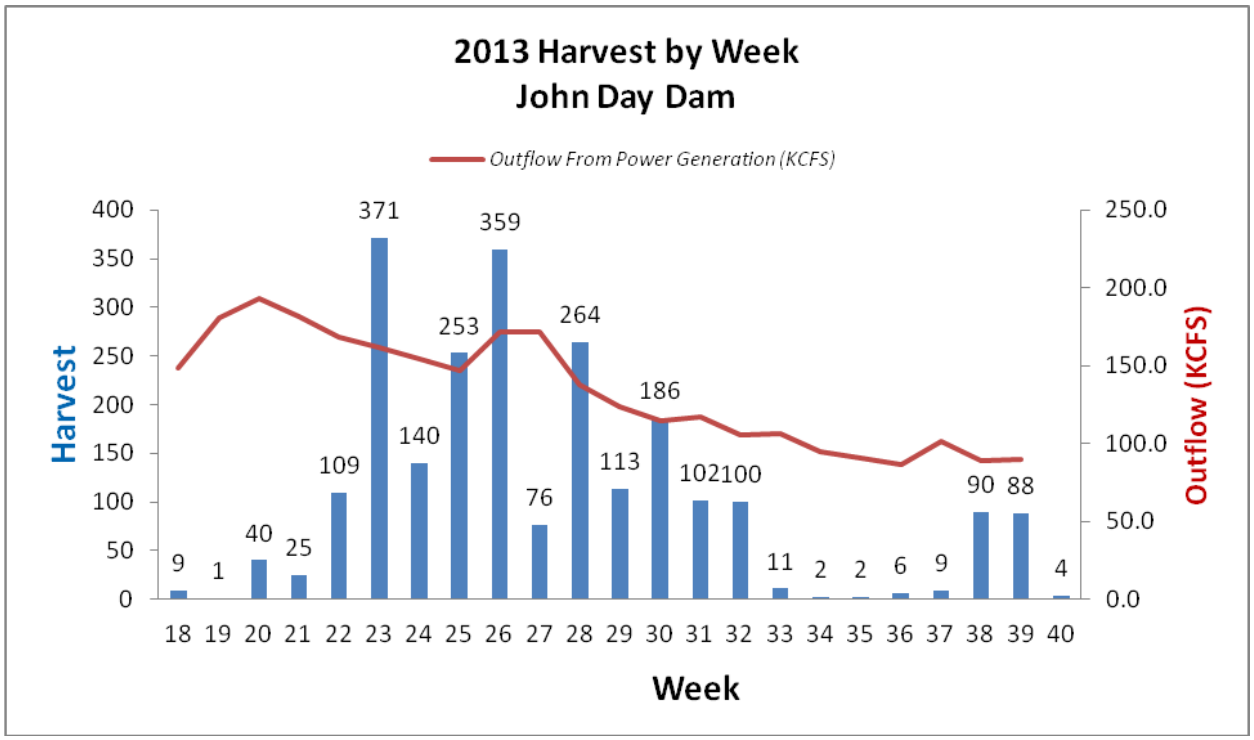


Figure 16. 2013 Weekly Dam Angler Harvest of Northern Pikeminnow at the John Day Dam vs Outflow.

As documented in previous Dam Angling Reports (Winther 2012, Dunlap 2011, Hone 2010), certain turbines at the John Day Dam created water flow conditions more favorable for harvesting northern pikeminnow than others. Of the total pikeminnow harvest at the John Day Dam in 2013, turbine #5 (T5) was the single best producing area with 28% of the total documented harvest (Figure 17). Turbine 10 (T10) had been the best angling location in 2012 with 24% of total harvest, Turbine 3 (T3) had been the best angling location in 2011 with 20% of total harvest and Turbine 5 (T5) had been tops in 2010 with 22% of harvest.

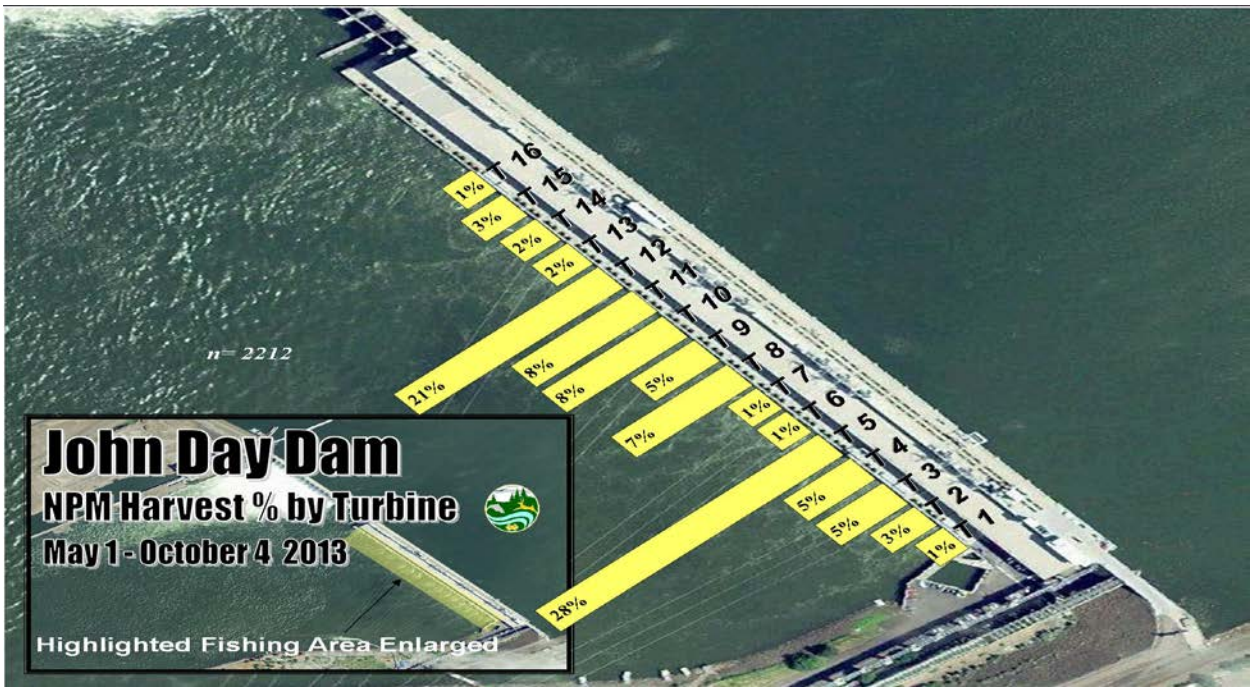


Figure 17. 2013 Overall Percent of Northern Pikeminnow Harvest by Area (T=turbine#)

Unlike previous years, harvest during the 2013 Dam Angling season did not appear to follow a seasonal pattern (figure 18). During the 2010-2012 seasons harvest generally shifted away from the spillway and towards the Oregon shore over the course Dam Angling season. One issue that really became problematic in 2013 was the shortage of productive turbines (from a fishing and harvest point of view), especially late in the year. Often there was only one turbine generating power and that turbine was the only location where the Dam Angling crew could catch fish. This meant that only one or two members of the Dam Angling crew were able to fish effectively at any one time. In an effort to deal with this phenomenon, the crew experimented with splitting shifts. A morning crew would fish early in the day (5 a.m.-1 p.m.) and the evening crew would fish (5 p.m.-11:00 p.m.). The split crew concept did show some promise for handling these types of low water river conditions in the future.

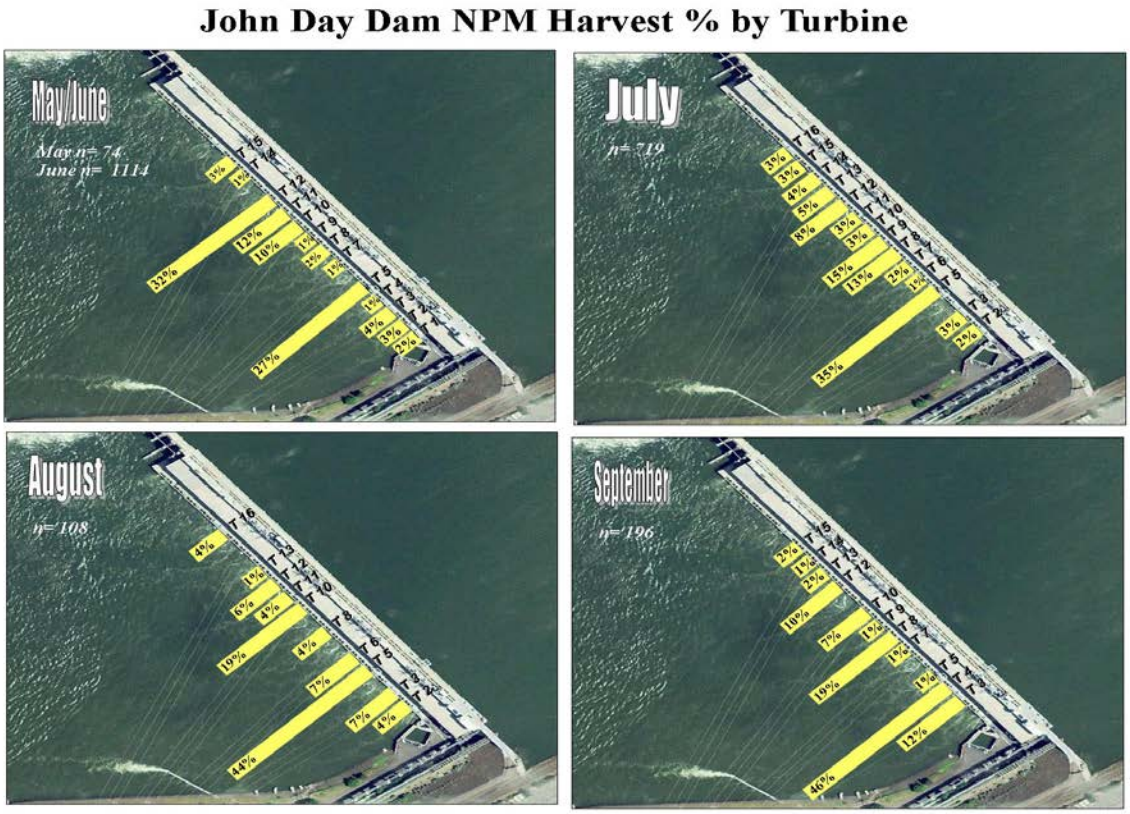


Figure 18. 2013 Monthly Percent of Northern Pikeminnow Harvest by area (T=turbine#)

Incidental Catch

While the Dam Angling crew did not target other fish species in their angling activities, white sturgeon (ws) were the most common species incidentally hooked at the John Day Dam in 2013. The Dam Angling crew hooked 285 white sturgeon at the John Day Dam in 2013, almost all of which were larger fish that broke leaders and were not landed. The Dam Angling crew caught 202 smallmouth bass (smb) at the John Day Dam in 2013, and most were caught between turbines T11 and T12 (Figure 19). The Dam Angling crew also caught 15 walleye at the John Day Dam in 2013, compared to the 2010-2012 average walleye catch of 70. All incidental species caught by the Dam Angling crew at the John Day Dam in 2013 were released.

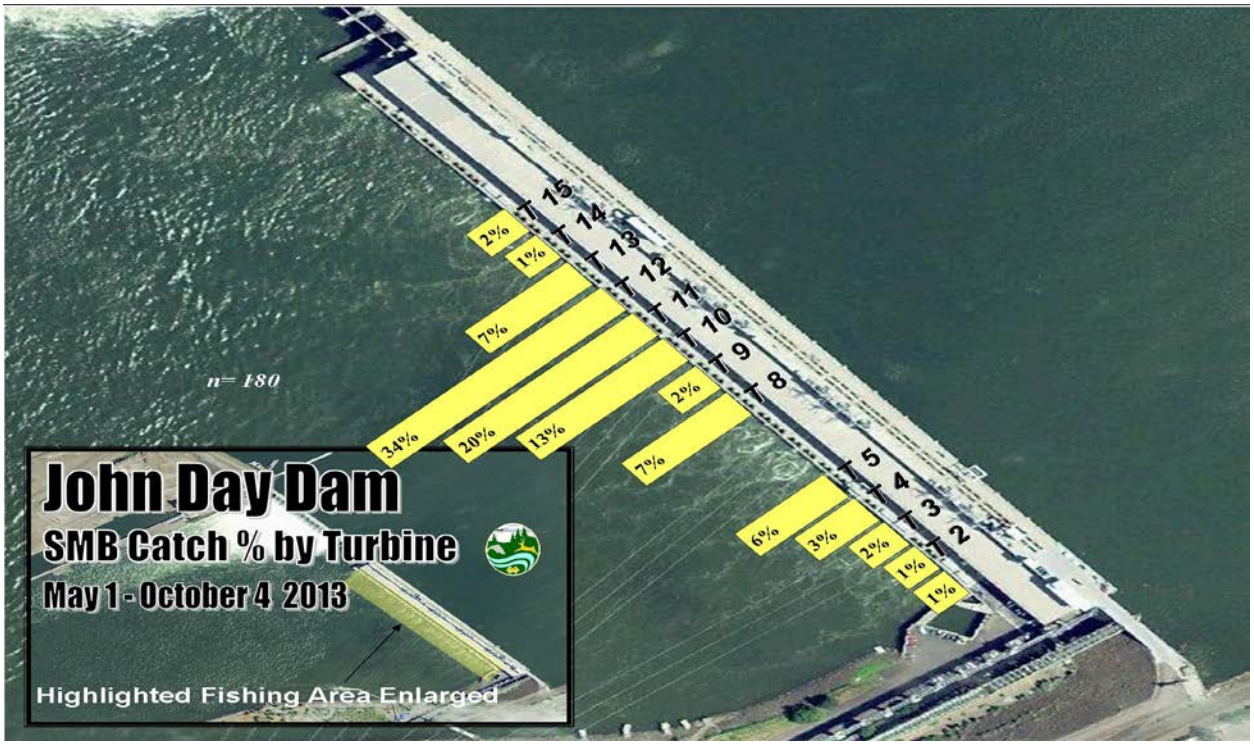


Figure 19. 2013 Incidental catch of smallmouth bass by Dam Angling crew at the John Day Dam.

Effort

Total angler hours of effort spent at the John Day Dam in 2013 was 901.75 hours (down from 1,038.75 hours in 2012), equaling 63% of total overall effort spent by the Dam Angling crew. To achieve that level of effort, the Dam Angling crew fished 67 days in 23 weeks at John Day in 2013, compared 49 days in 17 weeks in 2012. The 2013 Dam Angling crew averaged a combined 39.2 angler hours of effort per week and 13.5 angler hours of effort per day.

CPUE

The Dam Angling crew harvested 2,360 northern pikeminnow in 901.75 angler hours at the John Day Dam in 2013 for an overall average CPUE of 2.62 fish/angler hour. This rate was above the rates from previous seasons (Winther 2012, Dunlap 2011, Hone 2010) and ranged from .14 fish/angler hour in week 34 to 7.8 fish/angler hour in week 26 (Figure 20). Peak weekly CPUE at the John Day Dam occurred one week earlier than at The Dalles Dam. Even though the Dam Angling crew was only able to exceed our overall CPUE goal of 2.0 fish/angler hour at the John Day Dam for 10 of the 23 weeks fished at the John Day Dam, in achieving their highest CPUE level to date, they were still able to be efficient and effective in harvesting northern pikeminnow.

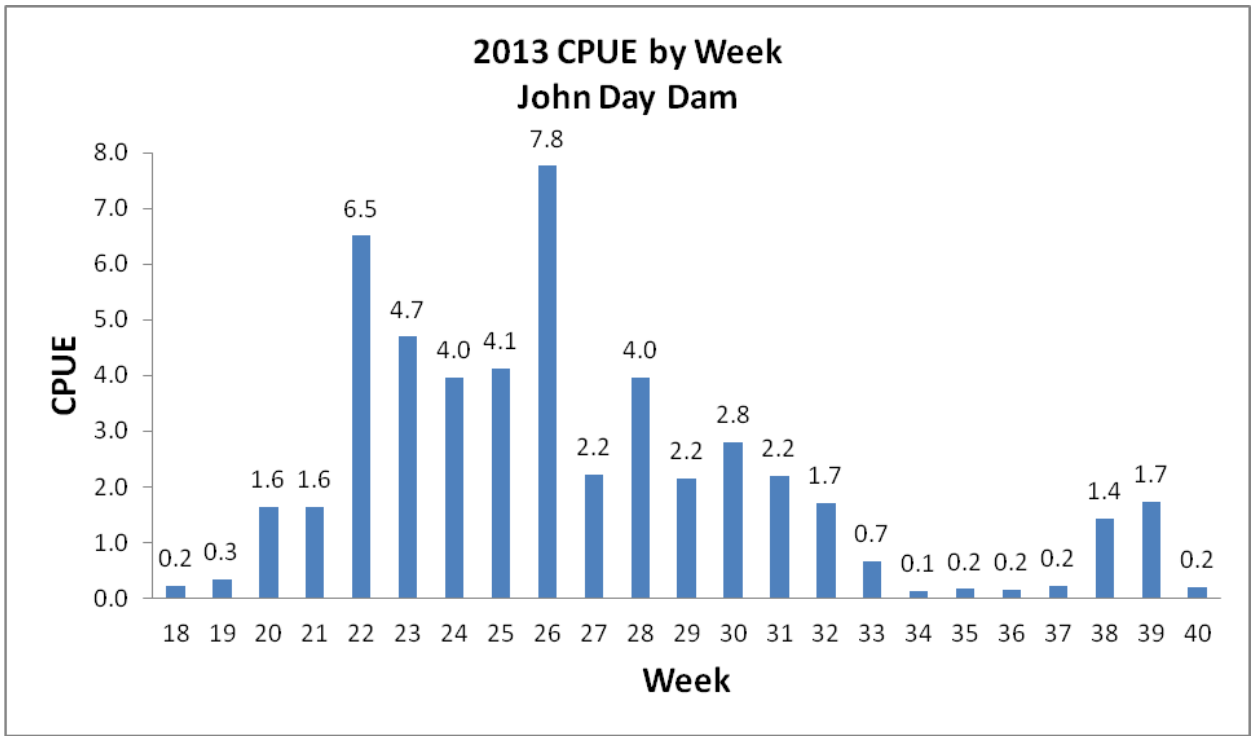


Figure 20. 2013 Weekly Dam Angling CPUE at John Day Dam.

Fork Length Data

Fork lengths were taken from 100% of all northern pikeminnow harvested at the John Day Dam during the 2013 Dam Angling Season. The length frequency distribution of harvested northern pikeminnow from the John Day Dam in 2013 is presented in Figure 21. The mean fork length for all measured northern pikeminnow harvested from the John Day Dam in 2013 was 352.5 which was our lowest mean fork length to date compared to the previous low of 368.9 mm in 2010 (Hone 2010).

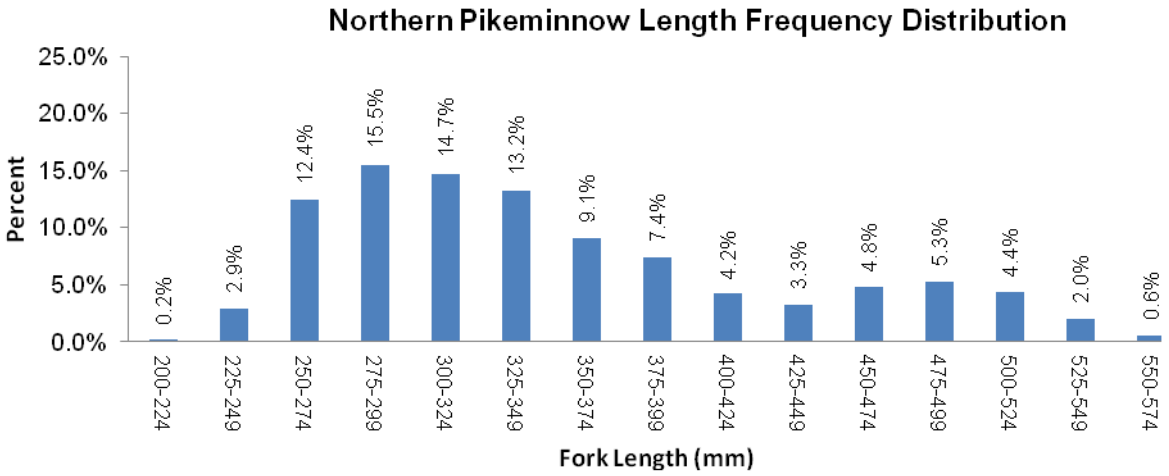


Figure 21. Northern pikeminnow Length Frequency Distribution at the John Day Dam in 2013.

SUMMARY

The fourth year of WDFW implementing the Dam Angling component of the NPMP at The Dalles and John Day dams was not as successful as the previous two seasons in overall harvest (4,039), but was our most successful season to date in terms of overall CPUE (2.74). Good early season river conditions allowed a fast start for harvesting northern pikeminnow at both The Dalles and John Day dams, but later in the year also created challenges in reaching our 2.0 fish angler hour goal. Despite the challenges, using past Dam Angling experience and our Defined Angling Strategy (DAS) protocol for use in allocating angling effort between the two projects, we were able to maximize efficiency for harvesting of northern pikeminnow in 2013, even though we were not able to achieve better harvest. Given that we had less than optimum river conditions for the second half of the 2013 season, one potential issue we discovered was that the low water limited areas of productive fishing during certain times of the year. It also appeared that peak harvest for each of the two projects may have occurred at nearly the same week in 2013 so that additional planning and Dam Angling protocols should be developed to address this issue if it comes up in the future.

Fork length data from northern pikeminnow harvested by the Dam Angling component of the NPMP continued to document that mean fork lengths of northern pikeminnow harvested at both The Dalles and John Day in 2013 dams were considerably larger than the mean fork length of northern pikeminnow harvested in the Sport-Reward Fishery (324.2 mm at The Dalles Dam, 352.5 mm John Day Dam and 276.3 mm in the NPSRF). Mean fork lengths for harvested northern pikeminnow at both projects also appear to be trending downwards over the four seasons that we have conducted Dam Angling. Tag recovery data indicated two spaghetti tagged northern pikeminnow were recovered by the Dam Angling crew at The Dalles Dam and 1 at the John Day Dam, and that 14 additional northern pikeminnow with PIT tags and lost spaghetti tags were also recovered between the two projects. Finally, the Dam Angling crew also recovered 8

PIT tags from juvenile salmonids that had been ingested by northern pikeminnow with an occurrence rate of 1:505, well above the 2013 SRF rate of 1:2,190.

The 2013 Dam Angling crew incidentally hooked 312 white sturgeon , and caught 270 smallmouth bass, 64 sculpin, and 16 walleye between the two projects while attempting to harvest northern pikeminnow. We also consistently continue to see many juvenile lamprey regurgitated by northern pikeminnow harvested at both The Dalles and John Day dams during periods of high juvenile lamprey migration. As has been the case for all years that WDFW has conducted the Dam Angling component of the NPMP all incidental species caught by the Dam Angling crew were released.

RECOMMENDATIONS FOR 2014

1.) Continue to implement Dam Angling component the NPMP in order to remove predatory northern pikeminnow from the Boat Restricted Zones in the tailrace areas of The Dalles and John Day dams where participants in the Northern Pikeminnow Sport-Reward Fishery are not able to access.

2.) Plan for Dam Angling activities to occur during similar times of year as the 2013 NPSRF in order to take advantage of fishery knowledge gained during over the 2010-2013 Dam Angling seasons as related to maximizing harvest.

3.) Continue to utilize (and modify as needed) the Defined Angling Strategy (DAS) protocol developed in 2012 which uses a minimum CPUE goal for determining where to allocate Dam Angler effort in order to maximize harvest of northern pikeminnow.

4.) Continue to improve data collection in the areas of scanning other incidentally caught predator fishes for PIT tags, defining incidentally hooked versus caught fishes and in enumerating juvenile lamprey regurgitated by northern pikeminnow caught by Dam Anglers in 2014.

5.) Continue to investigate and further develop northern pikeminnow angling techniques in 2014 that will improve Dam Angler CPUE and/or allow exploitation of northern pikeminnow in areas not currently fishable.

6.) Explore and plan for the use of split crews to optimize duel high harvest opportunities at each project at the same time.

REFERENCES

Barr, C., E. Tinus, M. Gardner, C. Mallette, and A. Storch. 2014. Report [C] - System-wide predator control program: fisheries and biological evaluation. Oregon Department of Fish and Wildlife, Contract Number 56795. 2013 Annual Report to the Bonneville Power Administration, Portland, Oregon.

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 (Northern Pikeminnow Management Program). 1991 Annual Report. Contract DE-B179 -90-BP07084, Bonneville Power Administration, Portland, Oregon.

E.C. Winther, Dunlap. P.V., Hone, J.D., and . 2012. Northern Pikeminnow Dam Angling on the Columbia River. Report D *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). 2012 Annual Report, project number 90-077. Bonneville Power Administration, Portland, Oregon.

Dunlap. P.V., Hone, J.D., and E.C. Winther. 2011. Northern Pikeminnow Dam Angling on the Columbia River. Report D *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). 2011 Annual Report, project number 90-077. Bonneville Power Administration, Portland, Oregon.

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.

Hone, J.D., P.V. Dunlap and E.C. Winther. 2010. Northern Pikeminnow Dam Angling on the Columbia River. Report D *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). 2010 Annual Report, project number 90-077. Bonneville Power Administration, Portland, Oregon.

Nelson, J. S. and five co-authors. 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. Beamsderfer, 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-A179-82 BP34796 and DE-A179-82BP35097) 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.

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.

Vigg, S. and C.C. Burley. 1989. Developing a predation index and evaluating ways to reduce salmonid 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-A179-88BP92122. Annual Report to Bonneville Power Administration, Portland, Oregon.

Hone, J.D., E.C. Winther, and P.V. Dunlap. 2013. 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). 2013 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

APPENDIX A
Terminal lures used by 2013 Dam Angler crew

Bluegill
Gitzit Tube 3.75" & 5"

Smoke/Black Copper
Gitzit Tube 3.75" & 5"

Dark Smoke Hologram
Gitzit Tube 3.75" & 5"

Pearl White
Gitzit Tube 3.75" & 5"

Smoke/Green & Gold Glitter
Gitzit Tube 3.75" & 5"

Clear Pepper
Gitzit Tube 3.75" & 5"

Pumpkin/Black & Green Glitter
Gitzit Tube 3.75" & 5"

Grey Shad
Gitzit Tube 3.75" & 5"

Hologram Shad
Gitzit Tube 3.75" & 5"

Smoke/Silver Glitter
Gitzit Tube 3.75" & 5"

Rainbow Trout
Gitzit Tube 3.75" & 5"

Brown Melon/Black & Purple Glitter
Gitzit Tube 3.75" & 5"

Zoom Fluke *Smokin Shad 3"*- 5"

Zoom Fluke *Houdini 3"* - 5"

Zoom Fluke *Smokin Silver 3"* - 5"

Zoom Fluke *White Pearl 3"* - 5"

Sassy Shad *Pearl* 4"

Zoom Fluke *Baby Bass 3"* - 5"

Perks Delight
Dry Creek 2 3/4"

Roboworm 5" & 6"

Shimmer Shad
Dry Creek 2 3/4"